CENTRIC 2012

The Fifth International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services

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CENTRIC 2012

Forward

The Fifth International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services (CENTRIC 2012), held on November 18-23, 2012 in Lisbon, Portugal, addressed topics on human-oriented and personalized mechanisms, technologies, and services, commonly known as I-centric.

There is a cohort of technologies that favored the so called “user-centric” services and applications. While some of them reached some maturity, others are to prove their economics (WiMax, IPTV, RFID, etc). The human-oriented and personalized technologies and services rely on a key set of features, some to be deployed, others getting more mature (personal profiles, preferences, identity, proximity, personal devices, etc.). Following, advanced applications covering human related activities benefit from personalized and human-oriented networks and services, especially preventive and personalized medicine, body networks and devices, or anticipative systems.

The conference provided a forum where researchers were able to present recent research results and new research problems and directions related to them. The conference sought contributions presenting novel result and future research in all aspects of user-centric mechanisms, technologies, and services.

Similar to the previous editions, this event continued to be very competitive in its selection process and very well perceived by the international community. As such, it attracted excellent contributions and active participation from all over the world. We were very pleased to receive a large amount of top quality contributions.

We take here the opportunity to warmly thank all the members of the CENTRIC 2012 technical program committee as well as the numerous reviewers. The creation of such a broad and high quality conference program would not have been possible without their involvement. We also kindly thank all the authors that dedicated much of their time and efforts to contribute to the CENTRIC 2012. We truly believe that thanks to all these efforts, the final conference program consists of top quality contributions.

This event could also not have been a reality without the support of many individuals, organizations and sponsors. We also gratefully thank the members of the CENTRIC 2012 organizing committee for their help in handling the logistics and for their work that is making this professional meeting a success.

We hope the CENTRIC 2012 was a successful international forum for the exchange of ideas and results between academia and industry and to promote further progress in personalization research.

We hope Lisbon provided a pleasant environment during the conference and everyone saved some time for exploring this beautiful city.

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Assessing the Effect of Domotics used as an Assistant to Meal Preparation with People with an Intellectual Disability

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***Abstract*— Interventions in all life settings of a person with an intellectual disability makes social inclusion possible. Although access to apartments is an important element to promote social participation, several obstacles limit their access. For this reason, it seems that technology can be of assistance to people in completing their daily tasks. Innovative technology encompasses domotics (house automation). The objective of the research presented in this article is to evaluate the effect of using domotics as an assistant to meal preparation. This research presents new ideas and new results and is directly related to the field of user-centric networking and services and more specifically the user adapted services. Twelve people with an intellectual disability carried out two recipes with and without technological assistance. Results show that people were able to use the assistant and by so doing, decreased the necessary human assistance for doing the task. This research also sheds new light on new intervention methods in home settings.**

Keyword-self-determination; assistive technology; domotics; autonomy; cooking.

I. INTRODUCTION

Many authors consider the fact of living in a home environment to be essential for the promotion of social participation of individuals [1][2]. Currently, research and intervention settings are working together in order to develop mechanisms that encourage access to different residential settings for people with an intellectual disability [3][4]. Unfortunately, for them, access to this type of apartment is riddled with obstacles. Foremost, for several people with an intellectual disability, access to apartment living is highly limited due to the necessary abilities and skills required to perform certain tasks. Thus, the significant limitations regarding reasoning, planning, problem solving and abstract thought may have considerable impacts on their ability to complete complex house tasks. Moreover, significant limitations regarding adaptive behaviours jeopardise their possibility of having access to these apartments. Overall, integration into these settings requires one to acquire and apply a certain number of functional and adaptive abilities (meal preparation, house cleaning, ensure the safety of his/her home and of his/herself, etc.) [1]. Certain researchers consider it possible for people with an intellectual disability to overcome many of these obstacles and to participate actively within their community with the assistance of assistive technologies [5].

The article first presents the use of technology in the daily lives of people with an intellectual disability. The following section presents the research conducted up to now on the use of automation to support the preparation of meals. Thereafter, the objectives of the research, the proposal and participants are described. The results obtained are explained and discussed in the final sections of the article.

II. ASSISTIVE TECHNOLOGIES IN DAILY LIFE

Proulx et al. [6] describes a study that evaluated different aspects of apartment life for people with an intellectual disability. Results show that the task of preparing a complete meal for people with an intellectual disability who live in an apartment is the most difficulty. For these individuals, meal preparation is generally the daily life activity that requires the most assistance [7]. Therefore, meal preparation plays an important role in people's lives.

Several measures are used to support people with an intellectual disability in the preparation of their meals. In rehabilitation settings, illustrated recipes in pictogram style, are commonly used. In the past few years, these visual aids have gradually been transferred onto handheld devices. These task assistants not only display each step of the recipe but also use picture prompting in order to offer people the proper feedback and reinforcement in carrying out their task. These systems are particularly helpful in assisting people in fulfilling their daily life activities and in reducing the assistance needed to perform a task, which in turn, encourage self-determination [8]. The progress made in the field of data processing as well as access to inexpensive cameras and video editing software have also made it possible to use videotaping to assist meal preparation. The results of these video methods, which have been developed and tested in the past few years, show that these technologies reduce the number of mistakes made during recipe-making and promote learning that is maintained over a period of several weeks [9][10]. Finally, it is important to mention that studies

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showing the effectiveness of these technologies had individuals follow simple recipes (e.g., reheating a dish in the microwave, making a sandwich, and preparing cookies and deserts).

III. DOMOTICS AS A NEW APPROACH TO MEAL PREPARATION ASSISTANCE

While these technologies are being used to assist meal preparation in home settings, domotics makes it possible to create safe environments which ensure continuous support for the initiation and realisation of routines in residential contexts [11].

Most research evaluating the effects of domotics have been carried out in the fields of information technology and engineering and have focused primarily on technology development intended for older people and people with physical disabilities [12][13][14]. In physical rehabilitation settings, domotics is especially used for surveillance and injury prevention with the elderly and disabled people, people with physical disabilities or with craniocerebral traumas.

The purpose of the research, until now, has been to use domotics to carry out certain tasks for the person. Little research has focused on specifically evaluating the application of domotics with the perspective of self-determination, that is to say, assist the person in the successful completion of his/her daily tasks. Recent research shows that this type of environment encourages greater independence (meals, choice of daily activities) and a sense of control over the achievement of daily activities [15]. Moreover, users are generally quite satisfied and perceive ubiquitous technology as meeting their needs and giving them greater control over the achievement of their activities [15]. Results from these initial studies also tend to show that environments using domotics promote certain conditions such as safety, autonomy, independence, a better quality of life and community integration and are all conducive to the expression of self-determination, which turn encourage the social participation of individuals [15][16]. In social and human sciences, little research has studied the application of these technologies with human beings. Until now, only two studies on the application of domotics in a residential setting have been carried out with people with an intellectual disability [5][17]. Consequently, there is no doubt as for the application of these technologies with people with an intellectual disability.

IV. THE STUDY

The next sub-sections present the research objectives, the experimental site, the research proposal used and the method of analysis.

A. Study objectives

In one of the initial studies on the use of domotics with people with an intellectual disability, this technology was studied from the angle of self-determination. The general objective of this study is to perform an initial evaluation of the contribution of domotics when used as a meal preparation assistant for people with an intellectual disability. The research also pursues three specific objectives: a) to examine the effectiveness of domotics in helping a person complete a recipe; b) to verify if there is a difference in the length of time required to complete a recipe using domotics; c) to examine if the use of domotics reduces the frequency as well as the type of human support offered to the person in the completion of a recipe of a more complex nature.

The choice of meal preparation is strategic. On a cognitive level, meal preparation involves many challenges particularly in relation to planning, reasoning, problem solving and memory. This daily life task allows different assistance methods to be tested. This study is amongst the very few that evaluate the applicability of domotics with people with an intellectual disability.

B. Description of the experimentation site and of the technology

Research was carried out at the DOMUS laboratory. This laboratory, situated at the University of Sherbrooke, is equipped with an apartment that uses domotics, which is furnished with basic domiciliary equipment. For the purpose of this study, an assistant for meal preparation was created and set up in the apartment. This assistant is the result of collaborative work between specialists stemming from different fields (occupational therapy, psychology, special education, design and computer science) [11]. The dynamic contextual assistant is composed of three main components.

Sensors. First of all, electromagnetic sensors, movement detectors and tactile carpets collect information on the activities performed by the participant. All of the information collected by the sensors is analysed by the Archipel software.

Assistance interface. The second system component is the assistance interface, which is presented on a tactile screen placed on a workable kitchen surface. When using the tactile screen, the person may press the buttons “before” and “next” to visualise accomplished steps or simply to see the following steps, which is helpful to plan the preparation of the recipe. Finally, the person may, if need be, press on the “video” button for video prompting (visualise a short video sequence) that shows explicitly how to perform the task.

Object locator. Locating objects and ingredients in the kitchen is an important component in ensuring the successful preparation of a recipe. The installed interface in the apartment can help the person find objects in his/her environment. When the person presses the button for the localisation assistance, a home menu displays categories of objects and ingredients. When the person presses on the desired object, the system activates a small diode integrated in the doors and drawers to indicate exactly where the object is located.

Four elements guided the development of this assistant to help individuals follow recipes. First of all, the graphic elements of the interface stem from the Pocket Coach software marketed by AbleLink technologies and were tested on people with an intellectual disability [18]. Secondly, researchers of this study also followed the recommendations of researchers concerning the creation of interfaces

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specifically geared at a clientele with an intellectual disability [19][20]. Finally, the fact that research results [21][22] showed that video prompting is effective for teaching culinary tasks to a population with an intellectual disability convinced researchers to add a concrete assistance standard using video sequences.

C. Participants

The research was comprised of twelve participants. Sampling was done according to an accidental non-probabilistic method. Participants were selected according to three inclusion criteria: 1) adults (18 years and over) with a mild intellectual disability without an associated physical disability or mental health problems; 2) living in an autonomous and supervised apartment or in foster homes; 3) regularly participating in meal preparation. Out of the twelve participants, 7 were women and 5 were men.

D. Design, variables and experimental procedure

The research uses 2x2 factorial design (with and without technology). This design makes it possible to control potential bias sources associated to the internal validity of the research such as the learning effect and familiarisation with the environment and with the type of recipe. Participants were randomly divided into the two experimental groups. Thus, depending on the group assignment, persons in group 1 carried out an A-B plan (Time 1 without technology / Time 2 with technology) and persons in group 2 carried out a B-A plan (Time 1 with technology / Time 2 without technology). In condition A, the participant prepares a recipe without the help of domotics. Condition B corresponds to the introduction of the independent variable (assistive technology using domotics) and requires the participants to carry out routines with the help of the computer system. In both conditions, the researcher is present and offers help to the participant when needed. The level of help offered by the researcher is recorded (dependent variable). In both conditions, the participant has at his/her disposal a paper version of the recipe that describes the ingredients and the procedure to follow.

For the purpose of the research, the participants spent three days at the DOMUS laboratory apartment of the University of Sherbrooke. Every day, the participant must spend between 1 to 3 ½ hours for experimentation purposes. The first day constitutes a preparatory phase. This phase is not part of the experimental design and its goal is to introduce the participant to the functioning of the computer and apartment components. During this preparatory phase, the researcher introduces the participant to the functioning of the tactile screen. In order to do so, the researcher plays three games of tic-tac-toe with the participant. The researcher then prepares a pancakes recipe with the participant. During the preparation, the researcher intentionally makes mistakes in order to demonstrate to the participant how to react to signals given out by the apartment. The two following days are devoted to experimentation and data collection. As soon as the participant arrives, the researcher explains the recipe to be carried out, the steps to be accomplished and the expected end result. Both recipes are relatively complex. Participants must prepare either spaghetti or macaroni from scratch. Thus, they must cut and cook the vegetables, add the meat, prepare the sauce and cook the pasta. Both recipes have the same number of steps (n=12), use the same ingredients (except for the type of pasta) and have the same cooking time. The last step is the only difference. The researcher also informs the participant as to whether he or she must follow the recipe with or without the computer's assistant.

E. Analysis of results

A camera on the ceiling films each experiment. The video sequences are then viewed in order to identify precisely the help given by the researcher. Help behaviours and participant reactions are listed in an Excel document and compiled for each participant along with the precise time that help was given and in which manner for each condition. In order to have a more accurate idea of the level of help needed to complete a recipe, help behaviours are coded according to four categories taken from the support intensity scale of the American Association on Mental Retardation [23], they are: monitoring, verbal prompting, gestual prompting, full physical assistance. For condition B, another category was added: assistance with the technology. In order to ensure data validity, counter-coding was done and the level of agreement between-judges was considered satisfactory. Descriptive analyses are then carried out (percentage, average, standard deviations). When it is statistically possible, paired samples t tests are used in order to examine if differences between means are significant.

V. RESULTS

The overall results are described in the next sub-sections.

A. Accomplishment time and help given by the researcher

Participants were all able to complete the recipes in both conditions. The average time to complete the recipe with the technology is 72.00 minutes (SD = 15.06) and without the technology is 70.83 minutes (SD = 12.66), $t(11) = 0.34$, $p = .74$ (two-tailed).

In general, we observed a considerable decrease in the help offered by the researcher for the completion of a recipe when we compared the conditions with and without the use of technology. Thus, when the person carries out the recipe without the technology, the researcher must offer assistance on an average of 40.58 times (SD = 24.25) compared to the situation with the technology where required help falls to 18.33 times (SD = 11.30), $t(11) = 4.06$, $p = .002$ (two-tailed).

The detailed analysis data of the types of assistance offered to participants for each condition are displayed in Table 1. The major portion of the assistance offered by the researcher for the accomplishment of the recipe can be found under verbal prompting. Verbal assistance given in the domotic condition was 91.9% and 86.2% in the condition without domotics. The analysis of the video sequences shows that the researcher essentially gave guidelines, answered participants' questions or confirmed that the actions were adequate. The second most used assistance by participants was gestual prompting. The analysis shows that the

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researcher mostly pointed out the location of objects and ingredients in the kitchen. The other types of assistance were used less by participants (monitoring and physical assistance). However, these types of assistance were also reduced by more than half in the domotic condition.

TABLE 1. SUPPORT PROVIDED FOR THE COMPLETION OF THE RECIPES WITH AND WITHOUT DOMOTICS

Domain	With domotics (n = 12)		Without domotics (n = 12)	
	M	*SD*	*M*	*SD*
Monitoring	.17	.39	.33	.47
Verbal prompting	14.25	19.19	34.92	21.32
Gestual prompting	.67	.78	3.67	4.01
Full physical assistance	.50	.80	1.67	1.07
Total help for recipes	*15.59*	*10.07*	*40.58*	*24.25*
Technology	2.75	2.89	---	---
Total help provided (recipe, technology, unexpected)	*18.33*	*11.30*	*40.58*	*24.25*

The video sequencing analyses of condition B show that people use the different components of the assistant to complete the tasks. The two components most often used are the picture prompting and the object locator. Participants use picture prompting to see each step concretely in order to complete the recipe. The participants then imitate the behaviour presented on the picture. Nearly all participants used the object locator to find utensils and ingredients. Many used it systematically to locate all of the necessary utensils and ingredients for the accomplishment of their recipe. The analysis also shows that many participants take great pleasure in using this function. Video prompting is the less frequently used function by participants. In this condition, the researcher gave a certain type of additional assistance specifically related to the technology. The analysis of results shows that in this condition, the researcher helped the participants 2.75 times on average for the use of different domotic functions built into the apartment. The detailed analysis shows that the assistance given is related to the use of the video and the buttons on the interface as well as the comprehension and interpretation of verbal messages and light signals.

However, an important variation in the intensity of the use of the technological assistance for each participant is noticed in the standard deviation.

B. Results related to individual scores of participants

The research sample was heterogeneous in relation to kitchen abilities. The high standard deviations clearly illustrated this situation. Indeed, the analysis of individual scores indicates a very important variability in the intensity of the support given to participants.

Results show, with the exception of two participants (#7 and #11), that all other participants were given less support when using the assistant to carry out tasks. These two participants belong to group 2 (with domotics / without domotics).

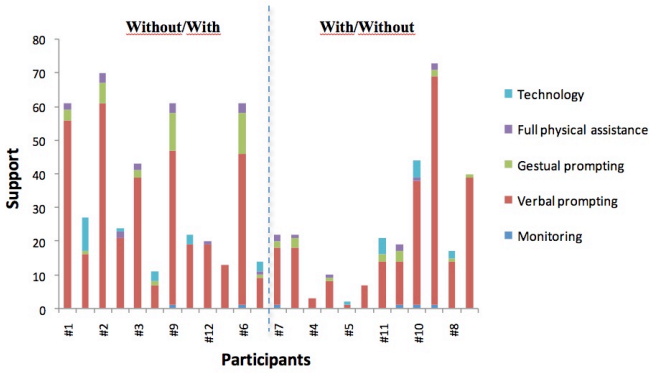

Figure 1. Indivual scores for the support provided for the completion of the recipes with and without domotics.

As for candidate #7, we notice a consistency as to the quantity of overall support given by the researcher with (n = 22) and without technology (n = 22). For this candidate, the most frequent type of support given is verbal. A more detailed analysis of the videos shows that for both conditions, the candidate requested, on several occasions, the approval of the researcher (for example, she asked the researcher if the quantity of the ingredient was correct or if she was doing the task in the correct manner). Concerning candidate #11, we noticed a decrease in the support offered when she did not use the assistant to carry out her tasks (with n=21 / without n=19). However, in the domotic condition, the video sequencing analysis shows that the researcher intervened 5 times with the candidate regarding technology. The help offered was given in relation to the functioning of the tactile screen. Thus, if we only focus on the assistance given for the recipe, we notice an increase in the assistance when comparing the condition with technology (n = 16) and without technology (n = 19), which is also the case for all the other candidates.

C. Results according to the group membership of participants

The use of the 2x2 factorial design made it possible to control the influence of certain variables. The analysis of the results according to group membership represents the situation well. These results are presented in Figure 2.

The candidates in group 1, follow the recipe without domotic and then with domotic (group without/with). In this condition, help given is notably less in the condition without domotics (M = 52.67; SD = 18.27) and with the use of domotic (M = 18.50; SD = 6.65). Concerning this condition, we observed a decrease of verbal assistance between the conditions without (M = 44.33; SD = 14.75) and with (M = 14.17; SD = 5.53) and an important decrease in the number gestual prompting given to persons between the conditions without (M = 5.67; SD = 4.93) and with (M = 0.50; SD = 0.55). In group 2, the conditions are reversed. It is in this condition that the difference is the smallest between both

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conditions; with technology (M = 18.17; SD = 15.38) and without technology (M = 28.50; SD = 24.70).

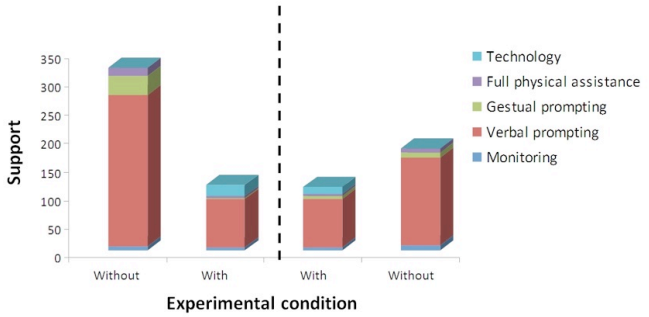

Figure 2. Total support offered for both experimental conditions.

Finally, results show that the help offered is similar and this, regardless of whether the domotic is used first (M = 18.50; SD = 6.65) or secondly (M = 18.17; SD = 15.38). This therefore shows constancy for this intervention method.

VI. DISCUSSION

The results obtained identify the contributions of an innovative technology used with people with an intellectual disability for the preparation of recipes. The discussion will refer to the study's three objectives.

A. Effectiveness of domotic as an assistant for people with an intellectual disability when in carrying out a recipe

The proposed technology is innovative and until now, few studies reviewed the implementation of this technology with people with an intellectual disability. This study wanted to verify if these persons were able to use this type of technological support and gain certain benefits. The study shows that these persons were able to use the assistant to prepare recipes and understand the different options offered. All participants used the picture prompting and the object locator. Even though several studies show the positive impacts of using video prompting, participants seldom used this method of assistance [22]. It seems that several did not know how to activate this function. Researchers must then reflect on ways to access more easily this type of assistance on the interface.

The complexity of the technology led us to believe that the participants would require a great deal of assistance to use this technology. Results show that the preparatory period was in itself sufficient for participants to comprehend the functioning of the tactile screen as well as the assistant for the preparation of the recipe. Our experiment showed that tactile screens are effective in simplifying interactions with the computer.

B. Impacts on the time of completion of the recipe

Results related to the time of completion of the recipe show a minimal difference between with and without technology. Hence, the technology in place does not lengthen the time devoted to meal preparation. This element is important for the future of this technology. Indeed, the technologies proposed to people should not make task completion more difficult. This element could bring people to lose interest.

C. Effect on the necessary human assistance for the completion of a complex recipe

This study is audacious; a relatively complex technology was combined with a recipe with a certain degree of difficulty. This study differentiates itself from other research that generally uses simple recipes such as preparing sandwiches, reheating meals in the microwave, etc. Nevertheless, this study shows that this technology does reduce the human assistance needed by the person to follow a recipe. Results of this study are similar to that of previous studies exploring the effect of technology as an assistant to the completion of tasks in a home setting [22][24][25][26]. The decrease in assistance is essentially at a verbal and gestual prompting level. The analysis of experimental conditions shows a certain stability of the technology. Thus, whether it is used in time 1 or in time 2, the level of human assistance remains relatively stable. Future studies should look into the effects of this technology when applied repeatedly to examine whether this tendency is maintained over time or if there is an observable learning effect after several consecutive uses of the assistant.

Finally, we cannot dismiss the heterogeneity of the sample, which had an important impact on the results obtained. Future research should be done with a sample of people that have similar abilities in carrying out a recipe. We believe that the success in applying this type of technology is largely determined by the identification of the needs and abilities of future users.

D. Global effects of the technology

Several effects could not be explained. On the other hand, interactions with the participants and informal discussions with them allow us to believe that there is an important potential for these technologies in relation to the dimensions of self-determination. Results clearly show that the assistant to help individuals follow recipes had a positive impact on the behavioural autonomy of participants.

VII. CONCLUSION

The research on domotics intended for people with an intellectual disability is an innovative and promising research field. It appears that SDST (have beneficial effects on the lives of people with an intellectual disability, facilitating inclusion and the fulfillment of the role of an active citizen within the community. According to us, the development of this research field is a first step towards the implementation a new innovative residential model in the next few years. This solution will possibly make it easier to save money for home care services and diversify the range of services offered. Research will indisputably have concrete repercussions on the life of people with an intellectual disability.

REFERENCES

[1] P. Morin, D. Robert and H. Dorvil, "Le logement comme facteur d'intégration sociale pour les personnes classées

 ISBN: 978-1-61208-232-5

malades mentales et les personnes classées déficientes intellectuelles," Nouvelles pratiques sociales, vol. 14, Dec. 2001, pp. 88-105.

[2] R. McConkey, S. Abbott, P. N. Walsh, C. Linehan and E. Emerson,"Variations in the social inclusion of people with intellectual disabilities in supported living schemes and residential setting, " Journal of Intellectual Disability Research, vol. 51, March 2007, pp. 207-217, doi: 10.1111/j.1365-2788.2006.00858.x

[3] J. Mansell, B. Ashman, S. Macdonald and J. Beadle-Brown, "Residential care in the community for adults with intellectual disability: needs, characteristics and services," Journal of Intellectual Disability Research, vol. 46, Nov. 2002, pp. 625-633, doi: 10.1046/j.1365-2788.2002.00440.x

[4] P. K. S. Wong and D. F. K. Wong, "Enhancing staff attitudes, knowledge and skills in supporting the self-determination of adults with intellectual disability in residential settings in Hong Kong: a pretest-posttest comparison group design," Journal of Intellectual Disability Research, vol. 52, March 2008, pp. 230-243, doi: 10.1111/j.1365-2788.2007.01014.x

[5] Y. Lachapelle, D. Lussier-Desrochers and H. Pigot, "Des TIC en soutien à l'autodétermination des personnes présentant une déficience intellectuelle," Revue québécoise de psychologie, vol. 28(2), 2007, pp. 111-123.

[6] J. Proulx, L. Dumais and Y. Vaillancourt, "Le logement à soutien gradué: Évaluation d'un projet prometteur pour les personnes ayant une déficience intellectuelle," (Cahiers du LAREPPS, No 07-09). Montréal: Laboratoire de recherche sur les pratiques et les politiques sociales (LAREPPS) - Université du Québec à Montréal (UQAM), 2007.

[7] OPHQ, "La participation sociale des personnes handicapées au Québec: les activités de la vie quotidienne: la vie communautaire," Proposition d'une politique gouvernementale pour la participation sociale des personnes handicapées. Drummondville: Office des personnes handicapées du Québec, 2007.

[8] G. E. Lancioni, M. F. O'Reilly, P. Seedhouse, F. Furniss and B. Cunha, "Promoting Independent Task Performance by Persons With Severe Developmental Disabilities Through a New Computer-Aided System," Behavior Modification, vol. 24, Oct. 2000, pp. 700-718, doi: *10.1177/0145445500245005*

[9] R. A. Rehfeldt, D. Dahman, A. Young, H. Cherry and P. Davis,"Teaching a simple meal preparation skill to adults with moderate and severe mental retardation using video modeling," Beharioral Interventions, vol. 18(3), 2003, pp. 209-218.

[10] R. Shipley-Benamou, J. R. Lutzker and M. Taubman, "Teaching daily living skills to children with autism through instructional video modeling," Journal of Positive Behavior Interventions, vol. 4, July 2002, pp. 166-177, doi: *10.1177/10983007020040030501*

[11] H. Pigot, D. Lussier-Desrochers, J. Bauchet, S. Giroux and Y. Lachapelle, "A Smart Home to Assist Recipe Completion," In A. Mihailidis, J. Boger, H. Kautz and & L. Normie (Eds.). Technology and Aging, Selected Papers from the 2007 International Conference on Technology and Aging (pp. 35-42). Amsterdam : IOS Press. (2008)

[12] K. Chapman and K. McCartney, "Smart homes for people with restricted mobility," Property Management, vol. 20(2), 2002, pp. 153-166, doi: 10.1108/02637470210428356

[13] R. Cucchiara, C. Grana, A. Prati, and R. Vezzani, "Computer vision system for in-house video surveillance," Intelligent distributed surveillance systems, vol. 152(2), 2005, pp. 242-249.

[14] H. Eriksson and T. Timpka, "The potentiel of smart home for injury prevention amoumg the eldery," Injury Control and Safety Promotion, vol. 9, Aug. 2002, pp. 127-131, doi: 10.1076/icsp.9.2.127.8694

[15] S. Martin, C. Nugent and A. Porter-Amstrong, "User perspectives: Living and working with in a "Smart Home" environment," In S. Giroux & H. Pigot (Eds.). From smart homes to smart care (pp. 33-41). Amsterdam : IOS Press. 2005

[16] J. Lundell, "Ubiquitous computing to support older adults and informal caregivers," In S. Giroux & H. Pigot (Eds.). From smart homes to smart care (pp. 11-22). Amsterdam : IOS Press. 2005

[17] S. Junestrand, G. Mollin, K. Tollmar and U. Keijer, "User Study of Video-Mediated Communication in the Domestic Environment With Intellectually Disabled Persons," International Journal of Human-Computer Interaction, vol. 15(1), 2003, pp. 87-103.

[18] D. K. Davies, S. E. Stock and M. L. Wehmeyer, "A Palmtop Computer-Based Intelligent Aid for Individuals With Intellectual Disabilities to Increase Independent Decision Making," Research & Practice for Persons with Severe Disabilities, vol. 28(4), 2003, pp. 182-193.

[19] D. K. Davies, S. E. Stock and M. L. Wehmeyer, "Enhancing Independent Internet Access for Individuals with Mental Retardation through Use of a Specialized Web Browser: A Pilot Study," Education and Training in Mental Retardation and Developmental Disabilities, vol. 36(1), 2001, pp. 107-113.

[20] C. M. Okolo, C. Bahr and H. Reith, "A retrospective view of computer-based instruction," Journal of Special Education Technology, vol. 12, 1993, pp. 1-27.

[21] T. B. Graves, B. C. Collins, J. W. Schuster and H. Kleinert "Using Video Prompting to Teach Cooking Skills to Secondary Students with Moderate Disabilities," Education and Training in Developmental Disabilities, vol. 40(1), 2005, pp. 34-46.

[22] J. Sigafoos, M. O'Reilly, H. Cannella, M. Upadhyaya, C. Edrisinha, G. E. Lancioni, et al., "Computer-Presented Video Prompting for Teaching Microwave Oven Use to Three Adults with Developmental Disabilities," Journal of behavioral education vol. 14, Sept. 2005, pp. 189-201, doi: 10.1007/s10864-005-6297-2

[23] J. R. Thompson, B. R. Bryant, E. M. Campbell, E. M. Craig, C. M. Hughes, D. A Rotholz, et al., "Supports Intensity Scale (SIS-F)," Wahinton,DC: American Association on Intellectual and Developmental Disabilities, 2008.

[24] G. E. Lancioni and M. F. O'Reilly, "Teaching food preparation skills to people with intellectual disabilities: A literature overview," Journal of Applied Research in Intellectual Disabilities, vol. 15, Sept. 2002, pp. 236-253, doi: 10.1046/j.1468-3148.2002.00122.x

[25] G. E. Lancioni, E. Van den Hof, F. Furniss, M. F O'Reilly and B. Cunha, "Evaluation of a computer-aided system providing pictorial task instructions and prompts to people with severe intellectual disability," Journal of Intellectual Disability Research, vol. 43, Feb. 1999, pp. 61-66, doi: 10.1046/j.1365-2788.1999.43120165.x

[26] L. Mechling, "Use of video prompting, via a portable DVD player, laptop computer, or PDA as self-prompting devices for persons with moderate intellectual disabilities," ATIA Orlando: Showcasing Excellence in Assistive Technology, ATIA 2009. Orlando, Fl, USA.

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User-Centric IT Security

How to Design Usable Security Mechanisms

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***Abstract*—Nowadays, advanced security mechanisms exist to protect data, systems, and networks. Most of these mechanisms are effective, and security experts can handle them to achieve a sufficient level of security for any given system. However, most of these systems have not been designed with focus on good usability for the average end user. Today, the average end user often struggles with understanding and using security mechanisms. Other security mechanisms are simply annoying for end users. As the overall security of any system is only as strong as the weakest link in this system, bad usability of IT security mechanisms may result in operating errors, resulting in insecure systems. Buying decisions of end users may be affected by the usability of security mechanisms. Hence software providers may decide to better have no security mechanism then one with a bad usability. Usability of IT security mechanisms is one of the most underestimated properties of applications and systems. Even IT security itself is often only an afterthought. Hence, usability of security mechanisms is often the afterthought of an afterthought. Software developers are missing guidelines on how to build security mechanisms with good usability for end users. This paper presents some guidelines that should help software developers to improve end user usability of security-related mechanisms, and analyzes common applications based on these guidelines.**

Keywords-usability; IT security; usable security.

I. INTRODUCTION

Any improvement of the overall security level of any system requires to improve the security level of all subsystems and available mechanisms as the overall security level of a system is determined by the weakest link in this system [12]. Howe et al. found that current software and approaches for security are not adequate for end users, because these mechanisms are missing ease of use [10]. Arce identifies the end user as weakest link in a company [12]. Hence, improving the usability of security mechanisms helps to improve the overall security level of a system.

Examples of bad usability of security mechanisms are all around. Bad usability of security mechanisms may slow down the adoption of a security system. This happened for example with email encryption. Today, it is very unlikely that an average user uses email encryption. Major problems for average users are key exchange and trust management, both having a very bad usability in common email encryption solutions. **Figure 1** shows a completely useless error message during the generation of a key pair for email encryption as one example of bad usability.

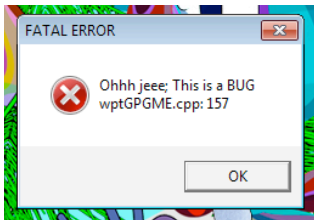

Figure 1. Error message during generation of a key pair for email encryption

The use of email encryption in companies shows that an improved usability may lead to the adoption of the formerly despised technology. In companies, key exchange and trust management are usually not done by the users themselves, but they can rely on central infrastructures such as a central company directory with keys that are trusted by default (all employees). Such a directory ensures average users can use email encryption.

The example of email encryption shows that designing security mechanisms with good usability is worth an effort. For the ordinary software developer, i.e., non security expert, it makes sense not to implement core security mechanisms like encryption algorithms or signature algorithms. Those mechanisms are usually available in security libraries written by security experts and could be easily used by software developers. However, software developers often decide on how security mechanisms are integrated into an application. For example, when implementing an email encryption security solution like GPGMail [11], the software developer decides on the interfaces for setting up trust and importing keys. Both mechanisms are application specific, hence must be implemented by the application developers. Usually, these functionalities are exposed to the users, hence should have a good usability. This paper presents some guidelines that should help software developers to improve end user usability of security-related mechanisms. To underline the importance of the presented guidelines, weaknesses of security mechanisms in common applications regarding usability for end users are shown in an analysis of common applications and security mechanisms on basis of the presented guidelines.

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Other important aspects of software security, e.g., secure coding guidelines, testing of security, and threat analysis are out of scope of this paper.

The rest of this paper is structured as follows: Section 2 gives an overview on related work. Section 3 presents guidelines for usable IT security mechanisms. Section 4 analyzes the usability of some common security mechanisms and applications. Section 5 concludes the paper and gives an outlook on future work.

II. RELATED WORK

Several standards focusing on usability in general exist, e.g., EN ISO 9241 [2]. In EN ISO 9241-11, which is part of EN ISO 9241, requirements for the usability of system are described. These requirements include effectiveness, efficiency and satisfaction. EN ISO 9241-10, another part of EN ISO 9241, lists requirements for usable user dialogs. However, the rules of EN SIO 9241 are very general and not targeted on security mechanisms. The design guidelines presented in this paper interpret the general requirements and rules of EN ISO 9241 and its parts for the special case of security mechanisms.

Other publications like [3][4][5][6][7] focus on the usability of security mechanisms in special applications (e.g., email encryption), or focus on the usability of special security mechanisms (e.g., use of passwords). The guidelines presented in this paper are more general such that they are useful for the design of a wide variety of applications and security mechanisms.

Markotten shows how to integrate user-centred security engineering into different phases of the software development process [1]. However, the emphasize of Markotten's work is more on integration of usability engineering into the software development process than on a design guide.

To summarize, previous works either are not focused on usability of IT security at all or are focused on one special aspect of usable IT security. A set of guidelines for software developers to consider during design of an application is missing. This paper presents some guidelines for software developers to help them improve the usability of security-related functionality.

III. GUIDELINES FOR GOOD USABILITY OF SECURITY MECHANISMS

The guidelines presented in this section are the result of several years in teaching IT security to beginners (and seeing their difficulties) as well as industrial experience in the design of products requiring IT security mechanisms that are operated by end users. The guidelines reflect our viewpoint on usability of security mechanisms. It is not assumed that those guidelines are complete. It is important to notice that the usability of any system depends on the specific user and his experiences, knowledge and context of use, which includes the task at hand, the equipment at hand, and the physical and social environment of the user. Hence, it is hard to objectively evaluate the usability of a system. However, we hopes that the following set of nine design guidelines coming from the field may be of help for software developers:

G1 Understandability, open for all users: As this paper focuses on usability for end users, the average end users should be able to use the security mechanism. Otherwise, the security mechanism is not useful for the intended audience. The average user neither has a special interest in IT security nor understands IT security. It is the responsibility of the software developer to hide as many security mechanisms as possible from the user. For those security mechanisms that are exposed to the end user it is necessary to get security awareness. The process of educating people is easier if suitable metaphors are used. A good metaphor is taken from everyday life of the average user, and is easy to grasp. A good metaphor is simple but powerful in its meaning. Example: an email encryption application should not use the term "encrypted email". It is better to talk about a "secret message for xy" or "email readable only by xy" where xy is the receiver of the message.

Usable security should be available for all users. It should especially not discriminate people. For example, usable security mechanisms should not exclude disabled people that use special tools to access applications (e.g., Braille reader for vision impaired people). Example of compliance with G1: if captchas are used in an application, multiple versions of the captcha should exist. Each version of the captcha should address another sense.

G2 Empowered users: Ideally, a usable security mechanism should not be used to restrict the user in what he is doing or what he wants to do. This allows end users to efficiently fulfill their tasks. Efficiency is one of the general usability requirements of EN ISO 9241 [2]. The absence of user restrictions often results in a better acceptance of security by users. The focus of a security mechanism should be on protecting the user. Any security-motivated restriction of the user should be carefully evaluated regarding necessity for system security and adequateness. The user should at least have the impression that he is in control of the system and not the system is controlling him. Security mechanisms should interfere with the usual flow of user activities in the least possible way. Security mechanisms should allow the user to execute activities in any way he wants. Other drivers than protecting the user and the system should not be motivation for restrictions. Especially, users should not be restricted by a security mechanism for the only reason of copyright protection or other business reasons. While such security mechanisms are of great use for businesses, they constantly restrict the user, hence force him to bypass security mechanisms. As users are very imaginative in bypassing unwanted restrictions, it is very likely that a non-security-motivated restriction decreases the security level of a system. The Apple iPhone is a good example: as the phone enforces many restrictions, many user bypass the security mechanisms by using a jailbreak software to revoke those restrictions.

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Another important rule is that the user should decide on trust relations. A security mechanism should not enforce trust relations given by a software vendor. The user should always have the possibility to revoke preinstalled trust relations. Trust relations should only be established in advance for the purpose of IT security. For example, having a preinstalled certificate to verify software patches is OK. Establishing trust relations out of business purposes should be avoided. Example of compliance with G2: applications should haven an interface that lists preinstalled certificates. The user should have the possibility to revoke certificates and install custom certificates.

G3 No jumping through hoops: Users should only be forced to execute as little tasks as possible that exist only for IT security reasons. Otherwise, users get annoyed and refuse collaboration with IT security mechanisms. The ideal security mechanism does not interfere with user tasks at any time (also see G2). An example on how to not design security mechanisms are captchas: the user is forced to read a nearly unreadable and meaningless combination of letters and numbers and enter it before he can execute the wanted task. Example of compliance with G3: an application that uses a challenge-response mechanism similar to hashcash [9] instead of a captcha to avoid abuse of a service by automated scripts.

G4 Efficient use of user attention and memorization capability: Users have problems memorizing data that does not belong to their social background. Hence, they tend to use all kind of optimization to reduce the amount of data they have to remember. This is why users only use approximately 3-4 passwords for all logins where they need passwords. Given the inflationary use of logins in web applications, it is very likely that an average user uses his passwords on multiple sites or for multiple purposes (e.g., for login, for encryption, …). But not only does an average user use the same password more than once, he also selects easy to remember passwords as he is not good in memorizing passwords with a mix of upper and lower case letters, numbers and special characters. Hence, security mechanisms should require the user only to remember little data or no data at all. Example of compliance with G4: An application uses an existing account from another site for login, e.g., by using OpenID [8]. The user can use an existing account, hence does not have to remember another password.

Security mechanisms should only require as little interaction with the user as possible. The security mechanism should only requests the attention of the user if it is absolutely necessary. Interaction with the user should be done in the most minimalistic way. See also G1 for user interaction. Example of compliance with G4: an email encryption application that does not ask a user for each mail if he wants to encrypt the mail or not. Instead, the email application offers a configuration option to always encrypt mails. Additionally, the email composition window clearly states the current protection status and offers a possibility to override the preferences.

G5 Only informed decisions: A user only feels secure and cooperates with a system if the system does not ask too much of him. Hence, users should only have to make decisions they can decide on. If there is an important security decision to take, it must be ensured that the user has the capability to make this decision. This means that the user has enough information about the situation that requires him to make a decision, and it must be ensured that the average user is capable to make an informed decision on this issue. If it is not clear if the user can decide on an issue, the decision should be avoided. G5 is hard to achieve and requires a careful examination during the design of an application.

G6 Security as default: Good usability requires efficiency. Hence, the user should not have to configure security when he first starts an application. Software for end users should always come preconfigured such that the software is reasonable secure and usable. All security mechanisms of a system should be delivered to the end user with a configuration that offers adequate security for the end users. The configuration effort must be minimized for users. This requires an analysis of the security requirements of average users during software development prior to the deployment of the software to find the adequate security level for most users. Example of compliance with G6: a home wifi access point comes preconfigured with a random WiFi password.

G7 Fearless System: The security system should support a positive attitude of the user towards the security system. A user with a positive attitude towards security mechanisms is cooperative and more likely to not feel interrupted by security mechanisms. Hence, security mechanisms should protect the overall system in a way that the user neither has fear when the system is in a secure state nor feels secure when the system is not in a secure state. The security state of the system should be visible at all times. A security mechanism should be consistent in its communication with its user. A security mechanism should not use fear to force users to obey security policies or get a wanted reaction. G7 is hard to achieve and requires a careful examination during the design of an application.

G8 Security guidance, educating reaction on user errors: Users tend to make mistakes, especially in respect to IT security. It is important that the security system hinders the user to make mistakes. However, as blocked operations can be very frustrating for users, the response of the security system must provide information why a given operation was blocked and should also offer a solution on how the user could proceed. The solution must be adapted on the situation and should keep the overall security of the system in mind. A security system should guide the user in the usage of security mechanisms. Errors should be prevented and there should be ways to "heal" errors. Example of compliance with G8: when an email encryption application fails to encrypt an email because of a missing public key of the recipient, the error message should explain how to import certificates from and how to verify certificates by comparing fingerprints of

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keys. To "heal" the error, the email encryption application offers to send the mail as password-protected PDF and instruct the user to call the recipient and tell him the password for the PDF.

G9 Consistency: Consistency allows users to efficiently fulfill their tasks. Security mechanisms should fit into both the application and the system context where they are used. Security mechanisms should have the look and feel the user is used to. G9 is hard to achieve and requires a careful examination during the design of an application.

IV. Analysis of the Usability of Common Security Mechanisms and Applications

In this section common applications and security mechanisms are analyzed on basis of the guidelines given in Section III. The analysis identifies room for improvement in these applications and security mechanisms. It also shows some good examples for certain aspects of security usability.

A. E-Mail Encryption using GPGMail

The encryption process itself is fairly easy, usually requiring one click to enable email encryption. However, key and trust management requires significant effort. For a secure exchange of public keys, the user has to get the public key itself (e.g., from a key server or the homepage of the receiver of a message) and verify the authenticity of the key. Certificates may be in use. The authentication requires the use of another channel to communicate with the key owner (e.g., telephone or in person) and to read a number to the owner that is meaningless for the user. There is no guidance for this process. Then, the user has to change the trust of the exchanged public key. It gets more complicated when using a web of trust for trust management: for the web of trust to work, the user must decide on how trustworthy a person is to verify public keys/certificates in addition to managing direct trust into keys. The distinction between those different types of trust is very hard to understand for average users.

This application is compliant with the following guidelines:

- G2 (user decides on trust relations)
- G4 (minimal interaction)
- G7 (does not frighten user)
- G9 (usually good integration, depends on system, mail client)

This application is not compliant with the following guidelines:

- G1 (hard to understand trust management and process of key verification)
- G3 (complicated trust management)
- G5 (hard to understand trust management and process of key verification)
- G6 (not set to "encrypt all" by default)
- G8 (not much guidance with trust management)

B. Forced Updates

Keeping a system up-to-date requires a timely use of provided security patches. However, many users are quite lax in applying security patches. Hence, nowadays more and more software providers let not the users decide on when to patch a system but automatically apply security patches as soon as available. While this relieves the user from applying patches, it does not take into consideration the situation of the user at the moment of a forced update. The update process may require downloading a large amount of date. This is a problem when the user is temporary on a low-bandwidth connection. The update process may change security or trust relevant configuration of the application, e.g., by revoking certificates or adding new certificates that are considered trustworthy by the software provider. Often, forced updates cannot be stopped by the user, hence hinder the user.

This security mechanism is compliant with the following guidelines:

- G1 (easy to understand)
- G5 (no user decisions involved)
- G6 (keeps system up-to-date)
- G7 (does not frighten user)
- G8 (no user action necessary (or possible))
- G9 (well integrated)

This security mechanism is not compliant with the following guidelines:

- G2 (user can not decide to not apply a patch, user can not decide on time to apply patch (e.g., do not patch presentation application before presentation on CENTRIC 2012))
- G3 (in some cases user has to wait until patch was applied)
- G4 (full attention of the user when waiting for process to finish)

C. Captchas

A captcha is a security mechanism avoiding that services are used by automated scripts. In theory, a captcha should be designed in a way that only humans can solve the given problem. Common captcha design requires users to read a distorted and meaningless combination of letters and numbers and enter it before he can use the service. **Figure 2** shows a captcha that is even worse from a usability point of view. Another side effect of the use of captchas is that captchas usually discriminate against disabled people (e.g., vision impaired people).

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Figure 2. Complicated captcha

This security mechanism is compliant with the following guidelines:

- G5 (no user decision needed)
- G6 (always used)
- G7 (does not frighten user)
- G8 (gives instructions on how to use it)

This security mechanism is not compliant with the following guidelines:

- G1 (discriminates against disabled people)
- G2 (does not allow users to use automation tools)
- G3 (additional task without value for the user)
- G4 (unnecessary user interaction)
- G9 (many different kinds of captchas are in use)

D. *HTTPS Certificate Validation in Common Browsers*

HTTPS allows for confidential and integrity protected communication on the web. For example, HTTPS is used for online banking or shopping. Nowadays HTTPS is widely used on the web. However, for a secure communication it is necessary to avoid man-in-the-middle attacks. To do so, certificates are used to authenticate the web site that one communicates with. As it is not practicable to install a certificate for each and every web site one visits, most common browsers come with preinstalled certificates of so-called Certificate Authorities (CAs). A browser accepts all certificates that have been signed by such a CA. For example, Mozilla Firefox version 14.0.1 comes with over 70 preinstalled CA certificates. The browser software developer decides on the trustworthiness of a CA (and hence on the trustworthiness of web sites), not the end user.

Figure 3 shows a typical error message of Firefox when encountering a certificate signed by an unknown CA. The text of this error message is too complicated for average users. Above this, average users are not capable of deciding on the validity of unknown certificate anyway. As this error often occurs, the users get used to it and usually just add a security exception to the system to access the web site, bypassing the security mechanism. Adding a security exception involves multiple steps (see **Figure 4** for a screenshot of the second page of the error message when clicking on “Add Exception”.

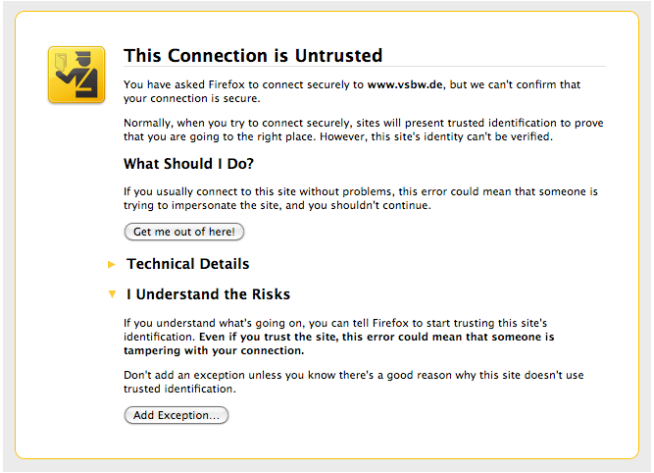

Figure 3. Typical error message of Firefox when encountering an unknown certificate

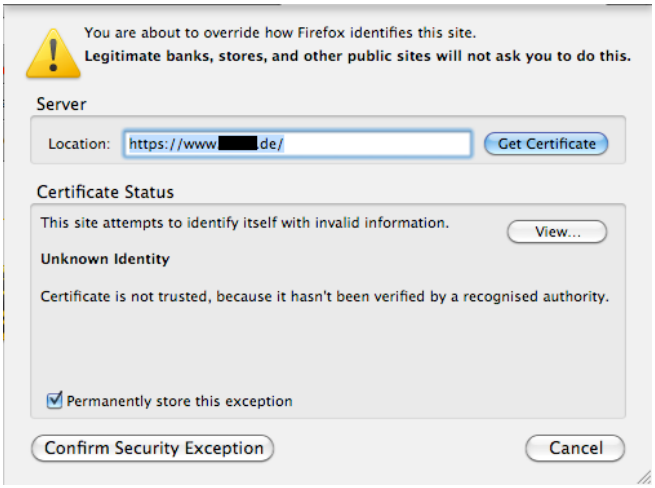

Figure 4. Second dialogue page if user clicked "Add Exception"

This security mechanism is compliant with the following guidelines:

- G6 (large number of preinstalled CAs for secure communication)
- G8 (guidance is given, however the texts used are not suited for average users)

This security mechanism is not compliant with the following guidelines:

- G1 (hard to understand error message given when browser encounters an unknown certificate / a certificate from an unknown CA)
- G2 (many preinstalled CA certificates, the user does not initially decide on trust relations. However, expert users can change the trust settings)
- G3 (annoying additional tasks when unknown certificate / a certificate from an unknown CA is encountered)

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- G4 (error unknown certificate happens often, hence most users simply ignore the message and add a security exception)
- G5 (no informed decision possible)
- G7 (error message unknown certificate implies an ongoing attack)
- G9 (look and feel is not consistent with the rest of the browser)

V. CONCLUSION AND FUTURE WORK

This paper presented guidelines for software developers to improve the usability of security-related mechanisms. The analysis of security mechanisms in common applications showed weaknesses in the usability of security-related mechanisms as well as good examples of security usability.

Future work will include the design of usable security mechanisms for common problems, e.g., certificate handling and trust management as well as a user satisfaction study on the effectiveness of the guidelines. The applicability of the guidelines will be checked with software developers that are no security experts. The guidelines presented in this paper are focused on usability for the end user. Future design guides will also focus on better usability for other groups, e.g., system administrators, testers, and developers.

REFERENCES

[1] D.G.T. Markotten, "User-Centered Security Engineering", in: NordU2002 – The 4:rd Eur/Open/USENIX Conference, Helsinki, Finland, 2002

[2] ISO, "Ergonomie der Mensch-System-Interaktion", EN ISO 9241

[3] J. Sunshine, S. Egelmann, H. Almuhimedi, N. Atri, and L. Cranor, "Crying Wolf: An Empirical Study of SSL Warning Effectiveness", in: USENIX Security Symposium, pages 399-416, 2009

[4] S. Adams and M. Sasse, "Users are not the Enemy", in: Communications of the ACM 42, December issue, pages 40-46, 1999

[5] A. Whitten and J. Tygar, "Why Johnny can't Encrypt: a Usability Evaluation of PGP 5.0", in: Proceedings of the 8th conference on USENIX Security Symposium, Volume 8, Berkeley, CA, USA, 1999

[6] M. Zurko and R. Simon, "User-centered Security", in: Proceedings of the 1996 Workshop on New Security Paradigms", New York, USA, pages 27-33, 1996

[7] C. Birge, "Enhancing Research Into Usable Privacy and Security", in: Proceedings of the 27th ACM International Conference on Design of Communications, New York, NY, USA, 2009

[8] OpenID Foundation, "OpenID Authentication 2.0 – Final", http://openid.net/specs/openid-authentication-2_0.html, accessed 08.09.2012

[9] Adam Back, "Hashcash – A Denial of Service Couter-Measure", Technical Report, 2002, http://www.hashcash.org/papers/hashcash.pdf, accessed 08.09.2012

[10] A. Howe, I. Ray, M. Roberts, M. Urbanska, and Z. Byrne, "The Psychology of Security for the Home Computer User", 2012 IEEE Symposium on Security and Privacy, 2012

[11] https://www.gpgtools.org/gpgmail/index.html, accessed 08.09.2012

[12] Ivan Arce, "The Weakest Link Revisited", IEEE Security & Privacy, March/April 2003, 2003

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Quantifying the Quality of Business Models

A State of the Practice

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***Abstract* – Companies increasingly show that the choice of the right business model is a crucial success factor. In particular, the software industry is characterized by a high degree of dynamics within their business activities. To stay competitive in a continuously changing business environment, companies must be able to adapt their business models to external or internal influencing factors. Business models are often seen as a mediator between a company's strategy and its business processes. Hence, this paper has a strong focus on the existing dependencies between business models and business processes. To gain insight on how companies currently measure the quality of their business models, several expert interviews have been carried out. To obtain significant results, the expert interviews have been carried out within one specific industry branch, namely, the software industry. The interviews have shown that, in practice, so far, there does not exist a standardized framework to measure relevant key performance indicators (KPIs) from business processes to determine the existing interrelations between business models and business processes.**

Keywords – Business models; business processes, adaptability; performance measurment; software industry

I. INTRODUCTION

The last decade has shown that the concept of business models has proven to be an increasingly important factor in literature, as well as in practice. Especially, companies in fast evolving sectors such as the software industry, demonstrate that business models form the basis for most innovations these days [1]. IBM's Global CEO study has shown that CEO's are increasingly forced to adapt their business models to dynamic factors to stay competitive within the continuously changing business environment [2]. Hence, companies must be flexible enough to adapt their business models to external and internal influencing factors [3]. So far, research on business models has a strong focus on static aspects, not adequately taking into account the huge amount of dynamic factors that continuously affect a company's business model [4][5].

Due to the lack of existing theory in the area of interest, this paper follows a design-oriented approach [6]. Several semi-structured interviews with experts from the software industry and different areas of expertise have been carried out. Based on these results, shortcomings of business model management in practice are identified and collected as requirements for deriving a framework to obtain feedback from business processes with the goal to adapt the current business model. Hence, this paper has a strong focus on the "bottom-up perspective" (feedback loop from business process level back to the business model level), providing practitioners an overview of relevant KPIs that serve as feedback parameters for business model adaptations.

The outline of the document is as follows. First, an overview of business models and business processes and their interrelations is given in Section 2. Section 3 explains the methodology and the results of the interviews carried out to gain insights in the transformative influence of business processes on business models. Section 4 summarizes the main results and gives an outlook on future research.

II. LITERATURE ANALYSIS ON BUSINESS MODELS AND BUSINESS PROCESSES – A STATE OF THE ART

A. Business Models

There is a large number of definitions for the term "business model" found in literature (e.g., [4][7–11]). Al-Debei et al. define a business model as "an abstract representation of an organization, be it conceptual, textual, and / or graphical, of all core interrelated architectural, co-operational, and financial arrangements designed and developed by an organization presently and in the future, as well as all core products and / or services the organization offers, or will offer, based on these arrangements that are needed to achieve its strategic goals and objectives" [12]. Hence, business models serve for understanding a company's business logic by containing a set of concepts and objects which are described by their relationship amongst each other [13][14]. Business models are used as management tool as they support the planning and the design of innovative business concepts to demonstrate a company's future orientations [15]. Furthermore, business models are also used in the field of requirements engineering e.g., for

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choosing needed information and communication technology to implement a company's current business model into practice [16].

The business model concept has already been addressed in literature in 1957 by Bellmann et al. [17] as well as in the 1960s by Jones [18]. Since the internet boom in the late 1990s however, the business model concept gains importance ever since [1].

In this paper, the consideration of dynamic factors plays an important role. For this reason, existing interrelations between a company's business model and its underlying business processes have to be taken into consideration in order to learn from business processes. The following sub-section gives an overview on the basic aspects about business processes.

B. Business Processes and the Software Value Chain

As already shown in the previous sub-section, business models provide a view on aspects about value creation within the enterprise [13]. In contrast to business models, business processes represent a chain of logically related activities that have to be carried out within a certain order [19]. Thereby, the consideration of organizational aspects also plays a significant role [20]. Another definition describes business processes as several activities that provide a company's customers a certain value in form of an output by requiring several input factors [21].

To be able to measure the quality of a company's business model based on its underlying business processes and value chains, relevant KPIs have to be derived first. To define industry-specific KPIs, we have a strong focus on one distinct industry branch, named software industry. Figure 1 depicts the value chain of the software industry which has been derived by several empirical and literature studies [22].

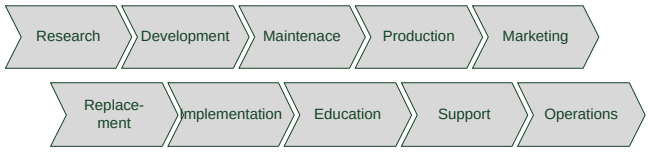

Figure 1. Value Chain of the Software Industry [23]

Software value chain activities serve for the identification of changes within the business processes of a software producing company that are caused by modifications on the underlying business model. A certain number of business processes is assigned to each activity in the value chain activity diagram. This means several related business processes are merged within one single value chain activity. If certain business processes are modified by external or internal influencing factors, these changes have a significant influence on the corresponding value chain activity. In the following, the above mentioned value chain activities will be described:

- Research: The conceptualization of a first vision of a product, fundamental research and first feasibility studies [24].
- Development: The core activities of a software producing company (e.g., requirement analysis, software design, software development, technical documentation, verification and validation). It refers to the process of software development.
- Maintenance: The continuous supervision of all required production facilities. Thus, "Maintenance" is responsible for the quality of the manufactured software products.
- Production: Encompasses product composition, production and packaging. This activity is mainly characterized by a physical reference.
- Marketing: This software value chain activity is „associated with providing a means by which buyers can purchase the product and inducing them to do so, such as advertising, promotion, sales force, quoting, channel selection, channel relations, and pricing [25]."
- Replacement: This activity includes the decision whether an existing system will be replaced by an alternative system [26].
- Implementation: Encompasses the installation, configuration and adaptation of a specific software product [24]
- Education: The user's instruction and explanation of the developed product. Within Support error corrections and improvements of the software product as part of the waterfall model are carried out [24][26].
- Operations: Comprise the monitoring within the accomplishment of specific software product by an information system [24][27]. To avoid damages caused by data loss, backups have to be carried out and releases have to be continuously actualized.

The following section gives an overview about the existing relationships and dependencies between business model layer and the level of business processes, encompassing the presented value chain.

C. Interdependencies between business models and business processes

Business Models are often described as a mediator between a company's strategy and its business processes [28]. These interrelations are depicted in Figure 2 and form the basis for the conduction of the expert interviews that are presented in the following section:

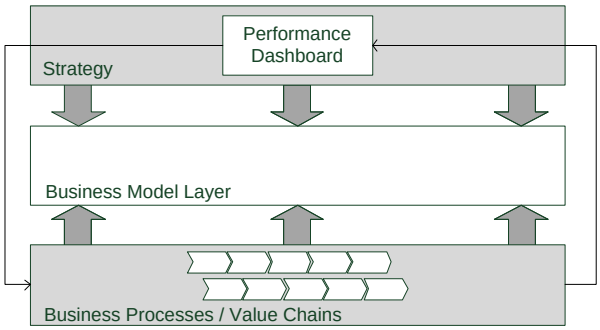

Figure 2. Intedependencies between strategy, business models and business processes [3]

Especially the connection between a company's strategy and its business processes shows that business model analysis should not only be conducted top-down but also bottom-up, beginning from business process level. The main focus of this paper is in analyzing the interrelations between business models and the layer of business processes. Therefore, relevant KPIs for each value chain activity are needed, which serve as feedback parameter for the underlying business model. This means, a continuous feedback loop arises which is essential for business model adaptability. Hence, business models gain flexibility which is needed for the adaptation to influencing factors (e.g., market developments or changing prices).

III. CONDUCTION OF THE INTERVIEWS

In this section, the conduction of the interviews with experts from the software industry is described. First, the scientific goal of the expert interviews is described, followed by an explanation of the results and implications for business model research.

A. Methodology

As already shown in the previous sections, existing interdependencies between business models and business processes are a so far an understudied area of high practical relevance [3]. The bottom-up perspective has not been analyzed in literature and practice so far. Hence, to gain insights in how companies shape and implement this feedback mechanism in practice, an empirical study within the software industry has been conducted. We employ an explorative study design that follows the ideas of grounded theory [29]. This inductive approach "means to start with individual cases, incidents or experiences and develop progressively more abstract conceptual categories to synthesize, to explain and to understand [the] data and to identify patterned relationships within it." [30]

The data for the study was collected in semi-open interviews with experts from different software companies and areas of expertise. In total, 13 interviews of 30 to 90 minutes length each have been conducted. Interviewees were selected based on two guiding principles. First, the overall composition of companies in the sample should be as broad as possible – both in terms of company size and field of business. This principle aimed at ensuring generalizability of the results for the entire software industry. Second, the experts contacted should have deep insights into the area of interest in order to be able to structure the concrete field of action logically and precisely. Consequently, we identified interviewees whose daily business is located between management and reporting, at the border between operations and strategy. Following the second principle also entailed a specialization of knowledge: most interviewees surveyed for the empirical study were experts covering a small part of the value chain only.

B. KPI Usage in Software Enterprises

The most diverse perceptions about the constitutional definition and evaluation of software specific KPIs are present in the companies surveyed. Even within bigger enterprises, there is a discrepancy in KPI usage depending on the respective value chain activity.

Many interviewees have significant problems in connecting their collected KPIs to their business models. Another noticeable aspect is that many software firms are not able to assign relevant KPIs to each activity in the software value chain because they are still in the process of defining relevant key measures for their business processes. Most of the companies surveyed do not have a superior performance measurement system and do not carry out internal or external benchmarking. However, if KPIs are measured, this is predominantly done on a regular basis.

In the analysis of the interviews, two paths / characteristics to classify the usage of process KPIs in enterprises emerged. On one hand, there is the maturity and elaboration of performance measurement systems as a basis for the definition, measurement, monitoring and tracking of KPIs. Several companies already set up such a measurement system, some are about to conceptualize such a system, but others are not covered by any data collection mechanism concerning process KPIs. Based on the experts' descriptions, the maturity of their performance measurement systems can be broken down to a number of criteria. They include:

- the existence of a KPI measurement system,
- whether the system is completely set up and KPIs are defined,
- if the defined KPIs are automatically measurable and
- how distinctive the institutionalization of the measurement is

Some companies establish particular units for setting up a performance measurement system that interacts with all sub-activities of the generic software value chain.

On the other hand, there were many different perceptions concerning the importance of process KPIs for strategic decisions and the strategic orientation on those performance measurement systems. This characteristic can also be broken into three criteria to classify the companies' positions:

- first, there is the general awareness of the connection between process KPIs, and the business model,
- second, the perceived importance of such a performance measurement system for strategic decisions,
- as a third criterion, companies were asked to give examples for past strategic adjustments in their business model caused by certain developments of process KPIs

The evaluation of the experts' interviews highlights the very diverse KPI usage in software enterprises. These differences can be the result of the different company sizes, the products' nature or the respective business models, besides the general attitude towards the usage of process KPIs for strategic decisions.

C. Exemplarily KPIs

During the interviews, it was difficult for the experts to ad hoc establish a link between KPIs monitoring the processes of their respective value chain activity and the related business model elements. In order to lead them to the

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actual research question, they were at first asked to list as many process KPIs as possible. Favored by the classification of the experts into the software value chain's activities, it is logical to also subsume the key measurements presented by them in this manner. As already mentioned in the previous section, most KPIs were presented within the activities holding high user and customer contact, such as marketing and support. In contrast, activities such as research, production and implementation are not represented by many key measures. This tendency however can also be due to the few questioned enterprises.

The collected KPIs can be found in Table 1. Most of the KPIs are hard KPIs, as they can be easily described in numbers (e.g., number of bugs, business contacts, fixes, and open/closed tickets are hard KPIs). In contrast, soft KPIs (e.g., customer satisfaction), do not occur as countable units, but can also be translated into numbers to make them comparable. Other categorizations can be time, differentiating into non time-related and time-related KPIs, such as implementation time and time for user training, or permanently and irregularly monitored KPIs.

TABLE 1. RESULTS OF THE EXPERT INTERVIEWS

Value Chain Activity	**Named KPIs by the interviewees**
Research	• Rated Feature Requests • Elaboration Time
Development	• Implementation Time • Number of Implementation Inquiries • Time Units for Definition and Test • Number of Customer Complaints • Product Quality • Number of Bugs • Developers per Software Project • Profit Margins • Number of rescheduled milestones • Log in time • Number of accesses to shop • Social contacts (number of sent Mails, interactions between friends)
Maintenance	• Number of Customer Complaints • Number of Bugs • Implementation Time • Number of Implementation Inquiries • Time Units for Definition and Test • Product Quality • Developers per Software Project
Production	• Completion time
Marketing	• Sales Growth • Brand Awareness Level • Number of Business Contacts • Effort per Marketing Activity • Revenue per Marketing Activity • Conversion Rate • Number of contacts/potential customers (after marketing campaigns, presentations, monthly) • Participants/Customers per contact • Customer Acquisition Rate (Sign up numbers: number of users per time periods) • Log in numbers (concurrent user capacity, general log in frequency, time spent playing the online game, identified peaks of use) • Customer Churn Rate (Funnel for tracking user losses: taken burdens at payment procedure) • Payment behaviour (amount spent, time intervals)
Replacement	• Number of carried out Software Updates • Implementation time for the replacement of legacy systems
Implementation	• Time for implementation
Education	• Number of certified consultants • Time for user training • Number of trained people • Training portfolio
Support	• Number of fixes • Number of support calls (absolute/average/per employee/per customer/per transaction/per active installation) • Number of open/closed tickets (distribution per employee/time period) • Costs per solved ticket • Error rate (distribution of found bugs) • Customer satisfaction index (initial reaction time, response quality, accessibility, friendliness, competence, time to solution, technical comprehensibility) • Number of forwarded support calls (to development, maintenance) • Average Support carried out per employee • Escalation rate • Average Processing Time • Effort for Rework
Operations	• Number of Participants • Transactions per Time Unit • Data Volume per Time Unit • Employee Satisfaction Index • Number of developers per project • Response time

Table 1 shows that most interviewees were able to assign most KPIs to the value chain activities Development, Maintenance, Marketing, Support and Operations. The majority of the interviewees share the opinion that measuring KPIs according to the underlying value chain and business model can be an indicator for successfully adapting a company's business model. There is also a large consensus amongst the interviewees that research on business model adaptations based on KPIs is a highly relevant topic in future research. The results also show that, in practice, there is still no holistic and systematic approach of performance measurement within the software industry. This, however, represents a lack in research, as only a systematic evaluation of current events affecting a company' s business model gives decision makers adequate motivation for changing specific elements of their business model. The measurement of the aforementioned KPIs can be carried out by several performance measurement systems which enable to measure the quality of business processes and sending the collected information to a company's strategy. By this means, the

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collected KPIs can be used on strategic level to be matched to the building blocks of the underlying business model [31].

IV. CONCLUSIONS AND OUTLOOK

This paper contributes to the understanding of the existing interconnections between the business model and the layers of strategy and business processes. The state of the art analysis and the expert interviews have shown that, so far, there is no standardized framework in literature and practice that efficiently supports measuring KPIs from business processes on business models and vice versa. This aspect, however, is essential for enterprises to be able to analyze, define and adapt their current business model to internal or external environmental factors. In a next step, further analysis will be carried out to determine how these derived KPIs will influence decisions on business model adaptations.

The study revealed that there is a lack of practical tools and conceptual work that addresses a systematic link between business processes and business models. Thus, future work should have a strong focus on these interrelations. First research work addressing a formalized description of business models have already been addressed by deriving a business model framework which has also been formalized in an ontology [32].

This paper depicted relevant KPIs and value chains in the software industry. Future research should also focus on different industry branches. By this means, a conceptual framework for different industry branches can be derived, containing the most significant KPIs for business model adaptations. Another research question addresses on agile enterprise software which is capable to support the described feedback loop between business processes and business models.

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REFERENCES

[1] J. Magretta, “Why Business Models matter,” Harvard Business Review, vol. 80, no. 5, 2002, pp. 86–92.

[2] IBM, “IBM - Global CEO Study.” 2010.

[3] C. Di Valentin, A. Emrich, D. Werth, and P. Loos, “Conceiving Adaptability for Business Models: A Literature-based Approach.,” in International Conference on Information Resources Management (Conf-IRM-12), 2012, pp.1-12.

[4] W. Chesbrough, Henry and S. Rosenbloom, Richard, “The Role of the Business Model in capturing Value from Innovation: Evidence from Xerox Corporation’s technology spin-off companies,” Industrial and Corporate Change, vol. 11, no. 3, 2002, pp. 529–555.

[5] H. Bouwman and H. de Vos, Mobile Service Innovation and Business Models, 1st ed. Berlin: Springer, 2008.

[6] T. Wilde and T. Hess, “Forschungsmethoden der Wirtschaftsinformatik - Eine empirische Untersuchung,” Wirtschaftsinformatik, vol. 49, no. 4, 2007, pp. 280–287.

[7] P. Timmers, “Business Models for Electronic Markets,” Journal on Electronic Markets, vol. 8, no. 2, 1998, pp. 3–8.

[8] A. Osterwalder and Y. Pigneur, “An e-business model ontology for modeling e-business,” in Proceedings of the 15th Bled Electronic Commerce Conference, 2001, pp. 1–12.

[9] J. Linder and S. Cantrell, “Changing Business Models: Surveying the Landscape.” 2000, pp. 1–15.

[10] A. Afuah and C. Tucci, Internet Business Models and Strategies: Text and Cases, 2nd ed. New York: McGraw Hill, 2004.

[11] B. Mahadevan, “Business Models for Internet-based E-Commerce: An Anatomy,” California Management Review, vol. 42, no. 4, 2000, pp. 55–69.

[12] M. M. Al-Debei and D. Avison, “Developing a unified framework of the BM concept,” European Journal of Information Systems, vol. 19, no. 3, 2010, pp. 359–376.

[13] A. Osterwalder and Y. Pigneur, “Clarifying Business Models: Origins, Present, and Future of the Concept,” in Communications of AIS, 2005, pp. 1-25.

[14] T. Burkhart, J. Krumeich, D. Werth, and P. Loos, “Analyzing the Business Model Concept: A Comprehensive Classification of Literature,” in International Conference on Information Systems (ICIS-11), 2011, pp. 1-19.

[15] M. Schief and P. Buxmann, “Business Models in the Software Industry,” in International Conference on System Sciences (HICSS-11), 2011, pp.1-10.

[16] J. Gordjin, H. Akkermans, and H. van Vleet, “Business Modelling is not Process Modelling,” in Proceedings on the 1st International Workshop on Conceptual Modeling Approaches for e-Business, 2000, pp. 40–51.

[17] R. Bellman, C. Clark, D. Malcolm, and F. Ricciardi, “On the construction of multistage, multi-person business game,” Operations Research, vol. 5, no. 4, 1957, pp. 469–503.

[18] G. M. Jones, “Educators, Electrons, and Business Models: A Problem in Synthesis,” Accounting Reviews, vol. 35, no. 4, 1960, pp. 619–626.

[19] H. Oesterle and R. Winter, Business Engingeering – Auf dem Weg zum Unternehmen des Informationszeitalters, 2nd ed. Berlin: Springer, 2003.

[20] A.-W. Scheer, ARIS – Modellierungsmethoden, Metamodelle, Anwendungen, 4th ed. Berlin: Springer, 2001.

[21] M. Hammer and J. Champy, Business Reengineering. Frankfurt. 1994.

[22] A. Pussep, M. Schief, T. Wildjaja, P. Buxmann, and C. Wolf, “The Software Value Chain as an Analytical Framework for the Software Industry and Its Exemplary Application for Vertical Integration Measurement,” in American Conference on Information Systems (AMCIS-11), 17th Americas Conference on Information Systems, 2011, pp.1-8.

[23] A. Pussep, M. Schief, and T. Widjaja, “The Software Value Chain: Methods for Construction and Their Application,” in European Conference on Information Systems, 2012.

[24] D. Messerschmitt and C. Szyperski, Software Ecosystem. Cambridge: MIT Press, 2003.

[25] M. Porter, Competitive Advantage. London: Free Press, 1985.

[26] I. Crnkovic, M. Chaudron, and S. Larsson, “Component-based Development Process and Component Lifecycle,” Journal of Computing and Information Technology, vol. 13, 2005, pp. 321–327.

[27] W. Royce, “Managing the development of large software systems,” in Proceedings of IEEE, 1970, pp.328-338.

[28] M. Morris, M. Schindehutte, and J. Allen, “The Entrepreneur’s Business Model: Towards a unified Perspective,” Journal of Business Research, vol. 58, no. 6, , 2005, pp. 726–735.

 ISBN: 978-1-61208-232-5

[29] G. Glaser, Barney and L. Strauss, Anselm, The Discovery of Grounded Theory. Strategies for Qualitative Research. Aldine Pub, 1967.

[30] K. Charmaz, "Grounded theory," in Rethinking methods in psychology, J. Smith, Ed. London: Sage, 1995, pp. 27–49.

[31] "MIT Communications Futures Program," 2012. [Online]. Available: http://cfp.mit.edu/.[retrieved: June, 2012].

[32] T. Burkhart, M. Schief, S. Wolter, J. Krumeich, C. Di Valentin, D. Werth, and P. Loos, "A Comprehensive Approach towards the Structural Description of Business Models," in International ACM Conference on Management of Emergent Digital EcoSystems (MEDES), 2012, pp. 1-8.

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Building Trusted National Identity Management Systems:

Presenting the Privacy Concern-Trust (PCT) Model

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***Abstract*—This paper discusses the effect of trust and information privacy concerns on citizens' attitude towards national identity management systems. We introduce the privacy-concerns-trust model, which shows the role of trust in mediating and moderating citizens' attitude towards identity management systems. We adopted a qualitative research approach in our analysis of data that was gathered through a series of interviews and a stakeholder workshop in Ghana. Our findings indicate that, beyond the threshold level of trust, societal information privacy concern is low; hence, trust is high, thereby encouraging further institutional collaboration and acceptance of citizens' informational self-determination.**

Keywords-Identity Management; PCT Curve; Privacy Concern; Trust; Trusted Identities.

I. INTRODUCTION

Although digital Identity Management (IdM) is fundamental to electronic government, globally, its implementation and adoption by citizens usually presents complex issues for its many stakeholders. The complexity has been attributed to the fact that it transcends technological issues as well as policy, legal, institutional, and economic aspects of society. The complexity is also compounded by the rate, at which standards and technological solutions become obsolete; the flexibility and ease of collection, use, dissemination of data; and the increased link-ability of information to the data subject. This raises the potential for privacy concerns [1].

Ironically, previous privacy research has shown that individuals disclose personal information in exchange for some economic or social benefit subject to the "privacy calculus", an assessment that their personal information will subsequently be used fairly, and that they will not suffer negative consequences [2]. Moreover, where individuals can exercise some degree of control over data collection and use; information is collected in the context of an existing relationship; the information collected or used is relevant to the transaction; and they believe the information will be used to draw reliable and valid inferences about them; citizens are less likely to raise concerns. Unfortunately, this is usually not the case. These phenomena often occur without direct involvement or control of the data subjects.

Governments in many countries have implemented some form of identity management as a critical enabler of government to citizens' interactions, and in facilitation of business transactions. Unfortunately, the costs of implementations are usually not matched by the benefits and citizens' adoption of the expected or improvement in public services. This makes it difficult for governments to justify the implementation, since it often leads to embarrassment [3, 4].

In spite of its use being lower than expected, identity management can play a leading role, if the factors that affect its takeoff are properly addressed. Trusted identities ecosystems have been found to be very critical to the success of digital IdMS. This research focuses on understanding the key stakeholder concerns on information privacy in regards to the collection, storage, use, and transmission of personal identity information [5], and how such concerns should be addressed to ensure trusted identities.

The rest of the paper is organized as follows; the next section discusses the theoretical background for trust and privacy concerns, followed by a description of our research design and methods. We then discuss our findings from the stakeholder workshop and the interviews. We present our conclusions and recommendations for further studies in the final part of the paper.

II. THEORETICAL BACKGROUND

The growing deployment of innovative systems for collecting, processing, and sharing personally identifiable information places data subjects in a vulnerable situation and has propensity to undermine confidence in identity management systems. A 2012 Europe-wide survey [6] revealed that online users are naturally concerned about risks in online transactions, and that users are not in control of their personal information disclosed on the Internet. The survey also revealed that users employ a variety of offline and online methods to protect their identity; 62 % of users better understand how to protect their identity in the offline transactions using data minimization techniques, whilst 90 % trust national institutions and banks more than Internet service providers and e-shops [6]. Such observations cannot be true in many developing countries.

In developing countries many of the electronic government projects are viewed with suspicion with very low level of trust in the institutions that manage credentials. The source documents required for proofs of identities, i.e., civil registration systems are often unreliable [7] due to several instances of multiple registrations and enrolment of unqualified people. Businesses, usually, have difficulties in verifying the authenticity of credentials individuals presented for access to services. Credentials can in many instances only be

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verified manually, resulting in undue delays and customer frustration with its attendant privacy information implications.

A. Information Privacy Concerns

The issue of privacy is generally based on cognitive perceptions rather than on rational assessments. Privacy concern has been used as a key privacy construct by researchers [8, 9]. Smith et al. [10] developed the concern for information privacy (CFIP) model for operationalizing privacy concerns based on data collection, errors, secondary use, and unauthorized access to information or invasion. Collection, use and transmission of personal information by identity providers and relying parties must in principle be based on tacit or explicit consent by service providers to protect the interest of data subjects [2]. Citizens, therefore, become apprehensive, when their interests are not observed, or the perceived risk of the abuse exceeds the benefits derived from such implied social contracts.

These tensions between organizational use of personal information and societal information privacy concern are very topical in privacy research [11]. Previous studies have defined privacy as *the ability of an individual to exercise some degree of control of the access that others have to their personal information* [12]. Privacy is at risk, if individuals are unable to exercise control over their personal information during social interactions and business transactions [13, 14], and it is therefore disheartening for privacy-aware citizens to find out that inaccurate, out-dated, excessive or irrelevant data about them are stored by others.

Information privacy concerns can be categorised as

- *Illegitimate use of information* [10], *and*
- *Secondary use of personal information without the consent of the data subject, for purposes outside the primary reason for data collection* [1].

Therefore, it is imperative that organizations develop information practices that address the perceived risks and citizens concerns in order to project an innate trust [15, 16]. Although privacy concerns are almost always measured at an individual level of analysis, societal concern (overall privacy concerns of a nation) should reflect the concerns of its citizens and organizations [17, 18]. Various governmental interventions like regulations and controls are implemented to address societal information privacy concerns. Although Bélanger & Crossler [17] and others have discussed the privacy concern, there is still a need to clarify *how privacy concern and trust affect each other within the context of identity management*. This is one of the objectives of this study.

B. Trust

Trust plays an important role in societal discourses and attitudes towards electronic identification systems. Due process requires that organizations apply best practices in data acquisition and also strive to prevent illegitimate access by others to personal data in their custody. Bhattacharya et al. [19] describes trust as having a multidimensional construct and defined trust as an expectancy of positive or non-negative outcomes that one can receive based on the expected action of another party in an interaction characterized by uncertainty [19]. Broadly, trust is considered as a firm belief in the reliability, competence, qualification, ability, strength, integrity, truthfulness, honesty, sincerity, and loyalty of the other party to transaction or interaction [20].

In their study on "an alternative model of trust", Mayer et al. [15] modelled the concept of trust by categorizing the key attributes of trustworthiness as the trustees' ability to fulfil the trusting action, the benevolence of trustees' intentions, and their integrity [15, 21]. Their definition was based on one person's beliefs about the characteristics of another person. In effect, trustworthiness can be operationalized using these three attributes of the trustee. Ability signifies competence or perceived expertise, business sense and judgement. Consistency, fairness and reliability describe integrity, whereas loyalty, openness and availability signify benevolence [15, 16]. These attributes are important determinants of the success of IdMS, since it can affect the usage behaviours of the systems.

A trust relationship is made up of three elements – the truster, the trustee, and the context in which trust is conferred [20]. Trusters are the citizens and relying parties, the trustees are the credential issuers and service providers, and the context is an IdMS or the electronic identity card scheme.

Perception of trust can be either due to the technology or the institutions [22]. A low citizens trust in credentials issuers and IdMS will be a major disincentive to accept the IdMS, since there is lack of identity assurance [23]. Such lack of trust can lead to unfavourable outcomes of the IdMS. Likewise, a low trust in credential issuers coupled with a high trust in the technology leads to a situation, where citizens might use technology as a competitive tool against the unpredictable and sporadic results. In such a scenario the IdMS will be viewed with suspicion and cynicism by the citizens [24, 22].

C. Relationship Between Trust and Privacy Concern

Various studies have established a relationship between trust and people's willingness to forgo their privacy concerns [25, 26]. What is not certain is the nature of the relationship between privacy, trust and societal attitude towards identity management systems. Trust is known to be a mediator between privacy concerns and behaviour [26, 27]. Thus, trust (the mediator) is what explains the effect that privacy concern (independent or predictor variable) has on societal attitude (the dependent or criterion variable). For instance, a correlation between income and cancer might be explained by a correlation between income and smoking (the mediator), and then between smoking and cancer. Thus, according to mediation models, privacy has little or no direct effect on behaviour; instead any effect can be explained by the links between privacy and trust, and then between trust and behaviour.

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The relationship between privacy concern and trust can also be explained using the concept of moderation [28]. Moderators are variables that affect the directions and strengtsh of a relationship between an independent and a dependent variable [28]. Thus, in the case of privacy and trust, where there is high trust, privacy concern exerts an influence on behaviour, while in low trust environments privacy concern may have a negligible impact on behaviour, since behaviour is limited by the lack trust. This study explains mediator and moderator relationships between privacy concerns, trust and citizens attitudes towards national identity management systems.

D. Modelling Identity

Wilton [29] described digital identity as the relationship of identity between a person at the time of enrolment, and a person at the time of authentication [29]. Thus, identity is not just a snapshot of a person, but part of a process from enrolment and credential issue to credential presentation, authentication and revocation [29]. When such a process is not followed or abused, citizens become concerned and lose confidence in the system or the identity service providers.

E. Privacy Concern-Trust Curve

Generally, societal interactions and business relationships begin from a low level of trust (distrust) and high privacy concern. With disclosure of more information, strong institutional cooperation and user awareness, users are able to exercise some degree of user control over their personal information, resulting in the establishment of a certain level of trust. Thus, citizens become more empowered and revise their negative perceptions about the IdMS and identity service providers. This establishment of trust reduces the initial privacy concerns. Thus, a high privacy concern is associated with low level of trust, and reduction in privacy concern results in an increase in trust. In other words, the mediating and moderating effect of trust can result in either a negative or positive societal attitude changes towards IdMS.

The qualitative relationship between trust and privacy concern is shown in Fig. 1. A certain threshold level of trust must be overcome, before the citizens are ready to open up for interaction. The figure also shows that absolute trust or zero privacy concern is not possible within a trusted identities environment, and hence the curve can only asymptotically approach the two axes. The purpose of the trust framework therefore is for society to establish the framework that can overcome the trust threshold. Beyond this level, trust and privacy is adequate to encourage more collaboration, creation of new identity-based services, institutional collaboration, etc.

III. RESEARCH DESIGN AND METHODS

This study entailed two main phases – an exploratory phase, which saw the development of the model based on literature, and a qualitative based confirmatory phase, which was used to evaluate the model. The conceptual model on the basis of theoretical considerations is part of an on-going research project that seeks to present a reliable and valid instrument for measuring trusted identities ecosystem. The exploratory phase of the study was organized in line with two-step approach for operationalizing constructs and identifying measures [30]. Due to the multi-stakeholder nature of trusted national identities, we decided to adopt a research approach that engages the key actors and hence a qualitative methodological approach was deemed the most appropriate means for data collection from a societal perspective [31, 32]. We also applied the concepts of Interpretative Phenomenological Analysis [33] in our data analysis because of its usefulness in understanding the experiences of individuals. The overarching research question was *"what are the key requirements for crafting a trusted identities ecosystem"*.

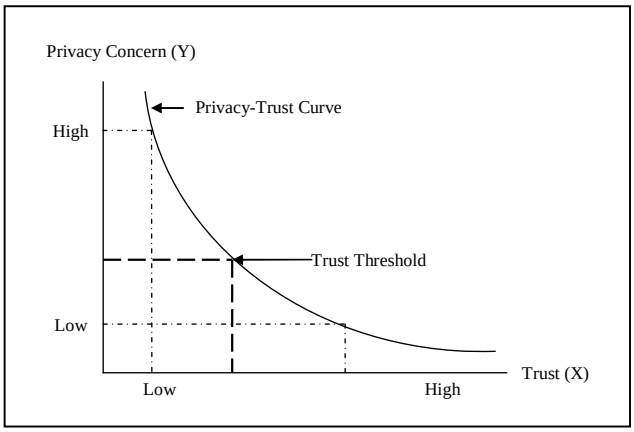

Figure 1. Qualitative relationship between privacy concern and trust.

A. Stakeholder Workshop

Given the societal level of analysis, a stakeholder workshop was organized in Accra, Ghana. All the major stakeholders involved in the collection, storage use and issue of identity were represented, including Registrar of Births & Death, The Passport Office, Driver and Vehicle Licensing Agency (DVLA), National Identification Authority (NIA), National Health Insurance Authority (NHIS), Electoral Commission (EC), Ghana Revenue Authority, financial institutions and identity-related businesses, academic institutions, national institutions and non-governmental organisations involved in civil right advocacy, and the general public. The identification challenges in Ghana are considered to be typical of many developing countries.

During the workshop participants were offered the opportunity to discuss a number of prepared questions and scenarios. To inform discussions, participants listened to presentations on various aspects of trust, privacy and secondary uses of personal information. The presentations also highlighted the key concepts of trusted identities and the policy, technological and regulatory implications as well as related IdMS research and practices in OECD countries [34, 35]. The ideal situation as illustrated on Figure 2 was used to explain the benefits of trusted identities.

Some of the discussion questions were:

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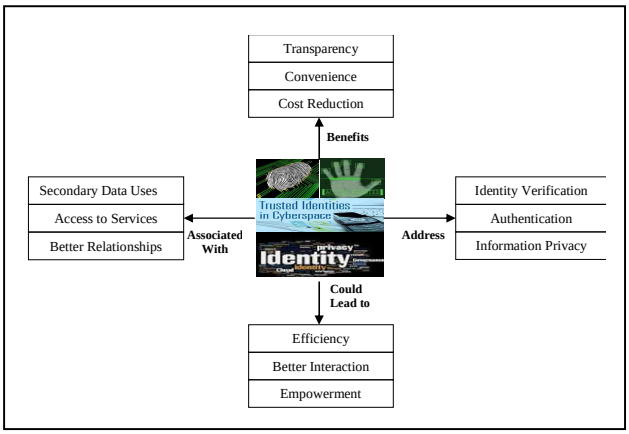

Figure 2. Dimensions of Trusted Identity Management Systems.

1. *What are the potential benefits and risks regarding the secondary uses of personal information?*
2. *What are the major challenges in relying on existing credentials presented for access to services?*
3. *How can institutional cooperation be encouraged given the conflicting regulations?*
4. *What attributes does citizens look for before trusting organizations with respect to secondary use of personal information?*
5. *What can be done to address issues arising from inappropriate use and/or exploitation of personal information?*
6. *What regulations, legislation, and/or policies are needed to address the evolving challenges?*

B. Interviews

A series of stakeholder interviews were conducted before and after the workshop. The pre-workshop interviews were made to identify the key issues and challenges from different perspectives. This helped in choosing and phrasing the discussion questions for the stakeholder workshop. The follow-up interviews were conducted to clarify some of the points raised during the workshop to solicit for further information. Interviewees included the officials of identity issuers, policy makers, journalists, private businesses involved in identity verification, and identity card manufacturers.

C. Transcription and Coding

Although raw data can sometimes be of interest in research they do not usually help the reader to understand the world under scrutiny and participants' views without a systematic analysis to illuminate the situation under investigation [36]. Transcripts were thus initially coded to aid meaningful analysis. Data coding, which is an important part of analysis, involves subdividing data into chunks of varying-sized words, phrases, sentences or whole paragraphs, and assigning categories [37]. Thus, codes are labels for allocating units of meaning to descriptive or inferential information compiled during a study. One of the key objectives of our coding approach is to identify relevant examples of the phenomena and analysis of the phenomena tp discover distinct patterns, differences and commonalities [37].

Transcript of the workshop discussions and the interviews, in the form of audio-visual recordings, interview notes and summary of discussion sessions, were produced by the authors. The introductory background of speakers and interviewees were, however, included for coding and analysis purposes. This was meant to maintain speaker anonymity. No attempt was made to identify speech patterns, since that was not the focus of our research. The nature of the discussions and interviews was such that initial coding would not have been helpful since participant interviewees were from diverse backgrounds, and opinions were varied. Each of the transcripts was coded on the basis of the background of the various speakers, since each of the participants and interviewees were told to introduce themselves before speaking. This served as basis for coding and sub-categorization of the transcript.

IV. DISCUSSION OF FINDINGS

A. Societal Concerns

Comments and statements made by participants during the interviews and workshop revealed a number of societal concerns and the various sources of them. Some of the concerns are listed below:

- *"The identity agencies are only there to please their political party and not because they are skilled".*
- *"If the electoral commission knew what they are doing, why will they opt for a biometric system without a means of verification"?*
- *"The information on the National Identification Authority website is so scanty that I have no idea what is going on."*
- *"I wonder if the officials of the identification agencies read our emails or even if the emails get to the organisations in the first place, because they never respond to emails sent to addresses they have provided".*
- *"If I have a problem, I have no idea how to reach them by phone or on the Internet, except if I walk to their head office"*
- *"I do not know the use of all the information collected by many of the identification agencies. For instance, I do not understand, why my actual date of birth is stated on my driving license, when they could have simply stated that I am over eighteen or qualified to drive."*
- *"Since one can present different documents as proof of identity during voter registration or drivers' license acquisition, it gives room for multiple registrations."*

Such comments show the need for societal assurance that their opinions are taken seriously. In a situation, where citizens do not get responses for the concerns raised, it gives the impression that citizens are not involved in decisions that concern them. It is therefore important to empower citizens in order to generate commitment and contributions. In essence, when citizens' opinions are taken seriously, they feel

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that they are involved in decision-making and empowered, resulting in increased trust [38, 39].

Moreover, recruitment of unqualified personnel shows a lack of ability and integrity, which are all key attributes of trustworthiness [15, 40]. This is also manifested in comments like

- *"I always read stories in the dailies about impersonation and people making fake documents especially passports and birth certificates; many of the officials are involved"*.

However, citizens would like to have informational self-determination - a sense of freedom to do what is interesting, personally important, and psychologically vitalizing [41]. Such concerns lead to distrust in government institutions and therefore very critical that the system for tracking vital source documents like birth and marriage certificates is improved. The key aspects of the civil registration that need to be made efficient include, birth, marriage and death registration.

B. Segregation of Personally Identifiable Information

Article 7.1 of the United Nations Convention on the Rights of the Child states that *"the child shall be registered immediately after birth and shall have the right from birth to a name, the right to acquire a nationality, and as far as possible, the right to know and be cared for by his or her parents"*. The birth certificate for instance contains the given name, surname (or family name), gender, date of birth, place of birth, and father and mother names. Given the importance of the birth certificate in the establishment of the core identity, its abuse in the form of multiple registration and registration of illegitimate people defeats its usefulness. If the birth registration system were to be strengthened, it could act as the basic document that all residents must rely on for initial registration.

The information on the birth certificate represents the 'Basic Identifier Set' (BIS) – information that can help identify a person and does not change over time [29]. Hence, the birth certificate can be a very useful document in addressing issues of multiple registrations, especially when individuals are made to use the number throughout life. In that case, enrolment of foreign nationals who reside in the country should be based on travel documents as part of the processing of residence permit.

Certain transactions requiring proofs of additional information might require credentials that show the individual's Personally Identifiable Information (PII) – additional information that is useful for identifying a person but may change over time, such as addresses, marital status, physical characteristics like height, hair/eye colour, or complexion [29]. The PII provides additional information that can typically not be found in the BIS. For border control purposes passport may be preferred more than a birth certificate. In other sector-specific transactions and interactions, other attribute data are necessary for effective identity verification. This kind of data is information that on its own might not be able to identify a person, but will provide important traces when linked to either the BIS or PII data, or when such data are aggregated over time and space (e.g. healthcare records, tax return information, driver's and vehicle licence, banking and insurance information. Given the sometimes sensitive nature of such information, e.g. health records, it might require additional level of security to avoid linkability to the BIS and PII. In essence, other attribute data are identity-related, albeit 'sector-specific',

C. Strong Focus on Identity and not Credentials

A common misunderstanding on the part of credential issuers and policy makers during the workshop was the equation of strong credentials to efficient identity management systems. This became apparent from statements like *"we have introduced biometric based ID cards that are difficult to forge"*.

There is, therefore, the need to move away from credentials towards unique identification. A credential such as a passport or driving licence typically includes some items from each of the three aspects of identity – the BIS, PII such as height, eye colour, and some sector-specific data such as entitlement to drive specific classes of vehicle, or visas indicating entitlement to enter a specific country. This is illustrated on Fig. 3.

A distinct feature of a credential is that it encapsulates attributes and entitlements in a reliably verifiable form. There is therefore the tendency to equate such documents as representing the identity of a person when in fact they might not be representative in a given context. For instance, passports and driving licences have historically been presented as foolproof documents loaded with the necessary information that can enable the holder to access services and for authentication purposes. This is not without drawbacks, since it is susceptible to revealing more information about the holder than is necessary in any given authentication context. Using a passport for proof of age will no doubt reveal the passport holder's name, place of birth and citizenship, and a driver's licence used for similar purpose can also reveal your date of birth and address.

A focus on identity will also make it easier to enforce policies appropriate to the data in question, particularly when different sector-specific data items entail different policy controls. For instance, entitlement to drive a vehicle may not be part of major privacy concern, whereas credit status will, hence data security policies could be segregated to address such data. On the other hand, since healthcare history and medical conditions are very sensitive, a different set of policies will apply. Graphically, one might think of this as the ability to segregate identity data into sector-specific segments and cater for discrete management policies by sector and data type (cf. Fig. 3). Thus, within a given data segment, assertions of identity ('the holder of this credential is XX') may make one kind of data security policy appropriate, while assertions of other attributes ('the holder of this credential has been treated for Repetitive Stress Injury') may require quite different policy treatment.

D. Application of Privacy Enhancing Tools

Various privacy-enhancing and minimal disclosure technologies have been tested that address the requirement not to reveal unnecessary details in transactions. For instance, the

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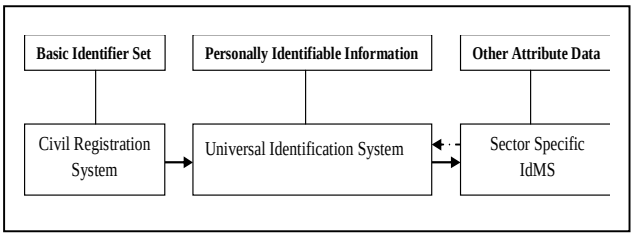

Figure 1. Personal Information and how it can be segregated.

touch2ID biometric application allows users to prove their age without storing or revealing extra details about the individual [42]. Similarly, the ABC4Trust project has released and tested guidelines for implementing attribute-based credential technologies focusing on trust, based on Idemix and U-prove technologies [43, 44, 45].

In an online context disclosure of excess data can be avoided. Credentials can realistically encapsulate just those data items, which serve to uniquely identify the holder (such as the BIS), as long as they provide a way of linking to the rest of the holder's personal data, which may be held elsewhere. In other words, the option now exists to make use of the distributed nature of networked computing, so as to allow much more flexible 'placement' of identity data of different types. This is valuable in terms of policy control, because it makes it possible to apply controls at the place where the data is held, rather than trying to enforce it wherever the credentials are verified.

E. Encouraging Trusted Environment

Trust is what moderates and mediates citizens' privacy concerns and attitudes towards IdMS. Thus, individuals are likely to engage in transactions, if their level of trust exceeds their personal privacy concern threshold, which is reached, when the potential benefits outweigh the risks. This threshold will always depend on the type of transaction and the amount of identifiable information revealed. For instance, transactions requiring the revelation of other attribute data might require a lower trust threshold. Thus, when positive steps (i.e., data minimisation) are taken to improve the IdMS, the moderation effect of trust will cause citizens to revise their attitude towards the IdMS, leading to more trust in the credential issuers and the technology and thereby moving down and to the right on the trust threshold. Similarly any negative actions on the part of credential issuers will increase the privacy concern and thereby causing a move upwards and to the left on the privacy trust curve. The trusted identities framework in the United States, where the interest of all stakeholders in the identity ecosystems are taken into account, is a clear step taken by the US government to increase trust [35].

V. CONCLUSIONS AND FUTURE RESEARCH

This paper discussed the issues and challenges associated with accountable management of personal identifiable information and the provision of more user control over personally information. The findings from this study suggest that information privacy concerns can affect the posture of society in relation to attitudes and preferences for regulatory environments and willingness to accept a particular identity management system [8, 18, 46, 26]. We also highlighted the relationship between information privacy concern and trust from a societal perspective, and its effect on trusted identity management systems.

Our findings show that unreliable civil registration system can be a major reason for such concerns. Given that the civil register is in many instances a key source document for credential acquisition, its unreliability leads to all kinds of credential abuses. Hence, governments especially in developing countries must focus on strengthening the civil registration system in order avert such abuses of personal identity information.

Our work clearly shows the two steps towards establishment of a trusted national framework, which are typical for the situation in many developing countries. Initially, trust is low and privacy concerns are high, because of poor implementations, but once the initial problems are identified and addressed, it is possible to pass a threshold level of trust, thereby reducing privacy concerns and paving the way for business and interaction. This is the point at which societal trust in Identity service providers is high enough to encourage institutional collaboration [22], and citizens' informational self-determination [41]. We also highlight the need for policy makers to categorise personal information in a way that will encourage secondary uses of personal information whilst ensuring that sensitive personal information is released only to legitimate people.

This study focused mainly on citizens' attitudes towards identification systems in Ghana and that poses a number of issues in terms of generalizability that will need to be tested. For instance, there are peculiar dynamics pertaining to every country and for that matter the inferences drawn might not be representative for all developing countries. Moreover, the use of a qualitative research approach also gives room for inferences that are not tested empirically, as is the case of quantitative research. In the future it will be interesting to examine quantitatively the relationship between trust and privacy concerns in relation to citizens' attitudes towards identity management systems.

REFERENCES

[1] M. J. Culnan, "How Did They Get My Name?: An Exploratory Investigation of Consumer Attitudes toward Secondary Information Use," *MIS Quarterly*, vol. 17, no. 3, pp. 341-363, 1993.

[2] P. H. Jos, "Social Contract Theory: Implications for Professional Ethics," *The American Review of Public Administration*, vol. 36, pp. 139-155, June 2006.

[3] E. A. Whitley and G. Hosein, "Global Identity Policies and Technology: Do we Understand the Question?," *Global Policy*, vol. 1, no. 2, May 2010.

[4] P. Seltsikas and R. M. O'Keefe, "Expectations and outcomes in electronic identity management: the role of trust and public value," *European Journal of Information Systems*, vol. 19, pp. 93–103, 2010.

[5] C. J. Bennett and C. D. Raab, The Governance of Privacy Policy Instruments in Global Perspective, Aldershot: Ashgate, 2003.

[6] W. Lusoli, M. Bacigalupo, F. Lupiañez, N. Andrade, S. Monteleone and I. Maghiros, "Pan-European Survey of Practices, Attitudes and

Policy Preferences as regards Personal Identity Data Management," European Commission JRC Scientific and Policy Reports, Luxembourg, 2012.

[7] WHO, "World Health Statics 2012," WHO Library Cataloguing-in-Publication Data, France, 2012.

[8] J. H. Smith and T. Dinev, "Information Privacy Research: An Interdisciplinary Review," *MIS Quarterly*, vol. 35, no. 4, December 2011.

[9] K. A. Stewart and A. H. Segars, "An Empirical Examination of the Concern for Information Privacy Instrument," *Information Systems Research*, vol. 13, no. 1, pp. 36-49, March 2002.

[10] H. J. Smith, S. Milberg and S. Burke, "Information privacy: Measuring individuals' concerns about organizational practices," *MIS Quarterly*, vol. 20, no. 2, pp. 167–196, 1996.

[11] R. Mason, "Four Ethical Issues of the Information Age," *MIS Quarterly*, vol. 10, no. 1, pp. 4-12, 1986.

[12] A. F. Westin, Privacy and Freedom, New York: Athenaeum, 1967.

[13] D. J. Solove, "A Taxonomy of Privacy," *University of Pennsylvania Law Review*, vol. 154, no. 3, pp. 477, 2006.

[14] R. Clarke, "Internet privacy concerns confirm the case for intervention," *Communications of the ACM*, vol. 42, no. 2, pp. 60-67, February 1999.

[15] R. C. Mayer, J. H. Davis and D. F. Schoorman, "An Integrative Model of Organizational Trust," *The Academy of Management Review*, vol. 20, no. 3, pp. 709-734, July 1995.

[16] J. K. Adjei and H. Olesen, "Keeping Identity Private," *Vehicular Technology Magazine, IEEE*, vol. 6, no. 3, pp. 70-79, September 2011.

[17] F. Bélanger and R. E. Crossler, "MIS Quarterly," *Privacy in the Digital Age: A Review of Information Privacy Research in Information Systems*, vol. 35, no. 4, pp. 1017-1041, December 2011.

[18] P. A. Pavlou, "State of the Information Privacy Literature: Where are we now and whee should we go?," *MIS Quarterly*, vol. 35, no. 4, pp. 977-988, 2011.

[19] R. Bhattacharya, T. M. Devinney and M. Madan, "A formal model of trust based on outcomes," *The Academy of Management Review*, vol. 23, no. 3, pp. 459-472, July 1998.

[20] WP17, "D17.4: Trust and Identification in the Light of Virtual Persons," FIDIS, 2009.

[21] A. N. Joinson, "Privacy Concerns, Trust in Government and Attitudes to Identity Cards in the United Kingdom," *Proceedings of the 42nd Hawaii International Conference on System Sciences*, 2009.

[22] T. S. Teo, S. C. Srivastava and L. Jian, "Trust and Electronic Government Success: An Empirical Study," *Journal of Management Information Systems*, vol. 25, no. 3, pp. 99–131, 2008.

[23] S. J. Crosby, "Challenges and Opportunities in Identity Assurance," March 2008. [Online]. Available: http://www.hm-treasury.gov.uk/media/6/7/identity_assurance060308.pdf.

[24] S. Srivastava and T. Teo, "Citizen trust development for e-government adoption: Case of Singapore," in *Ninth Pacific Asia Conference on Information Systems*, Bangkok,, 2005.

[25] M. J. Culnan and P. K. Armstrong, "Information Privacy Concerns, Procedural Fairness, and Impersonal Trust: An Empirical Investigation," *Organization Science*, vol. 10, no. 1, pp. 104-115, 1999.

[26] N. K. Malhotra, S. S. Kim and J. Agarwal, "Internet Users' Information Privacy Concerns (IUIPC): The Construct, the Scale, and a Causal Model," *Information Systems Research*, vol. 15, no. 4, pp. 336-355, 2004.

[27] J. Nickel and H. Schaumburg, "Electronic privacy, trust and self-disclosure in e-recruitment. In extended abstracts on Human factors in computing systems," in , New York, USA, 2004.

[28] R. M. Baron and D. A. Kenny, "The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations," *Journal of Personality and Social Psychology*, vol. 51, no. 6, pp. 1173-1182, 1986.

[29] R. Wilton, "Identity and privacy in the digital age," *International Journal of Intellectual Property Management*, vol. 2, no. 4, pp. 411 428, 01-01 2008.

[30] A. Burton-Jones and D. W. J. Straub, "Reconceptualizing System Usage: An Approach and Empirical Test," *Information Systems Research*, vol. 17, no. 3, pp. 228–246, September 2006.

[31] J. W. Creswell, Qualitative inquiry and research design: Choosing among five approaches, 2nd ed., Thousand Oaks, CA: Sage Publications, 2007.

[32] R. K. Yin, Qualitative Research from Start to Finish, New York: The Guildford Press, 2011.

[33] J. A. Smith, "Reflecting on the development of interpretative phenomenological analysis and its contribution to qualitative research in psychology," *Qualitative Research in Psychology*, vol. 1, no. 1, pp. 39-54, 2004.

[34] OECD, 2011. [Online]. Available: http://dx.doi.org/10.1787/5kg1zqsm3pns-en.

[35] NSTIC, "National Strategy for Trusted Identities in Cyberspace: Enhancing Online Choice, Efficiency, Security, and Privacy April 2011," The White House , Washington, 2011.

[36] T. Basit, "Manual or electronic? The role of coding in qualitative data analysis," *Educational Research*, vol. 45, no. 2, pp. 143-154, 2003.

[37] I. Dey, Qualitative Data Analysis A User Friendly Guide for Social Scientists, London: Routledge, 2005.

[38] A. Wilkinson, "Empowerment: theory and practice," *Personnel Review*, vol. 27, no. 1, pp. 40-56, 1998.

[39] WHO, "WHO User empowerment in mental health – a statement by the WHO Regional Office for Europe," WHO Regional Europe, Copenhagen, 2010.

[40] R. Hardin, "The Street-Level Epistemology of Trust," *Politics & Society*, vol. 21, no. 4, pp. 505-529, 1993.

[41] E. Deci, J. Connell and R. Ryan, "Self-determination in a work organization," *Journal of Applied Psychology*, vol. 74, no. 4, pp. 580-590, 1989.

[42] C. Evry, "Proof-of-age scheme prepares to expand across Wiltshire," 2010. [Online]. Available: http://www.wiltshiretimes.co.uk/news/inyourtown/wiltshire/8239556.Proof_of_age_scheme_prepares_to_expand_across_Wiltshire/.

[43] J. Camenisch, I. Krontiris, A. Lehmann, G. Neven, C. Paquin, K. Rannenberg and H. Zwingelberg, "Architecture for Attribute-based Credential Technologies – Version 1," 2011.

[44] IBM_Research, "IDEMIX (Identity mixing) Project Overview," 2010. [Online]. Available: http://www.zurich.ibm.com/pri/projects/idemix.html. [Accessed 28th February 2012].

[45] Microsoft_Connect, "Microsoft U-Prove Community Technology Preview R2," 2010. [Online]. Available: https://connect.microsoft.com/site1188.

[46] F. D. Davis, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," *MIS Quarterly*, vol. 13, no. 3, pp. 319-340., 1989.

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User Modeling and Attention Support: Towards a Framework of Personalization Techniques

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***Abstract*— This paper aims to elaborate on the role of user modelling for personalization and enhanced attention support. User modelling is an important element in the management of personal profiles and identity of users, but also a key element for providing adaptive features and personalized interaction. In this paper, we present personalization as the process consisting on the customization, and the adaptation of the interaction along the structure, the content, the modality, the presentation and the level of attention required. The paper surveys personalization techniques and provides concrete examples of personalized interaction. In particular, the paper focuses on the role of user modeling for enhanced, personalized user support within interactive applications. The key contribution of the paper is to propose a framework of personalization techniques and to identify new forms of personalization that aim at taking into account human cognitive capabilities and emotions.**

Keywords personalization; user modeling; attention support; persuasion; social networks; personalization techniques.

I. INTRODUCTION

User modelling is a way to bypass the lack of information provided by the users and personalize the interaction with applications that adapt to their users' needs and accommodate their preferences. Personalization, contextualization and more recently attention support [1, 2] represent key elements for achieving intelligent features in advanced interactive applications. Personalization will also be a defining characteristic for a next generation of web applications and services, a defining characteristic of a new generation of services and applications on the Web. Such applications develop deeper relationships with their users, provide more value to users who return more often and ultimately offer more targeted experiences for each user according to her/his personal need [3]. Personalization may be defined as the process that enables interface customization, adaptations of the functionality via the structure, content, modality and presentation in the interaction in order to increase its relevance for its individual users [4]. Personalization may also take into account the limited human cognitive capacities (e.g., quantity of information that the brain can process, or its limited multitasking capabilities), emotions and cultural differences to provide an interface that is more attention effective.

In general, the goal of personalization is to improve the efficiency of the interaction with users, to simplify the interaction, and to make complex systems more usable [5]. Personalization is a way to overcome "one size fits all" type of applications. Personalized recommendation systems will feed us with news, new music, new products, targeted advertisements, according to preferences, moods and interests of the users [6].

A first step in achieving personalized interaction is the elicitation of the user model's characteristics (preferences, habits, needs). User models data can be created either: (1) by people explicitly specifying it (setting their preferences); (2) by automatic extraction (profiling) or (3) through a combination of the two methods. User modeling processes are a complex task, and the whole process of collecting personal data is subject to legal regulations in many countries and states. Furthermore, users are more careful about the disclosure and use of their personal information. A number of issues including the lack of reliability of the information "declared" in the profile, or its incompleteness due to several reasons including privacy concerns have to be handled in the construction of the user profiles and the associated personalization techniques. Both user concerns about the use of personal data and privacy regulations frequently impact on what personalization methods can be used [7].

The paper surveys personalization techniques and provides concrete examples of personalized interaction. This paper aims to elaborate on the role of user modeling for personalization and enhanced attention support. In particular, the paper focuses on the role of user modeling for enhanced, personalized user support within interactive applications. This article argues that user modeling may represent a key component for providing attention support (e.g., in supporting users allocating and better focusing their cognitive resources in learning or working). The key contribution of the paper is to discuss the different types of personalization and to propose a framework of personalization techniques. Furthermore the framework includes attention support and persuasion as emerging new forms of personalization.

The second section provides an overview of related work in the area of personalization and attention support. The third section is dedicated to the presentation of the different elements of the taxonomy. The fourth section gives real-case

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usage scenarios and discusses future personalization mechanisms. The last section concludes and presents future related work.

II. LITERATURE REVIEW

Personalization brings a utility as well as a conviviality function with "high-touch" impact for the users. From the utility perspective, personalization is important as significant differences between users can be observed and furthermore, users have different needs, goals and tasks at hand. An important form of personalization is interface customization, usually initiated by the user. However, studies conducted by Yahoo reveal that most often people do not take time to personalize or customize their experience [8]. Their study revealed that most often users use the default web page and mainstream users do not take time to customize or personalise their experience. Generally, users do not like to provide information and only the most experience users, "the power users", take the time to personalise or customize and they can "do amazing things" that truly reflects their personal interests and are of great benefit for them. Furthermore, the study suggests that no matter how well designed a tool is, users may find unexpected ways to use it.

User modeling associated with personalization techniques enable changes in the structure, content and modality of applications in order to match the needs and preferences of users. In contrast to customization, where users specify their preferences manually, personalization means automatic adaptation according to user profiles. Personalization can be seen as a prediction problem: the system tries to predict the user's level of interest in, or the utility of, specific content categories, pages, or items, and rank these according to their predicted values [9]. A large variety of personalization techniques [10, 11] are proposed in the literature and automatic personalization can be classified as: content-based, collaborative filtering and rule-based filtering systems. A comprehensive overview of data mining algorithms for user modelling and personalization techniques can be found in [9, 12, 13]. Web mining, the application of data mining techniques to discover patterns from the Web, can help to define such user profiles on the basis of the history and current actions of the user and his/her interactions with the application or with other users [9]. While collecting large amount of data for analysing user profiles, privacy concerns have to be considered [6] and the field of privacy-enhanced personalization has recently developed [7]. Furthermore, user models can be mapped to the context and generate a personalized structure, content or modality according to the context. Contextualization refers to an adaptation of the interface taking into account the user's context and thus creating context-aware systems [14]. Context-aware systems represent the type personalization that create an interaction that is relevant to user's context, which can include their current work process (what there are working on), the current location, people personal preferences, type of device, or current activity.

Personalization may take into account the cognitive capabilities of users, and address problems such as information overload, interaction "burnout", the difficulty to manage too many tasks at the same time, or other psychological aspects (e.g., boredom). In that case, the user model may incorporate elements such as mental states (e.g., bored, overwhelmed, aroused, etc.) that will be taken into account in the personalization for instance by "tuning" the cognitive effort required in the interaction (e.g., reducing the complexity of the interface and the flux of solicitations), or by providing stimulation to the user (for instance when an attention dropout has been identified).

A number of taxonomies for personalization have already been proposed in literature [10, 15-17]; however they are neither complete, nor they reflect the current state of the art of actual applications.

III. TOWARDS A CLASSIFICATION OF PERSONALIZATION TECHNIQUES

As described in the previous section, personalization has many facets and uses many different techniques. These very different approaches of personalization techniques are classified in a taxonomy, which can guide both researchers and practitioners in future developments of personalization domain.

Based on the literature review presented in the previous section, the article proposes a taxonomy of personalization techniques, extending the basic types of personalization presented in [10], that spans three dimensions, see Fig. 1:

- Types of personalization: What is personalized?
- Elements of personalization: Which elements are used for personalization?
- Methods of personalization: How the personalization is done? (customization or user-driven personalization, automatic or system-initiated personalization)

Additionally to the four basic types of personalization (structure, content, modality and presentation) presented in [10], we added attention support and persuasion as new dimensions that have recently been discussed in the literature. Attention support considers the human cognitive limitations such as the human limited absorbing and processing capabilities. Persuasive personalization takes into account the time and strategies that are necessary for humans to change and adopt new behaviors or beliefs. In our framework, personalization or adaptation techniques can be therefore classified in six main categories: personalization of structure, content, modality, presentation, attention support and persuasion (see Fig. 1).

According to the information used for personalization, one can distinguish the characteristics of the user and the context in which the user is situated. Furthermore, personalization can be classified in two ways: user-driven (customization), automatic or agent-based (semi-automatic).

A. Types of Personalization

1) Personalization of structure refers to the way in which the hypermedia space is structured and presented to the different groups of users. Personalization of the structure of an application or website means altering the location of

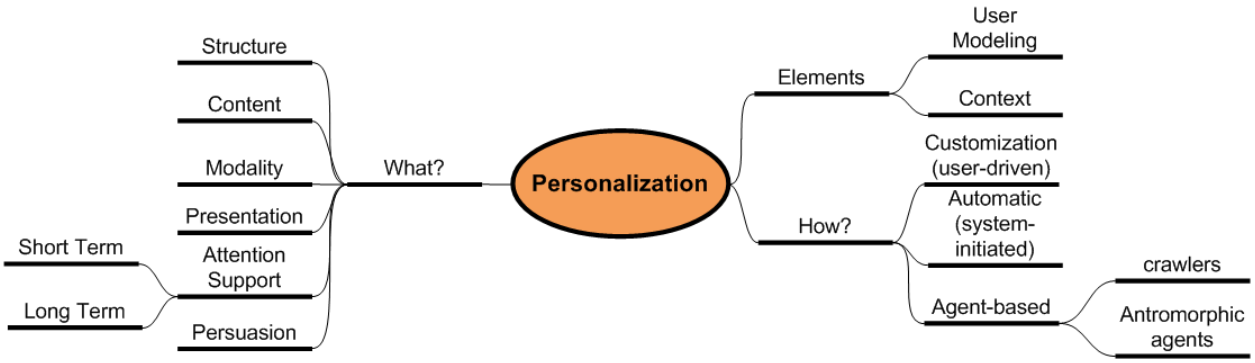

Figure 1. A taxonomy of personalization techniques

content including text, images and the location of available links. This aspect of personalization involves placing the links and content where they are more relevant for the user. Different users may see different layouts. This structuring can help the identification of the important information (putting important information at the top), but also can facilitate navigation through personalized navigation or "adaptive navigation support" [18] enabling a number of actions such as: creating shortcuts on more frequent actions, adaptive ordering, direct guidance or alternative actions). When a user navigates from one item to another, the system can manipulate the links (hide, sort, annotate) to provide adaptive navigation support [19].

The personalization of structure guides the user in his interactions in a non-intrusive manner by making more accessible the more likely actions to be followed or disables certain functions and therefore narrowing down the space of possibilities in order to increase efficiency and usability.

2) Personalization of content refers to the process of dynamic tailoring the information that is presented to the different users according to their profiles (e.g., needs, interests, level of expertise, etc). The adaptation of content facilitates the process of filtering and retrieval of relevant information. The content can be selected to be relevant to the specific characteristics of users, and the location or context of the activities in which they are engaged at a given time. These techniques of adaptations enable users to spend less time to search and retrieve relevant knowledge/information or products. On the web, personalized content can take the form of recommended links or products, targeted advertisements, or text and graphics according to the user's preferences [11].

A traditional approach to personalization of content, especially in web applications, is collaborative filtering used by Amazon [20] or Google News [21]. The current user's ratings of certain objects are matched with the ratings of similar users to give recommendations for objects the current user has not ranked. Another example of the personalization of content is personalized search. Personal preferences according search results that are stored over longer periods of time integrated into the search process [22]. Data about users search history have to be collected (e.g., with Google Web History or via cookies on the user's computer). The search history data are later used for ranking or filtering search results. The "filter bubble" [23] warns us about the potential downside of personalized search. It is argued that through personalized search we limit the exposure to new information, new points of view which could be detrimental for the users on long term.

The personalization of content enables to select the content that is more likely to be relevant to the user and help users to deal with the information overload problem.

3) Personalization of modality empowers the users to choose betweendifferent modalities of information visualization. New modalities of information visualization have recently emerged. These new forms of information visualization go beyond a text or tree based view of documents or information. Intelligent information portal bring a new designs of the user interface with a graphical view representation (e.g., Kartoo, Brain, ClusterMap, 3D representations). The personalization of modality enables changes from text to other types of media to present the information to the user (image, video, animations or audio) if they are available in the system based on various criteria such as: cognitive style, learning style, preferences, physical disabilities, type of display or device, etc. The selection of the modality can be done according to the user characteristics, culture, context, type of device in use but also according to the nature of the content (some modality can be more adapted to the delivery of some particular content). Numerous studies reported in [24] have emphasized that cultural differences are important for the selection of image modality, colour selection, and information presentation in general.

4) Personalization of presentation empowers the users to choose between: different presentation styles such as: different layouts, skins or size of fonts. Other preferences can include the presence or absence of anthropomorphic interface agents, the preferred languages, etc. Different types of sortings, bookmarking, shortcuts can also be included in an advanced hypermedia system. Cultural adaptation is another element that differentiates the personalisation of presentation taking into consideration

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significant cultural differences _(e.g. Western vesus Chinese style). Cultural differences are important for website design, visual representation and information organisation [24]. According to [25] personalization of appearance through customization gives the possibility to express oneself and is correlated with both cognitive and emotional effects.

5) Personalization of attention (or attention supporting personalization) refers to the process aiming at making the interaction more attention effective, and in particular at reducing the cognitive effort. The support for the management of attention can be done at four levels: perceptual (filtering information); deliberative (help in reasoning and decision making); operative (reduce the cognitive effort necessary to complete a task); and metacognitive (learn how to be more effective at managing attention). Attention support is important because our attention can be easily diverged by various interruptions and because information of all types and qualities abounds [1].

Attention support is a particular form of personalization, aiming at personalizing the interaction in order to support users in being more effective and attentive on the main tasks or in relation with the tasks or goals they need to perform. In cognitive science, attention represents a very broad concept that includes a variety of aspects such as perception, information overload, and interruption, multi-tasking to name just a few. Attention can be supported both in the short term and in the long term. In the first case, it consists in helping reducing the cognitive load during human computer interaction, by reducing the amount of information displayed, by displaying it at a right level of prominence, or by notifying information (e.g., reminders) in a way that minimize the level of distraction. In the second case, it consists in assisting users in allocating their cognitive processes in a way that is the more effective over longer period of time. For instance, the support of long term attention may consist in helping users in allocating their time, and at selecting the types of actions that are the more effective so as to accomplish an objective. Attentive user interfaces [26] are designed to reduce the cognitive effort by reducing the amount of information presented to the user, by limiting the interruptions or by helping this user to recover after an interruption by restoring the previous context of his work [27].

The personalization of attention considers the human cognitive limitations such as the human limited absorbing and "processing" capabilities. This is in particular relevant for teaching and learning. Learning analytics is an area which has recently emerged that aims to manage the attention of learners based on their activities and interaction traces.

6) Persuasion. Persuasive technologies aim to shape, reinforce or change the behavior, feelings or thoughts of users, e.g., to maintain a healthy lifestyle or to purchase products. Usually, persuasion is not tailored to specific user groups with wide-ranging goals and needs [28]. A fusion of personalization and persuasion, e.g., by providing personalized messages or adapting the user interface, leverages the effect of persuasion [29].

IV. ELEMENTS OF PERSONALIZATION

Personalization is a data-intensive process and can be based on two main kinds of information that is evaluated:

- User modelling, the characteristics of the user (user data and usage data)
- The user's context or state (e.g., location of the user, current activity)

A. User modeling

User models or user profiles include user related data such as user's name, address, interests, preferences, skills, etc. This information can be collected explicitly via forms or questionnaires, but also implicitly via various user modeling techniques of usage data. The explicit data can be enriched/ complemented by usage data, directly observed or implicitly recorded from user actions. An overview of the various types user modeling techniques and characteristics of the models can be found in [6]. Usage data includes information about clicking on links, session length, or articles watched and purchased [30]. Usage information is available via the Web server logs, but is also increasingly made available by Web tools such as online social networking systems via the exportation of the activity streams. This information is then processed by applying data mining techniques such as clustering, association rules discovery, classification, and sequential pattern discovery, in order to reveal useful patterns that can be further analyzed and exploited in order to generate a more personalized experience.

B. User's context

Adaptation to context refers to the dynamic adaptation process to a changing environment in which the user operates or works. Context-aware systems represent the type of systems that create an interaction that is relevant to user's context, e.g., location, current work process (what they are working on), the current organizational settings (culture of the organization), personal characteristics or mental states (e.g., boredom). Context aware systems have been proposed also for the design of more effective e-learning systems [31].

C. Forms of personalization

One can distinguish between different methods of personalization:

- Customization, initiated by the user who set up his own preferences
- System-initiated or automatic through adaptive interfaces, services, or more recently attentive user interfaces
- Proactive personalization via agent-based or semi-automatic personalization through crawlers or anthropomorphic agents

1) Personalization through customization: is the process of creating a customized user experience taking into account users preferences and/or specific characteristics of

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the user. When customizing, the user is in control in specifying his own preferences and requirements manually, and is able to adapt the interface in a way that is the most fitted to his particular needs. At this level customization process may consist of setting preferences that will be taken into account to parameterize the interface, but it may also consist in allowing users to literally design the interface itself by assembling the different components. Examples of the latest category can be found in information portals such as: iGoogle, MyGoogle or NetVibes.

2) Automatic personalization or system-initiated personalization: personalization can also be achieved in more sophisticated manner through automatic personalization or adaptive interfaces. In this later case, the interface and the interaction are dynamically generated, in a way that is expected to fit to each specific user. Practically, adaptive user interface rely of a user model that includes the most important characteristics of the user. Adaptive systems may make use of data from the user model/profile, his usage data and/or context. This data can be processed, analyzed and predictions about user's future behavior, intentions or goals are made. Automatic personalization relies on various types of algorithms and in particular data-mining algorithms as presented in section II.

3) Agent-based personalization: may include adaptive focused crawling [32] to help locate resources about particular topics of interest for a user or through the use of various agents including anthropomorphic characters [33]. Agents-based have been designed with the purpose of personalization of interaction or providing enhanced user support through a dialogue with the user in domains such e-learning or e-commerce [32]. Anthropomorphic characters try to mimic and behave like a human and they can play different roles (e.g., guide a user is searching, help, discuss, entertain).

V. DISCUSSION AND USE CASES OF PERSONALIZATION

Online social networks provide a fast-developing application domain of different methods of personalization. The different personalization mechanisms contribute to improved effectiveness attention by reducing the amount of information processed and reducing the level of interruption and distraction.

At the level of **content personalization**, a typical personalization mechanism consists of friends' recommendations that are likely to be friends or acquaintances. These recommendations are typically done using collaboration filtering technique, and are inferred by mining the social network of the member. Furthermore, the disclosure of information can be parameterized taking into account the social proximity (close friends have access to more information than acquaintances or complete strangers). The social network is notified of changes of other members' profile or with information that are relevant to a given member (such as common friends or groups affiliation).

As an example of **personalization of presentation**, users can select the number of items to be displays in the suggestion box for possible new contacts and the location of this suggestion box in the web page. Users can select to have more or less information from a specific person in their list.

A user can decide how to get informed about news in his/her network – via mail or via sms on the mobile phone. These mechanisms are a form of **personalization of modality** as described in the previous section. As web notification, suggestions boxes can provide a non-disruptive means of notifying users of an event or to indicate a suggestion what other people might be interesting. Social navigation is also a new form of navigation support that has developed with the context of social network applications. Few attention support mechanisms are also included. Such mechanisms include notifications of birthdays, applications advertisements or events that might be of interest.

Personalization in online social networks makes use of both individual characteristics (e.g., all the personal information such as age, position) as well as of user-generated content (list of favorites, ratings), the context (such as the recent activity of the members in his/her social network). Personalization in these systems is specified **both explicitly** by members (for instance when they select the level of notification or set their privacy preference) or **automatically generated** by the system (when they provide relevant recommendations).

An analysis of common features and current limitations of social networks applications have been described in [34]. Such limitations can be addressed through advanced personalized features enabled by Semantic Web technology. Personalization in social networks using Semantic Web technologies will enable more up-to date and relevant content and stronger social connection through semantic browsers and semantic mashups [34]. Semantic Web technology and advanced data models will enable to integrate different data sources and facilitate dynamic data integration from different data sources through semantic mashups. Thus a busy user will spend less time to find relevant events and share them with his/her friends in case she /he wants to.

Finally, attention-aware systems are taking into account the cognitive effort in the interaction for short term or for longer period of time. This is particularly relevant to application that support teaching, training and learning. More specifically, (short term) attentive user interfaces [24] are able to make the graphic user interaction more attention friendly, by displaying information at the right level of prominence, or by managing interruptions (e.g., prioritizing or delaying them). Long term attention management systems offer assisting users in managing their attention over longer period of time (weeks, or month), via the capture, analysis and visualization of activities and the provision of guidance. Such systems has been proposed in the context of online social interaction [2], learning [35] or work, and typically consists in providing an analytic component (e.g., learning analytics dashboard) and a recommendation system.

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VI. CONCLUSIONS AND FUTURE WORK

Personalization techniques represent a way to enhance the user experience, to help users cope with increased information overload, to support attention management with the ultimate scope of helping users to be more effective, help users in the decision making process or persuade the users and customers. However personalization is a challenging, broad area of research that overlaps several research fields and it poses a complex set of both usability studies [36], trust [23] and privacy concerns. With system-initiated personalization which is the more advanced form of personalization the users are less in control and therefore trust and privacy concerned are important.

This paper examines the different forms of personalization and proposes a classification of the different existing personalization techniques according to three dimensions: types of personalization, elements of personalization and methods of personalization. In addition to the four forms of personalization (structure, content, modality, presentation) discussed in the literature, this article introduces two new forms of personalization: attention support and persuasion. In particular, we elaborate on the management of attention or attention support.

This framework can be applied in the different application domains and it may be further developed and may enable researcher and practitioners achieve an overall understanding of personalization methods, techniques and elements. Further research on attention support, collective intelligence and personalization mechanisms will enable application to provide more value to the users who return more often or targeted experiences for each user according to his/her needs, capabilities, interests or preferences.

REFERENCES

[1] Roda, C. and T. Nabeth, Attention management in organizations: Four levels of support in information systems, in Organisational Capital Modelling, measuring and contextualising, A. Bonfour, Editor. 2008, Routledge. pp. 214-233.

[2] Nabeth, T. and N. Maisonneuve, Managing Attention in the Social Web: The AtGentNet Approach, in Human Attention in Digital Environments, C. Roda, Editor. 2011, Cambridge University Press. pp. 281-310.

[3] Alag, S., Collective Intelligence in Action, ed. G. Manning. 2009.

[4] Razmerita, L., User Modeling and Personalization of Knowledge Management Systems, in Adaptable and Adaptive Hypermedia, S.Y. Chen and G.D. Magoulas, Editors. 2005, Idea Group Publishing. pp. 225-245.

[5] Fischer, G., User Modeling in Human-Computer Interaction. User Modeling and User Adaptive Interaction, 2001. Kluwer Academic Publishers: pp. 69-85.

[6] Brun, A., A. Boyer, and L. Razmerita, Compass to Locate the User Model I need: Building the Bridge between Researchers and Practitioners in User Modeling, in User Modeling, Adaptation and Personalization (UMAP), 18th International Conference, UMAP 2010, Hawaii, USA, P. De Bra, A. Kobsa, and Chin, D., Editors. 2010, Springer-Verlag: Berlin-Heidelberg. pp. 303-314.

[7] Kobsa, A., Privacy-Enhanced Web Personalization, in The Adaptive Web- Methods and Strategies of Web Personalisation, P. Brusilovsky, A. Kobsa, and W. Nejdl, Editors. 2007, Springer. pp. 628-670.

[8] Manber, U., A. Patel, and J. Robison, Experience with personalization of Yahoo! Commun. ACM, 2000. 43(8): pp. 35-39.

[9] Mobasher, B., Data Mining for Web Personalization, in Tha Adaptive Web, A.K. P. Brusilovsky, and W. Nejdl, Editor. 2007, Springer-Verlag: Berlin Heidelberg. pp. 90-135.

[10] Kobsa, A., J. Koenemann and W. Pohl, Personalised hypermedia presentation techniques for improving online customer relationships. The Knowledge Engineering Review, 2001. 16(02): pp. 111-155.

[11] Mobasher, R. and R. Cooley, Automatic Personalization based on Web Usage Mining. Communications of the ACM, 2000. 43(8): pp. 142-151.

[12] Frias-Martinez, E., S.Y. Chen, and X. Liu, Survey of Data Mining Approaches to User Modeling for Adaptive Hypermedia. IEEE Transactions on Systems, Man and Cybernetics - Part C: Applications and Reviews, 2006. 30(6): pp. 734-749.

[13] Eirinaki, M. and M. Vazirgiannis, Web mining for web personalization. ACM Transactions on Internet Technology, 2003. 3(1): pp. 1-27.

[14] Zimmermann, A., M. Specht, and A. Lorenz, Personalization and Context Management. User Modeling and User-Adapted Interaction: The Journal of Personalization Research, 2005. 15(3-4): pp. 275-302.

[15] Wu, D., I. Im, M. Tremaine, K. Instone and M. Turoff, A Framework for Classifying Personalization Scheme Used on e-Commerce Websites. in Hawaii International Conference on System Sciences. 2003. 36th Annual Hawaii International Conference on System Sciences (HICSS'03).

[16] Correia, N. and M. Boavida. Towards an integrated Personalization Framework: A Taxonomy and Work Proposals. in Workshop on Personalization in Electronic Publishing. 2001. Malaga, Spain.

[17] Blom, J. Personalization - a Taxonomy. in CHI'00 Conference on Human Factors in Computing Systems. 2000. The Hague, Netherlands.

[18] Brusilovsky, P., Adaptive Navigation Support, in The Adaptive Web, P. Brusilovsky, Kobsa, A and Nejdl, W., Editor. 2007, Springer. pp. 263-290.

[19] Brusilovsky, P. and M. Maybury, T., , From adaptive Hypermedia to adaptive Web. Commun of the ACM, 2002. 45(5): pp. 30-33.

[20] Linden, G., B. Smith, and J. York, Amazon.com recommendations: item-to-item collaborative filtering. IEEE Internet Computing, 2003. 7(1): pp. 76-80.

[21] Das, A., M. Datar and A. Garg, Google news personalization: scalable online collaborative filtering, in Proceedings of the 16th international conference on World Wide Web2007, ACM: Banff, Alberta, Canada. pp. 271-280.

[22] Keenoy, K. and M. Levene, Personalisation of Web Search, in Intelligent Techniques for Web Personalization, B. Mobasher, Anand, S.S., Editor. 2005, Springer: Berlin. pp. 201-228.

[23] Pariser, E., The filter bubble: What the Internet is hiding from you. 2011: Penguin Press HC.

[24] Callahan, E., Cultural Similarities and Differences in the Design of University Web sites. Journal of Computer-Mediated Communication, 2005. 11(1): pp. 239-273.

[25] Monk, A., F. and J. O. Blom, A theory of personalisation of appearance: quantitative evaluation of qualitatively derived data. Behaviour & Information Technology, 2007. 26:3: pp. 237-246.

[26] Vertegaal, R., Attentive User Interfaces. Commun. of the ACM, 2003. 46(3): pp. 30-33.

[27] Vertegaal, R., et al., Designing for augmented attention: Towards a framework for attentive user interfaces. Computers in Human Behavior, 2006. 22(4): pp. 771-789.

[28] Berkovsky, S., J. Freyne, and H. Oinas-Kukkonen, Influencing individually: fusing personalization and persuasion. ACM Transactions on Interactive Intelligent Systems (TiiS), 2012. 2(2): article no. 9.

[29] Andrews, P.Y., System Personality and Persuasion in Human-Computer Dialogue. ACM Transactions on Interactive Intelligent Systems (TiiS), 2012. 2(2): article no. 12.

 ISBN: 978-1-61208-232-5

[30] Markellou, P., M. Rigou, and S. Sirmakessis, Minning for Web Personalization, in Personalized Information Retrieval and Access, N. Chen, Editor. 2008, IGI Global. pp. 77-97.

[31] Nabeth, T., A. Angehrn, and R. Balakrishnan, Integrating 'Context' in e-Learning Systems Design, in Proceedings of the IEEE International Conference on Advanced Learning Technologies (ICALT 2004)2004: Joensuu, Finaland. pp. 355-359.

[32] Micarelli, A. and F. Gasparetti, Adaptive focused crawling. Lecture Notes in Computer Science, 2007. 4321: pp. 231-262.

[33] Brna, P., B. Cooper, and L. Razmerita, Marching to the wrong distant drum: Pedagogic Agents, emotion and student modeling, in Workshop on Attitude, Personality and Emotions in User-Adapted Interaction in conjunction with User Modeling, Workshop on Attitude, Personality and Emotions in User-Adapted Interaction in conjunction with User Modeling Conference 2001: Sonthofen, Germany.

[34] Razmerita, L., R. Firantas, and M. Jusevičius. Towards a New Generation of Social Networks: Merging Social Web with Semantic Web. in 5th International Conference on Semantic Systems. 2009. Graz, Austria: Proceedings of I-KNOW'09 and I-SEMANTICS'09.

[35] Duval, E. Attention Please! Learning Analytics for Visualization and Recommendation. . in 1st International Conference on Learning Analytics and Knowledge (LAK). 2011. Banff, Alberta.

[36] Jameson, A., Adaptive Interfaces and Agents, in Human-computer interaction handbook J.A. Jacko and A. Sears, Editors. 2003, Mahwah, NJ: Erlbaum. pp. 305-330.

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A Traffic Adaptive Backoff Approach for Wireless Networks

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***Abstract*—An efficient backoff algorithm is required to achieve a high network capacity in wireless networks. The IEEE 802.11 Distributed Coordination Function (DCF) has generally been used in wireless LAN. The DCF algorithm uses a Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) with a Binary Exponential Backoff (BEB). The increasing solution of Contention Window (CW) in BEB is very effective to decrease the probability of collision. But, BEB cannot be adaptive to the dynamic change of traffic load, so it sometimes acts as the cause of the delay and the collision. This paper proposes a Traffic Adaptive Backoff Algorithm (TABA) which tunes the value of CW parameter depending on the slot utilization and the collision count during a monitoring period. TABA determines a more appropriate CW, so it reduces the delay to access the channel and the collision rate without the decrease of throughput. In this paper, we evaluate the performance of the proposed TABA, and compare the TABAs performance with existing backoff algorithms by using simulation. Our proposed mechanism shows that it outperforms the existing methods because it has better adaptability to the load variation of the network.**

Keywords-wireless networks; backoff; contention window.

I. Introduction

The Distributed Coordination Function (DCF) of the IEEE 802.11 [6] that used Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA) [8] is a representative Medium Access Control (MAC) protocol [1] for wireless networks. It is based on a random slot selection basis from the Contention Window (CW) in which all stations participating in transmission are involved. In the CSMA/CA, every contending station senses the carrier before the transmission. The carrier sense avoids collisions by testing the signal energy in the occupied band. When the station does sense the carrier, it starts to transmit its frames. When the channel, however, is detected as busy, it schedules its transmission at random moments to decrease the probability of a collision. At each collision, the station increases its CW exponentially. This exponential increase of CW is very effective in reducing the probability of a collision. It sometimes, acts however, as the cause of a transmission delay of data. The proper selection of backoff parameters is an essential factor in enhancing the network performance. In this paper, we propose a Traffic Adaptive Backoff Algorithm (TABA), which tunes the length of the CW period depending on the slot utilization and the collision count during the monitoring period. Our mechanism reduces the delay and the collision rate without the decrease of throughput. Section 2 describes the existing backoff algorithms. Section 3 and Section 4 present the TABA and simulation results. Section 5 contains the conclusion.

II. Related Works

A. Binary Exponential Backoff Algorithm (BEB)

The basic access method in the IEEE 802.11 MAC protocol is the DCF which is a CSMA/CA protocol [1]. The backoff count is determined as a pseudo-random integer drawn from a uniform distribution over the interval [0,CW]. The set of CW values shall be sequentially ascending, with integer powers of 2 minus 1, beginning with CW_{min} and continuing up to CW_{max} value. The value of CW shall take the next value every time there is unsuccessful attempt of transmission until reaching the value of CW_{max}. The CW shall be reset to CW_{min} after every successful attempt transmission, and shall remain at the value of CW_{max} until it is reset.

B. Estimation-Based Backoff Algorithm (EBA)

In [2], they proposed Estimation-Based Backoff Algorithm (EBA) to tune the backoff window size depending on the number of idle slots during the backoff period. The EBA algorithm estimates the system status by using the idle slot counts during the backoff period, and it determines a proper contention window size that accurately matches the current network conditions. But, the CW range which EBA set is shorter than the CW range which BEB set. It reduces transmission delay in low offered low. It is caused many collisions.

III. Proposed Scheme

In this paper, we propose Traffic Adaptive Backoff Algorithm (TABA) which adaptively updates the length of CW

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depending on the estimate of channel utilization at each node to enhance the system performance. The detailed algorithm is as follows.

Given N nodes in wireless network, a random variable X is defined as the number of nodes to transmit their data during a slot. Then, the probability that k nodes out of N nodes try to send their data is given by

$$P(X = k) = \binom{N}{k} p^k (1 - p)^{N-k} \quad (1)$$

where p denotes the probability that a node has data to transmit during a slot. We can get the probability that the channel is IDLE during a slot, denoted by ***P(IDLE)*** by setting $X = 0$ in Eq.(1). Similarly, we can also get the probability of the successful packet transmission during a slot in the wireless network, denoted by ***P(SUCC)*** by setting $X = 1$. In addition, we can get the probability that there happens a collision during a slot, denoted by ***P(COLL)***, as follows.

$$\begin{aligned} P(COLL) &= 1 - P(SUCC) - P(IDLE) \\ &= 1 - Np(1-p)^{N-1} - (1 - p)^N \end{aligned} \quad (2)$$

And we can get the throughput S of the wireless network by

$$S = \frac{P(SUCC)}{P(COLL) + P(SUCC) + P(IDLE)} = P(SUCC) \quad (3)$$

We differentiate S with regard to p to find the value of CW maximizing S, denoted by CW_{TABA}, by

$$\frac{dS}{dp} = N(1 - p)^{N-1} - N(N - 1)p(1 - p)^{N-2} = 0 \quad (4)$$

So, we have

$$CW_{TABA} = N \quad (5)$$

In our algorithm, all nodes should examine the status of slots during a monitoring period (denoted by T) with a length of several time slots. Another random variable Z is defined as the number of collided slots when k nodes out of N nodes transmit their data during the monitoring period T. From (1) and (2), we can easily get the average value of Z by

$$E(Z) = T \times P(COLL) \quad (6)$$

The number of slots used to carry data plus the collided slots, denoted by U, can be obtained by

$$U = T\left(1 - 2(1-p)^N\right) \quad (7)$$

Arranging (7) with respect to N, we have

$$CW_{TABA} = \frac{log(T - U) - log(2T)}{log(T - 1) - log(T)} \quad (8)$$

Figure 1 shows the algorithm and notation of parameters used in the TABA. The duration of the monitoring period T is determined based on measurement of the collision count and slot utilization. T is initially given 8 slots, and stays unchanged if there is no collision. It is also reset to 8 slots every successful transmission. If the node experiences a collision, the value of T will be determined depending on the value of CW_{TABA}. If $T < CW_{TABA}$, T will be doubled for each collision in the same way as the BEB. However, if $T \geq CW_{TABA}$, T will not be changed even though there is a collision. This way, we can adaptively adjust the length of backoff period depending on the collision count and slot utilization.

N = Number of contention nodes
BT = Backoff time
BE = Backoff Exponential
CW = Contention Window
CW_{TABA} = Optimal CW
T = Monitoring period
U = Number of successful slots plus collision slots during T

Count U
$CW_{TABA} = \frac{log(T-U) - log(2T)}{log(T-1) - log(T)}$
BT = Random(0, CW_{TABA} - 1)
If collision occur and ($T < CW_{TABA}$)
    $BE \leftarrow BE + 1$
    $T \leftarrow 2^{BE} - 1$
else collision occur and ($T \geq CW_{TABA}$)
    $T \leftarrow T$
End if

Figure 1. Traffic Adaptive Backoff Algorithm

Figure 2 shows an example for determining the length of CW and T. Initially, assuming that $T = 8$ and $U = 6$, then we have $CW_{TABA} = 14$ from (10). This means that there will be a good possibility that the nodes can transmit their data without collision using a contention window with a length of 13 slots. In this case, the backoff time is randomly selected from [0, 13]. If there happens a collision in this case, the monitoring period T changes to 15 because $T < CW_{TABA}$. On the other hand, when $T = 15$ and $U = 4$, we will have $CW_{TABA} = 11$, the backoff time is randomly selected from [0, 10]. If there happens a collision at this time, the monitoring period T does not change because $T \geq CW_{TABA}$.

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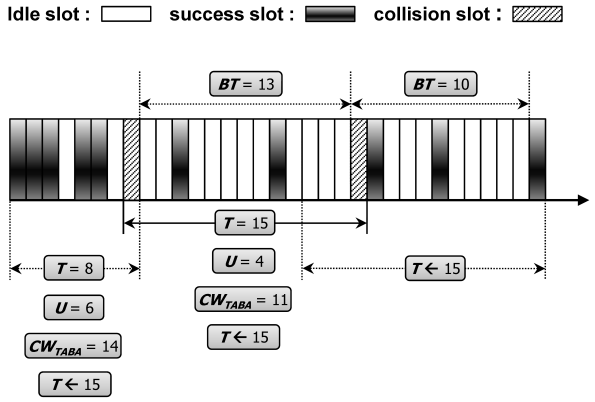

Figure 2. Example of TABA operation.

IV. Simulation

In order to evaluate the performance of our mechanism, a simulation study has been performed. We evaluate the performance in terms of the delay, the collision count, and the throughput. The system model for analysis consists of an Access Point (AP) and nodes. The number of nodes is assumed infinite. It is also assumed that all stations only transmit their packets to AP and AP does not generate its own packets. In addition, several assumptions have been made to reduce the complexity of the simulation model. The first, the effects of propagation delay are neglected assuming that the transmission distance is very close in order to transmit a packet. The second, the channel is error-free, that means that each transmitted packet was successfully and correctly received at its destination. The third, the packet transmission where is all stations transfer to AP is assumed to be a Poisson traffic source and there is no interference from the nearby Basic Service Sets (BSSs). The parameters used for the performance evaluation are listed in Table 1.

Table I
Parameter in The Simulation.

Parameter	Value
Monitoring period (T)	8 ~ 1023 slots
Min of CW_{TABA}	7 slots
Max of CW_{TABA}	7796 slots
Paket size	100 bytes
Slot time	50us
Transmission Rate	16Mbps

Figure 3 shows the average length of CW in our algorithm and the existing algorithms. When the offered loads are below 0.5, the TABA selects a shorter CW than the BEB. On the other hand, when the offered loads are over 0.6, the TABA selects a longer CW than the BEB. We can also see that the TABA gives a longer CW than the EBA over all the range of offered loads. This indicates that the TABA selects the CW more adaptively to the network traffic than other existing algorithms. And, this can contribute to reducing collision ratio while enhancing throughput.

In Figure 3, we see that the TABA provides a longer CW than the BEB when the offered load is heavy. This contributes to reducing collisions as shown in Figure 4. We can see that the EBA gives much more collision count than the TABA because it uses a shorter CW.

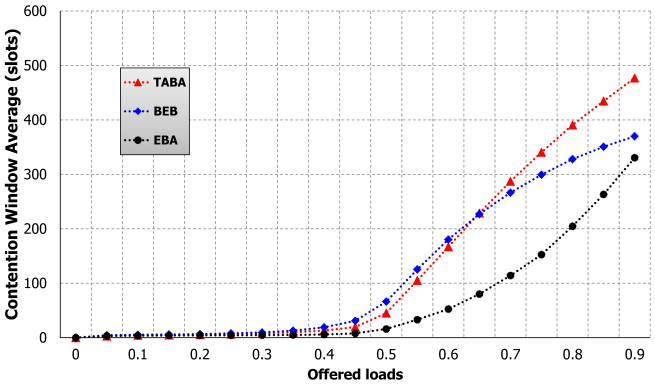

Figure 3. The average length of contention window.

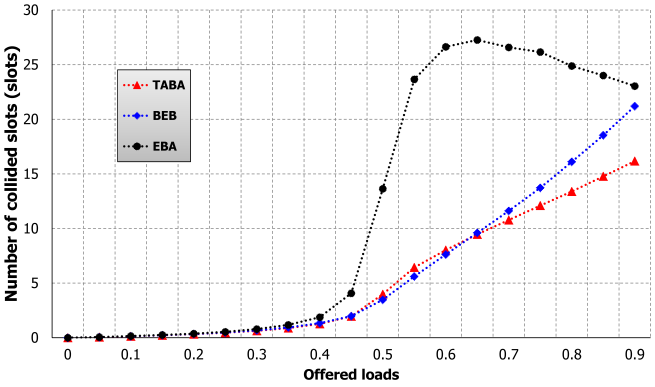

Figure 4. Collision Count.

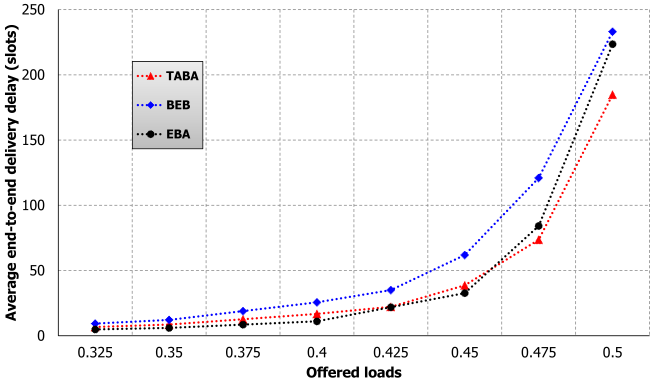

Figure 5. Average end-to-end delivery delay.

Figure 5 shows the average end-to-end delay that includes

the waiting time at the interface queue and transfer time. We can see that our algorithm provides a shorter end-to-end delay at low traffic intensities than the existing algorithms. On the other hand, we can see no significant difference among all algorithms under heavy offered loads even though the TABA uses a relatively longer CW than the existing algorithms. This indicates that the TABA adaptively adjusts CW depending on traffic loads in the network.

Figure 6 shows the throughput in the TABA and the existing schemes. As shown in Figures 3 and 4, the EBA selects a shorter CW than the BEB and the TABA. For example, if the TABA selects 13 for CW, the node experiences a single collision on the average until a successful transmission when the offered load is 0.4. On the other hand, if the EBA selects 6 for CW. In this case, the node experiences two collisions on the average until a successful transmission. This example indicates that a shorter CW of the EBA can contribute to reducing delay time, but it causes more collisions. The EBA uses a relatively shorter CW. This can contribute to reducing delay time, but it causes more collisions and thus lower throughput when the offered load approaches to high value. Since the TABA adaptively determines the length of CW, it can produce a higher throughput when the offered load is heavy due to less collision. In addition, the TABA also offers a higher throughput at low traffic intensities because it reduces the delay in comparison with BEB and EBA.

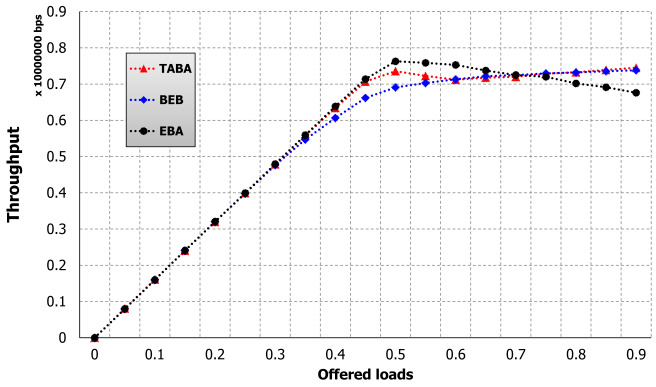

Figure 6. Throughput..

Simulation results assure that our TABA scheme can offer a higher throughput by choosing the appropriate value of CW depending on the slot utilization and the collision count. It can also reduce the delays without a noticeable increase of collisions.

V. Conclusion and Future works

The proper choice of the CW parameters has a positively large influence on the network performance in the wireless network. In this paper, we proposed Traffic Adaptive Backoff Algorithm (TABA) to dynamically select the size of CW depending on the slot utilization and the collision count during the monitoring period. We compared the performance of our algorithm with the existing backoff algorithms. Simulation results indicate that the TABA dynamically adapts to the variation of the wireless protocols, and may reduce the MAC protocol delay and collision rate without a decrease in throughput. For future work, we plan to eliminate assumption for simulation and use a test bed with realistic environment.

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References

[1] P802.11, IEEE Standard for Wireless Lan Medium Access Control(MAC) and Physical Layer (PHY) Specifications, Nov. 1997.

[2] Seok-Won K, Jae-Ryong C, and Jae-Hyun K, A Novel Estimation-Based Backoff Algorithm in the IEEE 802.11 Based Wireless Network, Consumer Communications and Networking Conference (CCNC), 2010, pp. 1-5.

[3] Cali F., Conti M., and Gregori E., "IEEE 802.11 Protocol : Design and Performance Evaluation of an Adaptive Backoff Mechanism," IEEE Journal on Selected Areas in Communications, Vol. 18, No. 9, pp. 1774-1786, 2000.

[4] J. Lee, W. Kim, and H. Kim. Estimation of Number of Tags in ALOHA-based RFID Systems, KICS, 07-7 Vol. 32, No. 7, 2007.

[5] Bianchi G., Fratta L., and Oliveri M., "Performance evaluation and enhancement of the CSMA/CA MAC protocol for 802.11 wireless LANs," Proceedings of PIMRC'96, Seventh IEEE International Symposium, 1996, Vol. 2, pp. 392-396, 1996.

[6] Jost Weinmiller, Hagen Woesner, Jean-Pierre Ebert, and Adam Wolisz, "Analyzing and tuning the distributed coordination function in the IEEE 802.11 DFWMAC draft standard," Proceedings of MASCOT96, 1996.

[7] Romdhani L., Qiang Ni, and Turletti T., "Adaptive EDCF: Enhanced Service Differentiation for IEEE 802.11 Wireless Ad-Hoc Networks," Proceedings of WCNC 2003 IEEE, Vol. 2, pp. 1373-1378, 2003.

[8] Wookwon Lee and Khan M.A., "CSMA/CA with Multiple-Variable Contention Window for Wireless Multimedia Communication Systems," Proceedings of the 10th ICT(Int'l Conferrence on Telecommunications)," Vol. 2, pp. 938-942, 2003.

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On-site Knowledge Transfer in Agriculture: TalkingPot

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***Abstract*— Recently, the continuity of agricultural knowledge transfer has grown in importance because of a decrease in the number of agricultural workers. In agriculture, novice agricultural workers gain knowledge through on-site agricultural work. Therefore, on-site agricultural work is important for the transfer of knowledge in agriculture. This system targets the cultivation of potted plants and compares the user's history of agricultural work and experts' history of agricultural work. The system constructs the rules of the user's failure habits and the plant pot communicates with the user based on these rules. This enables the user to obtain knowledge directly in on-site agricultural work.**

Keywords-Knowledge transfer, agriculture, tacit knowledge, explicit knowledge, SECI model.

I. INTRODUCTION

Knowledge transfer is currently a very important theme in business and education, and has been the subject of a great deal of attention [1]. The issue of knowledge transfer is being tackled in a variety of contexts, for example, system engineering, artificial intelligence, and so on. However, these approaches involve a number of problems. This study tackles the problem of transferring knowledge in agriculture. Agriculture is not corporatized in Japan, and hence, has typically been transferred through direct communication from parents to their children or senior farmers to juniors over long periods of time. In recent years, however, the number of people who have been changing jobs from corporate employees to farmers has been increasing. In addition, the number of expert agriculture workers has been decreasing rapidly [2][3]. Thus, the opportunities for novice agriculture workers to directly learn from experts have also decreased. As a result, the need for agricultural knowledge to be transferred to inexperienced workers has increased as well. On the other hand, with the increase of home gardens allowing the cultivation of crops, a gardening boom has taken place among people young and old in Japan, and the need for agricultural knowledge to be transferred to such people is also increasing.

However, as such trends are relatively recent, the newly increased needs for the transfer of agricultural knowledge have been satisfied via the trial and error process until now. In the agricultural field, transferring or acquiring knowledge is problematic because appropriate cultivation methods vary according to various environments. Thus, it is difficult for novice agriculture workers to acquire customized knowledge only through standardized manuals. Recently, the possibility of global knowledge sharing through the new ubiquitous network architecture has arisen. This study proposes a framework by which novice agricultural workers can access the knowledge of experienced agricultural workers via a network. In particular, this study targets the cultivation of potted plants. The plant pot communicates with a novice agriculture worker, considering the differences between the experiences of the novice and experts. Through the dialogue with plant pots, the novice agricultural workers can learn useful practical knowledge on-site during agricultural work. There have been a number of studies and support systems aimed at enabling objects to provide information to users, and this study is characterized by the changing nature of plants and their environments.

Section II describes related concepts and some agricultural studies. Next, we introduce the previous study and its problems in Section III, and describe the proposed system in Section IV. Finally, we examine the prototype system in Section V and discuss our conclusion and future work in Section VI.

II. RELATED CONCEPTS

A. Tacit Knowledge

Nonaka and Takeuchi defined tacit knowledge to be "knowledge gained from individual experiences or specific situations, which can include intangible elements such as beliefs, views, value systems, and so on" [4]. This concept was a refinement of Michael Polanyi's concept of tacit knowledge [5]. Agricultural knowledge regarding necessary tasks, know-how, and experience gained from failures could be classified as tacit knowledge.

B. SECI Model

The SECI model was defined by Nonaka and Takeuchi as a knowledge acquisition process used to share tacit knowledge within a company. This model repeats 4 processes, which are given below.

i . Tacit to Tacit (Socialization)
ii . Tacit to Explicit (Externalization)
iii . Explicit to Explicit (Combination)
iv . Explicit to Tacit (Internalization)

Figure 1 shows the flow of the SECI model.

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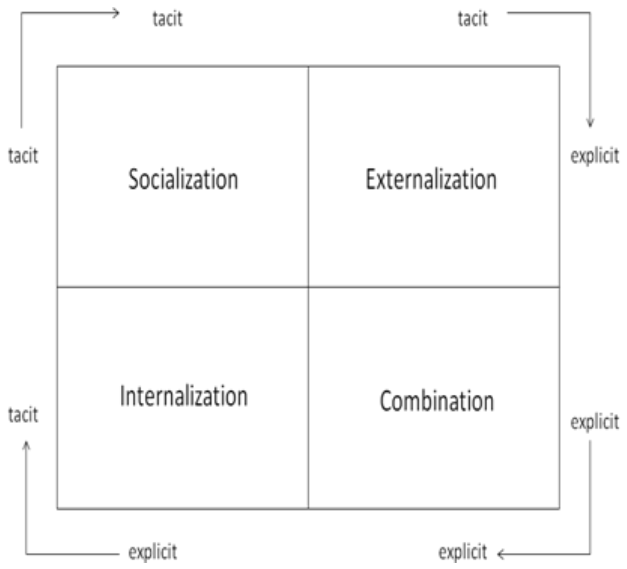

Figure 1. Flow of SECI model.

These four processes lead to the creation of new knowledge. The transfer of agricultural knowledge can also be classified into the four steps of the SECI model, with examples of each step being as follows.

i . Socialization

Novice agricultural workers work together with experienced agricultural workers. Novice agricultural workers can thus observe them, and then imitate them, learning the techniques of experienced agricultural workers.

ii . Externalization

Novice agricultural workers and experienced agricultural workers note down their observations during agricultural work.

iii . Combination

Novice agricultural workers summarize what they have noted down. In addition, novice agricultural workers also transcribe what was noted down by experienced agricultural workers.

iv . Internalization

Novice agricultural workers work alone without the help of the experienced agricultural workers.

Several studies have been conducted on agricultural support, but have been inadequate thus far. Examples include "Cloud Computing Applied for Agriculture and Other Fields" [6], which uses the cloud service of Fujitsu, and "PotPet: pet-like flowerpot robot" [7]. However, these support systems or studies place importance on product management and enjoyment of cultivation. Thus, it is difficult for a novice agricultural worker to learn directly from their experiences on-site. In addition, there have been almost no support systems from the aspect of "objects that can provide information to people".

III. PREVIOUS STUDY

A. *Agricultural Knowledge Transfer*

This study is based on our previous research, titled "Agricultural Knowledge Transfer based on Experience from Failures" [8]. The previous system aimed to support the transfer of knowledge that is deemed necessary as a result of failure experience, using the SECI model.

B. *Construction of Previous System*

The flow of the previous system involves 5 main functions. An explanation of each function and the corresponding SECI model process are given below.

i. Retrieval of Failure Experience (Socialization)
ii. Recommendation of Relevant Failure Experience (Socialization)
iii. Registration of Failure Experience (Externalization)
iv. Construct rules (Combination)
v. Information (Combination)

The system does not actually implement the Internalization part of the SECI model; instead, novice agricultural workers have to select the right choice before doing the actual work, which therefore plays the role of Internalization in the SECI model.

Figure 2 shows an image of the previous system, and Figure 3 shows the main screen of the previous system.

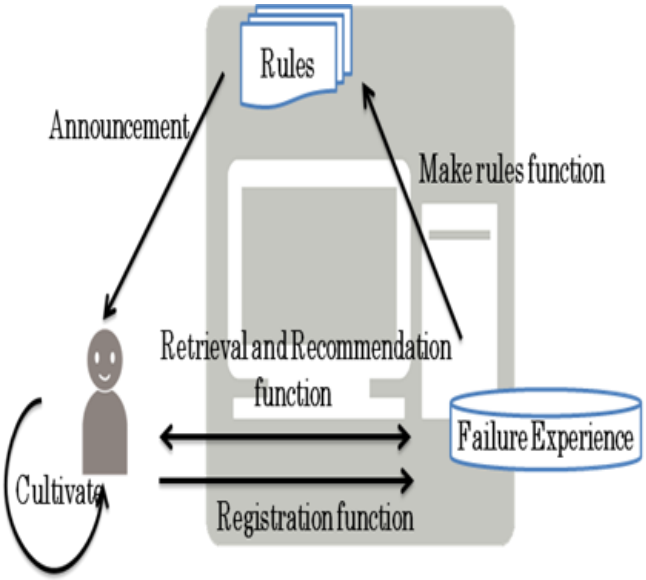

Figure 2. Image of the previous system.

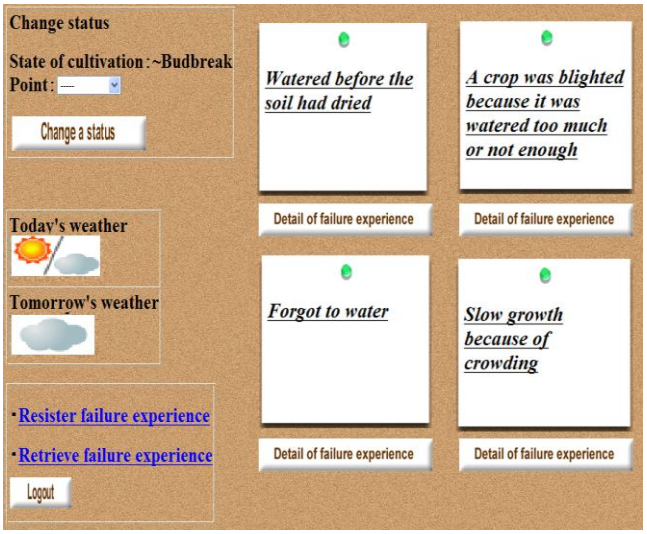

Figure 3. Main screen of the previous system.

C. Evaluation of Previous System

An evaluation experiment was conducted on the previous system. The purpose of this evaluation was confirming whether the subjects actually learned from experienced agriculture workers and their own experiences. In addition, the system also confirmed whether or not the subjects were able to gain individual knowledge. Before the evaluation, a questionnaire was provided on their knowledge of agriculture, with 29 university students from a Social Communication Laboratory completing the questionnaire form. 6 subjects who gave the same answers to the questionnaire were then selected because of the assumption that their knowledge of agriculture would be basically the same. The evaluation involved the method of cultivation being classified into 3 patterns, the results of which were then compared. The 3 patterns were:

i. Pattern where nothing was utilized
ii. Pattern where a manual was utilized
iii. Pattern where our system was utilized

The results of interviews were classified into three kinds of knowledge and experience, with the classified knowledge "Knowledge the subjects learned from this system or a manual", "Knowledge the subjects learned via experience" and "Chores the subjects experienced". One of the results of the interviews is given below, which is based on the above classification.

TABLE I. RESULT OF "USING NOTHING AT ALL"

< Knowledge the subjects learned from this system or a manual>
Nothing in particular
< Knowledge the subjects learned via experience >
Don't plant too many seeds at one time
< Chores the subjects experienced >
Planted a little less seeds / Watered the crop everyday / Watered the crop using a glass container and tap

TABLE II. RESULT OF "USING A MANUAL"

< Knowledge the subjects learned from this system or a manual>
Water the crops carefully / Don't overwater
< Knowledge the subjects learned via experience >
Nothing in particular
< Chores the subjects experienced >
Planted seeds in a line / Watered the crop carefully / Watered the crop using the right amount

TABLE III. RESULT OF "USING THIS SYSTEM"

< Knowledge the subjects learned from this system or a manual>
Narrowly-spaced planting results in slow growth The crop can be blighted because of being watered too many times or not watered enough
< Knowledge the subjects learned via experience >
Mizuna seeds are very small / Take care not to plant seeds too close to each other / Mizuna leaves are not very big
< Chores the subjects experienced >
Planted seeds at appropriate spacing / Didn't plant one seed per space but instead two

The subjects cultivated mizuna (*Brassica rapa nipposinica*) in pots for a month, then they were interviewed, and the results of the 3 patterns were then compared.

The results led to the following discoveries:

<Pattern where nothing was utilized>
Subjects gained knowledge from experience.

<Pattern where a manual was utilized>
Subjects gained knowledge from the system or a manual.

<Pattern where the system was utilized>
Subjects gained knowledge not only from the system or a manual but also from actual experience.

The traditional transfer of agricultural knowledge has involved a method in which experienced agriculture workers provide novice agriculture workers with knowledge and experience, and the novice agriculture workers then gain individual knowledge via actual experience. These steps are typically used to transfer agricultural knowledge. The pattern that uses our system is thus fairly similar to these steps when compared to the other 2 patterns.

The system can therefore be used to efficiently transfer agricultural knowledge.

D. Problems

In the previous study, transferring agricultural knowledge was proved to be effective through the use of failure experience and the SECI model. However, agricultural work was assumed to be done after referring to the failure experience information in front of a computer. In the transfer of agricultural knowledge, it is typical that knowledge is shared and exchanged between people. Using the system via a computer therefore appears somewhat unnatural, and using the computer and doing the agricultural work will be recognized as two unrelated things. Moreover, it will be difficult for users to relate knowledge acquired during agricultural work to knowledge acquired from the

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system, because they would appear to be separate processes. In addition, the failure experiences registered by users are "noticed failure experiences." Thus, the system cannot provide any useful knowledge about failures that novice agriculture workers do not notice. The present study, therefore, suggests a framework that users can use to aid the face-to-face transfer of agricultural knowledge during actual agricultural work.

IV. PROPOSED SYSTEM

A. *Media Equation*

The Media Equation involves a "person corresponding unconsciously and socially in treatment of an object" [9]. This suggests that a user can treat an object in the same way as treating a person.

An example of a study using the Media Equation is "Clothes Which Propose Fashion Coordinate Based on the Previous Experience" [10]. The current study uses this theory in aiming to aid knowledge transfer.

B. *System Approach*

This system attempts to rectify problems in the previous research through the "Media Equation". In addition, we propose a framework to help the user gain knowledge with the same feeling as when the user works with a real person. A method in which a plant pot provides information while talking to the user during agricultural work, in particular, is used. This results in the user feeling that they are working together with another person, because the plant pot provides a form of communication. In addition, the user can act according to the information provided by the plant pot. Thus, the user can learn know-how from the plant pot and do the agricultural work at the same time. Moreover, the plant pot provides information based on the agricultural work. Thus, the user can acquire knowledge about "unnoticed failure experiences". Figure 4 illustrates the concept of this system.

Figure 4. Image of the proposed system.

C. *System Flow*

The proposed system is based on the approach written in the preceding section. The system flow is described below.

i. Acquires basic data of the cultivation situation and the details of agricultural work by using various sensors.
ii. Stores the basic data as the cultivation history of a novice agriculture worker.
iii. Compares the cultivation history of the novice agriculture worker and the registered expert agriculture workers.
iv. Based on this comparison, detects wrong or problematic cultivation methodology and stores these as rules.
v. Monitors agricultural work by the novice agriculture worker based on these rules.
vi. If problematic behavior is detected, the plant pot communicates this to the worker based on the relevant rule.
vii. Repeats "i" to "vi" processes.

Figure 5 shows the composition of this system.

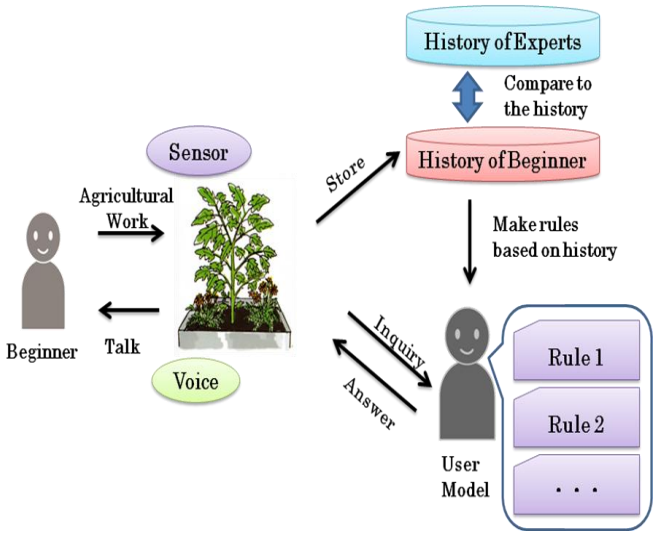

Figure 5. Composition of the proposed system.

V. PROTOTYPE SYSTEM

A prototype system is currently under development according to the system flow described above. The prototype system focuses especially on watering. Watering crops is an essential part of agricultural work. In addition, it tends to rely on personal experience and almost all manuals fail to specify precise quantities of water. Thus, the act of watering contains many kinds of failure experiences that agricultural workers do not notice.

A. *Data Acquisition Method*

In the prototype system, 3 kinds of data relating to watering are obtained.

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i. Watering quantity
ii. Watering interval
iii. Watering date and time

Sensors are used to obtain these data. In the case of "i", the system uses the weight sensor to measure the weight of the plant pot. Then, it compares the weight before watering and after watering. Thus, the system can obtain the data relating to the quantity of watering.

In the case of "ii", the system uses the soil moisture sensor to measure the degree of soil moisture. Thus, the system can obtain the data relating to the interval of watering.

In the case of "iii", the system connects to the network and obtains the date and time of watering.

B. Rule Construction

This system uses the "MT method" [11] to construct rules. The MT method is used to determine tendencies such as, for example, whether a person has a propensity to cancer or not. Using this method, the system determines whether the agricultural work will fail or not. In the prototype system, we used 4 kinds of data relationship: "water quantity and temperature", "water quantity and soil moisture", "water quantity and temperature difference from previous day" and "water quantity and soil moisture difference from previous day". The flow of the rule construction is described below. This is based on the relationship of "water quantity and temperature" and sample data relating to watering.

i. Determine the central point of the unit space consisting of the experts' data of water quantity and temperature.
ii. Divide into 4 groups (A,B,C,D) based on the central point, classify the novice worker's data (X).
iii. Determine the distance (R) from the central point of the experts' data to the novice's data.
iv. Construct rule based on the classified group and the distance. In this example, Rule 4 will be made.

Figure 6 shows an example of the central point of the data relating to water quantity and temperature, Figure 7 shows an example of classified novice's data based on the central point, Figure 8 shows an example of the distance from the central point to the novice's data and Table 1 shows an example of rules relating to water quantity and temperature.

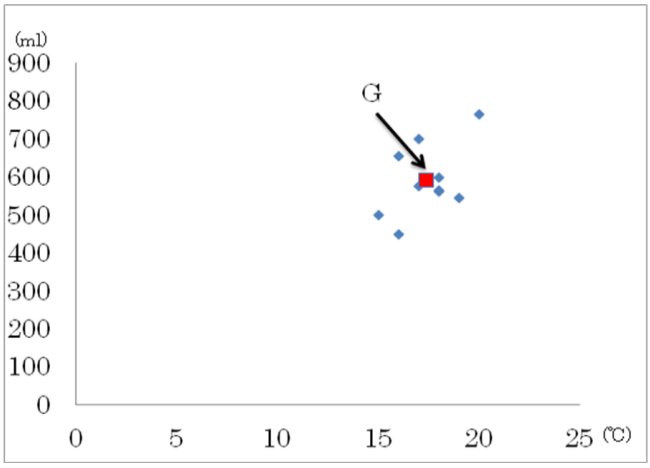

Figure 6. Example of the central point of the data relating to water quantity and temperature.

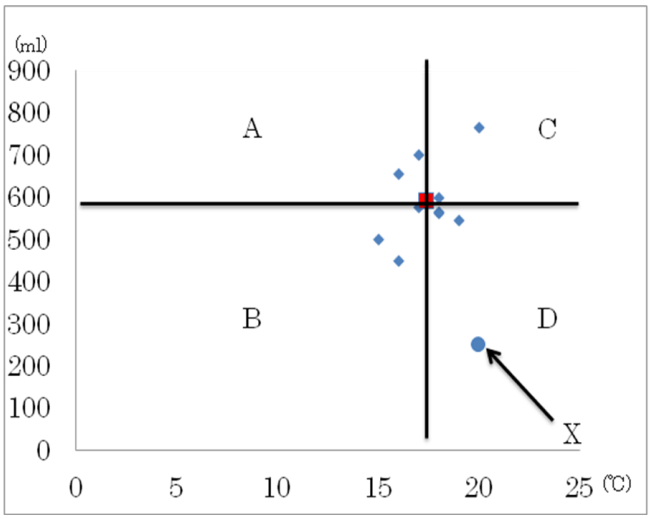

Figure 7. Example of classified novice's data based on the central point.

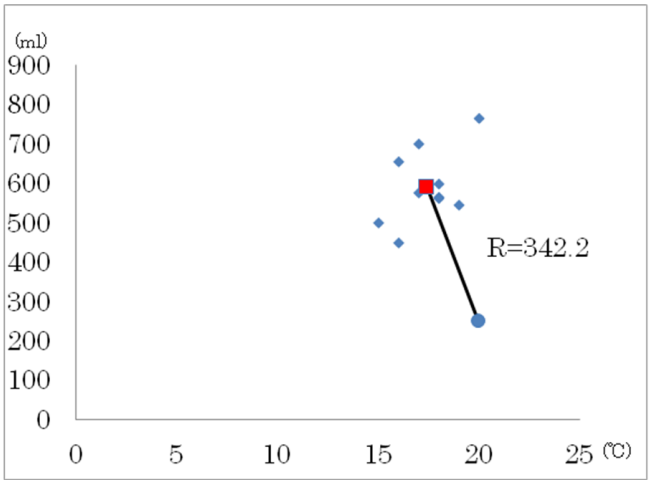

Figure 8. Example of the distance from the central point to the novice's data.

TABLE IV. EXAMPLE OF RULES RELATING TO WATER QUANTITY AND TEMPERATURE

If (group=A and R>300)
Then make Rule 1
"Higher quantity of water when temperature is low"

If (group=B and R>300)
Then make Rule 2
"Lower quantity of water when temperature is low"

If (group=C and R>300)
Then make Rule 3
"Higher quantity of water when temperature is high"

If (group=D and R>300)
Then make Rule 4
"Lower quantity of water when temperature is high"

The system constructs rules according to these algorithms. Rules made by the system are based on the novice's agricultural work. In addition, the rules contain knowledge about "unnoticed failure experiences". Thus, even if the novice does not notice a problematic behavior, the system would make and store the rule automatically and communicate to the novice. Finally, the novice can obtain knowledge about "unnoticed failure experiences" by communicating with the plant pot based on the rule.

VI. CONCLUSION AND FUTURE WORK

In this paper, we have proposed a framework to help the transfer of agricultural knowledge via communication with plant pots, which stores the data of expert agricultural workers. The next step will be to conduct evaluation on the use of these data and on the prototype system. In this evaluation, we will compare the watering data of the novice worker with and without using the prototype system. We will then confirm whether the distance from the central point of the experts' data to the novice's data is shorter when using the system. By using this method, we will be able to confirm the efficiency of the prototype system.

REFERENCES

[1] Miyajima, S., Zukai 2007 nen mondai no subete ga wakaru (Understand all the issues of 2007). Gijutsu-Hyohron Co., Ltd. Tokyo, Japan. 2006.

[2] Ministry of Agriculture, Forestry and Fisheries of Japan, The 84TH Statistical Yearbook of Ministry of Agriculture, Forestry and Fisheries 2008-2009.
http://www.maff.go.jp/e/tokei/kikaku/nenji_e/other/n045.xls
[retrieved: 11, 2012]

[3] Ministry of Agriculture, Forestry and Fisheries of Japan, The 85TH Statistical Yearbook of Ministry of Agriculture, Forestry and Fisheries 2009-2010.
http://www.maff.go.jp/e/tokei/kikaku/other/n045.xls
[retrieved: 11, 2012]

[4] Nonaka, I and Takeuchi, H., *The Knowledge Creating Company*. Oxford University Press, Oxford, England. 1995.

[5] Polanyi, M., *The Tacit Dimension*. University of Chicago Press, Chicago, USA. 1967.

[6] Hori, M., et al., Cloud Computing Applied for Agriculture and Other Fields. *Magazine of Fujitsu*. 2010, vol61, no3, pp. 314-320.

[7] Kawakami, A., et al., PotPet: Pet-like Flowerpot Robot. *73th Information Processing Society of Japan*. Tokyo, Japan. 2011, 1W-6.

[8] Isoe, Y and Nakatani, Y., Knowledge Transfer in Agriculture based on Failure Experiences. *73th Information Processing Society of Japan.* Tokyo, Japan. 2011, 6R-7, vol. 4, pp. 881-882.

[9] Reeves, B and Nass, C., *The Media Equation, How People Treat Computers, Television, and New Media Like Real People and Places*, University of Chicago Press. 1996.

[10] Fukuda, M and Nakatani, Y., Clothes Which Propose Fashion Coordinate Based on the Previous Experience. *73th Information Processing Society of Japan.* Tokyo, Japan. 2011, 2ZA-8, vol. 4, pp. 881-882

[11] Taguchi, G and Kanetaka, T., *MT system ni okeru gijutsu kaihatsu (Developing technologies in the MT system).* Japan Standards Association, Japan. 2002

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A Route Recommendation System in Disaster-Struck Areas with Consideration for Preferences of Affected Drivers

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***Abstract*— This paper proposes a route recommendation system in disaster-struck areas with consideration for the preferences of affected drivers. Although routes to a destination and traffic information such as congestion can be obtained easily, there are routes which disaster victims will wish to avoid. For example, when a tsunami warning has been made, it is necessary to avoid routes near the sea, and to take a safe route which is higher in elevation than the height of the tsunami. Accordingly, our proposed system searches for routes in consideration of the psychology of affected drivers. By searching for an appropriate route for affected drivers, it is expected that smooth road traffic can become a reality without causing road congestion.**

Keywords- traffic information; disaster prevention; route recommendation; navigation system

I. INTRODUCTION

This paper proposes a route recommendation system for disaster situations with consideration for the preferences of victims. There are routes which disaster victims will wish to avoid. For example, when a tsunami warning has been made, it is necessary to avoid routes near the sea, and to take a safe route which is higher in elevation than the height of the tsunami. It is possible to position this study as the field amalgamated by ITS and disaster prevention. The paper organized as follows. In this section we present the relationship between earthquakes and roads, and briefly introduces ITS. In the next section we present related work. System overview is presented in Section 3, and the results of the comparison with other systems are presented in Section 4. Section 5 presents a conclusion and future work.

A. Earthquakes and Road Traffic

Japan is a country of frequent earthquakes, with many earthquakes occurring every year. The Great Hanshin Awaji Earthquake of 1995 recorded a seismic intensity of 7.3 in Kobe, killing 6,434 people. The Great East Japan Earthquake in 2011 recorded a magnitude of 9.0. This earthquake was a plate earthquake, thus causing major damage by the resulting tsunami, which had a recorded maximum height of 15.8m in Iwate Prefecture. The disaster caused the confirmed deaths of 15,616 people, with a further 4,949 people recorded as missing. The tsunami reached 5 kilometers inland along the coastline and swept away houses, roads, railroads, bridges and even reinforced concrete buildings. Cars, large ships, and airplanes were also carried by the waves, becoming the cause of further damage to buildings.

Seismic intensity is classified as follows in Japan.

i. Seismic intensity of 1-2: the quake is perceptible by humans.
ii. Seismic intensity of 3-4: Buildings are shaken.
iii. Seismic intensity of 5-6: Buildings start collapse and landslides occur.
iv. Seismic intensity of 7+: Many buildings completely collapse and major damage occurs.

Earthquakes of a seismic intensity of 5 or greater have occurred more than 100 times in Japan since the year 2000. An earthquake damages buildings, traffic networks, and lifelines. Particularly, the traffic network is often greatly damaged due to earthquakes, which prevents the delivery of relief goods.

In 2004, the Mid Niigata Prefecture Earthquake occurred, causing railways, such as the Joetsu Shinkansen line, and roads to close. Among major roads, the Hokuriku Expressway, the Kan-etsu Expressway, and National Routes 8, 17, and 116 were closed, causing the transport of goods to be suspended. However, the road network played an important role in the transport of relief goods by ensuring access to alternative routes, as shown in Figure 1[1]. In this figure, the Kan-etsu Expressway (blue line) was out of use, and two detours (red lines) were alternatively used.

The same situation was found in the Tokachi-Oki Earthquake occurred in 2003, also causing major damage by tsunami [2].

A peculiar driver psychology can be observed in disaster-struck areas. During the Great East Japan Earthquake in 2011, many drivers avoided routes near the sea in fear of being killed by the approaching tsunami. As a result, heavy traffic occurred due to the increase in cars on mountain roads where traffic is usually light.

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This paper proposes a route recommendation system in disaster-struck areas, targeting affected drivers with consideration for this kind of psychology of victims.

Figure 1. Ensuring alternative routes (map data provided by Yahoo Maps)

B. *Intelligent Transport Systems : ITS*

ITS have the purpose of improving the efficiency, safety and serviceability of automobile traffic. As ITS technology progresses, many benefits can be obtained in various areas. Among these, the field of automotive navigation systems is notable. Automotive navigation systems provide traffic information containing traffic congestion information, and search for the most suitable route to the destination. Such technology is already a feature of many people's daily lives.

However, there are only a few opportunities to apply this technology to traffic problems in disaster situations. These support by ITS elicit an effect to solve the problem in unusual situation. In the next section, such trials are introduced and problems to be solved about road traffic in disaster-struck areas are revealed.

II. RELATED WORK

Various studies have been conducted on navigation systems. Especially, the NAVITIME and MapFanWeb systems are very famous in Japan for providing traffic updates, enabling drivers to get the route to their destination easily. NAVITIME provided by NAVITIME JAPAN is the Total Navigation solution that allows users to plan travel routes from various transportation methods - including trains, subways, buses and taxis. MapFanWeb is same services, map retrieval, route research, transfer guidance.

These services, however, are useful in everyday use and special functions are required in disaster situations.

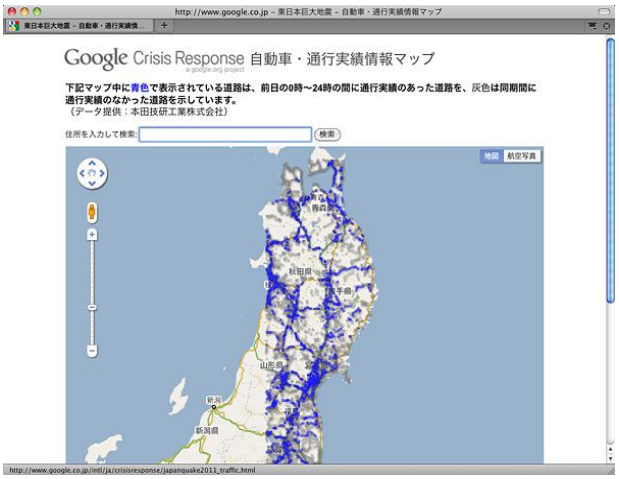

Figure 2. Google's Map of Automobile Traffic Performance

A. *Map of Automobile Traffic Performance*

Google provided maps of Automobile Traffic Performance during the 2011 earthquake and tsunami disaster [3] (Figure 2). Using these maps, many drivers were able to travel easily in the disaster area. This service displays roads which were accessible between 0:00 and 24:00 of the previous day in blue, and roads which were inaccessible during the same time period in gray. The service is renewed every 24 hours.

B. *Probe Car System*

Probe car systems, which regard individual vehicles as moving sensors and provide traffic, weather information, etc. generated from vehicles, are attracting much attention. Among the systems realized are primarily probe traffic congestion information systems based on vehicle positions, time stamps, etc. [4]. For example, such systems can obtain local weather information from combination of the GPS data and activation of windshield wipers. These systems are also able to get traffic congestion information by using the information of the car's speed. While having the advantage of collecting local data, probe car systems have the disadvantage of only being able to collect data when the car is actually running.

C. *Route Preference During Disasters*

Figure 3 shows a map of Tagajo, Miyagi Prefecture, which was hit by the tsunami in the Great East Japan Earthquake of 2011. National Route 45 and Prefectural Roads 23 and 10, principle roads in Miyagi, all became inaccessible due to tsunami damage (circled in red on Figure 3). These roads were restored after one month, but many drivers, afraid of further tsunami damage, continued to take the Rifu Bypass Highway (circled in blue on Figure 3) which is 3 kilometers inland instead of the coastal roads. As

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a result, major traffic congestion occurred on the highway due to the increase in cars.

Figure 3. Map of Tagajo (map data provided by Google Maps)

Even when drivers in disaster situations use navigation systems to search for their destination, navigation cannot fulfill its role, if there are roads rendered inaccessible by damage. Thus, it is expected that the drivers in the disaster situations uses the navigation systems by combining the information about road condition they know. To solve this problem, in this paper, we propose a navigation system that reflects the results of road condition detection. Furthermore, the system recommends roads based on the psychological analysis of drivers in disaster situations. That is, roads which is preferred by the drivers are predicted by the systems and proposed to the drivers.

III. SYSTEM OVERVIEW

This study proposes a navigation system which combines the results of road condition detection.

A. *Fundamental Policy of Proposed System*

i. Ignore inaccessible roads when searching for the route to destination.

Ordinarily, when a route to destination is searched for in a navigation system, it recommends the route in consideration of shortest journey time and traffic conditions, but this is for non-disaster situations. In fact, there is no guarantee that the roads can be used normally after a disaster. Maps of performance of automobile traffic display such information, as stated above. In this study, the proposed system searches for the route to a destination containing no inaccessible roads.

ii. Recommend appropriate routes according to the type of disaster.

There are various types of disaster (landslides, tsunami, floods, etc.), and drivers may need to use different roads according to the type of disaster. For example, when a landslide occurs, this system displays safe roads, ignoring roads near mountains and other places where landslides are likely to happen. When a tsunami occurs, this system displays safe roads which are higher in elevation than the predicted height of the tsunami. Thus, this system selects the route in consideration of elevation and distance from the sea and mountains. Because of this, it is expected that the driver can arrive to the destination safety. Further, if there are any roads that the driver does not want to take, the system can search for the route after the driver has deselected such roads.

iii. Display the optimal alternative route for the driver

If all drivers take the route recommended by the system to avoid the tsunami, too many cars will concentrate on the road and there will be danger of traffic congestion. However, traffic congestion must be avoided in order to ensure smooth access for emergency vehicles. Therefore, it is necessary to propose a route which enables emergency vehicles to arrive at their destination safely, and as quickly as possible.

Also, as cars exist in different sizes (large, medium, and small), in order for each size to drive safely, it is important to ensure sufficient road width in the route to the destination. For example, when the system proposes a safe road to drivers of large cars, they may not be able to pass if the road is too narrow, which would waste time unnecessarily. Thus, avoidance of traffic congestion and realization of smooth road traffic can be attained by proposing the optimal route separately to drivers of each size of vehicle.

B. *Use of Floating Car Data*

Floating car data are driving data used by the Internavi-a Floating Car System provided by the Honda Motor Company to drivers in Japan [5]. Internavi recommends routes and allows display of the newest road information by using detailed road information from cars equipped with the system, in addition to information about trunk roads and highways via VICS. Furthermore, it is possible to generate traffic information from floating car data. It can be expected that smooth road traffic which avoids congestion can be realized by using floating car data.

C. *Details of System*

The proposed system is implemented in a Windows environment, using Java as the development language and JavaScript to display the route on a map (provided by Google Maps). Although the system can be applied to any location, we used the area shown in Figure 4 as a model area to investigate the necessary functions of the system.

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We can retrieve the route to the destination in the target area. In this system, the user selects a point of departure, destination, and the disaster (tsunami, landslide, or flood) that the user needs to avoid, and the system proposes the optimal route in consideration of these terms.

For example, if the selected disaster is a tsunami, the system will propose a route which has sufficient distance from the coastline. To be specific, the system targets routes which are predicted not to be damaged by the tsunami on the hazard map provided by the Ministry of Land, Infrastructure, Transport and Tourism. Furthermore, the system proposes the shortest route among the roads unaffected by tsunami, because if the proposed route is too far from the coastline, the driver will take too much time.

The information related to the proposed route is recorded as XML data, and the system displays the safe route on a Google Map based on this XML data.

If there are any roads that the user wants to avoid, the system will propose a route excluding these. For example, the system proposes a route which will not be affected by tsunami according to the hazard map, but the user is worried that this road may be dangerous. In such cases, the user can deselect the route they do not want to use, and search for the route again in consideration of this.

Figure 4. Target area, Yokkaichi. (map data provided by Google Maps)

All intersections within the target area are assigned a number, and the road is modeled as connecting these intersections. Suppose the target area in Figure 5, composed of 5 intersections and 5 roads. Intersection 2 is linked to Intersections 1 and 3. Each intersection has data of the longitude and latitude. The intersections where cars can pass safely are recorded as XML data.

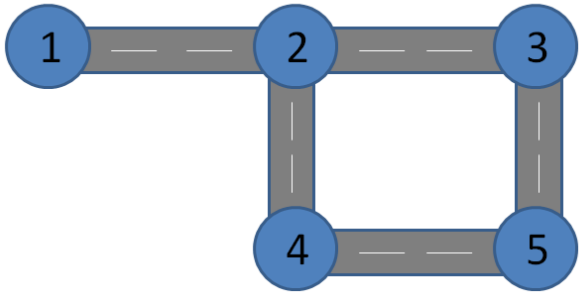

Figure 5. Example of road formation.

This system consists of 5 Java classes. XML data is produced by executing these, and displayed on a Google Map using JavaScript. A diagram of the system process is shown in Figure 6.

D. *System Target Area*

Although the proposed system can target any area, in the evaluation of this paper, we targets part of Yokkaichi, Mie Prefecture, as follows. The area is 7 kilometers from north to south, where north is the point where National Route 23 and a Prefectural Road 502 cross, and south is the point where National Route 23 and Prefectural Road 401 cross. This system targets national roads and prefectural roads in this area, shown in yellow on Figure 4.

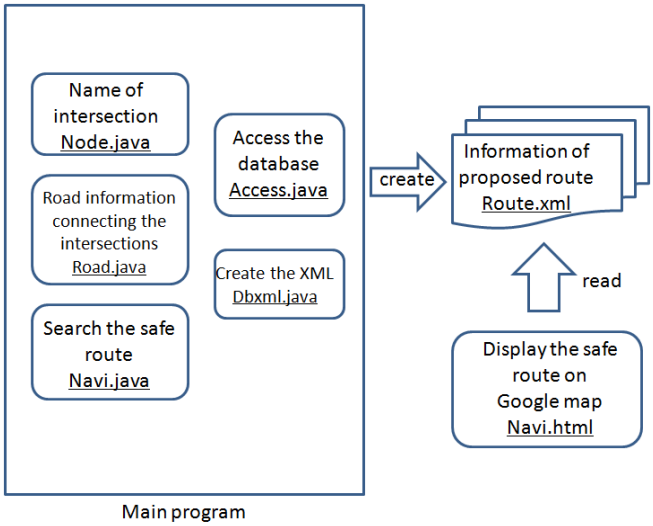

Figure 6. System process.

Tokai, Tonankai, and Nankai earthquakes occur periodically every 100-150 years, so it is predicted that one will strike without fail in the first half of this century. Regarding the Tokai earthquake, it it possible that one may happen at any moment, as none have occurred since 1854. Furthermore, these earthquakes have often occurred at the same time or in close succession. There are predictions of major damage due to these earthquakes in Yokkaichi. This

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area has the sea in the east, so there is a danger of tsunami damage similar to the Great East Japan Earthquake.

IV. RESULTS OF COMPARISON WITH OTHER SYSTEMS

A. *Results of Each Navigation System*

The same departure and destination were set in NAVITIME, MapFanWeb, and the proposed system. Figure 7 shows the route recommendation results by these systems. A recommendation result by NAVITIME is indicated in blue, MapFanWeb in red, and the proposed system in green. NAVITIME and MapFanWeb recommended National Route 23, along the sea, while the proposed system selected National Route 1, which is further inland than National Route 23.

Figure 7. Recommendation results (map data provided by Google Maps).

B. *Comparision with Hazard Map*

A hazard map is a map that highlights areas that are affected by or vulnerable to a particular hazard. They are typically created for natural hazards such as earthquakes, volcano eruptions, landslides, flooding, and tsunami. Hazard maps help prevent serious damage and deaths, and help victims to take refuge quickly and precisely. Figure 8 shows a hazard map of Yokkaichi [6]. This map data provided by the Ministry of Land, Infrastructure, Transport and Tourism.

Figure 8. Hazard map of Yokkaichi(map data provided by the Ministry of Land, Infrastructure, Transport and Tourism)

The proposed route of NAVITIME and MapFanWeb passed through the area which is colored yellow on the hazard map. This area will be affected by tsunami. However, one of our system only passes the uncolored area, so it may be said that drivers will be more likely to reach their destination safely in comparison to the other recommended routes.

National Route 1 is recommended as an alternative route instead of National Route 23, in the route proposed by our system.

When the authors confirmed our system's recommendation with a student from Yokkaichi, we were told that National Route 1 has two lanes each way and a wide lane, meaning it will be easy to drive, so it is no problem as an alternative route. However it is prone to heavy traffic on a routine basis, so if traffic from National Route 23 is diverted to National Route 1, it has the potential to cause a traffic jam. Thus, we received advice that our system should disperse cars to several other safe roads.

V. CONCLUSION AND FUTURE WORK

In this paper, we proposed a route recommendation system for disaster situations which considers the preferences of victims. We demonstrated the effectiveness of our system, which proposes a safe alternative route, avoiding places known to be dangerous according to a hazard map.

The proposed system uses a hazard map provided by the Ministry of Land, Infrastructure, Transport and Tourism to target roads which will not be affected by disasters. However it is not always true that the effects of a disaster will spread exactly as indicated on a hazard map. Accordingly, some effects may occur in places which are predicted not to be affected on the hazard map after an

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actual disaster. In order to avoid such problems, a system which constantly renews information relating to traffic flow, as in Google's map of performance of automobile traffic described above, will be necessary.

In additional, the proposed system does not consider the amount of traffic, including traffic jams, that will be generated by diverting a large number of cars to alternative routes. Thus, there is a possibility that traffic jams will occur if all drivers take the route recommended by this system. Therefore, an area for improvement would be to ensure that the system recommends the route in response to the amount of traffic, and attempts to avoid traffic jams.

In the future, we aim to improve the system so that it can recommend a route in consideration of the amount of real-time traffic, and renew real-time road information regarding routes which have recently become inaccessible due to disaster or construction works.

REFERENCES

[1] Y. Kumagai, J. Y. Choe, and T. Nakano, "Road communication at the time of disaster", 2005, Prevention Times 220, pp. 64-69.

[2] Y. Tanioka, Y. Nishimura, K.Hirakawa, F. Imamura, I. Abe, Y. Abe, K. Shindou, H. Matsutomi, T. Takahashi, K. Imai, K. Harada, Y. Namegawa, Y. Hasegawa, Y. Hayashi, F. Nanayama, T. Kamataki, Y. Kawata, Y. Fukasawa, S. Koshimura, Y.Hada, Y. Azumai, K. Hirata, A. Kamikawa, A. Yoshikawa, T. Shiga, M.Kobayashi, and S. Masaka,

"Tsunami run-up heights of the 2003 Tokachi-oki earthquake", Earty Planets Space, 56, pp. 359-365, 2004.

[3] Map of performance of automobile traffic, provided by Google Crisis Response.

http://www.google.com/intl/ja/crisisresponse/japanquake2011_traffic.html Accessed on 2012/7/4

[4] Y. Hada, T. Suzuki, H. Shimora, K. Meguro, and N. Kodama, "Issues and Future Prospect on Practical Use of Probe Vehicle Data for Disaster Reduction: Provision of the Vehicle Tracking Map in the 2007 Niigataken Chuetsu-oki Earthquake," 2nd Ed.,Vol. 9. (Special Edition) pp.148-159.

[5] Probe-Car Information System ITS Center, Japan Automobile Research Institute

http://www.jari.or.jp/resource/pdf/research-testing/kenkyu3_03.pdf Accessed on 2012/7/4

[6] Hazard map of Yokkaichi, the Ministry of Land, Infrastructure, Transport and Tourism. http://bousai2.city.yokkaichi.mie.jp/home/02_hazard_map_hinanjyo/01_hazard_map/pdf/0402.pdf Accessed on 2012/7/4

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A Sightseeing Navigation System without Route Information

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***Abstract*—A novel sightseeing navigation system that does not show route information is proposed. Most existing navigation systems support efficient sightseeing by giving users the detailed route information such as the shortest route. However, casual sightseeing by foot in which tourists can freely choose time and place is a major trend in Japanese tourism in recent years. Therefore, a sightseeing navigation system that does not show a map was designed, based on the "Benefit of Inconvenience," which is the novel concept that inconvenient things can have a positive effect on people. This approach is expected to prompt users to interact with their surrounding environment. Two evaluation experiments were conducted in Kyoto, and it was proved that the proposed method can increase opportunities for new discoveries and chance encounters during sightseeing.**

Keywords-Navigation System; Benefit of Inconvenience; Landmark; Preferences.component.

I. INTRODUCTION

In the current information society, a wealth of information makes our lives comfortable and convenient. It has become natural to cut out wasted time from our lives and to demand efficiency. Moreover, various types of information device which increase efficiency have been developed or researched. In today's capitalism society, a cognizance that time is limited and it is essential for us to use it effectively is expanding widely. On the other hand, there are benefits which have been overlooked in the pursuit of efficiency. These benefits have been regarded as a minor factor in trends of recent years, but are now beginning to gain attention as the "Benefit of Inconvenience" [1]. Using a somehow inconvenient system enables the user to obtain benefits which are easily hidden, more than an existing convenient system which demands efficiency.

While the systems which are considered to have the "Benefit of Inconvenience" are gaining attention in this way, the sightseeing style of recent years is also changing. Traditionally, the package tour has been the most popular sightseeing style in Japan. The package tour is a travel product wherein the entire process, from departure to destination, is managed by a tour company. Common practice is for the tour company to determine the route and time schedule for sightseeing and then let the participants enjoy their sightseeing following the instruction of a tour guide. However, another sightseeing style has come into use significantly in recent years. This is a style wherein tourists determine the process of their sightseeing themselves and enjoy their trip without using a package tour. Ishimori [2] describes this as "autonomous tourism." In addition, "Travelers Trends 2010", published by the Japan Travel Bureau Foundation [3], calculated that the number of people who were interested in gourmet food, history, urban tourism, and strolling had increased by 10% in 2009 compared to 2007. All these factors indicate that tourists expand their interest to various things and want experiences of various types. Therefore, just as Ishimori points out, the sightseeing style in Japan is changing from moving efficiently along a predetermined route to freely visiting places of interest anywhere, anytime. Tourists are looking for new discoveries and chance encounters.

However, most sightseeing navigation systems used by tourists during sightseeing are adapting the algorithms used in car navigation systems. These navigation systems recommend the shortest route and methods of transport from a departure place to a destination, and attach a high value to the efficiency of user movement. For example, NAVITIME [4] is a famous application. This enables users to go to their destination in the shortest time without getting lost the way. In fact, an efficient sightseeing route scheduled by a navigation system is an effective way for people who do not have much time. However, considering the recent sightseeing trends in Japanese, such methods are not effective for increasing number of tourists who demand fun and memorable sightseeing, even if they need to spend a little more time. Emphasis on efficiency will restrict the user's area of activity and opportunities for new discoveries and chance encounters that may happen during sightseeing. A new approach is required to support tourists for enjoying their sightseeing opportunistically and fortuitously.

This paper proposes a novel approach to sightseeing support which targets tourists who are carrying out casual sightseeing on foot. More concretely, adapting the idea of "Benefit of Inconvenience", the proposed system does not provide the detailed route information in a sightseeing area but only landmarks on the way to a destination. As a result, it promotes interaction with the environment surrounding the users which was previously unnoticed, and fosters new discoveries and chance encounters. In this research, two evaluation experiments were conducted with two types of prototype system.

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In the next section, the proposed method is described. In Section 3, we present the evaluation experiment, then the problem of the proposed method. Then this paper moves to another proposed method, and its evaluation experiment. Finally, a discussion and a conclusion are described.

II. PROPOSED METHOD 1

A. *Skil-tronics*

The concept of skil-tronics exists in the field of "Benefit of Inconvenience". This is a system design model proposed by Nishino [5] that requires some skills from its users in order to use the designed equipment. The proposal of skil-tronics does not compensate for high-technology by skill or extend skill by high-technology, but prompts creation by the combination of high-technology and skill. Therefore, users are able to gain benefit by manipulating on their own skill instead of relying on a machine to do everything.

Our proposed sightseeing navigation system is innovated by utilizing the concepts of skil-tronics and "Benefit of Inconvenience."

B. *Proposed Method*

1. Without Route Information

The proposed sightseeing navigation system does not provide users with the detailed route information but with a point of departure, a destination and landmarks on the way. Therefore, users are not able to see the route or the city district. In this way, their attention is naturally drawn to their surrounding environment.

Cases in which users get lost may happen, because the system does not show a map. However, they look around themselves more than usual when they get lost. As a result, they are able to experience a special kind of sightseeing which is different from existing navigation systems which suggest the shortest route. In response to this system, they are prompted to pay attention to their surrounding environment, and it can be expected that opportunities for new discovery and chance encounters will increase during their casual walking sightseeing.

2. Guidance to Landmarks Using Photos

This system shows landmarks of some points on the way to a destination. Each landmark is given a landmark number (1-6), a landmark name and a photo. The landmarks involve alleyways, historic buildings, distinguishing objects and so on. The users stroll around looking for them in numerical order and reach the destination. Moreover, some landmarks are located in hard-to-find places, and some pictures were taken from the opposite side of the traveling direction. These are contrivances designed to entertain the users.

C. *System Fuctions*

The proposed system is an application for Apple Inc.'s iPhone, written in a programming language Objective-C. It is equipped with the Global Positioning System (GPS) and users are able to use it anytime, anywhere. Fig. 1 shows the main screen of the system. Users embark on casual walking sightseeing while relying on this screen. The pins on the screen indicate the landmarks predetermined by this system.

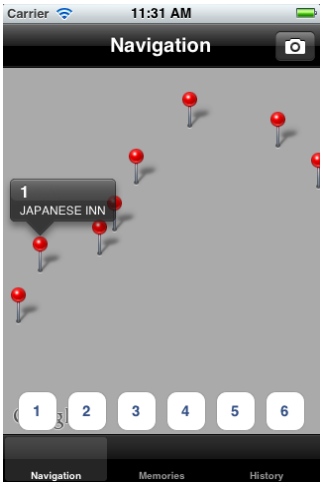

Figure 1. System Main Screen

Figure 2. History Screen

The numbered buttons on the bottom part of the screen are linked with the landmark number. When the users tap the numbered button, the landmark designated with that number is shown on the main screen.

In addition, this system has the functions of taking and recording photos, using the camera mounted on the iPhone. Users can use these functions by tapping the camera button on the upper right of the screen. By doing so, users are able to take photos of surroundings that they like during sightseeing, and then to save them with the location information which is obtained from GPS (Global Positioning System). They are called "Memories of Sightseeing." Moreover, this system has the function of recording the user's traveling history. This is called "History of Sightseeing." (Fig. 2).

By using these two functions, users are able to review their data after casual walking sightseeing, and reflect on their sightseeing easily.

III. EVALUATION EXPERIMENT 1

A. *Experiment Method*

An evaluation experiment with 8 human evaluators was conducted in order to verify the effectiveness of this navigation system. The experiment was conducted with Kyoto as the experiment area, and subjects strolled from Kyoto station to Kiyomizu-dera temple. The reasons why Kyoto was chosen as the evaluation experiment area are given below. The experiment was carried out in January 2011.

1. The area is suitable for casual sightseeing by foot, because there are various famous spots including historical places, cultural places and so on.
2. Tourists are able to enjoy the streetscape of Kyoto, which has many Japanese old-style houses along with narrow and winding alleyways.

The evaluators in the experiment were 4 men and 4 women in their twenties who live in the Kansai area. They were assigned randomly to three groups without considering

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their gender, age, previous experience of sightseeing in Kyoto, and so on.

The evaluators were asked to answer two types of questionnaire in order to gather evaluation data on the usefulness of the system.

1. Questionnaire before the experiment

The purpose of this questionnaire was to investigate the evaluators' attributes. The specific contents were their gender, number of previous sightseeing trips in Kyoto, whether they had previously experienced walking to Kiyomizu-dera from Kyoto Station, and the purpose of their usual sightseeing.

2. Questionnaire after the experiment

The purpose of this questionnaire was to inquire into the evaluators' opinions and reflect on this experiment. During the questionnaire, they used the "Memories of Sightseeing" and "History of Sightseeing" functions for reference.

B. Results by Group

Group A: This group got lost frequently. Therefore, they were not able to find one of the landmarks. A key factor for this was assumed that the system does not show detailed route information. Indeed, the evaluators in Group A explained in the questionnaire after the experiment that "it was difficult for us because we did not know our current position." On the other hand, they described that "the opportunity to take small roads rather than taking the main street increased. As a result, we were able to enjoy a townscape of Kyoto that we usually do not experience." Therefore, Group A was able to make a new discovery and chance encounter.

Group B: This group's evaluators commented that "we had a conversation different from the usual kind during sightseeing." A factor in this was that since this system did not show the map, they frequently consulted each other about how to reach the destination.

Group C: This group paid close attention to their surrounding environment by looking at the landmark photos. As a result, they answered that they "felt like detectives." In addition, they happened to visit a temple that they had never known about before.

Fig. 3 shows the required time for each group. Google Maps calculates a walking time of 40 minutes from Kyoto Station to Kiyomizu-dera. So they took double to three times longer.

C. Validity of Not Displaing Route Information

From the questionnaire after the experiment, the gaze of the evaluators was raised and they paid more attention to their surroundings by not showing route information. In addition, they answered that they were able to find some spots which they had never known about, and they took rarely-used routes. From these results, it was verified that not showing the detailed route information induced opportunities for new discoveries and chance encounters. This is also an effect of the "Benefit of Inconvenience."

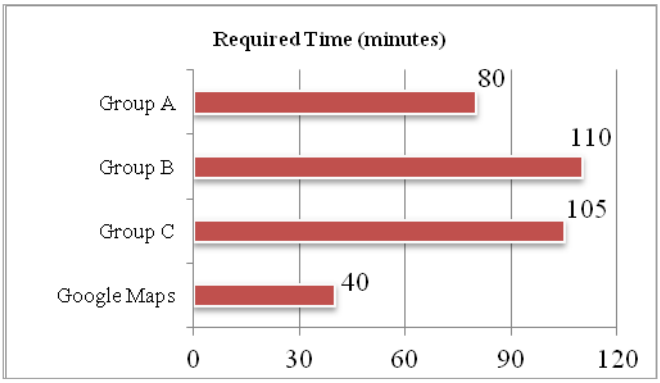

Figure 3. Required Time of Experiment 1 by Group

D. Differences from Existing Navigation System

In answer to the question "How did you enjoy this sightseeing trip compare to the usual?" all evaluators replied that they had enjoyed it. One of the evaluators told us: "I usually consider getting to the destination in the shortest time when I do ordinary sightseeing. But, this system made me enjoy the spots on the way, and they stood out in my memory strongly." Thus, the effectiveness of our proposal for a new sightseeing navigation system was verified.

IV. PROBLEMS

From the results of the evaluation experiment, opportunities for new discoveries and chance encounters were increased by not showing the detailed route information. This trip, however, was not a completely free trip. The landmarks had been predetermined by the system and evaluators were not able to select the landmarks which they wanted to visit. Therefore, the three evaluator groups followed almost the same route. This suggests a major problem that users are not able to visit spots of interest freely anywhere, anytime, which is the main concept of casual walking sightseeing. In fact, some evaluators remarked that "the landmarks which we visited were not attractive for me" in the questionnaire after the experiment.

On the other hand, evaluators answered that they enjoyed looking for the landmarks, as if they were doing "orienteering." Key factors accounting for this are that the system's navigating method is completely different from that of existing systems, and that they felt a game element in which they cooperate to look for the landmarks. However, one group lost their way because the clue to find the landmark exists only in photos. Therefore, they were not able to find one of the landmarks, and that caused a point of dissatisfaction with the system.

In addition, some subjects answered that they had wanted to visit famous spots in Kyoto. Therefore, it is important for the system to recommend not only spots on the way to the destination, but also some famous sights. This relates to the fact that they were not able to select their preferred landmarks.

In the next section, a second sightseeing navigation system is proposed in order to resolve these problems.

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V. PROPOSED METHOD 2

A. Approach

The second sightseeing system has a function to recommend the landmarks which are considered preferences of users (tourists who are carrying out casual sightseeing by foot) in order to resolve the problems of the previous system, in which the users were not able to select the landmarks they like and sometimes got lost. This new system will allow the users to experience a different, personalized route. As before, it does not provide detailed route information, since not showing the map was proven to be effective by the experiment on the first system. However, this system has added improvements. The detail of two new functions is described below.

B. Landmark Recommendation Based on Personal Preferences

The degree of enjoyment of sightseeing depends on how much the tour experience differs from everyday life, and how much it coincides with the interests of the tourist [6]. Therefore, the purposes of sightseeing vary greatly from person to person. The first system, however, predetermined the landmarks which are recommended to users. Therefore, the users were not able to select the landmarks that they wanted to visit. To solve these problems, the new system recommends plural landmarks to the users during the casual walking sightseeing based on personal preferences. To consider personal preferences is megatrend in a recommendation system. For example, Amazon [7] is known to collaborative filtering and it has proved effective [8, 9]. Personal preferences in the second system are grouped into three kinds: "Landscape," "History" and "Gourmet Food and Shopping." Users select the preference that coincides with their preference on the welcome screen of this system.

C. Navigation Using Direction Information

When people are casually sightseeing by foot in an unfamiliar city, they generally feel anxious or excited because they cannot know what lies ahead on the road. This factor is the "difficulty of prediction" [6]. If this acts on people's psychological state, a feeling of anxiousness of not knowing what will happen next induces a feeling of expectation. Ultimately, it remains strong in the memory even after the issue is solved.

The second proposed navigation system uses information relating to current position, direction, distance, and photos of landmarks based on the preferences of users, which are recommended automatically by the system. It does not provide users with the detailed routes to destinations, in common with the first system. This concept is also based on the "Benefit of Inconvenience." By hiding information in this way, users feel anxious or excited, which results in being even more satisfied with the sightseeing experience. Furthermore, afterwards the experience becomes a good memory.

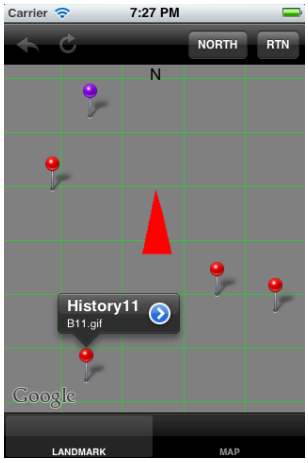

Figure 4. New System Main Screen Figure 5. New System Photo Screen

D. Function of Second System

The improved system also uses Apple Inc.'s iPhone and the development language is Objective-C. The iPhone is used for the same reasons as stated for the first system.

First, the user is asked to input a destination and the purpose of the tour, with choices selectable from among "Landscape," "History" and "Gourmet Food and Shopping" on the welcome screen of the system. The purpose is to consider the preference of the user. Then the system recommends to the user four or five landmarks that match their preferences, near to their current position (within 300 meters). These landmarks include at least one landmark that does not match the user's purpose, for the sake of variety of landmarks. The user selects one of the proposed landmarks based on their photos and other information, and walks around the city to find it.

Fig. 4 shows the main screen of the second system. This improved system recommends four or five landmarks in addition to not showing route information, so that the user can select the landmark which they want to visit. Those landmarks are based on the user's personal preferences.

The arrow in the center of Fig. 4 is an electronic compass that constantly points to the north. It appears when the user taps the "NORTH" button shown in Fig. 4. The user checks the direction to the landmarks in a method that is similar to using a magnetic compass, and recognizes the approximate direction to get there.

Fig. 5 shows landmark photo information. These photos were taken in advance using the iPhone camera. In addition, they were chosen as being attractive landscapes or historic buildings on the basis of our subjective viewpoint. Finally, the information is saved in the landmark database as one set comprised of the photographic information, location, and genre of preferences.

In addition, the second system has the function of updating landmarks. When the system detects that a user has entered within a 30 meter radius of a recommended landmark, the user can update the landmarks. When the user updates the landmarks, a new set of four or five landmarks in that area are recommended to the user. At that time, the current position is set as the updated landmark.

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VI. EVALUATION EXPERIMENT 2

A. Experiment Method

A second evaluation experiment was carried out in Higashiyama, Kyoto. The point of departure was Kyoto City Hall and the destination was Yasaka Shrine. The reasons why this area was chosen as the evaluation experiment area are that it is easy for tourists to understand the direction because Kyoto streets area laid out in a grid pattern, in addition to the reasons given for the first evaluation experiment. The experiment was carried out in January 2012.

The evaluators in the experiment were 9 people in their twenties who live in the Kansai area. They were divided into three groups on the basis of the objects of their personal preferences, and how frequently they had visited Kyoto.

In addition, they were divided in consideration of whether or not they were able to go to Yasaka Shrine from Kyoto City Hall without consulting a map. Options for the preferences were "Landscape", "History" and "Gourmet Food and Shopping." Table 1 shows the group composition of the evaluators.

The evaluators were asked to walk freely to the destination of Yasaka shrine from the departure point of Kyoto City Hall using the second navigation system. After the explanation of how to use the system and the experimental procedure, each group was provided with one iPhone equipped with the system. The experimental procedure is described below.

First, the evaluators selected one landmark from the landmarks that are recommended by this system. Then, they walked freely using the system. Finally, they arrived at the destination by repeating this procedure several times. Moreover, they were asked to answer three types of questionnaires in order to gather evaluation data on the usefulness of the system.

1. Questionnaire before the experiment
   The purpose of this questionnaire was to inquire into the evaluators' personal preferences and to divide the groups.
2. Questionnaire during the experiment
   This questionnaire was conducted each time the evaluators reached a landmark. The purpose of this questionnaire was to inquire into their opinion on the selected landmark, and reflect on the route to the landmark.
3. Questionnaire after the experiment
   The purpose of this questionnaire was to obtain feedback from the evaluators about the experiment.

TABLE I. EVALUATOR GROUP COMPOSITION

	Group A	Group B	Group C
Preference	Landscape	Gourmet food	Gourmet food
Kyoto sightseeing experience	1-2 times	More than 3 times	More than 3 times
Go without consulting map	Can	Cannot	Cannot

B. Results by Group

Group A: This group selected "Landscape" as their personal preference. It took the group an hour and a half to walk to the destination from the point of departure. The landmarks that they visited during the experiment were three in total. It is notable that they were all interested in "Landscape" at first. However, they selected different genres for landmarks.

Group B: This group selected "Gourmet Food and Shopping." It took the group an hour and forty minutes to walk to the destination. The landmarks that they visited were five in total. The notable point of Group B is that they selected the gourmet food landmarks that coincide with their preferences five times. The reason why they selected these was in a large part due to the time when the experiment was conducted (from 12:00 to 14:00).

Group C: This group used a method consisting of receiving recommendations for landmarks in all of the genres without considering their personal preferences. This was done in order to observe the effect of the personal preferences on selection of landmarks. It took the group an hour and fifty minutes to stroll to the destination, and they visited four landmarks in total. The standout point of this group is that they lost their way several times because they were not familiar with the experiment location, and because they were confused about how to use the system. On the other hand, they were able to travel via traditional Kyoto-style alleyways that are generally not passed through on the way to the landmark.

Moreover, they were able to see the famous *maiko* of Kyoto. At the end, they answered that they had a fun time.

Fig. 6 shows the required time for each group in the second experiment. Google Maps calculates a walking time of 20 minutes from Kyoto City Hall to Yasaka Shrine.

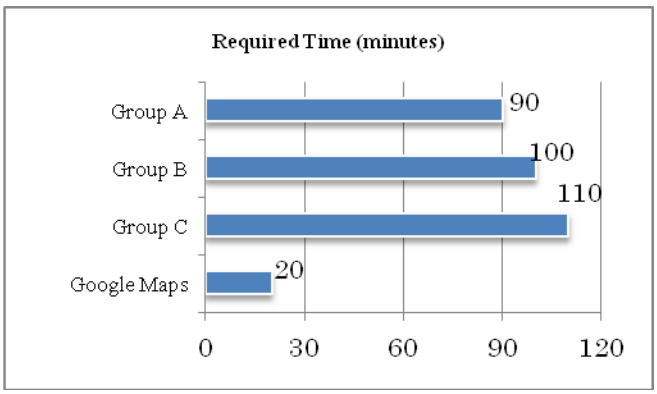

Figure 6. Required Time of Experiment 2 by Group

TABLE II. DISTANCE TO THE DESTINATION

	Group A	Group B	Group C	Sum
Near	5	6	4	15
Suitable	4	9	5	18
Far	0	0	3	3

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C. Validity of the Landmark Recommendation Based on Personal Preferences

The improved system is designed so that users are able to choose landmarks freely in order to resolve the problems of the first system. As a result, some evaluators recounted in the questionnaire after the experiment that they enjoyed the process of selecting the landmarks in consultation with each other. Moreover, although the second system recommends landmarks based on the personal preferences of the users, the evaluators mainly selected the landmarks from the perspective of whether or not the photo was attractive. Therefore, it was established that they do not select landmarks that coincide with their personal preferences, but they select the landmark with the most attractive photo. As a result, it is highly important to show "attractive photos" in order for users to select the landmark.

D. New Discovery

Evaluators were asked, "Did you feel that the distance to the landmark was 'far'?" in the questionnaire conducted during the experiment. Almost all evaluators answered "Near" or "Suitable" to this question. Table 2 shows the detailed results for that question (Subjects were asked to answer each time they visit a landmark). Regarding this, it is thought that the evaluators purposely avoided selecting landmarks that were located far away from their current position, and that they already knew the route to the landmarks because some subjects were familiar with the evaluation experiment location. This system has a function that recommends landmarks within approximately 300 meters from the current position when landmarks are updated. Therefore, the efficacy of the function that limits the range of the recommended landmarks was verified.

Next, the case in which the evaluators felt the distance to the landmark was "Far" is explained. Group C was the only group to answer "Far" in the entire experiment. The reason given by all who answered "Far" was, "because we lost our way." Reasons for Group C getting lost are suggested below.

1. They were not familiar with the experiment area.
2. They did not know how to use the system appropriately.
3. They did not pay enough attention to the landscape around them.

In other words, the landmark that they selected was not so far away, but they felt exhausted due to the extra walking time from losing their way. In addition, they felt anxiety because they did not know where the recommended landmark was. these negative effects made them feel that the distance was "Far."

VII. FUTURE WORKS

The required time to walk to Kiyomizu-dera from Kyoto Station is about 40 minutes according to the calculation of Google Maps. However, it took an average of about 90 minutes using the old system in the first experiment. Likewise, the required time to walk to Yasaka Shrine from Kyoto City Hall is about 20 minutes. However, it took over 90 minutes for all groups in the second experiment. Both systems target casual walking sightseeing, in which tourists visit anywhere, anytime. Therefore, neither of our systems take account of the sightseeing time. However, spending too much time makes users exhausted, and they might not go to the places they wanted to. Therefore, we need to consider the sightseeing time in this system.

The second system set the genre of the recommended landmarks based on users' preferences. However, it could also be said that it is important for users to receive recommendation for many attractive landmarks without considering their preferences. Therefore, other methods of recommendation need to be incorporated in order to recommend a wider array of landmarks.

The second system attached photo information only. However, some evaluators stated that, "we wanted other information about the landmark," in the questionnaire given after the experiment. For example, they requested information on topics including shop business hours and history.

VIII. CONCLUSION

In this paper, the focus is on casual walking sightseeing in which tourists can visit anywhere at anytime freely, without being pressed for time. Moreover, our proposal of a novel sightseeing navigation system aims to increase opportunities for new discoveries and chance encounters. Therefore, neither of our systems show detailed route information, with the purpose of the "Benefit of Inconvenience." As a result, it was established that such an approach can make users pay more attention to their surrounding environment. In addition, from our evaluation experiments on two types of prototype system, the effectiveness of not showing the map, and how to recommend the landmarks to attract users, were verified.

REFERENCES

[1] H. Kawakami, "System Design based on Benefit of Inconvenience and Emotion," ICCAS-SICE, pp. 1184-1188, 2009.

[2] S. Ishimori, "The Potentialities of Autonomous Tourism in the Twenty-first Century," Senri Ethnological Reports, Vol. 23, pp. 5-14, 2001 (in Japanese).

[3] Japan Trabel Breau Foundation, "Travelers Trends 2010," pp. 34, 2010.

[4] NAVITIME JAPAN, NAVITIME, http://www.navitime.co.jp, 2012.

[5] J. Nishino, "Skil-tronics design," SICE Symposium on System and Information 2009, pp. 554-557, 2009 (in Japanese).

[6] I. Maeda, T. Sasaki and T. Oguchi, "Kankou no Shakai Shinrigaku (Social psychology of Sightseeing)," Kitaoji Shobou, Kyoto, 2006.

[7] Amazon.com, amazon, http://www.amazon.com, 2012.

[8] Y. Hijikata, "Techniques of Preference Extraction for Information Recommendation (<Special Features> Exploiting, Customer Preferences: The Leading Edge of User Profiling Technique)," IPSJ Magazine, Vol. 48, No. 9, pp. 957-965, 2007 (in Japanese).

[9] Y. Hijikata, T. Shimizu, S. Nishida, "Discovery-oriented Collaborative Filtering for Improving User Satisfaction," Proceedings of the 14th international conference on Intelligent user interfaces, pp. 67-76, 2009.

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A Simulation System for Tsunami Evacuation Behavior in the JR Osaka Station Area

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***Abstract*— In response to an estimation of the likelihood of occurrence of the Tonankai and Nankai earthquakes, it is predicted that tsunami damage will occur in the JR Osaka Station area, the third biggest business center in Japan. The purpose of this study is to propose a system that evaluates the effectiveness of tsunami evacuation guidance and tsunami countermeasures, based on computer simulation of behavior of evacuees. There are many companies, department stores, hotels, large underground shopping centers and railway/ subway stations in this area. Various kinds of elements must be considered in order to plan safe evacuation. For example, there must be major disruptions between people who try to evacuate from buildings and people who try to get out of the underground shopping center and buildings. In this paper, the first step of the study is reported, that is an evacuation simulator to collect data fundamental for devising a method for inducing evacuation.**

Keywords-Tsunami; earthquake; simulation; multi-agent system; Osaka City; evacuation.

I. INTRODUCTION

Earthquakes occur so often in Japan that it is particularly well known as an earthquake-prone country. At present, there are four major earthquakes predicted to occur in Japan in the near future: the Tokai earthquake, the Tonankai earthquake, the Nankai earthquake, and the Tokyo Metropolitan earthquake. In particular, the probability of occurrence of the Tokai earthquake in the next 30 years is estimated to be 87%, and those of the Tonankai and Tokai earthquakes are also estimated to be greater than 60% [1]. If these earthquakes actually occur, there must be massive damage and many stranded people unable to return home.

In the Tohoku Great Earthquake in 2011, there was a major disruption by over 5 million stranded people in Tokyo and the surrounding areas. The same situation is predicted in Osaka City, the second largest city in Japan, which would be greatly affected by the Nankai and Tonakai earthquake. JR Osaka Station, Midosuji (a main street in the city), Osaka City Hall, etc., are located in Osaka City. These are specified as being within the predicted tsunami flood region, and it has been predicted that massive damage to the municipal subways and underground shopping centers will occur. There are many people, particularly tourists, shoppers and commuters, in the area of JR Osaka Station, and there is the possibility of about 420,000 people being trapped; widespread confusion may occur as they take refuge from a tsunami during an earthquake disaster [2]. In addition, secondary and tertiary disasters may result from the original disaster. They are the disasters that occur subsequent to when a disaster occurs. Therefore, there is a need to conduct quick and precise evacuation guidance in the context of reviewing prevention measures to reduce major damage in Osaka City. Evacuation simulation by computer is thought to be effective because it is difficult to conduct an experiment of evacuation guidance on a real-life scale in the JR Osaka Station area, which may result in major traffic congestion and disruption.

In order to solve these problems, this research aims to construct a working environment that can evaluate the evacuation guidance and tsunami countermeasures by simulating the behavior of disaster victims on a computer, targeting JR Osaka Station and its surrounding areas.

II. RELATED WORK

A. Evacuation Simulation: State of the Art

Various research and development of crowd evacuation behavior simulations have been conducted in relation to fire and tsunami situations [3][4]. In order to develop a method for predicting evacuation behavior that incorporates panic conditions, we will examine the state of the art in terms of numerical analysis methods.

1) Physical Model Method

The physical model method [3] assumes that a crowd will take action following specific physical laws.

This commonly used method regards crowds as fluid, and calculates the number of people per speed and space by design of the line of flow in buildings, which is called the fluid model. In cases when the crowd acts smoothly, this method is effective and highly reliable. It is capable of simulating situations where the flow of people is blocked, by setting the proper parameters using calcuation, but it is also necessary to set parameters considering the structure of buildings.

An individual member of the crowd is regarded as a single rigid body, and the grains model [3] has been used to

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model their movement in situations where they move while interacting with each other. Compared with the fluid model, this is capable of expressing detailed movement, but the calculation costs higher.

Over the past few years, several studies have been conducted on simulation models using the potential model as a highly physical model [3]. It is possible to simulate various evacuation behaviors including blockades by setting appropriate potential to the spatial properties of route, individuality of evacuees, and the disaster situation, etc., but the reliability of results depends on the quality of the set potential. It is capable of simulating situations, but there are no principles or methods of determining potential objectively, so it is not suitable for predicting emergency evacuation behavior, where ensuring reliability is important.

2) Cellular Automaton Method

The cellular automaton method [3] is used to calculate the movement of crowds as a state transition between cells, following a simple rule using probability by dealing with time and space discretely. Although the rule is simple, it is possible to form a complex transition pattern by splitting time and space among a large number of cells. In the case of evacuation behavior, if state transition between cells is modeled as the ensemble behavior of each pedestrian, it is possible to implement various patterns of behavior by including or ignoring various elements of the determined behavioral rules of each evacuee. As a consequence, it is capable of reproducing complex state transition. The degree of freedom in setting the form of walking space and positioning facilities is high, and it is possible to easily program and to calculate complex boundary conditions, such as smoothly flowing evacuation patterns and blocked evacuation patterns.

This method is suitable for classifying qualitative patterns of state transition, but the quantitative prediction is limited. It is capable of predicting quantitatively by increasing the complexity of the rule, but this is not a strong point of this method.

3) Multi-agent Simulation

The multi-agent method "constructs a system bottom-up from the behavior of many autonomous agents" [4]. It regards individual elements constituting the system as agents, makes them act autonomously and simulates the behavior of the system. This method is sometimes described as an advanced type of the cellular automaton method, but it is notable for modeling decision-making and actions of individual evacuees, and has been practiced in the field of artificial intelligence since the late 1980s.

At present, it is possible to obtain reliable results through designing suitable agents, and various kinds of multi-agent simulation have been researched. For example, multi-agent simulations of evacuation behavior in fire emergencies have been developed, and it is planned to diversify to other disaster situations. In social technology, multi-agent simulations of risk management in nuclear power plants have been developed. For earthquake disasters, multi-agent simulations have also been used to predict fire suppression and the actions of the police, etc.

B. Related Research

Various research and development of crowd evacuation behavior simulations have been conducted in relation to fire and tsunami situations. For example, Hori et al. conducted evacuation behavior simulations in underground spaces [3]. They experimented with multi-agent simulation on evacuation behavior from a subway station with five underground levels to the ground during an earthquake. Consequently, they were able to analyze evaluation findings such that the evacuation time of individual evacuees is uneven and increases according to the number of people.

In addition, Watanabe et al. developed an evacuation simulation model for tsunami situations using multi-agent simulation. During planning of community development of disaster prevention for tsunami situations, this research can examine both maintenance of material aspects and policy [5]; for instance, questions such as what kind of maintenance will enable all evacuees to escape within a set period of time.

III. Outline of Proposed System

A. Current Problems

Until now, many studies have been made on simulations of human behavior using computers [6], [7]. In a conventional simulator, the principal purpose is to model the actions of evacuees simply as fluid and to simulate this movement, but simulators of not only physical interaction among evacuees but also social interaction have been developed recently. Fundamental questions still remain unanswered. As mentioned in Section II, there have been many simulations such as those targeting the damaged region, those conducted in internal spaces such as tower buildings, department stores, underground shopping centers, etc.; but there are not many simulators that model evacuation in metropolises such as Tokyo and Osaka, in which there are many large buildings and various groups of people. In addition, large-scale and large-area simulations of evacuation behavior which consider evacuee inflow to buildings do not exist. For this reason, it is not possible to predict what situations will occur in Osaka City during an earthquake in terms of collisions between people who try to evacuate to buildings and people who try to get out of the underground shopping center and buildings.

Furthermore, there is an immediate need to reconsider planning of disaster prevention related to the Nankai earthquake affecting Osaka City in the wake of the 2011 Tohoku Great Earthquake and Tsunami. In particular, measures in relation to tsunami resulting from an earthquake are a main object to be reconsidered. As the Yodo River is located close to JR Osaka Station and Hankyu Umeda station, it is predicted that widespread damage and confusion will occur in the event of a tsunami. In order to reduce such a damage, it is necessary to consider effective tsunami countermeasures. Currently, quick and precise evacuation guidance within the limited time period before a tsunami occurs is effective.

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However, private companies and Osaka City administration do not share a specific control strategy for tsunami occurrence. For this reason, it can be assumed that firstly, the information needed to formulate a tsunami evacuation manual is lacking, and secondly, even if such information exists, it is not shared. As a result, individual company or institution is making a separate guidance manual for evacuation. In the case of actually basing evacuation guidance on such manuals, it is not clear whether these constitute effective guidance for a particular region. For instance, even if tsunami refuge buildings are capable of accommodating stranded people, they have a psychological resistance to moving higher than the third floor in buildings when elevators and escalators make emergency stops after an earthquake. In consequence, widespread confusion may occur in the case of many people remaining on lower floors while further evacuees enter the building. The same collision may occur on both the ground and underground levels. In order to resolve such problems, it is necessary to make a system that is capable of inspecting how evacuees will behave considering various evacuation situations.

B. *Proposed System*

The purpose of this study is to develop a computing system that simulates evacuation behavior of people at the time of tsunami precaution in major cities, including in the ground and the underground, and buildings. Furthermore, it is our goal to provide fundamental data for specifying tsunami refuge buildings and selecting the evacuation guidance method and system, the guiding location, etc. This paper is the first step in this objective, and thus we have developed a simulator of evacuation behavior which targets people located only on the ground level. Using this, we conducted a simulation targeting the area around JR Osaka Station and Umeda Station in various situations.

The following functions are considered in the system.

1) *Functions*

a) Target area: The target area is defined as the area within a kilometer radius of JR Osaka Station.

b) Evacuation route: The evacuation route used by evacuees is the shortest distance on the road network to JR Osaka Station. Further, it assumes that there are no obstacles such as cars on the road. In this research, we used Dijkstra's algorithm [8] to measure the fastest time to finish taking refuge, and it is set so that the evacuees do not take any detours even if the walking speed decreases due to dense crowding. We plan to consider the influence of road traffic and some disaster's phychological reaction in future research.

c) Walking speed: The speed used as a standard is considered to be 66.6m/min per one person/square meter from the relationship between crowd density and speed of the evacuees on the evacuation route. It is set so that the speed decreases as the congestion of people increases.

d) Tsunami refuge buildings: In order for evacuees to take refuge in places other than the goal, buildings in which large numbers of evacuees, such as Umeda Station, department stores, and tower buildings etc. are designated. As such, buildings specified as tsunami refuge buildings are designated as buildings for emergency evacuation.

e) Evacuee limit: A control panel can be created so that the number of evacuees who can be accommodated in those buildings can be adjusted, and it can be set up with various values.

f) Graphical representation: The X-axis indicates lapsed time and the Y-axis shows the number of evacuees who have taken refuge in each building on the time series graph of the evacuee number.

IV. SYSTEM ARCHITECTURE

A. *Development Environment*

This research implements "artisoc 3.0", a multi-agent simulator developed by KOZO KEIKAKU ENGINEERING Inc. The rule description language is mainly Microsoft's Visual Basic. Artisoc 3.0 can graphically capture the motion of agents with numeric output, a 2D map and a 3D map.

The program construction of artisoc is a stepwise structure, as shown in Figure 1.

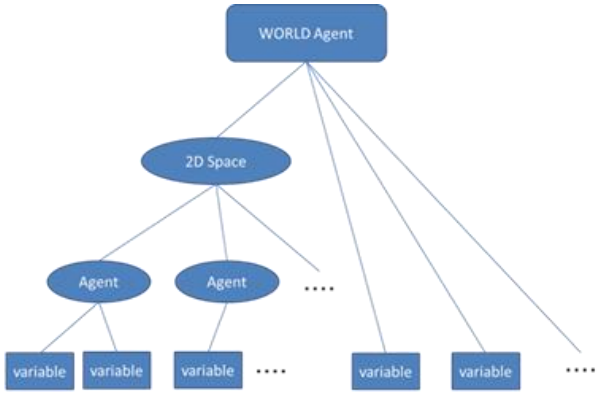

Figure 1. Artisoc program structure

B. *Simulation Flow*

The simulation flow of this system appears in Figure 2. Each step is explained below.

1) The evacuation route calculation agent calculates the shortest route to the goal using Dijkstra's algorithm and saves the data file.

2) The evacuee agents located at each intersection take the shortest route from each position to the goal based on this data. When all evacuees have finished taking the route, they are indicated on the map of the intersections by a green circle.

3) As shown in Figure 3, we set the evacuee limit for each emergency refuge building using a control panel. The slide bar is capable of adjusting the number of evacuees by units of 100 persons.

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4) The evacuees start to take refuge at the goal. This simulation continues to run until all evacuees finish their journey, and it automatically finishes when all have completed refuge.

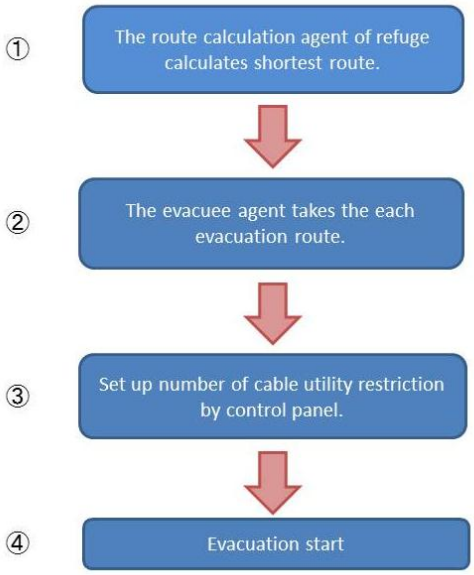

Figure 2. Simulation flow

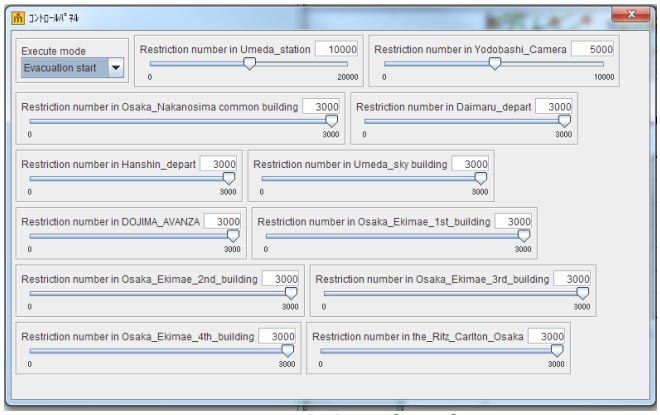

Figure 3. Control panel

C. *Evacuee Behavior during Simulation*

When we execute this simulation, the evacuee agent is displayed with a green circle and positioned at each intersection. Each green circle represents a group of 100 evacuees. In this experiment, this system only simulated the behavior of evacuees on the ground, so their numbers were set at approximately 200,000 persons.

In addition to this, this simulation assumed a situation where all evacuees would go to JR Osaka Station when an earthquake occurs. Therefore, JR Osaka Station is designated as the goal, which forms the basis of their behavior. The evacuation routes are shown in Figure 4, where green lines indicate roads, and the evacuees walk to the goal by the shortest route as calculated by Dijkstra's algorithm. In addition, as shown in Figure 5, when evacuees find emergency refuge buildings within 3 units around them, they do not go to JR Osaka Station but take refuge in these emergency buildings. However, if the number of evacuees that can be accommodated in each of these buildings reaches the established limit, they cannot enter, and thus return to the route going toward JR Osaka Station.

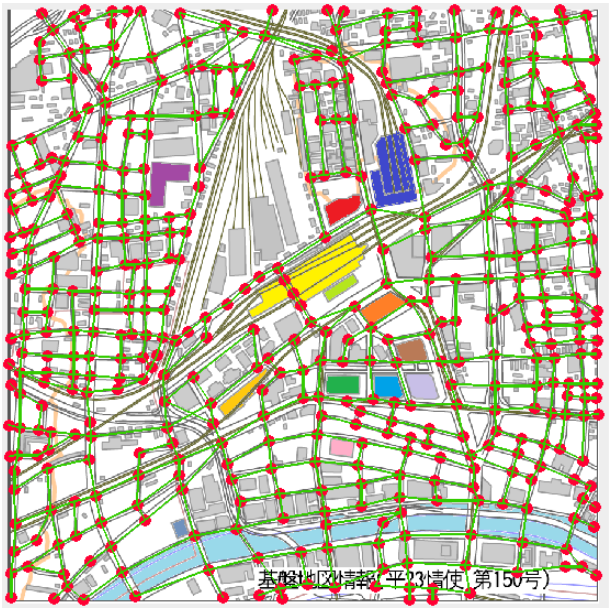

Figure 4. Evacuation routes and interactions

3	3	3	3	3	3	3
3	2	2	2	2	2	3
3	2	1	1	1	2	3
3	2	1	0	1	2	3
3	2	1	1	1	2	3
3	2	2	2	2	2	3
3	3	3	3	3	3	3

Figure 5. Range of evacuees' view

In general, walking speed is said to be 66.6 meters per minute to population density of 1 person per square meter. However, each evacuee agent is assigned a group of 100 persons in this simulation, so it is predicted that their movement will be slow compared with typical walking speed. Accordingly, this was set to 40 meters per minute by considering such factors as the various physical constraints of group movement and the Fruin's Level of Service [9], etc. Furthermore, we set the speed to fluctuate according to the congestion situation on the evacuation routes. Table 1 summarizes the numerical values of these fluctuations.

TABLE 1. WALKING SPEED

	Congestion factor		
	0-2	3-4	5-

Speed[m/min]	40	30	20

D. Designation of tsunami refuge buildings

In this simulation, the evacuees take refuge not only at JR Osaka Station but also in surrounding buildings. As shown in Figure 3, a control panel can be created so that the number of evacuees that can be accommodated in those buildings can be adjusted, and it can be set up with various values. Table 2 summarizes the names of the tsunami refuge buildings and the number of evacuees that can be accommodated within.

TABLE 2. BUILDING NAMES AND ACCOMMODATED NUMBER OF PERSONS

	Color	**Accommodated number(persons)**
Umeda Station	Blue	0-20000
Yodobashi_Camera	Red	0-5000
Osaka_Nakanoshima common building	Grayish blue	0-3000
Daimaru_Department Store	Pea Green	0-3000
Hanshin_Department Store	Orange	0-3000
Umeda_Sky Building	Purple	0-3000
DOJIMA_AVANZA	Pink	0-4000
Osaka_Ekimae_1st_building	Green	0-4000
Osaka_Ekimae_2nd_buildin g	Sky Blue	0-4000
Osaka_Ekimae_3rd_building	Light purple	0-4000
Osaka_Ekimae_4th_building	Brown	0-3000
Ritz_Carlton_Osaka	Bright yellow	0-2000

E. Execution Screen

The execution screen of this simulation is shown in Figure 6.

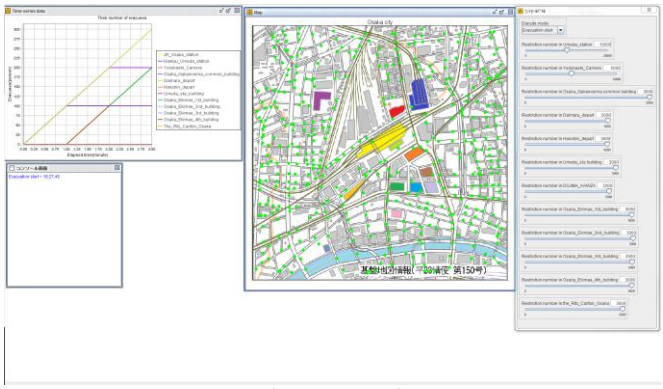

Figure 6. Execution Screen

V. RESULTS

A. Case Study

In this simulation, we can set the maximum possible number of accommodated evacuees in each emergency refuge building using a control panel. In this research, the simulation was conducted using various proportions of evacuees accommodated in the refuge buildings, as described in the conditions listed below.

1) When the proportion of evaacuees who can be accommodated is 0%.

2) When the proportion of evaacuees who can be accommodated is 20%.

3) When the proportion of evaacuees who can be accommodated is 50%.

4) When the proportion of evaacuees who can be accommodated is 80%.

5) When the proportion of evaacuees who can be accommodated is 100%.

The data obtained by using the above proportions in shown in Figure 7. The transition of evacuees unable to find refuge each time is shown by a time series graph.

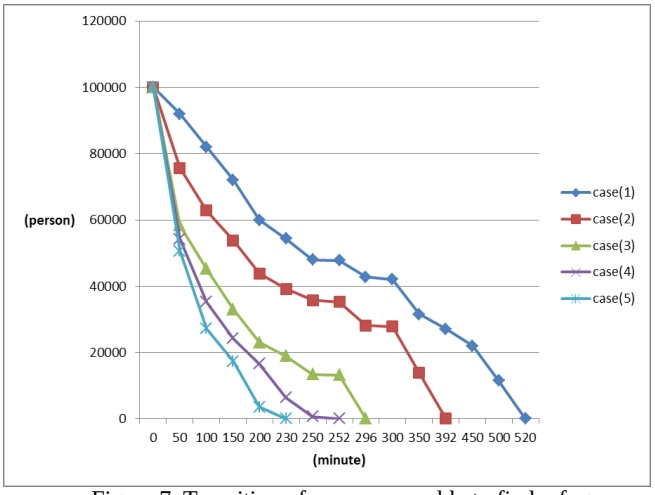

Figure 7. Transition of evacuees unable to find refuge

B. Discussion

In the case of Condition 1, Figure 7 shows that it takes a maximum time of 520 minutes until completion of refuge. Although evacuees go only to JR Osaka Station, it became apparent that it will take a considerable length of time for a group of 100,000 people to converge. Furthermore, the simulation result clearly shows that the time taken to complete refuge becomes shorter as the proportion of evacuees accommodated in the refuge buildings becomes higher. As a result, in this paper it can be concluded that designating tsunami refuge buildings such as stations, department stores, tower buildings, etc. enables evacuees to take refuge effectively and quickly in cases where they converge on one location.

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However, the predicted time period for a tsunami to hit Osaka City is about 140 minutes after an earthquake, so the time calculated by the simulation exceeds the tsunami warning time, even with a crowd of 100,000 people. In this simulation, although there is the time lag before evacuees reach to JR Osaka Station, so many people actually aim at it. 100,000 people is said to be not few, but further more people have to be considered in the simulation.

Further, evacuees can cross the road in front of the station in this simulation, but it is predicted that the street will be clogged with traffic and they will be difficult to do so freely. Although there are foot bridges, it is predicted that their utilization will be limited because of dangers due to use by large numbers of people. A large group of over 400,000 persons is thought to converge in JR Osaka Station area, and a large crowd will remain in this area for a long period of time.

In the future, it is necessary to improve the system so that it can consider factors such as what is the best way to accommodate crowds of evacuees, and how many buildings are required as evacuation base facilities, etc. on the assumption that a situation like the one described in this paper occurs.

VI. CONCLUSION AND FUTURE WORK

The purpose of this research is to develop an evacuation guidance method for the area around JR Osaka Station, and we have proposed a system that is able to simulate how evacuees will act in this area as the first step towards that purpose. So far, we have developed a simulator of evacuation behavior which targets only the people on the ground level. Using this, we conducted a simulation targeting the area around JR Osaka Station and Umeda Station in various situations. It is predicted that evacuation simulation using computer is effective because it is problematic to conduct an experiment of evacuation guidance on a real-life scale in the crowded JR Osaka Station area.

In this simulation, we did not deal with the interaction between people trying to evacuate from buildings, the subway and the underground shopping center to the outside and people who are already outside. In cases where large crowds stay on the ground, it is predicted that evacuees will not be able to go easily outside from buildings and the underground shopping area. Therefore, it is predicted that many will stay in the places around the station. At the same time, it is possible that the psychological pressure caused by the short time period until a tsunami hits will cause panic. Therefore, we plan to expand the functions of this system in order to be able to simulate cases where evacuees will go out from buildings to take refuge at ground level, as the next step in our research, and we consider the function of some disaster's phychological reaction in this simulation.

ACKNOWLEDGMENTS

We would like to extend our sincere thanks to KOZO KEIKAKU ENGINEERING Inc.

REFERENCES

[1] Cabinet Office, Government of Japan. White Paper on Disaster Management 2010. Tokyo:2010.

[2] Office of Emergency Management. What to do in an Emergency(Living Information). *Osaka:2011*

[3] M. Hori, Y. Inukai, K. Oguni, and T. Ichimura, "Study on developing simulation method for prediction of evacuation processes after earthquake," SOCIO TECHNICA, Tokyo, Japan. 2005, vol. 3, pp. 138-145,

[4] A. Ouchi, H. Kawamura, and M. Yamamoto, The foundation and application of multi agent system, Calculation paradigm of the complex system engineering., Tokyo, Japan. Corona, 2002.

[5] K. Watanabe and A. Kondo, "Development of Tsunami evacuation simulation model to support community planning for Tsunami disaster mitigation," J.Archit.Plann, AIJ, Tokyo Japan, 2009, vol. 74, No. 637, pp. 627-634.

[6] B. Maury and J. Venel, "Handling of contacts in crowd motion simulations," University of Paris, in Press, Orsay Cedex, France.

[7] A. Kirchner and A. Schadshneider, "Simulation of evacuation processes using a bionics-inspired cellular automaton model for pedestrian dynamics," Physica A: Statistical Mechanics and its Applications, Germany, 2002, vol. 312, pp. 260-276.

[8] E.W. Dijkstra, "A note on two problems in connection with graphs," Numer. Math., 1959, vol. 1, pp. 269-271

[9] J.J. Fruin, "Pedestrian planning and design," Trans. Masamitsu Nagashima, Tokyo, Kashima, 1974.

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Communication Support System Between Persons with Dementia and Family Caregivers using Memories

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***Abstract*—Persons with dementia have lost important memories, and their caregivers are exhausted by caring for them, especially family caregivers. We aim to support persons with dementia recall memory by talking about their memories together, place them in their life history, and communicate with their caregivers. The proposed system uses photographs as triggers for memory recollection. The demonstration verified that recollection support of memory using photographs is promising as triggers for conversation and organization of memory, while further revisions are required.**

Keywords-Persons with dementia; caregivers; recall; photograph; memory; communication.

I. INTRODUCTION

Recently, Japan has progressed into an aging society, resulting in an increase of persons with dementia [1] [2]. Although the symptoms of dementia change depending on the type of disease, the main symptoms can be divided into core symptoms and BPSD (Behavioral and Psychological Symptoms of Dementia). The core symptoms are the decline of aspects of intelligence function, such as defects of memory and impaired orientation. BPSD include wandering and hallucinations, which become a heavy burden for care workers. For the family members and other relatives it seems that persons with dementia cannot understand anything. A decline in emotional function, however, does not always accompany the decline in intelligence function. Therefore, sufficient consideration is needed when caring for dementia patients. In Japan, family caregivers often support persons with dementia in addition to using day-care facilities, but their circumstances are deeply stressful, because they often do not have sufficient knowledge of dementia and so give care to them by trial and error, and they cannot take their eyes off their patient. It is also often hard to obtain cooperation with surrounding communities, due to the negative image of dementia and low social recognition.

In this study, we aim to support the recall of memories of a patient and his or her family, the most familiar presence for persons with dementia. Family caregivers talk together about their memory. This is not an act of the caregiver taking care of the patient alone, but one which creates a good environment in order to help each other. Also, if neither the person with dementia nor the family can recall the memories, we provide a trigger for recollection by presenting social events and information similar to the lost memory. As a result, persons with dementia can recall memories about their family, and family caregivers are able to actively communicate with other members including the person with dementia.

A brief outline of this paper follows. In chapter 2, we describe the significance and role of memory, which is lost by dementia. Chapter 3 describes research trends of persons with dementia and caregivers. Chapter 4 and 5 describe system proposal and system functions, which is based on the consideration in chapter 3. Finally, chapter 6 describes evaluation of the system.

II. FUNCTION OF MEMORY

This section describes the significance and role of memory, which is lost by dementia.

Memories are our own private episodes, formed from an individual person's experiences in the past. Even if people experienced the same episode, how they feel about it may differ from person to person [3]. Moreover, our present "egos" has been formed by the accumulation of our own episodes. Memories are fully private unless we talk to someone about them. Thus, memory has the role of reminding us of our consciousness of self.

Viewed from another side, people talk about their memories to prompt mutual understanding. Talking together on the pasts means exchanging a part of their egos. As a result, people are able to prompt mutual understanding. Therefore, memory has a role of building and maintaining human relationships.

However, people forget memories as time goes on. People find it hard to recall memories which they have not recalled for a long time, and thus triggers are required to recall them. Examples of triggers include seeing a photograph, reading a diary, talking with family and friends, hearing a long-forgotten tune, and smelling an old familiar perfume. In particular, photographs hold a variety of types of information. They are associated with a specific annotation, such as date and time, place, and events. A photograph helps people indulge in reminiscence

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alone and share their memories with others, led by various annotations involved in it.

A. Memory Communication

Memory has two roles: first one is to remind us of our past experiences, and second is to build and maintain human relationships, as stated above. In addition, having a conversation with others promotes memory sharing and increasing our memories. Normal actions such as talking with family and friends are communication carried out unconsciously; but can be characterized as memory exchanging or 'Memory Communication' [4].

Memory Communication requires the following three elements.

a) The communication methods and partner(s).
b) The memory and a related episode.
c) Something that acts as the trigger to recall the memory.

Many elderly persons talk with family and friends on a regular basis. Talking about memories is an effective way to communicate with a stranger in nursing care homes or hospitals. Communication methods are to meet and talk in person, and bring photographs. Further, recently cell phones and the Internet have been developed, allowing people to communicate with others even if they are far away. It can be predicted that triggers will be different for each elderly person, but looking at photographs of past eras and listening to old popular songs certainly promote remembering.

We have described the significance and role of memory in this section. Memory belongs to each individual person and is an important element for expressing one's personality. However, persons with dementia gradually lose their memory, thus losing proof of their existences.

III. RESEARCH TRENDS

A. Support Systems for Persons with Dementia

Recently, widespread use of cell phones and the Internet is progressing. As a result, support systems which utilize such equipment have been rapidly increasing, such as, a movement navigation system using photographs [5], and a remote interactive support system [6].

a) Movement navigation system using photographs.

Traditional map-based movement support systems are not effective for persons with dementia because it is difficult for them to learn the route and recognize landmarks. Consider this problem and developed a system which encourages understanding of the route by using photographs and animations on a cell phone. It shows a direction to turn at a junction and indicates important signs which show the correct route to a destination, as shown in Fig.1.

b) Remote interactive support system.

This system uses a videophone, and is able to show photographs and videos about memorable episodes even from a distance (Fig.2). Persons with dementia and their caregivers can reminisce and share memories at home, looking at the same photos and videos, without going to a public institution. As a result, persons with dementia can obtain some stabilization of their mental state, and this system can reduce the burden on the caregiver.

B. Organization Support for Caregivers

There have been only a few attempts to support in-home care. Examples of support services for caregivers include the use of nursing home care and care helpers. However, these services cannot sufficiently reduce the burdens on family caregivers, because the use of nursing home care is expensive and the utility time is limited.

Under this situation, there have been some movements in which caregivers have taken the initiative to confront the difficulties of care. For example, the Male Caregiver Network is an organization of which the members comprise of male caregivers [7]. The activities of the organization include holding exchange parties and lectures for male caregivers. Many of the participants include both veteran caregivers and beginners. These events are a great reassurance to beginners because they can consult with caregivers in similar circumstances. Conversely, veteran caregivers can reflect on their care history through communication with the participants. The members can generate motivation to continue care. In this way, the organization aims to provide a place to talk about and share the worries of care between caregivers.

C. Consideration

Researches which use information technology to support persons with dementia share the aim to enable them to live an independent life. If they can lead as independent a life as possible in their home, this will reduce the burden of caregivers. Most researches do not aim to target caregivers directly.

However, providing support for caregivers, not only for persons with dementia, is necessary because if persons with dementia live in their own homes, they need help from their family caregivers. They need plenty of nursing care time, and as a result, the burden on caregivers increases and they become exhausted. An environment which supports the caregiver and listens to their troubles is required. Caregivers are taking initiatives themselves such as in the 'Caregivers Male Network', but not every caregiver can participate in these activities. Furthermore, previous research focuses on only negative aspects of home care [8]. The burden of care of persons with dementia has been found to be greater than care of persons without dementia. However, recent studies have identified a need to approach the positive aspects of home care [9]. Although caring for family members is recognized as a road which everyone must eventually take, on the other hand, it is difficult to continue due to the heavy burden. Therefore it is necessary to develop a support system for in-home care as part of the social system.

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Figure 1. Movement navigation system.

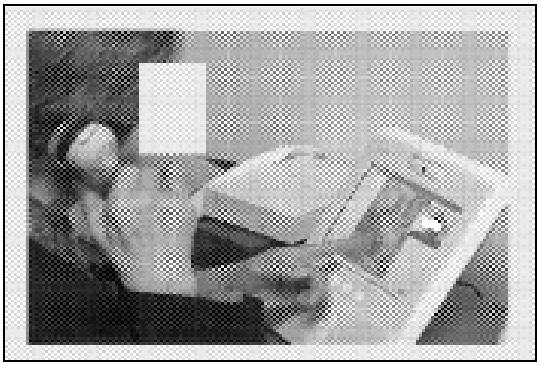

Figure 2. Remote interactive support system.

IV. SYSTEM PROPOSAL

A. System Summary

In this study, photographs are used as a trigger to recall memory. People can extract rich information from photographs because they have variety of visual cues about their contents. People have a tendency to promote their bonding by confirming the shared experiences and photographs provide an opportunity to start a conversation about shared memories of the family. Furthermore, most families have kept photographs in the family album for many generations.

Rich information of photographs can be classified as follows:

a) Date and time, location when the photo was taken.
b) Reason why the photo was taken at that place
c) Relationships with person(s) in the photo.
d) Feelings about the scenery and objects in the photo.

Thus, the information obtained from one single photograph can be abundant. In this system, we register the event, location, and date and time as information about each photograph. As many photographs simply show daily life spent with family, these photographs are useful for recalling memories of happy past days and promoting bonding of family through communication of shared happiness.

B. Proposed Method

Users (persons with dementia, family, and family caregivers) register annotation of each photograph - event, location, and date - as a set into the photo information database. Then, when a photograph is selected, the system displays the event, the location, and the day, in that order. This is because the event, which we place first, is considered as an experienced and repeated memory. Experienced and repeated memory is comparatively well retained.

However, it is difficult for persons with dementia to recall a detailed memory just by looking the registered information of the photograph. Furthermore, the family caregiver may not always remember the event shown in the photograph. Therefore, as information to aid memory recollection, the system shows another photograph registered with similar information or associated social events. The content in the social events database stores effective information for recollection, such as social events which occurred during the same period or information associated with the dementia patient's hobby.

In addition, by registering and displaying the life story of the person with dementia that are recalled, they are able to look back on their own history and place each episode in order on the timeline.

The following steps indicate how to use the system and Fig. 3 shows a graphical representation of the system process.

a) Register the photograph information: the location, the date, and the event.
b) Show the information of the selected photograph. If only using registration information is not enough to trigger recollection, show another photograph with similar information.
c) If both the dementia patient and the family caregiver do not remember the photograph, and effective content which is judged to help recollection exists in the social events database, the system refers to the social events database.
d) Show the result of the inquiry.
e) The family members share the recalled memories through conversation about the period, the location, or the event of the photograph. Then, if a new memory is recalled, the content is added to the photograph database.

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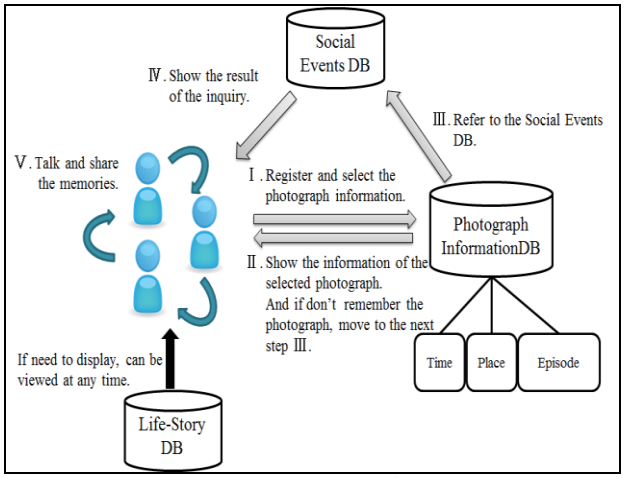

Figure 3. Graphical representation of the system process.

V. SYSTEM FUNCTIONS

A. *Registration Function*

Using the registration function, the system registers a photograph, the photograph information, social events information, and life story information. Photographs are stored one by one in a special folder, and photograph information, social events information, and life story information are stored in a corresponding database respectively. Fig. 4 shows an example of the photograph information registration screen. The photograph name is set to the photo's date and time of registration to aid smooth use of the system. The reason why the system uses the date and time of registration as the photo name is that it would be difficult for persons with dementia to decide and input names for photos. In addition, the reason why the system registers the photographs one by one is that users are expected to recall some related memories by looking at each photograph.

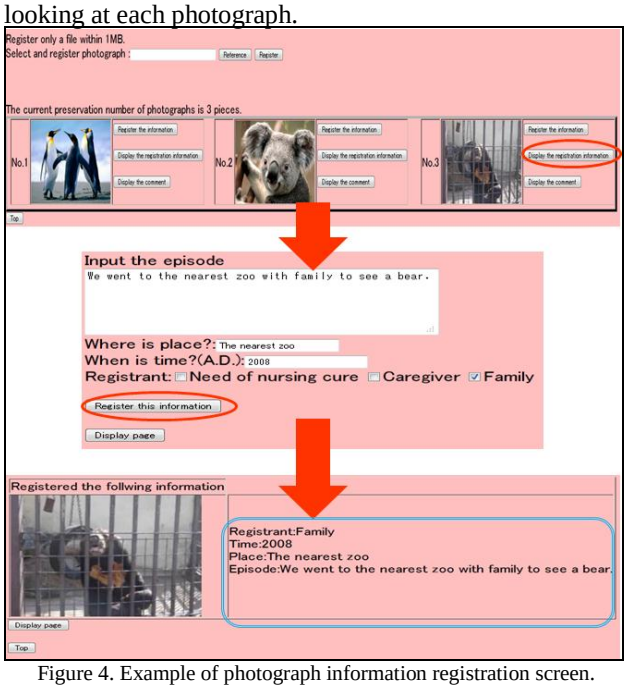

Figure 4. Example of photograph information registration screen.

B. *Recollection Support Function*

The recollection support function is described below.

a) Fig. 5 shows another registered photograph taken during the same period and its photograph information.

b) Fig. 6 shows the social events of a similar time, taken from the social database

c) Fig. 7 shows the dementia patient's life story.

Figure 5. Example of a photograph taken at a similar time

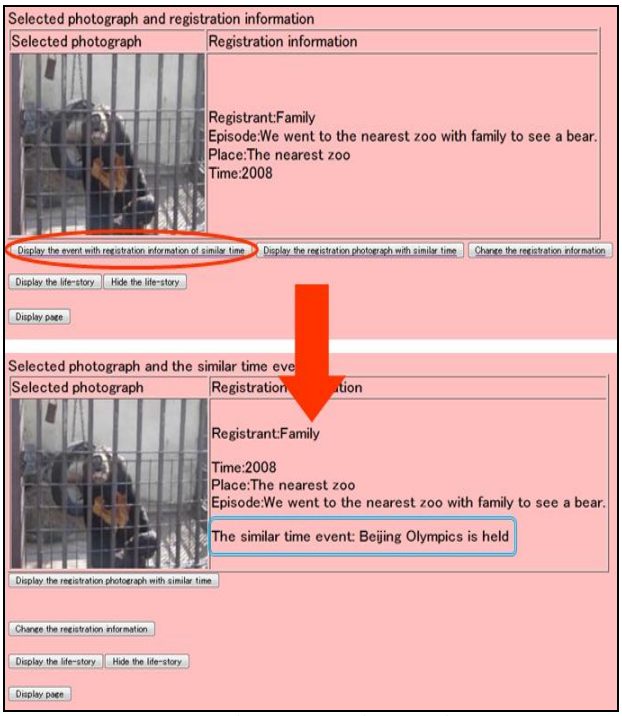

Figure 6. Example of photograph of events of a similar time

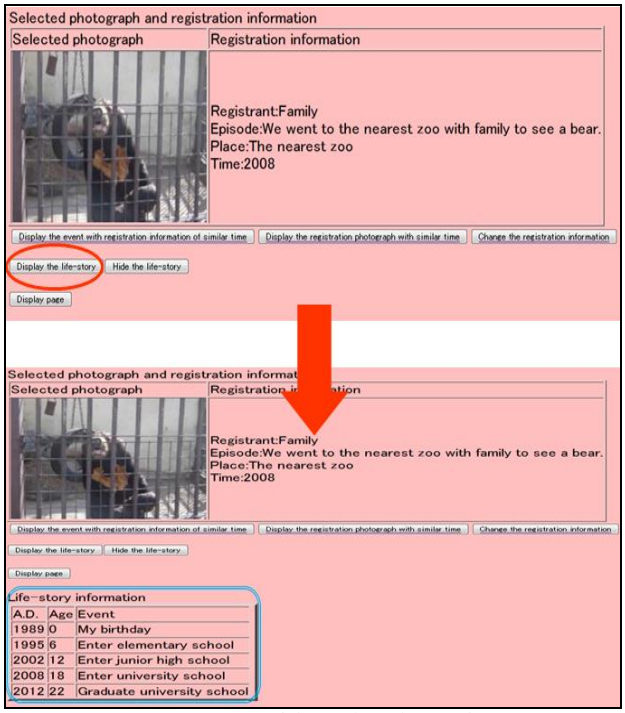

Figure 7. Example of dementia patient's life story

The registered photographs are displayed in chronological order and when a photograph is selected, its information is shown. When the system shows the selected photograph's information, it displays the event, the location, and the date in that order, as stated above. Afterwards, it shows the associated social events, the registered photographs with similar information, and the dementia patient's life story. The reason why the system shows photograph information taken during the same period is that photographs of the same period have some kind of relationship with the selected photograph, and users may recall the memory even if they do not remember the details of the photograph. In this system, "same period" is defined as when the registration year is the same. In addition, the system shows the life story of the person with dementia in order to support recollection. The life story information is not always shown, however. Users can show or hide the life story information optionally. The system supports recollection by using life story, enabling dementia patients to look back on their lives.

VI. EVALUATION

A. *Evaluation Summary*

An evaluation experiment was conducted with the cooperation of four participants, A and B were family caregivers, C and D were veteran caregivers. The evaluation method was to ask them to use the system and discuss on the information of each registration, then afterwards, to answer a questionnaire on a 4-point scale. In addition to the questionnaire, we asked them to write free comments about the system.

B. *Evaluation Results*

Table I shows the questionnaire items, and Table II shows the evaluation results. In Table II, 1-point means that it's difficult and there are many works, and 4-point means that it's appropriate.

As is evident from the results in Table II, there was variation in the answers about inputting the information into each database. This was largely dependent on the user's experience level of personal computers. In fact, one of the evaluation participants had never used a personal computer before, and answered that it was hard to input the information into each database. Therefore it is necessary to develop the man-machine interface to improve ease of input for people who have never used a personal computer.

Regarding the efficiency of using memories, we obtained feedback that "memories are useful for supporting elderly persons, because they often talk about old times". In addition to this feedback, another feedback was obtained that the recollection stories might be different depending on the user's gender. For example, in the man's case, he would talk about his acts of heroism and events of the days of working. But in the woman's case, she would talk about child-rearing. Furthermore, the users suggested the opportunities to communicate with persons with dementia during the registration process. However, there was the negative opinion that the system will be difficult for persons with dementia to use, because usefulness of the system will be influenced by their mental state at the time of use. If their state is unbalanced, they will be unable to use the system. Another negative feedback indicated that the system may not be useful for all persons with dementia, because there may be memories that they do not want to recall. Such situations should be considered in using this system for persons with dementia.

Regarding the recollection support function, the opinion was obtained that the system encouraged recollection of memory that preserves the user's uniqueness. The information which is registered in each database depends on the individual. Furthermore, the life story is useful for the recollection of old memories, because it represents one's own history. Talking about old memories and one's life story is effective communication. However, the life story function is still poor in this system. The life story function needs to be improved to efficiently aid memory recollection and sharing.

The responses to Questions 9 and 10 suggest that this system has the ability to aid recollection of memory and better communication with others. If a new memory is recalled, it becomes a common memory, and the users can talk about it and communicate with each other.

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TABLE I. QUESTIONNAIRE CONTENT

Q1	Photograph information DB: Can you input smoothly?
Q2	Photograph information DB: Does it take a lot of work to use?
Q3	Social events DB: Can you input smoothly?
Q4	Social events DB: Does it take a lot of work to use?
Q5	Life story information DB: Can you input smoothly?
Q6	Life story information DB: Does it take a lot of work to use?
Q7	Life story: Do you feel the life story is useful for recall?
Q8	Life story: Were you able to visualize or recall that time?
Q9	Effectiveness: Did you recall anything other than the information which was displayed by the system?
Q10	Effectiveness: Could you communicate with your partner well?

TABLE II. EVALUATION RESULTS

	Q 1	**Q 2**	**Q 3**	**Q 4**	**Q 5**	**Q 6**	**Q 7**	**Q 8**	**Q 9**	**Q 10**
A	3	2	3	2	2	2	2	3	3	3
B	1	3	1	3	3	3	2	2	3	4
C	3	2	3	2	3	2	3	2	3	3
D	2	2	2	2	3	2	3	3	3	4

VII. CONCLUSION AND FUTURE WORK

In this study, a support system was proposed to aid memory recollection for persons with dementia and family caregivers by using photographs and associated information. The system supports the recollection of memory via information about the selected photograph and related social events. Therefore, by talking about these, we aimed to intensify the activation of family communication.

The next step of this study is to improve this system through consulting with persons with dementia.

REFERENCES

[1] Cabinet Office, "White Paper on Aging Society", 2010, pp.2-3 (in Japanese).

[2] H.Shimokata, "Epidemiological Statistics in Japan", Special Edition of Japan Clinical, 4th-Ed, Vol.62, 2010, pp.121-126 (in Japanese).

[3] R.C.Shank, "Dynamic Memory: A Theory of Learning in Computers and People", New York Cambridge University Press, 1982.

[4] K. Yamasita and H. Nojima, "Portable Personal Memory for Communication", HCI2001: Symposium on Human Interface, 2001, pp.503-506.

[5] H. Kaminoyama, T. Matsuo, F. Hattori, K. Susami, N. Kuwabara, and Shinji Abe, "Walk Navigation System Using Photographs for People with Dementia", HCI2007: Symposium on Human Interface, 2007, pp.1039-1049.

[6] N. Kuwabara, S. Abe, K. Yasuda, and K. Kuwabara, "Networked Reminiscence Therapy for Individuals with Dementia by using Photo and Video Sharing", ASSETS 06: The 8th International ACM SIGACCESS Conference on Computers and Accessibility, 2006, pp.125-132.

[7] M. Saito, "Fragile love? male caregivers in Japan", The 18th Annual Conference on Men and Masculinities, 2010.

[8] K. Sugiura, M. Ito, and H. Mikami, "Family caregiver burden caused by behavioral and psychological symptoms of dementia: Measurement with a new original scale", Nippon Ronen Igakkai Zasshi. Japanese Journal of Geriatrics, Vol. 44, 2007, pp.717–725 (in Japanese).

[9] E. Saito, T. Kunisaki, and Y. Kanegawa, "Study on the positive intention and continuity aspects of care for family caregivers", Japanese Society of Public Health, 3rd-Ed, Vol. 48, 2001, pp.180–188 (in Japanese).

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What Is There For Supper?
Remote Access to the Stock of Food in a Smart Kitchen

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***Abstract*—This article shows the first steps of a new remote access technology for a smart kitchen. With a mobile device and this technology the user will be able to remotely check the foodstock at home by using a smartphone application. Therefore, we firstly integrated a scale application and Radio–Frequency Identification (RFID) to measure the fill level of food boxes in the kitchen. This information is processed and stored by a specific component of an information system called *FillLevelCheck*, which is part of a smart kitchen project. By setting up a connected web server this information will be available online and can be requested by mobile web applications. This article describes the functionality of the information system component FillLevelCheck and the used hardware. In a next step, we will continue setting up the web frontend and the mobile application for remotely accessing the information. Altogether, this article presents a solution to measure fill levels of food boxes, which is more comfortable than other applications and acceptable for users.**

***Keywords*-Smart Kitchen; Information System; Remote Access;**

I. Introduction

The idea of the remote food access system is part of a smart kitchen project (UARKit- Ubiquitous Augmented Reality kitchen [7]). There a lot of different tasks occur, e.g., cooking a meal. These tasks are supported by tracking the user and showing him projected hints where an ingredient is located in the room and what to do with it. Beside the research concerning correct Augmented Reality projections for cooking steps, we set up a system component called *FillLevelCheck*. It collects information about fill levels in the meaning of storing the remaining amount of food (types) in the kitchen. For this task, we concentrate on the left amount of food not on the usability of the food like their durability or smell.

For UARKit, this information also enables different technical functions like projecting the amount of the next ingredient which has to be thrown into the cake dough (projection of coloured shapes on the butter for the amount of butter which has to be taken). Another use case is the presentation of suggested recipes which are possible for the current stock of food as a list.

The FillLevelCheck consists of two parts. The first part will be explained in this paper and concerns the hardware solution behind the measurement of the food (box) fill level. The second part is currently work in progress and only will be described as a draft.

For the target applications, e.g., recipe or buying list provisioning the measurement unit of every ingredient type will be its weight. The identification of the weighted objects is done by using RFID. This technology is of growing interest especially in the (food) producing and packaging industry. Beside the common barcode identification RFID has the chance to become a resistant method of identifying disposable articles such as food packages.

The following section gives insight into the measurement of physical contents of boxes. Section 3 describes the (proposed) functionality of the current system and its aim. At the end, a summary and a discussion will involve the comparison between the used and alternative technologies.

II. Measuring and Accessing Fill Levels

A lot of research has been done due to the topic of measuring fill levels especially in physically measuring the contents of tanks filled with liquids or granular material. Various patents for devices and methods exist. Current approaches use ultrasonic or electromechanical technologies for sensors which measure fill levels of liquids, such as water [1][2][8]. Here, a measuring device is connected to each tank that has to be monitored. These devices still are very big and expensive and cannot be used for the UARKit application of measuring disposable articles with the FillLevelCheck component. Additionally, the information about the content measured in various possible physical units is not necessary for this application. Because of the non existing restrictions for food box sizes, the data about fill levels expressed as a percentage can not be used for recipe provisioning.

However, with this work, we want to set up a measuring method which is based on the weight of the food. This statement is necessary for a system which is able to handle different food boxes with liquid or non-liquid contents at the same time. Weight, therefore, is the lowest common

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denominator for the entities gram, litre, and pieces. Furthermore, weight can be measured in a very simple way which is only barely susceptible to measurement errors. Additionally, the sensor technology should be inexpensive and must have an interface to integrate it in the smart kitchen hardware and software. This means that an ultrasonic sensor can not be attached to each food box the kitchen contains. The measurement has to be integrated in the furniture of the kitchen.

Different technologies are suitable to additionally identify objects. Possible are, e.g., barcodes combined with optical identification technologies. We cannot use this because a lot of food packing do have this code on the bottom or in an area where occlusions inhibit the optical identification. Another problem is the missing technical expandability. Barcode reader can only recognize one code per measurement. This means if the user has more than one object to put it on the shelf (typically two) he has to hold each in front of the reader one after another, whereas RFID reader can read up to 30 objects per second (measurement loop). Furthermore, RFID is not influenced by optical occlusions. But, because of the current little availability of RFID tags on food packing, for this project, we use boxes with RFID tags. The food has to be put in these boxes before they can be identified. The boxes, therefore, have to be initialized as connected to a specific food content like flour at the moment the system is launched.

Another similar project already uses weight sensors and RFID [4]. They identify food ingredients and collect them to facilitate the choice of food or recipes for healthy cooking. Therefore, a similar sensor and identification platform is installed. But, in this project no remote access is possible or planned. In addition the user has to collect the food boxes he wants to take for his meal and must place them together on a so called counter. Our project wants to integrate weight sensors and identification in every furniture, to realize a hidden information system for all the food which is there. It should reduce the need of unusual user behaviour as much as possible. It also will help organizing the stock of food for a lot of different applications around this system.

Remote Access to smart home information (systems) is a well–defined research field and today also a huge market for consumer applications. Computer-based services at home can be monitored and controlled interactively from anywhere in the world via the Internet. This incorporates safety checks when the user is away as well as entertainment controlling from one room which has influence on every display or stereo in the whole house [3], [5].

Accessing the information about the left amount of food at home only involves another type of information and another relating database structure. We, therefore, will concentrate on using technologies which are highly flexible and fast, easy to develop and integrate, and with which we can setup a high data privacy level. This is of great importance because of the very private (and attractive) user data about what a user buys and eats.

III. Preliminary Survey

The usage of an additional information system for checking fill levels in a kitchen is connected to specific user behaviour. This is reduced to one step. Right after the food has been bought it should be put into a RFID box which is prepared for one food type. Figure 1 shows examples for these boxes and the intended content.

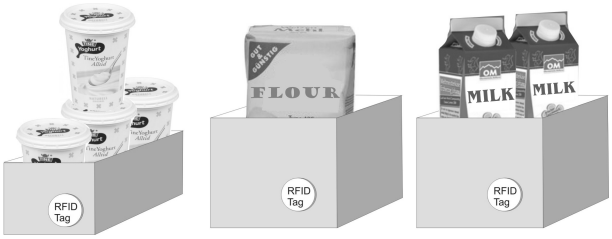

Figure 1. Examples for RFID tagged boxes and food content.

Because of the need for this unusual kitchen behaviour we did a preliminary online survey. We, therefore, asked 50 people (27 male, 23 female, average age of 30.58 years, standard deviation 6.6) online. The question was whether people would sort their food into these boxes to have an information system as described above. The online survey offered a short description of the proposed system and possible applications like the mobile usage of buying lists for specific recipes or the provision of recipes which are possible with the current stock of food. The description was closed with the picture seen in Figure 1.

The question whether the unusual behaviour is acceptable to have the system followed the picture. The answer possibilities were presented with a 5-level Likert scale in german analogue to the english scale with the options from ”strongly agree” (for analytic reasons connected to the number 5) to ”strongly disagree”(number 1) and the mid option ”neutral”(3).

Descriptive statistics. 50 participants answered the question. 5 of them had no preference and clicked ”neutral”. 8 % chose ”strongly agree”, 46 % decided for ”agree”, 32 % for ”disagree”, and 4% for ”strongly disagree”. The arithmetic mean is 3.22 (st. dev. 1.11) which shows the tendency to accept this task.

We did not ask for reasons for this decision because of its complexitiy. We already made this experience while making surveys for developping other smart home applications. The reasons in this case must be found out in further studies.

IV. The FillLevelCheck Component

A. FillLevelCheck System Setup

The system component for measuring and storing fill levels of food boxes consists of different hard- and software parts. The system setup is shown in Fig. 2.

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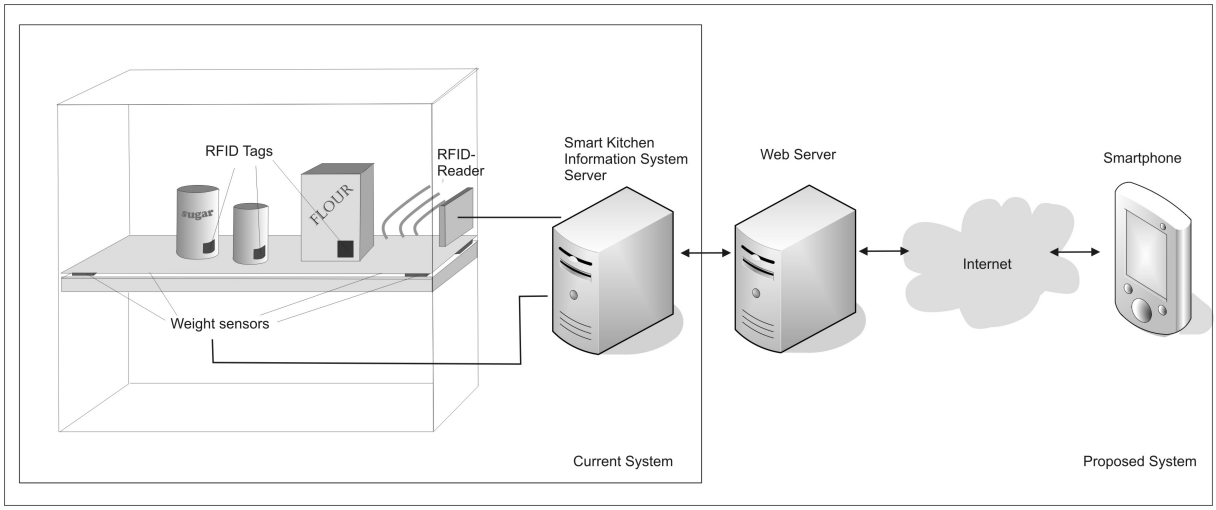

Figure 2. System setup

For the object identification, we use RFID-Reader and tags which are fixated on each food box. Therefore, we applied passive transponder at the frequency of 125 kHz with inductive power supply. This ensures a maximum reading distance of up to 30 cm. The advantage of these tags, compared to usual tags using the frequency at 13,56 MHz, is, that the range of the reader is large enough to identify the boxes while being small enough not to read the information from other shelfs (no reader overlap). This reduces data collisions if more than one reader is installed in one shelf. Additionally difficult climate conditions can be handled with these tags like a high humidity because they have a robust design (plastic jacket). Furthermore, if only small numbers of tags should be red by one reader but a lot of those reader have to be installed the costs for the expensive tags at 125 kHz but cheaper reader pay off for the kitchen application.

For the measurement of weight sensors are attached under an additionally installed shelf base above the normal base (see Fig. 2). For a later installation of such a system this is an easy way of incorporating sensors and cables.

Both of these hardware parts are connected to the information system server which is implemented using Java. It handles a lot of components like optical user tracking and information presentations which are adapted to the used display (different types are used in the kitchen) and the shown information (navigational hints to a searched object or presentation of recipe step).

Measuring and storing the fill levels is solved within two steps for later accessing the whole stock of food in the kitchen.

The first step is the identification of all objects which are available on one shelf. Therefore, every object has to be recognized by the RFID reader. This happens automatically if the object tag gets into the reading distance of the RFID reader. But, every object has to pass the reader actively (the user has to hold the object in this way once) if the dimensions of the shelf allow greater distances than 30 cm between objects and RFID reader. The information about all currently available object IDs (up to 30 object IDs per second) is used for the data integration of object identifier and current weight difference.

The second step involves a weight measuring loop which provides the weight of the whole shelf base for the information system and for the database. This means that if one object is taken away or put into the shelf the difference between the past weight and the current weight are compared. If the box (and the content) is taken away (difference in ID list from step 1) the database holds the old weight value for this ID. The appropriate value 'weight' will be updated if the same object (ID) is recognized again and the weighting loop result shows the difference. If the object is new, a new entry is generated with the current weight difference. The measurements provided by the weight sensors are currently requested every 200 milliseconds (adaptable).

Afterwards, the database contains the frequently updated information about which food boxes are there and which weight they have. This database will be requested by the remote access system. This will enable the information provosioning of at least possible meals by knowing the amount of ingredients which are necessary for suggested meals (from a stored list) and which are available in the kitchen. Also a buying list can be created for a proposed recipe or a weekly purchase.

B. FillLevelCheck Functionality and Open Issues

The measurement of shelf base weights and the identification of objects are designed fit together. More precisely, a cause of measurement and database failure can only be generated by these two components and a measurement time overlap of the two parts.

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Figure 3. Three screenshots of an exemplary fill level measurement by using a scale and RFID (stucked on the shelf)

Despite the investigations of an optimal loop duration for the weight measurement it is still possible that a user is able to put more than one object on the shelf within 200 ms. In this case typically two objects are put on the shelf because the user has one object in each hand. This results in the described unclear assignment of the weight differences for both food boxes in the database.

The system, therefore, can only handle one object per 200 ms. From our experience a user is not able to place two objects in that way that the measurement identifies both objects and measures the different weight for both so that it is unclear which weight belongs to each of the boxes. Nevertheless, if two objects or more are put back into the shelf the calculation can not assign the taken contents to the database entries and throws an exception.

One obvious solution could be the shorter loop duration to avoid the time overlapping processes of putting two (or more) objects in the shelf. But, in this case situations are still possible where the user puts objects into the shelf at the exact same time (equal up to one millisecond). The minimal possible time range of uncertainty or time overlapping relates to the computers capacities because of the implementation methods and latencies of opening serial ports for reading the values of the weight sensors. These durations have influence on the minimum loop duration. Thus, the risk of getting a database error varies between systems.

In our tests the system measurements had been correct for taking weights of the objects and identifying them for a weighting loop duration of 200 ms.

Another problem is the possible existence of different food boxes (and tags) for the same or very similar contents, e.g., sugar (normal sugar, powdered sugar, brown sugar, etc.). The tags we use are associated only with one numerical identifier. These identifiers have to be associated with a special ingredient (category) once they are new in the shelf to avoid the described problem. At this point of work, the user has to sort the object into the right box (right after he or she has bought it). Currently, there is no possibility of recognizing objects automatically because of the missing RFID tags in the food industry. If this application is established in the future this information can be stored in the tag and must not be determinded by the user anymore. Also other interactive identifying technologies like barcodes are suitable for this purpose.

With an automatic identification of the box contents the information system implementation has to be changed in that way that a category order sorts the ingredients by their contents or categorial relations. This avoids that recipe suggestions only relate to one box with sugar and misses other boxes where also sugar can be found. But it also enables automatic substitution suggestions if one specific ingredient is missing but another very similar ingredient is available, e.g., oregano is missing, but marjoram is there. However, the appropriate sorting techniques may have any degree of complexity relating to the purpose. For our proposed system the apriori assignment of the user is the knowledge base for the applications 'buying list' and 'recipe suggestion'.

The left risk of not recognizing each food box on its own and reading collisions for (two or more involved) RFID reader with more than 30cm radio distances also is an open issue. But, the usage of low frequencies for the RFID tag technology and user instructions avoid this problems nearly hundred percent. The recognition only fails if the tag (or food box) is moved by the user with too much distance to the reader. Beside the web application development we therefore will incorporate a feedback sign (visual or acustic) to give feedback about the correctness and amount of recognized food boxes.

V. Remote Access

The system component, so far, is able to manage and provide valid values for the available weight of foods in the (shelf of a) kitchen which are stored and accessed via

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a database. No simple user interface is available yet. The planned additional component of a web server will make these data available online especially for mobile devices (see Fig. 2). The appropriate application will suggest recipes for the left food or can answer the question what to buy if the user is in the supermarket and does not know his stocks of food at home.

Therefore, a web and a mobile application will be implemented in the next step of our work. We will use the play! framework [9] to first set up the web application. This framework enables quick and easy application development on the basis of the model, view, controller–pattern. Thus, the information provided by the database can be accessed by simply calling the website via a browser and using a personal login. Therefore, we incorporate projects like play–siena–user [6].

The next step will be to develop this access via a native mobile application for smartphones. This intention is related to the trends of interactive applications where smartphone hardware is integrated in web search processes. In our case, this for example could be a recipe suggestion generation by scanning a barcode of a food box or recognizing a RFID tag in the supermarket. The customer benefit would be that if, e.g., the substitution application of the information system at home already knows that a similar product is available there he or she does not need to buy the new product.

VI. Summary and Discussion

In this article, we described the state of work concerning a new system which enables the remote access to the stock of food in a smart kitchen. Beside different other system components in the kitchen like user tracking this system measures and stores fill levels of food boxes. In the next step, we will develop a smartphone and web application with a user interface to access this information by, e.g., having a buying list for a specific recipe or suggestions for at least possible meals with the available food in the kitchen. The current system setup incorporate RFID and weighting techniques for a storage of data in a database which will be accessable via web.

The system, in general, is designed to also help people with handicaps or the elderly. Therefore the system provides simple diplayable lists for the existing stock of food. The user must not search the shelfs. The application of appropriate recipe suggestions for the left food also allows a greater variety of meals (also for specific nutrition schedules) with avoiding (vicious) eating habits. Nevertheless, the system helps to avoid unnecessary purchases and trips to the supermarket.

The open issues for such a system are the measurement loop durations for the weight sensors and the approriate identification performance to generate only valid data without unclear database assignment states. Also, the problem of needed tasks, instructions, and feedback signs in a user interface should be designed in a user friendly way.

References

[1] H. Auber, M. Mellert, M. Mosmann, and T. Oehler. Fill level measurement device and a method for operating such a fill level measurement device. Patent US 6769300, September 2000.

[2] W. Brutschin, A. Kaiser, C. Sawitzki, and K. Okazaki. Electromechanical fill level measurement unit. Patent WO/2012/089635, July 2012.

[3] Marmitek BV. Smart solutions at home. http://www.marmitek.com/de/index.php, 2012. $[retrieved : Oct., 2012]$.

[4] J. Chi, P.and Chen, H. Chu, and B. Chen. Enabling nutrition-aware cooking in a smart kitchen. In *CHI '07: Extended abstracts on Human factors in computing systems*, pages 2333–2338, 2007. doi: 10.1109/MPRV.2010.75.

[5] Karlsruhe Institute of Technology. Energy smart home lab. http://www.kit.edu/besuchen/8992.php, 2012. $[retrieved : Oct., 2012]$.

[6] Open Project. Project play–siena–user. http://code.google.com/p/play-siena-user/, 2012. $[retrieved : Oct., 2012]$.

[7] UARKit Project. Ubiquitous Augmented Reality Kitchen. http://www.mms.tu-berlin.de\-/menue/forschung\-/projekte/uarkit/, 2012. $[retrieved : Oct., 2012]$.

[8] A. Wiedekind-Klein. Contactless filling level measurement of liquids. Patent US 20110314907, December 2011.

[9] Typesafe Zenexity. play! framework. http://www.playframework.org/, 2012. $[retrieved : Oct., 2012]$.

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Standardizing the Evaluation of QoE by Users

A methodology to estimate the acceptance of interactive services

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***Abstract*— Every potential service user has had some experience while using a wide variety of interactive services. Therefore, a pre-established concept is carved of what is considered to be a good service when using it. This interferes directly on how the user evaluates the service globally and, consequently, the score that will be given during a test. Being a primarily subjective evaluation, the methodology that estimates the quality of experience requires a method that could translate all this experience into consistent evaluations regarding service acceptance. The objective of this paper is to shape a methodology to estimate the QoE considering the evaluation adjustment of a group of potential users in order to achieve a reference model for future periodic evaluations for a given interactive service.**

Keywords-Quality of Experience; methodology; usability; command response time; interactive service.

I. INTRODUCTION

Quality of Experience (QoE) can be defined as the acceptance of an application or service subjectively perceived by the user regarding performance and usefulness, including system components (terminal, network, service infrastructure, etc.), as well as context of use and end-user expectations [1]. The concept of Quality of Experience has being considered for many kinds of services and it is used for a variety of issues ([2], [3] and [4]). Nevertheless, the assessment of interactive services (services that allow users to interact with the provider through some network) that takes into account the user's opinion is largely based on a single score ([5] and [6]). The most common method is capturing a score based on a discrete scale (for example, 5: Excellent, 4: Good, 3: Fair, 2: Poor and 1: Bad, [7]) or a continuous quality scale and then calculate de Mean Opinion Score [8]. In this case, the authors use a methodology based on a Difference Mean Opinion Score (DMOS), which takes into account the presentation of a sequence of videos and among them there are videos with a specific and high quality format. By comparing the scores of low quality videos with the high quality ones (see also [9]), it is possible to overcome the fact that people have distinct notions about scoring. When assessing a service, it must take into consideration that people have different expectations and they translate these expectations in distinct manner for each distinct service. But it is not rare that developers are not able to simulate and test high quality reference format hidden among other formats of the interactive service. For interface navigation testing, for example, developers have usually just one option of interface and it is not known *a priori* whether it is already on a high quality basis or not.

For this reason, it is necessary to consider another way to create a reference and then compute the acceptance based on a score. This paper will propose a methodology that combines two answers from users: The score on a well known five-point scale and the binary answer about whether the service is acceptable for use on a routine basis. This approach will provide a reference curve of score and acceptability which accounts for the target market and the assessed service.

The user QoE evaluation regarding an interactive service should consider that a given group of users may have different expectations on the use of the technology, taking into account previous experiences and distinct contexts of use. Being mainly a subjective evaluation, some mechanisms must be established to examine the differences during the evaluation, both on site and in the laboratory. In general, the test structure includes five layers, assembled according to the features and types of measures associated:

- User: target audience using the service defined by factors such as class, age, etc.
- Terminal: TV receiver (fixed or mobile), cellular phone, notebook or any physical device used to receive the service. The devices can be fixed, nomadic or mobile, which include features, such as, video resolution, size, processing capacity and control buttons.
- Service: services evaluated by this methodology include: VoD, IPTV, HDTV, chat and telephone.
- Application: data that compose the service, such as: video, audio, voice and data.
- Transport network: physical means through which the service reaches the end-user. They are networks such as: IP, RF, GPRS, 3G, etc.

These aspects are taken into account in order to structure the experiments that will consider, also, critical factors perceived by the users. These are key factors and they are described as follows:

Usability: established parameters that include browsing, presentation, authentication, remote control, usage facility,

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visual appearance and interface. Each of these contains aspects that must be observed during interaction as a method to assure quality of experience. Examples of usability parameters are listed in Table I.

TABLE I. EXAMPLES OF PARAMETERS REGARDING USABILITY

Usability		
ID	*Parameter*	*Characteristic*
1	Navigation	Numbers of steps in order to conclude the task.
2	Presentation	Organization of text and graphic data on the screen.
3	Authentication	Ability to perform authentication so that it is neither a discouraging factor nor a hindrance to perform the task.
4	Remote control	Adaptation of keys to the task's main functions.
5	Interface	Icon legibility considering size, definition and colors. Text legibility considering size, type and colors of the used font. Functions mapping assuring easy learning and low impact when accumulating functions.

Accessibility: parameters related to usage facility during interaction so that they meet exceptional/specific requirements as well as people with low literacy. Examples of parameters are listed in Table II.

TABLE II. EXAMPLES OF PARAMETERS REGARDING ACCESSIBILITY

Accessibility		
ID	*Parameter*	*Characteristic*
1	Text reading	Program that helps people with hearing and visual disabilities to understand the text.
2	Change of contrast	Interface that allows changing the contrast for people with partial visual disability to read texts.

Intelligibility: parameters are established for browsing through content, display of content, use of iconography, suitable language, facility to understand and the information to be displayed. Examples of parameters are listed in Table III.

TABLE III. EXAMPLES OF PARAMETERS REGARDING INTELLIGIBILITY

Intelligibility		
ID	*Parameter*	*Aspects to be evaluated*
1	Browsing	Demonstration of steps on how to browse through application contents.
2	Iconography	Size and colors of icons, representative and intuitive icons.
3	Presentation	Icon type, size and color.
4	Suitable language	No use of technical terms and accessible language.
5	Intelligibility	Suitable language and no use of technical terms and accessible language.
6	Information	Level of interest, level of understanding and amount of data displayed.

Command response time: parameters related to access time used for an application as well as the system startup. Examples of parameters are listed in Table IV.

TABLE IV. EXAMPLE OF PARAMETERS REGARDING COMMAND RESPONSE TIME

Command Response Time		
ID	*Parameter*	*Aspects to be evaluated*
1	Response time for channel switching	Acceptable time between performing the action and its result.
2	Initialization system	Time needed for the application to reinitialize.

Audio and video: parameters for audio, video and synchronization are established. Examples of parameters are listed in Table V.

TABLE V. EXAMPLE OF PARAMETERS FOR AUDIO AND VIDEO

Audio and Video		
ID	*Parameter*	*Aspects to be evaluated*
1	Video	Display quality, including verifying distortions (video quality in terms of parameters such as bit rate, encoding type, etc.)
2	Audio	Quality, including verifying distortions (audio quality in terms of parameters such as bit rate, encoding type, etc.)
3	Synchronization	Media synchronization.

For every key factor originated from the human-computer interaction, there are several studies on the test operations performed in laboratories [10].

In general, during the development of the product or service, tests are performed until a final format is achieved, ready to be launched. However, for QoE evaluation, an already tested and reformatted product is used according to the tests performed during the development phase (for usability, see [11]). Tests performed to assess the QoE will focus mainly on the user's sensation when watching a video or performing some task, which will be evaluated according to its acceptance level. The following section describes the methodology whose objective is to shape the parameters that influence the user's QoE resulting in a QoE estimate. After presenting the methodological aspects, Section 3 presents the test conditions that should be considered to perform the estimation of QoE, explained in detail in Section 4. We will also present, in Section 5, a case study in which a QoE estimate is calculated for a T-Commerce interactive service (commerce service that could be provided by broadband networks). Finally, the conclusion and future work are presented in Section 6.

II. PRESENTING THE METHODOLOGY

The QoE analysis is connected to the users' perception on the use of technology. Thus, the purpose of the QoE estimate methodology is to provide a value that would quantify the subjectivity of the user evaluation as a form of acceptance probability threshold. Generally, users are encouraged to combine the evaluations regarding the specific use of a given service in two ways: the first is to provide a score according to a pre-established scale, and the second is to determine whether or not the service is acceptable regarding its usage only (market aspects are not included). The combination of both will be used to adjust the scale and provide an answer suitable for the target audience.

Based on the model adjustment analysis, the score and the acceptance status of the service are submitted to a

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heuristic procedure that results in the service usage acceptance probability threshold (given its characteristics). This value, which necessarily varies between 0 and 1, is the *a priori* QoE estimate for interactive services in the after development phase. This value structures market aspects and provides clear data on the number of people within the target market that would be ready to use the service according to the evaluated format. However, the same method can be applied throughout the use of the service when already settled in the market. Therefore, a score compilation algorithm and analysis can be used as a recurring evaluation to improve the service during its life cycle.

It is worth mentioning that by calculating this estimate, a preparation is required to establish the evaluation parameters, given the complexity of some types of services. Hence, the methodology includes a brief description of the service as well as the target audience. From the service description, key factors are selected for evaluation, and for each key factor, essential tasks are determined. This selection follows a set of rules, but it continues to be subjective depending on the analysts' viewpoint. The tasks, which are arranged in groups according to the key factor, are provided to one or more groups of potential users previously selected. These groups will evaluate the service according to the laboratory environment, during the *a priori* phase of the methodology. Then, the results will be analyzed according to the procedures and statistical analysis described throughout this paper. Figure 1 illustrates the methodology plan.

Each stage relies on a set of procedures that must be followed according to the rules and the analysts' critical evaluations. After the *a priori* evaluation of the service regarding QoE, two paths emerge: i) the service is forwarded for market analysis and deployed as tested, or ii) the service returns for adjustments and new laboratory tests are performed. In the latter case, the same methodology is applied following the described structure until it achieves an acceptable level of QoE and fit to be submitted to market analysis. If required, after the service deployment, QoE levels can be controlled in real time.

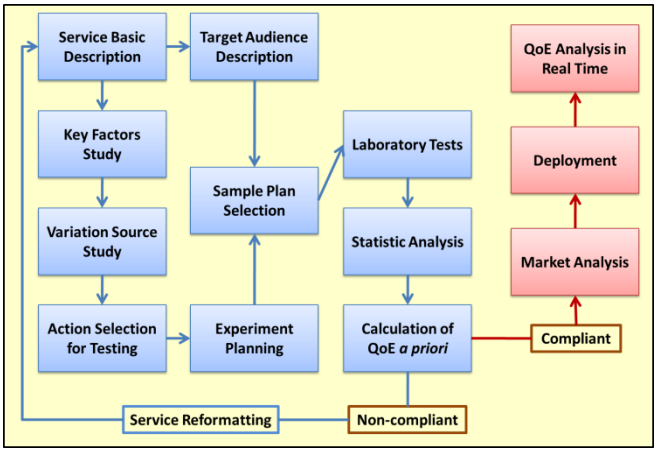

Figure 1. Methodology for QoE estimate

The next section will address the aspects related to conducting the tests in order to gather informations and users' perceptions about a general interactive service.

III. ESTABLISHING TEST CONDITIONS

The service key factors establish the laboratory test types that will be performed to estimate the QoE. By describing the service, it is possible to identify which key factors will be the centerpiece of the evaluation. So, the first step is to enumerate these factors according to the service. Based on this definition, the specialists should critically analyze the importance of each factor regarding the global use of the service. The definition of this importance, as a unit to calculate the final estimate, can adopt a multi-criteria analysis method such as, for instance, AHP ([12] and [13]) or simply the weight distribution according to the factors, so that the sum of all weights is equal to 1 (one). This importance can also be analyzed by the users that shall perform the tests. Then finally, the values are used to calculate the QoE estimate.

Regardless of the value assigned to each key factor, breakpoints can occur. Breakpoints are variable values that affect the use of a service, but they are not included in the essential setup. To state an example, the quality of the telecom network to provide a service that depends on the communication between a server and a user terminal. These breakpoints, when they occur while using the service, can affect the QoE even if the value of a given key factor is null. Therefore, the QoE estimate depends on the conditions of such variables herein named as variation sources. Some examples of variation sources that are important in the eyes of the user are:

- Network problems: network conditions can affect significantly the user's perception regarding the QoE. When structuring a service, it is expected that, even with variations in the network conditions, this fluctuation does not exceed a limit to cause the user dissatisfaction. This limit is considered the breakpoint. For QoE estimate, this variation is considered only if the probability for a breakpoint to occur is from average to high.
- Server overload problems: as more users start to use the service, a server overload is very likely to happen, resulting in a downgrade of the service. Similar to the network, the service is designed to support a maximum number of users simultaneously. For instance, in this case, the breakpoint is the number of simultaneous users that lead to the server overload. Another example is the maintenance, which reduces performance and may even interrupt the service momentarily. Only cases involving average and high probability of occurrence should be considered in the QoE evaluation.
- Corrupt service file: in general, this variation source is caused by small problems with service codes or by a type of virus. This type of variation source risk is handled throughout the testing process with developing the product. However, in some cases, it

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is assumed that some service files can be deteriorated and they can be fixed though maintenance. In this case, this variation source should only be considered for QoE calculation when its probability is from average to high. When unknown *a priori*, only the QoE evaluation in real time would provide useful data for maintenance.

- Terminal used and network access service contracted by the user: these variation sources are not included in the service structure. However, when launching a service, the entrepreneur must consider the innumerous terminals with specific characteristics. When the impact is significant depending on the terminal in use, the QoE calculation method should include tests on different terminals. For the network access service contracted by the user, the service specification must inform the potential user on the minimum network service conditions required to use the service or consider the item as "problems with the network".
- Renewable content that changes the user perception: if the service depends on the addition of new content, the user perception can vary significantly when content quality specifications are changed. The QoE is estimated according to the service structure when being tested in the laboratory. If the content quality control is not performed before the item becomes a complete service, the QoE calculation method may consider several contents from which the average is drawn. Again, this must be taken into consideration only when the probability is from average to high.

In case a variation source should occur, laboratory tests must include the simulations related to the effect of the source variation. The criteria definition to simulate the variation sources depends on the average condition and its standard deviation. Then, the simulation criteria are estimated for a final setup of the laboratory tests to be performed.

Therefore, within each key factor, actions to be performed by the users in order to use the service are described. It is not unusual for the number of possible actions to be so high that it becomes unfeasible to perform the laboratory test. It is at this moment that the specialists extract the most relevant actions related to the service being evaluated. Several actions are similar, and therefore, there is no need to evaluate all of them. Similar to the laboratory test, only one user sample is used, as well as an action sample that strictly represents the core of the service. The addition of this set of actions to be performed by the service users (part of the target audience) to the different conditions from the variation sources results in the final setup of the laboratory tests.

The actions of each key factor are tested in specific laboratories using appropriate equipment and physical conditions according to the methodology objective. The amount of test conditions depends on the number of actions to be evaluated and the conditions to simulate the variation source. For this reason, to optimize the QoE estimate, the use of condition randomization methods based on the Design of Experiments theory [14] is recommended.

Thus, every test session will include a given number of test conditions and, for each test condition, the potential user will perform two types of evaluations:

- Score for every action regarding the use of service, which can be translated into image quality, easy usage, visual comfort, audio quality, etc. This score follows the scale described next: 1 : very <negative characteristic>; 2: <negative characteristic>; 3: neither <negative characteristic> nor <positive characteristic>; 4: <positive characteristic>; and 5: very <positive characteristic>
  The description that replaces <characteristic> depends on the type of task or action that is being evaluated, for instance: 1 to perform a "painstaking" task or 4 for a good image.
- Acceptance condition, i.e., if the user thinks it is acceptable to use a service with the characteristics similar to the tested one. Only two answers are possible: yes or no.

The purpose of both questions is to fine-tune a priori what is an acceptable score for the target audience and, as a result, in real time estimates, this score would be the direct outcome of the QoE estimate. After obtaining the laboratory test results, the data are consolidated and the QoE estimate methodology is performed.

IV. ESTIMATING QOE

The first analysis to be performed is the adjustment of a curve with the following variables: Score and Acceptance. The adjustment method to be used is the logistic regression [15] that takes the form of equation (1). The Score variable is independent, while the Acceptance is dependent. For the Acceptance, the value 0 (zero) is used for a negative opinion, whereas 1 (one) is used for a positive one.

$$ln\ (p/(1-p)) = a + b*score(1) + c*score(2) + \\ + d*score(3) + e*score(4) + f*score(5) \quad (1)$$

where:
ln p/(1-p) is the acceptance or non-acceptance of the image quality;
p is the acceptance probability, for a given *score(x)*;
a, b, c, d, e, f: are the parameters adjusted by the logistic regression;
score(x): is equal to 1 if the score is *x* or *0*, otherwise

When performing the adjustment, the result will be parameters *a* and *b*. Then, to resolve the equation, parameters *a* and *b* are replaced with their corresponding adjustment values (stated here with the symbol ^). Thus, with equation (2) the value of *p* is obtained for each score value.

$$p = e^{\hat{a}+\hat{b}x}/(1+e^{\hat{a}+\hat{b}x}) \quad (2)$$

The objective of this adjustment is to fine-tune the scores that are considered acceptable for a given set of actions. Every user has a different tolerance level that may vary when translating the perception into a score. By adjusting the acceptance regarding the score, the variation is tuned and, as

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a result, a reference curve is obtained. The curve is obtained by adjusting the linear regression [16] between the acceptance probability and the scores, as shown in equation (3).

$$p_{calc} = c + d*scores \quad (3)$$

As stated previously, the purpose of the QoE estimate methodology is to provide a value that would quantify the subjectivity of the user evaluation as a form of acceptance probability threshold. The acceptance threshold is associated with the lowest acceptance probability for a given X% from a sample amongst those that received the highest acceptance score. That is, the samples are organized from the highest acceptance score to the lowest acceptance score. The score to be considered is the one given by the last tester that sums X% of the total sample. Then, the final score is compared with the results from equation (3), and the QoE of the key factor being analyzed will be its corresponding calculated *p*. In this methodology, the percentage considered is 50% of the sample with the highest acceptance (average estimate). However, this value varies according to the specialists or service representative. Figure 2 illustrates this procedure.

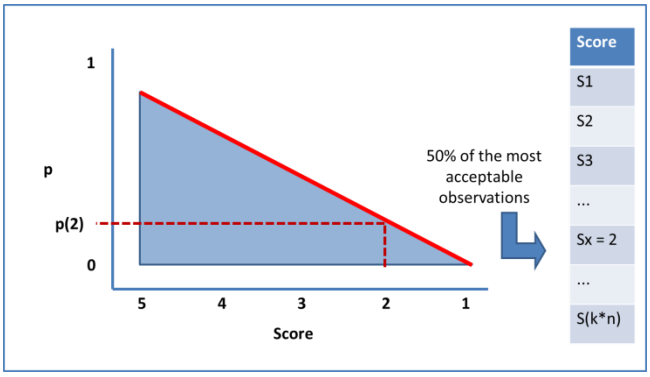

Figure 2. Acceptance probability threshold according to the best 50% score

This procedure is replicated for every key factor. To estimate the service QoE final value, the weights assigned to each factor are used. The final estimate will be calculated using equation (4):

$$QoE = w_1 * p(limite)_1 + \ldots + w_s * p(limite)_s \quad (4)$$

where:

w_i, from $i = 1$ to s, is the weight of each key factor;

s is the amount of the service key factors.

At this stage, the *a priori* methodology to estimate the QoE is completed. However, the reference curve, obtained from the linear regression, can be used to evaluate periodically the service in a real environment of usage, once it is feasible to question the user remotely, throughout its use. Consequently, it will be possible to ask the user to provide a single score.

V. APPLYING THE METHODOLOGY TO ESTIMATE QOE

As an example and in order to perform the methodology proof of concept, a service developed by CPqD and supported by FUNTTEL (Telecommunications Technology Development Fund) was selected: T-Commerce. The objective of this service is to sell products through interactive TV using the remote control. By using an interactive Digital TV terminal the user can browse through the T-Commerce window to search for products and services or check the listed ads. The key factors considered for this study are the usability and the command response time, with weights of 0.45 and 0.55, respectively. The variation source to be evaluated refers solely to the command response time factor, which assigns three server overload conditions, simulating different day-times of the service simultaneous usage. For the usability factor, a group of potential users was asked to evaluate the tasks in a laboratory environment, and for each task two questions would be answered (score and acceptance). For the command response time factor, the potential user was asked to evaluate two tasks with three server overload conditions (simulated in laboratory). Each task was evaluated regarding the command response time, from the command up to the return of the screen. Both the score and the acceptance were requested for this key factor. After obtaining the two laboratory test results, the logistic regression was performed for both key factors: usability and command response time. Probabilities for each score value were calculated according to parameters *a* and *b* resulting from the logistic regression (see the list in Table VI), as established in equations (1) and (2).

TABLE VI. ACCEPTANCE PROBABILITIES

Score	Acceptance probability – Usability	Acceptance probability – Command response time
1	0.40	0.00
2	0.86	0.60
3	0.82	0.92
4	0.92	1.00
5	1.00	1.00

After calculating the probabilities and scores, a linear regression was performed on each case being studied, as established in equation (3). The result parameters for usability factor were: c = 0.4205 and d = 0.1261. The result parameters for command response time factor were: c = -0.0159 and d = 0.24. Then, both curves are used as a reference to finally estimate the QoE. Figure 3 illustrates the reference curve for usability and command response time parameters.

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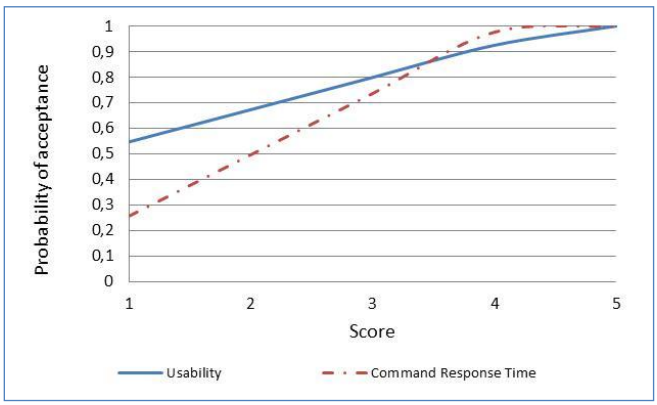

Figure 3. Acceptance probability threshold according to the best 50% score

As stated previously, the purpose of the QoE estimate methodology is to provide a value that would quantify the subjectivity of the user evaluation as a form of acceptance probability threshold. Based on the reference curve, the acceptance probability threshold is achieved considering the average observation, i.e., after organizing the data from the best to the worst scores, the score representing the observation completing 50% of all observations is selected. The score is chosen and linked to its acceptance probability, according to the reference curve. The average score of the usability factor was 4, with a probability threshold provided by the reference curve equal to 0.93. For the command response time factor, the average score was 3, which means a probability threshold of 0.70. By using the weights from each key factor, QoE *a priori* of the T-Commerce service is calculated, as established in equation (5).

$$QoE_{T\text{-}Commerce} = 0.45*0.93 + 0.55*0.70 = 0.80 \qquad (5)$$

The QoE value for the T-Commerce service shows that its current format is well accepted by the potential users. However, it is crucial to perform a follow-up of this indicator, once the command response time can change according to the number of users accessing the server simultaneously. Thus, this QoE can change significantly according to the diffusion curve regarding the service usage.

VI. CONCLUSION AND FUTURE WORK

Fine-tuning is used to provide a feeling very close to the reality of potential users, considering that the assignment of scores and words have different meanings depending on each individual. Based on the sample tuning that represents the target audience profile, the reference curve will be used as the basis for real time estimate of QoE.

The application of the methodology for QoE estimate, although presented here as a mode for the product's final evaluation, it may be used also as a mean to evaluate in development services when building the accessibility and usability features, for example. In addition, it can be used to find the lack of technical evaluation threshold, which may be of inconvenience to the user. The variation sources for each service can be evaluated in two ways. One method is to separate the estimates distinctively for comparison. The other, for the T-Commerce service, is to evaluate the situation that changes throughout the usage. The overall situations will provide the service characteristics. In this case, the number of the test environment situations must be equal to the number of real usage situations, even by estimate.

By evaluating QoE data in different communication services, it is possible to compare the results and take more accurate decisions on the design, marketing and sales. This user perception can be used to improve technical performance and achieve a satisfactory QoE. This can reduce the number of telecommunication services rejected by potential consumers.

Finally, an additional application of the methodology is introduced, which includes the periodic evaluation of QoE along the service life cycle. This application is crucial to predict the service downfall due to dissatisfaction. Therefore, improvements by adjusting QoE can be made to avoid churning. This application can be included within the service interface and its data can be extracted in real time, allowing for easy product decision making.

The methodology presented provides a mean to estimate in which level a certain interactive service would be accepted by potential user consedering technical aspects. This approach brings a probability reference curve on acceptability rather than a single score outcome. Therefore, it is usefull, especially because the user expectations about some new service is normally unknown *a priori*.

The future steps of the present work are to apply the methodology to other interactive services and to validate the outcomes in a real market basis.

REFERENCES

[1] ITU-T, Recommendation P. 10/G. 100 Amendment 1, "New Appendix I – Definition of Quality of Experience (QoE)", International Telecommunication Union, 2007.

[2] I. Wechsung, K. P. Engelbrecht, C. Kühnel, S. Möller, and B. Weiss, "Measuring the Quality of Service and Quality of Experience of Multimodal Human-Machine Interaction", Journal on Multimodal User Interfaces, vol. 6, Issue 1-2, July 2012, pp. 73-85.

[3] H. A. Tran and A. Mellouk, "QoE Model Driven for Network Services", Wired/Wireless Internet Communications – Lecture Notes in Computer Science, vol. 6074, 2010, pp. 264-277.

[4] D. K. Moore *et al.*, "Linking Users' Subjective QoE Evaluation to Signal Strength in an IEEE 802.11b/g Wireless LAN Environment", EURASIP Journal on Wireless Communications And Networking, vol. 2010, pp. 1-12, Article ID 541568, doi: 10.1155/2012/541568.

[5] ITU-T, Recommendation G.1080, "Quality of experience requirements for IPTV services", International Telecommunication Union, 2008.

[6] P. Huang, Y. Ishibashi, N. Fukushima, and S. Sugawara, "QoE Assessment of Group Synchronization Control Scheme with Prediction in Work Using Haptic Media", International Journal of Communications, Network and System Sciences, vol. 5, 2012, pp. 321-331, doi:10.4236/ijcns.2012.56042.

[7] ITU-R BT.500-13, "Methodology for the Subjective Assessment of the Quality of Televiosion Pictures", International Telecommunication Union, 2012.

 ISBN: 978-1-61208-232-5

[8] K. Seshadrinathan, R. Soundararajan, A. C. Bovik, and L. K. Cormack, " Study of Subjective and Objective Quality Assessment of Video", IEEE Transactions on Image Processing, vol. 19, Issue: 6, June 2010, pp. 1427-1441.

[9] H. R. Sheikh and A. C. Bovik, "An Evaluation of Recent Full Reference Image Quality Assessment Algorithms", IEEE Transactions on Image Processing, vol. 15, Issue: 11, Nov 2006, pp. 3440-3451.

[10] L. S. G. Piccolo, G. C. Bonadia, and C. A. Tambascia, "Technical application and HCI methods to evaluate interactive TV service QoE" (Aplicação de técnicas e métodos de IHC para avaliar a QoE de serviços de TV interativa), IHC2010, vol. I, 2010, pp. 225-230, Belo Horizonte, Brazil.

[11] C. A. Tambascia, E. M. Menezes, and R. E. Duarte, "Usability evaluation using eye tracking for iconographic authentication on mobile devices", Mobility 2011 – The First International Conference on Mobile Services, Resources, and Users, October 23-29, 2011, Barcelona, Spain.

[12] T. L. Saaty, "The Analytic Hierarchy Process – Planning, priority setting, resource allocation", McGraw-Hill, Inc. , 1980.

[13] D. Kim, "An Integrated Framework of HoQ and AHP for QoE Improvement of Network-Based ASP Services", Engineering Annals of Telecommunications, vol. 65, no. 1-2, 2010, pp. 19-29, doi: 10.1007/s12243-009-0143-9.

[14] D. C. Montgomery, Design and analysis of experiments, 8th ed., New York: John Wiley & Sons INC., 2012.

[15] D. W. Hosmer and S. Lemeshow, Applied Logistic Regression, 2nd ed., New York: John Wiley & Sons INC., 2000.

[16] D. C. Montgomery, E. A. Peck, and G. G. Vining, Introduction to Linear Regression Analysis, 5th ed., New Jersey: John Wiley & Sons INC., 2012.

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Application of QoE evaluation methodology

A study of the user's acceptance threshold regarding image quality

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***Abstract* — Taking into consideration the methodology to evaluate the user's quality of experience (QoE), the objective of this work is to evaluate the video image acceptance threshold regarding its compression ratio. The aim is to connect technical and subjective assessments gathered directly from the user. During this first phase, aspects regarding the transport network failure were evaluated. The ultimate goal of this work in progress is to obtain the technical parameters associated with the QoE, so that the best setup is used when adding videos to the Digital TV interactive services.**

Keywords-Quality of Experience; compression ratio; video; network condition.

I. INTRODUCTION

The objective of video compression systems is to reduce the bit rate required for transmission or storage with enough quality for the application. In general, two techniques are used: the exploration of the psychovisual properties of the human visual system and the reduction of the statistical redundancy in images (spatial and temporal). Depending on the efficiency of the compression algorithm used, some kinds of degradations are introduced in the video signal, which can be perceptible or not to the end user. In general, these degradations do not occur separately and the final quality perceived by the user will be affected through the combination of all the effects since the creation of the content, its encoding, packaging, transport up to the reception and display on the user's device. Due to all the technical variables influencing the image quality, the user acceptation is not necessarily determined by each of these factors. Although the technical evaluation has great importance on the final quality, it is the user's attitude towards the service (video on demand, streaming, among others) that will determine the proper level of quality. There are many studies regarding technical aspects of image quality ([1] and [2]). Those studies carry interesting and successful methodologies to assess technical variables on image. But on a market point of view, the best quality is not always requested. The best quality is not always perceived by end users and their previous experiences about a particular service. To include user's perceptions on assessment process provides information on balance between the "best" and the "enough", optimizing the use of resources to deliver a service. As stated in [3], 'methods to assess the visual quality of digital videos as perceived by human observers are becoming increasingly important…'. This study takes into consideration the user opinion about quality of images. The concept of Quality of Experience has taking much attention for all kind of service and it is being used for a variety of issues ([4], [5] and [6]).

Quality of Experience (QoE) can be defined as the acceptance of an application or service subjectively perceived by the user regarding performance and usefulness, including system components (terminal, network, service infrastructure, etc.), as well as context of use and end-user expectations [7]. Nevertheless, the assessment of services that takes into account the user's opinion is largely based on a single score ([3] and [8]). When assessing a service, it must take into consideration that people have different expectations and they translate these expectations in distinct manner for each distinct service. For this reason, this paper will consider a methodology that combines two answers from users: The score on a well known five point scale and the binary answer about whether the service (or video image in the case) is acceptable for use on a routine basis. This approach will provide a reference curve of score and acceptability which accounts for the target market and the assessed service.

Considering the methodology to evaluate the user's QoE [9] based on laboratory tests, the purpose is to evaluate, throughout several video sessions, the threshold of the technical variables values that will be perceived by the user, and which are not accepted by the market.

The typical procedure for subjective evaluation consists of submitting to a group of evaluators a sequence of video streaming within a controlled environment. Based on these sequences, the evaluator is asked to give an opinion on the quality and acceptance in watching a program with the same image quality level. After the opinions are gathered, a statistical analysis is performed resulting in numbers for comparison.

The purpose of the work in progress is to evaluate, at first, different video compression ratios (considering the same codec used for all five cases) in the viewpoint of the user's QoE. The following steps will be to introduce simulations regarding the network quality in the user's perception. This paper analyzes two network quality cases (simulated on laboratory) in addition to five compression ratios. The ultimate goal for future work is to obtain data based on different types of images with five video compression ratios and through several packet loss

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simulations (in order to simulate network conditions), so that a threshold value is obtained regarding the users acceptance.

At first, the compilation of scores and the acceptance regarding the image quality are performed in order to evaluate the user's QoE. Then, these values are submitted to a logistic regression, with categorical variables (see, for instance, [10]) regarding acceptance probability evaluation according to the score. Based on this set of probabilities, the linear regression between the scores and the probabilities is performed in order to obtain the reference curve. In this methodology, the final value of the QoE is the probability obtained from the data average score of 50% of the most positive scores. As a standard, only probabilities above 0.7 will be deemed acceptable. In the following sections, the laboratory test conditions, the analysis and the preliminary results will be presented.

II. TEST PREPARATION

During the first phase, where the objective was to evaluate separately the user's perception regarding the image quality according to the video compression ratio, simulation preparation procedures were performed to be presented to the user.

First, nine 11-second images were selected with different levels of complexity, such as movement, landscape, drawings, etc. Each image went through five video compression ratios: 3 Mbps, 6 Mbps, 9 Mbps, 12 Mbps and 15 Mbps. Furthermore, each compression ratio condition also passed through a packet loss to simulate transport network failure. As a result, 90 test conditions would be evaluated. Every single test condition was evaluated at least by ten users. The video room was fitted with a 42" TV and three seats for the evaluators at a distance of three meters from the TV set. As a whole, ten 15-minute test sessions were performed with three evaluators each, as well as a number of random image conditions (see design of experiments methodology by [11]). Each evaluator was given a questionnaire with the following questions:

- What score would you give image 1: 5, Excellent; 4, Good; 3, Average; 2 Poor; or 1, Very poor?
- Would you watch a program with this image quality?

The evaluators were requested to answer the two questions for every displayed image.

The data for analysis were obtained only after the ten laboratory test sessions were performed, with each condition repeated ten times. The purpose of the different complexity levels of the images was to obtain the average score of the displayed videos that simulate standard TV programs. For this reason, they were not considered as variables to be studied. The variables considered for user QoE analysis include the compression ratios divided in five levels and the packet loss divided in two: with and without loss. The following table illustrates the analysis.

TABLE I. CONFIGURATION OF PERFORMED TESTS

Compression Ratio	*Without packet loss*	*With packet loss*	*With and without loss*
3 Mbps	Yes	Yes	Yes
6 Mbps	No	No	Yes
9 Mbps	No	No	Yes
12 Mbps	No	No	Yes
15 Mbps	Yes	Yes	Yes

(*) Although all types of combinations were calculated, only the extremes are analyzed in this paper.

The analyses presented in the next section are:

A comparison between the QoE estimate at a compression ratio of 3 Mbps and 15 Mbps (both with and without packet loss): the main goal is to evaluate whether packet loss simulation was perceptible to the user so that other simulations are created with more loss conditions during the next tests (higher or lower than the current test).

A comparison between the compression ratios, considering both packet loss conditions: the objective is to evaluate the compression ratio separately and to determine the ratio perceptible to the user in terms of QoE.

III. ANALYSIS

The QoE analysis is connected to the users' perception on the use of technology. Thus, the purpose of the QoE estimate methodology used is to provide a value that would quantify the subjectivity of the user evaluation as a form of acceptance probability threshold. As stated previously, the evaluator was requested to give a score according to the pre-established scale and then determine if the image quality is acceptable for a standard TV program. The combination of both will be used to adjust the scale and provide an answer suitable for the target audience.

Through an analysis based on model adjustments, the scores and the acceptance status of the service are submitted to a logistic regression, followed by a linear regression that results in a reference curve (given its characteristics). This value, which varies between 0 and 1 necessarily, is the QoE estimate. This value structures market aspects and provides clear data on the number of people within the target market that would watch the program within the evaluated format.

Equation 1 shows the logistic regression adjustment:

$$ln\ (p/(1-p)) = a + b*score(1) + c*score(2) + d*score(3) + e*score(4) + f*score(5) \quad (1)$$

where:

In p/(1-p) is the acceptance or non-acceptance of the image quality;

p is the acceptance probability, for a given *score(x)*;

a, b, c, d, e, f: are the parameters adjusted by the logistic regression;

score(x): is equal to 1 if the score is *x* or *0*, otherwise.

Equation 2 shows the acceptance probability:

$$p = e^{\hat{a}+\hat{b}x}/(1+e^{\hat{a}+\hat{b}x}) \quad (2)$$

where *b* is the parameter for *score(x)*.

After calculating the probability for each score and each test condition, the reference curve was adjusted by the linear regression. The results are presented in two parts. Firstly, the analysis is performed considering the comparison between the images with the five compression ratio values, without distinguishing whether or not there is a packet loss. Then,

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another analysis is performed to assess if the procedure used to simulate the packet loss is perceived by the user. To do so, the video compression ratios at 3 Mbps and 15 Mbps with and without packet loss are compared. Table II lists the probability values according to the reference curves in both analyses:

TABLE II. ACCEPTANCE PROBABILITY BY SCORE – ANALYSIS 1

	Analysis 1				
Score	*3 Mbps*	*6 Mbps*	*9 Mbps*	*12 Mbps*	*15 Mbps*
1	0.04	0*	0*	0*	0*
2	0.24	0.20	0.2	0.17	0.19
3	0.45	0.46	0.45	0.44	0.44
4	0.65	0.71	0.69	0.70	0.69
5	0.86	0.96	0.95	0.97	0.93

(*) Minimum and maximum approximate values.

TABLE III. ACCEPTANCE PROBABILITY BY SCORE – ANALYSIS 2

	Analysis 2			
Score	*3 Mbps without packet loss*	*3 Mbps with packet loss*	*15 Mbps without packet loss*	*15 Mbps with packet loss*
1	0.12	0*	0*	0*
2	0.29	0.22	0.17	0.21
3	0.46	0.45	0.41	0.48
4	0.63	0.68	0.65	0.74
5	0.80	0.9	0.89	1*

(*) Minimum and maximum approximate values.

After the calculation, the reference curves were adjusted to the five compression ratio cases and the four combinations between the compression ratios and the packet loss status. The purpose of reference curves is to associate the given score with the QoE estimate in cases when scores given by the users are still required, even after the product is launched. Figure 1 illustrates the five adjusted reference curves, while Figure 2 shows the four curves related to the packet loss status.

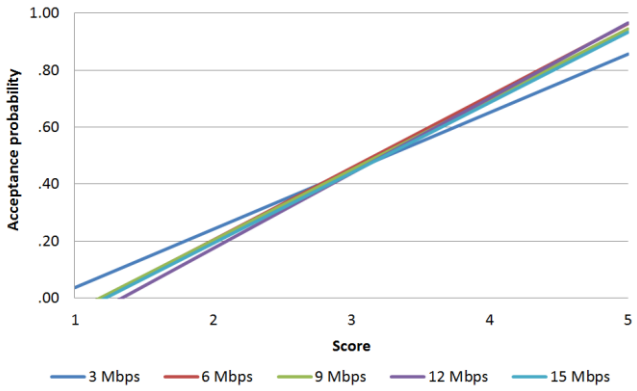

Figure 1. Reference curve – Analysis 1

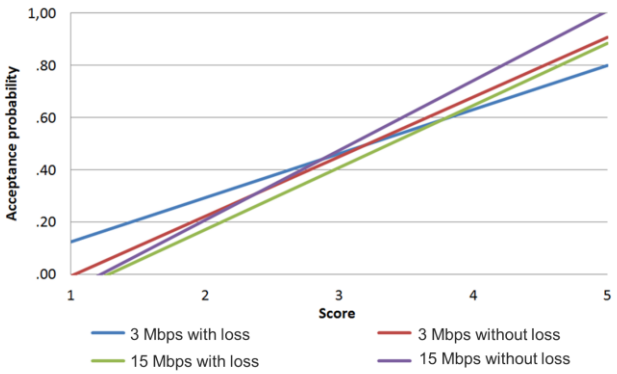

Figure 2. Reference curve – Analysis 2

In this context, the QoE estimated is the probability obtained from the curve regarding the average score of 50% of the data compiled during the laboratory tests. Figure 3 shows the QoE estimate of each compression ratio setup.

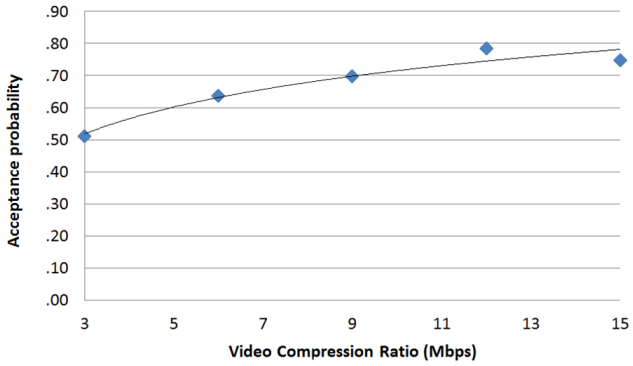

Figure 3. Quality of Experience estimate

As shown in Figure 3, the QoE level increases according to the compression ratio, which means that the user is aware of the difference in quality between the images. However, the perception is decreased when considering compression ratios at 12 Mbps and 15 Mbps. The QoE values are established by the probability of a person to agree to watch a program with the image quality under evaluation. Furthermore, the probability for the person to accept the service, considering that he/she belongs to the 50% potential users, is 0.75 for the 15 Mbps compression ratio and 0.78 for 12 Mbps. Within the acceptance criteria, the user considers the images with 9 Mbps compression ratio to be of good quality, even if the difference with better ratios is perceptible.

To evaluate if the criteria to run the network interference simulation, with random packet loss throughout the video, cause changes in the image quality, tests were performed comparing high-quality and low-quality images, with and without packet loss. Figure 4 shows the QoE estimate for each case. Simulation 1 represents cases with no packet loss, whereas Simulation 2 represents packet loss.

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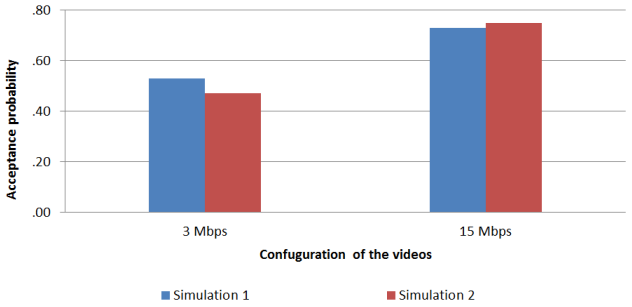

Figure 4. Quality of Experience estimate

The analysis shows that the difference obtained from the comparison is due to the compression ratio. When this characteristic is discarded, 3 Mbps image quality is perceived less in Simulation 2 than in Simulation 1. However, when performing the chi-square test to evaluate whether there was a significant difference, the result was 0.99. By comparing the calculated value (0.99) with the value from the chi-square table, considering 5% significance (3.84), the result indicates that there is no evidence the packet loss simulation is perceived by the user regarding image quality. On the other hand, by comparing the compression ratios, both with packet loss, the calculated value of the chi-square test was 12.11, much higher than 3.84. This means that the image quality level is perceived by the user.

IV. FINAL CONSIDERATIONS

At this fist part of the project, the analyzed data was used to evaluate the user perception mainly regarding the different video compression ratios, considering a group of images with different levels of complexity. The objective was to evaluate if the user perceived the difference in the image quality and when it would be acceptable. The results obtained from the analysis showed that there is a perception and the images with compression ratios above 9 Mbps are accepted, according to the established criteria. Nevertheless, the difference between the 6 Mbps and 9 Mbps compression ratios is considerable only with 10% significance level. Images with 3 Mbps compression ratio are substantially distinct from all other conditions.

To evaluate the packet loss status, a specific methodology for randomized image degradation was used. The result was not perceived by the user. Therefore, to evaluate the tolerance thresholds on the network aspects, new simulations with specific packet loss techniques with a larger scope than the one used in this study must be performed.

Similarly, other variation sources will be the object of analysis in future studies. Examples of variation sources are: network parameters and the different sizes and technologies used in the receivers. The objective is to obtain a response surface in order to evaluate how the set of parameters contributes to a tolerance threshold or acceptance of a program in the user's perception, translated in QoE estimates.

REFERENCES

[1] Z. Wang, L. Lu, and A. C. Bovik, “Video Quality Assessment Based on Structural Distortion Measurement”, Signal Processing: Image Communication, vol. 19, no. 2, Feb. 2004, pp. 121-132.

[2] C. Yim and A. C. Bovik, “Evaluation of Temporal Variation of Video Quality in Packet Loss Networks”, Signal Processing: Image Communication, vol. 26, no. 1, Jan. 2011, pp. 24-38.

[3] K. Seshadrinathan, R. Soundararajan, A. C. Bovik, and L. K. Cormack, “ Study of Subjective and Objective Quality Assessment of Video”, IEEE Transactions on Image Processing, vol. 19, Issue: 6, June 2010, pp. 1427-1441.

[4] I. Wechsung, K. P. Engelbrecht, C. Kühnel, S. Möller, and B. Weiss, “Measuring the Quality of Service and Quality of Experience of Multimodal Human-Machine Interaction”, Journal on Multimodal User Interfaces, vol. 6, Issue 1-2, July 2012, pp. 73-85.

[5] H. A. Tran and A. Mellouk, “QoE Model Driven for Network Services”, Wired/Wireless Internet Communications – Lecture Notes in Computer Science, vol. 6074, 2010, pp. 264-277.

[6] D. K. Moore *et al.*, “Linking Users’ Subjective QoE Evaluation to Signal Strength in an IEEE 802.11b/g Wireless LAN Environment”, EURASIP Journal on Wireless Communications And Networking, vol. 2010, pp. 1-12, Article ID 541568, doi: 10.1155/2012/541568.

[7] ITU, Recommendation G.1080. “Quality of experience requirements for IPTV services”, 2008.

[8] J. Xu, L. Xing, A. Perkis, and Y. Jiang, “On the Properties of Mean Opinion Scores for Quality of Experience Management”, IEEE International Symposium on Multimedia (ISM – 2011), Dec. 2011, pp. 500-505, doi: 10.1109/ISM.2011.88.

[9] G. C. Bonadia, C. A. Tambascia, and E. M. Menezes, “Standardizing the Evaluation of QoE by Users – A Methodology to Estimate the Acceptance of Interactive Services”, The Fifth International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies and Services (CENTRIC 2012), Nov. 2012, in press.

[10] D. W. Hosmer and S. Lemeshow, Applied Logistic Regression, 2nd ed., New York: John Wiley & Sons INC., 2000.

[11] D. C. Montgomery, Design and analysis of experiments, 8th ed., New York: John Wiley & Sons INC., 2012.

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An Approach to Developing an Agent Space to Support Users' Activities

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Abstract— **Information and communication technology and ubiquitous technology allowed developing smart services for supporting users in their daily life. However, users experience great difficulties for finding rapidly the information they need when they need it, essentially because the current information systems seems to be based on a system-centric approach. In this paper, we discuss a new approach centered on users' requests, using an Agent Space that contains Personal Agents, Social Agents and a Mediation Agent. We distinguish between Real Space, the space in which the user lives and Digital Space, the space containing social information. A personal agent interacts with a user to recognize the user's activity in real life and a social agent interacts with objects in Real Space and with social information data in Digital Space. A Mediation Agent saves social information according to its role and distributes it to all interested agents. The agents are designed to run on the OMAS platform, a distributed multi-agent platform.**

Keyword-multi-agent system; personal assistant; agent platform; agent space.

I. INTRODUCTION

The growth of Information and Communication Technology enables us to receive various kinds of information from the Internet using high performance personal computers and recent advanced network technology. Many people can easily send (store) and receive (use) information in a Digital Space (DS). After a while however, the DS ends up containing a large amount of data and information.

Furthermore, the rapid development of ubiquitous technology also enables information systems to access Real Space (RS) through mobile communication devices like smart phones. Various kinds of sensor devices can also be deployed anywhere in the RS and large amounts of multimodal information about users and their surroundings can be acquired and saved in the DS. Using such information, very convenient services called "anytime" or "anywhere" can be provided for users, daily and widely [1].

However, users have a difficult time finding the information and help they need when they need it, because it may be hidden in an enormous amount of useless information in the DS [2]. When a user has to look for some event or for somebody in the RS through the information the DS provides, the user may have to operate different applications and interfaces. Unskilled users may loose important opportunities they could exploit if they had the skill to work with complex information systems.

The agent-based technology is one of the possible solutions for distributing information from the DS to an unskilled user in the RS [8]. An Agent Space (AS), built as a well-designed collection of agents, can be a platform to meet users' requests in the RS using proper social information from the DS [6]. The users' requests change continuously following their activities in the society. Similarly, the contents and organization of the social information in the DS change according to the changes in the society in the RS. Thus, meeting users' requests with social information can be very difficult for conventional static algorithms when they try to solve the problem autonomously. This is a reason why users need skills to handle the computer and the network efficiently. Moreover, skilled users waste their time watching web sites and data in the DS.

Because current information systems have been designed using a system-centric approach generally so far, users have problems finding information rapidly. Our approach on the other hand is user-centric and we design an Agent Space that is deployed between the RS and the DS in order for agents to match users' requests with proper social information.

In this paper, we aim at developing an agent space that consists of Personal Agents, Social Agents and Mediation Agents. An agent in this paper is designed as a complex cognitive multi-threaded system that has a function of recognizing, choosing goals and intending to use them, having knowledge, performing actions and using memory. Such functions are provided for agent developers by the OMAS platform and we extend the platform by connecting it to sensors and devices in the RS that behave as if they were OMAS agents [3]. Finally, we discuss an example of an Agent Space supporting work activities of coworkers at an office by watching them through sensor agents.

II. AN AGENT SPACE INTERACTING WITH REAL SPACE AND DIGITAL SPACE

A collection of agents is called an Agent Space (AS) in which all agents receive events and perform actions from/to objects in RS/DS. We assume in this paper that all agents run on distributed multi-agent platform connecting them over the Internet and LANs and includes knowledge base functions provided by the associated MOSS environment [4], and interface functions that connect agents to RS/DS.

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An AS, shown in Fig. 1, consists of Personal Assistant Agents (PA), Social Agents (SA) and a Mediation Agent (MA). A PA interacts with a particular user to support the user answering requests and following the user in RS. An SA interacts with DS to acquire social information represented by data in the DS. The MA selects and saves a particular domain of social information according to its given role and it distributes it to interested agents of the AS.

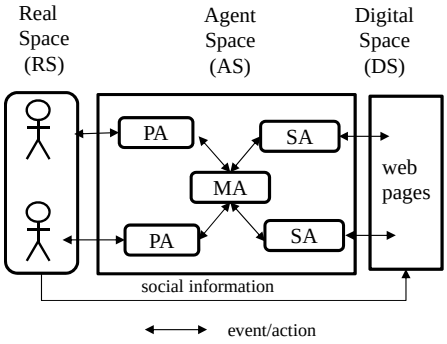

Figure 1. Agent Space Interacting with RS and DS

Until now, many research projects, such as Ambient Intelligence or Smart House, have led to and promoted ubiquitous technology using sensors and actuators like cameras, microphones, or speakers deployed in the RS. Furthermore, many research works like Web Service Computing, Semantic Web, Web Mining, have promoted the Web Service technology in DS, to make the DS data machine readable using knowledge-intensive frameworks.

The technology is bringing in functions to recognize user's actions, to help user's actions automatically, to mine social information from data in Web pages, such as the service of Social Network, and to post news automatically to interested users of a domain. The functions are incorporated in particular application to provide each particular domain a smart service for users. In this case, users must have the skills to select and utilize such services depending on their situation and what they want to do.

In this paper, we discuss the integration of the function of ubiquitous technology and web service technology through an AS from a user-centric point of view: We examine the following points:

(1) modeling a Basic Agent to define a common agent architecture in AS,

(2) agentifying programs of ubiquitous and web service functions for AS to interact with RS and DS,

(3) modeling PA, SA and MA by modifying the Basic Agent model to give each of them a role and appropriate knowledge.

III. A MODEL OF A BASIC AGENT

A. A Model of a Basic Agent

An agent space, shown Fig. 1, is a multi-agent system consisting of Basic Agents (BAG) and Event/Action Agents (EAAG) as shown in Fig. 2. A BAG is a component of PA, SA and MA implementing a logical process and using knowledge models. An EAAG is a component agent of PA, SA and MA dealing with interactions with RS and DS according to its role . A BAG receives events from agents and sends actions to agents as shown in Fig.2. An event or action is described by a message between agents that are defined in the OMAS framework. The content of an event/action is defined by an Agent Space Ontology letting agents communicate and cooperate with one another.

An EAAG receives events from agents and sends actions to agents. It also receives events from sensors in RS and descriptions from DS. It sends signals to control actuators and descriptions to write data into DS. EAAGs transform signals and descriptions into an event that is defined in the Agent Space Ontology. The EAAGs also transform actions from other agents into signals to control actuators in RS and descriptions to change data in DS.

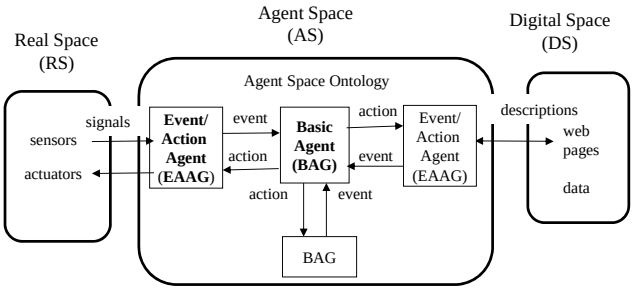

Figure 2. Basic Agent and Event/Action Agent

As shown in Fig. 2, a BAG has three kinds of knowledge named Memory, Knowledge and Goal in order to make an action to the RS and the DS using devices according to events acquired through sensors deployed in the RS/DS. The BAG also makes actions of sending messages to other BAGs and receives messages as events from other BAGs. Memory, Knowledge and Goal are all modeled by the Property Driven Model that is a frame-based knowledge model [4], and saved into knowledge bases that are managed by the MOSS knowledge base management system [5] provided in the OMAS agent platform.

```
agent BAG (event)
data:      Memory, Knowledge, Goal
  Memory <- Cognition( event,);
  action   <- Decision( Memory);
  Memory  <- Intention( action, Memory);
do action
```

Figure 3. Procedural Descriptopn of a Basic Agent

A structure for an agent was proposed by Russel and Norvig [10]. Based on the structure of agents, Fig. 3 shows a BAG procedure for selecting an action. It consists of three functions Cognition, Decision and Intention. A function of Cognition updates a Memory following the reception of an event from the RS/DS. Memory is a knowledge base that

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represents the current state of the world of an agent and records the history of actions the agent has done. We specify a basic model of the world for an agent, common to all agents when they begin to run on the OMAS platform. The knowledge of the environment and of the society of a user is represented as a set of class objects, and instance objects generated from the knowledge and saved in a Memory in each agent. The event in Fig. 3 is described as an instance generated from the knowledge of environment and society.

The Decision function in Fig. 3 returns an action of the BAG for controlling a device, referring to Memory, Goal, Actions. The action is defined in the knowledge base named Action and can be executed by a device of Fig. 2. The Intension function in Fig. 3 updates a Memory that records a history of actions and a prediction that the BAG intends to change a state in the RS before it received an event.

In this paper, a model describing the knowledge of the RS and DS is represented by a frame-oriented knowledge representation model Property Driven Model [4]. The function of transforming signals from sensors in the RS into an event described by the model of the RS and the DS, that defines descriptions of a knowledge base named Memory in Fig. 3, is assumed to be processed in the sensor of Fig. 2 in the RS. The data in the DS are also transformed into the descriptions defined in the model M. The Memory in Fig. 3 represents a current state of the RS and DS as a memory of a BAG.

B. Agentification of Sensors and Devices

The concept of agentification was discussed by Shoham as a component of the Agent-Oriented Programming framework that refers to bridging the gap between the low-level machine process and the intension level of agent programs [11]. In this paper, the concept of agentification is used to connect the AS, the RS and the DS. Agentification is a method to connect a program, a sensor and devices into an agent that communicates with other agents in the AS using an Agent Communication Language as shown in Fig. 5. When a system that runs in an executing platform autonomously becomes operational for a BAG thanks to a function, then we say that the function agentifies the system. An agentified system communicates with other BAGs as a BAG with Agent Communication Language although the inner architecture of the agentified system is different from a BAG.

For example, in Fig. 4, we suppose that a system consisting of a recognition program and a sensor keeps recognizing the position and poses of a user in the RS. The recognition program receives signals from a sensor and transforms them into a perception of poses and positions that is defined by a representation of a knowledge model of a BAG in Fig. 4. An agentification program creates a message consisting of items including a description that represents an event perceived in the AS recognized by a recognition program and a sensor.

On the other hand, an action from a BAG is sent to an agentified system to control a device giving an effect to an object in the AS. A message from an agent is transformed into a command for a control program of the device. A program to transform a result of a recognition program into a message and to transform a message into a command to a control program is called a base program of EAAG.

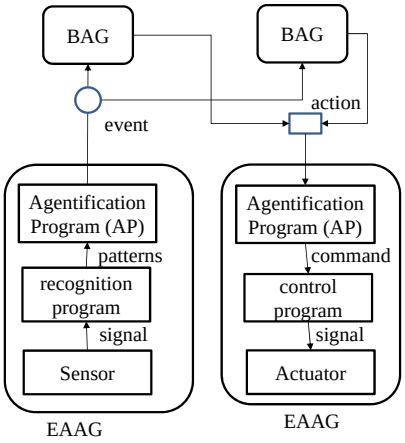

Figure 4. Structure of Event/Action Agent

A basic function in an EAAG has an inner state and decision function logically the same as for the BAG defined in Fig. 3. It receives a message from a BAG and a perception from a recognition program. It sends a message to a BAG and a command to a control program, based on functions of Cognition, Decision and Intention referring to knowledge bases in Fig. 3. However, the basic functions of an EEAG are currently implemented by a simple C++ program.

An advantage of the agentification is to be able to share a number of systems consisting of sensors and devices in the RA by agents in the AS. Agentification is an effective method for implementing a user-centric information system as shown in Fig. 1.

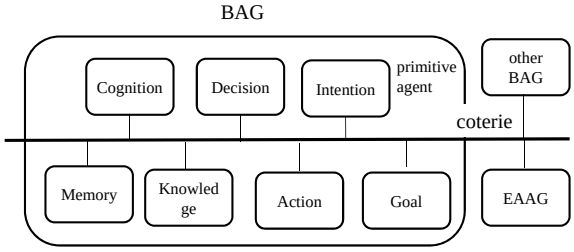

Figure 5. Multi-agent-based Architecture of a Basic Agent

Fig. 5 shows the internal architecture of a BAG as defined in Fig. 3. A BAG is a multi-agent system consisting of primitive agents that are programmed using an OMAS agent programming language. The OMAS agent platform allows to implement many agents that work in a runtime environment as a multi-agent system. Every function and every knowledge base is implemented as a BAG or a system of BAGs. A space where BAGs work using broadcast communication is called a coterie. Other BAGs and EAAGs can join a coterie to cooperate.

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Fig. 6 shows the architecture of a primitive generated on an OMAS agent platform. A primitive is a multi-threaded system. It has an internal knowledge base management system to manage several knowledge bases, because the models introduced previously like Memory or Knowledge will be huge and will have to be divided into several sub-models. A scan process deals with an input message (event) to analyze the message as shown in Fig. 6. If it is a message asking for information or requesting to execute a task, then the primitive agent searches its knowledge base generating dynamically a task process (a new thread) then eventually sending a message to another primitive agent in the BAG as a subtask.

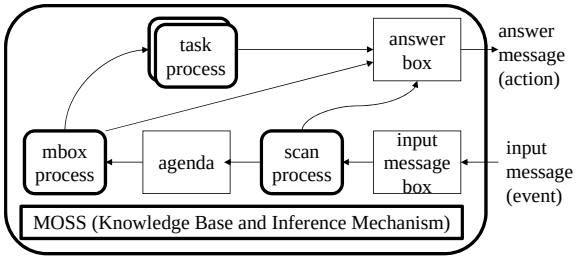

Figure 6. Structure of a Primitive Agent of OMAS platform

IV. DESIGN OF AGENT SPACE

Fig. 7 shows the structure of an AS consisting of three types of BAGs that are PA, SA and MA. Users live in the RS and work supported by PAs that find information in the DS. In this paper, we assumed that PAs and SAs in the AS can interact with users and objects through EAAGs that control sensors and devices deployed in the RS/DS.

A PA is a BAG that interacts with a single user, called its master, in order to support her persistently. A PA also interacts with objects and events through sensors and actuators deployed in the RS. A PA has a user model (UM) of its master described in a knowledge base for interacting with its master tightly and continuously.

A series of signals from a sensor is transformed into a set of descriptions modeled by the Memory component of a BAG. It is a list of symbols defined by a protocol between the devices and the PA. An action is a list of symbols defined by a set of descriptions modeled in the Memory component of the BAG. It is specified by a protocol between the output devices and the PA. The action is transformed into a series signals for controlling the devices [9]. A PA has ontologies that represent a level of cognition. A set of descriptions modeled by the Memory component is a list of symbols defined by the higher level of the ontology. It

represents the cognition of the PA and is shared by other PAs and BAGs. Messages may include the set of descriptions modeled by the Memory component in their content, and are exchanged among agents that are related.

The goal of a PA is to support its master to find the user's requests by conversing with her and following her through the sensors. When the PA recognizes a request from the user, it sends a message to another agent asking it to process the request. Agents process tasks cooperatively with other agents in the AS. They can be pre-installed or added dynamically according to provider needs.

A Social Agent SA is a BAG meant to search and save information concerning a particular social domain in the RS/DS. It provides it to other BAGs by accessing resources in the DS, using their communication protocols [7]. SAs also search and save information concerning a particular social domain in the RS by accessing sensors embedded in the RS. SAs acquire social information from sensors deployed in the RS directly like PAs.

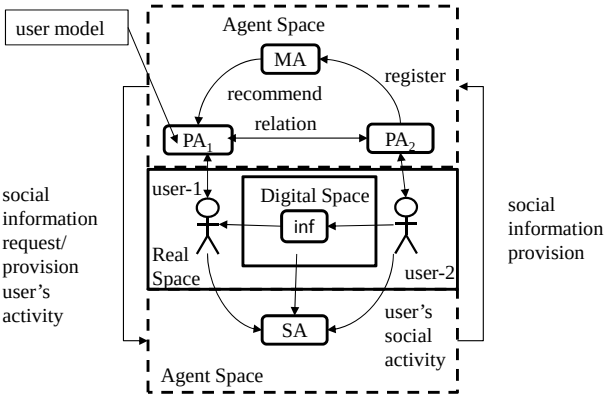

Figure 7. Structure of Agent Space

The agent space AS is a collection of agents resulting of a bottom up approach like web sites and new users. Users of the AS create their own PAs and SAs to their convenience and according to their interests. Some users may want to use the AS as a place to deliver advertising information. A Mediation Agent is a BAG for finding relations between BAGs in the AS and providing information about such relations.

When an agent is generated in the AS, it has an initial set of relations to some MAs for sharing information. It must acquire knowledge by watching actions and exchanging information. Knowledge acquisition by combining users' actions and shared knowledge is a growing and active area of study [12].

V. DESIGN OF PERSONAL AGENT AND SOCIAL AGENT TO SUPPORT SOCIAL ACTIVITIES OF A USER

A. Design of Personal Agent

A PA is designed for a particular user who owns it and installed in the AS that interacts with the RS and the DS. The PA supports its master according to the user's requests based on a user model. It cooperates with other PAs, TAs and SAs as shown in Fig. 7. If the user model is not adapted to the agent's goal, the user cannot receive better services from the DS. Actually, a PA for a user is designed with goals,

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knowledge and properties different from other PAs because each user has different goals, knowledge and properties.

Therefore, a PA should have the ability to acquire a user model and preferences after it is installed and runs in the AS. Acquiring a user model is still a difficult problem in artificial intelligence. However, it is very important for the user-centric program to be able to acquire user's properties to make a user-centric service.

In order to develop a PA dedicating its actions to supporting its master, we have to design the following BAG functions adding to the conventional fundamental functions of agents:

(1) several built-in knowledge bases of a general owner user model and a general society model adding to Memory, Knowledge and Goal,

(2) set-up function of the models of an owner user when it is installed in the AS,

(3) function to update the model of the owner user regarding actions in the RS and requests to it,

(4) function to update the social model regarding actions of the owner user with other users in the RS.

Therefore, we extended the BAG decision procedure defined Fig. 3 to define a new procedure for a PA as shown in Fig. 8. A PA incorporates two knowledge bases: UserModel (UM) and a SocialModel (SM) adding to the knowledge bases shown Fig. 8 to answer the item (1) described above. A PA also incorporates two functions: UpdateUM and UpdateSM in the procedure of a BAG as shown in Fig. 8 to answer item (3) and (4). A variable named userModelFlag is introduced to invoke a conversation graph to initialize the Memory, UserModel and SocialModel through a dialog with the master to answer item (2). While the userModelFlag is ON, the PA continues the dialog with the user to add new information to the knowledge bases.

B. Design of Social Agent

An SA keeps watching social relations between users in the RS using event in the RS and the DS sent by the agentification program (EAAG) as shown in Fig. 4. An SA shares messages concerning events from the RS with PAs in order to keep watching over dedicated user domains, like a family, an office, a section of a factory, or a special interest group.

The SA incorporates a SocialModel shared by PAs having interests in a domain they are designed to support. The SocialModel is a knowledge base representing relations between users belonging to the domain, social activations of each user and domain knowledge to describe special configurations, roles in a society and so on. The UpdateSMl is a knowledge-based procedure in particular a definition of the domain, maintenance of the SocialModel, interrelations between domains.

When the SA recognizes a relation between users, the relation is saved in the SocialModel by a pattern of events sent by sensors. Therefore, in the process of recognizing a social relation, the SA begins to build a hypothetical relation and waits for the following events from the AS to verify the hypothesis as shown in Fig. 9. The hypothesis is saved and managed in a knowledge base of SocialHypotheses and is changed and verified by a function Watch shown Fig. 9. After the hypothesis is verified, a SocialModel of the SA is maintained by the UpdateSM function.

```
agent PA (event)
referTo: Memory, Knowledge, Goal, UserModel, SocialModel;
  Memory      <- Cognition( event);
  UserModel  <- UpdateUM(Memory);
  SocialModel<- UpdateSM( Memory, UserModel );
  action         <- Decision( Memory, UserModel, SocialModel);
  Memory  <- Intention( action, Memory);
do action
```

Figure 8. Procedure of a Personal Assistant of OMAS platform

```
agent SA (event)
referTo: Memory, Knowledge, Goal, SocialModel, SocialHypothesis;
  Memory      <- Cognition( event);
  SocialHypothesis <- Watch( Memory);
  SocialModel <- UpdateSM(Memory, SocialHypothesisl);
  action         <- Decision( Memory, SocialModel, SocialHypothesis);;
  Memory  <- Intention( action, Memory);
do action
```

Figure 9. Procedure of Social Agent of OMAS platform

VI. AN EXAMPLE OF AN AGENT SPACE FOR OFFICE WORKERS

Fig. 10 shows an example of a system for applying our AS design to support workers at an office space. Agents in Fig. 10 run persistently in the AS playing different roles. In a simple situation we assumed that a worker user-1 and a worker user-2 are working in the same office. A personal agent PA_1 watches user-1 and another, PA_2, watches user-2 continuously through sensors. PA_1 and PA_2 have models of their users and user's social activities. For example the user is working in the office now. However, if PA_1 doesn't know that user-2 is a colleague of user-1 at a company he belongs to, then the PA_1 does not know the name of the PA of user-2. PA_2 seems to be in the same situation. A problem in this example is how the two agents can cooperate in order to support a collaborative relation between their masters working in the office in the RS.

We are aiming at solving the problem to develop an SA to watch the office space using sensors. The SA has a social model of collaboration at an office and regards the two users as a pair of coworkers when a user comes close to the desk of another user to engage in a conversation. The information of a relation that user-1 and user-2 work together at an office may be sent to an MA that supports a group of PAs of workers in an office space. We suppose that, when a worker begins to start working in the office space, the PA of the user registers to an MA. Then the MA knows that PA_1 and PA_2 are personal agents of coworkers and sends that information to PA_1 and PA_2. Then, the two PAs include the knowledge into their social model. Using that knowledge,

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the two PAs can support the collaboration of the two users as shown in Fig. 11.

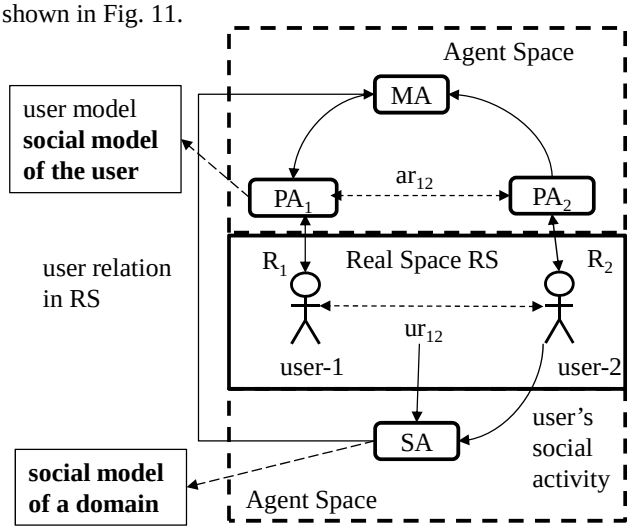

Figure 10. Architecture of a Primitive Agent of OMAS platform

We are developing an example of an Agent Space on the OMAS agent platform. The platform provides an agent programming language, an agent communication language and a knowledge representation language to incorporate knowledge bases in any agent for developers of agent systems to install the functions of BAGs designed in Fig. 3. PAs and SAs receive messages from sensors via Connection Programs programmed in C++. The Kinect, pressure sensors, cameras and microphones are used as sensors in this example. Each PA converse with a particular user using natural language through a keyboard and a display and through a vocal speech interface partially.

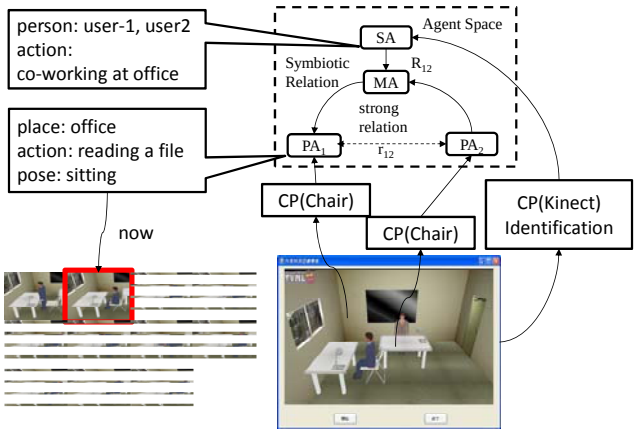

Figure 11. An Example of a Relation between two Workers

A set of descriptions that represent sitting poses of a worker in a knowledge base of a user model is common to all PAs and is initially installed in each PA. A PA should acquire social situations of work dynamically.

VII. CONCLUSION AMD FUTUREWORK

We aimed at developing an Agent Space containing Personal Assistant, Social Agents and Mediation Agents, in order to make information systems in the Digital Space user-centric and to reduce users' cognitive load. Our approach to develop user-centric information systems was to introduce an agentification method using an agent platform in order to connect the agent space to the Real Space and to the Digital Space. The agentification function wraps a sensor and a recognition program into an agent that works on the agent platform. By cooperating with sensing agents developed using this method, a Personal Assistant watches over a user and a SA watches over relations among users.

A Personal Assistant has several knowledge bases for recognizing actions of its master and a Social Agent has several knowledge bases for recognizing relations between users. If enough knowledge can be acquired in the knowledge bases of these agents, then they can support a group of users by understanding the situations of the users. Generally, when an agent is started on an agent platform, it has only initial knowledge bases consisting of typical knowledge. To better support its user, it should acquire proper knowledge from the Real Space and the Digital Space. A Mediation Agent is expected to support the knowledge acquisition for the agents.

Our models of Social Agents and Mediation Agents are still conceptual and just prototypes. In order for the agents to play important roles that are expected by users, enhanced methodology for knowledge acquisition and learning functions of agents will be required in future. We plan to expand the network of OMAS agent platform to global users. At the present, the agent platforms in France, Brazil, Mexico and Japan are connected and worked. In this experiment, we found that we should solve multi-lingual problems and also multi-culture problems in the Agent Space. Finally, the problem of the security and safety in Activity in Daily Life supporting by the Agent Space is very difficult and important problem we have to consider in future work.

Acknowledgment

We would like to thank colleagues working in projects of Symbiotic Computing (http://symbiotic.agent-town.com/) and OMAS framework.

REFERENCES

[1] K. Lyytinen and Y. Yoo: Issue and Challenges in Ubiquitous Computing, CACM, vol. 45, No. 12, pp. 63-65, 2002

[2] Kitsuregawa, M.: Info-plosion: Retrospection and Outlook, The Journal of the Institute of Electronics, Information, and Communication Engineers, Vol.94, No.8, pp.662–666 (2011)

[3] Barthès, J.-P.A., OMAS - A flexible multi-agent environment for CSCWD, Future Generation Computer Systems, vol. 27, pp. 78-87, 2011

 ISBN: 978-1-61208-232-5

[4] Barthès, J.-P.A., UTC/GI/DI/N196 PDM4 (pdf 728K), http://www.utc.fr/~barthes/references/index.html.

[5] Barthès, J.-P.A., UTC/GI/DI/N219 - MOSS 7 Primer (pdf 617K) http://www.utc.fr/~barthes/references/index.html

[6] N. Shiratori, K. Sugawara,Y. Manabe, S. Fujita, and B. Chakraborty, Symbiotic Computing Based Approach towards Reducing User's Burden Due to Information Explosion(Invited Paper), IPSJ Journal Vol. 51 No. 12 1234-1243, 2011M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[7] K. Sugawara, S. Ben Yaala, Y. Manabe, C. Moulin, N. Shiratori, and J. A. Barthès, Conversation-based Support for Requirement Definition by a Personal Design Assistant, Proc. of 10th IEEE International Conference on Cognitive Informatics and Cognitive Computing, pp.262-268, Banff, August 18-20, 2011

[8] K. Sugawara, S. Ben Yaala, Y. Manabe, C. Moulin, N. Shiratori, and J. A. Barthès, Conversation-based Support for Requirement Definition by a Personal Design Assistant, Proc. of 10th IEEE International Conference on Cognitive Informatics and Cognitive Computing, pp.262-268, Banff, August 18-20, 2011

[9] K. Sugawara, and S. Fujita, Non-verbal Interface of a Personal Agent based on Symbiotic Computing Model, Proc. of 10th IEEE International Conference on Cognitive Informatics and Cognitive Computing, pp.336-339, Banff, August 18-20, 2011

[10] S. Russel, and P. Norvig, Artificial Intelligence A Modern Approach, Prentice Hall, 2003

[11] T. Suganuma, S. Imai, T. Kinoshita, K. Sugawara, and N. Shiratori, "A Flexible Videoconference System based on Multiagent Framework", IEEE Transactions on Systems, Man, and Cybernetics part A, Vol.33, No.5, pp.633-641, 2003.

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Architecture of an Interactive Classification System

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***Abstract* – The paper describes the design of interactive inductive learning-based classification system. The architecture of machine learning systems can be viewed from two perspectives, namely, (1) the stages of system design and (2) model of system's functioning and components. Both of these design issues of different existing classification systems are discussed in the related work. A general architecture for the interactive classification system is proposed. Domain-dependent parts of the system are specified in the more detailed architecture of the interactive multi-label classification system for study course comparison. Interactive inductive learning-based classification system in uncertain conditions could ask a human for decision, and it is has been proven that applying this approach can reduce the number of misclassified instances, especially, when the initial classifier performs poor.**

Keywords–classification; inductive learning; machine learning; software architecture; supervised learning.

I. INTRODUCTION

Machine learning (ML) is the ability of a computer program to improve its own performance, based on the past experience [1]. Classification is one of ML tasks where the program learns to classify new instances from a human or environment provided training set. Classification problems arise in a number of areas, like credit scoring, pattern recognition, medical diagnostics, document classification, etc.

Motivation for creating an interactive classification system comes from several sides. One of them is inappropriateness of the automated classification methods for all domains where ML techniques could be applied to. Application domains are getting more complex in terms of data amount, representation forms, relationships within data, etc. In the real world information is often organized in vague or complicated forms like plain text, semi-structured text, graphs, etc. The transformation from original data to classifier-acceptable data structures is needed, and in this process some information can get lost or mapped inaccurately. This leads to creation of an incomplete classifier that does not generalize well the problem domain and probably will not be able to make predictions for all new unseen instances when the classifier is applied. Consequently, ML approaches face new challenges in solving tasks which could benefit from automated solutions but do not conform to typical ML application areas. Furthermore, people who are well aware of the complexity of the domain usually do not believe in a fully automatic approach and are ready to invest some efforts towards a more suitable solution [2].

Other facilitator for developing an interactive classification system is the practical need in the area of curricula comparison. This task is very time-consuming for humans and is also not trivial for application of ML methods directly because of the mixture of domain features.

Therefore, the mechanism for human involvement in handling instances that cannot be classified using only the classifier is proposed [3]. This mechanism (1) deals with instances which the classifier was not able to classify, by asking a human to decide a classification, and (2) improves the classifier's knowledge base with the rules derived from this experience. There is no single agreement on using this term in the literature, therefore, in this work, an "interactive classification system" is denoted as a system which involves human in handling instances that the classifier is not able to classify.

In our previous research on development of the interactive classification system, different existing approaches of interactivity in the classification process have been examined [3], and ways of incorporating human classified instances into the classifier revealed [4]. Proposal to apply the interactive classification approach to the university study course comparison problem has been given in [5], defining it as a ML task in [6] and adding a formal background in [7]. In [8] a common sight over curricula comparison as a problem of both information extraction and classification is given. This paper follows the suit and proposes general architecture for interactive classification systems, as well as specifies a more detailed architecture of the interactive multi-label classification system in a domain of study course comparison. The background for development of the interactive classification system is based on different existing architectures of "non-interactive" classification systems due to the lack of detailed interactive system descriptions. The intended interactive system is to be built using the best practices from former approaches and reusing ideas where appropriate.

The paper is organized as follows. Section II surveys the related work on different existing classification system architectures, starting with the general system's design, which is common for interactive and non-interactive systems, and following with system's functioning, which is separated for both types of systems. The architecture of the proposed interactive classification system is introduced in Section III. Section IV defines the particular classification problem and gives a short description of design decisions towards the interactive multi-label classification system for university study course comparison. Conclusions and the intended future work are given in Section V.

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II. ARCHITECTURE AND DESIGN OF CLASSIFICATION SYSTEMS

Representation of architecture of ML systems can be taken from two viewpoints, namely, (1) the stages of system design and (2) model of system's functioning (components). This section amalgamates design stages and models of system's functioning from a wide variety of authors, represented in a joint format by the author of this paper. Summarization of different existing architectures, especially from the two mentioned viewpoints, to the best of author's knowledge, has not been done before. Existing approaches are being analyzed and compared regarding the common elements in them. Typical communalities found are denoted in schemas with the same representation (bold block lines and interrupted block lines) and summarized at the end of subsection *A*.

In this section, firstly, proposed approaches for the system's development life cycle will be described, and, secondly, system's functional models will be explained. System's development stages do not vary much regarding the amount of interactivity built into the system, but system's functioning is different in these cases, therefore, topic is discussed separately for "non-interactive" and interactive classification systems.

To clarify the terms used in this paper, the difference between the classifier and the classification system has to be explained. In the context of the paper, the classifier means the exact model or rule set according to which a new unseen instance can be classified, whereas the classification system is an extended functional structure which allows to pre or post-process data and applies the classifier. Designing of the classification system includes designing the classifier. The latter is produced by a ML method, in this case supervised learning algorithms which induce the classification model in the form of a tree or If-Then rules. Thus, the classification system is a classifier and its peripherals which ensure the classification process.

There are different types of ML applications, therefore, in literature the corresponding systems are named variously. Some are called pattern recognition systems [9], others are called classification systems [10], inductive learning systems [11], inductive learning technique applications [11] or just learning systems [12]. However, they share the same fundamental elements in the path that is followed to design the application [11]. These systems can also be a part of intelligent systems, since the definition of an intelligent system is "system that learns during its existence"[13]. Thus, the characteristics of intelligent systems are also applicable to classification systems. In this paper, the term "classification system" will be used, unless the authors of the reviewed literature had insisted on defining it otherwise.

A. Designing classification systems

In the design theory, there are several types of design problems. In general, design tasks can be divided into three classes [14], [15], which can be characterized as follows.

1. Routine

In the routine design, knowledge sources and problem-solving strategies are generally known in advance and a priori plan of the solution exists.

2. Innovative

In the innovative design, problem-solving strategies are generally known, but the problem lacks a set of constraints. It can be called as an original combination of existing components.

3. Creative

In the creative design (also called the original design), neither problem-solving strategy nor knowledge sources are known which leads to a major invention or an entirely new product.

In the space of possible designs, the routine design involves implementation of a known type; the innovative design involves generation of new subtypes; the creative design involves generation of entirely new types [15]. Some authors, e.g., [16], suggest usage of the fourth class, namely, redesign.

By the definition of design problems, design of the "standard" classification system is more like a routine design task with choosing the right components and tuning the parameters.

Cherkasskey [17] claims that good understanding of the whole classification procedure is important for any successful application. He adapts approach from Dowdy and Wearden [18] and presents the general experimental procedure for development of the classification system (see Figure 1).

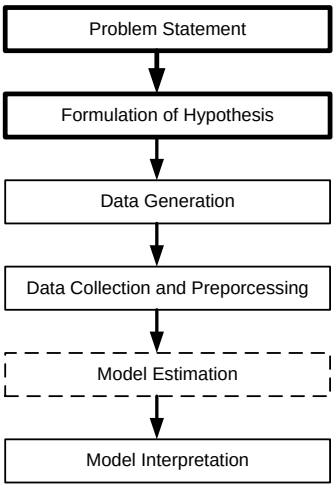

Fig. 1. Design stages adopted from Dowdy and Wearden [18]

- Statement of the problem

Domain-specific knowledge and experience are usually necessary in order to come up with a meaningful problem statement. It is important not to focus on the learning methods used instead of a clear problem statement.

- Hypothesis formulation

The hypothesis in this step specifies an unknown dependency, which is to be estimated from experimental data. At this step, a modeler usually specifies a set of input and output variables for the unknown dependency. There may be several hypotheses formulated for a single problem.

- Data generation/experiment design

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This step is concerned with how data is generated – under the control of a modeler or not. Further, it is important to make sure that the past (training) data used for model estimation and the future data used for prediction, come from the same (unknown) sampling distribution. If this is not the case, then, in most cases, predictive models estimated from the training data alone cannot be used for prediction with the future data.

- Data collection and preprocessing

This step has to do with both data collection and the subsequent preprocessing of data. Data preprocessing includes at least two common tasks: outlier detection and removal and data encoding and feature selection.

- Model estimation

The main goal is to construct models for accurate prediction of future outputs from the known input values.

- Interpretation of the model and drawing conclusions

In many cases predictive models need to be used for human decision making. Hence, such models have to be interpretable in order to be useful because humans are not likely to base their decisions on complex ‘‘black- box’’ models. Note that the goals of accurate prediction and interpretation are rather different because interpretable models would be simple but accurate predictive models might be rather complex.

Different design components of a learning system are given by Mitchell in his notable book “Machine Learning” [12]. Figure 2 demonstrates the involved steps.

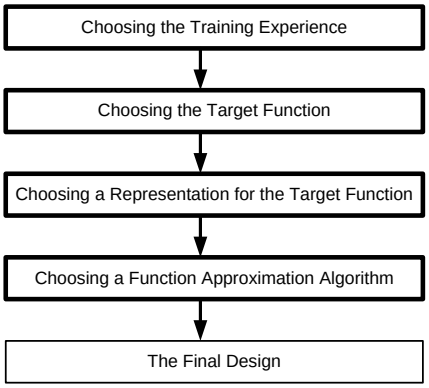

Fig. 2. Design stages adopted from Mitchell [12]

- Choosing the Training Experience

The first design choice is training experience from which the system will learn. It is very responsible decision because training experience significantly impacts success or failure of learning system. Learning experience could be used directly or indirectly, with teacher-provided or self-generated learning examples and can represent real examples distribution more or less precisely.

- Choosing the Target Function

It is also, sometimes, hard to define the choice. If the target function is too difficult to learn perfectly, some approximation can be applied instead.

- Choosing a Representation for the Target Function

The choice of representation involves a crucial tradeoff between expressiveness and simplicity.

- Choosing a Function Approximation Algorithm

In order to learn a target function, a set of training examples is required. Examples are derived from training experience and the learning algorithm is specified for choosing the weights to best fit the set of training examples.

- The Final Design

The final design phase leads to the system’s model, and the learning system is naturally described by four distinct modules that represent the main components in many learning systems. It will be described in the next subsection.

Design process is also sufficiently discussed in the context of pattern recognition systems. These systems share similar development stages; variations are in the focus and features of particular patterns. Figure 3 represents a development model of the classification system which is adapted from both [9] and [10].

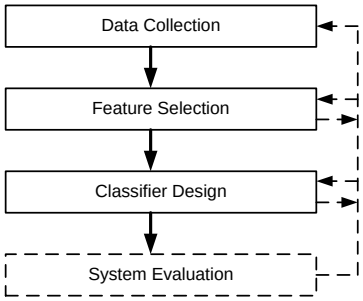

Fig. 3. Design stages of a pattern recognition system

As is apparent from the feedback, stages are interrelated and can be used to return and redesign earlier stages.

- Data Collection

This stage constitutes a large part of the entire time and effort for designing a classification system.

- Feature Selection

If necessary, this includes feature generation and extraction. This is similar to “Choosing the Training Experience” in Mitchell’s [12] model, and also is defined as a critical design step. Prior knowledge about application domain plays a major role in choosing features. One desires features which are simply to extract, invariant to irrelevant transformations, insensitive to noise, and useful for distinguishing different classes.

- Classifier Design

This stage also stands for Choosing Model and Classifier Training. A lot of design questions should be considered here, including the class of algorithms to apply, choice of particular method to use, specific parameters, etc. It might involve serious analysis or experimentation to decide upon these questions.

- System Evaluation

Evaluation of results is important both to measure the performance of the system and to identify the need for improvements in its components.

Vardenius and Someren, in their survey [11] about the application of inductive learning techniques (ILT), argue that one “must take a broader view than strict application of an ILT

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to a dataset". They claim that an ILT application is a project the result of which is (1) either a system that can support the user in solving his problem, or (2) a body of knowledge that enables the user to solve the problem himself. The project approach can be described in the form of process models.

An approach for developing a classification system which also covers all relevant levels of the project life cycle is proposed by UK Department of Trade and Industry [19] (see Figure 4). The system's design includes some stages relating project management that were not encountered in the models mentioned earlier in this section. However, the formal aspects of the process are not very well developed in this design model switching the focus on monitoring and control possibilities of application development.

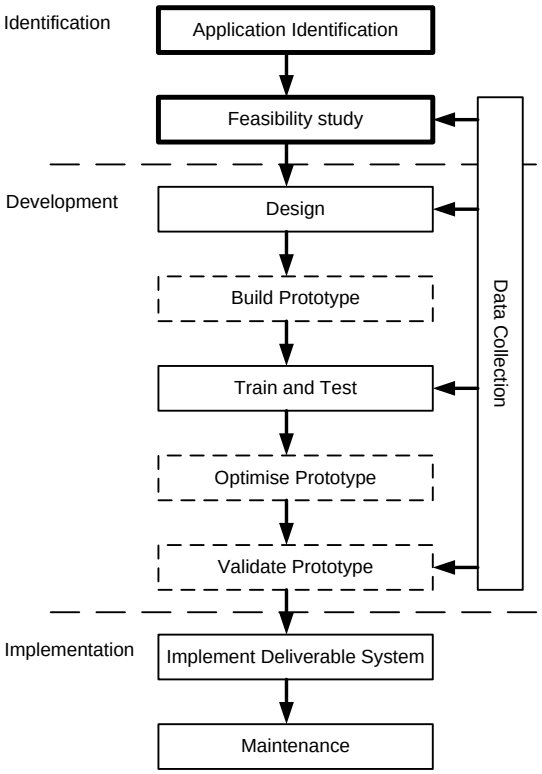

Fig. 4. Design stages adopted from [19]

As stated in the beginning of the section, classification systems fall under the intelligent system category. Bielawski and Lewand in their book [20] propose five step procedure for designing intellectual systems (see Figure 5).

The most important are said to be the first two steps. It also corresponds to previously discussed opinions from other authors.

Vardenius and Someren conclude that there is no uniform view on inductive learning system development. However, they find that the process of classification system application consists of three levels and a control element.

- Application level

In this level, a real world problem is to be analyzed, including identification of resources (such as data, human experts), decomposing the problem, constructing a conceptual model, defining the scope of solution. ML approaches can be used to solve the whole problem or just a part of it.

- Analysis level

This level includes data acquisition, attribute selection, pre-processing, etc. Very important part of this stage is selection of one or more appropriate learning techniques.

- Technique level

Additional choices about selected learning algorithms could be considered, e.g., different parameters of method application.

- Control element – project management

During execution of all levels, decisions and constraints should be taken. This element ensures implementation of the learning system in line with actual user needs.

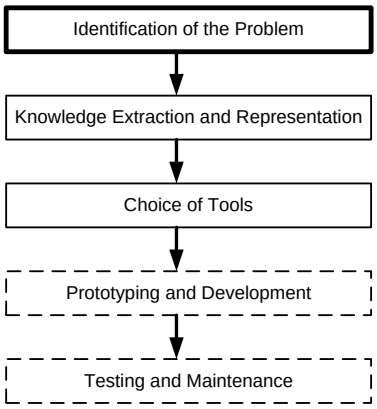

Fig. 5. Intellectual system design steps [20]

There are several conclusions that can be made after reviewing classification system development approaches. Most of the models described in this section give a great weight to initial stage which is called either a problem statement and formulation of hypothesis [18], identification of the problem [20], application identification and feasibility study [19] or incorporates a set of stages from choosing the training experience to choosing a function approximation algorithm [12] and denoted with bold block lines. Another common thing is that the design process of the classification system in some form should contain analysis for choosing the best solution for a particular task. Creating a classification system for a new application is rarely the case of one-way direct software implementation; therefore, the search for appropriate classification system elements (algorithms, methods, parameters, etc.) is done either in analytical way or carrying out experiments (shown with interrupted block lines or feedback arrows in schemas), or even implementing a prototype (like in the models of [19], [20]).

In general, the design process of an interactive classification system does not differ from a design of a non-interactive system, therefore, in this context no need for a new approach arises.

B. Functioning of classification systems

If design explains how to create a classification system, what actions to take and which questions to consider, the

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architecture of the system describes how the final system operates and from which parts it consists of. In this aspect arises the need for diversification of non-interactive and interactive system architectures.

1) Non-interactive classification systems

A simple but accurate schema of classifier's functioning is given by Han and Kember in [21]. Similar models are presented also by other authors. In Figure 6, the data classification process can be separated in two stages. In the learning part, training data is analyzed by a classification algorithm. The learned model or the classifier can be represented in different forms, e.g., classification rules. In the classification part test data is used to estimate the accuracy of the classifier. If the accuracy is considered acceptable, the rules can be applied to the classification of new data.

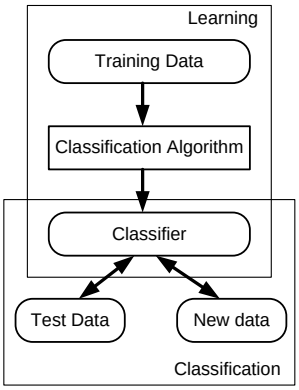

Fig. 6. Classifier building an applying model

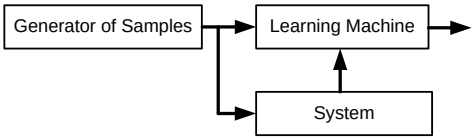

Fig. 7. Learning scenario components by Cherkassey [17]

However, this model does not qualify for a classification system; it is only the schema for building a classifier and is a part of a classification system.

Cherkassey [17] presents a general learning scenario which involves three components: Generator of random input vectors, System that returns an output for a given input vector, and the Learning Machine that estimates an unknown (input, output) mapping of the System from the observed samples (see Figure 7). The given formulation is very general and describes many practical learning problems found in engineering and statistics, including classification.

Another learning task is given by Mitchell [12]. He describes a learning cycle of the system which improves its own performance through repetition (see Figure 8).

- Performance System

This is the module that solves the given performance task by using the learned target function(s). It takes an instance of a new problem as input and produces a trace of its solution as output.

- Critic

Takes the history as input and produces as output a set of training examples of the target function.

- Generalizer

Receives the training examples as input and produces an output hypothesis as its estimate of the target function. It generalizes from the specific training examples.

- Experiment Generator

Its role is to pick up new problems that will maximize the learning rate of the overall system. It takes the current hypothesis (currently learned function) as input and outputs a new problem for the Performance System to explore.

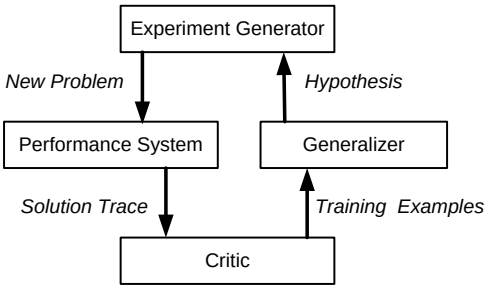

Fig. 8. The main components in learning systems by Mitchell [12]

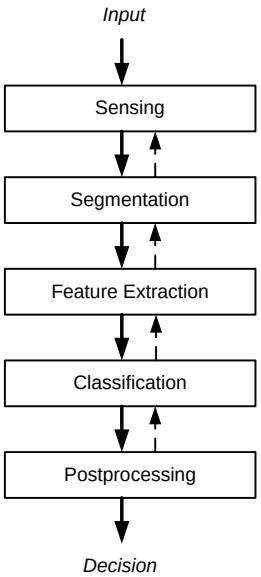

Fig. 9. The components of a typical pattern recognition system [9]

Figure 9 shows a diagram of the components of a typical pattern recognition system [9]. A sensor converts system inputs into signal data. The segmentor isolates sensed objects from the background or other objects. A feature extractor deals with object properties that are useful for classification. The classifier uses extracted features to assign an object a class. The post-processor takes into account other considerations to make a decision of further actions. Although the description stresses a one-way data flow, the feedback from higher levels back to lower levels is also possible.

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2) Interactive classification systems

Regarding architecture descriptions of interactive classification systems they are few, scattered and of different types. Most well known interactive approaches to classification are based on active learning [22], data visualization (e.g., [23]) and ripple down rule [24].

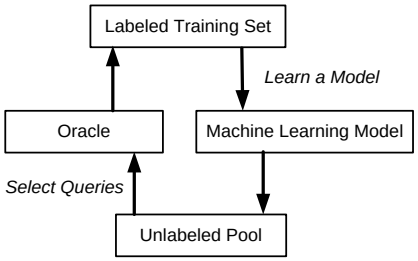

Fig. 10. The pool-based active learning cycle [25]

Active learning is a subfield of machine and is based on hypothesis that if the learning algorithm is allowed to choose the data from which it learns. it will perform better with less training [25]. Figure 10 illustrates the most common type of active learning – the pool-based active learning. A classification system may begin with a small number of instances in the labeled training set, request labels from the oracle (usually a human) for one or more selected instances from the pool, and learn from the query results. There are several scenarios in which active learners may pose queries, and there are also several different query strategies to decide which instances are the most informative. The architecture of system's functioning is given in [23].

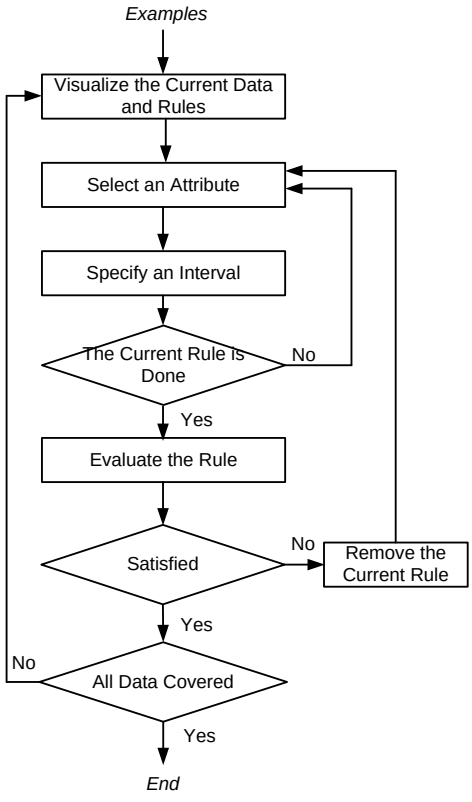

Fig. 11. Rule construction in CVizT system [23]

CViZt system's part for building rules is depicted in Figure 11. Building of the classifier is to interactively and iteratively construct classification rules one by one. The aim of visualizing the current data and rules is to give a look into distribution of the dataset and ease perceiving correlations between attributes. Rule construction consists of selecting attributes and their respective interval of values which is done by a human. A potential rule is automatically evaluated. If the rule accuracy is greater than the pre-specified threshold, then it is accepted and appended to the classifier. The process is repeated until all examples are covered by rules. This approach relates to rule construction by human which is in a sense similar to ripple down rules. The latter is one of the approaches to directly acquire and encode knowledge from human experts.

Several research papers of the last twenty years refer to the concept "interactive inductive learning" or explore the idea of human interaction in the concept learning process. Systems and approaches proposed in these papers are from distinct fields and suggest different types of human interaction. The following types of human interaction are described in [26-32].

1. Systems where the human feedback is asked to evaluate only the given result (decision or prediction).
2. Systems that learn concept classification based on the classification by human.
3. At first, human is giving his/her knowledge to the system and affirming the rules that are induced by the system afterwards.
4. The human evaluates and selects the rules induced by the system in the classifier forming stage.
5. Learning systems where the human is the learner and the computer should be able to interact in a user-friendly way.

The full survey of the above-mentioned related works can be found in [3]. Interaction with a human in these systems takes place in different phases of learning. However, no explicit architectures are provided there. Although these approaches are interactive, they do not conform to the problem being addressed in this paper – creating the classifier automatically and involving a human to deal with unclassified instances.

To sum up the related work, the architecture of classification systems is described in literature quite widely. Differences between the given architectures are determined mainly by focus, scope or the intended application area. However, there are no major contradictions between them. Descriptions of classification system architectures usually are either in terms of general classifier building guidelines or summary of very abstract components. We assume that more detailed architectures of classification systems are domain specific and hard to reuse for other purposes (e.g., CVizT system), therefore, not widespread across scientific literature. Every new case requires a problem domain analysis with respective design decisions. Therefore, also the interactive classification system has to be designed on demand, taking into account the specificity of the need for computer-human interaction in the final architecture.

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III. INTERACTIVE CLASSIFICATION SYSTEM

This section explains the proposed interactive classification system's architecture from different viewpoints. Stages of the system's design will be described in the next section when a particular classification problem will be set, which will serve as a background for making domain-specific design decisions.

A. Main components of the interactive classification system

Figure 12 shows the tasks which should be carried out within a classification system for domains with complex data types and the need for appropriate pre-processing and structuring.

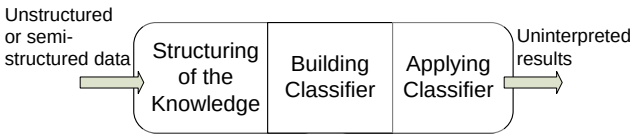

Fig. 12. The main tasks in classification process for unstructured or semi-structured input data

Different parts of this process have various domain dependencies with respect to implementation and reuse.

- Structuring of the Knowledge

Looking from the system's development viewpoint, this is a domain dependent task. The necessary techniques and methods for processing of data are hard to establish without the knowledge of data representation forms in a particular problem domain. Data can be held in structures which require specific extraction and preparation of attributes.

- Building Classifier

This is a relatively domain independent stage and can be defined prior to application for a particular problem area. Principles of the classifier forming are well studied and used. However, the choice of a particular learning approach, method and parameters is tightly connected with actual data, since there are no domain independent reasons to favor one classification method over others [3].

- Applying Classifier

Technical aspects of classification may be considered domain independent, but the choice of how to represent the results is affected by the initial data structure and further processing needs (both for systems and humans).

The output of classification gives uninterpreted results which could be passed to some framework for domain specific interpretations or further processing.

One can conclude that the specification of initial data processing can be given only in connection with a particular application domain, while classifier building and most of decision about classifier applying can be made in advance. Domain less dependent tasks can be defined in earlier architecture development stages than the dependent ones.

B. General architecture of the system

The need for interactivity requires this functionality to be represented in system's architecture. The aim of developing interactive approach is not to improve one certain learning algorithm. Instead it is necessary to develop an extension for those algorithms which lack mechanism for dealing with unclassified instances or where this mechanism can be replaced. This approach affects the way how the classifier is applied to new instances, not the way it learns and makes the predictive model.

The amount of necessary changes in the classification part (in comparison to "standard" non-interactive approach) depends on particular learning scheme and its implementation. If the information about unclassified instances is achievable after the attempt to classify them, uncovered instance handling can be added as an external supplement without modifying the initial classification process. Otherwise, the new instance classification procedure should be extended with the possibility to trace unclassified instances. Figure 13 shows how the interactivity is implemented into the general model of the classification process.

Blocks with solid line are "standard" elements of the classification system, e.g., similar to the one in Figure 6 (in Section II.*B)*. Blocks and arrows with interrupted lines are introduced to ensure interactivity with a human expert in order to assign a class value for unclassified instances. This includes the further mentioned functions.

1. Capturing unclassified instance(s) which were not covered by any rule in the classifier applying stage.
2. Forwarding these instances and additional information to the human.
3. Receiving and processing the human decision.
4. Using the human-provided knowledge to update the learning examples.

The fourth step –updating of the classifier – is an issue that is discussed in more details in the recent work [4].

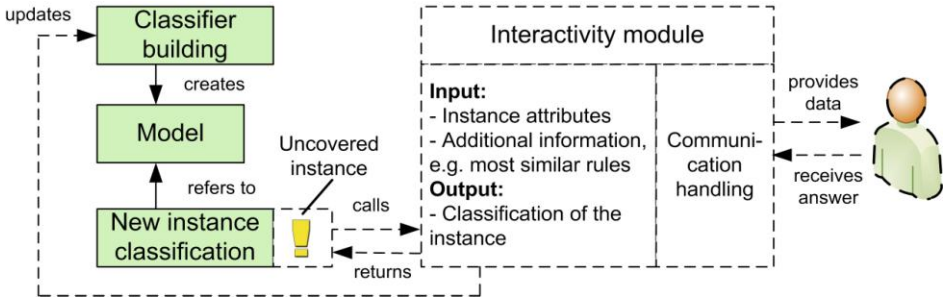

Fig. 13. Inclusion of interactivity in the general classification model

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C. *Modules of the system*

For the proposed interactive classification system a modular architecture is chosen. Such architecture is chosen because the modules are relatively independent from each other and can be changed and replaced without affecting other parts of the system which would be not the case if an integrated architecture was applied. Since there are some domain dependent parts in the intended architecture, it is more suitable to use modules where some of them can be static while others change for each application area.

Each module has its own purpose and tasks. One or more modules are involved in performing specific functions. Table I describes each module in details, explaining its functionality and connectivity with other modules.

In practice modules communicate not only directly; examples to learn from and induced rules are stored in separate data bases, and particular module functions are activated by a human. Figure 14 shows physical data flows and initiations of processes in the system, including the user who is actually a part of the interactive classification system.

Figure 14 shows actions typically performed in the interactive classification system, avoiding details of inner processes within modules. The user passes the learning data to the Data processing module through the user interface requesting data preparation for further processing. Prepared data is saved in the Examples storage and the response about the achieved results is presented to the user. When the user initiates creation of the classifier, the Classifier building module uses data from the Example base and infers model to be stored in the Rule base, also representing the results to the user. To assign classification to a new instance or a set of instances, user invokes the Classifier applying module. If the classification can be made by rules in the Rule base, the user receives classification results as a response. If there is an instance or instances which cannot be classified, the Classifier applying module sends a request to the Interactivity module to handle the situation. The Interactivity module asks for an expert classification of the instance through interface; this is the situation when a request for a response is being sent from the system to the user, not vice versa. After receiving the user feedback, the Interactivity module gives a response to the Classifier applying module which shows the classification results to the user as previously. The Interactivity module also updates the Example base with a new training example that was built from the unclassified instance and the user-given classification to it. Afterwards the Interactivity module sends a request to the Classifier building module to start a new learning cycle and update the Rule base. However, this is not the only scenario possible for the system's usage.

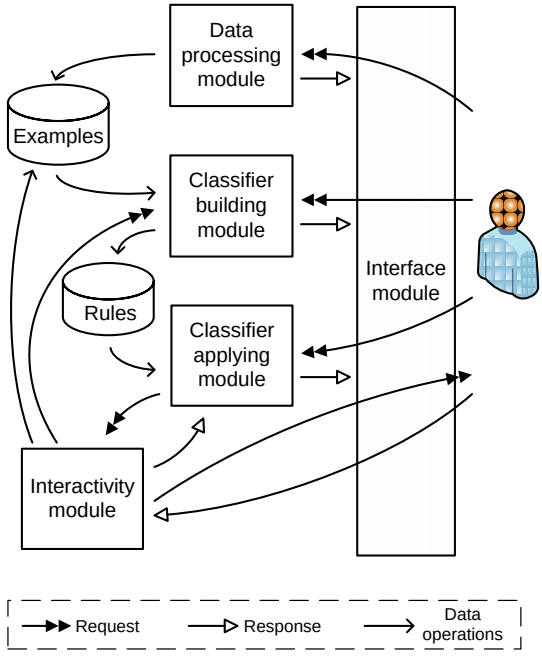

Fig. 14. Functioning of the interactive classification system

IV. Architecture of the Interactive Classification System for Study Course Comparison

The need for a specific type of a classification system arises from a problem domain. As described in the related work (Section II), the statement of the problem, analysis of the domain specific factors and application identification are basis of system's development. All further design decisions should be based on actual necessities, of course, taking into account technical capabilities. The area for which the interactive classification system is to be specified is the curriculum management.

Almost every model from section II.*A* could be applied to describe the design of the interactive classification system. However, design steps will be defined with respect to the procedure of Bielawski and Lewand [20]. This description framework is preferred most due to its simplicity and general concordance with the system to be designed. It is an appropriate framework to explain the decisions made during the design stages. In table II, the main design steps are analyzed.

TABLE I

Modules of the Interactive Classification System

Data processing module
Provides exchange of data representation formats. - Ensures the user with the possibility to input learning data in different layouts and helps the user with data structuring. - Ensures the user with the possibility to view learning data and classification rules in different representation formats. - Ensures data transformation for inner processes within and between modules. Direct connection with other modules: - Interface module
Classifier building module
Produces a classifier or a model for the given learning data set. The classifier in internal structures is represented as an application-specific model. If-Then rules can be extracted from this format (if the representation form of the learning algorithm itself produces rules). This module is based on already implemented learning schemes. Direct connection with other modules: - Interface module
Classifier applying module
Applies the given classifier to the provided instances, finds classification and

calculates statistics. This module is based on the already implemented learning schemes which are extended with the ability to intercept instances that are not covered by any rule from the classifier. In this case the interactivity module is called. Direct connection with other modules: - Interface module - Interactivity module
Interactivity module
Ensures communication handling with a human. Closely tied to the classifier applying module. - Represents an unclassified instance and additional information to the human expert as well as receives the answer. Additional information about the instance is, e.g., most similar rules. - Initiates classifier updates after receiving a human's response. - Ensures handling human requests for classifier representation in form of rules. Direct connection with other modules: - Interface module - Classifier building module
Interface module
Ensures human-friendly communication between the system and its user. - Represents data. - Transmits predefined human requests and inputs to other modules of the system. Direct connection with other modules: - All system's modules

TABLE II

DESIGN STEPS OF THE INTERACTIVE CLASSIFICATION SYSTEM

1. Identification of the problem
Globalization and student mobility have led to the need for curricula and study course comparison. This comparison is necessary in order to make sure that learning curricula in a foreign institution still matches the requirements of its home curriculum. Another important area where curricula are to be compared is curriculum development. However, comparison of curricula is based on the compatibility analysis between individual courses. A course comparison is a very time consuming process if performed only manually. The main domain characteristics which play a significant role in design decisions are the following [6]. **Understanding decision making steps is important for a human**. This condition defines the use of the decision tree or rule generating algorithms among all ML methods because of their explanatory power. **Small initial learning base.** This condition causes suspicion of inducing an incomplete classifier. Therefore, an interactive classifier would be useful. **Many classes with similar probability to appear.** As a curriculum usually consists of ten to fifty different study courses and there is no ground for preferring one course over the others, a default rule for assigning a class to unclassified instances is not a proper approach. **Multi-label class membership.** In the case of course classification a certain course can be similar to several other courses; therefore, an assignment of more than one class is possible.
2. Knowledge extraction and representation
To compare different study courses, one needs to define course features that can be used for comparison. The study course is an issue that does not naturally possess well-defined attributes relevant for the comparison of course contents. Attributes used to describe study courses in the classification system should not only be representative but also available. It is not always that education providers and trainers give a detailed description of course contents [33]. However, learning outcomes usually are well described; therefore, they can be used as a means for study course compatibility analysis. Besides learning outcomes other accessible attributes can be involved in classification, namely, study level, number of credit points for the course, etc. The comparison of learning outcomes has to be unified since the verbal description of learning outcomes may vary for different educational institutions. For mediation of learning outcomes European e-Competence Framework could be used since it is European-wide framework for ICT competences.
3. Choice of tools
In this case tools mean not only software tools but also the very learning algorithms used to induce the classifier. A domain with natural multi-label class memberships, like course comparison, requires appropriate learning methods. To save time and efforts for implementing basic learning algorithms, already prepared tools and libraries could be used. It the case with multi-label classification needs there are not too many tools to choose from. *Mulan* library for multi-label classification is chosen because (1) it is based on *Weka* tool which implements many classification algorithms for experimenting, and (2) it is extendable (that is important for dealing with unclassified instances, adding human-friendly interface, and introducing interactivity in the classification system). Both *Mulan* library and *Weka* software are written in Java which consequently leads to implementing the whole classification system in Java.
4. Prototyping and development
Finding the best classification algorithm, tuning parameters, verifying chosen features can be done most powerful by experimenting. Implementing prototype helps to pre-evaluate system's performance and decide about architectural details.
5. Testing and maintenance
The testing stage is meant to evaluate different parameters of the classifier and other parts of the system, e.g., ease of use for a human. During execution of the system it should be capable of classifying new instances as well as communicating with a human and updating the classifier with the knowledge achieved from interaction with the human expert.

The prototype of the interactive classification system has been developed and applied in the domain of study course comparison as well as on Medical data set *(from Computational Medicine Center's 2007 Medical Natural Language Processing Challenge)*. More detailed results of the experiments with proposed interactive classification system are published in [34]. It is proved that applying the interactive approach can reduce the number of misclassified instances, especially, when the initial classifier performs poor. However, subsequent research includes comparing the achieved results with other approaches used in course comparison and applying the interactive classification for other domains.

V. CONCLUSIONS AND FUTURE WORK

This paper proposed the architecture of an interactive inductive learning-based classification system that in uncertain conditions could ask a human for decision and improve the knowledge base with the rule derived from this human-made decision. The architecture of the system is specified for application in a particular problem domain which, in this case, is the university study course comparison. The design steps of an interactive classification system lead to the particular design and implementation decisions, e.g., modular architecture, use of the *Mulan* library for implementing multi-label classification algorithms, etc.

Research on classification systems caused creation of several taxonomies. Firstly, terms "classifier" and "classification system" were distinguished, and secondly, classification system's design stages were separated from the system's structure and functioning.

Contributions of the paper are the following:

- Different existing classification systems' architectures are summarized from the viewpoint of design and functioning, complemented with analysis of the common elements in them.

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- General scheme with main stages of the classification process for domains with unstructured or semi-structured input data is given, providing also separation of domain dependent and independent parts in a system's architecture.

- The general architecture of the interactive classification system is provided highlighting the aspects where interactivity makes difference from the "standard" classification approaches.

- Modules of the interactive classification system, their main properties and interrelations are defined. The modules are: Data processing module, Classifier building module, Classifier applying module, Interactivity module, and Interface module.

- For the particular case – study course comparison – one architecture of system's design is applied to describe decisions made in the development process.

Future works include further refinement of the modules, developing, prototyping, and experimenting with the system.

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REFERENCES

[1] K. J. Cios and L. A. Kurgan, "Hybrid Inductive Machine Learning: An Overview of CLIP Algorithms.," in *New Learning Paradigms in Soft Computing*. vol. 84, ed Heidelberg, Germany: Physica-Verlag GmbH, 2002.

[2] R. Coletta, *et al.*, "WebSmatch: a platform for data and metadata integration," DataRing Project meeting June 20 2011 Montpellier

[3] I. Birzniece, "From Inductive Learning towards Interactive Inductive Learning," *Scientific Journal of Riga Technical University. Computer Sciences. - Applied Computer Systems* vol. 41, pp. 106-112, 2010.

[4] I. Birzniece, "Interactive Inductive Learning System: The Proposal," in *Proceedings of the Ninth International Baltic Conference Baltic DB&IS 2010*, Latvia, Riga, 2010, pp. 245 -260.

[5] I. Birzniece, "Interactive Inductive Learning Based Study Course Comparison," in *Rethinking Education in the Knowledge Society*, Switzerland, Ascona, 2011, pp. 339 – 347.

[6] I. Birzniece, "Interactive Inductive Learning System," in *Selected papers from the DB&IS 2010*, Latvia, Riga, 2010, pp. 380-393.

[7] I. Birzniece and M. Kirikova, "Interactive Inductive Learning: Application in Domain of Education," *Scientific Journal of Riga Technical University. Computer Sciences. - Applied Computer Systems*, vol. 47, pp. 57-64, 2011.

[8] I. Birzniece and P. Rudzajs, "Machine Learning Based Study Course Comparison," in *Proceedings of the IADIS International Conference on Intelligent Systems and Agents 2011 (ISA 2011)*, 2011, pp. 107-111.

[9] R. O. Duda, *et al.*, *Pattern Classification*, 2nd ed.: Wiley - Interscience, 2001.

[10] S. Theodoris and K. Koutrumbas, *Pattern Recognition*, 3rd ed.: Elsevier, 2006.

[11] F. Verdenius and M. W. v. Someren. (1997) Applications of inductive learning techniques: a survey in the Netherlands. *AI Communications*. 3 - 20.

[12] T. Mitchell, *Machine Learning*: McGraw Hill, 1997.

[13] W. Fritz. (2010, September 12). *Intelligent Systems and Their Societies*. Available: http://intelligent-systems.com.ar/intsyst/glossary.htm

[14] D. C. Brown, "Intelligent Computer-Aided Design," in *Encyclopedia of Computer Science and Technology*, J.G.Williams and K.Sochats, Eds., ed, 1998

[15] J. S. Gero, "Design Prototypes: A Knowledge Representation Schema for Design," *AI Magazine* vol. 11, pp. 26 - 36, 1990.

[16] A. Bahrami, "Routine design with information content and fuzzy quality function deployment," *Journal of Intelligent Manufacturing*, vol. 5, pp. 203 - 210, 1994.

[17] V. Cherkassky and F. Mulier, *Learning from Data: Conceptrs, Theory, and Methods*, 2nd ed.: John Wiley & Sons, 2007.

[18] S. M. Dowdy and S. Wearden, *Statistics for research*, 2nd ed. ed. New York: Wiley 1991.

[19] DTI, *Neural Computing*, "Department of Trade and Industry" ed.: Learning Solutions, 1994.

[20] L. Bielawski and R. Lewand, *Intellignet Systems Design: Integrating Expert Systems, Hypermedia, and Database Technologies*: John Wiley & Sons, 1991.

[21] J. Han and M. Kamber, *Data Mining: Concepts and Techniques*, 2nd ed.: Elsevier, 2005.

[22] B. Settles, "Curious Machines: Active Learning with Structured Instances," University of Wisconsin-Madison, 2008.

[23] J. Han and N. Cercone, "Interactive Construction of Classification Rules," presented at the Proceedings of the 6th Pacific-Asia Conference on Advances in Knowledge Discovery and Data Mining, 2002.

[24] P. Compton and R. Jansen, "A philosophical basis for knowledge acquisition," *Knowledge Acquisition*, vol. 2, pp. 241-258, 1990.

[25] B. Settles, "Active Learning Literature Survey," University of Wisconsin–Madison2010.

[26] M. Okabe and S. Yamada, "Interactive Web Page Retrieval," in *Active Mining: New Directions of Data Mining*, ed Amsterdam OS Press, 2002, pp. 31-40.

[27] R. C. Tanumara, *et al.*, "Learning Human-Like Color Categorization through Interaction," *International Journal of Computational Intelligence*, vol. 4, pp. 338-345, 2007.

[28] W. Buntine and D. Stirling, "Interactive Induction," in *Machine Intelligence: Towards An Automated Logic of Human Thought*. vol. 12, J. E. Hayes, *et al.*, Eds., ed New York Clarendon Press, 1991.

[29] M. Hadjimichael and A. Wasilevska, "Interactive Inductive Learning," *International Journal of Man-Machine Studies*, pp. 147-167, 1993.

[30] M. L. Wong and K. S. Laung, *Data Mining Using Grammar-Based Genetic Programming and Applications*. USA: Kluwer Academic Publishers, 2000.

[31] X. Li, *et al.*, "Learning in an Ambient Intelligent World: Enabling Technologies and Practices," *IEEE Transactions on Knowledge and Data Engineering*, vol. 21, pp. 910-924, 2009.

[32] T. P. Minka and R. W. Picard, "Interactive Learning with a „Society of Models"," in *Proceedings of the 1996 Conference on Computer Vision and Pattern Recognition*, 1996, pp. 447-452.

[33] I. Birzniece and M. Kirikova, "Interactive Inductive Learning Service for Indirect Analysis of Study Subject Compatibility," in *BeneLearn* Belgium, Leuven, 2010, pp. 1-6.

[34] I. Birzniece, "Machine Learning Approach for Study Course Comparison," in *International Conference on Machine Learning and Data Mining (MLDM 2012)*, Berlin, Germany, 2012, pp. 1-13.

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Dynamic Ontology Supported User Interface for Personalized Decision Support

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***Abstract*—European citizens are increasingly aware of the influence of air quality and weather on their health and quality of life. At the same time, more environmental information is freely available through a plethora of websites, dedicated portals, and web services. In order to exploit these data for personal decisions one has to identify, retrieve, and combine the information that is relevant to one's personal situation, planned activity, and information need. Often, this task is hindered by different data formats, display styles and data resolutions. The PESCaDO system is a web-based decision support system addressing this issue. The inquiry to the system, as well as the system's result, can cover a broad range of environmental aspects and personal situations and is therefore quite complex. In this work we present a novel approach on how the system can actively assist users in all steps of the decision making process, especially by enhancing the user interaction. This approach combines an intelligent dialog steering method based on analyzing the domain ontology with flexible, dynamic data visualizations for a situation depending orchestration of data sources. Both aspects have been evaluated in on-line user studies, as well as with an expert evaluation of the whole system.**

***Index Terms*—interactive systems; user interfaces; semantic web; decision support systems; environmental factors;**

I. Introduction

With the broad availability of service-oriented web sites that provide environmental data like weather or air quality information, more and more citizens are increasingly aware of the influence that such data can have on personal decisions regarding their health and quality of life. Access to such information is nowadays provided either statically, or at best through user-defined search, which both might be biased towards what the data provider considers relevant to the user's information need. Making sense of the information for environmental decision support, however, requires more than just retrieving information; instead it needs to be related to other information, taking different perspectives on it, and semi-automatic refinement, in short - it requires analysis.

However, traditional as well as visual analysis [1] systems often tend towards being either powerful, feature-rich software tools for tackling domain-specific tasks or generic construction kits for building personal solutions from abstract operators. In both cases they are tailored to expert users willing to learn the usage of rather complex user interfaces with multiple, potentially coordinated visual perspectives and elaborate interaction mechanisms.

Bringing these two observations together, there is a need for an interactive system suitable for casual users that enables them to exploit available data for supporting their personal decisions. The EU funded project PESCaDO tackles this challenge for the environmental data domain by reducing the complexity through personalized interaction techniques and ontology based user assistance. The resulting web-based system provides end user decision support based on data that is automatically extracted from the web and orchestrated using interactive visualizations. At the beginning of each request, the user's information need can be formulated as an abstract query independently from the available data sources. Here, the user is assisted by an intelligent dialog steering mechanism incorporating user profiles, domain knowledge, and context information to highlight missing input parameters and guide the user towards a serviceable and personalized request.

The user's input is formalized using PESCaDO's Problem Description Language (PDL) and associated with available data sources and the system's codified knowledge in the form of an ontology. Using semantic inference algorithms, relevant data is extracted and interpreted from the web and the most important information is isolated and orchestrated to fulfill the request. Finally, to present the results to the user, the system uses an adaptive mechanism to select an adequate ensemble of interactive and configurable visualizations that try to combine requirements resulting from the request as well as personal user preferences and data driven necessities.

This paper focuses on two aspects of PESCaDO that allow for personalized query and result presentation. First, the overall approach is described in Section III together with a short introduction of the system's aspects that are not detailed further in this paper. Section IV then describes how an intelligent query steering can be realized by accounting for previously submitted information, user profiles, and domain knowledge. Section V will give details on the personalized selection and configuration of visualizations and how the user can interact with and adapt visualizations to fit his particular information needs. The described query and visualization components have been individually evaluated through web-based user studies and the complete PESCaDO system was thoroughly tested by environmental specialists. The results of these evaluations will be presented in Section VI. Finally, Section VII concludes and gives an outlook on future work.

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II. Related Work

This section summarizes existing work related to our two main contributions; intelligent user interfaces and dynamic visualization of environmental information.

A. Intelligent User Interfaces

In the context of this work, we define *intelligent user interfaces* as systems that react individually on user input based on background information, e.g., the user's profile, previous input, or domain knowledge. This definition is in line with *intelligent support systems* discussed in the work of Delisle and Moulin [2] but does not necessarily have to be based on machine learning algorithms. They can be grouped into three, not necessarily disjunct, categories inspired by Dryer [3].

1) Guides: support users by providing additional information for their tasks. This guidance may range from formatting information for input fields to user manuals for choosing the correct form. If guides dynamically take into account the available information, they can also be considered 'intelligent'. For instance, the *COACH* system [4] builds an adaptive user model and provides contextual help by commenting on the user's actions. Guides are useful for providing local and not too complex information about the currently focused aspect of the user interaction.

2) Wizards: support users by structuring complex input forms into separate, sequential, and thematically coherent pages. Each page can take the previously provided information into account, e.g., to include or exclude branches of the predefined course of the dialog. In WOLD [5], e.g., a wizard for generating new user interfaces can suggest parameter values. Wizards profit from the fact that only few interactive elements are available at any point in time. However, with increasing task complexity it becomes harder to define thematically coherent but independent subtasks to be grouped in a linear structure.

3) Reactive Systems: can actively influence the current dialog. This is often implemented through the use of *agents* [6] and covers a wide area of applications from saving previous input for automatic input completion, to learning the user's behavior to better adapt dialogs to their needs. An example can be found in the system of Lee et al. [7], which supports tourists in planning a path through cities to meet different sightseeing interests. In *mixed-initiative* systems [8], e.g., as in the work of Frank et al. [9] for trip planning, the active part changes between user and machine. While this can also be achieved by using agents, the clearer role definition leads to less user astonishment.

The intelligent user support for personalized query formulation of PESCaDO is a combination of these principles in the form of a guided wizard that reacts intelligently on the user input using an automatically derived rule set.

B. Dynamic Environmental Data Visualization

Traditional visualizations for environmental data can be seen in many forms and application domains. From popular media, most people are familiar with certain iconic representations of meteorological data, like sun-/cloud-symbols for overall weather conditions. Research in visualization has also introduced additional unconventional and advanced representation forms ranging from large-scale weather statistics to representations of complex simulation models [10]. However, there are just a few visualization approaches that allow representations to be automatically configured and adapted based on data and/or user aspects or that account for inherent uncertainties in environmental data.

1) Adaptive Representations: The foundations for the concept of adaptive, data driven visualization models were laid by Mackinlay [11] who presented the idea of automatic visualization systems (AVS) that generate visualizations intelligently based on relational data structures. He interpreted graphical representations as parts of a graphical language. The APT (A Presentation Tool), presented in his work, applies artificial intelligence methods to choose from representations like bar charts and scatter plots. Recently, this idea was extended [12] to allow for automatic representations for visual analysis within the Polaris system [13] . The authors present the Show Me user experience that allows the user to select alternatives and configure visual variables in small multiples of text tables, aligned bars, stacked bars, line charts, scatter plots, and Gantt chars. The idea to use ontology mappings to decide which visualizations should be chosen to represent given web data was presented by Gilson et al. [14], where domain ontologies and visual representation ontologies were linked through a semantic bridging ontology specifying the appropriateness of a given mapping from data to representation. Although these approaches cover many aspects of common data, they fall short of handling combinations of multiple independent data layers and deciding on appropriate combinations of visualizations to represent them, as needed for the personalized decision support scenario of the PESCaDO system. Furthermore, the integration of user models within the decision path and the possibility to interact with visual configuration parameters is underrepresented in these works.

2) Uncertainty: Some researchers have addressed the problem of visualizing uncertain information. Olston et al. [15] demonstrate in bar charts, scatterplots, and line charts, the need to indicate clearly the difference between statistical uncertainties and bounded uncertainties. Statistical uncertainty describes values that can be distributed over an infinite range with a peak on some expected value. Contrastingly, bounded uncertainty guarantees that values lie within a known interval. They propose to use error bars to indicate statistical uncertainties and a technique resembling an ink smearing effect to show bounded uncertainties. Hengl and Toomanian [16] examine the usage of uncertainty visualizations for map data and demonstrate techniques using whiteness in color and pixel mixtures to indicate the proportion of errors in heatmap representations. These techniques are similar to the ones that were applied in our work. However, they have not been used in association with data and user adaptive presentation techniques, which poses a completely new design challenge.

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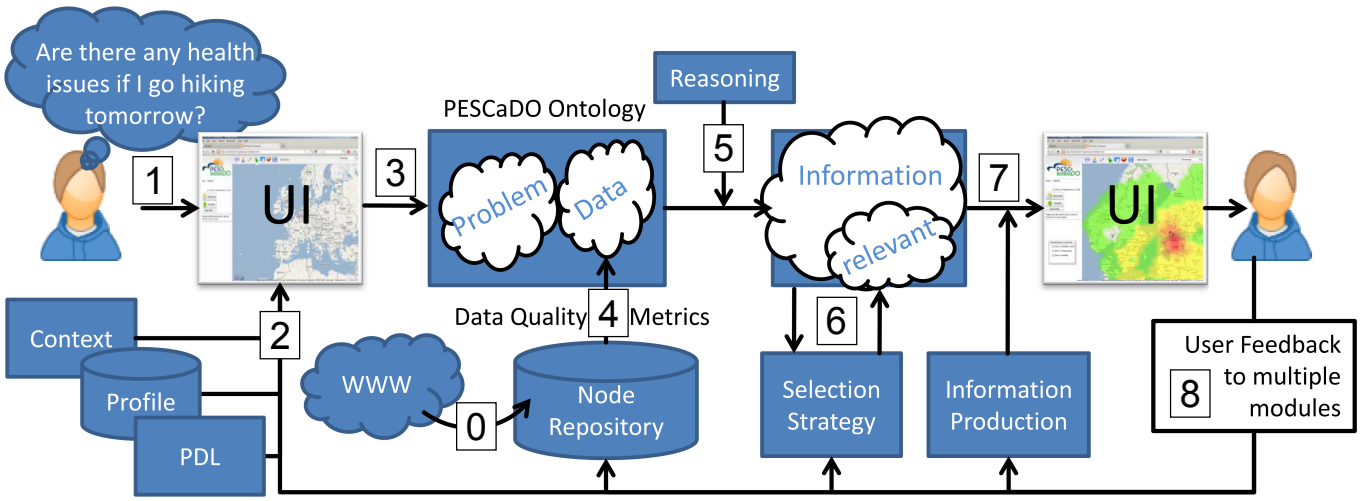

Fig. 1. The decision support loop of the PESCaDO system going from data extraction (0) and the generation of a request (1+2), over the result computation (step 3-6), to a dynamic result representation (7) and interactive feedback (8).

III. Approach

To achieve a combination of simple and fluent user experience together with powerful analysis capabilities, the PESCaDO system builds on two cornerstones: A personalized intelligent query support and a configurable, user tailored result presentation. These components will be described in further detail in the following two sections. Building on these components, the PESCaDO decision support process can be separated into eight steps (see Figure 1 for all steps):

As part of a preprocessing step, a node discovery service identifies web data sources for different time spans, environmental aspects, and geographic regions through keyword spice targeted searching [17]. The resulting resources are categorized, their content is extracted, and the gained information is stored in a repository on a daily basis (step 0). Based on the user's information need (step 1), personal profile, domain ontology, and current session context, an intelligently steered dialog supports the user in supplying the necessary information to complete a serviceable and useful query (step 2). This query is translated into semantic structures using the PDL, which is defined as part of the PESCaDO ontology, in order to validate the user input and associate it with the ontology content (step 3). The semantic structures are then aligned with the available environmental information (step 4) and possible implications are calculated by a general-purpose Semantic Web reasoner (steps 5). Finally, the result is filtered according to a selection strategy (step 6) and presented textually as well as visually in the form of an orchestrated and configurable ensemble of visualizations tailored to user and data needs (step 7). Additionally, the results can be used as the basis for adjustments and feedback in order to refine the query (step 8), if the user's demands should not be satisfied.

Steps 3 to 6 are not described further since it would go beyond the scope of this paper. Instead, we refer to [18], [19] and [20] for more details on the overall PESCaDO approach.

IV. Intelligent Support for Query Formulation

In order to deliver a user interface (UI) that is as generic as the expressiveness of the PDL, but at the same time coherent enough to be comprehensible, the visual interface is personalized intelligently according to available context information and the user's information need. Usually the available context is the set of valid queries, the user profile, the already supplied information, and the execution environment, i.e., the browser of the user. Only as much information as needed to form a valid query is requested to keep the user's effort low.

This work focuses on how to exploit a domain ontology for supporting the user to form meaningful queries. The PESCaDO ontology [21] is compiled from manually crafted scenarios, semi-automatically constructed domain knowledge, and existing domain ontologies. It describes, amongst the relations between activities, diseases, and environmental data, also the valid queries that it can handle. These valid queries are implicitly defined, e.g., through subclass relations, class restrictions, and generic properties (e.g. hasStartDate). Our approach analyzes the ontology for these constructs and automatically generates a simple set of rules that the UI can than interpret during a user session. We thereby use preexisting information to better support the user without manually designing the relationships between the input elements.

On the front end, the UI is designed as an intelligent wizard dialog hovering over a geographical map. This geographic area of interest is the natural link between the query generation and the visual result presentation on the same canvas. The wizard allows a free navigation between the pages in order to avoid patronizing the users. After each user input, the UI evaluates the rule set derived from the ontology to identify forbidden inputs or required fields based on the already stated information. The resulting information is used to highlight the relations between input fields in case of an inconsistent query to enable the users to resolve these issues efficiently.

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After the minimum input parameters for the request type are entered, the user can submit her query to the system for decision support. Prior to sending the collected information to the server, the user can review it by inspecting the input parameters on the map (in case of a route or area selection) and a textual summarization of selected data values.

A. Rule Generation

Because every user input needs to be instantiated in the ontology for the result computation, the system has a direct mapping between user input elements and ontology concepts. For each pair of these concepts their ontological relation is examined to infer if they require or exclude each other. Table I lists the relevant class relations that are used to generate the rules. Additionally, *data-type properties* that map to literals instead of concepts, such as *hasStartDateTime*, are examined to create further rules for date ranges and route definitions.

Let us take the first rule of Table I as an example. The subclass of an ontological class is a more detailed definition of the parent class. *Hiking* is a subclass of *Outdoor Activity*. If users state to undertake an *Outdoor Activity*, they have to state one and only one of the subclasses, too. Therefore, a rule is created for each subclass such that: If the parent class is selected and none of its siblings is selected, the subclass is a required input. Because this rule exists for each subclass, they are all required unless one is selected.

Of the roughly 640 concepts in the PESCaDO ontology, 26 were relevant for the UI because they have a mapping to input elements. From their relations and properties, 56 rules were generated and stored in an XML file. The rule's format allows for an easy evaluation in the UI component by substituting the class names for a Boolean, stating if the related variables are filled in by the user. The rule effects are implemented as factors that are multiplied on a fixed standard weight for each input element. Higher weights increase the importance of an input field. Here, *forbidden* has a factor of 0 and *required* has an arbitrary large factor of 1024. Based on additional context data, other rule effects and factors between these two extremes are conceivable to indicate recommended fields.

B. Highlight Guided Input Form

Based on the now known explicit rules, the input fields can be grouped on pages ordered according to the fields' influence. When the most important fields are filled in at the beginning of the interaction, most of the other input fields should already be marked as required/forbidden by the time the users have to fill them in. In this process, even pages having only forbidden fields are not skipped automatically in order to show inexperienced users potentially available fields and give them the opportunity to go back and change the input that forbid the desired ones. The overall progress within the wizard can be seen by a numbered list of pages at the top of the dialog, which also allows navigating between the pages. Here, the current page and pages with errors are marked by different colors.

TABLE I
THE INFERRED RULES FROM ONTOLOGICAL RELATIONS. HERE, Z_i ARE THE SIBLINGS OF Y AND L IS THE LEAST COMMON ANCESTOR OF ALL Z_i. THE PREFIX *count* IS USED TO COUNT THE OCCURRENCES OF Y.

Ontology Relation	Resulting Rule	Rule Effect
Y subClassOf X	$X \wedge \neg(Z_1 \vee ... \vee Z_n)$	requires Y
S hasSomeValuesFrom $\{Z_1...Z_n\}$	S	requires L
not(S hasSomeValuesFrom $\{Z_1...Z_n\}$)	S	forbids Y
X hasOnlyValuesFrom(Y)	X	requires Y
X hasExactCardinality(1, Y)	X	requires Y
X hasMinCardinality(2, Y)	X	requires count:Y

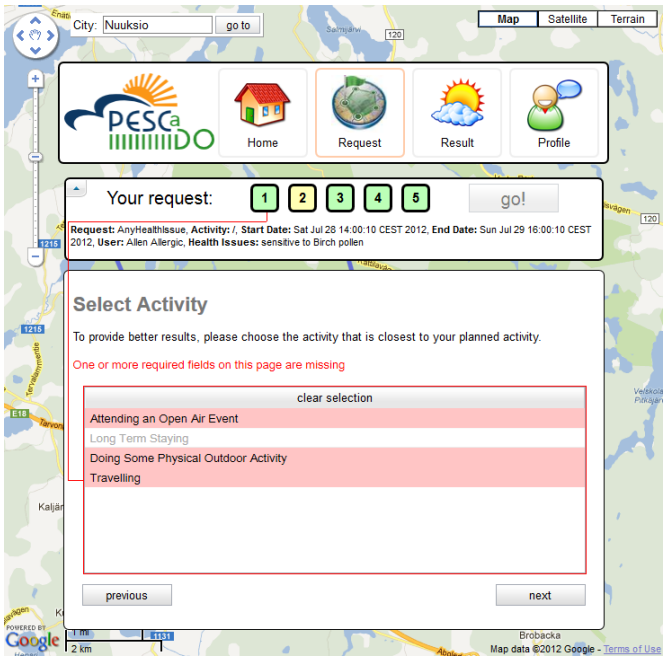

Fig. 2. The PESCaDO query generation wizard. The top row of buttons access different parts of the UI. On the *request* page, four of the wizard's pages have been filled in successfully (green numbers). The current page (yellow) has an error because an input on the first page (red line) requires the user to fill in an activity. A summary of the user-supplied information is given immediately below the page numbers. In the background, a Google Map environment is available for region selection and result visualizations.

Every input field's widget implements its own highlighting methods. This way, even complex and non-standard input methods like a route selection can be highlighted in an optimal way. In the PESCaDO query formulation (see Figure 2), the highlighting of forbidden fields or unfilled required fields follows the common convention to change the color of the fields' borders and backgrounds to gray or red respectively, and including an error message in the vicinity. Additionally, a red line connects conflicting inputs in order to facilitate the tracing of errors. If one of the conflicting widgets is situated on a different page of the wizard, the red line connects to the appropriate page number at the top of the dialog.

The rule effects of the user input are recalculated whenever the user changes a formerly conflicting widget or if the mouse cursor hovers over a navigation control to go to another page of the wizard. If the users did not yet confirm their input, the UI first shows only a warning for the inconsistent input by

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marking them yellow. Navigating to different pages confirms the input and then shows the inconsistent input as an error.

V. Result Representation and Feedback

The response of the system is composed of the environmental data that was deemed relevant for the problem and a natural language description of the situation including potential guidelines that refer to the planned activity and the user's profile. To enable the user to interpret the data quickly, a web based environmental data visualization component was developed that employs different visualization techniques to show the environmental situation, embedded in the same interface in which the query was generated. This approach exploits the geospatial nature of the data and also presents the data in the surrounding of the region of interest.

The visualization component is parameterizable to allow for personalization, allow the stacking of visualizations for the concurrent display of different environmental information, and to make concrete values easily distinguishable. It is based on a generic, uncertainty-aware, environmental data model and a set of flexible visualization methods.

If multiple environmental data types are deemed relevant simultaneously, the system decides on the mode (textual vs graphical) in which the environmental information will be displayed. Additionally, it tries to map data types to visual attributes (shape, size, color, position) without delimiting the overall interpretability. In these decisions, the data types, users' profiles, and their previous interactions are considered by a reinforcement learning approach. When users reassign the selected visualization techniques to different data types interactively, this information is send back to the server to further train the mode selection.

A. Geographical Data Model

In order to allow dynamic user adjustments of the parameters and mappings, every visualization technique has to work on the same generic data model. Of course, not every technique is suitable for visualizing a certain data type - e.g. wind direction vectors cannot be visualized with a bar chart display - but the implemented software interface to the data is the same for all data types. It comprises 1) a *data source* component to access the data in a standardized way, and 2) *data objects* that contain the actual data used by the visualization techniques.

1) Data Sources: Environmental information can be provided by web resources and the data node repository in various types, resolutions, dimensions, and with different degrees of uncertainty. Therefore, data sources are used as a mediator that translates and unifies the data into a generic fixed resolution data format. As an example, a temperature heatmap overlay needs to compute a color value for every pixel of the map, whereas the available data providers might only supply one value for each city in the area. The data source offers the functionality to extend these values to the map's resolution by either returning the same value for every pixel within the boundary of a city, or by interpolation.

Each data source provides meta-data about the environmental data that it delivers in order to allow the visualization to adapt itself to the specific data type. Therefore, each environmental aspect has its own set of meta-data like the name of the aspect, its unit of measurement, the specific subtype of data that it returns, and the thresholds for categorizing continuous data. These meta-information can be overwritten on a per user level so that, e.g., the color-coding could be personalized to account for specific sensitivities of a user.

2) Data Objects: Every request for data is answered by a data source with an object of an abstract *data* class. The two main data types are *atomic data* and *complex data*. Atomic data is further divided into having only a single value (e.g. ozone concentration) or an interval of possible values (e.g. min/max temperature). Complex data can be arbitrarily composed (e.g. wind data as combination of single valued wind strength and a wind direction interval) or be a set of similar data types (e.g. air quality as a set of single valued pollutant concentrations). Due to the importance of uncertainty in PESCaDO, each of the data object used in the visualization has an uncertainty score between 0 and 1.

B. Visualization Modes

The visualization component of the system features a set of web-based visualization techniques that are capable of representing environmental data on a map, after they were requested from corresponding data sources. Some of the techniques are tailored to depict a specific data type, e.g. particle flow for wind data, but most are suitable for visualizing multiple types. They can be divided in two main groups; 1) area based visualizations showing continuous data and 2) glyph-based visualizations showing data at sample points using special icons. An example of some of the available visualization techniques can be seen in Figure 3.

1) Area based visualization: Because the spatial extent of the visualization covers the whole area of interest, it can only depict data at one given point in time. If different time steps are relevant (e.g. throughout one day or multiple days) an animation can be used to give an overview and the users can browse through the time steps manually using a slider control.

Well-known examples of area based visualization techniques are *heatmaps* and *isolines*. While heatmaps use color to depict continuous data in two-dimensional areas, isolines depict points on the map where the visualized data matches a predefined value. In our case, these visualizations are drawn semi-transparently over the map and the conversion from data values to color values is based on the thresholds defined in the data source's meta-information. It can therefore be personalized to the current season and each user individually. Isolines are a well-known metaphor for representing atmospheric pressure and use only limited screen space and no color. They occlude minimal information from the background or other data visualizations and can be used in conjunction with color-based views. Both techniques are suitable for showing a broad overview and are mainly applicable to densely sampled data; otherwise the interpolation between the actual data points

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Fig. 3. Examples of available result visualizations: a particle flow view of wind data on the left side, a combination of a single point label with a normalized line graph along a route on the middle left, a field of wind data glyphs on the middle right, and a bar chart repeated on multiple points in time along a user selected route on the right side.

can lead to false impressions. This can be counteracted by increasing the translucency if the uncertainty is high.

A special visualization technique for wind data is *particle flow*. Similar to isolines, it occludes little screen space and does not employ color. It is generated by seeding particles at random locations and let the wind data (strength and direction) virtually transport the particles. This transport creates a path that can be drawn on the map and can even be animated for a stronger sensation of the wind velocity.

2) Glyph-based visualization: Glyphs only denote data at singular locations. However, they can be spatially extended by repeating them along a route or in a regular grid within an area. Additionally, they can be moved to a separate view outside of the map while showing data from, e.g., the current location of the mouse cursor on the map.

In the proposed framework, each glyph depicts exactly one data object, but multiple glyphs can be combined to form glyph-based visualizations. This has the advantage that each glyph in the view can depict a different point in time, thereby eliminating the need for exploring a time range manually. For this, an intuitive mapping from geospatial positions to time is needed, which can be found as user-planned routes with timestamps for each waypoint. This simulates the actual travel/hike and shows the data of time when the users will probably arrive at a given location.

Labels and weather icons are common means to convey information to the users. The data value with its unit of measurement, or the appropriate icon, is placed at the specified geographical location, usually - but not necessarily - of a fixed size. An example within the PESCaDO prototype are wind arrows, which map the average wind direction to the rotation of the arrow, the possible directional interval is mapped to an arc in front the arrow, the magnitude is mapped to either size or an animation speed, and uncertainty is mapped to the intensity of a Gaussian blur over the whole icon.

For atomic or composed scalar data - which is the majority of environmental data - (stacked) bars can be used to denote data values to the height of a bar. They can also show negative values by extending below the baseline, as well as intervals and uncertainty by adding error margins or color variations. If bars are repeated along a route, their orientation is changed according to the principle direction of the baseline to avoid overlapping (see last panel in Figure 3).

For displaying multiple data types along a user-defined route, the route itself can function as a baseline for a line chart, which maps the individual data values on sample points of the route as the current height of a line orthogonal to the dynamic baseline. In order to unify the scale of the chart for different data types and simplify the interpretation of data, each value is normalized according to three value ranges for *good*, *medium*, and *bad* values. This qualitative normalized scale is then shown as colored bands behind the lines. The data source's meta-information is again used for the normalization, which allows for user level personalization of the chart.

3) Visualization Manager: All visualization types and available data types are registered at the Visualization Manager component as map overlays and/or separate displays. Some of them offer additional control widgets and legends for integration into the UI. Among the default control widgets is a time slider, which controls the visualized point in time. Also, the visualization manager has its own user interface that controls the mapping from data type to visualization technique for personalization.

VI. Evaluation

The ontology supported query generation framework was evaluated in a web based user study. Two different tasks (plan a hike and get air quality information) to be performed with two alternative versions of the user interface were presented to the users. The task/UI combination and order of the UIs where randomized to avoid learning effects. Besides the presented approach, a previous version of the user interface was used for comparison. This version did not highlight errors dynamically but employed hard-coded error checks prior to sending the user query to the system and hid specific input fields based on defined inputs. During the interaction the time and correctness of results were measured and questionnaires on the user satisfaction and UI preference had to be filled. Overall, 56 participants completed the evaluation. The results showed that the improved UI could be used more effectively and reduces the amount of errors in the submitted queries. Consistently, most users clearly preferred the improved UI. These results were deemed significant by a t-test ($\alpha = 0.05$). A significant speed-up in using the new UI could only be observed during the second task, which means that familiarizing with the scenario is probably the major time constraint.

We also performed a web based user study on the usage of adaptive environmental visualizations amongst 55 participants. Focusing on the aspects of data uncertainty and automatic selection of combined visualizations the participants were asked to solve several information gathering tasks and to rate the systems performance in a questionnaire. During these tests

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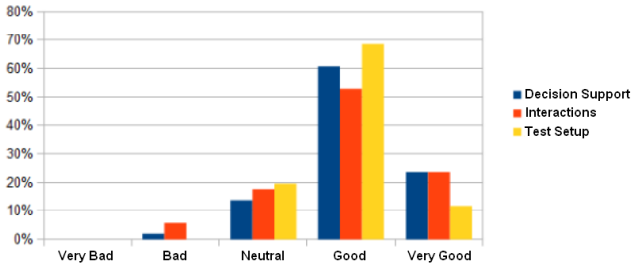

Fig. 4. Results of the adaptive visualizations evaluation. The bars show the users rating of the overall decision support (blue), the interaction methods (red) and the test system (yellow).

we also measured the correctness of the results. In a first phase the users were presented with the individual visualization types in order to learn how to interpret them. Here, two thirds of the participants correctly identified the temperature (3°C tolerance) using only the heatmap. In the subsequent test, the users were shown temperature, wind and air quality data in different combinations (e.g. temperature as heatmap, wind as particle flow, and air quality as bar charts) and they were asked to plan a bicycle ride within a certain time frame and map area. From the questionnaire answers and the correctness of the results we found that the simultaneous display of these data types could be mastered in a coherent fashion that helps the users to get a holistic picture of the situation. The users found the presented methods overall useful and could use them well to solve the presented tasks. The user rating of the information gathering process is shown in Figure 4.

Finally, the PESCaDO system was evaluated by an environmental expert user panel consisting of seven participants. The majority of users deemed the provided information comprehensible and useful and they stated that they would use this kind of service. They found the interface suitable for decision support and pointed out that showing the actual data is important to them. The *particle flow* was not considered to be a good visualization for wind data by some participants.

VII. Conclusion and Future Work

This work presented a novel approach to help end users in formulating complex decision support queries and interpreting the exhaustive results by exploiting domain ontologies and personalization. It is based on externalizing implicit rules that define valid queries in order to guide the user by an improved UI with a coherent structure and dynamic highlighting. The system's results are given in textual and visual mode and provide a personalized overview to suite the visual vocabulary of the user. It therefore allows lay users to employ rich, semantic web based decision support to their day-to-day problems. The visualization component of the approach is tailored to the environmental domain. However, the intelligent support for query formulation could be applied to UIs of other ontology-based systems. In future work, we will examine further possibilities of ad-hoc rule generation based on machine-learning and a unification of error highlighting and default value prediction.

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References

[1] J. Thomas and J. Kielman, "Challenges for visual analytics," *Information Visualization*, vol. 8, no. 4, pp. 309–314, 2009.

[2] S. Delisle and B. Moulin, "User interfaces and help systems: from helplessness to intelligent assistance," *Artificial Intelligence Review*, vol. 18, no. 2, pp. 117–157, Oct. 2002.

[3] D. C. Dryer, "Wizards, guides, and beyond: rational and empirical methods for selecting optimal intelligent user interface agents," in *Proc. 2nd Int. Conf. Intelligent User Interfaces*. New York, NY, USA: ACM, 1997, pp. 265–268.

[4] T. Selker, "COACH: a teaching agent that learns," *Communications of the ACM*, vol. 37, no. 7, pp. 92–99, Jul. 1994.

[5] J. Stocq and J. Vanderdonckt, "WOLD: a mixed-initiative wizard for producing multi-platform user interfaces," in *Proc. 9th Int. Conf. Intelligent User Interfaces*. New York, NY, USA: ACM, 2004, pp. 331–333.

[6] M. Wooldridge, "Intelligent agents: The key concepts," in *Proc. 9th ECCAI-ACAI/EASSS 2001, AEMAS 2001, HoloMAS 2001 on Multi-Agent-Systems and Applications II-Selected Revised Papers*. London, UK, UK: Springer-Verlag, 2002, pp. 3–43.

[7] C.-S. Lee, Y.-C. Chang, and M.-H. Wang, "Ontological recommendation multi-agent for tainan city travel," *Expert Systems with Applications*, vol. 36, no. 3, pp. 6740–6753, Apr. 2009.

[8] M. Armentano, D. Godoy, and A. Amandi, "Personal assistants: Direct manipulation vs. mixed initiative interfaces," *Int. J. Human-Computer Studies*, vol. 64, no. 1, pp. 27–35, Jan. 2006.

[9] M. Frank, M. Muslea, J. Oh, S. Minton, and C. Knoblock, "An intelligent user interface for mixed-initiative multi-source travel planning," in *Proc. 6th Int. Conf. Intelligent User Interfaces*, ser. IUI '01. New York, NY, USA: ACM, 2001, pp. 85–86.

[10] T. M. Rhyne and A. MacEachren, "Visualizing geospatial data," in *ACM SIGGRAPH 2004 Course Notes*. New York, NY, USA: ACM, 2004. [Online]. Available: http://doi.acm.org/10.1145/1103900.1103931

[11] J. Mackinlay, "Automating the design of graphical presentations of relational information," *ACM Trans. on Graphics (TOG)*, vol. 5, no. 2, pp. 110–141, 1986.

[12] J. Mackinlay, P. Hanrahan, and C. Stolte, "Show me: Automatic presentation for visual analysis," *IEEE Trans. Visualization and Computer Graphics*, vol. 13, no. 6, pp. 1137–1144, 2007.

[13] C. Stolte, D. Tang, and P. Hanrahan, "Polaris: A system for query, analysis, and visualization of multidimensional relational databases," *IEEE Trans. Visualization and Computer Graphics*, vol. 8, no. 1, pp. 52–65, 2002.

[14] O. Gilson, N. Silva, P. Grant, and M. Chen, "From web data to visualization via ontology mapping," in *Computer Graphics Forum*, vol. 27, no. 3. Wiley Online Library, 2008, pp. 959–966.

[15] C. Olston and J. D. Mackinlay, "Visualizing data with bounded uncertainty," in *Proc. IEEE Symp. Information Visualization*. Washington, DC, USA: IEEE Computer Society, 2002.

[16] T. Hengl and N. Toomanian, "Maps are not what they seem: representing uncertainty in soil-property maps," in *7th Inter. Symp. Spatial Accuracy Assessment in Natural Resources and Environmental Sciences*, M. Caetano and M. Painho, Eds., 2006, pp. 805+.

[17] S. Oyama, T. Kokubo, and T. Ishida, "Domain-specific web search with keyword spices," *IEEE Trans. Knowledge and Data Engineering*, vol. 16, pp. 17–27, 2004.

[18] L. Wanner, S. Vrochidis, S. Tonelli, J. Moßgraber, H. Bosch, Ari Karppinen et al , "Building an environmental information system for personalized content delivery," in *ISESS*, ser. IFIP Advances in Information and Communication Technology, J. Hrebícek, G. Schimak, and R. Denzer, Eds., vol. 359. Springer, 2011, pp. 169–176.

[19] M. Rospocher, "Pescado ontology documentation," Tech. Rep., 2010. [Online]. Available: http://www.pescado-project.eu/Pages/Pdfs-pages/PESCaDO_Ontology_Documentation_2.0.pdf

[20] E. Pianta and S. Tonelli, "KX: A flexible system for keyphrase extraction," in *Proc. of SemEval 2010*, 2010.

[21] The PESCaDO Project, "The PESCaDO Ontology." [Online]. Available: http://www.pescado-project.eu/ontology.php (retrieved 13. Sept. 2012).

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An Active Program-based Design for User-Centric System by Symbiotic Computing

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***Abstract*— User-centric systems are active programs which always pay attention at users. In this case, users don't need to give explicitly their position to a system which receives it thanks to electronic devices. More, a user-centric system has to provide services to users without explicit request. We have proposed the concept of Symbiotic Computing, which can become the base technology of user-centric systems. We present a concept based on agent-oriented programming, for building systems that support users automatically.**

Keywords-user-centric; symbiotic computing;

I. INTRODUCTION

The kind of activities required to develop a human-oriented and personalized computing is an open problem of software engineering [1]. The eXtreme Programming (XP) [10] is mainly considered as a human activity in software engineering. The Service-oriented Architecture (SOA) may be used to generate user-centric services and contents [2]. XP and SOA require human-activities on system development and maintenance, but we are more concerned by automatic system adaptation to users. The title, "an active program–based design for user-centric system by symbiotic computing" claims that a user-centric system should be designed as an active system. Such a system is built around an autonomous agent. This concept was proposed in paper [11].

A middleware for user-centric systems is a new foundation of platforms that deliver services [3][4]. Infrastructure as a Service, IaaS, Platform as a Service, PaaS and Software as a Service, SaaS are developed as a cloud computing. IaaS, PaaS and SaaS are good solutions to satisfy number of users in the Internet, but a service in a cloud computing should be operated by users.

Advanced research works presented during The Fourth International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services (CENTRIC 2011), identified several problems to achieve a user-centric system. The first one is a "Low user acceptance" [5]. Many devices support users to satisfied their requirements, but, in general, not all users are satisfied with those services. Users feel to be forced to use specific devices and to obey complex procedures. Users may be bored with using digital devices and networked services; they have other things to do. We defined two requirement specifications to create user-centric systems. The first one is that a user-centric system always has to be aware of the user's situation without expressed authentication. The second one is that a user-centric system has to bring services to users without explicit instruction.

In other words, an intelligent agent is necessarily required for a user-centric system. We focus on two things that are: find a proper user for a system and deliver a service without action of the user.

II. SYMBIOTIC COMPUTING

To develop a user-centric system, we use the concept of Symbiotic Computing [6]. Symbiotic Computing was proposed to bridge the gap between the real space and the digital space by creating symbiotic relations between users in the real space and information resources in the digital space. Symbiotic Computing is not ubiquitous computing as it may seem at a first glance. The key concept of Symbiotic Computing is based on Perceptual Functions and Social Functions. A Perceptual Function translates a signal from real space into a symbol in Symbiotic Space. Social Function translates a signal inside the Symbiotic Space. A signal in real space is captured by processes (**P** in Figure 1). A signal in Symbiotic Space is captured by elements of the Symbiotic Space itself.

Symbiotic Computing looks like Ubiquitous Computing, but normally Ubiquitous Computing does not care about user. A system based on Symbiotic Computing always keeps a contact with a user. This concept is *a priori* mechanism.

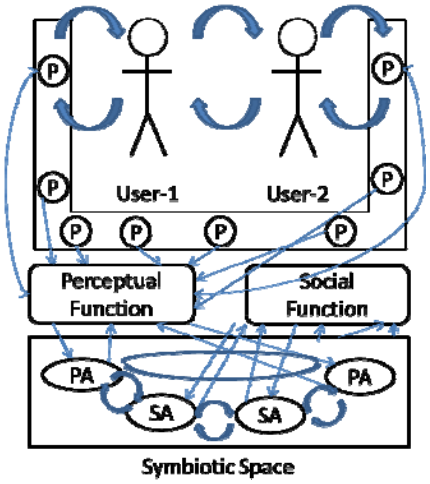

Figure 1. Symbiotic Computing

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In Figure 1, **P** may be a computational process which provides a service to a user such as a web browser, a mailer or a smartphone application and so on, or **P** may be a sensor which captures a signal in real space such as a video camera, a GPS device, or a microphone and so on. **PA** is a Partner Agent and **SA** is a Social Agent. A partner agent is attached to a unique user in real space. On the other hand, a social agent is an entity which corresponds to a social activity in real space and digital space.

III. PASSIVE VS. ACTIVE

Most of applications in a smart phone such as iPhone or Android device achieve passive actions from user's operations. A basic action of a passive system occurs from a user's request. A little bit more active system is able to trigger some action. A simple push action may be driven by a timer in a system. A typical example is an alarm for waking up a user application. A smarter push application may use another system (for example, on the internet) to provide suitable information. A passive system is shown in Figure 2.

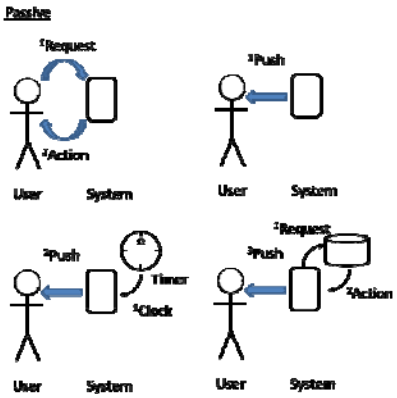

Figure 2. Interactions Between a User and a Passive System

Another problem of passive user-centric system is the incapacity to recognize a user. A user does not appear in front of a system. But, a system will still push information for user. A worse case is when a fake user uses a user-centric system. Of course, a user-centric system would have an authentication for a proper user. But, sometimes, a user does not care about a device after authentication. A fake user takes a benefit for a proper user. On the other hand, a proper user may become nervous with a user-centric system, because, the system often pushes information without considering the user's situation or context. For example, a user in an important meeting may see the system pushing information about an Olympic game score. And the more a user gets skills to use a system, the more she becomes irritated by an inappropriate system. This problem in passive system is shown in Figure 3.

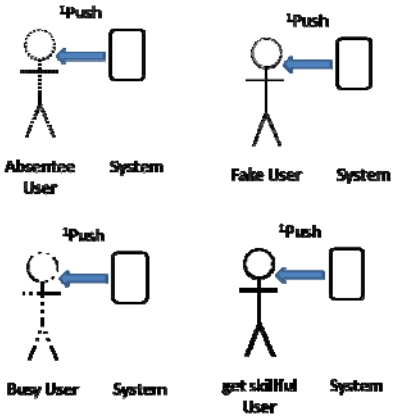

Figure 3. Passive System Fails User Cognition

To avoid problems caused by passive systems, a user-centric system must have two functions. The first one is a user cognition function and the second one is a generating service function. A simple active system model is shown in Figure 4. When using an active system, a user does not make actions for triggering effects; an active system always follows the user's behavior by using Perceptual Function and Social Function.

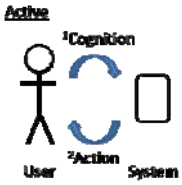

Figure 4. Active System

IV. EXPERIMENTAL ENVIRONMENT

We show in Figure 5 an experimental environment to test an active system in Symbiotic Computing. Four web cameras are capturing scenes every minute in a laboratory. The first objective is to identify a user from captured images.

The graphical image processing is supported by the OpenCV, the well-known middleware for graphical based image recognition. A captured image is an example of signal in real space and is translated into symbols by perceptual functions. When a web camera captures a room image, a system supported by the OpenCV captures a face image from this room image, and then looks for a corresponding face image in database thanks to the SIFT algorithms. Finally, a system creates a symbol which identifies Mr. A in the room image (Figure 6).

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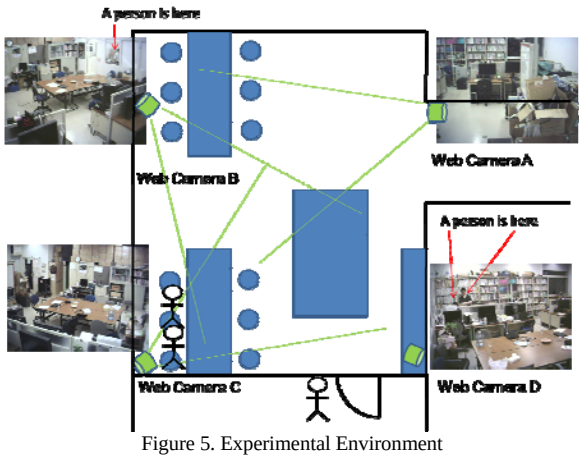

Figure 5. Experimental Environment

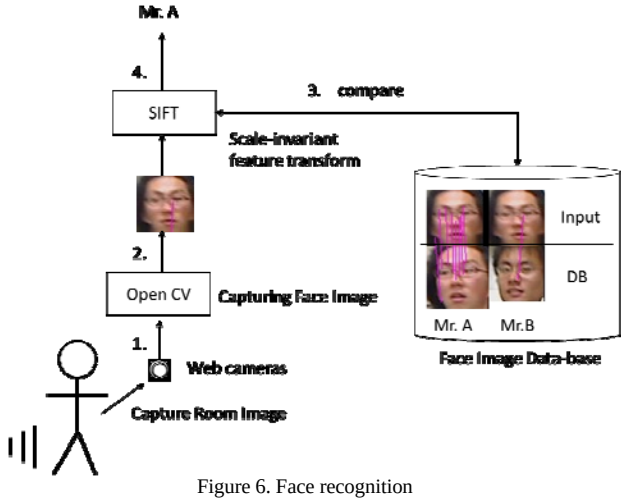

Figure 6. Face recognition

V. ACTIVE PROGRAM BASED DESIGN

The concept of active system has been presented in Section III. We make a template of active program based design for user-centric system. Agent-oriented programming [8] is a base of our template.

Agent-oriented programming is based on "mental-state" to check a set of assumptions about agent cognition. The mental-state corresponds to an expression of real space and identifies a proper user.

Partner agents always follow a user. A partner agent captures real world elements and generates symbols. A symbol comes from one of it Perceptual Function. A symbol expresses a real world element with Vectors. Vectors are a set of symbols and value vectors. A Decision is due to a set of rules applied by an active action to serve a user. All of rules begin to check a user's symbol. If a user's symbol does not exist in Vectors, a default rule of a partner agent is fired for searching a user. A Criterion is a set of meta-rules of a partner agent. A rule in a criterion evaluates the Perceptual Functions which create a symbol. If a bad symbol comes from a Perceptual Function, a Criterion will require another Perceptual Function to create a good symbol for identifying a user. The Partner agent model is shown in Figure 7.

Currently, we are implementing the concept of active program based design for user-centric system with our multi-agent framework [9] written in Steel-Bank Common Lisp.

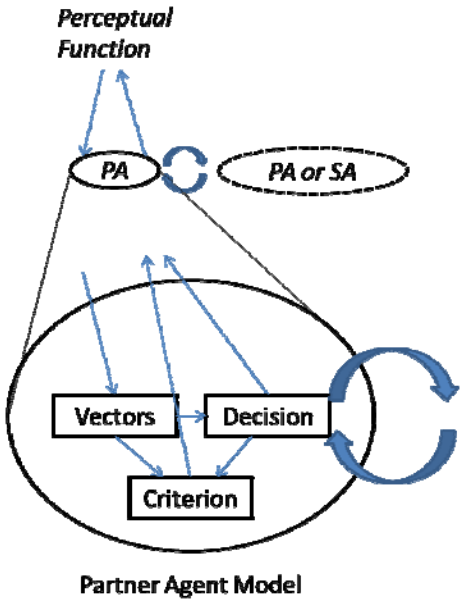

Figure 7. Partner Agent Model

VI. CONCLUSION AND FUTURE WORK

In this paper, we showed the problem of passive system which does not recognize user. We also showed the concept of Symbiotic Computing which is based on an agent-oriented programming model. A system which is based on Symbiotic Computing principles is able to recognize a user. Such a system will support a user without reconfiguration by a developer.

In order to support a user, a system always uses two functions. The first one is the function that recognizes a proper user at every time. The second one is the function that automatically delivers a service by considering the user's situation.

We showed an experimental environment in section IV. And, we currently implement a prototype system with our multi-agent framework. The prototype system will identify a proper user.

In the future, we will implement perceptual function and partner agent, and we will define a formal design model of a user-centric system based on Symbiotic Computing.

REFERENCES

[1] M. DeBellis and C. Haapala, "User-Centric Software Engineering," IEEE Expert, pp. 34–41, February 1995.

[2] S. Komorita, M. Ito, H. Yokota, C. Makaya, B. Falchuk, D. Chee and S. Das, "Loosely Coupled Service Composition for Deployment of Next Generation Service Overlay Networks," IEEE Communication Magazine, pp. 62-72, January 2012.

 ISBN: 978-1-61208-232-5

[3] R. E. Schantz, "Middleware for Distibuted Systems," http://www.agentgroup.unimore.it/didattica/ingss/Lec_Middleware/Schmidt_Middleware.pdf (last access, 2012/July/31).

[4] K. Henricksen, J. Indulska, T. McFadden and S. Balasubramaniam, "Middleware for Distributed Context-Aware Systems," http://henricksen.id.au/publications/DOA05.pdf (last access, 2012/July/31).

[5] Y. Chen and C. Leung, "A Study on the Lost Seeking Devices and Systems for Dementia-Patients," CENTRIC 2011, pp. 15-21, ISBN: 978-1-61208-167-0, October 23-29, 2011 - Barcelona, Spain

[6] N. Shiratori, K. Sugawara, Y. Manabe, S. Fujita and B. Chakraborty, "Symbiotic Computing Based Approach Towards Reducing User's Burden Due to Information Explosion," Journal of Information Processing, Vol.20, No.1, pp. 37-44, January 2012.

[7] K. Sugawara, Y. Manabe and S. Fujita, "Mobile Symbiotic Interaction between a User and a Personal Assistant Agent," ICCI*CC2012, August 22-24, 2012, Kyoto, Japan

[8] Shoham, "Agent-oriented programming," Artificial Intelligence, Vol.60, pp. 51-92, 1993

[9] S. Fujita, K. Sugawara and C. Moulin, "The Design of a Symbiotic Agent for Recognizing Real Space in Ubiquitous Environment," Advances in Cognitive Informatics and Cognitive Computing, Springer, pp. 13-32, 2010

[10] Kent Beck, "Extreme Programming Explained: Embrace Change," Addison-Wesley Professional, 1999

[11] S. Fujita, H. Hara, K. Sugawara, T. Kinoshita, N. Shiratori, "Agent-Based Design Model of Adaptive Distributed Systems," Applied Intelligence, Vol. 9, pp. 57-70, 1998

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A new mediator-based architecture for the dynamic service composition

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***Abstract*— Nowadays, the effective and adaptive dynamic Web service composition is a major challenge for a real success of Web services. In fact, the heterogeneity of the environment and autonomy of web services make it difficult to compose web services dynamically from various service providers. This problem is also accentuated by the increase of the user mobility. By analyzing the actual technology and its evolution, we propose in this article a mediator-based architecture that allows users to dynamically compose the ubiquitous web services. Furthermore, the approach we have adopted also facilitates the semantic web. A model which is implemented in .NET has validated the feasibility of our proposal.**

Keywords-Web service composition; context adaptation; mediator; semantic web; user-centric.

I. INTRODUCTION

With the rapid development of the web technology, the Web Service (WS) has attracted great attention in the industry domain. The WS, with its full autonomy and loose-couple interface, provides an ideal integrate approach for the implementation of the application deployed on the Web in various domains.

With the rise of the applications based on the Internet, as well as the B2B/B2C and the development of Cloud Services and Internet of Things (IoT), service integration and performance requirements continue to increase. It is difficult to meet the user's needs through a single specific service. So, the dynamic service composition attracted the attention of academics and business in the past few years. However, there are several problems to solve in the process of composing dynamic services. First of all, we cannot easily integrate the WSs from the different suppliers because of the heterogeneity of the environment and the autonomy of WS. Secondly, due to the dynamic nature of the operation and process treatment, coding in a fixed form is no longer applicable. Thirdly, because of the user mobility and their diverse needs, we need a mechanism to dynamically discover, select and combine the WSs in the inter-organization and cross-platform.

With the development of the Cloud Computing and the occurrence of the increasingly diverse WSs, as well as the democratization of mobile terminal (Smartphones, Tablet), more and more users would like to perform a sequence of operation automatically according to their logic which refers to use a series of individual existing WS.

Therefore, it is appropriate for us to conceive architecture to provide the service composition such a benefit with the development of SOA. One of the key issues is the semantic web. It allows not only to solve the problem of mismatching between the web services, but also to automatically identify the functional equivalent service entities. The latter is very useful to answer another key question that is the adaptation to the context (or ubiquity), which is to be able to replace a service entity by another functionally equivalent one. We believe that the mediator-based approach that we propose could be a response to these two key questions.

In this paper, our work is in the context of NGN/NGS (Next Generation Network/ Next Generation Service) which refers to the paradigms—heterogeneity, mobility and user-centric. Based on analyzing current language, technology and the method of the service composition, we propose a mediator-based architecture to achieve dynamic service composition. We present the overall vision and we discuss the technical solutions for the key component within it. We illustrate the feasibility of our proposal through a model that we have achieved and we present an application of our architecture through a use case.

In our model, the mediator has a Knowledge Base of WSs, each of them is assigned with a descriptor, a kind of meta-model that contains various information, including the inputs/outputs and constraints, the syntactic and semantic (for the semantic web extension), and the location of available entities to provide service (allows context adaptation) as well as the contextual information. A natural extension is the creation of meta-WS, which can be integrated into the above knowledge base exactly in the same manner as a real basic WS. These meta-WSs are a kind of "proxy". Thus, our WS-mediator also allows the

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creation of the true "intermediaries" to which we refer as a semantic extension. In particular, a WS-mediator can be used to select, at run time for instance, the best WS according to the using context. Exploring the knowledge on the existing WS for the purpose of semantic web can also create such a WS-mediator. On the point related to the context adaptation, our work is conducted partially within the French ANR/VERSO/UBIS project, which proposes a general architecture providing ubiquitous services that include identifying, for each service (within the meaning of abstract term), functionally equivalent services entities. Our work has been in effect for the partial framework ANR / UBIS.

This article is organized as follows. In Section 2, we present the related work about the current technology and solutions of the service composition. In Section 3, we conceive our proposal -- a mediator-based architecture and its main features. Section 4 shows our model which is implemented based on the .NET 4.0. An application on a scenario is illustrated in Section 5. Finally, conclusion and the future work are presented in Section 6.

II. RELATED WORK

Different views and focuses on the approaches for the Web service composition have been suggested in the literature during the last years. All of these try to provide languages, methods and models in order to propose efficient solutions for this problem.

Generally speaking, there are three types of language for the service composition. First of all, there is the process-oriented description language. Such as the BPEL4WS [1] (Business Process Execution Language for Web Service) and WS-CDL [2] (Web Services Choreography Description Language), BPEL4WS is largely used in the industrial domain. It devises a business process into an abstract and executable process. In addition, it defines the model and description language of the business process behavior. Thus, it greatly facilitates the process description and execution. WS-CDL describes peer-to-peer collaborations of participants by defining, from a global viewpoint, their common and complementary observable behavior, where ordered message exchanges result in accomplishing a common business goal. Both languages are XML-based, so they are usually applied to describe the Orchestration and Choreography [3]. Secondly, AXML [4] is a data-oriented language that is used in some specific areas such as astronomy or meteorology in order to handle the heterogeneous and massive data sources. The third type is the semantic-oriented language such as OWL-S [5] (Semantic Markup for Web Service) and SAWSDL (Semantic Annotation Web Service Description Language) [6]. By adding the semantic information into the description of Web service, it is possible to make the data and functionality machine-understood in the life cycle of a WS, and then generate a dynamic process of composing various WSs automatically.

With regard to the existing methods and tools for service composition, the WSMF (Web Service Modeling Framework) coined the term data mediation in the WSs context, the aim is to strengthen the semantic feature in order to automatically discover, compose and execute the services. It defines preconditions and effects and can be used for semantic annotation of WSDL with WSDL-S. However, there is no mechanism to describe Choreography or Orchestration in the WSMF, which seems an incomplete mix of semantic and syntactic. The WSMX (Web Services Modeling Execution Environment) is the reference implementation of WSMO [7][8] (Web Service Modeling Ontology). The principle of WSMF design is: a) strict decoupling of various components of the web service; b) use of the mediator to coordinate the various components. Thus, WSMF defines four elements, i.e. Ontology, Goal, Web Service and Mediator. WSMX creates an environment for WSMF and then increase business process automation in a very flexible manner while providing scalable integration solutions. The METEOR-S [9] project at the LSDIS Lab, University of Georgia, aims to extend the standards (SOAP, WSDL, UDDI) with Semantic Web technologies to achieve greater dynamism and scalability. They endeavor to define and support the complete lifecycle of Semantic Web processes [10]. In SWORD [11], a service is represented by a rule that expresses certain given inputs, and the service is capable of producing particular outputs. A rule-based expert system is then used to automatically determine whether a desired composite service can be realized using existing services. SWORD does not require (but could benefit from) wider deployment of emerging service-description standards such as WSDL, SOAP, RDF and DAML. Comparing to the traditional Petri Net based framework for Web services composition, the model proposed in [20] makes use of a kind of high level Petri nets called G-Nets instead of elementary ones. Basic and advanced constructs which are supported by the proposed algebra are syntactically and semantically defined. Considering the no-functional aspect, [23] provides a model which meets the QoS requirements of service consumers, guarantees the availability of Web Services composition and maximizes service providers' benefit. Meanwhile, [24] takes the QoS, user preference and the service relationships into account and proposes a method based Viterbi algorithm to reason out the global optimal solution of web composition service.

From the perspective of realization, we can define the service composition as manual, semi-automatic and automatic. The manual service composition [12] demands the user to clarify the process through GUI or a text editor, and then submit such process to the execution engine. For example, BPWS4J provides an eclipse plug-in which use WSDL and BPEL to describe the executable process. A model ontology tool named Protégé [13] can work with OWL-S API [14]. It can produce the OWL through WSDL, and then create the service composition with the service element manually selected by the user. The automatic or semi-automatic technology use the artificial intelligence (or AI planning) during the composition process. SWORD [11] adopting the service description based on rules, composes

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services across details of the initial and final states, but it asks the user to specify the states of the service and lacks the part of service discovery. [21] propose a set of heuristics to effectively prune a large number of candidate abstract services and a novel approach to fully automate the generation of abstract services from a service community that consists of a set of functionally similar services. However, it lacks the human intervention. The IEEE Next-Generation Service Overlay Networks (NGSON) working group is focusing on the integration. The NGSON architecture was proposed [15] according to the NGSON concept with its extension for service composition. Sivasubramanian et al. [16] proposes some criteria to identify the levels of dynamism and automation in service compositions. Moreover, the NGSON group proposes a strategy where different techniques can be used to make compositions more automatic and dynamic with a model driven approach. However, a problem of such approach exists where, although the method can generate the process model automatically, there is a lack of the interactions between the designers and the process. This means it cannot accept the designer's decision as auxiliary information to generate next flow path during the composition process at runtime, because only the syntactic binding exists. Radiant [17] is an eclipse plug-in graphical tool that enables one to annotate existing Web service descriptions with Ontologies to create SAWSDL files [18]. Besides, there is also the "mash up" type composition approach, which offers a better legerity. For example, APIhut [19] builds a nice ecosystem in which one can reuse Web APIs, but advanced capabilities must also be developed in order to lead to dynamic configuration and composition for complex services. Moreover, following the survey and observation under the traditional composition context, Syu et al. [22] suggests two approach patterns and point out possible future challenges as well as directions, to the influence of the mature of mobile devices and environment.

Taking into account the current methods and the technologies of the service composition, we can add semantic information hierarchically in our mediator to realize our architecture. Concerning the specification and implementation of process, we adopt a process-oriented approach to achieve the control and execution for the service composition. In general, our architecture was integrated by several elements proposed in the existing solutions, for example the knowledge base of WSMF, the semantic annotation of METEOR-S, the matching of input/output in SWORD.

III. PROPOSITION: ARCHITECTURE AND FUNCTIONALITIES

We present hereafter the main architecture of our mediator and the functional entities within our approach.

The user begins by choosing the web services that he wants according to his logic. The WSs are registered in the Knowledge base with all the information of each WS element, and in particular, a model for each WS. Furthermore, the functional semantics, domain ontology and parameter ontology based Web service description methods can be used for WS composition that allow the semantic web. The composition is done, in our current prototype, through a Graphic User Interface, script-based extension will be added in the future. In this way, we get a composed execution entity that is totally autonomous. As the composition is based on the model of the WS, the Mediator-based system monitors Web Services at different locations in the Internet and dynamically assesses their dependability.

Figure 1 shows our proposal, initially, our mediator provides the basic function of data mediation for the service composition. The modules within the mediator work with the human intervention, the Process model of service composition can send its transaction taking into consideration of QoS, certain restraint and rules [23] as well as the models and algorithms [24]. In addition, the mediator adopts a knowledge base with WS available that can be dynamically composed. This database allows our architecture to provide both the extension to the Semantic Web and the ability of the context adaptation (ubiquity). Indeed, by identifying the WS (identified in the database) which are best suited to the user's semantic logic, the mediator is able to provide an appropriate service composition. On the other hand, we can also identify the service entity suited to the service (abstract) depending on the user preference through the same logic. This can be coupled with the service discovery that is dynamically fed by the knowledge base. The mediator can use the service entity which is best suited to the location of the user and ensure the context adaptation.

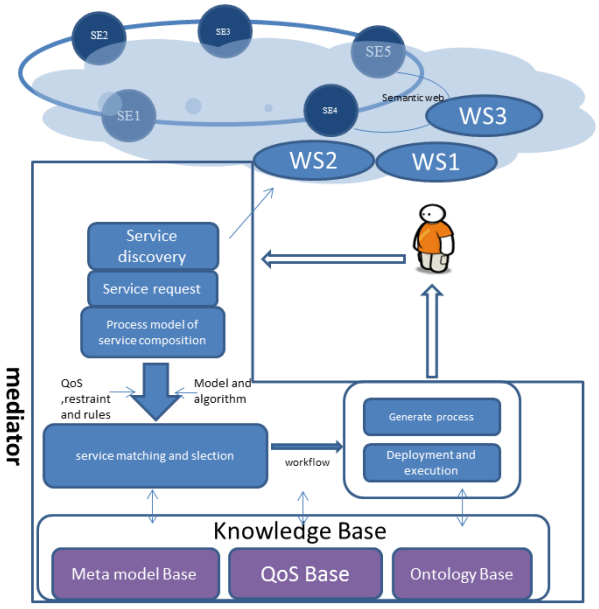

Figure 1. A mediator-based architecture

Our mediator can also provide the mapping between elements of SAWSDL. To illustrate various mapping representation options, we can use SPARQL for

representing mappings through the ontology knowledge base. The reasoning ability of ontology can help to resolve the substitution operation for the mismatching problem of web services so that we have a context adaptation with the semantic extension. The semantic extension will be integrated in accordance with certain rules for effective bonding to form a new web service composition. If there is no single service that could meet the user requirements, we can proceed by deductions and the dynamical combinations of semantic, based on the self-descriptions and the marks on the OWL-S of either the functional or the non-functional requirement among the known web services. Therefore, our approach enables us to access a loose-coupled way for the WS-mediator both on syntax and semantic. The implementation of the semantic extension (which will be based on existing tools [8] [11] [18]) is out of the scope of this paper.

A. *Knowledge base*

We get inspiration from storage of knowledge in WSMF and storage of XML in METEOR-S, and then we define a Knowledge Base which identifies the web services known to the mediator. The purpose of the Knowledge Base is to gather all the information (URI, operation, input / output from WSDL) of Web Services. The Knowledge Base is made manually (offline) in the current phase of our work. We define three sub-bases in our Knowledge Base:

- Meta model Base, which identifies the models of processes. For the common used services, a synoptic model can be generated by the service provider.

- QoS Base, which is used to store the QoS information. The mediator may find the semantic description of QoS based on WSDL during the period of discovery and matching. In the process of matching and optimization, QoS performance evaluation may be associated with the operation parameters during execution, so it is useful to save them to feedback. For example, considering the reliability of the service, we should refer to the success rate of execution because it is not comprehensive only depending on the service provider.

- Ontology Base, which is to store and manage the ontology service description and the semantic annotation, the upper level ontology and the domain specific ontology.

B. *Discovery, matching and selection*

Service discovery consists of two parts: a) the semantic discovery of each service request to create a process; b) the semantic discovery of service registered in UDDI that contains semantic information. The discovery of the semantics process, coupled with that of WS identified in Knowledge base, allows the identification of WS which may be involved in the process depending on their semantics. If we want to compose two web services, we will begin with choosing the services that we want to use, testing whether the services are available by the QoS restraint and rules, and checking the inputs and outputs of them. Both the syntactical and semantic heterogeneity may exist in the input and output messages that are exchanged between WSs. Once the services are ready to be used, the binding will be implied in the invocation of the composed services, and then we have the service selection done.

C. *Generation and Execution*

The execution entity receives the process model provided by the composition module. By setting the WSDL files and workflows, the output is an XML file that contains the entire process / composition. The execution entity receives the composition scheme provided by the composition entity. The mediator then generates an execution entity that is completely autonomous and re-usable.

IV. IMPLEMENTTATION

Based on SOA and WSC technologies, we have implemented our approaches and provided a comprehensive tool. The tool suite accepts WSs described using standard language such as WSDL as well as SAWSDL, which can provide us a semantic extension. The description of the process is done through an intuitive graphical interface to specify the user's logic, requirements and goals. From this description (which may be also provided as script), the component "mediator" of the system composes the services identified in the BDC, and then generates the composition as an execution entity that is available to the user.

We choose to implement the tool using web service developed in WCF (Windows Communication Foundation) of the Framework .NET 4.0. Because WCF supports not only SOAP message, but also it can be configured to support standard XML data that is not wrapped in SOAP, or can even be used to support other formats. This yields opportunities for evolutions such as the integration of the RESTful service.

We build the WCF based on three elements:

- Address: the address that the user must connect to use the service.
- Binding: the protocol to be used by the user to communicate with the service.
- Contract: the information exchanged between the mediator and the user so that he knows how to use the service.

The tool suite is an integrated developing environment for the process designers to

- Import candidate WSs and their description files
- Specify process hierarchies, initial state and goals

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- Generate the plan and convert the plan into the corresponding execution entity.

In order to realize the three points mentioned above, we define and create the service contract and its parser module to provide the output of the previous WSs exactly match the required input of the successive WS. The Service contract is defined

- To be exchanged between the mediator and user
- To allow the user to know what are the methods proposed by the service and how to use them.

The development of the Service Contract is performed through the 3 following metadata:

- <ServiceContract>: This metadata is used to define a class. It serves to indicate the class or an interface is a Service Contract.
- <OperationContract>: This metadata is attached to the methods that we want to expose through WCF service. Thus, it is technically possible to expose certain methods of a class to the user.
- <DataMember>: This attribute is placed before the properties of classes to define objects that are then going to exchange the parameters with the service.

For example, we want to compose the WSs Multiplication, Subtraction and Addition (see Figure 2)

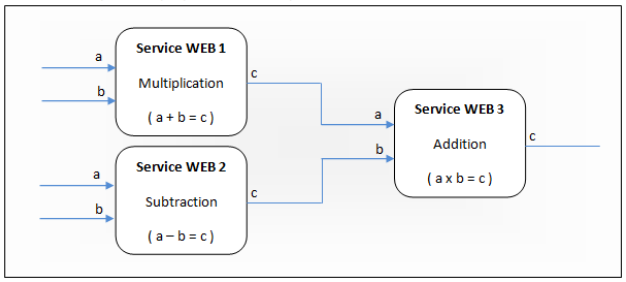

Figure 2. Example for the service composition

The service contract outlines the information that describes the service delivery. It defines a mechanism for the service orchestration between the service elements. It defines in particular the interface specification and describes the service logic and service purpose as to implement the process information about the service elements to supply a more efficient treatment. The service contract focuses on the organization and parsing of input/output data treatment as well as the QoS (if needed). Figure 3 provides the details of the service contract with schema XSD (XML Schema Document)

```
<?xml version="1.0" encoding="utf-8" ?>
<Contrat xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
         xsi:noNamespaceSchemaLocation="Structure_Contrat.xsd">
  <Services>
    <Service>
      <ServiceNom>Addition</ServiceNom>
      <Inputs>
        <Input>
          <InputNom>a</InputNom>
          <InputType>int</InputType>
        </Input>
        <Input>
          <InputNom>b</InputNom>
          <InputType>int</InputType>
        </Input>
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      <IndiceOut>2</IndiceOut>
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      <Nom_Input>b</Nom_Input>
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      <IndiceOut>3</IndiceOut>
      <Nom_Output>RéponseSoustraction</Nom_Output>
    </ServiceConnecte>
  </Relation>
</Contrat>
```

Figure 3. Schema XSD of the service contract

Then we parse this XSD file and generate the code (see Figure 4) that allows creating the execution entity for the end-user.

```
AttributService i21= new AttributService();
i21.nom = "b";
i21.type = "int";
Soustraction3.Inputs.Add(i21);
AttributService O20= new AttributService();
O20.nom = "RéponseSoustraction";
O20.type = "int";
Soustraction3.OutPuts.Add(O20);
Soustraction3.ServiceTete=true;
_liste.Add(Addition1);
Multiplication2.Suivant = Addition1;
Addition1.getInput("a").connextion=Multiplication2.getOutput("RéponseMultiplicatio
n");
_liste.Add(Multiplication2);
Soustraction3.Suivant = Addition1;
Addition1.getInput("b").connextion=Soustraction3.getOutput("RéponseSoustraction");
_liste.Add(Soustraction3);
}
public List<Service> liste
{
get { return _liste; }
}

}
}
```

Figure 4. Part of Code to generate the execution entity

Finally in the GUI, we will get the result in “Figure 5”

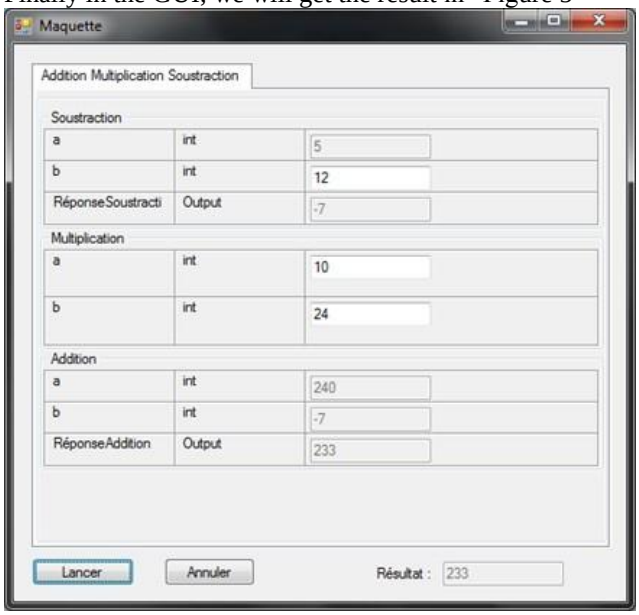

Figure 5. Result in the GUI

V. APPLICATION

We present below an application of our system through the following use case scenario.

This is a provider for customizing the web services specialized in real estate. For this, it has identified the WSs in its Knowledge Base; on the other hand, the following services can be claimed by a potential user:

- WS1: « Square Habitat » is a service of real estate
- WS2: « Mappy » is map service (Google/Apple)
- WS3: « BUS » : is a carpool service
- WS4: a service of local real estate agent

The available services are provided through the interface "Catalog" that the user can preselect and then create his own logic using these services through a GUI. The transaction is to find the corresponding service elements to achieve the composition and generate executable code available to the user.

"Figure 6" shows the interface that allow user to specify the desired services and their sequence by his own logic. For example, searching for properties, and then identifying the location of the real estate agent in order to find a way to get there by carpooling. So as to the context adaptation of the composition, the mediator must replace the concrete service entity by a "proxy", which is a meta-WS symbolizing the abstract service. The role of meta-WS is to identify and operate the concrete entities which are best suited at run time depending on their context.

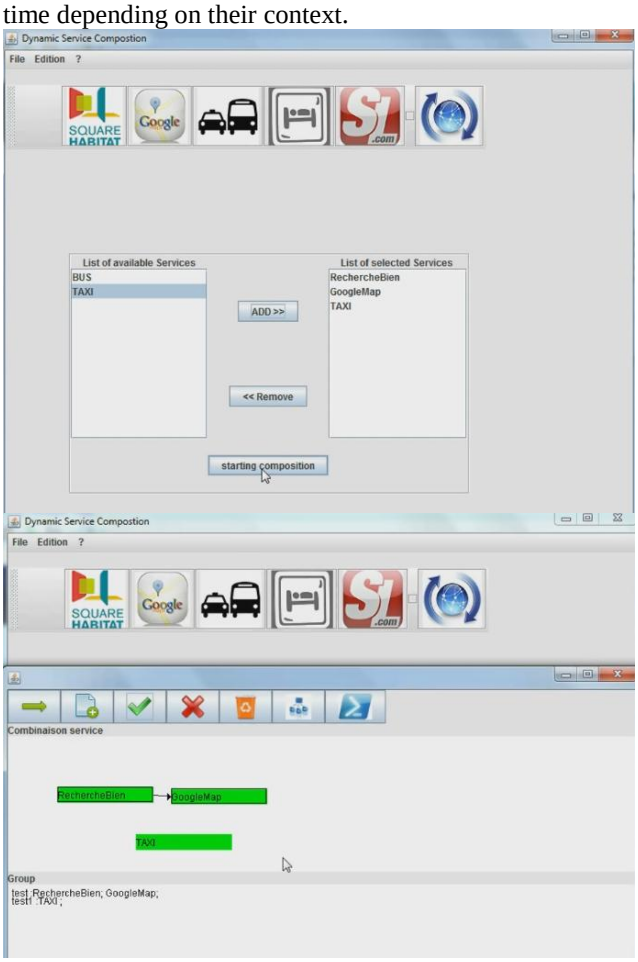

Figure 6. Application

VI. CONCLUTION AND FUTURE WORKS

In this paper, we propose a mediator-based architecture for dynamic service composition. We have clarified the main functionalities. Meanwhile, we show the potential capacity of this architecture to integrate the semantic web and to ensure the context adaptation. We presented a model (based on .NET/WCF) that we developed to validate our proposal and to provide a functional service composition tool ultimately. Furthermore, we should pay attention to the RESTful Web services which are lightweight. This

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supposition, however, is going to be considered in our future work.

REFERENCES

[1] Web Service Business Process Execution Language Version 2.0. OASIS Standard, 11 April 2007. http://docs.oasis-open.org/wsbpel/2.0/wsbpel-v2.0.pdf [retrieved: November, 2012]

[2] Web Services Choreography Description Language Version 1.0 , W3C Candidate Recommendation 9 November 2005, http://www.w3.org/TR/ws-cdl-10/ [retrieved: November, 2012]

[3] C. Peltz, Web services orchestration and choreography. IEEE Computer .36(10): pp.46-52 (2003)

[4] INRIA future Project Team Gemo. Management of Data an Knowledge Distributed Over the Web. http://www.inria.fr/rapportsactivite/RA2005/gemo/gemo.pdf [retrieved: November, 2012]

[5] OWL-S:Semantic Markup for Web Services.W3C Member Submission 22 November 2004.http://www.w3.org/Submission/OWL-S/. [retrieved: November, 2012]

[6] Kopecký, J., Vitvar, T., Bournez, C., and Farrell, J. (2007). SAWSDL: Semantic Annotations for WSDL and XML Schema. IEEE Internet Computing, 11(6), pp.60-67. doi: 10.1109/MIC.2007.134.(2007)

[7] http://www.wsmo.org/TR/ [retrieved: November, 2012]

[8] Web Service Modeling Ontology(WSMO),W3C Member Submission 3 June 2005. http://www.w3.org/submission/WSMO/. [retrieved: November, 2012]

[9] http://lsdis.cs.uga.edu/projects/meteor-s/ [retrieved: November, 2012]

[10] P. Rajasekaran, J. Miller, K. Verma, and A. Sheth, Enhancing Web Services Description and Discovery to Facilitate Composition, International Workshop on Semantic Web Services and Web Process Composition, Proceedings of SWSWPC (2004)

[11] Ponnekanti S R and Fox A., SWORD: A developer Toolmit for Web Service Composition. Proceeding International WWW Conference (11). (2002)

[12] IBM Alphaworks, BPWS4J, http://www.alphaworks.ibm.com/tech/bpws4j. [retrieved: November, 2012]

[13] The Protégé ontology Editor and Knowledge Acquisition System. http://protege.stanford.edu/. [retrieved: November, 2012]

[14] Sirin E. OWL-S API. http://www.mindswap.org/2004/owl-s/api/. [retrieved: November, 2012]

[15] Macaya,C., Falchuk, B., Dana Chee Lin, F.J. Das, S. Ito, M. Komorita, S. Chiba, and T. Yokota, H.: Services Composition based on Next-Geeration Service Overlay Networks Architecture. In:New Technologies, Mobility and Security (NTMS), 2011 4th IFIP International Conference, pp.1-6. IEEE Computer Society,Paris (2011)

[16] Sivasubramanian, S.P., Ilavarasan, E., and Vadivelou, G.: Dynamic Web Service Composition: Challenges and Techniques. In: Intelligent Agent & Multi-Agent Systems, 2009. IAMA 2009.International Conference, pp.1-8. Philharmonic Luxembourg (2009)

[17] Radiant SAWSDL/WSDL-S Annotation Tool http://lsdis.cs.uga.edu/projects/meteors/downloads/index.php?page=1 [retrieved: November, 2012]

[18] Gomadam, K. et al., Radiant: A tool for semantic annotation of Web Services. in The Proceedings of the 4th International Semantic Web Conference , ISWC (2005).

[19] K.Gomadam et al., A faceted Classification-Based Approach to Search and Rank Web APIs, to appear in Proc. IEEE Int'l Conf. Web Services , IEEE Press (2008)

[20] Bachtarzi, F. Chemaa, S, and Chaoui, A. A G-Net based approach for Web service composition, Innovation in information & Communication Technology(ISIICT), pp.19-24 (2011)

[21] Xumin Liu and Hua Liu, Automatic Abstract Service Generation From Web Service Communities, Web Services(ICWS), 2012 IEEE 19th International Conference , pp.154-161 (2012)

[22] Yang Syu, Shang-pin Ma, Jong-Yih Kuo, and Yong-Yi FanJiang, Asurvey on Automated Service Composition Methods and Related Techniques, 2011 IEEE Ninth Internationl Conference on Services Computing(SCC), pp.290-297 (2012)

[23] Zhenpeng Liu, Junbao Liu, Jimin Li, Aiguo An, and Jianmin Xu, A model for Web Services Composition Based on QoS and Providers' Benefit, Wireless Communications , Networking and mobile Computing, 2009, pp.1-4 (2009)

[24] Lizhn Cui, Jian Li, and Yongqing Zheng, A Dynamic Web Service Composition Method Based on Viterbi Algorithm, ICWS, 2012 IEEE 19th International Conference, pp.267-271 (2012)

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The Experimentation of Implementing Chase View in Landing Phase

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***Abstract*— Situation awareness could be considered as one of the most important factors that directly influences the pilot operation. In order to enhance the pilots' situation awareness, this research was carried out by implementing a new display method, chase view, in flight simulator, not only to provide the front view, but also the airframe configuration. During the experiment, the training time and attempting times, area of interest of eyes and the flight performance of the landing phase were evaluated to determine the usability of chase view. And according to the results, the chase view could enhance the situation awareness during landing phase.**

Keywords-situation awareness; chase view; AOI; flight path.

I. INTRODUCTION

According to NASA's statistics, about 70%-80% of the aviation accidents could be attributed to the performance of human, and among these accidents, decision errors contribute to 35% [1]. Decision making, as known, is directly related to the situation awareness of the pilots, which means if pilots have a thorough consciousness about what happen instantly and what is going to happen about the components or the whole aircraft, the disaster like turning off the wrong faulty engine, happened on the 8th of January 1989, of the British Midland Airways Boeing 737-400 which resulted in the loss of 47 lives [2] would have been avoided.

The definition of situation awareness is formally described as the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future [3]. Therefore, it includes three levels: firstly, perceiving critical factors around; secondly, understanding the means of those factors; thirdly, understanding what will happen in the near future [4].

A lot of researches have been carried out to enhance the situation awareness of the pilots. For example, the Highway-in-the-sky (HITS) display [5] gives the path of the aircraft, conveying primary flight path guidance through use of a tunnel-in-the-sky [6], and 2D coplanar display contains a top-down view of the flight environment in the top panel [7]. Synthetic vision systems have been already wildly used in the aircraft as a solution to such problems as controlled flight into terrain and low-visibility condition [8].

All the studies reviewed above were about how to present a clear front view of the aircraft to the pilots. However, none of them was dealing with the failure of the airframe if the annunciation in the cockpit was ambiguous, like whether the landing gear was correctly released, and whether the flap was in proper position. Under the condition of the chase view, the viewpoint was located above and rear the aircraft, therefore the information of the airframe and the front view was combined together to provide a more useful scene to the pilots.

In this research, the chase view was used in a flight simulator as a method to enhance the situation awareness.

When the subjects operated the landing phase, the training time and times, area of interest (AOI) of eyes [9] and the flight performance will be discussed later.

II. METHOD

A. Apparatus

The apparatus comprised two parts: the flight simulator and eye-tracking device.

The flight simulator part, as shown in Figure 1, includes four workstations to simulate the landing phase and record the behavior of the subjects and the flight performance of the landing phase, six 22-in. Liquid Crystal Display (LCD) monitors to present the display information of the aircraft and a spherical screen to display the outside view of the airplane. This flight simulator is flexible, and it could be easily changed to several types of aircrafts according to the demands. In this research, the Boeing 777 was used as prototype to carry out the experiments.

Figure 1. the Flight Simulator

The second part of apparatus is SmartEye eye-tracking system from SensoMotoric Company from Sweden. This

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eye-tracking device could give out many characteristics of the eye movement data during the experiments like Duration Time, Size of Pupil, Blink Rate, and etc. In this research, the eye-tracking device is used to record the AOI of the subjects.

B. Procedure

A scenario of landing phase was built up in the flight simulator, and Boeing 777 model was used in. The typical 'T' layout, however, was changed in following way: a chase view of the aircraft was presented in front of the subjects, and the Prime Flight Display (PFD), Navigation Display (ND) were presented in the middle display, as shown in Figure 2.

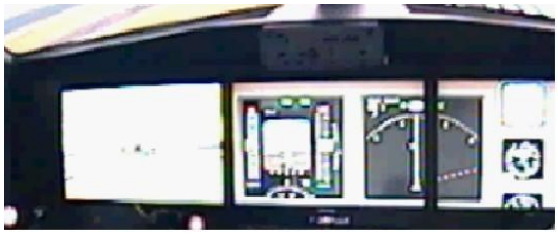

Figure 2. Layout of Chase View

Landing phase began from 2000 feet above the surface, and the distance was 6 nautical miles from the runway of San Francisco International Airport, which height is 13 feet above the sea level. The time to complete the landing was less than 2 minutes, and the whole progress was recorded by scene camera. During each landing, the subject needed to manipulate the aircraft well through control wheel and throttle. Moreover, they needed to lower the landing gear at 1000 feet, and to drop the flaps at 500 feet. This scenario was built up according to the Pilot Operation Procedure and Flight Crew Training Manual [10].

Before the real experiment, the subjects were given some training time to be familiar with the operations in the flight simulator, and the time and times to finish the first landing completely (landing on the runway) from the very beginning were recorded during the practice.

After training and the calibration of eye-tracking device, the experiment was carried out. Each subject was asked to accomplish three landing, no matter landing on the runway or crashing, the times and eyes parameters were recorded for analysis and discussion.

C. Participants

Eight master students from the School of Aeronautics and Astronautics to be the subjects, who all have aviation studying background more than 2 years, were participated in this experiment. They have the knowledge on aircraft design, and know well about the landing process, but without experience on how to manipulate an aircraft in a flight simulator. Among the eight subjects, the whole average age was 20.53 (SD=1.24).

The same eight students also manipulated the same B777 model, however, the layout of display was the normal way after a week, and they just provided comparative data in practical phrase.

D. Measurements

The collection of measurements accomplished through two phrases as following.

Firstly, during the practice, each subjects had 20 minutes of test-flight. At this process, the total time and attempting times of each subject to finish the first landing completely (landing on the runway), and the overall times of successful landing in training were recorded. These data would give some advices on training time and training strategy in some extent.

Secondly, during the experiment, the eye movement of each subject was recorded by eye-tracking system. Eye movement could reflect the attention of the subject allocated when he/ she completes a task. These data were used to determine the AOI of each subject when he/ she carried out the landing. The AOI comprised four parts: Chase View area; Primary Flight Display area; Outside area and Other area. Furthermore, the whole flight process of each subject was also recorded.

III. RESULTS

A. A ttempting Times and Time for first landing

Among the eight subjects, two of them finished the landing on runway within 5 times, three of them between 6-8 times, one in 9 times, one above 10 times, and one did not land successfully, as shown in Table 1.

Except the subject who did not complete landing, the mean times of other subjects is 6.71 (SD = 2.81), which is much smaller than the times by normal layout of B777 in the same flight simulator that is the mean times is 9.17 (SD = 3.49), and the mean times of landing in training is 3.37 (SD =1.85).

And the other data of subjects who operated under normal layout is shown in Table 2, and the comparative results of attempting times and times of landing are shown in Figure 3 and Figure 4, respectively.

Table 1. Chase View

Subject	Attempting Times of first Landing	Time (min)	Times of landing
1	9	12	3
2	6	10	4
3	8	11	3
4	6	8	5
5	?	20	0
6	4	7	4
7	3	5	6
8	11	14	2

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Table 2. Normal Layout

Subject	Attempting Times of first Landing	Time(min)	Times of landing
1	6	7	3
2	5	7	3
3	10	14	2
4	14	18	1
5	12	15	1
6	8	10	2
7	?	20	0
8	?	20	0

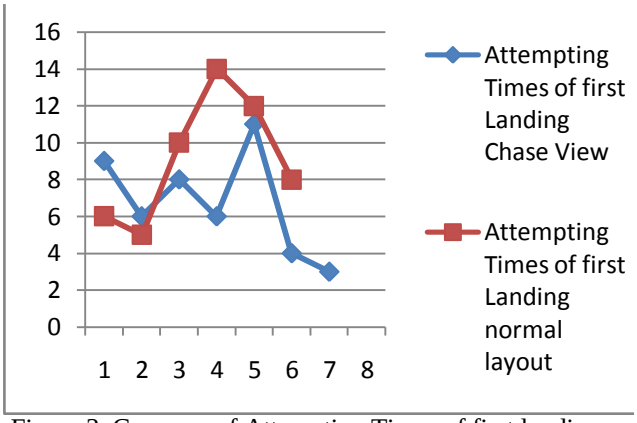

Figure 3. Compare of Attempting Times of first landing

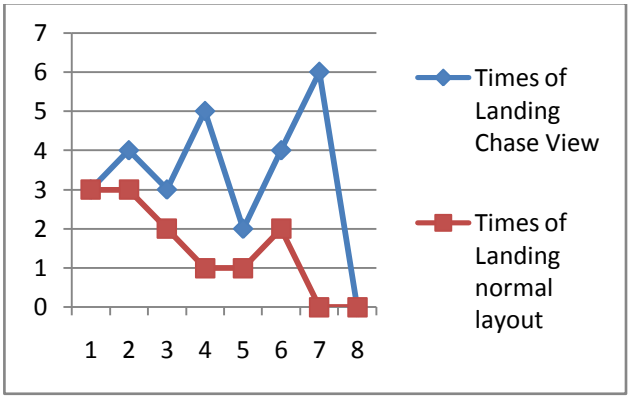

Figure 4. Compare of Times of successful Landing

From Figure 3 and Figure 4, both on times of successful landing and the attempting times, the Chase View is better than Normal Layout. Furthermore, ANOVA analysis was used to determine the significance. Comparing times of successful landing, the effect is significant ($F = 5.81$, $p<0.05$), however, the effect on attempting times is not significant enough ($F = 1.56$, $p>0.23$).

B. AOI and Flight Performance

As described above, the areas of interest included four parts: Chase View area (CVA); Primary Flight Display area (PFDA); Outside area (OUTA) and Other area (OA).

Each subject was needed to accomplish three landing, no matter landing on the runway or crashing. The flight performance determining here are by the times of successful landing in three attempts and whether the landing is overweight landing or not. Table 3 gives mean seconds that each subject paid on different areas within the three landing.

Table 3. the results of the AOI

Subject	Seconds of CVA	Seconds of PFDA	Seconds of OUTA	Seconds of OA
1	50.57	57.85	0.9	0.12
2	44.76	12.15	14.06	1.25
3	63.35	66.61	0.03	0.2
4	69.02	19.89	35.82	0.03
5	0.25	0.2	13.9	63.69
6	22.39	40.18	22.38	0.32
7	28.35	40.64	48.44	3.82
8	67.82	12.93	6.41	23.61

Figure 5 shows the distributions of the results more clearly, where the blue part is Chase View area, red part is PFD area, yellow part is Outside area, and green part is Other area.

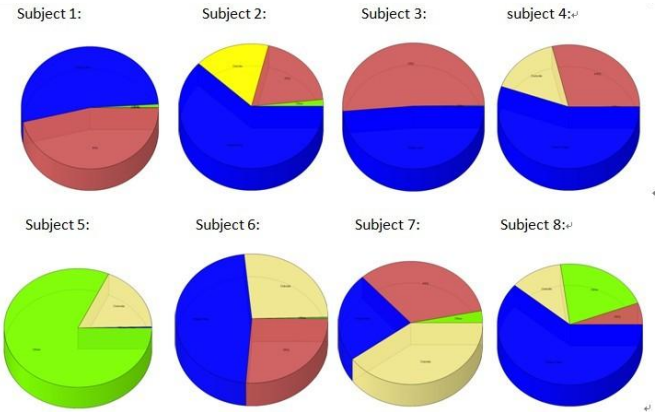

Figure 5. Distribution of the eye location of the subjects

And Table 4 presents the numbers of successful landing and the numbers of overweight landing of each subject.

Table 4. Results of the flight performance

Subject	Numbers of successful landing	Numbers of overweight landing
1	1	1
2	2	1
3	2	2
4	3	2
5	0	0
6	3	2
7	3	1
8	1	1

From the Table 4, Subject 7 did excellent in the experiments, while the pattern of distributions shows that it

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combines three main areas: CVA, PFDA and OA. Subjects 2, 4 and 6 also did good job. Comparing their patterns, they paid more attention on the Chase View area. Subject 1, 3 and 8 did common during the experiment. There were almost no focus of outside area of subjects 1 and 3, and subject 8 paid more attention on other area. The performance of subject 5 was bad. However, it was consistent with the performance in training phase. This may because that the subject 5 felt frustration during the practice, and did not cooperate well during the experiment.

Furthermore, to determine the correlation of each area with attempting time, the correlation coefficients were calculated as follow Table 5.

Table 5. the correlation coefficients of each area with attempting time

	CVA & Time	PFDA & Time	OUTA & Time	OA & Time
correlation coefficients	-0.29	-0.44	-0.60	0.86

According to the correlation coefficients, CVA, PFDA and OUTA had negative correlations with attempting time, since CVA gave out the state of the aircraft on certain moment, PFDA provided the main control information and OUTA supplied the situation awareness of what was happening in front of the aircraft. All of these are essential to safe flight and successful landing, while OA had a positive correlation with attempting time. Moreover, the abstract value of correlation coefficient of CVA versus attempting time was not as high as expect, however, the correlation coefficient of OA versus attempting time was high, which was consistent with the expectation.

IV. DISCUSSION

The main aim of this research was to examine the influence of Chase View on landing phase. The research included two phases: training phase and experimental phase.

In training phase, the comparative data between the Chase View and the normal layout show that, to novices, the different on attempting times to first landing was not obvious. The disparity, however on times of successful landing was significant. Therefore, subjects performed better under the condition of Chase View than normal layout. This could be considered that Chase View would be helpful during the early training period. It could enhance the experience of the novice about how the aircraft really operates in the real environment quickly, and arouse the interest to manipulate it.

The results during the experiments showed that the flight performance was closely related to the distribution of eyes focus of the subject, and the Chase View improved the flight performance in some extent. However, the recommended pattern was to combine the Chase View, PFD and Outside parts together. It also means that the PFD information indispensable not only to pilots, but also to the novices. Furthermore, from the recorded video of eye-tracking device, when the eyes attention located on PFD area, the subjects were almost observing the information of speed and altitude. This was reasonable, since the attitude information could be obtained from Chase View, and the speed and altitude are also essential for landing. Moreover, Outside View is also important, especially to the novices, but not necessary. This is a common sense. After effective training, the pilots must have the skill to land under the condition of minimum visibility requirements by instrument landing system. According to the analysis of correlation coefficients, the abstract value of correlation coefficient of CVA versus attempting time was not as high as expect. It is probable that the smart combination of CVA, PFDA and OUTA that contributes an excellent performance. And the correlation coefficient of OA versus attempting time was high, which was consistent with the expectation, since the more irrelevant attention paid the probability of terrible performance was higher.

V. CONCLUSION AND FUTIRE WORK

In this research, the Chase View was used in the flight simulator. According to the analysis of the training performance and the flight performance, the Chase View could be helpful during the early training period and improve the training efficiency. During the landing phase, although the Chase View cannot replace the normal layout, it could enhance the situation awareness of the operators.

Further study would be carried out in several aspects. Firstly, more subjects will be anticipated in the training phase, and the training time will be expended. Then, the performances of Chase View and normal layout could be compared to determine whether the enhancement of situation awareness is significant or not, and the appropriate pattern of combination of CVA, PFDA and OUTA which would result in a better performance will also be considered.

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REFERENCES

[1] Shappell, S.A. and Wiegmann, D.A., "A Human Error Analysis of General Aviation Controlled Flight Into Terrain Accidents Occuring between 1990-1998," Federal Aviation Administration, Washington DC. 2003.

[2] Report on the accident to Boeing 737-400-GOBME near Kegworth, Leicestershire on 8 January 1989. Air Accidents Investigation Branch. 1989

[3] Endsley, M.R. "Design and evaluation for situation awareness enhancement." In Proceedings of the Human Factors Society 32nd Annual Meeting. Santa Monica, CA: Human Factors Society. 1988

[4] Endsley, M.R., "Situation Awareness In Aviation System, Handbook of Aviation Human Factors," Mahwah, NJ : Lawrence Erlbaum Associates. 1999

 ISBN: 978-1-61208-232-5

[5] Williams, K., "Impact of aviation highway-in-the-sky display on pilot situation awareness," Human Factors, vol. 44, pp. 18-21. 2002

[6] Alexander, A.L. and Wicken, D.C., "3D Navigation and Integrated Hazard Display in Advance Avionics: Performance, Situation Awareness, and Workload. Technical Report," AHFD-05-10/NASA-05-2, NAS Langley Research Center. 2005

[7] Wickens, C.D., "The when and how of using 2-D and 3-D displays for operational tasks." In Proceedings of the IEA 2000/HFES 2000 Congress. Santa Monica, CA: Human Factors and Ergonomics Society. 2000

[8] Prinzel, L.J., Kramer, L.J., Comstock, J.R., Bailey, R.W., Hughes, M.F., and Parrish, R.V., "NASA synthetic vision EGE flight test," In Procceedings of the 45th Annual Meeting of the Human Factors and Ergonomics Society. Santa Monica, CA： HFES.2004

[9] Ulf Ahlstrom and Ferne Friedman-Berg, "Subjective Workload Ratings and Eye Movement Activity Measures." Technical Report DOT/FAA/CT-05/32. U.S. Department of Transportation & Federal Aviation Administration. 2005

[10] Continental Airlines, Inc. "Flight Manual", Continental Sec. Intro TOC-1, Rev. 11/01/02 #9. 2005

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A Context-aware Model for the Analysis of User Interaction and QoE in Mobile Environments

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***Abstract*—This paper describes a novel approach to model quality of experience (QoE) in mobile environments. A meta-model is created to establish a set of parameters to dynamically describe the interaction between the user and the system, as well as the context in which it is carried and the attractiveness of that process. A uniform representation of user-system interaction in mobile contexts is provided. This helps user-related applications to determine QoE of users, and allows the comparison between different interaction records. Its run-time nature also allows context-aware applications to make model-based decisions in real-time to adapt themselves, and thus providing a better experience to users. As a result, this meta-model provides unified criteria for the inference and analysis of QoE in mobile contexts, as well as for implementing user profiling based on successful-QoE experiences.**

***Index Terms*—quality of experience; context-aware; QoE modeling; interaction modeling; user profiling.**

I. INTRODUCTION

Quality of Experience (QoE) is a subjective measure of users' experiences with a service. It focuses on those aspects that users directly perceive as quality parameters, and that finally decide the acceptability of a service. QoE is not just related to Quality of Service (QoS), but it is a broader construct beyond technical and objective system performance metrics [1], [2], [3], [4]. It encompasses users' behavioural, cognitive, and psychological states along with the context in which the services are provided to them. This is particularly true in mobile contexts, where applications are dynamically used in different scenarios and social contexts [4].

Moreover, context-aware systems extract, interpret, and use context information to adapt their functionality to the current context of use [5]. By "context" we mean any information used to characterize the situation of an entity, e.g., person, place, or object, and that is considered relevant for the user-system interaction analysis. Hong et al. [6] differentiate among external context, which involves data referring to the physical environment, e.g., location, sound, time of the day, etc., and internal context, which involves data related to the cognitive domains of the user, e.g., emotional state.

Complexity of interaction within mobile scenarios has increased dramatically in the last few years. Users and their handheld devices are continuously moving in several simultaneous fuzzy contexts [6]. This dynamic environment sets special requirements for mobile applications' usability and the acceptance of such systems. A close relationship between interaction, its context, and QoE can be found in these environments. However, the lack of a uniform approach for modeling the information related to interaction within a specific context is obvious [7]. This is why this work proposes incorporating user ratings and context-aware information into user-system interaction analysis methods, providing a uniform basis to quantify interaction within mobile scenarios, and use it to determine QoE.

However, incorporating these data into user-system interaction analysis processes poses several problems. One of them is deciding what parameters are useful to capture QoE in mobile contexts [4]. We consider essential that such parameters have to be collected, as far as possible, by using current devices' capabilities. The low standardization of technologies used in context-aware systems is also a problem [6]. A common representation of the context of applications is needed to support standard analysis and decision processes, as well as to support cooperation between different QoE analysis applications. A related problem is how to build "standard" user-interaction profiles, which are used by applications or systems to adapt themselves to provide a better QoE.

According to these problems, the following research questions are posed:

Q1: How can rating and context information be properly incorporated into interaction analysis processes?

Q2: How can QoE of different users be compared to each other, as well as QoE inferred from different systems and/or contexts?

Q3: Is it possible to build a user's interaction profile based on successful-QoE experiences?

To answer these questions, this paper briefly describes the design of a meta-model arranging dynamic interaction parameters. This meta-model is augmented with parameters describing users' perception of interaction quality, as well as context information. It provides a uniform representation of user-system interaction within real mobile contexts. Instances of this meta-model provide a basis to determine and compare QoE of users in such contexts, as well as to make decisions at run-time to provide a better users' experience.

The rest of the document is structured as follows. Section II

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describes an overview of the meta-model design mentioned above. Section III describes some considerations about the implementation and the applications of the meta-model in current mobile scenarios. Finally, Section IV includes some conclusion and future lines of work.

II. QoE-aware Interaction Analysis

The approach described in this paper tries to give an answer to the three research questions posed above. First, to answer research question Q1, the design of a meta-model including interaction, user-rating and context data is proposed. It structures all these data to be the basis for the implementation of QoE analysis and inference processes. We propose to base this meta-model design on an existing one [8], [9] which is being developed in parallel to this work, in a joint effort between the Cátedra SAES [10] and the Telekom Innovation Laboratories [11] to quantify interaction in multimodal contexts.

The base meta-model describes interaction by turn, i.e., each time the user or the system take part in the dialog, following a dialog structure, i.e., a set of ordered system- and user-turns. This "step by step" description of interaction creates a relationship between data and time, providing new opportunities for the dynamic analysis of interaction. This meta-model handles different modalities at the same level using common metrics to describe interaction. These metrics are structured within a common representation, allowing the comparison among different interaction records. Collected data (turn content, meta-communication, I/O information, and modality description) are partly based on the well validated parameters and concepts described in [12], [13].

Since the base meta-model only quantifies user-system multimodal interaction, it was extended in to ways. On one hand, user-rating parameters as the used in questionnaires like AttrakDiff [14] were added to measure how attractive and user-friendly is the product under test. On the other hand, the model was extended with new parameters to describe the interaction context in mobile scenarios. Thus, the model not only provides a link between interaction data and time, but new links between interaction and, for example, user's opinions, information about location, social context, device features, etc. are created. Figure 1 depicts the kind of parameters considered by the proposed design.

Human-computer interaction parameters —included in the base meta-model— are used to quantify the interaction of the user with the system, e.g., quantity of information provided by the system, average reaction time of the user. *User rating* parameters are used to measure the experience of users with the system under test, e.g., motivating, human, clearly structured. They measure how attractive the system/application is in terms of usability and appearance. The validity of questionnaires like AttrakDiff as a method to extract users' experience is shown in related work, e.g., [15].

Communication parameters describe the features of device connectivity, e.g., if the user is on-line or not, connection bandwidth. *Location and time* parameters describe the position of the user while interacting the system, as well as a

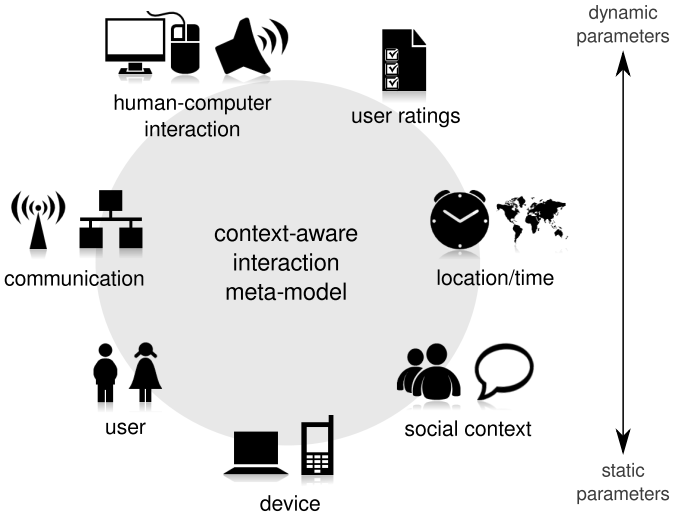

Figure 1. Design overview of the proposed meta-model.

time reference, e.g., the user is moving, it is Friday night. *User* parameters describe peculiarities of the person using the application and the device, e.g., gender, age, disabilities. *Social context* parameters are those that can be extracted from social media, and are interesting for the interaction analysis, e.g., if the user is along with their friends, if he/she is within an office context. Finally, *Device* parameters describe the peculiarities of the device being used, e.g., screen size, input and output methods.

Some of these parameters are run-time and have to be collected many times during interaction, e.g., quantity of user input at a specific time. Others are not, and are collected only once, e.g., screen resolution. This feature is specially relevant to know where the parameters are included in the model design. Run-time ones are included at turn-level, while static ones are included at dialog level.

Instances of this meta-model describe user-system interaction within its mobile context, and are ready to support further analysis, comparison, transformation, and decision processes. The great majority of the parameters described above are intended to be collected automatically, e.g., by using tools like the Android HCI Extractor [16] which extracts multimodal interaction data at run-time. However, those based on subjective judgments of the user or the expert have to be manually annotated in most of cases. Anyway, automatically collected or not, the same metrics —structured into a common representation— are used to quantify the interaction between the user and the system. This provides experts and tools with unified criteria to describe the interaction process. Different interaction records can be analyzed and compared regardless of the system/application under testing, the interaction context, even the modalities used to provide input and output data. This answers research question Q2.

To answer question Q3, the reader can consider an instance of the meta-model described above as a three-dimensional representation of an interaction "occurrence". These dimensions

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are the user who is performing the interaction ($u \in U$, U the set of all users under study), the application or system with which the user interacts ($a \in A$, A the set of all applications or systems under study), and the context in which the interaction process is performed ($c \in C$, C the set of all the possible contexts under study.) Let I be a set of instances of the model described above, each instance $i_n \in I$ represents one of the interaction occurrences in the space (u_i, a_i, c_i). If we consider all the instances i_n in the space (u_i), i.e., all the interaction occurrences of the user u_i, these can be used to build a "user interaction profile" representing the features of the behavior of this specific user.

Maybe using only one dimension to analyze interaction is not useful to make decisions. However, if for example the interaction occurrences in the space (u_i, a_i) are used to build a profile, we can analyze the behavior and ratings of a user using the same application in different contexts. Thus, the application can be adapted to the current context, as mentioned in [4]. Using the occurrences in the space (u_i, c_i) allow us to analyze how the user behaves in a specific context, and those in the space (a_i, c_i) are valid to analyze how different users interact with an application in a specific context. The process gets more complex if sub-dimensions of these three dimensions are considered, but this is not the goal of this paper. This shows that instances of the proposed meta-model are valid to create different interaction profiles not only related to users, but also related to the system/application in use or the interaction context.

Finally, we consider essential the easy incorporation of the proposed solution into current mobile devices, i.e., tablets, smartphones, etc. From a practical point of view, developed solutions should be easily built into the kind of devices used nowadays. This not only fosters using such a kind of testing tools into current applications and systems, but it will ease the full implementation of context- and QoE-aware methods in real life, and not only for laboratory environments [6]. This is why we argue for using current devices capabilities to collect interaction and context data, e.g., the windowing system to collect touch interaction metrics, internet-based applications to get social information, device's sensors as GPS to get position. Even users' perception of interaction quality when possible, e.g., encouraging the user to rate interaction at run-time. Therefore, advanced sensors are not required to fill the model instances.

III. Meta-Model Implementation and Applications

Our implementation of the base meta-model will use the facilities offered by the Eclipse Modeling Framework (EMF). The widely used EMF allows the definition of comprehensible, flexible and extensible meta-models, as well as the syntactically validation of concrete model instances. Tools like EMF help to make the modeling process more effective, and provide indispensable functionality to validate and extend the meta-model [17]. EMF provides model transformation and automatic code generation functionality as well. The design of the meta-model will be used to automatically generate the source code, which has to be integrated into the applications in which new model instances will be created.

To collect interaction and context parameters automatically, it is proposed using a tool based on the Android HCI Extractor. [16] This open-source tool can be extended to collect, as far as the device allows, all the interaction and context data necessary to fill model instances. User ratings might be automatically collected as well, e.g., by showing questionnaires after test trials. This tool will be used to create model instances at run-time. Such instances are valid to represent many different interaction scenarios, from the usage of an application during some minutes, to the usage of a device during hours. Despite the architecture and behavior of the HCI Extractor can be ported to other mobile systems —it uses a reduced EMF Java implementation that can run in many platforms— currently only Android is supported. However, Android can run in many different mobile platforms, e.g., smartphones, tablets, netbooks, smart-tv, etc.

Once created, the instances provide a basis on which to implement different analysis and evaluation processes. QoE inference is the first result that comes to mind. The data included into a model instance can be used to systematically determine the QoE of a user within a mobile context. Interaction data can be fused with context information and users/experts ratings to determine QoE, e.g., by using Bayesian networks as in [4] Moreover, thanks to the run-time nature of the meta-model, QoE can be estimated in real-time. In case the resulting value is not the expected, the interaction history and the context can be analyzed for a specific interval of time to make a decision that makes QoE to improve, e.g., by adjusting microphone settings, changing screen brightness.

As a common representation is used, different instances can be easily compared to each other, e.g., to detect why QoE worsens when using an application in a different scenario, to know why an application provides a better QoE than another. Finally, model transformation processes can be implemented using the high expressiveness of EMF-based tools, e.g., ATL [18]. Original model instances can be transformed into instances of other meta-models, which provide different perspectives of the data collected during the interaction process, e.g., a summary meta-model linking only context and ratings data, a statistical meta-model aggregating users ratings. Thus, model transformation is valid to build user interaction profiles as well. Let *Model_B* be a meta-model describing the user interaction profile. Several instances of the meta-model proposed in this paper (say *Model_A*) can be used to build an instance of the new model by simply using ATL transformation rules. The process is completely automatic, as data in *Model_A* instances are used by ATL to fill data fields in the *Model_B* instance according to the rules.

Some validations tests were conducted in the context of the PALADIN project [8], [9]. The participants used multimodal input (speech + touch) to book a restaurant within an Android smartphone. These tests where used to show the validity of the interaction meta-model on which the proposed solution is based. Similar tests can be conducted to show the validity of

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the solution proposed in this work, but now using a context-dependant application and collecting real or simulated context data. Then, the model instances will be used to determine QoE of each participant using different modalities or a combination of them.

IV. Conclusions and Future Work

The design of a meta-model including data about user-system interaction and its context is described. Most of the parameters included in this design are collected using current devices' capabilities; subjective ones have to be annotated manually. This meta-model provides a common representation of interaction, allowing the inference, analysis and comparison of QoE in mobile contexts. A relationship between user-system interaction, its context, and users' perception of quality is created. Moreover, a strong relationship between these data and time is provided as well, opening up new opportunities for the dynamic analysis of QoE. Its dynamic nature also allows to make QoE-aware decisions at run-time. Instances of this meta-model are also valid to create user interaction profiles based on successful-QoE experiences.

This approach poses lots of challenges with which to deal until reaching its final implementation. One of them is treating the variety, diversity and big amount of interaction and context data. This solution is not aimed at modeling "the entire world", but only data that is relevant for the analysis of QoE have to be considered. A well balanced set of parameters has to be chosen for the model design. This set should be as small as possible, but enough to determine QoE in mobile contexts.

Choosing an adequate abstraction level for the parameters is also very important, e.g., the user is in a specific geographic coordinate vs. the user is in the office. Dealing with cognitive data automatically is also challenging. Emotional state of the user and cognitive elements have to be incorporated into the meta-model, as well as users' quality perception and experts' verdicts. Users' security and privacy problem should be also posed and discussed.

Acknowledgement

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References

[1] S. Möller, K.-P. Engelbrecht, C. Kühnel, I. Wechsung, and B. Weiss, "A Taxonomy of Quality of Service and Quality of Experience of Multimodal Human-Machine Interaction," in *First International Workshop on Quality of Multimedia Experience (QoMEX'09)*, July 2009, pp. 7–12.

[2] W. Wu, M. A. Arefin, R. Rivas, K. Nahrstedt, R. M. Sheppard, and Z. Yang, "Quality of experience in distributed interactive multimedia environments: toward a theoretical framework," in *ACM Multimedia*, W. Gao, Y. Rui, A. Hanjalic, C. Xu, E. G. Steinbach, A. El-Saddik, and M. X. Zhou, Eds. ACM, 2009, pp. 481–490. [Online]. Available: http://dblp.uni-trier.de/db/conf/mm/mm2009.html#WuARNSY09

[3] K.-T. Chen, C.-J. Chang, C.-C. Wu, Y.-C. Chang, and C.-L. Lei, "Quadrant of euphoria: a crowdsourcing platform for qoe assessment." *IEEE Network*, vol. 24, no. 2, pp. 28–35, 2010. [Online]. Available: http://dblp.uni-trier.de/db/journals/network/network24.html#ChenCWCL10

[4] K. Mitra, A. B. Zaslavsky, and C. Åhlund, "A probabilistic context-aware approach for quality of experience measurement in pervasive systems." in *SAC*, W. C. Chu, W. E. Wong, M. J. Palakal, and C.-C. Hung, Eds. ACM, 2011, pp. 419–424. [Online]. Available: http://dblp.uni-trier.de/db/conf/sac/sac2011.html#MitraZA11

[5] H. Byun and K. Cheverst, "Utilizing context history to provide dynamic adaptations." *Applied Artificial Intelligence*, vol. 18, no. 6, pp. 533–548, 2004. [Online]. Available: http://dblp.uni-trier.de/db/journals/aai/aai18.html\#ByunC04

[6] J. Hong, E. Suh, and S. Kim, "Context-aware systems: A literature review and classification," *Expert Systems with Applications*, vol. 36, no. 4, pp. 8509 – 8522, 2009. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0957417408007574

[7] C. Bolchini, C. A. Curino, E. Quintarelli, F. A. Schreiber, and L. Tanca, "A data-oriented survey of context models," *SIGMOD Rec.*, vol. 36, pp. 19–26, December 2007. [Online]. Available: http://doi.acm.org/10.1145/1361348.1361353

[8] P. Mateo and S. Hillmann, "PALADIN: a Run-time Model for Automatic Evaluation of Multimodal Interfaces," 2011. [Online]. Available: http://www.catedrasaes.org/wiki/MIM

[9] ——, "Model-based Measurement of Human-Computer Interaction in Mobile Multimodal Environments," in *NordiCHI*. ACM, 2012. [Online]. Available: http://www.prometei.de/fileadmin/ammi-nordichi2012/04ammi12_mateo_hillmann.pdf

[10] Cátedra SAES de la Unviersidad de Murcia, http://www.catedrasaes.org, [Online; accessed Oct. 2012].

[11] Telekom Innovation Laboratories, http://www.laboratories.telekom.com, [Online; accessed Oct. 2012].

[12] ITU-T Suppl. 24 to P-Series Rec., "Parameters describing the interaction with spoken dialogue systems," Geneva, Switzerland, October 2005.

[13] C. Kühnel, B. Weiss, and S. M. ller, "Parameters describing multimodal interaction - Definitions and three usage scenarios," in *Proceedings of the 11th Annual Conference of the ISCA (Interspeech 2010)*, T. Kobayashi, K. Hirose, and S. Nakamura, Eds. Makuhari, Japan: ISCA, 2010, pp. 2014–2017.

[14] M. Hassenzahl, M. Burmester, and F. Koller, "AttrakDiff: Ein Fragebogen zur Messung wahrgenommener hedonischer und pragmatischer Qualität. (A questionnaire for measuring perceived hedonic and pragmatic quality.)," in *Mensch & Computer*, G. Szwillus and J. Ziegler, Eds. Teubner, 2003, pp. 187–196. [Online]. Available: http://dblp.uni-trier.de/db/conf/mc/mc2003.html#HassenzahlBK03

[15] I. Wechsung, K.-P. Engelbrecht, A. B. Naumann, S. Schaffer, J. Seebode, F. Metze, and S. Möller, "Predicting the quality of multimodal systems based on judgments of single modalities." in *INTERSPEECH*. ISCA, 2009, pp. 1827–1830. [Online]. Available: http://dblp.uni-trier.de/db/conf/interspeech/interspeech2009.html#WechsungENSSMM09

[16] P. Mateo, "Android HCI Extractor," 2011. [Online]. Available: http://code.google.com/p/android-hci-extractor

[17] J. W. Kaltz, J. Ziegler, and S. Lohmann, "Context-aware web engineering: Modeling and applications." *Revue d'Intelligence Artificielle*, vol. 19, no. 3, pp. 439–458, 2005. [Online]. Available: http://dblp.uni-trier.de/db/journals/ria/ria19.html#KaltzZL05

[18] F. Jouault, F. Allilaire, J. Bezivin, and I. Kurtev, "Atl: A model transformation tool," *Science of Computer Programming*, vol. 72, no. 1-2, pp. 31–39, June 2008. [Online]. Available: http://dx.doi.org/10.1016/j.scico.2007.08.002

[19] Sociedad Anónima de Electrónica Submarina (SAES), http://www.electronica-submarina.com, [Online; accessed Oct. 2012].

[20] University of Murcia, http://www.um.es, [Online; accessed Oct. 2012].

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Personalized Mobile Services Using Weighted Instance Based Learner for User Profiling

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***Abstract*—Today, mobile device users receive a variety of services and information delivered to their mobile devices. Many of these are irrelevant, far from the user's satisfaction level and may likely be regarded as spam messages by the user. This results in the users to look for the relevant services by themselves, which would be time consuming and may cause inconvenience. User profiling has created opportunities for mobile service providers to provide a channel for user awareness as well as to achieve high user satisfaction. Apart from traditional collaborative and content-based methods, a number of classification and clustering algorithms have been used for user profiling. Instance Based Learner is a comprehensive form of the Nearest Neighbour algorithm and it is suitable for user profiling as users with similar profiles are likely to share similar personal interests and preferences. In our previous work we proposed a weighted classification method, namely Weighted Instance Based Learner, and evaluate its performance on user profiling. According to the simulation results Weighted Instance Based Learner, performs better than Instance Based Learner, on user profiling by reducing the error up to 28% on the selected dataset. In this paper, we aim to demonstrate how Weighted Instance Based Learner algorithm can be used for the user profiling for the provisioning of personalized mobile services. For this purpose a scenario has been proposed and implemented as a Java Mobile Application on NetBeans IDE 7.1.**

Keywords-User Profiling; Personalization; Machine Learning.

I. INTRODUCTION

Many works in the literature show that mobile recommendations have become very popular due to the growing diversity, availability and use of mobile information services [1]. Personalization of the mobile services is therefore an opportunity to help to improve the quality of service. Personalized mobile services aim to match users' requirements by considering when, where and how the users require the service to be delivered. The success of these applications relies on how well the service provider knows the user requirements and how well this can be satisfied. The user profile is the representation of the user and holds information about the user such as personal profile data (demographic profile data), interest profile data and preference profile data. These profiles are the outcome of the user profiling. In user profiling applications the major challenge is to build and handle user profiles. In the literature two fundamental user profiling methods have been proposed for this purpose. These are the collaborative and the content-based methods. It is also possible to use a hybrid of the two methods. The collaborative method has been built on the assumption that similar users, with respect to the age, sex, and social class, behave similarly, and therefore have similar profiles [2]. The content-based method, on the other hand, has been built on the concept of content similarity and assumes that users behave similarly under the same circumstances [2]. For example, the moreTourism, mobile recommendations for tourism [3], uses a hybrid method. The proposed recommendation system here takes into account the tags, provided by the users, to provide tourist information profiled for users with similar likes depending on the user profile (user tag cloud), location in time and space, and the nearby context. For example, nearby historical places and museums. Similarly in [4], Fernandez et al., proposed a tourism recommender system that offers tourist packages (i.e., include tourist attractions and activities) that best matches the user's social network profiles. Different from [3], the proposed hybrid system provides recommendations based on both the user's viewing histories (Digital Television (DTV) viewing histories received from the user's set-top boxes via a 2.5/3G communication network) and the preferences in the social network (i.e., preferences of the user's friends). Apart from the traditional profiling methods, a number of classification and clustering algorithms found applications within the user profiling process in personalization. This paper aims to show how the Weighted Instance Based Learner (WIBL) [5] classification algorithm can be used for the user profiling to provide personalized mobile services.

The rest of this paper is organized as follows: Section II provides information about the WIBL. Section III presents the scenario for this paper, while Section IV outlines a detailed overview of the system. Implementation of the scenario, is given in Section V. Finally Section VI concludes this paper.

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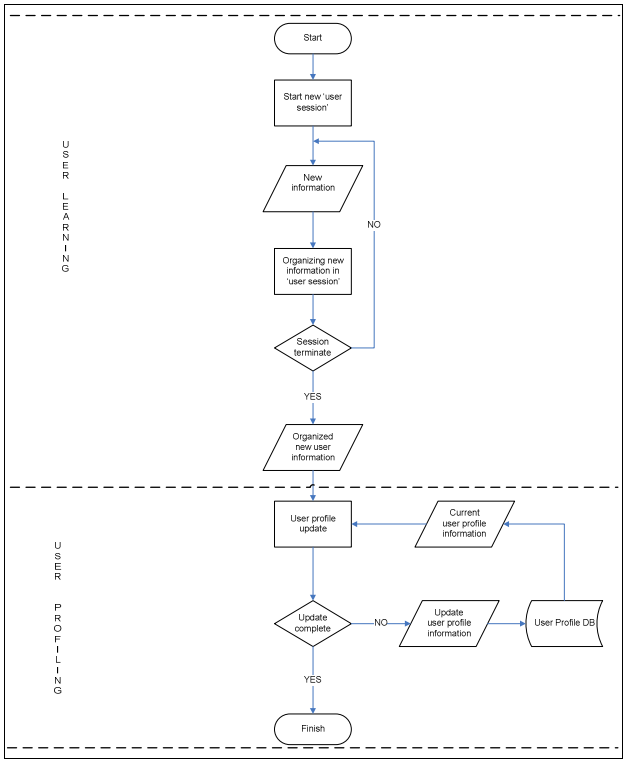

Figure 1. Flowchart of the user learning and user profiling.

II. Weighted Instance Based Learner (WIBL)

Instance Based Learner (IBL) is a comprehensive form of the Nearest Neighbour (NN) algorithm; which normalizes its attributes' ranges, processes instances incrementally and has a simple policy for tolerating missing values [6]. In contrast to IBL, the WIBL assigns weights to the attributes and considers the weighted distance of the instances for classification. Here, relevant attributes are aimed to have more influence on classification than irrelevant attributes. In WIBL the function that calculates the distance between test instance (new user) X_i and the training instance (existing user) Y_j is;

$$dist(X_i, Y_j) = \sqrt{\sum_{k=1}^{A} w_{k,l}(C_m)\ g(x_i(k), y_j(k))}\ , \qquad (1)$$

where

$$w_{k,l}(C_m) = P(C_m|f_k(l))\ . \qquad (2)$$

Here, l is equal to the value of the $x_i(k)$. Therefore, the selection of which weight is to be used for a particular attribute value is based on k and $x_i(k)$. Note that $g(x_i(k), y_j(k))$ is evaluated as it is in IBL [6]. In [5], presented simulation results illustrated that WIBL performs better than IBL on user profiling by reducing the error up to 28% on the selected dataset. For the simulations the dataset used was provided in [7], named 'Adult Data Set'. This dataset was created by Barry Becker via extracting information from the 1994 census database. From this dataset demographic information of 6000 instances (5000 training and 1000 test) have been adopted and used to create a complete dataset of user profiles for the simulations.

The WIBL enables the use of a user profile dataset of a single service with other services too. This is archived by feature weighting. Although the content of the dataset stays the same, the weighting values will be recalculated/updated when the dataset is used for another service.

III. Proposed Scenario

In this scenario, we focus on a mobile advertising service. Here, we introduce a personalized mobile advertising service called Discounts, Promotions and Deals (DPD). DPD advertising service provides discount, promotion and deal advertisements to the user according to the user's profile. Furthermore, for this scenario, DPD is concerned with the food industry, and a restaurant service called MyRestaurants, has been chosen. MyRestaurants can be used by the registered users only. The following user is assumed for this scenario.

Ren is a 30 years old Londoner. She is working as a property adviser in a company located in central London. She has got both an iPhone and a BlackBerry Smartphone, which have been provided by the company. She uses her BlackBerry for work related duties while her other mobile phone is a part of her personal life. Ren decided to subscribe for the personalized mobile advertising service, MyRestaurants. Through her mobile device, each of the advertisements are presented with the link where a user can follow for more information. Ren prefers to receive the advertisements everyday and prefers to check these out in the morning time. Subsequently, on Monday morning, around 9am on her way to work, Ren signs into the MyRestaurants service through her iPhone. She receives the advertisements. She is pleased with the one of a meal deal offer as the restaurant is very close to her work place and she has previously thought about trying out its food. Ren follows the provided link to book a table through the restaurant's mobile-web.

IV. System Overview

The following three subsections explain the user learning, user profiling and restaurant recommendation for this scenario. Figure 1 shows the flowchart of the user learning and profiling. User learning process starts whenever the user signs into to the MyRestaurants. Here, the system monitors user's feedback towards the given recommendations until user signs out from the system (i.e., session terminates). Following this, the new information from the learning process

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53	<10	Male	Football	Rock	Political	Nature-Trekking	Married-civ-spouse	Private	11th	Husband	Handlers-cleaners

Kusak Restaurant	Turkish	<30	order of 3-course meal for two comes with a free bottle of wine	New Cavendish Street London, W1W 6UW

Figure 3. Example of user profile information and restaurant profile information.

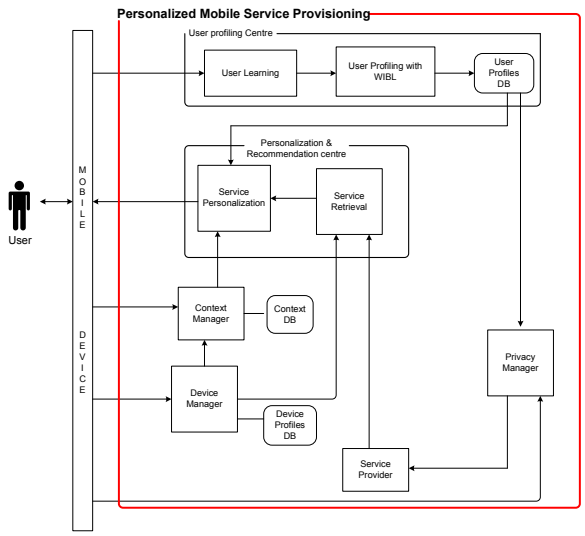

Figure 2. Architecture of personalized mobile service provisioning.

Figure 4. User enters her user-id and password to sing-in.

is used for the user profiling. In this process, a classification algorithm WIBL will update the user's profile information in the user profile dataset with using the information from user learning process. Following subsections give more detailed information on the aforementioned processes. Moreover, it was considered that an investigation of the user privacy issues, device management and context management is out of the scope of this paper.

A. User Learning

For this scenario, we assume that the information given by the user during the subscription is to be used for the initialization of the user's profile. Note that this corresponds to the directly/explicitly information gathering. The user's response (user feedback) to the provided services will then be used to update the user's profile implicitly. Each user is represented with three sets of user profile information that are interest profile, demographic profile and preference profile. It is worth pointing out that the location preference of the user will be kept in the user profile. Each user will have an identification (i.e., user-id and password) for the purpose of authentication for the service. Here, the system will automatically assign user a user-id and a password when she subscribes for the service. An initial password can be changed by the user following first sign in. After subscription and registration, the system continuously monitors user's feedback and behaviour towards the provided services to learn more about her (i.e., what services she likes, when and where). For example, monitoring Ren shows that she prefers to receive the advertisements every morning while travelling to work.

B. User Profiling

For this scenario, the WIBL [5] is used for the user profiling. Here, WIBL will assign different weights to the user's user profile attributes to increase the impact of relevant attributes in classification so as to define the user's service preferences more precisely. Which user receives what advertisements is decided by making use of the user's profile information and the class that the user belongs to. In this way, the same advertisements can be sent to the users that share the same class and these users receive the advertisements that most of the users in the same class showed a liking for.

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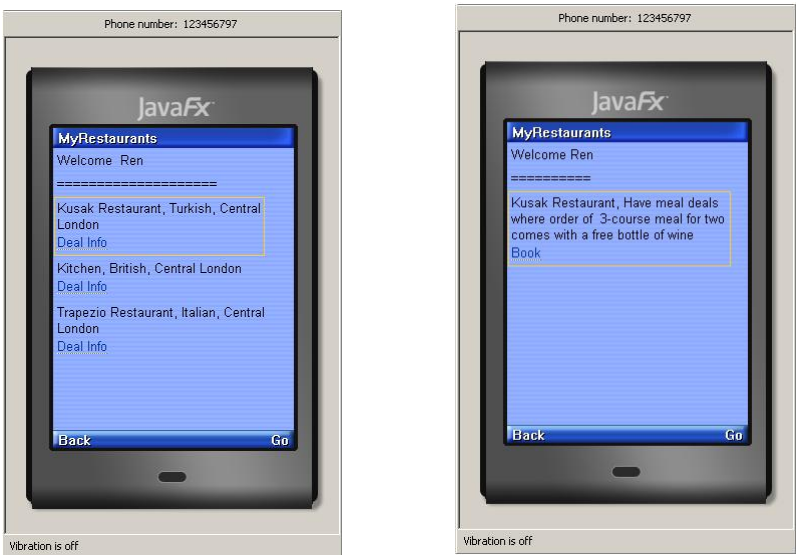

Figure 5. User's daily restaurant deals and detailed deal information.

User's location preference and user's current location are two important parameters for providing the right location based advertisements. For example, when it comes to the location based advertisements, Ren prefers the ones that are close to her work place so her location preference is 'work'. However, she is a property adviser and she needs to travel to different UK cities very often. Hence, when Ren is away, she will receive location based advertisements based on her user profile information and current location rather than her preferred location. The current location can be extracted from the GPS (Global Positioning System) information of the user's mobile device.

C. Restaurant Recommendation

For personalized mobile services, various architectures have been proposed [1][8][9][11]. Here, personalized restaurant recommendations are the outcome of the personalization process. In this scenario, the personalization process uses user profile information to personalize (filter) the restaurants to be recommended to the user. In Figure 2, detailed information of this process is shown. From this figure it can be seen that there are three inputs to the 'service personalization': user profile, service to be personalized, and current context information. Context information (i.e., location) and device capabilities are obtained from the mobile device. These are considered to be important for accurate user interface adaptation and personalization. Here, a privacy manager uses user's sign in information and user profile information to decide who can use the user profile information for what purpose, who the user is and if they have the right to use the provided service. It is worth pointing out that, like each user, each restaurant has to subscribe to MyRestaurants to be recommended to the users. This means that service provider acts like a bridge between users and restaurants.

Figure 3 is an example of some of the demographic, interest and preference information of a user in user profile with the following order: Age, Annual Income, Sex, Sport Interest, Music Interest, Book Interest, Leisure, Marital Status, Employment, Education and Profession. The WIBL uses this given data to predict the user's cuisine preferences. Here, user's cuisine preference is represented with its probabilistic distribution function, which enables the user to receive recommendations from different types of restaurants. These probabilities can change, based on the users feedback to the given recommendations. In this study, the user's clicks on the given recommendation is considered as a positive feedback. Here, the system counts each click on recommended restaurants and utilizes this information to update the user's cuisine preferences. Therefore, user's current information and new information are incorporated together to update the user profile information.

As mentioned previously, the user's location preference information (home, work or elsewhere) is also kept in the user profile and used for the location based restaurant recommendations. Gasson et al. [10] shows what kind of personal information can be obtained by monitoring a user's mobile device while in [1] it has been shown how the GPS data can be converted into text format. This method makes it possible to compare restaurants' location and user's location preference (or user's current location in case of elsewhere) to provide accurate recommendations. Similar to the user profile dataset, restaurant information is kept in the restaurants dataset. Figure 3 shows an example for the restaurant profile information. In this separate dataset, each restaurant is represented with the following attributes:

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Name, Cuisine Type, Price, Deal Description and Location. Here, each of these are used to classify restaurants based on their cuisine types using IBL [6].

V. Implementation of the Proposed Scenario

This section implements the proposed scenario and shows the usage of a DPD-Restaurant application, named MyRestaurants, from the user's point of view. The scenario is implemented as a Java Mobile Application (Java ME) on NetBeans IDE 7.1. Note that for this scenario we assumed that user Ren is already subscribed for the service. Following her subscription, Ren started using the service. To check her restaurant recommendations she needs to sign into the system using her user-id and password (see Figure 4). Here, prompt information is compared with the information in the user's profile for authentication. Ren's successful sign in redirects her to the MyRestaurants main page. This main page displays two options: 'My Account' and 'My Deals'. The first option, 'My Account', redirects her to a new page where she can change her password, location preference and user-name. The user-name is different from the user-id and it is used for display purposes. In this scenario the user prefers her user name to be 'Ren'. 'My Deals', on the other hand, redirects her to a new page. This new page includes daily restaurant recommendations (see Figure 5). Each recommendation has a link, which provides more information about the deal and the restaurant (also see Figure 5). Here, if she wants, she can follow another provided link to make a booking.

VI. Conclusion and Future Work

In this paper, a real life scenario for personalized mobile services is presented. Here, the aim was to illustrate how WIBL classifier can be used for user profiling in mobile environments so as to provide personalized mobile services.

The IBL classifier is a comprehensive form of the NN algorithm. WIBL is a modified version of the IBL, where weights were assigned to the attribute values and classification of the users are done based on the weighted distances. In our previous work we showed that WIBL decreases the error rate of IBL up to 28% and therefore increases the classification accuracy performance on user profiling.

The proposed scenario provided for here, focuses on the mobile advertising service, namely MyRestaurants. This scenario is implemented as a Java ME on NetBeans IDE 7.1. Here, each user is represented with three sets of user profile information that are interest profile, demographic profile and preference profile. Similarly, restaurant information is also kept in the restaurants dataset. Detailed information on both datasets together with user learning, user profiling, restaurant recommendation and the implementation of the scenario have also been provided in this paper. Based on the work carried out here, it can be conclude the WIBL for user profiling can be used to provide more accurate personalized mobile services. In our future work, we would like to test our proposed scenario with real users. It will be also interesting to compare the performance of WIBL with different personalized mobile services.

References

[1] K. F. Yeung and Y. Yang. A proactive personalized mobile news recommendation system, IEEE Developments in E-systems Engineering, pp.207-212, 2010.

[2] G. Araniti, P. D. Meo, A. Iera, and D. Ursino. Adaptive controlling the QoS of multimedia wireless applications through user profiling techniques, IEEE Journal on Selected Areas in Communication, 21(10), pp.1546-1556, 2003.

[3] M. R. Lopez, A. B. B. Martinez, A. Peleteiro, F. A. M. Fonte, and J. C. Burguillo. MoreTourism:mobile recommendations for tourism, IEEE International Conference on Consumer Electronics, pp.347-348, 2011.

[4] Y. B. Fernandez, M. L. Nores, J. J. P. Arias, J. G. Duque, and M.I.M. Vicente. TripFromTV+:Exploiting social networks to arrange cut-price touristic packages, IEEE International Conference on Costumer Electronics, pp.223-224, 2011.

[5] A. Cufoglu, M. Lohi, and C. Everiss. Weighted instance based learner (WIBL) for user profiling, IEEE International Symposium on Applied Machine Intelligence and Informatics, pp.201-205, 2012.

[6] D. W. Aha, D. Kibler, and M. K. Albert. Instance-based learning algorithms, Machine Learning journal, 1(6), pp.37-66, 1991.

[7] A. Asuncian and D.J. Newman (Accessed: 2 July 2012), UCI Machine Learning Repository, Irvine, CA: University of California, School of Information and Computer Science, 2007.

[8] S. Loeb and E. Panagos. Information filtering and personalization: context, serendipity and group profile effects, Annual IEEE Consumer Communications and Networking Conference-Emerging and Innovative Consumer Technologies and Applications, pp.393-398, 2011.

[9] T. D. Pessemier, T. Deryckere, K. Vanhecke, and L. Martens. Proposed architecture and algorithm for personalized advertising on iDTV and mobile devices, IEEE Transactions on Consumer Electronics, 54(2),pp.709-713, 2008.

[10] M. N. Gasson, E. Kosta, D. Royer, M. Meints, and K. Warwick. Normality mining: privacy implications of behavioural profiles drawn from GPS enabled mobile phones, IEEE Transactions on Systems, Man, and cybernetics-Part C: Applications and Reviews, 41(2), pp.251-261, 2011.

[11] B. Mrohs and S. Steglich. Architectures of future services and applications for mobile user, IEEE Symposium on Applications and the Internet Workshops, pp.128-131, 2005.

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Interference Force Reduction for Power Assist Systems Controlled at Arbitrary Operational Point

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***Abstract*— In this study, we propose an innovative multiportal human interface (M-HI) for power assist systems (PASs). This M-HI allows users to apply an operational force anywhere on the PAS. Because of this, the workspace of the PAS is extended and its end-effecter can be controlled as the user wishes. However, when users control a PAS at an intermediate joint, this joint does not always move in the same way as the end-effecter does. In this paper, we consider the number of links and degrees of freedom of a multilink manipulator. The relation between a control point and the limit of its motion is measured and analyzed. An operational position harmonization method is proposed through this relation. This method enables users to more accurately control the end-effector of a 3-link PAS at its intermediate joint.**

***Keywords*- Human robot interaction, User interfaces, Manipulator dynamics.**

I. INTRODUCTION

A. Background

No matter how large its workspace is, the area in which an ordinary power assist system (PAS) can operate is limited because of its restricted user motion space (see **Fig. 1(a)**). In addition, ordinary PAS requires the user to stay close to the target object. This situation may cause the object to catch on the user during motion, and may lead to a collision [5]. In this paper, we propose an innovative multiportal human interface (M-HI) [7]for PASs as a solution to these problems. M-HI enables users to control a PAS's end-effecter from anywhere on the system, and applying M-HI expands the effective workspace of a PAS, as shown in **Fig. 1(b)**. Thus, M-HI enables a user to control the PAS's end-effecter beyond the limitations of the human motion space.

During the control of a PAS, the user has some sense of the system's motion at the operational point. However, this motion is different from the actual end-effecter motion because of the degrees of freedom (DOFs) between the user and the end-effecter. Such differences are thought to affect the maneuverability and work accuracy of PASs.

Applying M-HI, therefore, carries the risk of reducing both maneuverability and user control sensitivity due to the difference between the operational force direction and operational point motion. Thus, controlling a PAS autonomously is necessary for not only tracing the user's operational force but also improving maneuverability. For example, in Koyama et al.'s research of HARO (a Human-Assisting Robot), the interference between a PAS and user caused by the mechanical construction of the system is reduced by using a filtering interference force method [4]. Kawamoto et al.'s HAL (Hybrid Assistive Leg)-3 [1], [3] PAS for gait disorder rehabilitation is controlled by estimating a user's intention from their myoelectric activity. In contrast, master-slave systems (MMSs) are not limited by the user's motion space. For example, Ishii's ASTACO (Advanced System with Twin Arms for Complex Operations) [2], Yokokohji's bilateral MMS [11] and Onal's bilateral MMS [6] enable

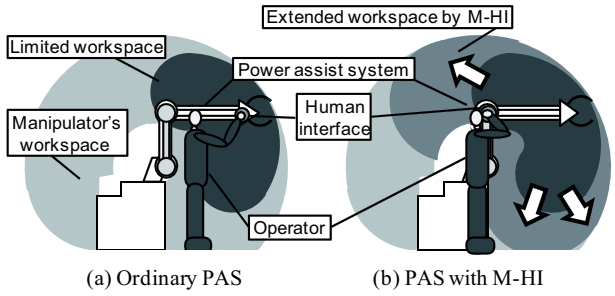

Figure 1. Extending the workspace of a PAS by applying M-HI.

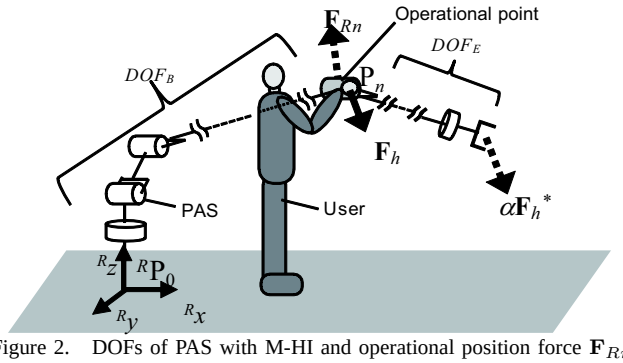

Figure 2. DOFs of PAS with M-HI and operational position force $\mathbf{F}_{Rn}$.

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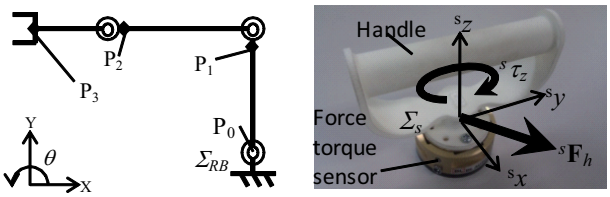

(a) Experimental PAS model (b) Force/torque sensor

Figure 3. Experimental PAS model.

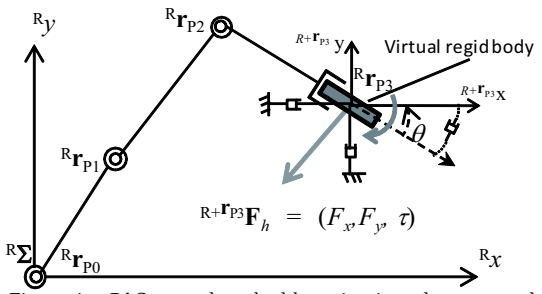

Figure 4. PAS control method by using impedance control.

the user to instinctively control the slave system by using a master system with the same DOFs. However, to realize such instinctive control, a high-specification master system is required.

For comparison, the characteristics that distinguish ordinary PAS, MSS and PAS with M-HI are as follows. In the proposed system, our M-HI technology enables the user to control the end-effecter's motion anywhere on the PAS and thus expands the effective workspace.

M-HI does not require a special master system. Moreover, by using an existing PAS and a force sensor, a system can be realized in which the user does not get needlessly close to target material. However, a PAS's end-effecter and other parts have different DOFs, and the force feedback is different for arbitrary operational points. These factors may strongly affect control sensitivity and accuracy. The conceptual model of our multilink PAS with M-HI is shown in **Fig. 2**.

The control response may become negative if the user's operational force $\mathbf{F}_h$ and the operational point force $\mathbf{F}_{Rn}$ are different. However, by following research such as Koyama et al. and Kawamoto et al., and controlling the PAS autonomously to fit to each individual situation, improvement of the PAS's maneuverability can be expected.

B. Purpose

We focus on the mutual interference between a PAS and user from the viewpoint of the force effect on the PAS by the user. We thus define the force as this effective force and experimentally analyze the relation between the user's operational force and operational point force.

In addition, we demonstrate the effectiveness of M-HI with respect to expanding the effective workspace of a PAS consisting of multi-DOF manipulators. An experiment applying M-HI to a 3-dof PAS, which limits the motion to the sagittal plane, is carried out, and the maneuverability of this system is evaluated. Controlling from an intermediate joint of the PAS, the motion of the control point sometimes has interference from the operational force. In this paper, we have two goals. Firstly, we try to measure and analyze the interference force betwen a user and an actual PAS. Secondly, we suggest a method to decrease the interference force and harmonize the control point force and operational force to improve maneuverability. We name this method 'operational point motion harmonization' (OPMH) and evaluate its effectiveness using computer simulation.

In this paper, the experimental condition and fundamental control method of M-HI are explained at next section. In the section three, fundamental operational force measurement and analysis are mentioned. In the fourth section, the improve method against operational force interference are proposed. In the fifth section, the method is evaluated. In the last saction, the paper is summarised.

II. Application of M-HI to 3-link PAS

A. Experimental setup

The experimental setup, PAS model and installed position force-torque sensor are shown in **Fig. 3**. In this experiment, we use a 3-link 3-DOF manipulator with the installed force/torque sensor as a PAS on $\mathrm{P}_1, \mathrm{P}_2$ or P_3. The PAS is moved by an impedance control method, where the motion is limited to the sagittal plane in this case.

B. 3-DOF PAS with impedance control

Our experimental 3-link PAS moved on impedance control method. The position and posture of 3-link PAS $\mathbf{r}_{\mathrm{P}_{3ref}} = [x_{3ref}, y_{3ref}, \theta_{3ref}]^T$ are calculated by the follow equation :

$$\mathbf{M}\frac{d^2\mathbf{r}_{\mathrm{P}_{3ref}}}{dt^2} + \mathbf{C}\frac{d\mathbf{r}_{\mathrm{P}_{3ref}}}{dt} = \alpha\mathbf{F}_h \qquad (1)$$

This impedance method controls the PAS's motion by calculating the physical reaction of a virtual solid body [8], [10]. A user inputs an operational force and torque $\mathbf{F}_h(F_x, F_y, \tau)$ to the sensor attached to the PAS. The PAS's end-effecter motion is then calculated as the behavior of the virtual solid body given by Eq. (1). Here, $\mathbf{F}_h$ is the user's operational force, α is the assist ratio, $\mathbf{M}$ is the inertial matrix, $\mathbf{r}_{\mathrm{P}_{3ref}}$ is the position and orientation of the virtual solid body and $\mathbf{C}$ is a matrix of the system viscosities. The impedance control model of the 3-link PAS considering the end-effecter's position is shown in **Fig. 4**. According to the control method, the PAS's end-effector realizes the user's operational force.

C. Application of M-HI for 3-link PAS

To apply M-HI, the operational force input to the end-effecter point must be estimated from the operational force given at an arbitrary operational point [7]. In this paper, this estimation is simply defined to make the evaluation of the proposed method straightforward:

$$\mathbf{F}_h^* = \mathbf{F}_h \quad (2)$$

Thus, we treat $\mathbf{F}_h$ and $\mathbf{F}_h^*$ as being the same from the basic viewpoint of the PAS's base. Using $\mathbf{F}_h^*$ as the operational force input to the end-effecter enables an arbitrary point control without changing the PAS's fundamental control system. In the next subsection, we discuss the motion DOFs of intermediate point control.

D. Motion limitations of arbitrary point control on a multilink system

If we wish to move the end-effecter through an arbitrary motion, the requirements to move with the desired motion are determined by the dimensions of the PAS's motion space while accounting for the solid body motion DOFs. When the PAS's motion space is one-dimension, the PAS only needs 1 DOF. When the PAS's motion space is two-dimensional, the PAS needs 2 DOFs for position and 1 DOF for orientation. When the PAS's motion space is three-dimensional, the PAS's needs 3 DOFs for position and 3 DOFs for orientation, specifically 6 DOFs in total [9]. We define the relation between a motion DOF and joint DOF of a PAS composed of a series of link manipulators by using Fig. 2. If the PAS moves in three-dimensional space, greater than 6 DOFs are required, those to realize the motion from the PAS's base to the user (DOF_B) and those from the user to the PAS's end-effecter (DOF_E). However, in this report, we do not treat such a complex manipulator, but instead our manipulator has a more limited number of DOFs. Therefore, DOF_B and DOF_E in our experimental setup are not enough to achieve free movement in three-dimensional space. In the next section, we discuss the maneuverability of the PAS with M-HI by considering the operational point force affect to the user.

III. Operational point interference force

A. Definition of operational point interference force

To evaluate the maneuverability of the PAS with M-HI, we consider the relation between the user's operational force $\mathbf{F}_h$ and the PAS's operational point force $\mathbf{F}_{Rn}$. This relation is determined by studying the position and orientation of the 3-DOF manipulator in which the motion space is limited to the sagittal plane. As a result, we see that the motion of the operational point is different from that of the PAS's end-effecter. For example, to achieve the motion in **Fig. 5** by controlling the PAS from the second link end P_2, the user must move the PAS's end-effecter position perpendicularly in the down direction and change its rotation counterclockwise as shown. According to Fig. 5, the operational point P_2 moves in the opposite direction to the operational force $\mathbf{F}_h$. The user has to control the PAS with a response $\mathbf{F}_{Rn}$ affected by the operational point. Hence, as an intuitive control for the PAS's end-effecter, we apply a method that realizes an amplified estimated operational force $\alpha\mathbf{F}_h^*$. However, this method is considered to decrease the operational sensitivity when the force caused by $\mathbf{F}_{Rn}$ differs from $\mathbf{F}_h$. We define the operational point interference force $\mathbf{F}_a$ through $\mathbf{F}_h$ and $\mathbf{F}_{Rn}$ as follows:

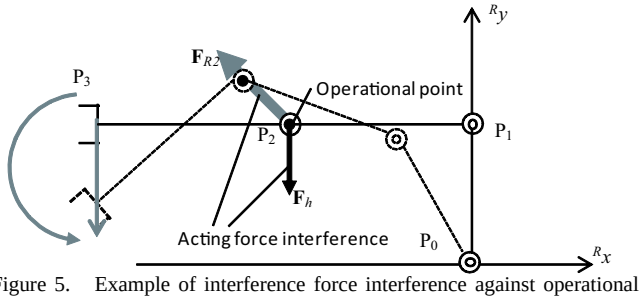

Figure 5. Example of interference force interference against operational force.

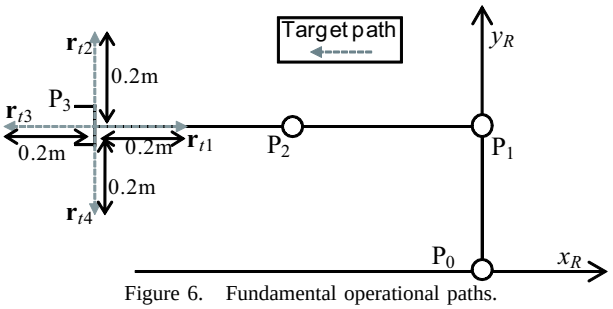

Figure 6. Fundamental operational paths.

$$\mathbf{F}_a = \mathbf{F}_{Rn} - \mathbf{F}_h \quad (3)$$

B. Experimental control accuracy of PAS with M-HI

We apply M-HI to an actual PAS and measure the control accuracy. In this experiment, we evaluate the tracking error of the PAS's end-effecter when controlled from an intermediate joint. During each trial, the user attempts to move the end-effecter to the target position. The user's control of the end-effecter motion is measured with the force/torque sensor, which is attached to P_3, P_2 or P_1, as shown in Fig. 3. The user inputs operational forces in the up, down, forward and backward directions, corresponding to $\mathbf{r}_{tn}, (n = 1 \cdots 4)$, respectively, until the end-effecter position moves by 0.2 m The user performs 10 repetitions in each direction. The target paths are shown in **Fig. 6**. The evaluation criterion, the target

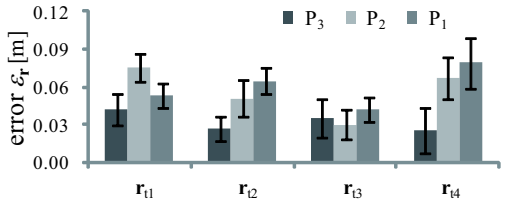

Figure 7. Experimental operational accuracy of PAS with M-HI.

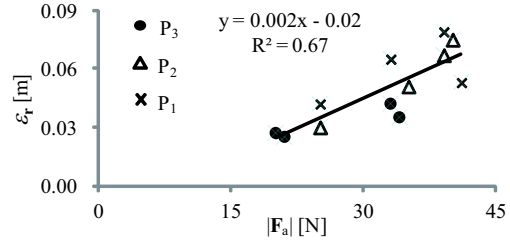

Figure 8. Correlation between average operational point interference force $|\mathbf{F}_a|$ and control accuracy $\varepsilon_{\mathbf{r}}$.

path tracking error, is defined by follow equation:

$$\varepsilon_{\mathbf{r}} = \frac{1}{N_s}\sum_{i=0}^{N_s}\sqrt{|{}^{\mathrm{P}_{e0}}\mathbf{r}_{\mathrm{P}_{3_i}}|^2 - \frac{({}^{\mathrm{P}_{e0}}\mathbf{r}_{\mathrm{P}_{3_i}} \cdot {}^{\mathrm{P}_{e0}}\mathbf{r}_{t_n})^2}{|{}^{\mathrm{P}_{e0}}\mathbf{r}_{t_n}|^2}} \qquad (4)$$

Here, P_{e0} means intitial end-effecter positon, $\mathbf{r}_{t_n}$ is position of the target path, $\mathbf{r}_{P_{3_i}}$ is end-effecter position on the coordinate of P_{e0} and N_s is the total step count. According to Eq. (4), a small value of $\varepsilon_{\mathbf{r}}$ indicates a small error between the end-effecter and target paths. The experimental results are shown in **Fig. 7**. Compared with P_3 control, both P_1 and P_2 controls have large target path tracking errors $\varepsilon_{\mathbf{r}}$. We have thus verified the decrease in control accuracy of the PAS with M-HI. The relation between the average interference force $|\bar{\mathbf{F}_a}|$ and control accuracy $\varepsilon_{\mathbf{r}}$ is shown in **Fig. 8**. Analysis of these data show that the correlation coefficient is 0.76, and we have therefore also verified the correlation between tracking error and $|\bar{\mathbf{F}_a}|$. These results infer that control accuracy improvement can be expected by reducing the operational force interference. We now propose a maneuverability improvement method that takes account of this operational force interference.

IV. Operational point motion harmonization

We propose a method to reduce the interference force interference and to harmonize this force and the operational position. We term this method "operational point motion harmonization control (OPMH)". OPMH has two goals; firstly, to reduce the interference force on the operational point, and secondly, to minimize the end-effecter motion error. A schematic of the OPMH control algorithm is shown in **Fig. 9**, and the operational force interference reduction algorithm is shown in **Fig. 11**. Here, the difference $\mathbf{F}_a$ is thought of as the correction force of the operational point motion that must be added alongside $\mathbf{F}_{Rn}$. If the operational point moves due to the combination of the correction force

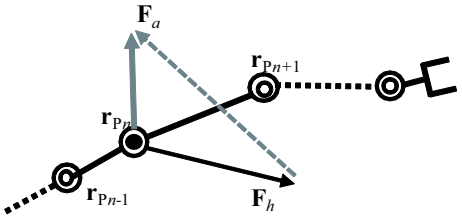

Figure 9. Definition of the interference force $\mathbf{F}_a$.

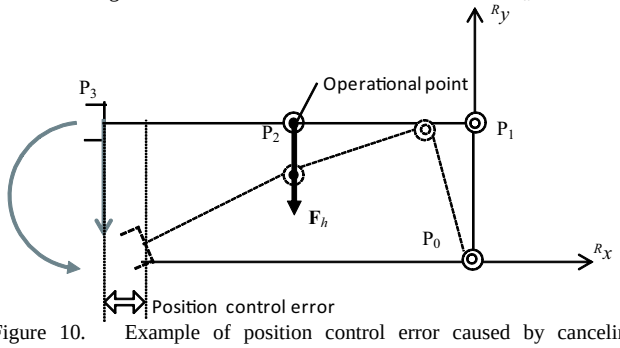

Figure 10. Example of position control error caused by canceling interference force.

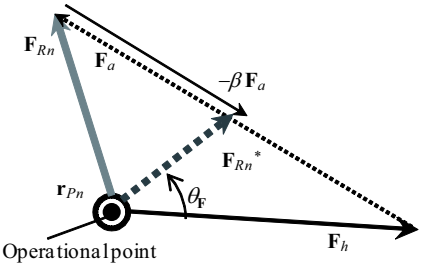

Figure 11. Concept of operational point motion harmonization.

and $\mathbf{F}_{Rn}$, then the motion is the same as that due to $\mathbf{F}_h$. However, the end-effecter motion will be different from that calculated by the impedance control method. For example, if 3 DOF PAS with M-HI as seen **Fig. 10** controlled P_2 following the operational force $\mathbf{F}_h$, P_3 motion has some errors compared with the motion calculated by impedance model. Therefore, we define the product of the correction force and β as the OPMH force $\beta\mathbf{F}_a$, which then gives the modified operational point force $\mathbf{F}_{Rn}^*$ as follows:

$$\mathbf{F}_{Rn}^* = \beta\mathbf{F}_h^* + (1-\beta)\mathbf{F}_{Rn} \qquad (5)$$

According to the above definition, if β is close to 1, then the operational point motion is close to that given by the operational force. By optimizing β, we can reduce both the interference force interference at the operational point and the end-effecter motion error. Thus M-HI enables the user to accurately control the PAS's end-effecter from anywhere on the PAS. The control flow of OPMH, including β optimization, is shown in **Fig. 12**. The evaluation function V for optimizing the system is defined as follows:

$$V = V_f + V_p \qquad (6)$$

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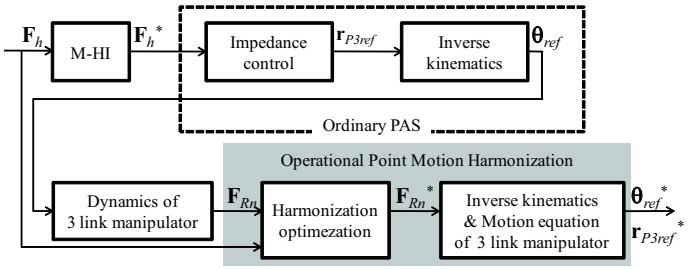

Figure 12. Block diagram of OPMH.

Here, V_f denotes the effect of operational interference and V_p denotes the error of the end-effecter motion resulting from the impedance model. V_f and V_p are given by follow equations.

$$V_f = 0.5\cos(\theta_{\mathbf{F}} + 1) \quad (7)$$

$$\theta_{\mathbf{F}} = \cos^{-1}\left(\frac{\mathbf{F}_{Rn}^* \cdot \mathbf{F}_h}{|\mathbf{F}_{Rn}^*||\mathbf{F}_h|}\right) \quad (8)$$

$$V_p = 0.5\cos(\theta_P + 1) \quad (9)$$

$$\theta_P = \cos^{-1}\left(\frac{\Delta\mathbf{r}_{\mathrm{P}_3}^* \cdot \Delta\mathbf{r}_{\mathrm{P}_{3ref}}}{|\Delta\mathbf{r}_{\mathrm{P}_3}^*||\Delta\mathbf{r}_{\mathrm{P}_{3ref}}|}\right) \quad (10)$$

$$\Delta\mathbf{r}_{\mathrm{P}_3}^* = \mathbf{r}_{\mathrm{P}_3}^*(t+\Delta t) - \mathbf{r}_{\mathrm{P}_3}(t) \quad (11)$$

$$\Delta\mathbf{r}_{\mathrm{P}_{3ref}} = \mathbf{r}_{\mathrm{P}_{3ref}}(t+\Delta t) - \mathbf{r}_{\mathrm{P}_3}(t) \quad (12)$$

Here, $\Delta\mathbf{r}_{\mathrm{P}_{3ref}}$,$\Delta\mathbf{r}_{\mathrm{P}_3}^*$ means amounts of change of P_{3ref} and P_3^* position, and their definition are shown in **Fig. 14**. V is minimized through optimization of β. In Eq. (7), V_f is changed between 0 and 1 by the direction of $\mathbf{F}_a$. In Eq. (9), V_p is changed between 0 and 1 by the direction that gives a decrease in the end-effecter motion error resulting from the reduction of $\mathbf{F}_a$. Hence, OPMH optimizes β such that V is minimized through V_f and V_p. If V_f takes precedence, then β becomes close to 1, and if V_p takes precedence, then β becomes close to 0. Examples of each evaluation function during the controlling of PAS with M-HI and applying OPMH are shown in **Fig. 13**. In this experiment, β is optimized by the following method. During a step controlling the PAS with M-HI, β is changed from 0.00 to 1.00 in increments of 0.01. In each β, the evaluation function V is calculated. The β which has the smallest V is chosen as the optimized β in this controlling step. We see a clear change in β from 0 to 1 dependent on the values of V_f and V_p. The definitions of $\Delta\mathbf{r}_{\mathrm{P}_{3ref}}^* and \Delta\mathbf{r}_{\mathrm{P}_{3ref}}$ are shown in Eq. (12),(11) and **Fig. 14**. Here, Δt represents the time during a step calculating the PAS motion and moving the PAS.

V. Evaluation of OPMH

We evaluate the effect of OPMH by using both a computer simulation to remove individual variation of experimental motions and guarantee repeatability. We evaluate the effect of OPMH through computer simulation by examining the control accuracy and interference force. Following the experiment in Section 3, the user inputs an operational force $\mathbf{F}_h$ to the four targets $\mathbf{r}_{t1\cdots4}$ shown in Fig. 6. In the current experiment, the absolute value of $\mathbf{F}_h$ increases from 10 to 40 N in 10 N intervals, and we evaluate the operational point interference force and the end-effecter tracking error.

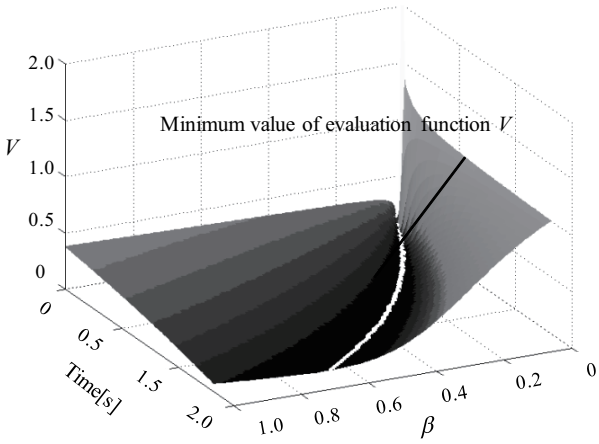

Figure 13. Example of β optimization.

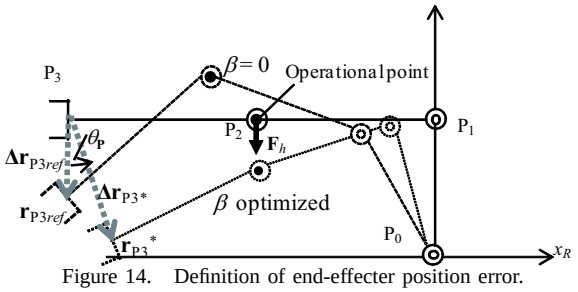

Figure 14. Definition of end-effecter position error.

A. Interference force $\mathbf{F}_a$ reduction

We verify the interference force reduction effect of applying OPMH by using the average interference force $|\bar{\mathbf{F}_a}|$ during a trial as defined by the follow equation:

$$|\bar{\mathbf{F}_a}| = \frac{1}{N_s}\sum_{i=0}^{N_s}\left(|\mathbf{F}_{Rn_i} - \mathbf{F}_{h_i}|\right) \quad (13)$$

The experimental results are shown in **Fig. 15**. In these figures, $\beta = 0$, $\beta = 1$ and β is optimized denote the respective cases of not considering the interference force, completely canceling out the interference force and applying OPMH with β optimization considering the interference force and end-effecter motion error. Fig. 15 shows the $|\bar{\mathbf{F}_a}|$ compared by $|\mathbf{F}_h|$ under the target path $\mathbf{r}_{t4}$. We can see that the interference force $|\bar{\mathbf{F}_a}|$ is increased by increasing the operational force $|\mathbf{F}_h|$. However, irrespective of the magnitude of $|\mathbf{F}_h|$, $|\bar{\mathbf{F}_a}|$ is decreased by applying OPMH. $|\bar{\mathbf{F}_a}|$ reduction ratio was 16.3% at P_1 and 19.1% at P_2.Therefore, we confirmed the interference force $\mathbf{F}_a$ reduction by OPMH.

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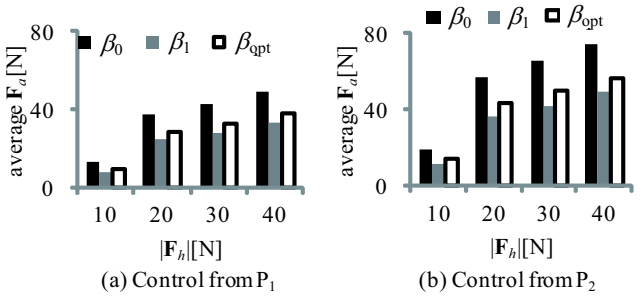

Figure 15. Average interference force from simulations under the target path $\mathbf{r}_{t4}$.

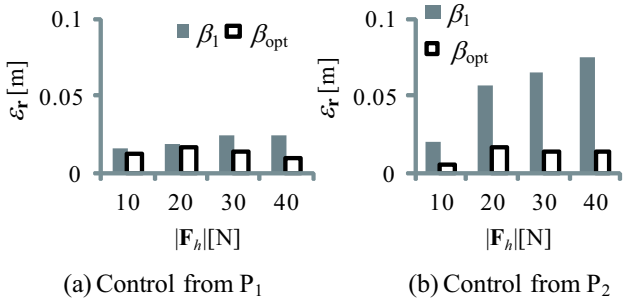

Figure 16. Average end-effecter position error of simulations under the target path $\mathbf{r}_{t4}$.

B. Target path tracking error

Next, we evaluate the motion error of PAS's end-effecter caused by applying OPMH. The motion error of PAS's end-effecter is calculated by Eq. (4). The experimental results are shown in **Fig. 16**. Here, the simulations of the case when $\beta = 0$ are not plotted since $\mathbf{F}^*_{Rn} = \mathbf{F}_{Rn}$ and hence $\varepsilon_{\mathbf{r}} = 0$ from Eqs. (5) and (4). Fig. 16 shows $\varepsilon_{\mathbf{r}}$ compared by $\mathbf{F}_h$ under the target path $\mathbf{r}_{t4}$. According to the figure, $\varepsilon_{\mathbf{r}}$ values under the optimized β is less than the values under the $\beta = 1.0$ as we had expected. The error of the end-effecter when position tracking to the target path was 23.8% at P_1 and 60.6% at P_2.According to this result, an improvement in control accuracy is found by using OPMH and its parametar β optimization. The experimental resulats of $|\mathbf{F}_a|$ and $\varepsilon_{\mathbf{r}}$ shows that the PAS with M-HI applied OPMH move canceling $\mathbf{F}_a$ with minimum P_3 motion error. Therefore OPMH is expected the improvement of operational feelings with the minimum P_3control accuracy loss.

VI. Conclusion

In this report, we applied M-HI to a 3-link PAS. We defined the force affected by the PAS's operational point as the interference force and analyzed the interference phenomenon of this force. We proposed OPMH as a method for reducing the interference force interference and for tracing the user's operational force. We evaluated the effects of OPMH by computer simulation. From the experimental results, we have shown the improvements in operational accuracy and efficiency of applying OPMH to the PAS with M-HI. Regarding operational accuracy, the error of the end-effecter when position tracking to the target path was 23.8% at P_1 and 60.6% at P_2.According to experimental result, OPMH is expected the improvement of operational feelings with the minimum control accuracy loss as we had expected. Therefore, we confirmed the effectiveness of OPMH applying PAS with M-HI.

References

[1] T. Hayashi, H. Kawamoto, and Y. Sankai. "Control method of robot suit HAL working as operator's muscle using biological and dynamical information". *Proc. of IEEE/RSJ International Conference on Intelligent Robots and Systems*, pp. 3063–3068, Aug 2005.

[2] A. Ishii. "Operating System of a Double-Front Work Machine for Simultaneous Operation". *Proc. of Int. Symp. Automation and Robotics in Construction*, pp. 539–542, 2006.

[3] H. Kawamoto and Y. Sankai. "Power Assist System HAL-3 for Gait Disorder Person". *Proc. of the 8th Int. Conf. on Computers Helping People with Special Needs*, pp. 196–203, 2002.

[4] T. Koyama, M. Q. Feng, and T. Tanaka. "Development and Motion Control of a Wearable Human Assisting Robot for Nursing Use". *Human Friendly Mechatronics(ICMA 2000)*, pp. 105–110, 2001.

[5] A. E. McMichael. "Army Materiel Handling Accident Analysis ". *Proc. of the Human Factors Society 32nd Annual Meeting 1988*, pp. 889–891, 1988.

[6] C. D. Onal and A. Sabanovic. "Bilateral control with a reflex mechanism on the slave side". *Proc. of Industrial Electronics Society 31st Annual Conference of IEEE*, pp. 849–852, Nov 2005.

[7] F. Shibukawa, T. Tanaka, and S. Kaneko. "Multi-portal Human Interface". *Proc. of the Int. Conf. IEEE Industrial Electronics*, pp. 4259–4264, 2009.

[8] T. Tsuji, H. Akamatsu, K. Harada, and M. Kaneko. "On-line Learning of Rob ot Arm Imp edance Using Neural Networks". *Journal of Robotics Society of Japan*, Vol. 17, No. 2, pp. 234–241, 1999.

[9] K. Yamane and N. Yoshihiko. "Pin-and-Drag Synergetic Interface for Choreography of Human Figures". *Journal of Robotics Society of Japan*, Vol. 20, No. 3, pp. 335–343, 2002.

[10] I. Yasuyuki, S. Tachi, and H. Arai. "A Method of Impedance Control of a Master-slave Manipulation System". *Journal of Robotics Society of Japan*, Vol. 10, No. 4, pp. 490–500, 1992.

[11] Y. Yokokohji. "Bilateral Control of Master-slave Manipulators for Ideal Kinesthetic Coupling". *Proc. of IEEE Int. Conf. Robotics and Automation*, pp. 849–852, 1992.

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