CyMED: a Plateform for Supporting Collaboration and Coordination of Home Care Teams using a Process Oriented Approach

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Abstract — **Recently, more and more patients are treated in their homes by multiple health and social care actors, from different organizations, public or private, characterized by their mobility and their schedule variability. In this paper, we investigate the difficulties inherent in home care collaboration related to communication, process orchestration and planning. To handle these kinds of difficulties, we present our coordination platform called Cyber Management of Elderly and the Disabled (CyMED), whose ambition is to use a mix of cooperation and process oriented tools, in order to facilitate the cooperative work of health and social care actors. With this approach, we aim to highlight the importance of organizational aspects in the context of homecare.**

Keywords-HomeCare; Coordination; Flexible Workflow; Declarative Workflows; Healthcare social network.

I. INTRODUCTION

Recently, healthcare in industrialized countries is facing great challenges regarding the increase in the elderly population and people with chronic diseases which require monitoring and care management on a long-term basis [5] [6]. Consequently, industrial countries have to reconcile different goals: improving efficiency, personalization and equity of healthcare delivery while limiting financial resources [5]. Nowadays, to handle this issue, more and more patients are treated and taken care of in their own homes. Home healthcare (i.e., homecare) includes all health services (e.g., medical, para-medical and nursing), social services (e.g., domestic home-help) and financial services (e.g., insurance) provided for the needs of the patient at home [14]. Moreover, modern homecare propose new technological services (sensors, robots and applications) to monitor patients at home [1][5][6]. Homecare services (human, technique, technological) are often delivered completely independently by stakeholders belonging to various organizations from the public or private sectors. Family members and relatives are also involved in the care delivery [14]. Consequently, the collaboration and the coordination get more complicated between the homecare providers due to the fact that they belong to different organizational units often with different organizational structures, goals, knowledge, way of working and responsibility regarding health and life privacy [1] [6]. Over the last few years, many European or French projects have been developed for the homecare improvement [5]. Most of these projects focus on a dissemination of tele-monitoring solutions via an extensive use of sensors and robots at home, leaving issues related to process (coordination) aspects unanswered [5] [12]. From our viewpoint, the needs of homecare stakeholders are more focused on improving the organization and the coordination of their activities than on increasing the use of telemedicine at home [4]. In particular, managers from different homecare organizations need to set up common goals and routines for collaboration at the operational level and means to follow-up the quality of delivered services [14]. In this paper, we explore further the needs for collaboration between different health and social care providers, relying on interviews, surveys and scientific literature. To handle the coordination issues in homecare, we are developing a platform called Cyber Management of the Elderly and the Disabled (CyMED), for the orchestration of the different kind of homecare services. The suggested solutions are based on a patient and process oriented perspective to emphasize the importance of the organizational aspect. The remainder of this paper is organized as follows. Section II presents the different types of homecare processes. Section III presents our approach to define and orchestrate homecare processes. Next, the CyMED platform is presented in Section IV. Section V presents a survey of healthcare social networks and platforms existing in the market or from research projects. Finally, section VI concludes the paper.

II. HOMECARE PROCESSES

Compared with hospital-based care, Homecare introduces new functions, new activities and new actors (such as the family, the coordinator, the equipment provider) in the process of care (see Figure 1) [1][6]. The only means of communication between the different homecare stakeholders is a simple physical notebook where each stakeholder notes the date of the visit, the actions performed or the patient health's change [3][4][17]. A multitude of other information media may also be used: medical records, social service records, fax, telephone, etc. Indeed, the cooperation of these stakeholders is asynchronous since they communicate rarely directly or meet face to face [16].

 ISBN: 978-1-61208-384-1

Moreover, homecare stakeholders differ widely regarding their way of working, need of information and technical skills. For instance, healthcare providers are often computer literate and possess their own information system support. On the contrary, social providers and elderly people have often little computer literacy and may be reluctant to use a computer-based system in their daily work.

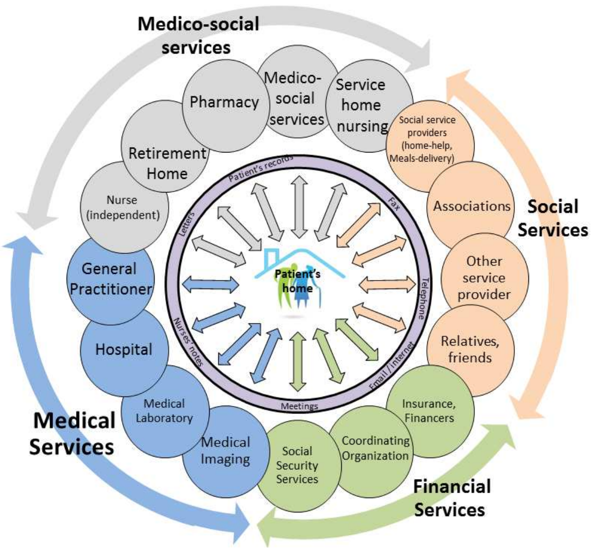

Figure 1. Homecare ecosystem

From our study of the activities in the field of homecare, we deduced that homecare processes are by nature **inter-organizational, collaborative and ad-hoc**. We distinguish, principally, two types of homecare processes [4]:

- An **organisational care process** which encapsulates administrative and logistic sub-processes and can be broken down into several phases: patients' requests and admissions**,** organisation of care processes (e.g., the elaboration of care plans and patients' discharges) and support processes (related to the logistical, financial and quality aspects).
- A **care process** made up of day-to-day care activities delivered at home by nurses, doctors, social services or the family's patient members.

Managing this kind of processes with traditional workflow systems is complex due their following features [1][3]:

A. *Personalized processes*

Although, homecare administrative and logistic processes are generally well-structured and often repetitive, care processes are, on the contrary, unstructured and very specific to each patient's heath state and environment.

B. *Collaborative Processes*

Homecare processes and responsibilities are distributed over multiple participants, with their own goals and procedures, working together to achieve a common objective (the wellbeing of the patient). They are also strongly influenced by the experience and the knowledge of the stakeholders (i.e., knowledge-intensive processes) [7].

C. *Dynamic processes*

Homecare processes require continuous adaptation of their structures due to the change in laws and care protocols. They also need to adapt their behavior when exceptional situations occur (arising from human or material issues) [9].

D. *Time constrained processes*

There are different types of temporal constraints on homecare processes: scheduled tasks (with a fixed start and end date), unscheduled tasks (e.g., when a physician consults blood test results) and tasks with frequency over time (e.g., a patient need two nurse visits per week for three months).

E. *Regulated Processes*

The homecare domain is governed by general rules and constraints related to healthcare protocols, data privacy and actions' traceability.

III. A FLEXIBLE WORKFLOW APPROACH TO MANAGE HOMECARE PROCESSES

There is a need for technological support in controlling and monitoring homecare processes to increase their efficiency and ensure the continuity of care. Workflow technology is potentially a means for achieving this end. Given the specificity and the inherent flexibility of homecare processes, we selected the Yet Another Workflow Language (YAWL) workflow management system for the coordination of work among homecare participants [10]. We justify the choice of the YAWL system as follows: First of all, YAWL is an open source academic system and its modelling language is very expressive. In particular, YAWL allows modelling and implementing cancellation and multiple instantiation of tasks (e.g., shared tasks), which are often encountered in homecare processes (see Figure 2). Second, YAWL offers unique support for flexible processes through the use of "*worklets*". In this way, specific activities, whose implementation is left open, are linked to a repository of possible actions (i.e. worklets). Based on contextual information, the desired action is chosen. Also, during enactment it is possible to add new actions to the repository. Finally, YAWL offers a link to the workflow engine DECLARE [13] which allows the enactment of loosely structured processes. DECLARE provide powerful ways of supporting "*extreme*" flexibility because it uses a declarative constraint-based approach. In this way, DECLARE allows specifying in a process model what should be done and not how to do it, using a set of tasks and constraints between these tasks. The users can execute activities in any order and as often as they want, but they are bound by the defined constraints. Furthermore, DECLARE also supports dynamic change, so that it is possible to deviate from the pre-modeled process template by adding or removing tasks or constraints. YAWL and DECLARE work

 ISBN: 978-1-61208-384-1

together in such a way that structured parts of the process are handled by YAWL while unstructured parts are handled by DECLARE. In addition, DECLARE supports decision making by providing the users with history based recommendations [15] during process execution using its link to the process mining tool ProM [8][11].

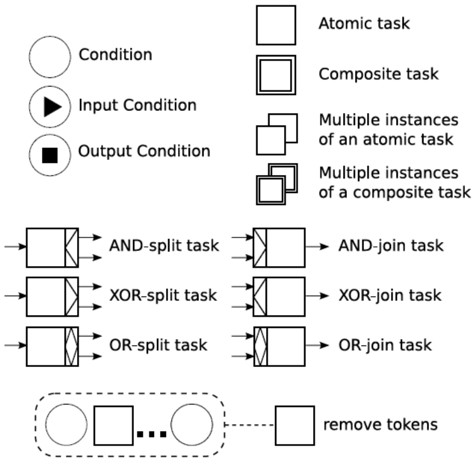

Figure 2. Symbols used in YAWL.

We illustrate the suitability of YAWL for homecare process enactment through a simplified medical prescription process, depicted in Figure 3. After the preparation of the required medicines, the delivery is organized in different modes depending on the patient's context (e.g., pick up medicines from the pharmacy or home delivery). We used the *worklet* service for modeling the different delivery mode by linking a multiple atomic task "*Medicines delivery*" to the *worklet* service. After the diffusion of a medical prescription, at any stage of the care process, it is possible for a doctor to cancel the care plan and to reschedule another one via the cancellation task "*Prescription cancellation*". During a treatment, a supervision of a patient is organized, illustrated by the *composite* task "*Treatment Supervision*". This task is linked to the *Declare* service. In this way, it is possible for the homecare participants to execute their assigned tasks ("*Check blood pressure*", "*Ask for drug tolerance*" and "*Give breakfast*") in any order as long as they respect the constraints defined on these tasks. It is also possible to dynamically add or delate tasks, on the fly. Despite the expressive power of the YAWL system, which make it one of the best candidate to orchestrate homecare processes (structured or loosely structured), there are some limitations: YAWL is an academic workflow management system therefore we need to teste its limitations for implementing real-life workflows. The predefined rules' templates embedded in the DECALRE system can't express temporal frequency constraints (i.e., a task has to be redone every day, once time, during a week). The DECALRE designer may also seem not easy to use for homecare participants to add and remove tasks dynamically.

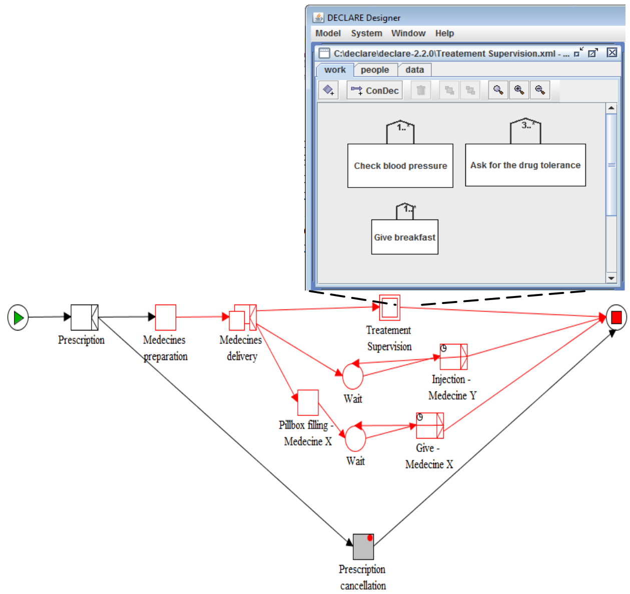

Figure 3. A simplified prescription plan

IV. THE CYMED PLATEFORM

A. *CyMED target architecture*

The architecture of the CyMED platform is based on the following main components (see Figure 4):

- A multi-modal communication system, combining tablets, PCs, TVs, fax and telephone. Information sharing may be via email, chat, audio messages or video meetings.

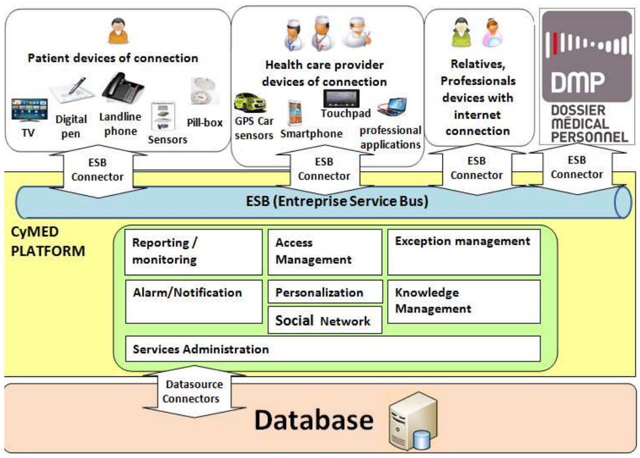

Figure 4. CyMED overall architecture

- A flexible workflow management system (YAWL system) to orchestrate the different services.
- An Enterprise Service Bus (ESB) which guarantees the interoperability and integration of the data sources and applications.

The CyMED platform will also be connected, when deployed, to diverse medical applications and to the National Electronic Health record in France, called DPM. The DMP was designed to enable coordination based on medical data sharing. However, we believe that an efficient coordination of homecare participants can be done only via an integrated approach using advanced technologies for data sharing, communication, and process orchestration.

B. CyMED main services

Let us note that the CyMED platform is under construction and a first version containing the healthcare social network is already available. The main functionalities of our platform are the following:

The healthcare social network

CyMED encapsulates a collaborative social network tailored to homecare services coordination and exchange of information. Each community is private and is built around one patient. It may involve the patient's relatives, homecare professionals and different organizations (laboratories, hospitals, insurers or coordination centers). A member may have several profiles depending on the community where he/she belongs. For instance one person may be invited in the community of the patient A as a relative and also be invited in the community of another patient B as a healthcare professional. Each profile has access to specific functionalities of the platform and has different access rights on the information displayed on a community. There are also different means to communication between the same community members via text, audio or private messages (see Figure 5).

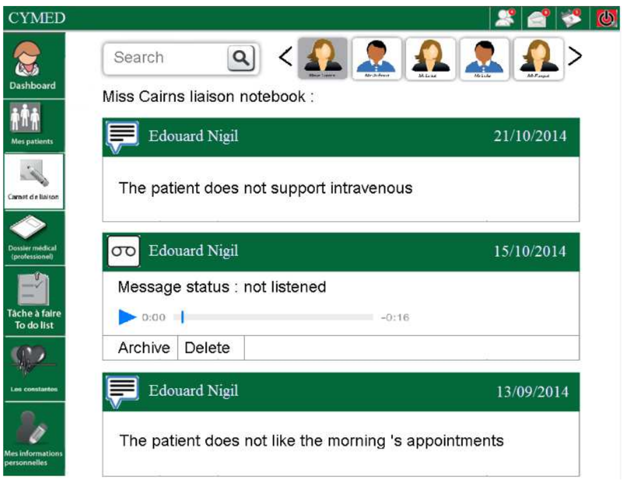

Figure 5. An example of a patient's community wall (user interface of healthcare professionals)

The voice messenger is a functionality proposed in our platform to improve communication among homecare participants, allowing them to record voice messages from their mobiles devices. We also propose a system of private chat and video meeting accessible by all the member of a patient's community.

Personalized Human Machine Interface

Our goal is to design a Human Machine Interface that is customizable (color, text size and font, etc.) and adjustable to the patients' deficiencies and loss of autonomy, at one hand, and to the responsibilities of homecare participants, on the other hand. For instance, we have worked on the specification of a personalized and adaptable event reminder service used by the patients and the homecare participants in their daily work. This service allows customizing, per type of events and per profile: the reminder type (sound, visual, contacting a relative, etc.), the frequency, and the reminder message content (key information to be transmitted).

The to-do-list functionnality

The tasks assigned to each member of a patient's community are managed via the *to-do list functionality* (see Figure 6).

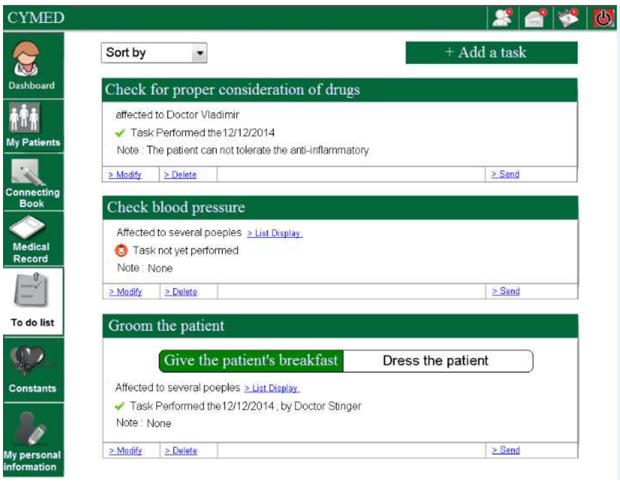

Figure 6. An example of a to-do-list (user interface of healthcare professionals)

This to-do-list acts as the *worklist* of the YAWL engine and acts also as an interface between the DECLARE designer and the DECLARE engine. Using such a To-do-list, a homecare participant or a patient, may define and assign tasks or care plans (if they are healthcare professionals) to other members of the same patient's community.

Social networks Key Performance Indicators (KPIs)

The homecare system in France is funded by regional public units which need to be reliably informed of the involvement, interaction and service efficiency of homecare participants. To answer these kinds of questions, we identified the following list (table 1) of key performance indicators (KPIs) which allow measuring the engagement and service levels of a patient's community on the CyMED platform (see Figure 7).

 ISBN: 978-1-61208-384-1

TABLE 1. DETAILED LIST OF SOCIAL NETWORKS KPIS

Social network Capital	Number of contacts with a direct relationship with the patient. It is measured by yearly total volume of contacts, vol. and % of contacts / category.
Number of social network gaps	Number of contacts categories within a patient private community with no contact. It is measured by total volume of contacts categories with 0 contacts per private community.
Patient medical data exceptions	Number of patient health abnormal data requiring actions to be taken, e.g., number of medications administrated but not taken. It is measured by daily total volume of exceptions notified.
Level of community engagement	Number of new events submitted by private community members. It is measured by monthly total volume of events generated by a category of the community or by a member of the private community.
Quality of service provided by the community	Share of alerts and/or tasks managed and completed by the private community. It is measured by monthly total volume of managed alerts and total volume of completed tasks by the community, or by a category of the community or by a member of the community.

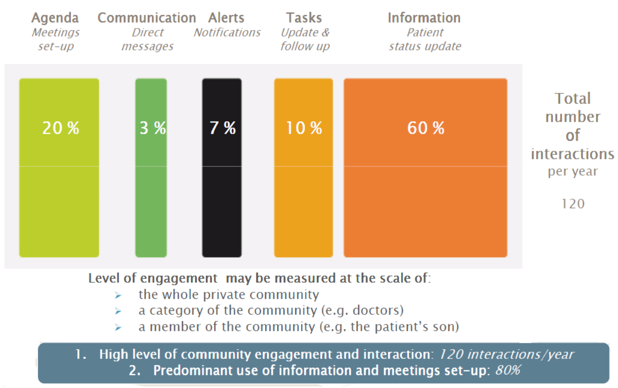

Figure 7. Social networks KPIs- Patient network involvement level

Health monitoring and detection of loss of autonomy

CyMED will encapsulate a monitoring system in order to detect alarming situations (e.g., falls) or any degradation of the patient's status (e.g., loss of autonomy). The detection of loss of autonomy is based on information reported by different types of sensors (weight, fall detection, power consumption, etc.) or questionnaires from the patients, caregivers, social providers and relatives. The CyMED platform will introduce flexibility in alert diffusion by allowing: (1) to customize alert thresholds per patient, (2) to adapt the alert diffusion process depending on the patients' context and the availability of his/her member community, and (3) to cancel alert diffusion process any time by authorized homecare participants.

Planning service

The CyMED platform encapsulates a scheduling service to organize the appointments and events of the patients and all the homecare participants. A patient agenda is shared between all his/her community members with different views on its details. The planning service can also provide optimization functionalities if the users want to optimize their daily scheduling. In this case, several criteria are taken into account expressed in terms of: unavailable or available time slots per type of service, availability per geographic areas, and distance between appointments' locations, etc. If an appointment is cancelled, the planning service will propose to a homecare participant the nearest provider who can replace him/her, relying on a homecare participants' locator.

C. Implementation

CyMED platform is based on a Service Oriented Architecture (SOA) architecture using an Enterprise Services Bus (ESB). We have chosen to use ESB architecture in order to have a flexible architecture allowing easily plugging of new applications, data sources and web portals. The standard parts of the social network will be generated from the framework LifeRay. The presentation layer will be provided by the Apache Web server. The processing layer and the business services are provided by the J2EE application server (Tomcat), communicating via asynchronous messaging. These autonomous services are integrated on an ESB (e.g., Mule) controlled and sequenced by the workflow engine YAWL. A secure connection layer protocol (Secure Sockets Layer - SSL) will be used to ensure the environmental safety of the platform. It will allow the encryption of the connection and also guarantee authentication through the use of cryptography. Finally, to ensure the interoperability of data exchange between the different services we are going to use international healthcare standards, such as DICOM (Digital Imaging and Communications in Medicine) and Health Level-7 (HL7).

V. RELATED WORKS

The issue of collaboration and coordination between homecare participants was treated by few European projects and studies [2][5][14][12][17]. For instance, in [16] the authors suggested a number of methodological measures and IT solutions, to support organizational development and coordination on both the managerial and operational levels. However, no solution was implemented. In [6], two design concepts were presented to improve homecare coordination, based on a voice messenger and on augmented paper binder. However, the proposed approach focus on enhancing communication rather than improving homecare processes enactment. A model of coordination for homecare processes was proposed in [4] based on recursive description of actions and shared reference. However, the proposed coordination model is not flexible and therefore is not adequate to manage homecare processes. More recently, an approach to automatically adapt the process of homecare for elderly people needs was proposed in [17]. This approach relies on ontology matching between homecare domain and concepts of Business Process Modeling Notations (BPMN). The drawback is that the produced process models are specified in BPMN notation which is not adequate to model flexible or loosely structured processes. Moreover, this approach doesn't take into account the agenda of the different homecare participants when the tasks of homecare processes are scheduled. Social networks approach was also successfully used in order to ease the access to healthcare information, collective learning, manage health conditions, and crowd sourced eHealth research. *PatientsLikeMe* is an example of patient-driven healthcare social network that encourages information exchange and collaboration between patients and doctors. *Hellohealth* (*hellohealth.com*) is another kind of social network which enables healthcare providers' identification and appointments' management. In comparison, we can say that the advantage of the social network of CyMED is that it combines a communication approach (chat, video, text and voice messages) with a process oriented approach (process orchestration via the YAWL system). Its goal is also to integrate different healthcare applications and sensors to facilitate patient's monitoring and the communication between different homecare participants and systems.

VI. Conclusion

In this paper, we present the overall architecture of our coordination platform, currently under construction, which offers a package of services, such as: the orchestration service (via the flexible workflow management systems YAWL and DECLARE), the communication service (via a dedicated homecare social network), and the monitoring service, etc. Future work will involve: (1) Implementing and deploying the system in real-life environments. (2) Implementing the optimization planning service and test its synchronization with the YAWL system [10] when tasks and appointments are rescheduled. (3) Defining constraint templates for the declarative workflow engine DECLARE [13] tailored to homecare. (4) Defining a mechanism based on ontologies and on the *worklets* service of YAWL to represent domain knowledge and patients' context [2] in order to facilitate the personalized construction of homecare workflows. (5) Extending the proposed approach with process mining capabilities applied on real-life data to extract, analyze and improve running homecare processes (e.g., extract homecare best practices) [11]. Moreover, it will be interesting to adapt the recommendation mechanism (relying on process mining) implemented in DECLARE to recommend tasks to homecare participants following the patients' health state contexts, preferences and constraints [15].

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