Seamless Mobility – Improved QoE in Mobile Telephony Through QoS-Sensitive (HOCIS) Convenience Messages

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***Abstract* — Business communication should become more effective through Unified Communications (UC) solutions. With UC, communication services such as telephony, video conferencing, presence, chat, file sharing, etc. become available independent of location or end device. Seamless mobility - the possibility of remaining connected on a mobile device while the connection is being handed off between different networks - is the most important technical factor in efficient mobile communication, especially in the field of UC telephony, which uses both conventional mobile and Internet Protocol (IP) networks for voice calls. Unforeseeable external influences on the quality of service (QoS) and unforeseeable operating conditions of the mobile technology frequently result in connection disruptions. This wastes the user's time and energy and results in a poor performance rating. Based on the example of a mobile UC solution, this paper presents the requirements placed on mobile UC telephony. The QoS barriers, user expectations, and principles for the design of QoS-sensitive interaction are summarized. An example is provided of how the UC-telephony user's quality of experience (QoE) can be increased on the basis of a Handover Convenience Information Support (HOCIS) by means of implementing QoS-sensitive user interaction.**

Keywords — Unified Communications; Fixed Mobile Convergence (FMC); Handover Convenience Information Service (HOCIS); Quality of Service (QoS); Quality of Experience (QoE); QoS/QoE relationship; Voice over Internet Protocol (VoIP);

I. Introduction

To achieve reliable seamless mobility, i.e., the possibility for the user to remain continuously connected across various network standards, current and future technologies for the development of a Unified Communications (UC) environment must be able to handle differing – both known and unknown – connection standards, end devices, and application combinations [1]. To ensure this, both network technologies and user navigation must continuously be expanded. The key points of this paper summarize the results of a user-centric design approach that foresees both an expansion of network compatibility and of user experience. It is the researchers' goal to perform an innovation process in developing a user-friendly interface for mobile UC, by the means of a patent-based QoS-sensitive backend technology. The process aims at improving the Quality of Experience (QoE) of mobile workers [2] potentially using UC telephony. Hence, the following Sections summarize the implementation process (analysis, planning, design and development, evaluation, optimization, and implementation) of the so-called "Handover Convenience Information System" patent (HOCIS) [3] in the mobile clients of an existing Voice over Internet Protocol (VoIP) UC environment. The results stated in this paper are excerpts from the transfer research between the TELES FMC+C Innovations GmbH and the Institute of Electronic Business (IEB). To that end, the IEB performed, among other things, primary and secondary research in the form of expert and development workshops, as well as user surveys, focus groups, and analyses of literature. The paper is structured in two main parts. Whereas Sections II to IV provide an overview of current service and design challenges as well as the researchers' findings for a QoS-sensitive user experience design (UXD), Sections V and VI present the case study report of the research-based innovation process, which led from a network technology patent to a user centric service implementation.

II. QoS Service Barriers and Ramifications for the Use of Mobile UC

UC technology will determine the future of telecommunications [4]. However, according to estimates, there are few concrete figures on the actual use and prevalence of UC technologies. In 2011, Ralf Lehmann spoke of a limited UC prevalence (12 percent) and usage primarily by large corporations [5]. Just as little information is available about the development as on the actual prevalence; there are hardly any figures for the providers' network failure and disruption rates. If it can be assumed that higher data rates and better Wi-Fi connections can be found in offices than the comparatively high fluctuations of mobile networks, the UC technologies in the end depend on the provider's quality of service. External disruptions occur frequently [6]. This holds true especially for mobile data transmission, as here the utilization of the faster Fourth Generation (4G)/Long-term Evolution (LTE) technology is relatively rare. In Germany, for instance, significantly less than 10 percent of mobile communication customers use the new LTE technology, while classical telephony and

 ISBN: 978-1-61208-402-2

Universal Mobile Telecommunications System (UMTS) Internet are much more important for the majority of users [6]. Beyond this differing prevalence of technical standards, the technical challenges, for example, circuit switched fallback (CSFB), must also be overcome [8]. Consequently, unknown disruptions and interruptions, varying connection and network standards and unforeseeable usages must be taken for granted in technology that uses VoIP.

For the user, such connection and bandwidth problems in mobile or stationary VoIP usage have a negative impact or result in a communication breakdown. In such cases, users frequently resort to the simple call with the generally better-established Second Generation (2G)/Global System for Mobile Communications (GSM). For the communication process, this generally results in a change of application and telephone number. Such connection problems waste the user's time and are frustrating. On the other hand, for providers of UC solutions, such situations represent the hazard that the negative perception will be directed at the application. Qualitative interviews by the IEB have shown that in cases of a disruption, a user can rarely distinguish between QoS, bandwidth problems, or software failures.

III. QoS and QoE – Requirements for the Design of QoS-sensitive User Interaction

UC telephony aims to provide increased communication effectiveness, in particular for business telephony. The IEB conducted a user group analysis and surveys of a group of demographically diverse volunteers for the purpose of determining user needs in UC telephony clients. The results showed that the user group of this technology is heterogeneous and their specific requirements can hardly be predicted. This technical and user-specific variability for the expansion of seamless mobility in the professional UC environment shows that mobile telephony applications will have to be able to react flexibly to usage-specific and technical influences. The expert workshops and focus groups demonstrated that along with the requirements for the flexible use of the application, the user also requires a simplification of the technical processes and functional possibilities. Surprisingly, fundamental feedback about telephony status was expressed as one of the primary wishes of the users. It is precisely this example that shows that the service blueprints of conventional mobile telephony apparently contain gaps between the background processes and users' activities. This means that background processes, such as network status and quality or network handovers, have not yet been sufficiently expanded as touch-points (i.e. interaction moments between device and user). The volunteers requested a touch-point for the immediate information about the call being broken off as a service function. Furthermore, those surveyed displayed a great discrepancy in their understanding of technology and in their willingness to learn, as well as in the telephony and cost behavior. For these differing uses and contexts, there was the requirement that universal, comprehensible, but individually configurable service functions would have to be designed. The application-specific user requirements therefore must be implemented with the primary requirement of user friendliness (according to Richter these are: Effectiveness, efficiency, performance, promotion of learning, learnability, potential to be remembered, flexibility, degree of freedom, adjustment, satisfaction, acceptance, task suitability, customization to individual needs, transparency, openness, self-descriptiveness, support, compatibility, conformance to expectations, consistency, uniformity, tolerance, fault tolerance, feedback, manageability, controllability) [9] – and always pursuing the aim of allowing for an interruption-free call.

IV. QoS and QoE – Principles for the Design of QoS-sensitive User Interaction

QoS-sensitive interaction is a unique segment of the field of interaction design that needed be achieved. Whereas video telephony software like Microsoft's Skype offers a visual and acoustic feedback when a call is temporarily interrupted, voice telephony applications rarely give a prompt feedback. The herein described approach on QoS-sensitive user interaction with (HOCIS) convenience messages requires more elements than hold or waiting music. Whilst other UC applications such as Unify's Soft Client, Cisco's Jabber or ComdaSys' MC Client partly provide service functions like network handover between different mobile data networks and handover functions between devices, this approach aims at providing an integrated set of QoS-sensitive support functions for all UC telephony options. This development focuses on a user interaction principles which combines status information, options evaluation and user assistance. From the accompanying research and development, the IEB has determined the following principles that must be pursued in the design of the user interaction and call control: The graphical user interface (GUI) should be based as closely as possible on the specific interaction habits using Android or Apple's mobile Operating System (iOS). Here, however, a distinction between the phones' basic telephony application and the UC application is still required. The handling of the interaction scenarios, during and prior to the call, requires adaptability to individual user preferences. For the sound design of the user interaction, the evaluation with the focus groups showed that a design similar to the telephone sounds the users have already learned, so-called auditory icons (use of such sounds, which are taken from daily life and that are closely linked to the event used for because of previous experiences (for instance: crumple up a paper). A multidimensional conveyance of information is possible, for instance, through indications regarding, size, age, or size of a problem) [10], does not provide enough distinction. For innovative functional parameters like warnings, abstract sounds, i.e., earcons (abstract, synthetic sound events which can create an own, simple language, with variations (density, timbre, level, speed, frequency) of melodic or rhythmic motifs) [11], have proven to be more effective. The design of the sounds takes on a more important role than the conventional design of internal, functional sounds, such as waiting music and call waiting. The fact that most service functions occur during the call means that the challenge is to provide a sensitive sound design that provides the user with the necessary information about the function and purpose [12] while simultaneously creating a minimum level of distraction. The design of the functional sounds is subject to special volume (amplitude), pitch (frequency), and timbre (spectrum) [13] requirements. They should be audible within complex user contexts, but also distinguishable from the device's own telephony application sounds. These goals can be reached by integrating various functional parameters in a "family" of sounds. The specific requirements for QoS-sensitive interaction design are part of the fundamental need to communicate complex, technical processes in multisensory messages and implement them in options. To properly service user expectations and user demands, the messages must be customizable and adjustable in both form and function. These principles are also applied in the following case study.

V. CASE STUDY: IMPLEMENTATION OF CONVENIENCE MESSAGES IN TELES FMC+C'S UC1000

The requirements for the QoS user interaction described above are the result of recommendations for the implementation of the HOCIS patent in the existing mobile UC clients of the TELES FMC+C company, which is currently available for iOS and Android devices [14]. Key Features of this client are: Single-number service; Seamless call handover between GSM and Wi-Fi, UMTS and LTE with convenience messages; Mobile VoIP, callback and callthrough; Visual voicemail, fax, presence and instant messaging; Extension dialing; Integrated corporate address book; Call transfer from desk phone to mobile phone and vice versa; Mobile access to desk phone features; Customizable to any IP Centrex or IP Centrex. Beyond the functions typical for UC, such as single-number service, instant messaging, presence, integrated company phonebook, etc. the application provides special features, including seamless handover between GSM, Wireless Fidelity (Wi-Fi) technology, UMTS, and LTE connections, and "convenience messages" which communicate information about the status of the telephony service to the user based on a QoS-sensitive evaluation of the telephone background process. The process of evaluating QoS input and translating it into so-called events is handled by the patented HOCIS solution. In particular, QoS information such as signal strength, packet loss, jitter, latency, as well as information about roaming status and network availability or loss, are evaluated, interpreted and reported in events (Table I).

TABLE I. QOS SENSITIVE EVENTS

QoS sensitive events	
#	***Description***
1	Wi-Fi/3G/4G available
2	Wi-Fi/3G/4G with special attributes
3	Slow quality decrease
4	Constant bad quality
5	Disconnect
6	Handover complete
7	Roaming
8	Manual handover

These eight events of the HOCIS patent are the inputs that are available for the QoE/QoS service functions and option menus for the UC1000 mobile clients. These events form the interface between the background processes and the user. The corresponding design of the touch-points provides the user with 10 use cases so as to allow more effective and reliable VoIP-UC telephony. To that end, service functions in the use cases (Table II) distinguish between the network and the device prior to and during the call and the handover. In accordance with a successful or failed service process, the interaction is designed so that continuous communication is maintained.

The aim of QoS-sensitive convenience messages is to offer the user the greatest number of alternative options for an ongoing communication process. The decision as per which events and their corresponding messages were implemented in the frontend of the client and which ones were considered as background processes, in other words as automatic service functions, was based on the researcher's user experience design (UXD) process which included qualitative and quantitative methods. This process consisted of the above-mentioned expert workshops, focus groups and usability tests.

Based on the results of this process, the TELES system of "Convenience Messages" consists of multisensory elements that allow the user to receive the corresponding system messages for any system, always with the aim of providing a more comfortable and reliable telephoning experience. Among the elements included in multisensory convenience messaging (see example in Table III) are: graphic elements, text elements (on-display) sound elements, vibration elements, light-emitting diodes (LED), voice elements.

 ISBN: 978-1-61208-402-2

TABLE II. USE CASES FOR CONVENIENCE MESSAGES

#	**Use cases for convenience messages**
1.1	Cost savings – during call *(successful)*
1.2	Cost savings – during call *(failed)*
1.3	Cost savings – before call *(e.)*
1.4	Cost savings – before call *(f.)*
2.1	Optimization of quality – during call *(e.)*
2.2	Optimization of quality – during call *(f.)*
3.1	Cost savings / Roaming – during call
3.2	Cost savings / Roaming – during call *(f.)*
3.3	Cost savings / Roaming – before call *(e.)*
3.4	Cost savings / Roaming – before call *(f.)*
4.1.1	Forced handover: Change of network – during call *(e.)*
4.1.2	Forced handover: Change of network – during call *(f.)*
4.1.3	Forced handover: Change of network – before call *(e.)*
4.1.4	Forced handover: Change of network – before call *(f.)*
4.2.1	Forced handover: Change of device – during call *(e.)*
4.2.2	Forced handover: Change of device – during call
4.2.3	Forced handover: Change of device – before call *(e.)*
4.2.4	Forced handover: Change of device – before call *(f.)*
5.1	Early warning: Decreasing quality of call – during call *(e.)*
5.2	Early warning: Decreasing quality of call – during call *(f.)*
6.1	Fundamentally poor quality of call – during call *(e.)*
6.2	Fundamentally poor quality of call – during call *(f.)*
6.3	Fundamentally poor quality of call – before call *(e.)*
6.4	Fundamentally poor quality of call – before call *(f.)*
7. 1	Loss of connection *(e.)*
7. 2	Loss of connection *(f.)*
8.1	Active call
9. 1	Automatic handover – during call *(e.)*
9. 2	Automatic handover – during call *(f.)*
9. 3	Automatic handover – before call *(e.)*
9. 4	Automatic handover – before call *(f.)*
10.0	Menu settings: Messages

Because mobile telephone users have different preferences, the users can decide for themselves if they wish to be notified by sound, LED or vibration. Each of these elements can be set or adjusted in the application's settings menu and used in combination or individually. The user's preferences are then also reflected in the user's cost behavior: the user may prefer a less expensive connection (and a higher risk of connection loss and warnings about disruptions) or high connection quality and call continuity (with possible higher costs). The configuration menu allows for settings that reflect the preference for these service functions. Depending on the service function (costs or quality), the individual elements (sound/vibration/LED) can be set separately. In another sub-menu a choice between "optimization" and "warning" can be set according to the user's preference. Not only can the user define whether or not to be informed about cost features with an on/off switch, but a sub-section also provides an option to be warned about cost hazards or separately informed about potential cost savings.

TABLE III. EXAMPLE OF CONVENIENCE MESSAGE

9.1. Automatic handover– during call	
Element	***Description***
Graphic	Progress symbol […]
Sound	*Hold sound (starts after 2 secs. in case of delay)*
	- With successful handover: confirmation sound
	- With failed handover: error message
Text	"Please wait"
	- or with termination: e.g. "Please try to restore connection."
Vibration	-
LED	Continuous short blinking, yellow
Voice	*- Lost connection: "Please wait while we try to reconnect you."*

VI. CONCLUSION

Mobile UC/UCC telephony is a permanent service process (voice call availability and continuity). User touch-points of the UC/UCC service result from telecommunication activities. These are triggered by the user, but are controlled by permanent and situational background processes. The UC1000 mobile client including convenience messages improves the telephony experience by means of specially designed QoS sensitive messages that support the user of mobile VoIP telephony and provide greater transparency and opportunities for intervention. The increase in QoE occurs in particular through:

- Improved telephony quality resulting from the use of innovative network technology
- Automatic user navigation in handling connection problems
- Feedback about the telephone connection and call quality, and warnings about possible interruptions
- Tips for improved connection options and call quality
- Assurance of improved user telephony experience through service-oriented user interaction
- Consolidation of the QoS and QoE relationship

- Extension of seamless mobility

For the users of the UC1000 Mobile with HOCIS, the implementation of QoS-sensitive messages and service functions offers the potential for increased QoE in UC telephony. Beyond the basic feedback about the status of the telephony service, the UC1000 with HOCIS also offers service functions such as cost control, cost warning, quality warning, device management, and forewarning features. These features provide the user with transparency, extended options, and control of telephone bills and private and business telephony with a single device.

The merger of the extended network handover technology HOCIS with an integrated research and interaction design process through the IEB has resulted in a user-oriented expansion of the UC1000 to include the HOCIS application. Reliable connections, transparency, and user navigation are increased by means of a service-oriented interaction concept. Each user can individually configure how to be informed, warned, and assisted with QoS service functions – through text, graphics, sound, LED, vibration or voice messages. The innovative core is in the development of multisensory user navigation, which is based on an interaction concept with its own sound design, voice messages, and media elements. The result is an improved sense of QoS and increased QoE of professional UC telephony. The UC1000 with HOCIS, including QoS-sensitive convenience messages, is a system that routinely aids the professional user's telephone communication efficiently and in a service-oriented manner, across all UC functions.

This example for the implementation of convenience messaging in an existing UC client on the basis of the HOCIS technology demonstrates a unique approach for QoS-sensitive user interaction. The possibility to adapt this system to any provider's telephony infrastructure shows that the potential greatly exceeds the application in Unified Communications. Based on this result, it can be assumed that QoS-sensitive user interaction offers opportunities for wider-ranging applications in telecommunications and consolidates the QoS/QoE ratio to the user's benefit.

ACKNOWLEDGMENT

For research cooperation: Prof. Dr.-Ing. Sigram Schindler, Christian Negrutiu, Ivan Ivanovic and Marius Witke. For the temporary support of the project leadership: Dr. Anna Riedel. For input and participation in the workshops: Carl-Frank Westermann, Lenard Gimpel, Michael Pietrek, Thomas Ness and Daniel Wetzel. For discussion of the content: Jörg Müller and Jochen Maria Weber.

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