User-centric Design of Mobile & Remote Health Care and Safety Services and Supporting Technologies for China and Finland

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***Abstract*—UBI-SERV project investigates services and technology for ubiquitous computing (e.g. services applying networked, embedded computers) in welfare technology and services. User-centric design approach is applied to pinpoint the cases that fulfill research border conditions, focusing on senior citizens and selected public safety services, both in Chinese and Finnish service technology market, so that academic objectives, i.e. user-centric design goals and true business cases, can be simultaneously investigated. Also, we strive to efficient utilization of usability research methodology, general resources and scientific expertise of our research consortium. The project has research teams at Helsinki University of Technology (TKK) and Peking University (PKU).**

Keywords—User-centric design, remote health care, public safety, wireless networks, mobile phones, sensors

I. INTRODUCTION

With rise of the people's life standard and the advance of medical techniques, the span of human life has extended and the population of the elders has increased. It is expected that the worldwide population of those over 65 reaches 761 million by 2025, that is more than double what it was in 1990 [1]. From 2002 to 2012 the proportion of Chinese aged over 50 will increase to 29% from 22% [2]. There are several associated problems. For instance, it is difficult to place senior citizens in private nursing homes, as it is still very expensive, or it may also be culturally unacceptable to elders to be cared for away from their immediate members. An overwhelmed pension system limits the spending power of the senior citizen and this gets even more challenging the ratio of workers to retirees continues to decline. In Finland the aging of population is recognized to form a severe challenge to healthcare economy and quality.

On the other hand, the rapid development of wireless communication technology is having a fundamental impact to the life of ordinary people both in China and Finland. While the technology is global in nature, the related ecosystem around the technology is different in different geographical regions. Although basic needs of people are similar the human and economical factors as well as society and culture greatly differ between China and Finland. This diversity is setting big challenges to the design of services, applications and corresponding technology.

In our project we apply user-centric design approach to pinpoint from the field of Welfare Technology and Services (WTS) the cases that fulfill research border conditions. As such, WTS is a very large research area covering two major frontiers of health and public safety referring to health management, health monitoring and medication reminders as well as public safety and security services. We focus on senior citizens and selected public safety services, both in Chinese and Finnish service technology market, so that academic objectives, user-centric design goals and true business cases can be simultaneously investigated. Also, we strive to efficient utilization of usability research methodology, general resources and scientific expertise of our research consortium.

The project modules are: Work Package (WP) 1 User-centric Design, WP2 Glocal (global & local) Networking Technologies and Services, WP3 Public Safety, and WP4 Remote Tele-care Technologies and Services. WP1 and WP5 Security, Reliability, Ethics and Safety affect all use-cases (Figure 1). This approach aims to develop truly usable, cost-effective WTS for both China and Finland by taking care of the user, service, environment, regulatory and technology levels simultaneously.

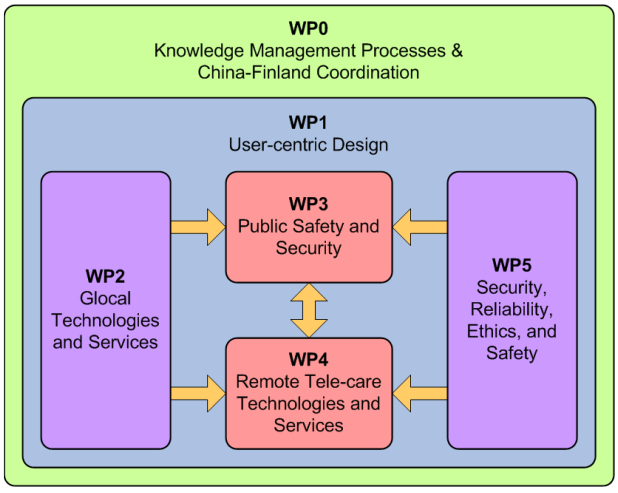

Figure 1. UBI-SERV project structure

II. USER-CENTRIC DESIGN

Work Package 1 (WP1) User-centric Design provides research methods for other work packages. Our approach for each service is characterized by qualitative and ethnographic research methods (e.g. focus groups, observations, and diaries). A start-up workshop and requirements meetings conducted at TKK aim to specify usability requirements that will be tested in the research and development processes. After the requirements meetings the project is focused on intermediate research modules to be carried out in China and in Finland.

Generally, the work of the human-centric group in this project will focus on three main themes: exploring user needs for the services with emphasis on neighbor and location awareness, evaluating usability (i.e. usability testing, heuristic evaluation) of the system architectures at various stages of the development process, and evaluating acceptability and the quality of service experienced by the target user groups [3].

III. GLOCAL TECHNOLOGIES AND SERVICES

Communications technology advances and associated service developments are creating a new service ecosystem that is at the same time local and global in nature and can be called as Glocal (Global & Local) Service Ecosystem (GSE).

WP2 Glocal Technologies and Services covers the following aspects: glocal services and requirements set by human-centric design, recent technological advances that will greatly impact to the available enablers in localized service provision – notably the introduction of Home Base Station (HBS or femtocells) concept –, future evolution towards ubiquitous human-centered mobile computing, and techno-economical characters of the Glocal Service Ecosystem.

In the case of indoor femtocell deployment, a range of computer simulations is carried out to investigate the impacts of several environmental factors on the indoor and indoor-to-outdoor radio propagations. The radio performances are compared under different assumptions of building internal structures, radio spectral usage schemes and access policies in both uplink and downlink. Compared with macrocell-only systems, it has been shown that femtocells enable a good indoor coverage by creating small high-throughput hotspot and delivering the user traffic locally through premise broadband to the core networks. The study on femtocells also covers a use case where femtocells are used as indoor 3G access points by an emergency indoor tele-trauma care service. The service is required to provide on-site emergency personnel with specific medical instruction from a remote surgeon by videoconferencing and other rich multimedia medical data transfer. The simulation results indicate at least an order of magnitude reduction in service outage rates when femtocells are utilized, in comparison to the macrocellular case.

Also techno-economic and interference analysis [4][5] of home base stations is done within the project. In the future, the research on femtocells will also deal with issues related to the use of femtocells for carrying calls and data in emergency communications.

The chronically ill patients are often treated at home, leading to a scarcity of interpersonal contact. Modern online social networks can help the people keep in contact with their relatives and friends, but are most often only used by the young – while many of the patients in need are elderly. A part of our research studies the usability of provided online social networks for the elderly or chronically ill.

Another field of research has been evolution of Radio-frequency Identification technologies suitable for health care applications, e.g. mobile-phone-readable 2.4GHz RFID sensor tags [6] and dual-band Ultra-wideband RFID memory tags [7] which can contain data-logging sensors, as well as their usability [8].

IV. PUBLIC SAFETY AND SECURITY

Public safety and security (PSS) communication services are the main theme of Work Package 3 (WP3) of UBI-SERV. The research focus on WP3 is within the general context emergency telecommunications (EMTEL).

The four main EMTEL areas specified by European Telecommunications Standards Institute (ETSI) Special Committee (SC) on EMTEL are emergency calls or sessions i.e. communication from citizens to authorities or organizations (ETSI SR 002 180), public safety communications i.e. communication between authorities or organizations (ETSI TS 102 181), warning systems i.e. communication from authorities or organizations to citizens (ETSI TR 102 182), and communication between citizens during emergencies (ETSI TR 102 410).

Here the authority/organizations collectively refer to emergency first responders (fire-fighters, police, paramedics etc.), emergency control centers, and public safety answering points. The aforementioned specifications and reports set the baseline user and system requirements for the underlying communications technologies that enable services for public PSS purposes. These requirements should be taken into account when specifying communications architectures, protocols and services for PSS use cases.

PSS services enable effective interactions between (and among) senior citizens and authorities (e.g. police, emergency medical services, fire services etc.). These PSS services are typically life-critical services that place stringent requirements on Quality of Service (QoS), availability, security and usability under high-pressure.

Recently, indoor solution based on femtocellular networks has been proposed in order to provide capacity gains and ubiquitous coverage for in-building 3G (and beyond) communications. To that end, a femtocell is a reliable, user-deployed, operator-managed, broadband gateway between local (residential) and global networks that could be reused for delivery for PSS services in a residential environment.

In UBI-SERV we have analyzed the limitations of macrocellular mobile networks for early warning dissemination (e.g. due to some impending natural hazard) and identified the benefits of leveraging femtocells for the purpose of disseminating early warning messages to senior citizens in their place of residence [9]. Furthermore, we studied the exploitation locally available femtocellular resources for multimedia emergency telemedicine sessions (initiated by paramedics) for transmission of bio-signal data, image scans and interactive video call traffic between senior citizens residence and a receiving hospital [10].

V. REMOTE TELE-CARE TECHNOLOGIES AND SERVICES

In WP4 Remote Tele-care Technologies and Services, we study the remote health monitoring networks, terminals, and services.

The monitoring system is to prevent people from the disease or harm by giving a warning or advice in time.

Using the wireless sensor to track the routine activities of daily life, e.g., how does one do physical exercise and what habits does one have.

The services should be able to assist user's life in chronic and geriatric care and producing savings in health personnel costs – without increasing risks, but even improving the overall quality of the treatment instead. This function is becoming increasingly important both in China and in Finland. Measuring bio-signals and activity signals at same time gives basic information for the services. The objective of this function is to create a supporting, techno-economically balanced, service realization with user centric design methodology and border conditions.

In case of critical situations, life-saving services and technology is an important function we are going to research. This function requires the application to work with paramedics giving the first aid to the people in need. Whenever an accident happens, the person may be in critical situation by health or some other reason. The question is if his/her doctors, relatives and friends can be informed immediately through the system. Can all the associated health-care personnel get all the information they need? This requires well-organized communications and information processing.

One of the major problems for chronically ill old patients at home is medication compliance. Many types of medication require compliance to be effective. Physician or nurse is not available at home everyday (or many times a day) to deliver the medication. People often forget or overlook taking medicine unless symptoms are felt, resulting in harmful response to the medication or null effect. A mobile phone can be used to remind the patient automatically (medication calendar) or even to check if the medication package has been opened [3].

Contemporary advancements and cases of remote health care system deployments in China and countries inside European Union have been reviewed. The key barriers of implementing applicable remote health care system were identified through an analysis of economical, technical, political, and ethical aspects (Figure 2) [11].

Usage scenarios of ubiquitous healthcare have been studied, especially considering treatment to chronic diseases like diabetes and hypertension. Also cloud computing technology has been examined for remote health care and welfare applications. A study of advantages of cloud computing in building applicable ubiquitous healthcare systems and services is being conducted, as well as economic analysis of cloud computing as a solution for analyzing and storing medical data.

VI. SECURITY, RELIABILITY, ETHICS, AND SAFETY

WP5 Security, Reliability, Ethics, and Safety (SRES) influences all other work packages. All the research functions of the tele-care module relate to SRES questions that we will pay special attention in our focus group gatherings striving to keep a close touch with service operators and potential device manufacturers and governmental authorities during the whole project time.

VII. CONCLUSIONS

UBI-SERV project, now near to the end of its first year, is well on track with a Finnish university (TKK) cooperating with a Chinese one (PKU). Networking with companies, as well as other research projects, in Finland, EU, and China has been an essential part of the project.

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