Augmented Processes: A Case Study in Healthcare

Petri Pulli[1], Olli Martikainen[2], Ye Zhang[1,2], Valeriy Naumov[1], Zeeshan Asghar[1], Antti Pitkänen[1]

[1]University of Oulu, Department of Information Processing Science, Oulu, Finland
Email: petri.pulli@oulu.fi, valeriy.naumov@oulu.fi, zeeshan.asghar@oulu.fi, antti.pitkanen@oulu.fi
[2]The Research Institute of the Finnish Economy (ETLA), Helsinki, Finland
Email: ye.zhang@etla.fi, olli.martikainen@etla.fi

ABSTRACT
A fundamental transformation of services is underway. The public and private services are recognized as the new source of productivity growth and dynamism in economy. Modern economies are soon 90% based on services. Information and Communication technologies (ICT) are a key factor in this development. We explore how ICT can be used to improve healthcare processes by using the research framework of the Value Creation in Smart Living Environment for Senior Citizen (VESC) project. Two new concepts: Augmented Processes and Mist Computing are proposed. We demonstrate these concepts in the context of processes dealing with remote assistance of senior citizen in outdoor navigation and in kitchen assistance for meal preparation. Additionally, we perform a case study in the Helsinki Meilahti Hospital where we developed a mobile application called Ping App to demonstrate the idea of Augmented Processes to improve healthcare workflows and to identify possible improvements.

Keywords
ICT services; healthcare; Augmented Process; Mist Computing

1. INTRODUCTION
A fundamental transformation of services is underway, driven by the developments in Information and Communication technologies (ICT) [22]. The public and private services will be the new source of productivity growth and dynamism in economy, that is changing the structure of employment, the division of labor and the character of work and its location. Modern economies are soon 90% based on services [17]. As the both private and public services are constantly growing, this brings the service sector a lot of pressure to improve practices and productivity. Recently, various studies have been investigating tools and methods that aim to improve healthcare processes. The main goal of the 'Value Creation in Smart Living Environment for Senior Citizen' (VESC) project has been to develop smart services that facilitate healthcare for elderly people and to support independent living. Figure 1 shows the future smart living environment for elderly people by the VESC project. In the VESC project, the living processes of the senior citizens are modeled and connected to the service processes of the healthcare institutions. The service processes are supported by the Service Logic Execution Environment (SLEE), which is distributed to the mobile personal workstations of the service personnel. The research question has been how to optimally improve the service quality and productivity by developing the service processes with the aid of mobile communication.

The process models of the VESC project can be stored and executed as virtual processes in the SLEE. If parameters from real processes are transferred to the SLEE, the processes can be optimized in the model level and this optimized data can be used to improve the real process execution. We shall discuss this continuum of real and virtual process execution in the next chapter. We will call processes improved with ICT tools using virtual process data as Augmented Processes. Further, we call the special case architecture, where the ICT applications reside in mobile phones, as Mist Computing, contrasted to Cloud Computing, where the processing resources are centralized.

The second part of this study considers the improvement of a real hospital process. First, we refer to current research on the application of ICT in healthcare. ETLA, the Research Institute of Finnish Economy has performed several case studies in Meilahti Hospital, Helsinki. We have applied VESC's Bluetooth process data acquisition system [21] that collects real-time process data using Bluetooth communication technology. Using this technology, in combination with interviews of hospital personnel, ETLA currently has already modeled treatment processes in Meilahti hospital. Based on the results of wireless process data acquisition and interviews several improvement possibilities of processes have been identified. We will apply ICT to improve these hospital workflows. In this paper, we present one case example, an application developed for the Emergency Department.

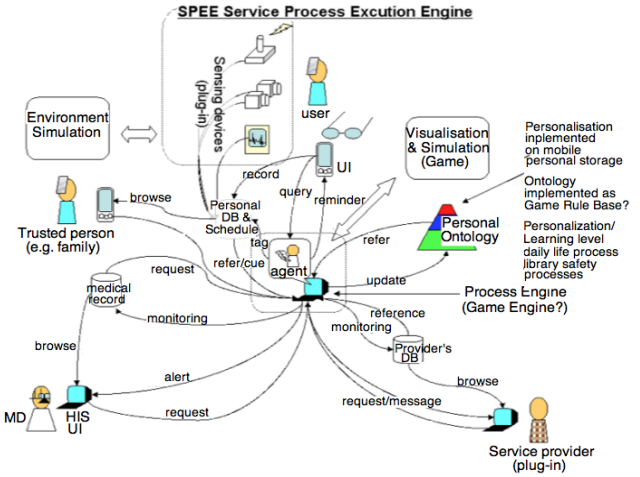

Figure 1. The Smart Living Environment for the Elderly.

The case example makes use of the proposed new concepts: Augmented Process and Mist Computing. The Emergency Doctor consultation process is augmented with a phone call analysis application that runs in the doctor's smart phone. We provide a brief description of the requirements based on interviews with doctors and present the framework and the implementation of the application, which was called as Ping App. Last, we illustrate the evaluation setup and analyze the results, and finally, we conclude our work.

2. CONCEPT DEFINITIONS

In the services transformation the services group in three categories [22]:

1) *Irreducible Services*, which rely on humans to deliver services, and where services are typically created at the same time and in the same place they are delivered.
2) *Hybrid Services*, which rely on a combination of humans and electronic tools to deliver services, using ICT and other systems to leverage or enhance human capabilities. This combination is often constituted as a system.
3) *Automated Services*, which rely on ICT or other technologies to deliver services that have been codified, digitized, and made available, often using electronic communication or distribution tools.

In Virtual reality research the mixing of virtual construct into reality have described in the Reality – Virtuality continuum [15] shown in Figure 2.

To the extreme left of this continuum is the Real World, for example, an environment that is in no way modified by any virtual synthetic object. To the extreme right is the Virtual World, a completely computer generated synthetic world. In between these two extremes we have some mix of both the real world and the virtual world [15]. The service categories above can be represented in Figure 2 as follows. Irreducible Services can be considered as Real Environment, where no ICT support does not yet exist. Hybrid Services can be modeled as Augmented Reality, where the ICT system supports the service. Automated Services are then special cases of Augmented Virtuality, where real system parameters are taken into the ICT system and the service is automated.

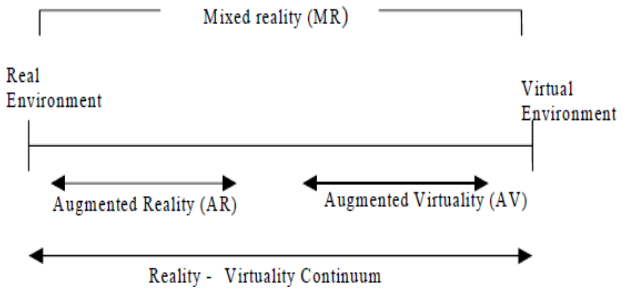

Figure 2. The Reality – Virtuality continuum

2.1 Augmented Process

When we improve a real process with an ICT application, which uses data or parameters from the real world and which provides to the process personnel information, which can be used to improve the process execution, we call this improved process as A*ugmented Process*. Hence, typical to augmented processes is that data from the real process is used and processes, and the processed data is further used to improve the real process.

Our definition of augmented process shares similarities with concept of *mediated reality* [14] which refers to the ability to add to, or subtract information from, or otherwise manipulate one's perception of reality through the use of mobile or ubiquitous devices.

Research of ubiquitous smart living environments has been seen as a potential solution to support elderly in their daily activities and thus possibly enabling them to live at home longer. In addition to separate devices like smart phones and ubiquitous devices such as projectors and touch-based surfaces, smart environments could include different kind of sensors or sensing devices user can wear or that can be placed in the environment of the user. Keeping aged persons active also has many positive health outcomes (e.g. slow down the weakening of the memory) and it might even improve the quality of life by enabling more social interactions and giving them a feeling of independency.

Because senior citizens have special needs in their daily lives, developing service architecture for senior citizens with dementia is not an easy task. Users are individuals with diverse needs, and that is why it is extremely important that development requirements should be generated from real user needs of senior citizens, rather than trying to tackle the problem from a purely technical point of view. Senior citizens themselves are in many cases not capable or unwilling to use new kind of technology.

The term *teleoperation* can be defined as "doing work at a distance", although "work" may mean almost anything. However, the “distance” term is vague. It can refer to physical distance and can also refer to scale [9]. A surgeon using micro-manipulator technology to conduct surgery on a microscopic level is an example of scaled tele-operated system [18]. Teleoperation has been used in tele-robotics for guiding robot from a distance. Areas were teleoperation techniques has been widely used are: deep-sea exploration, space operations, military operations, medicine (e.g. tele-healthcare and telesurgery), construction work (heavy work machines) and surveillance. Like teleoperation, *telepresence* is a compound word, which means "presence from distance". In many cases term is defined as a task-specific meaning, where "presence" requires feeling that you are emotionally and socially connected with the remote world through sensor information (e.g. vision, sound or force). More precisely this means that the information operator receives about the teleoperator and the task environment is sufficient and natural to create an illusion of physical presence at the remote site [9]. Interfaces are an essential part of teleoperation. In many cases teleoperation interfaces can be classified as direct, multimodal/multisensor, supervisory control and novel [9]. At this point has to mentioned that even if it might sound ethically wrong to identify senior citizen with teleoperated robot, there are a lot of useful aspects that can be found on teleoperation research and in the research of supervisory controls. Specially architecture and the user interface (UI) solutions for handling remote clients can be utilized.

As the first example, we have used mobile phones, which gather the real-time process data that is needed in the augmentation, as shown in Figure 3. Our second example is an augmented process in context of augmented kitchen for senior citizen is depicted in Figure 4. The essential idea is to augment senior citizen user's view with arrows and markers that assist user to carry out daily routine of meal preparation and eating with the help of workflow engine for routine augmentation and remote assistant for solving problem situations. We are developing this kitchen scenario in cooperation with prof Sei Ikeda NAIST Japan.

2.2 Mist Computing

The grid computing concept has been widely used in scientific research, energy industry, banking and education already for several years. In this work, we adopt the idea of grid computing but bring it to mobile and ubiquitous devices instead of traditional computers. Therefore, we propose a new concept: *Mist Computing*. Mist computing complements cloud computing where computing is performed far away, in the 'cloud'. Similar research conducted by Chu [5] extends an implementation of grid computing to mobile and ubiquitous devices and addresses some limitation problems mobile and ubiquitous devices introduce, such as limited resource and limited battery life. In our definition, mist means that the emphasis of computing and interaction takes place at the edges of the cloud, therefore it extends the cloud computing to peer-to-peer direction. In our research, mobile devices such as smart phones are used as the devices for data gathering of real processes as well as processing environments for the augmented processes.

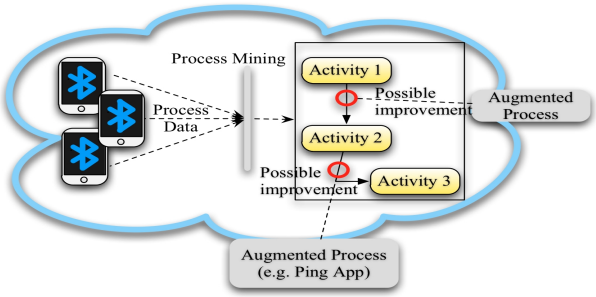

Figure 3. The Data collection for an Augmented Process

3. RELATED WORK

It has been more than three decades that Information Technology (IT) has been used in hospital systems. Comprehensive surveys about using ICT in healthcare are available, for example Johanna Viitanen conducted a national questionnaire study on clinical ICT systems in 2010 in Finland, with the participation of 3929 physicians [20]. Bindakheel, A. conducted a case study in healthcare at University of Malaya Medical, [3] they also use methods like interviews, group discussion among 70 staff to determine the adoption of ICT and found out ICT leads to more accurate diagnoses, reduces medical mistakes and helps to solve health-related issues. Furthermore, Kaplan, B. studied the success and failure in health IT implementation [11] and Lenz, R. [7] studied the potential of using IT technologies in the analysis of healthcare processes. All these existing assessments show that there is large potential in the healthcare sector to improve the productivity and quality.

The hospitals offer public services, which have unique characteristics: the treatment processes are complex and require several special skills, and healthcare practices vary between areas and depend on the local regulation. There are studies from several kinds of perspectives: Mattila, E. presents a concept for ICT assisted health promotion from the perspective of occupational healthcare [13] while Vida, M. presents a framework of ICT solutions aiming to improve medical workflow and processes in obstetrics [19]. The study of Alpay, L. takes both technology and cognitive issues into account in their research on ICT enabled healthcare communication [2].

In 2002, regarding the evolution of medical practices, Fieschi predicted the prospective impact of ICT development for the next 10 years [8]. Later in 2003, a new expression, 'telehealth' was proposed by Mohan, J., which refers to the integration of ICT, human-machine interface technologies and healthcare treatments [16]. In Malaysia [1], a conceptual clinic Information System (IS) framework for small, medium and enterprise clinics was designed. Another study of using advanced wireless technologies in hospital area is conducted in Finland, which aims to improve healthcare quality, processes and logistics of public hospitals [10]. As Bossen, C. stated in Europe and US, the major concern of using ICT to support the complex working of the healthcare sector is to develop electronic health records [4].

In the VESC project, we adopted the idea of process mining [6] and developed a process data acquisition system by using Bluetooth technology [21]. This solved our field data collecting problems for process modeling. The combination of Bluetooth based data collection with qualitative hospital personnel interviews enabled us to model healthcare processes in Meilahti Hospital. Furthermore, based on the analysis of the results [21], we propose the concept of augmented process that uses ICT to improve healthcare workflows. Based on our case study in Meilahti Hospital, we learn that emergency telephone consultation service is critical for professional guideline, moreover it contributes to a decrease in the cost of non-urgent cases. Therefore, it is useful to reduce the burden on doctors and to improve the workflows using ICT.

4. FRAMEWORK OF AN EXAMPLE AUGMENTED PROCESS

In analyzing and improving the hospital processes, the procedure of our research is the following: First process data is gathered by automatic process data acquisition system [21] and from interviews with the hospital personnel. The data includes activities that compose the process, performer of each assignment, duration of each activity and time order of this activities. Next we model healthcare processes based on event logs and interview transcripts. As the third step, we use the Three Viewpoint Model (3VPM) [12] to analyze the performance of the process. 3VPM includes a dynamic performance analysis with connected queuing networks, performance analyses of alternative improvement plans for the process and a comparison of the current process and improved processes. Forth, verify alternative improvements of the process and develop a specific augmented process. During the development of a new augmented process, the method of semi-structured interview is used to capture more accurate requirements and prototyping is used as requirements validation tool.

4.1 A Case Study

Based on the results of wireless process data acquisition and interviews, we identified some improvement possibilities in the workflow of the Emergency Department of Meilahti Hospital. The Meilahti Hospital belongs to the Helsinki University Central Hospital (HUCH) and is the largest hospital in Finland. The emergency telephone consultation in the Emergency Department is responsible for giving 24 hour guidelines for urgent treatments, such as specialized medical care and examinations, surgery and neurology. Due to the high frequency of emergency calls, answering consultation phone calls and writing paper report is a burden for the doctors. In reality, recording paper report this is always disturbed by other tasks, for example another incoming phone call. Therefore, this could lead to the inefficiency of work, interruption of their work on hand and high missing rate of records.

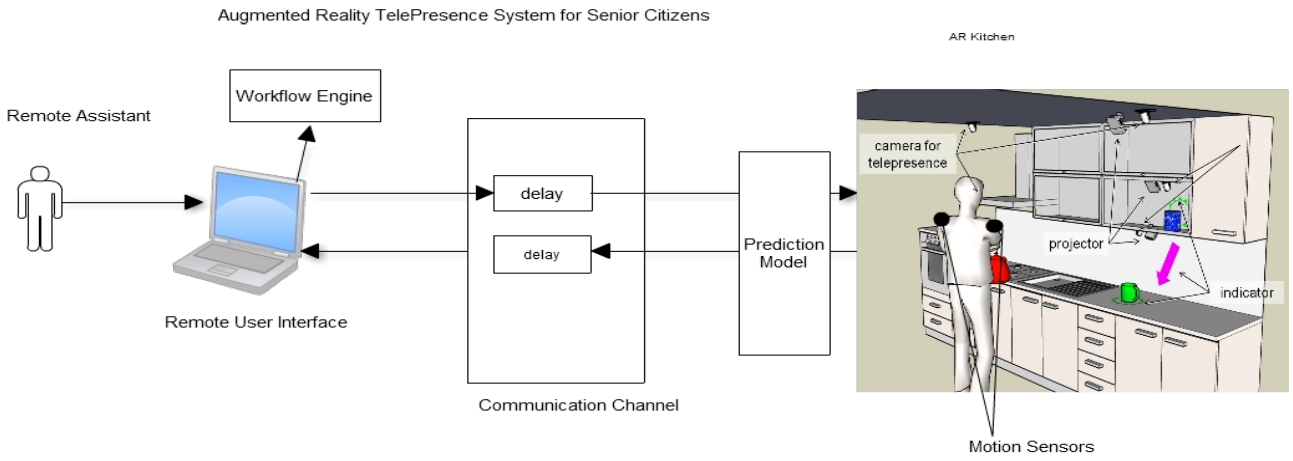

Figure 4. Augmented Kitchen System for Seniour Citizen. Image on the right courtesy prof Sei Ikeda NAIST Japan.

According to our study, there is a big potential to apply ICT to improve workflows. By interviewing doctors in that department we learned following requirements:

1) Emergency consultation phone call could come from HUCH hospitals, hospitals in Helsinki area, distant hospitals, private hospitals, primary health care or emergency services.
2) Callers are mainly the ward staff, including neurologists, internists, anesthesiologists, occupational health care doctors, junior doctors, general medicine doctors, ambulance crew, nurses and medical students.
3) Some of the phone calls are not relevant, meaning calls should be directed to other people. Currently there are no statistical results showing what special guidance is needed for the staff or how to reallocate consultation services.

4.2 Framework of Ping App

To optimize the consultation calls of Emergency Doctors, we augmented their consultation process with the application called Ping App. The application runs in the smart phone of the doctor and is based on the wireless process data acquisition system developed in the VESC project. Ping App is designed to record related information of emergency phone calls automatically. This guarantees the accuracy and timeliness of the data of consultation phone call, while at the same time it helps to reduce the workload of doctors. The idea of Ping App is shown in Figure 5. It works as a background service, which means it runs behind the scene and the user cannot stop its working with user interactions. We use a broadcast receiver listening to the boot state of the mobile phone, so the Ping App will be started at boot time of the phone and will keep running in the background until a phone call is received. Within the background service, there is a telephony manager which is responsible for listening to phone call state changes. When users finish an incoming phone call, the service will show a Graphical User Interface (GUI) as pop-up dialog to interact with the user. This GUI presents a questionnaire constructed by the Ping App and the answers are phone call related information that we need. In the end, the information will be stored onto the phone's memory card.

From the hospital personnel we learned that more than 30 IT application were used by the nurses in the ward for various tasks. We were surprised how much time was needed daily to only open and close the applications. To decrease the workload and to improve the productivity of nurses and doctors the application invocation should be automatic. Thereby, as a very important objective in developing augmented processes, the application should pop up and open automatically, when needed. The usability is also a main concern. The Ping App design follows main important usability requirements, such as simple and intuitive user interfaces that don't require doctors to have professional computer skills. Moreover, since we work with a touchscreen application, the choices in a list should be limited, so we split questions with a lot of possible answers into two related questions; The interaction was designed as multiple-choice answering which tries to provide a familiar experience for users so they don't need to spend any effort to learn to know the application.

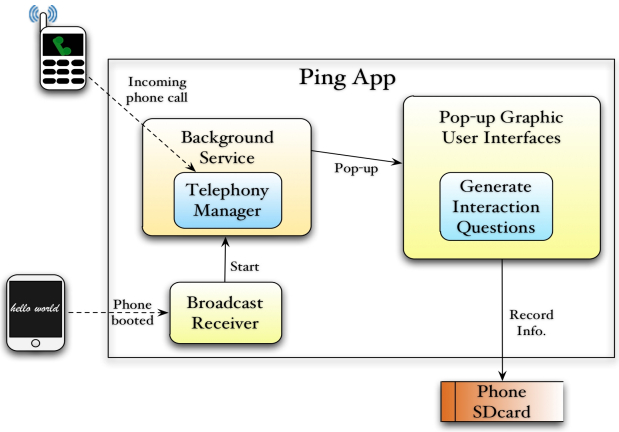

Figure 5. Framework of Ping App

5. IMPLEMENTATION

5.1 Targeted Platform

In this work, we chose Android as our targeted platform. Android is one of the most popular mobile operating systems at the moment. Android is an open source operating system that is based on Linux kernel version 2.6. The development and releasing is in the hands of by the Open Handset Alliance. It includes a large group of companies, such as mobile operators, handset manufactures, semiconductor companies, software companies and commercialization companies. Moreover, Android has a variety of open-source libraries and the Dalvik virtual machine that is optimized for mobile devices.

5.2 Development Tools

Android has a variety of tools to support development, such as a device emulator and the Java Debugging Wire Protocol (JDWP) debugger. In this work we use Eclipse development environment with the Android Development Tools (ADT) plug-in. Eclipse is a multi-language Integrated Development Environment (IDE) whose ability can be extended by using Eclipse plug-ins. ADT is one of Eclipse plug-ins, which supports for building Android targeted projects. Eclipse with ADT is highly recommended by Android Developers. ADT is a framework to create user interfaces, add components based on the Android Framework APIs and it provides Android SDK tools for debugging[1].

5.3 Implementation

Ping App was developed based on our previous Bluetooth process measurement system [21] but runs as an independent background service.

1) Permission. First, we need to grant the usage permissions in the manifest file, including READ_PHONE_STATE and RECEIVE_BOOT_COMPLETED. These permissions allow accessing particular events and data on the device, such as the phone states and 'BOOT_COMPLETED' broadcast when the device is booted.

2) Service. To implement the background service described in the framework, the Service component in Android is used. It runs in the background without interacting with users and it has a reference to the TelephonyManager that provides access to information of telephony services. The implementation listens to PhoneStateListener, which is used for monitoring telephony state changes, such as call state changes on the device. There are three phone call related states that we are interested in: ringing, answering incoming call, user hanging up and phone returning to idle state.

3) BootBroadcastReceiver. This class inherits from the base BroadcastReceiver class and is used for receiving the specific broadcast 'BOOT_COMPLETED'. The Service will start automatically and run in the background when the phone has booted.

4) Activity. The pop-up GUI described in the framework, is implemented using a floating style Activity component. Activity is a window for placing GUIs and responsible for interacting with users. The GUIs are defined in a declarative way by using Extensible Markup Language (XML) layout files. We have more than one generated question and the answers for each question are presented in a list, so we use the ListView component and an ArrayAdapter implementation that supplies data to the ListView dynamically. All questions and answers are also stored as string-array in the XML resource file. Only when users actually answered a phone call, this Activity will be started to gather phone call related information. Next, the PhoneCallRecordManager functionality is used to store the phone call record onto phone's memory card.

6. EVALUATION

To demonstrate that the augmented process we developed in this work can improve the work flow of emergency telephone consultation, we conducted 2-day practical testing. It was in the Emergency Department in Meilahti Hospital with one of the doctors who are responsible for emergency telephone consultation.

We collected 24 phone call records in total, containing phone call related information such as the date and time, incoming phone number, call duration, originating area and unit, where the patient is directed to, the professional level of the caller, whether it is a relevant call. Table 1 presents a sample of the emergency phone calls recorded during the testing. Instead of writing paper reports, doctors only need to answer multiple choices questions which pop up on the screen right after the phone call is ended. Then, the Ping App generates automatically a succinct report. This tool greatly reduces the workload of Emergency doctors, ensures completeness of the records of consultation phone calls and helps to reduce the time needed in handwriting that is often interrupted by next calls.

According to the testing results, 20.8% of phone calls are irrelevant, which should be answered by other departments. This verifies that doctor's workload can be reduced, for example by providing appropriate education, or by reallocating consultation services. Furthermore, other information, such as the frequency of incoming calls, call duration, and professional level of the caller also can be used in further analysis that aim to improve the productivity.

7. CONCLUSION

This paper explored how ICT can be used to improve the quality and productivity of healthcare processes and two new concepts, namely augmented process and mist computing, were proposed. In typical healthcare process research it is challenging to measure exactly the real process models and to find out the optimal process improvements. Thereby, the Bluetooth process data acquisition system was built in VESC project. Further, to find out the available process improvement benefits, the 3VPM methodology was developed. Combined with staff interviews, the models of some treatment processes in the Meilahti hospital in Helsinki were analyzed. Several improvement possibilities were found, and we developed a mobile application called Ping App to demonstrate the idea of augmented process. Ping App runs in the smart phone of the emergency doctor and improves the workflow related to emergency phone calls in the hospital.

Furthermore, our future research will concentrate on the development of Augmented processes that adopt Mist Computing and improve productivity in the healthcare domain.

8. ACKNOWLEDGMENTS

We would like to thank the "Academy of Finland MOTIVE/ VESC" project for the support and research funding. We thank the ETLA, Research Institute of Finnish Economy's project 'ICT, Service Innovations and Productivity' and funding from Technology Industries of Finland Centennial Foundation and Tekes – the Finnish Funding Agency for Technology and Innovation. We thank the Helsinki University Central Hospital for supporting research case study.

[1] Android Developers website. (visited 1.9.2011). Retrieved from: http://developer.android.com/index.html

Table 1. Sample Records of Emergency Phone Calls

Date	Incoming_Phone_Number	Begin Time	End Time	Timezone	Duration (s)	From	Unit	Will_Direct_To	Professional_Level_Of_Caller	appropriateness
26/08/2011	+35894711	11:13:10	11:17:9	Europe/Minsk	239.0	Distant Hospital	Hyvinkää Hospital	Other Regional Hospital	Neurologist	Is appropriate
26/08/2011	0504279462	11:22:40	11:24:53	Europe/Minsk	133.0	HUCH	Meilahti Other Specialists	Meilahti Hospital (Emergency Clinic)	Internist	Is appropriate
26/08/2011	0947174026	11:53:15	11:53:47	Europe/Minsk	32.0	HUCH	Meilahti Other Specialists	Meilahti Hospital (Emergency Clinic)	Neurologist	Is appropriate
26/08/2011	+358504270121	12:8:45	12:9:42	Europe/Minsk	57.0	HUCH	Meilahti Neurology	Meilahti Hospital (Emergency Clinic)	Neurologist	Is appropriate
26/08/2011	+35894711	12:21:43	12:23:37	Europe/Minsk	114.0	Distant Hospital	Hyvinkää Hospital	Meilahti Hospital (Emergency Clinic)	Neurologist	Is appropriate
26/08/2011	0504286765	12:34:12	12:35:0	Europe/Minsk	48.0	HUCH	Jorvi Hospital	Meilahti Hospital (Emergency Clinic)	Neurologist	Other consultation number possible
26/08/2011	0192242511	12:36:45	12:40:44	Europe/Minsk	239.0	Distant Hospital	Tammisaari Hospital	Other Regional Hospital	Internist	Other consultation number possible

9. REFERENCES

[1] Aliza. bt Sarlan, Rohiza bt Ahmad, Wan Fatimah Bt Wan Ahmad, and P.D.D. Dominic. 2009. *Hybrid approach of conceptual framework for SME clinics in Malaysia*. In Proceedings of the 11th International Conference on Information Integration and Web-based Applications & Services. ACM, New York, NY, USA, 577-581.

[2] Alpay, L., Toussaint, P., and Zwetsloot-Schonk, B. 2004. *Supporting healthcare communication enabled by information and communication technology: can HCI and related cognitive aspects help?* In Proceedings of the conference on Dutch directions in HCI. ACM, New York, NY, USA, 12-16.

[3] *Bindakheel, A. and Rosnah, N. 2006. Adoption of ICT at hospital: a case study of UMMC*. ICECT, Proceedings of the 2nd International Conference on Electronic Computer Technology, 157-160.

[4] Bossen, C. 2006. *Representations at work: a national standard for electronic health records*. In Proceeding of the 20th anniversary conference on Computer supported cooperative work. ACM New York, NY, USA, 69-78.

[5] Chu, D.C. and Humphrey, M. 2004. *Mobile OGSI.NET: grid computing on mobile devices*. Grid Computing, Proceeding of the 5th IEEE/ACM International Workshop, 182-191.

[6] Cook, J.E. and Wolf, A.L. 1995. *Automating process discovery through event-data analysis*. In Proceeding of the 17th International Conference on Software Engineering. Seattle, Washington, USA, 73-82.

[7] Lenz, R. and Reichert, M. 2007. *IT support for healthcare processes – premises, challenges, perspectives*. Data Knowl.Eng, 39-58.

[8] Fieschi, M. 2002. *Information technology is changing the way society sees health care delivery*. International Journal of Medical Informatics, 85-93.

[9] Fong, T. and Thorpe, C. *Vehicle teleoperation interfaces,* Autonomous Robots, vol. 11, no.1, July 2001.

[10] Hamalainen, M., Pirinen, P., and Shelby, Z. 2007. *Advanced wireless ICT healthcare research*. Mobile and Wireless Communications Summit, 16th IST, 1-5.

[11] Kaplan, B. and Harris-Salamone, K. 2009. *Health IT Success and Failure: Recommendations from Literature and an AMIA Workshop*. Journal of the American Medical Informatics Association, 91–99.

[12] Martikainen, O. and Halonen, R. 2011. *Model for the Benefit Analysis of ICT*. 17th Americas Conference on Information Systems, AMCIS, 1 – 10.

[13] Mattila, E., Koskelo, J., Lappalainen, R., Salminen, J., Nyman, P., Lahteenmaki, J., Leino, T., and Korhonen, I. 2007. *A concept for ICT assisted health promotion in the occupational healthcare*. Engineering in Medicine and Biology Society, EMBS, 29th Annual international Conference of the IEEE, 1786-1789.

[14] Mediated Reality with implementations for everyday life Presence Connect. Teleoperators and Virtual Environments, August, 2002.

[15] Milgram, P., and Colquhoun, H. 1999. *A Taxonomy of Real and Virtual World Display Integration*. Mixed Reality: Merging Real and Virtual Worlds, Tokyo, Japan, Ohmsha / Springer-Verlag.

[16] Mohan, J., and Raja-Yaacob, R-R. 2004. *The Malaysian telehealth flagship Application: a national approach to health data protection and utilisation and consumer rights*. International Journal of Medical Informatics, 217-227.

[17] Pajarinen, M., Rouvinen, P., and Ylä-Anttila, P. 2010. *Where the value is created (in Finnish: Mistä arvo syntyy*). ETLA Series B 247, Taloustieto Oy.

[18] Sheridan, T. *Telerobotics, Automation, and Human Supervisory Control*, MIT Press: Cambridge, MA. 1992.

[19] Vida, M., Lupse, O., Stoicu-Tivadar, L., and Stoicu-Tivadar, V. 2011. *ICT solution supporting continuity of care in children healthcare services*. Applied Computational Intelligence and Informatics, SACI, 6th IEEE International Symposium, 635-639.

[20] Viitanen, J., Hyppönen, H., Lääveri, T., Vänskä, J., Reponen, J., and Winblad, I. 2011. *National questionnaire study on clinical ICT systems proofs: Physicians suffer from poor usability*. International Journal of Medical Informatics,708-725

[21] Zhang, Y. 2011. *Real-time wireless acquisition of process data*. ETLA, the Research Institute of Finnish Economy, Discussion papers no. 1250.

[22] Zysman, J., Feldman, S., Murray, J., Nielsen, N.C., and Kushidai, K. 2010. *Services with Everything: The Digital Transformation of Services From Economic Sinkhole to Productivity Driver*. BRIE Working Paper 187a, 1-53.