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Telemedicine and Cooperative Remote Healthcare Services: COPD Field Trial

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Abstract. The introduction of sustainable telemedicine solutions throughout Europe requires the development of secure, flexible and expandable systems and the evaluation of their operation in real-world settings such as field trials. This paper describes a system for a remote monitoring and care support field trial with Chronic Obstructive Pulmonary Disease (COPD) patients. By following a user-centred-development and Privacy by Design approach, the needs of all involved user groups could be addressed, while fulfilling, at the same time, national requirements with emphasis in security and privacy protection. The solution covers specific applications and services for COPD patients and their remote care takers, but allows the generalization of its applicability to other patient groups.

Keywords. eHealth, telemedicine, nursing informatics, Health ICT, system implementation, National Health Policies and Informatics

Introduction

The average life span of people is increasing [1], leading to a scenario where a high percentage of the world-wide population is affected by ageing-related chronic diseases. For instance, Chronic Obstructive Pulmonary Disease (COPD) will be the fourth most common cause of death by 2030, according to a projection from the World Health Organization [2]. This development leads to the need for patient-centred efficient care solutions that help to keep patients independent as long as possible. At the same time, efficiency is a major challenge for the medical sector. Medical routine supervision of patients with chronic diseases have a high potential for efficiency gains, by giving support to patients in their private homes, while avoiding unnecessary consultations.

In this paper, we present a case study of a field trial system for the secure remote monitoring and support of home-based COPD patients. The scientific scope is the information and communication technologies (ICT) needed for the end-to-end system, including the approach of Privacy by Design (PbD). The study is carried out in 3 phases: (1) initial design, development and test phase (including description of the target telehealth and telecare applications and services, analysis of technical requirements, state-of-the-art systems, and the development of an end-2-end solution; (2) pilot test phase with a small number of test patients, including system tests and refinements; and (3) field trial phase within the FP7 EU project "United4Health" [3]. The structure of this paper follows these phases, and concludes with a brief evaluation and discussion of the solution including an outlook for further research.

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1. Target Services and Requirements

Chronically ill patients need frequent monitoring of their health condition and prompt follow-up at the point-of-care. The trial system for the United4Health project will support remote monitoring and follow-up assistance for the patients after being discharged from hospital to their homes, additionally considering the need for a close collaboration of different health care organizations.

The system (see Figure 1 for the reference system overview) will provide the following main services and functionalities:

- Daily measurement of blood oxygen saturation (SpO_2) and pulse.
- Electronic patient questionnaire for daily reporting of COPD symptoms.
- Anonymized and encrypted data transmission to Electronic Health Record (EHR) and Personal Health Record (PHR) systems.
- Telemedicine system for the collaborating healthcare organizations, providing follow-up support with overview of patients' status and access to monitoring data.
- Video consultation and follow-up support between health care staff and patients.

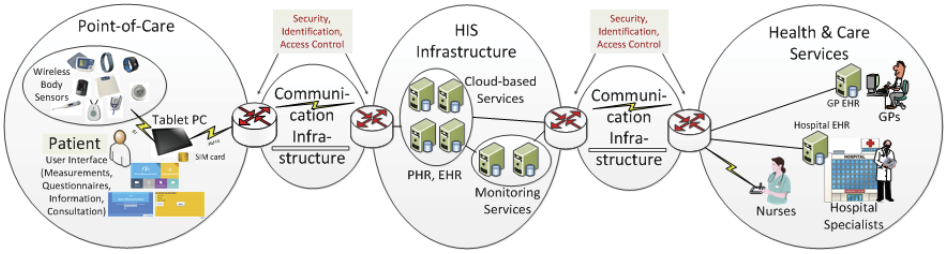

Figure 1: Reference System Overview

2. The Field Trial System

Most emerging telemedicine systems are proprietary, transmitting the information through a dedicated communication gateway device and providing very limited integration of the point-of-care environment with a generic, standard-based HIS infrastructure. The presented trial system widely corresponds to the Continua End-to-End reference architecture [4], while the Continua "WAN device" is separated into a data aggregation component (see the Information Integration Platform (IIP) [5] in the software architecture overview of Figure 2) and a value-adding services component.

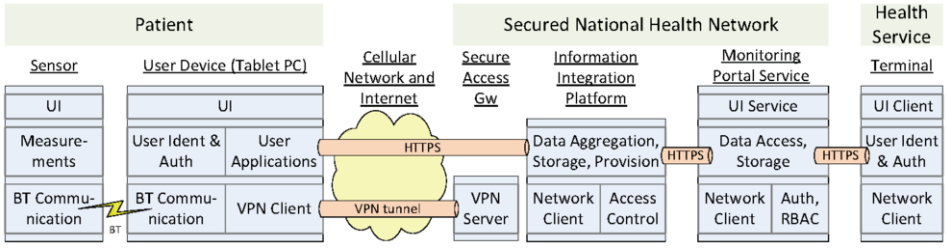

Figure 2: Software Architecture Overview

The solution development has followed a PbD principle, implementing a hierarchical ***security concept***. All data communication between patient's tablet PC and

the Secured National Health Network takes place through an encrypted VPN tunnel in the Cellular Network and Internet infrastructure. The transmission of user data from the tablet PC (sensor measurements and questionnaire answers) to an IIP is additionally encrypted by utilizing HTTPS. The Monitoring Portal Service accesses the patient data provided by the IIP also via HTTPS, and provides an encrypted monitoring UI to various Care Service providers. Patients identify and authenticate themselves through the tablet's user applications. Privacy protection is achieved by an anonymized identifier for the patient data. Any health care professionals identify and authenticate themselves towards the portal service, to provide Role Based Access Control (RBAC) to the patient data. The access of different services to the IIP is controlled by an identity-based Discretionary Access Control (DAC).

The development of application and service UIs has followed a ***user-centred design*** (UCD) process. Relevant user groups have been involved as "co-designers" in the iterative interaction design, implementation and testing of patient applications on the tablet PC as well as the monitoring services for care professionals.

Aiming for ***Interoperability and Integration*** with legacy HIS components, the implementation of the communication solution for the system components utilizes open Internet standards, e.g. HTTP(S) protocol and RESTful Web Service interfaces to IIP. The medical sensor devices are certified by the Continua Alliance to allow an easy integration of the Bluetooth communication protocol with the tablet PC. The implementation of the tablet PC software in Java provides platform portability.

3. Discussion, Conclusion and Outlook

The presented system has been designed for sustainability in a phased approach and deployment in the secured National Health Network infrastructure. It is being used in this national network until summer 2015 as a field trial system involving up to 200 patients, representing the Norwegian contribution of the EU FP7 project United4Health [3]. To our knowledge, similar national solutions in other countries do not fulfil the security requirements for the deployment in the Norwegian Health Network. The scope of the trial covers the technical feasibility of the system, usability aspects for patients and care professionals, suitability for the collaboration of care providers, and care efficacy for the patients. Corresponding research results are separately presented. The architecture follows the Continua reference architecture [4] with an implementation that can be easily adapted for patients with other (chronic) diseases. The xHRN interface for integration with standard-based EHR systems is an ongoing work.

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