Functions For eHealth Communication Systems Design

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***Abstract*—The design of eHealth systems calls for a clear needs analysis and functions based on the users' perspective. However, this is often the most difficult part of designing eHealth service systems, because of the diversity of users and diversified needs. This paper provides a general mapping and overview of the basic functions of eHealth systems identified through two studies: (1) a comprehensive study of the resource book of eHealth projects under the European Sixth Framework programme (FP6), and (2) a theoretical study based on the framework of Activity Theory. The first study provides the eHealth system designers with an overview of a number of important and particular functions that the users/citizens need in order to get good services; while the second study presents a fundamental 'skeleton' and architecture for providing those particular functions in an orderly and coherent system.**

***Index Terms*—eHealth, needs analysis, functions design, system architecture**

I. INTRODUCTION

During the period 1988-2006 the European Commission (EC) has been initiating and funding research and development activities regarding eHealth for about 650 million Euro in approximately 450 projects. eHealth is now on the governmental agenda of EU Members States to be implemented on a broader scale. A European Union Action Plan

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for a European eHealth Area was published by the commission in April 2004 [2]. Among others, the following missions are mainly addressed:

- Empowering health consumers (patients and healthy citizens) to enable citizens to manage their well-being through access to qualified sources of health information and active participation in illness prevention, enabling patients to participate, with better knowledge and responsibility, in the processes of care and rehabilitation, through intelligent monitoring systems as well as through relevant and personalized health information.
- Assisting health professionals by providing them with access to timely relevant information at the point of need, new tools for better management of risk and systems to acquire up-to-date biomedical knowledge and ???
- Supporting health authorities and health managers by facilitating health authorities to manage properly the on going re-organization of health delivery systems.

In order to implement the above mission, a concrete time table for actions has been set up as followings:

- By the end of 2005, each Member State is to develop a national or regional roadmap for eHealth.
- By the end of 2006, Member States, in collaboration with the European Commission, should identify a common approach to patient identifiers.
- By the end of 2006, Member States, in collaboration with the European Commission, should identify and outline interoperability standards for health data messages and electronic health records, taking into account best practices and relevant standardization efforts.
- During the period 2004-2008, Member States should support deployment of health information networks for eHealth based on fixed and wireless broadband and mobile infrastructures and Grid technologies.
- By the end of 2005, a European Union public health portal will give access to European level public health information. Health portals shall offer dedicated information on safety at work and workplace health risks.

- By the end of 2005, there will be a strengthening of early warning, detection, and surveillance of health threats through enhanced information and communication technologies tools.
- By the end of 2008, the majority of all European health organizations and health regions (communities, counties, districts) should be able to provide online services such as tele-consultation (second medical opinion), e-prescription, e-referral, telemonitoring and telecare.

In this context, Sweden published 'A National IT Strategy for Healthcare' in March 2006[7]. Here, the cooperation and interoperability among different healthcare actors is in main focus. By effective use of ICT, Swedish healthcare should aim toward a vision that:

- Citizens, patients, and relatives should have easy access to all relevant information about healthcare and own health situation
- Professionals in healthcare sectors should have access to shared and functional ICT support to secure patient and facilitate their daily work.
- Responsible administrations should have efficient ICT support to follow up patients' security, care quality together with their work activities and resource planning.

To approach this vision, six areas are specified as main targeted areas for the national level strategy:

- Harmonizing laws and regulations for further development and integration of IT applications.
- Creating a shared information structure and standards
- Creating a shared technical infrastructure
- Creating preconditions for IT supported cooperative work
- Providing accessibility to information across organizational boundaries
- Making information and services easily accessible to citizens.

II. IDENTIFIED FUNCTIONS FROM STUDY OF E-HEALTH PROJECTS IN FP6 AND IN SWEDEN

To start with, a number of central functions for eHealth systems are identified based on the main focus of the eHealth area in the EU's Sixth Research and Development Framework Programme (2002-2006)[3]: The basic purpose of eHealth in this programme is stated as 'Research and development on advanced ICT-based eHealth systems and services focusing on integrated health information systems, intelligent environment for health professionals and online health services for patients and citizens. Proposed applications should exploit advances in networking and mobile communications and ensure interoperability with existing networks. Moreover, eHealth applications should build on best practices established throughout Europe and ensure all aspects of confidentiality and privacy. Examples of proposed applications include regional health information networks, decision support for health professionals, mobile applications for health monitoring, home care monitoring and support to autonomy of patients. '

Under this basic statement of purpose, in the following, several recent and/or still on-going eHealth projects are briefly presented ,based on their provided functions.

A. Study of Some FP6 eHealth Projects

MYHEART - Fighting Cardio-Vascular Diseases by Preventive Lifestyle & Early Diagnosis. The mission is to empower citizen to fight cardio-vascular diseases by preventive lifestyle and early diagnosis.

The starting point is to gain knowledge concerning a citizen's actual health status. To gain this information, continuous monitoring of vital signs is mandatory. The approach is therefore to integrate system solutions into functional clothes with integrated textile sensors which are defined as intelligent biomedical clothes, the combination of functional clothes and integrated electronics and process on-body. The processing consists of making diagnoses, detecting trends and reacting on these. This is combined with feedback devices, which are able to interact with the user as well as with professional services.

- CLINICIP - Closed Loop Insulin Infusion for Critically Ill Patients

The project provides an intelligent system for improved health status monitoring of critically ill patients. A local system is developed comprising biosensors for the determination of glucose in blood. Based on the continuous measurement, an adaptive control algorithm generates advice and thus represents a decision supporting system in an early project stage.

- AMICA -Assembling Data and Knowledge at the Point of Care to Improve Medical Decision Making and Prevent Errors

The main objective is to bring together at the point of care all information available on patients in the electronically accessible universe, together with relevant knowledge and evidence; and make use of this data and knowledge in computerized decision support modules, to improve medical decision-making and prevent medical errors. Thus it intends to implement a system that will prepare and deliver to the point of care a

fully integrated patient-object including all data available concerning the patient in the electronic universe. Generic mechanisms for intelligent decision support that will be triggered by patient profiles, based mainly on causal probabilistic models; and use it to construct modules that will address main problems in medical decision-making and medical error prevention.

- ARTEMIS - A Semantic Web Service-based P2P Infrastructure for the Interoperability of Medical Information systems

The objective of the ARTEMIS project is to develop a semantic Web services based interoperability framework for the health care domain. Main objectives are: (1) providing interoperability of medical information systems through semantically enriched Web Services in which Web service ontology is defined to describe both the service functionality and service messages based on the standards provided by the prominent healthcare information standard bodies like HL7, CEN TC251, ISO TC215 and GEHR; (2) providing interoperability of Electronic Health Records (EHRs) through Web Services; (3) providing an integration environment for disparate applications both within health care domain and with the organizations they communicate with.

- DICOEMS - A Diagnosis Collaborative Environment for Emergency Situations.

DICOEMS aims to deliver an eHealth platform that acquires and transfers critical information from the place where a medical emergency occurs in cases of accidents and natural disasters to remotely located health specialists for immediate assistance. Under stressed and time critical conditions, the care provider (a medical doctor, nurse, paramedical personnel etc.) who is in charge of the patient needs a user friendly utility to acquire critical medical data (such as vital signs) to assess the medical condition, offer appropriate first-aid, communicate the findings and patient status to a network of health experts -no matter where they are physically located - and closely cooperate under their guidance for the effective management of the emergency, and needs information about the specific geographic area.

B. Study of Some Swedish eHealth Projects

Recently, there have been many Swedish eHealth projects conducted under the same theme as proposed in the FP6. In the following, some of these projects are briefly presented in order to high-light relevant functions for design of eHealth systems.
@home (www.ds.se/facile/): functions as monitoring and central switch-off for ‘good night’ ‘good bye’ for oven, door, water, kitchen, TV, light, refrigerator, and personal medical clock, booking time, etc.

- Vallgossen (www.jm.se): basically the same aim as @home, but adding more functions concerning medical care such as to measure EKG, blood pressure, blood glucose, body temperature, and sending this information to care providers (in order to reduce unnecessary visits), and allowing communication with care providers through video conversation.
- Smart lab (www.hi.se/smartlab): A test environment for new IT based help tools

(for handicapped people and care providers), similar to smart home (remote control to home environment, as curtains, lights, oven, etc.).

- Lötsjögården (www.alleato.se): A security alarm clock that can sense temperature, motions, pulse that are compared with preset values and send alarm if values are abnormal or if the user manually presses the button. Care providers can unlock the door with smart cards. Information about visits can be directly stored in hand computers and transferred to information systems (?). Relatives can be given access to the system.
- ACTION (www.hb.se/action): A psychological support system for elderly to keep in contact with their relatives. It provides contacts between relatives and elderly, as well as care providers, community support to migrate loneliness by chat, entertainment (TV PC, camera, Mic. (?), ISDN, type of visual phone)
- Telemedicine to elderly in Norrbotten: (Arvidsjaur municipality, www.carelink.se): Personnel in elderly home healthcare regularly need contact with elderly at home and with other care providers. The system provides municipality personnel with access to read medical journals from county council journal (and vice versa). Even during the visit at the elderly person's home, personnel can access journal via wireless portable computer. Visual phone (TV in combination with PC conference system) connects elderly person's home and municipality care providers.
- Sustains: Uppsala county council: a digital patient journal accessible via internet for patients (health account), access to home doctor, and time booking.
- Smärtverkstaden (Kalmar County Council, www.smartverkstaden.se): Internet based forum 'community' where people exchange experience and advice on how to reduce pain. 'My journal' – a diary book for process can be reference for care providers
- Mina Vårdkontakter: (Stockholm County Council, www.vardguiden.nu): System provides patients with a health account to renew prescriptions, book a time for visiting, and put questions to care providers.
- Trygghetsdoktorn (www.skandia.se/lifeline - trygghetsdoktorn): System provides advice concerning different diseases and accidents, preventive measures and following observations of diseases or accidents within 60 min. between 7-24 by specialized medical doctors.

- Infomedica (www.infomedica.se) public medical advice Q/A, (Landstinget and Apotek) search engine FAQ, experts answer questions within 7 days.
- Virtuell vårdgivare (virtual care providers) The aim of the system is to let elderly (patients) take more responsibility to measure own health parameters, and send to a monitoring centre that is open 7/24, and the data of medical history can be stored as profile of the person and accordingly to get advice from care providers.
- IMIS (www.IMISCare.org) Integrated Mobile Information System for healthcare. This project is being conducted by the author. The basic goal is to design a Web based communication platform for both healthcare receivers and healthcare providers. It focuses on a generic and sustainable architecture that can be used to integrate various monitoring terminals and ready-made functions.

It is an intelligent decision support system for self health management and control by applying agent technology.

C. Basic Functions Identified for eHealth Systems

By summarizing the functions presented above from a number of recent/on-going eHealth projects in Europe and Sweden, we can then get the following list of functions that can be a reference for eHealth system designers:

- Monitoring: Continuous (on-line) monitoring of vital signs, such as EKG, blood pressure, blood glucose, body temperature, body alarm clock, monitoring and central switch-off for 'good night' 'good bye' functions, environment alarm.
- Communication/accessibility: The system should provide access to journal even through wireless. The journal should bring together at the point of care all information relevant to the care of patients, and combined with relevant knowledge and evidence. Some functions like re-new prescriptions, book time for visit, and ask questions to care providers should also be included.
- Knowledge and decision making: providing public medical advice Q/A (Infomedica) armed with search engine FAQ. 'My journal' function in which patients' medical history can be stored as profile to decision support and advice from care providers should be designed. System should also provide knowledge concerning citizen's actual health status, making diagnoses, detecting trends and reacting on it. Together with feedback devices, the system should be able to interact with the patients as well as with professional services.
- Support relatives and social life: providing psychological support through contact with relatives by e.g. video chat. Entertainment (films, music, games, news, etc.). Functions like 'community' forum where people exchange experience and advice should be included.

III. THEORETICAL MODEL FOR ARCHITECTURE DESIGN

The theoretical framework Activity Theory [1] (figure 1) has been widely applied in analysis of complex social and organizational activities, such as hospital care business [5]. The author has applied the model as the architecture or skeleton for integration and construction of diversified databases (www.IMISCare.org). It is proposed that this model can cover all important dimensions/components that are involved in the healthcare activity system. More details about the activity theory and the model can be found in references [6].

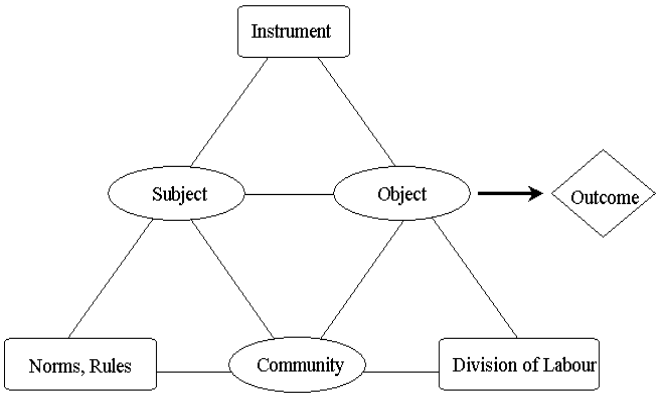

Fig. 1. The activity model (Engeström, Y., 1987).

In the following text, the word ‘care-receivers’ implies citizens who receive healthcare, not necessarily a patient. The word ‘care-providers’ implies all professionals who deliver healthcare, even relatives and neighbours who are involved in delivering healthcare to someone. And the word ‘users’ implies all people who use the system. Mostly they are either a ‘care-providers’ or a ‘care-receiver’.
Ideally, the model in fig. 1 suggests a platform that has six databases/components in order to provide complete information to support healthcare activity:

1) Database for care-receivers: The database should cover the most important and permanent information about the care-receivers, according to some well recognized standards, such as the EU standards of ‘patient identifiers’. Links to all his/her care-providers should be provided.
2) Database for care-providers: The same as care-receivers’ identifiers, the database should cover all relevant and permanent information about the care-providers. Links to all his/her care-receivers should be provided.
3) Tools or instrument base (e.g., alarm, schedule, time booking, journal): The tools/functions identified from the above study of eHealth projects should be located in this base. The users (either care-providers or care-receivers) should be able to easily integrate (add, delete, etc.) a ready-made tool package into his/her tool base.
4) Community network: This should provide the social contacts to the users, depends on the users, the network could be, e.g., shopping centres, banks, taxi,

pharmacy to healthcare receivers, and other departments and colleagues, care-providers in other regions to care-providers.//??//

5) Laws, rules and norms applied in healthcare: This should provide the users with a free text searching function to find relevant information about different social laws, contracts, and decisions.
6) Labour division in healthcare. This should let the users know whom they should contact when a conflict or problem needs to be resolved (who is responsible for this?)

1) CONCLUSION

Through the study of a number of EU FP6 financed eHealth projects together with some Swedish projects, combined with the human activity theory approach, this paper has presented a general reference for eHealth system designers for documenting need specification. Since the need specification is crucial to initiate the design process, the provided functions and the architecture should be helpful to designers. In a specific design, different targeted user groups and different services, the needed functions will have to be specific. However, the contribution of this paper is to provide designers with a general overview and reference for their specific tasks.

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