Electronic personal health record in pervasive computing

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Abstract

Since the use of paper records causes emerging problems, the importance of information technology in health and medical fields can be realized. Now according to this importance, in this article it has been tried to provide a view of pervasive computing technology in medical field and healthcare and telemedicine for people treatment. The goal of this article is to provide a concept or system architecture for a pervasive health care system. Requirement analysis has been done based on related contents, and variety of different perspectives has been proposed about system, but as the domain of this system was completely vague at the first place and is limited by each resource which is used for requirement analysis, vague requirements couldn’t explain more features as the system concept contains a wide range of possible functions and features. So by use of software architecture techniques a system concept has been provided. This work has been recognized structural requirements and logic view of making the system. However some structural requirements have not been met by the provided structural draft and as a result more works has to be done in this filed.

Keywords: personal health record, electronic health record, telemedicine, healthcare, pervasive computing
1. Introduction

Pervasive health and cure is a new filed which uses computer systems for improving medical cares. One of its important and key advantages is improving people’s health and welfare for example by empowering them in playing a more active role in maintaining their health. One of the specific technologies which have been considered increasingly in recent years is Personal Health Records (PHR). Personal health record systems are usually web based applications which store health related information in databases. People can manage their health information in a secure environment. Actually this information is obtained from doctors of medical centers, devices and the user itself [17]. These systems are a range of functional domains; from basic store of health data to support of basic decisions and interoperability with information system of healthcare professionals. In comparison with information systems which healthcare professionals use, PHR systems explicitly let the user to record information. These systems can be known as telemedicine tools. Actually this technology is referred to the application of information technology from distance by the goal of providing and transferring medical knowledge and service which creates a kind of time and place independency in medical filed by use of media tools. This science leads to curing patients through web, providing service in disease prevention, prescribing and having electronic health record [3]. Advantages of using telemedicine technology in electronic record system are time and cost reduction, redeployment reduction, improving patient cares, improving competitive environment and better access to doctor [1][3]. So we can summaries the goals of this technology in three cases of access improvement, cost improvement and competitive environment improvement. However till now there is no consensus on what should be or could be a part of PHR system, or on that which tasks should be executable. These conditions prevent more progress of specific solutions related with patients’ health record systems and patients’ empowerment. However we can use similar terms with PHR. For example Electronic Health Record (HER) system which its primary goal is integrated access to patients’ data and its unified display [6][7]. Actually PHR like HER contains types of health information, family history, disease recognition and healthcare, with the difference that PHR is only accessible and launchable by person or user [17]. Presented article covers models of using physical readiness and risk management and besides these cases, chronic disease management. Also analyzing requirement based on related contents is considered. These requirements are used for creating
a structural draft of comprehensive patient empowering and pervasive health care system.

2. Pervasive Computing In Healthcare

Pervasive health and cure is a new filed which uses computer systems for improving medical cares. One of its important and key advantages is improving people’s health and welfare for example by empowering them in playing a more active role in maintaining their health. One of the specific technologies which have been considered increasingly in recent years is Personal Health Records (PHR). Personal health record systems are usually web based applications which store health related information in databases. People can manage their health information in a secure environment. Actually this information is obtained from doctors of medical centers, devices and the user itself [17]. These systems are a range of functional domains; from basic store of health data to support of basic decisions and interoperability with information system of healthcare professionals. In comparison with information systems which healthcare professionals use, PHR systems explicitly let the user to record information. These systems can be known as telemedicine tools. Actually this technology is referred to the application of information technology from distance by the goal of providing and transferring medical knowledge and service which creates a kind of time and place independency in medical filed by use of media tools. This science leads to curing patients through web, providing service in disease prevention, prescribing and having electronic health record [3]. Advantages of using telemedicine technology in electronic record system are time and cost reduction, redeployment reduction, improving patient cares, improving competitive environment and better access to doctor [1][3]. So we can summaries the goals of this technology in three cases of access improvement, cost improvement and competitive environment improvement. However till now there is no consensus on what should be or could be a part of PHR system, or on that which tasks should be executable. These conditions prevent more progress of specific solutions related with patients’ health record systems and patients’ empower ment. However we can use similar terms with PHR. For example Electronic Health Record (HER) system which its primary
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Fig. 1. Conceptual model of healthcare in pervasive computing

3. ELECTRONIC HEALTH RECORD

Electronic health record system is a resource of health related information so that can be processed by computer systems [2]. This system is the health record of people and contains health information related to the person which had come to the medical center. Actually implementing ERP system causes adaptation of patients and medical center personnel, instant access to health information,
footwork reduction [4], data reusing ability, access of valid persons to information and remove of paper system [6]. But according to mentioned advantages there are also shortages in this system for example technical, cost, attitudinal and behavioral limitation of people and organizational restrictions. Among them attitudinal-behavioral limitation of persons has a more prominent role to others [5] so it should be tried to reduce mentioned limitations of the system. As all systems follow a goal, there is no exception for ERP systems and its main and primary goal is integrated access to the patient’s data and unified display of this data [6][7]. ERP system tries by eliminating existence limitations, to provide peoples’ health information in any time and place through pervasive computing technology for facilitation and acceleration of the development process of health system. Whatever is considered as incoming information of this system is shown in Fig. 2.
4. Gathering Information

Gathered information by extensive healthcare systems usually contain data related to health, life style and well-being. Data might origin from different resources such as the user itself. The types of information which can be gathered contains: health monitoring, vital signs, prescribing, sensitive information, activities, environmental variables and disease history. Information about low dosage, new laboratories, known disabilities and unusual conditions will be useful in health monitoring. Information might be obtained from different resources such as sensors, portable wearable computers, databases which might have information about the patient, or in some cases from patient’s inputs [10]. Health monitoring contains simultaneous measure of multiple parameters in a long duration without disturbing patient’s life. These supervisions get easier by use of health monitoring equipment next to the patient (enchased), on the patient (wearable), near patient (portable), and around patient (environmental).

4.1 Information Gathering Methods

Since that most PHR and EHR systems contain methods for gaining information, in this article it has been shown that requirements, need to gain information which finally might be recorded in PHR. There are lots of technologies for gathering information. For example health monitoring which might help to prevent events, or according to [9] long-term supervision helps better understanding of diseases and improvement of doctor- patient relationship. Long-term supervision also might
help better understanding of disease period. Therefore lots of approaches based on technology have been developed to support people in having a more active role in disease management and improving relation of patient with doctors [9]. So health monitoring is one of the most common ways of gathering information about health automatically. In figure 3 a general view of different types of health monitoring and its concepts is provided [10]. In this figure health monitoring is done in two behavioral and physical ways. Control can be done actively or inactively. Health control is actually implemented when the person needs proceedings alternatively, continuously or by a specific event. Now this supervision can be done during a special event through patient or based on an event time. All states of health monitoring have application for the moving patient or the patient at the rest. But for receiving data and vital information for monitoring, there is need of wearable devices, manual control devices and intelligent environments. However for transferring data and information to doctor and nurse in medical center, pervasive computing technology which sends real-time data and is related to inside and outside environment and also communication technology which is limited to inside, can be used. So it can be concluded that it is important to support more than one resource of health monitoring. This requirement will be more tangible in requirement analysis section (system has to support many health monitoring resources). So according to this requirement it can be said that all system requirements have to obtain necessary information for recording in personal health record. For example when health data is received through sensors, system must be able to support different measuring devices and at any possible time gain data from data resources automatically. These requirements are expressed in requirement analysis section.
5. System Requirement Analysis

In this section the key requirements of the system are proposed. Also system requirements are gathered and investigated. As the result, requirements have been used for system concept and architecture draft. In the following a set of requirements is gathered. Access of user to his/her health information, access of user to health knowledge, system license for communication between patient and expert, reasonable access to system, information sharing for expert by system, encouraging shared decision making by system, encouraging healthy life style by system, data control by user, authorizing the EHR entered data, security observance, allowing access to personal health record by others, simplicity of user authentication, data sharing in EHR by user, printing health information by user, automatic investigation of integrity of shared data, parent access permission to system (about children), not restricting the application to a specific technology, guest user access permission by the person, tracking physical readiness and life style information by system, following up data related to environmental conditions by system, system ability in health information recovery about user’s social relations, health record system containing actions and instructions, important diseases, health providers, family history, life style, care plan, vaccines, allergies and harmful reactions, doctor prescription and medicine, laboratory test, investigating inconsistencies by system, system time limitation based on its data validation, providing report of data changes by system, providing simple information by system, letting online
data sharing by user, support of system for different resources of health monitoring, using sensor’s raw data by system, support of pervasive systems, use of extra textual information by system, intangibility of data gathering methods, recognition and elimination of incomplete and defaced data by system, providing information in an easy and understandable way to user, discovering correlation among health data, support of sending and receiving information through social networks, suggesting or warning positive or negative condition of user’s health by system, using multiple medicine database by system, avoiding from creating fear of illness or health condition, and system flexibility in different platforms. When information gathering is being done in a PHR system, this information can be from some beneficiaries like users and patients, doctors and healthcare experts and health insurance and health payers. One of the most important advantages of PHR is patient’s more access to wide spectrum of valid health information, data and knowledge [8]. By having access to health information, the possibility of using this information for obtaining more control on person’s health is created. Actually if people are informed and obtain skills, will gain more control on their health [12]. Also having more information helps doctors in better decision makings. This means PHR might become a channel for modified sharing of medical records [8]. So beside patients, doctors will be participant in information gathering through PHR system. And at the end, another system’s beneficiaries are health insurance and health payers which in PHR system cause less costs of chronic disease management and fewer costs in health plan. Whatever is needed in these requirements is actually about empowering patients in order to use the PHR system better.

6. SYSTEM CONCEPT

In this section system is shown as a structural draft and system deployment is shown in a deployment display chart. So we can divide the system to three main subsystems; Client systems which run in users’ client devices and can work as independent systems, Beside client systems, there is a repository system which is used as a complete support of users’ data, and finally an Access Control System (ACS) which is an auxiliary storage for data exchange with third party in order to maintain system’s security.

6.1 System Deployment Display
Fig. 4 shows a sample of a system deployment. Client Systems (CS) contain 6 components of personal health record, repository access, guest access, data gathering, empowering and user interface which are being hosted by systems and different executive devices. So it is possible that client applications be different in supported operational adjustments depending on devices’ capabilities. However PHR maintenance functions and also capability of connecting to repository systems in order to send or receive PHR data exist in all clients and inserting access permission for third party exist in access control system. Connection between client and repository systems contain four component of web service management, persistence management, customer management and access control system and also client and access control systems contain three component of guest access management, persistence management and service management, and is done by Service Oriented Access Protocol (SOAP) which is in relation with Hyper Text Transfer Protocol Secure (HTTPS). Web services are chosen because they support the idea of floating pair relationship so that systems stay extensible. Structural-based services especially in web services’ structures, for the reason of their intrinsic support of floating pair relationship, services are interesting in the whole organizational boundaries for PHR ecosystems [11]. The relation between repository system and access control system is through protocol and since so far SOAP should be used with HTTPS, it can be said that using that in here is a simple decision. However this relation should transfer much data and both repository and access control systems might be on one device and therefore probably use of HTTPS seems to be unnecessary.
Fig. 4. System deployment display

6.2 Concept Investigation

In this part the proposed concept will be evaluated in terms of quality. In this concept, concentration was on removing concerns about central functions of maintaining records, empowering and data gathering. All these functions were divided to modular components which most of them are yet in costumer’s system. External systems were only ready for information sharing (access control system) and storing and backup (repository system). This system has provided lots of non-functional requirements. By use of web services among different systems and few of classes in whole boundaries of system components and the principle of eliminating system pairings, a simple replacement of all possible components has been emerged. From the other side, some structural requirements haven’t completely been met. Moreover, some details about classes and data structure have remained vague and unknown.

7. Requirements Revision

In this section defined structural requirements have been revised and based on realization of current state the architectural draft which was provided before, has been explained. Based on revision 17 structural requirement have been met and 19 realized requirement can’t be considered as met requirements in current draft and in total 5 case of that hasn’t been met. A sample of met requirements is proposed in this part. Based on figure 4 system have to be a distribution system of customers which are usually in an incongruous relation with each other, customers
should work on most operating systems and as a result there is a need to implement lots of them like android, iOS, Linux, Windows and Windows phone. System has to have an online repository to store all encrypted information of users and service customers as a support. Repository should only store and transfer encrypted data. Repository should be managed for security and stability by a not defined resource in inline storing with specific logic. Each client should be able to manage other clients (adding, removing, editing reliable client), each client by sharing a reliable client should be able to transfer encrypted data from/to repository, each client should execute exactly one client application, each client application should have a user interface, and each client application should store user’s data based on client’s device capacity. Devices with lower memory should only store recent and usually required data, while devices with higher capacity should store more information, each client application should have access to personal health record data, and each client application should only perform with provided operation by customer device. Besides application requirement limitations, user should be able to add modules to each client separately or remove from it. All data should be encrypted with one encryption key. There should be a decryption key for decrypting data. Only a reliable client should be able to send or restore data from repository, PHR data should be stored in a dedicated database, knowledge base should be stored in a dedicated database, and persistence logic should separate database management system and access methods so that system is independent from database management system. Persistence logic of repository should check PHR data for conflict or interfere with existed data. Communication methods should use the capability of service receiver devices, system should naturally support data gathering from Bluetooth protocol, Wi-Fi protocol and files inside a file system. System should naturally support gathering raw data form sensors, system should naturally support information gathering from user’s manual input. Gathered data should always be annotated automatically by resource, timestamp, and location information. System should naturally support from entry and exit of PHR data from/to file systems, system should naturally support entrance of PHR data through dedicated interfaces by HIS request (for example PHR, EHR). System should naturally support from exit of PHR data to health information system interfaces (for example PHR, EHR). System should support from entry and exit from standard file types (like HL7CCR/CCD), system should naturally support knowledge extraction from web protocols (like HTTP/HTTPS, FTP), system should contain a mechanism for decomposing extracted components from web for
gaining information, software logic should be scalable, in which a module should contain a logic for specific function, module should be independent from client’s platform, module should yet be approved by a specific reference. System should know the module permissive for client’s application interface in order to change appearance and behavior of the application, system should know the module permissive for empowering components of supporting decision to be proper for future research findings, visualization, unions and etc. and finally system should know the module permissive for data gathering components to be proper for future measuring and data gathering devices such as daily level activity recognition systems and etc.

8. Proposed Changes

Architecture draft development is a repetitive process. According to time limitation of this plan, only first repeat can be done for providing it. In this section some changes have been proposed which should be done in next cycle repeat. Access system control doesn’t propose input capability yet. This introduction needs a more complete and accurate data management compared to PHR customers and repository system. Based on the complexity of the method of supporting decision and empowering, it should be considered that empowering component get completely divided to a separate system. It should be considered that knowledge base be located separately as well and preferably get combined with dedicated empowering system. Some work should be done on development of proper abstract data types which could be used in component in favor of system reformation. For interactions this should be kept limited as much as possible to support principle of removing system pairing. Classes and components need new names so that vague names get destroyed. Vague names might be a barrier for implementation. Capability to use is a huge region and should be done in a dedicated research because it is very important that the user understand the provided information accurately and truly. As the result of this research, user interface logic can be chosen or developed. A proper protocol for communication between access control system and repository system should be found. In a case which two systems are on one device, the protocol must be efficient.

9. CONCLUSION
The goal of this article was adjusting draft of a concept or system architecture for pervasive healthcare system. Extensive analysis of requirements is done based on related documents and a variety of different perspectives about proposed system and its components has been covered. The domain of this system was vague at the first place and is restricted with any source which is used for requirement analysis. Vague requirements couldn’t explain more features because the system concept itself contains an extensive range of possible functions and features. Therefore based on these requirements, a system concept has been provided with use of software architecture region techniques. This logical perspective with its official descriptions is related with lots of structural requirements. This perspective might serve as a base for a specific system. However some structural requirements have not been provided by provided structural draft and as a result there has to be more work in this field. Also based on pervasive computing technology existence in data and information redeployment, need of this technology in healthcare section specially use of it in health record is more tangible and has become an inseparable part of healthcare system. Future work based on this article in the first place contains continuous effort for architecture draft completion in order to gain all architecture requirements. Also contains market analysis in order to define proposed system’s financial value and finding financiers for development financings. While market analysis, an empirical research has to be done so that target audiences and perceived usefulness of system is recognized.
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