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Human Health Parameter Monitoring System Based on Mobile and Cloud Computing

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Abstract

Now-a-days healthcare industry is growing enormously due to the increase in elderly population and decline in birthrate. A healthcare becomes a big issue due to lack of availability of expert doctors. Due to this issue there is a paradigm shift from need based health monitoring to preventive health monitoring service. Keeping in view this scenario we are proposing a health care system which will be integrated with cloud computing. That will make system capable of generating EMR i.e. Electronic Medical Records of patients which will play a beneficial role for patient's diagnostic and rapid improvement process as well as for medical practicing doctors who need vast medical cases for their own study purpose. This system will keep track of patient's health in a timely manner and generate a alert when the patient's vital parameters crosses the normal value. The major data will be transferred to the cloud storage that can be accessed by registered expert doctors and patients via Android App.

Keywords-Cloud computing, EMR, Android App

INTRODUCTION

Cloud Computing is a commercial extension of computing resources which provides scalable resources and economic benefits to its users over the internet. It acts as software and provides data access and storage services which don't need the knowledge of the end users physical location and the systems configuration that provides the computing resources. In Cloud Computing, the users use the web browsers as an interface, while the software and data are stored on the remote servers and hence it is device independent. In recent years, many healthcare organizations have started using wireless senor networks to remotely monitor patient health. Many healthcare organizations and insurance companies have also started using the electronic medical record (EMR) system by which the medical records are maintained in a centralized database in the form of an electronic record and the records are stored in the cloud. The paper proposes an approach where the health status of a patient is retrieved and delivers health-promoting messages in a non-interruptive fashion through a wireless body-area network; they can communicate with medical services[1]. Applications deployed on the cloud for manipulate electronic medical records. The general scope of our work is to propose an architecture to integrate the healthcare cloud with wireless sensor network technology through smart phones. The healthcare apps on smart phones monitor patients' health wirelessly providing real-time updates of the patients health condition to the doctors and other medical professionals via the cloud. State of the art review on cloud computing in healthcare[2-3]. The proposed architecture contains a filter system running on the smart phones, which takes the patient's health records from the smart phone apps and compares with a lookup table, which contains the normal readings of the different health parameters. If the incoming health readings to the filter are found to be abnormal, then an

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alert SMS is sent to the doctors with whom the patient is associated and a copy of the record is also sent to 3 the cloud running an EMR system maintained by the hospital. The patient may be in a real emergency situation and he may not be aware that he is in danger. The filter identifies that the patient may be in a serious emergency situation based on the historical and current values of the sensed data [4]. If the filter determines the situation to be critical, a consolidated report is sent to the doctor through SMS, along with the location (address) of the patient, sensed through the GPS sensor running on the smart phone. Since, the health records have to be confidential and secure. The Health Insurance Portability and Accountability is a set of rules on who has access to the patient's health records. In order to comply with the rules and regulations whenever there is an emergency alert, the alert SMS is sent only to the authorized and appropriate medical professionals who can access that patient's health data. The proposed key search algorithm helps to find the appropriate medical professionals for different health abnormalities and ensures that the patient's abnormal health data is sent only to the appropriate medical professionals. However, this algorithm works only when there is a single abnormal input to the filter system. Our work therefore also proposes a priority ranking algorithm, when multiple historical abnormal data have to be considered. Our system provides a secure framework whilst providing the benefits of the cloud.

LITERATURE REVIEW

In recent years we have witnessed the use of Internet for various health care related reasons from the perspective of end-users, especially patients. The users, who when being ill used to depend only on the doctor and his treatment, now want to actively influence and take control over their health and the healing process. The Web, with the different services it provides and novel mobile technologies, represents a suitable and reliable communication and collaboration channel. Primary health care demands of users in the context of (their) health are: to get as much information as one can from different aspects about a specific disease; to take more active role in curing the disease; to use the applications and electronic services with which one can simplify the process ofhealing, [5,6,7] etc. These e-services in collaboration with health care institutions, their services and information systems, combined with active role of all participants of health care system, are defined as e-health, which is a part of the global strategy of Health 2.0. In recent years in the context of global e-health activities, many different applications and services have been developed which serve users in improving their health or getting the information they need. The services can be roughly divided into three groups which enable 1) acquiring information, 2) social inclusion and networking, and 3) information and automation of different user scenarios with health care institutions. Even though Internet offers a great potential in developing services in the area of e-health, huge amounts of data and different fragmented services cause trouble for the users. They have trouble identifying suitable and verified services from the aspect of reliability, safe use and data confidentiality [8,9]. Due to fragmentation of information, users have to utilize several different applications and services at the same time, which takes more time, especially because of disconnection of some services, which can clearly be associated. Because of the dimension of the Internet, users are not even aware of the existence of some services. A potential solution for these troubles lies in the development of a larger collaboration system that will logically connect different services and applications and consequently enable access through one entering point. This is at the same time one of the goals of the project in the context of e-health. Modern technological solutions have not always been successfully accepted among the healthcare providers and users due to unreliability of the systems and additional bureaucracy. One of the key aspects for successful adoption of a new information system by health care professionals is in helping them to become more effective and obtain control over all dependent sub-systems, which are crucial for providing good quality services (and content that is being served). Hence the quality of the cloud service is necessary for the involvement of professionals

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and for the existence of the user community [10,11]. Because of the sensitivity of the field it is necessary to pay special attention to data acquisition, data security, data storage, collection and processing. It is necessary to ensure the results will be in accordance with all current regulations in Slovenia which concern personal data: Personal Data Protection Act, Electronic Communications Act, Patient's Rights Act, Decision – Surveillance of the Location and Health State of the Patients, Decision – Global Positioning System (GPS) surveillance, etc. With the review of online health service market, we can conclude that a lot of applications exist to facilitate the planning of a healthy lifestyle and help diagnose and cure diseases, though most of these tools are intended for foreign markets. Particularly, for the Slovenian market there is little quality interactive content dealing with health issues of type Web 2.0. Based on the list of applications a plan was made to implement several applications to help patients with treatment of their health problems. Much work is being performed to integrate services of WSN and. But this work is only in initial stages and facing challenges of the real world[3].

METHODOLOGY

E -healthcare

The adoption and use of ICTs has transformed several industries in the world (Wickramasinghe et al., 2005). The development of these technologies within the healthcare sector has resulted into e-health, known also as e-healthcare. According to Jordanova and Lievens (2011) e-healthcare may be defined as the health care practice supported by electronic devices and communication, including a broad range of health care systems such as electronic medical records (EMR), electronic prescriptions (EPS), healthcare knowledge management (HKM), and remote monitoring. Its implementation in medical care is essential for high quality and cost-effective healthcare services, prevention of medical errors, improving healthcare staff performance and physician efficiency, and a better physician-patient relationship (Piontek et al., 2010). According to Gustafson and Whyatt (2004) e-healthcare has contributed to medical care by using internet to provide distant services such as telemedicine in remote areas, moreover, the main benefit of e-healthcare refers to the use of internet for a fast dissemination of health related information such as electronic health records (EHR), adverted in literature also as electronic medical records (EMR), personal health records (PHR), or digital medical record (DMR). These records provide information related to patient demographics, past medical history, progress reports, problems that the patient was or is facing, medication, laboratory, and more, generating a complete patient record from cradle-to-grave (Grimson, 2001; Ouma and Herselman, 2008).

Nevertheless, the new uses of e-health and internet in health care services are mainly focused on the integration of capabilities and interconnectivity between growing numbers of very small mobile sensors devices capable to communicate with one another based on a new emerging technology denominated internet of things (IoT) (Tsirbas et al., 2010). Referred as the evolution of information and communications over the next few decades, IoT is transforming the healthcare system providing a variety of new promising possibilities for health care Provision that extends the scope of traditional e-Healthcare services, introducing Items, advertised as "Smart" and people interacting and sharing information.

Internet-of Things (IoT)

A new source for e-healthcare services

Internet-of Things (IoT) or also Internet-connected objects (ICO), refers to a novel paradigm that introduces smart items i.e. wireless sensor networks (WSN) and radio frequency identification (RFID) devices for many applications in order to optimize resources extending service offering and service design. Considered a new service system, IoT seek how to satisfy the users' different services for different areas' special needs (Bao et al., 2012). For this purpose, allows people and technologies to take actions that provide added value through key systemic interactions of service systems (1) Human-to-Human (H2H), (2) Human-to-Machine

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(H2M), and (3) Machine-toMachine (M2M) (Tao et al., 2014). In IoT domain, Internet connectivity of smart objects can be used to remotely determine their state so that information systems can collect up-to-date information on physical objects and processes', enabling the "observation" of real world attributes (Mattern and Floerkemeier, 2010). A clarifying and very illustrative definition of this paradigm defines it as "a vision of the future Internet where connecting physical things, from banknotes to bicycles, through a network will let them take an active part in the Internet, exchanging information about themselves and their surroundings. This will give immediate access to information about the physical world and the objects in it leading to innovative services and increase in efficiency and productivity" [12-13].

The real-time data acquisition from the physical world will lead to the introduction of various novel business services and may deliver substantial economic and social benefits (Alexander et al., 2002; Haller and Hodges, 2002). In healthcare IoT technology makes possible to collect data from smart items anywhere and anytime facilitating better decision-making capabilities focused on empowering patients in prevention and treatment of disease [14]. IoT may bring a wide range of opportunities and benefits to healthcare system improving quality of care tracking patient's daily activities, food intake, and physiological parameters helpful for medical diagnoses, treatment regimens and medical care. Thus, improves efficiency while reduces cost (Miorandi et al., 2012).

In general, it is expected from internet of things (IoT) to give rise to extensive varieties of hybrid products (smart items) that provide both, conventional physical functions and information services. If a particular object (i.e. patient) becomes an access point for relevant services, the smart item will provide sensible and reliable information vital for decision making. This will contribute to change from episodic-care to continuous-care services by remotely taking care of patients at home instead of the traditional care at hospital facilities (Kijl et al., 2010).

Smart Item technology

Extending e-healthcare

By a smart item we refer to a device capable to provide some data about itself or the object it is associated with and that has the ability to communicate this information (Haller and Hodges, 2002). Using real time object tracking, smart items provide machine-readable information about an object's identity and its surroundings in a more timely fashion wireless communication, improving decision making, opportune responsiveness and extending business services (Haller and Hodges, 2002; Anke et al., 2006; Evangelos et al., 2011; Bornhovd et al., 2005). Endowed with an increasing potential to improve daily human life in near future; smart items technology represents an attractive alternative to the traditional healthcare services from both the economic perspective and the patient comfort viewpoint (Bachmann et al., 2012). Its progressive implementation in healthcare for tracking user's lifestyle patterns and health status employing comfortable non-invasive small sensing devices [15], implies an unprecedented step towards decentralization of healthcare services, enabling a new scenario characterized by ubiquitous and pervasive health monitoring in everyday life (Alemdar and Ersoy, 2010).

1 Radio Frequency identification (RFID)

RFID is a wireless tracking technology which utilizes radio waves for collecting and transferring data, with the capability of sending and receiving information without human involvement (Yao et al., 2010). The basic RFID composition consists in readers (beacons), tags (transponders) and end servers that process the collected data from the tags (Anand and Wamba, 2013). Principally, this technology allows any tagged device to be mobile, intelligent and communicate with an organization's overall ICTs (Curtin et al., 2007). This technology has been widely adopted on the supply chain management (SCM) domains mostly for logistic services [16], important benefits such as improving information quality, reliability and time savings, and improved alignment of information exchanged with customers and suppliers have influence its

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implementation in different service sectors (Wamba, et al., 2009). It was primarily adopted by healthcare institutions for the elimination of paper-based mechanisms, reduction of medical errors, and patient waiting time (Chowdhury and Khosla, 2007; Yu et al., 2006). Over time, its usage spread vastly towards new services such as inpatient drug delivery, blood identification, and equipment tracking (Chen et al., 2010). Its adoption have also extended the scope of healthcare services, nowadays is possible to use smartphones with RFID-sensor capabilities as a platform for monitoring of medical parameters, a new technological branch of e-Health now commonly referred to as m-Health (Eriksen et al., 2014). The advantage gained is in prevention and easy monitoring of diseases, ad hoc diagnosis and providing prompt medical attention in cases of emergencies (Bandyopadhyay and Sen, 2011).

2 Wireless Sensor Network (WSN)

WSNs are intelligent network application systems that autonomously collect, integrate and transmit data by incorporating the latest technological achievements in microelectronics, network and communications (Prathap et al., 2012). Basically, the concept "network" comes from the interconnection of several (more than one) Sensor nodes. By nodes we refer to unobtrusive, wireless, lightweight and miniaturized small embedded devices capable of sensing, processing and communicating several physiological signs (Lounis et al., 2013). Every single node plays a different role in the network, sensing different parameters simultaneously such as ECG, EMG, EEG, among others. Thus, these parameters provides patient and doctors insight into physiological and physical health signals that are critical to the detection, diagnosis and treatment of health related problems. Finally, by combining these real-time health parameters, doctors and caregivers are able to provide healthcare services that are better tailored to the specific needs of an individual (Ko et al., 2010; Bachmann et al., 2012; Aminian and Naji, 2013; Othman et al., 2014), Its implementation may bring important benefits for healthcare staff such as timely Information, information accuracy, system Usability (i.e. confident in performing), reduced costs, and high user satisfaction followed by a higher quality of service perceived by patients (Chang et al., 2012).

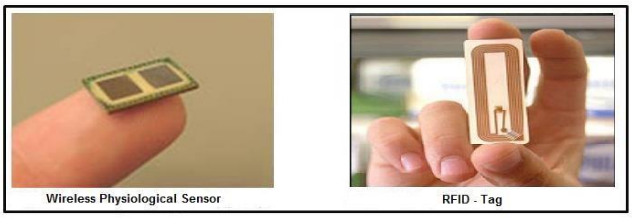

Figure 1. Smart items WSN-RFID for healthcare services

From a service perspective, the use of smart items in e-healthcare adopts a particular servitization strategy define as Product service System (PSS). Primarily, the concept of Servitization was firstly introduced by Vandermerwe and Rada (1988), and since then a large body of research has been developed. The term refers to a major business transformation where companies "shift" from selling products to selling an integrated combination of products and services that deliver value in use, i.e. a Product-Service System (PSS). Thus, a PSS refers to an integrated product and service offering that delivers value in use, where both the product and the service are considered as one single offering (Baines et al., 2007).

In the e-healthcare "shift" services will be provided through critical smart items (i.e. WSN-RFID), used as medical devices (products) capable to offer constant care by means of diagnosing and monitoring health conditions (services). This servitization option can be categorize in 3 main groups (Baines et al., 2007). (i) *product-oriented PSS*, product ownership with additional services attached to the product itself. (ii) *useoriented PSS*, the availability of the product is sold characterized by rent, leasing, etc. and (iii) *results-oriented PSS*, the result or final solution is sell instead of a product - based on maintenance and future support by the provider. In PSS terms, WSN-RFID devices would be the product in the offering and its classification will depend on the level of technical support for services

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offered by the provider (commonly healthcare institutions) and the services associated for those devices. Nevertheless, depending on the agreement between providers and patients; these devices could take the form of product-oriented, use-oriented or results-oriented PSS.

An important feature of smart items lie in their capability to enhance informatization i.e. information which can be exploited and transmitted through servitization, or what is the same information as a service (Opresnik et al., 2013). These devices allows the extraction of highest quality information from patients that once in power of healthcare providers requires to be analyzed using e.g. data mining or business intelligence techniques, with this information healthcare institutions may not only enhance existing services, but also discover usage habits of the product, new needs or identify changes in pattern usage. As a result, information provided by a smart item can be returned back to the patient in the form of a service e.g. recommending personalized best practices related to a product usage, changes in medication routines or in a treatment plan. Figure 1 depicts the concept of Informatization as part of servitization.

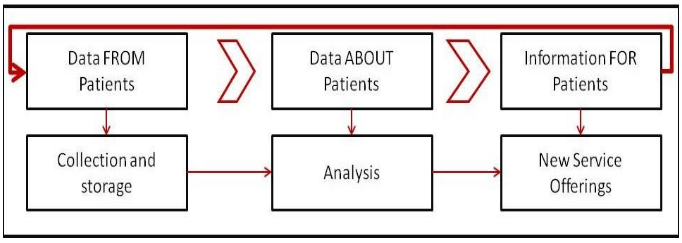

Figure 2. Informatization process as part of servitization in smart healthcare services, adapted from (Opresnik et al., 2013).

Cloud Computing e-healthcare in a cloud environment
There is no universal or standard definition of cloud computing, nevertheless, the most concise and widely recognized definition is provided by NIST and defines it as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."(Mell and Grance, 2009).

Cloud computing cannot be sufficiently understood as a standalone phenomenon in the IT market, but rather as a core ingredient of a larger transformation of the IT industry that impacts the entire IT ecosystem (Oredo and Njihia, 2014).This new paradigm is transforming rapidly the way IT infrastructure is being delivered and consumed offering users and businesses computing resources designed and governed in the form of services (Wang et al., 2010), reclassifying IT from an expensive "capital expenditure" to a pay-as-you-go "operating expenditure" (Venters and Whitley, 2012), where the cloud service provider (CSP) is the one who maintain and manage all the computing resources that are offered to the end user in the form of services, relieving end-users from acquiring and hosting hardware and software resources. Thus, fulfilling all the requirements of an advance service where the provider takes on the responsibility for ensuring asset availability, condition and performance. (Baines and Shi, 2014).

Cloud computing has attracted increasing attention of healthcare institutions mostly due to its capacity to change the whole healthcare scenario improving quality of service at reduced costs, certainly, promising advantages that in a recent past were unreachable for this sector. During last decades this sector is facing an increasing demand on healthcare services while the shortages in qualified healthcare professionals such as doctors, nurses and pharmacists form one of the toughest challenges confronting healthcare providers (Young, 2002). Nevertheless, new technological advancements in ICT have facilitated the emergence of new and more effective diagnoses and treatment techniques that certainly can be extended and improved in a cloud environment (Singh et al., 2008). Managing e-healthcare architecture in the cloud environment may introduce several opportunities to healthcare service delivery (Shimrat, 2009), this means data storage, and software solutions that facilitate the daily routines and

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procedures of healthcare operations in a flexible and scalable way through effective service-level-agreements (SLAs) i.e., "pay as you use" contracts (AbuKhousa et al., 2012).

By adopting Cloud computing healthcare institutions may focus more on increasing quality of delivered healthcare instead of managing their own IT, reducing or even eliminating the high-cost of technical departments to support and operate the in-house infrastructures. This is a considerable benefit for smaller hospitals, community care and physician practices, which can now implement advanced IT infrastructures and services to support their healthcare operations without facing high initial and operational costs. Moreover, cloud computing facilitates information sharing (internally and externally) and provides anywhere/anytime access to medical data (PHR, EMR, EHR) among healthcare institutions involved in the care process, which is of utmost importance in healthcare (Deng et al., 2011; Lounis et al., 2013). Regarding to this, the sensitive nature of medical data requires focusing specific attention on privacy policies to ensure data protection (Lori, 2009), which has been identified as one of if not the key challenges faced by cloud computing (Lounis et al., 2013). Ultimately, the promising potential and benefits including reduced cost, higher efficiency, convenience, ease of use, and its convergence with technologies such as mobile computing, wireless networks, and sensor technologies make of Cloud computing the technological breakthrough capable of transforming the way healthcare is practiced; empowering professionals to deliver better services and extending patient's healthcare services anytime, anywhere, using mobile devices (Kaur and Chana, 2014; Lai and Wang, 2014).

Cloud service (service delivery) models can be classify in three main categories: as Software a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS), these services are delivered and consumed (on demand) in real-time via internet (Mell and Grance, 2011).

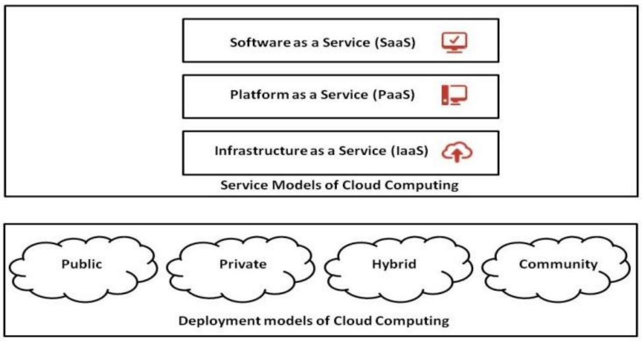

Figure 3. Cloud computing service models and cloud service deployments.

Smart health care services

Smart healthcare services refers to measuring user's living conditions and health status using small sensing devices and collecting their data under daily life (Suzuki et al., 2013). These services allow people to do their normal daily routines, occupations and activities while receiving appropriate, timely and high-quality ubiquitous healthcare services, without any limitations of time and space. The main goal of smart services in healthcare is to provide personal health information (PHI) in real time for supporting health care professionals. Thus, with this information doctors are capable to offer a broad range of services such as diagnosing, prevention, treatment, rehabilitation, support and care. Moreover, in time, these services can be customized in order to satisfy each patient's special needs and requirements through the informatization process.

We present an example of an overall cloud based framework for smart healthcare services. This framework attempts to illustrate the new scope of e-healthcare by adopting WSN-RFID smart items and depicts a "smart" healthcare scenario were smart items extract data from patients and transfers the information to the cloud. Once in the cloud healthcare institutions may use patient personal health information (PHI), collected in the form of medical data e.g. PHR, EMR, EHR to monitor patients' vital parameters and perform the above mentioned services (i.e. diagnosing, prevention, treatment, rehabilitation, etc.).

ISSN No: 2348-4845
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The overall framework considers two main groups of users. (i) Healthcare institutions; represented by doctors and care staff, and (ii) household members; represented by patients and relatives. Both interest groups may have access to the information on a timely basis through EMR system and Patient care portal, respectively. The target group for smart healthcare services is compound by patients with a strong need for home care (Sung and Chang, 2014). This type of patients mostly suffers from chronic diseases, long-term conditions, and physical disabilities. The smart items selected for the architecture are principally sensors (WSN) for detecting electrical, thermal, optical, chemical, genetic, and other signals with physiological origin, capable to estimate features indicative of a person's health status. Sensors, characteristics and usage are described below.

- Electrocardiography (ECG) provides electrical activity of the heart, helpful to discover heart arrhythmia.
- Electromyography (EMG) provides electrical activity of the skeletal muscles, helpful to detect neuromuscular diseases.
- Electroencephalography (EEG) provides electrical spontaneous brain activity, helpful to detect epilepsy.
- Photoplethysmography (PPG) provides data to measure blood oxygen saturation, helpful to detect blood-flow volume.
- Continuous Glucose Monitor (CGM) provides data to determine glucose levels, diagnostic procedure for the diabetic patients.

Moreover, the purposed framework is divided in five levels:

(i) *Patient input level*, once connected to the body of a patient, smart items start sensing the respective physiological parameters that they are assigned to accomplish in an unobtrusive way while patients live their normal life (Malhi et al., 2012). (ii) *Smart items level*, in this level smart items are responsible for sensing and sending the information to the RF wireless communication device. This device stores the collected data from the sensor nodes and made available to the approved users via wired or wireless internet connection (Upton and Halfacree, 2013). (iii) *Data aggregation level*, once the information is received by the RF wireless communication device is forwarded to the respective cloud (Public, Private or Hybrid) depending on the deployment model selected by the healthcare institution (Mell and Grance, 2011). (iv) *Cloud computing level*, Patient's health records (PHR, EMR, EHR) are stored in the cloud deployment model selected by the healthcare institution where the information will be available on a timely basis for the user groups (Lounis et al., 2013). (v) *Monitoring output level*, normally patients, family members and care staff get a restricted information access to health records; while on the other hand, doctors have full access to health records. They are even allowed to make notes, prescriptions and write observations regarding to different states of the patients health (Parane et al., 2014). Each level is represented by the fundamental constituents necessary for the provision of smart healthcare services. Figure 4 depicts our overall cloud based framework for smart healthcare services.

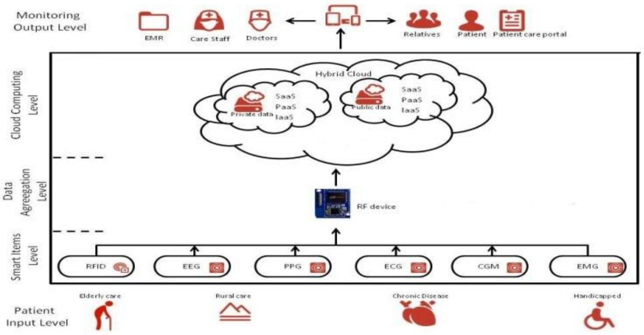

Figure 4. Cloud based framework for smart healthcare services.

CONCLUSION

This paper proposes a framework for secure HealthCare Systems based on big data analytics in mobile cloud computing environment. The framework provides a high level of integration, interoperability, and sharing healthcare providers, patients and practitioners. The cloud permits a fast Internet access and sharing by authenticated users. Big data analytics helps analyze patient data to provide right intervention to the right patient at the right time. The proposed framework applies a set of security constraints and access control that guarantee integrity, confidentiality, and privacy of medical data. The ultimate goal of the proposed framework is to introduce a new generation of HealthCare system that are able to provide healthcare services of high quality and low cost to the patients using this combination of big data analytics, cloud computing and mobile computing technologies. In the future we plan to design and implement HealthCare system based on the proposed framework. We observe research proposals for various application fields including emergency healthcare, home healthcare, assistive healthcare, and telemedicine, as well as storage, sharing and processing of large medical resources (e.g., images) in general. Gaining popularity among users, cloud computing is believed to improve accessibility of health data, ensure efficient management and usage of medical resources, facilitate collaboration among healthcare organizations, and open new possibilities for healthcare. However, security and privacy still remain the main concerns. Further research potential is observed in the security and privacy area, the proposals' development, simulation in thereal world settings and extension to mobile computing.

The implementation of the work is under processed. This work is only in initial stages and facing challenges of the real world.

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