IoT-based Software Platform for Delivering Ubiquitous Healthcare

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Abstract

Eminence healthcare is one of the utmost significant dynamics in how individuals perceive their quality of life. Internet of Things (IoT) visualizes a future in which any services can be interrelated by means of appropriate information and communication technologies which will bring technological revolution in the fields of smart homes, healthcare systems, monitoring and logistics. This paper presents the application of IoT-based Software Platform and addresses some essential parameters and characteristics of each of the applications of Ubiquitous Healthcare.

Keywords: IoT, Ubiquitous Healthcare

1. Introduction

Nowadays, the Internet is used by more than two billion customers around the world to browse contents, send and receive emails, access multimedia resources, play online games, and social networking, Moreover, the Internet is also expected to serve as a global platform to interconnect physical objects 'Things', thus enabling new ways of working, interacting, entertaining and living [1,2]. Internet technology has become ubiquitous within our society which is infiltrating all aspects of our lives, and it is better to call it as necessity rather than a convenience. The great potential for health information technology (IT) to improve the quality and efficiency of clinical health care has yet to be realized [3]. Health IT applications have disrupted clinical workflow and decision-making in unpredictable and even dangerous ways [4,5]. Rigorous methods for designing and evaluating health IT lag behind its widespread deployment. Designing health IT means contending with the complexity of health care work. The additional complexity introduced by combining health care and interactive systems can disrupt care, discourage adoption, and undermine health IT's great potential value [3].

The impact of U-health on health care structures can be significant and hence needs to be implemented carefully and managed well. Information system (IS) is the branch of knowledge concerning the purpose, design, uses, and effects of information systems in organizations. IS an interdisciplinary study, drawing chiefly from computer science on the technical side and from business/management studies on the organizational side; it may also, however, embrace aspects of economics, psychology and sociology, statistics, and operations research. The IoT is envisioned as a network of billion people, objects, machines interacting to one another, invisibly connected with sensors, actuators, making useful in everyday lives.

2. Related Works

The Future will be dominated by the 'Internet of Things' which will serve as a global platform to interconnect physical objects, things, human, thus, enabling new ways of working communication, interacting, entertaining, and living. In the last several years, healthcare providers and consumers have been slow, even reluctant, to embrace internet applications primarily because of the limited availability to technologies that would ensure data security in general, and patient confidentially in particular.

2.1. Patient-centered Medical Home

Interrupted, disease-oriented care in hospitals is not the most effective or efficient way to deliver care. The advent of the patient-centered medical home (PCMH) acknowledges this reality. It promotes care relationships across a spectrum of providers and in a variety of locations, of which the one that is most attractive to the patient is their home. This approach encourages patients to become stakeholders in their care. The care delivery system will be designed so that it fully exploits information technology, helps coordinate care across the community and monitor the patient's conditions, and supports patient awareness. It is the advances in IT to support real-time monitoring that will make PCMH the norm, the standard clinical practice. Hospitals will be able to discharge patients earlier, because they know that the patient's condition can be continuously assessed, and interventions can take place to ensure acuity is addressed outside of the hospital environment [6].
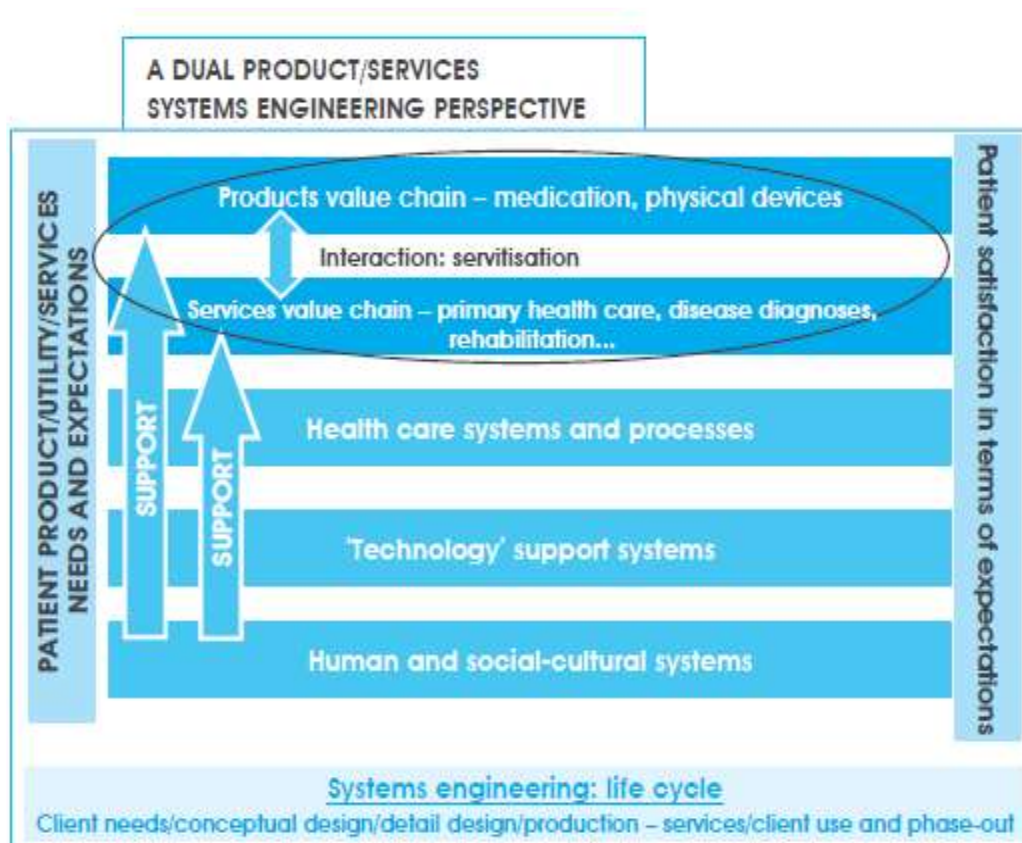

Figure 1. Systems Health Care Perspective [6]

One of the challenges the health care community will face on this journey is the need to establish national standards that will ensure systems integration and interoperability. To

this extent, an office of health standards compliance has been established. Telemedicine has been defined as the use of information technology to deliver medical services and information from one location to another, and includes medical care delivery, consultation, diagnoses and treatment, as well as the education of patients and staff. Such a definition resonates with the systems health care perspective presented in Figure 1.

2.2. Hospitals as Networks

Building hospitals without walls; care for patients without borders Increasingly, hospitals are part of their communities, and all communities are facing the demographic and disease challenge, as described earlier [7]. Hospitals may have to implement complex, multi-organizational processes to address these challenges in an efficient and effective manner. A shift in paradigm is called for that will mean large, tertiary hospitals building networks of smaller hospitals and primary care clinics. Care can then be divested to these networks, made available closer to the patient's home and therefore more convenient. This model will require coordination of all providers in the network and flow of information to continually manage the care of a patient through time.

2.3. Patients exercising choice

Healthcare systems are under close scrutiny by society. With patients having a bigger say in what they choose and demand for, government policy is impacted and in turn, healthcare providers. Healthcare needs to become demand-driven to satisfy the needs of citizens and governments. Patients increasingly want to decide how and when to engage with their healthcare environment. Governments, health authorities and the medical profession will be challenged to provide patients with the information and services that will allow citizens to make informed choices about their healthcare [8]. This will mean publishing data on indicators of quality (such as outcome data, readmission rates, so on) and also introducing ways for patients to book appointments at hospitals at times that suit the patient, not the provider.

2.4. Informed patients and the rise of social media

Patients are becoming more and more involved in their healthcare, with a higher stake in the journey than before. Patients are simply better informed than ever before. Information about medical conditions and treatments are now easily available on the Internet. This has to some extent, shifted the focus of the patient-provider relationship towards the patient. The advent of social media is also driving healthcare interactions in new ways [9]. Patients are exploiting these resources to discuss treatments, procedures and even individual practitioners. Alongside, healthcare practitioners, agencies and charities too will need to use social media to communicate with their citizens; in times of crisis this will become a critical mechanism.

2.5. The people aspect of e-health technology

Over the years, health care professionals have grown accustomed to documenting and storing patient information in paper-based documents and filing systems. An interview with the manager of a large private sector clinic revealed that, while the institution had acquired a state-of the-art EMR system, most of the doctors still made use of a paper based system. The EMR system was essentially used for billing purposes and for forwarding accounts to medical aids. Changing the way, we do things is deemed to be an organizational culture issue, and traditionally the logic of culture change, based on scientific management principles, is inherently flawed. Developing mission and vision statements of telemedicine will hardly change the well-entrenched values, norms, beliefs and related cultural artefacts that act as perception and behavioral determinants.

2.6. Healthcare Innovation

Innovation in healthcare continues to be a driving force in the quest to balance cost containment and health care quality. Innovation is considered to be a critical component of business productivity and competitive survival.
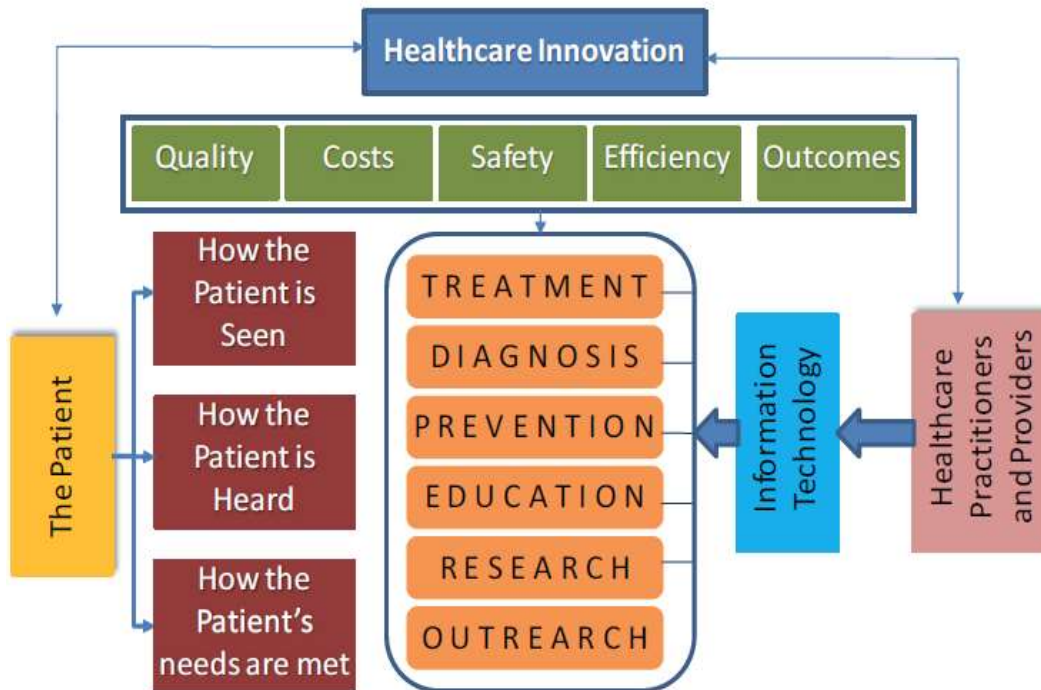

Figure 2. Innovation in Healthcare [7]

As Figure 2 shows, healthcare organizations serve six distinct purposes – treatment, diagnosis, prevention, education, research and outreach. In serving these purposes, healthcare organizations must effectively manage quality, costs, safety, efficiency and outcomes. At the very core of healthcare innovation are the needs of patients and the healthcare practitioners and providers who deliver care. Quite often, healthcare organizations arrive at innovation by relying on new or existing information technology. When successful, healthcare innovation focuses on three areas the most – a) how the patient is seen, b) how the patient is heard, and c) how the patient's needs are met [7].

3. Virtual Network of U-Healthcare Interconnected Database

Creating a u-healthcare database from scratch is a daunting task, that is very expensive, time consuming, and extremely difficult to implement. The severity of these detrimental aspects of a national database can be alleviated through inter-organizational cooperation. Rather than having a single central database, the national database would merely be a repository of data stored in individual organizational databases. This approach promotes data sharing and increases the benefits to users, while also reducing the development costs. Figure 1 shows the proposed architecture of a U-healthcare database network.
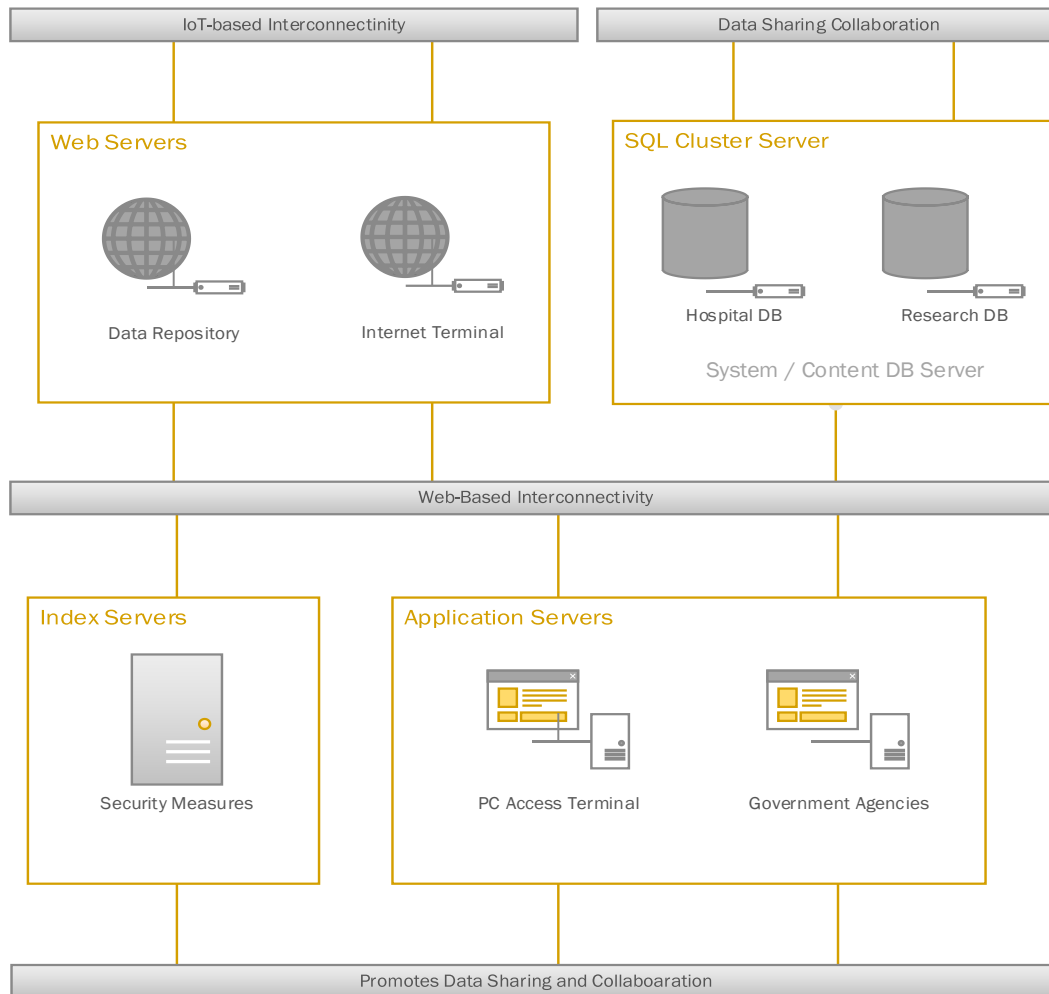
Figure 3. Virtual Network for U-Healthcare Database Network Model

The creation of a national healthcare database is still a distant goal. Patient privacy is a serious matter, and existing legislation greatly restricts the sharing of patient information. Patient confidentiality is a growing concern that is restricting the creation of a national healthcare database. Many view electronic records as easily corruptible and volatile when compared to their hardcopy counterparts. Dispelling these myths is a major obstacle blocking progress. While the creation of a national database used by all clinicians is still a distant goal, healthcare organizations need to begin improving their internal IT. While such products have been available since the mid-1980's, many estimate that it will take another decade before electronic record systems become the norm. Users of new technology require time to accept the benefits and change internal practices to accommodate the new systems. There is a learning curve associated with any new product, however the trend to achieve a user-friendly system has substantially reduced this timeframe.

3.1. U-Healthcare Functional Model

Information systems help reduce the rate of errors in the medical industry. Implementing IT in the manufacturing industry has allowed many firms to adopt a 'zero defects' policy. When faced with increasing malpractice insurance costs, healthcare providers should also turn to IT for help with improving quality care and patient safety. An effective information system should track patients throughout their tenure at a medical facility, reducing errors in the treatment process. Ideally, no errors should occur – the

physicians should be empowered with all the necessary knowledge thereby preventing the occurrence of adverse events. Unfortunately, this is not realistic. Patients' conditions worsen for myriad reasons, usually at no fault of the care provider. IT should then provide a rapid response to the situation, immediately notifying physicians of the problem and alerting other personnel who can provide aid. The advent of Personal Digital Assistants (PDAs) coupled with cellular technology enable effective data interchange without tying providers down to traditional means of communication. As shown in Figure 4, by automatically relaying patient data to a physician's PDA, the information system could provide a critical link in the healthcare chain. Furthermore, IT could monitor the situation, tracking the performance of individual patients and ensuring a watchful recovery from an adverse event.
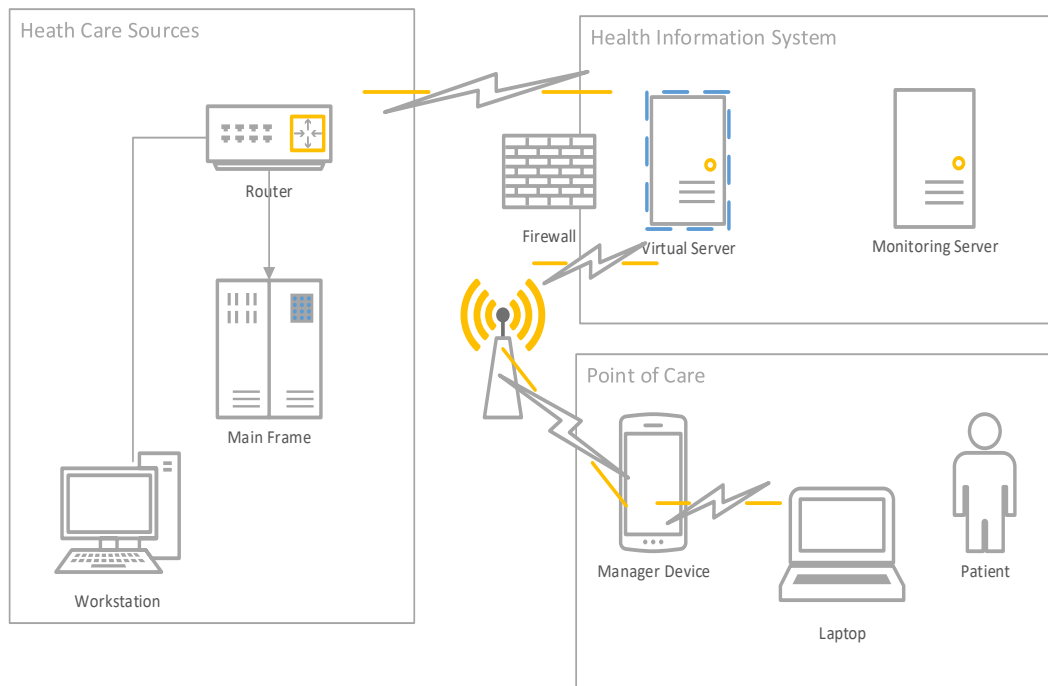

Figure 4. U-Healthcare Functional Model

Device authentication will ensure that only authorized devices are allowed in the network. In healthcare, diseases such as diabetes rely on accurate measurements for treatment, if a device is lost or is replaced with a rogue device and then introduced into the ecosystem, there are high chances of it sending the wrong reading, which will trigger the wrong treatment that might endanger the patient's life. Different organizations, clinicians, and care professionals get access to the data from the patients. This can be viewed through a web-portal containing details of the data being monitored from the HCS infrastructure.

3.2. IoT-Based U-Healthcare Framework

Information systems have the capability to increase the mobility and interconnectivity of healthcare providers, which will then improve the safety and quality of care for patients. By embracing the electronic way through reliance on continuously evolving technologies, healthcare providers can bridge the proximity gap between patients and clinicians. Traditional treatment methodologies require physicians and patients to be at the same location, or for the absentee physician to be near a telephone to answer questions and relay diagnoses. Healthcare providers are already familiar with the process of relaying information using pagers and mobile telephones, so the additional capabilities of PDAs

and Wi-Fi technology will be an incremental improvement rather than a revolutionary change.
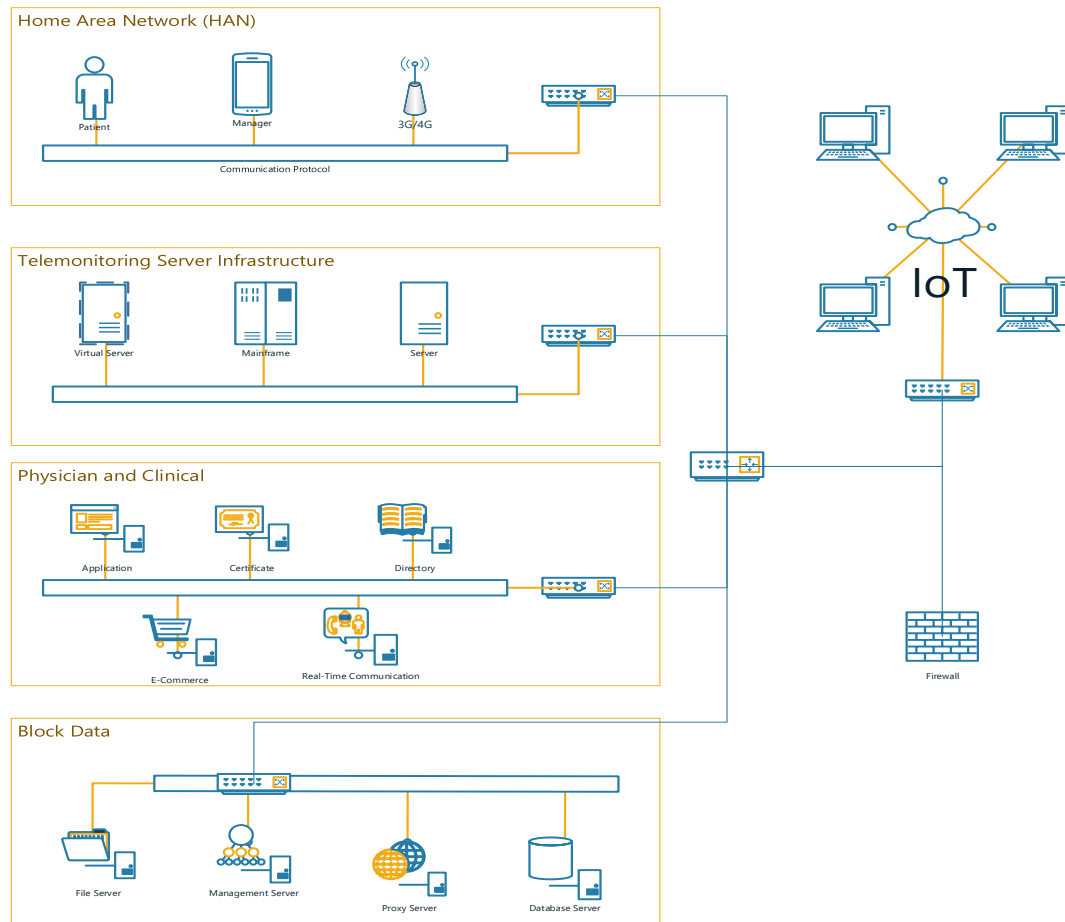

Figure 5. IoT-Based U-Healthcare

The PDA has revolutionized the availability of reference information to healthcare providers. Physicians now have instant access to information about the latest pharmaceutical products and the recommended doses of these drugs. While this alone improves the accuracy of prescriptions, the process is further augmented with the use of decision support systems. After accurately calculating doses and potential drug interactions, the computer can legibly print the prescription or notify a pharmacy for the patient. In a similar manner, the use of a legally binding e-signature would allow physicians to remotely prescribe drugs via a PDA or other electronic means.

Advances in medical technology and connected devices are also changing the physical environment at home. Innovations like electronic pills that track medication compliance, sleep monitors, personal electrocardiogram devices and other standalone digital sensors create a bridge between individuals and healthcare professionals, providing flexibility of care and greater insight into patients. Affordable and user-friendly telehealth platforms and in-home monitoring devices will make inhome patient monitoring the norm, allowing remote caregivers to be notified in real-time of any incidents and improving access of healthcare services to regional areas.

3.3. IoT: Enabling outcome based care, anywhere

A long held view that providers owned the patient record is slowly changing with consumers demanding control over their own health information and a realisation that

quality and safety is improved and waste and duplication eliminated when every clinician involved in patients' care can access the same information. Recent developments see general practitioners enabling patients to download key elements of their EMR and shared care plan to their mobile device and synching changes – truly putting up to date clinical information in the hands of the consumers.
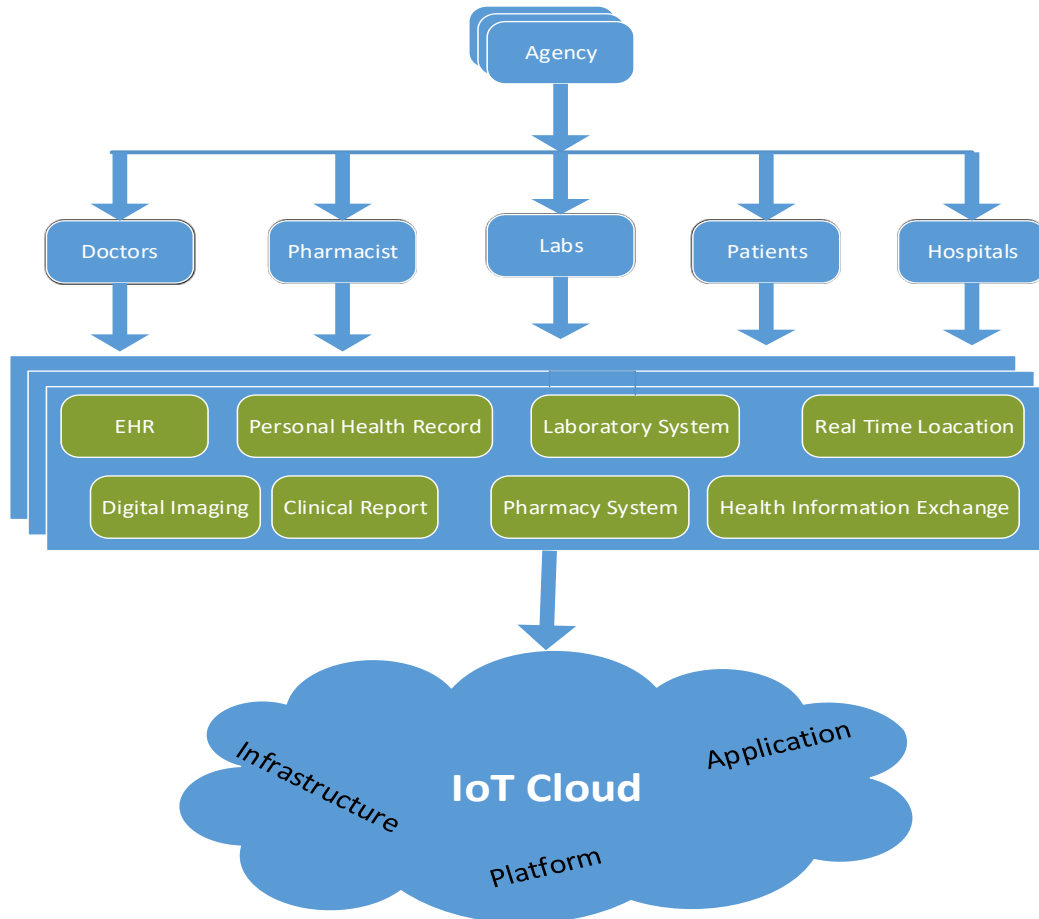

Figure 6. Personalized and Connected Health

Develop partnerships and alliances that can more effectively integrate patient care pathways through encouraging more co-ordinated delivery of care (*e.g.*, aged care and health, primary care and acute care). Establish partner management capability to enable third parties to form part of the pathway where appropriate. Organizations should take a patient-centered approach to the design, delivery and evaluation of healthcare services, with a focus on empowering patients to be more in control of their health and needs. Support the creation of health social networks that connect patients, providers, entrepreneurs and research, and provide a place to build support communities where patients can share their experiences. Patients and clinicians should have a role in evaluating, planning, and testing the layout of healthcare facilities, particularly when it comes to patient units and patient rooms, in order to create a more comfortable environment as shown in Figure 6. Consider utilising open innovation to gather new and more innovative hospital or clinic designs. This becomes particularly powerful when you provide insights learned from the empathy stages of human-centric design. Changing demographics, technologies and care pathways will require an unprecedented level of flexibility in healthcare facility design.

3.4. Cloud Server Infrastructure

The current study proposes cloud infrastructure for ensuring availability and security of EHR. The proposed file system will be a distributed file system that encrypts all the data blocks. The data blocks will be replicated and placed randomly on a number of cloud block storage servers. However, it is worth to note that each country will have different jurisdictional requirements on data security. In order to improve security, the meta-data part of the file will not be stored in the cloud. The meta-data is protected so that in case an intruder manages to decode a block of data, it would still be very difficult to read the whole file.

In the surgery/clinic, different people might have access to patient records; therefore, there is a need to protect the privacy and confidentiality of a patient's health records. Only authorized personnel with the right access rights depending on their job roles should be allowed to have access to these records. Therefore, the current study proposes the use of a capability based system because capabilities allow to run a role-based mechanism so restrictions can be based on the roles of different people within the healthcare system such as doctors, nurses, technicians, and administrators.
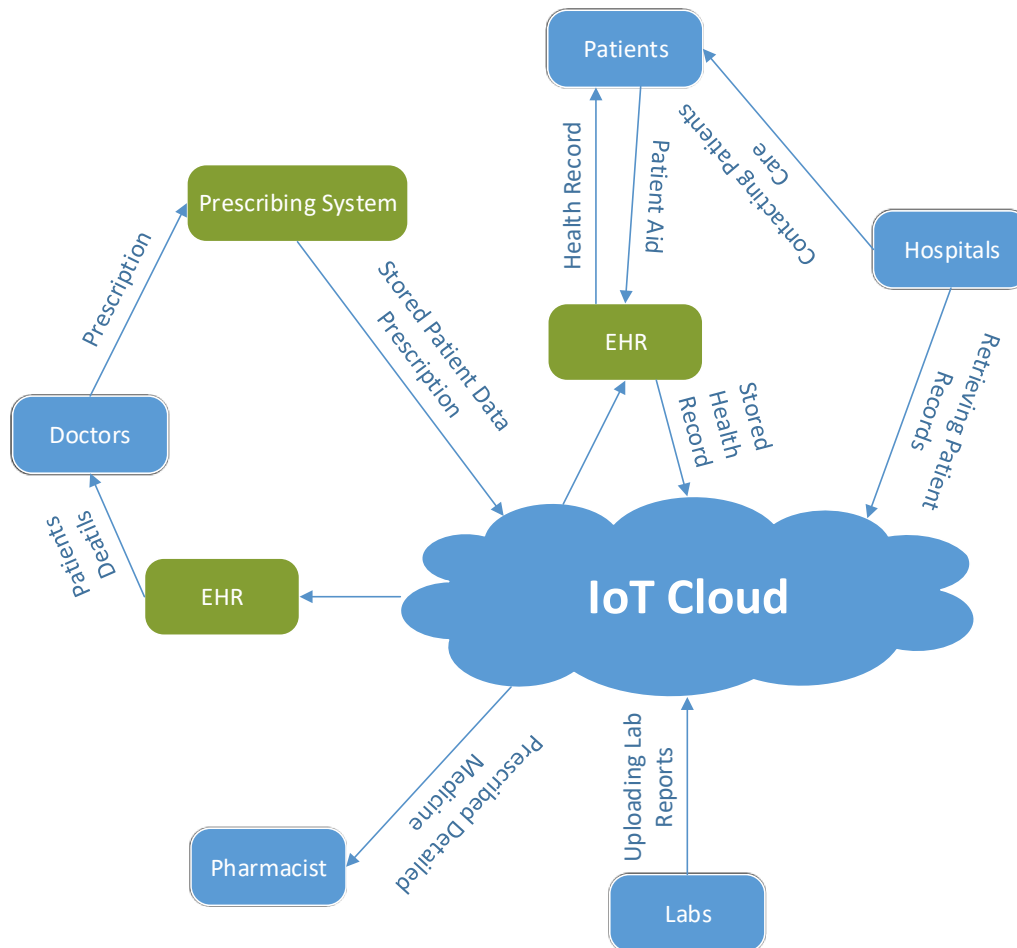

Figure 7. Cloud Server Infrastructure

4. Conclusion

IoT- based U-healthcrae technologies have the potential to improve health care service delivery to the broader community. In order to implement the technologies, however, a number of challenges will have to be addressed. These include network access and

bandwidth, staff training, and – above all – the formulation and implementation of a new management strategy. A key consideration in the formulation of this strategy is the emphasis on creating a culture that is conducive to e-service delivery at the various facilities that will be affected by the system. Conceptual work products can specify clearly what an interactive health IT system must be able to accomplish in a manner that is independent of any particular technology, process, or even cognitive strategy. They serve as an important complement to conventional procedural models. They clarify what an interactive health IT system must accomplish to be successful, reduce the complexity of workflow models that guide the design of health IT.

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