Evaluation of Pervasive and Ubiquitous Healthcare Systems

Kashif A. Khan and X. Wang
Network Research Group,
University of Plymouth, Plymouth, UK.
E-mail: info@network-research-group.org

Abstract

Over the past few years the wireless technology has changed people lives with their newest products and there is no any doubt that the wireless will change the world future of networking scenarios. This research paper is presenting in-depth evaluation and investigation of the Pervasive and Ubiquitous healthcare system in the light of existing wireless sensor healthcare systems and their wireless devices. This investigation is also encompassing on most recent wireless sensor networks, wireless devices deployment issues, which involves in modern healthcare safety critical domains of the patients. This research work is responses to the researcher with future suggestions and strategies based on careful analysis and evaluation of existing healthcare system with wireless sensor networks scenarios. This research paper contains the brief discussion of wireless healthcare issues, which are much concern about the patient awareness of this modern healthcare technology through an analytical survey results. These survey results are obtained through online questionnaires form which acquire the patient’s social, quality, safety and cost/finance problems during collaboration with wireless healthcare systems. Overall this research paper has future recommendation and open a new era for the researcher to overcome the existing wireless healthcare problems and improve the workability of the wireless devices in healthcare systems.

Keywords

Introduction

Public health and safety is the major part of modern healthcare system and its work is to provide the safety and entire services to the patients when and where needed especially in case of emergencies. Most of the healthcare systems are trying to do their best in providing the maximum facility to the patients. But after the publishing a report from Institute of Medicine of the National Academy of Sciences, which claiming that between 44,000 and 98,000 American die each year as a result of preventable medical errors in 1999 [Ball et al. 2003], most of the healthcare systems has become more sensitive about the human health. They just want to reduce the medical errors and increase the patient health and that could only be done with the help of modern Information techniques and their devices. So, most of the healthcare system has adopted a new information technology techniques and devices in providing the entire medical facility to the patient. This research paper with the title of “evaluation of pervasive and ubiquitous healthcare systems” is the evaluation of wireless technologies i.e. wireless sensor network and wireless devices with their contemporary methodologies which are currently functioning with healthcare systems. These wireless technologies are providing dissimilar wireless facilities in healthcare systems with reliability, flexibility, QoS, mobility, security and cost effectively and how much a patient is fully aware of these modern wireless healthcare systems.

1. Wireless Healthcare Systems

The wireless networks have improved the communication among patients and physician through its wide range of availability and delivered the medical treatment any time and any-
where, which has reduced the medical errors in healthcare of the patients. It also increases the wireless technologies effect with intelligent and wearable wireless devices like mobile phone with help of wireless network. The Wireless Healthcare System is that “which provides the tools required for screening, monitoring, and managing of General Consumer Health, Disease Management and Fitness in any healthcare systems” [Card Guard Website]. The wireless healthcare systems have some characteristics and issues related to medical healthcare.

1.1. Characteristics of Wireless Healthcare Systems

Here are some most common characteristics of wireless healthcare systems which are very briefly described here:

- **Telemedicine** is the main feature of wireless healthcare system and has the ability to integrate with wireless healthcare devices by supporting the telecommunication and wireless technologies collectively.
- In pervasive wireless healthcare systems *e-Health* is providing facilities to their patients to communicate with their physicians by getting email access. This e-Health concept is the same as E-Commerce.
- The *mobile Health* is an important feature of wireless healthcare system as this providing the medical facilities with the help of latest mobile device or PDA’s and is also quite accommodating in emergency situations where immediate diagnoses and response entail.
- *Location based services* also enhanced the medical facilities by tracking the location of the victims and presents the immediate response to the patients while using wireless devices in healthcare systems.
- The *intelligent system* is support the wireless healthcare system intelligently and remotely by adopting automatic managing approaches like biometrics and robotics. This intelligent system will use for location tracking technology and to filter emergency calls by matching different health reports of the victims.
- Wearable devices can be failed during online monitoring due to intrusion of electrical and mechanical home appliances. These intrusions can be the failure cause of wireless devices, networks and application services. The fault tolerance of these devices should be improved by adopting fault detection and monitoring mechanisms [Shiva et al.].
- Wireless healthcare system also has a very common feature which is the *remote monitoring* of patients their own homes.

The above defined features are the most common features available in mostly healthcare systems and also facilitating the users with their impressive features.

1.2 Issues in Wireless Healthcare Systems

No doubt, the newly developed and implemented wireless healthcare systems are performing well and serving the humanity with their technological advancement, but still some of the issues related to medical data confidentiality, wireless devices availability and wireless medium security is in under process for fully implementation with no fears. Here are some issues highlighted which are normally occurs in majority of the already implemented wireless healthcare systems. The very brief description of each of them is as follow:

- **Confidentiality** and privacy of medical patient’s records is one of the big issues in wireless healthcare systems while using internet as communication protocol. Most of the wireless healthcare systems are currently working to reduce the privacy theft by using the latest designed systems available in the form of software.
- **Consent** means that how much awareness, patients has to this modern wireless healthcare technology treatments. The basic function of the consent is to explain the
legal and other risk issues to the patient’s health while using the modern telemedicine
techniques and also fully informed approval during patient’s physical treatment or
examinations, to access the patient’s electronic data in healthcare systems.

- **Liability** in healthcare system mean, the physicians or healthcare managing authorities
should fully aware of the most up-to-date and modern technologies and their standards
before going to be launched due to the sophistication in new developed technology and
is not easy to use for a common person.

- **Security** of medical data and medical assessment through wireless is one of the biggest
issues in healthcare industry. In present modern era, the wireless technique has a lot of
security threats and external accessibility media like viruses, hackers and other more
security threats. The security threats can be reduced by using the closed system, virtual
private network and increase the usage of firewall during communications [Kelly *et al.*
2002].

- **Dependability** and access control of medical data in healthcare system are also the
important issues mean what are the common factors which have to be subsequent in
every healthcare systems and access control mean to define the rules or policies to
access the patient data with correlated to the privacy, integrity and confidentiality
issues in healthcare systems. Both these issues can be manageable by implementing
the authentication and access security techniques.

- The **cost deployment** of medical devices and wearable sensor network could effects the
overall cost of the treatment in wireless healthcare systems. Some of the existing
implemented wireless healthcare systems are also charging services charges from the
patients in wireless healthcare system. So, the cost of deployment and extra charges
should be negotiable.

The above mentioned are very common issues which are normally exist in each of the existing
wireless healthcare systems.

2. Wireless Sensor Networks

The wireless sensor networks allow the hardware devices to wider acceptance in the
physiological monitoring of the patients in crucial stages of their health. These sensor
networks have the ability to increase the processing, computational, energy consumptions and
wireless communication through their devices between the patients and medical healthcare
services providers using a link or communication protocol. This part of paper is describing a
very concise picture of existing or implemented wireless sensor networks and their benefits,
limitations and evaluation matching with present requirements of wireless healthcare systems.
There are three main categories of sensor networks are currently available and are wearable,
mobile and wireless sensor which are based on personal area networks respectively.

There are some example of existing wearable wireless sensor networks like CodeBlue,
AMON, HealthGear, and BSN which are using the wearable devices like in the form of a
wrist watch, designed chips which can be directly attached with human body, and interactive
home where the wireless healthcare devices can communicate with wireless healthcare
facilities. The mobile wireless sensors normally worked with mobile devices and they can
communicate with wireless healthcare systems with modern mobile phones. The examples of
mobile existing wireless sensor networks are mPCA and MobiCare healthcare systems. The
third category of wireless sensor healthcare system is personal area sensor network which
interact with wireless healthcare system through WLAN i.e. the Wireless LAN. The example
of these personal area sensor networks is Vision – the Future Hospital which is only designed
only for testing bases and still under consideration in medical Labs. These wireless sensors
networks are serving the humanity will tangible facilities but the problem is that how, but now finally the author moving to analysis and investigation phase of this research area.

During research of this subject area, the author has found that what are the main operating entities of these wireless healthcare systems? These are wireless medium, physicians and the patients which are directly attached with wireless healthcare system. The author has decided to conduct a small scale of investigation related to wireless healthcare awareness to the physicians and patients has and what are their thinking about these wireless sensor networks. The investigation involved the distribution of a small size of survey in the form of questionnaires. The rest of the part of this paper is describing the survey methods and discussion related to the obtained results from survey questionnaires.

3. Methodology used for survey

Initially the literature related to this specific survey is searched and collected from all available sources like libraries, internet, newspaper, books, magazines and electronic and published journals. The data collection is carried out by adopting the research strategies defined by the Cresswell [Cresswell, 2003]. According to Cresswell, there are many types of technique or approaches can be used to collect data from the available sources, but in case of author he used evaluation approach defined by the Cresswell.

3.1 Evaluation Approach

The evaluation approach is another research category for analysis of the data. This approach is a combination of different approaches including the experimental analysis and practical analysis, but in case of my evaluation and investigation, I used a Survey approach for one of my part of evaluation related to the awareness of a common people about the modern healthcare systems.

In this survey I intended to look at wireless healthcare devices and networks with medical healthcare as “Patient Prospective” and the intention is that the results from this work should be of interest for all those vendors and wireless healthcare systems for their future works. I designed and conduct this survey using three approaches i.e. quantitative, qualitative and mixed approaches [Cresswell, 2003].

In the start of this survey I was not be able to construct questionnaires to be used in a quantitative survey about the measurements of awareness, attitudes, and behavior. I simply did not know that what type of questions to ask. So, I choose the “Qualitative research is exploratory and is useful when the researched does not know the important variables to examine. This type of approach may be needed because the topic is new. The topic has never been addressed with a certain sample of group of people, or existing theories do not apply with the particular sample or group under study” [Cresswell, 2003].

4. Discussion and Survey Results

Through this survey, I accomplished the desired results and now be able presently longing to underline those issues of the wireless and their devices which have to face a common person in wireless medical healthcare systems and to collect the literature related to wireless healthcare systems. 37% of people show interest in wireless healthcare system and the rest of 63% have aborted from the survey due to less technological knowledge. According to the
collected results, it can be presenting that some patient’s uncertain behaviour against this wireless healthcare systems and they still crave to carry on with present and currently running healthcare systems.

Almost 63% of people are not happy with the present environment in healthcare systems or hospitals and they recommend improving the healthcare system with more technological advancements due to reduced the timing wastage standing in queues (Figure 1). On the other hand, they do not have greatly knowledge on wireless devices used in healthcare systems and the newest techniques i.e. online monitoring and online medical prescription through wireless communication links but average of 55% results that they prefer to visit personally to the physician wait for long appointments and then collect the prescription by hand (Figure 2). This is another example of patient’s uncertainty behaviour against these modern wireless healthcare systems.

More than 55% percent people are thinking that internet is a suitable wireless medium which can be used in wireless healthcare systems but it must maintain the security, reliability, interpretability, and reusability issues during the whole communication between client-serve communications. The newly established healthcare systems should be cost effective, less consumption of time and also provide the extreme level of treatment and training.

The results obtained from survey are also showing the death rate increasing due to the unsatisfactory and careless behaviour of physicians.
The wireless technology is boost up the healthcare systems with its steady, fast, computerized and location based characteristics but these wireless medium still has security issues like confidentiality, availability and integrity of the wireless data (figure 8). The majority of the participants are preferring electronic data accessed techniques and also suggesting that the administration should adopt recently skills defined access policies, encryption, and up-to-date the users for authentication update to maintain the electronic records. These results are also suggesting that wireless usage can be increase in healthcare systems if there should be an increase in wireless access points, use 2.4 GHz or more powerful range cordless phones, WAP coverage, use Wi-Fi channels, reduced environmental issues and protect the wireless systems from security thefts like hackers and viruses.

The survey results represents that wireless healthcare systems will be acceptable for a common person if these devices and wireless healthcare systems will compatible with existing
approaches, fit in cultural and social modes, user friendly, cost effective and provide the extensive healthcare facilities in a single environment.

Over all the survey results are very impressive and this survey accomplish its desired approach. I suggested in the light of survey results that people intend to adopt the new wireless technology in healthcare system but they are still in indecisive situation either they have to assume these new technology or not?

5. Conclusion and Future Recommendations

Wireless technology is broadening the entire world networks scenario with their wireless devices. These technologies are also working with every aspect of human life even in medical sciences. The medical science is using wireless technologies for medical treatments, facilitating and monitoring patients at their own homes. The next 15 to 20 years of future will be the essential time for medical industry and medical staff due to wireless devices and wireless sensor networks. The manufacturing organizations or vendor are functioning to developed new cognitive wireless systems with distributed network capabilities. They are functioning to shaped new control system which can get the widely used public attention anywhere and will remain the hidden from the users. Here are some future recommendation which I think that would help out to the physicians and patients while interacting with wireless healthcare. These are:

- **Broader HealthCare Services** – wireless services could be improved in healthcare systems especially facilitating the users at their homes. According to survey results (Figure 9), the people suggested that deploy the IT services with broader telemedicine ranges and medical records in paperless format would improve the wireless healthcare services and the wireless can provides the fast connectivity any-where with collaboration of medical patients records (Figure 7).

- **Provide Fault Tolerance** – In pervasive computing, the term fault tolerance is implies on the wearable healthcare devices at home, there is an intrusion can be occur between the medical sensor wireless devices and the electrical, mechanical and automobile appliances. So, the newly developed sensor networks and device should be capable of showing non-intrusive behaviour. According to Shiva Chetan, “the fault tolerance issue have not yet properly addressed in pervasive and ubiquitous healthcare systems” [Shiva et al., 2004].

- **Awareness and Training** – According to survey results, the people are not well aware off the online monitoring and online prescription wireless healthcare systems techniques (Figure 2) and they are prefer to visit the physicians and prescribed from him at hospitals instead of modern healthcare systems (Figure 4). In future, we would have to take some solid step to enhance the awareness of such type of sensor network and devices among customers or patients. If they will properly aware of all these devices then they will adopt them, and it is only possible with adopting some motivation techniques like survey, newsletter and seminars.

- **Improve Data Confidentiality** – wireless should improve the data security and confidentiality. According to survey results, most of the survey participants prefer Internet as the most suitable wireless medium for wireless healthcare systems (Figure 3) but they still have to face confidentiality of medical data is one of their big issues (Figure 8). So, the newly developed healthcare system would follow the data privacy
and confidentiality standards define in Data Protection Act 1998 and secure the medical data from third party like viruses and hackers by defining some authentication and authorization policies.

In research paper, I locate that the both patients and physician are the most interactive entities, which involved with wireless healthcare systems and wireless devices. After careful analysis of my designed survey results, I found that only 37 % of people are conscious of wireless healthcare technology and these 37 % participants still have ambiguity in their minds, either they would accept and use them or not? Which is directly associated with wireless sensor networks and their devices. Majority of them are willing to adopt these new wireless technology but they do not know how to manage it? Another main cause, I have illustrated that the cost of new wireless technology to the patients is the cost of wireless sensor facilities and their devices is too high and could not affordable for an ordinary patient, and the third cause is that there is a very rare research work available on wireless fault tolerance of wireless devices in healthcare systems. In wireless healthcare system, most of the wireless devices are wearable and normally attached with the human body. So, while in wireless communication with the patients, the wireless devices could be interrupted with the home mechanical and electrical appliances due to magnetic interference between two devices, and the wireless signals could be dropped. So, if the wireless healthcare systems want to improve these technologies then they would have to reduce the cost, produce and distribute the appropriate understanding to the patients about the new wireless healthcare technology. Hence, from this research paper evaluation it is clear that the existing wireless healthcare system still have some ambiguity to their implementation and deployment issues and their architecture. They still desires for further research before fully deployed in wireless healthcare industry because the patients do not ready to take risk with their lives.

6. References


