IoT and Mobile Application Based Model for Healthcare Management System

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ABSTRACT

The last decade has witnessed extensive research in the field of healthcare services and their technological upgradation. To be more specific, the Internet of Things (IoT) has shown potential application in connecting various medical devices, sensors, and healthcare professionals to provide quality medical services in a remote location. This has improved patient safety, reduced healthcare costs, enhanced the accessibility of healthcare services, and increased operational efficiency in the healthcare industry. The current study gives an up-to-date summary of the potential healthcare applications of IoT- (HIoT-) based technologies. It is necessary to develop an innovative solution in the Smart Building context that increases guests' hospitality level during the pandemics in locations like hotels, conference locations, campuses, and hospitals. The solution supports features intending to control the number of occupants by online appointments, smart navigation, and queue management in the building through mobile phones and navigation to the desired location by highlighting interests and facilities. Moreover, checking the space occupancy, and automatic adjustment of the environmental features are the abilities that can be added to the proposed design in the future development. The proposed solution can address all mentioned issues regarding the smart building by integrating and utilizing various data sources collected by the internet of things (IoT) sensors. Then, storing and processing collected data in servers and finally sending the desired information to the end-users. Consequently, through the integration of multiple IoT technologies, a unique platform with minimal hardware usage and maximum adaptability for smart management of general and healthcare services in hospital buildings will be created.

KEYWORDS: *IoT, HIoT, internet, things, smart, health, medical, technological, management, hospital, applications*

INTRODUCTION

Internet of Things (IoT) is a computing process, where each physical object is equipped with sensors, microcontrollers and transceivers for empowering communication and is built with suitable protocol stacks which help them interacting with each other and communicating with the users. In IoT based healthcare, diverse distributed devices aggregate, analyse and communicate real time medical information to the cloud, thus making it possible to collect, store and analyse the large amount of data in several new forms and activate context based alarms. This novel information acquisition paradigm allows continuous and ubiquitous medical information access from any connected device over the Internet.

As each one of the devices used in IoT are limited in battery power, it is optimal to minimise the power consumption to enhance the life of the healthcare system. This work explains the implementation of an IoT based In-hospital healthcare system using ZigBee mesh protocol. The healthcare system implementation can periodically monitor the physiological parameters of the In-hospital patients. Thus, IoT empowered devices simultaneously enhance the quality of care with regular monitoring and reduce the cost of care and actively engage in data collection and analysis of the same.[1,2]

The Internet of Things (IoT) has been a game-changer across the globe. We see its influence in our day-to-

day lives as well as work. With the emergence of broadband internet and Wi-Fi capabilities and sensors. We are seeing the penetration of wearable and Smartphone's soars. All these things, combined, have provided a clear path for the IoT in the everyday lives of people. It also had its influence in different sectors of the economy, including healthcare.

Various industries have adopted connected devices, and the IoT more. One of them is the healthcare domain wherein their professionals have watched this trend quite carefully to make their works more convenient, efficient, and automated in the future. In fact, according to a forecast conducted by Business Insider, it was revealed that the growth of the installed base of healthcare IoT devices (excluding wearable's) would be from roughly 95 million in the year 2015 to 646 million by the year 2020.

There are lots of breakthrough technologies like mobile app development, artificial intelligence, IoT solutions, Chatbot development, AR-VR, etc. These go to show that the future of the healthcare industry is on the right track and growing steadily. For example, did you know it is possible to employ AR-VR for remote surgery and medical learning purposes also?

With the help of IoT-based mobile applications, there is tremendous scope for enhancing the quality of the treatments, which will go a long way in improving the health of the patients. With the introduction of IoT in the healthcare domain, it is possible to resolve significant problems for people like increase R & D cost and rise in the cost of healthcare amenities. It even tries to counter the shifting demographics in the emerging market and meeting the needs of an ageing population that is looking for personalized medication facilities.[3,4]

Let's now trace back the history connected with the introduction of IoT in the healthcare industry. It was in the year 2009 when electronic healthcare emerged in the US. It started to gain impetus after the emergence of the Health Information Technology for Economic and Clinical Health Act (HITECH Act). This resulted in the adoption of Electronic Health Records (EHR) and other supporting technology.

Then come the portal technology which engaged patients to become more engaged in their treatment. This way, it became possible for the patients to access their medical records, prepare for appointments, and contact their doctors. The next innovation was the home monitoring systems. These automated systems enabled patients to become more engaged in their treatment since it allowed patients and health care providers to keep a check on individual health records in real-time mode. All this happen, while the patients stayed at home. This is handy for patients with chronic illness and older people.[5,6]

The next obvious step towards innovation was IoT. It enabled electronic devices to capture or monitor data and connect them to a private or public cloud. This way, it became more comfortable for devices to trigger certain events automatically. There are lots of medical devices employed in the healthcare domain, like blood-gas analyzers, smart beds, mobile x-ray machines, ultrasound units, glucose meters, etc. These are all IoT based devices that can aid in transforming patient care.

Now, that you have got a basic idea about how IoT based mobile applications came into existence, in the next section, we will look at some IoT based mobile app solutions that can prove to be a boon for the healthcare domain.[7,8]

This element is an integral part of the IoT. With the help of the internet of things, it is possible to provide proper healthcare to the people who are in dire need of it. There are lots of people who die because they are not given timely treatment. This problem is resolved through this IoT solution.

Wearable app monitoring solutions in the healthcare industry assist the doctors in tracking the health of any patient even if he/she is not present at the hospital. With the help of IoT, devices fixed with sensors inform the concerned healthcare providers whenever there is any change in the vital functions of the patient. This way, it is possible to get the most accurate results.

These IoT solutions apply complex algorithms that assist in examining the data of the patients. This way, the patient can always expect proper attention and medical care. The fantastic thing is the information collected in the device is stored in the cloud.

With the help of remote monitoring, the patients can spend less time at the hospital. If there is any change in the daily activity of the patient, alerts are sent directly to the concerned person and family members in case the patient is old. These remote monitoring devices are available as wearable, so they can quickly be taken anywhere.

It has been researched by the Center for Disease Control and Prevention in the United States, nearly one patient out of every 20 gets an infection due to a lack of proper hand hygiene in hospitals. There are lots of patients who have lost their precious lives as a result of unhygienic conditions resulting in infection. Here, the IoT healthcare application can come up with a solution to this problem. [9,10]

In real-time, whenever a doctor/nurse approaches a patient without washing their hands, a sensor would beep. This would assist them to remember to wash their hands before visiting a patient. In turn, this will aid in maintaining proper hygiene.

Not only that, you even gets to learn about the complete details of the healthcare worker like his ID, time, and location. This information is already there in the database which is then transferred to the concerned authorities.

Discussion

Blockchain can be an extremely vital component to provide IoT based healthcare solutions. Everyone knows that it can be effectively employed in the banking & finance sector. However, not many are aware that it can be used in the healthcare industry too. We all know that in large hospitals, there are lots of transactions being processed, which requires safe storage of data. All this is possible with the help of blockchain technology.

You can employ Ethereum, a decentralized platform where applications run precisely the way they are programmed. All this is done without any chance of fraud with proper authentication of the person who gives access. This way, transactions between significant industries and hospitals can be secured with the help of blockchain technology.

Thanks to IoT, it is possible for the doctors to track the devices used for treating patients with the aid of real-time location services. There are times when the medical staff keeps specific devices out-of-sight, which makes it difficult for other staff members to locate it. You can easily locate medical devices and apparatus like nebulizers, pumps, scales, defibrillators, or monitoring equipment tagged with sensors. This way, it becomes easy to track using IoT. Apart from this, you can even use IoT devices for environmental monitoring, like checking the temperature of the refrigerator, etc.[11,12]

IoT assists healthcare providers to predict the arrival of patients recovering in the Post-Anesthesia Care Unit (PACU). It is even possible to monitor the status of the patients in real-time.

The healthcare industry always has to keep an eye on the budget. Along with this, it also has to ensure that the infrastructure is updated to enhance the patient experience. Due to the seamless connection between IoT devices, this is now possible.

Medical staff today can access the patient information from the cloud for a very long period. The ultimate objective of the hospital is to provide quality medical care. That can be ensured by spending a nominal amount on the infrastructure.

IoT can help achieve this endeavor by:
1. Providing room lighting with the assistance of personal control;
2. Being in constant communication with the families and friends of the patient through email services;
3. Providing prompt attention to the needs of the patients.[13]

These are some applications that employ IoT to ensure that healthcare professionals can take care of the patients in a better way. There is a definite scope for advancement in IoT for the healthcare domain. If you are interested in creating an IoT based mobile application for the healthcare domain, get in touch with an experienced mobile app development company today!

Internet of things (IoT) is an emerging technology that helps in reducing the human efforts. IoT refers to the physical objects connected to each other over the internet. In reference to the healthcare sector various equipment and gadgets like a thermometer, ECG, blood pressure measuring machine, heart rate monitor etc. are interconnected via various sensors. People are becoming more inclined towards the use of the Internet of things. The growing elderly population and the increase in chronic diseases generate a need for the healthcare sector to find ways to provide services at the convenience of the patient. Many people in India do not have access to proper medical services due to which the health of these people suffers. Nowadays the government is taking so many initiatives to support and provide help to the people living in the rural area. The IoT has the potential to several benefits for health applications such as remote health monitoring, fitness programs, chronic diseases, children care and elderly care. Furthermore, it allows sharing and controlling the information between human to human or human-object or between objects using the Internet via ubiquitous sensors. Therefore, various medical devices, sensors, and diagnostic and imaging devices can be viewed as smart devices or objects constituting a core part of the IoT. The IoT-based e-Health monitoring method will help in reducing the number of visits to a doctor, and even the doctor can monitor his or her patient from anywhere. As this is a technology not so feasible now, but in coming years, this technology will meet the physical world definitely. The e-Health solutions provided through IoT devices are more accurate and accountable in the emerging IoT business landscape, which offers and provides various opportunities and challenges to an industry. [14,15]

The IoT technology is still understudy to utilise it in the health sector in different regions in order to

combine the information with control and monitoring such as China, US, Canada, etc. As a historical background, the Internet of Things was discovered by Kevin Ashton in 1998 to facilitate information exchange over the wide-world where every physical object connected through the Internet with a unique identification and can be monitored everywhere. One of the facilities of IoT for information systems is that it can provide services anywhere, anytime, and on any media. In healthcare, the Internet of Things enables the potential benefits to achieve a high rate of exchange of massive information among organisations and organisation itself. Some advantages of using Internet treatments included self-paced, interactive, of tailored service, multimedia format, greater accuracy reporting symptoms, timely information, accessibility, low cost, standardisation and increased user and supplier control of the intervention.

Sensor technology and automated data collection enable passive monitoring of psychological states that can alert patients and healthcare providers to acute and chronic stress states. These sensors can be used in monitoring patients, tracking daily activities, and caring for the chronic disease people or patients who have special states. This information offers treatment that is evidence based from the information obtained from sensors and monitoring activities. All the applications of this technology culminated in increased comfort, convenience, and better management, thereby improving the quality of life. Table 1 shows the multiple advantages and disadvantages of Internet of Things-based healthcare monitoring and management of health system.[16,17]

Table 1. The IoT advantages and disadvantages.

		Explanation	Sources
Advantage	Monitoring	Remote patient monitoring continues to grow and help physicians diagnose and treat illnesses and diseases with obtaining reliable information with a negligible error rate.	[27, 28]
	Sensing	IoT with intelligent medical sensors will enhance the quality of life significantly and prevent the occurrence of health problems.	[22]
	Low-cost solutions	Reduce unnecessary visits by doctors, and readmissions come from patients with chronic diseases and reduce testing cost.	[29]
	Ubiquitous access	Allow and increase the accessibility from anywhere, any time and any media allowing flexibility and mobility to the users. Enable real-time access services to the healthcare provider to access patient information and help them to make better decisions.	[30]
	Better quality of healthcare management	Increase the care quality and control by enhancing the management of drugs, reduce the medical error, enhance the patient experience, improve the disease management and improve outcome of treatment.	[31, 32]
	Unified information	Automated data collection enabled from health information resources such as monitoring, first aid, tracking, analysis, diagnosis, alarm-triggering, locating and collaboration with medical healthcare under unified communication platform and exchanged the health record.	[27]
	Time	This facilitates the interaction among the parts of an enterprise and allows for reducing the time necessary to adapt itself to the changes imposed by the market evolution.	[33]
Disadvantage	Complexity	The IoT is a diverse and complex network. There is a need of multiple services to grow device counts, massive increases of Internet bandwidth with a need to drive requirements for lower latency, greater determinism and processing closer to the edge of the network. Thus, any failure or bugs in the software or hardware will have serious consequences. Even power failure can cause a lot of trouble.	[34, 35]
	Compatibility	Although different manufacturers will be interconnected, the problem issue of compatibility when manufacturers do not agree to a common standard will make the people buy appliances from a certain manufacturer, leading to its monopoly in the market.	[23]

	Security and privacy	A location tracking and collect inappropriately information for any person considering as a challenge in the using of IoT services in the healthcare system. The patient concern of attacks his personal identity and privacy maybe arise. Therefore, bring big data from millions of things in a healthcare system can cause many security challenges.	[36, 37]
	Massive health data	In IoT, devices assemble and communicate information directly with each other via Internet and the cloud manages to collect record and analyse data blocks. But the 'things or devices' which are producing a massive amount of data are blowing out day-to-day, which needs to be treated and managed.	[38, 39]

Results

Data exchange and automation using Internet of things (IoT) is a rapidly growing technology. It includes sensors, cyber systems – the things in IoT and cloud computing. To reach humans in real time, cyber systems communicate collaboratively at each stage over the Internet. The advances in Internet innovation have made possible techniques for the conveyance of healthcare. Networking infrastructure and common access can encourage sharing of patient data and clinical information making the Internet a perfect tool for remote patient observing applications [1]. Sinnapolu et al [2] demonstrated integrating wearable devices with IoT and cloud to monitor health parameters and rendering assistance in case of emergency. It is an exemplary solution to the problem of communication and reporting system and attempts to address the case of an incapacitated patient driving an automobile. Similar health monitoring systems can enhance the quality of life, especially for elderly people.[18]

As adults age over 65 years, they need continuous health monitoring. Their population is increasing since the past two decades. By 2025 it is expected to reach 1200 million among which 80% will be from developing countries [3], [4]. A rapid adaptation of smart phones [5] and web applications makes them a preferred platform for health monitoring systems. Embedded device platforms have evolved rapidly and are now available with many communication options, preferably wireless. A comparative evaluation of existing health monitoring systems for wear ability, security, ease of use and storage requirements was made by Gupta et al to identify desirable features missing in contemporary systems [6]. However, an overuse of the devices and network bandwidths can interrupt real time monitoring. To the best of our knowledge, health monitoring systems simultaneously implementing multimode communication have not been designed. We therefore present a system that uses three modes – GSM, BLE and Wi-Fi, in tandem or together, to ensure continuity in health monitoring.

Healthcare devices represent one of the fastest-growing sectors of the IoT market. In fact, the value of this sector-which is sometimes called the Internet of Medical Things (IoMT)-is predicted to reach $176 billion by 2026.[40]

To understand what IoMT means for IoT as a whole, and how healthcare IoT devices need to be monitored and managed, you must understand the multiple ways in which IoT devices can be used for healthcare. While the most popular example of IoT in healthcare is remote patient monitoring-meaning IoT devices that collect patient data such as heart rate and body temperature-there are many other examples of IoT in the healthcare industry.

IoT devices offer a number of new opportunities for healthcare professionals to monitor patients, as well as for patients to monitor themselves. By extension, the variety of wearable IoT devices provide an array of benefits and challenges, for healthcare providers and their patients alike.[19,20]

1. Remote patient monitoring

Remote patient monitoring is the most common application of IoT devices for healthcare. IoT devices can automatically collect health metrics like heart rate, blood pressure, temperature, and more from patients who are not physically present in a healthcare facility, eliminating the need for patients to travel to the providers, or for patients to collect it themselves.[39]

When an IoT device collects patient data, it forwards the data to a software application where healthcare professionals and/or patients can view it. Algorithms may be used to analyze the data in order to recommend treatments or generate alerts. For example, an IoT sensor that detects a patient's unusually low heart rate may generate an alert so that healthcare professionals can intervene.

A major challenge with remote patient monitoring devices is ensuring that the highly personal data that these IoT devices collect is secure and private.[37,38]

2. Glucose monitoring

For the more than 30 million Americans with diabetes, glucose monitoring has traditionally been difficult. Not only is it inconvenient to have to check glucose levels and manually record results, but doing so reports a patient's glucose levels only at the exact time the test is provided. If levels fluctuate widely, periodic testing may not be sufficient to detect a problem.

IoT devices can help address these challenges by providing continuous, automatic monitoring of glucose levels in patients. Glucose monitoring devices eliminate the need to keep records manually, and they can alert patients when glucose levels are problematic.

Challenges include designing an IoT device for glucose monitoring that:
A. Is small enough to monitor continuously without causing a disruption to patients
B. Does not consume so much electricity that it needs to be recharged frequently.

These are not insurmountable challenges, however, and devices that address them promise to revolutionize the way patients handle glucose monitoring.[21,22]

3. Heart-rate monitoring

Like glucose, monitoring heart rates can be challenging, even for patients who are present in healthcare facilities. Periodic heart rate checks don't guard against rapid fluctuations in heart rates, and conventional devices for continuous cardiac monitoring used in hospitals require patients to be attached to wired machines constantly, impairing their mobility.

Today, a variety of small IoT devices are available for heart rate monitoring, freeing patients to move around as they like while ensuring that their hearts are monitored continuously. Guaranteeing ultra-accurate results remains somewhat of a challenge, but most modern devices can deliver accuracy rates of about 90 percent or better.[35,36]

4. Hand hygiene monitoring

Traditionally, there hasn't been a good way to ensure that providers and patients inside a healthcare facility washed their hands properly in order to minimize the risk of spreading contagion.

Today, many hospitals and other health care operations use IoT devices to remind people to sanitize their hands when they enter hospital rooms. The devices can even give instructions on how best to sanitize to mitigate a particular risk for a particular patient.

A major shortcoming is that these devices can only remind people to clean their hands; they can't do it for them. Still, research suggests that these devices can reduce infection rates by more than 60 percent in hospitals.

5. Depression and mood monitoring

Information about depression symptoms and patients' general mood is another type of data that has traditionally been difficult to collect continuously. Healthcare providers might periodically ask patients how they are feeling, but were unable to anticipate sudden mood swings. And, often, patients don't accurately report their feelings.[33,34]

"Mood-aware" IoT devices can address these challenges. By collecting and analyzing data such as heart rate and blood pressure, devices can infer information about a patient's mental state. Advanced IoT devices for mood monitoring can even track data such as the movement of a patient's eyes.

The key challenge here is that metrics like these can't predict depression symptoms or other causes for concern with complete accuracy. But neither can a traditional in-person mental assessment.

6. Parkinson's disease monitoring

In order to treat Parkinson's patients most effectively, healthcare providers must be able to assess how the severity of their symptoms fluctuate through the day.[23,24]

IoT sensors promise to make this task much easier by continuously collecting data about Parkinson's symptoms. At the same time, the devices give patients the freedom to go about their lives in their own homes, instead of having to spend extended periods in a hospital for observation.

Other examples of IoT/IoMT

While wearable devices like those described above remain the most commonly used type of IoT device in healthcare, there are devices that go beyond monitoring to actually providing treatment, or even "living" in or on the patient. Examples include the following.

7. Connected inhalers

Conditions such as asthma or COPD often involve attacks that come on suddenly, with little warning. IoT-connected inhalers can help patients by monitoring the frequency of attacks, as well as collecting data from the environment to help healthcare providers understand what triggered an attack.

In addition, connected inhalers can alert patients when they leave inhalers at home, placing them at

risk of suffering an attack without their inhaler present, or when they use the inhaler improperly.

8. Ingestible sensors

Collecting data from inside the human body is typically a messy and highly disruptive affair. No no enjoys having a camera or probe stuck into their digestive tract, for example.

With ingestible sensors, it's possible to collect information from digestive and other systems in a much less invasive way. They provide insights into stomach PH levels, for instance, or help pinpoint the source of internal bleeding.[31,32]

These devices must be small enough to be swallowed easily. They must also be able to dissolve or pass through the human body cleanly on their own. Several companies are hard at work on ingestible sensors that meet these criteria.

9. Connected contact lenses

Smart contact lenses provide another opportunity for collecting healthcare data in a passive, non-intrusive way. They could also, incidentally, include micro cameras that allow wearers effectively to take pictures with their eyes, which is probably why companies like Google have patented connected contact lenses.

Whether they're used to improve health outcomes or for other purposes, smart lenses promise to turn human eyes into a powerful tool for digital interactions.[25,26]

10. Robotic surgery

By deploying small Internet-connected robots inside the human body, surgeons can perform complex procedures that would be difficult to manage using human hands. At the same time, robotic surgeries performed by small IoT devices can reduce the size of incisions required to perform surgery, leading to a less invasive process, and faster healing for patients.

These devices must be small enough and reliable enough to perform surgeries with minimal disruption. They must also be able to interpret complex conditions inside bodies in order to make the right decisions about how to proceed during a surgery. But IoT robots are already being used for surgery, showing that these challenges can be adequately addressed.[27,28]

Conclusions

In order to make the most of IoT for healthcare, critical security challenges must be addressed.

Above all, IoT device developers, managers and healthcare providers must ensure that they adequately secure data collected by IoT devices. Much of the data collected by medical devices qualifies as protected health information under HIPAA and similar regulations. As a result, IoT devices could be used as gateways for stealing sensitive data if not properly secured. Indeed, 82 percent of healthcare organizations report having experienced attacks against their IoT devices.

Developing secure IoT hardware and software is one step in addressing this challenge. Equally important, however, is ensuring that IoT devices in healthcare are managed properly in order to protect against data from unmonitored devices falling into the wrong hands. A patient monitoring device that has an older version of software or firmware, or a device that is not properly decommissioned after it is no longer needed, for example, could offer attackers an opportunity to infiltrate a network or steal protected health information.[29,30]

Proper discovery and classification of all IoT devices on a healthcare provider's network helps guard against this risk. Once IoT device networks are properly identified, classified, regulated, and secured, managers can track device behavior to identify anomalies, perform risk assessments and segment vulnerable from mission-critical devices.

In a hyper-connected healthcare enterprise, the quantity and heterogeneity of IoT devices creates a complex and increasingly untenable reality for healthcare technology, IT and security organizations. Leaders struggle to understand exactly what's connected to the network, what it's doing, and how to regulate and protect it all.

Ordr Systems Control Engine (SCE) can enable visibility, and security of all of your connected medical devices. It can identify, classify, profile behavior and risk, and secure all medical and IoT assets in your healthcare organization. Once you understand the behavior and communications of every connected device, you can proactively secure them using micro segmentation policies enforced on your existing network and security infrastructure, without touching or modifying the devices. You can even use Ordr to maximize the utilization of all of your connected medical devices.[40]

References

[1] Mitchell S, Villa N, Stewart-Weeks M, Lange A. The Internet of Everything for Cities. Connect. People, Process. Data, Things to Improv. 'Livability' of Cities Communities; Cisco. 2013. pp. 1-21

[2] Downing NL et al. Health information exchange policies of 11 diverse health systems and the associated impact on volume of

exchange. Journal of the American Medical Informatics Association. 2016; 34(13): 150-160

[3] Vest J. R. Health information exchange: national and international approaches. In Health Information Technology in the International Context. Vol. 12. Statesboro, GA, USA: Emerald Group Publishing Ltd; 2012: 3-24

[4] Pagliari C. Health information exchange as a complex and adaptive construct: Scoping review. Journal of Innovation in Health Informatics. 2016; 23(4): 633-683

[5] Rosenfeld S, Koss S, Caruth K. Evolution of state health information exchange/A study of vision, strategy, and progress. In: AHRQ Heal. IT Publ. No. 06. 2006

[6] Miller AR, Tucker C. Health information exchange, system size and information silos. Journal of Health Economics. 2014; 33(1): 28-42

[7] WHO. Health Information. World Health; 2008

[8] Tharmalingam S, Hagens S, Zelmer J. The value of connected health information: Perceptions of electronic health record users in Canada. BMC Medical Informatics and Decision Making. 2016; 16(1): 93

[9] Ghane K. Healthcare information exchange system based on a hybrid central/federated model. In: 36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC). 2014. pp. 1362-1365

[10] Chatterjee P, Armentano RL. Internet of things for a smart and ubiquitous eHealth system. In: 2015 International Conference on Computational Intelligence and Communication Networks (CICN). 2016. pp. 903-907

[11] Hassanalieragh M et al. Health monitoring and management using internet-of-things (IoT) sensing with cloud-based processing: Opportunities and challenges. In: Proc. of 2015 IEEE Int. Conf. Serv. Comput. SCC. 2015. pp. 285-292

[12] Riazul Islam SM, Kwak D, Humaun Kabir M, Hossain M, Kwak K-S. The internet of things for health care: A comprehensive survey. IEEE Access. 2015; 3: 678-708

[13] Davis FD, Bagozzi RP, Warshaw PR. User acceptance of computer technology: A comparison of two theoretical models. Management Science. 1989; 35(8): 982-1003

[14] Turcu CE, Turcu CO. Internet of things as key enabler for sustainable healthcare delivery. Procedia-Social and Behavioral Sciences. 2013; 73: 251-256

[15] Zhang H, Han BT, Tang Z. Constructing a nationwide interoperable health information system in China: The case study of Sichuan Province. Health Policy and Technology. 2017; 6(142151): 142-151

[16] Serrano KJ et al. Willingness to exchange health information via mobile devices: Findings from a population-based survey. Annals of Family Medicine. 2016; 14(1): 34-40

[17] Vest JR, Zhao H, Jasperson J, Gamm LD, Ohsfeldt RL. Factors motivating and affecting health information exchange usage. Journal of the American Medical Informatics Association. 2011; 18(2): 143-149

[18] Koru G, Alhuwail D, Topaz M, Norcio AF, Mills ME. Investigating the challenges and opportunities in home care to facilitate effective information technology adoption. Journal of the American Medical Directors Association. 2016; 17(1): 53-58

[19] Ghani MKA, Jaber MM, Suryana N. Barriers faces telemedicine implementation in the developing countries: Toward building Iraqi telemedicine framework. ARPN Journal of Engineering and Applied Sciences. 2015; 10(4): 1562-1567

[20] Kadhum AM, Hasan MK. Assessing the determinants of cloud computing services for utilizing health information systems: A case study. International Journal on Advanced Science, Engineering and Information Technology. 2017; 7(2): 503-510

[21] Roy A, Zalzala AMS, Kumar A. Disruption of things: A model to facilitate adoption of IoT-based innovations by the urban poor. Procedia Engineering. 2016; 159: 199-209

[22] Sallabi F, Shuaib K. Internet of things network management system architecture for smart healthcare. In: 2016 Sixth International Conference on Digital Information and Communication Technology and its Applications (DICTAP). 2016. pp. 165-170

[23] Li S, Da Xu L, Zhao S. The internet of things: A survey. Information Systems Frontiers. 2015; 17(2): 243-259

[24] Ullah K, Shah MA, Zhang S. Effective ways to use internet of things in the field of medical and smart health care. In: 2016 International

Conference on Intelligent Systems Engineering (ICISE). Islamabad, Pakistanpp: IEEE; 2016: 372-379

[25] Jog Y, Sharma A, Mhatre K, Abhishek A. Business approach for IoT based health solutions in India with respect to osterwalder framework. International Journal of Bio-Science and Bio-Technology. 2015; 7(6): 173-188

[26] Lim AK, Thuemmler C. Opportunities and challenges of internet-based health interventions in the future internet. In: 2015 12th International Conference on IEEE Information Technology-New Generations (ITNG). 2015. pp. 567-573

[27] Keh HC et al. Integrating unified communications and internet of M-health things with micro wireless physiological sensors. Journal of Applied Science and Engineering. 2014; 17(3): 319-328

[28] Rghioui A, L'Aarje A, Elouaai F, Bouhorma M. The internet of things for healthcare monitoring: Security review and proposed solution. In: Information Science and Technology (CIST). 2014. pp. 384-389

[29] Bui N, Zorzi M. Health care applications: A solution based on the internet of things. In: Int. Symp. Appl. Sci. Biomed. Commun. Technol. 2011. pp. 0-4

[30] Rasid MFA et al. Embedded gateway services for internet of things applications in ubiquitous healthcare. In: International Conference on Information and Communication Technology (ICoICT); Figure. 2014. pp. 145-148

[31] Manate B, Munteanu VI, Fortis TF, Moore PT. An intelligent context-aware decision-support system oriented towards healthcare support. In: Complex, Intelligent and Software Intensive Systems (CISIS): 2014 Eighth International Conference on IEEE. 2014. pp. 386-391

[32] Zdravkoví M, Noran O, Trajanoví M. On pervasive healthcare information systems in the internet of things. In: 25th Australasian Conference on Information Systems (ACIS2014); Auckland, NZ. 2014

[33] Atzori L, Iera A, Morabito G. The internet of things: A survey. Computer Networks. 2010; 54(15): 2787-2805

[34] Felipe Fernandez GCP. Opportunities and challenges of the internet of things for healthcare. In: 2014 EAI 4th International Conference on Wireless Mobile Communication and Healthcare (Mobihealth); IEEE. 2014

[35] Rathore MM, Ahmad A, Paul A, Wan J, Zhang D. Real-time medical emergency response system: Exploiting IoT and big data for public health. Journal of Medical Systems. 2016; 40(12): 283

[36] Santos A, Macedo J, Costa A, Nicolau MJ. Internet of things and smart objects for M-health monitoring and control. Procedia Technology. 2014; 16: 1351-1360

[37] YIN Y. The internet of things in healthcare: An overview. Journal of Industrial Information Integration. 2016; 1: 3-13

[38] Nandyala CS, Kim HK. From cloud to fog and IoT-based real-time U-healthcare monitoring for smart homes and hospitals. International Journal of Smart Home. 2016; 10(2): 187-196

[39] Blake MB. An Internet of Things for Healthcare; 2015

[40] Catarinucci L et al. An IoT-aware architecture for smart healthcare systems. IEEE Internet of Things Journal. 2015; 2(6): 515-526