Survey Based Analysis of Internet of Things Based Architectural Framework for Healthcare System

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***Abstract*— Healthcare is an important gradation in life and IoT has made this healthcare a get-at-able, easy way to live. Its popularity in the world of technology and the internet, IoT is increasing in every field of life with the health sector. Due to the hypnosis feature, IoT is becoming more focused on the healthcare industry. However, although, it has not yet been implemented for the wider scope of hospitals around the developing countries. Among many IoT tools, IoT brings tools to strengthen the workplace such as health, safety, and the medical environment. In this paper, introduce and describing a comprehensive survey of IoT concerning IoT Technologies, Healthcare methods, statistics, System architecture, enabling technologies, security and privacy issues and success cases applied in healthcare. This paper will explore the relationship between Physical System in Healthcare (PSH) and IoT based Healthcare, both in which play an important role in intelligent Cyber worlds but IoT is a vital role. Moreover, we surveyed to investigate between the edge computing and IoT based Healthcare and discuss issues in edge computing. The results of the investigation can be applied in developing countries.**

Keywords— **Physical System in Healthcare (PSH), Hospital Management System (HMS), Survey, Internet of things (IoT).**

1. INTRODUCTION

The term of IoT (Internet of Things) defines a network connected to the physical objects through the Internet. These physical objects include technology to interact with the internal factors as well as the external environment. IoT is an interconnected computing device, the mechanical and digital machine that provides unique identifiers (Unique identifiers UIDs are commonly used in the healthcare industry, reporting medical information such the patient's name, creating the personal code) to the objects, animals or humans, and the ability to transfer data through a network, which can perform human-to-computer interactions [1]. The Internet of Things (IoT) seamlessly opens up a world of possibilities treatment in the biodiversity and the advancement of technology changing the world of thought as well as the development of smartphones and other handheld gadgets.

Over the past few years, modern technology and gadgets have been developed to monitor the critical resources in healthcare and other hospitals. But most of these systems are just maintaining a database of patients. These systems have just implemented telemedicine by the way of technologies of telecommunication, teleconferencing and video conferencing. Literature has shown that these systems lack of quality and are expensive and we need a better communication and monitoring system.

If we talk about HMIS from all around the world, there are some countries, which have better mobile patient care systems. We have discusses the basics of IoT for Healthcare such as IoT Technologies, Healthcare Methods, System Architecture, Enabling Technologies, Security issues and success cases applied in healthcare and describe the relationship between physical and IoT in Healthcare. In the Physical system, we need to physically attend our hospital and be treating in our modern life. But IoT in Healthcare we don’t physically attend the hospital. So, we save time and cost. Finally, we will analyze the Hospital Management system with real data.

1. RELATED WORKS INSTANCE OF ACCOMPLISHMENT IN IOT HEALTHCARE

The broader centralization and interconnection capabilities of IoT technology are difficult to over-review. Let’s contemplate on IoT endowments in healthcare in more details. IoT smart healthcare brings health observation, remote monitoring, physical hospital and digital infrastructure of IoT organization and we say that in the age of medical health is a whole new balance is relevant in IoT. NHS England - an 'executive non-departmental public body of the Department of Health and Social Care'- announced that it will support a remote diabetes treatment solution in 2018 [2]. They also stated that thousands of people with diabetes across the country are benefited from glucose monitors on the NHS. Monitoring data can be easily accessed through mHealth technology.

An investigation, the survey [3] by Amna Pir, M. Usman Akram has shown that the statistical data in the Medical sectors. He presented an IoT based on the architectural framework with a context of awareness for hospital management systems. This survey to investigate the decision to adopt the IoT based system in Pakistani Hospitals. The accumulated results indicate that participants want to adopt this system and most of the group of people agreed that IoT based HMIS would provide better monitoring and earlydiagnosis to improve the outcomes.

The survey [4] by Asst. Prof. M. Gokilavani discussed numerous healthcare IoT strategies and processes, and also end up with some major problems. They faced challenges during the developing those systems and the security issues and also have the concern of identification as a future extension for upcoming projects.

In [5] Lei Yu et.al proposes an architecture of smart hospital bases on IoT in order to overcome the disadvantages and his experiment proves the smart hospital can effectively solve the prominent problems existing the diagnosis and treatment of hospital and it brings a positive and profound effort for the present diagnosis and treatment model in hospital.

Luca [6] et.al proposes a smart architecture automatic monitoring and tracking of patients, biomedical devices within hospital and nursing institutes. A smart hospital system (SHS) which relies in technologies, specifically RFI, WSN and smart mobile. The SHS is able to collect in real time data with the Hybrid Sensing Network (HSN).

By Aminian [7] et.al presents a monitoring system that has the capability to monitor physiological parameters from multiple patient bodies. In the proposed system, a coordinator node has attached on patient body to collect all the signals from the wireless sensors. This system can detect the abnormal conditions, issue an alarm to the patient and send a SMS/E-mail to the physician. And the system in multi-patient architecture for hospital healthcare and compared it with the other existing networks based on multi-hop relay node in terms of coverage, energy consumption and speed.

In [8] G. Zhang et.al design a kind of semantic medical monitoring system model in the cloud based on the IoT sensors. All massive sensor data will be stores into the HDFS. Design two algorithm (1) massive semantic medical roles processing algorithm without external communication and (2) massive semantic medical roles processing algorithm with external communication.

In [9] Lin Yang et.al

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1. USED OF IOT TECHNOLOGIES IN HEALTHCARE
2. *Radio Frequency Identification (RFID):* Radio Frequency Identification (RFID)is a technology and system that transmits data and which is used to detect sensors.

The Healthcare system is becoming more and more invested in RFID technology.So, recent market research has revealed there will be an exponential growth of RFID technology in that industry by 2021 [13]. One of the reasons that RFID is expanding considerably in the industry is the sheer number of applications that can benefit. In hospitals that have been outfitted with the technology, RFID is present in many forms – from the tracking of surgical tools to tracking patients and staff. RFID Collected data and sent to a Local Area Network a database installed server. Users can retrieve the data using an application installed on the server (Togt, Bakker, and Jaspers, 2011) [14]. While RFID has been implemented in Healthcare, limited adoption and use of RFID remains some challenges (Chong, Liu, Luo, and Boon, 2015) [15].

Some of the RFID applications being deployed in hospitals all over the world:

1. **Medicine** Inventory Tracking and Authentication:

RFID can be achieved with tracking inventory almost any type of clauses or items however, but effectively the tracking RFID systems can be challenging when tracking liquid-filled assets. There is a growing and changing supply of hospital medicine that should be tracked to keep them in bulk for their patients. RFID can reduce the amount of time spent counting, pharmaceuticals can be calculated, accurate data can be confirmed, and medicines are available in the right type and quantity in hands. Some hospitals and pharmaceuticals also use RFID tags for authentication [16].

1. **Patient,** Attendees Tracking:

Some hospitals are using RFID technology as well as instances of active RFID to track patients and Attendees throughout the hospitals. Patients and staff are given RFID Tags for 4 reasons.

* + - 1. For verify patents information.
      2. Reduce waiting time for patents and staff.
      3. To locate patents.
      4. For staff workflow.

Hospitals have used active RFID in Real-Time Location Systems (RTLS) to identify problems [17].

1. **Medical Equipment’s** Tracking:

Medical equipment such as hospital beds, testing machines, doctors useable scalpels, scissors, clamps, and retractors, etc. are needed for surgeries that need to always be on hand, clean, disinfect, and ready to use. The RFID tags ensure that each equipment was disinfected before use, a properly implemented system can apply lighting to individual equipment in a sterile manner. Using an RFID tag is the way to keep tracking of these assets for the smart hospitals [18].

1. **Security:**

Security is another factor such as unauthorized access, access ability, and use of hospital equipment to certain rooms or areas to prevent people. By using the RFID tag, the hospital's security can be ensured and secure for all systems [16]. Theinformation provider should able to use from observing the use of the system. A system administrator must be able to implement access control on user information.

1. *Edge Computing:* With a healthcare industry important as, the adoption of Edge Computing will drive the healthcare towards a brighter future. Edge Computing offers the healthcare sector a very practical, accessible and deployable technology that is likely to be a game-changer for hospitals and clinics around the world. The network architecture, pushing specific data, processing, and services away from the centralized infrastructure of the cloud to the edge of the network where the data raise [19] [20]. The edge computing is compacted between the cloud and all IoT Health devices add important features to the system:
   * + 1. **Real-time data analytics and solve data problem:** Time-sensitive application is a necessity to process and act on health data in seconds. Creating a large amount of data through these IoT edge devices can be valuable, but the responsibility of managing and maintaining it also poses a challenge for healthcare providers. Numerous of this data is unstructured and not well-defined, flooding cloud infrastructures that are often not ready to run the powerful analytical programs needed to manage it in an easy-to-use way. Edge computing applications have the efficient to solve this data problem. The powerful machine learning algorithms hosted in edge computing data centers that maintain the highest standards in regulatory compliance [19] [21].
       2. **Traffic Reduction:** The limited network bandwidth, it is not enough and not necessary to transfer enormous the volume of raw big data from millions of e/mHealth devices to the cloud. Edge computing reduces data transport costs, reduce data stolen, and filter and compact the medical data before delivering which can be significant for data-intensive applications [20].
       3. **Device Management and Data Delivery:** Device management includes device discovery, count how many devices are used in hospitals, device registration and login, and device control. Edge nodes can use three data delivery techniques (i) Message-based (ii) Request-based and (iii) Publish-based [19].
       4. **Supply Chain Management:** The more exciting edge computing uses involves the operation of industrial supply chains management. The way medical facilities on sensor-equipped IoT edge devices can revolutionize the way of handle inventory. Inventory management based on smart RFID tags can remove time-consuming papers and manual sequences when data collection devices on usage patterns can use predictive analytics to determine the hardware is likely to fail. Fleet cars equipped with GPS and other sensors can track the location of important shipments in real-time. For organizations struggling to control rising costs, IoT health care supply chain innovations provide an opportunity to gain operational efficiency at the margins and represent one of the most compelling edge computing uses [19].

Edge computing can soon qualify the Medical industries with the ability to perform without connecting to a remote data center. On-edge computing with intelligent of IoT will be able to collect patient data, transfer, analysis data to the local clinic or doctor, and give physician staff almost real-time information. Patient data, can be reviewed with the doctor if the patient is not present and without an appointment.

1. *Two-dimensional Code:* A barcode is a visual means of representing data that can be read by a machine to retrieve the data. Barcode must be readable by barcode scanners. The common formats are 16 color BMP, GIF, JPEG, PNG, TIFF, two-dimensional bar code image etc. Those data are generally either handwritten or typed into an electronic medical record (EMR) system frequently missing or incorrect reports. The 2D barcode can allow fast, accurate, and automatic capture of these data by a handheld imaging device, which can prolong these fields to an EMR and / or IIS. The critical component is that the 2D barcode is used for identifying the medicine information, medicine expiration date etc. [22].

Patient info. Identification Wristbands:The patient's wristbands of the hospital identification system, and display patient identification is enhanced using 2D barcodes. 2D barcode wristbands can make scanning easier when printed around the surface of the band and facilitate patient identification [23].

<https://blog.atlasrfidstore.com/7-things-can-track-hospitals-using-rfid>

CHALLENGES OF IOT IN HEALTHCARE

**As much as the Internet of Medical Things seems** to be revolutionary and highly-efficient, there are still some major challenges of IoT in healthcare this tech concept must overcome down the road. With large, game-changing integrations such as this one, there comes along a myriad of technical difficulties and adaptation issues. The main include:

Underdeveloped initiatives. Many IoMT initiatives directed at battling chronic diseases or other issues still need time to grow and develop. This technological niche as a whole must grow a lot in order to start providing regular enhancement results.

Possible lack of available memory. IoT sensors and devices can general colossal amounts of data, all of which is important and needs to be analyzed. This poses a question of huge data repositories that must hold all those volumes of info for indefinite terms.

Difficulties with regular updates. With so many hardware solutions comes as much software for powering and managing it all. This software must be timely updated in order to run smoothly and stay at its latest version. And here’s where constant updates will require lots of effort and might spawn many technical issues.

Personal sensitive data security. An IoT-powered medicine is a hardware-backed system that functions through the Internet. And online systems get hacked and breached. This spawns a chance of important private data being potentially undermined.

Global healthcare regulations. The IoMT still has to be approved by global healthcare regulatory bodies worldwide. This will take time and may keep many innovations at bay just because of some formalities.

ADVANTAGES AND DISADVANTAGES OF IOT IN HEALTHCARE

Considering the above-mentioned challenges of IoT in healthcare, there are, indeed, downsides as well as benefits when it comes to the medical IoT.

Advantages of IoT in healthcare

The ‘all-consuming’ connection of health devices and data centralization brings many significant benefits to the table, such as:

All-around technological enhancement. Renderinghospital visits unnecessary, passively accumulating and deeply analyzing important health data, etc. We’ve already pondered on all these advanced techcapacities galore enough. The IoMT provides space for fantastic long-term innovations.

Cost savings. One of the greatest advantages of IoT in healthcare is that efficient autonomous systems will cost less to manage and ‘employ’ in the long run. Things are even better when it comes to patient cost savings due to fewer hospital journeys as well as accelerated diagnostics and treatment.

Accessibility. Doctors can view all the necessary data on command and check real-time patient conditions without leaving their office.

Disadvantages of IoT in healthcare

Alternatively, some downsides that come along with the massive implementation of the IoT in healthcare include: Privacy can be potentially undermined. As we’ve already mentioned, systems get hacked. Lots of attention will need to be focused on data security, which requires significant additional spending. Unauthorized access to centralization. There is a chance that dishonest interlopers may access centralized systems and realize some cruel intentions.

Global healthcare regulations. International health administrations are already issuing guidelines that must be strictly followed by governmental medical establishments integrating the IoT in their workflow. These may restrict possible capacities to some extent.

IOT TRENDS IN HEALTHCARE OF 2019

In 2019, there can be defined several IoMT trends implemented by majorities of startups worldwide. Wearables continue to top the market. Major mobile technology providers like Apple and Android are enhancing and updating their authentic wearables, adding them with more health tracking features. And the rest of the world isn’t shy to follow the tendency, spawning numerous various-purpose mini devices. Surgical robotics become a common reality. AI-powered, robotic surgical means show to be more precise than real doctors on more than one occasion. There are still limitations and risks involved, but the technology is definitely in the spotlight and is looking to become more widespread in the nearest future. Integration of other prominent technologies with the IoT expands the horizon. AI, AR, Machine Learning, Big Data, blockchain, and smart contracts — all of that fuel up and expands the IoT powers even further. AI is already better and far more precise in predicting, for one instance, women’s breast cancer.

FUTURE OF IOT IN HEALTHCARE

Full-blown smart hospitals by 2020, mHealth as a regular, common thing on a global scale, and reduced physical visits to hospitals — this is only an approximate picture of the IoMT success. With that being said, as young as the concept is, it isn’t really regarded to be that novel by progressive hospitals of the now. Most of them are either implementing major IoT techniques or capabilities or already have enhanced parts that are in their calibration stage.

SUMMARY

Let us emphasize once more that the IoT can be nothing short of a revolution in the field as important on the global scale as healthcare. there are still many difficulties, peculiarities, and technological obstacles to overcome. And even though there are, currently, downsides as well as advantages to the concept, things seem to go very well for this technological innovation.

We are pretty confident that if you ask most medical professionals about their opinion on the subject, they will say that full IoMT integration and adaptation is the only logical way of development for advanced medicine of the future.

With that being said, enjoy the life-saving, health-improving fruits of the massive technological progress.

1. Patnaik, Alankrit, and Deepak Gupta. "Unique identification system." International Journal of Computer Applications 7, no. 5 (2010): 46-51.
2. <http://www.pharmatimes.com/news/nhs_to_fund_continuous_blood_glucose_monitoring_system_1260230>
3. Amna Pir Muhammad ; M. Usman Akram ; Muazzam A. Khan "Survey Based Analysis of Internet of Things Based Architectural Framework for Hospital Management System".
4. Asst.Prof. M.Gokilavani, Asst.Prof. Gripsy Paul Manickathan, Dr. M.A.Dorairangaswamy "A SURVEY ON IOT MEDICARE APPLICATION: ISSUES AND CHALLENGES",International Research Journal of Computer Science (IRJCS) ISSN: 2393, Issue 04, Volume 6 (April 2019)
5. Lei Yu School of Computer and Information, Hefei University of Technology, Hefei, China 2 School of Medical Information Technology, Anhui University of Traditional Chinese Medicine, Hefei, China Email: fishstonehfut1006@163.com Yang Lu, XiaoJuan Zhu School of Computer and Information, Hefei University of Technology, Hefei, China Email: luyang.hf@126.com, xjzhu@aust.edu.cn “Smart Hospital based on Internet of Things” ,10 October 2012.
6. Catarinucci, Luca, Danilo De Donno, Luca Mainetti, Luca Palano, Luigi Patrono, Maria Laura Stefanizzi, and Luciano Tarricone. "An IoT-aware architecture for smart healthcare systems." IEEE Internet of Things Journal 2, no. 6 (2015): 515-526.
7. Aminian M, Naji HR (2013) A Hospital Healthcare Monitoring System Using Wireless Sensor Networks. J Health Med Inform 4: 121. doi:10.4172/2157-7420.1000121
8. Zhang, G., Li, C., Zhang, Y., Xing, C. and Yang, J., 2012, October. SemanMedical: A kind of semantic medical monitoring system model based on the IoT sensors. In 2012 IEEE 14th International Conference on e-Health Networking, Applications and Services (Healthcom) (pp. 238-243). IEEE.
9. Jingjing, Yang, Hao Shangfu, Zhang Xiao, Guo Benzhen, Liu Yu, Dong Beibei, and Liu Yun. "Family health monitoring system based on the four sessions internet of things." Telkomnika 13, no. 1 (2015): 314
10. Yang, L., Ge, Y., Li, W., Rao, W., & Shen, W. (2014, May). A home mobile healthcare system for wheelchair users. In Proceedings of the 2014 IEEE 18th international conference on computer supported cooperative work in design (CSCWD) (pp. 609-614). IEEE.
11. ref
12. ref
13. I. Erguler, “A potential weakness in RFID-based Internet-of-Things systems”, Pervasive and Mobile Computing, vol. 20, pp: 115-126, 2015.
14. Piet. J.M.Bakker Monique W.M.Jaspers, “Journal of Biomedical Informatics”, Volume 44, Issue 2, April 2011, Pages 372-383, Received 27 March 2010, Available online 17 December 2010.
15. Alain Yee-Loong ChongFelix TS ChanKeng-Boon Ooi,” Predicting RFID adoption in the healthcare supply chain from the perspectives of users”, Article in International Journal of Production Economics 159 January 2014 with 139 Reads DOI: 10.1016/j.ijpe.2014.09.03
16. <https://blog.atlasrfidstore.com/7-things-can-track-hospitals-using-rfid>
17. <https://www.atlasrfidstore.com/rfid-readers/>
18. <https://www.atlasrfidstore.com/sensor-rfid-tags/>
19. Firouzi, Farshad, Bahar Farahani, Mohamed Ibrahim, and Krishnendu Chakrabarty. "Keynote paper: From EDA to IoT eHealth: promises, challenges, and solutions." IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems 37, no. 12 (2018): 2965-2978.
20. <https://www.healthitoutcomes.com/doc/edge> computing-and-healthcare-looking-to-the-future-0001
21. <https://dzone.com/articles/the-future-of-healthcare-starts-with-edge-computin>
22. Tan, Jasper, and Simon GM Koo. "A survey of technologies in internet of things." In 2014 IEEE International Conference on Distributed Computing in Sensor Systems, pp. 269-274. IEEE, 2014.
23. Solving the miz of the dimensional and one dimensional linear barcides in healthcare environments.“ https://www.zebra.com/content/dam/zebra\_new\_ia/en-us/solutions-verticals/product/barcode-scanners/imagers/solution-briefs/2d-scanner-healthcare-solutions-brief-en-us.pdf”