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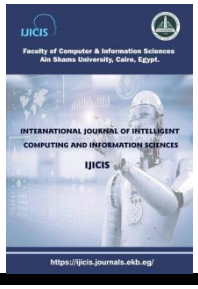

SMART Hospital Management Systems Based on Internet of Things: Challenges, Intelligent Solutions and Functional Requirements

Dalia Kamal A. A. Rizk*

Department of Computer Science, Faculty of Sciences and Engineering, The American University in Cairo, Cairo, Egypt
drizk@aucegypt.edu

Hoda M. Hosny

Department of Computer Science, Faculty of Sciences and Engineering, The American University in Cairo, Cairo, Egypt
hhosny@aucegypt.edu

El-Sayed M. El-Horbaty

Computer Science Department, Faculty of Computer & Info. Sciences, Ain Shams University, Cairo, Egypt
sayed.horbaty@yahoo.com

Abdel-Badeeh M. Salem

Computer Science Department, Faculty of Computer & Info. Sciences, Ain Shams University, Cairo, Egypt
abmsalem@yahoo.com

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Abstract: *Nowadays, Internet of Things (IoT) is invading almost all sectors of life since it is based on connecting living or non-living things together through computer technology. It is responsible for connecting physical objects together through the internet. Healthcare and hospitals are one of the most important sectors that require a lot of attention to transfer their old form of documentation into SMART management systems. It is essential to analyze health data in order to increase the quality of patient's care. Egypt being a development country is starting to substitute its old governmental systems into electronic SMART technology. IoT devices produce different types of data and transfer them to the cloud computing for storage and analysis. The benefits of using IoT in collecting, transferring, and analyzing patients' data for the hospitals are attracting a lot of researchers. Therefore, the arrangement of smarter and more money saving healthcare services are becoming highly required. Security and privacy, device communication, and data collection and management are some of the challenges that face the IoT technology especially when used with hospital's data. Accordingly, a proposed reference model for making SMART hospital management system is under construction in order to achieve the best performance. The model is taking into consideration both the functional and non-functional requirements of the different participants involved in the hospital management system.*

Keywords: *Internet of Things (IoT), Healthcare, Hospital Management System, SMART Healthcare.*

* Corresponding author: Dalia Kamal A. A. Rizk
Department of Computer Science, Faculty of Sciences and Engineering, The American University in Cairo, Cairo, Egypt
E-mail address: **drizk@aucegypt.edu**

1. Introduction

Internet of Things (IoT) is becoming one of the important topics in the Information Technology (IT) field. It is planned to transfer the real-world objects into virtual objects. It is intended to give the world not only the control of things, but also to learn the status of things [1]. This is clear from the many different disciplines using the IoT such as: education, industry, agriculture, healthcare, and so on. Since a special focus is being directed to the introduction of electronic technological communication devices in different sectors in the governments especially in those of the developing countries. Egypt is starting to mingle the different technology aspects in its various governmental sections. For example, [2] introduced a framework to help in decision-making regarding the IT infrastructure at the Ministry of Higher Education in Egypt. Their proposed framework gives guidance to choose between different technologies. It also helps in estimating how ready is the organization to implement this new technology. Another important sector that experiences the invasion of the usage of computer technology in its domain is the healthcare. The medical sector is one of the essential life sectors that requires a lot of investigation by the computer researchers. Hence, researchers are keeping the healthcare domain as a main sector for study. For example, [3] proposed an intelligent advisory system for decision-making based on artificial intelligence (AI) methods to diagnose and give the correct treatment for patients with X-ray images and/or hand-written text reports. Moreover, since the AI is a vital field for prediction and machine learning is one of its subsets, then this branch has penetrated in the IoT and cloud environment. This was illustrated when the authors of [4] used the machine learning techniques to predict the user's charging behavior in the cloud environment based on their charging history logs. They presented a model that minimize the number of transactions of charging requests, while maintaining the revenue steady. Accordingly, it is significant to have different testing activities for the IoT based systems. This was illustrated in [5] where they presented a framework for IoT-based test cases (TCs) prioritization. As a search-based technique, they used the local Hill Climbing (HC). They name their framework as the "IoT-based Enhanced Continuous Integration and Regression Testing Framework (IoT-ECIRTF)". The paper organization: in section 2 we overview the most significant related work, in section 3 we explain the challenges of IoT to smart hospital management systems, in section 4 we describe some real solutions for using IoT in healthcare systems and in section 5 our discussion is presented. Section 6 concludes the paper and points out directions for further work.

2. Background and Related Work

Nowadays, the introduction of information technology is becoming widely spread in the healthcare field. This is due to its accuracy, fastness of transferring data, and easiness of access.

2.1. Personal Reading Sensors

For example, in [6], they used the IoT technology to transfer the vital readings of the patient to an external place if needed. Their architecture is based on reading the primary values of the pulse, respiratory, and body temperature of the patient through a wireless wearable sensor. The readings of these sensors are to trace the patient till an extraordinary reading is being detected and an external intervention is needed. The architecture [6] proposed to use the Bluetooth Low Energy (BLE) as the way of communication for the healthcare IoT. Accordingly, the physicians can access their patients live

data whenever needed for critical patients. Figure 1 shows how the wearable sensors can transmit signals to be used for either tracking the patient's health status or contacting emergency if needed.

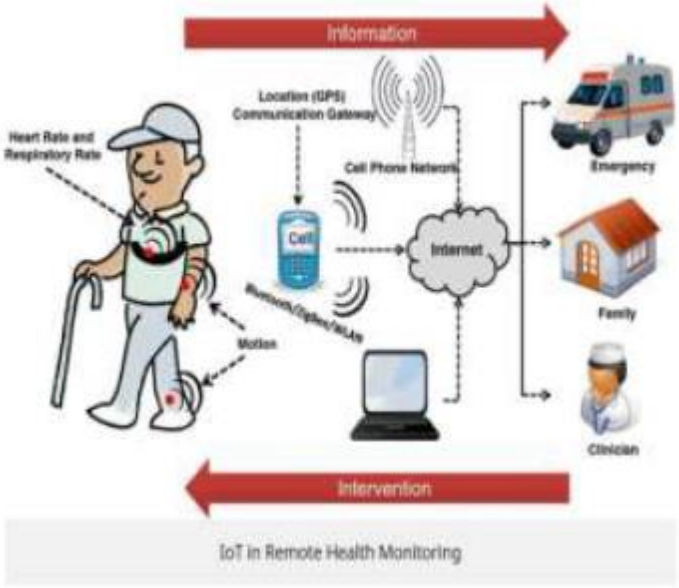

Figure 1: IoT in Healthcare (Adapted from [6])

Similarly, the architectural framework presented by [7] which targeted the usage of IoT for health-related matters. Here, the authors used a medical sensor as its main component to measure and upload to the cloud the therapeutic measurements. Furthermore, the proposed framework facilitated the access of the uploaded data by using certain smart phone applications.

2.2. Hospital Implementing IoT Technology

The usage of IoT is invading the healthcare sector in a tremendous and fast way due to its capabilities as shown in an Indian healthcare framework proposed by [8]. As a result of the huge number of populations in India and since it contains a lot of villages, the framework divided around each ten villages to be aided by a doctor at the "Gramin chikitsa seva kendras (GCSK)" [8]. This place offers limited medical services to these villages and also, collects data for each patient and records them in a smartcard. However, when a critical case occurs and the doctor is not able to handle the situation, the patient is transferred to the IoT furnished hospital where the patient's data has been already sent earlier. Hence, the proposed framework saved time and helped in providing the immediate healthcare to any patient.

This was also clear when the author in [9] introduced a solution for the hospital management system by using the technology of Internet of Things (IoT) where smart devices are connected by sensing devices and thus creating a lot of connections over the internet.

2.3. Bring Your Own Device (BYOD)

The author of [9] acknowledged the different problems that could face any hospital management system. He discussed the problems such as: connectivity, Bring Your Own Device (BYOD),

management, storage, and security as problems that can be faced. However, the presented solution used the IoT gateway to solve these problems by connecting the old communication networks with sensor networks. It also can handle the arriving data while taking into consideration the bandwidth and can manage devices with the appropriate protocol conversion. The proposed solution is based on device-to-device (D2D) communication as shown in figure 2, where this leads to a better device management system. This way of communication also, helps to obtain the important data in the real time and convert it to intelligent information. The author's solution [9] also included the topic of vehicle-to-vehicle (V2V) communication which is the transporting data wirelessly between motor vehicles. Accordingly, using both technologies D2D and V2V to collect data from the patient's devices and when a catastrophe happens to the patient, an alert is transformed to both the hospital for emergency and to the surrounding vehicles for attentive response.

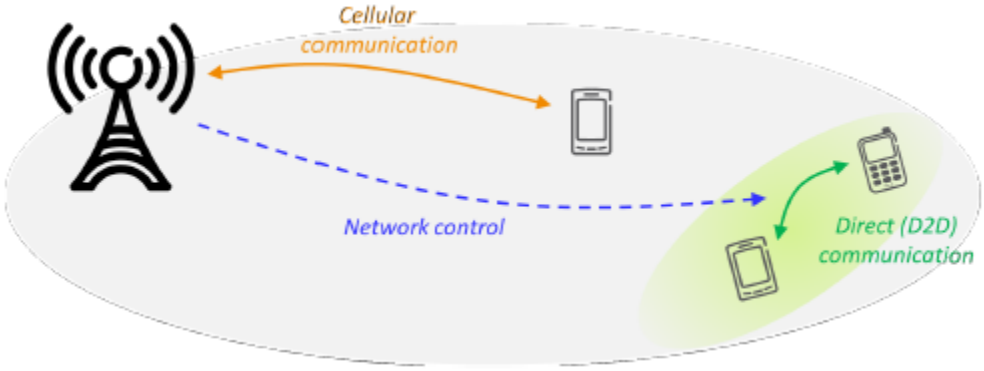

Figure 2: D2D Communication (Adapted from [9])

Another framework that took into consideration the IoT and Cloud technologies while acknowledging the usage of Bring Your Own Device (BYOD) has been proposed by [10]. The framework should contain different applications to provide access to the diverse stakeholders such as: physicians, patients, family members, hospitals, labs, pharmacists, or public legal authorities. Applications that are included in the framework could be: e-prescribing system, electronic health records (EHR), personal health records (PHR), clinical decision systems, and pharmacy system. Accordingly, the digitized health information for patients will be recorded and easily accessed.

3. Challenges of IoT to SMART Hospital Management Systems

Alike to the benefits of IoT to the healthcare sector, it also has some contests. This section discusses the challenges that the SMART hospital management system in specific and the healthcare sector in general face. Some of these challenges are being addressed by different researchers and have found adjustable solutions and others are still under investigation.

3.1. Inter-Realm Authentication

Challenges presented by [11] such as: inter-realm authentication and interoperability, health information exchange, and device communication all dispense into one huge challenge which is security and privacy. Inter-realm authentication deals with giving trust to transact digital health information for organizations that have many domains. The deficiency of interoperability for the inter-real

authentication can easily leads to the diminishing of data privacy. The obstacle for the wide distribution of the Health Information Exchange (HIE) systems is due to the fearfulness of security and privacy. Device communication deals with unalike manufacturer protocols for different sensors and servers leading to the loss of data privacy. Consequently, the theme of security and data privacy can be considered as the major challenge for adapting the IoT technology to the healthcare sector.
Additional challenges [11] for the IoT of smart hospital management systems could be the management of both collecting and organizing the data and designing and implementing the multi-disciplinary systems.

3.2. Security and Privacy

Subsequently, some researchers started to investigate the issue of security and data privacy for the medical division. For instance [12] who collected and presented a framework for the security requirements of the IoT, then applied them specifically to the smart healthcare services. They focused on certain security features such as: access control, integrity, authentication, confidentiality, network and system security. Figure 3 shows the framework which offers the smart oriented medical institution the following services: authentication, encryption, privacy protection, and key management. These services are offered through a smart healthcare manager that consists of information manager and certification manager. The proposed framework was tested and showed that it can contribute to the construction of safe healthcare services using IoT technology.

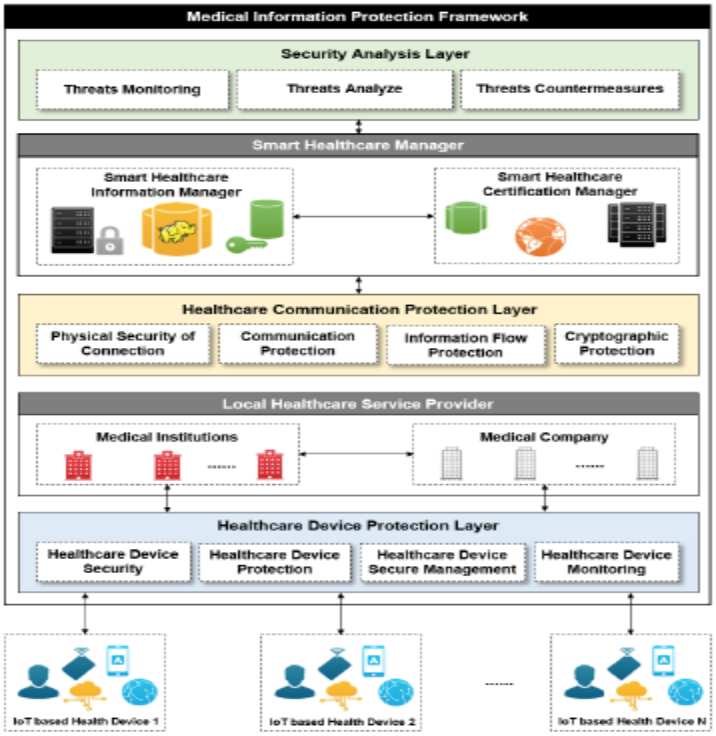

Figure 3: Framework for Medical Information Protection (Adapted from [12])

Another example that dealt with security, but for cloud computing clients, was proposed by [13]. They acknowledged the importance of data security for cloud users since each service needs different safety ways for protection. In [13], they produced a new model for data security in the cloud computing environment. They divided their model into four approaches, namely: Scheduling, Through-Off, Batch, and Virtual Machine Modes. The authors used the CloudAnalyst which is a CloudSim based application to test their algorithm. Accordingly, their proposed model showed interesting observations in security threats management along with the acceptance of the user accessibility.

Of course, it is hard to totally prevent all security dangers ahead of time because of the utilization of different gadgets and technical components especially when dealing with healthcare services. It is much harder to consider full security levels especially with IoT environment because of different usage of sensors that could have inadequate performance. However, the convention of information and communications technologies such as IoT and cloud computing are offering countless services in the medical sector especially when joint with the artificial intelligence technology through the usage of wearable devices [12].

4. Real Solutions for Using IoT with Healthcare Systems

The following section gives real solutions proposed for using the technology of IoT in the healthcare sector. According to [14] who did a survey to study the application of IoT services in the healthcare systems during the time of 2010 till 2016. They found out that most research on the use of IoT in the medical services area were forcing a few constraints that are based on the context or investigating specific domains for specific healthcare needs. However, little research was conducted for the sake of implementing IoT in hospitals. Thus, more investigation is expected to sum up the utilization of such models for emergency clinics as all current models intended for specific necessities to meet and fix the recent concerns.

Moreover, a new technological system which is called Cyber Physical Systems (CPS) has been proposed by [15] as shown in figure 4. It is expected to change the way of how people interact with the physical world where it simplifies the orderly conversion of enormous data into information. The authors are presenting an architecture using the CPS and the wireless sensor networks (WSNs) for the use of healthcare applications in the cloud computing. The architecture is divided into three parts based on the usage of healthcare applications such as monitoring and decision support systems. The first part in the architecture is the communication part, then the computation part, and the final part for the proposed CPS healthcare architecture is the resource management part. The created CPS for machine tools can be utilized to develop and examine working data, survey the health status of serious parts and then improve the general effectiveness and dependability of the equipment by foreseeing the approaching failures.

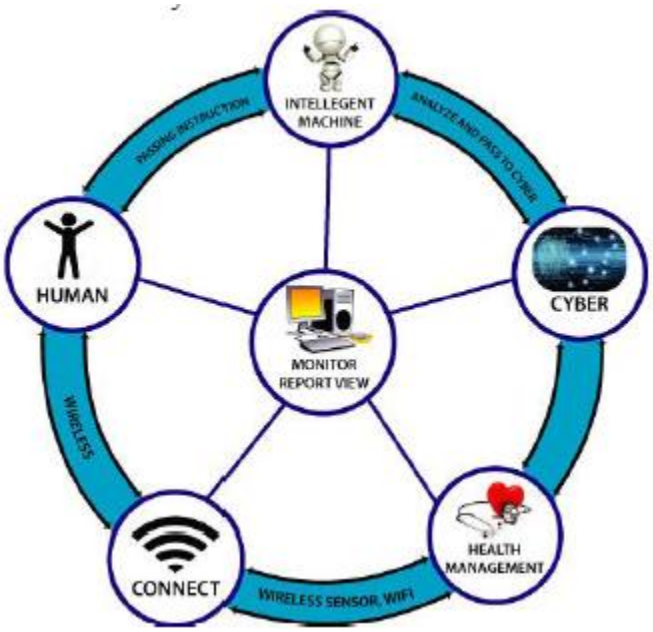

Figure 4: CPS Workflow Cycle (Adapted from [15])

Therefore, the authors [15] here talked about the usage of many latest technologies such as: IoT, sensors, Wireless Sensor Networks (WSN), RFID technology, intelligent connection, data to information conversion, cyber, cognitive device, knowledge base, and computer numerical control (CNC). Furthermore, the proposed architecture of CPS is equipped for computerizing and unifying data processing, healthcare evaluation and visualization. It also goes through all the important steps to obtain data, process information, introduce to the clients, and then support decision-making. Finally, a case study was presented to show the joining of CPS architectural features to manage and process the computer numerical control (CNC) machines which are commonly used for production. It can be considered as an introduction to a new convention to the healthcare sector to help in processing the data and taking decisions accordingly.

The importance of analyzing health data is not only to increase the quality of patient care, but also to decrease the costs of healthcare usage. Since the Internet of Things (IoT) devices are producing a huge amount of data and transferring them to the cloud computing for storage and analysis, then this will delay the development of healthcare services that relies on time.

Accordingly, the authors of [16] presented a framework that collected health data from different wired/wireless sensors and transmitted them to a secure Edge-of-Things (EoT) layer. Figure 5 shows the architecture of the proposed EoT framework. Its importance does not only lie in transferring data, but it also has the capabilities of real-time analytic services. This layer does a partial real-time analysis on the biosignal data to determine abnormal ones and accordingly send smart decision-making to clients. This layer also, sends the input health data along with the analyzed ones to the cloud computing for further analysis and to be saved due to its huge quantity. Therefore, the EoT acts as a middle computing layer between IoT actuators and the cloud computing as it has the ability of real-time computing and storage properties, but on a smaller scale than cloud computing. The architecture of their framework is designed to accomplish specific tasks which are data aggregation, safe storage, and finally analysis of data. The

proposed EoT [16] framework uses a Fully Homomorphic Encryption (FHE) to protect the sensitivity of the patient's data and to analyze these data in an encrypted domain. In order to analyze the large and heterogenous amount of data, the authors [16] developed a distributed method for clustering-based techniques which are considered an appropriate tool for providing clinical decision-making. They used two clustering-based techniques which are: "K-Means Clustering (KMC) and Fuzzy C-Means Clustering (FCMC)". Finally, they did an experimental evaluation to their proposed framework using the "Google Cloud Platform (GCP)" and "a real heart disease dataset from the University of California Irvine's (UCI)". They showed how their framework performs from an accuracy and execution time points of view.

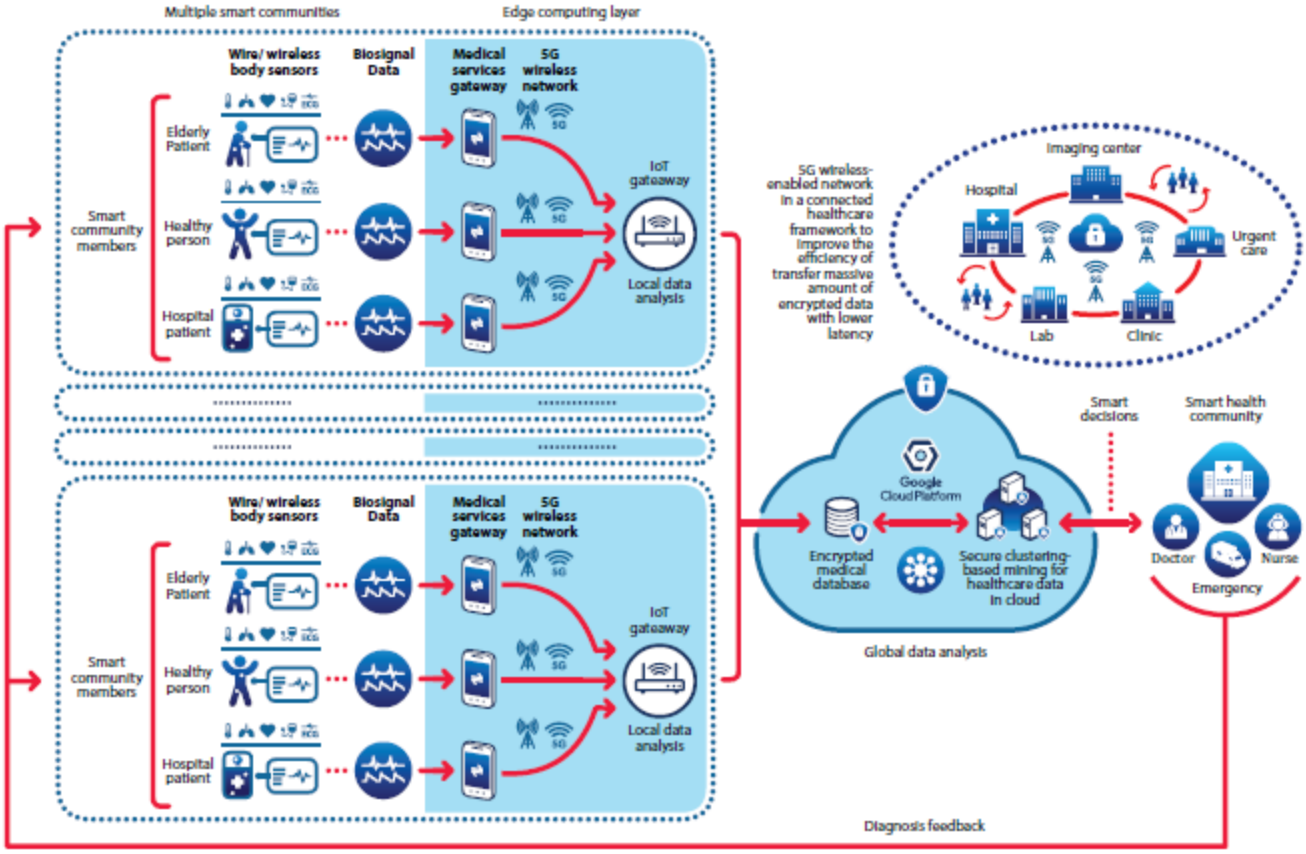

Figure 5: Architecture of EoT Framework (Adapted from [16])

Additionally, the significant objectives of healthcare systems are to have a low cost along with high efficiency and easy accessibility healthcare services. A cognitive Internet of Things (IoT)-cloud-based smart healthcare monitoring framework has been proposed by [17,18] as shown in figure 6. The framework consists of smart sensor devices that are constantly reading the movements, gestures, and facial expressions of the patient and recording them as physiological and psychological data. In order to read and record these data, the framework used the cloud and the cognitive IoT technologies. The cognitive system is analyzing the patient's data all the time and providing the best actions in the real time. Moreover, if a critical case occurred, the cognitive system warns the medical staff through sending to the healthcare provider and contacts the smart ambulance if needed. The framework used the electroencephalogram (EEG), and its seizure detection cases as its testbed. Accordingly, the signals coming from the IoT EEG smart sensors are sent to the smart devices such as smartphones or laptops,

then they are furtherly sent to the cloud. The data are being processed by the proposed seizure detection system based on their severity. Hence, if the cognitive system detects a seizure case, a notification is sent to the appropriate stakeholders and the patient's data are sent to the deep learning module proposed by the framework [17,18]. Finally, the evaluation of the system based on its detection and classification gave an accuracy of 99.2% and sensitivity of 93.5% as their results.

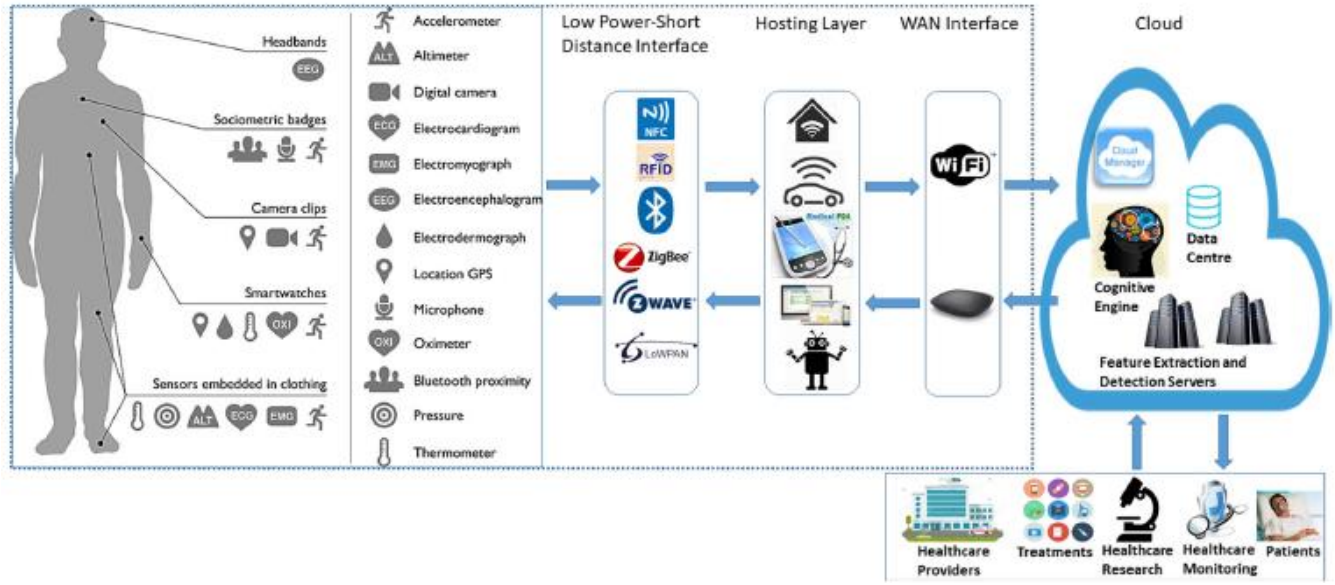

Figure 6: Cognitive IoT-Cloud SMART Healthcare Framework (Adapted from [17])

Moreover, another solution for the usage of IoT in smart healthcare systems was proposed by [19]. The proposed architecture was divided into two sub-architectures: Meta fog-redirection (MF-R) and Grouping and Choosing (GC). The MF-R architecture is for collecting, transferring, and storing the data. The GC architecture is responsible for securing the data while being transferred from the Fog to the Cloud computing. The MF-R architecture is based on collecting health data mainly: heart rate, respiratory rate, body temperature, and blood pressure and sugar level through the IoT sensors. The IoT readings are compared against the clinical limits, and when are not within these limits, a voice notification message along with the readings are sent to the physicians through the Fog computing. On the other hand, if the readings are fine then they are transferred to the Cloud computing for storage. Accordingly, one of the key requirements of transferring big data to the Cloud is data security and here the architecture of the GC is introduced. This architecture is used to prevent any unauthorized trials of accessing the big data on the cloud. It also, protects against any intruders during the transferring phase from the Fog to the Cloud computing. The GC architecture depends on receiving the data from the IoT devices and sending them to the fog by using the near edge technology. This technology works on reducing the bandwidth and thus taking less time for collecting and transferring data. The GC architecture also classifies the data read by the IoT devices into Sensitive, Critical, and Normal by using a data categorization function to achieve the security services of the storage phase. Additionally, the proposed framework offered a prediction model for to anticipate the heart diseases patients. Finally, the authors [19] assessed the performance of their proposed framework by measuring the CPU usage and

the inter arrival time. They also evaluated the framework against other metrics such as: "Sensitivity; Specificity; Precision; recall and F-Measure".

5. Discussion and Methodology Adapted

Nowadays, the customary process in the medical healthcare systems is to track the patient's vital readings such as: blood pressure, temperature, heart rate, and respiratory rate. These readings are considered as an indicator for the criticalness of the patient. Accordingly, the IoT technology helped so much in recording these readings without interfering in the patient's daily activities. These IoT devices could be small in size and thus could be implemented in smart wearable watches, clothes, jewelries, glasses, or in the smart phones. Therefore, they can help in remote monitoring and easily accessing the patient, thus improving the healthcare, time, and treatment managements. Moreover, the information collected by the IoT devices are easily transferred to the cloud computing mainly for storage. Analysis and interpretation of these information could also be done at the cloud or at the edge computing or at the fog computing technologies based on the required rapidity of the analyzed data. It is believed that the fog and the edge computing technologies have higher processing capabilities than the cloud computing. The most focused drawback of IoT along with other technologies as cloud computing is the security and privacy of data while reading and transferring. However, since the obstacle is clear then many solutions can be proposed for resolving it. Accordingly, to have a reference model for building up a complete SMART healthcare system, there should be a minimum of requirements. In other words, each healthcare system should contain a group of fixed functional and non-functional requirements to act as the basic structure for this system. Additional requirements could be added along the way based on additional extensions, innovations, or necessities. Hence, based on the readings of [20 – 24], the essential functional and non-functional requirements for the SMART healthcare systems are listed below in table 1.

Table 1 Essential Functional and Non-Functional Requirements for the SMART Healthcare Systems

Functional Requirements	Non-Functional Requirements
Ease of Usage	Security and privacy
Self-Services	Maintainability
Data Sharing (Global)	Availability
Access Control	Performance

6. Conclusion and Future Work

The medical community needs to be provided with the accurate information about the patient at the correct time to take the right decision. Patients can be treated during their course daywork without being interrupted through using SMART healthcare systems. The importance of the notification timing of the patient's status lies in saving this patient's life. The usage of IoT is known for its diverse proficiencies in different aspects. It helps in providing the data quickly to be either stored, recovered, or processed. In the field of healthcare systems, IoT can be of a great asset with the momentary medical readings of patients. It also can help with other healthcare activities such as image capturing and drug supervision.

From our point of view, there should be minimum requirements to act as a base for any healthcare architecture. However, in this research, we showed that there were no standards for building a SMART architecture for the healthcare systems. Previous studied frameworks showed that they were established based on specific needs per each application. They were tailored for precise organization or field needs. The proposed methodology targets the basic requirements for the healthcare systems using the IoT technology. It takes into consideration the importance of handling critical cases where an alert should be sent to the care giver to evaluate the severity of the case. Time and security are not only the critical requirements for the medical community, but also, the accuracy of health data and the punctuality. Data being collected are to be saved using the cloud computing technology. Accordingly, a list of both functional and non-functional requirements has been proposed in this methodology along with their implementation to show the best practices needed for achieving the ideal performance of healthcare systems. It is intended to implement this architecture in the real medical field and examined by the different medical stakeholders.

References

1. S. Madakam, R. Ramaswamy, S. Tripathi, Internet of Things (IoT): A Literature Review, Journal of Computer and Communications 3 (2015) 64-173.
2. K. Ali, S. Mazen, E. Hassanein, A Proposed Framework for the Organization Readiness Assessment of IT Innovation Adoption in E-Government Environment, International Journal of Intelligent Computing and Information Science 17(3) (2017) 33-50.
3. A. Amin, A Medical Probabilistic Advisory System (MPAS) Based on Independent Artificial Intelligent Techniques to Support Decision-Making, International Journal of Intelligent Computing and Information Science 20(1) (2020) 28-43.
4. K. Ibrahim, M. Aborizka, F. Maghraby, Prediction of Users Charging Time in Cloud Environment Using Machine Learning, International Journal of Intelligent Computing and Information Science 18(2) (2018) 39-57.
5. N. Mohamed, S. Moussa, N. Badr, M. Tolba, Enhancing Test Cases Prioritization for Internet of Things Based Systems Using Search-Based Techniques, International Journal of Intelligent Computing and Information Science 21(1) (2021) 84-94.
6. S. Qamar, A. Abdelrehman, H. Elshafie, K. Mohiuddin, Sensor Based IoT Industrial Healthcare Systems, International Journal of Scientific Engineering and Science 2 (2018) 29-34.
7. D. Rajput, R. Gour, An IoT Framework for Healthcare Monitoring Systems, International Journal of Computer Science and Information Security 14 (2016).
8. A. Kakkar, Shaurya, An IoT Equipped Hospital Model: A New Approach for E-governance Healthcare Framework, International Journal of Medical Research & Health Sciences 8 (2019) 36-42.
9. M. Rahman, Smart Hospital System Depending on IoT. https://www.academia.edu/25158626/Smart_Hospital_System_depending_on_IoT, 2016 (accessed 6 June 2021).
10. S. Tyagi, A. Agarwal, P. Maheshwari, A Conceptual Framework for IoT-based Healthcare System using Cloud Computing, In: the India IEEE, 2016, p. 503-507.

11. S. Zeadally, F. Siddiqui, Z. Baig, A. Ibrahim, Smart Healthcare Challenges and Potential Solutions Using Internet of Things (IoT) and Big Data Analytics, Emerald Insight 4 (2019).
12. J. Choi, C. Choi, S. Kim, Medical Information Protection Frameworks for Smart Healthcare based on IoT, In: the Proceedings of the 9th International Conference on Web Intelligence, Mining and Semantics, 2019, p.1-5.
13. S. ElAshry, M. El-dosuky, M. Rashad, H. Abdelkader, A Novel Security Model for Data Management in Cloud Computing, International Journal of Intelligent Computing and Information Science 16(1) (2016) 59-69.
14. MA. Dauwed, A. Meri, A. Fahad, N. Hashim, Sh. Omar, Classification of Internet of Things (IoT) Models in Healthcare Systems, In: the 2nd International Conference on ICT in Education, 2017.
15. O. Rahaman, A. Shuvo, M. Abul Kashem, Cyber Physical Systems for Healthcare, International Journal of Advanced Research 6(10) (2018) 36-46.
16. A. Alabdukatuf, I. Khalil, X. Yi,M. Guizani, Secure Edge of Things for Smart Healthcare Surveillance Framework, In: the IEEE Access, 2019, p.31010-31021.
17. M. Alhussein, G. Muhammad, MS. Hossain, SU. Amin, Cognitive IoT-Cloud Integration for Smart Healthcare: Case Study for Epileptic Seizure Detection and Monitoring, Mobile Networks and Applications 23 (2018) 1624-1635.
18. M. Alhussein, G. Muhammad, MS. Hossain, SU. Amin, A. Rahman, Cognitive Smart Healthcare for Pathology Detection and Monitoring, In: the IEEE Access, 2019, p. 10745-10753.
19. G. Manogaran, R. Varatharajan, D. Lopez, P.M. Kumar, R. Sundarasekar, C. Thota, A New Architecture of Internet of Things and Big Data Ecosystem for Secured Smart Healthcare Monitoring and Alerting System, Future Generation Computer Systems 82 (2018) 375-387.
20. F. Liu, J. Tong, J. Mao, R. Bohn, J. Messina, L. Badger, D. Leaf, NIST Cloud Computing Reference Architecture, National Institute of Standards and Technology, U.S Department of Commerce, Special Publication (2011) 500-292.
21. C. Pino, R.D. Salvo, A Survey of Cloud Computing Architecture and Applications in Health, In: the Proceedings of the 2nd International Conference on Computer Science and Electronics Engineering, 2013.
22. IT Reference Architecture for Healthcare, ATOS. https://atos.net/wp-content/uploads/2016/06/atos-itah-architecture-for-healthcare-whitepaper.pdf, 2011 (accessed 6 June 2021).
23. S. Devata, A. Olmsted, Modeling Non-Functional Requirements in Cloud Hosted Application Software Engineering, The Seventh International Conference on Cloud Computing, GRIDs, and Virtualization (2016) 47-50.
24. K. Daimi, L. Li, X. Lu, N. El-Nazeer, Requirements Engineering for Home Health Care Software Systems, In: the Proceedings of the 2010 International Conference on Software Engineering Reseach and Practice, 2010, p. 83-91.