International Journal of Sensors

Review Article
Published: 28 Mar, 2019

Study and Analysis of Sensors in a Smart Hospital System

*Lakhoua Mohamed Najeh**

Research Laboratory Smart Electricity and ICT, SEICT, University of Carthage, Tunisia

Abstract

Smart hospital system is original and complete hospital automation software that suites to approximately every hospital or medical institution from patient visits to operation to pathology test. The objective of this paper is to present a review on sensors used in a smart hospital system. In fact, hospitals are required to do more with less, while also keeping speed with technology and patient expectations. Excellence in hospitals results, efficiency in the supply chain and improvement of the patient experience are the drivers behind developing medical facilities that meet healthcare needs now and in the future. Then, an application for monitoring patients and some methods for the analysis and modeling are presented.

Keywords: Smart hospital system; Sensors; Monitoring; System modeling

Introduction

A hospital is a health care institution providing patient treatment with specialized medical and nursing staff and medical equipment. Currently, hospitals are mainly staffed by professional physicians, surgeons, nurses, and allied health practitioners, whereas in the past, this work was usually performed by the members of founding religious orders or by volunteers.

The hospital is a center of healthcare services that, nowadays, can be considered as a highly technological corporation. Then, the integration of Information and Communication Technology (ICT) in the healthcare sector has been one of the important areas of research since last two decades.

Smart hospitals systems consist of functions of sensing, actuation, and control in order to represent and analyze a situation, and make decisions based on the accessible data in a predictive or adaptive manner, thereby performing smart actions [1]. In fact, a healthcare system is the organization of people, institutions, and resources that deliver health care services to meet the health needs of target populations.

Based on the advancements in healthcare our perception of healthcare is changing quite fast. For any standard existing Hospital Information System there are several main problems that hinder automation like, fixed information point or inflexible networking mode [2].

Improving patient flow is a way to refine health services. In fact, an efficient patient flow can improve the quality of services and the utilization of resources. A smart environment could facilitate the experience of individuals within a physical space, such as a hospital. Meanwhile, a smart healthcare environment could improve patient flow through an efficient scheduling policy and the utilization of healthcare resources by an optimized capacity plan [3].

This paper can be loosely divided into four parts: First, we present the need for monitoring for smart hospital systems. Then, we present a review on smart hospitals systems in particular the use of sensors. In section three, we present a method for structured analysis of smart hospital systems and application for monitoring patients. Finally, the last section presents conclusion and future work.

Monitoring of Smart Hospitals Systems

Healthcare is very important feature in every body's life and Information technology. It is playing an important role in providing better health with number of advancements [4].

Monitoring and supervision concepts are also essential. Talking about supervision implies a hierarchical organization of the smart hospital system. Supervision optimizes its operation and ensures safety. Monitoring is used to detect anomalies without necessarily acting directly on the system. In this case it is a help to the human operator, a tool that can be used to better fulfill his task.

Continuous monitoring and gathering of vital signs are important for the treatment of critical care patients in the hospital. In fact, surveillance is the monitoring of behavior, activities, or other

OPEN ACCESS

Correspondence:
Lakhoua Mohamed Najeh, Research Laboratory Smart Electricity and ICT, SEICT, National Engineering School of Carthage, University of Carthage, Tunisia,
E-mail: MohamedNajeh.Lakhoua@enicarthage.rnu.tn

Received Date: *20 Feb 2019*
Accepted Date: *25 Mar 2019*
Published Date: *28 Mar 2019*

Citation:
Najeh LM. Study and Analysis of Sensors in a Smart Hospital System. Int J Sens. 2019; 1(1): 1001.

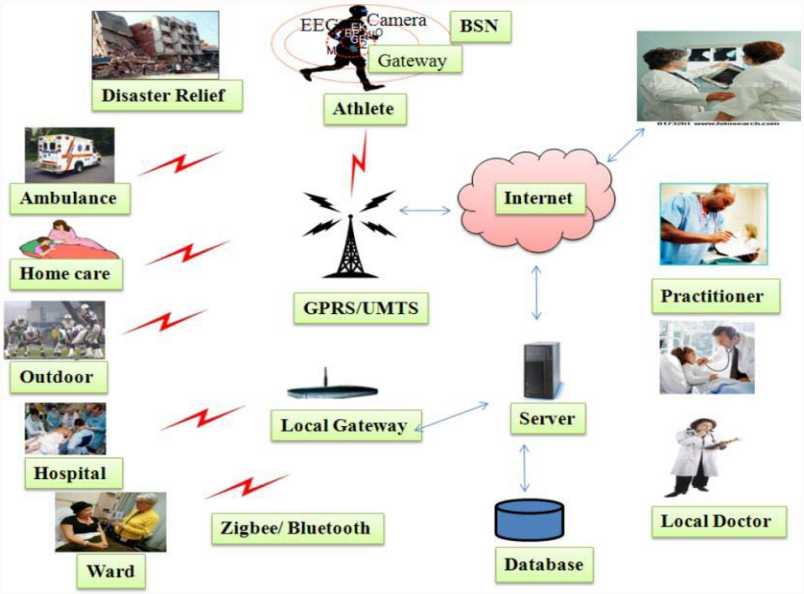

Figure 1: Example of a healthcare application [7].

changing information for the purpose of influencing, managing, directing, or protecting people [5,6].

Figure 1 shows an example of a healthcare application using wireless medical sensor networks [7].

Review on Smart Hospitals Systems

The development of information system in smart hospital systems has been presented in various researches. In fact, Information Systems is an academic study of systems with a specific reference to information and the complementary networks of hardware and software that people and organizations use to collect, filter, process, create and also distribute data.

Researchers Fariborzi and Moghavvemi [8] have proposed the architecture of a ubiquitous healthcare system for hospitals and care institutions which is based on application of wireless sensor networks. This system aims to obtain vital signals like ECG and body temperature from multiple patients and transmit it through wireless network to the network coordinator node which is under direct supervision of physician and expert hospital staffs. The wireless nodes that have been utilized for demonstration of the system are Tmote sky from Moteiv, which are compatible with IEEE 802.15.4 standard and emerging Zigbee technology for low power applications. To establish and maintain the network for large number of mobile nodes and increase the network lifetime, mesh topology and an energy-aware link-quality-based version of source routing protocol has been used in this system.

Researchers Park et al. [9] have presented that according to development of medical communication system concerned with diagnosis, IT convergence technology like PACS and sensor network is considered in hospitals environment. Zigbee among these various network technologies highlighted sensor networks because of low power, low cost for system composition and good network acceptance. However, the maximum transmission distance of the Zigbee is less than 100 m. Furthermore, Zigbee can be interfered from WLAN and Bluetooth. To solve these problems, a novel interoperation technology of the wireless and wired sensor networks has been proposed in this paper. The new technology is based on the CATV network which is usually constructed in hospitals. Therefore, additional infrastructure is not needed for the interoperation. The proposed method enables us to a stable and economical communication.

Researchers Nadeem et al. [10] have presented an application of Radio Frequency Identification (RFID) technology in healthcare sector to give better, reliable and secure services. RFID systems are integrated into hospital information systems and offer full automation and streamline the significant modules of patient identification, staff allocation, doctors, medicines and treatments. The authors have proposed RFID based conceptual framework for smart hospital management system which provides a safe and secure patient data management system. They also emphasize the importance of RFID in healthcare domain with the assist of an example case study with a working prototype application.

Researchers Chaczko et al. [11] have proposed an approach in architecting solutions which can be used as framework to address general issues in integration of enterprise level solutions. The methodologies discussed in TOGAF version 9 are used to demonstrate the feasibility of proposed solution. The authors have introduced the problem space/scenarios, constraints, requirements, enablers, risks, sample legacy application architectures and proposed integration solution presented with TOGAF components. The growing number of waiting lists, rising pressure on medical professionals and accountability for medical negligence are only part of the motivation to take initiative towards holds a core model integration strategy in various legacy infrastructure systems.

IoT in smart hospital systems has been presented in various researches. In fact, IoT is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect and exchange data, creating opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions.

Researchers Muhammad et al. [12] have presented IoT based

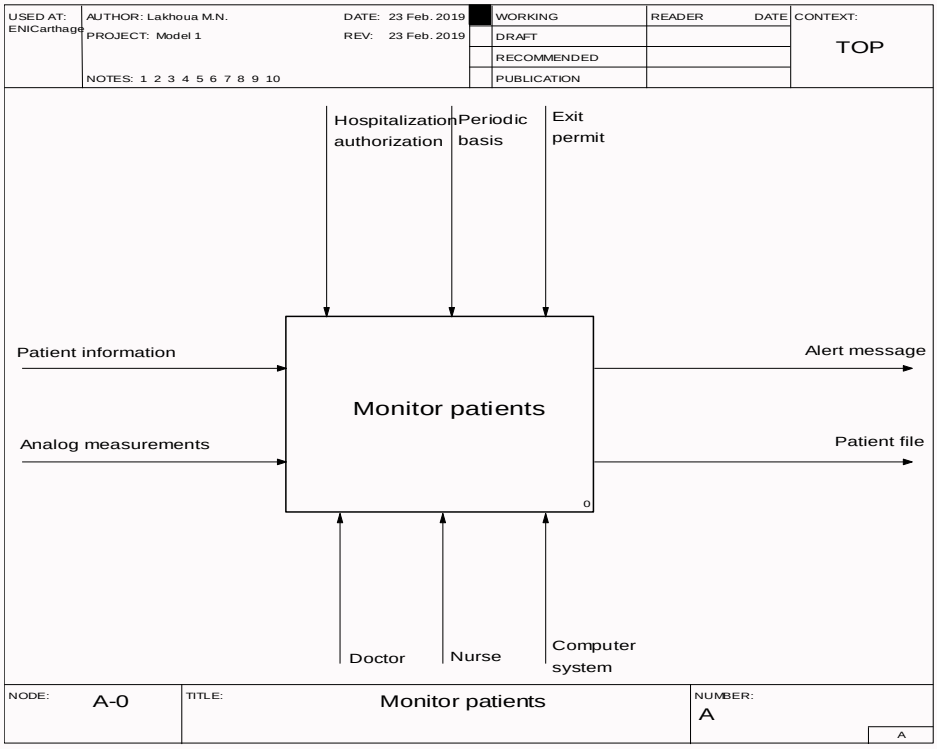

Figure 2: Node A-0 of the SADT model.

architectural framework with context awareness for hospital management systems. They have used context awareness as middleware above network layer to overcome the problem of data management. Furthermore they did survey to investigate the decision to adopt the IoT based system in Pakistani Hospitals. Survey was questionnaire based. The accumulated results indicate that participants want to accept this system and most of the population agreed that IoT based HMIS would offer better monitoring, communication and early diagnosis.

Researchers Zhang et al. [13] have proposed architecture to connect intelligent things in smart hospitals based on NB-IoT, and introduce edge computing to deal with the necessity of latency in medical process. As a case study, they have developed an infusion monitoring system to monitor the real-time drop rate and the volume of remaining drug during the intravenous infusion. Finally, they have discussed the challenges and future directions for building a smart hospital by connecting intelligent things.

Researcher Catarinucci et al. [14] have proposed a novel, IoT-aware, smart architecture for automatic monitoring and tracking of patients, personnel, and biomedical devices within hospitals and nursing institutes. Staying true to the IoT vision, they have proposed a smart hospital system, which relies on diverse, yet complementary, technologies, specifically RFID, WSN, and smart mobile, interoperating with each other through a Constrained Application Protocol (CoAP)/IPv6 over low-power wireless personal area network (6LoWPAN)/representational state transfer (REST) network infrastructure. The simple proof of concept implemented to validate the proposed a smart hospital system has highlighted a number of key capabilities and aspects of novelty, which represent a significant step forward compared to the actual state of the art.

The scheduling and monitoring of smart hospital systems has been presented in various researches. In fact, scheduling is the method by which work specified by some means is assigned to resources that complete the work. The work may be virtual computation elements such as threads, processes or data flows, which are in turn scheduled onto hardware resources such as processors, network links or expansion cards.

Researchers Gonnot et al. [15] have presented that modern hospitals are equipped with a variety of medical devices for the care of the patients. A particular group of devices are the ones that monitor the patients' vitals such as heart rate, oxygenation or blood pressure. Monitoring these vitals allows the doctors and nurses to respond quickly in case a patient's condition is degrading and even to save his life. The disadvantages of such a system are that it is usually bulky, and patients who are wired cannot move away from the room. This paper proposes an efficient monitoring infrastructure for hospitals using compact and wireless devices that can be worn by every patient at all time, transmitting real-time data to a central place, which can be accessed by the doctors for expert diagnosis.

Researchers Wang et al. [16] have explored a dynamic scheduling policy to get better the patient flow, and an efficient capacity scheme based on the varying patient flow. This scheduling policy and the capacity scheme can be built in a smart hospital environment through wireless sensor networks and smart healthcare systems. The research applies a formal modeling approach that can give a quantitative analysis of systems. This approach, performance evaluation process algebra, can give strict definitions for the patient flow in order to model the dynamic scheduling policy and the capacity scheme; moreover, it provides a scalable performance analysis by the fluid flow approximation. Finally, this paper is concerned with how formal method might be used to model and analyze the scheduling policy and the capacity plan on improving the healthcare service previous to exploitation.

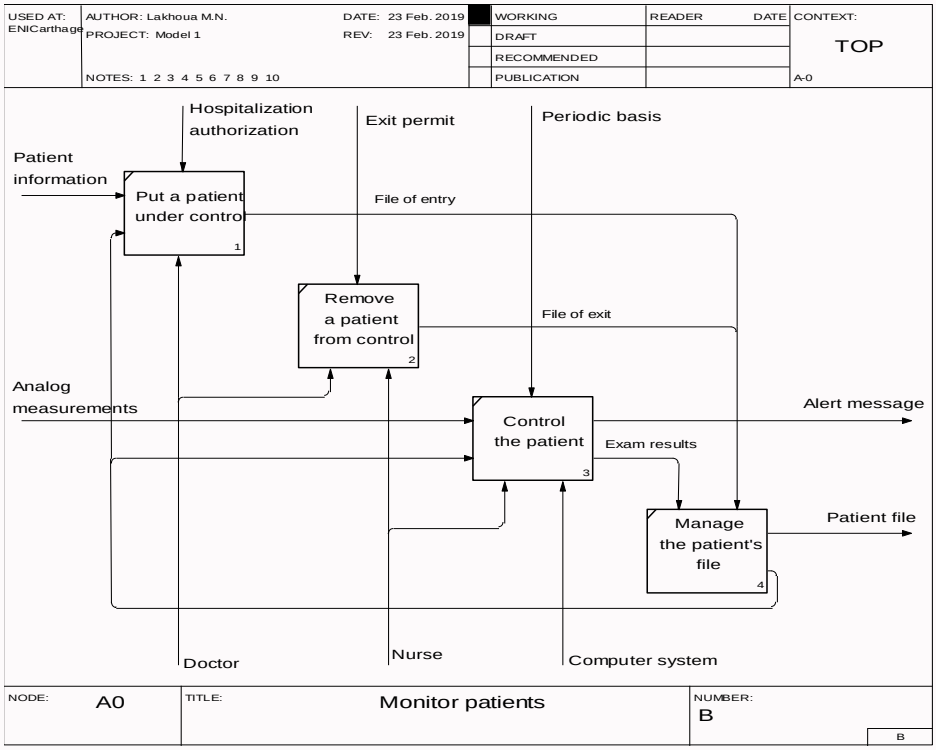

Figure 3: Node A0 of the SADT model.

Researchers Guru et al. [17] have presented a Smart Hospital Gown that contains one or more compute units, a multitude of sensors for collecting the patient's temperature, breathing rate, sweating, pulse rate, and other vital information. The patient can just wear the gown without requiring any additional external wires or sensors/monitors to be attached to the patient. In this demo, they have demonstrated the Smart Hospital Gown and showed its user friendliness and usefulness in providing a better, low-cost, and incessant monitoring system for critical care patients.

Analysis and Modeling of Smart Hospital Systems

The methods of analysis and modeling consist in solving a problem while using them according to the established rules and permitting to describe the evolution of the system [18,19].

Analysis system, or system approach, belongs today to the scientific current that analyzes the elements of complex processes as components of a together where they are in relationship of dependence mutual. His area of study is not limited to the mechanisation of idea: systemic analysis is a methodology that organizes information to optimize action. The system approach aims to simplify any complex, lead to a model that allows acting on it, once we have understood its hardware configuration and dynamic structure [20,21].

A team of a method development must be composed of members having a big experience in the methodology and modeling languages [22].

For the system modeling, there are numerous methods oriented functions, or decisions, or organization or reorganization, or information, or resources.

Presentation of SADT method

The SADT (Structured Analysis Design Technique) represents an image of the system. It is a method of analysis to understanding why a system exists, or must be designed, what functions it must fulfill and finally, how they are realized, and whatever of the complexity [23]. The method is based on a graphical model, proceeds by down approach in the sense that are going from general to more detailed, by focusing on system activity [24].

The purpose of SADT is to recognize and model, in an information flow diagram, decision-making processes and management tasks related with systems. SADT is a graphical language, generally used for the analysis of complex the specifications of a system during the design but can also apply to existing system [25].

Analysis of monitoring patients

A program of monitoring of patients is required for a hospital [26]. Each patient is monitored by an analog device that measures parameters such as: heart rate, temperature, blood pressure, etc. The program reads the parameters on a periodic basis (specific to each patient) and stores it in a database. For each patient, safe limits are specified by parameters (ex.: patient X permitted temperature between 36.5 and 37.5). If a setting out safety limits or an analog device goes down, the nurse station is informed.

Figure 2 presents a representation of the node A-0 of the SADT model. This diagram contains the following data: patient information, analog measures, authorization of hospitalization, periodic basis, discharge, alert message, and patient file. We take the following activities media: doctor, nurse, computer system.

Figure 3 presents a representation of the node A0 of the model SADT. This diagram contains the following activities: place a patient under control, remove a patient from control, check the patient and

manage the patient's record.

Conclusion

In this paper, we have presented the critical component for smart hospital systems which is the ability to provide a valuable service of insight, which was simply not possible or available earlier. So, a review on smart health systems and sensors used are presented.

The system modeling allows us to describe exchanges of information among the diverse components of a smart hospital system and the diverse parameters presented in the constitution of models. This is why the need for a system approach has been presented.

The SADT method seems adapted to the modeling of smart hospital systems for at least one reason: this method applies perfectly to the multi-technological systems, that is to say, it adapts to electric, electronic and software systems that we get in a smart hospital system.

References

1. Varadan K. Handbook of Smart Systems and Materials. London: Inst of Physics Pub; 2005.
2. Alter S. Work System Theory: Overview of Core Concepts, Extensions, and Challenges for the Future. J Assoc Inf Syst. 2013;14(2):72-121.
3. Jemal H, Kechaou Z, Ben Ayed M, Alimi AM. A Multi Agent System for Hospital Organization. IJMLC. 2015;5(1):51-6.
4. Wigmore I. Internet of Things (IoT). TechTarget. 2014.
5. Lyon D. Surveillance Studies: An Overview. Cambridge: Polity Press; 2007.
6. Hamdani MA, Nasri A, Zairi H. Design of a microwave biosensor using a defected CSRR for cancer cells characterization. IEEE 4th Middle East Conference on Biomedical Engineering (MECBME); 2018 Mar 28-30; Tunis, Tunisia. New Jersy: IEEE; 2018. P. 7-10.
7. Kumar P, Lee HJ. Security Issues in Healthcare Applications Using Wireless Medical Sensor Networks: A Survey. Sensors (Basel). 2012;12(1):55-91.
8. Fariborzi H, Moghavvemi M. Architecture of a Wireless Sensor Network for Vital Signs Transmission in Hospital Setting. International Conference on Convergence Information Technology (ICCIT 2007); 2007 Nov 21-23; Gyeongju, South Korea. South Korea: IEEE; 2007. p. 745-9.
9. Park JY, Cha Y, Kang S, Jin K, Hwang JA. Interoperation of wired and wireless sensor networks over CATV network in hospitals. 2nd International Conference on Mechanical and Electronics Engineering; 2010 Aug 1-3; Kyoto, Japan. IEEE; 2010. p. 420-3.
10. Nadeem M, Shah A, Waqas A, Bhatti Z, Abubakar A, Abid Malik HM. RFID based smart hospital management system: A conceptual framework. The 5th International Conference on Information and Communication Technology for The Muslim World (ICT4M); 2014 Nov 17-18; Kuching, Malaysia. IEEE; 2014. P. 1-6.
11. Chaczko Z, Chiu C, Kohli AS, Mahadevan V, editors. Smart Hospital Management System: an integration of enterprise level solutions utilising open group architecture framework. 3rd International Conference on Computer Science and Information Technology; 2010 July 9-11; Chengdu, China. China: IEEE; 2010. p. 8-15.
12. Muhammad P, Akram MU, Khan MA. Survey Based Analysis of Internet of Things Based Architectural Framework for Hospital Management System. 13th International Conference on Frontiers of Information Technology (FIT); 2015 Dec 14-16; Islamabad, Pakistan. IEEE; 2015. p. 271-6.
13. Zhang H, Li J, Wen B, Xun Y, Liu J. Connecting Intelligent Things in Smart Hospitals Using NB-IoT. IEEE Internet of Things Journal; 2018 Jan 12; China. China: IEEE; 2018. p. 1550-60.
14. Catarinucci L, de Donno D, Mainetti L, Palano L, Patrono L, Stefanizzi ML, et al. An IoT-Aware Architecture for Smart Healthcare Systems. IEEE Internet of Things J; 2015. p. 515-26.
15. Gonnot T, Yi W, Monsef E, Govindan P, Saniie J. Sensor network for extended health monitoring of hospital patients. IEEE Healthcare Innovation Conference (HIC). Seattle, WA: IEEE, USA; 2014. p. 236-8.
16. Wang L, Chen X, Ding J, Thomas N. Patient Flow Scheduling and Capacity Planning in a Smart Hospital Environment. IEEE Access; 2015 Dec 17; China. China: IEEE; 2016. p. 135-48.
17. Guru M, Hasan R, Khan R. Towards non-intrusive continuous healthcare monitoring with the Smart Hospital Gown. 14th IEEE Annual Consumer Communications & Networking Conference (CCNC); 2017 Jan 8-11; Las Vegas, USA. NV: IEEE; 2017.
18. Demri A, Charki A, Guerin F, Christofol H. Functional and dysfunctional analysis of a mechatronic system. Annual Reliability and Maintainability Symposium; 2008 Jan 28-31; Las Vegas, USA. NV: IEEE; 2008. p. 114-9.
19. Islamova OV, Zhilyaev AA, Bozieva AM. SADT technology as a tool to improve efficiency in the use of process approach in management of engineering enterprise. IEEE Conference on Quality Management, Transport and Information Security, Information Technologies (IT&MQ&IS); 2016 Oct 4-11; Nalchik, Russia. Russia: IEEE; 2016. p. 65-8.
20. Lakhoua MN, Khanchel F. Overview of the methods of modeling and analyzing for the medical framework. Scientific Research and Essays. Acad J. 2011;6(19):3942-8.
21. Lakhoua MN, Khanchel F, Laifi S, Khazemi S. System analysis of medical equipment for healthcare management. Int J Eng. 2016;14(4):17-20.
22. Lakhoua MN. The Need for systemic analysis and design methodology of the medical equipments. IJSS. 2018;8(1).
23. Ross DT. Structured Analysis (SA): A language for communicating ideas. IEEE Transaction on Software Engineering; 1997 Jan; Washington DC, USA. USA: IEEE; 1977. p. 16-34.
24. Marca DA. SADT/IDEF0 for Augmenting UML, Agile and Usability Engineering Methods. In: Escalona MJ, Cordeiro J, Shishkov B, editors. International Conference on Software and Data Technologies, ICSOFT 2011. Berlin: Springer-Verlag Berlin Heidelberg; 2013. p. 38-55.
25. Jaulent P. Génie logiciel : les méthodes SADT, SA, E-A, SA-RT, SYS-P-O, OOD, HOOD. Paris: Armand Colin, France; 1992.
26. Jaulent P. SADT : un langage pour communiquer/IGL Technology. Paris: Eyrolles, France; 1989.