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Medicine

REVIEW ON SMART HOSPITAL MANAGEMENT SYSTEM TECHNOLOGIES

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ABSTRACT:
A SMART HOSPITAL SYSTEM IS AN INFRASTRUCTURE COMPONENT THAT RELIES PROFOUNDLY ON THE ACTUAL RESOURCES MADE ACCESSIBLE TO IT FOR ITS PROPER FUNCTIONING, OPERATION AND MAINTENANCE. THE OBJECTIVE OF THIS PAPER IS TO PRESENT THE TECHNOLOGIES USED FOR A SMART HOSPITAL MANAGEMENT SYSTEM. IN FACT, THE EXTENSIVE USE OF INTERNET OF THINGS (IOT) PLAYS AN IMPORTANT ROLE IN IMPROVING THE QUALITY OF MEDICAL CARE, BRINGING CONVENIENCE FOR PATIENTS AND IMPROVING THE MANAGEMENT LEVEL OF HOSPITALS. THEN, A REVIEW ON SMART HOSPITAL SYSTEM AND SOME METHODS FOR THE ANALYSIS AND MODELING ARE PRESENTED.

KEY WORDS: SMART HOSPITAL SYSTEM; INFORMATION SYSTEM; SYSTEM ANALYSIS.

INTRODUCTION

Smart systems include 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, thus performing smart actions. 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.

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.

This paper can be loosely divided into four parts: First, we present a review on smart health systems in particular the infrastructure of the smart hospital system. Then, we present the need for technology for smart hospital systems. In section three, we present some methods for analysis of smart hospital systems. We review some methods here for the motive that we

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think them to be reasonably representative of the general kinds of methods in use. The methods include SADT (Structured Analysis Design Technique), UML (Unified Modeling Language), GRAI (Graphs with Results and Actions Inter-related) and GIM (GRAI Integrated Methodology). Finally, the last section presents conclusion and future work.

THE NEED FOR TECHNOLOGY FOR SMART HOSPITALS SYSTEMS

Healthcare is very important feature in every body's life and Information technology[2]. It is playing an important role in providing better health with number of advancements.

As Internet of Things (IoT) is aimed to connect everything to Internet, there are billions of sensors which are attached to things to access data and connect these things to internet. So the data provided by these sensors is increasing very fast. We require handling this big data on personals gadgets as well on central databases.

Due to its popularity in technology and internet world, IoT is rising in every field of life and so in health sector. Health is something in which its center is more concentrated due to its hypnotic features.

The scheduling is a plan of procedure for a proposed objective especially with reference to the sequence of and timeallotted for each item or operation necessary to its completion. In fact, the scheduling policy can be built in a smart hospital environment through wireless sensor networks and smart healthcare systems.

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 changing information for the purpose of influencing, managing, directing, or protecting people.

REVIEW ON SMART HEALTH 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[3].

Researchers Youjun and al.[4], have presented a smart hospital information frame to deal with diverse medical information. First, a ubiquitous smart hospital information system model under Wisdom as Service architecture is presented. With this model, medical information can be organized into varied levels. In this model, many methods of organizing medical information (offline computing) and smart services delivering (online computing) are presented. The methods are used to provide medical knowledge advice services to patients according to their personalized condition and context. As an example, a smart medical knowledge

[2] I. Wigmore, Internet of Things (IoT), TechTarget, June 2014.
[3] R. Fakhfakh, F. Khanchal, A. Klouz, N. Achour, Determinants of tobacco use habits among hospital staff in Tunisia, Preventive Medicine, 52(6),April 2011, pp. 478-479.
[4] L. Youjun, Z. Wan, J. Huang, J. Chen, Z. Huang and N. Zhong, A Smart Hospital Information System for Mental Disorders, IEEE/WIC/ACM WI-IAT, Vol.1, 2015, pp.321- 324.

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recommendation system, namely SKeWa, was built to reveal the usefulness of the model and the methods.

Researchers Nadeem and al.[5], 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 present complete 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 too underline the significance of RFID in healthcare domain with the help of an example case study with a working prototype application.

Researchers Chaczko et al.[6], have proposed an approach in architecting solutions which can be exploited as framework to deal with general issues in integration of enterprise level solutions. The methodologies discussed in TOGAF version 9 are exploited 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 increasing number of waiting lists, rising pressure on medical professionals and accountability for medical inattention are only part of the motivation to take initiative towards holds a core model integration strategy in different legacy infrastructure systems.

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 and al.[7], have presented IoT based architectural framework with context awareness for hospital management systems. They have exploited context awareness as middleware on top of network layer to overcome the problem of data management. Furthermore they did review to investigate the decision to assume the IoT based system in Pakistani Hospitals. Review was questionnaire based. The accumulated results indicate that participants want to acknowledge this system and most of the population agreed that IoT based HMIS would suggest better monitoring, communication and early diagnosis.

Researchers Zhang and al.[8], 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.

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[5] M. Nadeem, A. Shah, A. Waqas and Z. Bhatti, A. Abubakar, H. Abid M. Malik, RFID based smart hospital management system: A conceptual framework, The 5th International Conference on Information and Communication Technology for The Muslim World (ICT4M), 2014.

[6] Z. Chaczko, C. Chiu, A.S. Kohli and V. Mahadevan, Smart Hospital Management System: an integration of enterprise level solutions utilising open group architecture framework, International Conference on Computer Science and Information Technology, Vol.5, 2010, pp. 8-15.

[7] P. Muhammad, M.U. Akram and M.A. Khan, Survey Based Analysis of Internet of Things Based Architectural Framework for Hospital Management System, 13th International Conference on Frontiers of Information Technology (FIT), 2015, pp. 271 - 276.

[8] H. Zhang, J. Li, B. Wen, Y. Xun and J. Liu, Connecting Intelligent Things in Smart Hospitals Using NB-IoT, IEEE Internet of Things Journal, 2018, Vol. 5, Issue: 3, pp.1550-1560.

Researcher Catarinucci and al.[9], 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 various, yet complementary, technologies, particularly 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 confirm the proposed a smart hospital system has highlighted a quantity of key capabilities and aspects of innovation, which represent a significant step forward compared to the actual state of the art.

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 Chen and al.[10], have considered the performance of diverse scheduling policies in a smart environment. Models are generated under a hospital scenario, and are exploited to simulate patient flow under three scheduling policies. SimJava 2.0 is exploited as the most important simulator in this work. The findings frequently show that the dynamic scheduling policy has enhanced performance than the static scheduling policy.

Researchers Wang and al.[11], have explored a dynamic scheduling policy to get better the patient flow, and a professional 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 provide 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. To conclude, this paper is concerned with how formal method might be exploited to model and analyze the scheduling policy and the capacity plan on improving the healthcare service previous to exploitation.

Researchers Guru and al.[12], 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 immediately 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 openness and usefulness in giving a better, low-cost, and continual monitoring system for critical care patients.

[9] L. Catarinucci, D. de Donno, L. Mainetti, L. Palano, L. Patrono, M.L Stefanizzi and L Tarricone, An IoT-Aware Architecture for Smart Healthcare Systems, IEEE Internet of Things Journal, 2015, Vol.2, Issue: 6, pp. 515-526.
[10] X. Chen, N. Thomas and M. Harrison, Performance Evaluation of Scheduling Policies in a Smart Hospital Environment, International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery, 2011, pp. 585-592.
[11] L. Wang, X. Chen, J. Ding and N. Thomas, Patient Flow Scheduling and Capacity Planning in a Smart Hospital Environment, IEEE Access, 2016, Vol.4, pp. 135-148.
[12] M. Guru, R. Hasan and R. Khan, Towards non-intrusive continuous healthcare monitoring with the Smart Hospital Gown, IEEE Annual Consumer Communications & Networking Conference, 2017.

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ANALYSIS AND MODELING OF SMART HOSPITAL SYSTEMS

In this part, we review here some methods for analysis and modeling of smart hospital systems for the motive that we think them to be reasonably representative of the general kinds of methods in use.

In fact, 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.

The systems analysis is a process of collecting and interpreting facts, identifying the problems, and decomposition of a system into its components. In fact, system analysis is conducted for the reason of studying a system or its parts in order to identify its objectives. It is a problem solving technique that improves the system and ensures that all the components of the system work efficiently to achieve their purpose.

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.

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

For system modeling, there are numerous methods oriented functions, or decisions, or organization or reorganization, or information, or resources[13].

The SADT 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. 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[14].

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.

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[15].

UML is a standardized general-purpose modeling language in the field of software engineering. UML includes a set of graphic notation techniques to create visual models of software-intensive systems.

UML offers a standard way to visualize a system's architectural blueprints, including elements such as: actors; business processes; logical components; activities; programming language statements; database schemas and reusable software components.

UML combines techniques from data modeling (entity relationship diagrams), business modeling (work flows), object modeling, and component modeling. It can be used with all

[13] M.N. Lakhoua and M. Rahmouni, Investigation of the study of the methods of the enterprise modeling, African Journal of Business Management, ISSN: 1993-8233, Vol. 5(16), 2011, pp. 6845-6852.
[14] D. T. Ross, Structured Analysis (SA): A language for communicating ideas, IEEE Transaction On Software Engineering, 3(1), 1977, pp. 16-34.
[15] M.N. Lakhoua, F. Khanchel, Overview of the methods of modeling and analyzing for the medical framework, Scientific Research and Essays, Academic Journals, vol. 6, no. 19, 2011, p. 3942 - 3948.

processes, throughout the software development life cycle, and across different implementation technologies. UML has synthesized the notations of the Booch method, the Object-modeling technique (OMT) and Object-oriented software engineering (OOSE) by fusing them into a single, common and widely usable modeling language. UML aims to be a standard modeling language which can model concurrent and distributed systems. UML is a de facto industry standard, and is evolving under the auspices of the Object Management Group (OMG).

The GRAI method (Graphs with Results and Actions Inter-related) has been developed to the University of Bordeaux. It consists in analyzing the present decisional system of the enterprise and to conceive the future system while guaranteeing the functional and temporal global consistency. It is about a matrix representing functions (in column) and time (in line) fundamental for the decision making to short, medium and long term. The GRAI model is based on theories of the complex systems and on the discreet activity theory. This approach is characterized by three elements: models of reference, formalisms of modeling and structured approaches[16].

The GRAI modeling is the only existing modeling that proposes a representation of the decisional structure of the enterprise. This representation is important to detect incoherencies in the coordination and the synchronization of decision making and in the dynamics of evolution of the enterprise[17].

The GIM method (GRAI Integrated Methodology) has been developed to the GRAI laboratory of the University of Bordeaux in 1988. It assured the consistency of modeling formalisms. It made references to the GRAI model to study and to improve the performance of the enterprise.

The model presented (Table.1) illustrates eight specific objectives to achieve the global objective (OG): Information System of a Smart Hospital System.

The decomposition of these specific objectives into results lead to intermediate results, activities, sub-activities, tasks and under tasks is presented (Table.1).

Table.1. Model of Information System of a Smart Hospital System

N°	Code	Activity
1	OG	*Information System of a Smart Hospital System defined*
2	OS1	Management of the Information System of a Smart Hospital System assured
3	R1.1	Improvement of the Information System assured
4	R1.2	Assessment of the Information System assured
5	R1.3	Control of the Information System assured
6	R1.4	Maintenance of the Information System assured
7	R1.5	Functioning of the Information System assured
8	OS2	Security of the Information System of a Smart Hospital System assured
9	R2.1	Security of the information assured
10	R2.2	Confidentiality of the information assured
11	OS3	Circulation of the information of a Smart Hospital System assured
12	R3.1	Implementation of a secure information flow circuit assured

[16] G. Doumeingts, La Méthode GRAI. PhD. Thesis, University of Bordeaux I, Bordeaux, France, 1984.
[17] M.N. Lakhoua and H. Wertani, Overview of Conceptual Modeling for Complex Systems, CMSAM 2018, Wuhan China, September 27-28, 2018.

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13	R3.2	Availability of timely information assured
14	OS4	Appropriate information media of a Smart Hospital System assured
15	R4.1	Operation of information media assured
16	R4.2	Conviviality of supports assured
17	R4.3	Availibility of supports assured
18	R4.4	Supports of the information identified
19	OS5	Analysis of effective information of a Smart Hospital System assured
20	R5.1	Actions of Improvement proposed
21	R5.2	Causes of failure identified
22	R5.3	Failures detected
23	R5.4	Informations traited interpreted
24	OS6	Efficient information processing of a Smart Hospital System assured
25	R6.1	Efficiency of the treatment system assured
26	R6.2	Informations enregistred
27	R6.3	Informations collected
28	OS7	Archive information of a Smart Hospital System assured
29	R7.1	Security of archived informations assured
30	R7.2	Locations of archival information identified
31	R7.3	Supports of archival information identified
32	R7.4	Duration of archival information determined
33	R7.5	Archival informations identified
34	OS8	Characterization (properties / elements) of the information of a Smart Hospital System assured
35	R8.1	Information needs identified
36	R8.2	*Information source defined*
37	R8.3	Destinations for the informations defined

CONCLUSION

The hospital is a center of healthcare services that, nowadays, can be considered as a very 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.

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

Starting from this study of smart hospital systems discussed in this paper, work is in progress to extend general strategy for analysis and modeling of a smart hospital system based on structured methods.

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