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Modern Intelligent Health Systems: Standards, Recommendations, Designs, Simulation

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ABSTRACT: The Internet of Things and machine learning promise a new era in healthcare. The advent of transformative technologies such as implantable and wearable medical devices (IWMDs) has made it possible to collect and analyze physiological signals from any person at any time. Machine learning allows us to identify patterns in these signals and make health predictions in both every day and clinical situations. This expands healthcare coverage from common clinical contexts to widespread everyday scenarios, from passive data collection to active decision making. Despite the existence of an extensive literature on IWMD-based and clinical health systems, the fundamental problems associated with the design and implementation of smart health systems have not been adequately addressed. The main objectives of this article are to define a standard framework for smart health, designed for both every day and clinical settings, to explore modern smart health systems and their constituent components.

KEY WORDS: Internet of things, machine learning, medical devices, intelligent systems, smart healthcare.

I.INTRODUCTION

Healthcare is essentially defined as the improvement or maintenance of health and relevant facilities through the diagnosis, treatment and prevention of the disease, sickness, injury or mental disorders in people. Physicians and health professional provides healthcare services. The integral part of the healthcare industry comprises of Nursing, medicine, dentistry, optometry, pharmacy, physiotherapy and psychology. Access to healthcare depends on demography, socioeconomic conditions and health policies and may differ across nations, boundaries, communities and individuals. Healthcare systems are meant to address the health requirements of target populations. Healthcare is conventionally considered as an important factor for the well-being of people around the world. An impelling healthcare system can identify the irregular health conditions and make diagnoses from time to time. The swiftly aging populace and the related rise in chronic illness are playing a significant role in modern healthcare structures, and the demand for resources from hospital beds to expert medical personnel is increasing at an alarming rate. Evidently, a solution is needed to curtail the pressure on manual healthcare systems whilst continuing to implement high-quality care to unstable patients, by using all the technical advancement at our disposal. An efficient healthcare system can contribute to a significant part of a country's development, economy and industrialization.
Health service research evaluates innovations in various health policies including Medicare and Medicaid coverage, discrepancy in utilization and access of care. Smart healthcare comprises of m-health, e-health, electronic resource management, smart and intelligent home services and medical devices. The Internet of Things (IoT) can sense, assemble and transport data without human intervention over the network. Thus, Internet of Things (IoT) enabled healthcare technologies are suitable for remote health monitoring.
Often, there have been situations where a patient falls extremely sick and by the time an ambulance is arranged and the patient to rushed to the hospital, the situation worsens. In case of medical emergency, real-time monitoring can save lives. Real-time monitoring can be achieved using IoT devices/Applications to collect and transfer health data like blood sugar and oxygen levels, blood pressure, ECG plots and weight to physician over Internet [8]. These collected data are stored in the cloud for further action by the authorised personnel regardless of their time and place. A study conducted via the Center of Connected Health Policy indicates that due to remote patient monitoring on heart failure patients reduced the readmission rate to 50%.

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In case of an emergency, a patient can contact a doctor situated at a distant location via a smart phone application only. With mobility solutions in healthcare, the doctor/physician can instantly check the vitals of the patient and identify the ailment. Besides, numerous healthcare delivery chains that are predicting the manufacture of machines which can deliver drugs on the basis of a patient's prescription and the data related to the aliment(s) available on the linked devices. This will act as an impetus to saving money and resources [2].
Technology has attracted more or less all industries inclusive of finance, business, healthcare, and others. Intending to revolutionize the treatment with a prior and proper diagnosis the healthcare industry is the right upfront to adopt the advancement in the technology. The IoT (Internet of Things) has considerably captured the healthcare industry in a comparably short period. For instance, due to the connected devices, there is the possibility of allowing older persons to concern the doctor safely in their place. It helps doctors to grant the benefit of having recourse with the respective specialists worldwide regarding the complex cases. However, every pro have its cons attached to it. Accordingly, any technological advancement comes up with its challenges which have to succeed with proper trafficking. Following are some challenges associated with its implication for the users of healthcare IoT devices.

II. LITERATURE SURVEY

The scope of large number of applications of IoT in healthcare instigate the individuals to avail the facility. The application of IoT in a medical centre provides a remote healthcare service as reducing tracking staff, patients and inventory, ensuring availability of critical hardware, reducing emergency room wait time and enhancing drug management and so on. Following sections addresses the various healthcare applications of remote monitoring of patient, elderly care, remote medication, telemedicine and providing consultancy through smart applications [20].
IoT is the network that contains a variety of physical objects with embedded technologies for communication and sensing process. IoT term offers improvements to the modern people for easing their lives by IoT devices such as sensors, actuators, smartphones, etc. The growth of mobile users, the development in communication technologies and the raising capacities of cloud technologies bring the smart city, smart home, smart healthcare concepts into people' daily lives. IoT provides a global ecosystem where IoT devices can share their measured data and with cloud servers to accomplish their determined goals without human interaction and cooperate to create new applications. Different protocols and communication types such as Bluetooth, ZigBee, Wifi, 5G and so on, can be utilized in IoT networks according to network requirements, user satisfaction and wireless communication ranges. The generated and transferred data can be analyzed and used for classification, decision making and planning, etc. According to the purpose of the utilization of the measured data, the outcomes of the data, opening a door, changing the room temperature, alerting abnormal situations, changing traffic lights, and so on, are evaluated instantly or, for example, the generation of databases, creating useful results from the raw data, are transmitted to cloud servers or third-party components of the network.
The development of 5G wireless communication systems, which has paved the way for providing high throughput and low latency for their users, can be considered as a key factor in the enhancement of IoT applications and services. Due to the increasing number of connected devices and the massive growth of data volume generated by IoT sensors, IoT without 5G technologies cannot meet the user's demands for high Quality of Service (QoS). At this point, 5G can support IoT systems in the context of increasing throughput, transmission coverage, energy efficiency, reliability, and reducing delay. With the interaction of different kinds of smart devices, IoT brings adaptability and comfort in conveying in different conditions for observing and communication purposes [7]. Embedded sensors and IoT devices that measure ECG signals, blood pressure, body temperature, oxygen saturation level, body movements, etc. can be utilized on a patient's body or in hospital and home environments. Smart healthcare enables various information which can be related to an individual's health status to utilize for diagnosing diseases. The utilization of the smart healthcare frameworks with various IoT abilities allows distant monitoring and continuous following of patient's medical issue, long term review of patient's wellbeing records, decreasing clinical costs and expanding the innovation for giving patient-driven care rather than medical clinic-driven treatment.

III. PROBLEM STATEMENT

Smart Healthcare infrastructure can be divided into five 4 units such as physiological sensor unit, processing unit, communication and transmission unit, storage and computing unit, data analytics and decision-making unit [6]. Smart healthcare devices not only measure and monitor the physiological data but also process and transmits the medical data to remote healthcare or other IoT devices. Smart healthcare devices communicate through short-range communication technologies such as Bluetooth, Zigbee, Wifi, etc. to other IoT devices or through long-range communication

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technologies such as Worldwide Interoperability for Microwave Access (WiMAX), Lora, 4G, 5G, etc. to remote health centres and clouds. Extracting meaningful analyses from the raw medical data and decision making by the utilization of these extracted analyses are very powerful tools to diagnose diseases and find abnormality patterns of the patient's health status. The storage of measured and analysed data of patient's health status occurs on cloud units to be evaluated by doctors and medical staff later. For a better understanding, the basic network architecture of smart healthcare systems is visualised in Figure 1.

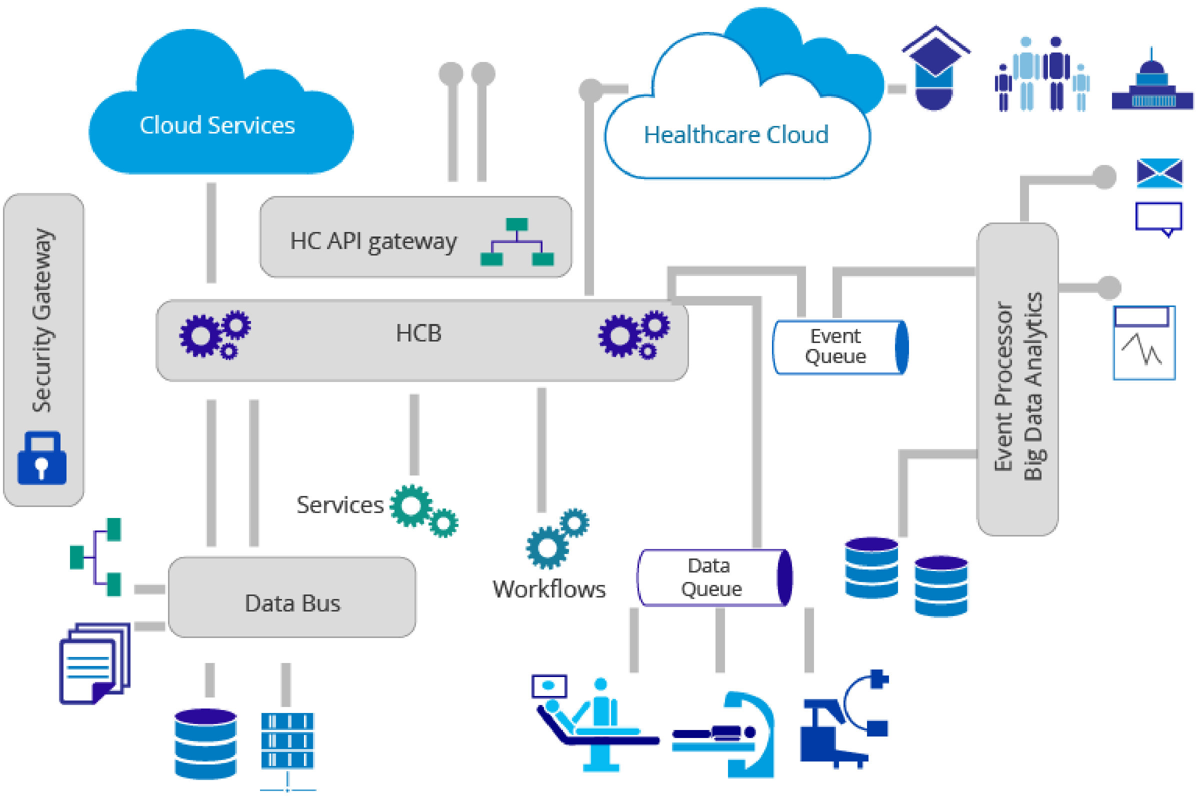

Fig. 3.1. Connected Health Reference Architecture.

With the acquaintance of new technologies to improve the above-recorded individual features, the general performance of smart healthcare is improving. Each below-mentioned emerging technology provides different enhancements for different layers, which can be explicated in the view of their functions and main requirements, which correspond to these functions. To a better understanding, the main requirements and functions of the different layers in smart healthcare infrastructure are summarized in Figure 2 [3].

WBAN technologies

For a better understanding of smart healthcare systems, WBANs which are the fundamental network type in IoT smart healthcare applications should be mentioned briefly. WBANs are the creating networks that are planned and produced for the human body to screen and communicate the continuous physiological boundaries. Independently associated different clinical sensors and actuators situated on, in, around or/and close to the human body constituent WBAN to screen physiological signs. A commonplace WBAN made up with one sink and a few sensor hubs on, around or embedded in the human body [5]. WBANs have an enormous potential to reform the eventual fate of medical services observing by diagnosing numerous dangerous illnesses and giving continuous patient checking and because of that, WBANs are specified for the various deployment of IoT healthcare services.

The main wireless communication technologies being utilized are ZigBee, WLAN, and Bluetooth in WBANs. Also, different protocols have been proposed and intended for WBAN such as IEEE 802.15.4, IEEE 802.15.6 and IEEE 802.15.1 [21]. These protocols and communication technologies are selected for providing low power gadgets, low range, and low information rate.

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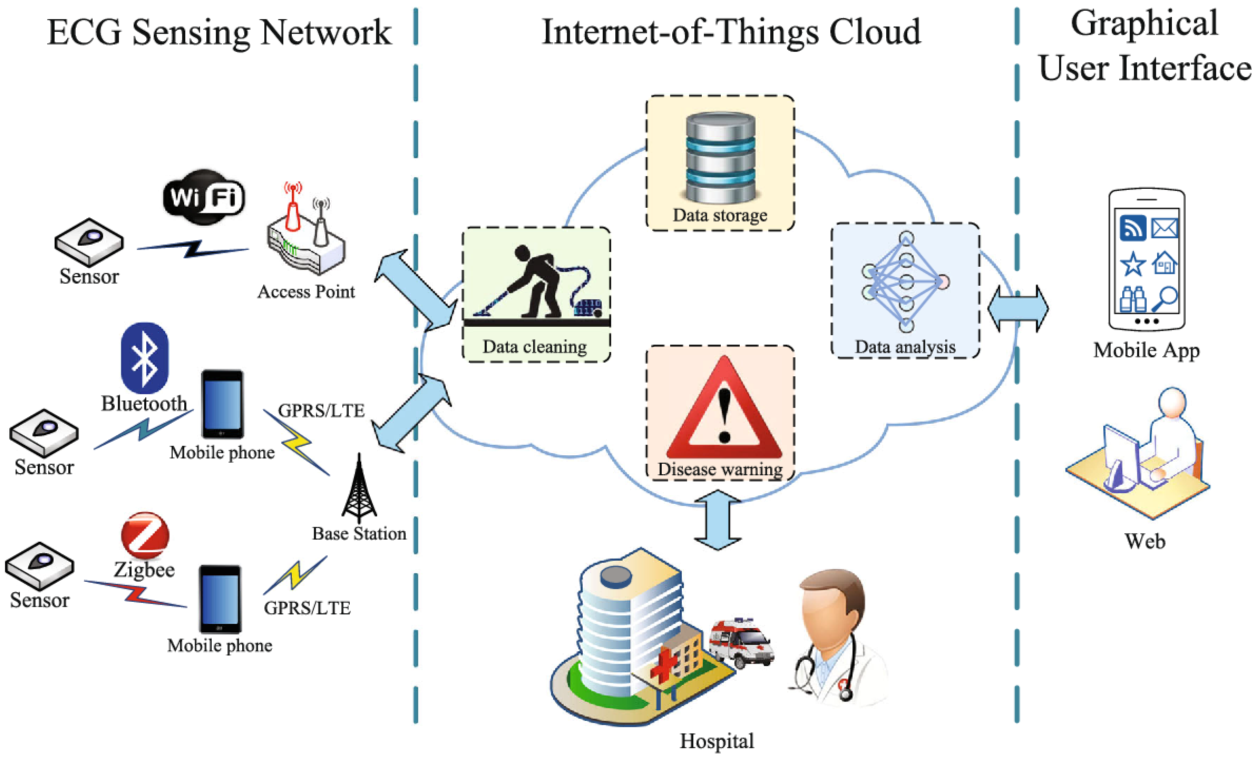

Fig.3.2. The main functions/requirements of each layer in Smart Healthcare Systems.

Machine Learning

ML and AI have a tremendous impact on smart healthcare systems by enhancing the management of a high volume of 5 data, ensuring low-latency and reliable outcomes. The critical effect of AI has been on the detection and prediction of issues that necessary complex clinical tests and the utilization of ML can help in the finding of the problems continuously and give customized medical care. ML algorithms can be applied to learn the mobility patterns of the network to provide proactive solutions to the changing network dynamic. With the acceptance of AI in medical care units, the immense informational indexes created from the healthcare units can be prepared through various AI calculations to do expectation and investigation for medical services [16]. It is hard for a professional or clinical expert to investigate any patient's example and indications to analyze illness from enormous data of every patient. Which can be taken care of viably by different machine and profound learning calculations with the least mistake rate and higher precision when contrasted with the medical experts. AI algorithms can deal with the immense number of data that are gathered from various smart IoT gadgets inside a group of time and anticipate the outcome, which created electronic health reports at that point ship off the separate clinical allotments for additional examination and ideas. Herewith, The utilization of ML in smart healthcare systems are in three significant zones to give customized medical services such as diagnostics, assistive systems, and patient monitoring and alarm systems. In this paper [10], the authors propose a recurrent neural network (RNN) algorithm with a long-short time-domain (LSTM) to provide energy-efficient, high accessible, predictive medical treatments. Checking the patient and quickly acting after a basic circumstance comprises significant tasks of clinical staff, in any case, a patient might be in a critical circumstance prompting his demise. First, scoring mechanism for vital signs which are held by biomedical sensors is conducted. Easing for handling the huge amount of data and providing a correlation between various medical information are achieved by this mechanism. Then the LSTM prediction method applied to the medical information which means the system can keep the necessary information for their users and predict the abnormalities by processing the historical medical data.

Fog Computing

Fog computing means processing the measured data by sensors on the sensor devices or the devices that are closed to sensors instead of on cloud servers or remote healthcare centres. So basically, it can be said that an enhanced fog computing algorithm means a low-latency diagnosis or alert mechanism. Fog computing empowers the organization to convey the cloud administrations at the organization level with the computational capacities appropriated locally at the organization level, unlike the cloud frameworks, which are carefully concentrated. The fog nodes also help in decreasing energy use by restricting significant distance transmissions utilizing a time limit calculation for choosing the neighbours.

SDN-NFV technologies

5G technologies are relied upon to empower the worldwide financial yield of 12.3 trillion by 2035 [4]. With technologies such as SDN and NFV, network slicing can be used to provide instant medical treatment. It is achieved by virtualization of network device functions to suit the requirements of the network in real-time such as efficient energy utilization, improved resource allocation and management, and enhanced security and privacy. Network slicing can separate the main physical layer into an unattached logical network for controlling the subject to network slice to accomplish the functions for the particular wearable gadgets [17]. SDN architecture is a key solution to make the traditional network structures less complex. SDN provides a global view of the network and a central control mechanism by separating the SDN control plane and data plane. Therefore, applications and services can be more programmable, manageable, flexible and more precise with the tools and mechanisms provided by SDN [9]. Thereafter; by using NFV, network resources can be efficiently allocated to virtual networks, and adding, removing, or updating a function for all or subset of end-users becomes much more manageable. NFV guarantees the improvement of asset provisioning to the end-users with high QoS and ensures the exhibition of virtual organization activities including least latency and failure rate. In [12], an SDN based smart healthcare framework with a lightweight authentication scheme is proposed. The proposed framework uses SDN technology to cope with load balancing and insufficient utilization of network resources. First, each IoT device transmits its measured sensor data to edge servers by a secured channel which is protected by hash functions and secret keys. After that, edge servers communicates an SDN controller to obtain an intelligent decision for load balancing and network resource utilization. By the centralized and intelligent control mechanism of SDN, the proposed framework can manage an efficient load distribution mechanism on the edge servers to ensure a low delayed and high-rated communication. Simulation results show that the proposed framework beats the present smart healthcare systems on aspects of latency, network overhead, throughput and average response time [13, 14, 15, 18, 19].

Communication and Transmission: The various sensors placed on the body communicate and transmit data to the central node through a short range communication method using low powered Bluetooth or Zigbee. The central node further transmits the aggregate data obtained from the nodes to the cloud through internet connectivity where relevant parties like the practitioners, nurses and specialist can access. When selecting either short or long range communication method, several factors will be considered that include security, robustness and high availability. Other issues relating to effect on human body should be considered as in the case of the short range communication.

Smart healthcare system is faced with numerous challenges; among which are[11]:

a) Funding: One of the major problems facing smart healthcare system is funding. IoT infrastructures are not easy to acquire; they are costly, thereby making its implementation very difficult. The maintenance of smart healthcare system is also costly.

b) Bureaucracy: Bureaucracy and lack of clear communication channels and collaboration culture are some of the difficulties confronting smart healthcare system. Organizational and cultural changes often are more difficult than technological changes [1].

c) Lack of computer knowledge among health practitioners: Many of the health practitioners have little or no knowledge of computer. This in no small measure has negatively contributed to the backwardness experienced implementing smart healthcare system.

d) Epileptic Power Supply: Epileptic power supply can hinder the success of the remote healthcare delivery project.

e) Security and Privacy: Data insecurity and infringement of privacy through multiple devices and protocols are the major limitations of IoT applications in healthcare delivery. This is a serious issue as vital information about patient which is in the cloud can only be accessible through IoT multiple devices and protocols.

IV. PROPOSED SIMULATIONS FOR SMART HEALTHCARE SYSTEMS

When patients share and use multiple resources, a queuing network usually arises. Consider, for example, a patient that visits the Orthopedic outpatient clinic and then needs to have an X-ray at Radiology; or the surgical patient who is operated in the OR, then cared for at the Intensive Care Unit (ICU) and subsequently cared for in a nursing ward. The formulation and analysis of these queuing network models is usually not straightforward. This likely explains why (discrete-event) simulation is a commonly used approach to analyze healthcare problems. Simulation models are robust in terms of the setting they can represent, however they are very time consuming to develop and require a vast amount of data (-analysis). Also, the resulting model is, with a few exceptions, not generic and thus not suitable to represent other problems or organizations other than the one it was build for.

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Despite the fact that many real world problems do not exhibit exponential service times, open Jackson networks have been used in numerous applications, often with good results. However, to analyze networks of general queues, the Queuing Network Analyzer (QNA) is a better alternative. The QNA was developed in 1983 by Ward Whitt for approximate analysis of open networks of G/G/s queues with FCFS service discipline. There are several variations on the QNA, also known as reduction or decomposition methods. In this subsection we summarize the basic QNA algorithm. The calculations involved with the QNA are usually straightforward and can be done by hand. However, when the parameters need to be changed often, we suggest using a spreadsheet program such as MS Excel. QtsPlus also supports the analysis of general queuing networks. Even though the QNA has proved to be very useful, other approximation methods give better results when the network is highly congested [22,23].

V. QUEUING NETWORKS IN SMART HEALTHCARE SYSTEMS

In healthcare, the systems that have been reported varied in using low-level simulation scripting languages such as C++ [9], or using intermediate-level simulation tools that incorporated low-level scripting with enhanced graphic interface such as MATLAB [16], or using high-level simulation frameworks with minimum needs of scripting such as Anylogic[8]. Results in table 1 shows shifting to high-level simulation tools rather than scripting languages. A trend of using ARENA in discrete event simulation was spotted. Netlogo was mostly the platform for Agent based simulation [24].

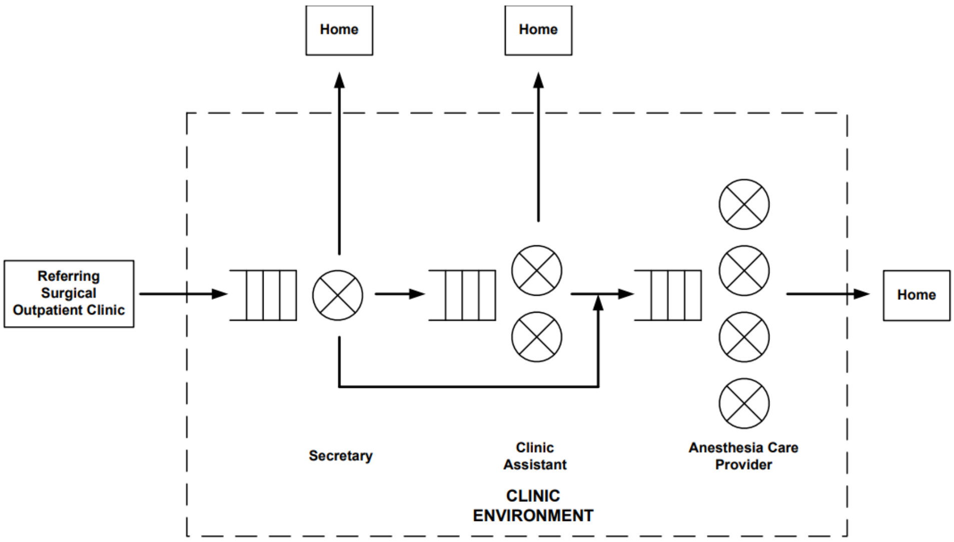

Fig.5.1. Queuing networks in smart healthcare systems.

To identify bottlenecks in the PAC's operations, the clinic was modeled as a multiclass open queuing network (Fig. 5.1.). There were three patient classes: children, adults eligible for direct (walk-in) screening, and adults requiring an appointment because of their (more severe) health status. The PAC queuing network has three separate (connected) queues, where the employees act as servers. Patients only enter the PAC through the secretary queue, but may leave the system at any queue. The PAC queuing network was analyzed using a decomposition method, based on the QNA. This method consists of three steps. We first summarize the method and then provide a detailed description of the model with the corresponding formulas. First, the multi-class network is reduced to a single class network. This is done by aggregating all patient flows that enter a queue. Then the workload ρ is calculated for each queue. This already gives significant and valuable information; recall that ρ is a measure for the fraction of time employees are busy. In the next step, the single class open queuing network is analyzed, where the mean contact time and scv of the joint arrival and service processes at the three queues are deduced. In the final step the mean waiting time per queue is calculated, using the variables that were derived in step 1 and 2.
In the initial analysis of the PAC queuing network, it was found that the secretary and anesthesia care providers functioned as bottlenecks. Consequently, several alternatives were formulated together with clinic staff, in order to remove these bottlenecks. All alternatives were evaluated using the queuing network model, resulting in one alternative that outperformed the others. In this alternative, several tasks were redistributed and the patient arrival process was amended

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such that the arrivals were spread more equally over the day. In the year following the implementation of the alternative clinic design, patient arrivals increased (unexpectedly) by 16%. In the old situation, this would likely have resulted in even longer patient waiting times. However, the mean patient length of stay at the PAC did not increase significantly, and more patients (81%) were offered the direct screening.

VI. CONCLUSION AND FUTURE WORK

In the grand scheme of smart healthcare, its main objective is the high deployment of smart healthcare devices by users in their daily lives. Besides all of the benefits of the smart healthcare system, it has its issues such as interoperability, energy, security, resource management, low latency tolerance, etc. and along with the development of IoT technologies. Researchers are in a tendency to provide better healthcare service by introducing new methods and techniques to overcome the challenges in section IV. Therefore, many emerging technologies such as machine learning, AI, blockchain, fog computing, SDN, NFV, network slicing, etc. are in demand to develop smart healthcare systems. In this paper, we discuss the major emerging technologies in use for smart healthcare. We mention the main applications and services of smart healthcare systems. We highlight the challenges that IoT healthcare systems deal with and we sort and stated the latest methods and techniques that the authors have proposed. With all the studies cumulatively, smart healthcare is proceeding and will be proceeding to spread to our daily lives.

The evolution of simulation modelling in healthcare over the past two decades has been optimistic: more scientists and researchers are conducting exploratory research with advanced modelling as platforms evolve into more efficient contexts for implementation, while developers try to adapt ABM and DES platforms to the growing user communities in different disciplines.

This paper has provided a thorough theoretical background on networks of queues and examples of how networks of queues may be used to model, analyze and solve health care problems. In that respect, often, the theory has to be amended or extended. This contribution has made health care professionals increasingly aware of the possibilities and opportunities queueing networks have to offer to tackle the challenges they are facing, now and in the future.

REFERENCES

[1]. Adewale, O. S. (2004). An Internet-based telemedicine system in Nigeria. International Journal of Information Management, 24(3), 221-234.
[2]. Akmandor O. and Jha N. K. Smart health care: An edge-side computing perspective. IEEE Consumer Electron. Mag., 7(1):29–37, Jan. 2018.
[3]. Ali Tunc M., Emre Gures, Ibraheem Shayea A Survey on IoT Smart Healthcare: Emerging Technologies, Applications, Challenges, and Future Trends
[4]. Barakabitze Alcardo Alex, Ahmad A., Rashid Mijumbi, and Hines A.. 5G network slicing using sdn and NFV- a survey of taxonomy, architectures and future challenges. Comput. Networks, 167.
[5]. Chatterjee S., Chatterjee S., Choudhury S., Basak S., Dey S., Sain S., Ghosal K.S., Dalmia N. and Sircar S. Internet of things and body area networkan integrated future. In 2017 IEEE 8th Annual Ubiquitous Computing, Electronics and Mobile Communication Conference (UEMCON), pages 396–400.
[6]. Einab K.A.M., Elmustafa S.A.A.: Internet of Things applications, challenges and related future technologies. World Sci. News 67(2), 126–148
[7]. Gubbi J., Buyya R., Marusic S., Palaniswami M.: Internet of Things (IoT): a vision, architectural elements, and future directions. Future Gener. Comput. Syst. 29, 1645–1660
[8]. Gupta P., Agrawal D., Chhabra J., Dhir P.K.: IoT based smart healthcare kit. In: International Conference on Computational Techniques in Information and Communication Technologies (ICCTICT), IEEE, Mar 2016, pp. 237–242
[9]. Gures E., Shayea I., Alhammadi A., Ergen M., and Mohamad H. A comprehensive survey on mobility management in 5G heterogeneous networks: Architectures, challenges and solutions. IEEE Access, 8:195883–195913.
[10]. Harb H., Mansour A., Nasser A., Cruz E. M., and de la Torre D´ıez I. A sensor-based data analytics for patient monitoring in connected healthcare applications. IEEE Sensors Journal, 21(2):974–984. Network, 34(5):254–261.
[11]. Jackson Akpojaro, Rotimi-Williams Bello Smart Healthcare System: A Primer // International journal for innovative research in multidisciplinary field issn: 2455-0620 volume - 5, issue - 3, mar – 2019 Monthly, Peer-Reviewed, Refereed, Indexed Journal with IC Value: 86.87
[12]. Li J., Cai J., Khan F., Rehman A.U., Balasubramaniam V., Sun J., and Venu P. A secured framework for sdn-based edge computing in iot-enabled healthcare system. IEEE Access, 8:135479–135490.
[13]. Mahmudov Salimjon Modeling Flow of Smart City Network: Review and Analysis,2021 International Conference on Information Science and Communications Technologies (ICISCT),1-6,2021,IEEE
[14]. Mahmudov Salimjon Olimjonovich Algorithm of Distributing Traffic Flows in a Software-Defined Networks,"International Journal of Advanced Research in Science, Engineering and Technology (IJARSET)",11,9,14935-14942,2020,ISSN:2350-0328 IJARSET
[15]. Mahmudov Salimjon, Temirova Dilfuza Load Balancing Method in Smart City Networks based Software Defined Networking,2021 International Conference on Information Science and Communications Technologies (ICISCT),,,1-5,2021,IEEE
[16]. Mohanta B., Das P., and Patnaik S. Healthcare 5.0: A paradigm shift in digital healthcare system using artificial intelligence, IoT and 5G communication. In 2019 International Conference on Applied Machine Learning (ICAML), pages 191–196
[17]. Muhammet Usak, Milan Kubiatko, Muhammad Salman Shabbir, Olesya Viktorovna Dudnik, Kittisak Jermsittiparsert, and Lila Rajabion. Health care service delivery based on the internet of things: A systematic and comprehensive study. International Journal of Communication Systems, 33(2):e4179, 2020. e4179 IJCS-19-0281.R1.

[18]. Nishanbayev T.N., Abdullayev M.M., Maxmudov S.O. The model of forming the structure of the “cloud” data center,2019 International Conference on Information Science and Communications Technologies (ICISCT),,,1-4,2019,IEEE
[19]. Nishonboev T., Abdullaev M., Maxmudov S., ,A model for the formation of the cloud structure of a data center based on SDN,"International Conference on Information Science and Communications Technologies (ICISCT) Applications, Trends and Opportunities",,,,2019,
[20]. Pattnaik, Prasant Kumar; Mohanty, Suneeta; Mohanty, Satarupa (2020). [Intelligent Systems Reference Library] Smart Healthcare Analytics in IoT Enabled Environment Volume 178
[21]. Sallabi F., Naeem F., Awad M., and Shuaib K. Managing IoT-based smart healthcare systems traffic with software defined networks. In 2018 International Symposium on Networks, Computers and Communications (ISNCC), pages 1–6, 2018.
[22]. Zonderland ME, Boer F, Boucherie RJ, de Roode A, van Kleef JW (2009) Redesign of a university hospital preanesthesia evaluation clinic using a queuing theory approach. Anesthesia and Analgesia 109(5):1612-1621
[23]. Zonderland ME, Boucherie RJ, Litvak N, Vleggeert-Lankamp LCAM (2010) Planning and scheduling of semi-urgent surgeries. Health Care Management Science 13(3):256-267
[24]. Almagooshi, S. Simulation Modelling in Healthcare: Challenges and Trends. Procedia Manufacturing, 3, 301–307. doi:10.1016/j.promfg.2015.07.155