Journal of Information & Optimization Sciences
ISSN 0252-2667 (Print), ISSN 2169-0103 (Online)
Vol. 44 (2023), No. 6, pp. 1179–1194
DOI : 10.47974/JIOS-1456

A proposed customized architecture for 5G-IoT based smart healthcare system: 5G-IoT-SHS

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Abstract

The emergence of new technology is making enormous changes in healthcare which is the largest industry in the world. Therefore, a smart healthcare system is required that can communicate across different available network devices and applications. This will enable patients and doctors to trace, observe and record sensitive patient data with medical readings. The Internet of things (IoT) has a great contribution to put the healthcare sector in its leading state to provide the safe and healthy environment for patients and to enable

This work was carried out in Arya Bhatt Lab, GEU, Dehradun, India

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doctors to give outstanding care remotely. The integration of 5G and IoT can be utilized to address these issues due to its capability to handle massive amounts of data with low latency and offers larger bandwidth, fast data rates, and greater reliability. It has heightened the patient involvement and satisfaction due to its capability to make the real time uncomplicated and competent communication among patients and doctors. Thus, a comprehensive smart healthcare architecture including 5G is required. This research is presented a literature review on various healthcare architectures and proposed a customized architecture for a 5G-IoT based smart healthcare system that incorporate different sensors, technology standards and communication protocols. The proposed architecture is validated using a software called Cisco Packet tracer, demonstrating the effectiveness and dependability of the suggested system. This work was carried out in Arya Bhatt Lab, GEU, Dehradun, India.

Subject Classification: *68M11, 90B18, 90B80.*

Keywords: *IoT, 5G, Smart healthcare, Framework, Simulation tool.*

1. Introduction

The idea of smart healthcare emerged with the advancement of information technology. It is not just a simple technological improvement, but a comprehensive, multilevel shift away from disease-centered care towards patient-centered care, clinical information towards regional medical information, general management towards individualized management, and a shift away from disease-focused care towards preventive healthcare to revamp the current healthcare system [1]. Thus, healthcare will be more effective, practical, and individualized. There are multiple participants involve in the formation of smart healthcare system, such as doctors, patients, hospitals, and research institutions. According, to survey by many researchers, the cost of healthcare in many countries by 2050 are expected to grow from 20 to 30% of the GDP [2]. Thus, several technologies like IoT, 5G, artificial intelligence, cloud computing etc. are used to provide strength to the healthcare system. IoT and 5G together with biotechnology are utilized to give heights and agreeable enlightenment to healthcare system.

The IoT can be characterized as a network of gadgets that communicate with one another through machine to machine (M2M) interactions, allowing the gathering and sharing of data. IoT technology has been widely recognized as an emerging potential option to better the healthcare system due to its pervasive application in every aspect of life. There are several specific uses for which IoT healthcare system has been designed such as remote health monitoring, emergency patient handling, medication, and routine physical health check-up, and finding the patient the closest medical services such as doctors, paramedics, ambulance

services, rehabilitation, management of diabetes, and many others. As a result, it can increase accessibility to healthcare services, lessen the burden on the healthcare system, and improve people's ability to always manage their own health [3]. IoT offers a lot of potential for the healthcare system, but it also faces numerous challenges in healthcare system including the safe processing of big data sets, the lack of a standardized format for data produced by devices, security, and privacy concerns, and many more. As a result, a strong IoT based healthcare system design using a variety of technologies is required [4].

Therefore, in order to meet the requirement of IoT in Smart Healthcare Systems, 5G technology has been developed. This technology is utilized to connect a larger number of devices compared to 4G. As compared to earlier wireless technologies the unique combination of high-speed connectivity, low latency, and increased effectiveness and efficiency makes 5G more than just rapid download speeds. This technology has a variety of distinctive characteristics, including high carrier frequencies, large base station and device densities, numerous antennas, and enormous bandwidth. Hence, this powerful technology has the features to overcome the limitations of IoT in healthcare and changed the situation of healthcare industry from remote diagnosis to remote surgery. The 5G system has high quality connectivity that can enhance participation amongst medical experts and improve the diagnosis and patient care. The analysis of data in real time become easier and stable with the use of AI software with 5G infrastructure in IoT based smart healthcare system [5]. Therefore, 5G gives lowers costs, shortens the time for medical attention, and provides the user flexibility. The potential of technology itself have led to a buzz surrounding 5G in the field of intelligent healthcare systems. In this paper, we have presented a framework for 5G-IoT based Smart healthcare system (5G-IoT-SHS) to achieve: Accurate, efficient, Convenient, cost-effective methods to meet patient and healthcare provider needs. The key contribution of our work are as follows:

- A 5G-IoT based Smart healthcare system framework (5G-IoT-SHS) is proposed to enhance IoT based healthcare system performance by using modern network technology of 5G itself. This framework is suitable and reliable for advanced health services.
- The framework uses a layered approach to address components, technologies, functions, and protocols.
- The validation of proposed framework through cisco packet tracer shows that the framework is simple to use, easy to maintain and cost effective.

The rest of the paper is organized as follows: The summary of different frameworks that had been proposed to implement 5G technology in IoT based Smart healthcare system and IoT based framework for healthcare system is presented in section 2. Section 3 proposed a 5G-IoT based Smart healthcare system framework (5G-IoT-SHS). The validation of proposed framework through the software called Cisco Packet Tracer to show the efficiency and reliability of proposed frameworks presented in Section 4. Finally, the conclusion is given in section 5.

2. Literature Review

Many frameworks have been proposed to implement 5G in IoT based smart healthcare systems. These frameworks focus on the security, applications, and efficiency domain. In this section, we present the summary of some published previous work (Table 1) related to frameworks of healthcare system, IoT and 5G based smart healthcare systems.

Table 1
Literature Review of 5G-IoT Frameworks

Year	Author	Technology	Description
2018	Soraia Oueida et al [6]	IoT	• The author has suggested a resource preservation net (RPN) healthcare framework based on Petri net for emergency wards. The framework includes cloud and edge computing also. • The proposed model is explained theoretically and validated also. • Modelling and optimization are done for Some key performance matrics like resource usage rate, average patient waiting time etc.
2018	Maruf Pasha et al [10]	IoT	• A customised IoT based framework which is based on interoperability issues, is proposed. • The framework that is being proposed, is based on many technical standards and communication protocols. • The experiment demonstrates that a gateway device can be used to provide interoperability between various IoT standards, protocols, and devices.

Contd...

2019	Bessie Malila, Tinashe, E.M. Mutsvangwa [11]	5G	• The author has suggested an architecture for the security of mHealth system based on 5G. • The proposed architecture incorporates the design concepts of 3GPP architecture. • The author has also identified the security risks in every domain and suggested the security measures to mitigate the risks.
2020	Sumit Sharma et al. [12]	IoT	• The author has proposed the Internet of health framework (DeTrAs) which is based on deep learning for the benefit of Alzheimer sufferers. • The working of proposed framework is completed in three phases. • Author has included various machine learning algorithms which shows 10-20% accuracy.
2020	Kashif Hameed et al [13]	IoT	• An intelligent healthcare system built on IoT and machine learning is proposed. • The suggested approach uses temperature, heart rate and blood pressure sensors to evaluate the condition of patient being observed and utilize the innovative and enhanced diagnostic method based on fuzzy neural networks. • The decision support system was employed by the author to reduce the time constraints associated with the traditional store-and-forward approach of telemedicine in remote locations.
2020	Yangan Zhang et al [14]	5G-IoT	• A proposed telemedicine system for remote health monitoring and automatic disease diagnosis uses mobile edge computing (MEC) and artificial intelligence (AI). • IoT, Cloud Computing and MEC are the three layers that make up the system. • On the MEC layer, the DL (Deep learning) model is used to diagnose ECGs.

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2021	Xiaoyong Tang et al. [9]	5G	• Author has proposed an 5G based architecture for smart healthcare information infrastructure that incorporate healthcare dedicated network and MEC. • Two new network elements that is iGW (industry gateway) and smart healthcare dedicated cloud platform iMEP (Industry multi access edge platform) is introduced. • The proposed architecture meets the hospital specific requirement and the long-term evolution.
2021	Shailendra Rathore et al [8]	5G-IoT	• The author has suggested a four-layer security structure for 5G enabled IoT systems that is powered by deep learning (DL) and blockchain. • Blockchain is employed for security, while deep learning is used for data analysis operations. • To verify the suggested framework's viability in real-world applications, it was simulated on a commonly used object detection task.
2022	Jyoti Srivastava et al [7]	IoT	• Author has included a comparison of several IoMT architectures. • Presented a comparable study for various data collection techniques to cultivate the truthfulness of collected data. • Author has presented a study on IoMT framework based on AI in order to maintain the energy efficiency of the frameworks.
2022	Amit Sundas et al. [17]	IoT	• Author has suggested a security framework named HealthGuard, which is based on machine learning. • The proposed framework is tested in a range of hospital wards. • Tested outcomes show the 91% rate of accuracy for the framework, proving its efficiency.

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2022	Fernanda Famá et al. [15]	IoT	• The author has proposed an IoT-based framework for healthcare system to monitor wirelessly and classify the status of patient. • The architecture is having the FHIR standard, Bluetooth Low Energy technology and the MQTT protocols at higher level, internal level and at the data acquisition level accordingly. • For the purpose of satisfying both functional and non-functional requirements, a use case scenario is also presented.
2022	Jianqiang Hu et al. [18]	5G	• The author has suggested a 5G-based architecture for secure smart healthcare monitoring in order to accomplish rapid and accurate data exchange and reduced latency services for patients with emergencies. • The framework incorporates a 5G-IPv6 communication network, a context-aware health scenario identification-based similarity measure, and a mechanism for data sharing based on blockchain. • To track hypertensive heart disease, a prototype system is also used.
2022	VV Satyanarayana Tallapragada et al. [14]	IoT	• The author has covered the BSN-based mobile system's privacy and security concerns. • Based on study, author has acknowledged the protection need and the integration of strong security mechanisms and protocols. • Lastly, the author has suggested a safe IoT based healthcare system, named BSN care.

3. Proposed Work

The proposed architecture makes use of a layered methodology to offer a full mechanism of collecting data from the sensors to cloud storage, that can be obtained either locally or remotely. The architecture includes the Sensor, Network, Cloud, and Service Access layers (Figure 1). The data originating in perception layer and then sent to the MEC server, lying at

network layer. The middle stage for processing of data that uses edge computing and AI technology is called MEC server. It gives fast decision in emergencies [21]. The Layer which will periodically transmit the gathered information to the cloud layer, that will permanently store and managed the data through 5G network, is referred to as Network layer. The data stored at the cloud layer can be accessed by users from service access layer. The description of the elements, technologies, and functions present at each layer is described below:

Perception layer: The Function of this layer is to collect used to gathered the patient information from the environment. The various components lie at sensor layer are Data collectors(sensors), communication technologies, Barcode and RFIDs, and IoT gateway device. The sensors are used to keep track of and gathered patient health data [21]. Sometimes a patient's body may have sensor devices attached to it or embedded in it. Body temperature, and pulse oximetry sensors are a few of the sensors found at the sensor layer that are used to track a patient's various health vitals. The information gathered by these sensors is sent to the network

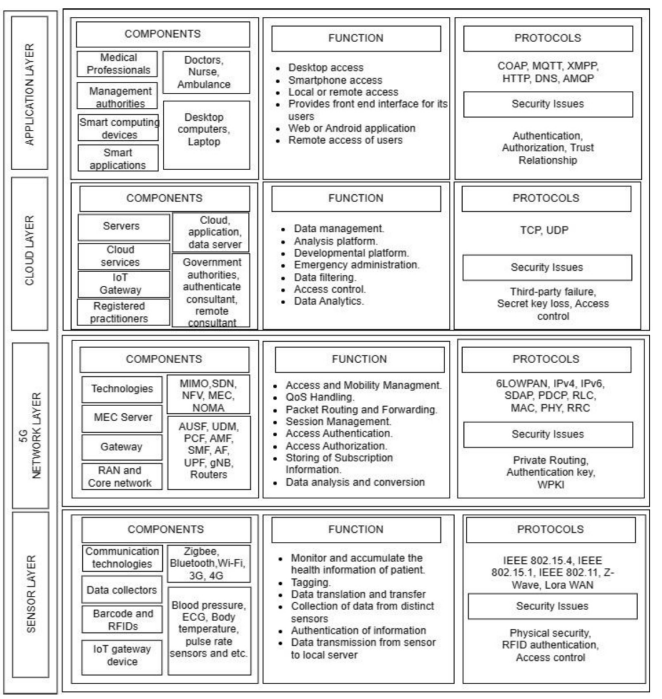


Figure 1

Proposed Layered Architecture

layer. Lora WAN, RFID, Zigbee, Bluetooth and NFC are some of the various technologies used at sensor layer to communicate with IoT devices. Ethernet, IEEE 802 series, LORA, Z-Wave are the different protocols which supports sensor layer. Physical security, RFID authentication and the Access control are the different security issues exist at this layer [10].

Network Layer or 5G Layer: There are several communication techniques to transmit data from the sensor layer to the network layer, but we have chosen the 5G network to link the physical layer to the cloud. Therefore, the network layer, also known as the 5G layer, is the second tier of the suggested architecture. Wireless connectivity is provided by 5G to stationary or mobile devices [10]. Through 5G wireless communication, this layer transmits the information obtained by sensors at the perception layer to the storage layer. RAN (Radio access network), MEC server, core network, Gateway device and different technologies are the various components exist at network layer. RAN incorporate next generation Base stations(gNB), data forwarding devices, multiple cutting edge wireless technologies (MIMO, small cells, mm wave, NOMA etc). RAN is also labelled as hardware layer of 5G network. It also provides the integration of devices to the core network [22]. 5G core network is divided into two parts: User plane and Control plane. User plane has UPF having the ability to forward traffic between RAN and the Internet. Control plane act as a forwarding path to swap information for operation of the service. MEC server lying at network layer is used to perform the preprocessing and analysis of data, before transmitting the data gathered from sensor layer to cloud layer. Besides data forwarding to the cloud layer, there are lot of functions performed at network layer these are Packet routing and forwarding, Access and mobility management, QoS handling, Access authorization. The protocols supported by network layer are 6LoWPAN, PDCP, RLC, MAC, PHY and RRC. Private routing, authentication key, and WPKI are the security issues exist at network layer [18].

Cloud Layer: The data obtained from the network layer is stored, estimated, and processed in this layer. It is composed of different servers like cloud server, data centers, application servers and servers for data. The various components lie at this layer are registered practitioners as government authorities, remote consultants, IoT gateway, and authenticate consultants [22]. This layer also offers a wide range of services, including storage of data permanently, data integration from various sites utilizing data integration services, data analysis, and a variety of programming tools to create several applications for smart health systems. Additionally, an authentic list of distant consultants is controlled via cloud storage. TCP

and UDP are the protocols include at this layer and Third-party failure, Secret key loss and the access control are the security issues lie at this layer [18].

Service access layer: By utilizing access applications, the service access layer makes the services of the smart health unit accessible. Desktop computers or smart computing devices can be utilized to installed Applications. Doctors or other medical professionals can have access to a patient's medical records, whenever necessary [10]. The patient data can be access from cloud storage by using various applications protocols like COAP, MQTT, XMPP, AMQP, HTTP. Medical professionals, Smart computing devices, management authorities, modern web technologies and desktop computers are the different components lie at this layer [22]. This layer also offers the front-end interface for its users. Authentication, authorization, and the trust relationship are the security issues lie at this layer.

4. Experimental Setup and Configuration

Cisco packet tracer (CPT) is the main technology that is used to simulate a healthcare network. CPT is a simulation tool developed and produced by Cisco Systems. Packet Tracer provides a virtual environment where users can create network topologies, connect devices, and simulate network traffic. Packet Tracer allows users to create virtual networks by simulating various network devices such as routers, switches, PCs, servers, and wireless devices. It provides a graphical interface for designing network topologies and connecting devices together. Users can configure network devices in Packet Tracer by accessing their command-line interfaces (CLIs) or graphical user interfaces (GUIs). This enables users to practice configuring and managing different network devices and protocols. It supports users in the design, configuration, and troubleshooting of several types of networks including LAN and WAN [23]. It also supports in addressing the security issues by utilizing security protocols. CPT has many key features like packet tracer workspaces, packet tracer modes, protocols, modular devices, multiuser functionality, tutorials, Help, activity wizard, Lab grading function, international language support. CPT interface provides inbuilt devices to be added in the network.

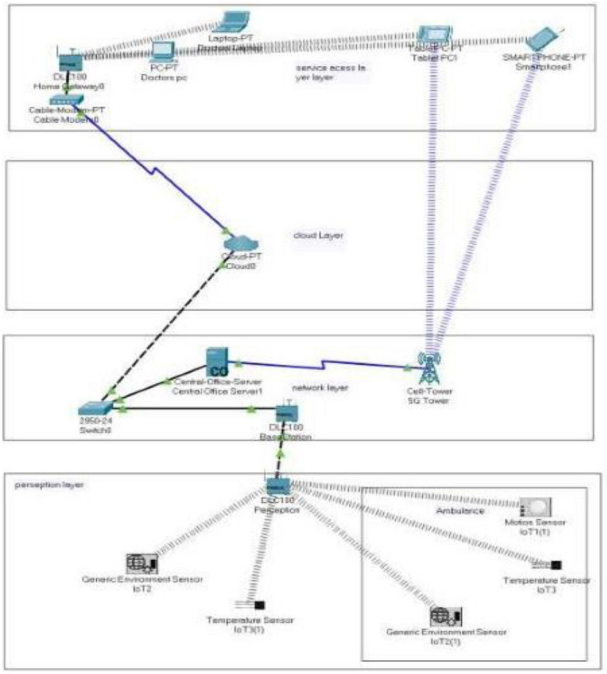


Figure 2

Configuration of the proposed scenario

To simulate this healthcare network, a new released cisco packet tracer has been used, which include different objects used for building a network like motion sensor, temperature sensor, and other IoT device (Figure 2). Virtual mode of smart healthcare system is designed where gateway connects multiple devices wirelessly and provides automatic addressing to devices connected to the gateway. There are four main steps of the proposed scenario:

- Add the network's Gateway
- Connect the wireless network to 5G IoT devices.
- Add a networked end user device.
- Create the network and test it.

Figure 3 to 6 shows smart applications in various type of scenarios, also shows various devices configuration at different layers that is perception, network, cloud, and service access layer.

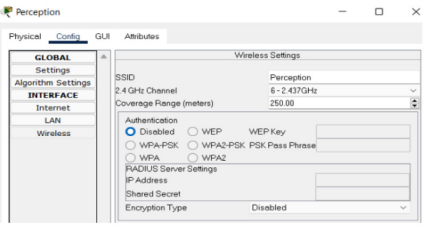


Figure 3

Configuration at perception Layer

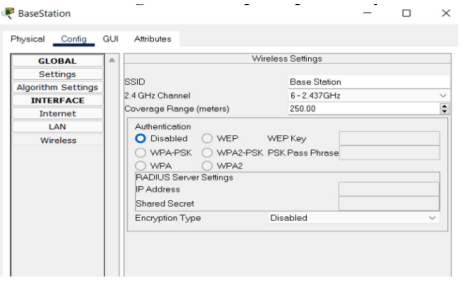


Figure 4

Configuration at Network Layer

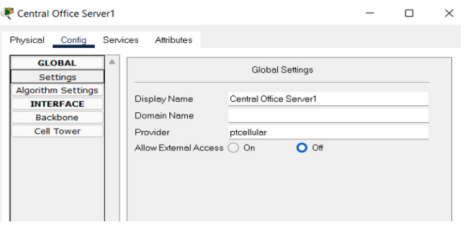


Figure 5

Configuration at Cloud Layer

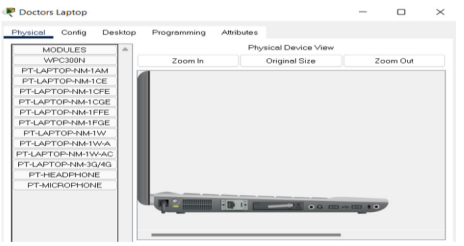


Figure 6

Configuration at service access layer

5. Conclusion and future work

The use of IoT technology has increased in every aspect of life, Over the past few years. Particularly in the area of healthcare, this developing technology has made a significant contribution to improving patient and physician comfort. There are lot of applications of IoT which will provide lot of benefits to healthcare but there are certain limitations also. 5G technology is used to overcome these problems. Although various research issues have been brought up with the 5G-IoT technology adoption. A variety of study has been done in the field to mitigate the issues and discover better deployment methods. Various structures have been suggested to effectively implement the smart health services. The 5G-IoT-SHS, a specialized framework based on 5G-IoT in the healthcare system, is suggested in this study. The framework investigates several IoT and 5G aspects for smart health services. It consists four layers, each of which carries out a specific function. The model is then simulated using a software called Cisco Packet Tracer, which displays the configuration of various IoT devices, 5G base stations, and different gateways to demonstrate how devices are connected to it. In the future, we intend to create a thorough infrastructure that can be merged into the existing framework.

Conflicts of Interest

The authors declare that they have no competing interests.

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