

NEXT GENERATION IOT BASED TELEMEDICINE TECHNOLOGY FOR DEVELOPING HEALTHCARE

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Abstract— This paper represents the latest invention in the field of telemedicine system and how telemedicine system is improving by the help of IoT is also introduced. Different sensors, monitoring process with the help of IoT is discussed with their working principle in the field of telemedicine system. Advanced communication technologies such as Zigbee, GSM module is helping to build co-relation between doctor and patient in remote area. The main application of this paper is to make people understand about this kind of technology and to give people the best treatment with monitoring. This paper also discusses about the barriers of telemedicine system and solutions to make it better. At last, this paper describes about the involvement of stakeholders in telemedicine system and how they can turn away the telemedicine into new stages with the help of IoT is also discussed. After maintaining these issues, the IoT based telemedicine system will become more advanced, more accurate and updated.

Keyword: WBAN, FBG, UAV, FAIDM, Blockchain, Telehealth Robot, Brain swelling sensor, COVID-19

I. INTRODUCTION

Internet of things has drawn a lot of attention in recent times. IoT has successfully combined virtual space and real world on the same surface. The main strength of IoT are the configuration of conscious autonomous devices and smart environment like smart home, smart cities, smart health etc. According to the Cisco, there were 50 billion connected objects with about 200 billion connections in 2020. IoT comes on spotlight because of being anticipated to be an important element of 5G networks. IoT contribution in 5G infrastructure changes the application schemes in many sectors especially real time communication between peoples and data-based machine. 5G network can able to work with lots of IoT device at the same time. In future, a form of 5G networks based IoT networks will assembles virtual reality, smart phone, sensors and other wireless communication devices. By this, IoT with 5G will influence our social life mostly. After internet and mobile cellular system, telemedicine is counted as the extensive intelligence which is considered that third wave of information technology. At the beginning, people were communicating through email and social networking system. But today's world required that every objective has to connect through internet and that is the main achievement of IoT. By connecting to the internet, information can be possible to globally share and for this it makes accessible from remote places. As well as, IoT plays essential role in healthcare. There are so many sections where IoT used such as, tracking patients in hospitals, identifying the appropriate medicine, monitoring patients from remote places and it is termed as telemedicine. Researchers are previously researched and agreed that for telemedicine rural areas can be cover by wide variety of healthcare services which improves the quality healthcare. Telemedicine appeared in under development country at the beginning of 2000s. The physicians and surgeons were communicating by informal tele-communication with their advisor, friends in different countries. It was unorganized and most of the medium were based on store and forward technologies like telegram, email etc. The focus of this paper is to highlight the some IoT technologies for healthcare.

The topic is very broad and it is almost impossible to describe all the available technologies in IoT for telemedicine. After all, the study is aimed to provide some deep analysis about the topic together with its effect in real life and conclusion.

II. STRUCTURE OF TELEMEDICINE

A. Work flow of Telemedicine

Telemedicine is many sided techniques which can produce emergency care in critical and non-critical situation. Telemedicine delivers a service for store medical history, AI diagnosis, medical streaming applications, real time monitoring which helps physicians to give treatment patients more effectively. In the below, an example of work data is shown:

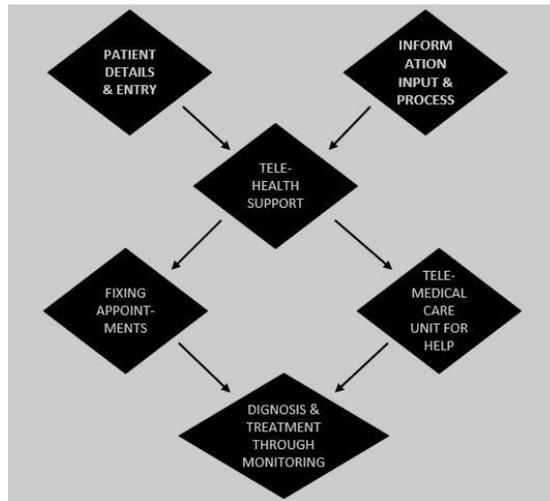


Fig. 1. Work flow

In the figure, the first one refers patient information such as symptoms, complication, case history etc. After that, patient's entry process is started and it allows to communication. Then the input data kept to telehealth supportive care unit. Doctoral assistant observes it well. In next, appointment is fixed by understands the situation. Besides, the telemedical care unit is available to serve for any system errors or solving any complaints, taking necessary steps etc. Once the disease is properly diagnosed, the doctor advises the patient accordingly and tells him/her to take the medicine. The patient will then be monitored until fully recovered.

B. Telecommunication technologies

Telemedicine technology used to communicate or establish connection between health care systems and us. These could be telephony, cellular mobile communication, modems and satellite technology. Telephony are basic services of telephone which contains copper wire, fiber optic cable, point to point microwave radio, HF radio etc. Modems has faster data rate then telephone network service. They are act like as a modulator, demodulator and they are capable of higher data transmission. The main usage of it is video conferencing. Cellular mobile communication role is same as the other two technologies. If an example can be given like it can be used to send ECG data from ambulance to hospital. Cellular communication communicates via radio links. It is providing beneficial and stable communication system for medical emergencies. Satellite technology can use for deliver telemedicine services to another area where is lack of terrestrial network. Mobile satellite communication can able to provide Information immediately. The applications are transmission of basic information to remote clinics, dealing with medical emergencies via video conference etc.

C. Features of Telemedicine

There are many features based on the opportunities of telemedicine. Such as, chronic health management, prescription compliance, store and forward, throughout care etc. Chronic health management is based on home monitoring system. It consists of health issues, advance technology (touch screen), high tech sensors, record heart patterns, blood pressure, oximeters, glucose levels etc. Then it's sent to the health care center by wireless and record in cloud. Prescription compliance is important feature specially for the elderly. It performs like an alert system for take medicine on time. Health complications increase for not taking medicine on time and for this he/she has to be admitted to the hospital. For this, it acts like a reminder system. Store and forward feature is able to capture high resolution diagnostic pictures or data which allows to stock and shared with patients and doctors virtually. Throughout takes care for all under serious and critical cases. An example might go such as sleep disorder. A system can monitor the sleep patterns, breathing to investigate the problem, body positions and suggest treatment plans to patient. [1]

III. ARCHITECTURE OF IOT

Current technology largely depends on IoT. Until now, it has not been possible to give any definite structure for IoT or not everyone could come to a same conclusion. Different researcher has been providing different architectures. Now, some common layer and layer of healthcare will be discussed.

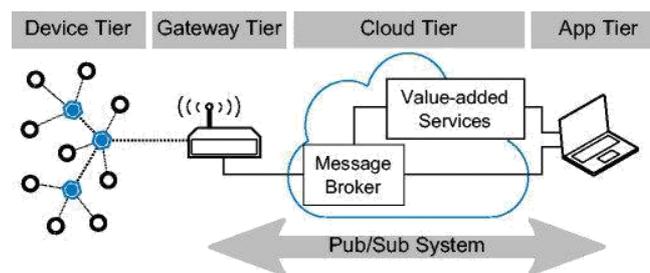


Fig. 2. General IoT structure

Edge technology layer has physical devices such as embedded systems, sensors, RFID tags. RFID tags is one type of tracking system that uses radio frequency. Edge technology layer gather information from those devices, then process and make communication with others. Access gateway layer task is same as well as it produces others services such as data publishing, maintaining and subscribing. It's collected data from sensors and this data can be processed on mobile, tab type devices. Middleware layer plays an important role which allows transformed, optimized information for sending and build connection between application and internet. Application layer makes accessible of all information in the type of GUIs, visualization. GUIs are type of visualization indicator. Those are, as like general layer of architecture of IoT. Other side, Biomedical data body temperature, blood pressure, glucose level, saturation level etc. are collected by sensor network layer. Then it sends data to a node which is named gateway layer. Nodes extract information from here. Then extracted information go to cloud data center layer. This layer is modifying information to make analysis, decisions and other activities. At the same time, a database is made to record medical history, images, videos, ICU signals etc. By this, it monitors the patient health condition. Besides, from the data storage engineers, scientist can work and research. To do research, machine learning algorithm is applied. [2]

IV. APPLICATIONS OF TELEMEDICINE

Many applications of telemedicine are currently using, many researches are ongoing and many models are proposed already. Between them some of the old and new applications are highlighted in details below:

A. WBAN based Telemedicine sensors

One or more sensors merged to form a network called Wireless Body Area Network (WBAN) which mainly observe the health condition of the patient. Wireless body area network (WBAN) is a sensor which built a network that means it is connected with medical appliances, health sensors and it is actually wireless type. The sensors should be installed on the surface of inside the tissue of the body, skin or away from the skin. For monitoring the diabetic's patient's glucose, it is placed into tissue of cells. For heart rate, blood pressure, pulse measuring, it is positioned on the surface.

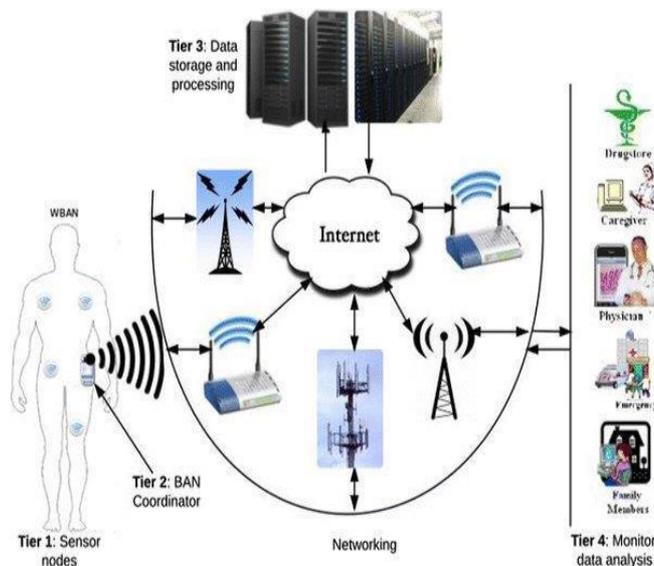


Fig. 3. WBAN basic architecture

There are some types of nodes here which are control connections and send information mainly like coordinator, relay, end type. Coordinator perform like a gateway, end blocked to perform unnecessarily and relay helps to sense data from the other nodes. Besides, actuator performs based on the receiving information from nodes. For example, when sensors produce glucose reading to the actuator, then it decides how much insulin is need for the diabetic patient then. Each reason of use sensor needs different frequency, data rate and utilization of energy. For instance, glucose sensor requires extreme lower power consumption, few data rate. ECG needs low power consumption and 3kbps data rate. Blood pressure sensors needs higher power and less than 10bps data rate. Motion sensor requires 35kbps data rate. The architecture of WBAN shows that how much important communication is. There are also 3 tiers. In tier 1, data is created from body sensors and transmits. In tier 2, the data is proceeding and it has good control over the management and security. Then data reached to tier 3 via access point. It's sent data to another sever for storing or observation. By using, IoT based technology, we can be notifying on our smart devices. [3]

B. Anesthesia patient monitoring

IoT cloud-based network plays vital role for monitoring the patient who has made unconscious. It's actually permitting online monitoring. Anesthesia means short term loss of sensation which is applied to prevent pain during surgery. This architecture helps the anesthesiologist to remain connected with all the patients under his control.

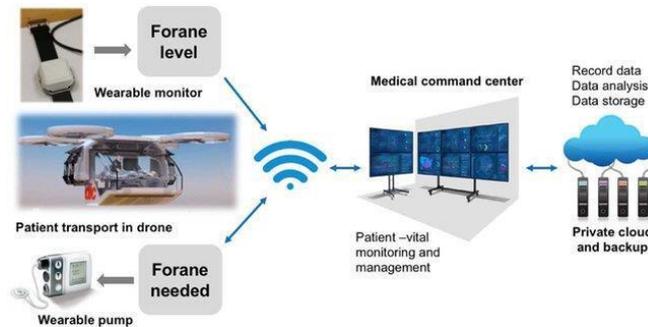


Fig. 4. Anesthesiologist monitoring system

Mobile/smartphone/smartwatch is used here and it got data from Therapeutic Drug Monitoring (TDM) system on the patient and transmit data to cloud. TDM mainly calculate the amount of medicine in patients' blood. The data transmitting process is done by Raspberry Pi (RPI) and it's without wire. Thus, anesthesiologist is able to monitor the patient health status through mobile app. If measured data went out of span then android app will provide notifications or alert by strong vibration or sound. Besides, it is also possible to connect with other smart devices. That's how teleconsulting is implemented. [4]

C. Monitoring by using FBG

The full form of FBG is Fiber Bragg Grating which is used to construct IoT sensor devices to create telemonitoring system. Optical fiber sensors are also used which is based on the FBG. The designed system can monitor Ballistocardiogram (BCG) which helps to measure respiratory rate, pulse rate, etc.

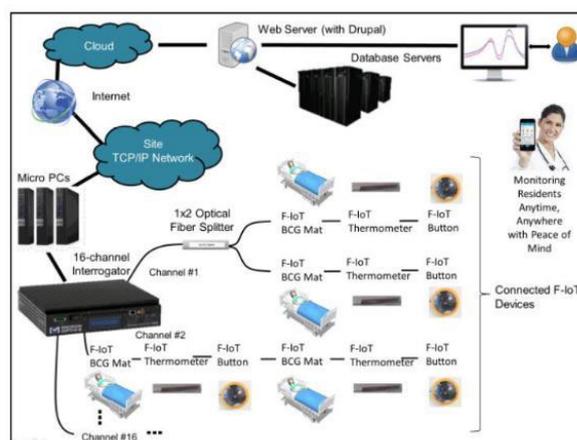


Fig. 5. Fiber Bragg Grating

It can calculate the rate with minimum error and the vital thing is that it can monitor accidental bed exit of patients or deteriorates health condition of patient. In any unexpected condition it will provide real time alert to notify medical staffs, physicians which is really need in large nursing homes or

hospitals. Fiber Bragg Grating is index change onward the core of the optical fiber that is periodic or aperiodic. The reflective index varies conduct to the reflection of the light. By using this technology, sensors are packed into IoT devices and create F-IoT. F-IoT devices are associated in parallel or series by optical fibers by sense. The sensing element is optical sensing interrogator. The interrogator is connected to the server. For this system, Drupal is used as framework as well as bootstrap framework also can be used. Those are used to make connection between different sensors with the users. How many devices can be connected at the same time this is relying on the wavelength of interrogator. There are some advantages but the main advantage is FBG is stable and power source is no need. Besides, they can adjust any condition and it is safe for long term monitoring. [5]

D. New healthcare system (UAV)

There has been a lot of gossiping and talk is going on about UAV in recent past and recent year. Based on this it is possible to create a new health care system for providing better service. In this system, UAV is used as ambulance and it will be able to fly and reach to emergency site without any hindrance. UAV normally equipped with different sensor nodes, GPS, wireless nodes, display screen etc. Main goal here is that to provide high quality communication link and reduce response time. In normal, the emergency healthcare depends on hospital position, vehicles, traffic system etc. But in this system emergency health service mostly depends on UAV and IoT. There are 4 layers here and their functions are data gathering layer has sensor nodes which collects data and describe health condition, then communication layer makes connections between cloud, devices and hospital etc. Moreover, monitoring of the patient after the operation is very important. That's why, researchers are proposed IoT cloud-based Anesthesia monitoring system. By this, it is possible to create safe monitoring network.



Fig. 7. New healthcare system

The communication should be wired or wireless. Wired system used for real time communication or large amount of data providing. Zigbee, Wi-Fi, LTE, NFC are used as for wireless communication. Next, data center layer is matched the information and make list as per requirements. After analysis, it sends results to user, nearby hospitals, medical workers etc. Smart terminals layer is displaying the information and Smartphone is one kind of smart terminals where we can also check the health conditions. [6]

V. HOW TELEMEDICINE SOLVING PROBLEMS

There are several types of applications which have been described above that how they work, where is used telemedicine and so on. Within those application, some of them are proposed like cloud anesthesia monitoring, UAV based healthcare. In some areas of chine, UAV based healthcare already has been used experimentally. But, it is not completely done yet. At this moment, we will just focus on how we can solve the problems or obstacles. WBAN can create a multi patient

monitoring environment which is a great opportunity for us. Moreover, it offers flexibility also improves life care options and cost savings options. There is a good advantage which is that it is possible to monitor through any portable device (e.g. smartphone, tablet). On the other side, it allows us to monitor patient's health condition from a distance. It can also play an important role in different countries. Anesthesia is a procedure which is very important in pre-surgical. It has an effect even after the operation. The general Anesthesia may cause some side effects like nausea, vomiting, headache, instability of neurons.

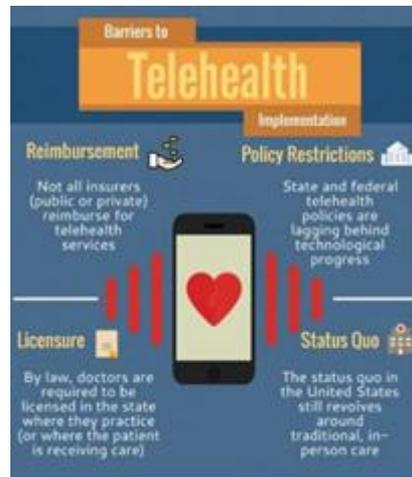


Fig. 8. Telemedicine system

It also saves data, so the anesthesiologist can know before applying that the figure out the problems which is related to Anesthesia to the patient. FBG based can be used in telemedicine system for monitoring which will help in more healthcare. F-IoT thermometer, F-IoT BCG sensor mat and F-IoT button can monitor patient's condition continuously. The main thing is that, it can detect movement. There is many hospitals do not have state-of-the-art facilities and no staff have stayed to the patients at night. So, sometimes abnormal bed exits of patient need to monitor. That's why, FBG can be good sign. It will be very beneficial for children that FBG can also alarm a signal in a sudden increase in fever. UAV based health-care which is designed to reduce the response time of getting treatment. Good and proper treatment is very important within time but sometimes it is not possible. For this reason, many patients die without any treatment. Therefore, the reason behind not getting treatment at the time of needs which are wasted in traffic jam for stacking, no one around to help during illness, nit getting first aid etc. However, traffic jams are not a big problem in busy cities. So, there will be needed an alternative way to respond quickly. Also, is also a good way to give first aid very quickly.

VI. BARRIER FOR TELEMEDICINE

There are some applications which have been already discussed so far. Which describes how the system works, how it serves and how they solve the problem. If it will possible to make proper and perfect these technologies or solve those limitations then it's usage will increase in the next generation. Although the percentages of first aid is less for developing countries and underdeveloped.

countries. That's why, it is a big challenge for establishing or implementing. From WBAN sensors, we have been getting to know it's promising, inexpensive and monitoring capability during activities for affordable over the world, a number of challenging issues should be overcome such as its complex system design, customization, security, and social issues. The main thing is need to ensure security and secure information.



Fig. 9. Barrier for Telemedicine

There are a lot of discussion happening this report regarding cloud anesthesia monitoring through there are some limitations for telemedicine technology such as clinician's cam use this technology for intending to monitor the depth of anesthesia but which may not reflect the real underlying level of awareness and for this monitor will find incorrect result. Moreover, it is also important to maintain cyber security because there is big threat. FBG sensors are mainly used for monitoring purpose but there are some limitations such as it also has so much sensitive issue due to temperature. When temperature changes different results may appear. In shortly, it has some cross-effect problems due to temperature. Zigbee which is a telecommunications way, it has added new dimension to the ECG monitoring. UAV based health-care system offers great idea to solve the problems. But the main problem is that it is so much expensive. It also needs a good manpower who can operate it. However, if it becomes damage on the process, there will be more losses. There are some other big issues such as fraud, abuse, misdiagnosis for error, controlled substances and so on which are the obstacles of telemedicine.

VII. SOLUTIONS FOR PROBLEMS

There are lots of limitations but the main one will describe now. In the telemedicine system, there has some common problem one is cyber-attack. IoT offers huge value to many sectors especially in health sector. But IoT based health faced several security problems. Mainly, the data security and patient privacy are directly connected. If it is not possible to transmit collected information safely then it is not becoming reliable. Or, if something breaking the results for interrupt the transmission then it becomes also problematic to the health staffs such as doctors, nurses, surgeons. Healthcare is mostly aimed for cyber-attack according to the result of Vector Networks analysis report. Actually,

there is no telemedicine is safe. Malicious action is one of the dangerous cyber-attacks. It is operated by a people or organization with bad intentions. By this they want to achieve their targets, which should be economical or political. They are actually reprogrammed, reconfigured, the network-based device by malicious action. It can shut down medical connected apparatus, make paralysis of health information system, expose medical sensitive data, take money and take life of patients. It is need to draw a cyber-attack map to know the threats and identify the weakness and have to take necessary action according to the situation. Ransomware is special type of malware and threats and it encrypt the data and prevent hospital from accessing it. That's why, hospital can't monitor and it makes delay in the treatment and to solve this problem, make sure the back up plans, easy recovery system and capable to face the threat. Denial of service is the most harmful and it can weaken a strong system and make down to infrastructure for some hours. IoT contains RFID system which has id and by interrogation it is easy to cloning. To prevent this RFID, readers and server must be unchangeable. At this situation, it is necessary to include some integrity, confidentiality, anonymity in shared patient information, access control Those are divided into several security layers which make it difficult to evade and also blockchain-based security service can provide data privacy, integrity and anonymous data sharing capability which is under research this era is to make it better. [7]

The telemedicine solution provider: There are 6 domains that providers are accessed on and they are:

1. Effectiveness of care
2. Access/ Availability of care
3. Experience of care
4. Utilization and Risk-Adjusted Utilization
5. Health Plan Descriptive Information
6. Measures collected using electronic clinical data system

In IoT based telemedicine system, there should be strict requirements for smooth implementation of telemedicine. For this research there is research was done which was to establish the effects of Stakeholders involvement on the telemedicine projects in Nairobi County, Kenya with a specific focus on Access Afya. This project was to determine the extent of stakeholder involvement on the telemedicine projects. This descriptive research design was used and target population was 50 employees of Access Afya working in medical, IT, management and quality assurance departments. A census survey was conducted and data was collected through a questionnaire. From the survey they were found on the extent of stakeholder involvement in the telemedicine project, 65%, 36%, and 27% that the healthcare organization, the government, and the telemedicine solution provider respectively were involved. Therefore, there are another some stakeholders such as patients and doctors.

A. The healthcare organization

This type of organizations has to reduce the patients service time and costs. They provide no need to take time off of work. They do eliminate child or elder case issues. It easily accesses to specialist.

B. The government

Government is here to protecting against health care fraud. Sometimes they provide financial supports to any medical institutions.

The providers increase the quality of care, promote interoperability, decrease costs. bed rest or serious consequences result actually need to be hospitalized for proper treatment.

C. Doctors

The doctor has also called the telemedicine physicians. They are here to monitoring prescription medications usage, using the IoT based device with proper way like all necessary information such as the patients' health conditions, blood pressure level and so much more remotely.

D. Patients

The patients have to make sure that their smartphone, tablet or pc are ready, check insurance, make an appointment, describe symptoms etc. [8]

IX. STAKEHOLDER'S INVOLVEMENT TODAY'S WORLD

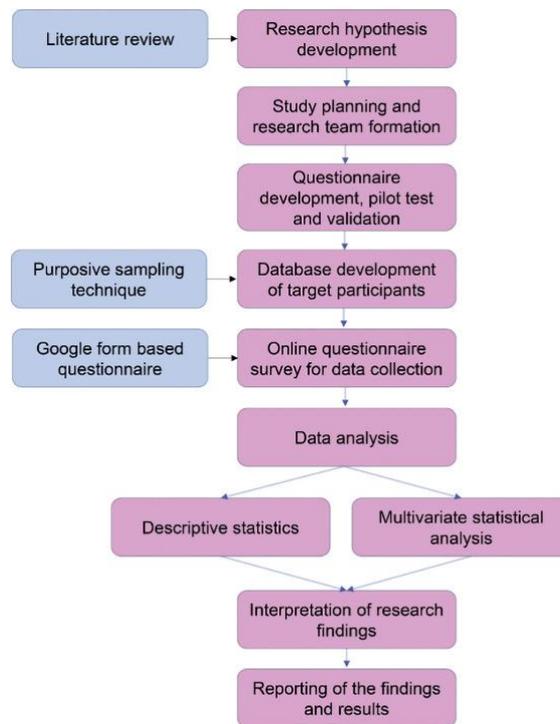


Fig. 10. Healthcare flow chart during pandemic

In the figure, a flow chart is shown which is a common example of telemedicine as well as application and it has been implemented as an effective model in many countries in the current pandemic COVID 19. It will be more beneficial if it can be fully described and further propagated. At first in the chart, it is seen that, patients choose virtual platform which can be asynchronous method (email, message, web portal) or synchronous method (video conferencing) healthcare flow chart during pandemic. In asynchronous method, patient mainly do self-assessment like checking the symptoms and if there is positive symptom then patients have to move on synchronous method. That means patient have to contact with physician for follow up. Then physician will observe and identify health problem. From asynchronous side and synchronous side, if there is no problem find out then patient will be stay at home and he will be monitoring but if problem found in synchronous side, then patient need to go to the hospital for test. The physician will then give the necessary tests to diagnose and check the physical condition. If the patient's condition is good after the test, he will be asked to take treatment from home with medicine and take.

VII. NEXT GENERATION OF TELEMEDICINE

A. Doctor robot

Autonomous telehealth robot can help for remote patient monitoring. Like some robot act like a doctor. They make rounds the hospital, sharing live feed and send to specialist who can consult by on screen. For this, in rural area, doctors can check conditions from far away. Other robots allow surgeon to contribute with operations remotely by seeing the same view and performing the procedure.

B. Brain swelling sensors

Brain swelling sensors: This sensor has less amount of size which are implemented within the cranium to help brain surgeries keep track of severe brain injuries and avoid further deathly swelling. They measure pressure on the brain and are able to dissolve by itself in the body without further medical interference. Adding IoT in this device, it will be more efficient. The data from the device at brain will pass faster and the data will more accurate.

C. Smart video pills

A smart pill can travel through a patient's intestinal tract and take pictures as it travels. It can then send the collected pictures information to a wearable device, which in turn would send it to a dedicated smartphone app. It can also visualize the gastrointestinal tract and colon remotely. In this pill, IoT can be added. After that, this device can improve it working process and there will be no need a wearable device. [9]

D. Blockchain based secure service

For the next generation IoT based telemedicine system, blockchain based secure telehealth system will be more important for telemedicine. The solution which utilizes blockchain-based smart contract in the key of establishment, data access and data sharing process. The blockchain storage is extended with the IPFS (Interplanetary File System) to reduce blockchain storage growth to support the huge number of connected nodes. The access control to the patients for data sharing are handled through the smart contracts.

E. FAIDM in Telemedicine

FAIDM refers to federated anonymous identity management which is for medical privacy protection in telemedicine system. It will be provided a secure way to protect medical privacy such as secure transmitted data which is related to privacy of patients. Also, It will be provided anonymous identities for devices in order to reduce the possibility of leaking transmitted medical data and real information of device and its owner. Therefore, if one of devices transmit abnormal data, it will provide traceability for servers of medical Institute.

XII. CONCLUSION

This report was discussed about IoT based telemedicine system in details. Besides, the necessity of telecommunications in the medical sectors which has been described. The scope of telemedicine is wide through this report highlights some of it. The main thing of telemedicine is offering is to provide treatment to the patient from a distance. In addition, we are able to keep the patient under observation continuously. As a result, it is possible to take quick action on any problem of the

patient. Also, several applications have been described. Where it can be seen that, it allows us to quick response, take information data from home, store the information, create possibilities to make new healthcare system and so on. So, it can be seen that how much advantages and possibilities it has. As well as, trying to find out the limitations of telemedicine in the report. The telemedicine system has not yet to become popular. But the big countries have already started to thinking about it, giving importance and they have started investing. But it still needs a lot of improvement. As well as, kore research is needed to address most of the problems raised in the structure in different countries.

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