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PROPOSED SYSTEM USING IOT AND GIS TO GENERATE ELECTRONIC MEDICAL RECORDS

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Abstract

Every aspect of human's life is affected by the Technological revolution breakthroughs, it has significant effects on our modern lives, and a highly favourable and helpful influence on the medical industry. In the last era, there were great improvements in the fields of Internet of Things (IoT) and Geographic Information Systems (GIS) that allowed healthcare to evolve rapidly and created a new concept of healthcare delivery. This paper explores the potential benefits of using IoT and GIS in healthcare, including improved patient outcomes, enhanced data analytics, and more personalized and efficient healthcare delivery. With the growing adoption of these technologies the healthcare industry has the potential to transform the way patient care is delivered and managed. A new approach about how the real-time data can be handled and transferred from IoT devices to the Electronic Medical Records (EMRs) has been discussed. Also a system has been proposed to generate these records. The use of IoT and GIS in Electronic Medical Records has several implications on the field of medical health care from improved patient care, increased efficiency to better decision-making and reduced costs, which makes the need for these technologies inevitable. And as these technologies continue to develop, we can expect to see even more benefits from their use in healthcare.

Keywords: Healthcare, Patient care, Decision-making, Electronic health report, Healthcare stakeholders

1. INTRODUCTION

The healthcare industry is rapidly adopting and constantly seeking innovative ways and new technologies to improve patient care and efficiency. Two of the most promising technologies for healthcare are the Internet of Things (IoT) and geographic information systems (GIS). These two technologies can be used together to create electronic medical records (EMRs) that are more comprehensive, accurate, and accessible than traditional EMRs. IoT devices such as wearables and medical sensors can be used to collect a wide range of real-time data about patients, including their vital signs, location, and activities. This data can be used to create a more complete picture of the patient's health and to identify potential problems early on, increase efficiency, reduce costs, and better decision making [1], [2]. GIS can be used to visualize this data and to track patient trends over time. This information can be used to improve care planning and to identify areas where resources are needed and to map healthcare facilities and track disease outbreaks. By combining these technologies, healthcare providers can develop more comprehensive EMRs that provide a more accurate and complete picture of patient's health status. [3] The rest of this paper is organized as follows:

In section 2, the related work of this paper is presented. Section 3 outlines a background about healthcare, IoT and sensors. Section 4 describes the proposed system architecture, and its benefits. Finally, section 5 concludes the paper.

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2. RELATED WORK

When Kevin Ashton tried to connect objects to the internet via RFID tags in 1999, IoT was founded, (designed to make it easier for computers to manage objects) [1], [2]. Shunsuke Doi, et al. in [3] explored that we can develop a Patient Access Area Model by using a Geographic information system (GIS), and, to evaluate the balance of medical supply and future demands in small areas, he simulated patients' access to hospitals. We set the accessible area by patients' transit time for each hospital. The IoT is quite a new topic in the healthcare sector. Probably, this is due to healthcare organizations that operate in a highly regulated sector. Thanks to the continuous development of wearables and smartphones, the different IoT-based healthcare devices have transformed the traditional healthcare system into a smarter one, closer to the needs of patients. It leverages IoT innovations to move away from the old hospital-centered practice and to create a new patient-centered way of acting [4].

In the healthcare context, IoT can be defined as a network of intelligent sensing devices and physical objects which are connected for the collection, monitoring, and control of healthcare data. In fact, through the detection sensors incorporated in the objects worn (gloves, watches, glasses, etc.), That are connected via wired or wireless networks to tablets or smartphones, patient data can be immediately consulted by doctors and patients themselves [4], [5]. There are several definitions of IoT in the literature. Some of them prefer the type of connectivity (Radio Frequency Identification, Wireless Sensor Network), that binds different objects, and others focus on the type of object (services and applications) and its application domains (smart cities, traffic congestion, waste management, etc.) [6], [7]. Zeitz, et al. in [8] used ArcView 9.0 GIS software to describe spatially the US adult asthma prevalence data from the 2003 Behavioral Risk Factor Surveillance Survey (BRFSS) database. Also, they analyzed healthcare services data including lacking a PCP, lacking health insurance, and deferring care because of cost. Race was used as a stratifying variable in their analyses. Edmund et al. in [9] show that nowadays, more and more government agencies, companies and healthcare organizations are moving towards electronic records from records on paper. The Electronic Medical Record (EMR) system is being used to capture, organize, maintain, and retrieve patient’s medical records. The electronic medical record is the ancestor of both the electronic health record and the electronic patient record. An EMR is the digital documentation of each use of the health service done by a single person, and the electronic patient record (EPR) is a computer-based clinical data system designed to replace paper-based patient records [10]. Marc D. Gellman in [11] elucidates The EMR includes information on patient demographics, progress notes, medications, vital signs, clinical history, immunizations, laboratory results, and reports of diagnostic procedures. Melton, et al. in [12] elucidate Today’s EHR landscape includes challenges around EHR data entry, increased patient participation in EHR data entry, certified EHRs with increased inter-operability, and several regulatory requirements often leveraging EHRs. Fiaz Ahmed and Mohamed O Khozium, proposed a system using VORD methodology which is developed to help out people in a rapid, easy and a cheap way when they face any emergency situation at their homes such as Asphyxia, Obstruction of Air Passages, Bites and Stings, Electricity Shock etc. [13]

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3. BACKGROUND

3.1 IoT in healthcare:

IoT healthcare systems provide real-time data and insights into patient health, enable remote monitoring and t. However, of chronic illnesses, enabling remote monitoring and management of chronic conditions However, there are also several challenges that need to be addressed to fully realize the potential of IoT healthcare systems. Here are some of the challenges and opportunities in IoT healthcare systems [4], [5]:

3.1.1 Security and Privacy:

One of the biggest challenges facing IoT adoption in healthcare is security and privacy. Connected devices used in healthcare generate vast amounts of sensitive data, including patient health information and personal data. This data needs to be protected from unauthorized access, hacking, and other security threats. Additionally, healthcare organizations need to comply with regulatory requirements such as HIPAA in the United States and GDPR in Europe, which place strict requirements on data security and privacy. Addressing these challenges requires implementing strong security measures, such as encryption, access controls, and regular security audits.

3.1.2 Interoperability:

IoT devices and platforms used in healthcare are often developed by different vendors and may use different protocols and standards, making it difficult to integrate and share data between different systems. Interoperability standards need to be established to enable seamless data exchange across different devices and platforms. Additionally, healthcare organizations need to invest in data integration and management systems to ensure that data is accurate, complete, and up to date across different systems.

3.1.3 Data Quality and Accuracy:

IoT devices used in healthcare generate large amounts of data, but the quality and accuracy of this data can be affected by factors such as sensor accuracy, data transmission errors, and device malfunctions. To ensure that IoT data is accurate and reliable, healthcare organizations need to invest in data analytics tools and processes to validate and verify the data generated by IoT devices.

3.1.4 Cost:

Implementing IoT devices and platforms in healthcare can be expensive, requiring investments in hardware, software, and infrastructure. Additionally, maintaining and upgrading these systems can be costly over time. To address this challenge, healthcare organizations need to invest in cost-efficient IoT solutions that provide value for their investment.

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The IoT (Fig. 1) can be divided into four main layers [14]:

- Perception layer: This layer consists of the physical IoT devices themselves, such as sensors, actuators, and gateways. These devices collect data from the environment and transmit it to the next layer.
- Network layer: This layer is accountable for conveying data from the perception layer to the application layer. It includes the communication protocols, routers, and gateways that allow devices to communicate with each other.
- Processing layer: This layer is responsible for storing, processing, and analyzing the data collected from the perception layer. It includes cloud computing platforms, edge computing platforms, and data warehouses.
- Application layer: This layer is responsible for providing users with the ability to interact with the IoT system. It includes web applications, mobile applications, and other software that allows users to view, analyze, and control the data collected from the IoT devices.

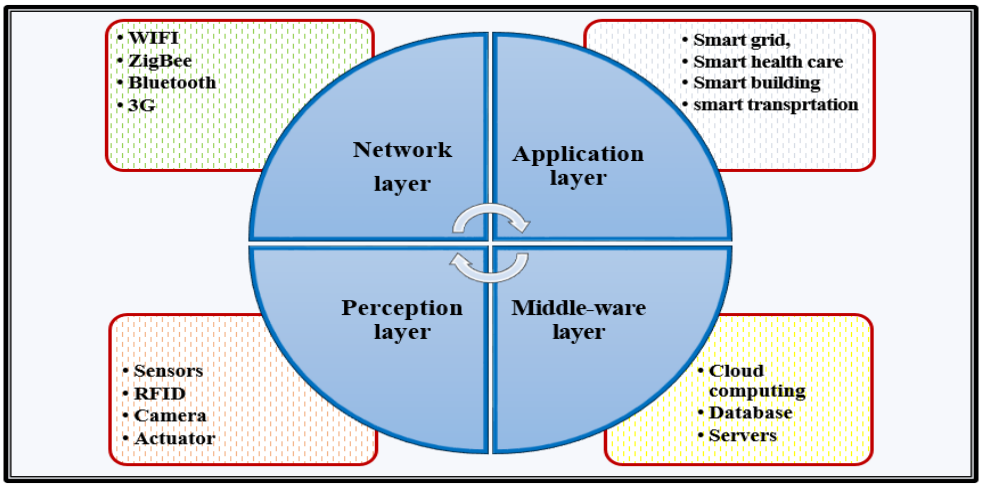

Figure 1: IoT Layers Architecture

3.2 Electronic Medical Records:

EMRs are the digital versions of paper charts which have traditionally been used in healthcare settings. EMRs store patient data such as demographics, medical history, medications, allergies, and test results. They can also be used to generate reports, order tests, and communicate with other healthcare providers.

- EMRs offer several benefits over paper charts, including:
- Improved patient care: EMRs can help providers to track patient progress and make informed decisions about treatment.
- Increased efficiency: EMRs can help to automate tasks such as scheduling appointments and ordering tests.

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- Reduced costs: EMRs can help to reduce administrative costs by eliminating the need for paper charts.
- However, there are also some challenges associated with EMR implementation, such as:
- Data security: EMRs contain sensitive patient data, so it is important to ensure that this data is secure.
- User adoption: EMRs can be complex to use, so it is important to train users on how to use them effectively.
- Cost: EMR implementation can be expensive, so it is important to carefully consider the costs and benefits before implementing an EMR system.

4. Proposed system Architecture:

The Proposed system architecture for IoT in healthcare as shown in (Fig. 2) consists of four main components: IoT devices, Gateway, Data Storages & Management, EMRs, and stakeholders

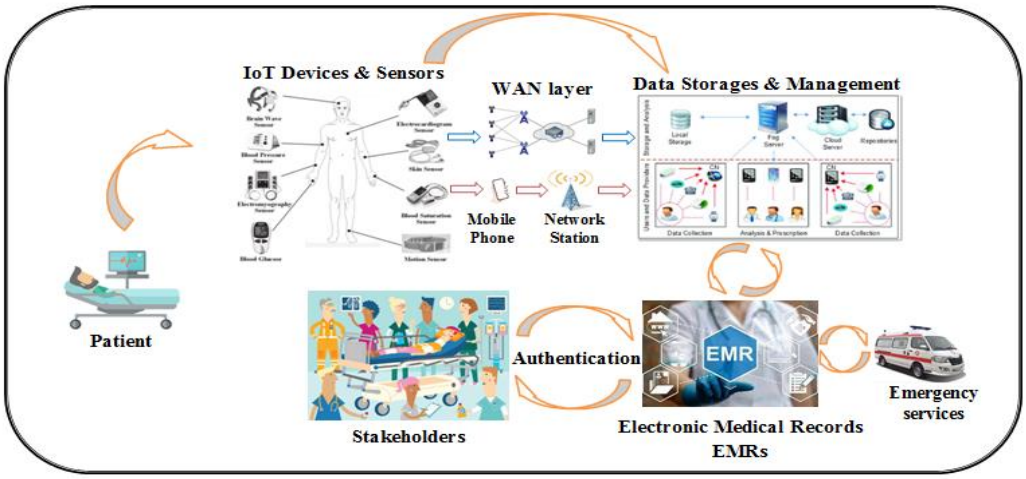

Figure 2 : Proposed System Architecture

4.1 IoT Devices:

IoT devices are the first component of the system architecture, as they enable healthcare providers to collect data from patients in real-time. This data can be used to monitor a patient's health status and detect any potential issues before they become more serious [2][3]. These devices can include wearables, sensors, and monitors that are used to collect data from patients. For example:

- Wearables: These devices are worn on the body and can track a patient's activity levels, heart rate, and sleep patterns. Examples of wearables include fitness trackers, smartwatches, and health monitors.

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- Sensors: These devices can be placed on a patient's body or in their environment to monitor a specific aspect of their health. For example, sensors can be used to monitor a patient's glucose levels, blood pressure, or body temperature.
- Monitor devices: These devices are used to monitor a patient's health status or deliver treatment. Examples of medical devices include insulin pumps, pacemakers, and nebulizers.

Gateway is placed between IoT sensors Network and the Cloud as an intermediate layer. The gateway receives data from the IoT devices and sends it to the cloud platform.

It may also perform some data processing and filtering before transmitting the data to the cloud platform. The gateway can be a physical device or a software component that runs on the IoT device itself [13], [14].

4.2 Data Storages & Management:

The Storages & Management is the second component of the system architecture. It receives data from the IoT devices and stores it in a database (Local servers, Cloud servers, Fog servers) [15]. It may use machine learning algorithms and analytics to analyze the data and generate insights about a patient's health status and make a data filtration process to assign the correct data to the correct stakeholder. These insights can be used to generate an electronic medical record (EMR) for the patient. The EMR contains information about the patient's medical history, current health status, and any medications they are taking [10]. The EMR can be accessed by healthcare providers to monitor a patient's health status and provide appropriate care.

4.3 Electronical Medical Records:

EMRs are electronic records of a patient's medical history and current health status. The EMRs are generated by the cloud platform using data collected from the IoT devices and analyzed using machine learning algorithms and analytics. The EMRs can be accessed by healthcare providers to monitor a patient's health status and provide appropriate care. Some of the key features of EMRs include:

4.3.1 Comprehensive patient information: EMRs contain comprehensive information about a patient's medical history, current health status, and any medications they are taking. This can help healthcare providers make more informed decisions about a patient's care and help the paramedic and specialist doctors to make better, fast and more efficient examination of the patient [11], [12].

4.3.2 Improved accuracy and completeness: By automatically collecting and analyzing data, the system can generate more accurate and complete records than traditional paper-based systems.

4.3.3 Visualizing patient data & emergency services enhancement: Using GIS data in EMRs to connect with emergency services like ambulances offers several benefits:

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- Geographical Patient Information: EMRs contain geographical data, allowing the system to identify the nearest emergency service stations based on the patient's location.Fig.3.
- Real-Time Incident Mapping: The GIS component of the EMR system generates real-time incident locations, enabling emergency services to visualize the precise location of the emergency and dispatch the nearest ambulance accordingly.
- Emergency Facility Identification: GIS data integrated into the EMR system identifies nearby healthcare facilities, ensuring prompt transfer of patients requiring immediate medical attention beyond what can be provided in the ambulance.
- Resource Allocation: GIS data helps emergency services allocate resources effectively by identifying areas with higher emergency call volumes and specific types of emergencies.
- Routing and Navigation Assistance: GIS data helps calculate the most efficient route for ambulances to reach the incident location, considering factors such as traffic conditions and road closures.Fig.4
- Enhanced Communication and Coordination: GIS data in EMRs facilitates seamless communication between emergency services and healthcare facilities, providing paramedics with additional patient information like medical history and allergies.

Figure 3: Shows the location of the available medical services providers in Makkah

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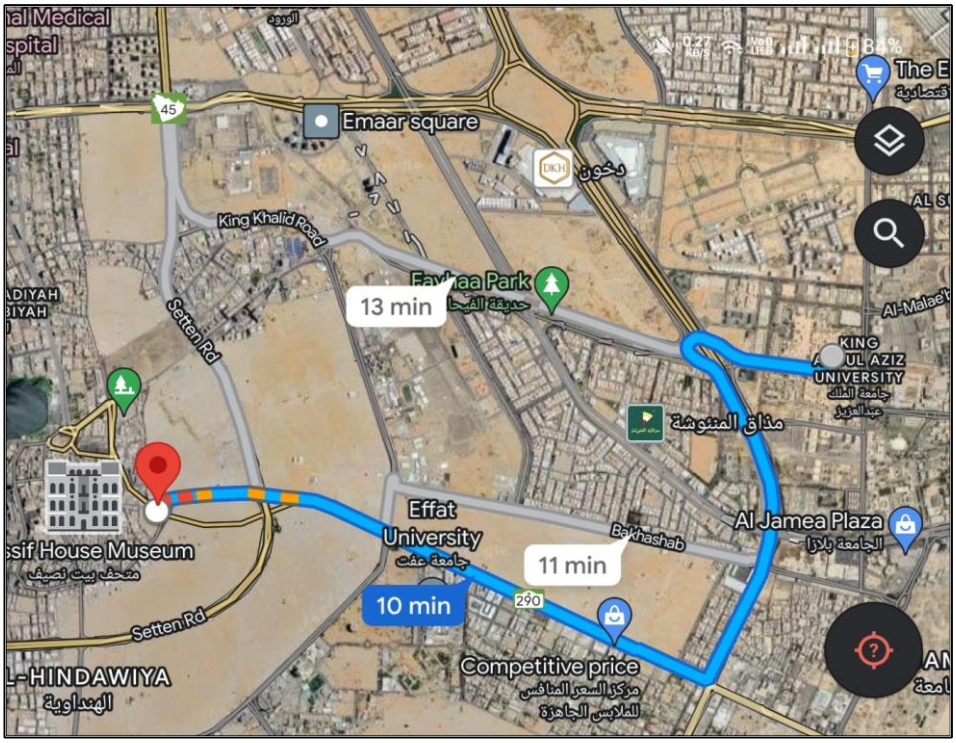

Figure 4: shows example path for the emergency service providers in real time

4.3.4 Easy access to patient data: EMRs can be accessed by healthcare providers, Doctors, paramedics, Hospitals, Ministry of health, technical staff, and patients from any location, which can improve the coordination of the health care and minimize the risks of medical errors. This access is authenticated, and the data is assigned to each of these stakeholders by and assumption algorithm which make this data is on the point for each one of them [13] for example:

- The healthcare providers and payers don't need to know about patient temperature data or oxygen rate but need to know how many patients need a thermometer.
- The Ministry of health needs data about how many patients go to the hospitals per month.
- Doctors need to know all patient data that can help him determine the patient's condition.

The system stakeholders and what activities should be handled are being shown in Fig.5

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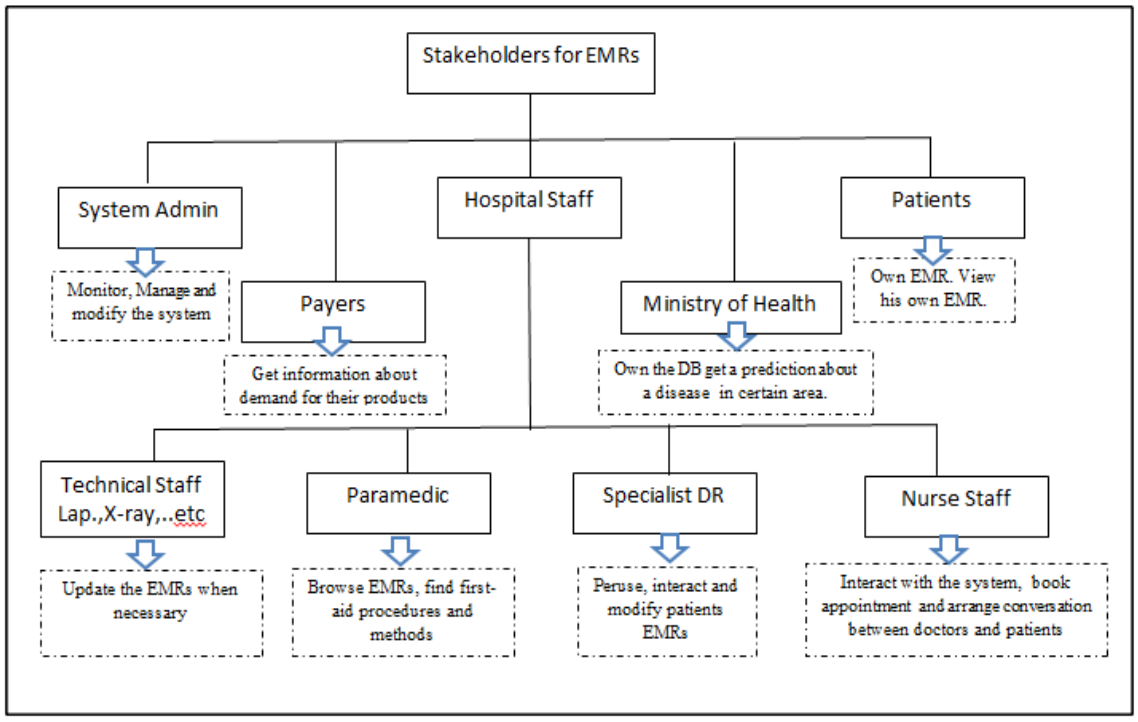

Figure 5 Stakeholders for EMRs including activities

So, to drive this data as explained above the system makes a process in the data given from IoT devices. This process depends on data filtration algorithm, data assumption algorithm, and data analysis to drive the correct data in the write way to stakeholders.

This proposed system introduces the following:

- **Real-time Monitoring:**

One of the key benefits of using IoT devices in healthcare is real-time monitoring. IoT devices can collect data from patients in real-time, providing healthcare providers with a continuous stream of information about a patient's health status. This can help detect early warning signs of health problems and prevent complications. For example, a wearable device that monitors a patient's heart rate and blood pressure can alert healthcare providers if the patient's readings are abnormal, allowing them to take immediate action.

- **Remote Patient Monitoring:**

The system enables remote patient monitoring, which can reduce the need for hospital visits and improve patient outcomes. Remote patient monitoring allows patients to receive care in the comfort of their own homes, reducing the risk of hospital-acquired infections and improving patient satisfaction. For example, a patient with diabetes can use a glucose monitoring device to track their blood sugar levels at home. The data collected by the device can be transmitted to the cloud platform and used to generate an EMR for the patient.

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Healthcare providers can then review the patient's EMR remotely and make treatment recommendations as needed.

- **Improved Accuracy and Completeness of EMRs:**

By automatically collecting and analyzing data, the system can generate more accurate and complete records than traditional paper-based systems. EMRs generated by IoT devices can provide a comprehensive view of a patient's health status, including their medical history, current health status, and any medications they are taking. This can help the healthcare providers in making more informed decisions about a patient's health care. In addition, EMRs generated by IoT devices can be updated in real-time, ensuring that the information is always up-to-date.

- **Improved Coordination of Care:**

Generated EMRs can be accessed by healthcare providers from any location, which can improve the coordination of care and reduce the risk of medical errors. For example, a patient's primary care physician, specialist, and pharmacist can all access the patient's EMR to ensure that they are providing coordinated care. This can help reduce the risk of medication errors, duplicate tests, and unnecessary treatments.

- **Cost Savings:**

IoT devices and EMRs can help reduce the cost of healthcare by improving efficiency and reducing the need for hospital visits. For example, remote patient monitoring can reduce the need for hospital visits, while EMRs generated by IoT devices can reduce the amount of time and resources needed to maintain paper-based records. In addition, the use of IoT devices can help healthcare providers identify potential health problems before they become more serious, reducing the need for expensive treatments and hospitalizations.

5. CONCLUSION

In this paper a Healthcare System Architecture using IoT was proposed, the use of IoT in healthcare to generate EMRs has the potential to revolutionize the healthcare industry. The benefits of IoT in healthcare include customized treatment, predictive analytics, remote patient monitoring, and cost savings. However, there are also challenges that need to be addressed, such as data security, data privacy, interoperability, and integration with existing healthcare systems. As IoT technology continues to advance, it is important to address these challenges to fully realize the benefits of IoT in healthcare.

This system is based on the idea of how to collect data from different IoT devices then analyze and manage these data to generate EMRs. Every patient has his own EMR which contains all of his medical history. On the other hand, the rest of the stakeholders have the access to the essential data they might need by the authentication and data assumption process.

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