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Asthma Patients' Cloud-Based Health Tracking and Monitoring System in Designed Flashpoint

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ABSTRACT

Asthma is a chronic illness that causes improper respiratory organ function and breathing problems. Three hundred fifty million people worldwide have bronchial asthma, or one in 12 adults. Self-monitoring is the first step in managing chronic illness. This lets doctors and people monitor and address health conditions in real-time. Telemonitoring is a phrase used in IT to remotely monitor the health of patients who are not in hospitals or medical centers. Wearable medical sensors, such as IoT-based remote asthma and blood pressure sensors, capture real-time information from remotely located patients. The medical information is then transmitted through the Internet for medical diagnosis and therapy. Classical Spirometry measures how effectively a patient's lungs function and requires supervision. We want to support impacted patients; thus, we built a monitoring system. With sensors including heartbeat, dust, temperature, and humidity, the device will collect health-related data and upload it to the cloud, helping doctors diagnose patients. This study uses private cloud computing to track and monitor real-time medical information in approved areas. In addition, the private cloud-based environment called a bounded telemonitoring system is meant to capture real-time medical details of patients in the medical centers inside and outside medical wards. In addition, a new wireless sensor network scenario is intended to monitor patients' health information 24/7. This research secures medical information access and guides future medical system development.

Key words: Asthma Patients, cloud-based monitoring system, cloud-based health tracking, smart inhaler

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INTRODUCTION

Today, the cloud is required to develop IoT systems for hosting data and remotely managing devices everywhere. It acts as a database with millions of members working every day. As a result, IoT apps send sensor data to the cloud from vast resources. Cloud computing's application layer processes and analyzes data (Achar, 2015). IoT devices are proliferating, leading to 'Big Data,' where vast amounts of data must be handled and analyzed. IoT monitors Asmtha patients by sensing their heartbeat behavior and sending recorded pulse counts to the cloud. The hospital, doctor, or patient's family can monitor his condition and transmit feedback to the sensor to boost the recording rate.

In cloud computing, the public cloud effectively monitors information and administers services for pervasive healthcare systems, scalability, and security. As medical information is valuable and must be secured during transmission over the Internet, many medical organizations have not used public cloud platforms due to security concerns and to maintain a high level of security during information exchanges. Public cloud services are efficient and trustworthy, yet they have weaknesses because they are available to anyone. Private cloud computing is a trusted solution for medical information exchanges, ensuring information confidentiality and permitted access (Heilig & Voss, 2014). Medical companies can also use other vital resources.

Eucalyptus, called "Elastic Utility Computing Architecture for Linking Your Programs to Useful Systems," mainly deploys for private and hybrid cloud computing services and is an open software used to implement infrastructure as a service (IaaS), network as a service, and storage as a service. These services are made available for end-users by consolidating with other cloud infrastructures. ECG analyses were hosted as a SaaS web service on the public cloud (Achar, 2016). In cloud computing, the platform-as-a-service (PaaS) layer uses three key modules, including "container scaling manager or tomcat container, workflow engine as a service platform, and Aneka application platform," to handle hosted software processing and satisfy user requests. Upon user requests, the container scaling manager adjusts the number of containers to process user queries to the workflow engine, which regulates overall processing and jobs assigned to medical software workflow and Aneka PaaS middleware. Cloud load balancing also handles workflow waiting-request scheduling and average user requests in a session.

The private computing platform is the most efficient approach to handling a company's devoted resources, especially from a security standpoint, and keeping their information internal as part of administrative regulations without enrolling external entities (e.g., outside the business). Cloud computing delivers and manages an elastic pool of resources based on end-user requirements; private cloud computing uses resources dedicated to a single business, while public cloud computing uses a shared resource pool. The difference between public and personal cloud computing is minimal; for example, extensive scaling of Internet services and applications is managed by public cloud, and virtualization technology is used by private cloud computing. However, they share many characteristics, including a pool of resources, independent access, resource elasticity and management, and resource metering.

For life demands and to improve and satisfy medical needs, significant advances have been made in medical sectors that are significant for indoor and remote-home patients. Wireless sensor devices and networks allow for remote patient care and facility monitoring (Alemdar & Ersoy, 2010). Monitoring remote (located) patients' status (i.e., blood pressure, heart rates, sugar level, and others) helps detect acute diseases before emergency conditions occur and provide medical services for caregivers to manage risk cases of patients and cognitive disorders. Usually, medical sensor devices are embedded or placed on specific patient parts where medical rates (or information) are required to be measured. The practical information is then wirelessly transmitted, monitored, and stored at the designated controller site (or computer machine), where authorized persons (or trusted medical advisors) are situated for information analysis and diagnosis. Researchers have recently combined computer networks, cellular networks (2G, GRPS, and 3G), and wireless sensor networks to produce context-aware medical applications. With the emergence of inconspicuous sensor devices, Bluetooth devices, and RFID-based sensor devices for medical systems, automated configuration with wireless network make it possible to process patients' acquired information from anywhere. These improvements are credited with minimizing abrupt, critical circumstances of patients during emergencies and reducing the impact of diseases, as they are recognized and treated before binding. Finally, remote monitoring of patients' health or telemonitoring systems using sensor devices and wireless sensor networks help coordinate between patients and medical advisors and medical sensor devices and other aspects of the telemonitoring system (Ko et al., 2010).

Building a private healthcare system addresses security challenges based on the needs of health organizations and health centers (or hospitals) in our situation. Deploying a private cloud platform for the healthcare system helps save costs and network consumption (Reddy et al., 2012). This project creates a private cloud computing platform using Microsoft's virtualization technology to access and monitor inner and outward patient medical information. Net platform for designing and using infrastructure-as-a-service personal cloud computing for medical information monitoring, analysis, and automated classification.

Statement of the Problem

Asthma is a chronic inflammatory disorder that affects the lungs and weakens the airways due to excessive mucus accumulation (Kiotseridis et al., 2012). This results in limited oxygen being given to essential organs, which can hurt their function. People with asthma frequently exhibit various symptoms, which can ultimately lead to a diagnosis of asthma (Prieto et al., 2007). However, it is currently unknown what the precise cause of asthma is. Nevertheless, several studies have demonstrated that an increase in asthmatics can be attributed to a confluence of genetic and environmental variables worldwide. This horrible disease is a hazard to public health for people of all socioeconomic backgrounds. The primary triggers of an asthma attack can seem very different from one person to the next. For example, when someone has asthma, their airways become smaller, weaker, and filled with smoke (Saito et al., 2015). In addition, significant volumes of mucus contribute to the air's tendency to become thicker. This is something that continues to be true even in modern times. Even being in this region can cause an asthma attack, much like it would happen to someone allergic to food or other substances that affect their body. Through a battery of diagnostic procedures, an allergist can establish whether or not you have asthma. If it is found to have asthma, the allergist will collaborate with us to determine the most effective treatment plan for us to take our long-term condition under control.

There are various types of asthma, such as primary, intermediate, and critical levels; an individual's asthma can vary significantly from person to person (Sullivan et al., 2007). However, there has been a rise in the number of youngsters falling ill from exposure to airborne pollutants, as reported by medical professionals working in a big Indian community. This project presents a framework for identifying air pollution by continuously monitoring the air using a variety of sensors. Additionally, this research aims to assist patients in lowering their chance of developing asthma by giving them a piece of advanced equipment. For example, suppose the patient's collection of air particles is higher than a certain threshold. In that case, the android app will notify the patient of this fact and provide them with suitable recommendations. In addition, the user's health state is routinely checked and kept up to date in the database, which assists the user in independently taking preventative measures and allows them to get in touch with their doctor in the event of an emergency.

The following are the primary goals of the paper:

- To enhance and monitor the general health conditions of asthma patients.
- To take appropriate safety measures for the patients.
- To maintain constant vigilance on the patient's surrounding surroundings.

Cloud Computing in Healthcare Industry

The application of cloud computing in the medical industry has seen significant recent growth. Throughout the pandemic, the utilization of cloud computing was critical to the operation of the healthcare system (Xiong et al., 2009). Every medical institution, including physicians and nurses, has benefited from developing IT infrastructures in recent years.

Increased use of cloud computing systems in the healthcare industry has potential benefits, including enhanced patient privacy, decreased operational costs, and enhanced quality of care delivered via remote operation and teamwork. In addition, the application of cloud computing in the medical industry has brought forth new ways to improve the operational capabilities of information technology systems.

The application of distant servers accessed through the internet is at the heart of cloud computing in the healthcare industry. It helps store medical information, manage it, and process it. Cloud storage allows healthcare professionals and medical organizations to securely keep a vast amount of data on web servers in a simple and hassle-free way. In most cases, IT professionals are responsible for maintaining such servers. The typical architecture of cloud computing as it applies to the healthcare business is seen in Figure 1.

As a result of the implementation of the EMR (Electronic Medical Records) Mandate, medical businesses have begun utilizing cloud-based solutions to store and protect their patients' medical records. In addition, healthcare companies have accepted cloud-based solutions despite having no plans to move their existing data centers to the cloud.

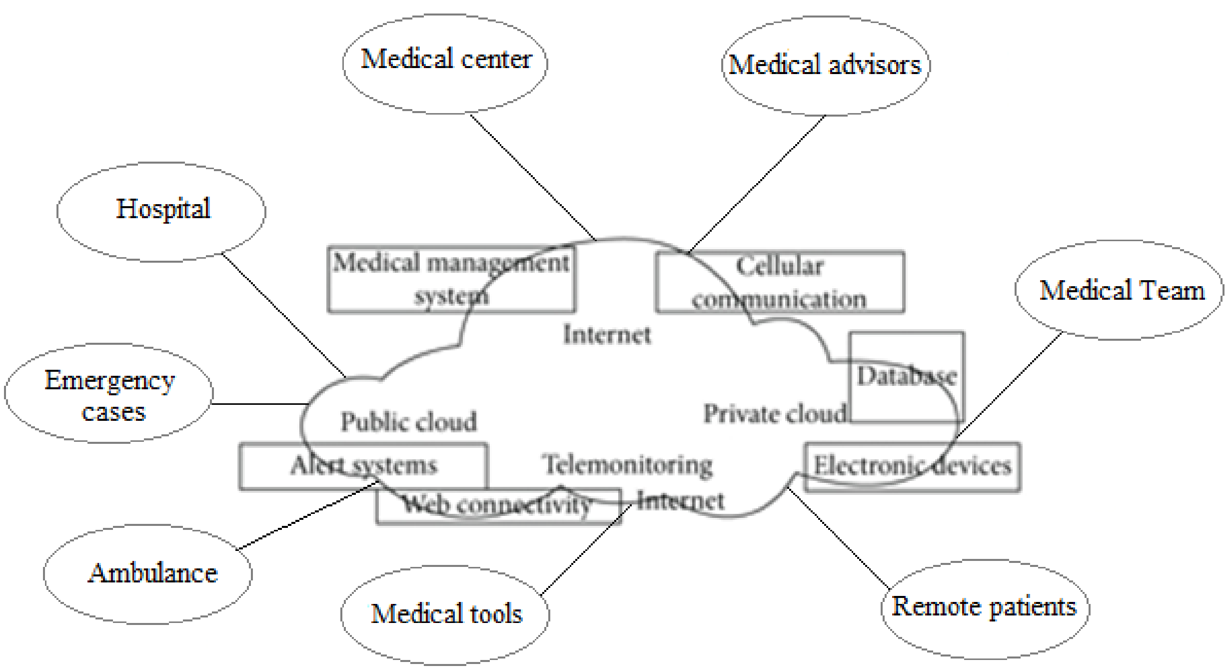

Figure 1: Illustrates a typical cloud computing architecture for use in healthcare systems.

Pervasive medical gadgets and their connectivity with advanced networks or the Internet have given new visions for medical diagnosis, therapies, monitoring, wireless body area networks (WBAN), and remote patient monitoring. Pervasive devices or medical sensors are connected to specific parts of patients' bodies to measure blood pressure, heart rates, sugar level, and other medical signals. The practical medical information is transmitted to the medical assistant or medical advisor via wireless media, including cellular networks, for further diagnosis. As part of the telemonitoring system, automated medical analytic tools, such as IoT-based remote asthma analyzers, analyze medical information in real time. Several medical healthcare systems have been deployed to monitor the interior or remotely placed patients' health to overcome emergency cases and to fight against and diagnose important diseases before they worsen. Cloud computing systems are effective and scalable solutions for current networks and play a huge role in healthcare information monitoring, acquisition, and storage. Using public cloud computing for healthcare makes system processing more efficient and manageable. In addition, it means the hospital can use public cloud services to underpin continuum healthcare and manage administration and other IT requirements that can retrieve real-time patient information without delay, be truly synchronized and securely shared among systems (and users), and be scalable in workload cases. In addition, a health organization can manage its entire organizational structure using cloud computing infrastructure, resulting in a coherent-optimal healthcare system.

Top healthcare cloud computing benefits

Healthcare cloud computing benefits include:

- **Affordable healthcare data storage:** Healthcare practitioners generate tons of digital data annually. Lab tests, insurance claims, EMRs, and medications. Cloud technology efficiently manages data. Cloud-based analytical tools can consume more data when cloud computing delivers excellent storage.
- **Telemedicine's growth:** Cloud computing has boosted telemedicine in healthcare. Cloud-based apps and telehealth systems assist share healthcare data, offer patient health insurance, and improve availability. Many apps have expanded functions like virtual medicine analysis or video-conferencing doctor's sessions. Cloud computing enhances telemedicine care.
- **Patient satisfaction:** Using cloud-based healthcare technologies, clinicians can provide real-time access to lab test results, medical information, and doctors' notes. Better understanding helps patients keep their health. Cloud computing in healthcare eliminates unnecessary testing and prescriptions.
- **Cooperation:** Cloud-based healthcare promotes collaboration. Patients no longer need individual medical records due to cloud-based EMR. Doctors can examine past consultations and share data. It saves time and improves diagnosis and treatment.
- **Interoperability:** Interoperability involves integrating data from any source into the healthcare system. Cloud technologies promote interoperability in healthcare and make patient data accessible for flexible distribution and insights to improve care. Cloud computing in healthcare lets doctor’s access patients' medical data from several sources, distribute it, and give on-time protocols.

TELE MONITORING SYSTEM VIA CELLULAR PLATFORM

Holter is a patient-worn unit that provides GPS (global positioning system) information in case of emergency. Figure 2 shows a telemonitoring system that monitors asthma patient information by connecting to an ECG device in real-time and store-and-forward mode using a Holter and a controller (or server). Patient information is sent through MMS using GPRS/GSM networks when necessary. Holter stores and evaluates patients' ECG data. In real-time, aberrant heartbeat rates are measured to assess heart rates accurately. To do this, an algorithm classifies heart rate recordings to discover strange heart rates. Based on the observed speeds, the associated medical advisor is notified by MMS in real time. MMS is a new technology developed by the 3GPP (third-generation partnership project) that allows for transmitting multimedia messages of varying sizes (text, audio, and video). As the ECG equipment is directly attached to the patient and measured information is assessed (or classed), resulting in aberrant heart rates, this information is simultaneously transferred to the server in the form of MMS, with embedded Holter-GPS information. In addition, MMS uses GSM/GPRS networks and transmits patient information via TCP/IPs. The server stored (monitored) patient information and auto-streamed it to medical advisors. The authorized medical advisor analyzes incoming information, provides comments, and sends MMS back to the server to maintain in touch with the patient. On the server end, GIS software is deployed to locate patients in emergency cases; as the supplied MMS contained GPS information, this information is used to find the patient's location. Both the patient and the medical advisor send MMS in real-time. Real-time mode is more reliable since MMS (e.g., aberrant heartbeat rates) is transmitted, stored, and evaluated quickly. In a store-and-forward manner, the Holter continuously recorded and saved ECG data for 48 hours and transferred it to a server for storage and analysis. In this situation, wired networks and TCP/IPs carry information over the internet.

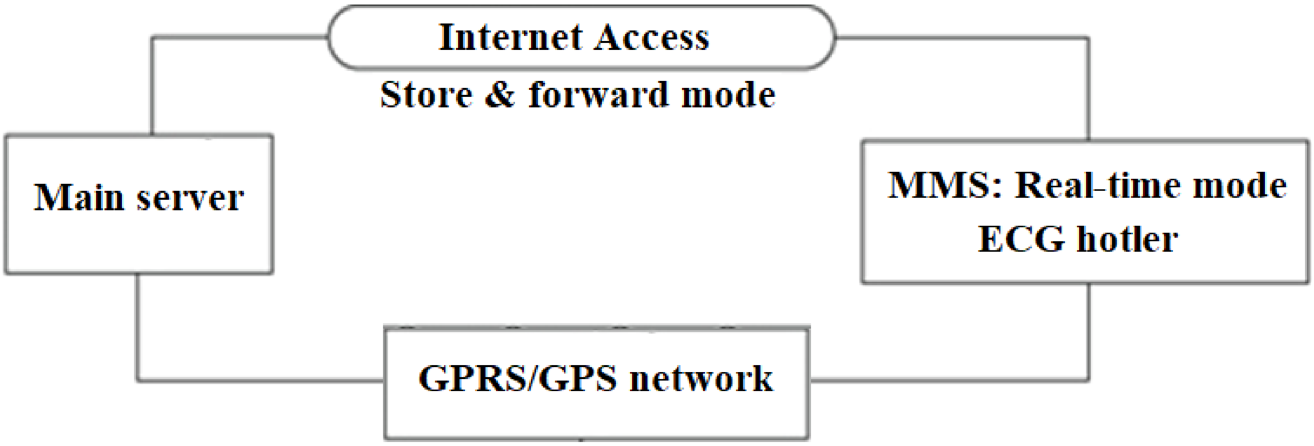

Figure 2: Telemonitoring system via cellular access

As noted above, wireless sensor technologies have caused significant changes in medical systems. For example, existing works monitored the patient's status or conditions using fall detection, gesture and posture detections, GPS-based patient tracking, medical sensors, and RFID tags typically used in the monitoring systems. Telemonitoring systems reduce the consequences of sudden critical diseases (i.e., arrhythmia causes) and provide future trends for pervasive healthcare systems. With these tools, patients may track and monitor essential emergency scenarios. For example, children and elderly with mental and chronic sickness (and other physical disabilities) can also live safer, happier, and more independently. Finally, cloud computing is required to make the new extension a part of healthcare or telemonitoring systems (Wen et al., 2008). Real-time information, such as heart normal & abnormal rates, will be captured, analyzed, stored, and viewed by authorized medical advisors.

Most IT-based systems, such as educational, industrial, transportation, and medical procedures, now communicate through cloud computing, which minimizes end-user workload difficulties and complexities without expensive software or hardware. Ambient intelligence (AMI) is a new communication trend based on a ubiquitous communication platform, a cloud computing environment that provides interaction between end-users and various electronic or sensor devices over wireless sensor networks, and a context-ware design that meets users' technological needs (Milenkovi & Otto, 2006). In the suggested Cloud-IO design, telemonitoring, location identification, and communication services were modeled to be unified and functioning in the cloud computing environment.

- In telemonitoring, the required information was acquired from users or patients in a wireless network using medical and biometric sensors.
- Cloud-IO included location identification, which provided real-time identification of cloud users and other network items by estimating their positions. These algorithms efficiently managed warnings from cloud users and configured system entities. Implementing position estimate techniques, such as FDOA and TDFA, that are more accurate than existing and suitable for inside and outdoor location estimations.
- Text and voice messages were enabled to move across the proposed cloud platform using various wireless sensor devices to meet overall communication goals, along with microcontrollers, routing systems, and queuing managing algorithms.

SYSTEM DESIGN AND MODELING

When a patient is experiencing symptoms of difficulty breathing, the physician and other references connected to asthma patients note that the patient's heart rate beats at a much faster pace. As a result, the choice was made to utilize a heartbeat sensor to monitor the speed of the heartbeat. Cloud computing is a practical, scalable, and cost-free approach to deploying software, platforms, and infrastructures in IT. Organizations use cloud computing to meet organizational, industrial, and other needs. Private cloud computing employing visualization is the most excellent answer for an enterprise that wishes to keep its resources protected in its data center, away from outsiders or external entities. In private cloud computing, visualization is deploying, employing, and managing organizational resources or programs operating in virtual machines (VMs) instead of installing them in special hardware, which consumes substantial capital and management costs.

System Center 2012 is used to provide a private cloud computing platform for accessing and monitoring hospitalized cardiac patients' medical records. This system has a few paradigms that enable personal cloud computing values for new system development with specified workloads and platform entities: (1) An administrator builds the cloud and updates IT-deployed apps. (2) A developer entity is designated to build a virtual environment by the virtual machine (VM) concept and approve VMs. IT specialists build and deploy cloud applications, and a system center is allocated for problem detection and fixing in private cloud computing.

In this study, the database keeps track of patient information acquired through ECG device connectivity. MySQL is used to deploy and store each patient's medical information using a unique identifier. When data is transmitted in real-time, it is stored as table records and retrieved depending on medical queries.

In this study, a mobile application is one of the new developments modeled to retrieve real-time asthma information from medical equipment. For this reason, a medical application is built and modeled, which will be installed on an authorized cellular device with a user name & security password from the cloud to automate connectivity with external medical devices (such as ECG devices) via Bluetooth and Wi-Fi. After logging onto the cloud, the software is installed on a mobile device, and ECG information is viewed in real-time. Laptops or tablets can also view real-time medical information before cloud registration. This project aims to acquire readings from connected ECG devices and generate reports in a private cloud-computing environment, which limits medical system access to the medical center frontier. To do this, a wireless sensor network is created and networked within a hospital; nevertheless, signal strength covers most of the hospital.

Chat Engine and Special Purpose Access: The suggested system design included a chat engine to facilitate group chat (or text communication) among the medical advisors. Several group conversations would help battle crucial diseases and improve patient health. The proposed system uses a private computing platform and is fully accessible to retrieve comprehensive information limited to the medical center. In rare cases, medical advisors can access the data via cell phones outside the medical center. Using this service, medical advisers can continually examine their chosen patients' current medical status and offer feedback, for example, on health treatments, via a cellular application chat box on the Internet. These are essential demos to prevent patient medical complications.

Information Capture and Storage: Real-time medical information can be retrieved remotely from anywhere, which is significant in getting information and monitoring. In the current study, communication is limited to local private body area networks, a network that retrieves patient information using noninvasive medical equipment; in our case, we use ECG devices and ECG belt with wireless sensor (ECGBWS) according to scenarios, inward monitoring (IWM) and outward monitoring (OM) (OM). This study deployed a potential security mechanism, through cryptography, for ECGBWS protection against unauthorized entities and would employ self-launched attacking scenarios to ensure measurement efficiency against insecurities and from security mechanism evaluation (process).

Permanent caregivers in this study are individuals, medical advisers, and medical personnel who care for patients during short and long-medical treatments. The cellular medical application provides detailed access; access may be limited to designated patients. Few patients are assigned to one doctor and 2-3 medical staff members; the cellular application only provides detailed real-time information about these patients, which is viewed on a cellular device. The detailed report in the table includes comprehensive information about patients' and current medical knowledge. The existing medical system is built to apply a security solution against enemies or unauthorized individuals inside the medical facility or intercepting from outside the network. In all circumstances, security must be controlled to avoid inside/outside attacks, as medical information is always essential. Therefore, approved access will be allowed to the patient's caregivers, such as patient family member(s), for a few days or based on the patient's treatment session to support extra services, such as buying medicine, delivering meals to the patient, and other vital services which the patient needs. In addition, caregivers or family members can obtain patient information via a medical app on a cell phone. It is also important to tell the caregiver in case of an emergency or the indication for patient services (such as medicine intake schedule, eating, & others) while they are not near the patient or outside the patient room/ medical ward.

Conclusion

Asthma is characterized by various symptoms, including trouble breathing, coughing, wheezing, and shortness of breath. Asthma, however, does not have a known causal cause; as a result, it cannot be cured but can be controlled by providing appropriate direction and treatment. However, asthma self-management is still a crucial component of effective treatment for the condition. This research presents a portable device that can be combined with an Android app to monitor the environmental elements that people living with asthma are exposed to and their health metrics. The data collected by this device is then transmitted to the cloud.

As technology needs rise, medical systems have been updated with new advanced technologies (intelligent medical systems); yet, there are still various obstacles, such as carrying remotely situated information and remote connectivity issues, primarily in healthcare systems. Also, updating existing systems with new advances raises costs. Therefore, cloud computing is one of the best alternatives in the modern world. In this study, based on medical organizational specifications and communication requirements, including security requirements, a private cloud computing environment is designed & modeled where the medical information of heart patients registered or residing in the hospital is accessed and monitored in real time. AES algorithm protects overall communication in the planned private cloud computing environment, meeting the system's security criteria. The study also produced an enormous platform of knowledge about arrhythmia causes and the arrhythmia chat engine, where medical advisers can discuss thoughts and solutions to fight against cardiac illnesses.

The technology monitors asthma patients' heartbeats and stores them for examination. A heartbeat sensor is not hopeful but reflects the patient's state since one of the acute asthma symptoms is rapid breathing and heartbeat rate. According to test results, utilizing heartbeat sensors contributes to this field. Future work could involve more sensors and protocols. Shortly, this project will be expanded to include hybrid cloud computing, which aims to deliver medical services to remotely placed patients and measure medical information continually. In addition, the study will be updated with the Internet of Things (IoT) technology, which offers automated communication services via the Internet and will assist in the design of new advanced medical systems.

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