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Role of IoT and Cloud Computing in Digital Healthcare

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Abstract: The Internet of Things (IoT) and cloud computing (CC) have arisen as new platforms in the twenty-first century's ICT revolution. Experts believe that the Cloud IoT paradigm can considerably improve healthcare services and contribute to its ongoing and systematic improvement if it is adopted in the healthcare industry. With the latest innovations in the Internet of Things (IoT) and Cloud Computing, the sector of healthcare is becoming increasingly explored. The Internet of Things will assist physicians and hospital employees in carrying out their responsibilities in a more comfortable and informed manner. With the most recent innovative solutions, the majority of the obstacles associated with the use of IoT and Cloud Computing have been handled, and this technology has the potential to be a big revolution with several benefits in the digital future. The healthcare industry is one of the most promising applications for the Internet of Things technology. When it comes to urgent situations, the most significant application of the Internet of Things is the ability to monitor and make timely judgments. Because of this technology-based treatment strategy, there is an unparalleled chance to improve the quality and productivity of treatments, as well as the well-being of patients and the ability of the government to provide more financing. We present a complete review of the key applications of IoT and CC in healthcare in this paper. Additionally, this paper will discuss the state of the art and gap analysis of various levels of integration components by examining several existing ideas for Cloud-integrated IoT-Health systems. Moreover, this paper discusses the role of IoT in the pharmaceutical business, including its problems and uses. Finally, the author identifies research problems and future directions.

Keywords: IoT; healthcare system; cloud computing; pharmaceutical manufacturing; security; privacy.

I. INTRODUCTION

Organizations and individuals can access virtualized computing, storage, and networking resources in a dynamic manner via the internet via cloud and fog computing. As of now, these resources are more scalable and cost-effective than physical ones. Data centers, each housing tens of thousands of computers, are where most cloud services are housed. These systems must be able to handle a high volume of service requests while maintaining acceptable processing times and low energy and hardware costs. These facilities have stifled the development of new systems, such as those in healthcare. The rise of big data is influencing the development of these computer systems.

Healthcare is an important area for both developing and developed countries since it directly affects people's lives. Healthcare research and development should be ongoing to help improve the quality of life by tackling various health conditions and diseases. The advancement and latest advances in technology have clearly improved the Healthcare sector. The introduction of cutting-edge computer technologies can enhance the present capabilities of the Healthcare and Medical Sector. This powerful computer technology can help doctors diagnose ailments earlier. These powerful computer technologies can help improve the accuracy of early disease detection. Other sectors are already benefiting from the developing and breakthrough computer technologies. In addition to the Internet of Things (IoT), there are numerous other technologies to consider.

Big data applications can be supported by Cloud Computing since it provides the necessary computing, storage, apps, and networking. Cloud Computing-enabled applications can extract valuable information that can be used to make better decisions in a wide range of industries, including healthcare [1,2,3].

Cloud computing (CC) uses the internet to supply computing services such as servers, databases, networking, software, and data analytics [4,5,6]. Also, the current shift from centralized (cloud computing) to decentralized (fog computing) paradigms is making news. Fog computing analyzes data at the edge, enabling real-time processing, improving data

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privacy, and lowering costs. The rise of mobile devices, artificial intelligence (AI), and cloud computing lays the groundwork for IoT in healthcare to change all aspects of human life. For instance, machine learning and deep learning models can be used in order to detect breast cancer [7-11], PCOS [12,13], lung diseases [14-18], COVID-19 [19-26], gastric cancer [27] and so on.

Despite the many benefits of CC in diverse applications, there are still many difficulties that affect CC's effectiveness. Clinical information system based on CC created by IBM and Active Health Management (US healthcare provider). Information from sources such as laboratory results and electronic medical records (EMR) can be accessed easily. This technology can automatically alert doctors about conflicting or missed medications, as well as patient reactions to treatment for chronic asthma. This system also includes statistics that allow physicians to compare their performance to hospital quality standards.

Healthcare services are constantly challenging since diseases arise from time to time. The Internet of Things (IoT) is commonly used to connect medical resources and give smart healthcare services to chronic sickness sufferers. Healthcare monitoring has come a long way. These successes show the value of IoT in healthcare and its bright future. Despite the progress, the topic of how to fast and systematically develop intelligent IoT-based healthcare systems remains ambiguous. More and more researchers and companies are working on IoT-based technology to improve healthcare systems. Also, new IoT technology has opened doors for smart hospital development. There are also issues with self-learning and self-improvement, hardware (e.g., wearable and implanted sensors), standardization, privacy, and security. Thus, integrating IoT with other technologies, services, and communication solutions is important to IoT performance. When compared to the traditional internet, IoT unites all sorts of connected “Things” into a comprehensive network of interconnected computer intelligence without human interaction. The adoption of IoT and the development of wireless communication technology allow caregivers to transmit patient health data in real-time. With a single touch, several current sensors and portable devices can monitor particular human physiological indicators such as blood pressure.

II. CLOUD COMPUTING (CC) IN HEALTHCARE

It is a technological paradigm in which a large number of remote servers are linked and hosted on the internet, allowing end-users to store data, process it, and access it from anywhere at any time. Cloud computing infrastructure charges are typically depending on the amount of time you spend using it [28]. The following are some of the benefits of using the internet as a storage medium:

1. There are a variety of networks that can be used to deliver the services to users, including virtual private networks (VPN), wireless fidelity networks (Wifi), very small aperture terminal networks (VSAT, Ethernet, and ISDN), fiber networks, and more [29, 30, 31, 32, 33].

2. It is scalable in both vertical and horizontal dimensions, allowing it to be upgraded at any time as the processing needs of the application change. A vast number of people may now access some of the world's most powerful computers from the comfort of their own homes, thanks to cloud computing's flexibility and affordability.

3. Various organizations throughout the world can share the same infrastructure for their computing needs, allowing them to exchange services and information with other like-minded individuals and companies. Cloud computing is now accessible to a wider range of enterprises because of this model of sharing.

4. Internet connection on mobile devices has made it easier to use and access information. Smartphones, laptops, tablets, and other devices can also be used to access cloud computing services. With this, users have easy access to cloud computing resources such as services, applications, and infrastructure.

In healthcare, technology uptake has always been extremely slow. Historically, hospitals have employed information technology services and infrastructure to support a variety of management systems, including information management, inventory management, laboratory management, and billing and payment administration. However, due to a lack of available IT infrastructure and the significant expense connected with it, many of the aforementioned technologies have not been implemented centrally. In a hospital or any healthcare business, priority is always given to medical devices over IT infrastructure, which makes sense. This is where cloud computing comes in, as it is an extremely cost-effective way to manage IT infrastructure. Cloud computing (CC) is typically utilized in healthcare to provide Infrastructure as a Service (IaaS), which offers centralized computing and storage capacity with high availability (HA) and accessibility from anywhere and at any time for the deployment of various functional modules. Telemedicine, remote clinical

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consultation, medical picture storage and analysis, clinical research, and information interchange are just a few of the cloud-based healthcare applications.
Telecardiology's major goal is to store ECG data in central cloud storage, allowing for hospital and clinic interoperability. This would also allow the cardiologist to access a patient's past and present ECG recordings and interpret them. This telecardiology technology allows for centralized ECG storage and interoperability, enhancing research across healthcare providers and providing a centralized teleconsultation platform for patients and doctors [34].

Cloud storage is preferred by hospitals and other healthcare organizations to save the costs of local hardware and storage. Large volumes of genetic data, radiological pictures, and electronic health records are stored in the cloud. Sharing data between facilities and regions without remote cloud storage may delay treatments. Figure 1 summarizes the functionalities of cloud computing in the field of healthcare.

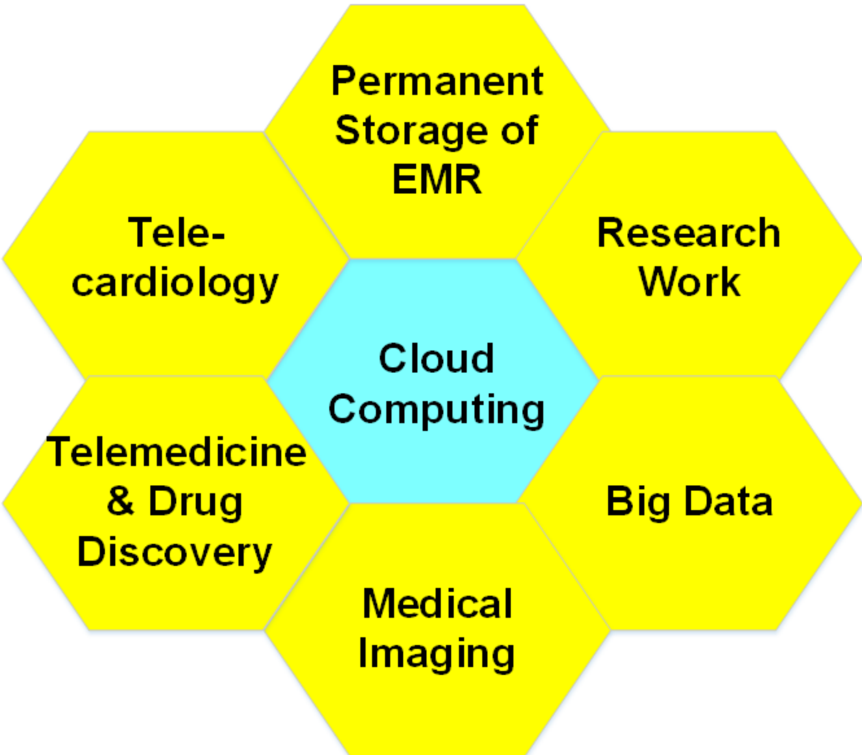

Fig. 1 Functions of CC in healthcare

A research work of McKinsey found that there are 22 definitions of CC. CC is divided into three main services: Infrastructure as a Service (IaaS), Platform as a Service, and Software as a Service (SaaS) [35, 36]. There are four types of clouds: (1) public cloud for the general public to buy and access from service providers such as Amazon; (2) private cloud that organizations that build them own for their employees to use; (3) hybrid cloud that blend and use both private and public clouds, and (4) community cloud which is based on the membership and development of research communities with similar interests [37].

III. IoT DRIVEN HEALTHCARE

Research, clinical practice and patient management can all benefit from the Internet of Things in healthcare. Additionally, it has a wide range of uses in the insurance and manufacturing industries. There are four concepts that underlie the IoT's contribution in all of the aforementioned settings. Sensors, monitors, detectors, equators, and cameras are all networked devices that support the collection of data. The second fundamental of data conversion is mentioned here. It is important to note that the analog input from sensors and other relevant devices must be converted to digital form before further processing can take place. In most cases, a cloud-based data storage solution is used to accomplish this third principle. Users can then use this information to make informed decisions based on advanced analytics modalities that process and analyze data. Healthcare organizations are already implementing the ideas outlined above, from patient records written on paper to interconnected laboratory databases. They can have a direct and immediate effect when they are made with the help of the IoT. Figure 2 shows the basic IoT infrastructure in healthcare.

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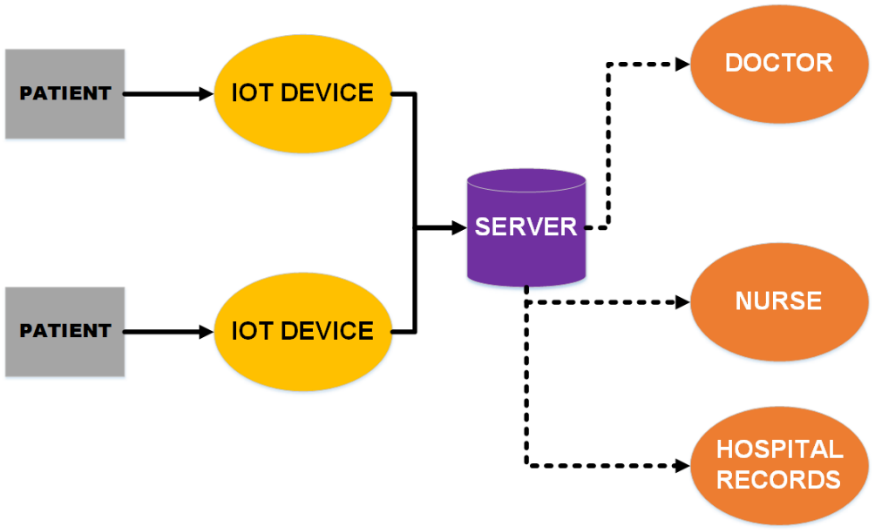

Fig. 2 Basic infrastructure of IoT in healthcare

Wearable technology dominates IoT infrastructure when it comes to patients. Oxygen saturation, blood pressure, and pulse/heart-rate monitors can all be included in wearables, depending on a patient's medical history and the parameters that need to be tracked. Thanks to these technologies, it is possible to provide tailored attention in the event of an acute illness or gradual decline. In conjunction with fitness tracking software or appointment and referral systems, they can serve as reminders as well. Thanks to the Internet of Things (IoT), physicians may communicate with their patients, colleagues, and the clinic or laboratory in real-time. If one of his patients has an arrhythmia, a cardiologist may be alerted, and if one of his patients has hypoglycemia, a diabetologist can be alerted. A doctor is always available to help in both situations. Patients' compliance can be monitored by doctors. In addition to the outcomes (such as a rise in blood pressure) when individuals neglect their treatment, device monitoring can also be an issue. According to this, pillboxes may be counted on a daily basis to see how many times they have been opened. A growing body of evidence demonstrates that IoT devices' datasets can help doctors determine the optimum therapy and management strategy for their patients. Personalized treatment will benefit greatly from this. Future treatment-to-outcome research could be based on these enormous datasets.

In the coming years, it is projected that the Internet of Things will be used in a variety of other applications to improve people's quality of life. There is numerous further Internet of Things applications in the healthcare arena, including patient surveillance, ultraviolet radiation monitoring, and medical refrigerators.

The following are some factors regarding IoT that are based on existing papers and research and should be taken into account.
(a) The new 3c technical: Communication, Cloud Computing, and control are all represented by the 3c. The synthesis of technologies enables perceptive technology, sophisticated network technology, artificial intelligence technology, and automatics to operate cooperatively to actualize object and person interconnection.

b. Complexity: The IoT, a complicated process of the material, energy, and information exchange, happens all the time and consists of a complex network;
c. Interoperability: A large number of devices and technologies in IoT makes interoperability a key issue in this field;
d. Scalability: In an IoT system, the data are generated all the time, for which data deluge, scalability, and extensibility should be taken into account;
e. Dynamics: The architecture of IoT is dynamic, which allows the system components to be reconfigured when it is needed at any time.

IV. Healthcare Concepts and Applications

Aside from in-person meetings and telephone calls, physician-patient interactions were confined to text messaging and telemedicine. Doctors couldn't remotely check patients' health and treat them in time. These technologies enable real-time healthcare applications, unlock the full potential of IoT and cloud computing in healthcare, and support physicians in providing outstanding healthcare services. Patient involvement and satisfaction have grown because IoT and cloud computing has made patient-doctor communication more accessible and efficient. Remote monitoring also minimizes

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hospital stays and prevents readmissions. This reduces healthcare expenses and improves treatment outcomes. IoT and cloud computing are enhancing healthcare by enabling new IoT-connected medical equipment and improving patient contact. Patients, families, doctors, hospitals, and insurance companies are increasingly benefiting from the IoT and cloud-based healthcare apps. By bringing numerous concepts to the scientific community, IoT and cloud computing are transforming the healthcare industry.

(a) Internet of m-Health Things: Numerous IoT-enabled healthcare solutions make use of smartphones. Additionally, healthcare or ambient assisted living solutions cannot be offered or built today without taking mobile health support into account. Healthcare solutions utilizing smartphones are classified in this system as applications that aid in diagnosis, clinical communication, drug reference, or medical education. It uses mobile computers, medical sensors, and cloud computing to keep track of patient vitals in real-time and to send data to a CC framework. Practitioners can retrieve data to efficiently observe, diagnose, and treat patients. Because it is fully networked and mobile, it may be the foundation for new IoT and cloud computing applications in the future in health care as it is now.

(b) Wearable gadgets and smartphones: Wearable technology is a current trend and an IoT characteristic. Wearable technology in healthcare saves money and benefits both doctors and patients. From smartwatches to smart wristbands and spectacles. These smart devices have many sensors that can capture data about the user's health or environment and upload it to a database or fog layer for real-time analysis. People also use smartphones to look at or send data from these wearable devices to a CC framework that can be used to store and process the data.

(c) Cognitive IoT: In a tailored CIoT framework, all sensors (body sensors or environmental sensors) must work together to efficiently monitor the patient's health. As a result of this, the IoT and cloud computing for healthcare framework is smart enough to make timely judgments based on collected data. Cognitive IoT healthcare research focuses on processing and analyzing large amounts of data. Designers of IoT-based healthcare applications are very interested in medical ontologies and semantics. Semantic data representation and message-oriented middleware were proposed as a cognitive IoT framework. The structure supplied personalized info to semantic subscribers (consumers) who followed a subject. Semantic message brokers send data from publishers to subscribers. As a result, interoperability requires the semantic portrayal of all transmitted data.
On the other hand, a more extensive system for managing semantic health data was shown in [76]. The suggested framework can automatically infer and generalize. Thus, it promotes data mining and expands IoT in healthcare.

(d) Blockchain: Blockchain is a new technology that's being utilized in a wide range of networks to assure security and reliability. The current transaction management system is being replaced with blockchain technology, which is preferred in many transaction management systems.
The issues with the current banking system are as follows:
(i) High transactional fees
(ii) Double spending
(iii) Banks have become synonymous with cries

Blockchain, the decentralized technology that powers bitcoin, has solved the problem of centralized banks. A blockchain is an encrypted public distributed database. In a centralized design, every node is connected to a central coordination system. This central coordination system will communicate, pass, and authorize all information amongst the nodes. If the central coordinating platform fails, all of these individual dependent nodes will be disconnected. So, moving from a centralized to a decentralized system is urgently required. In a decentralized system, multiple coordinators will exist. A decentralized system has no centralized authority, and each node acts as a coordinator. Each node connects to other nodes, and there is no central coordinator.

A blockchain is a chain of blocks, with each block containing all recent validated transactions. Each block stores all transaction data and computes a consolidated hash code. After the transaction is verified, the block is added to the blockchain, and the chain grows.

Public, private, and consortium blockchains exist. Like Bitcoin, a public blockchain is open to anyone on the globe. Anyone who is a miner on the blockchain can read and write data. You can think of the main things that make blockchain a good technology for making an IoT-style network for healthcare more secure and reliable as "decentralization," "open source," "autonomy," "immutability," and "anonymity."

Healthcare data collection equipment is divided into four categories: medical embedded devices are inserted into the human body, medical wearable devices are prescribed by doctors, and wearable health monitoring devices are worn on

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the body. The major goal of remote patient monitoring (RPM) is to protect data from the hackers. Blockchain technology secures the data. Using decentralization, blockchain protects data against numerous attackers. Smart contracts on the blockchain authenticate the data.

V. IoT in Healthcare Applications

This area covers wearable technology, portable gadgets, healthcare sensors, and the newest medical technologies. These technologies are IoT innovations that may help solve numerous healthcare challenges. Sensors are one way the IoT is used in healthcare. Many current sensors can track a patient's vital data and send it immediately to a network or via mobile devices. Sensors allow doctors to monitor a patient's health in real-time and treat them accordingly. Sensors can also track a user's essential information when exercising or tracking their sleep quality. Medical sensors can monitor BG, heart pulse, BP (Blood Pressure), arterial oxygen, and mood tracking and alert patients or doctors if anomalies arise. Figure 3 depicts some contributions of IoT in healthcare applications.

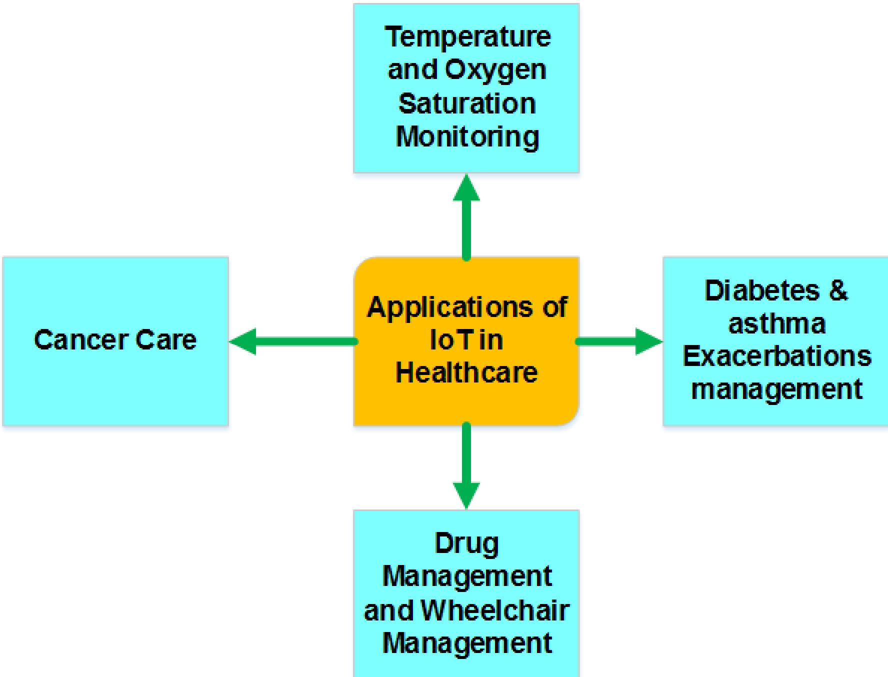

Fig. 3 Applications of IoT in Healthcare

Clinical trials of cancer care wearables have already begun. In 2018, the American Society of Clinical Oncology Annual Meeting featured a randomized clinical trial. It tracked patients with head and neck cancer with a Bluetooth-enabled weight scale and blood pressure cuff and an app that sent regular and emergency information to their doctors. The study included 400 patients, and those who used the IoT-based system had fewer symptoms than the weekly-assessed control group [38, 39, 40].

Diabetes can be considered a model disease that includes oral medication, injectable insulin, blood glucose monitoring, and blood pressure monitoring. Many existing gadgets already have IoT-based continuous glucose monitoring. Although type 1 diabetics (T1D) require constant monitoring and quick intervention, mounting evidence suggests that T2D patients may benefit from similar measures. Smart insulin pens can help Diabetes Mellitus patients track their treatment adherence (DM). Contrary to popular belief, similar devices might be utilized for pillboxes. These days, wearables are monitored by doctors and connected to smartphone apps. Using IoT, doctors could be warned of patients who aren't taking their medication sooner. Automation of insulin administration has been long expected in T1D therapy. Potential regulatory and management issues have hampered clinical device adoption. Several physician and patient advocacy initiatives have already been launched, considering how the IoT can help overcome these obstacles. An automated and IoT-secured closed-loop system can be very significant for T1D patients at risk of diabetic ketoacidosis [41,42,43].
Pulse sensor and temperature sensor can be used for monitoring an asthma patient. It can be used to detect suicidal thoughts and provide cognitive rehabilitation for people with dementia or mild cognitive impairment [44, 45]. The

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signals are processed by the microcontroller board, and then the data is forwarded to the cloud for storage via the hypertext transfer protocol (HTTP).

Human body temperature is an important variable used by doctors to diagnose patients. A drop in core body temperature can signal some conditions (including sepsis and trauma). Many diseases can be tracked by taking a patient's temperature. A thermometer attached to the body (rectum, mouth, ear, and vagina) is a frequent method of detecting body temperature, although it is painful for patients and raises the risk of infection. However, with the advent of the IoT in healthcare, numerous alternatives have been presented. For example, an intelligent 3D-printed hearable gadget with an infrared sensor was shown in [48], which can monitor ear temperature via the eardrum. The device had a wireless module and data processing circuits for data processing. They showed how the smart earbud accurately measured ear temperature despite ambient changes and user activity. It had a microphone and an amplifier, so it could also be used as a hearing aid. Difficulties in developing a wearable core body temperature thermometer [46, 47].

The blood oxygen saturation level is a critical physiological indicator for monitoring the circulatory system and is also used in healthcare and medical therapy. Non-invasive technologies for oxygen saturation tracking overcome limitations associated with conventional methods and indicate the possibility for real-time monitoring, which has significant advantages over remote monitoring. Recently, a non-invasive tissue oximeter was proposed that could acquire information about the heart rate, oxygen saturation level, and pulse characteristics. Following that, data was transported through GPRS/WiFi/Zigbee networks to a remote server and processed by an expert decision-making system [49, 50].

Drug management is a critical sector of the healthcare industry where IoT technology has a beneficial influence by effectively resolving high-cost issues associated with drug development, as well as drug storage and preservation. As a result, an increasing number of start-ups and researchers are working on this subject. Radio-frequency identification and the Internet of Things were used in conjunction to handle medications in an intelligent drug store system [51]. It was divided into three major portions. The authors demonstrated how they configured sensors and an RFID chip to efficiently sense environmental parameters in the first section. The second section discussed the data flow and communication protocol used to connect sensors to a Raspberry PI. Finally, the final component specified the roles of all users when it came to data access. On the other hand, an abstract system was developed in [51] to address the issue of sensitive temperature monitoring for medication storage by utilizing both RFID tags and sensors to change the temperature appropriately for each type of drug.

A wheelchair helps disabled persons both physically and mentally. The electric wheelchair was created to help disabled individuals become more self-sufficient in their daily activities rather of relying on others. However, it failed to assist disabled patients with limited mobility due to brain damage. As a result, a smarter and easier to navigate wheelchair has lately been discussed. A smart wheelchair with IoT-based steering and real-time obstacle avoidance is one example of wheelchair management [53]. The steering system used real-time video capturing and image processing to detect impediments. The m-health concept was also used in the construction of a smart wheelchair using infrared sensors and wearable device sensors [54]. The device includes a smartphone app that processed sensor data and presented outcomes for carers to monitor the impaired from a distance.

VI. CONTRIBUTION OF IOT IN PHARMACEUTICAL MANUFACTURING

Automated processing systems can be used to increase medication production efficiencies and other important tasks. IoT-enabled devices can easily share operational data with other devices or engineers. And this information helps manage the industry in a way that increases productivity. Pharmaceutical production involves processing, manufacture, extraction, purification, and packaging. The manufacturing process is separated into two primary stages: producing the active medication ingredient and converting it into the completed pharmaceutical drug product. Tablet production includes grinding, blending, granulation, drying, compression, coating, and packing.

The Internet of Things (IoT) is becoming increasingly prevalent, and embedded devices are used to connect everything. Patients, medication, marketing, and pharmaceutical businesses are the fundamental aspects of the pharmaceutical sector, and they are all interconnected through the use of hyper technologies and Internet of Things connectivity. Only because of the Internet of Things will medications be delivered and records will be able to be moved from one location to another. Patient connectivity with network protocols, as depicted in figure 4, is required for medication delivery monitoring and real-time tracking to be possible.

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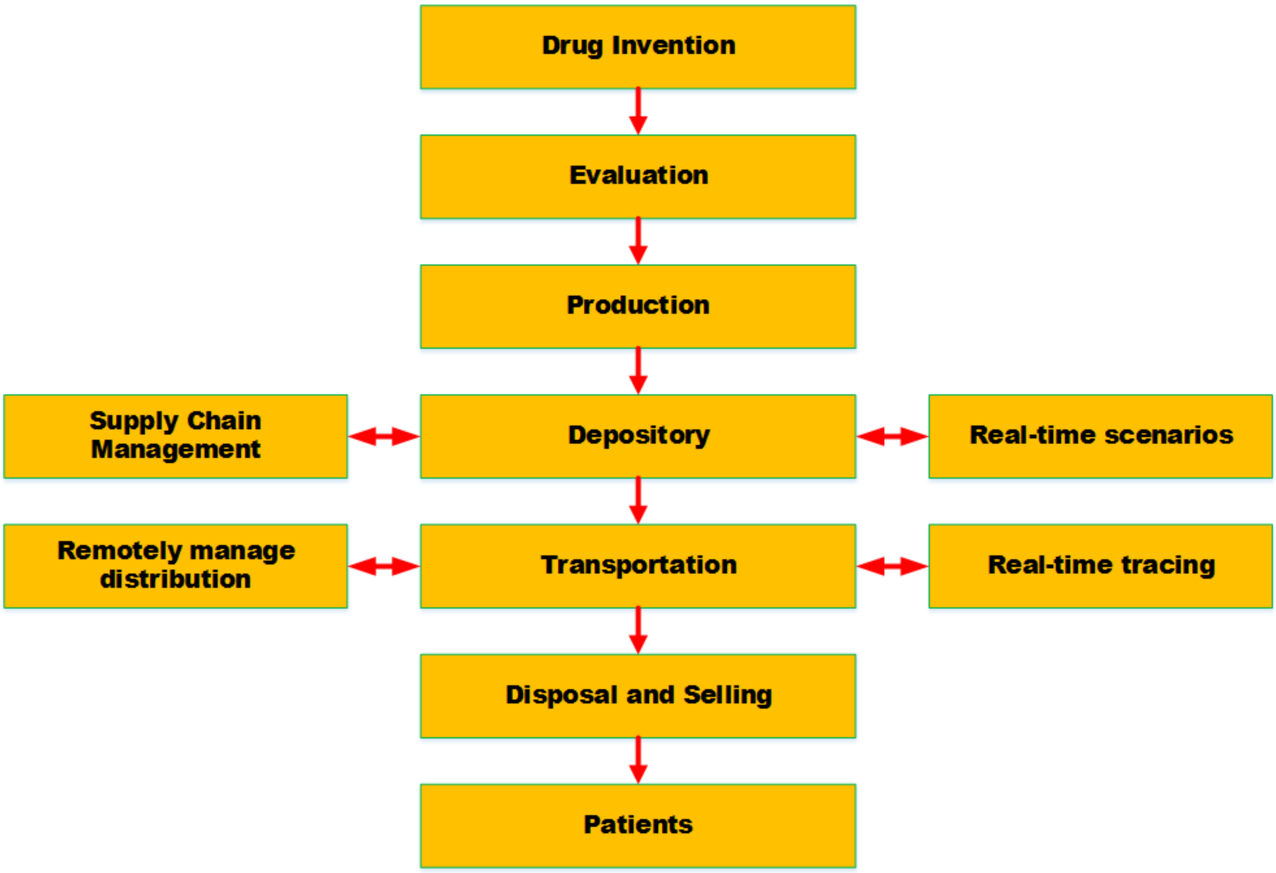

Fig. 4 IoT in pharma (Adopted from [79])

Using IoT-based applications, the pharmaceutical industry is producing clinically smart medicines, a big investment area. It studies the entire pharmaceutical production cycle from raw materials to finished product packaging. By monitoring the system, lags are reduced, and superfluous effort is removed. Sensors provide real-time process data and intelligent decision-making to the central network, ensuring product quality. Stages including granulation, milling, coating, and packaging are validated by continuous surveillance. To preserve product quality, all environmental variables in a pharmaceutical process must be monitored. Using smart devices and sensors, IoT can track real-time production quality. The environment has a major impact on pharmaceutical drug manufacturing. So IoT may be used to monitor environmental conditions. Using real-time sensors, IoT hopes to make medication production visible. Environmental characteristics, including humidity, light, temperature, and radiation exposure, can be controlled by clever equipment. For these reasons, an alarm may be triggered. IoT sensors can monitor product quality. Sensor data helps comprehend product development cycle stages. The details include raw materials, temperature fluctuations, disposals, and transportation. The product's quality is solely determined by real-time monitoring. Pharmaceutical IoT apps that monitor industrial processes maintain product quality. Quality control is vital in the pharmaceutical industry.

IoT allows pharma firms to connect with the next level and meet consumer expectations quickly. Connecting people, devices, and supply chain operations into a single network is straightforward with IoT . The pharma business should invest in high-quality IoT architecture to handle heavy-duty services and IoT-based security solutions. Standardization is a difficult task in the pharmaceutical industry. IoT allows pharma firms to connect with the next level and meet consumer expectations quickly. Connecting people, devices, and supply chain operations into a single network is straightforward with IoT. The pharma business should invest in high-quality IoT architecture to handle heavy-duty services and IoT-based security solutions. Standardization is a difficult task for drug companies. Balancing project requirements and operational demands with KPIs may be too difficult. They can also challenge management to change a sensitive issue that involves people, processes, and responsibilities. Every industry prioritizes health and safety. A worker's total health and safety can be assessed by looking at common characteristics such as proportion of illness or injury, absenteeism, accidents, and property damage. So efficient monitoring improves safety. When producing medications utilizing IoT-based networks, it is vital to maintain the system in order to ensure factory safety and security.

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VII. Open problems and new trends in CC and IoT Integrated Health Systems

The creation and development of new CC and IoT applications has been the focus of many initiatives by researchers, companies, and governments. With the current research, we encourage greater insights into the obstacles that this potential integrated technology faces, and more efforts to address the open research concerns outlined in this work. Highlighting certain outstanding challenges and pointing out future networking research areas in CloudIoTHealth applications are the next steps we take. Technology requirements for CloudIoT-Health systems include the following.

6.1 Network communications: There are several heterogeneous network technologies involved in CloudIoT-Health applications, which necessitate continuous data transfer and a huge increase in bandwidth demand. Access management's ability to provide continuity and optimize bandwidth utilization is still an unresolved question, on the other. A large number of CloudIoT-Health systems necessitate continuous, fault-tolerant, and reliable data flow from the objects to the cloud. For example, a patient who wears sensors on their body may not be able to communicate with the gateway (e.g., smartphones). In order to avoid an accumulation of errors, circumstances that are predisposed to connection failure require special support [55].

6.2 Data warehouse: In order to preserve the integrity and security of the data and datasets collected by CC, they should be stored in safe, easy-to-use, and dependable databases. An intelligent system is needed in the data warehouse because not all the data and datasets can be utilised at the same time. As an important research area, CloudIoT-Health is linked to Big Data and faces a number of obstacles.

6.3 Machine learning techniques: Big data services require intelligent algorithms, systems, and services to handle thousands of data sets, understand the relationship between all different variables, process all the requirements, and present all outputs [56, 57], all of which are provided by artificial intelligence and machine learning [58, 59,77,78]. The next phase is to develop prediction algorithms that can detect certain diseases at an early stage (e.g., breast cancer and HCV).

6.4 Standardization: Many academics believe that a lack of standards is a major obstacle to the integration of CloudIoT and health. Web-based interfaces already connect the majority of devices to the Cloud, making cloud-based apps easier to design [60, 61]. They do, however, impose network burden, delay, and data processing overhead because they are not specifically intended for effective machine-to-machine communications. Because the cloud and the objects both employ non-standard heterogeneous interfaces, interoperability is still a challenge.

VIII. Cloud Security Issues and Challenges

This section discusses key cloud security vulnerabilities. A cloud security issue occurs when anything negative happens to digital assets stored in the cloud. This report categorizes security challenges into four groups:

(1) **Data security issues:** These include data storage, backup, integrity, access, and breaches. Cloud computing is a unique data-sharing mechanism that allows user data to be processed remotely and shared with stakeholders as needed. Thus, cloud data security is a major concern for SaaS, PaaS, and IaaS users. Authentic users can only access, transfer, or edit data that they are entitled to, while illegitimate resources cannot be requested.

(2) **Network and services security issues:** This category comprises security issues related to networks and services such as Service /Account hijacking, insider threats, virtualization, and multitenancy issues.

Cloud-based solutions allow users to access data and services. User credentials or sessions can be hijacked. Attackers exploit passwords to access cloud services and change account data. Unauthorized users with passwords can access customer data and steal, alter, delete, or sell it to malicious third parties. Companies' reputations might be harmed, and personal data can be misappropriated, causing financial loss to organizations or consumers. Client data may be exposed during cloud account hijacking instances, which may have legal concerns for businesses like healthcare [63].
Using virtualization, cloud computing can maximize the utilization of resources. It is possible for cloud customers to pay only for the resources they utilize. They pay just for the services and resources they use, such as CPUs, RAM, bandwidth, or operating system. Numerous security flaws can be introduced into a system through the use of virtualization technologies, and many new security dangers can arise as a result. In virtualized environments, security is a major concern because of the increased number of points of entry and interconnection density [64] that virtualization brings.

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(3) **Applications security issues:** It includes issues related to cloud-based applications such as malware injections, malicious insiders development life cycle, and UI issues.

Since this attack has become a major security concern in cloud systems, cloud settings for multi-user support must be done with caution. Incorrect cloud configurations lead to data leaks and malware attacks, which can harm the entire cloud computing environment of the enterprise and the cloud service provider alike.. Embedded code execution in cloud services that may be run as SaaS in cloud servers is used to perform malware injections. Some of these injections are kept secret for an extended period of time, raising serious concerns in the cloud computing context [65]. In the cloud, this virus grows rapidly because of its ease of execution. One more important security concern needs to be addressed here. Invasive malware assaults such as the VM escape, hyper-call attack, distributed denial of service (DDoS), hyper-jamming, and VM escape, prime, and probe are all common [66].

(4) **People-related security issues:** Issues involving people such as trust management issues, compliance issues, human resource, and legal issues are included in this category.

Cloud-based systems are more vulnerable to social engineering and phishing emails. A malevolent user can quickly connect into a system once they have access to login details or other confidential data [67]. Internal attacks can be disastrous. Like illegal access, authorized users harming the cloud environment is extremely risky. An insider threat can be an ex-employee or any other stakeholder. Intrusion may be carried out by malicious outsiders who have power or authority over a victim [68]. They can access consumer accounts and financial data. Insider attacks are difficult to detect and prevent since they are deemed normal access with no alert. However, logging software can only be employed after an assault has caused harm. Most firms have this security issue due to a lack of cloud standards, internal access point management, and monitoring. Cloud computing security reference architecture is made with the help of NIST cloud computing reference architecture.

Biometric systems such as Iris recognition [69-72], Face recognition [73-75], Fingerprint etc. can be adopted by the organization to reduce the probability of this issues.

IX. CONCLUSION

Cloud Computing (CC) and Internet of Things (IoT) integration enables additional storage, processing, scalability, and networking capabilities in the IoT that had previously been constrained due to the IoT's characteristics in the healthcare sector. Additionally, new potential for artificial intelligence (AI) and data mining algorithms [for example, artificial neural networks (ANN), nature-inspired optimization algorithms, and genetic algorithms (GA)] can be addressed for real-time data analysis and knowledge mining. Nowadays, there are several items in our daily lives that require connectivity. The secure and effortless interaction of these objects can significantly improve the quality of daily life. We conducted a review of the literature on cloud computing and the Internet of Things and their role in healthcare systems in order to determine their complementary characteristics and the primary drivers for integrating them into a unique environment for healthcare systems that we refer to as a "cloud-integrated IoT-driven health system."
Administrations, organizations, and research groups from all over the world are collaborating closely to ensure that the healthcare business undergoes a seamless change as a result of IoT and cloud computing. This research is beneficial for readers interested in gaining knowledge about many areas of IoT and cloud computing in healthcare. It provides a comprehensive IoT and cloud computing framework for healthcare, enabling applications to leverage the IoT and cloud computing backbone, as well as a platform for medical data transmission between medical devices and remote servers or cloud computing platforms. Because many new ideas and applications are being added to the process of integrating IoT and cloud computing in healthcare, this survey also briefly categorizes and sums them up for people who want to learn more.

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