Hybrid Cloud/Fog Environment for Healthcare: An Exploratory Study, Opportunities, Challenges, and Future Prospects

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Abstract: The healthcare system has been in the frontline in recent years, and new technologies have greatly benefited healthcare. Researchers have tried to find solutions to different problems associated with the healthcare system by applied various modern technologies approaches. Such technologies are cloud and fog computing. The recent advances in the Internet of Things in the areas of healthcare have help patient data to be dispersed in multiple locations. This makes researchers proposed solutions based on cloud computing to manage healthcare data. However, such solutions present challenges like context-awareness, latency, and a large volume of data. Hence, there is the probability of an increase in processing and transmission errors occur as healthcare datasets become larger and more complex. Thus, fog computing becomes an alternative to reduce healthcare data management complexity by increasing its reliability. Consequently, it is essential to comprehend the associated challenges and problems before employ fog computing-based architecture to manage healthcare data. Therefore, this paper discusses the areas of applicability of hybrid cloud/fog computing in the healthcare system. Discusses several extraordinary opportunities brought by cloud/fog computing in healthcare and the research challenges of cloud/fog computing deployment in the healthcare system. The application of hybrid cloud/fog computing brings an application and its components running in a "distant" cloud closer to end-users and data sources such as wireless sensors. The main benefit of bringing them together in healthcare is the low latency.

Keywords: Hybrid cloud, Fog computing, Healthcare system, Internet of Things, Latency, Technologies

1 Introduction

The healthcare sector faces challenges including budget pressures, management of various service delivery, and growth in aging populations [1]. The increased use of information and communications technology (ICT) will help the healthcare sector reduce if not totally overcome these challenges [2]. In connection to the need to make service delivery more effective, ICT innovations have contributed to higher healthcare Technology adoption [3-4]. To help healthcare, ICT has been used to provide greater access to medical records [5] and the area of decision making in healthcare system, ICT has additional ability to help in minimize costs and enhance service deliveries [2], [5-6].

One of the world's most recent groundbreaking technology is cloud computing (CC). In day to day life, the applications of CC are increasingly growing. The introduction of CC is so common today that it is used even in the health care sector. Since the advancement of CC in health care has been taking place at a rapid pace in recent times, we can expect a significant part of healthcare services to shift to the cloud and thus concentrate more on providing people across the globe with a cost-effective and reliable healthcare service. The healthcare industry is taking an initiative to migrate to these cloud-based systems despite a widespread perception that such cloud boundaries and security problems will obstruct the transition. Many physicians and hospitals are heading into these clouds today in order to provide their patients with better health care facilities.

Why are providers of healthcare services switching to the cloud? The explanation for the change is simple: a greater need for healthcare systems that are effective. According to the report, cardiology, a branch of medicine that definitely benefits from efficient data storage and retrieval systems, is one of the many areas in which cloud-based healthcare software has a crucial presence, particularly in tasks such as accessing current and historical patient data. The facts that much less funding is required for maintenance and much less expenditure is needed for medical software licensing and related expenses are also contributing to the increased popularity.

In the delivering of an efficient Information Technology (IT), CC offers an innovative system and play paramount roles. The technology is identified has one of the major technology that can enhance the level of services in various fields especially in healthcare system service deliveries. When combines Internet of Things (IoT) and CC technologies in healthcare system, they benefited in equal manner with mutual understanding in handling medical information. Developed a monitoring system combining the two technologies has been proved efficient even at the remote environment that is very useful for caregivers and physicians. The cloud is used has a supportive technology in an IoT-based system to enhance the performance of the system in terms of computational capability, storage, resource utilization and reduced energy consumption. Also, cloud has been favour from IoT-based system by enhancing service deliveries globally and deliver unspeakable services in a distributed and dynamic manner. The IoT-based cloud framework can still be extended in the smart environment for the development and application of new service delivery. Table 1 compared the cloud and fog computing using IoT-based requests.

Table 1. Appraisal of Cloud and Fog Computing

Requirements	Cloud Computing	Fog Computing
Mark User	Internet Users	Mobile Users
Location of servers	Within Internet	Edge nodes
Service type	Global information	Localized information services
Geographical Distribution	Centralized	Distributed
Distance between client and server	Multiple hops	Single hop
Delay jitter	High	Low
Latency	High	Low
Type of connectivity	Leased line	Wireless
Location awareness	No	Yes
Server nodes	Few	Large
N/W bandwidth	More	Low
Reply time	Minutes	Milliseconds, sub-seconds
Security	Less secure	Very secure

The Cloud alone can no longer handle the huge amount data generated by IoT devices, a new powerful computing models are required. The security concerns, low latency, speedy processing requirements of needs new powerful computing techniques to best place processing, conserve network bandwidth, and making IoT-based system operates in a reliable environment. [7]. All these IoT-based system requirements can never be met with the traditional CC architectures alone, therefore, a better and powerful computing model is required. Latency transfers data from the network edge to the data center for processing, thus creates the dominant strategy. Bandwidth is quickly outpaced by traffic from thousands of users. Also, the cloud servers neglect other protocols the IoT devices use, and interact only with IP. The best location for most IoT data to be analyzed is close to the machines that generate and function on that data and this is called computing with fog.

To close the gap and bridge linking IoT-based devices, a powerful technology called fog computing has been launch help in processing the huge amount of data produced by the devices. The processing of the computational resources at the edge becomes easy with fog model, and handling and outlining the data from IoT devices become easy and greatly improved. The idea of cloud computing is very similar to the fog computing since both are built with virtual systems and offer many of the similar architectures and features that facilitate the versatility and scalability of computing, storage and networking resources on demand supplies. Although with the emerging trend in networking in terms of demand, the two technologies have a wide barrier. The businesses and the end-users are free using cloud computing from defining certain specifics, such as storage capacity, limits on computing and the cost of network connectivity. The problem for real-time latency-sensitive applications require nodes meet their delay requirements are still arising [8-9].

The issue of security of these huge volume of data should also be main concern for any business minded experts because the problem causes to their reputation and their constrained by the law to keep all data safe. The cloud based provides the liberty of accessing data from the service providers anytime in any part of the world, hence, exposure the IoT-based data to security and privacy threats. In medical practice, the use of cloud/fog computing has increased tremendously.

To gain more accurate diagnose results, cloud/fog has been widely used to decrease the burden on the medical experts, and help in decreasing the decision time of traditional methods of diagnosis process. There are significant and improvement in the treatment, prediction, screening, drug/vaccine development processes, and application of medication in healthcare sectors with continuing expansion in cloud/fog computing. The applications of cloud and fog computing has reduced human intervention in medical processes and cost of medical applications has totally reduced. The cloud is now close to end-users with the introduction of fog computing. The fog enables computational at the edge of the network, and the cloud storage has greatly been expanded.

This triggers the idea of a cloud-focused cutoff and embarks on how the sequence of data generated by IoT-based devices can be stored and operated. A new vision of fog computing was introduced by CISCO allow billions of connected devices applications run directly at the edge of the network [10-11]. The fogging as it called by fog computing, is a distributed database that either the network edge or a remote data center manages its service, and the program runs on them. Fog is about the real world being dealt with. The Edge or Fog paradigm addresses the problems with the basic concept of finding small servers in the vicinity of users and devices called edge servers [12]. Therefore, this paper presents the applicability of hybrid cloud/fog computing in the healthcare system. The opportunities and challenges of cloud and fog computing were also discussed. The deployment of cloud and fog computing has greatly help the smart healthcare system.

2 Applications of Cloud Computing in Smart Healthcare System

Cloud computing will play an essential part in absorbing healthcare transformation expenses, optimizing assets and bringing the new age of technology to life. Emerging policies are targeted at obtaining data at anytime, anywhere that can be achieved by transferring health data to the cloud. This contemporary distribution model will make healthcare more productive and operational and lowering the price of innovation expenditures [13], but it also presents some obstacles due to issues regarding the security of sensitive health information and compliance with specific criterion such as HIPAA. Healthcare providers, taking into account these security and privacy concerns, can unquestionably reap the benefits of cloud computing technologies and provides substantial benefits, such as assisting to expand the eminence of service for patients and reducing healthcare spending [14].

Cloud computing's critical features are: (1) self-service on demand, (2) wide grid access, (3) resource sharing with other occupants, (4) swift elasticity, and (5) calculated facilities. In complex resources, clouds offer benefits such as processing energy or storage abilities, universal access to resources from anywhere at any time, and high resource versatility and scalability. In several business fields, these advantages have been the purpose for the growing acceptance of cloud computing. This principle has also evidently been adopted in the area of healthcare in recent years. At least in the mainstream literature and is provided by healthcare IT firms, but even in the systematic past work done on cloud computing for healthcare applications is gaining interest, a continuously growing number of papers and books appears.

The cloud with IoT-based online application work efficiently over the ordinary cloud-based applications. The medical, bank, and military are instance of sectors that have benefited greatly with emerging models. The cloud-based in IoT-based system has helps in providing medical sectors with effective services in the areas of monitoring and access of medical records remotely. IoT-centric application has help to collect necessary data like frequent changes in health status in real-time. Also, the capture data from IoT-based devices will be analyzed using artificial intelligence for effective diagnosis of disease at the correct time before the illness reach advance stages.

The capacity to share data between different systems would be one of the main advantages of cloud computing. This capacity is something that IT urgently needs for healthcare. Cloud computing, for example, can enable health care professionals share data such as EHR, doctor's references, medications, insurance data, research reports stored via various information systems. In the radiological market, where many organizations have switched to the cloud to minimize their computing costs, and promote the sharing of pictures, this is already happening [15]. Cloud computing has provided clinics, hospitals, insurance providers, pharmacies, and other healthcare companies the ability to agree to cooperate with each other and exchange healthcare data to provide improved service quality and minimize costs. Looking at the developments in the industry, it seems that once all the obstacles it presents are resolved, cloud-based schemes will eventually turn out to be the standard in healthcare.

The healthcare system's ecosystem, which comprises health insurance providers, hospital and physician networks, laboratories, clinics, patients and other institutions, is vast, diverse and highly nuanced [16]. And all of these must operate under many government regulations [17]. In order to function efficiently and rapidly in this ecosystem, it is vital that any sensitive details be exchanged confidentially and in a safe way between these agencies quickly and accurately between them. In the healthcare sector, protecting the patient's data is known to be very sensitive to privacy issues. Possibly one of the reasons why the development of healthcare moving into the cloud has negatively affected. Innovative technology and resources must be managed when it comes to cloud sharing. However, as they theoretically range between cities, states and even nations, there are many other records, knowledge and resources that can definitely benefit from collaboration by cloud usage.

Private clouds tend to be deployed first because of security issues in the current scenario and then shift into public networks [16]. It may be a good idea to first set out the healthcare industry's top priorities and then analyze which elements of cloud computing can be efficiently implemented to support them. Efficiency of services provided to patients and customers, privacy, data security & integrity and catastrophe recovery seem to be at the forefront of today's rising global health care costs [17-18]. Some of the inherent features can be leveraged to meet some of these objectives, such as flexible architecture, data centers for the provision of permanent data, protection models, and rapid access to information, among others.

Cloud computing encourages IT facilities that are accessible from all locations and at all times [19]. It is a new mechanism, not a new technology, to deliver computing services [20]. Examples of non-medical cloud services are Microsoft Office 365 and Google Docs, while examples of medical service apps are Microsoft HealthVault and Google Health platforms [21]. Compared to traditional computing, there are three major enhancements provided by the cloud computing model: (1) computationally intensive solutions are accessible on request, (2) service delivery without charge. customer upfront commitment requirements, and (3) flexibility for short-term use [22]. Many sectors have been influenced by the cloud model and it is estimated that approximately 80% of today's businesses will have embraced cloud computing by 2020 [15]. In addition, companies that lack capital and infrastructure should implement cloud computing to set up on-site applications [23]. Cloud computing, especially within the Electronic Health Records (EHRs) field is transforming healthcare IT [24]. Cost minimization in IT investments will contribute to improved healthcare facilities [25], and estimated that drug costs can be decreased by 80% and payment can be done within 2 hours for patients and insurance providers as compared to up to 7 days with an implementation.

To dynamically compute patient records with sensors that are attached to medical equipment to process data for collection, accessibility and distribution, a cloud-based framework has been suggested. During any disease outbreak, this device can reduce typical errors or data collection errors manually [26-27], not just simplification of the procedure, but also increased access to high quality data [28]. By combining the ambulance services with patient records, the Greek National Health Service has built an emergency care program in the cloud, ensuring direct access for doctors while being willing to use all resources while maintaining low costs as much as possible [29].

In Australia, as a partnership between Telstra and the Royal Australian College of General Practitioners (RACGP) suggested an e-Health cloud [15]. The goal of this collaboration is to develop diagnostic and respond to situations, medical software, medications, and training and referral facilities. Cloud processing technologies has provided successful support for bioinformatics research in the medical field [15], [30-31]. Although cloud computing has several value-added ideas driven by a novel paradigm of IT service distribution over the Network, economic benefits appear to be the most significant factor in its popularity and widespread acceptance.

Lowering the cost of healthcare delivery is a significant catalyst for the implementation of cloud technology in healthcare. This expense has risen to such immense proportions that governments are facing severe problems with funding. The realization that patient care can be enhanced by technology while lowering costs has ensured that policymakers are able to drive the historically sluggish healthcare sector to a faster rate of adoption. Big data development in healthcare is another significant factor [32]. When the quantity of digital information grows, the capacity to manage this information is becoming an increasing challenge. This knowledge embraces the keys to prospect clinical developments, but is also inaccessible to scientists. Cloud Computing can be the supporting reason for large-scale knowledge exchange and convergence [33]. The paper by Merelli, et al., [34] addresses high-performance computing (HPC) bioinformatics solutions, Big Data analysis paradigms for computational biology, and the challenges that are still accessible in the fields of healthcare.

In particular, the authors pointed out that, thanks to virtualization that prevents transferring too much big data, cloud computing solves big data management and analysis problems in many fields of healthcare. In addition, in the particular area of telemedicine, it is critical to have an infrastructure to support high throughput, high capacity of storage and safe connectivity to allow effective management and automatic analysis of broader patient populations. Horizontal scalability (i.e. the capacity of a device to efficiently extend its resource pool for managing heavy loads) and spatial usability (i.e. capacity to retain performance, usefulness or usefulness independent of local area concentration advancement to a more dispersed geographic pattern) are two criteria that can be fulfilled by cloud computing [33]. In the medical imaging region, the amount of data can exceed petabytes thanks to high-resolution imaging instruments. It is also apparent that the Cloud Computing

Paradigm will render a significant benefit to addressing the computational needs relevant to medical image reconstruction and processing and to facilitating large exchange of digital images and also advanced control processing.

Cloud computing is a new and progressively evolving field of healthcare improvement. In combination with a pay-per-use model, universal, on-demand access to nearly limitless resources allows for new ways of creating, providing and utilizing services. In a "OMICS setting", cloud computing is also used in genomics, proteomics and molecular medicine computing. Medicine is a collaborative and highly data-intensive endeavor [35]. Advances in the OMICS fields produce large quantities of data to be processed and stored (genomics, proteomics and the like).

The subordinate use of medical data with text-or data mining techniques also implies an increasing request for complex, accessible services. These tools are also solitary temporarily used so that stable infrastructure projects are difficult to justify and, alternatively, flexible on-demand services are pursued. To meet these demands, cloud computing seems to be a feasible alternative. Commercial providers such as Amazon and Microsoft pledge to make available at their fingertips hundreds of virtual machines, almost instantly and only they're just wanted for the moment. The benefit of such deals is that they only have to be paid for the setup, scale and period they are essentially used during these services.

Massive medical costs and the maintenance of big data during any disease outbreak require technical advances so that at any time and everywhere, everybody has access to healthcare services. The development of technology has allowed telehealth to provide online healthcare facilities. For patients that are permitted to travel, for villages in rural zones, and for individuals that do not have access to medical care, remote facilities are useful. The uses for telemedicine include the transmission and storage of medical images, video conference patient counseling, continuing education, and facilities in the electronic healthcare field. Sadly, the use of telemedicine technology is hindered by technical and financial costs [36]. To this effect, studies have given cloud computing that offers, among other things, remote support capability, accessible transparent resources, efficient large internet connectivity, scalable and resources pooling, robust medical data sharing and processing, and the sharing of big data patient records.

Many studies have found that inadequate access to patient information is the explanation for most medical errors especially during infectious diseases outbreak [37]. The cloud-based medical system has been regarded as a possible system to increase openness and reduce the extent of medical errors during disease diagnosis in order to correct health data [38-39]. Many medical organizations have also chosen cloud storage to obtain and store broad patient data and maintain their electronic health records systems. Electronic health records have evolved rapidly over the last decade, providing a gorgeous basis for data mining to recognize designs and styles in the big data industry in healthcare. Another common point for exchanging medical data is the interchange of electronic health records. By communicating a common hub, these businesses facilitate healthcare sectors to transmit information rather than maintaining ties with many peer businesses [40].

Cloud computing also offers secure storage and sharing resources that can reduce the amount of local traffic to make organizations agile [41]. By reducing the cost needed for starting up automated medical records, which is lacking in many healthcare segment facilities, it will improve the efficiency of the healthcare sector [42]. During disease outbreak, prescriptions and diagnoses, for instance, can be shared through the cloud over different systems. Therefore, for service enhancement and higher standards, hospitals and doctors exchange patient records. The primary advantages of electronic health record cloud storage are the capacity to exchange patient records with other specialists at home and overseas, the facility to pool data in one location, and the capacity to access files anytime, anywhere. Electronic health record cloud computing enables patients to view, replicate and transfer their own secure health records [43]. Regardless of the influences of cloud computing to capture and store large health data, the prime problem is the failure of the network, protection, and privacy of patient information that users, hackers, malware, and so on are exploiting [44-45].

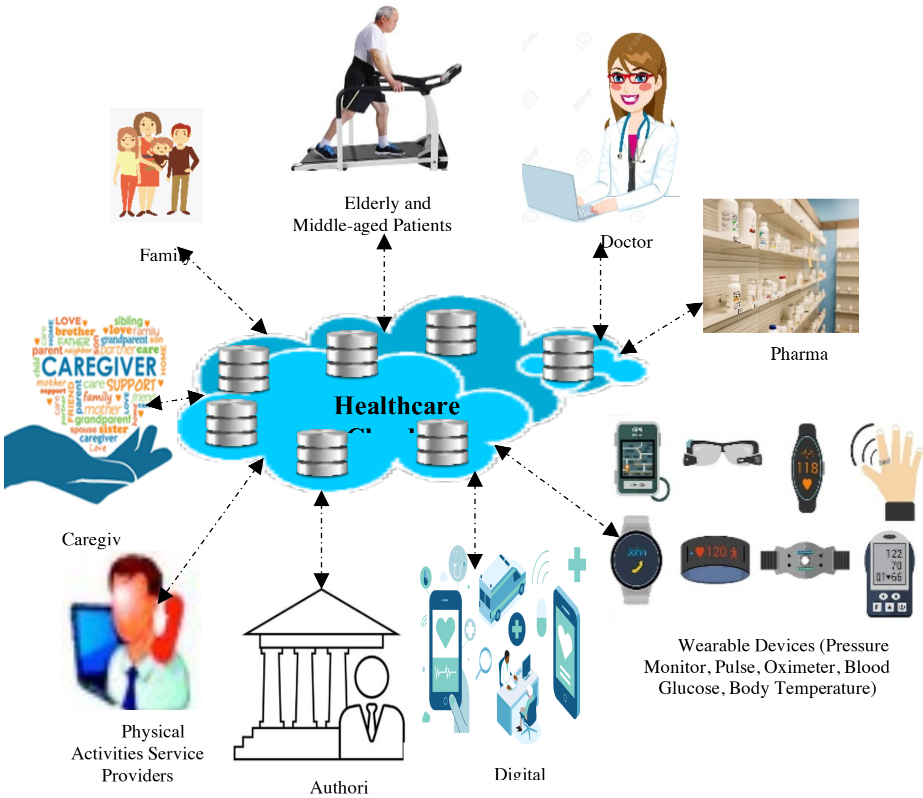

Fig. 1. Applications of Cloud in Smart Healthcare System

Fig. 1 displayed the applicability of cloud computing in smart healthcare system. There is an increasing influx of people to urban areas today. Healthcare facilities are one of the most critical characteristics that have a major effect on people arriving in city centers during infectious disease outbreak globally. Metropolises are therefore financing a digital transition to offer residents with healthy environments [46]. On the other hand, because of its huge number, high speed, and high variety, conventional models and methods for full conservational performance assessment are threatened by the advent of big data [47]. Also, because of their carbon emissions, conventional ICT systems damage the atmosphere [48]. On the other hand, cloud services are a cost-effective medium for accommodating large-scale infrastructure systems have gained considerable acceptance. The use of cloud computing is, therefore, a significant phase in the green processing process that saves resources and protects the atmosphere. The use of sufficient equipment and cloud space saves the organization's resources and eliminates the costs related with cooling systems, computers, and central servers. Nevertheless, cloud computing supports renewable computing with energy savings, rendering dangerous articles less harmful [49].

Through using intelligent mobile computers, cloud computing has inspired healthcare specialists to observe the wellbeing of patients at home remotely [50]. In addition, IoT will build a network by leveraging integrated sensors to track the patient's real-time health status and control the treatment process. The IoT would also play an important role in the development of health care for the next generation. Although health monitoring systems for IoT-based patients are popular, observing them outdoor hospital requirements increases the IoT's cloud computing capabilities for the handling and storing of health data [51].

3 Applications of Fog Computing in Smart Healthcare System

The fog computing allows new range of applications and services by extending the CC model. The fog has the following distinct features: a) heterogeneity of applications, (b) knowledge location and low latency (c) broad physical circulation; (d) flexibility; (e) produce huge number of nodes; (f) wireless access predominant; (g) real-time applications and heavy presence of streaming; (h) heterogeneity of applications. Since the edge of the network of fog are not specifically located, they are highly scalable, hence, network services between end devices and conventional cloud data centers. Both fog and cloud building blocks are networking tools, storage, and computation, edge network created various features that make fog a non-trivial cloud extension.

The help endpoints come with rich network edge resources give birth to fog computing with low latency applications requirement, with application like augmented reality, video streaming and gaming. Fog computing targeted applications with dispersed implementation that are more centralized on the cloud.

For instance, Fog play an active role through proxies and access points in providing moving vehicles with high-quality streaming located along highways and tracks. Large-scale sensor networks are other examples of inherently distributed systems require fog computing, and storage resources to monitor the smart grid and the environment. As evidenced in sensor networks, wide range geo-distribution, and Smart Grid required large number of nodes.

For applications communicating directly with the mobile devices, thus highly in supports mobility techniques like the LISP protocol, which decouples host identity from location identity. These mobile applications require a distributed directory system. The applications involve real-time interactions rather than the batch processing in small cloud application. The fog nodes will be deployed in a wide environment since the nodes come in various shape. Streaming is a good example of fog computing supporting certain services seamlessly and requires the cooperation of various providers. Therefore, the applications must be federated across domains, and very necessary to be able to interoperate their components. The fog plays prominent role in ingestion and processing of the data close to the source.

To prolong the life span of battery or make it harvest electricity, Wireless Sensor Nodes (WSNs) are very useful, and are made for this purposes. The WSNs needs low bandwidth, low processing power, small memory, uni-directional sink collector sources to function very well. The tinyOS2 a de facto standard operating system are example of this class of sensor networks has basic processing, and transmission of static sink with environmental sensing. The motes have been used to collect environmental data like temperature, amount of rainfall, light intensity, and humidity among other [8].

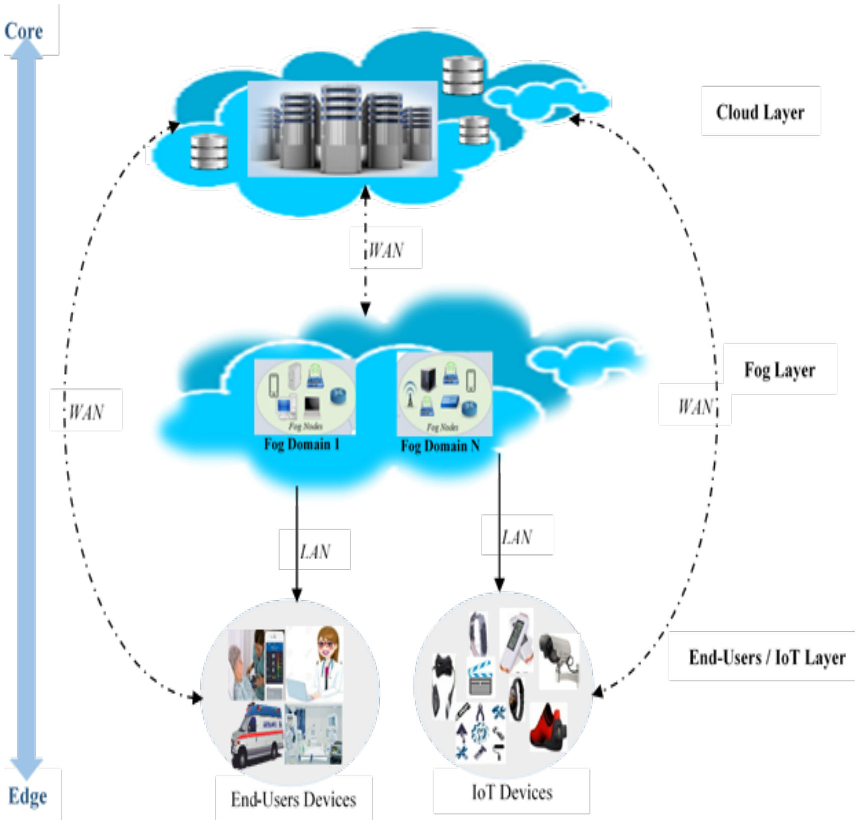

Fig. 2: The Fog Computing in Smart Healthcare System

Fig. 2 displayed the fog computing ecosystem in smart healthcare system. The WSNs progressed in many directions like in the areas of wireless sinks, multiple sinks, distributed sinks, and to meet the requirements of modern applications, smartphone sensors has been proposed. The WSNs in successive incarnations has provided energy restricted in use. The actuators are requiring to perform physical acts in applications beyond sensing and monitoring like in deploying sensors, even carry, open, close, move, focus, and target. The actuators provide sensor networks with new dimensions can monitor either a device or the measurement process itself. Since the controller node to actuators, sensors to sink, the flow of information is not unidirectional, but bi-directional from the sensors to the sink. The issues of stability and possible oscillatory activity could not be ignored, it then becomes a closed-loop device in a subtler, but critical way. The jitter and latency become a dominant concern in systems that need a rapid and real-time response [8].

In Kashi, & Sharifi, [53] the contributions of Actuator Networks and Wireless Sensor to coordination of WSANs were discussed. The results of the survey shown that WSAN have two networks in one architectural layout (i) the wireless sensor network, and (ii) mobile ad hoc network (MANET). (Banka, et al., [54] embedded in their work collaborative Adaptive Sensing of the Atmosphere (CASA) with emphasize on new technologies with higher bandwidth need a collaborative sensing environment. Zink, et al., [55] to provide technical deployment information of fog computing. The Fog's features like proximity and position sensitivity, geo-distribution, hierarchical organization make it the appropriate platform for both WSNs and WSANs in helping discharge their energy-restricted [8].

Fog computing takes resources to the edge of the network as an extension to cloud computing. This effectively brings the benefits and power of the cloud closer to the place where the data is produced, thereby assisting and speeding up "on-the-fly solutions" for applications in smart healthcare system. This decentralized model's main objective is to bring devices and software to the edge of the network where the data is generated. Fog computing's main aim is to reduce the amount of data that is transmitted to cloud data centers for processing and analysis. It also improves security, a key issue in the IoT industry [8].

The fog layer is like a junction point where enough networking, computing, and storage resources are available to manage local data collection, which can be readily obtainable and deliver fast results. Low-power system-on-chip (SoC) systems are used in most situations because they are meant to preserve the trade-off between processing performance and power consumption. Cloud servers, on the other hand, have the power to conduct advanced analytics and machine learning jobs to combine time series generated by a variety of heterogeneous or mixed kinds of items [56].

The rapid development in wireless technology, IoT is able to generates huge amount of medical data, smart devices, and customized enhance services. Such big medical data can be of countless in types, like text, multimedia, and image, which the cloud server needs to store, analyze and process [57]. The high latency, security problems, and network traffic arises has a result of the handling of big cloud medical data. The fog computing was introduced to minimize the burden of the cloud been a new computing platform. The fog also helps in bring the cloud service closer to the network edge, the layer acts as a flyover between the terminal device and the conventional cloud server. Hence, the fog computing allows a refined and secured healthcare services.

The edge of the network is an ideal place for analyzing real-time health information where data is originally created. The feature of fog computing placed it ahead of cloud computing like data pre-processing, local data analytics, data security and privacy, temporary storage, data trimming, distributed, decentralized storage. Both distributed fog and centralized cloud server are needed in an IoT-based application like health monitoring systems to efficiently perform big data analytics. The use of fog computing as an intermediary has created a better way of handling cloud database on the IoT-based devices for real-time healthcare system [57].

4 Challenges of Cloud and Fog Computing in Smart Healthcare system

The big data 5Vs data importance was has a results of huge amount of patients' data receives from the medical device such as volume, veracity, variety, and velocity. As a result, fog node is needed to connected to receive, store, process, and communicates with IoT-based devices. The system administrative configuration must be controlled to forestall the data fluctuation between fog and cloud computing. To handle various types of data like text, videos, audios and image files, fog layer standard protocols and data format are needed from various like smartphone, and a smartwatch. For regular data transfer and urgent data requests, the Smart eHealth gateway must be aware of sufficient routing.

The data collection takes place either from medical sensors or portable devices. There is need for adequate protection for medical facilities so that patient can use their smartphone for health status updates. The use of smart healthcare system creates possible ways of expanding healthcare system to the whole population. The appointment time used by patients to see physicians, or waits for diagnosis outcomes can be reduced with the use of the intelligent healthcare system. This also provides direct access to real-time medical care and services. To maintain trust between patients and medical experts, the scalability of a smart healthcare system must be taking with all seriousness, and this will in turn save quality time.

It is a main concern and it is not appropriate to obtain information from end-users through unauthorized entities, this in addition, poses threats to personal safety of medical data. The main problem in the introduction and deployment of the smart healthcare system is security and privacy. However, with the integration of these layers, security is needed in any layer, such as system layer, fog layer and cloud layer [58]. Another problem facing fog computing is heterogeneity that refers to the various communication-capable devices. The devices like smartphones, autonomous vehicles with other IoT smart devices are at the bottom of the layers within IoT-based system.

The heterogeneity within IoT-based system arises during data processing, data formatting, and data clearing, thus creates difficulty in processing medical information. The enabling of network to connect with various sensors is an example challenge in smart healthcare system for the monitoring of patients. For this to take place, heterogeneity must be present when the data is transferred to another system for processing or analysis. The fog layer while going up to the next layer involves various nodes, clusters, switches, and other devices that are needed during data processing and communication facilities [59]. In the designing of architecture that enable multiple monitoring of devices, heterogeneity is therefore, an important factor to communicate with the patient using devices like heart rate, body temperature, and blood pressure sensors [60].

There is another research issue in fog computing due to the location of network, their protection can create a concern. The threats that are not present in an organized cloud architecture arises in fog computing working at the edge of the network pose a treat. The major treat from this problem is when an attacker transmits and change contact between two parties, patients are in the middle attack [61]. There may be compromise gateway between patient monitoring sensors and fog node that processes the information from patient in smart healthcare system. A serious problem may arise if the intruder changed the data being handled by IoT-based system, this may create serious implications for the welfare of these patients [62].

For the protocols and interfaces for various products and services in fog computing, there are no standard rules and regulations available in smart healthcare system. There should be a standardization put in place to standardize healthcare system like a dedicated agency are needed to solve this problem. This will help in data dissimilarity, and helps to accomplish the real-time response. For a good standardization issues like communication protocol, data aggregation interfaces, system interfaces and gateway interfaces should seriously be considered [63].

There are broads range of communication protocols, such as WiFi, similar to the application diversity issue. To be interoperable, the fog node should therefore perform the required protocol translation on various internal layers, such as network layers, message layers, and fog layer data annotation layers. Also, there should be complex regulatory systems before healthcare tools and equipment are available on the market for consumers used. The stakeholders and end-users of ehealth products should be part of design team to provide input on their likes, dislikes, and comforts. This is going long ways help in building user-friendly interfaces and patient-centric intelligent medical devices [63].

Authentication techniques that is also needed in cloud-fog computing is one of the security services issues, and its needed in their architectural design. There must be proper authentication from the end-users or devices before accessing any services to the receiver-end like the server. Since fog devices provided services after the end-user authentication, then fog computing plays an important role, similarly, both end-user and fog devices must also authenticate by the cloud server before approving access to resources [64]. The one-way authentication approach is too simple for a smart healthcare system. However, due to vast amount of networks, shared authentication is also equally necessary to avoid the cloud masquerade attacks.

The security issues extremely important to be take into consideration in sharing authentication protocol, where the attacker is tries to impersonate by behalf like end-user or fog serves an action similar to man-in-the-middle attack. If these attacker attacks in any way, the legitimate end user, fog server) will suffer from receiving the original message. Another important thing in cloud and fog models are to create safe contact between fog devices, cloud servers and the end-users. An adversary can launch several security threats in this context. Therefore, it’s very imperative and difficult research issues developing of a robust authentication protocol for the cloud-fog computing model [64].

The major cloud-fog computing paradigm is the three-layer architecture, therefore, one of the security issues is the man-in-the-middle attack. The attackers traps the messages from the sources end and modifies before sending another message to the recipient by crack the protection framework. This problem common to various applications like wireless sensor network, cloud computing, smart grid among other. Protecting an attack became an important security issues because an attack can be launched between the fog and cloud servers [64].

The attacker retrieves the message clearly from the sender in replay and forwards the same message to the recipient to initiate this attack. There is no useful cryptographic mechanism at a standstill that can secure the reply attack. The time stamp technique is one of the current ways to preserve it. However, due to time synchronization issues, it is not ideal for distributed environments. In order to protect reply attack, security protection is therefore necessary. In all cryptographic protocols, the perfect forward secrecy property is extremely significant. That if the entity's private key is somehow revealed, the encrypted key previously identified must not be disclosed to the attacker.

When the receiver-end receives the message exactly the same as it is sent by the sender, then the principle of data integrity been confirmed and established. It is also one of the significant characteristics required in cloud-fog models. In general, the end-user is accessed from either fog or cloud service info. The credibility of the data needs to be provided whenever data needed is been sent from the fog or cloud server. In the same way, if the end-user wishes to send data, integrity should be maintained either to the fog or the cloud server. The current cryptography techniques called the hash function like SHA-1, MD5, SHA-2 among other should be used to provide integrity feature. Several researchers have been working on it and are seeking to gain solid assets of honesty. The issues of credibility and effective handling of complexity is remains open research problems in cloud-fog computing model.

5 The Future Prospects of Cloud and Fog Computing

The fog computing is predicted to play a prominent role in Tactile Internet, an emergence technology. The current Internet allow the delivery of content like text, voice, and video, the skill sets are distributed over the networks through the Tactile Internet. The distribution of the skill set will be achieved by haptic communication, implying the remote control of physical tactile sensations in real time. Telesurgery, telerehabilitation, platoons of cars, and virtual reality are some examples of future applications [60].

The Tactile Internet operate over tactile-human interfaces with a core and edge domain together with a functional architecture comprises a likely distributed master domain hosted by intelligent Tactile Support Engines. The fog application managed edge works like remote controlled robots [65]. The major pre-requisite for effective connection in fog computing are Ultra-responsive and ultra-reliable connectivity. An end-to-end latency of 1ms or less is needed and a maximum of one second of outrage yearly. The 5G technology has been identified as an enabler of the Tactile Internet for offering ultra-responsive and ultra-reliable connectivity. The edge and cloud computing are also an enabler of the said technology [65-66]. The holistic approach of fog computing incorporates end-users and IoT-based devices with fog layer and cloud layer with associated interactions make fog an ideal enabler.

The fog systems can naturally be mapped into the Tactile Internet functional architecture. The IoT and end-user layer is part of the managed domain like remotely controlled robots and with a touch human-systems interface called the master domains. The managed domains belong to the layer of end-user devices domains while the master domains belong to the IoT-based devices domain. The edges are clearly the fog layer with the intelligent Tactile Support engines. The cloud can be very useful when there is need for large storage and powerful processing. Bring the architectural and algorithmic together in fog computer are the prospect of Tactile Internet but their research directions and challenges are beyond the scope of this chapter.

From the architectural perspective, the design of an ultra-responsive and ultra-reliable higher layer APIs and protocols for fog device both inter and intra layers communications is an instance of challenge of fog computing in Tactile Internet. Both the transport and application protocols operate on top of the physical and MAC protocols layer required 5G ultra-responsive and ultra-reliable. It will be important to take into account recent attempts to design novel ultra-high data rates [67]. The functionality split between the cloud layer and the fog layer is just another example of a challenge. From the algorithm repositories, the intelligent Tactile Support Engines in the fog layer can be fed into the cloud layer directly. There components are located in both technologies for an efficient storage and processing in cloud layer, and harness mutually proximity in fog layer.

Also, the combination of cloud and fog computing in building a robust IoT-based system will help in edifice a strong and fast processing system in smart healthcare system. Also, the ultra-responsiveness and ultra-reliability need algorithms running in the device to guarantee touch applications. The fog system provided an enabling platform for running various tasks related to Tactile Internet applications in fogs or cloud layers. There is a need for novel algorithms for task planning due to network traffic that may occur on the computing nodes with other variables where tasks are performed and delay sometime will far surpass the 1sm threshold. This is necessary to make sure that activities are carried out within the cumulative threshold and is not surpassed 1ms. To have an optimal task scheduling, novel machine learning and artificial intelligence algorithms are required. To predict behavior and reactions, they may run exclusively in the fog stratum or even in a distributed manner through cloud and/or fog strata. The fog layer helps to reduce the total network load during network connection in IoT-based platform, and this will help meet the latency requirement of 1ms. Various sophisticated algorithm like neural network based techniques and simple regression models can be considered in modeling the system [68].

6 Conclusion and Future Research Directions

The smart healthcare system has the capacity of producing and communicating huge quantities of data produced from IoT-based devices and sensors. The sizes and quantities of networking equipment are more than ever and the volume of data grows even more than ever before. For example, IoT-based devices and sensors can be used to capture and collect patient physiological features and check metrics for the purpose of patient diagnosis and monitoring. The emergence of cloud computing has touch almost all the human life domains; especially smart healthcare system has greatly benefited from the paradigm. The cloud computing has brought a technological revolution needed by IoT-based services like high processing, storage capabilities, heterogeneity, and computation resources among others. Nevertheless, in IoT-based system cloud computing has weaknesses when it comes to high delays that require real-time response, and it has a low delay response time, thus not match the industrial control system of smart healthcare system. The fog computing architecture is heterogeneous devices, and geographically distributed ubiquitously connected at the end of a network to provide collaboratively variable and flexible communication, storage services, and computation. The new computing paradigm has various advantages in applications where real-time, low latency, and high response time are utmost importance like in the case of smart healthcare system. Therefore, the chapter present general review of technologies of cloud and fog computing in smart healthcare system. The applicability of both on smart healthcare systems is discussed, the challenges, and the future prospects of cloud and fog computing are elaborate discussed. The fog computing present better infrastructure by providing low latency, distributed processing, better security, fault tolerance, and a good privacy when compared with the cloud computing infrastructure. The fog infrastructure sufficiently produces various fog nodes, virtualized data centers, and edge device networks to connect the IoT-based devices for the purpose of implementing large storage and rich cloud computing. The fog computing offered millisecond to sub-second latency faster that real-time interaction, perform better than cloud computing in low-latency applications, and supports multitenancy where cloud computing cannot have provided. In future work, the prospects of both cloud and fog models will be extended in smart healthcare system to provide a quick and real-time health diagnosis and monitoring for patients suffering from any diseases. Fog computing is very necessary majorly because cloud's recorded healthcare data may be subject to different types of security risks. Finally, the challenges of cloud and fog computing needed to be looked into and find a lasting solution to insure reliable and flexible deployment of cloud and fog computing models in smart healthcare systems.

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