Opportunities and Challenges of Integrating Cloud Computing, IoT and Healthcare

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Abstract- Technology enabled healthcare is widely accepted because of its accuracy and fast response. Integrating Cloud into this scenario help to analyze patient's history and also doctor's assumptions in an effective way. This helps in enhanced treatment options. Realtime health monitoring and analysis based on IoT device or apps and cloud computing ensure anytime, anywhere access to the data with greater accuracy. Along with the advantages, integrating Cloud Computing. IoT, and healthcare arise new challenges also. This paper studies the integration of Cloud Computing, IoT and Healthcare in detail and identifies the opportunities and challenges that results from this integration.

Keywords – Cloud Computing, Big Data, IoT , Healthcare

I. INTRODUCTION

Nowadays, Internet of Things (IoT) is growing remarkably in the healthcare sector. This includes health monitoring, fitness tracking etc. Covid19 accelerated the use of IoT enabled healthcare for remote monitoring and tracking. Patients can stay at home, while he/she is being monitored by health department using the data generated by the sensors. The devices generate lots of data and that has to be stored and analyzed with great speed and accuracy. Integration of cloud and IoT offers advanced healthcare. The major challenges of IoT devices can be solved with the help of cloud computing. Based on the speed of generation of data in IoT devices, it has to be processed in cloud environment and data need to be visualized and/or produce predictions with greater accuracy.

In the past few years, many tools and techniques have been developed for automating healthcare sector. IoT, Cloud computing, and various kind of sensors attributed towards the success of this automation. Any kind of sensor data is a major source of big data. So, all the challenges of big data processing add to healthcare sector also. Data gathering, processing, and management has to be done with atmost care in healthcare data. Cloud Computing provide solution for storage and processing of this healthcare data.

Accuracy and speed are the two major factors that healthcare sector demands. With the fast growth of sensor technology, healthcare data gathering has become an easy task. But management of these data including storage and processing require efficient techniques. Cloud Computing provide an effective solution for handling the data. Cloud provides many tools for data handling. Along with the advantages, integration with cloud computing raises new challenges also.

The rest of the paper is organized as follows. Integration Cloud Computing, IoT, and Healthcare is explained in section II. Opportunities and challenges of integrating Cloud Computing, IoT and Healthcare are presented in section III. Concluding remarks are given in section IV.

II.INTEGRATING CLOUD COMPUTING, IOT IN HEALTHCARE

Cloud Computing, Big Data, and IoT are increasingly interconnected."Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [1]. There are large number of cloud platforms that help individuals and organizations to make use of highly scalable infrastructure without the burden of managing it.

IoT help to create more personalized medicines. According to [2], the expenses for creating a solution on the basis of IoT will reach up to $1 trillion by 2025. "The Internet of Things (IoT) describes the network of physical objects (things) that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet" [3]. The data from IoT sensors have to be handled effectively to get accurate result. The different phases are Acquisition, Compression, Storage, Processing,

Assessment. Among these phases, compression is an optional phase. Like that encryption can also be included if the data has to be stored securely. If data is stored in encrypted form it has to be decrypted before processing.

With the help of IoT, wearable devices can be developed to monitor health status of patients remotely. It can also be used to understand our own health status. Hospitals and other health organizations can monitor patients' dataremotely. Covid-19 accelerated the demand of IoT devices for remote health monitoring.Sensors generate high volume of data and these data need to be stored and processed in high velocity. IoT devices has limitations on storage, scalability, processing and networking capabilities [4]. The integration of Cloud Computing with IoT provides solution for this.

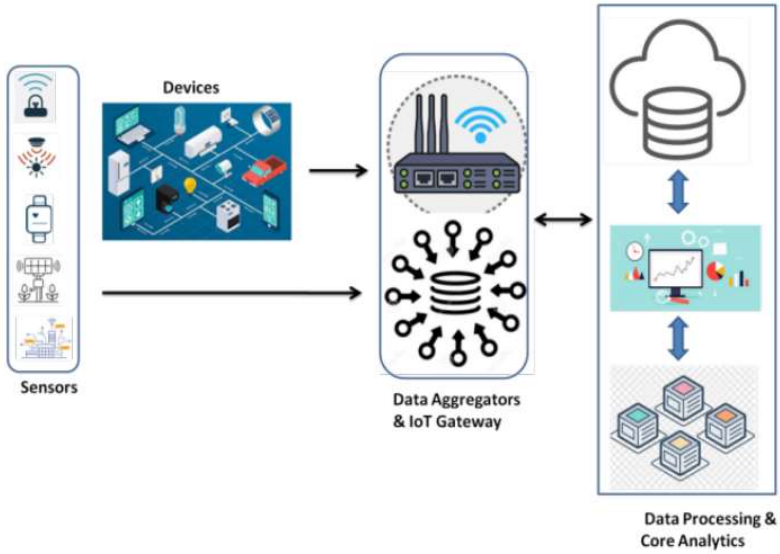

Fig. 1 Cloud based IoT architecture for Patient Remote Monitoring [5]

IoT support healthcare system for improved services delivery and it also enabled the healthcare services in appropriate way [6].The data generated from IoT devices have to be processed by various analytical tools to investigate the impactof certain events or decisions[7]. Internet of Things (IoT) and Big Data Analytics are increasingly gaining popularity for the next generation of eHealth and mHealth services [8]. Doctors, Patients, Pharmacists, Labs, Hospitals are the major actors on the IoT based healthcare framework [9]. These actors are directly or indirectly connected to the clouds in Cloud integrated IoT based healthcare system. According to [10], when hospital at home care model was applied to heart failure patients it demonstrated increased time to readmission, reduced index costs and improved health related quality of life, with no significant differences in adverse events

III. OPPORTUNITIES AND CHALLEGES OF INTEGRATING CLOUD COMPUTING, IOT IN HEALTHCARE

IoT helps to achieve safer and smarter living. There are opportunities and challenges that result from this integration [2-13]. The main advantages of IoT in healthcare are

i) **Remote Medical Assistance:** Wearable IoT devices have direct contact the person and the data generated can be accessed remotely by the healthcare workers or organizations. Direct contact with the patient is not required at all. Diagnosis can be done irrespective of the distance between the health worker and patient.

ii) **Minimal Errors:** Diagnosis is done based on the data generated from the sensors. Sensors generate data more effectively than manual diagnosis. So, the chance for errors will be minimal.

iii) **Efficiency:** All the stages from data gathering to diagnosis will be efficient in the case of IoT. Compared to manual diagnosis,efficiency of the system will be much higher.

iv) **Speed and Accuracy of Diagnosis:** Diagnosis is not done manually. The data generated from the sensors are analyzed and diagnosis is done by the system. So,the result will be more accurate. And the speed of data generation and analysis will be in high speed.

v) **24x7 tracking and assistance:** The IoT sensors are highly connected and the health workers can monitor 24x7. So the individual attention will be more.

vi) **Security:** The IoT sensors are designed and developed to ensure high security. The data transfer also will be in a secure manner. The entire processing is done in a secure environment.

vii) **Cost efficient:** The data generation and processing are done without manual intervention. The sensors generate data in high speed. The devices are durable and error free. So the entire system will be cost effective.

The main disadvantages of IoT in healthcare are

i) **Privacy Of Patients:** The patients' data are generated by the wearable devices. The data are sensitive data. If the data is leaked, the patient's health and sensitive information will be compromised. This will have more dangerous consequences. This would counter the benefits of IoT.

ii) **Accidental Failures:** There is chance for accidental failures of any of the components in the system. If any such failure occurs, the patient will be disconnected from continuous monitoring and this will result in entire system failure.

iii) **Malware**: There is chance for malwares in

iv) **Threat of unauthorized access:**Patient data is very valuable. So, confidentiality has to be ensured for healthcare data. Unauthorized access may lead to many risks.

v) **Memory Limitations**: Most IoT healthcare devices have low on-device memory [11]. Their memory may not be adequate in case of healthcare data analysis and diagnosis process with ensured data security.

Although IoT based healthcare has many advantages, the main drawbacks can be addressed with the integration of cloud computing [13-22]. The main advantages of integrating Cloud Computing in Healthcare Industry are

i) **Speed:** Healthcare industry generate high volume data. This data has to be stored and processed with high velocity. Cloud computing provides an environment with high-speed data access.

ii) **Reduced Cost:** Creating and managing an infrastructure for storing and processing healthcare data is a process that demands high-cost hardware and software. Cloud computing provide cost effective solution for this.

iii) **Ease of Collaboration:** The main advantage of cloud computing is ease of collaboration. People from anywhere across the world can collaborate at any time with the help of cloud-based solutions. Healthcare data require collaboration of patients, doctors and other related organizations or personnel.

iv) **Scalability:** Cloud Computing provides high scalability. Cloud providers have resources that can be scaled up or scaled down based on the requirement. Users just need to pay for the resources they use.

v) **Availability:** Healthcare data should be available at anytime from anywhere. Cloud computing improves the availability of data both present and historic data. This helps to make diagnosis accurate.

vi) **Security:** The healthcare data have to be stored and processed with high security. Data loss cannot be tolerated. Cloud computing provides highly secure environment for storing and processing.

vii) **Less System Management Effort:** The system to store and process is available as a service. So, management will be done by the provider. Healthcare sector is not needed to work on system management.

The main disadvantages of Cloud Computing in Healthcare Industry are

i) **Limited Control:** The infrastructure is completely managed by the service provider. Although service provider ensures guaranteed service, we have a concern about the infrastructure provided.

ii) **Data Security:** Cloud Service provider implement the best security standards. But still there is a threat of hackers. Health data is the most valuable data for individuals and there is risks while storing and processing on third party infrastructure. No service provider can ensure hundred percentage risk free environment.

iii) **If the provider goes offline:** Since all the data are on cloud, and cloud services are accessed online, if the service provider goes offline, we cannot access anything. So the healthcare will be delayed till the system comes online. In the case of healthcare data each fraction of time is very important.

iv) **Outages:** The cloud service provider provide services for multiple organizations. These organizations actually share the infrastructure of the provider. So there may be a chance for outage.

Nowadays blockchain technology is also came to be integrated with IoT and cloud. Blockchain integration helps to detect whether any compromise has been occurred to patients' data. Blockchain integration provides the secrecy and protection of control system in real time conditions [17]. The integration with IoT and Cloud Computing improve the healthcare sector in a very positive way. Since the cloud-based system can store patient's history and this data is availableirrespective of any boundaries. Integrating cloud computing and IoT with healthcare provide significant contribution towards healthcare sector.

IV.CONCLUSION

While integrating Cloud Computing, IoT and healthcare, the advantages of both the technologies will be available in the application scenario. Challenges during data gathering, processing, and management will be minimized with the help of these two technologies. IoT sensors gather data and these data are generated at high velocity. So processing of these data should also be done in that pace. Cloud Computing has solution for this. The infrastructure, platform, and software management will be by the service provider. So the time and effort for management can be contributed to other innovative techniques on improving healthcare domain.

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