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Challenges in Conglomerating Fog computing with IOT for building Smart City

Ms Poonam Rana,
A.P., Department of Computer Application, Chandigarh Group of Colleges, Landran, Mohali Punjab
poonam.9013@gmail.com

Dr Kirti Walia
Professor, University Institute of Computing, Chandigarh University, Gharuan, Punjab
kirti.e8889@cumail.in

Dr. Amanpreet Kaur
Associate Professor, IT Department, Chandigarh Engineering College, Landran, Mohali, Punjab
er.amanpreet14@gmail.com

***Abstract*- IoT and Fog Computing are the latest solutions that help in better analytics and decision-making for many of the market domains. The Internet of Things (IoT) is a term used to signify the number of devices or objects that are attached together using an Internet connection. Fog Computing is a decentralized and flexible system that helps to deliver and transport data and useful information across the Cloud and IoT. Fog computing's goal is to locate basic computation services at the edge of the network where they are needed this helps in the reduction of the distance the data has to travel resulting in an increase in the performance. Fog computing enhances the concept of Cloud Computing. There are various Cloud services available in the market viz Microsoft Azure Cloud, Amazon Web Services, Google Cloud, Alibaba Cloud, IBM Cloud, etc. IoT and Fog Computing go hand in hand and work together in providing an overall better IoT service. This paper discussed the benefits of using Fog Computing and IoT together in Minimizing latency, Conserve network bandwidth, less operating cost, more security, more reliability, and many more for building smart infrastructure for cities.**

***Keywords*- Fog Computing, Cloud Computing, IoT, Smart Cities.**

I. INTRODUCTION

Internet of Things (IoT) has evolved over period of time. Now days IoT applications are in seen in each field of computing and technology. For creating smart cities IoT has played vital role[1]. With the advancement of the IoT devices, the implementation of the smart city was ultimately realized. The motive of the formation of a smart city is the creation of healthcare, better security, ease of life. IoT is the prevalent useful solution that initiates a big change in world. IoT can take care of large amount of data. Due to sensor technology found in use these days, it can help us creating smart things. Data is sent to Cloud by all the IOT devices for further communication. Just because the cloud environment is centralized, IOT devices are facing challenges in accessing the data within the time range. Just to reduce the latency found in the communication new technology i.e., Fog Computing has been introduced and the latency is reduced as the storage facilities are provided at the edge devices i.e. near devices of the user with which the distance of travel of data has reduced as compared to cloud resulting in better performance and less latency. Smart cities[2] have been developed with the help of Fog computing in this era. Almost in every field these days IOT Applications have been implemented and helped for the better communication. There are many domains in which IOT has already been implemented many of them are like governance, healthcare, manufacturing, retail, home automation, peoples' security, research and education, defense ,transportation and many other fields [3].Fog computing is a more dispersed medium which is being used as a replacement for Cloud computing in these days for effective communication of the data with more ease and accuracy. This process helps in handling and storage capacity of the data closer to the edge of the web work to provide solutions more quickly and closer to the smart devices which usage the IOT over the network. With this ease the data flow is more faster and error free. There is an interdependence among different smart devices like smart phones, smart cars, traffic lights, smart watches, smart industrial equipment's, industrial sensors. Burglar alarms which lead to diversity of the output produced by them and hence provide diversity in the smart cities [4] being created.

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In Fig. 1 the IOT Communication Structure is divided into three levels where Fog computing is acting as middle layer between Cloud data centers and IoT devices.

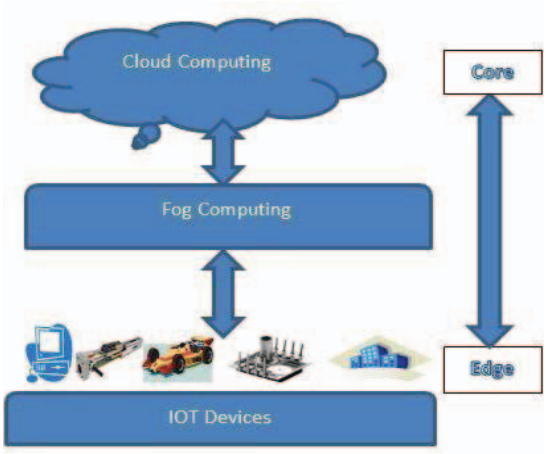

Fig 1. IOT Communication Structure

II. FOG COMPUTING

The cloud is a centralized resource that provides ease to users for computing, storage and connectivity. This leads to performance and delay issues. To overcome various issues facing in cloud a decentralized system is created by Cisco called as fog computing. The basic motive was to move storage and calculation systems close to sensors, equipment and devices which generate huge amounts of data so that latency is highly reduced. To transmit and get data from the clouds smart devices require high bandwidth and low latency that is achieved using fog computing.

III. FOG COMPUTING CHARACTERISTICS

Fog computing incorporates the paradigm of cloud computing to the edge of the network, thus activating various applications and services[5].

A. Low latency

The key feature is that its location is near to edge, with location awareness waiting time and latency is reduced.

B. Geographical distribution

Services and applications in the fog are widely distributed throughout space and the country. Fog plays an active role in delivering high-quality streaming to moving vehicles via proxies and access points located along highways and railroad tracks.

C. Mobility

Distributed System needs computing and storage resources for monitoring smart grid. Hence many solutions such as Locator/ID Separation Protocol LISP protocol, advance architecture and mobility management mechanism are applied in fog devices. Therefor Fog embedded applications can directly link with smart devices.

D. Numerous Network Nodes

Large sensor networks and smart grids for monitoring the environment are other examples that require distributed computing and various resources.

E. Real-time interactions

To provide quick and speedy services without any interruptions is an important attribute of Fog computing, that involve real-time interactions.

F. Heterogeneity:

Fog node Heterogeneous devices included in environment are computers, servers, laptops, printers, payers, smartphones, and physical objects. That means building a space where all the devices/gadgets are connected over the network.

G. Interoperability:

This is the key network communication features of Fog computing. Fog Computing is setting up the required interoperability measure to strengthen Fog computing resource recovery.

H. Improved data security

Data security and privacy is major concern that is rising in every field. To address these security and privacy concerns, resources are turned over to computing in the fog. This prevents sensitive data from reaching vulnerable public networks and makes it inaccessible to cyber criminals. Fog computing allows you to find malware and infected files early in the cycle at the device level before they infect entire network.

IV. EMERGING APPLICATIONS OF FOG WITH IOT FOR SMART CITIES

Fog with IoT has emerged various applications in the field of building smart cities providing

infrastructure that leads to smart Nation as shown in figure 2 given below:

Fig. 2. Applications of Fog with advantages of IoT.

A. *Smart Agriculture*

The concept of smart agriculture began in the last few years. Smart sensing and computing plays an important role in smart agriculture. Fog computing provides a platform for deploying sensors in the field of continuous crop observation. Sensors continuously store data in fog nodes that detect crop requirements and send alerts to farmers about crop requirements.

B. *Smart Traffic Lights and Intelligent Transportation system*

To eliminate traffic congestion with minimal human interference, fog computing plays a vital role. Sensors built into smart traffic lights can detect overtaking vehicles, calculate speed, relative distance and analyze collected traffic data. Make real-time decisions based on data. Smart lighting system can be used in the smart cities to reduce power consumption and increase energy efficiency.

C. *Waste Management System*

Smart sensor and fog computing applications enable monitoring of waste levels in the city, providing a more efficient waste management method. Waste management is a big challenge for crowded cities, because this task involves high energy consumption, money, and resources. Therefore, to improve quality of life, to reduce cost and energy consumption an optimized and integrated smart management system is introduced in smart cities.

D. *Water Management System*

Fog based infrastructure with IoT Technologies helps to build cost effective and energy efficient water management system to check quality of water. Water management systems can be deployed with a variety of sensors to provide relevant information such as distributing, consumption and reuse of water resources to increasing the efficiency of smart cities [6]. Smart water management system plans and develops technological approaches to monitor water related issues. Smart water management system analyzes the data collected from the sensors located in the system. Can reduce water loss and improve the city's water system[7].

E. *Smart Health*

IoT provides an apt infrastructure for improving the health system for providing quality of life. Home treatment, remote monitoring of patients, emergency health care and therapy assistance are done by smart health system. To improve health and safety of humanity, increase efficiency and to minimize operating/diagnosis cost robust intelligent health care system plays vital role.

F. *Smart Grid*

Smart grid enhances the energy utility using communications technology, smart sensors, routers and through private, dedicated networks connecting devices that are distributed to businesses and homes citywide, Smart meters Data concentrators Transformers Sensors Smart grid IoT technologies contribute to robust and efficient energy management solutions lacking in the existing framework.[8].

V. GLOBAL INVESTMENT TREND OF IoT SEGMENTS IN SMART CITIES

Smart Cities are the main applications of IoT devices these days, Cities today are to adhere the modern demands of the citizens. Many cities are in competition these days to provide the best possible facilities and economic vitality. Planning committees are in continuous research to innovate and adapt to Internet of Things. Figure 3 shows the global trends in building smart cities continent wise.

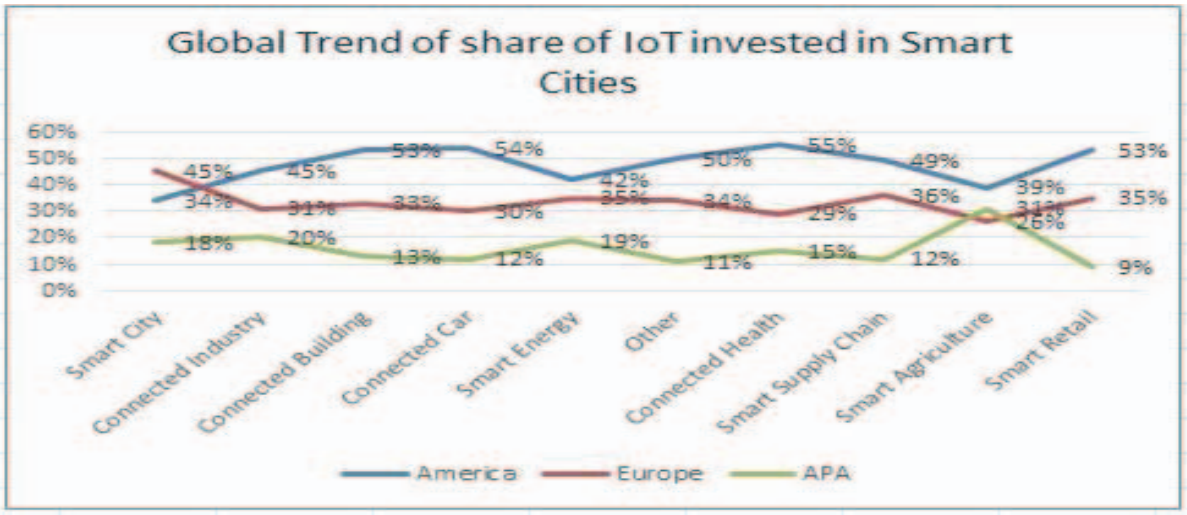

Fig 3: Global Trend of share of IoT in Smart cities

From Zion's Market research the market of IoT especially for Smart Cities was estimated to be of USD73.9 Billion in 2018 and it is expected to be USD330.0 Billion by 2025[18].

By Using IoT and Fog Computing in many domains these days there are many aspects which are improved for people's personal, social and economic growth. It is making people's life more easy and hustle free by providing more security, career opportunities, advanced health services, innovation and automation [17] as shown in figure 4.

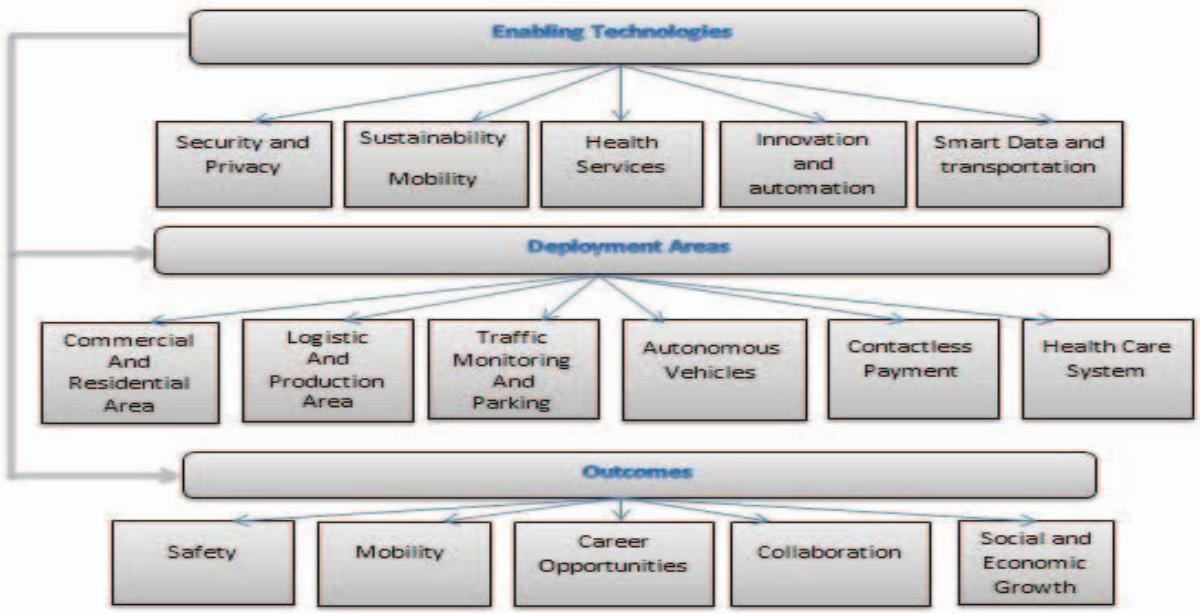

Fig 4 : Enabling technologies Deployment Areas and Outcomes to be considered in smart city deployment.

VI. FOG COMPUTING CHALLENGES

There are many problems that need to consider as we know Fog computing works in a distributed environment. In table1. Discussed the challenges of Fog computing with their solutions.

TABLE1.FOG COMPUTING CHALLENGES AND THEIR SOLUTIONS

Parameters	Author	Challenges	Solution
Management	Chenlei Liu et al.[9]	Resource management, updating management, energy management	data and control messages transmission, security authentication, and task processing
Security	Jianbing Ni,et al[8]	Identity authentication, access control, intrusion detection, data integrity	Cooperative and anonymous authentication, Attribute and role based access control, host and network based intrusion detection system
Distributed Framework	Jianbing Ni,et al.[8]	Privacy preservation data aggregation	Using IoT applications such as real-time services, temporary storage, data transmission, and distributed computing, we considered several promising IoT applications for the fog nodes.
Energy Efficiency	Ghazaleh Javadzadeh, et al.[6]	Energy consumption, availability, bandwidth management, latency reduction	Fog computing provide these solutions with the support of 5G.
Data Quality and Integrity	Husam Rajab et al.[6]	The application of IoT to smart cities is essential for both quality and integrity. For example, smart grids collect vast amounts of data from diverse sources.	To deploy intelligent systems and sensors with IoT for building intelligent applications
Load Balancing	Mandeep Kaur et al.[2]	Fog computing follows distributed framework hence few servers are overloaded and few are under loaded. Load balancing is also a big concern.	A prototype of a waste management system is proposed that implements load balancing in the fog layer. Smart containers are used to filter the data and the load balancer to balance the load on each node.

Fog computing has been found to work in a distributed environment, so there are many issues to consider. Here are some of the limitations /challenges of fog computing:

A. Storage limitation

To get quick responses, many tasks can be pre-processed locally. But, local or end devices may not have appropriate computing and storage resource to complete tasks. Hence more energy-efficient and powerful devices are required [11].

B. Data Management

With massive increase in IoT devices, billions of data being shared. Hence there must be a clear description of the organization, administration, and association of data achievement technologies and companies to manage these techniques. The fog will depend mainly on dispersed administration process that has not yet been tested at this exceptional scale.

C. Security

In this type of computing there are many devices which may be vulnerable to numerous attacks. The two major challenges which are to be taken care is the fog atmosphere are data and network[9].There are many other factors which are to be taken care here as the devices of the fog are created in non-secure environment so any attack or any vulnerability can easily be captured in the system. The devices should be run at the edge very securely in Fog [10].

D. Mobilization challenge

Open-Fog is termed as an N-level environment. Due to very high growth in the number of fog level layers creates delay problems. Deployment results will be taken in consideration when deciding on requirements such as the sort of work performed by separate level, the general sensors used, the competence of the fog equipment and the reliability and delay of the fog equipment. However, it is essential to consider how these requirements will be met[9].

E. Integration between cloud and fog nodes

The fog frameworks are having both cloud and edge equipment's. These devices are collaborated at the edge in heterogenous way and should be kept in consideration while treatment of cloud architecture is done to ease the calculations and storage to be done in distributed way. Thus, endways integration of fog equipments and cloud servers need to be dynamically allocated.

F. Distributed framework

The Fog framework is found to be decentralized in nature due to which the redundancy is there. There will be the replication of the similar kind of code on the devices that are found on the edge of the network [12] framework. Hence, there is need to reduce the redundancy in the decentralized architecture.

VII. CONCLUSION

This study is based on the Fog computing with support of IoT for formation of smart infrastructure in cities. This paper has presented characteristics of Fog computing, application of Fog computing in Smart cities, also discussed the challenges which are being faced. Hence Fog computing with amalgamation of IoT Technologies helps to resolve these challenges. Such as for security rather sending the sensitive data on cloud there can be data breach; this solution can send the data locally to the devices. So, in this way Fog computing is all time safer option for any highly secured data transmission. Customer interaction and support is very much easy in Fog Computing as users have to share the services they want and the place they want. This way business can respond to the users very quickly with this information. Fog computing main challenge is its reliability on data transport as many times limited availability, lower speed and peak congestion can lower down the performance these need to be resolved.

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