Survey on Different Computing Systems and its Challenges in the Resource Constrained IoT Devices

M. Priyanka[1] Dr. Smitha[2]
[1,2]Velammal Engineering College, India

Abstract— With the rapid growth of Internet of Things (IoT) applications, the initial centralized cloud computing technique faces several issues such as high latency, low capacity and network failure. To overcome these issues, edge and fog computing bring cloud closer to the IOT devices. Though there are different computing task performed based on the environments, IOT devices still faces the delay in response. This paper primarily focuses on open issues and future research directions regarding fog computing and the IoT are discussed.

Keywords: Internet of Things, Cloud Computing, Edge Computing, Fog Nodes, Fog Computing

I. Introduction

The Internet of Things (IoT) is a network of computational devices which connect and communicate through the Internet. The main function of IoT is the interconnectivity of devices that collect and exchange information vai the embedded software, cameras and sensors which sense things like light, sound, distance and movement. Smart devices are operated automatically, or are controlled and monitored remotely[7].The most Fundamental Components of IOT are Sensors/Devices, Connectivity, Data Processing ,User Interface. The Internet of Things is one of the spotlight innovations which has the ability to provide unlimited benefits to our society. The development of the IoT has reached a stage at which many of the things/objects around us will have the ability to connect to the Internet to communicate with each other without human intervention[6]. Initially, the IoT was introduced to reduce human data entry efforts and use different types of sensors to collect data from the different environments and allow storage and processing of all these data.

As the IoT is identified by limited computations in case of processing power and storage, it affects from many troubles such as performance, security, privacy and reliability. The integration of the IoT with the cloud, known as the Cloud of Things (CoT), is the perfect way to overcome most of these issues[8]. The CoT identifies the flow of IoT data gathering and processing and suggests quick, low-cost installation and integration for complex data processing and deployment. The integration of IoT and cloud computing provides many advantages to different IoT applications. However, as there are a large number of IoT devices with heterogeneous platforms, the development of new IoT applications is a difficult task, because IoT applications produce huge amounts of data from sensors and other devices. These big data are consequently analyzed to determine decisions, With respect to various actions. To send all these data to the cloud needs excessively high communication bandwidth. To overcome these issues, fog computing comes into action[2].

To provide reliable IoT applications using small, low power, battery operated devices different designs have to be considered, both in hardware, communication and software implementations. To cope with these different requirements, this paper primarily focuses on the different computing systems and its challenges in processing the data from IOT devices[9].

II. Literature Review

A. Levels of Computing Systems in IOT Applications

1) Cloud Computing

The term 'cloud computation' is defined as the use of computing resources, as well as the software level, through the use of services transferred over the Internet[8]. Current days, cloud computing services comprise one of the world's largest areas of competition between giant companies in the IT sector and software. Cloud Computing is a computing technique which can be formed as a base technology in the growth of IoT [10]. Through the integration of IoT and Cloud we have the opportunity to expand the use of the available technology that provided in cloud environments i.e for processing and storage. Through the integration of IoT and Cloud Computing could be observed that Cloud Computing can fill some gaps of IoT such the limited storage and applications over the internet[9]. Also, IoT can complete some needs of Cloud Computing that is the main issue of limited scope.

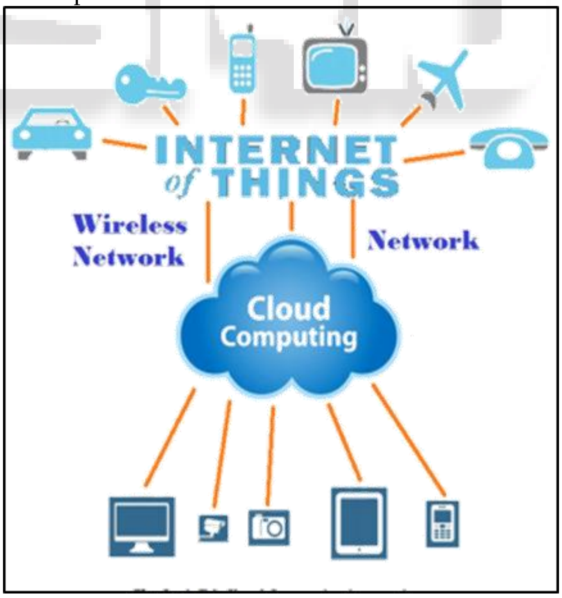

Fig. 1: Cloud Computing Paradigm

2) *Edge Computing*

It is a computational technique which relies on resource rich servers deployed close to the end-devices. One option to realize an edge computing platform is to deploy resource-rich servers in the network to which end-users connect. Present virtual machine based cloudlets deployed on Wi-Fi access points, one hop away from end-devices. The characteristics of the edge computing are as follows[5]: Low-latency communication is critical for several IoT applications, including connected vehicles, mobile gaming, remote health monitoring, warehouse logistics and industrial control systems. An increasing amount of data generated by IoT deployments today are high intensive of bandwidth, including video from surveillance cameras, police patrol cars and user devices. Placing computational resources one-hop away from high-bandwidth data sources implies that less data need to be sent to the distant cloud data Centers[6]. Device mobility places additional demands on low latency processing of device data. Indeed, edge computing paradigm support transmission of virtual resources based on the end-devices mobility, thus allowing the data computed by these devices to be processed locally and with a satisfactory quality of experience.

3) Fog Computing

Fog computing is a platform with limited capabilities such as computing, storing and networking services in a distributed from between different end devices and classic cloud computing. It forms a good solution for IoT applications that are latency-sensitive.

Fog computing is an extended form of the cloud but closer to the things that collide with IoT data. As shown in Figure, fog computing acts as an intermediate between the cloud and end devices which brings processing, storage and networking services closer to the end devices themselves. These devices are called fog nodes. They can be deployed anywhere with a network connection. A fog node can be a device with computing, storage and network connectivity such as, switches, routers, video surveillance and cameras embedded servers[1].

Fog computing is a framework which is distributed that offers IoT applications at the edge of the network by maximum extension edge resources. The main feature of fog computing is to manage the IoT data locally by using the fog nodes placed near users to bring about the management of data storage, computation, transmission, control and management[1]. Compared with cloud computing, fog computing has five distinguished features as follows:

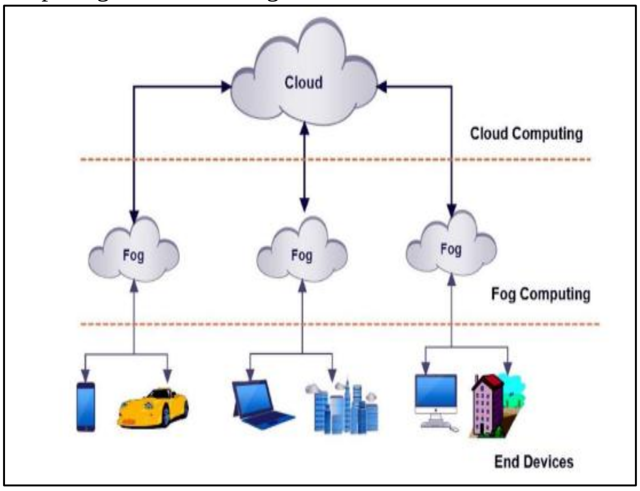

Fig. 2: Fog Computing Paradigm

a) Location Awareness:

[2] The fog nodes location can be traced actively or inactively to support devices with maximum services at the network edge. Fog computing relies on local IoT app that are accessible for the devices at specific areas through certain fog nodes. Therefore, it is aware of the regions of the devices based on the fog nodes location.

b) Geographic Distribution:

The fog nodes are placed at certain positions, such as on highways or roadways, on cellular base stations, on a museum floor and at any point of interest. The reason is to guarantee that the fog nodes receive a high-quality data stream from IoT devices, when those devices pass between the two fog nodes.

c) Low Latency[5]:

Thanks to the computing and storage resources, fog nodes can provide computation services and make decisions based on local data without the cloud. Since the fog nodes are primary to the IoT devices, the delay in the response is much lower than made by the cloud.

d) Large-Scale IoT Applications Support:

Fog computing supports large-scale IoT applications, it brings heavy management overhead to the centralized cloud. In large-scale IoT applications, such as environmental monitoring, power grid management, water treatment management and climate change monitoring, fog computing has its ability and power and autonomy to manage billions of IoT devices[2].

e) Decentralization:

Fog computing is a decentralized architecture in which there is no centralized server to manage resources and services. The fog nodes self-organize to produce real-time services and IoT applications to users.

Features	Cloud	Fog
Latency	High (Eventual Consistency)	Low (Locality)
Explicit Mobility	N/A	Yes
Architecture	Centralization	Decentralization
Service Access	Through Core	At the Edge / On Handhold Device
Local Awareness	N/A	Yes
Geographic Distribution	N/A	Yes
Scalability	Average	High
Availability	High	High
# of users/devices	Tens/Hundreds of Millions	Tens of Billions
Content Generation	Central Location	Anywhere
Content Consumption	End Devices	Anywhere
Software Virtualization	Central Corporate Facilities	User Devices/Netowrk Equipment

Table 1: Comparison of Cloud and Fog nodes Features

B. Fog Assisted IOT applications

Components	Fog-assisted IoT Applications
Smart Transportation	Traffic Management and Surveillance , Decentralized Vehicular Navigation, Smart Traffic Lights,Inter-state Bus Entertainment , Parking Sharing and Management , Road Surface Condition Monitoring.
Smart Grid	Home Energy Management , Microgrid Energy Management ,Energy Consumption Collection , Smartphone Energy Saving.
Smart Healthcare	Wearable Big Data Analysis ,Speech ,Smart E-health Gateways ,Fall Detection for Stroke Patients, Prediction of Sudden Cardiac Death, Patient Activity Tracking, Patient Care in Hospitals, Human Health Monitoring.

Table 2: FOG Assisted RealTime IOT Applications

Thus fog node have computational and storage capabilities, it behave as a replacement of cloud or a private cloud close to IoT devices, handling local real-time computation services. Specifically, the fog nodes placed at the network edge provide IoT applications and services, and get data from the IoT devices to make decisions and control the actions of these devices within millisecond response time. Therefore, many delay sensitive IoT applications can be placed to achieve fast decision making based on aggregated local data. We show some examples of fog-assisted IoT applications, in which fog nodes provide fast decision-making for users.

C. Comparison of Different Computing Systems

Types of Computing	Merits	Demerits
Cloud Computing	Cloud computing with its different models and implementation platforms help companies to manage and analyze this data, enhancing the overall efficiency and working of IoT system[9]	Due to continuous monitoring of Iot devices Cloud storage got accumulated with bulk of junk files. Processing the data in cloud takes very long time which makes slow response.
Edge Computing	By storing and computing the data closest to its source, reduce the lag time and improve the overall application performance. As a result, the data in real-time can be analyzed without delays[5]. When most of the data are stored and processed "at the edge", there is no need of an abundance of cloud storage. Unnecessary[6] information can be filtered out and backup only the relevant data.	The huge amount of data transferred adds frequent stress on the network links to the cloud[6]. A node has a need to maintain a counter for each sender, if it were to consequently receive packets from a large group of sending nodes, resulting in high memory overhead. The edge of the network is not properly defined and the nodes expected to participate in the communication at the edge level can vary.
Fog Computing	Fog computing is integrated with IoT to extend computing[2], networking resources and storage to the edge of a network. The rapid growth of IoT leads to the generation of huge amounts of data, which acquires massive computing resources, storage space and network bandwidth[1].	IoT has unsupported features such as low latency, location awareness and geographic distribution[5]. These are crucial issue for some IoT applications, which are smart traffic lights, home energy management and augmented reality.

Table 3: Analysis of pros and cons in IOT Computing Systems

III. FUTURE WORK

In the current trend of the Internet of Things (IoT) technology is more useful in healthcare in terms of mobile health and remote patient monitoring. IoT produces the rapid amount of data which can be processed using cloud computing. But for real-time remote health monitoring applications, the lag caused by transmitting data to and from the cloud and the application is unavoidable. So when the health monitoring devices start uploading the current condition of patient from smart home or hospital to the cloud continuously. The Fog-node receives the data and computes the collected data and generates events for abnormal cases. When an event is triggered the fog-node sends alert to doctor, ambulance and relatives based on the threshold of event occurred. But in recent research installation of fog nodes and maintaining as a server is again a financial constraint to the organization , so we going to implement the computation undergone in edge or fog servers in patient's mobile device with one-time-pad security[3].

IV. CONCLUSION

In order to overcome the scalability problem of the different Internet of Things architecture i.e.,data produced from the distributed IoT devices are transmitted to the remote cloud through the Internet for further analysis, the authors propose edgeIoT, a novel approach to mobile edge computing for the IoT architecture, intended to handle the data streams at the mobile edge.

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