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Fog Computing and Its Comparative Study with Other Cloud Based Technologies

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Abstract: Cloud computing is having a significant impact on IT sectors as it provide economical solution for dynamically changing hardware & software related requirement of users but as the users are moving towards hand held mobile devices having lesser computation capability, storage and power availability. There are different technologies available which solve the above given problem. This paper compares several emerging technologies for which cloud has formed the basis. It also provides general overview and performs comparative study of this technology.

Keywords **-** *Cloud Computing, Cloudlet, Fog, IOT devices, MEC.*

I. Introduction

Cloud computing is a combination of service oriented architecture and many other computing strategies such as multi tenancy, virtualization, resource pooling, elasticity and service-oriented architecture. The development of Cloud computing technology faced many critical obstacles such as security, availability, accountability, Fog Computing is an extension of cloud computing in which data, computing resources, storage and applications are placed between the data source and the cloud. It brings the power and advantages of cloud closure to the place where data was created and some action is performed on data.

II. Fog Computing

Fogging or fog computing is a distributed infrastructure where some of the services, application and data is managed at middle layer of cloud and hardware. It is now being promoted by the Open Fog Consortium which has recently published some white papers. Fog is "cloud closer to ground"[1]. Components of an application are hence able to run in a geo-distributed fashion using the services provided by the distributed infrastructure, wherein the resource management policies controls and manages the resource services offered by each device. These hardwares can be any IOT device, smart device or sensor. IoT devices/sensors are highly distributed at the edge of the network these devices receives and generates a lot of data.These edge devices does not have that much computation capability and storage resources available to perform advanced analytics and machine-learning tasks on data while cloud have all the computation as well as storage resources but these clouds might be far away to handle timely requests.In addition to it sending data from end devices to cloud and receiving response will be time consuming and has some security issues with real-time and latency-sensitive service requirements.

A Fog computing environment is consist of all traditional networking devices such as routers, switches, set top boxes, proxy servers, Base Stations (BS),etc. All these devices are placed closer to IoT devices/sensors as shown in Fig. 1. These traditional devices incorporates diverse computing, storage, networking capabilities which helps in service-applications execution , real-time interactions , scalability and interoperability. Fog computing saves us from excess network traffic, congestion, capital and operational expenses that occurs if cloud computing is used by IoT applications and devices.

Fig.1 also shows the three layers of fog system: The cloud layer, the fog layer, and the IoT/end-users layer. The fog layer can be formed by one or more fog nodes that can include edge routers, switches, gateways, access points,PCs, smartphones, set-top boxes, etc. As for the IoT/end-users layer is consist of two sub layers, the first including end-user devices and the second including IoT devices and it is not necessary to have both the layers simultaneously in the architecture.

Fog computing distributes computing resources and application services at any point between the data source and the cloud.It provides higher efficiency with low amount of data to be transmitted to the cloud for data processing, analysis and storage [1] .

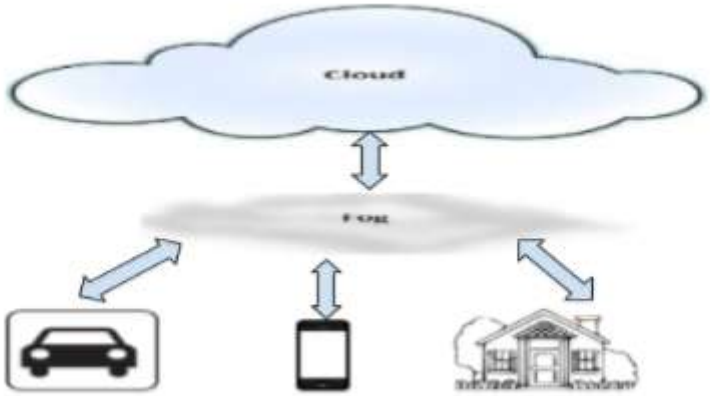

Fig 4: Fog System

Research Areas in Fog Computing:

As fog computing is an emerging field with lot of research opportunities. The main research areas of fog computing are related to architecture and algorithm. This architecture should be capable of resolving issues related to provisioning, communication and resource management. Till now many application specific architectures such as healthcare application, smart living and smart cities applications, connected vehicles applications has been proposed. Algorithms addresses the issues related to resource sharing, task scheduling, offloading and load redistribution, content storage and distribution and last but not the least energy consumption but still fog computing lacks in proper standards or guidelines.

III. Advantages of Fog Computing

The advantages of fog computing includes:

- ➢ It allows processing to take place at the edge of network with the help of fog nodes and enables processing at specific locations which results in low latency[3].
- ➢ Fog computing can save network bandwidth by processing selected data locally, instead of sending it to the cloud for analysis [3].
- ➢ It also offers densely-distributed points for gathering data generated by the end devices. This is done through proxies, access points, and routers positioned at the network edge, near the sources[9].
- ➢ Increased Security-As lower amount of data needs to be transmitted to the cloud hence there is an increases in security as compared to cloud computing

IV. Other Cloud Related computing Technologies

The cloud computing has gained popularity in 2006, when Amazon.com has released its Elastic Compute Cloud product [3]. Now a day's many cloud service providers are available in market such as SAP, Google, Microsoft, IBM etc providing IaaS, PaaS, SaaS as a service [2]. As the data centers used by cloud are not situated near to end devices (smart and IOT devices) which results in large round-trip delay related to request of end device, network congestion and QoS issues. To overcome this problem edge computing has been proposed in which data processing is performed near the source of the data i.e. at the edge of the network. Edge Computing mainly consist of end devices (e.g. smart phones , IOT devices etc.), edge devices (e.g. border routers, gateways, set-top boxes, bridges, base stations, wireless access points etc.), edge servers (server that resides between two networks)and other components. This type of computing provides faster responses to the request but it does not provide IaaS, PaaS, SaaS as a utility. Some of the edge computing technologies are given below:

- Mobile Edge Computing (MEC)-It has played an active role in modern evolution of cellular base stations. In MEC it is not necessary to connect to distant cloud data centers. It runs the applications and performs processing related work closer to the cellular customer.It bring computational and storage capacities to the edge of the network within the Radio Access Network and hence reduces network congestion and response time of application [4].
- Cloudlet-Cloudlet has been proposed by Carnegie Mellon University (CMU).It is a small-scale data center or cluster of computers designed to provide cloud computing services to mobile devices, such as Smartphone, tablets and wearable devices, within close geographical proximity. It follows the three tier architecture containing mobile device – cloudlet – cloud. In order to meet the changing demands of new application and new devices (e.g. lower battery consumption) Microsoft Research has given the concept of micro data centre as an extension of today's hyper scale cloud [5]. All these technologies aim to create a platform that provides computing power, storage and networking services between end devices and traditional Cloud Computing. Today, fog computing is in developing phase ,it has to overcome a lot of challenges such as architecture, security, network, storage and resource provisioning constraints

Comparison of MEC, Cloudlet and Fogging

Comparison Criteria	MEC	Cloudlet	Fogging
Driven By	It is driven by industry consortium, The European Telecommunications Standards Institute (ETSI) and launched in Sept 2014 [5].	Carnegie Mellon University (CMU) has developed Cloudlets.	It is driven by openfog consortium, -it is in developing phase all specifications are also not available [6].
Basic Concept	The MEC brings computation and storage resources to the edge of mobile network enabling to run the highly demanding applications at the User End while meeting strict delay requirements [7].	Cloudlets are resource rich cluster of computer having virtualization capability and located closer to mobile users, so that they can respond to their requests fast while maintaining a strong Internet connectivity [4].	The Fog Computing is a decentralized Computing infrastructure consists of many Fog Computing Nodes placed between the end devices and the cloud [8].
Interaction with clouds	It functions only in stand-alone mode. It could not interact with a distant cloud.	Cloudlets can function in either stand-alone mode or connected to a cloud, although there is almost no work on how they can interact with the cloud.	Fog is an extension of cloud.
Applications supported	aims at any application that is better provisioned at (mobile and non-mobile) edges (including mobile offloading).	Cloudlets focus mainly on mobile offloading application.	It enables applications that can span in cloud and edge both. It is best suited for real-time and IOT based applications[5]

V. Conclusion

Fog Computing, Mobile Edge Computing and Cloudlet all supports the Edge Computing technology and all these technologies have a thin hair line difference in the way they support the different applications. Some of these differences are highlighted in this paper. A lot of research has been done by the researchers in proposing and developing these features, but they are interpreted differently by different consumers and researchers. Thus, there is a need of proper standardization in terms of the implementation of Fog Computing, Mobile Edge Computing and Cloudlet.

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