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Impact of Mobile Edge Computing in Real-World

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ABSTRACT

Today's world is seeing an increasing usage of mobile devices and sensor rich devices such as smartphones, tablets and wearable devices such as smart watches. The volume of data that is generated by these devices is huge. Centralized cloud computing architectures cannot address the problems of network latency and jitter, degrading QoS (Quality of Service) and QoE (Quality of Experience) and other challenges in the world of mobile users. In this paper, we survey the impact of Mobile Edge Computing in the real world, an emerging edge computing technology to bring the cloud computing paradigm beyond the centralized architecture towards the edge of the network, nearer to the devices.

Keywords : Cloud Computing, Edge Computing, Mobile Edge Computing

I. INTRODUCTION

With the internet boom and the rapid and concurrent development of processing technologies and storage facilities, computing resources have become more affordable and readily available than ever before to end-users. In recent years, cloud computing has advanced to bring together several technologies to provide a scalable and reliable way to meet the demand for computing and storage resources.

The NIST Definition of Cloud Computing states that 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.

Cloud computing shares as well as derives several aspects from different technologies such as Grid Computing, Utility Computing, Virtualization and Autonomic Computing. Virtualization technology is leveraged by servers to provide computing resources as a utility.

Cloud computing offers several benefits to business owners such as no up-front investment, low operational cost, high scalability, rapid elasticity, pay-per-use model, reduced maintenance expenses and many more.

The traditional cloud computing architecture deploys centralized resources which can serve a large number of users. A typical public cloud vendor builds large data centres in various geographic locations. This resource is then made available to users through cloud provisioning. Apart from offering Infrastructure as a Service (IaaS), the centralized cloud computing model also provides Platform as a Service (PaaS) and Software as a Service (SaaS).

In recent years, applications are increasingly targeted towards mobile devices and smartphones. A large number of services are delivered through mobile phones. A tremendous number of smart devices and

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objects are embedded with sensors, enabling them to sense real-time information from the environment. However, mobile devices and smart devices are constrained in terms of storage capacity and computing power. Cloud computing can thus address this constraint by removing the processing and storage away from the mobile devices.

II. EDGE COMPUTING PARADIGM

The Edge is defined as any computing and network resource along the path between the data sources and the cloud data centres. For example, a gateway in a smart home is the edge between home devices and the cloud. Edge computing refers to the enabling technologies allowing computation to be performed

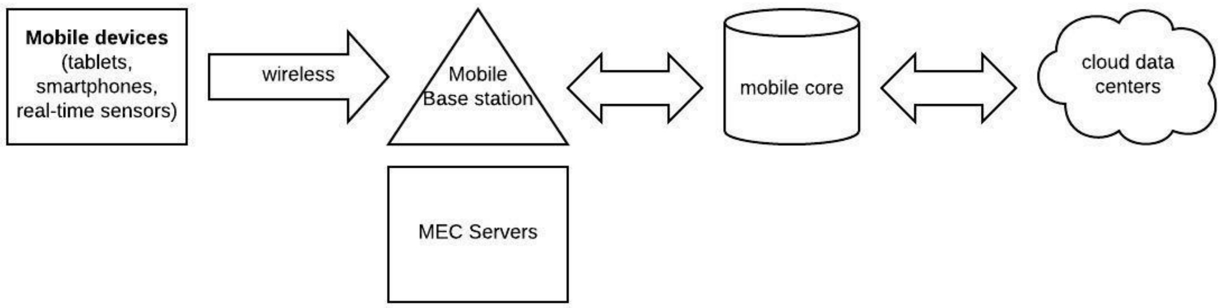

Figure 1: Mobile Edge Computing

But a centralized cloud computing architecture will not address problems inherent in a mobile environment e.g. delay, network latency, jitter, context-awareness. Mobile devices also generate a huge amount of real-time data such as user mobility behaviour, local network conditions and user locations. But a centralized cloud service cannot directly access local contextual information generated by mobile devices.

As a result, new computing architectures are emerging which are making use of the cloud computing paradigm but are hosted nearer to the devices.

In Section 2, we will take a brief look at the edge-computing paradigm. In section 3 and 4, we will survey the concepts and architecture of mobile edge computing and its impact in the real world. In the final section, we will conclude with a brief take on the challenges ahead for mobile edge computing.

at the edge of the network, on downstream data on behalf of cloud services and upstream data on behalf of IoT services and mobile services.

The Edge computing paradigm consists of having network nodes with computational and storage resources close to the devices (mobile phones, sensors) at the edge of the current network. Edge computing meets the increasing performance needs of data-driven services of the mobile environment using computational and storage resources close to the end devices at the edge of the current network. It calls for the processing of data at the edge of the network, rather than at the core of the cloud.

Edge computing can potentially address the concerns of response time requirement, battery life constraint, bandwidth cost saving, as well as data safety and privacy, typical challenges of smart devices in a mobile network.

In an IoT (Internet of Things) architecture, in which all smart devices such as smart cars, wearable devices, laptops, sensors, and industrial and utility components, are connected via a network of networks and empowered with data analytics, high volumes of data are generated at a fast rate. The internet is not scalable and efficient enough to handle the big data generated by IoT. It is also necessary to explore and analyse the valuable data in real-time. Edge computing architectures can be designed to collect, classify and analyse such big data from IoT at the mobile edge itself.

The main idea of edge computing is not to isolate from the centralized computing paradigm but rather to have intermediate computing facilities between the end devices and the current cloud.

Several edge computing architectures and concepts have emerged in recent times. Some of them are fog computing, mobile edge computing, mobile cloud computing.

III. MOBILE EDGE COMPUTING

Mobile edge computing (MEC) is emerging as a very promising computation architecture by pushing computation and storage closer to end users with both strategically deployed and opportunistic processing and storage resources. It is the result of the convergence between communications and computing. MEC aims to smoothly integrate cloud capabilities into the mobile network.

MEC, as defined by the European Telecommunications Standards Institute (ETSI), refers to a distributed MCC system where computing resources are installed within the RANs (Radio Access Networks), close to the mobile-device end of the Internet. Under this specification, MEC aims to provide an IT service environment and cloud computing capabilities at the edge of the mobile network.

Mobile Edge Computing (MEC) is different from Mobile Cloud Computing (MCC) in the sense that in MCC, the computing resources may be centralized or distributed. There is an inherent limitation of MCC,

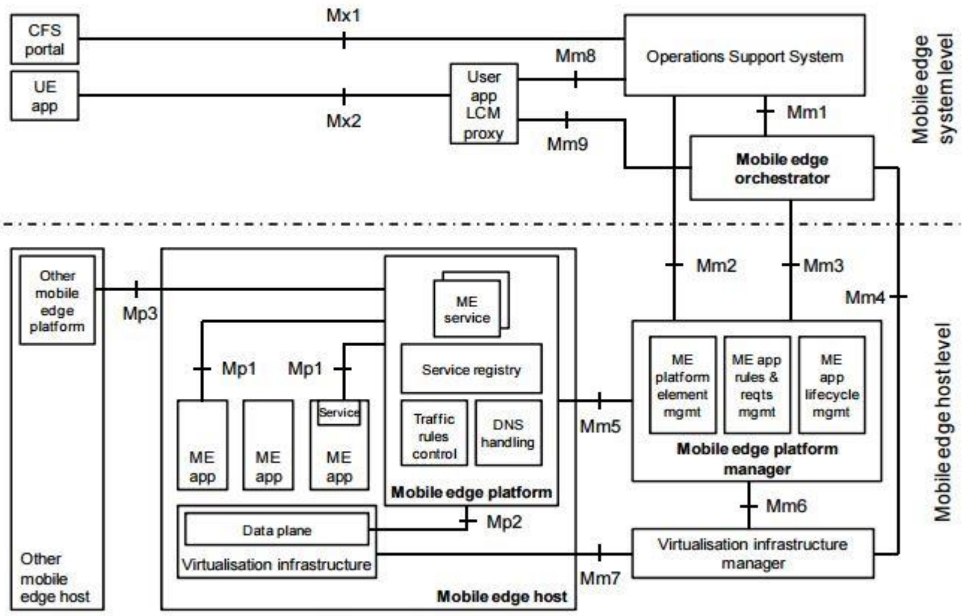

Figure 2: MEC Reference Architecture

namely, the long propagation distance from the end user to the remote cloud center, which will result in excessively long latency for mobile applications. MCC is thus not adequate for a wide-range of emerging mobile applications that are latency-critical.

Figure 1 shows the basic structure of the MEC architecture, in which there are three main components:

A. The Edge Devices

The edge devices include all types of devices, both mobile phones and IoT (Internet of Things) devices.

B. The Edge Cloud

Edge cloud is the less resourceful cloud deployed in the mobile base station. This cloud manages the basic network traffic including forwarding and filtering of data. It is also responsible for hosting mobile edge applications. For e.g. edge health care application.

C. The Public Cloud

Public cloud infrastructure is the traditional cloud hosted in the public internet.

Figure 2 shows the MEC reference architecture as described by ETSI standards. The major components of the MEC architecture can be described as follows.

The Mobile edge host (ME host) is an entity consisting of mobile edge platform and the virtualization infrastructure that provides compute, storage and network resources for the mobile edge applications.

Mobile edge platform (ME platform) represents a collection of baseline functionalities that are required to run applications on a particular ME host and to enable mobile edge applications to discover, advertise, offer and consume the ME services.

Mobile edge applications (ME applications) are running as virtual machines on top of virtualization

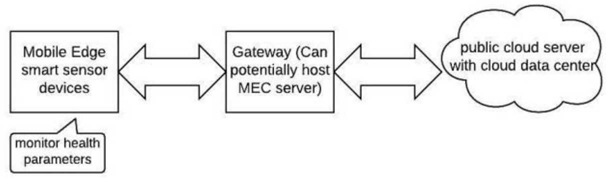

Figure 3: MEC in smart health care

infrastructure provided by the ME host.

Mobile edge platform manager (MEPM) is a host level entity which manages the ME platform elements, ME application rules and requirements and the ME application lifecycle management.

Mobile edge orchestrator (MEO) is the central function in the ME system as it has the visibility over the resources and capabilities of the entire mobile edge network. The orchestrator maintains information on the entire ME system as it has knowledge on all the deployed ME hosts, the services and resources available in each host, the applications that are instantiated and the topology of the network. The ME applications may indicate their requirements e.g. for the resources, services, location and performance, such as maximum allowed latency, and it is the MEO whose responsibility is to ensure that the requirements are met.

MEC allows network operators to provide new services by opening up their Radio Access Network edge. Operators can provide smart nodes at the edge of the network. These nodes will run virtualized software on general-purpose hardware. These edge nodes can emulate part of the central cloud and do various other functions.

Several layers in the traditional cloud stack needs to accommodate changes brought about by mobile edge computing architecture. It includes the layers of servers, virtualization and Operating System in the cloud stack.

IV. IMPACT OF MOBILE EDGE COMPUTING

Mobile edge computing has brought about benefits for both consumers and operators. Several consumer oriented services like Augmented Reality, Video Streaming, Remote Desktop, Gaming and operated oriented services like Big Data analysis, IoT connectivity and Connected Vehicles have gained from MEC. It has also brought about significant improvement in terms of network performance and QoE improvement. Some of the areas impacted by mobile edge computing are given below:

A. Video Optimization

Mobile video streaming traffic is predicted to account for 72% of the overall mobile data traffic by 2019. Thus optimizing video according to network conditions and the mobile device's resource constraint is a challenge.

MEC enables intelligent video acceleration by informing the video server of the optimal bit rate to use, given the radio network conditions for a particular video stream. MEC also enables reduction of battery consumption of mobile devices during video calls by offloading computing and power intensive tasks like video encoding/decoding to the MEC server.

B. Augmented Reality

Augmented Reality (AR) is a combination of a view of the real-world environment and supplementary computer-generated sensory input such as sound, video, graphics or GPS data.

AR service can be implemented on a MEC cloud as the data generated by the service is highly localised and time-sensitive. Since the MEC server will be deployed nearer to the device (mobile camera, smart glasses), it can render localised content very quickly.

C. Smart Health Care

MEC based cloud computing solutions can enhance different characteristics of a smart health care system. Figure 3 shows a potential architecture for MEC in smart health care IoT system. Smart sensors and devices can monitor several health parameters like blood pressure, temperature etc. An IoT Gateway can host a MEC server, which can receive the data, analyse and respond to any early warnings and emergencies.

D. Smart Building Services

Smart building services like security, tracking, climate control, smart signage, face recognition and entry control can be realised through local computing and control capability.

A MEC server cloud hosted in the local IoT gateway can process device communication and the data generated in such smart buildings.

E. IoT Connectivity

IoT devices are often resource constrained in terms of processor and memory capacity. Various devices are connected through different means such as Wi-fi, 3G, LTE and others. The MEC server that can be hosted in an IoT gateway, can provide analysis and real-time provisioning of these devices and enable applications to respond in real-time.

F. Big Data Analysis

The wide spread usage of intelligent mobile devices generates vast amount of end-user usage data. The analysis of this big data can help the enterprise market in decision-making. The traditional cloud computing can result in high bandwidth consumption and high latency in their analysis. MEC can complement the cloud server with better response time, low bandwidth consumption and low latency.

G. Content Caching

The emergence of MEC has enabled caching of content at the network edge and also processing at the edge. MEC can leverage the edge caching and processing ability to improve caching efficiency and even transcoding of video data.

H. Computational offloading

Most mobile applications are compute intensive and results in poor performance since mobile devices are constrained for battery power, memory and computing power. A low resource server like MEC cloud can be delegated with atleast part of the computing tasks enabling mobile devices to run thin clients. MEC can thus offload compute intensive tasks away from devices.

I. Content Delivery

Content delivery technology optimizes web content at the web server to provide services with high availability, high performance and to reduce network latency. MEC cloud servers with its proximity to the edge, can provide dynamic optimization of web contents based on the network.

V. CONCLUSION

While mobile edge computing offers many benefits, there are also many challenges ahead, both technical and non-technical.

Mobile edge computing is a recent architecture and standardization is an important step to bring in more takers and for widespread implementation. The heterogeneity of the end devices as well their means of connectivity is another challenge to develop and deploy MEC. MEC servers should be able to switch networks without compromising on the benefits like low latency, low bandwidth consumption and high response-time and high QoE. Security and scalability are other challenges faced by network providers while deploying MEC servers.

Mobile edge computing inspite of its challenges, can help advance mobile networks into a programmable world. MEC is seen as a key technology in the evolution of 5G and future mobile networks. Thus Mobile edge computing cloud architectures promises high impact in smart environments.

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