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A Brief Survey of Future Computing Technologies in Cloud Environment

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ABSTRACT

New network developments, such as the Internet of Things (IoT), autonomous communities, intelligent metering, virtual/enhanced technology, and driverless driving, are evolving with the exponential growth of inevitable wireless technologies and pervading networking technologies. The manufacturing and research societies have been providing a range of network computing paradigms in recent years, including fog computing, mobile edge computing, and dew computing. While utilizing various terminologies, their core idea is to expand cloud computing and shift the computing system from distant data centers to edge routers, base stations, and local servers nearer to customers, thus addressing the inefficiencies that cloud computing is facing and offering improved user interface and consistency. Throughout this article, thoroughly sum up and examine the paradigms of future cloud computing indicated in recent years.

Keywords: *Cloud computing, Fog computing, Edge computing, Mobile Edge computing, Dew computing.*

1. Introduction

Computer and networking systems have evolved and expanded quickly in recent years, encouraging the growth of cloud computing. This growth has nevertheless also revealed certain intrinsic weaknesses and limitations correlated with cloud computing, which in the future cloud computing context contributed to the evaluation and study of the network computing model. Initially, the quick technical growth of all-around mobile devices has developed and is commonly utilized as a range of modern smart devices. For starters, the global availability of smart mobile devices (e.g. smartphones) since 2011 has surpassed that of the Personal Computer (PC). In 2016, there were 7 billion global mobile subscribers [1] and China's mobile Internet usage hit 0.9 billion [2].

In recent years, intelligent watches, intelligent wristbands, and other intelligent wearable devices have also evolved quickly, using intelligent wearable devices as a day to day life. Moreover, various smart or intelligent sensor instruments with differing sizes and capacities have been installed in towns, societies, and also in hill and lake regions like a compass, webcam, and water/fire sensors. These smart or intelligent systems provide substantially different capacities for processing, storage, network access, and energy use, and it is very challenging to extend cloud computing to these mobile devices and sensors due to its features of centralized computing and storage. The capacity of these diverse kinds of devices of cloud computing is often challenging to optimize. Then omnipresent network architectures were designed and implemented. There is the extensive usage of 4G-LTE, LTE-A, WiFi, and other cellular internet systems.

Besides, 5G network and D2D networking systems have been developed and will be available for consumer usage in the years to come. Wireless broadband development accelerates consumer connectivity to cloud resources and strengthens user experience. Consequently, future criteria for access pace and end-user requests are yet to be fulfilled. Mobile internet streaming uses various network bandwidths concerning online content. Besides, transmission delay has an important influence on consumer satisfaction. As a consequence, the advancement of 5G and D2D technology has contributed not only to a major guiding factor but also to new problems for Cloud Computing, i.e. how the usage of constantly upgraded network equipment and technologies will further enhance customer satisfaction. In the meantime, the advancement of Software Defined Networking (SDN) and Network Function Virtualization (NFV) innovations have increased edge network routing device's processing and storage capability such that their roles can be expanded and customized to the unique needs of the customer.

Besides that, with its centralized processing which creates significant obstacles for the continuous formulation and support of cloud computing, user requirements emerging from the development of consolidated network technology are conflicting with the cloud computing principle. Also, the fast expansion of all-embracing mobile devices and pervasive networks has produced a broad range of innovative network technologies and services. The key aspects have increasingly become known to the public: the Internet of Things (IoT), the Internet of Vehicles (IoV), the Internet of Everything (IoE), the smart world, the intelligence community, the smart grid, social networks, and content/ media/service networks.

Virtuality/Augmented Reality (AR), Self-driving/Unmanned Aerial Vehicles (UAVs), and other emerging network technologies and services have gained attention throughout recent years. This has introduced yet another obstacle to cloud computing only having a central computing model to address all the needs correlated with the quick development of these modern network technologies and services.

In brief, the continuous technology growth of all-round smart devices and on various networks, as well as the resulting emerging network software and facilities allows it impossible for a cloud computing paradigm to evolve and extend to different forms of technology and application scenarios for its unified storage and distribution model. For this cause, industry, and academics have been seeking innovative network computing paradigms in the future cloud period since 2011[3]. In the meantime, there have been recommendations and improvements on Fog Computing [4], Mobile Edge Computing (MEC) [5], Dew Computing [6], and other future cloud computing paradigms. Because research on these latest network computing paradigms is crucial for the advancement of the whole computer and communications market, this review, examine and summaries newly established network computing paradigms in future cloud computing to facilitate ongoing research and development.

This article demonstrates in-depth the future cloud computing paradigms, including fog computing, MEC, and dew computing, to help readers grasp principles correlated with different future cloud computing paradigms. The groups in Cisco, European Telecom-Standards Institute (ETSI), and the research community all respectively proposed these modern paradigms and each has its focus owing to its particular objectives and clear fields of implementation. While these future cloud computing paradigms vary in terms of objectives, technologies, and fields of implementation, their core principles remain the same. That is to suggest, they aim to implement cloud infrastructures more physically and logically similar to end-users and their devices and then use the tools for computing and storing them in local infrastructures to complete the required measurement or storage of end-users easily, thus speeding up processing and response times and increasing user experience. It undertook a comparative study of future cloud computing paradigms to gain insight into the creation and implementation of future cloud computing paradigms and to consider the different aspects of current network computing paradigms to provide a systematic summary of their emphases and distinctions.

If the future cloud computing model introduced by business or academics will be adopted and implemented broadly relies on the cumulative influence of several variables. It is impossible to foresee just what future cloud computing model would dominate. However, it's known that in the immediate future cloud computing paradigms can expand rapidly in reaction to strong opportunities. It has also carried out a key study of future cloud computing prospects from a variety of viewpoints.

The remainder of the article is structured as Section 2 deals with the relevant work in future cloud computing development. Section 3, provides briefs on future cloud computing methodologies. Section 4 provides a thorough analysis and evaluation of future cloud computing paradigms and the conclusion of the article were given in Section 5.

2. Related Works

In [7] the authors addressed the capabilities of Fog Computing as the potential response to the difficulties of building a flexible network infrastructure. The whole article introduces a modern icloudfog design that can be reconfigured and supports the IoT. The icloudfog enables fog to be used in different fixed, mobile, and mixed forms.

In [8] the authors focus on Cloud IoT Integration context-conscious resources. The whole work provides a base for developing and implementing a modern network communication that raises knowledge of the background among IoT data processing devices.

In [9] the authors explore a paradigm focused on edge computing to incorporate situational knowledge in intelligent cities. The modern theory of dew computing was invented with scientific advancements. Its style of coding is at its genesis. Several researchers analyze this area.

In [10] the authors analyze the computing-based IoT architectural modeling approach provides a summary of the dew association. It explains how the dew server is implemented and merged with the IoT into the cloud-based solution.

3. Methodologies

These recently evolving computing paradigms are referred to together as future cloud computing paradigms. While numerous organizations, with diverse backgrounds, have proposed new future cloud computing paradigms, they share common concepts, proposals, and technical approaches. The underlying concept of these paradigms is to find the cloud near to the surface. This ultimately includes expanding cloud computing from the data center to network edges nearer to end-users, thus addressing network problems correlated with cloud computing and improving user's service processing rates and efficiency improvements. Technologically, committed servers and computers or tiny data centers on network limits are installed close end users to understand small-scale central processing utilizing the same technology like those found in cloud computing. Of course, these recent future cloud computing paradigms do not depart exclusively from cloud computing, but they are instead a natural progression of cloud computing from centralizing to small-scale centralization and delivery, which can also be interpreted as an ancient regression of the computing model transmitted by PC. It gives a thorough description of some common future cloud computing paradigms in the subsequent areas.

3.1 Fog Computing

The fog computing idea was first suggested in 2011 by Cisco's network system manufacturer. The following are the definition of Fog computing by them.

"Fog computing is an architecture that is horizontal. It deploys computing, organizing, managing the network tools and facilities between the cloud and intelligent stuff everywhere".

Its core features are mentioned as:

The architecture was horizontal: *Facilitating multi-industry vertical and technology fields to deliver intelligent applications to consumers and businesses.*

Continuous cloud-to-thing service: *Able to deploy resources and apps between both the back-end cloud and the knowledgeable thing.*

Level of the system: *Bridge numerous protocol levels from the knowledgeable thing and the network edge to the back-end cloud. Not just are a wireless communication device, a protocol layer, and a component of the terminal system, although it is cloud coverage.*

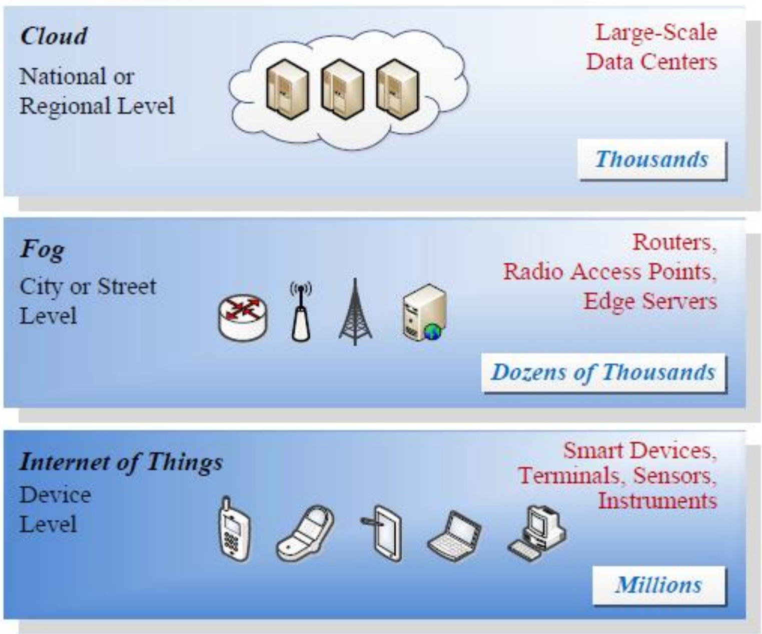

Fig.1: Fog Computing Architecture

The previously mentioned description often concerns primarily the usage of IoT or IoE fog computing. This concept, therefore, guarantees consistency of service provision across the entire route between both the terminal system and the back-end cloud. No consensus has yet been reached on the concept of fog computing. The description it chooses is compatible with the original fog computing introduction. Some scientists or organizations give their interpretations or extensions to fog computing context. Because of the time limits, these expanded concepts are not addressed here. Figure 1 shows the fog computing architecture in the cloud environment.

3.2 Mobile Edge Computing (MEC)

ETSI proposed the MEC principle for the first time in September 2014. MEC varies from Fog Computing because it has been developed and promoted by communications equipment manufacturers as a post-cloud computing paradigm. This model also puts special focus on communications assistance and associated applications.

Initially, MEC was described as follows:

"MEC supports software engineers and content companies with cloud computing technologies and IT service ecosystems at the edge of mobile networks. The whole system is characterized by extremely low latency and high bandwidth and software that can access the information on the wireless network in real-time".

The major features of its market dimension are as follows:

- A modern supply chain and energy-intensive economy focused on creativity and market value.
- Providers may enable third parties to open their wireless network connectivity edge and allow third parties to utilize creative software and utilities flexibly and rapidly.
- It will include mobile customers, companies, and vertical sector industries with fresh and creative software and services.

This description by the ETSI the MEC emphasizes trade, opportunities, and the associated technologies. MEC was specifically introduced to respond to mobile connectivity context specifications. It integrates connectivity with IT and offers user-friendly value-added features with IT and cloud computing technologies in the Radio Access Network (RAN). Most specifically, the transition in terminology further expands the MEC scope as originally described by ETSI. MEC providers are therefore no merely constrained to wireless networks.

MEC hubs operated by major vendors may be distributed across several various network styles, enabling MEC hosts to cooperate on edge applications. You can install MEC services on LTE, 3G radio network (RNCs), Wi-Fi access points, edge network routers, and corporate-edge servers.

Thus, quick local networks can be distributed directly on the edge of the network and various connectivity solutions are required for these services. More specifically, the incorporation of various connectivity technologies to increase the capability and the option of access technologies for uplinking/downlinking can be rendered in compliance with client requirements. Figure 2 details the MEC architecture.

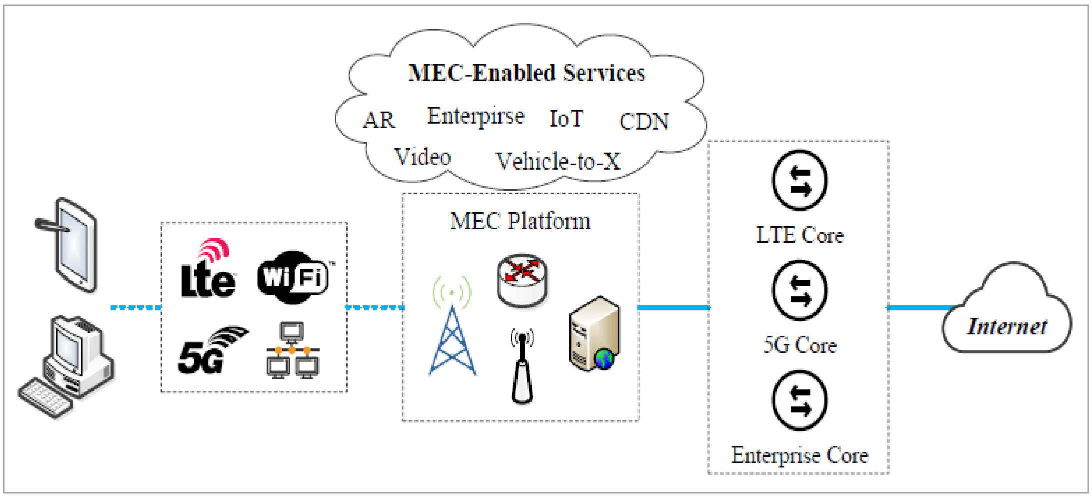

Fig.2: MEC Computing Architecture

3.3 Dew computing

The academic group implemented Dew Computing in 2012 and the simple cloud-dew architecture was completely illustrated in 2015. Dew computing is a generalized cloud-dew framework and its description is just as following.

"Dew computing is a cloud computing software organizing paradigm aimed at completely exploring the benefits of PCs and cloud computing resources. Application is structured as per the cloud-dew architecture in the dew computing framework. Local machines can deliver a rich variety of functions regardless of cloud resources and can even operate with cloud services".

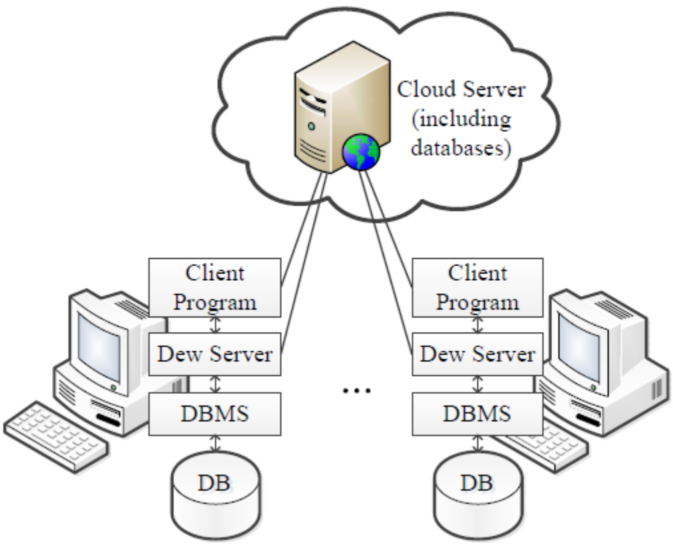

Fig.3: Dew Computing Architecture

The major features of dew computing are as follows:

- The goal is to guarantee the functionality of a website even though internet links are not accessible.
- Cloud-dew infrastructure has an extra dew server similar to the commonly designed client-server architecture that is a Network server deployed on a local user's device.

- ❖ In the cloud-dew architecture, user knowledge is processed not just on the cloud but also with the local machine of the user.
- ❖ Cloud-dew architecture will also assist consumers in accessing the Internet without a link to the Internet.

The standard cloud-dew design routine is to delegate computing activities between central and local servers. Figure 3 gives a cloud-dew architecture schematic diagram.

4. Discussion of the Study

Here it discusses the disparity in future cloud computing paradigms in this segment. To make it easy for viewers to grasp the three future cloud computing paradigms, they are capable to recognize its concepts. A comprehensive comparison of the parallels and disparities between these three paradigms is shown in Table 1. The whole thorough comparison reveals that while their descriptions vary, they have common characteristics, including low latency and near to end-users. They even provide their very own special functionality.

Fog computing encapsulates IoT technologies, while MEC concentrates on the wireless connectivity network from the point of view of networking providers, independent of coordination among terminal systems and cloud centers. Dew computing emphasizes consumer and cloud communication, ignoring the edge and the wireless connectivity network. As such, an overall trend of the future cloud computing model incorporates consumer device communication and exploits the resources of facilities situated close to the end-user. In the end, suppliers of a machine, computing, and networking resources could decide about the place at which those services are performed (for example user system, neighboring user devices, adjacent facilities, and remote data centers).

Table 1: Comprehensive comparative of future cloud computing paradigms

	Fog computing	MEC	Dew computing
Users	Mainly mobile users	Mainly mobile users	Common Internet users (including mobile users)
Distance to users	Very close	Very close	Very close
Access network	Mainly wireless	Mainly wireless	Wireless and wired access
Network latency	Low	Low	Low
Distance between client and server	One or multiple hops	One hop	One or multiple hops
Deployed Hardware	Routers, switches, access points, gateways, etc.	Radio access points, base stations, etc.	On-premise computers
Deployment environment	Edge and near-edge	Network edge	User equipment
Usage of virtualized platforms	Yes	Yes	No
Usage of end device	Yes	No	Yes
Service type	Local service	Local service	Local service
Service access	Edge or user-handheld devices	Edge	User-handheld devices
Typical application scenarios	IoT, smart grid, Internet of vehicles	Augmented reality, intelligent video acceleration, IoT	Web browsing

5. Conclusion

This article discusses the fundamental essential principles of future cloud computing and highlighted its inevitable trend toward progress in various gaps that prevent the further development of future cloud computing. The convergence of future cloud infrastructure with some computing technologies is important for the application of simple features that need different concepts. It provided a complete survey of the latest computing models and their effects on future cloud computing activity. To enable researchers to consider the advancement of future cloud computing and the parallel growth of cloud computing concepts, here it compares the impacts on future cloud computing in-depth. At that point, it could conclude that various scientific options exist to address different problems raised by combining smart technologies with cloud services concepts.

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