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Comparative Study Between Cluster Computing, Grid Computing, Cloud Computing, Mobile Cloud Computing, Fog Computing, Edge Computing and Mist Computing

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***Abstract*: This paper represents the different computing types, their characteristics, advantages, and disadvantages of cluster computing, grid computing, utility computing, cloud computing, mobile cloud computing and fog computing. In this paper, we also discuss the technologies of mobile cloud Computing like grid computing utility computing, fog computing etc. In this paper there will be an overview for other types of computing and highlight the differences between these computing types and also discuss the future scope of these different computing technologies.**

***Keywords*: cloud computing, mobile cloud computing, grid computing, utility computing, cluster computing.**

1. Introduction

Frameworks are a form of computing in which a bunch of computers (often called nodes) are connected through a LAN (local area network) so that, they behave like a single machine. A computer cluster helps to solve complex operations more efficiently with much faster processing speed, and better data integrity than a single computer and they are only used for mission-critical applications. In terms of scalability, clusters provide this in their ability to add nodes horizontally. This means that more computers may be added to the cluster, to improve its performance, redundancy, and fault tolerance. This can be an inexpensive solution for a higher-performing cluster compared to scaling up a single node in the cluster. This property of computer clusters can allow for larger computational loads to be executed by a larger number of lower-performing computers.

A. Types of Cluster Computing

- Load Balancing Clusters: This system is used to distribute workload across multiple computers.
- High Availability Clusters: This system is used to utilize redundant operations in the event of node failure in clusters of computers [1].
- High Performance Clusters: This computer network methodology is used in supercomputers and cluster computing to solve advanced computation problems.

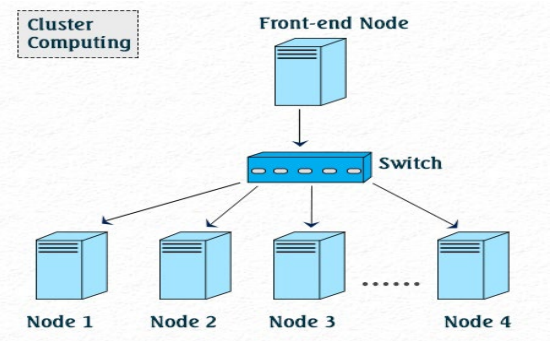

Fig. 1. Cluster computing

B. Advantages of Cluster Computing

1. Easy to deploy
2. Cost efficiency
3. Expandability high availability of resources

C. Disadvantages of Cluster Computing

1. Difficult to find failure
2. No need to experience
3. Programming is hard to be improved when software is different between the nodes

2. Grid Computing

Grid Computing sometimes referred to as “distributed” computing, is the combination of computer resources from more than one administrative domain to reach a common goal. How does it do this? [2]. It taps into the unused process cycles of computers within a network to solve tasks that are otherwise too intense for a stand-alone machine to handle. Resources that can be drawn upon include processing power, memory, and data storage. When a task is assigned, it gets broken down into different sub-tasks, which are then divvied up and sent out to different machines within the network [9]. As the tasks are completed, the results get sent back to the controlling unit, which then collates them to form a cohesive output. Grid computing is generally used to solve large-scale scientific or mathematical problems the type that requires a huge number of

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computer processing cycles or access to large amounts of data. They've been used commercially for applications like drug discovery, economic forecasting, seismic analysis, back-office data processing, etc.

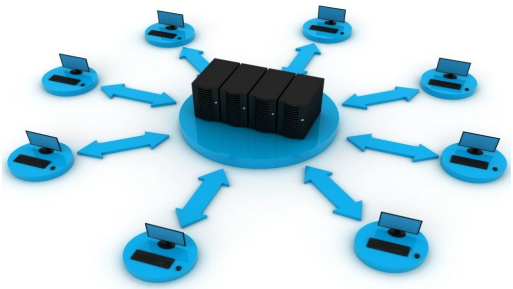

Fig. 2. Grid computing

A. Advantages

- It offers compatibility of all the computers in large companies.

B. Disadvantages

- Reliability issues
- Need license of different software and hardware

3. Utility Computing

Utility computing refers to a type of computing technology and business models that provide services and computing resources to the customers, such as storage, applications, and computing power. this model has the advantage of a low cost with no initial price to reach the computer resources [4]. This repackaging of computing services is the foundation of the shift to on-demand computing, software as a service, and cloud computing models which later developed the idea of computing, applications, and network as a service. Utility computing is a kind of virtualization, which means the whole web storage space and computing power which it's available to users is much larger than the single time-sharing computer [9].

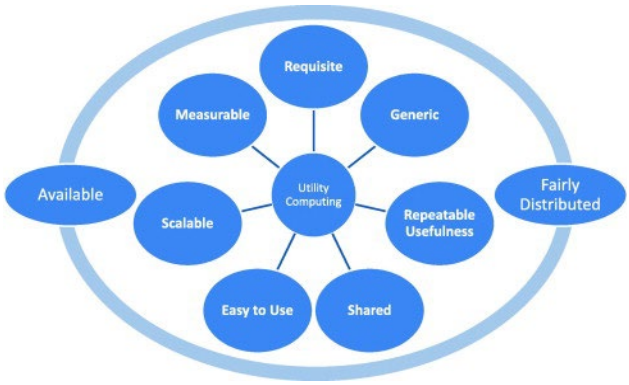

Fig. 3. Utility computing

A. Advantages

- No need to buy large servers for applications
- More efficient in use of resources

B. Disadvantages

- Needs fast interconnection between computers

4. Cloud Computing

Cloud computing allows users to share resources, utilize software, and access personal files from any computer that has Internet access [3]. It derives largely from the UNIX paradigm of having multiple elements, each one exceptional at one task, as opposed to a larger element whose performance is not as efficient. There are four types of cloud computing [7]:

A. Public

Resources are offered over the Web to the general public on a self-service basis

B. Community

Resources are shared between different organizations from a specific community.

C. Private

Operates for a single organization.

D. Hybrid

Composition of two or more clouds (private, public, community) that remain unique from one another but are bound together to offer the benefits of multiple deployment models.

E. Advantages

- It gives minimal control over to the customer.
- The major issue of cloud computing is security issue.

F. Disadvantages

- It gives minimal control over to the customer.
- The major issue of cloud computing is security issue.

Fig. 4. Cloud computing

There are also three main services that cloud computing can provide:

1) Infrastructure-as-a-Service (IaaS)
2) Platform-as-a-Service (PaaS)
3) Software-as-a-Service (SaaS)

5. Mobile Cloud Computing

Mobile Cloud Computing refers to an infrastructure or an environment where both data process and data storage happen outside of the mobile device. Mobile Cloud Computing is the combination of mobile computing and cloud computing that includes hardware, software, and communication for performing different operations like accessing information, storing data, and running different applications on mobile devices [6]. The focus of Mobile Cloud Computing is to provide

accurate, real-time, and valuable information to the user or client. The motive of Mobile Cloud Computing is to modify the execution of mobile phone applications with a rich user experience and efficient results [7]. It also provides business opportunities to both cloud providers and network operators [4]. It is a kind of rich mobile cloud computing technology that unifies resources of cloud computing and different network technologies with functionality like mobility that are used to serve mobile devices from anywhere, anything with the use of Ethernet and internet with the heterogeneous environment and environment which have pay -as –you use principle in mobile cloud computing [8].

Fig. 5. Mobile cloud computing

A. Advantages

- Improving Reliability
- Extending Battery Lifetime
- Ease of Integration
- Scalability

B. Disadvantages

- Security and Privacy issues in Cloud Computing
- Low Bandwidth
- Dependency and Vendor Lock-In
- Limited Control and Flexibility

6. Fog Computing

Fog computing can be perceived both in large cloud systems and big data structures, referring to the growing difficulties in accessing information objectively [5]. This results in a lack of quality of the obtained content. The effects of fog computing on cloud computing and big data systems may vary. However, a common aspect is a limitation in accurate content distribution, an issue that has been tackled with the creation of metrics that attempt to improve accuracy [3].

Fog computing, also known as fog networking or fogging, is a decentralized computing infrastructure in which data, computing, storage, and applications are distributed in the most logical, efficient place between the data source and the cloud. Fog computing essentially extends cloud computing and services to the edge of the network, bringing the advantages and power of the cloud closer to where data is created and acted upon [4]. The goal of this is to bring basic analytic services to the network edge, improving performance by positioning computing resources closer to where they are needed, thereby reducing the distance that data needs to be transported on the network, and improving overall network efficiency and performance [7]. Fog computing can also be deployed for security reasons, as it can segment bandwidth traffic, and introduce additional firewalls to a network for higher security [6].

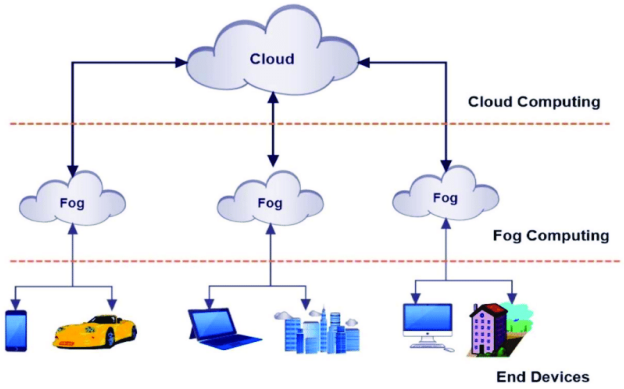

Fig. 6. Fog computing

A. Advantages

- Big data system
- It has the power of the cloud closer to where data is created and acted upon.

B. Disadvantages

- Fog computing must be improved performance
- Reducing the distance that data needs to be transported on the network

7. Edge Computing

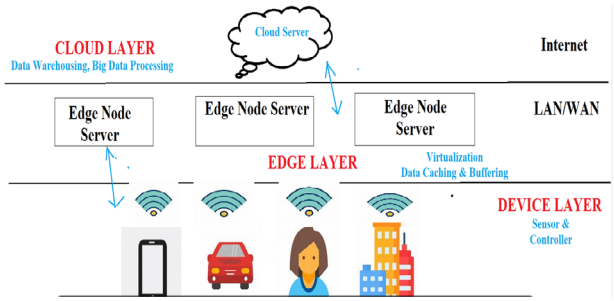

Fig. 7. Edge computing

Edge computing brings processing and storage systems as close as possible to the application, device, or component that generates and collects data. This helps reduce processing time by removing the need for transferring data to a centralized processing system and back to the endpoint. As a result, data is processed more effectively, and the requirements for internet bandwidth are less [2]. This keeps operating low cost and enables the use of applications in remote locations that have unreliable connectivity. Security is also maximized as the need for interaction with cloud platforms and networks is minimized. Examples of edge devices are remote control cars, sensors, laptops, and smartphones [7].

Edge computing is very helpful for environments that require real-time data processing and minimal latency. This includes applications such as autonomous vehicles, the Internet of Things (IoT), software as a service (SaaS), rich web content

Table 1
Comparison between different cluster and grid computing techniques

	Cluster Computing	**Grid Computing**
1	Homogeneous Network	Heterogeneous Network
2	Dedicated to a single task	Grid also does another task
3	Aggregation of resources	Segregation of resources
4	Computers are connected by high-speed LAN Bus	Computers are connected by low-speed Bus
5	Centralized network topology	De-Centralized network topology
6	Uses: Web Logic Applications, Server database	Uses: Predictive modeling, automation, simulation
7	Centralized resource management	Distributed resource management
8	Computers are located closely	Computers are in a large area
9	Cluster computing has no owner	Grid systems have an owner
10	Follow centralized architecture	Follow distributed architecture

Table 2
Comparison between cloud and utility computing techniques

	Cloud Computing	**Utility Computing**
1	Resource allocation is managed by the cloud provider	Resource allocation is managed by the user
2	Examples of cloud computing: IBM Cloud, GCP, AWS	Examples of utility computing: IBM Utility computing, Oracle utility computing
3	Provides on-demand scalability	It provides scalability, offers based on actual usage
4	High Reliability	Reliability depends upon infrastructure
5	Users pay for resources through subscription methods	It pays by following a consumptions-based pricing model

Table 3
Comparison between fog and edge computing techniques

	Fog Computing	**Edge Computing**
1	Fog computing reduces bandwidth requirements	Edge computing reduces latency
2	It connects IoT devices in real time	It provides strict data privacy and security
3	Fog computing is used in predictive maintenance applications like IoT Sensor, Healthcare applications, and Gaming	Edge computing is used in autonomous vehicles, cars, and drones.
4	It is a little bit expensive	It is cost-saving in nature
5	Fog computing closed to data resources	Edge computing combines edge and Cloud computing benefits
6	High Interoperability	Low Interoperability
7	Real-time decides to process	Decision-making in nature
8	Network closed to edge	Network at the edge
9	Scalable within network	Hard to scale
10	Medium latency	Low latency

delivery, voice assistants, predictive maintenance, and traffic management systems [3].

In the edge networks, cloud computing is dedicated to completing tasks that require more computing power, such as large-scale artificial intelligence (AI) and machine learning (ML) operations.

8. Mist Computing

Mist computing is all about putting computing power on the very edge of the network, on the actual sensors of the device [4]. This computing power usually comes in the form of microchips or microcontrollers embedded in the device. Mist computing is the extension and variation of Edge computing, enabling remote orchestration and smart management like smart cars controlling systems of Edge computing device functionality, including data acquisition, data processing, and control [4].

9. Conclusion

Cloud computing has become an important paradigm for delivering and managing various services over the Internet. Cloud computing provides more efficient, more flexible, and less expensive IT services to end users. The main consideration and target behind MCC (Mobile Cloud Computing) is to improve the functionality of mobile devices regardless of the resource limitations of mobile devices. In the future time mobile cloud computing represents the major and best model for mobile applications. Fog computing can also be deployed for security reasons, as it can segment bandwidth traffic, and introduce additional firewalls to a network for higher security. Utility computing is a kind of virtualization, which means the whole web storage space and computing power which it's available to users is much larger than the single time-sharing computer. Grid Computing sometimes referred to as "distributed" computing, is the combination of computer resources from more than one administrative domain to reach a common goal. A computer cluster helps to solve complex operations more efficiently with much faster processing speed, and better data integrity than a single computer and they are only used for mission-critical applications. In this paper, we will learn about edge and mist computing also which are also related to the cloud computing concepts.

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