

Fog Computing: Issues, Challenges and Future Directions

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ABSTRACT

In Cloud Computing, all the processing of the data collected by the node is done in the central server. This involves a lot of time as data has to be transferred from the node to central server before the processing of data can be done in the server. Also it is not practical to stream terabytes of data from the node to the cloud and back. To overcome these disadvantages, an extension of cloud computing, known as fog computing, is introduced. In this, the processing of data is done completely in the node if the data does not require higher computing power and is done partially if the data requires high computing power, after which the data is transferred to the central server for the remaining computations. This greatly reduces the time involved in the process and is more efficient as the central server is not overloaded. Fog is quite useful in geographically dispersed areas where connectivity can be irregular. The ideal use case requires intelligence near the edge where ultra-low latency is critical, and is promised by fog computing. The concepts of cloud computing and fog computing will be explored and their features will be contrasted to understand which is more efficient and better suited for real-time application.

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1. INTRODUCTION

Networking is shaped by two obvious trends - Cloud-based Internet and mobile computing. Cloud computing [1, 2] forms a basic need for all organizations that deal with large amount of data. Cloud forms to be very efficient in storing large amount of data and providing access to it from anywhere in the world. This could lead to unauthorized access to personal data or a firm's private data [3]. In relation to cloud-computing, bringing services to the edge of the network is fog computing. Fog computing deals with user behaviour profiling and decoy information technology to prevent unauthorized access. In Fog Computing, computing resources and application services are distributed in the most logical, efficient places, at any point along the continuum from the data source to the cloud. Fog computing is defined as "a scenario where a large number of heterogeneous wireless devices are connected together in a network, communicate and potentially cooperate among them and with the network to perform storage and processing tasks without the intrusion of third parties". Although this definition is debatable, this defines how fog computing differs from the related technologies.

Fog Computing avoids primarily to store data in large-scale data centers. Fog Computing offers a significant amount of measurement, control and configuration is performed at or near the end-user. Fog Computing supports emerging Internet of Everything (IoE) applications that demand real-time/predictable latency. Fog supports densely distributed data collection points, through devices called Fog nodes [4]. The major difference between cloud computing and Fog computing is on the support of location awareness. Fog Computing, composed of geo-distributed Fog servers, targets to deliver the localized and location based

services [5]. It is centralized or distributed in regional areas. Fog servers have localized data storage center that avoids delay in computing

2. OVERVIEW

Fog computing is defined as a distributed computing paradigm that fundamentally extends the services provided by the cloud to the edge of the network [6]. Cisco defines it as fog computing is considered as an extension of the cloud computing paradigm from the core of network to the edge of the network [7]. It facilitates the computation, storage and networking between the end devices and the traditional cloud servers. Instead of running application only in the cloud, fog computing involves the cloud as well as the edge devices between the end devices and cloud servers to run the application. Fog computing takes advantages of both edge and cloud computing while it benefits from edge devices' close proximity to the endpoints, it also leverages the on-demand scalability of cloud resources[8]. It basically reduces the load on the cloud server by efficiently using the resources available in the edge nodes to do partial computation and also it reduces the traffic to the cloud server by doing filtering operations in the nodes.

There are mainly two concepts which are usually confused with fog computing. These concepts are Mobile Edge Computing (MEC) and Mobile Cloud Computing (MCC). MCC basically suggests that both the data storage and data processing is done outside the mobile in a cloud. So it moves the data and computing power from the individual mobile to the cloud. MEC is similar to that of a Cloudlet. It can be seen as a cloud computing paradigm in a more concentrated. It is like a cloud server running on an edge of a mobile network [9]. Fog computing is a mixture of two of these concepts along with features of its own making it more reliable and useful.

3. ISSUES

Fog computing extends cloud computing and acts on Internet of Things. These devices, called the fog nodes can be deployed in any environment with a network connection. Fog computing has additional storage resources at the edges to process the requirements. Hence, the Fog server needs to adapt its services leading to management and maintenance cost. In addition, the operator needs to encounter the following issues:

3.1. Privacy

Fog computing being dominated by wireless primarily, there is a big concern for network privacy. Network operator generates configurations manually, fog nodes being deployed at the edge of Internet, massive maintenance cost is involved [10]. The leakage of private data is gaining attention while using networks. The end users are more accessible to the Fog nodes. Because of this, more sensitive information is collected by Fog nodes than remote cloud. Encryption methods like HAN (Home-Area Network) can be used to counter these issues.

3.2. Security

The main security issue is the authentication of the devices involved in fog computing at different gateways. Each appliance has its own IP address. A malicious user may use a fake IP address to access information stored on the particular fog node. To overcome this access control an intrusion detection system has to be applied at all layers of the platform [11].

3.3. Network Management

Being connected to heterogeneous devices, managing the fog nodes, the network, connection between each nodes will be burden unless SDN and NFV techniques are applied [12].

3.4. Placement of Fog Servers

Placing a group of fog servers in such a way that they deliver maximum service to the local requirements is an issue. Analyzing the work done in each node in the server before placing them reduces the maintenance cost [13].

3.5. Delay in Computing

Delays due to Data aggregation, Resource over-usage reduces the effectiveness of services provided by the fog servers, causing delay in computing data. Data Aggregation should take place before data processing, Resource-limited fog nodes should be designed scheduling by using priority and mobility model.

3.6. Energy Consumption

Since fog environments use large number of fog nodes, the computation is distributed and can be less energy-efficient. Hence, reduction of energy consumption in fog computing is essential [14].

4. APPLICATIONS

Fog computing have huge benefits in the real time applications. It is broadly used in IOT applications which involves real time data. It acts as an extended version of cloud computing. It is an intermediate between the cloud and end users (closer to end users).It can used in both the ways, that can be between machine and machine or between the human to machine.

4.1. Mobile Big Data Analytics

In IOT (Internet of things) data is collected in bulk and it can't be stored in cloud (Not efficient enough). In such situations it is beneficial to use fog computing instead of cloud computing as fog nodes are much closer to end systems.It also eliminates other problems such as delay, traffic, processing speed, delivery time, response time, storage data transportation and data processing. Fog computing could be the future of IOT applications.

4.2. Water Pressure at Dams

Sensors installed in dams send data to the cloud where the data is analyzed and officials are alerted in case of any discrepancies. The problem faced here is the delay of information which could be dangerous. To solve this, Fog is used, and since it is near the end systems it is easier to transmit data, analyze it and give instantaneous feedback.

4.3. Smart Utility Service

Here the main aim is to conserve time, money and energy. The analysis of data needs to run every minute to stay updated. This mostly involves the end users therefore cloud might not serve the purpose. These applications inform users everyday as to which appliances conserve more energy. IOT also creates a lot of traffic in the network where sending other data is difficult therefore fog is a good alternative.

4.4. Health Data

When data needs to be transferred from one hospital to another high security and data integrity is a must. This can be provided by using Fog since the data is transferred locally. These fog nodes can be used by the labs to update the patient's lab records which can be accessed by the nearby hospitals easily. Hardcopies of medical history and health issues of a patient need not be carried as these unified records can be accessed by any doctor.

5. ARCHITECTURE

One major problem faced with cloud computing is the bandwidth, especially on wireless networks. The problem only increases as the Internet of things continues to expand with a large number of physical objects connected wirelessly. Fog computing solves this problem by storing data in local computers and devices generally referred to as fog nodes. Any device with computing, storage and network connectivity can be utilized as a fog node e.g. hand-held devices, tablets, PC's, routers etc. These fog nodes are managed by Fog Data Service which serves various purposes like control and security of data, data reduction, data virtualization and edge analytics. Data could also be sent to the cloud for long term analytics.

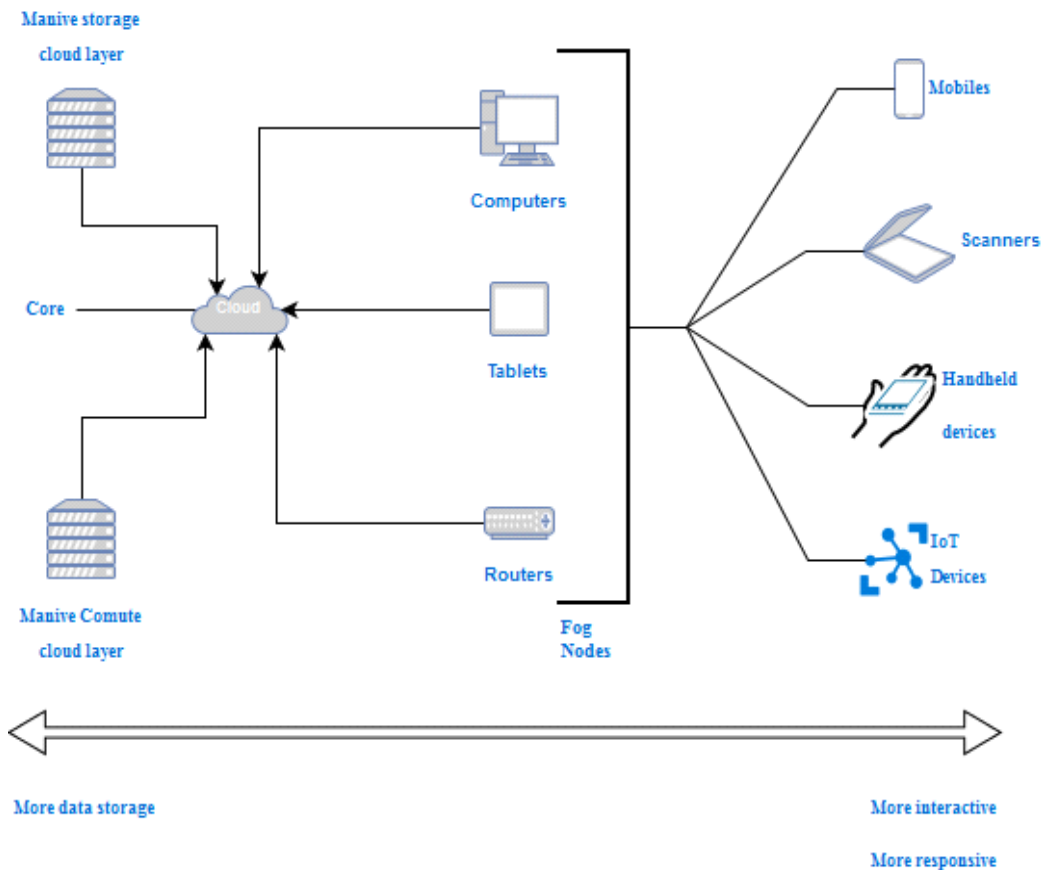


Figure 1. Fog computing architecture

6. COMPARISON BETWEEN CLOUD COMPUTING AND FOG COMPUTING

Cloud computing is a great solution when there is an uninterrupted access to a cloud server capable of processing and transmitting data quickly to the end device. Fog computing is mainly an architecture of heterogeneous devices in which certain applications and services are managed at the node by a smart device but the actual management is by the cloud. Fog computing primarily targets the mobile users while cloud targets the general internet users. The service type is localized in fog computing whereas in cloud, it's globalized. Though the storage is limited in fog computing compared to cloud computing, the distance between the users is very less that it can be communicated through wireless connections but in cloud computing, communication is through IP networks.

Comparing the parameters of fog and cloud computing, in fog computing, Mobility is supported whereas in cloud it's limited. The number of service nodes in fog is more than in the other. Real time interactions are supported in the former while it's not supported in the latter. Providing local security in cloud is tedious while it is possible in Fog computing.

Table 1. Comparisons of the Parameters of Cloud and Fog computing [15]

| Parameters | Cloud computing | Fog computing |
|--------------------------------|------------------------|-----------------------------|
| Server nodes Location | Within the Internet | At the edge of the network |
| Client and Server Distance | Multiple hops | Single/Multiple hops |
| Latency | High | Low |
| Delay Jitter | High | Very low |
| Security | Less secure, Undefined | More secure, can be defined |
| Awareness about Location | No | Yes |
| Vulnerability | High Probability | Very low probability |
| Geographical Distribution | Centralized | Dense and Distributed |
| Number of Server nodes | Few | Very Large |
| Real Time Interactions | Supported | Supported |
| Kind of last mile connectivity | Leased line | Wireless |
| Mobility | Limited support | Supported |

7. CONCLUSION

Fog Computing and its applications has been discussed .Fog computing has the ability to handle the flooding of data created by Internet of Things on the edge of the network. The characteristics of fog computing like mobility, proximity to end-users, low latency, location awareness, heterogeneity and due to its real-time applications fog computing platform is considered as the appropriate platform for Internet of Things. Fog computing is entering an exciting time, where it can positively affect operational costs. Fog computing resolves problems related to congestion, space and internet traffic. Fog computing also provides an intelligent platform to manage the distributed and real-time nature of emerging IoT infrastructures. Developing these services at the edge through fog computing will lead to new business models and opportunities for network operators.

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