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Abstract	There is a famous saying that goes “Necessity is the mother of invention”. In today’s globalized world people are getting stuck with many problems like data management, time management, and security and privacy concerns etc. There are traditional methods like cloud computing, cloudlet, and mobile management techniques to sort out the processing, storing, and executing of the data. But with the passage of time, the world is exploring new areas and these traditional methods are on the wane in terms of data handling. In this paper we discuss the technology that helps in data management, time management and security issues. We also addresses some real time scenarios.

Keywords (separated by '-')	Cloud computing - IoT - Fog computing - Edge computing

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Fog Computing: Overview, Architecture, Security Issues and Applications

Kishore Dasari and Mounika Rayaprolu

Abstract There is a famous saying that goes "Necessity is the mother of invention". In today's globalized world people are getting stuck with many problems like data management, time management, and security and privacy concerns etc. There are traditional methods like cloud computing, cloudlet, and mobile management techniques to sort out the processing, storing, and executing of the data. But with the passage of time, the world is exploring new areas and these traditional methods are on the wane in terms of data handling. In this paper we discuss the technology that helps in data management, time management and security issues. We also addresses some real time scenarios.

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1 Introduction

Computing is a term that can be defined as a unique process which utilizes computer technology for computing a particular task or goal. Cloud computing, social computing, grid computing, and parallel computing all come under the umbrella of computing. It is accurate to say that computing computes the data.

In the late 1990s when the internet was not widely used, technocrats used a technology called cloud computing to compute data. Cloud computing is a technology whereby remote servers are hosted on the internet to store, manage and process data.

In the early twentieth century the internet saw an immense growth and has totally changed the world. Internet use began to grow rapidly. With the huge usage of the internet, the concept of the "Internet of Things" (IoT) came into existence.

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The IoT is generating a huge amount of data and it is apt to say that a huge volume of varied high-velocity data is being generated by the IOT. So, analyzing and processing these three “v”s (volume, variety, and velocity) of data using cloud computing is creating latency. To minimize these drawbacks, technocrats have come forward with a technology called fog computing.

2 Overview of Fog Computing

In this digital and technological world, the birth of any technology happens by considering three “w”s (what, why, and when). In this section we focus on what fog computing is, why use fog computing, and when to consider using fog computing.

2.1 What Is Fog Computing?

Fog computing, also called edge computing, is an extension of cloud computing. Fog computing acts as a bridge between cloud computing and the IoT.

Fog computing is a term coined by Cisco that analyzes the IoT data at the network edge where it is generated [1]. A large amount of heterogeneous data is analyzed, stored and processed at the current position. Fog computing sends only the historical data to the cloud for storage and analysis rather than sending a stream of data.

2.2 Why Fog Computing?

Handling the high volume, variety and velocity of IoT data exposes a few cons. They can be:

Unreliable network: Sharing of devices is the main policy in cloud computing. In that process the network plays a key role. A network can be defined as a group of interconnecting devices. So in such scenarios ICT devices like laptops and mobiles are not connected to a specific device. Instead they are interconnected among each other which results in congestion, causing unreliability in the network.

Latency: To act on data in cloud computing, the data collected from devices is sent to the cloud server where the data is analyzed and processed, and is then sent back to the device. This creates a time delay.

Lack of mobility support: The main motto of the IoT is to interconnect all the devices through the internet and provide a platform for communication. However, cloud computing is not competent enough to support the dynamic processing of data. So it is clear that cloud computing is not suitable for mobile processing.

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Location awareness: Location awareness refers to a process of identifying the location using devices. As cloud computing is static, it does not support the collection of data from a diverse geographical range.

Security issues: Security is one of the major issues in today's world. There are many security parameters like authentication and encryption etc. In cloud computing, in order to process data it should be transferred from the devices to the cloud server. In this process the data may be lost in the middle or it may be stolen by unauthorized users.

So, to overcome all these drawbacks a novel model called fog computing came into being.

2.3 When to Consider Fog Computing?

When data has to be collected at the extreme edge: In the IoT, data is collected from end devices. Consider a scenario of a smart home. A smart home consists of sensors such as temperature, humidity, etc. When the number of members increases at home, the temperature sensor collects the data and makes changes accordingly.

Millions of heterogeneous data across large geographic area gets generated: Heterogeneous data can be also defined as distinct data.. As fog computing is associated with the IoT we get data from several different resources. For instance, consider a smart city. To perpetuate a smart city we need traffic management, weather forecasting, water management, electricity management, hospitality, transportation, food facility, health care, etc. Collecting and processing such diverse data in cloud computing decreases efficiency and increases latency.

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3 Characteristics of Fog Computing

The characteristics of fog computing are displayed below:

Low latency: Fog computing collects the data from the device and acts on the data where it is generated. This reduces the time gap.

Widespread geographical distribution: The fog nodes are capable of collecting data from a diverse geographical range.

Mobility: Fog computing furnishes the distributed infrastructure. With this, all the fog devices spread at the network edge. This creates mobility in data collecting and data processing.

Predominant role of wireless access: As fog computing is designed to act on IoT data, it is sufficient to say that the accessing of information happens through the internet thus supporting wireless access [2].

Strong presence of streaming and real time applications: Fog computing is now used widely in virtual and augmented reality, and artificial intelligence in order to handle the vast amount of data.

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Heterogeneity: Fog computing supports the IoT, so it communicates with different kinds of devices. It is not confined to homogeneous data as it doesn't stick to a single device.

4 Working of Fog Computing

Fog computing extends the cloud to be nearer to things that evolve and act on the IoT data with the help of a device called a fog node. Fog nodes can be industrial controllers, switches, routers, and embedded servers.

Developer's port IoT applications for fog nodes at the network edge ingest data from IoT devices. Then the fog IoT application directs heterogeneous data to the appropriate place for analysis.

This can be briefly explained as: The most time sensitive data is analyzed on the fog node nearer to whatever is producing the data. Data that can wait seconds or minutes for action is moved along to an aggregation node for analysis and action. Less time-sensitive data is sent to the cloud for historical and big data analytics.

Fog nodes:

Receives information from IoT devices using any protocol (wireless protocol or wired protocol) [3]

Runs IoT embedded applications for real time control and analysis with millisecond response time

Provide transient storage and send periodic data to the cloud.

Cloud platform:

Receives and interfaces data summaries from many fog nodes

Can send new applications to fog nodes.

5 Architecture of Fog Computing

The architecture of fog computing, which is also known as open fog architecture, is a three-layer architecture (Fig. 1). AQ3

The first layer comprises embedded sensors that act as fog nodes and collect the data from end devices.

The second layer possesses multiserver edge nodes and performs fog data services such as data reduction, control response, and data visualization.

The third layer is the core layer that sends historical data to the cloud.

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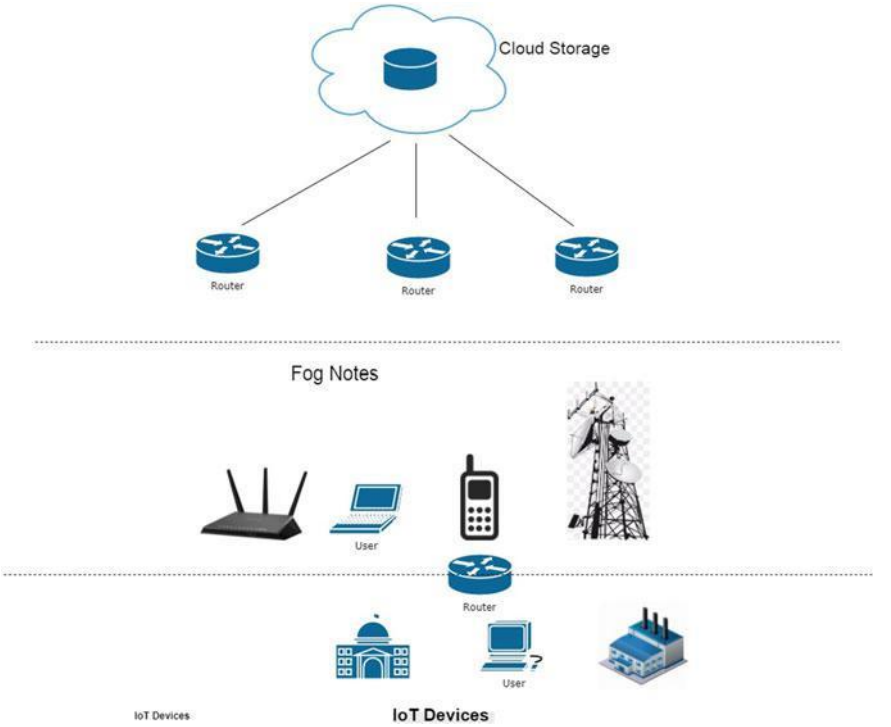

Fig. 1 Fog architecture

6 Security Issues and Mechanisms

In today's global world security is the major concern for any individual. In this section we discuss some of the security concerns, their case studies and mechanisms for respective issues in fog computing [4].

The major security issues can be divided into:

6.1 Data Issues

Data is a precious piece of fact. Data threats in the fog affect the data and cause insecurity for the information present in the server.

Data breach: A data breach is an issue where the confidential information of organization is appropriate unauthorized users. From statistics it has been shown that from 2005 to June 2015, the number of data threats was 6,284.

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Mechanism: In order to prevent this data breach in the fog layer we use a decoy technique. In this decoy technique we use decoy data, i.e. replicated data to confuse the attackers. This decoy technique is similar to a honeypot.

Data loss: Data loss occurs by data deletion, data corruption, or a fault in the data storage. Statistics have shown that in 2013, around 44% of data servers have been attacked by brute force method thus leading to data loss.

Mechanism: To avoid this problem we use a data recovery technique. In this we use a server called a data backup server. The original information is stored at a main server and from there streams of information are stored at a data backup server.

6.2 Network Issues

Network is the key factor in fog computing. Providing security to the network is the essential goal. Basic network issues can be:

Account hijacking: This is the process where the attacker tries to hack the account in order to steal the identity of the user.

Mechanism: A combination of decoy and data recovery techniques gives rise to the solution to account hijacking.

Denial of service (DOS): A DOS is a process in which the communication of Source and destination is prevented. A man in the middle attack(MITM) is an example of a DOS

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Mechanism: To prevent a MITM attack we use an encryption technique. In this we provide a strong encryption between the client and the server. In this, the server authenticates the client's request by processing a digital certificate and then a connection is established.

7 Applications

Web optimization: Researchers from Cisco are employing fog computing to enhance the performance of websites. Traditionally, for every HTTP request, the web page makes a round for content, style sheets, redirections, scripts, and images. Fog nodes can help in retrieving, integrating, and executing them simultaneously. This minimizes latency.

Smart meters: With the expansion of the smart grid, a vast amount of data is collected, processed, and transmitted from smart meters with the help of a Data Integration Unit. The data integration process takes long time because of the low bandwidth capacity of hardware. This can be prevented using fog computing. Initially, a fog-based router is attached with smart meters that assemble the data reading of all sub-meters with a predefined time. All values are then moved to a second fog platform for data reduction [5].

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Intelligent food traceability: Food is one of the basic needs for any living being. As a human it is our responsibility to preserve the quality of food. Fog computing uses a solution called food traceability management. The quality of a food item is predicted by a cyber physical stream (CPS) that makes decisions. This quality information is sent to the fog network, where the entire supply chain is traceable.

Smart agriculture: The IoT is strong enough to render information such as crop yields, rainfall, pest infestation, and soil using sensors. Fog computing collects this data from sensors using fog nodes and the data is analyzed periodically.

Augmented brain computer interaction: Communication is the main theme of the IoT. Fog computing is a technology that supports the IoT. So fog computing is creating a platform to communicate on. Considering this objective, fog computing has introduced a real time brain detection system using multi-tier fog architecture.

8 Future Work

Mobile phones have become an essential part of every human life. It is not an exaggeration to say human survival is almost not possible or is at least a bit tough without a mobile. And today's world is racing to introduce novel approaches in mobile communication. Currently, we are using the fourth generation of mobiles (4G). However, the intensive use of mobiles has bought a massive growth in the consumption of mobile data. This is paving way for the fifth generation of mobiles (5G). Fog computing is helping in delivering this 5G approach with better service quality.

9 Conclusions

Time and tide waits for no man. With the passing of time everything in the world changes. And this applies to the internet. A rapid growth in the internet has occurred and this has led to the Internet of Things. To manage this IoT a technology called fog computing has been developed.

In this paper we have gone through the evolution of the IoT, the drawbacks of cloud computing, an overview of fog computing, the architecture and working of fog computing, fog computing security issues and their mechanisms, and fog computing applications. By realizing the nature and functions the fog computing is the best technology to cope with the IoT data and to thus deliver a quality service to customers.

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