Fog Computing

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Abstract - *Fog Computing is a technology that extends cloud computing and services to the edge of the network. Cloud Computing is able to keep up with the current data processing and conventional demand but it is unclear whether it will keep up to the demand put forth by the Internet of Things. Fog Computing provides an architectural solution to address some of these problems. It provides data, computation, storage and application services to the users like cloud. Fog Computing enables a new breed of applications and services, and that there is a fruitful interplay between the Cloud and the Fog, particularly when it comes to data management and analytics. Security issues in this area are also described with the solutions. Fog Computing, thus makes itself an appropriate application for a number of IoT applications and services.*

Key Words**: Fog, cloud, fog nodes, IoT, smart grid, smart city, connected vehicle**

1. INTRODUCTION

Cloud Computing is an emerging technology that is revolutionizing IT infrastructures and flexibility. With cloud computing, users are able to remotely store their data in the cloud. It is an internet based model of computing where the shared information, software and resources are provided upon demand. This enables the users to access the cloud computing resources anytime from any suitable platform such as a cell phone, mobile computing platform, desktop and laptops. It is the means of delivering any and all technology – from computing power to computing infrastructure, services and applications to users as a service whenever and wherever they required it. Thus it can be defined as a group of computers and servers connected together over the Internet to form a network. Today, as many enterprises and large organizations are beginning to adopt the Internet of Things, the need for large amounts of data to be accessed more quickly, and locally, is ever-growing. This is where the concept of "Fog Computing" comes to play. The metaphor "fog" comes from meteorological term for a cloud closer to the ground. Indeed in computer sciences the term "fog" explains the extension of services provided by cloud to edge devices. In the perspective of Cisco, fog is an extension of cloud. In this paper we would explain in detail how fog computing is emerging as an extension to cloud. [1-3]

2. LIMITATIONS OF CLOUD COMPUTING

Cloud offers services like platforms, storage and other resources through the internet from a remote data centre. Benefits like saving cost on physical resources, efficiency, opportunities, innovations, flexibility are provided by it. Although, cloud has several advantages to both users and service providers, it has certain limitations too. Cloud computing frees the end user and the enterprises from the specification of many details. This bliss becomes a problem for latency-sensitive applications, which require nodes in the vicinity to meet their delay requirements. Thus increasing the round trip time. Also cloud has a requirement of high speed reliable Internet connectivity, has limited bandwidth, does not exercise any data protection mechanisms, platform dependent and has limited control as well as flexibility. The emerging trends in networking such as large distributed Internet connected sensor networks, Internet of Things (IoT), mobile data networks and also real time streaming applications have characteristics that cannot be satisfied by cloud computing. Thus fog computing is a collaboration of Internet of Things and cloud computing.[4][5]

3. WHAT IS FOG COMPUTING?

The fog extends the cloud to be closer to the devices that produce and act on IoT data. These devices can be situated anywhere with a network connection which can be factory, a power pole, alongside a railway track, in a vehicle, or on an oil rig. These are called as fog nodes. Any device with computing, storage, and network connectivity can be a fog node. Fog computing is a decentralized computing infrastructure in which computing resources and application services are distributed in a logical and efficient place at any point, along the path from the data source to the cloud. The most important goal of fog computing is to improve efficiency and reduce the amount of data that needs to be transported to the cloud for processing, analysis and storage. Although this is mostly done to get efficiency, it can also be done for security reasons.[6][7]

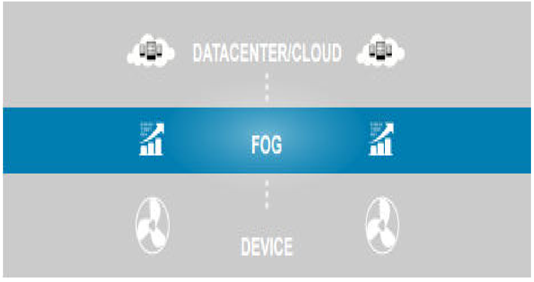

Figure 1: The fog extends the cloud closer to the devices producing data

4. HOW FOG COMPUTING WORKS?

The data is originally generated at the edge devices and sensors. Since these edge devices do not have the resources required for storage and computation to perform analytics and machine learning tasks so they send their data to the cloud wherein the cloud servers are located too far away to process and respond on timely basis. Sending all the raw data to the cloud through internet may bring up implications of security, privacy. Here is where fog comes into picture. Fog nodes perform functions like- to ingest data from IoT devices, analyzing collected data, store the data for 1-2 hours and send periodic reports to the cloud.

- Most time-sensitive data is analyzed on the fog node which is closest to the edge device.
- Data that can wait for seconds or minutes can be passed on to other aggregated nodes for analysis.
- Data which is least sensitive is sent to the cloud.

Thus the cloud would receive these reports from fog nodes, analyze the IoT data from different sources, and also send new application rules to respective fog nodes. Therefore, fogging allows for short-term analytics at the edge, and the cloud performs resource-intensive, longer-term analytics.[6][7]

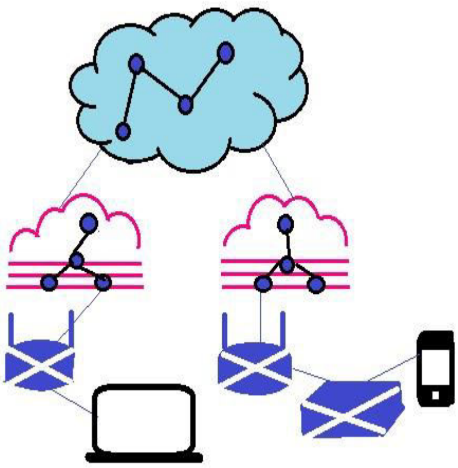

Figure 2: Fog architecture

5. ADVANTAGES OF FOG COMPUTING [4-7]

1) Conservation of bandwidth: Fog requires less bandwidth as only selective and appropriate data is sent out on the cloud for processing and thus it is cost effective.

2) Low latency: The data is analyzed where it is generated; hence the round trip time is less leading to low latency.

3) Real-time interactions: Important fog applications involve real-time interactions rather than batch processing.

4) Geo-distribution: In sharp contrast to the more centralized cloud, the services and applications targeted by the fog demand widely distributed deployments. The fog, for instance, will play an active role in delivering high quality streaming to moving vehicles, through proxies and access points positioned along highways and tracks.

5) Support for mobility: It is essential for many fog applications to communicate directly with mobile devices, and therefore support mobility techniques, such as the LISP protocol 1, that decouple host identity from location identity, and require a distributed directory system.

6) Greater business agility: Developers can quickly develop fog applications and deploy them where needed. Machine manufacturers can offer MaaS to their customers. Fog applications program the machine to operate in the way each customer needs.

7) Better security: Fog nodes can be protected using the controls, physical security, cyber security solutions we use to protect other parts of environment. Also as the data is kept close to the edge devices, in turn improves security.

8) Deeper insights, with privacy control: The data needs to be analyzed locally and therefore no need to send it to the cloud.

6. APPLICATIONS OF FOG COMPUTING

Data collected at extreme edges like vehicles, ships, factory floors, roadways, railways, etc generate data across huge geographical areas and so it becomes necessary to analyze and act on the data in less than a second.

1) Connected Vehicle: The Connected Vehicle deployment displays a rich scenario of connectivity and interactions: cars to cars, cars to access points

(Wi-Fi, 3G, LTE, roadside units [RSUs], smart traffic lights), and access points to access points.[5]

2) Smart traffic Lights: The smart traffic light node interacts locally with a number of sensors, which detect the presence of pedestrians and bikers, and measures the distance and speed of approaching vehicles. It also interacts with neighbouring lights to coordinate the green traffic wave. Based on this information the smart light sends warning signals to approaching vehicles, and even modifies its own cycle to prevent accidents.[5]

3) Smart Grid: Fog computing allow fast, machine to machine (M2M) handshakes and human to machine interactions (HMI) which would work in cooperation with the cloud. Energy load balancing applications may run on network edge devices, such as smart meters and micro-grids. Based on energy demand, availability and the lowest price, these devices automatically switch to alternative energies like solar and wind. Fog collectors at the edge process the data generated by grid sensors and devices, and issue control commands to the actuators. They also filter the data to be consumed locally, and send the rest to the higher tiers for visualization, real-time reports and transactional analytics. Fog supports temporary storage at the lowest tier to semi-permanent storage at the highest tier. Global coverage is provided by the Cloud with business intelligence analytics.[8]

Figure 3: Smart Grid

4) Smart City: Fog computing would be able to obtain sensor data on all levels of activities of cities and integrate all the mutually independent network entities within. The applications of this scenario are facilitated by wireless sensors deployed to measure temperature, humidity, or levels of various gases in the building atmosphere. In this case, information can be exchanged among all sensors in a floor, and their readings can be combined to form reliable measurements. Sensors will use distributed decision making and activation at Fog devices to react to data. The system components may then work together to lower the temperature inject fresh air or open windows. Air conditioners can remove moisture from the air or increase the humidity. Sensors can also trace and react to movements (e.g., by turning light on or off). Fog devices could be assigned at each floor and could collaborate on higher level of actuation. With Fog computing applied in this scenario, smart buildings can maintain their fabric, external and internal environments to conserve energy, water and other resources.[8]

5) Mobile Computing System: Fog computing organize highly virtualized computing and communication facilities for mobile users. Fog computing provides desirable localized services. With low-latency and short-distance local connections Fog computing can provide mobile users with the demanded services. This significantly improves the service quality provided to mobile users and, it save bandwidth cost and energy consumptions. Fog computing enable the linking of cloud based Internet and the mobile computing.

7. SECURITY ISSUES IN FOG COMPUTING [9]

Fog computing involves various providers like: the fog provider (entity which provides infrastructure to the users.), service provider (entity which uses the infrastructure to deliver applications/services to the end users) and consumers of the services provided. Each portion has its own security measures and their own requirements. This can lead to loss of control over data, especially the providers and consumers. As the providers are not aware of the contents and security requirements of their infrastructure and the consumers as they cannot control data of their own. The security of stored data is the main issue as data is stored on a third party; in turn the traditional security measure cannot be implemented directly. In this case, cryptographic methods can be used.

As data centres prove to be a major component in fog computing, data is managed between them in a cooperative manner. The distributed protocols ensure security. But when attacks happen neither the attacker nor the file attacked is identified.

Man-in -middle attack, a very traditional hostile attack has higher probability of taking place. The gateways in the fog area can be spoofed. It would be difficult for the fog nodes and Iot devices to communicate using encryption and decryption as it may utilize more battery of mobile devices. A solution to this could be using Intrusion Detection System.IDS can be used for analyzing and controlling access as well as they generate log files for detecting malicious behaviour. These systems can also detect Denial of Service attacks and port scanning.

8. CONCLUSION

Although cloud computing is still preferred when it comes to Iot applications, it is quickly becoming outdated. It would be very soon that fog computing takes over and cloud is pushed to the side lines. The way the Internet of things is growing, it needs a special infrastructure base that can handle all its requirements, and fog computing seems to be the most suitable option available. Fog computing accelerates awareness and response to events by eliminating a round trip to the cloud for analysis. It avoids the need for costly bandwidth additions by offloading gigabytes of network traffic from the core network. It also protects sensitive Iot data by analyzing it inside company walls. Ultimately, organizations that adopt fog computing gain deeper and faster insights, leading to increased business agility, higher service levels, and improved safety. Thus, Fog Computing will play an important role in Iot applications to provide a good user experience.

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