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Fog Computing: Characteristics and Challenges

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Abstract: *In cloud computing, the word cloud (also phrased as "the cloud") is used as a metaphor for "the Internet," so the phrase cloud computing means "a type of Internet-based computing". It can also be defined as a group of computers and servers connected together over the Internet to form a network. Though cloud computing offers several leverages, but it has some downside too, that during load balancing of data in cloud data centers the internet faces problems of network congestion, less bandwidth utilization, fault tolerance and security etc. This is where the concept of "Fog Computing" comes to play. It easily transfers sensitive data without delaying to distributed devices. Fog is similar to the cloud only difference lies in the fact that it is located more close to end users to process and give response to the client in less time.*

Fog Computing, also termed as "fogging", is a distributed infrastructure in which a smart device manages certain application processes or services at the border of the network, but others are still managed in the cloud. It is, essentially, a central layer between the cloud and the hardware to enable more efficient data processing, analysis and storage, which is achieved by reducing the amount of data which needs to be transported to the cloud.

Keywords: cloud computing, fogging, fog computing services, load balancing

1. INTRODUCTION

Cloud computing is achieving popularity and gaining attention in business organizations. It offers a variety of services to the users. It is a global, appropriate, on-demand network access to a shared pool of configurable computing resources [1]. Due this ease, software companies and other agencies are shifting more towards cloud computing environment. To achieve better operational efficiency in many organizations and small or medium agencies is using Cloud environment for maintaining their data. Cloud Computing is a combination of a number of computing strategies and concepts such as Service Oriented Architecture (SOA), virtualization and other which rely on the Internet. The term "Fog Computing" was introduced by the Cisco Systems as new model to ease wireless data transfer to distributed devices in the Internet of Things (IoT) network paradigm. [15]

Fig1 describes how fog is relates and where relies with clouds.

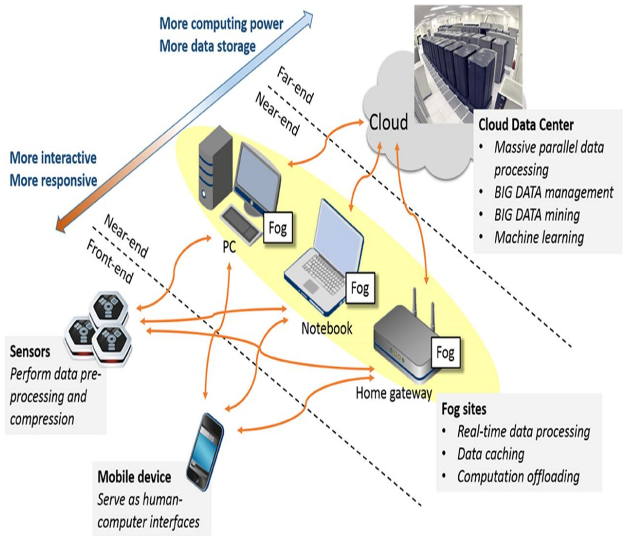

Figure 1: Fog Framework

It is considered as a delivery platform in which resources are provided as a service to the client through the Internet. Although, Cloud Computing provides an easy way for accessing, managing and computation of user data, but it also has some severe security risks. There are some traditional security mechanism such as identity, authorization and authentication, but now these are not sufficient [2]. Fog computing, also known as fog networking, is a decentralized computing infrastructure in which computing resources and application services are distributed in the most logical, efficient place at any point along the continuum from the data source to the cloud. A simple three level hierarchy is shown in figure2. In this framework, each smart things and interfaces is attached to one of Fog devices. Fog devices could be interconnected and each of them is linked to the Cloud.

The goal of fog computing is to improve efficiency and reduce the amount of data that needs to be transported to the cloud for data processing, analysis and storage. This is often done for efficiency reasons, but it may also be carried out for security and compliance reasons [3].

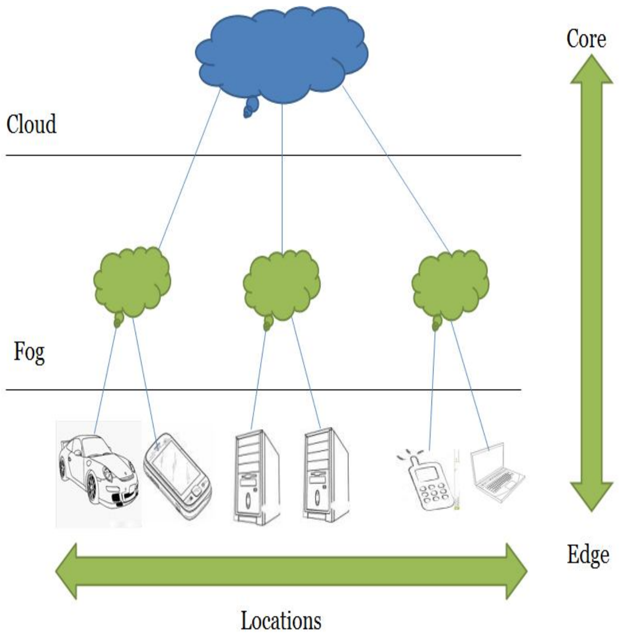

Figure 2.1: Fog Computing

Shifting from Cloud to Fog (fig 3.1) [16]: Fog computing improves the Quality of service and also reduces latency. Because of its wide geographical distribution the Fog computing is well suited for real time analytics and big data. While Fog nodes provide localization, therefore enabling low latency and context awareness, the Cloud provides global centralization [4] [17].

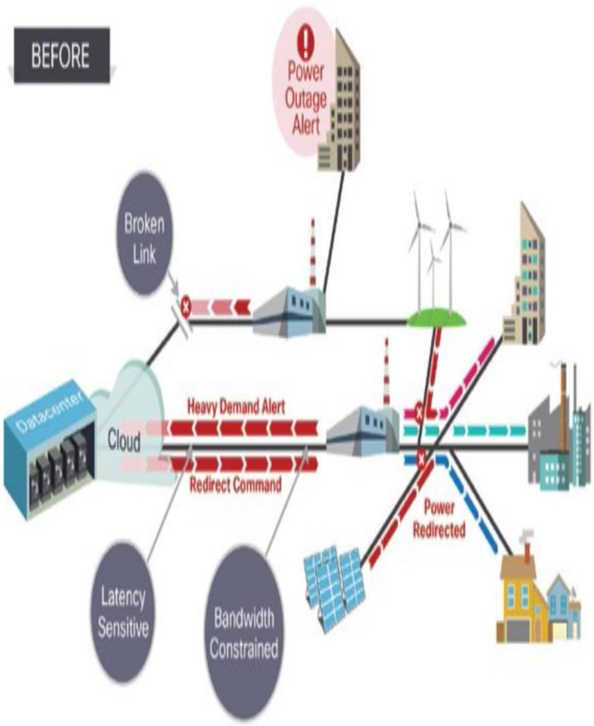

Figure 2.2: Cloud architecture before the advent of fog technology

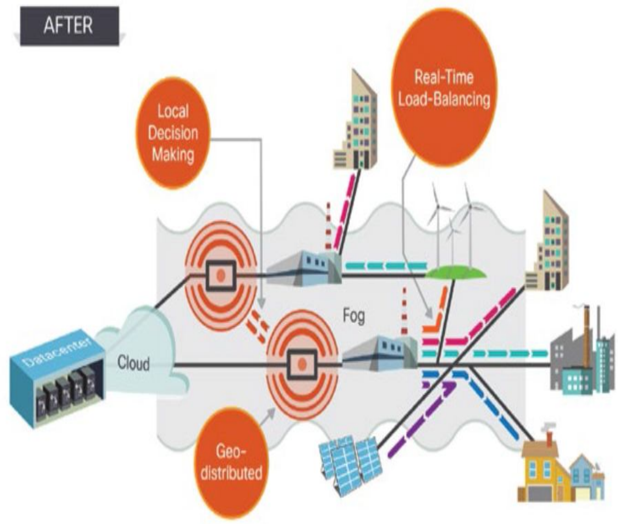

Figure 2.3: Cloud architecture with the advent of fog technology

Fog computing provides- Low latency and location awareness, it has Wide-spread geographical distribution, supports Mobility, is compromised due to the large number of nodes. The main task of fog is to deliver data and place it closer to the user who is positioned at a location which at the edge of the network. Here the term edge refers to different nodes to which the end user is connected and it is also called edge computing. If we look according to architecture fog is situated below the cloud at the ground level.

2. LITERATURE REVIEW

Why do we need Fog Computing? What can we do by using Fog Computing? These can be analyzed by reviewing some existing researchs. Nisha Peter et. al. [9] represented a Small computing works that locally processed and responses to the end users without the use of cloud. For the performance evaluation author had taken IOX platforms as a simulation tool. KC Gouda et. al.[5] presented an approach which needs to be evaluate in different cloud platform for finding the cost effectiveness by using the virtualization. Ivan Stojmenovic et. al. [6] investigated advantages of Fog computing services in several domains, such as Smart Grid, wireless sensor networks, Internet of Things (IoT) and software defined networks (SDNs). And examine the state- of-the-art and disclose some general issues in Fog computing including security, privacy, trust, and service migration among Fog devices and between Fog and Cloud. Swati Agarwal et. al. [7] proposed an efficient architecture and algorithm for resources provisioning in fog computing environment by using virtualization technique. After the simulation result author concluded that the proposed strategy can be allocated resources in optimized way and better than existing algorithms in terms of overall response time, data transfer cost and bandwidth utilization in fog computing environment. Clinton Dsouza et.al.[8] proposed a policy-based management of resources in fog computing, expanding the current fog computing platform to support secure collaboration and interoperability between different user-requested resources in fog computing by adopting eXtensible Access Control Markup Language (XACML).Pranati V. Patil et.al.[7] listed the advantages of Fog computing, and analyses its applications in a series of real scenarios and discuss the state-of-the-art of Fog computing and similar work under the same umbrella. Shanhe Yi et. al.[10]; In this paper author presents a survey on fog computing focusing on its concepts, applications and underlying issues one may encounter in designing and implementing fog computing system. In this paper author apply guest operating system in hypervisor and different issues as fog networking, quality of services, interfacing and programming models, computation offloading and accounting, billing and monitoring etc.

3. CHARACTERISTICS OF THE FOG COMPUTING

Fog computing possess various characteristics, some of them are listed below:

- ***Heterogeneity:*** Fog Computing is a highly virtualized platform that yields compute, storage, and networking services between end devices and traditional Cloud Computing Data Centers, typically, but not elite located at the edge of network. Compute, storage, and networking resources are the building blocks of both the Cloud and the Fog [11].
- ***Edge location:*** The origins of the Fog can be traced to early proposals to support endpoints with rich services at the edge of the network, including applications with low latency requirements (e.g. gaming, video streaming, augmented reality.
- ***Geographical distribution***: In sharp contrast to the *more centralized Cloud*, the services and applications targeted by the Fog demand widely distributed deployments. The Fog, will play an active role in delivering high quality streaming to moving vehicles, through proxies along highways and tracks [12].
- ***Large-scale sensor networks:*** To monitor the environment and the Smart Grid are other examples of inherently distributed systems, requiring distributed computing and storage resources.
- ***Very large number of nodes***, as a consequence of the wide geo-distribution, as evidenced in sensor networks in general and the Smart Grid in particular.
- **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, that decouple host identity from location identity, and require a distributed directory system.
- ***Real-time interactions***. Important Fog applications involve real-time interactions rather than batch processing.
- ***Interoperability and federation***. Seamless support of certain services (streaming is a good example) requires the cooperation of dierent providers. Hence, Fog components must be able to interoperate, and services must be federated across domains

4. CHALLENGES

There are many problems that will have to be addressed to make the fog a reality [11]. First we need to identify such problems so that researcher can concentrate on them. Some of open challenges for the fog can be listed as below:

1) **Discovery/Sync**: Applications running on devices may require either some agreed, centralized point (e.g. to establish an upstream backup if there are too few peers in our storage application;

2) **Compute/Storage limitation**: Current trends are improving this fact with smaller, more energy-efficient and more powerful devices (e.g. one of today‘s phones is more powerful than many high end desktops from 15 years ago). Still new improvements are granted for non-consumer devices;

3) **Management** : Having potentially billions of small devices to be configured, the fog will heavily rely on decentralized (scalable) management mechanisms that are yet to be tested at this unprecedented scale;

4) **Security**: The same security concerns that apply to current virtualized environments can be foreseen to affect fog devices hosting applications. The presence of secure sandboxes for the execution of droplet applications poses new interesting challenges: Trust and Privacy. The fog will allow applications to process user‘s data in third party‘s hardware/software. This of course introduces strong concerns about data privacy and its visibility to those third parties;

5) **Standardization**: Today no standardized mechanisms are available so each member of the network (terminal, edge point...) can announce its availability to host others software components, and for others to send it their software to be run;

6) **Programmability**: Controlling application lifecycle is already a challenge in cloud environments. The presence of small functional units (droplets) in more locations (devices) calls for the right abstractions to be in place, so that programmers do not need to deal with these difficult issues [12].

5. ARCHITECTURE OF FOG COMPUTING

The design of fog architecture or the key components of fog architecture are divided in to three layers: Heterogeneous Physical Resources, Fog Abstraction Layer and Fog Service Orchestration Layer

a. **Heterogeneous Physical Resources**: Heterogeneous in nature, ranging from high-speed links connecting enterprise data centers and the core to multiple wireless access technologies towards the edge. 3G/4G, LTE, Wi-Fi etc.

b. **Fog Abstraction Layer**: A uniform and programmable interface for seamless resource management and control. The layer provides generic APIs for monitoring, provisioning and controlling physical resources such as CPU, memory, network and energy.

c. **Fog Service Orchestration Layer**: Provides dynamic, policy-based life-cycle management of Fog services. Managing services on a large volume of Fog nodes with a wide range of capabilities is achieved with the following technology and components:

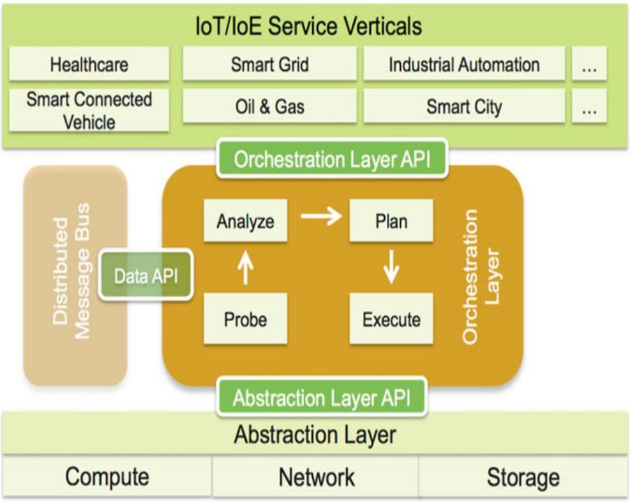

Figure 5.1 Architecture of Fog Computing

- Foglet Software Agent,
- Distributed Database, persistent storage to store policies and resource meta-data,
- Policy-Based Service Orchestration, provides policy-based service routing, i.e., routes an incoming service request to the appropriate service instance that confirms to the relevant business policies.

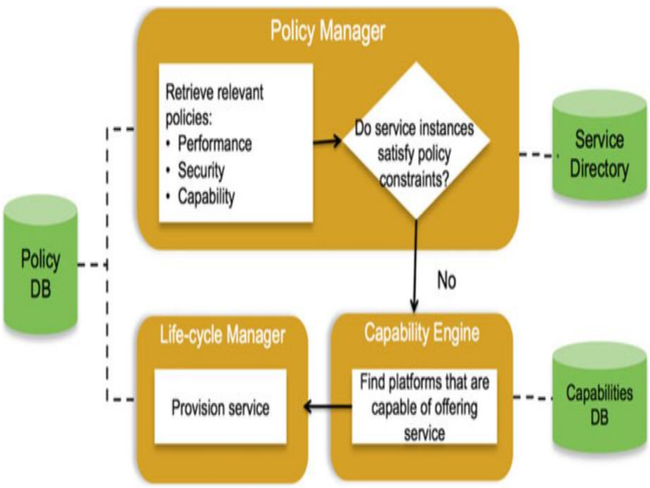

Figure 5.2: Policy based orchestration framework of Fog Computing

6. CONCLUSION

Fog Computing is not a replacement for Cloud Computing but may be a future of cloud computing.. Fog Computing is a big step to a distributed cloud – by controlling data in all node points, fog computing allows turning datacenter into a distributed cloud platform for users. Fog is an addition which develops the concept of cloud services. Fog computing is proposed to enable computing directly at the edge of the network, which can deliver new applications and services especially for the future of Internet. It extends the Cloud Computing paradigm to the edge of the network, thus enabling a new breed of applications and services. This survey discusses definitions of fog computing with similar concepts, gives characteristics which will clarify the application domain of fog computing, and mentions various aspects of challenges we may encounter when design and implement fog computing systems. Besides, issues related to QoS, interfacing, resource management, security and privacy are highlighted. Fog computing will evolve with the rapid development in underlying IoT, edge devices, radio access techniques, SDN, NFV, VM and Mobile cloud. We think fog computing is promising but currently need joint efforts from underlying techniques to converged at fog computing". By using the concepts of fog computing, if the same device can be used for these kind of processing, data generated can be put to immediate use and deliver a much better user experience.

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