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A Comparative Study Between Cloud Computing and Fog Computing

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Abstract

Today's world is facing the challenge of Covid19. During this pandemic, the researcher introduced several IoT devices to make life easier. IoT devices like liquid soap dispensers, Blood Oxygen Saturation (SpO2), monitor. This IoT device uses edge and fog computing. Fog computing is an extension of Cloud Computing. In this particular article, we make an extensive comparison among edge, fog, and cloud computing. Our article also demonstrates how technology moves towards edge computing from Cloud core systematically. We also discuss two simulation tools for cloud and fog computing each. Both of the tools provide real life environment for cloud and fog simulation. For simulation purpose, we use CloudSiM for Cloud and iFogSim for fog computing.

Keywords: Cloud computing, Fog computing, Edge computing, CloudSim, iFogSim. Simulator

1. Introduction

Nowadays cloud computing [1] is the last word for massive computation capabilities. The data center is the principal object of cloud computing. Cloud computing developed gradually after Cluster and Grid computing[2]. Whether we consider the cloud, grid, or fog computing each of these is a part of Distributed computing[3]. Virtualization[4] is the backbone of cloud computing. NIST[5] suggested four deployment models of cloud computing. These are discussed below.

a. Private cloud

b. Pubic cloud

c. Hybrid cloud

d. Community cloud

Private cloud models used by private users or companies are sometimes called internal or corporate clouds also. No other outside the organization can access this cloud service. The public cloud is available for the public. Anyone from the globe can access this cloud service. A hybrid cloud is the combination of these two. In the community cloud, the infrastructure is shared between two or more organizations.

In terms of service model [6], cloud computing is divided into three major parts

a. IaaS(Infrastructure as a service)

b. PaaS (platform as a service)

c. SaaS (Software as a service)

***Infrastructure-as-a-Service (IaaS*)** is the ability to process, store, network, and provide provisioning. Other fundamental computing resources: the user can deploy and run arbitrary applications;this may include software and operating systems.

Platform-as-a-Service (PaaS)offers the opportunity to execute consumer-created or purchased software using provider-supported programming languages and software. The end customer does not manage or control the resources of the underlying cloud, including the network, operating systems, servers, or storage.

Software-as-a-Service (SaaS) offers the opportunity to use cloud-computing services that are supplied by the cloud service provider. Via a thin-client GUI, such as a Web browser (e.g., web-based email), the applications are available from multiple client devices. The user does not monitor or control the underlying cloud infrastructure, including the network, operating systems, storage, servers, or even actual application functionality, with the potential exception of minimal user-specific application configuration settings.SaaS, PaaS and IaaSare illustrated by figure 1 below.

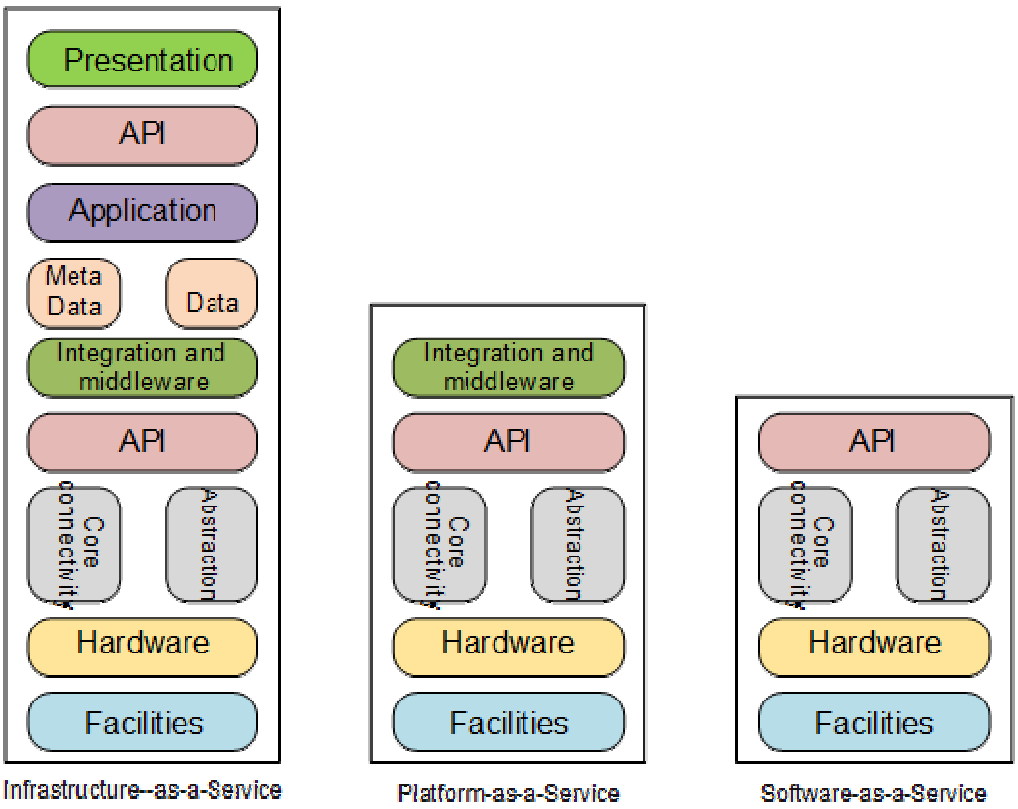

Figure 1: Cloud Service Model

2. Why fog computing?

Fog computing [7] is an extension of cloud computing. Three are several reasons behind the invention of fog computing. IoT devices generate time-sensitive data, which means we need faster results to be more precise, getting results within a few milliseconds. Another major drawback is that current cloud computing models are not deployed in such a manner that they can handle 3V (variety, velocity, volume) [8] of data generated by IoT devices. The IoT devices sensors continuously generate data based on certain

analyses the actuator in the IoT device takes the decision. Sometimes it is very necessary to take some action by actuation within a second in life and death situations. However, if we do cloud computing it will not fulfill the following aspect [8].

Latency: Minimization of latency is the major issue in cloud computing. Because in some emergency services a fraction of a second dose matters. Therefore, we can reduce the latency by processing those data near the edge devices.

Network Bandwidth: Transferring the huge amount of data generated by IoT devices to a Cloud datacenter requires huge bandwidth network connectivity. In the case of fog, these huge amounts of bandwidth costs can be reduced.

Data security: Data security [15] is one of the major issues in cloud computing. IoT requires haptic feedback; clouds generally use heavy encryption algorithms for ciphers. However, in the case of clouds, the data centers are geographically distributed over the globe. That means we need to take additional security measures on this.

Host selection: Sensor-generated data move to an appropriate host is another big challenge in cloud computing. In the case of fog, it transfers nearby distributed fog nodes for processing. The IoT device-generated data should process fast. Not all the data is time-sensitive, for this kind of data we need to move the data in the cloud.

3. Architecture

Cloud and Fog both the architecture are similar up to few percentages. The below figure 2, demonstrates a combined architecture between fog and cloud. As we discussed earlier, fog is an extension of the cloudcomputing .In that particular architecture at the bottom layer is called the edge layer. Here several edge device (IoT devices) is connected with nearest fog node for instant processing. The upper layer of that edge layer is the fog layer. Here a small data center provides thecloud like services to the below edge layer[8]. The fog layer acts as an aggregator also thousands of edge device can get services from this layer . When the task requested by users is too big or needs massive computation, then the fog layer act like an intermediator between cloud and users. The fog layer is also responsible for sending the result processed by the cloud to the users. The last layer or upper layer is Cloud. The data center is the backbone of the cloud. Inside data centers, there are several host or physical node, which is responsible to provide infrastructure for Virtual Machines (VMs). VMs are the logical machine, which creates to serve task request by users. Actually all the computation done in VMs at datacenter. Datacenter broker (DCB)[9] decides that a particular task is to be assigned in which VMs for processing.

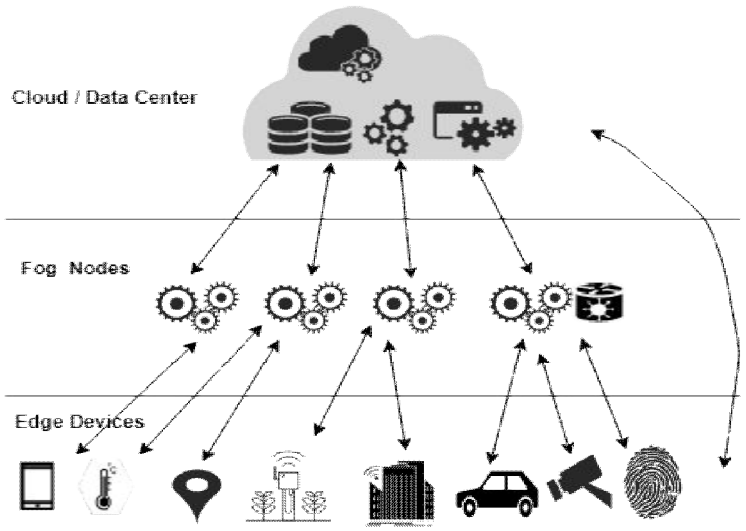

Figure 2: Combined Architecture (Cloud & Fog)

Edge Devices: These devices are in the bottom layer of fog computing architecture. Most of the IoT devices are time sensitive devices. While expecting the result within a few milliseconds edge devices process the data the processor embedded itself.

Fog Nodes: The upper layer of that architecture is fog layer [11]. Based on the time sensitivity, required computation and bandwidth dependency data sent to this fog layer. Sometimes fog layer is not sufficient for data analysis therefore; we need help from cloud layer also. Fog layer works as an intermediate layer between clouds and fog.

Cloud Core: Cloud Core consists of data centers. Data center is everything for cloud; it is used for computation,storage, infrastructure provider, platform provider, software provider. Cloud provides everything as pay as you go policy[12].

Researcher published a lot of article regarding the architecture of fog computing. There have some similarities and dis-similarities among those. In the below figure 3 illustrate the generic architecture of fog computing which is proposed by CloudsLab [13][14].

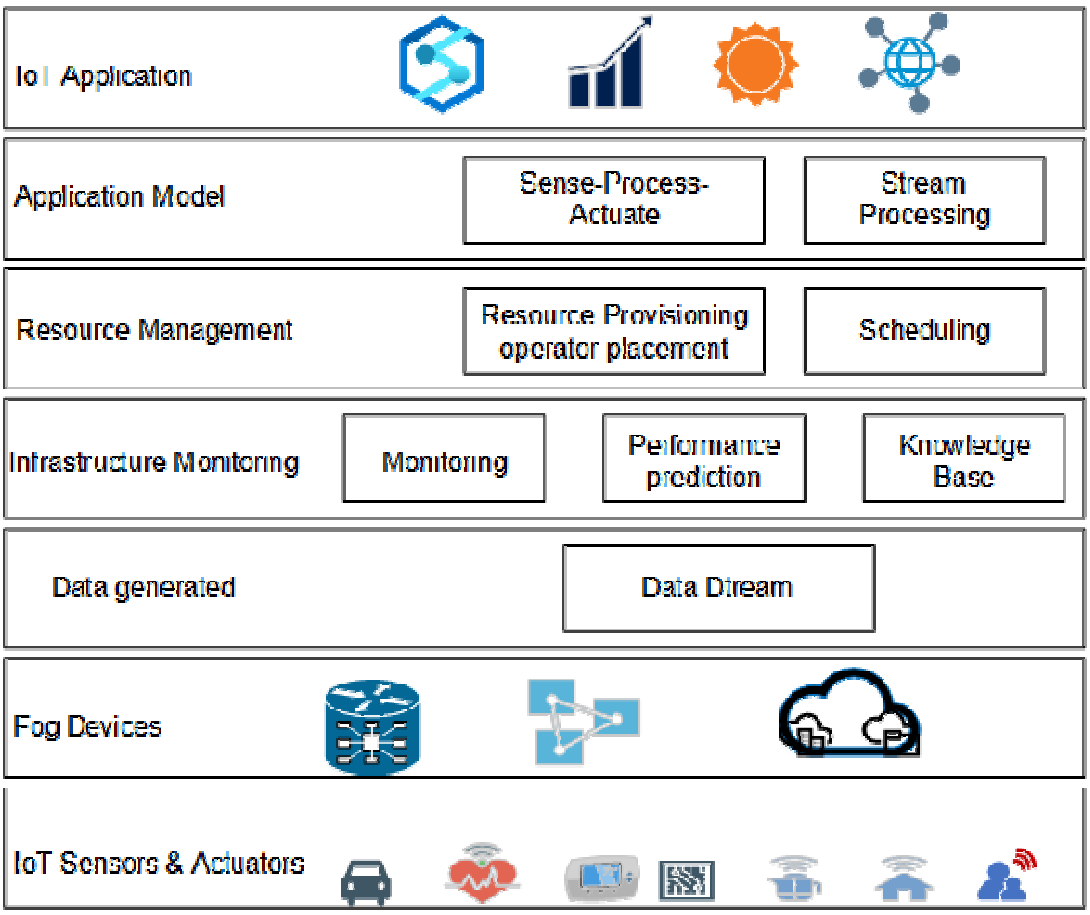

Figure 3: Fog Computing Architecture [14]

4. Comparison between Cloud and Fog Computing

As we know that the fog computing is an extension of cloud .Cisco introduce fog computing to solve some difficulties which are associated with cloud. Behind every fog there must have some cloud. Fog layer is mini version of cloud. In the bellow, table the actual deference's between fog and cloud are illustrated.

Table 1: Comparison between Cloud and Fog

Topic	Fog Node close to IoT devices	Fog Aggregation	Cloud
Response time	Millisecond	Few second s to minutes	Minutes, day ,weeks, month
Geographically	Very local area covered	Wider area covered	Global

Covered	example: beside railway track	Example: city	
Applications	Telemedicine, Traffic control	Simple analysis	Big data analytics
Processing capability	Lower among three	Medium	Highest
Data stored Time	Transient	Short duration: hours, days,or weeks	Month or years
Scalability	Less scalable	Medium	Highest
Security	Less Secure , light weight cryptography	Some level of security can be implemented	No time bound, can implement highest level of security.
Simulator (Research)	OPNET, OMNET++, SimuLTE, ns-3, INET framework, iFogSim[14]	CloudSim	CloudSim[13]. GreenCloud. iCanCloud. EMUSIM. GroudSim. DCSim

5. Simulation

Simulation is one of the major parts of applied research. In the cloud, it is not possible to deploy a real data center practice. It may need a few billion dollars to deploy a full-fledge datacenter. Therefore, the solution is simulators. There are a few simulators available for research purposes these are: CloudSim[13]. GreenCloud. iCanCloud. EMUSIM. GroudSim. DCSim (Data Centre Simulation), etc. Among those simulators, CloudSiM is one of the best simulators that provide a real-life environment. In fog and edge computing, some options are also available these are: OPNET, OMNET++, SimuLTE, ns-3, INET framework, iFogSim[14], Veins, SUMO, etc. In fog simulator iFogsim is one of the best the extend from CloudSim project and both are completely written in JAVA. Sample data generated by various IoT devices also available inside these simulators. Both the simulator works on almost all platform. To make the relief scenario the researcher has to define a class and formulae the problem as required. Thousands of researchers recommended these two similar for Cloud and fog-related research work.

6. Conclusion

In that particular paper, we discussed how fog computing is introduced, working principles, and the differences with the most popular cloud computing. We also find the drawbacks of cloud and fog. Currently, IoT with Fog computing is one of the hot topics in the research field. Fog computing is in the infant stage until today. May researchers working on this, but their lot of work can be done especially on

Load balancing, energy efficiency, and security issues, etc. Now a day everybody is talking about sustainable development. Among 20 sustainable development, energy consumption and carbon footprint are major issues. Energy consumes by fog devices in the fog aggregation layer also increases carbon emission. Using some VM selection and placement algorithms, we can fully utilize the resource and reduce energy consumption.

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