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A review of fog computing and its simulators

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Abstract

Fog computing is defined as the distribution of computing resources between the data devices and the cloud or any other data centre in a distributed computing infrastructure or process. This paper briefly reviews the various definitions, applications, architecture and fog simulators proposed by researchers over the years. In this paper, a comparison table is presented which highlights the key features of simulators available like FogtorchII, iFogSim, Fogbus, MyiFogSim etc.

Subject Classification: *68 Computer Science, 68T09 Computational aspects of data analysis and big data, 97P80 Artificial intelligence*

Keywords: *Fog, Cloud computing, Privacy, Fog Simulator.*

1. Introduction

The Internet of Things (IoT) idea promises to connect "things" to the Internet, such as material things with sensors and/or tags, mobile components like cellphones and vehicles, consumer electrical devices and household appliances like freezers, televisions, and medical devices. Sensor data from these objects is retrieved, gathered, and interpreted at public/private clouds in cloud-centric IoT applications, resulting in considerable

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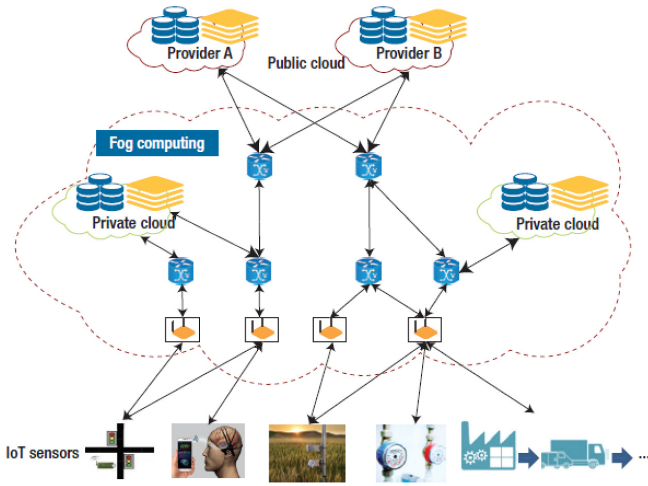

Fig. 1

Distributed data processing in the environment of fog-computing [10]

latencies. Fog computing addresses this issue in the development of real-time IoT applications by utilising proximity-based processing resources across IoT levels such as gateways, cloudlets, and network switches or routers. Fog computing is a model to support the cloud to decentralize the distribution of data centre computing resources (e.g., servers, storage, software and services) to users to boost user experience in data centres, service efficiency and their experience [3,9]. Fog is yet another dimension of a decentralized communication network and is closely related to IoT and cloud computing. Cloud vendors of public infrastructure as a service (IaaS) can be considered as a high-level, global data endpoint; the edge of the network is the place where IoT application data is generated [19, 25].

Data needs to be analyzed as rapidly as feasible for certain applications. Fog computing can generate low-latency network connections between devices and endpoints for analytics. This design, in effect, limits the amount of accessible bandwidth when compared to sending data to a data center or cloud for processing all the way to the back [32, 58, 59].

The bottom layer contains the end devices, such as sensors and devices, as well as software that optimises their performance. These components communicate with edge devices, such as gateways, and subsequently with cloud services via the very next layer, the network. Infrastructure flows throughout the resource management layer, allowing for quality-of-service compliance. Finally, frameworks make use of fog

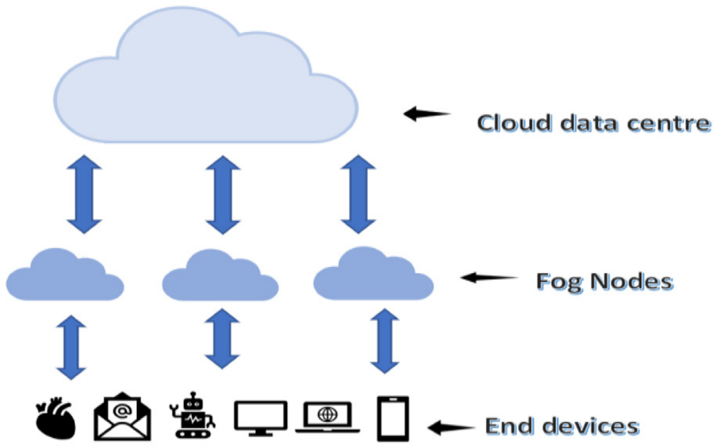

Fig. 2

Fog Computing architecture

computing programming approaches to provide users with intelligent services [10,24,56].

Fog computing has variety of applications, which are shown below in figure 3:

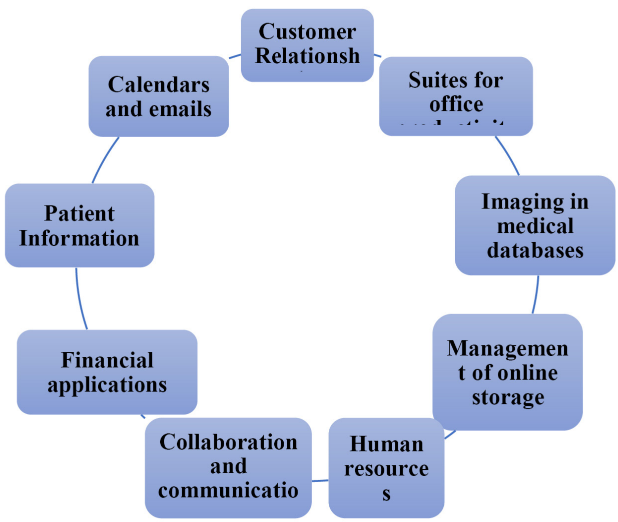

Fig. 3

Applications of Fog Computing

2. Related Study

This section covers in brief the related study covered by many researchers related to Fog Computing. They have discussed the various frameworks created using the implementation and capabilities of fog. Authors compared the various simulator tools like FogNetSim++, iFogSim, FogTorchII, EdgeCloudSim, IOTSim, EmuFog, Fogbed. They concluded that many, though still a limited number, of the current simulators put greater focus on fog computing. They have significant scalable and mobility support issues. Although all of the current simulators use DES as their fundamental technology, three of them are constrained by their dependency on CloudSim, particularly in terms of scalability. As a result, there is a pressing demand for simulation software that includes more coverage of fog and edge computing features. To explore the key components of Fog computing, Moysiadis, V et al. [17] in their study discussed the presentation of representative simulators and software. Computing, in the sense of the Fog Computing framework, describes many elements of challenges that we can encounter when designing and implementing sociable Iot solutions in accordance with the implementations of large-scale IoT networks. The justification for this is seen in the argument over data storage, which considers the importance of system capacity in present Fog Computing systems. M. Ficco et al. [13] proposed a semi research method in which a component of the testing situation is modeled while the experimental edge and fog nodes are executed in the real world. The use of a pseudo-dynamic simulator is one of the best ways to help main competitors in the field of edge-fog systems deal with the new challenges posed by Iot applications. In addition to this, Coutinho, A. et al. [38] introduced Fogbed, an integration framework and set of tools for fast fog component development and testing in virtualized environments. Fogbed allows the installation of fog nodes as software containers under various network configurations, using a desktop approach. Its architecture follows the low-cost specifications, versatile configuration, and compliance with other technical systems in the real world. The proposed solution enables for the evaluation of fog elements with third-party applications via standard interfaces, excluding recent methods. Fogbed utilizes datasets to model the collection of data on virtual IoT gateways gathered from each machine and sensor. Research work of some authors discussed proposing and presenting the result sets of various frameworks and algorithms built based on cloud and fog computing.

3. Fog Computing Simulators

In this section, we are comparing the various simulators used along with fog computing. We will be focusing on the factors like availability, performance, implementation. Based on the studies presented by various authors such as FogTorchII [50] which is developed in Java. It is an extension to FogTorch. According to the researchers, FogTorch allows you to assign many QoS profiles to each communication channel based on a probability distribution. FogTorch is used by a vast number of people. It runs multiple times, each time inputting a different Fog infrastructure and selecting a QoS profile for each communication link. In another research work done by Gupta, H et al. [51], the authors proposed a simulator called iFogsim.

Table 1

Comparison of Simulators

Simulator/ Tool	Whether Open Source?	Infrastructure	Key features	Limitations/ Future scope
FogTorchII [8,50]	Yes	Fog computing model based	facilitate the deployment of multi-component IoT apps to Fog infrastructure with QoS in mind to estimate monthly expenses. Latency, as well as download and upload bandwidths, are all considered QoS criteria.	Limited bandwidth, warranty, Liability
iFogSim [51]	Yes	Similar to fog computing, fog devices, network communication links	Offers for the investigation and comparison of resource management options based on QoS characteristics such as latency under different	Scalability and mobility

Contd...

			workloads. (tuple size and transmit rate). iFogSim can handle large-scale simulations in the context of the IoT.	
MyiFogSim [53]	Yes	Addon to iFogSim	support policies for virtual machine migration for mobile users	Configuration of network
FogBus [54]	Yes	PHP, Java, Fog Nodes	FogBus uses Blockchain, authentication, and encryption to secure critical data operations. It's also simple to set up, scalable, and energy and cost-effective.	Limited communication network
FogWorkflowSim [55]	Yes	Fog Nodes, Cloud	Fog workflow simulation and performance evaluation using an automated simulation toolkit	Mobility of end devices, task scheduling of tasks with different priorities.

Fog computing is defined as an architecture with capabilities similar to cloud computing but located near the network's edge, according to the fog computing definitions. Because it implies a hierarchical fog device design, it does not support hardware communication. Authors Forti, S et al. [52] discussed about another popular tool for fog computing simulation i.e., FogDirector which is a tool whose working principle can be defined by depending on a RESTful API, It's possible to utilise it to manage the entire lifecycle of IoT applications across Fog systems. Authors further used this tool and proposed a prototype simulation environment, FogDirSim, compliant with the FogDirector API, by depending on a RESTful API, it may be used to manage the complete life-cycle of IoT applications across Fog infrastructures. FogDirSim, a prototype simulation environment that uses a RESTful API to handle the whole life-cycle of IoT applications over Fog networks. FogDirSim lets you compare various application management techniques using a range of stated performance parameters (such as uptime, energy consumption, resource utilisation, and alert kind), as well as stochastic workload variations and underlying infrastructure failures. FogWorkflowSim's core functionality is the simulation of a complex Fog Computing environment and processing system. Instead of starting from scratch, FogWorkflowSim inherits the functions of iFogSim and WorkflowSim [56]. WorkflowSim was designed to aid researchers in evaluating their workflow optimization approaches with greater precision and assistance than currently available solutions.

4. Conclusion

Depending on the application, a fog computing framework may have a range of components and services. Computing portals that receive data from the data source, as well as various collection terminals such as routers and switches that connect assets inside a network, are examples. In this paper, we critically reviewed the various fog simulators proposed by researchers over the years like iFogSim, FogWorkflowSim, MyiFogSim, FogBus. In our review, we also compared these simulators on the basis of infrastructure and availability and limitations. The comparison proposed in the paper can be useful for upcoming research work in the area of cloud computing, IOT and fog computing.

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