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# Fog Computing Architecture, Applications and Security Issues

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## ABSTRACT

Fog computing spreads the cloud administrations and services to the edge of the system, and brings processing, communications and reserving, and storage capacity closer to edge gadgets and end-clients and, in the process, aims at enhancing versatility, low latency, transfer speed and safety and protection. This article takes an extensive and wide-ranging view of fog computing, covering several aspects. At the outset is the many-layered structural design of fog computing and its attributes. After that, chief advances like communication and inter-exchange, computing, etc. are delineated, while showing how these backup and facilitate the installations and various applications. Following that, it is shown that how, despite fog computing being a feature-rich platform, it is dogged by its susceptibility to several security, privacy, and safety concerns, which stem from the nature of its widely distributed and open architecture. Finally, some suggestions are advanced to address some of the safety challenges discussed so as to propel the further growth of fog computing.

## KEYWORDS

5G, Cloud Computing, Edge Computing, Fog Computing, Internet of Things, Security and Privacy, Software Defined Networking, Vehicular Ad-hoc Networks (VANET)

## 1. INTRODUCTION

The internet has revolutionized the computers, communication and communication technology like nothing has ever before. The internet's invention is one of mankind's most cherished accomplishments. Yet, the seepage of its use and adaptation of technology is changing its terrain rapidly. The specter of new technologies coming together and linking with each other faster has created new paradigms like Cyber-Physical System (CPS) and the Internet of Things (IoT). What is unimaginable is the wireless connection of devices to our physical bodies, to each other and absolutely everything around us at any time (Atzori, Iera, & Morabito, 2010; Ning et al. 2016). Thus, IoT implies an expansion of Internet through which physical objects are connected virtually, with the ability to provide smart services to its users.

Naturally, this interaction between devices is slated to create gargantuan amounts and diversities of information and data. It is interesting to consider some figures. Cisco predicts that by 2020 some 50 billion devices will be connected to the Internet, and the data and information generated by devices, people, things, appliances etc. will amount to 500 zettabytes. And by 2019, out of this, 45 percent

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of data generated by IoT will be interpreted, processed, analysed and saved at the network's edge (Evans, 2011; Cisco global cloud index: Forecast and methodology, 2016).

Along with the mushrooming of data, the pace of data creation is fast increasing, too. For instance, findings related to healthcare services show that 30 million users create about 25,000 tuples data per second (Cortes, Bonnaire, Marin, & Sens, 2015) with respect to healthcare-linked IoT communication. This means the data storage and processing mechanisms that we have in place at present are unable to keep up with what is expected (He et al., 2017). And traditional computing versions, like distributed computing etc. are failing to handle this deluge.

But the advent of cloud computing has emphatically altered the scenario of information technology. By getting rid of such factors like proportional expenses, scalability, getting rid of upfront IT investment etc., it has brought in substantial advantages for IT users (Ghahramani, Zhou, & Hon, 2017; Xia, Zhou, Luo, & Zhu, 2015; Yuan et al., 2017; Zhang & Zhou, 2018; Zheng et al., 2017).

Thus, owing to its potent computational power and capacity to store (Aembrust et al., 2010; Fernando, Loke, & Rahayu, 2013), cloud computing emerged as an effective method for data processing. At the same time, though, there are some inherent issues with cloud computing. For one, cloud computing is a consolidated, centralized computing representation that performs computations in the cloud. This means that all the data, information, requests and what have you have to be dispatched to the cloud. And while the pace of processing of data has increased swiftly, the bandwidth of network has not kept equal pace.

So, for massive amounts of data, bandwidth of network is turning out to be a hindrance in cloud computing. And this is causing long latency, the duration of time it takes for data to go from point to another. And the issue is compounded when increasing number of devices are linked to Internet because applications that are sensitive to latency begin to face grave problems of long delays. For instance, systems in some IoT applications, such as emergency response (Qiu, Qiao, & Wu, 2017), smart healthcare (Cao, Chen, Hou, & Brown, 2015; Stantchev et al., 2015), traffic light system in smart transportation, smart grids (Qiu et al., 2017) and other latency-sensitive applications (Arkian, Diyanat, & Pourkhalili, 2017) may perforce need an extremely short response time and support of mobility. In short, it was found that these challenges stemming from the unprecedented growth of IoT, with respect to latency, bandwidth of network, mobility support, dependability, location awareness, security etc., could not be effectively tackled by the model of cloud computing.

And thus, emerged a new paradigm named Fog computing, to surmount the issues listed above (Luo & Pan, 2017; Luan, Gao, Li, & Sun, 2015). Fog computing, it is established, effortlessly facilitates working between center of cloud and devices that are at the network edge, and thus morphs as a better solution to tackle the problems presented by cloud computing. In (Bonomi, 2011) describe Fog computing "as a geographically distributed, highly virtualized architecture where diverse multifarious devices at the brink of network are universally linked in conjunction to offer communication, flexible computation and storage facilities" (Yi, Hao, Qin, & Li, 2015).

It is worth noting that both cloud and fog computations deliver to end users application services, computation, storage and data (Ivan, & Sheng, 2014). But certain telling features distinguish fog from cloud. Fog is a platform that locally processes huge amounts of data, enables installation of software on diverse hardware (Khan, Parkinson, & Qin, 2017), has dense geographical distribution, offers support for mobility (Bonomi, Milito, Zhu, & Addepalli, 2012) and is decentralized and close to end users.

A case in point displaying and proving the aspect of latency is a system of traffic lights. In a system of traffic lights not based on Fog, between the cloud server and monitoring probes there might be 3 to 4 jumps or hops. This makes it difficult to make actual-time decisions and the problem of network latency pops up. If the system is Fog-based, however, monitoring probe serves like a sensor and the traffic lights as actuator. The Fog node can transmit a normal condensed video which can exist in the cloud for some duration. The Fog can take an instantaneous decision to turn green the related traffic lights when it records headlights of an ambulance flashing, to enable the health-care

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