Chapter 47
From Cloud Computing to Fog Computing:
Platforms for the Internet of Things (IoT)

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ABSTRACT

This article describes how in recent years, Cloud Computing has emerged as a fundamental computing paradigm that has significantly changed the approach of enterprises as well as end users towards implementation of Internet technology. The key characteristics such as on-demand resource provision, scalability, rapid elasticity, higher flexibility, and significant cost savings have influenced enterprises of all sizes in the wide and successful adoption of Cloud Computing. Despite numerous advantages, Cloud Computing has its fair share of downsides as well. One of those major concerns is latency issues which has relevance to the Internet of Things (IoT). A new computing paradigm has been proposed by Cisco in early 2014 and termed 'Fog Computing'. Fog Computing otherwise known as Edge Computing is the integration of Cloud Computing and IoT. Being located in close proximity to the IoT devices, the Fog assists with latency requirements of IoT related applications. It also meets the data processing needs of IoT devices which are resource constrained by bringing computation, communication, control and storage closer to the end users. Clouds continue to offer support for data analytics. One can think of the IoT-Fog-Cloud as being part of a continuum. This article surveys the current literature on Fog Computing and provides a discussion on the background, details and architecture of Fog Computing, as well as the application areas of Fog Computing. The article concludes with some recommendations in the areas of future research.

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1. INTRODUCTION

Cloud Computing is now established as transformative computing paradigm. It is gaining momentum primarily for providing on-demand scalable resources at low costs with minimal effort involved. Organizations are choosing the cloud over traditional computing; deploying their enterprise applications to reap the benefits of superior performance, increased scalability, elasticity, high flexibility and cost savings. There are three service models provided on the cloud: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS). In IaaS the consumer is provided with the capability of provisioning storage, processing and networks and run arbitrary services. In this model, the consumer does not control the cloud infrastructure, storage and processing (Ahuja, 2015). In PaaS the consumer is provided with the capability of deploying applications on the cloud using the provider's tools and, libraries and languages. Here the provider controls the infrastructure and the consumer only has access to deploy applications and change configuration settings related to deployment (Ahuja, 2015). In SaaS the consumer is provided with the capability of using provider's applications that are running on the cloud. In this case, the applications are either accessible from a web interface or a program interface. The provider controls the cloud infrastructure also (Ahuja, 2015). However, not all the applications hosted on the cloud would be benefitted and generate some business value. There are certain applications that are transaction-intensive and demand low latency over the network. It is very challenging and impractical to host and run these types of applications on the cloud.

Moreover, rapid development of technologies and exponential growth of Internet of Things can contribute to the data traffic. Internet of Things (Janssen, n.d.) ecosystem includes any 'thing' or device that can be connected to internet, identified uniquely (IP address) and allowed to communicate with other devices over a network. It is expected that Internet of Things would reach 50 billion by year 2020 (Valerio, 2014). This will inevitably result in the generation of enormous amount of data, which needs to be stored, processed and accessed. Every bit of data needs to be transmitted to and from the cloud for data analysis, which requires great deal of bandwidth, money, as well as time. The centralized data center notion of Cloud Computing is not the right choice to push terabytes of data generated, to the cloud every day. There is a need for holistic approach or model that can effectively distribute large volumes of data and place it closer to the source.

To address the latency and security issues and to support growing IOT, Cisco has proposed a new computing paradigm and coined the term 'Fog Computing' which describes bringing the cloud closer to the ground (CISCO, n.d.a). Fog Computing enables nearby routers to handle data operations and reduce latency thereby enabling IoT by proper distribution of IoT workloads (Kleyman, 2013). The data, processing, and applications are placed at the edge of the network, as close as possible to the users, instead of managing entirely in the cloud. Fog model contributes to the applications that require low latency, geographically distributed applications, location awareness and fast mobility applications.

This paper focuses on the Fog Computing model and its applicability to IoT. It provides a detailed survey of the state-of-the-art in Fog Computing as existing in current literature. Discussion on how the Fog Computing model serves as an enabler for IoT and overcomes some of the limitations of Cloud Computing is provided. The interplay of IoT-Fog-Cloud is also described, including the architecture of the Fog Computing model. Application areas of Fog Computing are also provided. Research opportunities in Fog Computing are highlighted.

The remainder of this paper is organized as follows. Next section presents the related work in Fog Computing. Section 3 discusses the Fog Computing and its advantages in detail. Architecture of Fog

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