Chapter 2
Dynamic Fog Computing:
Practical Processing at Mobile Edge Devices

Sander Soo
University of Tartu, Estonia

Chii Chang
University of Tartu, Estonia

Seng W. Loke
Deakin University, Australia

Satish Narayana Srirama
University of Tartu, Estonia

ABSTRACT

The emerging Internet of Things (IoT) systems enhance various mobile ubiquitous applications such as augmented reality, environmental analytics, etc. However, the common cloud-centric IoT systems face limitations on the agility needed for real-time applications. This motivates the Fog computing architecture, where IoT systems distribute their processes to the computational resources at the edge networks near data sources and end-users. Although fog computing is a promising solution, it also raises a challenge in mobility support for mobile ubiquitous applications. Lack of proper mobility support will increase the latency due to various factors such as package drop, re-assigning tasks to fog servers, etc. To address the challenge, this chapter proposes a dynamic and proactive fog computing approach, which improves the task distribution process in fog-assisted mobile ubiquitous applications and optimizes the task allocation based on runtime context information. The authors have implemented and validated a proof-of-concept prototype and the chapter discusses the findings.

DOI: 10.4018/978-1-5225-5693-0.ch002

INTRODUCTION

The information systems designed for integrating the Internet of Things (IoT) (Gubbi et al., 2013) are usually applying the global centralized model, in which the IoT devices rely on distant management systems. Such a model is considered to be a drawback in terms of agility (Bonomi et al., 2012). In many real-time ubiquitous applications such as augmented reality, environmental analytics, ambient assisted living, etc., mobile device users require rapid responses. However, the latency caused by the distant centralized model is too high, even though the mobile Internet speed has improved significantly during the last few years. To address this problem, Fog Computing (Fog) (Bonomi et al., 2012) introduces data pre-processing with the computers in the vicinity of the data sources and end-user applications located in the edge network of IoT systems.

In general, Fog computing resources, which are known as Fog nodes, are mediating devices that connect the edge network with the Internet. Some typical examples are industrial integrated routers (e.g., Cisco 829 Industrial Integrated Services Routers), home hubs or set-top boxes that are employed as wireless Internet access points together with embedded virtualization technologies (e.g., Virtual Machines) or containerization technologies (e.g., Docker containers (https://www.docker.com)), which allow clients to deploy software onto them. Compared to the traditional distant Cloud computing model, which requires sending all the data to the Distant Data Center (DDC) for the processing, Fog can provide much better agility.

Although Fog-driven IoT system provides explicit enhancement in performance, it also faces numerous challenges in terms of connectivity (Zhang et al., 2015), discoverability (Troung-Huu et al., 2014), efficient deployment (Ravi & Peddoju, 2014; Guo et al., 2016; Ceselli et al., 2017; Lin & Shen, 2017) and so on. While many of the previous works focused on Fog deployment for specific use cases, this chapter aims to address the mobility issue raised in the case of integrating Fog with ubiquitous mobile applications.

Imagine a mobile ubiquitous care application that needs to provide real-time environmental information to its user by continuously collecting and processing data derived from the surrounding environment while its user is moving in outdoor areas. For improving the efficiency, the mobile device (i.e. delegator) is distributing its computational tasks to vicinal Fog servers (i.e. workers). However, the delegator may need to repeatedly resend the tasks to different Fog nodes, due to the dynamic nature of the mobile environment, where the limited wireless signal coverage of the Fog nodes could cause failure in delivering results.

Consequently, it raises a question:

How can the system avoid the situation that requires the delegator to re-send tasks to the other workers due to the failed process result delivery?

In order to address the question, this chapter proposes a proactive task distribution framework for mobile Fog environments. The proposed framework consists of two core schemes:

- Proactive task distribution, which is an extension of the Work Stealing scheme (Loke et al., 2015) that provides the mechanism to hasten the speed of task distribution.
- Context-aware Work Stealing, which provides an optimal decision-making mechanism that helps workers (Fog nodes) to decide how they should participate in the distributed processes.