The Emergence of Edge-centric Distributed IoT Analytics Platforms

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Abstract

Traditionally, analytical processing for IoT systems is performed, managed, and controlled in the cloud. The IoT devices are primarily tasked with the role of data collection and delivery to the cloud platform for further data filtration and event detection. This approach works fine provided provisioning of hypothetically unbounded computational, networking (*i.e.* persistent Internet connection) and storage infrastructures for IoT systems is always available. However, this is not viable practically due to many reasons including: 1) continuous transfer of data between device and cloud increases bandwidth utilization for device-cloud communication, and 2) increased financial burden on end-users for cloud resource and service utilization. Given the new breed of IoT devices have significant onboard processing capabilities such as the ones offered by mobile smart phones that are located at the edge of the IoT platform, this chapter presents the discussion on an edge-centric IoT platform and proposes a multi-tier architecture to perform distributed data analytics. In addition, three major contributions that enable edge-centric distributed IoT analytics systems are presented in this chapter.

1. Introduction

The phenomenal growth in IoT devices and systems has opened many new research avenues [1]. This massive growth is leading towards gigantic data production and requires sophisticated systems to perform analytical operation and uncover useful insights from underlying data [2, 3]. The topological settings of existing systems are based on three levels namely, IoT devices, edge servers, and cloud data centers (see Figure 1) [4]. At the first level, the IoT devices perform data collection operations by monitoring its surroundings using onboard sensors. In addition, the devices perform data filtration and actuation operations to respond in the external environments. At the second level, the nearby edge servers collect data streams from connected IoT devices and perform local data processing to transfer reduced data streams in cloud environments. At the third level, the cloud data centers provide unbounded cloud resources for IoT devices and cloud-based IoT applications. The IoT applications spans over all three levels but the control of application execution always remain at cloud level [4]. This approach increases the dependency over Internet connections and enforces the devices to transfer data streams to cloud data centers prior to any analytic operations.

A device-centric distributed analytic system is presented in this chapter. The cloud-first approach increases the data communication cost and network data movement in cloud data centers [5, 6]. There exists many application areas where local analytics in IoT devices are beneficial and given priority over global analytics in cloud data centers. The device-centric IoT systems have multiple benefits [7]. The IoT devices perform local analytics which reduce dependency over edge servers and cloud data centers. Also, the device-specific analytic operations are performed with minimum latency as compared to cloud-based data analytics.

Moreover, the integration of local knowledge patterns to form the global patterns requires less cloud resources as compared to processing raw data streams in cloud environments [8, 9].

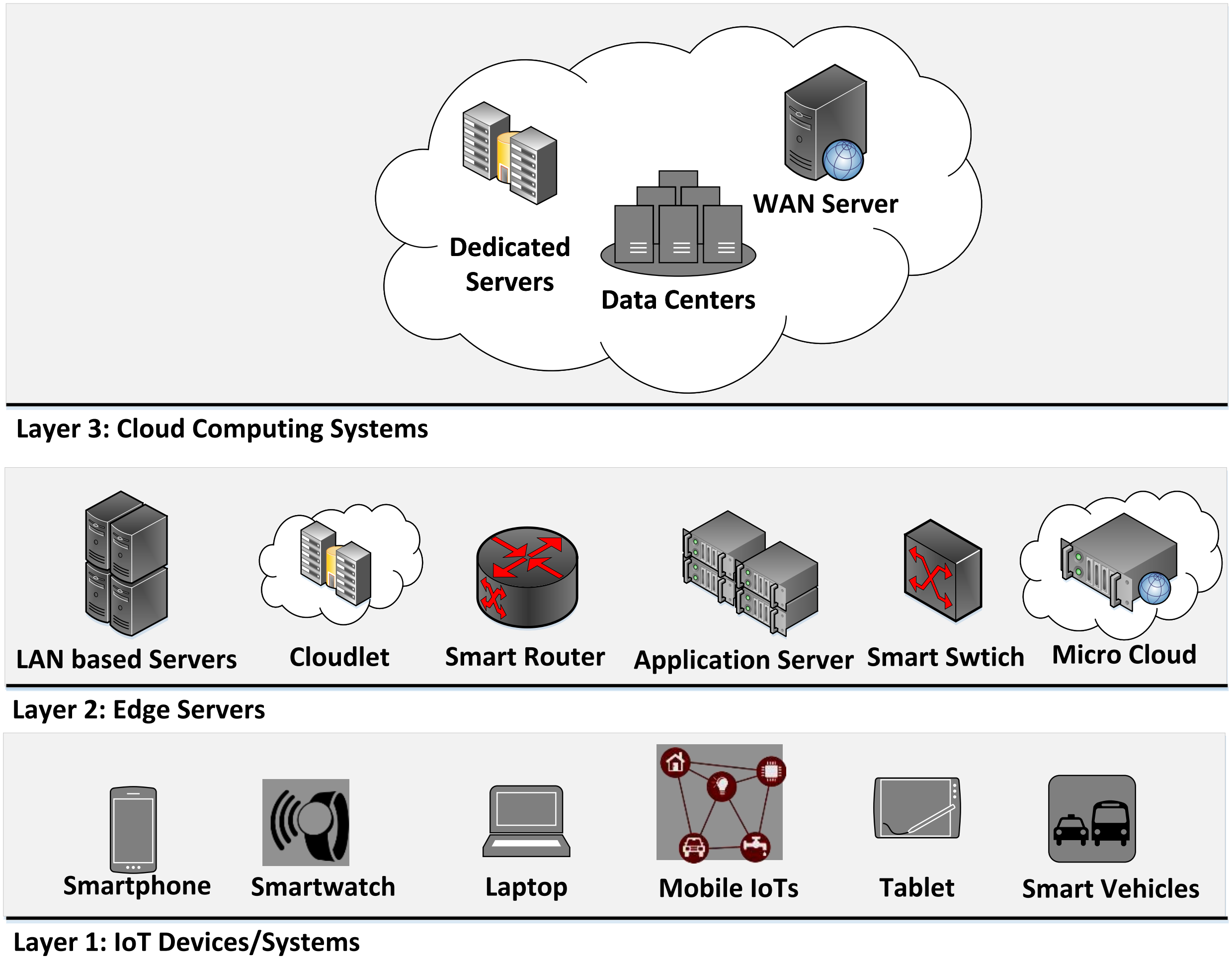

Figure 1. Topological setting of IoT systems.

Before moving further, first let us have a look at the operational view of IoT systems (see Figure 2). The IoT systems work at four levels [10, 11], namely, (i) physical, (ii) communication, (iii) middleware, and (iv) application. The physical layer is based on three level topological setting of IoT devices, edge servers, and cloud data centers. A large plethora of devices and systems are involved at this stage in order to provide sensing, processing, and storage resources for IoT applications. The communication layer enables multiple communication interfaces and protocols for device-to-device and device-to-cloud communication. These communication interfaces include Wi-Fi, Zigbee, Z-wave, 6LowPAN, Cellular, NFC, LoRaWAN, and Ethernet, to name a few. The middleware layer enables the sensing, data transfer, data management, data storage, and data processing operations and use device management, privacy, and security policies to perform end-to-end system management. Finally, the application layer provides the functionality to deploy different kinds of IoT and big data applications at both IoT device end and at the cloud data centers.

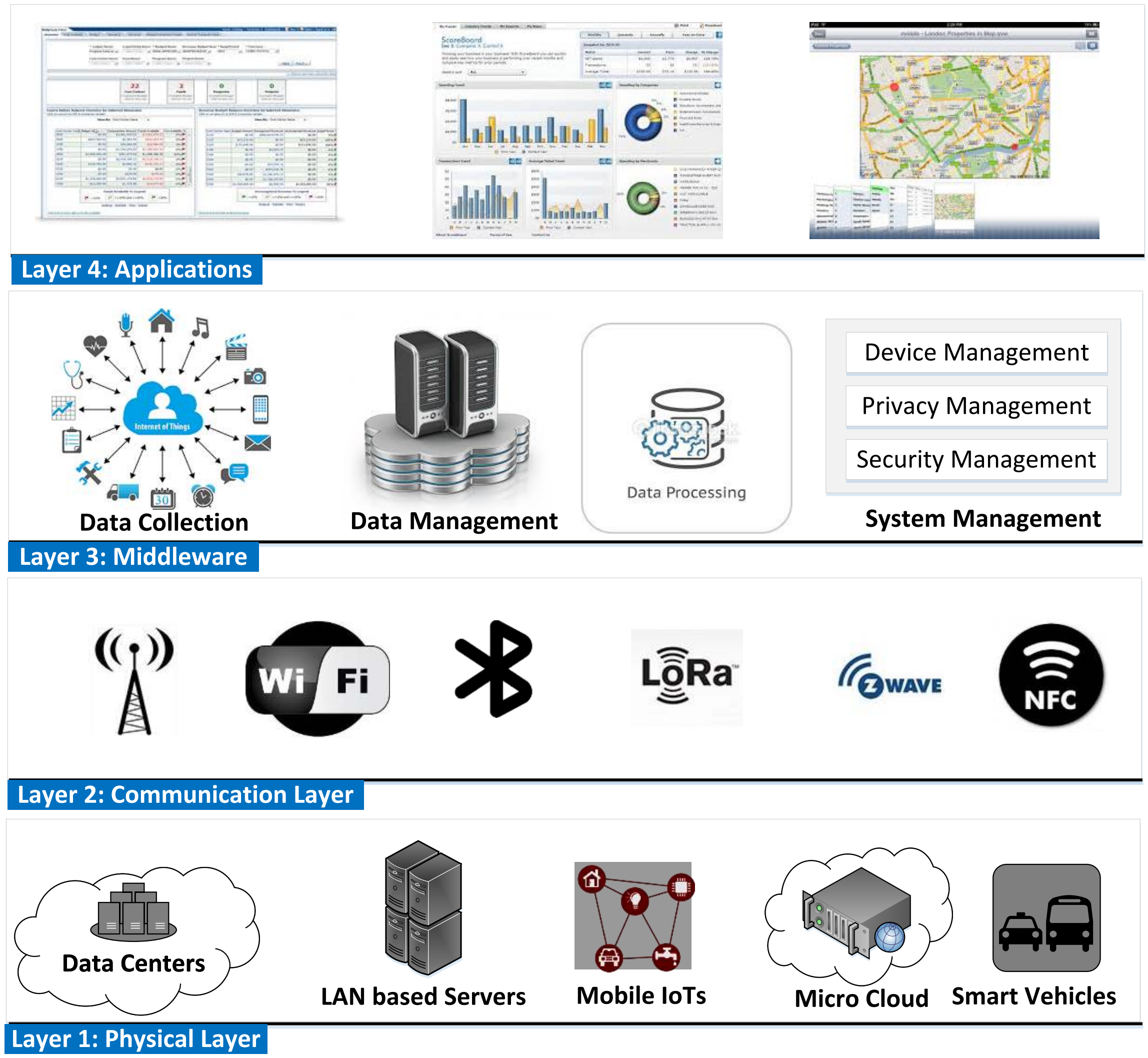

Figure 2. Operational view of IoT system.

This chapter is aimed to present device-centric distributed IoT analytic system and highlights three major contributions namely, MOSDEN [12], CARDAP [13], and UniMiner [7, 14]. The rest of the chapter is organized as follows. Section 2 defines the role of analytics in IoT systems and discusses variants of analytics methods and cloud based analytics systems for IoTs. Section 3 presents device-centric mobile and immobile IoT systems. Section 4 presents the speculated multi-tier architecture for device-centric distributed analytic systems. Section 5 presents the overview of MOSDEN, CARDAP, and UniMiner. Finally, Section 6 concludes the chapter.