Chapter 33
Internet of Things Service Provisioning Platform for Cross-Application Cooperation

Shuai Zhao
Beijing University of Posts and Telecommunications, China

Shou-lu Hou
Beijing University of Posts and Telecommunications, China

Bo Cheng
Beijing University of Posts and Telecommunications, China

Yang Zhang
Beijing University of Posts and Telecommunications, China

Le Yu
China Mobile Communications Corporation, China

Jun-liang Chen
Beijing University of Posts and Telecommunications, China

ABSTRACT

With the development of Internet of Things (IoT), large-scale of resources and applications atop them emerge. However, most of existing efforts are "silo" solutions, there is a tight-coupling between the device and the application. The paradigm for IoT and its corresponding infrastructure are required to move away from isolated solutions towards cooperative models. Recent works have focused on applying Service Oriented Architecture (SOA) to IoT service provisioning. Other than the traditional services of cyberspace which are oriented to a two-tuple problem domain, IoT services are faced with a three-tuple problem domain of user requirement, cyberspace and physical space. One challenge of existing works is lacking of efficient mechanism to on-demand provisioning the sensing information in a loosely-coupled, decentralized way and then dynamically coordinate the relevant services to rapidly respond to changes in the physical world. Another challenge is how to systematically and effectively access (plug) the heterogeneous devices without intrusive changing. This paper proposes a service provisioning platform which enables to access heterogeneous devices and expose device capabilities as light-weighted service, and presents an event-based message interaction mode to facilitate the asynchronous, on-demand sharing of sensing information in distributed, loosely-coupled IoT environment. It provides the basic infrastructure for IoT application pattern: inner-domain high-degree autonomy and inter-domain dynamic coordination. The practicability of platform is validated by experimental evaluations and a District Heating Control and Information System (DHCIS).

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INTRODUCTION

The Internet of Things (IoT) is a concept in which the virtual world of information technology integrates seamlessly with the real world (Uckelmann, Harrison, & Michahelles, 2011). With the development of IoT, large-scale of resources (sensors, actuators, RFID, etc.) and applications on top of them emerge. The reasonable application pattern of IoT is inner-domain high-degree autonomy and inter-domain dynamic coordination. However, most of the existing efforts are still "silo" solutions, in which the devices and the applications are tight-coupling (Zorzi, Gluhak, Lange, & Bassi, 2010). This tight-coupling application paradigm cannot support applications to share and reuse resources, and interact with each other. Moreover, in vertical "silo" solutions, the application developer has to bridge this gap between the upper application and the underlying technical details "manually" and has to be an expert in both worlds (Bimschas et al., 2011). However, the upper application developers are interested in real-world entities (things, places, and people) and their high-level states rather than devices and underlying technical details (Pfisterer et al., 2011). Consequently, the paradigms for IoT and their corresponding infrastructures are required to open up or break the current application silos and move away from isolated stand-alone solutions towards more cooperative models (Guinard, Trifa, Karnouskos, Spiess, & Savio, 2010). Recent works have focused on applying Service Oriented Architecture (SOA) to IoT service provisioning (Guinard et al., 2010; Motwani, Motwani, Harris, & Dascalu, 2010; Teixeira, Hachem, Issarny, & Georgantas, 2011; Wu Yuexin, 2012), that is, real-world devices which are directly related to the physical world will be able to offer their functionality via service interfaces. The services provided by these devices are referred to as *real-world services* (Bimschas et al., 2011). Other than the traditional services of cyber-space which are mainly oriented to a two-tuple problem domain of user requirement and information space, IoT services are faced with a three-tuple problem domain of user requirement, cyberspace and physical space (Ma, 2011).

The service provisioning environment of IoT is actually distinctive. Traditional service provisioning is designed for the human-machine and machine-machine interactions, and does not consider the distributed large-scale sensing information. The information providers and consumers often directly communicate with each other explicitly in a request-response paradigm. However, IoT services also need to address the seamless interactions with the real world. A variety of sensors will generate vast amounts of sensing information which need to be fused and shared by different applications. Moreover, real-world services are found in highly dynamic environments where devices and their services constantly degrade, vanish, and re-appear (Bimschas et al., 2011). Besides, as the IoT services directly sense and control the physical world, it has the requirement of rapid response. So, one challenge of existing works is lacking of efficient mechanism to on-demand provisioning the sensing information in a loosely-coupled, decentralized way and then dynamically coordinate the relevant services based on the information to rapidly respond to changes in the physical world.

Moreover, the IoT environment is currently quite fragmented. Each industry vertical has developed its own technical solutions without much regard to reuse and commonality. The hardware, software, data formats and communication protocols of today's embedded world are heterogeneous. It is far away from forming a unified standard, or maybe it is not possible for different domains to follow a same standard, such as OPC_UA in industrial control domain and ZigBee in Wireless Sensor Network (WSN). So, in the near future, all embedded devices over one standard is extravagant hope, the urgent matter is to adapt and shield the device heterogeneity. There are typically two ways to adapt device: deploying the adaptation in the embedded devices or in the gateways (W. Wang, Barnaghi, Cassar, Ganz, & Navaratnam,