Chapter 4
Cloud-Based IoT System
Control Problems

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ABSTRACT

Cloud computing and IoT are two very different technologies that are both already part of our life. Their adoption and use are expected to be more and more pervasive, making them important components of the Future Internet. A novel paradigm where Cloud and IoT are merged together is foreseen as disruptive and as an enabler of a large number of application scenarios. In this chapter, we focus our attention on the integration of Cloud and IoT. Reviewing the rich and articulate state of the art in this field, some issues are selected; Cloud Radio Access Network (C-RAN), Mobile Cloud IoT (MCIoT), Social Cloud (SC) and Fog Radio Access Network (F-RAN). C-RAN provides infrastructure layer services to mobile users by managing virtualized infrastructure resources. SC is a service or resource sharing framework on top of social networks, and built on the trust-based social relationships. In recent years, the idea of SC has been gaining importance because of its potential applicability. With an explosive growth of Mobile Cloud (MC) and IoT technologies, the MCIoT concept has become a new trend for the future Internet. MCIoT paradigm extends the existing facility of computing process to different mobile applications executing in mobile and portable devices. As a promising paradigm for the 5G wireless communication system, a new evolution of the cloud radio access network has been proposed, named as F-RANs. It is an advanced socially-aware mobile networking architecture to provide a high spectral and energy efficiency while alleviating backhaul burden. With the ubiquitous nature of social networks and cloud computing, IoT technologies exploit these developing new paradigms.

NEWS-VENDOR GAME BASED RESOURCE ALLOCATION (NGRA) SCHEME

C-RAN has been emerging as a cost-effective solution supporting huge volumes of mobile traffic in the big data era. To exploit next generation C-RAN operations, a main challenging issue is how to properly control system resources. Recently, S. Kim proposed the News-vendor Game based Resource Allocation (NGRA) scheme, which is a novel resource management algorithm for C-RAN systems. By employing

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the news-vendor game model, the NGRA scheme investigates a resource allocation problem with bar-
gaining solutions. In dynamic C-RAN environments, this game-based resource management approach
can practically adapt current system conditions while maximizing the expected payoff.

Development Motivation

Modern computation and communication systems operate in a new and dynamic world, characterized
by continual changes in the environment and performance requirements that must be satisfied. Dynamic
system changes occur without warning and in an unpredictable manner, which are outside the control
of traditional operation approaches (Addis, 2013). At the same time, popularity of mobile devices and
related applications in various fields are increasing significantly in everyday life. Furthermore, applica-
tions become more and more complex, Quality of Service (QoS) sensitive and computation intensive
to perform on mobile system. Therefore, new solution concepts need to be developed that manage the
computation and communication systems in a dynamically adaptive manner while continuously ensuring

Cloud Radio Access Network (C-RAN) is a new system architecture for the future mobile network
infrastructure. It is a centralized, cloud computing based new radio access network to support future
wireless communication standards. C-RAN can be implemented based on the concept of virtualization.
Usually, virtualization is an enabling technology that allows sharing of the same physical machine by
multiple end-user applications with QoS guarantees. Therefore, it helps to reduce costs while improving
a higher utilization of the physical resources (Addis, 2013; Zhu, 2014).

No one may deny the advantages of C-RAN services via virtualization technologies. However, there
are some problems that need to be addressed. Most of all, next generation C-RAN systems should take
into account QoS guarantees while maximizing resource efficiency. However, because of the scarcity of
system resource, it is difficult to satisfy simultaneously these conflicting requirements. For this reason,
the most critical issue for the next generation C-RAN system is to develop effective resource allocation
algorithms (Vakilinia, 2014). But, despite flexibility and great potential applicability, resource allocation
problem in C-RAN has received scarce attention as of today.

To design a resource allocation algorithm in C-RAN systems, it is necessary to study a strategic
decision making process. Under widely dynamic C-RAN conditions, system agents can be assumed as
intelligent rational decision-makers, and they select a best-response strategy to maximize their expected
utility with other agents. This situation is well-suited for the game theory. News-vendor game (Malakooti,
2014; William, 2009) is a mathematical game model in operations management and applied economics
used to determine optimal inventory levels. Typically, it is characterized by fixed prices and uncertain
demand for a perishable product. Therefore, this model can represent a situation faced by a newspaper
vendor who must decide how many copies of the day’s paper to stock in the face of uncertain demand and
knowing that unsold copies will be worthless at the end of the day. The original concept of newsvendor
game appeared to date from 1888 where F. Edgeworth used the central limit theorem to determine the
optimal cash reserves to satisfy random withdrawals from depositors. The modern formulation dates

Motivated by the aforementioned discussion, the NGRA scheme was developed. The main goal of
the NGRA scheme is to maximize resource efficiency while providing QoS guarantees. In dynamically
changing C-RAN environments, the game process in the NGRA scheme is divided two stages; the
competitive stage and the bargaining stage. At the competitive stage, system resource is allocated in a