7 Data Management for Mobile Ad Hoc Networks

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7.1 Introduction

The overall goal of data management and processing in mobile ad hoc networks is to allow individual devices to compute what information each device needs, when the device needs it, and how it can obtain the information. This chapter identifies the fundamental challenges and outlines ongoing and needed future work to achieve this goal.

Until recently, research on mobile data management was dominated by the client–proxy–server model requiring an infrastructure support. In this model, mobile devices connect to the Internet and serve as client end points. They initiate actions and receive information from servers, which reside on the network and provide the infrastructure support to the clients. This earlier research focused primarily on the development of protocols and techniques that deal with disconnection management, low bandwidth, and device resource constraints. This allows applications built for the wired world, e.g., World Wide Web and databases, to run in wireless domains using proxy-based approaches [8, 46]. In systems based on the cellular network infrastructure or wireless local area network infrastructure, the traditional client–proxy–server interaction is perhaps an appropriate model where the client database can be extremely lightweight [10], has a (partial) replica of the main database on the wired side [43, 75], or where selected data are continuously broadcast into the environment and cached by the clients [1, 35].

With the widespread use of short-range ad hoc networking technologies, such as Bluetooth [9], an alternative data management model becomes necessary. These networking technologies allow spontaneous connectivity among mobile devices, including handhelds, wearables, computers in vehicles, computers embedded in the physical infrastructure, and (nano)sensors. Mobile devices can suddenly become both sources and consumers of information. There is no longer a clear distinction between clients and servers, instead devices are now peers. To further complicate the matter, there is also no longer a guarantee of infrastructure support. Consequently, for obtaining data, devices cannot simply depend on the help of some fixed, centralized server [61]. Instead, the devices must be able to cooperate with others in their vicinity to pursue individual and collective tasks. This will lead devices to become more autonomous, dynamic, and adaptive with respect to their environments.

This chapter describes the origins of this novel mobile peer-to-peer computing model and relates it to traditional mobile models.

More importantly, this chapter introduces problems that arise in traditional mobile data management systems as well as additional problems specifically related to mobile ad hoc networks. The three fundamental sources of these problems represent the underlying wireless ad hoc networking technologies, the traditional issues relating to data management in any mobile computing paradigm, and the problems related to context awareness.

This chapter also surveys proposed solutions to each problem category. Despite the fact that wireless ad hoc networking technologies and peer-to-peer based data management paradigms attempt to solve similar problems, the chapter illustrates that there is a very limited effort on crosslayer interaction, which is essential for mobile ad hoc networks. This gap between the research on networking, data management, and context awareness in pervasive computing environments is the fundamental problem of allowing a device to compute *what* information the device needs, *when* the device needs it, and *how* it can obtain the information.

To overcome this problem, this chapter then presents the MoGATU model [58–63] – a novel peer-to-peer data management model for mobile ad hoc networks. The key focus of MoGATU is to narrow the gap to its minimum by enabling mobile devices to proactively learn their current context and adjust their computing functionality according to their users' needs and preferences. MoGATU abstracts all devices using communication interfaces, information managers, information consumers, and information providers. The information manager is the fundamental component of the model. It is responsible for majority of the data management and communication functionality. It is composed of multiple components, which are responsible for (1) data and service discovery, (2) query processing, (3) join query processing, (4) caching, (5) transactions, (6) reputation, and (7) data-based routing among peer devices.

7.2 Origins of Mobile Peer-to-Peer Computing Model

Mobile computing applications can be classified into three categories – client–server, client–proxy–server, and peer-to-peer – depending on the interaction model.

In the client–server model, a large number of mobile devices connect to a small number of servers residing on the wired network, organized in a cluster. This model is a direct evolution of the distributed object-oriented systems like CORBA and DCOM [72]. Here, mobile devices terminal-like client end points, initiating actions and receiving information from servers on the network. The servers then represent powerful machines with high bandwidth wired network connectivity and the capability to connect to wireless devices. Primary data and services reside on, and are managed by, the servers. Servers are also responsible for handling lower level networking details, such as disconnection and retransmission.