

Chapter 1

Introduction

The considerable mobile services sector growth around the world was certainly the major phenomenon of the 1990s in the telecommunications field. The concept of ubiquitous communication (everyone and everywhere) has become an essential requirement for Internet users. A high demand for mobile communications has led to the development of new multimedia services and to the evolution in user requirements in terms of throughput and universal mobility throughout different systems. We have witnessed the birth of 2nd generation mobile telephony cellular systems (GSM, CDMA, etc.) and the more difficult emergence of 2.5/3rd generation mobile systems (GPRS, UMTS, CDMA2000, etc.) which offer high throughputs of a few dozen Kbps (GPRS) to hundreds of Kbps (UMTS, EDGE). In addition, we are witnessing a large increase of mobile users in companies where the structure is becoming less organized. In fact, employees are now more often equipped with laptop computers and spend more time working with multifunctional teams that are trans-organizational and geographically dispersed.

Wireless local area networks (WLANs) were designed as data transmission systems to ensure a connection which is independent from the physical location of computer peripherals making up the network and which use wireless connections instead of a wired infrastructure. It is a practical and interesting network connection solution providing mobility, flexibility and low deployment and usage cost. After being considered an isolated and immature technology, local wireless access now appears to be a key component in a centralized architecture integrating wireless and mobile technologies (IEEE 802.11b/a/g/n, IEEE 802.15, IEEE 802.16, IEEE 802.20, Ultra Wideband, 2G/3G). In addition, two other adjacent domains have quickly

2 Wireless Ad Hoc and Sensor Networks

appeared: first ad hoc mobile networks (MANET, *Mobile Ad hoc NETworks*) and, more recently, sensor networks. These networks are infrastructureless with a very simple network deployment capability paving the way for new applications and offering solutions in multiple environments that have no infrastructure.

MANETs are found within several systems; wireless local networks (the IEEE 802.11 family, Hiperlan2), personal area networks (Bluetooth) or other systems such as home networks (HomeRF, etc.). The simple deployment capability of an ad hoc network paves the way for applications which have not been able to emerge until now and offers solutions for multiple environments (far away zones, rescue zones, etc.). Network services provided in these configurations are configured and created *on the fly*. In the ad hoc context, radio transmission support characteristics, network mobility, hidden/exposed nodes and other factors make traditional protocols defined for wired or cellular networks inadequate. Because of this, a series of mechanisms is offered, addressing several issues/aspects such as routing, security, applications, etc.

On the other hand, wireless sensor networks represent a new type of system that has emerged thanks to the great technological progress in intelligent sensor development, powerful processors and wireless communication protocol fields. It is a very promising technology which will offer a wide range of new applications in civil as well as military sectors (environment monitoring, data collection, control, etc.). This type of network, which is made up of hundreds and even thousands of elements, aims at collecting environmental data, processing and disseminating the collected data. It has inherent characteristics which are: high density, node unreliability, frequent topology changes and resource limitation constraints (power, processing, memory capacity, communication, etc.). These characteristics raise new challenges to the practical deployment of this type of network such as energy consumption optimization, self-organization, fault tolerance, security, etc.

In this book, we investigate several relevant and interesting research issues related to both types of mentioned networks, such as unicast routing, multicast routing, quality of service, security, service discovery, clustering/self-organization, etc.

Our main objective is to report contributions from corresponding research communities in the different concerned fields. We have decided to follow a descriptive approach with the purpose of drawing up complete states of the art of the various cited fields and to provide personal contributions of the authors and to clearly illustrate their advantages and limitations and finally to set the milestone for future work. Any reader who is interested in improving their knowledge of the technical concepts will find a list of references and recent publications at the end of each chapter.

The wealth of concepts and the diversity of domains involved have led me to organize this book into 11 chapters which are described below.

After the introduction in Chapter 1, Chapter 2, which is written by Stéphane Ubéda, presents a detailed description of the concepts and principles used in MANETs. The author focuses on work related to unicast ad hoc routing, which is a critical basic function that any ad hoc network must support. Routing in ad hoc networks, which is different from traditional IP routing, is a particularly complex problem because of node mobility, resource limitations and unreliability of wireless links. A panoply of more adapted algorithms was proposed by the IETF's MANET workgroup (Internet protocol standardization organization). Three main classes have quickly emerged: proactive or table-driven protocols, reactive or on-demand protocols and hybrid protocols. The author describes these three main groups and specifies some of the most representative protocols such as AODV, OLSR, TBRF and DSR. The author reminds the reader of major remaining critical problems, and some of them are explained in the following chapters: routing (and its different subclasses: unicast routing, multicast routing and hierarchical routing), mobility management, quality of service support, radio interface problems, energy consumption, scalability and security, etc.

Ad hoc networks are completely infrastructureless; their changing topology and limited resources raise the problem of quality of service support at different levels (access to support, signaling, etc.) even more so because of greater complexity. By focusing on routing, Pascale Minet clearly explains these constraints in Chapter 3. A specific solution is described which is QoS OLSR. A performance evaluation study carried out by simulation enables us to judge the stability of obtained routes, the bypassing of overloaded network zones, load-balancing between routes and accurate use of resources. Obviously, ad hoc routing with quality of service remains a new research field where contributions are still few. The necessity for a global hierarchical architecture for quality of service control is obvious; it will be important to study inter-layer interaction in order to optimize global performance.

In addition, because of its importance for grouped communications, multicast routing has the capability to optimize resource usage and therefore conserves bandwidth, and thus seems to be an adequate technique for ad hoc networks. Houda Labiod, author of Chapter 4, covers these aspects. She provides a short state of the art on multicast ad hoc routing protocols and presents a new solution, the Source Routing-based Multicast Protocol (SRMP). The main idea is to introduce a new routing concept based on quality of connectivity which can use one or several metrics related to the ad hoc environment and/or to applications.

In Chapter 5, written by Fabrice Theoleyre and Fabrice Valois, the authors discuss a critical problem for autonomous networks (ad hoc or sensor networks):

4 Wireless Ad Hoc and Sensor Networks

self-organization. This latter represents a specific and inherent characteristic for this type of network, resulting from the natural existence of the collaboration ability of nodes to provide network services such as routing, localization, dissemination, security, etc. The goal of most of the cited works is to define an efficient self-organized structure of the network based on efficiently using some properties of nodes such as autonomy, dynamicity, improvement of protocols, adaptation to temporal and spatial environment variations, robustness and scalability. This chapter largely covers notions relative to this domain by describing recent studies as well as a new approach based on the concept of *virtual topology*. This approach improves two mechanisms: energy-conserving and routing.

The omnipresence of communications and services reveals the possibility for a user to access services and resources wherever, whenever or from whatever terminal is used, whether it is fixed or mobile. This capability is at the heart of the networks discussed in Chapter 6 by Mohamed Bakhouya and Jaafar Gaber. This chapter is dedicated to the discovery and emergence of services. We find a new self-adaptive original approach based on the creation of server communities to provide services available from the network. It is implemented with the help of an adaptive middleware, influenced by concepts of the human immune system. An alternative paradigm to the traditional client/server paradigm is proposed.

Chapter 7 is written by Abdellatif Obaid and Azzedine Khir and discusses the service discovery in a different way. The authors focus on protocol aspects when merging service discovery with routing in ad hoc mobile networks. A new mechanism called SEDIRAN is presented and introduces improvements to the proposition from Koodli and Perkins positioned above the reactive routing protocol AODV. This solution consists of adapting routing to the needs of the service discovery mechanism.

In Chapter 8, Romain Mellier and Jean-Frédéric Myoupo present a state of the art on the different clustering techniques developed for ad hoc networks, including two (or more) hop clusters. Following a presentation of the improvement of one of the discussed techniques, two applications are detailed: the problem of initialization and mutual exclusion.

Sylvie Laniepce discusses routing and data transmission security in ad hoc networks in Chapter 9. Indeed, security in particular is a crucial and very complex problem for these networks. This chapter outlines the major propositions by emphasizing points of vulnerability and describing the different mechanisms and a list of possible threats. The author concludes that the proposed solutions present some limitations in terms of robustness, performance and reliability.

Chapter 10, written by Sébastien Tixeuil, discusses distributed algorithms in large-scale systems. It focuses on fault-tolerant distributed algorithms when used in the context of wireless sensor networks. Following a description of related work based on a general taxonomy of faults in distributed systems, the author demonstrates that scaling is compromised by generally used assumptions in fault-tolerant algorithms. Several solutions are then introduced to propose techniques derived from self-stabilization in a large-scale context.

Fábricio A. Silva, Linnyer B. Ruiz, José M. Nogueira and Thais R. Braga address code mobility in sensor networks in Chapter 11. The goal is to make it possible for sensor nodes to adapt their behavior to application requirements with the use of code mobility. The authors focus on a method based on mobile agents that has been evaluated and compared to a traditional “client-server” approach. The results show that the decision in choosing which approach to adopt depends on the network’s characteristics and on the complexity of network tasks, which in turn largely depends on the code size.

Chapter 12 discusses specific ad hoc networks called vehicle-to-vehicle communications or VANET, constituting a main component in intelligent transport systems (ITS). In this chapter, the authors focus on the study of a main component in ITS systems, vehicle-to-vehicle communication as well as the associated services. They outline the state of the art by describing the major existing projects and several problems such as routing, data dissemination, mobility, access and security.

We hope this book, which deals with several relevant and interesting research fields, will bring a global, realistic and critical vision of the evolution of spontaneous and autonomous networks (ad hoc and sensors), as emphasized by the various authors of this book. Moreover, there remains a large number of research projects to explore.

I personally want to express my gratitude to all the authors for their very interesting contributions and the quality work accomplished, as well as to the proofreaders who had the enormous task of helping me in the final drafting of this book.