Preface

The need to transfer increasing amounts of data in a formidable number of environments in a flexible and reliable way has resulted in the exponential growth of wireless networks. The expanded use of wireless networks has led to significant improvements in digital and RF circuits, new large-scale circuit integration, and other miniaturization technologies that make portable radio equipment smaller, cheaper, and more reliable. Wireless Local Area Networks (WLANs) represent flexible data communications systems that can be implemented as an extension to or as an alternative for a wired LAN. Using a form of electromagnetic radiation as the network medium, most commonly in the form of radio waves, wireless LANs transmit and receive data over air, thus minimizing the need for wired connections (cables). Wireless LANs offer the advantage of combining data connectivity with user mobility. By combining mobile devices with wireless communications technologies, the vision of being connected at anytime and anywhere is quickly becoming a reality. The use of ubiquitous systems and technologies is very close on the horizon.

Whereas today’s expensive wireless infrastructure depends on centrally deployed hub and one hop stations, mobile ad hoc networks consist of devices that autonomously self-organize in networks. In ad hoc networks, many individual devices must work together seamlessly to make a network function correctly. The operation of so many devices that must work collaboratively while dynamically adjusting to a quickly changing topology is what makes ad hoc wireless networking so difficult to realize.

The many physical and economic limitations of wireless networks also represent important challenges. The large degree of freedom and their self-organizing capabilities make ad-hoc networks completely different from any other networking solution. For the first time, users have the opportunity to create their own networks, which can be deployed with more ease and at less cost than convention cabled networks. In short, difficulties related to the development of technologies and their subsequent deployment pale in comparison to the potential rewards.

Ad-hoc networks represent a key step in the evolution of wireless networks. However, they inherit the traditional limitations of wireless and mobile communications, including the efficient use and allocation of bandwidth resources, energy consumption and coverage.

A Mobile Ad Hoc Network (MANET) is formed by a collection of mobile nodes which communicate using a wireless medium. Additionally, a MANET can be defined as an autonomous network with no single point of coordination. These types of networks are characterized by their dynamic topologies, limited bandwidth and restricted power. Each individual mobile node in a MANET can potentially transmit information using a direct link or a multi-hop link to propagate packets to a destination node. As a result, all the mobile nodes in a MANET must implement a single routing strategy. Consequently, the design of fast and efficient routing protocols is essential to insure the efficient performance of mobile ad hoc networks.
Mobile nodes in a MANET do not require a specific hierarchical sub-network addressing scheme, unlike wired networks that require a specific IP address for each member of a specific sub-network. As a result, MANETs and wired networks face different routing issues related to how to provide the necessary connectivity between nodes. Whereas routing in conventional networks is carried out by assigning specific IP addresses, there is no previously established routing information for nodes within a MANET. This is precisely because IP addresses function based on the premise of a set, stable and static connection. MANETS, on the other hand, must work precisely in environments that are highly dynamic and mobile, making assigning specific addresses extremely challenging. In order to provide connectivity in dynamically changing topologies, nodes within MANETs usually have to forward routing information to other nodes outside the MANET, and there is usually no implicit support for the connectivity between mobile nodes and a wired network via an access router (AR).

Recent advances in micro-electro-mechanical systems (MEMS) technology have made the deployment of wireless sensor nodes a reality, in part, because they are small, inexpensive and energy efficient. Each node of a sensor network consists of three basic subsystems: a sensor subsystem to monitor local environment parameters, a processing subsystem to provide computation support to the node, and a communication subsystem to provide wireless communications to exchange information with neighboring nodes. Because each individual sensor node can only cover a relatively limited area, it needs to be connected with other nodes in a coordinated fashion to form a sensor network (SN), which can provide large amounts of detailed information about a given geographic area.

Sensors are devices that produce a measurable response to a change in a physical condition like temperature and pressure. Basically, each sensor node is comprised of a sensing, processing, transmission and power unit. The processing unit is responsible for collecting and processing signals transmitted from sensors and forwarding them to the network. The transmission unit provides the signal transfer medium from sensors to the exterior world or computer network. It also has a communication mechanism to establish and maintain the wireless sensor network, which is usually ad-hoc. The power supply unit consists of a battery and a dc-dc converter that powers the node.

Sensor networks are generally deployed into an unplanned infrastructure where there is no a priori knowledge of their specific location. The resulting problem of estimating the spatial coordinates of the node is referred to as location. Most of the proposed localization techniques today depend on recursive trilateration/multilateration techniques.

Consequently, a wireless sensor network (WSN) can be described as a collection of intercommunicated wireless sensor nodes which coordinate to perform a specific action. Unlike traditional wireless networks, WSNs depend on dense deployment and coordination to carry out their task. Wireless sensor nodes measure conditions in the environment surrounding them and then transform these measurements into signals that can be processed to reveal specific information about phenomena located within a coverage area around these sensor nodes.

WSNs have a variety of applications. Examples include environmental monitoring—which involves monitoring air, soil and water, condition-based maintenance, habitat monitoring (determining the plant and animal species population and behavior), seismic detection, military surveillance, inventory tracking, smart spaces, and many more. Despite their many diverse applications, WSNs pose a number of unique technical challenges due to the following factors: fault tolerance (robustness), scalability, production costs, operating environment, sensor network topology, hardware constraint, transmission media and power consumption.
To date, the ZigBee Alliance has developed a communication standard for WSNs to support low-cost, low-power consumption, two-way wireless communications. Solutions adopting the ZigBee standard will be embedded in consumer electronics, home and building automation, industrial controls, PC peripherals, medical sensor applications, toys and games.

The enormous cost of providing health care to patients with chronic conditions requires new strategies to more efficiently provide monitoring and support in a remote, distributed, and noninvasive atmosphere. Wireless electromechanical sensors allow the internal biologically-controlled mega-network, governed by the central nervous system, to communicate with an external body sensor network by means of wireless communication technology. This is particularly significant because it permits internal biological functions to be communicated to a monitoring center, where a real-time diagnosis can be made and an intervention plan can be developed. The term “biologically-controlled mega-network” refers to the central nervous system and the proper execution of complex biological systems, which depends on the intricate coordination of a large number of events and their participating components.

Diverse projects around the world are trying to improve the quality of medical attention by providing remote medical monitoring. These projects are currently developing mobile monitoring systems and integrating remote monitoring into their healthcare protocols, in order to provide expanded healthcare services for persons who require monitoring and follow-up, but do not require immediate medical intervention or hospitalization.

The importance of monitoring patient health is significant in terms of prevention, particularly if the human and economic costs of early detection can reduce suffering and medical costs. The early diagnosis and treatment of a variety of diseases can radically alter healthcare alternatives or medical treatments. This is particularly true with illnesses such as cardiovascular disease or diabetes. In the case of cardiovascular disease, 4% of the population over 60 and more than 9% of persons over 80 years of age have arrhythmias, or abnormal heart rates, which require occasional diminutive electrical shocks applied to the heart. Sensors can identify at-risk patients by monitoring and transmitting their real-time cardiac rhythms to medical professionals who can subsequently determine whether or not they require a pacemaker to assist establish and maintain normal sinus rhythm.

Diabetes is an increasingly significant progressive chronic disease that affects several vital organs. The number of people diagnosed in the United States with diabetes has increased dramatically the last 40 years, mainly due to obesity. Presently, approximately 24,000 people become blind and 56,000 people suffer renal failure because of diabetes every year in the United States. Once diagnosed, patients require constant monitoring of their blood glucose levels. Type II diabetes patients often do not require insulin to effectively manage this disease. These patients rely on effective management protocols requiring periodic blood samples at specified intervals, as well as dietary restrictions, weight loss in the case of obese patients, and exercise. The management of diabetes generally requires motivation and adherence to a new lifestyle that, in large part, depends on changing habits and behaviors. Body sensor networks used to manage diabetes will one day involve implanted sensors, not only to monitor patient glucose levels, but to administer insulin in a timely fashion. In sum, the abovementioned chronic diseases exemplify the need for biochemical and physiological continuous monitoring.

Future applications in agriculture will extensively employ wireless sensor networks that function in real time in conjunction with communications systems, mechanical actuators, and even robots to monitor and intervene in crop cultivation. A WSN permits remote monitoring of many parameters, depending on the type of sensors used and the coverage area. This type of network consists of a large number of sensor nodes that are wirelessly connected to each other, to electromechanical devices, and to a com-
munications network, all of which form a triad to monitor and control crop development. Generally, each node of a WSN consists of sensors and/or actuators. Sensors are characterized by their limited memory and computation capacities, but one advantage of sensors is that they require little power to perform their functions. Wireless sensor networks consisting of many nodes are currently being used in densely populated large scale areas. WSNs can have homogenous structures, where all nodes present similar characteristics, or heterogeneous structures, where some nodes are more powerful than others or are differentiated by physical characteristics, including the type of battery or antenna the individual nodes use, or whether specific nodes are static or dynamic.

Future developments in automobile manufacturing will also include new communication technologies. The major goals are to provide increased automotive safety, to achieve smooth traffic flow on the roads, and to improve passenger convenience by providing them with information and entertainment. In order to avoid communication costs and guarantee the low delays required for the exchange of safety related data between cars, inter-vehicle communication (IVC) systems based on wireless ad-hoc networks represent a promising solution for future road communication scenarios. IVC allows Vehicles to organize themselves locally in ad-hoc networks without any pre-installed infrastructure. Communication in future IVC systems will not be restricted to neighbored vehicles travelling within the radio transmission range, as in typical wireless scenarios, the IVC system will also provide multi-hop communication capabilities by using “relay” vehicles that are travelling between the sender and receiver. Vehicles between source-destination act as intermediates vehicles, relaying the data to the receiver. As a result, the multi-hop capability of the IVC system significantly increases the virtual communication range, as it enables communication with more distance vehicles.

Current developments in wireless ad hoc routing protocols have fuelled the development of hybrid networks which allow the integration of MANETs to the Internet. There is currently an intrinsic problem related to mobility in computer data networks which implement the IP network protocol stack. This issue is related to the fact that an IP address is commonly used as the node’s identifier and locator within a sub-network. When a node changes its point of attachment to the network (e.g. the mobile node moves to a different sub-network) the assigned IP address can no longer be used as a locator for the node in the new sub-network. To address this issue, different proposals such as the Mobile IP mechanism have been developed to support macro-mobility (i.e. mobility between different administrative domains). There are presently two important proposals to provide macro-mobility support for the IPv4 and IPv6 network protocol stacks, namely mobile IPv4 (MIPv4) and mobile IPv6 (MIPv6). It should be noted that the IPv6 protocol stack supports mobility, but this mechanism is only effective in wireless networks where the mobile nodes are one-hop away from the access router.

This book is organized as follows:

- Section I describes theory and application of wireless sensor networks;
- Section II analyses the operation and application of wireless ad hoc networks
- Section III discusses how to integrate traditional wired infrastructure and ad hoc networks into hybrid networks.

In more detail:

**Section 1** includes chapters titled: *A Survey on Location in Wireless Sensor Networks, Low Power Design Techniques for Wireless Sensor Networks, A Forward and Backward Secure Key Management*

Section 3 includes: Challenges of Emerging Technologies in Transportation Systems, IP Mobility Support in Hybrid Wired Mobile Ad hoc Networks and Game Theory for Resource Allocation in Wireless Networks.

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