Preface

INTRODUCTION

Wireless Sensor Networks (WSN) are an emerging field, with special characteristics, includingthe capability of easy deployment with a number of different applications. Sensor networks normally consist of small nodes with limited capability for computation and communication. The major share of research in the last decade pertains to WSN. The main reason for the popularity of wireless sensor networks is because of ease in deployment and low cost. Its main function is to collect the data, resulting of any physical event occurrence in the network area and then send it to the sink. This book focuses on wireless sensor networks in general, and operations including routing, energy efficiency, and the management aspects.

This book is intended for anyone who wants to cover a comprehensive range of topics in the field of wireless sensor networks paradigms and developments. It is both for an academic audience (teachers, researchers, and students, mainly of post-graduate studies) and professional audience. Readers of this book are pre assumed familiar with the concepts and paradigms of wireless sensor network concepts and its related concepts. It provides guidance for technology solution developers from academia, research institutions, and industry, providing them with a broader perspective of wireless sensor networks.

This book contains 27 excellent chapters authored by a group of internationally experienced professionals and researchers in the field of computer science, communication, and networking. Contributors also include younger authors, creating a value-added constellation of dynamic authors. Concerning the environments from which the contributions are presented, the chapters came from academia, research institutions and industry.

Organization of the Book

This book is designed to cover a wide range of topics in the field of wireless sensor networks. It includes three sections that provide a comprehensive reference for wireless sensor network by covering all important topics, including an introduction, MAC, Routing Protocols, TCP, performance and traffic management, time synchronization energy efficiency, applications, and security. Each chapter is designed to be as a stand-alone as possible; the reader can focus on the interested topics only. The chapters are described briefly as follows.

Section 1: Introduction

Chapter 1 provides a brief technical introduction to WSN, with background and history and an understanding of sensor networks, design constraints, security issues, and a few applications sensor networks are enabling. A brief discussion of the network topologies that apply to wireless sensor networks are also discussed in this chapter.

Chapter 2 throws a light on the recent developments and future directions of research in WSN topology management that maintain wireless network connectivity in an energy-efficient manner.

Chapter 3 compiles some related information on the basis of studied literature, regarding WSN management, including WSN background, issues and challenges, proposed solutions, and research trends.

Chapter 4 includes a detailed description of interoperability in heterogeneous WSN using the IEEE 1451 standard. It focuses on personal area networks (PAN) with smart sensors and actuators. In this chapter, the authors explore different options to apply the IEEE 1451 standard using SOAP or REST Web service style in order to test a common syntactical interoperability that could be predominant in future WSNs.

Chapter 5 presents literature review for MAC, routing, and cross layer design protocols that proposed for WSN. This chapter discusses and compares the most well-known MAC protocols for WSN according to layers integrated, intended applications, and cross-layer objectives. The authors classified the routing protocols for WSN into data centric routing protocols, hierarchical routing protocols, location based protocols, QoS aware routing protocols, and application. Finally, this chapter discusses some cross layer design protocols.

Chapter 6 presents a review and comparison of different algorithms proposed recently for underwater sensor networks (UWSNs). The UWSNs are finding different applications for offshore exploration and ocean monitoring.

Chapter 7 presents a survey on the Wireless Sensor Network Testbed (WSN-Testbed). The WSN-Testbed is a platform for experimentation of development projects. It enables realistic and reliable experimentation in capturing the subtleties of the underlying hardware, software, and dynamics of the WSN. The authors adopt and describe a classification methodology for WSN-Testbeds. Consequently, they present a generic architecture for the different classes of WSN-Testbeds. Carefully, this chapter discusses and analyzes a variety of 30 WSN-Testbeds. Finally, the authors believe that this chapter is a contribution towards realizing the important role that a WSN-Testbed plays in hastening the industrial adoption for the promising WSN technology.

Chapter 8 provides an overview of techniques to mitigate Hot Spot impacts, such as the uneven distribution of sensors, routes that balance energy consumption, sink mobility, and the use of unequal clustering. Further, it depicts an approach for achieving mitigation of sink centered Hot Spots.

Chapter 9 provides an overview of different location aware algorithms to focus to save the energy resource of sensor network. The chapter describes the current available approaches, issue and challenges with current approaches and future directions for node localization, one by one. Node localization is highly important for large sensor networks where users desire to know about the exact location of the nodes in order to know the data location.

Section 2: Energy Efficiency of WSN

Chapter 10 presents a survey of energy efficient routing protocols in sensor networks by categorizing architecture based routing. Furthermore, it classifies the architecture based routing into two main areas: flat or location based routing protocols, and hierarchical based routing protocols. The authors present a survey of relevant literature in order to highlight the advantages of hierarchical based routing, particularly with respect to the deployment of mobility routing. Finally, this chapter is helpful in providing new perspectives and paradigms for the design and analysis of energy efficient routing protocols.

Chapter 11 investigates the use of various cooperative diversity techniques in wireless sensor networks to increase the transmission range, minimize power consumption, and maximize network lifetime.

Chapter 12 analyzes the effect of density on inter cluster and intra cluster communication and evaluates a hybrid cross layer scheduling schemes to enhance the lifetime of the WSNs. The authors suggests a hybrid cross layer scheduling scheme at the application layer that puts the redundant nodes to sleep if they are used for some other energy intensive tasks. Performance studies in the chapter indicate that the proposed communication strategy is more energy efficient than the conventional communication strategies, which employ the sleep/wake up pattern at application layer.

Chapter 13 proposes a multi-objective particle swarm optimization (MOPSO) algorithm to optimize the number of clusters in a sensor network in order to provide an energy-efficient solution. The proposed algorithm considers the ideal degree of nodes, and battery power consumption of the sensor nodes. The main advantage of the proposed method is that it provides a set of solutions at a time. This chapter performed extensive simulations to compare the proposed approach with two other well-known clustering techniques: WCA and CLPSO-based clustering.

Chapter 14 presents the studies and analysis on the approaches, the concepts, and the ideas on data packet size optimization for data packets transmission in underwater wireless sensor network (UWSN) and terrestrial wireless sensor network (TWSN) communications. This chapter starts off with the studies and analysis on prior arts found in UWSN and then moves on to the similar works found elsewhere in the TWSN communications counterparts. In addition, it summarizes comparison on some important issues related to data packet size optimization approaches used in UWSN and TWSN communications. The findings in this chapter may be helpful to readers who are interested in the R&D of data packet size optimization techniques with the intention to formulate new data packet size optimization framework or algorithms.

Chapter 15 proposes a novel approach to employ high-altitude platforms (HAPs) to remove the relaying burden and/or de-centralize coordination from wireless sensor networks (WSNs). The approach can reduce the complexity and achieve energy efficiency in communications of WSNs, whereby applications require a large-scale deployment of low-power and low-cost sustainable sensors. Moreover, the authors review and discuss the main constraints and problems of energy consumptions and coordination in WSNs.

Chapter 16 describes the importance of quality of service QoS and focuses on operational and architectural challenges of handling QoS, as well as requirements of QoS in WSNs. It discusses a selected survey of QoS aware routing techniques by comparing them in WSNs. Finally, the chapter highlights a few open issues and future directions of research for providing QoS in WSNs.

Chapter 17 presents low complexity processor designs for energy-efficient security and error correction for implementation on wireless sensor networks (WSN). This chapter describes Minimal Instruction Set Computer (MISC) processor designs with a compact architecture and simple hardware components. The MISC is able to make use of a small area of the FPGA and provides a processor platform for secu-

rity and error correction operations. In this chapter, two example applications, which are the Advance Encryption Standard (AES) and Reed Solomon (RS) algorithms, were implemented onto MISC. The MISC hardware architecture for AES and RS were designed and verified using the Handel-C hardware description language and implemented on a Xilinx Spartan-3 FPGA.

Chapter 18 provides an overall understanding of the design aspects of Medium Access Control (MAC) protocols for Wireless Sensor Networks (WSNs). The authors first discuss the basics of MAC design for WSNs and present a set of important MAC attributes. Subsequently, they discuss the main categories of MAC protocols proposed for WSNs and highlight their strong and weak points. After briefly outlining different MAC protocols falling in each category, the authors provide a substantial comparison of these protocols for several parameters. Finally, this chapter discusses future research directions on open issues in this field that have mostly been overlooked.

Chapter 19 proposes an algorithm for the detection of malicious sensor nodes based on Kullback-Leibler distance between the current target position distribution and the predicted sensor observation, while the best communication path is selected, as well as the highest signal-to-noise ratio (SNR) at the cluster head (CH). The efficiency of the proposed method is validated by extensive simulations in target tracking for wireless sensor networks (WSN).

Chapter 20 presents an improved energy-efficient Ant-Based routing algorithm (IEEABR) in wireless sensor networks. The proposed IEEABR approach has advantages of reduced energy usage and achieves a dynamic and adaptive routing, which can effectively balance the WSN node power consumption and increase the network lifetime. This chapter covers applications and routing in WSNs, different methods for routing using ant colony optimization (ACO), a summary of routing algorithms based on ant systems, and the Improved Energy-Efficient Ant-Based Routing Algorithm approach.

Chapter 21 describes an "Event Based Detection" model to simulate the results in terms of energy savings during field activities like a fire detection system in a remote area or habitat monitoring, and it is also used in security concerned issues. The model is designed to detect events (when occurring) of significant changes and save the data for further processing and transmission. In this way, the amount of transmitted data is reduced, and the network lifetime is increased. The main goal of this model is to meet the needs of critical condition monitoring applications and increase the network lifetime by saving more energy.

Section 3: Application, Theoretical and General

Chapter 22 uses the concepts of game theory to design an energy efficient MAC protocol for wireless sensor networks (WSNs). This enables the authors to introduce persistent/non-persistent sift protocol for energy efficient MAC protocol and to counteract the selfish behavior of nodes in WSNs. Finally, the results show that game theoretical approach with the persistent/non-persistent sift algorithm can improve the overall performance as well as achieve all the goals simultaneously for MAC protocol in WSNs.

Chapter 23 surveys routing algorithms in Euclidean, virtual, and hyperbolic space for wireless sensor networks (WSNs) that use geometric structures for their route decisions. This chapter starts with the importance and impulse of the geographical routing in WSNs that exploit location information of the nodes to determine the alternatives of the next hop node on the desired routing path. The scalability of geographical routing encourages more effort on the design of virtual coordinates system, with which geographical routing algorithms are built up and applied to route data packets in the network.

Chapter 24 provides the basics of wireless sensor network (WSNs) security to help researchers and engineers in better understanding of this applications field. The authors provide the basics of information security, with special emphasis on WSNs. Moreover, this chapter gives an overview of the information security requirements in these networks. Threats to the security of data in WSNs and some of their counter measures are also presented.

Chapter 25 discusses the development of wireless sensor networks (WSNs) for intelligent transport systems. Due to the electronic revolution in the vehicle, the role of wireless sensors and their interaction amongst themselves and with the environment is gaining importance. For successful interaction of information from environment/vehicle, there is a need for wireless networking of the information from different sources. Mainly, this chapter sheds light on the development of WSNs for intelligent transport systems, newer network architectures, protocols, and algorithms that are being developed.

Chapter 26 The middleware is a very important component in the wireless sensor networks (WSNs) system. It has major challenges that are generic for any distributed systems as well as specific ones that are inherent to the physical nature of WSNs systems due to its resource constraint nature. The authors classify WSNs middleware systems as event based middleware, system abstraction based middleware, application and network aware system, and query based systems to gain a better understanding of such systems.

Chapter 27 presents a novel grid-based localization technique dedicated for forest fire surveillance systems. The proposed technique estimates the location of sensor node based on the past and current set of hop-count values, which are to be collected through the anchor nodes' broadcast. The proposed algorithm incorporates two salient features, grid-based output and event-triggering mechanism, in order to improve the accuracy while reducing the power consumption. The estimated computational complexity of the proposed algorithm is O(Na) where Na is the number of anchor nodes. Through computer simulation, results showed that the proposed algorithm shows that the probability to localize a sensor node within a small region is more than 60%.

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