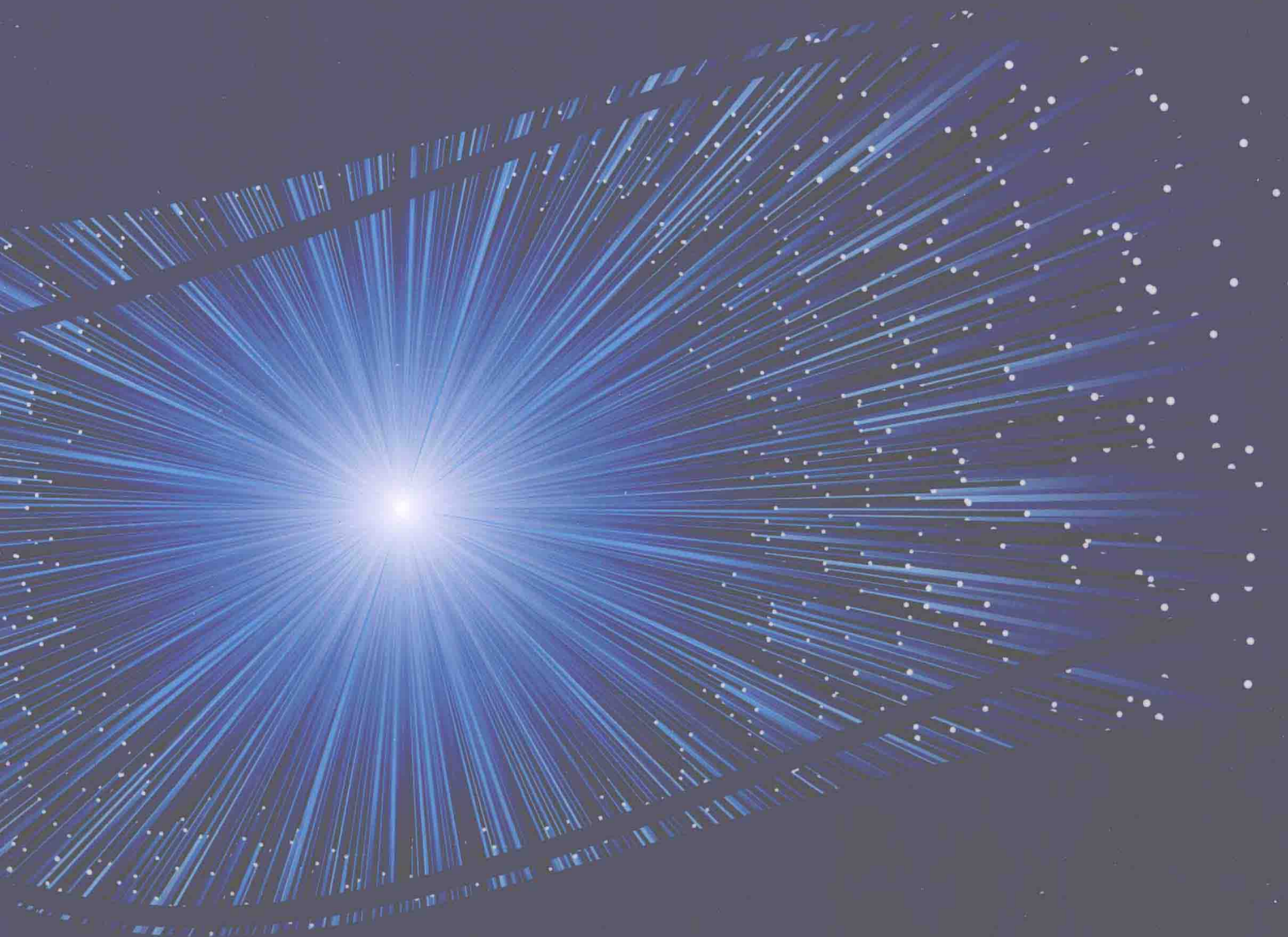
Handbook of Research on

Advanced Wireless Sensor Network Applications, Protocols, and Architectures



Niranjan K. Ray and Ashok Kumar Turuk

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Handbook of Research on Advanced Wireless Sensor Network Applications, Protocols, and Architectures

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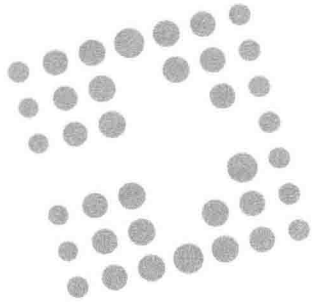

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List of Contributors

Preface

Communication networks have become an integral part of our society for faster and reliable exchange of information. Further, wireless networks have enhanced the communication capability, and can provide ubiquitous connectivity at any instant of time. Wireless Sensor Networks (WSNs) is a variant of wireless networks which have been in used in different areas, from environmental monitoring to battlefield communication, patient care to a smart home system, etc. Applications of WSNs are increasing day-by-day with the emergence of new technology. However, due to their inherent limitations in computation and, communication capability, an efficient management of a large amount of sensed data is a major concern. An efficient approach is required to handle the issues associated with implantation and deployment of sensor technology in a different domain. Sensor network technologies and research outputs are often used under different names. For example, Body Area Networks, The Internet of Things, Machine-to-Machine Communications, Sensor-Cloud Infrastructure, Cyber-Physical Systems, Cognitive Networking, Real-time Location Systems, etc. These applications and a new domain of research will continue to benefit from the advances made by the sensor network research community. We hope that this book will expand the horizon and help us look towards new goals and outcomes for sensor network research and development in the next decade. These applications and new areas of research will continue to benefit from the advances made by the sensor network research community. This book aims to address the issues and challenges that advanced applications of WSN have faced in implementing the new technologies. This book also addresses different aspects of theoretical issues in designing and implementing WSN in challenging environments. This book covers some recent topics in wireless sensor networks.

ORGANIZATION OF THE BOOK

The book is designed to cover a wide range of topics in the field of WSNs. This book is organized into eighteen chapters; each covers a unique topic in detail.

Chapter 1: This chapter addresses the coverage problem in WSNs with a special emphasis on 3D sensor deployment. Several approaches to the coverage problem in 2D and 3D design of WSNs is discussed. The chapter also studies various coverage and connectivity solutions proposed in the design of 3D WSNs.

Chapter 2: This chapter discusses the techniques for sensor data fusion. It explains the process of gathering measurements and observations from various similar or dissimilar sources and sensors, extract the required information, draw logical inferences, and then combine or fuse these to obtain an enhanced status and identity of the perceived or observed object. These acts of information processing and decision making are very crucial for the survival and growth of human beings, as well as many other living creatures, and termed as multisource multisensory information fusion.

Chapter 3: A comprehensive survey of connected dominating set (CDS) construction algorithms with their merit and demerits is discussed in this chapter. The chapter also discusses some open issues and problems in CDS.

Chapter 4: This chapter classifies and discusses different routing protocols for WSNs. A comparison of routing protocols based on the following metrics: power usage, data aggregation, scalability, query basis, overhead, data delivery model and QoS parameters is presented.

Chapter 5: Mesh communications is emerging as a popular networking solution. This chapter studies the mesh design for WSNs. Scalability, performance, and volatility of a mesh network is discussed.

Chapter 6: Wireless Ad-hoc Sensor Network (WASN) has drawn significant attention due to its unique capabilities to deal with complex network operation in a highly resource-constrained network. In this chapter, clustering and hierarchical routing for WASN is presented. Optimization strategies applicable to cluster routing process is also discussed.

Chapter 7: This chapter discusses the impact of the structure of the data gathering trees on nodes and network lifetime in wireless sensor networks. The two categories of data gathering trees – node weight-based and link weight-based – are studied and compared.

Chapter 8: This chapter discusses the design of health monitoring system using WSNs.

Chapter 9: In this chapter, performance evaluation of IEEE 802.15.4 network is carried out both for the star and mesh topology using different routing protocols.

Chapter 10: This chapter discusses the different mechanisms to enhance the spectrum efficiency of the wireless channel. The fundamental concept of MIMO-OFDM system, channel estimation methods, and spectrum utilization is presented.

Chapter 11: Different energy efficient techniques are discussed in this chapter. A few techniques for enhancing the lifetime of Mobile Ad Hoc Network is also presented.

Chapter 12: This chapter studies possible attacks on WSN and classifies them according to their strength, action, security requirements and impact on different layers of WSN. Various metrics to evaluate the characteristic, behavior and dependency of these attacks along with their countermeasures are discussed.

Chapter 13: This chapter discusses security issues at the network layer in Mobile Ad Hoc Networks. Further, different intrusion detection and their protection mechanism are also discussed.

Chapter 14: This chapter presents some practical challenges and issues involved in Internet of Things (IoT). Some theoretical tools have been discussed that can be explored in the future.

Chapter 15: This chapter, proposed a few models for improving the security and privacy of Internet of Things (IoT). It also identifies different security and privacy issues that need to be considered.

Chapter 16: Basics of cloud computing, security requirements, and some of the security techniques are discussed in this chapter. It also discusses some existing solutions.

Chapter 17: Current and future security solutions for low energy wireless body area networks (WBAN) is discussed in this chapter.

Chapter 18: Different mechanisms to achieve green computing is discussed in this chapter.

OBJECTIVE OF THE BOOK

This comprehensive and timely publication aims to be an essential reference source, on the available literature in the field of Wireless Sensor Networks. This will also provide further research opportuni-

ties in this dynamically changing field. It is expected that this text will provide the resources necessary for researchers, advanced-level students, technology developers to adopt and implement the advances technology and applications in WSN.

TARGET AUDIENCE

Academicians, researchers, advanced-level students, and technology developers will find this text useful in furthering their research exposure to pertinent topics, advanced technology, and applications in WSN and assisting in furthering their research efforts in this field.

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Chapter 2

The Data Fusion Model maintained by the JDL (Joint Directors of Laboratories) Data Fusion Group is the most widely-used method for categorizing data fusion-related functions. This paper discusses the current effort to revise and expand this model to facilitate the cost-effective development, acquisition, integration and operation of multi-sensor/multi-source systems. Data fusion involves combining information in the broadest sense to estimate or predict the state of some aspect of the universe. These may be represented in terms of attributive and relational states. If the job is to estimate the state of a people (or any other sentient beings), it can be useful to include consideration of informational and perceptual states in addition to the physical state. Developing cost-effective multi-source information systems requires a standard method for specifying data fusion processing and control functions, interfaces, and associated data bases. The lack of common engineering standards for data fusion systems has been a major impediment to integration and re-use of available technology. There is a general lack of standardized or even well-documented performance evaluation, system engineering methodologies, architecture paradigms, or multi-spectral models of targets and collection systems. In short, current developments do not lend themselves to objective evaluation, comparison or re-use. This paper reports on proposed revisions and expansions of the JDL Data Fusion model to remedy some of these deficiencies. This involves broadening the functional model and related taxonomy beyond the original military focus, and integrating the Data Fusion Tree Architecture model for system description, design and development.

Chapter 3

In a Wireless Sensor Network (WSN), all the nodes are deployed randomly and are energy constrained. There is no physical backbone infrastructure. So, for effective communication between the nodes, a virtual backbone can be used. A virtual backbone can be formed by constructing the Connected Dominating Set (CDS). In past few years, efficient and fast construction of CDS in a wireless network is the main research problem in topology control. In this chapter, the authors have given a comprehensive survey of the CDS construction algorithms with their merit and demerits. They concluded the chapter with some open problems and interesting issues in this field are proposed.

Chapter 4

In Wireless Sensor Network (WSN), the routing protocols have been given attention because most of the routing protocols are application and architecture dependent. This chapter presents routing protocols for wireless sensor networks and also classifies routing in WSN. Chapter gives five main classifications of routing protocols in WSN which are data-centric, hierarchical, location-based, network flow and QoS aware and opportunistic routing protocols. The focus has been given on advancement of routing in WSN in form of opportunistic routing, in which the sensor nodes utilize broadcasting nature of wireless links and the data packets can be transmitted through different paths. The routing protocols for WSN are

described and discussed under the appropriate classification. A table of comparison of routing protocols on the basis of power usage, data aggregation, scalability, query basis, overhead, data delivery model and QoS parameters has been presented.

Chapter 5

Mesh communications is emerging as a popular networking solution. Mesh networks have a decentralized and multihop design. These characteristics arouse interest for the research of the following features: cooperation, task distribution, scalability and communication with limited infrastructure support. This chapter studies relevant solutions in Wireless Sensor Networks (WSNs) with a mesh design that is used with mobile devices. The use of mobile devices on WSNs has recently grown due to: hardware evolution, large number of embedded sensors and daily high utilization of handheld devices. Consequently, novel requisites in the design and implementation of WSNs urge to be satisfied: autonomy of sensors battery and, efficient data exchange amongst sensors and the Internet. A real mesh testbed with two Layer 2 mesh solutions (Open802.11s and B.A.T.M.A.N) was implemented with different topologies. Some relevant results for a mesh network are discussed in terms of its scalability, performance and volatility.

Chapter 6

Advancement in wireless technology made human life become simple and easy going. Wireless Ad Hoc Sensor Network (WASN) is one of the friendly wireless networks used to monitor the most unfriendly and ever changing dynamic environment that restricts continuous human attention. WASN has drawn significant attentions due to its unique capabilities to deal with complex network operation in highly resource constrained network construct. This ad hoc and unstructured deployment of tiny sensor nodes operate with controlled transmission range, processing capabilities, as well as very limited battery backup. The severe power depletion affects the existence of active nodes. Hence, data forwarding and reliable packet routing in such phenomenon oriented network becoming a challenge. In this chapter the clustering and hierarchical routing approaches for WASN environment has been briefly presented followed by some optimization strategies applicable to cluster routing process. This chapter can help researchers to think fresh dimensions of ongoing research in WASN cluster routing.