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Wireless Body Area Networks and Their Applications – A Review

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ABSTRACT In this paper, a comprehensive review of the wireless body area network is provided. A review of the WBAN architectures, standard network topologies, and WBAN communication protocols is discussed in detail. Also, the security requirements of WBAN, security threats and types of attacks, and authentications used in WBAN are discussed. The paper also includes very detailed coverage of antenna types, antenna designs, and flexible antennas used in WBAN with some design considerations and comparisons. Some new energy harvesting technologies, materials used for energy harvesting, and energy management are also discussed. Energy harvesting and power management is an ever-growing area of research. Despite the fact that there are many nanogenerator-based energy harvesting methods, the demand for more efficient energy harvesting mechanisms is ever-increasing. The paper has an extensive discussion of energy harvesting and power management methods. Subsequently, some reviews of recent developments in wearable sensors and novel materials for developing wearable sensors are discussed. Finally, the application areas of WBAN are discussed.

INDEX TERMS Body area network, network security, wireless communication protocols, wearable sensors, energy harvesting, WBAN, flexible sensors, IoT

I. INTRODUCTION

A Wireless Body Area Network (WBAN) is a network of devices comprising sensors, actuators, and transceivers placed on the surface of the body, under the skin, or inside the body as implanted or digested devices. WBANs have become an interesting topic for researchers in many fields due to the rapid developments happening in the internet of things (IoT) research. The applications of WBAN and IoT have wide usages including remote health/fitness monitoring, rehabilitation, military and sports training, active combat operations, livestock farming, interactive gaming, personal information sharing, secure authentication, assisted living, etc. [1], [2]. The number of different types of sensors that are made for IoT applications increases rapidly, making the use of WBAN more cost-effective for many fields. Further, the amount of information that the WBANs provide from people in the field could never be obtained without wireless access. Such information is widely used for monitoring and training people on specific activities. It is obvious that with the increase in WBAN usage, there will be a rise in network issues and these

issues need to be addressed to get the maximum use of future WBAN. Since the WBAN generates and transmits personal biological information, the network security requirement is paramount. Other major issues are the power management of the WBAN, developing different sensors with minimum energy usage, and optimizing the network parameters for the best power management. Energy harvesting from the surrounding environment and through human movements is another crucial area of interest in WBAN where researchers have provided many different solutions [3]. Intra and inter WBAN data transmission consumes a considerable amount of power and choosing the correct antenna for a specific application is also critical. Antenna designs play a great role in reducing power usage, reducing the channel-loss, and increasing throughput [4]. The flexibility of sensors is another critical issue and therefore developing flexible sensors is another demanding research area [5], [6]. To provide comprehensive knowledge on all the above-mentioned areas of interest, this review paper analyses the commonly used and recently proposed WBAN architectures and communication

Wireless Body Area Networks Technology Implementation And Applications

**Mohammed I. Khalaf,Dhiya Al-
Jumeily,Alexei Lisitsa**



Wireless Body Area Networks Technology Implementation And Applications:

Wireless Body Area Networks Mehmet R. Yuce, Jamil Khan, 2011-12-06 The book provides a comprehensive overview for the latest WBAN systems technologies and applications The chapters of the book have been written by various specialists who are experts in their areas of research and practice The book starts with the basic techniques involved in designing and building WBAN systems It explains the deployment issue *Ultra Wideband Wireless Body Area Networks* Kasun

Maduranga Silva Thotahewa, Jean-Michel Redouté, Mehmet Rasit Yuce, 2014-04-17 This book explores the design of ultra wideband UWB technology for wireless body area networks WBAN The authors describe a novel implementation of WBAN sensor nodes that use UWB for data transmission and narrow band for data reception enabling low power sensor nodes with high data rate capability The discussion also includes power efficient medium access control MAC protocol design for UWB based WBAN applications and the authors present a MAC protocol in which a guaranteed delivery mechanism is utilized to transfer data with high priority Readers will also benefit from this book s feasibility analysis of the UWB technology for human implant applications through the study of electromagnetic and thermal power absorption of human tissue that is exposed to UWB signals

Intelligent Wireless Sensor Networks and the Internet of Things Bhanu Chander, Anoop Benet Nirmala, Koppala Guravaiah, G. Kumaravelan, 2024-06-12 The edited book Intelligent Wireless Sensor Networks and Internet of Things Algorithms Methodologies and Applications is intended to discuss the progression of recent as well as future generation technologies for WSNs and IoTs applications through Artificial Intelligence AI Machine Learning ML and Deep Learning DL In general computing time is obviously increased when the massive data is required from sensor nodes in WSN s the novel technologies such as 5G and 6G provides enough bandwidth for large data transmissions however unbalanced links faces the novel constraints on the geographical topology of the sensor networks Above and beyond data transmission congestion and data queue still happen in the WSNs This book Addresses the complete functional framework workflow in WSN and IoT domains using AI ML and DL models Explores basic and high level concepts of WSN security and routing protocols thus serving as a manual for those in the research field as the beginners to understand both basic and advanced aspects sensors IoT with ML DL applications in real world related technology Based on the latest technologies such as 5G 6G and covering the major challenges issues and advances of protocols and applications in wireless system Explores intelligent route discovering identification of research problems and its implications to the real world Explains concepts of IoT communication protocols intelligent sensors statistics and exploratory data analytics computational intelligence machine learning and Deep learning algorithms for betterment of the smarter humanity Explores intelligent data processing deep learning frameworks and multi agent systems in IoT enabled WSN system This book demonstrates and discovers the objectives goals challenges and related solutions in advanced AI ML and DL approaches This book is for graduate students and academic researchers in the fields of electrical engineering electronics and communication engineering computer

engineering and information technology

Applied Computing to Support Industry: Innovation and Technology

Mohammed I. Khalaf, Dhiya Al-Jumeily, Alexei Lisitsa, 2020-01-07 This book constitutes the refereed proceedings of the First International Conference on Applied Computing to Support Industry Innovation and Technology ACRIT 2019 held in Ramadi Iraq in September 2019 The 38 revised full papers and 1 short paper were carefully reviewed and selected from 159 submissions The papers of this volume are organized in topical sections on theory methods and tools to support computer science computer security and cryptography computer network and communication real world application in information science and technology

Autonomous Sensor Networks

Daniel Filippini, 2012-11-27 This volume surveys recent research on autonomous sensor networks from the perspective of enabling technologies that support medical environmental and military applications State of the art as well as emerging concepts in wireless sensor networks body area networks and ambient assisted living introduce the reader to the field while subsequent chapters deal in depth with established and related technologies which render their implementation possible These range from smart textiles and printed electronic devices to implanted devices and specialized packaging including the most relevant technological features The last four chapters are devoted to customization implementation difficulties and outlook for these technologies in specific applications

Industry

4.0 and People Analytics Vinod Kumar Shukla, Praveen Kulkarni, Deepika Gaur, Pradeep N, Jean Paolo G. Lacap, Amina Omrane, 2024-07-05 Industry 4 0 is revolutionizing the way companies do business by integrating new technologies into workplace practices and into production facilities and throughout their operations This new volume provides an insightful examination of the role of people analytics the data driven and goal focused method of studying people processes functions challenges and opportunities at work to elevate these systems and achieve sustainable business success in the era of Industry 4 0 It explores the use of AI and other technologies in analyzing cognition human potential and talent management for studying workplace diversity and inclusion in performance management and reward analytics to enhance emotional and social intelligence in decision making for employee training programs for employee wellness enhancement for leadership development and more

Ambient Assisted Living and Enhanced Living Environments

Ciprian Dobre, Constandinos x Mavromoustakis, Nuno Garcia, Rossitza Ivanova Goleva, George Mastorakis, 2016-11-02 Ambient Assisted Living and Enhanced Living Environments Principles Technologies and Control separates the theoretical concepts concerning the design of such systems from their real world implementations For each important topic the book bridges theory and practice introducing the instruments needed by professionals in their activities To this aim topics are presented in a logical sequence with the introduction of each topic motivated by the need to respond to claims and requirements from a wide range of AAL ELE applications The advantages and limitations of each model or technology are presented through concrete case studies for AAL ELE systems The book also presents up to date technological solutions to the main aspects regarding AAL ELE systems and applications a highly dynamic scientific domain that has gained much interest in the world of IT in the last decade In

addition readers will find discussions on recent AAL ELE technologies that were designed to solve some of the thorniest business problems that affect applications in areas such as health and medical supply smart city and smart housing Big Data and Internet of Things and many more Introduces readers to technologies supporting the development of Ambient Assisted Living applications Explains state of the art technological solutions for the main issues regarding AAL and Enhanced Living Environments Reports the development process of scientific and commercial applications and platforms that support AAL and ELE Identifies the advanced solutions in the context of Enhanced Living Environments *Sensor Networks for Smart Hospitals* Tuan Anh Nguyen, 2025-01-23 *Sensor Networks for Smart Hospitals* shows how the use of sensors to gather data on a patient's condition and the environment in which their care takes place can allow healthcare professionals to monitor well being and make informed decisions about treatment Written by experts in the field this book is an invaluable resource for researchers and healthcare practitioners in their drive to use technology to improve the lives of patients Data from sensor networks via the smart hospital framework is comprised of three main layers data insights and access Medical data is collected in real time from an array of intelligent devices systems deployed within the hospital This data offers insight from the analytics or machine learning software that is accessible to healthcare staff via a smartphone or mobile device to facilitate swifter decisions and greater efficiency Describes the fundamentals of sensors biosensors and smart hospitals Explains how sensors and implanted nanodevices can be used in smart healthcare Discusses how intelligent wireless medical sensor networks can be used for healthcare in the future Companion volume to *Advanced Sensors for Smart Healthcare*

Ultra Low Power Transceiver for Wireless Body Area Networks Jens Masuch, Manuel Delgado-Restituto, 2013-03-28 *Wireless Body Area Networks* WBANs are expected to promote new applications for the ambulatory health monitoring of chronic patients and elderly population aiming to improve their quality of life and independence These networks are composed by wireless sensor nodes WSNs used for measuring physiological variables e.g. glucose level in blood or body temperature or controlling therapeutic devices e.g. implanted insulin pumps These nodes should exhibit a high degree of energy autonomy in order to extend their battery lifetime or even make the node supply to rely on harvesting techniques Typically the power budget of WSNs is dominated by the wireless link and hence many efforts have been directed during the last years toward the implementation of power efficient transceivers Because of the short range typically no more than a few meters and low data rate typically in between 10 kb/s and 1 Mb/s simple communication protocols can be employed One of these protocols specifically tailored for WBAN applications is the Bluetooth low energy BLE standard This book describes the challenges and solutions for the design of ultra low power transceivers for WBANs applications and presents the implementation details of a BLE transceiver prototype Coverage includes not only the main concepts and architectures for achieving low power consumption but also the details of the circuit design and its implementation in a standard CMOS technology **Proceedings of the Ninth International Symposium on Consumer Electronics 2005 (ISCE 2005),**

14-16 June 2005, Macau SAR Robin Bradbeer, Y. H. Shum, 2005 Issues for 1998 2003 2008 2011 2014 cataloged as a serial in LC Towards the Wireless Information Society: Systems, services, and applications Ramjee Prasad, 2006 Accompanying DVD ROM contains further details on critical topics related to the research discussed in the book Internet of Nano-Things and Wireless Body Area Networks (WBAN) Fadi Al-Turjman, 2019-05-13 The Internet of Nano Things IoNT is a system of nano connected devices objects or organisms that have unique identifiers to transfer data over a computer or cellular network wirelessly to the Cloud Data delivery caching and energy consumption are among the most significant topics in the IoNT nowadays The book addresses data routing and energy consumption challenges and proposes nano sensing platforms in critical Wireless Body Area Networks WBAN This book covers both design and implementation aspects of data delivery models and strategies in a smart application enabled by the WBAN It focuses on smart data delivery approaches and energy savings aspects in a reliable IoNT systems **Proceedings of the 25th Annual International Conference of the IEEE**

Engineering in Medicine and Biology Society IEEE Engineering in Medicine and Biology Society. Conference, 2003
 Power Efficient Ultra-wideband Based Wireless Communication for Wireless Body Area Network Applications Kasun Thotahewa, 2014 Ultra wideband UWB is a lucrative wireless technology for Wireless Body Area Network WBAN applications requiring a power restricted operation high data rate and high level of miniaturisation An Impulse Radio UWB IR UWB system transmits data by means of short duration pulses Because of the pulse based nature of this data transmission less complex modulation schemes such as Pulse Position Modulation PPM and On Off Keying OOK can be used in IR UWB based systems resulting in significant power savings Because of the simplicity of pulse generation IR UWB transmitters require a reduced hardware complexity compared to other candidates such as Orthogonal Frequency Division Multiplexing OFDM based UWB enabling a low form factor and improved power efficiency This dissertation contributes to the state of the art in the IR UWB technology for WBAN applications in three major areas namely Power efficient Medium Access Control MAC protocol design for IR UWB based WBAN applications Development of a low power sensor platform and evaluation for on body communication Feasibility analysis of the IR UWB technology for human implant applications through study of the electromagnetic and thermal effects caused by UWB signals Although IR UWB transmitters provide excellent benefits such as high data rate transmission low power consumption and simple hardware implementation IR UWB receivers remain a bottleneck for the use of IR UWB technology in WBAN applications because of the following reasons Firstly IR UWB receivers are complex in design and consume excessive amount of power Secondly the synchronisation of IR UWB pulses at the receive stage using low power front end circuitry is a major difficulty that restricts the use of IR UWB receivers in WBAN applications An IR UWB based communication system has to be designed in a manner such that it enhances the advantages provided by IR UWB transmitters while avoiding the complexities introduced by IR UWB receivers In order to achieve this objective this dissertation presents a dual band communication system that uses IR UWB for data transmission from sensor

nodes while using narrow band technology for data reception The MAC protocol plays a vital role in determining the data transmission efficiency of IR UWB based WBAN applications Unlike in wireless narrow band applications MAC protocols for IR UWB applications should be designed in a manner so as to incorporate the unique advantages provided by the physical layer properties of IR UWB signals This dissertation presents the design and evaluation of a new dual band MAC protocol for WBAN sensor nodes This MAC protocol improves the advantages provided by IR UWB signals such as high data rate transmission and low power operation while avoiding the complexities introduced by IR UWB reception at the sensor node end In addition data priority is taken into consideration during the design of the MAC protocol and a guaranteed delivery mechanism is utilised to transfer high priority data The performance of the suggested MAC protocol is analysed extensively using simulations in terms of critical parameters such as packet error rate throughput packet delay and power consumption These simulation studies have provided optimised design parameters for hardware implementation of sensor nodes that use the proposed MAC protocol for WBAN applications Although IR UWB has been identified as a viable wireless technology for WBAN applications there are no full implementations of low power and small size IR UWB sensor platforms for healthcare monitoring applications in both commercial domain and research domain This dissertation presents the implementation and evaluation of a complete communication platform for WBAN applications that includes sensor nodes coordinator nodes and interfacing computer software In order to overcome the limitations created by the use of IR UWB receivers in IR UWB based sensor platforms this dissertation presents an implementation method for WBAN sensor nodes that uses IR UWB for data transmission from sensor nodes to coordinator nodes up link and a narrow band link to receive control messages from coordinator nodes to sensor nodes down link This unique technique provides the means of achieving low power consuming sensor nodes with high data rate capability Wireless communication for implantable devices is another potential area for the use of the IR UWB technology in WBAN applications Implantable systems such as neural recording systems and wireless endoscopy devices require high data rates low power consumption and small form factor These requirements can be fulfilled by the use of IR UWB technology This dissertation demonstrates the feasibility of the IR UWB technology for implant applications through the study of electromagnetic and thermal power absorption of human tissue that is exposed to IR UWB signals These studies are conducted through finite element simulations using human body models In addition the path loss of UWB signals for various implant applications such as neural recording units and capsule endoscopy systems are studied using numerical modelling techniques and provides a predictive model that can be used as a guide in designing IR UWB systems for implant applications The findings of this research contribute to the improvement of wireless healthcare monitoring systems by introducing a high data rate low power and efficient communication mechanism The dual band sensor nodes that are developed as the final product of this research are capable of operating at scalable data rates up to 5 Mbps with a power consumption as low as 11 nJ/bit The unique features of the MAC protocol suggested in this dissertation enable

the dual band communication system to operate in varying channel conditions with a controllable BER around 10⁻⁴. Simulation based analysis carried out in order to investigate the feasibility of IR UWB for implant communication shows that it is possible to set the IR UWB transmit power in the in body channel at a higher level than the FCC spectral mask such that tissue power absorption levels fall within the regulatory levels while outdoor power levels meet the FCC spectral requirements. These peak transmit power levels depend on the position of the implant within the human body. The path loss analysis carried out for UWB based Wireless Capsule Endoscopy (WCE) devices shows an average path loss of 80 dB for an in body propagation distance of 80mm.

IEEE Engineering in Medicine and Biology Magazine, 2003 **Proceedings of the IEEE Engineering in Medicine and Biology Society, Region 8 International Conference**, 2000 Materials Science, Computer and Information Technology S.Z. Cai, Q.F. Zhang, X.P. Xu, D.H. Hu, Y.M. Qu, 2014-07-16. Selected peer reviewed papers from the 2014 4th International Conference on Materials Science and Information Technology MSIT 2014 June 14-15 2014 Tianjin China **Academic Press Library in Biomedical Applications of Mobile and Wireless Communications: Wireless UWB Body Area Networks** Matti Hamalainen, 2014-03-05. Wireless sensor and body area networks (WSN and WBAN) respectively have been seen as a future way to monitor human's psycho-physiological signs remotely. There are a number of standards that could be used for building WBAN systems. However, wireless UWB networks based on IEEE 802.15.4a offer the advantages of a large frequency range and low power spectral density making it suitable for both WSNs and WBANs used for medical applications. The technology has matured sufficiently that it can be used to develop products for the marketplace. This book presents how the IEEE 802.15.4 2011 (former IEEE 802.15.4a) can be used in wireless body area networks (WBAN) for healthcare and welfare related applications. It gives a short overview on the IEEE 802.15.4 family and then gives details of IEEE 802.15.4 2011 based solutions. Presents how the IEEE 802.15.4 2011 (former IEEE 802.15.4a) can be used in wireless body area networks (WBAN) for healthcare and welfare related applications. Gives a short overview on the IEEE 802.15.4 family. Gives details of IEEE 802.15.4 2011 based solutions.

Proceedings of the ... IEEE Instrumentation and Measurement Technology Conference, 2004 *From WPANs to Personal Networks* Ramjee Prasad, Luc Deneire, 2006. This one stop resource offers you complete state of the art coverage of wireless personal area networks including critical discussions on current standards, important research and applications in the field. The book gives you a solid overview of Bluetooth and IEEE 802.15, the foundations of WPAN technology and explains how the Personal Operating Space (POS) concept is ushering in the WPAN revolution. It details how invisibility, automatic connection, service discovery and security form the POS and how the POS is the universal interface in WPANs.

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