Wake up Radio with Medium Access Control for wireless Networks: Survey and Discussions

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ABSTRACT

Wireless Sensor Networks are one of the most promising technologies in decades. WSNs are frequently utilized in applications such as medical, autonomous vehicles, networking, smart homes, environmental areas and other emergency applications. They are composed of huge quantities of sensor nodes capable of sensing, communication, processing, and storage. Transferring sensing data between these nodes faces several challenges due to the node's constraints, e.g., energy limitation, low computational capability, and low memory. In this paper we review the wireless sensor network protocol for the number of applications using wake up radio calls.

Keywords: Wireless Sensor Network, Duty Cycling, Frequency, Power Transmission, Wake-up Radios.

INTRODUCTION

Wireless Sensor Network (WSN) consists of multiple detection stations, called sensor nodes, spatially distributed and used to monitor physical or environmental conditions such as temperature or humidity, and to send its data in a cooperative manner through the network to a base station [1]. To do so, every node is usually equipped with sensors, a microcontroller and a transceiver.

Sensor nodes are typically small, lightweight and portable, yet WSNs can provide ubiquitous sensing and sensory data access through sensing-as-a service.

Among different power management techniques (e.g. dynamic voltage and frequency scaling, power transmission management), duty-cycling is the most popular approach to adapt the power consumption in WSNs. Indeed, this technique does not require sophisticated hardware components since microcontrollers and radio transceivers usually support sleeping modes for saving energy during idle time. Using this technique, the average energy consumption of a sensor node is controlled by dynamically adapting its wake-up interval. Thus, the PM also impacts the activation period of the Medium Access Control layer (MAC) controlling the wireless communications which usually represents a major part of the energy consumed by sensor nodes. Therefore, designing an efficient MAC protocol is the key to optimize the system performance in terms of energy, data throughput and latency [1].

Based on applications, WMSNs' traffic can be classified into two main categories, multimedia streams (e.g., video streaming) and multimedia data (e.g., snapshot multimedia content). Each of these categories can be further classified, according to the level of Quality of Service (QoS) required by the overlying application, into real-time and delay tolerant. Multimedia streaming applications put a lot of effort on achieving high bandwidth for a steady flow of data while real-time applications require a delay-bounded delivery of packets. In these cases, energy efficiency is of a lower priority. However, these applications are out of the scope of this paper. Here, they focus on non-streaming and delay-tolerant WMSNs that require relatively lower bandwidth demands than streaming ones [10].

Researchers and industry are trying to enhance the performance of wireless sensor networks in cost, throughput rate, energy consumption, robustness, networks throughput, quality of service and security, etc. In recent years, a lot of hardware and software enhancement has been achieved to improve the performance of wireless network. A series of logical techniques have been deployed to achieve the required network performance, such as energy aware MAC layer or cross-layer design technique, efficient sensing technique, and remarkable improvement in hardware design, etc., but these techniques have their own limitations.

Recently, cognitive techniques have been applied in wireless sensor networks to solve the limited performance of conventional WSNs. The cognitive technique is the process of knowing through perception, planning, reasoning, acting, and continuously updating and upgrading with a history of learning. The successfully integration of cognitive radio into wireless sensors, which could solve many challenges and limitations in current conventional WSNs, as mentioned above. Cognitive radio could achieve unutilized licensed and unlicensed spectrum band, which has the ability to utilize the available spectrum with opportunity. The incumbents or primary users (PU) have the right to use the spectrum anytime, whereas secondary users (SU) can utilize the spectrum only when the PU is not using it. CR allows unlicensed users to access multiple licensed channels opportunistically.

This nature of CR gives potential advantages to WSNs by increasing the communication reliability and improving the energy efficiency in high load network applications.

The rest of this paper is organized as follows in the first section we describe an introduction of about the wireless sensor network and protocol. In section II we discuss about the Wake up radios for the medium access control protocol, in section III we discuss about the related work. And finally in section IV we conclude and discuss the future scope.

II WAKE-UP RADIOS

Recent developments in CMOS power dissipation have resulted in the new paradigm for communication technology of wake-up radios (WuR). WuR technology is a novel, energy efficient hardware solution that offers listening power consumption orders of magnitude lower than that of traditional radios utilized in WSNs. For instance, the wake-up receiver (WuRX) adopted in this work requires 0.56 _A of current in listening mode while CC2420 radio module requires 18.8 mA. Recently, numerous WuRX hardware solutions have been developed and tested, each optimizing different parameters such as operating power, receiver sensitivity, communication range, frequency, and latency. A vast majority of these solutions are RF based, but alternatives include acoustic and optical. As these devices are low-power designs, the traditional radio and WuRXs are orthogonal to each other in terms of data rate and receiver sensitivity. This limits the choice of modulation techniques, receiver complexity, and the achievable communication range of WuRXs.

As a consequence of the ultra low power consumption, WuRXs are typically used in an always-on manner, but are only able to receive a simple, wake-up signal, hence motivating their name. Some WuRXs also provide computational capabilities at the cost of a few additional microwatts, allowing them to decode data embedded in the signal. As a result, it is possible to perform address matching or configure system parameters without activating the other sub-systems of the sensing node [8].

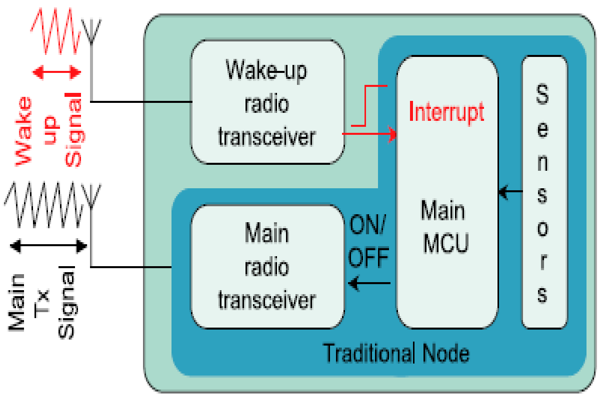

Fig 1: Node wake-up Radio architecture [9].

III RELATED WORK

Many researchers have proposed different MAC protocols in recent years with an aim to reduce the sensor nodes' energy consumption. The most common method is duty cycling, which involves turning off the transceiver intermittently to reduce the amount of energy used. Next, a sender-initiated protocol is introduced in which the sender sends a long preamble to seek the receiver's attention. This method has advantages over the synchronous MAC protocol because nodes in sender-initiated protocols do not need clock synchronization to create a schedule.

Alain Pegatoquet, Trong Nhan Le, Michele Magno et al. [1] In this paper, they present an innovative MAC protocol for energy-harvesting based WSNs exploiting ultralow-power wake-up radios. To overcome the limited range typical of wake-up radios, a multi-hop wake-up scheme based on a dual radio system is proposed enabling asynchronous communications between a base station and any node of the network while maintaining a low latency and a high energy efficiency. To reduce energy consumption, wake-up calls and data packets are transmitted using two distinct data rates. Combined with destination address decoding, using a higher data rate for data transmission also minimizes the risk of collisions. Their approach has been applied to monitoring applications composed of autonomous sensor nodes powered by indoor light energy. Md. Mahedee Hasan, Amit Karmaker, et al. [2] In this paper, a novel cooperative communication based asynchronous medium access control protocol is proposed for minimizing the adverse effects of asymmetric links and fulfilling sufficient QoS requirements. It forms a tree architecture among the nodes that allows a node to choose an alternative path to the sink in case of link asymmetry. Such tree formation significantly decreases the hidden terminal collisions. It also proposes a wakeup scheduling algorithm that uses the level number, duty cycle, and metrics value (residual energy, channel state information and distance) for the dynamic selection of wakeup time for each node. Finally, an efficient relay node selection algorithm is proposed that takes into consideration both cases: when the link is fully symmetric and when there is an asymmetric link. Mohammed Sani Adam, Lip Yee Por, et al. [3] In this research, a new protocol is proposed to prevent the problem mentioned above. The proposed mechanism has four components, and they are Initial control frame message, traffic estimation function, control frame message, and adaptive function. The initial control frame message is used to initiate the message transmission by the receiver node. The traffic estimation function is proposed to reduce the wake-up frequency of the receiver node by using the proposed traffic status register (TSR), idle listening times (ILTn, ILTk), and "number of wake-up without receiving beacon message" (NWwbm). The control frame message aims to supply the essential information to the receiver node to get the next wake-up-interval (WUI) time for the transmitter node using the proposed adaptive function.

Shah Murtaza, Rashid Al. Masud, Asmidar Abu Bakar, Salman Yussof et al. [4] In this research they observed that, due to the dynamic and random deployment of network topology, there is a significant drop in data delivery in single-radio due to single channel assignment to radio. In contrary, multi-radio mechanism has low delay, significant throughput (more data delivery rate) and can perform well in case of mobility. Moreover, multi-radio mechanism has more interference reduction as compared to single-radios. Unlike single radio based MAC protocol, in multi radio MAC protocol, control channel and data channel can be separated for control radio and data radios respectfully thus synchronization can be omitted in designing dynamic and robust MAC protocol. But, there is high scope of energy inefficiency in deploying multi-radio MAC protocol. Designing a MAC protocol is application specific. Murukesan Loganathan, Rosemizi Abd Rahim, et al. [5] This work focusses on reviewing software-based optimization for energy efficiency specifically in the network layer of the communication stack. The taxonomy of the routing protocols is derived based on (a) topology (b) reliability (c) network structure and (d) communication model. Due to the page constraints, only the topology and reliability-based routing protocols are reviewed from the energy efficiency perspective. Besides, the strength and weakness of the protocols are presented along with the ideas that can be used to improve the protocols further. Finally, the paper concludes with ideas to propel further research in this field. Vasily Desnitsky, Igor Kotenko et al. [6] The paper analyzes conditions of applicability of energy resource exhaustion attacks performed by various classes of intruders, models them on physical implementations of devices for two application areas, and calculates their performance indicators. Application areas are a TCP/IP network of end-user mobile devices and a self-organizing mesh network designed for operational management and emergency response. Muhammad Shafiq, Maqbool Ahmad et al. [7] In this paper author propose a new Multiple Access Control (MAC) protocol for CR-based IEEE 802.11ah systems, called Restricted Access with Collision and Interference Resolution (RACIR).They introduce a decentralized group split algorithm that distributes the participating stations into multiple groups based on a probabilistic estimation in order to resolve collisions. Furthermore, they propose a decentralized channel access procedure that avoids the HPT problem and resolves interference with the incumbent receiver. They analyze the performance of their proposed MAC protocol in terms of normalized throughput, packet delay and energy consumption with the Markov model and analytic expressions. The results are quite promising, which makes the RACIR protocol a strong candidate for the CR-based IoT environment. Rajeev Piyare, Amy L. Murphy et al. [8] In this article author presented a novel system that combines the unique power source of a Plant-Microbial Fuel-Cell to produce the electrical power to sustain a standard Tmote node coupled with a wakeup receiver. By providing a novel receiver-initiated MAC protocol that exploits both the wake-up receiver as well as the main, CC2420 radio on the Tmote, they concretely demonstrate in the laboratory that a 30s sampling rate can be sustained for a single remote node, in a star topology. Future work is required to experimentally establish scalability and the capabilities of the system outside the laboratory. Rajeev Piyare, Amy L. Murphy et al. [9] In this paper they present a comprehensive literature review of the research progress in wake-up radio (WuR) hardware and relevant networking software. First, they present an overview of the WuR system architecture, including challenges to hardware design and a comparison of solutions presented throughout the last decade. Next, they present various medium access control and routing protocols as well as diverse ways to exploit WuRs, both as an extension of pre-existing systems and as a new concept to manage low-power networking. Tarek AlSkaif, Boris Bellalta et al. [10] In this paper they investigate the suitability of several WSNs MAC protocols from different categories for low data rate WMSNs by analyzing the effect of some network parameters, such as the sampling rate and the density of multimedia sensors on the energy consumption of nodes. First, they develop a general multi-class traffic model that allows us to integrate different types of sensors with different sampling rates. Then, they model, evaluate and compare the energy consumption of MAC protocols numerically. They illustrate how the MAC protocols put some constraints on network parameters like the sampling rates, the number of nodes, the size of the multimedia sample and the density of multimedia nodes in order to make collisions negligible and avoid long queuing delays. Numerical results show that in asynchronous MAC protocols, the receiver-initiated MAC protocols (RI-MAC and PW-MAC) consume less energy than the sender-initiated ones (BMAC and X-MAC). B-MAC outperforms X-MAC when the sampling rate of multimedia nodes is very low and the polling periods are short. PW-MAC shows the lowest energy consumption between the selected asynchronous MAC protocols and it can be used in the considered WMSNs with a wider range of sampling rates.

IV CONCLUSION AND FUTURE SCOPE

Wireless sensor networks (WSNs) with energy harvesting capabilities have drawn increasing attention in the last few years, as they enable long-term monitoring applications. To increase the network lifetime and minimize servicing, WSN nodes are more and more equipped with rechargeable storage devices, coupled with ambient energy-harvesting systems able to extract energy from light, heat or vibrations? Energy harvesting systems also overcome battery replacement costs in difficult access zones. In this paper we review the emerging medium access control protocol for wake up radios for the asynchronous communications.

REFERENCES:-

[1] Alain Pegatoquet, Trong Nhan Le, Michele Magno, “A Wake-Up Radio-Based MAC Protocol for Autonomous Wireless Sensor Networks”, IEEE TRANSACTIONS ON NETWORKING, VOL. 27, 2019, pp 56-70.

[2] Md. Mahedee Hasan, Amit Karmaker, Mohammad Shah Alam, Andrew Craig, “Minimizing the Adverse Effects of Asymmetric Links: A Novel Cooperative Asynchronous MAC Protocol for Wireless Sensor Networks”, Sensors 2019, pp 1-24.

[3] Mohammed Sani Adam, Lip Yee Por, Mohammad Rashid Hussain, Nawsher Khan, Tan Fong Ang, Mohammad Hossein Anisi, Zhirui Huang, Ihsan Ali, “An Adaptive Wake-Up-Interval to Enhance Receiver-Based Ps-Mac Protocol for Wireless Sensor Networks”, Sensors 2019, pp 1-16.

[4] Shah Murtaza, Rashid Al. Masud, Asmidar Abu Bakar, Salman Yussof, “Towards Developing a MAC protocol for outer-WBAN communication for pilgrims’ health monitoring during hajj: A feasibility study “,International Journal of Engineering & Technology, 2018, pp 263-1271.

[5] Murukesan Loganathan, Rosemizi Abd Rahim, Zunaidi Ibrahim, Thennarasan Sabapathy, Muzammil Jusoh, R Badlishah Ahmad, Mohamed Elobaid Elshaikh, Mohamed Nasrun Osman, “Recent Advances in Wireless Sensor Network Routing Protocols: An Energy Efficiency Perspective”, IEEE 2018, pp 1-9.

[6] Vasily Desnitsky, Igor Kotenko, Danil Zakoldaev, “Evaluation of Resource Exhaustion Attacks against Wireless Mobile Devices”, Electronics 2019, pp 1-16.

[7] Muhammad Shafiq, Maqbool Ahmad, Azeem Irshad, Moneeb Gohar, Muhammad Usman, Muhammad Khalil Afzal, Jin-Ghoo Choi, Heejung Yu, “Multiple Access Control for Cognitive Radio-Based IEEE 802.11ah Networks”, Sensors 2018, pp 1-28.

[8] Rajeev Piyare, Amy L. Murphy, Pietro Tosato, Davide Brunelli, “Plug into a Plant: Using a Plant Microbial Fuel Cell and a Wake-Up Radio for an Energy Neutral Sensing System”, IEEE 2017, pp 1-9.

[9] Rajeev Piyare, Amy L. Murphy, Csaba Kiraly, Pietro Tosato, Davide Brunelli, "Ultra Low Power Wake-Up Radios: A Hardware and Networking Survey", IEEE COMMUNICATIONS SURVEYS & TUTORIALS, 2017, pp 2117-2157.

[10] Tarek AlSkaif, Boris Bellalta, Manel Guerrero Zapata, Jose M. Barcelo Ordinas, "Energy Efficiency of MAC Protocols in Low Data Rate Wireless Multimedia Sensor Networks: A Comparative Study", Preprint submitted to Journal of Ad Hoc Networks, 2016. Pp 1-19.

[11] T.R.Saravanan, M. Jayapriya, M.Gayathri, "A wireless sensor application for energy management in home appliances using smart", International Research Journal of Engineering and Technology, Vol-5, 2018. Pp 1218-1224.

[12] Anzar Mahmood, Nadeem Javaid, Sohail Razzaq, "A review of wireless communications for smart grid", Elsevier ltd. 2015. Pp 248-260.

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