International Journal of
Emerging Research in Management &Technology
ISSN: 2278-9359 (Volume-4, Issue-4)

Research Article

April 2015

A Review on Energy Aware MAC and Routing Protocols over Wireless Sensor Networks

Gurpreet Singh[1], Meenu Talwar[2], Sumit Kumar[3]
[*]Research Scholar, CGC College of Engineering,
Landran Road, Mohali, India
[2, 3]AP, CGC College of Engineering,
Landran Road, Mohali, India

Abstract—

A sensor network is a network of many smart devices, called nodes, which are spatially distributed in order to perform an application-oriented global task. The field of wireless sensing holds the potential to greatly change the way we live. Pushing these devices to smaller, cheaper, and more functional implementations greatly increases the scope of their application. WSNs will proliferate in a vast range of potential applications including academic, industrial, agricultural, domestic, military. In typical sensor network applications, the sensors are left unattended for a long period of time once they have been deployed. Keep in mind that improving QoS communication and energy efficiency is a system-wide task over WSNs. Many wireless sensor network MAC and routing protocols have been proposed and implemented yet. Efficient data dissemination is big challenges for WSNs. There are plenty of MAC and routing protocols have been specifically designed for WSNs where energy awareness is an essential design issue. There are some sensor MAC and routing protocols that rectifies many problems of efficient data dissemination; reducing the energy consumption of WSNs nodes, robust and reliable communication thus increasing the overall network lifetime. Managing uncertainty in such a resource-limited system in order to attain high-quality results will be an important issue. In this paper, we tries to investigate the problem of achieving high quality probabilistic results over uncertain data in sensor networks.

Keywords: WSN, QoS, MAC.

I. INTRODUCTION

A. Wireless Sensor Network

Wireless Sensor Networks (WSN) can be defined as self-configured and infrastructure less wireless network made of small devices equipped with specialized sensors and wireless transceivers. A sensor network is an infrastructure comprised of sensing, computing, and communication elements that gives an administrator the ability to instrument, observe, and react to events and phenomena in a specified environment. Sensor networks represent a new frontier in technology that holds the promise of unprecedented levels of autonomy in the execution of complex dynamic missions by harnessing the power of many inexpensive electromechanical micro-devices. A sink or base station acts like an interface between users and the network. One can retrieve required information from the network by injecting queries and gathering results from the sink. Typically a wireless sensor network contains hundreds of thousands of sensor nodes. The sensor nodes can communicate among themselves using radio signals [7].

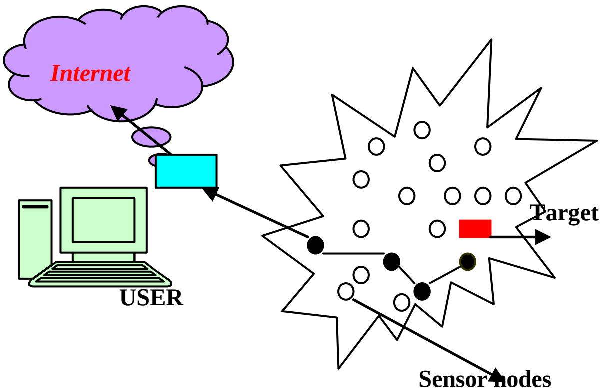

Figure 1.1: General Architecture of a Wireless Sensor Network.

A wireless sensor node is equipped with sensing and computing devices, radio transceivers and power components. The individual nodes in a wireless sensor network are inherently resource constrained: they have limited processing speed, storage capacity, an communication bandwidth. After the sensor nodes are deployed, they are responsible for self-organizing an appropriate network infrastructure often with multi-hop communication with them. Then the on board sensors start collecting information of interest. Wireless sensor devices also respond to queries sent from a control site to perform specific instructions or provide sensing samples. The working mode of the sensor nodes may be either continuous or event driven.

B. Wireless sensor Node Architecture

The architecture of a wireless sensor device is very simple. A WSN is composed of three main functional units: a sensing unit, a communication unit and a computing unit. General architecture of a wireless sensor node is, as shown in figure 1.2. These different elements of wireless sensor nodes are as follows [6, 8]:

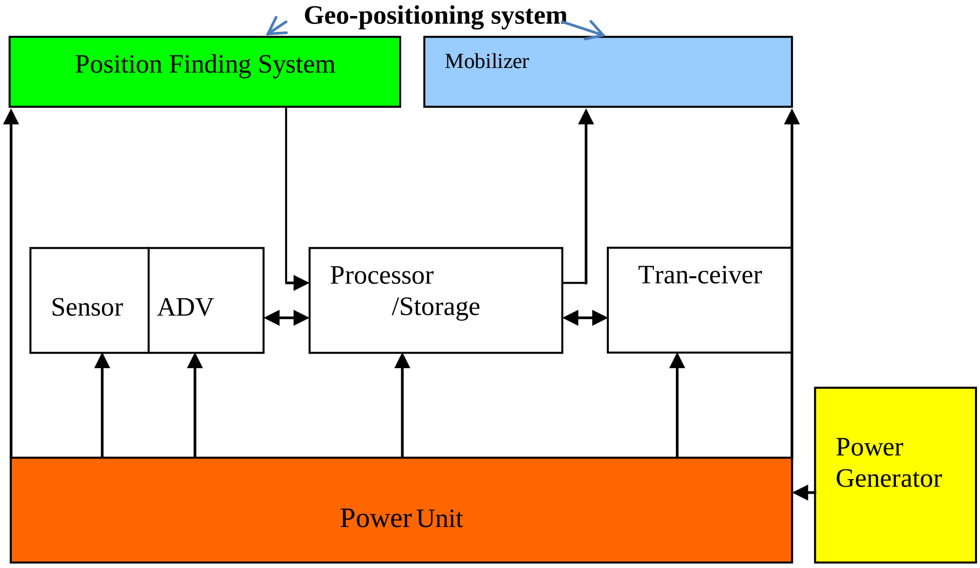

Figure 1.2: General Architecture of a Wireless Sensor Node

- *Processor:*

The computational tasks on a WSN device include the processing of both locally sensed in-formation as well as information communicated by other sensors. Processor may also incorporate advanced low power design techniques, such as efficient sleep modes and dynamic voltage scaling to provide significant energy savings.

- *Memory/storage:*

Storage in the form of random access and read-only memory includes both program memory and data memory. The quantities of memory and storage on board a WSN device are often limited primarily by economic considerations, and are also likely to improve over time.

- Transceiver:

WSN devices include a low-rate, short-range wireless radio (10–100 kbps, <100 m). Radio communication is often the most power intensive operation in a WSN device, and hence the radio must incorporate energy-efficient sleep and wake-up modes.

- *Sensors:*

Due to bandwidth and power constraints, WSN devices primarily support only low-data-rate sensing. The specific sensors used are highly dependent on the application; for example, they may include temperature sensors, light sensors, humidity sensors, pressure sensors, accelerometers, magnetometers, chemical sensors, acoustic sensors, or even low-resolution imagers.

- *Geo-positioning system :*

In many WSN applications, it is important for all sensor measurements to be location stamped. The simplest way to obtain positioning is to pre-configure sensor locations at deployment, but this may only be feasible in limited deployments. Particularly for outdoor operations, when the network is deployed in an *ad hoc* manner, such information is most easily obtained via satellite-based GPS. However, even in such applications, only a fraction of the nodes may be equipped with GPS capability, due to environmental and economic constraints. In this case, other nodes must obtain their locations indirectly through network localization algorithms.

- *Power Generator:*

For flexible deployment the WSN device is likely to be battery powered. While some of the nodes may be wired to a continuous power source in some applications, and energy harvesting techniques may provide a degree of energy renewal in some cases, the finite battery energy is likely to be the most critical resource bottleneck in most WSN applications.

C. Need for New Routing Protocols

The traffic pattern in WSNs is also different than in ad hoc networks. In ad hoc networks, we can assume that the traffic is distributed uniformly among all pairs of nodes of an ad hoc network. In WSNs, this may not be a very realistic assumption. In WSNs, the traffic flow is more likely to be between one or more sinks (base stations) and a set of or all of sensor nodes.

WSNs are most of the time application specific, the classical layered architecture, where each network layer is independent from each other, is not a very efficient paradigm for WSNs. Therefore, cross-layer design, where a couple of layers designed together or layers interact with each other to use resources in a more efficient manner, can be a more favourable paradigm for WSNs. As a result of this, the routing layer used in WSNs is usually application aware [1, 3]. In other type of networks, the routing layer cannot look inside and process the content of received packets. But in WSNs, the routing layer can look inside the received packets and can process the payload. This facilitates in-network processing of data in WSNs. For example, aggregation inside network is possible which reduces the amount of data transported and the number of packets transmitted. This saves energy. Moreover, since sensor nodes carry data belonging to a single application as opposed to ad hoc network nodes, which carry traffic of different types of applications at the same time, application specific policies can be applied. In WSNs, nodes can be assumed to be not mobile. But in wireless ad hoc networks, mobility is a common case for most of the scenarios. Therefore routing protocols for WSNs can be designed assuming there will be no mobility. This assumption facilitates more efficient design. Since nodes in a WSN are expected to be operated with irreplaceable batteries and in harsh environments, it is highly possible that some nodes will become non-functional at random times after they got deployed to the field. The routing protocols should be adaptive to those cases where some nodes fail and cannot take part in routing anymore. Therefore we need routing solutions that are robust against node failures and resource lack [2].

D. Sources of Energy Consumption

There are several sources of energy consumption in WSNs [3, 4] and those sources need to be opposed in order to save energy at the routing layer. Here are the sources of energy consumption related to communication as below:

- *Packet transmissions* : Each packet transmission causes energy consumption and energy consumed is proportional to the number of packets transmitted. Therefore a routing scheme that reduces the number of packet transmissions can save energy.
- *Packet receptions*: Each packet that is received by a node is processed and therefore causes energy consumption. The processing includes demodulation, copying of bytes, etc. Therefore routing protocols should try to reduce the packet receptions. A node sometimes receives not only the packets destined to itself, but also the packets destined to other nodes in the vicinity. This is called overhearing of packets. Each such packet is also received and processed at the transceiver electronics before actually dropped at the MAC layer. Therefore each such packet also causes energy waste. The number of overheard packets should be reduced.
- *Idle listening*: When a sensor node is in idle listening mode, not sending, or receiving data, it can still consume a substantial amount of energy. Therefore, a sensor node that is not sending or a receiving data should not stay in idle listening mode, but should go into sleep (be powered off). Depending on the communication technology, there might be several low-power modes available. Those modes should be used whenever possible.
- *Packet size*: Size of a packet determines how long a transmission will last. Therefore it is effective in energy consumption. We have to reduce the packet sizes if possible. This can be achieved, for example, by combining several packets into one large packet, or by compression.
- *Distance*: The distance between the transmitter and receiver affects how much output power is required at the transmitter to send the packets to the receiver; this in turn affects the energy consumption. Routing algorithms can select paths that use shorter distances between nodes and in this way can reduce energy consumption.

II. RELATED WORK

In Ref. [1], the authors present recent advancements in wireless communications and electronics, which have enabled the development of low–cost sensor, networks. The sensor networks can be used for various application areas (e.g., health, military, home). For different application areas, there are different technical issues that researches are currently resolving. The current state of the art of sensor networks is discussed in this a survey on sensor networks.

In [2], a novel scheme for a MAC address assignment is proposed. The two key features in this approach are the exploitation of spatial address reuse and an encoded representation of the addresses in data packets. To assign the addresses, they proposed a purely distributed algorithm that relies solely on local message exchanges. Other silent features of this approach are the ability to handle unidirectional links and the excellent scalability of both the assignment algorithm and address representation. In typical scenarios, the MAC overhead is reduced by a factor of three compared to existing approaches.

In [3]**,** in their paper studied the WSN and gives comparison and classification of Routing Techniques in Wireless Ad Hoc Networks. They define the Wireless ad hoc network as a collection of mobile nodes forming a temporary network without the aid of any centralized administration or standard support services regularly available on conventional networks. It differs from the infrastructure-based network by not having base stations to rely on but the network achieves connectivity by using an adhoc routing protocol. Absence of any fixed infrastructure pose number of different problems to this area. Some of the challenges that require standard solutions include routing, bandwidth constraints, hidden terminal problem and limited battery power. This paper present a comprehensive review for routing features and techniques in wireless ad hoc networks. For more than a dozen typical existing routing protocols, they compare their properties according to different criteria, and categorize them according to their routing strategies and relationships. Their paper discussed various criteria for classifying routing protocols and provided comparisons of more than a dozen routing protocols for wireless ad hoc network. There are still many challenges facing wireless ad hoc networks. However, because of their inherent advantage wireless ad hoc networks are becoming more and more prevalent in the world

P. Jiang1 et al. [4], gives a short overview of recent routing protocols for sensor networks and presents a classification for the various approaches. The four main categories studied in their paper are data-centric, hierarchical, location-based, and network flow and QoS-aware. Then, the existing hardware research platforms are explored as well as the software platforms such as simulation and development tools. Although the performance of these protocols is promising in terms of energy efficiency, further research would be needed to address issues such as Quality of Service (QoS). Another interesting issue for routing protocols is the consideration of node mobility. New routing algorithms are needed in order to handle the overhead of mobility and topology changes in such energy constrained environment. Since the routing requirements of each environment are different, further research is necessary for handling these instances.

In [5], summarized recent research results on data routing in WSN and classified the approaches into three main categories, namely data-centric, hierarchical and location-based. Few other protocols followed the traditional network flow and QoS modeling methodology. Their study also observed that there are some hybrid protocols that fit under more than one category.

The most interesting research issues in their study related to routing protocols for WSN are how to form the clusters so that the energy consumption and contemporary communication metrics such as latency are optimized, the consideration of node mobility, and integration of WSN with wired networks (i.e. Internet).

According to Xufei Mao et al [6], Opportunistic routing has been shown to improve the network throughput, by allowing nodes that overhear the transmission and closer to the destination to participate in forwarding packets, i.e., in forwarder list. The nodes in forwarder list are prioritized and the lower priority forwarder will discard the packet if the packet has been forwarded by a higher priority forwarder. One challenging problem is to select and prioritize forwarder list such that a certain network performance is optimized. In this paper, we focus on selecting and prioritizing forwarder list to minimize energy consumption by all nodes. We study both cases where the transmission power of each node is fixed or dynamically adjustable. We present an energy-efficient opportunistic routing strategy, denoted as EEOR. Our extensive simulations in TOSSIM show that our protocol EEOR performs better than the well-known ExOR protocol (when adapted in sensor networks) in terms of the energy consumption, the packet loss ratio, and the average delivery delay.

Yuping Dong et al [7], proposed applications for tracking or surveillance purposes based on WSN. Border security monitoring and terrorist attack prevention are just two of many crucial homeland security applications which rely upon WSN technologies. In these applications, a great amount of sensors powered by batteries are deployed in a particular region. They detect events, process and relay data to the sink node at the base station. Power conservation is critical to these sensors. In this paper, we propose a routing algorithm which separates the sensor nodes to several scheduling sets and keeps track of the energy level of each sensor. This algorithm balances power consumption among sensors, and therefore prolongs the network lifetime. Simulation results verify that our algorithm outperforms the EECCR algorithm proposed in.

Elham Hajian et al [8], there is all about the increase in lifetime of WSN by using automata for optimal route selection. These algorithms introduced for data transmission in such networks up to now, a single route is used for data transmissions that results in decrease in energy of nodes located on this route which in turn results in shortened network lifetime. In this paper a new method is proposed for selection of data transmission route that is able to solve this problem. This method is based on learning automata that selects the route with regard to energy parameters and the distance to sink. In this method energy of network nodes finishes rather simultaneously preventing breakdown of network into 2 separate parts. This will result in increased lifetime. Simulation results show that this method has been very effective in increasing network lifetime.

J. H. J.H. Kang et al. [9], proposed a layer-based algorithm to solve the unique ID assignment problem. According to this algorithm, headers take roles of the sink node in each group and they assign neighbors' IDs instead of the sink node. The proposed algorithm aims at assigning globally unique IDs to each node by using two grouping algorithms. Through these two grouping algorithms, it forms two-layer groups. This algorithm can start by building layer-based groups to assign IDs. This algorithm leads to save energy consumption by reducing communication overhead due to these well-organized layer-based groups. Through simulation reslts , the authors demonstrates that a high percentage of nodes (more than 99%) are assigned globally unique IDs with 25% efficient energy consumption than the reactive ID assignment scheme. The sink node can not only easily assign IDs to all other nodes via header nodes, but also save the energy consumption up to approximately 25% and reduce the communication overhead up to 40% than the reactive scheme according to the simulation.

P. P. Rewagad et al. [10], proposed Simple, Efficient. systematically formation of path connected cluster and Automatic Address Assignment for Wireless Sensor Network.. The Automatic address assignment scheme assigns each node both level-1 and level-2 addresses as its network address. The authors also provide information how to allow nodes to utilize shortcuts. In this paper, ZigBee has been proposed for addressing and routing on WSNs. It supports three kinds of network topologies, namely star, tree, and mesh networks. In ZigBee, network addresses are assigned to devices by a distributed address assignment scheme. Before forming a network, the coordinator determines the maximum number of children of a router (Cm), the maximum number of child routers of a router (Rm), and the depth of the network (Lm). The propose a low-cost, fully automated scheme to initialize it, assign addresses to nodes, and conduct ZigBee-like tree routing. First, a distributed network formation procedure will be launched by the coordinator t to divided nodes into two sets C and P. Then, a two-level address assignment scheme is conducted to assign a level-1 and a level-2 addresses to each node. A level-1 address is to uniquely identify a path or a cluster. A level-2 address is similar to ZigBee addressing but is confined within one cluster/path.

Q. Hu [11], proposed an energy efficient MAC protocol with adaptive transmit power scheme based on SMAC/AL named ATPM (Adaptive Transmit Power MAC). In SMAC/AL, all the nodes transmit data with a fixed power level, no matter how close the involved nodes are. The proposed ATPM can calculate the distance between the sender and the receiver by measuring the received power, and then adaptively decide the appropriate transmit power level according to the propagation model and distance.Simulations have been done to evaluate the performance of the proposed new protocol, by which we can find out that ATPM can really reduce energy consumption compared with SMAC/AL.

III. CONCLUSION

Wireless sensor networks are appealing to researchers due to their wide range of application potential in areas such as target detection and tracking, environmental monitoring, industrial process monitoring, and tactical systems. However, lower sensing ranges result in dense networks, which bring the necessity to achieve an efficient medium access control protocol subject to power constraints. Sensor networks are expected to be deployed in an adhoc fashion, with nodes remaining largely inactive for long time, but becoming suddenly active when something is detected. These characteristics of sensor networks and applications motivate a MAC and routing protocols that is different from traditional wireless in several ways: energy conservation and self-configuration are primary goals, while per-node fairness and latency are less important. Most routing protocols designed for WSNs follow a data-centric approach where the destinations are specified not by numerical addresses, but by values of the attributes of the data included in the packets. Data-centric routing is a new approach that is proposed for WSNs. Since WSNs are application-specific, the design space for routing algorithms for WSNs is very large. Efficient data dissemination and reliable MAC protocols are big challenges for WSNs.

REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, “Wireless Sensor Networks: A Survey,” Journal of Computer Networks 2002, vol.38, pp.393–422, 2002.

[2] C. Schurgers, G. Kulkarni, and M. B. Srivastava, “Distributed On-demand Address Assignment in Wireless Sensor Networks,” In Proceedings of IEEE Transactions on Parallel and Distributed Systems, Vol.13, pp. 1056-1064, October 2002.

[3] P. Jiang, Y. Wen, J. Wang, X. Shen, and A. Xue , “ A Study of Routing Protocols in Wireless Sensor Networks,” In IEEE, Vol. 1, pp. 266-270, June 2006.

[4] K. Akkaya , M. Younis , “A Survey on Routing Protocols for Wireless Sensor Networks,” In Elsevier, Vol. 3, pp. 329-345, May 2005.

[5] S. Dai, X. Jing, L. Li, “ Research and Analysis on Routing Protocols for wireless sensor networks,” In IEEE, Vol. 1, pp. 407-411, May 2005.

[6] Elham Hajian, Kamal Jamshidi,” Increasing WSN Lifetime by Using Learning Automata for Optimal Route Selection” International Conference on Information, Networking and Automation (ICINA) 2010, p.p 215-218.

[7] Yuping Dong, Hwa Chang and Zhongjian Zou, “Energy Aware Routing Algorithm for WSN Applications in Border Surveillance” Tufts University Medford, MA, p.p 530-535, 2010

[8] M. Ilyas and I. Mahgoub., “Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems”, International Journal of Distributed Sensor Networks, vol. 4, no. 4, pp. 369- 369, 2008.

[9] Jung Hun Kang, Myong-Soon Park, “Layer-based ID Assignment for Sensor Networks” IEEE, pp. 395-400, 2007.

[10] Prashant P. Rewagad, Harshal K. Nemade, “Automatic Cluster Formation and Address Assignment for Wireless Sensor Network” International Journal of Engineering and Science, Vol. 1, Issue 11, pp. 14-17, December 2012.

[11] Q. Hu, “An Energy Efficient MAC Protocol with Adaptive Transmit Power Scheme for Wireless Sensor Networks”, Journal of Multimedia, Vol. 6, No. 2, 2011.

