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A Survey On Routing Issues And Routing Protocols In Wireless Sensor Networks

Anbumalar.S[1], Prabhadevi.S[2]

[1] PG Scholar, Department of Computer Science & Engineering
Nandha Engineering College, Erode
anbu4malar@gmail.com

[2] Professor, Department of Computer Science & Engineering
Nandha Engineering College, Erode
s.prabhadevi@gmail.com

Abstract: ***Wireless Sensor Networks (WSN) has many applications like disaster relief operations, biodiversity mapping, medicine and health care. Recent researches show that many routing protocols are being developed that prolong the network lifetime and reduces energy consumption. Although there are many challenges in WSN only some are addressed. The main challenges to be addressed are energy consumption, Quality of Service (QoS), power management and network lifetime enhancement. To overcome these issues many efficient and effective routing protocols should be used. This paper surveys the routing design issues and routing protocols in WSNs.***

Keywords: WSN, routing protocols, network lifetime, energy consumption, quality of service

1. Introduction

A Wireless Sensor Network (WSN) is a group of spatially distributed autonomous sensors to monitor physical or environmental conditions like temperature, pressure and sound. The Wireless network is a dense of sensors, which collect data and also scatter environmental data. WSNs ease monitoring and controls the physical environments from distant locations with minimal energy consumption They have applications in a class of fields such as weather monitoring, climate monitoring, structural monitoring and gathering sensing information in remote locations by using sensors and sensor nodes [7,12].

A sensor network is a computer network composed of a massive number of sensor nodes [3]. Usually these devices are small and low priced, so that they can be produced and diffused in huge numbers, and so their resources in terms of data draining speed and bandwidth usage are severely restricted. There are different sensors such as pressure, thermal, microphone, etc. The sensor node is a node in the sensor network that is capable of performing some processing, gathering sensory information and communicates with other nodes in the network [3].

The various characteristics of wireless sensor networks are lifetime, scalability, coverage, responsiveness, routing methods and latency, maintenance, data collection. Routing is the process of selecting best paths in a network. To solve the problems in routing the data a various routing algorithms and routing mechanisms are used. These routing mechanisms and routing protocols have considered the characteristics of sensor nodes along with both application and architecture requirements. The various characteristics of wireless sensor networks are lifetime, scalability, coverage, responsiveness, routing methods and latency, maintenance, data collection. In this survey paper, routing protocols and some routing issues are discussed. The rest of the paper is organized as following sections: Section 1.2 presents system architecture, Section 1.3 presents the characteristics, Section 1.4 presents the literature survey on the routing protocols and routing protocol design issues, Section 1.5 presents comparison table and Section 1.6 presents a conclusion.

1.1 System Architecture for Wireless Sensor Network

All the nodes in the sensor network communicate with to each other either directly or through by other nodes. In WSNs, the routing is slightly different form the other networks. The reason is, there is no global credit scheme to deploy the sensor node in the network so an IP-based protocol can be applied here and all the nodes present in the network do not communicate. The sensor nodes are communicated with internet by using sink node. All collected sensor data are forwarded to sink node. The following Figure1 illustrates the structure of the sensor node.

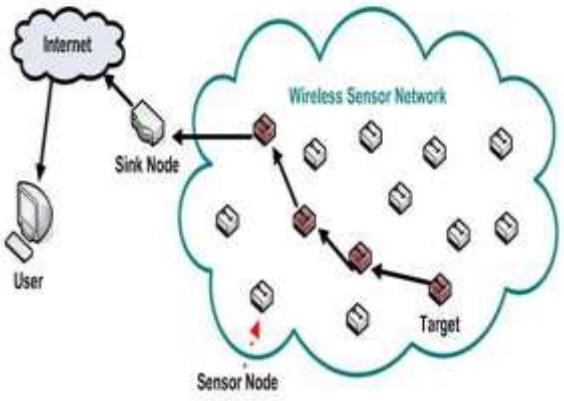

Figure 1. Architecture for Sensor Network

1.2 Characteristics of Wireless Sensor Networks

The main characteristics of a WSN are energy harvesting with optimal power policy, ability to manage with node failures, node mobility, node heterogeneity, Scalability to wide

ranging of distribution ability to resist raspy environmental conditions, ease of use and design of cross layer.

1.3 Routing Protocols

Designing of routing protocol in wireless sensor network is a problematic issue of concern mainly due to several factors like hardware constraints, fault tolerance, scalability, production costs, sensor network topology, transmission media and power consumption. The existing routing protocols TEEN, LEACH, PEGASIS etc address the some of the issues in routing data.

Threshold sensitive Energy Efficient sensor Network Protocol (TEEN)

Low Energy Adaptive Clustering Hierarchy (LEACH)[1] is one of the very first hierarchical routing protocols. LEACH includes distributed clustering and utilizes randomize rotation of cluster heads to evenly distribute the energy load in the network. It calculates a threshold value to elect the cluster head. LEACH protocol is very suitable for the applications, in these application requires a constant monitoring.

Power-efficient gathering in Sensor Information System (PEGASIS)

Power-Efficient Gathering in Sensor Information System (PEGASIS) is a near-optimal chain-based protocol [4]. In PEGASIS, nodes need to communicate to its nearest neighbor and they propagate to the base-station. Unlike LEACH, PEGASIS avoids cluster formation and uses only one node in the chain to transmit data to the base station.

Threshold sensitive Energy Efficient sensor Network Protocol (TEEN)

TEEN is a routing protocol for enhanced efficiency in WSNs. TEEN is suitable for reactive networks [1]. TEEN protocol is used for a simple temperature sensing application. The nodes sense their environment constantly. The sensed values can be stored in an internal variable in the node that is called the Sensed Value (SV).The node sets its data equal to the current value of sensed attribute and this value is transmitted. Employing soft threshold prevents from the redundant data transmission.

1.4.1 Routing Protocol Challenges

1.4.1.1 Energy Consumption

The main goal of the routing protocols is efficient information arrival between nodes in the sensor network. Thus, energy consumption is a greatest issue in the design of routing protocol in WSNs. Because of the limited energy resources of sensor nodes, information needs to be delivered in an energy efficient approach without compromising the content accuracy. Hence, many regular routing metrics such as the shortest path algorithm may be relevant. Instead, the reasons for energy consumption should be thoroughly investigated, and novel energy-efficient routing metrics should be developed for WSNs.

In GSTEB [4], the authors have proposed an energy efficient protocol for minimizing energy consumption. The energy efficient protocol is a General Self-Organized Tree-Based Energy-Balance routing protocol (GSTEB), which construct a routing tree using process information. In this protocol scheme, Base Station (BS) broadcasts their selection message to all other sensor nodes by assigning the root node. Finally, each node selects its parent by being only itself .Simulation results have showed that GSTEB has an improved performance than other energy efficient protocols in balancing energy consumption.

An effective transmission strategy plays a vital role in enlarging the lifetime and reduces the energy consumption of WSNs. An optimal distance based transmission procedure has been brought bring forward on the support of Ant Colony Optimization (ACO) in [8]. Essentially, aside introducing two concepts most energy efficient distance and most energy balanced distance, a local optimal-distance achievement mechanism is presented for not only high energy efficiency but also good energy balancing in WSNs. By working out a network lifetime assessment method, a global optimal distance acquirement scheme is provided to achieve energy depletion minimization for sensor nodes with minimal energy consumption.

The authors of [10] have come out with a novel routing scheme based on Energy Delay Index for Trade-off (EDIT). By considering EDIT, perform the cluster formation process in cluster head election. Cluster head election is a part of hierarchal routing protocols.

A dominant issue of research in WSNs with dense and random deployment of sensors is to minimize the energy consumption while ensuring the adopted coverage of the field of interest and connectivity of the network. The authors of [2] provide a demand-based coverage and connectivity preserving routing protocol to provide desired coverage and connectivity requirements in WSNs. The protocol reduces the energy consumption by assigning the minimum required sensing range to the sensors and using a scheduling protocol to periodically turn off the communication radios of the sensors in a coordinated manner and a local route optimization with a power control technique. Their proposed protocol is fully distributed and does not use any geographical information. They scheme has a distributed scheduling protocol to periodically turn off the communication radios of the non backbone sensors. Also a local route optimization with power control technique was used to reduce the energy expenditure. The system prolongs the lifetime of the network without compromising the desired coverage and connectivity.

In $(ACH)^2$ [12], provides an away Cluster Heads (CHs) with adaptive clustering habit scheme $(ACH)^2$ for WSNs. This projected scheme maximizes the steadiness period, network lifetime, and throughput of the WSN. The prettiness of this proposed scheme is its away CHs formation, and free association mechanisms. The algorithm controls the election and selection of Control Heads and it ensures the uniform load. On the other hand, free association mechanism removes back transmissions. Thus, this scheme operation minimizes the overall energy expenditure of the sensor network.

In a classic wireless sensor network, the node batteries near the sink drain quicker than other nodes due to the data traffic engaged towards the sink, leaving it attentive and disorderly the sensor data reporting. To lessen this problem, mobile sinks are projected. They implicitly provide load balanced data delivery

and achieve uniform energy expenditure across the network. On the other hand, marketing the position of the mobile sink to the network introduces an overhead in terms of energy consumption and information delays. In this scheme, they have proposed a Ring Routing [20], a novel, disseminated, energy efficient mobile sink routing protocol, suitable for various sensor applications, which aims to minimize this overhead and decreases the energy consumption. Ring Routing is a hierarchical routing protocol based on a ring structure which is intended to be easily accessible and easily reconfigurable.

Data collection is a major operation in wireless sensor networks. The design of data collection approach is challenging due to the limited energy recourses. This paper proposes a novel compressive data collection scheme for wireless sensor networks [9]. This technique uses the Opportunistic Routing (OR) for compressing data in WSN. Based on the real data sets, the simulation shows the performance of forwarding the packets and collecting the data from different paths. This reduces the energy consumption and maximizes the network lifetime.

1.4.1.2 Quality of Service

Sensor applications are time sensitive and so data must be transmitted within a specific time frame at the particular moment. The data have sensed with the longer elapse of time, data might become irrelevant leading to latency issues. Preservation of energy that impact the lifetime of the network in sensor applications and it is compared with the quality of data being transmitted.

QoS routing is an important research issue in WSNs, especially for mission-critical monitoring and surveillance systems which requires timely and reliable data delivery [19]. Existing work exploits multipath routing to guarantee both reliability and delay QoS constraints in WSNs. In this method the node selects and prioritizes the forwarding candidate set in an efficient manner. It is used to decreases the energy consumption and guarantees the quality of service. However, the multipath routing approach suffers from a significant energy cost. In this work, they provide the Geographic Opportunistic Routing (GOR) for QoS provisioning with both end-to-end delay and delay constraints in WSNs [19]. To improve the efficiency of QoS routing in WSNs, they have analyzed the problem of efficient GOR for multiconstrained QoS provisioning in WSNs.

To solve the problem of quality of service the authors introduced the novel approach, Curved Stick (CS) approach [17] that has reduced the energy consumption and guarantees the packet delivery. CS approach improves the performance by reducing path length, end to end latencies and overall energy consumption.

In WSNs, the existing multipath routing schemes have demonstrated the effectiveness of traffic distribution over multipath to fulfill the quality of service requirements of applications. Thus, by considering the packet delivery, congestion control and security for multipath, it is attractive to design a reliable, efficient and fault-tolerant routing scheme. A threshold algorithm is applied to split the packets into various segments [6]. The network traffic and load balancing algorithm that can adaptively adjust the load over multipath is proposed to improve the quality of service.

1.4.1.3 Network Lifetime

Depending on various factors, including the WSN topology and the availability of resources, the energy consumption of nodes in different paths of the data collection tree may vary widely, thus affecting the network lifetime of the overall network. The energy efficient randomized switching algorithm is used to improve the network lifetime [14].It poses the challenges are scalability and efficiency.

An energy-balanced routing method based on forward-aware factor (FAF-EBRM) has been proposed for maximizing network lifetime [1]. FAF-EBRM method is used to balance the energy consumption, improve the network lifetime and guarantees high quality of service. In the experiments, the performance of FAFEBRM is compared with LEACH and Energy Efficient Unevent Clustering (EEUC). The simulation results show that FAF-EBRM outperforms LEACH and EEUC for balancing the energy consumption and network lifetime.

The authors of [5] have come out with a novel tree based diversionary routing scheme for preserving source location privacy using hide and seek strategy to create diversionary or fake source node, which periodically emits fake event. This scheme also maximizes the network lifetime of wireless sensor network. The main idea is that the lifetime of wireless sensor networks depends on the nodes with high energy consumption and their scheme minimize energy consumption in hotspot and creates redundancy diversionary routes in non hotspot regions with abundant energy. It achieves privacy preservation and also network lifetime maximization.

Di Tang et al. [11] has proposed a novel secure and efficient Cost-Aware SEcure Routing (CASER) protocol to address the issues of routing data through two adjustable parameters: energy balance control (EBC) and probabilistic-based random walking. To solve this problem, they proposed an efficient energy deployment strategy to optimize the network lifetime and message delivery ratio under the same energy resource and security requirement and also provide a security analysis on the produced routing protocol. The novel CASER protocol can provide an excellent tradeoff between routing efficiency of data and energy balance in the network, and can significantly extend the lifetime of the sensor networks.

In sensor networks energy efficiency is very important for efficient transmission of data. In Progressive Decentralized Single-Hop (PDSH) data gathering protocol is proposed [13].The PDSH data gathering method works in uniformly deployed sensor networks. The main idea is to balance the energy consumption ratio between every neighboring ring. This scheme works with several phases, in each of which sensors may act in singlehop node or multihop mode. The rate of well balanced energy consumption results in the extension of the system's life time. This PDSH method also adapts in general cases and has been proven by mathematical demonstration to totally balance the energy consumption. This progressive decentralized scheme provides the best performance result for maximizing network lifetime.

To solve the issues of network lifetime a new novel methodology by joint designing of asynchronous sleep wake scheduling and opportunistic routing scheme has been developed. The Framework provides an optimal link cost assignment which yields the maximum lifetime in a distributed shortest path routing strategy. To obtain the approximate solutions by developing a heuristic algorithm, it is used to achieve the best performance problem. In particular, the

framework provides an optimal route selection to evaluate the energy efficiency in sensor networks was presented [15].

1.4.1.4 Power Management

The major issue in wireless sensor network is power management. The routing scheme for power management issues has been explained as follows.

An optimal control approach is used to solve the problem of routing protocols in sensor networks where the goal is to maximize the network's lifetime. In optimal and energy allocation scheme, the energy sources (batteries) at nodes are not assumed to be ideal but rather behaving according to a dynamic energy consumption model, which captures the linear and nonlinear behavior of actual batteries [18]. This optimal control approach shows that this optimal policy is, under very fair conditions, robust with respect to the battery model used. A joint routing and initial energy allocation problem over the network nodes with the same network lifetime maximization objective were focused.

Existing harvest-aware routing protocols incorporate node residual battery and forecast energy harvest information into routing decision information. Gina Martinez et.al [7] proposed novel a route selection scheme that considers the network power wastage due to battery over charging, which has been previously considered. This is complete by minimizing the cost of routing data associated with the energy consumption due to packet transmission, and the energy diffusion due to battery overcharge. Energy reaping technology enables WSNs to support power-hankering applications that may otherwise be impractical with current battery capacity limits.

To achieve reliable wireless communications within WSNs, this is essential to have reliable routing protocols to evaluate the reliability performance of different routing protocols. The authors of [20], have provided a model the reliability of different types of sensor nodes: are energy harvesting sensor nodes and battery-powered sensor nodes. Then this scheme presents a wireless link reliability models for each type of sensor nodes, where effects of different parameters like battery life-time, noise and location uncertainty are considered for analyzing the wireless link reliability. The single path routing algorithm reduces the achievable network throughput. Based on the sensor node and wireless link reliability models, they have compared the performance of different routing algorithms in terms of end-to-end path reliability and number of hops.

1.5 Comparison Table

The following table1 gives the comparison of various existing techniques and their advantages.

ISSUES	ROUTING PROTOCOL SCHEMES	ADVANTAGES
Energy Consumption	LEACH, DEEC,EEUC and Ring Routing	To minimize the energy consumption
Network Lifetime	ANYCAST, TEEN, RaSMaLAI And GSTEB	To improve the network lifetime
Quality of Service	GOR (Geographic Opportunistic Routing)	Guarantees the quality of service
Power Management	Optimal Control Approach, Wastage Aware Routing	To reduce the power consumption

Table1. Various routing schemes comparison

1.6 Conclusion

Wireless Sensor Networks have created wide range of challenges that still needs to be addressed. In this paper, our focus was on routing issues and routing protocols that have been developed for WSNs. In future work, number of sensors can be deployed in wide area to analyze the performance of the wireless sensor networks by developing new routing scheme.

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Author Profile

S.Anbumalar received the B.E. degree in Computer Science and Engineering from SVS College of Engineering in 2014. He is currently doing his M.E Computer science and Engineering in Nandha engineering college, Erode, India.