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A Review of Routing Protocols in Wireless Sensor Network

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Abstract: **Wireless Sensor Networks (WSN) is the collection of hundreds or thousands of homogenous and self-organized nodes which are called sensor nodes with great capabilities like sensing, computation, wireless communications and these sensors have the ability to communicate either among each other or directly to an external Base Station. These Sensor nodes will collect information and also plays an important role of a Router by communicating through wireless channels. The basic task of sensor networks is to sense the various events, collect all data and send it to their requested destination. Routing protocols of sensor networks are responsible for maintaining the routs in the network. Different routing protocols are designed to fulfill the shortcomings of the recourse constraint nature of the WSNs. This paper presents a review of the main routing protocols proposed for wireless sensor networks. In this paper, we analyze recent routing protocols for wireless sensor network and classify in three types of approaches according to network architecture in WSN. The three main categories on the basis of network structure are Flat-based, Hierarchical-based and location based routing protocols. Routing Protocols are also classified according to the operation they performed. This category consists of five types of routing protocols. Each routing protocol is described under the appropriate category followed by possible future research areas. This paper also includes various design issues and Routing challenges used in Wireless Sensor Network.**

Keywords: Wireless Sensor Network, Routing Protocols, Design Issues, Routing challenges, Network structure.

INTRODUCTION

Wireless Sensor Networks (WSNs), is one of the most important technologies for the twenty - first century. The deployment of wireless sensor networks has grown dramatically during the recent years, as they are increasingly used in many applications. The medical, environmental and military sectors are some of the most important areas, where the recent developments in WSNs technology have seen a wide use. WSNs consist of inexpensive, low power sensor nodes, which collect and disseminate data [1]. It can be viewed as a network consisting of hundreds or thousands of wireless sensor nodes which collect the information from their surrounding environment and send their sensed data to Base Station or Gateway Sensor node[2]. The important requirements of WSN are: Use large number of sensors, energy consumption is low, Self organization capability, and Querying ability. (ii) slower than wired networks (ii) Configuration is very complex when compared with Wired Networks.

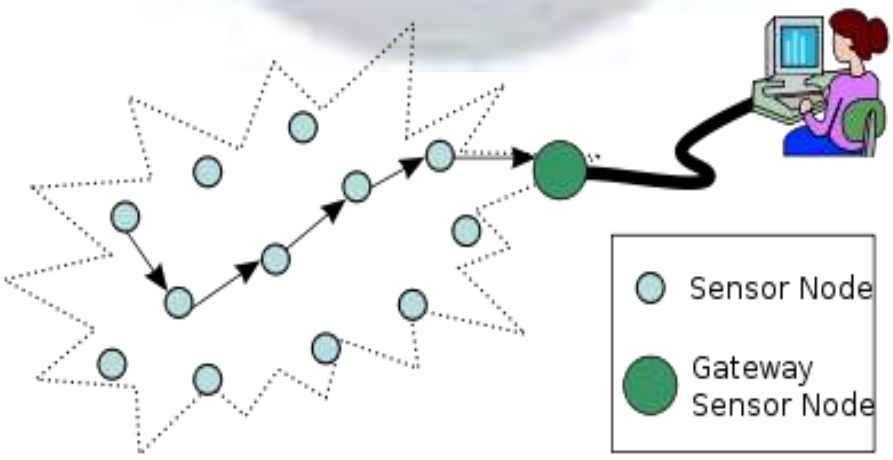

Figure 1: Wireless Sensor Network

Routing is a process of determining a path between source and destination for data transmission. In Wireless Sensor Networks, the network layer is mostly used to implement the routing of the incoming data and Routing protocol is an important factor in design of a communication stack. In multi-hop networks the intermediate sensor nodes have to relay their packets towards Base Station. Routing protocols, designed for sensor networks, must accomplish high reliability. In this paper, we analyze the current routing protocols and classify them into three categories on the basis of network structure. Very nearly the majority of the routing protocols can be delegated Flat-based, hierarchical or location-based[3]. Flat -based protocols are query based and depend with respect to the naming of desired information, which helps in disposing of numerous excess transmissions. Hierarchical-based protocols focus on clustering the nodes so cluster heads can do some collection and reduction of data in order to save energy. Location-based protocols uses the positioning of data to relay the information to the desired regions instead of the entire system.

In WSN, the routing protocols [4]are application specific, data-centric, capable of agglomeration of data and optimizing energy consumption. Main characteristics of routing protocols for WSN are simplicity, energy awareness, adaptability and scalability due to limited energy supply, limited computation power, limited memory and limited bandwidth of WSN [5]. The reminder of this paper is organized as follows. First we will discuss various Routing Challenges and Design Issues used in Wireless Sensor Network. Then, we will classify different routing protocols for wireless sensor network based on the architecture of network and their operation . At last we conclude this paper.

ROUTING CHALLENGES AND DESIGN ISSUES IN WIRELESS SENSOR NETWORK

The main design goal of WSNs is to carry out data communication while trying to prolong the lifetime of the network. There are numerous design and communication challenges in WSNs because of its application domain and their network structures. Besides, it also constraints resources nature makes it more difficult to cope with these challenges. The deployment of WSNs can vary both by its network structure and application type therefore it is required to consider both the design and communication challenges for efficient communication. Furthermore, these challenges have a greater influence on routing protocols design and degrade its performance. Both sensor nodes and base station have the influence on the performance of routing protocols of WSNs in following ways [6]:

- **Node Deployment:** Node deployment in WSNs is application dependent and affects the performance of the routing protocol. In a sensor network, the deployment is either deterministic (manual) or self-organizing (random). In deterministic situations, the sensors are manually placed and data is routed through pre-determined paths. But in self-organizing systems, the sensor nodes are randomly distributed creating an infrastructure in an ad hoc manner. When the distribution of nodes is not uniform, optimal clustering becomes a necessity to enable energy efficient network operation. In some applications like battle field and wildlife monitoring, sensor nodes are randomly deployed like being dropped from an airplane.

- **Scalability:** A system is said to be scalable if its effectiveness increases when the hardware is put-on and proportional to the capacity added [8]. Routing schemes make efforts with the vast collection of motes in WSNs which should be scalable enough to talk back to the events take place in the environment. The number of sensor node in the target area may be on the order of hundreds or thousands, or more so protocols must be able to scale to such high degree and take advantage of the high density of such networks. To handle network scalability, routing algorithm should have the capability to cope with scalable network.

- **Fault Tolerance:** Due to the uncertain deployment nature of WSN, the failure of sensor nodes can be seen due to harsh environmental conditions, physical damage or due to running out of power. But to achieve better performance, the networks should be fault tolerant. If a node failure occurs, the network should have the capabilities to maintain its functionalities and its performance should not be affected or the effect should be minimal [6].In case of failure of any sensor nodes, MAC and routing protocols must accommodate formation of new links so that sensor node failure should not affect the overall task of the sensor network.

- **Quality of Service:** Quality of service is determined by different applications differently. In some application the data transmission in time efficient manner is considered to be quality of service while in others low energy consumption or energy conservation is regarded as quality of service. In the later case the emphasis is on energy-aware routing protocols[7].

- **Transmission Media:** Sensor nodes communicating with each others in a multi-hop network are linked together by wireless medium hence the operation of this network is affected by some traditional problems that are usually attached with a wireless channel [7].Generally, Transmission Media is wireless (RF or Infrared), which is affected by fading and high error rate and affect the operation of WSNs.

- **Localization:** As in the wireless network, sensor nodes are deployed in ad-hoc manner so they do not have knowledge about their position. The problem of determining the position of nodes is called localization. The problem can be solved by: GPS, Beacon nodes and Proximity based localization. Other techniques such as Moore's algorithm, Radio Interferometric Positioning System and mobile assisted localization can be used.

- **Data Aggression:** Data aggregation is the combination of data from different sources by using functions such as suppression (eliminating duplicates), min, max and average. Similar packets from multiple nodes can be aggregated to reduce the transmission. Basically, It is a task of collecting the data from different sensors by removing the redundant data. The information aggregated must be delivered to sink node without loss of information. It is a major issue in Wireless sensor network as it determines the lifetime of network. There are number of security threads in data gathering which are reduced by compression technique and aggregation technique. The main goal of data aggregation algorithms is to gather and aggregate data from different sources by using different functions such as suppression, minimum(min),maximum(max) and average to achieve energy efficient and traffic optimization in routing protocols so that network lifetime is enhanced [8].

- **Hardware Constraint:** Wireless sensor network consists of sensor nodes, processing unit, transmitters, receivers and power unit. All Subunits of sensor node (e.g. sensing, processing, communication, power unit and mobilizer etc.) must consume extremely low power [9] and be contained within an extremely small volume. Hardware should be in such way that it should be capable of operating with high volumetric densities.

- **Energy Conservation:** As energy consumption determines the lifetime of the Wireless sensor network. Hence it becomes the major issue in Wireless sensor network. Majority of sensor nodes use battery power as their energy source. The sensor network can be deployed in hazards conditions so it becomes difficult to change their batteries or provider the energy so there is requirement of developing the networks which efficiently use the battery as energy [11].The energy consumption depends upon major operations of the sensor nodes which are Sensing, Communication and Data processing. The large amount of energy is consumed during the communication. Therefore the efficient protocols should be used at each layer in order to control energy consumption. Batteries with high power as rechargeable batteries like solar panel can be used in some wireless sensor networks. Multi-hop routing will consume less energy than direct communication.

- **Power Consumption:** Requirement such as long life time of sensor networks and restricted storage capacity of sensor nodes has directed to search a new scope to alleviate power consumption. Sidra Aslam discussed several schemes such as power aware protocol, cross-layer optimization, and harvesting technologies which help in reducing power consumption constraint in WSNs [10]. In multi-hop sensor networks, the multi-functioning of some nodes such as data sender and data router can cause topology change due to power failure which require new path for data transfer and restructure the network.

- **Production Cost:** The cost of single node is enough to justify the overall cost of the sensor network. So the cost of each sensor node must be kept low. When the cost of traditional sensors is less than cost of network then Wireless sensor network is not justified.

Besides, the above design issues there also exists communication challenges in WSNs which also degrade the performance of routing protocols. Routing protocols plays an important role in data transmission between source and destination. Therefore it is necessary to choose routing protocols for applications on the basis of routing objectives and application demand. Routing objective can be categorized on the basis of delivery needs.

ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORK

Routing in wireless sensor networks differs from conventional routing in fixed networks in many ways. There is no infrastructure, wireless links are not reliable, sensor nodes may fail, and routing protocols have to meet strict energy saving requirements. Many types of routing algorithms were developed for wireless networks in general. Different routing protocols are designed to fulfill the shortcomings of the recourse constraint nature of the WSNs. The deployed WSN can be differentiated according to the network structure or intended operations. Therefore, routing protocols for WSN needs to be categorized according to the nature of WSN operation and its network architecture.

WSN routing protocols can be subdivided into two broad categories, network architecture (structure) based routing protocols and operation (property) based routing protocols.

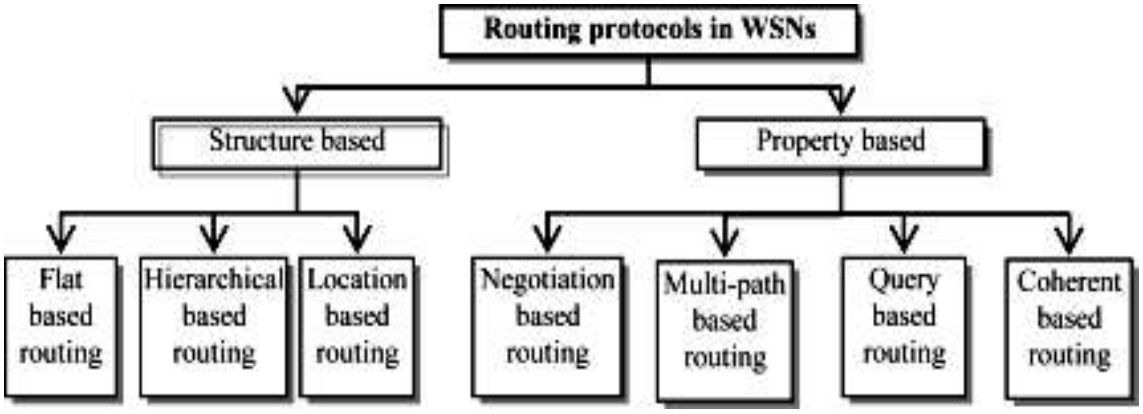

Figure 2: Classification of Routing Protocols in WSN

I. Architecture based Routing Protocols

Protocols are divided according to the structure of network which is very crucial for the required operation. The protocols included into this category are further divided into three subcategories according to their functionalities. Some examples of these protocols are

- Flat-based routing protocols
- Hierarchical-based routing protocols
- Location-based routing protocols

i. Flat-based Routing Protocols

When huge amount of sensor nodes are required, flat-based routing is needed where every node plays same role. Since the number of sensor nodes is very large therefore it is not possible to assign a particular Id to each and every node. This leads to data-centric routing approach in which Base station sends query to a group of particular nodes in a region and waits for response. Examples of Flat-based routing protocols are[12,13]:

- E nergy Aware Routing (EAR)
- Directed Diffusion (DD)
- Sequential Assignment Routing (SAR)
- Minimum Cost Forwarding Algorithm (MCFA)
- Sensor Protocols for Information via Negotiation (SPIN)
- Active Query forwarding In sensor network (ACQUIRE)

ii. Hierarchical-based Routing Protocols

When network scalability and efficient communication is needed, hierarchical-based routing is the best match. It is also called cluster based routing. Hierarchical-based routing is energy efficient method in which high energy nodes are randomly selected for processing and sending data while low energy nodes are used for sensing and send information to the cluster heads. This concept of hierarchical-based routing contributes greatly to the network scalability, lifetime and minimum energy. Examples of hierarchical-based routing protocols are[12,13]:

- Hierarchical Power-Active Routing (HPAR)
- Threshold sensitive energy efficient sensor network protocol (TEEN)
- Power efficient gathering in sensor information systems
- Minimum energy communication network (MECN)

iii. Location-based Routing Protocols

In this kind of network architecture, sensor nodes are randomly distributed in an area of interest and mostly known by the geographic position where they are deployed. They are located mostly by using GPS. The distance between nodes is estimated by the signal strength received from those nodes and coordinates are calculated by exchanging information between neighboring nodes. Location-based routing networks are [12,13]:

- Sequential assignment routing (SAR)
- Ad-hoc positioning system (APS)
- Geographic adaptive fidelity (GAP)
- Greedy other adaptive face routing (GOAFR)
- Geographic and energy aware routing (GEAR)
- Geographic distance routing (GEDIR)

II. Operation based Routing Protocols

WSNs applications are categorized according to their functionalities. Hence, classification of routing protocols is done according to their operations to meet these functionalities. The main aim behind their classification is to achieve optimal performance and to save the scarce resources of the network. Protocols classified to their operations are:

Table 1: Architecture based Routing Protocols

Routing Protocol	Basic Principle	Advantages	Examples
Flat-based	**Data- centric Routing Approach**	**Best suited for large amount of sensor nodes**	**SPIN.EAR, SAR, MCFA**
Hierarchical-based	**Cluster based routing approach**	**Energy efficient method, increased network scalability and lifetime**	**TEEN. MECN, HPAR**
Location-based	**Nodes are located by means of GPS**	**Best routing, reduce energy consumption, optimize the whole network**	**GEAR. GEDIR, APS**

- Multipath routing protocols
- Query based routing protocols
- Negotiation based routing protocols
- QoS based routing protocols
- Coherent routing protocols

i. Multipath Routing Protocols

As its name implies, protocols included in this class provides multiple path selection for a message to reach destination thus decreasing delay and increasing network performance. Network reliability is achieved due to increased overhead. Since network paths are kept alive by sending periodic messages and hence consume greater energy. Multipath routing protocols are[14]:

- Multi path and Multi SPEED (MMSPEED)
- Sensor Protocols for Information via Negotiation (SPIN)

ii. Query based Routing Protocols

This class of protocols works on sending and receiving queries for data. The destination node sends query of interest from a node through network and node with this interest matches the query and send back to the node which initiated the query. The query generally uses high level languages. Query based routing protocols are[14]:

- Sensor Protocols for Information via Negotiation (SPIN)
- Directed Diffusion (DD)
- COUGAR

iii. Negotiation based Routing Protocols

This case of protocols uses high level data descriptors to eliminate redundant data transmission through negotiation. These protocols make intelligent decisions either for communication or other actions based on facts such that how much resources are available. Negotiation based routing protocols are[14,15]:

- Sensor Protocols for Information via Negotiation (SPAN)
- Sequential assignment routing (SAR)
- Directed Diffusion (DD)

iv. QoS based Routing Protocols

In this type of routing, network needs to have a balance approach for the QoS of applications. In this case the application can delay sensitive so to achieve this quality of service, metric network have to look also for its energy consumption which is another metric when communicating to the base station. So to achieve better QoS, the cost function for the desired QoS also needs to be considered. Example of such routing are [14,15]:

- Sequential assignment routing (SAR)
- SPEED
- Multi path and Multi SPEED (MMSPEED)

v. Coherent Data Processing Routing Protocols

Coherent data processing routing is used when energy-efficient routing is required. In this routing scheme, nodes perform minimum processing (typically, time-stamping, suppression etc) on the raw data locally before sending for further processing to other nodes. Then it is sent to other nodes called aggregator for further processing known as aggregation [14,16].

Data processing in non-coherent processing involves three phases. In first phase target detection, its data collection and preprocessing of its data takes place. Then for the cooperative function the node needs to enter in phase 2 where it shows its intention to neighboring nodes. Here all neighboring nodes must be aware of the local network topology. Finally, in step 3 a center node is selected for further refined information processing. Therefore central node must have enough energy resources and computation abilities [14].

Table 2: Operation based Routing Protocols

Routing Protocol	Basic Principle	Advantages	Examples
Multipath-based	**Multiple path selection**	**Decrease delay , increase network performance**	**MMSPEED,SPIN**
Query-based	**Sending and receiving of queries for data**	**Self-adaptive, reduced average delay**	**COUGAR, DD, SPIN**
Negotiation-based	**Eliminate redundant data transmission**	**Efficient computation, scope of optimization**	**SPAN,SAR, DD**
QoS-based	**Balance approach for QoS**	**Better quality of service**	**SAR, SPEED, MMSPEED**
Coherent	**Minimum processing on raw data**	**Energy efficient routing**	–

CONCLUSION

In recent years, the routing protocols in WSN has become one of the most important research areas and introduced unique challenges compared to traditional data routing in wired networks. The main concept behind the routing protocol design is to keep the sensors operating for a long time, thus extending the network life time. Therefore, routing protocols designed for WSNs should be as energy efficient as possible to prolong the lifetime of individual sensors and network. In this paper we have identified a comprehensive list of routing challenges and design issues associated with Wireless Sensor Networks. We have also surveyed a sample of routing protocols by taking into account several classification criteria. For each of these categories, we have discussed a few example protocols. Each protocol has further types of protocols that are mainly used for routing the way to the packets broadcasting from sensor to the base station. Although many routing protocols have been proposed in WSN, but many issues still exist. So, there are still many challenges that need to be solved in the sensor networks. Routing protocols in WSNs is still an area of research as sensor nodes are finding newer and newer applications with time.

REFERENCES

[1]. I.F. Akyildiz, S. Weilian, Y. Sankarasubramaniam, E. Cayirci, A survey on sensor networks, IEEE Communications Magazine 40 (8) (2002) 102–114.
[2]. Sarjoun S. Doumit, Dharma P. Agrawal: Self-Organizing and Energy-Efficient Network of Sensors, IEEE, pp. 1-6 (2002).
[3]. Parul Khurana, Inderdeep Aulakh Punjab University Chandigarh, India "Wireless Sensor Network Routing Protocols: A Survey" International Journal of Computer Applications Volume 75– No.15, August 2013.
[4]. I. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," IEEE Communications Magazine, Volume: 40 Issue: 8, pp.102-114, August 2002.
[5]. Thomas Watteyne, Antonella Molinaro, Maria Grazia Richichi and Mischa Dohler, "From MANET To IETF ROLL Standardization: A Paradigm Shift in WSN Routing Protocols", IEEE COMMUNICATIONS SURVEYS & TUTORIALS, VOL. 13, NO. 4, FOURTH QUARTER 2011, pp. 688-707.
[6]. S. Vijayanand, R.M. suresh, "AN OVERLOOK ON ROUTING TECHNIQUES IN WIRELESS SENSOR NETWORKS," IET-UK International Conference on Information and Communication Technology in Electrical Sciences, Dr. M.G.R. University, Chennai, Tamil Nadu, India, 2007, pp.557-998.
[7]. A. Khetrapal, "Routing techniques for Mobile Ad Hoc Networks Classification and Qualitative/ Quantitative Analysis," Department of Computer Engineering, Delhi College of Engineering University.
[8]. Nandini .S. Patil and P. R. Patil, "Data Aggregation in Wireless Sensor Network", IEEE International Conference on Computational Intelligence and Computing Research, 2010.
[9]. Mark Hempstead, Michael J. Lyons, David Brooks, and Gu-Yeon Wei, "Survey of Hardware Systems for Wireless Sensor Networks " Journal of Low Power Electronics Vol.4, 1–10, 2008.
[10]. Sidra Aslam, Farrah Farooq and Shahzad Sarwar, (2009) "Power Consumption in Wireless Sensor Networks", Proceedings of the 7th International Conference on Frontiers of Information Technology.
[11]. Yang wenguo and Guo Tiande, "The Non-uniform Property of Energy Consumption and its Solution to the Wireless Sensor Network", 2nd International Workshop on Education Technology and Computer Science, March 6-7, 2010, pp. 186- 192.
[12]. G. Acs and L. Buttyabv. "A taxonomy of routing protocols for wireless sensor networks," BUTE Telecommunication department, Jan. 2007.
[13]. Jamal N. Al-Karaki, A.E. Kamal, "Routing techniques in wireless sensor networks a survey," Wireless Communications, IEEE Publication Vol.11, Issue. 6, pp.6- 28, Dec. 2004.
[14]. A. Khetrapal, "Routing techniques for Mobile Ad Hoc Networks Classification and Qualitative/ Quantitative Analysis," Department of Computer Engineering, Delhi College of Engineering University.
[15]. S. Sharma, D. Kumar and R. Kumar, "QOS-Based Routing Protocol in WSN," Advances in Wireless and Mobile Communications. ISSN 0973-6972 Vol. 1, No. 1-3, pp.51-57, 2008.
[16]. X. Hong, K. Xu and M. Gerla."Scalable Routing Protocols for Mobile Ad Hoc Networks," IEEE Network, University of California at Los Angeles, Aug. 2002.

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