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A Comprehensive Study of Various Routing Protocols in Wireless Sensor Network

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ABSTRACT

A Wireless Sensor Network (WSN) is a group of nodes prepared into a helpful network. Each node made up of handing out capability, may contain various types of memory, and have a RF transceiver, a power source and accommodate various sensors and actuators. Each node is joined to one or sometimes to a number of sensors. The nodes converse wirelessly and often self-organize after being deployed in an ad hoc fashion. Such systems can revolutionize the way we live and work. This paper describes the different routing protocols in WSN into three categories on the basis of network structure. The existing routing protocols presented with identifying the WSN routing protocols and their advantages and disadvantages are analyzed.

Keywords: WSN, Routing Protocols, Network Structure, clustered sensor network.

1. INTRODUCTION

WSN composed of small nodes with sensing, calculation, and wireless communications capabilities. Many routing, power management, and data transmission protocols have been particularly designed for WSNs where energy alertness is an essential devise issue. Routing protocols in WSNs might differ depending on the applications and network architecture.

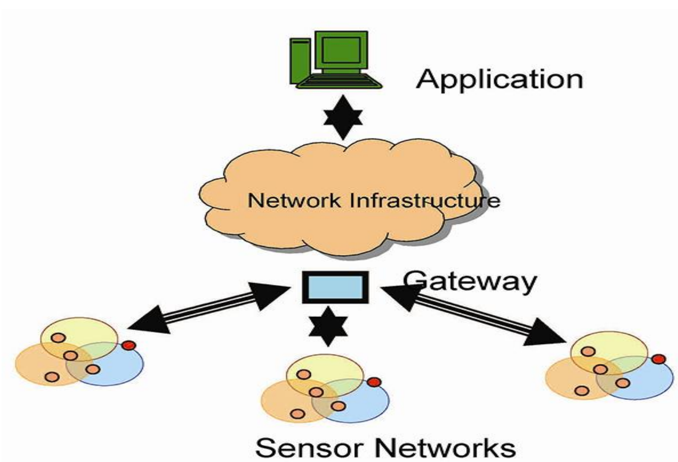

Figure 1: Wireless Sensor Network Architecture

WSNs are highly distributed networks of small, light weight wireless nodes, deployed in large numbers to monitor the environment or system by the measurement of physical parameters such as temperature, pressure humidity, sound, vibration, pollutants and collectively relay their sensed data to the sink node. Each node in the network allied to each other. Each sensor node in the network consists of three subsystems:

1) The subsystem which is used to sense the environment, Known as Sensor Subsystem
2) The subsystem which performs the local computations on the sensed data called as Processing Subsystem, and

3) The subsystem which is responsible for sharing the sensed data with the neighboring sensor nodes, known as Communication Subsystem

The Sensor Subsystem senses the data in the environment and the Processing Subsystem processes the sensed data. The communication subsystem sends the cumulative data to the sink node. A sensor network consists of different types of sensors such as seismic, thermal, visual, and infrared. The size of a sensor node may vary from micro to macro. The cost of the sensor nodes are varying from one to few hundred dollars. The sensor nodes communicate through wireless within the short distance.

There are some key features of a sensor network associated with routing techniques given as below:

1) Sensor nodes are limited in resources and is deployed in a pre-defined or random way
2) Nodes in a sensor network may not have global identification (ID) because of the large amount of over head and large number of sensors [1]
3) The data in sensor networks are bound either downstream to nodes from a sink or upstream to a sink from nodes.

2. WSN AS CLUSTERED SENSOR NETWORK

We consider WSN as clustered sensor networks because clustering allows for scalability of MAC and routing. Cluster heads also serve as fusion points for aggregation of data, so that the amount of data that is actually transmitted to the base station is reduced.

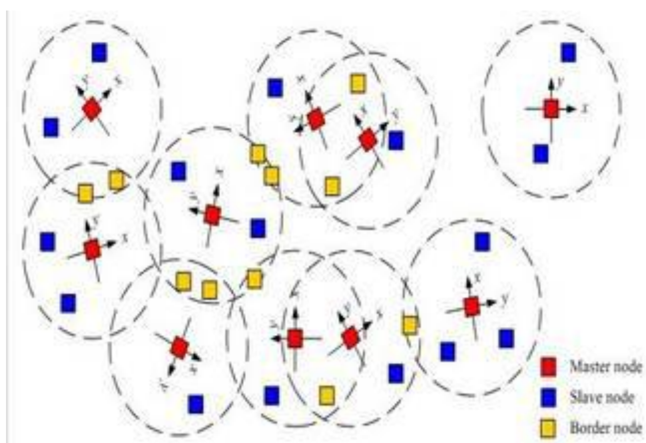

Figure 2: WSN as clustered sensor network

Clustered sensor networks can be classified into two broad types:-

Homogeneous sensor networks:

In this network all the sensor nodes are identical in terms of battery energy and hardware complexity. In this network it is evident that the cluster Head nodes will be over-loaded with the long range transmissions to the remote base station, and the extra processing necessary for data aggregation and protocol co-ordination with static clustering. Consequently the cluster head nodes expire before other nodesHowever it is desirable to ensure that all the nodes run out of their battery at about the same time, so that very little residual energy is wasted when the system expires.

Heterogeneous sensor networks:

In a heterogeneous sensor network, different battery energy with two or more different types of nodes are used. In few cluster head nodes, more complex hardware and the extra battery energy can be embedded in that way reducing the hardware cost of the rest of the network. However fixing the cluster head nodes means that role rotation is no longer possible. To reach the cluster head, the sensor nodes use single hopping and the nodes that are farthest from the cluster heads always spend more energy than the nodes that are closer to the cluster heads.

On the other hand when nodes use multi-hopping to reach the cluster head, the nodes that are closest to the cluster head have the highest energy burden due to relaying. Consequently there always exists a non-uniform energy drainage pattern in the network. Sensor networks have two desirable characteristics which are lower hardware cost, and uniform energy drainage. The homogeneous networks achieve the latter while heterogeneous networks achieve the former. But in the same network, both features cannot be incorporated.

Single hop and Multi-hop Clustered sensor networks:
The sensor nodes communicate directly with the cluster head using a single hop transmission called *single hop network*. To adjust their transmit power the nodes are assumed to have power control features.

In a *multi-hop network*, node uses multi-hopping to reach the cluster head. In both cases, the cluster heads use single hopping to reach the base station, since we assume a remote base station.

Applications of WSN: There are broad applications of **WSN,** which as**-** Area monitoring, Air pollution monitoring, Forest fires detection, Greenhouse monitoring, Landslide detection, Machine health monitoring, Water/wastewater monitoring, Landfill ground well level monitoring and pump counter, Agriculture, Fleet monitoring and Environmental monitoring etc. A number of WSNs have been deployed for environmental monitoring.

3. DIFFERENT ROUTING PROTOCOLS

Routing in WSNs can be divided into flat-based routing, hierarchical-based routing, and location-based routing depending on the network structure. In flat-based routing, all nodes are typically assigned equal roles or functionality. In hierarchical based routing, nodes will play different roles in the network. In location-based routing, sensor nodes' positions are exploited to route data in the network.

A routing protocol is considered adaptive if certain system parameters can be controlled in order to adapt to current network conditions and available energy levels. In addition to the above, routing protocols can be classified into three categories, proactive, reactive, and hybrid, depending on how the source finds a route to the destination. In proactive protocols, all routes protocols, routes are computed on demand. Hybrid protocols use a combination of these two ideas.

When sensor nodes are static, it is preferable to have table-driven routing protocols rather than reactive protocols. A significant amount of energy is used in route discovery and setup of reactive protocols. Another class of routing protocols is called cooperative. In cooperative routing, nodes send data to a central node where data can be aggregated and may be subject to further processing, hence reducing route cost in terms of energy use. Many other protocols rely on timing and position information.

Flat-Based Routing (Flooding):
In flat-based routing, all nodes are typically equal and act the same functionality. Each node not only can collect the data from the interesting events, but also can relay the information data by serving as a relay node. The initial routing table is builded by flooding. According to whether the establishment and maintenance of routing table is initially sponsored by the sink nodes, flat-based routing can be classified into three modes:

Even-driven mode: Sensor Protocols for Information via Negotiation
Sensor Protocols for Information via Negotiation (SPIN) that disseminates all the information at each node to every node in the network assuming that all nodes in the network are potential BSs. This enables a user to query any node and get the required information immediately. These protocols make use of the property that nodes in close proximity have similar data, and hence there is a need to only distribute the data other nodes do not posses. The SPIN family of protocols uses data negotiation and resource-adaptive algorithms.

Nodes running SPIN assign a high-level name to completely describe their collected data (called meta-data) and perform metadata negotiations before any data is transmitted. This ensures that there is no redundant data sent throughout the network. The semantics of the meta-data format is application-specific and not specified in SPIN. For example, sensors might use their unique IDs to report meta-data if they cover a certain known region. In addition, SPIN has access to the current energy level of the node and adapts the protocol it is running based on how much energy is remaining. These protocols work in a time-driven fashion and distribute the information all over the network, even when a user does not request any data.

The SPIN family is designed to address the deficiencies of classic flooding by negotiation and resource adaptation. The SPIN family of protocols is designed based on two basic ideas:

1)Sensor nodes operate more efficiently and conserve energy by sending data that describe the sensor data instead of sending all the data; for example, image and sensor nodes must monitor the changes in their energy resources.
2) Conventional protocols like flooding or gossiping-based routing protocols waste energy and bandwidth when sending extra and unnecessary copies of data by sensors covering overlapping areas [2].

Rumor Routing Each node maintain a event table, the table entries contain the basic description of events, source node, last hop node; in addition, there exists a long lifetime message, which is used to broadcast the description of events in WSNs [5]. Rumor routing is the same as SPIN in essence; the main difference is that it maintain a list of events information table, therefore it maintains a path to source nodes. So after initialization of flooding, corresponding path information has been established [6]. Thus it avoids a large number of flooding process in SPIN, and then significantly save energy. The protocol is mainly applied to those scenarios with a large number of queries and a small number of events. If network topology frequently changes, performance of rumor routing will be substantially reduced.

Energy-Aware Routing
The Energy-Aware Routing protocol is a destination initiated reactive protocol, is to increase the network lifetime Although this protocol is similar to directed diffusion, it differs in the sense that it maintains a set of paths instead of maintaining or enforcing one optimal path at higher rates. These paths are maintained and chosen by means of a certain probability. The value of this probability depends on how low the energy consumption is that each path can achieve. By having paths chosen at different times, the energy of any single path will not deplete quickly [7].

This can achieve longer network lifetime as energy is dissipated more equally among all nodes. Network survivability is the main metric of this protocol. The protocol assumes that each node is addressable through class-based addressing that includes the locations and types of the nodes. The protocol initiates a connection through localized flooding, which is used to discover all routes between a source/ destination pair and their costs, thus building up the routing tables. High cost paths are discarded, and a forwarding table is built by choosing neighboring nodes in a manner that is proportional to their cost. Then forwarding tables are used to send data to the destination with a probability inversely proportional to the node cost.

Traditional flooding model
Flooding and gossiping are the most basic traditional network routing. They do not need to know the network topology. Each sensor nodes will transfer those messages received to their neighbors nodes, and this process will be repeated until the messages arrive at sink nodes or is overtime due TTL. Gossiping improves flooding algorithm in some ways, and each sensor nodes only transfer the messages to a random neighbor node [8]. However, even though flooding and gossiping is very simple and suitable for any network structure, but both algorithms are not practical in application-specified network, and they can easily bring implosion and overlap problems.

Query-driven mode based protocols:
a) Directed diffusion
Directed diffusion is a data-centric (DC) and application-aware paradigm in the sense that all data generated by sensor nodes is named by attribute-value pairs. The main idea of the DC paradigm is to combine the data coming from different sources en route (in-network aggregation) by eliminating redundancy, minimizing the number of transmissions, thus saving network energy and prolonging its lifetime. Unlike traditional end-to-end routing, DC routing finds routes from multiple sources to a single destination that allows in-network consolidation of redundant data.

In directed diffusion, sensors measure events and create gradients of information in their respective neighborhoods. The BS requests data by broadcasting interests. An interest describes a task required to be done by the network. An interest diffuses through the network hop by hop, and is broadcast by each node to its neighbors. As the interest is propagated throughout the network, gradients are set up to draw data satisfying the query toward the requesting node. Each sensor that receives the interest sets up a gradient toward the sensor nodes from which it receives the interest. This process continues until gradients are set up from the sources back to the BS.

b) Gradient-based Routing
This algorithm makes an improvement on Directed Diffusion, in order to get the total minimum hop numbers other than the total shortest time. In the process of transmitting Interest messages, the algorithm takes the minimum hops between sink nodes and sensor nodes as its height value, and calculates the height difference with its neighbor node as a link Gradient of two nodes [9]. When routing data, nodes select the link with the largest Gradient to forward data. While being flooded, Interest messages record the number of hops taken. This allows a node to discover the minimum number of hops to sink, called the node's height. The difference between a node’s height and that of its neighbor is considered the gradient on that

link. A packet is forwarded on the link with the largest gradient. Although the techniques to increase the network lifetime are built upon GBR, the main principles are general enough to also apply them to other ad-hoc routing protocols

4. LOCATION BASED ROUTING or GEOGRAPHIC PROTOCOL

The location-based routing concept was developed for packet radio networks and interconnection network. This protocol assumes that the sensor nodes know their location information. The source node sends the data to the destination where the location of the destination is already known. Location information helps to route the data to reach the destination. Those algorithms require location information for sensor nodes. We assume sensor nodes can directly obtain their position or calculate the distance according to other position known nodes.

Minimum Energy Communication Network:
MECN is firstly designed for wireless networks and found that it also can be directly applied to WSNs by the researchers. It is noticed that the cost of direct communication between two nodes is higher than forwarding data by several relay-nodes. So MECN identifies a relay region for every node, which consists of all relay-nodes that are more energy efficient than direct transmission. When two nodes need to exchange messages, MECN will choose a minimum energy path to transmit data according to Bellman-Ford shortest path method [10].

The main idea of MECN is to find a sub network that will have fewer nodes and require less power for transmission between any two particular nodes. In this way, global minimum power paths are found without considering all the nodes in the network. This is performed using a localized search for each node considering its relay region.

Small-MECN:
The small MECN (SMECN) is an extension to MECN. In MECN, it is assumed that every node can transmit to every other node, which is not possible every time. In SMECN possible between any pair of nodes are considered. However, the network is still assumed to be fully connected. The sub-network constructed by SMECN for minimum energy relaying is provably smaller than the one constructed in MECN. Hence, the sub-network constructed by SMECN is smaller than the one constructed by MECN if the broadcast region is circular around the broadcasting node for a given power setting. The subnetwork computed by SMECN helps in sending messages on minimum- energy paths. Moreover, the sub network constructed by SMECN makes it more likely that the path used is one that requires less energy consumption [11].

Geographic and Energy-Aware Routing (GEAR):
GEAR protocol proposed for routing queries to target regions in a sensor field. The localization equipments (GPS) help the sensor nodes to know their current locations. The sensors are aware of their left over energy and also the location information and remaining energy of their neighbors [12]. GEAR uses energy aware heuristics that are disseminate the packet inside the target region. The idea is to restrict the number of Interest in Directed Diffusion and add geographic information into Interest packet by only considering a certain region rather than sending Interest to the whole network by means of flooding. GEAR uses based on geographical information to select sensors to route a packet toward its destination region [13].

Then, GEAR uses a recursive geographic forwarding algorithm to energy aware and geographically informed neighbor selection heuristics to route a packet towards the target region. Therefore GEAR save energy consumption significantly in this way. GEAR introduces an estimated cost and a learning cost and chooses next hop by calculating the difference between the estimated cost and the learning cost [14].

Geographic Adaptive Fidelity (GAF):
GAF is an energy-aware location-based routing algorithm designed primarily for mobile ad hoc networks, but may be applicable to sensor networks as well. The network area is first divided into fixed zone and form a virtual grid. Inside each zone, nodes collaborate with each other to play different roles [15].

Coordination of Power Saving with Routing Span protocol is used in WSN to improve the energy efficiency of sensor nodes. During the idle time, the radio will be turned off to save the energy. When it receives a packet, a coordinator forwards the packet to a neighboring coordinator if any, which is the closest to the destination that is closer to the destination [17].

5. HIERARCHICAL BASED ROUTING

Many researchers carried out their research in the hierarchical routing and a hierarchical approach breaks the network into clustered layers. Nodes are grouped into clusters with a cluster head that has the responsibility of routing from the cluster to the other cluster heads or base stations. Data travel from a lower clustered layer to a higher one [24]. Although, it hops from one node to another, but as it hops from one layer to another it covers larger distances. This moves the data faster to the base station. Clustering provides inherent optimization capabilities at the cluster heads [25].

CONCLUSION

Routing in sensor networks is a new area of research, with a limited but rapidly growing set of research results. This paper, a great deal of analysis and research is presented, and classify the routing protocols into three categories: Flat-based routing (Flooding), Hierarchical-based routing (Clustering) and Location-based routing (Geographic) on the basis of network structure. There also highlight the advantages and disadvantages of each routing protocols. As our study reveals, it is not possible that a routing algorithm is suitable for all scenarios and for all applications. Although many routing protocols have been proposed in WSNs, many issues still exist and there are still many challenges that need to be solved in the sensor networks.

REFERENCES

[1]. S. Hedetniemi and A. Linesman, "A Survey of Gossiping and broadcasting in Communication Networks," IEEE Network, vol. 18, no. 4, 1988, pp. 319–49.

[2]. D. Braginsky, D. Estrin, "Rumor Routing Algorithm for Sensor Networks. in the Proceedings of the First Workshop on Sensor Networks and Applications (WSNA)," Atlanta, GA, October 2002.

[3]. I. Akyildiz et al., "A Survey on Sensor Networks," IEEE Commun. Mag., vol. 40, no. 8, Aug. 2002, pp. 10214.

[4]. http://www.ieee802.org/15/

[5]. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayiri, "A surveyon sensor networks," IEEE Communications Magazine, vol.40, Issue:8pp. 102-114, August 2002.

[6]. D. Braginsky and D. Estrin, "Rumor Routing Algorithm for Sensor Networks," Proc. 1st Wksp. Sensor Networks and Apps., Atlanta, GA, Oct. 2002.

[7]. R. C. Shah and J. Rabaey, "Energy Aware Routing for Low Energy Ad Hoc Sensor Networks," IEEE WCNC,Orlando, FL, Mar. 17–21, 2002.

[8]. S. Hedetniemi, A. Liestman. "A survey of gossiping and broadcasting in communication networks. Networks," 1988, 18(4): 319349.

[9]. C. Schurgers, M.B. Srivastava, "Energy efficient routing in wireless sensor networks," in the MILCOM Proceedings on Communications for Network-Centric Operations: Creating the Information Force, McLean,VA, 2001.

[10]. V. Rodoplu, T. H. Ming, "Minimum energy mobile wireless networks,"IEEE Journal of Selected Areas in Communications, 1999, 17(8): 1333

[11]. L. Li, and J. Y. Halpern, "Minimum-Energy Mobile Wireless Networks Revisited," IEEE ICC 2001, vol. 1, pp. 278–83.

[12]. G. Xing, C. Lu, R. Pless, and Q. Huang, "On greedy geographic routing algorithms in sensingcovered networks", Proceedings ACM MobiHoc'04, Tokyo, Japan, May 2004, pp. 31-42.

[13]. Y. Yu, D. Estrin, R. Govindan, "Geographical and Energy-Aware Routing: A Recursive Data Dissemination Protocol for Wireless Sensor Networks," UCLA Computer Science Department Technical Report, UCLA2CSD TR20120023 , May 2001.

[14]. Y. Xu, et al., "Geographyinformed Energy Conservation for Ad-hoc Routing," Proc. 7th Annual ACM/IEEE Int'l. Conf. Mobile Comp. and Net., 2001, pp. 70–84.

[15]. B. Chen, K. Jamieson, H. Balakrishnan, and R. Morris, "Span: An energy-efficient coordination algorithm for topology maintenance in ad hoc wireless networks", Proceedings ACM MobiCom'01, Rome, Italy, July 2001, pp. 85-96.

[16]. B. Chen, K. Jamieson, H. Balakrishnan, and R. Morris, "Span: An energy-efficient coordination algorithm for topology maintenance in ad hoc wireless networks", Wireless Networks, vol. 8,no.5, Sept. 2002, pp. 481-494

[17]. B. Nath and D. Niculescu, "Routing on a curve", ACM SIGCOMM Computer Communication Review, vol. 33, no.1, Jan. 2003, pp. 155-160.

[18]. Jamal Al-Karaki, and Ahmed E. Kamal, "Routing Techniques in Wireless Sensor Networks: A Survey", IEEE Communications Magazine, vol 11, no. 6, Dec. 2004, pp. 6-28.

[19]. N. Bulusu, J. Heinemann, and D. Estrin, "GPS-less Low Cost Outdoor Localization for Very Small Devices", IEEE Personal Communication Magazine, vol. 7, no. 5, Oct. 2000, pp. 28-34.

[20]. I. Stojmenovic and X. Lin, "GEDIR: Loop-Free Location Based Routing in Wireless Networks," Int'l. Conf. Parallel and Distrib. Comp. and Sys., Boston, MA, Nov. 3–6, 1999.

[21]. F. Kuhn, R. Wattenhofer, and A. Zollinger, "Worst-Case Optimal and Average-Case Efficient Geometric Ad Hoc Routing," Proc. 4th ACM Int'l. Conf. Mobile Comp. and Net., 2003, pp. 267–78.

[22]. S.K. Singh, M.P. Singh, and D.K. Singh, "A survey of Energy-Efficient Hierarchical Clusterbased Routing in Wireless Sensor Networks", International Journal of Advanced Networking and Application (IJANA), Sept.–Oct. 2010, vol. 02, issue 02, pp. 570–580.

[23]. Y. Yu, R. Govindan, and D. Estrin, "Geographical and energy aware routing: A recursive data dissemination protocol for wireless sensor networks", Technical Report UCLA/CSD-TR-01-0023, UCLA Computer Science Department, May 2001.