Analysis of Routing Protocol of Wireless Sensor Network

Dr.M.Murugesan

Professor in Computer Science&Engineering, Anurag Engineering College (Autonomous, Ananthagiri (V&M), Suryapet (Dt) ,Telangana (TS)-508206.
murugeshvim@gmail.com

Abstract— Severalroutingprotocolshavebeenproposedtomaximizethesensornetworkslifetime.However,highly restricted resource and frequent node failure are two major challenges. Relevant technical research into wireless sensor network has become an issue of intense interest. In recent years, achievements in research on routing protocol of wireless sensor network have been summarized, analyzed and compared. Features of wireless sensor networks have been introduced and key factors of its routing protocol design have been introduced. According to the realization features of protocol, routing protocol of wireless sensor network has been divided into five categories, and each category of important protocols has been elaborated and analyzed. Finally, the features of these protocols are summarized and compared and the development trend of such research has been forecasted.

1.INTRODUCTION

AWirelesssensornetwork(WSN)iscomposedofa large number of sensor nodes deployed in an ad hoc manner. Each sensor node senses phenomena in the environment in which it is deployed, performs a local processing on the sensed data, and then transmits it to a sink. WSNs have been used in many application domains such as intelligent houses, intelligent agriculture, battlefield surveillance, integrated patient monitoring, environment monitoring, chemical/biological detection and other commercial applications . As sensor nodes arebattery-poweredandareuneasy,ifnotimpossibletorecharge,the energy efficiency is a critical design concern in WSNs. This implies minimizing energy of calculation, sensing and communication tasks. But, especially minimizing communications as, radio transmission is expensive in terms of energy. In recent years, research on WSN routing protocol has become a topic of great interest in the research into wire- less sensor networks. Relatively important WSN routing protocols were summarized in this thesis and they are classified into five categories according to the realization feature of protocols: flooding routing protocol, hierarchical routing protocol, routing protocol oriented on data, routingprotocolbasedonpositioninformationprotocolbasedonQoS.Themosttypicalroutingprotocols of these five categories are introduced respectively. The structure of the wireless sensor network and key factorsof the routing protocol design are introduced in Section 2; existing WSN routing protocols are classified and the typical routing protocols of each category are introduced in Section 3; routing protocols are analyzed andcompared in Section 4;

A wireless sensor network is composed of a large number of sensor nodes deployed in the monitoring area and it forms an ad hoc network system via wireless communication. It is aimed to sense, collect and process the information of the monitoring object in the area covered by network. The organization of the wireless sensor network is shown in Figure 1. A large number of sensor nodes are distributed in the monitoring area to collect and monitor data of an object and transmit the data processed by collaboration with sink nodes. The sink nodes transmit information to task management nodes via the Internet or communication satellite. Each sensor node in the wireless sensor network combines the functions of node and router of a traditional network [3].
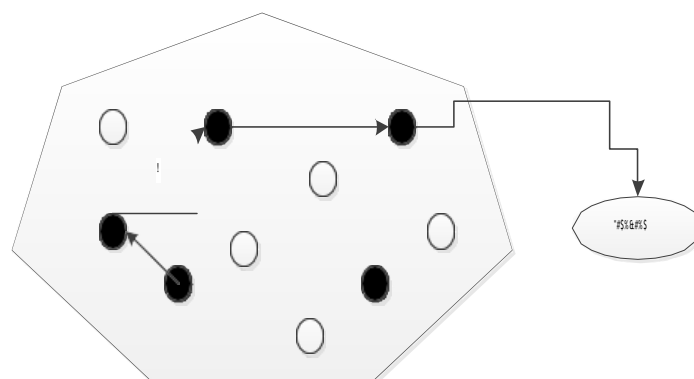

Fig 1.   Organization of Wireless Sensor Network

Compared with the traditional wireless MANET net- work, the wireless sensor network has the following unique features:

(1) Highly restricted resource: as the resource limit of the sensor node is powerful, transmitting power, on-board resource, processing ability, communication bandwidth and storage capacity are all restricted in a lowscope.

(2) Noglobalidentification:thenumberofsensornodes is great and the overhead would be very large if not main- taining global identification. Therefore, being different from traditional routing protocol, global identification is generally not adopted in the sensor network [4,5];

(3) Many-to-one communication: different from point- to-point communication of a traditional network, almost all the applications in the sensor network require multiple source sensor nodes to transmit the data acquired to spe- cific sink nodes[7].

(4) Big data redundancy: multiple source sensor nodes canacquirelargeamountsofsimilardatasotheamountof data redundancy of the sensor network is large. As wire-lesssensornetworkisgreatlydifferentfromthetraditional MANET, and the design objectives and realization meth- ods of their routing protocols are different. Therefore, MANETroutingprotocolcannotbedirectlyappliedinthe wireless sensornetwork.

B. Key factors of WSN routing protocoldesign

The major technical challenge of wireless sensor net- work is to complete sensing, communication and control functions when energy resource, computing power, stor- age space and communication ability of nodes are highly restricted. Therefore, the main design objective of the routingprotocolofthewirelesssensornetworkistoestab- lish an effective energy path, form a reliable dataforward- ing mechanism and realize the maximum life cycle of network. The structure of the wireless sensor network has the following key factors affecting its routing protocol design.

(1) Network dynamic: most network system structures assume the sensor node is static and the sink node is mov- able. Whether the monitoring object is moving or static depends on the specific application. For example, in the application for military target tracking, the monitoring objective is dynamic and moving, and in the application forforestfireprevention,themonitoringobjectisstill[8].

(2) Network topology: divided into fixed and ad hocto- pology configurations. In a fixed topology, sensor nodes are configured manually and data are transmitted via the preset path; in an ad hoc topology, nodes are scattered randomly in an ad hocform.

(3) Data sending mode: the data sending mode can be divided into continuous mode, event-driven mode, re-quest-driven mode and mixed mode subject to different application demands. Continuous mode means that the sensor nodes send data periodically subject to preset time intervals; event-driven mode and request-driven mode meanthatthesinknodesproduceacorrespondingeventor request to trigger data sending; mixed mode is a combina- tion of the abovemodes.

(4) Node type: generally all the sensor nodes are iso- morphic. If a sensor with a different function is needed in a specific application, there are isomorphic sensor nodes. Recently,somesuggestreplacingthesensornodewiththree functions of data forwarding, sensing and collecting with special node with weak resource limitation.

(5) Path selection: there are two selection modes of multi-hop and single hop. Sending energy of broadcast frequency identification is in direct proportion to the square of the distance. As energy consumption of the multi-hop path is less than that of a single-hop path, the multi-hop path is adopted. However, the overhead of to- pology management and link connection of a multi-hop path is large, so a single-hop path is more effective when the distance between the sensor node and sink node is short.

As WSN is highly correlative with application, the WSN routing protocol has diversity as well and it is diffi- cult to evaluate which protocol is better. Generally, the following indexes are required to evaluate whether the routing protocol design of a wireless sensor network is successful.

(1) Energyeffectiveness/lifecycle:energyeffectiveness is the most important factor in the sensor network design. Reducing energy consumption as much as possible to prolongthelifecycleofthenetworkistheprimarygoalof WSN routing protocol design[9].

(2) Reliability/fault tolerance: sensor node loses are eas-ilyduetoenergyexhaustionorenvironmentalinterference, but a partial sensor nodes' lose will not affect the task of the entirenetwork.

(3) Scalability: there may be hundreds or thousands of sensor nodes in some applications and the routing design will collaborate with a large number ofnodes.

(4) Delay:delaytimeofthesensornetworkrefersto the time from observer sending the request to receiving re- sponse information. Delay must be reduced as much as possible during the design of the routingprotocol.

2.WSN ROUTING PROTOCOLANALYSIS

A.   Classification of WSN routingprotocol

Data are transmitted reliably between sensor nodes and sinknodesinthewirelesssensornetworkviatheprotocol. As the wireless sensor network is highly correlative with the application, a single routing protocol cannot meet different application demands. Subject to the features of different applications, many routing protocols have been studied. These protocols can be generally classified into five categories: flooding routing protocol, hierarchical routing protocol, data-oriented routing protocol, position- based routing protocol and QoS-based routingprotocol.

(1)Floodingroutingprotocol:thisisanoldroutingprotocol. It does not need topology structure to maintain network and routing computation and the node receiving information would directly forward the data package toan adjacent node. For an ad hoc sensor network, flooding routing is a relatively direct method, but it can case message "implosion" and "overlap" easily. Energy limit is not considered here so it has a flaw of a "blind spot of re- source".

(2)Hierarchical routing protocol: the basic idea of such a protocol is to cluster sensor nodes and communication within a cluster is completed by cluster head nodes. Cluster head nodes can gather and integrate data to reduce the transmissionamount,andfinallytheclusterheadnodecan send integrated data to the sink node. This mode can meet the scalability of the sensor network and maintainthe energy consumption of the sensor node to prolong the life cycle of the network.

(3)Data-centric Protocols: The first category of routing protocols we consider at this survey are data-centric protocols, including SPIN (Sensor Protocols for Information via Negotiation) [11] and Rumor routing [2]. Datacentric routing protocols can be further divided into event-driven, query-driven, or a combination of both, depending on whether sources or destinations initiate data flow. SPIN is the first data-centric routing protocol. It includes a family of protocols used to efficiently disseminate information in a wireless sensor network. SPIN-1 is a source-initiated protocol. It applies a 3-stage (ADV-REQ-DATA) handshake interface for disseminating data. SPIN nodes assign high-level names to their data, called meta-data. They use meta-data to negotiate with each other before transmitting data.. Its features include attribute-based naming, data-centric routing, and in-network aggregation. Each sensor node names its data with one or more attributes. A destination node sends interests requesting for data, based on these attributes. Interests are flooded over the network. When a node receives an interest from a neighbor, it sets up a gradient to send data to the neighbor. Each node only knows the neighbor from whom it got the interest. It is possible that each node would receive the same interest from more than one neighbor. In this way, multiple paths can be set up from the source node to the destination node. Among these paths, one or a few high rate paths are defined and other paths remain low rate. It reduces network traffic and energy consumption through meta-data negotiation. The limitation of SPIN is that it does not guarantee data delivery. Source nodes have to talk to interested nodes directly. It is possible that interested nodes and sources are partitioned by uninterested nodes.

(4) Position-based routing protocol: this forwards re- quests or data to the needed area by use of position infor-mationofanodetonarrowthetransmissionscopeofdata. In fact, many routing protocols of the sensor network assume the position of a node is given, so nodes can be divided into different domains subject to position infor-mation of a node. Data transmission based on domain can narrow transmission range, reduce the communication amountofintermediatenodesandprolongthelifecycleof thenetwork.

(5) QoS-based routing protocol: the energy-aware QoS route must guarantee the effective use of band width and efficient energy path in the entire connection time. QoS- based routing protocol applies to real-time applications such as real-time tracking of military targets and emer- gency eventmonitoring.

3.**COMPARISON OF WSN ROUTING PROTOCOL CHARACTERISTICS**: This section compares the performance and characteristics of routing protocols of wireless sensor networks from the aspects of life cycle, extendibility, path selection, energy awarenes, data aggregation, location information, information storage, mobile nodes, real-time and reliability (fault-tolerant ability). Table 1 shows the results of comparison between various kinds of routing protocols as mentioned above. Since the design of routing protocol of wireless sensor networks is closely related to application, inpracticalapplication,atthetimeofselectingtherouting protocol, the specific application and characteristics of all routing protocols will be consideredcomprehensively.

Algorithm	The life cycle	Expand sex	Path selec-tion	Energy awareness	Data ag-gregation	Location information	Stored in-formation	Mobile nodes	Real time	Reliab ility
Flooding	short	bad	Multi-hop	None	None	No need	None	A sensor node Gathering node	bad	better
Gossiping	longer	bad	Multi-hop	None	None	No need	None	A sensor node Gathering node	bad	better
LEACH	longer	bad	Single hop	have	have	No need	Have	None	bad	better
TEEN	longest	good	Multi-hop	have	have	No need	Have	None	good	bad

PEGASIS	longest	bad	Multi-hop	have	have	No need	have	None	bad	bad
SPIN	longest	bad	Multi-hop	None	have	No need	None	A sensor node Gathering node	bad	bad
DD	longest	good	Multi-hop	have	have	No need	have	A sensor node Gathering node	bad	good
Rumor	longest	good	Multi-hop	have	have	No need	have	none	bad	better
GPSR	Longer	good	Multi-hop	none	none	need	none	A sensor node Gathering node	bad	better
GEAR	longest	good	Multi-hop	have	none	Need	none	A sensor node Gathering node	bad	better
SAR	Longer	Bad	Multi-hop	have	none	No need	Have	None	Good	Good
PEED	Longest	bad	Multi-hop	have	none	Need	have	None	good	good

4. CONCLUSION

Compared with the traditional wire network and wire- less MANET network, resources are highly restricted and nodesareeasytoloseefficacyinwirelesssensornetworks, thus the design of its routing protocol faces new challenges. This paper summarizes and analyzes the research achievements of routing protocols of wireless sensor net- works in recent years, and divides them intoflooding routing protocol, hierarchical routing protocol, data-centered routing protocol and routing protocols based on location information and QOS. The paper makes corresponding algorithm analysis on each kind, and finally compares and summarizes the characteristics of these protocols. With the continuous development of the application, the routing protocols of wireless sensor networks still have many problems that need further research, and the following are the main points:

Effectivenessofenergy:Inwirelesssensornetworks, frequent transmission consumes more energy; reduces data traffic, restrains transmitting unnecessary data on nodes, and improves energy efficiency, whichareprioritiesinthedesignofWSNroutingprotocol.

Reliability: Nodes of wireless sensor networks easi- lyloseefficacy.Howtocalculateroutingthroughnetwork information that is easy to get from nodes, make sure that routing is easy to recover when breaking down, and how to highly reliably transmit data are key matters to be solved in the design of routingprotocol.

5. References:

[1] A. Rubeaai, F. S. Sarab, K. Brajendra, "Region based three dimen- sional real-time routing protocol for wireless sensor networks," *Proceedings of IEEE Sensors*, pp.233-236.

[2] H. A. Tom, H. Falah, "Location aware sensor routing protocol for mobile wireless sensor networks," *IET Wireless Sensor Systems*, vol. 2, pp. 49-57, April2016.

[3] W. Runze; S. Xiaoping, "An improved ACO-based security routing protocol for wireless sensor networks," *Proceedings-2013 International Conference on Computer Sciences and Applications*, CSA 2013, pp. 90-93.

[4] M. Kumarasamy, Vallipuram, "An energy aware heuristic-based routing protocol in Wireless Sensor Networks," *2014 17th Inter- national Conference on Computer and Information Technology*, ICCIT 2014, pp.53-58.

[5] D. R. Gawade, S.L. Nalbalwar, "A centralized energy efficient distance based routing protocol for wireless sensor networks," *Journal of Sensors*, vol.21, pp.212-216, April 2016.http://dx.doi.org/10.1155/2016/8313986

[6] Z. Xuedan, D. Yuhan; L. Xiaokang, "Adaptive energy-harvesting aware clustering routing protocol for Wireless Sensor Networks," *2012 7th International ICST Conference on Communications and Networking in China*, CHINACOM 2012 - Proceedings, pp. 742- 747.

[7] P. Kamalakkannan, "Enhanced cluster based routing protocol for mobile nodes in wireless sensor network," *Proceedings of the 2013 International Conference on Pattern Recognition, Informat- ics and Mobile Engineering*, PRIME 2013, pp.187-193.

[8] H. Pulagam, "Multiple aggregator multiple chain routing protocol for heterogeneous wireless sensor networks," *2013 International Conference on Signal Processing and Communication*, ICSC 2013, pp.127-131.

[9] W. Yineng, "Distributed energy aware routing protocol for large- scale wireless sensor network," *12th Annual Mediterranean Ad Hoc Networking Workshop*, MED-HOC-NET 2013, pp.111-115.

[10] B. Doina, "An evolutionary framework for routing protocol analy- sis in wireless sensor networks," *Lecture Notes in Computer Sci- ence*, vol. 7835, pp. 1-11, April 2013.http://dx.doi.org/10.1007/ 978-3-642-37192-9_1