ISSN 2250-3153

Data Centric Based Routing Protocols for Wireless Sensor Networks: A Survey

A.G.Gokula Kumar*, R.Thiyagarajan, N.Sripriya****

*PG Scholar, PITAM, Anna University, Chennai, Tamil Nadu.
**Assistant Professor, PITAM, Anna University, Chennai, Tamil Nadu.

Abstract- Sensor networks are quite different from traditional networks in different ways: sensor networks have severe energy concerns, redundant low-rate data, and many-to-one flows. Routing protocols developed for other adhoc networks cannot be applied directly in WSN because of the energy constraint of the sensor nodes. Data-centric technologies are needed to perform in-network aggregation of data to yield energy-efficient dissemination. Sensor networks are used in many applications like environment monitoring, health, industrial control units, military applications and in the various computing environments. Since sensor the entire sensor node are battery powered devices, energy consumption of nodes during transmission or reception of packets affects the life-time of the entire network. In this paper we model data-centric routing and compare its performance with traditional end-to-end routing schemes.

Index Terms- Wireless sensor networks, Data-centric routing protocols, Data aggregation, Directed diffusion, One-shot complex queries, Novel adaptive approach, Resource adaptation.

I. INTRODUCTION

Routing in wireless sensor network (WSN) is divided in four categories:

- Data-centric protocols
- Hierarchical protocols
- Geographical protocols
- Quality of service(QOS) based protocols

In WSN it is not feasible to assign a global identification to a node due to high density and overhead it. The features of these sensor nodes include small size, low cost, low computation power, multifunctional(can perform sensing, data processing, routing etc.), easily communicate within short distances etc. Originally wireless sensor networks were designed for military applications (which include battlefield surveillance, object protection, intelligent guiding, remote sensing etc.) but nowadays it has wide range of civilian applications also in the areas like environment, health, home, space exploration, chemical processing, disaster relief and other commercial areas.

II. CHALLENGES FOR ROUTING PROTOCOL

Since WSN's have their own challenges utilizing traditional routing protocol is not workable. In following some challenges are discussed:

A. Energy consumption

The main concern in developing protocols for WSNs is energy consumption. Due to limited energy resource, data shall be delivered in an energy-efficient manner. Thus, conventional routing protocols are not suitable.

B. Scalability

Scalable routing protocol can expand to support increasing workloads. To provide scalability in WSN, distributed protocols are needed. Due to high density of nodes in WSN, full image of topology cannot be obtained in a node; therefore distributed protocols which rely on a limited knowledge of topology are preferred.

C. Addressing

Regarding to the high number of sensor nodes in WSN assigning a unique address to each node is not viable. Therefore, address-based routing protocols are not suitable for this type of networks. In addition, in WSN, information from a collection of sensors are preferred over the information from individual sensor nodes. Addressing mechanisms which do not rely on unique ID are used.

D. Robustness

There is no dedicated router in WSNs; consequently routing protocols operate on sensor nodes. Regarding the high probability of node failure in WSNs, it is intrinsic for routing protocols to provide robustness to node failure.

III. WIRELESS SENSOR NETWORK DESIGN CHALLENGES

Depending on the application, different architectures and design goals/constraints have been considered for sensor networks. Since the performance of a routing protocol is closely related to the architectural model, so the design of the routing protocols for WSN is challenging. This section attempts to list down the main aspects involved in the design challenges of sensor networks.

A. Limited Energy Capacity

The big challenge for the network designers in hostile environments is energy. Since sensor nodes have limited energy capacity because they are battery powered. So when the energy of a sensor reaches a certain threshold, they become faulty and are not able to function properly which affects the overall network performance to great extent. Consequently the routing protocols designed for sensors should be as energy efficient as possible to extend their lifetime, and hence prolong the network lifetime.

B. Sensor Location

Managing the locations of the sensors is another challenge that features the design of the routing protocols. Most of the proposed protocols assume that the sensors either are equipped with GPSreceivers or use some localization technique to learn about their locations.

C. Limited Hardware Resources

Only limited computational functionalities can be performed by sensors due to their limited processing and storage capacities beside limited energy capacity. These hardware constraints present many challenges in software development and network protocol design for sensor networks.

D. Node Deployment

Topological deployment of the sensors in WSNs is application dependent and finally affects the performance of the routing protocol. The deployment is either deterministic or self-organizing. In deterministic situations, the sensors are manually placed and data is routed through pre-determined paths. However in self-organizing systems, the sensor nodes are scattered randomly creating an infrastructure in an ad hoc manner. In that infrastructure, the position of the sink or the cluster-head is also crucial in terms of energy efficiency and performance.

E. Data Aggregation

In WSN the redundancy of data generated from sensor nodes is a key concern. Similar packets from multiple nodes can be aggregated to reduce the extra overhead due to number of the transmissions. Many proposed routing protocols are using data aggregation technique to achieve energy efficiency and data transfer optimization.

F. Diverse sensing application requirements

Sensors networks have a wide range of diverse applications. Each application has its own specifications and constraints different from other application. There is no network protocol which can fully meet the criteria of all applications. Therefore the routing protocols designed should compute an optimal path and guarantee the accurate data delivery to the sink on time**.**

G. Network Characteristics and Unreliable Environment

The WSN is consistently prone to frequent topology changes because of extremely vulnerable to node failure, sensors addition, deletion, node damage, link failure, sensor energy exhaustion etc. also susceptible to noise, time consistency and errors due to wireless nature of the network. So the network routing protocol/mechanism be capable of sustain the network topology dynamics, increase network size, energy consumption level, sensor nodes mobility and their related issues like coverage and connectivity to retain specific application requirements.

H. Scalability

Scalability is very important in WSN as the network size can grow rapidly. So the routing protocols should be designed to work consistently, keeping in consideration that sensors may not necessarily have the same capabilities in terms of energy, processing, sensing, and particularly communication. Furthermore, care should be taken to design routing protocol as there could be asymmetric communication between sensors instead of symmetric (a pair of sensors may not be able to have communication in both directions).

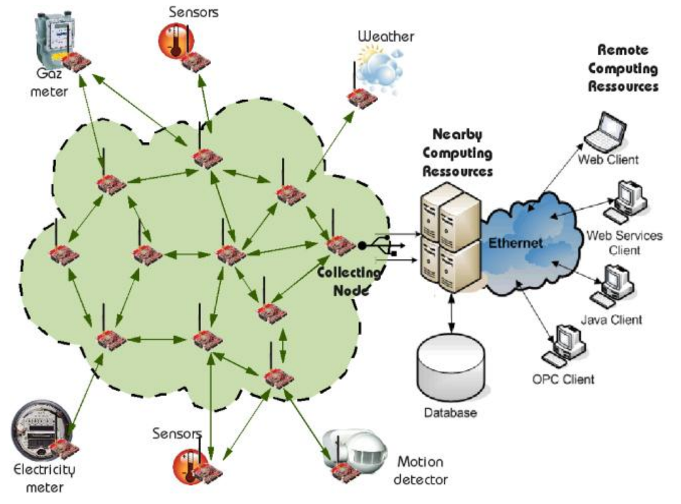


Figure 1: Structural view of wireless sensor networks.

IV. Data-centric routing protocols

Data-centric protocols differ from traditional address-centric protocols in the manner that the data is sent from source sensors to the sink. In **address-centric** protocols, each source sensor that has the appropriate data responds by sending its data to the sink independently of all other sensors. However, in **data-centric** protocols, when the source sensors send their data to the sink, intermediate sensors can perform some form of aggregation on the data originating from multiple source sensors and send the aggregated data toward the sink. This process can result in energy savings because of less transmission required to send the data from the sources to the sink. In this section, we review some of the data-centric routing protocols for WSNs.

3.1 Sensor Protocols for Information via Negotiation (SPIN):

SPIN protocol was designed to improve classic flooding protocols and overcome the problems they may cause, for example, implosion and overlap. The SPIN protocols are resource aware and resource adaptive. The sensors running the SPIN protocols are able to compute the energy consumption required to compute, send, and receive data over the network. Thus, they can make informed decisions for efficient use of their own resources. The SPIN protocols are based on two key mechanisms namely **negotiation** and **resource adaptation**. SPIN uses **meta-data** as the descriptors of the data that the sensors want to disseminate. The notion of meta-data avoids the occurrence of overlap given sensors can name the interesting portion of the data they want to get. It may be noted here that the size of the meta-data should definitely be less than that of the corresponding sensor data. This allows the sensors to use their energy and bandwidth efficiently.

There are two protocols in the SPIN family: SPIN-l (or SPIN-PP) and SPIN-2 (or SPIN-EC).While SPIN-l uses a negotiation mechanism to reduce the consumption of the sensors, SPIN-2uses a resource-aware mechanism for energy savings. Both protocols allow the sensors to exchange information about their sensed data, thus helping them to obtain the data they are interested in.

3.2 Directed Diffusion (DD):

Direct diffusion is a data centric query based and application-aware protocol where data aggregation is carried out at each node in the network. The nodes will not advertise the sensed data until a request is made by the BS, and all the data generated by sensor node is named by attribute-value pairs. The gradient specifies data rate and the direction in which to send the events. The node which receives the events information from the source attempts to find a matching entry in its interest cache. All sensor nodes in a directed-diffusion-based network are application-aware, which enables diffusion to achieve energy savings by selecting empirically good paths, and by caching and processing data in the network. Caching can increase the efficiency, robustness, and scalability of coordination between sensor nodes, which is the essence of the data diffusion paradigm.

3.3 Rumor Routing (RR):

Rumor routing is another variation of Directed Diffusion and is mainly intended for contexts in which geographic routing criteria are not applicable. Generally Directed Diffusion floods the query to the entire network when there is no geographic criterion to diffuse tasks. However, in some cases there is only a little amount of data requested from the nodes and thus the use of flooding is unnecessary. An alternative approach is to flood the events if number of events is small and number of queries is large. Rumor routing is between event flooding and query flooding. The idea is to route the queries to the nodes that have observed a particular event rather than flooding the entire network to retrieve information about the occurring events. In order to flood events through the network, the rumor routing algorithm employs long-lived packets, called agents. When a node detects an event, it adds such event to its local table and generates an agent. Agents travel the network in order to propagate information about local events to distant nodes. When a node generates a query for an event, the nodes that know the route, can respond to the query by referring its event table. Hence, the cost of flooding the whole network is avoided. Rumor routing maintains only one path between source and destination as opposed to Directed Diffusion where data can be sent through multiple paths at low rates.

3.4 COUGAR:

A data-centric protocol that views the network as a huge distributed database system. The main idea is to use declarative queries in order to abstract query processing from the network layer functions such as selection of relevant sensors etc. and utilize in-network data aggregation to save energy. The abstraction is supported through a new query layer between the network and application layers. COUGAR proposes architecture for the sensor database system where sensor nodes select a leader node to perform aggregation and transmit the data to the gateway (sink).The gateway is responsible for generating a query plan, which specifies the necessary information about the data flow and in-network computation for the incoming query and send it to the relevant nodes. The query plan also describes how to select a leader for the query. The architecture provides in-network computation ability for all the sensor nodes. Such ability ensures energy efficiency especially when the number of sensors generating and sending data to the leader is huge. Although COUGAR provides a network-layer independent solution for querying the sensors, it has some drawbacks: First of all, introducing additional query layer on each sensor node will bring extra overhead to sensor nodes in terms of energy consumption and storage. Second, in network data computation from several nodes will require synchronization, i.e. a relaying node should wait every packet from each incoming source, before sending the data to the leader node. Third, the leader nodes should be dynamically maintained to prevent them from failure.

3.5 Active Query Forwarding in Sensor Networks *(ACQUIRE):*

ACQUIRE is another data centric querying mechanism used for querying named data. It provides superior query optimization to answer specific types of queries, called **one-shot complex queries for replicated data.** ACQUIRE query (i.e., interest for named data) consists of several sub queries for which several simple responses are provided by several relevant sensors. Each sub-query is answered based on the currently stored data at its relevant sensor. ACQUIRE allows a sensor to inject an active query in a network following either a random or a specified trajectory until the query gets answered by some sensors on the path using a localized update mechanism. Unlike other query techniques, ACQUIRE allows the queries to inject a complex query into the network to be forwarded stepwise through a sequence of sensors.

3.6 DRUG:

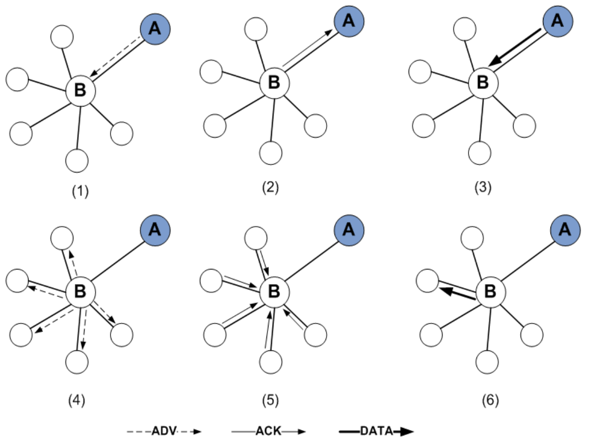
This protocol introduces a novel adaptive approach to find an optimal routing path from source to sink when the sensor nodes are deployed randomly deployed in a restricted service area with single sink. This also aggregates the data in intermediate node to reduce the duplicate data. Data centric protocols more focus on data rather than the address of the destination. Here our approach focuses on both data as well as the destination address. DRUG protocol uses three types of messages to communicate between different nodes as shown in Figure 3, such as:

(i) **ADV**: new data advertisement. When a sensor node has data to share, it can advertise this fact by transmitting an ADV message containing meta-data.

(ii) **ACK**: request for data. A SPIN node sends an ACK message when it wishes to receive data.

(iii) **DATA**: data message. DATA messages contain actual sensor data with a meta-data header. ADV and ACK messages contain only meta-data.

In networks where the cost of sending and receiving a message is largely determined by the messages size, ADV and ACK messages will therefore be cheaper to transmit and receive than their corresponding DATA messages. DRUG protocol is efficient than both spin and flooding. The pictorial representation of the DRUG protocol is as follows



V. COMPARISSION OF ROUTING PROTOCOLS

ROUTING PROTOCOLS	**CLASSIFICATION**	**MOBILITY**	**POWER USAGE**	**DATA AGGREGATION**	**SCALABILITY**	**MULTI PATH**			
SPIN	FLAT	POSSIBLE	LIMITED	YES	LIMITED	YES			
DD	FLAT	LIMITED	LIMITED	YES	LIMITED	YES			
RR	FLAT	VERY LIMITED	N/A	YES	GOOD	NO			
COUGAR	FLAT	NO	LIMITED	YES	LIMITED	NO			
ACQUIRE	FLAT	LIMITED	N/A	YES	LIMITED	NO			
DRUG	FLAT/ HIERARCHICAL	LIMITED	LIMITED	YES	GOOD	NO			

VI. CONCLUSION

Routing in sensor networks is a new area of research, with a limited, but rapidly growing set of research results. In this paper, we investigated a comprehensive list of data-centric protocols. There are many issues need to be addressed by researchers e.g.: energy efficiency and life time. Great advantages are achieved because of not using ID instead a general question regarding a special phenomenon to be asked and a response to be gathered. The best algorithm which an implement this idea is ACQUIRE and is strongly recommended to be used in future.

REFERENCES

[1] .-H. Chang, L. Tassiulas, "Energy Conserving Routing inWireless Ad-hoc Networks," INFOCOM, 2000.

[2] Seong-Hwan Cho and A. Chandrakasan, "Energy Efficient Protocols for Low Duty Cycle Wireless Microsensor Networks", ICASSP 2001, May 2001.

[3] A Manjeshwar and D. P. Agrawal, "TEEN: A Routing Protocol for Enhanced Efficiency in Wireless Sensor Networks" in Proc. of 15th International Parallel and Distributed Processing Symposium, pp. 2009–2015.

[4] Kemal Akkaya and Mohamed Younis. A survey on routing protocols for wireless sensor networks., Elsevier Ad hoc Networks, 3(3):325–349, May 2005.

[5] I. F. 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.

[6] B. Krishnamachari, D. Estrin, S. Wicker, Modeling data centric routing in wireless sensor networks, in: Proceedings of IEEE INFOCOM, New York, June 2002.

[7] Y. Yao, J. Gehrke, The cougar approach to in-network query processing in sensor networks, in: SIGMOD Record,September 2002.

[8] W.R. Heinzelman, J. Kulik, and H. Balakrishnan "Adaptive Protocols for Information Dissemination in Wireless Sensor Networks," Proceedings of the Fifth Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom '99), Seattle, Washington, August 15-20, 1999, pp. 174-185.

[9] N. Sadagopan et al., The ACQUIRE mechanism for efficient querying in sensor networks, in: Proceedings of the

First International Workshop on Sensor Network Protocol and Applications, Anchorage, AK, May 2003.

[10] Shalli Rani1, Jyoteesh Malhotra, Rajneesh Talwar," EEICCP—Energy Efficient Protocol for Wireless Sensor Networks "proceeding scires Wireless Sensor Network, 2013, 5, 127-136.

[11] Ying Zhang and markusFromherz "A robust and efficient routing framework for wirekess sensor networks." In 20th International conference on Advanced Information Networking and Applications, vol. 2, 20-26 April 2006.

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

[13] D. Estrin, L. Girod, G. Pottie, and M. Srivastava, "Instrumenting the World with Wireless Sensor Networks," International Conference on Acoustics, Speech and Signal Processing (ICASSP 2001), Salt Lake City, Utah, May 2001.

[14] D. Braginsky, D. Estrin, Rumor routing algorithm for sensor networks, in: Proceedings of the First Workshop on Sensor Networks and Applications (WSNA), Atlanta, GA, October 2002.

AUTHORS

First Author- A.G. Gokula Kumar, PG Scholar, PITAM, Anna University Chennai, Tamil Nadu.
Second Author- R.Thiyagarajan, Assistant Professor, PITAM, Anna University, Chennai, Tamil Nadu.
Third Author- N.Sripriya, Assistant Professor, PITAM, Anna University, Chennai, Tamil Nadu.