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Comparative Study of Routing Protocols in Wireless Sensor Network

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Abstract: Wireless Sensor Networks consist of small nodes with sensing and computation, communication capabilities. Wireless network are highly dependent on specific application and are constrained by energy, storage capacity and power. To increase the lifetime of networks, energy awareness is essential consideration if we analyze routing protocols. Routing protocols of sensor networks are responsible for maintaining the routs in the network. 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: Flat, Hierarchical and location based routing protocols. We study tradeoff between energy and communication overhead savings in every routing prortcols.We also highlighted the advantages and performance issues of each routing technique.

Keywords- wireless sensor networks, routing protocols, network structure, Hierarchical routing, Flat Routing Protocols.

I .Introduction

Sensor networks have emerged as a promising tool for monitor the physical world, networks of battery powered wireless sensor network that can sense, process and communicate. A WSN consists of a large number of low cost, low powers and multifunctional wireless sensor network have been widely used in the industry, traffic, environmental protection, military and many other fields. Especially in the absence of the existence of the back bone of network, such as the dangerous region that man cannot get there, the battle field, and other destructive areas .These sensor nodes communicate over short distance via a wireless medium [1].

A sensor network is a network of many tiny disposable low power devices, called nodes. The tiny sensor nodes, which consist of

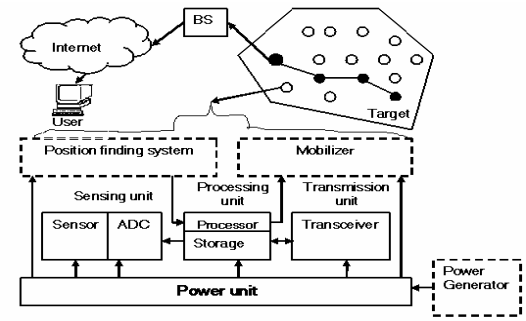

Fig.1 Components of Sensor Nodes and scattered Sensor nodes

sensing, data processing and communicating components. As shown in fig.1,each node consists of four components: power unit and central processing unit (CPU).sensor unit and communication unit. They are assigned with different tasks. The important requirements of WSN are: Use large number of sensors, Low energy consumption, Self organization capability, and Querying ability. Networking unattended sensor has effect on the efficiency of many military and civil applications such as distributed computing, weather monitoring and security. In this paper, we analyze the current routing protocols and classify them into three categories on the basis of network structure. The reminder of this paper is organized as follows. First we discussed various routing protocols for wireless sensor network. Then we discuss the network architecture and design

objectives and we described, the network design challenges and routing issues. Then we compared the various routing protocols are discussed and compared. At last we conclude this paper.

II Network architecture and design objectives

Different architectures and design constraints have been considered for sensor networks. The performance of a routing protocol is related to the architectural model [2].

2.1 Network Architecture

Sensor network consists of three main components .these are the sink, monitored events and sensor nodes. Routing messages from moving node more challenging since route stability is more important factor, in addition to energy , bandwidth etc.

2.2 Node deployment

Another consideration is the topological arrangement of nodes. The arrangement of sensors is either deterministic or self organizing. In self organized systems, the sensor nodes are scattered randomly creating a path in an ad hoc manner. However in deterministic system, the sensors are manually placed and data routed through predetermined paths. The position of the sink or cluster head is also crucial in terms of energy and performance.

2.3 Energy deliberation

The process of setting up the routes is greatly influenced by energy considerations. Most of time sensors are scattered randomly over an area of interest.

2.4 Node capabilities

All sensor nodes are assumed to be homogenous, having equal capacity in terms of computation, communication and power. Set of sensors raises multiple technical issues related to data routing.

2.5 Data Latency and Over Head

These are considered as the important factors that influence routing protocol design. Data aggregation and multi hop relays cause data latency. Some routing protocols create excessive overheads to implement their algorithms, which are not suitable for energy constrained network.

III. Routing Protocols in WSN

Routing in WSN differs from conventional routing .There is no infrastructure, wireless links are unreliable, sensor nodes may fail ,and routing protocols have to meet strict energy saving requirements. Many routing algorithms were developed for wireless networks. When sensor nodes are static, it is preferable to have table driven routing protocols rather than using reactive protocols. a significant amount of energy is used in route discovery and setup of reactive protocols. All major routing protocols classified into seven main categories shown below:

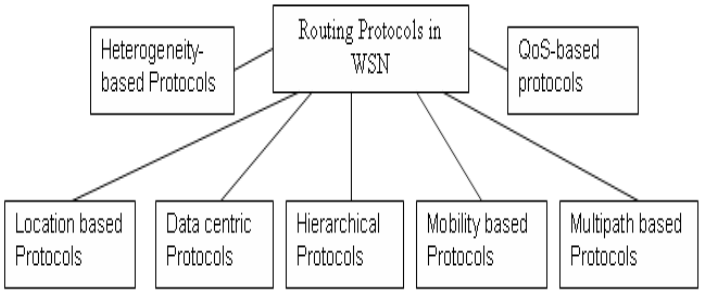

Fig.2 Classification of Wireless Sensor Network

3.1Location Based Protocols

The location information based routing protocol uses location information to guide routing discovery and maintenance as well as data forwarding, enabling directional transmission of the information and avoiding information flooding in the entire network. Location information is needed in order to calculate the distance between two particular nodes so that energy consumption can be estimated [3].

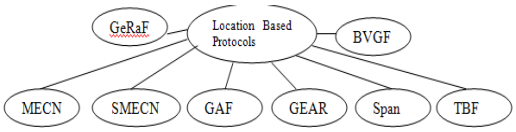

Fig.3Classification of Location based protocols

3.1.1 GEAR

In this algorithm, each node keeps an estimated cost and a learning cost of reaching the destination through neighbors. The estimated cost is a combination of residual energy and distance to destination. Hole occurs when a node does not have any closer neighbors to the target. If there are no holes, the estimated cost equal to the estimated cost is equal to the learned cost. The learned cost is propagated one hop back every time a packet reaches the destination so that route set up for next packet will be adjusted.

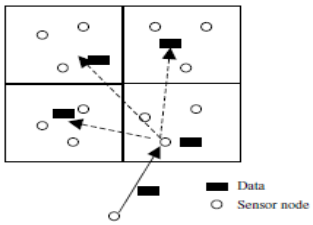

Fig.4 Geographic Forwarding in GEAR

3.1.2. Geographic Adaptive Fidelity (GAF)

GAF is used for WSN because it favors energy conversation. As shown in Fig.4, the state transition diagram has three stages, discovery, active and sleeping. When a sensor enters the sleeping state, it turns off radio for energy saving .In discovery state, a sensor exchange discovery messages to learn about other sensors in the grid. In active state, a sensor periodically broadcast its discovery message to inform equivalent sensors about its state.

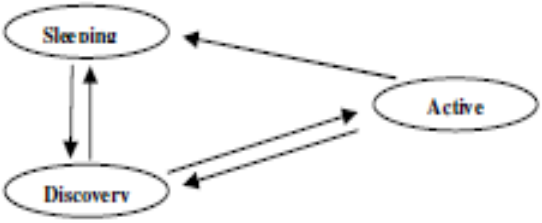

Fig.5 State Transition Diagram of GAF

3.1.3. MECN and SMECN

Minimum energy communication network set up and maintains a minimum energy network for wireless networks by utilizing low power GPS. This protocol has two phases:

1. It takes the positions of a two dimensional plane and constructs a sparse graph, which consists of all the enclosures of each transmit node in the graph. The enclose graph contains globally optimal links in terms of energy consumption.

2. Finds optimal links on the enclosure graph. It uses distributed shortest path algorithm with power consumption as a cost metric.

The small minimum energy communication network (SMECN) is an extension to MECN.In SMECN protocol; every sensor discovers its immediate neighbors by broadcasting a discovery message using some initial power that is updated incrementally.

3.2 Hierarchical Protocols

Clustering is an energy efficient communication protocol that can be used by the sensors to report their sensed data to the sink. Hierarchical routing is to efficiently maintain the energy consumption of network. This provides inherent optimization capabilities at the cluster heads. A network is composed of several clusters[4]. Each cluster is managed by a special node, called cluster head, which is responsible for coordinating the data transmission activities of all sensors in its cluster. Representative Protocols of hierarchical routing are as follows:

(a) PEGASIS (b) HEED
(c) TEEN (d) APTEEN
(e) LEACH

3.2.1 TEEN and APTEEN

Threshold sensitive Energy Efficient sensor Network protocol (TEEN) .The sensor network architecture is based on a hierarchical grouping where closer nodes from clusters and this process goes on the second level until base station is reached. TEEN is not good for applications where periodic reports are needed since the user may not get any data at all thresholds are not reached.

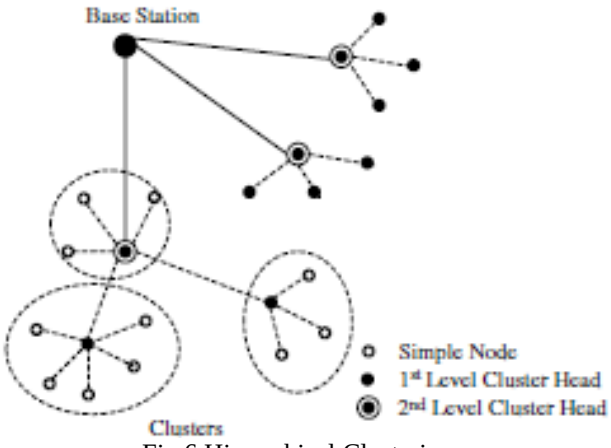

Fig.6 Hierarchical Clustering

The Adaptive Threshold sensitive Energy Efficient sensor network protocol (APTEEN).The architecture of APTEEN is same as TEEN.APTEEN supports three different query types: historical, to analyze past data values, one time, to take a snapshot view of the network and persistent to monitor an event for a period of time.

3.2.2 LEACH

Low energy adaptive clustering hierarchy (LEACH)is most popular hierarcal routing protocol for sensor networks.LEACH is a hierarchical protocol in which most nodes transmit to culster heads,and the culster heads compress and aggregate the data and forward it to the base station.LEACH assumes that each node has a radio powerful enough to directly reach the base station or the nearest cluster head , but that using this radio at full power all the time would waste energy.
Nodes that have been cluster heads cannot become cluster heads again for P rounds.At the end of each round,each node that is not a cluster head selects the closest cluster head and joins that cluster to transmit its data.

3.2.3 PEGASIS

Power Efficient Gathering in Sensor Information Systems, which is near optimal for this data gathering application in sensor networks.In PEGASIS is to form a chain among the sensor nodes so that each node will receive from and transmit to a close neighbor.gathereed data moves from node to node and a designated node transmits to the base station[5].
For collecting data in each round , eac node receives data from one neighbor, fuses with its own data and transmit to other neighbour on the chain.In Fig. ,node c2 is the leader,and it will pass the token along the chain to node c0.Node c0 will pass

its data towads node c2. After node c2 receives data from node c1, it pass the token to node c4, and node c4 will pass its towards node c2.

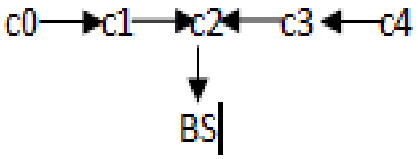

Fig.7 Token passing approach

In above example, node c0 will pass its data to node c1. Node c1 fuses node c0's data with its own and the them transmit to the leader.After node c2 passes the token to node c4 ,node c4 transmits its data to node c3 .Node c3 fuses node c4's data with its own and then transmit to the leader.Node c2 waits to receive data fron both neighbours and fuses its data with its neighbor's data. Finally , node c2 transmits one message to the BS.

3.3 Data –centric protocols

Data centric protocol different from traditional address centric protocols in the data they carry. While in ad hoc networks individual data items are important, in sensor networks it is the aggregate data carried in the data rather than the actual data. In data centric routing, the end nodes, the sensors themselves, are less important than data itself. The sink sends queries to certain regions and waits for data from the sensors located in a selected region. Data centric protocols are classified in to nine categories of routing protocols are as follows:
SPIN, DD, RR, MCFA, GBR, IDSQ, CADR, COUGAR, ACQUIRE, EAR [6].

3.3.1 SPIN

Sensor Protocols for Information via Negotiation was designed to improve classic flooding protocols. It fit under data delivery model in which the nodes sense data and disseminate the data throughout the network by means of negotiation. SPIN nodes use three types of messages for communication:

- ADV-When a node has new data to share; it can advertise this using ADV message containing Metadata.
- REQ-Node sends an REQ when it needs to receive actual data.
- DATA-DATA message contains actual data.

The SPIN family Protocol is made up of four protocols, SPIN-PP, SPIN-EC, SPIN-RL and SPIN-BC.

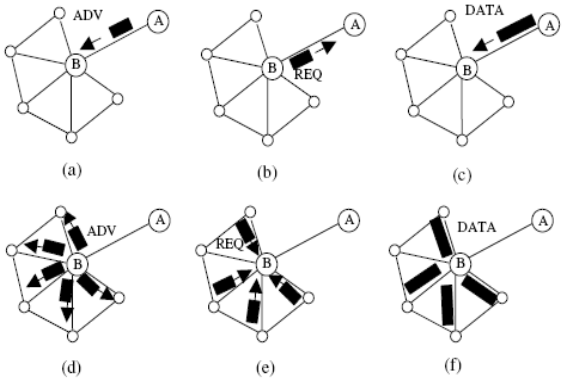

Fig.8 SPIN Protocol

In above fig.

(a) Node A starts by advertising its data to node B
(b) Node B responds by sending a request to node A.
(c) After receiving the requested data.
(d) Node B then sends out advertisements to its neighbors.
(e) Who in turn send request s back to B (e-f).

IV. COMPARISON OF ROUTING PROTOCOLS

In this paper we compared the following routing protocols according to their design characteristics.

Table1
Classification and Comparison of routing protocols in WSN

Routing Protocols	Data Aggregation	Power Usage	Scalability	Over head	Query Based	QoS	Data delivery model
GAF	No	Ltd	Good	Mod	No	No	Virtual grid
GEAR	No	Ltd	Ltd	Mod	No	No	Demand driven
SPEED	No	Low	Ltd	Less	Yes	Yes	Geographic
SPAN	Yes	Ltd	Ltd	High	No	No	Continuously
SAR	Yes	High	Ltd	High	Yes	Yes	Continuously
ACQUIRE	Yes	Low	Ltd	Ltd	Yes	No	Complex Query
SPIN	Yes	Ltd	Ltd	Low	Yes	No	Event driven
DD	Yes	Ltd	Ltd	Low	Yes	No	Demand driven
SOP	No	Low	Good	High	No	No	Continuously
VGA	Yes	Low	Good	High	No	No	Good
PEGASIS	No	Max	Good	Low	No	No	Chains based
TEEN&APTEEN	Yes	High	Good	High	No	No	Active Threshold
LEACH	Yes	High	Good	High	No	No	Cluster head
COUGAR	Yes	Ltd	Ltd	High	Yes	No	Query driven
CADR		Ltd	Ltd	Low	Yes	No	Continuously
GBR	Yes	Low	Ltd	Low	Yes	No	Hybrid
RR	Yes	Low	Good	Low	Yes	No	Demand driven

VI. Conclusion and Open issues

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 aim behind the routing protocol design is to keep the sensors operating for a long time, thus extending the network life time. In this paper, we compare and classify the routing protocols into three main categories: Data Centric Routing (Flooding), Hierarchical based routing (clustering) and Location –based routing (Geographic) on the basis of network structure. However, realization of sensor node satisfies the constraints introduced by factors such as fault tolerance, scalability, cost, hardware, topology change, environment and power consumption.

In future, this wide range of application areas will make sensor networks an integral part of our lives. An important issue for routing protocols is the consideration of node mobility .Most of the current protocols assumes the sensor nodes and sink are stationary.

Although many routing protocols have been proposed in WSN, many issues still exist and there are still many challenges that need to be solved in the sensor networks. The following parts describe some of these issues and challenges: First, How to effectively utilize bandwidth and energy for specific application. Second, How to adapt the mobile sensor networks and make sensor nodes self organizing and self configurable. Third, How to make routing protocols secure in WSN and assure that the transmitted messages are not tampered and Fourth, How to satisfy dense sensor networks with a large number of nodes and try to prolong the lifetime.

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