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A Survey on Different Routing Protocols in Wireless Sensor Network

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***Abstract*—In Wireless Sensor Network (WSN) all nodes are depend on the power of their battery, as battery power or batter energy is limited resource and at some point the power of sensor nodes may be deployed. Therefore they need special attention to minimize energy consumption of sensor nodes in wireless network. For WSN, optimization of energy consumption has greater impact because it directly corresponds to lifetime of networks. In WSN, sensor nodes have a limited transmission range and limited storage capacity. Maintenance of routes in wireless sensor network is the responsibility of the routing protocols. In this paper we discuss about the various routing protocols and study their behavior in WSN.**

I. INTRODUCTION

Now a day's wireless sensor network [1]-[2] becomes the interesting research area for research because it has fantastic effect on many practical applications. They authorize very fine survey on the surrounding of the environment which is very cost effective and now possible. Sensors network are perform very good in situation like hostile situation where the presence of human is very dangerous. The sensor network is used to transmit data in the form of array of sensor node to the server where the entire data repository. Wireless sensor network plays an important role in handling emergency, disaster relief operations military operations because these are very sensitive operations and require coordination and planning and that can only be possible through real time information. With the use of sensor device e can notify the small change in temperature, pressure, humidity and other physical condition. There are different variety of wireless sensor network [3] are present like thermal, infrared, seismic, radar, visual, magnetic and acoustic all are designed for the different purpose or monitor different conditions of environment. Every sensor node has many resources like energy, memory, computation ability and communication. If we have an army of these sensors we can monitor the entire physical world gathering important information's from the environmental events and also from the sky [4]-[5].

There are several issues with the wireless sensor network and some are very important like data availability and life time of the network as the deployment of these sensors in the emergency environment. The wireless system should provide effective and automatic action and also provide real time energy efficient and fault tolerant communication in the situation of crisis. There are five phases of the typical wireless sensor network [6] that are planning phase, deployment phase, post-deployment phase, operation phase and post-operation phase.

- In planning phase, the sensor deployment site is surveyed for the suitable deployment of the sensor network environmental conditions are also surveyed.
- In deployment phase, over a target region the sensors node are deployed randomly.
- In post-deployment phase, for the access of the coverage the operator of the sensor network need to estimate or identify the location of the sensors.
- The operation phase is that phase in which the sensor network simply monitor the target environment and gather data or information.
- The post operation phase is the phase in which the entire operation is shut down for future purpose or we can say destroying network.

The sensor node has some characteristics like data processing, sensing data and communication through other sensors. Sensors are the device that can be work continuously for sensing, identification, actuators control and also for location and event detection. These sensor nodes are very good at their work either they put inside or very close to the phenomenon. Sensor nodes are smart enough to carry local computation and only required data are processed. These may be work as a team or may be work as series of transmitter for the completion of the task that is assigned by the user. The advantage of these is that we do not have to assign positions to these nodes. Just simply deploy randomly in accessible or relief operation.

Sensor environment is a very intelligent environment here the large amount of information is gathered and analyzed without participation of human being. That's why wireless sensor network has so many applications like military applications [5], for the detection of target objects in the battle field; it is helpful in environmental research applications [7], for the prediction of flood, monitor disasters, tornado. It is also useful in industrial applications [8], for controlling or providing guidelines to machines and robots. It is also helpful in for educational application [9], childhood developmental monitor a and creation of the problem solving environment [10]

II. WIRELESS SENSOR NETWORK CHARACTERISTICS

There are unique characteristics in wireless sensor network are follow:

A. Deployment of sensor network is very dense and it has higher order of magnitude than that in MANET.

B. All the deployed sensor nodes are battery operated and they are deployed in very tough environmental condition. Therefore replacement of batteries or recharge of batteries is very difficult.

C. All deployed sensor nodes are very high capacity of storage, computation and highly energy but limited.

D. The deployment of sensor nodes is usually random and all sensors configure themselves in a communication network autonomously.

E. There is a danger of physical damage or sensors may be failure because they are deployed in very tough environmental conditions.

F. Different sensor is doing different work means sensors are designed for particular application. Network of sensor change their design when there is a change in application.

G. In many application of sensor network. Sensors node sensed data and send to sink by using multiple source between main sources to sink. Therefore they form the pattern like many to one.

H. There are many frequent changes in topology of network because of depletion in energy, failure of nodes, damage of nodes or fading in channel signals.

III. WIRELESS SENSOR NETWORK ROUTING CHALLENGES

For the designing of the very efficient wireless sensor network, it is very good for understanding the important factors of the wireless sensor network application. The requirements and protocols of wireless sensor network are very different from the traditional wireless ad-hoc network and ad-hoc algorithms are not well working for the wireless sensor network. Differences between wireless sensor networks and traditional networks are given below:

A. As we all know the energy of the wireless sensor nodes are limited and once they deployed in the network they cannot be accessible. We want that the sensor must be used for processing and communication but in optimal fashion so the lifetime of the sensor is extended. Everybody knows that the communication takes enough energy. For the long use of sensor the less energy should be used and there should be minimum communication.

B. There is one problem of sensor node that they fail very frequently and failed node are inaccessible therefore we need highly redundant data from nodes so that the failure of some nodes can be negligible.

C. In WSN, the lifetime of the sensor nodes is the very important issues. The lifetime of the sensor node is measured by parameter like time. Means time as long as the sensor node providing the quality data or we can say time until the sensor node die.

D. For cover the large area we need lots of wireless sensors. This is because the sensors are designed for the monitoring the small area, they have limited range as the range increases the accuracy decreases. Because of small transmission range we need to deploy large number of sensors to monitor the complete physical area.

E. The designing or organizing of the sensor network should be like this it can adaptable to change in terms of adding more nodes in case of some node failure. And also adaptable to the environmental condition. The other traditional network is only focus on decreasing the node deployment or maximizing the network throughput. The sensor network should be like this the lifetime of the network may be increased.

F. These types of networks are used for the special purpose applications. Therefore the protocols of this network are different from the general network. So we have to choose that communication pattern those improve the efficiency of the network.

G. As the wireless sensor network is so dense and create a very large network. So the global identification (GID) is not possible. Satellite requires line of site for providing the global position of the sensor network. But this is not possible because the sensors are used in very unwanted environmental conditions so the clear sight from satellite is not possible.

H. Sensors are the device which is used to continuously sense the target area. So the sensors provide the continuous information just like time series. It observes each and every time and passes information without stop. So the traditional storage is not an good idea in case of wireless sensor network.

I. In WSNs, the naming schemes are data-oriented. For example, in environmental monitoring system where the reading of the temperature may required. For these we fire a query and getting the temperature reading of the specific area. Instead of this we have to get temperature reading from the set of sensor nodes.

J. There are two type of node deployment can take place first is deterministic and second is self organized. The deployment of node can affect the overall performance of the network. Deterministic means the sensor node are placed manually and the path chose for routing is pre defined but in self organized situation the sensors are deployed randomly and they choose path according to the infrastructure.

IV. ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORK

Routing in wireless sensor networks differs from conventional routing in fixed networks in various ways. There is no infrastructure, wireless links are unreliable, sensor nodes may fail, and routing protocols have to meet strict energy saving requirements [8]. Many routing algorithms were developed for wireless networks in general. All major routing protocols proposed for WSNs may be divided into four categories as shown in Table 1. We review sample routing protocols in each of the categories in preceding sub-sections.

Category	**Representative Protocols**
Table Driven Routing	OLSR, Babel, DSDV
On Demand Routing	AODV, DSR, Power Aware DSR
Hybrid Routing	Zone Routing Protocol
Hierarchical Routing	CBRP, FSR

Table 1: Routing Protocols for WSN

V. TABLE DRIVEN ROUTING

A. Optimized Link State Routing Protocol (OLSR)

OLSR is a proactive routing protocol. These routing protocol find out the path when needed at the time of sending the data from the source node to the destination node. OLSR uses MPR (multipoint relay) to decrease the overhead in the network system. OLSR send two type of message : hello message and TC message. Hello message is send to the neighboring node to know the active nodes. Hello massage send only one hop away node from the other nodes.TC message is also known as topology control message TC message are only transmitted by the MPRs host. MID (Multiple Interface Declaration) message they are used to alert the neighboring node about the many OLSR interface addresses. MID message are transfer by the MPRs these are known as HNA (Host and Network Association) which provide the information about the external addresses.HNA is the modernized name of the TC message the only difference between them is HNA message is eliminated only when the time is over whereas the TC message only inform about the path cancelation [26]

B. Babel Routing Protocol

Babel is a free from loop table driven routing protocol

Which is intended to be efficient for both the networks using prefix-based routing and flat routing ("mesh networks"), and both these network are highly stable and dynamic networks . [9]

Babel was originally designed for wireless ad-hoc networks. Because of that, Babel is robust in the presence of mobility: only under very exceptional situations circumstances will Babel cause a transient routing loop.

The Babel protocol variant is also able to avoid interference by taking radio frequency into account.[10]

Unlike most routing protocols, which route either IPv4 or IPv6 but not both at the same time, Babel is the combination of both proactive and reactive routing protocol, in the sense that a single packet carry routes of multiple network-layer protocols (both IPv6 and IPv4 routes). This makes Babel efficient and simple to manage on both (IPv6 and IPv4) networks.

Weakness: Babel has two weakness that make it inappropriate for use in some situation:

1) Babel depends on periodic routing table upgrade rather than using a good quality transport (hence, in huge, fixed networks it creates more traffic than protocols that only send updates);

2) Babel does apply a hold time when a prefix is withdraw. Babel is not suitable for mobile networks that apply automatic prefix aggregation. [9]

C. Destination-Sequenced Distance Vector (DSDV)

Destination sequenced distance vector routing (DSDV) is protocol in which Packet Routing and management of Routing Table take place [11]

In an ad hoc network each mobile node maintains its routing table, in which all the available destinations are listed. For the transmission of packet in the ad hoc network there stored tables are used. If the topology of the network changes there is a need to updates it routing table. For that DSDV uses advertisement packet periodically if ant change detected it updates the routing table. All the tables of the nodes are dynamically updated by the broadcasting of the routing table update message. All the nodes update their routing with the use of that packet and again forward that message to their immediate neighbor for the updating of their routing table. This process continues until all the nodes in the network have at least one copy of that packet. if the node receive the multiple copies of the that updating packet with the same sequence number and with the same node the smallest metric of the update packet will be used and discarding the existing route.

The DSDV is designed to address the problem of loop to make the conventional routing best suitable for the ad hoc network but DSDV criteria is that it generate one more problem i.e route fluctuation. DSDV also not solve the bidirectional link problem of all distance vector routing protocols [12].

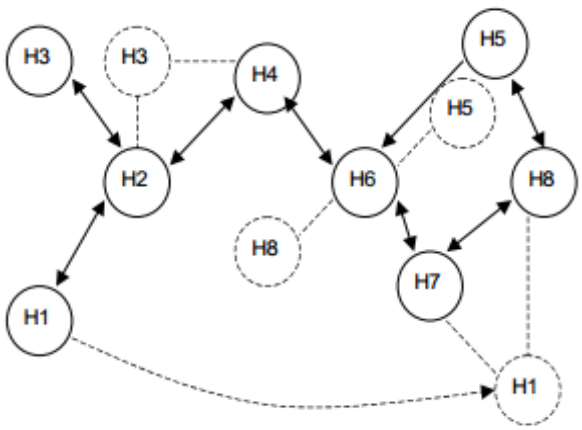

Fig1 : Example of an ad hoc network

VI. ON DEMAND ROUTING

A. Ad hoc On-Demand Distance Vector (AODV) Routing

AODV enables "dynamic, self-starting, multi-hop routing between mobile nodes wishing to establish and maintain an ad hoc network"[13].
AODV allows for the construction of routes to specific destinations and does not require that nodes keep these routes when they are not in active communication.
AODV avoids the "counting to infinity" problem by using destination sequence numbers. This makes AODV loop free.
AODV defines 3 message types:
– Route Requests (RREQs)
– Route Replies (RREPs)
– Route Errors (RERRs)
• RREQ messages are used to initiate the route finding process.
• RREP messages are used to finalize the routes.
• RERR messages are used to notify the network of a link breakage in an active route.

In path discovery process source communicate with neighboring nodes in which the source and neighboring node store the information of next hop corresponds to each flow of packet of data. Every node maintains a table having two separate counters (a) a node sequence number and (b) a broadcast id. The route request (RREQ) packet is send from the source node to its neighboring nodes for the path discovery.
The RREQ is uniquely identify by the pair of <srcID BcastID> whenever a new RREQ is broadcast by source then the broadcast ID is incremented. When a neighboring node receives a route request RREQ ,it either forward it to the next node or prepare a route reply RREP if it has a valid route after increasing the hop count. If a node receive multiple time RREQ indicating same broadcast ID and Source –ID then it will discard duplicate copies of the RREQ

RREQ include two sequence number one is source sequence number and another one is destination sequence number which is known to the source The source sequence number is used to maintain freshness information about the reverse route to the source and the destination sequence number specifies how fresh a route to the destination must be before it can be accepted by the source.
As the RREP is the reversed path of route request RREQ travels from all nodes to source [14]. To establish a reverse path a node archive the address of the intermediate node from which it received the first RREQ. These reverse path route entries are maintained for at least enough time for the RREQ to traverse the network and produce a reply to the sender.
Nodes can keep track of connectivity to neighbors using available data link or network layer mechanisms. RERR message processing is initiated when:
– a link break is detected by the node for the next hop of an route, or
– Receives a data packet destined for a node for which it has no (active) route, or
– Receives a RERR message from a neighbor for at least one
active route in its routing table.
Nodes must increment the destination sequence numbers of the routing entries contained in the RERR message before transmitting to nodes in precursor list. Nodes receiving RERR messages simply update their sequence numbers with those contained in the RERR message. Nodes must also mark these routing entries as invalid regardless of whether they are transmitting and/or receiving. This ensures that no predecessors may reply to a RREQ from a node on their successor path, thus providing loop freedom. RREQ messages are ultimately forwarded back to the originator who may initiate another RREQ message.

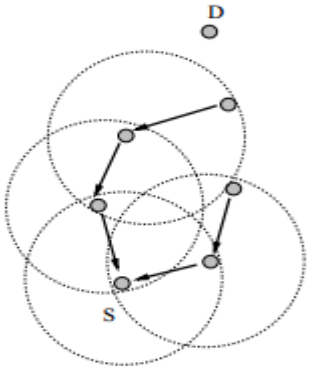

Fig 2: Reverse Path Formation

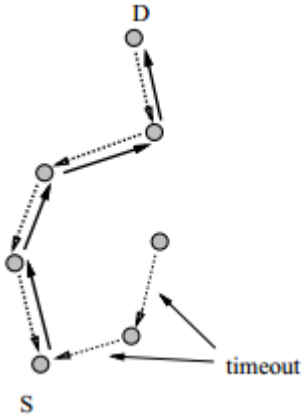

Fig 3 : Forward Path Formation

B. Dynamic Source Routing (DSR)

DSR is a on-demand routing protocol also know as a reactive routing protocol i.e it establish its route only on-demand.it has removed the concept of table-driven strategy. It doesn't send "hello packet" to neighbors to inform them about its presence. To set a route from source to destination source node send a RREQ in the network. RREQ packet is forward to the intermediate nodes. On receiving RREQ the node check the SRCID if it is first

copy of that request then node will forward it to the neighboring node otherwise discard it.

DSR uses route-cache at neighboring nodes. Route-cache is a memory that information from the source route contained in the data packet. On receiving the RREQ packet all the intermediate node set a reverse path to the source node. Once the route is set between source and destination node the sender specifies the path on the packet header of the packet which needs to traverse in that route to reach the destination. If the route is broken between the nodes then a error messages are generated and send to all the nodes. It maintains multiple routes to reach to destination. In practical scenario, it consumes more energy when compared to AODV.

VII. HYBRID ROUTING PROTOCOL

A. *Zone Routing Protocol (ZRP)*

ZRP is a hybrid routing protocol which means it is the combination of proactive and reactive routing component.ZRP was introduced by 'haas' in 1997.its aims to address the problem by taking the best properties from both the approaches.zrp is proposed to reduce the overhead of proactive routing protocol and to reduce the latency in reactive routing protocols. In ZRP we define a zone around each node by setting k-neighborhood (k=2). ZRP is formed by two sub-routing protocol: Intra zone routing protocol (IARP) which uses the concept of DSDV in the network and Inter zone routing protocol (IERP) which uses the concept of AODV in the network.

As seen, a zone is created for every node and packet is send from source node to destination node. If the destination is within the zone of source node then the information is send by using the concept of IARP .where every node maintain a updated table. Destination is not in the zone of source node than the ZRP uses the concept of IERP. In IERP the source node broadcast the message to broader node. Border node uses the concept of AODV which send a RREQ to the neighboring nodes for the path discovery o the destination. When the path is discovered the RREP is send back to the source. By using that path source send the packet to destination.

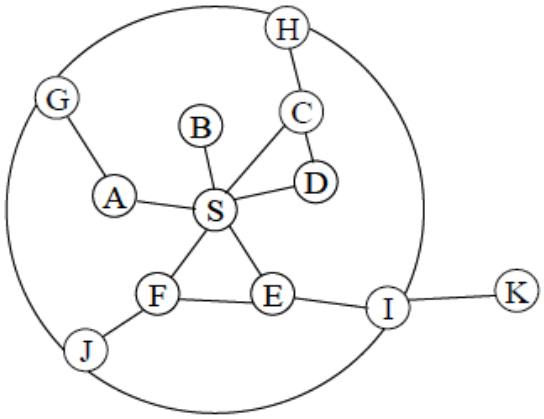

Fig 4: Example Routing Zone with p=2

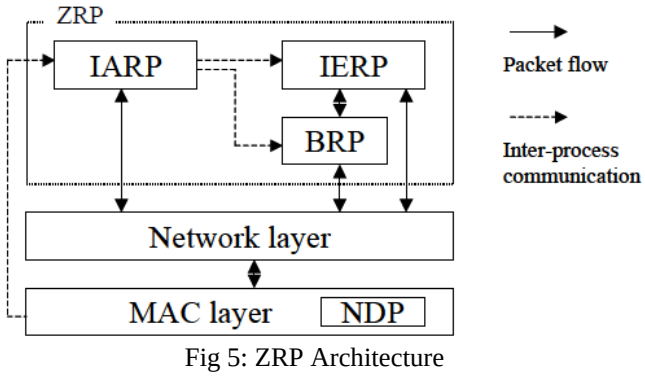

Fig 5: ZRP Architecture

VIII. HIERARCHICAL ROUTING PROTOCOL

A. *Cluster Based Routing Protocol (CBRP)*

CBRP (Cluster Based Routing Protocol) it is a distributed, scalable routing protocol which is an on-demand routing protocol. It uses clustering's structure where nodes are divided into cluster. By using "Clustering structure" approach CBRP minimize on-demand discovery traffic. CBRP uses "local repair" to reduce route acquisition delay and suggest to use uni-directional link to decrease new route discovery traffic. Each cluster have a cluster head which act as a base station and communicates with another cluster head.

In CBRP nodes periodically exchange "hello" with the neighboring nodes. Each node maintain a neighboring table having neighboring status as (c_head,c_member,c_undecided) having the link status as(uni-directional,bi-directional). Nodes are in four possible states these are: NORMAL, ISOLATED, CLUSTERHEAD and GATEWAY. Initially all nodes are in the state of ISOLATED [23].

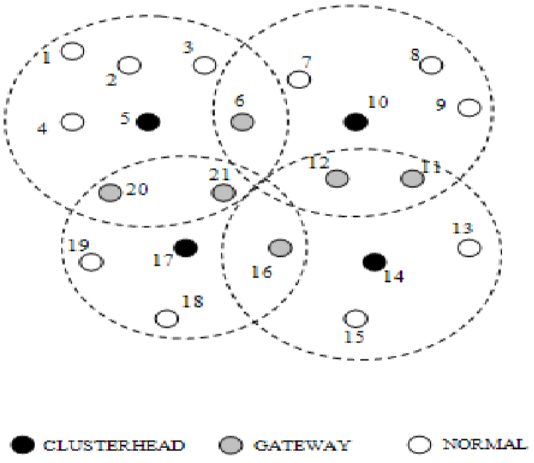

Fig 6: Cluster Formation

B. *Fisheye State Routing (FSR)*

FSR is a hierarchical and link state routing protocol which is adapted by ad-hoc mobile network. FSR uses the "fisheye" technique which was introduced by Kleinrock and Stevens [24], with this technique size of the information is reduced for graphical representation of data. The eye of a fish captures with high detail the pixels near the focal point. The detail decreases as the distance from

the focal point increases. By using "fisheye" approach accurate distance and path quality information about the neighboring nodes are maintained, as distance increases detail information becomes less.

FSR maintains a topology map at each node. In FSR, each nodes maintain a link state table based on the information received from intermediate nodes, and regularly exchange it with their neighbors only (no flooding). In this exchange process, the table entries having larger sequence numbers replace the ones with smaller sequence numbers..

In FSR circle having the different shades of grey define the fisheye scopes. Scope is a st of nodes that can be reached within a given no of hops. In this case ,figure is showing us three scopes 1,2 and 2 hops respectively. The radius and number of levels of each scope depend on the size of the network.

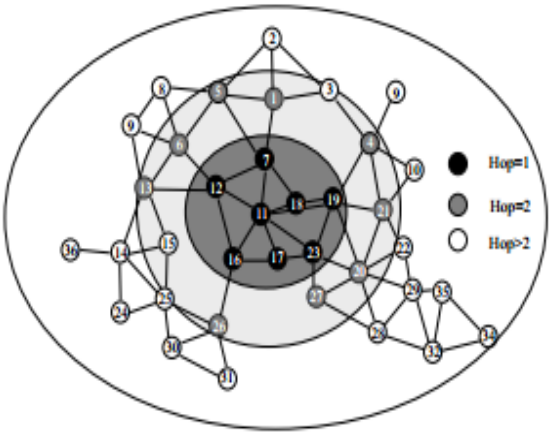

Fig 7: Architecture f Fisheye

IX. Conclusion

In this paper, we provided the necessary details of various type of routing protocols. So many research take place on routing protocols of MANET . Current research in routing protocols of MANETs tend to make many tradeoffs in various environment.

One of the main challenges of the WSN is the energy efficiency because of the limited energy source of sensors. The main objective of protocol design is to make sensors energy efficient and to keep them working for longer time period.

Main objective behind this paper is to explain various routing protocols in a single paper for an easy understanding of the WSN.

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