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Various Routing Protocols for Wireless Sensor Networks

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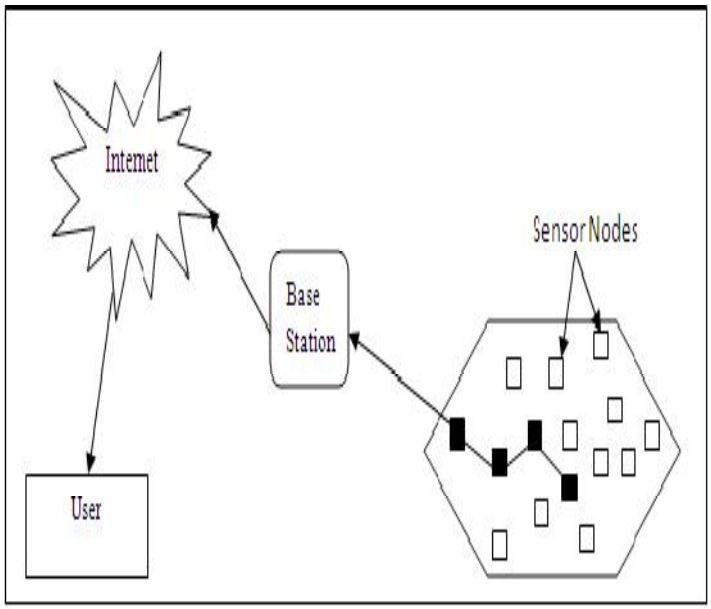
Abstract: From the recent few years, wireless sensor networks has become more and more attractive and are deployed in various fields such as biodiversity mapping, precision agriculture, medical and health care and security surveillance. Wireless sensor network has low cost, self- organizing behavior and sensing ability in very harsh environment. A wireless sensor network is a collection of tiny disposable and low power devices. A wireless sensor network contains a large number of sensor nodes. Routing plays a very important role in wireless sensor networks. Routing means finding the optimal path in a network. There are various routing mechanisms used in wireless sensor networks like flat routing, hierarchical routing, on demand routing protocols, location based routing protocols. This paper compares the various routing protocols on the basis of different parameters.
Keywords: Wireless sensor network, routing, SPIN, DSR, AODV, DSDV, LEACH, TEEN, APTEEN. GAF, GEAR.

I. INTRODUCTION

Wireless sensor networks are the network having light weight sensors mainly used for monitoring purposes. They monitor the physical parameters like temperature, humidity etc. The continuous enhancement in communication, computation and hardware technologies enable new devices known as sensor nodes. Sensors are generally equipped with data processing and communication capabilities. The components of nodes are a micro sensor to sense the desirable event, battery and a transceiver to communicate with the rest of the network. As the power supply, transmission bandwidth and processing capability are limited efficient routing becomes very important. Sensor nodes in a sensor network communicate with other nodes and collect the information. The collected information is then sent to the base station (sink) which further transfers it to the user by the help of an internet. Sensor node is made up of four basic components: a sensing unit, a processing unit, a transmission unit and a power unit. Sensing unit is used for collecting information and is further divided into two subunits: sensor and analog to digital converters(ADC). ADC converts the analog signals produced by the sensor to the digital signals. Processing unit usually consists of the microcontroller or microprocessor with memory, which provides intelligent control to the sensor node .Transmission unit also known as communication uit performs the task of data transmission and reception.



II. LITERATURE REVIEW

The routing mechanisms are divided into following types: flat routing protocols, hierarchical routing protocols, on demand routing protocols and location based routing protocols.

A. *Flat Routing Protocols*

In a flat topology, all nodes carry out the same exact tasks and have the same function. Information dissemination is performed hop by hop in general using the flooding technique. Flat routing algorithms are relatively effective in small-scale networks. Flat routing is relatively unsuitable in large-scale networks due to limited resources and more data processing and bandwidth are needed.
Example: Directed diffusion, SPIN.

B. *Hierarchical Routing Protocols*

In a hierarchical topology, nodes execute distinct tasks and are usually grouped into clusters on the basis of specific requirements. A cluster has a leader, called Cluster Head (CH), and member nodes. Nodes that have more energy are chosen as cluster heads and perform information dissemination and data processing, while nodes with lower energy act as member nodes and execute the task of information sensing.
Example: LEACH, TEEN, PEGASIS.

C. *On Demand Routing Protocols:*

This protocol generates routes only when a source demands it. In other words, when a source requires a route to a destination, the source initiates the route discovery process in the network. This process finishes when a route to destination is discovered or all possible paths have been examined without any success.
Example: DSR, AODV, DSDV.

D. *Location Based Routing Protocols*

Location-based protocols send the data to the desired regions rather than to the whole network. It uses the location information for the transmission of data. These protocols often require nodes to exchange coordinate information with their neighbors. Location information can be obtained from GPS (Global Positioning System) signals. Using location information, an optimal path can be formed by calculating the distance between two nodes.
Examples: GAF, GEAR.

III. COMPARISON BETWEEN DIFFERENT ROUTING PROTOCOLS

A. *Flat Routing Protocol*

In a flat topology, all nodes carry out the same exact tasks and have the same function.

1) *Directed diffusion:* In this protocol the query is flooded throughout the network, and gradients are setup to draw data satisfying the query toward the requesting node. Events start flowing toward the requesting node from multiple paths. This type of protocol is well suited only for persistent queries where requesting nodes are expecting data that satisfy a query for some duration. This makes it unsuitable for historical or one time queries as it is not worth setting up gradients for queries that employ the path only once. At most, in this protocol, data is aggregated at the intermediate nodes.
2) *SPIN(sensor protocols for information via negotiation):*It disseminatesall the information at each node to every node in the network. This enables a user to query any node and get the required information immediately. These protocols make use of the property that nearby nodes have similar data and thus distribute only the data which other nodes do not have. These protocols work proactively and distribute the information all over the network, even when a user node does not request any data.

B. *Performance Parameter*

1) *Packet Delivery Ratio(PDR):*It is described as the ratio of all delivered data packets received successfully at the destination node by the source node. This parameter also depicts that the greater value of packet delivery ratio means the better performance of the protocol

PDR= Number of packet receive / Total number of packet send

2) *End-to-end Delay*: It is described as the average time taken by the data packet to arrive at the destination node. End-to-end Delay depicts the delays caused during retransmission, route discovery process, queuing process, buffering process etc.

End to end delay = (Arrive time - Send time) / total number of connections

3) *Throughput:* It refers to how much data packet can be transferred from one location to another or from source node to destination node in a given amount of time. The higher the throughput value, the better will be the performance of protocol.
4) *Control-Overhead:* It refers to as the average amount of routing protocol control packets sent by the protocol in the network.

Parameter	Directed diffusion	SPIN
Packet delivery ratio	Greater	Lower
End to end delay	Lower	Greater
Throughput	Greater	Lower
Control overhead	Lower	Greater

C. Hierarcical Routing

In a hierarchical topology, nodes execute distinct tasks and are usually grouped into clusters on the basis of specific requirements.

1) *LEACH(Low Energy Adaptive Clustering Hierarchy):*Low Energy Adaptive Clustering Hierarchy is a hierarchical cluster based routing protocol. In this protocol, the network is distributed to clusters. A cluster is a group of adjacent sensors. Every cluster has a node called cluster head(CH). The cluster head is responsible of transmitting data between cluster nodes and the base station. Every node in the cluster sends its data to the CH, then the CH aggregates data and sends it to the BS. This technique avoids direct connection between the sensors and the BS, and hence reduces power consumption. Because if every sensor sends its data to the BS, a lot of power is consumed.
2) *PEGASIS(Power Efficient Gathering in Sensor Information System):* It is a chain based protocol. It is constructing chains of nodes instead of clusters. In this protocol, the sensor node sends its data to closest neighbor as next hop. Then the neighbor adds this data to its own and sends it to next, until the BS is reached. Here there are a few nodes (maybe one) communicate with the base station directly. The construction of the chain starts with the farthest node from the sink. Network nodes are added to the chain progressively, starting from the closest neighbor to the end node. Nodes that are currently outside the chain are added to the chain in a greedy fashion, the closest neighbor to the top node in the current chain first, until all nodes are included.
3) *TEEN(threshold sensitive energy efficient sensor network):*It organizes the sensor nodes into multiple levels of hierarchy. Here the data are transmitted from end nodes to CHs, which collect, aggregate, and transmit this data to higher level cluster heads until the BS is reached. In this protocol, Sensor node sends data according to a specific threshold defined by the network coordinator. If the value of observation doesn't reach the threshold, thesensor will not send the data.
4) *Performance Parameter:* The following criteria were used to evaluate the performance of the three protocols: 1.Transmission power
5) End to end delay
6) Data dropped during transmission
7) Amount of traffic received by the sink(base station)
8) Number of hops
9) Load of the network

PARAMETER	LEACH	TEEN	PEGASIS
Transmission power	Higher	Better	Lesser
End to end delay	Less	high	Very high
Data dropped	More	Less	Very Less
Traffic	More	Less	Very less
Number of	Minimum	Average	Maximum

hops			
Load of network	Very less	Less	More
Energy efficient	Most efficient	Less efficient	Very less efficient

D. On Demand Routing Protocols

This protocol generates routes only when a source demands it.

1) *AODV(adhoc on demand distance vector routing):* It is a pure on demand route acquisition algorithm. The nodes that are not on a particular path do not maintain routing information, nor do they participate in the routing table exchanges. As a result, the number of broadcasts required to create the routes on demand are minimized.
2) *DSDV(destination sequenced distance vector routing):*This protocol is based on the classic Bellman Ford routing algorithm. Each node maintains a routing table with a route to every possible destination in the network and the number of hops to the destination. Each such entry in the table is marked with a sequence number assigned by the destination node. The sequence number allows the node to distinguish the stale routes from new ones, and help avoid formation of routing loops.
3) *DSR(dynamic source routing):* DSR is on demand routing protocol based on source routing. The nodes maintain all source routes that they are aware of in cache. As new nodes are discovered, cache is updated. The protocol works in two main phases: route discovery and route maintenance.

E. Performance Parameter

1) Packet loss: Packet loss takes place whenever some packets travelling across the network fails to reach their destination node.

*2) End to end delay :*The end to end delay includes the queuing and the processing delay between each and every node in the available route.

3) Energy Consumed: Energy consumed by the Routing protocols during sending and receiving packets is an important parameter for consideration.

4) Packet Delivery Ratio: Packet delivery ratio is the ratio of delivery packets which is send by the source node and received by the destination node. When packet delivery ratio is high then we can say that performance is better.

Packet Delivery Ratio = (Total Received) * 100/ (Total Sent Packets)

5) Loss Packet Ratio (LPR): Loss Packet means, Packet can't reached the destination from the source. Loss Packet Ratio means, number of packets that can't receive by destination or that never reached the destination which is send by the source. Then the performance is better when Loss Packet Ratio (LPR) is low.

Loss Packet Ratio= (n Sent Packets-n Received Packets) / nSent Packets) * 10

PARAMETER	AODV	DSDV	DSR
Packet loss	More	Less	More
End to end delay	Less	More	More
Energy consumed	Less	More	More
Packet delivery ratio	Average	High	High
Loss packet ratio	Average	Low	Low

E. Location Based Routing Protocol

Location-based protocols send the data to the desired regions rather than to the whole network. It uses the location information for the transmission of data.

1) *GAF(Geographic Adaptive Fidelity):* Geographic adaptive fidelity is an energy aware routing protocol. In GAF the sensor field will be separated into grid squares, each sensor uses its location information to associate with other grids. This location information will be provided by GPS or by other location systems.

2) *GEAR(Geographic and Energy-Aware Routing):*GEAR is an energy efficient routing protocol proposed for routing queries to target the regions in the sensor field. The sensors will be equipped with localization hardware like GPS, localization system. With the help of this the sensors can know about their current positions. The sensors can know about its location, their residual energy as well as neighbors too. In order to select the sensors to route the packet towards destination it uses energy aware methods using geographical information. At that point GEAR uses recursive geographic forwarding to spread the packets inside the target region.

Performance parameter:

PARAMETER	GAF	GEAR
Latency	Moderate	Moderate
Scalability	High	Moderate
Energy awareness	High	Moderate
QoS	Low	Low
Traffic on network	Moderate	Moderate
Power usage	Low	Low
Transmission scheme	Multi-hop	Flat

Overall Comparison Between Different Routing Protocols

PARAMETER	SPIN	DD	LEACH	TEEN	PEGASIS	GAF	GEAR
Power usage	limited	limited	High	High	maximum	Limited	limited
Data aggregation	Yes	yes	Yes	Yes	no	No	No
Scalability	limited	limited	Good	good	good	Good	limited
Query based	Yes	yes	No	No	no	No	No
Overhead	Low	low	High	High	low	moderate	moderate

IV. CONCLUSION

This paper addresses the considerable comparison in various protocols like flat routing, hierarchical routing, on demand based routing and location based routing protocols. In flat routing protocols, directed diffusion is better than SPIN. In hierarchical routing protocols, LEACH is not recommended to deploy in large networks, because of the single hop routing technique. Also the network using LEACH consumes more power than the network using other protocols. When power is critical, and life time of the sensors is very important issue, it is better to deploy PEGASIS.In TEEN networks, the sensor node is more complicated. Nodes communicate in different levels providing good time and efficiency. It is useful when there are sudden changes in the environment because its architecture allows the user to observe a specific area in the network.in on demand routing protocols, AODV performs better than DSR AND DSDV. In location based routing protocols, GAF is highlyscalable, GEAR faces a problem of limited scalability.

V. FUTURE SCOPE

The future work will focus on implementing the wireless sensor networks with the help of swarm intelligence algorithms. The self-organization of wireless sensor networks is so similar to the swarm intelligence algorithm, especially the ant algorithm.
With the help of ant colony algorithm, the efficiency will improved and the energy consumption will decreased.

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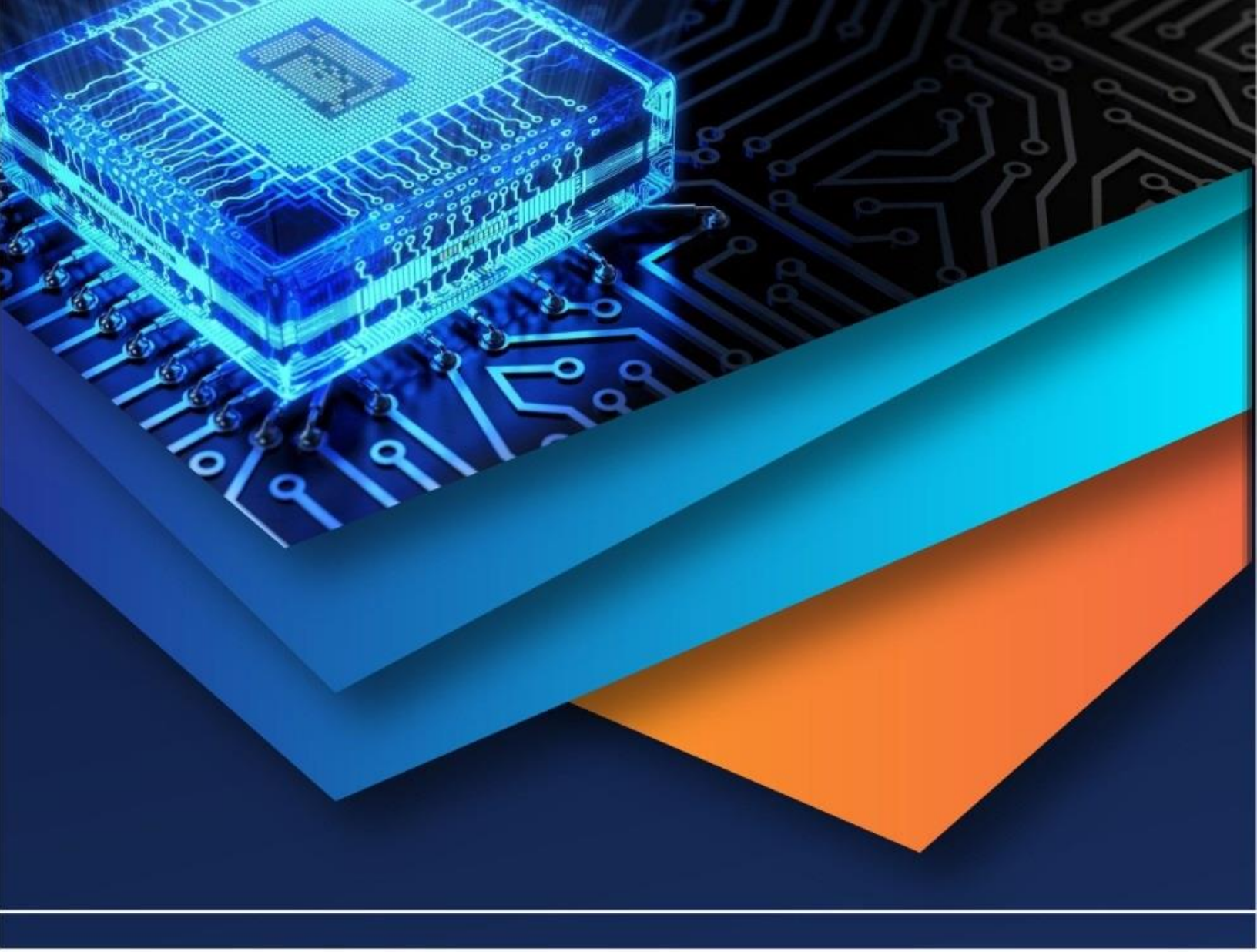

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