IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 1 Issue 6, August 2014.

www.ijiset.com

ISSN 2348 – 7968

# Analysis of Routing Protocols in Wireless Sensor Networks

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## Abstract:

Wireless sensor network provides a way of information sensing, processing, communicating and transfer of information. The sensor nodes depend on their battery to carry out these operations. Once the node runs out of its battery it will be discarded. Hence energy consumption in WSN plays a vital role in choosing a routing protocol. In this report we analyze types of routing protocols in WSN i.e, Flat routing and Hierarchical Routing. A comparison is carried out in terms of throughput, end to end delay and the node energy utilization.

## Introduction:

Advances in processing has made it possible to build tiny sensor nodes with the sensing and processing capabilities. The advances in wireless communication have made it possible to establish communication with the sensor nodes. The sensor nodes and their communicating capabilities together act as the backbone of the wireless sensor networks. Today wireless sensor networks are used in many areas. Few examples include military applications, environmental monitoring, health and medical applications and etc.

Each sensor node in network consists of 4 units namely a sensing unit, a processing unit, a transceiver and a battery. The only source of energy for nodes is the battery energy. Processing consumes less energy than the transmission of data. Hence the battery life plays a vital role in selection of the routing protocols for the wireless sensor networks. Usually sensor nodes are densely deployed in the area to be monitored. The network can be organized but in most of the situations it will be unorganized. Nodes continuously sense for the data and a data aggregation method is used to exchange the data within nodes and transmission to the sink node.

The existing protocols of the wireless networks will not be efficient for the wireless sensor networks due to several reasons,

1. Sensor nodes may not have the unique global id’s because of large number of sensors and the overhead associated with it.
2. Nodes are densely deployed hence the maintenance of table information creates overhead.
3. Sensor nodes have limited power hence battery life is important.
4. Sensor nodes are based on the broadcast.

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5. Sensor network must be self organizing.

Wireless sensor networks have their own routing protocols which are mainly based on the broadcast. Routing is mainly divided into two categories hierarchical and flat routing.

The different routing and data aggregation protocols present in flat routing protocols include, SMECN (small minimum energy communication network), flooding, gossiping and SPIN (sensor protocols for information via negotiation). We take up SPIN as an example of flat routing protocol in sensor network for implementation.

## SPIN (sensor protocols for information via negotiation)

SPIN is a modification of classic flooding. In classic flooding the information is forwarded on every outgoing link of the node. The drawbacks of flooding includes, draining out the battery life of the sensor network to a great extent. Hence a new protocol named SPIN was developed to overcome the drawbacks.

SPIN is an adaptive routing protocol, which transmits the information first by negotiating. As specified earlier, transmission of data consumes more energy. To cope up with this problem SPIN makes use of metadata of the actual data to be sent. Suppose a node has to send a sensed image file it first generates the metadata for image, and this metadata is broadcast. Metadata will contain the description of the message that the node wants to send. The actual data will be transmitted only if the node wishes to receive it. For this purpose SPIN makes use of 3 messages namely,

1. ADV
2. REQUEST
3. DATA

ADV: Before sending a message, a node first generates the descriptor of the message to be sent. This metadata is exchanged by making use of ADV message. ADV message informs the size, contents and requirements of the message. This helps the receiving node on deciding transmission of the message.

REQUEST: After receiving the ADV message receiver node verifies the descriptor whether the message is a duplicate and whether receiver node's battery capabilities are enough to transmit the data. If the node is interested in data, it replies with a REQUEST message to the sender node.

DATA: If the sender node receives a REQUEST message, it starts the actual transmission of data by making use of DATA message. This is the actual data transfer phase.

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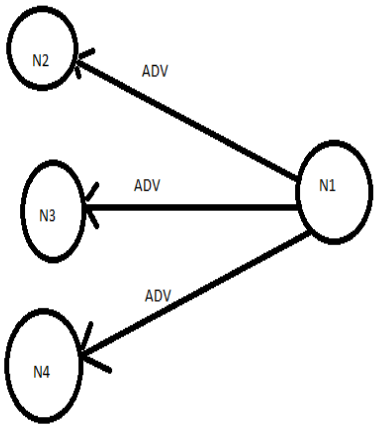


Fig 1. ADV message

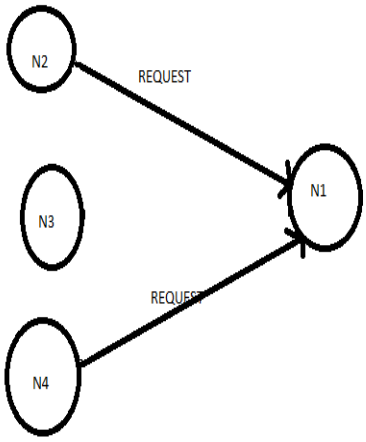


Fig 2. REQUEST message

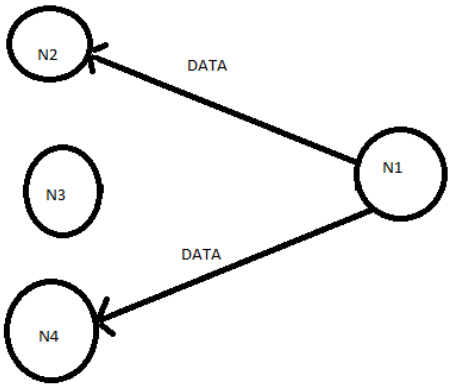


Figure 3. Showing working of SPIN.

The SPIN transmission is data centric; it is only transmitted to the nodes that have interest in the data. This process continues until the data reaches the sink node. SPIN reduces both the network overhead and the energy consumption in the transmission. There will not be duplicate messages in the network since nodes negotiate before transmitting the data.

Another set of routing protocols is hierarchical routing protocols. Hierarchical routing protocols create a hierarchy in the transmission of the sensed data. Different types of hierarchical routing are SAR (sequential assignment routing), LEACH, Threshold sensitive Energy Efficient sensor Network protocol (TEEN), Adaptive Threshold sensitive Energy Efficient sensor Network protocol (APTEEN), Energy Efficient Clustering Scheme (EECS), Hybrid Energy-Efficient Distributed Clustering (or HEED), Power-Efficient Gathering in Sensor Information Systems (PEGASIS). These routing protocols usually differ in the way cluster head is elected. LEACH is taken up as an example of hierarchical routing protocol.

**LEACH: (Low Energy Adaptive Clustering Hierarchy)**

LEACH is cluster based protocol which selects a cluster head periodically. Leach performs a self configuring cluster formation. It provides localized control for data transfers. The main idea in Leach is to evenly distribute the energy load in the network. Leach randomly selects few sensor

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nodes as the cluster heads. The sensor nodes join the cluster based on the signal strength received by the cluster head. Nodes transmit their data to the cluster head instead of sending it directly to the sink node. Periodically cluster head node compresses the data received by the other nodes and sends it as an aggregate to the sink node. The transfer of aggregated data packet reduces the amount of data that has to be sent to the sink node. This protocol is best suitable where there is need of constant monitoring. The role of cluster heads is periodically rotated among the nodes to prevent the battery of the cluster head from draining out.

Leach operates in two phases, a setup phase and a steady phase. The selection of the cluster heads and the formation of the cluster take place in the setup phase. In the steady phase actual data transfer to the sink takes place.

In the setup phase the leader election takes place and the heads are changed over time. To make a decision about the cluster head formation, every node selects a random number between 0 and 1. If this number is greater than the threshold the node is selected as the cluster head for the current round. The threshold value is calculated as,

$$T(n)=\begin{cases}\dfrac{p}{1-p*\left(r \bmod \frac{1}{p}\right)} & \text{if } n \in G \\ 0 & \text{others}\end{cases}$$

Where,

T(n) – the threshold value.

p- Fraction or percentage of number of cluster heads for the current round.

r- is the current round

G- is the set of the nodes that have not been cluster heads in the past 1/p rounds.

The protocol makes use of 3 types of messages,

1. ADVERTIZEMENT

2. JOIN REQ

3. SCHEDULE

ADV and JOIN REQ messages are used in the setup phase to form a cluster. Once a node is chosen as cluster head, it advertises itself by making use of ADV messages. A node may receive ADV messages from more than one cluster heads. Now the node verifies the signal strength of the cluster head node and sends a join request. The join request is sent only to the cluster head with higher signal strength.

In Leach the process is divided as rounds and each round consists of a setup phase and a steady phase.

In the steady phase, cluster head creates TDMA time schedules for the nodes in the cluster and assigns the time slot. Each node waits for its turn to transmit the data. Periodically cluster head creates an aggregate packet and forwards it to the sink node. This aggregate packet is based on all the data received by the cluster member

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nodes. After a certain period of time Leach again enters the setup phase.

Leach provides many good features for the network. It provides a clustered hierarchy, localized coordination and randomized rotation of cluster head. Leach is able to increase the lifetime of the network by sending aggregate of the data. There are also several issues in the assumptions of the Leach.

1. It assumes that all nodes can transmit with enough power to reach the sink which may not be true always. Hence Leach cannot be used for large networks.
2. It transmits data to the sink node periodically and hence it is not suitable for time critical applications.
3. Since sensor nodes are densely deployed there can be possibilities that in some areas there is concentration of cluster heads and in other area a node do not have any signal from cluster nodes.
4. Leach assumes each node has the same energy at the start of each round.

**Simulation and results** The model is simulated in Network Simulator-2. Temperature, Carbon monoxide, humidity, winds peed Data generators are used to provide the sensed data values to the nodes. Simulation is carried out on a set of 100 nodes and a base station. Every node runs on the same code.

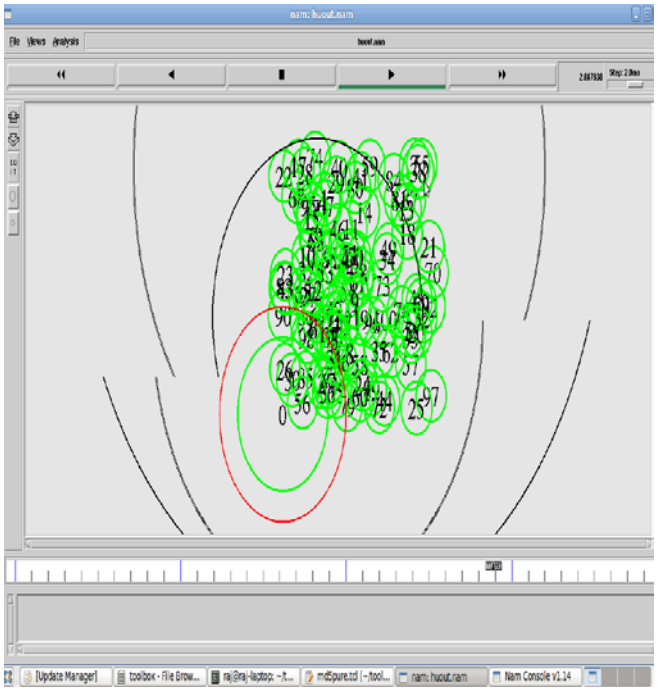

Fig 4 showing transmission of nodes

Average End-to-End Delay: Average end to end delay includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times of data packets.

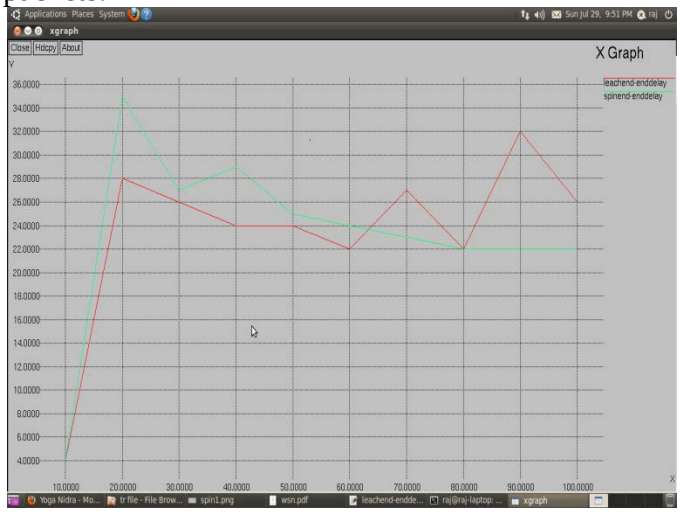


Fig 5. Showing average end to end delay

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Throughput: Includes the ratio of amount of packets received to the amount of forwarded packets during the simulation.

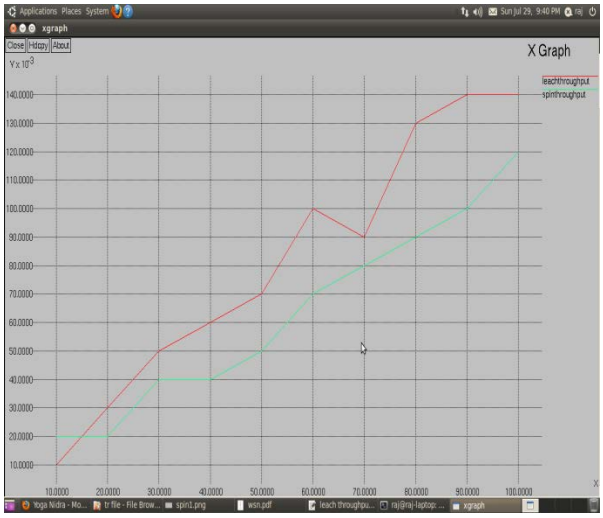


Fig 6. Throughput

Remaining node energy: It is the amount of battery energy remaining at the end of the simulation.

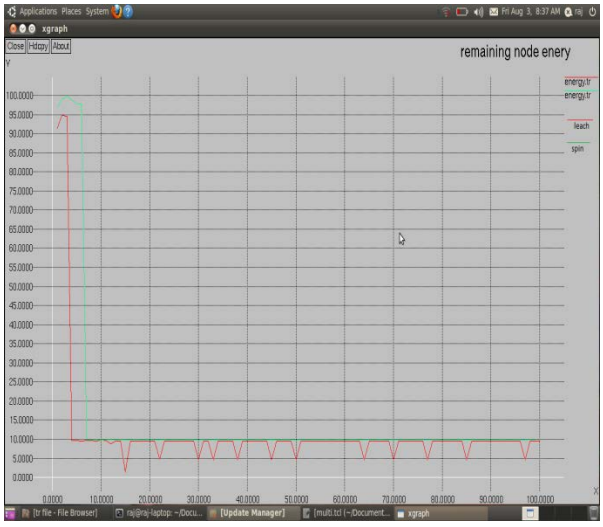


Fig 7. Remaining node energy

Since leach is a hierarchical routing protocol the nodes which had become leader heads would consume more energy. In case of spin protocol all the nodes perform the send operation at the same interval of time hence, all the nodes would consume same amount of energy.

## Conclusion:

The characteristic behavior of the routing protocols was observed using the Temperature, Carbon monoxide, humidity, winds speed Data generators application. From simulations it was observed that leach protocol enhances the network lifetime by the cluster head formation and increases overall energy efficiency of the nodes. Spin protocol simulation shows that it overcomes the drawbacks of the classic flooding by making use of the metadata. For the current data generator application, simulation results shows that Leach performance is better compared to spin protocol in terms of end to end delay and the throughput. In case of remaining node energy Spin protocol ensures that, all the nodes consume same amount of energy whereas in case of Leach the leader head nodes consume more energy as compared to the remaining nodes. From the results it can be concluded that Spin protocol is best suited for the time critical applications since it sends the data to the sink as soon as it receives data and it always assures shortest path to reach sink. Leach protocol sends data to the sink periodically, it is the duty of the cluster head to transmit the data to sink. So in time critical applications like military applications and patient monitoring Spin protocol is best suited over Leach protocol. Spin also keeps all the nodes informed about the current condition of the network. In critical

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applications keeping all the nodes informed is important. Overall about the routing protocols of the sensor networks it can be concluded that, the suitability and performance depends also on the type of application on which routing protocol is running. Wireless sensor network applications are increasing day by day. With the constraints on battery life of nodes, the area is one of the hot research topics and needs more improvements.

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