Performance Analysis of SPIN and LEACH Routing Protocol in WSN

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Abstract
Wireless sensor networks have emerged as a technology that are being quickly adopted due to their flexibility and use in a variety of environments. However, they consist of small, inexpensive devices or nodes that have severe constraints such as limited bandwidth, limited processing power, short battery life, small storage capability and are physically prone to external threats [1]. Sensor Network are emerging as a new tool for important application in diverse fields like military surveillance, habitat monitoring, weather, home electrical appliances and others. These sensor nodes have some constraints due to their limited energy, storage capacity and computing power. The energy efficiency is an important issue in WSN. Routing protocols makes the transmission in an efficient manner and ensures reliable delivery over multiple-hop relay in WSN. This paper analyses performance of the routing protocols.

Keywords: Wireless sensor networks LEACH and SPIN routing protocols, network structure, and energy efficiency.

I. INTRODUCTI'ON

A wireless sensor network [3], [5] with a large number of tiny sensor nodes can be used as an effective tool for gathering data in various situations. One of the major issues in wireless sensor networks is developing an energy-efficient routing protocol which has a significant impact on the overall lifetime of the sensor network. Sensor nodes measure the ambient conditions from the environment surrounding them. The applications of WSN are various from health monitoring to battle field. The practice of remote sensing has become greatly simplified by useful and affordable sensors as well as required software packages. Additionally, users can monitor and control the underlying environment from remote location. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy awareness is an essential design issue. Routing protocols in WSNs might differ depending on the application and network architecture. A sensor network (WSN) are highly distributed networks of small, lightweight wireless nodes, deployed in large numbers to monitor the environment or system by the measurement of physical parameters such as temperature, pressure humidity, sound, vibration, pollutants and collectively relay their sensed data to the sink node. Each node in the network connected to each other.

Each sensor node in the network consists of three subsystems:

1) The sensor subsystem which is used to sense the environment,
2) The processing subsystem which performs the local computations on the sensed data, and
3) The communication subsystem which is responsible for sharing the sensed data with the neighboring sensor nodes.

This paper aims to show analysis performance of routing protocol in wireless sensor network using data centric approach. Two Wireless Sensor Network simulator versions 2.34. Both of the routing protocols are selected from data centric routing. The result of the analysis for each protocol is compared and the best routing protocol using data centric approach is proposed for WSN. This paper examines the performance of each of routing protocols which improve the network efficiency and maximize the network lifetime.

II. Routing Protocols In Wsn

2.1 LEACH

LEACH [6](Low Energy Adaptive Clustering Hierarchy). These protocols uses cluster node for the purpose of transmission of information between the nodes. It is a self-organizing protocol and nodes organize themselves into local clusters and perform data transmission to the
Selection of cluster head node is not fixed and it depends on possibility of nodes, which possess high energy. Formation of cluster head is based on TDMA schedule for data transmission. Time Division Multiple Access (TDMA) used as a scheduling mechanism makes it prone to long delays when applied to large sensor networks. TDMA schedule prevents

data collision, among messages and preserve energy among non cluster nodes. The establishment of cluster head is as follows: Each node generates a random number between 0 and 1 and compares it with the threshold value P(n). If the number is less than the threshold value, it becomes the cluster head node. If it has been selected cluster head node in each round of cycle, the node's P (n) is set to 0 so that the node will not be re-selected as cluster head. Otherwise, the node is non-cluster head node in the current round. After the selection of cluster head, the head broadcast its own presence to all other nodes. After broadcasting the information, then all other nodes send the information to the cluster head. Together, these features allow LEACH to achieve the desired properties in the networks.

P(n)= p /1-p(r mod 1/p)
There are several desirable properties for protocol on these networks:
· Use 100's - 1000's of nodes
· Maximize the lifetime of system
· Maximize network coverage
· Use uniform, battery-operated nodes

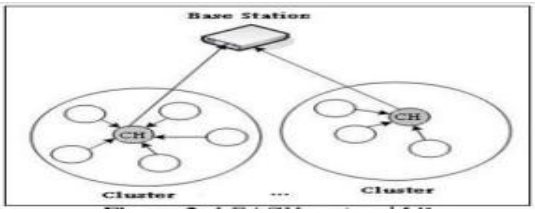

Fig 1: LEACH Protocol

As shown in fig.1, dark nodes specifies the cluster head and other non cluster head nodes send the information to cluster head on the basis of local information which in turn send the information to base station.
This protocol is divided into rounds; each round consists of two phases;

Set-up Phase
(1) Advertisement Phase
(2) Cluster Set-up Phase
Steady Phase
(1) Schedule Creation
(2) Data Transmission

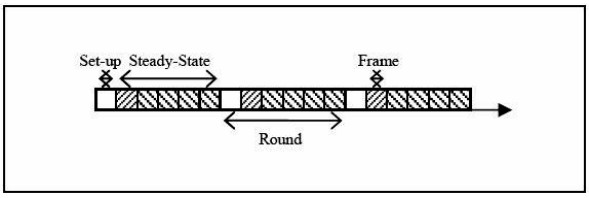

Fig.2: LEACH protocol phases [4]

Although LEACH is able to increase the network lifetime, there are still a number of issues about the assumptions used in this protocol. LEACH assumes that all nodes can transmit with enough power to reach the Base Station (BS) if needed and that each node has computational power to support different MAC protocols. Therefore, it is not applicable to networks deployed in large regions. It is not obvious how the number of the predetermined CHs (p) is going to be uniformly distributed through the network. Therefore, there is the possibility that the elected CHs will be concentrated in one part of the network. Hence, some nodes will not have any CHs in their vicinity. Furthermore, the idea of dynamic clustering brings extra overhead, e.g. head changes, advertisements etc., which may diminish the gain in energy consumption. Also, the protocol assumes that all nodes begin with the same amount of energy capacity in each election round, assuming that being a CH consumes approximately the same amount of energy for each node. The protocol should be extended to account for non-uniform energy nodes, i.e., use energy-based threshold.

2.2 SPIN

SPIN (Sensor Protocols for Information via Negotiation) Sensor Protocols for Information via Negotiation (SPIN) that disseminates all the information at each node to every node in the network assuming that all nodes in the network are potential BSs. This enables a user to query any node and get the required information immediately. These protocols make use of the property that nodes in close proximity have similar data, and hence there is a need to only distribute the data other nodes do not posses. The SPIN family of protocols uses data negotiation and resource-adaptive algorithms. Nodes running SPIN assign a high-level name to completely describe their collected data (called meta-data) and perform metadata negotiations before any data is transmitted. This ensures that there is no redundant data sent throughout the network. The semantics of the meta-data format is application-specific and not specified in SPIN. For example, sensors might use their unique IDs to report meta-data if they cover a certain known region. In addition, SPIN[5] has access to the current energy level of the node and adapts the protocol it is running based on how much energy is remaining. These protocols work in a time-driven fashion and distribute the information all over the network, even when a user does not request any data. The SPIN family is designed to address the deficiencies of classic flooding by negotiation and resource adaptation. The SPIN family of protocols is designed based on two basic ideas:

1) Sensor nodes operate more efficiently and conserve energy by sending data that describe the sensor data instead of sending all the data; for example, image and sensor nodes must monitor the changes in their energy resources.
2) Conventional protocols like flooding or gossiping-based routing protocols [2] waste energy and bandwidth when sending extra and unnecessary copies of data by sensors covering overlapping areas.

The drawbacks of flooding include implosion, which is caused by duplicate messages sent to the same node, overlap when two nodes sensing the same region send similar packets to the same neighbor, and resource blindness in consuming large amounts of energy without consideration for energy constraints. Gossiping avoids the problem of implosion by just selecting a random node to which to send the packet rather than broadcasting the packet blindly. However, this causes delays in propagation of data through the nodes.

SPIN's meta-data negotiation solves the classic problems of flooding, thus achieving a lot of energy efficiency. **SPIN is a three-stage protocol as sensor nodes use three types of messages, ADV, REQ, and DATA, to communicate. ADV is used to advertise new data, REQ to request data, and DATA is the actual message itself.** The protocol starts when a SPIN node obtains new data it is willing to share. It does so by broadcasting an ADV message containing metadata. If a neighbor is interested in the data, it sends a REQ message for the DATA and the DATA is sent to this neighbor node. The neighbor sensor node then repeats this process with its neighbors. As a result, the entire sensor area will receive a copy of the data. The SPIN family of protocols includes many protocols. The main two are called SPIN-1 and SPIN-2; they incorporate negotiation before transmitting data in order to ensure that only useful information will be transferred. Also, each node has its own resource manager that keeps track of resource consumption and is polled by the nodes before data transmission. The SPIN-1 protocol is a three-stage protocol, as described above. An extension to SPIN-1 is SPIN-2, which incorporates a threshold-based resource awareness mechanism in addition to negotiation. When energy in the nodes is abundant, SPIN-2 communicates using the three-stage protocol of SPIN1. However, when the energy in a node starts approaching a low threshold, it reduces its participation in the protocol; that is, it participates only when it believes it can complete all the other stages of the protocol without going below the low energy threshold. In conclusion, SPIN-1 and SPIN-2 are simple protocols that efficiently disseminate data while maintaining no per-neighbor state. These protocols are well suited to an environment where the sensors are mobile because they base their forwarding decisions on local neighborhood information.

One of the advantages of SPIN is that topological changes are localized since each node need know only its single-hop neighbors. SPIN provides more energy savings than flooding, and metadata negotiation almost halves the redundant data. However, SPIN's data advertisement mechanism cannot guarantee delivery of data. To see this, consider the application of intrusion detection where data should be reliably reported over periodic intervals, and assume that nodes interested in the data are located far away from the source node, and the nodes between source and destination nodes are not interested in that data; such data will not be delivered to the destination at all.

	LEACH PROTOCOL	SPIN PROTOCOL
Classification	Hierarchical	Flat

Mobility	Fixed BS	Poss.
Position Awareness	No	No
Power usage	Max	Ltd
Negotiation Based	No	Yes
Data Aggregation	Yes	Yes
Localization	Yes	No
Query Based	No	Yes
State Complexity	CHs	Low
Scalability	Good	Ltd
Multipath	No	Yes

Table1. Theoretical comparison between LEACH and SPIN Protocol

3. Performance Testing

This section discusses simulation on energy performance using Network Simulator 2.34. The simulation primarily study on routing energy usage in SPIN and LEACH.SPIN is negotiation based data dissemination protocol suitable for wireless sensor networks. Thus, it assumes that all sensor nodes can be sinks potentially. Every node uses meta-data to name their data. By using this metadata, each node can negotiate whether to deliver data or not to eliminate the redundant data transmission throughout the network. In other words, every node can make its communication decisions based on negotiations with neighbour nodes about application-specific knowledge of the data and the resource available to it. This negotiation enables sensors to distribute data efficiently with limited energy. Basically, SPIN [7] uses resource-adaptive negotiation mechanism. Before any data is really transmitted, a sensor node performs negotiations by using its meta-data. These negotiations are done by exchanging a new data advertisement message (ADV) and a request for data message (REQ) between the sender and the receiver. After the negotiation, the sender transmits its data to the receiver (DATA).SPIN assures that there is no redundant data sent throughout the sensor network. In addition, SPIN checks the current energy level of each sensor node and adapts the protocol depending on how much energy remains. In SPIN simulation testing, there is some limitation. The nodes is being designed and linked in shortest path. The negotiations are done by exchanging a new data advertisement message (ADV) will display in blue color links and a request for data message (REQ) between the sender and the receiver will display in green color links. After the negotiation, the sender transmits its data to the receiver (DATA) where will be displayed in red color links. The event will be the packets that being transmits along the gradient path. Every transmitting packet to nodes, the links will be displayed in red color. In short, SPIN simulation tests differentiate those message elements with colors. Each colors presenting different element of message in SPIN routing scheme.

LEACH is a clustering based protocol that includes the randomized adaptive self configuring cluster formation. Localized control for data transfers .Low energy media access and Application specific data processing such as data aggregation. The operation of LEACH is separated into two phases, the **setup phase** and the **steady state** phase. In the setup phase, the clusters are organized and CHs are selected and rotates this role to evenly distribute the energy load among the sensors in the network. In LEACH, the cluster head (CH) nodes compress data arriving from nodes that belong to the respective cluster, and send an aggregated packet to the base station in order to reduce the amount of information that must be transmitted to the base station. LEACH uses a TDMA/CDMA MAC to reduce inter-cluster and intra-cluster collisions. However, data collection is centralized and is performed periodically. Therefore, this protocol is most appropriate when there is a need for constant monitoring by the sensor network. A user may not need all the data immediately. Hence, periodic data transmissions are unnecessary which may drain the limited energy of the sensor nodes. After a given interval of time, a randomized rotation of the role of the CH is conducted so that uniform energy dissipation in the sensor network is obtained. LEACH assumes that all nodes can transmit with enough power to reach the Base Station (BS) if needed and that each node has computational power to support different MAC protocols. Therefore, it is not applicable to networks deployed in large regions. It is not obvious how the number of the predetermined CHs (p) is going to be uniformly distributed through the network. Therefore, there is the possibility that the elected CHs will be concentrated in one part of the network. Hence, some nodes will not have any CHs in their vicinity. Furthermore, the idea of dynamic clustering brings extra overhead, e.g. head changes, advertisements etc., which may diminish the gain in energy consumption. Also, the protocol assumes that all nodes begin with the same amount of energy capacity in each

election round, assuming that being a CH consumes approximately the same amount of energy for each node. The protocol should be extended to account for non-uniform energy nodes, i.e., use energy-based threshold.

4. Simulation Results

This section discusses simulation result performed on SPIN This section discusses simulation result performed

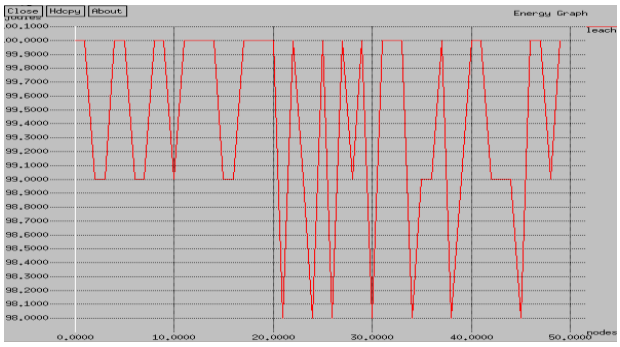

Fig 3 energy graph of LEACH

On SPIN and LEACH. There are fifty nodes being these protocols are tested on a number of factors. The main experiment is actually measure the energy of the network .When a node receives and transmit a data packet, the total energy will decrease and increase gradually. This simulation test network ran using 50 nodes for 2 minutes for both LEACH and SPIN. As observed from the below graph, SPIN fares much better than the LEACH protocol in terms of energy consumption. In LEACH as seen from the Fig 3, it will start with advertise its interest, and then waiting a request from any node before start transmitting data again. The energy of the network decreases rapidly and then increase and so on in 2 minutes. This is because the effective of transmitting and receiving data in the network. In LEACH protocol we have the limited energy. In it we have a given interval after a given interval of time; a randomized rotation of the role of the CH is conducted so that uniform energy dissipation in the sensor network is obtained. In LEACH protocol more energy is consumed because of head changes, advertisements etc.

In LEACH protocol more energy is consumed because of head changes, advertisements etc. In LEACH protocol the packet delivery ratio is more because of cluster heads. The end to end delay and dead nodes is more in LEACH because of randomized rotation of role of the cluster head as shown in figure and as the number of nodes the packet delivery ratio start decreasing.

As observed from the below graph in the LEACH end to end delay is more in LEACH Because of randomized rotation of role of the cluster head . In the LEACH protocol the packet delivery ratio is more because of cluster heads.As the number of nodes

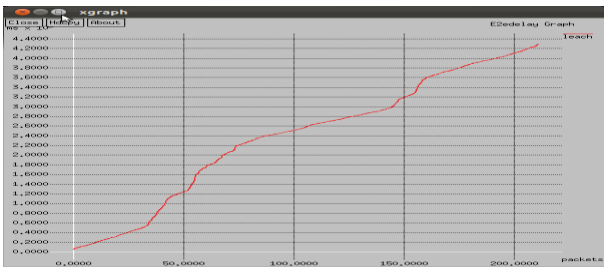

Fig 4 End to end delay graph of LEACH protocol

Increasing the packet delivery ratio start decreasing. The dead nodes in it is more due to randomized rotation of the protocol.

SPIN will start with advertise its interest, and then waiting a request from any node before start transmitting data again. SPIN
nodes negotiate with each other before transmitting data. Negotiation helps ensure that only useful information will be

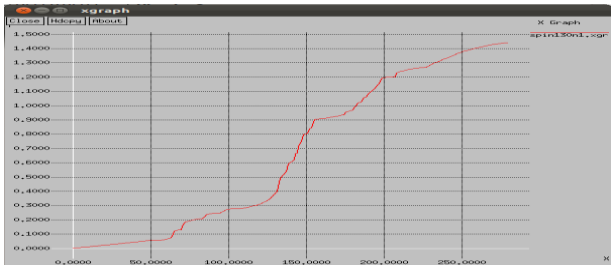

Fig 5 Energy graph of SPIN protocol

transferred. To negotiate successfully, however, nodes must be able to describe or name the data they observe. These descriptors used in SPIN negotiations are referred to as meta-data. From the result, it proves that meta-data negotiation keeps SPIN nodes from sending out even a single redundant data packet in a network .The result is based on average packet received by nodes. From Fig.5, the energy used by nodes dramatically decrease receiving packet from the first 20 seconds. This is because nodes that links to the shortest path nodes and after that the gradient links uses a lot of energy for transmitting and receiving packet. Thus, they generate overhead and reduce the life time of the nodes in the network. When this occurs, the topology and links for every node will change. The distance for for transmitting and receiving packet will be a bit less as compared to LEACH.

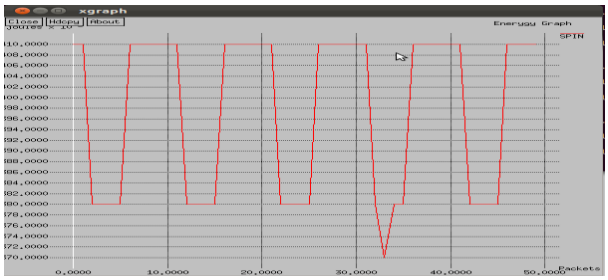

Fig 6 end to end Delay in SPIN protocol

The end to end delay in the SPIN protocol is same as that of LEACH for some starting packets but after that the delay in SPIN is less as shown in fig because of nodes link to shortest path end to end delay start increasing as number of nodes increases. SPIN operation will transmit almost zero redundant data packet and decrease the operation of sending wasted data packets.

5. Conclusion

Based on the study of these routing algorithms, it shows that some of the desirable features of a good energy efficient routing protocol for sensor network are:

If a routing algorithm can support multiple paths to a destination with low overhead, it could help in balancing the network load.

In SPIN and LEACH Protocol the LEACH has limited energy and it has the more energy consumption as compared to SPIN Protocol because of cluster head rotation .In LEACH Protocol after a given interval the cluster head are rotated and they also consume energy while rotating so it consume more energy where as SPIN uses less it do not have any cluster head .In it we first advertise the message than we send the data only those from which we get the request but this is only based on metadata negotiation only.

In LEACH the packet delivery ratio start is less as compared to SPIN .This is because of given interval of time in LEACH. In LEACH we have the limited time after that the transmission stop. But in SPIN no such time boundation so packet delivery ratio is large.

The end to end delay and dead nodes in LEACH is more as compared to SPIN. In starting end to end delay become same in both the cases after some interval there is difference .This is because the in LEACH there is cluster head rotation takes place so it have large end to end delay but in SPIN end to end delay is very less because it uses the Bellman Ford shortest path algorithm.

The dead nodes in LEACH Protocol are large because of cluster head rotation but SPIN has very less dead nodes because in it data transmission is based on the metadata negotiation of the nodes. So the LEACH protocol is most appropriate when there is a need for constant monitoring by the sensor network.

6. Acknowledgments

I take this opportunity to express my gratitude to all those people who extended their co-operation and played an important role in successful complementation of this thesis.

I express my sincere thanks to **Mrs. Sonia Juneja**, Head of IT Department and assistant professor in Computer Science & Engineering and Information Technology, for providing me invaluable support and able guidance throughout the thesis. She has been a source of inspiration for me that helped me in delivering the suggestions .Without whose support nothing could have been achieved.

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