A Review on Routing Protocol of Wireless Sensor Networking

DISSERTATION SUBMITED AS "MINOR PROJECT" IN
PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE
MASTER OF COMPUTER APPLICATIONS (MCA)
IN
COMPUTER APPLICATION
OF
WEST BENGAL UNIVERSITY OF TECHNOLOGY

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MASTERS OF COMPUTER APPLICATION (MCA)

OF

West Bengal University of Technology

Has completed their minor project work entitled **A Review on Routing Protocol of Wireless Sensor Networking.** They have fulfilled these requirements and the project can be successfully implemented. To far my knowledge goes their work was not submitted to any other University/Institution for the award of any degree, diploma, fellowship or other similar titles or prizes and the work has not been published in any journal or magazine.

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This is to certify that **Debayan Mukherjee, Soumya Das, Piya Chakraborty, Poulami Dutta**, **3rd year (5th Semester)** students of the MCA course of Sabita Devi Education Trust-Brainware Group of Institutions, under West Bengal University of Technology undertook a project as 'MINOR PROJECT', entitled **A Review on Routing Protocol of Wireless Sensor Networking** under the supervision of **Mr. Arpan Kisore Sarbadhikari, Assistant Professor, MCA department,** during 2014. They worked sincerely and regularly on this project and completed their assigned work satisfactorily.

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DECLARATION

This is hereby declared that We, **Debayan Mukherjee, Soumya Das, Piya Chakraborty, Poulami Dutta**, student of 5th semester of MCA, have carried out our 5th semester project work entitled **A Review on Routing Protocol of Wireless Sensor Networking** under the guidance of **Mr. Arpan Kisore Sarbadhikari, Assistant Professor, MCA department,** SDET-Brainware Group of Institutions and is done by ourselves in the fulfillment for the award of the degree of MCA in Computer Applications from West Bengal University of Technology. It is further declared that the project work has not been submitted to any other academic university for the award of any degree of examination.

The said project work will not be under any circumstances be used for any university or institution examination except for MCA of West Bengal University of Technology.

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We have received the assistance and cooperation of quite a number of people during our project **A Review on Routing Protocol of Wireless Sensor Networking**. So we hereby take the opportunity to extend our sincere gratitude to all those who have provided their assistance and cooperation and valuable suggestion from time to time in spite of their busy schedule.

First we would like to thank our project guide **Mr. Arpan Kisore Sarbadhikari.** He has not just helped us but provided his valuable suggestion from time to time. We would like to extend our sincere gratitude to **Mr. Mrityunjay Ghosh, Teacher-in-charge, MCA** and all other faculty members, entire technical Assistant team of **MCA** for their encouraging support and for providing us a pleasant atmosphere during the period of project development.

Lastly, we would like to thank our parents for their overall support.

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MINOR PROJECT

❖ **TITLE OF THE PROJECT**

A Review on Routing Protocol of Wireless Sensor Networking

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❖ **ABSTRACT OF THE PROJECT**

A Review on Routing Protocol in Wireless Sensor Networking defines a brief idea of different types of routing protocols used to make the network through a wireless media. The routers are used to sense the signal from its previous node and sends an information on the basis of the signal to the next neighbor nodes through that wireless network. In this review, we give a brief idea on different types of routing protocol and how they works with sample demonstrations.

❖ **KEYWORDS**

✓ **General Technology Keywords**
- Wireless Network, Sensor

✓ **Specific Project Technology Keywords**
- Routing Protocol, Cluster head

Content

Introduction

❖ Wireless Sensor Networking – Concept: [1]

A **Wireless Sensor Network (WSN)** consists of spatially distributed autonomous sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion, or pollutants. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance. They are now used in many industrial and civilian application areas, including industrial process monitoring and control, machine health monitoring, environment and habitat monitoring, healthcare applications, home automation, and traffic control.

❖ Functionalities of a typical Wireless Sensor Network:[2]

- ✓ Ability to withstand harsh environmental conditions
- ✓ Ability to cope with node failures
- ✓ Mobility of nodes
- ✓ Dynamic network topology
- ✓ Communication failures
- ✓ Heterogeneity of nodes
- ✓ Large scale of deployment
- ✓ Unattended operation
- ✓ Scalable capacity of node, only limited by bandwidth of gateway node

❖ Needs of Routers in Wireless Sensor Networks:

Routers in Wireless Sensor Networking are the most important part to make the network available and technically workable. The routers in wireless sensor networks are used to control all the sensors of the wireless network within that router, where the sensors are used to sense the proper data and information from its previous neighbor sensors and sends that data along with its own sensed data and information to the next neighbor node. Routers are able to catch all the data and information from all sensors within the wireless network.

Routing protocols in WSN [3]

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. Many routing algorithms were developed for wireless networks in general. All major routing protocols proposed for WSNs may be divided into seven categories as shown in **Table 1**. We review sample routing protocols in each of the categories in preceding sub-sections.

Table 1: Routing Protocols for WSNs [3]

Category	Example of Some Representative Protocols
Location-based Protocols	GAF, GEAR, TBF
Data-centric Protocols	SPIN
Hierarchical Protocols	LEACH, PEGASIS
Mobility-based Protocols	SEAD
Multipath-based Protocols	Sensor-Disjoint Multipath
Heterogeneity-based Protocols	CHR
QoS-based protocols	SPEED

✓ Location-based Protocols

In location-based protocols, sensor nodes are addressed by means of their locations. Location information for sensor nodes is required for sensor networks by most of the routing protocols to calculate the distance between two particular nodes so that energy consumption can be estimated. In this section, we present samples of location-aware routing protocols proposed for WSNs.

Geographic Adaptive Fidelity (GAF): GAF is an energy-aware routing protocol primarily proposed for MANETs, but can also be used for WSNs because it favors energy conservation. The design of GAF is motivated based on an energy model that considers energy consumption due to the reception and transmission of packets as well as idle (or listening) time when the radio of a sensor is on to detect the presence of incoming packets. GAF is based on mechanism of turning off unnecessary sensors while keeping a constant level of **routing fidelity** or uninterrupted connectivity between communicating sensors.

Geographic and Energy-Aware Routing (GEAR): GEAR is an energy-efficient routing protocol proposed for routing queries to target regions in a sensor field, In GEAR, the sensors are supposed to have localization hardware equipped, for example, a GPS unit or a localization system so that they know their current positions.

Trajectory-Based Forwarding (TBF): TBF is a routing protocol that requires a sufficiently dense network and the presence of a coordinate system, for example, a GPS, so that the sensors can position themselves and estimate distance to their neighbors. The source specifies the trajectory in a packet, but does not explicitly indicate the path on a hop-by-hop basis. Based on the location information of its neighbors, a forwarding sensor makes a greedy decision to determine the next hop that is the closest to the trajectory fixed by the source sensor.

✓ Data-centric Protocols

Data-centric protocols differ from traditional address-centric protocols in the manner that the data is sent from source sensors to the sink. In **address-centric** protocols, each source sensor that has the appropriate data responds by sending its data to the sink independently of all other sensors. However, in **data-centric** protocols, when the source sensors send their data to the sink, intermediate sensors can perform some form of aggregation on the data originating from multiple source sensors and send the aggregated data toward the sink. This process can result in energy savings because of less transmission required to send the data from the sources to the sink. In this section, we review some of the data-centric routing protocols for WSNs.

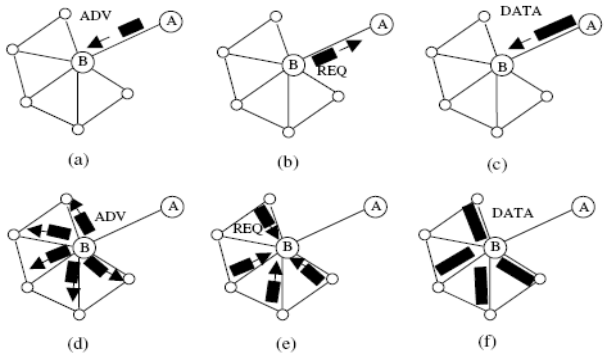


Figure 1: SPIN Protocol

Sensor Protocols for Information via Negotiation (SPIN): SPIN protocol was designed to improve classic flooding protocols and overcome the problems they may cause, for example, implosion and overlap. The SPIN protocols are resource aware and resource adaptive. The sensors running the SPIN protocols are able to compute the energy consumption required to compute, send, and receive data over the network. Thus, they can make informed decisions for efficient use of their own resources. The SPIN protocols are based on two key mechanisms namely **negotiation and resource adaptation**. SPIN enables the sensors to negotiate with each other before any data dissemination can occur in order to avoid injecting non-useful and redundant information in the network. SPIN uses **meta-data** as the descriptors of the data that the sensors want to disseminate. The notion of meta-data avoids the occurrence of overlap given sensors can name the interesting portion of the data they want to get. It may be noted here that the size of the meta-data should definitely be less than that of the corresponding sensor data. Contrary to the flooding technique, each sensor is aware of its resource consumption with the help of its own resource manager that is probed by the application before any data processing or transmission. This helps the sensors to monitor and adapt to any change in their own resources.

✓ Hierarchical Protocols

Many research projects in the last few years have explored hierarchical clustering in WSN from different perspectives. Clustering is an energy-efficient communication protocol that can be used by the sensors to report their sensed data to the sink. In this section, we describe a sample of layered protocols in which a network is composed of several **clumps (or clusters)** of sensors. Each clump is managed by a special node, called **cluster head**, which is responsible for coordinating the data transmission activities of all sensors in its clump.

As shown in Figure 2, a hierarchical approach breaks the network into clustered layers. Nodes are grouped into clusters with a cluster head that has

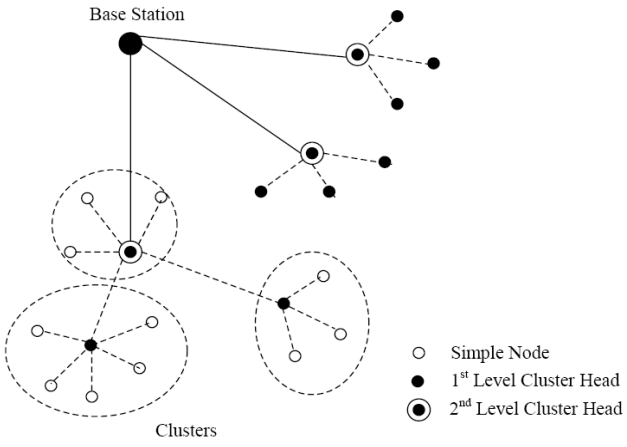


Figure 2: Hierarchical Protocol

the responsibility of routing from the cluster to the other cluster heads or base stations. Data travel from a lower clustered layer to a higher one. Although, it hops from one node to another, but as it hops from one layer to another it covers larger distances. This moves the data faster to the base station. Clustering provides inherent optimization capabilities at the cluster heads. In this section, we review a sample of hierarchical-based routing protocols for WSNs.

Low-energy adaptive clustering hierarchy (LEACH): LEACH is the first and most popular energy-efficient hierarchical clustering algorithm for WSNs that was proposed for reducing power consumption. In LEACH, the clustering task is rotated among the nodes, based on duration. Direct communication is used by each cluster head (CH) to forward the data to the base station (BS). It uses clusters to prolong the life of the wireless sensor network. LEACH is based on an **aggregation (or fusion)** technique that combines or aggregates the original data into a smaller size of data that carry only meaningful information to all individual sensors. LEACH divides the a network into several cluster of sensors, which are constructed by using localized coordination and control not only to reduce the amount of data that are transmitted to the sink, but also to make routing and data dissemination more scalable and robust. LEACH uses a randomize rotation of high-energy CH position rather than selecting in static manner, to give a chance to all sensors to act as CHs and avoid the battery depletion of an individual sensor and dying quickly.

The operation of LEACH is divided into rounds having two phases each namely,
(i) A setup phase to organize the network into clusters, CH advertisement, and transmission schedule creation
And,
(ii) A steady-state phase for data aggregation, compression, and transmission to the sink.

LEACH is completely distributed and requires no global knowledge of network. It reduces energy consumption by

(a) Minimizing the communication cost between sensors and their cluster heads,
(b) Turning off non-head nodes as much as possible. LEACH uses single-hop routing

Where each node can transmit directly to the cluster-head and the sink. Therefore, it is not applicable to networks deployed in large regions. Furthermore, the idea of dynamic clustering brings extra overhead, e.g. head changes, advertisements etc., which may diminish the gain in energy consumption. While LEACH helps the sensors within their cluster dissipate their energy slowly, the CHs consume a larger amount of energy when they are located farther away from the sink. Also, LEACH clustering terminates in a finite number of iterations, but does not guarantee good CH distribution and assumes uniform energy consumption for CHs.

Power-Efficient Gathering in Sensor Information Systems (PEGASIS): PEGASIS is an extension of the LEACH protocol, which forms chains from sensor nodes so that each node transmits and receives from a neighbor and only one node is selected from that chain to transmit to the base station (sink). The data is gathered and moves from node to node, aggregated and eventually sent to the base station. The chain construction is performed in a greedy way.

✓ Mobility-based Protocols

Mobility brings new challenges to routing protocols in WSNs. Sink mobility requires energy efficient protocols to guarantee data delivery originated from source sensors toward mobile sinks. In this section we discuss a sample mobility-based routing protocol for mobile WSNs.

Scalable Energy-Efficient Asynchronous Dissemination (SEAD): SEAD is self-organizing protocol, which was proposed to trade-off between minimizing the forwarding delay to a mobile sink and energy savings. SEAD considers data dissemination in which a source sensor reports its sensed data to multiple mobile sinks and consists of three main components namely **dissemination tree (d-tree)** construction, data dissemination, and maintaining linkages to mobile sinks. It assumes that the sensors are aware of their own geographic locations. Every source sensor builds its data dissemination tree rooted at itself and all the dissemination trees for all the source sensors are constructed separately.

SEAD can be viewed as an overlay network that sits on top of a location-aware routing protocol, for example, geographical forwarding.

✓ Multipath-based Protocols

Considering data transmission between source sensors and the sink, there are two routing paradigms: **single-path routing and multipath routing**. In single-path routing, each source sensor sends its data to the sink via the shortest path. In multipath routing, each source sensor finds the first *k* shortest paths to the sink and divides its load evenly among these paths. In this section, we review a sample of multipath routing protocols for WSNs.

Sensor-Disjoint Multipath: Sensor-disjoint multipath routing is a multipath protocol that helps find a small number of alternate paths that have no sensor in common with each other and with the primary path. In sensor-disjoint path routing, the primary path is best available whereas the alternate paths are less desirable as they have longer latency. The disjoint makes those alternate paths independent of the primary path. Thus, if a failure occurs on the primary path, it remains local and does not affect any of those alternate paths. The sink can determine which of its neighbors can provide it with the highest quality data characterized by the lowest loss or lowest delay after the network has been flooded with some low-rate samples. Although disjoint paths are more resilient to sensor failures, they can be potentially longer than the primary path and thus less energy efficient.

✓ Heterogeneity-based Protocols

In heterogeneity sensor network architecture, there are two types of sensors namely line-powered sensors which have no energy constraint, and the battery-powered sensors having limited lifetime, and hence should use their available energy efficiently by minimizing their potential of data communication and computation. In this section, we review a sample of heterogeneity-based routing protocols for WSNs.

Cluster-Head Relay Routing (CHR): CHR routing protocol uses two types of sensors to form a **heterogeneous network** with a single sink: a large number of low-end sensors, denoted by L-sensors, and a small number of powerful high-end sensors, denoted by H-sensors. Both types of sensors are static and aware of their locations using some location service. Moreover, those Land H-sensors are uniformly and randomly distributed in the sensor field. The CHR protocol partitions the heterogeneous network into groups of sensors (or clusters), each being composed of L-sensors and led by an H-sensor. Within a cluster, the L-sensors are in charge of sensing the underlying environment and forwarding data packets originated by other L-sensors toward their cluster head in a multi-hop fashion. The H-sensors, on the other hand, are responsible for data fusion within their own clusters and forwarding aggregated data packets originated from other cluster heads toward the sink in a multi-hop fashion using only cluster heads. While L-sensors use short-range data transmission to their neighboring H-sensors within the same cluster, H-sensors perform long-range data communication to other neighboring H-sensors and the sink.

✓ QoS-based Protocols

It is also important to consider **Quality of Service (QoS)** requirements in terms of delay, reliability, and fault tolerance in routing in WSNs. In this section, we review a sample of QoS-based routing protocols for WSNs.

SPEED: SPEED is another QoS routing protocol for sensor networks that provides soft real-time End-to-end guarantees. The protocol requires each node to maintain information about its neighbors and uses geographic forwarding to find the paths. In addition, SPEED strive to ensure a certain speed for each packet in the network so that each application can estimate the end-to-end delay for the packets by dividing the distance to the sink by the speed of the packet before making the admission decision. Moreover, SPEED can provide congestion avoidance when the network is congested. The routing module in SPEED is called Stateless Geographic Non-Deterministic forwarding (SNFG) and works with four other modules at the network layer. The beacon exchange mechanism collects

information about the nodes and their location. Delay estimation at each node is basically made by calculating the elapsed time when an ACK is received from a neighbor as a response to a transmitted data packet. By looking at the delay values, SNGF selects the node, which meets the speed requirement. If it fails, the relay ratio of the node is checked, which is calculated by looking at the miss ratios of the neighbors of a node (the nodes which could not provide the desired speed) and is fed to the SNGF module. When compared to Dynamic Source Routing (DSR) and Ad-hoc on-demand vector routing (AODV), SPEED performs better in terms of end-to-end delay and miss ratio. Moreover, the total transmission energy is less due to the simplicity of the routing algorithm, i.e. control packet overhead is less, and to the even traffic distribution. Such load balancing is achieved through the SNGF mechanism of dispersing packets into a large relay area. SPEED does not consider any further energy metric in its routing protocol. Therefore, for more realistic understanding of SPEED's energy consumption, there is a need for comparing it to a routing protocol, which is energy-aware.

Reviews on two important routing Protocols in WSN

❖ Review on LEACH Protocol:[4]

LEACH means 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.

$P(n) = p / 1-p(r \bmod 1/p)$

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

As shown in figure 3, 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

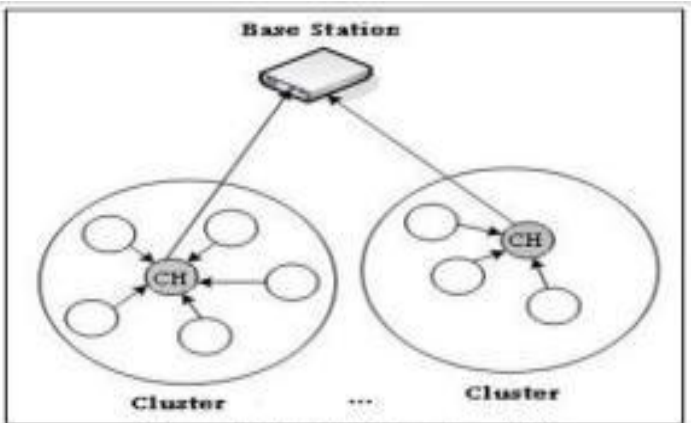


Figure 3: LEACH Protocol

Although LEACH is able to increase

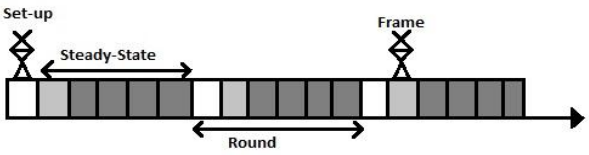


Figure 4: LEACH Protocol Phases

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 cluster heads, i.e., 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.

- **Algorithm of LEACH Protocol: [5][6]**

Cluster-heads can be chosen stochastically (randomly based) on this algorithm:

$P(n)=P/[1-P\{r*\mathrm{mod}(1/P)\}]$ for all $n \varepsilon G$

$T(n)=0$, where n=random number between 0 and 1

P=cluster head probability

G=set of nodes that weren't cluster heads the previous rounds

If $n < T(n)$, then that node becomes a cluster-head

The algorithm is designed so that each node becomes a cluster-head at least once.

❖ Review on SPIN Protocol:[4]

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.

In figure 5,

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

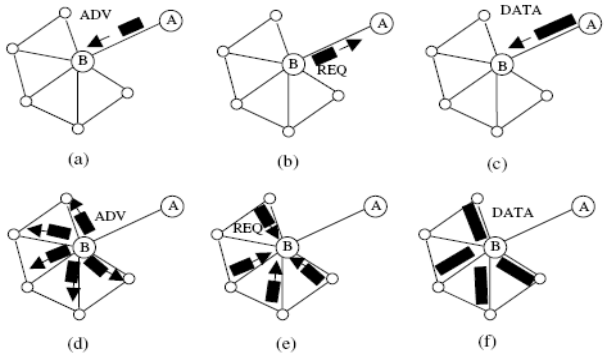


Figure 5: SPIN Protocol

❖ Difference between LEACH and SPIN protocol: [4][7]

LEACH PROTOCOL	SPIN PROTOCOL
i) LEACH protocol is Hierarchical.	i) SPIN protocol is flat.
ii) LEACH has fixed base station.	ii) Mobility of SPIN protocol is possible.
iii) Power usage of LEACH protocol is maximum.	iii) Power usage of SPIN protocol is limited.
iv) LEACH is not negotiation based protocol.	iv) SPIN is negotiation based protocol.
v) In LEACH protocol, localization is possible.	v) In SPIN protocol, localization is not possible.
vi) LEACH is a query based protocol.	vi) SPIN is not a query based protocol.
vii) The state complexity is high.	vii) The state complexity is low.
viii) Scalability of LEACH protocol is good.	viii) Scalability of SPIN protocol is low.
ix) LEACH does not support the multipath property.	ix) SPIN has the multipath property.

❖ Comparison between LEACH and SPIN protocol: [4]

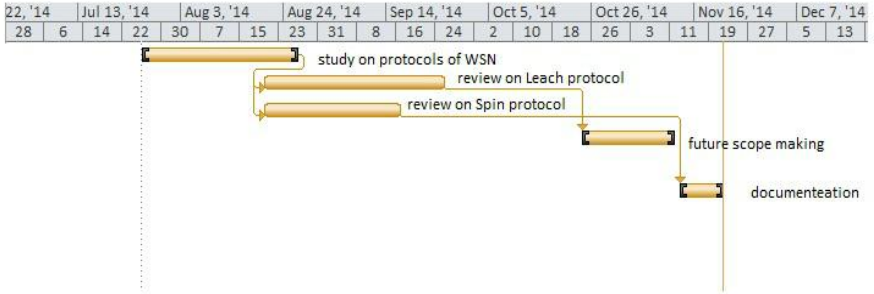
Parameters	LEACH PROTOCOL	SPIN PROTOCOL
Classification	Hierarchical	Flat
Mobility	Fixed BS	Possible
Position Awareness	No	No
Power usage	Max	Ltd
Negotiation Based	No	Yes
Data Aggregation	Yes	Yes
Localization	Yes	No
Query Based	No	Yes
State Complexity	CHs	Low
Scalability	Good	Ltd
Multipath	No	Yes

Gantt chart

PROCESS TABLE

	Task Name	Durat	Start	Finish	Predecessors
1	Study on Protocols of WSN	23 days	Sat 7/26/14	Tue 8/26/14	
2	Review on LEACH Protocol	27 days	Wed 8/20/14	Thu 9/25/14	1
3	Review on SPIN Protocol	20 days	Wed 8/20/14	Tue 9/16/14	1
4	Making of Future Scope of the Project	13 days	Fri 10/24/14	Tue 11/11/14	2
5	Documentation	7 days	Thu 11/13/14	Fri 11/21/14	3

GNATT CHART



TIMELINE

Figure 6: Gantt chart of the Project

Conclusion and possible future scope

A Review on Routing Protocol of Wireless Sensor Networking is a review on different Routing protocols of Wireless Sensor Networking (WSN). Specially, there are two most important protocols we mentioned in the project are, LEACH and SPIN protocol in WSN. We gave the review on these two protocols, the algorithms and the main work process of these two protocols with suitable diagrams. As we are in the review on these two protocols, we have a future scope of the project which will be some modification on any one of these two protocol's algorithm to make an algorithm better from the present algorithm. So, we have a possible future scope to make a better algorithm to make LEACH or SPIN better from now.

List of Figures

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