

A Study of Power and Energy Aware Routing Technologies in Wireless Sensor Network

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Abstract: - Wireless Sensor Network (WSN) is advanced technology of mobile Ad-hoc network deployed to perform a number of useful tasks. Sensors are low battery powered node used to sense some specific kinds of data or information. Data can be of any type such as humidity, temperature, pressure, air pollutions, vibration etc. Wireless network are capable to perform multipath routing in short distance to save energy and a power of particular node because network's nodes contains less battery power and energy. Sensor nodes are very small and fitted in large network area which can be static or movable so it is not easily possible to charge them frequently. For better performance of a network by saving the communication and processing power is only to increase node's life time. Power or energy consumptions are main issues for routing data packet in the network. Every power aware routing methods or algorithms has aim to maximize the minimum battery power of the node and minimize the total transmission and communication power which is needed to reach information to the destination node. Mainly WSN works on a large scale network area in which sensor nodes are deployed geographically. Reason Behind to develop the separate protocols for WSN is that user can not deploy directly MANET routing protocol in WSN. To save the power of sensor nodes many technologies were developed. Study of these technologies, algorithms and methods are introduced in this paper.

Key points:- Mobile AD-hoc Network, WSN, Routing Protocol, Power Aware Routing.

I. INTRODUCTION

Now a day's moving technology is on demand in the other word person can not only work from office but also from outside the office, which provide flexibility in working scenario. This is the main reason of development from wired LANs to wireless LANs (WLANs). Wired LANs are those which provide high bit rate to fulfill requirements of bandwidth consuming application like video conferences, streaming video, downloading high bit rate movies, pictures etc. within a second.

Ad-hoc Sensor Network or wireless Sensor Network is the combination of hundreds and thousands of small and tiny sensors [1]. These tiny sensor nodes have ability to either communicate with one to another sensor or direct communication with the base station (BS) connected externally. Sensor nodes have small size also have poor battery power used to communicate in small area of short distance. According to their functionality sensors can be of same type or different. Sensors are the nodes which perform some kinds of task such as sensing of specific type of data, data processing, and communicating components. A sensor network is made with the combination of many sensors that are densely used to deploy inside the geographic environment, this area in which sensors are deployed and connected with each other called sensor field as shown in Fig.1. The place where sensor nodes are fitted need not be

structured or predefined. Sensor network protocols and algorithms must have the capabilities of self structuring. Sensors have processing ability at the local level to carry out simple data computations and send only the required and partially processed data in data communication process.

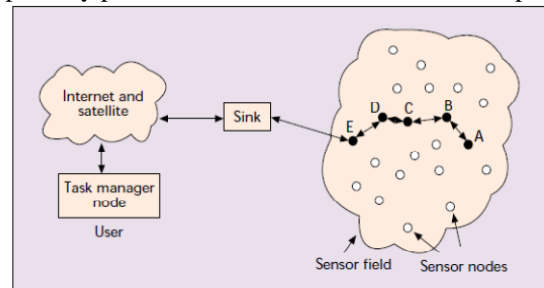


Fig. 1: Sensor Node Scattered in a Sensor field

A. Application of Sensor Network [2]:-

- Sensor nodes are used in the military application, for guidance the system of intelligent missiles, and finding of attacks by weapons, such as nuclear, biological or chemical.
- For environmental monitoring application Sensors are used for example in forest fire and air and water pollution.
- Sensors can be fit in patient body for diagnosis and monitoring.
- Now a day's a smart sensor nodes are using into appliances at home, such as ovens, refrigerators, and vacuum cleaners which can be communicate with each other or can be a central controlled.

B. Classification of Routing Protocols in WSN:-

Routing is the method to find the path or Route from source to destination for sending data. As we know sensor nodes are energy constrained so in power aware routing techniques has follows some rules and protocols in data communication process to save energy of sensor nodes, perform better scalability, better performance, and high throughput with less delay in communication.

There are mainly three basic types of Routing Protocols

[3], [4], [5] defined in wireless sensor network:-

1. Flat based
2. Hieratical based
3. Location based

These three basic above protocols are further classified into following protocols shown in Fig. 2:

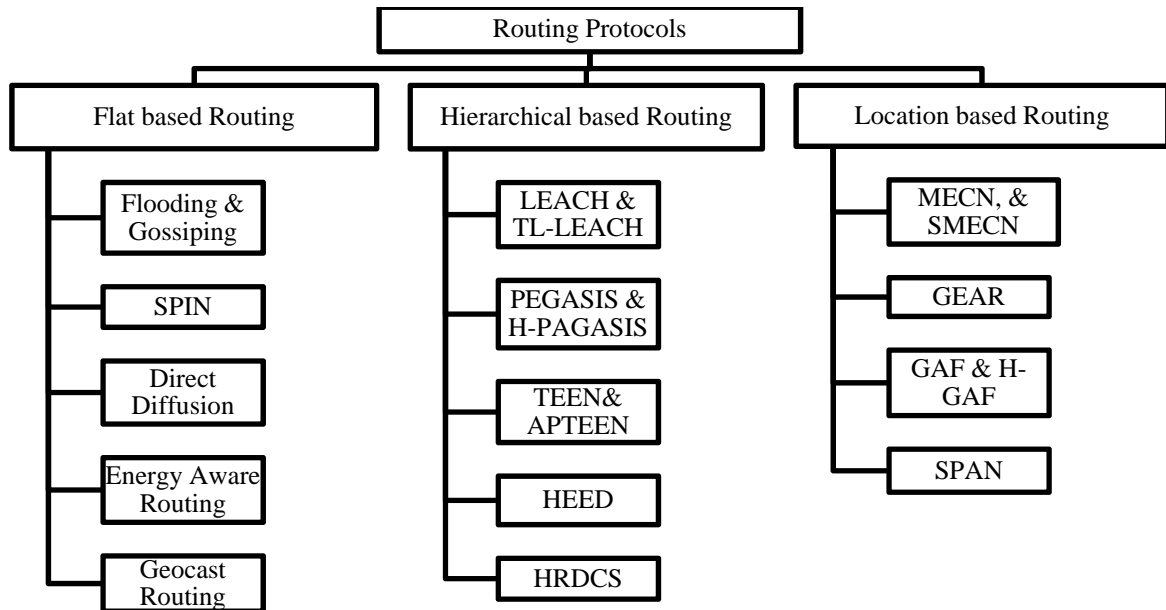


Fig. 2: Classification of Routing Protocols in WSN

C. Introduction about protocols:-

Flat based Routing:-All Nodes situated in the network structure are equal in some manner and working functionality are same for different nodes. To assign global identifier to each node in wireless sensor network is not possible in this type of routing because network consist dense deployment of sensor nodes and dynamic environment of wireless network. Flat based routing protocols are given following-

1. **Flooding & Gossiping:** - In flooding mechanism source node send a broadcast message which consist maximum hop count number to destination node. This message received by each node between source to destination and each node broadcast this message if maximum hop count is not reached and also that node is not destination node. Flooding does not maintain any complex topology and route discovery algorithm in the network. Flooding has some disadvantages given following-

- **Implosion:**-Duplicate message arrive to the same node.
- **Overlap:**-Same event sensed by more than one node.
- **Resource blindness:**-Because of redundant transmission of data packets it reduces the network lifetime.

Gossiping is an enhanced version of flooding in which nodes do not broadcast message to all node but send a packet to selected node only it solves the problem of implosion but time taken to propagate message throughout network is large. Gossiping consist lower overhead then flooding.

2. **SPIN:**-SPIN protocol called Sensor Protocol for Information via Negotiation. SPIN protocol is introduced to reduce the flooding protocol problem like overlap and implosion via negotiation, This protocol also prolong the network lifetime by introducing threshold based resource aware operation. SPIN protocol sends directly Meta data which contain

original data instead of sending raw data for establishment of network connection. SPIN send three types of messages to node which is interested in network for communication. Messages are ADV, REQ and DATA. SPIN broadcast ADV message containing meta data describing the original data to its neighbour node and if neighbour node interested in data then it reply with REQ message for data. And communication will start by sending data. This process will continuous till destination node will not receive original data. SPIN works on data-centric approach.

3. **Direct Diffusion:**-In direct diffusion protocol nodes perform individual operation instead of all operations performed by base station. In this protocol Request and queries for data sensed by node generated by sensor node itself instead of all request and queries generated by base station. In direct diffusion technique interest gradient parameter is used. Data comes on each sensor node is named by one or more attributes value and if other node is interested in this attribute then that node will express their interest. This attribute is nothing but a set of description for the data.

4. **Energy Aware Routing:**-An efficient method to minimize the energy cost for communication and for increasing the network lifetime energy aware routing protocol is introduced. In energy aware routing protocol data transmission is done by selecting multiple optimal paths instead of transmitting from one optimal path. Probability function decides the path for data transmission.

5. **Energy efficient Geocast Routing:**-Geocast routing protocol is based on operation in which packets are delivered to a group of nodes situated in geographical area within a specified limit. One of the routing protocol come in this category is I-min protocol in which with the specified probability function higher residual energy node is selected even if this is far away from destination and source node.

Hierarchical based Routing (Clustering):-It is a point to point routing mechanism which is responsible for guaranteed delivery of data. Large network is divided into number of clusters. These cluster nodes communicate with each other. Given following protocols comes in this category-

1. **LEACH & TL-LEACH:**-LEACH protocol is also called Low-Energy Adaptive clustering Hierarchy. This is the first developed protocol based on clustering method. Protocol works on probability function each node has a probability to select cluster head. Because every node has equal probability to select cluster head in each round cluster head change. TL-LEACH is advanced protocol of LEACH known as Two Level LEACH protocol in which cluster head is divided into two part first one is known as primary cluster head and second one is known as secondary cluster head. It reduces the number of nodes that transmits the data to the base station so energy dissipation is low as compare to LEACH. One disadvantage of LEACH is that it takes more energy for formation of cluster head. TL-LEACH reduces the energy dissipation in some limit as compare to LEACH.
2. **PEGASIS & H-PAGASIS:**-PEGASIS stand for Power Efficient Gathering in Sensor Information System. This protocol is an improvement on LEACH protocol based on optimal chain based protocol. LEACH protocol works on clustering technology but PEGASIS construct a chain of nodes in which each nodes communicate only with his neighbour node close to it. So it reduces the amount of energy used per round. For constructing chain of nodes greedy method is used.
PEGASIS works much better as compare with LEACH but time taken for transmission of data is higher which prolonged the network lifetime.
H-PEGASIS (Hierarchical PEGASIS) is an improvement on PEGASIS which allow concurrent transmission of data when nodes are not adjacent.
3. **TEEN & APTEEN:**-TEEN protocol is known as Threshold Sensitive Energy Efficient Sensor Network Protocol first developed for reactive networks. This protocol used for temperature sensing application. This protocol is developed to increase the energy efficiency in wireless sensor network. TEEN is developed for reactive network. Transmission in TEEN mainly depends on two parameters are hard threshold value and soft threshold value.
APTEEN (Adaptive Threshold Sensitive Energy Efficient Sensor Network Protocol) is an extension of TEEN. In APTEEN when cluster head is decided it broadcast all the parameters such as threshold values, count time and attributes to all over the nodes. The working performance of APTEEN lies between LEACH and TEEN protocol. Both protocol have one disadvantages that algorithm contains overhead and complexity when forming cluster.
4. **HEED:** - HEED protocol works on remaining energy of each sensor node in the network. Protocol works on energy efficiently in the network. Cluster head

selection is based on parameter of remaining energy of sensor node. HEED protocol implemented on tiny-OS. Node degree or average distance is used as a parameter. Two sensor nodes has same remaining energy in the network after one transmission has been done. In the HEED protocol it is calculated that clustering and data aggregation at least double the lifetime in the wireless sensor network. In HEED if Cluster node is near to the base station then node directly communicate with the base station and discharge quickly and energy is wasted that is used for formation cluster head.

5. **HRDCS:** - A hybrid relative distance based cluster scheme in wireless sensor networks which save the energy efficiently. Energy efficiency has great importance in this protocol. In HRDCS node construct the cluster for data collection and transmission in the network. Cluster head selected on the basis of transmission range from the base station. HRDCS works on distance between CH and BS and energy used at the time of cluster head construction.

Location based Routing:-For static network most of the time there is no need to concern about exact location information of any node but in mobile network like wireless sensor network in which sensor nodes are movable then its compulsory to keep the information about their locations. Location information contains distance between two different nodes for routing data. Distance is calculated on the basis of signal strength so that energy consumption is calculated. Following types of protocol comes in this category-

1. **MECN & SMECN:**-A location based routing protocol MECN (Minimum Energy Communication Network) as name implies works by using minimum energy for wireless sensor network and by utilizing low power GPS. This protocol is designed for mobile network by keeping the location information but it is best work for sensor network because sensor nodes are not mobile. MECN transmit data through relay region which consist nodes in a surrounding area. In place of direct transmission, transmission through relay region node saves the energy of node. MECN is self-reconfiguration protocol which dynamically solves the nodes failure and self adjust the deployment of new sensors.
SMECN (small minimum energy communication network) is improvement on MECN. In MECN network is assumed to be a fully connected but in SMECN a sub network from the network is constructed for efficient utilization of energy. But finding sub network from small network increase the overhead.
2. **GEAR:**-Geographical Energy Aware Routing is an improvement on direct diffusion method by adding geographical data of node. It is made to decrease the number of interests which is the data packet in direct diffusion method. Number of interest packets can be reduced by adding geographical information of particular node with the data packet which moves to only certain node in the geographical region rather than broadcasting interest packets to all nodes. GEAR helps

data packet to forward towards the targeted nodes only this technique helps for balancing the energy consumption for forwarding data packets and increase the network lifetime.

3. **GAF & H-GAF:** - GAF protocol is defined as geographical adaptive fidelity protocol. This protocol works on this method in which from large number of sensor nodes only few nodes are selected for transmission of data and other nodes are sleep so the

network size become small when transmit data and saves nodes battery when nodes not participating in communication.

H-GAF (hierarchical geographical adaptive fidelity) is an improved version of GAF which saves much more energy as compare to GAF. HGAF saves the battery power and node energy by enlarging the cell size and layered structure of GAF.

D. Comparison between different routing protocols [5]:-

Routing Protocol	Classification	Power Usage	Data Aggregation	Cluster Stability	Mobility Support	Query Based	Over head	Data Delivery model	QoS
Flooding & Gossiping	Flat based	High	Yes	No	Nil	Yes	High	Event driven	No
SPIN	Flat/Src initiated/Data Centric	Limited	Yes	No	Nil	Yes	Low	Event driven	No
Direct Diffusion	Flat/Data centric/Dst. initiated	Limited	Yes	No	Nil	Yes	Low	Demand driven	No
Energy Aware Routing	Flat based	Limited	Yes	No	Nil	Yes	High	Demand driven	No
Geocast Routing	Flat based	Limited	Yes	No	Nil	Yes	High	Demand driven	No
LEACH & TL-LEACH	Hierarchical/Dst. Initiated/Node-centric	High	Yes	Moderate	Nil	No	High	Cluster-Head	No
PEGASIS & H-PAGASIS	Hierarchical	Max	No	No	Nil	No	Low	Chain Based	No
TEEN & APTEEN	Hierarchical	High	Yes	Good	Nil	No	High	Active threshold	No
HEED	Hierarchical	High	Yes	Good	Nil	No	Low	Cluster-Head	No
HRDCS	Hierarchical	High	Yes	Moderate	Nil	No	Low	Cluster-Head	No
MECN, & SMECN	Location based	Limited	Yes	No	Limited	No	High	Relay Region sub network	No
GEAR	Location based	Limited	No	No	Yes	No	Mod	Demand Driven	No
GAF & H-GAF	Hierarchical/Location	Limited	No	No	Yes	No	Mod	Virtual Grid	No
SPAN	Hierarchical/Location	Limited	Yes	No	Yes	No	High	Continuously	No

Table no. 1 Comparison between the different routing protocols in WSN

E. Power aware routing metrics [6]:-

To save energy of sensor node for making network lifetime greater some metrics or parameters are considered to being improved by using some protocol or algorithms. These parameters are as given following:-

- Energy consumption per packet of any node should be minimal.
- Network connectivity should be maximizing for each node.
- Variance in node power levels should be minimum.
- Cost per packet should be minimum.
- Communication delay should be minimum.

II. RELATED WORK

Patel Dhaval et. al. [7] has proposed an algorithm to improve the performance of routing protocol based on on-demand. AODV protocol was protocol used to implement this approach in place of DSR protocol because AODV removes unnecessary information quickly and perform better with extra load. This approach mainly based on, to

find neighbouring nodes with proper routing path to the destination. Source node finds the energy level of other nodes by broadcasting the message. A threshold value by default defined used for comparison with energy level of other nodes, if any node contains energy level higher then threshold value is selected with less distance. It uses both distance and energy metric.

S. Yessad et. al. [8] and Samira Yessad et. al. [9] has proposed an EAR-Energy Aware Routing protocol is a reactive protocol, initiated by destination. Main idea behind EAR is to choose optimal path between available several paths found, with the probability of being chosen as energy metric assigned to the each path. So no duplicate node get selected next time. FEAR-Fair Energy Ware Routing is an advanced version of EAR, which used to improve the network lifetime. It reduces the probability used in the high demanded source node. FEAR reduces the probability of use of many nodes belong to several routes in the network. BEER is other routing protocol stands for Balanced Energy Efficient Routing protocol. It differ from FEAR protocol

just from one parameter that is N sent in NFTM (number forwarding table message) message.

Shah Ahsanul Haque et. al. [10] has proposed a method in which large numbers of heterogeneous nodes are considered for communication via radio signals. Each cluster formed by sensor node has one cluster head which is the storage node. Storage node is capable for storing and processing data and information. Sensor nodes select their cluster head and cluster according to the energy level and distance. This method works with wireless environment and does not consider the mobility of nodes. Method includes four steps:-

- Network model
- Cluster Head Selection
- Cluster Construction
- Sensing Scenario
- Data transfer

I Sakthidevi et. al. [11] has proposed a Fuzzy Based Trust Aware Routing Framework (FBTARF) for improvement in security of dynamic WSN. FBTARF also provides energy efficient routing and reliable trust provided by using fuzzification methods. Fuzzy based methods consider multiple constraints which provide better security and energy conservation. It also provides effective and efficient routing in dynamic WSN.

Nikhil Marriwala et. al. [12] has introduced a modified LEACH protocol which performs some modification in simple LEACH protocol. Simple LEACH protocol is based on clustering method in which clusters-Head are formed randomly. LEACH protocol divided WSN data into several clusters, each cluster selects a cluster-head which aggregates data coming from the cluster nodes, processes it and sends it to the base station. LEACH uses a random selection process in place of a fixed method. Modified LEACH works in a fixed manner which increases the WSN lifetime. In modified LEACH protocol cluster head is chosen on the basis of its maximum residual energy and minimum distance from the sensor nodes.

W. Chee-Wah Tan et. al. [13] has proposed a heuristic scheme Power and Mobility Aware Routing or PMAR protocol. This is able to control packet flooding during route discovery and link breakage because of node mobility. PMAR works like an optimization in static network PMAR able to reduce the network overheads.

Yang wenguo et. al. [14] has introduced a tuning transmission radii solution scheme for the purpose of energy conservation for solution, a semi grid network is constructed as an application and routing algorithm designed which tries to calculate the uniformity of nodes energy consumption and then the result is compared.

Tseng-Yi Chen et. al. [15] has proposed two energy efficient geographic routing algorithms (EEGRA) for WSN. It is based on geographic routing. Geographic routing algorithms have a low computation and storage requirement which fits for WSN environments. To measure the power consumption SINR (Signal to Interference and Noise Ratio) was used.

Xia Li et. al. [16] has introduced an AECRP (Adaptive Energy Efficient Clustering Routing Protocol). Basic concept of AECRP is based on LEACH but AECRP works

on particle swarm clustering method which uses improved particle swarm optimization (PSO) method. Clustering works by using two approaches-

1. Choosing cluster heads.
2. Self organization clustering.

Choosing the clustering head is a core part of clustering algorithm. This is based on improved PSO algorithm. Evaluation function is designed whose independent variable is calculated by remaining energy of nodes, the distribution within a cluster and among clusters. The particle whose evaluation function is large will be better for selection. So node whose energy is high or sufficient and position is appropriate can be selected as a cluster head.

Y. Khan et. al. [17] has proposed Location Aware Permanent CH (LPCH) and User Defined Location Aware Permanent CH (UDLPCH). Both protocols work on clustering method. Physically network field is divided into two regions in LPCH. Nodes are selected equally randomly in each region for deployment in network. Initially protocol works on LEACH protocol for first round CH are selected according to LEACH algorithm. Numbers of CH are constant from first to last round. This increases the network stability and also gives greater throughput.

UDLPCH is same as LPCH but differs in that, from starting or initial round user can define optimal number of CH's in each region. In case of UDLPCH greater stability period and throughput obtained as compared to LPCH.

Md Nafees Rahman et. al. [18] has proposed a concept of Relay Node in conjunction with PSO based algorithm. In multi-hop network communication the data collected from different sensor nodes in the network reach to the sink node through the nodes those are near from the sink node, because these nodes send and receive data frequently so it's greater possibility that they will die soon, because they pass a huge amount of data.

In this paper a simple concept of relay node is proposed which improves the network lifetime. Relay node collects data from different sensor nodes and sends it to the Sink node, so it reduces the data traffic of sensor nodes especially for those nodes which are near to the sink. Hence energy consumption of sensor nodes decreases and lifetime increases of the network. To find the optimal location from relay node to sink node is done by using PSO- particle swarm optimization algorithm.

Shobha Poojary et. al. [19] has introduced the scheme of routing protocol for wireless multimedia sensor network (WMSN) the proposed algorithm called Multipath Data Transfer (MPDT). MPDT introduced technique to select multiple paths from source to destination to transmit data in selected multiple paths. Protocol is immune from some specific attacks also. Protocol works on basically in two parts -

1. **Route set-up phase:** - In which if multiple paths are available then a path is set using maximum residual energy.
2. **Data Transmission phase:** - To transfer data from source to destination, data is split into m parts if m nodes are available in selected multi-path. To secure data RS (Reed Solomon) Encoding is used.

H. Y. Bohari et. al. [20] has proposed an algorithm in which distance is calculated from each of its neighbours from source to destination and also calculate minimum energy required to send the data packet which contained appropriate additional information. Higher energy node is selected with minimum distance compared by threshold value for routing data packet from selected path. Distance between two nodes in earth surface is calculated by its longitude and latitude coordinates.

III. CONCLUSION AND FUTURE WORK

Many researchers introduced routing techniques as discussed above for improvement in different parameters related to network node for example Energy, Delay, Throughput, Bandwidths, Transmission time. Routing with energy awareness is latest topic in the research to increase the network lifetime and performance. Sensor network can not adopt only single protocol globally so need to design a protocol which satisfies all conditions and parameters.

In future we are going to improve Routing Algorithm with considering power aware metrics for example-delay, transmission time, link cost and energy aware parameters to increase the node's lifetime, reliability of data, increase the throughput, higher packet delivery ratio.

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