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A Survey on Energy Efficient Routing Protocol for Wireless Sensor Networks

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***Abstract*—A critical need in wireless sensor networks is to achieve energy efficiency during routing as the sensor nodes have limited energy resources. The efficient energy consumption is the main issue in wireless sensor network. The efficient protocol should minimize the energy consumption. This paper presents a survey on energy efficient routing protocols in wireless sensor networks.**

***Keywords*— WSN, Routing Issues, Classification, Protocol Review.**

I. INTRODUCTION

Wireless sensor network consists of several tiny sensors called nodes. This node has three basic components: A sensing subsystem for data acquisition from the physical surrounding environment, a processing subsystem for local data processing and storage, a wireless communication subsystem for data transmission. The sensor nodes have the capability to collect and route data either to other sensor or back to an external base stations [2]. To get minimum energy consumption we should use the energy efficient routing protocol. Sensor nodes carry limited, generally irreplaceable power sources [1] Nodes are deployed in critical terrain also in large number, so it is difficult to replace or recharge the batteries. Lifetime of a sensor network depends on energy supply. Therefore it is necessary to design energy efficient routing protocol. Many routing, power management and data dissemination protocols have been specifically designed for wireless sensor network. Routing in WSN is very challenging due to inherent characteristics of wireless sensor network. Such constraints combined with a typical deployment of large number of sensor nodes pose many challenges to the design and management of Wireless sensor networks.

II. ROUTING FACTORS AND WSN DESIGN

Design of routing protocols in WSN is influenced by many challenging factors to addressed which are outlined and discussed as in [1] [2]

A. Fault tolerance

Some sensor nodes may fail or blocked due to lack of power, have physical damage or environmental interference. The failure of sensor nodes should not affect the overall task of the sensor network.

B. Node deployment

Node deployment in WSN is application-dependent and can be either manual or randomized. In manual deployment, the sensors are manually placed and data is routed through predetermined paths. However, in random node deployment, the sensor nodes are scattered randomly.

C. Energy consumption without losing accuracy

Sensor nodes can use up their limited supply of energy performing computations and transmitting information in a wireless environment. Sensor node lifetime shows a strong dependence on battery.

D. Scalability

The number of sensor nodes deployed in the sensing area may be on the order of hundreds or thousands, or more. Any routing scheme must be able to work with huge number of sensor nodes

III. ROUTING PROTOCOLS IN WSN

In general, routing in wireless sensor networks can be divided into flat-based routing, hierarchical-based routing, and location-based routing depending on the network structure. In flat-based routing, all nodes are typically assigned equal roles or functionality. In hierarchical-based routing, however, nodes will play different roles in the network. In location-based routing, sensor nodes' positions are exploited to route data in the network.

A routing protocol is considered adaptive if certain system parameters can be controlled in order to adapt to the current network conditions and available energy levels. Furthermore, these protocols can be classified into multipart-based, query-based, negotiation-based, Qos-based, or routing techniques depending on the protocol operation. In addition to the above, routing protocols can be classified into three categories, namely, proactive, reactive, and hybrid protocols depending on how the source sends a route to the destination. In proactive protocols, all routes are computed before they are really needed, while in reactive protocols, routes are computed on demand. Hybrid protocols use a combination of these two ideas. When sensor nodes are static, it is preferable to have table driven routing protocols rather than using reactive protocols. A significant amount of energy is used in route discovery and setup of reactive protocols. Another class of routing protocols is called the cooperative routing protocols. In cooperative routing, nodes send data to a central node where data can be aggregated and may be subject to further processing, hence reducing route cost in terms of energy usage.

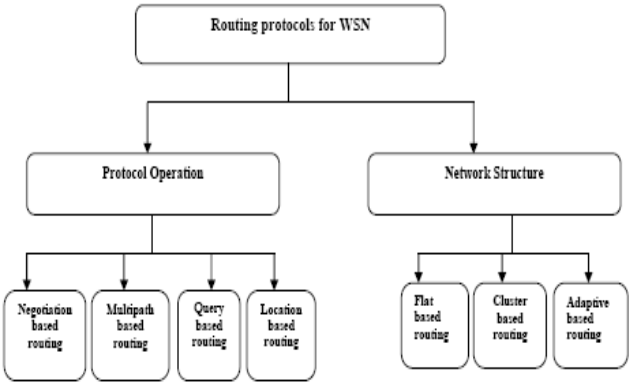

Figure 1: Classification of Routing Protocols

IV. Literature Review Of Energy Efficient Protocols

A) LEACH (Low Energy Adaptive Clustering Hierarchy)

A proposed protocol [4] is an adaptive clustering protocol for distributing energy load among the sensor nodes in network. LEACH uses single-hop routing in which each sensor node transmits information directly to the cluster head or the sink. It works in two phase:

1)The setup phase- In the setup phase ,the cluster are organized and the cluster heads are selected and each round stochastic algorithm is used by each node to determine whether it will become a cluster head.

2) The steady state phase- The data is sent to the base station the duration of the steady state phase is longer than the duration of the setup phase in order to minimize overhead.

Cluster head creates a TDMA (Time Division Multiple Access) schedule based on the number of nodes in the group. CDMA (Code Division Multiple Access) code is used for random communication inside the cluster. LEACH is not suitable for large network areas.

B) PEGASIS (Power efficient gathering in sensor information systems),

A greedy chain protocol [5] which resolves the data-gathering problem of the wireless sensor networks. The main thing is for each node to receive from and transmit to close neighbours and take turns being the leader for transmission to the base station. This approach will distribute the energy load evenly among the sensor nodes in the network. Initially the nodes are placed randomly in the field, and the sensor nodes are arranged to form a chain, which can either be accomplished by the sensor nodes themselves using a greedy algorithm starting from some node. Alternatively, the base station can compute this chain and broadcast it to all the other sensor nodes. For constructing the chain, all nodes have global knowledge of the network and then employ the greedy algorithm. A loop will be constructed to ensure that all nodes have close neighbours is difficult as this problem is similar to the travelling salesman problem. The greedy approach to constructing the chain is done before the first round of communication. It shows better results as compared to LEACH by removing the overhead of dynamic cluster formation, reducing the number of transmissions, and using only one transmission to the base station per round and shows better improvement if the network size increases.

C) PEACH (Power-efficient and adaptive clustering hierarchy)

A protocol, [6] which is a power-efficient and adaptive clustering hierarchy protocol for wireless sensor networks. In wireless sensor networks, by overhearing a node can recognize the source and the destination of packets transmitted by the neighbour nodes. Based on the overheard information, PEACH forms the clusters without additional packet transmission overhead such as advertisement, announcement, joining, and scheduling messages. PEACH is designed to operate on probabilistic routing protocols, in order to provide an adaptive multi-level clustering. As a result of the protocol design, PEACH is generally more scalable and efficient to the various circumstances than the existing clustering protocols of the wireless sensor networks. PEACH can be used on both location-unaware and location-aware wireless sensor networks. The location-unaware PEACH protocol can be used when the location information of each node is unavailable on the network. The location-aware PEACH operates when the localization mechanism such as a GPS-like hardware is available on sensor nodes. The communication cost in WSN is decreased by the reducing the data packets, and the clustering protocols improve the lifetime and the energy consumption of the wireless sensor networks. PEACH has no overhead on cluster head selection and forms adaptive multi-level clustering as compared to the existing clustering protocols.

D) TEEN (Threshold sensitive energy efficient sensor network protocol)

This is the first protocol developed for reactive networks. In this protocol [7] at every cluster change time, the cluster-head broadcasts to its members. Thus, the hard threshold tries to reduce the number of transmissions by allowing the nodes to transmit only when the sensed attribute is in the range of interest. The soft threshold further reduces the number of transmissions by eliminating all the transmissions which might have otherwise occurred when there is little or no change in the sensed attribute once the hard threshold. TEEN is well suited for time critical applications and is also quite efficient in terms of energy consumption and response time. It also allows the user to control the energy consumption and accuracy to suit the application. The main drawback of this scheme is if the thresholds are not achieved, the nodes will never communicate, the user will not get any data packet from the network and will not come to know about the nodes if they die. Thus, this scheme is not well suitable for applications where the user wants to get data regularly. Another problem is that a practical implementation would have to ensure that there collision-free cluster.

E) EEABR (Energy Efficient Ant-Based Routing)

Proposed protocol [8] which is based on the Ant Colony Optimization heuristic. Initially the forward ants are

sent to no specific destination node, which means that sensor nodes must communicate with each other and the routing tables of each node must contain the identification of all the sensor nodes in the neighbourhood and the correspondent levels of pheromone trail. For large networks, this can be a problem since nodes would need to have big amounts of memory to save all the information about the neighbouring nodes. The algorithm can be easily changed to save memory. If the forward ants are sent directly to the sink, the routing tables only need to save the neighbour nodes that are in the direction of the sink. This reduces the size of the routing tables and, in consequence, the memory needed by the nodes. The quality of a given path between a sensor node and the sink-node, should be determined not only in terms of the distance, but also in terms of the energy level of that path.

F) SOP (Self-organizing protocol)

Proposed protocol [9] which includes cluster architecture of LEACH with multi-hop routing to decrease transmission energy. In many WSN multi-hop routing is adopted. This makes a node that wants to transmit data to a destination node find one or multiple intermediate nodes. The communication occurs among all the nodes until the data packets reach the destination [10]. In brief, the data packets take several hops among the nodes in the network. The main advantage of this approach is that transmission energy consumption is reduced. But at the same time latency of the network and delay of data packets will increase. In some cases, no rigid requirements on latency, the multi-hop routing can lead to high energy efficiency. In this protocol when clusters are organized, the cluster heads form a multi-hop routing backbone. Every cluster member node sends data to the cluster head directly for the communication purpose. While for the communication between the cluster head and the base station, a multi-hop routing is adopted to reduce the transmission energy and minimize the difference of energy consumption among all nodes in the network. In order to reduce the probability of collisions at setup phase, some collision avoidance mechanism is added to CSMA MAC protocol. Thus it is more suitable to WSN. The assumptions are considered same as LEACH about the network model as follows. This means that all nodes can use power control to vary their transmission power and range. At the same time, each node has enough processing power to support different protocols and signal processing tasks.

V. CONCLUSION

In this paper we studied important issues of routing which influencing sensor network design. Although many routing protocols have been proposed for wireless sensor networks. We have reviewed several different protocols in terms of energy efficiency. From the review protocols, it is clearly seen so far that, the performance of protocols is worth promising in terms of energy efficiency. But it is not possible to design a routing protocol which will overcome all designing issues of WSN, as well as have good performance for all wireless sensor networks applications.

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