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WSN ROUTING PROTOCOLS: A REVIEW

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ABSTRACT

WSN is a set of connected tiny devices (sensor nodes) with limited energy resource. WSNs have ability to extract the information from the harsh and hostile environment without human interaction. Once, WSN is deployed, it is impossible to recharge or replace the energy resource due to inaccessibility of nodes. So, network lifetime and fault tolerance are critical parameters. It's become very important to handle energy resource carefully as it plays vital role in prolonging the network lifetime. In this paper WSN Routing Protocols are discussed to enhance the deep understanding of underlying issues in this domain.

KEYWORDS: WSN Routing Protocols, Taxonomy of WSN Routing Protocols.

INTRODUCTION

Wireless sensor networks have few limitations. First, Sensors are limited in terms of energy, transmission power, storage and computational capabilities (**Tiago *et al.*, 2006**). This creates new challenges for the design of routing protocols for WSNs (**Acs and Buttyan, 2007**). Thus, the routing protocol operations and networking must be kept much simpler as compared to other ad hoc network protocols. Second, WSN support thousands of potential applications, it is not possible to have one-thing-fits-all solution for these potentially very different possibilities. For example, the challenging problem of low-latency precision tactical surveillance is different from that required for a periodic weather-monitoring task.The design of arouting protocol must change with application requirements of a specific sensor network. Thirdly, in WSN data traffic has significant redundancy sincemany sensors may probably collect data based on a common physical phenomenon. Such redundancy needs to be minimized by the routing protocols to improve energy and bandwidth utilization without affecting the monitoring quality. Fourth, in many of the application scenarios, sensor nodes were generally stationary after deployment. However, in most of the recent scenarios for monitoring mobile events, sensor nodes are increasingly allowed to move and change their location, which results in unpredictable and frequent topological changes. Due to such different characteristics, researchers have proposed many new routing protocols to solve the routing problems in WSN. Based on the application and architecture requirements, routing mechanisms have been designed taking into consideration the inherent features of WSN. To minimize energy consumption, routing techniques proposed in the literature for WSN utilize concepts like, clustering,data aggregation(in-network) processing (**Heinzelman*et al.*, 2000**), different node role assignment and data-centric methods (**Krishnamachari*et al.*, 2002**).

WSN Routing Protocols

WSNs consist of several sensor nodes. Each node may have one or more sensors to get data from the physical world.This data is then bind into a packet before sending it to the destination. During the sending of data packets,it may pass through several nodes before eventually reaching the destination. To determine the path to be followed by a packet, Routing is the act of reaching packetto desired destination. To do this, a number of factors have to be taken into account. Routing protocols consider them during routing process.

Taxonomy of WSN Routing Protocols

Almost all of the WSN routing protocols can be classified according to the network structure and their operation mode. Depending on the network structurerouting protocols can be classified as flat, hierarchical or location-based. Furthermore depending

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on the protocols operation routing protocols can be classified as multipath-based, query-based, negotiation-based, QoS-based, and coherent-based (**Al-Karaki and Kamal, 2004**) (**Dai*et al.*, 2005**). Figure 2.1 illustrates classification of WSN routing protocols.

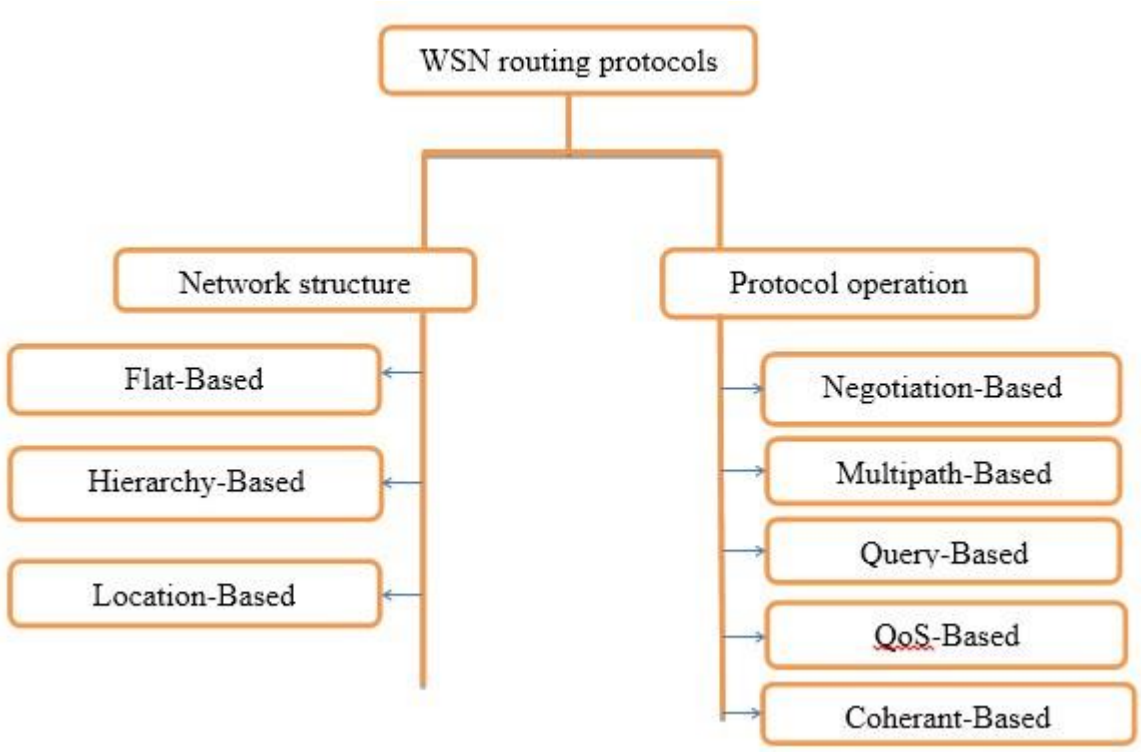

Figure 1: Classification of WSN routing protocols(Acsand Buttyan, 2007).

Network Structure based protocols
These protocols describe the characteristics of a network. The network characteristics can be divided into two groups based on the characteristics of base stations and the characteristics of sensor nodes.

Flat-based
In these networks, all nodes assigned equal role and there is absolutely no hierarchy. Flat routing protocols distribute information as needed to any reachable sensor node within the sensor cloud (Jolly and latify, 2006). Effort is made to discover the best route to a destination by any path.

Hierarchy-based
In this class of routing protocols, nodes play different role to conserve energy by arranging the nodes into clusters as shown in Fig. 2.2. Nodes in a cluster transmit to an appropriate CH,CH aggregates the collected information and forward it to the BS on behalf of other nodes within cluster (Heinzelman et al., 2000).

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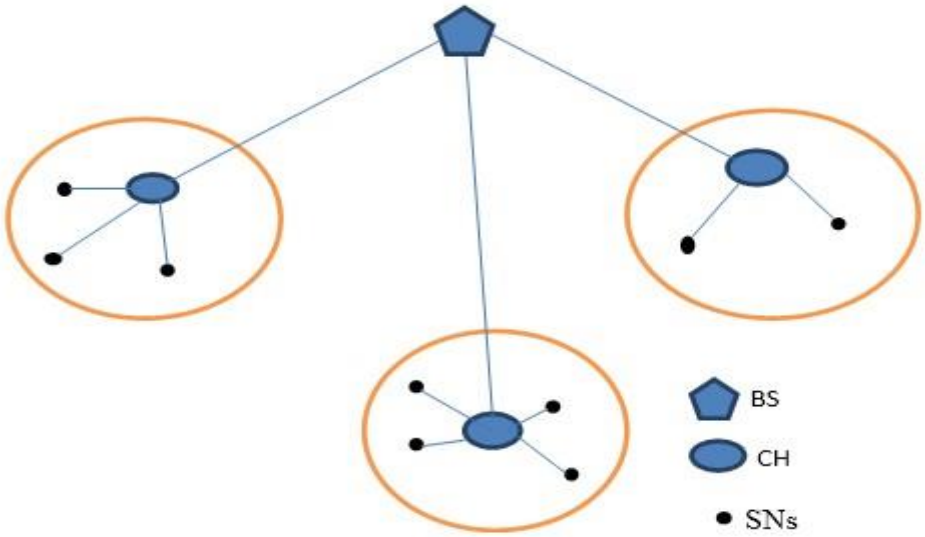

Fig. 2: Clustering nodes

Good clustering protocols play an important role in network scalability as well as energy efficient communication. On the negative side of it, clusters may lead to a bottleneck. This is because only one node communicates on behalf of the entire cluster. Due to this, energy depletion will be strongest in the CH node. In this study, hierarchical-based protocols are our main focus.

Location-based
Most of the routing protocols for sensor networks require location information for sensor nodesto calculate the distance between two particular nodes so that energy consumption can be estimated. Since there is no addressing scheme for sensor networks like IP-addresses, location information can be utilized in routing data in an energy efficient way (Jolly and latify, 2006).

Protocol Operation
Describes the main operational characteristics of a routing protocol in terms of communication pattern, hierarchy, delivery method, computation, next- hop.

Multipath-based
In this case, the network derives benefit from the fact that there may be multiple paths between a node and the destination. Using different paths ensures that energy is depleted uniformly and no single node bears the brunt (Acs and Buttyan, 2007).

Query-based
Here the focus lies on propagation of queries throughout the network by the nodes which require some data. Any node which receives a query and also has the requested data, replies with the data to the requesting node. This approach conserves energy by minimizing redundant or non-requested data transmissions (Mirembe, 2007).

Negotiation-based
In negotiation based protocols, the nodes exchange a number of messages between themselves before transmission of data. The benefit of this is that redundant data transmissions are suppressed. It should however be ensured that the negotiation transmissions are not allowed to exceed an extent that the energy saving benefit is offset by the negotiation overhead (Jiang and manivannan, 2004).

QoS-based
QoS based protocols have to find a trade-off between energy consumption and the quality of service. A high energy consumption path or approach may be adopted if it improves the QoS. So when interested in energy conservation, these types of protocols are usually not very useful and must be avoided (Duan and Yuan, 2006).

Coherent-based
In coherent-based protocols, data is sent to an aggregator node after minimum possible processing, and processing is then done at the aggregator. Coherent processing is energy efficient routing because it reduces the computation steps per node.

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However, the aggregator nodes must have more energy than the other ordinary nodes, or else energywill be depleted rapidly (Duan and Yuan, 2006) (Acs and Buttyan, 2007).

In addition to the above, routing protocols can also be classified into three categories: proactive, reactive and hybrid depending on how the source node finds a route to reach to the destination. In proactive protocols, route is determined before transmissions while in reactive protocols, route is computed on demand.

Hierarchy - Based Protocols

Hierarchical routing protocols attempt to conserve energy through formation of clusters, instead of each node communicating directly with the base station (Heinzelman et al., 2000). Network is organized into several clusters and a cluster head aggregates data in each cluster and forward it to the base station. LEACH is the fundamental protocol in this family over the years, other protocols have been derived from it as shown in Fig. 2.3

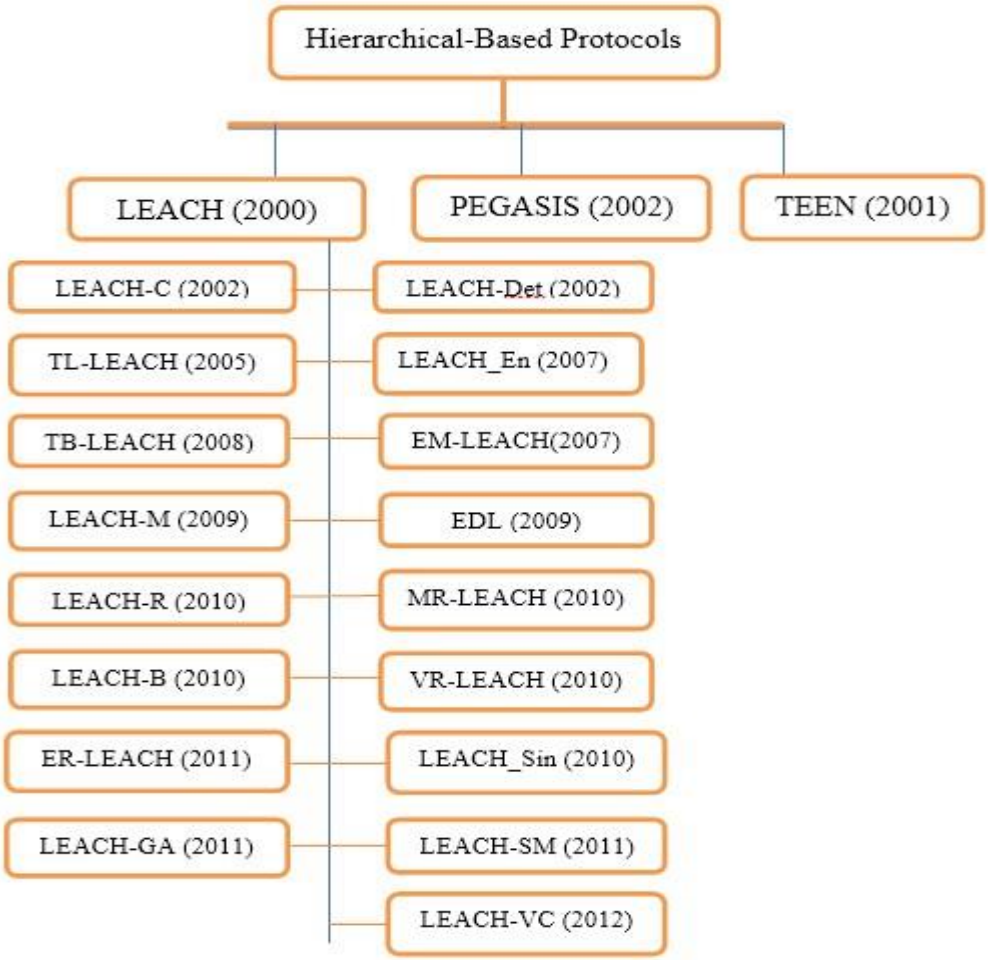

Fig. 3: Hierarchical routing protocols.

Heinzelman*et al.* (2000) proposed low-energy adaptive clustering hierarchy (LEACH) protocol, one of the most popular hierarchical routing protocols. In LEACH, the whole WSN divides into clusters each containing some cluster members and a cluster head (CH). The cluster members monitor the physical environment and transmit data to the respective cluster head. After receiving data from all member nodes, cluster head perform data aggregation and then send the information to the base station on behalf of others. To distribute the even workload on all the nodes, LEACH randomly select a cluster head over a period of time. LEACH operates in two phases namely Setup phase and steady state phase.

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Setup Phase: During this phase, nodes organize themselves into clusters and taking the decision to be cluster head. At the advent of this phase, each node generate a random number between 0 and 1. If number is less than a threshold *T(n)*, the node is elected as a cluster head for current round.

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

Where, p is the desired percentage of cluster heads (e.g. 0.05), r is the number of current round and Gis the set of nodes that have not been cluster-heads in last 1/p rounds. After Cluster head selection, rest of the nodes have to join the respective cluster. Every CH broadcast the advertisement (ADV) massage. Each non cluster head node determines its cluster based on received signal strengthof the advertisement from each cluster head. After receiving request from member nodes, CHs prepare the TDMA schedule and transmit to the cluster nodes. This completes the setup phase of LEACH.

Steady State Phase: In this phase each member nodes send their collected data to the CH in the allocated time slot. Nodes are always expected to have data all the time to send. After sending the data, nodes go to sleep mode until the next TDMA slot, to save energy. When all member node finish, CH performs data aggregation and/or data fusion and then send the information to the base station. After one round is completed, next round consisting of these two phases is followed.

Advantages

- **i.** Due to randomized rotation CH selection characteristic,LEACH distributes the energy load evenly among all the sensor nodes.
- **ii.** It limits most of the communication inside the clusters, and hence provides scalability in the network.
- **iii.** CH assigned the TDMA slot to each member, hence collision overheads are removed.

Disadvantages

- **i.** LEACH offers no guarantee about placement of CH nodes. These nodes even lie close to each other and still participate.
- **ii.** LEACH does not put a constraint on the number of nodes that become CH.
- **iii.** LEACH has more energy overheads during the setup phase.

CONCLUSION

This paper gives a brief overview about WSN Routing Protocols. Lots of advancements are going on in this specific domain. Continuous evolution in this area has added various dimensions in base atoms of concerned area. This study will be helpful for those working in the area WSN Routing Protocols.

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