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A Recent Survey on Routing Protocols in WSN and its Applications

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Abstract - **Wireless Sensor Networks (WSN) are made up of sensor nodes and sinks that have low power, low memory, and limited processing capability. The entire sensor nodes exchange the data to Sink via intermediate nodes. Energy is a scarce resource in WSN. So, efficient utilization of energy is a crucial role in WSN. Hence, the design of WSN routing is a prime challenge to increase the lifespan in WSN. Several energy-efficient routing algorithms for WSNs are described in this paper.**

Keywords- Energy conservation, Clustering, Cluster Head, Routing Protocol.

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I. INTRODUCTION

A WSN is one of the emerging technologies in Information and Communication Technologies, which creates more research interest on industry as well as academia [1, 2]. WSN is a collection of small commodities, which contain node with power supply, multi-functionalities such as sensing, and actuating and communication abilities from one node to another [4, 5]. WSN's architecture is seen in Figure 1.

The WSN consists of Sink and collection of Wireless Sensors (WS). The WS's generates the data and send to another WS through wireless medium. In recent years, many consumer and industry are focused more on WSN. The reason is that we can use the WSN in various application areas, namely healthcare sector, agriculture, intelligent transport, underwater sensor, etc. In general, the accuracy level is high in monitoring, while using more number of nodes deployed in our application. However, the sensor nodes are very small and it is more expensive. It is very difficult to replace the battery due to the different environments. The sensor nodes are dispersed across the network's coverage region. The sensor nodes generate the sensor readings and transfer into sink [6-8].

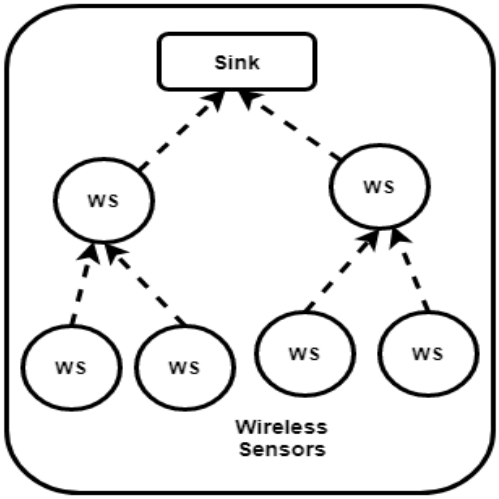

FIG.1 ARCHITECTURE OF WSN

The WSN follows the layered architecture for the protocol stack. The routing operation is performed in the network layer [9]. The layered design of the WSN protocol stack is seen in Figure 2.

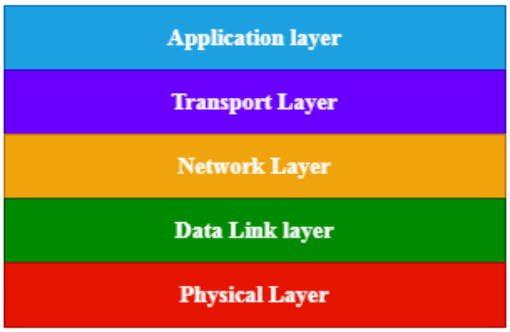

FIG.2 LAYERED ARCHITECTURE OF WSN PROTOCOL STACK

Routing is the most energy-efficient method of distributing data in a network. In the routing protocol, the Sink node can be placed as static or dynamic. To increase the network performance, conserving the energy is a critical parameter in WSN routing [10-14].

Conserving the energy is varied from the application to application. If the node's battery keeps on running in active mode, the energy will be depleted and battery will be drained. This problem has resulted in decreases the lifespan of the network node. Consumption of energy in each node depends on the sensing, aggregating, receiving and transmitting energy.

The following is the structure of the paper: The section 2 explains the many types of routing protocol. The conclusion is discussed in Section 3.

II. ROUTING PROTOCOLS IN WSN

A. Data Centric Protocols

The data centric protocols are suitable for large scale and dynamic environment of sensor nodes. In this routing, the global identifier assignment is not suitable for data transfer. So, the routing will be performed autonomously as per the user queries. The protocol able to select particular set of nodes to collect the data from it. The cluster or group formation is done by on-demand basis. The major advantage of data centric protocol is to gather or query particular area data instead of collecting particular sensor data [15].

ii. Sensor Protocols for Information via Negotiation (SPIN)

It is regarded as one of the initial study topics in the data centric routing protocol's development. The primary concept of SPIN is to send meta-data instead of send entire data packets from one node to another. For example, particular nodes are very close to each other's; almost all the nodes generate same data. This situation, it sends one packets instead of duplicate data packets. The SPIN protocol reduces the number of duplicate data. This reduces the network's energy usage. However, data collecting mechanism is not provided the guarantee of data exchange. To overcome the above mentioned issue, the researchers were introduced two types of SPIN protocols, namely SPIN1 and SPIN2. The SPIN1 is not suitable for energy aware routing in WSN. The types 2 SPIN protocol is suitable for energy aware routing. Thus, it prolongs the lifespan of the network [16].

ii. Gossiping and Flooding

Gossiping protocol: It follows the random neighbor broadcasting mechanism by resolving the issue of implosion for sensing the data from source to destination. However, it creates extra transmission delay while transferring data from one place to another.

Flooding: It is a mechanism to exchange the data from one node to another. The working mechanism of flooding is each node broadcast its own data to the adjacent node. Finally, the data moves from the source to its final destination. However, it creates more number of redundant while data exchange from sender to receiver.

iii. Directed Diffusion

It's a type of technique in a data-centric routing. The key principle of guided diffusion is the attribute-value pairs, which are based on the on-demand basis. It provides the communication between source and base station. It establishes the mesh topology and aggregates the data in the intermediate node and finally reaches the destination.

B. Hierarchical Protocols

In hierarchical routing, the nodes are distributed at random across the dense network. The single gate way cannot cover the large network area. So, the clustering concept is introduced for collecting and exchanging the data from one place to another [17].

The primary purpose of hierarchical routing is to reduce the amount of resources used by the network. Initially, it forms clusters and later on selects one Cluster Head (CH) for each cluster. The CH acts as leader role in the cluster and it has some responsibilities like receive, compress and exchange the data packets to Sink. The process of data compression saves the energy large amount in the network nodes.

i. *LEACH*

LEACH is a common clustering methodology [18] that is used in many applications. It is the base of various cluster based protocol. The nodes in the LEACH network are assigned to their positions at random. After that, the CH is chosen on the basis of probability. Once the CH is picked, the nearest neighbor nodes are created the cluster around the CH. Each cluster rotates the CH node according to the cluster's rotational basis. Cluster Members (CMs) transmit aggregated data to the CH node, which in turn distributes it to the Sink. The changes of CH calculation are given in Eq. (1)

$$Thres(n) = \begin{cases} \frac{Prob}{1-Prob(rand \bmod \frac{1}{Prob})} & if\ n \in G \\ 0 & Otherwise \end{cases} \quad (1)$$

Where Thres indicates the threshold value, n denotes total number of nodes, Prob is a probability value for acting as CH node, A random number from 0 to 1 is called a rand.

Nodes are designated CM in a cluster if the "Thres" value is less than 1. It has the effect of decreasing the energy consumption of network nodes while simultaneously increasing the data delivery ratio.

ii. TL-LEACH

The TL-LEACH protocol is an improved version of the conventional LEACH protocol. It has two levels of CH in the cluster. In each cluster, the secondary CH collects and aggregates the data, which is then passed to the main CH for further processing. Later, the Primary CH directly

exchanges the data to the Sink. The data aggregation is followed from the LEACH. The primary and secondary CH election strategy is also followed from the LEACH.

iii. *Energy Efficient Clustering Scheme (EECS)*

The EECS is one of the cluster based algorithm in WSN. It has two processes, cluster creation and selection of CH. The cluster formation procedure is different than LEACH. The cluster size is dynamically adjusted based on the location of the Sink. At any particular round, the preference of CH is determined by how much leftover energy a node in the cluster has at that time. This protocol enhances the network performances by means of network lifespan and data delivery ratio [19].

iv. *TEEN*

It is a mix of the data-centric clustering method and the hierarchical clustering algorithm. It is suitable for time critical situation. TEEN consists of cluster creation and selection of CH process. First, it creates the cluster on the basis of routing parameters. Later, the CH is found in the each cluster. In each cluster, the TEEN maintains the soft and hard threshold values transmit to all the CM's. The hard threshold is kind of value which indicates the value for sensed attribute. The soft threshold is value which indicates the small changes in the sensed attribute to activate the transmitter [20].

v. *APTEEN*

Enhanced version of TEEN protocol, which gathers both periodic and time-sensitive event data from the network. The Sink forms the clusters among the network nodes. Routing parameters are used to select the CH in each cluster. Later, the CH sends the threshold values to the CM's in the cluster. Finally, the CH performs the aggregation operation and exchange the data to the Sink. The advantage of APTEEN is performed on the basis of historical changes, periodic changes, etc. The protocol comparison is given in table-1.

TABLE I
DIFFERENT HIERARCHICAL ROUTING PROTOCOLS

Parameters and operations	LEACH	TEEN	APTEEN
Single hop	Yes	No	No
Data aggregation	Yes	Yes	Yes
Periodic event based query	Yes	No	Yes
CH are relay node	Yes	Yes	Yes
Sink is controlled the cluster formation	No	Yes	Yes

vi. *PEGASIS*

It creates a chain-like routing between the source and the destination. The primary goal of PEGASIS is to extend the network's life and raise the data transfer ratio. This protocol reduces the consumption of energy among the nodes when compared to LEACH protocol. In chain based routing, the data aggregation is performed in each and every level of nodes in the route. According to Table-2, you can see the network's lifetime.

TABLE 2
COMPARISON OF NETWORK LIFESPAN

Algorithm	Network Lifespan
LEACH	It saves the energy that 8 times better than traditional routing protocol
TL-LEACH	It provides the 30% of improvement than LEACH
EECS	It provides 35% of improvement than LEACH
PEGASIS	It provides 100% to 300% of improvement than LEACH

C. WSN Applications

The Applications of WSN are industrial application, healthcare monitoring, military application, smart home, environmental monitoring, smart grid, etc [21].

i. Healthcare monitoring

In healthcare monitoring, we can use different kind of sensor networks such as implanted, environment embedded and wearable. Implantable devices are medical devices that are put into the human body. The term "wearable" refers to equipment that may be worn on the body. Environment embedded system plays the sensors in the environment itself.

ii. Environmental monitoring

Environmental monitoring is kind of application of WSN, which is used to monitor the conditions like air pollution, forest fire detection, water quality assessment, natural disaster management, etc.

iii. Area Monitoring

In area monitoring, sensor nodes are placed in the region and are controlled remotely. Military application is one of the examples, which is used to find the enemy.

III. CONCLUSION

WSNs are made up of sensor nodes and sinks that have low power, low memory, and limited processing capability and are hence called wireless sensor networks (WSNs). The entire sensor nodes exchange the data to Sink via intermediate nodes. Energy is a scarce resource in WSN. So, efficient utilization of energy is a crucial role in WSN. Hence, the design of WSN routing is a prime challenge to

increase the lifespan in WSN. This paper addressed various energy-efficient routing protocols in the WSN.

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