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Hierarchical Energy Efficient Routing in Wireless Sensor Networks and its Challenges

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Abstract: ***Wireless sensor network consists of various sensor nodes connected through wireless media. Sensor nodes are tiny devices having lesser energy capabilities. Sensor nodes are either ad-hoc or mobile in their environment. Wireless sensor network route of transmission media is discovered by routing protocols and responsible for secure communication between sensor nodes. Energy is a precious resource of sensor nodes, and the entire lifetime of WSNs is depending on the energy capability of the sensor nodes. The fundamental problem is how to organize topology of WSN for deployed sensor nodes with lesser power consumption as possible. Major problems in wireless sensor networks which consume extra energy are interference, control message overhead, packet delay, unnecessary transmission, and bandwidth utilization. Therefore, energy efficient techniques are needed to overcome these problems. Hierarchical routing is the best routing method for finding optimal path between sensor nodes which enhance the lifetime of the network. This paper focuses towards various hierarchical energy efficient routing in wireless sensor networks and analyzes various features of WSN that should consider during designing of routing protocols.***

Keywords: Wireless sensor networks, clustering, energy efficiency, Hierarchical routing protocols.

I. INTRODUCTION

Due to much technical improvements in the past decade wireless sensor network have witnessed much development in the field of manufacturing such as low cast of sensor has economically feasible. The routing problems of WSN have been addressed by different authors. Various routing protocols have been proposed for a common objective like energy consumption, latency, and bit rate. Application of WSN involve battlefield investigation, building inspection, security surveillance, and civil applications for example weather monitoring, goal field imaging, distributed computing, interruption detection, sensing ambient situations such as temperature, movement, sound, light, the presence of the certain objects, and disaster management etc. Typically [1], Wireless sensor network consist of larger number of sensor nodes and each sensor nodes have the capability to communicate each other or directly to base station (BS) that is called as sink node. As more number of sensor over the sensing area will lead to more accurate and redundant data [2], [3]. In all these WSNs, battery is the only energy source of the nodes. Thus, energy conservation has become a crucial issue in WSNs.

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The WSN routing protocol can be broadly classified into Geographical routing protocol and Non-Geographical routing protocols. Geographical WSN routing protocol perform their routing on the basis of the source location, the next hop and the destination nodes while in the case of Non-Geographical routing protocol of WSN perform their routing on the basis of table driven and control packet overhead. Wireless sensor nodes are equipped with GPS and location of nodes directly available with the satellites.

If there is no activity done in WSN then some nodes go to sleep mode in location based routing protocols. Most of energy can be saved by having sleeping modes in WSN as possible. Several routing protocols have been proposed by various authors for wireless sensor networks still many issues remain to solve the problem. Energy efficient routing is a challenging issue for researchers.

II. MOTIVATION

WSNs gather information in various applications such as civilian and battle field monitoring that minimizes the involvement of human and user have increasing attention to researcher community in past decade due to its diversities of applications and characteristics, which offers various challenges in developing energy efficient protocols for medium access, routing, deployment, tracking, sensing, data gathering and fusion, coverage, and cross layer protocol design etc. Due to limited power of sensor nodes in WSN an innovative approach are highly needed to prolong the network lifetime. Limited power of sensor nodes in wireless sensor network makes it expensive and difficult to deployment in larger scale. Several authors have been focussed on developing a routing protocol which optimizes the energy consumption.

Energy aware protocol proved that self-configuring approach play a significant role that is well controlled energy consumption. Therefore energy efficient routing approach in wireless sensor networks has highest importance with respect to prolong lifetime of overall WSN. Approach of data routing and transfer of data to base station in WSN is very important issues. In this situation efficient routing with optimum consumption of energy and optimum path selection for data transfer in WSN is desired.

Sensor nodes in WSNs automatically discovered its surrounding, neighbour's information, topology information rapidly and organises into a connected network. There are following major research methodologies steps toward implementing energy efficient routing in WSNs.

- Equalization of energy consumption among sensors nodes to enhance the overall lifetime of the wireless sensor networks.

- To establish the optimal routes between the wireless sensor nodes, the intermediate nodes will be selected based on the ratio of its maximum residual energy to the distance between itself and the destination.
- Energy efficient optimization approaches to find an optimal path from each node to the sink.

The above three requirements highly demand that wireless sensor networks incorporate features such as self-organization, self-configuration and dependability.

III. ENERGY CONSUMPTION CHALLENGES IN WIRELESS SENSOR NETWORKs

In wireless sensor networks energy consumption is one of the important issues not only because of battery operated sensor nodes but also due to its significant impact on the idea of green computing. In wireless sensor network, Clustering approach plays important role. Clustering approach increases network life time, improved bandwidth utilization and also reduces wasteful energy consumption thereby reducing overhead. However clustering approach has certain limitations as follows:

A. Throughput

To ensure the stability in the wireless sensor networks certain level of throughput is required to fulfil the quality of services to the end user of network. In WSN interfering problems occurs when the channel sharing for higher data transmission. Besides other issues of WSN effects of interferences is also big important during simultaneous transmission of data in order to enhance the WSN capacity. In such scenario high throughput and low delay is difficult to achieve.

Throughput of wireless sensor networks is affected by various factors such as collision avoidance, control overhead, channel utilization and latency. Throughput maximization is a fundamental problem in WSNs. Therefore, we need an efficient coordination between throughput and power consumption [7].

B. Energy Efficient Design

In WSNs, energy consumption and prolonging life time of the network are two critical issues. WSNs nodes are low powered battery device, replacement of battery or recharge of battery is very difficult task in hostile environment.

The components of senor node consume a large amount of energy either in active mode or idle mode. Therefore there is a need of power management scheme to save the energy in idle mode by switching off the components that are not participated for a particular instance of time [8].

C. Energy saving in interference environment

The behaviour of WSNs is greatly affected by the deployment environment in wireless communication is unpredictable in different environment. Sensors are usually deployed densely in wireless sensor network. Due to this dense environment, it can suffer significant interference which greatly impairs network performance. Therefore, to discover different technique for reducing power consumption in the presence of interference and shadowing environments are also very important [9].

D. Message Delivery

The role of sensor nodes in WSN is sensing environment and delivering data to the base station. Since there are various sensing nodes in WSN to pass the data to the destination node, fairness is an important issues for researcher. Multi hop routing get worse the packet loss in WSNs, node near the destination have higher packet delivery. If sensor node has packet to send, it must be able to deliver the data at destination node. Poor data delivery performance may degrade performance of data transport and expand energy consumption. Therefore, the delivery ratio should be high [9].

E. Network Lifetime

Effective clustering approach reduces energy level in intra-cluster and inter-cluster communication due to this increases network lifetime. The energy consumption in wireless sensor networks is still challenge in industrial and research field [10].

F. Limited Energy

Nodes of wireless sensor networks have low powered battery and very small in size so that sensor nodes has limited energy storage for operating in network. So there is a need of an efficient approach for utilization of this limited energy. A proper clustering scheme can reduced overall energy consumed in the network [11].

G. Scalability

In WSN most of the sensor nodes deployed due to infrastructure less property. The node of sensor network has limited coverage range. For such scenarios a capable routing protocols are needed for handling a vast amount of sensor nodes. WSN consists of collection of large number of small nodes; it is not easy to preserve the global information of network for each node in sensor network [12].

H. Data aggregation

Data aggregation is a technique for eliminating the redundant data transmission in WSNs. Data aggregation is the fundamental procedures for saving the energy. Data aggregation is technique to gather and aggregate data so that network lifetime is enhanced. Most of times each sensor nodes duplicates sensed data to its sink node called base station lead redundancy at base station [13]-16].

IV. LITERATURE SURVEY

The lifetime maximization of WSNs has been an important issue for researcher in last two decades. Various advances have made for developing routing protocols to increase the lifespan of WSN. Various hierarchical routing algorithms such as Low Energy Adaptive Clustering Hierarchy, Hybrid Energy-Efficient Distributed Clustering, Power Efficient Gathering in Sensor Information Systems, Threshold Sensitive Energy Efficient Sensor Network algorithm played significant role[5], in which various cluster are formed and each cluster elects its cluster head for the purpose of communication to the base station which lead to energy conservation as all the data is collected by cluster head which is processed there and then transmitted to sink. In [6] author uses laurentz concept to enhance the lifetime of WSNs.

Laurentz concept balances energy consumptions among sensor nodes. Routing protocol and MaxEW uses social welfare function to calculate energy welfare for energy population. In [7] author developed a hierarchical network architecture for realistic situations, where primary nodes are energy renewable source and secondary nodes uses conventional battery system that perform just transmission process for sending the sensed data to primary nodes.

There are many different packet forwarding protocols exists that finds shortest path between sensor nodes by minimizing the number of hops in position based network routing algorithm. The shortest route is based on the position of the sender node, the position of the immediate neighbouring nodes, and the destination nodes. Compass routing [2]-[4], most forward within radius [2] and Geographical distance routing [5] are the most greedy forwarding algorithms. MFR chooses next forwarder nodes which go maximum progress towards destination node. It is also considered an energy efficient routing algorithm when using a constant transmission power since it reduces the number of hops.

DIR find the optimal routes by selecting forwarding sensor nodes in its transmission range and which is almost near to the direction of the destination node and also find number of hop count and limit the flooding of packet in the sensor network.

Geographic distance routing algorithm uses greedy routing algorithm, whose aim is same to DIR and MFR. In both only difference is selecting next forwarder node logic. Geographic distance routing algorithm selects a neighbouring node as next forwarding node between the node chosen as next forwarder and the destination node which has the minimum forward progress distance. Greedy algorithms minimize energy consumption by limiting the flooding, routing overhead, number of hop counts in the same route [13]. This route is maximum used route to forward the packets in the network and hence results quickly depletion of energy of the nodes. These depleted nodes are called dead sensor nodes. The dead nodes create disconnected networks. The lifetime of the wireless sensor networks is related to each of the individual sensor nodes. Designing a routing algorithm is a critical issue in WSN where the energy of sensor nodes used as a planned and efficient way. The energy of each sensor nodes should be fairly equalized to enhance the lifetime of sensor networks by selecting optimal route such way all sensor nodes consumed equal energy [14].

Authors in [7] have proposed a new routing position based algorithm to maximize the lifetime of sensor networks with the concept of equal energy consumption among sensor nodes. Unnecessary transmission of data is reduced by forwarding search space algorithm. A next forwarder selection function chooses different set of sensors for routing based on the residual energy, node degree, distance, and angle, which fairly balances the energy consumption among the sensor nodes.

In paper [9] author used combined approach of Huffman coding and Ant colony optimization based technique for lifetime maximization in sensor networks for randomly distributed networks. Author in this paper proposed ACO based multiple paths exploration and Huffman based optimal path selection in terms of number of hop count, load of energy in terms of residual energy. The path between source node and destination node is mathematically derived on the concept of ants namely Advancing Ant and Regressive Ant in Ant Colony Optimization.

In [16] authors developed a routing algorithm which works on the principle of ensemble data and optimal cluster head selection. This routing algorithm enhances the lifetime WSN but create problem of delay due to multifaceted operations. It selects the sensor node that has higher energy of sensor node that is situated far away from base station of WSNs.

In [17] authors developed LEACH MAC cluster head selection algorithm which removes the gap of the first node death and last node of death of sensor networks.

In [18] authors Noor Zaman proposed Position Responsive Routing Protocol (PRRP), to enhance the energy efficiency in WSN. In comparing to the LEACH and CELRP whereby the CHs are selected randomly among sensor nodes but in PRRP different parameters are used such as energy level, distance between nodes to sink and average distance of neighboring nodes from the candidate CH node.

V. COMPARSION OF MAJOR HIERARCHICAL ROUTING PROTOCOLS IN WSN

Table1 shows energy efficiency and complexity of different protocols LEACH(Low Energy Adaptive Clustering Hierarchy), HEED(Hybrid Energy Efficient Distributed Clustering), EECS(Energy Efficient Clustering Scheme), PEGASIS(Power Efficient Gathering in Sensor Information Systems), UCS(Unequal Clustering Size), TEEN(Threshold-sensitive Energy Efficient sensor Network), APTEEN(Adaptive Periodic Threshold Sensitive Energy Efficient sensor network), CCS(Clustered Based Compressive Sensing)and HGMR(Hierarchical Geographic Multicast Routing). TEEN protocol have very high energy efficiency as compare to LEACH, HEED, EECS, PEGASIS, UCS, APTEEN, CCS, and HGMR. LEACH and HGMR has low complexity as compare to HEED, EECS, PEGASIS, UCS, TEEN, APTEEN, and CCS.

Table-I: Energy efficiency and complexity of major routing protocols

Protocol Name	Energy Efficiency	Complexity
LEACH	Very low	Low
HEED	Moderate	Moderate
EECS	Moderate	Very High
PEGASIS	Low	High
UCS	Very low	Moderate
TEEN	Very High	High
APTEEN	Moderate	Very High
CCS	Low	Moderate
HGMR	Low	Low

VI. CONCLUSION

The components of senor node consume a large amount of energy, even if they are idle. Therefore, power management scheme are needed for switching off the components that are not required for a particular instance of time. To prolong the lifetime of the sensor nodes various energy efficient routing techniques have been proposed but satisfactory result not found. Efficient routing has a lot of challenging issues in applications it is a still evolving field which requires lot of research. In this paper major contribution of authors has been discussed.

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