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REVIEW ARTICLE

A Review of Energy Aware Routing Protocols for WSN

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ABSTRACT: A wireless sensor network is an infrastructure less, self organizing, bidirectional communication network of resources limited sensors which not only sense the environment but collaboratively achieve information gathering and dissemination tasks. The need to conserve energy to extend the network's lifetime is the most critical issue in the design of routing protocols for wireless sensor networks. In this paper, we present brief description and review of various energy aware routing protocols for wireless sensor networks. This can be achieved by using various methods like use of residual energy, putting inactive node in sleep mode, adaptive energy or topology or transmission range which not only enhances network survivability but also improves network performance. The study concludes with the recommendations for future to use adaptive threshold energy based strategy for better performance.
Keywords: Energy aware, routing, node energy, network lifetime, efficiency

1. INTRODUCTION

A wireless sensor network is a special network with large numbers of nodes equipped with processors, sensors and radios. These nodes collaborate to accomplish a common task such as environment monitoring or asset tracking. In many applications, sensor nodes will be deployed in an ad hoc manner without careful planning. They must organize themselves to form a multi-hop, wireless communication network. Unlike ad-hoc networks, recharging or replacing the sensors battery may be inconvenient, or even impossible in some monitoring environments [1]. Therefore the key challenge in the design of wireless sensor network protocols is how to maximize the network lifetime, which is limited by battery energy in sensor nodes, while providing the application requirement.

There has been considerable research in the area of energy efficient routing protocols. The research literature can be divided into two categories: *proactive* protocols, such as Destination-Sequenced Distance Vector (DSDV), Cluster-Head Gateway Switch Routing (CGSR) and Wireless Routing Protocol (WRP), which keep and update information in routing tables, and *reactive* or on-demand protocols, such like Ad hoc On Demand Distance Vector (AODV) and Dynamic Routing System (DRS), which construct routing tables when a packet is being sent to the destination [1]. In reality, the nature of an environment where WSNs are located is unreliable, dynamic, and indeterminate [1]. That requires more efforts to put into routing strategy to make wireless ad-hoc network protocols feasible in WSNs, especially with energy limitation. To make routing energy efficient various routing protocols were developed.

ROUTING STRATEGIES

There are so many routing protocols have been developed for wireless sensor networks. Due to limited processing and battery power traditional protocols cannot be used here. So routing protocols for WSN fall under three categories: 1) Direct Approach 2) Location based routing 3) Data centric routing [2].

Direct approach includes simple flooding type routing protocols which are not energy efficient protocols since they are easy in implementation. In location based routing nodes are identified by its location only. The locations of nodes are obtained by GPS receivers. Some protocols come under this category are-

- Greedy Approach
- Compass Routing
- DREAM (Distance Routing Effect Algorithm for Mobility)
- GPSR (Greedy Perimeter Stateless Routing)
- GEAR (Geographic & Energy Aware Routing)
- GAF (Geographic Adaptive Routing)

In data centric routing decisions are taken based on data held by the nodes in the network. Some protocols come under this category are-

- Directed Diffusion
- Rumor Routing
- SPIN

ENERGY EFFICIENCY IN ROUTING

Energy efficiency is one of the important factors for wireless sensor networks. Although energy harvesting from environment is also possible in some applications. But the focus is on sensor nodes with non rechargeable batteries. Due to limited energy resources and requirement of long operation time, innovative communication techniques need to be developed that consider to eliminate energy inefficiencies in all networking layers. In wireless communication, communication needs more power than data processing. More the nodes transmitting more will be battery consumption. So to reduce data redundancy data aggregation techniques are used. There are two types of data aggregation techniques [2]. The first type aggregates the data gathered from different sources and then sends the final data. The second type combines the data from different sources under single header and sends it to the sink node. This header packet consolidates and passes it to the base station without any modification to the original data from the sensors. Hence accuracy is improved [2].

Literature study on energy efficient routing in WSN concludes two categories of strategies [2]. These are

- Clustering approach
- Tree based approach

Clustering Techniques:

Clustering techniques are needed to enhance the scalability of the network. Apart from achieving scalability of the network it has more advantages like conserving communication bandwidth within the clusters, localising energy efficient route setup within the clusters etc. Routing protocols based on this approach are LEACH, HEED, and DECA etc. LEACH (Low Energy Adaptive Clustering Hierarchy) is a cluster based protocol which randomly selects a few nodes as cluster heads. These cluster heads remove data redundancy and send the aggregated packet to base station in order to reduce the information that must be transmitted to BS. In HEED (Hybrid Energy Efficient Distributed Clustering Approach, cluster head is selected on the basis of residual energy of the node. This method ensures that each node either will get a chance to become a cluster head or will join one of the neighbouring clusters. It not only extend networks' lifetime but also support scalable data aggregation.

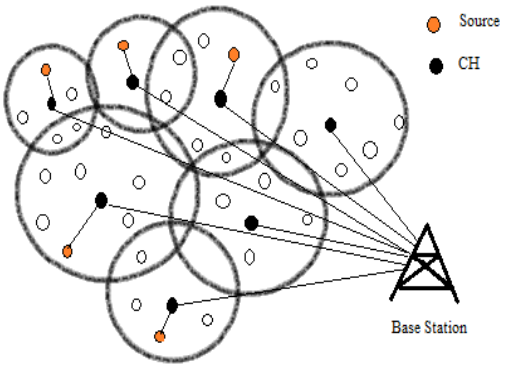

Fig. 1 Clustering of nodes.

Tree based approach:

In this approach, tree like structure is used to aggregate the data in hierarchical manner where leaves are the sensor nodes and the root is the sink node. As data travels through intermediate nodes, it gets aggregated itself. Some of the protocols based on this approach are PEGASIS, PEDAP etc. PEGASIS (Power Efficient Gathering in Sensor Information Systems) is a tree based protocol in which sensor nodes communicate only with their neighbours to reduce the power consumption. Since there are no cluster heads, it minimises the overhead effectively. In this method, the data aggregated by the sensor nodes will be sent to the sink node by one of the node in the chain. Hence each node will get a chance to transmit the gathered data.

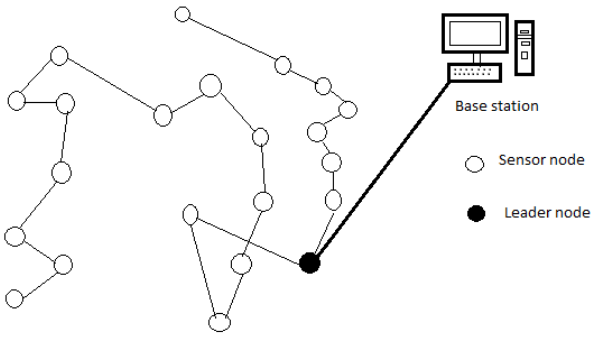

Fig 2. Data Gathering in PEGASIS.

2. REVIEW OF LITERATURE

P. S. Hiremath et. al (2013): This paper presents an on-demand routing protocol based on adaptive threshold transmission range and adaptive threshold energy which considerably extend network lifetime by improving energy utilisation in routing. In this paper, the transmission power of node is varied according to the minimum number of neighbouring nodes connected in the network. This paper concludes that the proposed protocol (ATRATE) is able to conserve energy and to prolong the network lifetime [3].

Savita Lonare et. al (2013): This paper provides survey of routing protocols for WSN which give better performance with limited resources. The author of this paper successfully concludes that energy factor is one of the most crucial factors to be considered while designing routing protocols. This paper summarises energy efficient routing protocols for WSN [4].

Akoijam Premita et. al (2012): In this paper , the author proposed a power efficient routing protocol which saves the energy by selecting the energy efficient path in the routing process. To increase the energy efficiency further transmission power of the nodes is also adjusted based on the location of their neighbours. The proposed protocol extend the life time of the overall sensor network by avoiding the unbalanced exhaustion of node battery powers as traffic congestion occurs on specific nodes participating in data transfer. However, there is need to handle overhead of mobility and topology changes in such energy restricted environment [5].

George-Emil Vieriu et. al (2011): This paper proposes a power aware adaptive routing protocol and topology control at network layer which is based on the residual operating time of sensor nodes. The proposed protocol can adapt to the changes of the energy reserves of the network. In addition to power monitoring power down management and sleep management is also implemented locally for each node [6].

Zhi Chen et. al (2010): In this paper the author proposes a new algorithm Adaptive Energy-Aware routing Protocol (AEAP), which is based on Link Estimation and Parent Selection (LEPS) protocol. This algorithm uses a broadcast delay method to suppress frequent updates to mitigate unnecessary rebroadcasts. It is a load balancing strategy which consider both energy state and link quality to

choose next hop among neighbouring nodes and cope with changes in topology with an adaptive node self-organisation mechanism [7].

Hanh-Phuc Le et. al (2009): This paper considers one of the energy constraints i.e. network survivability and tradeoffs which affects energy-aware routing strategies. The proposed adaptive energy-slope control (AESC) method try to keep each and every node alive for a certain required maintenance period. This method suppresses a mote from being a favourite intermediary node with high traffic for long period of time. In the proposed strategy, the network is expected to cope with worst cases of environment-dependent connectivity while still sustain energy-efficient connections in normal situations. The author concludes that the proposed strategy optimises the use of various energy sources like scavengers for each sub network so as to extend the network survivability [1].

R. Vidhyapriya et. al (2007): In this paper a reactive routing protocol called energy aware routing is introduced that is intended to provide a reliable transmission with low energy consumption. This protocol uses two metrics link quality and the available energy to identify an energy efficient routing path, which in turn minimizes packet collisions and increases the network lifetime. The author concludes that this algorithm uses less energy than traditional algorithms. However, further proposals are needed to confirm the delivery of packets under non-uniform transmission range. Also protocol must be improved to decrease the delay [8].

Backhyun Kim et. al (2006): In this paper, authors propose an energy-aware routing protocol to reduce the energy consumption of wireless sensor networks. This was accomplished by the combination of tree-based minimum transmission energy routing and cluster-based hierarchical routing. In this technique, a cluster-head is chosen with highest energy node such that the size of every cluster is less than and/or equal to *hops*. Every node can have different energy level which transmits its data to its cluster-head with short distance tree algorithm. Cluster head sends data to the other cluster-head or the sink with tree based minimum transmission energy algorithm due to the limit of nodes' transmission range. Since the node address represents its energy level, it is easy to reconstruct routing tree when wireless nodes or cluster-heads die. This technique is helpful to create a new route specially when a node, about to die, falling in the path of sink node [9].

3. CONCLUSION

This paper concludes that energy consumption is one of the most crucial factors for wireless sensor networks. There is a need to conserve energy of nodes by efficient utilization. For this purpose various algorithms and protocols have been proposed by various authors. Some proposed techniques were based on adaptive transmission range and topology whereas some authors suggested clustering and tree based approach. However, adaptive threshold energy based routing protocol seems to be more effective for enhancing network lifetime. This method will prevent a node from being a favourite intermediary node for long period of time, which results in replenishing the node energy with the help of energy scavengers like solar cells.

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