ENERGY OPTIMIZATION TECHNIQUES FOR WIRELESS SENSOR NETWORKS

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Abstract:Wireless Sensor Network (WSN) and Mobile Ad-hoc Networks (MANET) are two well-known types of the wireless networks which do not have a fixed infrastructure. They are popular because of their flexibility to create a network at any place where backbone network is not present. Such networks used to suffer from major challenges like limited power supply, efficient routing of packets and security of data from unauthorized access. This paper deals with the comparative analysis of the techniques proposed by scientists and researchers to enhance longevity of such network by minimizing energy consumption by the nodes of the network and propose a new technique based on that.

Key words:*Energy optimization, Mobile Ad-hoc Network, Routing, Wireless Sensor Network*

1. INTRODUCTION

Wireless Sensor Networks (WSN) [1] and Mobile Ad-hoc Networks (MANET) consist of large number of wireless portable deviceshaving limited energy sourcesand capable of communicating with each other without having any infrastructure.These kinds of wireless networks aredeployed in remote areas, war zones and inhospitable areas which are devastated by natural calamities. The advantage of these networks is that, once they are deployed, they form a network with each other to transfer dataand do not require time for configuring thenetwork. The major challenges in these networks includes routing efficiency, energy consumption, efficient bandwidth utilization and security issues. As the wireless nodes in runs on portable energy sources, so the energy consumption requires special attention to sustain the network connectivity. This paper focuses on the various causes of excess energy consumption in theseand discuss some of the popular energy efficient routing protocolsto enhance the life span of the network.

2. REASONS OF EXCESS ENERGY CONSUMPTION

In WSN and MANET, sustainability of both types of wireless networks depends on the longevity of their energy sources. The formal routing protocols used in wireless communication are effective in managing delay, bandwidth and network congestion but they overlook the importance of energy related parameters during packet transfer. From literature review [2], the reasons of excess energy consumption can be identified. These are unequal transmission energy due to different path length among the nodes, overhearing by the nodeswithin a network, retransmission of data or control information due to collision or network path congestion, encountering the common node during selection of best route, uneven load distribution and finally, the selection of routes for packet transmission through nodes which have less residual battery capacity.

3. ENERGY-EFFICIENT ROUTING TECHNIQUES

Energy efficient routing protocolsshould be implemented in Wireless Sensor Network and Mobile Ad-hoc Network to increase network longevity. Among the two broad categories of routing protocols known as proactive and reactive routing protocols, the reactive one is suitable because routing table is created only at the time of data transmission. So, the excess energy consumption, bandwidth consumption and system memory consumption can be reduced accordingly.

3.1.*Non-promiscuous Dynamic Source Routing Protocol (DSR-np)-* Among the various conventional wireless routing protocols [3-5], Dynamic Source Routing (DSR) protocol reduces excess energy consumption by dropping duplicate route request packets. The non-promiscuous variant of DSR protocol [6] reduces energy consumption by adding a header file at the source node. This header file contains address of all the intermediate nodes after a route has been selected between source and destination. Since each intermediate node of the route maintains a table of address of immediate neighbour node of that route. Therefore, any packet arriving at a node not containing the address of the node is dropped. By this mechanism, both overhearing of packets by nodes and excess energy consumption can bereduced. But the drawback is, alternate route selection in case of route failure becomes a little bit time consuming due to unavailability of unused nodes.

3.2.*Energy Dependent DSR (EDDSR):* In this protocol [7], prediction of lifetime of a network is estimated by the help of energy drain rate. Current energy level of a node is computed at a periodic interval of time from the residual battery power. When the battery power of node is well above threshold value, the node forwards the packet. On the other hand, when battery power goes below threshold value, the node starts rebroadcasting the route request packets to its neighbour to inform about the present condition. When battery power goes below the critical threshold value, the intermediate node stops packet delivery and generates route error message to source node to inform the source to search for an alternate route. It has been found from simulation that EDDSR is able to perform better than DSR protocol in higher traffic condition.

3.3.*Simple Energy Aware DSR (SEADSR):* This is another variant of DSR protocol [8] that introduces time delay ‘τ’ as an important metric in this algorithm. ‘τ’ is a function of power consumption by a node. This parameter is implemented by an intermediate node before the retransmission of route request (RREQ) packet. The value of time delay is obtained from the following relationship:

$$\tau = (C_{max} - C)\tau_{max}/C_{max} \quad (1)$$

Where, C_{max} is the battery capacity and C is the current battery level of the present node. ‘τ’, known as retransmission delay is directly proportional to the maximum allowable delay τ_{max}. It also directly proportional to the energy consumed by the node. It has been found that the route selected by conventional DSR algorithm does not select the optimal route due to chancesof reselect a route containing power exhausted nodes. Therefore, SEADSR algorithm increases the lifetime of wireless sensor network and mobile ad-hoc network by its capability to choose different paths at the same time for two different sources.

3.4.*Power Aware Routing (PAR) Algorithm:* Power Aware Routing Algorithm [9] considers the real time and non-real time data transfer as one of the key factors regarding energy consumption in a non-congested energy efficient route. This algorithm considersnode id, battery level status and traffic level of the network as necessary parameters that influence the energy consumption of the network. In relation to the battery energy available, three levels of batterystatus have been suggested.Level 1 status refers to battery level less than 20%, whereas level 2 refers to the battery level from 20% to 60%. Battery level above 60% is indicated by level 3.This algorithm has the ability to compute the total battery cost along with the number of weak nodes (which are denoted as level 1 status) in a given route. The presentlevel of traffic at each node isestimated from the number of packets that are buffered at the interface queue of a given node.The destination node selects route reply path to source node from the prior knowledge of nodes visited by route request packet and from the value of link status ratio R of the selected path. The mathematical relation to find link status ratio is given by:

$$R = \frac{E_{i,j}}{H_n} \quad (2)$$

In the above equation $E_{i,j}$ denotes the total residual energy of path and H_n denotes the number of intermediate hops. The minimum value of R is considered as 1 for a non-real time type of load and for real time type load, the value of R is 2. PAR algorithmcomputes the link status ratio of every different selected route for a given type of load. In this way, upon obtaining multiple link status ratio a route with minimum number of weak nodes is chosen whose battery energy level is less than 20%. Apart from the link status ratio and residual energy, the level of total traffic is also consideredas metric to find out the best route. For the minimum value of this metric on a selected route with no weak nodes present, the route is considered best among all the other routes. Simulation result on this algorithm reveals that, as the node density within a network increases, the remaining energy is also increased but the latency is also increased compared to the AODV and DSR protocol.

4. ANALYSIS OF ENERGY EFFICIENCY FOR DIFFERENT ROUTING PROTOCOLS

In the last few years numerous energy aware wireless routing protocols have been proposed. Every energy aware routing protocolhas their own benefits and limitations. A comparative analysis of the previously stated routing algorithms has been presentedin Table 1. Analysis of the aforesaid algorithms reveals that none of the algorithms satisfies all the criteria for best path selection between source and destination. Some algorithm lengthens the network lifetime but does not ensure guarantee for shortest path and minimum delay to the destination. There are some variants of DSR protocol that reduce energy consumption as well as maintain quality of service.This paper attempts to present a comparative analysis ofdifferent energy optimizing algorithms.

5. CONCLUSION AND FUTURE SCOPE

This paper deals with a very common but a burning issue of excess energy consumption in wireless sensor network and mobile ad-hoc networks. The probable reasons of the energy consumption have been pointed out and the research and analysis to minimize the energy consumption by the nodes has been studied. A comparative analysis of the proposed schemes and techniques has been discussed and tabulated. Literature survey of existing routing algorithm reveals that a group of variants of DSR algorithm reduces the energy consumption to a large extent, but at the same time the quality of the service is degraded. Based on these findings, the authors of this paper would like to propose a new algorithm where the network could be divided into a number of grids in which one node will be fully active and participating to packet transfer to other nodes in other grids. In the meantime the other nodes in a certain grid will be inactive for a predefined amount of time. This technique when incorporated with an energy efficient DSR algorithm, it may provide a more satisfactory result.

Table 1 Benefits and limitations of various routing schemes

Routing scheme	Benefits		Limitations	
Non-Promiscuous DSR (DSR-np)	(i)	Hidden and exposed nodes are set in sleep mode to minimize overhearing problem	(i)	Alternate route discovery is delayed during route failure or congestion in the path because nodes other than participating nodes go to sleep mode
Energy dependent DSR (EDDSR)	(i)	Route error message is transmitted to source when residual energy of node goes below threshold level	(i)	Intermediate nodes cannot send RREP packet to inform the source about the invalid route
	(ii)	Energy balance is achieved by avoiding weak nodes to take part in forwarding packet		
Simple Energy-Aware DSR (SEADSR)	(i)	Selection of energy-efficient route is based on delay parameter which is proportional to energy consumption	(i)	Increases the signaling overhead due to absence of route cache
			(ii)	Delay is more than DSR, but can be

	(ii)	No need to store route map in cache memory		maintained below 40 milliseconds with proper load balancing
Power Aware Routing (PAR)	(i)	Finds number of weak nodes based on battery status, traffic load type and intensity	(i)	Increases the delay in data transfer
	(ii)	Selects route with least number of weak nodes		

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