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Energy Consumption Control for Mobile Ad-hoc Networks: A Survey

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ABSTRACT
Energy consumption control in wireless ad-hoc networks is a more difficult problem due to non availability of access point in network. A node can be both a data source and a router that forwards data for other nodes. There is no centralized entity such as an access point to control and maintain the power control mode of each node in the network. There are number of challenges offered by mobile ad- hoc network environment like limited power, route failure, synchronization, security etc. Nodes in the mobile ad-hoc network environment have limited battery power. Extra amount of energy is needed by router to forward and to relay packets. In this paper, literature survey is carried out on energy consumption issues for wireless ad-hoc network.

Introduction

Mobile ad-hoc networks are based on a set of nodes which randomly communicate with each other over a wireless medium. These networks are without infrastructure and have multiple hops over wireless links. Wireless hosts are powered by batteries, which provide energy for a limited period. To conserve energy, power consumption control scheme is used to reduce energy consumption by varying the transmission power. Power consumption control in ad-hoc networks have been the focus of extensive research due to low energy capacity of network. Power consumption also depends on the medium access layer and protocol from physical to transport layers, which selects the minimum amount of transmission energy required to exchange messages between any pair of neighboring nodes. Transmission power consumption control includes important parameter like energy consumption. Transmission causes interference in the surrounding region due to shared nature of the wireless channel. Signal interference is reduced by reducing the transmission range, or the power level in network. Low-power level is increasing the relaying load on a node. Several medium access control protocols have been developed for wireless environments such as carrier sense multiple access, multiple access with collision avoidance IEEE802.11 and IEEE 802.11e.These MAC protocols are based on multiple design choices and utilize distinct medium access mechanisms. Modified ad-hoc on-demand distance vector algorithm is improved model of other ad-hoc algorithm. This algorithm minimizes the number of broadcast and control energy consumption by creating routes on-demand. Thus, energy management is an important issue in such networks. Efficient battery management, transmission power management is the major means of increasing the life of a node. Energy saving is done in two different ways: First is power saving and second is power control. Power saving means to reduce power consumption and Power control means to transmission power of mobile nodes. Power control problems\in wireless ad-hoc networks have become more complex due to its architecture. Mobile ad-hoc network functions are affected by the transmission power of node. Power control reduce data retransmission probability with a good assignment of transmission power, each transmitter guarantees its transmission in a low number of attempts and reduces its interference on other nodes. Mobile ad hoc network communication is made through space. Space transmission range is proportional to transmission power. Simultaneous transmissions in space are inversely proportional to average transmission range of nodes in a network. Energy consumption in mobile ad-hoc network reduced by reducing transmission power and reducing retransmission count. Efficient broadcast route discovery strategies that could reduce the number of retransmitting nodes of a broadcast message. These strategies can be grouped into four families: probability based, counter- based, area-based and neighbor-knowledge based methods:

Probability-based method

When a node receives a broadcast message for the first time, the node rebroadcasts the message with a certain probability. If the message received is already seen, then the node drops the message irrespective of whether or not the node retransmitted the message when it received the first time.

Counter-based method

When a node receives a broadcast message for the first time, it waits for a certain time before retransmitting the message. During this broadcast-wait- time, the node maintains a counter to keep track of the number of redundant broadcast messages received from some of its other neighbors. If this counter value exceeds a threshold within the broadcast-wait-time, then the node decides to drop the message. Otherwise, the node retransmits the message.

Area-based method

A broadcasting node includes its location information in the message header. The receiver node calculates the additional coverage area that would be obtained if the message were to be rebroadcast. If the additional coverage area is less than a threshold value, all future receptions of the same message will be dropped. Otherwise, the node starts a broadcast-wait-timer. Redundant broadcast messages received during this broadcast-wait-time are also cached. After the timer expires, the node considers all cached messages and recalculates the additional coverage area if it were to rebroadcast the particular message. If the additional obtainable coverage area is less than a threshold value, the cached messages are dropped. Otherwise, the message is rebroadcast.

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Energy Saving Schemes

Ad-hoc network is operated with battery. Energy consumption control is serious problem in mobile ad-hoc network. Literature review focus on energy saving by routing, Energy saving by transmission power, Energy Saving by transmission range.

Energy saving by Routing

It is observed from literature survey that mobile ad-hoc network arbitrarily motion of nodes results in unpredictable and frequent topology changes. Additionally, since nodes in a mobile ad hoc network normally have limited transmission ranges, nodes cannot communicate directly with each other. Hence, routing paths in mobile ad-hoc networks contain multiple hops, and each node in mobile ad hoc networks the responsibility to act as a router. Because of the importance of routing protocols in dynamic multi-hop networks, a lot of mobile ad hoc network routing protocols have been proposed in the last few years.

Most of the work today is based on energy efficient routing because power is main concern in ad-hoc wireless networks. Each and every protocol has some advantages and shortcomings. None of them can perform better in every condition. It depends upon the network parameters which decide the protocol to be used. Several protocols have been given regarding energy efficient routing and their modifications have also been proposed for use in ad-hoc networks.

Proactive Energy Efficient Routing

Destination-sequenced distance vector (DSDV)

It is based on Bellman ford algorithm. It removed the shortcomings (loops, count to infinity problem) of contemporary distance vector protocol which was not suited for ad-hoc networks. It is a destination based distance vector routing protocol in which every node maintains a routing table. This routing table contains all available destinations, the next node to reach to destination, and the no of hops between it. Whenever any node changes its position it broadcast the routing updates to the other nodes. Sequence number is used to avoid loop problems.

Keeping the simplicity of distance vector protocol it guarantees loop freeness it reacts immediately on topology changes. Since the route for destination is always available at the routing table of each node so there is no latency caused by route discovery. But broadcasting of routing updates may cause high traffic load between the nodes if the density of the nodes are high. So this protocol is best suited if the density of the ad-hoc network is low. However if the mobility of the node is too high broadcasting updates may cause time delay.

Advantages of DSDV

- DSDV protocol guarantees loop free paths.
- Count to infinity problem is reduced in DSDV.
- We can avoid extra trace with incremental updates instead of full dump updates. The path selection in DSDV maintains only the best path instead of maintaining multiple paths to every destination, with this the amount of space in routing table is reduced.

Limitations of DSDV

- Wastage of bandwidth due to unnecessary advertising of routing information even if there is no change in the network topology.
- DSDV doesn't support Multi path Routing.
- In DSDV it is difficult to determine a time delay for the advertisement of routes and also it is difficult to maintain the routing table's advertisement for larger network.

In DSDV each and every host in the network should maintain a routing table for advertising. But for larger network this would lead to overhead, which consumes more bandwidth.

OLSR (Optimized Link State Routing Protocol)

Optimized Link State Routing OLSR [4] incorporates two optimizations over the conventional link state routing in ad hoc networks. Each node selects a set of neighbor nodes called multi-point relays (MPRs). Furthermore, when exchanging link-state routing information, a node lists only the connections to those neighbors that have selected it as MPR, i.e., its Multipoint Relay Selector set .Further, the link state updates are diffused throughout the network only using these MPRs thus significantly reducing the number of retransmissions. The MPRs of a node are basically the smallest set of neighbors who can effectively reach all the two hop neighbors of that node. The MPRs of a node changes with node mobility and are updated using periodic HELLO messaging. A source-destination route is basically a sequence of hops through the multipoint relay nodes. Routes selected are shortest hop as in the conventional link state algorithm.

Advantages of OLSR:

- OLSR has less average end to end delay.
- OLSR is a flat routing protocol, which does not need central administrative system to handle its routing process.
- OLSR is well suited for an application which does not allow long delays in the transmission of data packets.

Limitations of OLSR:

- ·OLSR needs more time re-discovering the broken link.
- Wider delay distribution.
- OLSR requires more power when discovering alternative route.

Reactive energy efficient routing

DSR (Dynamic Source Routing Protocol)

DSR is a loop-free, source based, on demand routing protocol. This protocol is source-initiated rather than hop-by-hop. This is particularly designed for use in multi hop wireless ad hoc networks of mobile nodes. Basically, DSR protocol does not need any existing network infrastructure or administration and this allows the network to be completely self-organizing and self-configuring.

This protocol is composed of two essential parts of route discovery and route maintenance. Every node maintains a cache to store recently discovered paths. When a node desires to send a packet to some node, it first checks its entry in the cache. If it is there, then it uses that path to transmit the packet and also attach its source address on the packet. If it is not there in the cache or the entry in cache is expired, the sender broadcasts a route request packet to all of its neighbors asking for a path to the destination. The sender will be waiting till the route is discovered. During waiting time, the sender can perform other tasks such as sending/forwarding other packets. As the route request packet arrives to any of the nodes, they check from their neighbor or from their caches whether the destination asked is known or unknown. If route information is known, they send back a route reply packet to the destination otherwise they broadcast the same route request packet. When the route is discovered, the required packets will be transmitted by the sender on the discovered route. Also an entry in the cache will be inserted for the future use. The node will also maintain the age information of the entry so as to know whether the cache is fresh or not. When a data packet is received by any intermediate node, it first checks whether the packet is meant for itself or not. If it is meant for itself, the packet is received otherwise the same will be forwarded using the path attached on the data packet. Since in Ad hoc network, any link might fail anytime. Therefore, route maintenance process will constantly monitors and will also notify the nodes if there is any failure in the path. Consequently, the nodes will change the entries of their route cache.

Advantages of DSR

One of the main benefits of DSR protocol is that there is no need to keep routing table so as to route a given data packet as the entire route is contained in the packet header.

Limitations of DSR

The limitations of DSR protocol is that, it is not scalable to large networks and even requires significantly more processing resources than most other protocols. Basically, in order to obtain the routing information, each node must spend lot of time to process any control data it receives, even if it is not the intended recipient.

Energy Dependent DSR

EDDSR is energy dependent DSR algorithm which helps node from sharp and sudden drop of battery power. EDDSR provides better power utilization compare to LEAR (least energy aware routing) and MDR (minimum drain rate). EDDSR avoids use of node with less power supply and residual energy information of node is useful in discovery of route. Residual battery power of each node is computed by itself and if it is above the specific threshold value then node can participate in routing activities otherwise node delays the rebroadcasting of route request message by a time period which is inversely proportional to its predicted lifetime. EDDSR has further advantage over MDR because it can use route cache used by DSR.

AODV (Ad hoc On Demand Distance Vector Protocol)

Ad hoc On Demand Distance Vector AODV [8] is a variation of Destination-Sequenced Distance-Vector (DSDV) routing protocol which is collectively based on DSDV and DSR. It aims to minimize the requirement of system-wide broadcasts to the greater extent. It does not maintain routes from every node to every other node in the network rather they are discovered as and when needed and are maintained only as long as they are required. The key steps used by AODV for establishment of uncast routes are Route discovery and Route maintenance.

Route Discovery

When a node wants to send a data packet to a destination node, the entries in route table are checked to ensure whether there is a current route to that destination node or not. If it is there, the data packet is forwarded to the appropriate next hop toward the destination. If it is not there, the route discovery process is initiated. AODV initiates a route discovery process using Route Request (RREQ) and Route Reply (RREP). The source node will create a RREQ packet containing its IP address, its current sequence number, the destination's IP address, the destination's last sequence number and broadcast ID. The broadcast ID is incremented each time the source node initiates RREQ. Basically, the sequence numbers are used to determine the timeliness of each data packet and the broadcast ID & the IP address together form a unique identifier for RREQ so as to uniquely identify each request. The requests are sent using RREQ message and the information in connection with creation of a route is sent back in RREP message. The source node broadcasts the RREQ packet to its neighbors and then sets a timer to wait for a reply. To process the RREQ, the node sets up a reverse route entry for the source node in its route table. This helps to know how to forward a RREP to the source. Basically a lifetime is associated with the reverse route entry and if this entry is not used within this lifetime, the route information is deleted. If the RREQ is lost during transmission, the source node is allowed to broadcast again using route discovery mechanism.

Route maintenance

As long as the route remains active, it will continue to be maintained. A route is considered active as long as there are data packets periodically travelling from the source to the destination along that path. Once the source stops sending data packets, the links will time out and eventually be deleted from the intermediate node routing tables. If a link break occurs while the route is active, the node upstream of the break propagates a route error (RERR) message to the source node to inform it of the now unreachable destination(s). After receiving the RERR, if the source node still desires the route, it can reinitiate route discovery.

Advantages of AODV

The benefits of AODV protocol are that it favors the least congested route instead of the shortest route and it also supports both unicast and multicast packet transmissions even for nodes in constant movement. It also responds very quickly to the topological changes that affects the active routes. AODV does not put any additional overheads on data packets as it does not make use of source routing.

Limitations of AODV

The limitation of AODV protocol is that it expects/requires that the nodes in the broadcast medium can detect each others' broadcasts. It is also possible that a valid route is expired and the determination of a reasonable expiry time is difficult. The reason behind this is that the nodes are mobile and their sending rates may differ widely and can change dynamically from node to node. In addition, as the size of network grows, various performance metrics begin decreasing. AODV is vulnerable to various kinds of attacks as it based on the assumption that all nodes must cooperate and without their cooperation no route can be established.

Energy saving by transmission power

It is observed from this survey that high transmission power on a link may improve the quality, throughput on that link and increase the levels of interference on other links. A decrease in the transmission power can have the opposite effects practically from experimental data, identify three interference scenarios:

a) The overlapping case where aggregate throughput is achievable with two overlapping links. Aggregate throughput is not affected by power control.

b) The hidden terminal case, where proper power control can primarily improve fairness.

c) The potentially disjoint case, where proper power control can enable simultaneous transmissions and thus improve throughput.

Quality of signal transmission is also maintained by power control in a network. In the overlapping case, power control does not increase the maximum achievable throughput. In the hidden terminal case, power control improves the throughput.

Energy saving by transmission range

It is observed from survey that radio transmission range as a system parameter affects the energy consumption economy of wireless ad-hoc networks. On the one hand, a large transmission range increases the expected progress of a data packet toward its final destination at the expense of a higher energy consumption per transmission. On the other hand, a short transmission range consumes less per transmission energy, but requires a larger number of hops for a data packet to reach its destination.

Conclusion

In this paper, literature survey carried out the study, which need to be addressed in an attempt to promote energy consumption control for wireless mobile ad-hoc network. We have studied current energy saving techniques used at different levels. Energy saving at routing protocols level is much easier as compared to energy saving at mobile nodes. Each of these techniques saves some energy of mobile device and if we use these different techniques in a combined in a manner it saves lot of energy and increase the lifetime of network.

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