A REVIEW ON POWER AWARE ROUTING TECHNIQUE IN MOBILE AD HOC NETWORK LAYERS

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Abstract: A mobile Ad-hoc network (MANET) is a collection of wireless nodes that forms a network without central administration. The nodes in such kind of network serve as routers as well as hosts. The nodes can forward packets on behalf of other nodes and run user applications. These devices are operated on battery which provides limited working capacity to the mobile nodes. These batteries have a lifetime of a few hours of active workload and about 1-2 days of idle time. Power failure and the energy consumption of the nodes is a critical factor in the operation of a mobile ad hoc network. Power consumption can be optimized by disks, memory chips, CPU scheduling, applications and communication techniques. In this paper we try to review of existing research in power efficient routing technique for ad hoc networks.

Keywords: Ad Hoc Networks, Power aware protocols, network layers, routing protocols

I. INTRODUCTION

Mobile ad-hoc network is a group of wireless mobile nodes that forms a provisional network without any centralized administration. In MANET the communication between the mobile nodes is done via multi-hop paths. It may be necessary for one node to enroll other nodes forwarding a packet to its destination due to the limited transmission range of wireless network interfaces. Each mobile node operates as a host as well as a router forwarding packets for other mobile nodes in the network which may not be within the direct transmission range of each other. Each node participates in route discovery and in an ad-hoc routing protocol which allows it to determine multi-hop paths through the network to any other node. This idea of mobile ad-hoc network is also called infrastructure less networking, since the mobile nodes in the network dynamically establish routing among themselves to form their own network. Nodes operate in shared wireless medium [1]. Network topology changes unpredictably and very dynamically. Radio link reliability is an issue. Connection breaks are very frequent. Furthermore, parameters like density of nodes, number of nodes and mobility of these hosts may vary in different applications. There is no stationary infrastructure. Since there is no stationary infrastructure there is are some factor which become a critical for the communication. The main critical factor in Mobile Ad hoc network is power consumption. Due to this there delay during the data packet delivery and decrease the network lifetime. There are some many protocols for overcoming this problem. Routing in MANET is challenging due to node mobility, limitations for transmission bandwidth, battery power, and CPU time [2]. In MANET nodes cooperate in routing the packets to destination. Each node in the network communicates only with those nodes that are located within its communication range. The distance between source and destination may be at multiple hopes. Death of few or even single node due to energy exhaust will cause the breakdown in communication of entire network. While taking accumulated energy we will check the status of each node and it can be estimated after transmitting the required level path will be discarded.

II.ROUTING PROTOCOLS

Network routing in MANETs can be classified into three classes, proactive, reactive, and hybrid. Routing schemes use control messages to learn the network topology. Most proactive routing schemes use link state or distance vector routing algorithms.

a) Reactive Routing Protocols

Reactive routing is an on-demand routing scheme. Nodes learn about the network topology on an as-needed basis. Two of the better known reactive ad hoc routing protocols are Dynamic Source Routing (DSR) [3] and Ad hoc On-demand Distance Vector (AODV) [4]. Reactive routing protocols are characterized by two phases, the route discovery phase and the route maintenance phase. In the route discovery phase, nodes build their routing tables on demand. The sending node sends a route request for a packet in its sending queue for which it has no route information to the destination or whenever a node receives a packet not destined to it for which it has no route information to the destination. Nodes send route inquiries to neighbors and add an entry to a list of previously discovered routes.

b) Proactive Routing Protocols

In proactive routing, nodes periodically monitor the network for changes in network topology. Therefore, every node in the network keeps an up-to-date copy of current network topology information by periodically broadcasting and receiving control packets. For instance, when a node receives a packet destined to another node, it knows how and where to forward the packet for final delivery of the packet. This relatively detailed information about the topology helps to improve the routing performance. However, this improvement in routing may come at a cost of increased overhead and a decrease in network capacity for data. Several proactive routing exist for MANETs. Two commonly referenced ones are Optimized Link State Routing (OLSR) [5] and Destination Sequenced Distance Vector Routing (DSDV) [6].

c) Link State Protocol

In a link state protocol, each node keeps track of the changes that the network undergoes by keeping a map that reflects the state of all links in the network. Nodes use flooding, perhaps with some optimizations, to broadcast the link costs of their outgoing links to all neighboring nodes [6]. By exchanging link state, nodes learn the topology of the network. Each node creates a link-state packet that contains its identifier (ID), a list of its directly connected neighbors along with its cost to each one of them, a sequence number, and a time-to-live (TTL) value for the packet. These packets are broadcast whenever the TTL period expires or when the network topology changes. Link state routing is divided into two steps, flooding the network with link state information and the computation of routes based on link-state information [6][7].

d) Distance Vector Protocols

Distance vector protocols are based on the assumption that each node knows the distance (cost) to its immediate neighbors [6][7]. Thus, in distance vector protocols, all nodes create a list of distances to their immediate neighbors and distribute this list to their immediate neighbors. Initially, each node assigns a cost of one to each of its immediate neighbors and a cost of infinity to other nodes. Afterwards, the nodes exchange these lists with all of their immediate neighbors and start to replace the large costs with lower ones based on the received lists.

e) Hybrid Routing Protocols

Hybrid routing protocols combine the use of reactive and proactive routing protocols to obtain a better balance between the dynamic nature of MANETs and the routing overhead and to reduce the average end-to-end delay [5]. These protocols usually introduce a hierarchical structure to the MANET to reduce the number of control packet retransmissions during route discovery [6]. In hybrid routing protocols, each node maintains a set of nearby neighbors with which it will use a proactive routing scheme and a set of more distant nodes with which it will use a reactive routing scheme. The use of different routing strategies at different times at different locations is used in routing protocols such as the Zone Routing Protocol (ZRP) [7].

III. POWER CONSERVATION TECHNIQUES IN AD HOC NETWORKS LAYERS

Ad hoc network schemes can be categorized into physical, link (MAC), network, transport and application layer approaches or a mix of these approaches. Some of these schemes are adaptive, others are non-adaptive.

Some of the proposed energy conserving approaches includes:

- Turning off the network interface card (NIC) when the node is not actively engaged in Communication.
- Adjusting the power level according to the packet size.
- Partitioning the network into different clusters and allowing each cluster to use a different spreading code.
- Using transmission scheduling and slot reservation instead of contention-based schemes
- Using adaptive transmission strategies instead of persistent ones.

In multi-hop ad hoc networks, a large amount of energy may be wasted in listening by non-intended receivers. Since a lot of mobile devices are battery powered, this energy waste exacerbates the energy problem. Consequently, a lot of research has been conducted to improve the energy capacity of batteries and to reduce power consumption. From a computer engineering standpoint, reducing energy consumption helps prolong the network life, which increases communications time as opposed to reducing interference and solving the near-far problem as in code-division multiple access (CDMA) based systems [8].

a) Physical Layer

Techniques used in energy minimization at the physical layer include miniaturizing circuit components, using efficient channel coding techniques, and improving amplifier characteristics of radio frequency (RF) circuits. Communication, in general, requires a lot of processing and processing consumes energy. Therefore, protocols designed to minimize energy must achieve a balance between the opposing goals of error-free communication and energy minimization.

Lahriri, *et al.* [9] describe a new battery-driven system-level power management scheme, communication-based power management (CBPM), that aims to improve battery efficiency. CBPM regulates the execution of the various system components. System components are of two categories, bus masters and slaves. Bus masters are components that are capable of initiating a communication transaction such as central processing units and digital signal processors. Slaves, on the other hand, are components that respond to transactions initiated by masters such as memories. This scheme may delay the execution of some system components and adapt the current discharge of the system to suite the battery_s characteristics.

b) Medium Access Control(MAC)Layer

A comparison of power-saving techniques at the MAC layer in IEEE 802.11 and ETSI HIPERLAN is presented by **Woesner, *et al.*** [10]. In ad hoc networks, collisions and packet retransmissions deplete battery power unnecessarily. Therefore, it is highly recommended to avoid packet retransmissions as much as possible. Mobility is an inherent characteristic of ad hoc networks. As mobility increases, collisions increase and, hence, packet retransmissions increase. A transceiver going from the receive state to the transmit state consumes energy. As a result, protocols that use slot assignments as a scheduling mechanism suffer a large overhead. Thus, to reduce the turnaround time, i.e., the time it takes to transition from a receive state to a transmit state and *vice versa*, and minimize energy, it is preferable to reserve several contiguous slots when transmitting or receiving. Another solution in minimizing power consumption at the physical layer is to turn off the transmit/receive radio when the node does not anticipate any communication with other nodes.

Sivalingam, *et al*. [11] propose a reservation based scheduling approach in which nodes broadcast their transmission time schedules so that they can go into standby mode and switch back to active mode when their transmit time comes. The Energy Conserving Medium Access Control (EC-MAC) protocol [11] was developed with an energy conservation goal in mind. It was developed for an infrastructure based wireless network where a single workstation serves mobile nodes within its coverage area. The authors argue that this protocol can be extended to an ad hoc network by allowing the mobiles to elect a coordinator to perform the base station functions. Others have also devised new MAC protocols that take into account energy constraints .Careful reservation and scheduling of packets help to enhance the performance of the protocol and reduce collisions. This avoids retransmissions and, hence, reduces power consumption.

El Gamal, *et al.* [12] use an algorithm, Move Right, to solve a convex problem based on the idea that, in many channel coding schemes, lowering transmission power and increasing the duration of transmission leads to a significant reduction in transmission energy. The Power Aware Multi-Access (PAMAS) protocol modifies the Multiple Access with Collision Avoidance protocol (MACA) described by Karn [13]. PAMAS is based on the premise that by allowing separate channels for control and data packets, nodes know when and for how long to turn off their transceivers. Simulation results from the study show that a power savings of up to 70 percent can be achieved for a fully connected network [13].

c) Techniques at the Link layer

Avoiding and delaying transmissions when channel conditions are poor improve energy minimization. **Rao, Zorzi and Ramesh** [14] found that by improving currently used error control schemes to cater to limited energy devices produces favorable results. Therefore, persistence is not preferable when energy is a constraint. Due to the dynamic nature of wireless links, error rates due to fading, attenuation and interference are highly variable. As stated by **Zorzi, *et al.*** [14], error control schemes such as automatic repeat request (ARQ) and forward error correction (FEC) waste network bandwidth and consume energy. When using these techniques in wireless environments, care should be taken so that packet retransmission and error correction do not overwhelm the wireless channel.

Lettieri, *et al.* [15] describe an adaptive error control architecture that incorporates adaptive error control with forward error correction. This scheme changes the error control scheme according to the stream_s channel conditions over time. In wireless networks, channel conditions along with traffic characteristics dictate the type of error control scheme used.

Agrawal, *et al.* [16] study the effect of dynamic power control and forward error correction on power consumption. In their study, each node determines the minimal power and forward error correction required that satisfy a quality of service (QOS) constraint. In their technique, the signal is encoded twice with different transmission powers acting as boundaries for the upper and lower bound of transmission power.

d) Network Layer

In wireless networks routing can be either through a base station or access point, as in the case of infrastructure wireless networks, or through the mobile nodes involved in the network, as in the case of ad hoc networks. Routing in wireless networks must take into account node mobility and route management and, when energy-efficient routing is required, routing through nodes with ample energy is preferable when extending network life is the goal. Several schemes have been devised to minimize power usage.

Singh, *et al.* [17] use power- ware metrics for route discovery in addition to using PAMAS as a MAC protocol for their study. They report an energy improvement of 40 percent to 70 percent. The algorithm they use is based on lowest-cost, rather than shortest-hop, routing.

Chang and Tassiulas [18] propose a routing algorithm that maximizes the battery life leading to a maximization of the network lifetime. It maximizes the network lifetime by balancing routing and energy consumption among nodes according to the battery's energy reserves. Another scheme is to use heuristics to adaptively adjust the transmit power whenever a topology change occurs, keeping in mind the connectivity of the network.

Banerjee and Misra [19] developed a transmission power adaptive algorithm that finds the minimum energy routing path. The authors also use analytical methods to find the optimum transmission energy on each individual path in a multi-hop wireless network. In good channel conditions, more energy can be saved. Good channel conditions, generally, imply that packets reach their destinations error free. This leads to fewer retransmissions and ultimately, to increased network life.

Spyropoulos and Raghavendra [20] propose an energy-efficient routing and scheduling algorithm for use in nodes equipped with directional antennas. The authors argue that using omni-directional antennas leads to a large waste in energy since power is broadcast in all directions. Directional antennas can direct power toward the intended node.

Wieselthier, *et al.* [21] propose a similar approach, but for connection-oriented multicast traffic. The authors argue that the network life can be extended by incorporating the nodes_ residual energy into the cost function and equipping the nodes with directional antennas.

Feeney [22] has carried out simulations and experimental measurements of energy consumption on a per-packet basis for a Lucent WaveLan 2.4 GHz DSSS IEEE 802.11 wireless network interface card for two ad hoc routing protocols, DSR and AODV. The study measured the energy cost incurred at nodes that are in receiving range but are not destination nodes. The results indicate that the number of packets has a greater impact on energy consumption than packet size and that the power consumption cost of idle mode is high. Routing in wired networks relies on shortest paths and smallest delay. In wireless networks, the metrics differ since power limitation is a problem in mobile ad hoc networks. In this case routing through the closest node could hasten the death of that node. Therefore, other measures should be taken to alleviate this problem.

Singh, *et al.* [17] define five metrics for studying the performance of power-aware routing for unicast traffic: energy consumed per packet, time to network partition, maximum node cost, variance in power levels across nodes, and cost per packet. They study the effects of these metrics on end-to-end delay. Their results show that by using power-aware metrics instead of a shortest-hop metric, no extra delay is incurred.

Routing in MANETs requires the knowledge of node locations and the links between these nodes. This leads to higher communication overhead.

Stojmenovic and Lin [23] propose a loop-free localized routing algorithm. In this localized cost and power-cost routing algorithm, additional nodes are placed between the source and destination to make the transmission power linear. Thus, transmission power is in terms of d instead of $d\alpha$, where d is the distance between source and destination nodes and α is the propagation constant, where $\alpha \geq 2$. In localized power routing, nodes make decisions based on location, determined with Global Positioning System (GPS) devices, and distance from source to destination. For broadcast traffic, where intermediate nodes are required to retransmit the packet, ***Singh, et al.*** [24] show that channel allotment to nodes is important for power-efficient broadcast protocols. They also suggest that it is beneficial to spend some energy to gather topology information to determine the most energy-efficient broadcast tree.

Singh and Raghavendra [24] present a broadcast tree approach to share the cost of routing among all nodes in the system. In this case, a cost is associated with each node based on how much power the node has consumed. Priority in routing is given to nodes that have consumed lower amounts of power and nodes that have more neighbors. The study assumes that all nodes have only broadcast traffic. Packets from the same source may traverse different trees as the network topology changes.

Wieselthier, et al. [25], combine routing decisions with transmission power levels. They describe an algorithm for determining a source-initiated minimum-energy tree for broadcast or multicast session requests. Their results show that the exploitation of routing and transmission power decisions provides greater energy savings than algorithms that are developed for link-based, wired networks.

Feeney [22] compared the Dynamic Source Routing (DSR) protocol and the Ad Hoc on Demand Distance Vector (AODV) routing protocol in terms of their energy consumption. The study takes into account the cost of sending and receiving packets, routing overhead and dropped packets. The study indicates that there is considerable energy being wasted on flooding the network with data packets and MAC control packets. In addition, receiving and discarding packets consumes a substantial amount of power. The study also indicates that the cost of source routing headers in DSR is not significant, but operating the radio in promiscuous mode for routing and caching of routes wastes energy. The study also indicates that the generation of broadcast traffic in AODV results in high energy consumption.

d) Techniques at the Transport Layer

Several studies have been conducted to look at energy minimization at the transport layer. While TCP works well in wired networks, using the same version of TCP for wireless links can lead to inefficiencies in terms of performance and energy use. The characteristics of wireless links are inherently different than wired ones. Therefore, applying standard TCP to wireless links, without modification, may not provide good performance for wireless networks.

Several schemes have been proposed to reduce the effects of TCP retransmissions due to factors other than congestion. These schemes have been classified by **Jones, *et al.*** [26] into three groups: split connection protocols, link-layer protocols, and end-to-end protocols. The studies of **Gitlin *et al.*[15],** show that these schemes provide better performance than standard TCP due to their adaptability to the dynamic nature of wireless links. **Tsaoussidis, *et al.*[28**] studied the energy versus throughput performance tradeoffs for different TCP variations. Their findings indicate that balancing energy consumption and throughput can be accomplished through the error control mechanism. ***Kravets and Krishnan*** [29] have designed and implemented a protocol that selectively chooses short periods of time to suspend communication and shut down the transceiver. The algorithm handles the queuing and management of packets during this period.

e) Techniques at the Middleware and Application Layers

In an energy efficient system design, it is crucial to have the operating system and the applications that run on top of the operating system support the underlying power management mechanisms. Recent operating systems have incorporated the Advanced Configuration Power Interface (ACPI) standard that can power down devices that have not been used for a certain period of time or even shut down the entire system after a certain period of inactivity. Integrating power efficient features specific to wireless networks will certainly help increase the life of the network.

Other Evaluation Techniques and Methods

To test and evaluate the benefits and drawbacks of a scheme or an algorithm, an evaluation technique is needed. Evaluation techniques can be divided into three categories: simulation based, experimental, and analytical. Some combination of more than one technique may also be used. From the reviewed literature on power saving in wireless networks, three evaluation techniques are noted. A significant number of the performance evaluation studies are simulation based, followed by the mixed approach.

Singh, *et al.* [30] simulated a fixed network of 10 to 20 nodes and presented five power aware metrics that are different from the usual routing metrics such as shortest-path and link quality. The new metrics outlined in their paper are energy consumed per packet, time to network partition, variance in node power level, cost per packet, and maximum node cost. In their simulations, Singh, *et al.* studied the effects of these metrics on end-to-end packet delay. The performance of shortest-path routing was compared with that of least-cost routing. The simulations yielded significant reductions in energy cost by using shortest-cost routing as opposed to shortest-hop routing.

In **Bergamo, *et al.*** [31], the transmit power is used as the link cost function. Nodes need to store transmit power, *Ptx*, and estimate the receive power, *Prx*, and estimate link attenuation by subtracting (in dB) the transmit power and received power. Bergamo, *et al.* [31] also simulate Dijkstra and link state algorithms using a simple ad hoc simulator (SAM) that integrates all traffic features, terminal mobility, channel behavior, medium access schemes, and routing protocols. Several simulation parameters were used in the study, including the minimum power necessary to correctly receive a packet before de-spreading. In addition, the parameter α is set to 2.5. The α parameter characterizes the path power loss, i.e. the further the signal travels the more the loss in signal power ($d\alpha$), where d is the distance the signal has traveled.

Bergamo, *et al.* [31] found their distributed power control scheme achieves reduction in energy consumption while keeping the performance similar to that of the classic Dijkstra and Link State routing algorithms.

CONCLUSION

In this paper , we have discussed many techniques used in power-aware or power efficient routing protocols rely mainly on either dynamically changing the transmission power as a means to reduce energy expended in the network or route according to battery energy reserve of the nodes and, thus, prolong network life. In multiple-hop networks, exploiting transmission power or battery energy reserve as the sole means to save energy hastens the "death" of relay nodes that forward packets between a sender and a receiver. Such schemes also lead to uneven variation in the energy resources at different nodes.

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