SURVEY OF ENERGY EFFICIENT ROUTING PROTOCOLS IN MANET

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ABSTRACT

Mobile ad hoc networks (MANET) represent distributed systems that consist of wireless mobile nodes that can freely and dynamically organize itself into temporary ad hoc network topologies. A mobile ad hoc network is a collection of nodes that is connected through a wireless medium forming rapidly changing topologies. MANETS are infrastructure less and can be set up anytime, anywhere. I have conducted survey of simulation results of various MANET routing algorithms and analyzed them. The design of efficient routing protocols is a fundamental problem in a Mobile Ad-Hoc Network (MANET). Many different protocols have been proposed in the literature, each one based on different characteristics and properties. Some of these protocols have been studied and their performance have been evaluated in detail focusing on aspects like routing overhead, latency and route length. In this Project we concentrate on the energy consumption issues of the routing protocols. we will measure and compare the energy consumption behaviour of four routing protocols; Ad hoc On Demand Distance Vector (AODV) , the Dynamic Source Routing (DSR) , the Temporally Ordered Routing Algorithm (TORA) and the Destination Sequenced Distance Vector Routing (DSDV) with respect to energy consumption . Evaluating how the different approaches and algorithms affect the energy usage in the mobile devices.

Key words: MANET, Routing, AODV, DSDV, DSR, TORA

Introduction

A Mobile Ad Hoc Network (MANET) is a collection of wireless mobile nodes forming a temporary/short-lived network without any fixed infrastructure where all nodes are free to move about arbitrarily and where all the nodes configure themselves. In MANET, each node acts both as a router and as a host & even the topology of network may also change rapidly. These types of networks assume existence of no fixed infrastructure [1]. They are often useful in battle-field tactical operations or emergency search-and-rescue type of operations where fixed infrastructure is neither feasible nor practical . Mobile Ad hoc Networks (MANETs) have been an active field of research for the last few years. Fig1 shows simple example of MANET in which laptops communicate to each other and with mobile phones with out any acess point.

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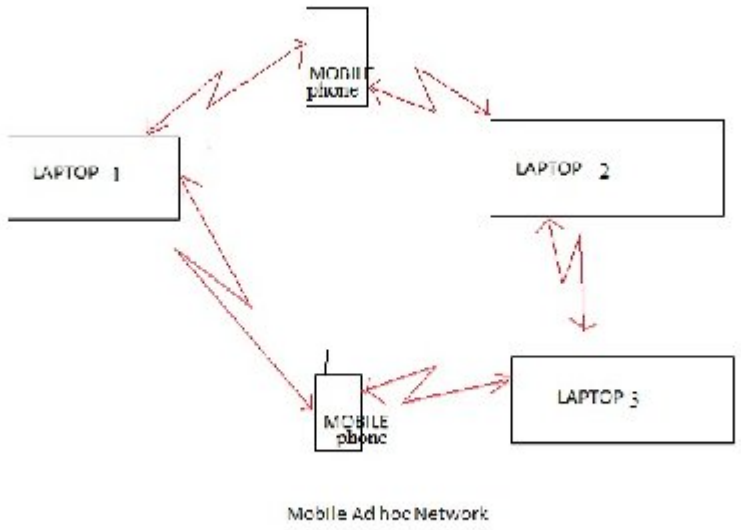

Fig. 01: Mobile ad hoc network example

The major characteristics of an mobile ad hoc network are :

- **Mobility:** Mobility can be individual node or group mobility involving random or pre-planned routes. Mobility affects routing and network performance since the network must re-learn node locations after movement.
- **Multi-hopping:** Data can traverse several nodes prior to reaching its destination and must account for obstacle negotiation, spectrum re-use and energy conservation.
- **Self-Organizing:** Ad hoc networks autonomously determine configuration parameters and topology.
- **Energy Conservation:** Nodes rely on limited battery power and usually can not generate power.
- **Scalability:** As the number of nodes in an ad hoc network increase, the complexity of routing and configuration management also increases.
- **Security:** Ad hoc networks are vulnerable to eavesdropping since transmissions occur in free space.

A MANET is a collection of mobile nodes that communicate without the assistance of a support infrastructure. This characteristic is desirable in various situations such as during natural disasters and in military environments where deploying an infrastructure can be expensive or infeasible.

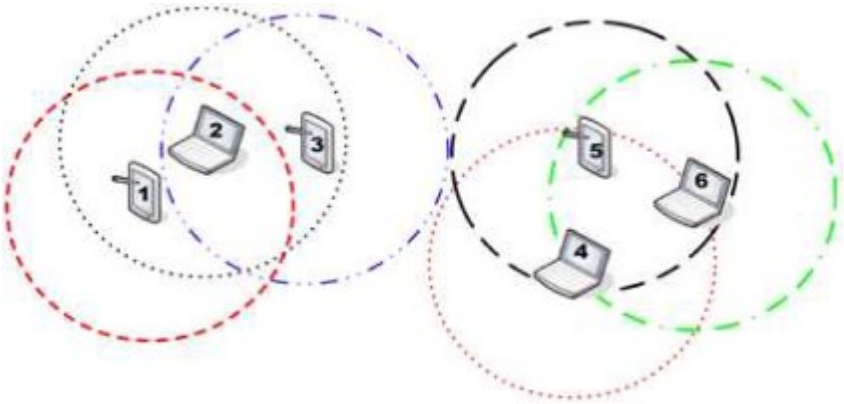

Figure 02: Ad Hoc Network with Six Nodes

Figure 2 shows an ad hoc network with six nodes outfitted with omni-directional antennas. Each node can send and receive data within its transmission range (each node is centered in its transmission range circle). If more than one node is in a circle, then communication can occur between the encircled nodes. Node 1 can communicate with node 2 since they are in the same circle (i.e., their transmission ranges overlap).Node 3, however, can only communicate with node 1 only if node 2 forwards the packets. Since none of the transmission ranges of nodes 1, 2, or 3 overlap with any of the transmission ranges of nodes 4, 5, or 6, there is no way for nodes 1, 2, or 3 to communicate with nodes 4, 5, or 6

Ad Hoc Routing Protocols: Routing in an ad hoc network is different than routing in an infrastructure-based network, because ad hoc networks have characteristics not found in infrastructure based networks such as multi-hop routing. A routing protocol can be evaluated using the following metrics

End-to-end Data Throughput and Delay: Throughput and delay are measured from the perspective of applications that use the routing. Throughput and delay measure a routing policy's effectiveness and are important when dealing with Constant Bit Rate (CBR) applications such as real-time audio or video.

Route Acquisition Time: This is the time required to establish route(s) when requested and is affected by the type of routing protocol.

Efficiency: This is the internal measure of the routing protocol's effectiveness and can be measured as either overhead or throughput versus input traffic. Figure 3 shows the routing protocols for ad hoc networks. The routing protocols for MANETs can be classified into two main types – proactive and reactive. Proactive, or table-driven routing protocols, maintain valid routes from each node to every other node in the network by establishing routes before data packets are sent across the network[2]. Periodic updates are flooded throughout the network to report link and topology changes.

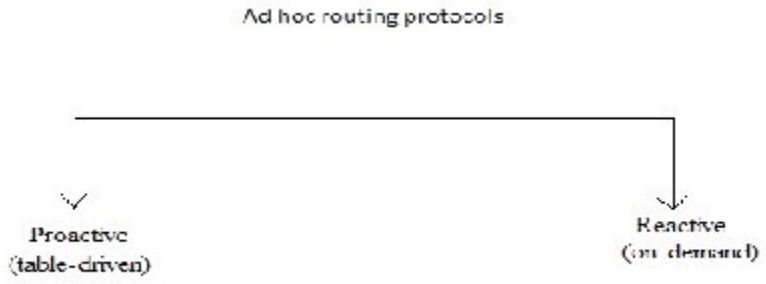

Figure 03: Classification of Ad Hoc Routing Protocols

Reactive are also called as on demand routing protocols where the routes are not predefined for routing [2]. This increases end-to-end delay compared to proactive routing protocols since routes are calculated when data packets are ready to be sent. However, periodic updates are not required as in proactive routing. Ad hoc On-Demand Distance Vector (AODV) is a reactive routing protocol.

DSDV Routing Protocol

Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing scheme for ad hoc mobile networks based on the Bellman-Ford algorithm . It was developed by C. Perkins and P. Bhagwat in 1994. The main contribution of the algorithm was to solve the routing loop problem which was found when using DV protocol. Each entry in the routing table contains a sequence number, the sequence numbers are generally even if a link is present; else, an odd number is used[10]. The number is generated by the destination, and the emitter needs to send out the next update with this number. Routing information is distributed between nodes by sending full dumps infrequently and smaller incremental updates more frequently.

DSR Protocol

Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks and was developed at Carnegie Mellon University [11]. It is similar to AODV in that it forms a route on-demand when a transmitting computer requests one. However, it uses source routing instead of relying on the routing table at each intermediate device. Determining source routes requires accumulating the address of each device between the source and destination during route discovery. The accumulated path information is cached by nodes processing the route discovery packets. The learned paths are used to route packets. To accomplish source routing, the routed packets contain the address of each device the packet will traverse. This may result in high overhead for long paths or large addresses, like IPv6. To avoid using source routing, DSR optionally defines a flow id option that allows packets to be forwarded on a hop-by-hop basis. This protocol is truly based on source routing whereby all the routing information is maintained (continually updated) at mobile nodes. It has only two major phases, which are Route Discovery and Route Maintenance. Route Reply would only be generated if the message has reached the intended destination node (route record which is initially contained in Route Request would be inserted into the Route Reply).To return the Route Reply, the destination node must have a route to the source node. If the route is in the Destination Node's route cache, the route would be used. Otherwise, the node will reverse the route based on the route record in the Route Request message header (this requires that all links are symmetric). In the event of fatal transmission, the Route Maintenance Phase is initiated whereby the Route Error packets are generated at a node. The erroneous hop will be removed from the node's route cache; all routes containing the hop are truncated at that point. Again, the Route Discovery Phase is initiated to determine the most viable route. Dynamic source routing protocol (DSR) is an on-demand protocol designed to restrict the bandwidth consumed by control packets in ad hoc wireless networks by eliminating the periodic table-update messages required in the table-driven approach.

AODV Routing Protocol

An Ad Hoc On-Demand Distance Vector (AODV) is a routing protocol designed for wireless and mobile ad hoc networks. This protocol establishes routes to destinations on demand and supports both unicast and multicast routing [11]. The AODV protocol was jointly developed by Nokia Research Center, the University of California, Santa Barbara and the University of Cincinnati in 1991.

The AODV protocol builds routes between nodes only if they are requested by source nodes. AODV is therefore considered an on-demand algorithm and does not create any extra traffic for communication along links. The routes are maintained as long as they are required by the sources. They also form trees to connect multicast group members. AODV makes use of sequence numbers to ensure route freshness. They are self-starting and loop-free besides scaling to numerous mobile nodes.

In AODV, networks are silent until connections are established. Network nodes that need connections broadcast a request for connection. The remaining AODV nodes forward the message and record the node that requested a connection. Thus, they create a series of temporary routes back to the requesting node.

A node that receives such messages and holds a route to a desired node sends a backward message through temporary routes to the requesting node. The node that initiated the request uses the route containing the least number of hops through other nodes. The entries that are not used in routing tables are recycled after some time. If a link fails, the routing error is passed back to the transmitting node and the process is repeated.

TORA Routing Protocol

The Temporally-Ordered Routing Algorithm (TORA) is an algorithm for routing data across Wireless Mesh Networks or Mobile ad-hoc networks. TORA : Temporally Ordered Routing Algorithm . Invented by Vincent Park and M.Scott Corsonfrom University of Maryland. TORA is an on-demand routing protocol. The main objective of TORA is to limit control message propagation in the highly dynamic mobile computing environment.Each node has to explicitly initiate a query when it needs to send data to a particular destination. TORA essentially performs three tasks[11]:(a) Creation of a route from a source to a destination.(b)Maintenance of the route.(c)Erasure of the route when the route is no longer valid.TORA uses three kinds of messages:(a) The QRY message for creating a route.(b) The UPD message for both creating and maintaining routes.(c) The CLR message for erasing a route. TORA attempts to build what is known as a directed acyclic graph (DAG) which is rooted at the destination.

Energy Efficiency

For a wireless networks, the devices operating on battery try to pursue the energy efficiency heuristically by reducing the energy they consumed, while maintaining acceptable performance of certain tasks. Using the power consumption is not only a single criterion for deciding energy efficiency. Actually, energy efficiency can be measured by the duration of the time over which the network can maintain a certain performance level, which is usually called as the network lifetime. Hence routing to maximize the lifetime of the network is different from minimum energy routing. Minimum energy routes sometimes attract more flows, and the nodes in these routes exhaust their energy very soon; hence the whole network cannot perform any task due to the failure on these nodes.

In other words, the energy consumed is balanced consumed among nodes in the networks. Routing with maximum lifetime balances all the routes and nodes globally so that the network maintains certain performance level for a longer time. Hence, energy efficiency is not only measured by the power consumption but in more general it can be measured by the duration of time over which the network can maintain a certain performance level. It goes without saying that node failure is very possible in the wireless network. Hence saving energy when broadcasting in order to recover from the node failure or to re-routing around the failed nodes is essential. By the same token, multicast has the same challenge to

achieve the energy efficiency. For unicast, it is highly related to the node and link status, which best choice from the energy efficiency point of view.

Literature Review

In this section we present literature review in details for routing protocols in MANETs:

In reference [1], Bilal et al. provides an overview of different protocols by presenting their characteristics and functionality, and then provides a classification of these different routing protocols available for the transmission in ad hoc networks. In this article we provide descriptions of several routing schemes proposed for ad hoc wireless networks. We also provide a classification of these schemes according to the routing strategy. The presented classification model of routing protocols is a meaningful attempt to clarify the vast field of adhoc routing protocols. In reference [2], Dinesh Singh et al Comparative Analysis of Energy Efficient Routing Protocols in MANETS (Mobile Ad-hoc Networks) have conducted survey of simulation results of various MANET routing algorithms and analyzed them. The routing algorithms considered are classified into two categories proactive and reactive. The algorithms considered are AODV, DSR, and DSDV. The performance measurements are based on the various parameters such as packet delivery fraction, average end to end delay and number of packets dropped. In reference [3] k. arulanandam et al. In this paper, provides an overview of energy Efficiency issues in ad hoc networks . Energy models widely used in analyzing and devising ad hoc protocols were discussed. The sources of energy consumption that pertain to communications in ad hoc network were shown to exist in four main modes of operation: transmitting, receiving, idle and sleep modes. The sources of energy consumption overhead such as idle condition, collisions and protocol control messages have been discussed. The metrics used for energy-efficiency strategies have also been explored briefly. They presented a case study which sheds light on some of the energy inefficiency issues encountered in ad hoc networks. In reference [4] Khiavi et al. in this paper evaluates performance of four commonly used mobile ad hoc routing protocols namely AODV, DSDV, DSR and TORA. Performance evaluation did in NS-2 simulator by doing many simulations. Comparison was based on Packet Delivery Ratio, Network Life Time, End-to-End Delay and Routing Overhead. By using simulation results they showed that DSDV gives better performance in wide range of simulation conditions. In reference [8] Shivendu Dubey et al.in this work analyse the energy consumption in traffic models (CBR, Pareto and Exponential) and measured using routing protocols namely AODV, OLSR and AOMDV. Simulation and computation of energy consumed, received and transmitted energy were done with ns-2 simulator (2.34 version) with parameter variation: number of nodes, pause time, average speed and send rate.

Proposed Work (Main Theme)

The overall goal of this work is to measure and compare the energy consumption behaviour of the four analysed routing protocols; Ad hoc On Demand Distance Vector (AODV) , the Direct Source Routing (DSR) , the Temporally Ordered Routing Algorithm (TORA) and the Destination Sequenced Distance Vector Routing (DSDV) with respect to energy consumption .

Methodology

Our basic methodology consisted of first selecting the most representative parameters for a MANET, then defining and simulating a basic scenario and finally, by varying the selected parameters, simulate and evaluate more scenarios. The five selected parameters are: 1) the mobile nodes number, 2) the moving area dimensions, 3) the node's mobility pattern, 4) the number of actual traffic sources and 5) the data traffic pattern. In the simulation, nodes move according to a model called "random waypoint" . Motion

is characterised by two factors: (a) the maximum speed and (b) the pause time. During simulation each node starts moving from its initial position to a random target point, selected inside the simulation area. The motion speed value is uniformly distributed between 0 and the maximum speed. When a node reaches the target point, waits for the pause time and after that, by selecting another random target point, it moves again. According to this scheme, a pause time value equal to the simulation time corresponds to a static network, while a 0 seconds pause time corresponds to a continuously changing network. All the traffic sources used in our simulations generated constant bit rate (CBR) data traffic. The traffic structure was defined by varying two factors: (a) the sending rate and (b) the packets size.

Simulation Environment

NS-2 is a discrete event, object oriented, simulator developed by the VINT project research group at the University of California at Berkeley. The simulation study is done by using widely recognized and improved network simulator NS-2 version 2.34 for Mobile Ad-hoc Networks (MANETs). NS-2 is powerful for simulating ad-hoc networks. In NS-2 the user has to imagine of a scenario, the number of nodes to be placed in the scenario, and then write the TCL scripts (*.tcl* file) specifying the node configurations parameters and some other *ns* commands required to start and stop *ns*. Motivation for Simulations are:

i. Cheap: does not require costly equipment
ii. Complex scenarios can be easily tested
iii. Results can be quickly obtained: more ideas can be tested in a smaller timeframe
iv. The real thing isn't yet available
v. Controlled experimental conditions: Repeatability helps aid debugging

Simulators help in easy verification of protocols in less time, money. NS offers support for simulating a variety of protocol suites and scenarios. Front end is OTCL, back end is C++. NS is an ongoing effort of research and development

Energy Consumption Model

According to the specification of the NIC modelled, the energy consumption varies from 230mA in receiving mode to 330mA in transmitting mode, using a 3.3V or 5.0V energy supply. In this work we have are assuming an energy supply of 5V. These values correspond to a 2,400MHz WaveLAN implementation of IEEE 802.11. When a node sends or receives a packet, the network interface of the node, decrements the available energy according to the following parameters: (a) the specific NIC characteristics, (b) the size of the packets and (c) the used bandwidth. This energy is used for the propagation model in *ns-2* to determine the energy with which the neighbours interface nodes will receive the packet, and consequently determine the successful or wrong packet reception.

Parameter for Energy Model

Parameter	Value	Parameter	Value
Network Interface	WirelessPhy	Idle Power	Watt
MAC Type	802.11	Receiving Power	Watt
Channel	WirelessChannel	Transmission power	Watt
Propogation	TwoRayGround	Transition Power	Watt
Antenna	OmniAntenna	Sleep Power	Watt
Radio Frequency	Watt	Transition Time	Seconds
Initial Energy	Joules		

Conclusion

As we know that mobile nodes in MANET are battery powered and we need to increase their life by reducing energy consumption by choosing a routing protocol which is energy efficient. In this work we will try to know which protocol is energy efficient in different scenarios .In this work we have given overview of different routing protocols namely AODV ,DSDV,DSR and TORA . In future work we will measure and compare the energy consumption behaviour of the four analyzed routing protocols; Ad hoc On Demand Distance Vector (AODV) , the Direct Source Routing (DSR) , the Temporally Ordered Routing Algorithm (TORA) and the Destination Sequenced Distance Vector Routing (DSDV) with respect to energy consumption .

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