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Simulation of Internet Connectivity for Mobile Ad Hoc Networks in Network Simulator-2

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Abstract*— Ad Hoc networking allows portable devices to establish communication independent of a central infrastructure. The issue of routing in a mobile ad hoc network becomes a challenging task since the mobile nodes are free to move randomly. There are several ad hoc routing protocols, such as Ad hoc On-Demand Distance Vector (AODV), Dynamic Source Routing (DSR), Optimized Link State Routing (OLSR) and Zone Routing Protocol (ZRP), which propose solution for routing within a mobile ad hoc network. In this paper the ad hoc routing protocol AODV is used and modified to examine the interconnection between a mobile ad hoc network and the Internet, for this purpose Network Simulator 2 (NS-2) has been used. Moreover, three proposed approaches for gateway discovery are simulated.

Index Terms---**Ad Hoc Network, Internet, Network Simulator 2, Routing Protocols.**

I. INTRODUCTION

A mobile ad hoc network is a network formed and functioning without any established infrastructure or centralized administration and consists of mobile nodes that use a wireless interface to communicate with each other. The mobile nodes are able to communicate beyond their transmission range by supporting multihop communication. Ad Hoc routing protocols can be classified into three classes: proactive, reactive and hybrid routing protocols. In proactive routing the routing table of every node is updated periodically. On the contrary, reactive routing is performed on-demand, i.e. the sending node searches for a route to the destination node only when it needs to communicate with it. Hybrid routing uses a mixture of these two routing approaches. That is, proactive routing is used in a limited area around the mobile node and reactive routing is used outside this area [8].

II. MOBILE AD HOC NETWORKING PROTOCOL STACK

The protocol stack for mobile ad hoc networks is shown in Fig. 1. The protocol stack consists of five layers: physical layer, data link layer, network layer, transport layer and application layer. The MANET protocol stack is similar to the Transmission Control protocol / Internet protocol (TCP/IP) suite as shown. The main difference between these two protocols stacks lies in the network layer. Mobile nodes use an ad hoc routing protocol to route packets. In the physical and data link layers, mobile nodes run protocols that have been designed for wireless channels [7].

<table>
<tr><td colspan="2">APPLICATION</td></tr>
<tr><td colspan="2">TRANSPORT</td></tr>
<tr><td>NETWORK</td><td>AD HOC ROUTING</td></tr>
<tr><td colspan="2">DATA LINK</td></tr>
<tr><td colspan="2">PHYSICAL</td></tr>
</table>

Fig. 1: MANET Protocol Stack [7]

This paper focuses on ad hoc routing which is handled by the network layer. The network layer is divided into two parts: Network and Ad Hoc routing. The protocol used in the network part is internet protocol (IP) and the protocol used in the ad hoc routing part is Ad Hoc On-Demand Distance Vector (ADOV) [5], [7].

III. AD HOC ON-DEMAND DISTANCE VECTOR

ADOV is a distance vector routing protocol that is reactive [4]. The reactive property of the routing protocol implies that it only requests a route when it needs one and does not require that the mobile nodes maintain routes to destinations that are not communicating. ADOV guarantees loop-free routes by using sequence numbers that indicate how new, or fresh, a route is. ADOV requires each node to maintain a routing table containing one route entry for each destination that the node is communicating with. Each route entry keeps track of certain fields.

A. Route Discovery

Whenever a source node desires a route to a destination node for which it does not already have a route, it broadcasts a *route request* (RREQ) message to all its neighbors. The neighbors update their information for the source and create *reverse route entries* for the source node in their routing tables. A neighbor receiving a RREQ may send a *route reply* (RREP) if it is either the destination or it has an unexpired route to the destination. If any of these two cases is satisfied, the neighbor unicasts a RREP back to the source. Along the path back to the source, intermediate nodes that receive the RREP create *forward route entries* for the destination node in their routing tables. If none of the two cases mentioned is satisfied, the neighbor rebroadcasts the RREQ. When searching for a route to the destination node, the source node uses the expanding ring search technique to prevent unnecessary network – wide dissemination of RREQs. This is done by controlling the value of the time to live (TTL) field in the IP header. The first RREQ message sent by the source has TTL= TTL_START. The value of TTL defines the maximal number of hops a RREQ can move through the mobile ad hoc network.

B. Route Maintenance

When a link in a route breaks, the node upstream of the break invalidates all its routes that use the broken link. Then, the node broadcast a route error (RERR) message to its neighbors. The RERR message contains the IP address of each destination which has become unreachable due to link break. Upon reception of a RERR message, a node searches its routing table to see if it has any route(s) to the unreachable destination(s) (listed in the RERR message) which use the originator of the RERR as the next hop, if such routes exist, they are invalidated and the node broadcasts a new RERR message to its neighbors. This process continues until the source receives a RERR message.

IV. DYNAMIC SOURCE ROUTING

Dynamic Source Routing (DSR) is a reactive routing protocol that uses *source routing* to send packets [2]. It is reactive like AODV which means that it only requests a route when it needs one and does not require that the nodes maintain routes to destination that are not communicating. It uses routing which means that the source must know the complete hop sequence to the destination. Each node maintains a route cache, where all routes are stored. The route discovery process is initiated only if the desired route cannot be found in the route cache. To limit the number of route requests propagated, a node processes the route request message only if it has not already received the message and its address is not present in the route record of the message.

V. OPTIMIZED LINK STATE ROUTING PROTOCOL

Optimized link State Routing Protocol (OLSR) is another protocol developed for mobile ad hoc networks [3]. It is a proactive protocol, which means that the mobile nodes exchange topology information with each other regularly. To keep the routing tables updated the network is flooded and every mobile node receives the same message from each of its neighbors. Thus, bandwidth and energy are wasted for useless messages. To avoid too many redundant retransmissions, the flooding process is optimized in OLSR. In OLSR, only some selected nodes forward the broadcast messages during the flooding process.

VI. ZONE ROUTING PROTOCOL

Zone Routing Protocol (ZRP) is a routing protocol that is designed for mobile ad hoc networks [1]. It's a hybrid protocol that is part proactive and part reactive. The proactive part uses a modified distance vector scheme within the *routing zone* of each node. The routing zone is determined by a zone radius, which is the minimum number of hops it should take to get any node. Thus, each node has a routing zone, which is composed of nodes within its local area. This proactive component is called *Intrazone Routing Protocol* (IARP). The reactive component is called *Interzone Routing Protocol* (IERP), and uses queries to get route when a node want to send a packet to node outside of its routing zone. ZRP uses a method called border casting in which a node asks all nodes on the border of its routing zone to look for the node outside of its routing zone.

VII. INTERNET CONNECTIVITY FOR MOBILE AD HOC NETWORKS

Internet connectivity is the ability of hardware devices or software packages to transmit data between other devices or packages within the Internet, or the ability of hardware devices, software packaged, or a computer itself to work with network devices or with other hardware devices, software packages, or a computer over an Internet connection. The access to the Internet from a multihop wireless network is investigated. To achieve this network interconnection, gateways that understand the protocols of both the mobile ad hoc network stack and the TCP/IP suite are needed. All communication between a mobile ad hoc and the Internet must pass through the Internet draft "Global Connectivity for IPv6 Mobile Ad Hoc Networks" [6], which describes how to provide Internet connectivity to mobile ad hoc networks. In particular, it explains how a mobile node and a gateway should operate [11], [5].

VIII. GATEWAY DISCOVERY

Gateway is a device that connects networks using different communications protocols so that information can be passed from one to the other. A gateway both transfers information and converts it to a form compatible with the protocols used by the receiving network. The question of whether the configuration phase with the gateway should be initiated by the gateway (proactive method), by the mobile node (reactive method) or by mixing these two approaches (hybrid method). In the following, the mechanisms of these three approaches are discussed [10].

A. Proactive Gateway Discovery

The proactive gateway discovery is initiated by the gateway itself. The gateway periodically broadcasts a gateway advertisement (GWADV) message which is transmitted after expiration of the gateway's timer, ADVERTISEMENT_INTERVAL. The time between two consecutive advertisements must be chosen with care so that the network is not flooded unnecessarily. All mobile nodes residing in the gateway's transmission range receive the advertisement. Upon receipt of the advertisement, the mobile nodes that do not have a route to the gateway create a route entry for it in their routing tables. Mobile nodes that already have a route to the gateway update their route for the gateway. Next, the advertisement is forwarded by the mobile nodes to other mobile nodes residing in their transmission range [12].

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B. Reactive Gateway Discovery

The reactive gateway discovery is initiated by a mobile node that is to initialize or update information about the gateway. The mobile node broadcasts a RREQ_Is to the ALL_MANET_GW_MULTICAST address, i.e. the IP address for the group of all gateways in a mobile ad hoc network. Thus, only the gateways are addressed by this message and only they process it. Intermediate mobile nodes that receive the message just forward it by broadcasting it again. The adventage of this approach is that RREQ_Is are sent only when a mobile node needs the information about reachable gateways [12].

C. Hybrid Gateway Discovery

To minimize the disadvantages of proactive and reactive gateway discovery, the two approaches can be combined. This results in a hybrid proactive / reactive method for gateway discovery is used. Mobile nodes residing outside this range use reactive gateway discovery to obtain information about the gateway. The gateway periodically broadcasts a RREP_I message which is transmitted after expiration of the gateway's timer, ADVERTISEMENT_INTERVAL. All mobile nodes residing in the gateway's transmission range receive the RREP_I. Upon receipt of the message, the mobile nodes that do not have a route to the gateway create a route entry for it in their routing tables. Mobile nodes that already have a route to the gateway update their route entry for the gateway. Next, the RREP_I is forwarded by the mobile nodes to other mobile nodes residing in their transmission range [12]

IX. NETWORK SIMULATOR

Network Simulator (NS) is an object-oriented, discrete event simulator for networking research. NS provides substantial support for simulation of TCP, routing and multicast protocols over wired and wireless networks [9]. The simulator is a result of an ongoing effort of research and development. NS is written in C++, with an Object Tool Command Language (OTcl) interpreter as a command and configuration interface.

X. SIMULATION SETUP

To be able to evaluate the implementation of the Internet draft "Global Connectivity for IPv6 Mobile Ad Hoc networks" in NS 2, some simulation scenarios must be run. This section describes the scenario, the movement model, communication model, and the parameters used in the simulation.

A. Simulation Scenario

The simulation scenario consists of 15 mobile nodes, 2 gateways, 2 routers and 2 hosts. The topology is a rectangular area with 800m length and 500m width. A rectangular area is chosen in order to force the use of longer routes between nodes between nodes than would occur in a square area with equal node density. The gateways are placed on each side of the area. The simulation time is 900 seconds.

B. Movement Model

The mobile nodes move according to the "random waypoint" [8]. Each mobile node begins the simulation by remaining stationary for *pause time seconds*. It then selects a random destination in the defined topology area and moves to the destination at a random speed. The random speed is distributed uniformly between zero (zero not included) and some *maximum speed*. Upon reaching the destination, the mobile node pauses again for *pause time* seconds, selects another destination, and proceeds there as previously described. This movement pattern is repeated for the duration of the simulation. The chosen values for pause time and maximum speed are shown in Table I.

Table I: General Parameters used in all Simulations

Parameter	Value
Transmission rang	*250 m*
Simulation time	*900 sec.*
Topology size	*800m x 500m*
Number of mobile nodes	*15*
Number of sources	*5*
Number of gateways	*2*
Traffic type	*Constant Bit Rate*
Packet rate	*5 packets/sec.*
Packet size	*512 bytes*
Pause time	*5 sec.*
Maximum speed	*10m/sec.*

C. Communication Model

In the simulation scenario, five mobile nodes communicate with one of two fixed nodes (hosts) located on the internet through a gateway. As the goal of the simulations was to compare the different approaches for gateway discovery, the traffic source was chosen to be a constant bit rate (CBR) source. Each source mobile node generates packets every 0.2 seconds. Each source generates 5 packets per second. Since each packet contain 512 bytes of data, the amount of generated data is 20 kbps for each source. The parameters that are specific for some simulations are shown in Table II.

Table II: Specific Parameters used in some simulations

Parameter	Value
ADVERTISEMENT_INTERVAL	*Varied from 2-60 seconds*
ADVERTISEMENT_ZONE	*3 hops*

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XI. SIMULATION RESULTS

In this section the effect of varying gateway advertisement intervals is evaluated. Since gateway advertisements are not sent in the reactive gateway discovery approach, the results for this approach are constant and independent of the advertisement interval. Each data point is an average value of 10 runs with the same communication model, but different randomly generated movement patterns.

A. Packet Delivery Ratio

Fig. 2. shows the packet delivery ratio with advertisement intervals between (2 – 60) seconds. As the figure shows, the packet delivery ratio is very high for all three gateway discovery approaches. The figure also shows that the differences between the three approaches are very small. However, the proactive and hybrid approaches have some large packet delivery ratio than the reactive approach, especially with short advertisement intervals. The reason is that the short advertisement intervals result in more gateway information. When the advertisement interval increases, a mobile node receives less gateway information and consequently it does not update the route to the gateway as often short advertisement intervals. Therefore, the positive effect of a periodic gateway information is decreased as these advertisement interval increases.

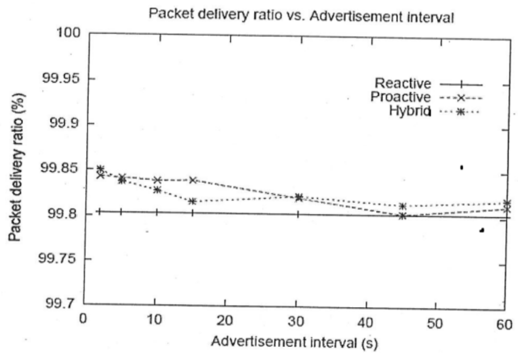

Fig. 2: Packet Delivery Ratio

B. Average End-to-end Delay

Fig. 3. Shows the average end-to-end delay with advertisement intervals between (2-60) seconds.

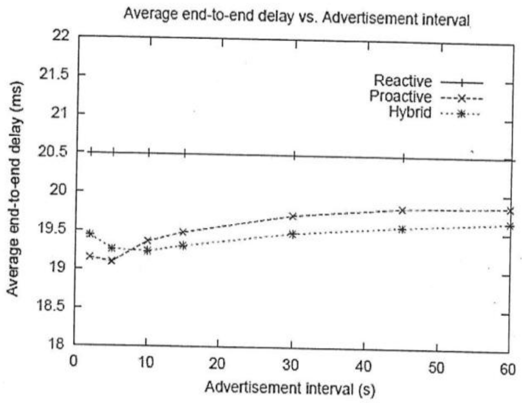

Fig. 3. Average end-to-end delay

As the figure shows, the average end-to-end delay is less for the proactive and hybrid approaches than for the reactive approach. The reason is that the periodic gateway information sent by the gateways allows the mobile nodes to update their route entries for the gateways more often.

C. AODV Overhead

Fig. 4. Shows the AODV overhead with advertisement intervals between (2-60) seconds. The AODV overhead is dominated by the periodically broadcasted RREP_I and GWADV messages. As the figure shows, the AODV overhead is larger for the proactive and hybrid approaches than for the reactive approach, especially for short advertisement intervals. This is an expected result since the proactive and hybrid approaches periodically broadcast gateway information no matter if the mobile nodes need them or not, while the reactive approach broadcasts gateway information only when a mobile node sends a request for it. Moreover, the figure shows that the AODV overhead decreases for the proactive and hybrid approaches as the advertisement interval increases. This is due to less frequent gateway information transmission.

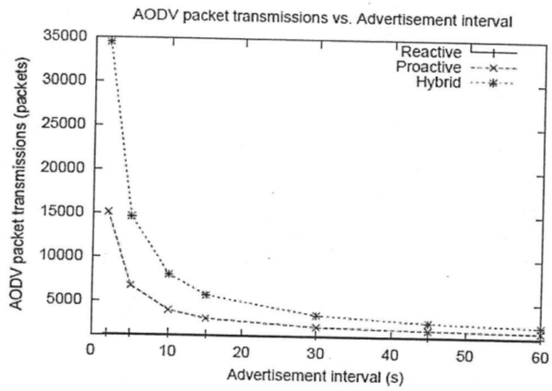

Fig. 4. AODV overhead

XII. CONCLUSION

The three methods for gateway detection are referred to as reactive, proactive and hybrid gateway discovery. The comparsion between these methods provide us useful information. Regarding the packet delivery ratio, the result is largely the same, regardless of which gateway discovery method is used. As for the average end-to-end delay, the proactive and hybrid methods perform slightly better than the reactive method. Concerning the routing overhead, when the advertisement interval is short the reactive method generates much less overhead than the proactive method, which in turn generates much less overhead than the hybrid method. When the advertisement interval increases, all three methods generate virtually the same routing overhead.

REFERENCES

[1] Z. J. Haas, M. R. Pearlman, and P. Samar, "The Zone Routing Protocol (ZRP) for Ad Hoc Networks", IETF Internet Draft, July 2002.

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International Journal of Engineering and Innovative Technology (IJEIT)
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[2] D. B. Johnson, D. A. Maltz, Y. Hu, and J. G. Jetcheva, "The Dynamic Source Routing Protocol for Mobile AD Hoc Networks (DSR), IETF Internet Draft Feb. 2002.

[3] T. Clausen, P. Jacquet, A. Laouiti, P. Muhlethaler, A. Qayyum, I, and Viennont, "Optimized Link State Routing Protocol", IETF Internet Draft, July 2002.

[4] C. Perkins, E. M. Belding, and S. Das, "Ad Hoc on Demand Distance Vector (AODV) Routing, IETF Internet Draft, Jan 2002.

[5] G. Holland, N, and S. Vaidya, "Analysis of TCP Performance over Mobile Ad Hoc Networks", IEEE Proceedings, ACM MOBICOM, 1999.

[6] R. Wakikawa, J. Malinen, C. Perkins, A. Nilsson, and A. Tuominen, "Global Connectivity for IPv6 Mobile Ad Hoc Networks", IETF Draft, Nov. 2001.

[7] J. Schiller, "Mobile Communication", 2000.

[8] MANET web page, http://www.ietf.org/html.charers/manet-charter.html

[9] S. McCanne, and S. Floyd, "Network Simulator (NS)". http://www.isi.edu/nsnam/ns/.

[10] Xi. J, and C. Bettstetter. "wireless Multihop Internet Access: Gateway Discovery, Routing and Addressing", in Proceeding of the International Conference on Third Generation Wireless and Beyond (3G wireless'02), San Francisco, USA, May 2002.

[11] R. Belding, Y. Sun, and C. Perkins. "Global Connectivity for IPv4 Mobile Ad Hoc Networks, IETF Internet Draft, Nov. 2001.

[12] D. E. Comer, "Internetworkying with TCP/IP: Principles, Protocols, and Architecture, Volume I, Fourth Edition, 2000.

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