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New Unicast Routing Protocol Using Comparative Study of Proactive, Reactive and Hybrid protocols for MANET

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Abstract—Mobile ad-hoc networks (MANETs) are self-configuring networks of nodes connected via wireless without any form of centralized administration. This kind of networks is currently one of the most important research subjects, due to the huge variety of applications (emergency, military, etc...). In MANETs, each node acts both as host and as router, thus, it must be capable of forwarding packets to other nodes. Topologies of these networks change frequently. There are three main classes of routing protocols for MANETs: reactive, proactive and hybrid. By studying advantages and disadvantages of each one, a new hybrid routing protocol is proposed. The new scheme of protocol considers utilizing merits of both reactive and proactive protocols, and implements them as a hybrid approach. It allows that a mobile node flexibly runs either a proactive or a reactive routing protocol with its velocity and its traffic. The new routing protocol is evaluated qualitatively. To verify the feasibility, a performance comparison with other typical existing routing protocols[13] is discussed.

Keywords— Manets, reactive, proactive, hybrid, AODV, OLSR, ZRP, DSR

INTRODUCTION

Mobile ad hoc networks (MANETs)[1][2] are autonomous systems of mobile hosts connected by wireless links. To achieve efficient communication between nodes connected to the network new routing protocols are appearing. This is because the traditional routing protocols for wired networks do not take into account the limitations that appear in the MANETs environment.

A lot of routing protocols for MANETs have been proposed in the last years. The IETF is investigating this subject and for example, protocols like AODV (Ad hoc On Demand Distance Vector)[4] and OLSR (Optimize Link State Routing protocol)[3] have been proposed as RFC's (Request for Comments). But, none of the existing protocols is suitable for all network applications and contexts. The routing protocols for MANETs can be classified in three groups: reactive, proactive and hybrid.

The proactive protocols are based on the traditional distributed protocols shortest path based. With them, every node maintains in its routing table the route to all the destinations in the network. To achieve that, updating messages are transmitted periodically for all the nodes. As a consequence of that, these protocols present great bandwidth consumption. Also, there is a great routing overhead. However, as an advantage, the route to any destination is always available. Thus, the delay is very small.

The reactive protocols determine a route only when necessary. The source node is the one in charge of the route discovery. As a main advantage, the routing overhead is small since the routes are determinate only on demand. As a main disadvantage the route discovery introduces a big delay.

The hybrid ones are adaptive, and combine proactive and reactive protocols

The major part of this work has been to find and study information on the current state of the art in MANETs, the routing protocols that are used (taking into account the advantages and disadvantages of each one depending on the kind of MANET), and to design a new routing protocol using the acquired knowledge.

In this paper we have evaluated the merits and demerits of four existing protocols and tried to figure out the new routing protocol which uses the plus points of each protocol. We have considered four existing protocols which are AODV, OLSR, DSR [6] and ZRP. The results of these three protocols are being compared and a new theoretical routing protocol is being proposed.

MOBILE AD-HOC NETWORKS: MANETS

Mobile Ad-Hoc networks or MANET networks are mobile wireless networks, capable of autonomous operation. Such networks operate without a base station infrastructure. The nodes cooperate to provide connectivity. Also, a MANET operates without centralized administration and the nodes cooperate to provide services. Figure illustrates an example of Mobile Ad-Hoc network.

The main characteristic of MANETs is that the hosts use wireless medium. In addition, they can move freely. Therefore, the network topology is changing constantly and they do not need any previous infrastructure to be used. Another characteristic is that the hosts perform as routers.

ROUTING PROTOCOLS FOR MOBILE AD-HOC NETWORKS

As it has been said, MANETs are necessary to have different routing protocols from the wired networks. There are three types of routing protocols for MANETS:

• Table-driven (Proactive)[7]: OLSR, TBRPF[8], DSDV (Dynamic Destination Sequenced Distance Vector)[9], CGSR (Cluster head Gateway Switch Routing protocol)[10], WRP (Wireless Routing Protocol), OSPF (Open Shortest Path First)[11] MANET, etc.
• Demand-driven (Reactive): AODV, DSR, TORA (Temporally Ordered Routing Algorithm)[12], etc.
• Hybrids: ZRP (Zone Routing Protocol), HSLS (Hazy Sighted Link State), etc. In the proactive protocols, each node has a routing table, updated periodically, even when the nodes don't need to forward any message.

REACTIVE ROUTING PROTOCOLS

These protocols find the route on demand by flooding the network with Route Request packets. The main characteristics of these protocols are:

• Path-finding process only on demand.
• Information exchange only when required.
• For route establishment, the network is flooded with requests and replies.

THE DYNAMIC SOURCE ROUTING (DSR)

DSR is a reactive routing protocol. It uses source routing. The source node must determine the path of the packet. The path is attached in the packet header and it allows updating the information stored in the nodes from the path. There are no periodical updates. Hence, when a node needs a path to another one, it determines the route with its stored information and with a discovery route protocol.
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THE AD-HOC ON DEMAND DISTANCE VECTOR (AODV)

The AODV protocol is a reactive routing protocol. It is a Single Scope protocol and it is based on DSDV. The improvement consists of minimizing the number of broadcasts required to create routes. Since it is an on demand routing protocol, the nodes which are not in the selected path need not maintain the route neither participate in the exchange of tables.

PROACTIVE ROUTING PROTOCOLS

These algorithms maintain a fresh list of destinations and their routes by distributing routing tables in the network periodically. The main characteristics are:

• These protocols are extensions of wired network routing protocols.
• Every node keeps one or more tables.
• Every node maintains the network topology information.
• Tables need to be updated frequently.

OPTIMIZED LINK STATE ROUTING (OLSR)

OLSR is a proactive link state routing protocol. It is a point to point routing protocol based in the link state algorithm. Each node maintains a route to the rest of the nodes of the ad hoc network. The nodes of the ad hoc network periodically exchange messages about the link state, but it uses the 'multipoint replaying' strategy to minimize the messages quantity and the number of nodes that send in broadcast mode the routing messages.

HYBRID ROUTING PROTOCOLS

These protocols are a combination of reactive and proactive routing protocols, trying to solve the limitations of each one. Hybrid routing protocols have the potential to provide higher scalability than pure reactive or proactive protocols.

THE ZONE ROUTING PROTOCOL (ZRP)

The Zone Routing Protocol is a hybrid routing protocol. It combines the advantages from reactive and proactive routing protocols. This protocol divides its network in different zones. These zones are the nodes local neighbourhood. Each node has its own zone. Each node can be into multiple overlapping zones, and each zone can be of a different size.
ZRP [5][6] run three routing protocols:

• Intrazone Routing Protocol (IARP)
• Interzone Routing Protocol (IERP)
• Bordercast Resolution Protocol (BRP)

IARP is a link state routing protocol. It operates within a zone and learns the routes proactively. Hence, each node has a routing table to reach the nodes within its zone.

IERP uses the border nodes to find a route to a destination node outside of the zone. IERP uses the BRP.

BRP is responsible for the forwarding of a route request. When the Route Discovery process begins, the source node asks to its routing table and if necessary, it starts a route search between different zones to reach a destination

A NEW ROUTING PROTOCOL FOR MANETS

Since there are many typical routing protocols proposed, it uses two existing protocols directly. For proactive areas, OLSR is utilized because it is very popular and performs well compared with other proactive routing protocols. Reactive nodes run AODV for no additional overhead introduced with the network growing. Besides, when the mobility is very high, AODV has impressive resilience.

PROTOCOL DESCRIPTION

The description of routing protocol is quite easy. Each node checks its velocity and its traffic periodically. If the velocity is smaller than a threshold X, or the traffic is higher than a threshold Z, then the node will try to join or to create a proactive area. Within this area, the features to use are the same that in the OLSR. If not, the node will work in reactive mode, using the same features that AODV. The proactive areas have a limited size in number of nodes. The number of nodes within an area cannot be greater than a threshold Y. If a node that wants to join an area does not find an area with less than Y nodes, it has to create a new area or it cannot work in proactive mode. But not all the nodes inside the area work like pure OLSR. There are some nodes that have to work as gateways to communicate the area with the outside. Similarly, not all the nodes outside the area work in the same way that AODV. Some of them have special features to allow the communication between reactive and proactive nodes.

ROUTING PROTOCOL PARAMETERS

First of all, there are some parameters that have to be described to understand the operation of it.

V=velocity

Periodically, the node checks its velocity to know if topology changes can happen. The velocity to have into account to switch from an operation mode to another is the average velocity.

X= threshold velocity=3.5 m/s

If we review different performance studies as we can see that AODV is better than OLSR in all the range of mobility since the point of view of the throughput, the total amount of generated network traffic, and the resilience. However, when the nodes are semi-static (at very low velocities) the OLSR can perform better in terms of delay end-to-end. This is because in a network with not many topology changes OLSR can almost always give the shortest path available.

N=number of nodes in the area

N is the number of nodes working in the same area using the proactive features.

Y= threshold number of nodes in an area = 90

The proactive area works in the same way that OLSR. OLSR reduces the number of "superfluous" forwarding, reduces the size of LS updates, and reduces the table size. However, while the number of nodes into an OLSR area increases, the number of control packets increase. For the study made in the OLSR should not exceed 400 nodes because it generates excessive control packets. In the study it is demonstrated that the packet delivery ratio decreases if the number of nodes is bigger than 100.

Therefore, a good threshold to the number of nodes in an OLSR network could be 90. OLSR allows choosing a big value for the number of nodes in a network, but when this value exceeds 100 the performance of the protocol may decrease. With the number of nodes 90, there is a margin of 10 nodes to reach this critical point.

T= Traffic

T is the traffic that a node manages. This traffic is just data traffic (with no control traffic), and can be both the traffic generated by the node and the traffic routed by the node and generated in others nodes.

Z= threshold value of traffic= 300 kbps

As explained before, when the traffic in the network is high, the nodes need to know the route to the destination as fast as possible. In this case a proactive routing protocol outperforms the reactive one because it already has the route when necessary.

A NODE OPERATION

A node working with this protocol will work using different features depending on its velocity, traffic and environment. It defines 6 different states for a node: Initial, R1 (Reactive 1), R2 (Reactive 2), R3 (Reactive 3), P1 (Proactive 1), P2 (Proactive 2) and P3 (Proactive 3) states.

• *Initial state*: When a node is reset it begins in an initial state. In this state the node must check its velocity and its traffic to decide in which mode it has to work. **We define "condition 1" as: "(V<=X) OR (T>Z)".** If condition 1 doesn't happen then it will work in the

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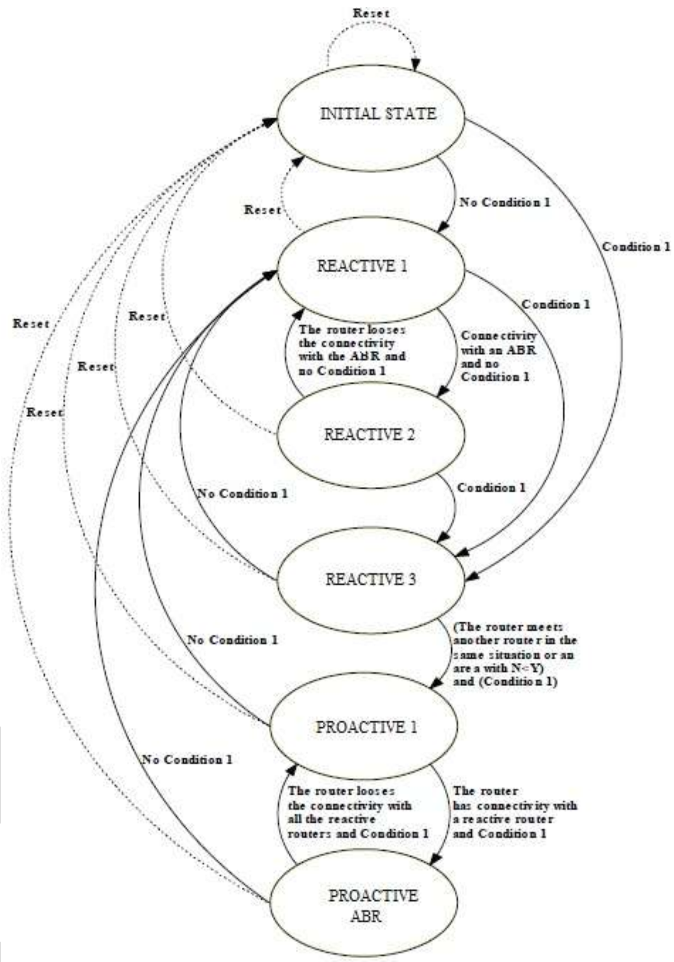
reactive mode (Reactive 1), but if condition 1 happens, then it will try to work in the proactive mode. Hence, the node will pass to the Reactive 3 state.

• *Reactive 1*: In this state, the node works using the AODV features. While condition 1 is not fulfilled and the node does not have connectivity with an area it will remain in the same mode of operation. In the case that the node discovers a node or more working in the Proactive 1 or Proactive 2 modes then it will work in the Reactive 2 mode. If condition 1 is fulfilled, then it will try to work in proactive mode (Reactive 3).



• *Reactive 2*: In this state, the node works using the AODV features, but also must process the control messages coming from the proactive zone. This is because it needs these messages to have, in its routing table, the proactive destinations. While there is no condition 1 and while the connectivity with any node working in the Proactive 1 or Proactive 2 modes continues the node will remain in the same state. If condition 1 is not fulfilled but the router loses the connectivity with the mentioned routers, then it will come back to the Reactive 1 state. If condition 1 occurs then it will try to work in proactive mode (Reactive 3 state).

• *Reactive 3*: This state exists for the reason that when a node decides that to work in proactive mode is better; firstly it must join or create an area. In this state the node still works using the AODV features, but also has to generate and to process the proactive control messages. If there is no condition 1 is happening the node will come back to the Reactive 1 state. But while condition 1 happens, the Node will try to join or to create an area. If it listens another node working in Reactive 3, Proactive 1 or Proactive 2 modes, then it will join the area unless in the area the number of nodes N is > Y. If N>Y the node remains in the same state waiting to listen to other area with less number of nodes.

• *Proactive 1*: In this state the router works using the OLSR features. If condition 1 is not fulfilled, the node will go to the Reactive 1 state. But when condition 1 is fulfilled, the node will continue working in this state unless it discovers a node working in the Reactive 1 or Reactive 2 states. Then it will go to the Proactive 2 state.

• *Proactive 2 (Area Border Router):* In this state the node works using the OLSR features but it has to understand the reactive routing messages (RREQ, RREP and RERR) because it needs to have in its routing table all the reactive 2 nodes connected with it. When an ABR (Area Border Router) receives a reactive routing message (RREQ, RREP or RERR) it must look for the destination. If the destination is inside its own area, then it answers to that message reactively. If not, it forwards them to all the others ABRs of its area. These exit ABRs will change the flags again. If condition 1 is not fulfilled the node will go to the Reactive 1 state. But while condition

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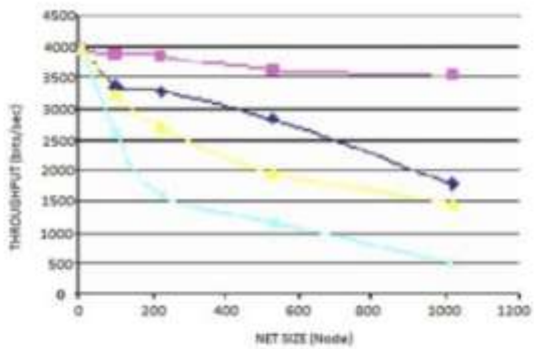
1 occurs the node will continue working in this state unless it lost all the connectivity with the nodes working in the Reactive 1 or Reactive 2 states. In this case it will go to Proactive 1 mode.
A node goes to Initial State from every state when it is reset.

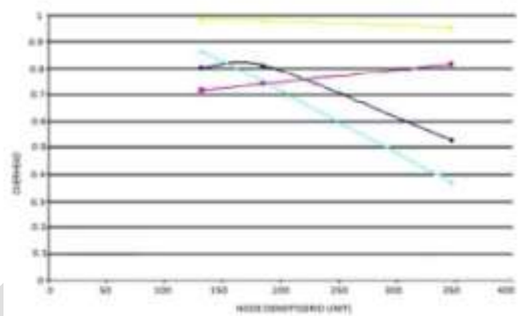
SIMULATION

ROUTING PROTOCOL SCALABILITY NETWORK SIZE



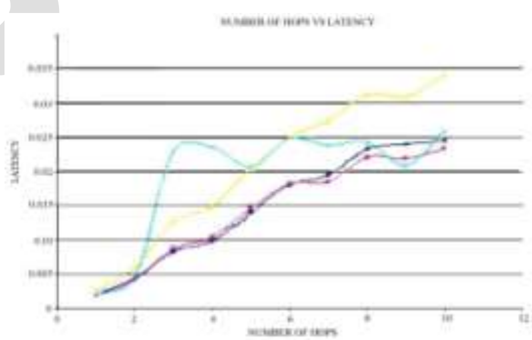
The network size vs. throughput graph in Figure plots the per-node average of application level observations of bps data received. According with these results, DSR is the best routing protocol when the network grows with this particular configuration. OLSR and AODV perform similar in the range of 0-100 nodes, but when the number of nodes is greater, AODV performs better.

NODE DENSITY



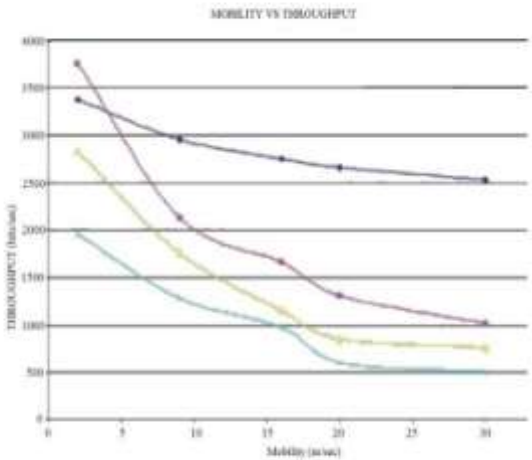
the Control Overhead curve for the Node Density experiments is shown. The control overhead measurements are normalized. The horizontal axis represents the distance between neighbouring nodes in the grid.
The sparse networks have higher paths lengths. Thus, in these networks there are more rebroadcasts of route requests, and more route reply packets. For that reason DSR increases its control overhead when the density is smaller. However, AODV begins with a high overload when the node density is high, but uses fewer control packets as the density is smaller.

NUMBER OF HOPS



The strangest result is to see that the latency for OLSR has the highest values from 1 to 10 hops, and generally the highest slope. For OLSR to lose its innate advantage in latency, network route convergence would have to be slower than route acquisition, and given the high control overhead data that was collected for this experiment set, it is easy to see that this is the case. However, under normal circumstances the OLSR is supposed to be the best of the analysed protocols since the point of view of the latency.

MOBILITY



AODV is the best here. DSR starts out with higher throughput in the lowest mobility case, but DSR optimizations seem less able to handle high mobility, but it still manages a second place finish. OLSR is the third place finisher. OLSR is somewhat less scalable than DSR, but follows a roughly similar curve of decline. ZRP is the worst in this roundup.

Graph keys: Dark Blue-AODV
Light Blue-ZRP
Pink-DSR
Yellow-OLSR

CONCLUSION

The AODV and DSR protocols will perform better in the networks with static traffic and with a number of source and destination pairs relatively small for each host. In this case, AODV and DSR use fewer resources than OLSR, because the control overhead is small. Also, they require less bandwidth to maintain the routes. Besides, the routing table is kept small reducing the computational complexity. Both reactive protocols can be used in resource critical environments.

The OLSR protocol is more efficient in networks with high density and highly sporadic traffic. The quality metrics are easy to expand to the current protocol. Hence, it is possible for OLSR to offer QoS. However, OLSR requires that it continuously have some bandwidth in order to receive the topology updates messages.

The scalability of both classes of protocols is restricted due to their proactive or reactive characteristics. For reactive protocols, it is the flooding overhead in the high mobility and large networks. For OLSR protocol, it is the size of the routing table and topological updates messages.

ZRP is supposed to perform well in large networks with low area overlapping. But in any of the papers considered to write this thesis ZRP showed a better performance that the other protocols. Besides, and as a disadvantage, there is an optimum zone radius for each environment as was studied.

The protocol is supposed to outperform the rest of the protocols under study in large networks with nodes having different traffic rates and different mobility degrees. Each node decides if it is better to work in proactive or in reactive mode. Hence, every node adjusts the control overhead and the resource usage to its necessities.

FUTURE WORK

This report has proposed a routing protocol for MANETs. Once the different existing routing protocols as well as their advantages and disadvantages were understood, the objective was to design a new protocol more suitable for networks with nodes moving freely. These networks should be able to be both large and small. Also the traffic pattern was taken into account to decide the features of each node.

Since there was no time to make a quantitative study by means of simulation, only a qualitative analysis was done. Therefore, as future work, protocol should be programed for example in NS-2 to carry out a performance study in comparison with the other protocols already implemented

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