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MANET's Routing Protocols: Comparative Study

Imad Ibraheem M. Abu Sa'da

Supervisor
Dr. Raid al-zaghal

Al-Quds University
Faculty of science and technology
Computer science department
Palestine

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<u>Thesis Approval</u>

Committee Members

Dr. Raid Al-Zaghal (Chairman) ___________________________________

Dr. Nedal Kafri (Internal Examiner) ________________________________

Dr. Mutasim Babaa'(External Examiner) ___________________________

March 6, 2010

Declaration

I Certify that this thesis submitted for the degree of master of computer science is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of that) has not been submitted for a higher degree to any other university or institution.

Signed:

Imad Ibraheem M. Abu Sa'da

March 6, 2010

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Abstract

MANET is a mobile ad hoc network and a new paradigm of wireless communication for mobile hosts (nodes) without administration and without infrastructure, Node mobility in MANET causes frequent changes of the network topology.

The main interest in this research will be the routing Protocols and routing protocol approaches of MANETs which must be able to keep up with the high degree of node mobility and unpredictable network topology. These routing protocols including ARPM (adaptive routing protocol) which is now under study, in addition, in this research the process of learning and teaching of routing protocols will be more easily.

However, there are many drawbacks, which mean that it is essential to continue the search for an efficient protocol for MANETs to reduce these drawbacks.

The recent comparison was between ARPM, proactive and reactive routing approaches. This comparison shows that ARPM is more efficient than proactive and reactive routing approaches [5].

This research contains a list for parameters and properties which contain the definitions. The parameters for comparisons were used to detect the best protocol which may be used to reduce the drawbacks of MANETs; the properties were used for establishing a simple reference to the properties of some routing protocols, which will make the knowledge and learning of these routing protocols easier.

The research will gradually search for the more efficient protocol from (DSDV, AODV, SHARP and ARPM) by doing theoretical and experimental comparison. In addition, other available comparisons conducted and published by other researchers, the experimental comparison was reached through simulations for DSDV and AODV using

GloMoSim. The simulation was exploited as bases for completing other comparisons and for reaching final conclusions.

In this study, main work was focused on ARPM and hybrid routing approach (SHARP routing protocol) because these two protocols are relatively new protocols in MANET. Comparisons were illustrated in tables containing parameters, properties and routing protocols, eventually, these tables will form the simple reference (reference guide) that we motivated.

Contents

Chapter Three

Simulations

Chapter Four

Chapter five

List of figures

1.1 MANET definition and characteristic:

MANET is a mobile ad hoc network and a new paradigm of wireless communication for mobile hosts (nodes) this kind of networks differ traditional networks or wired network it works spontaneously. In the past, the applications of MANET were proposed for military communications and disaster recovery, but now these applications are quickly expanding and spreading to include many applications related to multimedia technology and commercial interest and other civilian applications. These reasons encouraged the interested to make it under scope, so there have been profound and extensive researches since the last decade.

According to [Murphy et al., 1998], an ad hoc network is “a transitory association of mobile nodes which do not depend upon any fixed support infrastructure. Participants at a conference and disaster relief workers may find it necessary to interact with each other in this manner when the static support infrastructure is not available. An ad hoc network can be visualized as a continuously changing graph. Connection and disconnection is controlled by the distance among nodes and by willingness to collaborate in the formation of cohesive, albeit transitory community”.

In an ad hoc network, there is no fixed infrastructure, nodes communicate directly via wireless links without central administrator; frequent changes in network topology and nodes mobility are considered other characteristics of MANET [5].

1.2 Infrastructured and infrastrucureless of mobile network:

According to the infrastructure mobile networks are divided into two types, which enable the nodes to communicate with each other:

1. Infrastructured mobile networks (example: GSM): in this kinds of networks the mobile nodes communicate with access point like base stations connected to the fixed network infrastructure see Figure 1.2.1 [15].
2. Infrastructureless mobile networks: is known as mobile ad hoc network (MANET), in this network, group of nodes which form he network can communicate with each other dynamically without any access point. These nodes can exchange information directly or by an intermediate nodes without configuring a certain infrastructure; this supports the idea of being the nodes in MANET may have high mobility so the recent technology need a simultaneous configuring wireless network or connection between nodes see Figure 1.2.2 [15].

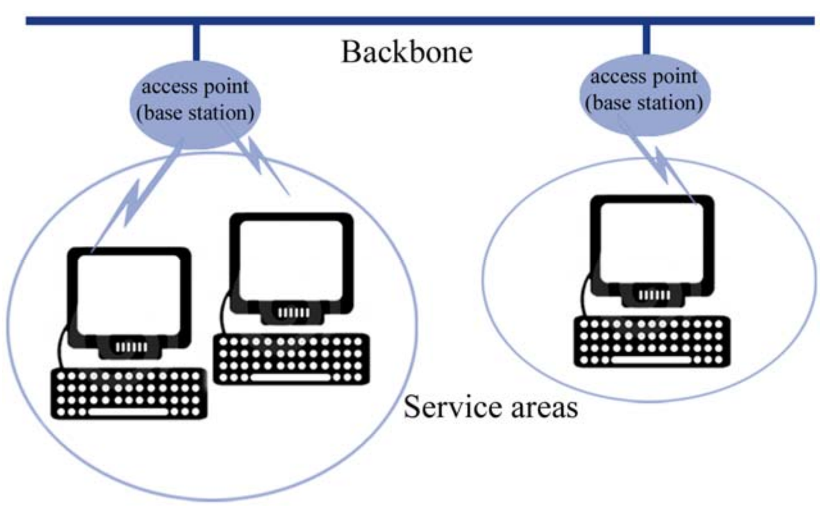


Fig.1.2.1 infrastructured mobile network

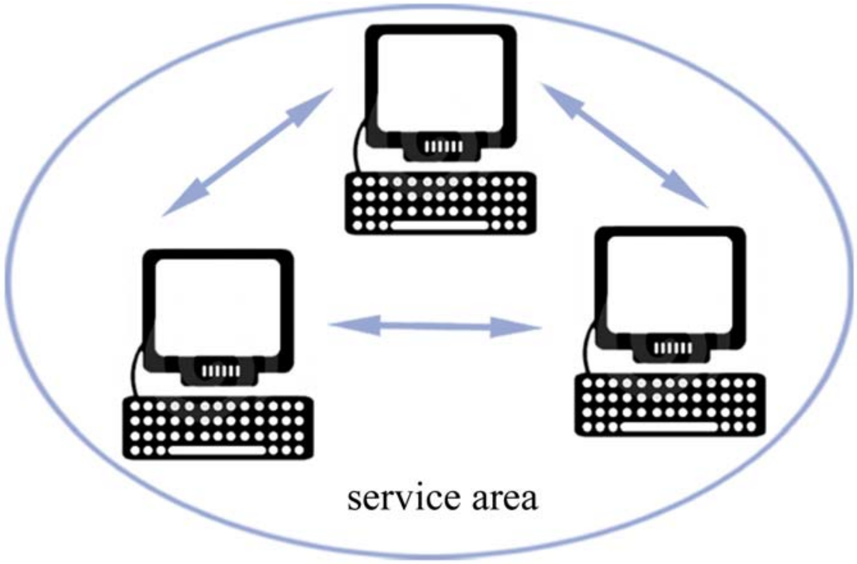


Fig.1.2.2 infrastructureless mobile network

1.3 Challenges of MANET:

MANET has many special features, which make MANET more popular and give it some advantages and facilities. However, at the same time this distinction makes MANET faces several challenges such as:

1- Dynamic topology, each node in MANET can continuously change its location connecting and disconnecting from the network, this makes the issue of routing packet between nodes a challenging task [5].

2- The limited processing and storing capabilities of mobile nodes, MANET nodes need a set of mechanisms to allow autonomous integration and configuration of the nodes to be in network.

3- Security, recent wireless research publications indicate that the wireless MANET presents a larger security compared to conventional wired and wireless networks mainly due to the common vulnerabilities of wireless connection.

4- Quality of Service (QoS): the United Nations Consultative Committee for International Telephony and Telegraphy (CCITT) recommendation has defined QoS as: "The collective effect of service performance which determines the degree of satisfaction of a user of the service" [13].

QoS is considered as an important attribute of routing protocols, during short period QoS becoming an area of interest.

It’s a measurement of guarantee of a set of service characteristics, such as jitter and bandwidth. QoS of routing protocols differs and it may be affected by several metrics such as end to end delay and overhead, so the routing protocol with good quality of services will satisfy the user requirements by higher degree and at the same time it will provide better performance.

Due to frequent changing environment of MANET, it is difficult to provide different quality of service level.

5- Internetworking, in addition to the communication inside the MANET there must be cooperation between MANET and traditional network, so to make the routing protocols in the mobile nodes living together is a challenge.

6- The nodes in MANET such as laptops and mobile phones use batteries which have limited life time; this is a challenge which encouraged many researches that focus on power conservation and power consumption [17].

1.4 Problem definition:

Because of mentioned challenges this kind of network has many drawbacks and challenges in routing process, so we have to search a proper protocol that meets the needs of MANET. In addition, some people find learning and educating routing protocols very difficult because. This is due to the large number of routing protocols proposed. also, determining and distinction the differences, similarities and properties of these routing protocol cause some difficulty so, there is a need for reference which contains a summary of some routing protocols, this reference may be used as educational reference.

1.5 Motivation and Solution:

Several amounts of researches has been proposed on developing skillful protocols specified to minimizing the drawbacks of MANET so, I will do this research which will focus on:

- The comparison of hybrid (SHARP), proactive (DSDV) and reactive (AODV) routing protocols.

- And comparison of ARPM routing protocol with proactive (DSDV) and reactive (AODV) routing protocols.

- Comparison of ARPM with SHARP routing as hybrid routing protocol.

To find the solution as it’s clear I will gradually do to conclude the differences between all approaches from the older to the recent protocols and do the comparisons by taking one routing protocol from each routing protocol approaches. These comparisons will help us find the best approach or protocol for MANET by displaying and analyzing some properties and parameters in details, routing protocols include the protocols which are now in the study as an adaptive routing protocol ARPM in comparison with SHARP (hybrid routing protocol). This comparison is considered hot topic in MANET [5], in addition I will do to make the identification of MANET routing protocols more easier by doing simple reference for the properties.

Simply, the motivation of this work is to search and detect an efficient, scalable, and adaptive routing protocol for MANET and to establish simple reference by searching the properties and use them in details, and verifying each piece of information by the analysis of the algorithms, simulation, and some time available information were used with mentioning it's origins as references.

1.6 Thesis organization:

Sections 1.1 and 1.2 of chapter 1 mention and discuss MANET definition and characteristics. Section 1.3 outlines the challenges of MANET. Section 1.4 defines problem of this search and the motivation. Section 1.5 organizes the thesis, and section 1.6 discusses some properties and parameters which are used widely in MANET routing protocol

Chapter two reviews and analyzes some of the existing routing protocol approaches such as proactive routing protocol (DSDV), reactive routing protocol (AODV), hybrid routing protocol (SHARP) and another routing protocol which are now in the study which is called (ARPM).

Chapter three contains the simulation model, simulations environments and simulations results.

Chapter four lists and analyzes some properties and parameters for mentioned routing protocols as an analytical comparison in three tables as follow:

- Comparison and properties in comparative pattern of hybrid (SHARP), proactive (DSDV) and reactive (AODV) routing protocols

- Comparison and properties in comparative pattern of ARPM routing protocol with proactive (DSDV) and reactive (AODV) routing protocols

- Comparison and properties in comparative pattern of ARPM with SHARP routing as hybrid routing protocol.

Chapter five summarizes the work and concludes the best of these routing protocols which satisfy the requirements of MANET which has the best properties in a certain conditions.

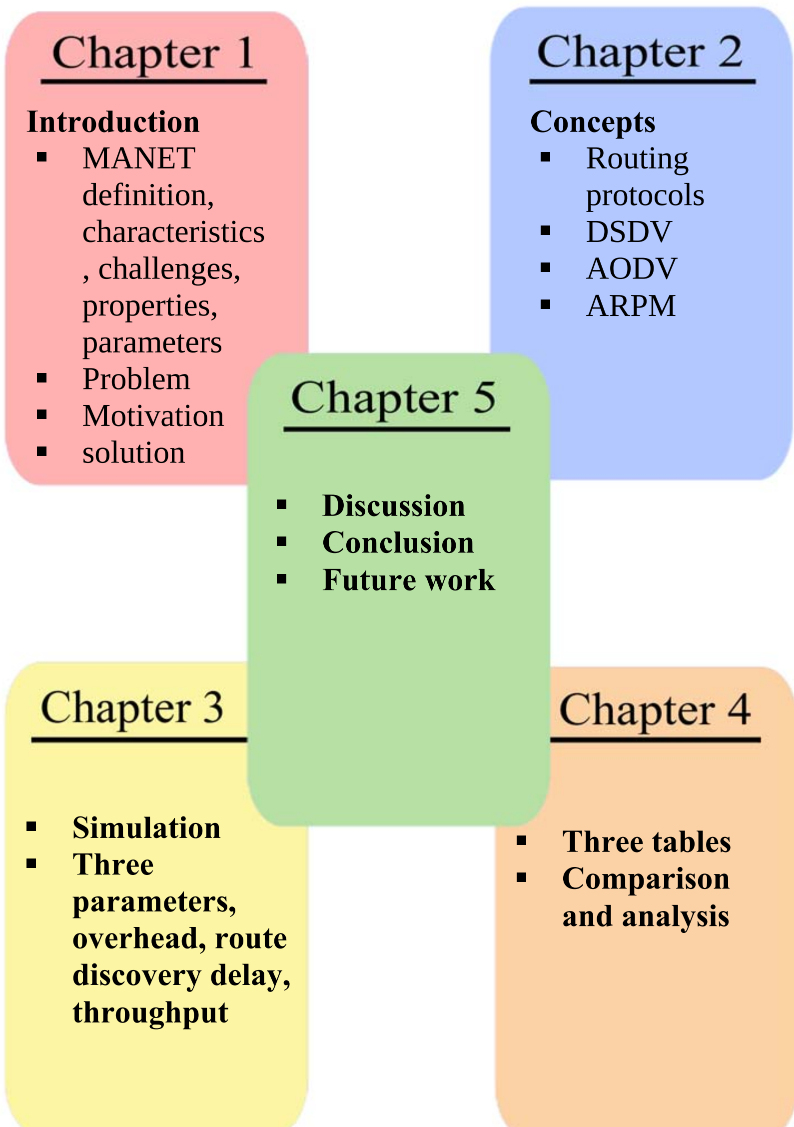


Fig1.6.1 thesis organization

1.7 Discussion of parameters and properties:

Definitions:

Route discovery: It is a procedure to discover and establish a new route to the destination when either the destination or some intermediate node moves [6].

Routing path: The routing Path is discovered and established whenever a source node needs to communicate with another node, and each node lying along any active path is considered a part of that path and affecting the routing to that path's destination.

Route discovery delay: There are several types of delays valuable to be considered such as end-to-end delay: the total time required for one bit to traverse from the sender to the receiver, delay jitter: the fluctuation or variation of end-to-end delay from one packet to the next packet within the same flow of packets, in my research we considered the route request delay which is the average delay per packet, which is required to find the path from the source to the destination [6].

Throughput of the actual data transmissions: throughput is a very important parameter in evaluating the modifications performance; it is calculated as the number of bits received per second.

Throughput is affected by the number of packets dropped or left wait for a route which is calculated as the summation of the number of packets dropped or left wait for a route for all the nodes.

The scalability: scalability of a network protocol could potentially be defined in many different ways, and at several different levels.

Scalability is the ability of a routing protocol to perform efficiently as one or more inherent parameters of the network grow to be large in value [10] [1].

The analytical study of scalability relationships in ad hoc networks can provide us with valuable insights into the proper design of ad hoc routing protocols and possibly related mechanisms at other layers. So far, the study of scalability in ad hoc networks has been mostly limited to simulation. However, a few significant analytical results have emerged fairly recently. [1]

Power Consumption: MANET may rely on batteries or other exhaustible means for their power for the nodes such as laptops and mobile telephone. For these nodes, the most important system design criteria for optimization may be power consumption because these power resources have limited living time so the power must be more conserved [4].

Reliability: the ratio of packets successfully delivered to the total number of packets sent, is how much the routing protocol is robust when transmitting the data, the assurance of transmitting and then receiving data successfully must be high, MANET has several reliability problems, because of the limited wireless transmission range, the broadcast nature of the wireless medium, mobility-induced packet losses, and data transmission errors [1] [6].

Bandwidth: is the capacity of wireless links which have significantly lower capacity than their hardwired counterparts.

Redundant route: If a node receives several copies of the same route request, these are considered as redundant; this happen by flooding and multi-path routing; the availability or timely determination of such redundant routes may be the single most important factor for successful transmission across an adverse network [3].

Overhead: is the ratio of the number of routing, messages generated by a routing protocol to the number of received data packets at the destinations. This metric is a measure of how many routing messages are needed to receive one data packet. It captures the efficiency of the routing protocol. [2]

Volume of Control traffic: is the measurement of how much the wireless medium of MANET is saturated with control messages between nodes, the control traffic scales linearly with the amount of control messages to be sent [2] [3].

2.1 Study and analysis of MANET routing protocols:

It is known that this kind of network has many Challenges because of mobility, changing topology and power consumption, so it requires specialized routing protocols in an attempt to provide efficient communication.

Many routing protocols have been proposed for MANET, and the main categories of these routing protocol approaches are:

-Proactive routing protocols approach.

-Reactive routing protocols approach.

-Hybrid routing protocols approach.

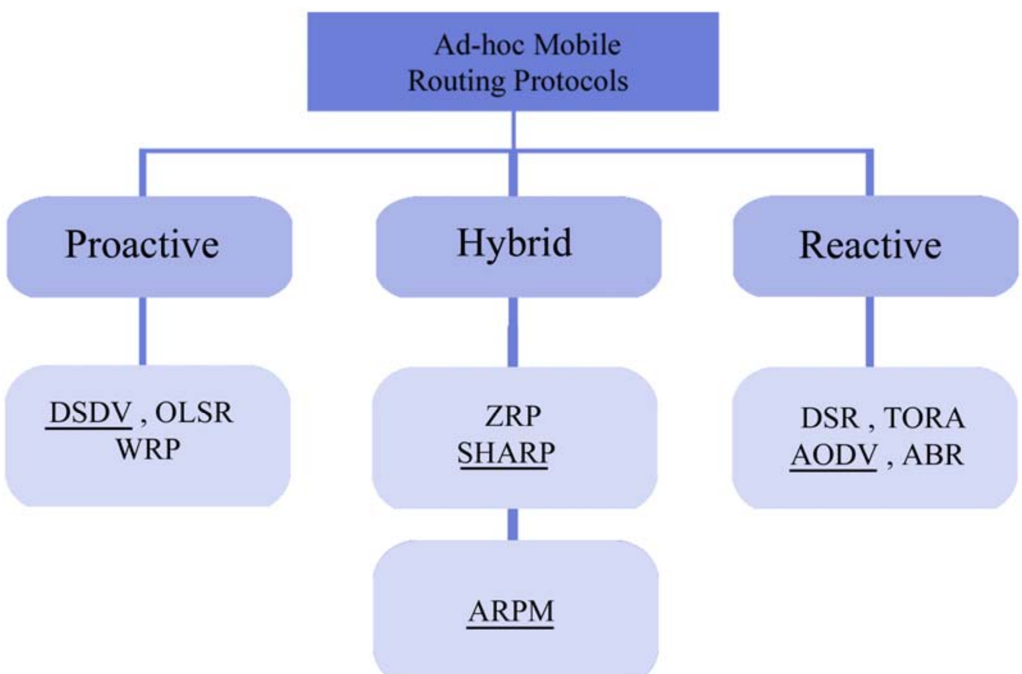


Fig.2.1.1 Some MANET's routing protocols

Proactive methods (table-driven) maintain fresh table by periodic updates for all routes to all nodes in the network including nodes that don't receive packets. Focus will be made on DSDV as an example of proactive routing approach in this research. However, some proactive routing protocols will be discussed:

- OLSR (table-driven routing protocol): is a reactive routing protocol based on optimized link-state scheme, which is based on multipoint relaying (MPR), MPR determines the routing information necessary to establish a connection between nodes in the network [6]. The routing information of nodes is periodically exchanged by using MPR [6].

- The Fisheye State Routing (FSR): is proactive routing protocol. FSR based on maintaining map at each node and propagates link state updates, it does not do flooding just determine neighbors and exchange with them the entire link state information. FSR does not need to frequently update the link state, because the link state exchange is periodical instead of event-triggered [1].

Reactive methods (on demand) do not maintain and constantly update their route tables, paths are established only when there is a need to forward packets, usually initiated by a source node. This research will focus on AODV as an example of reactive routing approach routing protocol, in addition to other reactive routing protocols:

- DSR: is a reactive routing protocol, DSR uses to make route to the destination two kinds of messages, route request (RREQ) and route request reply (RREP), these messages include the entire routing path information, when number of hops or node mobility increase, then additional overhead will be added due to generating large amount of route information [6].

- TORA is a reactive routing protocol; TORA introduces some improvement to proactive routing approaches. It is based on creating a directed acyclic graph (DAG), by this way TORA provide some useful facilities by offering fast and multiple routes to the destination with minimum overhead [20].

Hybrid methods combine or trade-off between proactive and reactive methods to find efficient routes, without much control overhead, I will focus in my research on SHARP routing protocol, but I will mention some hybrid routing protocol:

- Zone Routing Protocol (ZRP): is a hybrid routing protocol, ZRP based on dividing the network into zones these zones have a radius, intra-zone routing protocol (IZRP) which based on proactive routing approach and inert-zone routing protocol (IERP) which based on reactive routing approach, the routing is executed and implemented inside or outside a certain zone by IZRP and IERP, so ZRP is designed to find the balance between proactive and reactive routing approaches [1].

- The Location Aided Routing (LAR): is a hybrid routing protocol, based on determine location information for routing process, by location information LAR has been limited the area where route request is flooded [1].

- ARPM routing protocol is Tradeoff between reactive and proactive routing without a systematic clustering, so it’s not new routing protocol. It attempts to collect the advantages of proactive routing protocols approach and reactive routing protocols approach [5].

2.2 Proactive (DSDV) and reactive (AODV) routing protocols

As mentioned before, proactive routing protocol is the one in which all nodes attempt to gather and update a complete knowledge of paths to all other nodes in the network. In order to maintain correct route this is achieved by sending huge amount of control messages without matter if there are data traffic or not. By this way proactive routing protocol may waste bandwidth and increase overhead but at the same time it has fast way to discover the routing path by getting periodic routing information, and so this leads to reducing the delay.

2.2.1 DSDV

Proactive routing approach is based on traditional distance-vector and link-state protocols. Examples of proactive routing approach are: DSDV, WRP, TBRPF, and OLSR.

In this research, DSDV (Destination-Sequenced Distance Vector) has been selected as an example of proactive routing approach which is based on Bellman – Ford routing mechanism. In DSDV each node maintains routing table, which stores next hop towards each destination, a cost metric for the path to each destination, a destination sequence number that is created by the destination itself, and sequence numbers used to avoid formation of loops [20].

By routing tables, the packets are transmitted between nodes in the network, each node maintains its own sequence number, when neighborhood information is changed the routing information is updated this process happen periodically, this is necessary to avoid loops and to distinguish stale routes from new ones, figure 2.2.1.1 shows an example of DSDV .

Destination	Next hop	Number of hops	Sequence number	Install time
A	B	2	A550	T006_D
B	B	1	B080	T002_D
C	B	2	C800	T006_D
D	D	0	D801	T001_D
E	E	1	E555	T002_D

D's routing table

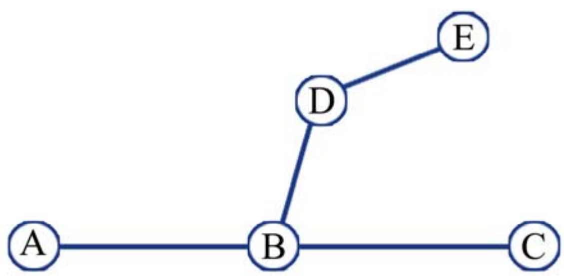


Fig.2.2.1.1 Five mobile nodes

Routing table for each node is updated by control messages, each node in the network periodically sends control messages to the neighbors Includes its own sequence number, route table update to tell the neighbors about the changes and to keep the table consistency.

When a certain node receives two routes to a destination from two different neighbors, it chooses the one with the greatest destination sequence number, but if equal, it chooses the route with smallest hop-count.

Periodic Routing table updates add some disadvantages such as creating lots of control traffic DSDV trying to solve or weaken this problem by using two types of routing update packets:

1. Full Dumps: by carrying all routing table information (Several NPDUs) and sending just relatively infrequent information.

2. Incremental Updates: Carry only information changed since last full dump, this way fits within one network protocol data unit (NPDU), but when updates can no longer fit in one NPDU, send full dump.

Ad hoc On-Demand Distance Vector (AODV) is a reactive routing protocol which keeps the routing information in each node so it defers the other reactive routing protocols. Additionally, it does not need to include total path for routing because the route process is calculated hop by hop.

AODV has higher performance than the other reactive routing protocols such as DSR by keeping routing information and routing table in each node.

2.2.2 AODV

2.2.2.1 AODV route discovery

When a node needs to determine a route to a destination node, its flooding route request RREQ. If a route exists, this node broadcasts a RREQ message to its neighboring nodes, which broadcast the message to their neighbors and so on. Otherwise, it saves the message in a message queue, and then it initiates the destination/intermediate node responds by sending a route reply (RREP) packet back to the source node using the reverse path established when the route request RREQ message is flooded to its neighbors. Since an intermediate node could have many reverse routes, it always picks the route with the smallest hop count. When a node receiving the request, either it knows a “fresh enough” route to the destination or it is the destination itself. As the RREP message passes through intermediate nodes, these nodes update their routing tables, so that in the future, messages can be routed through these nodes to the destination [20] [11].

Since an intermediate node could have many reverse routes, it always picks the route with the smallest hop count when a node receiving the request either, it knows a “fresh enough” route to the destination, or it is the destination itself.

When the source node receives the RREP, it establishes a forward path pointing to the destination node. The path from the source to the destination is established when the source receives the RREP.

Dealing with path failures in AODV is more complicated than in DSR. When a node detects the link failure to its next hop, it propagates a link failure notification message (an RREP with a very large hop count value to the destination) to each of its active upstream neighbors to inform them to erase that part of the route. These nodes in turn propagate the link failure notification message to their upstream neighbors, and so on, until the source node is reached.

A neighbor is considered active for a route entry if the neighbor sends a packet, which was forwarded using that entry, within the active route timeout interval. Note that the link failure notification message will also update the destination sequence number [11].

When the source node receives the link failure notification message, it will re-initiate a route discovery for the destination if a route is still needed. A new destination sequence number is used to prevent routing loops formed by the entangling of stale and newly established paths.

AODV saves bandwidth and performs well in a large MANET since a data packet does not carry the whole path information. As in DSR, the response time may be large if the source node's routing table has no entry to the destination and thus must discover a path before message transmission. Furthermore, the same problems exist as in DSR when network partitions occur.

To summarize the basic principles and objectives of AODV protocol which distinguish this reactive routing protocol about the other routing protocols; as its obvious AODV protocol initiates the discovery process just when it's needed by broadcasting the discovery packets, the distinguishing between local connectivity management and general topology maintenance is also one of the objectives of AODV protocol. In addition, it disseminates information about changes of local connectivity to those neighboring mobile nodes which are likely to need the information, in AODV each node has routing table, Sequence Number, and Broadcast-ID; routing table contain entries and each entry consists of destination address, next hop address, destination sequence number and hop count, sequence number a monotonically increasing counter used to maintain freshness information about the reverse route to the source, Broadcast-ID which is incremented whenever the source issues a new Route Request (RREQ) message [20].

2.2.2.2 AODV route maintenance

Each node is periodically monitoring a precursor list and an outgoing list.

A precursor list: is a set of nodes that route through the given node.

The outgoing list: is the set of next hops that this node routes through.

Each node does monitoring in order to detect route changes and different failures as follows:

- Failure of periodic HELLO messages:
- Failure or disconnect indication from the link level.
- Failure of transmission of packet to the next hop which can be detected by listening for the retransmission if it is not the final destination.

when a node sends HELLO messages to its precursors after it decides that no message has been sent to that precursor recently correspondingly, each node wait for an extended period of time to receive messages from each of its outgoing nodes if the node does not receive and the period for receiving the periodic messages is finished, then that node is presumed to be no longer reachable, then it removes all affected route entries and generates a Route Error (RERR) message which contains all destinations that have become unreachable and sends the RERR to each of its precursors to update their routing tables and turn forward the RERR to their precursors, and so on [11].

2.2.2.3 Example of AODV routing:

Figure 2.2.2.3.1 shows a wireless network with four nodes and its communication range, each node in the network can communicate only with its neighbors because of limited communication range.

Since node C is not neighbor of node A , then it will broadcast route request (RREQ) to it's neighbors, so node A will send (RREQ) to nodes B and D as shown in figure 2.2.2.3.2, when they receive the (RREQ), node B know the route to the destination, so it will send (RREP) to node A, but node D does not know the route to the destination, so it will broadcast (RREQ) to it's neighbors if there and will not send (RREP) to node A.

As we know a higher sequence number refer to fresher route because when the node send any type of messages, it will update it's sequence number, so when Node A is forwarding (RREP) to Node D. It notices that the route in the (RREP) has a better Sequence number than the route in its Routing List. Node a then replaces the route it currently has with the route in the Route Reply.

When node A receives the (RREP) from node B, it establishes a forward path pointing to the destination node. The path from node A to node C is established when the source (node A) receives the RREP from node B.

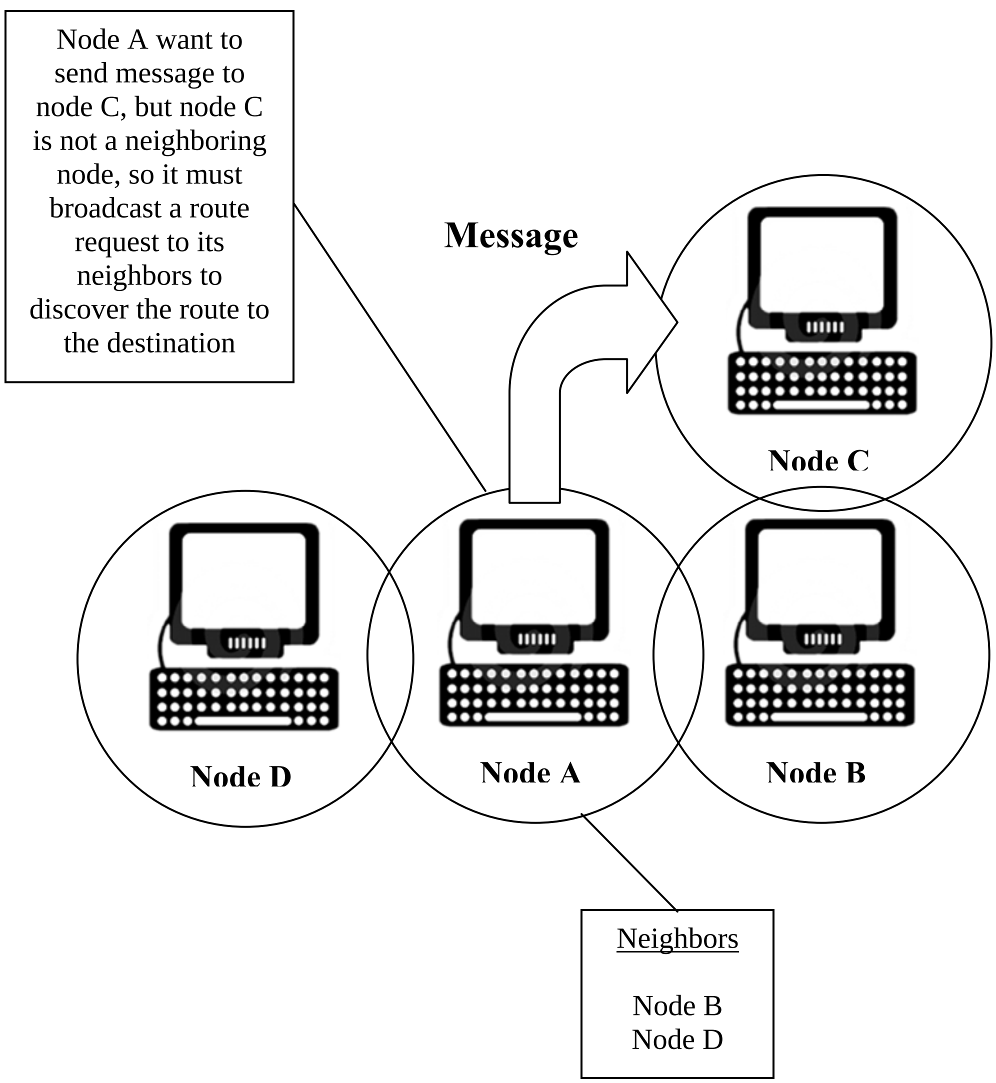


Fig.2.2.2.3.1 Wireless network with four nodes

Routing list			
node	Next hop	Seq #	Hop count
D	D	52	1
B	B	88	1
C	B	102	2

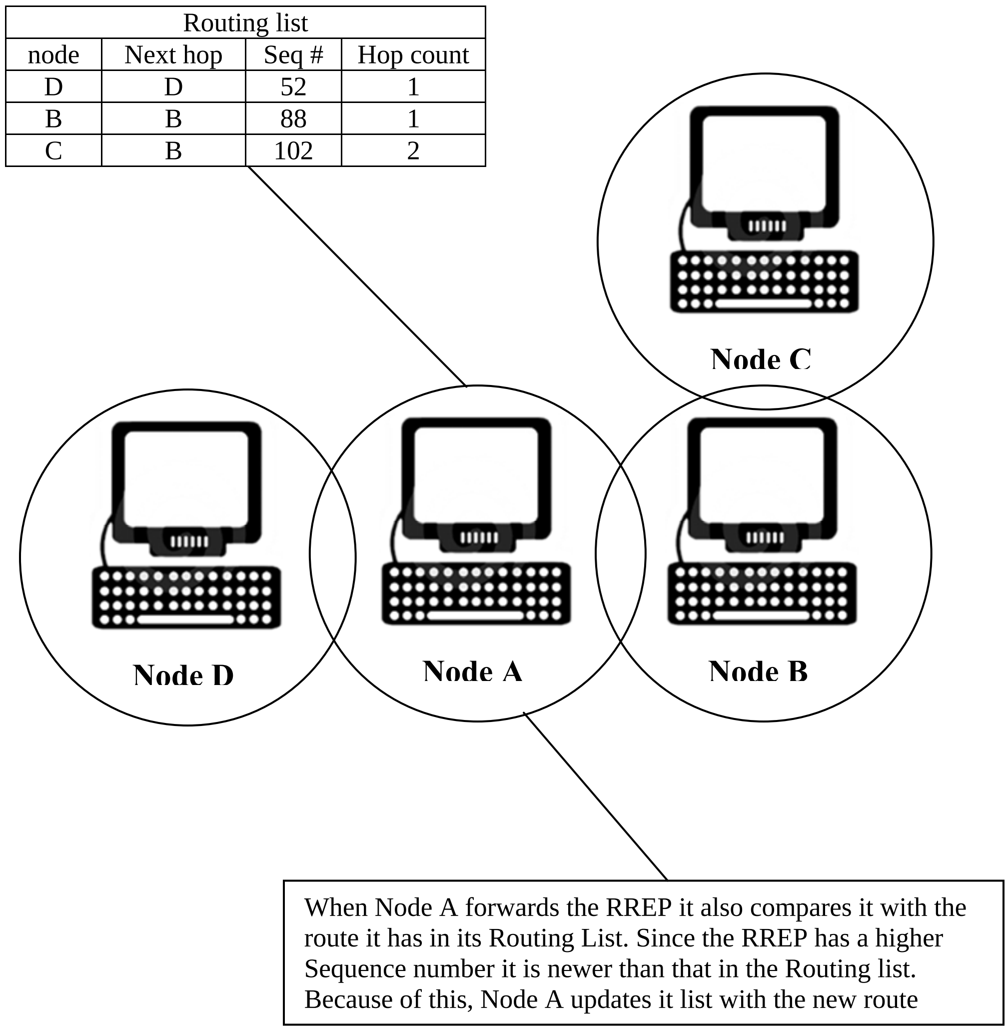


Fig.2.2.2.3.2 Wireless network with four nodes

2.3. Hybrid routing protocol (SHARP)

Hybrid protocols, such as ZRP, HARP, and ZHLS that combine proactive and reactive routing strategies, it attempts to collect the advantages of both reactive and proactive routing approaches.

There is a fundamental trade-off between proactive dissemination and reactive discovery of routing information.

Proactive protocols have some advantages such as the ability of providing low routing delay and good reliability through frequent dissemination of routing information, they entail high overhead and cause high volume of control traffic and its not suitable for large networks, reactive routing protocols can achieve low routing overhead, but may suffer from increased latency due to on-demand route discovery and route maintenance especially if the network has high mobility [5].

2.3.1 Sharp Hybrid Adaptive Routing Protocol (SHARP):

In MANET there have been many researches of proactive and reactive routing protocols, these researches try to solve the problems of dynamic topologies and traffic characteristics by proposing new routing protocols adapting between proactive and reactive routing protocols.

An example of these routing protocols is SHARP routing protocol which adaptively uses different routing protocols to get better performance, it combines reactive and proactive routing protocols to balance between the two and adapt the routing behavior according to traffic patterns.

The basic idea of SHARP is to create proactive routing zones around nodes which are linked by direct a cycle graph (DAG) routed at hot destination or around the most popular destination where there are lots of data traffic, and use reactive routing outside the proactive zone [3].

2.3.2 Sharp routing protocol characteristics and overview:

- Uses both reactive and proactive routing protocols.

- Adjusting the degree to which route information is propagated proactively or reactively, its self-driven process by SHARP based on determining the nodes working inside or outside zone, so each node in MANET with SHARP can independently determine the routing algorithm without matter in the routing algorithm of the other nodes based on the existence of this node inside or outside the zone.
- SHARP routing protocol adapts purely between reactive and proactive routing protocol based on MANET characteristics as attempt to increase the performance, to avoid high overhead of proactive routing protocol and high delay of reactive routing protocol.
- The node that has high popularity called (hot destination), SHARP creates proactive zones with node-specific zone-radius around hot destinations SHARP controls the performance of the routing protocol by dynamically adjusting the zone radius around each destination. Each destination node varies the size of the proactive zone around itself by taking into account the network characteristics, such as the mobility rate and the node-degree, as well as the data traffic characteristics, such as the number of sources and the distance of the sources from the destination.
- If the radius of zone equals r and the distance of a certain node from the zone equals d then if d<r the node maintains routes proactively and it's a member of the zone, if d>r the node maintains routes reactively.

- This enables SHARP to control different application specific performance metrics, such as routing overhead, loss rate, and delay jitter, and to have different nodes in the network that optimizes for different metrics simultaneously.
- SHARP is suitable and optimized for applications that exhibit spatial locality in their network communications because there are a head for each zone called hot destination participate the nodes in each route, so if the packets reach any node at zone periphery, SHARP amortizes the cost of maintaining routes to a given destination in proactive zone among all the sources that communicate with that destination node.
- The zone-radius at each destination is dynamically adapted based on incoming data traffic and mobility optimizing application specific goals; SHARP create relatively large zone around popular destination and relatively small zone around nodes that get little traffic.
- In SHARP as the radius of zone increases, the delay decreases and the reliability increases but will pay more in packet overhead in large zone.
- In SHARP as the radius of zone decreases, the overhead decrease and the delay increase, and the reliability also decrease because there will be more nodes work reactively.

2.4 ARPM: adaptive routing protocol for MANET

2.4.1 ARPM characteristics:

- ARPM based on the idea that the optimal routing lies between purely reactive and proactive routing, it's not new routing protocol. It uses the existing routing protocols as hybrid but does simply and efficiently [5].

- ARPM is suitable for all network applications (civilian, military, and commercial, personal) because it depends only on mobility and network topology.

- The routing in ARPM is automatic and independent on the routing of other nodes depending on the mobility and without a structure.

- Each node in ARPM measures single characteristic (mobility of the node) without need to disseminate it.

- ARPM routing activity exists in every area with a stable topology reducing the delay to find routes.

2.4.2 ARPM routing:

In MANET the nodes may have high mobility or low mobility, these two cases are separated by threshold, ARPM is dynamically switching between the two cases, which consider the node with high mobility behave reactively and the node with low mobility to behave proactively.

At the beginning each node works proactively and constructs routing tables and disseminates the routing information to neighboring nodes.

Each node observes the number of neighboring changes per time unit the target of this process is to determine the degree of mobility, if it detects that the neighboring change frequency exceeds a certain value called threshold, it stops its proactive behavior and switches to a reactive behavior.

The process of comparing the number of neighboring changes per time unit with threshold is executed by mobility evaluation function “fi”, which measures the degree of mobility of network is used, this function could be based on probabilistic model of network mobility.

Each node in the networks holds a mobility evaluation function "fi" that depends on the neighboring change frequency, so mobility evaluation function can be estimated locally by each node [5].

If ncf > d then

fi = true /* switch to a reactive activity*/

else fi = false; /*proactive activity*/end;

ncf: neighboring change frequency (number of neighboring changes per time unit).

d: a threshold

Mobility evaluation function

2.4.3 ARPM adaptation:

ARPM is switching between two approaches proactive and reactive in order to get the advantages of both, its adaptive routing protocol dynamically adapting the routing mechanism based on the degree of mobility of each node in the network.

All nodes with ARPM initiate the routing with proactive behavior and still working proactively as long as the mobility degree less than the threshold, if this condition changes (mobility degree greater than the threshold); the node stops its proactive behavior and dynamically eliminates routing tables and switch to reactive behavior.

By this way ARPM introduce some improvements:

- When a node detects that the neighboring change frequency exceeds a certain value (high mobility) called threshold, it stops its proactive behavior and switches to a reactive behavior, by this switching ARPM reduces the overhead and the volume of control traffic by reducing the number of control messages. In addition, measurement of the mobility degree is calculated locally by each node by mobility evaluation function, so the node does not require additional routing overhead to be calculated.

- When a node switching from proactive, it passes inactive mode as long as it does not involve in any route calculation, by this way ARPM may reduce power consumption.
- A reactive node still receiving routing table, if it detects low mobility it switches to proactive mode, by this way ARPM reduces the delay needed to set up the route and increases reliability.
- This switching process between proactive and reactive routing modes makes MANET to have nodes with proactive activity while others nodes with reactive activity, This feature accelerates route discovery for the reactive nodes because it stops flooding as soon as the route discovery flow meets some node or area in the network with a proactive activity that have a route for the destination sought for.
- ARPM is a trade off between reactive and proactive routing, the improvement vary between decreasing the delay or overhead, so the best improvement may be at the balance point; the point when the number of nodes behave proactively equal the number of nodes behave reactively.

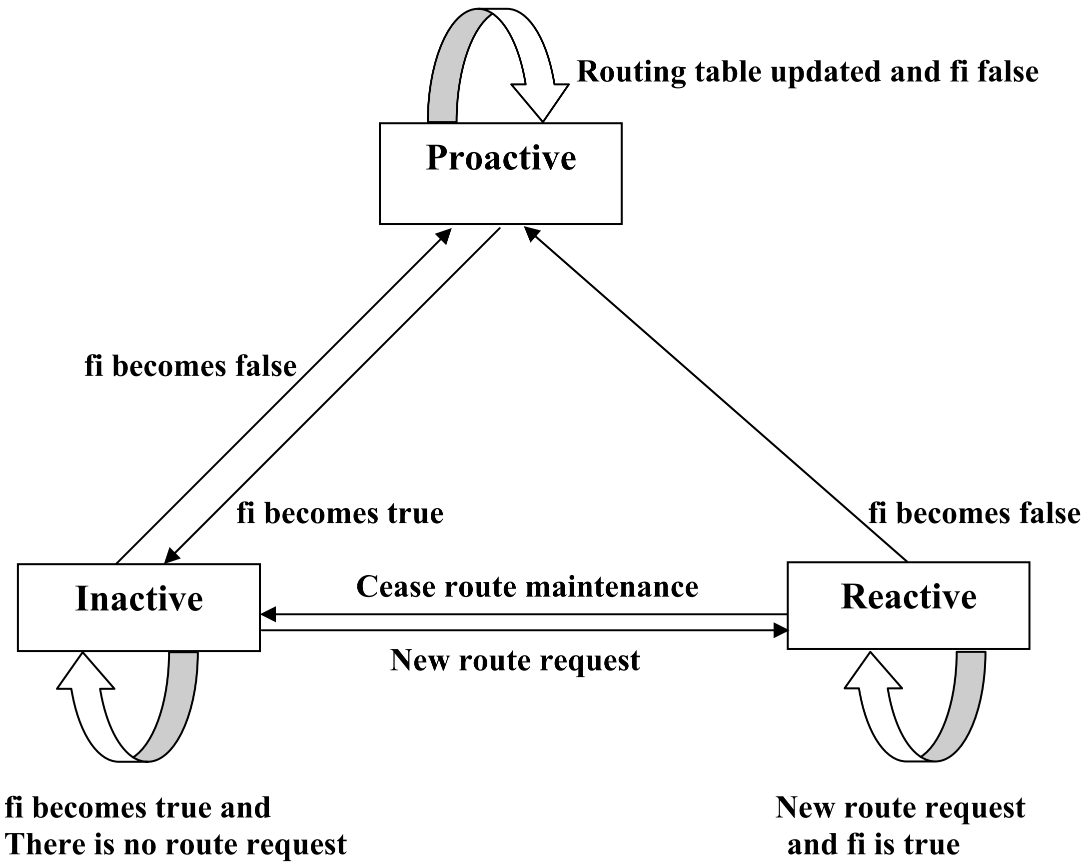


Fig.2.4.3.1 ARPM node states

2.4.4 ARPM nodes variations:

As obvious from the Fig.2.4.3.1 there are three states for the nodes in the network proactive, reactive and inactive:

- Proactive: if it is involved in routing tables and calculations.
- Reactive: if it does not ensure proactive routing table propagation even if it receives them.
- Inactive: when it enters a reactive mode of operation but is not involved in any route calculation process.

At the beginning all nodes in the network work proactively and disseminate the routing tables to neighbors when a node detects that neighbors mobility degree is high (fi high), it becomes reactive, if it is not already reactive, in this state:

- Does not disseminate routing information it eventually receives from proactive neighbors.
- The node uses reactive approach to discover a route if it is involved in a route calculation process.
- Otherwise it remains inactive.

When a node detects that neighbors mobility degree is low (fi false), a node resumes its proactive activity, and construct its routing tables with neighboring changes and, and then periodically broadcast them to its neighbors.

When a node receives a route request from a reactive node, it will respond immediately if it has ready a route to the destination, otherwise the node will behave reactively.

3.1 Simulation model

The research compared DSDV with AODV and the results were used as bases for analysis and conclusions, and three parameters have been used in the simulation:

1- Overhead: is the ratio of the number of routing, messages generated by a routing protocol to the number of received data packets at the destinations. This metric is a measure of how many routing messages are needed to receive one data packet. It captures the efficiency of the routing protocol.

2- Route discovery delay: is the average delay per packet, which is required to find the path from the source to the destination.

3- Throughput: throughput is a very important parameter in evaluating the modifications performance; it is calculated as the number of bits received per second.

Throughput is affected by the number of packets dropped or left wait for a route which is calculated as the summation of the number of packets dropped or left wait for a route for all the nodes.

Overhead, route discovery delay and throughput were studied for DSDV and AODV with varying the values of mobility degree, number of nodes, and speed of nodes. In this research the routing protocols are implemented in the network simulator GloMoSim (Global Mobile Information Systems Simulation Library). One routing protocol for each approach was selected; for proactive special concentration was made on DSDV, for reactive on AODV, and for hybrid on SHARP, in addition to ARPM.

Why GloMoSim?

GloMoSim is widely used in wireless network, its easy to educate because there are several free documentations, it has great features to create success and clear simulation:

- Scalable simulation environment using the parallel discrete-event simulation provided by parsec (C- based simulation language).

- Offers layered stack design.

- Offer the capability to determine the performance of alternative routing protocols during each layer

- Wide used in wireless network researches, various fields applicable in PAN, LAN, and MAN wireless networks.

3.2 simulations environments:

The seed of simulation equaled 1, terrain dimension 1000x1000 m, selection simulation time was 30 minutes, and the Position of nodes was read from NODE-PLACEMENT-FILE, mobility random-way point was selected, radio bandwidth was 2000000 and MAC protocol was 802.11

Simulation one: the parameter used in this part was overhead with changing the values of mobility four times, so simulation was done for four scenarios for each routing protocol, with minimum speed of 0 m/s to maximum speed of 10 m/s, number of nodes in the area were 70 nodes, and the mobility varies by changing the pause time as follow: 10, 40, 200, and 400 s.

Simulation two: the parameters used in this part were overhead, route discovery delay and throughput with changing the number of nodes, six scenarios were performed for each routing protocol, pause time was 40s, with minimum speed of 0 m/s to maximum speed of 10 m/s, number of nodes in this area varied as follow: 10, 30, 40, 50, 70 and 140 nodes.

Simulation three: the parameters used in this part were overhead, route discovery delay and throughput with changing the speed range of nodes, we executed five scenarios for each routing protocol, pause time was 40s, and number of nodes in this area was 70, the speed range varied as follow: 0-5, 5-10, 10-30, and 30-60 and 60-100 m/s.

Simulation four: the parameters used in this part were route discovery delay and throughput with changing the values of mobility four times, so four scenarios were executed for each routing protocol, number of nodes was 70 nodes, with minimum speed 0 m/s to maximum speed 10 m/s was selected, and the mobility varied by changing the pause time as follow: 2, 5, 10, and 20 s.

3.3 Simulations results:

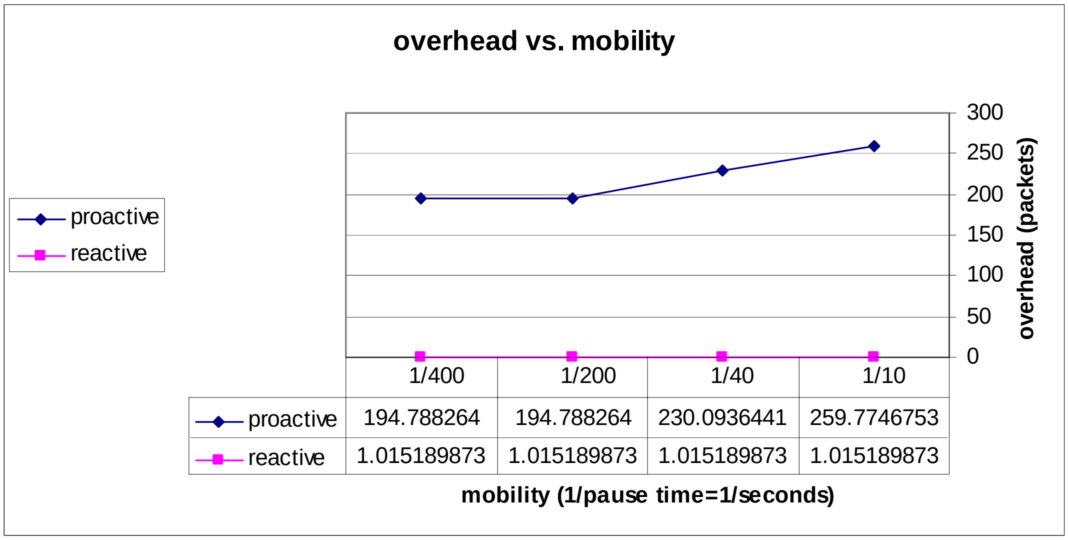
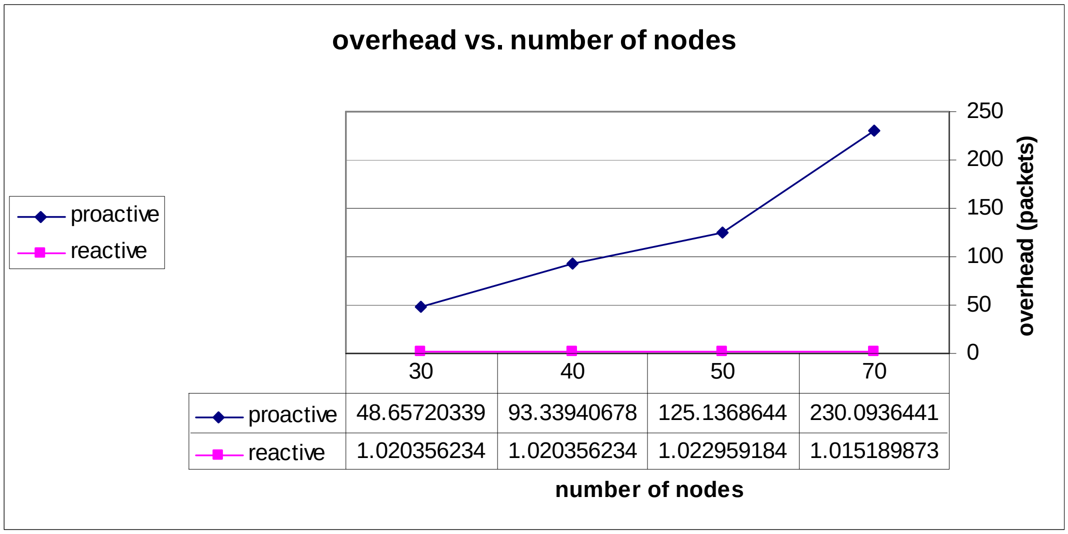


Fig.3.3.1 Overhead vs. mobility

☒ From Fig3.3.1 of simulation one we notes that for proactive the overhead increasing as the mobility of nodes in MANET increases, at very low mobility (1/40, 1/20) we notes that the overhead approximately constant, for reactive we notes that the overhead is constant and equal to 1.0151, when the mobility of nodes are increased, Fig.1 show that there are no impact of mobility on the overhead.



	30	40	50	70
proactive	48.65720339	93.33940678	125.1368644	230.0936441
reactive	1.020356234	1.020356234	1.022959184	1.015189873

Fig.3.3.2 Overhead vs. number of nodes

- From Fig.3.3.2 of simulation two we notes that for proactive when the MANET has large number of nodes this will cause huge overhead, as in figure when the number of nodes increasing from 30 to 70 nodes the overhead also increases approximately from 50 to 230 which is considered huge overhead, in contrast with reactive there are approximately no impact of number of nodes on the overhead, we find that the overhead ranging around 1.02 which is very low value compared with the overhead of proactive.

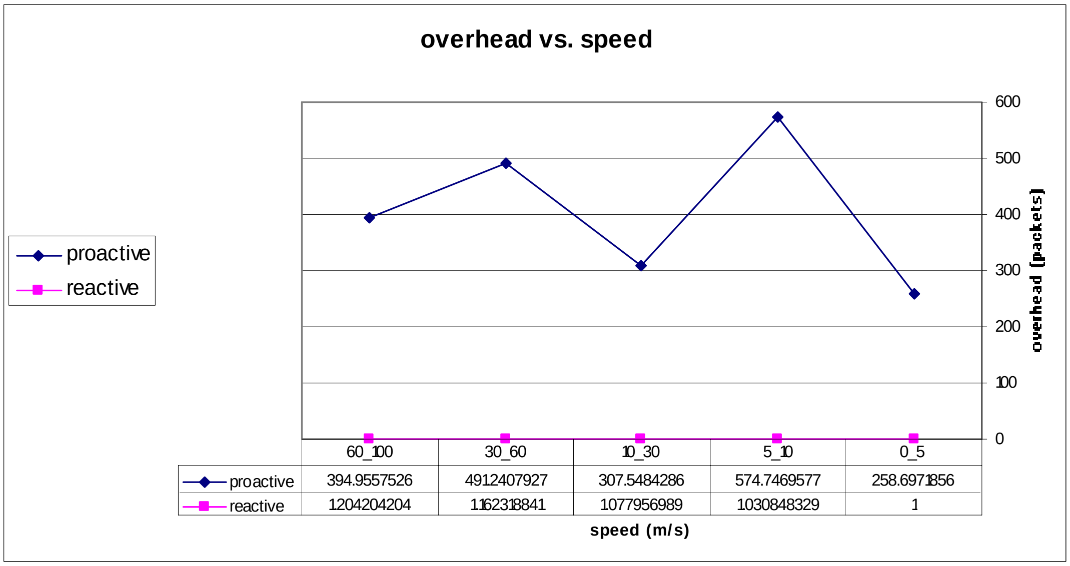
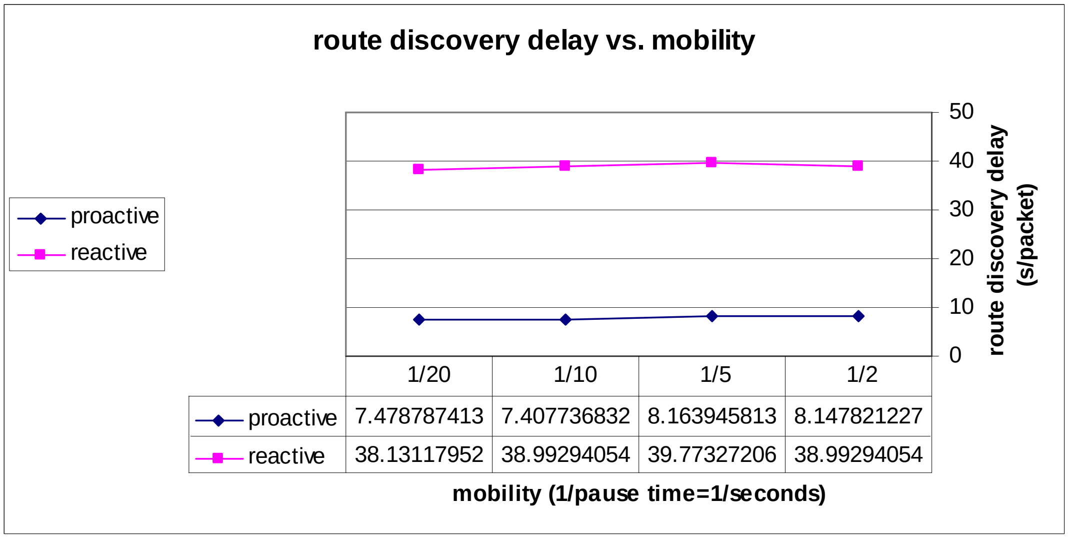


Fig.3.3.3 Overhead vs. speed of nodes

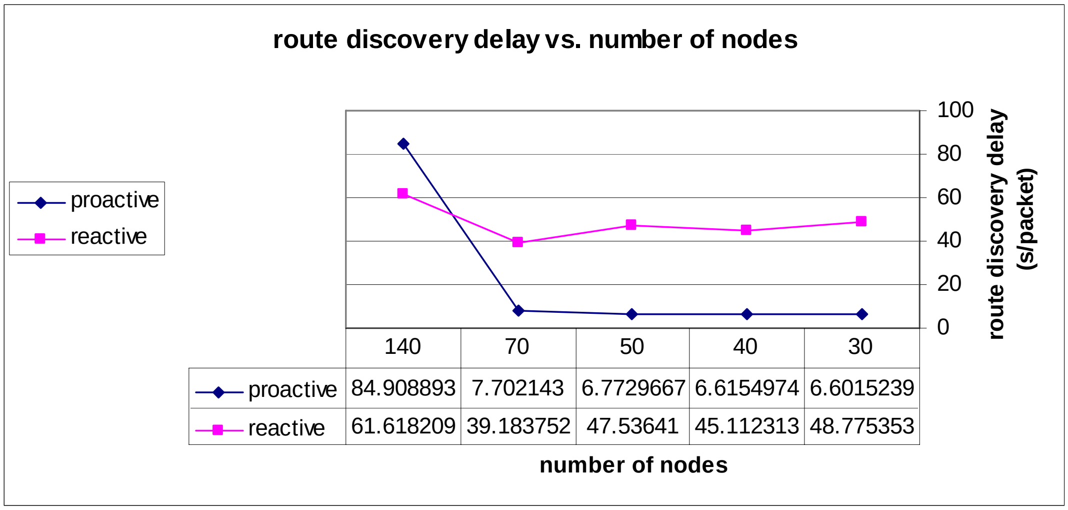
- From Fig.3.3.3 of simulation three we observe that for proactive the overhead rising and falling as we continue increasing the speed of nodes in MANET, so it is not obvious if there are a certain behavior between the speed of nodes and the overhead, it reach the maximum value of overhead at speed range 5 – 10 m/s and falling to smaller value of overhead at speed range 60 – 100 m/s, for reactive we notice that there are very low impact of speed on the overhead, when we increase the speed from range 0 – 5 m/s to 60 – 100 m/s we observe that the overhead increase from 1 to 1.2042, this increment is very small but continuous and without any interruption.



	1/20	1/10	1/5	1/2
proactive	7.478787413	7.407736832	8.163945813	8.147821227
reactive	38.13117952	38.99294054	39.77327206	38.99294054

Fig.3.3.4 Route discovery delay vs. mobility

- From Fig.3.3.4 of simulation four for proactive and reactive when we continuously increasing mobility we observe small changes in route discovery delay but without a certain behavior because it slightly rising and falling, for proactive we notice that the route discovery delay is very low and it can roughly be considered constant and ranging around 8s, for reactive we observe that that the route discovery delay is high and ranging around 39s.



	140	70	50	40	30
proactive	84.908893	7.702143	6.7729667	6.6154974	6.6015239
reactive	61.618209	39.183752	47.53641	45.112313	48.775353

Fig.3.3.5 Route discovery delay vs. number of nodes

- From Fig.3.3.5 of simulation two, for proactive by increasing the number of nodes from 30 nodes to 70 nodes we observe simple increment of route discovery delay, for reactive by increasing the number of nodes from 30 to 70, route discovery delay oscillating with simple differences without a certain behavior, but in any way and during this range, we notes that route discovery delay in reactive still greater than in proactive, when increasing the number of nodes to 170 nodes we observe a considerable increment in route discovery delay in case of proactive and reactive, and we observe that at 140 nodes the route discovery delay of proactive exceeds the value of route discovery delay in case of reactive.

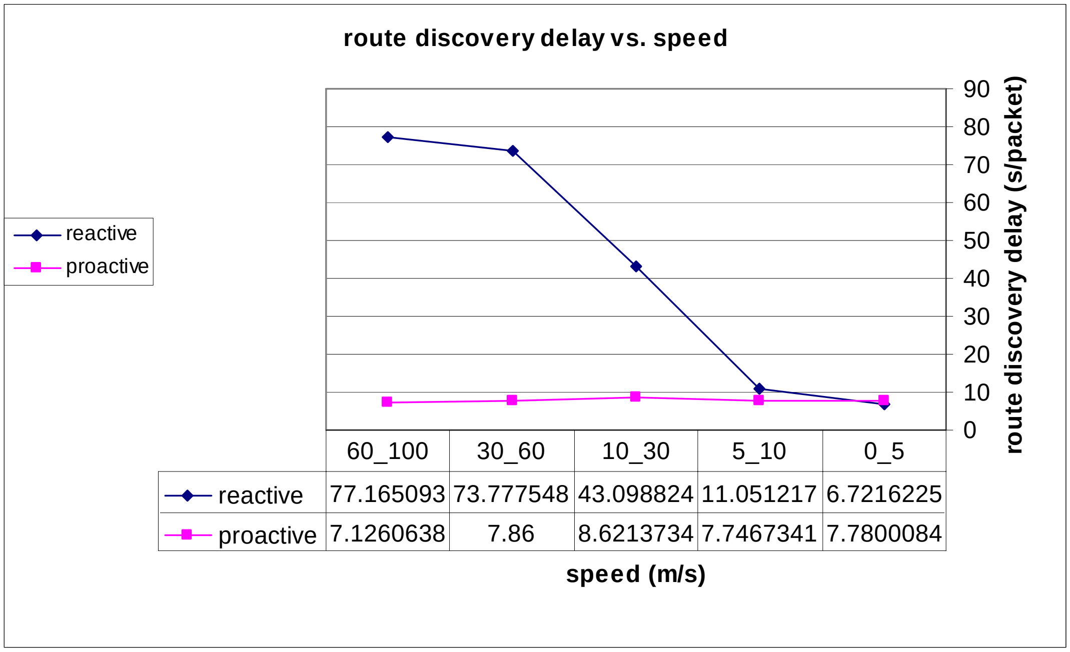
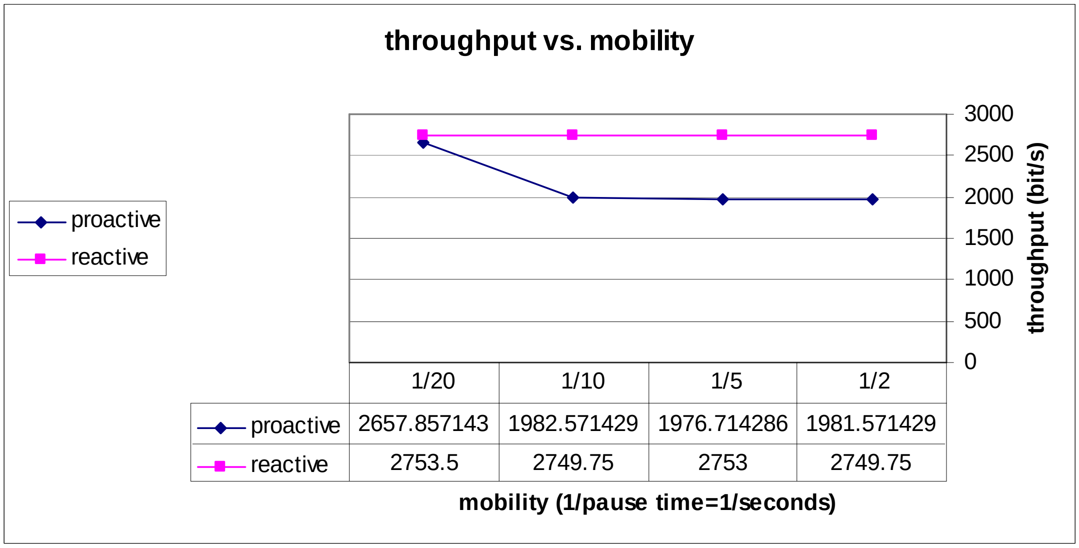


Fig.3.3.6 Route discovery delay vs. speed of nodes

- From Fig.3.3.6 of simulation three, for proactive we can roughly say that the route discovery delay is constant because it changing with very simple values raising and falling, but in case of reactive we observe that the route discovery delay is continuously increasing by large values when increasing the speed range of nodes, and in any way this figure shows that the route discovery during this range of speed for reactive is greater than the route discovery delay in case of proactive.



	1/20	1/10	1/5	1/2
proactive	2657.857143	1982.571429	1976.714286	1981.571429
reactive	2753.5	2749.75	2753	2749.75

Fig.3.3.7 Throughput of the actual data transmission vs. mobility

- From Fig.3.3.7 of simulation four we observe for proactive that throughput is constant during high values of mobility. When the mobility is decreased through values 1/10 and 1/20 we note that the throughput increase, while for reactive the throughput still constant at all values of mobility, but it is obvious that the throughput is higher in case of reactive from of proactive regardless of the values of mobility.

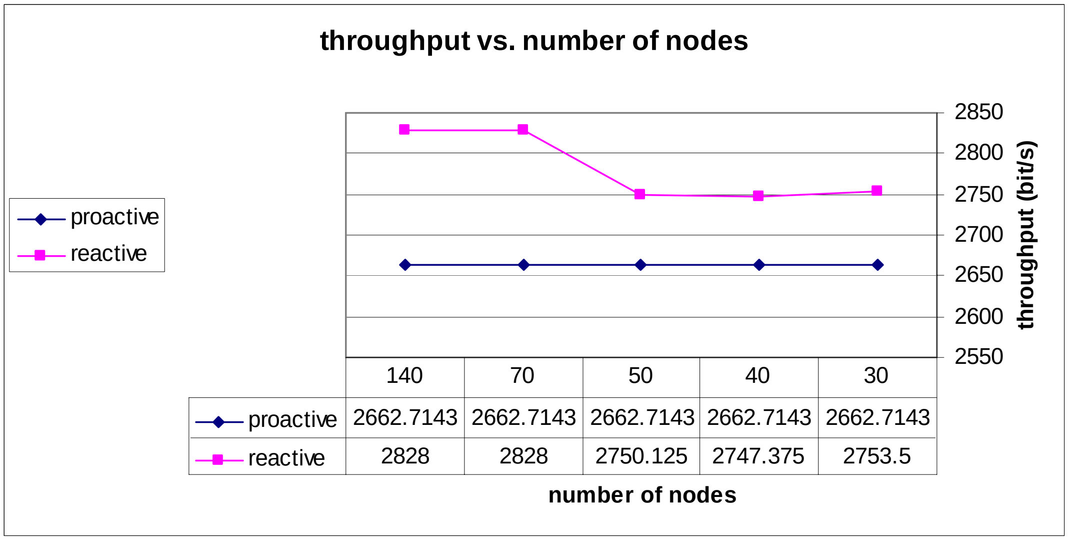


Fig.3.3.8 Throughput of the actual data transmission vs. number of nodes

- From Fig.3.3.8 of simulation two, for proactive the throughput still constant at 2662.714 bit/sec during changing the number of nodes from 30 nodes to 140 nodes, for reactive the throughput is higher than that in proactive, and it is constant or increasing slightly when increasing number of nodes.

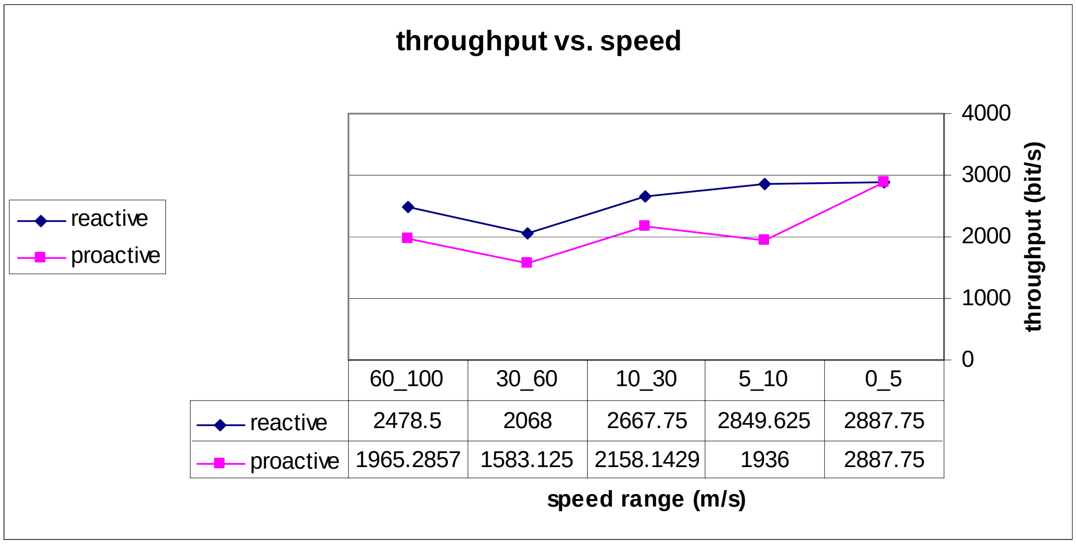


Fig.3.3.9 Throughput of the actual data transmission vs. speed of nodes

- From Fig.3.3.9 of simulation three, the throughput is still falling when increasing the speed range of nodes in case of proactive and reactive, but we can distinguish that the throughput is higher in case of reactive than that in proactive.

4.1 Comparisons and properties

Simulation was run for DSDV as an example of proactive routing approach and AODV as an example of reactive routing approach this simulation is executed for three parameters: overhead, route discovery delay and throughput, since SHARP and ARPM routing protocols use pure proactive and reactive routing approaches, the simulation is used as bases for completing my comparisons in addition to analyze the algorithm of routing protocols, all of that help me to analyze and discuss the properties, the comparisons and properties in comparative pattern in table one, two and three were showed, the entities in tables that signed by stars are considered as parameters, the other are considered as properties, the collection of parameters and properties construct the tables, which will be at the end my proposed simple reference (reference guide).

4.2 Table One (DSDV, AODV and SHARP routing protocols)

*Parameters / properties	Proactive routing protocol (DSDV)	Reactive routing protocol (AODV)	Hybrid routing protocol (SHARP)	Analysis / References
Route discovery	Periodic routing information updates.	Routing On demand, it delays route discovery until it is needed or required.	On demand outside the zone and proactively work inside the zone.	In proactive continuously discovers set of available routes for all nodes in the network. In the reactive the source discovers the desired distinction by sending RREQ and receiving RREP from the destination. SHARP is driven by fundamental trade-off between proactive and reactive.
Routing path	Periodically maintain a set of available routing paths for all nodes in the network	Routing path taken by routing reply	There is Multi-path routing by enabling SHARP which contain relatively short paths to the destination most of the time	In reactive the routing path mainly established when the source sends RREQ then receives RREP the destination for sending RREP uses the path determined in sending RREQ

*Parameters / properties	Proactive routing protocol (DSDV)	Reactive routing protocol (AODV)	Hybrid routing protocol (SHARP)	Analysis / References
***Route discovery delay**	Low, by periodic routing discovery, Proved by simulations tow, three and four	high because the route begin just on demand, Proved by simulations tow, three and four	Trade-off between proactive and reactive.	In proactive there are ready and available routing paths so the delay is low. In reactive a node does not perform route discovery or maintenance until it needs a route to another node or it offers its services as an intermediate node. SHARP at the beginning it acts as proactive so it has the same performance as proactive, after that and when constructing the DAGs the route discovery delay will depends on radius of DAGs and the mobility. Many simulations proved that SHARP trade-off between proactive and reactive so for high mobility, there are intermediate values of the zone radius where the route discovery delay is less than both, the purely reactive and the purely proactive routing components, for small values of the zone the route discovery delay will take its high values and vise versa.

*Parameters / properties	Proactive routing protocol (DSDV)	Reactive routing protocol (AODV)	Hybrid routing protocol (SHARP)	Analysis / References
*Throughput of the actual data transmissions	May be compromised. Proved by simulation 2,3 and 4	May be saved Proved by simulation 2,3 and 4	saved	At all conditions the throughput in SHARP is more saved than proactive and reactive because of multicast which increases the probability of receiving the packets.
*Overhead	(Huge overhead) because of frequent global flooding and if the mobility changes quickly overhead will increase, proved by simulation one, tow and three	Low overhead, it reduces routing overhead because they do not need to search for and maintain the routes on which there is no data traffic, proved by simulation one, tow and three	Some what high depending on mobility and the radius of DAGs. There are periodic maintaining DAGs and multi-path routing and overlapping which increase the overhead.	The overhead of reactive component gradually increases as the network becomes more mobile. The reactive component achieves low overhead when the mobility is low, while the proactive component incurs lower overhead when the mobility is high. For high mobility, there are intermediate values of the zone radius where the packet overhead is less than both, the purely reactive and the purely proactive routing components. Thus, no single value of zone radius is the best choice for all levels of mobility. (proved by simulation) [3]

*Parameters / properties	Proactive routing protocol (DSDV)	Reactive routing protocol (AODV)	Hybrid routing protocol (SHARP)	Analysis / References
Volume of Control traffic	High flooding of control messages	Low.	Some what low especially if the radius of DAGs is small.	In proactive Minimizes flooding of this control traffic by using only the selected MHs, called multipoint relays Only normal periodic control messages sent. In reactive the routing is only on demand so no much of control messages are needed. In proactive control messages sent only during periodic DAG reconstruction
Bandwidth	wasted	Highly saved bandwidth, especially if every data packet Carries the entire path information.	Slightly wasted specially inside the zone so if the radius is large more nodes act proactively and much bandwidth wasted.	Reactive Saves bandwidth especially during inactivity.

*Parameters / properties	Proactive routing protocol (DSDV)	Reactive routing protocol (AODV)	Hybrid routing protocol (SHARP)	Analysis / References
Power saving	Somewhat saved.	Somewhat saved.	Saved , The "node energy status" metric allows preferential avoidance of routes through battery-operated	Some simulation results indicates that reactive and proactive have approximately the same power saving, the power savings are similar and range between 25 percent and 60 percent of the total energy [4].
Functioning proactively	yes	no	Yes , inside zone	
Functioning reactively	no	yes	Yes , outside zone	
reliability	High because of flooding.	low	high	Reliability of SHARP is greater than it in proactive and reactive due to delivering the packets by multiple redundant paths, overlapping of DAGs and flooding in proactive which work locally.

*Parameters / properties	Proactive routing protocol (DSDV)	Reactive routing protocol (AODV)	Hybrid routing protocol (SHARP)	Analysis / References
scalability	Has problems, if we consider the number of nodes, see Fig.2 and Fig.5 we observe that the overhead and the route discovery delay is increasing when increasing number of nodes.	Good, if we consider the number of nodes, see Fig.2 and Fig.5 we observe that the overhead and the route discovery delay are approximately not affected by increasing number of nodes.	Good.	Reactive is scalable with respect to most parameters, proactive scales very well with respect to the frequency of the connections and the number of concurrent connections, SHARP is adaptive taking the advantages of both protocols so it's dealing with parameters more scalable.
Redundant route	Exist.	Do not exist.	High.	In SHARP high because of multiple redundant paths, in addition of overlapping of DAGs and SHARP locally work proactively so flooding will cause also redundant route. in proactive exist because of flooding and broadcast , Some computed routes may not be needed.

4.3 Table Two (DSDV, AODV and ARPM routing protocols)

*Parameters / properties	Proactive routing protocol (DSDV)	Reactive routing protocol (AODV)	Adaptive routing protocol for MANET (ARPM)	Analysis /References
Route discovery	Periodic routing information updates	Routing On demand.	It's accelerated.	ARPM does not require that all nodes have the same activity; nodes may be proactive or reactive depending on fi (mobility degree).
Routing path	Periodically maintain a set of available routing paths for all nodes in the network	Taken by routing reply.	Depending on mobility.	It determines the path by the periodic tables (does proactively) or by routing reply (does reactively) depending on fi.
***Route discovery delay**	Normal , by periodic routing maintenance, Proved by simulations two, three and four	Has a problem, , Proved by simulations two, three and four	At the beginning it's maintaining the routing proactively so both ARPM and proactive have the same performance but when the mobility increase ARPM takes trade-off between proactive and reactive.	In reactive a node does not perform route discovery or maintenance until it needs a route to another node or it offers its services as an intermediate node (proved by simulation) [5].

*Parameters / properties	Proactive routing protocol (DSDV)	Reactive routing protocol (AODV)	Adaptive routing protocol for MANET (ARPM)	Analysis /References
*Throughput of the actual data transmissions	May be compromised	May be saved	May be saved	At all conditions it will be better than proactive, but in comparison with reactive it depends on the mobility of nodes if it is low the throughput may be compromised greater than reactive.
*Overhead	(huge overhead) because of frequent global flooding and if the mobility changes quickly overhead will increase, proved by simulation one, two and three	Less overhead, it reduces routing overhead because they do not need to search for and maintain the routes on which there is no data traffic, proved by simulation one, two and three	Trade-off between proactive and reactive.	ARPM it starts the same performance as proactive and then as neighboring nodes changes increase the performance will be better than proactive and approaches to reactive behavior (proved by simulation) [5]

*Parameters / properties	Proactive routing protocol (DSDV)	Reactive routing protocol (AODV)	Adaptive routing protocol for MANET (ARPM)	Analysis /References
Volume of Control traffic	High flooding of control messages	Low, the routing is only on demand	Slightly Low, less than proactive and large than reactive especially if the mobility is high.	In proactive Minimizes flooding of this control traffic by using only the selected MHs, called multipoint relays Only normal periodic control messages sent.
Bandwidth	wasted	Exhaust limited bandwidth, especially if every data packet Carries the entire path information.	Exhaust slightly limited bandwidth, especially in reactive and inactive modes.	Wasted due to periodic updates, reactive Saves energy and bandwidth during inactivity.
power	Somewhat saved.	Somewhat saved.	Have roughly the same energy consumption with reactive.	Some simulation results indicate that reactive and proactive have approximately the same power saving [4].

*Parameters / properties	Proactive routing protocol (DSDV)	Reactive routing protocol (AODV)	Adaptive routing protocol for MANET (ARPM)	Analysis /References
Functioning proactively	yes	no	Yes , if the mobility is high	
Functioning reactively	no	yes	Yes , if the mobility is low	
reliability	high	low	Some what good at the beginning its working proactively	In proactive packets may be delivered to the destination on multiple paths.
scalability	Has a problem, see Fig.2 and Fig.5 we observe that the overhead and the route discovery delay is increasing when increasing number of nodes.	Good, see Fig.2 and Fig.5 we observe that the overhead and the route discovery delay are approximately not affected by increasing number of nodes.	Better than proactive and reactive.	Reactive is scalable with respect to most parameters , proactive scales very well with respect to the frequency of the connections and the number of concurrent connections, ARPM is adaptive taking the advantages of both protocols so its dealing with parameters more scalable.

*Parameters / properties	Proactive routing protocol (DSDV)	Reactive routing protocol (AODV)	Adaptive routing protocol for MANET (ARPM)	Analysis /References
Redundant route	Exist because of flooding and broadcast , Some computed routes may not be needed	Does not exist	Low , because the nodes that has high mobility will has redundant routes which work proactively especially at the beginning of establishing network	In reactive A simple flooding broadcast for route requests generates a considerable redundant packet overhead.

4.4 Table Three (SHARP and ARPM routing protocols)

*Parameters / properties	Hybrid routing protocol (SHARP)	Adaptive routing protocol for MANET (ARPM)	Analysis / References
Route discovery	If the source within the proactive zone routing is performed proactively but if the source outside it the route requests broadcast by AODV	The routing may be proactively or reactively depending on the mobility	ARPM shares SHARP the basic idea that the optimal routing lies between purely proactive and purely reactive routing.
Routing path	DAGs of SHARP contain relatively short paths to the destination most of the time, Multi-path routing, local link repairs and the construction protocol enables SPR to be a robust and efficient protocol.	Depending on mobility.	SHARP periodically updates and rebuilds the DAGs from scratch and it has the advantage of multi-path routing. But in ARPM simply the path is determined by periodic updates the routing tables (proactively) or by propagating the route query to its immediate neighbors when the connection is needed (reactively).

*Parameters / properties	Hybrid routing protocol (SHARP)	Adaptive routing protocol for MANET (ARPM)	Analysis / References
*Route discovery delay	At the beginning it acts as proactive so it has the same performance as proactive and as ARPM, after that and when constructing the DAGs the route discovery delay will depends on radius of DAGs.	At the beginning it's maintaining the routing proactively so both ARPM and proactive have the same performance but when the mobility increase ARPM takes trade-off between proactive and reactive (this is proved by simulation).	In SHARP routing protocol by increasing the radius the route discovery delay will be decreased because there will be more nodes will act proactively in the other hand when decreasing the radius the route discovery delay will be increased because there will be more nodes act reactively . So if we assume that radius equal zero then the route discovery delay will take its maximum value in this case ARPM will have better performance except when the mobility is very high in this case both may take the same performance but if we assume that radius equal diameter of the network then the route discovery delay will take its minimum value in this case SHARP will have better performance than ARPM except when the mobility is very low in this case both may take the same performance But when SHARP and ARPM take different values for radius and mobility the simulations proved that SHARP and ARPM trade-off between reactive and proactive.

*Parameters / properties	Hybrid routing protocol (SHARP)	Adaptive routing protocol for MANET (ARPM)	Analysis / References
*Throughput of the actual data transmissions	Has a high throughput.	Lower throughput than SHARP.	In SHARP Because of multi-path routing the chance for a packet to reach its destination is very high.
*Overhead	SHARP periodically updates and rebuilds the DAGs from scratch and it has the advantage of multi-path routing these make SHARP to have predictable overhead, in addition the overlapping regions share overhead. [3] By increasing the radius, SHARP will increase overhead to maintain routes in a larger zone. By decreasing the radius, SHARP can reduce routing overhead,	Trade-off between proactive and reactive. ARPM it starts the same performance as proactive and then as neighboring nodes changes increase the performance will be better than proactive and approaches to reactive behavior [3]	at the beginning all nodes act proactively in SHARP and in ARPM so both have the same performance, if we assume that the radius equal zero then the overhead will take minimum value and ARPM decreases overhead to the minimum value when the mobility is high but the performance of ARPM will be better than performance of SHARP because the periodic update and multi-path routing cause additional overhead. If we assume the radius equal the diameter of the network then overhead will take the maximum value, ARPM will take maximum value of overhead if the mobility is low but the performance of ARPM still better than SHARP the loss of DAGs and its rebuilding that produce additional overhead, another values for radius and mobility the simulations proved that SHARP and ARPM trade-off between proactive and reactive but ARPM still has better performance because of nonexistence of DAGs.

*Parameters / properties	Hybrid routing protocol (SHARP)	Adaptive routing protocol for MANET (ARPM)	Analysis / References
Volume of Control traffic	Little control traffic.	Less than SHARP especially if the mobility is very high because there will be huge number of nodes work reactively, but if we compare the worst case of SHARP when radius equal the diameter of the network and the worst case of ARPM when the mobility is very low in these two cases the control traffic will be high but in SHARP will be higher because of periodic constructing and maintaining DAGs.	SHARP nodes monitor traffic pattern and local network characteristics such as link failure rate and node degree, The zone sizes are then determined by each node in isolation solely based on local information. This control mechanism allows SHARP to shrink or grow the region of proactive routing; these measurements must be periodic and must be disseminated so all these require more control traffic. Whereas ARPM locally determine the proactive nodes automatically without constructing DAGs and without dissemination.

*Parameters / properties	Hybrid routing protocol (SHARP)	Adaptive routing protocol for MANET (ARPM)	Analysis / References
Bandwidth	considerable bandwidth is wasted	Exhaust slightly limited bandwidth, especially in reactive and inactive modes.	In SHARP the bandwidth is Wasted because of the fact that every packet is duplicated and sent on many different paths between the nodes.
Power saving	Somewhat saved, approximately near the values of proactive and reactive since it trades-off between them.	Have roughly the same saving of SHARP but because it has less traffic and overhead it may be more saving.	Some simulation results indicates that reactive and proactive have approximately the same power saving, the power savings are similar and range between 25 percent and 60 percent of the total energy [4].
Functioning proactively	Yes locally	Yes , if the mobility is high	
Functioning reactively	Yes outside zones	Yes , if the mobility is low	

*Parameters / properties	Hybrid routing protocol (SHARP)	Adaptive routing protocol for MANET (ARPM)	Analysis / References
reliability	High reliability	Some what good at the beginning its working proactively, and if the mobility is low because greater number of nodes will work proactively in which the packets may be delivered to the destination on multiple paths.	Reliability of SHARP is greater than it in ARPM due to delivering the packets by multiple redundant paths, overlapping of DAGs and flooding in proactive which work locally.
scalability	good	good	Reactive is scalable with respect to most parameters , proactive scales very well with respect to the frequency of the connections and the number of concurrent connections, SHARP and ARPM are adaptive taking the advantages of both protocols so its dealing with parameters more scalable.

*Parameters / properties	Hybrid routing protocol (SHARP)	Adaptive routing protocol for MANET (ARPM)	Analysis / References
Redundant route	High because of multiple redundant paths, in addition of overlapping of DAGs and SHARP locally work proactively so flooding will cause also redundant route.	Low , because the nodes that has low mobility will has redundant routes which work proactively especially at the beginning of establishing network	In ARPM if we assume that the mobility is very high then all nodes will work reactively so there is no redundant route , this case is similar to SHARP when the radius of DAG is equal zero, for the remainder values redundant route of SHARP will be greater because of the existence of multiple redundant paths and overlapping of DAGs.

Chapter five

5.1 Discussion

MANET is an ad hoc network with special properties (changing topology, mobility, security demands) for all of that, this kind of network needs special routing protocols.

Three phases of routing protocol had been proposed and introduced several solutions for MANET’s such as:

-Proactive approach

-Reactive approach

-Hybrid approach

And there is another routing protocol ARPM: adaptive routing protocol which introduces more solutions for MANET’s, it is not a new protocol it just uses proactive and reactive routing approaches, so it is considered an adaptive routing protocol. In this research an example of each routing approaches was discussed, so I did a review for DSDV, AODV, SHARP and ARPM.

This research strived to search a proper protocol that meets the needs of MANET by doing a comparison for some of routing protocols such as DSDV, AODV, SHARP and ARPM, this comparisons have been consolidated by doing simulation for bases including DSDV and AODV, in addition to analyze the algorithms of routing protocols.

The simulation for three parameters was executed, and listed in tables, and a property of these routing protocols was added to the tables, these completed tables form the simple reference (reference guide).

5.2 Conclusion and Future Work

From reviewing the tables we see at the beginning that AODV has some drawbacks that is not in DSDV and vise versa, simulation shows that the overhead in the network when using DSDV is very high and the route discovery delay is low, while the overhead in the network when using AODV is low and the route discovery delay high, this force the researchers to find other routing protocols that collect the advantages of both routing protocols such as SHARP and ARPM routing protocols, since these two protocols are adaptive routing protocols it is necessary that they will have better performance than both DSDV and AODV, this is proved by the analysis, and basic simulations and by some simulations that I referred to them in my discussion and tables.

The crucial comparison was between SHARP and ARPM routing protocols, since the nodes in the network may be either work proactively or reactively, the simulations help us know the performance result according to number of nodes work proactively or reactively, the route discovery delay in SHARP routing protocol depend on the radius of DAG's but in ARPM routing protocol it depends on mobility degree. At the beginning both has the same performance according to route discovery delay but after that the simulations proved that SHARP and ARPM trade-off between reactive and proactive. However, the process of constructing the DAG's and determining the popular destination need time which will cause some additional delay, the overhead at the beginning both SHARP and ARPM cause the same overhead but after that the mentioned simulations show that both trade-off between proactive and reactive depending on the radius of DAG's in SHARP and the mobility degree in ARPM, but the process of building and maintaining DAG's multi path routing and overlapping of DAG's add some overhead, whereas in case of ARPM it just makes the node evaluate single characteristics without dissemination , the throughput is better in case of AODV than in case of using DSDV, but for ARPM the throughput is always better than proactive unless if the mobility is very low it will be approximately the same, but the throughput of AODV is always better unless if the mobility is very high it will be approximately the same, the throughput in case of SHARP routing protocol is better than the throughput in case of ARPM routing protocol because of overlapping of DAG's and multi path routing.

The research shows that ARPM surpasses of SHARP by some parameters such as route discovery delay and overhead, but not by throughput.

In addition, we can note that AODV is better in case of large network, and DSDV is better in case of small network, as obvious by Fig.3.3.2 and Fig.3.3.5.

It is worthy to go deeply into the experimental side and by more parameters as a future work, also there are ARPM (agent-based routing protocol), may be useful to do a comparison between ARPM (adaptive routing protocol) and ARPM (agent based routing protocol) [6], in addition to develop this simple reference to make the education process of routing protocols simple and obvious by increasing number of parameters, properties, routing protocols and may be the tables to propose at the end complete and huge reference.

References

[1] Jakob Eriksson, Michalis Faloutsos, Srikanth Krishnamurthy, “Routing Scalability in MANETs”, Auerbach publications, 2006.

[2] Young J. Lee and George F. Riley , “A Workload-Based Adaptive Load-Balancing Technique for Mobile Ad Hoc Networks” , IEEE Wireless Communications and Networking Conference (WCNC) , 2005

[3] V. Ramasubramanian, Z. J. Haas, E. G¨un Sirer , “SHARP: A Hybrid Adaptive Routing Protocol for Mobile Ad Hoc Networks” , ACM new york , 2003

[4] Juan-carlos cano and pietro manzoni “Evaluating the Energy-Consumption Reduction in a MANET by Dynamically Switching-off Network Interfaces”, IEEE computer society Washington, DC, USA, 2001.

[5] H. L. seba “ARPM : an adaptive routing protocol for MANETs” , ACS/IEEE International Conference on Pervasive Services , 2006

[6] Manal Abdullah and Helen bakhsh “Agent-based dynamic routing system for MANETs”, ICGST-CNIR jornal, volume9, 2009

[7] Chi-kin chau, Jon crowcroft, Kang-won lee, starsky wong , “IDRM: Inter-domain routing protocol for mobile ad hoc networks”, UCAM-CL-TR-708 ISSN 1476-2986, university of Cambridge, 2008

[8] Nicklas beijar, “Zone Routing Protocol (ZRP)”, citeseerx.ist.psu.edu, university of technology, 2003

[9] Jing Xie, Luis Girons Quesada and Yuming Jiang, “A Threshold-based Hybrid Routing Protocol for MANET”, IEEE ISWCS, 2007

[10] J. Costa-Requena, T. Vardar, M. Ayyash and R. Kantola, “Scalable Hybrid Ad Hoc Routing Approach”, IJCSNS volume 6 no. 8, 2006

[11] Kwan-Wu Chin, John Judge, Aidan Williams and Roger Kermode “Implementation Experience with MANET Routing Protocols”, ACM new york volume 32, 2002

[12] F. aslam and Chi aching ooi, “Mobile Ad Hoc Networks”, www.docstoc.com, university of freiburg, 2007

[13] Zeinalipour-Yazti Demetrios “A Glance at Quality of Services in Mobile Ad-Hoc Networks” citeseer.ist.psu.edu, 2005

[14] Asis Nasipuri and Samir R. Das, “On-Demand Multipath Routing for Mobile Ad Hoc Networks”, ACM volume 6 , 2001

[15] Imrich Chlamtac, Marco Conti, Jennifer J.-N. Liu, “Mobile ad hoc networking: imperatives and challenges”, ad hoc networks volume 1 no.1, 2003

[16] P.sholander A. yankopolus and P. coccoli, “Experimental comparison of hybrid and proactive MANET routing protocols”, milcom 2002 proceedings, 2002

[17] Sunsook Jung, Nisar Hundewale, Alex Zelikovsky, “Energy Efficiency of Load Balancing in MANET Routing Protocols”, IEEE computer society, 2005.

[18] L. Bajaj, Mineo Takai, R. Ahuja, K. Tang, R. Bagrodia, M. Gerla, “GloMoSim: A Scalable Network Simulation Environment”, citeseer.ist.psu.edu, 1999

[19] A. H. abd rahman and z. ahmad zukarnain, “Performance Comparison of AODV, DSDV and I-DSDV Routing Protocols in Mobile Ad Hoc Networks”, European Journal of Scientific Research Vol.31 No.4, 2009

[20] Tao Lin, “Mobile Ad-hoc Network Routing Protocols: Methodologies and Applications”, Verginia polytechnic institute and state university, 2004

[21] K. Chin, “The Behavior of MANET routing protocols in realistic environments”, Telecommunications Information Technology Research Institute, 2005

Appendix

This appendix shows one case of the simulation, tries to illustrate, how we do the comparison between DSDV and AODV routing protocols, this case was executed in Simulation two, the parameters used in this part are overhead, route discovery delay and throughput with changing the number of nodes, I executed six scenarios for each routing protocol, I used simulation time 30 minutes, and the seed of simulation equal 1, terrain dimension 1000x1000 m, the pause time is 40 s, the Position of nodes is read from NODE-PLACEMENT-FILE, I choose mobility random-way point with minimum speed o m/s to maximum speed 10 m/s, radio bandwidth is 2000000, MAC protocol is 802.11, number of nodes in this area are varied is follow: 10, 30, 40, 50, 70 and 140 nodes.

But in this case I will illustrate the throughput when changing number of nodes to 30 nodes.

Figure 1 and 2 in the appendix are parts of a file called config.in file which contain all parameters, you can notes in the file how the number of nodes is changed to 30 nodes, and setting the routing protocol to be DSDV, we can replace DSDV to AODV to do the comparison.

```
#
SEED                1

#
# The following two parameters stand for the physical terrain in which the nodes
# are being simulated. For example, the following represents an area of size 100
# meters by 100 meters. All range parameters are in terms of meters.
#
# Terrain Area we are simulating.
#

TERRAIN-DIMENSIONS  (1000, 1000)

#
# The following parameter represents the number of nodes being simulated.
#

NUMBER-OF-NODES     30

#
#
#The following parameter represents the node placement strategy.
#- RANDOM: Nodes are placed randomly within the physical terrain.
#- UNIFORM: Based on the number of nodes in the simulation, the physical
#  terrain is divided into a number of cells. Within each cell, a node is
#  placed randomly.
#- GRID: Node placement starts at (0, 0) and are placed in grid format with
#  each node GRID-UNIT away from its neighbors. The number of nodes has to be
#  square of an integer.
#- FILE: Position of nodes is read from NODE-PLACEMENT-FILE. On each line of
#  the file, the x and y position of a single node is separated by a space.
#
```

Fig.1

```
##############################
#
# Currently the only choice.

NETWORK-PROTOCOL    IP
NETWORK-OUTPUT-QUEUE-SIZE-PER-PRIORITY 100

#RED-MIN-QUEUE-THRESHOLD 150
#RED-MAX-QUEUE-THRESHOLD 200
#RED-MAX-MARKING-PROBABILITY 0.1
#RED-QUEUE-WEIGHT .0001
#RED-TYPICAL-PACKET-TRANSMISSION-TIME 64000NS


##############################
#


ROUTING-PROTOCOL    BELLMANFORD
#ROUTING-PROTOCOL    AODV
#ROUTING-PROTOCOL    DSR
#ROUTING-PROTOCOL    LAR1
#ROUTING-PROTOCOL    WRP
#ROUTING-PROTOCOL    FISHEYE

#ROUTING-PROTOCOL    ZRP
#ZONE-RADIUS         2

#ROUTING-PROTOCOL    STATIC
#STATIC-ROUTE-FILE   ROUTES.IN
```

Fig.2

This file is nodes.input contains 30 nodes.

```
#
# NODE-PLACEMENT-FILE
# Format: nodeAddr 0 (x, y, z)
# The second parameter is for the consistency
# with the mobility trace format.
#
```

```
0  50s (18.2,  1, 0.2)
1  100s (20.3, 30.8, 0.01)
2  100S (20.4, 60.7, 0.12)
3  100S (20, 90.6, 0.05)
4  50s (18.2,  1, 0.2)
5  100s (40.3, 30.8, 0.01)
6  100S (20.7, 60.7, 0.12)
7  100S (20, 96.6, 0.05)
8  50s (18.2,  5, 0.2)
9  100s (20.3, 30.7, 0.01)
10  100S (20.4, 60.9, 0.12)
11 100S (20, 90.6, 0.1)
12  50s (18.2,  1, 0.7)
13  100s (20.3, 30.8, 0.03)
14  100S (20.4, 60.7, 0.18)
15  100S (20, 90.8, 0.05)
16  50s (18.2,  5, 0.2)
17  100s (20.3, 30.5, 0.01)
18  100S (20.4, 60.5, 0.12)
19  100S (20, 56.6, 0.05)
20  50s (18.2,  1, 5.2)
21  100s (20.3, 30.8, 6.01)
22  100S (20.4, 60.7, 6.12)
23  100S (26, 90.0, 0.05)
24  50s (18.7,  1, 0.2)
25  100s (20.3, 36.8, 0.51)
26  100S (21.4, 69.7, 0.12)
27  100S (20, 90.6, 9.05)
28  50s (18.2,  1, 0.6)
29  100s (20.3, 60.8, 0.01)
```

Mobility.in file is used to do a certain pattern of movement but we choose random mobility, so this file just contains the nodes with the locations.

```
#
# mobility trace format:
# node-address simclock destination(x y z)
# All lines for a node must be sorted in time increasing order.
#
0  50s (18.2,  1, 0.2)
1  100s (20.3, 30.8, 0.01)
2  100S (20.4, 60.7, 0.12)
3  100S (20, 90.6, 0.05)
4  50s (18.2,  1, 0.2)
5  100s (40.3, 30.8, 0.01)
6  100S (20.7, 60.7, 0.12)
7  100S (20, 96.6, 0.05)
8  50s (18.2,  5, 0.2)
9  100s (20.3, 30.7, 0.01)
10  100S (20.4, 60.9, 0.12)
11 100S (20, 90.6, 0.1)
12  50s (18.2,  1, 0.7)
13  100s (20.3, 30.8, 0.03)
14  100S (20.4, 60.7, 0.18)
15  100S (20, 90.8, 0.05)
```

```
16  50s (18.2,  5, 0.2)
17  100s (20.3, 30.5, 0.01)
18  100S (20.4, 60.5, 0.12)
19  100S (20, 56.6, 0.05)
20  50s (18.2,  1, 5.2)
21  100s (20.3, 30.8, 6.01)
22  100S (20.4, 60.7, 6.12)
23  100S (26, 90.0, 0.05)
24  50s (18.7,  1, 0.2)
25  100s (20.3, 36.8, 0.51)
26  100S (21.4, 69.7, 0.12)
27  100S (20, 90.6, 9.05)
28  50s (18.2,  1, 0.6)
29  100s (20.3, 60.8, 0.01)
```

Finally we run config.in file, glomo.stat file shows the statistics that we need, all statistics were copied to excel file and the average of throughput was calculated, and same steps must be done for AODV, the last column shows the average of throughput.

2662.714	180	Number of routing table broadcasts	RoutingBellmanf	Layer	0	Node
	241	Number of routing table trigger updates	RoutingBellmanf	Layer	0	Node
	6377	Number of routing table updates	RoutingBellmanf	Layer	0	Node
	6377	Number of routing packets received from UDP	RoutingBellmanf	Layer	0	Node
	21	(0) Client address	AppCbrServer	Layer	0	Node
	91.39306	(0) First packet received at [s]	AppCbrServer	Layer	0	Node
	247.3931	(0) Last packet received at [s]	AppCbrServer	Layer	0	Node
	0.003155	(0) Average end-to-end delay [s]	AppCbrServer	Layer	0	Node
	Closed	(0) Session status	AppCbrServer	Layer	0	Node
	100352	(0) Total number of bytes received	AppCbrServer	Layer	0	Node
	196	(0) Total number of packets received	AppCbrServer	Layer	0	Node
5146	5146	(0) Throughput (bits per second)	AppCbrServer	Layer	0	Node
	1)	from 0 to 1 (cid	AppFtpClient	Layer	0	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	1	Node
	269	Number of routing table trigger updates	RoutingBellmanf	Layer	1	Node
	5327	Number of routing table updates	RoutingBellmanf	Layer	1	Node

5327	Number of routing packets received from UDP	RoutingBellmanf	Layer	1	Node
2)	from 0 to 1 (cid	AppFtpServer	Layer	1	Node
180	Number of routing table broadcasts	RoutingBellmanf	Layer	2	Node
267	Number of routing table trigger updates	RoutingBellmanf	Layer	2	Node
3302	Number of routing table updates	RoutingBellmanf	Layer	2	Node
3302	Number of routing packets received from UDP	RoutingBellmanf	Layer	2	Node
1)	from 2 to 3 (cid	AppTelnetClient	Layer	2	Node
180	Number of routing table broadcasts	RoutingBellmanf	Layer	3	Node
231	Number of routing table trigger updates	RoutingBellmanf	Layer	3	Node
6685	Number of routing table updates	RoutingBellmanf	Layer	3	Node
6685	Number of routing packets received from UDP	RoutingBellmanf	Layer	3	Node
2)	from 2 to 3 (cid	AppTelnetServer	Layer	3	Node
180	Number of routing table broadcasts	RoutingBellmanf	Layer	4	Node
287	Number of routing table trigger updates	RoutingBellmanf	Layer	4	Node
5703	Number of routing table updates	RoutingBellmanf	Layer	4	Node
5703	Number of routing packets received from UDP	RoutingBellmanf	Layer	4	Node
180	Number of routing table broadcasts	RoutingBellmanf	Layer	5	Node
225	Number of routing table trigger updates	RoutingBellmanf	Layer	5	Node
6707	Number of routing table updates	RoutingBellmanf	Layer	5	Node
6707	Number of routing packets received from UDP	RoutingBellmanf	Layer	5	Node
180	Number of routing table broadcasts	RoutingBellmanf	Layer	6	Node
260	Number of routing table trigger updates	RoutingBellmanf	Layer	6	Node
5599	Number of routing table updates	RoutingBellmanf	Layer	6	Node
5599	Number of routing packets received from UDP	RoutingBellmanf	Layer	6	Node
180	Number of routing table broadcasts	RoutingBellmanf	Layer	7	Node

	227	Number of routing table trigger updates	RoutingBellmanf	Layer	7	Node
	6804	Number of routing table updates	RoutingBellmanf	Layer	7	Node
	6804	Number of routing packets received from UDP	RoutingBellmanf	Layer	7	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	8	Node
	242	Number of routing table trigger updates	RoutingBellmanf	Layer	8	Node
	6241	Number of routing table updates	RoutingBellmanf	Layer	8	Node
	6241	Number of routing packets received from UDP	RoutingBellmanf	Layer	8	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	9	Node
	254	Number of routing table trigger updates	RoutingBellmanf	Layer	9	Node
	5065	Number of routing table updates	RoutingBellmanf	Layer	9	Node
	5065	Number of routing packets received from UDP	RoutingBellmanf	Layer	9	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	10	Node
	237	Number of routing table trigger updates	RoutingBellmanf	Layer	10	Node
	6670	Number of routing table updates	RoutingBellmanf	Layer	10	Node
	6670	Number of routing packets received from UDP	RoutingBellmanf	Layer	10	Node
	28	(0) Server address	AppCbrClient	Layer	10	Node
	82.49	(0) First packet sent at [s]	AppCbrClient	Layer	10	Node
	197.49	(0) Last packet sent at [s]	AppCbrClient	Layer	10	Node
	Closed	(0) Session status	AppCbrClient	Layer	10	Node
	24064	(0) Total number of bytes sent	AppCbrClient	Layer	10	Node
	47	(0) Total number of packets sent	AppCbrClient	Layer	10	Node
1674	1674	(0) Throughput (bits per second)	AppCbrClient	Layer	10	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	11	Node
	232	Number of routing table trigger updates	RoutingBellmanf	Layer	11	Node
	5883	Number of routing table updates	RoutingBellmanf	Layer	11	Node
	5883	Number of routing packets received from	RoutingBellmanf	Layer	11	Node

		UDP				
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	12	Node
	260	Number of routing table trigger updates	RoutingBellmanf	Layer	12	Node
	6299	Number of routing table updates	RoutingBellmanf	Layer	12	Node
	6299	Number of routing packets received from UDP	RoutingBellmanf	Layer	12	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	13	Node
	262	Number of routing table trigger updates	RoutingBellmanf	Layer	13	Node
	2284	Number of routing table updates	RoutingBellmanf	Layer	13	Node
	2284	Number of routing packets received from UDP	RoutingBellmanf	Layer	13	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	14	Node
	222	Number of routing table trigger updates	RoutingBellmanf	Layer	14	Node
	5703	Number of routing table updates	RoutingBellmanf	Layer	14	Node
	5703	Number of routing packets received from UDP	RoutingBellmanf	Layer	14	Node
	17	(0) Server address	AppCbrClient	Layer	14	Node
	107.8	(0) First packet sent at [s]	AppCbrClient	Layer	14	Node
	273.9	(0) Last packet sent at [s]	AppCbrClient	Layer	14	Node
	Closed	(0) Session status	AppCbrClient	Layer	14	Node
	77824	(0) Total number of bytes sent	AppCbrClient	Layer	14	Node
	152	(0) Total number of packets sent	AppCbrClient	Layer	14	Node
3748	3748	(0) Throughput (bits per second)	AppCbrClient	Layer	14	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	15	Node
	241	Number of routing table trigger updates	RoutingBellmanf	Layer	15	Node
	6055	Number of routing table updates	RoutingBellmanf	Layer	15	Node
	6055	Number of routing packets received from UDP	RoutingBellmanf	Layer	15	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	16	Node
	248	Number of routing table trigger updates	RoutingBellmanf	Layer	16	Node
	5638	Number of routing	RoutingBellmanf		16	Node

		table updates		Layer		
	5638	Number of routing packets received from UDP	RoutingBellmanf	Layer	16	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	17	Node
	248	Number of routing table trigger updates	RoutingBellmanf	Layer	17	Node
	5193	Number of routing table updates	RoutingBellmanf	Layer	17	Node
	5193	Number of routing packets received from UDP	RoutingBellmanf	Layer	17	Node
	14	(0) Client address	AppCbrServer	Layer	17	Node
	107.8031	(0) First packet received at [s]	AppCbrServer	Layer	17	Node
	228.8031	(0) Last packet received at [s]	AppCbrServer	Layer	17	Node
	0.003098	(0) Average end-to-end delay [s]	AppCbrServer	Layer	17	Node
	Not closed	(0) Session status	AppCbrServer	Layer	17	Node
	56832	(0) Total number of bytes received	AppCbrServer	Layer	17	Node
	111	(0) Total number of packets received	AppCbrServer	Layer	17	Node
268	268	(0) Throughput (bits per second)	AppCbrServer	Layer	17	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	18	Node
	240	Number of routing table trigger updates	RoutingBellmanf	Layer	18	Node
	6494	Number of routing table updates	RoutingBellmanf	Layer	18	Node
	6494	Number of routing packets received from UDP	RoutingBellmanf	Layer	18	Node
	16	(0) Server address	AppCbrClient	Layer	18	Node
	70	(0) First packet sent at [s]	AppCbrClient	Layer	18	Node
	95	(0) Last packet sent at [s]	AppCbrClient	Layer	18	Node
	Closed	(0) Session status	AppCbrClient	Layer	18	Node
	3072	(0) Total number of bytes sent	AppCbrClient	Layer	18	Node
	6	(0) Total number of packets sent	AppCbrClient	Layer	18	Node
983	983	(0) Throughput (bits per second)	AppCbrClient	Layer	18	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	19	Node
	231	Number of routing table trigger updates	RoutingBellmanf	Layer	19	Node

	5925	Number of routing table updates	RoutingBellmanf	Layer	19	Node
	5925	Number of routing packets received from UDP	RoutingBellmanf	Layer	19	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	20	Node
	266	Number of routing table trigger updates	RoutingBellmanf	Layer	20	Node
	5208	Number of routing table updates	RoutingBellmanf	Layer	20	Node
	5208	Number of routing packets received from UDP	RoutingBellmanf	Layer	20	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	21	Node
	257	Number of routing table trigger updates	RoutingBellmanf	Layer	21	Node
	5746	Number of routing table updates	RoutingBellmanf	Layer	21	Node
	5746	Number of routing packets received from UDP	RoutingBellmanf	Layer	21	Node
	0	(0) Server address	AppCbrClient	Layer	21	Node
	91.39	(0) First packet sent at [s]	AppCbrClient	Layer	21	Node
	247.39	(0) Last packet sent at [s]	AppCbrClient	Layer	21	Node
	Closed	(0) Session status	AppCbrClient	Layer	21	Node
	100352	(0) Total number of bytes sent	AppCbrClient	Layer	21	Node
	196	(0) Total number of packets sent	AppCbrClient	Layer	21	Node
5146	5146	(0) Throughput (bits per second)	AppCbrClient	Layer	21	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	22	Node
	272	Number of routing table trigger updates	RoutingBellmanf	Layer	22	Node
	5009	Number of routing table updates	RoutingBellmanf	Layer	22	Node
	5009	Number of routing packets received from UDP	RoutingBellmanf	Layer	22	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	23	Node
	242	Number of routing table trigger updates	RoutingBellmanf	Layer	23	Node
	6747	Number of routing table updates	RoutingBellmanf	Layer	23	Node
	6747	Number of routing packets received from UDP	RoutingBellmanf	Layer	23	Node
	180	Number of routing	RoutingBellmanf		24	Node

	table broadcasts		Layer		
233	Number of routing table trigger updates	RoutingBellmanf	Layer	24	Node
6517	Number of routing table updates	RoutingBellmanf	Layer	24	Node
6517	Number of routing packets received from UDP	RoutingBellmanf	Layer	24	Node
180	Number of routing table broadcasts	RoutingBellmanf	Layer	25	Node
253	Number of routing table trigger updates	RoutingBellmanf	Layer	25	Node
4506	Number of routing table updates	RoutingBellmanf	Layer	25	Node
4506	Number of routing packets received from UDP	RoutingBellmanf	Layer	25	Node
180	Number of routing table broadcasts	RoutingBellmanf	Layer	26	Node
263	Number of routing table trigger updates	RoutingBellmanf	Layer	26	Node
5197	Number of routing table updates	RoutingBellmanf	Layer	26	Node
5197	Number of routing packets received from UDP	RoutingBellmanf	Layer	26	Node
180	Number of routing table broadcasts	RoutingBellmanf	Layer	27	Node
249	Number of routing table trigger updates	RoutingBellmanf	Layer	27	Node
5906	Number of routing table updates	RoutingBellmanf	Layer	27	Node
5906	Number of routing packets received from UDP	RoutingBellmanf	Layer	27	Node
180	Number of routing table broadcasts	RoutingBellmanf	Layer	28	Node
238	Number of routing table trigger updates	RoutingBellmanf	Layer	28	Node
6100	Number of routing table updates	RoutingBellmanf	Layer	28	Node
6100	Number of routing packets received from UDP	RoutingBellmanf	Layer	28	Node
10	(0) Client address	AppCbrServer	Layer	28	Node
82.49306	(0) First packet received at [s]	AppCbrServer	Layer	28	Node
197.4931	(0) Last packet received at [s]	AppCbrServer	Layer	28	Node
0.003417	(0) Average end-to-end delay [s]	AppCbrServer	Layer	28	Node
Closed	(0) Session status	AppCbrServer	Layer	28	Node
24064	(0) Total number of bytes received	AppCbrServer	Layer	28	Node

	47	(0) Total number of packets received	AppCbrServer	Layer	28	Node
1674	1674	(0) Throughput (bits per second)	AppCbrServer	Layer	28	Node
	180	Number of routing table broadcasts	RoutingBellmanf	Layer	29	Node
	267	Number of routing table trigger updates	RoutingBellmanf	Layer	29	Node
	4349	Number of routing table updates	RoutingBellmanf	Layer	29	Node
	4349	Number of routing packets received from UDP	RoutingBellmanf	Layer	29	Node

After repeating the scenario for AODV in the same environment, the figure for DSDV and AODV was plotted as in figure 3 in the appendix.

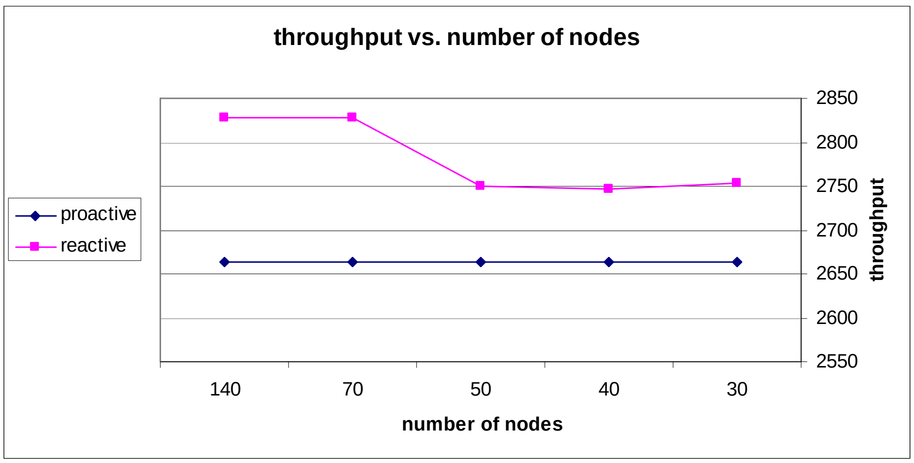


Fig.3

ملخص الرسالة

تتسم بالخصائص التالية: شبكات عن عبارة العشوائي هي التوجيه ذات المتنقلة الشبكات أن

- ليس لها بنيه تحتية.
- وتتكون من عدة نقاط متحركة مرتبطة عبر وصلات لاسلكية.
- هذه النقاط يمكنها التحرك بحرية وتقوم بتنظيم نفسها بصورة ذاتية.

الانتشار نطاق العشوائي بالإضافة إلى التوجيه ذات اللاسلكية المتنقلة الشبكات ديناميكية إن التنبؤ على المقدرة عدم عن فضلا مركزية، إدارة وجود الشبكات وعدم لهذا النوع من المحدود واختبار لمصممي تحد ومواضيع نقاط الآن حتى للتوسع تظل القابلة الشبكات داخل التنقل بحرية .التوجيه بروتوكولات

ذات التوزيع هذا طبيعة إن كما .والمفاجئ المستمر للتغيير الشبكات تخضع توزيع طبيعة إن تتسم التوجيه مشكلة تجعل الطاقة وقيود الاتصال قناة سعة محدودية الشديدة إلى جانب الديناميكية .بالتحدي

المتعلقة القرارات اتخاذ عند الاعتبار في هذه المشاكل التوجيه بروتوكولات تأخذ أن يجب حيث هي و المتعلقة بالشبكات الرئيسية القضايا أهم من واحدة تعد التوجيه بروتوكولات إن .بالتوجيه .اتصال بينهما نقطتين بين مسار أفضل تحديد عن المسئولة

لكن حتى الآن ما زالت الأبحاث تتوالى في محاولة لتطوير أو إيجاد بروتوكول يتعامل مع التحديات الصعبة للشبكات اللاسلكية المتحركة, إن وجود عدد كبير من بروتوكولات التوجيه في عدد كبير من الأبحاث جعل عملية التعلم و التعليم و إدراك هذه البروتوكولات أمرا صعبا.

لهذا فقد تم التركيز في البحث على إيجاد بروتوكول توجيه يتمتع بأداء عالي عن طريق عمل مقارنة بين أربع بروتوكولات من البروتوكولات ألمعروفه و هي : AODV, DSDV, SHARP, ARPM

بالإضافة إلى التركيز على عمل مرجع تعليمي بسيط يسهل عملية التعلم و التعليم للبروتوكولات و كذلك سوف يتم عمل لائحة بكل المتغيرات و الخصائص التي سوف يتم استخدامها في البحث و تعريفها و توضيحها بشكل كامل.

سوف يحتوي البحث على ثلاثة جداول تضم هذه المقارنات و تشكل في النهاية المرجع المطلوب, بحيث تحتوي هذه الجداول على ثلاثة متغيرات خاصة بالمقارنة و بالإضافة إلى عدد من الخصائص, عملية التحقق من النتائج سوف تكون بثلاثة طرق : التحليل, المحاكاة, بالإضافة الاستفادة من أبحاث سابقة و ذكرها في المراجع.