MANET Routing Protocols: Comparative Study*

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ملخص:

إن الشبكات المتنقلة ذات التوجيه العشوائي هي عبارة عن شبكات لاسلكية تتسم بالخصائص الآتية:

١. ليس لها بنيه تحتية.

٢. وتتكون من نقاط عدة متحركة مرتبطة عبر وصلات لاسلكية.

٣. هذه النقاط يمكنها التحرك بحرية، وتقوم بتنظيم نفسها بصورة ذاتية.

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

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

من هنا ينبغي أن تأخذ بروتوكولات التوجيه هذه المشكلات في الاعتبار عند اتخاذ القرارات المتعلقة بالتوجيه. إن بروتوكولات التوجيه تعد واحدة من أهم القضايا الرئيسة المتعلقة بالشبكات، وهي المسؤولة عن تحديد أفضل مسار بين نقطتين بينهما اتصال .

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 والتعليم، وإدراك هذه البروتوكولات أمراً صعباً.

لذلك ركَّز الباحثان على إجراء مقارنة لأربعة برتوكولات AODV, DSDV, SHARP, ARPM لدراسة مدى مقدرة كل منها على معالجة المشكلات التي تواجه هذا النوع من الشبكات.

ستكون عملية التحقق من النتائج بثلاث طرق: التحليل، والمحاكاة باستخدام Glomosim، بالإضافة إلى الاستفادة من أبحاث سابقة ذكرت في المراجع.

وفي النهاية سوف يحتوي البحث على ثلاثة جداول تضم هذه المقارنات، ومن خلال تحليلها يمكن استنتاج برتوكول يتمتع بأداء عالٍ، مقارنة بالبرتوكولات الأخرى التي عُولجت في البحث تبعاً للمتغيرات، وتشكل في النهايةً المرجع المطلوب، بحيث تحتوي هذه الجداول على ثلاثة متغيرات خاصة بالمقارنة يمكن الاستفادة منها في عملية التعلم والتعليم.

Abstract:

The interest in this research will be the routing Protocols and routing protocol approaches of MANET (mobile ad hoc network) which must be able to keep up with the high degree of node mobility and unpredictable network topology. These routing protocols include ARPM.

The research will gradually search for more efficient protocol from:

1. DSDV (destination-sequenced distance vector).

2. AODV (ad-hoc on-demand distance vector).

3. SHARP (sharp hybrid adaptive routing protocol).

4. ARPM (adaptive routing protocol).

This search will be done by theoretical and experimental comparison which will imply simulations of DSDV and AODV by GloMoSim (Global Mobile Information Systems Simulation Library). This simulation will be exploited as basis for completing the analysis and getting conclusions. In addition, we will use some available comparisons in other researches.

Introduction:

Problem definition and solution:

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 face several challenges such as:**

- 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.
- 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.

Several amounts of researches have been proposed on developing skillful protocols specified to minimizing the drawbacks of MANET so, **this research 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 Sc HARP routing as hybrid routing protocol.

To find the solution, the research will gradually do the comparison 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.

Related works:

V. Ramasubramanian, Z. J. Haas and E. G¨un Sirer (2003) introduced the Sharp Hybrid Adaptive Routing Protocol (SHARP), which automatically finds the balance point between proactive and reactive routing by adjusting the degree to which route information is propagated proactively versus the degree to which it needs to be discovered reactively.

Simulation studies showed that the resulting protocols outperformed the purely proactive and purely reactive protocols across a wide range of network characteristics[3].

Abdul Hadi Abd Rahman and Zuriati Ahmad Zukarnain (2009). In that paper three protocols AODV, DSDV and I-DSDV were simulated using NS-2 package and were compared in terms of packet delivery ratio, end to end delay and routing overhead in different environment; varying number of nodes, speed and pause time. Simulation results showed that I-DSDV compared with DSDV, reduced the number of dropped data packets with little increased overhead at higher rates of node mobility but couldn't compete with AODV in higher node speed and number of node[6].

H. Largraa Seba (2006) proposed an efficient protocol, called ARPM, which maintained good performance by adapting the routing process to the mobility of nodes.

Simulation results showed that ARPM protocol was more efficient than existing proactive and reactive protocols[5].

It is obvious that there are many papers which compared DSDV protocol with AODV, and SHARP with DSDV and AODV. The last paper compared the behavior of ARPM protocol with pure on demand routing protocol and pure proactive protocol.

This research compares routing protocols (DSDV, AODV, SHARP and ARPM) which includes the protocols which are now in the study such as an adaptive routing protocol ARPM, in comparison with SHARP by three parameters, **and verifying each piece of information by analyzing:**

- The algorithms of mentioned protocols.
- Simulation of DSDV and AODV as base of the analysis.
- Available simulations were used with mentioning it's origins as references.

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

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

The research takes DSDV 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 [7].

By AODV, when a node needs to determine a route to a destination node, its flooding RREQ (route request). 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 RREP (route reply) packet back to the source node using the reverse path established when the route request RREQ message is flooded to its neighbors.[7][8]

Hybrid routing protocol (SHARP):

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

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 DAG (direct a cycle graph) 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]

ARPM: adaptive routing protocol for MANET:

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 that the node with high mobility behave reactively and the node with low mobility 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.[5]

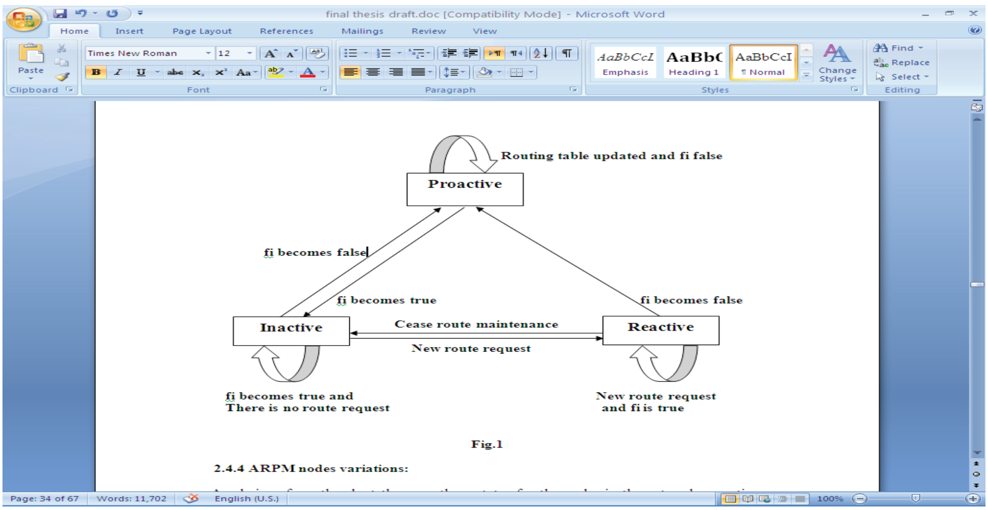
The process of comparing the number of neighboring changes per time unit with threshold is executed by mobility evaluation function fi as follows:

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



Node state chart

Simulation:

The research compared DSDV with AODV and the results were used as bases for analysis and conclusions, **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.

The routing protocols are implemented in the network simulator GloMoSim.

Why GloMoSim?

GloMoSim is widely used in wireless network. It is 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.
- Offers the capability to determine the performance of alternative routing protocols during each layer.
- Widely used in wireless network researches, various fields applicable in PAN, LAN, and MAN wireless networks.

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, The 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 the 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. The 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.

Simulations results:

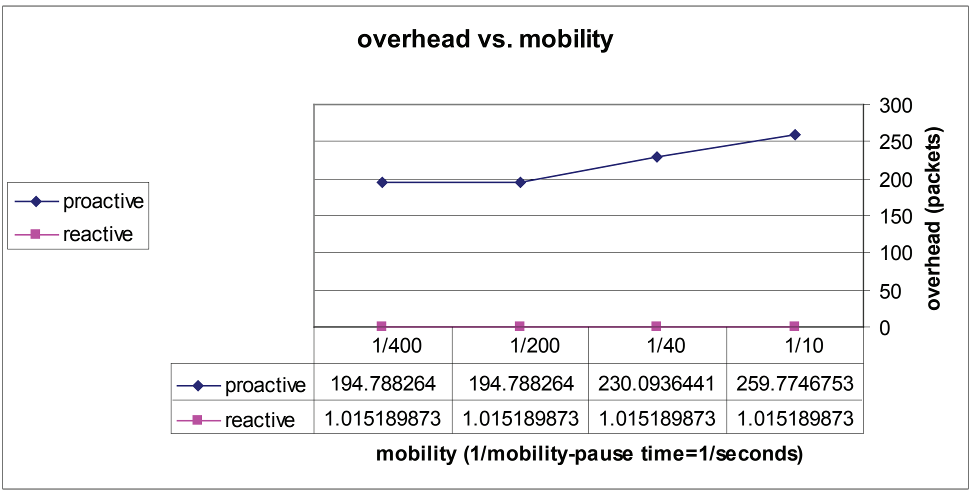


Fig.1 Overhead vs. mobility

From Fig1 of simulation one, we note that for proactive the overhead increasing as the mobility of nodes in MANET increases, at very low mobility (1/40, 1/20). It is clear that the overhead approximately constant, for reactive it is clear that the overhead is constant and equal to 1.0151.

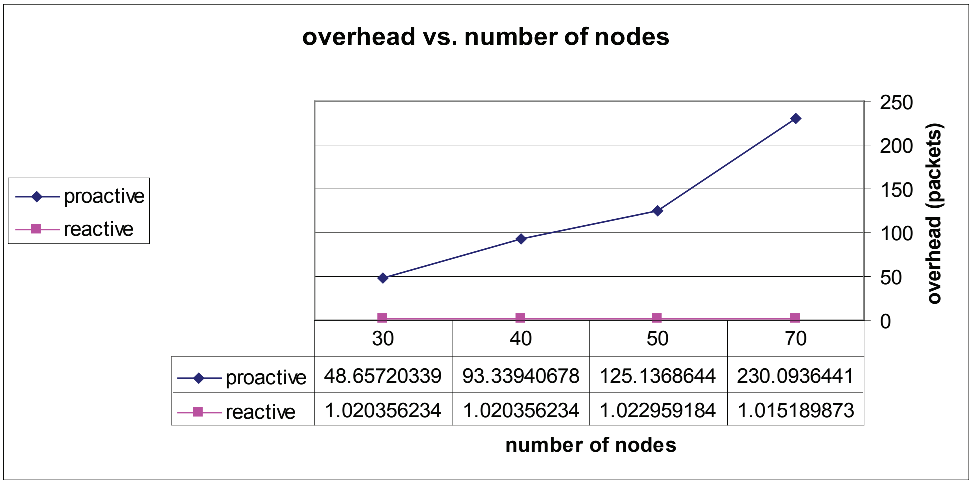


Fig.2 Overhead vs. number of nodes

From Fig.2 of simulation two, we note that for proactive when the MANET has large number of nodes, this will cause huge overhead, in contrast with reactive. We find that the overhead ranging is around 1.02 which is a very low value compared with the overhead of proactive.

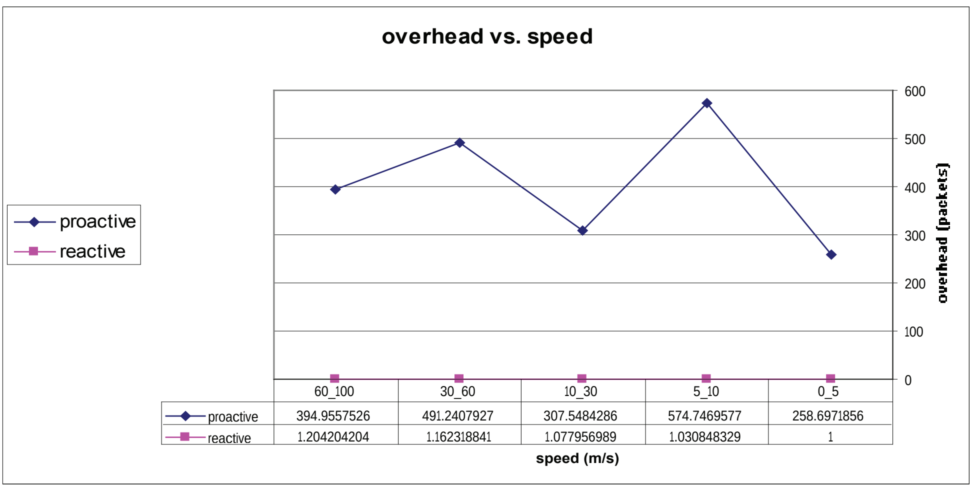


Fig.3 Overhead vs. speed

From Fig.3 of simulation three, we observe that for proactive the overhead is rising and falling as we continue increasing the speed of nodes in MANET.

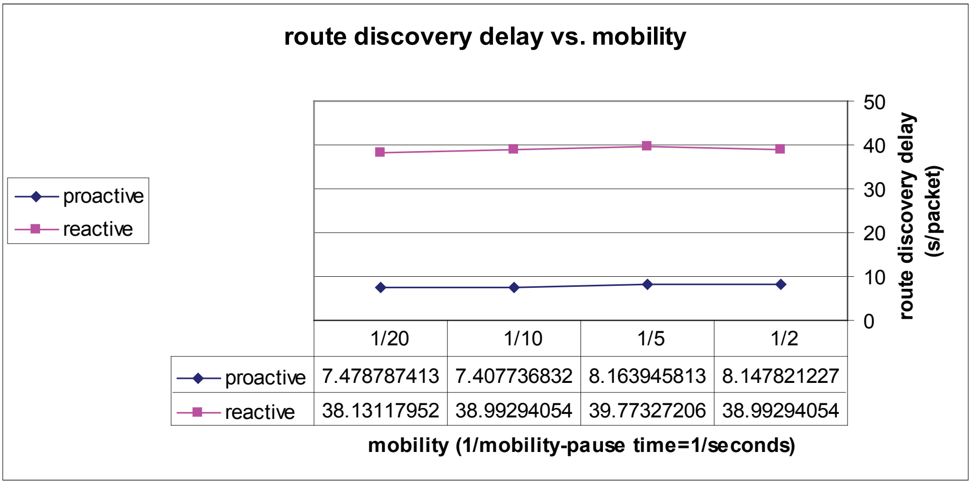


Fig.4 Route discovery delay vs. mobility

From Fig.4 of simulation four, 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 the route discovery delay is high and ranging around 39s.

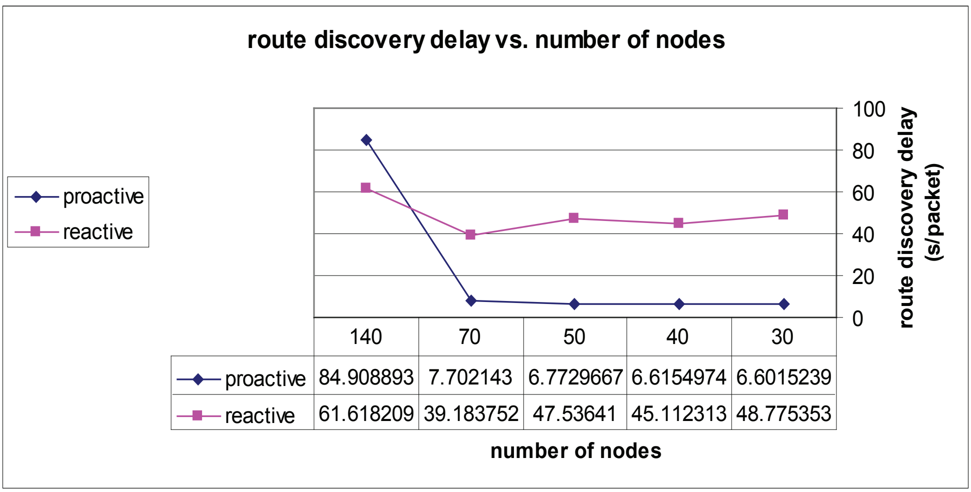
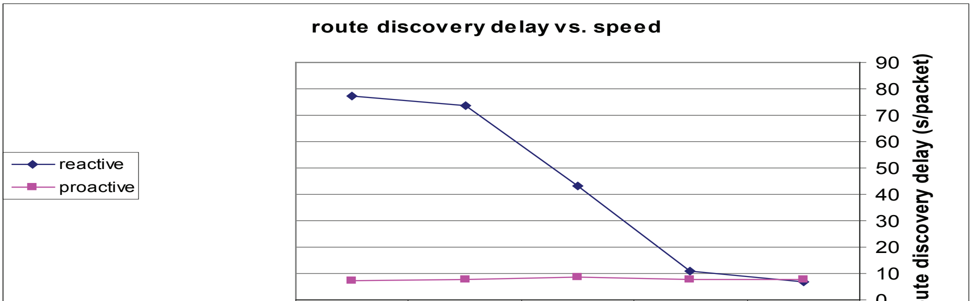


Fig.5 Route discovery delay vs. number of nodes

From Fig.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

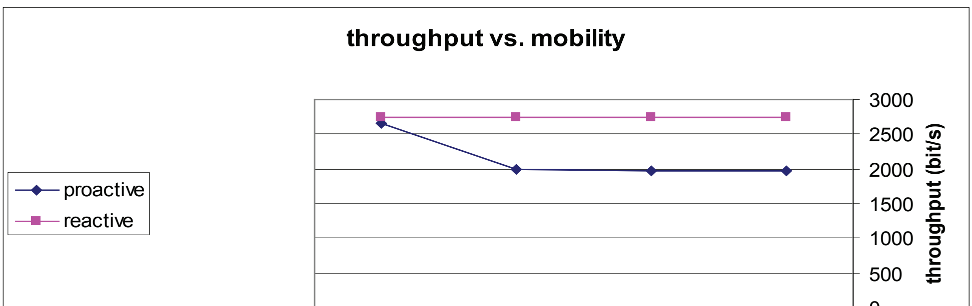
70, route discovery delay oscillating with simple differences without a certain behavior. When increasing the number of nodes to 170 nodes, we observe a considerable increment in route discovery delay in case of proactive and reactive, and we observe that at 140 nodes the route discovery delay of proactive exceeds the value of route discovery delay in case of reactive.



	60_100	30_60	10_30	5_10	0_5
reactive	77.165093	73.777548	43.098824	11.051217	6.7216225
proactive	7.1260638	7.86	8.6213734	7.7467341	7.7800084

Fig.6 Route discovery delay vs. speed

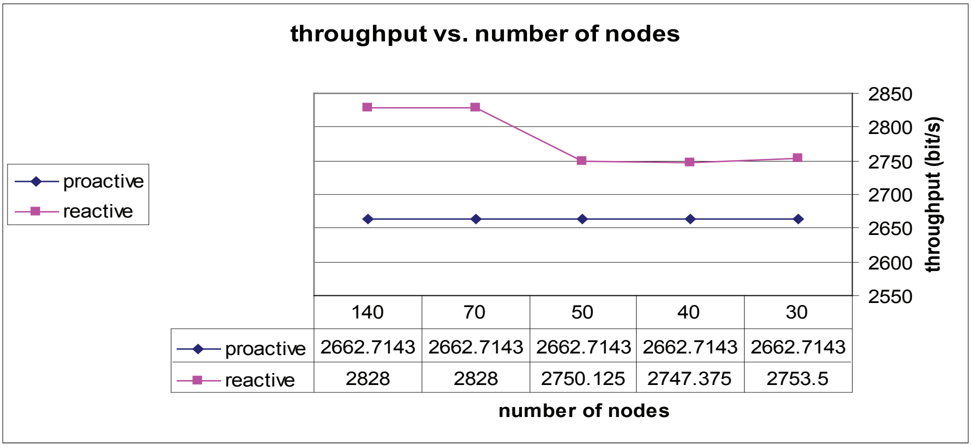
From Fig.6 of simulation three, in case of reactive, we observe that the route discovery delay is continuously increasing by large values when increasing the speed range of nodes, and in any way this figure shows that the route discovery during this range of speed for reactive is greater than the route 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.7 Throughput vs. mobility

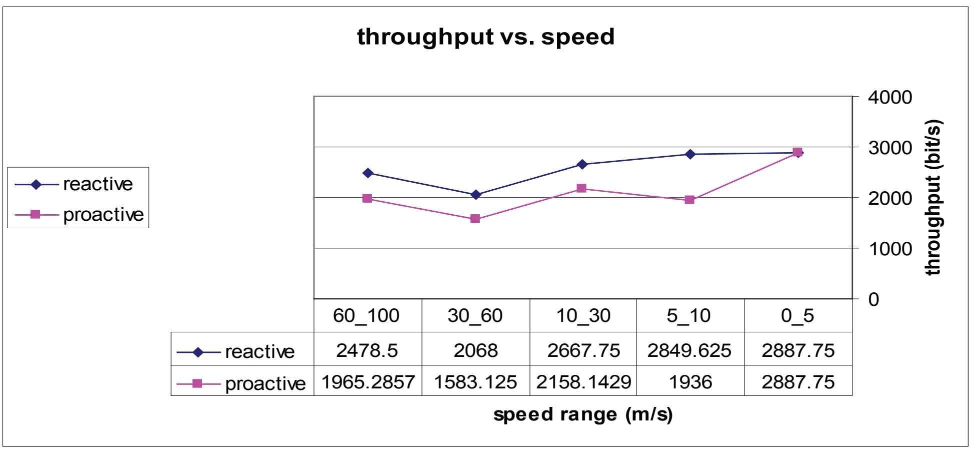
From Fig.7 of simulation four, we observe for proactive that throughput is constant during high values of mobility. When the mobility is decreased through values 1/10 and 1/20, we note that the throughput increases, while for reactive the throughput is still constant at all values of mobility, but it is obvious that the throughput is higher in case of reactive from of proactive regardless of the values of mobility.



	140	70	50	40	30
proactive	2662.7143	2662.7143	2662.7143	2662.7143	2662.7143
reactive	2828	2828	2750.125	2747.375	2753.5

Fig.8 Throughput vs. number of nodes

From Fig.8 of simulation two, for proactive the throughput is 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.



	60_100	30_60	10_30	5_10	0_5
reactive	2478.5	2068	2667.75	2849.625	2887.75
proactive	1965.2857	1583.125	2158.1429	1936	2887.75

Fig.9 Throughput vs. speed

From Fig.9 of simulation three we can distinguish that the throughput is higher in case of reactive than that in proactive.

Comparisons and properties:

The simulation is executed by Glomosim 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 the comparisons in addition to analyzing the algorithm of routing protocols, and some previous simulations. All this help us to analyze and discuss the properties. This research shows the comparisons in table one, two and three.

Table (1)

(DSDV, AODV and SHARP routing protocols)

Parameters	(DSDV)	(AODV)	(SHARP)	Analysis / references
Route discovery delay	Low, proved by simulations two, three and four	high, proved by simulations two, three and four	Trade-off between proactive and reactive [3].	Many simulations have 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. For small values of the zone the route discovery delay will take its high values and vise versa.[3]
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 [3].	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), proved by simulation one, two and three	Low overhead proved by simulation one, two and three	Some what high depending on mobility and the radius of DAGs.[3]	There are intermediate values of the zone radius where the packet overhead is less than both, Thus, no single value of zone radius is the best choice for all levels of mobility. (proved by simulation) [3]

Table (2)

(DSDV, AODV and ARPM routing protocols)

Parameters	(DSDV)	(AODV)	(ARPM)	Analysis / references
Route discovery delay	Normal , proved by simulations two, three and four	Has a problem, proved by simulations two, three and four	Depends on the mobility [5].	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. For ARPM At the beginning it's maintaining the routing proactively so both ARPM and proactive have the same performance but when the mobility increases ARPM takes trade-off between proactive and reactive.[5]
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) , proved by simulation one, two and three	Less overhead, proved by simulation one, two and three	Trade-off between proactive and reactive [5].	ARPM starts the same performance as proactive and then when neighboring nodes increase the performance will be better than proactive and approaches to reactive behavior [5]

Table (3)

(SHARP and ARPM routing protocols)

Parameters	(SHARP)	(ARPM)	Analysis / references
Route discovery delay	Depends on radius of DAGs.	Trade-off between proactive and reactive (this is proved by simulation [5]).	At the beginning it's maintaining the routing proactively so both ARPM and proactive have the same performance. If we assume that radius equals 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 equals 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 of radius and mobility the simulations proved that SHARP and ARPM trade-off between reactive and proactive.[3][5]

Parameters	(SHARP)	(ARPM)	Analysis / references
Throughput of the actual data transmissions	Has a high throughput.	Lower throughput than SHARP.	For SHARP Because of multi-path routing the chance of a packet to reach its destination is very high.
Overhead	Depends on the radius of DAGs.	Trade-off between proactive and reactive.	At the beginning all nodes act proactively in SHARP and in ARPM so both have the same performance. For SHARP if we assume that the radius equals 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 but because of the process of building DAGs and multi-path routing these make SHARP to have predictable 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 is still better than SHARP because the loss and rebuilding of DAGs that produce additional overhead. With other values of 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 [3][5].

Conclusion and Future Work:

We have tried in this research to find a protocol which has high performance to meet the challenges facing this kind of networks, and has the following characteristics:

- Low overhead.
- Low route discovery delay.
- High throughput of the actual data transmission.

The research shows that the crucial comparison was between SHARP and ARPM routing protocols, since the nodes in the network may 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 depends 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, but the process of constructing the DAG's and determining the popular destination need time which will cause some additional delay.

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 on 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 evaluates single characteristics without dissemination. The throughput is better in case of AODV than in the case of using DSDV.

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 the overlapping of DAG's and multi path routing processes.

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

From Fig.2 and Fig.5, we can conclude that DSDV is better for small networks and AODV is better for large networks.

So we need to go deeply into the experimental side and by more parameters. This is useful to be future work, also there are ARPM (agent-based routing protocol). It is worthy to execute comparison between ARPM (adaptive routing protocol) and ARPM (agent based routing protocol).

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