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Performance Optimization Wireless Ad Hoc Networks Based on Routing Protocols

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Abstract

A mobile ad-hoc network (MANET) is a group of wireless mobile nodes that dynamically form a network without any pre-established infrastructure or centralized administration. Because of the limited communication range between mobile nodes in ad hoc networks, several network hops may be needed to deliver a packet from one node to another one in the wireless networks. To do this communication, a routing protocol is used to determine routes between these nodes. Unfortunately, the mobility of the nodes can cause the network to change rapidly resulting in an unpredictability of the routes between any two nodes. This is the central dilemma in mobile ad-hoc network routing because the links are not reliable and can fail anytime. In this article we explore the key design tradeoffs that need to be considered when designing mobile devices to operate in ad-hoc mode. In particular, we explore the performance impact several of routing protocols based on the mobility rate and number of active sources.

Keywords: *Ad hoc network, routing protocol, sensor network, wireless network*

1. Introduction

A mobile ad-hoc network (MANET) is a group of wireless mobile nodes that dynamically form a network without any pre-established infrastructure or centralized administration. A MANET depends on mobile nodes that use a wireless interface to communicate with each other [1]. A mobile node can be a computer, printer, Global Positioning System (GPS), Personal Digital Assistant (PDA), Vehicle with mobile terminal [2] or any other device capable of sending and/or receiving data that generated by other mobile nodes on the network. These mobile nodes serve as both hosts and routers and forward packets on behalf of each other. Because of the limited communication range among mobile nodes in ad hoc networks, several network hops may be needed to deliver a packet from one node to another one in the wireless ad hoc networks. Therefore, numerous mobile nodes are able to communicate each other further than their transmission range supported by multi-hop communication. To accomplish this communication, a routing protocol is used to discover routes between these nodes. The mobility of the nodes can cause the network to change rapidly resulting in a high unpredictability of the routes between any two nodes. This is the central problem in mobile ad-hoc network routing because the links are not very reliable and can fail anytime [3-4].

Applications of ad-hoc networks include sensor networks, commercial and educational use, emergency cases and military communication [5]. As an example, we imagine the situation that a serious disaster has occurred in a particular region; consequently, the means of communications in that region such as mobile phones or the internet are completely down. In

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such a case, it is assumed that the emergency staff of the police, fire service, ambulance service, and even the national Self-Defense Forces will rush one after another to the scene of the disaster. Each vehicle in which they arrive is equipped with a mobile terminal that composes part of an ad-hoc network. Each staff member also carries one of these mobile terminals in hand.

A number of routing protocols have been published on routing protocols for ad hoc networks, but no outstanding solution has been found.

Ad Hoc routing protocols can basically be divided into three classifications: proactive (table-driven), on-demand (reactive), or hybrid (a combination of the previous two).

In Proactive Routing Protocols, consistent and up-to-date routing information to all nodes is maintained at each node. These protocols require each node to maintain one or more tables to store routing information, and they respond to changes in network topology by propagating updates throughout the network in order to maintain a consistent network view. Using the sequence number, the mobile nodes can distinguish stale route information and thus prevent the formation of routing loops. This type of routing protocols suffers from heavy overhead demands incurred by sending frequent updates in order to maintain consistent routing tables under the highly dynamic conditions.

In On-Demand Routing Protocols, the routes are created as and when required. This is a different approach from table-driven routing, in this approach the source initiate routing on demand. This type of routing creates routes only when desired by the source node. When a node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined. Once a route has been established, it is maintained by a route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired. When a source wants to send a message to a destination, it invokes the route discovery mechanisms to find the path to the destination. This often requires a significant delay, as a path is discovered.

Hybrid routing protocols try to combine the features of each type of protocol in order to minimize the drawbacks.

Unfortunately, there is no standard for routing protocol in wireless ad hoc network. Every routing protocol in ad hoc network has disadvantage and advantage depend on the topology of network, active sources, mobility rate, and traffic field [6]. A routing protocol can be better than others in the certain scenario but if the parameter of the network changed, it may become worse than others protocol. If the routing protocols for wireless ad hoc network could be dynamically change as the network dynamically changed, it will be able to provide better performance and throughput of the network.

In this paper we propose the adaptive routing protocol that can automatically determine the routing protocol depend on the size of network, mobility rate, and number of active sources. Our propose architecture can be seen on figure 1.

This paper is organized as follow: Chapter 2 give background about the related works that have been done. Chapter 3 describes the mechanism of the route discovery and the route maintenance for the DSDV, the DSR and the AODV routing protocols. Chapter 4 describes the methodology of our work and simulation models of the routing protocols. Chapter 5 describes the result of the simulations, and Chapter 6 concludes our work.

2. Related Work

All In [1], the authors compare the performance of two routing protocol DSR and DSDV using the ns2 network simulator. They studied the performance implications of a minor variation made to DSDV and the effects of changing different parameter in DSDV. The original value used for the periodic update interval in DSDV is 15 seconds. In [1], they made variation of the periodic update interval: 2, 5, 10, 15, 25, 45 and 75 seconds. They concluded that the DSR routing protocol is better than DSDV.

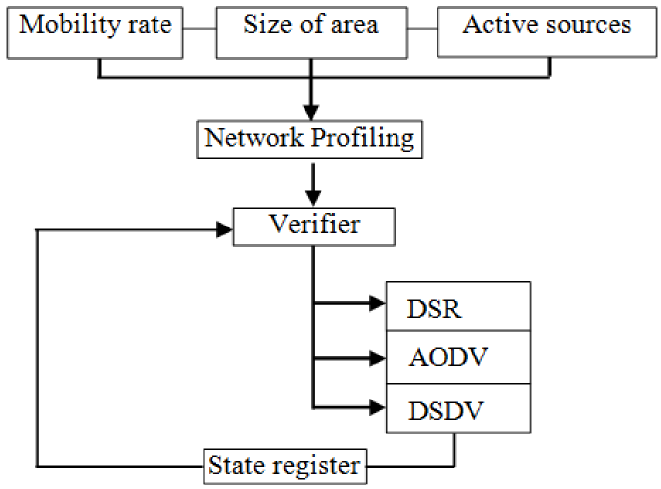

Figure 1. Proposed architecture with three routing protocols: DSR (Dynamic Source Routing), AODV (Ad Hoc on Demand Distance Vector Routing and DSDV (Destination Sequenced Distance Vector).

In [7, 8], the author compares the performance of two prominent on-demand reactive routing protocols for mobile ad hoc networks: DSR and AODV, along with the traditional proactive DSDV protocol. He concluded that the on-demand protocols, AODV and DSR perform better than the table driven DSDV protocol. Since both AODV and DSR did better, the author make an attempt to evaluate the performance difference between the AODV and DSR routing protocols by varying the mobility patterns and the number of traffic sources. Gupta then concluded that for application-oriented metrics such as packet delivery fraction and delay, AODV outperforms DSR in more "stressful" situation. His conclusions are different from ours. From our simulations, we concluded that the DSR protocol performs better than the AODV protocol. Gupta made the simulations using an earlier version of the ns2 network simulator [9]. This earlier version, which was release in 2002 had some bug, for detail see [10]. In our simulations, we used the ns3 network simulator (http://www.nsnam.org) version 3.17 that released in May, 2013.

In [11], the author modified the source code of the AODV routing protocol in accordance with the internet draft “Global connectivity for IPv6 Mobile Ad Hoc Networks”. The author extended an I-flag in the format of the Route Request messages and Route Reply messages for the AODV routing protocol. He simulated and compared the proactive routing protocol which is OLSR, the reactive routing protocol which is AODV and the hybrid routing protocol which is ZRP. He concluded that regarding the packet delivery ratio, the result is not big different. As for the average end to end delay, the proactive and hybrid methods perform slightly better than the reactive method.

In [12], the authors compare the performance of the DSDV, TORA, DSR and AODV wireless ad hoc network routing protocol using the ns-2 network simulator. They extended the ns-2 simulator to accurately model the MAC and physical layer behavior of the IEEE 802.11 wireless LAN standard including a realistic wireless transmission channel model. They presented the results of the simulations for networks of 50 mobile nodes. The modified

DSDV and AODV protocol were renamed DSDV- SQ (DSDV Sequence Number) and AODV-LL (AODV Link Layer) respectively. They concluded that the performance of the DSR protocol was very good at all mobility rates and movement speeds even though its use of source routing increases the number of routing overhead bytes. They also used an earlier version of ns network simulator developed in 1998. Moreover, the input parameters were different from the ones used in our simulations.

In [13] the author simulated the Zone Routing Protocol (ZRP) using the ns2 network simulator. The ZRP routing protocol is based on two procedures: the IntrAzone Routing Protocol (IARP) and the IntErzone Routing Protocol (IERP) [14]. The actual IARP is not specified and can include any number of protocols, such as the derivatives of Distance Vector Protocol (*e.g.*, AODV), Shortest Path First (*e.g.*, OSPF). The performance of the ZRP routing protocol was compared to the performance of the AODV routing protocol. The author concluded that the ZRP routing protocol behaves better than the AODV routing protocol.

There are many concerns when implementing a Manet, such as topology, routing protocol, network, mobility rate, number of node in the network, and privacy. This paper will focus on routing protocols. We propose a high performance wireless adhoc network system with the capability of adapting to dynamically network topology.

3. Wireless Adhoc Network Routing Protocols

Perhaps the most important property of ad-hoc networks is that they do not rely on any pre-existing network infrastructure. Instead, these networks are formed in an on-demand fashion as soon as nodes come sufficiently close to each other. This eliminates the need for stationary network components, such as routers and base stations as well as cabling and central administration. Nodes in an ad-hoc network should offer to forward network traffic on behalf of other nodes. If they refuse to do so, the connectivity between nodes in the network is affected in a negative manner. The functionality and usefulness of an ad-hoc network heavily depends on the forwarding feature of participating nodes. Ad-hoc networks are often autonomous in the sense that they only offer connectivity between participating nodes, but no connectivity to external networks such as the Internet. The dynamic topology imposed by ad-hoc networks is another very important property. Since the topology is subject to frequent changes, due to node mobility and changes in the surrounding environment, special considerations have to be taken when routing protocols are selected for the nodes.

Routing is not a new issue in computer networking. Link-state routing and distance vector routing have existed for a long time and are widely used in conventional networks. However, they are not very suitable for use in mobile ad-hoc networks, for a number of reasons:

- They were designed with static topology in mind. In an ad-hoc network, with a frequently changing network topology, the nodes move very frequently.
- They were designed with a wired network in mind. In such a network, links are assumed to be bidirectional. In mobile ad-hoc networks, this is not always the case; differences in wireless networking hardware of the nodes or radio signal fluctuations may cause uni-directional links, which can only be traversed in one direction.
- They try to maintain routes to all reachable destinations. In mobile ad-hoc networks with a very large number of nodes, such as a large wireless sensor networks, this may become infeasible because of the resulting very large number of routing entries.

- In mobile ad-hoc networks, periodic flooding of routing information is relatively expensive, since all nodes compete for access to the wireless medium (which usually offers a rather limited amount of bandwidth).

For a packet to reach its destination in an ad-hoc network, it may have to travel over several hops. The main purpose of a routing protocol is to set up and maintain a routing table, containing information on where packets should be sent next to reach their destinations. Nodes use this information to forward packets that they receive. Therefore, special routing protocols are needed for ad-hoc networks.

In this chapter, some ad-hoc routing protocols are described. The intention is not to present all existing protocols, nor to provide full technical details, but rather to describe the main ideas behind some of them and how they work. There are several classification in ad-hoc routing protocol: Proactive (table-driven), Reactive (on-demand-driven), and hybrid routing protocol as we described earlier in Section 1. For this paper, the DSDV, DSR and AODV routing protocol are of particular interest.

3.1. Destination Sequenced Distance Vector (DSDV)

Destination Sequenced Distance Vector (DSDV) is a hop-by-hop vector routing protocol requiring each node to periodically broadcast routing updates. This is a table driven algorithm based on modifications made to the Bellman-Ford routing mechanism. Each node in the network maintains a routing table that has entries for each of the destinations in the network and the number of hops required to reach each of them. Each entry has a sequence number associated with it that helps in identifying stale entries. This mechanism allows the protocol to avoid the formation of routing loops. Each node periodically sends updates tagged throughout the network with a monotonically increasing even sequence number to advertise its location. New route broadcasts contain the address of the destination, the number of hops to reach the destination, the sequence number of the information received regarding the destination, as well as a new sequence number unique to the broadcast. The route labeled with the most recent sequence number is always used. When the neighbors of the transmitting node receive this update, they recognize that they are one hop away from the source node and include this information in their distance vectors. Every node stores the “next routing hop” for every reachable destination in their routing table. The route used is the one with the highest sequence number i.e. the most recent one. When a neighbor B of A finds out that A is no longer reachable, it advertises the route to A with an infinite metric and a sequence number one greater than the latest sequence number for the route forcing any nodes with B on the path to A, to reset their routing tables.

3.2. Dynamic Source Routing (DSR)

The key distinguishing feature of DSR [15] is the use of source routing. That is, the sender knows the complete hop-by-hop route to the destination. Source routing means that each packet contains in its header an ordered list of addresses through which the packet should pass on its way to the destination. This source route is created by the node that originates the packet. The usage of source routing allows the routing of packets to be loop-free, avoids the need for keeping up-to-date routing information in intermediate nodes and allows nodes that overhear packets containing source routes to cache this information for their own future use. When a node in the ad hoc network attempts to send a data packet to a destination for which it does not already know the route, it uses a route discovery process to determine the route to the destination [16].

A node that wishes to send a packet to a destination checks in its route cache if it has a route available. If no route is found in the route cache, route discovery is initiated. The node initiating the route discovery broadcasts a Route Request (RREQ) packet, containing its own address, the destination (target) address and a unique request identification. Each Route Request also contains an initially empty list of nodes through which this particular Route Request packet has passed. Figure 4 is the illustration of the RREQ broadcast along the mobile nodes from the source node to the destination node. If a node receives such a Route Request and discovers that it is the target of the request, it responds with a Route Reply (RREP) back to the initiator of the Route Request. The Route Reply contains a copy of the accumulated route record from the Route Request. In Figure 5, show the RREP from node destination back to the source node. If a node receiving a Route Request instead discovers that it is not the target of the request, it appends its own address to the route record list of the Route Request, and re-broadcasts the Route Request (with the same request identification). Route Replies are sent back to the Route Request initiator using a route found in the route cache of the replying node. If no such route exists, the replying node should itself initiate a route discovery to find a route back to the originator of the original Route Request (and piggyback its Route Reply, to avoid possible infinite recursion of route discoveries).

If any link on a source route is broken, the source node is notified using a route error (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source if this route is still needed. DSR makes very aggressive use of source routing and route caching. No special mechanism to detect routing loops is needed.

3.3. Ad Hoc on Demand Distance Vector Routing (AODV)

AODV is a reactive ad-hoc routing protocol. It also discovers routes on an as needed basis via a route discovery process similar to route discovery in DSR routing protocol [17]. However, AODV adopts a very different mechanism to maintain routing information. It uses traditional routing tables, one entry per destination. This is in contrast to DSR, which can maintain multiple route cache entries for each destination. Without source routing, AODV relies on routing table entries to propagate a Route Reply (RREP) back to the source and, subsequently, to route data packets to the destination. AODV uses sequence numbers maintained at each destination to determine freshness of routing information and to prevent routing loops. All routing packets carry these sequence numbers.

When a node needs a route to a destination, it broadcasts a Route Request (RREQ) message. As this message is spread throughout the network, each node that receives it sets up a reverse route, i.e., a route towards the requesting node. As soon as the RREQ message reaches a node with fresh enough routes to the specified destination, or the destination itself, a RREP unicast message is sent back to the requesting node. Intermediate nodes use the reverse routes created earlier for forwarding RREP messages. If the source node moves, it may reinitiate its route discovery process. If the intermediate node moves, a special RREP is sent to affected source nodes. This could cause the destination node to initiate a route discovery of its own, if it needs to communicate with the requesting node (*e.g.*, to reply to a TCP connection request). To solve this, the originator of a RREQ message should set a gratuitous RREP flag in the RREQ if it believes that this situation is likely to occur. An intermediate node receiving a RREQ with this flag set and replying with a RREP must also unicast a gratuitous RREP to the destination node. This allows the destination node to learn a route back to the requesting node.

Nodes monitor the link status of the next hop in active routes, i.e., routes whose entries are marked as valid in the routing table. This can be done by observing periodic broadcasts of

HELLO messages (beacons) from other nodes, or any suitable link layer notifications. When a link failure is detected, a list of unreachable destinations is put into a RERR message and sent out to neighboring nodes, called precursors that are likely to use the current node as their next hop towards those destinations. For this purpose, nodes maintain a precursor list for each routing table entry. Finally, routes are only kept as long as they are needed. If a route is not used for a certain period of time, its corresponding entry in the routing table is invalidated and subsequently deleted.

The protocol stack for mobile ad-hoc compared is similar to TCP/IP suite [18]. The main differences between these two protocols stack lies in the network layer. Mobile nodes which are both hosts and routers use an ad-hoc routing protocol to route the packets. In the physical and data link layer, mobile nodes run protocols that have been designed for wireless channels [19].

4. Methodology

Our methodology to optimize performance wireless ad hoc networks based on routing protocols is outline in Figure 1. The simulation environment takes mobility rate, size of area, and active sources as inputs, and outputs the decision of routing protocol that will use in the network.

Three routing protocols wireless ad hoc network have been chosen to simulate the proposed architecture: Destination Sequenced Distance Vector (DSDV), Dynamic Source Routing (DSR), and Ad Hoc On Demand Distance Vector Routing (AODV).

The performance of wireless ad hoc network is not only depending on mobility rate, size of network, and number of active sources, but also the underlying routing protocol and its running environment, other applications running together with it. Hence, an automatic simulation environment presented in Figure 1 is utilized. The key elements of the methodology: network profiling, verifier and state register. Each of them is discussed in the following:

We start to analyze the network environment using information that has been broadcasting from each node in the network. In network profiling, we can profile the network by size of area, mobility rate, and number of active sources. The output of network profiling will be the inputs for the verifier. In the verifier, the information was processed follow the rules and the output of verifier is the decision of routing protocol that will be used in the wireless ad hoc network. In state register hold the state represent the current routing protocol that has been operating and the information about the network. If the information of the network changed then the state register will initiate the verifier to re-computing and analyzing the network.

In this paper we simulated our proposed architecture using ns-3 network simulator [20, 21, 22]. The network simulator ns-3 is an object-oriented, discrete event-driven network simulator developed at UC Berkeley and USC ISI as part of the VINT project. It is a very practical tool for conducting network simulations relating local and wide area networks, but its functionality has grown during recent years to include wireless networks and ad-hoc networking as well. The ns-3 network simulator has gained a vast popularity among participants of the research community, mainly because of its simplicity and modularity. It allows simulation scripts, also called simulation scenarios, to be easily written in a script-like programming language, OTcl. More complex functionality relies on C++ code that either comes with ns-3 or is supplied by the user. This flexibility makes it easy to enhance the simulation environment as needed, although most common parts are already built-in, such as wired nodes, mobile nodes, links, queues, agents (protocols) and applications. Most network components can be configured in detail, and models for traffic patterns and errors can be applied to a simulation to increase its reality. There even exists an emulation feature, allowing the simulator to interact with a real network [23]. Simulations in ns-3 can be logged to trace files, which include detailed information about packets in the simulation and allow for post-run processing with some analysis tool.

5. Results

In this paper, we simulate network traffic in multi hop wireless ad-hoc networks based on the proposed architecture as shown in Figure 1. Three wireless ad hoc network routing protocols have been chosen to complete our simulation: DSDV, DSR and AODV. To evaluate the performance of these three routing protocols, we build a packet level simulation which allowable us to monitor and compute the protocol's performance in a selection of environment. The simulation parameters were chosen to model an ad hoc network consisting of a group of mobile nodes moving around in the medium sized space. The area in which the mobile nodes move are square 500 meters and 700 meters on a side. We used the "CMUPriQueue" for the DSR protocol simulation and "Queue/DropTail/PriQueue" for the AODV protocol and DSDV protocol simulation. We evaluate the most important two metrics in the performance of ad hoc routing protocols:

5.1. The throughput

The total number of packet that successfully received by the destination divided by the total number of packets sent from the source.

Figure 2, 3 and 4, demonstrate the simulation result by applying different numbers of active sources with area 500 x 500 meters. The graphs show the throughput as a function of the mobility rate.

The DSDV routing protocol has a throughput of more than 70%. When the number of active sources was changed from 10 to 30, the throughput did not vary significantly.

The throughput of the DSR routing protocol and the AODV routing protocol were equal when the number of active sources was set to 10. However, the throughput of the DSR routing protocol was higher than the AODV routing protocol when the number of active sources was increased to 20 and 30.

The DSR routing protocol has a throughput of more than 95%, and it is stable when the number of sources were increased from 10, 20 and 30.

The AODV routing protocol has a throughput of more than 95% with the number of active sources was set to 10. The throughput decreases when we increase the number of sources.

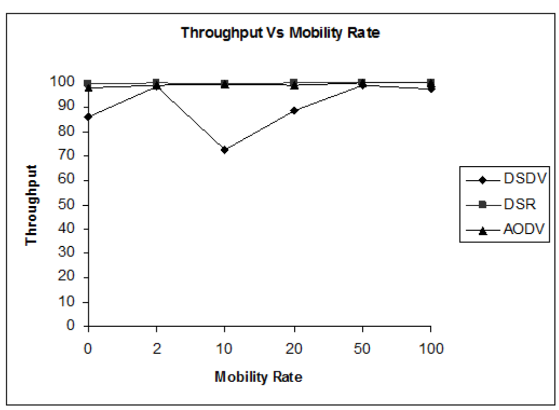

Figure 2. The throughput versus the mobility rate for 10 active sources and area 500 x 500

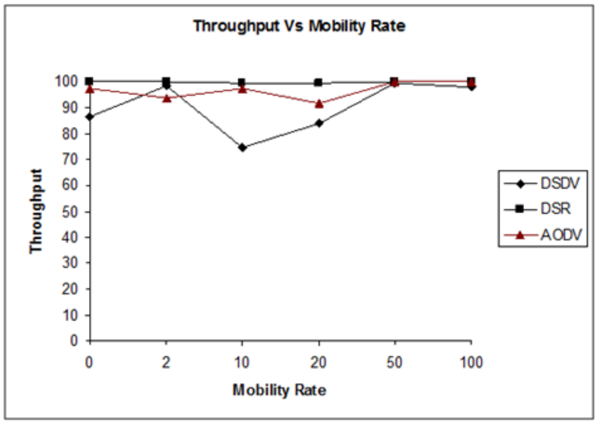

Figure 3. The throughput versus the mobility rate for 20 active sources and area 500 x 500

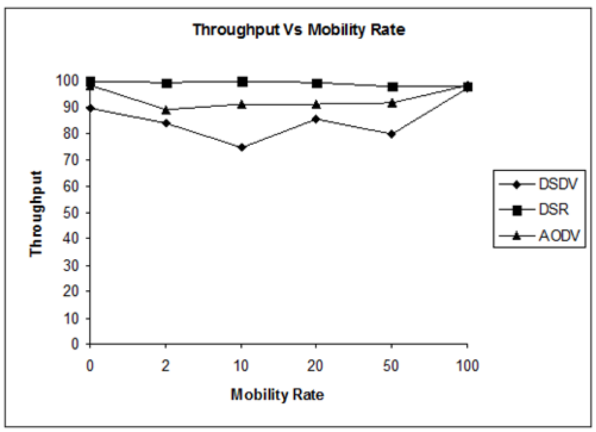

Figure 4. The throughput versus the mobility rate for 30 active sources and area 500 x 500

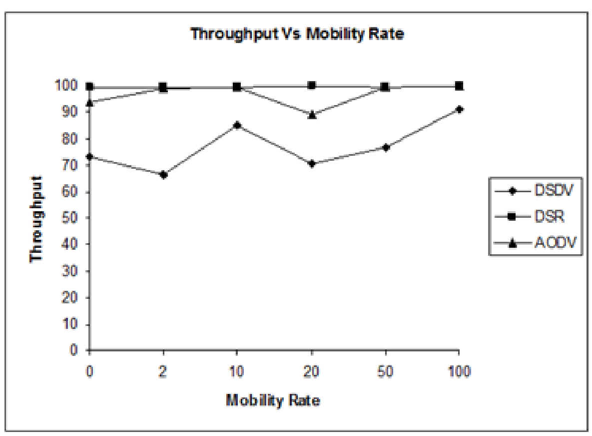

Figure 5. The throughput versus the mobility rate for 10 active sources and area 700 x 700

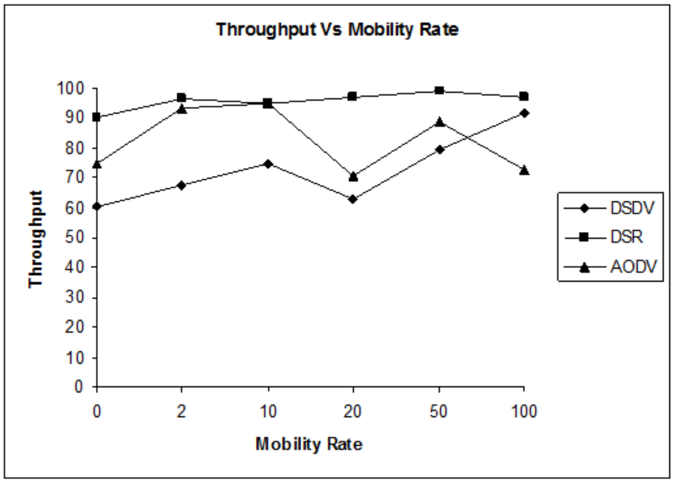

Figure 6. The throughput versus the mobility rate for 20 active sources and area 700 x 700

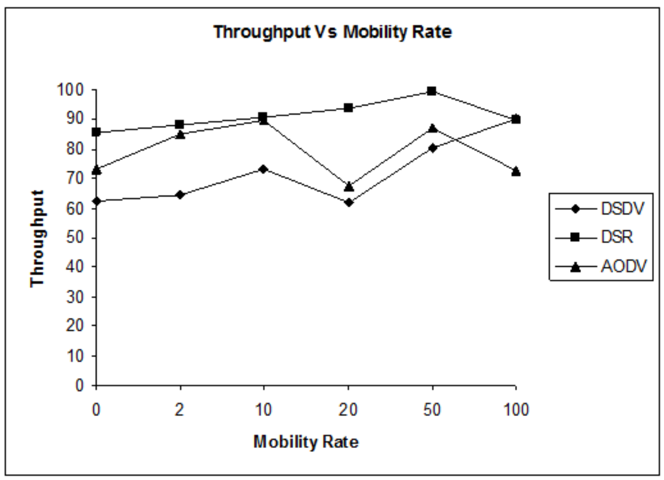

Figure 7. The throughput versus the mobility rate for 30 active sources and area 700 x 700

Figure 5, 6 and 7, demonstrate the simulation result by applying different numbers of active sources with area 700 x 700 meters. The graphs show the throughput as a function of the mobility rate.

In this topology, 700 x 700 meters, the DSR routing protocol has a throughput more than 98% with the number of active source 10. The throughput decrease when we increase the number sources, as showed in Figure 7. the throughput drop to 86% with the number of active source 30.

The DSDV routing protocol has a throughput of more than 60%. When the number of active sources was changed from 10 to 30, the throughput did not vary significantly.

The AODV routing protocol has a throughput of more than 90% with the number of active sources was set to 10. The throughput decreases when we increase the number of sources.

5.2. The average delay

The average time that packets spend in transit including all possible delays caused by buffering during the route discovery, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.

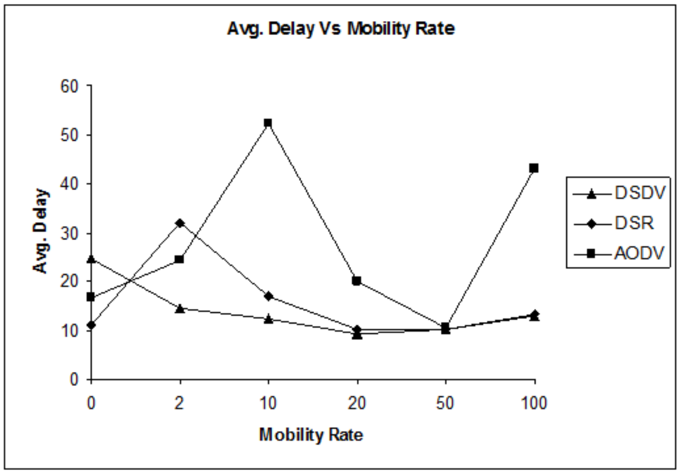

Figure 8. The average delay versus the mobility rate for 10 active sources and area 500 x 500

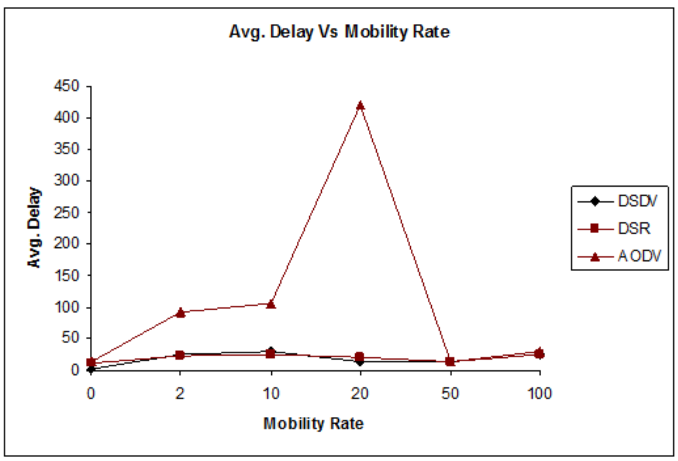

Figure 9. The average delay versus the mobility rate for 20 active sources and area 500 x 500

The graphs in Figure 8, 9 and 10 show the average delay of packet delivery as a function of mobility rate with area 500 x 500 meters. The average end to end delay of packet delivery was less than 40 ms for the DSDV routing protocol and the DSR routing protocol when the number of sources was set to 10, and less than 60 ms for the AODV routing protocol.

When we increase the number of sources to 20 and 30, the average end to end delay of packet delivery for the AODV routing protocol was significantly higher than the one for the DSDV routing protocol and the DSR routing protocol. The AODV routing protocol had an average delay of less than 450 ms, while the DSDV routing protocol and DSR routing protocol were relative stable.

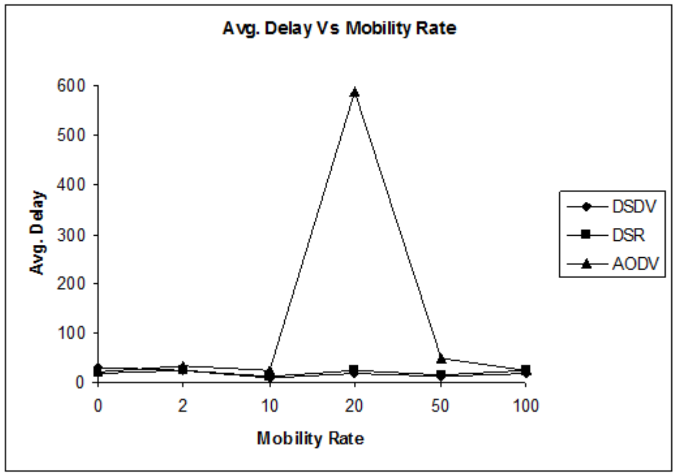

Figure 10. The average delay versus the mobility rate for 30 active sources, area 500 x 500

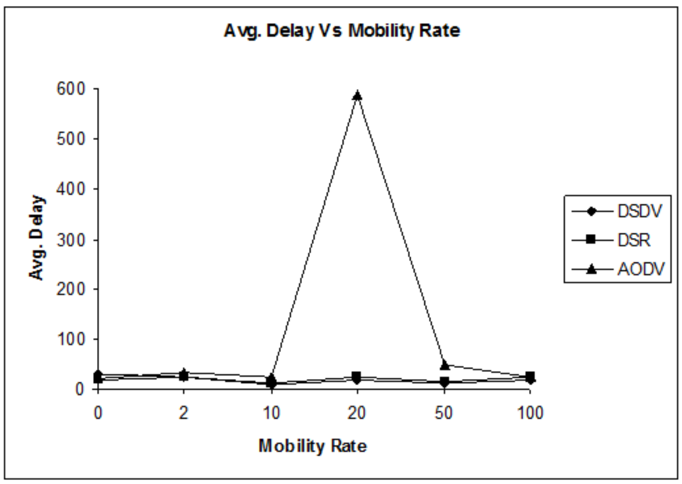

Figure 11. The average delay versus the mobility rate for 10 active sources, area 700 x 700

The graphs in Figure 11, 12 and 13 show the average delay of packet delivery as a function of mobility rate with area 700 x 700 meters. The average end to end delay of packet delivery was less than 40 ms for the DSDV routing protocol and the DSR routing protocol when the number of sources was set to 10, and less than 600 ms for the AODV routing protocol.

When we increase the number of sources to 20 and 30, the average end to end delay of packet delivery for those three routing protocol was significantly increase. The AODV routing protocol had an average delay of less than 980 ms, while the DSDV routing protocol had an average delay of less than 280 ms and DSR had an average delay of less than 780 ms.

Base on result above, the verifier will automatically choose the DSR as a routing protocol for this wireless ad hoc network because the throughput and delay are more stable than other two routing protocols.

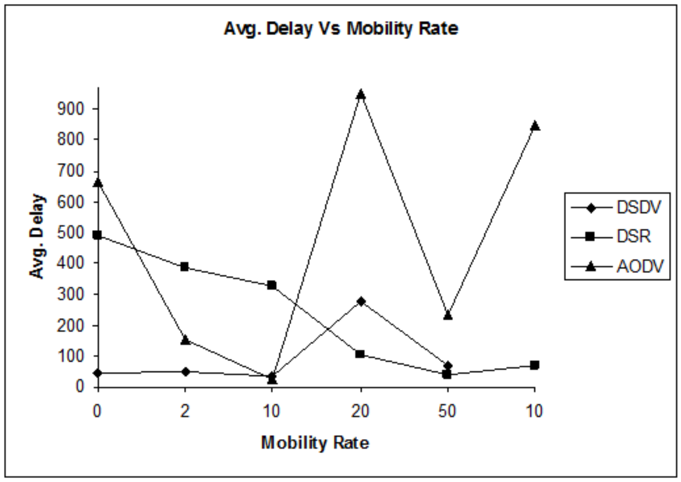

Figure 12. The average delay versus the mobility rate for 20 active sources, area 700 x 700

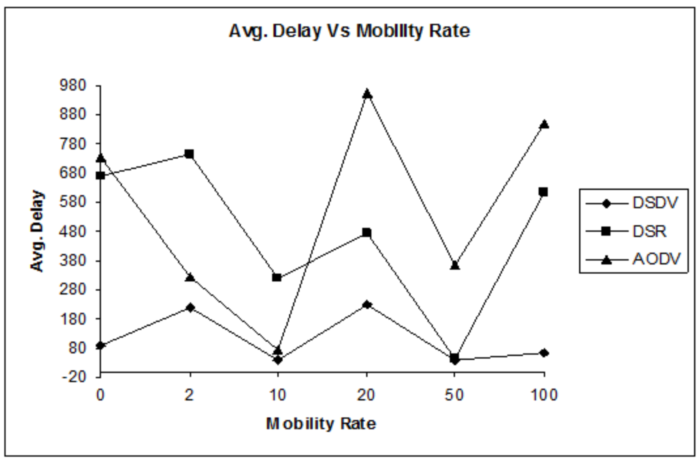

Figure 13. The average delay versus the mobility rate for 30 active sources, area 700 x 700

6. Performance Analysis

The AODV and DSR routing protocols are reactive on demand routing protocols. They outperformed the DSDV, proactive table driven routing protocol when varying the number of traffic sources. The performance of the DSDV routing protocol is poor, its throughput was drop to 70% in scenario 1 (500 x 500 meters) and drop to 60% in scenario 2 (700 x 700 meters). The reason for the low throughput is the fact that the DSDV protocols store only one route to each destination and use stale routing tables. In ad-hoc networks the link are easily broken because of the movement of mobile nodes. Therefore packets may be dropped.

The performance of the DSR and the AODV routing protocols is almost the same when varying the mobility rate for a small number of active sources. With a large numbers of active sources, the DSR routing protocol starts to outperform the AODV routing protocol. The DSR routing protocol always demonstrates a higher throughput than the AODV routing protocol. In scenario 1, the throughput is around 98% for DSR even when the number of sources increased to 30 active sources. DSR outperforms the other protocols because it uses source routing and caches multiple routes. When a link broke, the DSR routing protocol consider alternative routes from its cache, and does not depend on any periodic or timer-based activities. DSR exploits caching aggressively and maintains multiple routes per destination.

The AODV routing protocol has more route requests than DSR. In AODV if a link failure occurs while the route is active, the node upstream of the break propagates a RERR message to the source node to inform it of the now unreachable destination(s). After receiving the RERR, if the source node still desires the route, it can reinitiate a RREQ for the destination. Thus, due to the volatile nature of the links in ad hoc networks, link breakage is very frequent and this justifies the superiority of the DSR routing protocol over the other protocols as far as throughput and delay.

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