Performance metrics and comparative analysis of AODV and DSDV routing protocols for varying sources in Mobile Ad hoc Networks

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ABSTRACT
Mobile Ad hoc networks are a system of communicating nodes that do not have any specific infrastructure. Absence of central administration, unlike traditional networks, makes them an easy to implement access system. It provides for handy creation in emergency situations. Nodes are able to communicate with a hotspot (data service source) either directly or through indirect relaying system. A node can act as client or a relaying node. Also, a node has to make hops in order to reach the source node. These hops are predefined rather random and at the same time they are subject to variation due to mobility and quality of service. This means that hops are not aimless or random, rather they are authenticated and maintained within a node for routing. Routing becomes more complex when mobility is the chief characteristic of an Ad hoc system. Nodes appear and disappear and their information is updated by other nodes from time to time. Updation of routing information is also a complex phenomenon. It requires a number of important resource to maintain reliable and resilient routing procedure and process. To this effect, different routing protocols have been devised to address the above stated problems. Security, authenticity, reliability and seamless communication are the bedrock of such design. This paper discussed two of the most important distance vector (DV) routing protocols namely (Destination Sequenced) DSDV and (Ad hoc On Demand) AODV. Rationale for the choice of these protocols is that their core concept segregates them into table driven/ proactive (DSDV) and On Demand/ Reactive (AODV) types of MANET Routing Protocols. In introduction their modus operandi shall be discusses. In next section their design and issues related to them will be discussed. Further there is a section that discusses their chief characteristics and performance metrics in order to comprehend their usability in a given setting. Finally in the last two sections a comparative analysis based on simulation results is conducted and concluded.

Indexing terms/Keywords
Ad hoc networks, Demand Driven Routing, Vector Based Routing, DSDV, AODV

Academic Discipline And Sub-Disciplines
Communication Sciences, Telecommunication

SUBJECT CLASSIFICATION
Mobile Ad hoc Networks

TYPE (METHOD/APPROACH)
Simulation, NS-2
INTRODUCTION

Mobile Ad hoc networks do not have central administration and there is no administration system that cares for network operations. In 1968, in Hawaii USA, a protocol namely ALOHA was implemented to interconnect educational facility. Although the systems were fixed wireless, they were not mobile and it was simple to manage them as they remained in a fixed area of coverage. Another advancement in this type of connectivity was Packet Radio Network (PRNET). This evolution was limited to the relaying function of nodes. A far off node that did not have any approach to the hotspot made use of intermediary nodes as hops to reach the destination. Final stage of this development was the evolution of 802.11 IEEE standard for wifi [1]. The original system that was devices for wireless adhoc (immobile) ALOHA system used a single spot for communication, whereas, the advancement was able to achieve multi hop system for a grid like communication [2].

This provided a manifold ease and advantages for communication like power saving, highly available connectivity, quality of service etc. However there were constraints to such systems which will be discussed in next section. To differentiate an Ad hoc network from the others following points shall suffice the concept of MANETs on the whole:
1. Distributed Operation (No central administration)
2. Dynamic Topology (Ever Changing positioning of Nodes)
3. Nodes are usually low powered (mobile devices)
4. Links between nodes have different capacities
5. Each node maintains routing algorithm (hoping map to reach to the destination node)

However, the Quality of Service (QoS) is gauged for all the services that are provided through internet. This means that Ad hoc networks are similar to other networks for all types of streamings, browsing, telephony and transfer (FTP) services. In the later section we will see how performance metrics are defined and how they are used for comparative analysis. These metrics will be in direct relation to QoS.

NETWORK DESIGN AND AREAS OF RESEARCH IN MANETs

Typical Ad hoc network topology does not follow any specific shape. They tend to form dynamic construct that has routing procedure at their core. To understand this phenomenon, consider a mesh of 6 nodes that constitute a mobile ad hoc network. Here node 2 is a backend service provider to which all other nodes try to connect either through single hop or through routing of multiple hops.
In this case, node 3 and 1 are in direct contact with node 2 which is the service provider. It means that there is only one hop for them to access the node. For node 4 there are more than 2 hops. Node 4 will have to check for the more reliable and stable node for communication. It can cover hops in one of the three ways depending upon the channel state information. 4-1-3-2, 4-1-2, 4-3-1-2 or 4-3-2 are the paths that are available to get connectivity to the access router. Following parameters are necessary to take into consideration in order to push messages to and from a node [3].

1. Antenna Characteristics
2. Power Issues
3. Routing Problems
4. Link Information and
5. Authenticity (Security issues)

A well defined handshake takes place between the nodes in order to allow a reliable and resilient connectivity. Since mobile nodes tend to move geographically, the above mentioned parameters play a very important role in designing of routing algorithms. Here we are able to put forward a brief on the areas of research that lie at the core of research related to Ad hoc networks.

1. Asymmetric links that conduct two way communication (uplink and downlink). Direction of antenna, channel state information and line of sight issues are at the centre of research. This is because most algorithms are designed for symmetric communication.
2. Interference due to mesh topology. Issues related to overhearing the link that is formed between nodes come under the heated debate of network security. Also disturbance is natural to this type of interference which increases BER of the link.
3. Due to absence of central administration, redundant links information (which is usually maintained by admin) is also not available. A connection tends to resent on mobility.
4. Algorithms tend to crash in dynamic scenario. Due to Mobile IP allocation, Network layer resets when a node moves from its geographical location. Services of upper layers (like transport layer TCP) depends on the Network layer, are disturbed. To cover up this problems additional overhead is required which seriously affects the efficiency and data rate of transmission.

These issues can be categorized into two main fields of research. First is the Network Management Issues, while second category is Security Issues. As a summary these are given as follows.

**NETWORK MANAGEMENT CHALLENGES AND AREAS OF RESEARCH**

Due to lack of central administrative unity in Ad hoc network there are number of services, features and hierarchy that are not available. This lapse needs to be filled in one way or the other. Sometimes it is compromised or incorporated in each node. Following is the list of challenges faced:

1. Lack of Central Management
2. Information availability related to Mobility (so that redundancy could be preempted)
3. Scalability
4. Malicious Nodes that hamper integration of nodes
5. Loss of Information due to channel impairments and other routing issues
6. Power Management of Nodes
7. Bandwidth Efficiency and congestion issues

**SECURITY ISSUES AND AREAS OF RESEARCH**

Same level of Security model needs to be devices as OSI security model prescribes for other networks. The security paradigm consists of following services that need to be ensured:

1. Authenticity
2. Integrity
3. Non-repudiation
4. Availability
5. Confidentiality
These security services cover different types of attacks as Denial of Services, Routing Attacks, Impersonation, Jamming Attack, Man in the Middle Attack, Reply and eavesdropping. After discussing issues, challenges and major areas of research it is important to get an insight into the concept of reouting in MANETS

ROUTING IN MANETS

The communication is connectionless in Ad hoc networks due to the mobility factor in Nodes. This fact transpires the fact that normal routing protocols that are used in field communication is not applicable in MANETS. Each node discovers nearby nodes and maintains information regarding features as discussed above. There are two main types of routing procedures according to the node functioning [4]. These are Table driven routing and On-Demand routing.

<table>
<thead>
<tr>
<th>MANET Routing Protocols</th>
<th>Table driven/Proactive</th>
<th>On-Demand Driven/Reactive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DSDV</td>
<td>DSR</td>
</tr>
<tr>
<td></td>
<td>WRP</td>
<td>AODV</td>
</tr>
<tr>
<td>Hybrid</td>
<td></td>
<td>TORA</td>
</tr>
<tr>
<td></td>
<td>ZRP</td>
<td></td>
</tr>
</tbody>
</table>

Table driven approach relies on the fact that each node maintains routing information in the form of a table of nearby nodes and the condition of the link between them. From time to time these tables are maintained and updated soon with variation in the nodes around them. A number of routing protocols have been designed keeping in view this concept. Yet it is a complex technique because the abilities of nodes are limited. Few examples of this technique are destination sequence distance vector (DSDV), Global State Routing (GSR), Cluster Head Gateway Switching (CHGS) and Fisheye Routing (FER), etc. Similarly the second type of technique is more dynamic and in some cases more efficient than the table driven approach. This technique is known as On-Demand Routing since it does not necessarily maintains a list or table of routing nodes. It floods or inquires the mesh with a request of destination for routing. Best possible shortest paths are made available, as per the algorithm design, to a node. This route information is maintained until nodes are available or channel state remains above the threshold requirements. Some of the important routing protocols are, Ad hoc On-Demand Distance Vector Routing (AODV), Temporally Ordered On Demand Routing (TORA), Cluster Based Routing (CBR), etc.

A comparative analysis of both the types is given in the table below. This paper focuses on comparison between DSDV and AODV routing for which simulations have been carried out. Performance Metrics will be discussed in subsequent sections.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>On Demand Routing</th>
<th>Table Driven</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability of routing</td>
<td>Available when needed</td>
<td>Always available regardless of information needed</td>
</tr>
<tr>
<td>Routing philosophy</td>
<td>Flat</td>
<td>Mostly flat, except for GCSR</td>
</tr>
<tr>
<td>Periodic route updates</td>
<td>Not required</td>
<td>Required</td>
</tr>
<tr>
<td>Coping with mobility</td>
<td>Use localized route discovery</td>
<td>Inform other nodes to achieve as in ABR and SSR a consistent routing table</td>
</tr>
<tr>
<td>Signaling traffic generated</td>
<td>Grows with increasing mobility</td>
<td>Greater than that of on of active routes (as in ABR) demand routing</td>
</tr>
<tr>
<td>Quality of service support</td>
<td>Few can support QoS</td>
<td>Mainly shortest path as the most support shortest path QoS metric</td>
</tr>
</tbody>
</table>
COMPARATIVE ANALYSIS

This research compares two routing protocols, each from table driven and on demand routing technique. A brief on concept of both the technique is discussed in this section. In DSDV, each node has to maintain one or more routing table.

The destination information in terms of number of hops is available and alternate routes are also assessed and maintained. In order to choose from a number of alternate paths, a priority is set for a path depending upon the features and characteristics of the path. The best path is labelled as one. Rest follow depending upon the reliability and resilience. Main factors that contribute to the prioritizing of these paths are Channel State Information, Shortest distance/ Number of Hops, Mobility and Security certification, etc. There are two ways in which the routing information is shared among nodes. They involve dump mode in which all the information is dumped on each of the nodes. The other one is incremental update mode, in which only change in priority or route is conveyed to the nodes [5].

A figure of routing table is given for the Figure 2 mentioned above.

<table>
<thead>
<tr>
<th>Destination</th>
<th>Next Hop</th>
<th>Metric</th>
<th>Dest. Seq. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>123</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>516</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>1</td>
<td>212</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>1</td>
<td>168</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>2</td>
<td>372</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>INF</td>
<td>432</td>
</tr>
</tbody>
</table>

Unlike table driven approach, in AODV, routing table is not maintained rather a route is created on demand. In this case the distance vector works in a different way. This protocol is an improvement in table driven approach. It updates the routing topology with change in node positions. This protocol requires low processing and less resources [6]. Main features are that the node broadcasts route on demand only when required. The nodes do not have to maintain routes all the time. It distinguishes between maintenance and local connectivity. Any change in route and node topology is conveyed. The connection is established by a three way handshake process. In this process Route request is conveyed which is responded by Route reply message (RREQ and RREP) on the acceptance of conditions the route is established [7]. Also, there is a procedure to check for any change from time to time.

SIMULATION AND SIMULATION PARAMETERS IN NS-2

A simulation is conducted in Network Simulator 2, for a varying number of mobile nodes. In this simulation AODV and DSDV protocols were implemented and a number of performance metrics were compared for each set of nodes. Before getting closer to the simulation parameters are given in the table below. Note that simulation was carried out a duration of 200 seconds each for AODV and DSDV. The simulator (NS-2) with version 2.34 was the test bed and nodes were kept mobile. The simulation was systematically conducted for 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 number of nodes. The results will be discussed in next section keeping Performance Metrics in view.
As discussed the simulation was carried out for a series of settings that had different number of nodes and mobility aspect [8]. The performance metrics were:

1. Normalized Routing Load (no. of routing data transmitted per data packet at the destination)
2. Packet Delivery Fraction (ratio of data packet delivered to the destination to that of generated)
3. Average End-to-End Delay (Delays and latency due to all possible factors, namely, discovery, queuing, interference etc)

The simulation results are given below:

<table>
<thead>
<tr>
<th>Simulation Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulator</td>
<td>ns-2.34</td>
</tr>
<tr>
<td>Protocol</td>
<td>AODV</td>
</tr>
<tr>
<td>Simulation duration</td>
<td>200 seconds</td>
</tr>
<tr>
<td>Simulation area</td>
<td>1000 m x 1000 m</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>5, 10, 15, 20, 25, 30, 35, 40, 45, 50</td>
</tr>
<tr>
<td>Transmission range</td>
<td>250 m</td>
</tr>
<tr>
<td>Movement model</td>
<td>Random Waypoint</td>
</tr>
<tr>
<td>MAC Layer Protocol</td>
<td>IEEE 802.11</td>
</tr>
<tr>
<td>Pause Time</td>
<td>100 sec</td>
</tr>
<tr>
<td>Maximum speed</td>
<td>20 m/s</td>
</tr>
<tr>
<td>Packet rate</td>
<td>4 packets/sec</td>
</tr>
<tr>
<td>Traffic type</td>
<td>CBR (UDP)</td>
</tr>
<tr>
<td>Data payload</td>
<td>512 bytes/packet</td>
</tr>
</tbody>
</table>

**PERFORMANCE METRICS AND SIMULATION RESULTS**

**Packet Delivery Fraction (PDF)**

Fig. PDF AODV vs. DSDV (20 Nodes)
Fig. PDF AODV vs. DSDV (10 Nodes)

Normalized Routing Load

Fig. Normalized Routing Load AODV vs. DSDV (10 Nodes)

Fig. PDF AODV vs. DSDV (40 Nodes)
CONCLUSION

For varying number, dynamic and mobile nodes AODV has outclassed DSDV in all the chosen performance metrics. The performance metrics are derived from the study mentioned above in issues and challenges that Ad hoc networks confront. The NS-2 simulation parameters were kept constant for both the routing procedures. From the results it is revealed that with increase in mobility of the nodes the link failure also increase in addition to drop in performance and efficiency (refer to results above). Also, DSDV suffers more performance as compared to AODV which has proven an estimated 80% better efficiency. A a future course of research TORA, a variant of AODV, which is competent enough to replace AODV can be analysed in order to ascertain its reliability and efficiency.

ACKNOWLEDGMENTS

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Author’ biography

Kashif Faheem has received BSc. Engineering degree in Computer Information System Engineering (CISE) from KPK University Of Engineering & Technology, Peshawar, Pakistan (KPK UET Peshawar) in 2005. He had served as an O&M engineer for CDMA system from September 2005 to January 2005 in Telecard Pvt Ltd., Pakistan. From January 2006 to January 2008 had served as Planning Engineer in ZhongXing Telecom Pvt Ltd Pakistan (ZTE Pakistan a telecom vendor). Currently he is serving as a Manager Product in Pakistan Telecommunication Company Ltd (PTCL), a leading telecom operator in Pakistan from January 2008.

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