# Comparison Analysis of Group Routing Approaches for different Scenarios on Mobile Adhoc Networks (MANETs)

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## ABSTRACT
Ad-hoc networks may be divided into various groups of mobile nodes with various tasks and mobility patterns during tactical or emergency response operations. As a result, separate elements of a tactical network might be both ad hoc and disrupted at the same time. With only traditional Mobile Ad hoc Network (MANET) routing algorithms, it will be challenging to maintain good communication. As there are frequently no end-to-end connections in the network between sources and destinations, it causes substantial packet loss. The first strategy is to keep messages in the group leader's possession only. All communication between the group and other disconnected groups of mobile nodes is arranged and managed by the group leader. The second strategy involves storing every message that a group contains in each of its member nodes. In this method, member nodes interact with nodes in neighboring groups without relying on one another. Using four performance indicators, including average delay, packet delivery ratio, and throughput, we compare the effectiveness of the two systems in various scenarios.

## Keywords
MANET, Routing protocols, NS-2

## 1. INTRODUCTION
Wireless communication networks have been designed to be connected constantly or largely so. Any pair of network nodes that are connected have an end-to-end connection at all times. Core network services like routing attempt to resolve transitory problems, such as partitions and disturbances, by looking for alternate routes. Partitions are still seen as outliers, unusual, and short lived even in mobile ad hoc networks (MANETs), where links are more unreliable due to wireless channel impairments and mobility. In the first method, the group leader controls asynchronous communication with other disconnected groups of mobile nodes, while regular members act as message requesters and forwarders to and from their group leader. With collective motion, individuals move together. This routing design is an example of group communication centered on the leader. This strategy strongly depends on the group facilitator. Failure to communicate with the group leader will prevent communication with other groups, which could have a significant impact on crucial work. Furthermore, when there are several parallel communications amongst close-proximity groups, the group leader may act as a communication bottleneck. This may also reduce the volume of communications between nearby groups during their contact time. The second strategy is distributed group routing, in which each group member receives all messages that are contained inside that group. In this method, each member node plays the same duty and communicates with neighboring nodes on their own. Any communication that a member of one group receives from a member of another group must be communicated to all other member nodes. The increased overhead of this strategy offsets its greater robustness. These two routing strategies treat each group as a separate node for communication between groups. Both group routing strategies use MANET routing for intra-group communication while using DTN routing for inter-group communication. Under various circumstances, each of these two approaches has advantages and disadvantages.

## 2. MANET ROUTING SCHEMES
The distribution of network organization, link scheduling, and effective routing must be determined in MANETs. The three types of MANET routing protocols are proactive, reactive, and hybrid. Prior to actual communication, proactive (table-driven) protocols keep all network nodes' routing information up to current, and updates of any network changes are broadcast throughout the whole network. Prior to any data exchange, each node in the network retains route information to every other node. On demand, reactive protocols construct a complete route connecting the source and destination nodes. When a source node needs to forward a message to a destination node, the source node starts the route discovery process. Table-driven and on-demand routing techniques are both used in hybrid protocols.

- **Destination-Sequenced Distance:** The Bellman-Ford method is the foundation of the table-driven routing protocol known as destination vector routing (DSDV) [6]. In its route table entries for each destination, each node keeps track of the hop count metric, next hop, and sequence number generated by the destination node. To differentiate between the old and new route information, the destination node generates a sequence number.
- **Optimized Link State Routing Protocol (OLSR):** An improved proactive link state protocol for MANET is the Optimized Link State Routing Protocol [8]. Based on local information base (set of actual links for one hop neighbors), neighbor information base (details about one and two hop neighbors), and topology information base that are obtained by hello and topological control (TC) messages, each mobile node constructs its local route table.
- **Ad-hoc on-Demand Distance Vector Routing (AODV):** On-Demand Ad-hoc Distance A reactive routing technique called Vector Routing [17] uses destination sequence numbers to find the most current route to a given destination. When a source node needs to send a message, it finds the best path to the specified destination. A source node broadcasts a Route Request (RREQ) packet to the network, and intermediate nodes either rebroadcast the Route Request (RREQ) packet or send the Route Request (RREQ) packet back to the source node if they have

a valid route to the destination. On-demand route between source and destination nodes is created in this manner. Route error (RERR) packets are forwarded to the source node by intermediate nodes if any errors are found along the route.

- **Dynamic Source Routing (DSR):** Reactive routing protocols that use source routing include dynamic source routing [5]. Similar to AODV routing, the source node broadcasts a Route Request (RREQ) packet to the network. However, the intermediate nodes do not respond with a Request Reply (RREP) packet; instead, they merely add their addresses to the RREQ packet and forward it to the destination node. Based on the route record in the Route Request packet, the destination node subsequently sends a Request reply (RREP) packet back to the source node.

- **Zone Routing Protocol (ZRP):** A hybrid routing system called Zone Routing system [6] seeks to offer effective on-demand routing at a low search cost. Each node in ZRP has a routing zone that consists of nodes located k hops away from it. If the destination node is located within the source node's routing zone, ZRP will use any proactive routing protocol. The source node sends a route request to the border nodes that are k-hops away from it, however, if the destination node is in a different zone. Each border node determines whether the destination node is a part of its routing zone and, if not, adds its address to the route request packet before sending it to its own border node.

# 3. PERFORMANCE METRICS

In mobile wireless ad hoc networks, there might exist different network metrics to characterize performance of routing schemes. Nevertheless, some common metrics have been applied to evaluate and quantify the network performance of different routing schemes.

- The ratio of delivered messages to total messages sent is known as the delivery ratio. This is the first metric to determine whether a novel MANET or DTN routing strategy has a throughput advantage over existing MANET and/or DTN routing techniques.

- Average delay is the sum of all message delivery delays in the network. It serves as a crucial performance measurement parameter known as the delivery ratio. For the best communication, the average latency needs to be reduced as much as possible. It is essential for effective communication in extremely dire circumstances.

- The overhead ratio measures how many messages are consumed overall in the network, including control messages and message replicas. This measure makes it easier to calculate the amount of energy and bandwidth used for control messages. In situations where bandwidth is limited, routing systems with a low overhead ratio offer the best communication.

- The ratio of delivered data messages to all messages consumed is known as bandwidth utility. This measure aids in determining the portion of the total bandwidth that sent messages actually use. One of the criteria used by several MANET and DTN routing schemes to gauge how well they perform in comparison to other MANET and DTN routing strategies is bandwidth utility.

# 4. GROUP MOBILITY

Group mobility and entity mobility are the two primary categories of mobility in a mobile ad hoc network. Individual nodes move independently of one another during entity mobility. While in group mobility, mobile nodes that have a common goal or objective are typically grouped and moved as a unit. Additionally, group dynamics in group mobility are constrained, and mobile nodes are frequently clustered together and always maintain the same group membership. We assume that mobile nodes are arranged into specified groups for the sake of our study. In many real-world situations, this group formation criterion is appropriate. For instance, in military operations, the formation of the soldiers or the arrangement of the vehicles is decided upon in advance. Reference Point Group Movement (RPGM) is one of the models of group mobility that is frequently employed [11]. In RPGM, mobile nodes with the same mission (interest) follow the group's logical center. Each group member chooses their speed and direction deviation from the logical center in a random manner, and the group's destination is picked at random. In our simulation scenarios, the mobility model is altered so that the logical center moves according to the same Random way point mobility model (RWMM) [1] as in RPGM, but that each member's deviation from the logical center's speed and direction remains constant throughout the movement process. In this manner, routing inside a group is fixed, and the relative location of group members in relation to the logical center remains constant. Member nodes are connected to one another end to end.

# 5. SIMULATION METHODOLOGY

In our simulation, we used the NS-2 simulation program to implement both strategies. A discrete event driven simulator called NS-2 is designed for network research. Object-oriented Tool Command Language (OTcl) and C++ are the two languages that make up NS2. In contrast to OTcl, which assembles and configures objects and schedules discrete events, C++ decides the internal workings of the simulation (i.e., the back end). A Tcl control script provides input parameters. Before starting the NS2 simulation, the control script is required to configure the communications, routing, and application parameters, import created node mobility, and import generated traffic generation files. Since the NS-2 simulation tool is only appropriate for MANET simulation, we updated NS2 to incorporate DTN mechanisms in order to simulate DTN routing (intergroup routing) of both approaches. User's perspective on NS-2 MANET routing schemes is made simpler. Furthermore, as previously mentioned, we modified the group mobility employed in our study from RPGM[11] in a way that ensures that each member node's relative positional deviation from the group's logical center remains constant during the duration of the simulation.

# 6. TRAFFIC GENERATION

There are four traffic generation types used in NS-2.

- **A Constant bit traffic (CBR) generator:** This generates a fixed size payload burst for every fixed interval.

- **An exponential on/off traffic generator:** It acts as a CBR traffic generator during an ON interval and there is no any packet generation during an OFF interval. ON and OFF periods are both exponentially distributed.

- **A Pareto On/Off traffic generator:** It has similar mechanism as an exponential On/Off generator but the ON and OFF periods conform to a Pareto distribution.
- **A traffic trace generator:** It generates packet bursts according to a given trace file.

## 7. SIMULATION PARAMETERS

We don't set an upper size limit on the buffers in our simulation to compare performance metrics like delivery ratio and average delay of both approaches without limiting the size of the group leader's buffer in Leader based group routing and the size of the nodes' buffers in Distributed group routing. Both methods allow mobile nodes to construct their routing tables within the first five seconds of the experiment. Additionally, throughout the simulation period, nodes broadcast periodic Hello control messages every 2 seconds for the purpose of neighbor detection. The table that is supplied below lists every simulation parameter that was used in our simulation.

**Table 1 Simulation Parameters**

| **Antenna:** | **Omni Antenna** |
|---|---|
| Mac: | 802_11 |
| Network area: | 1000 m * 1000 m |
| Propagation: | Two Ray Ground |
| Radio transmission range: | 100 m |
| Carrier sensing range: | 250 m |
| Packet size: | 512 bytes |
| Transport layer protocol: | User datagram protocol (UDP) |
| Interface queue: | 500 packets |
| Bandwidth: | 2 Mbps |

## 8. SCENARIOS

Numerous simulation tests have been conducted in low- and high-mobility situations under various scenarios. The scenarios were selected to accurately reflect actual difficult issues that could arise in urgent circumstances. For instance, in real-world scenarios, some groups may be kept apart from other groups for an extended period of time. As a result, messages coming from or going to these groups from other groups may experience lengthy delays, potential propagation degradation factors, and/or bottleneck effects on their way there. Additionally, there may be times when groups communicate with multiple adjacent groups at once. Additionally, there may be times when groups communicate with multiple adjacent groups at once. Consequently, the situations we investigated for this work include these asymmetry concerns for mobile node data distribution. We have run simulations for three situations in both low- and high-mobility settings. One instance is when pairs of source and destination nodes are randomly selected from several groups. We conducted two separate experiments using different numbers of groups of mobile nodes for this situation. The second possibility we've thought about is asymmetric sending, or when nodes from just one group of nodes are used to generate traffic. One source node and one destination node are selected from each group except the source group for this experiment. This is a representation of what it truly means for groups to have to comply with orders from a group that oversees essential operations in emergency situations or tactical operations. The third case involves asymmetric reception, or when all of the destination nodes belong to a single group. One source node is selected from each group in this case, with the exception of the destination group, meaning that data dissemination is focused on a particular set of mobile nodes. This situation arises when rescue teams or emergency responders must keep in constant contact with a team that is deeply engaged in a crucial task or when the teams must continuously update a team that collects real-time information from several groups. The tables below give the parameters that are used for mobility and traffic generation.

**Table 2 Low mobility parameters**

| | |
|---|---|
| Min speed | 0.5 m/sec |
| Max pause | 10.0 seconds |
| Movement area | 990 m * 990 m |
| Max speed | 36 km/h |

**Table 3 High mobility parameters**

| | |
|---|---|
| Min speed | 0.5 m/sec |
| Max pause | 0 seconds |
| Movement area | 990 m * 990 m |
| Max speed | 72 km/h |

**Table 4 when source-destination pairs are chosen randomly from different groups**

| | |
|---|---|
| Traffic generation intervals | 1, 2, 5, 10, 100 seconds |
| No of source destination nodes pairs | 10 |
| Source-destination pair selection criteria | Randomly from different groups |

## 9. RESULTS

The outcomes of performance simulations for both leader-based and dispersed group routing strategies in terms of delivery ratio, average delay, quantity of duplicate messages, and average buffer size. These simulation tests aim to identify the inter-group routing strategy that performs best in the majority of circumstances.

### 9.1Average Delay

The mobility patterns of groups have a significant impact on average delays. The average message delivery time may be dramatically impacted by some of the groups' prolonged isolation. In leader-based group routing, the group leader decides how many messages will be routed to neighboring groups. If messages that cannot be transmitted to adjacent groups in a given encounter must wait a long time before other contact is detected with nearby groups, the bottleneck effect will be exacerbated by the mobility patterns of the groups. As we can see from Figure 1 below, distributed group routing has a lower average message delay than leader-based group routing. In terms of average delay across all traffic loads, distributed group routing performs better, and this is mostly because each node has all of the group's messages that are currently included in it in its buffer. In contrast to leader-based group routing, where each border node is dependent on the central node, there is no dependence on a single member node. As a result, there is a clear distinction in the two approaches' performance. In terms of the average delay measure, distributed group routing performs better than leader-based group routing.

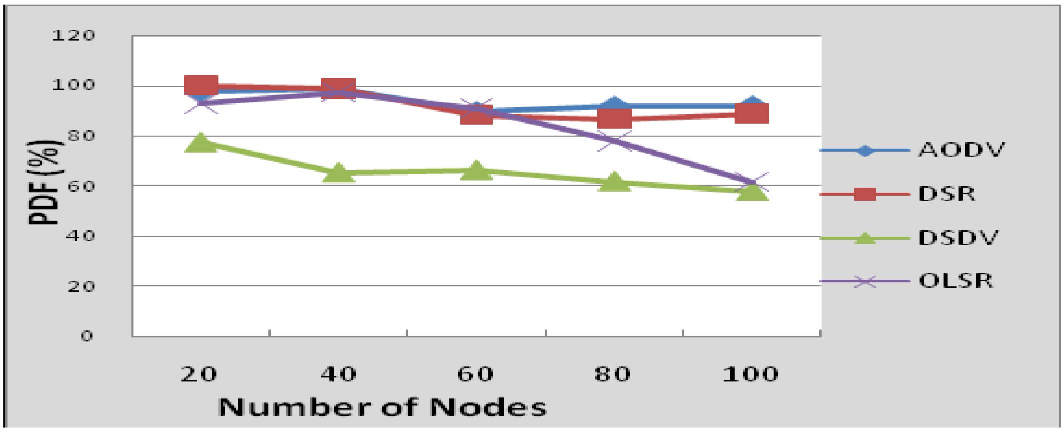


**Figure 1.1 Average Delay**

### 9.2 Packet Delivery Ratio

In our simulation we don't restrict the size of mobile node buffers, there are no messages lost as a result of buffer overflow. Messages can only expire if their time to live reaches zero, which is extremely rare, because we specify the life period of messages in terms of hops. Therefore, messages can only be lost as a result of collisions, receiver nodes migrating out of the transmission range, and concealed terminal issues. Exchange of communications between groups may potentially be impacted by an exposed terminal issue. Figure 2 below shows that when traffic loads are low, the delivery ratios of the two techniques are extremely near to one. We can observe very few messages being lost at low traffic loads as a result of nodes drifting out of transmission range. These issues arise in both strategies as a result of the nondeterministic contact times of various groupings. When the traffic load increases, a significant disparity between the two approaches tends to emerge. When there is a lot of traffic, group leaders become a bottleneck for the amount of messages that are sent to neighboring groups via leader-based group routing.

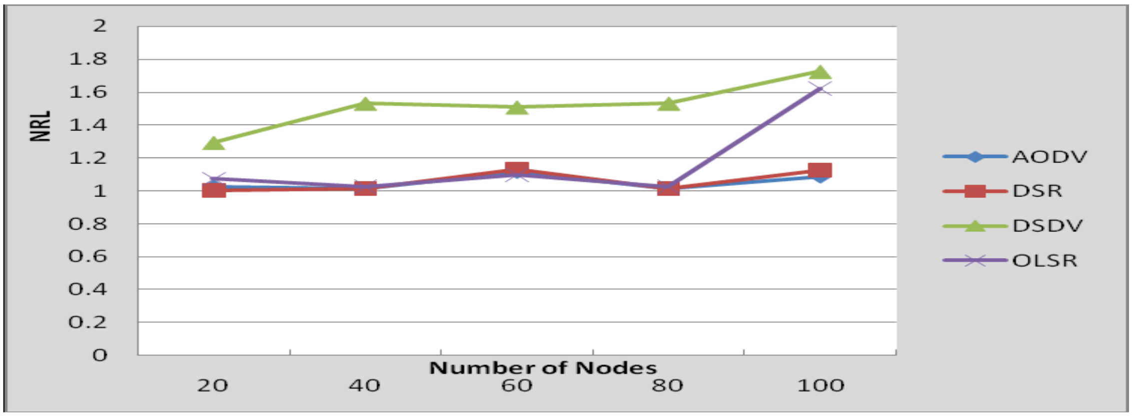


**Figure 1.2 Packet Delivery Ratio**

### 9.3 Throughput

The maximum number of groups a given message can pass through before it is sent to its destination group, taking into account the source group. Therefore, in this case, if destination groups don't come into contact with any of those intermediate groups that have copies, there may be a small number of messages that are unable to reach their destination groups. Due to the hidden terminal problem, where nodes move out of range of each other, messages may be lost. Additionally, communications are considered lost if they don't arrive within the second simulation time. Due to member nodes' independent contact with other adjuster nodes, distributed group routing has, for large traffic loads, achieved considerably higher delivery ratio values than leader-based group routing.

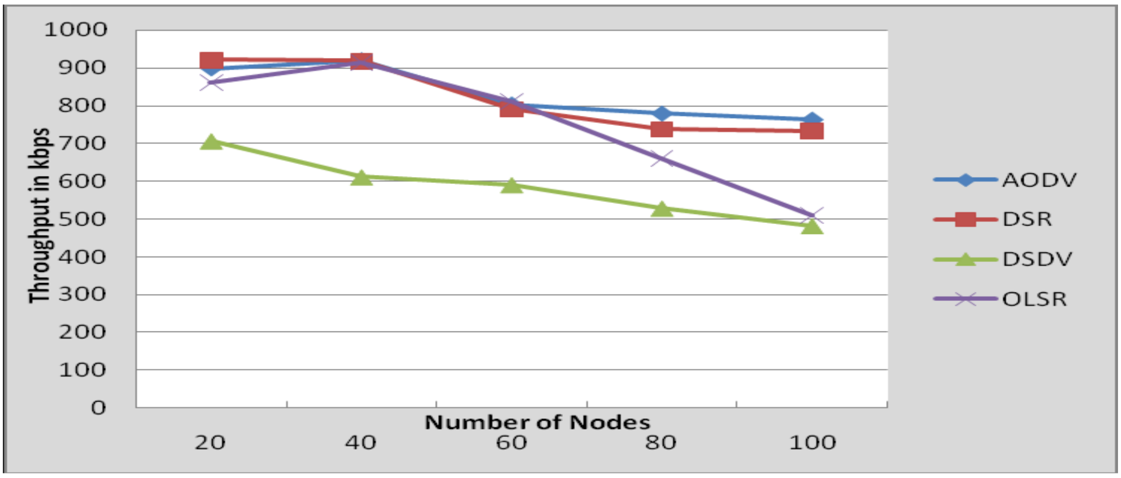


**Figure 1.3 Throughput**

## 10. CONCLUSION

A mobile ad hoc network may split up into smaller, isolated mobile ad hoc networks in certain dangerous circumstances. For instance, during rescue efforts, various groups of vehicles or rescue personnel may veer off in different directions to complete their tasks. As there is end-to-end connectivity between any pair of nodes within a group, members of the group move together and interact with one another via MANET routing protocols. However, when communicating with randomly encountered adjacent groups via routing, the group's nodes behave as a single entity. In order to deliver the best communication possible amid network failures in crucial scenarios, routing strategies therefore need to accurately depict real communication scenarios and integrate routing methods with traditional MANET routing schemes. For disconnected mobile ad hoc networks, we investigate and compare the performance of two group routing algorithms in our study. Group routing based on leaders is the first strategy. Messages are kept at the group leader in this method. The group leader has complete authority over communication with other groups. Messages sent to or from the group leader are only forwarded by the other member nodes. The second group routing strategy is dispersed, and each member node has every message that the group has in its buffer. In this method, inter-group communications produced by member nodes or obtained from another group are distributed as quickly as possible throughout the group. Additionally, copy management of a particular message within a group is carried out by disseminating a "decrease copy control message" throughout the group.

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