Performance Analysis of MANET Routing Protocols using ns-3 Mobility Models

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Abstract

A mobile ad hoc network commonly referred to as a MANET is made up of many nodes that can communicate to each other directly without the need of an access point or a central coordinator. Essentially all the nodes in the network can act either as an end system or an intermediate system. The nodes are also mobile and their movements and speed can be random, thus making its network topology very dynamic due to constant link breakages and formations, leading to deterioration in the performance of the MANET routing protocols. MANETs are not widely deployed and therefore mobility models are used in simulation environments to test network performance. This project uses four of the mobility models supported in the ns-3 network simulator to show the impact of mobility on MANET routing protocols. The attributes of the nodes that will be changing are velocity and node density; the performance parameters that will be evaluated are throughput, end-to-end delay, and routing overhead. The analysis will seek to answer the following questions: how does mobility and node density affect the performance of the different protocols? Does the underlying mobility model used affect protocol performance? Is there a superior protocol that performs better overall? And is there a mobility model that seems to offer better performance to all the protocols?
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Outline

• Introduction
• Background
  – MANET protocol
  – Mobility Models
• Simulation Model
• Performance Parameters
• Analysis of simulation results
• Conclusions
• References
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Introduction

• MANETs operate in the absence of infrastructure
  – Can be used in disaster relief efforts
  – Not widely deployed
  – Research is simulation based

• Traditional routing protocols not good for MANETs
  – Designed for stable topology with wired links

• Mobility scenarios vary

• Mobility model affects protocol performance

• Is there a better protocol overall?
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MANET Protocols

• DSDV
  - Proactive table-driven protocol
  - Every node contains routing entries to all nodes
  - Periodic updates
  - Sequence numbers to prevent routing loops
  - Hop count as cost metric.

• OLSR – Optimized Link State Routing
  - Proactive table driven link state routing protocol
  - MPR set used to optimize flooding
  - HELLO and TC messages for link state information
  - Only MPR nodes flood broadcast messages
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MANET Protocols

• AODV
  - On-demand routing protocol
  - Routes found by broadcasting RREQ packet
  - Contains source IP address, current sequence no.
  - Broadcast ID and recent sequence no. to dest.
  - Intermediate nodes or dest. node respond with RREP

• DSR
  - On-demand protocol using source routing concept
  - Header of each packet contains path to destination
  - Route Discovery and route maintenance mechanisms
  - Multiple routes to a destination cached
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Mobility Models

• Random Walk
  - Nodes randomly choose direction after traveling for
  - a specified distance or amount of time
  - At simulation boundary bounces off at an angle
  - Angle determined by the incoming direction

• Steady-state Random Waypoint
  - Nodes choose a waypoint randomly
  - Travels to it at a speed chosen from specified range
  - Pauses for a specified period of time; repeats again
  - Vmax and Vmin specified for steady state speed
  - Gets rid of nodal speed decay thus accurate results
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Mobility Models

• Random Direction
  - Nodes randomly chose direction
  - Travel to simulation boundary and pause
  - Chose another direction between 0 and 180 degrees
  - Repeats process again.
  - Good distribution of nodes in simulation area

• Gauss-Markov
  - Memory-based mobility model
  - Nodes travel for specified time interval (timestep)
  - Then change speed and direction
  - Next speed and direction based on previous ones
  - Alpha parameter determines randomness
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Simulation Model

- **ns-3 network simulator used**
- **CBR traffic using on-off application**
- **Set up for velocity scenario** has 50 nodes
  - Area of 1000 by 1000 meters
  - 25 flows
  - Varying velocity from 0.2 m/s to 40 m/s
- **Set up for node density scenario**
  - Area of 500 by 500 meters
  - Velocity of 2 m/s
  - Varying nodes from 10 to 50
- **Seed manager used to obtain dissimilar runs**
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Simulation Model

• 95 percent confidence interval
  – Show reliability of the results
• Simulation parameters used
  – Speed
  – Node density
• Ns3Master module used to parse trace files
• Simulations run on the ITTC cluster
### Simulation Model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Scenario</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>area</td>
<td>varying speed, varying nodes</td>
<td>1000 x 1000m, 500 x 500m</td>
</tr>
<tr>
<td>application data rate</td>
<td></td>
<td>4 pkt/s</td>
</tr>
<tr>
<td>data packet size</td>
<td></td>
<td>64 bytes</td>
</tr>
<tr>
<td>wifi mode</td>
<td></td>
<td>802.11b</td>
</tr>
<tr>
<td>transmission range</td>
<td></td>
<td>250 m</td>
</tr>
<tr>
<td>simulation time</td>
<td></td>
<td>1000 s</td>
</tr>
<tr>
<td>propagation loss model</td>
<td></td>
<td>range propagation loss model</td>
</tr>
<tr>
<td>traffic</td>
<td></td>
<td>CBR</td>
</tr>
<tr>
<td>node speed</td>
<td>varying network size</td>
<td>2 m/s</td>
</tr>
<tr>
<td>number of nodes</td>
<td>varying speed network</td>
<td>50</td>
</tr>
<tr>
<td>pause time</td>
<td>stationary RWP, random direction</td>
<td>100 s, 10 s</td>
</tr>
<tr>
<td>node traversal time</td>
<td>aodv</td>
<td>2 µs</td>
</tr>
<tr>
<td>enable buffering</td>
<td>dsdv</td>
<td>false, 15 s, 6 s</td>
</tr>
<tr>
<td>periodic update interval</td>
<td></td>
<td></td>
</tr>
<tr>
<td>settling time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Simulation table
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Performance parameters

• PDR
  - No. of pkts received divided by no. of pkts sent
• Delay
  - Time taken by pkt to reach destination from source
• Routing overhead
  - Fraction of bytes used by protocols for control msgs
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PDR

• AODV performs better with increasing velocity
• DSDV and OLSR performance deteriorate

Figure 5: Random Direction PDR vs. speed of nodes
Figure 6: Random Walk PDR vs. speed of nodes
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PDR

- SRWP offer better performance to protocols
- Less dynamic topology due to pause time

Figure 7: Gauss-Markov PDR vs. speed of nodes

Figure 8: Steadystate Random Waypoint PDR vs. speed of nodes
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PDR

- AODV PDR starts dropping after 30 nodes
- OLSR performs better due to MPR system

![Graph 1: Random Direction PDR vs. network size](image)

![Graph 2: Random Walk PDR vs. network size](image)
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PDR

- SRWP offers better performance
- Especially for the pro-active protocols

Figure 11: Gauss-Markov PDR vs. network size

Figure 12: SteadyState Random Waypoint PDR vs. network size
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Delay

- Delay unaffected by changing velocity
- No buffers for proactive protocols

Figure 13: Random Direction delay vs. speed of nodes

Figure 14: Random Walk delay vs. speed of nodes
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Delay

- In GM AODVs delay slightly rises at 32 nodes
- Still not a significant rise

Figure 15: Gauss-Markov delay vs. speed of nodes

Figure 16: Steadystate Random Waypoint delay vs. speed of nodes
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Delay

- AODV delay starts to rise after 30 nodes
- All nodes involved in route discovery

Figure 17: Random Direction delay vs. network size

Figure 18: Random Walk delay vs. network size
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Delay

- DSDV and OLSR delay not changing
- Routes already pre-fetched

Figure 19: Gauss-Markov delay vs. network size

Figure 20: SteadyState Random Waypoint delay vs. network size
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Overhead

- AODV overhead slightly rises
- Dynamic topology with increasing velocity

Figure 21: Random Direction overhead vs. speed of nodes

Figure 22: Random Walk overhead vs. speed of nodes
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Overhead

- AODV overhead steeply rising with increasing velocity in Gauss-Markov

Figure 23: Gauss-Markov overhead vs. speed of nodes

Figure 24: Steadystate Random Waypoint overhead vs. speed of nodes
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Overhead

- AODV overhead rising steeply after 30 nodes
- More nodes involved in route discovery

Figure 25: Random Direction overhead vs. network size

Figure 26: Random Walk overhead vs. network size
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Overhead

• Overhead slightly rises for OLSR and DSDV
• More nodes sending periodic updates

Figure 27: Gauss-Markov overhead vs. network size

Figure 28: SteadyState Random Waypoint overhead vs. network size
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Conclusions

• AODV better for high velocity scenarios
  – Problem of invalid route in cache minimized

• OLSR better in high node density scenario
  – Multi point relaying system
  – Overhead does not increase with node density

• SRWP offers better performance for protocols
  – Topology not changing very much
  – Due to pause time
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