Evaluating the Effect on Routing Traffic Load of Different Proactive Ad Hoc Routing Protocols (GRP vs OLSR) in a Simulated Mobile Ad Hoc Network Environment

Abstract - This poster aims to present the research conducted to evaluate the effects on routing traffic load in a mobile ad hoc network when choosing between two different proactive routing protocols. A review of relevant literature is described in the poster as well as the design and approach taken to conduct the experiment. The results of the experiment are presented and analysed and further discussion on the research is made before coming to final conclusions.

1. Introduction.

- The research documented by this poster aims to discover the effects on routing traffic load when the chosen ad hoc routing protocol is changed for a given simulation scenario.
- Mobile ad hoc networks (MANETs) provide an architecture-less alternative to traditional networking paradigms. This becomes useful for dynamic and spontaneous networking scenarios where it is infeasible for a network architecture (wired or otherwise) to be established before communication must be conducted. MANETs feature “no fixed routers” and nodes that are “capable of movement and can be connected dynamically in an arbitrary manner” and as such are often suitable for scenarios such as emergency response situations, law enforcement, and data collection in inhospitable terrains (Royer and Toh, 1999). The way in which communication functions within a MANET is governed by the routing protocol/algorithm and as such, different routing protocols offer varying advantages and disadvantages when routing communications. Two of the most widely considered classes of ad hoc routing protocols are reactive protocols (which generate routes between nodes on an as-needed basis) and proactive protocols (which propagate routes between nodes using regular updates of topological changes).
- Research constraints for this poster include the timescale under which the research must be conducted, and the resources available to and current knowledge possessed by the author.

2. Problem Statement/Aim and Objectives.

- The problem which this research aims to contribute to solving is understanding which of the proactive ad hoc routing protocols can perform in a generalised MANET scenario to give the lowest network routing traffic load.
- This research is important as some MANET scenarios will require the low end-to-end (E2E) latency and high throughput that a proactive routing protocol can generally provide better than a reactive protocol; but still aim to minimise routing load - a metric that would otherwise be best minimised using a reactive routing protocol. As such there is good reason to investigate which proactive routing protocol can minimise routing traffic load.
- The author hypothesizes that the proactive protocols investigated will exhibit somewhat similar values for routing traffic load.

3. Background/Contribution From Literature.

- In order to decide on which routing protocols should be considered to investigate the minimising of routing traffic load, an understanding of the existing MANET protocols should be gained. Jayakumar and Gopinath (2007) identify that due to nodes in a MANET being mobile that “routing protocols in wired network [sic] cannot be used for mobile ad-hoc networks”. As such, protocols that allow for the mobility of nodes must be used for MANETs.
- Royer and Toh (1999) identify two classes of MANET protocols, namely: ‘Table-driven’ and ‘Source-initiated’ (also known as proactive and reactive, respectively). In the proactive class they identify the protocols: DSDV, CGSR, and WRP; and in the reactive class they identify the protocols: AODV, DSR, TORA, ABR, and SSR. Later on, Jayakumar and Gopinath (2007) build on this knowledge by adding the FSR, OLSR, and TBRPF protocols to the table-driven/proactive class as well as mentioning the hybrid protocol ZRP. Later still, Sharma et al. (2019) add GSR to the proactive routing class; define hybrid protocols as its own category with the ZRP and ZHLS protocols; as well as identifying two new distinct protocol classes, namely: hierarchical (with the protocols FSR, CBRP, OSPF, CGSR, HSR) and geographic position based (with the protocols LAR, GPSR, DREAM, Geo cast).
- In their analysis of these algorithms, Jayakumar and Gopinath (2007) provide a simple comparison of measured effects exhibited by proactive and reactive protocols when they state how proactive protocols outperform reactive protocols when considering throughput and E2E delay, but that reactive protocols outperform proactive protocols when considering routing load. This corroborates the findings stated by Royer and Toh (1999) when they state how that table-driven protocols generate signalling traffic that is “greater than that of on-demand routing” due to the requirement for frequent route updates, which has the effect using more bandwidth as well as mobile node battery power.
- Since this research poster is not interested in the effects on battery power, it can be assumed that there is value in investigating which of the proactive routing protocols can maintain a lower routing traffic load, in order to cater to scenarios that require the low E2E delay of proactive protocols but still also aim to minimise routing traffic load as much as possible and where other QoS metrics such as packet loss or jitter are of a lower priority.
- Software such as NS3, OMNET++, Riverbed/OPNET, and GloMoSiM have each been acknowledged as suitable, within an academic context, for modelling MANETs in order to study how they work (Bakhtin et al., 2017). Due to this poster’s author’s expertise and available resources, the use of Riverbed/OPNET software for the simulation of MANETs is reviewed further. Aujla and Kang (2013) present (using OPNET) a rigorous evaluation on using both reactive and proactive protocols within multiple MANET scenarios using different node quantities. While their research could be considered quite general, they effectively detail the process by which they conduct their experiment and present their results clearly. A significant point to note is how that they use the proactive protocol: Geographic Routing Protocol (GRP), as part of their experiment, which had not been previously identified by the reviews of MANET protocols conducted by Royer and Toh (1999), or Jayakumar and Gopinath (2007), or Sharma et al. (2019). This may be due to GRP’s similarity to other geographic-based protocols identified by Sharma et al. (2019). The use of Riverbed/OPNET in simulating MANETs is further substantiated by its successful use by Rahman and Siddiqui (2016), Rao et al. (2019), and Saleh & Maruf (2018), to gain results for each of their experiments. From this it can be deduced that the OPNET modeller can be used suitably to investigate the effects on routing traffic load when using proactive protocols, of which OPNET allows for the use of GRP and OLSR, so those protocols are chosen for further study.

4. Experimental Design.

- This research poster’s experiment employs a simulation-based research methodology to help verify or deny the hypothesis made in § 2. This method is chosen to account for constraints identified in § 1 concerning researcher skill set and available resources.
- This experiment will be conducted in a simulated environment, using the OPNET modeller version 18. This tool was chosen due to the fact it has demonstrated effectiveness in modelling MANET systems as evidenced in papers by the papers that OPNET or Riverbed (a nearly identical software package), described in § 3. OPNET allows for the automatic data collection of metrics during the running of the simulation and can present this data in graph form.
- In order to evaluate the efficacy of each routing protocol this experiment selects: the routing algorithm as the independent variable to be investigated (GRP and OLSR); the simulation scenario as the controlled variable; and the routing traffic load as the dependant variable to be measured. The scenario (Fig. A) is developed after selecting to include the MANET Model Family in the OPNET topology options. Such a organisation of nodes is chosen in order to establish a generalised context for how common MANETs may operate. Mobile node ‘manet_station’ is chosen and placed in an initial grid of 5x5 nodes each spaced 10 metres apart. This is not in order to accurately model any one specific real-life scenario but to provide a generalised scenario that could be regarded as an approximate for many real-life ad hoc networking scenarios. As such the nodes are given a ground speed of 1.5 metres/second to approximate a walking speed; the random waypoint mobility model is chosen to simulate node movement; movement of the nodes is restricted to a 100 metre by 100 metre square; and the scenario is run for a simulated time of 2 hours. IP telephony is chosen as the simulation application in order to simulate an application likely common to many MANET scenarios (law enforcement, emergency services). Two scenarios are created using the same simulation configuration, except for in one scenario the chosen routing protocol is GRP, and in the other the chosen protocol is OLSR. See Appendix D for the node configuration parameters.
- In order to consider the ways in which simulation results are produced, and the variabilities that can produce them (such as random number generation), the two simulation scenarios are each run three times, using a different seed number for each simulation run, described in the simulation parameters (Appendix B and C).

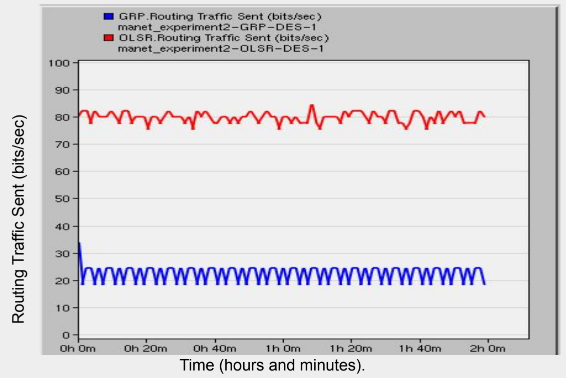

Fig. C. ‘mobile_node_0’ Routing Traffic Sent Statistics in bits/sec for GRP scenario (blue) and OLSR scenario (red) against time for the first run of the simulation.

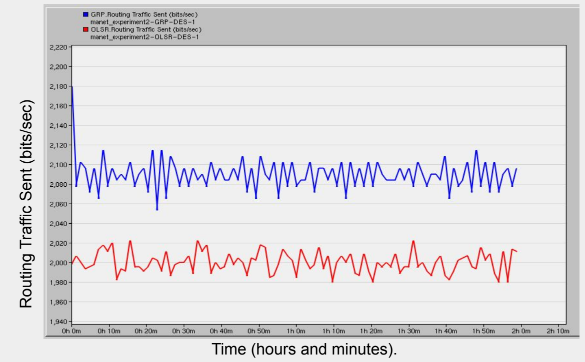

Fig. B. Global Routing Traffic Sent Statistics in bits/sec for GRP scenario (blue) and OLSR scenario (red) against time for the first run of the simulation.

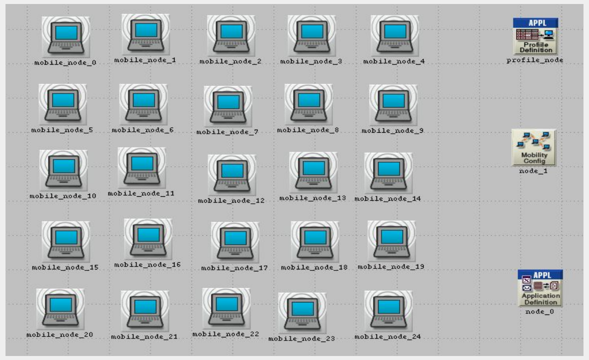

Fig. A. Simulation Topological Setup.

5. Results.

- In Fig. C it can be seen how that the sent routing traffic metric for ‘mobile_node_0’ is consistently greater in the scenario using OLSR than in the scenario using GRP. However, in Fig. B it can be seen that the results for total network sent routing traffic runs counter intuitively, as the scenario using GRP is consistently greater than in the scenario using OLSR. This was not expected as it would have been expected that if an individual node exhibits an on-average higher routing traffic then that would be consistent throughout all of the nodes in the scenario which would suggest that OLSR would overall produce a higher overall network routing load. The simulation results reveal that the opposite is true.
- Therefore, it can be inferred here that the OLSR algorithm implements measures which enable an overall sent routing traffic to be lower despite a single node (‘mobile_node_0’) exhibiting higher routing traffic load.
- The regularity of the sent routing traffic for ‘mobile_node_0’ (Fig. C) when using GRP indicates that GRP would be sending routing updates over regular time periods, each of which would be the same size. The initial spike in sent routing traffic for GRP seen in both Fig. C and Fig. B indicates that GRP would be sending more information as a part of the route initialisation process.
- The comparatively irregular metric for routing traffic sent for the OLSR scenario in ‘mobile_node_0’ (Fig. C) would suggest that OLSR more selectively chooses what information is sent with each routing update, which would explain why the value for sent routing traffic is irregular but between a close range (between 75 and 85 bits/sec).

6. Discussion

- From these results, it can be deduced that it may be possible for overall network routing traffic to be reduced by a factor of ~1.045 (~2090/~2000) when using OLSR over GRP, especially within scenarios that closely match the generalisations and assumptions made as part of the experimental design. As such, we can deduce that the hypothesis made in § 2 is, to a significant degree, correct as the reduction in sent routing traffic is quite marginal.
- If it can be assumed that ‘video conferencing’ applications are more analogous to IP telephony than e-mail is, it can be said that the results gained in this experiment can be corroborated by the results gained by Aujla and Kang (2013) as they demonstrate how GRP produced a greater network load over OLSR in each of their video conferencing scenarios.
- One limitation of the results gained in this experiment is that the only statistic evaluated is sent routing traffic. This leaves out any other impacts that choosing between OLSR and GRP may have, and as such it may have been more useful to capture other data such as packet loss or E2E latency do develop a more holistic analysis of the effect of each algorithm on a MANET scenario.
- A considerable limitation of the design of this experiment is that it considers MANETs in a very generalised sense, as such further analysis would be required to discover whether the results hold true for various other scenarios that are perhaps more based within real-life contexts to gain more accurate results.

7. Conclusion.

- Through conducting a literature review on MANET routing protocols, it was able to be understood how that proactive routing protocols generally underperformed against reactive protocols in maintaining a lower network load. With this information an experiment was able to be designed such that the routing load of two different proactive routing protocols could be investigated.
- In completing the experiment it could be determined that (for at least scenarios similar to the one presented in the experimental design) OLSR would outperform GRP in maintaining a lower total routing traffic load, but that the metric differences between the two are minimal.
- On discussion of the results it is justified to what extent the results are likely to be accurate as well as limitations with the experiment being described.

8. Future Work.

- To validate the results gained in this experiment to a greater extent, a practical experiment analogous to the simulation parameters could be designed using physical hardware to reveal more nuanced practicalities of the effects of using each protocol within a given scenario.
- This further work could be extended not just to considered the impacts on routing traffic load, but other QoS metrics, and also to consider the efficacy of hybrid or geographic based protocols against proactive and reactive routing.

Key References.

- Bakhtin, A., Volkov, A., Muratchaev, S., Galenko, V., & Konoplev, A. (2017). Development of MANET network model for space environment in NS3. 2017 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus), Young Researchers in Electrical and Electronic Engineering (EIConRus), 2017 IEEE Conference of Russian, 111–114. https://doi.org/10.1109/EIConRus.2017.7910506
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Additional References

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- Rahman, M. M & Siddiqui, A. B. (2016). *Performance analysis of Mobile Ad-Hoc Network using Different Routing Protocol (AODV, DSR).* International Research Journal of Engineering and Technology (IRJET)
- Rao, Y. C. & Kishore, P. & Prasad, S.. (2019). *Riverbed modeler simulation-based performance analysis of routing protocols in mobile ad hoc networks.* International Journal of Recent Technology and Engineering. 7. 350-354.
- Saleh, M. H. & Maruf, A. O. (2018). Development of an enhanced aodv energy management model and link stability in manet. Annals. Computer Science Series. 16th Tome 1st Fasc. – 2018

Appendix

A. First run simulation parameters

Common

Duration: 2 hour(s)

Seed: 128 Enter Mul

Values per statistic: 100

Update interval: 500000 events

Simulation Kernel: Based on 'kernel_type' preference (Preference set to "development")

Use OPNET Simulation Debugger (ODB)

Simulation set name: scenario

Comments:

B. Second run simulation parameters and results

Common

Duration: 2 hour(s)

Seed: 129 Enter Mu

Values per statistic: 100

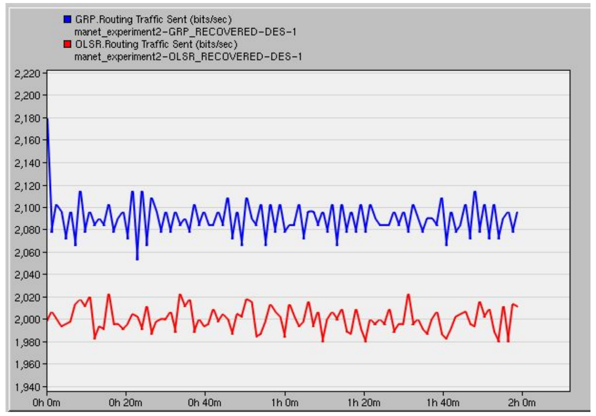
Update interval: 500000 events

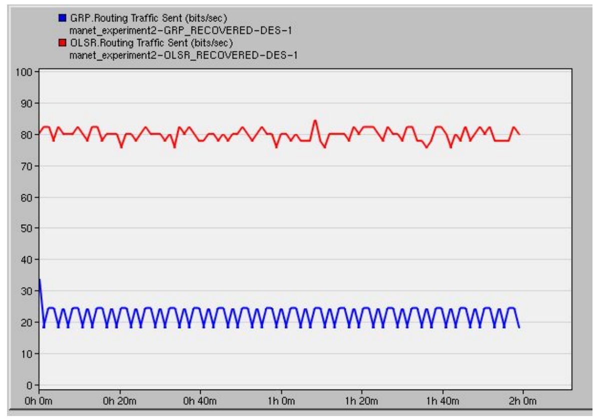
Simulation Kernel: Based on 'kernel_type' preference (Preference set to "development")

Use OPNET Simulation Debugger (ODB)

Simulation set name: scenario

Comments:





C. Third run simulation parameters and results

Common

Duration: 2 hour(s)

Seed: 130 Enter Multi

Values per statistic: 100

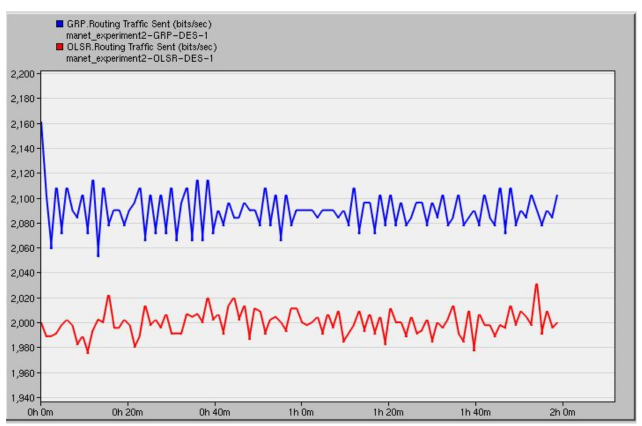
Update interval: 500000 events

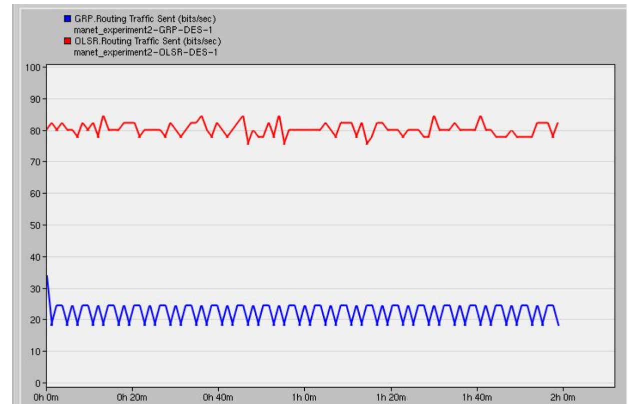
Simulation Kernel: Based on 'kernel_type' preference (Preference set to "development")

Use OPNET Simulation Debugger (ODB)

Simulation set name: scenario

Comments:





D. Node configuration parameters

Profile config.

Profile Configuration	(...)
Number of Rows	1
Mobile Profile	
Profile Name	Mobile Profile
Applications	(...)
Number of Rows	1
Voice_Application	
Name	Voice_Application
Start Time Offset (seconds)	No Offset
Duration (seconds)	End of Profile
Repeatability	(...)
Operation Mode	Simultaneous
Start Time (seconds)	constant (0)
Duration (seconds)	End of Simulation
Repeatability	Unlimited

Application config.

Application Definitions	(...)
Number of Rows	1
Voice_Application	
Name	Voice_Application
Description	(...)
Custom	Off
Database	Off
Email	Off
Ftp	Off
Http	Off
Print	Off
Peer-to-peer File Sharing	Off
Remote Login	Off
Video Conferencing	Off
Video Streaming	Off
Voice	IP Telephony

OLSR Routing config.

AD-HOC Routing Parameters	
AD-HOC Routing Protocol	OLSR
AODV Parameters	Default
DSR Parameters	Default
GRP Parameters	(...)
OLSR Parameters	(...)
Willingness	Willingness Default
Hello Interval (seconds)	2.0
TC Interval (seconds)	5.0
Neighbor Hold Time (seconds)	6.0
Topology Hold Time (seconds)	15.0
Duplicate Message Hold Time...	30.0
Addressing Mode	IPv4
SMF Functionality	Disabled

GRP Routing config.

AD-HOC Routing Parameters	
AD-HOC Routing Protocol	GRP
AODV Parameters	Default
DSR Parameters	Default
GRP Parameters	(...)
Hello Interval (seconds)	constant (20)
Neighbor Expiry Time (secon...	constant (10)
Position Update Parameters	Default
Backtrack Option	Enabled
Routes Export	Disabled
Number of Initial Floods	1

Traffic Generation config.

MANET Traffic Generation Parame...	(...)
Number of Rows	1
100.0	
Start Time (seconds)	100.0
Packet Inter-Arrival Time (sec...	constant (1)
Packet Size (bits)	constant (1024)
Destination IP Address	Random
Stop Time (seconds)	End of Simulation

Node Mobility config.

Random Mobility Profiles	(...)
Number of Rows	3
Default Random Waypoint	
Profile Name	Default Random Waypoint
Mobility Model	Random Waypoint
Random Waypoint Parameters	(...)
Mobility Domain Name	Not Used
x_min (meters)	0.0
y_min (meters)	0.0
x_max (meters)	100
y_max (meters)	100
Speed (meters/seconds)	uniform_int (0, 10)
Pause Time (seconds)	constant (100)
Start Time (seconds)	constant (10)
Stop Time (seconds)	End of Simulation
Animation Update Frequen...	1.0
Record Trajectory	Disabled