Analysis of Performance Evaluation in Routing Protocols of Wireless Mesh Networks

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Abstract--*Wireless Mesh Networks (WMNs) are the set of wireless nodes that can communicate with each other and forwarding each other's packets. WMNs are multi-hop networks consisting of routers, gateways and mobile nodes, they aim at guarantee connectivity. They act as a key technology for next generation WMNs due to their low cost and relative ease of deployment they are an attractive paradigm and are advantageous to other wireless networks. WMNs build a multi-hop wireless backbone to interconnect isolated Local Area Networks and to extend backhaul access to users not within range of typical access points.*

This paper analysed routing protocol such as Ad hoc on Demand Distance Vector (AODV), Dynamic Source Routing (DSR), GRP -Geographic routing protocol, Temporary Ordered Routing Algorithm (TORA), and Optimized Link State Routing (OLSR) used in WMN where AODV and DSR are reactive routing protocol, OLSR and GRP are proactive routing protocol and TORA is a hybrid routing protocol. The routing protocol have been analysed with the performance metrics of throughput and delay under the simulation of ftp traffic and database traffic. With OPNET simulator, the results shows that in terms of ftp traffic load, TORA has very long delay. For throughput, OLSR outperforms the other routing protocols. Under database traffic load, OLSR has long delay and for throughput, DSR and TORA have high throughput.

Keywords--*AODV - Ad hoc on distance vector; DSR - Dynamic source routing; FTP - File Transfer Protocol; GRP - Geographic routing protocol; WMNs -Wireless Mesh Networks*

I. INTRODUCTION

Wireless Mesh Networks (WMNs) are a set of wireless nodes that can communicate with each other and forward each other's packets. They have become popular because of ease deployment and low cost. Wireless mesh networks (WMNs) are dynamically self-organized and self-configured, with the nodes in the network automatically establishing an ad hoc network and maintaining the mesh connectivity [1]. WMNs, consisting of wireless access networks interconnected by a wireless backbone, and present an attractive alternative. Compared to optical networks, WMNs have low investment overhead and can be rapidly deployed. They can extend Internet Protocol (IP) connectivity to regions otherwise unreachable by any single access technology [2].

WMNs use three categories of protocols which are proactive, reactive and hybrid. Proactive routing protocols maintain routes to all destinations, regardless of whether these routes are needed or not. To preserve correct route information, a node must periodically send control messages. Therefore, proactive routing protocols may waste bandwidth since control messages are sent out unnecessarily when there is no data traffic. Reactive routing protocols only set up a route between a source and its destination when required this protocol are. Hybrid routing protocols combine both reactive and proactive routing to increase the overall scalability in the networks [2; 3].

This paper evaluates and compares the performance of ADOV, DSR, GRP, OLSR and TORA routing protocols in WMNs, in order to identify the most suitable in- terms of scalability, robustness, mobility, reliability and quality of service (QoS).

II. ROUTING PROTOCOLS

Routing protocols are very important in WMN for forwarding packets from source to destination. WMN shares some features with ad hoc network so routing protocol used in Mobile Ad hoc Network (MANET) can be applied to WMN. De Rango et al.[4] classify MANET routing protocols into four categories: proactive protocols, reactive protocols, hybrid protocols and cluster- based protocols.

A. Ad hoc On Distance Vector

AODV is a reactive distance vector routing protocol that have been optimised for mobile ad- hoc wireless networks. AODV makes extensive use of sequence numbers in control packets to avoid the problem of routing loops. It has Route Request Packet (RRP) which helps for communication to the unknown destination node and RRP contains an ID which will identifies route request [5].

AODV is divided to reverse route establishment and forward route establishment, in route establishment the source node broadcasts the RREQ

packets when the destination node receives the RREQ packet, will send the Route Reply (RREP) packet to source node. The forward node is established form source node to destination node and is used to transmit packets [6].

B. Optimized Link State Routing (OLSR)

OLSR is a proactive routing protocol. The routes is usually stored and updated when the route is needed. The route is immediately presented without any initial delay. There are some candidate nodes called multipoint relays (MPRs) which are selected and they are responsible to forward broadcast packet during the flooding process. OLSR is a hop by hop routing where each node uses its most recent routing information to route packets.

C. Dynamic Source Routing (DSR)

DSR is a reactive routing protocol which maintains information about the whole path from the source to the destination node. It discovers routes only when is needed. DSR consists of two types of mechanisms namely as: routing discovery and routing maintenance. Routing discovery is responsible for route calculation from source node to destination node. Routing maintenance monitors the availability of the current node [6].

D. Temporally Ordered Routing Algorithm (TORA)

TORA is a hybrid protocol and it is for multihop networks and is considered to minimise the communication overhead associated with adapting to network topology [7]. Is an algorithm protocol based on the link reversal concept also improves the partial link reversal method where it detect partition and stopping no-working link reversals. The effect in TORA is localised in a set of a nodes that are affected [8]. TORA has three operations namely as: Route creation, Route maintenance and Route erasure.

E. Geographic Routing Protocol (GRD)

GRP is classified as proactive routing protocol. It is hop-by-hop routing and its routing principle relies on geographic position information. Global Positioning System (GPS) marks each node's location. It uses flooding location distance update when a node moves and crosses a neighbourhood. Route locking is advantageous for node to return its packet to the last node [9].

III. RELATED WORK ON PERFORMANCE ANALYSIS OF ROUTING PROTOCOL

He et al [10] compared performance of two routing protocol of TORA and DSDV based on WMN because they share three standards: average grouping deliver rate which compare the number of package received by the destination node by the package received by the destination node by the package number send from the source node. Their results in terms of average group deliver rate shows that TORA delivery is low while DSDV performance is worse when mobility is high and it lead to packet drop because of alternative routes. For average end to end delay DSDV and TORA perform equally. Normalised routing overhead of protocols, it shows that TORA performance is good because it has overhead of both table driven and on-demand routing techniques while DSDV is only table driven protocol. TORA performs better under high mobility simulations than DSDV.

Ashraf et al. [11] analysed the performance of four ad hoc routing protocols which are two reactive (DSR, AODV) and two proactive (OLSR, DSDV) protocols for WMN using NS2 simulation. DSR performs best in all scenarios. AODV followed DSR but not for large networks. OLSR raked third, it gives stable performance due to its periodic routing exchange and DSDV performs worst in their simulation. They concluded that reactive protocol performs better than proactive protocols.

Oh et al [12] proposed a hybrid routing protocol and performance evaluation in a WMNs. The proactive protocols were applied depending on the hop count between source and destination nodes. The researcher adopted the DSDV for nearby destination and AODV for a remote destination. The hybrid routing protocol utilizes DSDV and AODV because each node maintains a single shared routing table for both DSDV and AODV. The result showed that the proposed hybrid routing protocol performs better than DSDV but worse than AODV in terms of transmission delay as the number of nodes in the network increases. For the smaller number of nodes in terms of routing load as the number of nodes in the network increases the proposed hybrid protocols performs worse than DSDV and better than AODV. The researcher concluded by limiting the coverage of DSDV and applies AODV in any other regions within WMNs to reduce the impact on the normal operation of user packet delivery that is caused by DSDV.

Snegupta [13] also analysed and simulate the AODV and OLSR routing protocol for both wireless ad-hoc network and WMN. They used OPNET modeler version for their simulation.

Their results show that AODV performs better with static traffics while OLSR is best in networks with high density and highly sporadic traffic.

A study by Zakrzewska et al. [5] proposed a performance evaluation of routing protocols for WMN using DSDV, OLSR, AODV and DSR. Their performance comparison was done with regard to the network size, network load and nodes mobility. The results showed that for network size AODV performs better in the scenarios of high mobility and network load, OLSR performs much better than DSDV and DSR.

A. Performance metrics

There are different kinds of metrics for the evaluation of the network performance of the routing protocols. We chose to use 3 which are namely as: throughput, delay and routing overhead for WMN routing network performance evaluation.

B. Simulation set-up

The simulation is performed using OPNET modeller 14.0 with the following statistics: 15 nodes randomly distributed in an area of 5km X 5km. the nodes moved in random waypoint model with a speed of 10 meter per second and the pause time of 100 seconds. The protocols that were studied for comparison in simulation are: AODV, DSR, OLSR, GRP and TORA. There are 6 profiles models identified:

- Ftp low: profile that is under low ftp load conditions.
- ftp medium: profile that is under medium ftp load conditions
- Ftp high: profile that is under high ftp load conditions.
- Database low: profile that is under low database load conditions.
- Database medium: profile is under medium load conditions.
- Database high: profile is under high load conditions.

We modeled the first 3.

Every profile created during simulation was applied to each of the protocols. Figure shows one of WMN profiles designed.

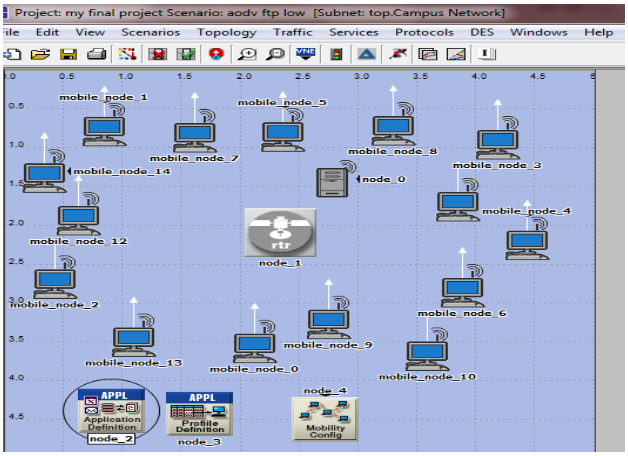
Figure 1 shows the WMN design for this project.

IV. THE SIMULATION TOOLS

There are several network simulators for example, NS-2 [14], Optical Micro-Network Plus Plus [15], and Qualnet [16]). There is also OPNET, simulation engine with a set of simulation developed by OPNET technologies, Inc.

We chose to use OPNET for simulation because it has various tools, source code editing environment tools, source code editing environment, network model editor, node model editor, process model editor and packets format editor are some of them.

Figure 1: Example of WMN design



C. Simulation, Interpretation and Discussion of Results

The performance analysis of the selected routing protocols namely as: AODV, OLSR, GRP, DSR and TORA are carried out based on throughput and delay performance metrics. Throughput and delay are compared among selected routing protocols under 6 profiles namely as: ftp low load, ftp medium load, ftp high load, database low load, database medium load and database high load.

D. Delay comparison among ftp low, ftp medium and ftp high

Figure 2, Figure 3 and Figure 4 demonstrate delay comparisons obtained for AODV, DSR, GRP, OLSR and TORA under ftp low load, ftp medium load and ftp high load. The x- axis in Figure 2, Figure 3 and Figure 4 represent time in minutes and y-axis represent delay in seconds.

Figure 2: Delay of routing protocols under ftp low traffic load

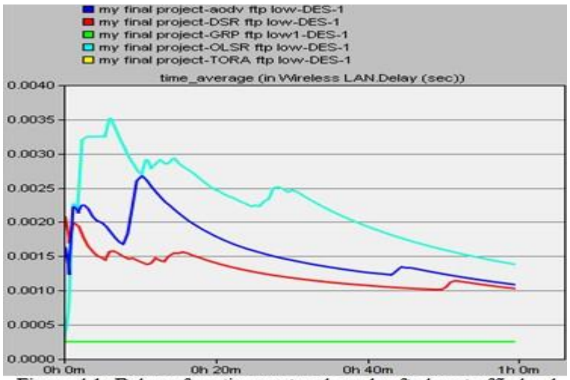


Figure 4.1: Delay of routing protocols under ftp low traffic load

Figure 3: Delay of routing protocols under ftp medium traffic load

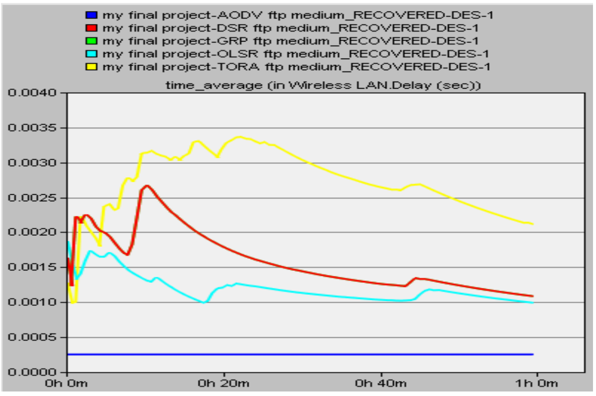


Figure 4: Delay of routing protocols under ftp high traffic load

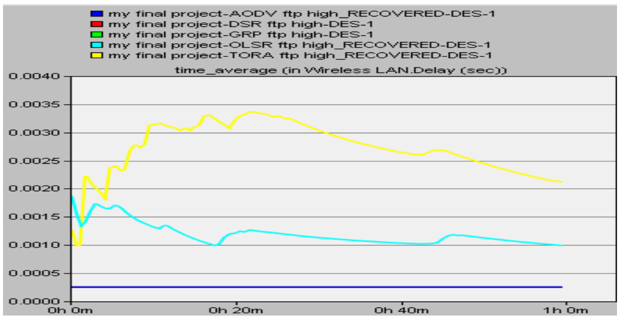


Figure 2 demonstrates the delay of routing protocols under ftp low traffic load. It is observed that OLSR had worse delay, AODV ranked number two with worse delay and DSR also has long delay. GRP and TORA have lower delay and they remain constant. In figure 3 the delay obtained for AODV, DSR, GRP, OLSR and TORA under ftp medium traffic load are shown respectively. TORA has worse delay, GRP and DSR ran number two after TORA with long delay and followed by OLSR rank number three with long delay. AODV is only protocol with low delay. Figure 4 depicts the delay of routing protocols under ftp high traffic load. TORA experienced very worse delay and OLSR had long delay. AODV, DSR and DSR have observed that they have very low delay and they are constant.

Figure 2 also shows that TORA and GRP have lower delay while OLSR started with extremely high delay and decreases with the time, AODV has high delay, DSR have long delay and also for DSR and AODV the delay decreases with time. Figure 3 also shows that under ftp medium TORA is leading with long delay it increasing and decreasing but still is higher on other routing protocols delay, DSR and GRP follow TORA with long delay; OLSR also has long delay but it lower than of DSR and GRP. AODV has very lower delay. Figure 4 d also epict delay of selected routing protocol under ftp high where AODV, DSR and GRP have very low delay. TORA has very long delay while OLSR also have long delay.

E. Throughput comparisons among ftp low, ftp medium and ftp high

Figure 5, Figure 6 and Figure 7 demonstrate throughput comparisons obtained for performance of AODV, DSR, GRP, OLSR and TORA under ftp low load, ftp medium load and ftp high load. Figure 5 shows the throughput of selected routing protocol under ftp high traffic load. OLSR has high throughput and outperforms the other routing protocols. TORA outperforms DSR, AODV and GRP. AODV, DSR and GRP throughput generated is very low and remains constant. Figure 6 demonstrate the throughput of selected routing protocols under ftp low traffic load. DSR outperforms the other routing protocols. AODV performs better than TORA, OLSR and GRP. TORA and OLSR ranked number three with low throughput. GRP throughput generated is constant and is very low.

Figure 5: Throughput of routing protocols under ftp high traffic load

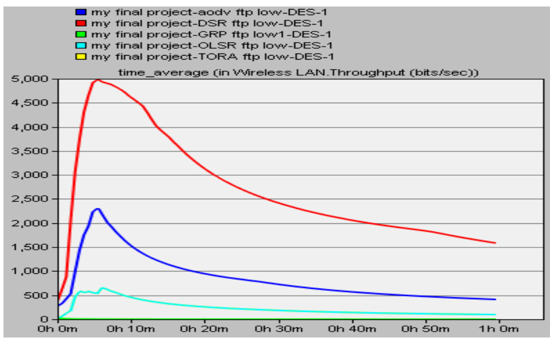
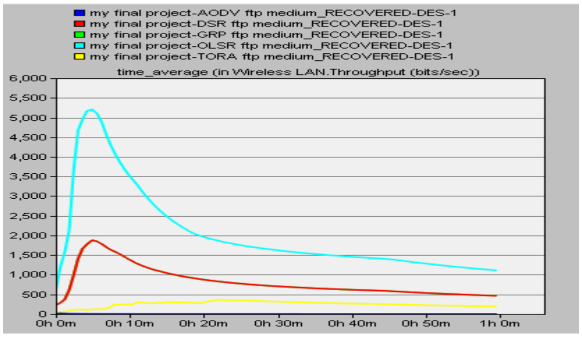


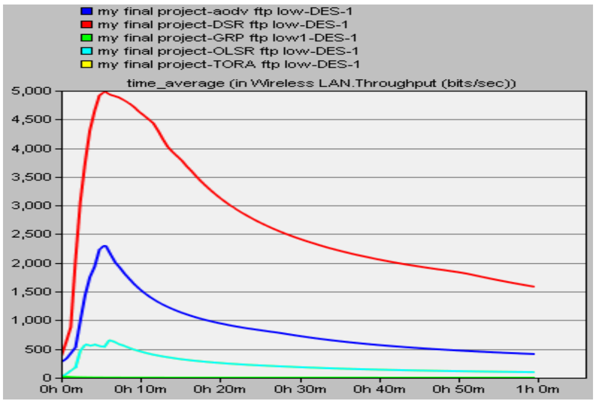
Figure 7 depicts throughput under ftp medium traffic load. OLSR outperforms all other routing protocols with high throughput. GRP and DSR perform better than TORA and AODV. TORA has low throughput but is better than of AODV. AODV has very low throughput and is constant.

Figure 7: Throughput of routing protocols under ftp medium traffic load



OLSR outperforms the other routing protocols in Figure 5 and Figure 7 in terms of ftp medium load and ftp high load, AODV, DSR and GRP throughput generated is constant in Figure 5 while TORA has low throughput but it is better than AODV, DSR and GRP. In Figure 6 TORA and OLSR outperform but decrease with time. AODV started with increasing throughput but when the times run it decreases. Throughput in GRP and TORA remains constant for ftp medium traffic load. In Figure 7 for ftp medium load, DSR and GRP perform better than TORA with decreasing throughput and AODV its throughput is constant.

Figure 6: Throughput of routing protocols under ftp low traffic load



V. CONCLUSION

We have analysed and evaluated the routing protocols performance in 3 ftp traffic loads using throughput and delay performance metrics. We discovered that in terms of delay under ftp medium load and ftp high load TORA is leading in high delay. GRP has very short delay that is continuous in ftp high load and ftp low load. For throughput OLSR outperforms other routing protocols under ftp medium load and ftp high load. AODV had low throughput.

The overall results shows that in terms of throughput OLSR performs best than other protocol because it is a table driven protocol while TORA lead with high delay. GRP experienced lowest throughput in many scenarios taken

VI. REFERENCES

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