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INVESTIGATING THE IMPACTS OF SCALABILITY AND MOBILITY ON THE PERFORMANCE OF MANET ROUTING PROTOCOLS

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Abstract

This paper investigates the performance of three MANET routing protocols (Ad Hoc On-Demand Distance Vector routing (AODV), Geographic Routing Protocols (GRP) and Optimised Link State Routing protocol (OLSR)) in terms of two performance metrics: delay and throughput. This study approaches the area from two particular perspectives: the impacts of varying nodes number and movement speed. This technical study is based on a simulation approach using OPNET Modeller 16.0 simulator. The simulation results show that the OLSR offers outstanding results in delay and throughput in all scenarios.

Introduction

Currently, there is a great deal of interest in the world of wireless technology. One of the recent developments in the field of wireless networks is the use of Mobile Ad hoc Networks (MANETs). MANET technology is being extensively deployed since it offers several features that traditional networks find difficult to emulate [1]. It was initially designed for military purposes, however it has now been expanded to include many commercial and industrial applications. MANET is comprised of a number of mobile nodes that are connected by using wireless links without a central facilitated infrastructure [2].

Nodes in MANET environment are mobile; hence the network topology keeps changing. This in turn generates great complexity in routing traffic from source to destination. To make an efficient routing, a routing protocol is required to find the optimal routes to be followed by data packets. In this regard, traditional routing protocols of wireless networks cannot be used directly for MANET, because they are not suitable for dynamic changing networks. MANET environment needs ad hoc routing protocols that perform efficient distributed algorithms for determining the connectivity of network organizations, routing and link scheduling in dynamic network topologies [2].

In this paper, we have selected three MANET protocols in order to investigate their performance in terms of throughput and delay and with varying network sizes and mobility. These protocols are Ad Hoc On-Demand Distance Vector routing (AODV) [3], Geographic Routing Protocols (GRP)[4] and Optimised Link State Routing protocol (OLSR)[5], which belong to reactive, geographic and proactive protocol categories respectively. This investigation is conducted using a simulation approach and utilises the simulation tool OPNET Modeller 16.0 [6].

Related Work

There are a number of researches have been conducted to study the performance of MANET routing protocols, such as [7, 8, 9, 10, 11]. In [10], the performance of four MANET routing protocols (AODV, OLSR, DSR and GRP) was evaluated in ordinary and large-scale networks and with different packet size patterns. It finds that OLSR has the least delay. AODV and DSR outperform OLSR and GRP for packet delivery ratio; however OLSR and GRP show better performance in the MAC delay. GRP has the least link layer retransmission, as well as it has better performance than reactive protocols (DSR, AODV) for End-to-End delay.

Perkins et al. [11] evaluates the impact of scalability, load and mobility in DSR and AODV. The study illustrated that DSR outperforms AODV when the network has a small number of nodes with low load and mobility. On the other hand, AODV has better performance than DSR when there are more nodes with high mobility and load in the network.

Evaluation Set-Up

The experiment is carried out using discrete event simulation software known as OPNET (Optimized Network Engineering Tool) Modeler version 16 [6]. It is one of the most widely used commercial simulators based on Microsoft Windows platform and incorporates more MANET routing parameter as compared to other commercial simulator available. It not only supports MANET routing but also provides a parallel kernel to support the increase in stability and mobility in the network. Author in [12] claims that OPNET's intensive analyzing feature provides best environment for comparing and coordinating the output obtained.

Two tasks have been conducted in order to evaluate the performance of three routing protocols. The used traffic is FTP (file size 50 kilobytes). Each task consists of three experiments, each experiment implements AODV, GRP and OLSR respectively. The behaviour of each routing protocol is evaluated in terms of throughput and delay. After simulating the designed model for 600 seconds, the results are collected. The selected speed for the three scenarios is 5 m/sec and there is no pause time between nodes.

A. Task1: Scalability Model

In this model, three scenarios are designed in order to observe the effect of scalability by using different number of nodes. Each scenario contains 20, 40 and 80 nodes respectively and the used node speed for the three scenarios is 5 m/s with no pause time.

In Figures 1, 2 and 3, we can see the throughput average values of AODV, GRP and OLSR protocols in three different network sizes: 20, 40 and 80 mobile nodes. The results show that the throughput of the three protocols increases when the number of mobile nodes are increased. This is because more nodes are available to generate or route packets to the destination. It is clear from these graphs that the throughput of OLSR is higher than that of AODV and GRP.

The OLSR shows a good stable throughput for MANET due to its proactive characteristic. Indeed OLSR is always engaged with maintaining and updating its routing information with all the network nodes by periodically broadcasting HELLO messages and Topology Control messages for discovering neighbourhood nodes and maintaining the routing table. Furthermore, its independency over network traffic and network density is another factor that helps OLSR to achieve higher throughput than reactive and geographic routing protocols. For AODV protocol, it illustrates more throughput than GRP, as shown in Figure 1. AODV does not exchange routing messages every time, eliminating the source routing overhead. It only obtains the required route when needed. On the other hand, GRP receives the least amount of throughput. It does not use routing table but is based on the node position.

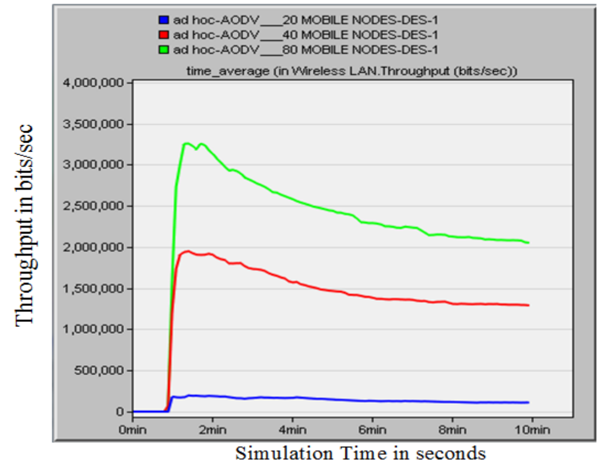

Figure 1: Throughput of AODV in three levels of scalability

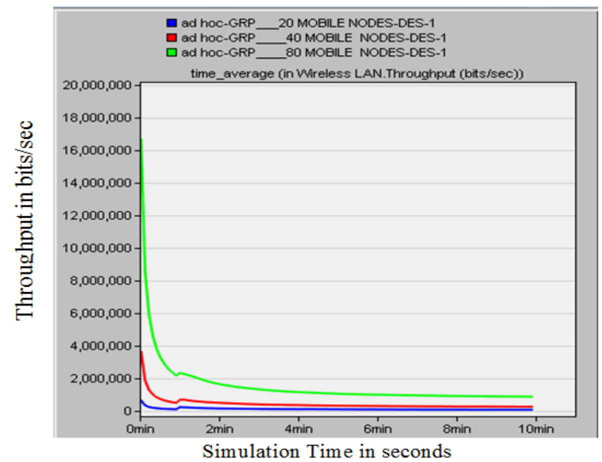

Figure 2: Throughput of GRP in three levels of scalability

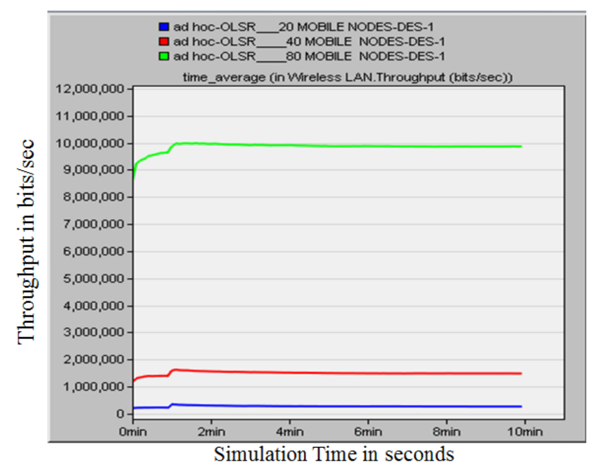

Figure 3: Throughput of OLSR in three levels of scalability

In Figures 4, 5 and 6, we can see the delay average values of AODV, GRP and OLSR protocols in three different network sizes: 20, 40 and 80 mobile nodes. AODV protocol in 80 nodes illustrates a higher delay than in 20 and 40 nodes. That is to say, the delay of AODV increases when the number of nodes increases. The reason for this is that the AODV protocol uses broadcasting method, which is rarely used in larger networks. It broadcasts the routing requests to the entire network and then continues to wait for the responses, thus making AODV and other reactive protocols display more delay than other proactive and geographic routing protocols.

On the other hand, the OLSR delay value does not show significant variation when the number of nodes increases. The delay of OLSR is the lowest in the three network sizes because of its proactive nature; it always has routes available due to periodic updating of the network routes, which results in a low level of delay in the discovery route process. Another obvious reason is that the OLSR divides network nodes into two groups; Multipoint Relays (MPR) nodes, and two hop neighbouring nodes. OLSR only uses MPR nodes to maintain "Neighbour Table" and to keep track of the other two hop neighbours. This mechanism makes OLSR more efficient in link update processes, and this helps to reduce network overhead, resulting in a low level of delay.

Likewise, GRP shows an almost constant average delay when the number of nodes is increased. This is due to the fact that GRP uses fuzzy routing criteria, which reduces the overhead caused by the flooding [13]. Fuzzy routing strategy limits the scope of the flooding, thus when a node sends a position update, the flood is only received by nodes that require the update. Moreover, GRP refers to the nodes by their location information, not address, and each node uses GPS technology to determine its own location without the help of other nodes, resulting in low overheads.

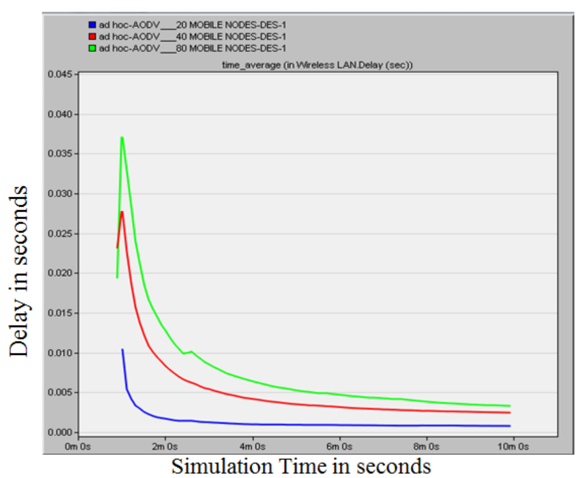

Figure 4: Delay of AODV in three levels of scalability

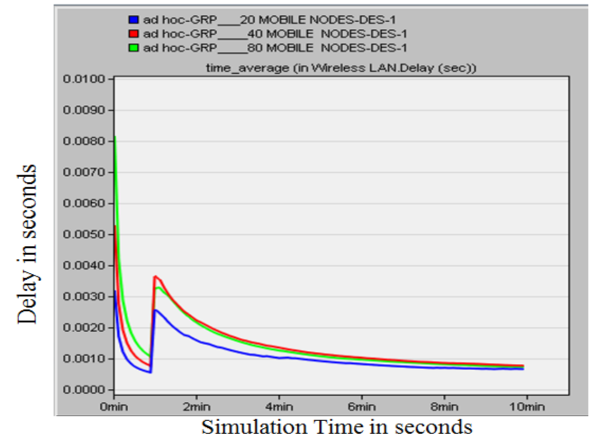

Figure 5: Delay of GRP in three levels of scalability

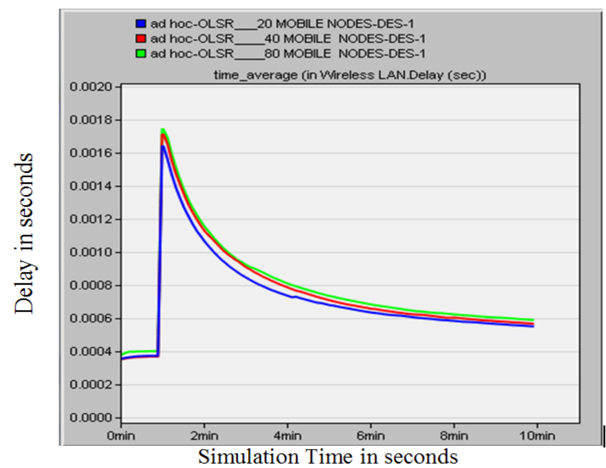

Figure 6: Delay of OLSR in three levels of scalability

B. Task2: Mobility Model

In this model, two scenarios are designed in order to observe the effect of mobility by using different nodes speed. The used node speeds for these two scenarios are 5 m/s and 20 m/s respectively with no pause time, and both scenarios contain 40 nodes.

From the simulation results, we can say that in Figure 7 the throughput of the AODV protocol decreases when the mobility rate increases. The obvious reason is that the presence of high mobility results in a stress for this protocol to forward lots of routing information because of frequent link failures and subsequent Route Discovery processes. This will result in large routing overhead, hence low throughput is likely to be induced in the network. On the other hand, the GRP protocol is found to maintain a consistent throughput even with higher nodes speed, as shown in Figure 8. It is very effective in high-mobility situations because it does not need routing table; instead, each node determines its own physical information without the help of other nodes. Furthermore, GRP uses a flooding strategy to obtain the location information of neighbouring nodes.

Likewise, the OLSR protocol keeps its performance at a constant level when the nodes speed shifted to a higher speed (see Figure 9). This is due to the fact that the OLSR is able to detect route failure and then carry out continuous searches for other possible routes to the destination, resulting in less packet loss. Further, the buffering feature helps OLSR to achieve a steady throughput. By comparing the three protocols, the throughput of OLSR continues to dominate that of GRP and AODV. Moreover, it is apparent that AODV shows a higher throughput than GRP even when mobility rate is increased.

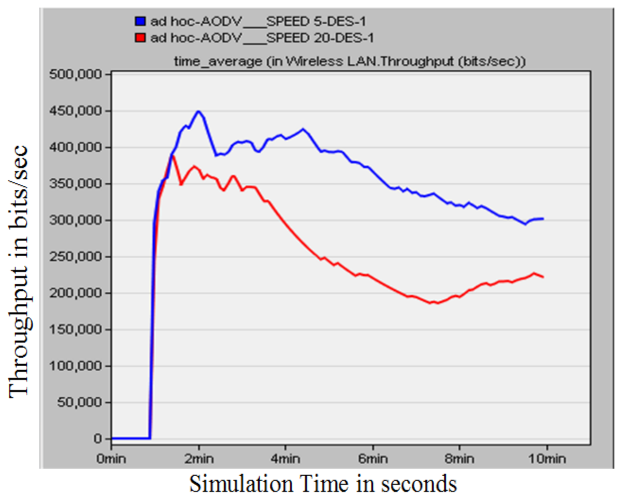

Figure 7: Throughput of AODV in node speed 5 and 20 m/s

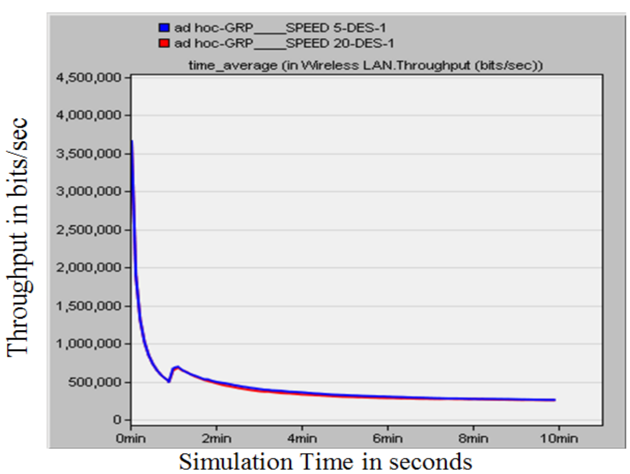

Figure 8: Throughput of GRP in node speed 5 and 20 m/s

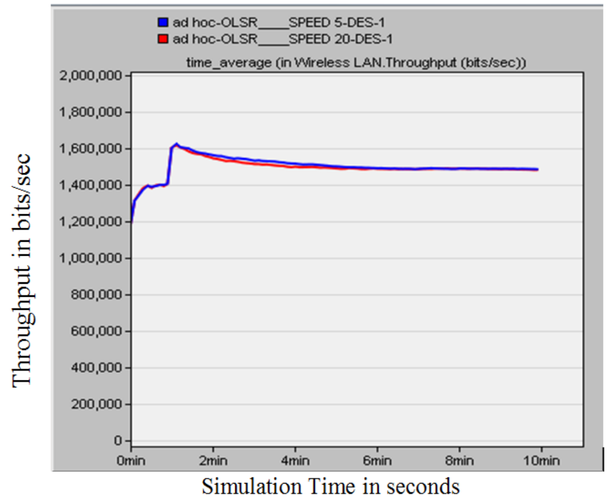

Figure 9: Throughput of OLSR in node speed 5 and 20 m/s

In addition, the mobility factor also affects the routing performance in terms of delay metric. High mobility rate causes pause time variations, and this result in a high delay. In Figure 10, we can observe that the delay of the AODV protocol increases when mobility rate increases. This is because AODV carries out searches for new routes only when they are needed, thus packets remain waiting at the buffers until the new route is found, which in turn leads to more delays. In addition, when a route breakage occurs due to high mobility, the route discovery process is required each time to establish the new route; a process that takes significant time on each occasion. As a result, delay is likely to increase in the network.

On the other side, as shown in Figure 11, GRP protocols remain at approximately constant delay even with high mobility. This is attributed to the fact that GRP refers to the nodes by their location information, not address, and each node is aware of its own location through GPS technology without the help of other nodes. As shown in Figure 12, the OLSR is slightly affected by nodes speed because it maintains the route before it is demanded so that packets are immediately forwarded when they arrive at the mobile nodes. When comparing the three protocols, it is clear that the AODV shows the highest average delay compared to OLSR and GRP protocols. By contrast, the OLSR illustrates the lowest delay even with varying nodes mobility.

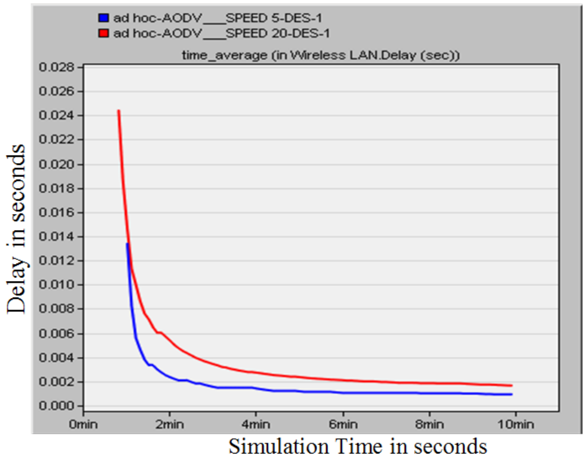

Figure 10: Delay of AODV in node speed 5 and 20 m/s

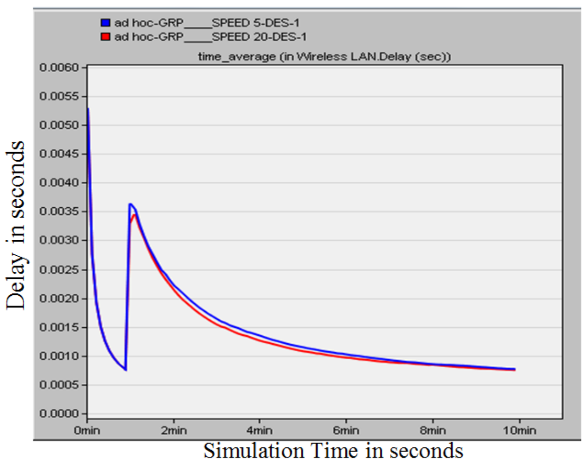

Figure 11: Delay of GRP in node speed 5 and 20 m/s

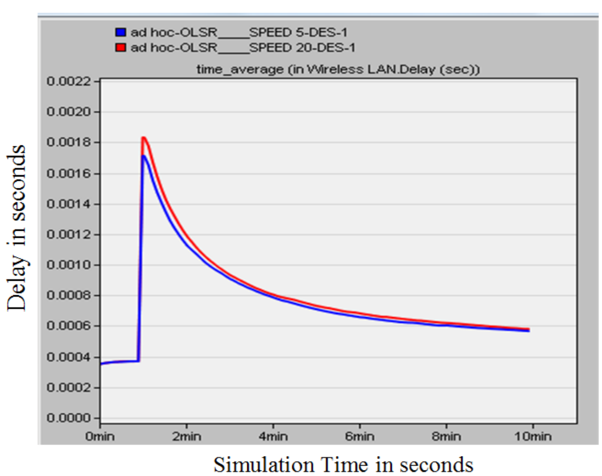

Figure 12: Delay of OLSR in node speed 5 and 20 m/s

Conclusions

This study makes contributions to the performance evaluation of three IETF standardized routing protocols in a MANET environment using FTP traffic. The proposed routing protocols are GRP, OLSR and AODV, covering a range of design features, such as geographic routing, hop-by-hop routing, flooding routing, on-demand route discovery and periodic advertisement. In this study, using simulation environment (OPNET 16.0), an investigation is carried out to ascertain how these protocols respond to different network conditions in a MANET environment, with respect to scalability and mobility. The performance of the three protocols is evaluated and analyzed by determining the results of two performance metrics: throughput and delay. The following key observations are formed from the simulation results, which are as follows.

After investigating the impacts of scalability and mobility in the proposed protocols, it can be concluded that OLSR is the most effective when compared with the GRP and AODV protocols respectively. GRP protocol performs well at a high mobility rate, as well as it is not affected by the number of nodes. The AODV protocol is suitable for small networks with a low mobility rate. The pursuit of future research may also include other ad hoc protocols such as DSR, TORA, DSDV and ZRP which can be evaluated. The future research may also include other performance parameters which were not included in this study, such as routing rate, download and upload time, packets loss, and Packet Delivery Fraction (PDF).

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