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Comprehensive Evaluation of DSDV, OLSR and AOMDV Routing Protocols for Efficient Packet Delivery

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Abstract: Mobile Ad hoc network also known as MANET as an infrastructure-less network without physically mounted routers, switches or mounted access point for network communication at strategic points. MANET is of great advantage as it aids high rate node dynamic mobility. Topologies that establish communication is not as compared to the normal wired topologies, but rather network routing protocols are the basis for effective network communication in MANET. In this research, the routing protocols which are Proactive and Reactive comprising of DSDV and OLSR, AOMDV respectively all simulated in a real-time network scenario, using NS3 at varying number of nodes shows network performance when there exist two varying parameters of End-to-End delay effect to Throughput of the network.
Keywords: DSDV, OLSR, AOMDV, MANET, NS3, Performance evaluation.

Introduction

Mobile Ad hoc network had existed since the mid-90s as a known area of research (Kumar Jha & Kharga, 2015). A network that is not built on a mounted access point or does not require a central control is regarded as an Ad hoc network. A fixed network infrastructure is not required for MANET to be formed, which takes the advantage of the communication capability of Radio Frequency (RF) and infrared during a decentralized connection framework (Matre & Karandikar, 2016). The network is determined by groups of devices that are referred to as nodes with wireless transceivers *(Ya-qin et al.*, 2010). Transceivers are capable of building a communication network at whatever point or location the network is being built, as well at whatever time a particular transceiver joins or leaves the network. MANET exhibits a dynamic nature, where nodes can move randomly with no fixed routes. As well nodes act as routers and host simultaneously. At a point where nodes are routers, routes to several nodes in the network are usually discovered and maintained (Shrivastava *et al.*, 2013). MANET has helped in playing a major role in the area of communication, especially when it applies to the use of wireless networks. Wireless networks popularity has been channeled to several applications that have considered factors that include: its ease of installation, its reliability, cost-effectiveness, bandwidth consumption rate, its power consumption rate for each node, security of the data transmitted must be assured as it is one of the primary goals according to Agu et al (2017); and most all total network performance (Chamkaur *et al.*, 2014; Francisca & Edward, 2015).

In mobile ad hoc network aside the challenges of network topology change that occur from broken network links, there exist a major problem of routing that involves asymmetric link, interference and routing overhead amongst others that pose a great challenge to mobile ad hoc network routing operation (Anchari *et al*., 2017; Chauhan & Sharma, 2016). Traditional routing protocols provide single or multiple paths that help in routing from source to destination node. Mechanism of protocols have several disadvantages that energy consumption is considered one major challenge, due to battery life consumed by each network used in ad hoc networks (Agarwal *et al.*, 2015), also attributes to network overhead when nodes communicate. There have been several studies and research carried out in this field, to propose a better protocol performance for routing. It is still open research because of the non-deterministic nature of topology, the problem of routing to which the purpose of this study is to perform an evaluation and analyze mobile ad-hoc network routing protocol, propose to simulate three routing protocols: DSDV, OLSR and AOMDV with varying number of nodes using network simulator 3.

Remainder of this paper is presented in the following sections. Sections II discuss reviews of existing performance evaluation carried out. Section III presents the methodology applied. Section IV, platform used for evaluation implementation and analysis are explained. Section V results obtained are discussed, while Section VI summary and conclusion on the paper are drawn.

Related Works

Decades of researchers have proved performance of several MANET routing protocol with several result obtained. Therefore, performance testing of MANET can be more efficient, if a wide variety of parameters are considered and as well tested on a very wide network range.

Works of Mohsin & Woods (2014) experimented on routing protocols AODV, DSDV, AOMDV, and DSR were simulated using NS2. A marine environment of both sparse and dense location was considered and analysis carried out gave results based on different parameters. The result showed that the AOMDV routing protocol is the most efficient due to its multipath route discovery. Measuring end-to-end delay of AODV, AOMDV, DSDV and DSR against pause time show DSDV exhibit lowest delay of all. In terms of packet delivery ratio and throughput, AOMDV and DSR compared to DSDV is proved the highest and it is observed AODV, DSDV, and DSR provide insufficient packet delivery when AOMDV is put to maximum use.

In the study of Adeyemi A, Kah M.O, Ahmed T, & Caleb A, (2019), using NS2 network simulator and AWK, performed an analysis of DSR, DSDV and AODV. Parameter metrics which include Throughput, PDR and Jitter were put into consideration. From simulation carried out and results analyzed increase in nodes greatly improves the performance of nodes based on the following parameters average throughput, PDR and Jitter. It is proven that number of nodes or larger network of above 35 nodes shows a better performance of AODV; as smaller networks aids the better performance of DSR.

Lei D, Wang T, Li J, (2015) the occurrence of dynamic change of topologies affects the performance of the various routing protocols AODV, DSDV, AOMDV and DSR under study. About 95% of a better performance considering the following parameters PDR, NRL and E2E delay for DSDV and DSR, shows good adaptability in PDR. AODV compared to DSR records lesser average, but load on DSDV is higher than DSR routing protocol. Both protocols are suitable for changing network topology. A multi-path routing protocol which is AOMDV has a lower average E2E delay compared to single-path protocols; it only has few aspects that need improvement which is: update and maintenance of backup paths, and multiple paths could at the same time transmit packets.

Overview of Routing in Mobile Ad hoc Network

Routing involves the choice of path in a given network communication scenario. Considering routing in MANET from a source to its destination is the choice of a suitable and right path. The term routing has been used severally in different network technologies, which are mostly telephony, electronic data and also the internet (Anchari *et al.*, 2017). For this study, the focus is more on routing in mobile Ad hoc networks. As physical wired network communication is not achieved without a guiding protocol, so also routing in mobile Ad hoc networks are guided by protocols, the mobile nodes use to search for route or path that connects several nodes to share data packets as shown in Figure 2.1. Protocols are said to be set of governing rules that enhance communication between two or more devices.

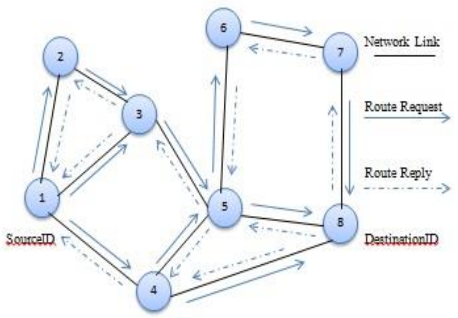

Figure 2. 1 Routing process in a mobile Ad hoc network

Routing Protocols Taxonomy in MANETs

A node in MANET due to its dynamic environment has the possibility of joining, leaving and moving around a network range, which has a great effect on packet routing. As posed, efficient packet routing appears to be one of the challenging problems in MANET. The sole aim of routing is to serve as a guide for packets communication via subnets to their final destination. As a result, it has open doors to researches that have proposed to proffer a solution to this problem, by designs of various routing protocols (Saeed *et al*., 2012). The designs of routing protocols in MANETs are not just for routing processes alone, but routing protocols must show the capability of handling a larger number of nodes with limited resources. For routing protocol to be effective in performance, it must exhibit the following qualities which include: distributed operation, loop freedom, demand-based operation, proactive operation, security and unidirectional link support (Kumar Jha & Kharga, 2015).

Proactive Routing Protocol

The proactive routing protocol can also be described as table-driven protocol, a modified version of Bell-man Ford algorithm (Chauhan & Sharma, 2016) that uses a link-state routing algorithm, which helps in terms of frequent information flooding about neighboring nodes. Up-to-date information between a pair of nodes is kept by proactive protocols; it is achieved by sending control messages periodically in a network. In this type of protocol, routes are always ready to use as needs demand.

***DSDV*: Known as Destination Sequenced Distance Vector routing which uses a proactive strategy in routing, a modified version of Bell-man Ford principle. In routing from source to destination, the Bell-man Ford principle was solely used in finding the shortest path, and also it is not a loop-free algorithm. It overcomes a loop problem of Routing Information Protocol (RIP). Due to topology changes in the Ad hoc network, RIP can no longer be put to use anymore (Istikmal *et al*., 2013). DSDV is a table-driven routing protocol that overcomes the Bell-man Ford algorithm problem because it is regarded as a loop-free algorithm. At each routing time, DSDV protocol updates the table when a source wants to transmit packets to the destination node. An update of a message which is incremented by one periodically is carried out in sequence. In terms of node broadcasting, packets sent are usually of two types which are the incremental dump which carries available information at each time and full dump carries only information changed at the very last dump (Chauhan & Sharma, 2016).

***OLSR*:** Optimized Link State Protocol (OLSR) is an example of a proactive routing protocol that is available always on demand. In terms of Classic OLSR, large control packet overhead generated by this protocol does not usually scale bandwidth requirement on wireless Ad hoc network especially when there is broadcast in the entire network. OLSR has been an optimized version of the Classic OLSR uses Multipoint Relays also known as MPR (Alamsyah *et al*., 2016) which is the only allowed to broadcast packet, thereby reducing overhead in information exchange. In OLSR, messages such as Hello and Topology Control (TC) are used for control messages, whereas the Hello message is used in information finding of link status, while in terms of periodical broadcasting of information about MPR selector list the TC messages are used. Multiple Interface Declaration (MID) is considered another class of message used by MPRs to broadcast throughout the network; other hosts also get informed by MID that multiple OLSR interface address can be used by announcing host.

Reactive Routing Protocol

Reactive routing algorithm operates based on on-demand of data packets. Reactive protocols minimizes routing overhead; that helps also to preserve the battery life of nodes (Rahman & Abbas, 2016). Internet Link State Distance Vector algorithm is a predecessor version, which is characterized by two mechanisms namely Route discovery and maintenance. At the process of route discovery, it carries out two processes route request and route reply, which varies from one protocol to another (Saeed *et al.*, 2012).

AOMDV: Ad hoc On-demand Multipath Distance Vector routing protocol (AOMDV) is an upgraded version of AODV protocol that computes multiple loop-free and link disjoint paths (Gharge & Valanjoo, 2014). On each entry of node routing to every destination, there are the list of next-hops alongside hop counts, as well as having the same sequence number that helps in maintaining route paths. For every destination, a hop count is advertised by a node, defined as maximum hop count for all paths, that helps advertise route of the destination. For duplicate route advertised, the node defines an alternate path to its destination. The assurance of loop freedom is ensured for a node by the acceptance of alternate paths to the destination if it has less hop count than advertised hop count. Due to the use of maximum hop count, advertised hop count experiences no change for the same sequence number.

Methodology

NS3 is a discrete-event network simulator was used, with its architecture modeled after network simulator 2 (NS2) licensed under GNU GPLv2, (Atif *et al.*, 2013; Gupta *et al*., n.d.). NS3 which is a synthesis of several predecessor tools, which include NS2, Georgia Tech Network Simulator (GTNetS), and YANS simulator. NS3 software prioritizes the use of standard input and output file formats for packet trace analyzers. Users are also provided links to GNU Scientific Library or IT++ as external libraries. It provides an ease of debugging as well as better alignment with current languages. By architecture, NS2 predecessor tool was the mixture of Object-oriented Tcl (OTcl) and C++ which proved hard to debug and Tcl became unfamiliar. The design of NS3 is purely based on C++ based models for ease of debugging and performance, and a Python-based scripting API integrated with other Python-based programming models. NS3 allows users to freely write simulations as either C++ main() programs or Python programs (Atif *et al*., 2013).

Physical Parameters

The work was carried out using NS3 simulation tool. It attempted to compare all three routing protocols using the same parameter set up as shown in the table below. For all the simulation, the same movement model was used; the number of traffic sources was set to 20, 40, and 60 nodes and at a 1000m x 1000m topology boundary. The parameters used are shown in the table below:

Table 1 Simulation Parameters

Parameter	Value
Topology generated/Nodes	20, 40, 60
Simulation Time/Second	200sec
MAC	Ad hoc WiFi Mac
MAC Standard	802.11b
Mobility Model	Constant Speed Propagation Delay
Node Speed	20ms
Propagation Model	Random Way Point Mobility Model
Topology Boundary Area	1000m x 1000m
Application	TCP
Routing Protocol	DSDV, OLSR, AOMDV

Performance Metrics

The simulation of DSDV, OLSR, and AOMDV were carried out and the estimation of their performance was calculated based on the following performance metrics:

Throughput: As parameter metrics in measuring Ad hoc network performance, throughput measures the successful average number of packets delivered per unit time over a communication path. It can also be calculated as the number of bits delivered per second. It is measured in bits per second (bits/sec) or kilobits per second (kbps) (Appiah, 2016). Mathematically, Throughput (S) can be represented as shown in equation (1):

$$S = \frac{Number\ deliveredPacket*Packet\_size}{Total\_SimulationTime}\ x\ 8 \quad (1)$$

End-to-End Delay: The Average End-to-End delay is the average time including all possible delays that are generated by queuing at interface queue, the process of buffering during routing discovery, propagation and transfer times of data packets, and delays retransmission of data packet from source node until packet is delivered to the destination node (Prabhakaran *et al*., 2013). Mathematically, Average End-to-End Delay (E2E Delay) can be represented in equation (2):

$$End-to-End\ Delay\ = \frac{1}{N}\sum_{i=0}^{N}(Rti - Sti) \quad (2)$$

Implementation and Results

DSDV, OLSR, and AOMDV were considered the logics implemented at different number of nodes (20, 40, and 60). NS 3 was the tool which simulation was run. Figure 2 was a generated simulation scenario by Network Animator as shown in Fig. 3 below.

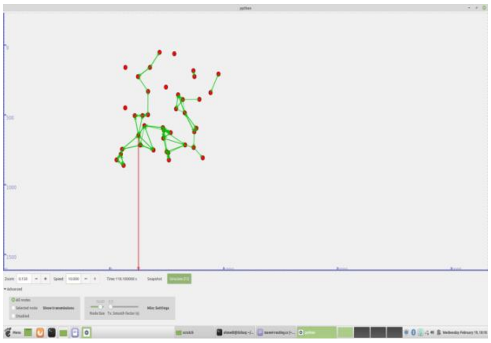

Fig. 3. Network Animator

Simulation Results and Evaluation

Results generated and obtained from the simulation Tcl scripts were categorized. Tables II, III, and IV show simulation results that compare the performance of DSDV, OLSR and AOMDV mobile Ad hoc network routing protocols. Table 4.1 shows the result for Average Throughput, Table 4.2 shows the result for Average End-to-End Delay whereas Table 4.3 shows the result for Average Energy Consumption and Table 4.4 shows the cumulative average of the three routing protocols.

Analysis of Results

Throughput: Fig. 4 shows the Average Throughput of all observed routing protocols with varying nodes (20, 40, and 60). It shows that at 20 nodes OLSR has the highest throughput performance over the other two protocols DSDV and AOMDV, followed by AOMDV which is next in terms of throughput performance and DSDV has the least average performance. At 40 nodes DSDV and OLSR exhibit similar throughput performance except for DSDV which has a slight increase in performance than OLSR and thus, AOMDV has the least performance. At 60 nodes, AOMDV has the highest throughput performance then followed by the OLSR and DSDV the least performance all shown in the figure below. The throughput which was varied at several nodes shows the dominance of OLSR in terms of performance gain over DSDV and AOMDV, which means OLSR performs better at 20 nodes but at nodes greater than 20 there is a decrease in performance. While as shown at a cumulative throughput performance, OLSR has the highest throughput, then AOMDV and lastly DSDV which is the least.

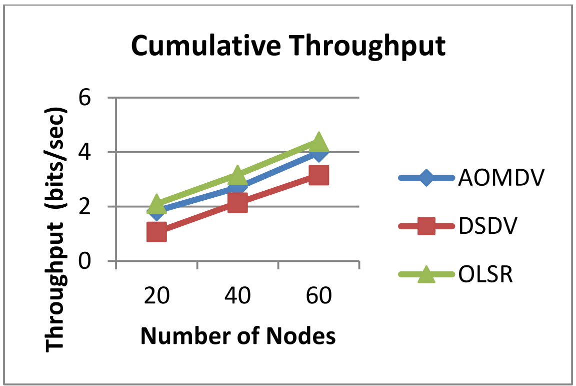

Fig. 4. Cumulative Throughput for DSDV, OLSR and AOMDV

End-to-End Delay**:** Fig. 5 shows the average End-to-End Delay of all the observed protocols at a varying number of nodes (20, 40, and 60). AOMDV shows it has the highest average End-to-End Delay at 20 number of nodes over DSDV and OLSR, OLSR which is seen to be next in performance and DSDV having the least End-to-End delay. At 40 nodes, AOMDV still has the highest performance, but this time DSDV is next highly performed then OLSR. As well as at 60 nodes AOMDV still dominates the rest, DSDV being the next and OLSR the least all shown in Figure below. Based on the results represented, DSDV and OLSR which are proactive perform better than AOMDV the reactive protocol in terms of average End-to-End delay, in fewer nodes (<40) OLSR has the least End-to-End delay making it of better performance compared to DSDV at a greater number of nodes (>20) and then AOMDV.

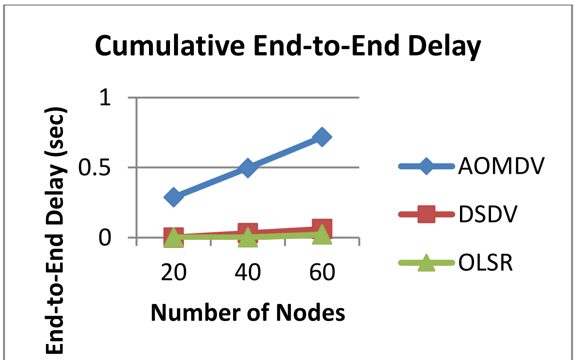

Fig. 5. Cumulative End-to-End Delay for DSDV, OLSR and AOMDV

Conclusion

The simulation study adopted in this research consists of three routing protocols DSDV, OLSR and AOMDV, which were deployed over to analyze their behaviour under three parameters, average throughput, and average end-to-end delay and average energy consumption. The motivation was to check the performance of the mentioned routing protocols in MANET according to outlined performance metrics. It has been a major issue when it comes to selecting an efficient and reliable routing protocol. In this simulation work, results were gotten which include result tables and simulation graphs in which the average statistical data were concluded. The analysis of the simulation figures 4.9, 4.10, and 4.11 showed the routing protocol behaviors at different mobile nodes ranging from 20, 40, and 60 as well as which routing protocol has better performance over another.

From the above analysis a cumulative performance of the routing protocols shows in Figure 4.13, OLSR outperforms the other two OLSR and AOMDV in terms of average throughput and average end-to-end delay. By interpretation, OLSR has higher throughput, less End-to-End delay followed by OLSR is AOMDV with also a high throughput, although has more End-to-End delay than. Finally, DSDV which is the least is seen to have also a better throughput performance and less End-to-End delay.

The study shows that OLSR is better in a Mobile Ad hoc Network compared to DSDV which is lesser and shows that proactive protocols have better performance in the network, although its performance may vary at other networks. At the end of this study, a conclusion is drawn that simulation and analysis of routing protocol performance do vary at different network scenarios and performance metrics considered.

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