# MPR Selection to the OLSR Quality of Service in MANET Using Preferred Group Broadcasting

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***Abstract*—Optimized link state routing (OLSR) is a proactive routing protocol that works on the mobile ad hoc network (MANET) by updating information on the routing tables regularly. This protocol has characteristics namely its rapid route search, it does not require any centered setting in handling routing process, it based on multi-hop routing, and it adopts the concept of multi-point relay (MPR). However, MPR node selection in standard OLSR has not worked optimally due to the choice of two-hop neighbors for every node. Furthermore, it results in a large number of topology control (TC) messages in broadcasting neighbor nodes. To overcome problems in OLSR performance, the researcher proposed an algorithm of Preferred Group Broadcasting (PGB) to select the MPR node optimally, reducing the excessive packet redundancy, and improving the quality of service (QoS). This algorithm selects the MPR node based on the most active signal grouping in reducing the number of messages or the excessive overhead during the routing process. The results of the simulation using network simulator version two (NS-2) show that OLSR performance using PGB improves the packet delivery ratio (PDR) by 27.35% and throughput by 14.66 Kbps. It decreases the packet loss by 27.28%, delay by 3.40 milliseconds, and topology control by 22 packets compared to standard OLSR.**

***Index Terms*—Mobile Ad hoc Network, OLSR, Quality of Service, Multipoint Relay, Preferred Group Broadcasting**

## I. Introduction

THE development of MANET has become popular and attracted researchers attention. It is due to its rapid characteristics, able to manage topology changes independently, cost-effective in spreading communication [1], environmentally friendly, and without permanent infrastructure support [2], [3]. MANET is very suitable to apply in areas experiencing a shortage of telecommunications infrastructure and emergencies such as detection of the flood, tsunami, earthquakes, forest fires, bridge structural health, military operations, telemedicine, and health monitoring. The applications of health monitoring are the breathing arrangements, brain recording, body temperature, blood pressure, heart rate based on wireless sensor network (WSN) using the zigbee protocol [4], and raspberry pi [5].The applications of multimedia communication services commonly used in internet networks such as multimedia streaming servers, interactive audio/video in real time, and voice over internet protocol (VoIP) implementation. The application of this system requires a multi-hop communication system [6], and most of the source nodes only focus on specific nodes. The performance of the routing protocol and QoS requirements is fundamental to improve the reliability and efficiency of communication [7] in providing excellent network quality [8], especially in MANET environments [9].

The routing protocol in MANET [10] consists of reactive (AODV, AOMDV, DYMO, DSR, TORA), proactive (OLSR, DSDV, B.A.T.M.A.N), and hybrid (ZRP, EIGRP). OLSR is a protocol that can provide routing to all existent network destinations using the MPR technique [11]. It also can support dense communication network systems [12] and protocols that are widely implemented in the MANET environment [13]. Optimal selection of MPR nodes affects the decrease in routing overhead from control traffic [14], energy consumption [15] [16], and QoS performance improvements [17] such as packet delivery ratio, throughput, delay, packet loss, and topology control. In standard OLSR, the selection of MPR uses Dijkstra or Greedy algorithm that only uses two hops to neighbors for each node. The selection of MPR nodes in the standard OLSR is not efficient because it produces excessive packet redundancy at each neighbor node.

To improve the standard OLSR performance, it requires an algorithm that can select MPR nodes optimally. One of the algorithms that can improve OLSR performance in selecting MPR nodes is the preferred group broadcasting (PGB). This algorithm selects MPR nodes based on the most active signal grouping to reduce the number of messages during the routing process (broadcast route request) and the excessive overhead during the broadcast [18]. Shorter calculations for the waiting time based on the strength of the transmitted signal. Only the node with the shortest time limit will rebroadcast the message.

From the statement above it can conclude that three things need to consider, namely: 1) the topology changes affecting QoS performance, 2) limited energy consumptions will affect QoS performance, and 3) the increase in the number of topology control messages can cause excessive redundancy. These three points were resolved to improve OLSR performance using the PGB algorithm by selecting MPR nodes. However, this the study focuses on point one and points three to increase the performance of OLSR using the PGB algorithm by selecting MPR nodes optimally.

Manuscript received June 10, 2018; revised December 29, 2018. This research supported by the Postgraduate Scholarship of the Ministry of Research, Technology and Higher Education of the Republic of Indonesia (RISTEKDIKTI) from 2014 to 2018, and the grant of Doctoral Dissertation Research in 2018.

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## II. Related Work

Several researchers have proposed the selection of MPR on OLSR in improving QoS, such as evaluating the performance of routing protocols in MANET and worldwide interoperability for microwave access (WiMax) based on QoS. It indicated that OLSR performance is better than AODV and TORA based on PDR, throughput, routing overhead by considering the time changes [19]. It is also better than ZRP, DSR in the term of a delay [20]. However, changes in the number of nodes have not evaluated.

The selection of MPR in OLSR using necessity first algorithm (NFA) in evaluating QoS through OPNET simulation shows that NFA can reduce the packets number of MPR and the topology control compared to using the Greedy algorithm [21]. However, QoS parameters such as packet delivery ratio, throughput, and delay have not evaluated.

The improvement of OLSR performance through the selection of MPR using the three-hop node method can reduce packet topology control, routing costs, and energy efficiency [22]. The proposed MPR concept can minimize the routing overhead (RO) and the delay [23]. However, QoS parameters such as packet delivery ratio and throughput based on the number of nodes have not evaluated.

The decreasing latency for detection to neighbors in the OLSR protocol uses broadcast based handshake (BHS) and unicast based handshake (UHS). The two proposed algorithms can minimize traffic control, especially in medium or high mobility networks [24]. However, QoS parameters such as packet delivery ratio and delays have not evaluated.

The selection of MPR using selector set tiebreaker (SSTB) and the stability drove MPR choice (SDMC) using OMNET show that the two proposed methods could reduce 15% topology control packet compared to the standard OLSR [25]. However, QoS parameters such as packet delivery ratio, throughput, and delay has not evaluated.

The development of algorithms to improve the MPR selection process using NS3 shows that a mobile-based OLSR can enhance the quality of the network, such as throughput and the number of packets received [26]. However, the QoS parameter considering the number of nodes has not evaluated.

The selection of MPR nodes based on the live broadcast on wireless ad hoc networks shows that the method can include two MPR node jumps and the throughput value may increase compared to the standard OLSR [27]. However, the QoS parameter and a dynamic environment has not evaluated.

## III. Description of OLSR and PGB Algorithm

### A. OLSR

OLSR is the development of link-state routing [28] that works in a MANET environment by adding the MPR mechanism to the forwarding packet process. The route information of the routing protocol updated regularly based on predetermined time intervals. OLSR uses periodically exchanged message protocols such as Hello and topology control (TC). The information system search related to the condition of the link and neighbor node done by the Hello message. TC serves to send messages to each neighbor node to targets through the selected MPR node. The choice of MPR in OLSR affects routing performance and it broadcasts TC messages from source to destination regularly. This TC message serves to disseminate information about neighbor nodes that have determined as MPR.

The MPR mechanism is a neighbor node chosen by nodes with individual specifications. The nodes selected as the MPR can be two hops from another node [29].MPR has a function to reduce duplication of the same control message or multiple retransmissions [30]. It also reduces routing overhead that can flood the network. MPR also used to build routes from source to destination so that MPR nodes can forward or receive the control packages. Each selected MPR node calculated as a symmetric neighbor node and all neighbor hops can reach through the MPR. The standard MPR selection mechanism generally uses the Greedy or Djikstra algorithm in calculating the number of MPR formed or giving the shortest route results. The OLSR has the advantage in optimizing the existent bandwidth usage and supports dense network communications [31].

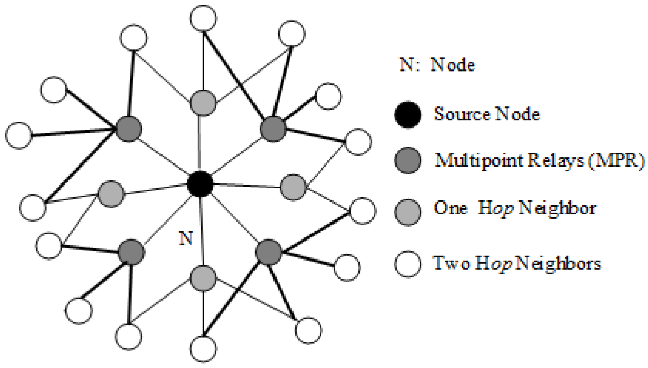


Fig. 1. MPRs Selection in OLSR

Fig. 1 illustrates the selection of MPR in the standard OLSR. The node collection starts from N as the source node. Next, the source node selects four nodes as MPR from eight nodes connected to one neighbor hop. The source node will communicate with all adjacent neighbors through the MPR node and only the MPR node can forward the message. From the results, four selected MPR nodes will not send messages to the same destination.

### B. Preferred Group Broadcasting (PGB)

The PGB algorithm is a broadcasting mechanism that aims to reduce broadcast overhead [32]. PGB can reduce redundancy transmission by finding stable routes with automatic correction capabilities and reduce the amount of RREQ [33]. Each node in the PGB will respond based on the signal strength level of the closest node. This signal strength is used to get the waiting period and only the node with the shortest duration of time will resend or forward the message.

PGB classified into three parts, namely: 1) preferred group (PG) is a collection of nodes for broadcasting, 2) IN is a group that has a more active signal than PG, and 3) OUT is a group that has smaller signaling than PG. The division of groups in PGB aims to determine the delay units used for each package. Each group will experience a delay, depending on the position and signal strength of the sender to the recipient. Fig. 2 shows that the value of Inner Threshold ($IT$) and Outer Threshold ($OT$) compared to the received power signal. In this concept, nodes can classify rxThreshold ($rxTh$) representing signal strength that matches the maximum broadcast range.

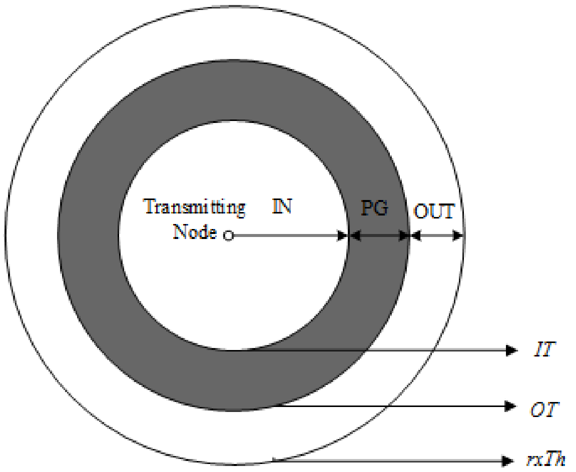


Fig. 2. The group division on preferred group broadcasting

The mathematical equations of $IT$, $OT$, and $rxThresh$ are:

$$IT = rxTh + fIT \tag{1}$$

The mathematical equations based on received signal strength are as follows:

$$OT = rxTh + fOT \tag{2}$$

The mathematical equation based on power range depends on $fIT$ and $fOT$ as follows:

$$\Delta P = IT - OT = fIT - fOT \tag{3}$$

### C. Performance of OLSR Using PGB

OLSR performance can improve through a combination with PGB in conducting the route search process and determining the potential node as an MPR node. The route search process and forwarding messages carried out in two stages, namely the route search process using OLSR and the selection of MPR using PGB. The use of the PGB algorithm in the OLSR is an MPR grouping to forward messages.

Fig. 3 shows the OLSR working principle using PGB. This working principle will go through two stages. The first stage for route search uses the Dijkstra algorithm, which operates on the standard OLSR protocol. Each node in the route search process will broadcast a Hello message to the neighbor node. The resulting route will form a routing table from the source to the target. The second stage is determining the position of the node using PGB. The resulting routing table will calculate for each resulting value of delay. The delay calculation will determine the location of the nodes to be in the IN, PG, or OUT area.

The PGB region categorized by the scope between the source node and the target node. Nodes in the PG area will be the top priority for forwarding messages to the scheduler list. This Scheduler serves to determine which route the node has after the grouping stage of the selected MPR. After passing the schedule list, a message checked whether the node had sent the same message or not. If the signal received is the same then it will drop. If the word has not posted before, it will forward as the selected node.

The grouping stage that is not in the PG area will enter the OUT area. If the node is not in the OUT or IN region, the node will drop. Nodes located in OUT or IN will go to the schedule list. This process is similar to the stage carried out by nodes in the PG area. The node that enters the checking stage checked whether it had sent the same message or not. If the message has not posted before, it will forward as the selected node. However, if the same message received, then it will drop.

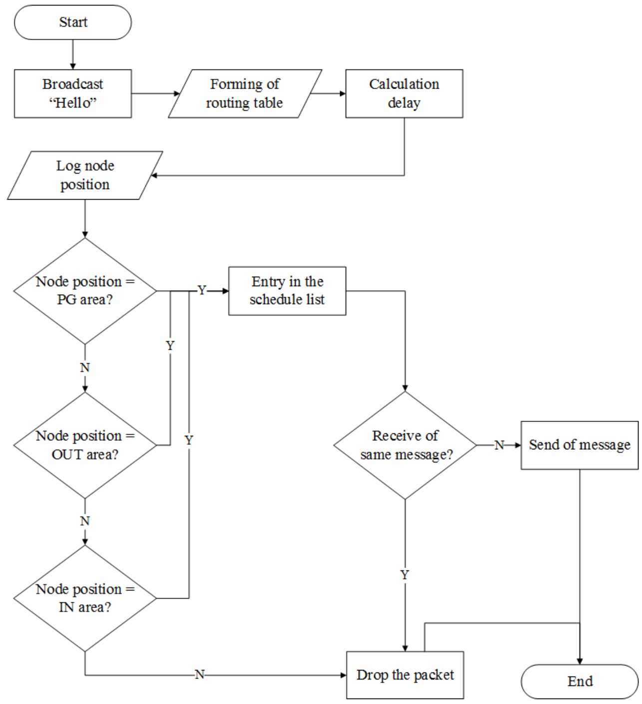


Fig. 3. Flowchart of the OLSR using preferred group broadcasting

## IV. Simulation Environment

This simulation aims to see the performance between the standard OLSR and the OLSR using PGB based on QoS by considering the varied number of nodes. Simulation is done by using NS2 version 2.35 [34] and by making program listings in the form of AWK scripts [35]. This simulation is an open source program and many researchers have used it in various research related to networks, both wireless and wired.

The number of nodes used is 200 with random changes. The area of the simulation used is 1000 meters x 1000 meters with a fixed speed setting of 20 m/sec. The simulation scenario gave the same treatment on the number of nodes that vary from 25, 50, 75, 100, 150, and 200 with a duration of 300 seconds. The purpose of assigning the same number of nodes on the standard OLSR and the OLSR using PGB is to ensure the level of accuracy produced by the simulation.

The node movement scenario used in this simulation is using a random waypoint model [36].The choice of this model based on the consideration that the direction of movement and the node speed to reach the destination made randomly [37]. This movement model changes nodes randomly towards the target with a fixed speed distribution of 20 m/sec. This speed is the maximum speed of a moving node in a simulation. The propagation selection uses a two-ray ground model. This model supports the node movement for direct path propagation, ground reflection [38], [39], and signal strength between the sender and the receiver. Table 1 shows the simulation parameters used in the study.

TABLE I
SIMULATION PARAMETERS

| Parameter | Parameter Value |
|---|---|
| Network Simulator | NS 2.35 |
| Operating System | Ubuntu 14.04 |
| Routing Protocols | OLSR, OLSR Using PGB |
| Number of Nodes | 25, 50, 75, 100, 150, and 200 |
| Propagation Model | Two Ray Ground |
| Mobility Model | Random Waypoint |
| Transport Protocol | User Datagram Protocol |
| Packet Size | 512 bytes |
| MAC Protocol | IEEE 802.11 |
| RTS/CTS | None |
| Number Packets | 1 Mbps |
| Simulation Time | 300 seconds |
| Simulation Area | 1000 m x 1000 m |

## V. RESULTS AND DISCUSSION

### A. Packet Delivery Ratio (PDR)

PDR is the number of packets that successfully received. It is proportional to the total packets sent by the source node. PDR is one of the parameters in QoS to indicate the success rate of the routing protocol.

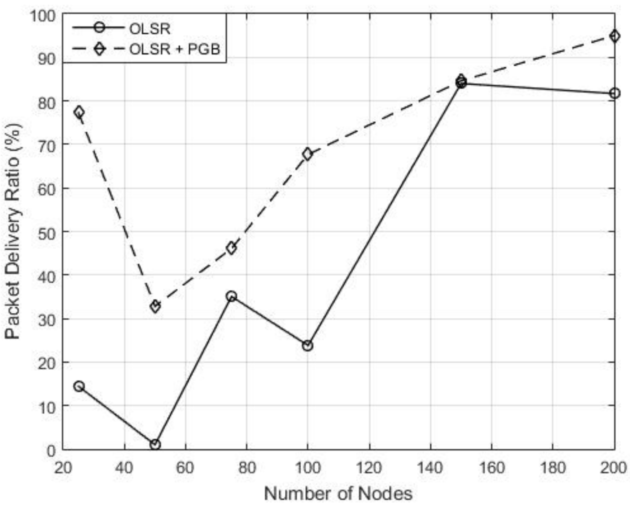


Fig. 4. The simulation result of the packet delivery ratio

Fig. 4 shows that there is a decrease in PDR values at nodes 25 to 50 in both the standard OLSR and the OLSR using PGB. The reduction in PDR value occurs because the number of packets sent and received is inconsistent. This change can observe based on the packet delivery file in two milliseconds. It indicates that some nodes send messages that do not match the number of packets received. It can conclude that many packets sent by the source node, but they fail to accept by the destination node. At nodes 50 to 150, the PDR value of the standard OLSR tends to increase and becomes stable. However, at the node 150 to 200, the number of PDR decreased again. In other, the PDR value tends to strengthen and stabilize in the results obtained by the OLSR with PGB at nodes 50 to 200. PDR increase occurs because 73% of the destination nodes successfully receive packets sent from the source nodes.

The PDR value in the standard OLSR tends to decrease and becomes unstable on each change in the number of nodes. This decrease occurs because the number of packets sent failed to receive by the destination nodes. The results obtained indicate that the OLSR using PGB has a better PDR performance than standard OLSR. The average PDR value for OLSR using PGB is 67.25% and standard OLSR is 39.90%.

### B. Throughput

Throughput describes the condition of data speed in a network. Routing protocols are determined to have good network performance, only if the value of throughput is high. Fig. 5 shows throughput of the standard OLSR and the OLSR using PGB tend to decrease in changes in nodes 50 to 100. A decrease in throughput value occurs due to packet transmission from nodes 54 to 58 that has a farther distance than the other nodes. It can understand that the effect of the distance between neighbor nodes causes a decrease in the signal and increasing the time needed in a route search.

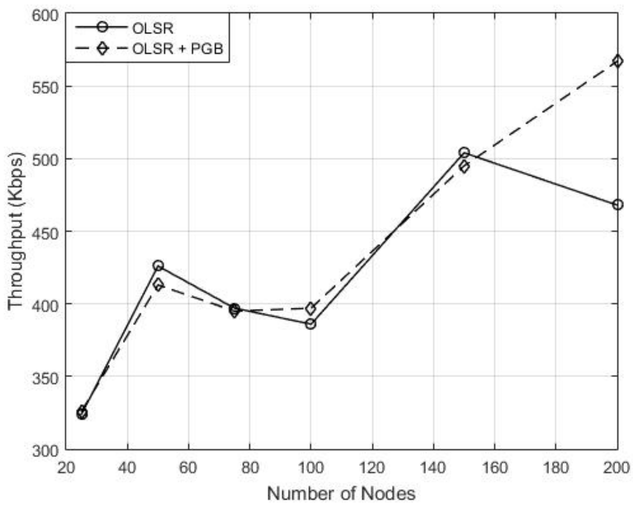


Fig. 5. The simulation result of the throughput

The standard OLSR throughput values from nodes 100 to 200 tend to decrease. The OLSR using PGB tends to rise and becomes stable. The average throughput in the OLSR using PGB become to increase caused by the ability to choose MPR nodes optimally which based on the results of the most active signal grouping. The results obtained indicate that the OLSR using PGB has better throughput performance than the standard OLSR. The average throughput value for the OLSR using PGB is 432.04 Kbps, and the standard OLSR is 417.38 Kbps.

### C. Packet Loss

Packet loss measured as the percentage of packets lost in connection with the packets sent between the source nodes to the destination node. The packet loss caused by a queue that exceeds the buffer capacity of each node. Fig. 6 shows that the value of the packet loss on the OLSR with PGB tends to decrease and stabilize in nodes 50 to 200. However, the amount of packet loss on the standard OLSR tends to increase in nodes 150 to 200.

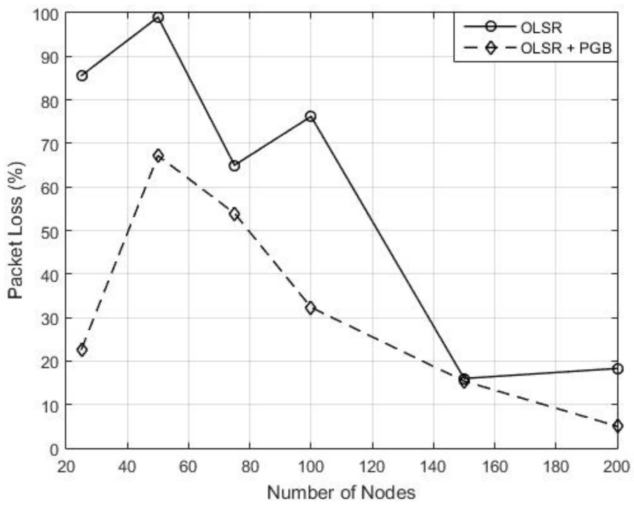


Fig. 6. The simulation result of the packet loss

The decrease of packet loss in the OLSR using PGB, especially smaller nodes, is caused by the packet loss that occurs from the source node to the destination. It is a minimal number compared to the standard OLSR. The results show that the OLSR using PGB has a better packet loss performance than the standard OLSR. The average value of packet loss of the OLSR using PGB is 32.75% and the standard OLSR is 60.03%.

### D. Delay

Delay is the required time to send data from source to destination. This parameter influenced by the amount of time used by the protocol in the route search. Fig. 7 shows that in nodes 25 to 200, the delay values in the standard OLSR tend to increase. However, the OLSR using PGB tend to decrease in nodes 75 to 200.

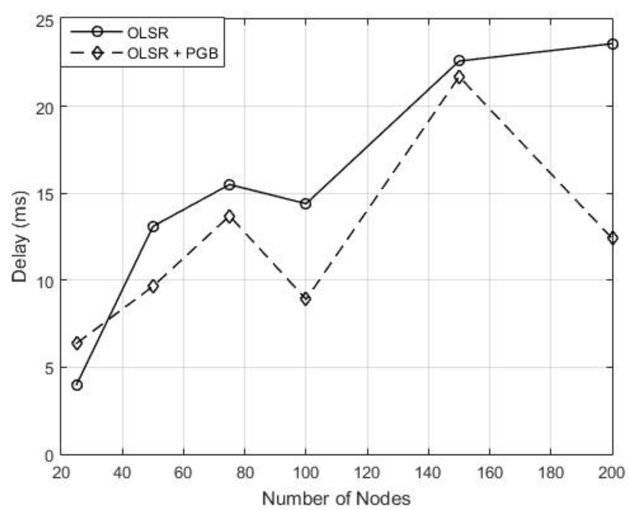


Fig. 7. The simulation result of the delay

The decreasing delay occurs because the selected node has a shorter distance. From the results, it indicates that the OLSR using PGB has a better delay performance than the standard OLSR. The average value of delay in the OLSR using PGB is 12.12 milliseconds and the standard OLSR is 15.52 milliseconds.

### E. Topology Control

The TC parameter shows the work efficiency of the routing protocol in sending the total packet from the source node to the destination. Each packet sent to several hops counted as one broadcast (one-hop). A high TC value indicates a wasteful bandwidth in package delivery. Fig. 8 shows that TC values on both the standard OLSR and the OLSR using PGB tend to rise at node changes from 50 to 200. However, specific changes in nodes 25 to 50 TC values on the OLSR using PGB tend to decrease. The decreasing TC values on the OLSR using PGB caused by the relatively small number of packets sent. Thus, they do not experience excessive packets significantly.

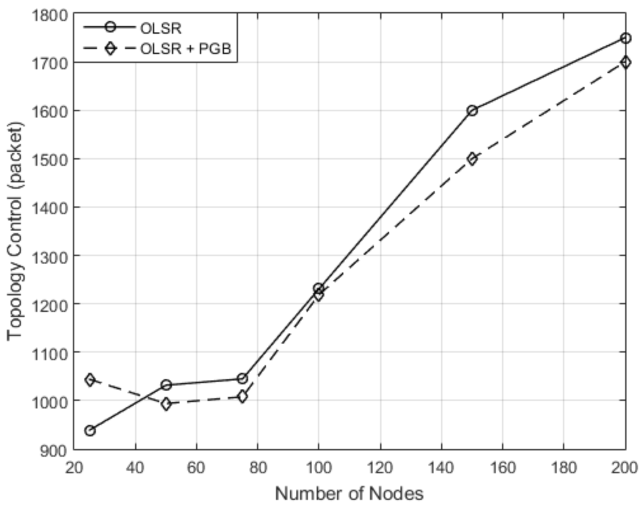


Fig. 8. The simulation result of the topology control

The results show that the performance of TC in the OLSR using PGB is better than the standard OLSR. The average value of TC in the OLSR using PGB is 1244.17 packets, while the standard OLSR is 1266.17 packets. The result of the decrease in TC values indicates that the OLSR using PGB can reduce excessive packet redundancy compared to the standard OLSR.

## VI. Conclusion

This research aims to evaluate the performance of the standard OLSR and the OLSR using PGB based on service quality (QoS) by considering changes in the number of nodes. Simulation results show that the OLSR performance using PGB is better than the standard OLSR regarding packet delivery ratios, the throughput, the packet loss, the delay, and the topology control. The increasing value of PDR and the throughput occur because OLSR using PGB is very selective and optimal in conducting MPR node selection. While the decrease in packet loss, delay, and topology control in OLSR using the PGB occur because there is only a minimal number of packets lost from the source to the target. The selected node has a shorter distance than the standard OLSR. The resulting topology control value shows that OLSR using the PGB can reduce the excessive number of packets in each shipment from the source to the destination.

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