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OPNET을 이용한 OLSR과 AODV 라우팅 프로토콜 성능 비교

Performance Comparison of OLSR and AODV Routing Protocols Using OPNET

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Abstract A Mobile Ad hoc network (MANET) is a network consisting of a set of wireless mobile nodes, which communicate with each other without centralized control or established infrastructure. In this paper, to obtain a better understanding of AODV (Ad hoc On-Demand Distance Vector Routing Protocol) and OLSR (Optimized Link State Routing Protocol) routing protocols, different performances are simulated and analyzed using OPNET modeler 14.5 with the various performance metrics, such as packet delivery ratio, end-to-end delay and routing overhead.
As a conclusion, in static analysis, the routing overhead of OLSR is affected by the number of nodes, but not data traffic. In AODV case, it is affected by both data traffic and number of nodes. In mobility analysis, routing overhead is not greatly affected by mobility speed in AODV and OLSR, and the PDR (Packet Delivery Ratio) of OLSR is decreased as the node speed increased, while AODV is not changed. As to delay, AODV is always higher than OLSR in both static and mobility cases.

Key Words : AODV, MANET, OLSR, OPNET 14.5, PDR

I. INTRODUCTION

With the development of wireless networks in recent years, mobile wireless communication in the world is becoming more significant and has increased in usage and popularity. In some emergency situations, such as fire and disaster, where mobile wireless networks can be utilized to establish an interoperable communications network, while the local infrastructure had been destroyed. Furthermore, also meetings or conventions where persons wish to quickly share information, and data acquisition operations in inhospitable and remote terrain [1].

A Mobile Ad hoc network (MANET) is a kind of wireless ad hoc network, which has mobile devices with self-configuring capability and is a network of mobile routers connected by wireless links. The terminals may be free to move randomly and organize themselves arbitrarily [2]. In ad hoc network, nodes do not have a priori knowledge of topology of network around them, the route should be discovered [3]. In this case, MANET routing protocols should be studied and utilized. Two kinds of routing protocols are more important and popular recently, one is proactive routing protocol. Example of proactive routing protocol is OLSR (Optimized Link State Routing Protocol) [4].

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And the other is a reactive routing protocol. Example of reactive routing protocol is AODV (Ad hoc On-Demand Distance Vector Routing Protocol) [5].

Some studies [6], [7], [8], [9] already had been evaluated the performance of the proposed routing algorithms. A detailed long-lived connection simulation in the study of Chandhry et al. (2005) [6] presented the AODV achieved good performance in high mobility speed comparing OLSR, while which performed better in static simulation. In contrast to this study, the performance in the study of Das et al. (1998) [7] showed that proactive protocols have the best end-to-end delay and packets delivery fraction, at the cost of higher routing load. However, their studies wereconducted under a certain number of limitations as explained. A simulation study of AODV and OLSR was done by Clausen et al. (2002) [8] and it was shown that AODV outperformed OLSR at higher speeds and lower number of traffic streams, and OLSR generated the lowest routingload. Lye and McEachen (2007) [9] showed that the PDR(Packet Delivery Ratio) of AODV and OLSR are also higher as the node speed increased in all cases, and the routing overhead of OLSR is higher than that of AODV in marine wireless ad hoc network. However, a systematic performance study of AODV and OLSR routing protocols was carried out in this paper. This work was also the major comprehensive evaluation on the performance of AODV and OLSR routing protocols using OPNET [10] modeler 14.5 under the various load conditions. While comparing the simulated performance of each other, the best suitable routing protocols were shown under the different environments.

The rest of the paper was organized as follows. In the following Section, the MANET routing protocols were briefly reviewed and studied. Section III discussed the performance of metrics and simulation environment. Then the simulated results were shown and analyzed in Section IV. Finally, conclusions and some recommendations for future work were given in Section V.

II. MANET ROUTING PROTOCOLS

A. Ad hoc On-Demand Distance Vector (AODV) Routing Protocol

AODV is a reactive routing protocol and constructs the route when the route is needed. In ad hoc network, AODV offers quick adaptation to the dynamic link conditions, self-starting and multi-hop routing, low processing and memory overhead, low network utilization, and determines the unicast routes to destination within the ad hoc network [5].The destination sequence number is used for each routing table entry to ensure loop freedom and identify the most recent path in ad hoc network.

In AODV, when a source requires a path to the destination, a route discovery will be started. Firstly, a route request (RREQ) message is flooded from the source in the network. Upon receiving such a message, a node examines its local route cache to check if a fresh route to the required destination is available. If so, the node unicastsa route reply (RREP) message to the source node. Otherwise, the RREQ is retransmitted using a pure flooding mechanism with local duplicate elimination [11]. As an optimization, in order to control network widely broadcast of RREQs, AODV employs an expanding ring search technique when flooding the message, where a RREQis issued with a limited TTL. If no RREP message is received within a certain time, the message is issued with a large TTL. If still no reply, the TTL is increased in steps by an increment value, until a threshold value is reached [12].

After this route discovery is performed and the route is established, any IP-packets to the destination buffered in the source node will be transmitted. If no route can be found, the data packets will be dropped.

When a link is detected to be broken, the detecting node issues a route error (RERR) message to its neighbors who have been using a route over the broken link. The nodes will then have to issue a new RREQ to repair the broken routes [13].

B. Optimized Link State Routing Protocol (OLSR)

OLSR is a proactive routing protocol and employs periodic message to exchange andupdate topological information in each node in the network. So the routes are always immediately available whenever needed [14]. In this case, OLSR will occupy a large number of bandwidths and resources. In order to reduce the possible overhead in the network, unlike a simple pure flooding strategy, OLSR applies an optimized flooding mechanism, namely Multipoint Relay (MPR), which is selected only by periodical hello messages and minimizes the problem of duplicated reception of message by reducing the same broadcast within a region. Figure 1[11] shows an example of pure flooding and diffusion using MPRs.

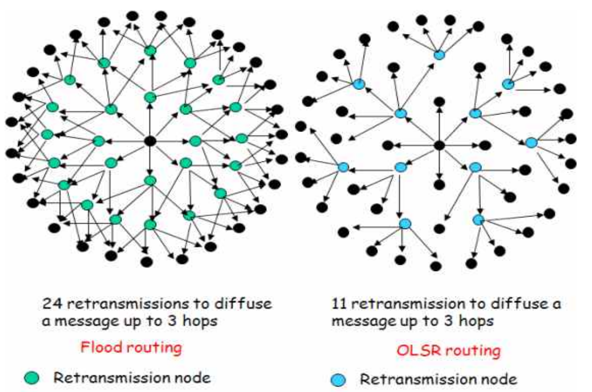


Figure 1. Pure flooding and diffusion using multipoint relays.

MPR nodes have the important roles:

1) When the node sends or forwards a TC message, only its MPR nodes among all its neighbors can forward a TC message.
2) The MPR nodes can forward broadcast messages during the flooding process, and reduce much more overhead.

OLSR uses two kinds of control messages: Hello and Topology Control (TC). Hello message isused for finding the information about the link status and the host's neighbors. The Hello message just can send only one hop away, so they are not forwarded anymore. But TC messages can broadcast throughout the entire network. TC message is used for broadcasting information about own advertised neighbors, which include at least the MPR Selector list. And also only MPRs can generate and forward the TC message [15].

In order to understand the difference between AODV and OLSR routing protocols, the comparison of the two kinds of routing protocols is provided in Table 1 [6].

Table 1. Comparison of Proactive and Reactive Routing Protocols

	OLSR	AODV
Network organization	Flat/Hierarchical	Flat
Topology dissemination	Periodical	On-Demand
Route latency	Always	When needed
Mobile handling	Periodical updates	Route maintenance
Communication Overhead	High	Low

III. SIMULATION ENVIRONMENT

In order to conduct a comparative performance study, all scenarios have been modeled and evaluated using the OPNET 14.5 network modeling environment from the OPNET technology.

A. Network Access Characteristics

The 802.11b in the distributed coordinated function (DFC) mode was used at the WLAN MAC layer. The Mobile Ad hoc network simulated consists of nodes placed randomly in a 5 x 5 km area. The random waypoint model was adopted as the mobility pattern [16].

B. Model Description

Two different types of models are used in the OPNET [9] simulations. The descriptions of each type of nodes are given in the following:

1) Wireless LAN Workstation: The wlan-wkstn node model represents a workstation with client-server applications running on TCP/IP and UDP/IP. The workstation supports WLAN connection at 1, 2, 5 and 11 Mbps. The supported protocols are: RIP, UDP, IP, TCP and IEEE 802.11.
2) Wireless LAN Server: The wlan-server model represents a server node with server applications running on TCP/IP and UDP/IP. This node supports IEEE 802.11 connection at 1, 2, 5 and 11 Mbps. The server's speed is determined by the connected link's data rate. WLAN server supports RIP, UDP, IP, TCP and IEEE 802.11.

C. Performance Metrics

The major three metrics used for evaluation of the relative performance of ad hoc routing algorithms are as follows:

1) Packet Delivery Ratio (PDR) - It is ratio between the number of packets delivered to the receiver and the number of packets sent by the source.
2) Routing Overhead - The routing overhead describes how many routing packets for route discovery and route maintenance need to be sent in order to propagate the data packet.
3) End-to-End Delay - This statistic represents the average elapsed time between transmission and reception of individual data packets in the network. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.

D. Routing Protocols Simulation Parameters

The simulation parameters of AODV and OLSR are listed in Table 2. Table 3 presentssome important parameters used in the simulation model for AODV and OLSR respectively for static and mobility environment.

Table 2. Simulation Configuration Parameters

	AODV	OLSR
Static Simulation		
No. of Nodes	25,36,49,64,81,100	25,36,49,64,81,100
Area (m*m)	5000 * 5000	5000 * 5000
Simulation time (s)	900	900
802.11b data rate	11 Mbps	11 Mbps
Mobility Simulation		
Speed (m/s)	5,10,15,20,25,30	5,10,15,20,25,30
Model	Random way point	Random way point
Moving Area (m*m)	5000 * 5000	5000 * 5000

Table 3. Parameters of AODV and OLSR Protocols

Parameter	AODV
Active Route Timeout (s)	3
Hello interval (s)	Uniform (1, 1.1)
TTL_Start (s)	1
TTL_Increment (s)	2
TTL_Threshold (s)	7
Parameter	OLSR
Hello interval (s)	2
TC interval (s)	5
Neighbor hold time (s)	6
Topology hold time (s)	15

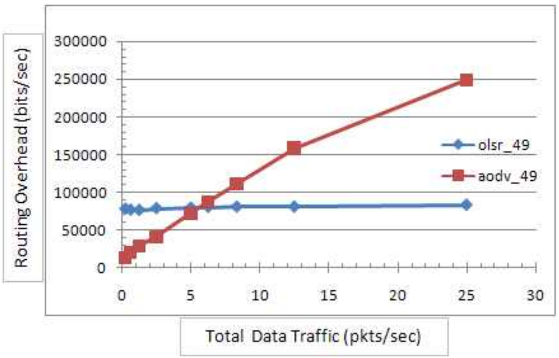
IV. RESULTS ANALYSIS AND DISCUSSION

In order to represent the main features of a real Ad hoc network, all the simulations have been done under the various load conditions to understand the performance evaluations. The UDP protocols had been used for simulating and comparing AODV and OLSR protocols in our scenarios.

A. Effect of Traffic Stream

In this section, the simulation was run at 49 nodes on the exponential concurrent data traffic. The data traffic generated rate changed from 0.01 pkts/sec to 1 pkts/sec. The three performance metrics are described in Figure 2.

As can be seen in Figure 2a, as the data traffic increases, routing overhead in OLSR remains steady, but in AODV, routing overhead increased proportionally. That is because



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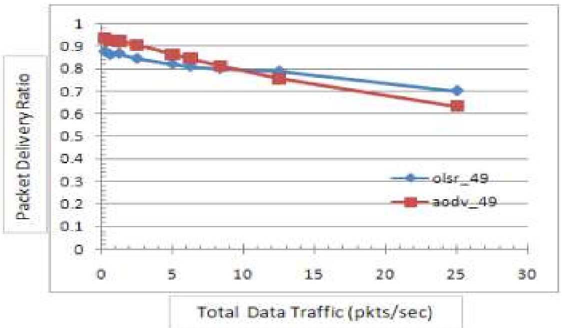

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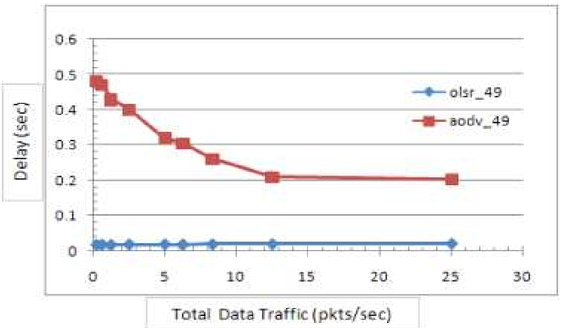


(c)

Figure 2. Effect of traffic stream on (a) routing overhead (b) PDR (c) delay.

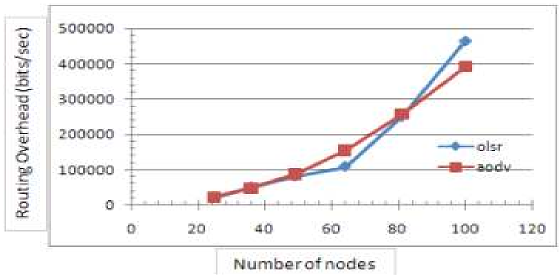
OLSR is a proactive routing protocol, each node broadcasts routing traffic regularly, no matter how many packets are generated. However, while the control traffic generated by the AODV from the repeated route discovery procedures in network, increases with an increased number of concurrently active data streams.

Figure 2b depicts the similar down trend of PDR in AODV and OLSR. With a large number of concurrent traffic streams, extra control traffic causes less available bandwidth for data traffic and increased chances of packet loss due to collisions and interface queue overflows.

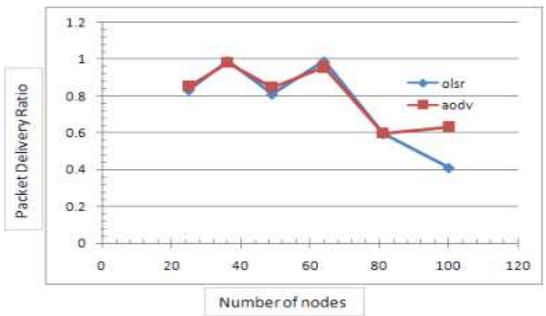
In Figure 2c, it reveals that AODV is higher than OLSR in delay, and OLSR remains stable. Because OLSR is a proactive routing protocol, which means when a data packet arrives at a node it can immediately be forwarded or dropped. But in AODV, if there is no route to destination, packets to that destination will be stored in a buffer while a route discovery is conducted, it may cause longer delays.

B. Effect of Network Size

The number of nodes varies from 25 to 100 on 0.25 pkts/sec data traffic rate in the simulations at the 25 kilometers square area. As the nodes increases, the network is becoming denser. In general, low density may cause the network to be frequently disconnected and high density may increase the contention, resulting in high routing overhead. The three performance metrics are displayed in Figure 3.



(a)



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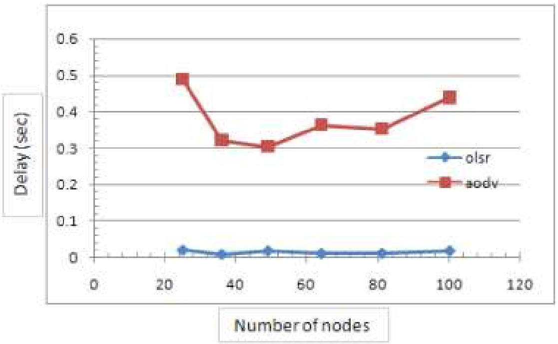

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Figure 3. Effect of network size on (a) routing overhead (b) PDR (c) delay.

In Figure 3a, routing overhead for both AODV and OLSR are increasing as the number of nodes changed from 25 to 100. In AODV route discovery procedure, the distance and hops between source and destination are increased, so routing overhead is increased. In OLSR, overhead is proportional to the number of nodes, because all nodes send a routing message periodically.

Figure 3b illustrates a general down trend of PDR in AODV and OLSR when the node is increased. Similar in Figure 2b, because of collisions and conflict between each node, the data packets received by the destination successfully are decreased.

From Figure 3c it can be seen that the delay in AODV is higher than OLSR, becauseOLSR can immediately forward or drop the data, and the data packets do not need to wait, but AODV should execute the route discovery procedure in order to deliver the packets causing long delay.

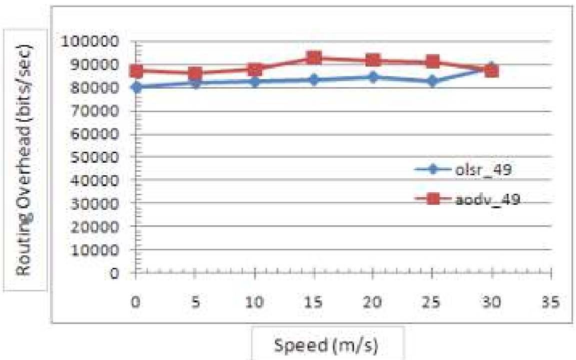
C. Effect of Mobility

For a better understanding of how the mobility speed affects routing protocol performance, the Random Waypoint model should be used. In this scenario the node speed is increased from 0 m/s to 30 m/s in steps of 5 m/s on 0.25 pkts/sec data rate with the same number of nodes, i.e. 49 nodes with a 25 kilometers square area. Once the destination is reached, another random destination is targeted after a pause time.The pause time, which affects the relative speeds of the mobiles, also varied. But in this scenario, the nodes move according to the random waypoint model without pause time. As expected, as the nodes speed increases, more packets are dropped due to unavailable routes. Figure 4 shows the effect of mobility of the three performance metrics.

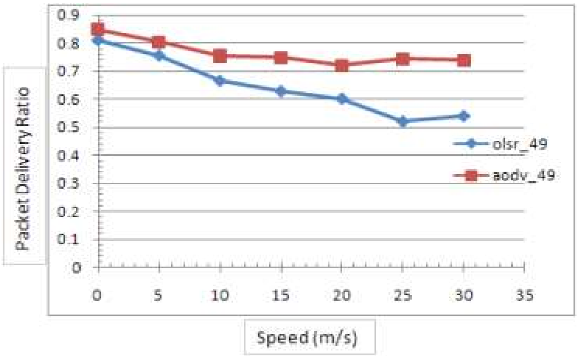
As shown in Figure4a, both AODV and OLSR remain steady in routing overhead, although node speed is increased. Routing traffic is broadcasted by OLSR regularly, but if no packet to be sent to destination in AODV, the node does not need to send routing traffic, on the other hand, the route discovery will be performed to find the route, it is not affected too much by mobility speed.

The trend of PDR explains the difference between AODV and OLSR in Figure 4b. OLSR shows a decreasing trend, but AODV presents a stable one. In high mobility speed, while the data packets are generated from the source, the node in OLSR can immediately send and forward to the destination, which already moves to another place, so the data will be dropped. But in AODV case, before finding the route to the destination, the data packet will be stored in a buffer, so it is not too much effect by mobility.

As explained in Figure 2c and Figure 3c, it is not difficult to depict Figure 4c, which shows AODV is higher than OLSR in delay. Even though the nodes speed increases, OLSR consistently presents the lowest delay.



(a)



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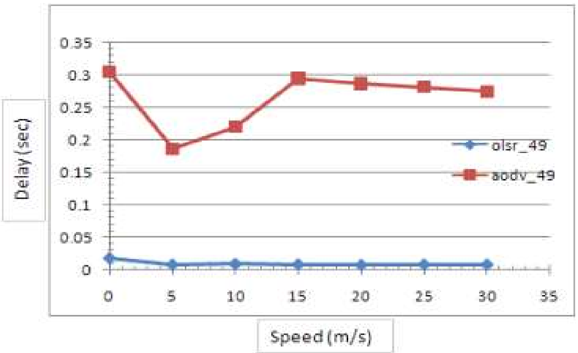

(c)

Figure 4. Effect of mobility on (a) routing overhead (b) PDR (c) delay.

V. CONCLUSIONS AND FUTURE WORK

Mobile ad hoc network routing protocol research is recently in progress. Drafts are continuously being updated and published. AODV and OLSR routing protocols are also getting better and more popular. In this paper, the performance studies of AODV and OLSR models were conducted under the different load conditions, and the three performance metrics were used to measure the evaluations of AODV and OLSR.

In static analysis, the routing overhead of OLSR is affected by number of nodes, but not data traffic. In AODV case, it is affected by both data traffic and number of nodes. In mobility analysis, routing overhead is not greatly affected by mobility speed in AODV and OLSR, and the packet delivery ratio of OLSR is decreased as the node speed increased, while AODV is not changed. As to delay, AODV is always higher than OLSR in both static and mobility cases.

It is important to point that further research is necessary to simulate performance evaluations of AODV and OLSR with other ad hoc routing protocols under the various environments, such as DSR (Reactive routing protocol), ZRP (Hybrid routing protocol). In addition, some researches on connecting MANET to infrastructure network are more interesting and challenging.

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