이동 애드혹 네트워크을 위한 새로운 라우팅 프로토콜 기법

Van-Vuong Ngo* · 장재신*
*인제대학교

Efficient New Routing Protocol for Mobile Ad Hoc Networks

Van-Vuong Ngo* · Jaeshin Jang*
*Inje University
E-mail : vanvuong@oasis.inje.ac.kr, icjoseph@inje.ac.kr

요 약

이동 애드혹 네트워크에서 널리 사용하고 있는 AODV 라우팅 프로토콜은 라우팅 경로를 결정할 때 홉수를 사용한다. 그러나 홉수가 송신노드와 목적지노드 사이의 통신경로를 정확하게 반영하지 못하므로 네트워크 성능을 향상시키기 위해 본 논문에서는 AuM-AODV 라우팅 프로토콜을 제안하였다. AuM-AODV 프로토콜은 홉수 외에 통신경로를 반영하는 보조 라우팅 메트릭을 사용한다. 또한 AODV와 동일하게 RREQ, RREP, 그리고 Hello 패킷을 사용하며, 각 통신노드들은 제어 패킷을 수신하면 라우팅 테이블을 갱신한다. 본 논문에서 제안한 AuM-AODV 라우팅 프로토콜을 NS-3 네트워크 시뮬레이터에 구현하였으며, 3가지 성능평가 척도를 사용하여 기존 AODV 프로토콜과 성능을 비교하였다. 성능평가 결과에 따르면 3가지 성능평가 척도에서 AuM-AODV 라우팅 프로토콜의 성능을 우수함을 알 수 있었다.

ABSTRACT

AODV routing protocol, one of the most studied routing protocols for the Mobile Ad hoc Network (MANET), uses the number of hops as the metric to choose a path from a source node to a destination node. If the path is deteriorated, it will cause many problems to the communication. In order to improve the performance of the network, we propose AuM-AODV routing protocol that contains an auxiliary metric besides the number of hops. Nodes using AuM-AODV use control packets such as Route Request (RREQ), Route Reply (RREP), and HELLO to exchange information about network topology like AODV routing protocol. AuM-AODV routing protocol is implemented in NS-3 for performance evaluation. We use three performance metrics, that is to say, throughput, packet delivery ratio, and average end-to-end delay. According to numerical results, the new AuM-AODV routing protocol has better performance over three performance metrics than AODV routing protocol.

키워드
AuM-AODV, metric, routing protocol, throughput

Ⅰ. Introduction

The Ad hoc On-demand Distance Vector (AODV) routing protocol [1] is one of the reactive routing protocols which provide efficient communications to Mobile Ad hoc Network (MANET) [2]. AODV uses the number of hops as the metric to choose the path from a source node to a destination node. That means the shortest path will be chosen. However, in some case, the shortest path is not the best path. If the shortest path is deteriorated or broken, it will cause a lot of problems to the communication. Therefore, we proposed AODV Routing Protocol with Auxiliary Metric (AuM-AODV) with contain a metric that based on the number of received HELLO control packets in a node. If a node receives many HELLO control packets, it means that the node is in an area which is dense of nodes. Considering both the number of hops and the number of received control packets, the source node can choose an appropriate path to the destination node.

Ⅱ. Ad hoc On-demand Distance Vector Routing Protocol

AODV uses Route Request (RREQ) and Route Reply (RREP) messages to find the path from a source node to a destination node. First, the source node broadcasts RREQs to its neighbor nodes. These neighbor nodes then forward the RREQs to other intermediate nodes until RREQs reach the destination node. The destination node will reply to the source node with a RREP that contains the information about the route from the source node to the destination node. The source node will base on the number of hops in the RREP to determine how it should update its routing table. Normally, the source node will update its routing table with the shortest path (the path has fewest hops from the source node to the destination node).

Nodes may offer connectivity information by broadcasting local HELLO messages. When HELLO messages from node B is received by node A, node A refresh all entries in its routing table in which node B appears to be the next hop. If A has not heard from B for some amount of time (no HELLO messages and no regular message was received by A from B), A assumes that B is no longer its neighbor and invalidates all routes through B (routes to all destinations in which B is the next hop).

Figure 1 illustrates an example of AODV path discovery process. The source node S tries to find a route to the destination node D, so node S broadcasts RREQs to other nodes. One RREQ goes from node S to node 1, then node 2 and finally reaches node D. Afterwards, Node D replies with a RREP. The RREP travels along the reverse path (node 2- node 1 – node S). Node S will transmit data after it receives the RREP. The RREQ that goes in the path node 3 – node 4 – node 5 – node 6 – node D will be discarded by node D. The redundant RREQ will be ignored by every node in AODV, so node D only reply the first RREQ and does not care about the second RREQ.

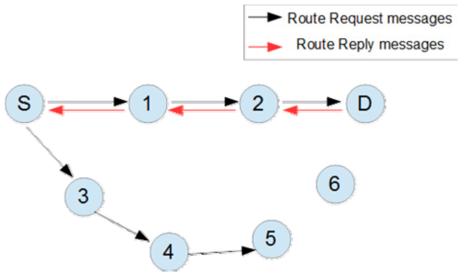

Figure 1. The path discovery procedure of AODV

Ⅲ. Ad hoc On-demand Distance Vector Routing Protocol

Ad hoc On-demand Distance Vector Routing Protocol with Auxiliary Metric (AuM-AODV) has the same path discovery procedure as that of AODV. However, the destination node will not discard the duplicate RREQs. Because each duplicate RREQ can travel in another route from the source node to the destination node, the reverse paths (the path with direction from destination node to the source node) can be independent of each other (node-disjoint paths). If one reverse path is disconnected, the other paths are still stable. When the destination node receives a RREQ, it generates a RREP and sends it to the source node along the reverse path. This process recurs each time that the destination receives a RREQ with different reverse paths.

Moreover, AuM-AODV uses one metric that contains both the number of hops and the number of received HELLO packets in each node. The metric is calculated by a function in which the number of hops has larger contribution than the number of received Hello packets. Therefore, the routing protocol tends to choose the path that is short first. The number of received Hello packets will give some information to support the process of choosing suitable path between some short paths. The nodes which receive many Hello messages often lie in the crowded region and have a high chance of involving in transmission. In case that there are some transmission links, these nodes can lose their energy faster than others. Besides, the network may suffer congestion in dense areas. With the information about the number of received Hello messages in each node, the data can be transmitted through less crowded areas, balancing the load of nodes. The metric replaces the “Hop count” field in the RREP control. This metric is accumulated on each passed node; the source node then will choose the path that has the smallest metric.

Table 1. RREP packet format of AODV

Type	Reserved	**Hop count**
Destination IP Address		
Destination Sequence Number		
Source IP Address		
Life time		

Table 2. RREP packet format of AuM-AODV

Type	Reserved	**Metric**
Destination IP Address		
Destination Sequence Number		
Source IP Address		
Life time		

Ⅳ. Numerical Results

Our simulations are implemented in NS-3 [3]. The simulation parameters are shown in Table 3. To evaluate the performance of AuM-AODV and that of the AODV protocol, we compare their Throughput, Packet Delivery Ratio and Average End-to-end Delay. For each routing protocol, the network has 2 data links.

- **Throughput**: The data rate of the transmission from the source node to the destination node.
- **Packet Delivery Ratio (PDR)**: The ratio of packets reaching the destination node to the total packets generated at the source node.
- **Average End-to-End Delay**: The time interval between transmitting time by the source node and arrival time at the destination node, which includes the processing time and queuing time.

Table 3. Simulation Parameters

Parameters	Values
# of nodes	50, 60, 70
Communication area	$500m \times 500m$
Velocity	Uniform(0, 5m/s)
Mobility model	Random waypoint
Application type	UDP with CBR
UDP period	2 ~ 30 sec
# of applications	2 UDP links
Packet size	1024 bytes
Packet arrival rate	20 packets/s
PHY/MAC	IEEE 802.11
Initial energy	10 J
Simulation period	100 sec

Figure 2 shows the AODV and AuM-AODV average throughputs of two data links. From these results, it is shown that AuM-AODV is generally more efficient than AODV.

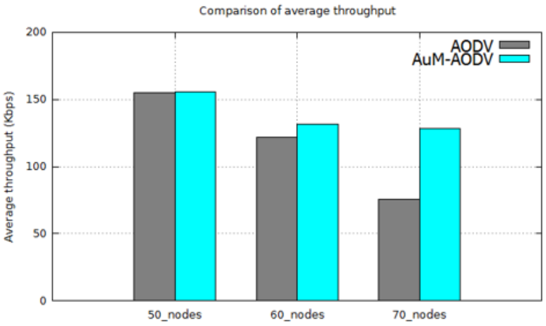

Figure 2. Throughput performance of AODV and AuM-AODV

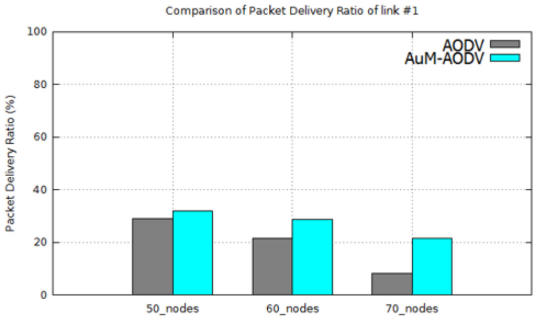

Figure 3. Packet delivery ratio of link #1

Figure 3 and Figure 4 present the numerical results of the AODV and AuM-AODV packet delivery ratio of each data link. It is evident that AuM-AODV has more received packets at the destination node than AODV.

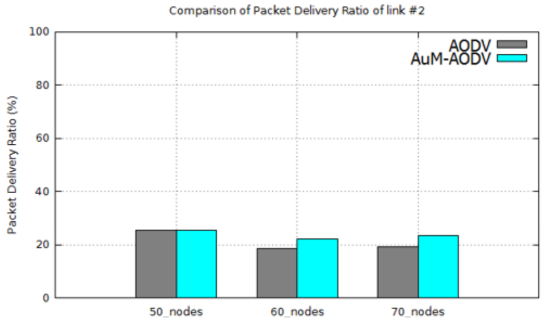

Figure 4. Packet delivery ratio of link #2

Table 4 and Table 5 show the numerical results of AODV and AuM-AODV from the aspect of the average end-to-end delay. According to these results, data packets of AuM-AODV need much less time to travel from the source node to the destination node.

Table 4. Average end-to-end delay of link #1

# of nodes	AODV (ms)	AuM-AODV (ms)
50	5.5721	5.4768
60	29.3576	28.0927
70	719.3043	73.828

Table 5. Average end-to-end delay of link #2

# of nodes	AODV (ms)	AuM-AODV (ms)
50	35.9768	37.2803
60	122.6071	82.1668
70	67.6836	35.4627

Ⅴ. Conclusion

We proposed a modified version of AODV routing protocol with consideration about the number of received Hello messages. The results show that AuM-AODV surpasses the performance of AODV in the throughput, the packet delivery ratio, and the average end-to-end delay. Our future work will focus on how to make two parallel metrics.

Acknowledgement

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