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An Adaptive Ttl-based Aodv Routing Protocol for Mobile *Ad Hoc* Networks

Chia-Chun Hsu, Hung-Wen Yang and Chou-Chen Yang
Department of Management Information Systems, National Chung Hsing University,
Taichung 402, Taiwan, Republic of China

Abstract: Mobile ad hoc networks (MANETs) are temporary networks without using any fixed infrastructure. Dynamic topology of MANETs often results in an easily-broken path especially when the node speed is high. Thus, finding a stable path using low speed nodes to route is the goal. On the other hand, most routing protocols use flooding approach and the propagation distance can be restrained by setting the time to live (TTL) field. When the TTL value declines to zero, the route request packet should be dropped. Accordingly, it may incur considerable routing overheads owing to aimless flooding. This study proposed an adaptive TTL-based protocol (AODV-TTL) modified Ad hoc On-Demand Distance Vector (AODV) routing protocol to route packets. The TTL value will be deducted dynamically according to the node speed and reaches zero quickly when the packet pass through some faster nodes. By this way, not only the broadcast range is restrained to a smaller range, the overall routing required number of broadcast packets can also be reduced. Consequently, the routing overheads will cut down and find a stable path because some faster speed nodes have been excluded automatically. Simulation results showed that AODV-TTL protocol can find a more stable path and offer better performance in the number of broadcast packets and throughput than original AODV.

Key words: Time to live (TTL), stable routing, controlled flooding, AODV

INTRODUCTION

Mobile ad hoc networks (MANETs) are temporary and decentralized networks. There is no any fixed infrastructure like base stations or access points. Dynamic topology is a unique characteristic of MANETs, it indicates that all the nodes along the path always change its position. The path is easily-broken when the topology changes rapidly. The speed of nodes is a critical factor. If the node speed is high, the topology will change rapidly and increase the probability of path failure. When the path failed, the source node should restart the route discovery procedure and it will bring additional routing cost. Accordingly, finding a stable path using low speed nodes to route is the goal.

Ad hoc On-Demand Distance Vector (AODV) (Perkins and Royer, 1999) is one of the most famous routing protocols in MANETs. It is a reactive routing protocol and it establishes a route on demand. Quickly reacts to changes in the network is one of its advantages. However, most of routing protocols are inefficient when the nodes are in the high speed environment as previous paragraph mentioned, AODV also has lower efficiency in this condition. This problem diminishes the performance of most of routing protocols.

On the other hand, most reactive routing protocols such as AODV, Dynamic Source Routing (DSR) (Johnson and Maltz, 1996) use flooding route request to start the route discovery procedure. The propagation distance of this kind of flooding approach is restrained by setting the time to live (TTL) field.

The TTL value is only decreased by one at each node. When the TTL value declines to zero, the route request packet should be dropped even though it didn't find the destination. Consequently, it may incur considerable routing overheads owing to aimless flooding.

This study proposed an AODV-TTL routing protocol that using adaptive TTL mechanism based on node speed. AODV-TTL protocol enhances the AODV by deducting the TTL value dynamically when the node speed exceeds the threshold value. By this way, the advantages are that the established path can avoid passing through some fast speed nodes and the broadcast range can be reduced.

Note that, there are three goals were achieved in AODV-TTL routing protocol:

- A smaller broadcast range
- A smaller overall routing required number of broadcast packets

Corresponding Author: Chou-Chen Yang, Department of Management Information Systems, National Chung Hsing University, Taichung, 402, Taiwan, Republic of China

- A more stable established path with faster speed nodes have been excluded automatically

Mobility problem is an important challenge in MANETs. A large number of routing protocols devoted to finding a stable routing owing to the dynamic topology in MANETs. Mobility prediction mechanism (Su *et al*., 2001) employ mobility patterns by user such as speed and move direction, it can predict the future state of network e.g., Link Expiration Time (LET) and finds a stable link between two nodes.

Subsequently, a Stable Weight-based On-demand Routing Protocol (SWORP) (Wang and Chen, 2006) was proposed. This protocol use the concept of weights to select a stable route. There are three factors about this protocol: Route Expiration Time (RET), the longest LET (Su *et al*., 2001) in the path, error count and hop count respectively. Then it calculates and selects the largest weight value for establish the most stable route.

A route-request selection protocol (Lian *et al*., 2007) use foregoing LET (Su *et al*., 2001) as threshold. When the upstream and downstream nodes collectively satisfy this threshold, the upstream node can forward the RREQ packet to the downstream node. In order to achieve this objective, the LET information should be stored in additional table in every node. By this protocol, the control overhead can be reduced and it can provide stability in high mobility networks.

Afterwards, a reliable QoS aware routing protocol was proposed in Wang and Lee (2009). The hop count of network parameter joins to the previous protocol. It use before-mentioned RET (Wang and Chen, 2006) divided by hop count to get a new value and select the most biggest value of paths to find a stable route. It means that when the LET is big and the hop count is little, it will be a stable path.

On the other hand, aimless flooding in large network will result in considerable routing overheads, because too many routing packets in the network. A novel controlled flooding protocol in Hughes and Zhang (2004) proposed two concepts: Trimmed Transmission Area (TTA) and Location Verification subsystem. The TTA algorithm can classify the network into largest and general percentage transmission area according to propagation range and modify the transmission area shape. The Location Verification subsystem can determine a node whether in the transmission area. If the node is in the expected area, it will directly flood. On the contrary, it will use TTA to modify the transmission area shape in order to reduce unnecessary traffic. Consequently, this protocol can achieve the following goals: restrict the flooding area and adjust the transmission area dynamically to reduce the number of nodes into routing.

A dynamical TTL mechanism was proposed in (Zou *et al*., 2008). It adds a time record field into route cache table and uses cached route history to adjust the TTL value dynamically. Accordingly, the broadcast range is restrained to a smaller range and unneeded broadcast can be avoided.

Another suppress broadcast redundancy mechanism was proposed in Lou and Wu (2007), the one hop neighbors of the source node only select forwarding nodes to retransmit the broadcast message according to following principles: (1) the neighbors into two hops distance between they and the source node (2) the one hop neighbors of the source node must be forwarding nodes or nonforwarding nodes but at least two forwarding neighbors are covered by them. This scheme can reduce the broadcast redundancy and provide a high delivery rate.

In summary, although the above protocols can aim at the stable routing and controlled flooding issues to solve separately, but they require additional resources to achieve their goals. The mobility prediction mechanism requires Global Positioning System (GPS) to assist in obtaining the mobile information in every node. Other protocols may need another new field in the routing table to record information or redundant calculation. These complicated procedures will decrease the performance of most of routing protocols. Then this study proposed a simple and efficient AODV-TTL protocol to solve above issues.

THE PROPOSED PROTOCOL

In AODV-TTL routing protocol, the goal is to make TTL value rapidly reaches zero especially when some nodes have faster speed along the path. Having nodes with overly fast speed is an indicator that the topology might be changed easily. In other words, the established path is not stable. For this reason, this study design an adaptive TTL-based protocol and focus on finding a stable path with smaller number of broadcast packets.

Figure 1 shows that the general routing protocols using flooding route request to start the route discovery procedure. The initial TTL value is assumed to be 30 here. The TTL value is only decreased by one at each node. Accordingly, the TTL value of first forwarding node is 29, the second forwarding node is 28 and the other forwarding nodes are also deducting the TTL value by this way until the value reaches zero. This kind of aimless flooding approach includes longer propagation distance and it may incur considerable routing overheads.

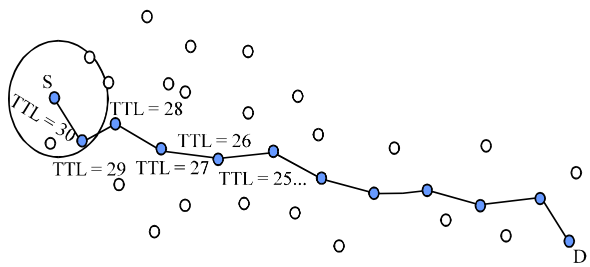

Fig. 1: Route discovery procedure of general flooding

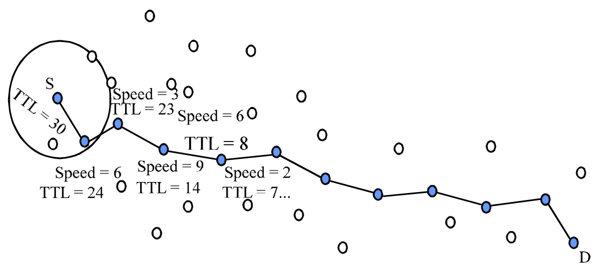

Fig. 2: Route discovery procedure of AODV-TTL

Figure 2 illustrates the route discovery procedure of AODV-TTL protocol and Table 1 shows the AODV-TTL routing protocol algorithm. The node speed is uniformly distributed between 0 and 10 m sec here. Although the initial TTL value is still 30, the TTL value is decreased by the speed at each node along the path if the speed exceeds the threshold value. Through simulation, the experiments adjust the various threshold values and find the best performance was located in half of maximal speed. In the beginning, the source node S floods the route quest packets to reach the destination D. When the first forwarding node receives the route request packet, it confirms with the speed value. The node detects its speed is 6 as result. Since the speed exceeds the threshold value. Its TTL value was deducted from 30 to 24.

Next, the second forwarding node receives the route request packet. It detects its speed is 3. Its TTL value is decreased by one based on general flooding approach here because its speed doesn't reach the threshold. Thus, the TTL value of the second forwarding node is 23.

Subsequently, the third forwarding node receives the route request packet and detects its speed is 9. Owing to the speed exceeds the threshold value, AODV-TTL algorithm deducted its TTL value from 23 to 14. So far the TTL value is decreased significantly from 30 to 14 at the third forwarding node, indicating AODV-TTL protocol can get a smaller broadcast range quickly when some faster nodes exist in the path. Afterwards deducting the TTL value until it reaches zero.

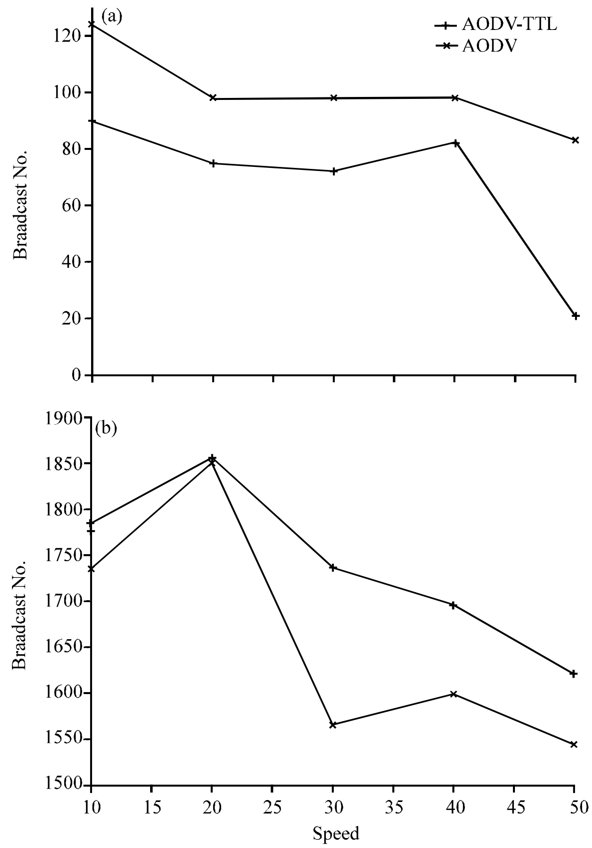

Fig. 3(a-b): Overall routing required number of broadcast packets under various speeds and (b) Throughput under various speeds

AODV-TTL routing protocol can achieve the following goals: broadcast range and overall routing required number of broadcast packets can cut down and the established path will be stable owing to a lot of faster speed nodes have been excluded automatically.

SIMULATION RESULTS

To evaluate the proposed protocol, this study implement for mobile ad hoc network in NS-2 network simulator and compare AODV-TTL protocol to original AODV. In the simulation, 100 mobile nodes are randomly positioned in an area of 1000×1000 m. There are totally 20 CBR connections between all the nodes. The packet size is set to 512 bytes and the rate is 10 packets sec^{-1}. The simulation runs for 300 sec. The node speed is uniformly distributed between 0 and 50 m sec^{-1}. The pause time is 0 sec^{-1}. The performance metrics are the number of broadcast packets and throughput.

Figure 3a shows that under various speeds, AODV-TTL achieves lower overall routing required

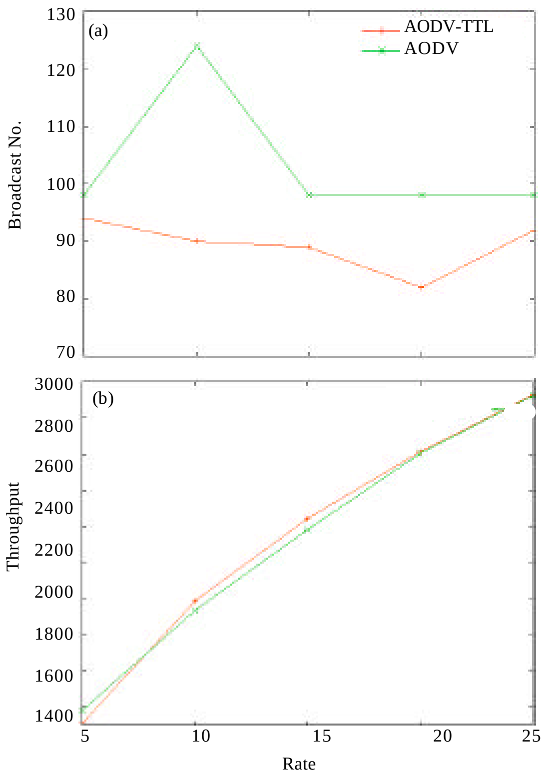

Fig. 4(a-b): Overall routing required number of broadcast packets in the different traffic loads and (b) Throughput in the different traffic loads

number of broadcast packets before establish a path than original AODV. The number of broadcast packets is reduced by 75% when the maximal node speed is 50 m sec^{-1}. AODV-TTL protocol deducts the bigger TTL value relatively when the node speed is high. The TTL value of most route request packets will decline to zero rapidly and packets will be dropped later. Accordingly, AODV-TTL protocol can find a path with lower number of broadcast packets.

Figure 3b illustrates the throughput under various speeds. AODV-TTL protocol offer better performance than AODV, especially when the nodes move fast in the network. The reason is that a lot of faster speed nodes have been automatically excluded by AODV-TTL protocol. The established path will be stable and increase throughput consequently.

In Fig. 4a and b, to evaluate the performance in the different traffic loads. Each of the sources generates 512 bytes data packet at a rate between 5 and 25 packets per second. The node speed is uniformly distributed between 0 and 10 m sec^{-1}. Figure 4a shows that AODV-TTL protocol also offers superior performance than AODV in

Table 1: AODV-TTL routing protocol algorithm

Algorithm	
1:00	AODV-TTL
2:00	For the current forwarding node
3:00	if (speed>maximal_speed/2)
4:00	TTL- = speed;
5:00	else
6:00	TTL -= 1

lower number of broadcast packets. In Fig. 4b, apart from the lower traffic load (5 packets sec^{-1}), most of higher packet rate have better efficiency in throughput. The reason is that AODV-TTL protocol can find a stable path. When the traffic load increases, the throughput can also enhance. On the contrary, the established path of AODV may easily-broken owing to dynamic topology and result in the worse throughput performance.

Compared with the protocols in the related work, AODV-TTL protocol use a simple mechanism to adjust the TTL value dynamically without complicated procedures such as create and store a new field in the routing table or redundant calculation. And it can simultaneously solve the stable routing and controlled flooding issues.

CONCLUSION

This study proposed an adaptive AODV-TTL protocol that improves the performance of AODV routing protocol by using the dynamic deducting TTL value mechanism. Different from AODV, the TTL value of AODV-TTL protocol can reach zero rapidly when the node speed is overly fast. The advantages of AODV-TTL protocol are reducing the overall routing required number of broadcast packets and can find a stable path. Simulation results showed that AODV-TTL protocol outperforms the general flooding approach in terms of number of broadcast packets and throughput especially in high-speed environments.

Practically speaking, some other factors would also affect the path stability such as energy consumption and signal strength. These factors will be further investigated. In addition, the deducting size of TTL value should be further design in order to adapt to the real MANETs environments.

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