A Mutual Authentication and Route Optimization Method between MN and CN Using AAA in Mobile IPv6*

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Abstract. In the basic routing scheme of the mobile IP, the packets sent by the correspondent node(CN) are delevered to the mobile node(MN) via MN's home network which causes the triangle routing problem. To solve this problem, the route optimization(RO) scheme for mobile IPv6 has been defined by the mobileip working group in IETF. The return routability(RR) is devised in the mobile IPv6 to provide the authentication capability between CN and MN. However, it is inherently weak in the security capability the message exchange procedure is relatively simple. In this paper, we propose a new authentication scheme based on AAA infrastructure while support RO. We represent the performance analysis results depending on the traffic pattern and the terminal movement speed. Our proposed scheme saves the cost up in compared to 20 percent to RR.

1 Introduction

This paper describes the authentication scheme for a mobile node to perform the RO with secure manner after entering to new subnet and completing the Home Registration. To eliminate the routing delay from triangle routing, the RO enabling direct routing should be performed. However, the various attacks such as DoS, DDoS and MITM can be carried out by an attacker with a little effort which may result in packets to be intercepted and rerouted to the attacker. Thus, the security function should be added to the RO. The mobileip working group has defined the RR as an authentication scheme for making RO secure. Focusing on the operation and message exchange overheads, the RR procedure is relatively simple but not able to provide strong security function. This paper proposes an integrated mechanism with AAA for authentication and the RO to CN and shows the results of performance analysis relative to the RR in terms of the cost. The traffic and mobility property where the MN moves with the mean rate of movement and receives packets with mean rate of length for a session are assumed. We have verified the effectiveness of the cost using our proposed model that shows the cost reduction up to 20 percent.

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Fig. 1. The AAA Authentication Model

2 AAA Authentication Model and Entities

Fig.1 shows the communication model to exchange the session key between MN and attendant and to register the current location of the MN to its home agent(HA) based on AAA(Diameter) infrastructure[1],[2].

The attendant is the first entity the MN encounters when it moves into a subnet and it take the policy to pass, drop and block the incoming and outgoing packets using pre-configured parameters. When the authentication from the AAA server is successful, the attendant acquires the session key from it to make the wireless link between MN and attendant secure and exchanges packets with MN. When the MN is about to carry out the RO after completing the home registration without session drop, V_AAA as a AAA(Diameter) server in visited link identifies the home subnetwork of CN by the address of CN. It then sends the authentication/binding key request message to the home AAA server of CN to verify the CN and perform the RO with CN in secure manner. H_AAA carries out the authentication using information of the MN(NAI of MN[4], Message Authenticator, Home Address of MN, Address of CN, etc) and returns the reply message to V_AAA.

3 An Authentication Architecture for Route Optimization

3.1 Proposed AAA Architecture for Authentication and Route Optimization

The six messages are defined for the authentication using AAA in care of RO. In the first step, the MN sends the authentication request message(EAPoL) to attendant to authenticate itself and get the key materials where the LC, NAI of the MN, RPI, HoA, HaA, an address of CN, aaa_key, attendant_key, SecureParam_I and CR are included in the request message. Upon receiving the message, the attendant relays the message to its AAA server after making a conversion of message syntax from EAPoL to Diameter. The two groups of AVP are defined such as Address AVP (Home-Address-Option, Home-Agent-Address-Option, CN-Address-Option) and Security AVP (Nonce-Option, AAA-Key-Option, Attendant-Key-Option, Security-Parameter-Option and Authenticator-Option). After referencing the NAI option in Diameter

Fig. 2. Authentication and biding key exchanges between nodes in different domains

message, the V_AAA finds out the home AAA server of the MN and forwards the message to it without modification. In turn, the home AAA server sends the keying materials sent from the MN to CN after finding the address of the CN by using the Address AVP. If the destination of the message is multiple CNs, the CN-Address-Option for two or more CNs are included in the message. H_AAA copies the message and sends the same message (ACR) to multiple destination after converting the Diameter message to private message format known to CN where the address of MN and SecureParam_I are included in it. Receiving the messages, the CN stores the SecureParam_I and returns the ACR where the SecureParam_R containing the security association generated from the CN is included. H_AAA receives the ACR and sends it to V_AAA after making a conversion to Diameter format where the SecureParam_R and result code are rebuilt as a AVP form, Security AVP(Security-Parameter-Option) and Action AVP(Result-Code-Option). Upon receiving the messages, the CN stores the SecureParam_I and returns the ACR where the SecureParam_R containing the security association generated from the CN is included. H_AAA receives the ACR and sends it to V_AAA after making a conversion to Diameter format where the SecureParam_R and result code are rebuilt as a AVP form, Security AVP(Security-Parameter-Option) and Action AVP(Result-Code-Option). If the MN and CN belong to different domains, the message exchanges between them is represented in Fig.2.

4 Performance Evaluation

4.1 System Model

The performance evaluation is based on the costs during the MN is completing the registration to CN for the RO after successful home registration. This paper refers to the approach described in [9] and [10]. We assume that the CN sends the packets to MN in the ratio of λ and the MN moves into another subnet in the ratio of μ . By considering the average number of packets delivered from the CN to MN for every movement, the Packet to Mobile Ratio (PMR) is defined as $p = \lambda / \mu$.

Fig. 3. A System Model for Cost Analysis

In this model, the internal and external link is connected each other and the weight is given to 1 and 2 for internal and external link, respectively. Thus $a=2$, $b=1$, $c=1$, $d=2$, $i=2$ and $h=2$ in Fig. 3.

4.2 Analysis of AAA Authentication Cost in Mobile IPv6

In the RR exchange[3], the total cost during the time where the MN moves and registers its location to CN is denoted as C_{RR} . It is the sum of the costs s such as the cost of the MN completing the home registration($C_{BUHA-RR}$), the cost of packet loss due to the delay of home registration($C_{loss-RR}$), the cost of registering the MN's location to CN for route optimization(C_{BU-RR}) and the tunneling cost of packets sent from CN to MN via HA during this time(C_{dt-RR}) as follows.

$$C_{RR} = (C_{BUHA-RR} + C_{loss-RR}) + (C_{BU-RR} + C_{dt-RR}) \quad (1)$$

The $C_{BUHA-RR}$ is $(2h+3r)$ as the home registration cost and $C_{loss-RR}$ is the cost of packets generated and sent to MN from CN during the registration delay time that are treated as the packet loss. The C_{data} the tunneling cost of single packet during the registration delay in Mobile IP is denoted as $\ell(i+h)+3r$ which means the cost of a packet traveling from CN to MN through the HA. Thus, $C_{loss-RR}$ is obtained as follow.

$$C_{loss-RR} = \lambda \times t_{BUHA-RR} \times C_{data} = \lambda(2t_h + 3t_r) \times \ell((i+h)+3r) \quad (2)$$

The cost of completing the binding registration for RO using the RR after home registration is defined as C_{BU-RR} which is denoted by the sum of costs depending on the distance and packet processing cost at each node.

$$C_{BU-RR} = 2(i+h) + 4d + 9r = 2(2d+i+h) + 9r \quad (3)$$

During the delay in the RR process, the packets destined to MN are tunneled to HA where the tunneling cost is defined as follows.

$$C_{dt-RR} = \lambda \times t_{BU-RR} \times C_{data} \quad (4)$$

The RR processing delay time is obtained as the sum of the transmission time of each link involved in packet traveling and the packet processing time at each node.

$$t_{BU-RR} = 2(2t_d + t_i + t_h) + 9t_r \quad (5)$$

Therefore, putting all together, we can obtain the total cost of the RR as follows.

$$C_{RR} = 2(2d + i + 2h) + 12r + \lambda(2(2t_d + t_i + 2t_h) + 12t_r) \times (\ell(i + h) + 3r) \quad (6)$$

For the proposed scheme, C_{AAA} the total cost of completing the RO starting from the MN's movement is represented as formula 7 in the same manner of RR where the $C_{BUHA-AAA}$ means the home registration cost, $(2h + 3r)$ of MN registering its CoA to HA and $C_{loss-AAA}$ is the cost of the packet lost during the home registration delay since the packets are lost during that time($t_{BUHA-AAA}$) before completing the home registration. .

$$C_{AAA} = (C_{BUHA-AAA} + C_{loss-AAA}) + (C_{BU-AAA} + C_{dt-AAA}) \quad (7)$$

$(2h + 3r)$ is obtained as follows where the $C_{data} = \ell(i + h) + 3r$ means the tunneling cost for a single data packet traveling from CN to MN via HA during the registration delay.

$$C_{loss-AAA} = \lambda \times t_{BUHA-AAA} \times C_{data} = \lambda((2t_h + 3t_r) \times \ell((i + h) + 3r)) \quad (8)$$

C_{BU-AAA} , the cost of authenticating MN and registering its location is denoted as follows.

$$C_{BU-AAA} = 4(b + c) + 2(a + d) + 13r \quad (9)$$

During the delay for authenticating peers and registering to CN, the packets from CN to MN traverse via HA. It implies the cost of tunneling packets as follows.

$$C_{dt-AAA} = \lambda \times t_{BU-AAA} \times C_{data} \quad (10)$$

The tunneling cost of the single packet (C_{data}) is denoted by $\ell(i + h) + 3r$ which means the cost of packet from CN to MN via HA. In our scheme, the delay time of authentication and registration is as follows.

$$t_{BU-AAA} = 4(t_b + t_c) + 2(t_c + t_d) + 13t_r \quad (11)$$

Therefore, the total cost of the proposed scheme is obtained as follows.

$$C_{AAA} = (4(b + c) + 2(a + d + h) + 16r) + \lambda(4(t_b + t_c) + 2(t_a + t_d + t_h) + 16t_r) \times (\ell(i + h) + 3r) \quad (12)$$

The cost ratio of the proposed scheme to the RR (C_{AAA}/C_{RR}) is obtained as equation 13 where the λ is replaced with $p \cdot \mu$ according to the definition of

$PMR(p = \lambda / \mu)$. This is for the comparison of the cost variation of C_{RR} and C_{AAA} in accordance with the variation of the PMR.

$$C_{AAA}/C_{RR} = \frac{4(b+c) + 2(a+d+h) + 16r + \rho \times \mu \times t_{BU-AAA} \times C_{data}}{2(2d+i+2h) + 12r + \rho \times \mu \times t_{BU-RR} \times C_{data}} \quad (13)$$

Fig. 4. The Cost ratio of C_{AAA}/C_{RR} when a mobile node moves at vehicle speed.

Fig. 5. The Cost ratio of C_{AAA}/C_{RR} when a mobile node moves at pedestrian speed.

4.3 Performance Evaluation

We assume the cost of processing a message at each node is the same ($r=1$). Also according the assumption that the cost weight of the link within the domain is 1 ($b=c=1$) and the link of entities in different domains is 2, the result of the formula 13

shows the graph in Fig. 4 and Fig. 5 depending on the variation of PMR value for the case of pedestrian speed and vehicle speed, respectively. As the MN moves faster, the traffic between MN and CN is increased and the cost ratio (C_{AAA}/C_{RR}) is significantly reduced.

In Fig. 5, at the PMR value of 43, the relative cost becomes down to 0.84 and 0.8 when the average packet length is 100 bytes and 1024 bytes, respectively.

5 Conclusions

This paper proposes a scheme to authentication the system model to analyze the cost and defines the Packet to Mobility Ratio(PMR) as average number of packets per movement. The cost the proposed scheme is compared to the RR and analyzed the variation of the cost ratio depend on PMR value. As the result of analysis, the more the PMR value is increasing, the more the cost of the proposed scheme is going down significantly in comparing with RR. The proposed scheme saves the cost about 16 and 20 percent than RR while the MN moves at the pedestrian speed where the average length of data packet is 100 and 1024 bytes, respectively. At vehicle speed, it saves the cost about 20 percent. we expect that the result of the proposed scheme is applicable to the new coming RO solution integrated with existing security infrastructure such as AAA.

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