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An efficient mobile IPv6 handover scheme

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Abstract Excellent handover performance is essential for deploying real time applications over wireless Internets. In this paper, this study present a novel handover scheme for Mobile IPv6. The proposed scheme is based on an infrastructure, which is called Cross-layer Address Resolution (CAR). A smart message interaction for the Binding Update procedure is also introduced. The prototype is illustrated first and a buffering approach adopted to achieve zero packet loss.

The proposed scheme, which is called Seamless Handover for Mobile IPv6 (S-MIPv6), evolved from Fast Handover for Mobile IPv6 (F-MIPv6). The problems in F-MIPv6, such as triangle route and sequence disorder, are solved by the proposed scheme. The S-MIPv6 avoids building tunnels and reduces registration delay. It is capable of cooperating with a Mobility Anchor Point (MAP) to take advantage from hierarchical networks. The S-MIPv6 is modeled and simulated. In a practical case, the disruption duration is close to the Data Link layer handover latency (50–100 ms). We believe that the proposed S-MIPv6 is capable of providing seamless handover for time critical services.

Keywords IPv6 · Handover · Macro-mobility

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1 Introduction

Wireless technology has been used extensively for Internet access and other IP-based communications. In wireless networks, handover is one of the most important issues for maintaining communication quality and convenience. In 1996, The Internet Engineering Task Force (IETF) designed Mobile IP to overcome the problems caused by handover [1]. Mobile IP is widely accepted as the most appropriate protocol for addressing IP mobility management in future wireless mobile networks.

In recent years, many researchers have endeavored to introduce new capabilities for next generation wireless networks. The IETF developed MIPv6 to resolve the limitations of MIPv4 and enhance mobile ability [2].

The IEEE 802.11b standard is the most popular wireless broadband technology. It is a simple and easy way for users to access the Internet through wireless LANs. Mobile capability is becoming more important in modern life. Many enterprises compete to provide state of the art applications. Lots of these applications are time-critical, for instance, the handover disruption of a phone service should be lower than hundred milliseconds, otherwise the customers appear uncomfortable. The network environment has become more complex than before. Under certain conditions present mechanisms may perform poorly. A number of applications have been proposed to improve performance during handover.

This paper presents a seamless handover scheme for wireless networks. A design, called Cross-layer Address Resolution (CAR), is proposed. CAR contains the information mapping between the Data Link Layer and Network Layer. A Trailblazer method is designed to maintain this information.

The rest of this article is structured as follows. In Sect. 2, we report on the relevant contributions in network layer handover. In Sect. 3 the CAR infrastructure is described. The infrastructure deployment is elaborated. This study model the system in Sect. 4 and evaluate the advantages and overhead within the mechanism. Section 5 presents a conclusion and future study.

2 Background and motivation

Next-generation networks are envisioned with an IP-based core network infrastructure. One of the research challenges is to develop mobility techniques that take the advantages of IP-based technology to achieve global roaming [3]. A number of contributions have been proposed to improve performance during handover.

2.1 Mobile IPv6

Mobile IPv6 comprises the IETF solutions to handle mobility of hosts in IPv6 networks. Its fundamental principle is that a Mobile Node (MN) should use two IP addresses: a permanent address, the home address assigned to the host and acting as its global identifier, and a temporary address, the Care-of Address (CoA), providing the host's actual location while it is away from its home network. The association between a MN's home address and CoA is known as a binding. While away from home, an MN registers its CoA with its Home Agent (HA) and Correspondent Nodes (CNs).

Access Routers (ARs) periodically broadcast the Router Advertisement (RA), which identifies the prefixes of associated subnets. MN could detect an L3 handover that occurred while it has moved from it's old AR (oAR) to new AR (nAR) by analyzing the RA. The MN then performs a new CoA and sends the Binding Update (BU) messages to HA and CNs in order to register a new binding.

With wireless LANs as the access method a MN could not communicate with multiple Access Points (APs) simultaneously. In the present mechanism a MN must disconnect from the old AP first and then establish a connection to the new AP whenever a handover occurs. The disruption will appear from the Data Link layer (L2) handover, and Network layer (L3) handover subsequently following it. The MN will not have any service until the CNs receive the BU message and then divert traffic to the nAR.

Packet loss relies on the upper layer protocols such as TCP to retransmit missing sequences. TCP-based connections will suffer from throughput reduction because the lost packets may be mistakenly treated as congestion. This will result in a slow TCP start mechanism and cause a disruption in communication. In some real-time applications not based on TCP connections, the packet loss also causes communication latency as well. Many solutions have been proposed to reduce the service disruption duration.

2.2 Fast handover for mobile IPv6

Fast Handover for Mobile IPv6 (F-MIPv6) [4] comes to address the following problem: how to allow an MN to send packets as soon as it detects a new subnet link, and how to deliver packets to an MN as soon as its attachment is detected by the new AR [5].

F-MIPv6 enables an MN to quickly detect that it has moved to a new subnet by providing the new AP and associated subnet prefix information, which is presented as [AP-ID, AR-Info] tuple. When attachment to an AP with AP-ID takes place, the MN knows the corresponding new router's co-ordinates including its prefix, IP address and MAC address. Through the address resolution, the MN also formulates a prospective new CoA, when still present on oAR's link. We consider the address resolution the key to handover performance and introduce this infrastructure into our process. In the RFC, there is no explicit description of how to maintain such information. This study will give a solution for it in the rest of this paper.

In order to reduce the Binding Update latency, F-MIPv6 specifies a tunnel establishment typically between the old CoA (oCoA) and the new CoA (nCoA). It results oAR tunneling packets destined for old CoA to new CoA. Such a tunnel would remain active until the MN completes the Binding Update procedure with its correspondents. There are two modes of operation in F-MIPv6, and they are *Predictive* and *Reactive* respectively, where both [4] and [5] provide a clear description.

In [6], the authors proposed an enhanced buffer management scheme for Predictive mode of F-MIPv6. It is able to improve the buffer utilization on routers, but F-MIPv6 still needs to face the problem of how to practically implement the architecture.

HAWAII [7] indicated that the forwarding-based scheme performed lower performance than non-forwarding based scheme in handover, and F-MIPv6 may also suffer from the triangle routing and packet sequence disordering.

The proposed scheme, which is called Seamless Handover for Mobile IPv6 (S-MIPv6), evolved from the F-MIPv6. There are similar procedures somewhere and several critical difference between them.

Basically, F-MIPv6 forms a local relay while handover occurrence. It performs some good characteristics but disadvantages in the same time. F-MIPv6 caused the problem of triangle routing which is indicated in our paper later. Besides, it is necessary to be fully F-MIPv6 supported on every access router which involved in the local handover.

On the contrary, this paper proposed an approach; it is more likely to be an end-to-end handover procedure. Both previous access router and new access router don't perform special function during handover procedure.

2.3 Hierarchical handover for mobile IPv6

HAWAII and Hierarchical Handover for Mobile IPv6 (H-MIPv6) [8] provide micro-mobility schemes for reducing the frequent registration to HA and CNs. H-MIPv6 has been widely discussed and the Mobility Anchor Point (MAP) is considered an efficient design for handover.

It is convenient to roam within MAP domain, but it is another story to move between different domains. Even we omit the suffering from the scalable problem; MN still felt miserable to the cross-domain handover.

There are numerous researches on improving the inter-domain handover in H-MIPv6. F-MIPv6 seems to be the key to facilitate high handover performance, and the hierarchy is a popular architecture for networks. To cooperate with F-MIPv6 is an intuitive approach to overcoming the weakness of H-MIPv6 [9]. It may be a solution to build tunnel between MAPs while MN roams between domains. Reference [10] presents a handoff architecture that builds on top of the hierarchical approach and the fast-handoff mechanism based on pure software-based movement tracking techniques. There are other proposed combinations of F-MIPv6 and H-MIPv6 [11, 12], but they are still far from offering a seamless handover environment.

2.4 Other approach

Smooth Handover provides a buffering scheme temporarily stores packets in oAR and then sent to a departing node. It is worthy of allocating buffers for catching packets may be lost in handover [13]. This scheme may cooperate with F-MIPv6.

Reference [14] is another scheme based on the buffering approach. A sender sends packets to the receiver's mailbox, which will in turn forward them to the destination. The mailbox may move around during handover according to specific principles, and then original mailbox will forward packets to new resident mailbox. During handover, a mobile node can decide whether to move its mailbox and report the handover to the Home Agent, or simply to report the handover to the mailbox. In this way, the scheme is adaptive and can be made to reduce the workload on Home Agent and minimize the total cost of message delivery and mobility management. It cooperates with hierarchical networks and reduces the overhead caused by changing associated MAP.

The Data Link layer trigger is the representative for cross-layer cooperation handover [15]. This scheme reduces the *Rendezvous* delay, which is the gap between the L2 handover and L3 handover. Data Link Layer perception is the beginning of a handover, and it has an advantage if L2 and L3 could work together. However, the L3 handover latency still dominates the duration of service disruption even L2 could notify L3 that there will be a handover happened. In order to lower handover latency, it is unavoidable to improve the registration procedure in the handover.

The hierarchical architecture is the advantage for handover and the multicast routing is an efficient scheme, which is evidenced by HAWAII. A multicast-based scheme [16] is proposed to be applied in local access domain and the Xcast routing scheme [17] made it suitable for the IEEE 802.11b. One of the most significant disadvantages in a multicast based scheme is that duplicated packets may disturb neighboring subnets. If possible, it would like to only send traffic to the necessary area. To indicate the handover target accurately, this study introduced the infrastructure, called Cross-layer Address Resolution (CAR), which is evolved from [18].

In this work, we take advantages from CAR to get information from the candidate subnet the same as F-MIPv6 does. This study will present a scheme to enable an MN performing a new CoA while it still connected to current subnet, and then to register to HA and CNs before it moves to a new subnet. A Binding Update method is introduced that brings high performance without packet loss during handover.

3 Seamless handover scheme for mobile IPv6

The proposed scheme, Seamless Handover for Mobile IPv6 (S-MIPv6), enables an MN performing a new CoA, and then to register to HA and CNs before the MN leaves from the original subnet. There are two modes in this scheme, a soft mode and hard mode, respectively. The soft mode routine presents fairly good performance for most applications. If any application needs extremely performance on minor (even zero) packet loss, it appeal to the hard mode routine.

An infrastructure, which contains the neighboring information of mapping between AP and AR, is required. In the following we introduce the Cross-layer Address Resolution (CAR) first and then describe how the proposed scheme works with CAR.

In the original Mobile IP, handover mechanism works with Home Agent (HA) closely, but we won't discuss the Home Agent effects in this paper. The major reason is that the HA won't involve in early stage of the proposed handover sequence. In our proposed scheme, CNs move to new subnet first and then notified HA. The operation of binding update is no different to other service hence they could be handle in the same time. It is no necessary to process HA updating before other handover procedure. For above reasons, we won't consider the HA effect in our proposed scheme, and we won't mention HA in following discussions.

3.1 Cross-layer address resolution

One of the major problems for present handover mechanism is that the MN cannot anticipate its next associated subnet.