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A unified MIPv6 and PMIPv6 route optimization scheme for heterogeneous mobility management domains

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ABSTRACT

Nowadays more and more wireless users are on move while accessing the Internet, and providing mobility support in IP networks has been a long-standing challenge. Client-based Mobile IPv6 (MIPv6) is the most widely known mobility management scheme, and fast emerging Proxy-based Mobile IPv6 (PMIPv6) scheme offers an alternative. However, some inherent problems such as route optimization in these schemes have not been totally solved. Although various proposals tried to tackle the route optimization problem, none of them has achieved a satisfactory success. Furthermore, most of them are not a comprehensive solution for coexisting MIPv6/PMIPv6 mobility environments. In this paper, we propose a unified approach to Route Optimization (RO) scheme based on a simplified MIPv6 Return Routability Procedure (RRP) protocol, called Traffic Driven Pseudo Binding Update (TDPBU), which can significantly improve the overall performance of mobility management schemes. Our proposed scheme can ensure immediate route optimization, regardless the heterogeneous MIPv6/PMIPv6 environment in which the MNs reside. Simulation results show that TDPBU can improve the performance in terms of the end-to-end latency, signaling cost, throughput, route optimization latency, route optimization blocking rate, and power consumption compared to original MIPv6 with RRP mechanism. Besides, the deployment cost and software complexity of both network entities and clients, are expected reduction.

1. Introduction

With quick advance in wireless technologies, more and more wireless user clients even servers are becoming mobile, hence provisioning of efficient mobility management in the IP-based wireless networks becomes increasingly important. Mobility management in heterogeneous IP-based wireless access networks is an important functionality for future Internet services since the mobile clients may be moving between multiple types of access networks, which involve several Layer-2 access technologies such as WiFi, WiMAX and UMTS Networks, and multiple Layer-3 mobile management technologies such as Mobile IPv6 (MIPv6) and Proxy Mobile IPv6 (PMIPv6).

In the currently most widely used version of the IP Mobility Protocol—Mobile IPv6 [1,2], enables a Mobile Node (MN) to arbitrarily change its point of attachment to the Internet. Since MIPv6 must be implemented in MNs to serve mobility management by themselves, it is also called Client based MIP (CMIP). On the other hand, the fast emerging Proxy based Mobile IPv6 (PMIPv6) [3–5] protocol provides an alternative for mobility management based on the assistance of local access network.

However, some inherent problems of these protocols have not been totally solved. For example, both of them incur large handoff latency during the period of network attachment, it results in difficulty to support real-time

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multimedia applications [6]; moreover, the most common problem is the Route Optimization (RO) [7] between a MN and its Correspondent Nodes (CNs). RO regards how to route those packets between a MN and a CN efficiently and reliably. Due to the high mobility in future Internet, it may incur two predicaments: (1) mass of CNs is also mobile (so-called Mobile Correspondent Nodes (MCNs)); (2) the communication path between two MNs changes rapidly. These two predicaments bring up problems which are the vastly increased encapsulation overhead and end-to-end latency caused by double tunnel encapsulations and double sub-optimal paths, respectively [7,8]. Thus, route optimization would be compulsory. Subsequently, various solutions have been proposed to accommodate these classic problems, but it still lacks an efficient solution for dealing with the route optimization procedure [2,6].

MIPv6 and PMIPv6 will very likely coexist in the future Internet. In such heterogeneous environments, the bottleneck is often between mobile users. Being able to provide effective route optimization solution between each communication pair is crucial in this environment. Unfortunately, in the standardization process of the route optimization specification, it lacks consideration that CNs are not always stationary, and they may be MNs as well. Further, such specification usually assumes that both communication parties are all CMIP-enabled MNs; the situation of PMIP is analogous to CMIP: assuming that both MNs are under proxy domain. This is not always true in real mobility environments because a MN located at CMIP domain may need to communicate with another MN on PMIP domain and seek an optimized path.

Suppose that N is the number of all active nodes on the Internet, ω is the proportion of MNs, and ρ denotes the proportion of all MNs located in the PMIP domain, so we have $\rho \times \omega$ denoting the proportion of PMIP clients, and $(1-\rho)\omega$ denoting proportion of CMIP clients. Assume that connections between any two nodes are randomized, then at most $2(\rho-\rho^2)\omega^2$ proportion of connections will experience cross domain mobile management. Since growing population of mobile users will result in the increase of ρ and ω in future Internet, assuming that MN and CN were in the same mobile management domain is irrational. Moreover, requesting the network entities to support multiple protocol suites is also unreasonable. Unfortunately, the route optimization management in CMIP and PMIP are often implemented independently, and a unified RO management is required in the future.

Route optimization problem in future IP mobile networks is quite different from today's mobility environments described above. In this paper, a novel route optimization solution for coexisting PMIP/CMIP mobile management domain based on *Traffic Driven Pseudo Binding Update* (*TDPBU*) scheme, and a subsidiary *Optional Post Authentication* (*OPA*) scheme are proposed. According to the performance evaluation results, we demonstrate that our proposed scheme can accomplish the low latency route optimization as expected.

The rest of the paper is organized as follows: In Section 2, we describe the route optimization problem between communication peers within different domains of mobile management and related works. In Section 3, the proposed scheme is elaborated. Application scenarios are demonstrated in detail in Section 4. Performance evaluation including simulation, numerical results and comparison are discussed in Section 5. Finally, Section 6 concludes the work. The Appendix lists the acronyms used in this paper.

2. Related works and problem description

IP mobility concerns the reachability of a MN and persistence of current sessions, as well as connections that conform to the basic requirements for supporting mobility on the Internet. Beyond these basic requirements, IP mobility must be able to support performance requirement in terms of fast handoff and route optimization as well as smoothness of data transport during handover period. In addition, the security issue between roaming MNs and home networks must also be concerned.

2.1. From client-based IP mobility towards proxy-based IP mobility

One of the design principles of the Internet service is intelligent endpoints and simple core network which provides minimum functionality. Client-based MIP (CMIP) is designed based on this principle. Although CMIP ensures seamless mobility for the mobile user session, it introduces some deficiencies, including wasting air-link bandwidth and increasing MN complexity due to signaling overhead and implementing mobile IP protocol suite in client, respectively.

To alleviate the above problems, the IETF network-based local mobility management (NetLMM) [4] working group has initiated tasks in defining a series of Proxy-based MIP (PMIP) [3] protocols, in which local mobility is handled by network side without involvement of the MN. The idea is that a MN moving across multiple *Mobile Access Gateways* (*MAGs*) has not to change its original IP address acquired from its home network; Further, the PMIP provides mobility support to MNs topologically anchored at a *Local Mobility Anchor* (*LMA*) of the access network, which forwards all data for registered MNs, and the MN does not need to participate in any mobility related signaling. In other words, the PMIP enables a mobility environment for all IP-based wireless terminals which lack built-in mobility capability, thereby hiding the mobility of both the IP layer and higher layers.

An additional goal of NetLMM is to simplify the deployment, integrate with and enhance existing solutions if suitable, to the mutual benefit of service operators and end users. The key benefits of PMIP are: decreasing complexity of MNs, enhancing capability for mobility, speeding up the handoff procedure, reducing the air-link consumption, and so on. Such concept brings up *Proxy Mobile IPv4* (*PMIPv4*) [9] and *Proxy Mobile IPv6* (*PMIPv6*) [2] in addition to the legacy client (host) mode *Mobile IPv4* (*MIPv4*) and MIPv6 [2], and the MIP is generally called CMIP in PMIP's perspective.

Today, MIPv6 and PMIPv6 are both candidates for the mobility management in 3GPP System Architecture