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D-PMIPv6: A distributed mobility management scheme supported by data and control plane separation

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ABSTRACT

Over the past few years, modern mobile subscriber devices such as Smartphones, tablets and PDAs have become more and more popular which use network resources in a more aggressive way and last for longer durations involving dramatically increasing traffic volumes. But traditional mobility management schemes have hardly taken this issue into account. Distributed mobility management is considered as a new trend for developing a mobility management scheme to address such an issue. This paper proposes D-PMIPv6, which is to achieve a distributed mobility management scheme supported by data and control plane separation based on PMIPv6. In the architecture of D-PMIPv6, the traditional functional entity Local mobility anchor (LMA) is split into two parts: Control plane LMA and Data plane LMA. We conclude with the three goals of distributed mobility management. With its elaborate design, D-PMIPv6 is proved to achieve these goals. Numerical results show that a single Control plane LMA can hold quite a number of MNs and the handover performance of D-PMIPv6 is acceptable compared to PMIPv6. Meanwhile, D-PMIPv6 can improve the performance in terms of the packet delivery cost compared to other mobility management schemes.

1. Introduction

In recent years, mobile subscriber devices and wireless access technologies have been greatly developed, leading to more people accessing the Internet via wireless connectivity and desiring ubiquitous mobile services [1]. According to a survey [2], it shows that the global mobile data traffic grew 2.3-fold in 2011, more than doubling for the fourth year in a row, and over the next few years it is estimated to remain at such high growth. It is believed that the traditional mobility management schemes cannot meet the requirements of people using network resources in the same manner as now.

For a traditional mobile management scheme such as Mobile IPv6 (MIPv6) and Proxy Mobile IPv6 (PMIPv6), it is typical that a logical single mobility anchor is in charge of managing mobility [3,4]. That is, routing functionality as data traffic and signaling messages both have to be forwarded to this mobility anchor, thus reducing system scalability and overall reliability. Recently, Distributed mobility management (DMM) is proposed to be a new trend of developing a mobility management scheme which is aimed at solving the above problem. And now it is the main effort of the IETF Distributed Mobility Management (DMM) working group [5].

The scenarios and approaches to achieve distributed mobility management are described in [6–9]. To the best of our knowledge, we summarize that there are, in the main, three goals of distributed mobility management. One is to release the burden of the mobility anchor. Splitting the control plane and data plane of the mobility anchor to avoid a single entity taking charge of both forwarding data plane packets and processing signaling messages is a solution, because the traditional mobility management schemes all have a single mobility anchor such as Home Agent (HA) or Local Mobility Anchor (LMA).

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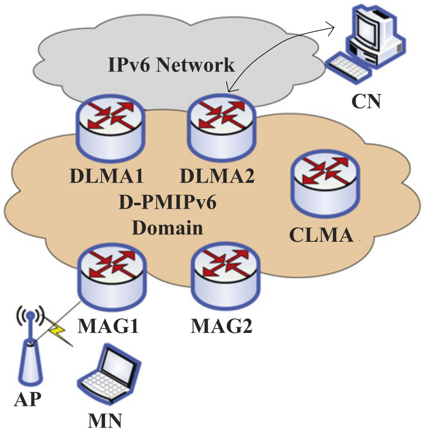

Fig. 1. The architecture of D-PMIPv6.

However, some schemes go even further to avoid setting up a mobility anchor to which the packets from a mobile Node (MN) must be sent, and the MN's traffic will be forwarded by the access router directly [10,11]. The second goal is to distribute the data plane traffic volumes. Route Optimization of MIPv6 is an effort on this way by which MN can establish a session with a Corresponding Node (CN) directly, but the drawback is that it involves all CNs to support such a mechanism. Localized Routing is to distribute traffic volume within the PMIPv6 domain [12]. But it is optional in existing mobility management schemes, and does not need to be considered at the very beginning of designing mobility schemes. The third goal is allocating mobility anchors that are topologically close to the MN, since in the real topology, the MN may be far from the mobility anchor. Extending MIPv6 protocols such as HMIPv6 and Global HAHA provide solutions on this way [13,14].

Till now there are three distributed mobility management schemes based on PMIPv6 as we know. Two of them put the emphasis on distributing the data plane traffic volumes and adopt the same idea [15,16]. For example, distributed mobility control in proxy mobile IPv6 networks (DMC) defined binding query and response messages, by which MNs can communicate with each other directly within the same domain. But considering the scenario MN communicates with CN which is outside the domain, there is still a single LMA to do both packet forwarding and signaling processing. Another scheme called Net-based DMM is described in [10]. In the context of Net-based DMM, the concept of domain does not exist anymore as well as encapsulation, and a functional entity called a Central Mobility Database acts as a control plane anchor processing all the signaling messages. Packets from MN would be routed to CN directly through an access router without encapsulation. This paper is to propose a network-based distributed mobility management scheme D-PMIPv6 supported by data and control plane separation. D-PMIPv6 follows the basic architecture of PMIPv6 [17]. By splitting the data and control plane of LMA, D-PMIPv6 can achieve the purposes of distributed mobility management efficiently.

D-PMIPv6 is proposed based on our previous work in more detail [18]. The remainder of this paper is organized as follows. Section 2 describes the basic design of D-PMIPv6 in detail including the mobility management scheme, handover procedure, localized routing mechanism and DLMA decision procedure. Section 3 evaluates the capacity, handover delay and packet delivery cost of D-PMIPv6. Section 4 concludes the paper finally.

2. Architecture

D-PMIPv6 borrows the architecture and several key terms from PMIPv6 to support mobility management. The architecture of D-PMIPv6 is to make an improvement based on PMIPv6 as shown in Fig. 1. MAG still manages the mobility related signaling messages for MN and track MN's movement just as it does in PMIPv6. The difference is that we split the data and control plane of LMA by a new defined Control plane Local Mobility Anchor (CLMA) and Data plane Local Mobility Anchor (DLMA). Actually, there are other efforts on the way to separate the logical function of LMA, and LMA is separated into three types of logical functions as described in [19]. In this paper, we described two kinds of LMA functions as follows.

- CLMA is to manage the signaling messages of binding registration. It allocates DLMA to MN as well as home network prefix (HNP), and maintains the Binding Cache Entry (BCE) for MN. Such BCE is extended with the additional DLMA address field.
- DLMA forwards the data plane packets, and it is also the topological anchor point for MN's HNP. DLMA maintains the HoA-to-PCoA mapping relationship of MNs which are anchored to it.

Such a data and control plane separation scheme looks very much like a ID/Locator separation scheme, because a control plane entity takes charge in maintaining the mapping relationship of MN. But we think there are still differences. In the context of ID/Locator separation (e.g. LISP [20]) mapping systems just maintain the mapping relationship of Endpoint Identifiers (EIDs) and Routing Locators (RLOCs), but for D-PMIPv6 CLMA also manages mobility related information such as Binding Cache Entry. We believe that one DLMA can take charge in forwarding the traffic originated from quite a number