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An analytical study of distributed mobility management schemes with a flow duration based model

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ABSTRACT

It is believed that traditional centralized mobility management cannot satisfy the demands of mobile data traffic which has dramatically expanded for years and will remain at a high growth rate in the long term. And now many efforts are putting emphasis on developing distributed mobility management schemes. This paper discusses the advantages of multiple Home Address (HoA) allocating, which is considered as an important character of distributed mobility schemes, by a flow duration based model for the first time as we know. We think that most Internet flows are very short and the best way of forwarding them is using local HoA instead of tunneling to a home link as described in the context of centralized mobility management schemes. We summarize the two cases of distributed mobility management schemes, called the multiple-level tunnel and the direct tunnel and propose a new flow duration based model to evaluate their performance. For the purpose of analysis, we study the cumulative distribution function of Internet flow duration based on our campus real data. Numerical results show that the relatively low velocity and short online time scenario is more suitable for distributed mobility management, and the direct tunnel scheme can always get better performance than the multiple-level tunnel case and the centralized mobility management scheme.

1. Introduction

In the context of traditional mobility management schemes such as Mobile IPv6 (MIPv6) and Proxy Mobile IPv6 (PMIPv6), Mobile node (MN) always uses the same Home Address (HoA) or the address generated by Home Network Prefix (HNP) for communication (Perkins et al., 2011; Bernardos et al., 2010). It is noted that in this paper we do not distinguish these two definitions. All of the Corresponding Nodes (CNs) are not aware of the movement of Mobile Node (MN) which is considered to remain reachable just as it is on the home link all the time. To achieve this purpose, data plane traffic from MN would be forwarded to the mobility anchor such as Home Agent (HA) and Local Mobility Anchor (LMA) over the tunnel to the home link if a route optimization mechanism is not introduced (Liebsch et al., 2011). We consider these traditional schemes as centralized mobility management schemes because the unique mobility anchor not only takes charge in forwarding all data plane traffic but also has to process mobility related signaling messages.

In recent years, with the rapid development of mobile Internet related technology, wireless handheld devices such as Smartphone and Tablet, which has more powerful processing capability and longer battery life than ever before, becomes more and more popular. People can access the Internet by higher wireless bandwidth and obtain the ubiquitous mobile service. According to a survey the global mobile data, which had reached 885 peta bytes per month by the end of 2012, is predicted to remain at a high growth speed, nearly doubling for the next few years in a row (Cisco Visual Networking Index, 2017). With the consideration of the system scalability, overall reliability and especially the dramatically increased traffic volume in recent years, the above centralized mobility management scheme can hardly be considered as efficient.

A new trend of developing mobility support is to design distributed mobility management (DMM) schemes, which is aimed at solving the above issues. DMM is to distribute the traffic in an optimal way and not to rely on any centralized mobility anchor (DMM, 2012). The requirements and the approaches to achieve DMM are described in Chan et al. (2013), Liu et al. (2013) and Chan et al. (2011). And our earlier work studied the three main goals of DMM (Yi et al., 2013), in which a PMIPv6 based DMM scheme supported by data and control plane separation is proposed.

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In the context of DMM, as MN always locates on the nearest mobility anchor, apparently the best way to communicate with CNs for MN is using a local HoA or HNP. However, when handover occurs, the traffic with a previous prefix should still be tunneled to a newly accessed mobility anchor as shown in Fig. 1. Thus it is easy to figure out that long flows would survive through several handovers. Here we propose the following interesting questions: How long is the Internet flow duration? How to evaluate the influence of flow duration on the performance of mobility management scheme? This paper will answer these questions hereafter.

This paper is based on our earlier work (Yi et al., 2012), which only considers the multiple-level tunnel case of distributed mobility management as we defined in this paper. However, in this paper we conclude two cases of distributed mobility management which are illustrated in Section 2 for comprehensive analytical study, and a more detailed performance analysis is given in Section 5. The remainder of this paper is organized as follows. Section 2 summarizes the main goals and several current efforts on distributed mobility management. Section 3 describes the flow duration based model and analyzes the distributed mobility management scheme's performance with such model. Section 4 reviews the previous research work of Internet flow duration and summarizes its probability density distribution characters based on our campus real data analysis. Numerical results are illustrated in Section 5. And finally Section 6 concludes the paper.

2. Distributed mobility management scheme

One of the most important requirements of DMM is reusing the existing standardized protocol. PMIPv6 based DMM schemes are introduced in Jung et al. (2011), Liu et al. (2012), Bernardos et al. (2011a), and Giust et al. (2011) propose a DMM scheme based on MIPv6 and Cryptographic Generated Addresses. Also other efforts put emphasis on a hybrid DMM scheme of MIPv6 and PMIPv6 (Bernardos et al., 2011b). The basic idea of such DMM schemes is similar. Mobility anchors are deployed in the Access Routers (ARs) which are distributed in a domain to track the movement of MN and process mobility related signaling messages. we conclude that an important benefit of DMM is that the traffic volume of MN can be forwarded localized. After handover has occurred, MN would be allocated a new HoA by which the subsequently generated traffic volume can be forwarded to CN through the nearby mobility anchor instead of tunneling to the home link as described in traditional mobility management schemes such as MIPv6 and PMIPv6 (Perkins et al., 2011; Gundavelli et al., 2008). Most of the efforts of working on DMM put emphasis on designing the mobility management procedure for one time handover. If the online time of MN is long enough, flows may survive through several handovers. Thus in this situation, we summarize that there are two cases for the mobility anchor to process the traffic volume with the previous prefix as shown in Fig. 1. They are the multiple-level tunnel scheme and the direct tunnel scheme respectively as we called.

Case one is defined as a multiple-level tunnel scheme which is shown in Fig. 1. At first after MN attaches to AR_1, it would obtain a HoA from HNP_1 by which MN establishes communication with CN_1. When handover occurs, MN attaches to AR_2 and a new HNP_2 would be allocated to MN. HNP_2 is used by MN to establish communication with new CN which is referred to as CN_2 at this time. Furthermore, AR_2 would signal AR_1 to set up a directional tunnel. Those flows with HNP_1 from MN are forwarded to AR_1 in the tunnel. As handover continues, it is possible for the MN to maintain multiple HNPs. When MN accesses AR_3 to obtain HNP_3, AR_3 would signal AR_2 to set up the multiple-level tunnel. And the

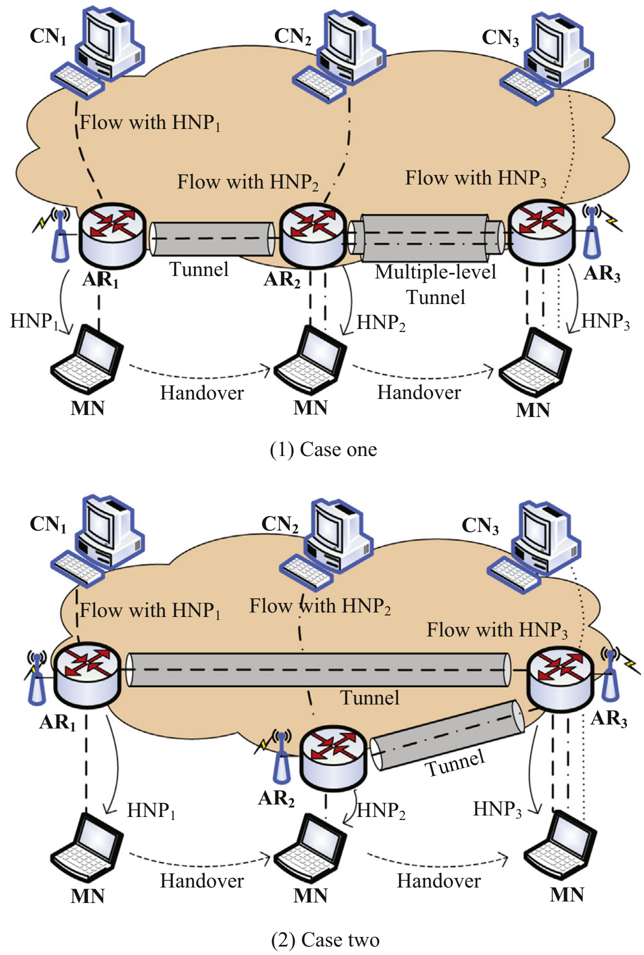

Fig. 1. Distributed mobility management architecture.

tunnel between AR_1 and AR_2 does not need to be removed. At this time, flows with HNP_1 from MN will be first sent to AR_2, and then they will be tunneled to AR_3 by the multiple-level tunnel. Thus in case one, the new attached AR will always set up the tunnel between itself and the previous AR.

Another case is defined as the direct tunnel scheme which is shown in Fig. 1. It is different from case one when MN maintains more than two HNPs. When MN attaches to AR_3 to obtain HNP_3, AR_3 would directly signal AR_1 and AR_2 to set up the directional tunnel. The tunnel between AR_1 and AR_2 should be removed at this time. The flows with HNP_1 or HNP_2 from MN will be tunneled to the AR_1 and AR_2 respectively. Thus in case two, the new attached AR should set up tunnels with all ARs whose HNPs are still used by flows.

For two cases, apparently case one can hardly be efficient from the aspect of flows delivery cost because of the multiple-level tunnel setup. But in case one, the mobility related signaling messages are only needed to be exchanged between the newly accessed AR and the previous AR. However in case two the newly accessed AR should exchange signaling messages with all former ARs. Considering the signaling cost, case one is more efficient than case two.

Apparently the efficiency of such DMM schemes partly depends on how long the flows last compared to the resident time of each AR, because long flows usually cause setting up of multiple-level tunnels or several tunnels as shown in Fig. 1. If the proportion of such long flows is too large, DMM schemes can hardly be considered as efficient. Our supposition is that the real Internet flows are usually very short, and the efficient way for traffic