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Experimentation and performance analysis of multi-interfaced mobile router scheme

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ABSTRACT

Network mobility (NEMO) aims providing seamless Internet connectivity of the whole mobile network that consists of mobile routers (MRs) and mobile network nodes (MNNs). The network moves around along with vehicles as a whole. According to NEMO basic support protocol (NEMO BSP), only one primary care of address (CoA) of MR can be registered with home agent, which will affect the handover performance. As an extension of NEMO BSP, multiple care of addresses (MCoA) registration scheme was proposed as Internet-draft and has received extensive researches.

This paper studies the Internet connectivity of mobile router (MR) on the basis stated above; MR is equipped with WLAN, CDMA and GPRS interfaces simultaneously. Concretely, a smooth handover algorithm is proposed and experimented on our platform successfully; round trip time (RTT) of each link and the handover process between different interfaces are analyzed, respectively. Furthermore, the service disruption time and packet loss ratio performances are also compared between uni-interfaced MR scheme of NEMO BSP and scheme proposed in this paper, and the results indicate that multi-interfaced scheme not only supports large area movement across heterogeneous networks of MR, it also provides a seamless handover with no packet loss and little service disruption time.

1. Introduction

With the increasing demand for seamless Internet connectivity of mobile hosts and mobile networks, the internet engineering task force (IETF) has specified protocols for host mobility (MIPv6 [1]) and network mobility (NEMO [2]).

NEMO BSP is concerned with managing the mobility of an entire network. The application scenario is public transportation, such as trains and buses [3]. NEMO BSP is based on MIPv6 with minimal extensions. Therefore, the handover mechanism of a mobile router (MR) is essentially the same as that of mobile node (MN) in MIPv6. In NEMO BSP, Mobile Router serves as a gateway; a permanent address called home address (HoA) is obtained on the home link as an identifier of MR. When MR moves away, it acquires a care of address (CoA) from the access router (AR) in foreign network. MR sends binding update (BU) message to its home agent (HA) located in the home network, binding the CoA with the HoA. HA replies a binding acknowledgement (BA) message. After the binding process, a bi-directional tunnel is established between MR and HA. Packets from corresponding node (CN) with the destination of MR's HoA are directly routed to HA, and HA are in charge

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of rerouting all packets to the CoA of MR through tunnel. Mobile network nodes (MNN) in the mobile network have permanent addresses taken from mobile network prefix (MNP) advertised on MR's ingress interface, and packets intended to or originated from the MNNs are encapsulated in the tunnel.

Recently, various multihoming [4] issues have been presented in the NEMO Working Group. Multihoming is necessary to provide constant access to Internet and to enhance the overall connectivity of hosts and mobile network [5]. In mobile environments, scarce bandwidth, frequent failures, and limited coverage areas of different network technologies particularly motivate multihoming. For example, wireless local area networks (WLAN) are the most widely used local wireless network system in schools, offices, airports, etc. WLAN can provide bit rate up to 11 Mbit/s based on IEEE802.11b, while its coverage area, known as hot spot, is too small, users cannot leave the hot spot until all transmissions are complete. On the other hand, CDMA and GPRS networks provide high mobility and "always on" connectivity for mobile users. However, their data rates are much lower than that of WLAN. Multihoming technology can augment the Internet connectivity and enable users to choose the preferred technology in terms of delay, bandwidth, etc. Tsukada et al. [6] and Paik et al. [7] realized the multihomed mobile network by access Internet simultaneously with multiple mobile routers, each MR is equipped with only one kind of interface, and the dynamic management scheme of multihomed mobile network was proposed. The motivations and the benefits of multihoming are described and illustrated through a number of scenarios in [8]. Wakikawa et al. [9] illustrated the research results of network mobility in WIDE project of Keio University, in their scheme only WLAN and CDMA interfaces are equipped on MR, and they cannot be used simultaneously. Furthermore, the downlink and uplink parameters of CDMA interface is tested and described. Shima et al. [10] gives the handover scheme of multi-interfaced MR in network mobility, no relative analysis are described anymore.

In this paper, we propose a multi-interfaced MR scheme and make experimentation on our platform. In this scheme, the MR is equipped with WLAN, GPRS and CDMA interfaces simultaneously. An inter-interfaces handover algorithm is proposed, and the performance during media handover is measured and analyzed.

The remainder of this paper is organized as follows: In Section 2, the multiple interface scheme of MR is described, including MCoA registration scheme, media handover decision and the interface handover operation. The experimentation overview and results are presented and analyzed in Section 3. Then, in Section 4, we give the performance analysis of service disruption time and packet loss ratio, and the comparison with uni-interfaced MR in NEMO basic support protocol is also illustrated. Finally, we provide concluding remarks.

2. Multiple interfaces scheme of mobile router

In this section, we will first introduce the MCoA registration scheme, and then the multiple interfaces scheme extended for MR is described, including the handover decision and interface handover operation.

2.1. Multiple care of addresses registration

According to MIPv6, mobile node (MN) may have several care of addresses, but only one CoA termed the primary CoA can be registered with its HA and CN. When MN is equipped with multiple interfaces and multiple CoAs are configured, there are multiple bindings to its HA. Ref. [11] was proposed as a NEMO extension to register multiple CoAs to a same home address (HoA) of MR. For doing so, a Binding Unique Identifier (BID) must be carried in each BU for the receiver. HA keeps bindings corresponding to the same HoA and distinguishes them by different BIDs as described in [11]. In order to maintain multiple bindings and make all the interfaces useful simultaneously when attaches to both foreign and home links, MN sets the 'H' flag in the BID mobility option illustrated in Fig. 2. There are also additional processes of Proxy Neighbor Discovery Protocol [11,13].

MCoA scheme aims to create multiple bi-directional tunnels between MR and HA. When the MR is equipped with WLAN, CDMA and GPRS interfaces simultaneously, the MCoA registration procedure is shown in Fig. 1.

As shown in Fig. 1, each of MR's interfaces configures a CoA and sends Binding Update (BU) message to HA. Each BU message contains a BID for each CoA, and all the CoAs are bound to MR's HoA. HA replies BA messages containing different BID sub-options, respectively. Then three bi-directional tunnels are established between MR and HA.

2.2. Inter-interfaces handover decision mechanism

Generally, when WLAN is not available, MR connects to Internet by CDMA/GPRS networks in regional area according to signal strength scanned. When WLAN network is available and the scanned signal strength is higher than the threshold S_{th}, WLAN will be used due to its bandwidth advantage.

In order to enable seamless handover between different interfaces, we extend the BID sub-option, which is shown in Fig. 2.The BID sub-option is included in BU, BA messages, etc.

In Fig. 2, "BID" has already been defined in [11] to identify different bindings. We add "D" flag and "pre_default_BID" flag on BID sub-option defined in [11]. "D" is used to indicate the occurrence of interface handover, while "pre_default_BID" is used to store the BID of the interface used before. The interface handover decision of MR is shown in Fig. 3, and the detailed working process of BID sub-option is described in the following section.

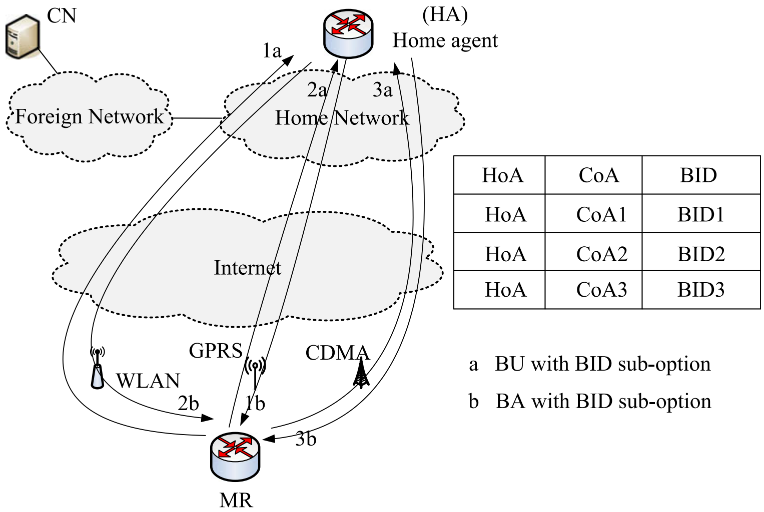

Fig. 1. Multiple care of addresses registration.

	Type = TBD	Length		
Binding Unique ID (BID)	Priority/Status	H	D	Reserved
Pre_default_BID	Reserved			
Care of address (CoA)				

Fig. 2. Modified BID sub-option.

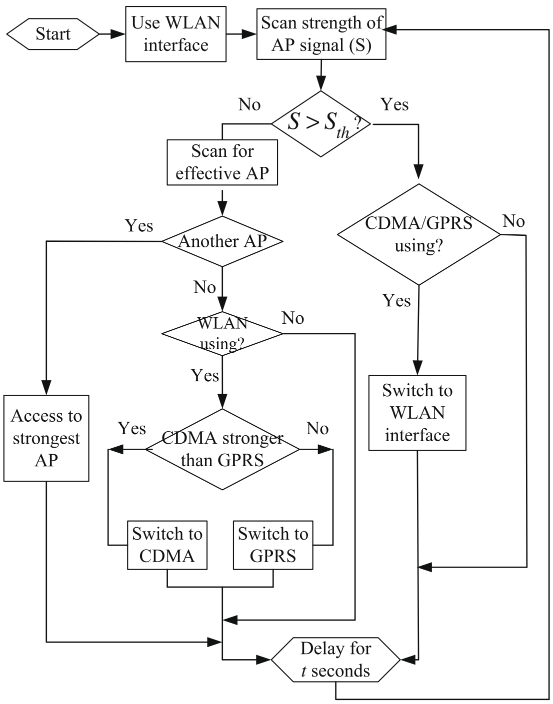

Fig. 3. Handover decision mechanisms.

As shown in Fig. 3, "Delay for *t* seconds" means that WLAN interface scans the signal strength of current access point (AP) at interval of *t* seconds. If the signal strength obtained is lower than S_{th}, it will search for other AP and access to the AP with