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Design of the multicast service for mobile users in the 802.16 network environment

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ABSTRACT

Middle-domain mobility management provides an efficient routing, low registration cost and handoff latency for layer 3 (IP layer) 802.16-based mobile network environment. In the middle-domain, the 802.16 base station (BS) acts as an agent or proxy to manage mobile networks to achieve this goal. The BS could only address external traffic but without internal case management. In order to complement this defect, an enhanced version for the middle-domain mobility management is designed in this paper. Moreover, we research and design the multicast extension for the middle-domain by applying the idea of the enhancement, which is called HMP (Hierarchical Multicast Protocol). Associated handoff scheme is also proposed in this paper. Since it is a complicated case for designing the multicast service in 802.16 network environment, we need a characteristic method to address this case. In order to fulfill this achievement of designing HMP scheme, we introduce a reduction process (RP) in this paper. By using the RP, a complicated 802.16-based network environment can be actually reduced to a simpler network environment. The mathematical analysis and simulation study are presented for performance evaluation. Simulation results have demonstrated that the enhanced middle-domain mobility management has the better network performance in terms of registration cost, handoff latency and routing cost in comparing with conventional mobility management schemes. Moreover, the proposed multicast extension for HMP scheme is simple and has scalability and network performance advantages over other approaches in mobile multicasting.

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1. Introduction

Mobility management [1–10] is an essential component in enabling mobility of hosts while maintaining the packet routing efficiency between the hosts. *Mobile IP (MIP)* [11–14] has been designed to serve the needs of the burgeoning population of mobile computer users who wish to connect to the Internet and maintain communications as they move from place to place. The proposed standard for Mobile IP (mobility management referred to as *macro-mobility*), however, has several drawbacks ranging from triangle routing and its effect on network overhead and end-to-end delays, to poor performance during handover due to communication overhead with the home agent (HA), and instead, *Cellular IP (CIP)* [15–18] (mobility management referred to as *micro-mobility*) was proposed. CIP provides local mobility and handoff support for frequently moving hosts, which means that mobile hosts can migrate inside a CIP network with little disturbance to active data flow.

Recently, a new wireless technology called 802.16 (or WiMAX) [19–28] is emerging. In our previous work [29], we have discussed that it is not suitable to fit macro- or micro-mobility technologies into 802.16-based network environment, because of frequent registration and increased handoff latency in Mobile IP, and lengthy internal data path with gateway in Cellular IP. Thus, *middle-domain mobility management* is proposed in [29] to insert in between macro-domain and micro-domain. The middle-domain mobility management for layer 3 (L3) 802.16 mobile network environment is designed to be able to accommodate different micro-mobility protocols and is transparent to macro-mobility and micro-mobility protocols. Moreover, it has significantly reduced the registration cost and handoff latency since localized registration is designed in the middle-domain. For the middle-domain, the 802.16 devices en route create the location cache for the corresponding mobile host. The registering procedure for Mobile IP in the middle-domain can be terminated at the crossover node (i.e. a shared node on the rooted path) because each 802.16 device en route intercepts the Mobile IP registration message for the location cache at crossover. Therefore, efficient mobility management can be addressed within the middle-domain.

Different from HMIPv6 [30] technology, middle-domain adopts an efficient direct routing through referring to these location ca-

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ches for packet delivery but not tunneling. The idea of improving handoff and communication performance for mobile nodes through using location cache is useful, particularly for the considered wireless mobile network environment. On the contrary, the tunneling is an inefficient routing for 802.16 network performance because of the IP-in-IP encapsulated packets and *Tunnel Convergence Problem*[31]. Though middle-domain provides low cost for home registration and less time for handoff, it does not still solve the problem of tunnel-based protocols. While acting in case of internal traffic, middle-domain mobility management does not be mentioned. To complement this defect, we consider supporting an enhancement for the middle-domain.

Moreover, demand for applications has recently risen such as (1) teleconferencing in which part of or all of the participants are mobile users in distributed networks, (2) live video, and (3) multiplayer online games, where mobile users located in different parts of the world participate via Internet. Multicasting could prove to be a more efficient way of providing necessary services for these applications. However, no efficient research into multicasting for WiMAX applications has been performed yet. Therefore, in this paper, we mainly aim to design the multicast extension by inheriting the idea of enhanced middle-domain mobility management, which is denoted by *HMP (Hierarchical Multicast Protocol)*. On the design of the HMP scheme, we find that the traditional tunnel-based multicast routing protocols such as BT[31,32], MoM [33] fitted into the 802.16 network environment are not appropriate and difficult since inefficient multicast routing problems such as *triangular routing*, *duplicate of tunnels*, *tunnel convergence problem* and *frequent DMSP* [33,34] *handoff problem* would occur. These problems would be mentioned and discussed in Section 4.1.

For simplifying the complicated case, a *Reduction Process (RP)* needs to be addressed in this paper. With the concept for RP, the HMP scheme can be easily designed based on the associated idea of the enhanced version for the middle-domain mobility management with the MoM-applied scheme to do the multicast service. Lastly, simulation study and theoretical analysis have demonstrated that proposed enhanced version for middle-domain mobility management and HMP scheme for multicasting can achieve better network performance in 802.16-based network environment.

The rest of the paper is organized as follows. First of all, we make a brief of survey of (1) conventional mobility management (2) middle-domain mobility management (3) multicast extension for Mobile IP, and (4) hierarchical mobile multicast in Section 2. An enhanced version for middle-domain mobility management is presented in Section 3. In Section 4, multicast extension associated with idea of middle-domain enhancement in the 802.16 network environment called *Hierarchical Multicast Protocol (HMP)* is proposed. Simulation environment and results for performance evaluation for mobility management (unicast version) and multicast case are mentioned in Sections 3.5 and 4.5, respectively. Theoretical analysis and characteristic for the middle-domain are researched in Section 5. Finally, Section 6 concludes this paper.

2. Related work

2.1. Conventional mobility management: MIP, FMIPv6, HMIPv6

For conventional mobility management, *Mobile IP* (MIP[11–14]), *Fast Handover for Mobile IPv6 (FMIPv6[46])*, and *Hierarchical Mobile IPv6* (HMIPv6 [30]) are all famous schemes which will be detailed as follows.

In Mobile IP, a *mobile host (MH)* uses two IP addresses: a fixed home address and a *care-of-address (CoA)* that changes at each new point of attachment (subnet). A router called *Home Agent (HA)* on an MH's home network is responsible for maintaining the mapping (binding) of the home address to the CoA. When a mobile host moves to a foreign network, it obtains a new CoA from the *Foreign Agent (FA)* and registers the CoA with its HA. In this way, whenever a mobile host is not attached to its home network, home agent gets all packets destined for mobile host and arranges to deliver to the MH's current point of attachment by tunneling the packets to the MH's CoA.

FMIPv6 provides seamless handover by minimizing handover latency, associated with anticipative movement detection to reduce handover latency and packet loss. After discovering one or more nearby access points, mobile host performs the layer 3 handover when it is connected to a *PAR (previous access router)*, and in this case, the PAR must have known information about an *NAR*

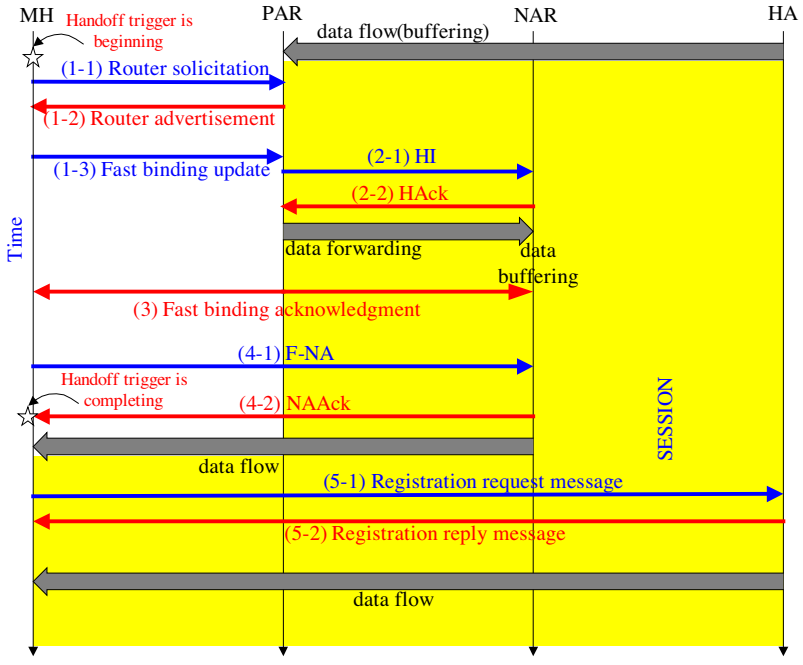

Fig. 1. Flow sequence chart for FMIPv6.