A Seamless Handoff Strategy for Heterogeneous Wireless Networks – based on Mobile IPv6

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Abstract

The third generation (3G) wireless networks are characterized by connectivity in anytime, anywhere, enhanced data services, and higher data rates to mobile users. It is an important and to be worthy of research issue that how to provide mobile users can roam among each different access technologies networks through seamless handoff mechanism. IPv6 will play an important role in future wireless access networks, in order to integrate with heterogeneous wireless networks, adopt IP backbone is the best solution. Besides, it can provide mobile users to roam seamlessly by Mobile IP technology.

The major objective of this paper is to propose an integrated architecture for UMTS network and IEEE802.11 WLAN. We also propose a Mobile IPv6 based seamless handoff strategy for this heterogeneous wireless networks to provide mobility management between UMTS and IEEE 802.11 WLAN for mobile users. Moreover, we hope to contribute our researches to beyond 3G (B3G) wireless networks.

1. Introduction

There are a lot of wireless network systems have been proposed and developed during the past few years. It is believed that multiple standards will coexist in the future. The issue that to provide mobility management between these heterogeneous wireless communication systems becomes more and more important. Different radio access networks have their own properties. In high-mobility wireless communication systems, such as Universal Mobile Telecommunication System (UMTS), provides high mobility for mobile users but with less data transmission bandwidth and speed. Opposite, it provides high data transmission bandwidth and speed but with lower mobility in low-mobility wireless communication systems such as IEEE 802.11 Wireless Local Area Network (WLAN). Therefore, it is very important to provide mobile users roaming between different radio access network systems. It is also the most important issue in the construction of Beyond 3G (B3G) wireless communication system.

A great number of mobile terminals and other wireless equipment will be connected to the Internet in the near future. The current Internet Protocol version 4 (IPv4) cannot provide a sufficient number of unique IP addresses for all elements connected to the Internet. The limited size and structure of the Internet address space of IPv4 has caused difficulties in coping with the explosive increase in the number of Internet users. IPv6 is a feasible solution for the problems identified with IPv4. By introducing Internet Protocol Version 6 (IPv6), which has a vast address space, each information device on a mobile mode can be an IPv6 host having an IPv6 address. Such hosts and sufficient numbers of IPv6 routers on a mobile node that are connected by wireless and wired links from an IPv6 network.

Mobility support for Internet devices is quite important, since mobile computing is getting more widespread. It is excepted that the number of mobile equipments will increase immense. Furthermore there are already first products of cellular phones offering IP services based on WAP or GPRS, and their number will increase

rapidly. Cellular devices of the 3G will be packet switched devices instead of circuit switched, therefore IP services on 3G cellular devices will be an integral part in the future. To support mobile devices, which dynamically change their access points to the Internet, the Internet Engineering Task Force (IETF) currently standardizes a protocol supporting mobile Internet devices, called Mobile IP [1]. There are two variations of Mobile IP, Mobile IPv4, based on IPv4, and Mobile IPv6, based on IPv6 [2].

This paper is organized as follows: in section 2, we describe the background of related technologies and the overview of Mobile IPv6. Section 3 presents our proposed integrated architecture of UMTS-IEEE 802.11 WLAN. Section 4 introduces a Mobile IPv6 based seamless handoff strategy for the heterogeneous wireless networks. Finally, we draw our future works and conclusion in section 5.

2. Background of Related Technologies

2.1. Heterogeneous Wireless Networks

There is a wide range of wireless devices used for communications purpose. Today, these can be characterized broadly as Wireless Personal Area Networks, Wireless Local Area Networks, Mobile Communication Systems, and Satellite Systems.

● Wireless Personal Area Networks
  Such as Bluetooth, HomeRF, and IEEE 802.15.
● Wireless Local Area Networks
  Such as IEEE 802.11and ETSI HIPERLAN/2.
● Mobile Communication Systems
  Such as AMPS, GSM, GPRS and UMTS.
● Satellite Systems
  Such as LEO and GEO.

Generally speaking, the systems with higher mobility have lower bandwidth and data rate. Opposite, the systems with higher bandwidth and data rate have lower mobility. Therefore, how to integrate these heterogeneous systems validly is an important issue in future wireless network. There are several proposal in this issue have be presented already, such as IST-WINE GLASS [3] and ETSI-BRIAN [4].

2.2. Mobility Management in Heterogeneous Wireless Networks

Mobility management is the most important issue in mobile data networks. From a general point of view, three kind of terminal mobility can be considered:

● Terminal mobility with respect to user communications that can be divided into discrete and continuous mobility. Discrete mobility takes place when movement of the terminal has to be managed only when the user is not in communication, whereas continuous mobility would require the maintaining of ongoing communications sessions while the user is moving with its terminal.
● Terminal mobility with respect to change in network access. This includes mobility within a single access network (i.e. same access technology as well as mobility between access networks of different type (vertical handoff).
● Terminal mobility with respect to administrative domains. Movement from one administrative domain to another (e.g. roaming between networks of two operators) will require so extra network functions (e.g. AAA) to be handle in a distributed manner among the domains.

In general, two mobility contexts according to network hierarchy can be identified namely, *macro-mobility* and *micro-mobility*. Macro-mobility takes place when moving between access points that are close to each other according to network hierarchy (e.g. between Node-Bs attached to the same RNC in UTRAN) while macro-mobility management handles mobility between distant access points according to network hierarchy (e.g. between different RNCs in UTRAN, between distant administrative domain, etc.). In this paper, we focus on the mobility management between access networks of different type, that is vertical handoff [5].

Figure 1 shows five different architectures for implementing handoff between GPRS and IEEE 802.11 networks [6][7]. The objective here is to reduce, as far as possible, major changes to existing networks and technologies especially at the lower layers such as MAC and physical layers. This will ensure that existing networks will continue to function as before without requiring current users to change to the new approach. The implementation involves incorporating new entities or protocols that operate at the network or higher layers to enable inter-tech roaming that will be transparent to the mobile user to the extent possible.

The first two architectures involve connecting the WLAN to the GPRS network through GPRS entities such as the SGSN and GGSN. In these cases, the wireless local area network will appear to be a GPRS cell or routing area respectively.

The GPRS will be a master network and the WLAN will be the slave network. This means that mobility will be handled by GPRS by considering the WLAN as one of its cells or routing areas. This may require dual mode PCMCIA cards to access two different physical layers. In addition, all traffic will first reach the GPRS SGSN or GGSN before reaching its final destination even if the final destination were to be in the WLAN/LAN itself. This will potentially cause bottlenecks in the GPRS network. Mobile IP is used in the third architecture to handle the issue of mobility management. Here, GPRS and WLAN are peer networks. Certain changes will be needed to support inter-tech roaming both on the terminal side and the network side. The virtual access point reverse the roles played by GPRS and WLAN in the first two architectures. Here, the WLAN is a master network and the GPRS is the slave network. Mobility is managed according to the IEEE 802.11 and IAPP specifications by the WLAN. The last architecture employs a mobility gateway (MG) in between the GPRS and WLAN networks. As with the mobile IP approach, GPRS and WLAN are peer networks. The MG is a proxy that is implemented on either the GPRS or the WLAN sides and will handle the mobility and routing issues.
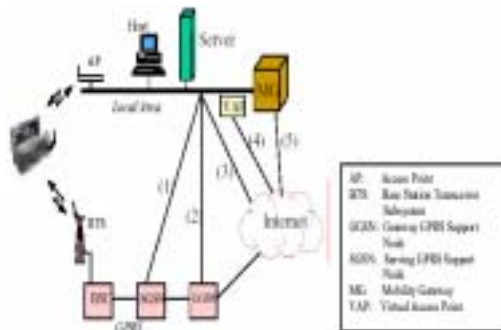

Figure 1. GPRS-WLAN Interconnection Architecture

2.3. The IETF Mobile IPv6

A Mobile IPv6 solution is currently being specified by the IETF IP Routing for Wireless/Mobile working group [2]. In Mobile IPv6, each IPv6 mobile node has at least two addresses per interface, namely the home address which is an IP address that is permanent to the mobile node, and the care-of address, which is associated with the mobile node when it visits a particular foreign subnet. Mobile IPv6 allows an IPv6 host to leave its home subnet while transparently maintaining all of its present connections and remaining reachable to the rest of the Internet. This is realized by Mobile IPv6

by identifying each node by its static home address, regardless of its current point of attachment to the Internet. While a mobile node is away from home it sends information about its current location to a home agent on its home link. The home agent intercepts packets addressed to the mobile node and tunnels them to the mobile node's present location.

Each time the mobile node moves from one subnet to another, it gets a new care-of address by stateless or stateful address autoconfiguration, such as DHCPv6.It then registers its Binding (association between a mobile node's home address and its care-of address) with a router in its home subnet, requesting this router to act as the home agent for the mobile node. This router registers this binding in its Binding Cache. At this point, the router serves as a proxy for the mobile node until the mobile node's binding entry expires. The router intercepts any packets addressed to the mobile node's home address and tunnels them to the mobile node's care-of address using IPv6 encapsulation. The mobile node sends also a Binding Update to its correspondent nodes, which can then learn and cache the new mobile node's care-of address. As a result of this mechanism, when sending a packet to any IPv6 destination, a host must first check if it has a binding for this destination. If a cache entry is found, the host sends the packets directly to the care-of address indicated in the binding, using an IPv6 Routing header. If no binding is found, the packet is sent to the mobile node's home address, which tunnels it to the care-of address as described previously. When sending a packet to a correspondent node a mobile node may use its home address as source address.

3. The Integrated Architecture for UMTS and IEEE 802.11 WLAN

In this section, we present a Mobile IP based seamless handoff strategy for heterogeneous wireless networks. We take UMTS networks and IEEE 802.11 WLAN for example, to reduce as possible as major changes to existing networks and technologies, we present an integrated architecture for them.

Figure 2 shows the integrated UMTS-WLAN architecture, different from the Mobile IP based architecture which discussed in last section, in that architecture, UMTS network and IEEE 802.11 WLAN are peer networks, that is, UMTS and WLAN are belong to different administrative domains. In this situation, if mobile nodes move away from its home network, maybe a UMTS or a WLAN environment, to an

access network with another different type, mobile nodes will need Mobile IP to handle their mobility. However, in our presented architecture, the UMTS and WLAN will be in the same administrative domain, that is, the heterogeneous wireless networks maybe have the same operator. Although UMTS and WLAN are almost belongs to different operators now, but we believe this situation will change in the future [8][9].
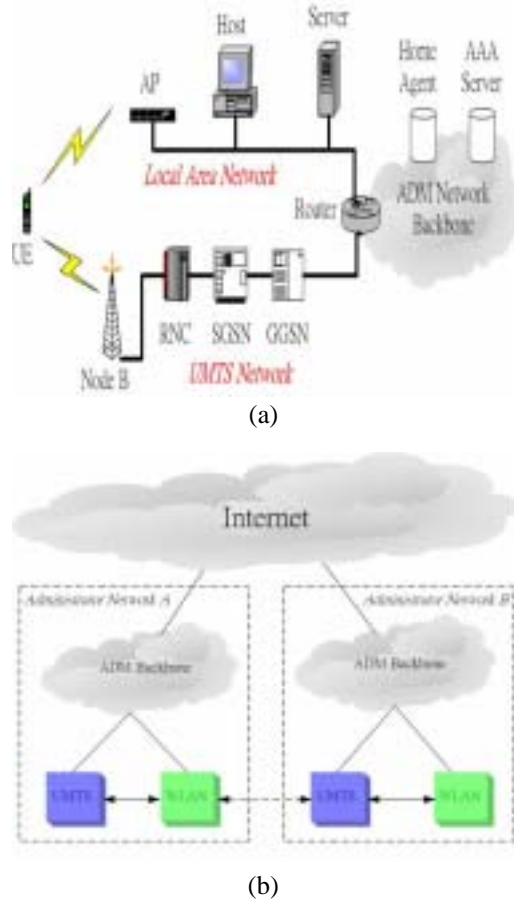

(a)

(b)

Figure 2. The Integrated UMTS-WLAN Architecture

In administrator network's point of view, UMTS network and WLAN both are its subnet, they connect to each other by routers (see figure 2(b)), in this scenario, the router play a role such as the mobility gateway that discussed in last section, it is responsible for mobility management of whole network. In the administrative backbone, the mobility of mobile nodes all handle by a common Home Agent. Besides, ADM backbone need a AAA server to handle mobile nodes' roaming.

4. The Mobile IPv6 based Seamless Handoff Strategy

According to the integrated architecture we described in last section, mobile nodes have four mobility types. They are (1) horizontal handoff in the same administrative domain, (2) horizontal handoff between different administrative domains, (3) vertical handoff in the same administrative domain, (4) vertical handoff between different administrative domains. There are many mechanisms to solve horizontal handoff issues already. In our study, we focus on vertical handoff issues, so we only discuss the last two handoff types (see figure 2(a)). In this section, we propose a Mobile IPv6 based seamless handoff strategy for this architecture.

Handoff may happen when signal strength between a mobile node and an access point become weak even lost. During the period of mobile nodes decide whether to handoff, mobile nodes need complex algorithm to decide the action by measure its quality of transmission first. In our proposal, we focus on that the procedures from once mobile nodes decide to handoff to exactly finishing handoff. Figure 3 shows the handoff procedure.

Now we assume a mobile node decide to handoff from UMTS to WLAN, then the mobile node will operate these action as blow:

1. Mobile node sends a "Vertical HO (HandOff) Request" to the AP (Access Point) in WLAN. This control message includes the mobile node's current IP address (Table 1).

Table 1. Vertical HO Request

Field 1(128 bits)
Current IP Address

2. AP decides the handoff type of the mobile node according the IP address from Vertical HO Request. If the mobile node's current IP and the AP's IP have the same network prefix, it means that the UMTS which the mobile node stay and the WLAN which the AP correspondence are belong to the same administrative domain. On the other hand, they are belongs to different operators. After this action, AP will send a Vertical HO reply to the mobile node. This control message includes the AP's IP address and handoff type of the mobile node (Table 2).

Table 2. Vertical HO Reply

Field 1(128 bits)	Field 2(1 bit)
IP address of AP(Node B)	Handoff Type

3. When MN receives the Vertical HO Reply from AP, it checks handoff type first. If handoff type is 0, it means that MN must operate vertical handoff in the same

4

administrative domain. Opposite, the MN must operate vertical handoff between different administrative domains. In the later situation, MN have to operate Mobile IPv6 procedure to get a new IP address, maybe a care-of address or it's home address.
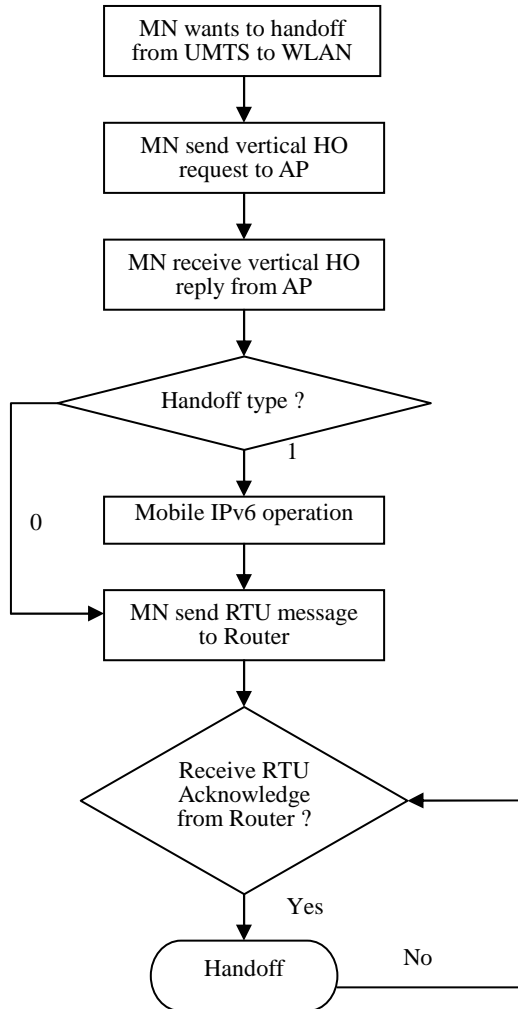

Figure 3. Vertical Handoff Procedures

4. After MN finishing Mobile IPv6 operation or receives the Vertical HO Reply, the MN will send a Routing Table Updating (RTU) to router, This control message includes the MN's current IP, AP's IP address, and network type of the mobile node will handoff to (Table 3).

Table 3. RTU Message

Field 1 (128 bits)	Field 2 (128 bits)	Field 3 (1 bit)
Current IP Address	IP Address of Last Hop	Network Type

5. Once the router receives RTU message, it will update its routing table according to the information in RTU message. It knows the packets must forward to the AP after the MN handoff to WLAN. Besides, router according to the network type to change packet to correct format. So, in this architecture, routers not only have the function of packet forwarding, but also have the function of packet exchanging.

6. When the router agree the MN's handoff, it will set up the connection with WLAN, then it reply a Routing Table Update (RTU) Acknowledge to MN through UMTS, then UMTS will release the connection with MN. Finally, MN can handoff to WLAN exactly, the handoff procedures already finish.

We also can understand these procedures by flow charts such as Figure 4 and Figure 5 shows. Figure 4 shows the handoff procedure of vertical handoff in the same administrative domain, and Figure 5 shows the handoff procedure of vertical handoff between different administrative domains. In these two flow charts, we both assume the MN handoff form UMTS to WLAN, on the other hand, if MN handoff from WLAN to UMTS, we only to exchange the roles of WLAN and UMTS.
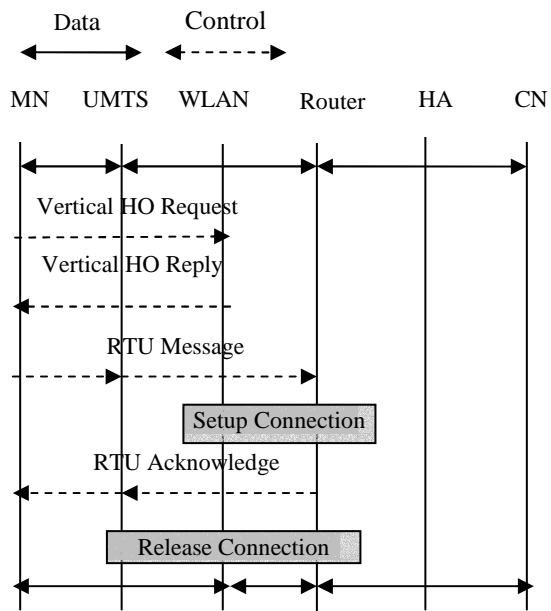

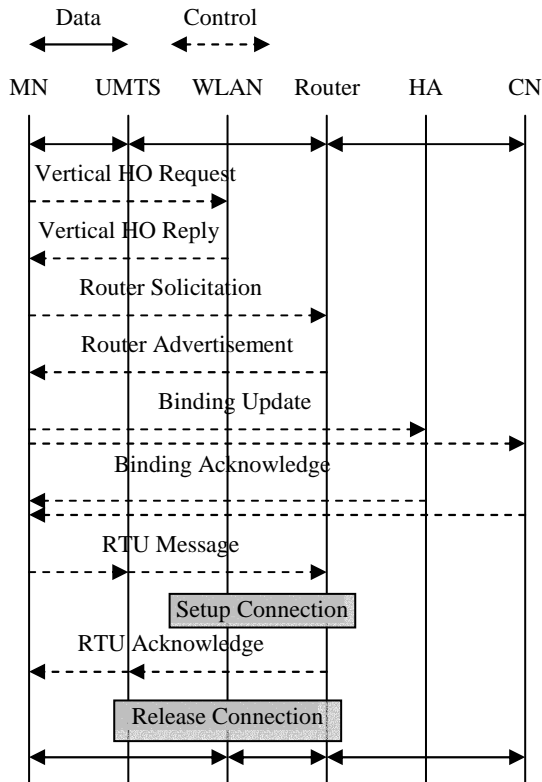Figure 4. Flow Chart of MN handoff from UMTS to WLAN in the same administrative domain

Figure 5. Flow Chart of MN handoff from UMTS to WLAN between different administrative domains

5. Conclusion and Future Works

In this paper, we propose a Mobile IPv6 based seamless handoff strategy for heterogeneous wireless networks. In B3G, mobility management between different access systems is an important issue. Hence, we proposed a integrated architecture of UMTS and IEEE 802.11 WLAN. By supplying this IPc6-based network, we provide access to a mobile IPv6 enabled Internet in support of fast moving mobile nodes. We also offer a seamless handoff method to improve handoff delay and to reduce data packet loss.

Our future studies will focus on Quality of Service (QoS) issues in B3G network. We will integrate Mobile IPv6 and Multi-Protocol Label Switch (MPLS) [10] to improve traffic overload in IPv6 Internet backbone and to ensure the Quality of Services in a real time demands for heterogeneous wireless networks.

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