A Handover Scheme Based on HMIPv6 for B3G Networks*

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Abstract. By complementary integration of UMTS and WLAN, a beyond third generation (B3G) mobile network has been proposed to establish better global roaming environments. The integrations of UMTS and WLAN are classified into two groups: loosely-coupled and tightly-coupled. A tightly-coupled network demands lots of investment and considerable amount of time to construct. On the other hand, a loosely-coupled network is more scalable and easier to implement than a tightly-coupled one while it has critical drawbacks of packet loss and blocking of services due to handover delay. To alleviate these drawbacks, this paper proposes a handover scheme between UMTS and WLAN, which is based on HMIPv6. The performance of the proposed scheme is evaluated adding the handover time of each step, and the blocking probability is computed in each scheme. The proposed internetworking scheme's performance based on HMIPv6 is two times more likely than that based on MIP.

1 Introduction

The ubiquitous age drew near, researches in mobile communications dramatically have increased allowing mobile access anywhere and anytime. Therefore, mobile technology should be needed and then Universal Mobile Telecommunication Systems (UMTS) [1] and IMT-2000 is revealed in the third generation (3G). Nevertheless developing 3G technology, supporting better services and internetworking with different systems are raised an important part. In Beyond Third Generation (B3G), Internetworking is possible with other different systems.

This work places focus on internetworking between IEEE 802.11 WLAN [2] and ETSI UMTS. While WLAN covers only small service area but supports high transmission speed and low cost, UMTS has wide area coverage with low speed and high cost. Accordingly, if WLAN and UMTS are combined together by completing

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strength and weakness, the noticeable result is expected. In order to inter-network between UMTS and WLAN, this work propose the internetworking based on Hierarchical Mobile IP version 6 (HMIPv6) [3] instead of MIP, so that the handover delay will be reduced.

2 Related Works

2.1 The Background: Internetworking Mechanisms

Internetworking mechanism between WLAN and UMTS is classified into two groups; tightly-coupled and loosely-coupled mechanisms [4]. Tightly-coupled internetworking directly connects UMTS Core Network (CN) and WLAN via Inter Working Unit (IWU). In tightly-coupled based networks, WLAN cell is regarded as UTRAN cell, so users from different networks communicate with each other with no modification, and further any service guaranteed from UMTS CN, such as security, quality of service (QoS), mobility and billing, is also offered to WLAN cells. The weak point of this mechanism is a long period and high expenses to implement it because changes in WLAN devices, such as loading UMTS module, are mandatory.

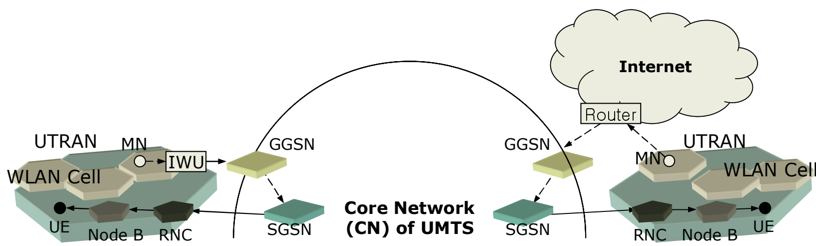

Fig. 1. Internetworking schemes where tightly-coupled internetworking and loosely-coupled internetworking is specified in the left and the right, respectively

In loosely-coupled internetworking scheme, no changes are required in WLAN devices. Nodes in different networks communicate with each other via Internet, as shown in the right of Fig. 1. In loosely-coupled based networks, aforementioned services for each different network should be provided separately. Interconnection of WLAN and UMTS is performed over Internet, so it has rather lower data rate than tightly-coupled based networks. However, this mechanism is preferred to the other because of high extensibility and scalability. Besides, no changes are necessary in WLAN for internetworking, and implementation will be accomplished within a shorter period with lower expenses.

2.2 Internetworking Between WLAN and UMTS Using MIPv4

For internetworking between WLAN and UMTS, [4] has proposed the loosely-coupled internetworking based on MIPv4. A Mobile Node (MN) operates the dual mode, which allows the MN to listen and handle any MAC frame whenever it roams. Each network has agents, such as home and foreign agents (HA/FA), for mobility service, and a WLAN is assumed home network. When a MN moves into UMTS, it starts with a L1 and L2 handover and then sends Attach Request and Active PDP/MM Context messages to SGSN for communication with UMTS. After that, A MN sends an Agent Solicitation message to a local FA and it receives an Agent Advertisement message, builds a CoA and sends a Registration Request message to HA for the binding update. After updating, HA sends a received packet to the foreign network.

Internetworking between UMTS and WLAN based on MIPv4 [4] has some problems, such as un-optimized routing paths, exhaustion of IP resources, weakness on security, disconnection due to roaming to ingress filtering employed networks, and may more. MIPv6 [5] is proposed to solve aforementioned problems and further provides robust mobility service. The foreign agent obsoletes in MIPv6, and instead access routers in foreign networks replace its role. By modifying [4], this work proposes the internetworking model based on HMIPv6 instead of MIPv4.

3 The Proposed Scheme: Internetworking Between WLAN and UMTS Using HMIPv6

When a MN communicates with correspondent node, it may enter the pollution area where it senses signals both from WLAN cell and UMTS cell at the same time. If signal strength from WLAN is closer to the threshold, the MN may lose connectivity or attempt to do handover to UMTS. If the MN decides to do handover, it reports handover to AP and Node B [6], switches its mode and handoffs to foreign networks. In MIPv6, when the MN is passed by lots of cell with fast speed, it needs to send frequently BU messages to HA. At the time, HA's signal overhead for registration and handover delay according to hop distance between SGSN (AR) and HA via Internet are increased. After all, services are disconnected so we'll apply the HMIPv6 [3] for reducing handover delay instead of MIPv6 as shown in Fig. 2.

In HMIPv6, three types of address are defined to identify MN's current location; home address, on-link care-of address (LCoA) and regional care-of address (RCoA). The MAP in HMIPv6 acts as an intermediate HA. When a MN moves from home to foreign network, MAP and home registrations are performed. While the MN roams within the same MAP domain, only local address (LCoA) will be changed, which triggers MAP registration. Only inter-MAP movement is notified to HA, which reduces signal message exchange between MN and HA.

This work assumes a MN is in WLAN as a home network, a MAP is selected one of GGSNs (ARs). That is, a MAP manages some GGSNs (ARs) for hierarchical structure as shown in Fig. 2. The detail explanation of proposed model, which the handover algorithm and MN's mode switching is shown by Fig. 3, is as follows.

When a MN handoffs from WLAN to UMTS for the first time, it detects its movement and performs L1 and L2 handovers. The MN sends a UMTS Attach message and active Packet Date Unit/Mobility Management (PDP/MM) Contexts [7] for sending or receiving packet data and for providing mobility information of it. Once the MN has valid session with UMTS, the UMTS Attach message exchange is not required. For router discovery, the MN may send Router Solicitation (RS) message, or it may receive unsolicited Router Advertisement (RA) message from access router on the visited network. From the RA message, a MN is able to build new addresses

(LCoA, RCoA) as specified [3] to identify its current location. Once a MN builds addresses, MAP and home registrations are followed.

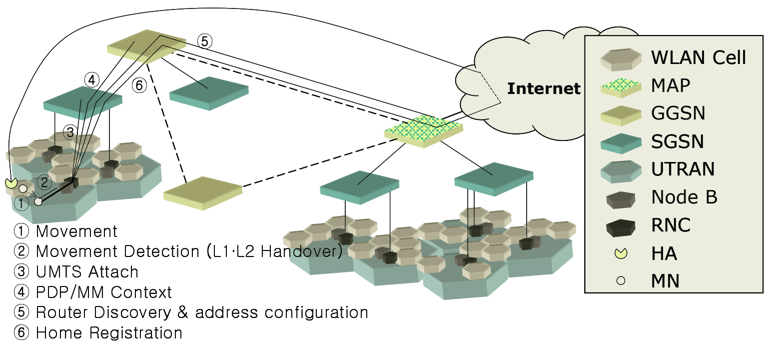

Fig. 2. Internetworking between WLAN and UMTS using HMIPv6

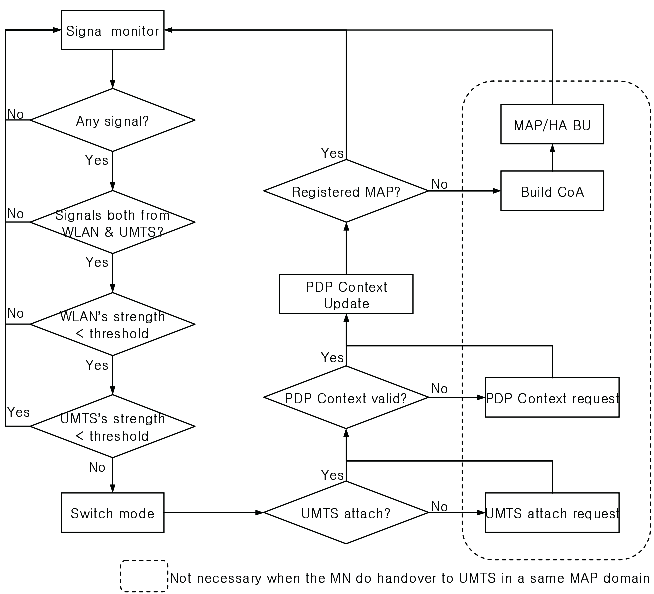

Fig. 3. Algorithm for Handover from WLAN to UMTS and mode switching

When a MN moves from WLAN into UMTS area for the first time, handover is processed as above. When the MN handoffs from WLAN to UMTS where it has visited before and it still has valid PDP/MM context, handover process becomes a different story. Simply, Routing Area Update message exchange between MN and SGSN operating as AR and MAP registration are performed for handover, as shown in Fig. 4.

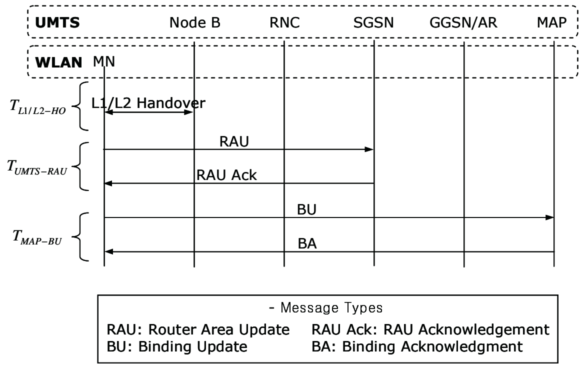

Fig. 4. Handover Signaling from WLAN to UMTS using HMIPv6 (When MN moves within the same MAP domain)

Handover latency is expressed with sum of $T_{L1/L2-HO}$, $T_{UMTS-RAU}$ and T_{MAP-BU}, as shown in (1), where $T_{L1/L2-HO}$ is L1/L2 Handover, $T_{UMTS-RAU}$ is Active PDP/MM Context, and T_{MAP-BU} is Binding Update to a MAP. The handover procedure is specified as follows.

$$T_{HMIPv6} = T_{L1/L2-HO} + T_{UMTS-RAU} + T_{MAP-BU} \quad (1)$$

• L1/L2 Handover ($T_{L1/L2-HO}$)

Changing of MN's mode and the access mechanism to wireless interface of foreign network is involved this step. L1 and L2 handovers delay time is control message processing time γ_{MN} of MN and access time delay T_{UMTS} between MN and Node B. Therefore, the processing time occurs in (2).

$$T_{L1/L2-HO} = \gamma_{MN} + T_{UMTS} \quad (2)$$

• Active PDP/MM Context ($T_{UMTS-RAU}$)

The MN has maintained a valid PDP/MM Context with UMTS, so it simply sends a Routing Area Update message. That is, a MN should use a previous original PDP/MM Context for the communication.

• Binding Update to MAP (T_{MAP-BU})

If a MN moves within a registered MAP domain, it sends a Binding Update message to the MAP instead of sending to HA.

4 The Numerical Result or Performance Analysis

For comparing and analyzing with the existing method and the proposed one, the system parameter is defined as show in Table 1.

Table 1. System Parameters

Input Parameter	Values	Input Parameter	Values
Traffic type	UDP	Message size	100 bytes
Link Parameters			
Wireless Link Data Rate	2 *Mbps*	UMTS link data rate	384 *kbps*
Transmission time (α)			
WLAN (α_{WLAN})	0.4 *ms*	WLAN (α_{UMTS})	2 *ms*
Propagation time (β)			
Wired link (β_{wire})	0.12 *ms*	Wireless link (β_{UMTS})	0.05 *ms*
Processing Time(γ)			
γ_{MN}, γ_{NodeB}, γ_{AP}	15 *ms*	γ_{HA}, $\gamma_{SGSN/AR}$, γ_{RNC}, γ_{MAP}	5 *ms*

4.1 Total Handover Delay

By applying system parameters from Table 1, the total handover delay is measured. The hop distance with HA and GGSN or with MAP and GGSN must influence the handover delay time because our internetworking scheme is attained via Internet.

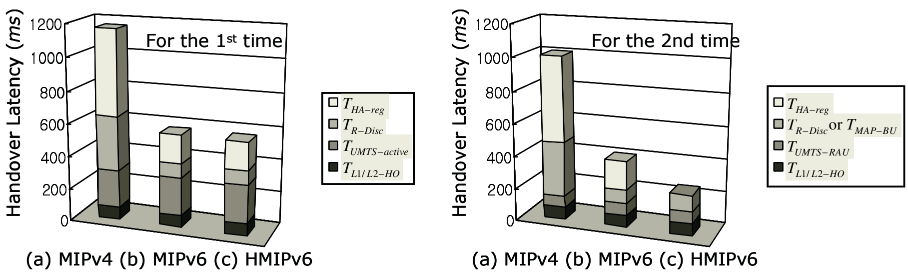

Fig. 5. Comparison of handover delay where the MN entered to UMTS for the first time and it has a valid session with UMTS is specified in the left and the right, respectively

When 5 hop distance between GGSN and HA, and 1 hop distance between GGSN and MAP are assumed, the total handover delay is as shown in Fig. 5. Fig. 5 shows that comparison of handover delay where the MN entered to UMTS for the first time and it has a valid session with UMTS is specified in the left and the right, respectively. When the MN has a valid PDP/MM Context, the handover latency using HMIPv6 is about 5 times more likely than using MIPv4 and is about 2 times more likely than using MIPv6.

4.2 Blocking Probability

When a MN moves from cell to other cells, if the cell residence time [10] is less than the total handover time, packets are lost and the network service is forcefully terminated by the link loss. This is called the blocking probability by the formula as below.

The total handover time, which is expressed as the exponential distribution function $f_{T_{HO}}$ with a mean value T_{HMIPv6}, if $T_{HMIPv6} > 0$, is given by (4).

$$f_{T_{HO}}(t) = \begin{cases} \dfrac{e^{-\frac{t}{T_{HMIPv6}}}}{T_{HMIPv6}}, & t \geq 0 \\ 0 & t < 0, \end{cases} \tag{4}$$

where T_{HO} is the random variable of signaling delay to the handover and T_{HMIPv6} is mean value of the total handover latency using HMIPv6. The dwell time of MN, which is presented by the exponential and gamma distributions, is given by (5) and (6).

$$f_{T_{cell-dwell}} \exp(t) = \begin{cases} \lambda e^{-\lambda t}, & t \geq 0 \\ 0, & t < 0, \end{cases} \tag{5}$$

$$f_{T_{cell-dwell}} gam(t) = \begin{cases} \dfrac{\rho e^{-\rho t}(\rho t)^{\omega-1}}{\Gamma(\omega)}, & t \geq 0 \\ 0, & t < 0, \end{cases} \tag{6}$$

where $T_{cell-dwell}$ is a residence time of MN in boundary cell, $\frac{1}{\lambda}$ is a mean dwell time of MN in the cell, ω is a shape parameter, σ is a mean value, and ρ is a scale parameter ($\rho = \sigma\omega$). The blocking probability of handover from WLAN to UMTS is given by (7) and (8).

$$\begin{aligned} P_{B_{\exp}} &= 1 - \Pr\{T_{HO} < T_{cell-dwell}\} = \Pr\{T_{HO} > T_{cell-dwell}\} \\ &= \int_0^\infty e^{\frac{-t}{T_{HMIPv6}}} \cdot f_{T_{cell-dwell}} \exp(t)dt \\ &= \int_0^\infty e^{\frac{-t}{T_{HMIPv6}}} \cdot \lambda e^{-\lambda t} dt \\ &= \frac{\lambda T_{HMIPv6}}{1 + \lambda T_{HMIPv6}}, \end{aligned} \tag{7}$$

$$\begin{aligned} P_{B_{gam}} &= 1 - \Pr\{T_{HO} < T_{cell-dwell}\} = \Pr\{T_{HO} > T_{cell-dwell}\} \\ &= \int_0^\infty e^{\frac{-t}{T_{HMIPv6}}} \cdot f_{T_{cell\_dwell}} gam(t)dt \\ &= \int_0^\infty e^{\frac{-t}{T_{HMIPv6}}} \cdot \frac{\rho e^{-\rho t}(\rho t)^{\omega-1}}{\Gamma(\omega)} dt \end{aligned} \tag{8}$$

In Fig. 6, the blocking probability is shown by exponential and gamma distributions according to the dwell time of MN from (7) and (8). When a MN moves from a WLAN cell into a UMTS cell, the blocking probability using MIPv6 is about two times more likely than that of using HMIPv6. Therefore, when the handover occurs, the proposed scheme reduces signal message exchanges so that the seamless handover can be safely provided.

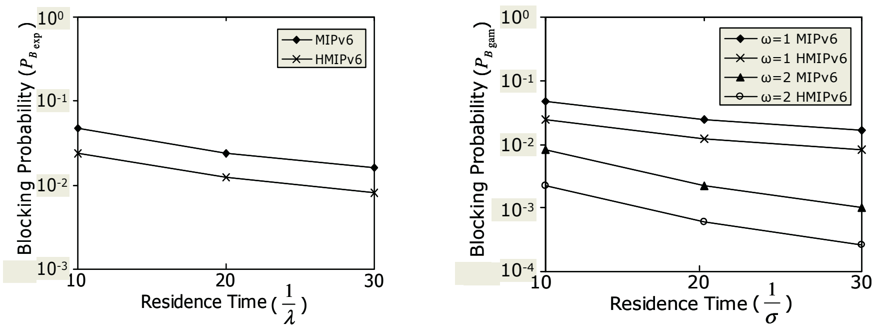

Fig. 6. Blocking probabilities versus residence time

5 Conclusions

Internetworking with other systems is considered as an important part in mobile communications. The loosely-coupled mechanism, which is important part of research on internetworking with UMTS and WLAN, is explained using MIPv4 and MIPv6. Internetworking with UMTS and WLAN becomes possible by using MIP. However, the MN has to register to HA via Internet when the MN handoffs to other network, so the handover latency takes no small times. Therefore, the packet loss and the non-guaranteed seamless service are occurred. In order to improve this problem, the internetworking with UMTS and WLAN based on HMIPv6 is proposed in this paper.

For evaluating the proposed scheme, the system parameter is defined. After that, the handover latency time and the blocking probability are enumerated. Hence, the results of proposed scheme where is the handover delay and the blocking probability is reduced twice more than the existing one, so it can provide the seamless service.

References

1. Heikki Kaaranen, Siamäk Naghian, Lauri Laitinen, Ari Ahtiainen and Valtteri Niemi: UMTS Networks: Architecture, Mobility and Services, John Wiley & Sons, (2001)
2. Mattbew S. Gast: 802.11 Wireless Networks: The Defimitive Guide, O'Reilly & Associates, (2002)
3. Soliman, H., Catelluccia, C., Malki, K. and Bellier, L., "Hierarchical Mobile IPv6 Mobility Management," work in progress, (2004)
4. Shiao-Li Tsao and Chia-Ching Lin, "Design and Evaluation of UMTS-WLAN Interworking Strategies", Proceeding of IEEE Vehicular Technology Conference 2002(VTC 2002) 56th, Vol. 2, (2002) 777 - 781
5. Pete Loshin: IPv6;theory, protocol, and practice. 2nd edn. Morgan Kaufmann (2004)
6. Janise McNair, Ian F. Akyildiz and Michael D. Bender, "An Inter-System Handoff Technique for the IMT-2000 System", INFOCOM 2000. Nineteenth Annual Joint Conference of the IEEE Computer and Communications Societies. Proceedings, Vol. 1, (2000) 208 - 216

7. Yi-Bing Lin, Yieh-Ran Haung, Yuan-Kai Chen and Imrich Chlamtac, “Mobility management: from GPRS to UMTS,” Wireless Communications and Mobile Computing, vol. 1 (2001) 339-359
8. Nektaria Efthymiou, Yim Fun Hu and Ray E. Sheriff, "Performance of Intersegment Handover Protocols in an Integrated Space/Terrestrial -UMTS Environment", IEEE Transactions on Vehicular Technology, Vol. 47, (1998) 1179 - 1199
9. 3rd generation Partnership Project. "Delay Budjet within the Access Stratum", TR 25.853, v.4.0.0, http://www.3gpp.org
10. F. Khan and D. Zeghlache, "Effect of cell residence time distribution on the performance of cellular mobile networks", Proceedings of IEEE Vehicular Technology Conference 1997 47th, Vol. 2 (1997) 949-953