Journal of Theoretical and Applied Information Technology

www.jatit.org

AN EFFICIENT METHOD OF MOBILE IP BASED HANDOFF MECHANISM FOR WLAN-GPRS INTEGRATED NETWORK

[1]Sibaram Khara, [2]Asish K. Mukhopadhyay
[1]Dept of ECE & EIE, College of Engineering & Management, Kolaghat 721171, Midnapur, India
[2]Dept of Computer Science and Engineering, Narula Institute of Technology, Kolkata 700108, India
Email: sianba@rediffmail.com, askm55@gmail.com

ABSTRACT

This paper proposes a new technique for Mobile IP (MIP) registration by WLAN host (WH) of the Internet through GPRS network. The home agent (HA) of WH resides in the Internet. The gateway GPRS Support Node (GGSN) provides foreign agent (FA) functionality for WH in GPRS. After successful attachment with GPRS network in roaming scenario, WH needs two mandatory passes for MIP registration with HA. In first pass, it establishes PDP context in GPRS network and in second pass, it sends MIP registration request to FA at GGSN. This two-pass registration causes substantial delay for handoff from WLAN to GPRS. To minimize this delay, we propose a one-pass MIP registration technique through GPRS network by modifying the *activate-PDP-context request* (APCR) message. In this scheme, the APCR message carries MIP-registration request in its information field to GGSN. Therefore, FA at GGSN can process MIP registration packet before completion of PDP context in GPRS network. Thus, both PDP context creation and MIP registration are accomplished in one pass of signaling. This technique reduces handoff delay from WLAN to GPRS minimizing the control signals. We observed from simulation results that the proposed one-pass technique reduces handoff delay by 18% compared to that of two-pass method proposed in [8].

Keywords: *AAA, GPRS, Mobile IP, PLMN, UMTS, WLAN.*

I. INTRODUCTION

The demand for high speed data transfer at user level for multimedia services is growing rapidly [1]. The bandwidth constraint has put up a challenge for high data rate at user level for next generation wireless networks. The mobile networks (2.5G-3G) provide data transfer rate (170Kbps/2Mbps) that can not support specialized multimedia services [2]. On the other hand, WLAN can provide much higher bit rate at user level (11Mbps/54Mbps). Mobile networks provide best coverage and WLAN provides best bit rate [3]. Therefore, in WLAN/GPRS integrated network, a mobile station (MS) can avail the best services of both the networks. WLAN can provide high bit rate on hotspot basis and GPRS can provide wide coverage on mobiity.

Design of dual mode terminal equipment [4, 5], mobility management and session continuity under vertical roaming are the key issues of WLAN/GPRS inter-working network [6]. A user may be subscribed either to WLAN network or to GPRS network or to both networks.

The home network of WH is the Internet which is connected to GPRS network at GGSN through Gi interface. GPRS mobile station (GMS) is subscribed to only GPRS network. The Internet service provider wishes to provide GPRS services to WH. So, the Internet has an agreement with GPRS operator so that WH can maintain IP session through GPRS also. An MIP based mobility and handoff management is performed with HA when WH moves within the Internet [7]. A GPRS mobility management technique is performed when GMS moves within GPRS. If WH moves from WLAN to GPRS, the GPRS network must provide FA agent functionality to WH for MIP based signaling with HA in the Internet. The FA is preferably be deployed at GGSN [8]. In another roaming scenario, GMS moves from GPRS to WLAN, now GGSN provides HA functionality for MIP based signaling. In such case, HA is deployed at the GGSN and an MIP based handoff signaling is performed between GMS and GGSN. Therefore, GMS's subscription and authority profiles for WLAN services are stored at GGSN itself.

IIEI	Information Element	Type	Presence	Format	Length
	Protocol discriminator	Protocol discriminator	M	V	1/2
	Transaction identifier	Transaction identifier	M	V	1/2
	Activate PDP context request message identity	Message type	M	V	1
	Requested NSAPI	Network service access point identifier	M	V	1
	Requested LLC SAPI	LLC service access point identifier	M	V	1
	Requested QoS	Quality of service	M	LV	4
	Requested PDP address	Packet data protocol address	M	LV	3 - 19
28	Access point name	Access point name	O	TLV	3 - 102
26	***MIP registration request packet***	***MIP registration request packet***	***M***	***LV***	***3 - 253***

WH must perform MIP based mobility management signaling through GPRS network with HA in Internet [8]. Thus she first performs the attachment signaling with GPRS network. In first pass she creates PDP context and in second pass she sends MIP registration packet to FA. This PDP context is essential in GPRS network to transport Internet IP packets through GPRS network to GGSN [9]. Therefore, MIP registration packet cannot be transported until the PDP context is created in GPRS network. This two-pass method of MIP registration in GPRS network increases hand off delay from WLAN to GPRS [8]. We propose a technique of combined PDP and MIP registration method. This technique helps to start MIP based signaling between FA at GGSN and HA in Internet before the complete establishment of PDP context. Both PDP context creation and MIP registration are feasible in one-pass signaling by inserting the MIP registration information in PDP request messages. A faster hand off can be achieved as this technique reduces the control signals for hand off from WLAN to GPRS. The rest of the paper is organized as follows. In Section II the related works are discussed. Section III elaborates the WLAN-GPRS inter-working architecture. Section IV discusses the proposed handoff management scheme between WLAN and GPRS which is established through simulation using NS-2 in section V. section VI contains the concluding notes.

II. REVIEW OF RELATED WORKS

An operator WLAN (OWLAN) system, based on loose coupling with GPRS network, has been proposed in [10]. There, the main design challenge was to transport the standard GSM subscriber authentication signals from the terminal to the cellular site using IP framework. So OWLAN needs implementing GSM SIM card reader, SIM authentication software module and roaming control module in MS. Network access authentication and accounting protocol (NAAP) was defined as an alternative to terminal EAP (extensible authentication protocol) protocol. NAAP, running over UDP, is capable of transporting GSM authentication messages through IP in WLAN access networks.

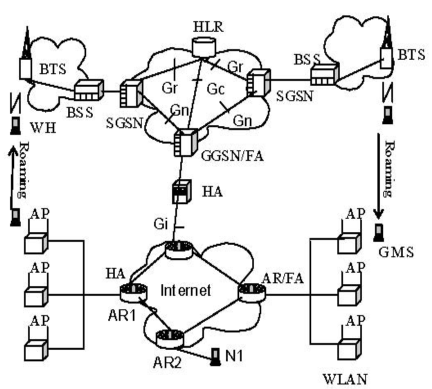
UMTS and 802.11 WLAN integration, based on tight coupling method, has been proposed in [11]. WLAN IP network is connected to SGSN (serving GPRS support node) through border router (BR). Intra-SGSN handoff from UMTS to WLAN is performed, and PDP context between SGSN and GGSN need not be upgraded. This enables faster handoff. This system requires MSs to maintain complex states for mobility management, which requires dual contact with WLAN as well UMTS. An application layer local mobility management is implemented for handoff signaling over IP in WLAN access network. This requires implementation of complex inter-working function at gateway router for cellular specific signaling with SGSN. WLAN service at hot-sport cannot be made public without UMTS availability.

UMTS/WLAN inter-working architecture, where AAA server has been implemented in 3G networks (UMTS), is presented in [12]. The 3G AAA server in the home PLMN terminates all AAA signaling with the WLAN and interfaces with other 3G components, such as home subscriber server (HSS), Home Location Register (HLR), charging gateway/charging collection function (CGw/CCF), and online charging system (OCS). AAA signaling uses EAP and DIAMETER protocol. The 3G AAA can also act as proxy server for another 3G PLMN in roaming scenario.

A critical review of the above works reveal that in GPRS/WLAN integrated network, MIP based mobility management for WLAN subscriber through GPRS network still needs more focus. Our work attempts to address this space for faster handoff from WLAN to GPRS by introducing a one-pass method of MIP registration through GPRS network.

III. GPRS-WLAN INTERWORKING

Figure 1 shows the inter-working architecture for WLAN/GPRS integrated network. WLAN is directly connected to external IP network which may be internet. GPRS network is connected to this IP network at Gi interface. HA/FA entity (HFE) is deployed at Gi interface. It acts as foreign agent when WH goes outside the WLAN and enters in GPRS coverage. GPRS operator has an agreement to provide the WLAN services of the Internet to GMS. Similarly, the Internet facilitates to WH with the GPRS services. HA at GGSN maintains the subscription and access profile of GMS for WLAN service. GPRS operator can maintain the agreement profile for WH in HLR. Therefore, it can impose access control during GPRS attach procedure.



:2

Figure 1. *Architecture of proposed GPRS/WLAN integrated networks.*

IV. **PROPOSED HANDOFF MECHANISM**

The subscription and service profile of GMS are maintained by GPRS network at two entities. Its GPRS profile is stored at home location register (HLR) and its WLAN profiles are stored at HA. The subscription and service profile of WH are maintained by its HA in Internet. In our proposed WLAN/GPRS interworking architecture, two types handoff procedures are performed.

A. Handoff from GPRS to WLAN

We take the scenario that a GMS is initially in GPRS network and she maintains a session with correspondent node (CN) N1 in the Internet through GPRS network (Fig.1). The terminal's GPRS system is active and WLAN radio system is in passive scan mode. When the GMS moves to WLAN hotspot, her WLAN card is activated on receipt of beacon signal from WLAN access point (AP) [13]. The GPRS sytem is triggered off and terminal performs association with AP. subsequently she performs MIP based registration with HA at GGSN. After MIP based handoff completion, she can send packets to CN through WLAN with much higher speed and packets are directly routed in the Internet. Thus GGSN acts as an anchor point of GMS while she is in a WLAN hotspot. The incoming packets from the Internet are routed to GGSN. If destination WMS is in a WLAN hotspot, GGSN forwards the packets to responsible FA using MIP tunneling.

B. Handoff from WLAN to GPRS

The AAA (authentication, authorisation and accounting) profiles of a WH are maintained at HA in Internet. A WH has the capability to access GPRS network. GPRS entertains IP connection for a WH because the GPRS operator has an agreement with the Internet. The GPRS network maintains the profiles for service and QoS that a WH can avail through GPRS network. A WH may have subscriptions to access GPRS network from selected cells or routine area also. When WH comes out of a WLAN hotspot, she will in cellular coverage. Therefore, her IP based ongoing sessions can continue through GPRS network. She will perform MIP based signaling for mobility and handoff management through GPRS netowrk.

GPRS network provides the bearer service for IP packets in conjunction with PDP context maintained at SGSN and GGSN. The MIP registration request is a IP packet which needs PDP context for transportation through GPRS network.

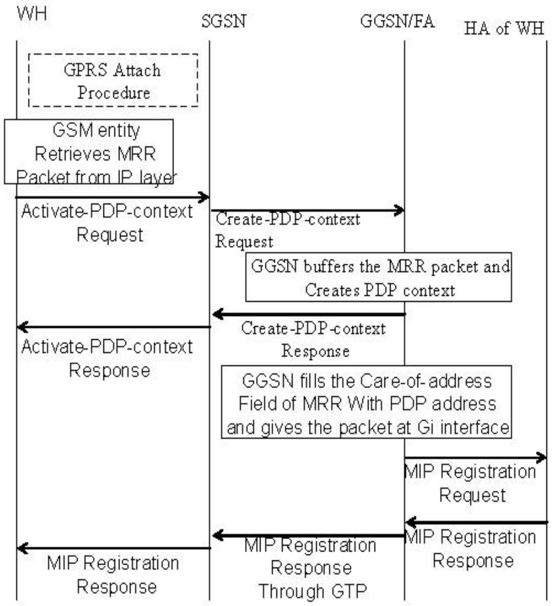


Figure 2. *The sequence of signaling for MIP based handoff from WLAN to GPRS*

This packet is dealt by FA at GGSN. Hence, after GPRS attach procedure, a WH needs two passes for MIP registration. In first pass, PDP context is created in GPRS network and in second pass, MIP registration is performed [8]. The handoff delay in two-pass method is substantially larger. We propose a one-pass technique for both PDP context activation and MIP registration to reduce the handoff delay. Before sending the activate-PDP-context request message, the GPRS session management (GSM) entity retrieves the MIP registration request [MRR] packet from network layer. Then, it inserts this packet in the information field of PDP request message.

C. One-pass Method

1. Following sequential operations are performed by a WH and GPRS network for hand off management [Fig. 2].

- WH performs GPRS attachment signaling with GPRS network and terminal equipment attains the GPRS attached state.
- GSM sub-layers of terminal retrieves the MRR packet from network layer.
- WH sends a modified *activate-PDP-context request* message to SGSN and it contains MRR packet.
- SGSN sends a modified create-PDP-context request to GGSN and it contains MRR packet.
- GGSSN creates PDP context and sends create-PDP-context response to SGSN.
- GGSN fills the care-of-address field of MRR message with the PDP address and gives the MRR packet to FA.
- Now FA processes the MRR packet for MIP signaling with HA and simultaneously, *create-PDP-context* response message travel through GPRS network.
- FA receives the MIP registration response packet from HA and gives this packet to GGSN addressed to WH.
- Now PDP is already established. Therefore the MIP response packet is tunneled to SGSN using GTP protocol and SGSN sends this packet to WH.

2. ***SAP and protocol stack for retrieval of MRR packdet****:* We define new service primitive for MRR retrieval by GSM entity from a new network leayer control entity, *WLAN/GPRS mobility agent* (WGMM) control entity. The WGMA is developed in control management entity in network layer which has well defined network layer service access point identifier (NSAPI) with SNDCP sublayer [15]. On the other hand, GSM sublayer has well defined SAP between SNDCP which is known as SNSM [Fig. 3(a)]. GSM entity can access service provided by SNDCP management entity through SNSM.

3. ***New Service primitives****:* We define following four new service primitives for retrieving the MRR packet.

a) SM-MIP-Registration.request: This primitive is used by SM layer before sending PDP activate request to network side [Fig. 3(b)]. This uses SNSM service access point to give information to SNDCP layer for retrieval of MIP registration packet from WGMA control entity. The information contains NSAPI which will be used for receiving the MIP registration accept packet.

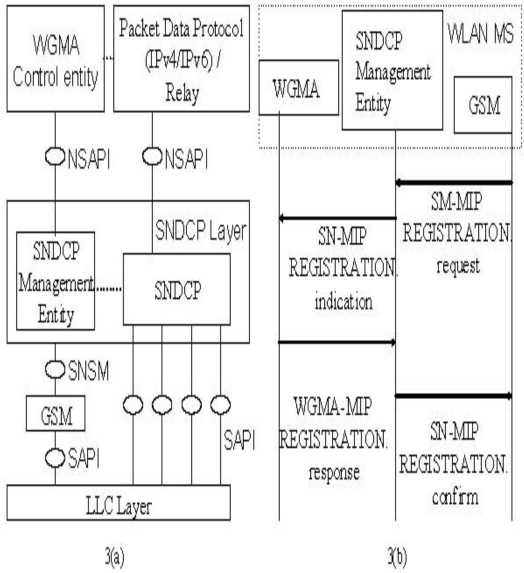


Figure 3. *(a) Protocol stack and service access point and (b) inter layer control signaling for retrieval of MRR packet from network layer by GSM entity.*

b) SN-MIP- Registration.indication: This is used by SNDCP layer to deliver the information given by SM entity for retrieval of MIP registration packet.

c) MA-MIP- Registration.response: This service primitive is to be used by WGMA. This is already configured with the home address of terminal equipment, address of HA and FA. For whole GPRS network the only FA functionality is implemented in GGME. WGMA gives this information to SNDCP sublayer. WGMA entity remembers the NSAPI through which it expects the MIP registration accept after the completion of PDP context establishement.

d) SN-MIP- Registration.confirm: This is used by SNDCP sublayer. It gives the received MIP registration pacekt from WGMA control entity to GSM entity.

TABLE I. FORMAT OF AMCR MESSAGE

Information element	Presence requirement
Routeing Area Identity (RAI)	Optional
Quality of Service Profile	Mandatory
Recovery	Optional
Selection mode	Mandatory
Flow Label Data I	Mandatory
Flow Label Signalling	Mandatory
End User Address	Mandatory
Access Point Name	Mandatory
Protocol Configuration Options	*Optional*
SGSN Address for signalling	Mandatory
SGSN Address for user traffic	Mandatory
MSISDN	Mandatory
Private Extension	Optional

4. ***Format of activate-MIP-PDP context request (AMCR) message**:* We define a modified format for AMCR message which is use in GSM entity. The unused bit pattern such as 01010110 can be used in message type field (Table 1). First eight information elements in the packet has been kept same as in activate PDP context request message. Out of these, first seven information elements are

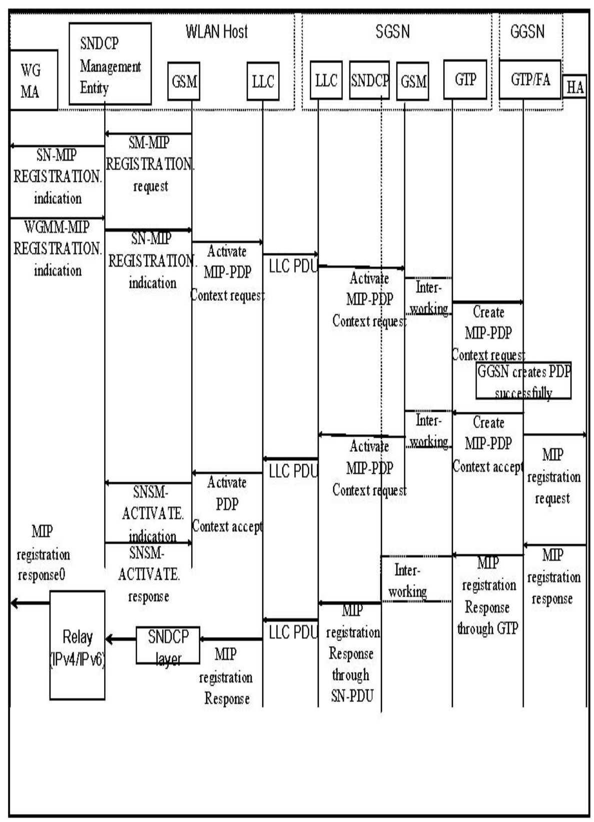


Figure 4. *The complete signaling for PDP actiate and MIP registration in one pass methodv*

mandatory for activate PDP context request [14] and eighth element is optional. The last element was protocol configuration options (PCO) in activate PDP context request packet and which was optional information element.

The purpose of PCO information element is to transfer external network protocol options associated with PDP context activation. For

TABLE II Format of CMCR Message

Information element	Presence requirement
Routeing Area Identity (RAI)	Optional
Quality of Service Profile	Mandatory
Recovery	Optional
Selection mode	Mandatory
Flow Label Data I	Mandatory
Flow Label Signalling	Mandatory
End User Address	Mandatory
Access Point Name	Mandatory
Protocol Configuration Options	*Optional*
SGSN Address for signalling	Mandatory
SGSN Address for user traffic	Mandatory
MSISDN	Mandatory
Private Extension	Optional

this optional information element, an MIP registration request packet can be used alternatively in AMCR message. This information element is distinguished by separate information element identity (IEI). Maximum length of PCO information element is 253 bytes. However in AMCR message this field can be specified for larger length if necessary.

The unused hexadecimal value such as 26 can be used as IEI for MIP registration request followed by length of MIP registration request packet. WLAN MS sends AMCR message to network side. SGSN sends MIP registration packet to GGSN through create-PDP-context request message.

5. ***Format of create-MIP-PDP-context request (CMCR) message****:* The CMCR is a new message type for GPRS tunneling protocl. Its format is similar to create PDP context request (CPCR) message except two information elements in the message. Its message type field bears new message identity for GTP and PCO is replaced by MIP registration packet [Tabel II]. Therefore, all esxiting primitives can be used to process the information elements for CMCR message except two informations.

6***. Complete hanfoff procedure with signaling in layer interfaces at each node.*** For handoff management, four sublayers in WH are active. GSM sublayer retrieves MRR packet from WGMA through SNDCP sublayer. Then, it sends a AMCR message to SGSN through LLC link. GSM sublayer of SGSN receives this message from LLC layer. The interworking function at SGSN sends corresponding CMCR message through GTP to GGSN. The SNDCP sublayer in SGSN is used for only packet data transfer. After receiving CMCR message, GGSN creates PDP context and sends a response packet to SGSN. After receiving *activate-PDP-context response* message, the GSM entity of WH informs SNDCP layer that LLC connection has already been established for data packet. GSM also gives the SAPI to used between LLC and SNDCP sublayer [14, 15]. After receiving MIP registration response packet from FA, GGSN deals it like a IP data packet. GGSN tunnels this packet to SGSN using PDP context.. Finally is is received by WH from SGSN usual way. The LLC layer at WH gives this packet to SNDCP sublayer through already configured SAPI. SNDCP gives this packet to network layer. Network layer does not take action for MIP registration packet, rather it gives this packet to WGMM emtity through its relay functionality.

TABLE III. VALUES USED FOR SIMULATION

MAC	802_11
Interface Queue	DropTail/PriQueue
Link Layer	LL
Antenna	Omniantenna
Interface queue length	700
Adhocrouting	DSDV
Data packet size	500 bytes
Mean link delay	50us
Link layer over-head	25us
Receive Threshold power	3.625 x 10-10w
Transmit Power	0.28183815w
Bandwidth between any two wired node	50Mb 15ms

V. SIMULATION

The network architecture [Fig. 1] has been simulated using NS-2.26. The typical values used for simulation is shown in Table III. We used WLAN as GPRS access network keeping the bit rate GPRS suite (144kbps) at user level. A WH is initially in its home networks under access router AR1. However the initial position of WH can be considered under any FA in IP network. The WH transmits packets to correspondent node (CN) N1 at a bit rate 2Mb per sec. However, any WLAN host in IP network can be considered as CN. When WH comes out of WLAN coverage, it initiates MIP based handoff signaling through GPRS network. We implemented FA functionality at GGSN and HA functionality at AR1. The GTP based signaling for handoff management is developed at SGSN and GGSN node. All control and data packets between SGSN and GGSN are transported using GTP. The simulation is carried out for one-pass and two-pass methods for MIP registration when WH moves from WLAN to GPRS. After handoff, the WH transmits IP packets through GPRS network to N1 at a maximum data rate of 144 Kb per sec.

VI. PERFORMANCE

Results obtained from simulation show that for a fixed packet size of 500 bytes, the handoff delay in one-pass method is reduced by 18.657% compare to that of two-pass method [Fig. 5(a)]. Figure 5 (b) shows the variation in handoff delay in both the methods with packet size varying from 100 bytes to 1000 bytes in steps of hundred. It is seen that for increasing packet size from 100 to 1000 bytes, handoff delay increases by 17.784% in one-pass method and by 21.852% in two-pass method.

We computed the inter arrival delay of received packets at CN before and after handoff from WLAN to GPRS [Fig. 6(a)]. The average inter arrival delay of received packets is 5.91ms before handoff and this corresponds to average throughput of 678.8Kb per sec. The average inter arrival delay after handoff is 27.78ms and it corresponds to throughput of 144Kb per sec. Figure 6(b) shows the bit rate received at CN before and after handoff in one-pass method. Handoff is initiated in 8th sec. During handoff signaling, the

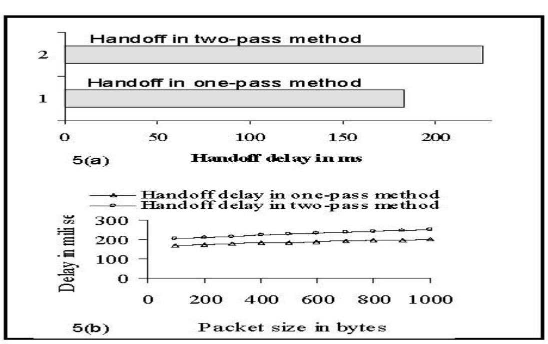


Figure 5. *(a) Average handoff delay in one-pass and two-pass method and (b) handoff delay in one-pass and two-pass method with increasing mean packet size.*

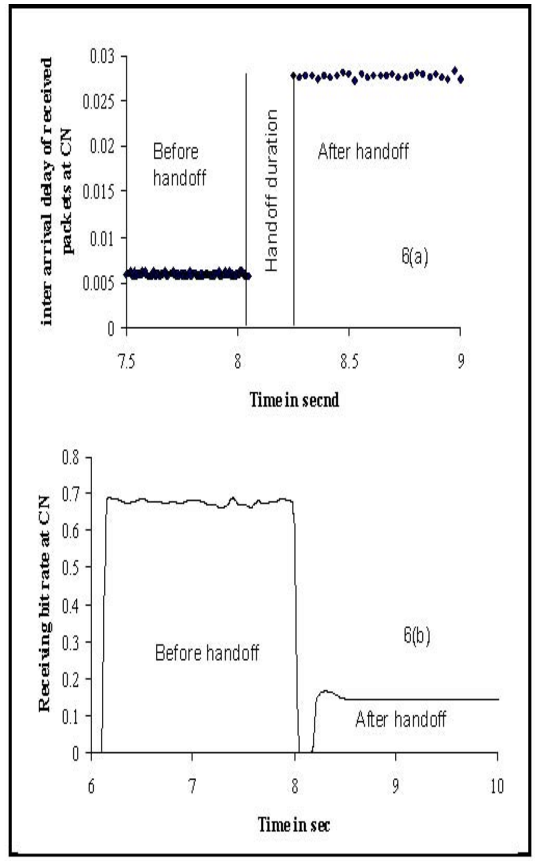


Figure 6. *(a) Jittering of received packets and (b) received bit rate before and after handoff in one-pass method.*

IP network still routes packets for CN already buffered in queue. Thus, CN still receives data packets during first phase of handoff session. We selected simulation parameters such that these packets do not flow beyond handoff session. Therefore, at the last stage of handoff session, throughput becomes zero. After handoff, WH transmits data at bit rate of 144Kb per sec through GPRS network. But, same session is continued although throughput goes very low. The simulation results for inter arrival delay of received packets and throughput are also observed in two-pass method of handoff [7(a), 7(b)]. It is seen that results are similar to those observed in one-pass method except increased handoff delay. Here, the duration for which CN does not receive any packet during handoff session is larger. Therefore, the duration for zero level of throughput is larger than that in one-pass method.

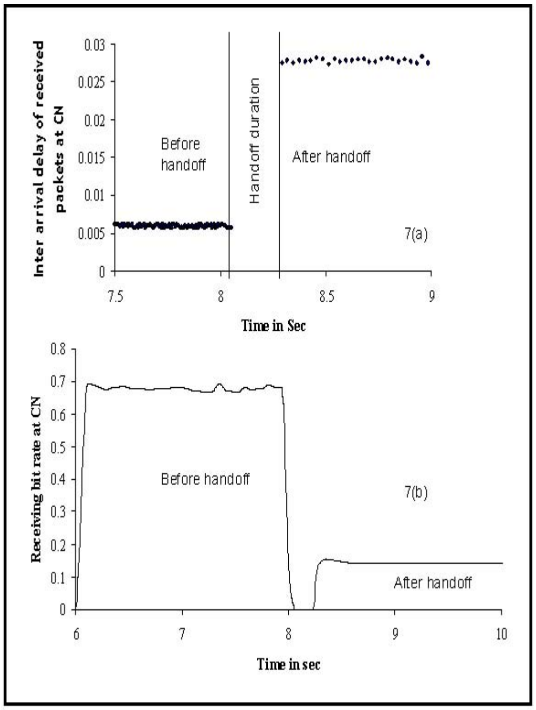


Figure 7. *(a) Jittering of received packets and (b) received bit rate before and after handoff in two-pass method.*

VII. CONCLUSION

In the proposed architecture, the Internet is loosely coupled to GPRS network. Both WLAN and GPRS networks converge to IP layer in integrated scenario. This architecture enables Internet subscribers to continue their IP sessions through GPRS network. Conversely, GPRS subscriber can also continue theirs IP sessions when they move to WLAN hotspots. The proposed WLAN/GPRS architecture and handoff technique, support MIP based mobility management under roaming between GPRS and WLAN. The one-pass method of MIP registration by WH in GPRS network reduces the control signals for MIP based handoff management through GPRS. The handoff latency is reduced by 18% compare to two-pass method of handoff, although the through put in both methods are comparable with each other.

VIII. REFERENCES:

[1] P. Mahonen, J. Riihijarvi, M. Petrova, and Z. Shelby, "Hop-by-Hop toward Future Mobile Broadband IP", IEEE Commun Magazine, Mar 2004, pp. 138-146.

[2] S. M. Faccin, P. Lalwaney, B. Patil, "IP Multimedia Services: Analysis of Mobile IP and SIP Interactions in 3G Networks", IEEE Commun Mag, Jan 2004, pp. 113-120.

[3] S. Simonens, P. Pellati, J. Gosteau, and K. Gosse, "The Evolution of 5 GHz WLAN Toward Higher Throughputs", IEEE Wireless Commun, Dec 2003, pp. 6-13.

[4] A. K. Salkintzis, C. Fors and R. Pazhyannur, "WLAN-GPRS Integration for Next-Generation Mobile Data Networks", IEEE Wireless Commun, Oct 2002, pp-112-124.

[5] H. Luo, Z. Jiang, B. Kim, N. K. Shankaranarayan and P. Henry, "Integrating Wireless LAN and Cellular Data for the Enterprise" IEEE Comp Soc, March-April 2003, pp-25-33.

[6] S.-C Lo, G. Lee, W.-T Chen "Architecture for Mobility and QoS Suport in All-IP Wireless Networks" IEEE Journal on selected areas in communications, vol-22, No 4, May 2004, pp-691- 704.

[7] C. Perkins, "IP mobility support " IETF RFC 3220 Jan 2002.

[8] H.-W. Lin, J-C. Chen, M-C. Hiang, C-Y. Huang, "Integration of GPRS and Wireless LANs with Multimedia Applications", Proceedings of IEEE Pacific Rim Conference on Multimedia 2002, pp. 704-711.

[9] 3GPP TS 04.07: "Mobile radio interface signalling layer 3; General aspects".

[10] J. Ala-Laurila, J. Mikkonen, and J. Rinnemaa, "Wireless LAN Access Network Architecture for Mobile Operators", IEEE Communications Magazine, Novmber 2001, pp-82-89.

[11] M. Jaseemuddin, "An Architecture for Integrating UMTS and 802.11 WLAN Networks", Proceedings of IEEE Symp on Comp. and Commun.(ISSC-2003), pp. 716-723.

[12] A. K. Salkintzis, "Interworking techniques and Architectures for WLAN/3G integration toward 4G Mobile Data Networks" IEEE

Wireless Commun, June 2004, pp-50-61.

[13] IEEE 802.11 Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, 1999, http//standard.ieee.org/getieee802/download/802.11-1999.pdf.\

[14] 3GPP TS 04.08: "Mobile radio interface layer 3 specification (Release 1998)".

[15] 3GPP TS 04.65; "Digital cellular telecommunications system (phase 2+); Genral packet Radio Service (GPRS); Subnet Dependent Convergence protocol (SNDCP)(Release 1999)".