INTEGRATION OF MEDIA POINT SYSTEM IN UMTS TO PROVIDE SESSION HANDOVER FOR SIP-BASED MULTIMEDIA SERVICES

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Abstract: *This paper describes a proposal for the tight-coupling integration of WLAN-based Media Points and 3GPP/UMTS systems. The approach extends the SIP based session management and mobility management proposed for a standalone Media Point network by connecting it to the UMTS network. The integration aims to provide seamless continuity for SIP-based services when performing vertical radio handover from UMTS to WLAN. The proposed solution builds largely on existing procedures, like the standard UMTS control plane protocols and the IETF CTP (Context Transfer Protocol). Session continuity is provided by keeping the current local IP address in the user terminal after handover. In order to save battery the usage of 3GPP Location Service mechanisms is proposed, which allow to switch off WLAN modules outside the WLAN coverage area.*

I. INTRODUCTION

The Media Point concept aims to allow mobile users to access personalized Internet-based services within public broadband hotspots. Media Points are wireless local area network (WLAN) access points, that are centrally controlled to strive for service session continuity in spite of discontinuous radio coverage. The Media Point concept has been described in detail in [1-5][15] for stand-alone Media Point systems. In order to enhance its service provision capability we propose the integration of Media Points with the 3G cellular Universal Mobile Telecommuication System (UMTS). In this paper we investigate a solution following the tight-coupling approach identified in [6]. In our scenario a user with a dual-mode mobile terminal wants to get service access anywhere and at any given time by using either UMTS or WLAN interface, which of one is more beneficial from the service quality or cost perspective. The description in this paper is limited to the transition from UMTS to WLAN. The opposite direction is very similar but omitted here due to limited space.

The paper is organized as follows. Section II provides a brief introduction into the Media Point network. Section III presents the service provision scenarios and the proposed integration architecture. We then describe the protocol for a lossless session handover while changing the radio access technology from UMTS terrestrial radio access network (UTRAN) to WLAN in Section IV. Finally, conclusions are given in Section V.

II. THE MEDIA POINT NETWORK

We consider the network architecture depicted in Fig. 1. The *Media Point Service Control (MPSC)* is a central entity, which monitors each user's availability and location, and collects personalized user data from the Internet servers, e.g., e-mail servers. The MPSC is connected to a set of *Media Point Controllers (MPCs)* with large cache capacity. Each MPC controls a group of *Media Points (MPs)*, that are usually located in close geographical proximity and establish the (public) broadband hotspots.

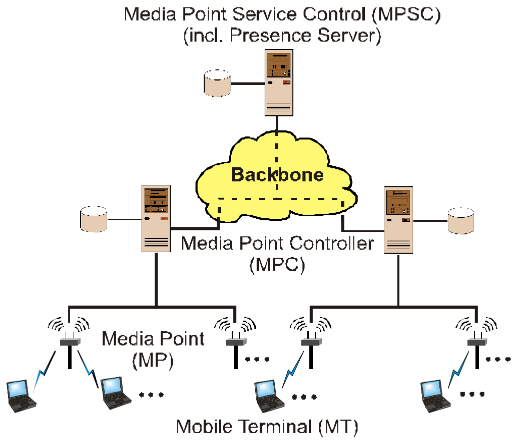

Fig. 1: Media Point network architecture

The mobility and session management is handled by the *Session Initiation Protocol (SIP)* as described in detail in [3]. Acting as a SIP *Presence Server* the MPSC is kept up to date on the user's availability. A *Mobile Terminal (MT)* registers itself at an MPC after it is associated with an MP and assigned an IP address via the dynamic host configuration protocol (DHCP). Hereby the serving MPC forwards the SIP registration message to PS. Whenever new personalized user data is available at MPSC and the addressed user is online, a new push session is initiated between MPSC, MPC and MT.

III. MEDIA POINT AND UMTS INTEGRATION

We envision an application-level integration of the WLAN-based Media Point network with the 3GPP IP Multimedia Subsystem (IMS). This approach seems reasonable as both systems employ SIP for their session management. The Media Point network in addition uses SIP for mobility management [3].

Following the tight-coupling approach [6], we propose to embed the Media Point nodes physically or virtually in the UMTS Core Network (CN). A close inter-working between the networks at lower layers could reduce the delays and overheads during vertical handover and service provision procedures.

A. Service Provision Scenario

We consider the scenario wherein the MPSC acts as a *service mediator* between user (MT) and an external Internet server (e.g., streaming server). While the MPSC controls the service session using SIP, the actual (user plane) communication takes place between the MT and the server directly. This is realized through the *3rd Party Call Control (3PCC)* capability of SIP [7,8].

We investigate a scenario with access to IMS-based services which use the MPSC to control the service across the UMTS network. Our goal is to allow the continuation of such services while switching the radio access between UTRAN and WLAN.

B. Integration Architecture

In order to minimize the service disruption we take the approach that the MT can keep its assigned IP address in spite of changing the radio access technology (RAT). While such system transition (i.e., vertical handover) might not be perceived by the Internet server that currently maintains a multimedia session with MT, it will not be transparent to the MPSC that has to control which radio interface to use to deliver the user data. Due to its new functionality regarding multi radio access management and third party session control, we now refer to the MPSC entity as *Multi Access and Session Controller (MASC)*. The proposed tight-coupling integration architecture is depicted in Fig. 2.

The MASC is logically connected to the UMTS domain via an IMS node. It may function as an external or internal SIP application server to the IMS. The MPCs are now connected to and controlled by the MASC through the Gateway GPRS Support Node (GGSN). Given that the MT keeps its local IP address after vertical handover, the proposed architecture allows the GGSN to route inbound IP packets to MT either through the Serving GPRS Support Node (SGSN) or the serving MPC without changing the packet's destination IP address. Due to security reason MASC, GGSN and MPCs should establish a *Virtual Private Network (VPN)*, e.g., using *IPSec*. Therefore the MASC is likely located next to the GGSN, although it is depicted as a separate node in Fig. 2. We further assume that the dual-mode terminal is capable to maintain active UMTS/UTRAN and WLAN connections simultaneously.

IV. INTER-RAT SESSION HANDOVER

The following session handover protocol aims to allow seamless continuity of SIP-based IMS and Media Point services using the proposed integration architecture. We make use of the 3GPP *Location Services* [9] and the associated *Mobile Location Protocol* [10] in order to exploit MT positioning to determine if an MT is within a Media Point coverage area. For this we assume that the MASC is roughly aware of the area covered by Media Point connectivity. Where no connectivity is available, the MT's WLAN transceiver module may be deactivated to save its battery.

A. Protocol Overview

The final goal of our protocol is to switch the packet transmission path between the MT and a correspondent server as the MT switches from UMTS to WLAN (Fig. 2). The path switch should be made transparent to the server (i.e., no IP address change) and packet loss should be minimized or eliminated. As the UMTS connection can be considered more reliable as a WLAN connection (due to the limited MP coverage), the *SIP control path* between MT and MASC (over UMTS) should not be switched or relocated during and after the handover. This way the MASC may still control the session even when the WLAN connection is broken up. The MASC takes further actions as multi access manager to resume the session.

First we consider the provision of IMS-based services via UMTS; the services are to be controlled by the MASC. Before the packet switched service, e.g., a video streaming service, can be offered, a suitable connection between MT and GGSN (called "PDP context" in 3GPP terminology) must be set up and a local IP address must be assigned to the

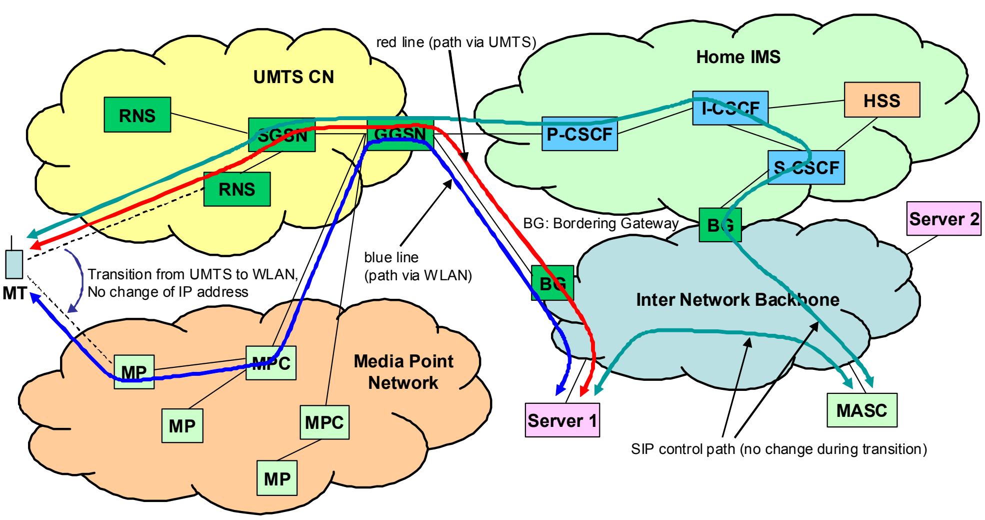

Fig. 2: Switch of packet transmission path due to system transition from UMTS to WLAN

MT. The MT then registers at the MASC through an IMS node. The MASC may then provide a list of available services to the user.

For example, given that the user requests a *video on demand* service, the MASC selects an appropriate (external) video streaming server (*Server 1* in Fig. 2) and invites both MT and server to establish a streaming session. After the invitations are accepted the video packets can be streamed between both parties directly using the real-time protocol (RTP) (i.e., red line in Fig. 2).

In case that the MT wants to switch its radio access from UMTS to WLAN while entering a Media Point coverage, the following procedures will be performed in order to prepare and execute a lossless session handover as well as to avoid perceptible interruptions (Fig. 3):

- system transition anticipation;
- handover preparation in UMTS core network;
- inbound packets forwarding and buffering;
- handover execution;
- PDP context update.

The proposed procedures adopt and extend existing signaling protocols, e.g. the lossless Serving Radio Network Subsystem (SRNS) relocation scheme specified by 3GPP for inter-domain handover [11] and the Context Transfer Protocol [12] to exchange context between IP capable nodes. It furthermore extends the WLAN UMTS inter-working approach of 3GPP [13] to the Media Point concept with SIP-based session management and SIP-based mobility management for WLAN.

B. System Transition Anticipation

Prior to a system transition the inbound packets (i.e., Packet Data Protocol (PDP) packet data units) that have been routed to GGSN, are transferred via GPRS Tunneling Protocol User plane (GTP-U) and Packet Data Convergence Protocol (PDCP) towards the MT via the UMTS radio interface. The same path and transport protocols also apply for uplink. The employed 3GPP location service mechanisms are used to notify the SGSN and the MASC of the event when the MT enters into a pre-defined geographical Media Point coverage. The MASC decides if further actions are needed to prepare for session handover.

C. Handover Preparation in UMTS Core Network

As part of the handover preparation the MASC sends the MT an instant SIP message to trigger the activation of its WLAN module. The pre-defined coverage area is assumed somewhat larger than the actual area such that the MT will not be able to detect and associate with a media point immediately after its WLAN module is activated.

After the corresponding MP (and its MPC) is identified, the MASC transfers a *Context Transfer Data* (CTD) message [12] including both the MT and MPC IP addresses to the GGSN. In addition the MASC transfers the MT IP address and MT identity within a CTD message to the serving MPC. The MT identity has to be a conforming Network Access Identifier (NAI), like e.g. the international mobile subscriber identity (IMSI).

The GGSN then duplicates each MT-addressed inbound IP packet before sending it to SGSN and radio network controller (RNC) via GTP-U tunnels for regular transmission via UMTS. The duplicates are then queued, buffered and associated with the MT context at GGSN. The sequence number assigned to each datagram – i.e. PDP packet data unit (PDU) – during the GTP-U encapsulation, is stored in a look-up table at GGSN. Each PDP PDU has an incremental index, which can be derived from the sequence number assigned by the standard GGSN relay functions. This allows the GGSN to associate the GTP-U sequence number with the corresponding PDP PDU.

D. Inbound Packets Forwarding and Buffering

At the time when the buffering of inbound packets at GGSN is started, there might be some packets that had been routed to and buffered in the RNC but not yet transmitted to the MT. In case that lossless handover is required these packets should be duplicated and queued at the GGSN too, before being forwarded to the serving MPC. Some signaling between the CN nodes before the packet forwarding can be performed:

1. GPRS Tunnelling Protocol – Control plane (GTP-C) is the GGSN-SGSN control protocol. A newly defined GTP-C message *SRNS Data Forward Request* is sent to the SGSN. It includes the MT identity and the GTP-U sequence number (SN_{first}) of the first downlink PDP PDU (IP packet) buffered/queued at the GGSN.
2. Radio Access Network Application Part (RANAP) is the SGSN-RNC control protocol. The SGSN determines the ID of the radio access bearer (RAB ID) used for user plane transmission and sends it within a standard RANAP message *SRNS Context Request* to the serving RNC.
3. The RNC responds with the *SRNS Context Response* message including the sequence number SN_{next} for the first downlink G-PDU still buffered at the RNC according to RAB ID. Due to possible GTP or PDCP fragmentations the first-in-buffer G-PDU is not necessarily the next inbound G-PDU to be sent (as PDCP PDU) to MT.
4. Radio Resource Control (RRC) is the control protocol between RNC and MT. For packet synchronization the RNC sends the MT the sequence number $SN_{PDCP,next}$ of the next downlink PDCP Service Data Unit (SDU) within a standard RRC message *Downlink Direct Transfer*. If the PDCP SDU is a fragment of a PDP PDU, the message includes an *offset value* indicating the amount of bytes of the previous fragment(s) of the PDP PDU already transmitted to MT.
5. A so-called “PDU offset counter” is introduced at the MT, which is set to the received *offset value*, otherwise to zero. It is incremented by the length of each PDCP SDU received via UTRAN. It is later

used to avoid repetition of already transmitted data as well as packet loss.

6. Back to the SGSN, SN_{next} is compared against SN_{first}. If $SN_{next} < SN_{first}$, it means that the RNC still buffers packets that are not yet queued at the GGSN and the packet forwarding should be executed. Otherwise the SGSN sends the *SRNS Data Forward Response* message to the GGSN (continue with *Step 8*).
7. As the RNC must know which packets to forward, the SGSN includes SN_{first} in the RANAP message *Information Transfer Indication* and sends it to the RNC. The *Information Transfer Confirmation* message is sent as response.
8. The SGSN sends the new GTP-C message *SRNS Data Forward Response* to the GGSN including SN_{next}. The GGSN notices if some PDP PDUs are to be forwarded. Otherwise (i.e., $SN_{next} \geq SN_{first}$) the GGSN starts to transfer the buffered inbound PDP PDUs to the serving MPC. Incoming PDP PDUs are further duplicated and routed to both the SGSN and the MPC (i.e., bi-casting) as long as the MT has not associated with the MP yet.
9. Back to the SGSN, packet forwarding is triggered by sending the RANAP message *SRNS Data Forward Command* to the RNC. It contains the RAB ID, GGSN IP address, and tunnel endpoint identifier of the receiving GTP-U entity at SGSN. It means that the packets should be addressed to the GGSN and transferred through the identified GTP-U tunnel.

The RNC (re-)encapsulates the PDP PDUs that have been extracted from the received G-PDUs numbered with SN_{next} up to SN_{first}-1, with GTP-U. In order to differentiate them from those ones with regular uplink PDP PDUs, the optional "other info" header field of forwarding G-PDUs is filled appropriately, e.g., with the string "FORWARDING" and the last one with "FORWARDING_LAST". Both types of G-PDU are multiplexed over the same tunnels towards the GGSN, whereby the destination IP address indicated in the forwarded PDP PDUs is still the MT IP address.

The GGSN routes and transmits the extracted PDP PDUs to the MPC while the regular uplink PDP PDUs are routed towards the addressed Internet server. After routing the last forwarded PDP PDUs to the MPC, the GGSN starts with the transmission of the previously queued PDP PDUs towards the MPC. Unless the MT has associated with the MP, the GGSN bi-casts all incoming PDP PDUs to both the SGSN/RNC and the MPC. The PDP PDUs are transferred to the MPC over an IPSec tunnel, that might be a permanent one. The IPSec sequence number allows the MPC re-sequence the forwarded PDP PDUs.

The MPC extracts and buffers the downlink IP packets for the MT and associates them with the MT context. It waits for (SIP) messages sent by the MT or the MASC before taking further actions. The preparation for a lossless session handover is thus completed.

E. Handover Execution

Once the MT has associated with the (expected) MP and the WLAN-specific or USIM-based authentication is completed, the IP address assignment via DHCP is initiated. The MT broadcasts a standard *DHCP Inform* message to indicate its current IP address to MPC. The MPC might store the session contexts of several mobile terminals. In order to allow the MPC associate the IP address with the MT context, the *DHCP Inform* message also includes the NAI-conformant MT identifier. The MPC responds with the *DHCP Ack* message to confirm the IP address.

A system transition has thus taken place and the MT must switch its IP communication context from UMTS to WLAN. The MT sends the MPC an instant SIP message to indicate the value of its "PDU offset counter".

The MPC then removes the indicated amount of data from the buffered inbound IP packets and starts to transfer the remaining buffered packets as well as the newly incoming packets to the MT via WLAN. The session is now completely handed off to WLAN and the system transition is transparent to the (external) server.

F. PDP Context Update

As the connectivity is assumed to be more secure via UMTS due to the larger coverage, it is desirable to maintain the session management connection between MT to IMS and the MASC via UMTS. The MT must therefore assign a new IP address, i.e., PDP address, for this connection. The PDP address can only be changed if the PDP context modification is initiated by the GGSN [13]. Otherwise the MT must first deactivate its PDP context, before it can activate a new one with a new IP address (Fig. 3).

An approach to allow the MT change its PDP address is to let the MT send an instant SIP message to the MASC via its UMTS interface after receiving the *DHCP Ack* message but before switching its IP communication context to WLAN. The SIP message indicates the performed handover and the request for a GGSN-initiated PDP context modification. The MASC sends then a *Context Transfer Data* (CTD) [12] containing MT contexts to initiate a PDP context modification, to the GGSN. An example context data could be the current status of the MT's UMTS interface associated with the assigned IP address. The GGSN then stops the routing of MT-addressed packets to the SGSN/RNC and updates its routing table to relay the incoming packets to the MPC solely. The GGSN initiates the standard PDP context modification procedure by sending the standard GTP-C message *Update PDP Context Request* to the SGSN to indicate the new PDP (IP) address to be assigned to the MT [13]. On completion the GGSN notifies the MASC of the result by sending a *Context Transfer Data Reply* (CTDR) message in response to the CTD.

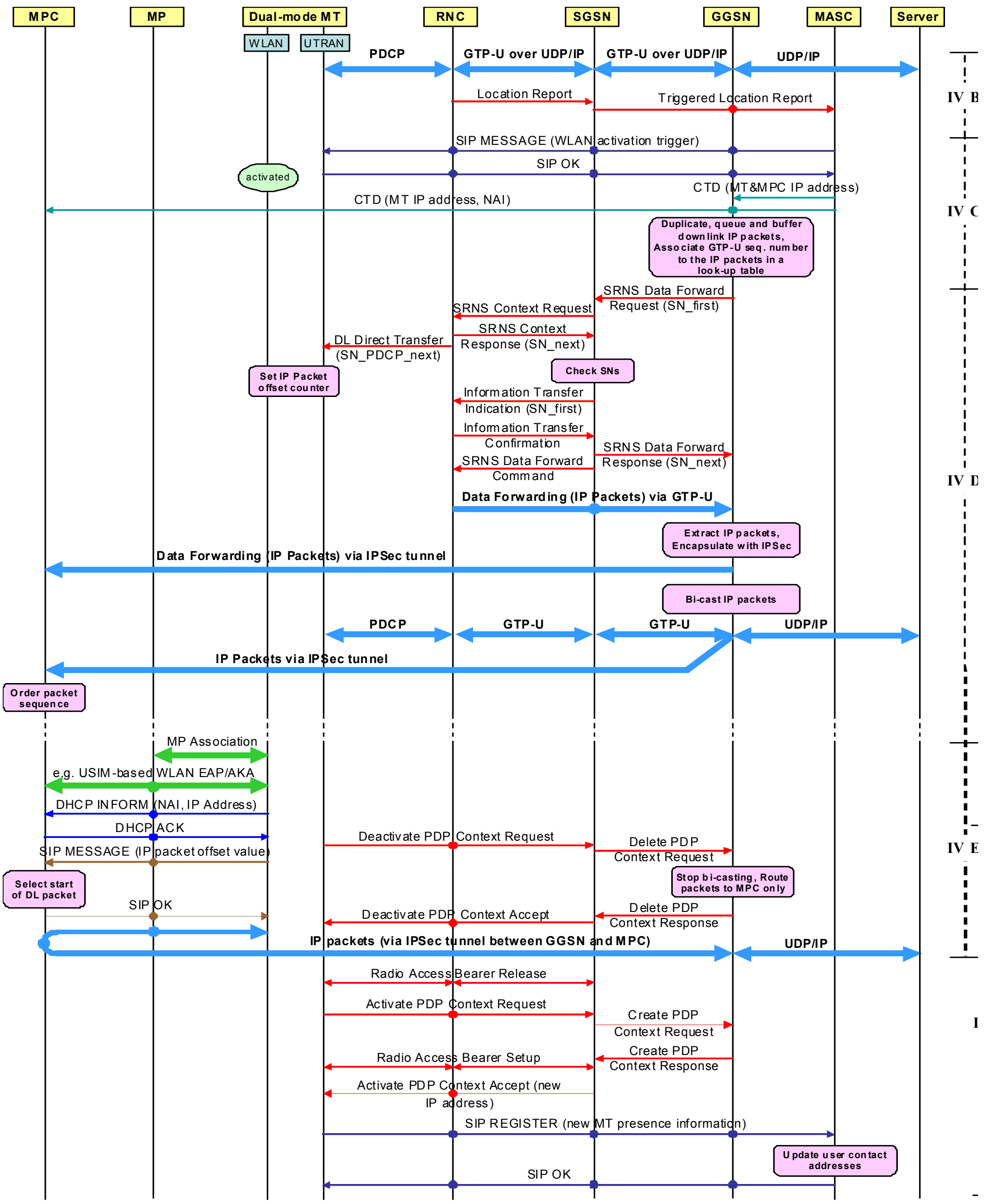

Fig. 3: Lossless session handover during the system transition from UMTS to WLAN

After being assigned a new IP address the MT may renew its SIP registration at the MASC and provide the MT presence information formatted with extensible markup language (XML). The following example indicates that the user *alice* can be contacted via UMTS and WLAN interfaces of her terminal with higher priority (= 0.7) allocated to WLAN:


```
<?xml version="1.0" encoding="UTF-8"?>
<presence xmlns="urn:ietf:params:xml:ns:cpim-pidf"
       xmlns:local="urn:mediapoint-net:pidf-
       status-type"
       entity="pres:alice@mediapoint.net">
  <tuple id="umts-interface">
    <status> <basic>open</basic> </status>
    <contact pty="0.3">IP:192.2.2.23</contact>
  </tuple>
  <tuple id="wlan-interface">
    <status> <basic>open</basic> </status>
    <contact pty="0.7">IP:192.2.2.12</contact>
    <access-router> <id>MPC-1</id>
      <contact>IP:192.2.30.18</contact>
    </access-router>
  </tuple>
</presence>
```


As both IP addresses are listed as contact information, the MASC may decide whether to use the UMTS or WLAN interface to contact the user if a new session is requested.

V. CONCLUSIONS

In this paper we have investigated how to integrate WLAN-based Media Points tightly into a cellular UMTS system. For this approach only existing signaling protocols have been used and extended to provide session continuity during vertical handover between UMTS and WLAN. The used signaling procedures are based on the SRNS relocation procedures of UMTS, the Context Transfer Protocol, as well as the SIP session and mobility procedures for Media Points, which have already been presented in previous work. The data connection to both UMTS and the WLAN Media Points is routed via IMS. The proposed scheme provides benefit to the user, as no change of IP address must take place in spite of system transition, such that the handed off session must not be interrupted and its parameters must not be re-negotiated. Keeping the previous IP address for the (new) WLAN connection may save the required DHCP procedure time of around 0.5 seconds according to [4-5]. In order to reduce battery consumption it is proposed to integrate UMTS Location Services into the multi-access management procedures in order to allow the WLAN interface card to be disabled outside of WLAN coverage. While the proposed mechanism requires considerable amount of signaling it largely adopts already existing signaling mechanisms.

VI. ACKNOWLEDGMENT

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VII. REFERENCES

[1] B. Walke, J. Habetha, I. Herwono, R. Pabst, D.C. Schultz, “The Wireless Media System: A Mobile Broadband System with Invisible Infrastructure and Low Radio Exposure of Humans”, In Proceedings of the ANWIRE 1st International Workshop on “WIRELESS, MOBILE & ALWAYS BEST CONNECTED”, University of Strathclyde, Glasgow, April 2003.

[2] B. Walke, I. Herwono, R. Pabst, “Service Architecture for Infrastructure based Multi-hop Networks based on SIP”, In Proceedings of ICCT 2003 International Conference on Communication Technology, April 2003.

[3] G. Plitsis, R. Keller, J. Sachs, “Realization of a Push Service for Media Points based on SIP”, In Proceedings of the 4th IEEE Conference on Mobile and Wireless Communications Networks, Stockholm, Sweden, September 2002.

[4] I. Herwono, J. Sachs, R. Keller, “A Prototype for the Provision of Mobility-Aware Personalized Services in Wireless Broadband Hotspots”, In Proc. Fifth European Wireless Conference (EW 2004), Barcelona, Spain, February 24-27, 2004.

[5] I. Herwono, S. Goebbels, J. Sachs, R. Keller, “Evaluation of Mobility-Aware Personalized Services in Wireless Broad-band Hotspots”, In Proc. Communication Networks and Distributed Systems Modelling and Simulation Conference (CNDS'04), San Diego, California, USA, January 18-21, 2004.

[6] ETSI, “Requirements and Architectures for Interworking between HIPERLAN/2 and 3rd Generation Cellular Systems”, TR 101 957, August 2001.

[7] J. Rosenberg, J. Peterson, H. Schulzrinne, G. Camarillo, “Best Current Practices for Third Party Call Control in the Session Initiation Protocol”, Internet Engineering Task Force, Internet Draft, draft-ietf-sipping-3pcc-03.txt, March 2003.

[8] J. Rosenberg, H. Schulzrinne, “An offer/answer model with session description protocol (SDP)”, RFC 3264, Internet Engineering Task Force, June 2002.

[9] 3GPP, “Location Services (LCS); Stage 1”, TS 22.071 v. 6.4.0, June 2003.

[10] Open Mobile Alliance, “Mobile Location Protocol (MLP)”, candidate version 3.1, March 2004.

[11] 3GPP, “Handovers for real-time services from PS domain”, TS 25.936 v. 4.0.1 Release 4.0, December 2001.

[12] J. Loughney (editor), “Context Transfer Protocol”, Internet draft, IETF Seamoby group, August 2004.

[13] 3GPP, “General Packet Radio Service (GPRS) Service Description; Stage 2”, TS 23.060 v. 6.1.0 Release 6, June 2003.

[14] 3GPP, “3GPP system to Wireless Local Area Network (WLAN) interworking”, TS 23.234 v. 6.3.0 Release 6, December 2004.

[15] I. Herwono, J. Sachs, R. Keller, “Provisioning and Performance of Mobility-Aware Personalized Push Services in Wireless Broadband Hotspots”, accepted for publication, Computer Networks, Special Issue on “Wireless Networks Performance and Protocols”, to appear 2005.