Optimal Initiation based Vertical Handover for UMTS-802.11 WLAN Overlay networks

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Summary

The next generation of wireless communications will be based on a heterogeneous infrastructure consisting different wireless and wired access systems where users will enjoy fast and seamless mobility and "anytime - anywhere" access to applications with least interruption and disruption of wireless connectivity .In this context, a strong need has been emerged to integrate WLAN with 3G mobile networks and design a hybrid architecture capable to suffice the needs of users with ubiquitous data services and seamless roaming .This paper addresses this need by introducing a vertical handoff algorithm for integrated UMTS-WLAN which uses signal strength as well as predefined threshold value to predict where and when the handover should occur, thus optimizing user throughput and network performance.

Key words:
UMTS, 802.11WLAN, Vertical Handover, RSS

1. Introduction

Now days, in wireless communication arena, the research interest has moved to the development of fourth generation (4G) mobile system. The term 4G is used broadly to include several types of broadband wireless & wired communication systems, not only cellular telephone systems. It is obvious that all we need to deploy 4G is to integrate the existing wireless communication technologies successfully. But the main barriers are-"How this integration will be deployed?" or "What will be the procedure to select a network in a heterogeneous environment?"

In this paper we use an overlay approach to establish a general integration framework between UMTS (Universal Mobile Telecommunications System)-GPRS(General Packet Radio System) & 802.11 WLAN. An integrated UMTS/WLAN architecture will support higher data rates in localized service areas combined with global 3G roaming and intersystem mobility. Later we propose a handoff algorithm to adaptively optimize the handover occurrence where we consider not only signal strength but also predefined threshold value as important factors for initiating handover.

The rest of the article is organized as follows: First we focus on the overlay approach for integration of UMTS / WLAN. Then we analyze three handover scenarios & propose a vertical handoff algorithm where we consider both received signal strength & maximum signal strength count as major factors for handoff initiation. Finally we discuss the simulation results before we conclude this paper.

2. Integration Architecture

A user in WLAN can use the 802.11 accesses for Packet Switched Service (PS) and the UMTS radio network for the Circuit Switched Service (CS). While a user is in UMTS area he/she can use UMTS radio network for both PS & CS service. But once the user enters into the WLAN coverage, the PS service through UMTS RNS is disconnected & re-established through the BR (Border Router) – SGSN path from WLAN. Thus the design assumes that a MN (Mobile Node) is a dual-mode terminal with two interfaces – one is UMTS interface and the other is 802.11 interfaces. The two interfaces can be active at the same time. Since the MN must have two interfaces for UMTS & WLAN respectively, there has to be a layer of abstraction says IAL (Interface Abstraction Layer) [1] between UMTS & WLAN drivers & the general IP layer. Figure 1 shows the architecture where SGSN is the integration point. Two handover scenarios can arise in this type of integration: MIHO (Mobile Terminal Initiated Handover) & NIHO (Network Initiated Handover). In case of NIHO there can be another module says IIS (Intelligent Interface Selection) [2] in the MN.

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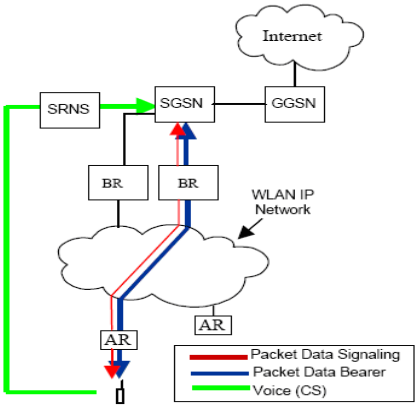

Fig. 1 UMTS-WLAN integrated architecture

The integration architecture depicted in figure 1 shows that the WLAN network is connected through border routers (BRs) to SGSN. A connection through UMTS network requires explicit signaling between the MN and the network to establish and manage the bearer path. The MN in 802.11 cells can maintain connectivity to WLAN network and UMTS through different interfaces. The UMTS connection is only used for voice service. This connection can also be used for PS signaling – that is to establish and manage the PS connection. Hence, the existing GPRS signaling protocol, e.g. PDP context, can be used for establishing bearer data path through WLAN network. But it needs significant changes in most of the GPRS procedures implemented at SGSN to distinguish the two cases where PS bearer paths are set-up through either UMTS RNS or WLAN. In another approach, which is adopted for this architecture, both bearer and signaling paths for PS connections are established through WLAN to the SGSN. This requires small changes in some of the existing GPRS procedures.

3. Proposed UMTS-WLAN Vertical Handoff Algorithm:

We propose an optimal initiation based vertical handoff algorithm to adaptively control the handover occurrence in an integrated UMTS-WLAN architecture. Here we consider not only signal strength but also maximum signal strength count as key factors for initiating handover. We consider the following variables to determine the vertical handoff:

λu: Predefined threshold value beyond which the handoff transition region begins
λ: The number of continuous received signals below threshold of RSS

Our proposed algorithm for vertical handoff between UMTS-WLAN is depicted by Figure 2

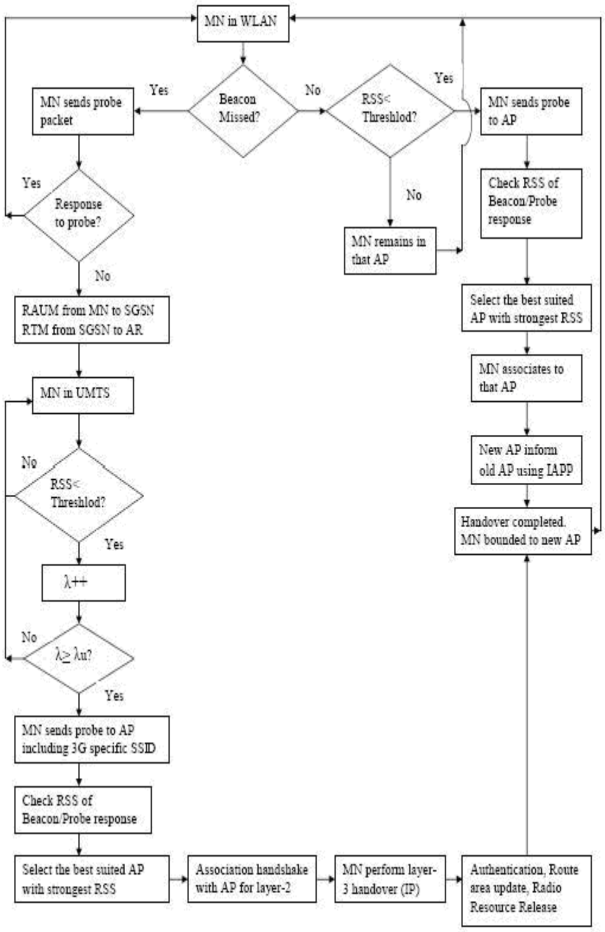

Fig. 2 Proposed Vertical Handover algorithm for UMTS-WLAN

Our proposal is based on three handover scenarios which are explained below:

3.1 Scenario-1: From UMTS to WLAN:

The WLAN APs periodically transmit beacons, which are received by all powered up MN roaming within the AP coverage area even those that are in power saving mode. The MN detects the inter-system handover condition by receiving beacons from the first 802.11 cell after moving to WLAN. It performs the UMTS-WLAN inter-system handover procedure, as shown in Figure 3

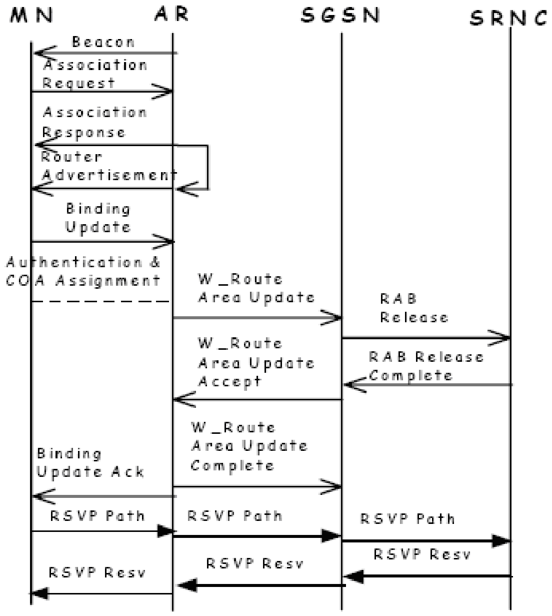

Fig. 3 UMTS to WLAN hand over scenario

While MN in UMTS it checks whether RSS (Received Signal Strength) <threshold. It allows RSS<threshold for certain times (λu) which is user defined. If it finds RSS<threshold for λu times then MN transmits a probe request including a predefined well-known (3G-specific) SSID, which would be supported by all WLANs that support inter working with 3G PLMNs. After confirming that a WLAN supports this 3G-specific SSID, it performs the association handshake with the AP to establish layer-2 connectivity. The AP generates a trigger to AR after issuing association response to the MN. The trigger causes AR to immediately unicast Router Advertisement (RA) to the MN. The trigger expedites the layer-3 handover process, as the AR in this case need not wait for Router Solicitation (RS) from the MN before sending out RA. It also saves an over-the-air messaging, i.e. RS.

Next the MN performs layer-3 (IP) handover. The RA contains pertinent information about the AR, e.g. its IP address etc, which are used by the MN to perform the Binding Update (BU) procedure with the AR [3]. The BU message contains the SGSN address and other UMTS-specific information to identify the mobile node and its mobility context in the SGSN. As a result of receiving BU message, the AR authenticates the MN with the AAA server and makes the care-of-address (COA) assignment. After authentication and COA assignment, the AR initiates the handover procedure with the SGSN by sending Route Area Update message. Before acknowledging the update message, the SGSN first sends RAB release message to the SRNC to tear down the radio access bearers used by the UMTS packet data service. The SRNC releases the radio resources and the channels for the packet data service and then sends RAB release complete message to the SGSN. Then, the SGSN sends W_Route Area Update Accept message to the AR. It also changes the MN's GPRS mobility state to WMM connected state. In the W_Route Area Update Accept message the SGSN includes the list of PDP contexts and the context from SRNC. These contexts remain opaque to the AR, which simply includes them in the Binding Update Acknowledgment (BU Ack) message to the MN. The AR first completes the handover with the SGSN by sending W_Route Area Update Complete message, and then sends BU Ack to the MN to signal the completion of the inter-system handover from UMTS-WLAN.

The MN after receiving the BU Ack message can initiate the resource reservation for the PDP connections inside WLAN. It can selectively reserve resources for some PDP connections and teardown others. Thus, all the remaining PDP contexts will have a corresponding RSVP state at both the MN and the SGSN.

3.2 Scenario-2: Access Point selection within WLAN

The basic unit of WLAN network is a Basic Service Set (BSS) with one Access Point [4, 5]. Several BSSs are connected to construct an Extended Service Set (ESS). We will persist with the term AP to maintain clarity in the ASSOCIATION procedure although the integration architecture clearly possesses AR's at the lowermost levels of the network structure. While the user that is associated with a BSS is moving, the handover procedure is initiated as follows:

1) The mobile terminal checks the Received Signal Strength (RSS) [4] of the periodically transmitted beacon signal from the currently associated AP.

2) If the RSS of beacon is found to be weaker than the threshold, the mobile terminal initiates the AP selection procedure.

3) In passive mode, the mobile terminal listens for the beacon signal from the neighbor APs, and in active mode, the mobile terminal transmits the probe request to the neighbor APs. The APs that receive the probe request send probe responses back to the mobile terminal.

4) The mobile terminal checks the RSS of beacon signals or probe responses from the neighbor APs, and selects the AP with the strongest signal strength which satisfies it's selection algorithm.

5) After choosing an AP, the mobile terminal associates to that AP.

6) After finishing the re-association of the mobile terminal, the new AP informs the old AP of the re association using

Inter-Access Point Protocol (IAPP) and the handover procedure is completed.

3.3 Scenario-3: From WLAN to UMTS:

When the MN moves out of the WLAN its 802.11 interface detects missing beacons. It attempts to detect AP by sending a probe packet. If MN doesn't get any response for the probe then it means handover from 802.11 to UMTS. Figure 4 shows the WLAN-UMTS handover procedure. The MN sends Route Area Update message (RAUM) [6] to SGSN through its UMTS interface including information that indicates that it is disconnected to the WLAN network. The message includes the IP address of the last AR it was attached with. The SGSN sends RSVP RESV TEAR message to the AR, which causes it to release the resources assigned to the MN.

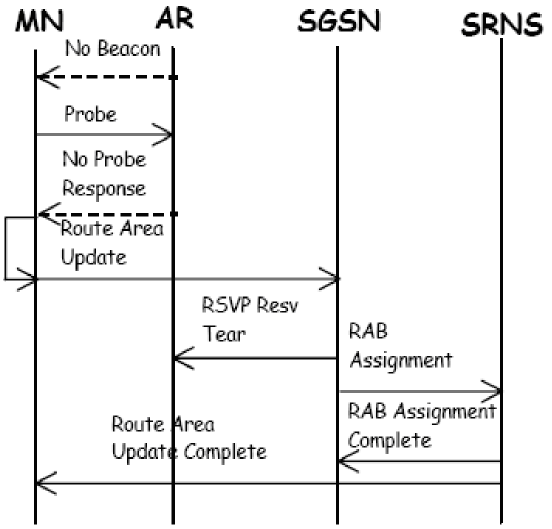

Fig. 4 WLAN to UMTS handover scenario

4. Simulation Structure and description:

For simplicity we assume that there are 3 APs surrounding the current AP each having different RSS value. The code requires a set of inputs, for example threshold signal, beacon signal, probe response etc.

While user is in WLAN, our proposed system checks every time whether beacon signal is missed or not. In this simulation it is determined by input variable (0 for missed, 1 for not). If beacon is not missed, RSS of the current AP is compared to the Neighbor AP's. All RSS values are generated by a random function. Strongest RSS value is measured and if it is greater than the RSS of current AP then the MN disconnects to the current AP and connects to that new AP.

On the other hand, if beacon is missed it checks for probe response. It is also done by input variable (0 or 1). If response of probe found then the program loop back to the beginning where beacon signal is checked. If probe response is not found the program enters into the UMTS section. Here RSS is compared to the Threshold value (RSS_{thres}). RSS is generated by a random function RAND. If RSS is less than RSS_{thres} then the value of λ is increased by one. λ is the variable which counts the number of times RSS is found less than RSS_{thres}. λ_u is the threshold of λ i.e. how many times we will allow the situation RSS< RSS_{thres}. When $\lambda \geq \lambda_u$, the program exits from UMTS section & checks the strength of RSS of neighbor AP's. Bubble sort algorithm is used to select the Strongest RSS signal. At this point handover is occurred and user connects to the WLAN.

Figure 5 shows a sample output of the proposed handoff algorithm

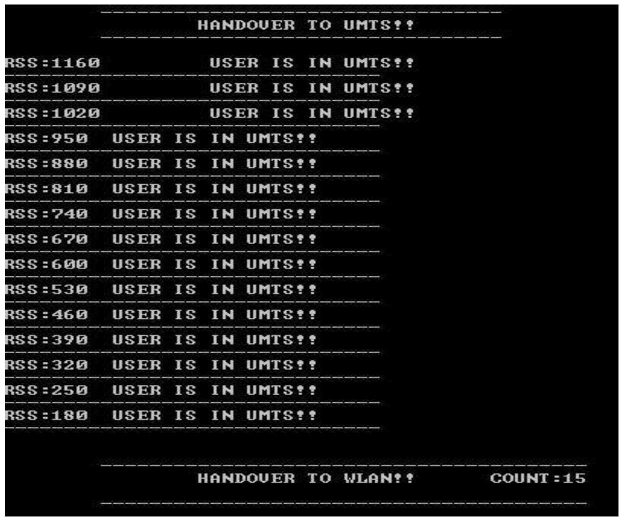

Fig. 5 Sample output of the proposed UMTS-WLAN handoff algorithm

5. Simulation Result:

We have tested the performance of the proposed algorithm over a varied range of simulation parameters. We present some of the results in the plots below. Figure 6 shows the threshold value of the RSS against the number of times MN remains in UMTS before handover. As it is proportional to time, we can say that whenever threshold value increases time spend in UMTS decreases. This is because the user/device criterion for a strong signal increases the possibility to handoff to WLAN which can ensure strong signal than UMTS.

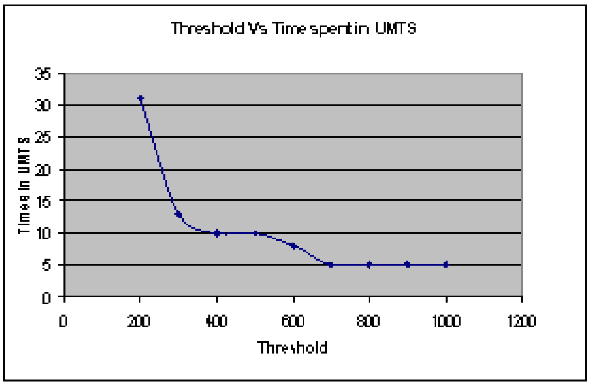

Fig. 6 Threshold Vs Time spent in UMTS

In Figure 7 we have plotted λ against time spent in UMTS before handover. If λ increases time spent in UMTS also increases and vice versa. Because the more number of times we allow RSS below threshold value the much time user will spend in UMTS.

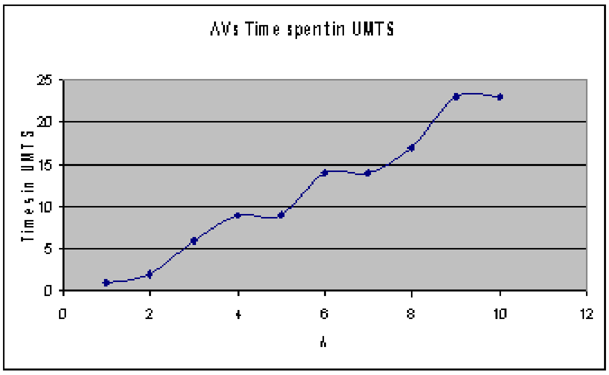

Fig. 7 λ Vs Time spent in UMTS

While beacon is not missed i.e.in case of handover between APs, we also found the following result in Table1.

Table 1 Output of handover between APs

Threshold	*Handover Result(Between APs)*
100	No Handover
200	No Handover
300	No Handover
400	Handoff to AP3
500	No Handover
600	No Handover
700	Handoff to AP2
800	Handoff to AP3
900	No Handover (RSS is below Threshold, But neighbor AP's RSS was less than current AP)
1000	No Handover (RSS is below Threshold, But neighbor AP's RSS was less than current AP)

Conclusion:

In this paper, we proposed an optimal initiation based vertical handoff scheme to adaptively control the frequency of handover occurrence. We proposed proper threshold values to control the handover initiation time according to the received signal strength & maximum signal strength count. This algorithm is specially developed to effectively manage traffic in the systems and avoid too early or too late initiation of the handover process. We measured the adaptive value of both received signal strength & maximum signal strength count against the value of time spent in UMTS. We have a future plan to measure the system performance to improve handover latency and packet loss. Moreover, we will study a method to improve the service quality with respect to optimized resource allocation.

References

[1]. Misra A, Das S, Dutta A, McAuley A & Das SK (2002) “IDMP-based fast handoffs and paging in IP-based 4G mobile networks”. IEEE Communications 3: 138-145.

[2]. Justino Santos, NunoS´enica, SusanaSargento and RuiAguiar “Mobility in Heterogeneous networks: Integration Process”. http://www.av.it.pt/

[3]. G. Dommety et al, Fast Handovers for Mobile IPv6, Internet Draft, draft-ietf-mobileip-fast-mipv6-02.txt, July 2001.

[4]. Muhammad Jaseemuddin, “An architecture for integrating UMTS and 802.11 WLAN networks”, WINCORE Lab. Dept. of Electrical and Computer Engg., Ryerson Univ., Toronto, Canada, November 2002

[5]. Ramjee Prasad, Luis Munoz, “WLAN’s And WPAN’s towards 4G wireless”, Artech House Publishers, Britain, 2003.

[6]. Iti Saha Misra and Anirban Banerjee, “MPLS Based Mobility Framework in 4G Architectures”, www.cs.ucr.edu/~anirban/Anir-IEEEtencon03.pdf

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