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Seamless Handover between UMTS and GPRS

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***Abstract*—UMTS is one step ahead from the 2.5G network GPRS and supports faster data rates with wide coverage area. GPRS and UMTS are already deployed in many countries but seamless handover between GPRS and UMTS still remains as a stumbling block for the service providers to fulfill the continuously increasing customer demand for internet and data access in the IP-based wireless network and to maintain incessant connection for the itinerant service consumers. In this paper we propose a method that mongrelizes 3GPP IMS and MIPv4 to resolve the seamless inter-system handover between UMTS and GPRS with a result of no packet loss and minimum latency so that the itinerant service consumers can get services without any interruption.**

Keywords-UMTS; GPRS; IMS; OPNET; handover

I. INTRODUCTION

Different Radio Access Technologies (RATs) are being integrated to fulfil the continuously increasing customer demand for internet and data access. UMTS and GPRS are the two most widely deployed access technologies until now, but seamless handover between these two access technologies to maintain incessant connection for the itinerant service consumers still remains as an obscure issue for the service providers. UMTS and GPRS differ in terms of spectrums, bandwidth, media access technologies, security mechanisms, performance and so on. The stumbling blocks for intersystem handover are maintaining the continuity of an ongoing session and keeping the IP address to be static. Henceforth, interworking between UMTS and GPRS at the application layer and network layer to resolve these two issues respectively can be useful to get the benefits from both the systems and to use the available spectrum more efficiently.

The rest of the paper is organized as follows: Some related works have been explained in the second section and our proposed method of handover algorithm is described briefly in the third section. The simulation environment built by the OPNET Modeler 14.5 and the results are described in the fourth section and finally we abrogate with a short concluding remarks followed by the acknowledgement of the work.

II. RELATED WORKS

The idea of intersystem handover is already being implemented by many researchers through out the world, while most of the works are between WLAN and GPRS/UMTS. The standard tight coupling method based handover strategy proposed in [1] makes WLAN and GPRS networks reliant on each by connecting WLAN with GPRS through SGSN with Iu-ps interface. The loose coupling method based approach used in [2] lets the data flow directly via the IP network by degrading the performance of handover. A Mobile IP based approach to handover between WiMAX and UMTS is proposed in [3] where the handover cannot be seamless because of using mobile device with single interface not capable of communicating with the two networks simultaneously. A 3GPP IMS based handover was proposed in [4] where the service continuity was not focused. IMS and Mobile IP were applied together in [5] and [6] for handing over between WLAN and UMTS/CDMA2000. This method was also applied in [7] to the handover between WiMAX and UMTS. Again, a single interface mobile device was used here resulting in a break-before-make type of handover.

III. PROPOSED METHOD

A. Interworking Architecture

The proposed architecture has three main features. Firstly, it uses a mobile device capable of maintaining identical radio links simultaneously with GPRS and UMTS with two different interfaces. To minimize latency and packet loss the preferred type of handover would be soft handover. But to achieve soft handover in different network environment, the mobile device requires multiple interfaces to communicate with the different networks at the same time as needed for soft handover. Our proposed device is also capable to process, monitor and compare the signals received through different interfaces and making decisions of handover when appropriate. The idea is that as soon as the user moves into an area having coverage for multiple access technologies, the device will complete the link layer registration with each access technology available there and will start getting services by doing service registration through an appropriate interface according to the priority of selection. The advantage of this hypothetical mobile device is that it eliminates the latency due to link layer registration after the decision is made to handover in the overlapping area. After the decision of handover the user just needs to make the service registration with the network to get services.

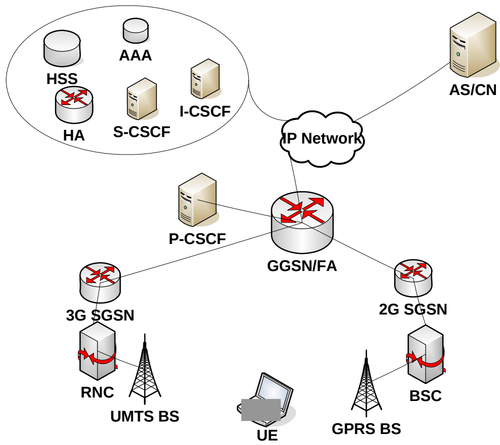

Figure 1. Proposed network diagram

The second feature of this architecture is that it uses Mobile IPv4 (MIPv4) at the network layer to provide high possible level of mobility between different IP subnets without changing the home IP address that allows maintaining transport and higher-layer connections. The next feature of this approach is the use of IP Multimedia Subsystem (IMS) defined by 3GPP capable of supporting any type of access technology (e.g. WiMAX, UMTS, GPRS, WLAN and fixed lines) to support session management and negotiation at the application layer.

The version of IP to be used is yet another issue. 3GPP IMS was proposed based on IPv6, while according to the early releases IMS can also be implemented using the IPv4. The SGSN does not support the IPv6 until 3GPP release-6. Hence, if IPv6 is used there will be an additional latency regarding to the NAT every time passing through the SGSN. But if IPv4 is used for IMS, UMTS and GPRS, it will become a flat platform and the latency related to NAT will be eliminated. Hence, IPv4 is used in our proposed method.

The proposed overall network is shown in Fig. 1. The foreign agent (FA) for both UMTS and GPRS networks is the GGSN. The home agent (HA) is situated in the home network. For the session continuity the server should be the same for each QoS. The application server of the IMS is the correspondent node (CN) of mobile IP. The server bandwidth is distributed among the network according to the speed to be supported and server channel frequency is kept less than the channel frequency of the base station so that there remains no in-transit packet in queue during the handover to eliminate the packet loss in the radio path.

B. *Working Principle*

The block diagram of our proposed handover algorithm is shown in Fig. 2; assuming the user is currently connected to UMTS network.

When the mobile device gets advertisement from a GPRS base station, it starts monitoring the RSS and makes the decision of handover when appropriate.

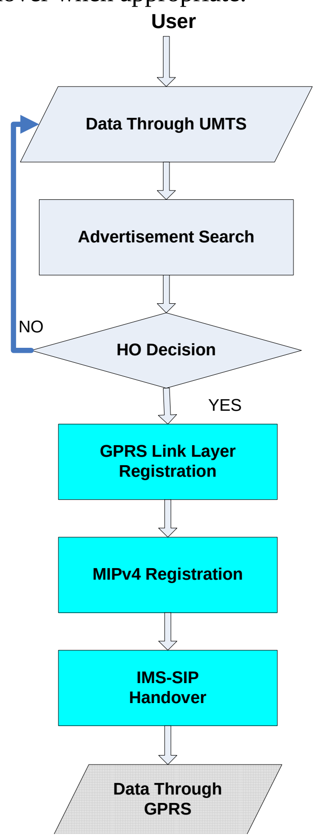

Figure 2. Handover algorithm (UMTS to GPRS)

At this stage, the user starts the link layer registration which comprises of the RRC connection, GPRS Attach and PDP Activation while the user is still getting data from UMTS network through appropriate interface. At the completion of link layer registration, the user completes the Mobile IPv4 registration which is followed by the service registration by IMS. At this stage, the server stops sending data through UMTS network and starts sending data through GPRS network. While the data pipeline still remains with the UMTS network. At this moment the user sends a "Bye" request to the UMTS network and handover is completed by breaking the data pipeline with UMTS interface.

IV. Results and Performance Analysis

A simulation environment was built by the OPNET Modeler 14.5 to implement and characterize the performance our hypothetical approach of intersystem handover.

A. *Simulation Model*

The OPNET Modeler 14.5 provides the standard UMTS model with various features of 3GPP standards. We have modelled a GPRS model based on the available UMTS model. To provide the appropriate QoS, the modeller supports a number a protocols including the SIP, while the provided SIP model does not support all the features of the IMS. The SIP-IMS model is available in the contributed models library of the OPNET University Program [8].

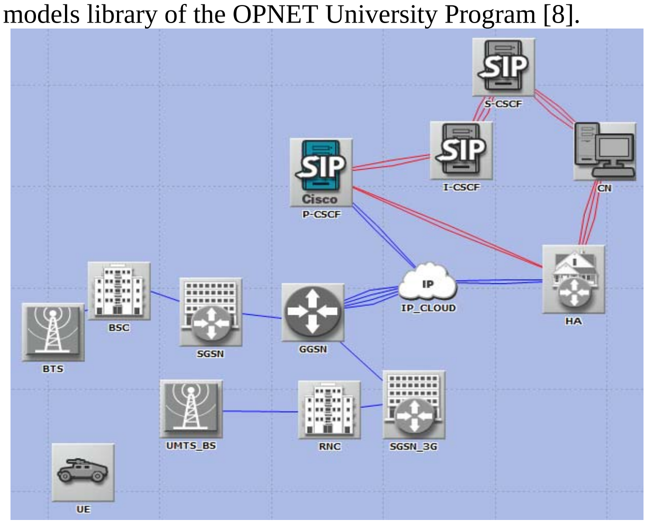

Figure 3. OPNET scenario

We had to make some modification of the model so that both UMTS and GPRS models can support SIP-IMS services. Yet, we also had to reform the available Mobile IP model of the OPNET Modeler to support both UMTS and GPRS networks including the Binding Update to prevent triangular routing of packets. In the Fig. 3 the developed scenario to handover between UMTS and GPRS is shown.

Both GPRS and UMTS networks assumed to be operated by the same service provider and connected under same GGSN that acts as the FA to which the P-CSCF is connected through which it can get the IMS services from the application server (CN). The application server also acts as the correspondent node for MIP. GGSN is connected to the HA located in the home network. P-CSCF connects to the I-CSCF where the registration for the IMS is done and S-CSCF selects the server according to the QoS requested by the user.

B. *Simulation Results*

We carried out the simulation for FTP session. We evaluated the latency of handover in both overlapping area and non-overlapping by our simulation.

The average latency for handover from UMTS to GPRS in overlapping area is 119 ms and in non-overlapping area is 1.814 sec. For handover from GPRS to UMTS, the latency in overlapping area is 118.7 ms and in non overlapping area is 1.813 sec. Hence, the latency for handover from UMTS to GPRS and GPRS to UMTS does not very too much in both overlapping and non-overlapping areas. The latency in non-overlapping area is much higher than that in overlapping area because of extra delay due to link layer registration in the non-overlapping area. The idea is that the user device completes the link layer registration with both networks as soon as it enters in as overlapping area and hence this delay is reduced during handover.

The user experiences an increase in speed when moving away from GPRS network area to UMTS network area as shown in Fig. 4.

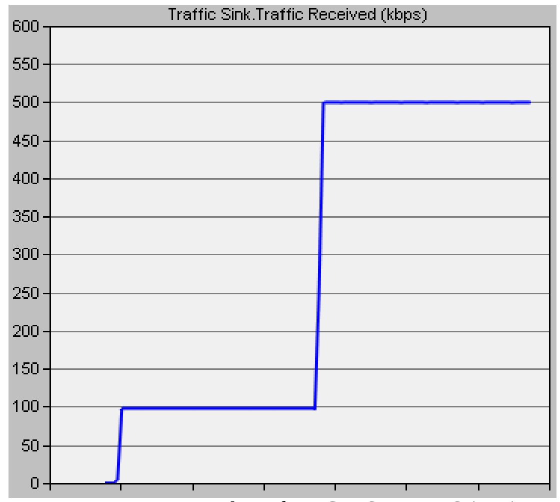

Figure 4. Handover from GPRS to UMTS (FTP)

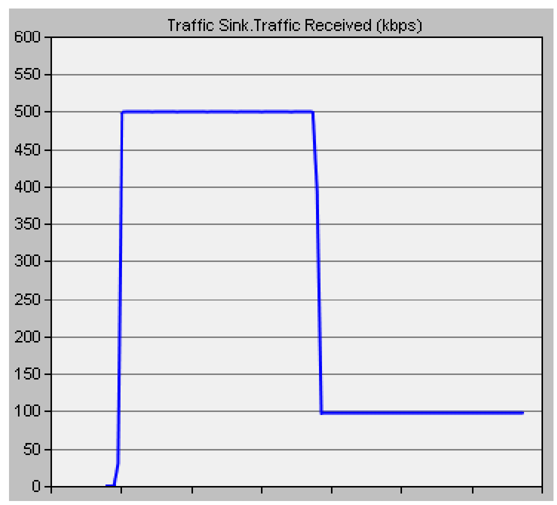

Figure 5. Handover from UMTS to GPRS (FTP)

Conversely, the user experiences a decrease in speed when moves from UMTS area to GPRS area as shown in Fig. 5.

The high latency of handover in non-overlapping area is also can be supported for seamless handover if the speed of the mobile user is not fast enough to leave the coverage of the current network in two seconds. The proposed mobile device with multiple transceivers is able to maintain the radio links with both UMTS and GPRS networks simultaneously which causes a make-before-break type of handover. When the handover process is going on through one transceiver, service continues through the other transceiver. So there is no packet loss for handover in the radio path and the high latency in non-overlapping area does not instigate a session drop to the end user. At the end of the handover process the server just re-directs the data packets to the new network. When the user starts receiving data packets from the new network, the mobile device sends a “Bye” request to the initial network and handover is completed.

Finally, we measured the ETE delay of traffic data in both networks for FTP which is about 57.7 ms in GPRS and 45.9 ms in UMTS. The ETE delay varies according to the pay load of the traffic. The maximum allowed jitter is 50ms and from the ETE delay found here it is obvious that our results are within the limit.

V. CONCLUSION

Our hypothetical method of inter-system handover is acquainted in this paper that can be used for both real time and non-real time applications without any packet loss during handover. Flow routing mechanism and for other reasons there might be some packet losses which are not related to the handover mechanism and out of the scope of this paper.

Finally, the handover latency will be higher in practical case than the results that we have got because of authentication process, security protocol management and billing system. Hence, there is no way to skip these processes and the related latencies. Our approach for intersystem handover can be a good solution for the up-coming 4G network as it uses a mobile device with multiple interfaces and intelligence of making handover decisions that is capable of granting high latency of handover.

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