Analysis of Intersystem Handover: UMTS FDD & WLAN

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Abstract: In today's world not only has mobile communication systems become more competitive, it has also become heterogeneous and globally networked [1]. Today's mobile phone users expect services which stretch beyond a simple audio conversation. Therefore it would not only depend on a traditional single traffic type, but on multiple traffic types. From a multi-service point of view, no radio system can effectively cover all services desired. Consequently it is necessary that integrating different Radio Access Technologies (RAT) are given prominence for future needs. This paper discusses the methods which have been proposed by the Third Generation Partnership Project (3GPP) in interworking Universal Mobile Telecommunication System(UMTS), using Frequency Division Duplex (FDD) transmission mode and Wireless Local Area Networks (WLAN); how and why interworking is possible, and finally a brief insight to a comparative analysis between *interworking* and *integrating*.

1 Introduction

One of the main features of the next generation systems, usually referred to as *systems beyond 3G*, is represented by the inter-operation of different fixed and mobile networks. Contrary to horizontal handover which is forwarding of an active connection from one cell to another of the same RAT, an inter-system handover implies switching from a serving cell of a given RAT to another RAT, e.g. UMTS FDD to WLAN. Depending on the level of integration that is necessary numerous approaches can be taken to combine different RATs. When the integration between different technologies are close, the provisioning of the service is more efficient and the choice of the mode in order to find the best radio access is faster. This could, for example greatly affect real time flows. On the contrary, a higher level of integration means providing a greater effort in the definition of interfaces and mechanisms that are able to support the necessary exchange of data and signaling between RATs.

2 3GPP Approach UMTS & WLAN

UMTS & WLAN interworking was considered by 3GPP TSG SA1 (Services) group. This working group drafted a technical report on a *Feasibility Study on UMTS-WLAN Interworking* [2], where not only different levels of interworking but also different environments were defined. Broadly it has been classified under two methods, i.e. Loose Coupling & Tight Coupling. From a macro point of view the main difference is how and where the WLAN is coupled to the UMTS network. The choice is mainly a trade-off between the required degree of modifications to standards, the seamlessness of interworking and amount of infrastructure in common.

Open Coupling This scenario is an open standard and is used for access and roaming. The term *Open coupling* indicates that there is no real integration effort between two or more access technologies. The WLAN and UMTS networks are considered as two independent systems that share a single billing scheme between them. Although a common database is used between the two; separate authentication procedures are used (i.e. SIM based authentication for UMTS and simple user name and password for WLAN)[3]. Thus a current session in use will always have to be terminated as it enters to a new RAT. Hence seamless handover will never be possible.

Loose Coupling In this scenario, there is a common customer database and an authentication procedure. In loose coupling the operator will still be able to utilize the same subscriber database for existing 3G clients and new RATs (WLAN) clients, allowing centralized billing and maintenance for different technologies. However the new link AAA-HLR requires standardization. Loose coupling is defined as utilization of a generic RAT (WLAN in our case) as an access network complementary to current 3G access networks. It utilizes the common subscriber database without any user plane Iu interface, i.e. avoiding the SGSN, GGSN nodes. As at present this is regarded by many the most attractive solution.

Tight Coupling The key characteristic of this scenario includes the possibility of seamless handover between UMTS and a WLAN. As a consequence it requires additional standardization as opposed to the perviously discussed methods. In tight coupling, the generic RAT network is connected to the rest of the UMTS network (the core network) in the same manner as other UMTS RATs (UTRAN, GERAN) using the Iu interfaces by means of *Interworking Unit* (IWU). One of the most relevant aspects of tight coupling interworking is that it foresees the definition of the Iu interface between different radio access technologies making vertical handover possible.

Integration This scenario is similar compared to the previous method regarding seamless handover. However in this case a WLAN can be viewed as a cell managed at the RNC level. This concept is not widespread because robust network planning is not pertinent for WLANs yet; owing to lack of geographical condensed presence of the system .i.e. interference levels are not considered because in common scenarios geographical spreading of Access Points (AP) ensures lack of interference from neighboring cells. However it should be noted that this method would be the ideal case from the end user perspective.

3 UMTS Network & Coupling

Combining the four previously discussed interworking methods, we get an overall view of where precisely each coupling method merge with the UMTS network. It should be noted that the integrated approach would have a IWU directly connected to a RNC in the same manner a Node B would.

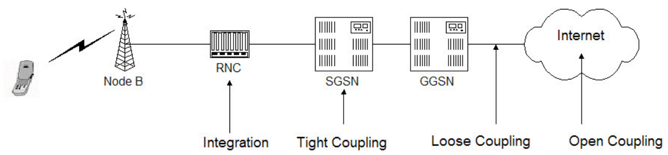


Figure 1: WLAN Coupled at different levels

4 Interworking - Possibility, Requirements & Triggering

Possibility - Slotted Transmission Mode & Sleep Mode UMTS utilizes a *slotted transmission mode* in the downlink, where by a single-receiver mobile station can carry out measurements on other frequencies without affecting its normal data flow. The information which is normally transmitted during a 10ms frame is compressed in time, either by code puncturing or by reducing the spreading factor by a factor of 2. As a result an idle time period of 5ms is created within each frame, which is used for inter-frequency measurement. WLAN too utilizes a similar method termed as the *sleep mode.* Terminals can be in one of sixteen sleep groups, each group having a different sleep periodicity, in which it carries out inter-frequency measurements. The idle period parameter is non standardized and could be set to a desired level by the operator.

Requirements - Designed for Interworking

- *Mobility* (Handover UMTS - WLAN) should be supported. The user should be notified of any possible degradation of the provided Quality of Service (QoS) due to change of access network.
- *Partnership or roaming agreements* between a UMTS network operator and a WLAN network operator should give the user the same benefits as if the interworking was handled within one network operator.
- *Subscriber Identification, Billing and Accounting* between roaming partners must be handled.

Triggering - Intersystem Handover Inter System Handover may be triggered due to the following reasons. The first two are operator specific while the latter is user specific.

- *Coverage Expansion* - at the initial roll out of UMTS coverage will be a limiting factor especially in the rural areas.

- *Load Balancing* - when the traffic in UMTS increases it would be an advantageous to handover certain part of the load to another RAT.
- *QoS requirement* - the user may demand a higher QoS for example at a higher price. If it is available the operator can then redirect it to another RAT which is capable of providing it.

5 Radio Resource Management (RRM)

Tight Coupling utilizes Unitary RRM (URRM) and comparatively less complex than integration which uses a Joint RRM (JRRM). RRM between two heterogenous RATs is complex and the exact details of performing it beyond the scope of this paper. We suggest the following method in which the QoS may be mapped, leading to the handover procedure and monitoring[4].

QoS Mapping		*Negotiation*	*Decision Making*	*Monitoring*
UMTS	*WLAN*			
Conversational Streaming Interactive Background	Low-Latency & Low Jitter Low Latency Low Loss Best-Effort	The response could be three fold *Positive*- Seamless *Negotiate* *Negative* - Drop	Depending on resource allocation proceed to execute handover	Mapped parameters have to be controlled and might trigger a reconfiguration procedure if parameters are under the level imposed by applications requirements

Table 1: RRM & Handover Procedure

6 Performance Analysis - Coupling or Integration ?

Our investigation was to observe if real time flows could be accommodated even in a tightly coupled environment (interworked), or whether an operator always had to opt for an integrated solution in order to obtain optimum performance. The simulated results are for a scenario where a user may be moving from a WLAN environment (serving) to a UMTS environment (target).

The Model In our study we model the IWU functioning as a *M/M/1* queuing system with a Poisson distributed traffic inflow with an average of 5 requests per minute, and performing a μ number of handovers per minute. It is assumed that the queue has infinite buffer size and the only way in which a customer is dropped from the system is due to the exhaustion of capacity in the target cell.

If the user experiences a seamless handover (ideally) the service time would be Exponentially distributed with an average time of $1/\mu$. If the user has to undergo an extended negotiation phase where the service level may be degraded, due to limited capacity, the average service time would increase, a value which is higher than $1/\mu$. The user may or may not be satisfied with the given data rate and may continue the session accordingly. However if the user is unfortunate enough to be handed over to a cell which can not provide capacity at any service class, that session would be terminated. Thus the service time in this case would be a time less than $1/\mu$.

With the above assumptions in place we simulate the scenario at a high load scenario plotting the average delay suffered by a user during the handover and IWU's processing capacity. Since we are interested in real time flows, we denote several threshold levels in the graphs.

The Analysis It was observed that the average delay between the two mechanisms were very similar to each other and was differentiated only by the RNC-MSC-IWU delay. Denoting this parameter as the Round Trip Time (RTT) further investigation was done to observe it's affect on real time flows. This parameter was of particular interest as it is directly related to the operators infrastructure.

The results indicate that we can have a trade off between the RTT and the processing power (handover rate) of the RNC/IWU. For higher RRT we would require a RNC/IWU with higher processing power, and visa versa.

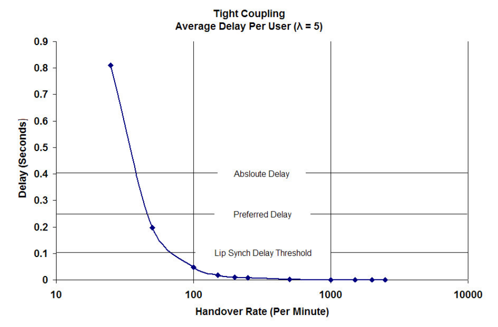
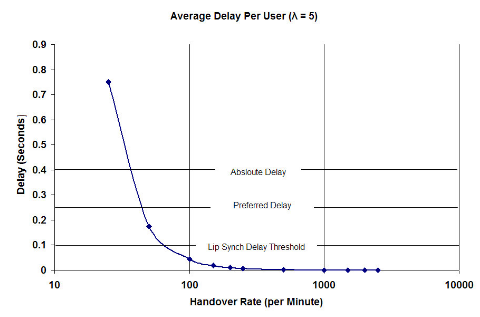
Tight Coupling	*Integrated*
	

Table 2: Delay Comparison of Tight & Integrated

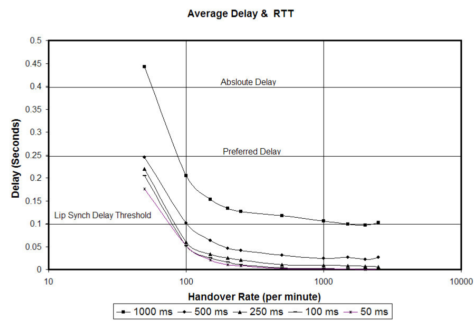


Figure 2: RTT & Delay Comparison

7 Conclusion

The loose interworking has an advantage of being simple and this will enable a rapid market entry. It also centralizes authentication and signalling information related to a user. A single operator can thus offer an integrated service plan to the user. However, the main drawback of loose coupling is it's inability to perform seamless handover.

We observed that under given presumptions, even under heavy loads, real time flows could be accommodated in tight coupling almost as similar to that of an integrated approach. An operator may look at tight coupling as a more viable solution; something which would be superior than loose coupling in terms of end user experience and almost comparable in performance with that of an integrated approach.

It should however be noted that the above conclusions are based on the actual handover based on a single *M/M/1* queue. This too would be further influenced by the handover strategy, algorithm used and load of the other nodes etc. Taking care of additional load could be studied by using several queues possibly for each QoS class, and observing the queuing behavior at each stage through the network. The possibility of guaranteeing the same QoS or if any service could be provided at all will be decided on the capacity of the target cell. The delay variation with the change of capacity will be left open for further study.

References.

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[4] Deploying service at the network edge - Karen Livoli, Product Manager, IP Routing Group, Unisphere Networks, Arlington, VA.