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Performance Analysis of UMTS and WLAN Integrated Network Architecture

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Abstract

A promising next generation wireless network model would combine the benefits of third generation cellular networks with those of Wireless Local Area networks. Integration of the wide geographical range of the former and the high data rates of the latter would provide hotspots with unprecedented capabilities that would revolutionize wireless communication. The achievement of these objectives crucially involves the development of integration architecture. Factors such as authentication, cost-performance benefit, security, accounting, handoff latency, mobility support, and billing mechanisms decide the integration point. In this article, we review two existing 3G-WLAN integration architectures: Tight and Loose Coupling. The study is performed via experimental simulation tests using OPNET in settings where the Universal Mobile Telecommunications Network (UMTS) network connects to a WLAN network at different integration points. These are the Serving GPRS Support Node (SGSN) and the Gateway GPRS Support Node (GGSN). Simulations of the two integration schemes studied measure the parameters and the application delays that occur in cases of direct communication across the UMTS-WLAN networks without first accessing external data networks. The results obtained from this study are compared. The application types studied include FTP, HTTP and VOIP. The parameters measured include load, throughput and end-to-end packet delay.

Keywords—UMTS, WLAN, loose coupling, Tight coupling

I. INTRODUCTION

Significant efforts to integrate the wide ranging terrestrial wireless networks while maintaining acceptable Quality of Service (QoS) guarantees are being made. These include proposals for inter-working gateways, and border location gateways. The telecommunications landscape has seen a sea change in the last twenty years. The rapid rise of wireless mobile communication and the explosion of wireless networking have had huge roles to play. The wireless revolution has also put increasing pressure on today's radio systems, demanding more and more capacity [1]. Today, traditional conversational audio, voice messaging, conversational video, e-mailing, file transfer, fax, telnet, streamed audio and voice, interactive games, and paging are come under the ambit of wireless services.

There are several alternatives to an interworking solution that could be explored. Research has shown [1] that the interwoven attributes of Universal Mobile Telecommunications System (UMTS) and Wireless Local Area Network (WLAN) make interworking a particularly attractive option. Low-bandwidth circuit and packet-switched service are provided by UMTS with high mobility over large geographical spaces. Complementarily, in smaller areas, WLAN provides a high-bandwidth packet switched service for low mobility use. We aim to evaluate the framework for roaming across UMTS and WLAN models and perform a comparison against the integration scenario but without a framework [2]. The framework has a hierarchical and distributed architecture. Predictive handoff, a profile server to support user subscribed services at the WLAN, proxy HLRs and bi-casting have been proposed and studied as features of this framework. A data redirection process was introduced to handle TCP packet loss. This is so we can evaluate the integration system without the framework.

Utilization of high-bandwidth WLANs in hot spots with a switch to UMTS networks when coverage or optimal network conditions are not available has become the current trend. However, the only available way to make this switch is to sign off the first network and consequently sign on to the next network for a new connection [3]. An obviously preferable mechanism would involve some sort of handover mechanism. Ongoing connections could in this way be shifted to the new network without cutting or attenuating the connection. However, such interchangeable use of packet-switched services across network boundaries involves technology a good way away from realization. We will discuss all the coupling scenarios of interworking between WLAN/UMTS and will infer from observations and measurements which one is the most suited to wireless networking.

A. ***UMTS Network Architecture***

UMTS stands for Universal Mobile Telecommunication System. It's a 3G (3^{rd} generation) technology known for its wide connectivity.Fig.1 shows that UMTS network Architecture consist of three domains: User Equipment (UE), UMTS Terrestrial Radio Access Network (UTRAN) and the Core Network (CN) [8]. UE is all the components involved in UMTS access. UTRANcomprises single/multiple Radio Network Sub-systems, each with its own Node B's (each has a coverage area called 'cell'). These connect to a Radio Network Controller (RNC). The component CN is a web of circuit switched networks that provide Packet Switched network (PS), voice and circuit switched services, packet based services[5]. It sometimes also provides a Home Location Register (HLR) which records subscriber locations as well as the services allowed for each one.

The PS network consists of a Serving GPRS Support Node (SGSN). This node routes packets inside the PS. It is crucial in mobility management, logical link management, and authentication and charging functions. Another important node is the Gateway GPRS Support Node (GGSN). This forms a gateway for external packet switched networks such as LAN, WAN or ATM network [5] [9].

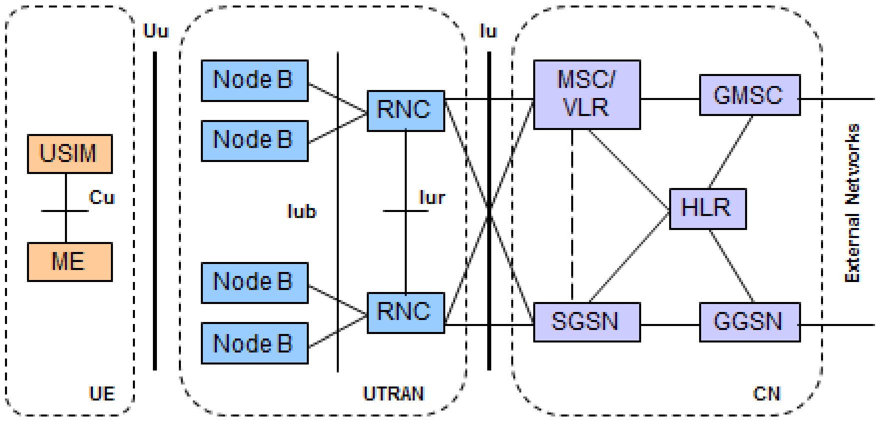

Fig. 1. UMTS Network Architecture

II. Design Goals:

The primary design goal for this paper is the interworking of UMTS and WLAN for opening up options such as alternate radio access networks for airports and other hotspots. Additionally, there has been focus on creation of an open simulation framework to study the issues and trades-offs involved in such interworked architecture. Crucially, the evaluation of performance of this integration through loose coupling and tight coupling is necessary to select the best performer for the next phase of study. We created UMTS and WLAN architecture in OPNET Modeler and focused on integrating both the networks using two types of coupling scenarios.

We simulated two coupling scenarios:

1. Loose Coupling
2. Tight Coupling

In open coupling, UMTS and WLAN utilize separate transport and access networks although using different authentication mechanisms [4,6]. In the so-called loose coupling level, the use of common authentication mechanisms via a link between the authentication, authorization and accounting (AAA) server in the WLAN subsystem and in the Home Location Register (HLR) of the UMTS subsystem is studied. Separation of the two is maintained.In tight coupling, the WLAN Access Point (AP) is connected to the Serving GPRS Support Node (SGSN) similar to a Radio Network Controller (RNC) shown in fig.2. Tight coupling integration model could support a handover between WLAN and UMTS.

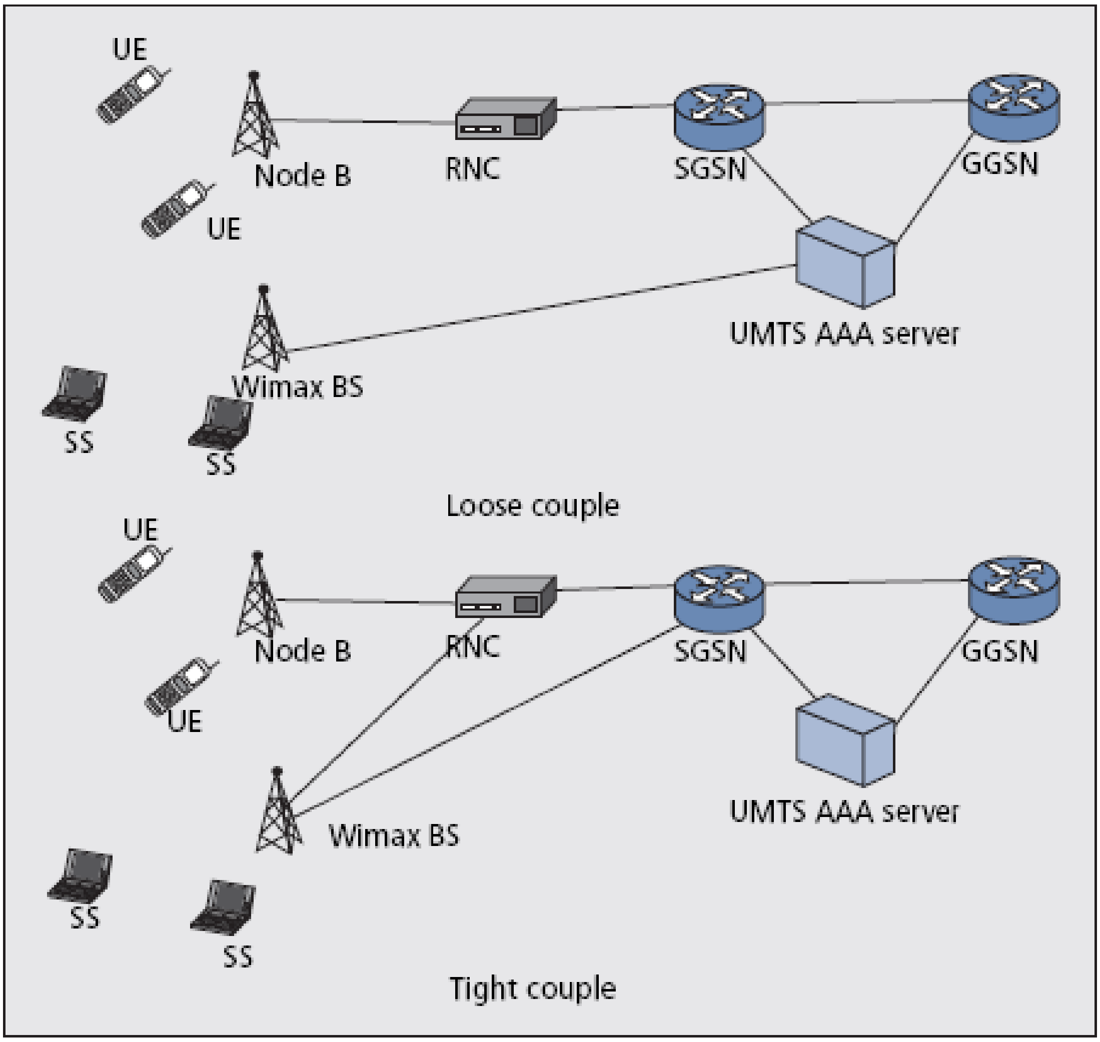

Fig. 2. Loose and Tight Couple Architecture

III. SIMULATED NETWORK DESIGN AND OUTPUT RESULTS

The project implementation took place in two stages.

- Stage One – Performing integration of the UMTS & WLAN Networks with a single user connected in both the networks [7].
- Stage Two – Performing integration of the UMTS & WLAN Networks with multiple users in both the networks. The scenarios taken for analysis are given in Table 1.

TABLE 1. NETWORK ANALYSIS SCENARIOS

Scenarios	NO.OF work stations in UMTS,WLAN	Coupling type
1	1	LC
2	1	TC
3	10UMTS,5 WLAN	LC
4	10UMTS,5WLAN	TC

To compare scenario 1 and 3:

- Delay remained the same for both the coupling models
- Load on the network was almost the same
- Throughput increased drastically with increased number of users in the integrated network

To compare scenario 2 and 4:

- Initially, the load was less when there were more users. Gradually, the load on both of the networks was the same
- The delay was higher for more number of users
- The throughput increased drastically with increasednumber of users in the integrated network

Overall, it was observed that the load was higher in Loose Coupling than in Tight Coupling. This can be seen in Fig. 5.It was also observed that delay observed was higher in Tight Coupling than in Loose Coupling. This can be seen in Fig. 6.

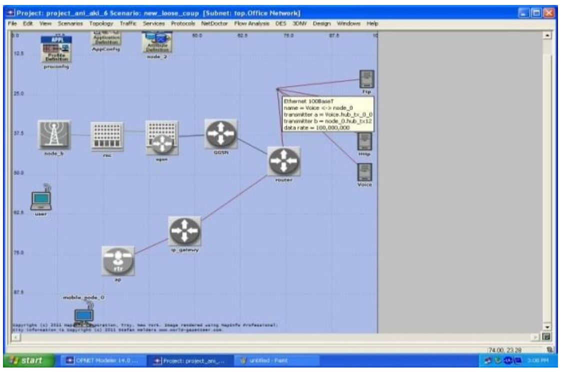

Fig. 3. Scenario 1: Loose Coupling (Single User)

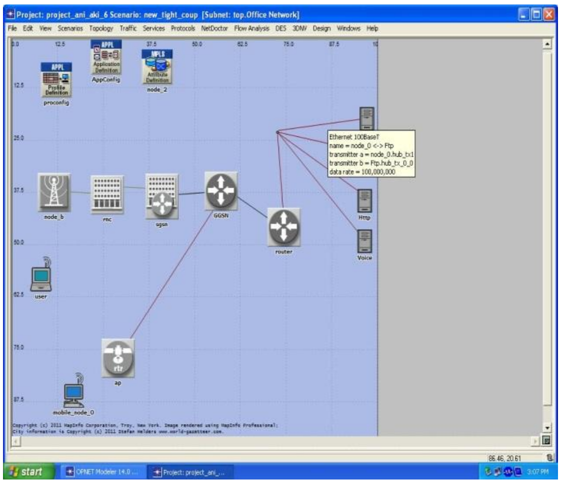

Fig. 4. Scenario 2: Tight Coupling (Single User)

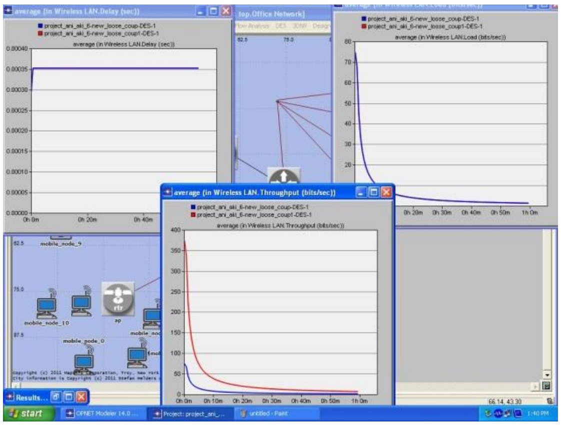

Fig. 5. Scenario 3: Loose Coupling (10 Users)

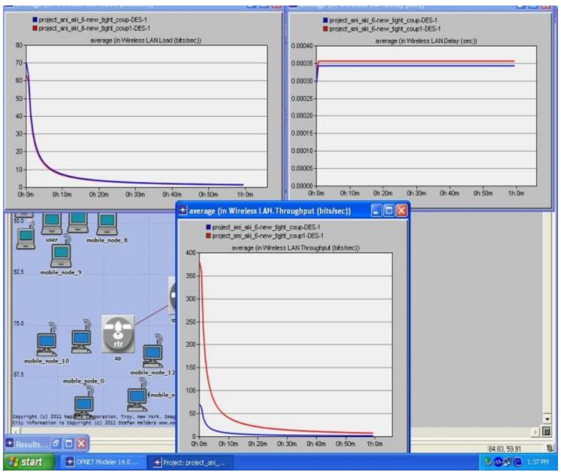

Fig. 6. Scenario 4: Tight Coupling (10 Users)

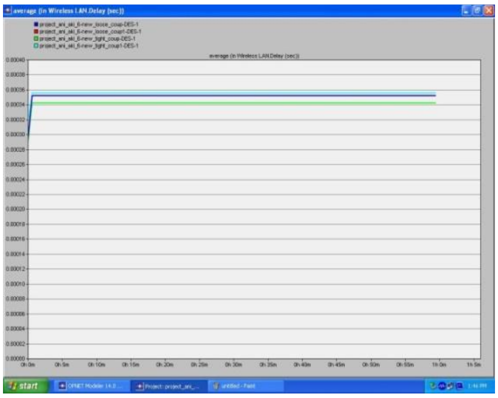

Fig. 7. Load Comparison in all Scenarios

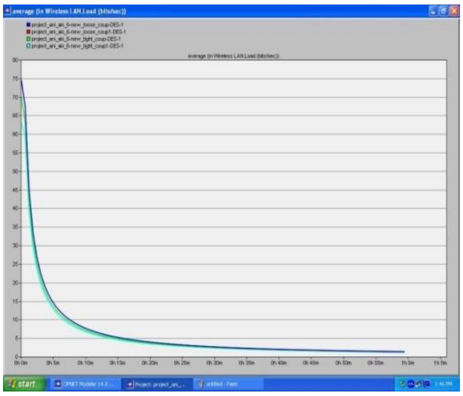

Fig. 8. Delay Comparison in all Scenarios

IV. CONCLUSION

From the evaluation of the performance of different architectural models that attempted to integrated UMTS andWLAN via SGSN or GGSN, important conclusions can be drawn. The approach used presupposes core network localized modifications. It also assumes that consideration of the integration interface alone is enough for the purposes of this study. The result is an architectural model where WLAN operation depends on core network support and the networks function entirely independently. The level of necessary modifications differs according to the varying provided capabilities in the WLAN system itself. The ideal choice of coupling method must form a perfect balance between requirements of the environment and the architectural complexity. With this is mind, the most promising UMTS-WLAN interworking model appears to be suggested by tight coupling architecture. Current market dynamism and the rapid deployment of WLANs suggest that mobile operators should consider provision of network access via WLANs that recycle tried and tested UMTS control mechanisms. The UE protocol must be able to support access via the WLAN interface however the UMTS-WLAN interworking architecture may be enforced.

This paper has undertaken qualitative analysis of coupling architectures based on their performances. In future the work may be extended to focus on similar analysis that instead emphasizes call admission control in interworking models.

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