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Integrating of WLAN / UMTS Network in Hot-Spot Locations Using OPNET

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ABSTRACT

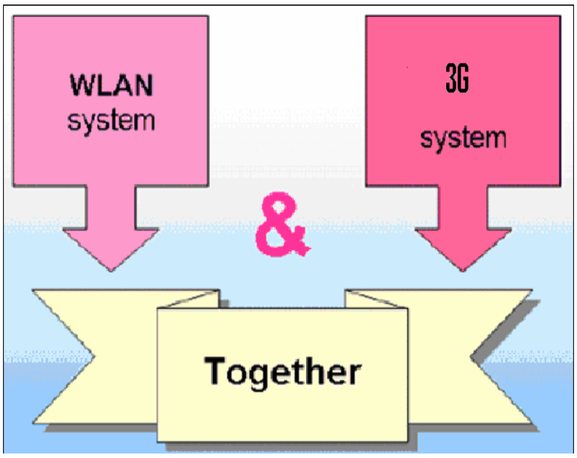
Currently, there is a strong need for integrating WLANs with third generation mobile network and develop heterogeneous mobile data networks, capable of ubiquitous data services and very high data rates in hotspots. Wireless third generation (3G) network is coming with many benefits and features for network users. 3G network main advantages are it provides more connectivity and reachability. In the other side, IEEE 802.11 Wireless LAN has it own advantages which are Broadband service with low cost and widespread technology. This paper evaluates the performance of two 3G/WLAN integration schemes: loose and open coupling, together with two mobility management schemes: Mobile IP and mobile stream control transmission protocol (mSCTP) for an airport as a typical example of a hot-spot location. In addition, the evaluation is carried out for a wide range of application mixes consisting of FTP, HTTP and multimedia Utilizing OPNET as the simulation platform and incorporating the required protocols. The handoff delay between the 3G and WLAN networks, the results indicate that a loose-couple integration solution together with Mobile IP provides the best performance.

Index Terms — Mobile Networks, Mobile IP, mSCTP, open & loose coupling and Handover.

1. INTRODUCTION

Recent research has intensively focused on the next generation communication systems that aim to meet the increasing demand for services with higher data rates and enhanced service quality. The successful deployment of wireless local area networks (WLANs) worldwide has yield a demand to integrate them with third-generation (3G) mobile networks, such as Global System for Mobile communications in Genera1 Packet Radio Service (GPRS), Universal Mobile Telecommunication System (UMTS) and Code Division Multiple Access. As one standard of third-generation (3G) cellular networks, Universal Mobile Telecommunications System (UMTS) supports integrated services and universal roaming with one cell covering up to several square kilometers. However, UMTS provides only limited data rate up to 2 Mbps, and UMTS networks are expensive due to the high cost of spectrum acquisition.

On the other hand, as a wireless data network, Wireless Local Area Network (WLAN) has been developed to provide high-data rate wireless data services Though WLAN is cheap due to the use of unlicensed free frequency band, WLAN has fairly small coverage area and does not provide infrastructure for ubiquitous access. That is, WLAN is targeted to low-mobility users in hotspots area such as hospital, railway station, airport and schools etc,. Therefore, it is compelling to seamlessly integrate the two systems together in order to expand the system capacity and provide ubiquitous access and high-speed services. The key goal of this integration is to develop heterogeneous mobile data networks capable of supporting ubiquitous data services with very high data rates in hotspots. The effort to develop such heterogeneous networks, also referred to as fourth-generation (4G) mobile data networks, is linked with many technical challenges, including seamless vertical handovers across WLAN and 3G radio technologies, security, common authentication, unified accounting and billing, WLAN sharing (by several 3G networks), consistent Quality of Service and service provisioning.



Proposal of Interworking for 3G and WLAN

In our article we deal with several of challenges and propose technical solutions that can effectively address them. In particular, we propose and discuss specific WLAN 3G interworking techniques and architectures that can support common authentication, authorization, and accounting (AAA), WLAN sharing consistent service provisioning and so on. Our architecture is based on the requirements associated with some typical interworking scenarios To properly integrate a WLAN into a 3G mobile network the optimum combination of an integration scheme and a mobility management scheme must be selected. Hence, the performance of two integration and two mobility management schemes is studied for integrating a WLAN into a UMTS network at an airport or railway station as a typical example of a hot-spot location. Further, the study considers different application mixes and traffic loads.

The studies are already defining six possible scenarios for service integration between 3G networks and WLANs. These scenarios range from the simplest form of integration, common billing and customer care, to the most complex form of integration, where access to 3G circuit-switched-based services with seamless mobility is allowed from the WLAN system. Of interest to this study are the 3rd and 4th integration scenarios where 3G packet-based services and service continuity is supported in the heterogeneous network. While studies from an architecture point of view are abundant, very few, if any, studies can be found on performance of these heterogeneous networks for various Internet applications. For example, the study in attempted to quantify the performance of a loose coupling Mobile IP based solution. In specific the study focuses on the optimization of the handoff latency figure measured at the transport layer for a generic traffic type that is not specified in the paper.

In this paper we attempt to evaluate the performance of four network integration solutions: open coupling with mSCTP, open-coupling with Mobile-IP, loose coupling with mSCTP, and loose-coupling with Mobile- IP. In addition, the evaluation is conducted using simulations for a varying range of traffic loads and mixes for three Internet applications; FTP, HTTP, and multimedia streaming. The purpose is to characterize the performance of applications and the network as a whole in terms of delay and throughput figures with respect to the four different integration solutions. We also quantify the handoff delay for the assumed traffic session to gauge the suitability of each of these solutions for supporting service continuity.

2. BACKGROUND

A. UMTS Network Architecture

A UMTS network consist of three interacting domains; Core Network (CN), UMTS Terrestrial Radio Access Network (UTRAN) and user equipment. The main function of the core network is to provide switching, routing and transit for user traffic. Core network also contains the databases and network management functions. The basic Core Network architecture for UMTS is based on GSM network with GPRS. All equipment has to be modified for UMTS operation and services. The UTRAN provides the air interface access method for User Equipment. Base Station is referred as Node-B and control equipment for Node - Bs is called Radio Network Controller (RNC). Node B provides the immediate wireless access for mobile subscribers, while the RNC assumes the management and control tasks within the UTRAN and interfaces with the rest of the UMTS network. The Core Network is divided in circuit switched and packet switched domains. Some of the circuit switched elements are Mobile services Switching Centre (MSC), Visitor location register (VLR) and Gateway MSC. Packet switched elements are Serving GPRS Support Node (SGSN) and Gateway GPRS Support Node (GGSN) and other functional entities..

B. General WLAN Architecture

The IEEE 802.11 defines the standard for WLANs. A set of stations that communicate in a Wireless LAN is called a Basic Service Set (BSS). The WLAN operates in either ad-hoc mode or infrastructure mode. The latter is relevant to the integration with wireless networks. In ad hoc a network architecture where these mobile stations directly talk to each other and are not connected to a wired network, e.g. the Internet or the corporate LAN, is an Independent BSS .In infrastructure a BSS that includes a central access point (AP) where all stations connect to, is no longer independent and referred to as an infrastructure BSS. All mobile stations need to communicate with the usually stationary AP to be able to exchange information. The AP functions as a relay for the stations as well as a gateway to the wired network if attached. An access point (AP) coordinates the transmission among nodes within its radio coverage area. A mobile node (MN) can only associate with one AP at a time. A number of APs can be interconnected through an IP routed network to form a WLAN IP network WLANs move out of hotspot applications and become pervasive extensions of corporate wired LANs; the world will need simpler and more permanent solutions to the co-channel interference problem.

C. Coupling scenarios

From an architectural point of view, these scenarios can be reduced to four levels of coupling. The first level is open coupling. In this case UMTS and WLAN make use of two separated access and transport networks and billing is common – although using different authentication mechanisms. The next level is the so-called loose coupling, which enables the use of common authentication mechanisms by providing a link between the authentication, authorization and accounting (AAA) server in the WLAN subsystem and the Home Location Register (HLR) in the UMTS subsystem, which are still kept separate. With tight coupling, the WLAN Access Point (AP) is connected like a Radio Network Controller (RNC) to the Serving GPRS Support Node (SGSN) in the Core Network (CN. An interworking Unit might be added. With tight coupling the handover between WLAN and cellular subsystems could be supported. Finally, with very tight coupling where the WLAN access point is connected to the RNC. The focus of this paper is to analysis the behavior for two coupling scenarios "Loose Vs. Open" Coupling. Also, studying the effects of adding mobility schemes "mSCTP and Mobile IP" over both integration scenarios.

D. Mobile Stream Control Transmission Protocol (mSCTP)

Transport layer mobility is proposed as an alternative to network layer mobility for seamless mobility management. Mobility management in the transport layer is solely accomplished by use of Stream Control Transmission Protocol (SCTP) and its currently proposed Dynamic Address Reconfiguration (DAR) extension. SCTP with its DAR extension is called Mobile SCTP (mSCTP). mSCTP is a transport layer protocol similar to Transmission Control Protocol (TCP) that operates on top of the unreliable connection-less packet network. It provides unicast end-to-end communication between two or more applications running in separate hosts and offers connection-oriented, reliable transportation of independently sequenced message streams. The biggest difference between mSCTP and TCP is multi-homing i.e. the idea of having several streams within a connection (multi-streaming) and the transportation of sequence of messages instead of sequence of bytes.

E . Mobile IP

Mobile IP is most useful in environments where mobility is desired and the traditional land line dial-in model or DHCP do not provide adequate solutions for the needs of the users. If it is necessary or desirable for a user to maintain a single address while they transition between networks and network media, Mobile IP can provide them with this ability. Generally, Mobile IP is most useful in environments where a wireless technology is being utilized. This includes cellular environments as well as wireless LAN situations that may require roaming. Mobile IP can go hand in hand with many different cellular technologies like CDMA, TDMA, GSM, AMPS, NAMPS, as well as other proprietary solutions, to provide a mobile system which will scale for many users. Each mobile node is always identified by its home address, no matter what its current point of attachment to the Internet, allowing for transparent mobility with respect to the network and all other devices. The only devices which need to be aware of the movement of this node are the mobile device and a router serving the user's topologically correct subnet.

3. OPNET

Optimum Network Performance (OPNET) simulation tool is very powerful simulation tool since it has standard model libraries which consist of many network standards and they are used in "Plug and Play" fashion. This has its benefits of removing coding overhead from the analyst and let him focus more in network analysis. Also, many network scenarios can be simulated by modifying elements' parameters. The model libraries are grouped by devices, links, LANs & Clouds and Utility objects. Also, many standard and vendor specific protocols are available and the devices can be easily configured to work for specific protocol. In addition, OPNET's user can build his own model using available model tools and OPNET has the ability to validate generated model. Randomness is key factor in OPNET simulation since many parameters are configured by probability functions. Therefore, single simulation scenario isn't enough to give accurate projection for real network behavior. As a result, there may be some discrepancy between the analytical study and simulation results and it should be within acceptable range as long as the difference is justifiable. Finally, OPNET is very powerful in terms of collecting simulation statistics where the user can select as many statistics he needs and the results can be calculated in any form (i.e. average, PDF, CDF and …etc).

4. PERFORMANCE EVOLUTION

We describe the simulation model and assumptions used to evaluation the four integration solutions of interest. The simulation model is designed using OPNET™ Modeler 14.5 and the simulation parameters were selected to accurately model an interworked WLAN-UMTS system supporting a "hot spot." To compare the performance of loose and open coupling schemes simulations are performed in both architectures with the same simulation parameters: number of nodes, traffic loads and mixes, etc. Thus, the network design shown in Figure depicts the model used for simulation. The design consists of three major parts; the WLAN network, the UMTS network, and the Internet Service Provider (ISP) network. The ISP network hosts the applications' servers available for customer access as well as the customer care and billing system (CC&BS). It should be pointed that the network design depicted in Figure is valid for both the open coupling and the loose coupling integration schemes. The difference between the two integration schemes is that in the case of the open coupling scheme the HLR is used for authentication by the UMTS network only, whereas in the case of the loose coupling scheme the HLR will be used for authentication by both the WLAN and the UMTS networks.

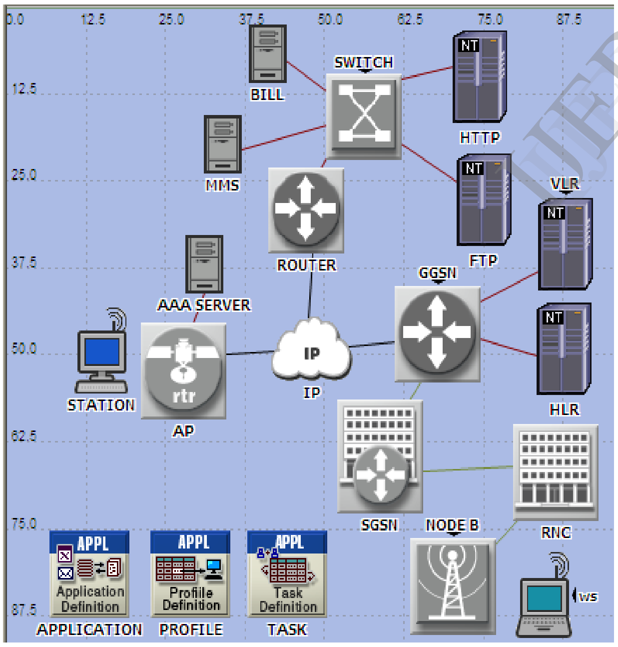
Our project focuses on evaluating the performance of these integration schemes through open and loose coupling and selects the best of this for the next phase.

1. Focus the design on the 3GPP proposed Scenario 2 for supporting 3G authentication and access control.

2. Utilize IP cloud as the common service interface for applications in order to guarantee independence of applications from the underlying radio access network.

The simulation model incorporates several custom made components (network entities and procedures) that were developed during this study and that were lacking from the OPNET™ Modeler 14.5. Some of the major components that were lacking include:

- **Support for AAA, HLR, and VLR.**
- **Support for mSCTP under both UMTS and WLAN Models.**
- **3) Support for Mobile IP under UMTS model.**



Network Design using OPNET

4.1Traffic Calculation

Traffic calculations are based on the following assumptions
1. Considering 5000 users with 1 Mbps for each user.

2. Implementing background traffic in all backbone links based on the traffic that passes every link with associated traffic percent.

3. The number of foreground users is decreasing as the number in the backbone decrease to show the difference between open and loose coupling with different number of users.

4. Assuming there are other networks that link to the same backbone. Therefore, we have mapped every number of simulation users to link user where it can handle 1000 users at a time with 1 Mbps for each. This will result on filling 1G link in the backbone.

4.2 Assumption

We have made the following assumptions to keep the simulation complexity manageable, while still meeting the research goals. This section describes assumptions made in modeling both the UMTS and WLAN data networks, as well as the interworking of these two technologies.

- **For Mobility purpose, the users will start moving from the home network (i.e. UMTS) to foreign network (i.e. WLAN) after five minute from starting the simulation.**
- **All UMTS users will move to WLAN network.**
- **Multimedia traffic is simulated as Video Conferencing.**
- **The foreground user is varies under different load (i.e. from 5000 to 1000) to show the difference between loose and open coupling with different number of users.**
- **The authentication process has been simulated using custom application.**

5. SIMULATION RESULT

The major focus of the paper is to study the performance of the integrated network given the two types of integration schemes and the two mobility management schemes. The performance metrics of the paper is concerned with are:

WLAN delay, WLAN throughput, each application response time, throughput and handover delay.

A. Traffic load

It has been observed that increasing the traffic load increasing the WLAN delay, and each application's response time and throughput. Further it is clear that increasing the traffic load is less significant on the MMS response time than on both the FTP and the HTTP response times.

B. Open vs. Loose Results

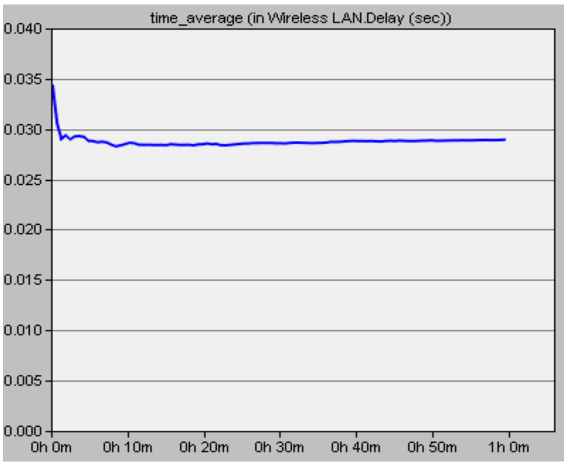
This paper studies Open Vs. Loose Coupling in terms of application/ WLAN/ UMTS traffic and response time. Also, the same matrices have been considered on analyzing mobility schemes. It is evident that both FTP and HTTP have higher throughput when the loose coupling schemes then when the open coupling scheme is used. In summary, the loose coupling scheme is preferred over the open coupling scheme since the loose coupling scheme provides for higher throughput for FTP and HTTP than the open coupling scheme.

C. Handover Delay Calculations

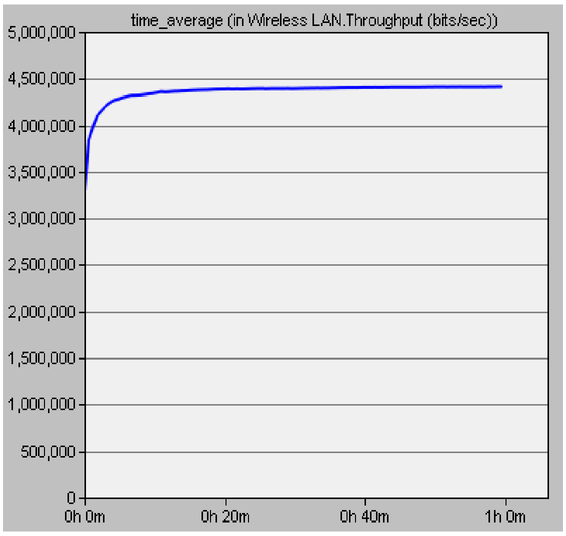
Mobile IP provides faster handover than mSCTP. Since mSCTP handover traffic is performed with application server. In addition, mSCTP over loose coupling produce very high handover delay when compared to other settings. Also, Mobile IP over loose coupling has higher delay than Mobile IP over open coupling due to authentications traffic between the AAA server and the HLR.

SIMULATION OUTPUYS:

1. WIRELESS LAN DELAY



2. WIRELESS LAN THROUGHPUT



6. CONCLUSION

While generic integration solutions for 3G/WLAN networks are abundant in the literature, very few, if any studies present performance evaluation for Internet applications for such heterogeneous networks. This paper attempts to bridge the gap and present a summary of performance figures obtained for four integration solutions. Using simulations the paper evaluates the performance of integrating a WLAN into a UMTS network in a hot-spot location such as an airport and railway station. We have considers two integration schemes: open coupling and loose coupling and two mobility management schemes: Mobile IP and mSCTP. Furthermore, this paper took into account varying both the traffic load and the application mix when conducting the simulations. The performance metrics considered in the paper include WLAN delay, WLAN throughput, each application response time, each application throughput, and the handover delay. The results show that the loose coupling integration scheme together with Mobile IP provides the overall best performance.

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