# A SIMULATION BASED EVALUATION ON THE PERFORMANCE OF INTEGRATED 3G - WIRELESS LAN NETWORK.

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**ABSTRACT**

*New generation of mobile communication systems will focus on seamlessly integrating existing wireless technologies including 3G cellular systems, wireless LAN and Bluetooth to create a wide coverage, improved capacity and enhanced QoS heteregeneous wireless communication system. It is envisaged that the next generation of wireless communication systems will support comprehensive and personalized services, providing stable system performance and quality of service.*

*In this paper we investigate and analyse the perfomance of a wireless communication system which consists of an integrated cellular communication system and a wireless LAN radio access networks inorder to determine an optimum combination of radio access technologies in a coverage area for efficient handling of mixed traffic requests from mobile users.*

## 1. INTRODUCTION

The envisaged new generation of wireless mobile system will complement and/or replace 3G systems, as well as second-generation (2G) systems that have already been in use for about a decade. One approach in designing such a wireless system will be in the same way as previous generation of wireless system, that is yet again focus on higher data rates (now beyond 2 Mb/s) and find new frequency bands for a worldwide standard [1] [2] [3]. However, it might not be this straightfoward as one of the main concern is that new generation of wireless infrastructure will be deployed in an environment where many other types of wireless, and wired, communications systems are already in place. Moreover, future wireless communications will become focused on services and user needs, thereby forcing the mixture of available wireless infrastructure elements to be used in more transparent way [4] [5] [6]. Therefore, the previously important air interface standard and frequency band issues will become secondary concerns.

In principal it is difficult to realize a single system which can support high data rate, mobility and offer wide coverage because the system performance (e.g. cell size and transmission data rate) depends on frequency bands [7]. Thus, the new generation wireless

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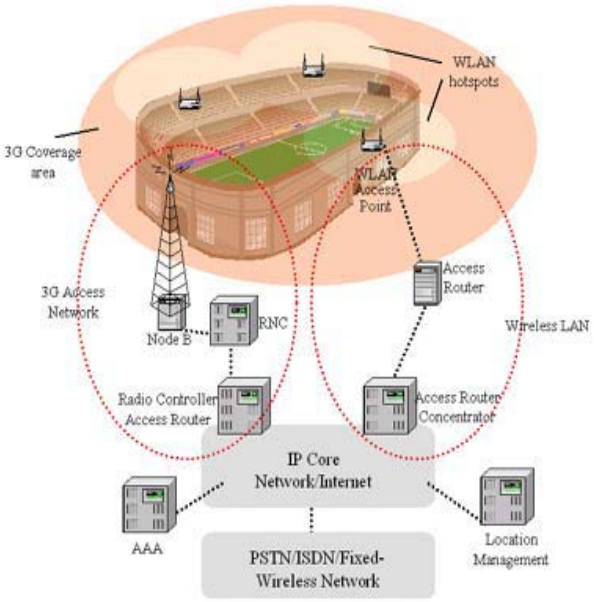


**Fig. 1**. An integrated 3G cellular and wireless LAN network scenario

communication systems are envisaged to include several different technologies of which some will offer high performance in providing high data rates and others will offer service coverage or high mobility. Current 3G W-CDMA wireless systems offer wider coverage, improved capacity and data rates up to 2 Mbps (can achieve up to 10Mbps in the reverse link for the case of HSDPA), whereas wireless LANs can offer data rates up to 54 Mbps and operate in unlicensed frequency band. Moreover, there are several major wireless LAN standards (802.11a, 802.11b and most recently 802.11g) operating on different frequency bands (2.4 and 5 GHz).

The ETSI, IEEE and 3GPP organisations address the 3G and wireless LAN interoperability topic in terms of architecture and protocols but do not current consider the possible interaction mechanism involved at the system level [8].

This paper assumes a multi-network scenario comprising 3G cellular system and wireless LAN (based on the 802.11 standard specifications) and looks at the optimum combination of the cellular base station and wireless LAN access point in a service area which will

efficiently distribute traffic over the two radio access networks (RAN), as a result increase the spectrum utilization efficiency of the whole system by ensuring that mobile terminals are served by the optimum radio access network (RAN) technology available. Fig. 1, shows a 3G cellular and wireless LAN integrated network scenario considered in this work. In this scenario the network is depicted to have a heteregeneous, distributed, all-IP network architecture which is envisaged to replace traditional ATM backhaul and core network. This core network will be dominated by connectionless packet switching technologies with gateway routers interfacing the network with a multitude of wired and air interface from earlier generation communications systems like PSTN/ISDN network and 2G and 2G+ technologies.

## 2. INTEGRATED SYSTEM SCENARIO

Traditionally, to handle mixed range of traffic, 3G systems uses a mixed cell layout architecture that consists of macrocells overlaid on micro and pico cells. In this type of network, the local traffic is operated on the micro and pico cells while the highly mobile traffic is operated on the macro cells thus reducing the number of hand-offs required for fast moving traffic [9]. In the envisaged 3G cellular and wireless LAN integrated system, the 3G cellular system will provide macro cell coverage because of its larger coverage potential whereas the wireless LAN access points will operate as micro or pico cells (hotspot coverage) as their coverage distance is limited from several tens of metres to about 300m. Fig. 2, shows the deployment scenario of a system having 3G macrocells overlaid on wireless LAN access point hotspots offering microcell coverage.

In this integrated network it is neccessary to consider the location of the transmitters so as to be sensitive to the coverage needs at the different receiver locations over the service area. Propagation prediction techniques are usually used to estimate the quality and instensity of coverage over a given area. Optimization models and algorithms can also be used to determine the best location site, as measured by a suitable merit of objective function, given a specific propagation model [10]. One of our goals is to locate the transmitters (3G cellular base stations and wireless LAN access points) so as to provide a coverage of required intensity (minimum path loss) to the entire service area under consideration.

Obviously a good transmitter location will result in an acceptable coverage performance by the transmitter (base station or access point) using a minimum amount of power and, hence, can result in a lower co-channel interference and in improved frequency re-use. In cellular systems interference is a major bottleneck in increasing capacity and always responsible for dropped calls. Bearing that in mind, we look at how different combination of wireless LAN access points in a service area served by 3G cellular base stations can offer improved performance to the whole system in a scenario

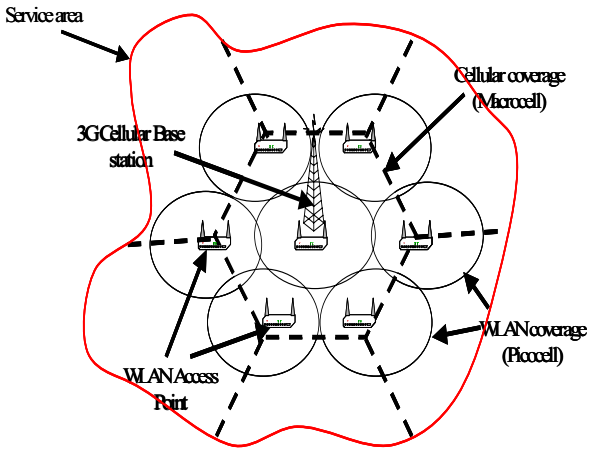


**Fig. 2**. Scenario for a system architecture showing an integrated 3G and wireless LAN network with 3G macrocell overlaid on WLAN micro cells

described in the previous section. The right combination of cellular and wireless LAN transmitters will offer better coverage with sufficient intensity while minimizing some measure of weighted path loss.

For the case of locating wireless LAN access points several methods can be employed whereby the simplest way is installing a wireless LAN by skiping the propagation analysis entirely and install the access point in the area where coverage is required which is referred to *user deployment*. An alternative approach is to divide the service area into equally sized rectangles and install an access point at the center of each such rectangle. This is *grid installation* and is the one considered in our studies (Fig.3) because it is simple to implement in the simulation model. Another method of installing access point is *coverage optimisation* which is more sophisticated, complex and costly. Further reading on wireless LAN infrastructure deployment can be found at [11] [12].

The key aspect of this system is that the choice of wireless network either 3G cellular network or wireless LAN is made by the user terminal, UT. The UT should be able to listen to and then according to the user preference concerning quality and type of application select the RAN which offers the best quality for the type of service required. Thus, the user terminal is equipped with multiservice capabilities which can enable it to access either of the two wireless networks.

## 3. SIMULATION AND RESULTS

A closed service area consisting of a number of 3G cells overlaid on the wireless LAN hotspots is assumed. The scenario we are looking at is like the one depicted in Fig. 1, where we assume a dense number of mobile users in predefined service area example a major sport event, concert etc. In this case we assume that the demand for network resources by the number of users is assumed to exceed the possible maximum which can be serviced by the cellular network thus re-

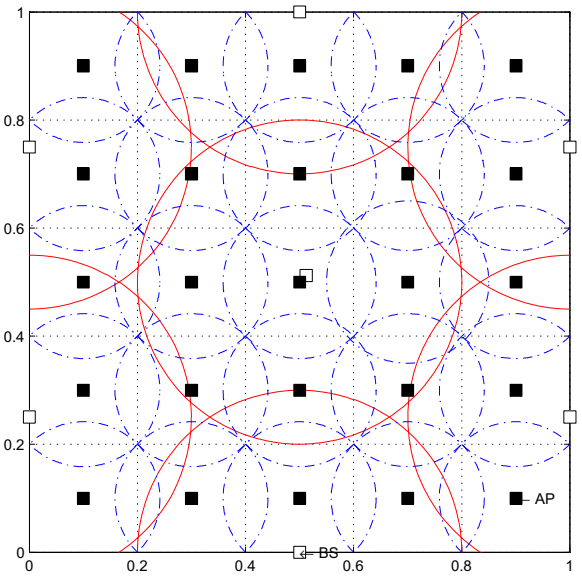


**Fig. 3**. A simulation snapshot showing base station access points deployment in a coverage area

**Table 1**. Simulation parameters.

| Parameter | 3G Cellular Network | Wireless LAN |
|---|---|---|
| Propagation model | $15.3dB + 37.6log_{10}d[m]$ | $47dB + 20log_{10}d[m]$ |
| Radius of cell/AP | 300m | 150m |
| Receiver threshold | -60dB | -85dB |

sulting in a number of requests for service being rejected because of network congestion. For simplicity user mobility is restricted, and call requests from mobile terminals can be defined to be speech service (voice), simple text msgs, email and chat (classified as low data rate - LDR) and streaming audio or video applications (high data rate - HDR).

Priority will be given to first try and connect the voice service connection requests to the 3G network and if the is no more available capacity then the request can be connected to the wireless LAN access point. The LDR service can either be connected to the 3G or wireless LAN network depending on the network condition. The HDR service will be connected to the wireless LAN network. All users stay in the same service area and they can access either the 3G cells or the wireless LAN access point hotspots depending on the available network resources and type of call being made. Therefore we consider a constant number of users in the service area but their requests for network resources vary.

For simulation the traffic distribution is set to 30%, 20% and 50% for voice, LDR and HDR respectively. The simulation platform takes into consideration the system configuration, propagation condition and service requirement. The simulated scenario considers a

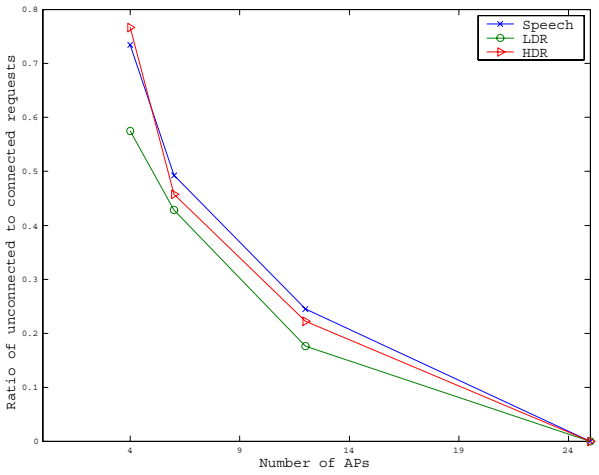


**Fig. 4**. Ratio of unconnected to connected requests with varying number of wireless LAN access points

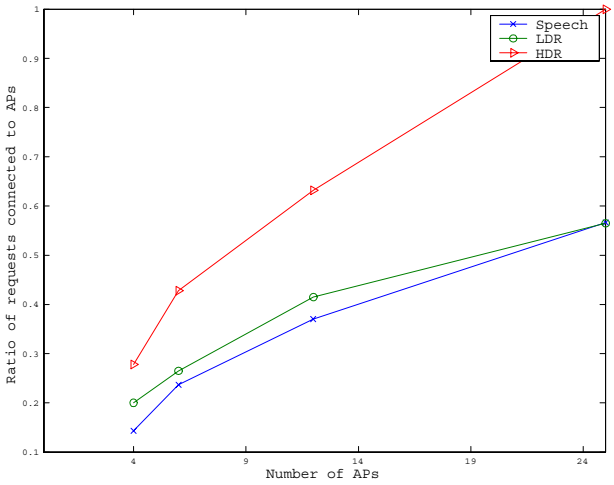


**Fig. 5**. Ratio of requests connected to wireless LAN APs

service area which has 3G cellular macro coverage and micro coverage offered by wireless LAN access points which is varied from sparsely distributed hotspots to complete overlapping APs coverage in the service area. A user terminal needs to establish a wireless link with the BS that minimizes the propagation loss between the BS and UT [2]. In a wireless access system that supports multi cell cellular system this criterion of minimizing propagation losses in nearly the same as the criterion of finding the reference signal in the downlink with the highest received level (in W-CDMA, the common pilot channel is used for this). Therefore UT connects to the optimal BS or AP having the lowest propagation loss between it and the BS or AP. The simulation parameters are given in table 1.

Fig. 4 depicts the case where the user service requirements where met by the network for the different traffic types. The vertical axis shows the ratio of the unconnected requests to connected for each traffic type. As illustrated in the figure, with increased num-

ber of wireless LAN access points in the service area, the ratio of the unconnected requests to any RAN decreases remarkably for all the traffic types. Fig.5 shows the ratio number of requests which is connected to the wireless LAN access points as the number of deployed APs is increased in the service area. The HDR requests to the AP are predominant as these requests are prioritized to be connected to the wireless APs.

## 4. CONCLUSION

In this paper we have investigated the possible interaction mechanism involved at the system level for a combined 3G cellular system and wireless LAN network. By introducing wireless LAN access point hotspots in a 3G service area which is densely populated with users having varying network resources requirements, the number of unconnected or dropped requests can be reduced significantly and traffic can be connected to the suitable RAN which will ensure required QoS requirement.

This simulation work has investigated the optimal integration scenario for 3G cellular communication system with wireless LAN networks to offer QoS in a heavily loaded mixed traffic environment. This model can be adapted to investigate how other emerging wireless access technologie can be easily intergrated into the heteregeneous wireless system.

The combination of cellular and wireless LAN offers possibility of achieveing anywhere, anytime Internet access bringing benefits to both users and providers.

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