

Integrating WLAN with GPRS/3G Wireless Networks

Wei Ye,

GER240, McClintock Ave.3715, University of Southern California,
Los Angeles, CA90089, yewei@usc.edu

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Abstract

This paper describes basic features of WLAN and compares WLAN with other related wireless technologies such as Bluetooth, Home RF, 3.5G systems, LMDS. It also discusses the motivations for mobile operators to develop WLAN and GPRS. In this paper, we creatively present two methods to provide seamless cover scenarios through integrating WLAN with GPRS system. The authentication of one method will be based on username and passport sent by Short Message service (SMS), the other method is based on the SIM-card authentication scheme. Finally, whether WLAN systems are 3G killers or helpers is discussed.

1 Introduction

The second-generation (2G) mobile communication systems now support larger numbers of subscribers and so helped alleviate the capacity problems faced by older AMPS systems. Nevertheless, the data rates supportable over GSM (Global system for mobile communication) and GPRS (General Packet Radio Service) systems are still quite limited, offering only between 10 and 40 kbps for data service. A number of short-range access technologies have emerged over the past few years: The most notable ones are WLAN (Wireless Local Area Network) IEEE 802.11b/a/g, Blue tooth, Home RF, HiperLAN2 and IrDa (infrared) etc. These technologies are all designed to provide short-range connectivity and/or cordless access for data communications using the unlicensed spectrum of 2.4 GHz or 5 GHz. While most of these technologies can offer a much higher data rate compared to today's mobile radio system, they are not designed to support high-speed mobility, and due to their design for higher data rate, the range of coverage is relatively limited in comparison to mobile radio systems.

Thus short-range access technologies can provide a competitive threat to conventional cellular business in traffic hot spots where the areas are concentrated and the traffic density is high such as airports, hotels, office building. Such technologies offer an opportunity for mobile operators to participate because the spectrum is not licensed and 2G/3G data services will not be able to deliver the same high-speed data throughput experience as that provided by WLAN at hot spot locations. How to

locate the role of WLAN and GPRS/3G, and how to provide better data services to mobile subscribers by WLAN will become an important problem for most mobile operators in the world. To explain the problem clearly, it is necessary to analyze the technical characteristics of WLAN first.

2 Technical analysis about WLAN

2.1 IEEE802.11

A wireless local area network (WLAN) is an alternative to cabling a local area network. Instead of using cables to connect equipment and devices to a fixed network, data traffic is transferred through a radio interface. This is supposed to give more freedom to the users without noticeably sacrificing data quality. The purpose of the IEEE 802.11 standard is “to provide wireless connectivity to automatic machinery, equipment or stations that require rapid deployment, which may be portable or hand-held, or which may be mounted on moving vehicles within a local area”^[1]

From the viewpoint of mobile operators, compared to other mobile radio communication systems, IEEE 802.11 has several main technology features^[2,3,4]:

(1) Much higher speed

Wireless LAN services enable users to connect laptops and PDAs to their Internet service provider or company intranet at high speeds. According to the IEEE standard, 802.11b can provide the data rate of 11Mbit/s at the 2.4 GHz ISM band, 802.11a can give the 54Mbit/s at 5GHz band, and 802.11g has a performance rating of 54Mbit/s at 2.4GHz band.

(2) Open (Unlicensed) spectrum.

IEEE suggests that 802.11a and 802.11b should be used in open spectrum; that is to say, people should be able to use it without applying for licenses from the government. Still now in China, the spectrum that 802.11b uses 2.4GHz is unlicensed, but the 5GHz spectrum that 802.11a uses is licensed.

(3) Short-range access and mobility.

Without direct obstacles, IEEE 802.11b can reach its efficient range is from 100m to 150m, IEEE 802.11a can provide from 75m to 150m, and 802.11g has a performance cover of 50m.

(4) Economic.

Compared to the 3G networks, WLAN has a Low equipment price and a low construction cost. At hot spot locations, the competitive price performance of 3G Network is inferior compared to WLAN.

2.2 IEEE802.11 versus other wireless technologies

(1) IEEE802.11 versus Home RF and Blue tooth

In the table 1, there are some detail comparisons between WLAN 802.11b and other short-range wireless technologies. For mobile operators, 802.11b is here to stay and is likely to be the most dominant player in the wireless LAN market for the immediate future.

Items	802.11b	Wi-Fi 802.11g	802.11a	Home RF	Blue tooth
Frequency	2.4Ghz	2.4Ghz	5Ghz	2.4Ghz	2.4 Hz
Number of carrier wave	14	14	5	75	
Data rates (bps)	≤11M	≤54M	≤54M	≤10M	≤1M
Physical Layer	Direct Sequence Spread Spectrum (DSSS)	DSSS /OFDM	Orthogonal Frequency Division Multiplexing (OFDM)	Frequency Hopping Spread Spectrum (FHSS)	FHSS

2.3 WLAN802.11 versus 3.5GHz, LMDS

Local Multipoint Distribution System (LMDS) is the broadband wireless technology used to deliver voice, data, Internet, and video services in the 25-GHz and higher spectrum (depending on licensing). 3.5 GHz fixed wireless technology is a point-to-multipoint architecture that was used to deliver voice and data services over the 3.5 GHz frequencies being allocated in Europe, Asia, and Latin America. Similar to Wireless LAN, 3.5 GHz and LMDS are fixed wireless access technologies, But for the operators, WLAN is used to provide one method for end users in the ‘last 100m’; while the 3.5 G and LMDS is used to provide the wireless transportation for data and voice in the ‘last kilometers’ in some places that the fibers and wires are not easy reach.

3. Motivations and solution principle for mobile operators

(1) Current main GPRS difficulty for mobile operators

There are still seldom mobile operators that can provide very fast mobile data service to cover all hotspots such as hotels, airports, large shopping mall, so roaming among mobile operators is very important. Although now 3GPP defines the protocol of 802.1xEAP-SIM, there are still no common protocols for interconnection between WLAN and GPRS/3G, which needs more WLAN providers to obey to ensure the realization of roaming, and WLAN requires more types of terminals for easy use and enhance the interoperability of equipment. The most important is that new application mode - - mobile data service needs to be cultivated.

(2) Motivations for WLAN and Mobile Network Integration

Though many years development and much investment for network infrastructures, there existed wide wireless coverage by GPRS/3G and there exists better opportunity for high speed by WLAN. As far as mobile operators, now there are possible solutions for seamless roaming between WLAN and GPRS/3G networks; so there exists a new way to provide better access to mobile data service and promote more value-added mobile data service for users.

(3) Basic Solution Principles for mobile operators

- a) Maximum reuse of GSM/GPRS infrastructure in order to reduce the investment as possible.
- b) Similar service cloning from broadband services and ease of usage provided for users, for example: automatic configuration, ease of network selection, secure and convenient access to network, friendly client software
- c) Smooth migration for mobile data services, smooth evolution and upgrade for mobile network operators and users side.
- d) Single bill & roaming support to provide the best convenience for users as possible.
- e) Step by step integration into 3G, for the sake of reducing the investment and technology maturity.

4 Two feasible solutions for public WLAN married to GPRS^[5,6]

WLAN can provide high-speed data connection, there still exist the problems--users can not access roaming data only by the pure WLAN network. With the introduction of GPRS, the problem of WLAN network roaming data for users will be solved. Another problem is that while GPRS already supports standardized billing, SIM-to-HLR authentication, mobility management, service management and so on, but the biggest issue with GPRS from the customer's standpoint is that it is generally slow – typically 10-40kb/s in most networks where it is deployed. The integration solution below (see Figure 1 and 2) will overcome both of these limitations, and use the advantage of GPRS and WLAN. The solution runs GPRS protocols in the customer's Laptop/PDA and in a local server, but uses WLAN for physical connectivity over the air interface, instead of GPRS system. The GPRS is “wrapped around” the 802.11. By doing this, we make the WLAN network look like a GPRS

network having GPRS end customers, when seen from the network side. The end customers, on the other hand, enjoy broadband data speeds from the WLAN connection – perhaps 1Mb/s or more,

4.1 scheme-1 Based on the SIM-card authentication (see Figure 1)

As it might be expected in a GPRS-based network, a SIM card is used for authentication. It authenticates the SIM against the HLR record in exactly the standard way that it is required by GPRS network. There is no “edge-server” or similar device with duplicate subscriber details and we interface into the GPRS core network and perform a standard authentication procedure. The SIM card is completely the same as that would be issued for a mobile phone.

In principle, the SIM card could be implemented on a laptop as software but most operators prefer hardware. The operator would likely issue a second SIM for a customer holding a mobile phone. Another way is the use of a SIM-USB adapter, a small and commercially available device, suitable for laptops, that enables the laptop to read the SIM directly. This avoids the problem introduced by some alternative “SIM authentication” systems, that the end customer would be forced to use a modified 802.11 WLAN card. In the longer term, we anticipate availability of SIMs is already packaged for direct insertion into a USB port, or in the case of PDA, packaged into a flash card or memory stick etc.

Main network nodes, except GPRS basic network nodes, will include access terminals, access points, access point gateway, and authorization servers.

(1) Access Terminals

The Access Terminal can be handset or a personal digital assistance (PDA), which can access to both WLAN and GPRS networks; it can also be a laptop installed with a WLAN network card with GPRS network card, or a dual-mode interface card. It can be any device supporting the IEEE 802.1x.

(2) Access Points

An Access Point (AP) is usual a device used to connect the WLAN terminal to the fixed wired packet-switched network, providing the wireless access services and data access services as well. An AP comprises a wireless processing module and an Ethernet interface module, wireless channel dynamic allocation, and protocol translation from 802.11 to 802.3.

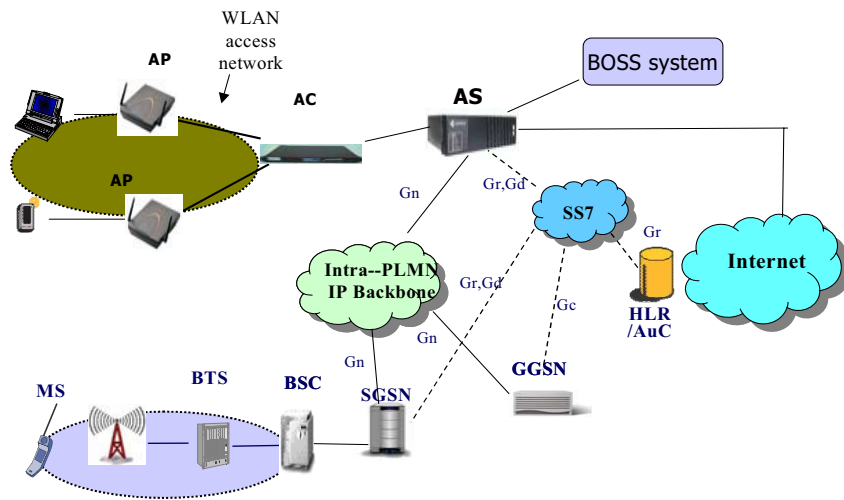
(3) Access Controller

An Access Controller (AC) encapsulates media stream coming from wireless terminals so that the media streams can cross over IP networks and reach AAA server through tunnel, and AC can control data speed and so on.

(4) Authorization Servers

The Authorization Servers (AS) provides authorization, authentication, and accounting services for both WLAN and GPRS terminals.

Figure 1: The integration architecture with authentication based on SIM



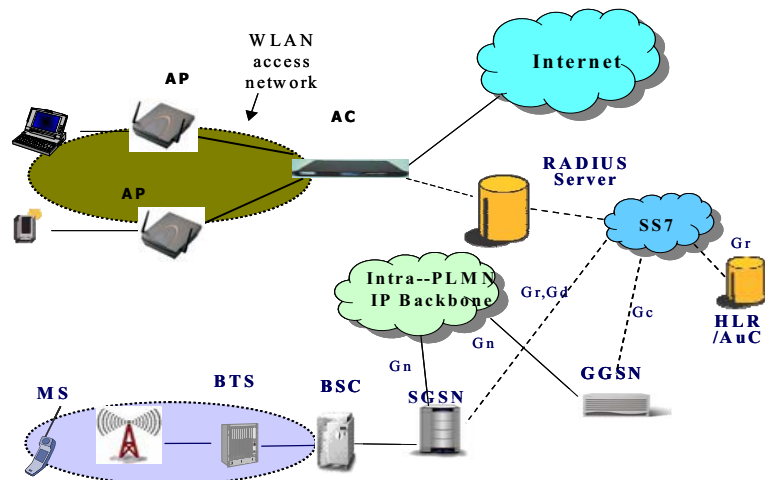
4.2 Scheme-2 Based on user mobile phone number (MSISDN) + password sent by SMS

Mobile subscriber can login in the public WLAN with using mobile phone number as the login name and instant password sent by short message system (SMS). And the bill will also be added to cell-phone bills, which realize “all in one bill” (See figure 2). The main different from scheme-1 is that the radius server provides authorization, authentication, and accounting services for both WLAN and GPRS terminals.

4.3 The compare with two solutions

4.3.1 Scheme-1 Authentication Based on the SIM-card authentication

Figure2: Authentication Based on mobile phone number(MSISDN)
+password sent by SMS scheme



(1) Main Advantage:

- Conform to GPRS network standards, both WLAN and GPRS network have similar network architecture and clear network topologies.
- Unified access servers offer some new access services very conveniently to users.
- Fast handoff across networks for terminal users.
- Low operating cost and easy

(2) Main disadvantage:

- To enable existed GPRS network to support the WLAN services; the software in network nodes must be updated.
- Its implementation is more difficult than that of the scheme-2

4.3.2 Scheme-2 Authentication Based on user Mobile phone Number (MSISDN) + password sent by SMS

(1) Main Advantage:

- WLAN and GPRS technologies exist independently without great interference with each other.
- Low threshold for technology integration with multiple mature products already available.

(2) Main disadvantage:

- When the simple IP technology was implemented by end users to access the networks with different servers, handoff between WLAN and GPRS will be disabled; when mobile IP technology is deployed, this will overload the network, as a result, the handoff remains inconvenient.
- Its integration only share the radius authorization server, hence, this solution does not appear really effective. So it will be a transitional solution.
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5 Related Issues

5.1 Charging and billing

To effectively realize the charge, the integration network must satisfy:

The WLAN access network shall be able to report the WLAN access usage to the appropriate GPRS/3G system; it shall be possible for the GPRS/3G system to command some operations on a specific ongoing WLAN access session. This can be useful in the context of prepaid processing; it shall be the role of the GPRS/3G system to process the WLAN access resource usage information into the compatible format (CDR). The following parameters may be used for charging and revenue accounting, basic access/session (pay by subscription), access/session duration, credit card access/session, calendar and time related charging, premium rate access/session, priority, Quality of Service, duration dependent charging, flat rate, volume of transferred packet traffic, rate of transferred packet traffic (volume/sec), multiple rate charge.

5.2 Handover/handoff

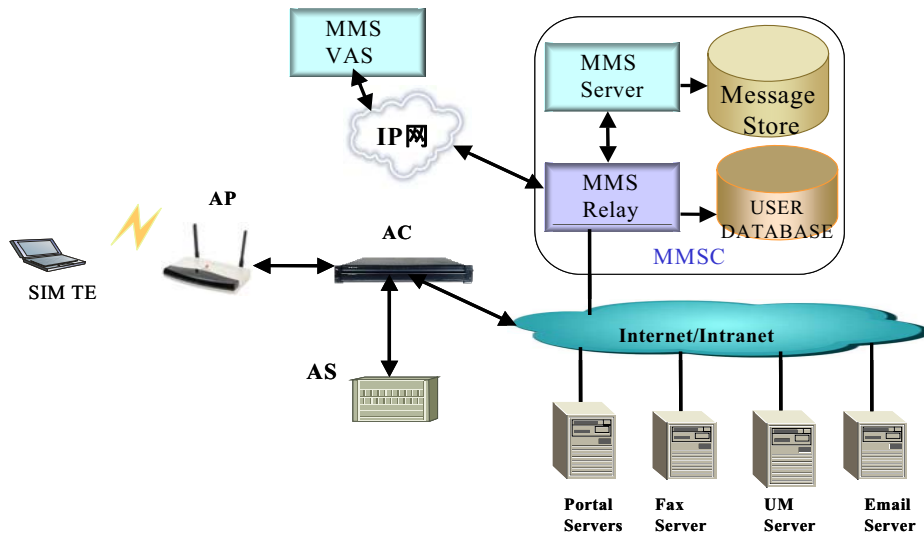
For handovers within the WLAN network, the terminal must have enough information to be able to make a handover decision for itself, or be able to react to a network decision to handover. Indeed these decision driven events are referred to as triggers, resulting in network centric triggers or terminal centric triggers. Simple triggers include the following:

- Network Centric: poor network resources or low bandwidth, resulting in poor or changing Quality of Service(QoS), change of policy based on charging.
- Terminal Centric: poor signal strength, change of QoS.

5.3 Mobile IPv6 in integrated network

Since IP V4 public addresses are very limited and such networks allow the terminal device in the “always on” world, IP V6 has been introduced in such the networks. There are several alternative ways of doing this such as dual stacking, tunneling and Inter-working, application-specific Inter-working etc.

Figure 3: Architecture of MMS service implement by WLAN and GPRS



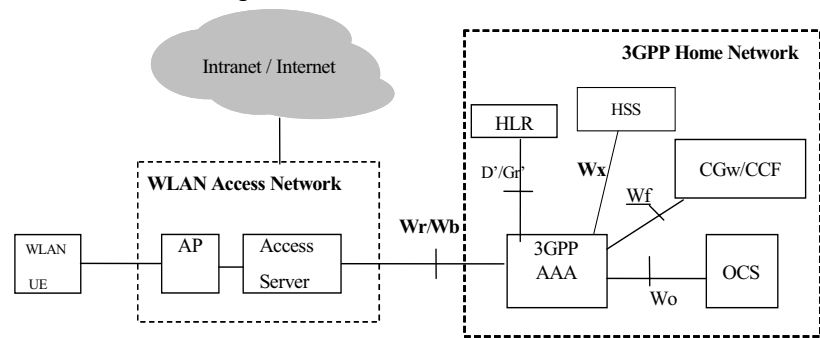
5.4 MMS service implement by integrating WLAN and GPRS

By using MMS (Multimedia Message Service), integrated networks can be provide to users with the voice, but also the multimedia information such as pictures, videos and games. Figure 3 is architecture with MMS service implement by WLAN and GPRS.

5.5Case Study: integrate WLAN and GPRS in China^[8]

China Mobile Communication Corporation, one of Fortune 500 world's Largest Corporations and the largest wireless operator in the world with over 200 million wireless subscribers. From 2001 till now, Facing increasing competition in data service marketing, the company need to solve such problems: How to retain and inherit the old investment for GSM networks with 60 billion dollar investment and GPRS networks with 1 billion dollar investments to improve his network and provide better data service for current 150 million mobile users without interfering their normal usage? Especially for hotspots that are not enough to support the effective usage about data service, But there are at least 5 thousands such hotspots in 100 major cities in China,

Figure 5 The Framework of WLAN and 3GPP



Wr/Wb : Authentication/Authorization, Charging Signal

Wx: WLAN AAA Infrastructure&HSS

D'Gr: WLAN AAA Infrastructure&HLR

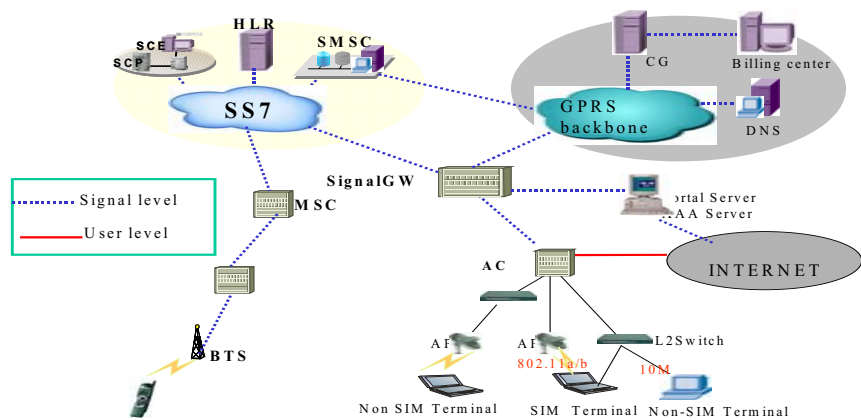
Wf: WLAN AAA & 3GPP CGw/

End to End Authentication : 802.1x EAP-SIM

Although many alternative ways exist to solve this problem with different cost and risk, China Mobile Communication Corporation finally implement the integrating WLAN and GPRS way to do it. The way is to build the local wireless area network (WLAN) network married to GPRS networks, which provide higher wireless access speed in hotspots through WLAN such as airports and provide widely seamless wireless data access though GPRS. Which only cost 0.1 billion dollar to build the large WLAN network for Chinese 100 cities for 5 thousand hotspots.

For the convenience of data service users, the project is carried out by both scheme-1 and scheme-2. Below is reference mode.

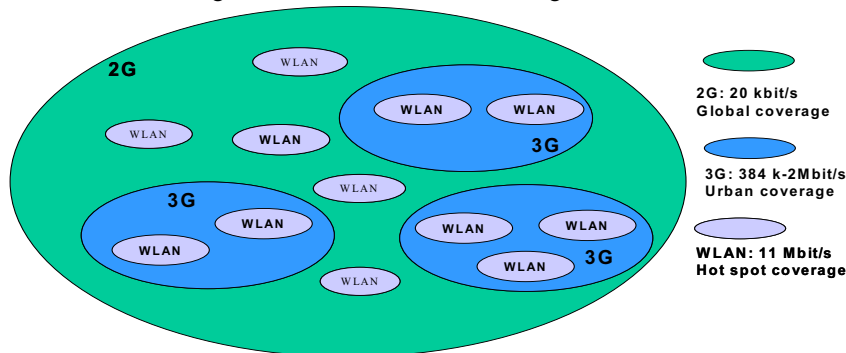
Figure 4 Reference mode in China mobile corporation



4.6 WLAN systems are 3G killers or helpers?

Compared to the existing mainly radio system GPRS and 3G, the main advantages of WLAN 802.11b are that it is equipped with High data rate meeting the requirement for high-speed wireless network access, with a low equipment price, with a low construction cost, and has with abundant applications in many countries. The main disadvantages is that it only provide small coverage, and average mobility, and work in free frequency band with being prone to be interfered. Figure 4 describes

Figure4 WLAN/2G/3G Coverage



the predicted coverage by WLAN and 2G/3G in the future five or ten years.

To expand the range and capability of data services that can be supported by digital mobile systems, service providers will have to upgrade their networks to one of the 3G technologies. These can support data rates from 384 kbps up to 2 Mbps, although most commercial deployments are expected to offer data rates closer to 100 kbps in practice. WLAN with low cost and high data rate can meet the requirements for data services in hot spot very well, and it is the supplementary access mode of 3G networks. In short, WLAN is the complement 3G and B3G networks and is not the competitor for 3G and B3G networks. Figure5^[7] points out the framework of WLAN and 3GPP network.

Now, IEEE defines the protocol under layer 2[PHY & MAC] and 3GPP specifies WLAN network architecture.

6 Conclusions

In this paper, we initially present the integrating WLAN and GPRS network with the authentication by two ways. One is based on SIM-card authentication, the other based on user mobile phone number (MSISDN) + password sent by SMS, and then the charging and billing is discussed. As one example, the MMS implement by WLAN and GPRS network is discussed. Although there still are some problems to be solved, such as roaming, safety, interference and compatible, today Chinese

mobile operators have implemented the integrating WLAN with GPRS scheme in the largest mobile communication network in the world. In the future 4G, what is the role between WLAN and B3G/4G is still discussed problem.

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Author:



Mr. Wei Ye, PhD candidate in University of southern California. He received his Master of Engineering degree from Automation Department, Tsinghua University, and was former project manager and engineer in China Mobile Communication Corporation headquarters for three years. Now His research interests include optimization models, wireless communication, and integration information system.