Talk 4: WLAN-GPRS Integration for Next-Generation Mobile Data Networks

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Abstract

- Ongoing wireless LAN standardization and R&D activities worldwide
  - Target bit rates higher than 100 Mb/s
- The recent successful deployment of WLANs in numerous hotspots justify the fact that WLAN technology will play a key role in wireless data transmission
  - Cellular network operators have recognized this fact, and strive to exploit WLAN technology and integrate this technology into their cellular data network
- There is a strong need for interworking mechanism between WLANs and cellular data networks
An interworking mechanisms, which effectively combine WLANs and cellular data network into integrated wireless data environment capable of ubiquitous data service and very high data rates in hotspot locations.

Two coupling mechanisms are discussed:

- A Tight Coupling Architecture
- A Loosely Coupled Architecture
To compete with WLAN technology, third-generation (3G) cellular systems promise competitive data rates, at speeds of up to 300 kb/s initially and increasing up to 2 Mb/s, with the same always-on connectivity of wired technology.

The current offering with “3G-like” services in efforts to generate new revenue stream in today’s environment:

- 2.5G cellular data technology, and in particular General Packet Radio Service (GPRS)
- To provide wireless data service at speeds of up to approximately 100 kb/s
- Is gaining support as a wide area data solution
It is commonly believed that operators must provide a **seamless** user experience between the **cellular** and **WLAN** access networks.

The calls for interworking mechanisms between **WLANs** and cellular data networks capable of providing **integrated authentication**, **integrated billing**, **roaming**, **terminal mobility**, and **service mobility**.

The following discussions describe the general aspects of integrated **WLAN-cellular data networks**.
Integrated WLAN and Cellular Data Networks

A cellular data network can provide relatively low-speed data service (up to 100 k/s) over a large coverage area. On the other hand, WLAN provides high-speed data service (up to 11 Mb/s with 802.11b and 54 Mb/s with 802.11a) over a geographically small area. An integrated network combines these two kind of data networks.
Roaming

These configuration vary in the area of ownership/management of the WLAN

- The first is that cellular operator owns and manages the WLAN
- The second is that wireless Internet service provider (WISP) is the owner
Multiple Access Options in an Integrated Data Environment

As the user moves, different choices become available.
Session Mobility

- Session mobility can be seen as an evolutionary step from roaming in this integrated environment.
- Session is defined as a flow of IP packet between the end user and an external entity.
- For example:
  - A mobile device capable of connecting to the data network through WLAN and cellular.
  - A laptop with an integrated WLAN-GPRS card, or a personal digital assistant (PDA) attached to a dual access card.
- The end user is connected to the data network and is in a session flow through one access network, say a WLAN.
As the user moves out of the coverage of the WLAN system, the end device detects the failing WLAN coverage and seamlessly switches the flow to a GPRS network.

The end-to-end session remains unaffected.

Typically, no user intervention would be required to perform the switchover from WLAN to GPRS:
- The user would not perceive this handover.

When the user moves back into the coverage of a WLAN system, the flow is handed back to the WLAN network.
The European Telecommunications Standards Institute (ETSI) specifies
- Loose coupling
- Tight coupling

With **loose coupling** the WLAN is deployed as an access network **complementary** to the GPRS network
- The WLAN utilizes the subscriber database in the GPRS network but features no data interface to the GPRS core network
- The loose coupling between the GPRS and the WLAN is carried out at the Gi reference point
This implies that with loose coupling the WLAN bypass the GPRS network and provides direct data access to the external packet data networks (PDNs)
A GPRS Reference Diagram Showing the WLAN Coupling Points
UMTS Network Architecture

- MS
- BS
- BSC
- BSS
- MSC/VLR
- SCP
- HLR
- GMSC
- PSTN
- IP NETWORKS
- Gb
- Gs
- Gi
- Gr
- Air
- Um
- Abis
- luCS
- luPS
- lub
- Uu
- NB
- RNC
- SGSN
- Backbone
- GGSN
- MAP
- CAP
- luR
- Iu
- IuPSIuCS
- IuPSIuPS
- Iub
- Iur
- Gn
- Gs
- Gi
- Gr
UMTS Network Architecture

MS/UE = 2G/3G Mobile Station
RAN = Radio Access Network
CAP = CAMEL Application part
GMSC = Gateway MSC
GGSN = Gateway GPRS Support Node
SGSN = Serving GPRS Support Node

BS/NB = 2G/3G Base Station
RNC = Radio Network Controller
MAP = Mobile Application part
IP Networks

Other Networks (GSM PSTN etc.)
A GPRS Reference Diagram Showing the WLAN Coupling Points
With **tight coupling** the WLAN is connected to the GPRS core network in the same manner as any other radio access network (RAN), such as GPRS RAN and UMTS terrestrial RAN (UTRAN)

- The WLAN data traffic goes through the GPRS core network before reaching the external PDNs
- The WLAN is connected to either **Gb** or **Iu-ps** reference points
The short-term trend is to follow the loose coupling approach and use (U)SIM-based authentication and billing. A subscriber can reuse his Subscriber Identity Module (SIM) card or his User Service Identity Module (USIM) card to access a set of wireless data service over a WLAN.

Loose coupling approach features limited session mobility capabilities compared to tight coupling.
Recently, several WLAN standardization bodies have agreed to set up a joint Wireless Interworking Group (WIG) to deal with the interworking between WLANs and cellular networks

- This activities is being primarily from Europe by ETSI BRAN

- Third Generation Partnership Project (3GPP)
  - A standardization body that maintains and evolves the GSM and UMTS specifications ([http://www.3gpp.org](http://www.3gpp.org))
last updated 8th September 2003 - T3 renamed
Six Interworking Scenarios

**Scenario 1:** Common billing and customer care

**Scenario 2:** 3GPP system-based access control and charging

**Scenario 3:** Access 3GPP GRPS-based service

**Scenario 4:** Service continuity

**Scenario 5:** Seamless services

**Scenario 6:** Access to 3GPP circuit-switched services
A Tight Coupling Architecture

- The tight coupling architecture that can fulfill the requirements of scenarios 1-4
- It assumes that the 802.11 WLAN is connected to the standard Gb interface (not Iu-ps), which is already deployed in live GPRS networks
  - Gb is specified from GPRS Release 1997
  - Iu-ps is specified from GPRS Release 1999

WLAN-GPRS Integration with Tight Coupling: System Configuration

- **HLR (AuC)**: Home Location Register (Authentication Center)
- **SGSN**: Serving GPRS Support Node
- **GGSN**: Gateway GPRS Support Node
- **CG**: Charging Gateway
- **GIF**: GPRS Interworking Function
- **Dual mode MS**: Dual mode Mobile Station
- **48-bit 802 MAC address**: 48-bit 802 MAC address
- **WLAN network**: 802.11 extended service set (ESS)
- **Beacon (SSID)**: Beacon with Service Set Identifier
- **BSS-1**, **BSS-2**, **BSS-3**: Basic Service Set
- **Feature servers**
- **Firewall**
- **Operator's IP network**
- **Internet**

**GIF**: GPRS interworking function
**CG**: Charging gateway
**HLR**: Home location register
**AuC**: Authentication center
**SGSN**: Serving GPRS support node
**GGSN**: Gateway GPRS support node
**BSS**: Basic service set
**AP**: Access point
Novel Solution for interworking between 802.11 WLANs and GPRS

- Seamless service continuation across WLAN and GPRS
- Reuse of GPRS AAA
- Reuse of GPRS infrastructure
- Support of lawful interception for WLAN subscribers
- Increased security
- Common provisions and customer care
- Access to core GPRS such as short message service (SMS), location-based services, and multimedia messaging service (MMS)
Tight Coupling over Gb: A Reference Diagram

WLAN access network
Defined by 802.11

Dual-mode MS
LLC
WLAN adaptation function (WAF)
WLAN radio subsystem
GPRS radio subsystem

WLAN access network

GPRS interworking function (GIF)
GPRS access network

Gb

Gb

GPRS core network

New interworking components
WLAN-GPRS Integration with Tight Coupling: System Configuration

Diagram showing the integration of WLAN and GPRS networks, including the roles of HLR (AuC), GGSN, SGSN, CG, and firewall. The diagram illustrates the connectivity between these components and the billing system. Key terms explained include:

- **GIF**: GPRS interworking function
- **CG**: Charging gateway
- **HLR**: Home location register
- **AuC**: Authentication center
- **SGSN**: Serving GPRS support node
- **GGSN**: Gateway GPRS support node
- **BSS**: Basic service set
- **ESS**: Extended service set
- **SSID**: Service set identifier
- **MAC address**: Media access control address
- **MS**: Mobile station

The diagram also highlights the 48-bit 802 MAC address.
Tight Coupling over Gb: Protocol Architecture

GMM/SM -> SNDCP -> LLC -> WAF

Um -> 802.11 MAC -> 802.11 X PHY

802.11 X PHY -> 100Base-T or other

802.11 MAC -> 802.3 MAC

802.3 MAC -> FR

100Base-T or other -> PHY (e.g. 703/704)

GPRS PHY

RLC/MAC

User data

SGSN

Base Station Subsystem
GPRS Protocol

Network Service

Frame Rely

Dual-mode MS

Access point

Gb

GPRS interworking function (GIF)
MSs are dual mode

- They support both GPRS and WLAN access in a seamless fashion
- **Seamless mobility** is achieved by means of the RA update (RAU) procedure
  - which is the **core mobility management procedure** in GPRS
  - When a mobile enters a **WLAN area**, a RAU procedure takes place, and subsequent GPRS signaling and user data transmission are carried over the WLAN interface
  - When a mobile exists a WLAN area, another RAU procedure takes place, and the GPRS interface is enabled and used to carry further data and signaling traffic
The WLAN adaptation function (WAF)

- Identifies when the WLAN radio subsystem is enabled and informs the LLC layer
  - Which subsequently redirects signaling and data traffic to the WLAN
  - All standard GPRS protocol operates on top of LLC function as usual and do not identify which radio subsystem is used
The Encapsulation Scheme

LLC-PDU

TLLI | QoS | LLC-PDU

WAF-PDU

802.11 MAC-PDU

Fr.Ctrl | Dur.ID | BSSID | MT-Addr | Gf-Addr | Seq.Ctrl | WAF-PDU | CRC

802.11 MAC header

WAF header

802.3 MAC-PDU

Gf-Addr | MT-Addr | Len/Type | WAF-PDU | CRC

802.3 MAC header
A Loose Coupling Architecture

- The loose coupling that provides interworking between GPRS and WLAN at the Gi interface
- The WLAN data traffic does not pass through the GRPS core network but goes directly to the operator’s IP network
- This architecture supports the integrated billing, via the billing mediator, in a common billing system
- Loose coupling utilizes standard IETF-based protocols for authentication, accounting, and mobility
  - It is therefore not necessary to introduce cellular technology into the WLAN network
WLAN-GPRS Integration with Loose Coupling: System Configuration

CAG: Cellular access gateway  
CG: Charging gateway  
HLR: Home location register  
AuC: Authentication center  
SGSN: Serving GPRS support node  
GGSN: Gateway GPRS support node  
AAA: Authentication, authorization, accounting  
FA: Foreign agent  
HA: Home agent
Session Mobility

- The loose coupling approach provides the session mobility across GPRS and WLAN domains.
- The FA in the GPRS network resides in the GGSN, while the FA in the WLAN can reside in an access router.
- The HA is located in the operator’s IP network.
- When the MS moves from GPRS to WLAN, it performs a MIP (Mobile IP) registration via the FA that resides in the WLAN.
- The FA completes the registration with the HA, by providing a care-of-address to the HA to be used as a forwarding address for packets destined to the MS.
The FA associates the care-of-address with that of that MS for the life of registration.

The MS does not need to change its IP address when it moves to WLAN.
A Loosely Coupled WLAN Control Plane for Authentication
<table>
<thead>
<tr>
<th>Category</th>
<th>Tight coupling</th>
<th>Loose coupling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authentication</td>
<td>• Reuse GPRS authentication for WLAN user</td>
<td>Cellular access gateway to provide SIM-based authentication interworking. RADIUS (only) based authentication is an alternative</td>
</tr>
<tr>
<td></td>
<td>• Reuse GPRS ciphering key for WLAN encryption</td>
<td></td>
</tr>
<tr>
<td>Accounting</td>
<td>Reuse GPRS accounting</td>
<td>Billing mediator to provide common accounting</td>
</tr>
<tr>
<td>WLAN-cellular mobility</td>
<td>SGSN is the call anchor, and intra-SGSN handovers provide mobility</td>
<td>Home agent is the call anchor, and Mobile IP handovers between GGSN and access router provide mobility. Home agent could be collocated at the GGSN or CAG, or somewhere in an external network.</td>
</tr>
<tr>
<td>Context transfer</td>
<td>Fine-grained context information is available, e.g., QoS parameters, information about multiple flows, etc.</td>
<td>Limited context transfer possible between GGSN and WLAN through current draft proposals in IETF Seamoby working group</td>
</tr>
<tr>
<td>System engineering</td>
<td>Impact of high-speed WLAN network on existing GSN from bearer and signaling standpoint is an issue</td>
<td>WLAN and GPRS networks can be engineered separately</td>
</tr>
<tr>
<td>New development</td>
<td>• WLAN terminal modifications for GPRS signaling</td>
<td>• CAG for SIM-based authentication</td>
</tr>
<tr>
<td></td>
<td>• Modifications in WLAN network or modifications in SGSN</td>
<td>• Billing mediator for accounting</td>
</tr>
<tr>
<td>Standardization</td>
<td>A new interface in the SGSN might be required, specifically for connecting to WLANs.</td>
<td>EAP-SIM and EAP-AKA is being pursued in IETF PPPext working group</td>
</tr>
<tr>
<td>Target usage</td>
<td>Applies primarily to WLAN networks owned by cellular operators. Has limited application when WISP is different from cellular operator.</td>
<td>Applies more broadly</td>
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