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Chapter 3:
WLAN-GPRS Integration for Next-Generation Mobile Data Networks

IEEE Wireless Communication, Oct. 2002

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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

Issues

- 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

Introduction

- 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

Cont.

- 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 theese two kind of data networks.
- LTE-advanced
  - 100 Mb/s in high-mobility environments and 1 Gb/s in low-mobility environments
- 802.11ac
  - 867Mbit/s, 1.73 Gbit/s, 3.47 Gbit/s, 6.93 Gbit/s (8 MIMO, 160MHz)

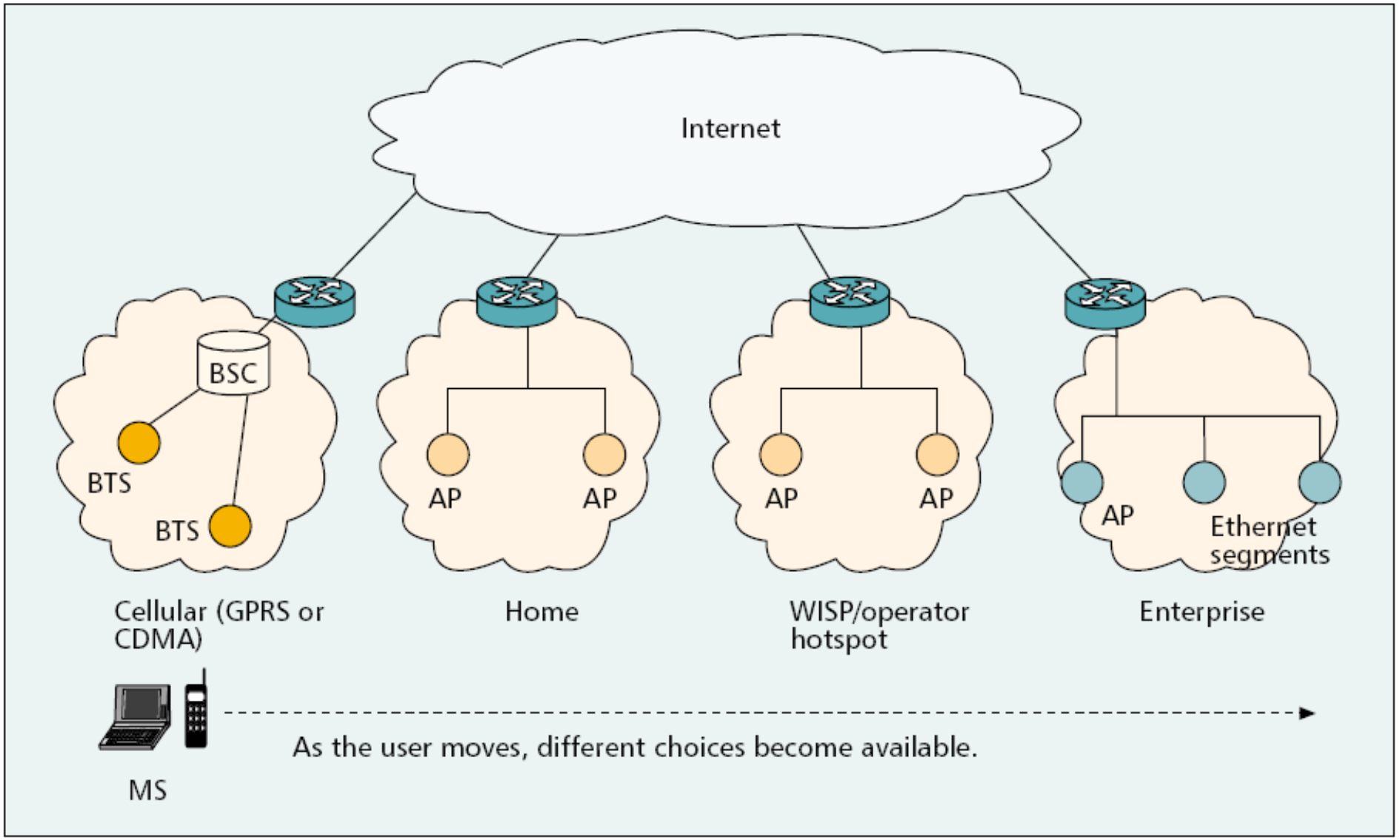
IEEE 802.11ac

- **IEEE 802.11ac**是一個正在發展中的802.11無線計算機網路通信標準，它透過 6 GHz頻帶（也就是我們所熟知的5 GHz頻帶）進行無線區域網（WLAN）通信。理論上，它能夠提供最少每秒1 Gigabit 頻寬進行多站式無線區域網（WLAN）通訊，或是最少每秒500 megabits（500 Mbit/s）的單一連線傳輸頻寬。
- 它採用並擴展了源自802.11n的空中介面（air interface）概念，包括：更寬的 RF頻寬（提升至 160 MHz），更多的MIMO空間串流（spatial streams）（增加到 8），多使用者的 MIMO，以及高密度的解調變（modulation）（達到256 QAM）。是802.11n的潛在繼承者。
- Quantenna公司在2011年11月15日推出了世界上第一隻採用802.11ac的無線路由器。Broadcom公司於2012年1月5日也發布了它的第一支支持802.11ac的晶片。

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



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

Cont.

- 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

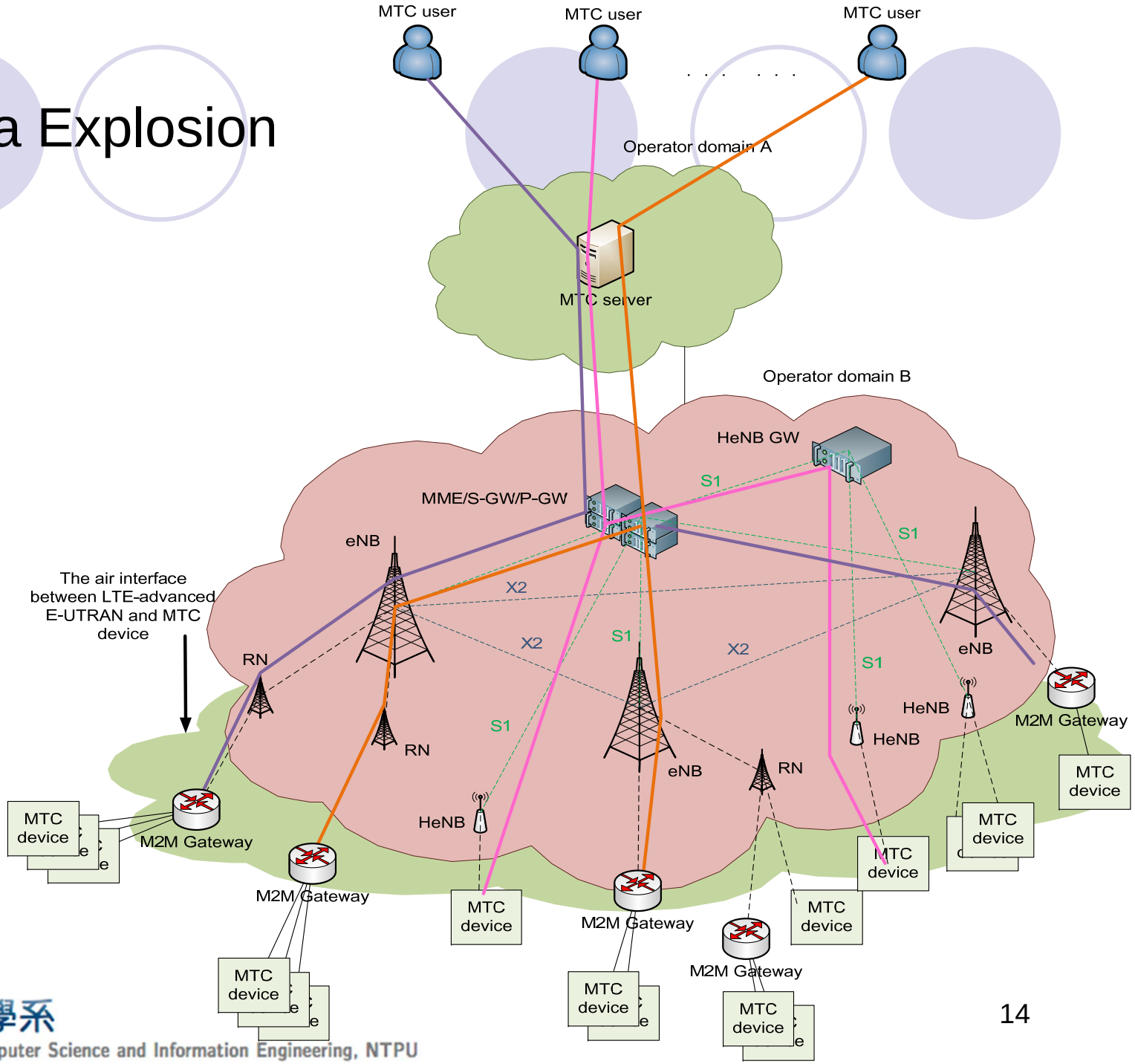
Interworking Architectures

- 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

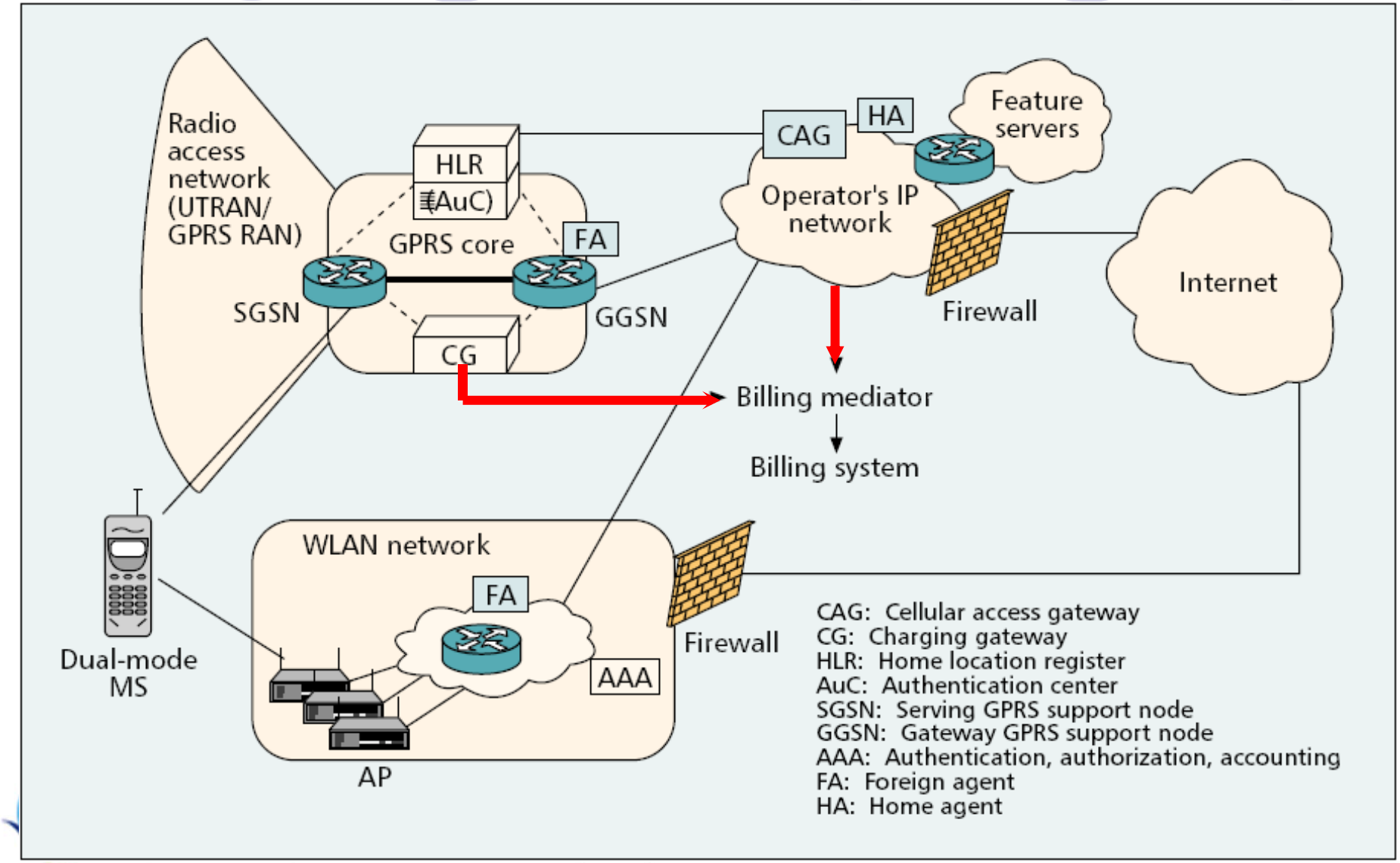
Cont.

- This implies that with loose coupling the WLAN bypass the GPRS network and provides direct data access to the external packet data networks (PDNs)

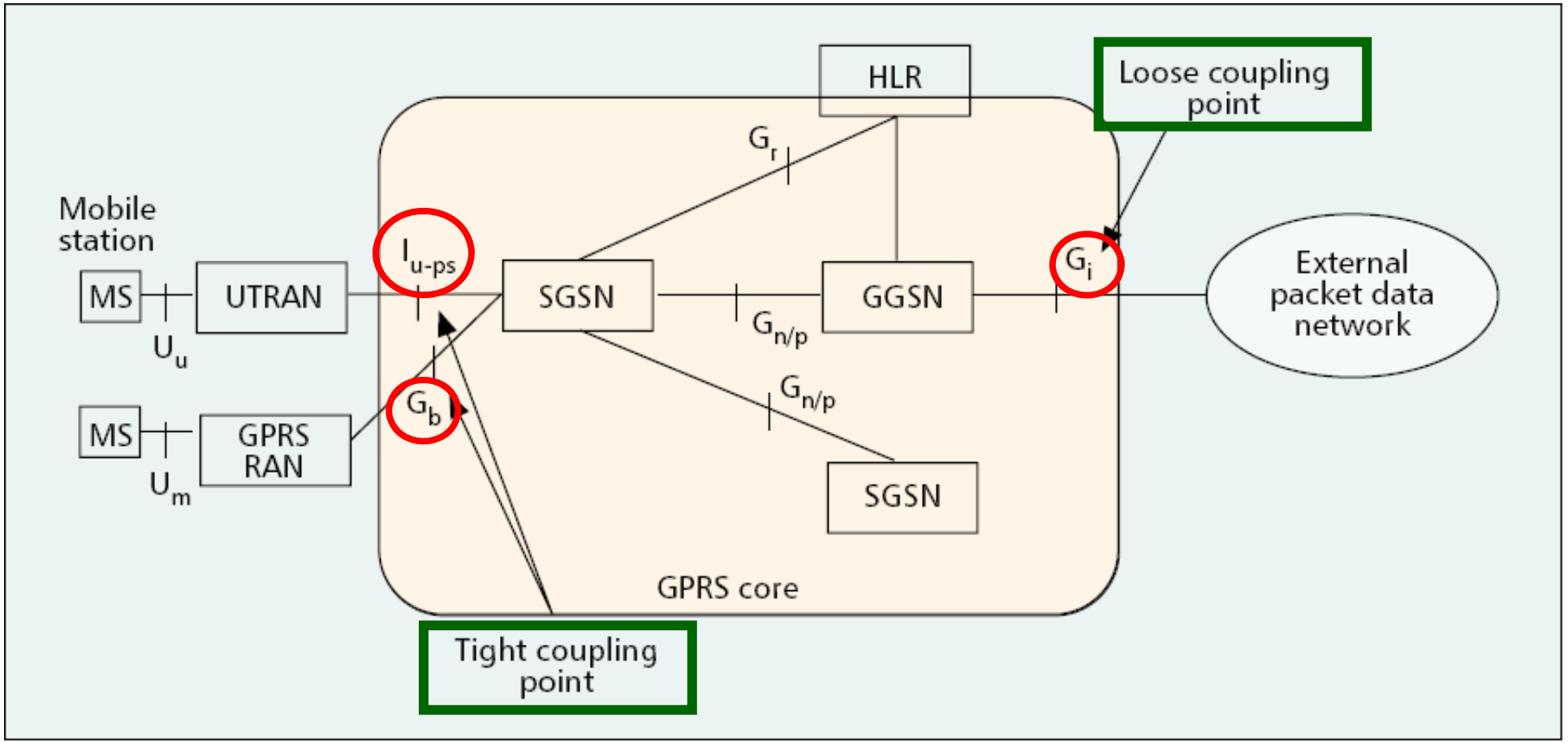
Big Data Explosion



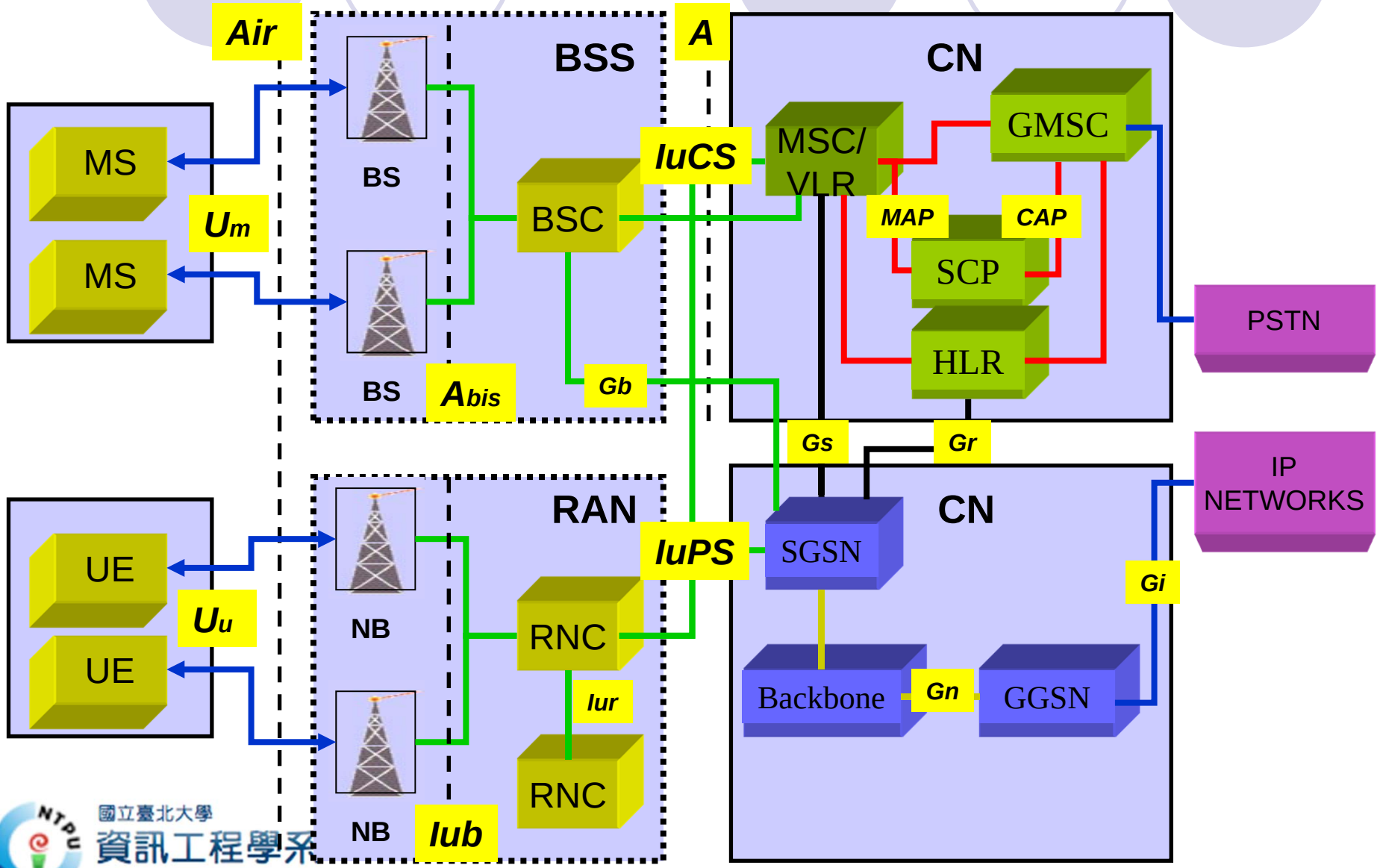
WLAN-GPRS Integration



A GPRS Reference Diagram Showing the WLAN Coupling Points



UMTS Network Architecture



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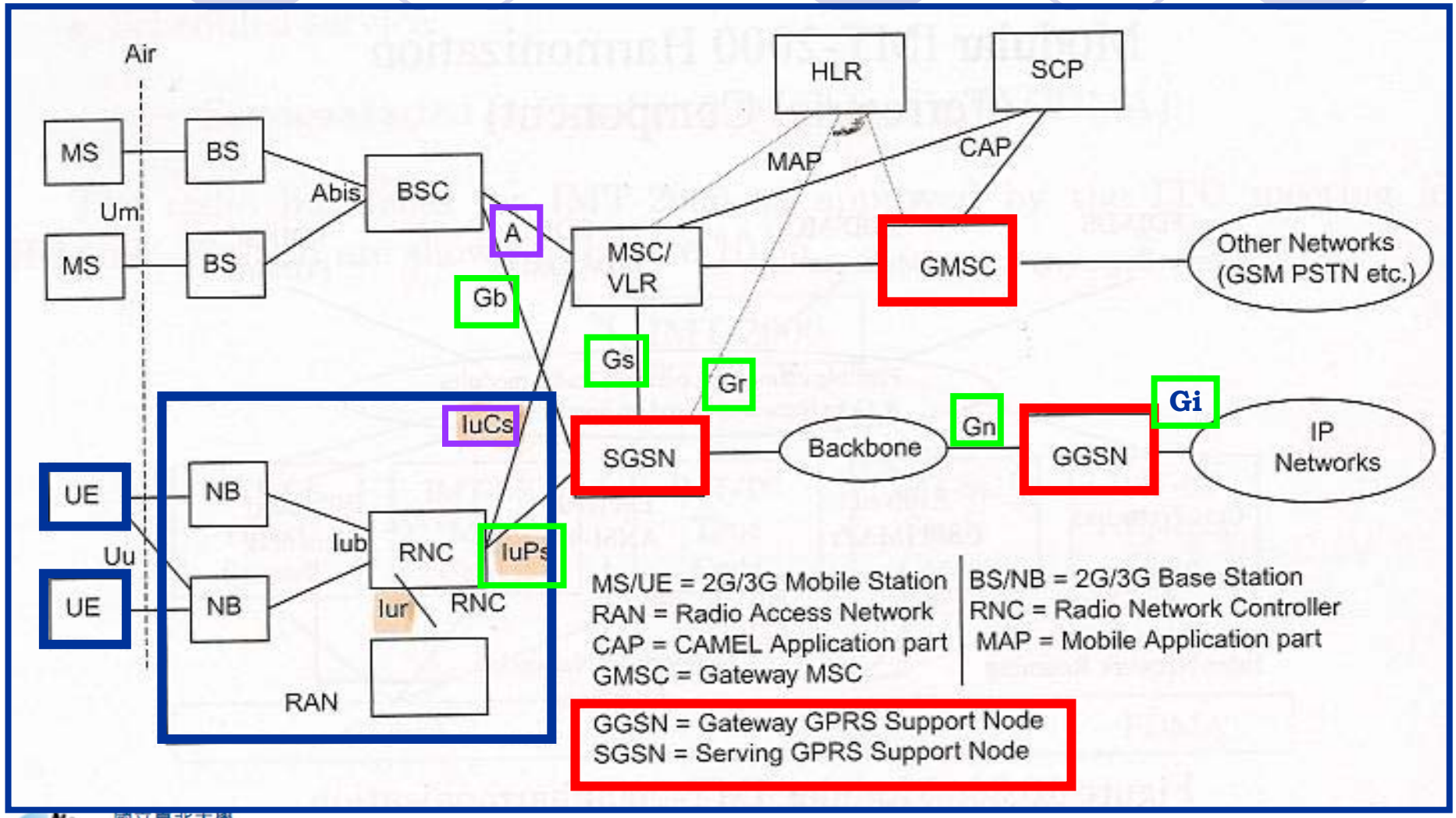

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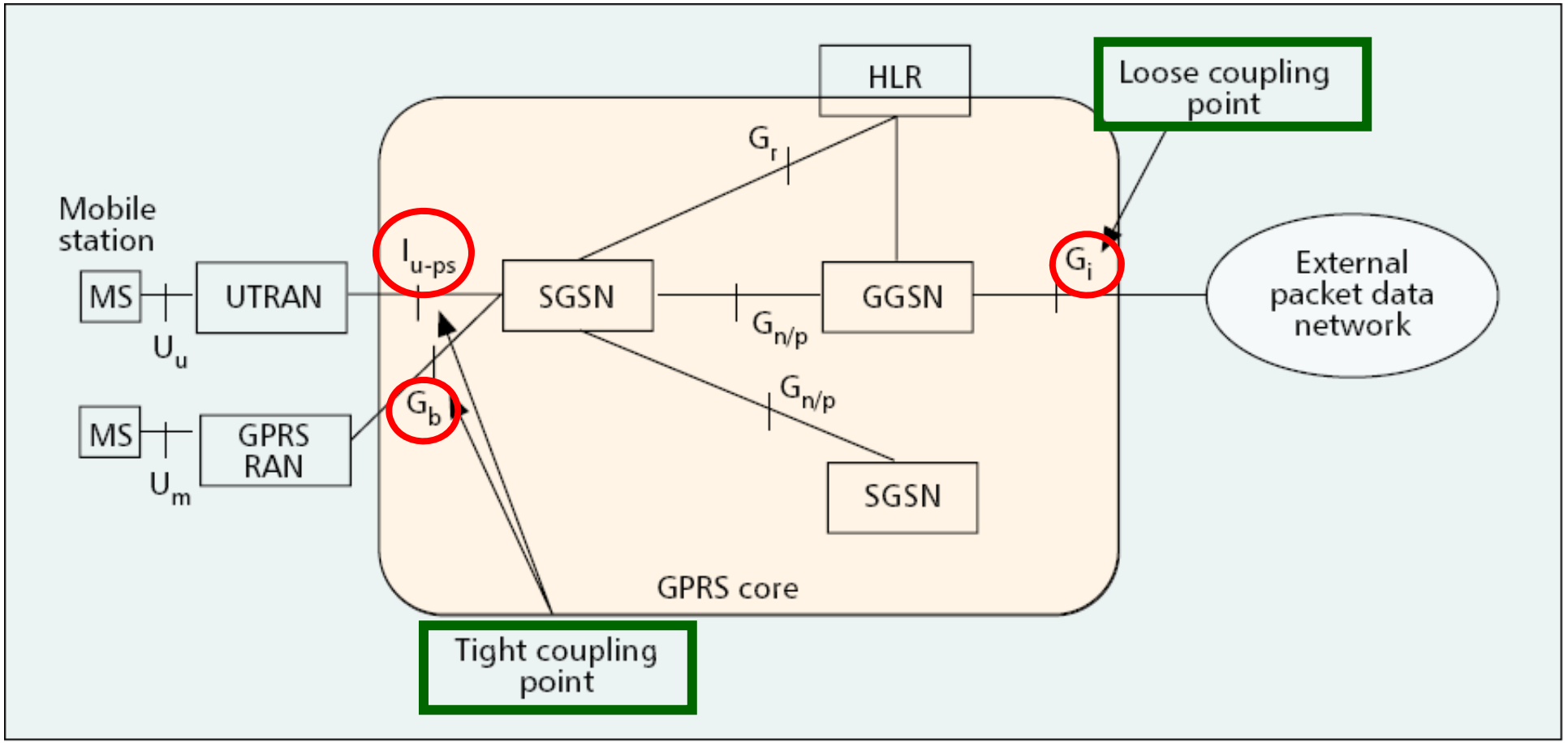

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- With tight coupling the WLAN is connected to the GPRS core network in the same manner as any other radio access network (RAN), such as GPRS RAN and UMTS terrestrial RAN (UTRAN)
  - The WLAN data traffic goes through the GPRS core network before reaching the external PDNs
  - The WLAN is connected to either Gb or Iu-ps reference points

Authentication

- 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

Current Standardization Activities

- 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)

structure of 3gpp - the Third Generation Partnership Project - Microsoft Internet Explorer

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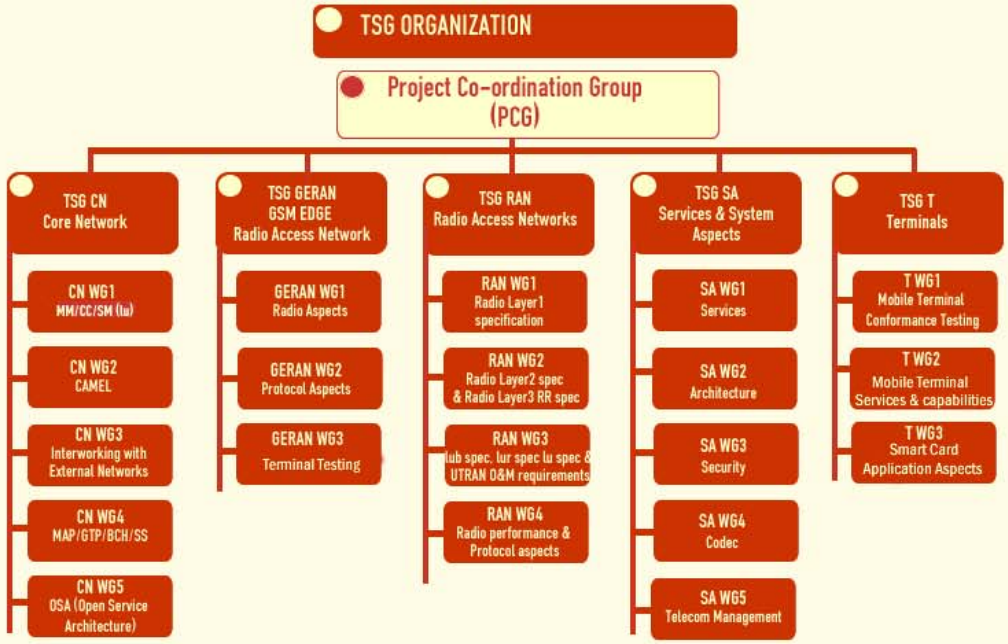

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Six Interworking Scenarios

Scenaro 1: Common billing and customer care

Scenaro 2: 3GPP system-based access control and charging

Scenaro 3: Access 3GPP GRPS-based service

Scenaro 4: Service continuity

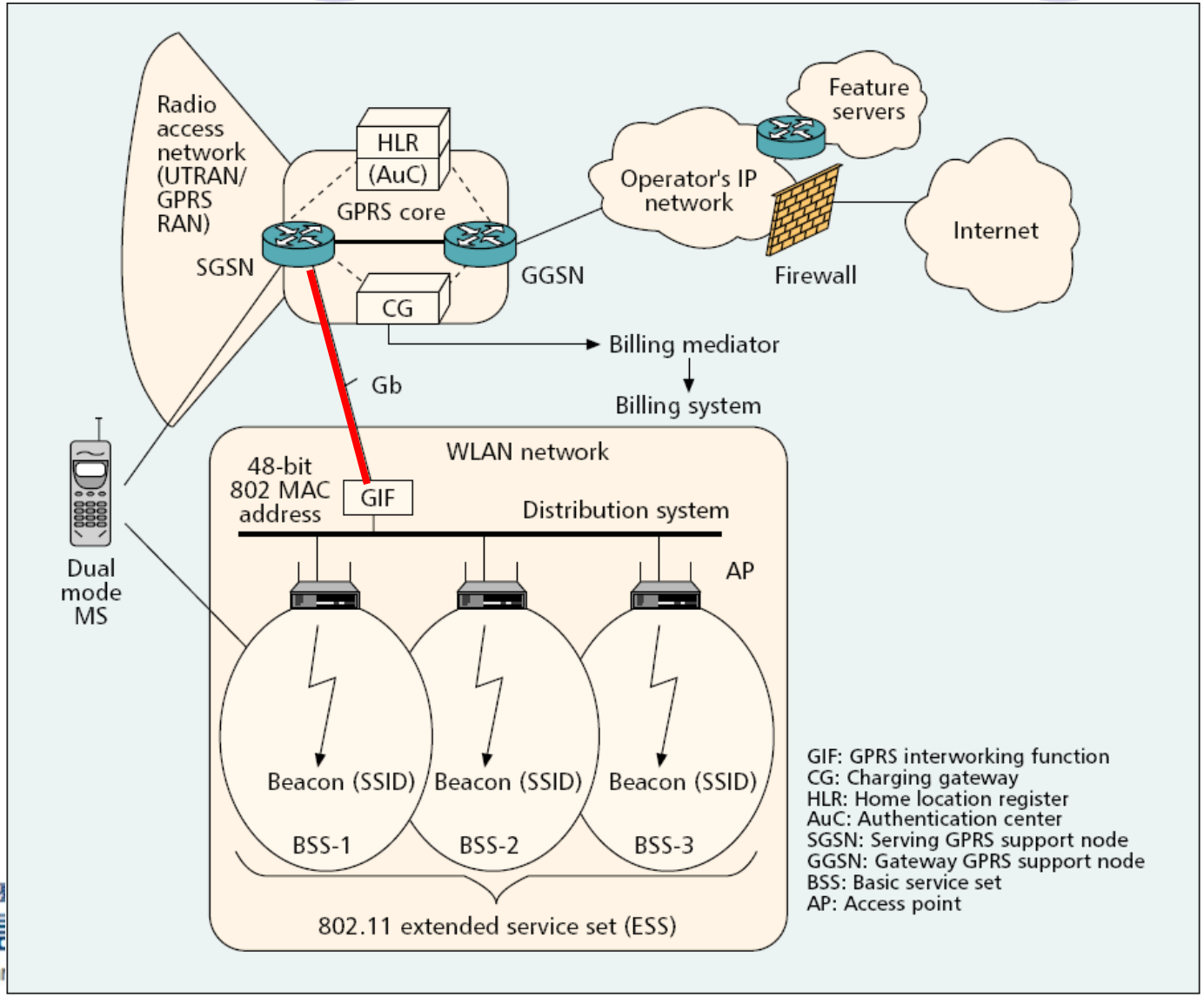
Scenaro 5: Seamless services

Scenaro 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
    - A. K. Salkintzis, "Chapter 3: Network Architecture and Reference Model," Broadband Wireless Mobile – 3G Wireless and Beyond, Wiley

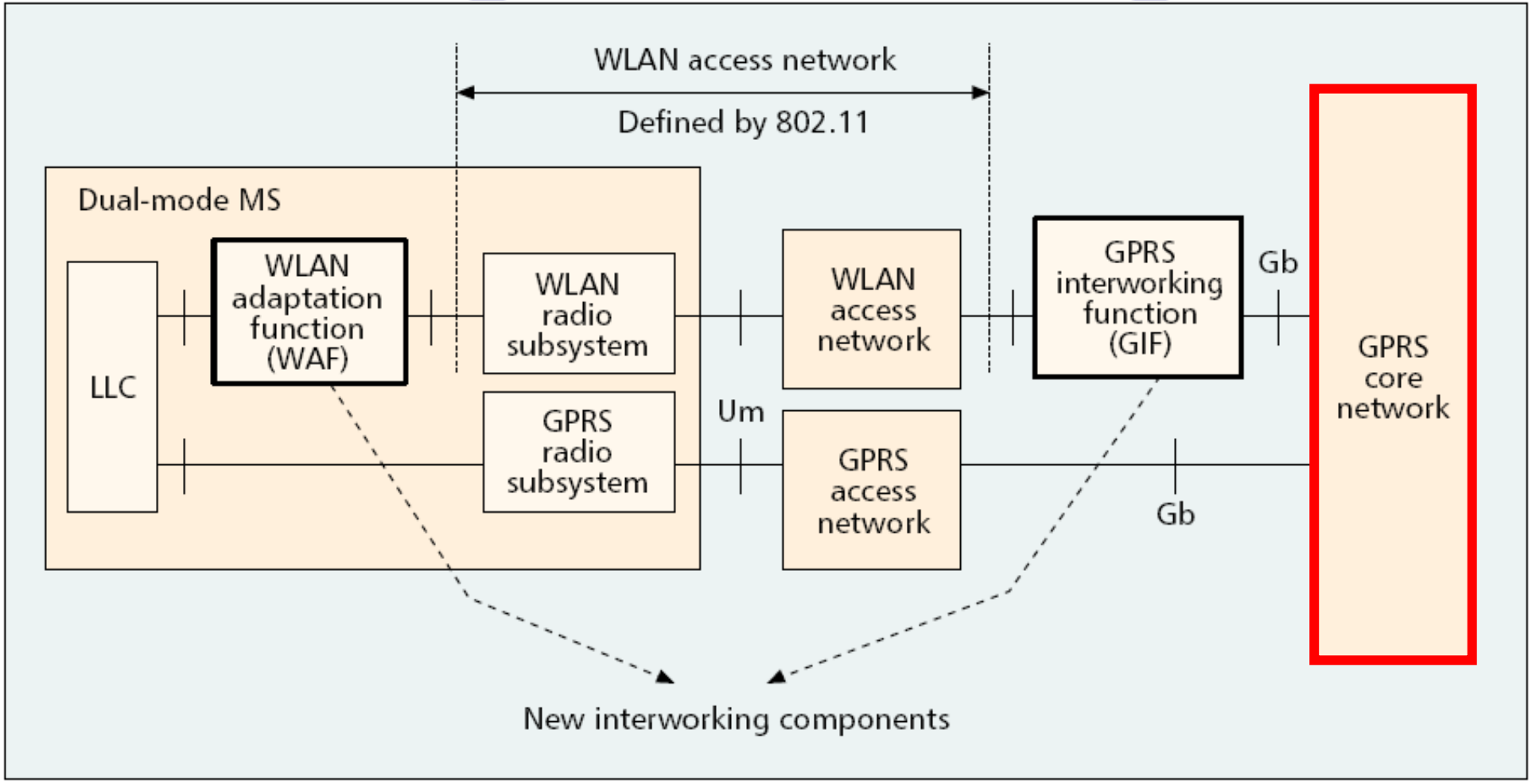
WLAN-GPRS Integration with Tight Coupling: System Configuration



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



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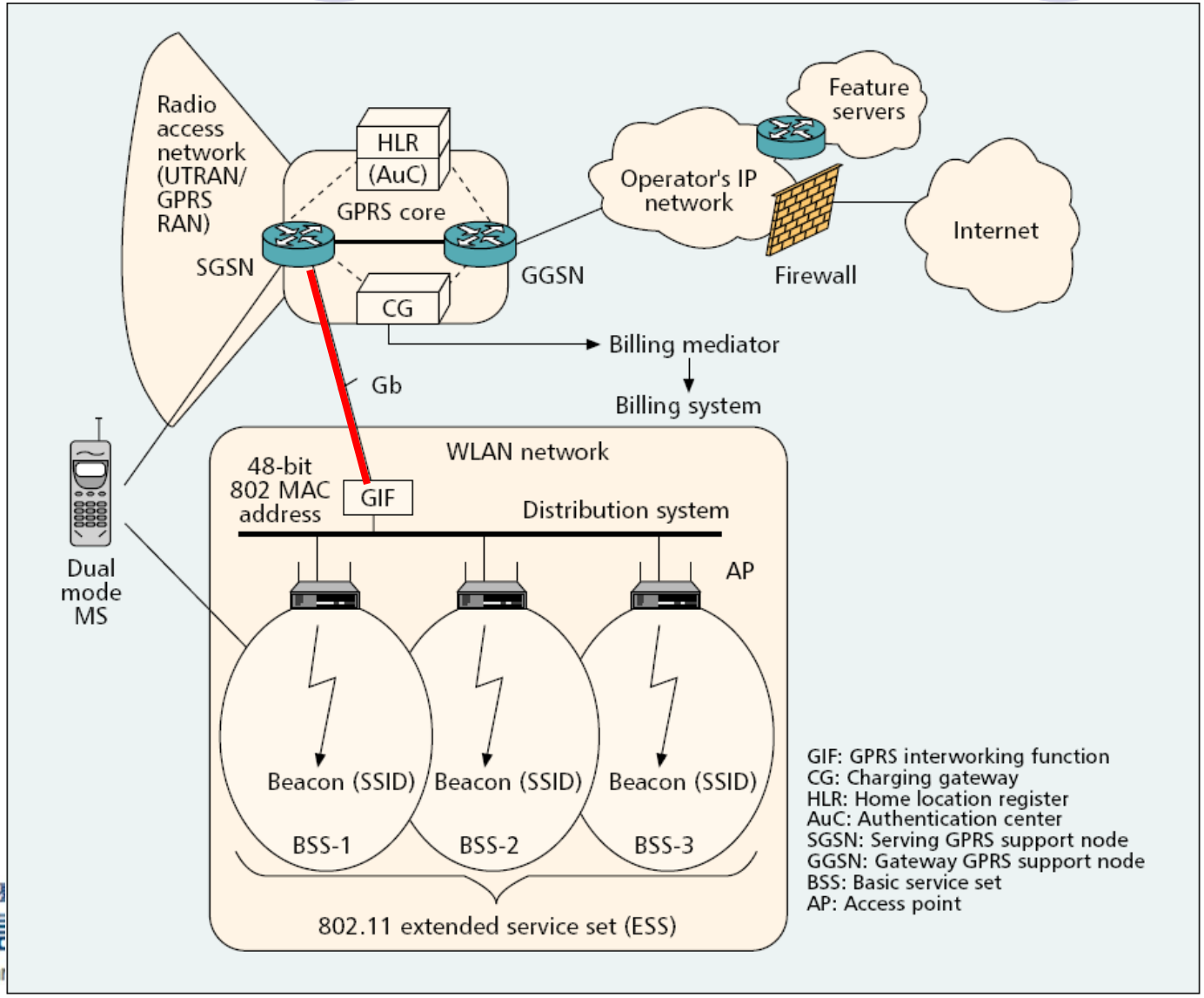
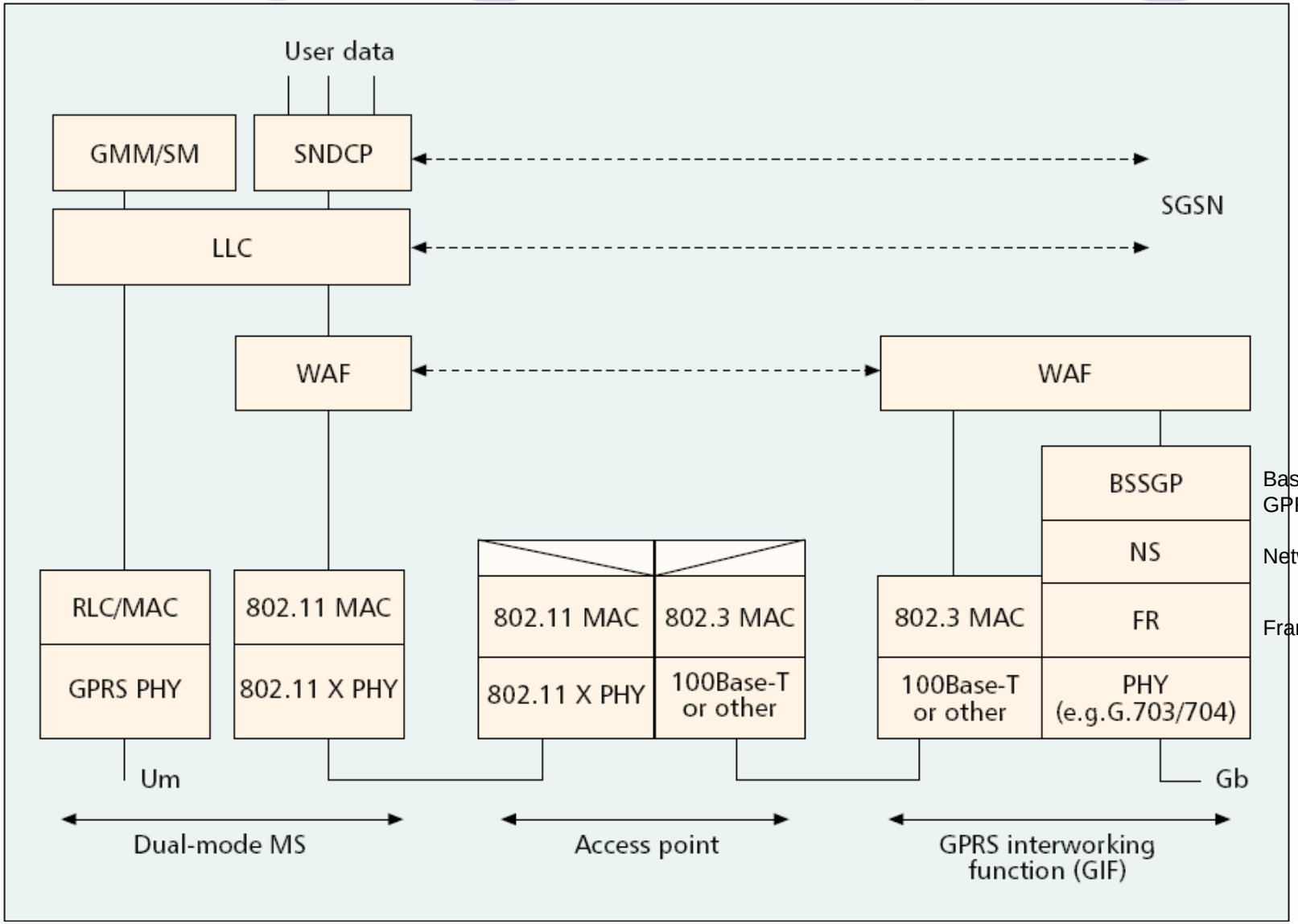


Tight Coupling over Gb: Protocol Architecture



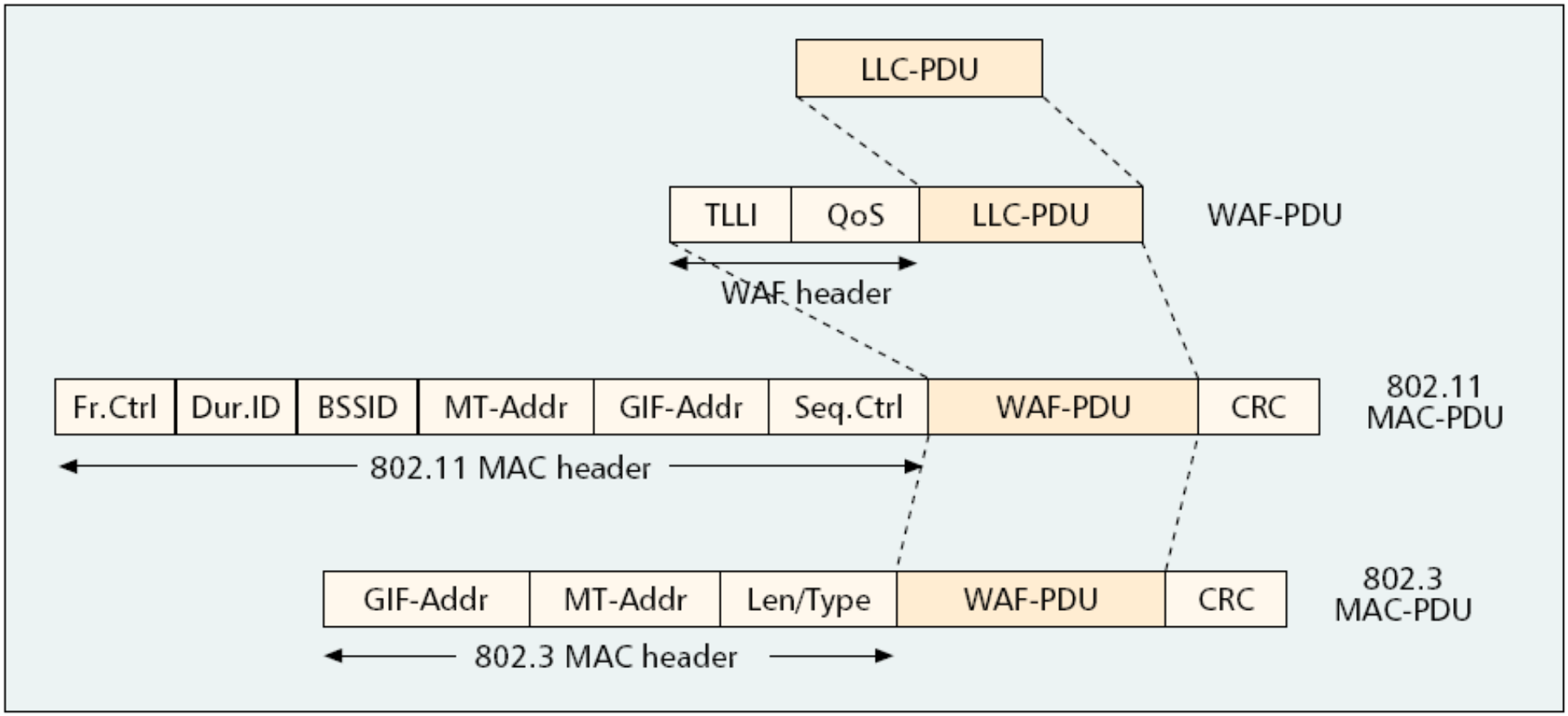
Seamless Mobility

- 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 interfance
    - 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

Cont.

- 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 subssytem is used

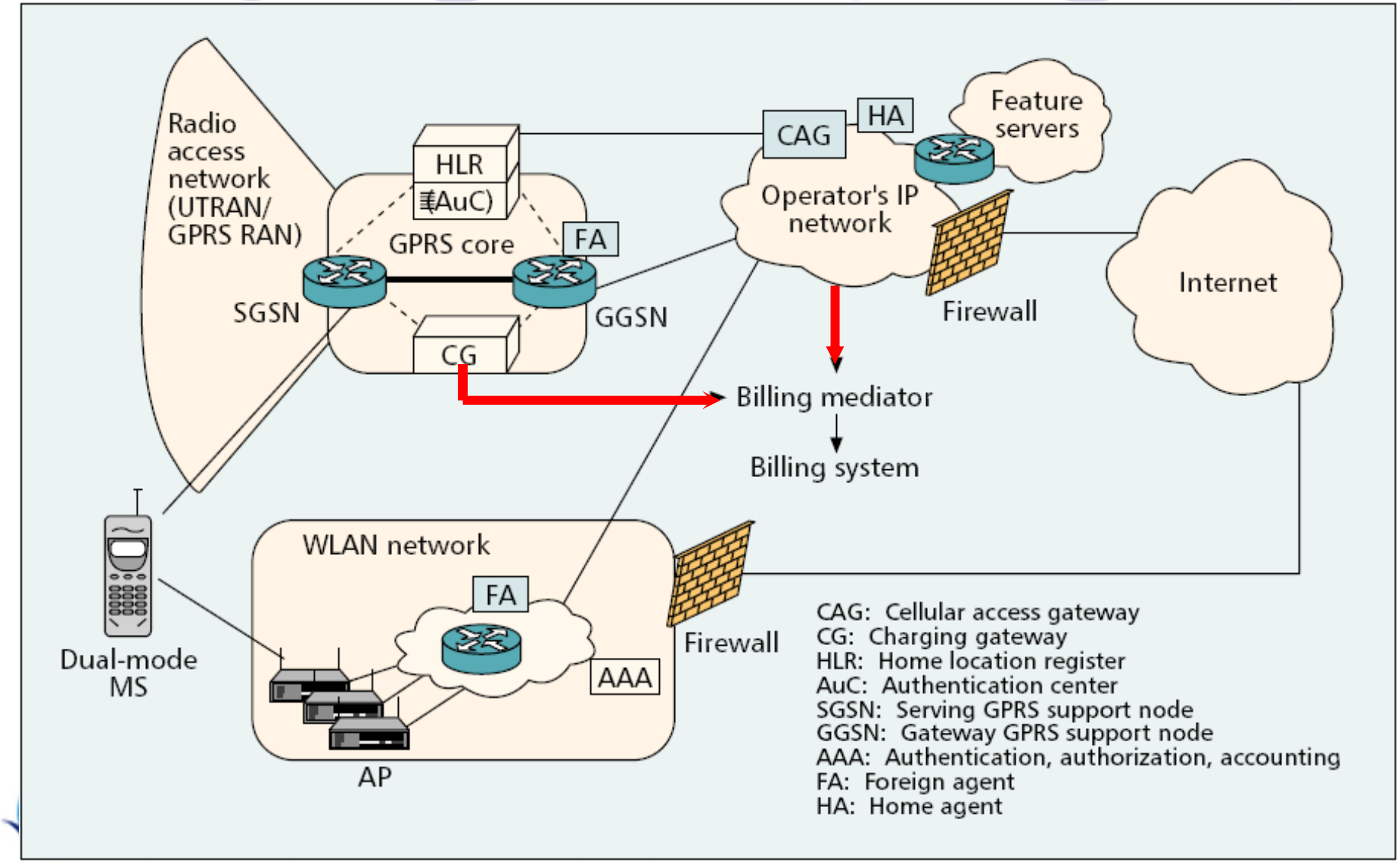
The Encapsulation Scheme



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



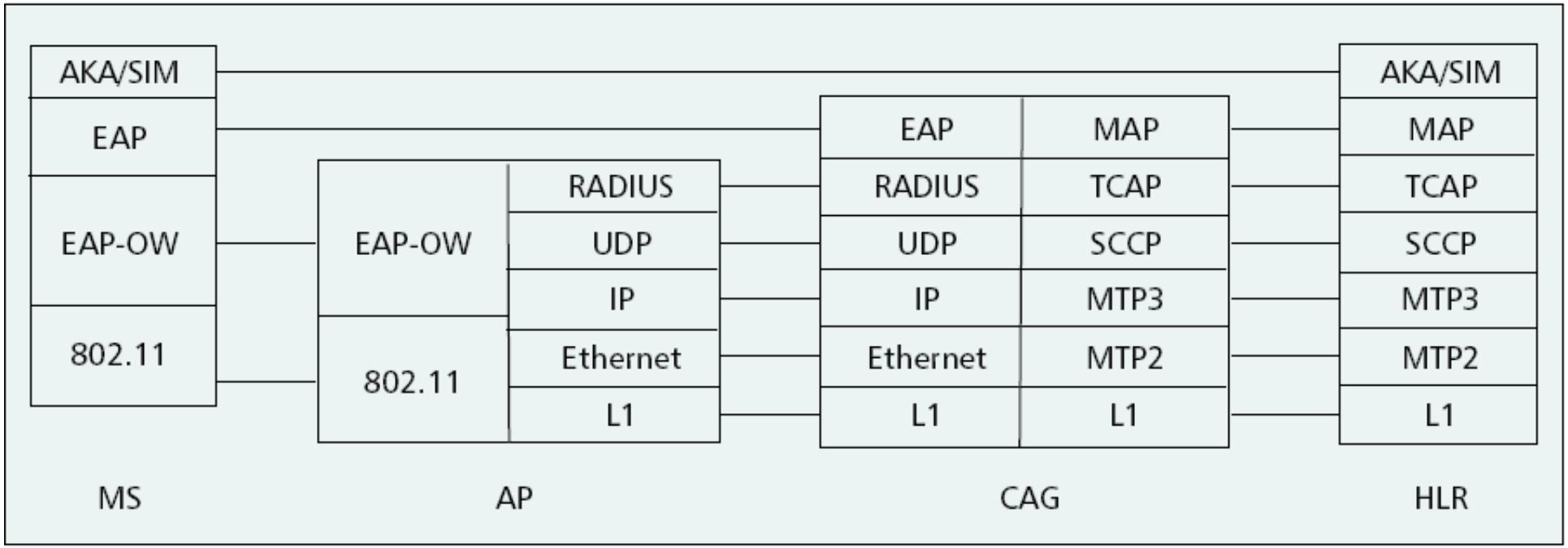
Session Mobility

- 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 resides 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

Cont.

- The FA the 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



Category	Tight coupling	Loose coupling
Authentication	• Reuse GPRS authentication for WLAN user • Reuse GPRS ciphering key for WLAN encryption	Cellular access gateway to provide SIM-based authentication interworking. RADIUS (only) based authentication is an alternative
Accounting	Reuse GPRS accounting	Billing mediator to provide common accounting
WLAN-cellular mobility	SGSN is the call anchor, and intra-SGSN handovers provide mobility	Home agent is the call anchor, and Mobile IP handovers between GGSN and access router provide mobility. Home sgent could be collocated at the GGSN or CAG, or somewhere in an external network.
Context transfer	Fine-grained context information is available, e.g., QoS parameters, information about multiple flows, etc.	Limited context transfer possible between GGSN and WLAN through current draft proposals in IETF Seamoby working group
System engineering	Impact of high-speed WLAN network on existing GSN from bearer and signaling standpoint is an issue	WLAN and GPRS networks can be engineered separately
New development	• WLAN terminal modifications for GPRS signaling • Modifications in WLAN network or modifications in SGSN	• CAG for SIM-based authentication • Billing mediator for accounting
Standardization	A new interface in the SGSN might be required, specifically for connecting to WLANs.	EAP-SIM and EAP-AKA is being pursued in IETF PPPext working group
Target usage	Applies primarily to WLAN networks owned by cellular operators. Has limited application when WISP is different from cellular operator.	Applies more broadly