Introduction to Wireless Networks

Chapter 7: Introduction to Heterogeneous Networks and ALL-IP Networks

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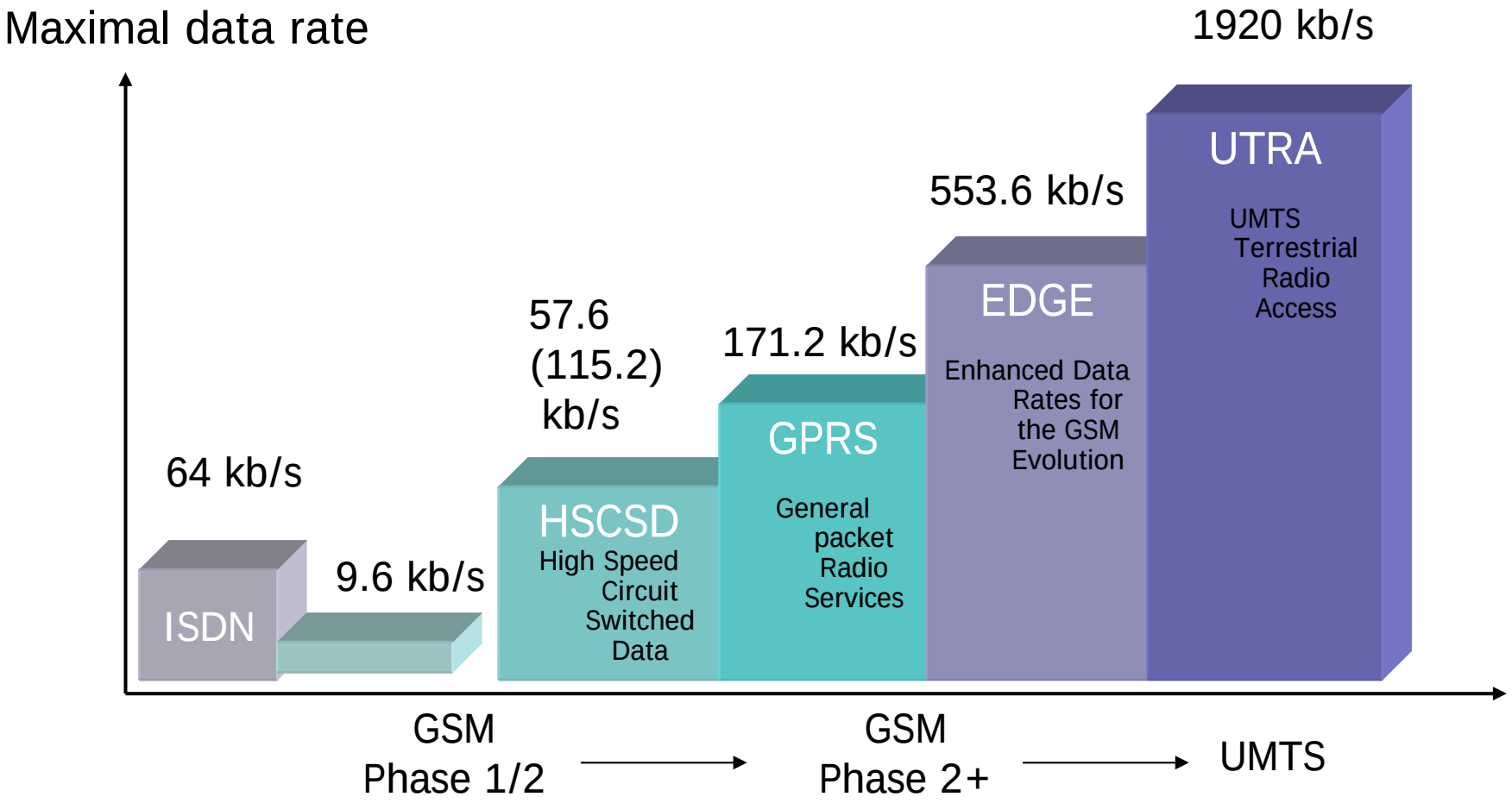
Outline

- Trend on Wireless/Cellular Networks
- Heterogeneous Wireless Networks
  - Datacom: Wireless Networks
  - Telecom: Cellular Networks
- Some Research Issues
  - Interworking Architecture
  - Mobility Management
  - QoS Guarantee
  - Security/AAA
- Conclusions

Cellular Networks (1/2)

- 1G: analog systems
  - AMPS, NMT, TACS
- 2/2+G: digital systems
  - GSM, CDMA
  - GPRS, EGDE
- 3G: IMT-2000
  - W-CDMA (UMTS)
  - CDMA2000
- Beyond 3G
  - All-IP architecture
- 4G
  - Heterogeneous networks
- 5G
  - ???

Cellular Networks (2/2)



Wireless Networks (1/2)

- 802.15 Wireless PAN (http://www.ieee802.org/15/)
- (http://www.ieee802.org/15/pub/TG4.html)
  - Communication between computers, mobile telephones, and other portable devices
  - Derive from the Bluetooth Spec.
  - 721 kb/s or up to 20 Mb/s in the 2.4 GHz band
- 802.11 Wireless LAN
- (http://grouper.ieee.org/groups/802/11/)
  - 1 or 2 Mb/s with infrared
  - 1 or 2 Mb/s with the frequency hopping spread spectrum in the 2.4 GHz band

MICAz - 2.4 GHz IEEE 804.15.4/ZigBee™ Compliant Mote

(http://www.xbow.com/)

Wireless Networks (2/2)

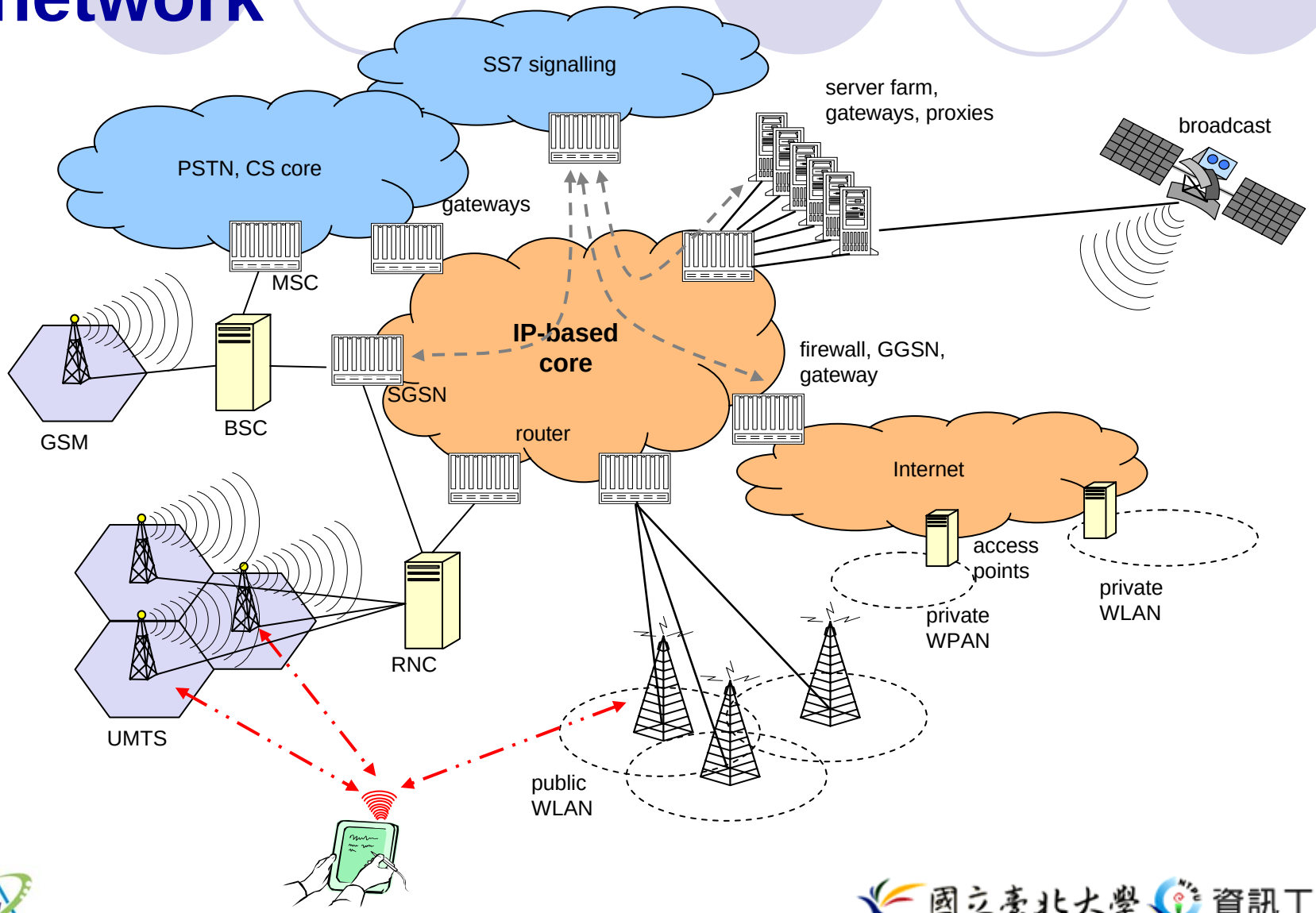
- Up to 11 Mb/s with the direct sequence spread spectrum in the 2.4 GHz band (802.11b) (Wi-Fi Standard)
- Up to 20 (54) Mb/s with the orthogonal frequency division multiplexing in the 2.4 GHz band (802.11g)
- Up to 54 Mb/s with the orthogonal frequency division multiplexing in the 5-6 GHz band (802.11a)

- 802.16 Wireless MAN (WiMax)
  - http://www.wimaxforum.org/home (WiMax Forum)
  - Broadband wireless access standards
  - Link commercial/residential buildings to core networks
  - Ranges of bands
    - 5-6 GHz, 2-11 GHz ,10-66 GHz

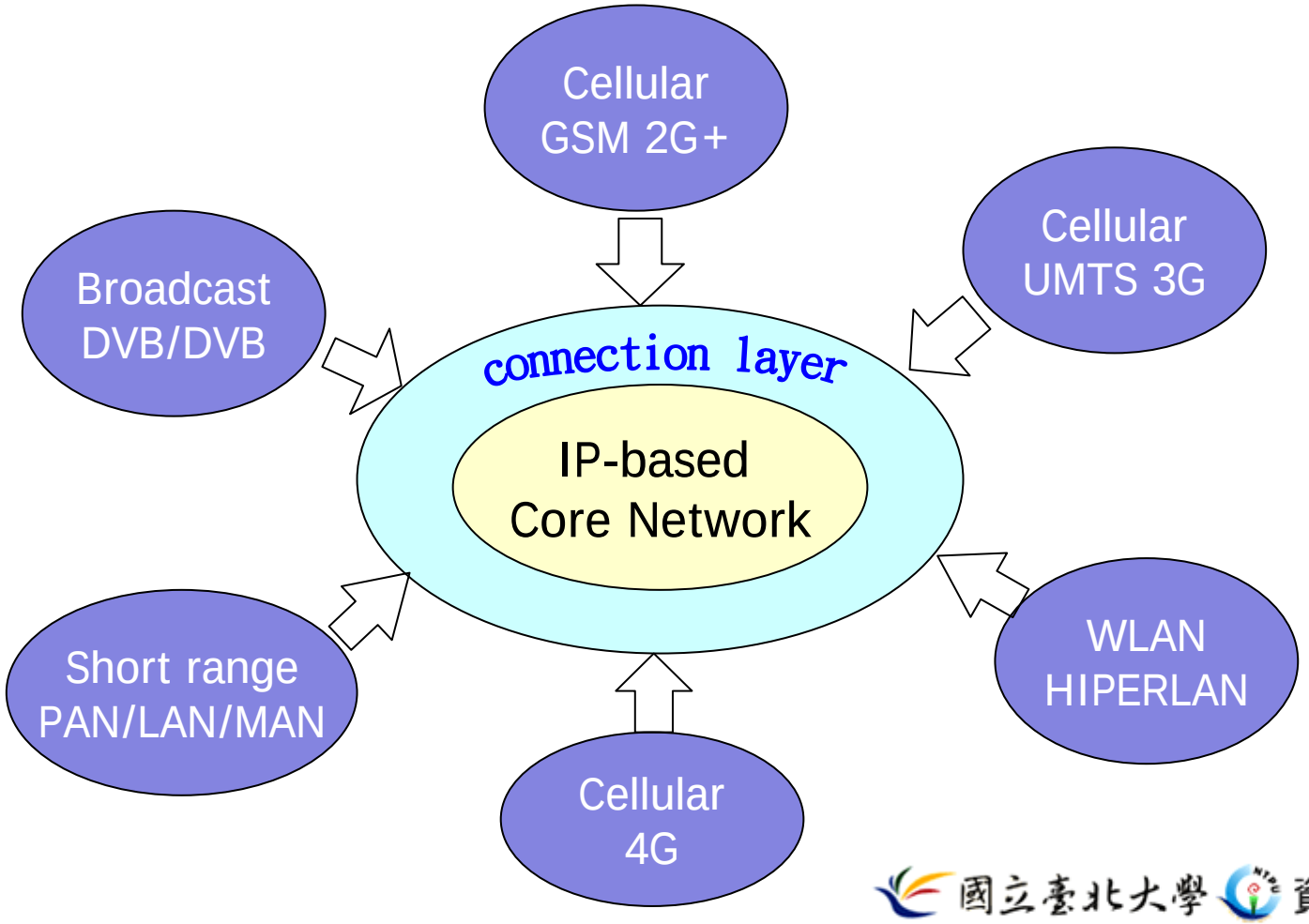
Next-generation Wireless Internet (1/2)

- Heterogeneous Networks
  - Including different access networks
    - GPRS, WLAN, MANET (mobile ad hoc)
  - Vertical/Horizontal handoffs
- All-IP Architecture and Connectivity
- Terminals with Software-Based Radio Interfaces

Example IP-based 4G/Next G/... network



Next-generation Wireless Internet (2/2)



All-IP Architecture

- **Advantages**
  - Integrated voice and data stack at end devices
  - Simpler signaling architecture
  - Lower operations and network management cost
- **Disadvantages**
  - IP headers waste wireless bandwidth
  - More complex terminals
  - Larger latency
  - Requires QoS support for packet voice

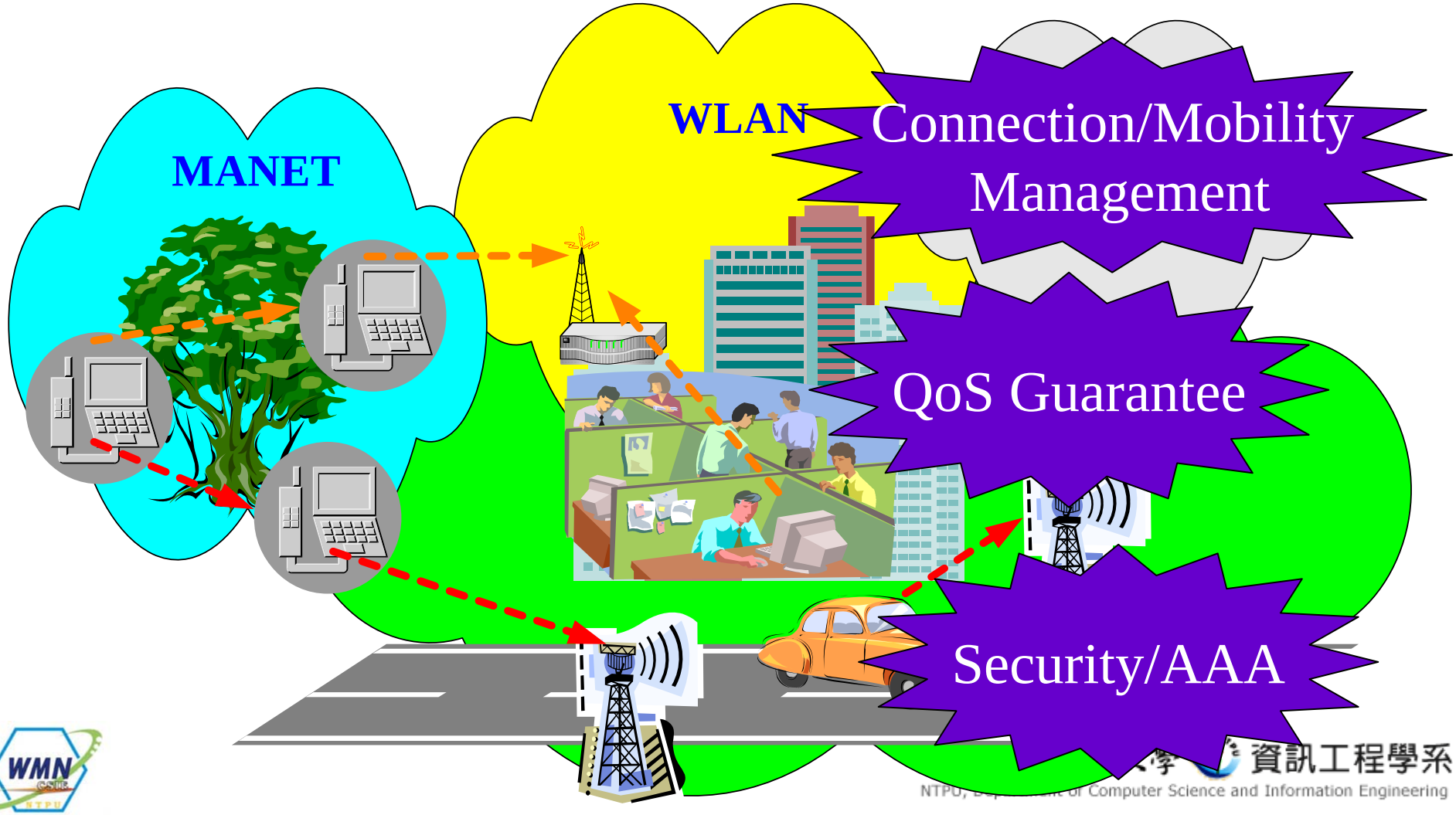
Integrated WLAN and Cellular Data Networks

- Integrated WLAN and Cellular Data Networks
  - A cellular data network can provide relatively low speed data service (up to 115.2Kbps with GPRS and 2Mbps with 3G system) over a large coverage area. On the other hand, WLAN provides high-speed data service (up to 11 Mbps with 802.11b and 54Mbps with 802.11a) over a geographically small area. An integrated network combines these two kind of data networks.
  - A kind of Heterogeneous Networks

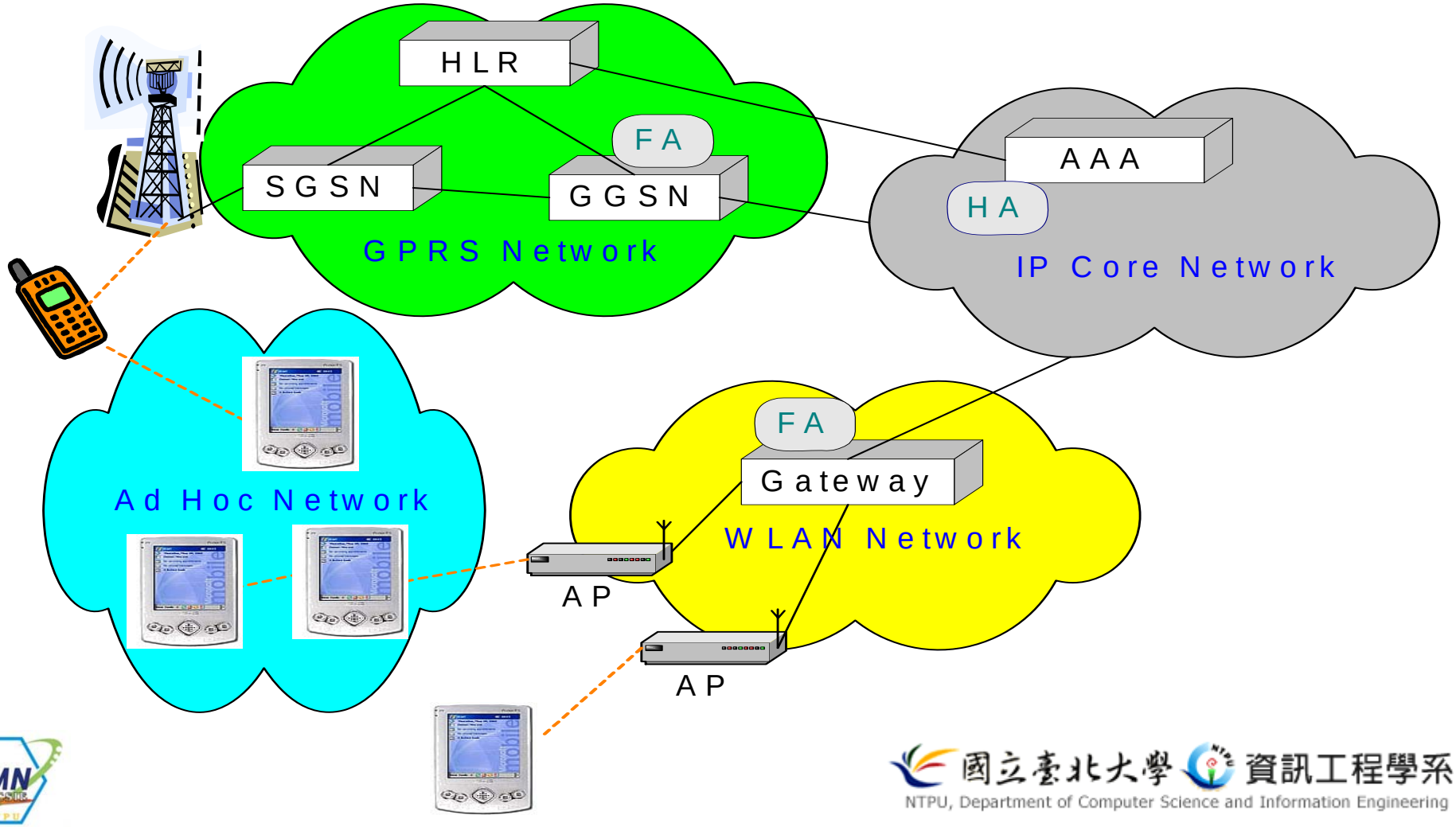
Integration

- UMTS (or GPRS) vs. WLAN
  - Coverage
    - UMTS (several kilometers) > WLAN (several hundred meters)
  - Data rate
    - WLAN (up to 54Mbps) > UMTS (up to 2Mbps when static) > GPRS (up to 115.2K bps)
- There is a strong need for interworking mechanism between WLANs and cellular data networks
- We discuss integrated UMTS/WLAN heterogeneous networks

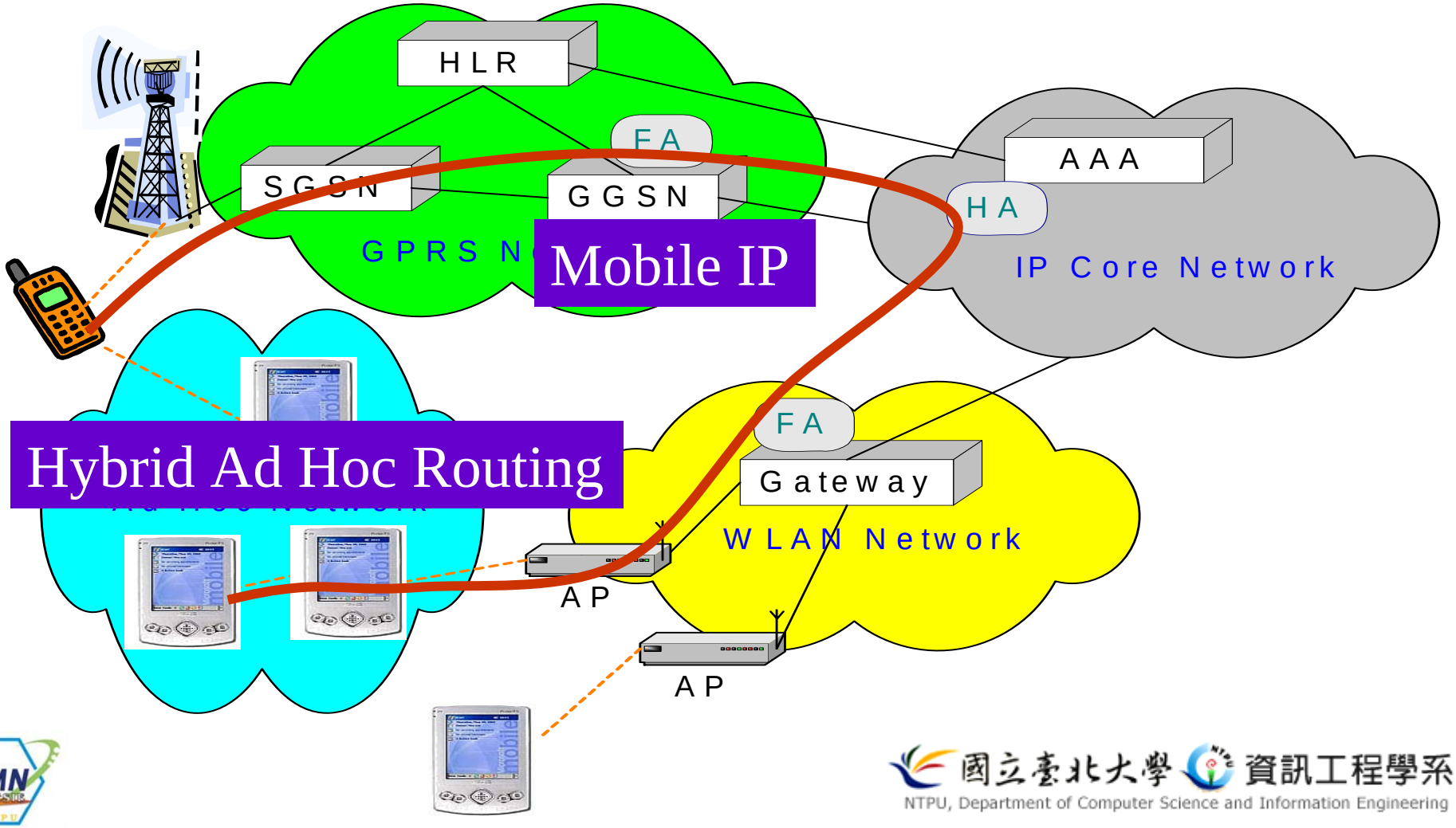
Integration of Heterogeneous Networks



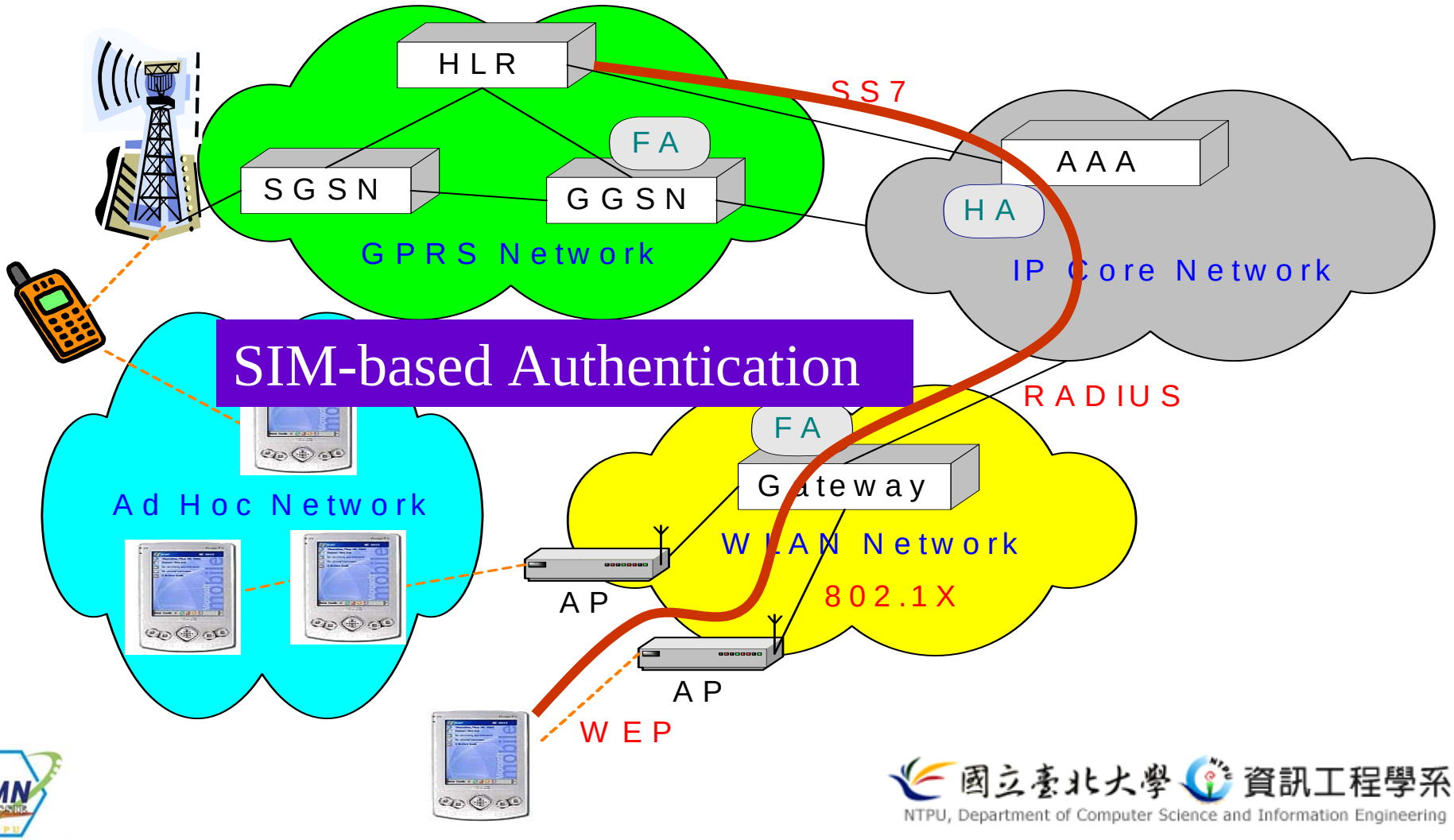
Scenario: Integration



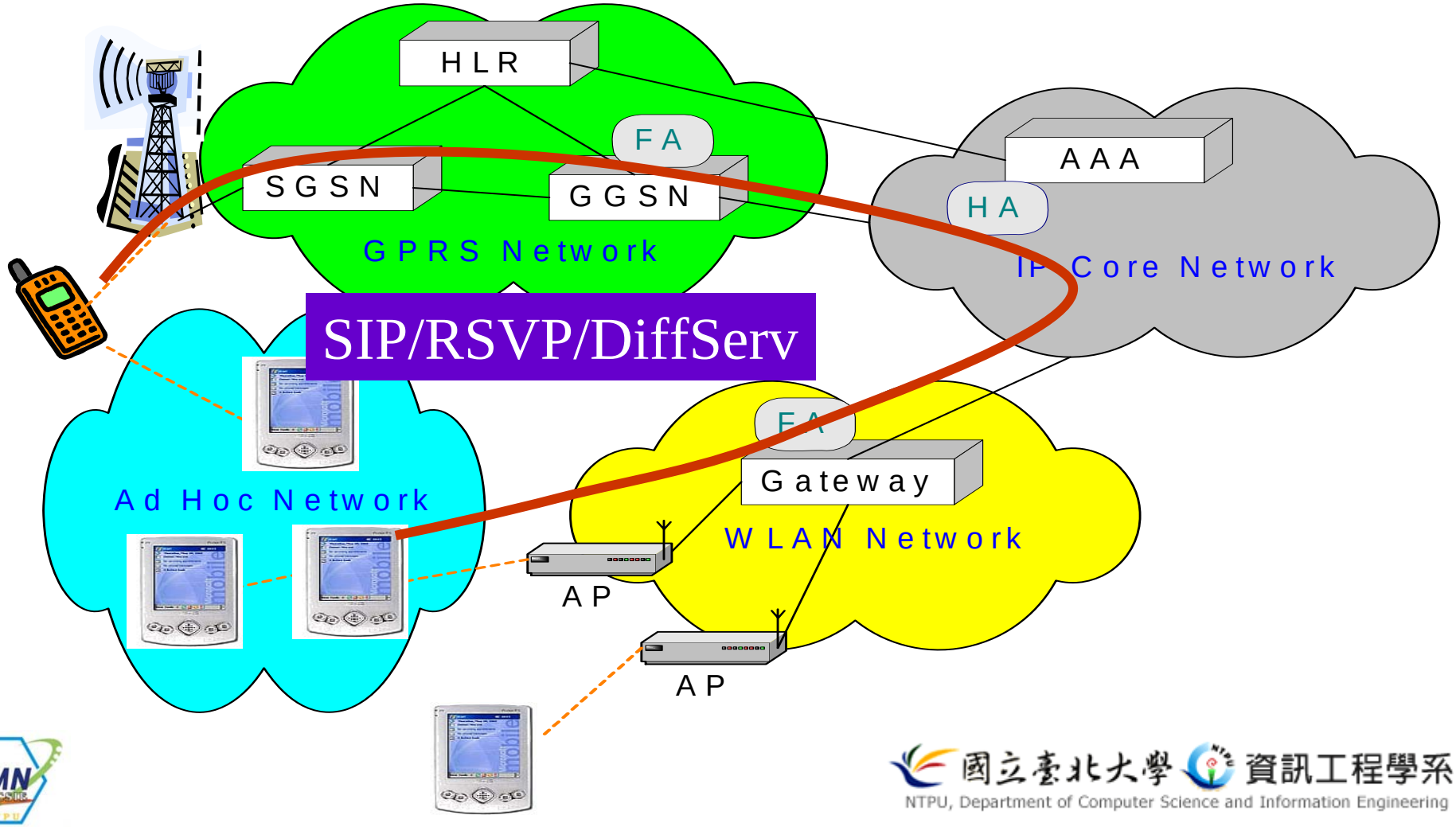
Scenario: Connection/Mobility



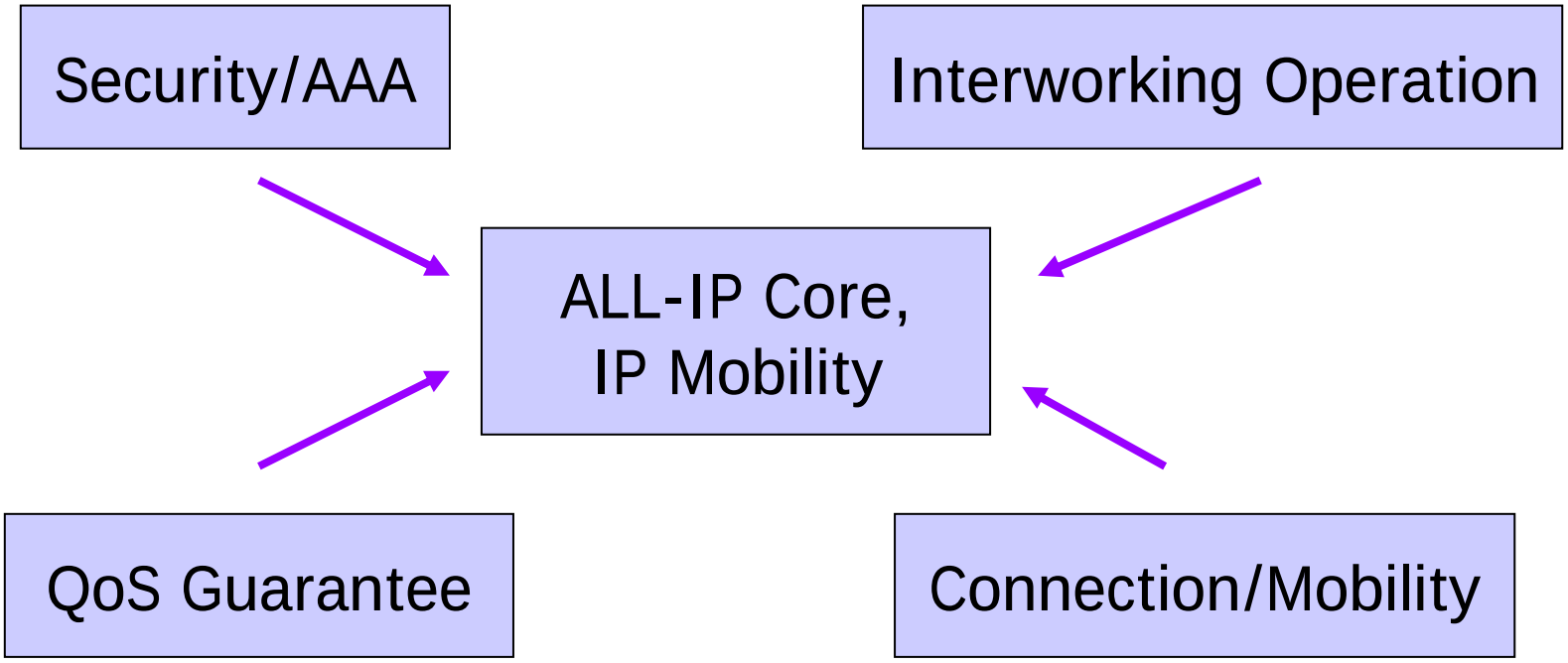
Scenario: Authentication



Scenario: End-to-End QoS



Research Issues in Heterogeneous Networks



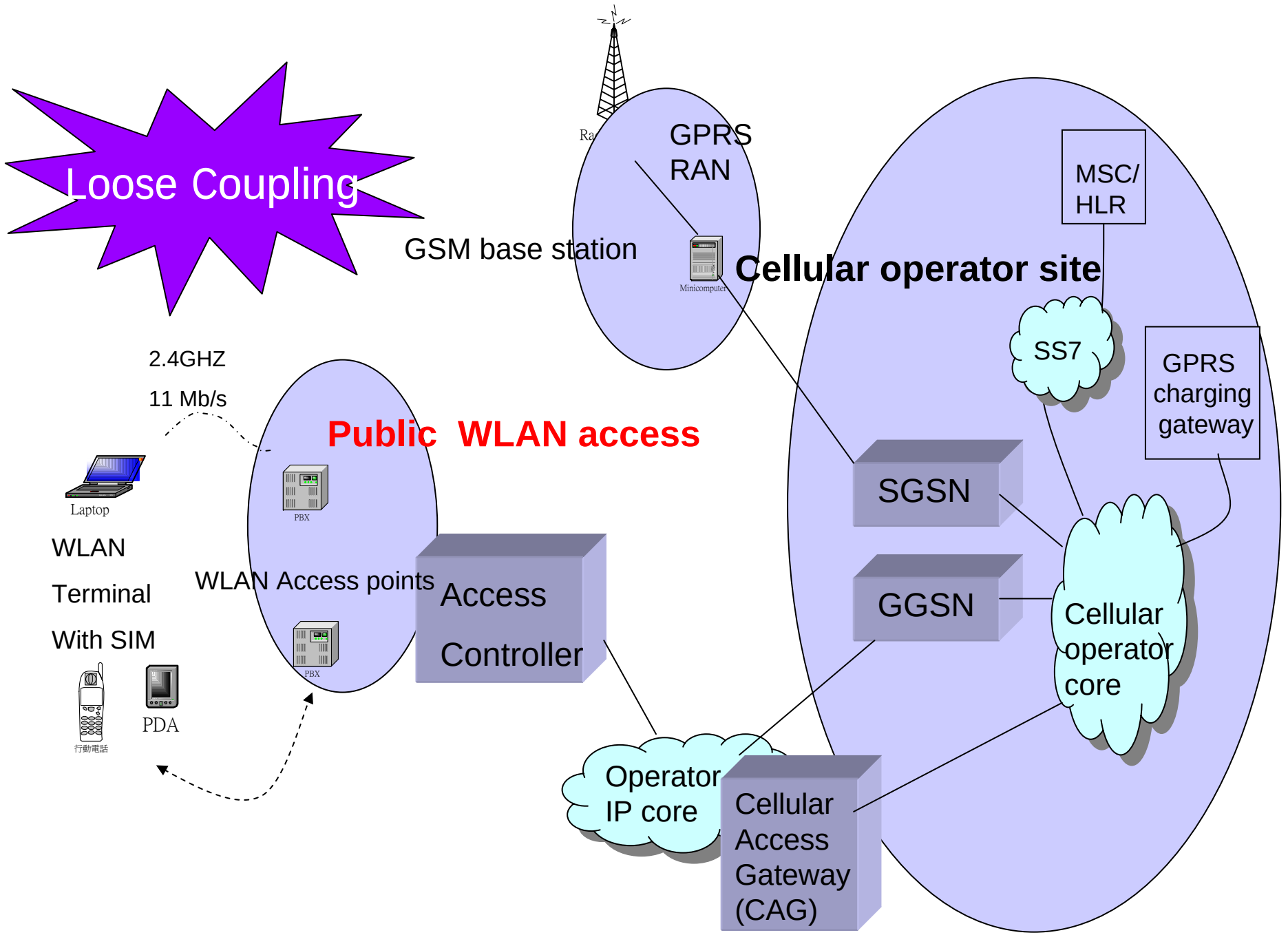
Interworking Architectures

- There needs 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
- The European Telecommunications Standards Institute (ETSI) specifies two coupling mechanisms:
  - A Tight Coupling Architecture
  - A Loose Coupling Architecture

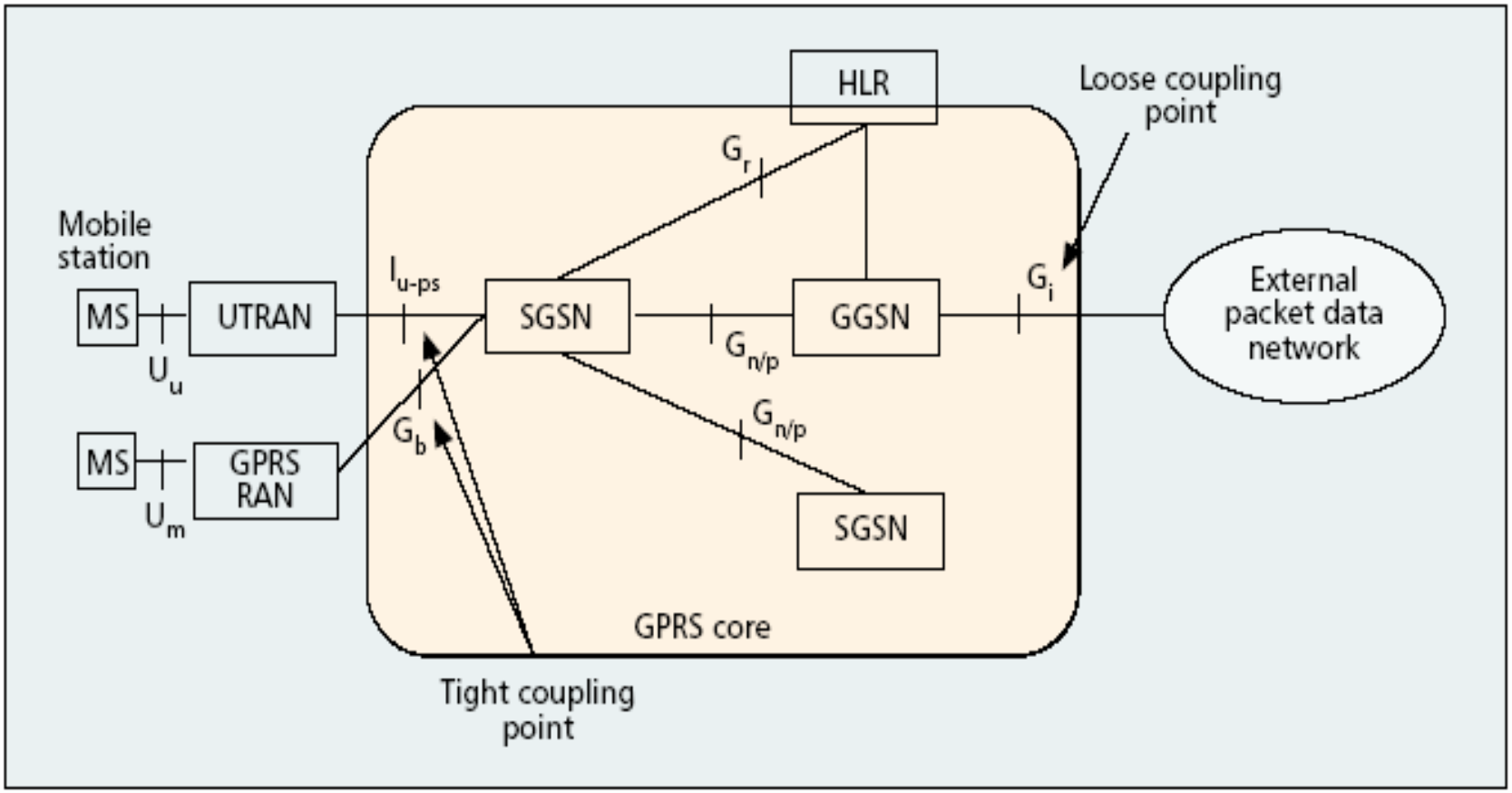
- Loose coupling: WLAN data traffic goes directly to the external packet data networks (PDN)
- Tight coupling: WLAN data traffic goes through GPRS core networks

Loose Coupling

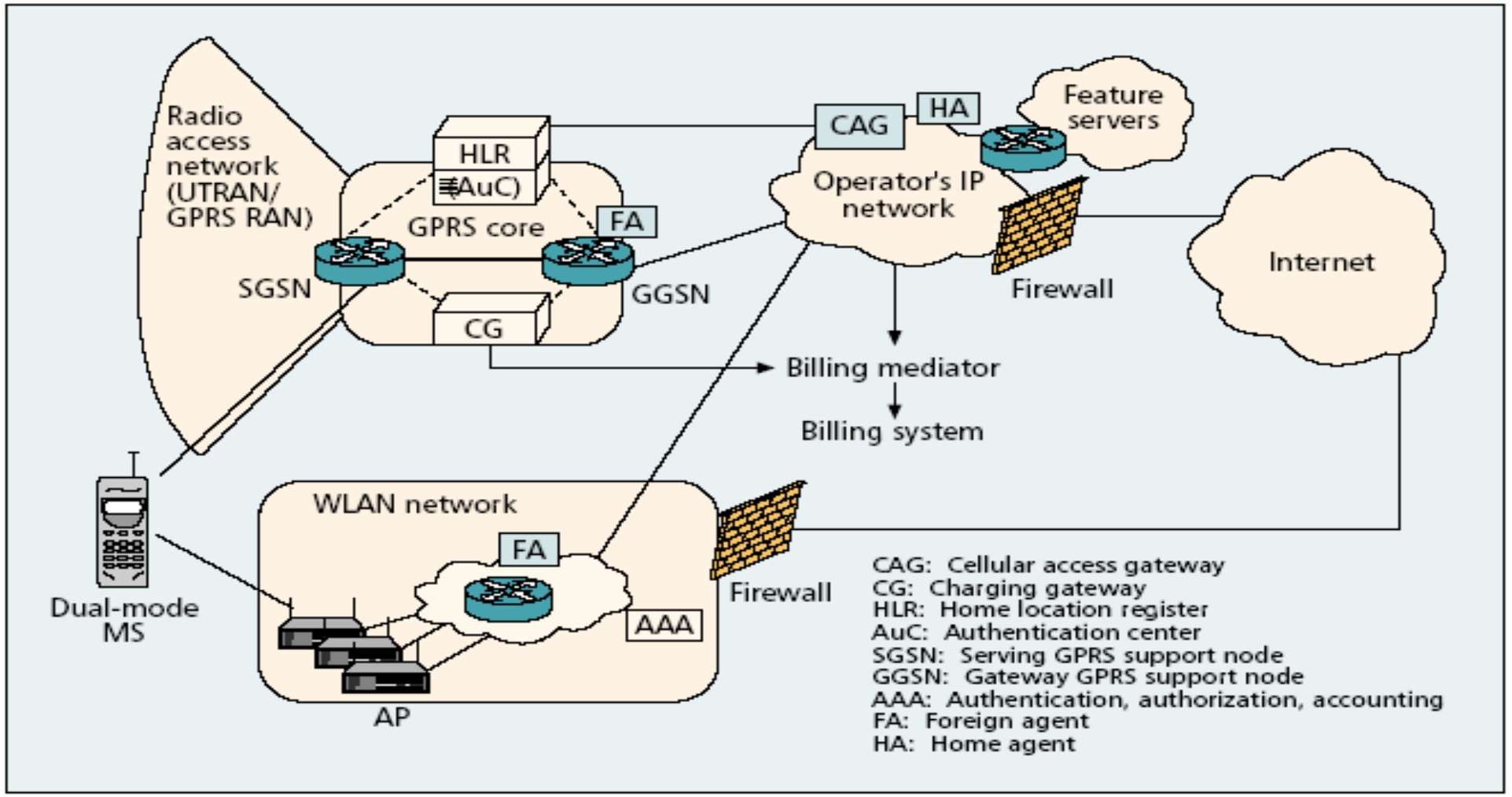
- WLAN is deployed as an access network complementary to the GPRS network
- Standard IETF-based protocols for AAA and mobility (e.g. Mobile IP)
- Need a common billing system


Loose Coupling
GSM base station
GPRS
RAN
Minicomputer
Cellular operator site
MSC/
HLR
SS7
GPRS
charging
gateway
2.4GHZ
11 Mb/s
Public WLAN access
Laptop
WLAN
Terminal
With SIM
PDA
行動電話
PBX
PBX
WLAN Access points
Access
Controller
SGSN
GGSN
Cellular
operator
core
Operator
IP core
Cellular
Access
Gateway
(CAG)

A GPRS Reference Diagram Showing the WLAN Coupling Points

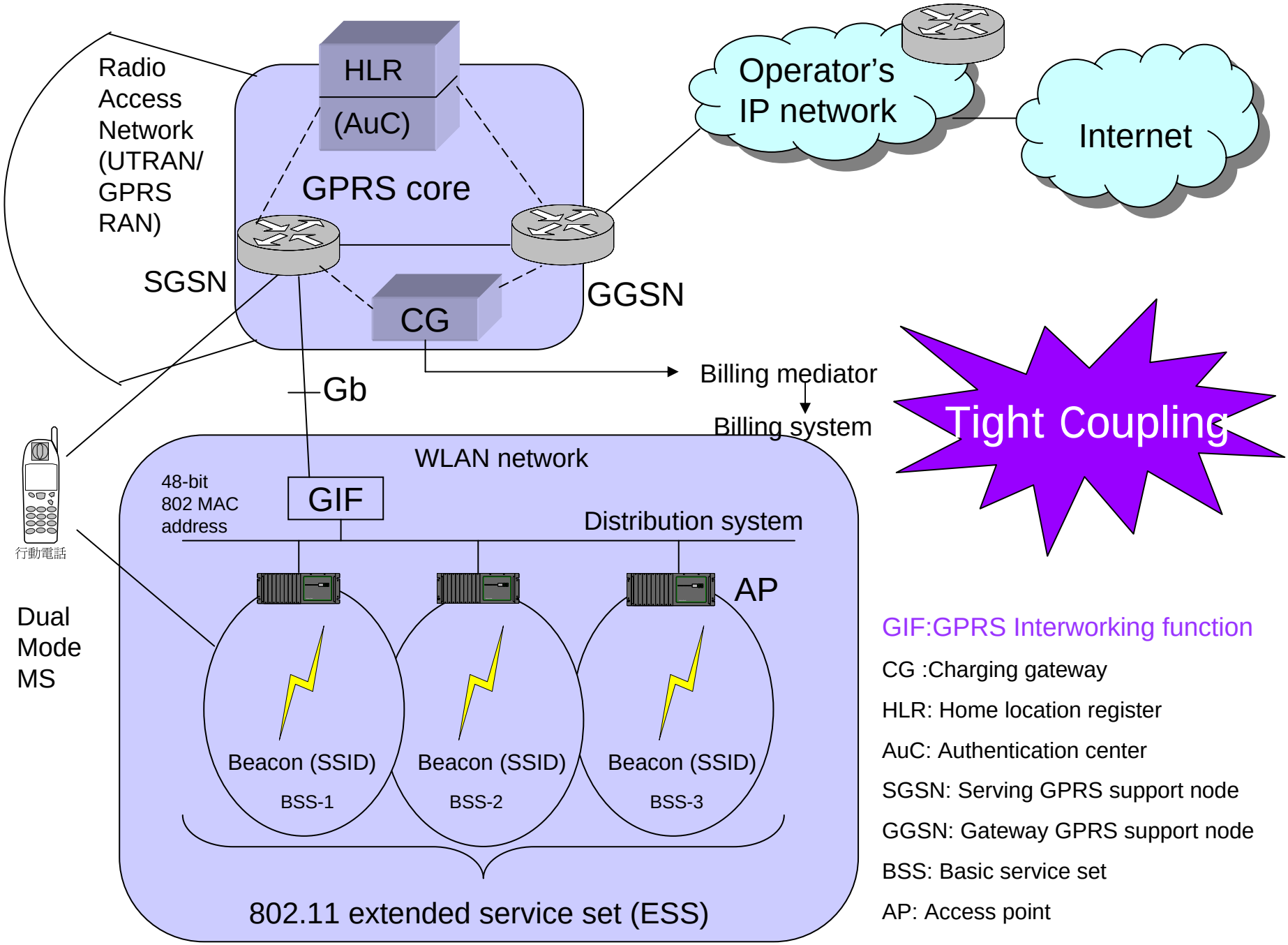


WLAN-GPRS Integration with Loose Coupling



Tight Coupling

- WLAN is connected to the GPRS core network as any other radio access network (RAN)
- WLAN is considered like any other GPRS routing area (RA)
- Reuse of GPRS infrastructure/AAA



GIF:GPRS Interworking function

CG :Charging gateway

HLR: Home location register

AuC: Authentication center

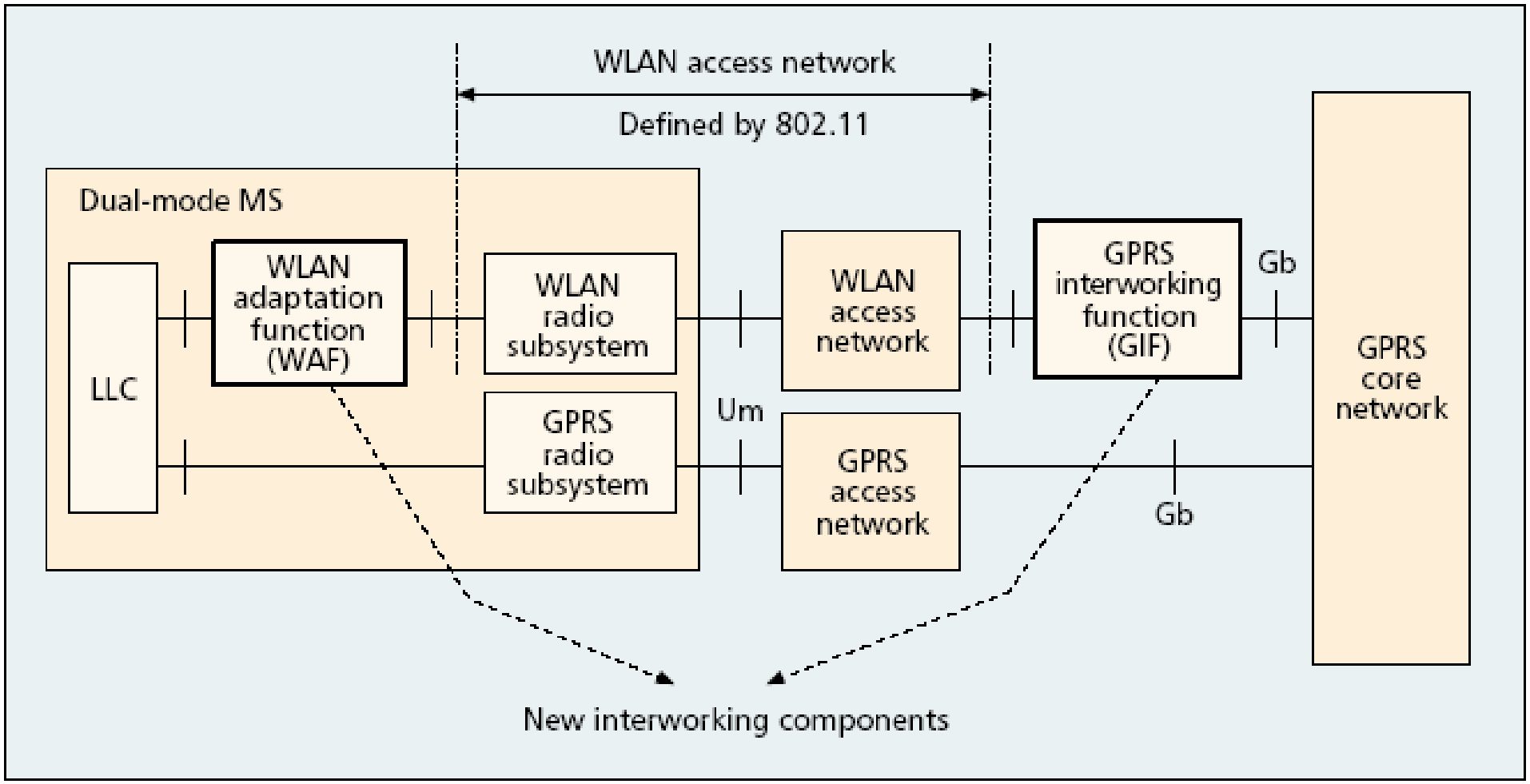
SGSN: Serving GPRS support node

GGSN: Gateway GPRS support node

BSS: Basic service set

AP: Access point

Tight coupling over Gb



Loose vs. Tight (1/2)

	Tight coupling	Loose coupling
Authentication	Reuse GPRS auth. and ciphering key	Cellular Access Gateway to provide SIM-based auth. interworking
Accounting	Reuse GPRS accounting	Billing mediator to provide common accounting
WLAN-Cellular mobility	SGSN (call anchor), Intra-SGSN handoff	Home agent (call anchor), Mobile IP handoff
Context transfer	Fine-grained context information (e.g. QoS Parameters)	Limited context transfer

Loose vs. Tight (2/2)

	Tight coupling	Loose coupling
System engineering	Impact of high-speed WLAN on GGSN	Engineered separately
New development	WLAN terminal, WLAN or SGSN modification	Cellular access gateway, billing mediator
Standardization	New interface in the SGSN	EAP-SIM, EAP-AKA (Extensible Authentication Protocol)
Target usage	Cellular operators owns WLAN Limited apps. when ISPs are different	Applies more broadly

Mobility Management: Overview

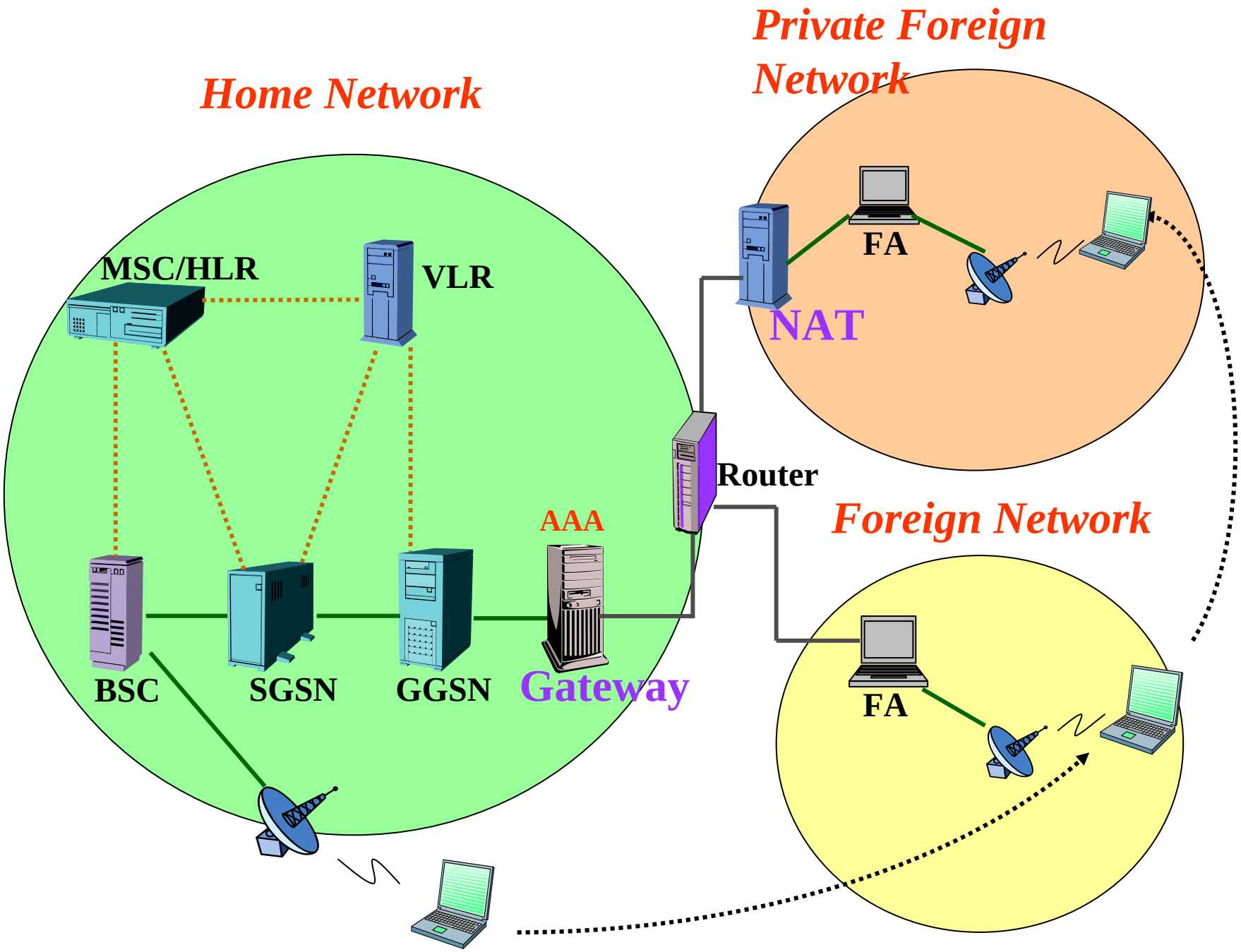
- Location Management
  - Goal: record the current location
  - Approach: HLR/VLR (cellular networks), Mobile IP, SIP (wireless networks)
- Handoff Management
  - Goal: keep network connectivity during handoff
  - Approach: hard, soft, seamless

Mobility Management: Research Issues

- IPv4 and IPv6 Integration
- Mobile IP + NAT
- Mobility over GPRS/WLAN/Ad Hoc Networks
- Seamless Handoff
- Handoff Prediction
- Handoff Decision in Vertical Handoffs

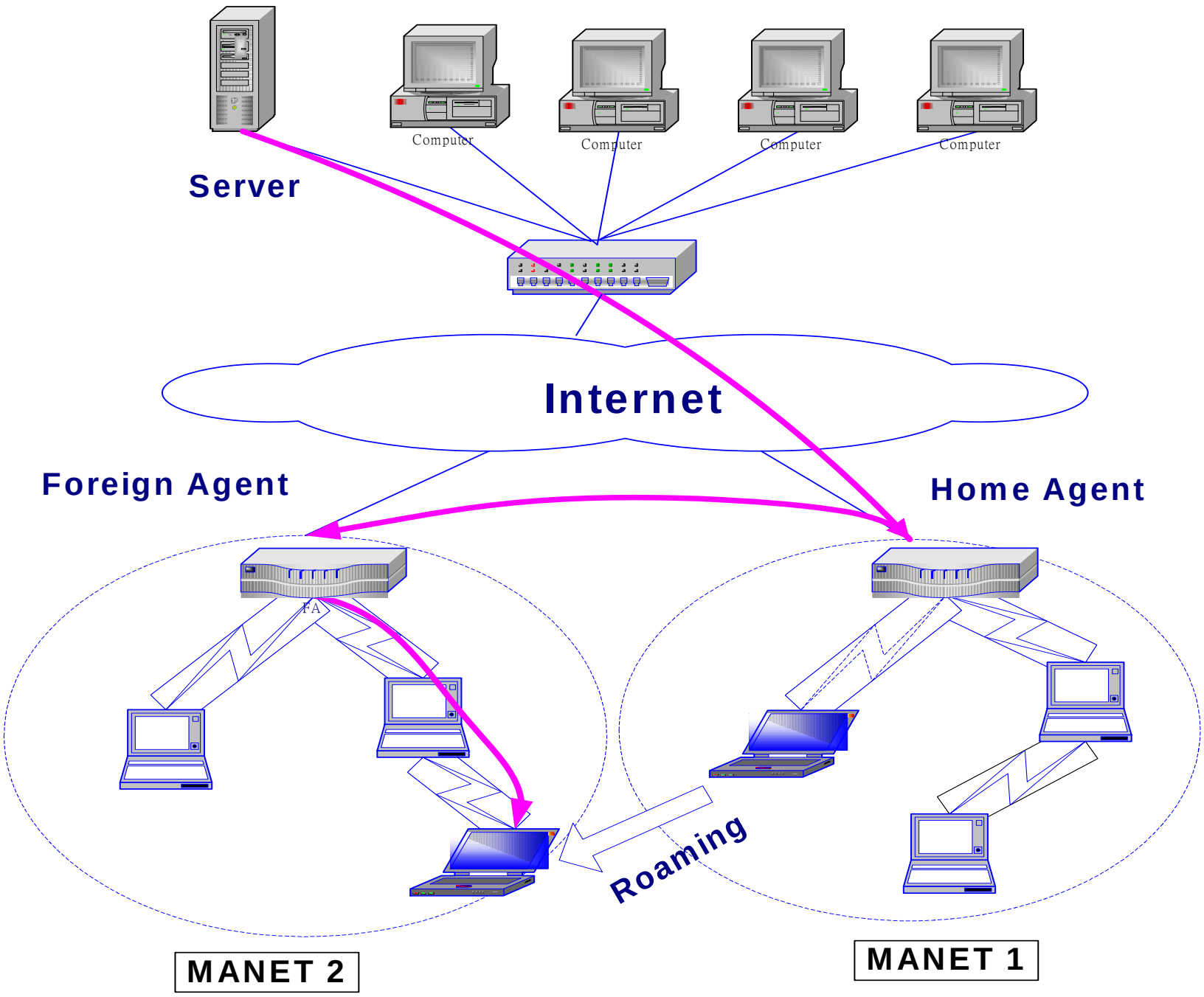
GPRS/WLAN Mobility

- Gateway Approach
  - HA locates in the dedicated gateway
  - GGSN and HA are connected via Gi interface
- NAT Problem
  - Mobile IP assumes uniquely routable IP address for all component, but it is not if they behind the NAT


Private Foreign Network
Home Network
MSC/HLR
VLR
FA
NAT
Router
AAA
Foreign Network
BSC
SGSN
GGSN
Gateway
FA

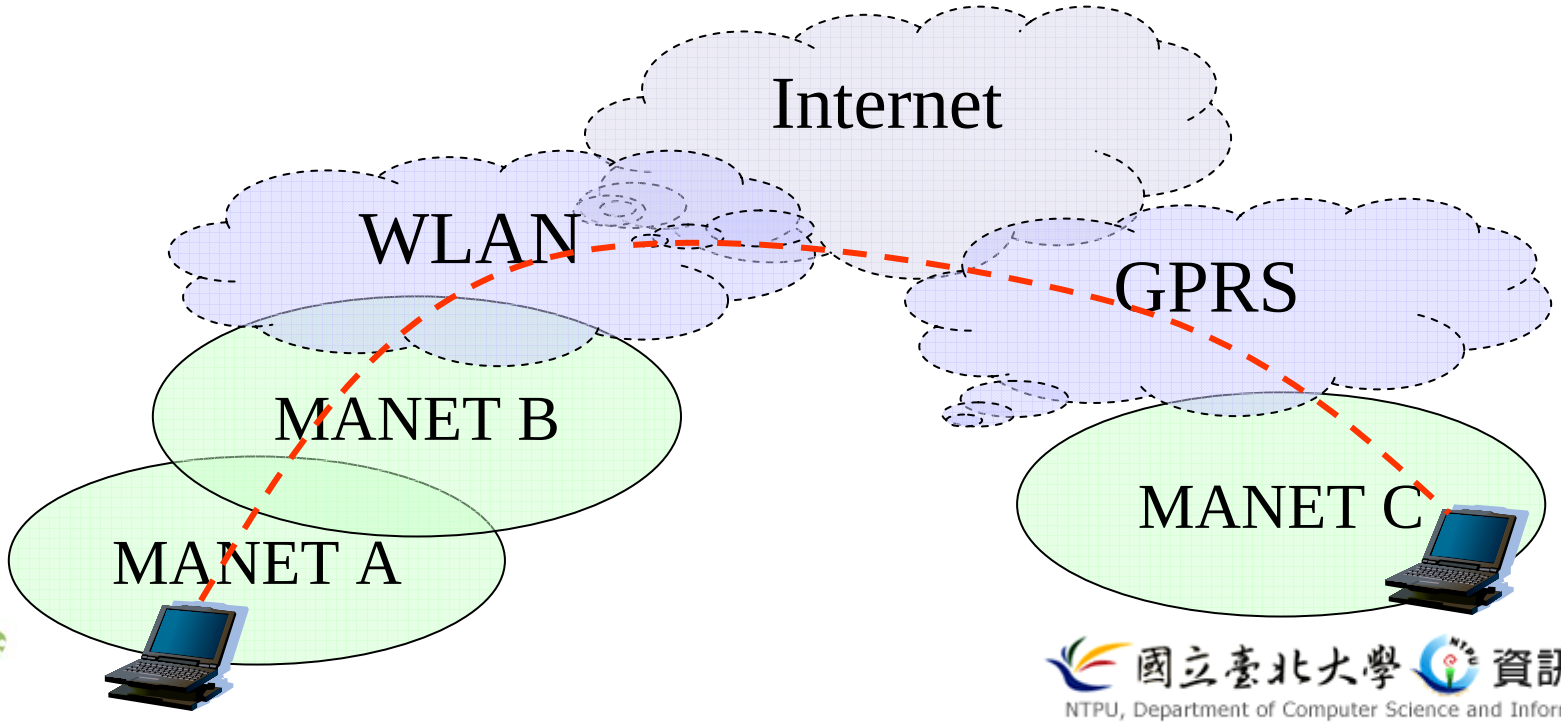
WLAN/Ad Hoc Mobility

- Some researchers integrate and implement Mobile IP on mobile ad hoc networks, which enables mobile hosts (MH) ubiquitously to access Internet services such as WWW, FTP, Email
- We modify Mobile IP protocol
  - By relaxing one-hop restriction
  - By using N-hop agent advertisements


Computer
Computer
Computer
Computer
Server
Internet
Foreign Agent
Home Agent
FA
Roaming
MANET 2
MANET 1

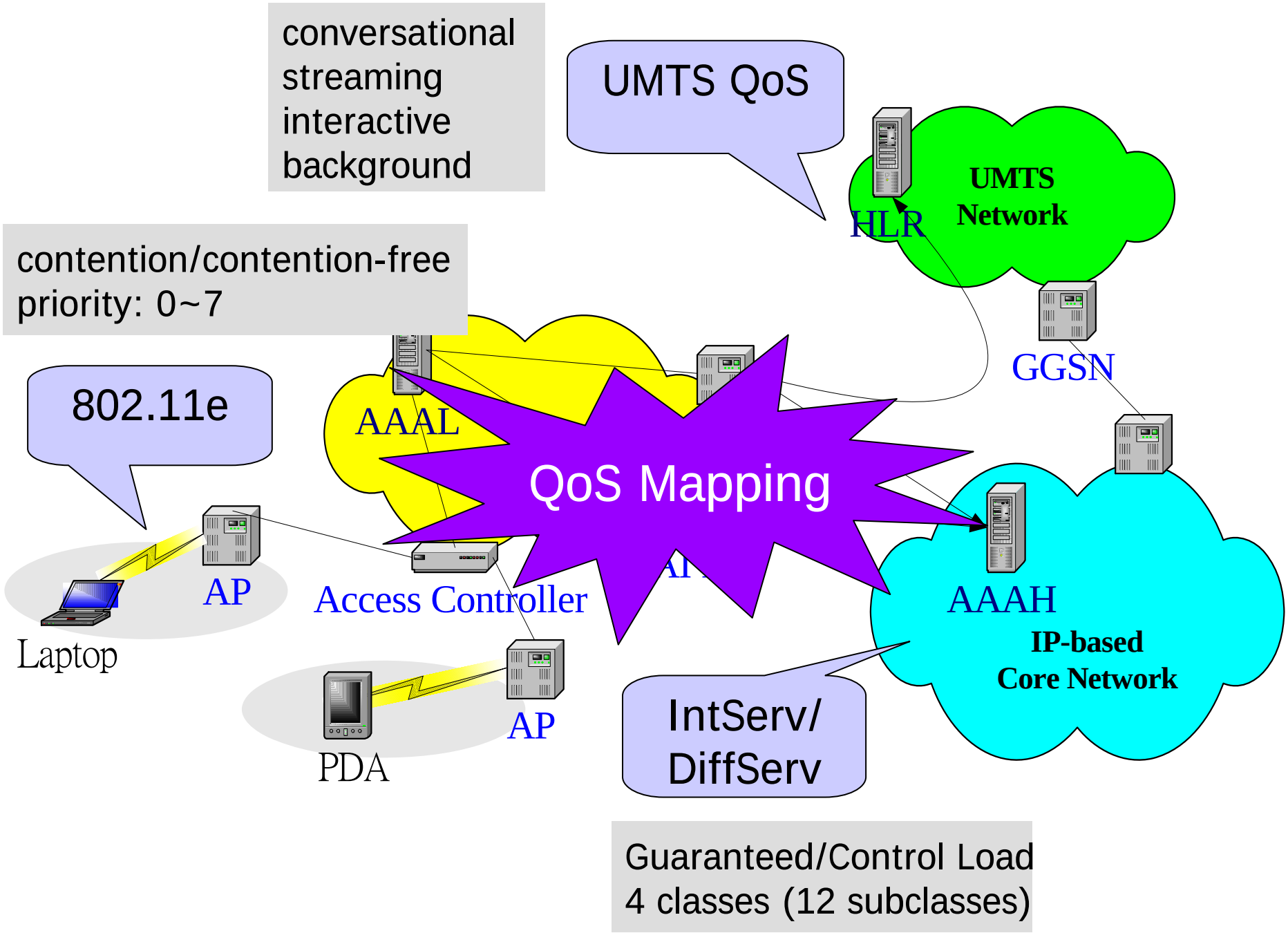
Hybrid Networking

- Group Management
- Route Discovery



Internet QoS

- Integrated Services Models (IntServ)
  - Reservation-based, per-flow
  - Hard guarantee
  - RSVP (resource reservation protocol)
- Differentiated Services Models (DiffServ)
  - Reservation-less, per-packet
  - Soft guarantee
  - DSCP (DiffServ code point), PHB (Per-Hop Behavior)

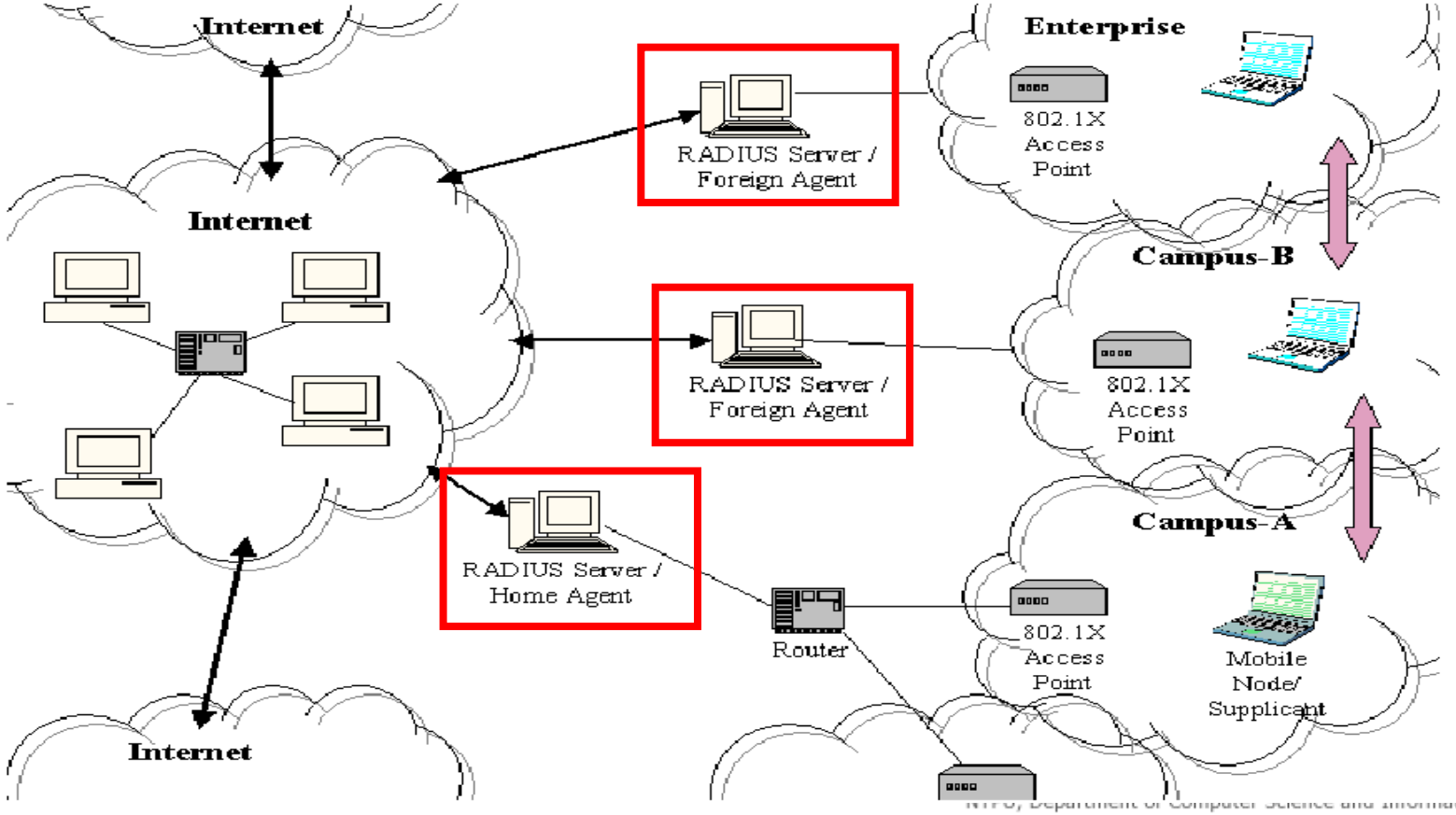

conversational
streaming
interactive
background
UMTS QoS
UMTS
Network
HLR
GGSN
contention/contention-free
priority: 0~7
802.11e
AAAL
QoS Mapping
AP
Access Controller
Laptop
AAAH
IP-based
Core Network
AP
PDA
IntServ/
DiffServ
Guaranteed/Control Load
4 classes (12 subclasses)

Security/AAA: Overview

- In order to enhance security of the IEEE 802.11 standard, 802.11i is being developed
- 802.11i includes the mechanisms
  - Enhanced encryption to WEP (Wired Equivalent Privacy)
  - Enhanced authentication based on 802.1x
- 802.1x defines a mechanism for port based network access control to provide compatible authentication and authorization protocols for devices interconnected by IEEE 802 LANs

Mobile IP over WLAN Security

- 802.11 Security by 802.1x and Radius



Conclusions

- Next-generation wireless Internet would be heterogeneous networks
  - GPRS/3G, WLAN, MANET
- Integration of heterogeneous networks is a challenge
- Various key issues should be addressed
  - security, QoS, energy efficient, mobility, geolocation, etc.

Homework #7:

1. What's the difference of WLAN-GPRS Integration by "loose coupling" and "tight coupling" ?
2. What's key futures of ALL-IP networks ?