無線網路多媒體系統
Wireless Multimedia System

Lecture 7: Network Mobility

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Agenda

- All-IP System: Beyond 3G
- Evolutions of PCS
- ALL IP Challenges
  - Mobile IP/Cellular IP
  - QoS Provisions: Integrated Service / DiffServ
- Next Week (Mobile IP)

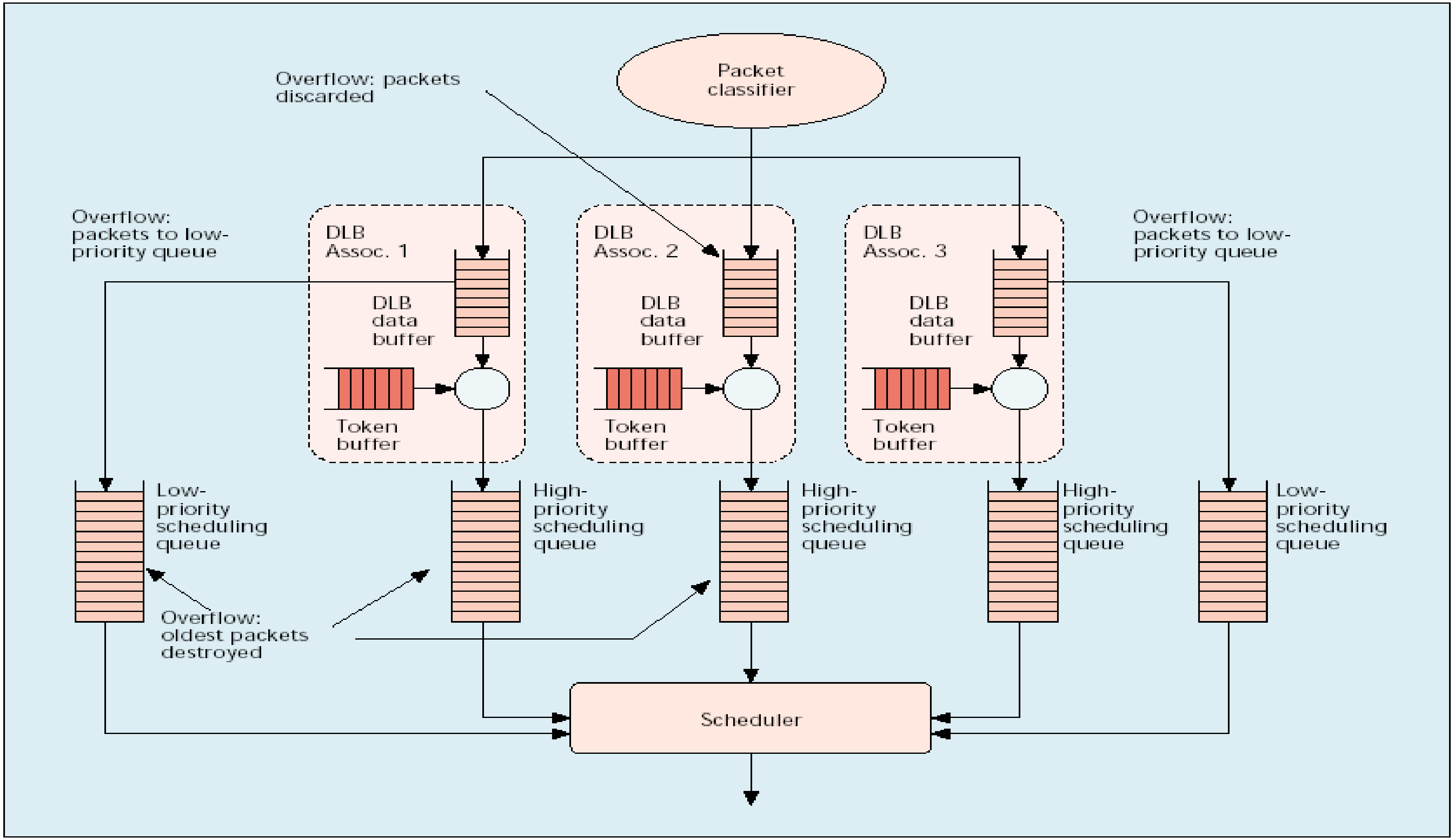
Reading

- [Bhagwat96] Pravin Bhagwat, Charles Perkins, and Satish Tripathi, “Network Layer Layer Mobility: An Architecture and Survey

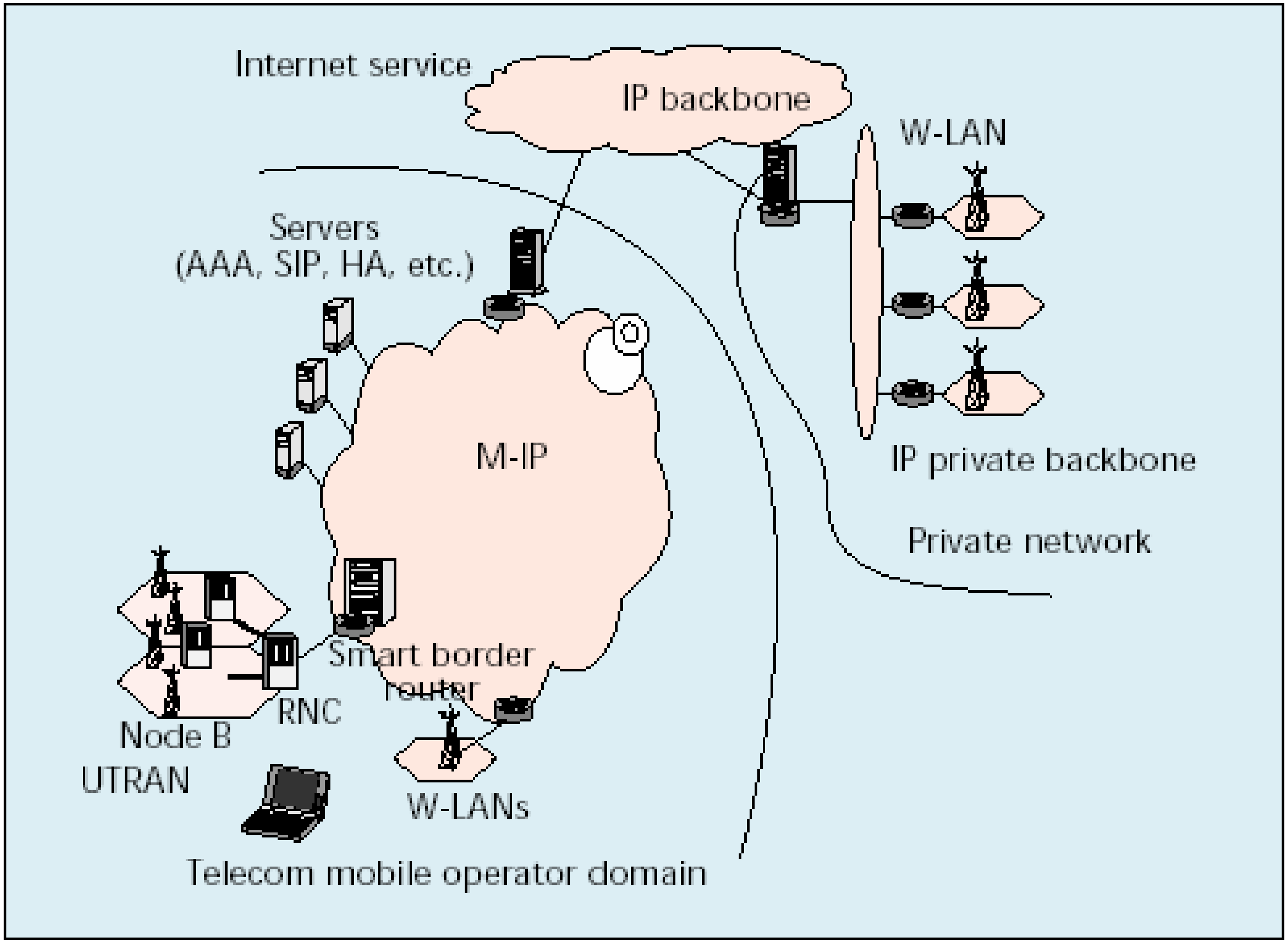
All IP

Something to happen?

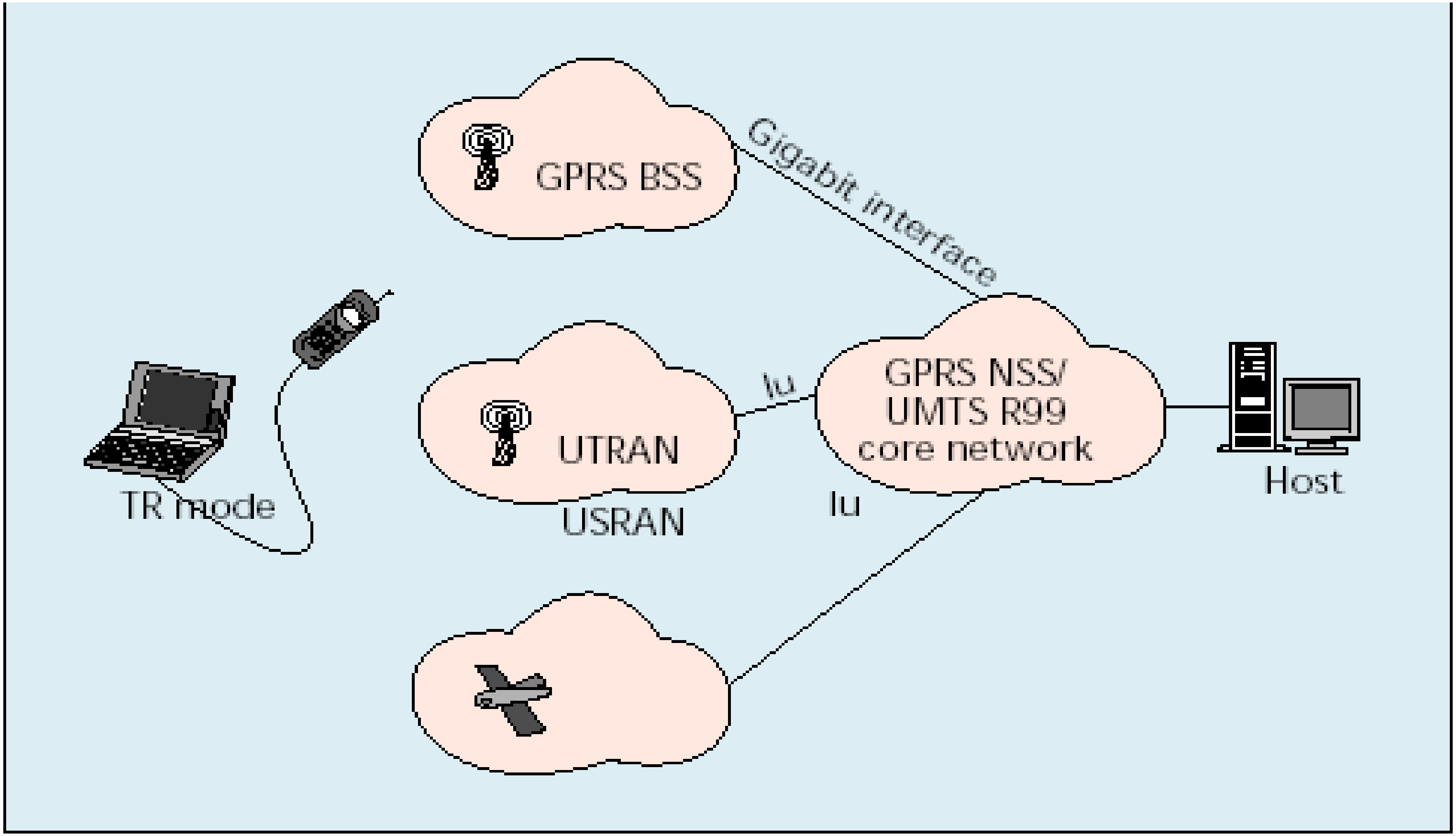
MT Scheduler



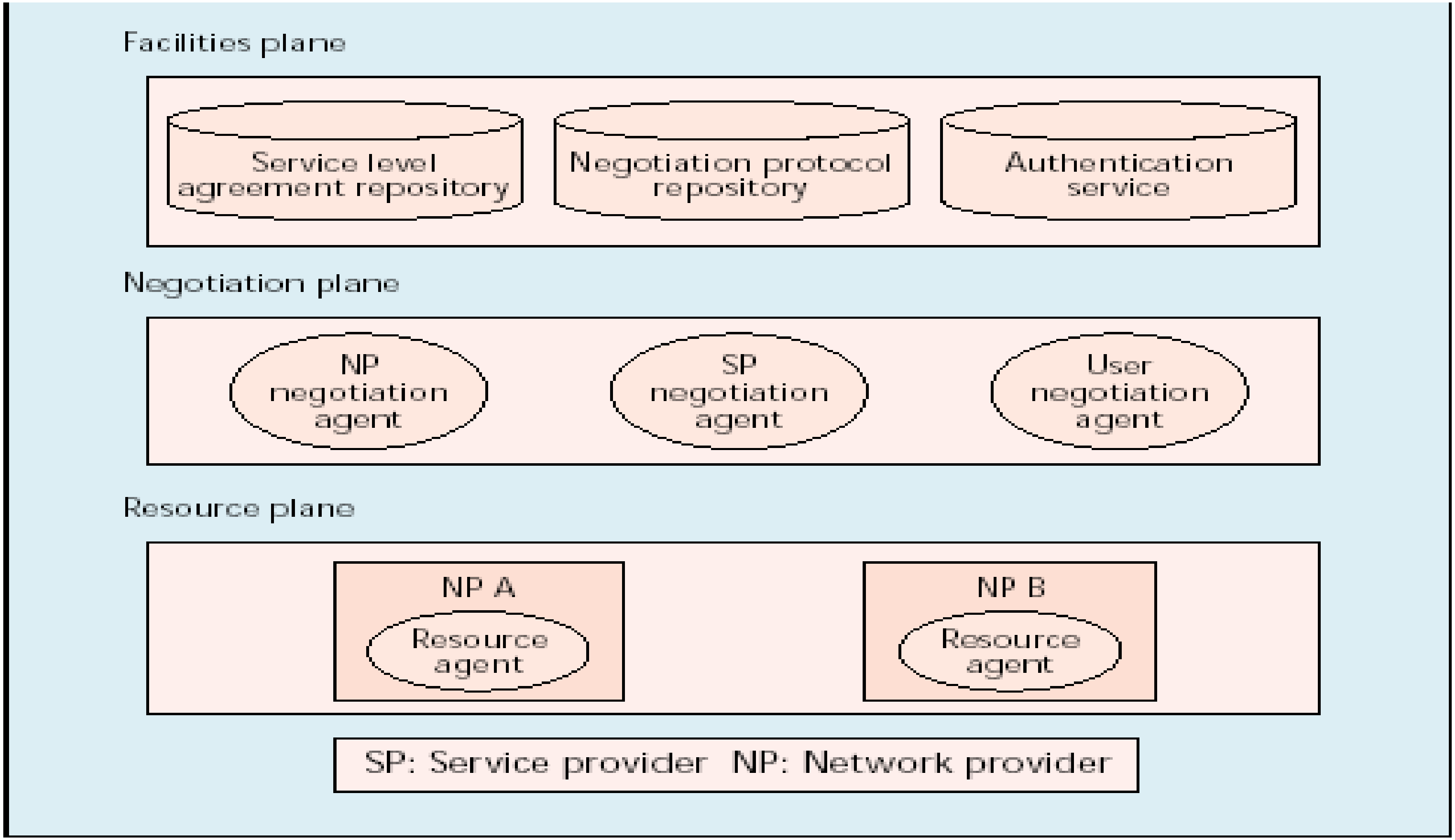
A IP reference Architecture for Wireless Mobile System



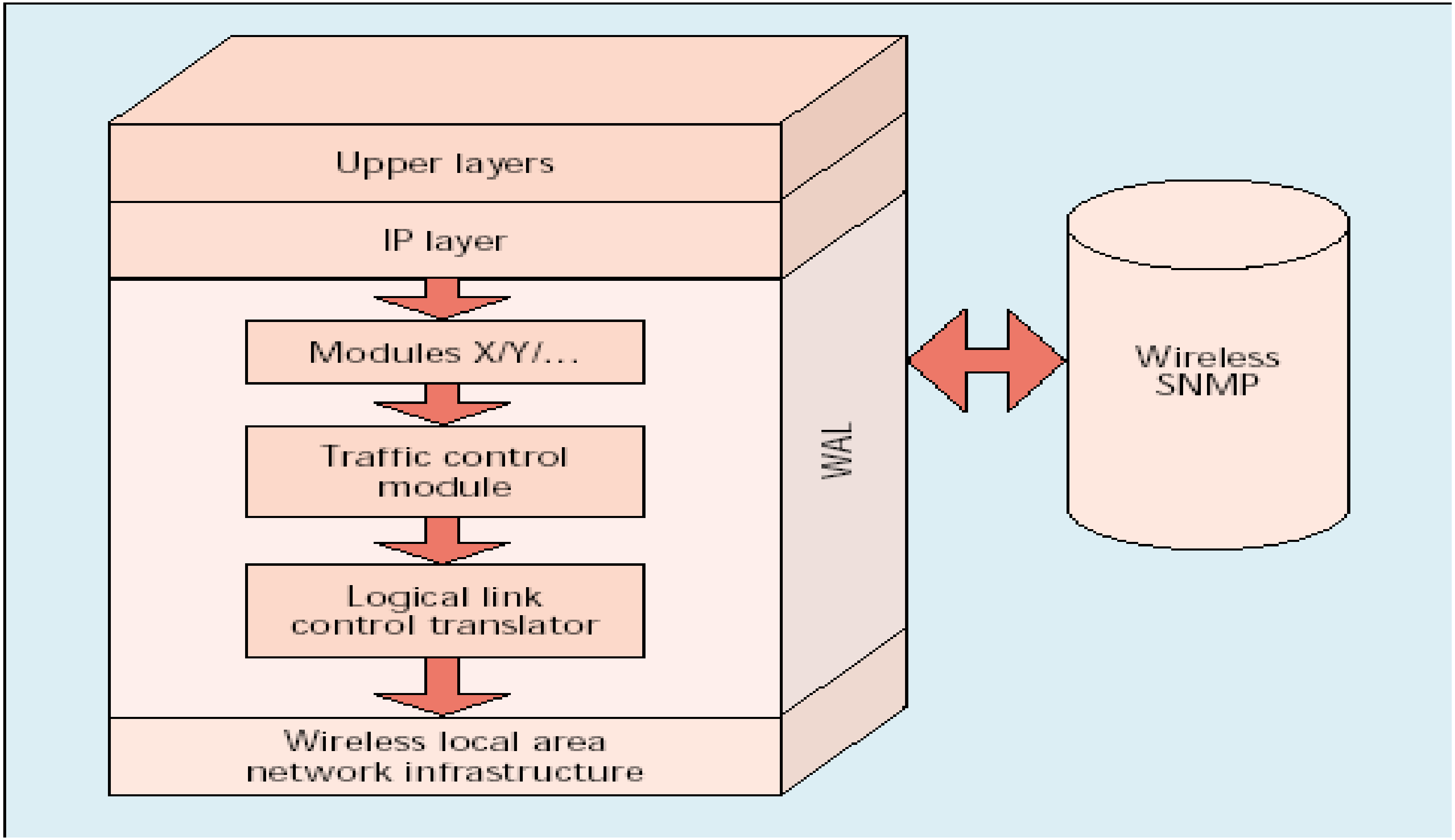
Integration Scenario



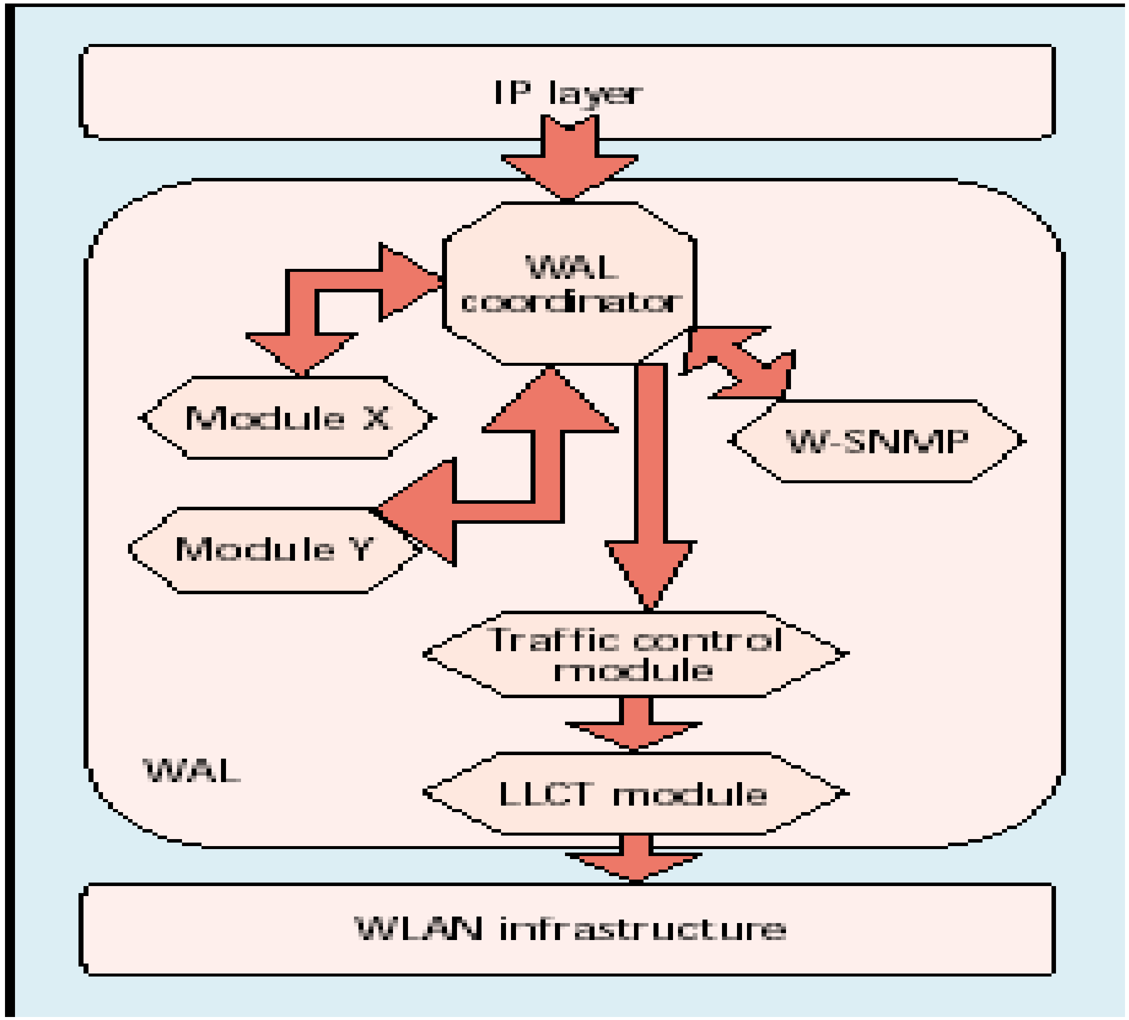
Resource Managements



WAL

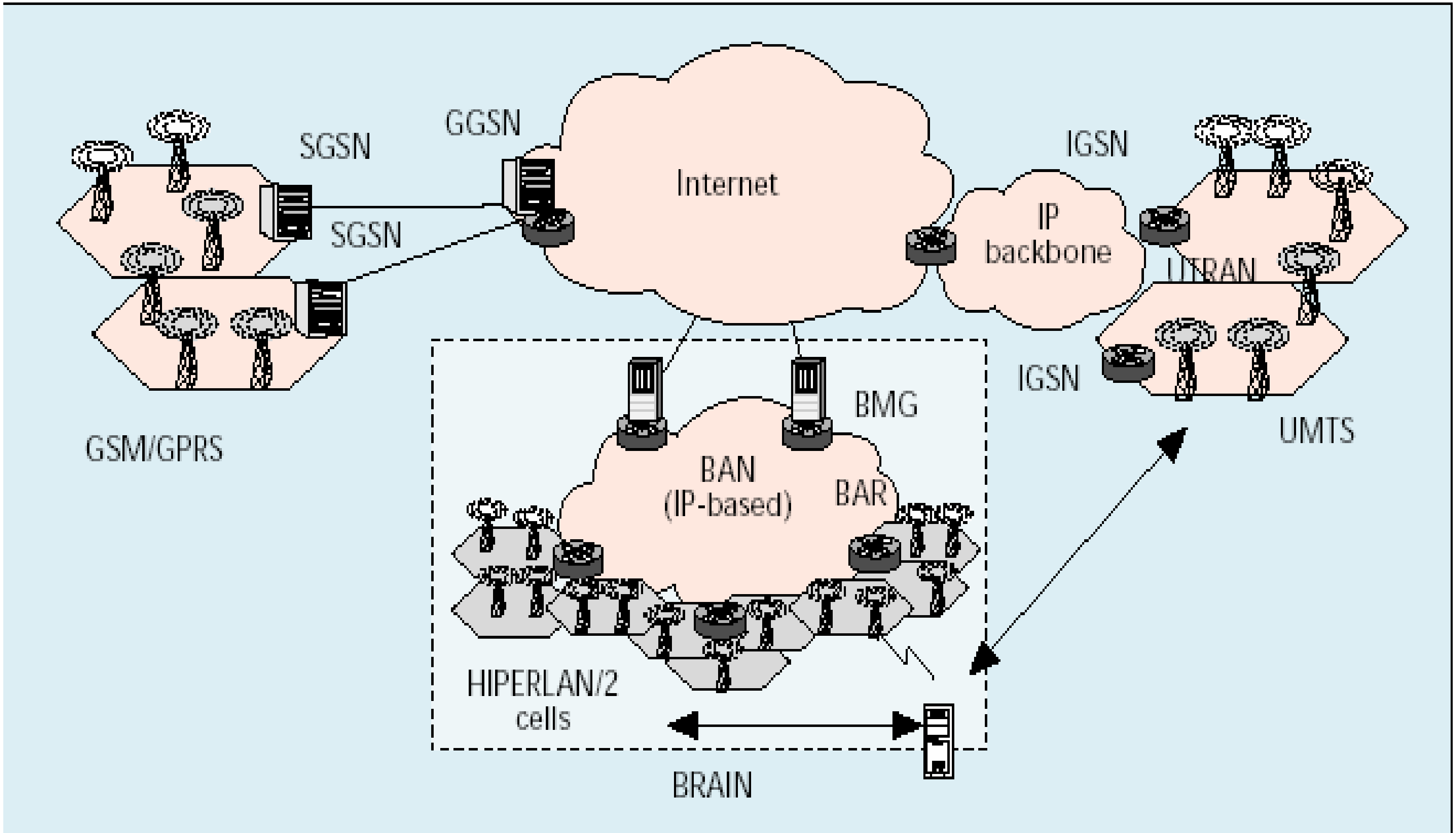

Upper layers
IP layer
Modules X/Y/...
Traffic control module
Logical link control translator
Wireless local area network infrastructure
WAL
Wireless SNMP

Detail WAL



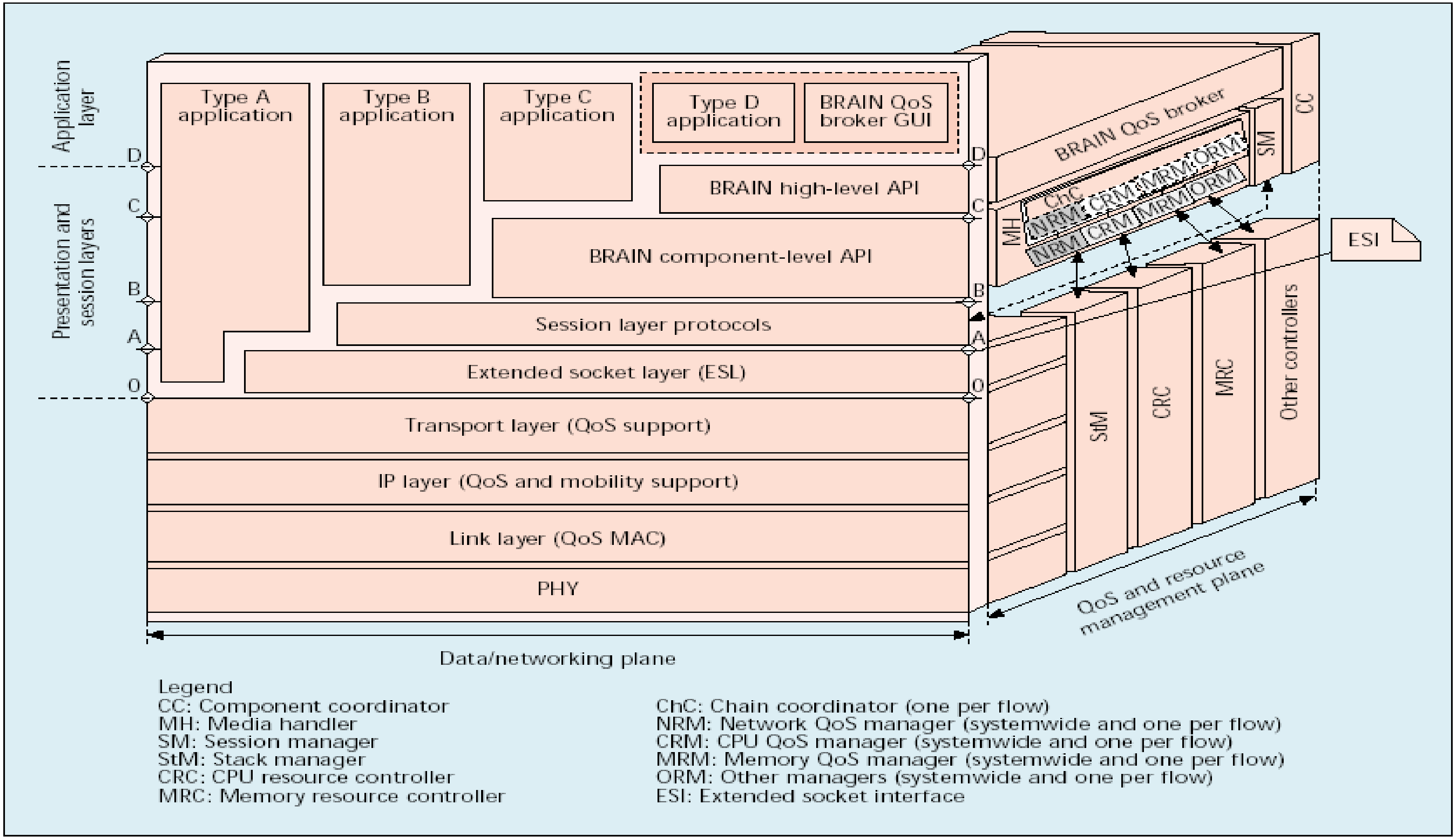
IP layer
WAL coordinator
Module X
Module Y
W-SNMP
Traffic control module
WAL
LLCT module
WLAN infrastructure

BRAIN

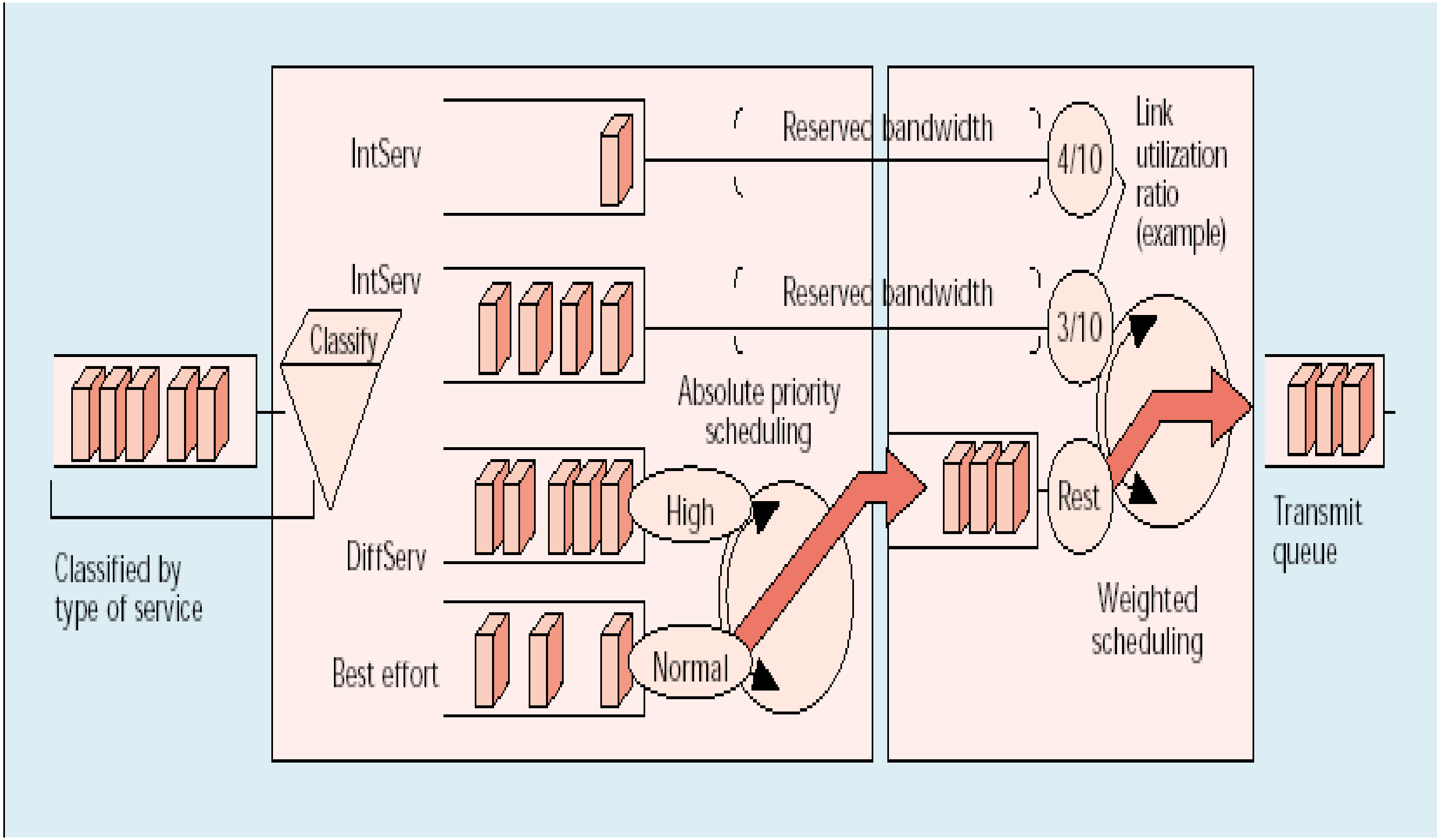


SGSN
GGSN
Internet
IGSN
SGSN
IP
backbone
UTRAN
IGSN
BMG
UMTS
GSM/GPRS
BAN
(IP-based)
BAR
HIPERLAN/2
cells
BRAIN

QoS Support


Application layer
Presentation and session layers
D
C
B
A
0
Type A application
Type B application
Type C application
Type D application
BRAIN QoS broker GUI
BRAIN high-level API
BRAIN component-level API
Session layer protocols
Extended socket layer (ESL)
Transport layer (QoS support)
IP layer (QoS and mobility support)
Link layer (QoS MAC)
PHY
Data/networking plane
BRAIN QoS broker
CC
SM
MH
ChC
NRM CRM MRM ORM
NRM CRM MRM ORM
ESI
StM
CRC
MRC
Other controllers
QoS and resource management plane
Legend
CC: Component coordinator
MH: Media handler
SM: Session manager
StM: Stack manager
CRC: CPU resource controller
MRC: Memory resource controller
ChC: Chain coordinator (one per flow)
NRM: Network QoS manager (systemwide and one per flow)
CRM: CPU QoS manager (systemwide and one per flow)
MRM: Memory QoS manager (systemwide and one per flow)
ORM: Other managers (systemwide and one per flow)
ESI: Extended socket interface

IP QoS Modeling



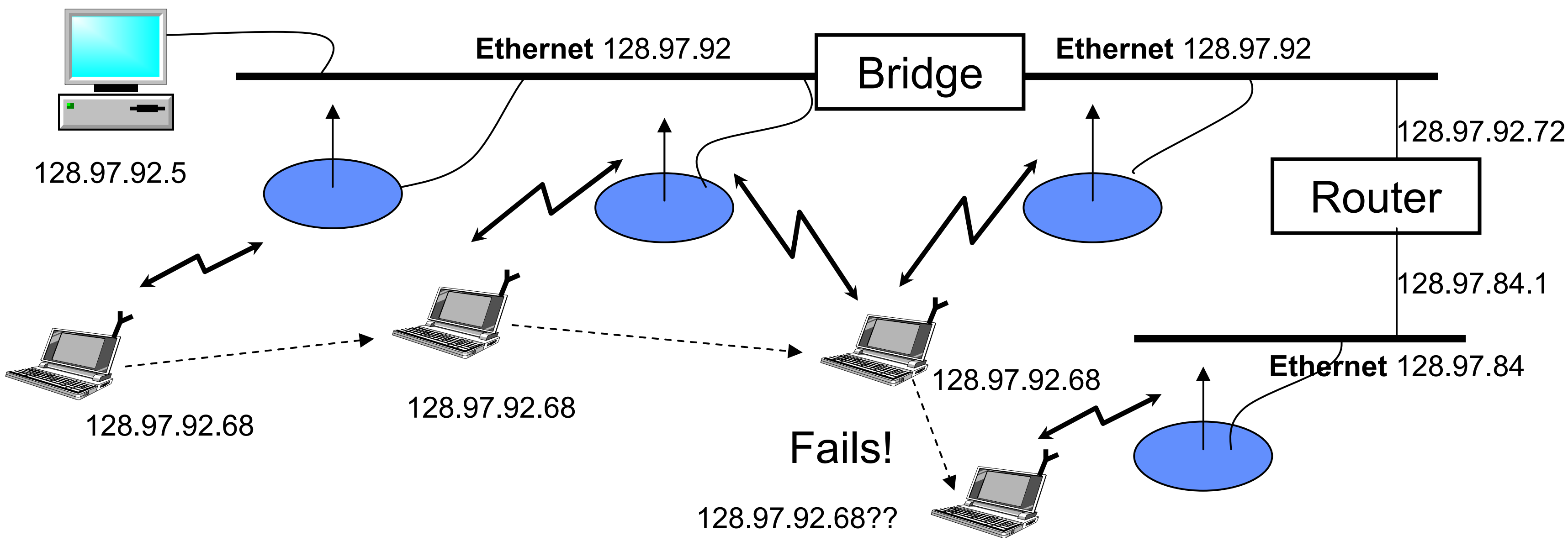
Lecture Outline

- Mobility in wireless LANs
- Problems in making Internet mobile
- Canonical packet forwarding architecture for Mobile-IP
- Columbia's Mobile-IP schema

Making the Internet Mobile

- Goal
  - Provide *continuous* IP connectivity to “mobile” users.
- Mobility == change in how MH accesses the internet
  - Physically move so that access to internet is via a different basestation.
  - Switch network interfaces
- Continuous connectivity
  - Datagrams for MH must be delivered to its current location
  - Mobility must be transparent to applications
    - Applications must not die or need to restarted
    - Performance transparency also desirable
- Desirable
  - Secure
  - Work across security domains
  - Require no changes to existing stationary hosts

Mobility in Wireless LANs: Basestation as Bridges

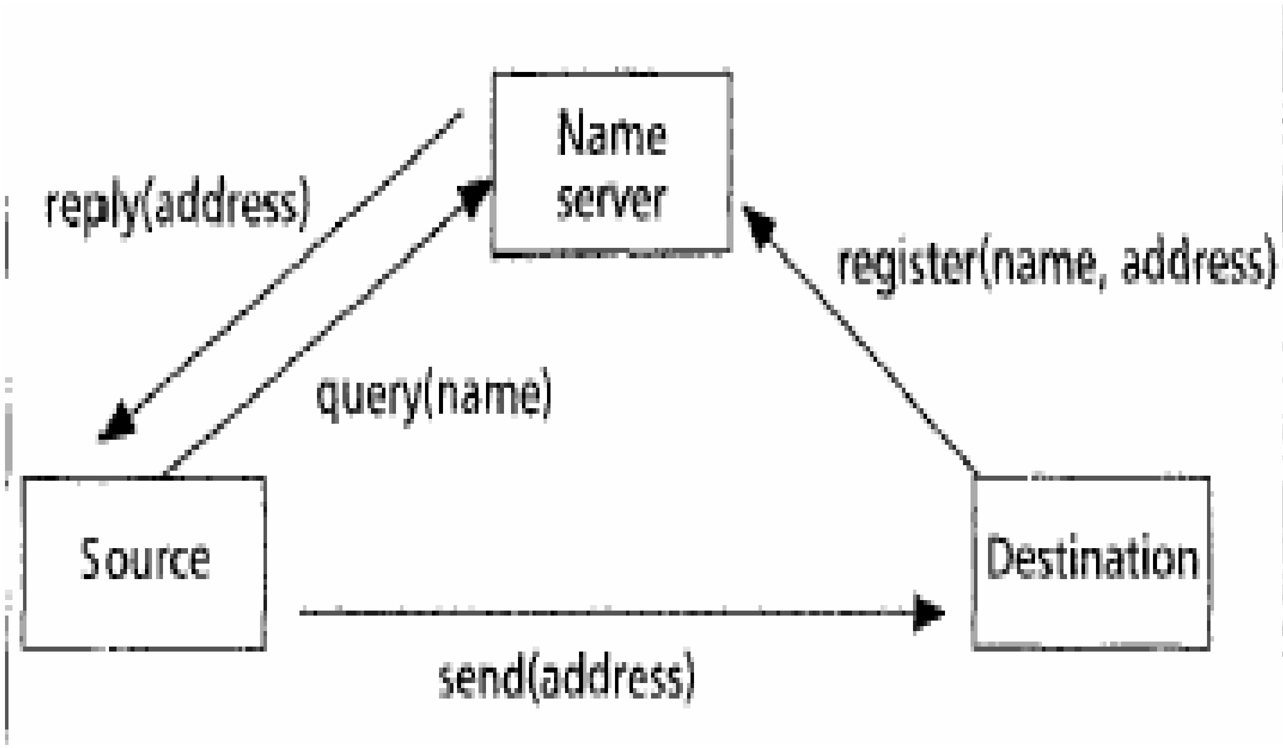


- Basestations are bridges(layer 2) – i.e. they relay MAC frames
  - Smart bridges avoid wasted bandwidth
- Works the within an ethernet(or other broadcast LAN)
  - Fails across network boundaries, and in switched LANs(e.g. ATM)

Internet Naming and Addressing

- Collection of networks that are connected by routers
- Each internet host(each network interface) has two identifiers:
  - Internet (IP) Address(32-bit)
  - Host Name (string)
    - Domain Name System (DNS) maps host names to IP address
- Applications refer to hosts by names
  - Use Domain Name System (DNS) to map host names to IP addresses
    - DNS lookup done once only at connection set-up
  - Transport protocols developed that assume this static binding
    - E.g. a TCP connection is identified by
      - *<Source IP address, source TCP port, destination IP address, destination TCP port>*
- Packets carry source and destination IP addresses
  - Routers use routing tables to forward packets based on destination address
  - Packet sent directly to destination within a network (e.g. ethernet)

DNS-based Resolution



Hierachical Addressing

- Routers maintain network topology in routing tables
- Flat IP address space would make routing tables huge!
  - Many many millions of hosts
- IP address space is therefore *hierachical*
  - IP address is a tuple: (*network id, host id)*
  - e.g., consider 192.11.35.53

Network id			Host id
192	11	35	53

- Internet routers required to maintain network topology only at the granularity of individual networks
  - Only network id part of destination address used in routing
  - Makes routing tables manageable

Key Observation: IP address serves two purposes!

- Endpoint identifier for transport and application layer
  - MH's IP address must be preserved to retain transport-layer sessions
    - All TCP connections would die if MH acquires a new IP address
- Routing directive for network layer
  - MH's IP address must be changed for hierarchical routing to work!
    - Packets will continue to get routed to the old network
    - DNS entry will also need to be changed

What should on do?

This is the primary problem in making Internet mobile!

“Non-solutions” to Internet Mobility

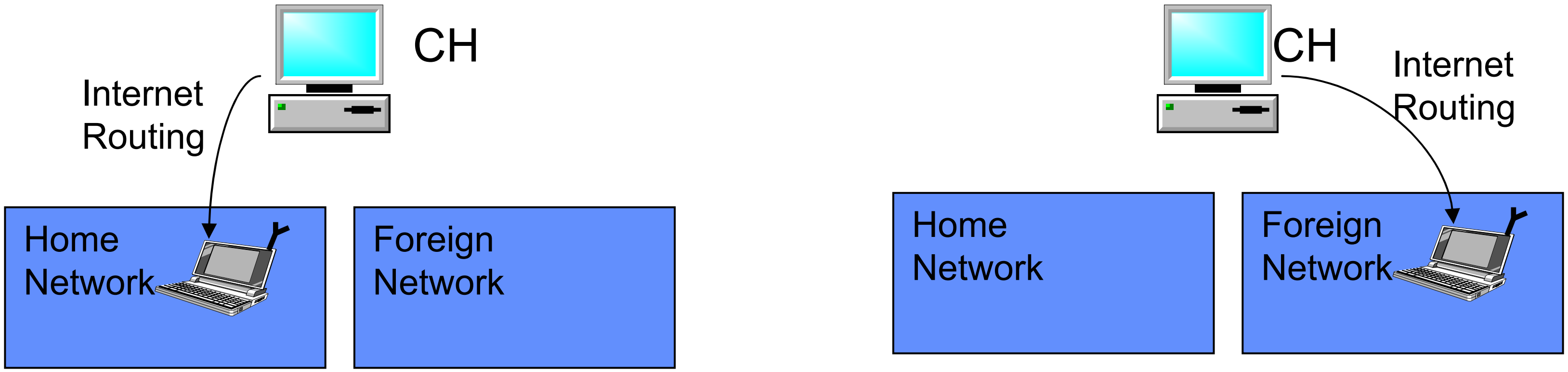
- Enhance DNS
  - Historically, DNS does not have dynamic *name-address binding* updates
    - Optimized for access cost
    - DNS clients cache DNS records
    - Hard to optimize for both access and update costs
  - Solves only part of the problem
    - TCP connections will still die!
- Keep per-MH routing information at all routers
  - Completely breaks the hierachical routing model
  - Unbounded grouth in routing table sizes at all routers
- Fix all the transport layer and higher protocols, and applications
  - Yeah, sure…..

Clean solutions: fix the network (IP) layer!

Making IP Network Layer Mobile

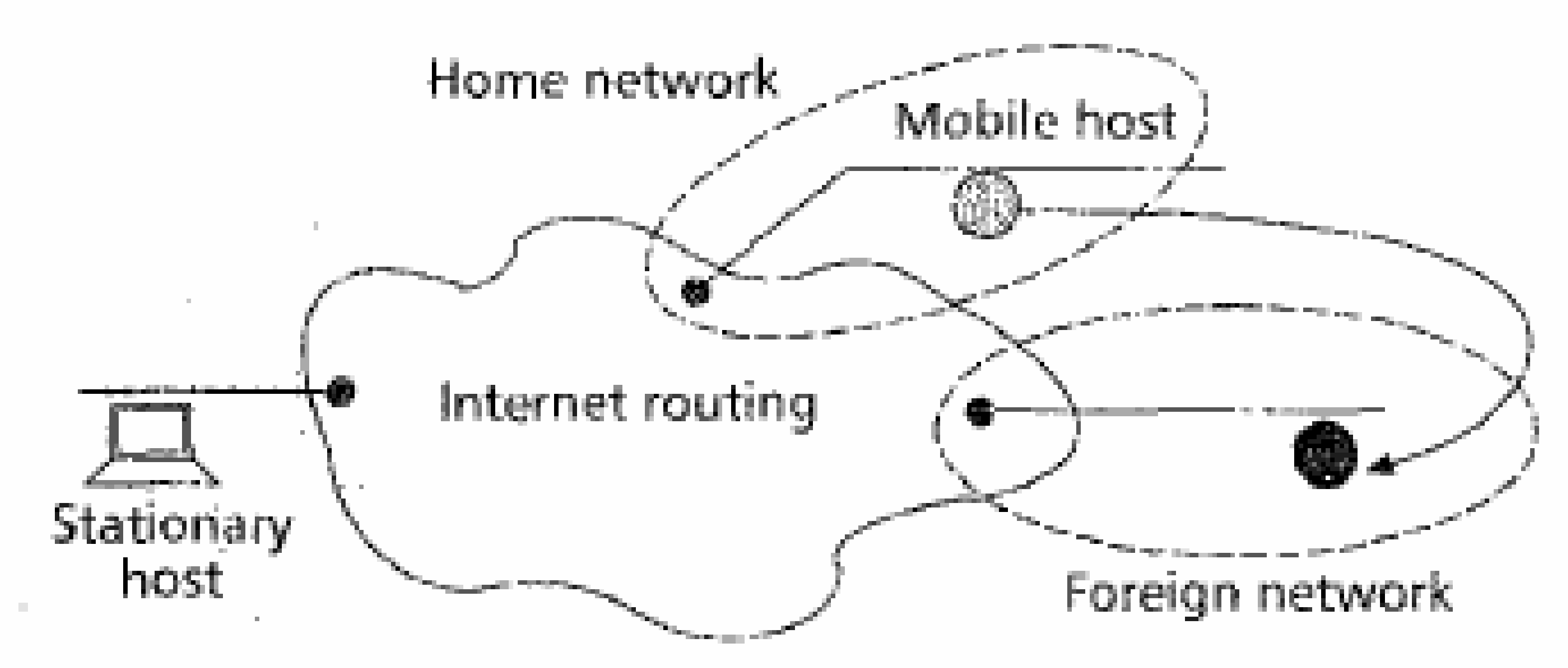
•Challenge of Mobile-IP

How to direct IP packets to MH that travels to a Foreign Network away from MH's Home Network?



- MH is assigned a home address as its IP address
  - Home network is the network containing the home address
  - DNS queries for MH return the home address
- Mobile-IP only concerned with moves across networks
  - Moves within home network (e.g. ethernet) handled by link-layer bridging.

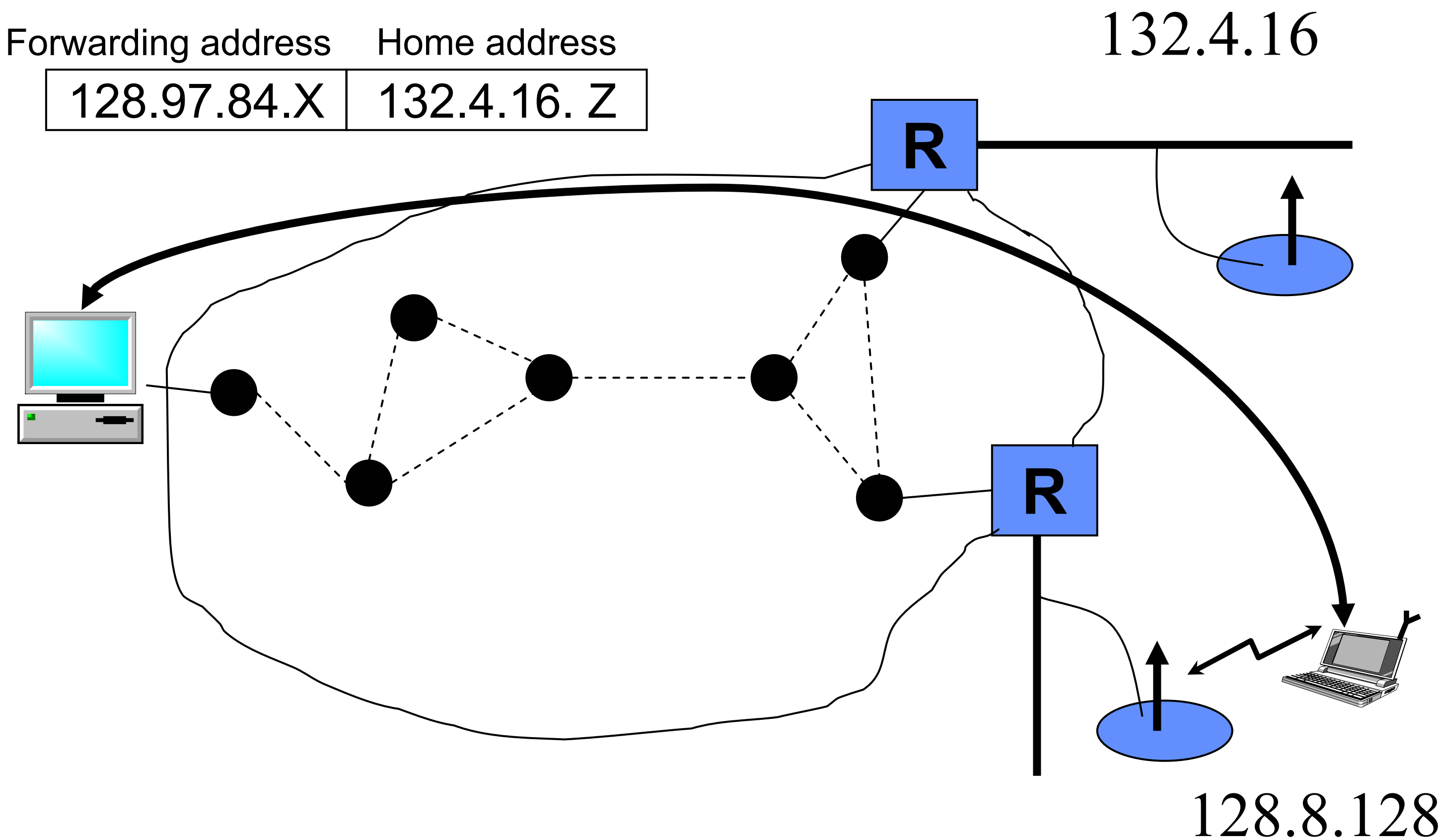
Illustration of terms



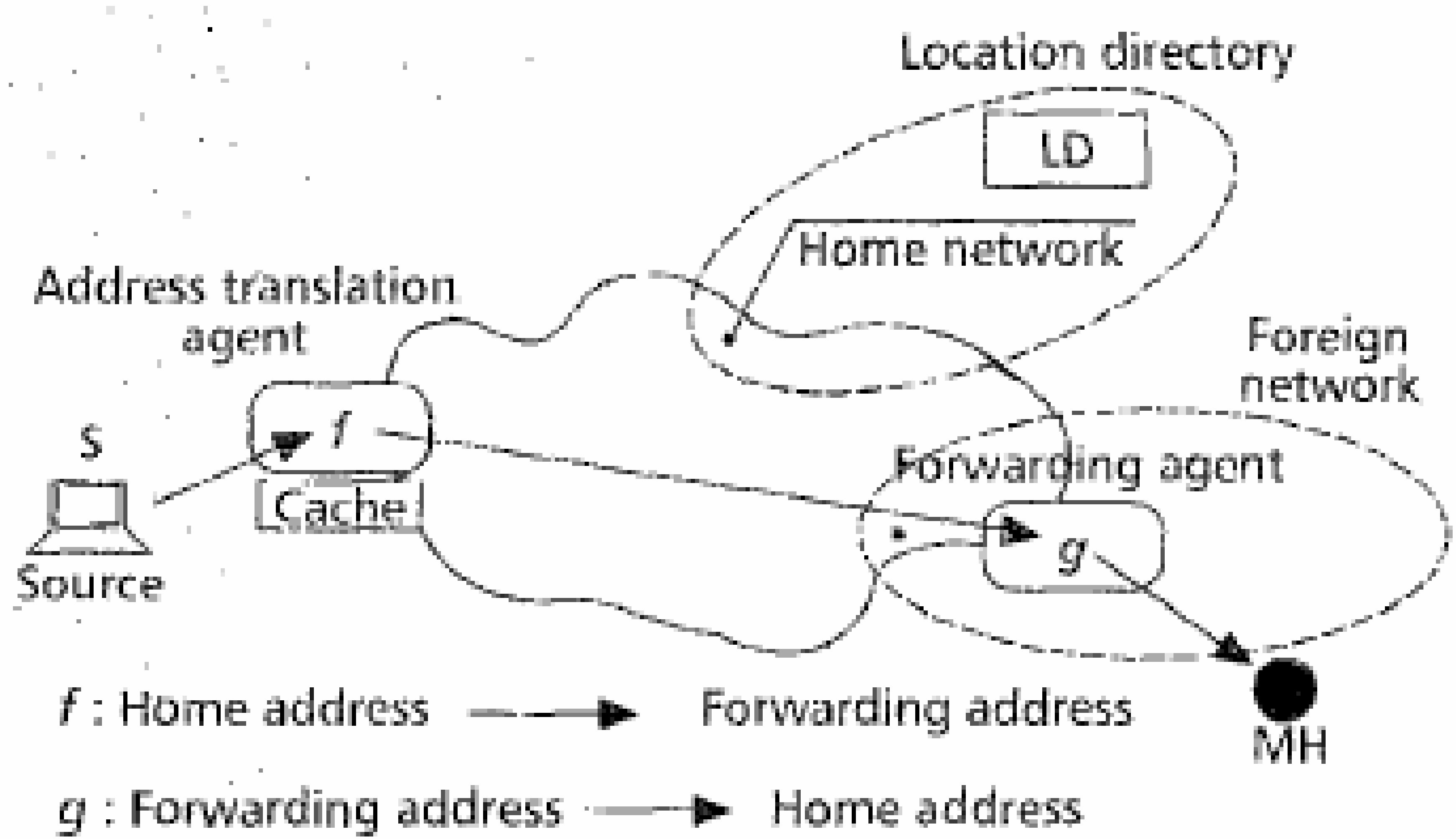
Key to Mobile-IP Two-Tier Addressing

- MH has two IP addresses associated with it
  - Does no mean two IP address are assigned!
- First component of the address serves as the routing directive
  - Reflects MH's point of attachment to Internet
    - Derived from the foreign network
  - Changes whenever MH moves to a new network
  - Internet routers use this address to route to MH's point of attachment
- Second component of the address servers as the end-point identifier
  - This is the home address
  - Remains static throughout the lifetime of MH
  - Only this address used for protocol processing above network layer
    - MH remains virtually connected to the home network
- Two-tier addressing Is only a logical concept
  - IP packet headers can't actually carry two addresses!
- MH to Stationary Host (SH) packets do not need special handling

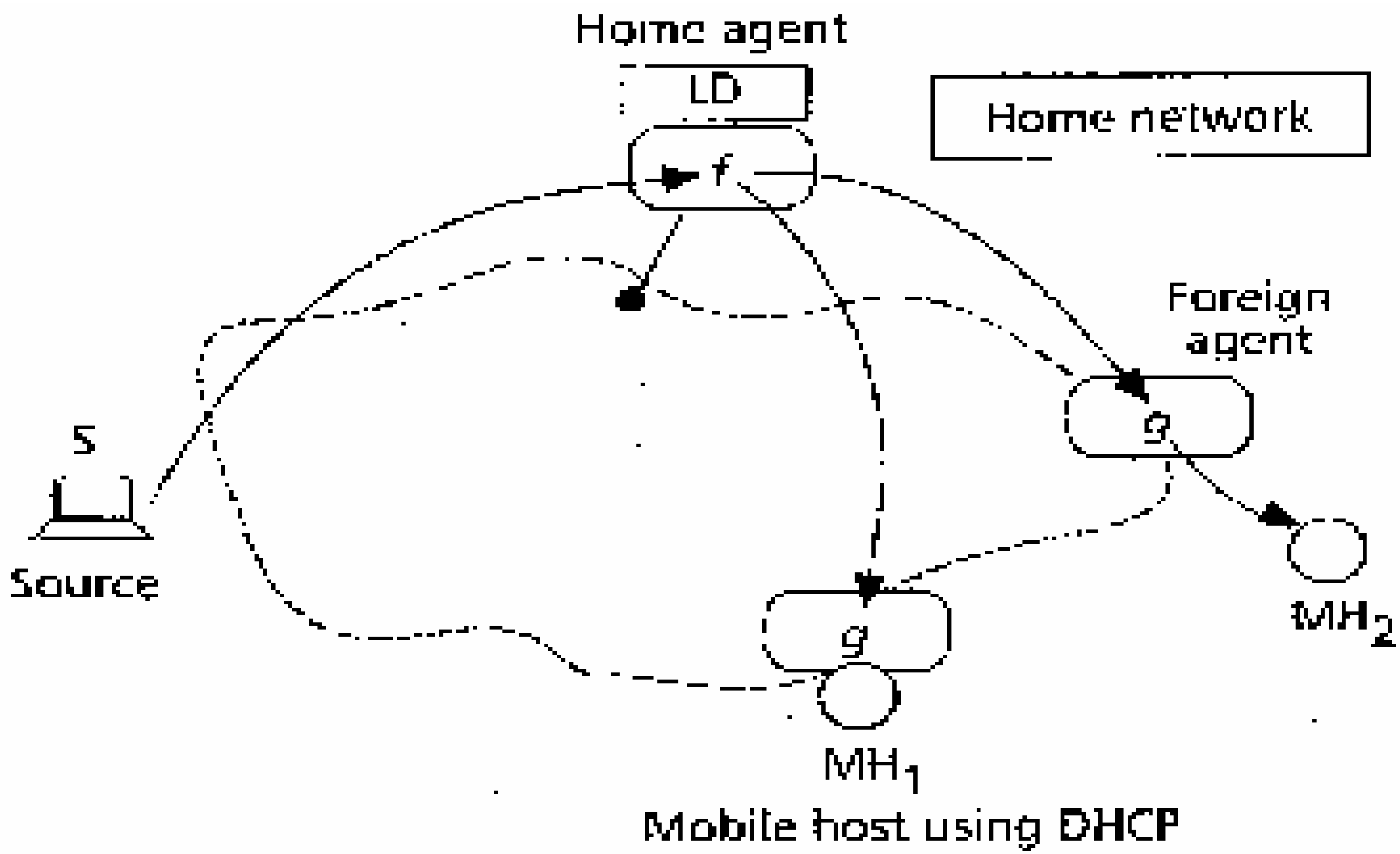
Two-Tier Addressing for Mobile Hosts



Packet Forwarding model



Canonical Mobile-IP Architecture



Components of Canonical Mobile-IP Architecture

- Forwarding Agent (FA)
  - Forwarding component of two-tier address is the address of FA entity
  - FA receives packets on behalf of MH
    - Packets contain FA's address as destination
  - FA maps forwarding address to MH's home address
    - FA: g(forwarding address)→home address
  - FA then relays the packet to MH
  - FA represents a function, not a machine

Issues:

- Where can FA be located?
  - MH, BS, somewhere else
- How does MH find the FA in a foreign network? (and, vice versa)
  - Route advertisement and registration protocol
  - FA periodically advertises its presence (beacons)

Component of Canonical Mobile-IP Architecture (contd.)

- Location Directory (LD)
  - Records association between home and forwarding addresses
    - Contains most up to date mapping of MH to its FA
  - MH sends updates to LD on moving
  - Issues:
  - Centralized vs. distributed realization
    - Centralized is infeasible – too many MHs in the Internet
  - How to distribute?
    - Cost operation
    - Security
    - Ease of location
    - Ownership
  - Possible distribution policy: *owner-maintains*
    - Some agent in home network maintains LD information for a MH responsible for security, authentication, updates, and distribution
    - a CH does not need to find the right LD component to query router in home network can forward to the correct LD component

Component of Canonical Mobile-IP Architecture (contd.)

- Address Translation Agent (ATA)
  - CH sends packets to MH at its home address
  - ATA replaces MH's home address with FA's address in packets
    - *ATA: f (home address) → forwarding address*
  - address translation involves:
    - Querying the LD
    - Obtain address of the FA corresponding to the MH
    - Use FA's address to forward packet to MH's location
  - Issues:
    - Where to locate ATA
      - At CH: but will need to change software in millions of hosts! elsewhere
    - Querying LD for every packet is expensive: cache LD entries?
      - Improves performance
      - but, requires maintaining consistency between LD and cached entries!

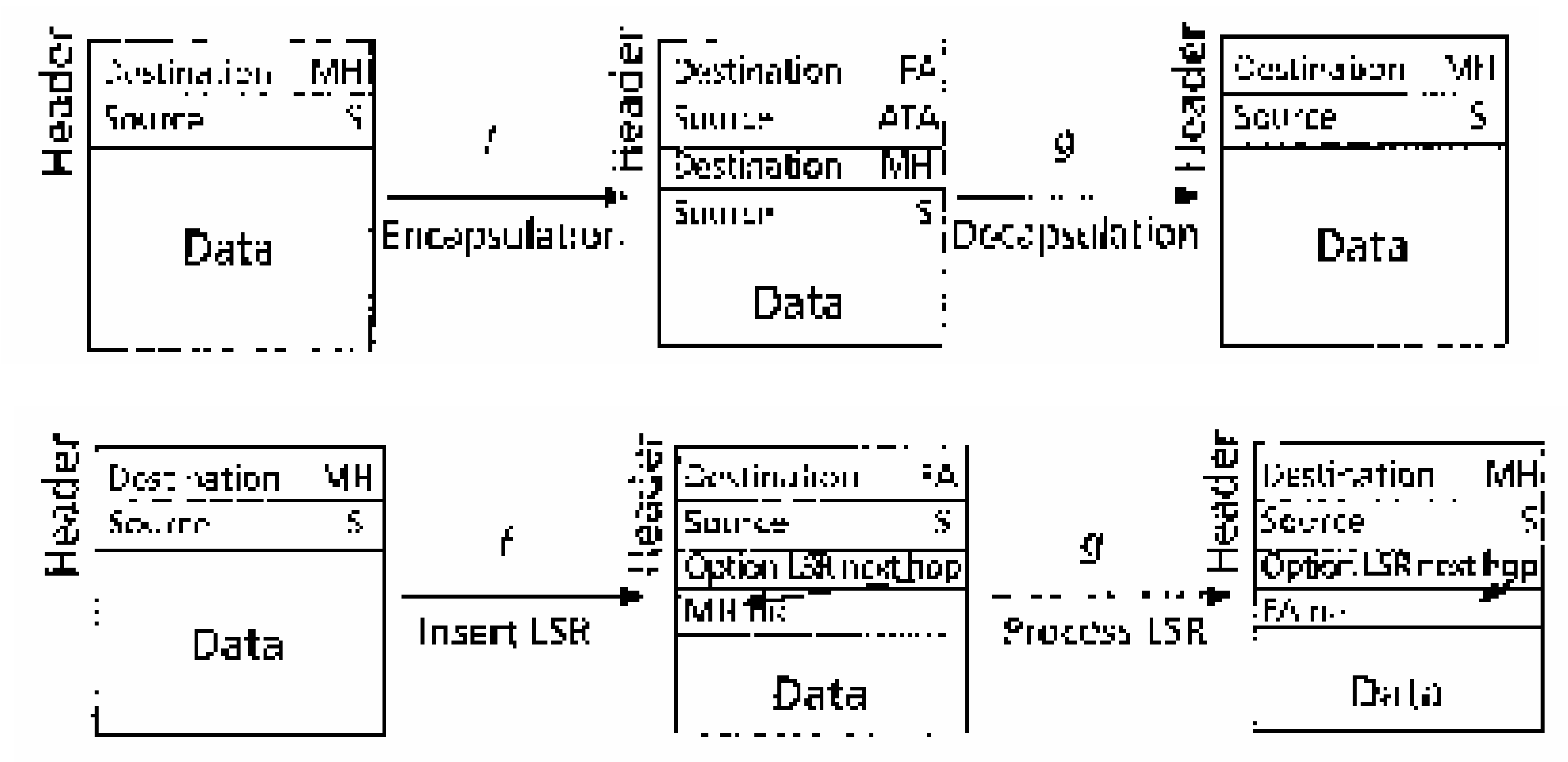
Location Update Protocol (LUP)

- LUP is the reliable mechanism for
  - Keeping LD up to date
  - Keeping cached LD entries consistent with master LD
- Choice of LUP depends on caching policy
  - Together the determine scalability and routing characteristics
- What if no LD caching
  - ATA must be collocated with LD to avoid per-packet queries
  - Packets from CH will first travel to home network before being sent to FA no optimal paths!
- What if there is caching?
  - Routing efficiency is improved no more travel to home network
  - but, vulnerable to security attacks cache updates must be authenticated otherwise, traffic to MH may be redirected away!

Address Translation Mechanisms

- Encapsulation approach (IP-in-IP tunnel)
  - ATA appends new header at the beginning of datagram
  - Outer header contains the forwarding address
  - Inner header contains the home address
  - Internet routes according to outer header
  - FA strips the outer header and delivers datagram locally to MH

ATM (Address Translation Mechanisms)



Address Translation Mechanisms (contd.)

- Loose Source Routing approach
  - Option in IP packets to specify a sequence of IP addresses to follow path is automatically recorded in the packet destination can send reply back along reverse path
  - ATA can use LSR to cause packets to MH to be routed via FA co-locate ATA at CH, and FA at MH
    - MH sends to CH using LSR, ATA/CH reverses the path

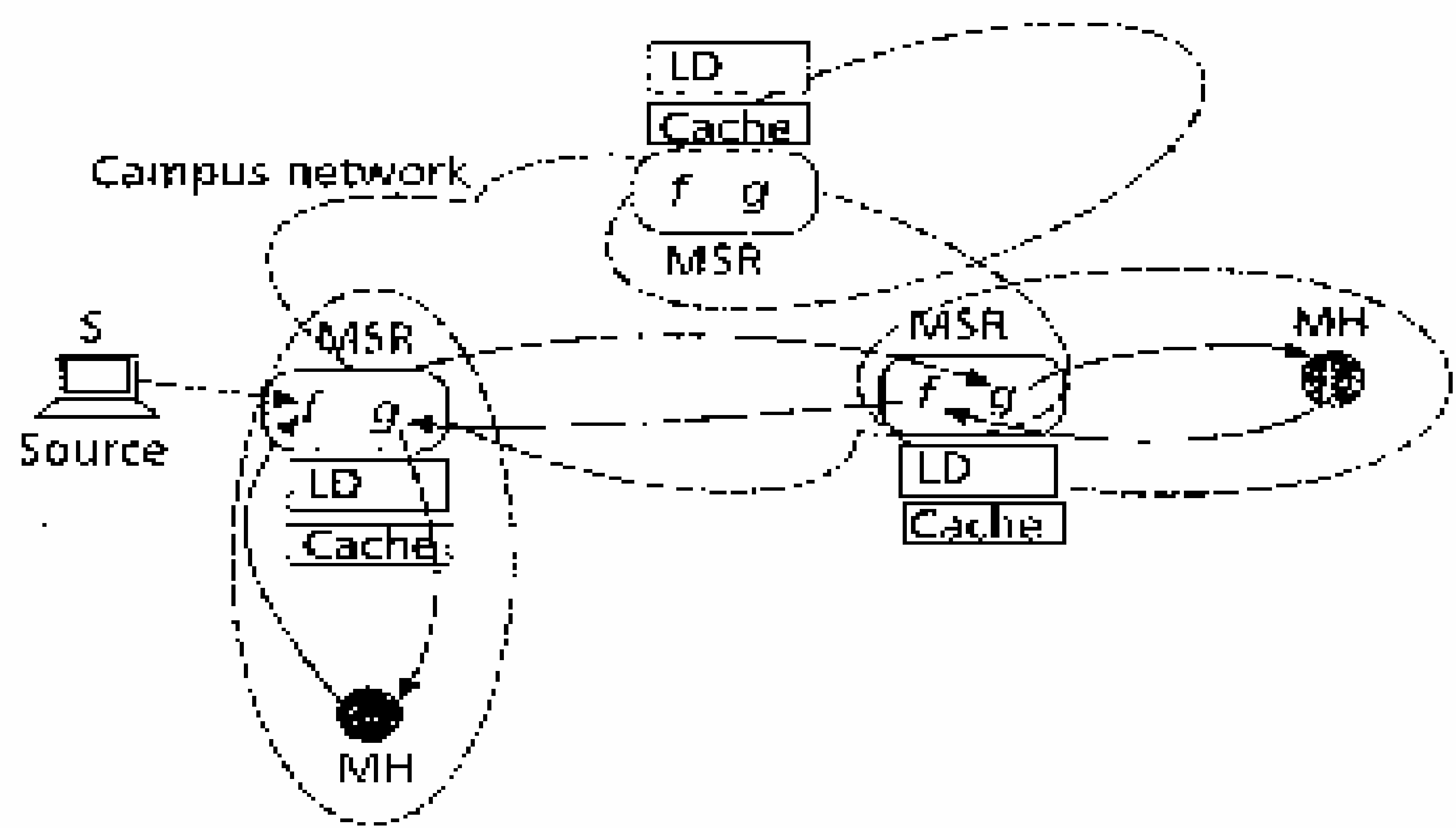
Various Mobile-IP Proposals

- Many Mobile-IP systems have been proposed (and some implemented)
  - Columbia's Mobile-IP
  - Sony's Virtual (VIP)
  - IBM's LSR Scheme
  - Stanford's MosquitoNet Scheme
  - IMHP (Internet Mobile Host protocol)
  - IETF's Mobile-IP for IPv4
  - IETF's Mobile-IP for IPv6
  - etc.
- All are special cases of the canonical mobile-IP architecture
  - Make different choices of
    - FA location
    - ATA location
    - Choice of LUP address translation mechanism

Example: Columbia's Mobile IP

- Campus environment with a reserved subnet for MHs
  - MHs home address are from the reserved subnet
- Group of cooperating Mobile Support Routers (MSR)
  - MSRs advertise reachability to wireless subnet via beacons
  - MHs conncect to campus backbone through MSRs
  - MSRs forward traffic to/from MHs
- On moving, MH registers with the new MSR
  - New location is provided to the previous MSR
- CH sends packet to MSR closest to CH
  - This MSR either delivers the packet of, forwards it to the right MSR after encapsulation
  - Right MSR is located by a multicast WHO_HAS query to other MSRs
- Wide area operation uses a pop-up mode
  - A temporary address is used by MH as a forwarding address
  - MH does its own encapsulation/decapsulation

Columbia Proposal



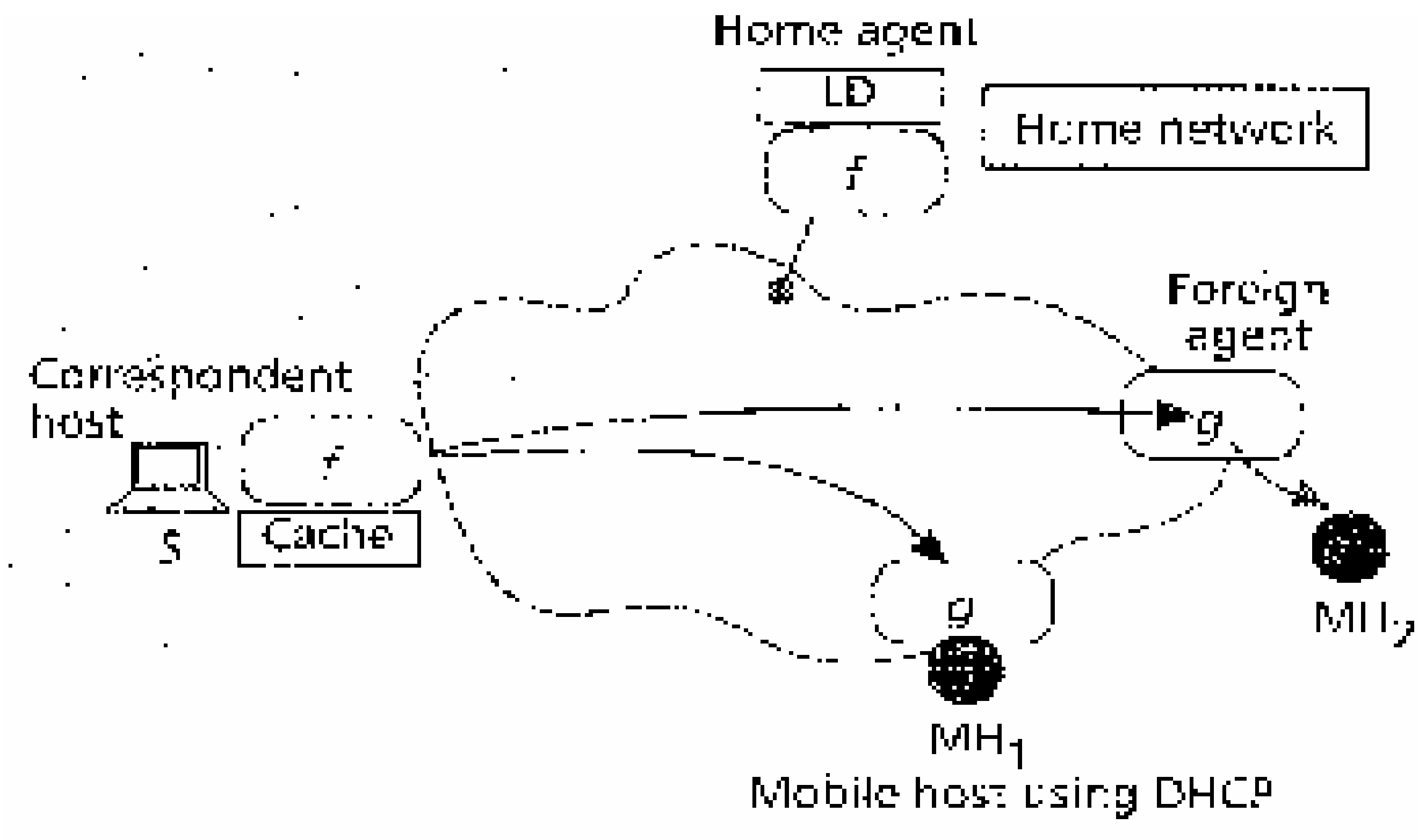
Columbia's Mobile-IP Mapped to Canonical Architecture

- MSR performs both encapsulation & decapsulation
  - Both f and g are collocated at MSR
  - MSR acts as FA for MHs in its coverage area
  - MSR acts as ATA for packets addressed to other MHs
- LD is distributed realization of the owner-maintains scheme
  - Each MSR maintains a table of MHs in its converage
  - MSRs are a distributed realization of home router
  - Tables of MHs in MSRs together constitute an owner-maintained LD
- Caching pollcy for LD entries is "need-to-know"
  - MSR sends WHO_HAS query if it does not know MH's location
- LUP is lazy-update
  - When MH moves, only primary and previous copy of LD entry is updated
  - Cached entries are assumed correct by default
  - Stale cache entry causes packet delivery failure, triggering WHO_HAS
- 100% backward compatible – no existing internet entities are affected

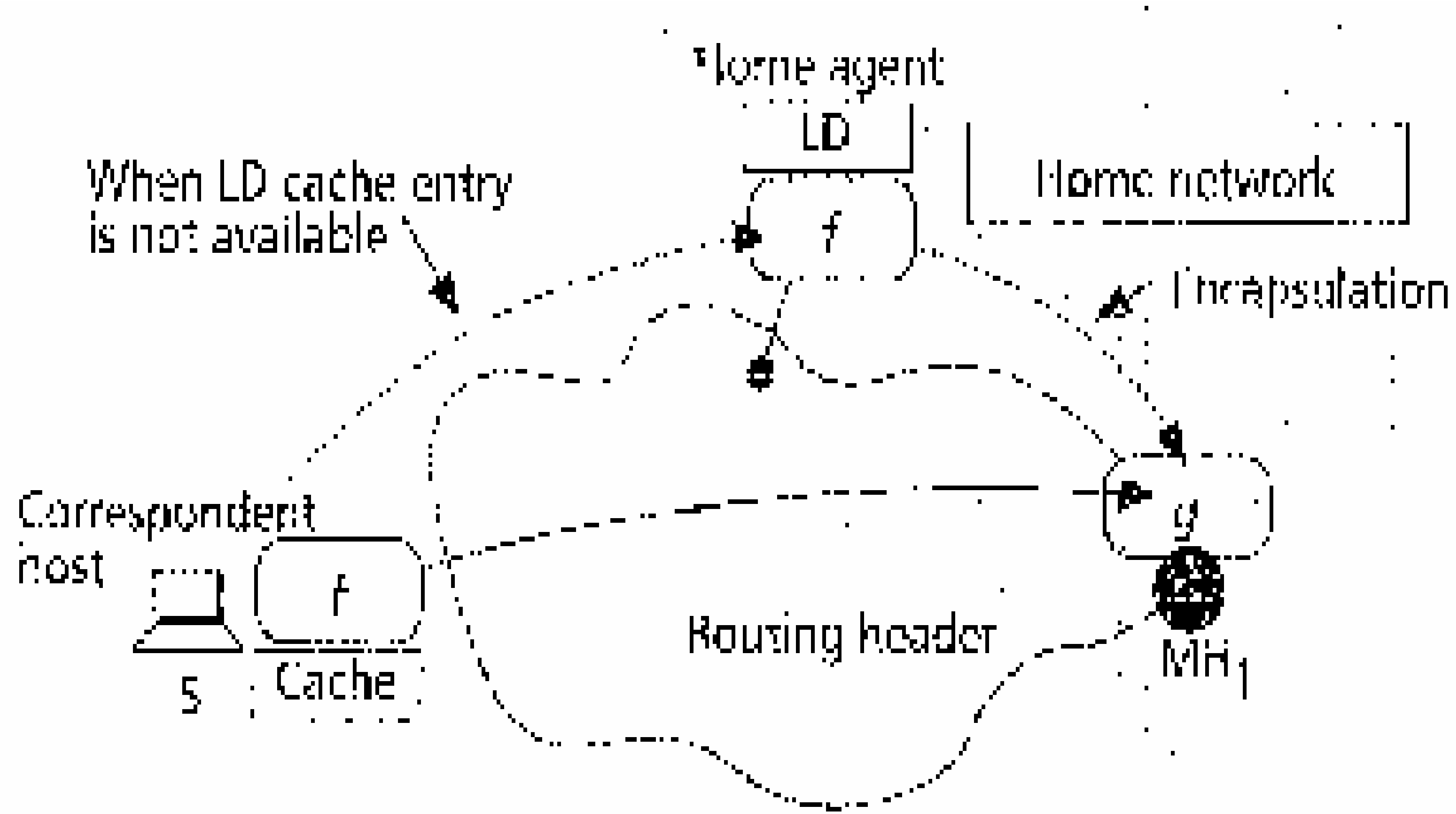
Performance Characteristics of Columbia Mobile-IP

- Control
  - LD cache at ATA is updated when packet routing is needed
  - Limits control traffic
  - But, slow “first” packet due to WHO_HAS query results in SYN packet beinf lost in TCP (start of transmission)
- Overhead of IP-in-IP
  - 20 bytes (4% on 500 byte packets)
- Routing
  - Requires routing to nearest MSR to be optimal
  - Not optimal for pop-up mode
- Implementation on 33 MHz 486 based MSRs
  - 1.4 ms for WHO_HAS
  - 45 microseconds for encapsulation (per packet overhead)

Route Optimization



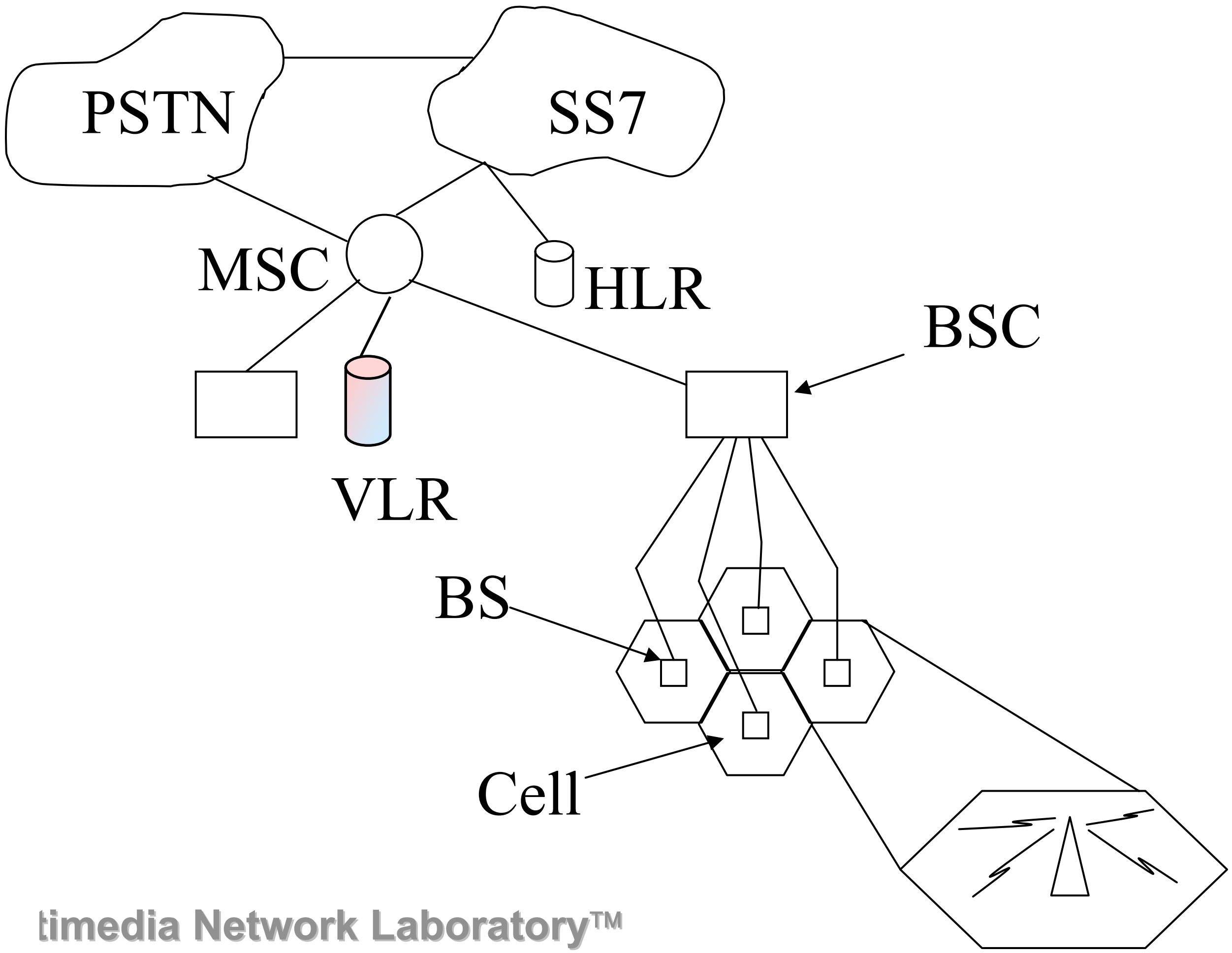
IPv6 Mobility Proposal



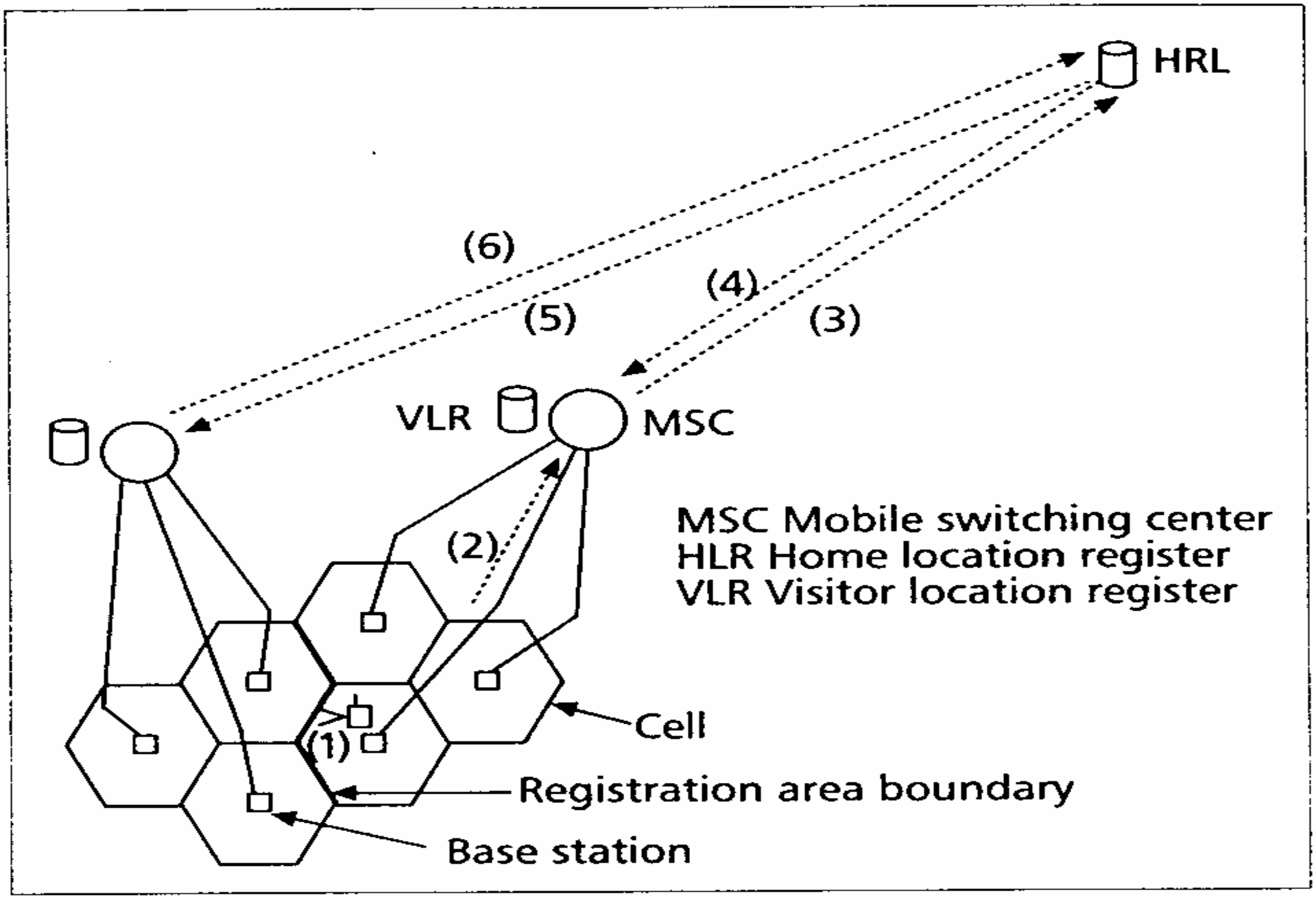
Evolutions of PCS

PCS Requirements

PCS network architecture

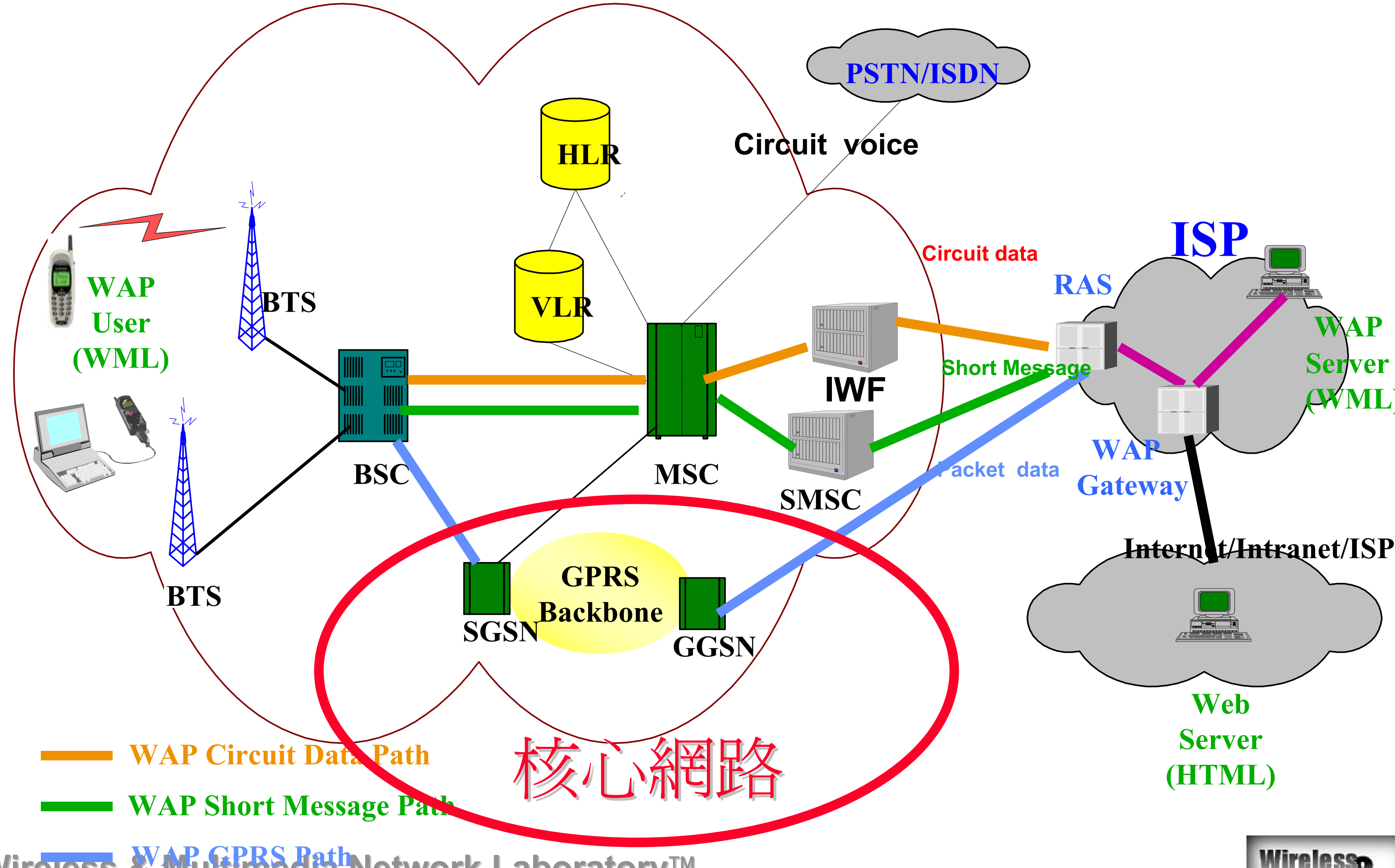


Location Update Procedure



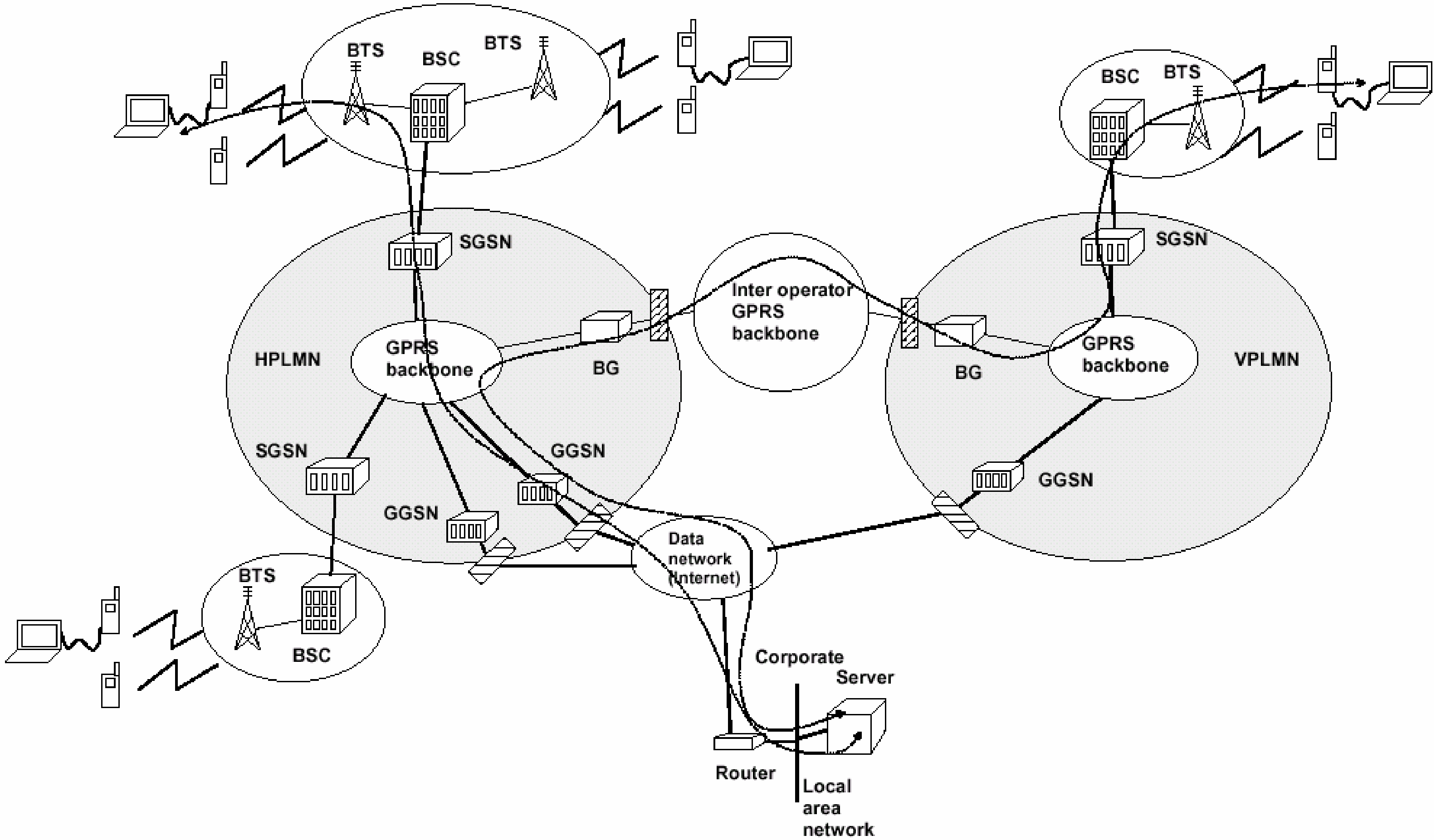
■ **Figure 3.** *Location registration procedures.*

GPRS

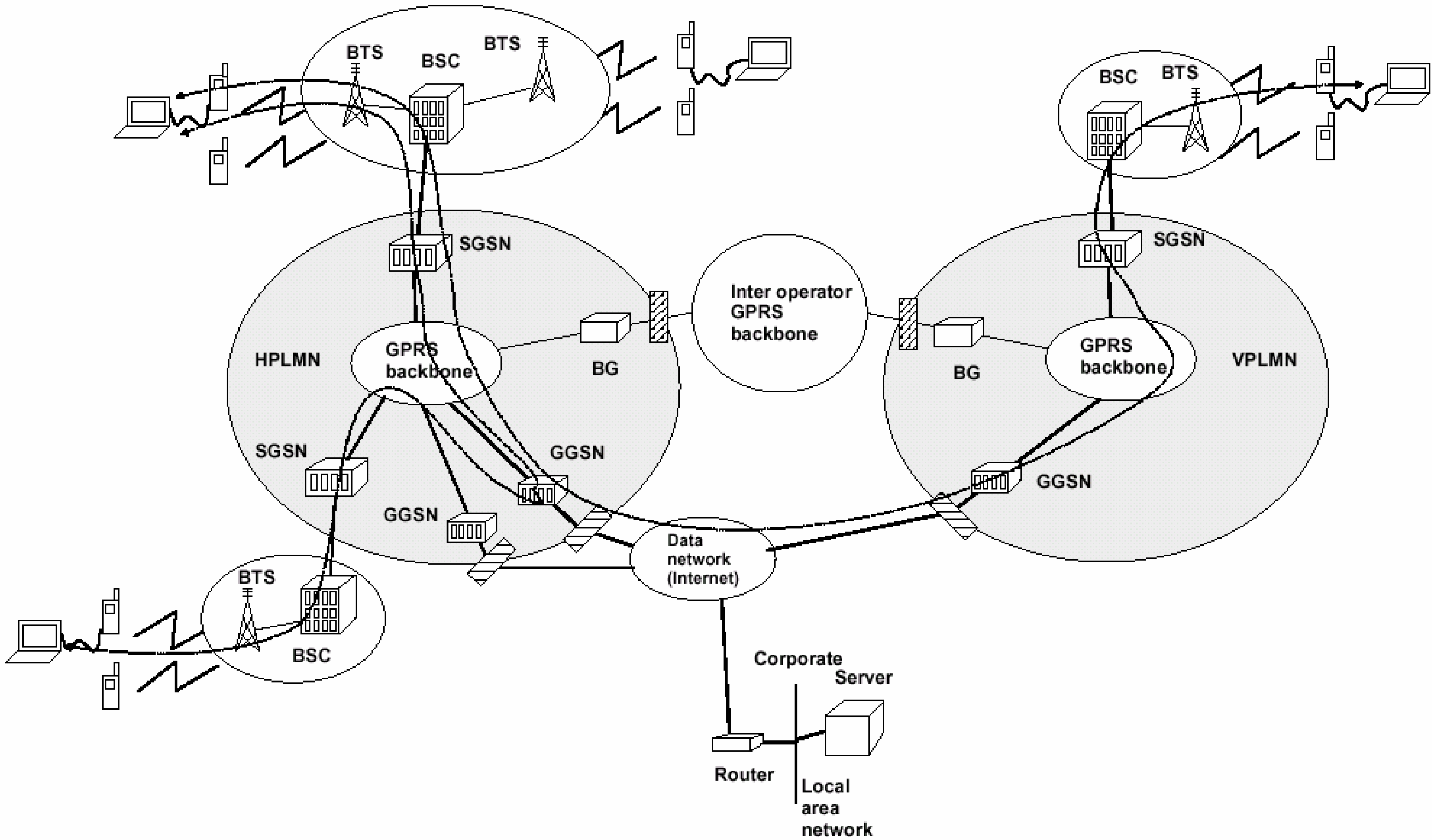


PSTN/ISDN
HLR
VLR
Circuit voice
Circuit data
WAP
User
(WML)
BTS
BTS
BSC
MSC
IWF
SMSC
Short Message
Packet data
ISP
RAS
WAP
Server
(WML)
WAP
Gateway
Internet/Intranet/ISP
Web
Server
(HTML)
GPRS
Backbone
SGSN
GGSN
核心網路
WAP Circuit Data Path
WAP Short Message Path
WAP GPRS Path

Data transfer MS-fixed



Data transfer MS-MS



Coming Challenges for IP

Location Managements~ handoff, roaming

QoS Transport~ Backbone delivery

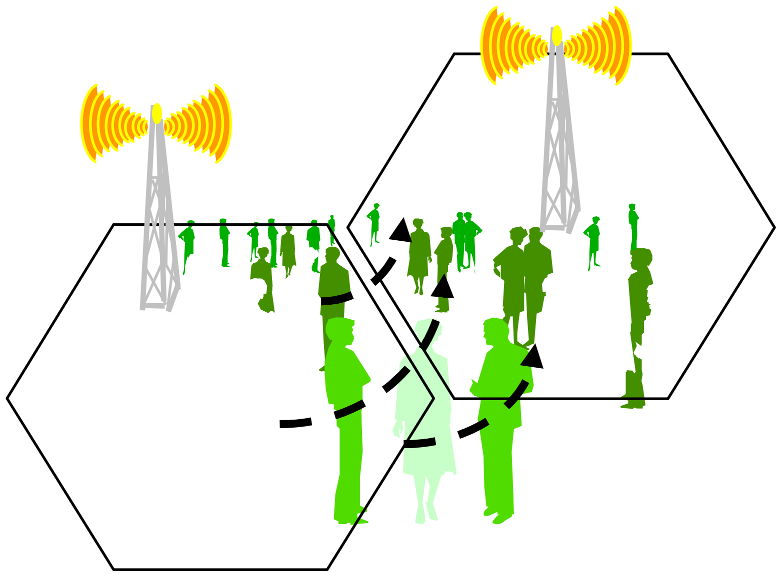
Mobility

- User mobility
  - Micro
  - Macro
- IP mobility support
  - Mobile IP
  - Cellular IP
  - HAWAII

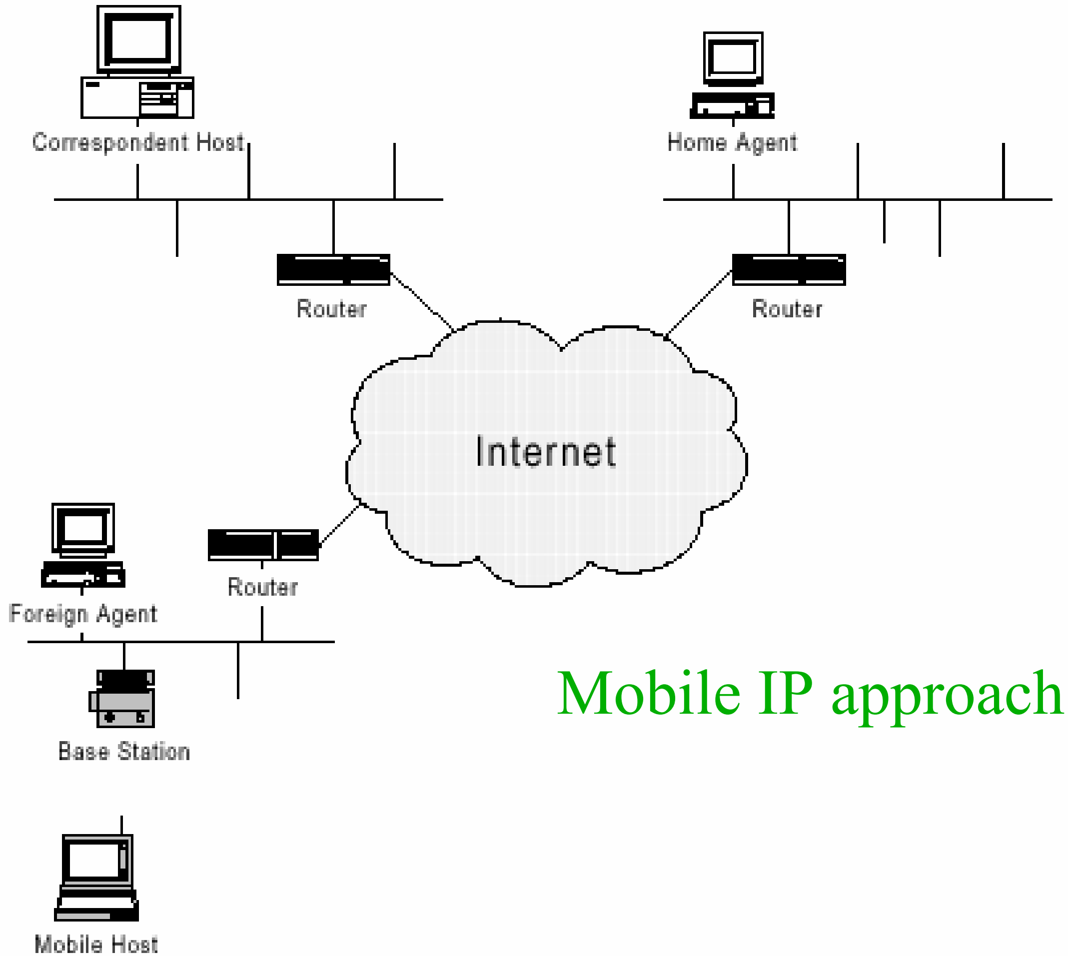
•Handoff issue

•Location management

•Paging

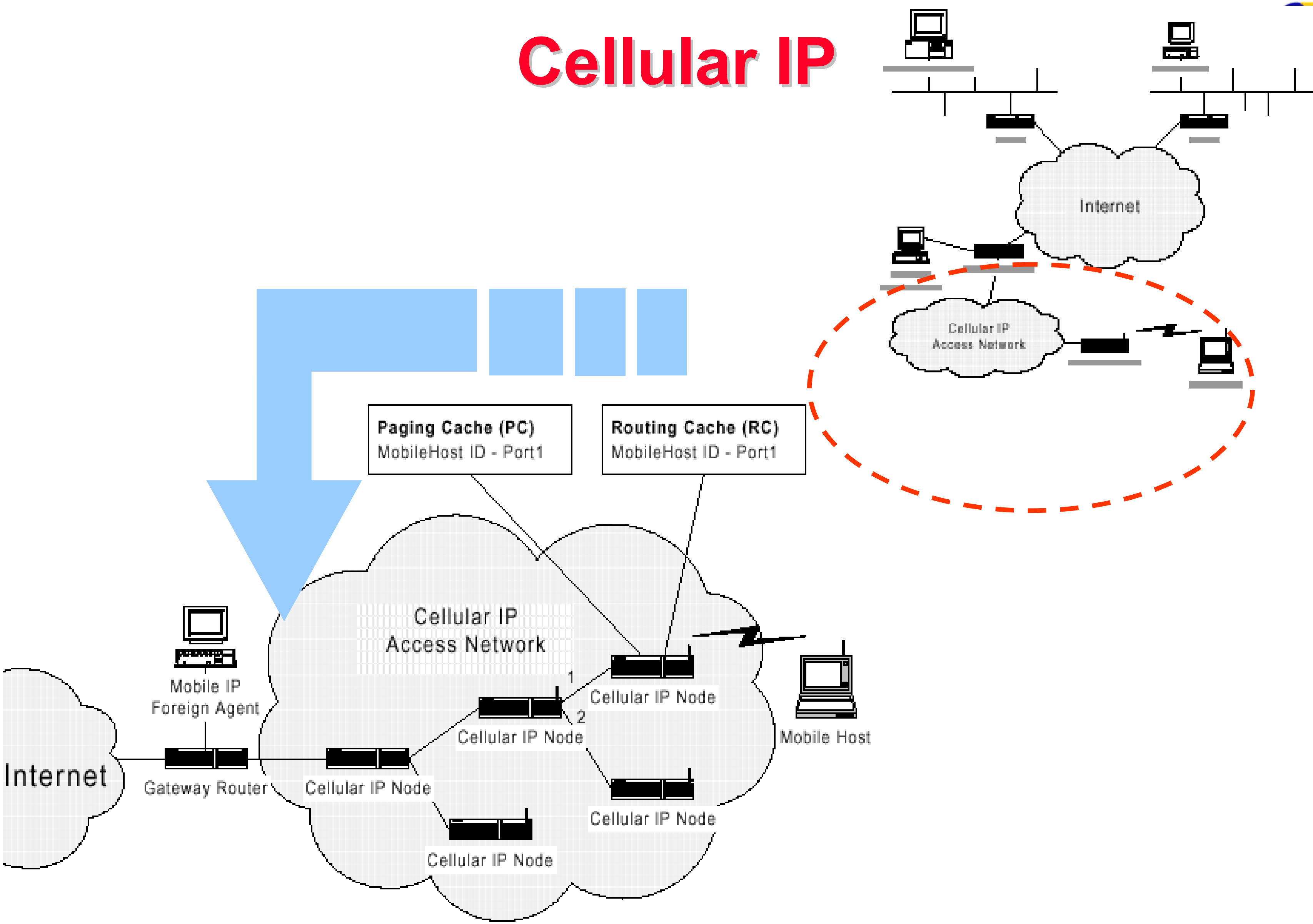


Nomadic wireless access



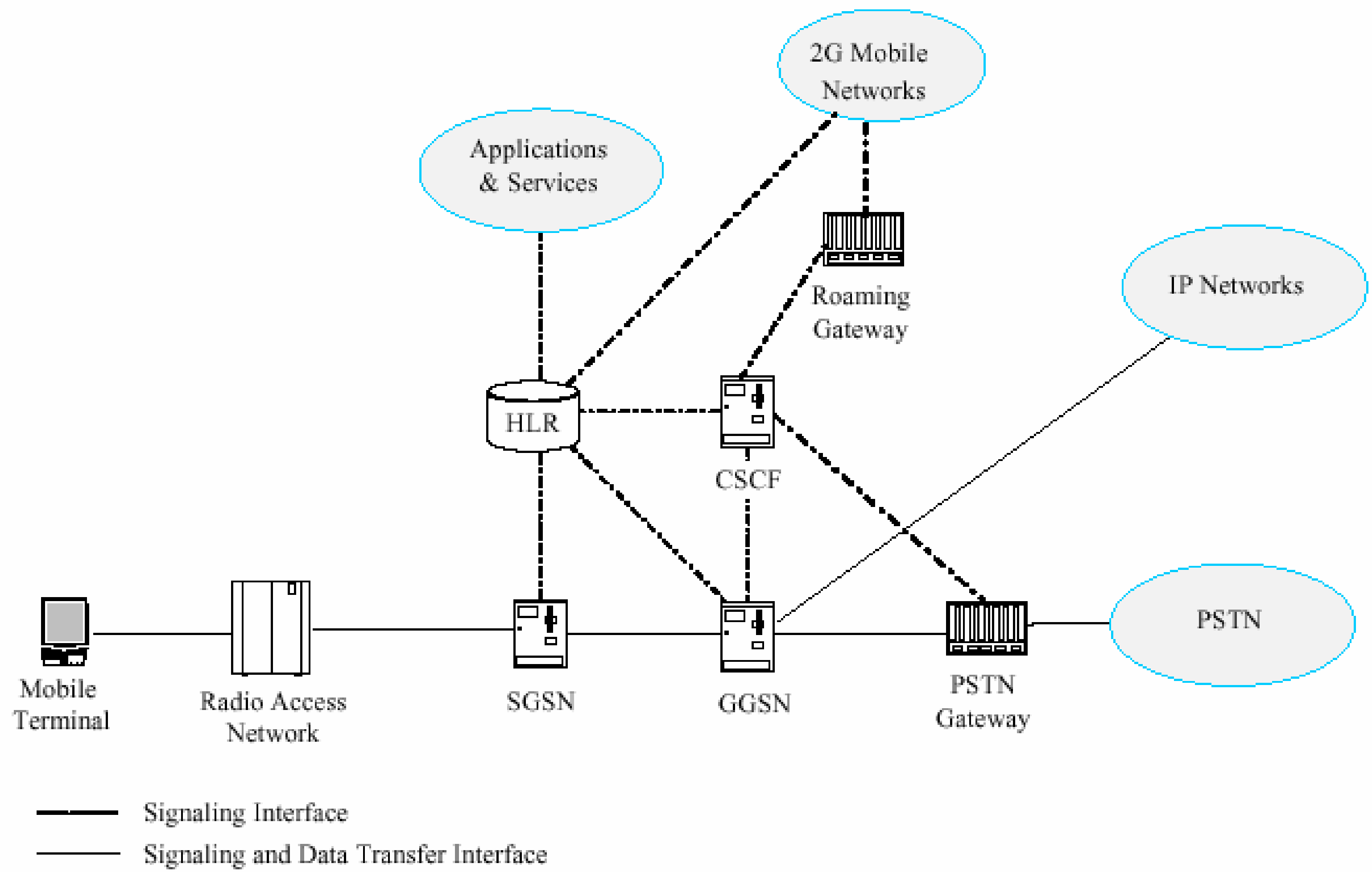
Mobile IP approach

Cellular IP

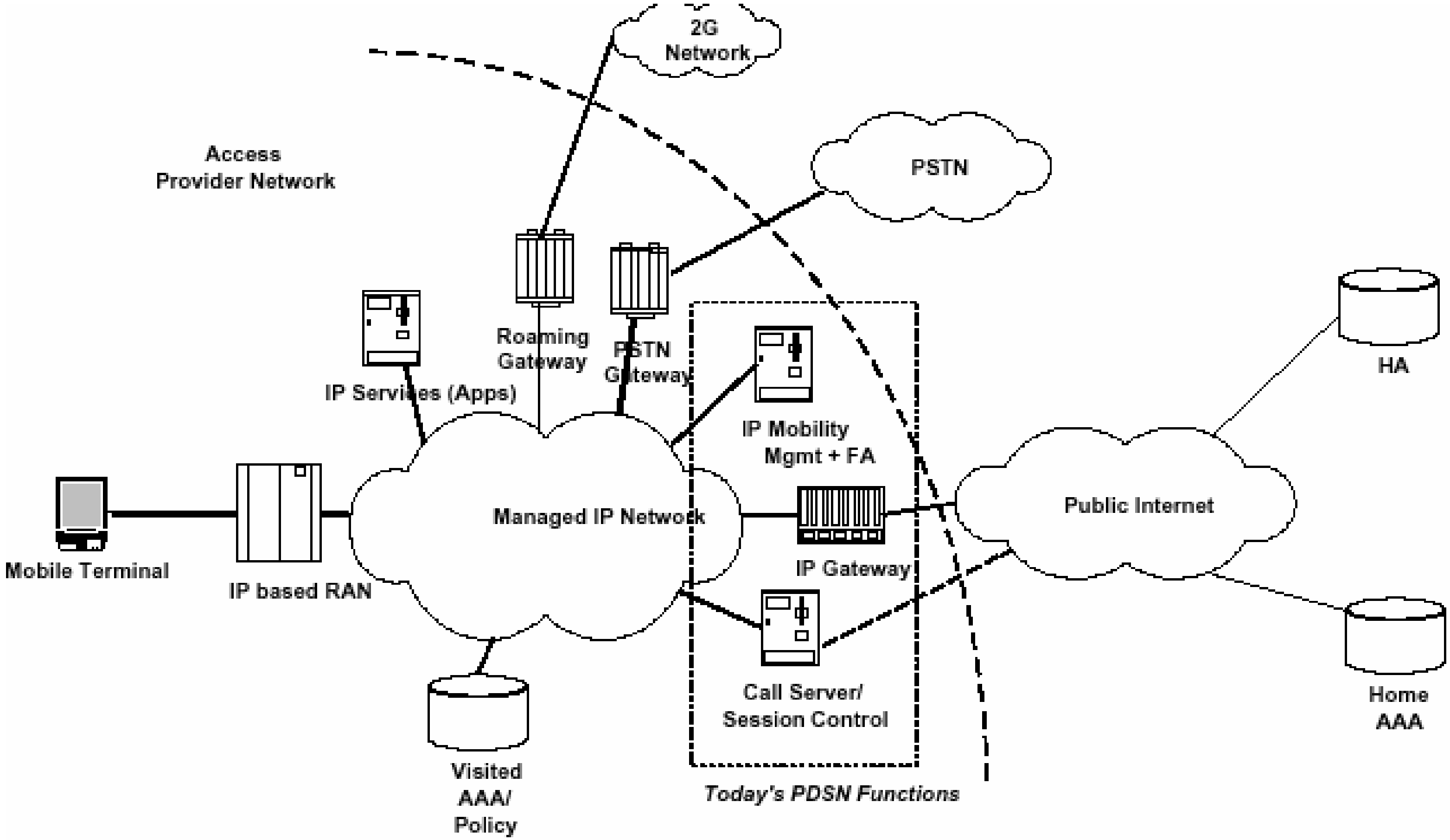


Internet
Cellular IP Access Network
Paging Cache (PC)
MobileHost ID - Port1
Routing Cache (RC)
MobileHost ID - Port1
Cellular IP Access Network
Mobile IP Foreign Agent
Internet
Gateway Router
Cellular IP Node
Cellular IP Node
Cellular IP Node
Cellular IP Node
Cellular IP Node
1
2
Mobile Host

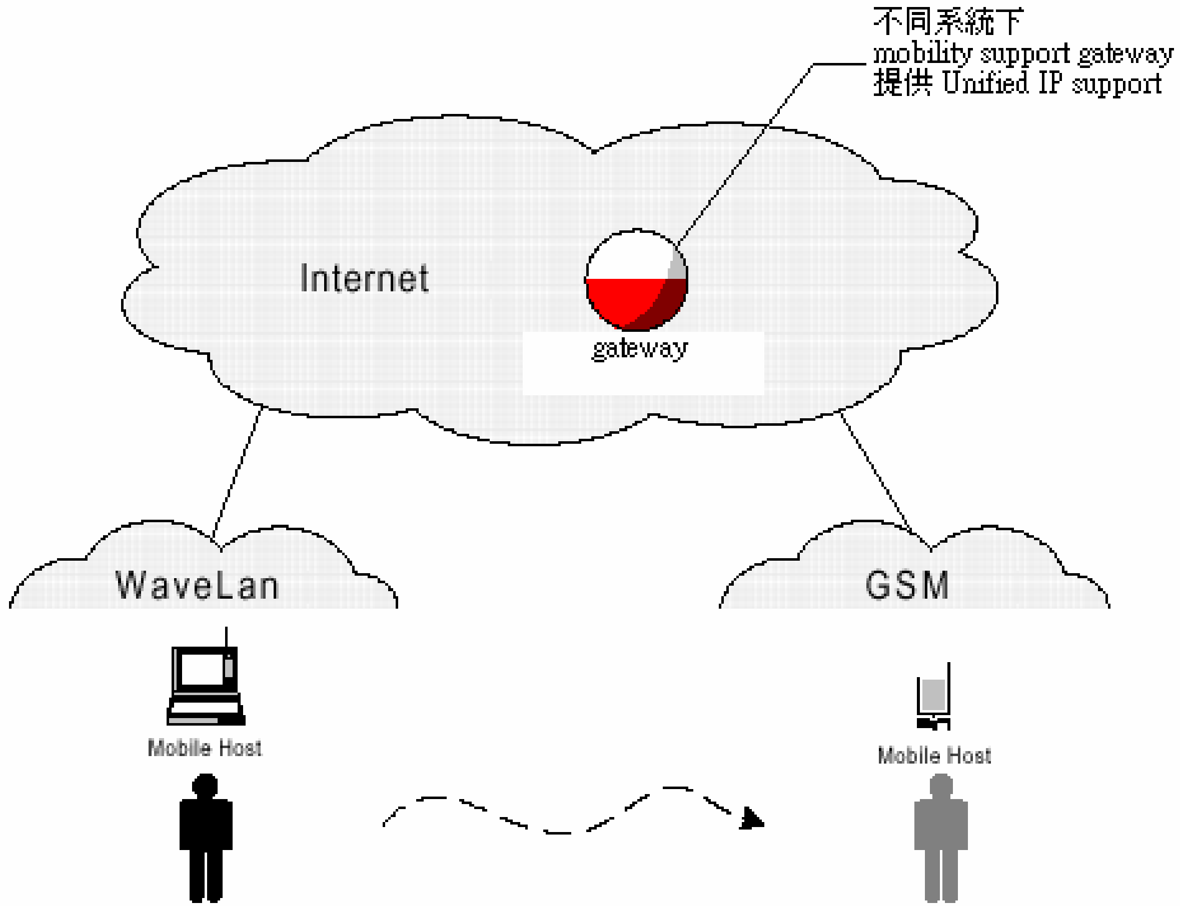
3GPP IP reference architecture



3GPP2 IP reference architecture

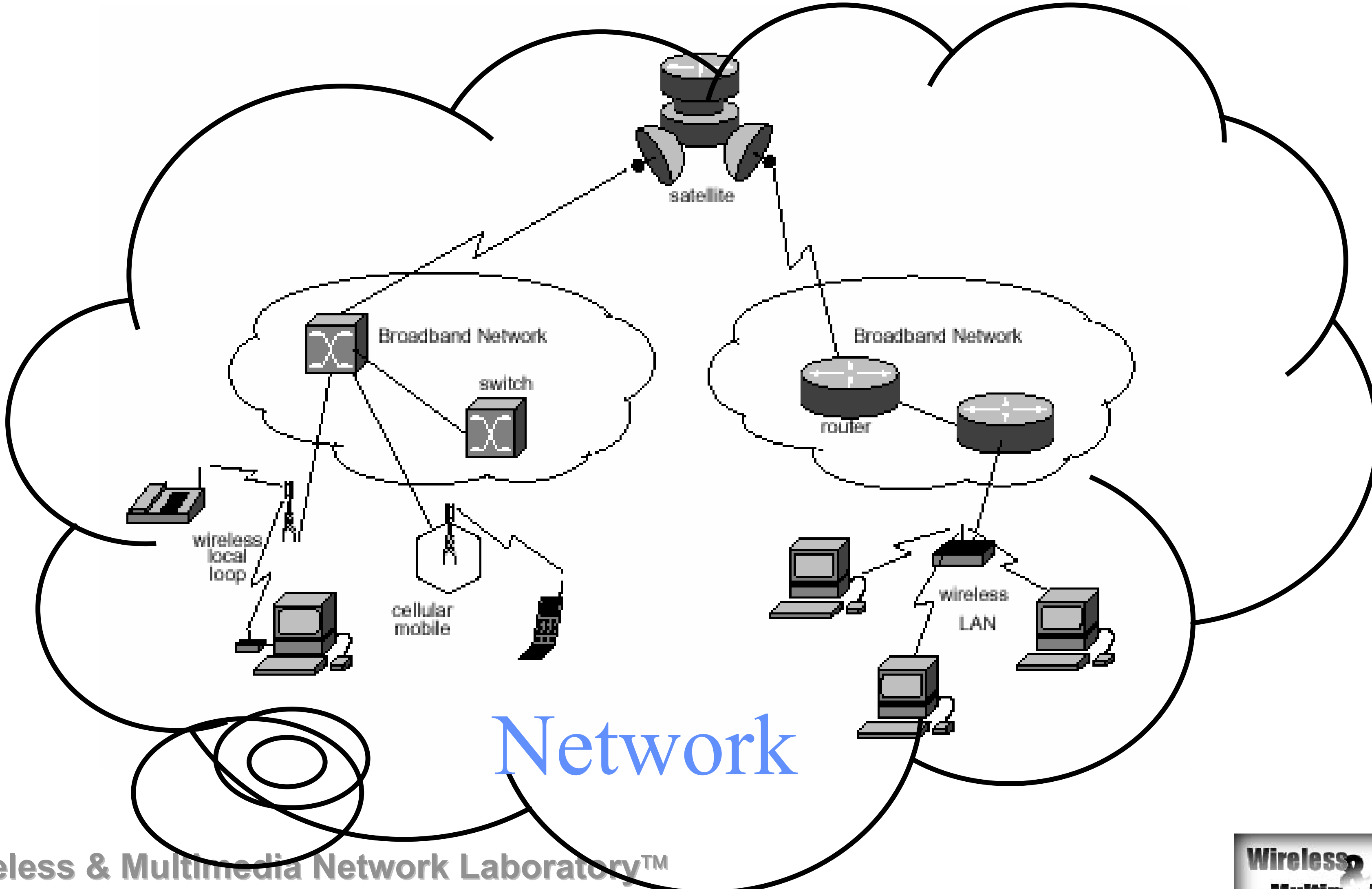


Heterogeneous access network



The Mobile People network architecture

Heterogeneous End System



Last Mile QoS Issues

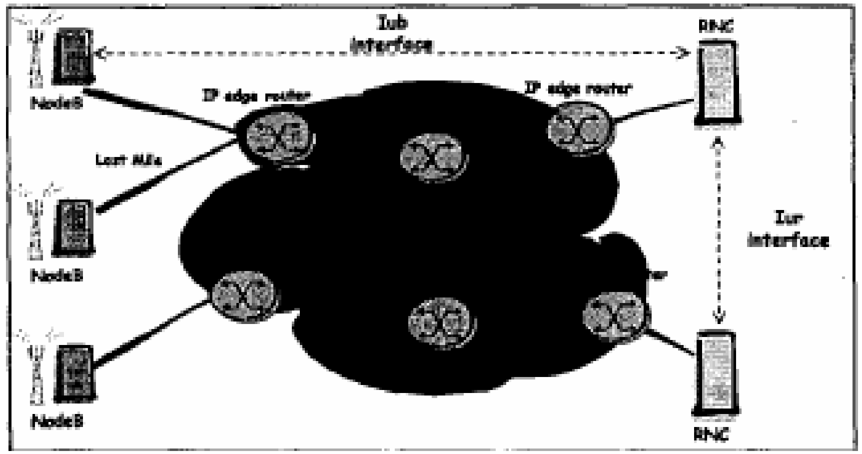
- Last mile connect NodeB and RAN. It is usually low bandwidth links.
- limit the transmission

  time for a packet.
- Three choices

  -- Fragmentation on a layer below

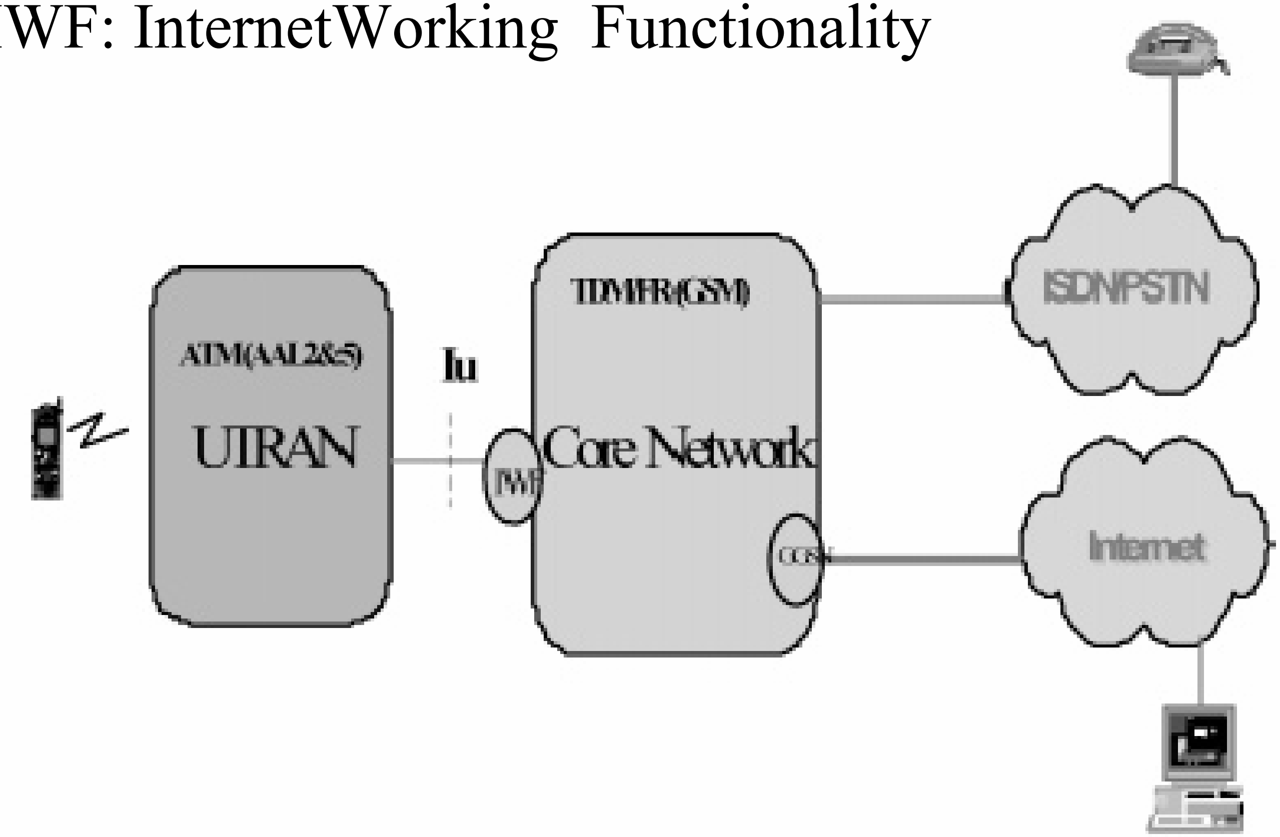
  -- Fragmentation on a layer above

  -- Fragmentation in IP Layer

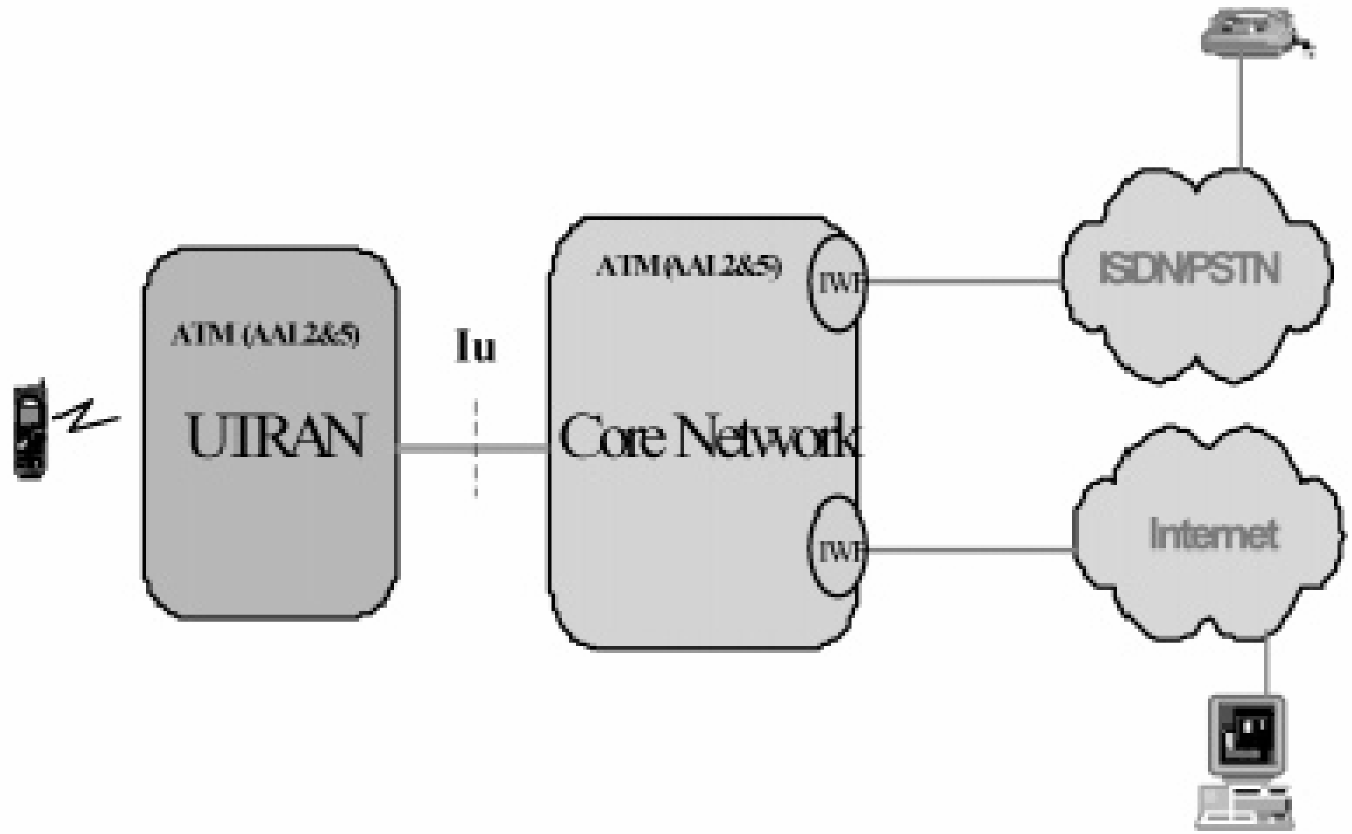


Option1

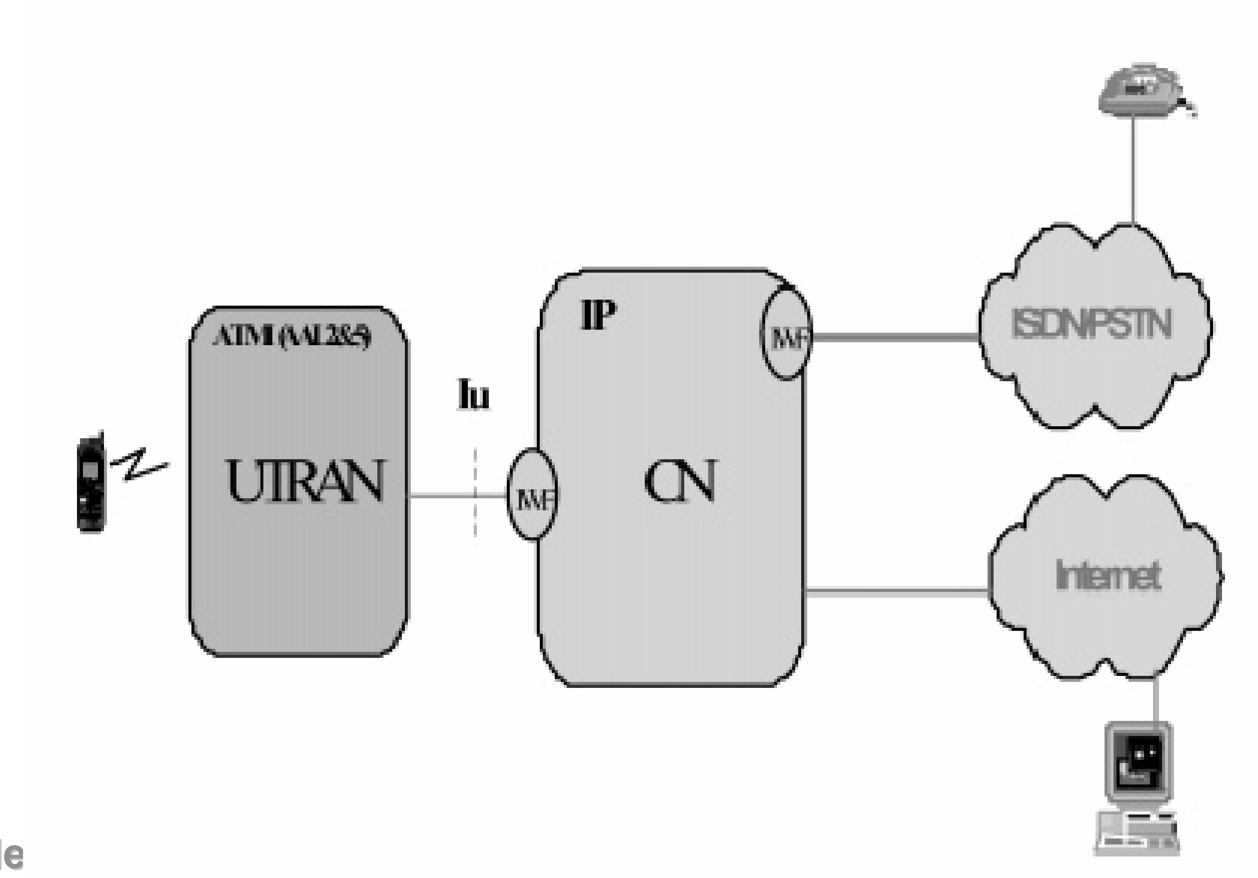
IWF: InternetWorking Functionality



Option 2


ATM (AAL2&5)
UTRAN
Iu
ATM(AAL2&5)
IWF
Core Network
IWF
ISDN/PSTN
Internet

Option 3



Option 4