無線網路多媒體系統
Wireless Multimedia System

Lecture 7: Network Mobility
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http://inrg.csie.ntu.edu.tw/wms

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)

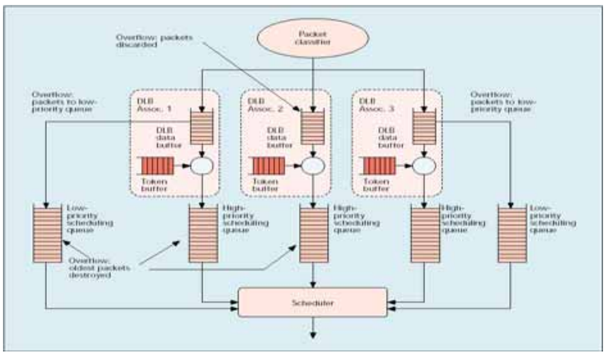
Reading

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

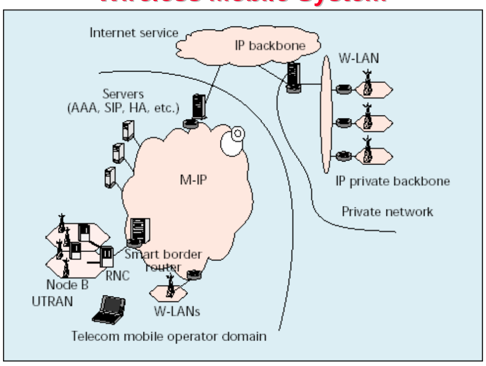
All IP

Something to happen?

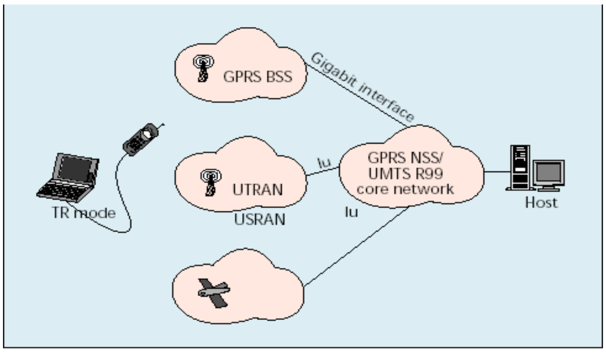
MT Scheduler



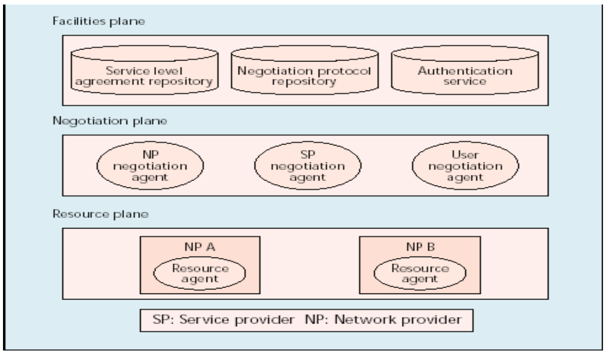
A IP reference Architecture for Wireless Mobile System



Integration Scenario



Resource Managements



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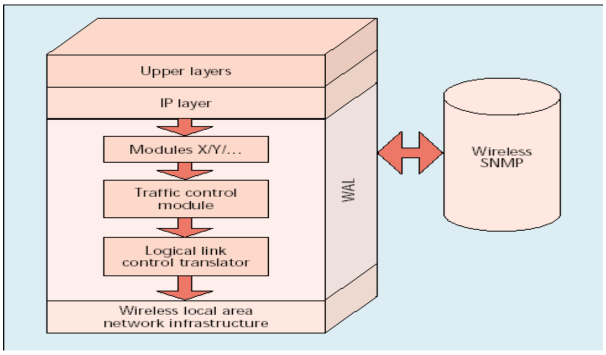
WAL



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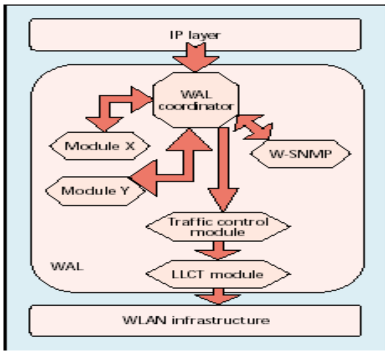
Detail WAL



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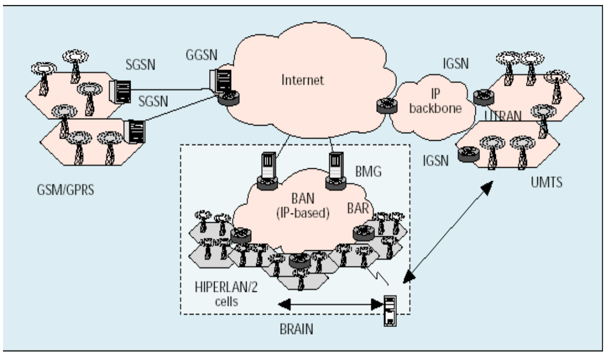
BRAIN



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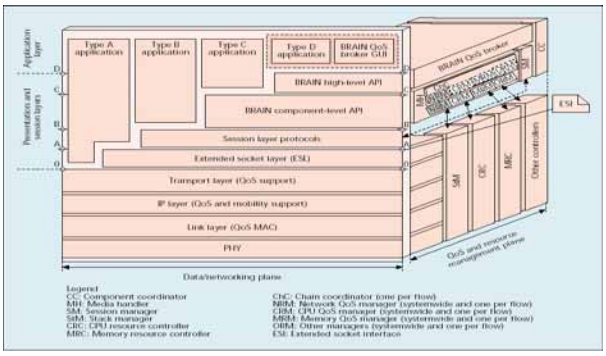
QoS Support



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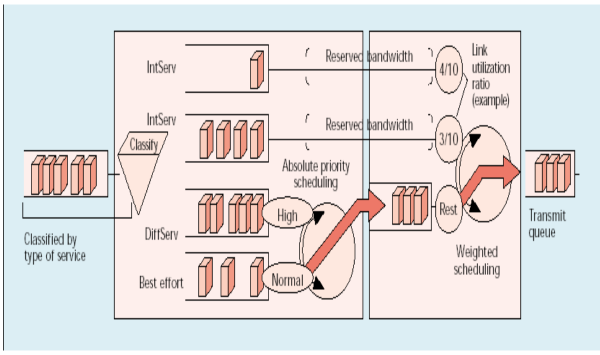
IP QoS Modeling



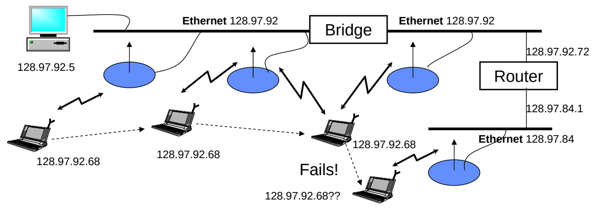
Lecture Outline

- 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

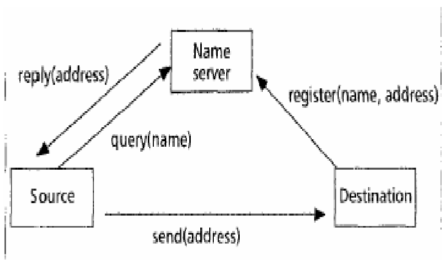


- Basestations are bridges(layer 2) – i.e. they relay MAC frames
  - Smart bridges avoid wasted bandwidth
- Works the within an ethernet(or other broadcast LAN)
  - Fails across network boundaries, and in switched LANs(e.g. ATM)

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

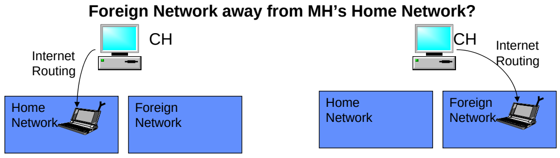
- Enhance DNS
  - Historically, DNS does not have dynamic *name-address binding* updates
    - Optimized for access cost
    - DNS clients cache DNS records
    - Hard to optimize for both access and update costs
  - Solves only part of the problem
    - TCP connections will still die!
- Keep per-MH 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

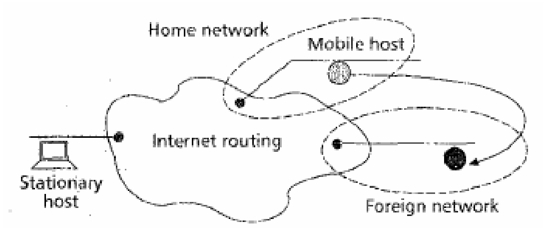
•Challenge of Mobile-IP

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.

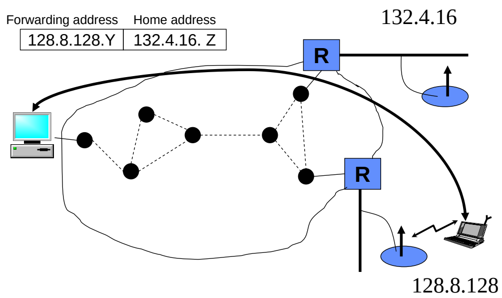
Illustration of terms



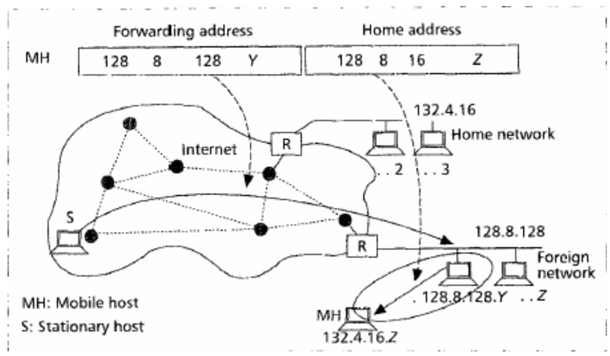
Key to Mobile-IP Two-Tier Addressing

- 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

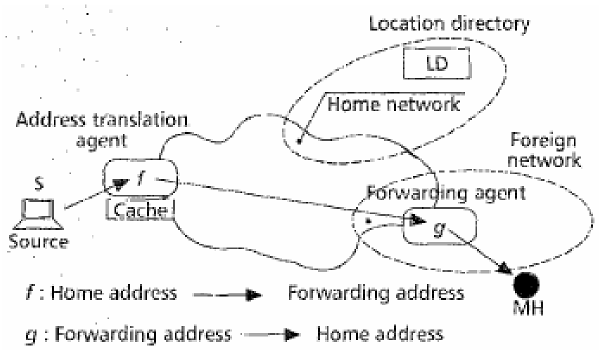
Two-Tier Addressing for Mobile Hosts



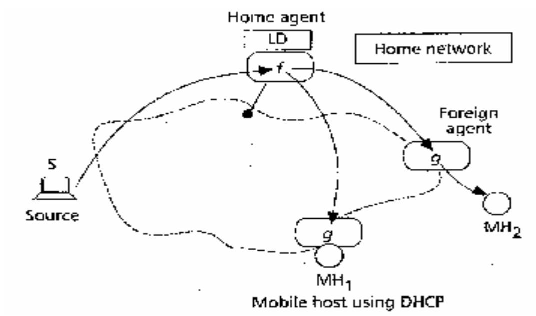
Typical Example



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!

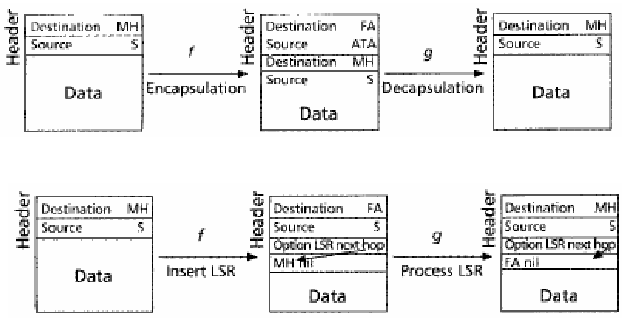
Location Update Protocol (LUP)

- 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

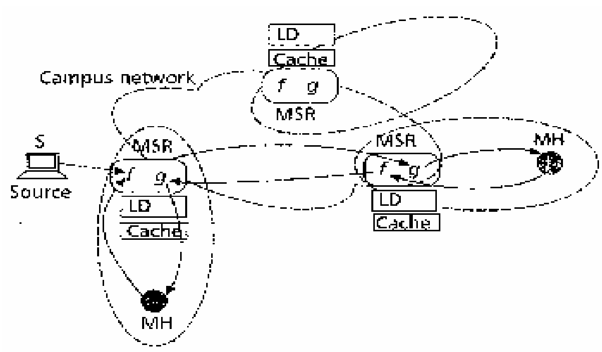
Various Mobile-IP Proposals

- 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



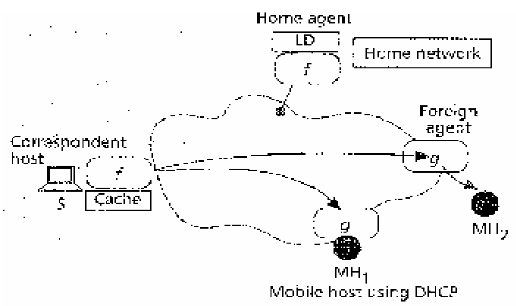
Columbia's Mobile-IP Mapped to Canonical Architecture

- 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



Route Optimizations

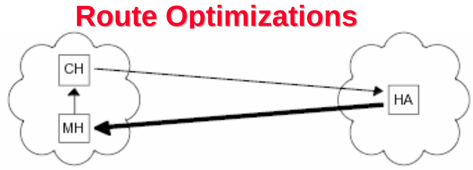


Figure 4. Behavior when CH is Close to MH

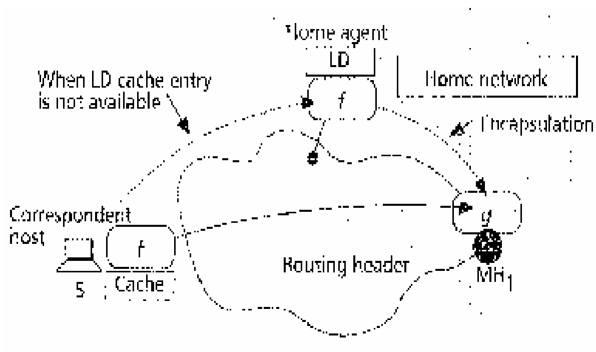
Figure 5. A Smart Correspondent Host.

Security Issues

Figure 2. Problem with Source Address Filtering

Figure 3. Bi-directional Tunneling

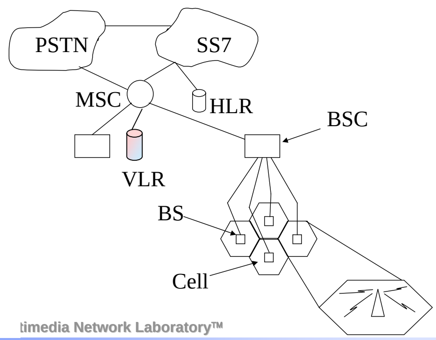
IPv6 Mobility Proposal



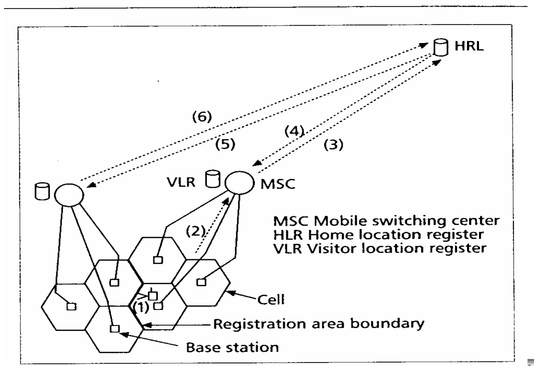
Evolutions of PCS

PCS Requirements

PCS network architecture

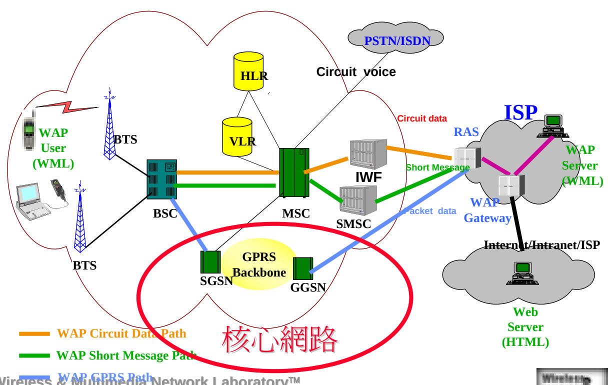


Location Update Procedure

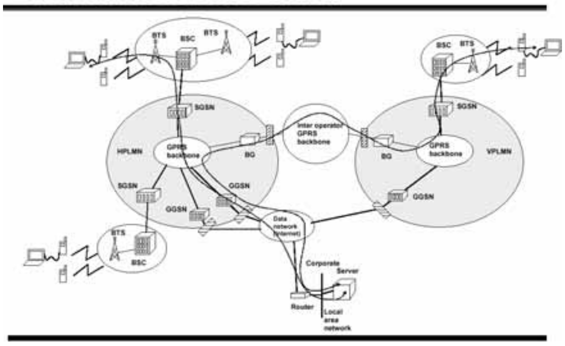


■ Figure 3. *Location registration procedures.*

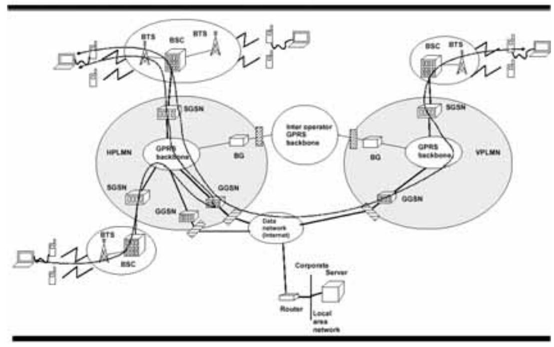
GPRS



Data transfer MS-fixed



Data transfer MS-MS



Coming Challenges for IP

Location Managements~ handoff, roaming

QoS Transport~ Backbone delivery

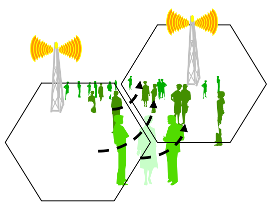
Mobility

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

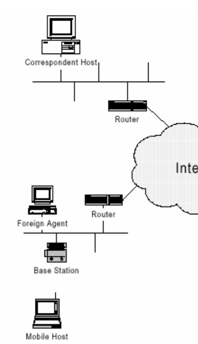
•Handoff issue

•Location management

•Paging

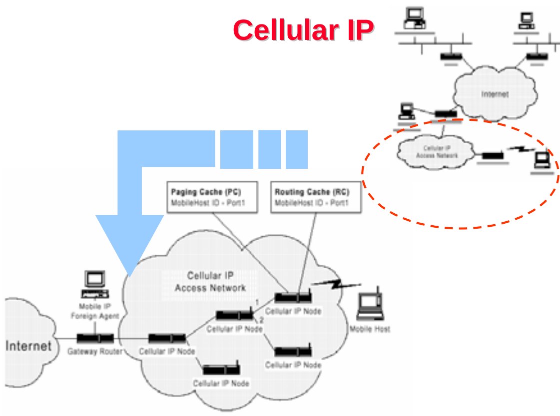


Nomadic wireless access

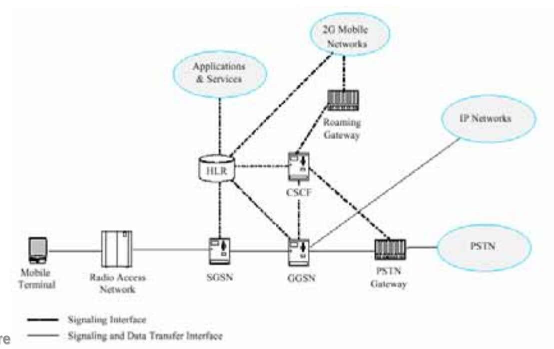


Mobile IP approach

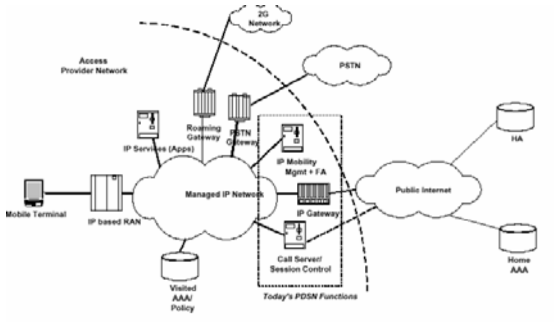
Cellular IP



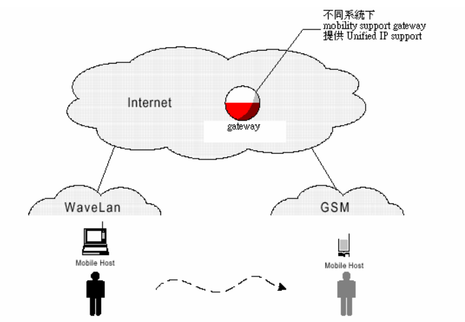
3GPP IP reference architecture



3GPP2 IP reference architecture

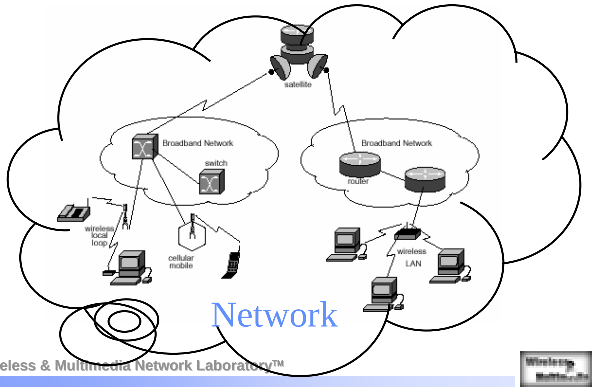


Heterogeneous access network



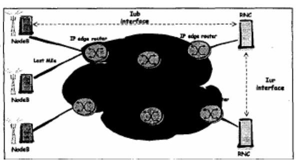
The Mobile People network architecture

Heterogeneous End System



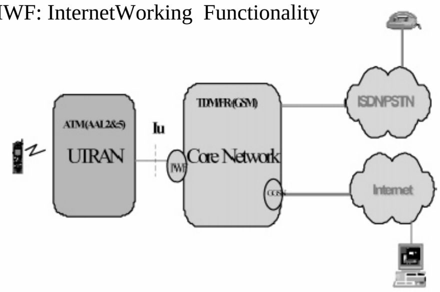
Last Mile QoS Issues

- 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

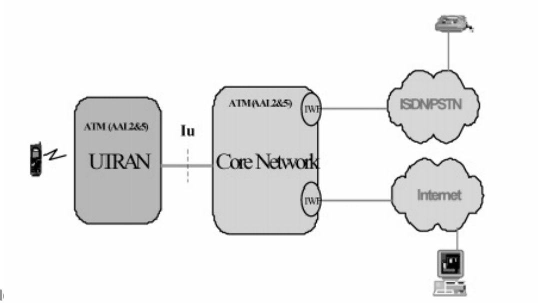


Option1

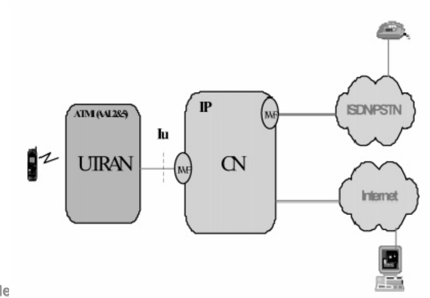
IWF: InternetWorking Functionality



Option 2



Option 3



Option 4