DoCoMo USA Labs

Towards an Internet Mobility Management Architecture

MobiArch Workshop
James Kempf
kempf@docomolabs-usa.com
December 1, 2006

Outline

- The Architectural Problem of IP Mobility
- A Sample of Existing Mobility Management Solutions
- NETLMM (NETwork based, Localized Mobility Management)
- Summary and Conclusions

The Architectural Problem of IP Mobility

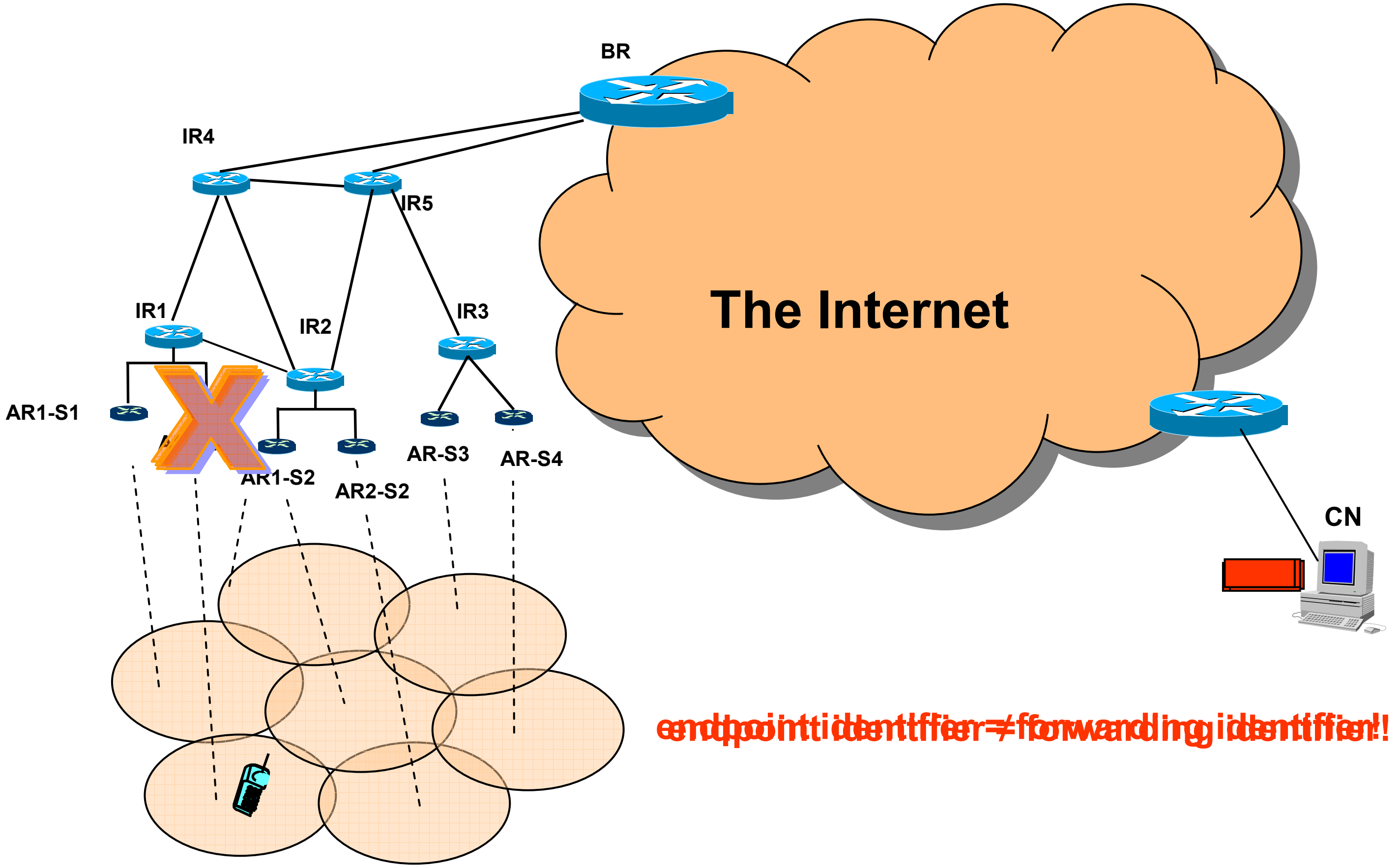
What is an IP Address?

- An endpoint identifier, uniquely identifying a communication endpoint, particularly to the Transport Layer
- A topological locator, indicating where in the network topology a device interface is located
- A forwarding identifier, allowing routing intermediaries to forward packets to a device interface
- In practice, only first and third are causally active, second is a derivative of third

Why is Mobility an Architectural Problem?

- For mobile hosts, the attachment point to the Internet changes over time
- Mobile host movement splits the functions of an address
  - Forwarding identifier changes since the attachment point changes
  - Endpoint identifier remains the same since the mobile host is the same
  - ➔ To maintain session continuity, forwarding must somehow track the topological change without changing the endpoint identifier
- Up until now, most applications have been nomadic and haven't needed session continuity
  - User sits down, opens a laptop, works for a while, closes the laptop moves to a new location...
    - Laptop gets a new IP address using DHCP each time the user moves
  - VoIP, other new services now require session continuity when the user moves between different locations
  - Truly mobile applications require mobiity management

Example


BR
IR4
IR5
IR1
IR2
IR3
AR1-S1
AR1-S2
AR2-S2
AR-S3
AR-S4
The Internet
CN
endpoint identifier ≠ forwarding identifier!

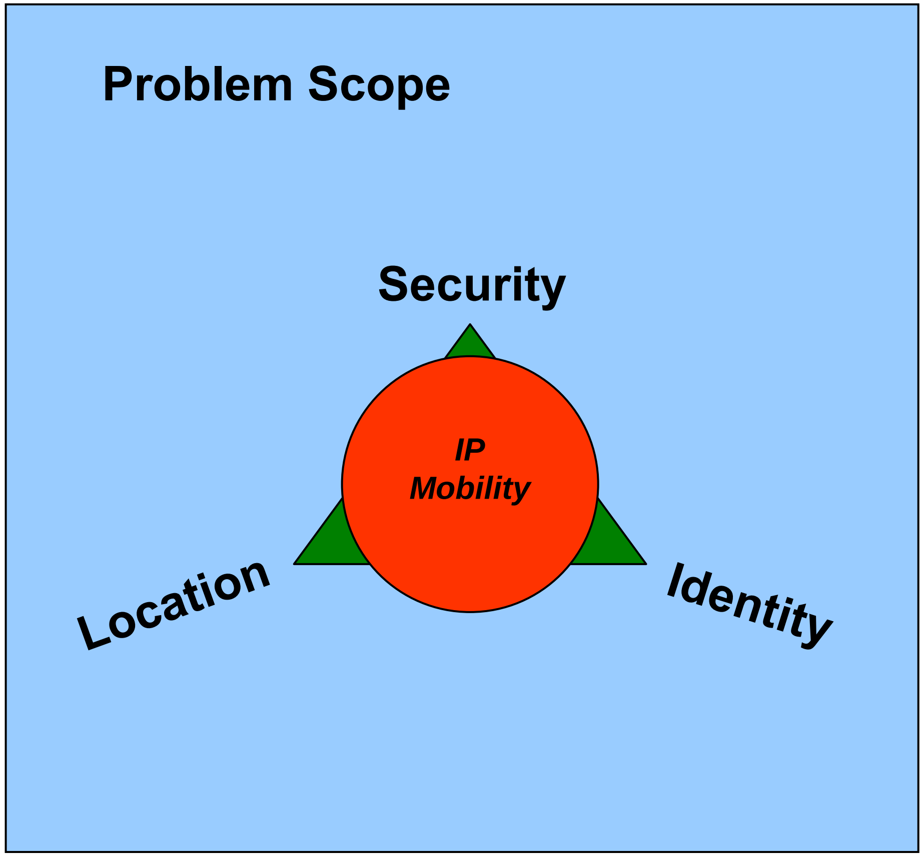
Why Isn't Mobility Management More Widely Deployed?

- IP mobility solutions have been around for a long time
  - Mobile IP has been available for 10 years
  - Only available in a couple link layer specific cellular deployments,
- Most usage has been nomadic
  - User sits down, opens laptop, works, closes laptop and moves
  - Nomadic usage pattern doesn't need session continuity
  - DHCP address configuration is sufficient
- Session based applications with longer session times need session continuity
  - Web browsing can be broken off and restarted after handover
  - VoIP session must survive a handover while the session is in progress

A Sample of Existing Mobility Management Solutions

Current Internet Architecture: Approaches to a Solution

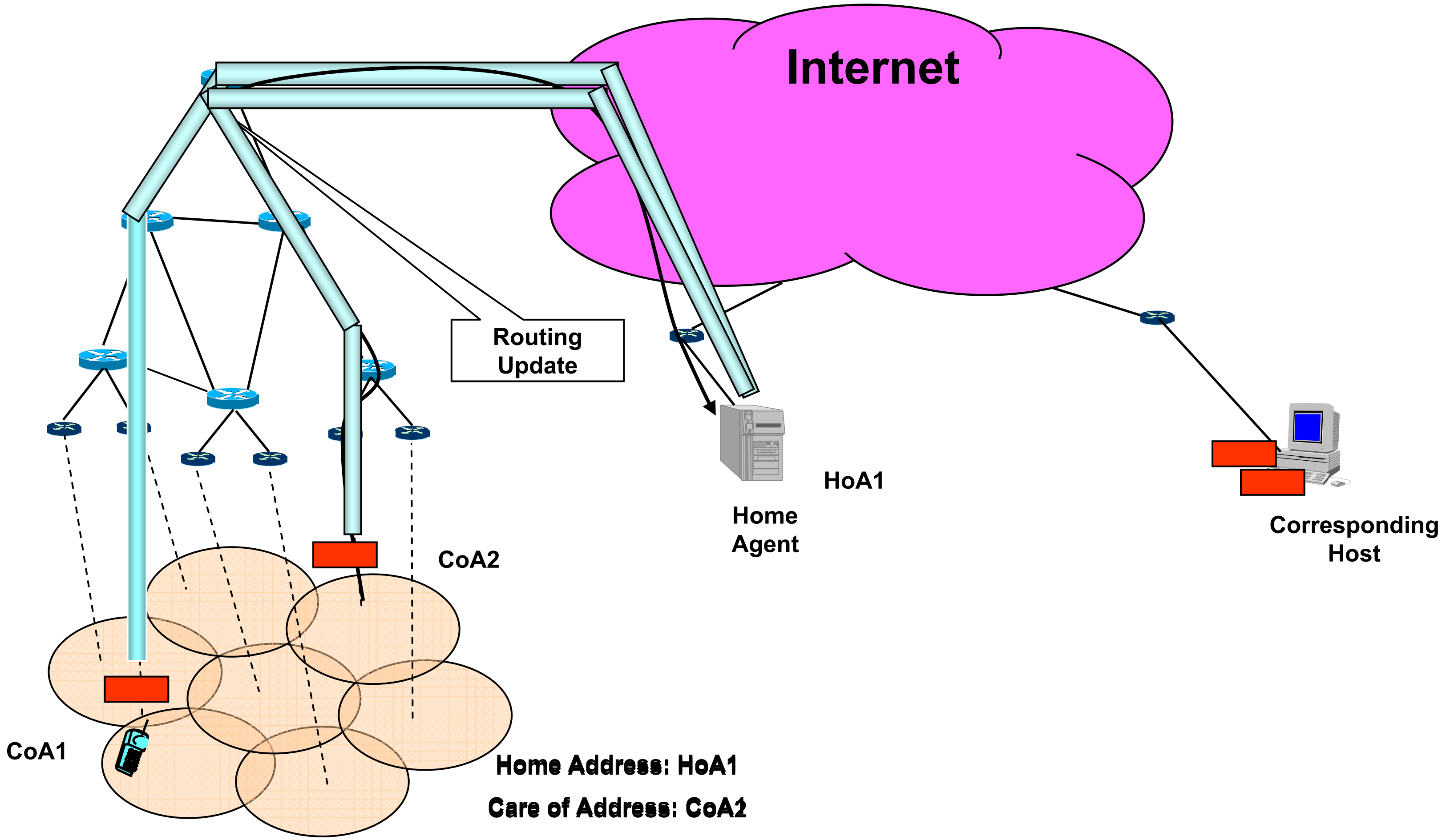
- Split the identity and location function of the IP address
  - – Use one IP address for identity, another for location
  - ➔ Mobile IP
- IP address is for location only
  - – Create a separate identity name space
  - ➔ Host Identity Protocol (HIP)
- Change routing so that identity and location function remain equal on move
  - – Overlay routing in the local topology
  - – Proprietary solutions
  - ➔ GPRS



Mobile IP Basics

- Internet Standards
  - Mobile IPv4 – RFC 3344
  - Mobile IPv6 – RFC 3775
  - Widely deployed in cdma2000 cellular network (North America, Korea, some in China and Japan)
- Basic Architectural Idea: split address functions
  - Forwarding identifier
    - Care of address - address on the local subnet
    - Changes as the mobile host moves from subnet to subnet
  - End node identifier
    - Home address – address on a server (the home agent) in the home network
    - Bound to the mobile host's Fully Qualified Domain Name (FQDN – DNS host name) and does not change
    - Identifies session endpoint to the Transport Layer
- Global Rerouting Overlay
  - Correspondent hosts send packets to the home address
  - Home agent reroutes the packets to the care of address using a tunneling overlay
  - Mobile host sends routing updates to the home agent when the care of address changes
    - Security handled by AAA between the mobile node, first hop router, and home agent for Mobile IPv4
    - Security handled by IPsec between home agent and mobile node for Mobile IPv6

Mobile IP Architecture



Problem: Two Japanese in America

- Long dogleg routes back to home agent in Japan
  - Could introduce substantial latency into VoIP
- Optimize routes by getting rid of overlay
  - Route optimization introduced into Mobile IPv6
- Mobile host signals directly to correspondent on movement
  - Sends new care-of address
  - Security complex: how can correspondent know that sender is authorized to change the IP address?
    - IPsec would require global authentication infrastructure
    - Return routability: new security protocol based on presumed security of routing infrastructure
- Correspondent switches to new address below transport layer
  - Home address still used as endpoint identifier
- Requires changes in *all* IPv6 stacks
  - Fixed servers (e.g. CNN.com) must do this too

Problem: Packet Delivery Latency

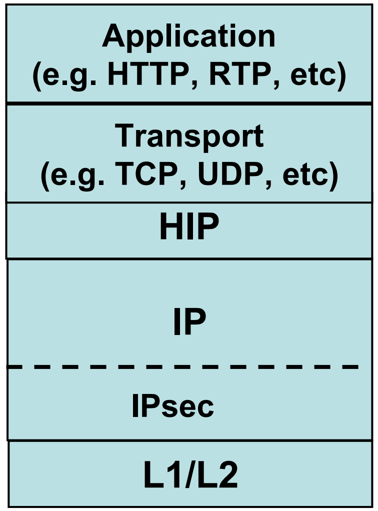
- Configuration of on a new subnet requires approximately 18 messages at the IP level depending on the address configuration mechanism used
  - IP level movement detection
  - Multicast listener discovery
  - Address configuration
    - Duplicate address configuration (DAD) if stateless
    - DHCP if stateful
  - Router address resolution
  - Binding update with the home agent
  - Return routability with the correspondent node for route optimization security
  - Binding update with the correspondent node for route optimization
- Depending on RTT this can considerably lengthen time before packets begin arriving a the new care of address
  - Packets delivered to the old care of address are dropped after the mobile node moves
- Some solutions to this problem (Fast Mobile IP, Optimistic DAD) but they require additional signaling and additional host to network security

➔ Performing Mobile IP handover on every link handover requires too much signaling overhead and may introduce too much packet delivery latency for some applications

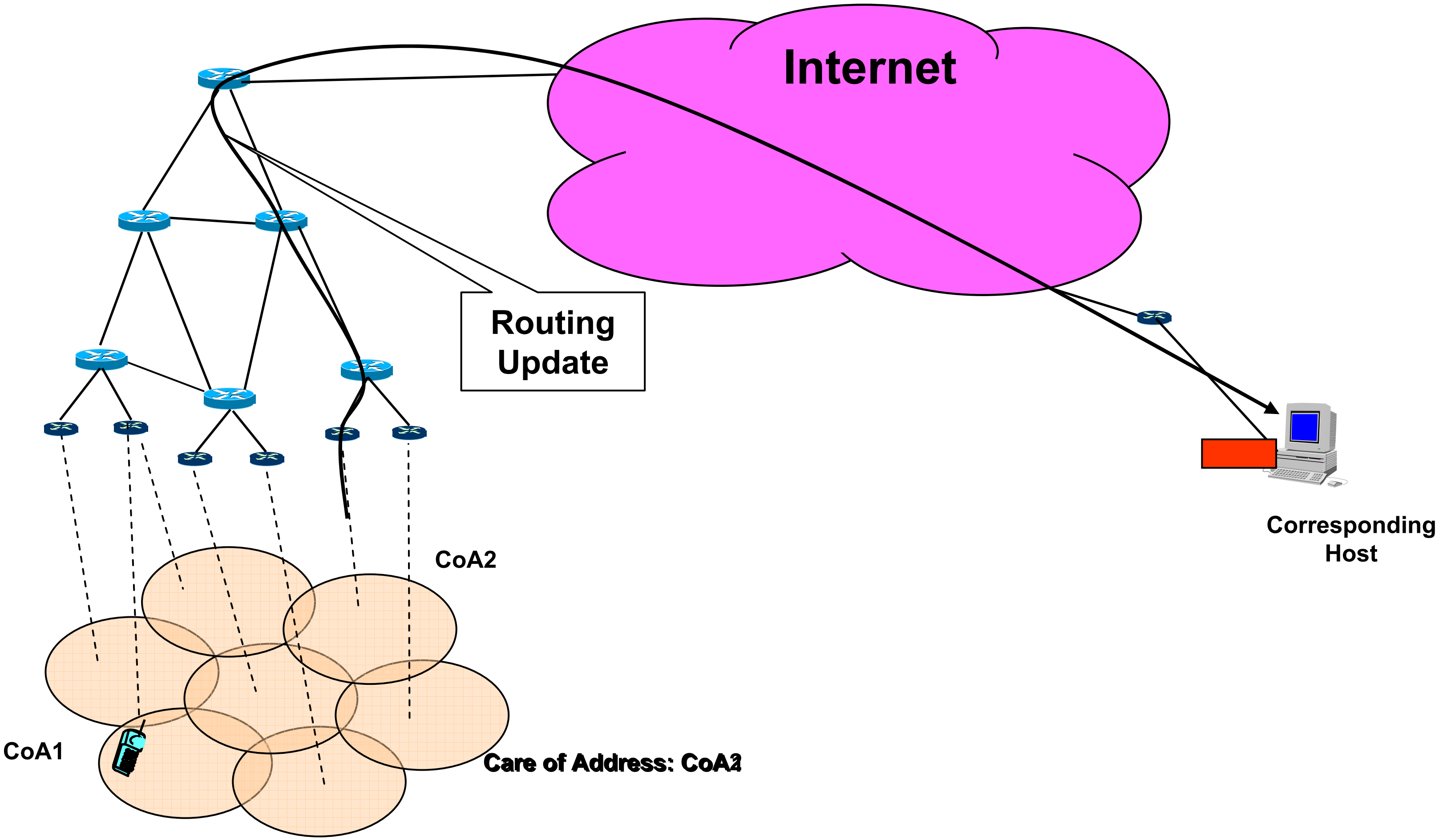
HIP Basics

- Experimental
  - Architecture: RFC 4423
  - Protocol: draft-ietf-hip-base-05.txt (not yet published)
  - Experimental deployments, but not widely deployed commercially
- Basic Architectural Idea: Create a new host identifier name space
  - Contacting host establishes an IPsec ESP tunnel with correspondent
    - Special kind of tunnel - bound, end to end tunnel
    - Establishes security between two endpoints
  - Host Identifier Tag (HIT) constructed as hash of public key
  - Traffic packets have ESP authentication and encryption
- HIT Layer
  - Between Transport Layer and Network Layer
  - Maps HIT to/from current IP address
  - Transport Layer identifies connection endpoints using HIT
- When current IP address changes
  - Host signals correspondent with change using HIT to identify itself
  - IPsec ESP authentication ensures host has the right to claim the HIT

HIP Stack


Application
(e.g. HTTP, RTP, etc)
Transport
(e.g. TCP, UDP, etc)
HIP
IP
IPsec
L1/L2

HIP Architecture



Problem: What if Correspondent is Also Mobile?

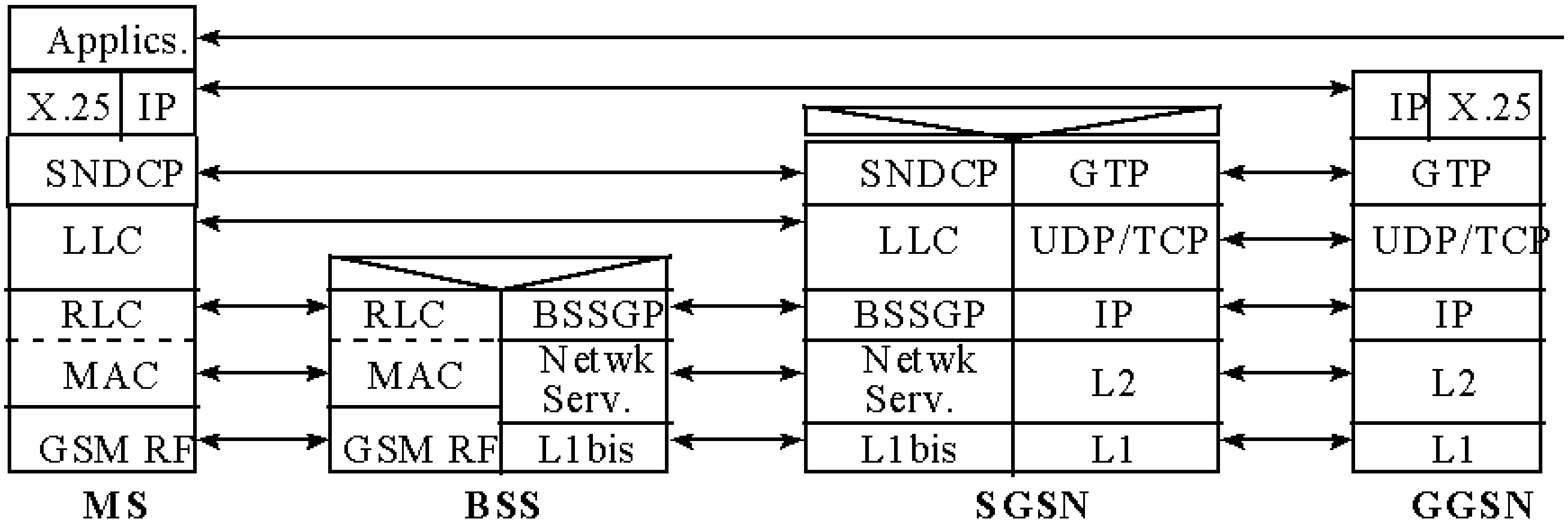
- If both move at the same time, signaling could get lost
  - More precisely, both move within RTT
  - Session fails
- Introduce a network functional elements to anchor mobility
  - Rendezvous server
- Rendezvous server acts as a fast name server
  - Dynamic DNS is too slow – 15 sec for change
  - Mobile host updates route to new address at the rendezvous server first
  - If correspondent loses the session, use rendezvous server to find new address
- Rendezvous server acts as a mobility anchor
  - Reroutes first HIP signaling packets through an overlay
  - No different from Mobile IP with route optimization

➔ HIP loses end to end character and much of its attraction over Mobile IP

GPRS Basics

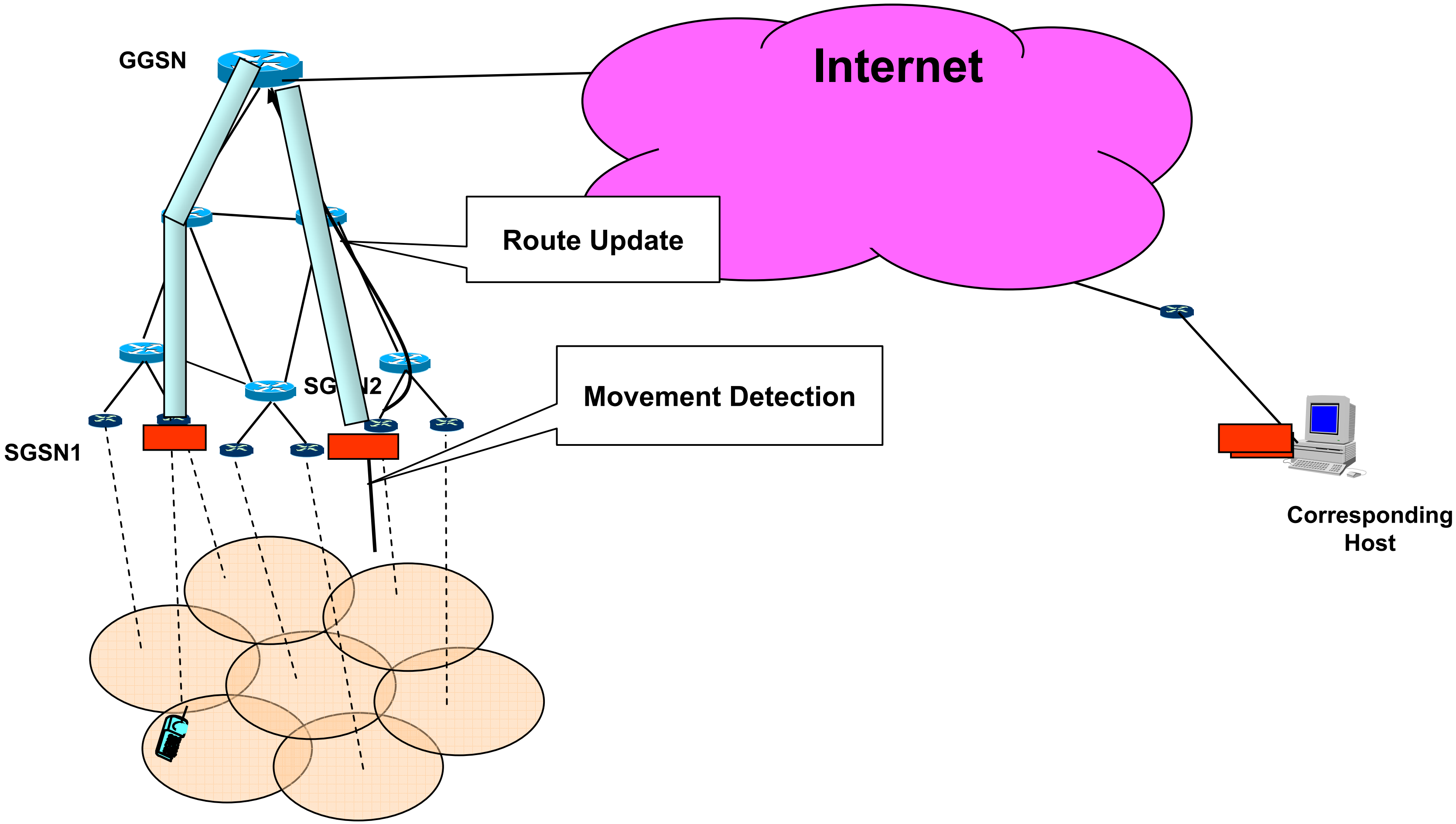
- Proprietary protocol for cellular systems utilizing GSM signaling
  - Legacy circuit-switched signaling using SS7/MAP protocol
  - Extensive, world wide deployment on two cellular wireless technologies
    - GSM
    - WCDMA
- Basic architectural idea: keep the IP address the same when the host moves
  - Locator and endpoint identifier functions are not split
  - Locator function is updated by the network on movement to match current location
- Local Rerouting Overlay
  - A mobility anchor (GGSN) maintains host routes to/from mobile host's current subnet
  - GGSN tunnels data plane traffic to/from last hop router (SGSN) on local subnet
  - Mobile host signals SGSN to detect movement but no change in IP address
  - SGSN signals host route updates to GGSN
  - GGSN updates tunnel endpoint

GPRS Stack



Applics.
X.25
IP
SNDCP
LLC
RLC
MAC
GSM RF
MS
RLC
MAC
GSM RF
BSSGP
Netwk Serv.
L1bis
BSS
SNDCP
LLC
BSSGP
Netwk Serv.
L1bis
GTP
UDP/TCP
IP
L2
L1
SGSN
IP
X.25
GTP
UDP/TCP
IP
L2
L1
GGSN

GPRS Architecture



Problems: Complex, Proprietary, and Limited

- Complex ties to legacy SS7 telephony signaling
  - GPRS also available on WLAN
    - Probably won't be deployed because there are simpler solutions
  - Many unnecessary hooks for QoS, charging, etc. that slow initial session establishment
- Proprietary to GSM Operators
  - Not a general solution for the Internet
- Limited topological scope for keeping address constant
  - Doesn't work when the mobile host changes to a different AS
    - BGP routed prefixes change
  - Also might not work for a service provider with a global network
- GSM Operators use a proprietary protocol to route from one GPRS network to another
  - No host involvement
  - Many technical flaws

➔ GPRS-like protocol with no SS7 legacy and confined to mobility management

Bottom Line

- There are too many ways to handle mobility management
- Many are specific to particular wireless link technologies
- Service application writers can never know whether mobility management will be available in the deployment environment
- Wanted: mobility management just works, everywhere, like routing does

NETLMM (NETwork based, Localized Mobility Management)

Three Tiered Mobility Management

- Layer 2 Mobility
  - Allows movement within an IP subnet
  - Movement from one wireless access point/base station to another
  - Causes a node's basic link to the network to move
    - Without it, a node loses link connectivity and basic networking fails
- Global Mobility
  - Movement between two IP subnets
  - Requires change in the identity to locator mapping
  - Causes a node's IP routing to move
    - Without it, a node loses forwarding service and packet delivery for existing sessions fails

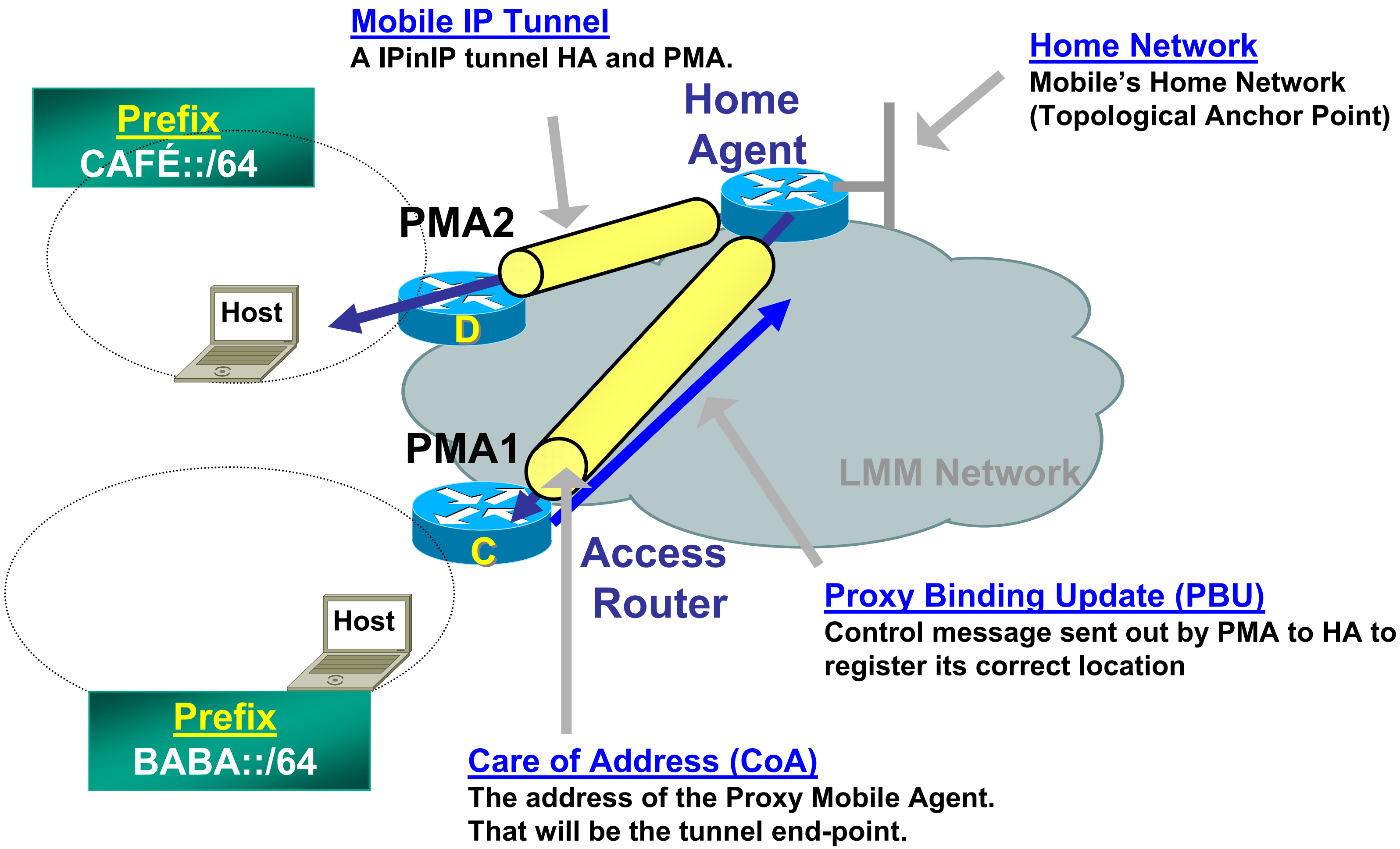
What is NETLMM?

- IETF Working Group developing a network based mobility management protocol for IPv6
- Network based: no involvement on the part of the host
  - Other than possibly simple IP level movement detection
- Localized Mobility Management: mobility management service is provided over a restricted chunk of topology not the entire Internet
  - Need another protocol for global mobility management
    - Global mobility management: session continuity between NETLMM domains and roaming
    - Provided by Client Mobile IP, HIP, etc.
- Mobility management just works if global mobility management isn’t needed
  - Provided network operators deploy NETLMM

Proxy Mobile IP

- IETF NETLMM WG has selected Proxy Mobile IP for mobility management
  - 3GPP2 requested IETF to standardize
  - Excellent deployment prospects
  - 3GPP is also considering
- Mobile IP client functions move to a proxy node at the access router
  - No localized mobility management functions on the terminal
  - Still need global mobility management (Client Mobile IP, HIP, etc.)
- Local home agent allocated in access network
- Home agent protocol changes from RFC 3775
  - RFC 3775 has strong end to end security, changes needed for Proxy Mobile IP
  - Possible addition of aggregated tunneling to improve prospects for traffic management
  - Other...

Proxy Mobile IP Overview



Why Not Use Proxy Mobile IP for Global Mobility Management Too?

- Proxy Mobile IP could support network-based global mobility management
  - Don't allocate a local home agent
  - Use home agent in home network
- But network-based Global Mobility Management may be harmful for Internet...
- Mobile terminals must be "access network-agile"
  - If access network doesn't have mobility management, terminals must still be able to move
  - Client-side mobility management is essential for this
- Tussle between large operators and small
  - Large operators could form closed roaming consortia with all members globally linked
    - "Mobility Walled Gardens"
  - Client side mobility management enables small operators to preserve a niche
  - Large operators benefit too
    - Small market roaming partner choice more competitive
- Protocol design to support local mobility management only???
  - Doubtful

Summary and Conclusions

Three Tiered Mobility Management Architecture

- Layer 2 mobility for movement within an IP subnet
  - All Layer 2 protocols support some kind of Layer 2 mobility management protocol
- Network-based, localized mobility management for movement within a constrained topological and geographical area
  - Local IP address doesn't change
  - Host involvement at IP level limited to movement detection
- Host-based, global mobility management for roaming and large topological movements
  - Change in local IP address due to service provider change or movement outside of localized mobility management domain
  - Host required to sense wireless on a new interface and move sessions to the interface