Objectives:

1) Understanding some popular service discovery protocols
2) Understanding mobility management in WLAN and cellular networks

Readings:

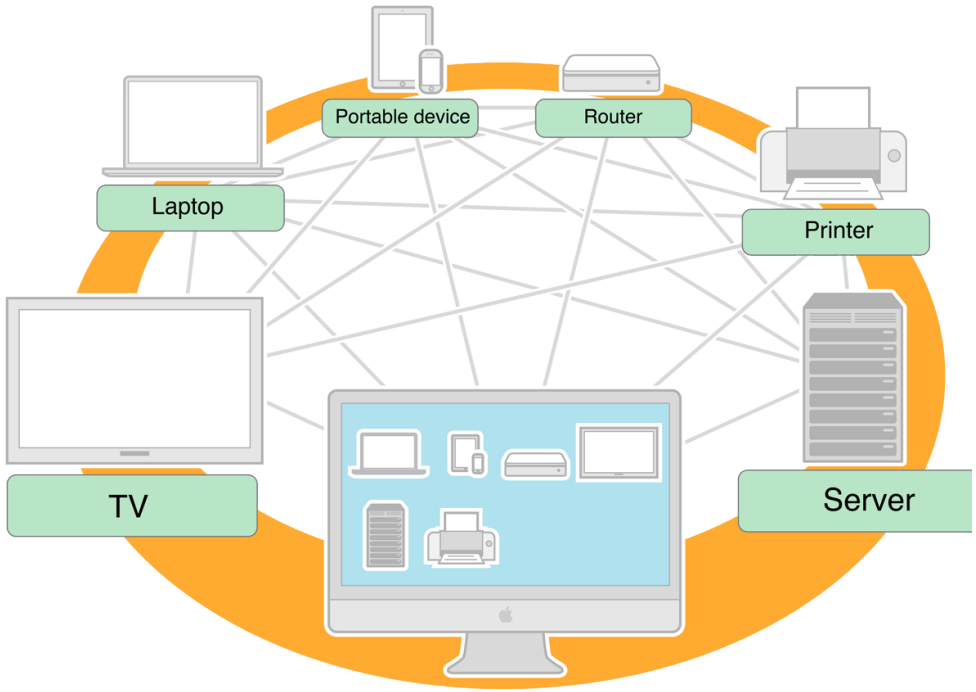
1. Fundamentals of Mobile and Pervasive Computing (chapt7)

SERVICE DISCOVERY AND MOBILITY MANAGEMENT

Part 1: Service Discovery

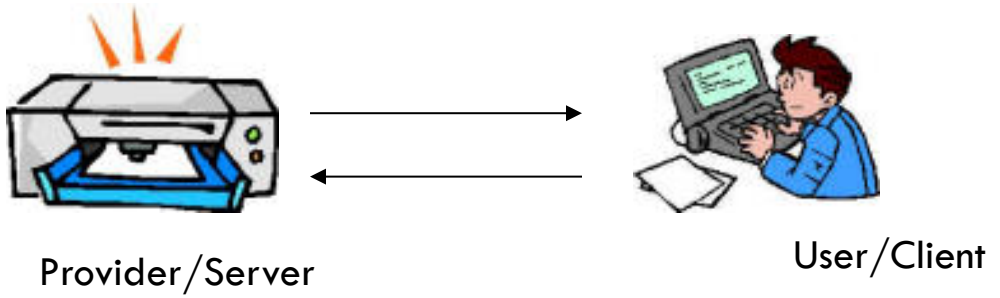
Service discovery

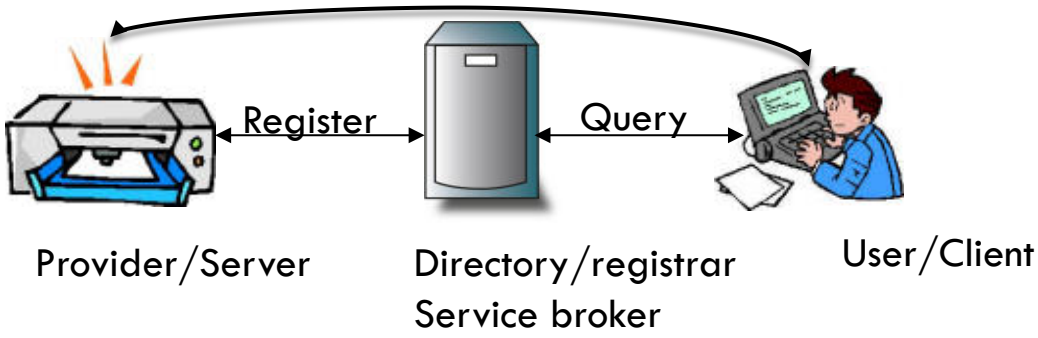
- What is service?
  - Storage, printing, display …
- Allows automatic detection of devices and services offered by these devices in a network
  - Done without human intervention
  - Particularly relevant in mobile settings



Service discovery entities

- Client (or user): the entity that is interested in finding and using a service
- Server: the entity that offers the service
- Directory (or server, broker, central, resolver): a node in the network that hosts partially or entirely the service description information





Components

- Directory repository
  - Centralized
  - Distributed
    - Hierarchical
    - Structured P2P
    - Ad hoc
- Service description
  - Attribute/value
  - Tree-like
  - XML
  - Ontologies (DAML)
- Announcement
  - Register
  - Multicast/broadcast
- Query/Service Access
  - Syntax
  - Ontology
  - Programming language dependency

Requirements for SD

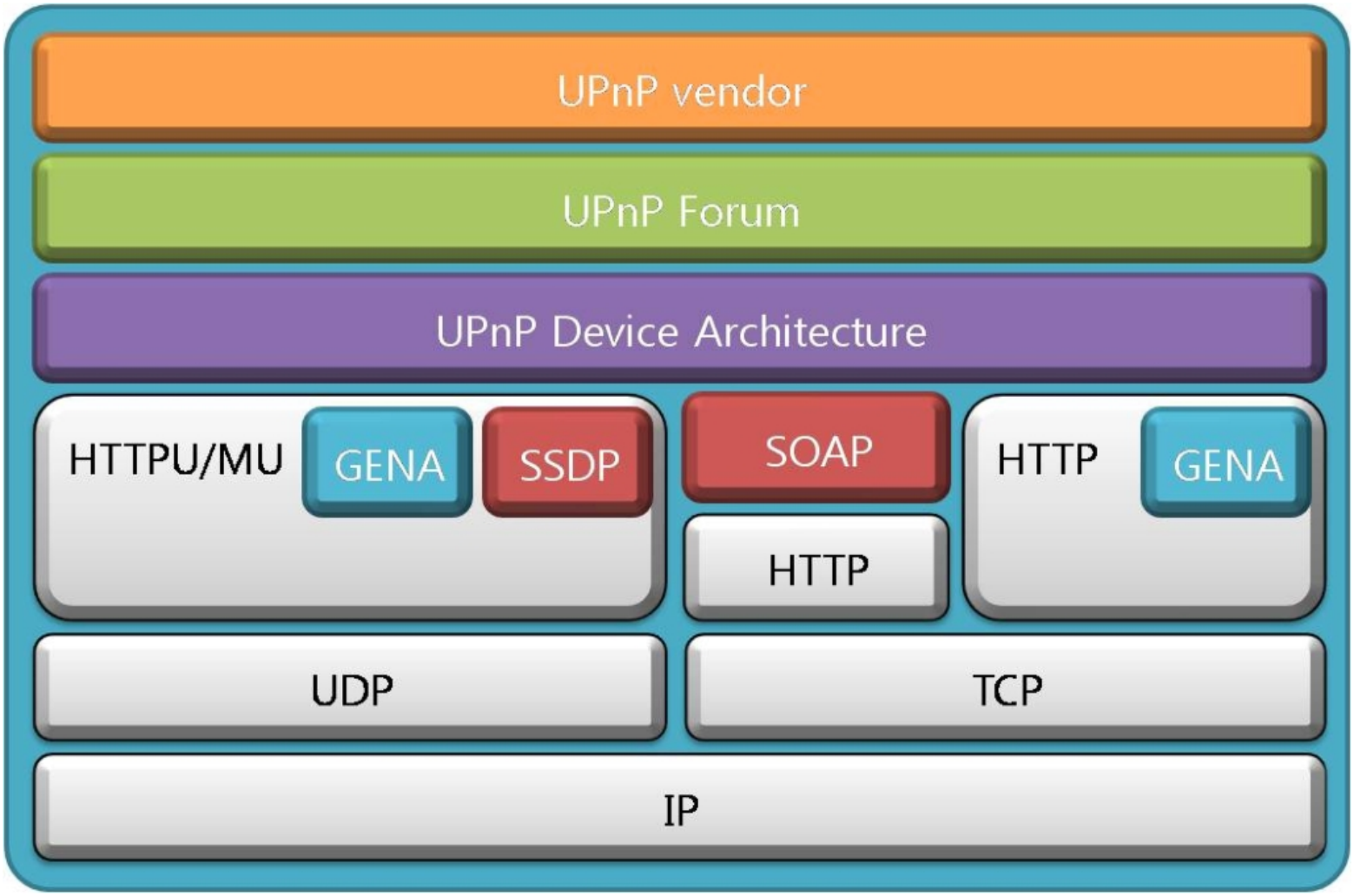
- Use of descriptive language: services needs to be semantically described
- Storage of service information
- Search for services
- Maintenance against changes in service description
- Maintenance against topology changes

Some Service Discovery Protocols (SDP)

	Jini	SLP	UPnP	Bluetooth	Bonjour
Main Entities	Lookup Service, Client, Service	Directory Agent, Service Agent, User Agent	Control Point, Devices (Services)	SDP Client, SDP Server (or both)	SDP client, SDP server
Service Repository	Lookup Service	DA (directory agent)	None	SDP Server	SDP server
Service Announcement	Discovery/ Join protocol	Service Registration	Multicast advertisement	Not Supported	Registration
Access to Service	Service proxy object based on RMI	Service type for discovered service	Invoking Action to service	Not Supported	mDNS query
Service Description	Interface type and attribute matching	Service type and attribute matching	Description in XML	Attribute ID and Attribute Value	Domain name
Adoption					

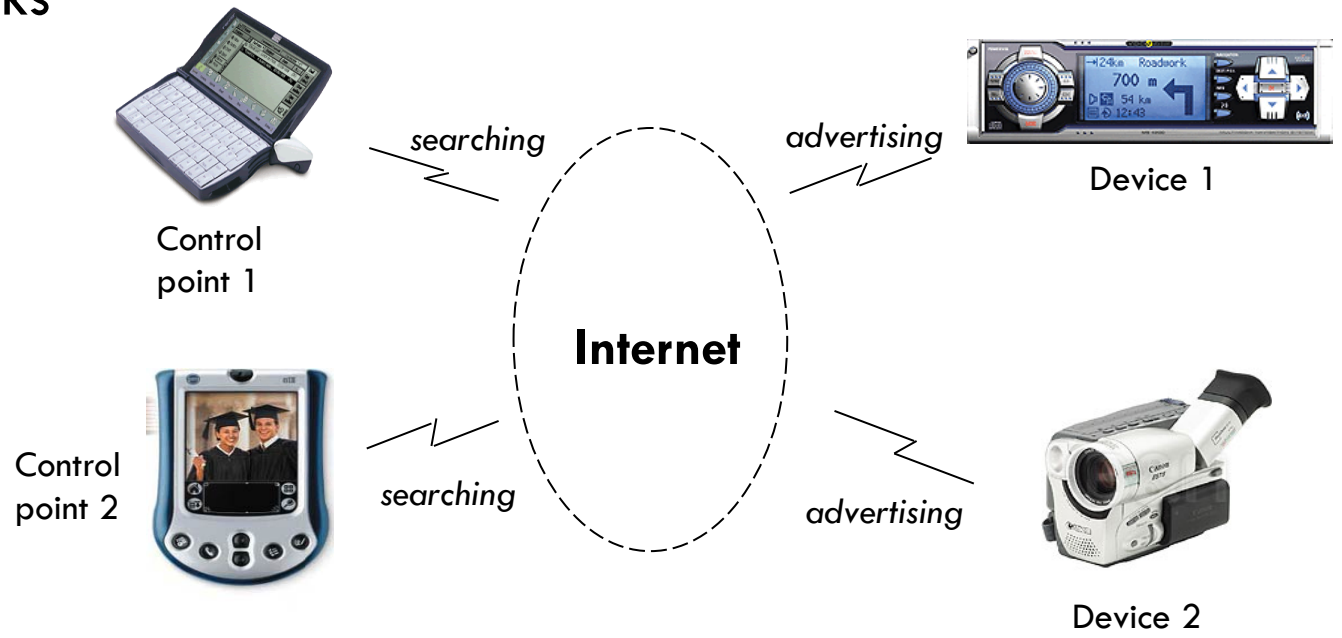
UPnP stack

GENA -- General Event Notification Architecture
SOAP – Simple object access protocol
SSDP – Simple service discovery protocol



Service Discovery in UPnP

- The Universal Plug and Play Protocol (UPnP) uses the Simple Service Discovery Protocol (SSDP) to locate the service in IP networks



- Both *searching* and *advertising* use HTTP Multicast.
- The response uses HTTP Unicast.
- UPnP targets to home-networking environments.

Joining and discovery

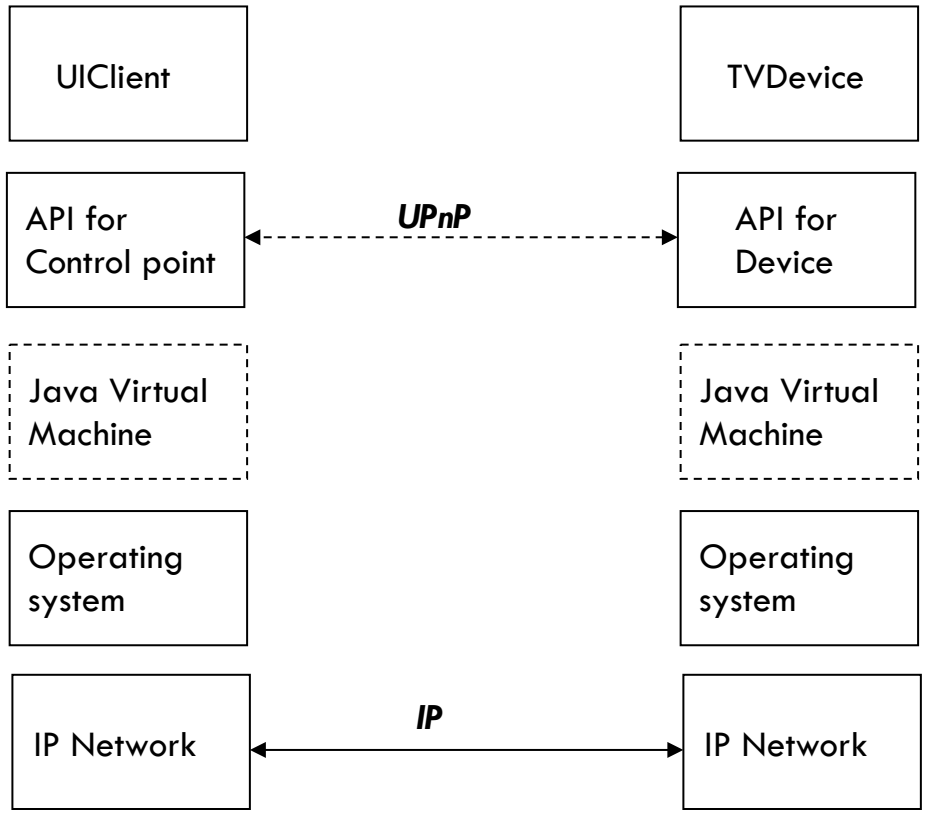
- UPnP control points are devices which use UPnP protocols to control UPnP devices
  - UPnP can work with or without control points (lookup service).
- JOINING: A joining device sends out an advertisement (ssdp:alive) multicast message to advertise its services to control points
- A control point, if present, can record the advertisement, but other devices might also directly see this multicast message.
- DISCOVERY: UPnP sends a search (ssdp:discover) multicast message when a new control point is added to a network. Any device that hears this multicast will respond with a unicast response message.

Service description

- UPnP uses XML to describe device features and capabilities.
- An advertisement message contains a URL that points to an XML file in the network that describes the UPnP device's capability.
- By retrieving this XML file, other devices can inspect the advertised device's features and decide whether it is important or relevant to them.
- XA UPnP description for a service includes a list of actions (control) to which the service responds and a list of variables that model the service's state at runtime
  - Control is expressed as a collection of Simple Object Access Protocol (SOAP) objects and their URLs in the XML file.

An example: A remote UIClient controls a TVDevice

1. UIClient and TVDevice use SSDP to discover each other.
2. UIClient retrieves the TVDevice description and get a list of associated services.
3. UIClient retrieves the service descriptions of interesting services.
4. UIClient starts interacting with TVDevice.



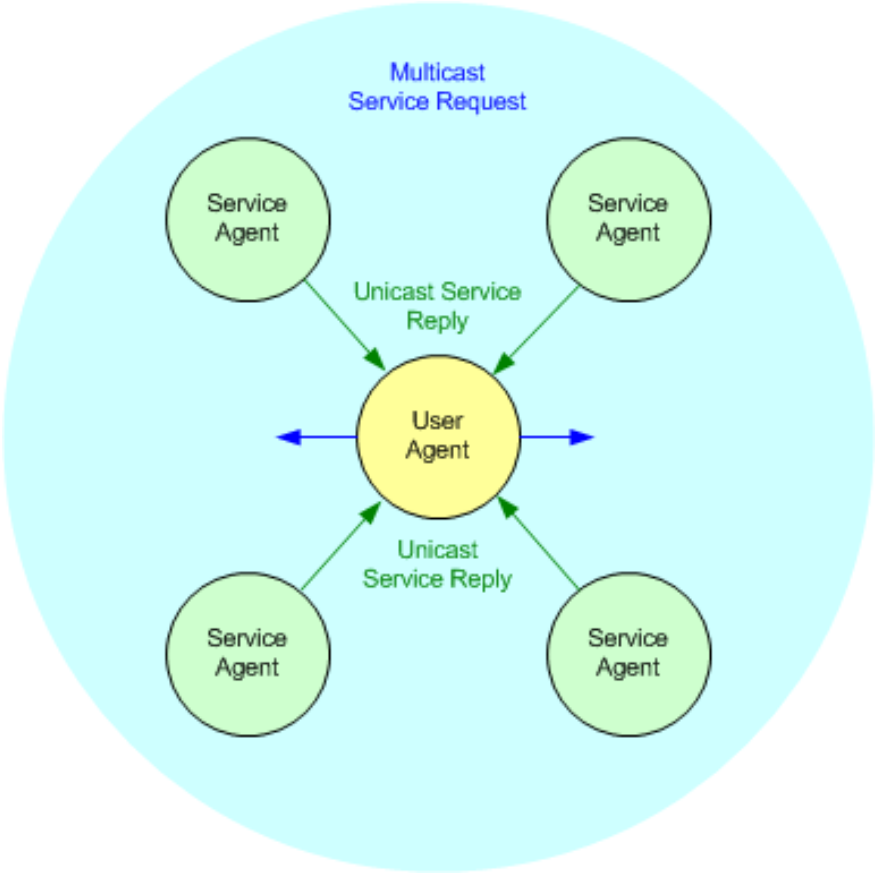
Service Location Protocol (SLP)

- An Internet Engineering Task Force (IETF) standard for decentralized, lightweight, and extensible service discovery
- It uses service URLs, which define the service type and address for a particular service.
  - service:<service-type>://<addrspec>
  - Example: "*service:printer:lpr://hostname*" is the service URL for a line printer service available at hostname.

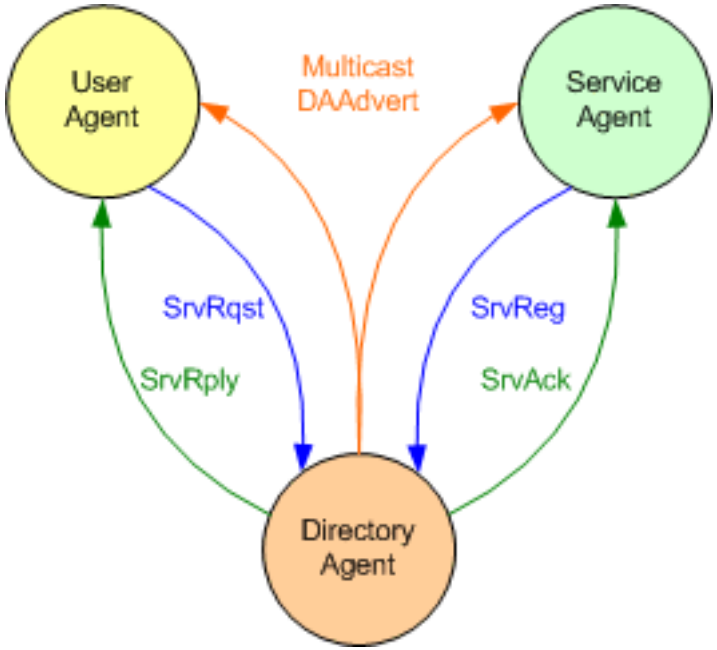
SLP: Actors

- User Agent (UA)
  - SLP Client communicates with SA or DA to access services
- Service Agent (SA)
  - Offers services directly or by registering with DA on behalf of application
- Directory Agent (DA)
  - optional actor to which all services register
  - DA can be discovered either by active or passive discovery
- SLP messages are transmitted over UDP or TCP

SLP: Service Discovery with DA



SLP: Service Discovery without DA



Service Discovery without DA

Source: http://www-128.ibm.com/developerworks/linux/library/l-slp/

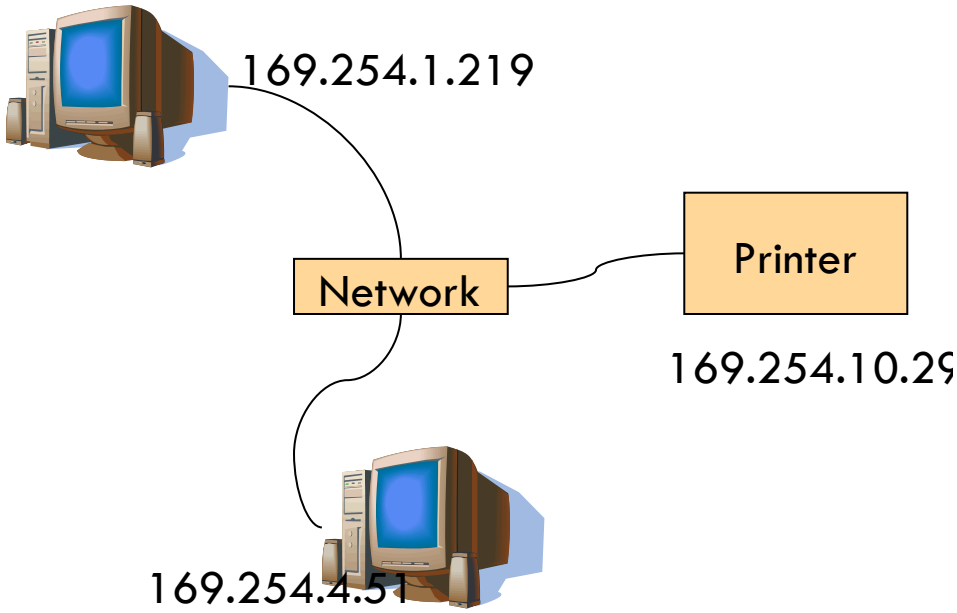
Bonjour

- Based on IETF zero configure IP networking (ZeroConf)
  - addressing (allocating IP addresses to hosts)
  - naming (using names to refer to hosts instead of IP addresses)
  - service discovery (finding services on the network automatically)

Source: https://developer.apple.com/library/mac/documentation/Cocoa/Conceptual/NetServices/NetServices.pdf

Link-local addressing

- No Central Address Server
- Pick a Random Address
  - In 169.254.0.0/16 range
- Communication done locally
- Can use ARP to check if the address is in use

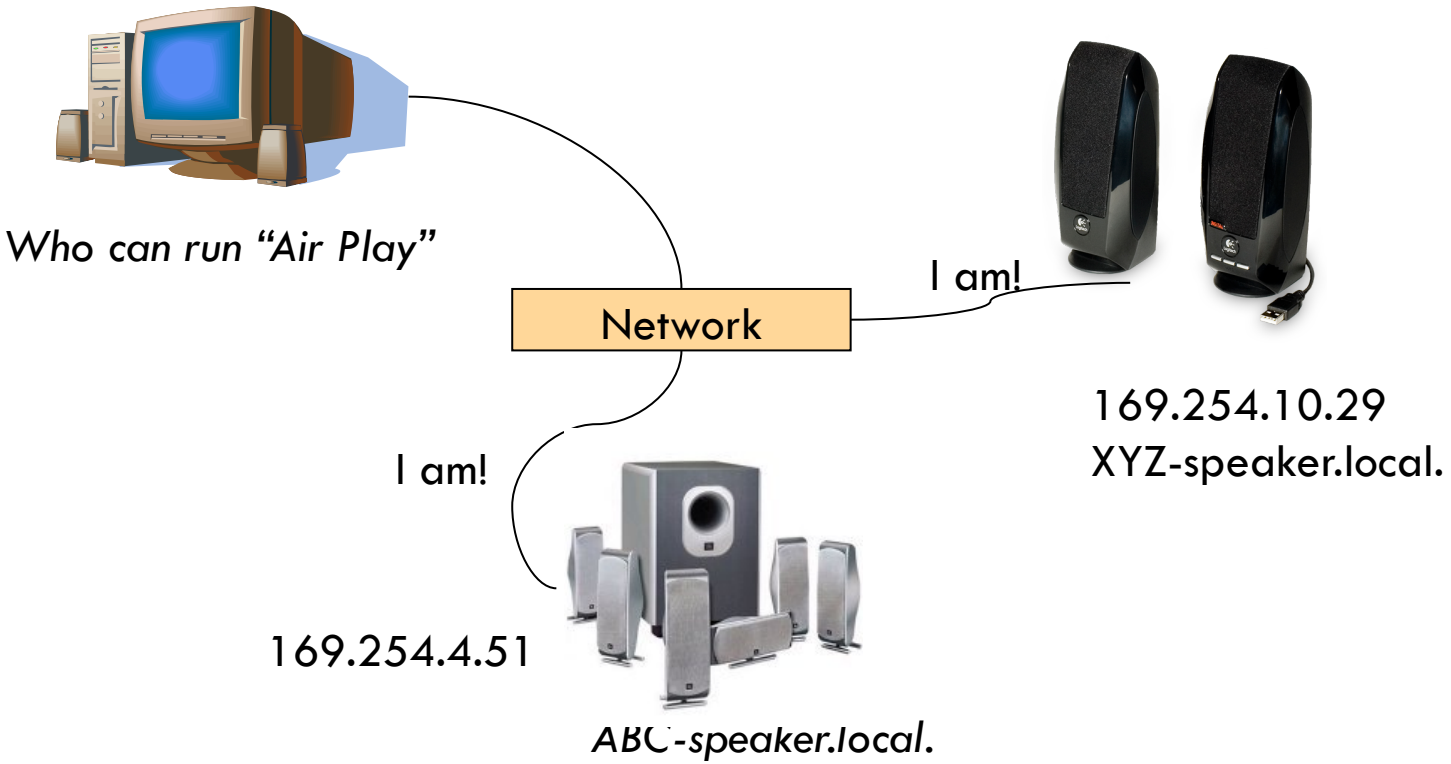


mDNS

- DNS-like Protocol
- Every Host Runs Responder
- Hosts Pick Own Names
- Communication over IP Multicast
- Link-local
- Resolves to Link-local or Regular Address
- Naming convention in Bonjour: XYZ-LaserPrinter.local

“Browsing”

- Return the list of all available instances of a particular type of service
- Local caching for past results

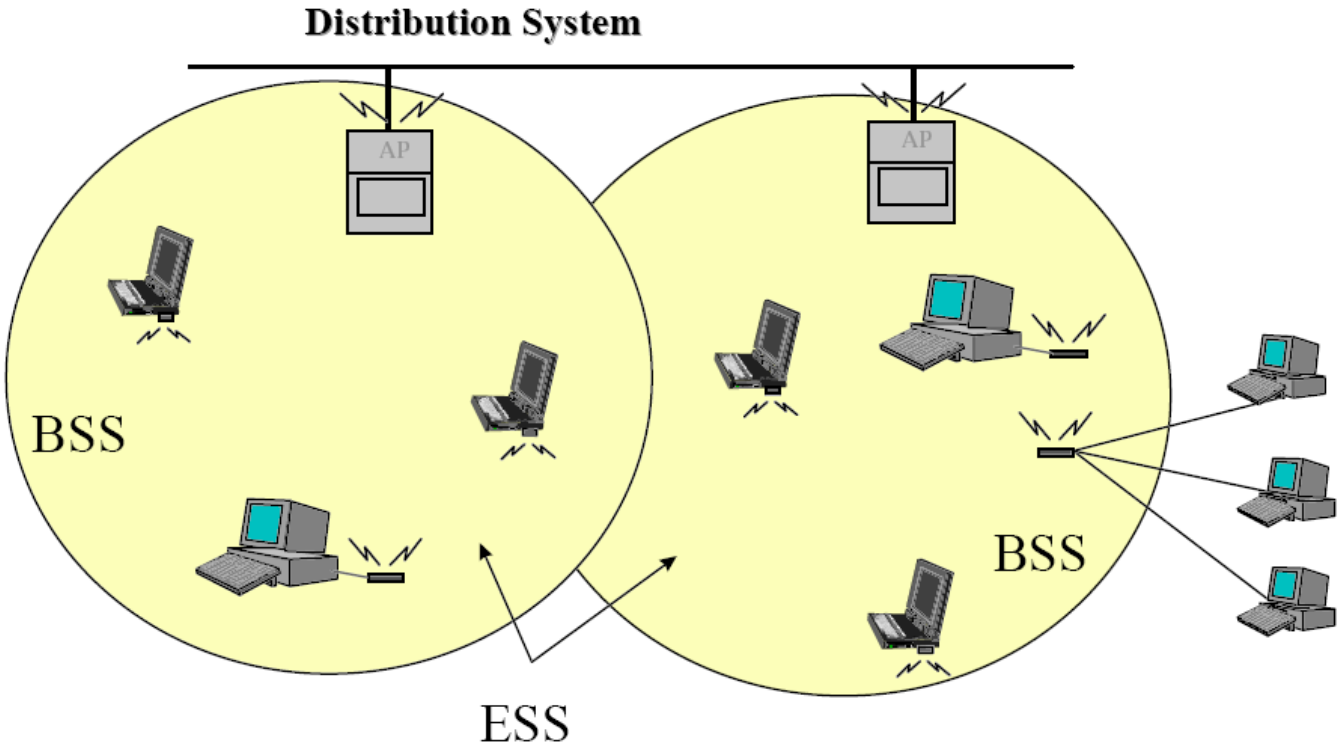


Part 2: Mobility management

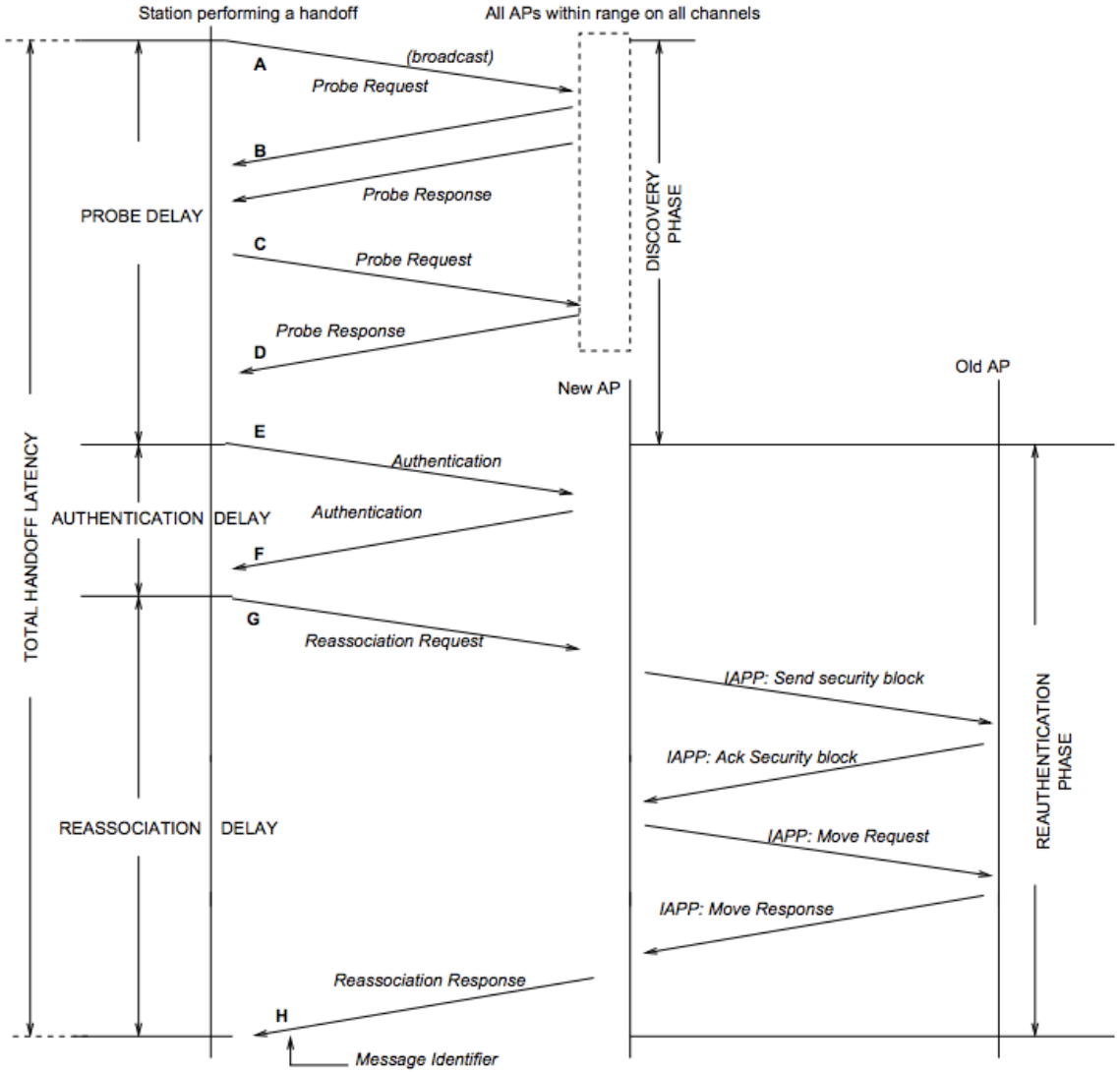
Issues

- Point-of-attachment changes with mobility in infrastructure networks
  - Within the same network
  - Across heterogeneous networks
- Try to hide the mobility from IP point of view
  - TCP Sockets are specified by the tuples (IP address, port #)
  - Sol: keep it at layer-2 if possible

WLAN



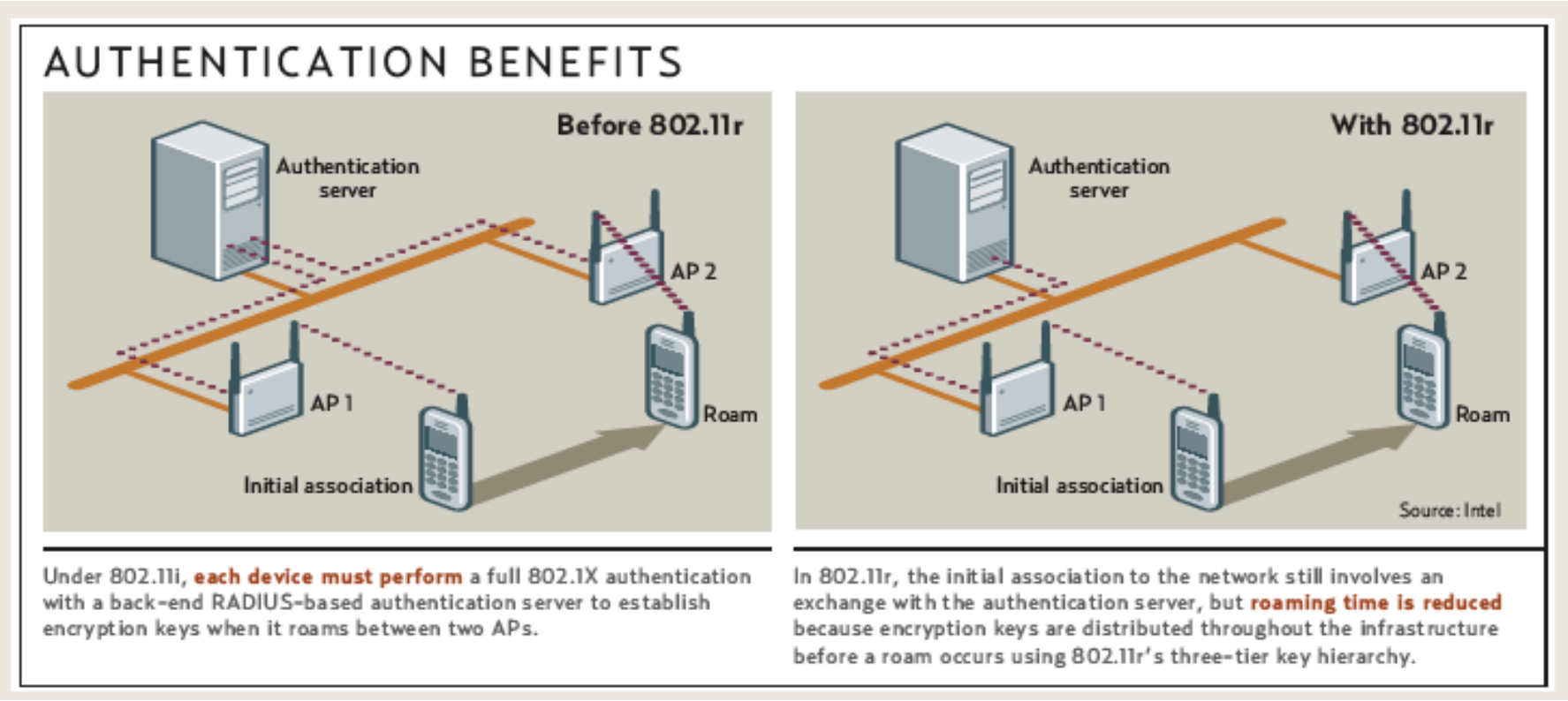
Message exchange



*Source: Mishra, "An Empirical Analysis of the IEEE 802.11 MAC Layer Handoff Process"

~100ms – 600ms

Remedy 1 – 802.11r

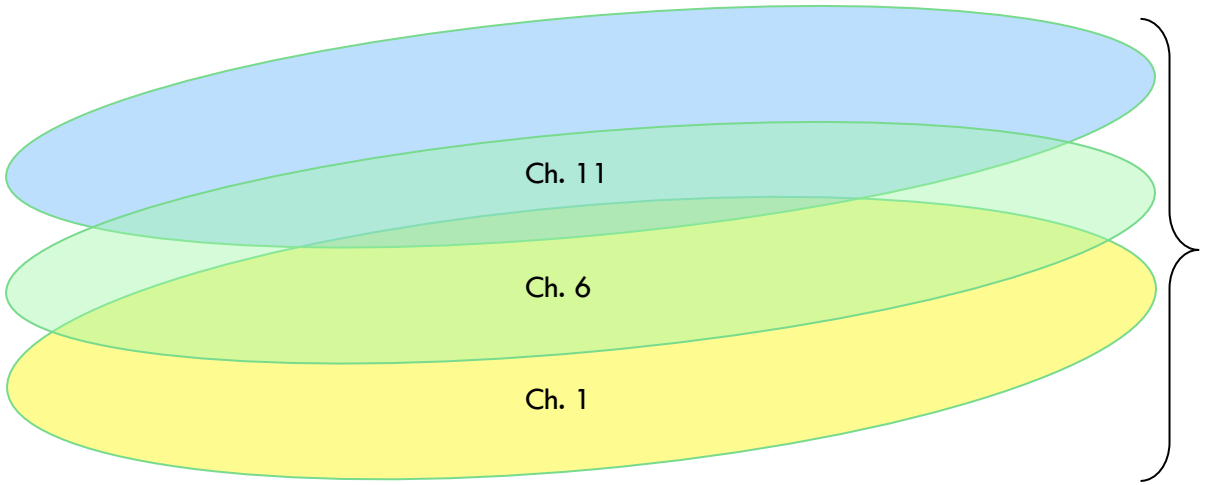


Can reduce the latency down to 40ms

From: Dava Molta, “802.11r: Wireless LAN Fast Roaming”, 2007

Remedy 2 – Virtual APs

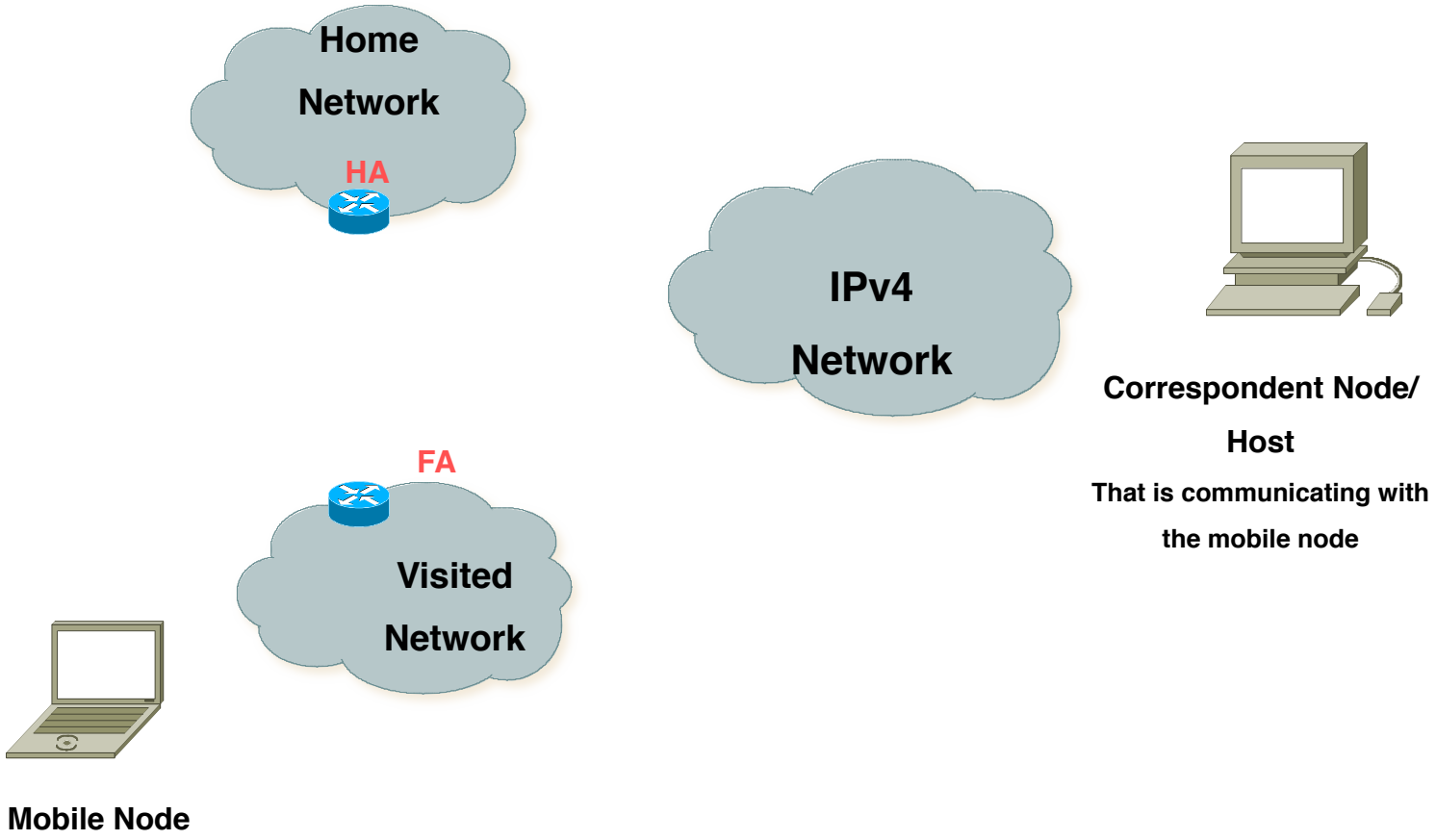
- All cells share the same channel
- Each user is assigned an virtual AP upon association
  - The virtual AP is handoff from one physical AP to another as users move



Mobile IP

- Mobile IP protocol allows location-independent routing of IP datagrams on the Internet
- Three components to standard:
  - indirect routing of datagrams
  - agent discovery
  - registration with home agent

Mobile IP Entities



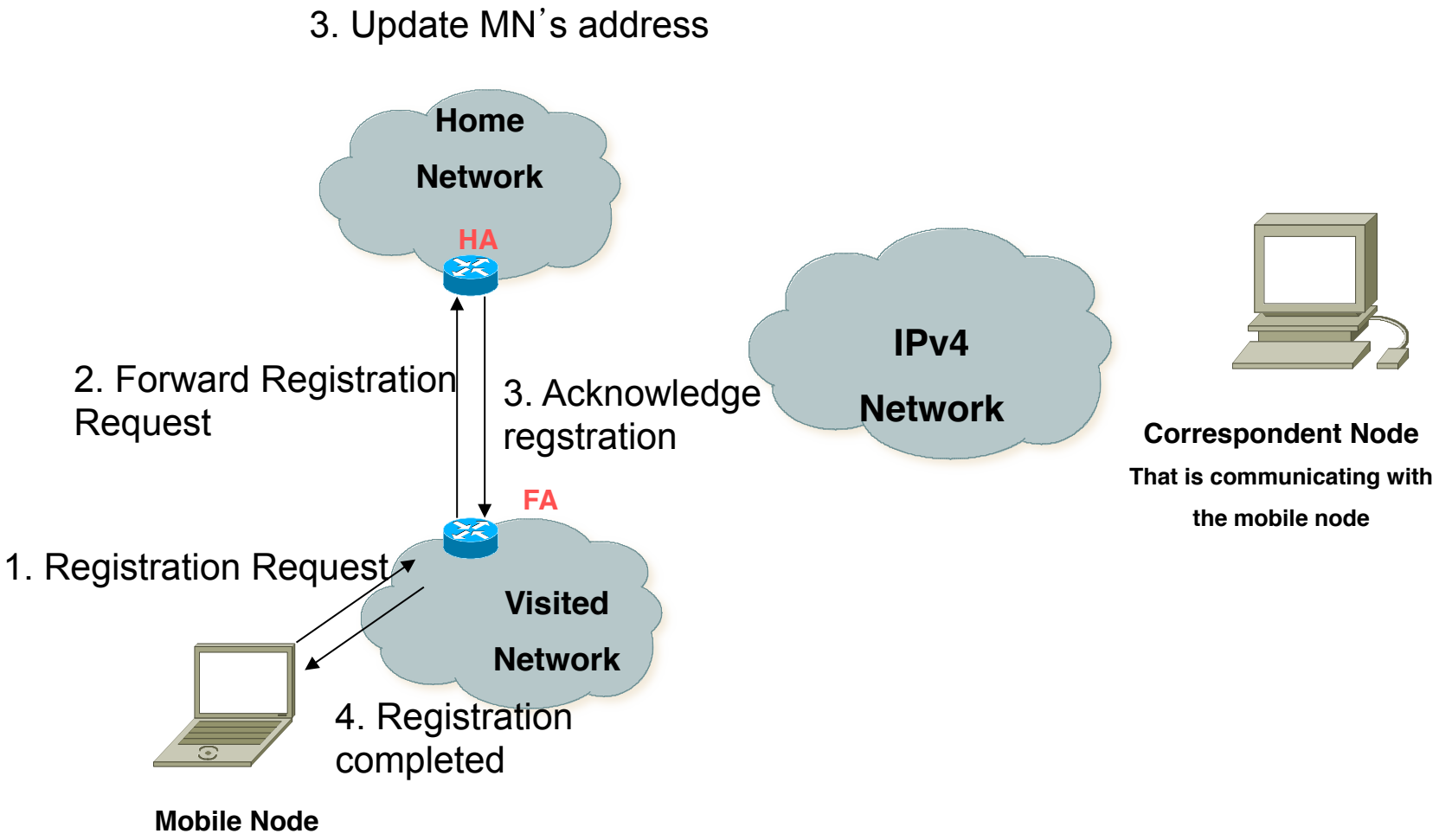
Mobile IP Entities

- Mobile Node (MN)
  - The entity that may change its point of attachment from network to network in the Internet
    - Detects it has moved and registers with "best" FA
  - Assigned a permanent IP called its home address to which other hosts send packets regardless of MN's location
    - Since this IP doesn't change it can be used by long-lived applications as MN's location changes
- Home Agent (HA)
  - This is router with additional functionality
  - Located on home network of MN
  - Does mobility binding of MN's IP with its "foreign address"
  - Forwards packets to appropriate network when MN is away
    - Does this through encapsulation

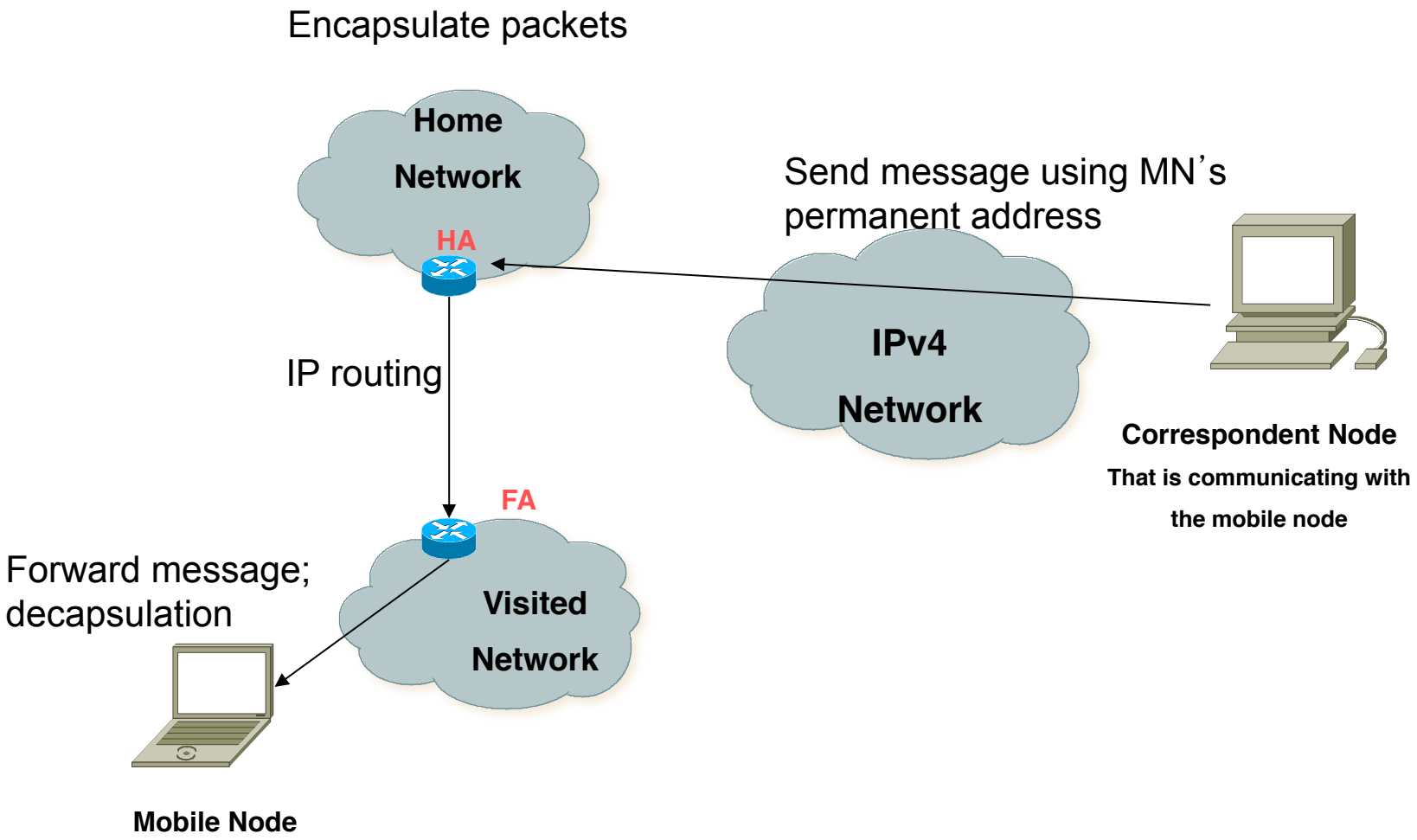
Mobile IP Entities contd.

- Foreign Agent (FA)
  - Another router with enhanced functionality
  - If MN is away from HA the it uses an FA to send/receive data to/from HA
  - Advertises itself periodically
  - Forward's MN's registration request
  - Decapsulates messages for delivery to MN
- Care-of-address (COA)
  - Address which identifies MN's current location
  - Sent by FA to HA when MN attaches
  - Usually the IP address of the FA
- Correspondent Node (CN)
  - End host to which MN is corresponding (eg. a web server)

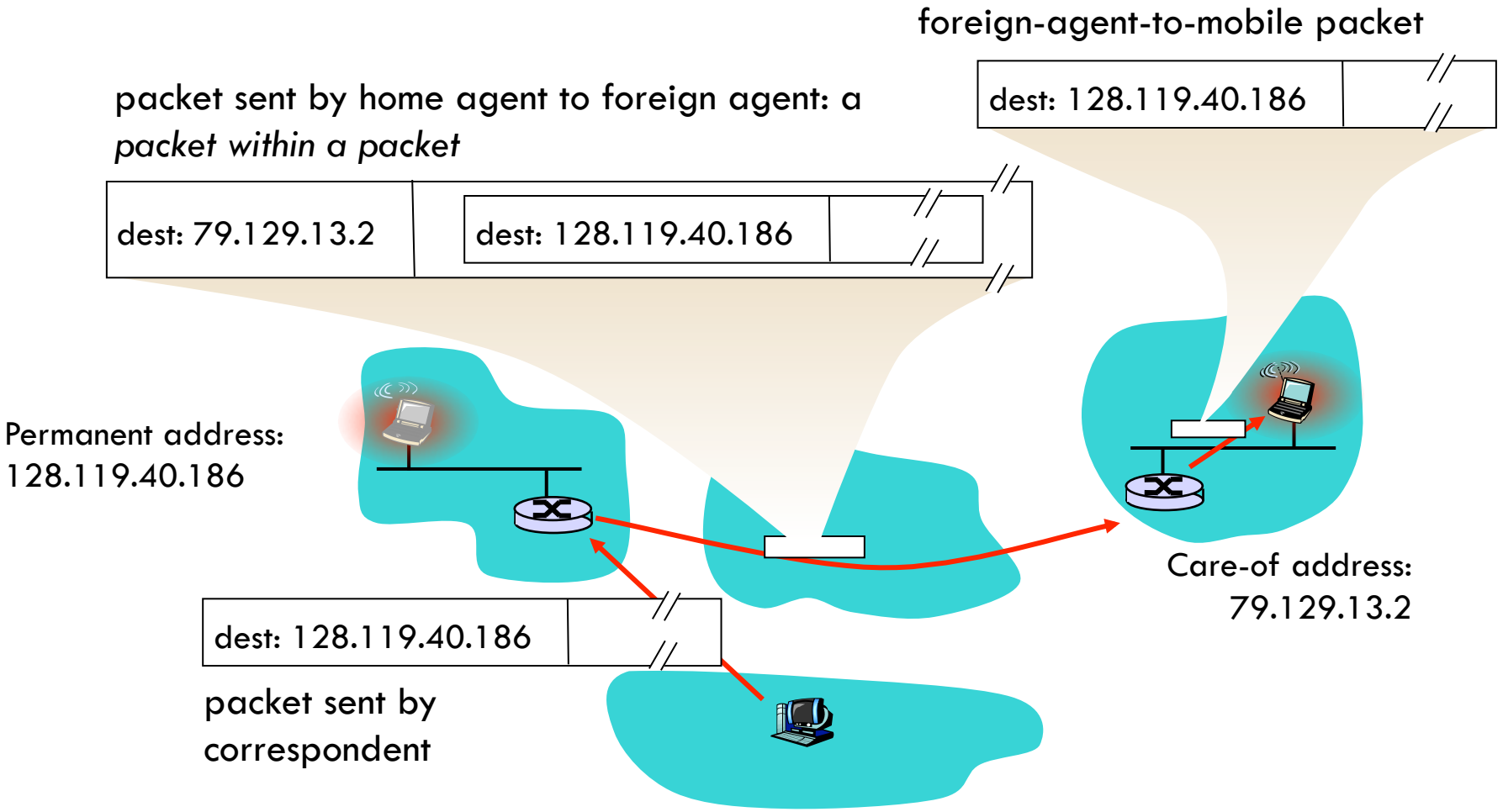
How does Mobile IP Work?



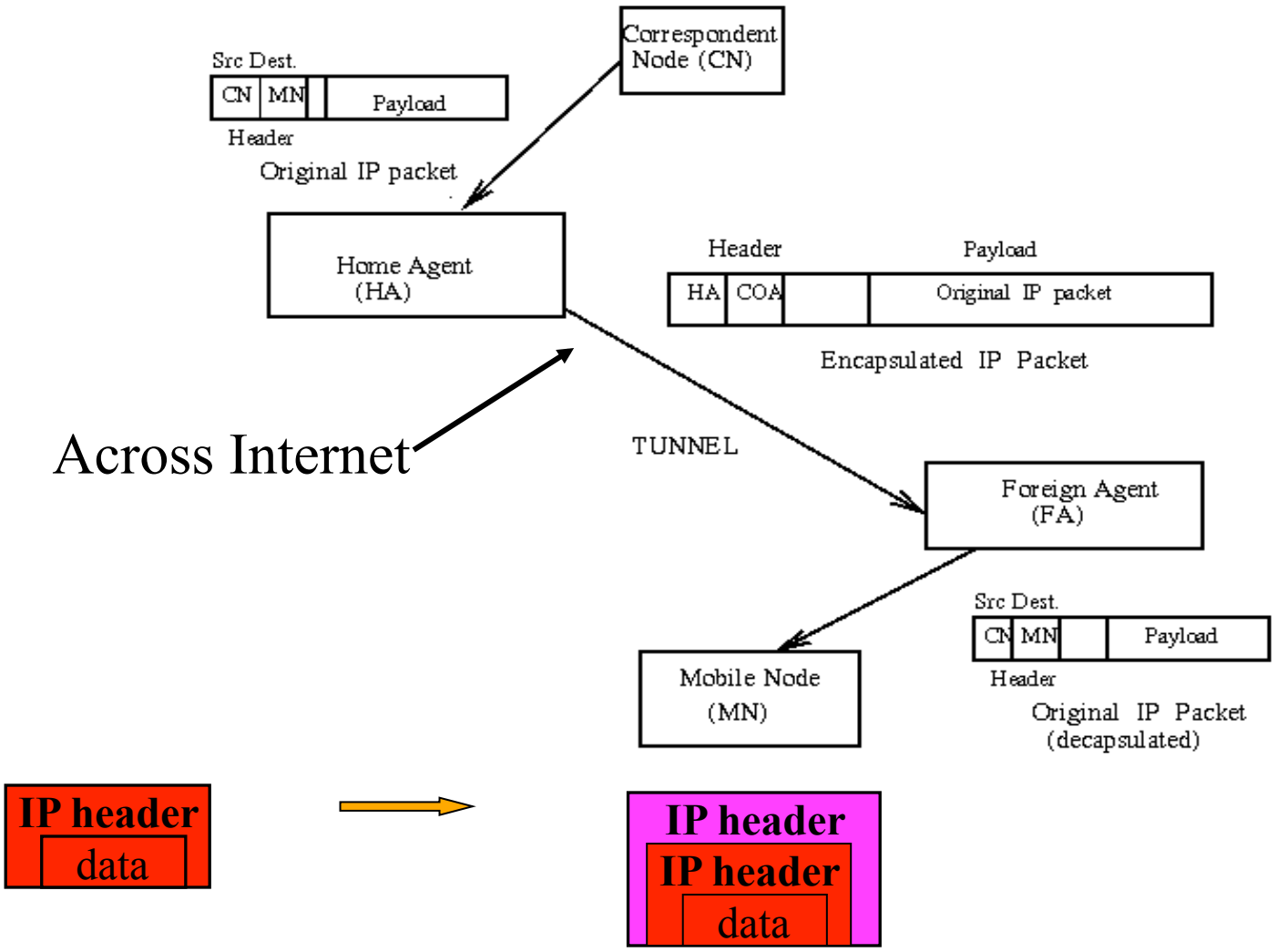
How does Mobile IP Work? (Cont'd)



Mobile IP Routing in Action

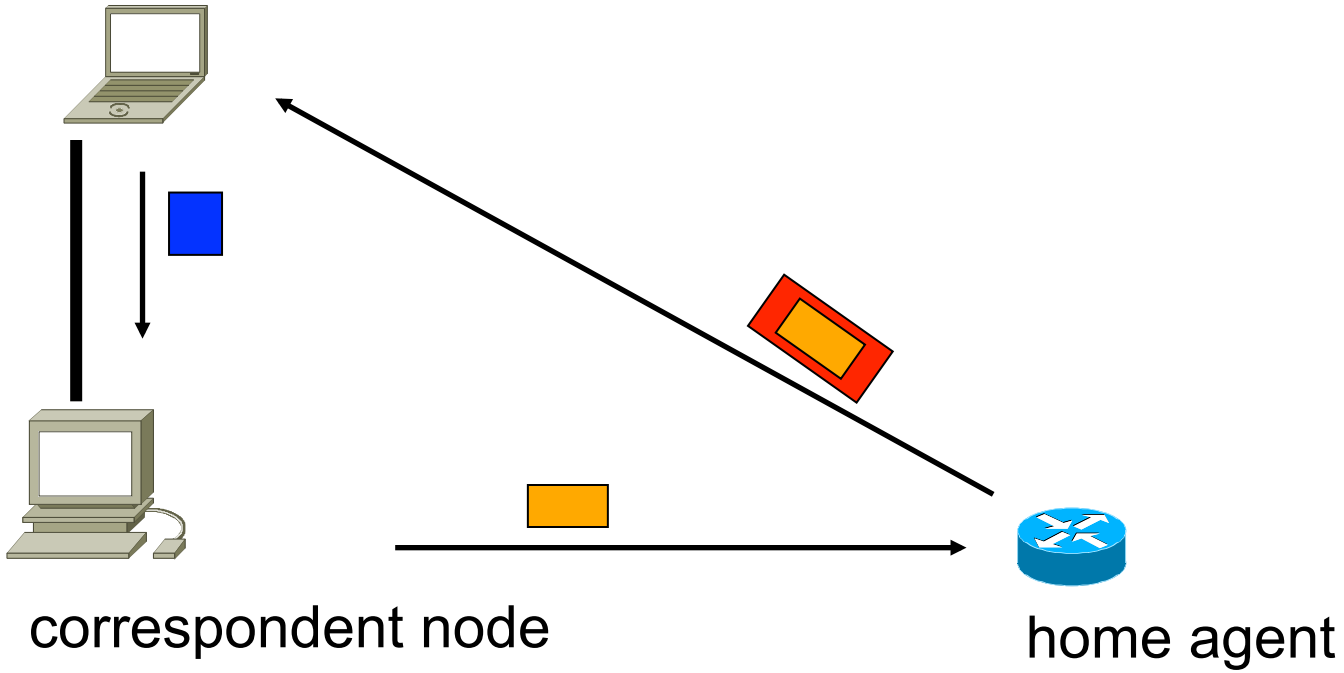


Mobile IP Tunneling

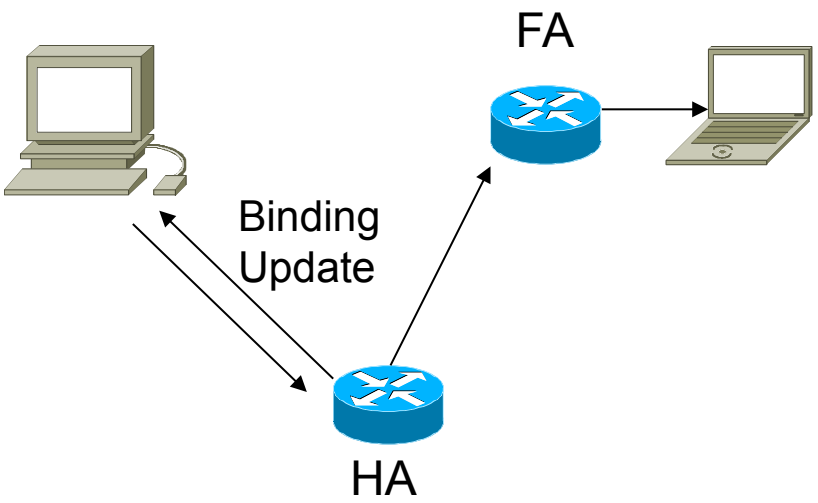


Problems with Mobile IP

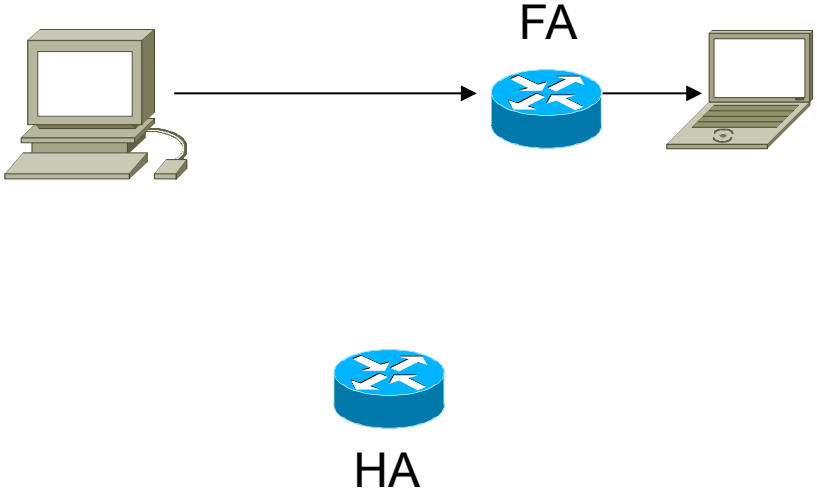
- Suboptimal "triangle" routing
  - What if MN is in same subnetwork as the CN to which it is communicating and HA is on the other side of the world?
    - It would be nice if we could directly route packets



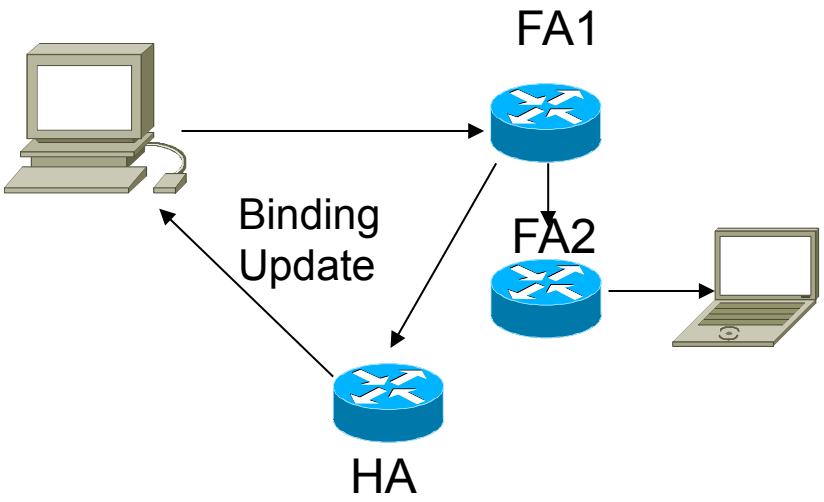
Route Optimization



a) First Packet to a MN

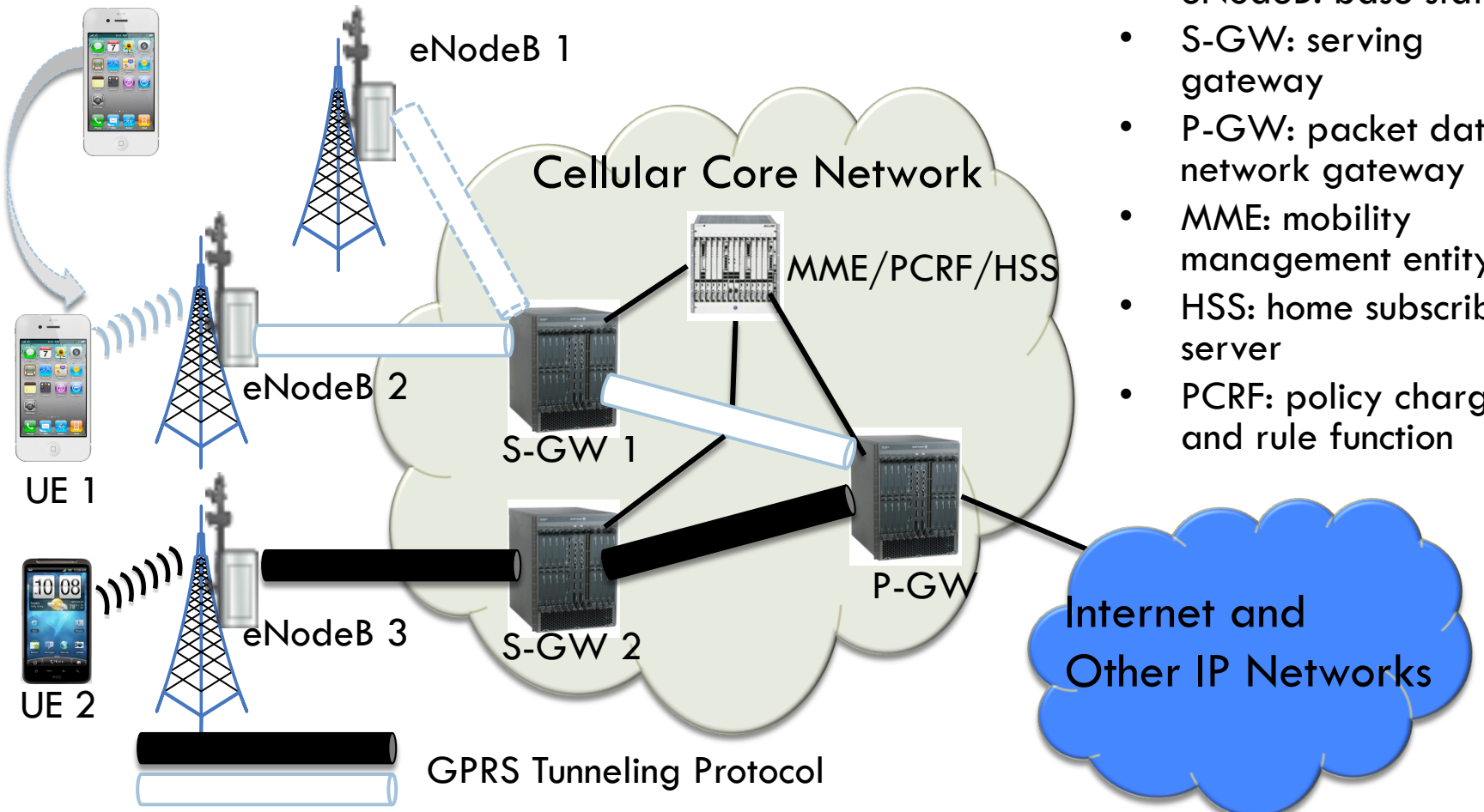


b) Subsequent Packets to a MN



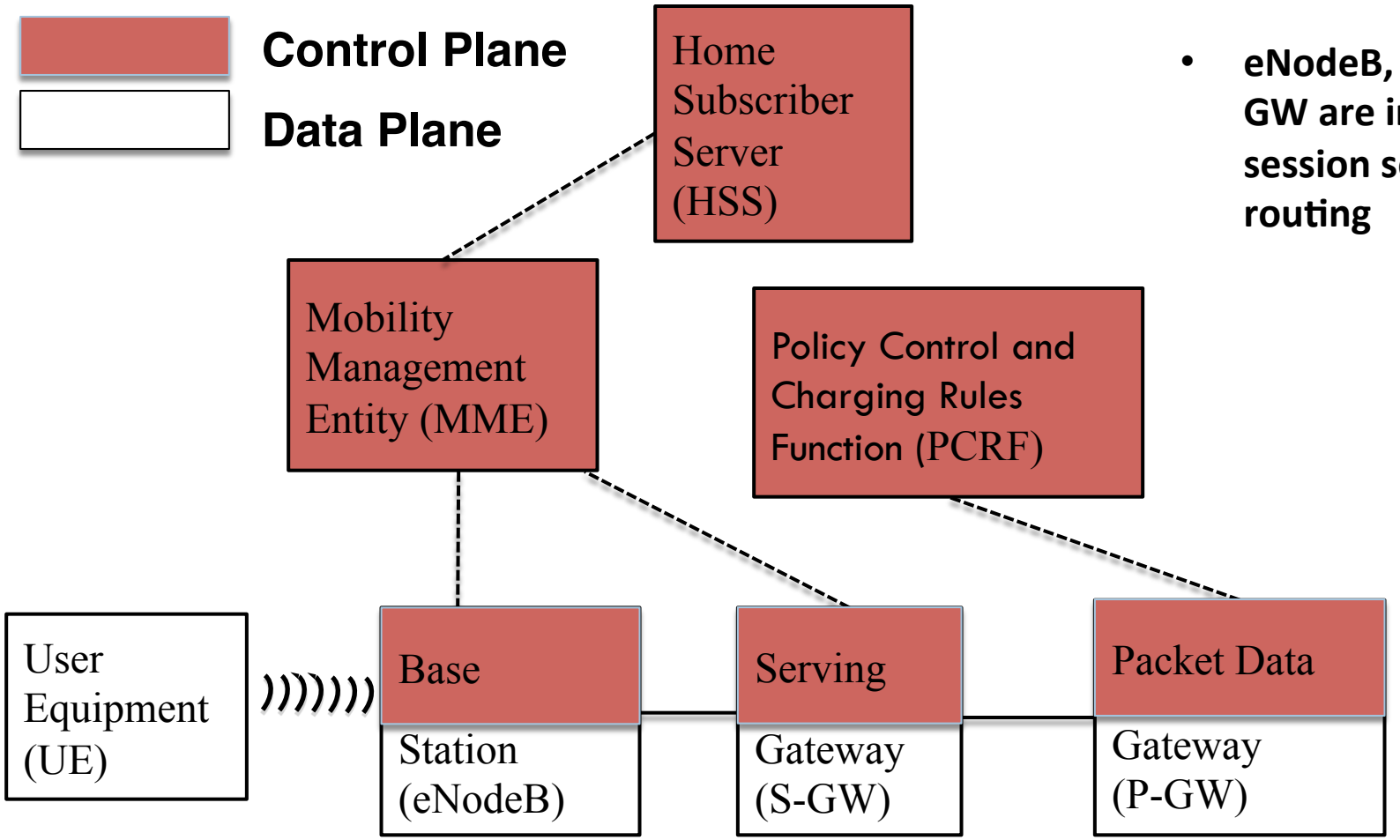
c) First Packet to a MN after hand-off

Mobility management in LTE



- UE: user equipment
- eNodeB: base station
- S-GW: serving gateway
- P-GW: packet data network gateway
- MME: mobility management entity
- HSS: home subscriber server
- PCRF: policy charging and rule function

LTE Architecture (Cont'd)

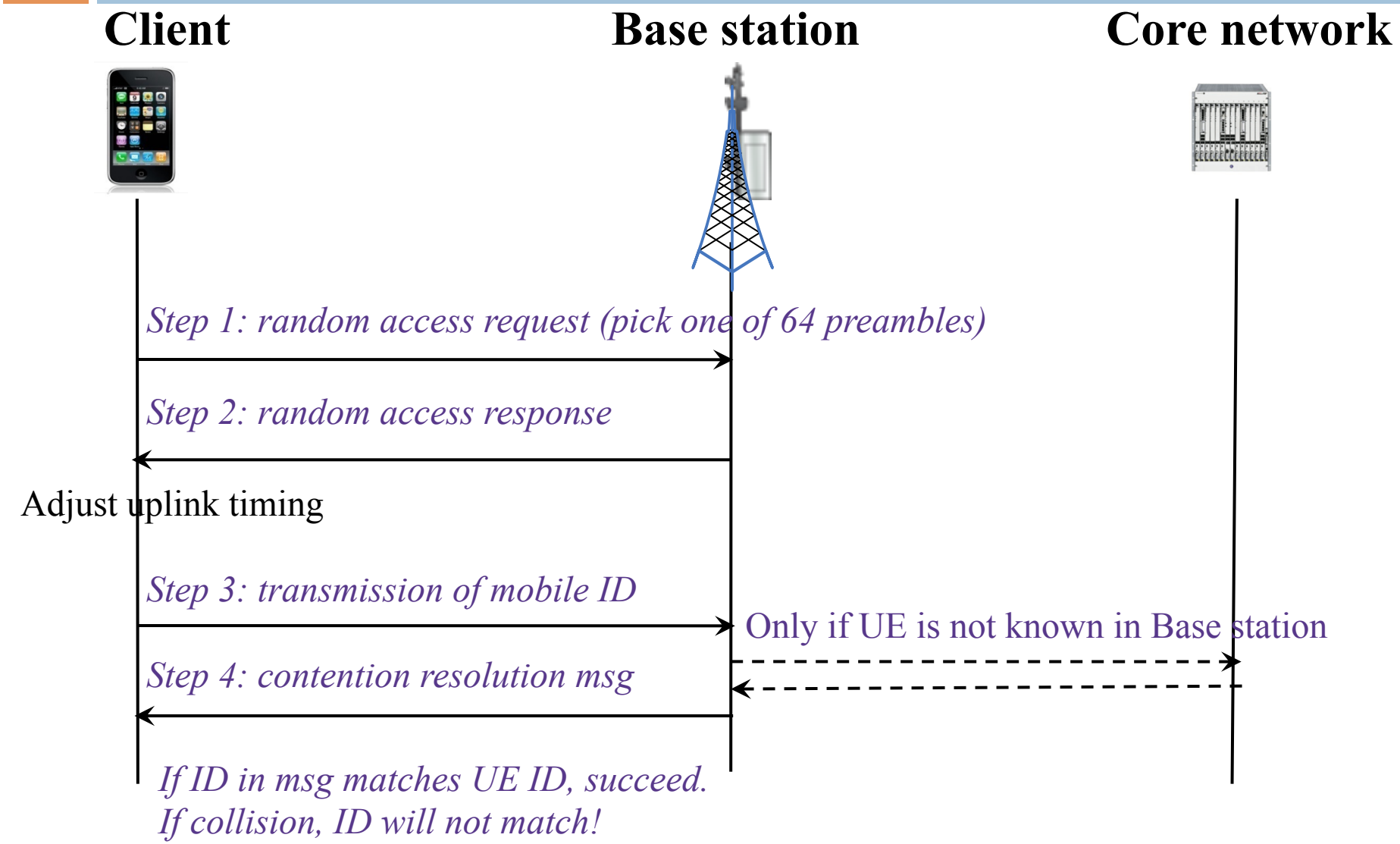


- **eNodeB, S-GW and P-GW are involved in session setup, handoff, routing**

Access Procedure

- Cell Search
  - Base station broadcasts synchronization signals and cell system information (similar to WiFi)
  - UE obtains physical layer information
    - UE acquires frequency and synchronizes to a cell
    - Determine the start of the downlink frame
    - Determine the cell identity
- Random access to establish a radio link

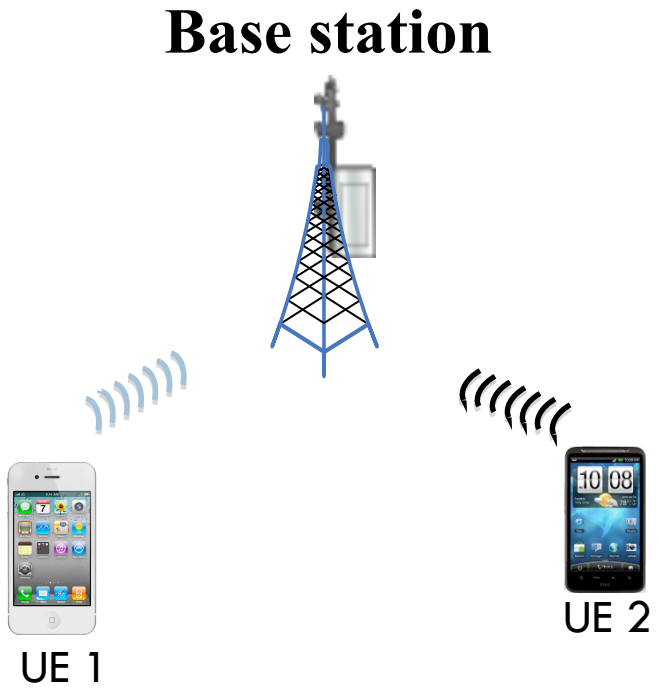
Random Access



Random Access (Cont'd)

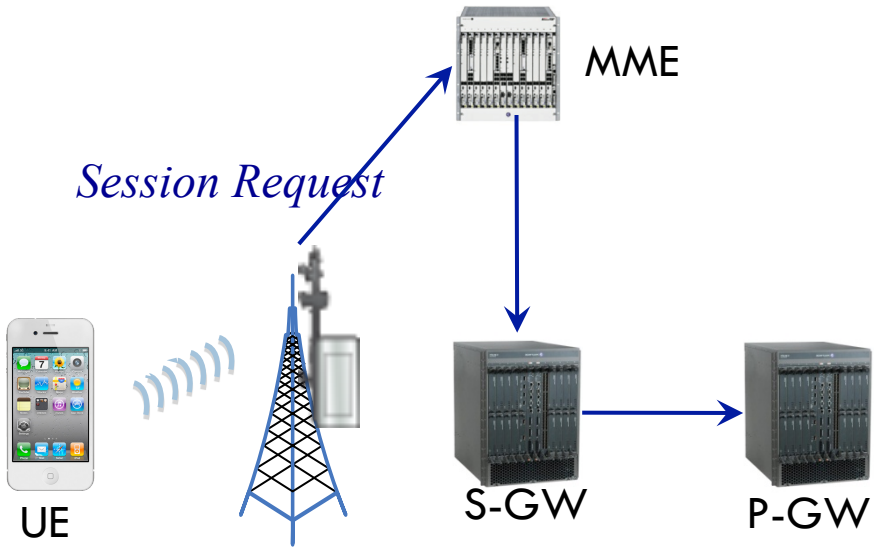
Why not carrier sensing like WiFi?

- Base station coverage is much larger than WiFi AP
  - UEs most likely cannot hear each other
- How come base station can hear UEs' transmissions?
  - Base station receivers are much more sensitive and expensive



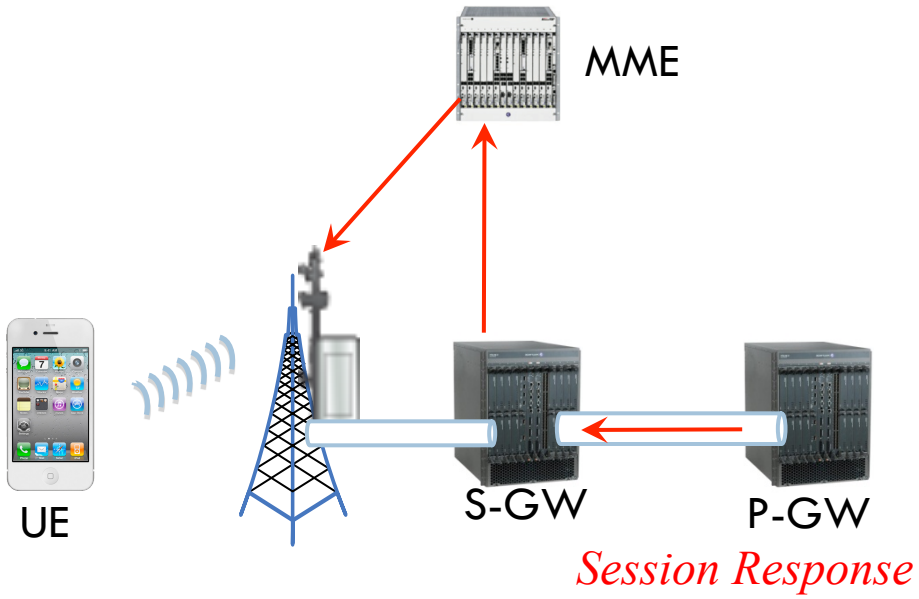
Connection Setup

- Session Requests
  - UE to base station
  - Base station to MME
    - MME obtains subscriber info from HSS, selects S-GW and P-GW
  - S-GW sends to P-GW
    - P-GW obtains policy from PCRF



Connection Setup (Cont'd)

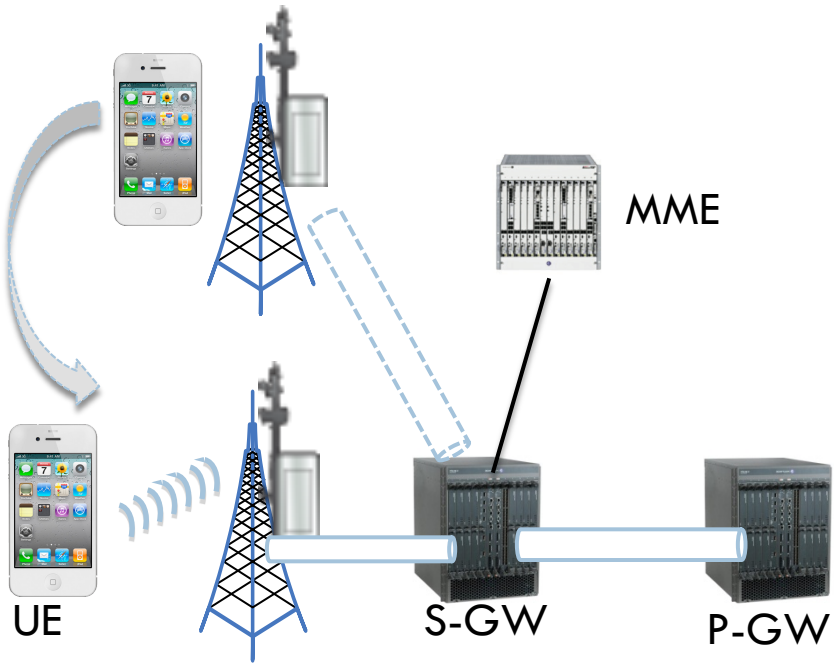
- Session Response
  - Establishes GPRS Tunnels (GTP) between S-GW and P-GW, between S-GW and UE
  - Base station allocates radio resources to UE



Mobility Management

Handoff

- Handoff without change of S-GW
  - No change at P-GW
- Handoff with change of S-GW or MME
- Inter-technology handoff (LTE to 3G)



Mobility Management (Cont'd)

Paging

- If S-GW receives a packet to a UE in IDLE state, inform MME
- MME pages UE through base station