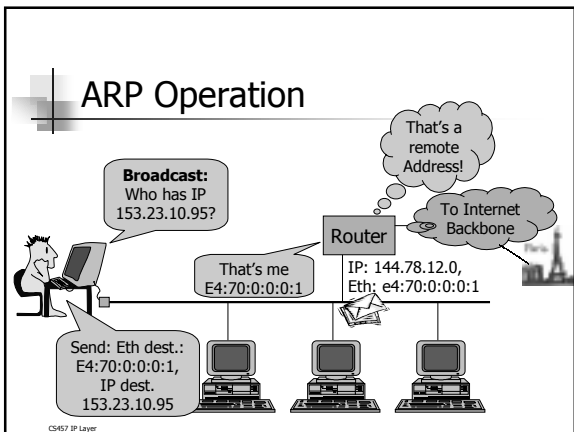
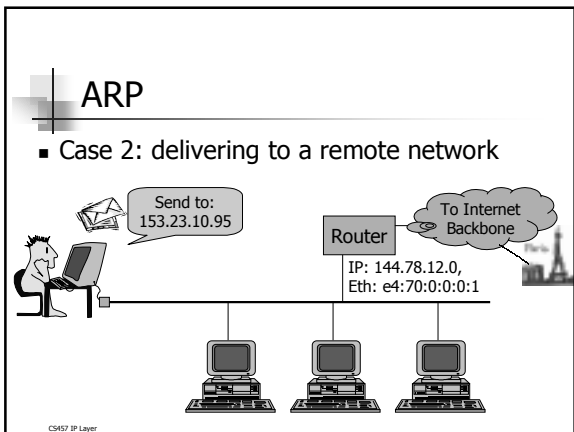
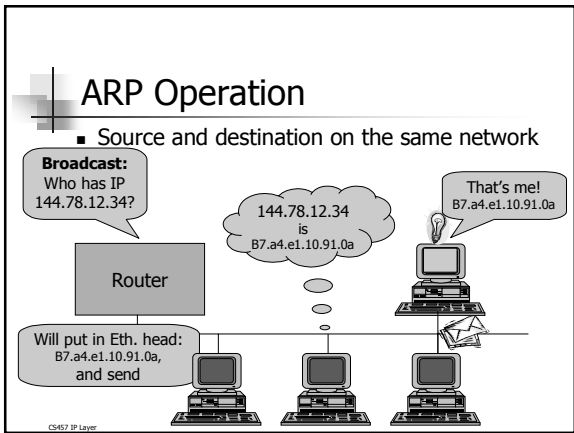
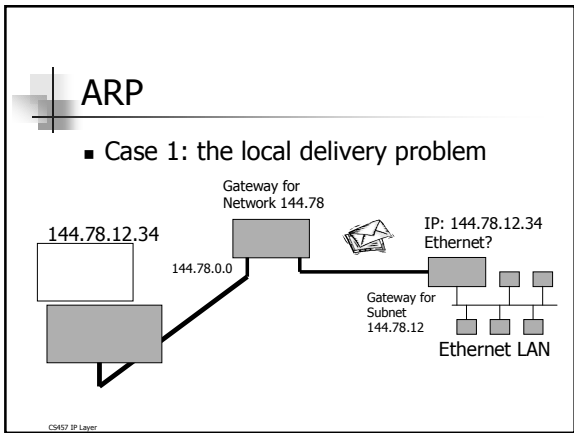
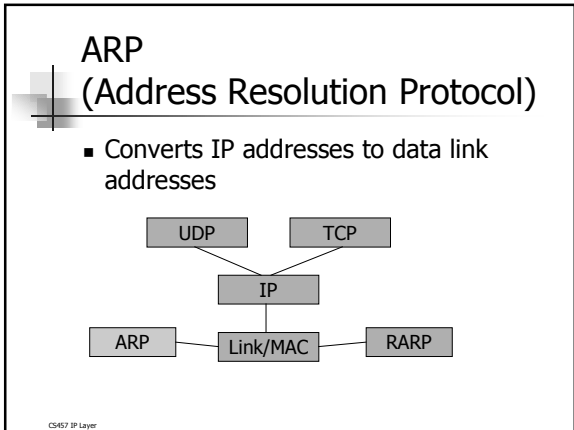


Advanced Topics in the Network Layer

ARP,
RARP (DHCP),
Tunneling,
Mobile IP



ARP

- On the remote network

Broadcast: Who has IP 153.23.10.95?

That's me!
56.15.f5.41.ee.b1

Sending to Eth.:
56.15.f5.41.ee.b1,

Router

Paris

CS457 IP Layer

Exercise

- What was in the packets' headers at each stage of the transfer?

| Eth Header | IP Header | Packet Data |
|-----------------|----------------|-------------|
| | IP source | |
| | IP destination | |
| Eth source | | |
| Eth destination | | |

CS457 IP Layer

Solution

| Step # | Source | | Destination | |
|--------|--------|-----|-------------|-----|
| | IP | Eth | IP | Eth |
| | | | | |

CS457 IP Layer

ARP Optimizations

- ARP can reduce the number of requests sent using some optimizations
 - Caching IP to data link address mappings
 - Machines can announce their hardware addresses when they boot. Others will cache it.
 - Cache entries must expire to allow replacing stale entries (15 min)

CS457 IP Layer

RARP (Reverse Address Resolution Protocol)

- Converts datalink addresses into IP addresses
- Useful for booting diskless workstations (Machines with disks can store their IPs in configuration files)

UDP TCP

IP

ARP Link/MAC RARP

CS457 IP Layer

Dynamic Host Configuration Protocol (DHCP)

- Uses ARP to assign IPs to workstations

DHCP Server

Relay Agent

Request IP for Eth address this

IP address

Broadcast: My hardware address is this. Who am I?

Your IP is that

CS457 IP Layer

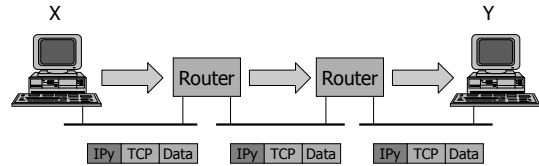
IP Tunneling

- A regular packet at the network layer looks like this:
 - (IP header (TCP header (data)))
- Tunneling is encapsulation of the above packet in another IP header:
 - (IP header (IP header (TCP header (data))))
- Tunneling allows creation of virtual links between a pair of routers.
- To the rest of the network the tunneled packet looks just like a regular IP packet.
- Example: Mobile IP uses tunneling to forward packets to the correct destination.

CS457 IP Layer

Normal IP Packet Forwarding

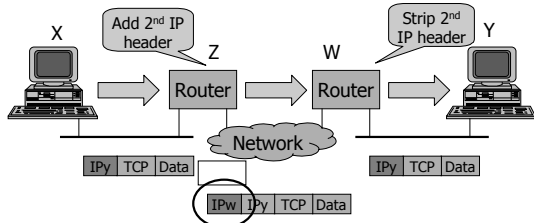
- Each router forwards the IP packet as is



CS457 IP Layer

Tunneling

- Each router forwards the IP packet as is

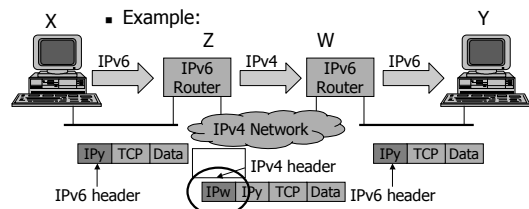


CS457 IP Layer

Why Tunneling?

- Virtual Private Networks (security)
- Connecting IPv6 (or other exotic routers) over an IPv4 network

- Example:

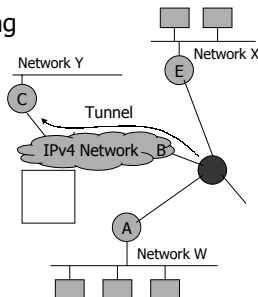


CS457 IP Layer

IP Forwarding Tables

- Support for tunneling

| Destination | Next hop (port) |
|-------------|------------------|
| Network X | E |
| Network Y | Encapsulate in C |
| Network W | A |
| Network C | B |



CS457 IP Layer

Mobile IP

- IP addresses encode network location
- Change of location → different network → different IP address.
- How to support host mobility?
 - Simple solution: Use DHCP to assign a new IP address when a roaming host (e.g., your laptop) is hooked up to a new network.
 - Problem?

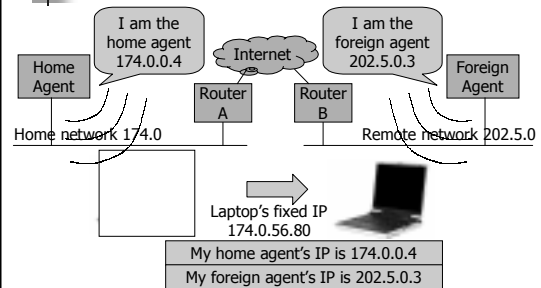
CS457 IP Layer

Mobile IP Goal: Mobility with a Fixed IP

- Consider a roaming user. The user's laptop may need to disconnect from network A, and connect to network B, without changing its IP address!
- Any running applications should remain unaware that the laptop changed networks

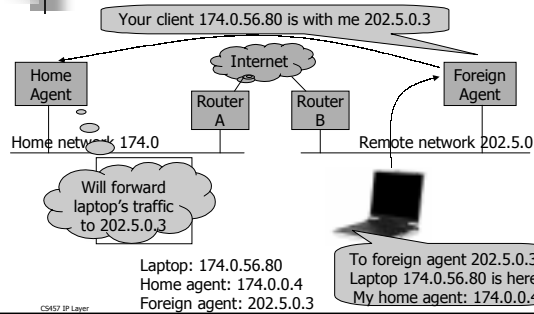
CS457 IP Layer

Mobile IP: Home and Foreign Agents



CS457 IP Layer

Mobile IP: Home and Foreign Agents



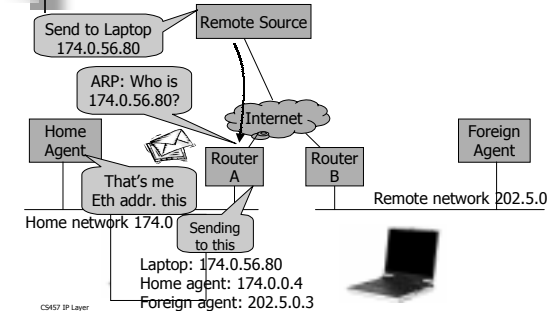
CS457 IP Layer

Routing to Mobile Hosts

- A home agent impersonates the mobile host:
 - Packets comes with the mobile's IP as destination
 - ARP request is issued
 - home agent replies with its hardware address
 - Packets is sent to home agent
- Home agent wraps packet in IP header with address of the foreign agent
 - Packet is received by the foreign agent
- Foreign agent strips the extra IP header and finds packet associated with the mobile host.

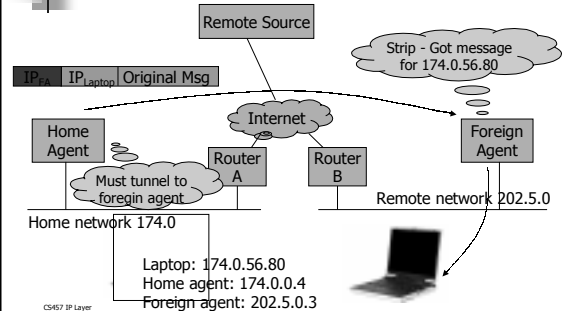
CS457 IP Layer

Routing to Mobile Hosts



CS457 IP Layer

Routing to Mobile Hosts



CS457 IP Layer

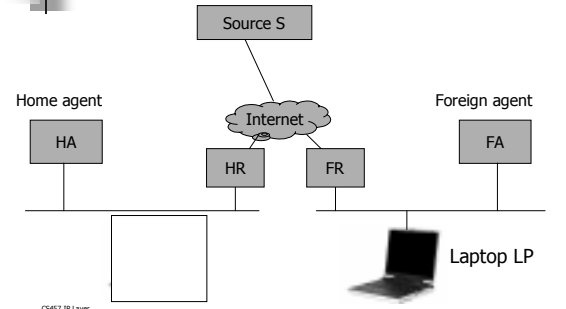
Exercise What's in the Packet Header

Assume each host X has IP address IP_X , and Ethernet address Eth_X . Consider source S, laptop LP, home agent HA, foreign agent FA, home router HR, foreign router FR.

| Step # | Source | | Destination | |
|--------|--------|-----|-------------|-----|
| | IP | Eth | IP | Eth |
| | | | | |

CS457 IP Layer

Exercise



CS457 IP Layer

Announcements

- Homework 4 is out.
- 1-page project description is due Thursday Oct 25th.
- Project groups – final matching

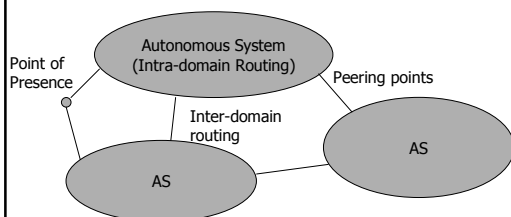
CS457 IP Layer

Advanced Topics

- Autonomous systems and Inter-domain routing
 - EGP/BGP
- Routing areas, IBGP
- IP Multicast
 - Link state multicast
 - Distance vector multicast
 - Protocol-independent multicast

CS457 IP Layer

Autonomous Systems



CS457 IP Layer

Challenges in Inter-domain Routing

- Scale – too many prefixes to worry about
- Incompatible local cost metrics
- Trust – can one trust advertisements from other domains?
- Routing policies (e.g., do not route traffic through domain X)

CS457 IP Layer

EGP: Exterior Gateway Protocol

- Overview
 - designed for tree-structured Internet
 - concerned with reachability, not optimal routes
- Protocol messages
 - neighbor acquisition: one router requests that another be its peer; peers exchange reachability information
 - neighbor reachability: one router periodically tests if the another is still reachable; exchange HELLO/ACK messages; uses a k-out-of-n rule
 - routing updates: peers periodically exchange their routing tables (distance-vector)

CS457 IP Layer

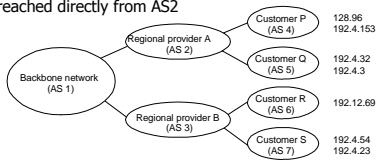
BGP-4: Border Gateway Protocol

- AS Types
 - stub AS: has a single connection to one other AS
 - carries local traffic only
 - multihomed AS: has connections to more than one AS
 - refuses to carry transit traffic
 - transit AS: has connections to more than one AS
 - carries both transit and local traffic
- Each AS has:
 - one or more border routers
 - one BGP speaker that advertises:
 - local networks
 - other reachable networks (transit AS only)
 - gives path information

CS457 IP Layer

BGP Example

- Speaker for AS2 advertises reachability to P and Q
 - network 128.96, 192.4.153, 192.4.32, and 192.4.3, can be reached directly from AS2
- Speaker for backbone advertises
 - networks 128.96, 192.4.153, 192.4.32, and 192.4.3 can be reached along the path (AS1, AS2).
- Speaker can cancel previously advertised paths



CS457 IP Layer

IP Version 6

- Features
 - 128-bit addresses (classless)
 - multicast
 - real-time service
 - authentication and security
 - autoconfiguration
 - end-to-end fragmentation
 - protocol extensions
- Header
 - 40-byte "base" header
 - extension headers (fixed order, mostly fixed length),
 - fragmentation
 - source routing
 - authentication and security
 - other options

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