# E6998-02: Internet Routing

## Lecture 23
## IP Mobility

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# Announcements

Lectures 1-21,23 are available.

Homework 5 is out, due last day of classes.

Are you close to finishing your projects?

**ALL PROJECTS ARE DUE ON DECEMBER 10!**

**NO EXTENSIONS OR INCOMPLETES WILL BE GIVEN!**

# The Mobility Problem

- How to move hosts around the Internet and maintain connectivity.

- Remember: address is where the host is (attached to).
  - Network attachment point.
- Remember: addresses are hierarchically assigned.
  - Necessary for scaling.
  - Reflected in the routing architecture.

- To move a host to a different attachment point:
  - Change its IP address.

    or
  - Eliminate hierarchical routing.

# Changing the Routing Architecture

- Propagate host routes (/32s or /128s).
  - We already have problems maintaining 100K routes.
  - 1M (or 4G) routes are unrealistic.
    - Not enough memory.
    - Not enough processing speed.
      - Especially if they move rapidly.
- Routing scales because addresses are aggregated.
- We've already seen the problems with multihoming.

# Changing the IP Address

- Just get a new address (with DHPC).
  - Works for web browsing!

- Cannot maintain established TCP connections.
  - Remember: IP address is also used as an Endpoint Identifier (EID).
- Applications sometimes have knowledge of IP address.
  - This also breaks NAT (that's good!).
- Works if mobile only originates connections.
  - Or there exists some other location service.

- No matter what we do, something will have to change.
  - Or break!

# Mobility at the Link Layer?

- Hide the fact that we changed networks.
- Works for *micromobility*:
  - Small geographical area.
  - Nearby cells.
  - Flat routing and/or bridging is economical.
- 802.11 does this.
- Moving ports on switches also does this.
- Link layer could be extended to provide this mobility.
  - L2TP?
- Different solution for each link layer type.
- Still does not give us mobility between network interfaces.

# Mobility at the Transport Layer?

- Tell the transport protocol that we changed IP address.
- Remote host would also need to be informed.
- All transport protocols would have to become mobility-aware.
- Still does not address the problem of finding the mobile's current address.

# Mobility at the Application Layer?

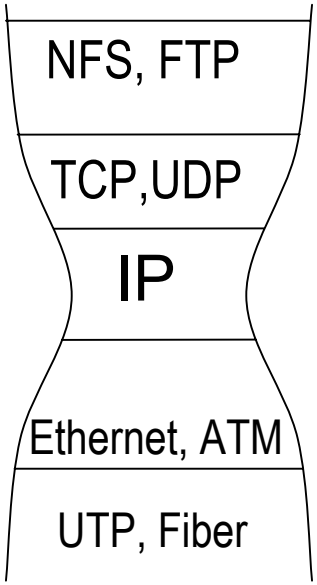
- Tear down TCP (or whatever) connections.
- Re-open connections after you've moved.
- Applications that care about mobility can change.

- Who initiates the reconnection?
  - What if both hosts are moving at the same time?

- Also does not address the problem of finding the mobile's current address.

# Back to the Network Layer

- Network layer is choke-point in the network stack.
- “Hourglass” figure:




- Putting mobility in the network layer allows both higher- and lower-layer protocols to use it.

# Network Layer Mobility

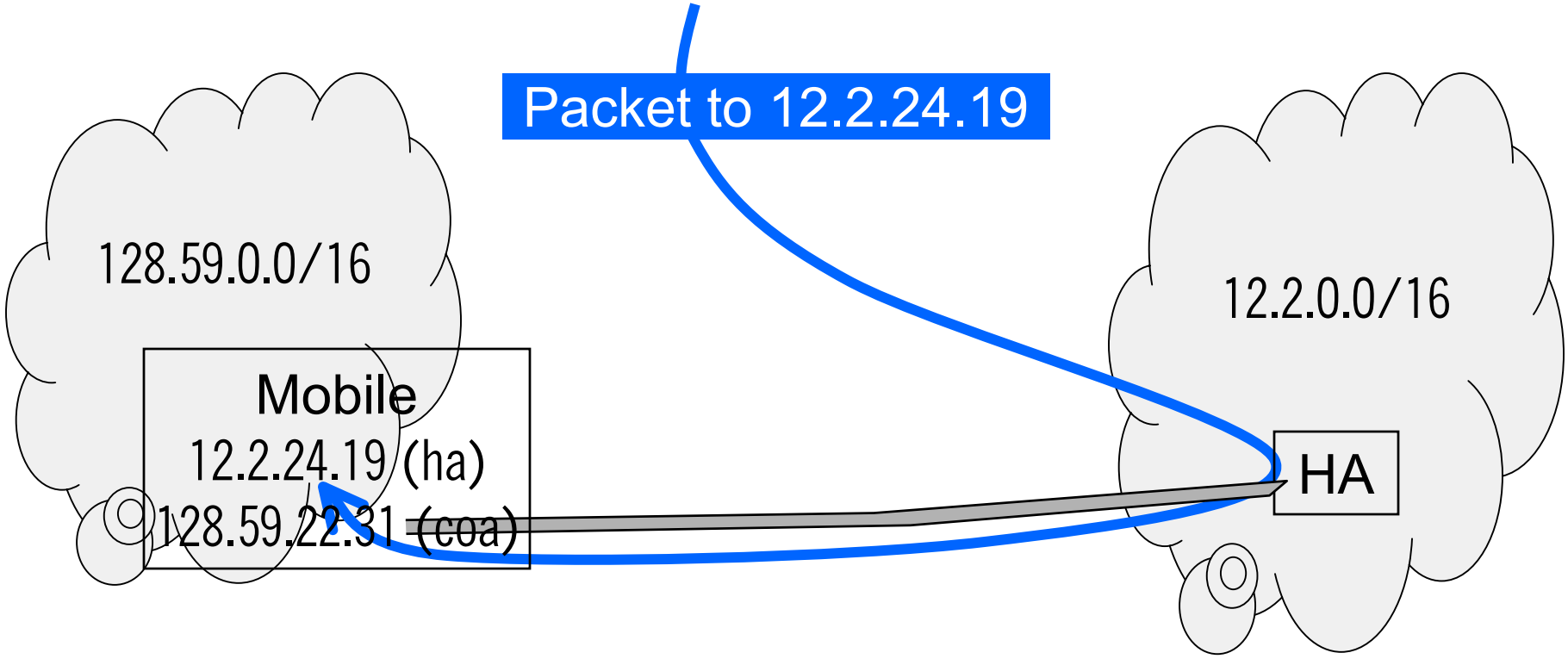
- Remember: Duality of IP addresses:
  - Locator (where in the topology a node is attached).
  - Name (used by protocols to identify node).

- Solution: give mobile two addresses.
  - Use one as a locator.
  - Use the other as a name.

- When locator ≠ name, use **tunneling** to get from one to the other.
- Effectively: introduce a new link-layer that is actually IP.
  - Use IP as a switching fabric for itself.

# Example

- Traffic **to** mobile is routed to its **name** (“*Home Address*”).
- The *Home Agent* (a router) picks it up.
- Tunnels it to its **locator** (“*Care-of Address*”).
- Traffic **from** mobile may have to be *reverse-tunneled*.



# Location, Location, Location!

- Even if we solve the addressing/routing problem…
- … we still need to find where the mobile went.

- How to map from name to location.
  - This is a problem regardless of the routing solution.

- In network-layer mobility:
  - How to find the care-of address from the home address.
  - A: Mobile tells the Home Agent.
  - Home agent tunnels traffic to mobile.

# Mobile IP

- Being designed since 1990.
- John Ioannidis, Dan Duchamp, Gerald Q. Maguire Jr.: *IP-Based Protocols for Mobile Internetworking*. ACM SIGCOMM'91, Zürich, Switzerland, September 1991.

- IETF WG since March 1992.
  - Longest-running IETF WG.

- RFC3344
- draft-ietf-mobileip-ipv6-19.txt

# Assumptions/Requirements

- No constraints on IP addresses.
  - Any host can become mobile.
- Nodes don't change addresses **too** frequently (<1Hz).
- Routing is still by destination address only.

- Change location regardless of distance.
- Change interface.

- Micro-mobility is still better solved in the link layer.

# Architectural Components

- *Mobile Node*.
  - A host that changes Network Attachment Points without changing its IP address.
  - *Home address*.
  - *Home network*.
- *Home Agent*.
  - A router that keeps track of Mobile Nodes and tunnels traffic to and from them.
- *Foreign Agent*.
  - A router that provides services to a mobile node away from its *home network*.
  - May terminate the tunnel from the HA.

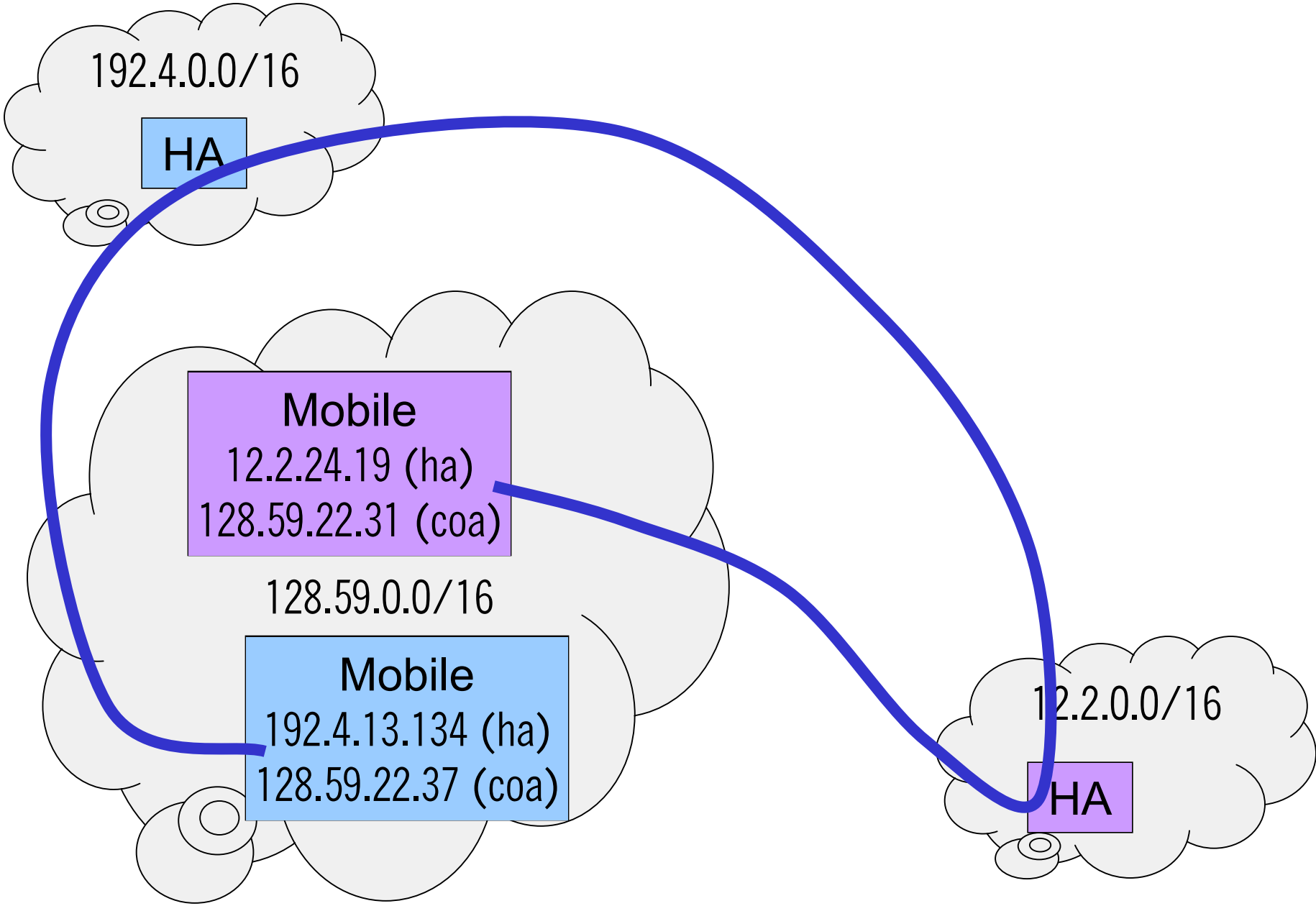
# Protocol Outline

- Mobility Agents (HA or FA) advertise their presence.
  - Extension to Router Advertisement ICMP packet (RFC1256).
  - Sent to 224.0.0.1 or 255.255.255.255.
- Alt: mobile nodes solicit a Router Advertisement.
  - Extension to Router Solicitation ICMP packet.
- Mobile receives Router Advertisement and determines whether it is on Home Network or Foreign Network.
- On home network: operates without mobility extensions.
  - If returning, de-register from HA.
- On foreign network:
  - Obtain care-of address.
  - Registers COA with HA.

# Care-of Addresses

- Foreign Agent Care-of Address:
  - An IP address of the FA.
  - Packets are tunneled to the FA.
  - Delivered locally using mobile's HA.
    - Mobile has registered with the FA.
  - Preferred: many mobiles share the FA COA.
- Co-located care-of Address:
  - An (additional) IP address of the mobile.
  - Acquired through different means (e.g., DHCP).
  - Mobile serves as its own tunnel endpoint.
  - Advantage: mobile can function without FA.

# Routing Inefficiencies



# Mobile IPv6

- Mobile IPv6: much cleaner design.
  - No installed base.
  - Still opted for network-layer mobility.

- MIPv6 supports the notion of the Binding Update.
  - A Mobile Host can tell its Correspondent Host its COA.
    - Whether mobile or stationary.
  - Still tunneling, but the tunnel does not go all over the world.

- Even more security issues (RTFIDs).

# Where *is* Mobile IP?

- Cisco, Solaris now have support.
- Even less deployment than Multicast.
- Last hope: 3GPP2.