

Mobile IP (Done right?)

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(Slides borrowed from Mary Baker's CS444N)

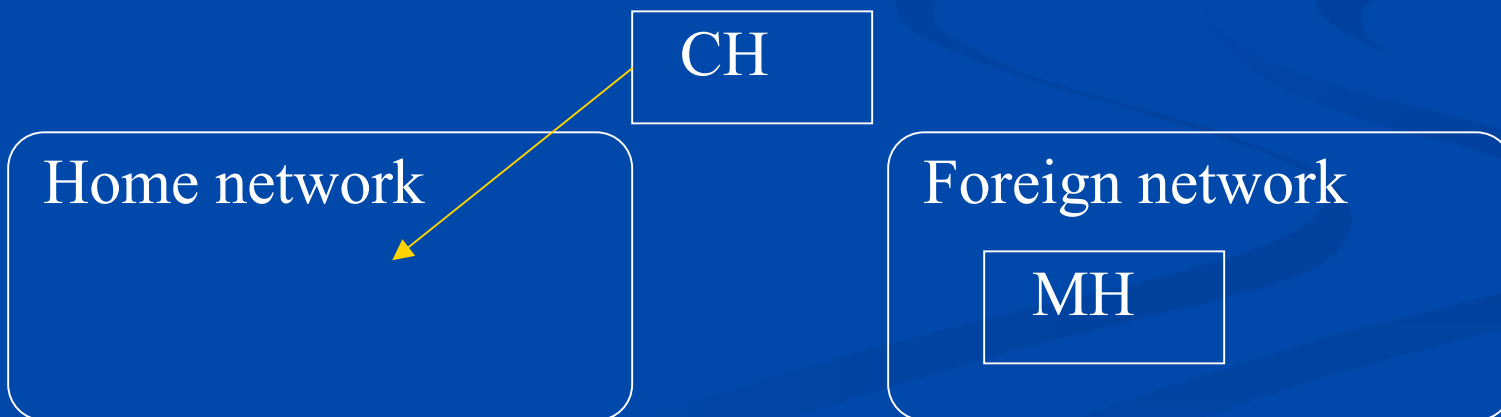
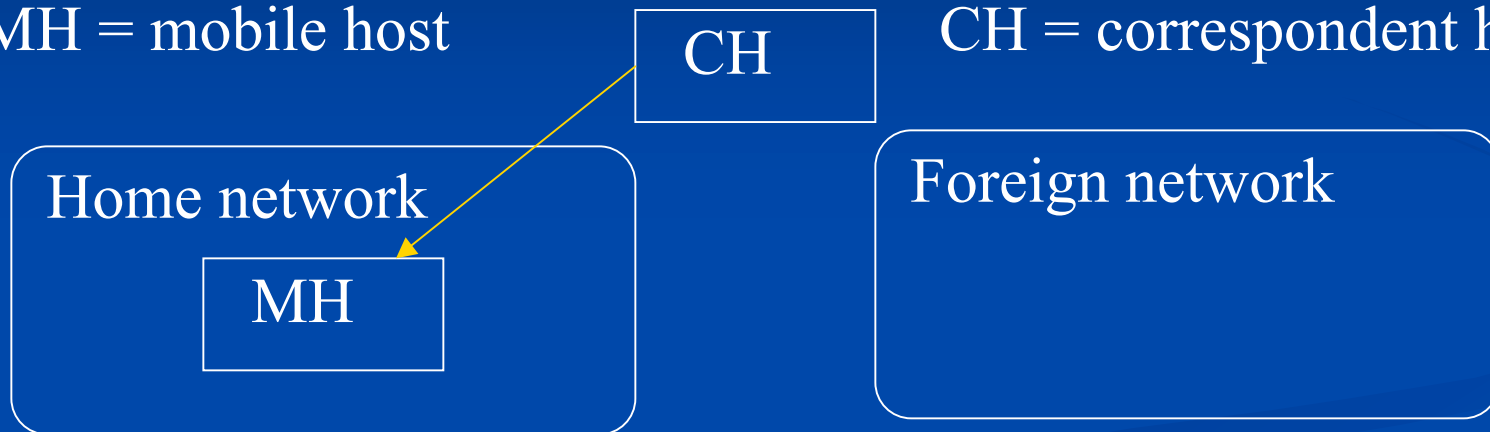
What's the Problem, Anyway?

- Internet hosts are identified by *IP address*
 - DNS translates hostname to IP address
 - IP address identifies a *network attachment point*
 - Sloppy use can mix naming and location
- Different attachment point, different IP
 - How can we *discover / locate* the host?
 - How can we *forward / route* to the host?

Mobile IP Vocabulary

MH = mobile host

CH = correspondent host



Multi-homing: Same Symptom

Network interfaces:

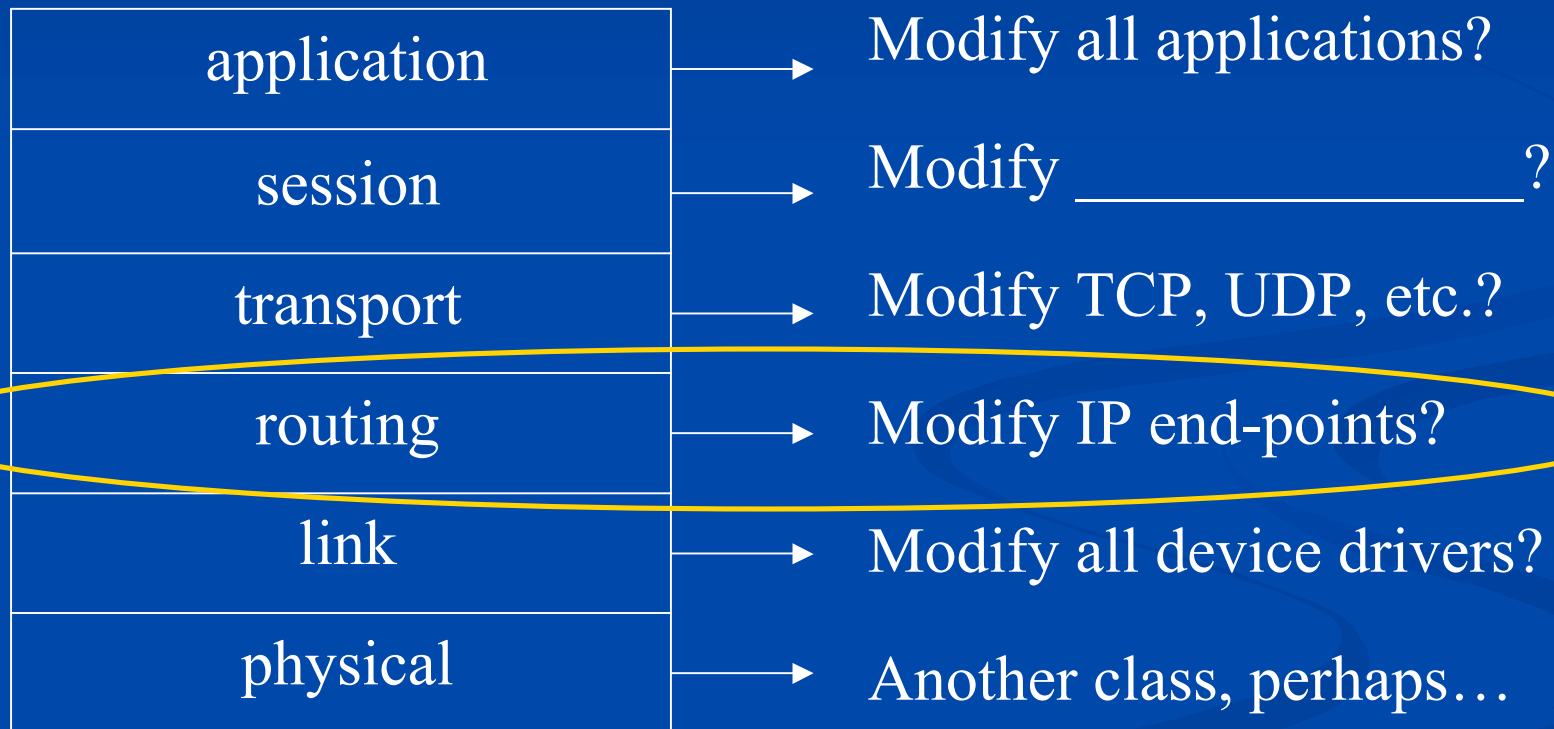
Mobile host	ether	132.239.15.X
	802.11	132.239.10.X
	modem	199.182.120.X

Administrative domains:

ucsd.edu
132.239.X.X

ix.netcom.com
128.32.X.X

Our Options, OSI Style



Why Layer 3?

- What about Layer 2 (physical layer)?
 - Intelligence (and expense) is in the network
 - End-points are cheap (handsets)
 - Allows for supporting infrastructure
 - Requires agreements / trust amongst multiple vendors
 - Examples:
 - A link / physical level (many wireless networks)
 - At routing level (Columbia, VIP)
 - Doesn't work when switching between technologies and often not between vendors
 - Need to change the routers

Why Layer 3? (cont)

- End-to-end Argument, broadly construed
 - Intelligence (and expense) is in the end-points
 - Network is cheap (relatively) and as fast as possible
 - Implies self-support for many activities
 - Less work/trust required amongst multiple vendors
- What about higher (transport, session) layers?
 - Promises increased usability, higher performance...
 - But, might not be backwards compatible
 - We'll see about that...

Mobile IP [Per+98]

- Self-defined(?) starting point
 - No modifications to Internet routers
 - No modifications to non-mobile hosts
- Resulting requirements
 - Doesn't deal with disconnectivity
 - Requires modifications to mobile hosts
 - Needs a "home agent" located at "home"

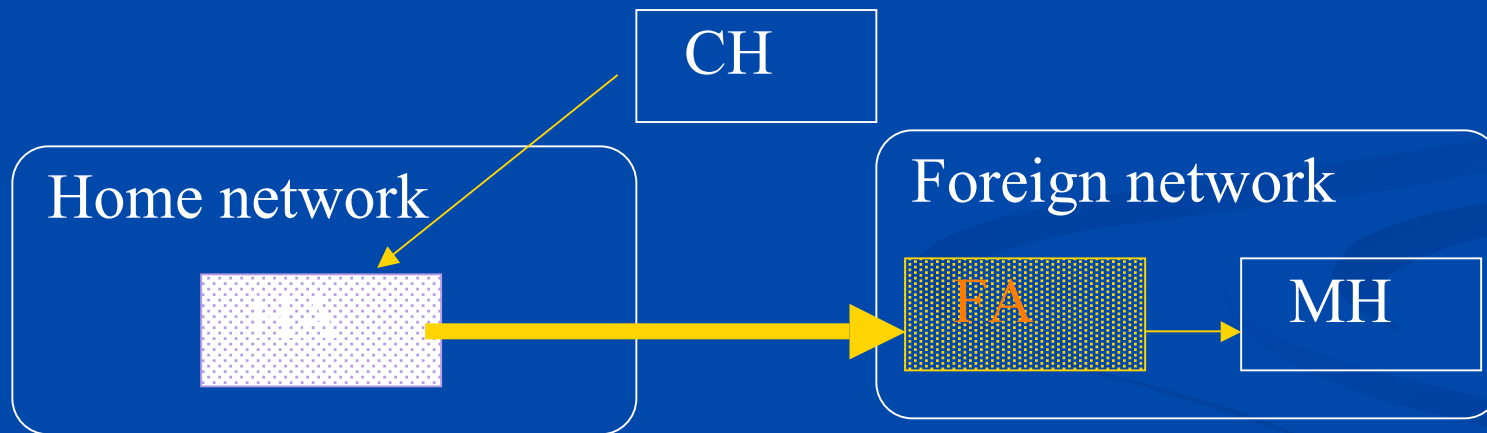
Routing to Mobile Hosts

MH = mobile host

CH = correspondent host

HA = home agent

FA = foreign agent



- MH registers new “care-of address” (FA) with HA
- HA tunnels packets to FA
- FA decapsulates packets and delivers them to MH

Packet Encapsulation

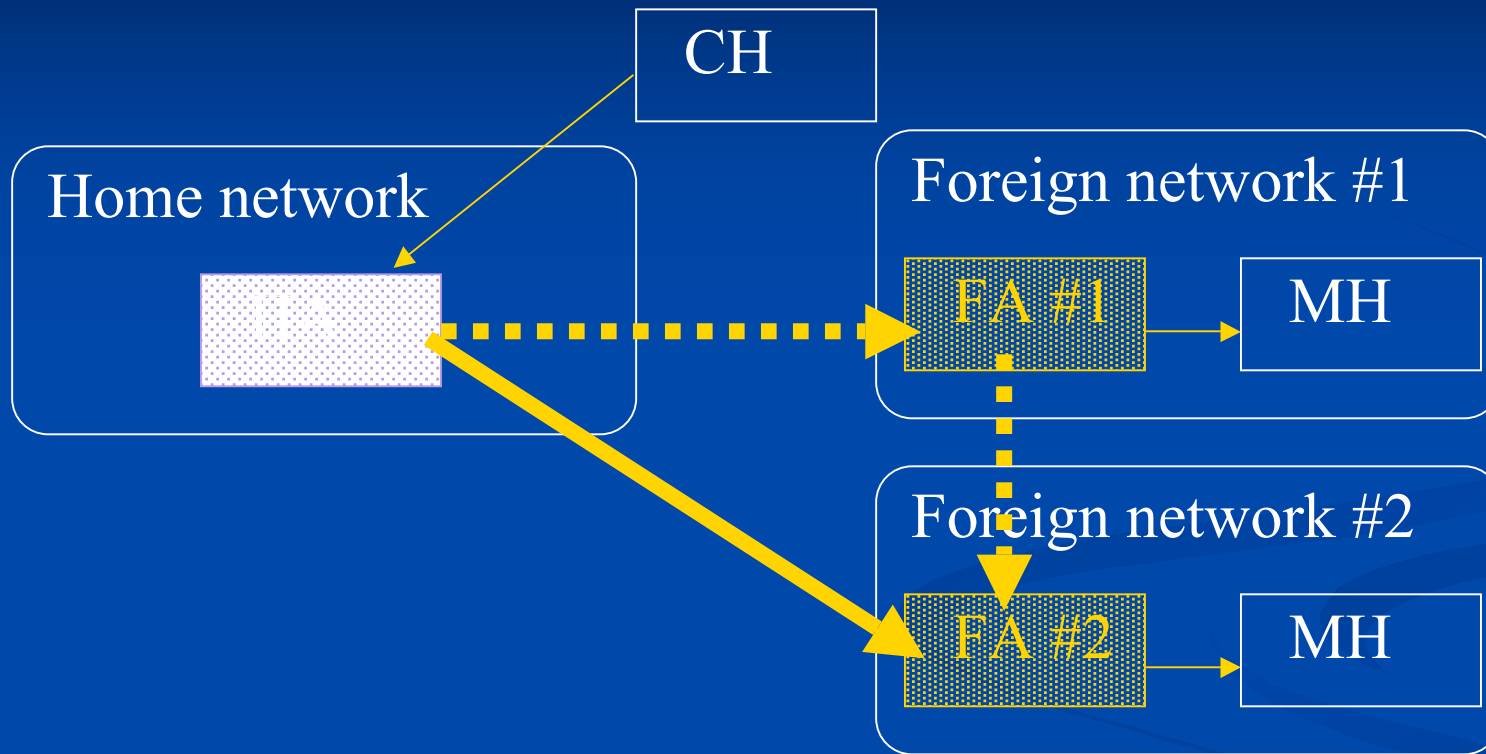
Packet from CH to MH

Source address = address of CH
Destination address = home IP address of MH
Payload

Home agent intercepts above packet and tunnels it

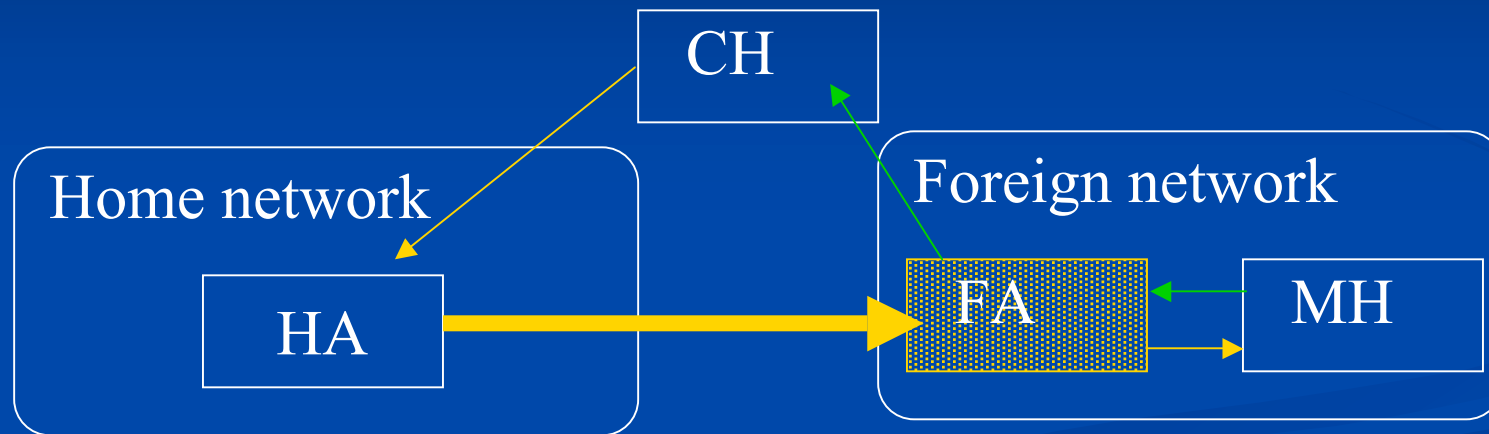
Source address = address of HA
Destination address = care-of address of MH
Source address = address of CH
Destination address = home IP address of MH
Original payload

Mobile Host Registration



- MH registers new address (FA #2) with HA & FA #1
- HA tunnels packets to FA #2, which delivers them to MH
- Packets in flight *can* be forwarded from FA #1 to FA #2

Routing From Mobile Hosts



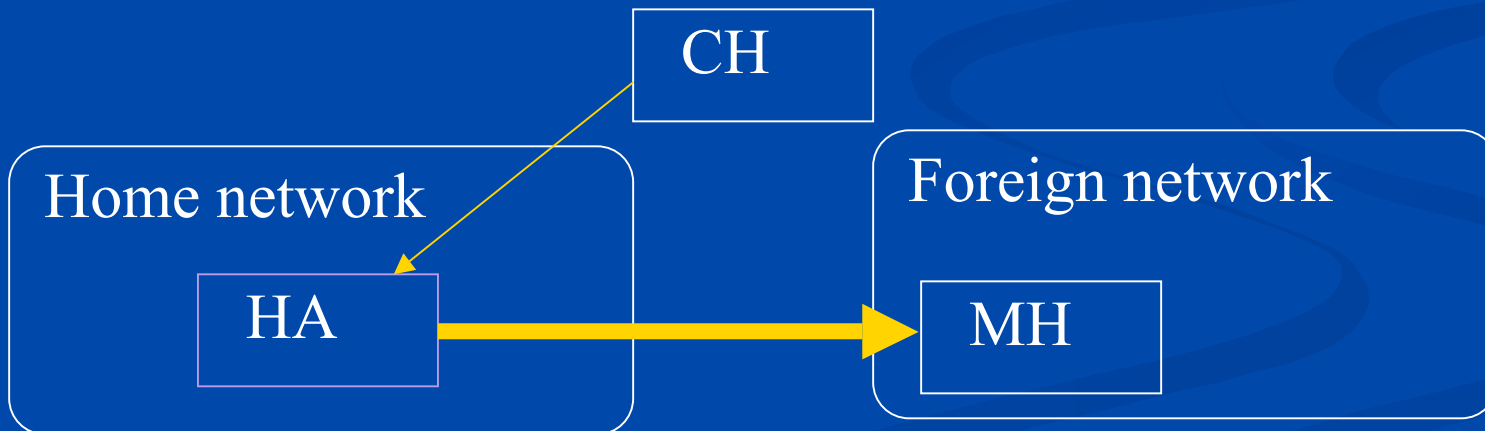
- Mobile host uses home IP address as source address
 - Transparent to correspondent host
 - No obvious need to encapsulate packet to CH
- So-called *Triangle Routing*

What's with Foreign Agents?

- A general solution, but what's the problem?
 - DHCP solves almost all the problems these days...
- Assumption of support from foreign networks
 - A foreign agent exists in all networks you visit?
 - The foreign agent is robust and up and running?
 - The foreign agent is trustworthy?
- Correctness in security-conscious networks
 - We'll see that "triangle route" has problems
 - MH under its own control can eliminate this problem

Obvious Alternative: No FA

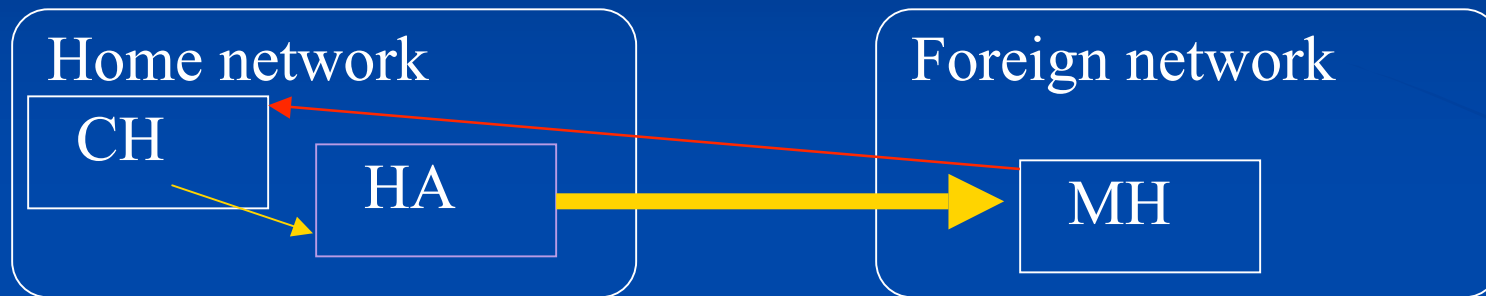
- Co-locate FA with MH
 - Needs to acquire its own address
 - Needs to decapsulate its own packets
 - Needs permission to route its own packets



Design implications

- The mobile host now has two roles:
 - Home role
 - Local role
 - Makes for a more complex mobile host
- But, results in more power
 - No need for foreign agent support
 - Might “simplify” administration
 - Could join local multicast groups, I suppose...

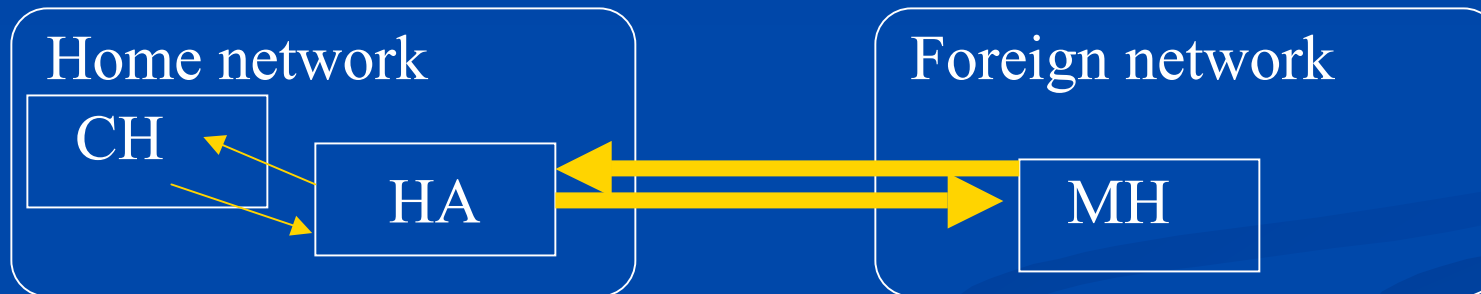
Ingress Filters: A Cute Hack's Worst Nightmare



- Ingress Filtering
 - Meant to protect networks, drops packets with “bogus” source IP addresses
 - For a MH in a foreign network, outgoing packets are out of luck...

“Solution”: Bi-directional Tunnels

- Provide choice of “safe” route through home agent both ways



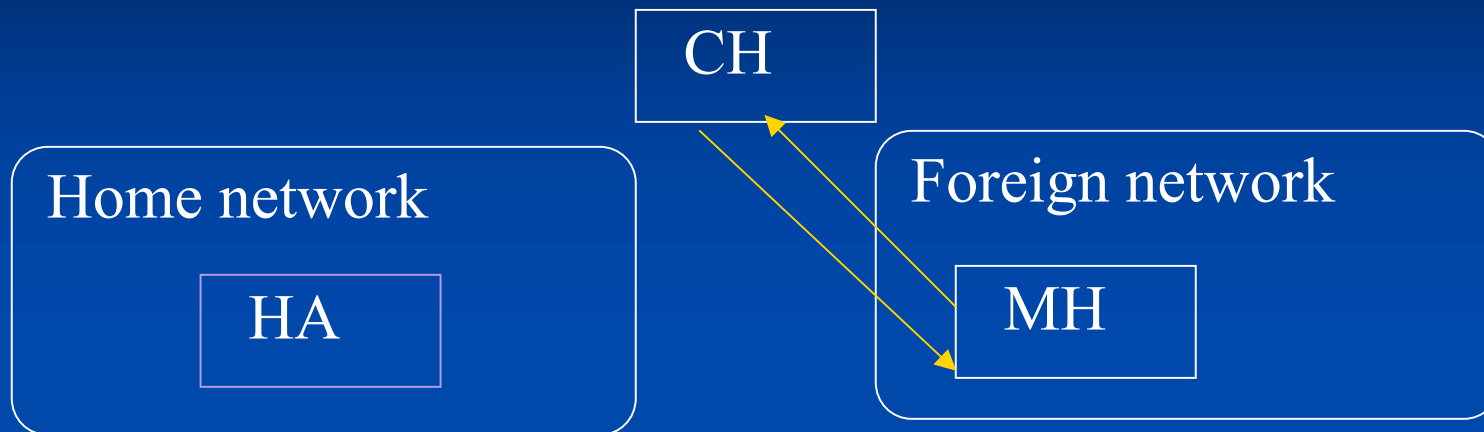
- This is the slowest but most conservative option

At the other extreme...

Problem: Performance

- Example: short-lived communication
 - When accessing a name server, why pay for mobility?
 - Do without location-transparency
 - Unlikely to move during transfer
 - Even if we did, can reissue request
 - Second answer might be better, anyway!
 - Works only when CH doesn't keep state about MH

Solution: yet more flexibility



- Use current care-of address and send packet directly
 - This is regular IP!
- More generally:
 - MH should have flexibility to adapt to circumstances
 - A range of options: from slow-but-safe to regular IP
 - Should be an end-to-end packet delivery decision (no FA)

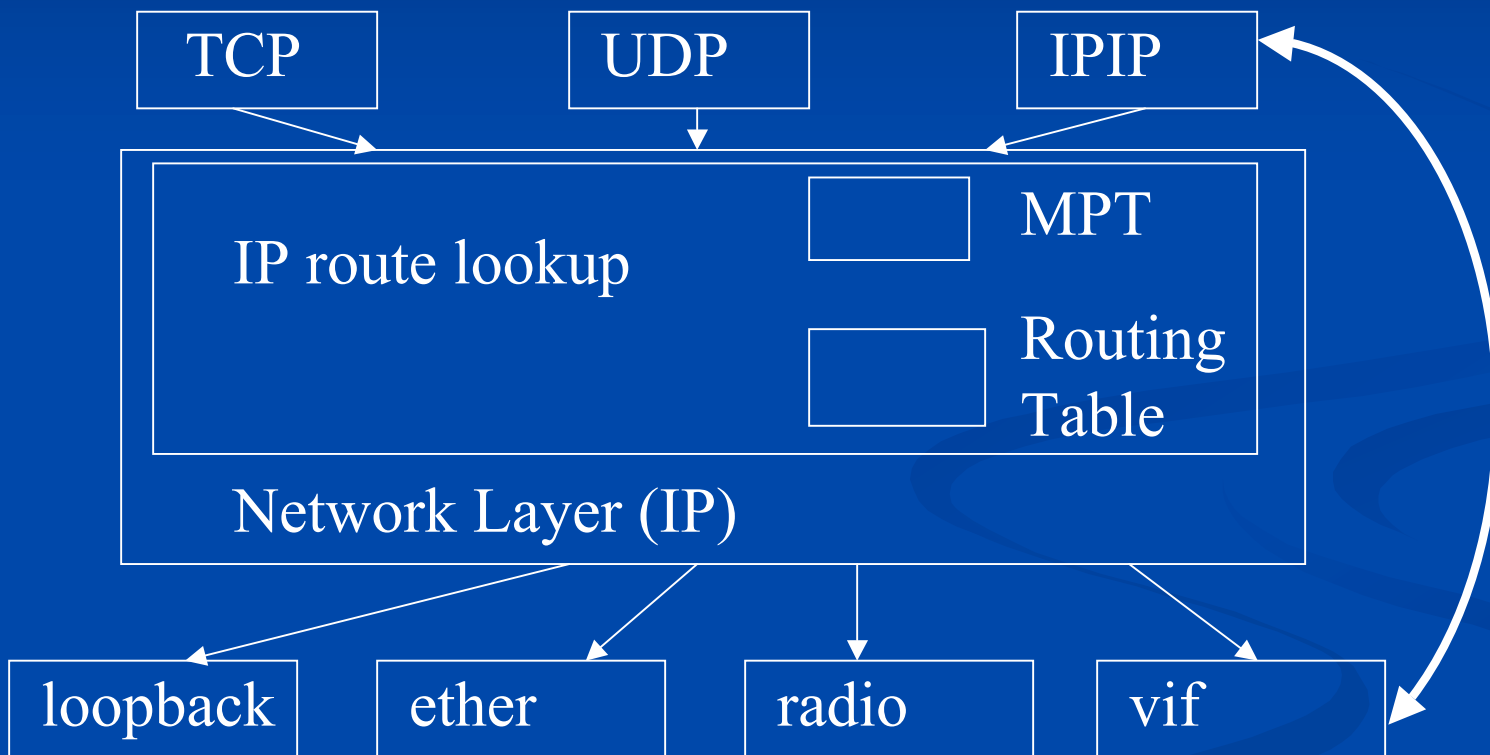
Routing options

- Allow MH to choose from among all options
- Options:
 - Encapsulate packet or not?
 - Which source address?
 - Tunnel packet through home agent or send directly?
- Choice determined by:
 - Performance
 - Desire for transparent mobility
 - Mobile-awareness of correspondent host
 - Security concerns of networks traversed
- Equivalent choices for sending packets to MH

Mobility 4x4 [CB96]

	Outgoing Indirect, Encapsulated	Outgoing Direct, Encapsulated	Outgoing Direct, Home Address	Outgoing Direct, Temp. Address
Incoming Indirect, Encapsulated	Most reliable, least efficient	Requires decapsulation on CH	No security- conscious routers on path	
Incoming Direct, Encapsulated		Requires fully mobile-aware CH	No security- conscious routers on path	
Incoming Direct, Home Address			Requires both hosts to be on same net. seg.	
Incoming Direct, Temp. Address				Most efficient, no mobility support

4x4 Implementation



Example MPT

- Traffic back to home net handles boundary routers
- All web traffic uses regular IP
- Other traffic uses regular “triangle route”
- Handles multicast addresses too (bi-directional or regular IP)

Destination	Netmask	Port Number	Transparent Mobility?	Bi-directional tunneling?
a.b.0.0	255.255.0.0	0	Yes	Yes
0.0.0.0	0.0.0.0	80	No	N/A
0.0.0.0	0.0.0.0	0	Yes	No

Figuring out which to use

- With bidirectional tunneling
 - Probe destination using triangle route
 - If it works, switch to that option
- With triangle route
 - If packets aren't getting through after some number of tries
- Hmm....

Is it fast enough to be seamless?

		Interval between packets	Packet loss (common case)	Packet loss (worst case)	Time in transition
Cold switch	Ether => ether	10 ms	0	1	< 10 ms
	Ether => radio	250 ms	1	4	< 1.25 s
	Radio => ether				
Hot switch	Ether => radio	250 ms	0	1	< 0.5 s
	Radio => ether				

Mobile IP issues on local network

- Host visiting local network with foreign agent
 - No real presence on local network
- Host visiting local network with its own IP address
 - Has a role on local network
 - Reverse name lookups through special name?
 - Or do you change the DNS entry?
 - Its IP address / HW address gets into local hosts' ARP caches
 - Which IP address should go into cache?
 - How do you update caches if host moves again?

Local ARP cache problem

- ARP caches store (IP address, HW address) pairs
- MH host visits foreign network
- Wants to talk directly back and forth to local hosts
 - If it wants to maintain connectivity with them after moving
 - Use home IP address
 - Other hosts address MH by HW address on local link
 - But if MH moves again, ARP cache entries are wrong
 - If it doesn't care
 - Use local IP address
 - If MH moves, ARP cache is wrong, but nobody cares

Multiple Network Interfaces – Why?

- Want to probe hosts through all active interfaces
 - Example: register with HA through new interface before switching to it
 - Helps with smooth handoff between types of networks
- Want transparent mobility for more than one interface
- Example:
 - One application users cheap / slow interface while another uses expensive / fast interface
 - Move to new network(s) or lose contact with one network
 - Don't want to restart either application

Why is this hard?

- System support missing in at least two areas
- Need “next hop” info for more than one interface
 - Need to be able to send packets beyond local subnet for more than one interface
 - Current support only uses gateway info for one interface
- Mobile IP doesn't separate traffic flows to different interfaces
 - (This isn't the Mobile IP “simultaneous binding” feature)
 - Current HA won't keep different bindings for more than one interface per host based on traffic flow

Multi-Homing Really Needs

Destination	Gateway	Netmask	Flags	Metric	Iface
a.b.0.0	0.0.0.0	255.255.0.0	U	0	eth0
c.d.0.0	0.0.0.0	255.255.0.0	U	0	st0
127.0.0.0	0.0.0.0	255.0.0.0	U	0	lo
0.0.0.0	a.b.0.1	0.0.0.0	UG	1	eth0
0.0.0.0	c.d.0.1	0.0.0.0	UG	100	st0