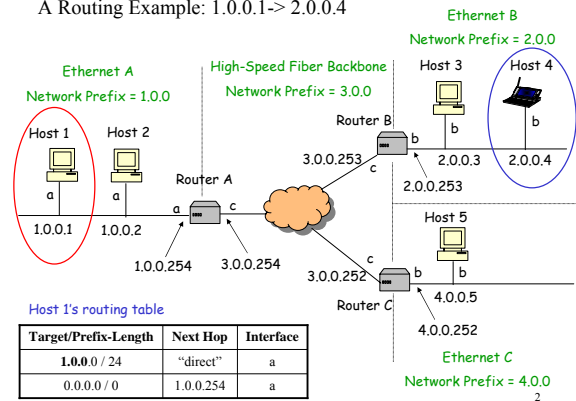


Mobile IP

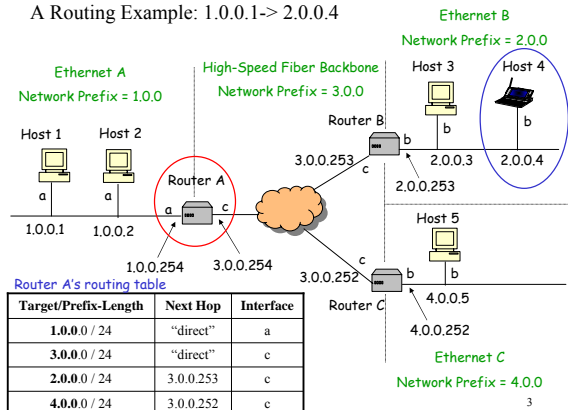
- Support for mobile hosts in the Internet
- Discussion based on IPv4
- Original work by John Ioannidis:
 - Protocols for Mobile Internetworking, Ph.D. thesis, Columbia University, 1993
 - First full implementation, Columbia University, 1991
- Many other implementations with slightly different approaches:
 - Sony 1991
 - IBM 1992
 - Harvard 1994
 - Linux Mobile IP 1996

1

A Routing Example: 1.0.0.1-> 2.0.0.4

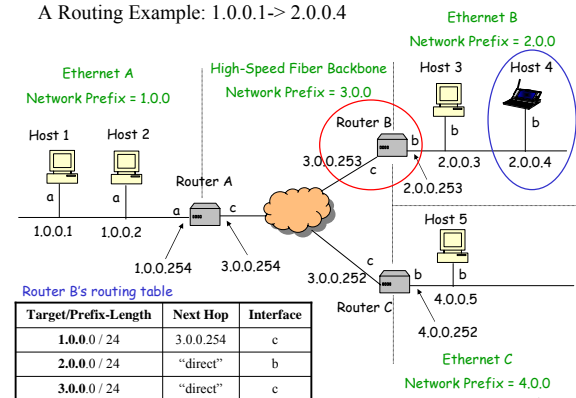


A Routing Example: 1.0.0.1-> 2.0.0.4

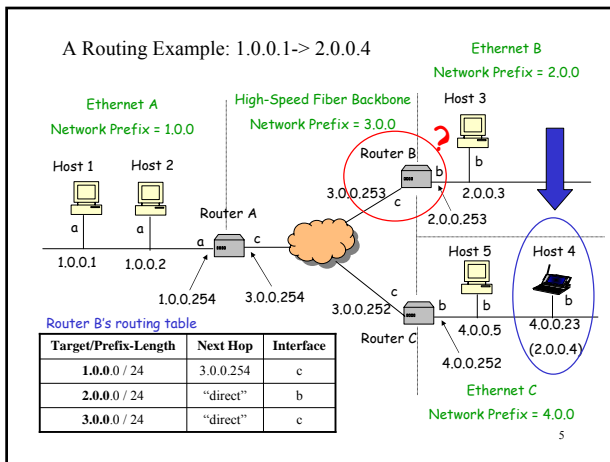


3

A Routing Example: 1.0.0.1-> 2.0.0.4



4



The Problem

- The packet cannot be delivered
- Host 4 is no longer connected to Ethernet B
- It has moved to Ethernet C
- Keeps the same IP address (2.0.0.4), or
- Is assigned (somehow) a new IP address (4.0.0.23)
- Router B will send:
 - An ICMP host unreachable message back to host 1
- Suggestions on how to solve this problem?

Solution 1: Host-specific Routes

- When host 4 keeps its old IP address (2.0.0.4)
- Enter host-specific routes into the routing tables of routers A, B and C:

Router A	Target/Prefix-Length	Next Hop	Interface
	2.0.0.4 / 32	3.0.0.252	c
Router B	Target/Prefix-Length	Next Hop	Interface
	2.0.0.4 / 32	3.0.0.252	c
Router C	Target/Prefix-Length	Next Hop	Interface
	2.0.0.4 / 32	"direct"	b

Solution 2: Change IP Address

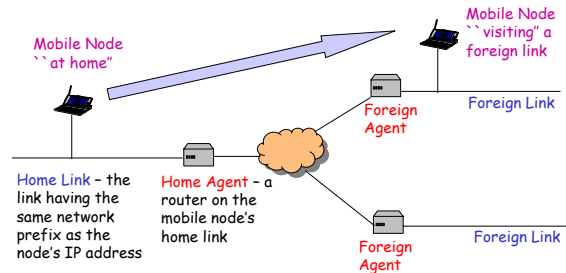
- Simply change the IP address of host 4, as it moves from Ethernet B to Ethernet C
- New IP address: 4.0.0.23
- Assignment via some automated way, DHCP
- Change the IP address of a host whenever it changes its point of attachment

Solution 3: Mobile IP

- A standard proposed to address the problem of mobile internetworking
- It allows a mobile node to use two IP addresses:
 - A fixed IP address, called *home address*
 - An IP address that changes at each new point of attachment, called *care-of address*
- Home address is a permanent IP address assigned by the node's home network
- Care-of address is a temporary address assigned by the foreign network (the network that the host visits)

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Entities and Relationships



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Home and Foreign Agent

- Home Agent:
 - A router on a mobile node's home network
 - Maintains current location information for the mobile node.
- Foreign Agent:
 - Serves as a default router for the registered mobile nodes

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Care-of Address: Foreign Agent CoA

- Two different conceptual types:
 - Foreign agent care-of address:
 - * IP address of a foreign agent (FA) that has an interface on the foreign link
 - * The FA may have more than one IP address; So, the network prefix need not be the same as the network prefix of the foreign link
 - * The same FA CoA can be shared by many mobile nodes simultaneously

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Care-of Address: Collocated CoA

- Collocated care-of address:
 - * An IP address temporarily assigned to a mobile node
 - * Can be used by only one mobile node at a time
 - * The network prefix must be the same as the network prefix of the foreign link
 - * It might be used by a mobile node in situations where no foreign agents are available

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Mobile IP Operation

- Three main mechanisms:
 - Agent discovery
 - Registration
 - Routing

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Mechanism 1: Agent Discovery

- Home Agents and Foreign Agents periodically broadcasts *Agent Advertisements*
- E.g. once every few seconds
- If the mobile node does not want to wait for the periodic advertisement, it can broadcast *Agent Solicitations* that will be answered by any foreign agent that receives it
- Mobile nodes determine whether they have moved from one link to another

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Movement Detection

- *Agent Advertisement* has a *Lifetime* field
- Specifies how soon a mobile node should expect to hear another advertisement from that same agent
- If the mobile node fails to hear an advertisement from that agent within the specified *Lifetime*, then it assumes that it has moved to a different link
- Also movement detection based on network prefixes

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Care-of Address

- A mobile node connected to a foreign link acquires a foreign agent care-of address from the *Agent Advertisements*
- If multiple care-of addresses are listed, any one of them can be used
- If a foreign agent is unavailable, the mobile node can obtain a collocated care-of address by DHCP
- Or a previously assigned collocated care-of address may be used

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Agent Discovery Security

- No authentication is required by the Mobile IP specification
- MAY be authenticated using IPsec mechanisms
- We can have malicious mobile nodes or malicious foreign agents
- You can come up with your own ways of exploiting this

18

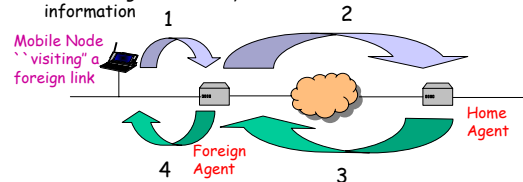
Mechanism 2: Registration

- Registration is the process by which a mobile node:
 - Requests routing services from a foreign agent
 - Informs its home agent of its current care-of address, which creates a *triple binding*:
 - * Home address | Care-of address | Lifetime
 - Renews a registration which is due to expire, *binding update*
 - Multiple triple bindings may be kept for the same MN (*almost* seamless handoff)
 - Deregisters when it returns to its home link

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Registering Foreign Agent Care-of Address

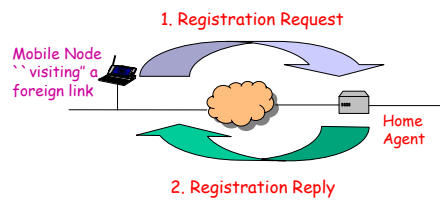
- The mobile node, with the assistance of a foreign agent, sends a *Registration Request* with the care-of address information



- When the home agent receives this request, it adds the necessary information to its routing table, and sends a *Registration Reply* back to the mobile node

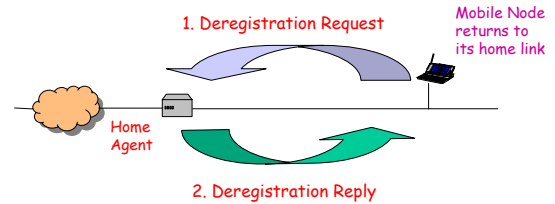
20

Registering Collocated Care-of Address



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Deregistration



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Authentication

- The home agent must be certain that registration was originated by the mobile node and not by some other malicious node.
- Registration of the care-of address requires authentication
 - The mobile node needs to prove its identity to its home agent
 - It is done by making use of a secret key known only to the mobile node and its home agent
 - Secret key is not sent as part of the communication
 - Mobile IP standard requires keyed MD5

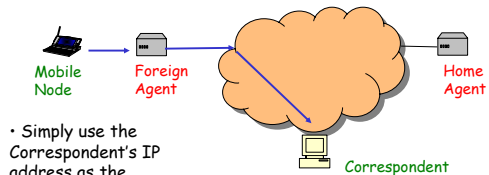
23

Mechanism 3: Routing

- Divided into different scenarios:
 - Mobile node → Correspondent node
 - Correspondent node → Mobile node
 - * With a foreign agent
 - * Without a foreign agent

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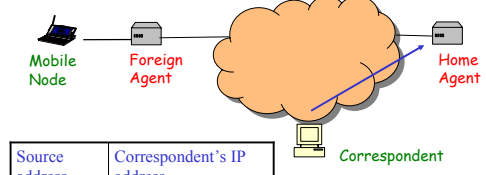
Mobile Node→Correspondent Node



- Simply use the Correspondent's IP address as the destination address
- How about the source address? Original IP address? Care-of Address?

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Correspondent Node→Mobile Node

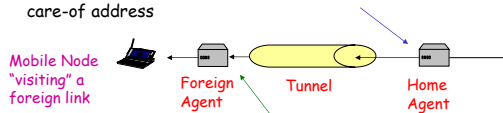


Source address	Correspondent's IP address
Destination address	Mobile's IP address

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Encapsulation is the Key

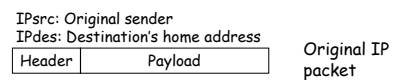
- The Home Agent intercepts packets destined to the mobile node's home address and tunnels them to the mobile node's care-of address



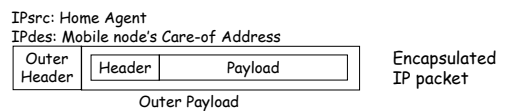
- The Foreign Agent removes original packet from the tunnel and delivers the original packet to the mobile node over the foreign link

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IP in IP Encapsulation

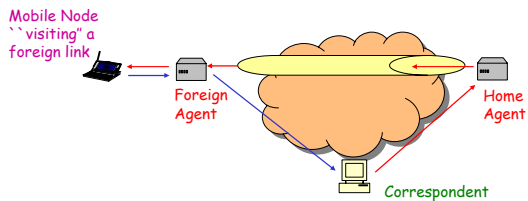


- The home agent inserts a new IP header, or tunnel header, in front of the IP header of any datagram addressed to the mobile node's home address



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Triangle Routing (1/2)



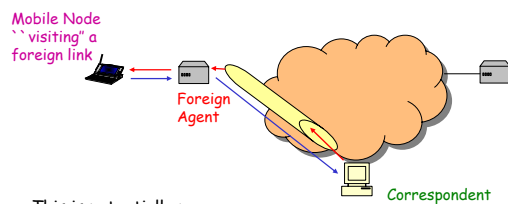
29

Triangle Routing (2/2)

- Waste of network resources
- HA is a bottleneck
- What about network partitions?
- Why doesn't the mobile node inform the correspondent of its care-of address and have it tunnel directly to the mobile node?

30

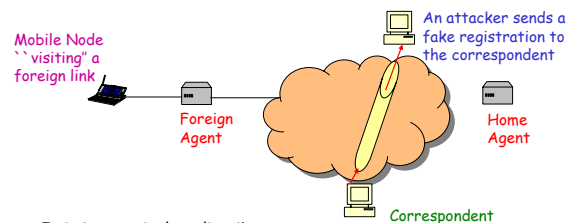
Optimized Routing



- This is potentially more efficient in terms of delay and resource consumption

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Main Obstacle: Security



- It is impractical to distribute keys between a mobile node and every other node with which it might correspond

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On the Home Network

- If the HA is the gateway host then picking up packets destined for the MH is trivial
- If the HA is **not** the gateway host then:
 - The HA pretends to be MH and responds to requests for MH's physical address (e.g. Ethernet address) with its own physical address
- ARP caches on all hosts have to be updated upon registration of the MH (ARP replies)

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On the Foreign Network

- The care-of address used for encapsulation may belong to the FA or may be a temporary address acquired by the mobile host (e.g. via DHCP)
- The MH must never send ARP frames on a foreign network
- The MH can obtain the FA's link-layer address from the *agent advertisement* messages

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Mobile IPv6

- There is no need for Foreign Agents since the MH can use the *Address Autoconfiguration* protocol to obtain a dynamic care-of address
 - No triangular routing
- Binding updates are supplied by encoding them as destination options in the IP header
- IPv6 provides security protocols hence simplifying the authentication process

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Further Reading

- C. E. Perkins, "Mobile networking through mobile IP," *IEEE Internet Computing*, pp. 58-69, Jan/Feb, 1998

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