Mobility

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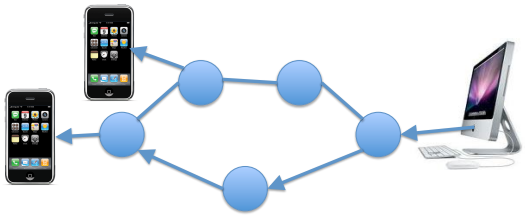
COS 461: Computer Networks

Lectures: MW 10-10:50am in Architecture N101

http://www.cs.princeton.edu/courses/archive/spr13/cos461/

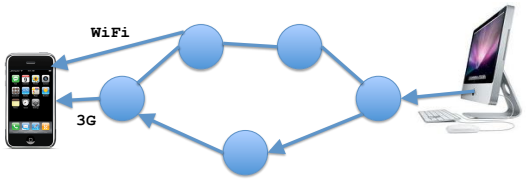
Why (and How) Things Move

Physical Mobility



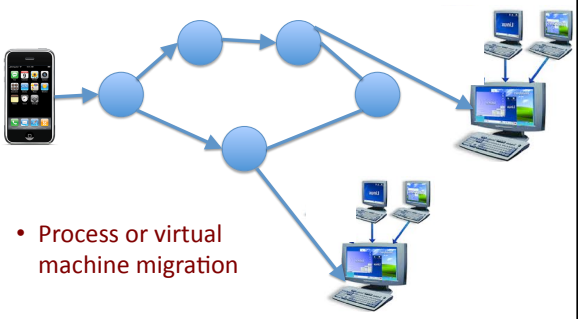
- Device attaches to a new attachment point

Multi-Homing



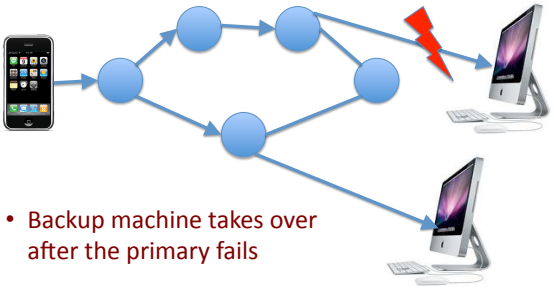
- Device starts using a different attachment point

Migration



- Process or virtual machine migration

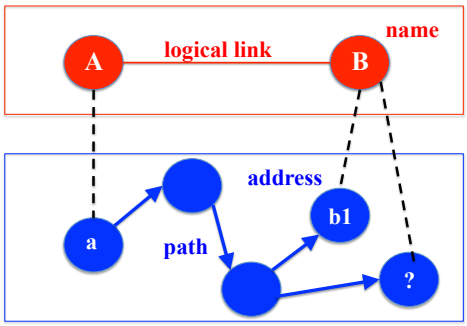
Failover



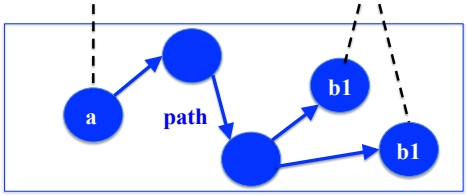
- Backup machine takes over after the primary fails

Handling Mobility

Change Address of Mobile Node?

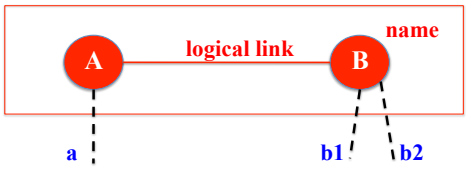


Keeping the Address the Same



- Mobility is a *routing* problem
  - Change the routes to reach the new location
  - Challenge: scalability of the routing protocol

Changing the Address



- Mobility is a *directory* problem
  - Change the mapping of name to address
  - Challenge: scalability of directory, updating neighbor

Two Internet Design Decisions

- Socket abstraction
  - Connection between a pair of fixed IP addresses and port numbers
  - Leads to more emphasis on routing solutions

- Interface addresses
  - Addresses refer to interfaces (adaptors)
  - Not the host, or the service

Routing Solutions

Address Stays the Same

Three Examples

- Ethernet
  - MAC learning of the new location
- IP routing
  - Inject IP address(es) at new location
- Mobile IP
  - Stationary home agent directs traffic to new location

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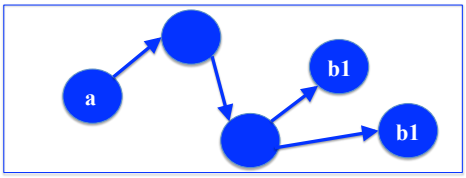
Example #1: Ethernet



- MAC learning
  - Learn b1's location when b1 sends a frame
  - Soft state: timeout the cached information

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Making Larger Ethernet Segments

- Ethernet handles mobility
  - IP address and MAC address stay the same
  - Switches learn to route to the new location
- But, larger networks have multiple segments
  - Cannot retain your IP address as you move
- Solution: virtual local area networks (VLAN)
  - Logical Ethernet segment spanning a campus
  - E.g., interconnecting the WiFi access points

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Pros and Cons

- Advantages
  - Seamless mobility, no changes to hosts or apps
  - No changes to MAC or IP addresses
- Disadvantages
  - Ethernet does not scale
  - Long paths, state per MAC address, flooding, …
- Widely used approach in campus networks

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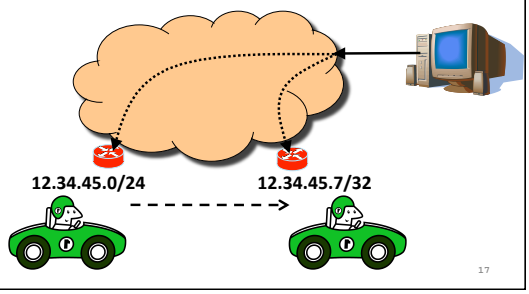
Example #2: IP Routing

- Node has a persistent address (e.g., 12.34.45.7)
- Injected into routing protocol (e.g., OSPF)



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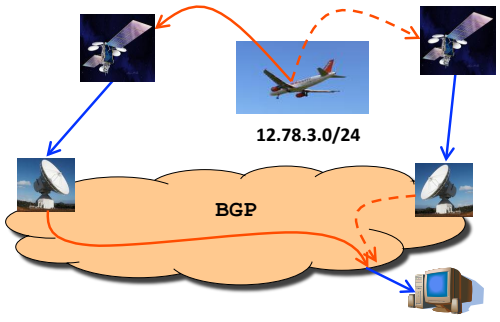
Boeing Connexion: Wide-Area Mobility



http://www.nanog.org/meetings/nanog31/abstracts.php?pt=NTk1Jm5hbm9nMzE=&nm=nanog31

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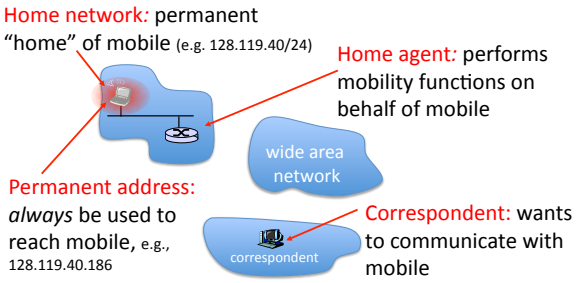
Pros and Cons

- Advantages
  - Seamless mobility, no MAC or IP address changes
  - Traffic follows an efficient path to new location
- Disadvantages
  - Does not scale to large number of mobile hosts
  - More routing-protocol messages
  - Larger routing tables to store smaller address blocks

Example #3: Mobile IP



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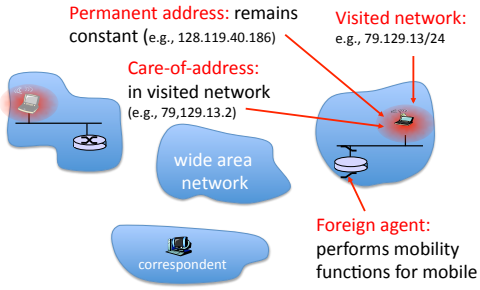

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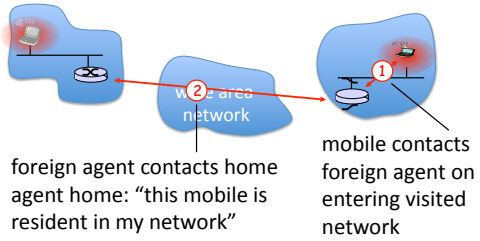

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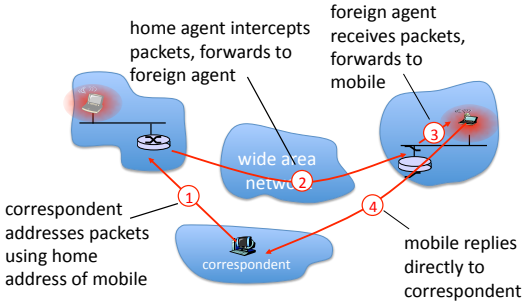


Pros and Cons

- Advantages
  - Seamless to the remote end-point
  - No routing-protocol overhead
- Disadvantages
  - Overhead of running home and foreign agents
  - Inefficient "triangle routing" (high "stretch")
  - Foreign agent sends "spoofed" IP source address

Questions

Between three mobility choices

(A) Ethernet (B) IP Routing (C) Mobile IP (D) All

Which option:

1. Scales to entire Internet
2. Less efficient communication when mobile
3. Seamless to endhosts
4. Mobility solution does not run risk of filtering

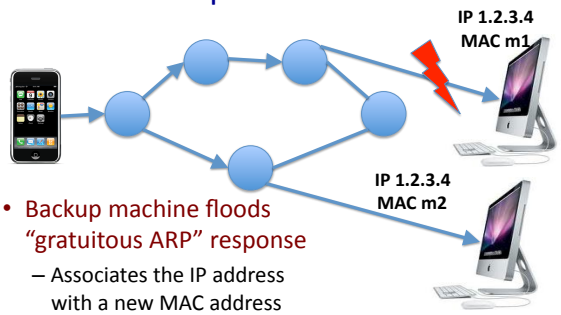
Directory Solutions

Change the mapping of name to address

Three Examples

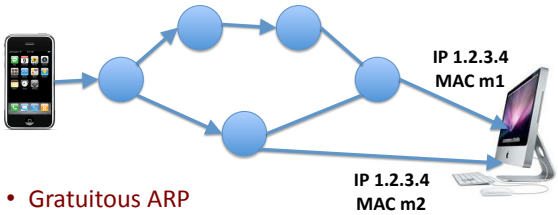
- Ethernet
  - Gratuitous ARP to change the MAC address associated with an IP address
- Dynamic DNS
  - DNS updates to change the IP address(es) associated with a domain name
- Various recent proposed designs
  - Updating the remote end-point (e.g., end host, edge switch) to use a new address

Example #1: Ethernet



- Backup machine floods "gratuitous ARP" response
  - Associates the IP address with a new MAC address
  - Hosts update their ARP cache

Ethernet Multi-Homing

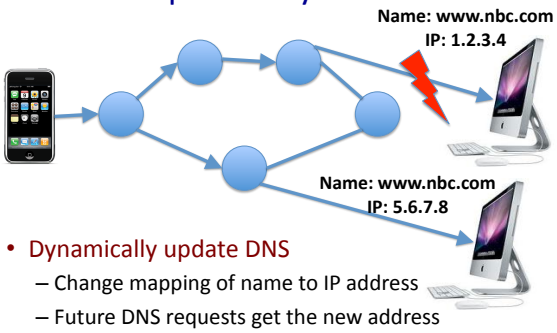


- Gratuitous ARP
  - Balance traffic over two interfaces
  - Fail over from one interface to the other

Pros and Cons

- Advantages
  - Seamless change from one MAC address to another
- Disadvantages
  - Works only within a single Ethernet subnet
  - Scalability limitations of Ethernet
- Used in data-center networks
  - But doesn't help with smart phones homed to multiple administrative domains

Example #2: Dynamic DNS



- Dynamically update DNS
  - Change mapping of name to IP address
  - Future DNS requests get the new address

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Applications of Dynamic DNS

- Replicated services
  - Direct future requests to a different replica
  - E.g., for failover, load balancing, performance, etc.
- Services on dynamically-assigned IP addresses
  - Residential user with a dynamic IP address
  - Directs clients to the server's current address
- "Fast flux" in botnets
  - Hiding phishing and malware delivery servers
  - … behind constantly changing IP addresses

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Pros and Cons

- Advantages
  - No new infrastructure
  - Leverages existing DNS servers
- Disadvantages
  - Only helps for new connections
  - Overheads of updating DNS servers
  - Stymied by DNS caching

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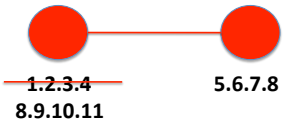
Example #3: Updating the End-Points



- Mobile node updates the remote end-point
  - Sends the remote end-point the new IP address
  - Allowing ongoing connection to continue
  - Can be used in conjunction with Dynamic DNS

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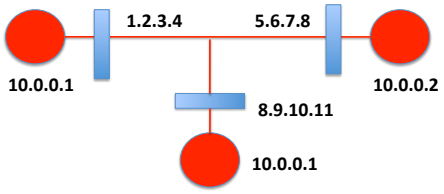
Updating the Edge Switches



- Update the switches
  - Hosts retain their addresses
  - Switches rewrite the addresses, or encapsulate
  - Used in some data-center networks

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Pros and Cons

- Advantages
  - Scalability of hierarchical addressing
  - Efficiency of routing along short paths
- Disadvantages
  - Changes to the end host (e.g., apps, TCP, etc.)
  - … or support from the edge switches
  - Difficulty when both end-points move at once
- Work in progress
  - Used in some data centers, recent standards/projects
  - E.g. Princeton's Serval project (www.serval-arch.org)

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Mobility Today

- Limited network support for mobility
  - E.g., within a single Ethernet subnet
  - E.g., among base stations on a campus
- Applications increasingly robust to mobility
  - Robust to changes in IP address, and disconnections
  - E.g., e-mail client contacting the e-mail server, and allowing reading/writing while disconnected

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Mobility Tomorrow

- Increasing demand for seamless IP mobility
  - E.g., continue a VoIP call while on the train
  - E.g., virtual machine migration within and between data centers
- Increasing integration of WiFi and cellular
  - E.g., multi-homed cell phones that can use both networks
  - E.g., servers with multiple interface cards
- Need better mobility & multi-homing solutions!

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