

Lecture 12: Naming

CSE 123: Computer Networks
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HW 2 due FRIDAY



Lecture 12 Overview



- Discovering addresses (DHCP/ARP)
- User-friendly names (DNS)
- Network address translation (NAT)



Layers of Identifiers

- **Link-layer (MAC) address** (e.g., 58:B0:35:F2:3C:D9)
 - ◆ Used by *network adaptors* to identify interesting frames
 - ◆ Unique, hard-coded identifier “burned into” network adaptor
 - ◆ Flat name space (of 48 bits in Ethernet)
- **IP address** (e.g., 128.54.70.238)
 - ◆ Used by *routers* to forward packets
 - ◆ Unique, topologically meaningful locator
 - ◆ Hierarchical namespace of 32 bits
- **Host name** (e.g., www.ucsd.edu)
 - ◆ Used by *humans* to specify host of interest
 - ◆ Unique, selected by host administrator
 - ◆ Hierarchical, variable-length string of alphanumeric characters

Naming Hierarchy for Scale



- MAC addresses: **58:B0:35:F2:3C:D9**
 - ◆ **OUIs**: assigned to vendors by the IEEE
 - ◆ **Adapters**: assigned by the vendor from its block
- IP addresses: **128.54.70.238**
 - ◆ **Prefixes**: ICANN, regional Internet registries, and ISPs
 - ◆ **Hosts**: static configuration, or dynamic using DHCP
- Host name: **www.ucsd.edu**
 - ◆ **Domain**: registrar for each top-level domain (e.g., .edu)
 - ◆ **Host name**: local administrator assigns to each host

Mapping Between Identifiers



- Address Resolution Protocol (**ARP**)
 - ◆ Given an IP address, provide the MAC address
 - ◆ To enable communication within the Local Area Network
- Dynamic Host Configuration Protocol (**DHCP**)
 - ◆ Automates host boot-up process
 - ◆ Given a MAC address, assign a unique IP address
 - ◆ ... and tell host other stuff about the Local Area Network
- Domain Name System (**DNS**)
 - ◆ Given a host name, provide the IP address
 - ◆ Given an IP address, provide the host name

Address Resolution Protocol



- Every node maintains an **ARP table**
 - ◆ (IP address, MAC address) pair
- Consult the table when sending a packet
 - ◆ Map destination IP address to MAC address
 - ◆ Encapsulate the packet and transmit in a frame
- What if the IP address is not in the table?
 - ◆ (Link-layer) Broadcast: “Who has IP address x.x.x.x?”
 - ◆ Response: “I do! MAC address yy:yy:yy:yy:yy:yy”
 - ◆ Sender caches the result in its ARP table

Whence come IP Addresses?



- You already have a bunch from the days when you called Jon Postel and asked for them (e.g. BBN)
- You get them from another provider
 - ◆ E.g. buy service from Sprint and get a /24 from one of their address blocks
- You get one directly from a routing registry
 - ◆ ARIN: North America, APNIC (Asia Pacific), RIPE (Europe), LACNIC (Latin America), AFRINIC (Africa)
 - ◆ Registries get address from IANA (Internet Assigned Numbers Authority)

How Do You And I Get One?

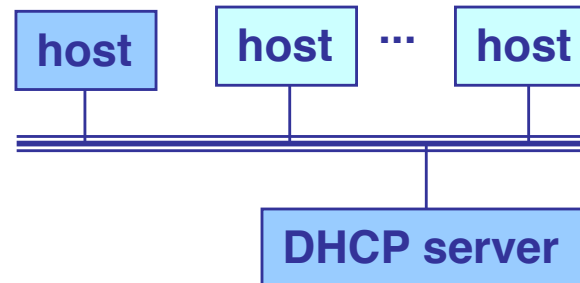


- Well from your provider!
- But how do you know what it is?
- Manual configuration
 - ◆ They tell you and you type that number into your computer (along with the default gateway, DNS server, etc.)
- Automated configuration
 - ◆ Dynamic Host Resolution Protocol (DHCP)



Bootstrapping Problem

- Host doesn't have an IP address yet
 - ◆ So, host doesn't know what source address to use
- Host doesn't know who to ask for an IP address
 - ◆ So, host doesn't know what destination address to use
- Solution: shout to discover a server who can help
 - ◆ Install a special server on the LAN to answer distress calls



DHCP



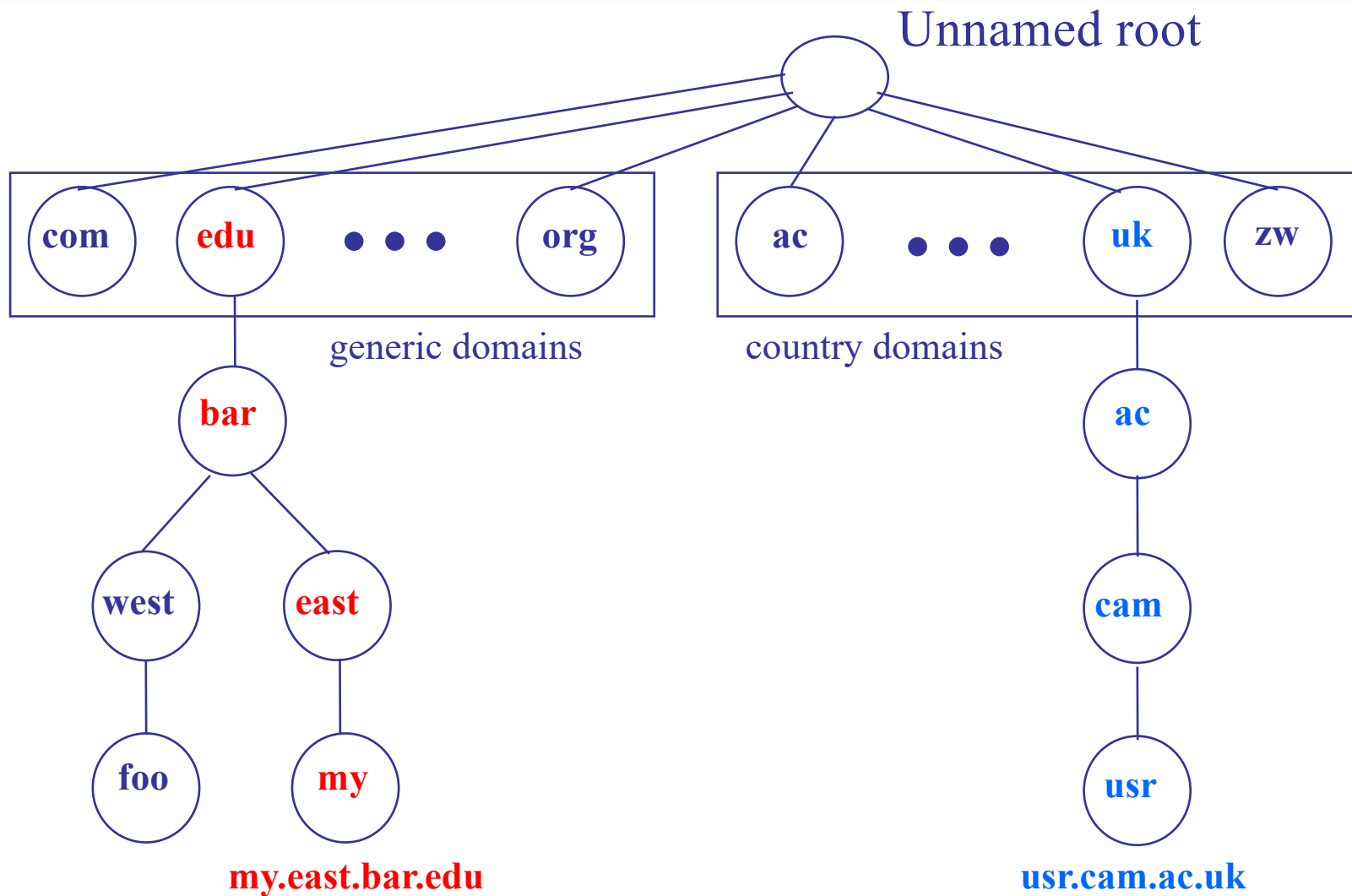
- Broadcast-based LAN protocol
 - ◆ Host broadcasts “DHCP discover” on LAN (e.g. Ethernet broadcast)
 - ◆ DHCP server responds with “DHCP offer” message
 - ◆ Host requests IP address: “DHCP request” message
 - ◆ DHCP server sends address: “DHCP ack” message w/IP address
- Easy to have fewer addresses than hosts (e.g. UCSD wireless) and to *renumber* network (use new addresses)
- What if host goes away (how to get address back?)
 - ◆ Address is a “lease” not a “grant”, has a timeout
 - ◆ Host may have different IP addresses at different times?

Domain Name System (DNS)



- Distributed administrative control
 - ◆ Hierarchical name space divided into zones
 - ◆ Distributed over a collection of DNS servers
- Hierarchy of DNS servers
 - ◆ Root servers
 - ◆ Top-level domain (TLD) servers
 - ◆ Authoritative DNS servers
- Performing the translations
 - ◆ Local DNS servers
 - ◆ Resolver software

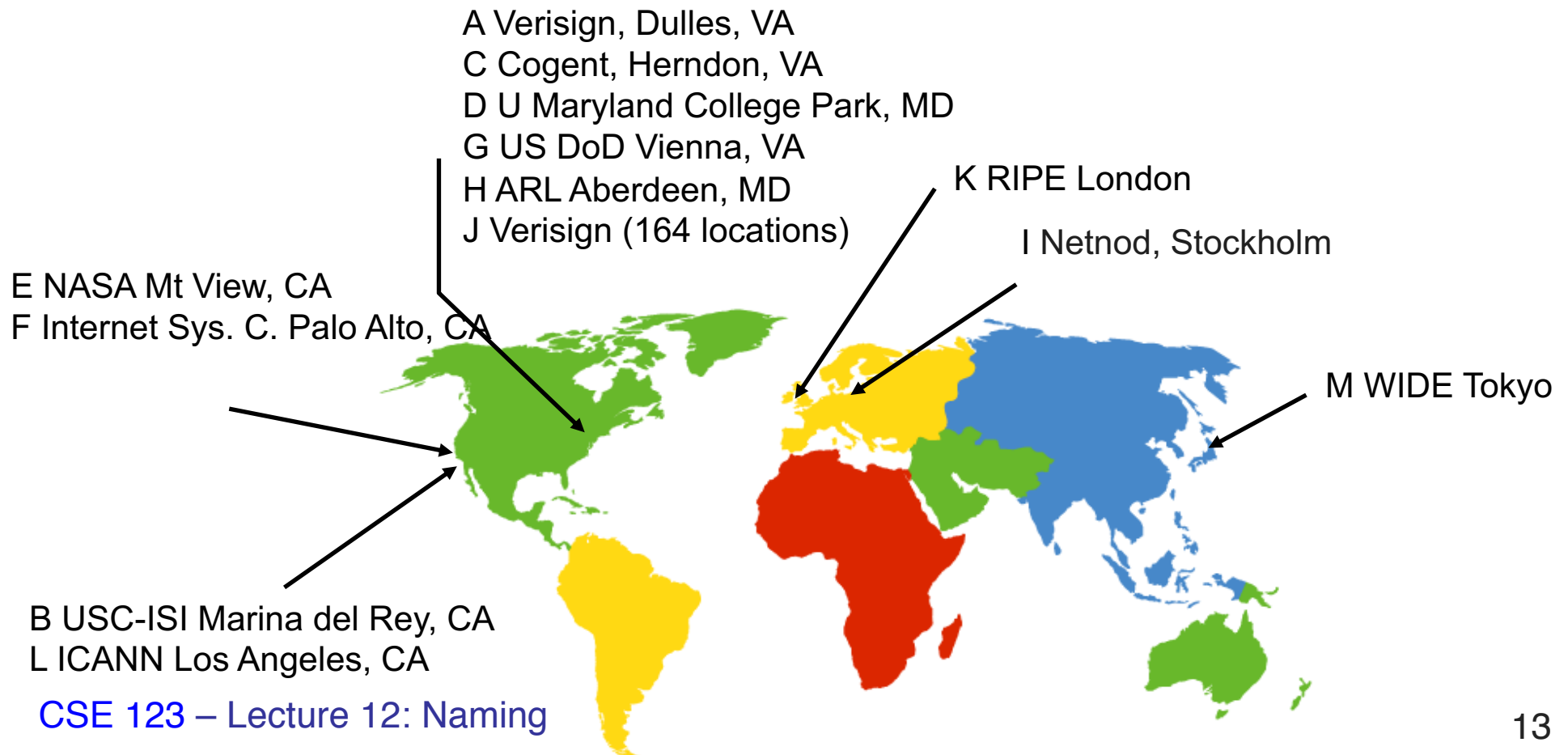
DNS: Distributed Database



DNS Root Servers



- 13 root servers (see <http://www.root-servers.org/>)
 - ◆ Labeled A through M



Using DNS

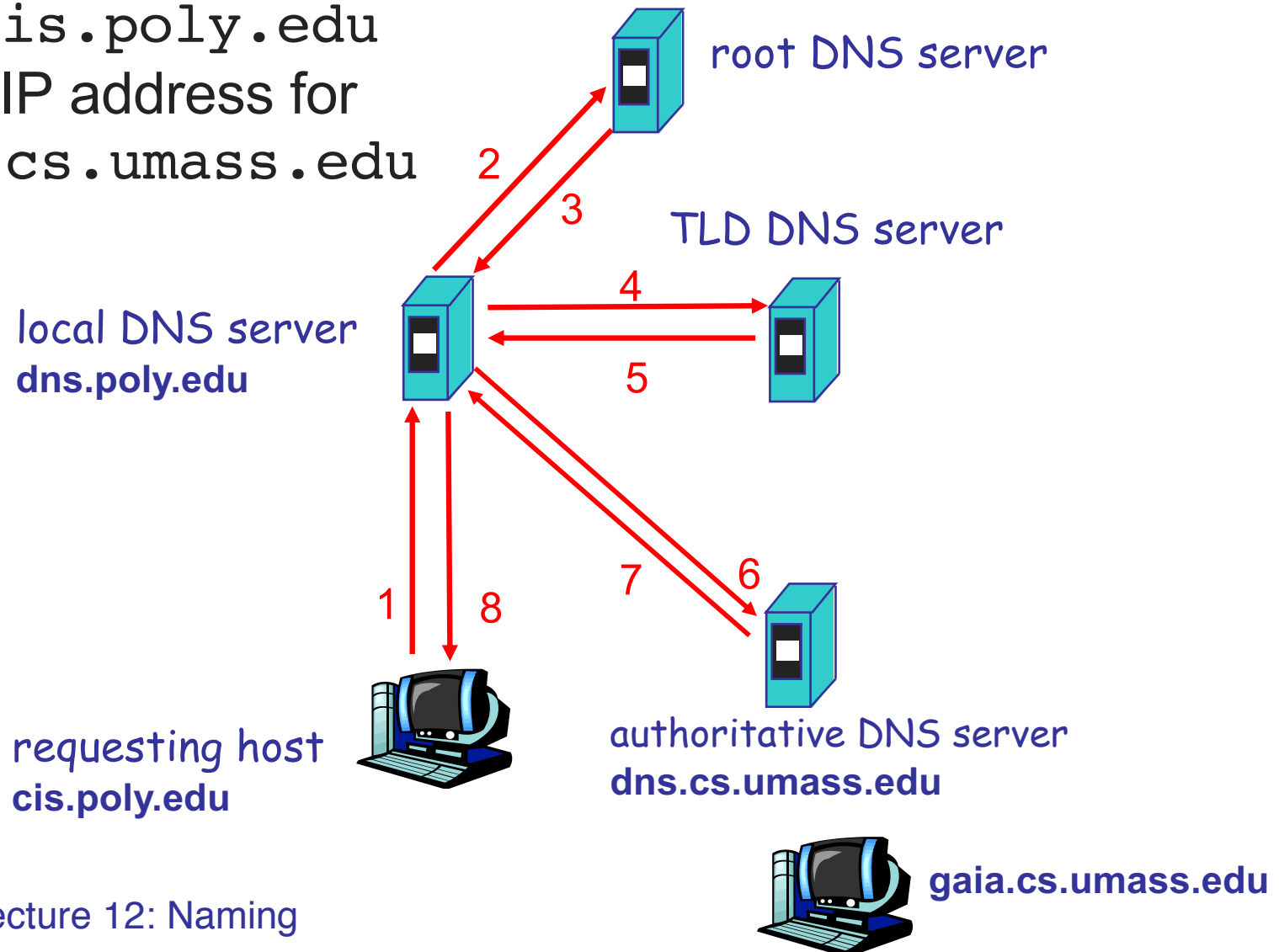


- Local DNS server (“default name server”)
 - ◆ Usually near the end hosts who use it
 - ◆ Local hosts configured with local server (e.g., `/etc/resolv.conf`) or learn the server via DHCP
- Client application
 - ◆ Extract server name (e.g., from the URL)
 - ◆ Do *gethostbyname()* to trigger resolver code
- Server application
 - ◆ Extract client IP address from socket
 - ◆ Optional *gethostbyaddr()* to translate into name

Example



Host at `cis.poly.edu`
wants IP address for
`gaia.cs.umass.edu`



Reliability



- DNS servers are replicated
 - ◆ Name service available if at least one replica is up
 - ◆ Queries can be load balanced between replicas
- UDP used for queries
 - ◆ Need reliability: must implement this on top of UDP
 - ◆ Try alternate servers on timeout
 - ◆ Exponential backoff when retrying same server
- Cache responses to decrease load
 - ◆ Both at end hosts and local servers

Private Address Space



- Sometimes you can't get/don't want IP addresses
 - ◆ An organization wants to change service providers without having to renumber its entire network
 - ◆ A network may be unable obtain (or cannot afford) enough IP addresses for all of its hosts
- IP provides **private address space** anyone can use
 - ◆ 10/8, 192.168/16, 172.16.0/20
 - ◆ These addresses are not routable—Internet routers should drop packets destined to these so-called **bogons**
- What good are they if can't use them on the Internet?

Network Address Translation



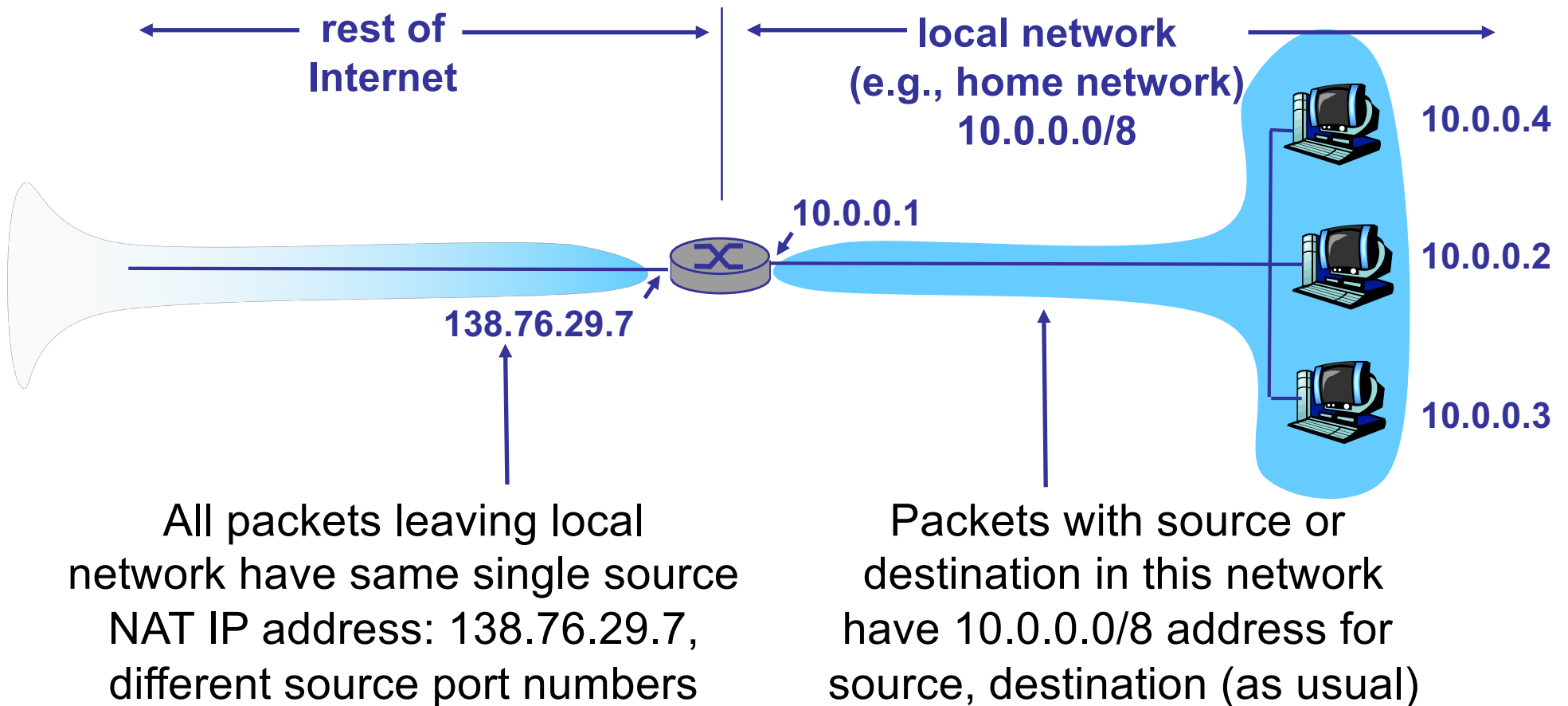
- Gateway router can rewrite IP addresses as packets leave or enter a given network
 - ◆ I.e., replace private addresses with public ones
 - ◆ Router needs to see and update every packet
- Maintains a mapping of private-to-public addresses
 - ◆ Simple case is a one-to-one mapping
 - ◆ Anytime network changes provider, just update mapping table
 - ◆ In more clever scenarios, can map a set of private addresses to a smaller set of public addresses
 - ◆ In the extreme map the entire private network to one public IP!

IP Masquerading

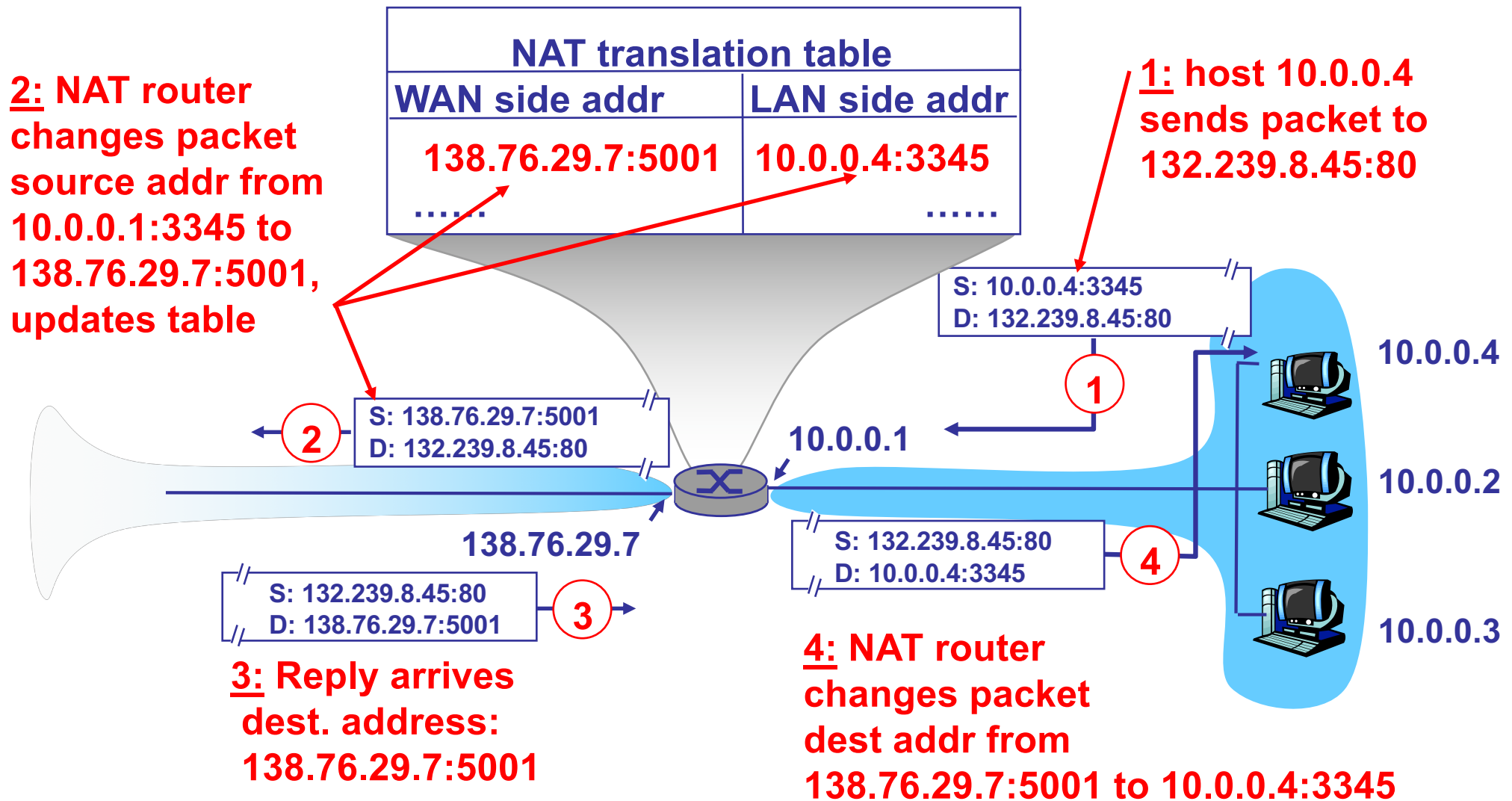


- A.K.A. Network Address and port Translation (NAT), Port Address Translation (PAT), or, colloquially, just NAT.
- Entire local network uses just one IP address as far as outside world is concerned:
 - ◆ can change addresses of devices in local network without notifying outside world
 - ◆ can change ISP without changing addresses of devices in local network
 - ◆ devices inside local net not explicitly addressable, visible by outside world (a security plus).

A NAT'd Network



NA(p)T Example



NAT Challenges



- End hosts may not be aware of external IP address
 - ◆ Some applications include IP addresses in application data
 - ◆ Packets will contain private IP addresses inside payload
 - ◆ Many NATs will inspect/rewrite certain protocols, e.g., FTP
- NAT'd end hosts are not reachable from the Internet
 - ◆ All connections must be initiated from within private network
 - ◆ Alternative is to configure fixed forwarding in NAT
 - ◆ Many protocols for [NAT traversal](#) to get around this

Summary



- IP to MAC Address mapping
 - ◆ Dynamic Host Configuration Protocol (DHCP)
 - ◆ Address Resolution Protocol (ARP)
- Domain Name System
 - ◆ Distributed, hierarchical database
 - ◆ Distributed collection of servers
 - ◆ Caching to improve performance

For Next Time



- Homework 2 due at beginning of next class
- Finish up Project 1; due next MONDAY!
- Midterm a week from today