


Computer Networks

CMSC 417 : Spring 2024

COMPUTER SCIENCE
UNIVERSITY OF MARYLAND

Topic: Internetworking: DHCP, NAT, ARP, ICMP (Textbook chapter 3)

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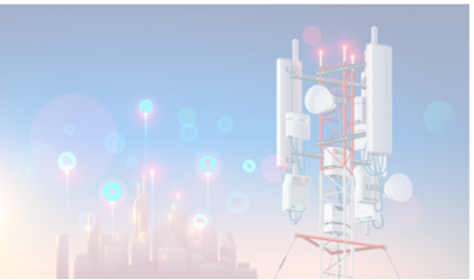
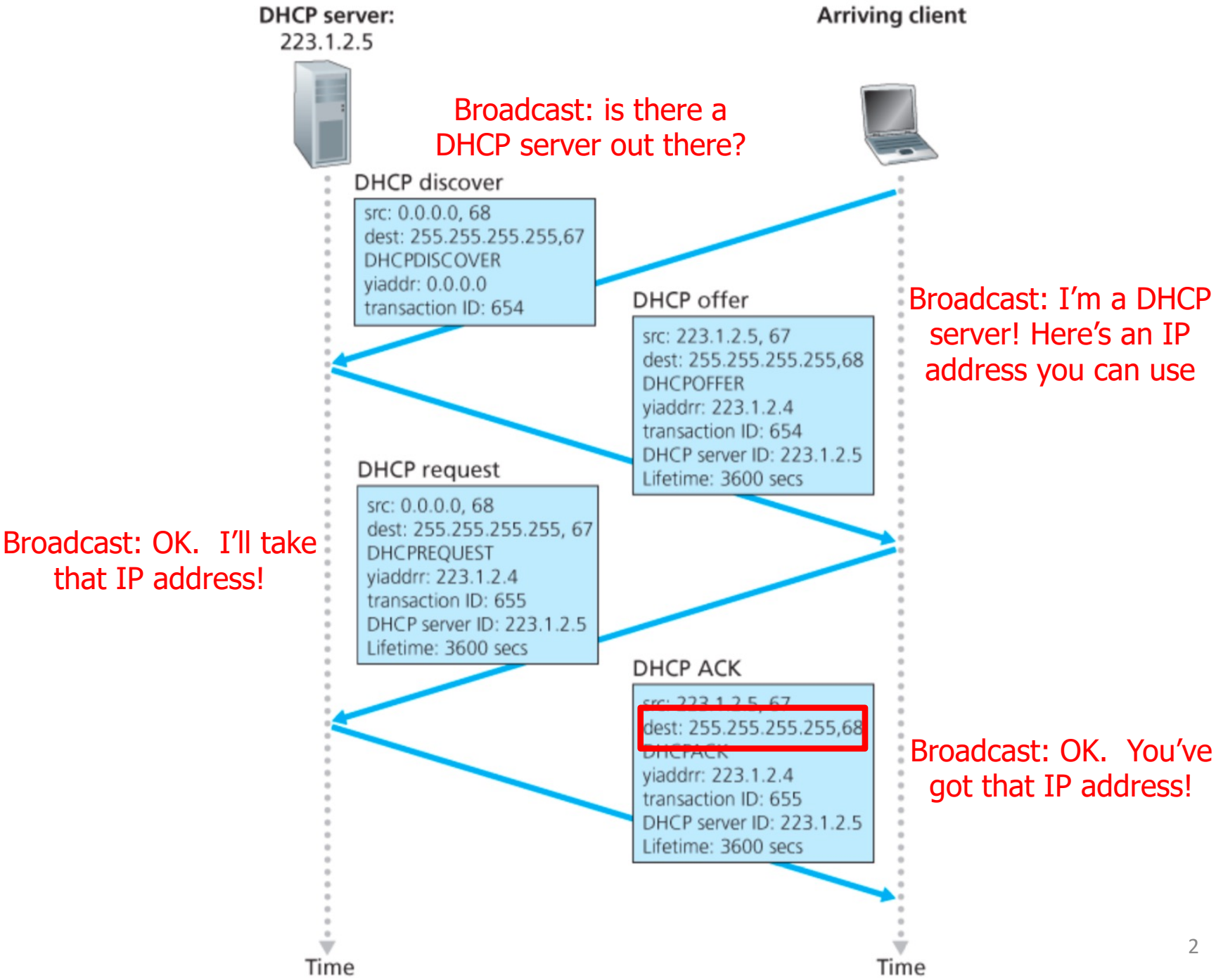
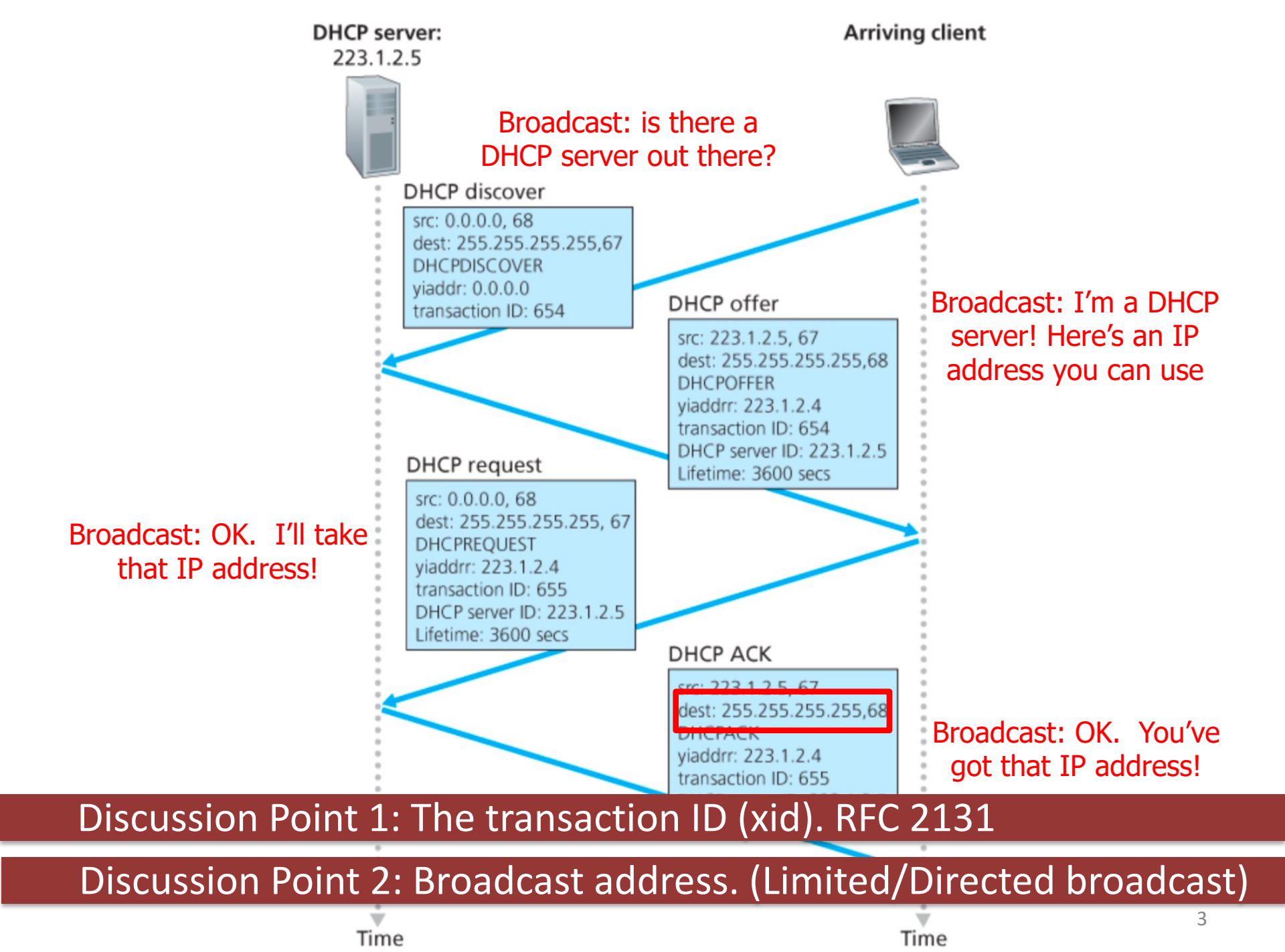
Tu-Th 2:00-3:15pm
CSI 2117

Feb 29th, 2024





DHCP server:
223.1.2.5
Arriving client
Broadcast: is there a DHCP server out there?
DHCP discover
src: 0.0.0.0, 68
dest: 255.255.255.255,67
DHCPDISCOVER
yiaddr: 0.0.0.0
transaction ID: 654
DHCP offer
src: 223.1.2.5, 67
dest: 255.255.255.255,68
DHCPOFFER
yiaddrr: 223.1.2.4
transaction ID: 654
DHCP server ID: 223.1.2.5
Lifetime: 3600 secs
Broadcast: I'm a DHCP server! Here's an IP address you can use
DHCP request
src: 0.0.0.0, 68
dest: 255.255.255.255, 67
DHCPREQUEST
yiaddrr: 223.1.2.4
transaction ID: 655
DHCP server ID: 223.1.2.5
Lifetime: 3600 secs
Broadcast: OK. I'll take that IP address!
DHCP ACK
dest: 255.255.255.255,68
yiaddrr: 223.1.2.4
transaction ID: 655
DHCP server ID: 223.1.2.5
Lifetime: 3600 secs
Broadcast: OK. You've got that IP address!
Time
Time



Discussion Point 1: The transaction ID (xid). RFC 2131

Discussion Point 2: Broadcast address. (Limited/Directed broadcast)

DHCP: more than IP addresses

DHCP can return more than just allocated IP address on subnet:

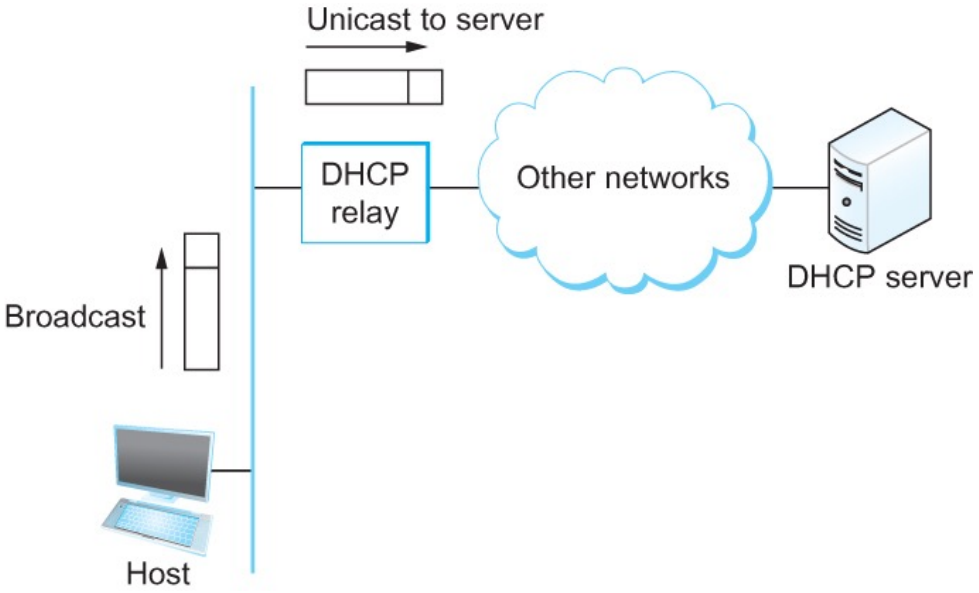
- address of first-hop router for client
- name and IP address of DNS sever
- network mask (indicating network versus host portion of address)

Dynamic Host Configuration Protocol (DHCP)

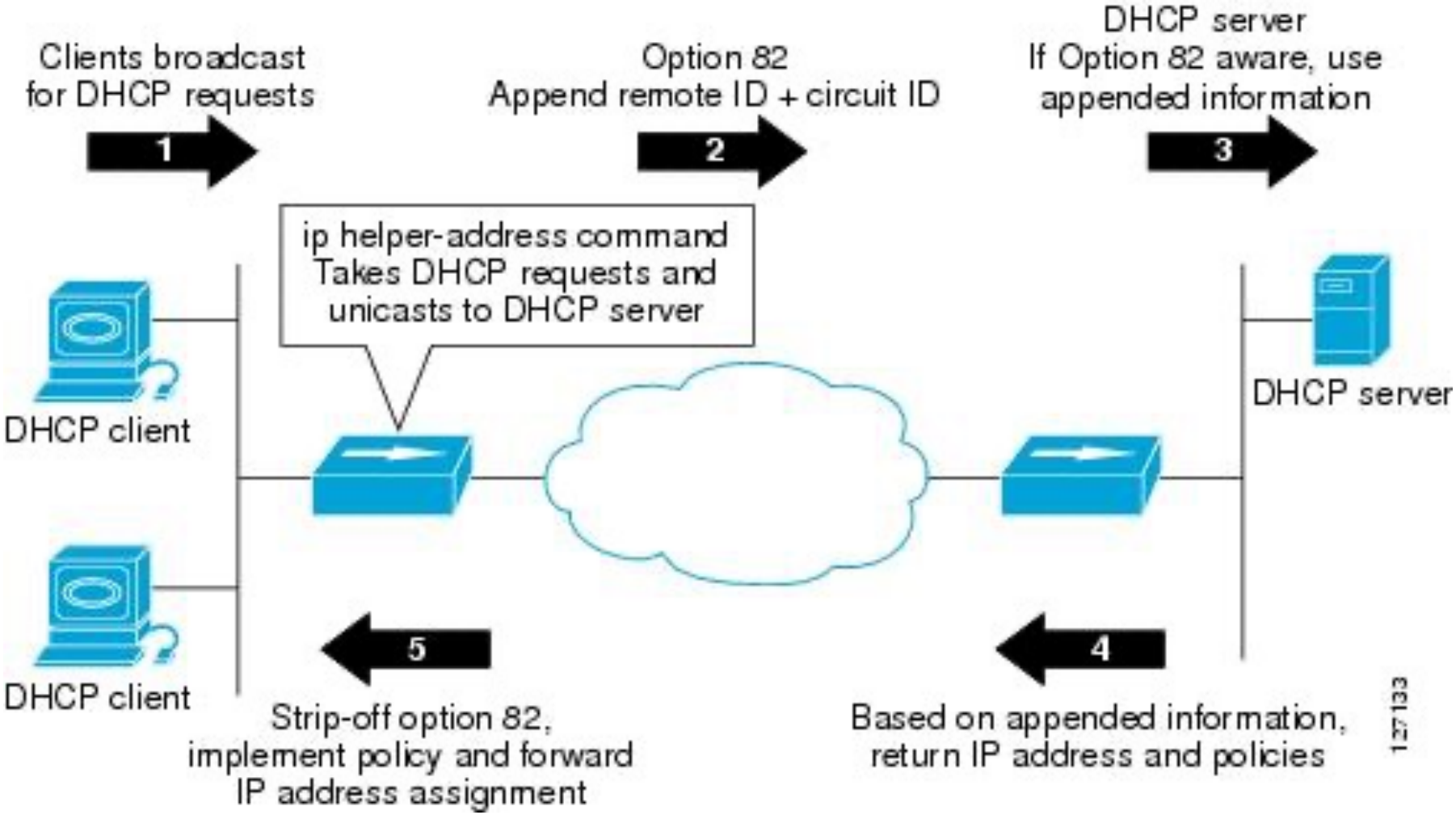
- DHCP server is responsible for providing configuration information to hosts
- DHCP server maintains a pool of available addresses
- There is at least one DHCP server for an administrative domain (a server or a relay agent per subnet)

DHCP relay

- Newly booted or attached host sends DHCPDISCOVER message to a special IP address (255.255.255.255)
- DHCP relay agent unicasts the message to DHCP server and waits for the response



DHCP relay


Clients broadcast
for DHCP requests
1
Option 82
Append remote ID + circuit ID
2
DHCP server
If Option 82 aware, use
appended information
3
ip helper-address command
Takes DHCP requests and
unicasts to DHCP server
DHCP client
DHCP client
DHCP server
5
4
Strip-off option 82,
implement policy and forward
IP address assignment
Based on appended information,
return IP address and policies
127133

Check your IP addresses
(ifconfig/ipconfig)

```
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        ether 38:f9:d3:21:07:2a
        inet6 fe80::c84:8160:88c8:ea96%en0 prefixlen 64 secured scopeid 0xa
        inet 10.104.215.30 netmask 0xfffff000 broadcast 10.104.223.255
        nd6 options=201<PERFORMNUD,DAD>
        media: autoselect
        status: active
```

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Private Address Space
&
NAT

ARIN
American Registry for Internet Numbers

Search Site or Whois

IP Addresses & ASNs | Policy & Participation | Reference & Tools | About

Home > Reference & Tools > Research > Statistics & Reporting > IPv4 Private Address Space and Filtering

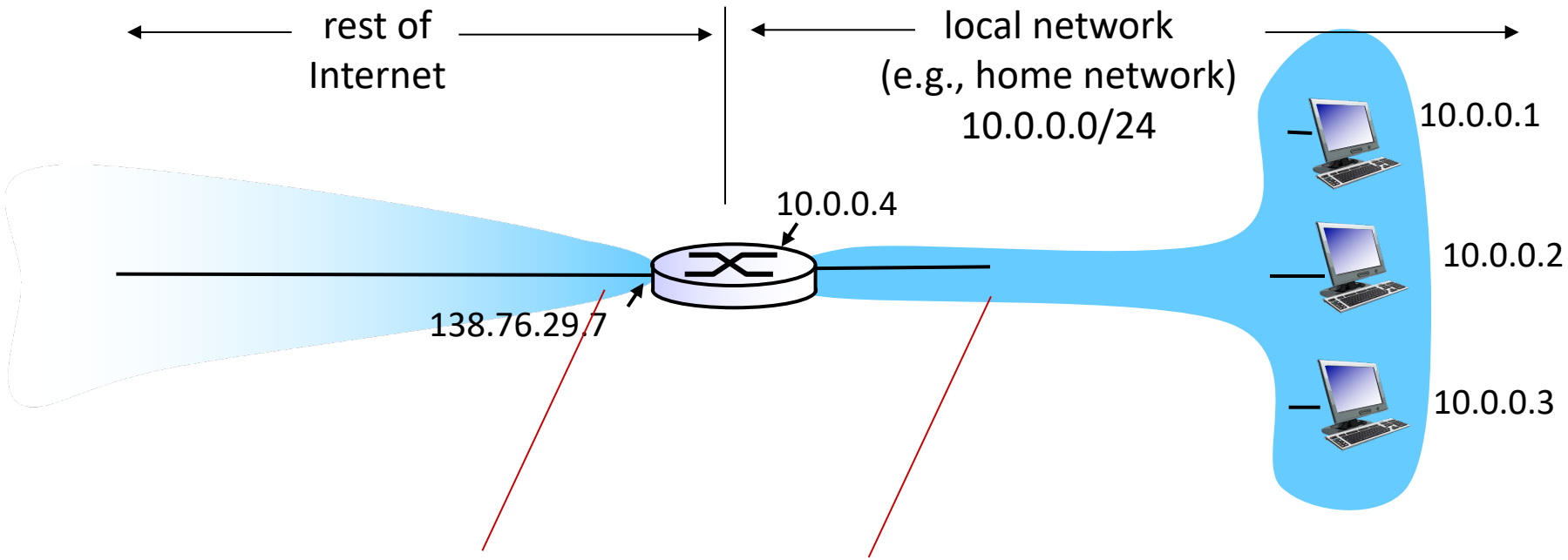
IPv4 Private Address Space and Filtering

According to standards set forth in Internet Engineering Task Force (IETF) document RFC-1918, the following IPv4 address ranges are reserved by the IANA for private internets, and are *not* publicly routable on the global internet:

- **10.0.0.0/8 IP addresses:** 10.0.0.0 – 10.255.255.255
- **172.16.0.0/12 IP addresses:** 172.16.0.0 – 172.31.255.255
- **192.168.0.0/16 IP addresses:** 192.168.0.0 – 192.168.255.255

Note that only a *portion* of the "172" and the "192" address ranges are designated for private use. The remaining addresses are considered "public," and thus are routable on the global Internet.

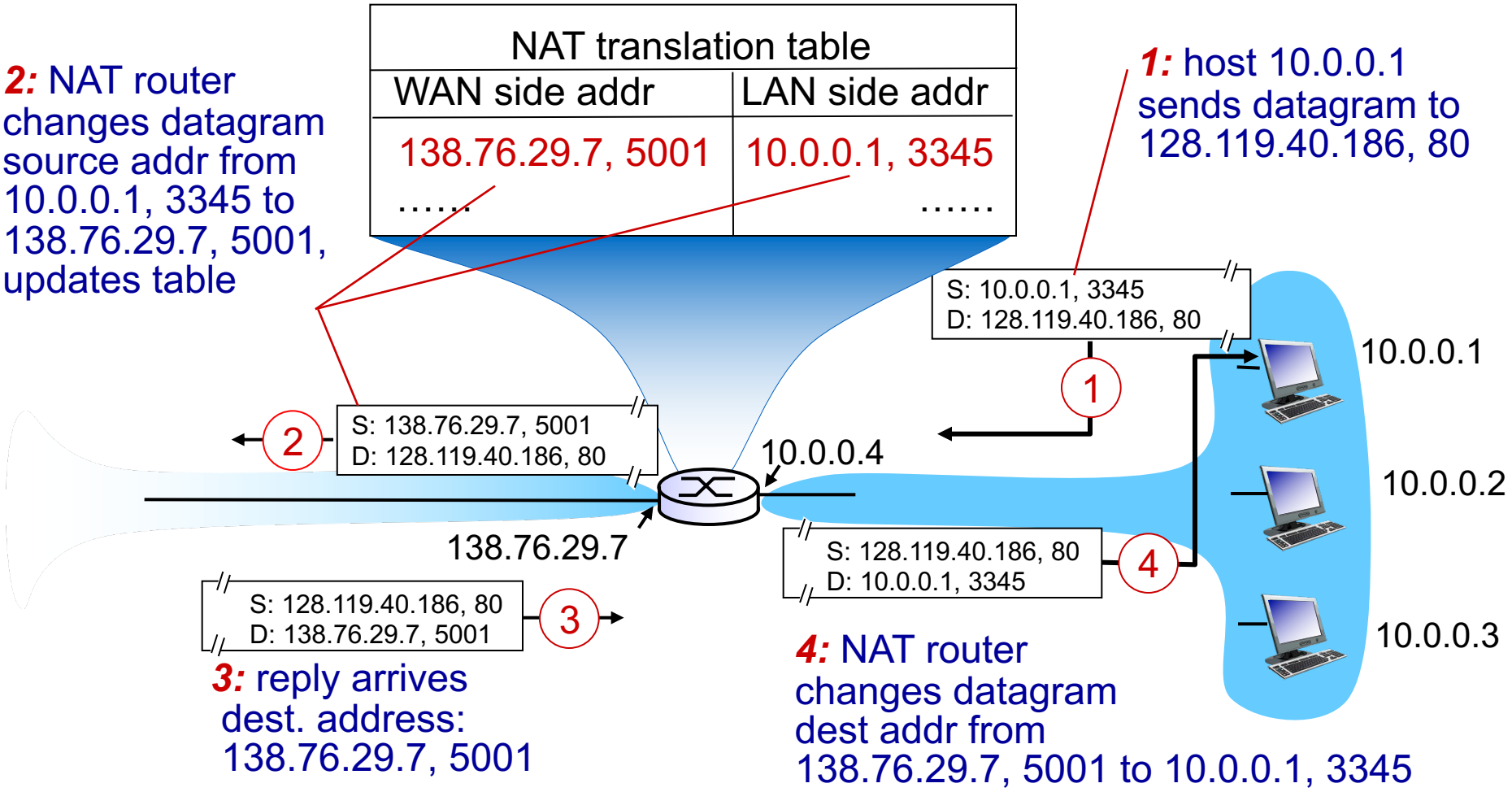
NAT: network address translation



all datagrams *leaving* local network have *same* single source NAT IP address: 138.76.29.7,different source port numbers

datagrams with source or destination in this network have 10.0.0.0/24 address for source, destination (as usual)

NAT: network address translation



NAT: network address translation

motivation: local network uses just one IP address as far as outside world is concerned:

- range of addresses not needed from ISP: just one IP address for all devices
- 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)

NAT: network address translation

implementation: NAT router must:

- *outgoing datagrams: replace* (source IP address, port #) of every outgoing datagram to (NAT IP address, new port #)

  . . . remote clients/servers will respond using (NAT IP address, new port #) as destination addr

- *remember (in NAT translation table)* every (source IP address, port #) to (NAT IP address, new port #) translation pair

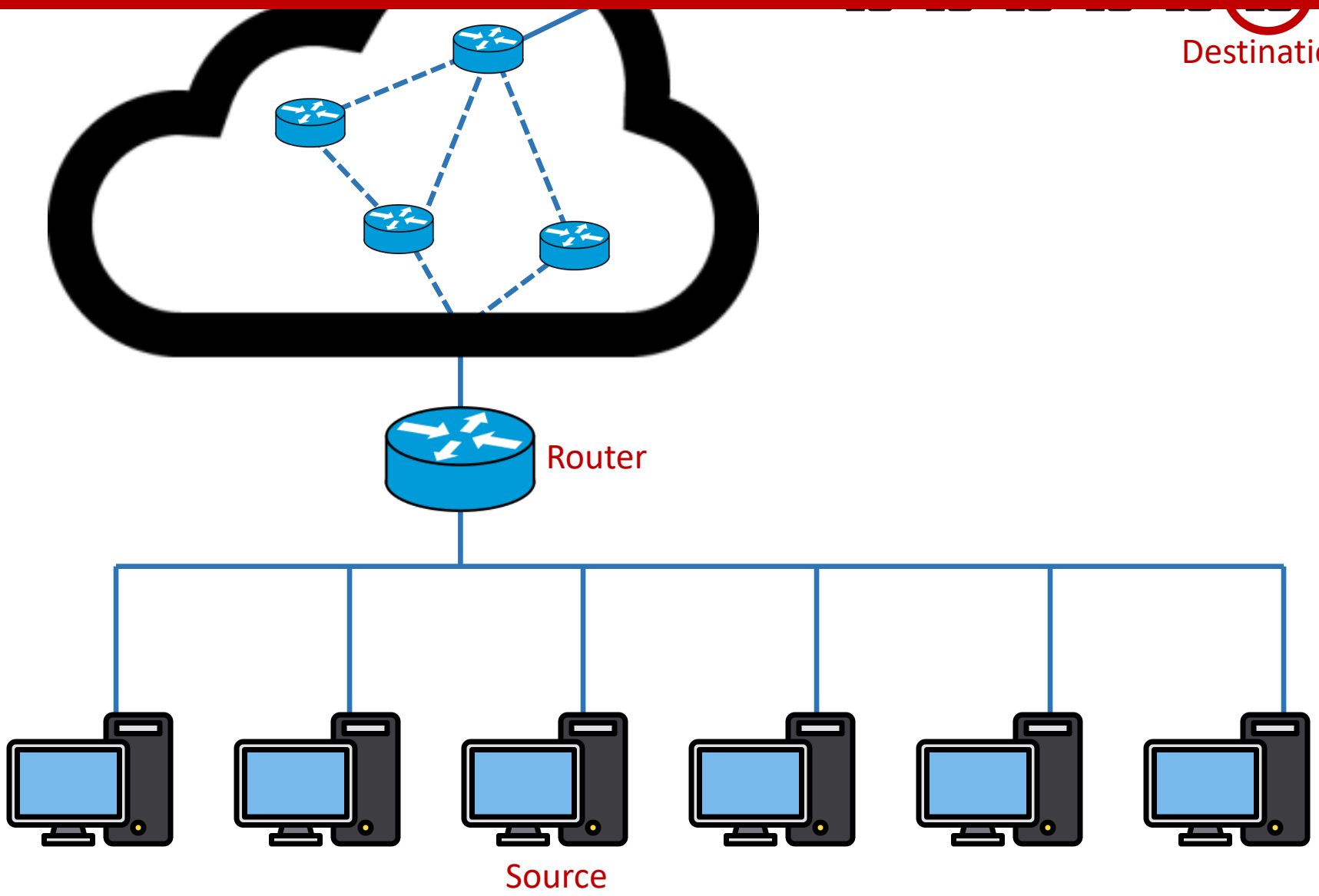
- *incoming datagrams: replace* (NAT IP address, new port #) in dest fields of every incoming datagram with corresponding (source IP address, port #) stored in NAT table

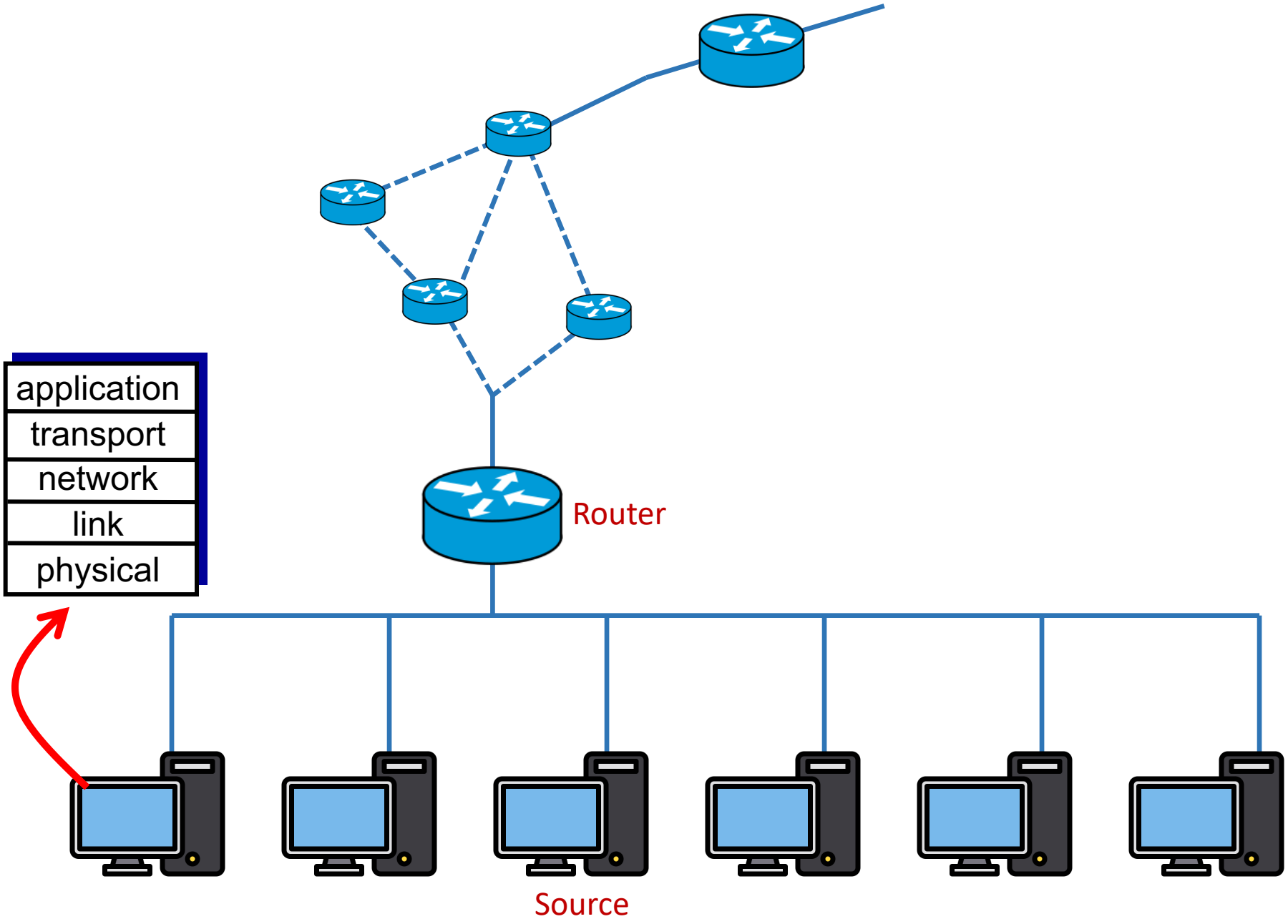
NAT: network address translation

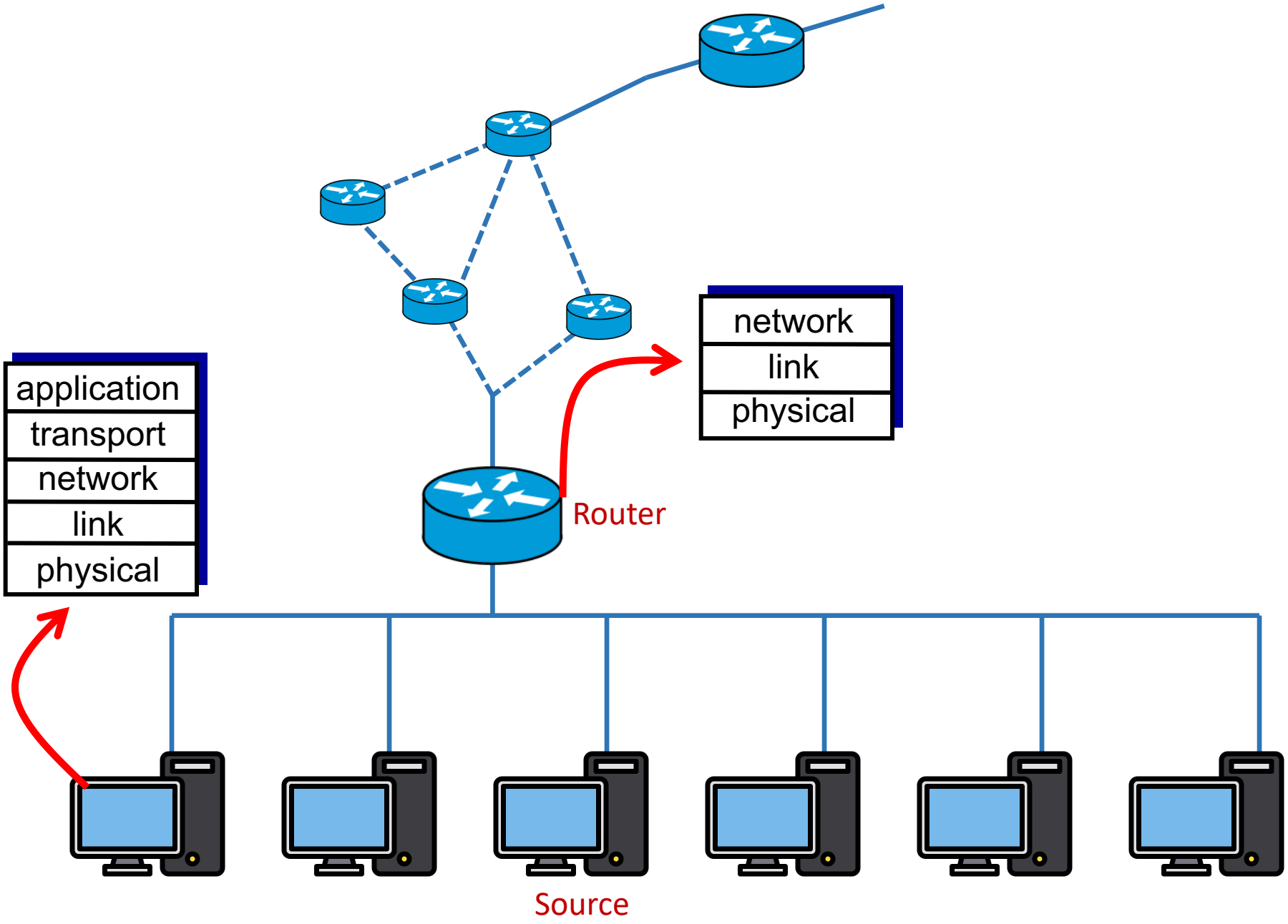
- 16-bit port-number field:
  - Over 60,000 simultaneous connections with a single LAN-side address!
- NAT challenges:
  - violates end-to-end argument
    - NAT possibility must be taken into account by app designers, e.g., P2P applications
  - NAT traversal: what if client wants to connect to server behind NAT?

Network-specific address (IP address) vs LAN-specific address (HW address)

Two perspectives of addresses: (1)Network-to-network & (2)machine-to-machine




application
transport
network
link
physical
Router
Source


application
transport
network
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physical
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link
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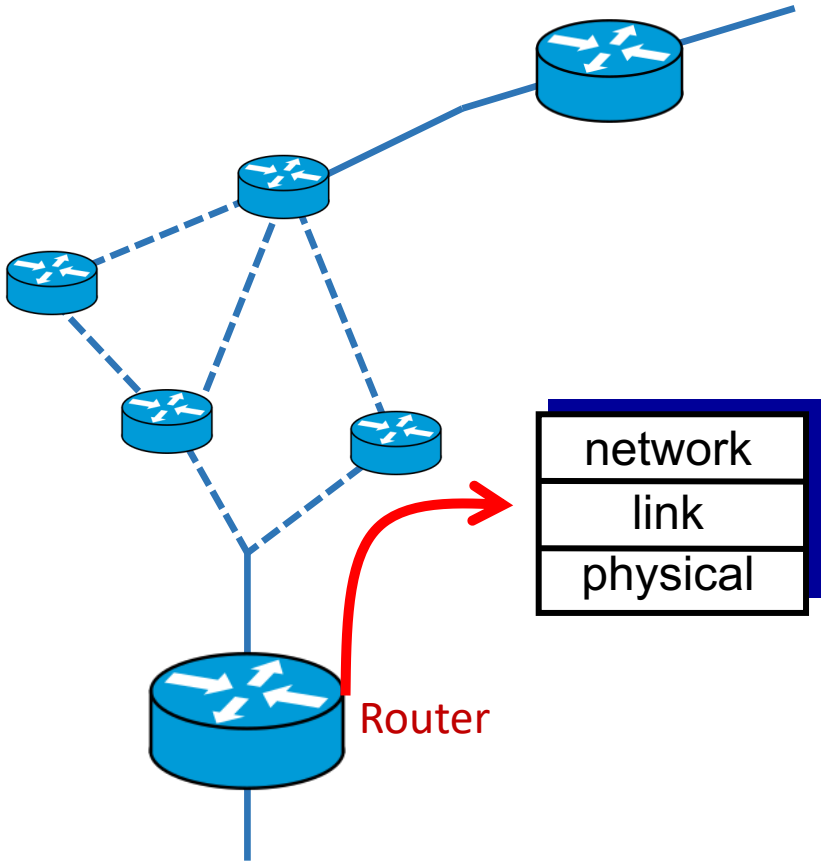
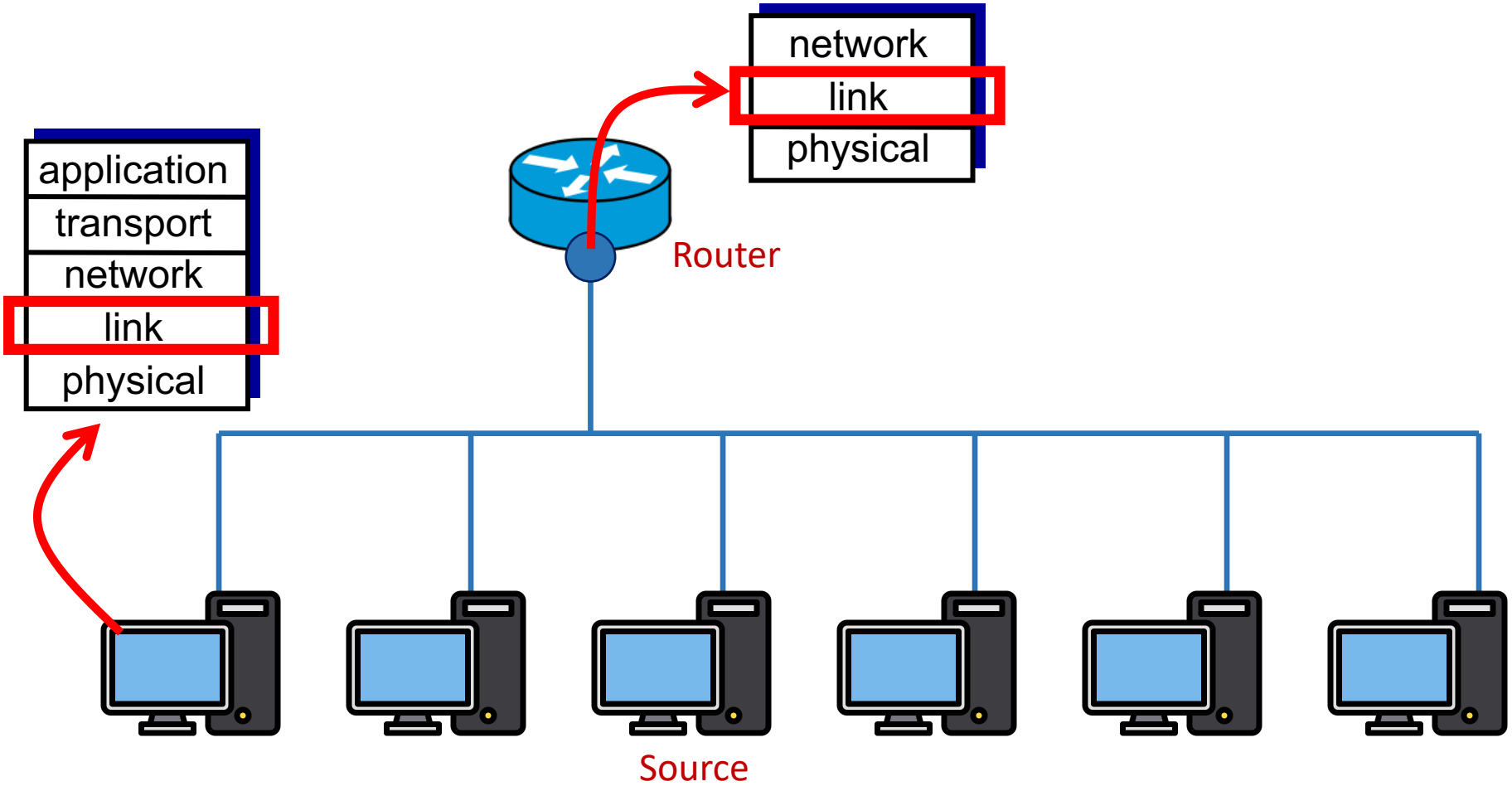
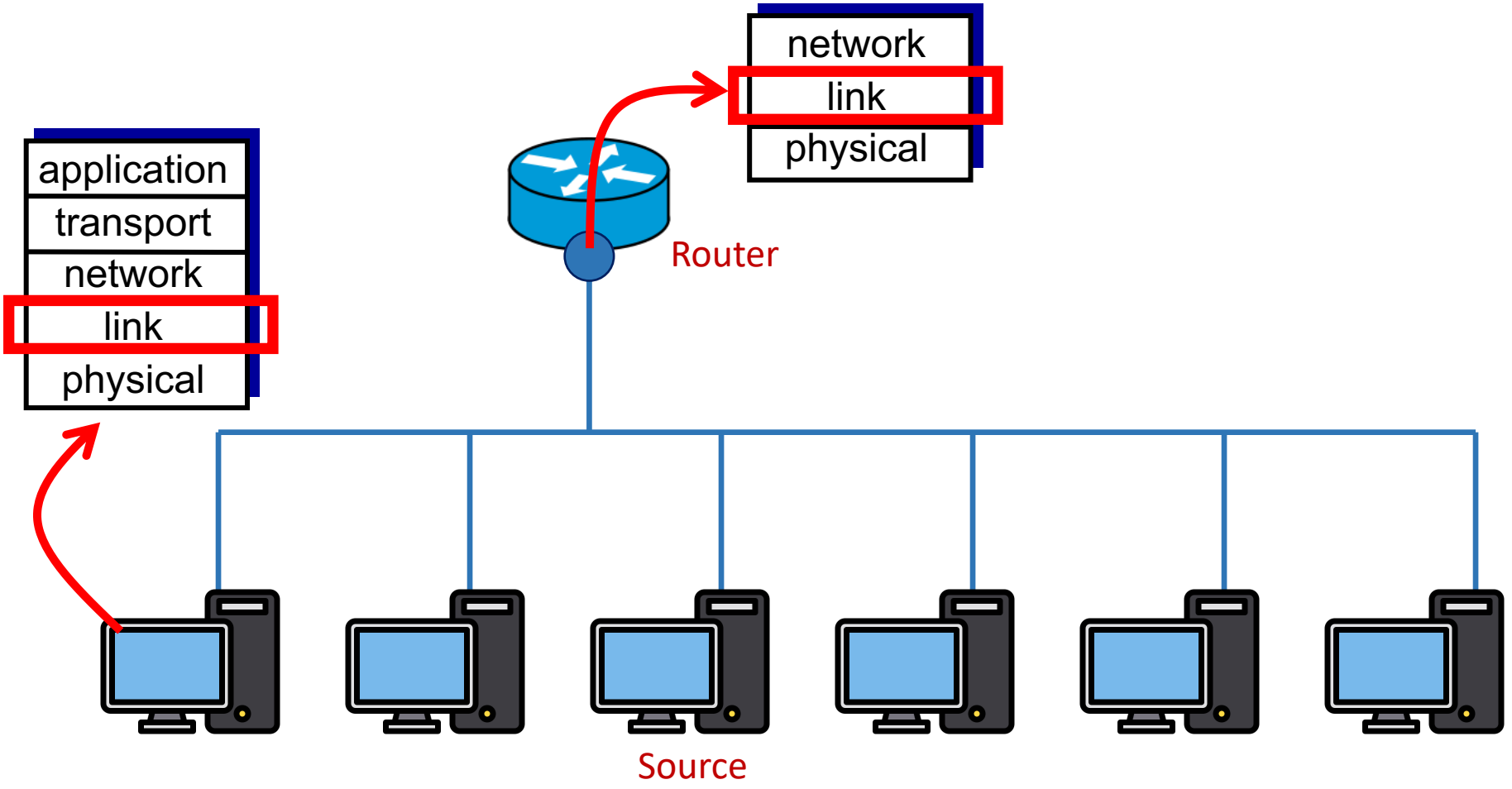
Router
Source



Hierarchical address for addressing networks
(IP address)


network
link
physical
application
transport
network
link
physical
Router
Source

Flat address for addressing machines at the link-layer (MAC address)



Address Resolution Protocol (ARP)

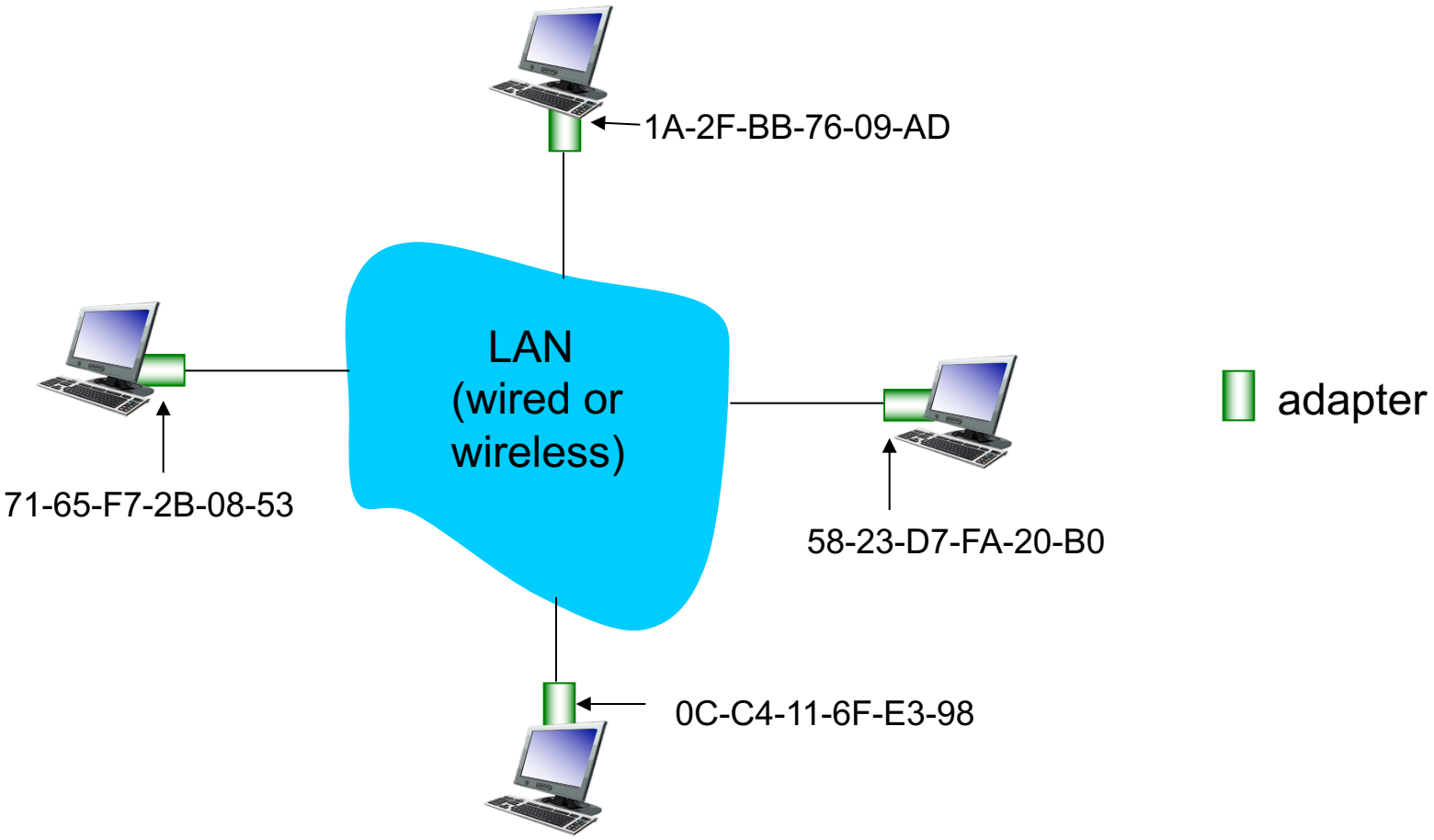
MAC addresses and ARP

- 32-bit IP address:
  - *network-layer* address for interface
  - used for layer 3 (network layer) forwarding
- MAC (or LAN or physical or Ethernet) address:
  - function: *used "locally" to get frame from one interface to another physically-connected interface (same network, in IP-addressing sense)*
  - 48 bit MAC address (for most LANs) burned in NIC ROM, also sometimes software settable
  - e.g.: 1A-2F-BB-76-09-AD

hexadecimal (base 16) notation
(each "numeral" represents 4 bits)

MAC addresses and ARP

each adapter on LAN has unique *LAN* addr. or MAC addr.

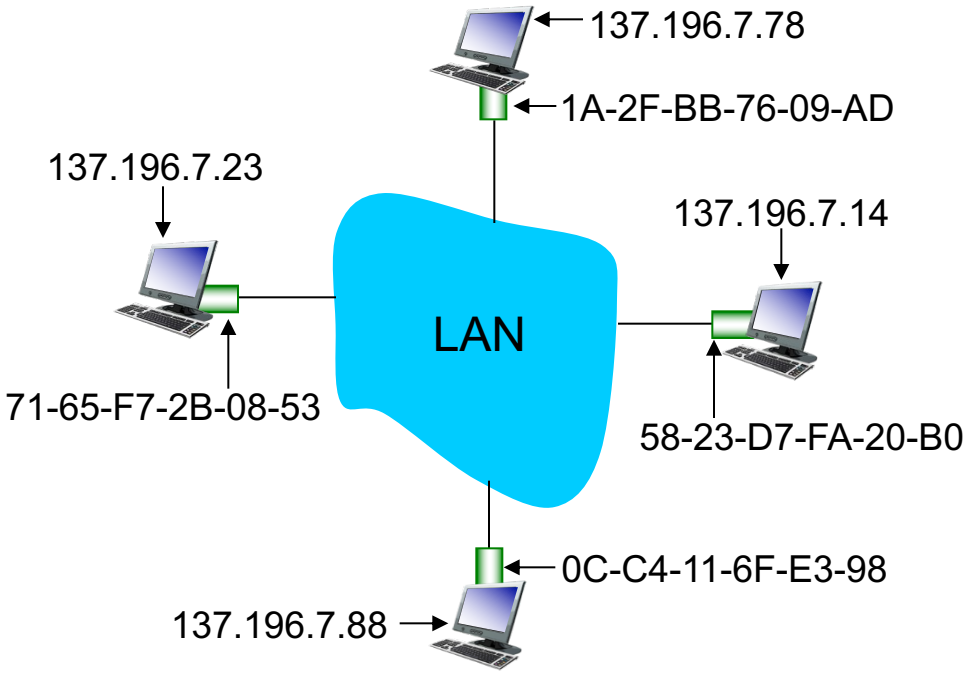


MAC addresses (more)

- MAC address allocation administered by IEEE
- manufacturer buys portion of MAC address space (to assure uniqueness)
- analogy:
  - MAC address: like Social Security Number
  - IP address: like postal address
- MAC flat address ➜ portability
  - can move LAN card from one LAN to another
- IP hierarchical address *not* portable
  - address depends on IP subnet to which node is attached

ARP: address resolution protocol

Question: how to determine interface's MAC address, knowing its IP address?



ARP table: each IP node (host, router) on LAN has table

- IP/MAC address mappings for some LAN nodes:

  < IP address; MAC address; TTL>

- TTL (Time To Live): time after which address mapping will be forgotten (typically 20 min)

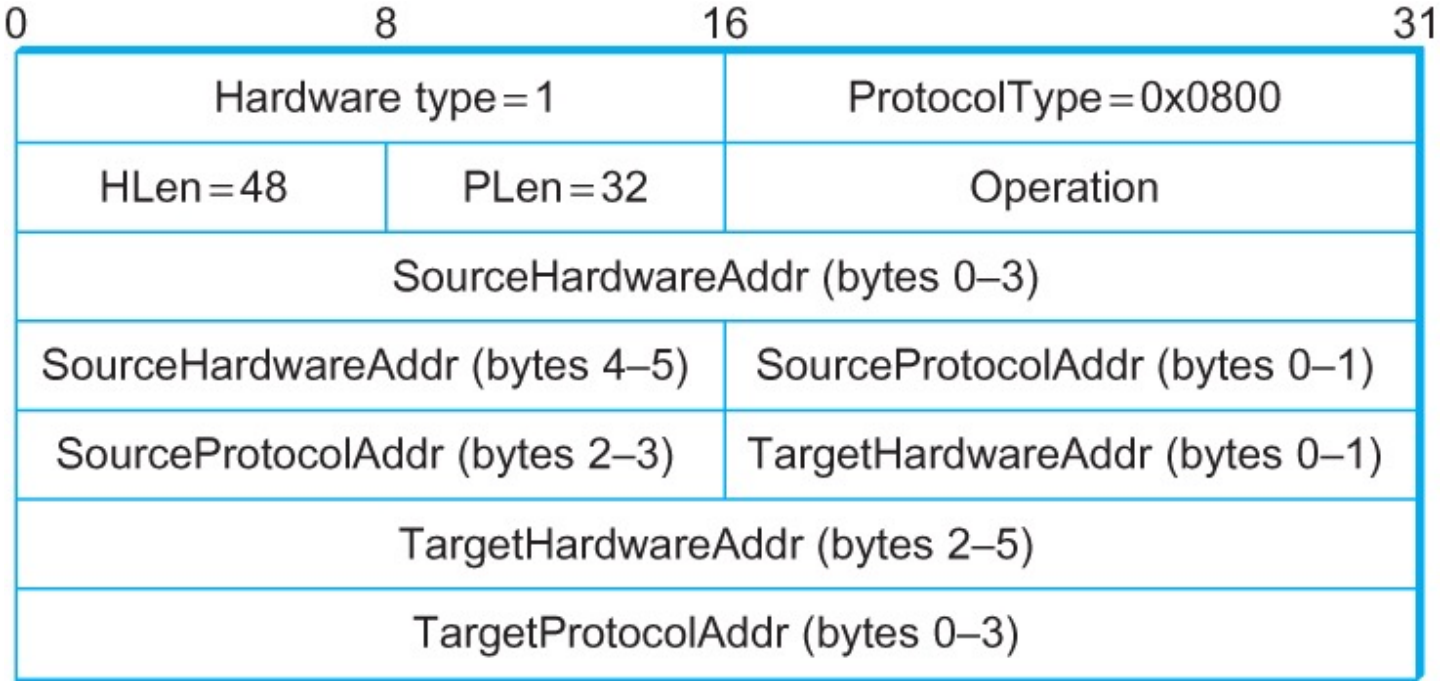
ARP protocol: same LAN

1. A wants to send datagram to B
   - B's MAC address not in A's ARP table.
2. A broadcasts ARP query packet, containing B's IP address
   - destination MAC address = FF-FF-FF-FF-FF-FF
   - all nodes on LAN receive ARP query
3. B receives ARP packet, replies to A with its (B's) MAC address
   - frame sent to A's MAC address (unicast)
4. A caches (saves) IP-to-MAC address pair in its ARP table until information becomes old (times out)
   - soft state: information that times out (goes away) unless refreshed
5. ARP is "plug-and-play":
   - nodes create their ARP tables *without intervention from net administrator*

Address Translation Protocol (ARP)

- Map IP addresses into physical addresses
  - destination host
  - next hop router
- Techniques
  - encode physical address in host part of IP address
  - table-based
- ARP (Address Resolution Protocol)
  - table of IP to physical address bindings
  - broadcast request if IP address not in table
  - target machine responds with its physical address
  - table entries are discarded if not refreshed
  - Query message include the physical address of the sending host. Why?

ARP Packet Format



- HardwareType: type of physical network (e.g., Ethernet)
- ProtocolType: type of higher layer protocol (e.g., IP)
- HLEN & PLEN: length of physical and protocol addresses
- Operation: request or response
- Source/Target Physical/Protocol addresses