

# Simple Internetworking: Address Translation

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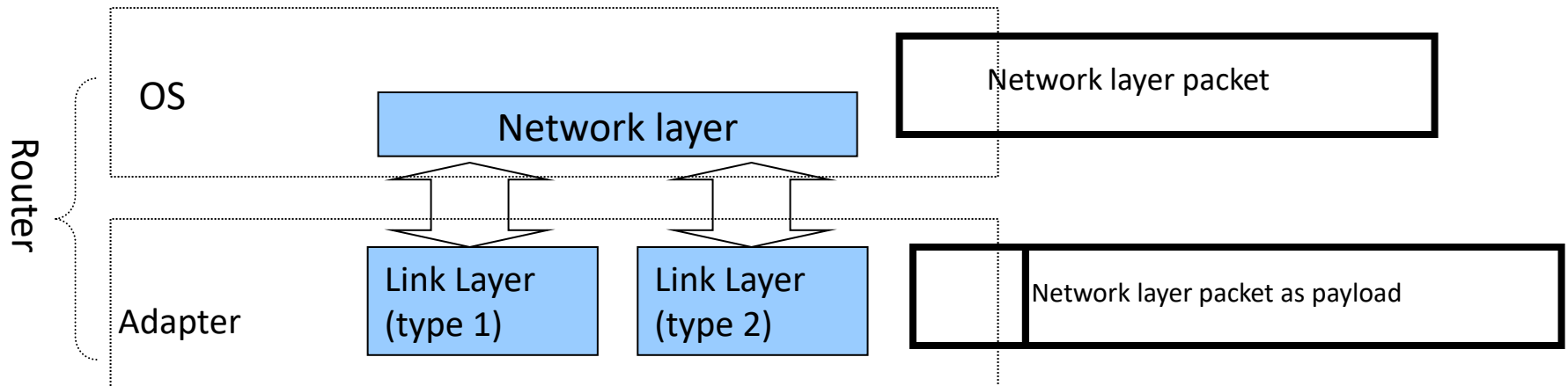
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# Outline

- Topic: internetworking
  - Case study: Internet Protocol (IP) Suite
- Simple interworking
  - Overview of **i**nternet and the **I**nternet
  - Global addressing scheme
  - Best effort service model and datagram forwarding
  - Packet fragmentation and assembly
  - **Address translation**
  - Host configuration
  - Error reporting

# Network Layer and Lower Layers

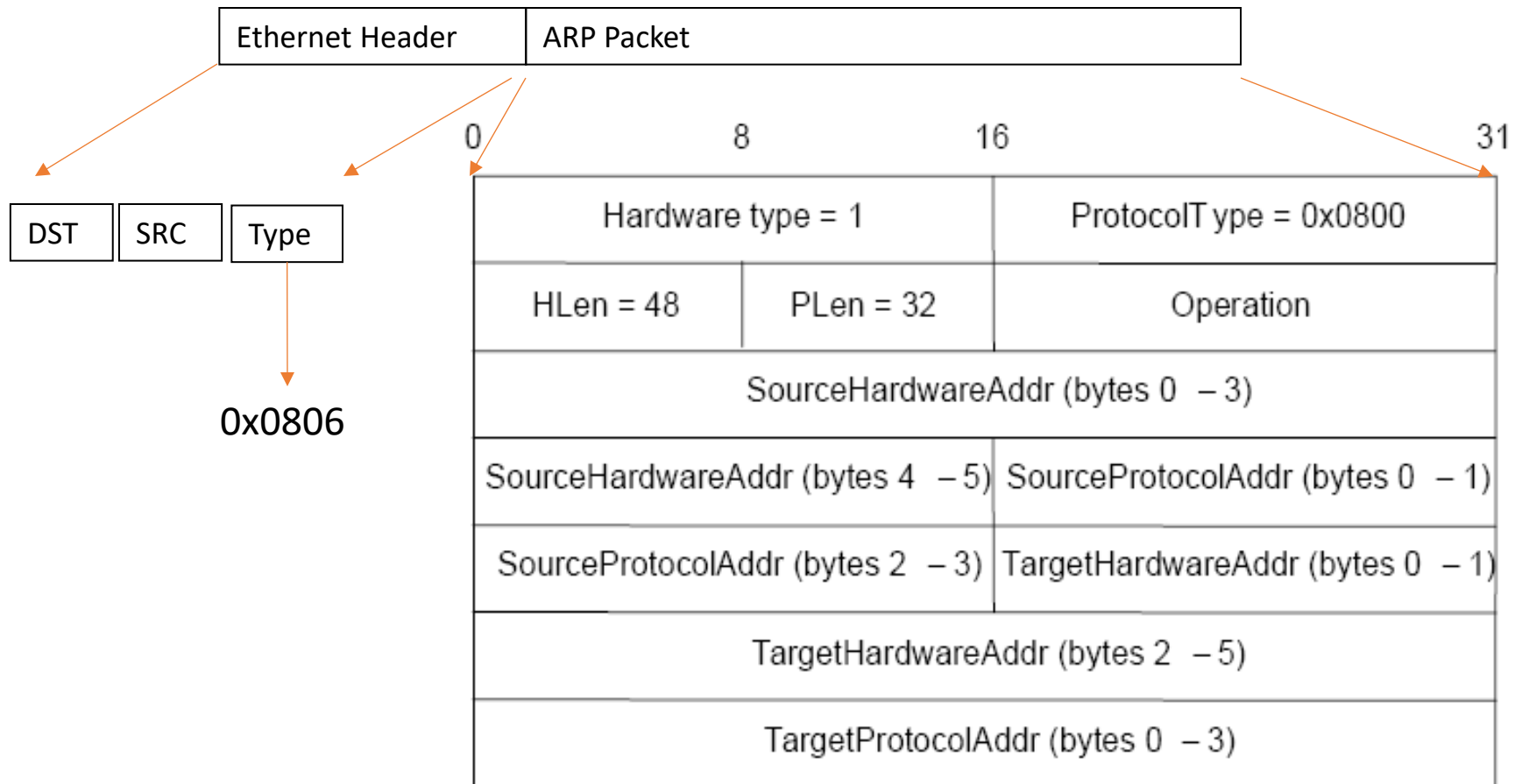


# Map IP Addresses into Physical Addresses

- 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

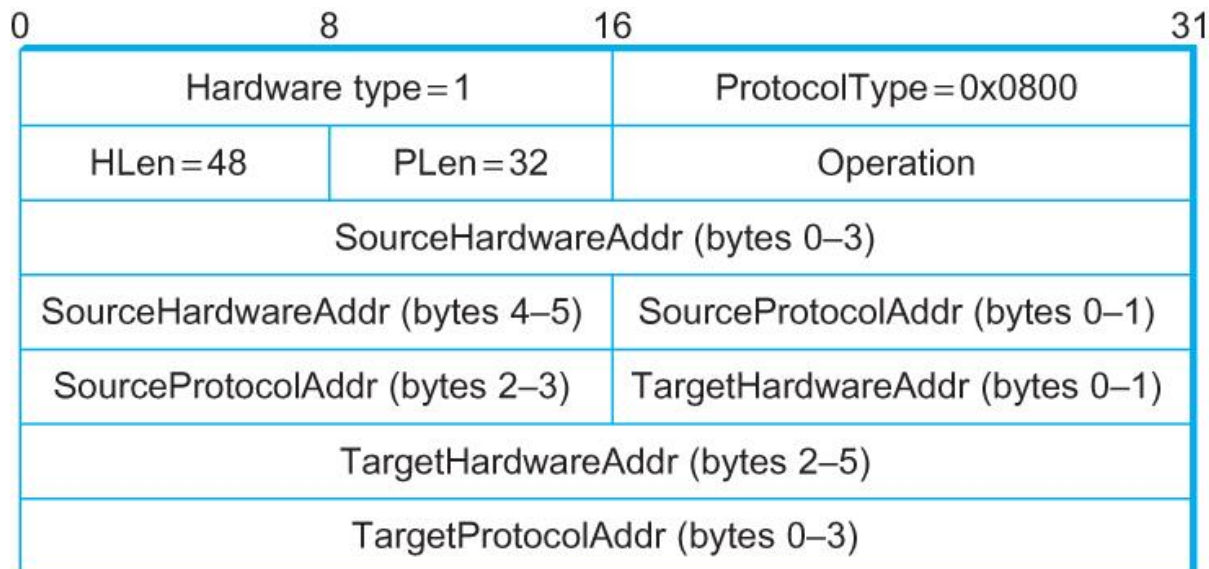
# ARP Packet Format

- An ARP packet is the payload of a frame



# ARP Packet Format

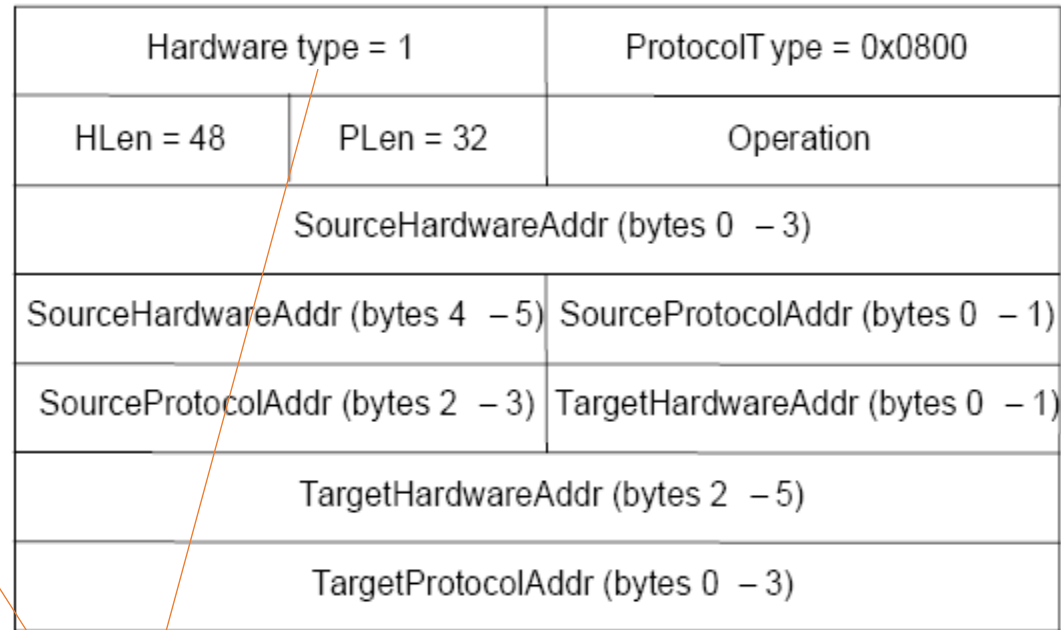
- HardwareType: type of physical network (e.g., Ethernet)
- ProtocolType: type of higher layer protocol (e.g., IP)
- HLEN & PLEN: length of physical and protocol addresses
- Operation: request or response
- Source/Target Physical/Protocol addresses



# ARP Packet: Examples



0 8 16 31



Operation (opcode)

- 1 request
- 2 reply
- 3 request reverse
- 4 reply reverse

0x0806

```

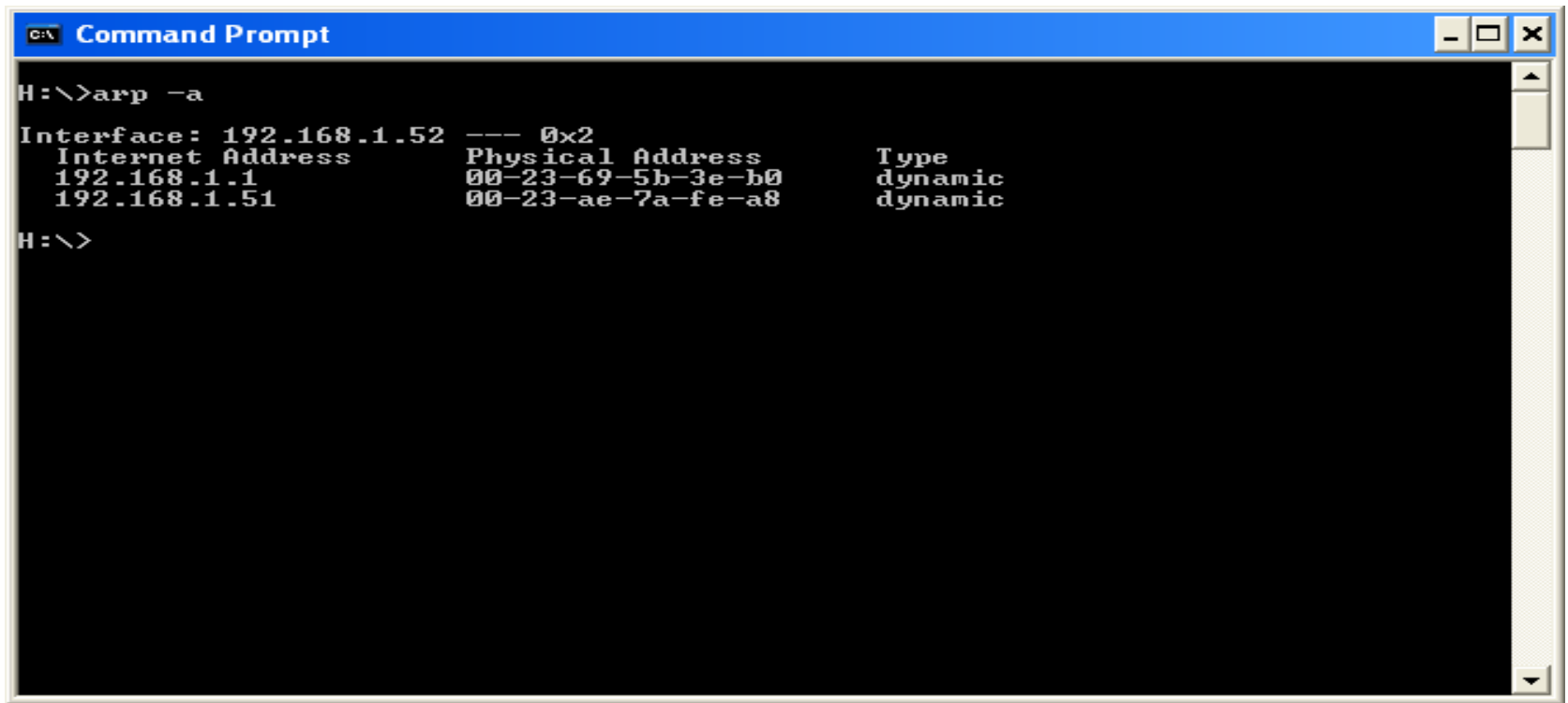
Interface: eth0
0000 ff ff ff ff ff ff 00 0c 29 a0 51 6d 08 06 00 01 .....).Qm....
0010 08 00 06 04 00 01 00 0c 29 a0 51 6d c0 a8 01 48 .....).Qm...H
0020 00 00 00 00 00 00 c0 a8 01 33 .....3
Interface: eth0
0000 ff ff ff ff ff ff 00 0c 29 a0 51 6d 08 06 00 01 .....).Qm....
0010 08 00 06 04 00 01 00 0c 29 a0 51 6d c0 a8 01 48 .....).Qm...H
0020 10/1/2024 00 00 00 00 c0 a8 01 33 .....3
  
```

# ARP: Discussion

- Prevent stalled entries
  - Table entries will timeout (~15 minutes)
  - Do not refresh table entries upon reference
- Fresh entries (reset timer)
  - Update table if already have an entry
- Reduce ARP messages
  - Update table with source when you are the target in ARP request messages



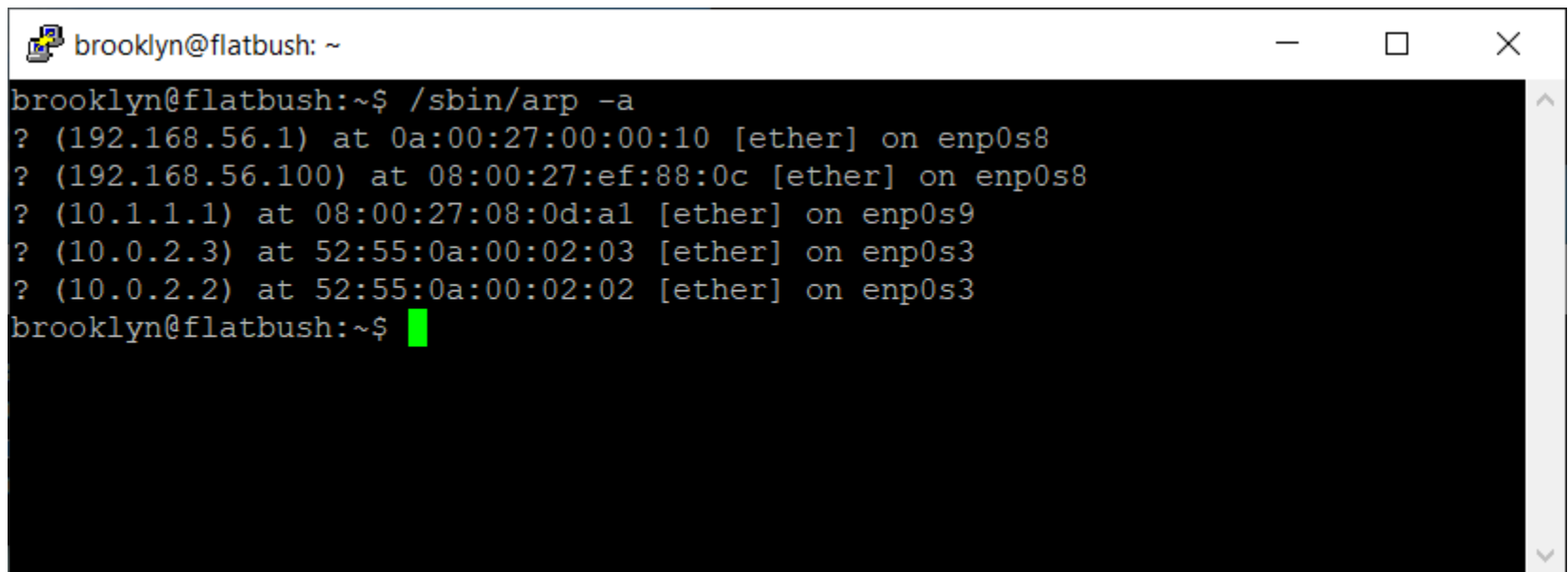
# Print ARP Table: Windows



```
c:\ Command Prompt
H:\>arp -a
Interface: 192.168.1.52 --- 0x2
Internet Address      Physical Address      Type
192.168.1.1           00-23-69-5b-3e-b0    dynamic
192.168.1.51          00-23-ae-7a-fe-a8    dynamic
H:\>
```

The screenshot shows a Windows Command Prompt window with a blue title bar. The command 'arp -a' has been executed, resulting in a table of ARP entries. The table has three columns: 'Internet Address', 'Physical Address', and 'Type'. The first entry is for the interface 192.168.1.52, which is associated with the physical address 00-23-69-5b-3e-b0 and is of type 'dynamic'. The second entry is for the IP address 192.168.1.1, with physical address 00-23-ae-7a-fe-a8, also of type 'dynamic'. The prompt 'H:\>' is visible at the end of the output.

# Print ARP Table: Unix

A terminal window titled 'brooklyn@flatbush: ~' with standard window controls. The terminal shows the command '/sbin/arp -a' being executed, resulting in a list of five entries in the ARP table. Each entry shows an IP address, a MAC address, the interface type (ether), and the interface name (enp0s8 or enp0s9). A green cursor is visible at the end of the last line.

```
brooklyn@flatbush:~$ /sbin/arp -a
? (192.168.56.1) at 0a:00:27:00:00:10 [ether] on enp0s8
? (192.168.56.100) at 08:00:27:ef:88:0c [ether] on enp0s8
? (10.1.1.1) at 08:00:27:08:0d:a1 [ether] on enp0s9
? (10.0.2.3) at 52:55:0a:00:02:03 [ether] on enp0s3
? (10.0.2.2) at 52:55:0a:00:02:02 [ether] on enp0s3
brooklyn@flatbush:~$ █
```

# Questions

- Why is the address translation problem?
- How does the internet solve this problem?

# Host Configuration

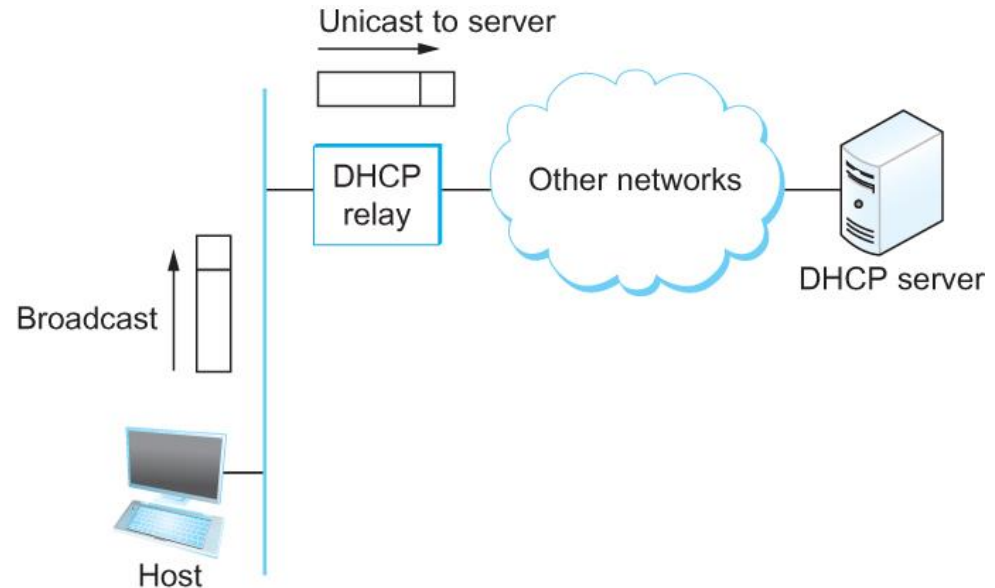
- Ethernet addresses are configured into network by manufacturer and they are unique
- IP addresses must be unique on a given internetwork but also must reflect the structure of the internetwork
- Most host Operating Systems provide a way to manually configure the IP information for the host
- Drawbacks of manual configuration
  - A lot of work to configure all the hosts in a large network
  - Configuration process is error-prone
- Automated Configuration Process is required

# Dynamic Host Configuration Protocol (DHCP)

- DHCP server is responsible for providing configuration information to hosts
- There is at least one DHCP server for an administrative domain
- DHCP server maintains a pool of available addresses

# DHCP

- 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



# Internet Control Message Protocol (ICMP)

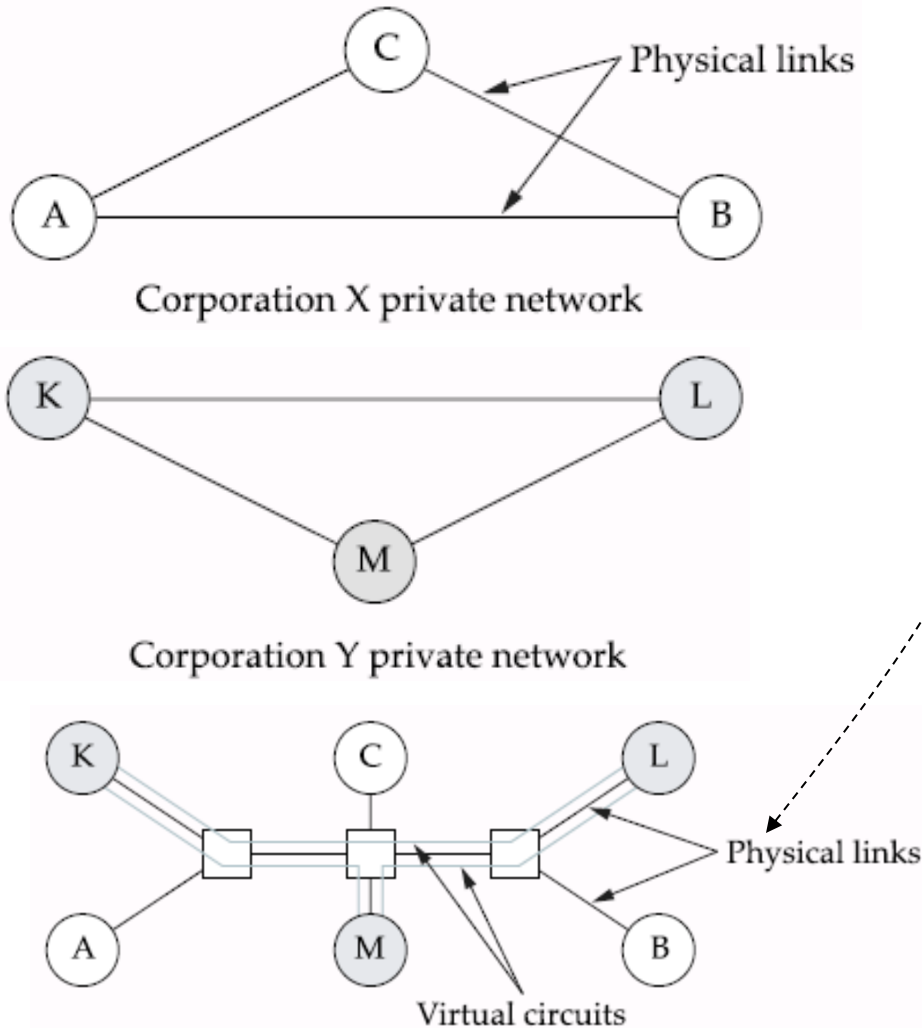
- Defines a collection of error messages that are sent back to the source host whenever a router or host is unable to process an IP datagram successfully
  - Destination host unreachable due to link /node failure
  - Reassembly process failed
  - TTL had reached 0 (so datagrams don't cycle forever)
  - IP header checksum failed
- ICMP-Redirect
  - From router to a source host
  - With a better route information

# Virtual Networks and Tunnels

- Internetworks often have shared infrastructure networks
- Data packets may not be forwarded without restriction
- Virtual Private Networks (VPN)
  - VPN is a heavily overused and definitions vary
  - An “private” network utilizing an shared network infrastructure

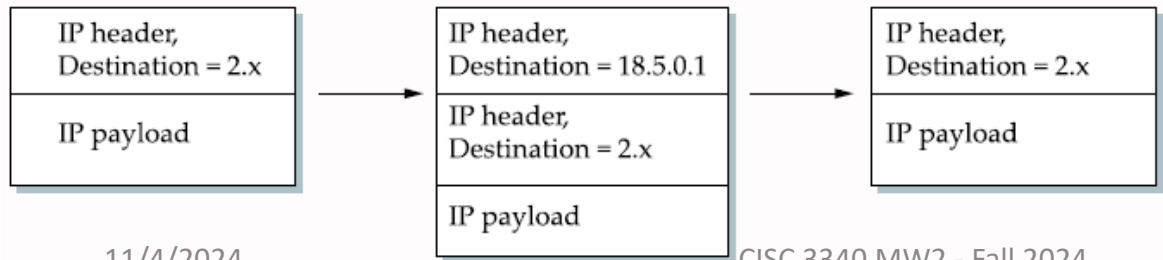
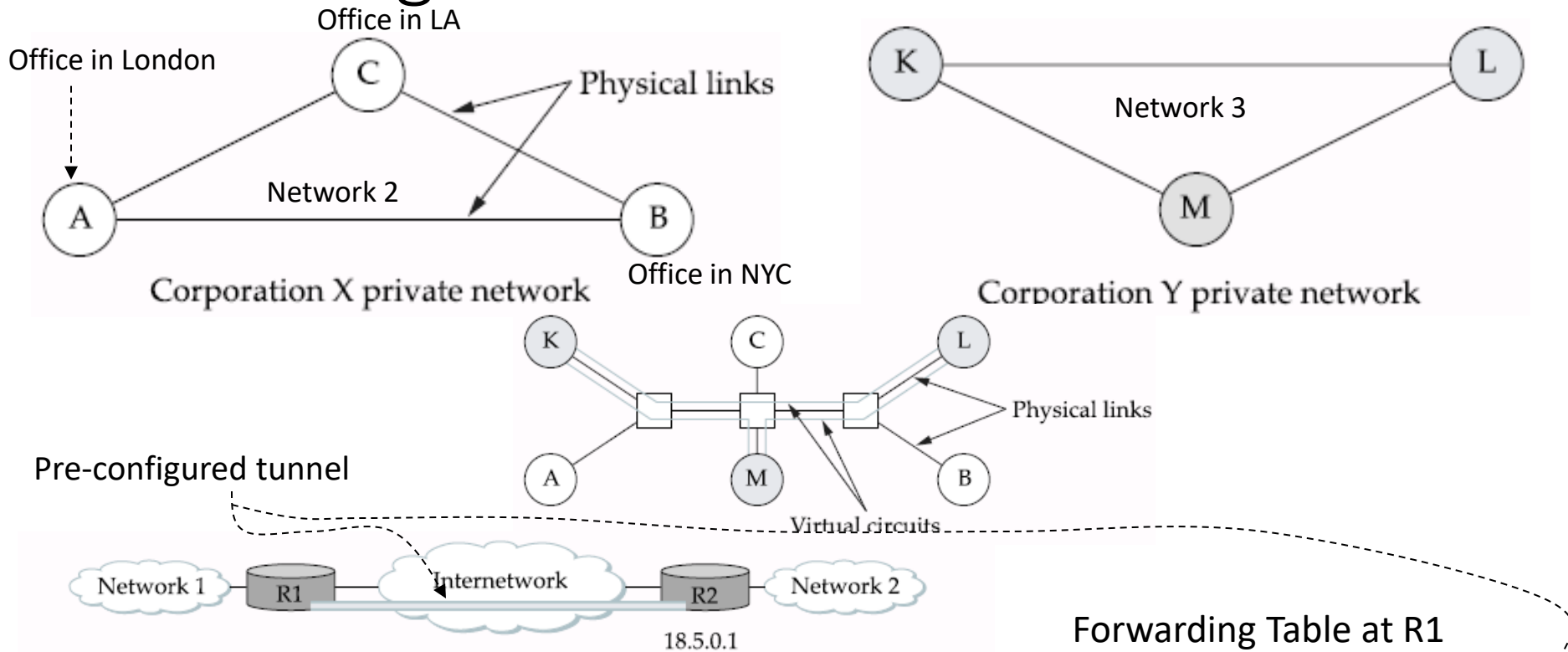


# Virtual Private Networks: Example



- Corporations X and Y want their own networks via “leased lines” belonging to other networks
- X wants to keep their data private
- So does Y
- X and Y have “virtual” private networks
- “virtualization” can be done on different layers
  - Layer 2 VPN
  - Layer 3 VPN

# Virtual Private Networks via IP Tunneling



Forwarding Table at R1

NetworkNum	NextHop
1	Interface 0
2	Virtual interface 0
Default	Interface 1

# Summary

- internet and the Internet
- Global addressing scheme
- Packet fragmentation and assembly
- Best effort service model and datagram forwarding
- Address translation
- Host configuration
- Error reporting