



# IPv4 (Part III)

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# Outline

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- IP Fundamental Operation
- Internet Protocol
- Addressing
- Supporting Protocol
  - ARP
  - ICMP: ping + traceroute
  - NAT
  - DHCP



# Network Address Translation (NAT)

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# Network Address Translation (NAT)

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- Private Network
  - Good practice to use private address
- Map local addresses to (real) public IP address(es)
- Security (not expose internal details)
- Alleviate IP depletion



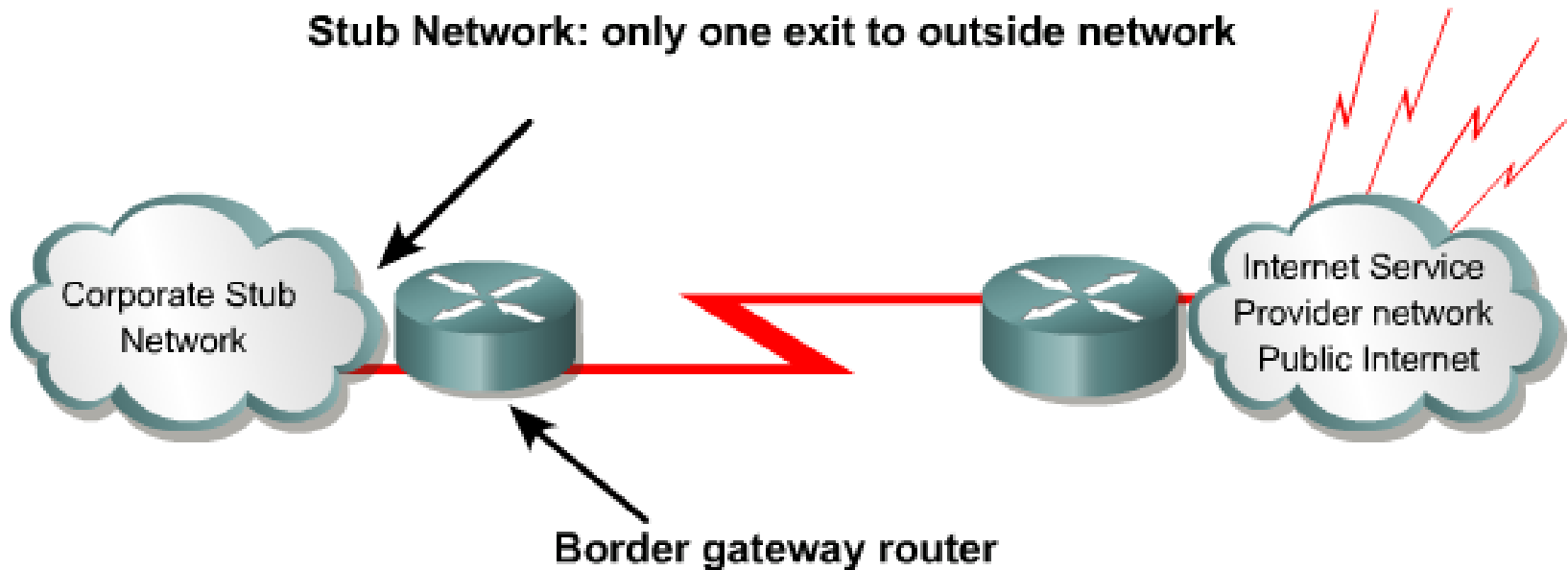
# Private IP address

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<b>Class</b>	<b>RFC 1918</b>	<b>CIDR prefix</b>
A	10.0.0.0 – 10.255.255.255	10.0.0.0/8
B	172.16.0.0 – 172.31.255.255	172.16.0.0/12
C	192.168.0.0 – 192.168.255.255	192.168.0.0/16

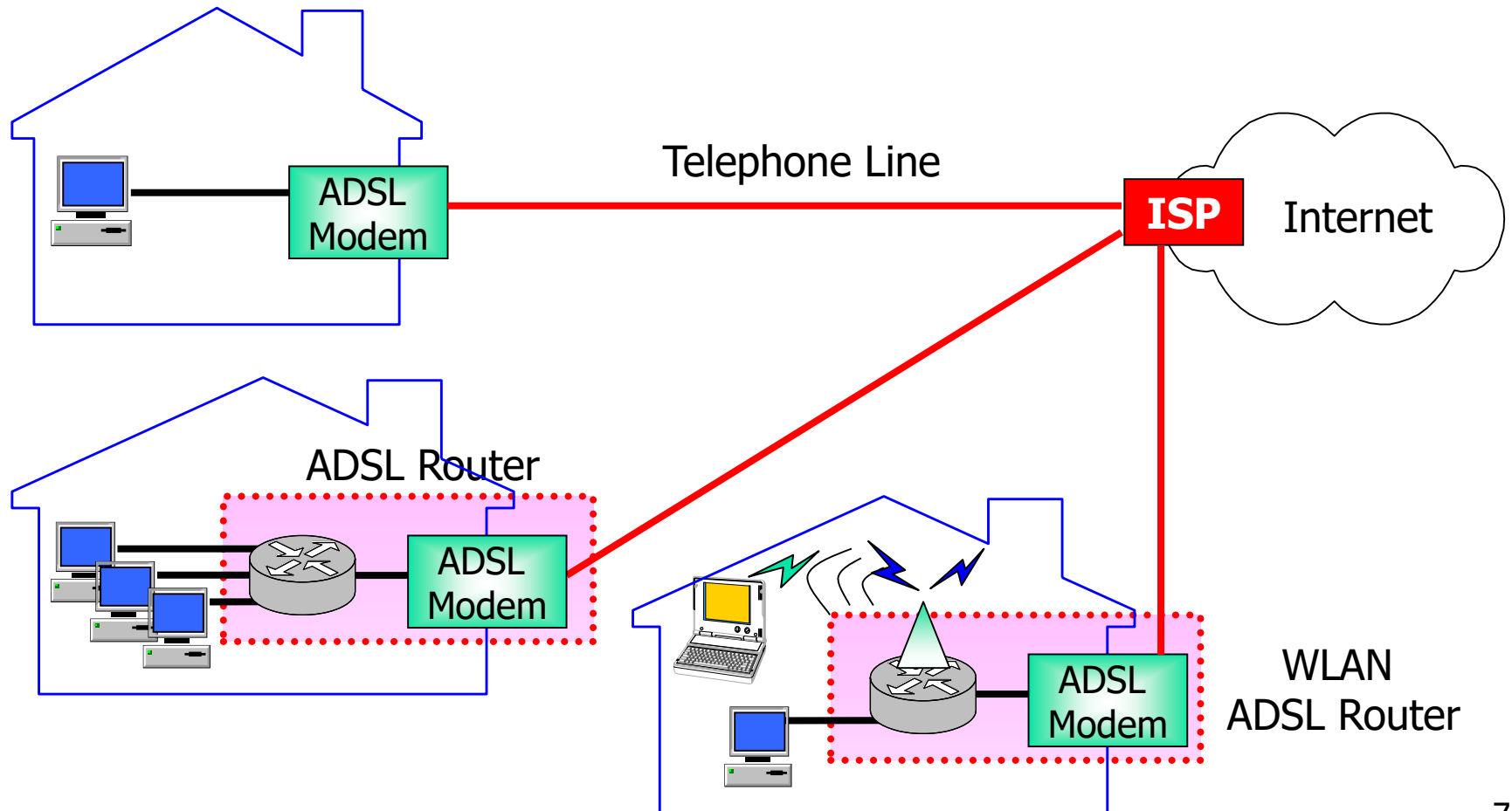
# Stub Network

- Operates at the border of a stub network

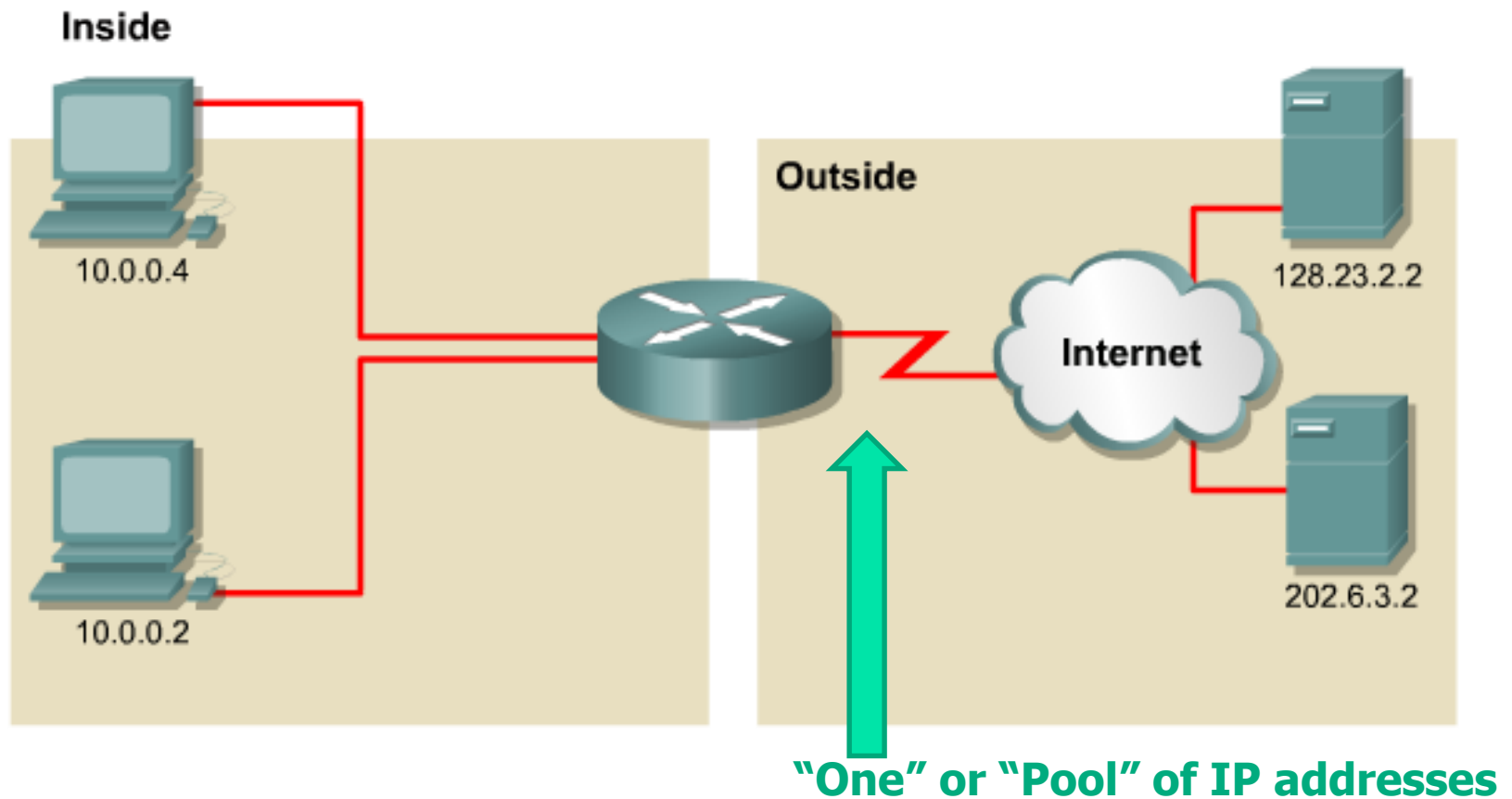


# Stub Network Example

## ADSL Connection

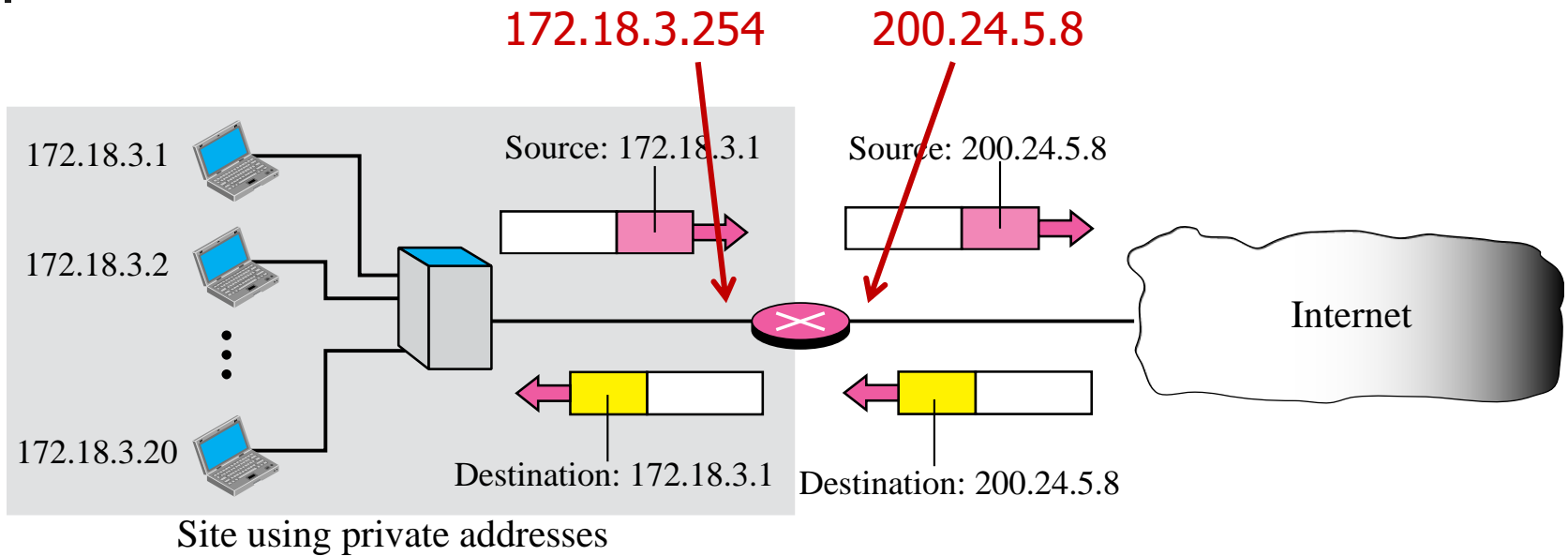


# NAT



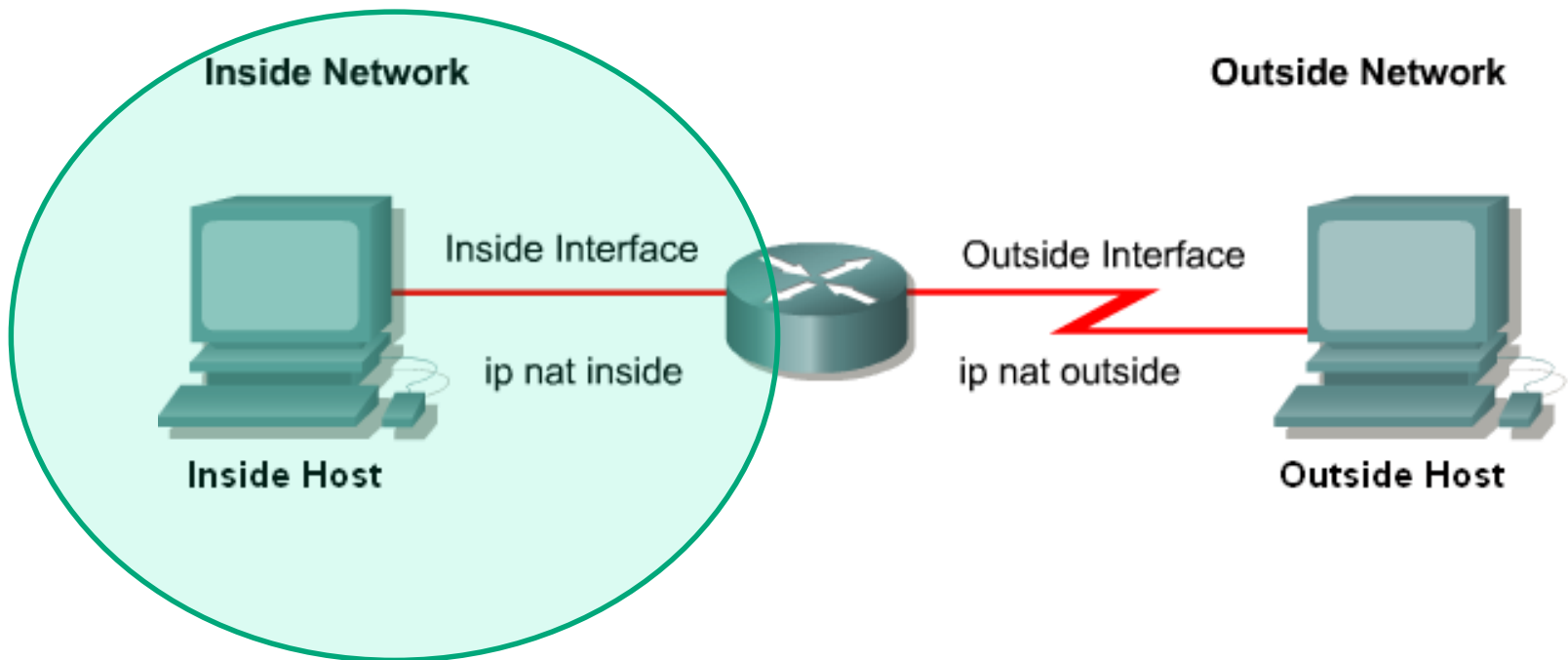


# Example

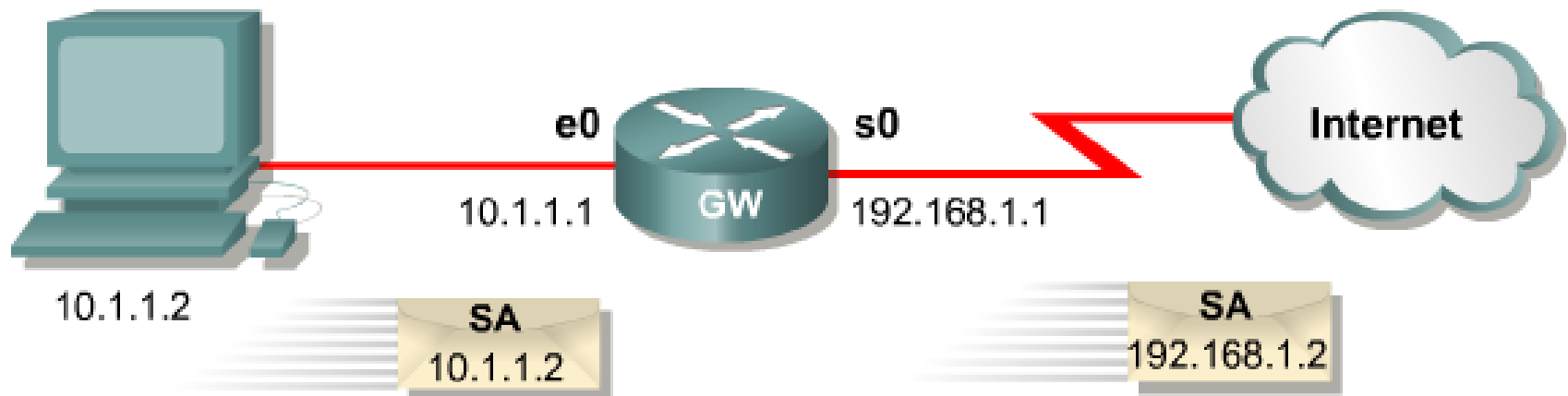


# Configure NAT

- Static Translation
- Dynamic Translation

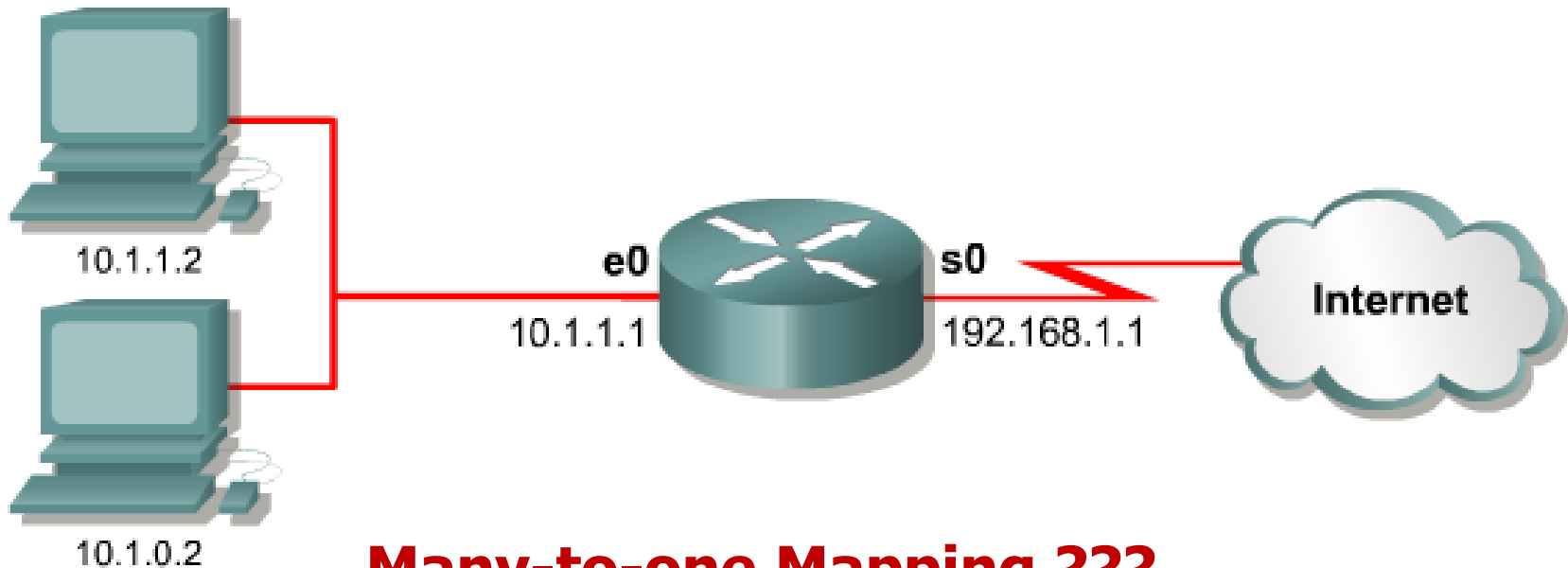


# Static Translation



```
hostname GW
!  
ip nat inside source static 10.1.1.2 192.168.1.2  
!  
interface ethernet 0  
  ip address 10.1.1.1 255.255.255.0  
  ip nat inside  
!  
interface serial 0  
  ip address 192.168.1.1 255.255.255.0  
  ip nat outside  
!
```

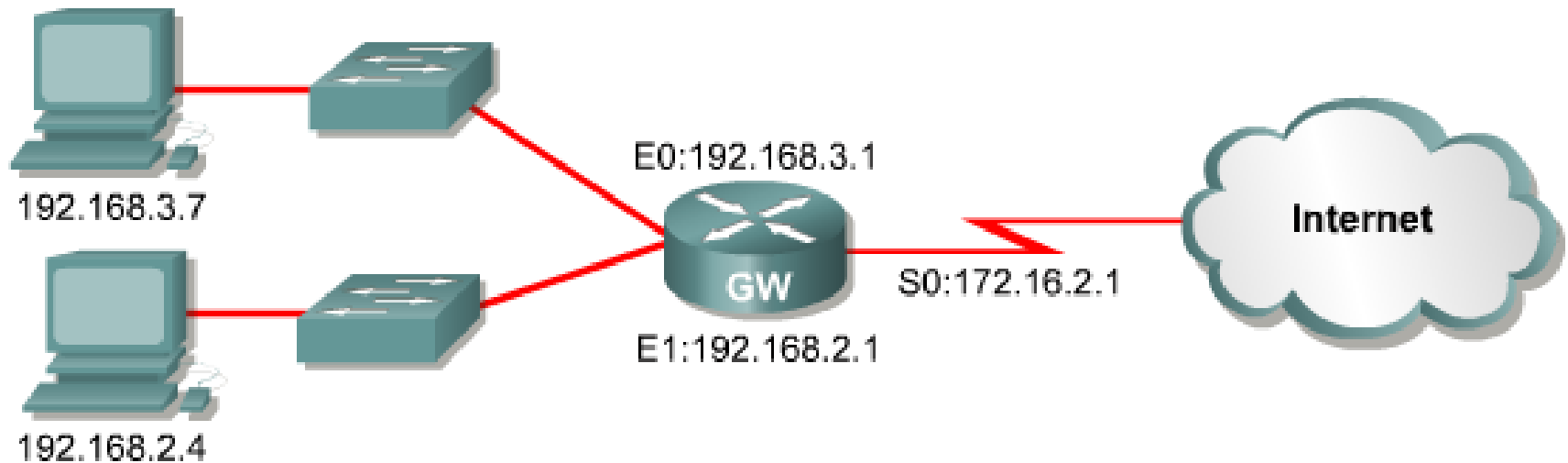
# Dynamic Translation



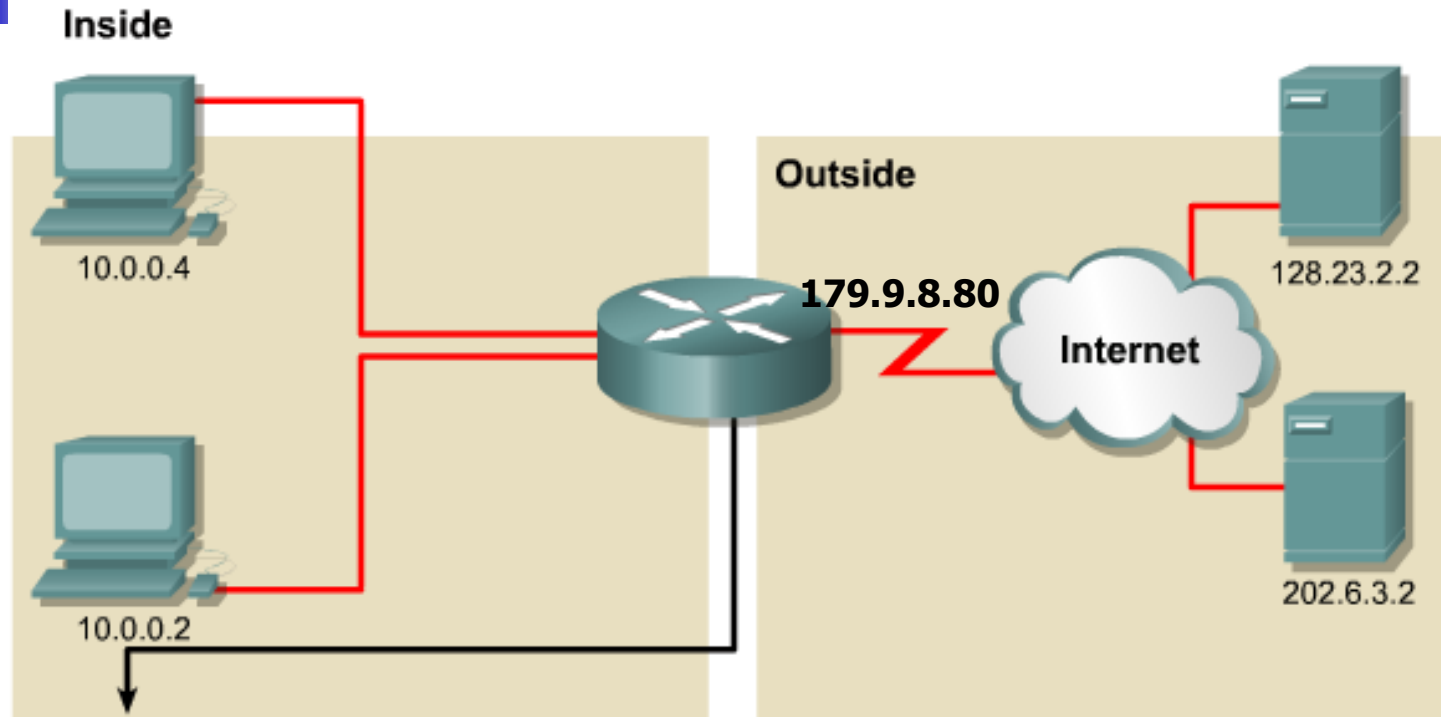
**Many-to-one Mapping ???**

Many inside IP → one outside IP

# PAT: Port Address Translation (Overloaded NAT)



# PAT



**NAT Table with Overload**

Inside Local IP Address	Inside Global IP Address	Outside Local IP Address	Outside Global Address
10.0.0.2:1331	179.9.8.80:1331	202.6.3.2:80	202.6.3.2:80
10.0.0.4:1555	179.9.8.80:1555	128.23.2.2:80	128.23.2.2:80



# Disadvantages of NAT

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- Delay
- Loss of end-to-end ability
- Might not work with some applications

HW: Find out what application does not work with NAT ?  
Please explain.



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  - ICMP: ping + traceroute
  - NAT
  - **BOOTP/DHCP ← Application Protocol**





# Bootstrap Protocol (BOOTP)

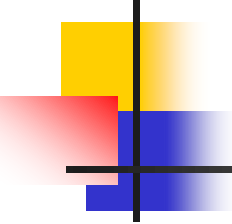
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# BOOTP

- RFC951 (Sep 1985) for RARP replacement
- Diskless terminal
- Discover its own IP address
- Download executable image file
- Small program built in chip
  - BOOTH and TFTP
- Application Protocol
  - Encapsulated in IP and UDP



<http://www.davewentzel.com/sites/default/files/vt510.jpg>



# TCP/IP Protocol Suite

## (Internet Model)

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**Applications**

User service and interface

4

**Transport**

Process delivery + Error (TCP/UDP)  
Reliable end-to-end (whole message)

3

**Network**

Move packets from source to destination  
Packet end-to-end (across network)

2

**Data Link**

Provide frames  
Node-to-node (same network segment)

1

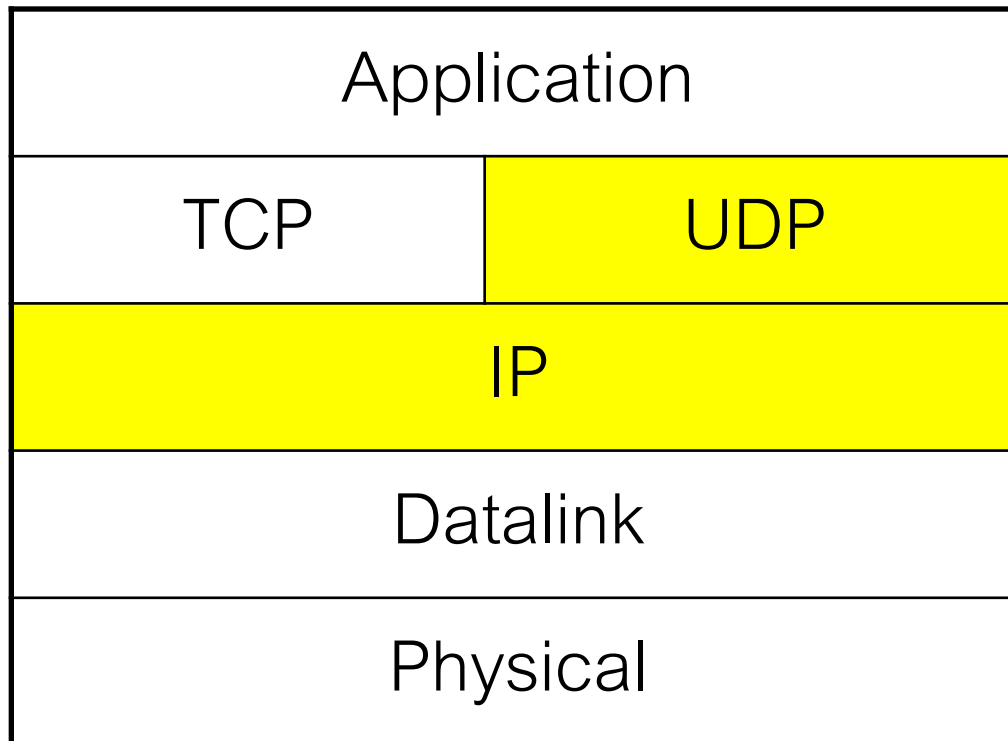
**Physical**

Transmission bit streams  
(mechanical and electrical spec)



# TCP/IP protocol Suite

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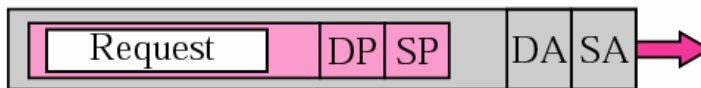
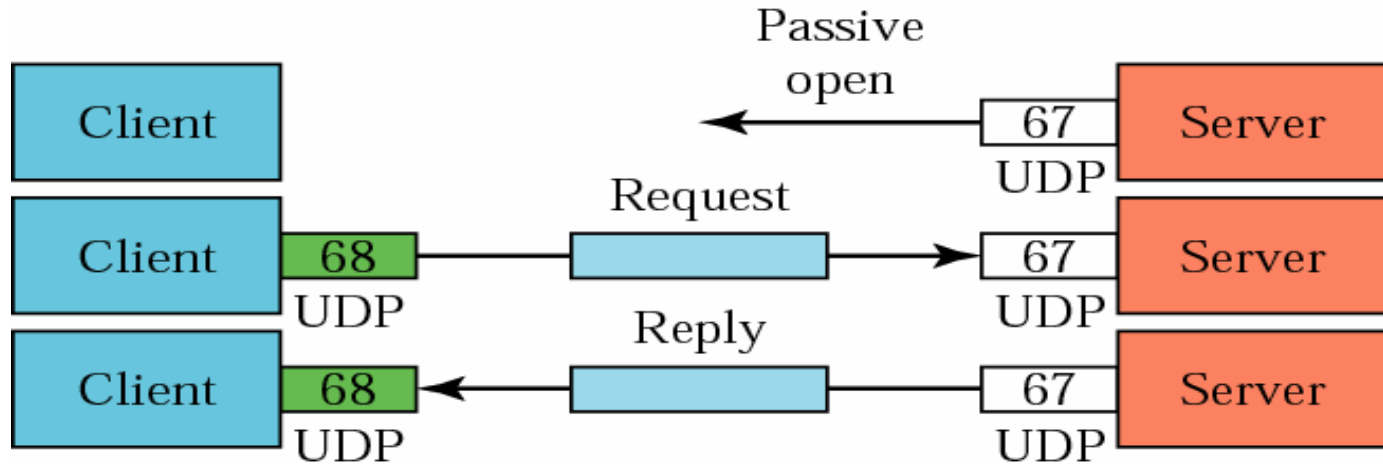




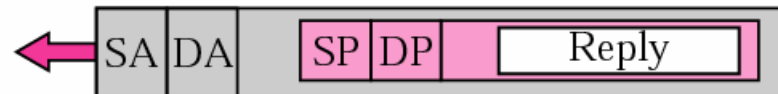
# BOOTP packet format

Operation code	Hardware type	Hardware length	Hop count
Transaction ID			
Number of seconds		Unused	
Client IP address			
Your IP address			
Server IP address			
Gateway IP address			
Client hardware address (16 bytes)			
Server name (64 bytes)			
Boot file name (128 bytes)			
Options			

# Operation



SP: Source port (68)  
 DP: Destination port (67)  
 SA: Source address (All 0s)  
 DA: Destination address (All 1s)



SP: Source port (67)  
 DP: Destination port (68)  
 SA: Source address (Server unicast address)  
 DA: Destination address (All 1s or client unicast address)



# Dynamic Host Configuration Protocol (DHCP)

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# DHCP

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- BOOTP Enhancement
- RFC 1531 (Oct 1993 – 8 yrs. After BOOTP)
- Same message structure as BOOTP
- Can choose among many DHCP servers

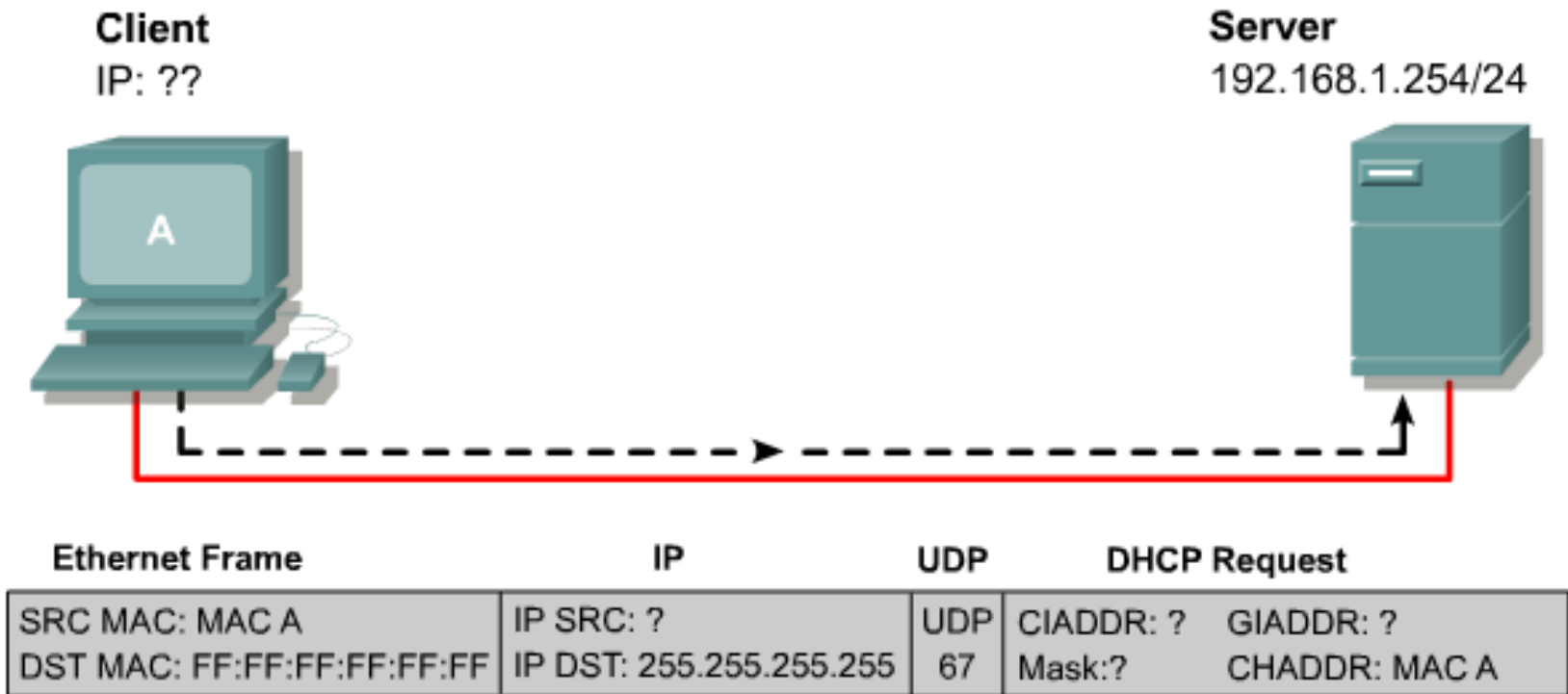




# DHCP packet

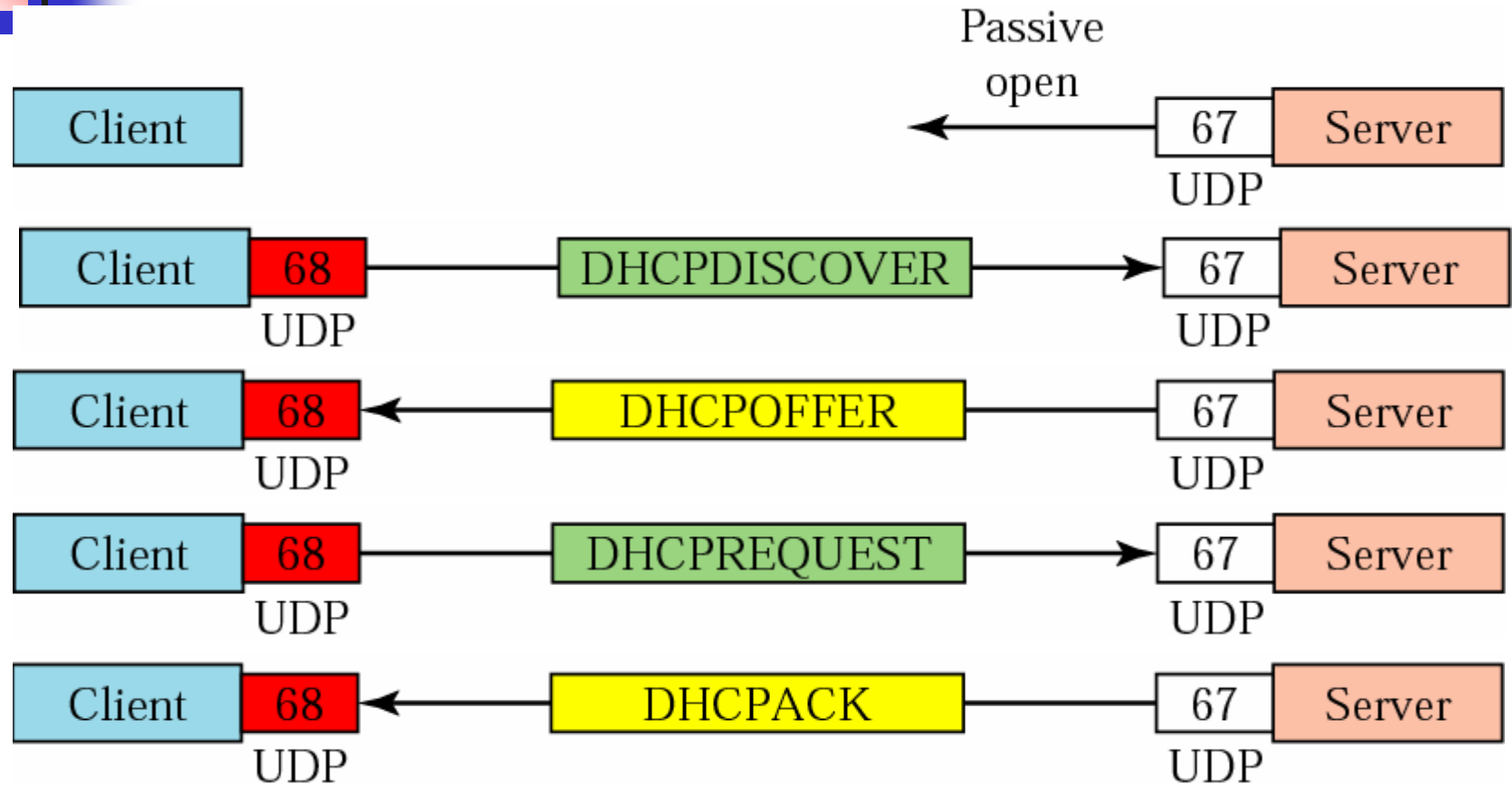
Operation code	Hardware type	Hardware length	Hop count
Transaction ID			
Number of seconds	<b>F</b>	Unused	
Client IP address			
Your IP address			
Server IP address			
Gateway IP address			
Client hardware address (16 bytes)			
Server name (64 bytes)			
Boot file name (128 bytes)			
Options (Variable length)			

# Operation

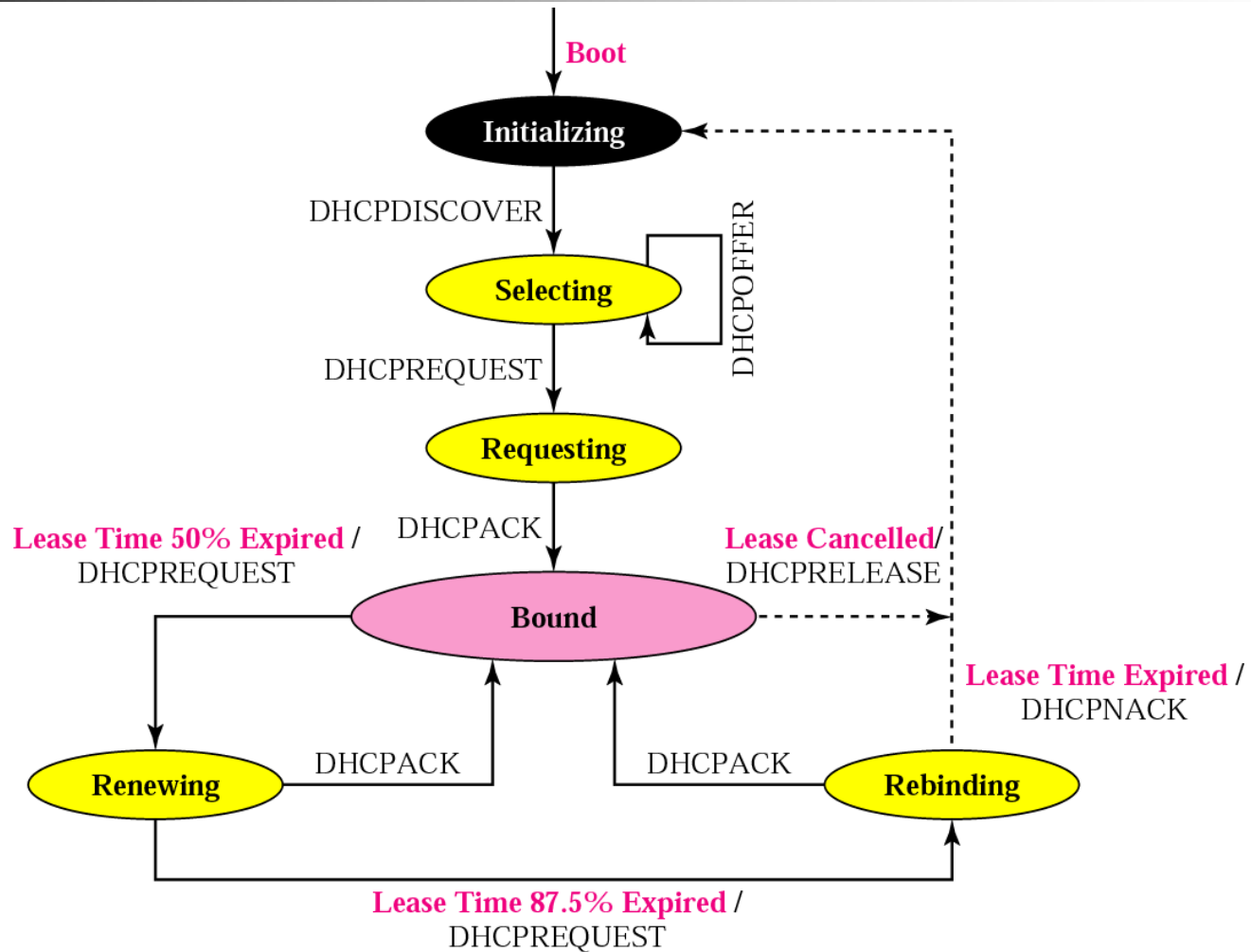


CIADDR : Client IP Address  
GIADDR: Gateway IP Address  
CHADDR: Client Hardware Address

# DHCP Message



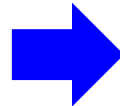
# DHCP transition diagram



# DHCP Relay

## Broadcast Ethernet Frame

Broadcast Ethernet Frame	IP	UDP	DHCP Request
SRC MAC: MAC A DST MAC: FF:FF:FF:FF:FF:FF	IP SRC: ? IP DST: 255.255.255.255	UDP 67	CIADDR: ? GIADDR: ? Mask: ? CHADDR: MAC A

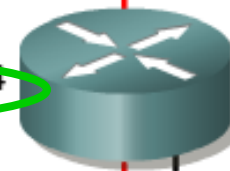


192.168.1.0

Gateway 192.168.1.1/24

e0: ip helper - address 192.168.2.254

Gateway 192.168.2.1/24



Gateway

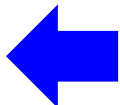


Server 192.168.2.254/24

192.168.2.0

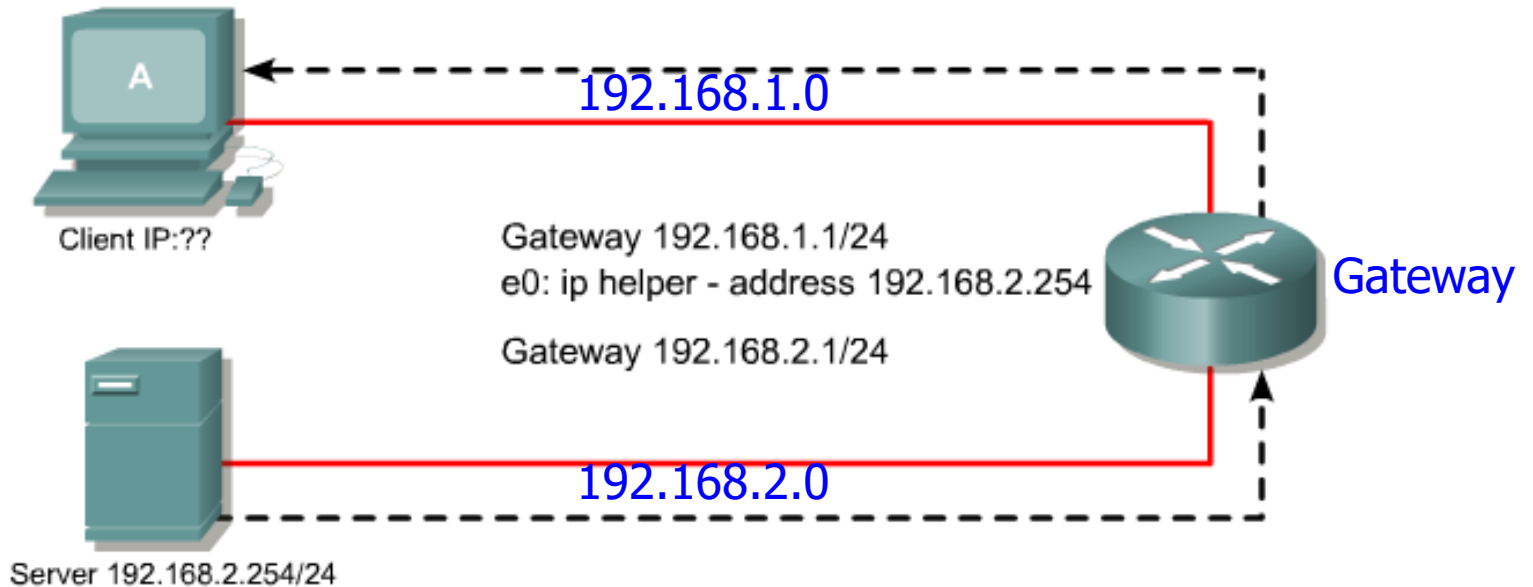
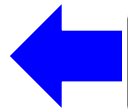
## Unicast Ethernet Frame

Unicast Ethernet Frame	IP	UDP	DHCP Request
SRC MAC: MAC Gateway DST MAC: MAC Serv	IP SRC: 192.168.2.1 IP DST: 192.168.2.254	UDP 67	CIADDR: ? GIADDR: ? Mask: ? CHADDR: MAC A

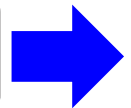


# DHCP Relay

Unicast Ethernet Frame	IP	UDP	DHCP Reply
SRC MAC: MAC Gateway DST MAC: MAC A	IP SRC: 192.168.2.254 IP DST: 192.168.1.10	UDP 68	GIADDR: 192.168.1.1 CHADDR: MAC A Mask: 255.255.255.0 GIADDR: 192.168.1.10



Unicast Ethernet Frame	IP	UDP	DHCP Reply
SRC MAC: MAC Serv DST MAC: MAC Gateway	IP SRC: 192.168.2.254 IP DST: 192.168.1.10	UDP 68	GIADDR: 192.168.1.1 CHADDR: MAC A Mask: 255.255.255.0 GIADDR: 192.168.1.10





# Summary

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  - ICMP: ping + traceroute
  - NAT
  - **BOOTP/DHCP ← Application Protocol**