



IPv4 (Part III)

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Outline

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



Network Address Translation (NAT)



Network Address Translation (NAT)

- 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

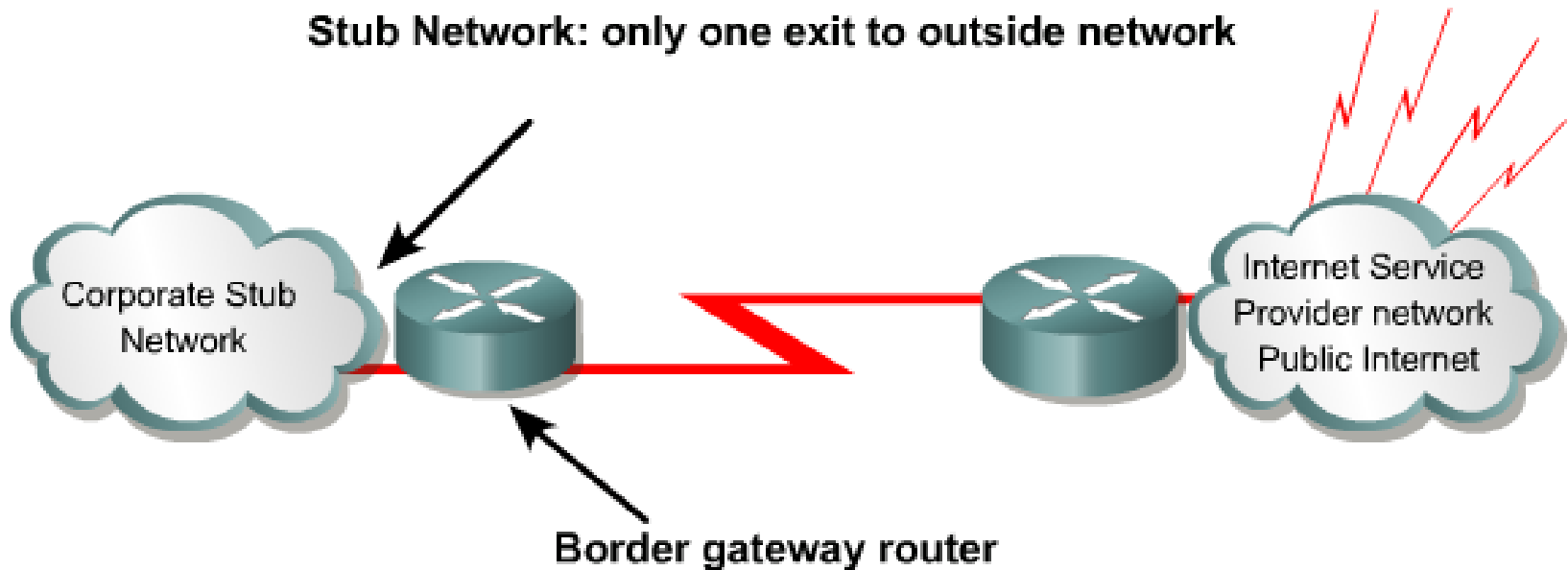


Private IP address

| Class | RFC 1918 | CIDR prefix |
|--------------|-------------------------------|--------------------|
| A | 10.0.0.0 – 10.255.255.255 | 10.0.0.0/8 |
| B | 172.16.0.0 – 172.16.255.255 | 172.16.0.0/12 |
| C | 192.168.0.0 – 192.168.255.255 | 192.168.0.0/16 |

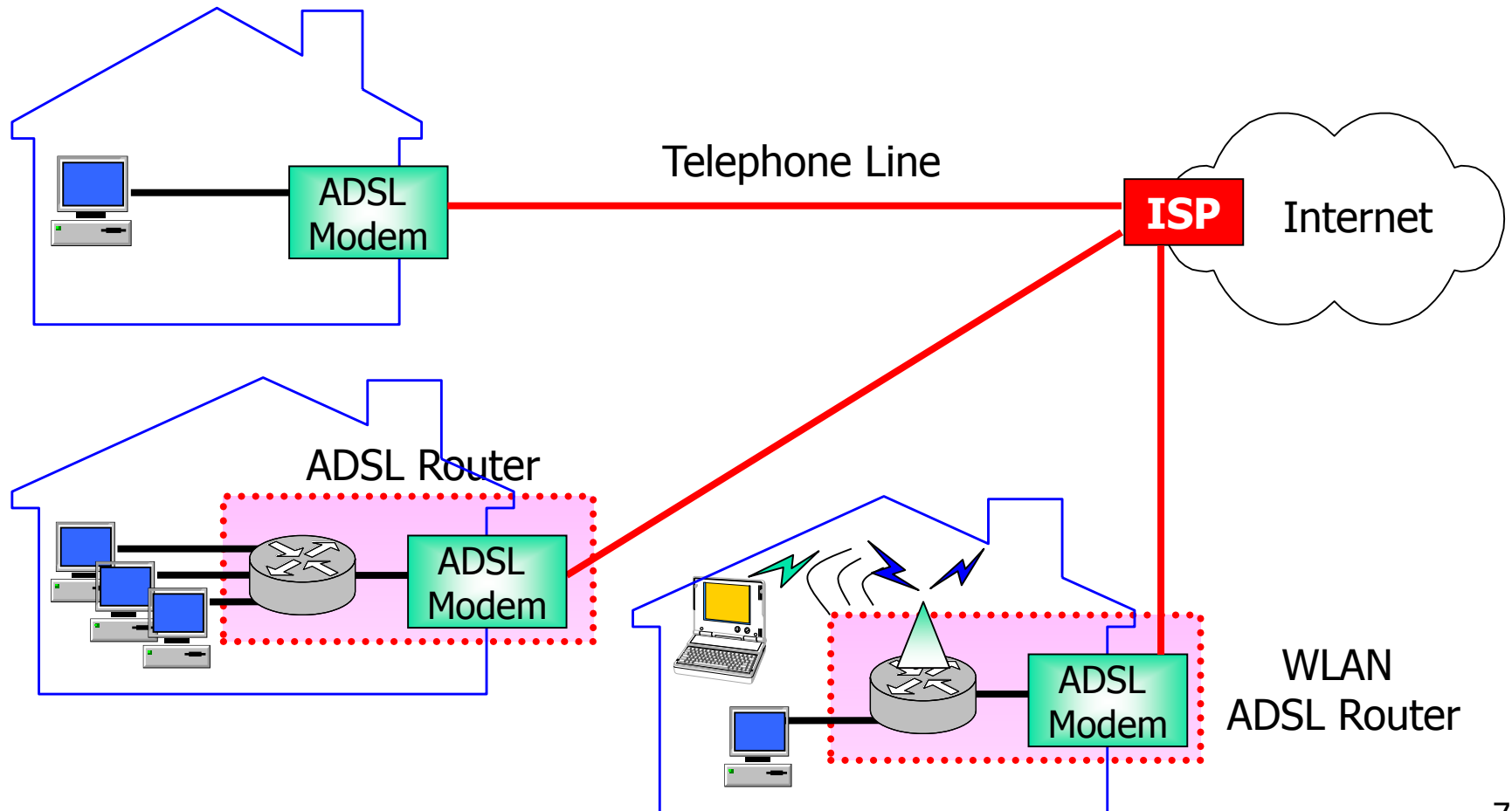
Stub Network

- Operates at the border of a stub network

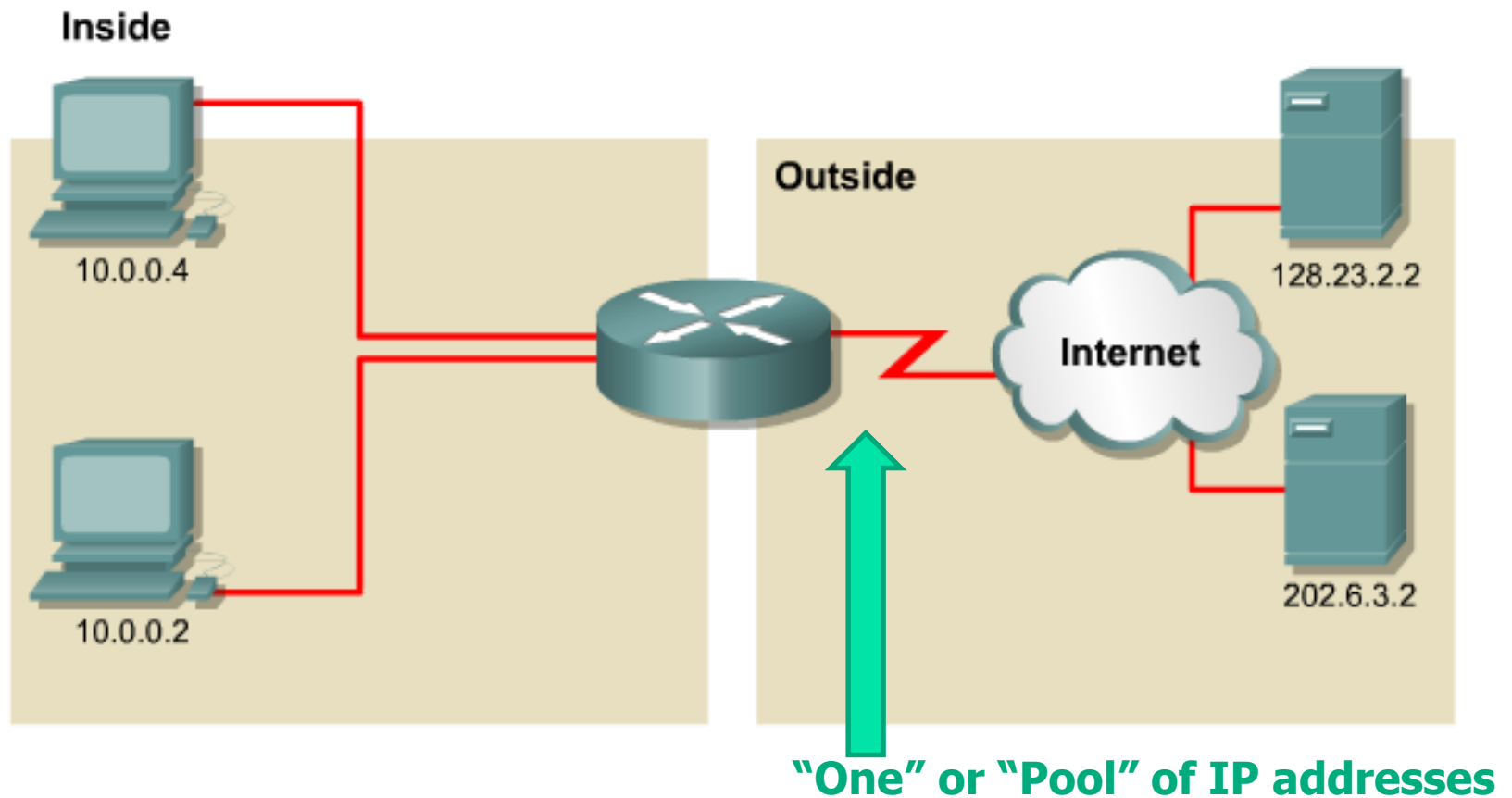


Stub Network Example

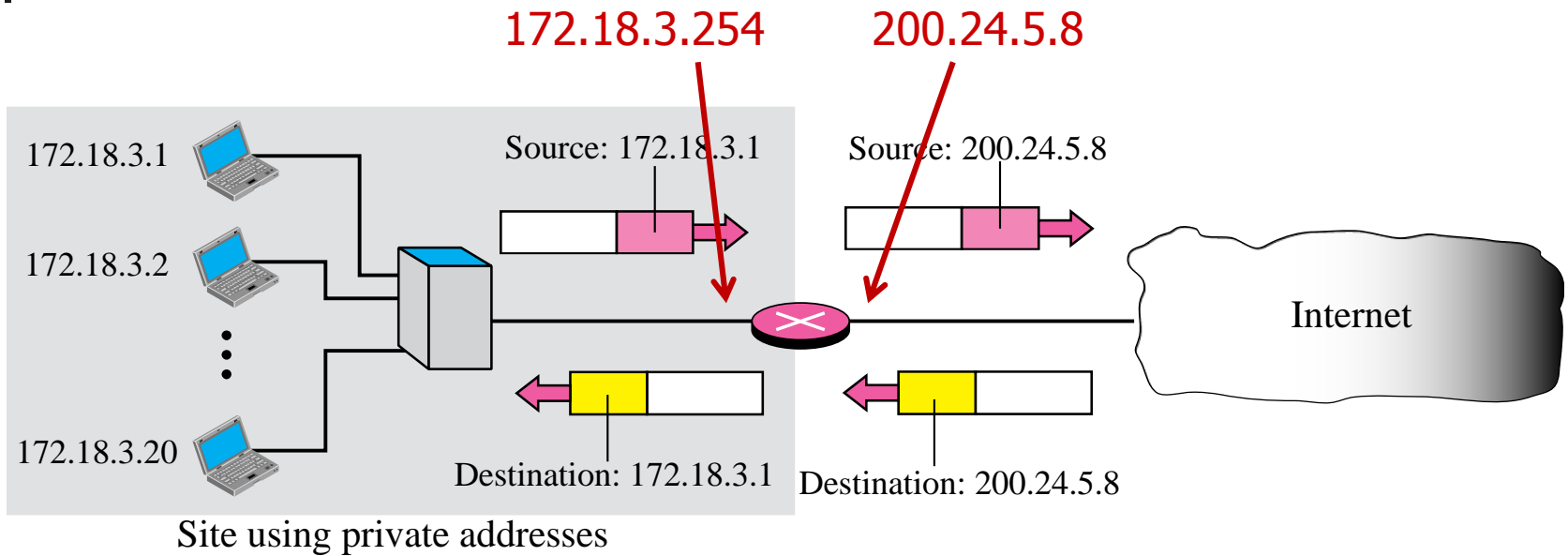
ADSL Connection



NAT

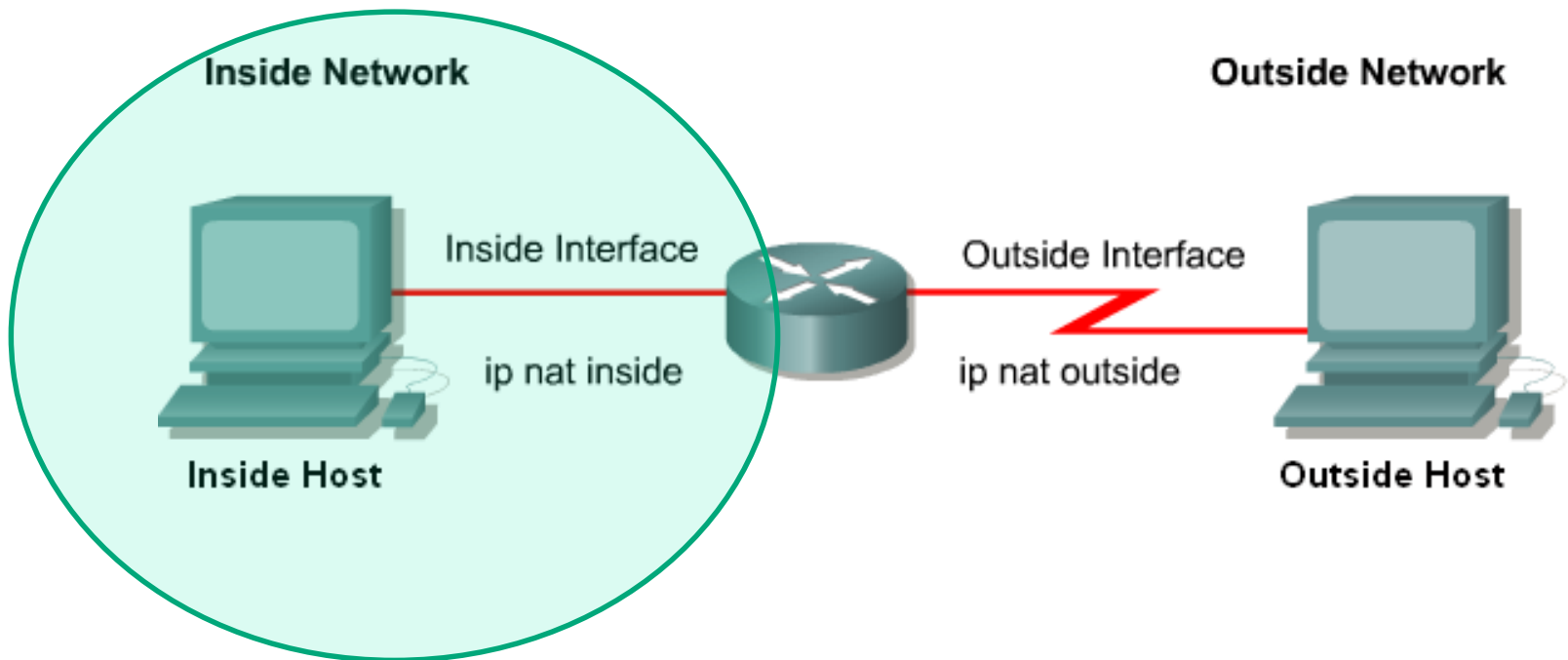


Example

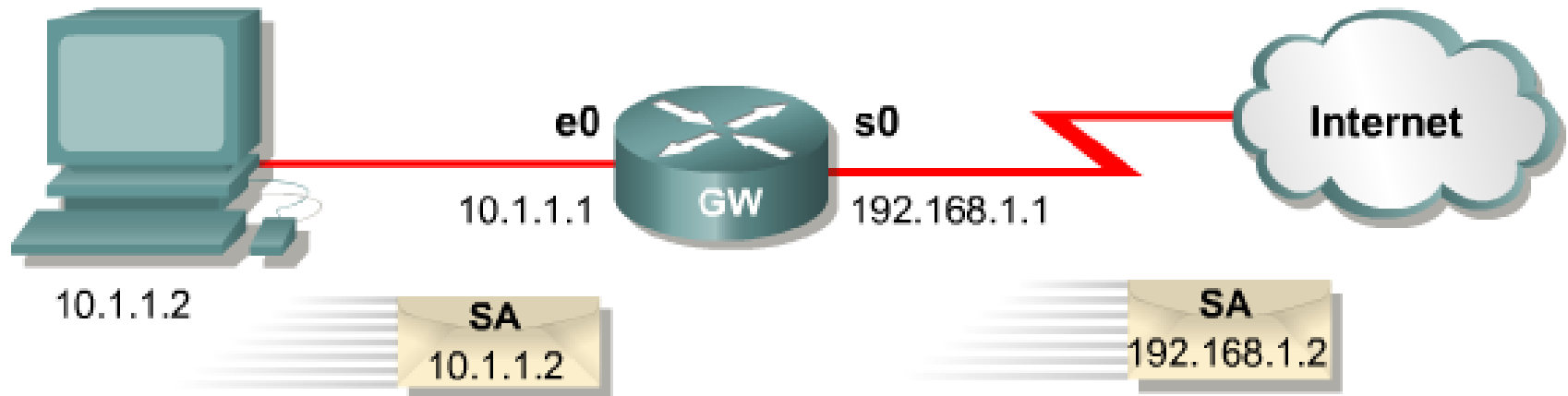


Configure NAT

- Static Translation
- Dynamic Translation

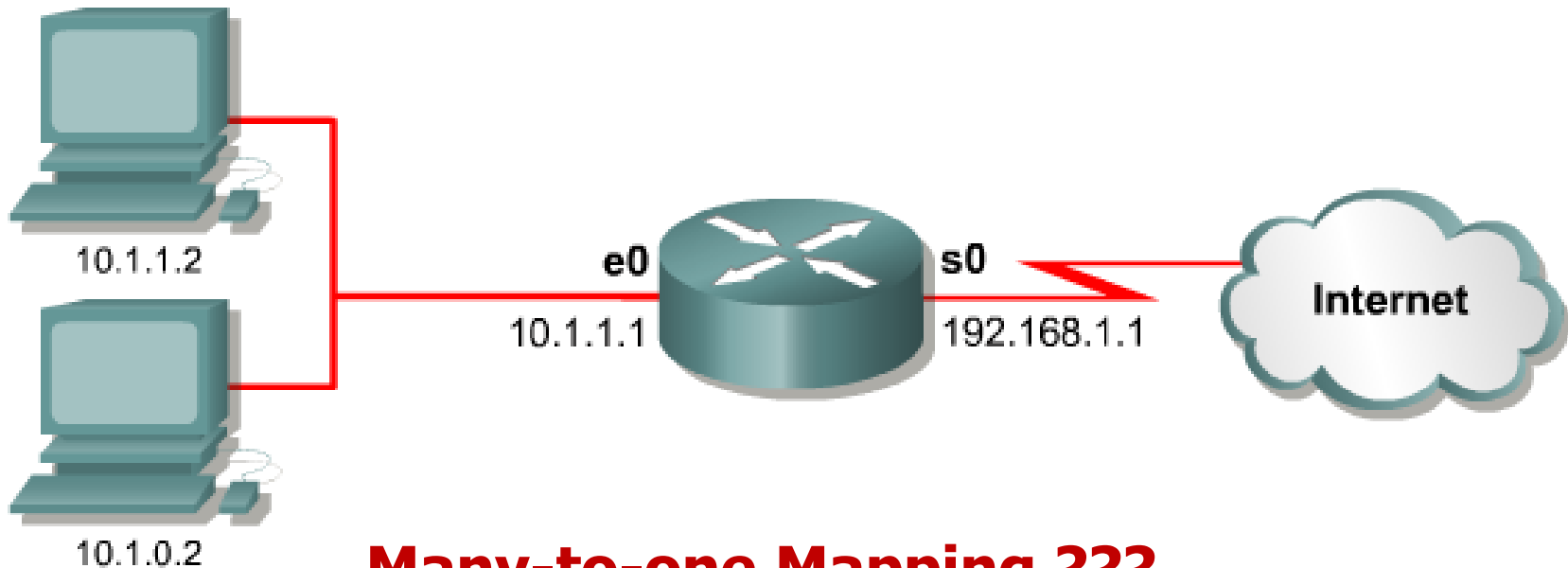


Static Translation



```
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  
!
```

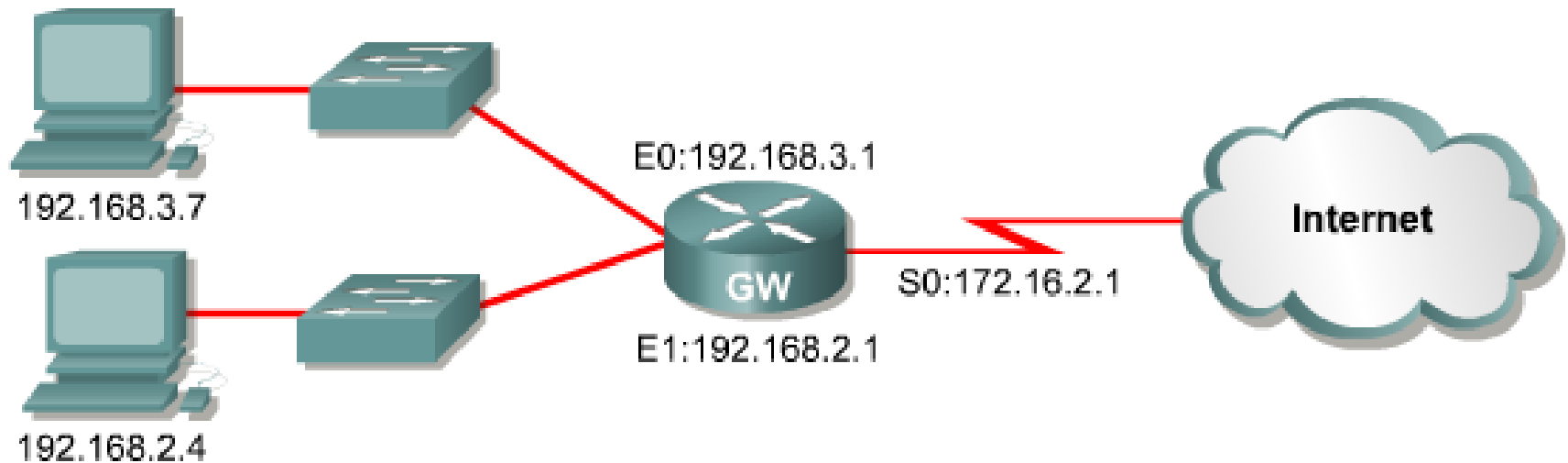
Dynamic Translation



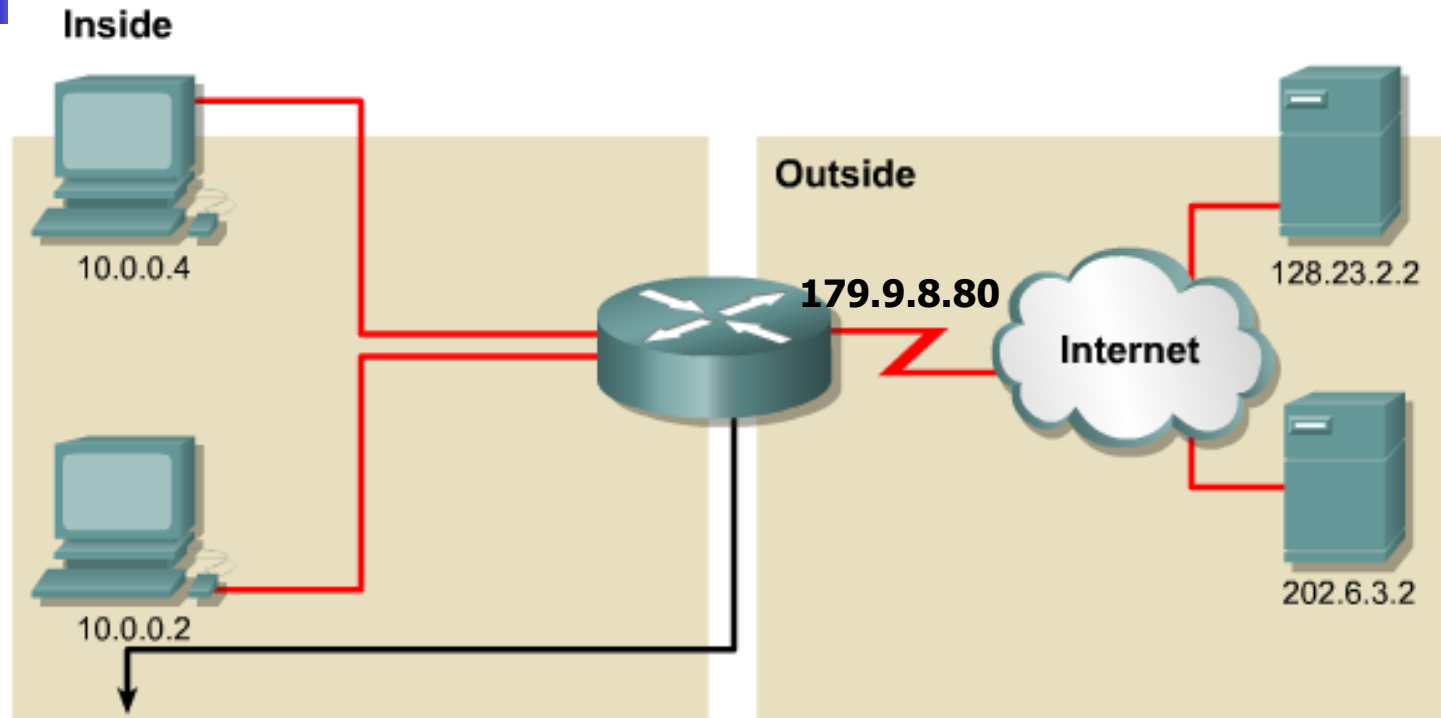
Many-to-one Mapping ???

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

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

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



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 - **BOOTP/DHCP ← Application Protocol**



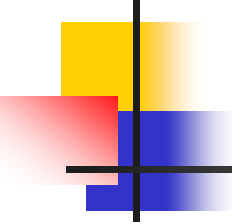
Bootstrap Protocol (BOOTP)

BOOTP

- Diskless terminal
- Discover its own IP address
- Download executable image file
- Small program built in chip
 - BOOTP and TFTP
- Application Protocol
 - Encapsulated in IP and UDP



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



TCP/IP Protocol Suite

(Internet Model)

5

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)

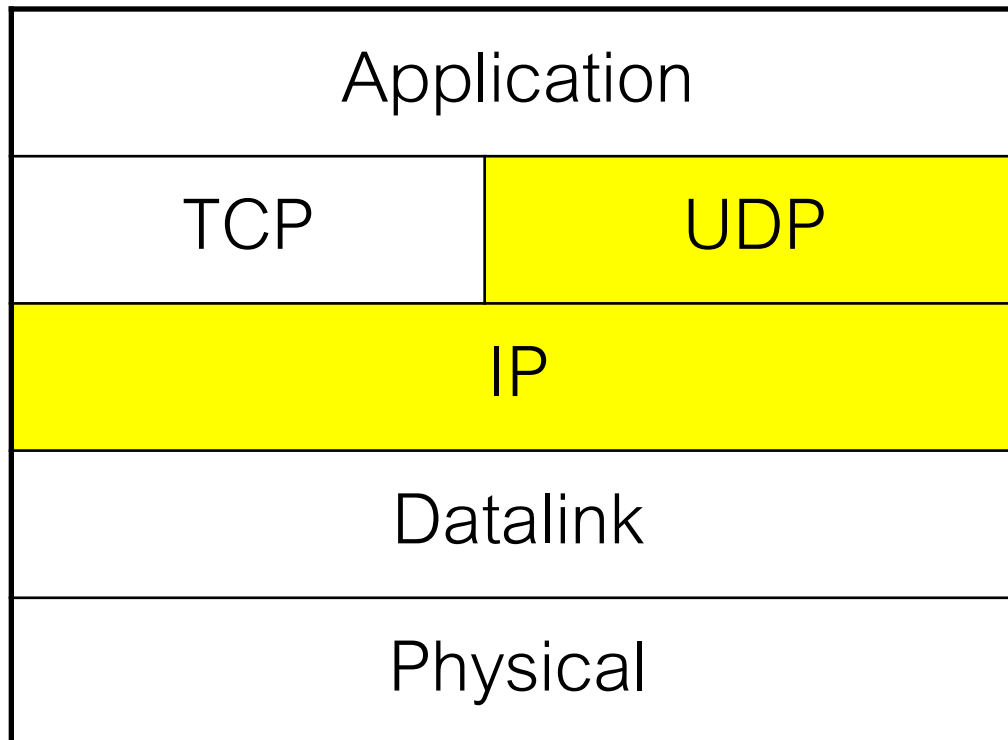
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Physical

Transmission bit streams
(mechanical and electrical spec)



TCP/IP protocol Suite

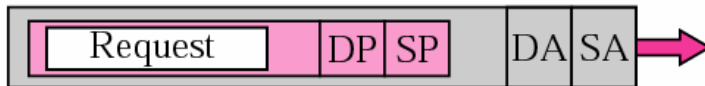
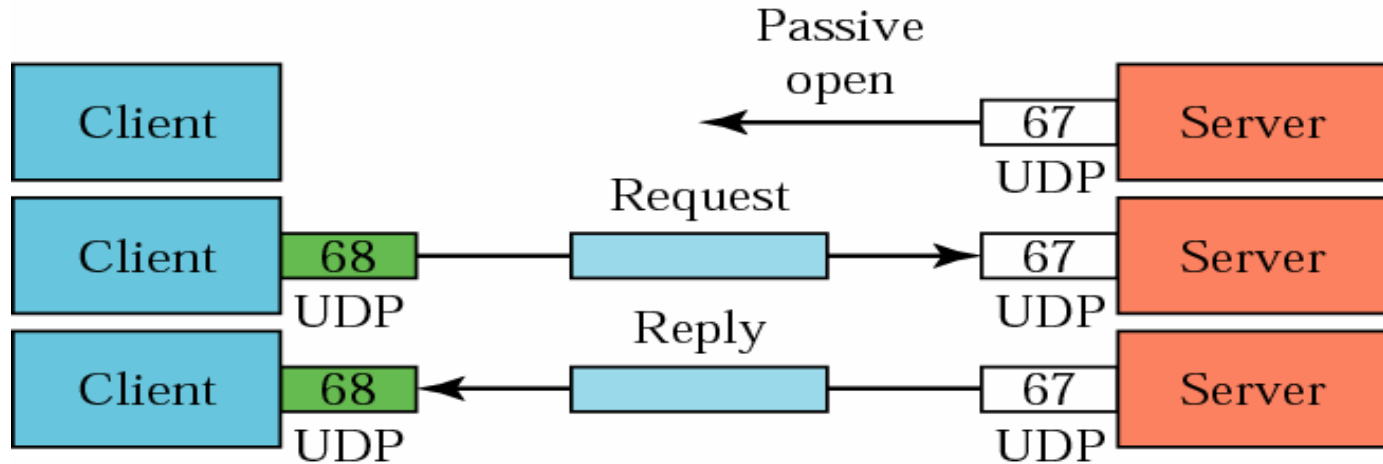




BOOTP packet format

| | | | |
|---------------------------------------|---------------|-----------------|-----------|
| 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)



DHCP

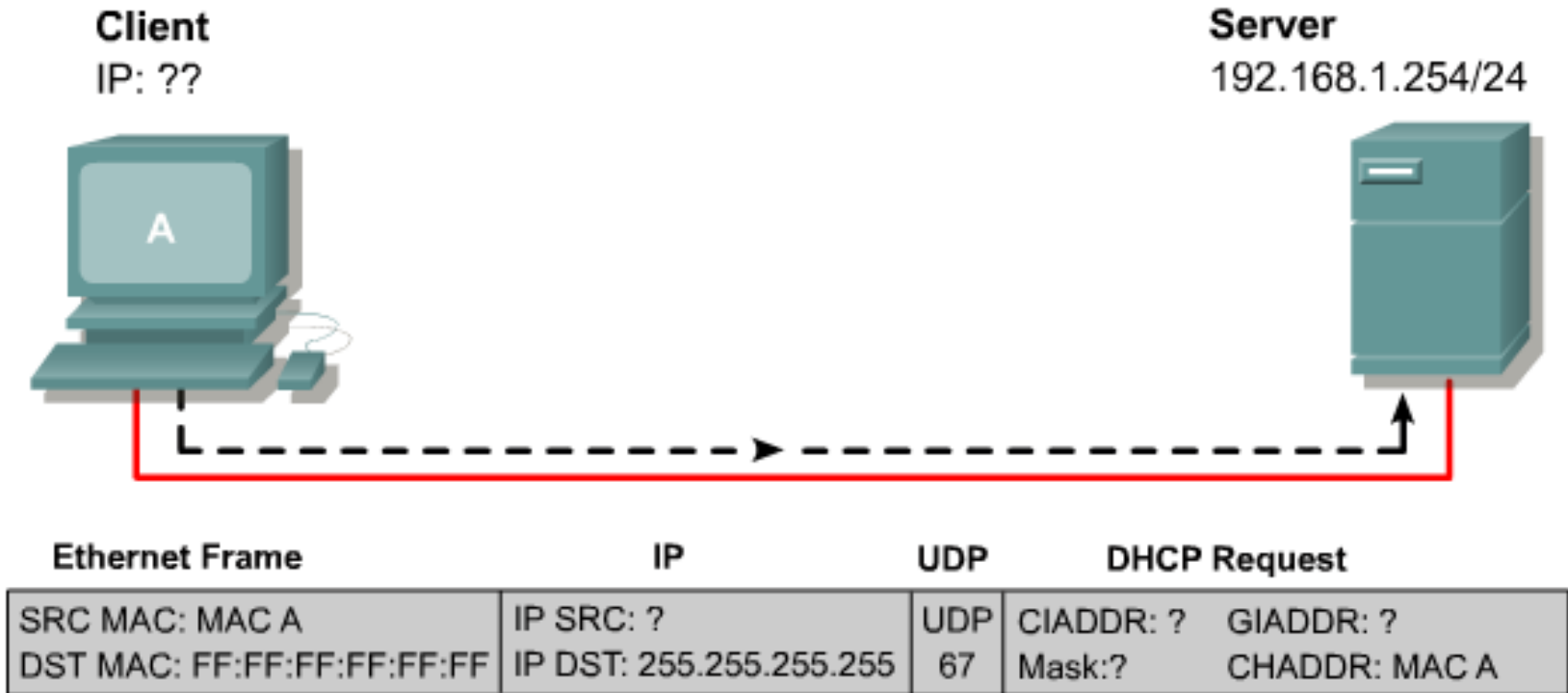
- BOOTP Enhancement
- Same message structure as BOOTP
- Can choose among many DHCP servers



DHCP packet

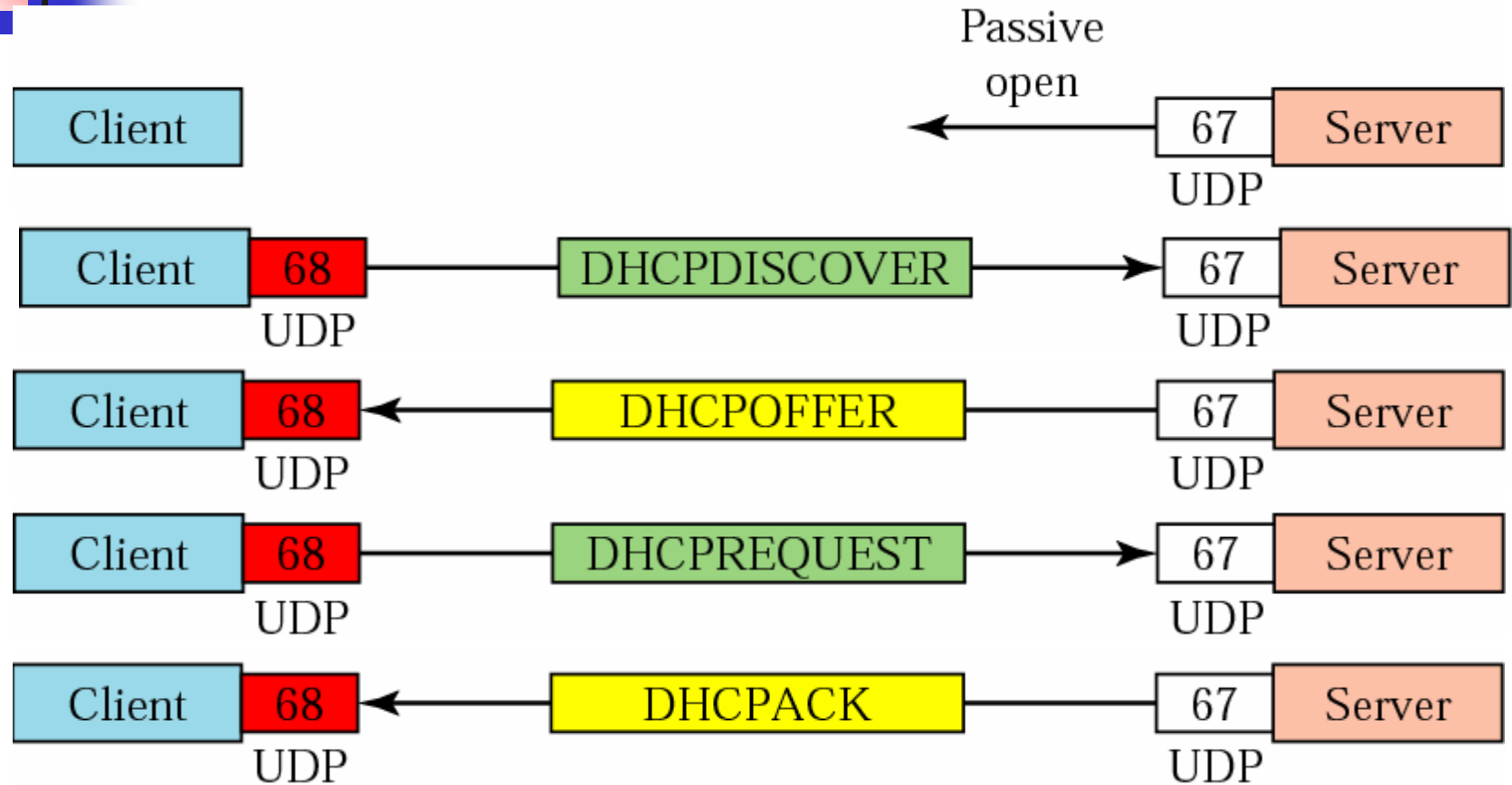
| Operation code | Hardware type | Hardware length | Hop count |
|---------------------------------------|---------------|-----------------|-----------|
| Transaction ID | | | |
| Number of seconds | F | Unused | |
| Client IP address | | | |
| Your IP address | | | |
| Server IP address | | | |
| Gateway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

Operation

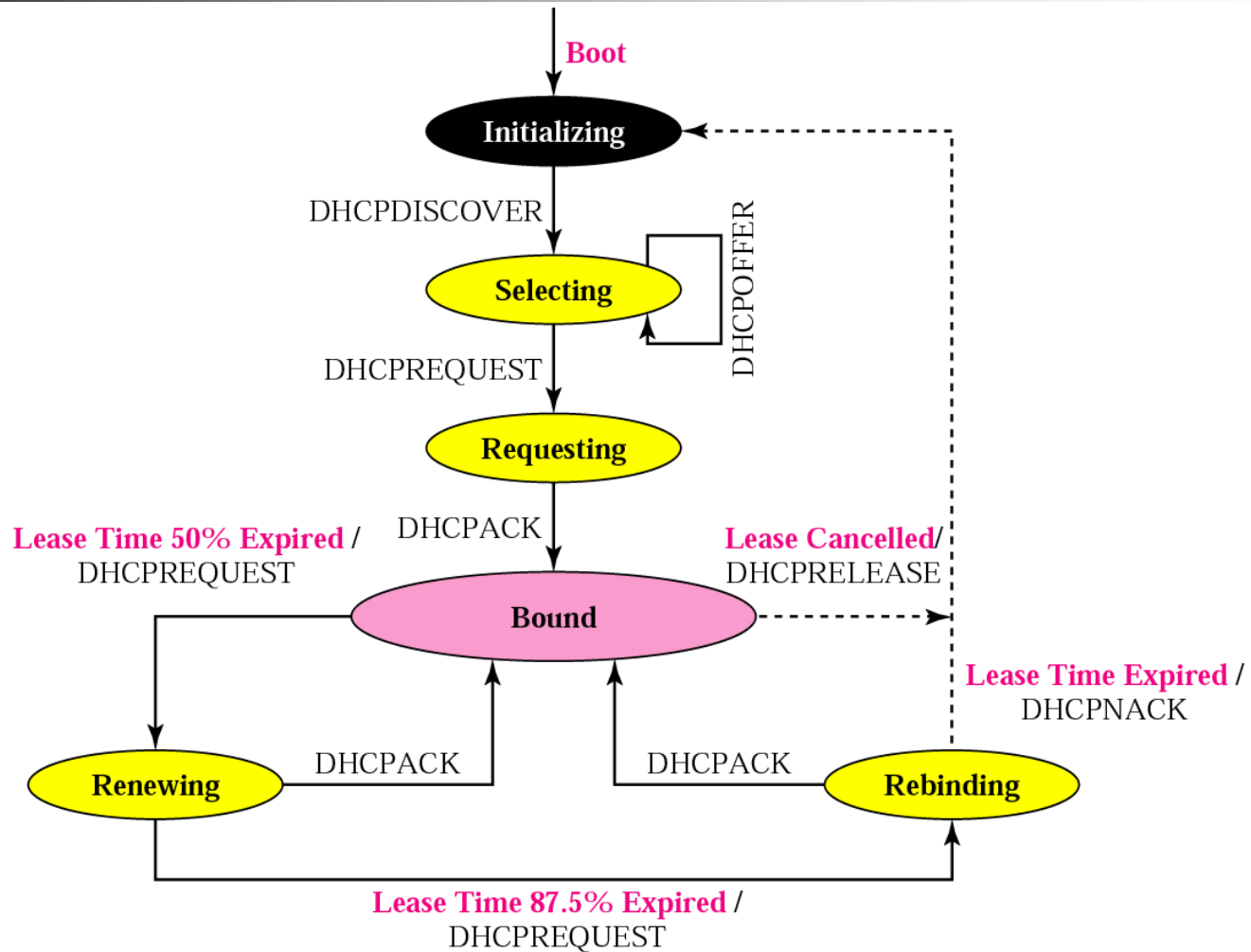


CIADDR : Client IP Address
GIADDR: Gateway IP Address
CHADDR: Client Hardware Address

DHCP Message



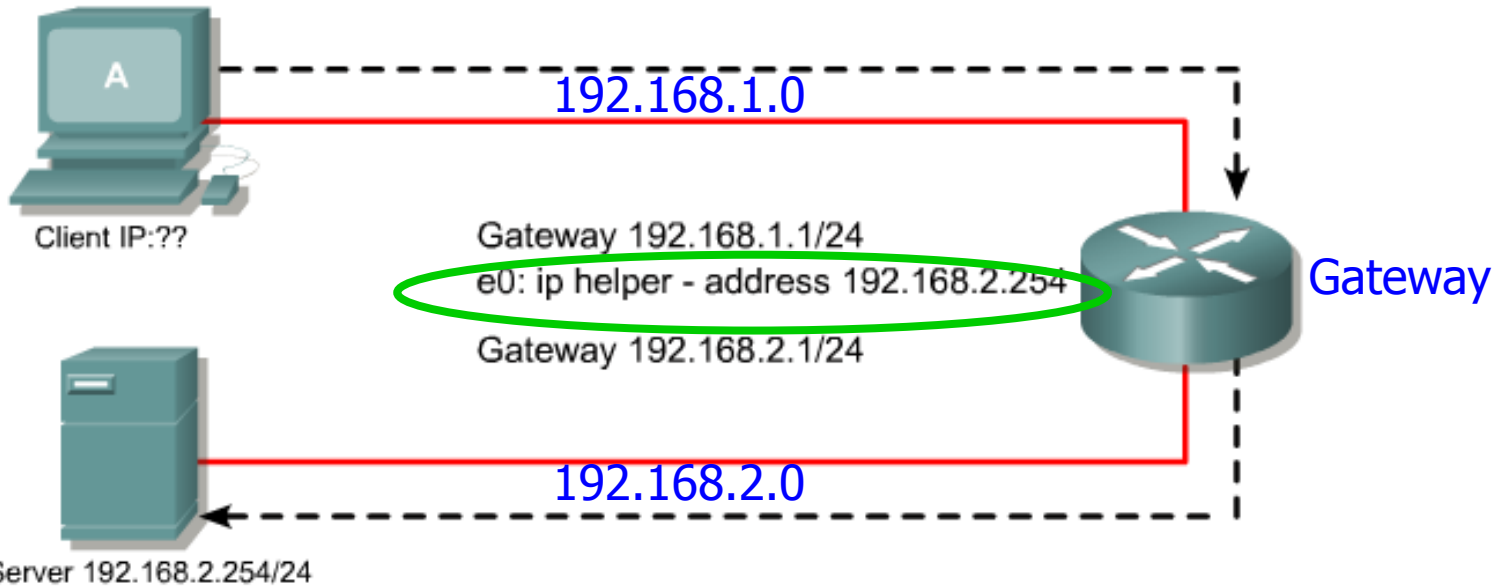
DHCP transition diagram



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 |

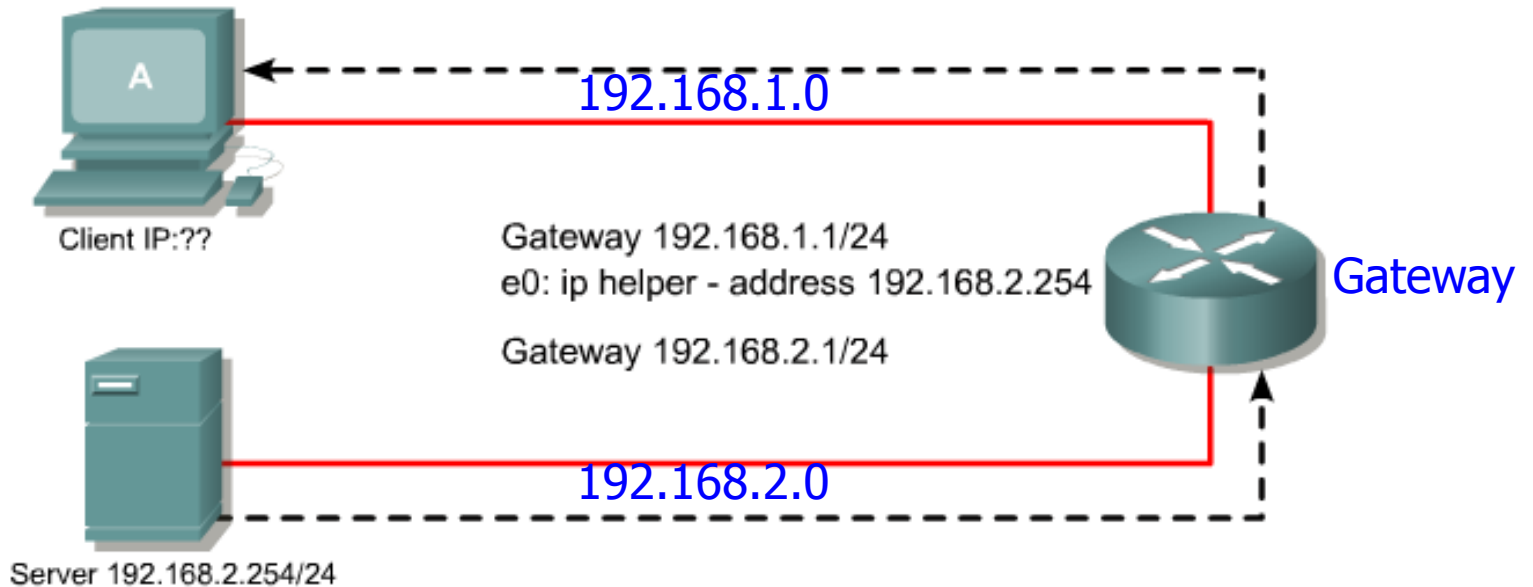


Unicast Ethernet Frame

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