



Inspiring Excellence

DHCPv4 & NAT

CSE 421 – Computer Networks

Department of Computer Science and Engineering
School of Data & Science



Inspiring Excellence

IP Addressing Services

Automatic IP Address Assignment

Address Translation

Objectives



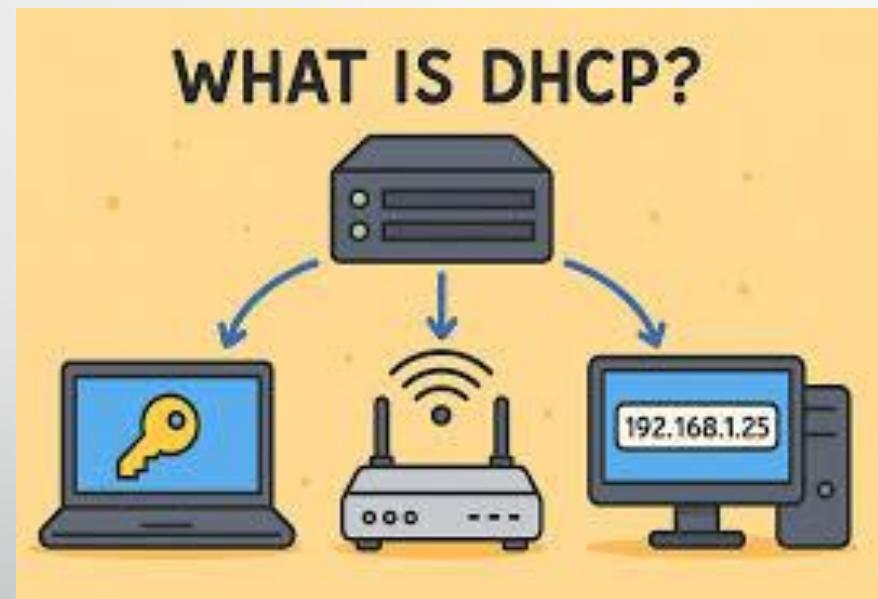
- DHCPv4 Concepts
- DHCPv4 Operations

- NAT Concepts
 - Introduction to NAT
 - PAT (NAT Overloading)
 - Port Forwarding

How devices get IP addresses automatically

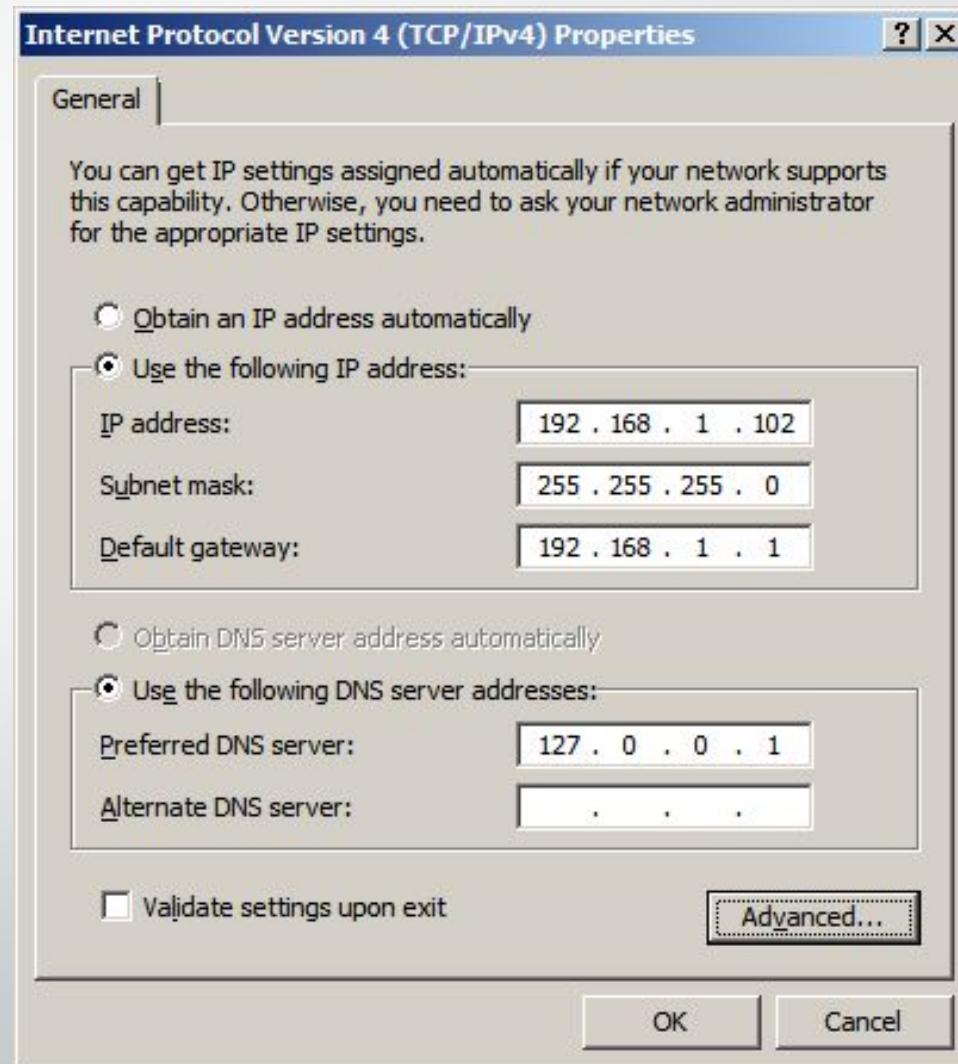
How many devices share one IP address

Dynamic Host Configuration Protocol (DHCP)



Assigning IPv4 Addresses : Static

- Every device that connects to a network needs **an IP address**.
- How to assign an IP address to a device?
 - **Static**
 - **Dynamic**
 - **Static :**
 - manually assigning ; stays fixed
 - used for devices must always be reachable
 - **Used for: Web servers, Routers, printers etc.**



Dynamic IPv4 Addressing

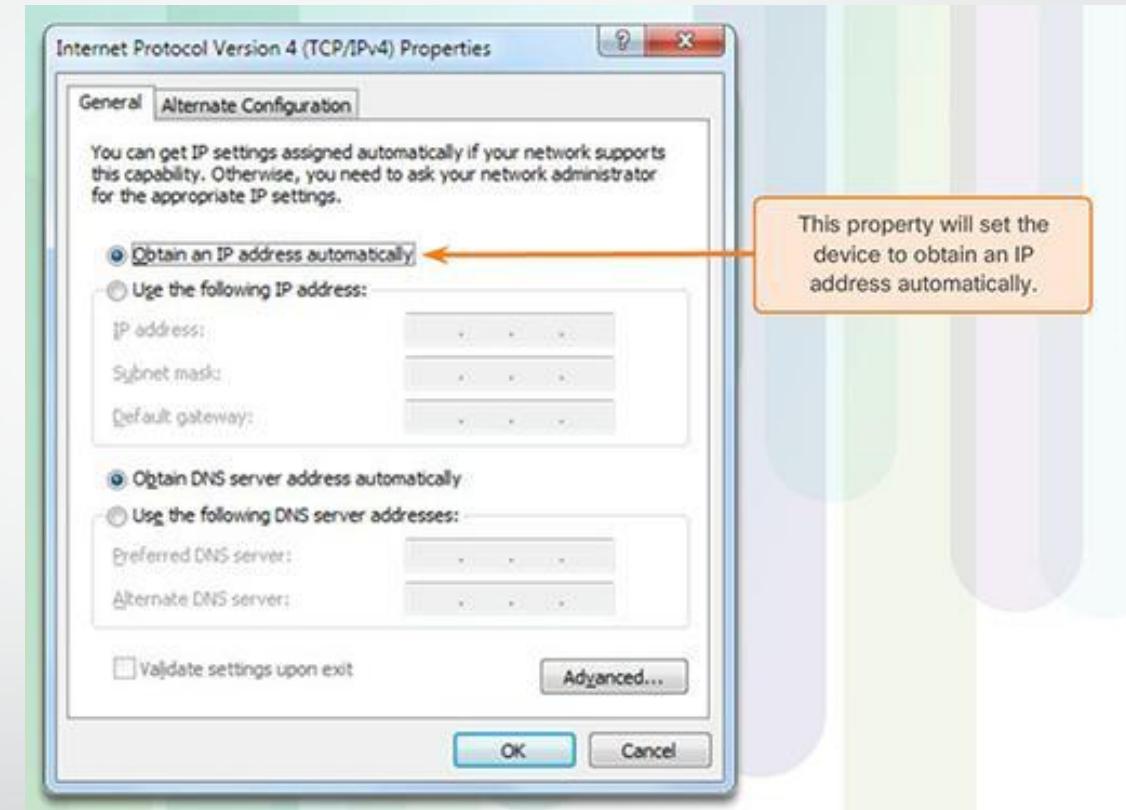
- **Dynamic :**

- assigns IP addresses automatically to devices.
- **Used for :** Laptops, phones, moving devices

- Who does this??

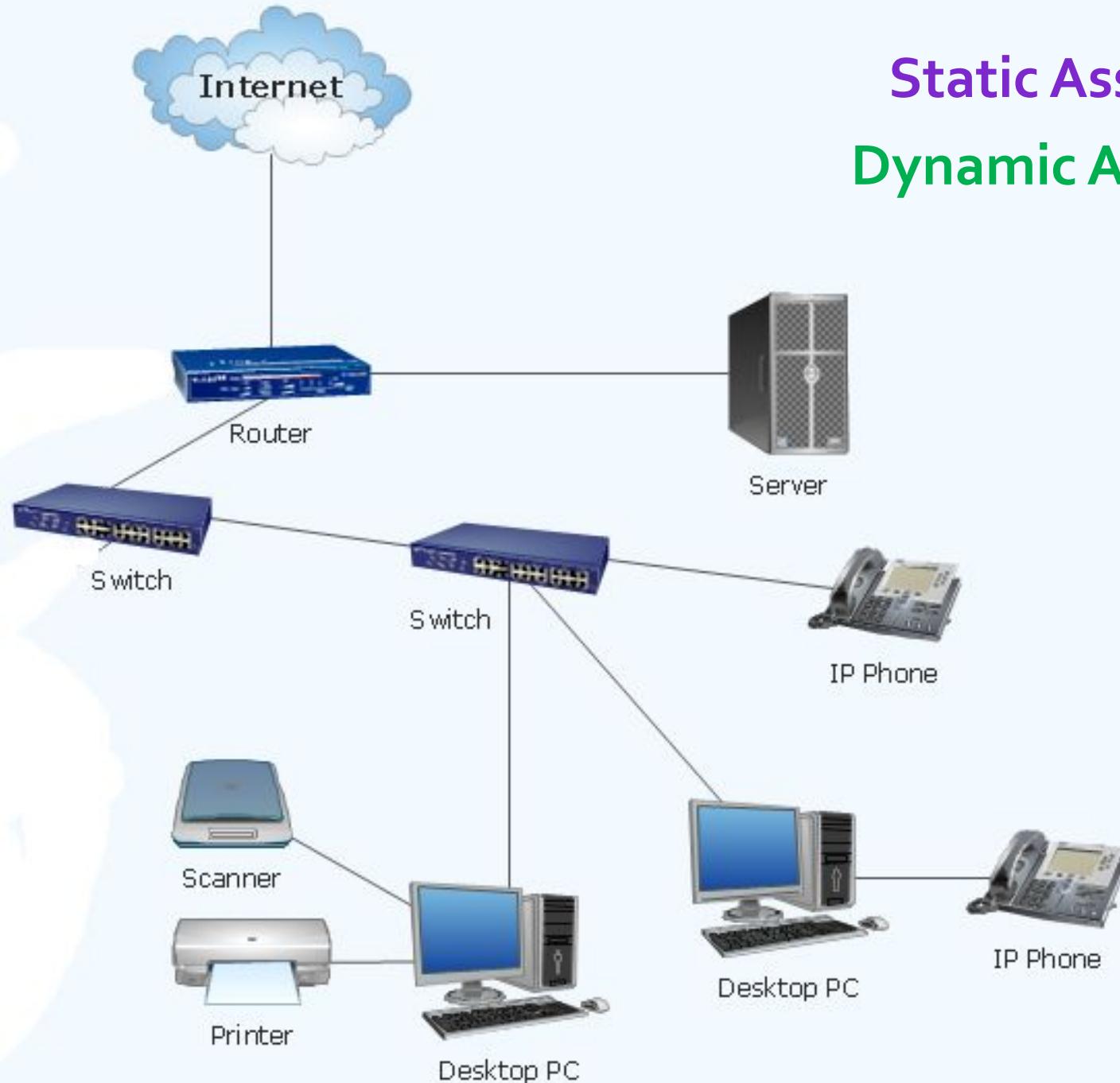


DHCP



Dynamic Host Configuration Protocol

Static Assignments? Dynamic Assignments?



Dynamic Host Configuration Protocol (DHCP)

Which device runs it?

- Used in large organizations
- More scalable.
- Easier to manage many clients
- Usually part of a **central server** (Windows Server, Linux DHCP, etc.)



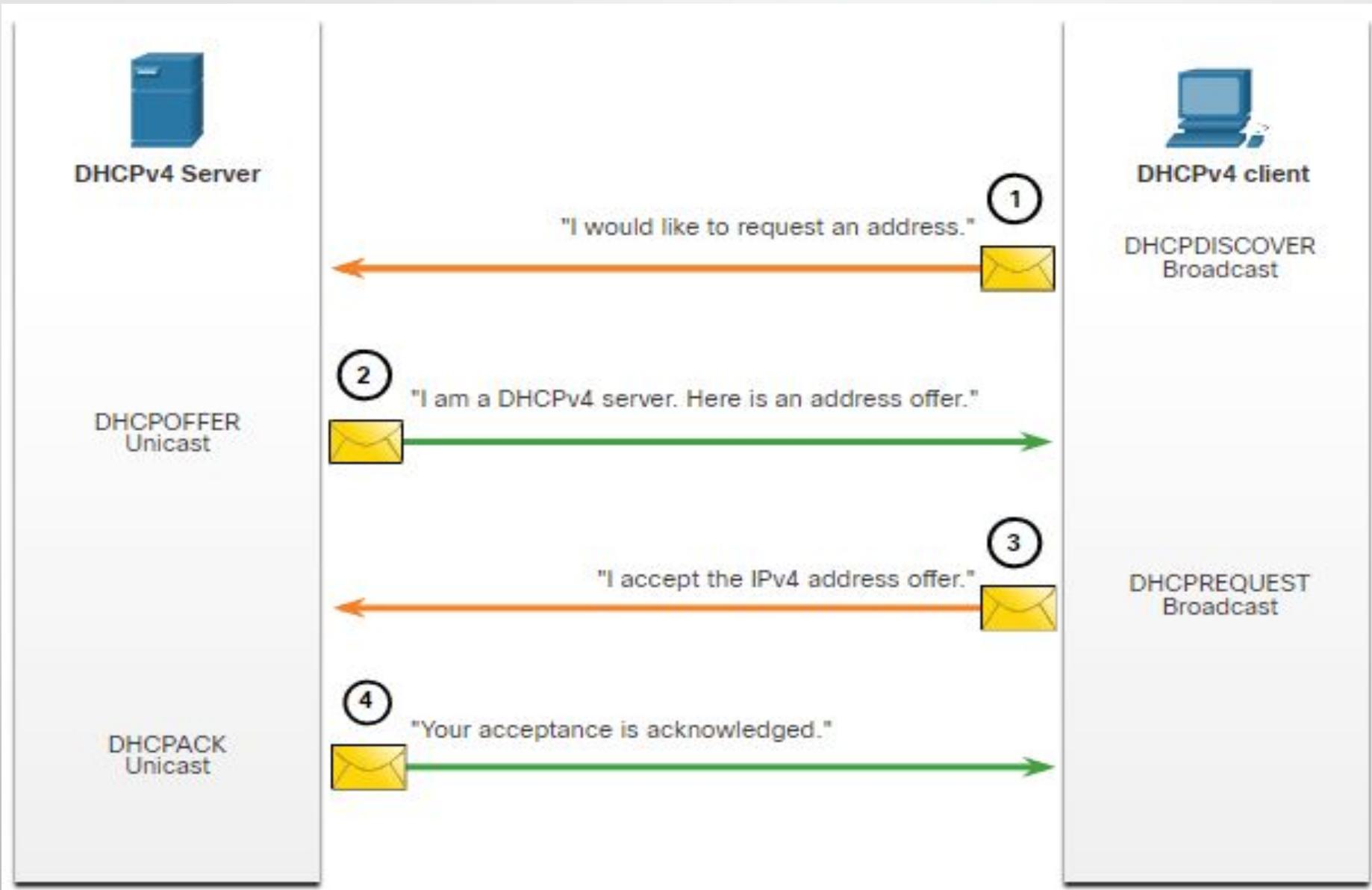
Servers

- Common in **homes, small offices (SOHO)**
- Cheaper
- Simple to configure
- Wi-Fi routers we use at home run DHCP automatically

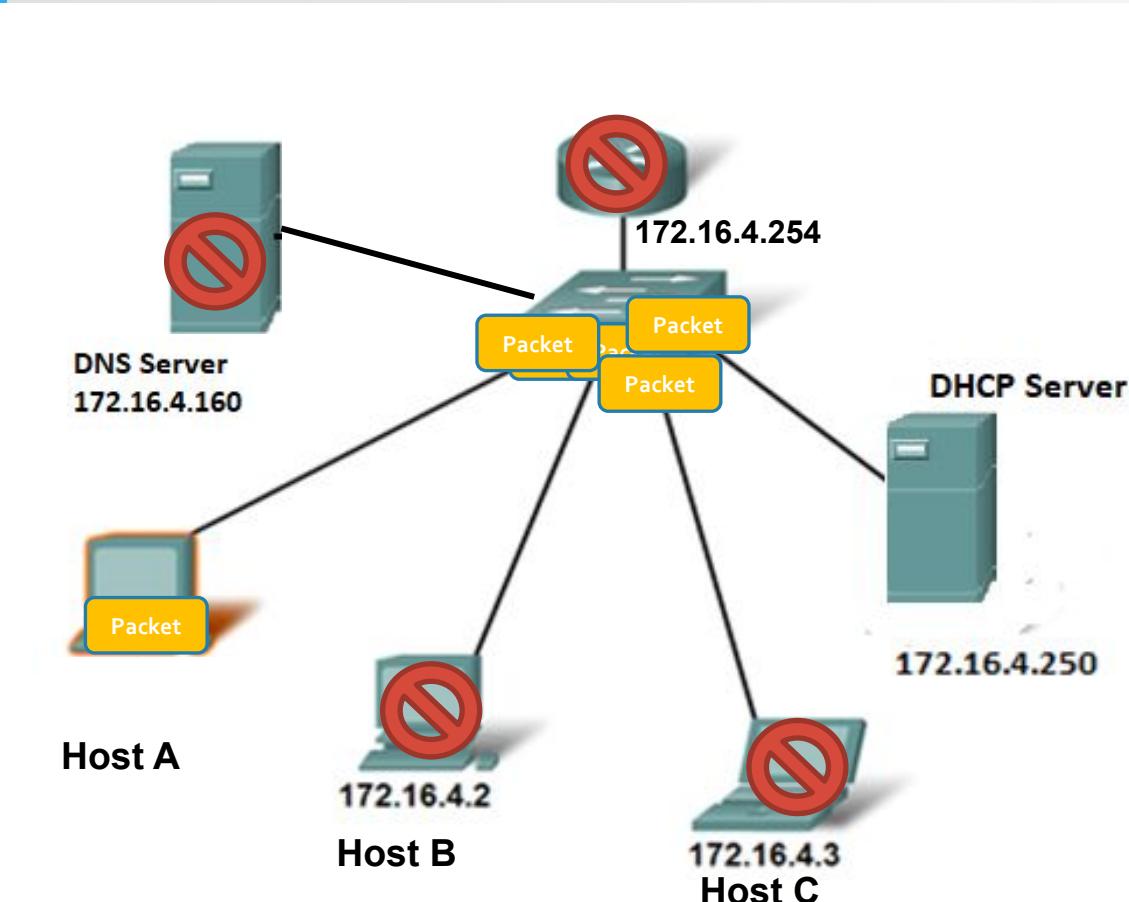


Routers

DHCP Operations



DHCP Operation - Start

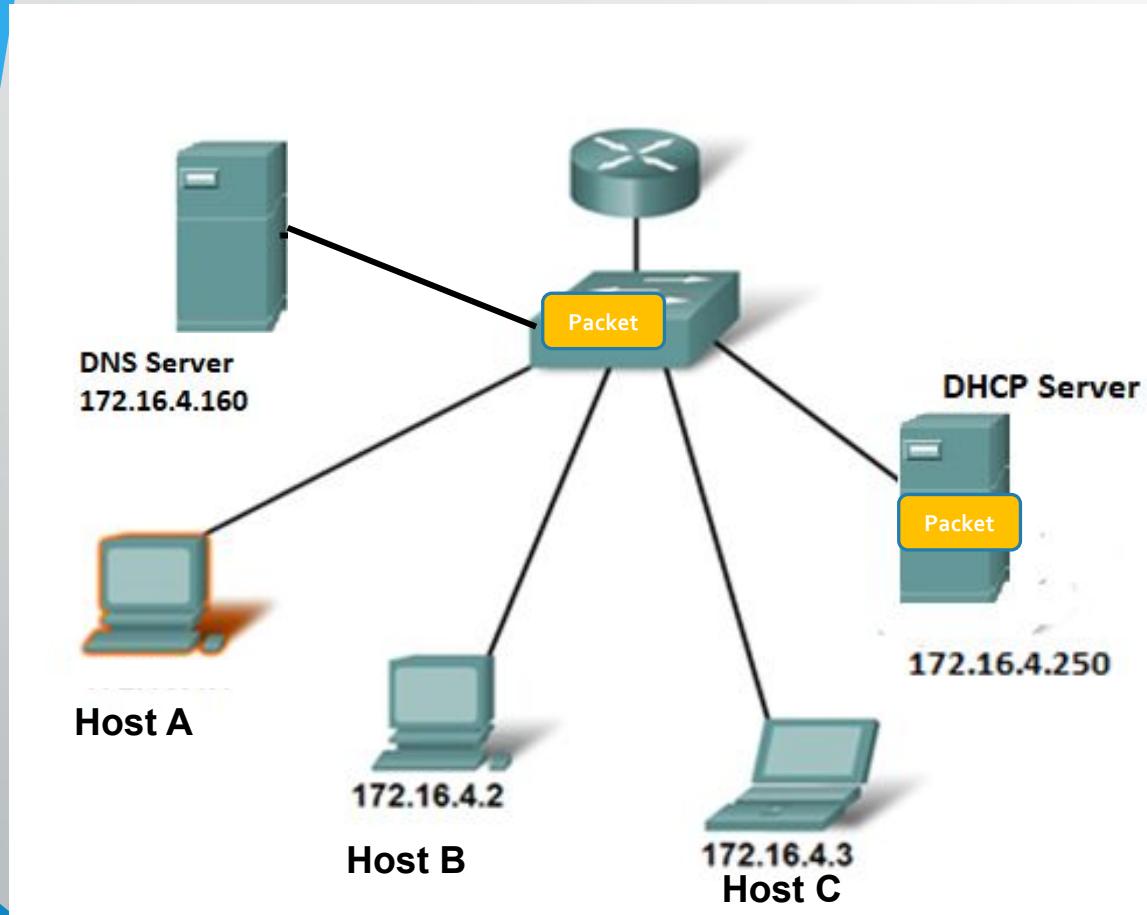


- **DHCP Discover (Broadcast packet)**

- Finds the DHCP server(s) on the network.

FFFF-FFFF-FFFF	Host A	255.255.255.255	o.o.o.o	67	68	DATA
Dest MAC address	Source MAC address	Dest IP address	Source IP address	Dest Port No	Source Port No	DATA

DHCP Operation

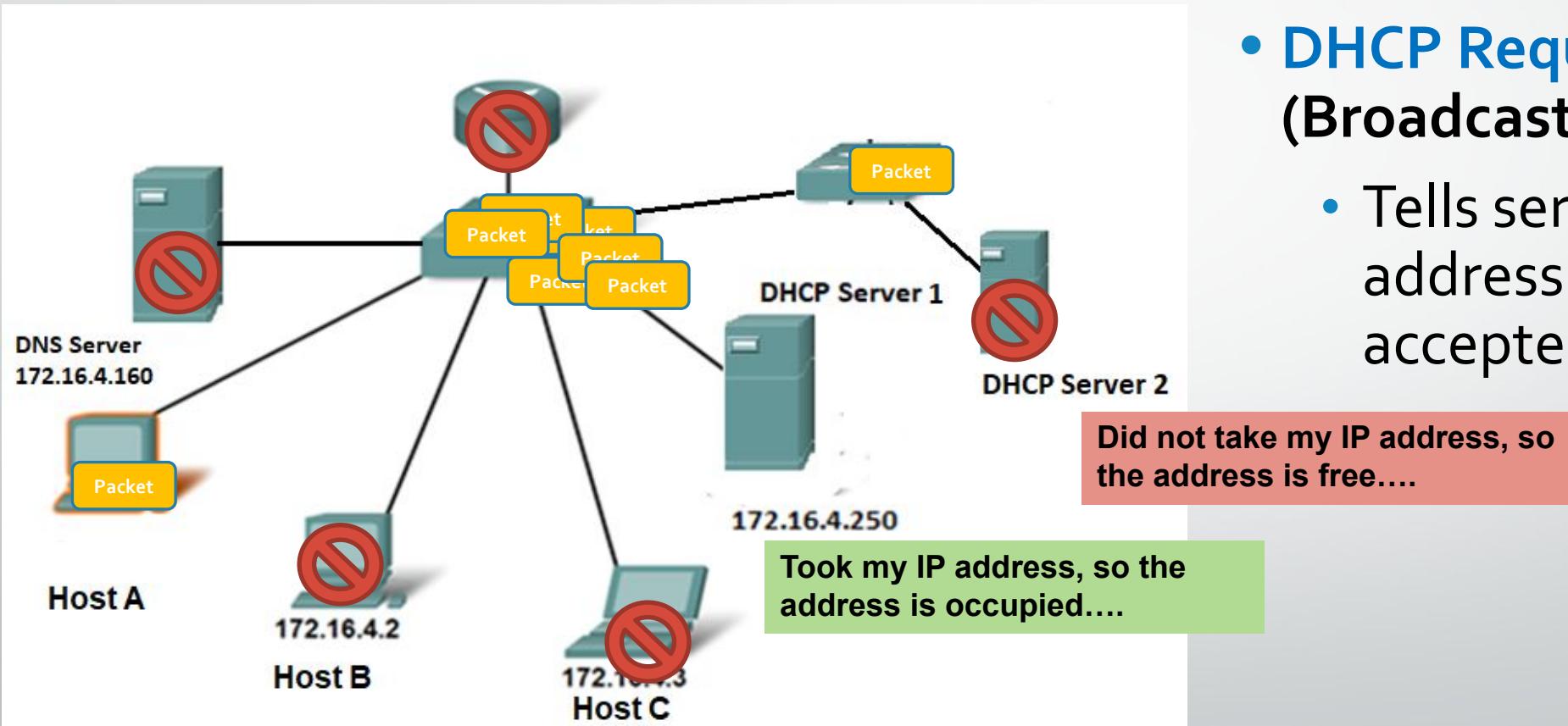


- **DHCP Offer (Unicast)**
 - Contains an available IP address to lease

IP address : 172.16.4.1
Subnet Mask: 255.255.255.0
Default Gateway: 172.16.4.254
DNS Server : 172.16.4.160
Lease Time : 3 days

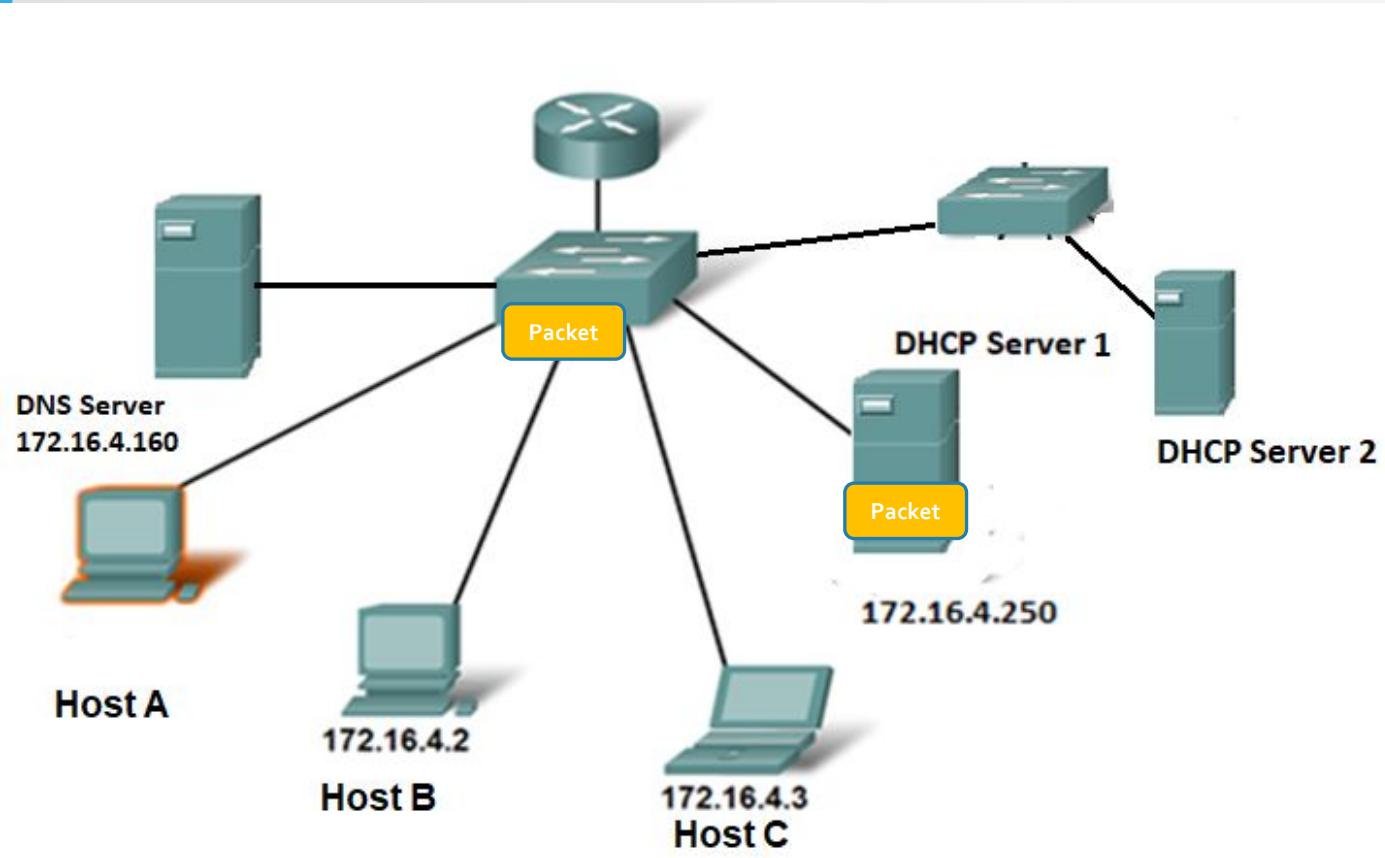
Host A	DHCP Server	172.16.4.1	172.16.4.250	68	67	DATA
Dest MAC	Source MAC	Dest IP	Source IP	Dest Port	Source Port	DATA

DHCP Operation



FFFFFFFFFF	Host A	255.255.255.255	172.16.4.1	67	68	DATA
Dest MAC	Source MAC	Dest IP	Source IP	Dest Port	Source Port	DATA

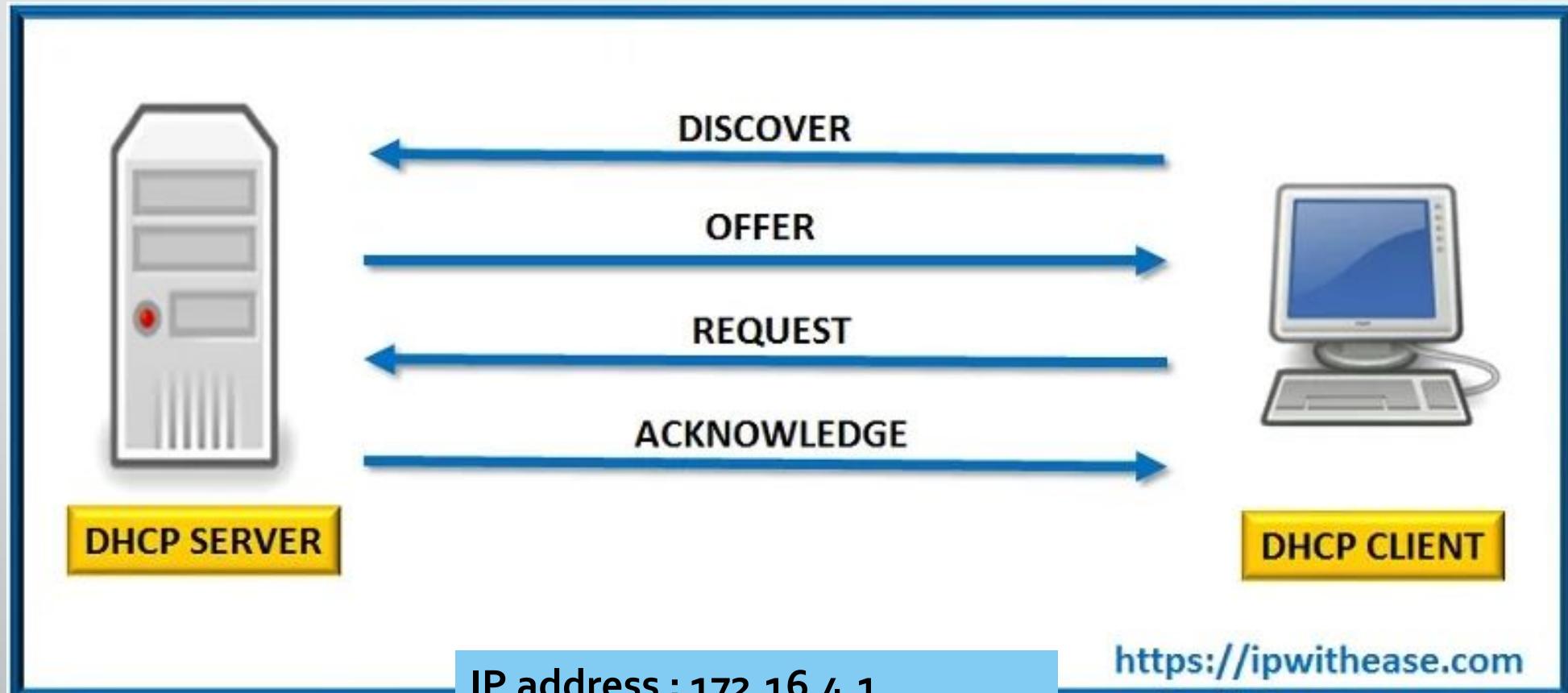
DHCP Operation



- **DHCP Acknowledgement (Unicast)**
 - Server Gives the OK to host to use the IP address.

Host A	DHCP Server	172.16.4.1	172.16.4.250	68	67	DATA
Dest MAC	Source MAC	Dest IP	Source IP	Dest Port	Source Port	DATA

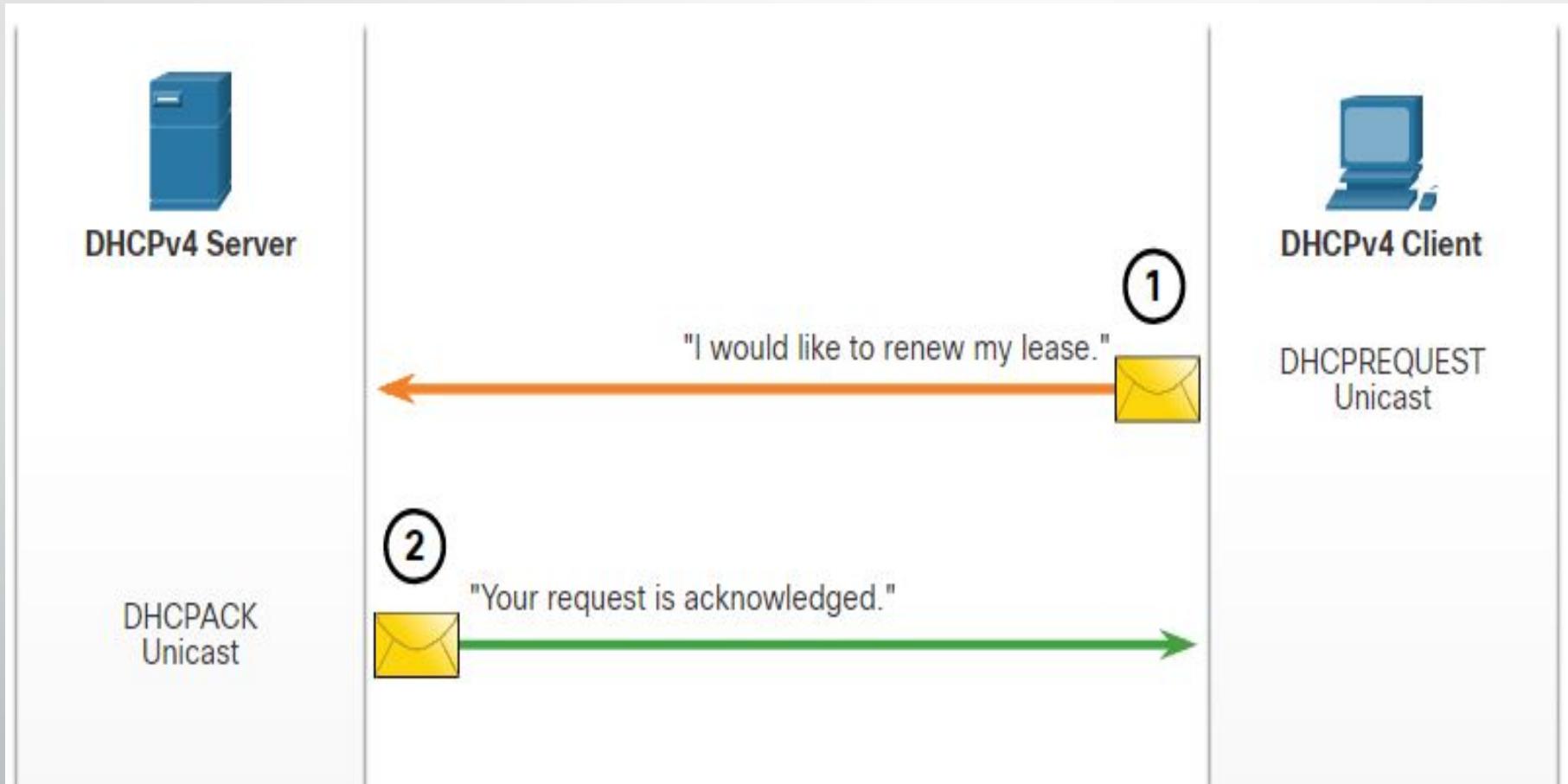
DHCP Operation (DORA)



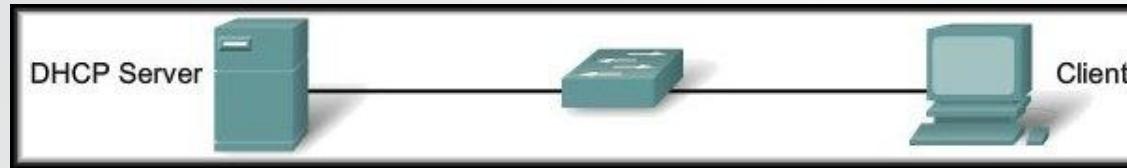
IP address : 172.16.4.1
Subnet Mask: 255.255.255.0
Default Gateway: 172.16.4.254
DNS Server : 172.16.4.160
Lease Time : 3 days

<https://ipwitthease.com>

Steps to Renew a Lease



DHCP Operation



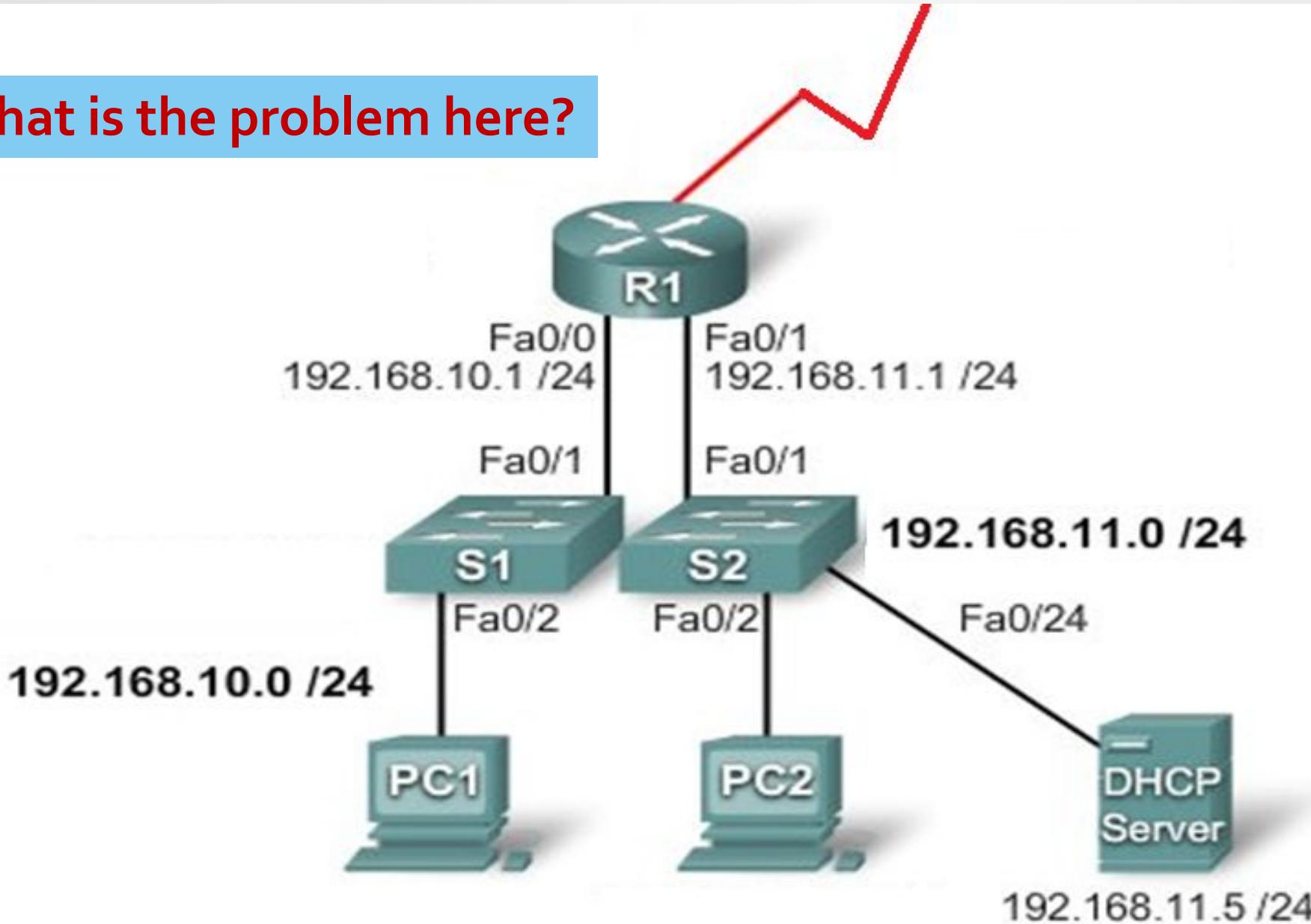
- DHCP works in a **client/server mode**.
- When the client connects, the server assigns or **leases** an IP address to the device.
- The host must contact the DHCP server periodically to **extend the lease**.
- The leasing of addresses assures that addresses that are no longer used are returned to the address pool for use by other devices.

DHCP RELAY



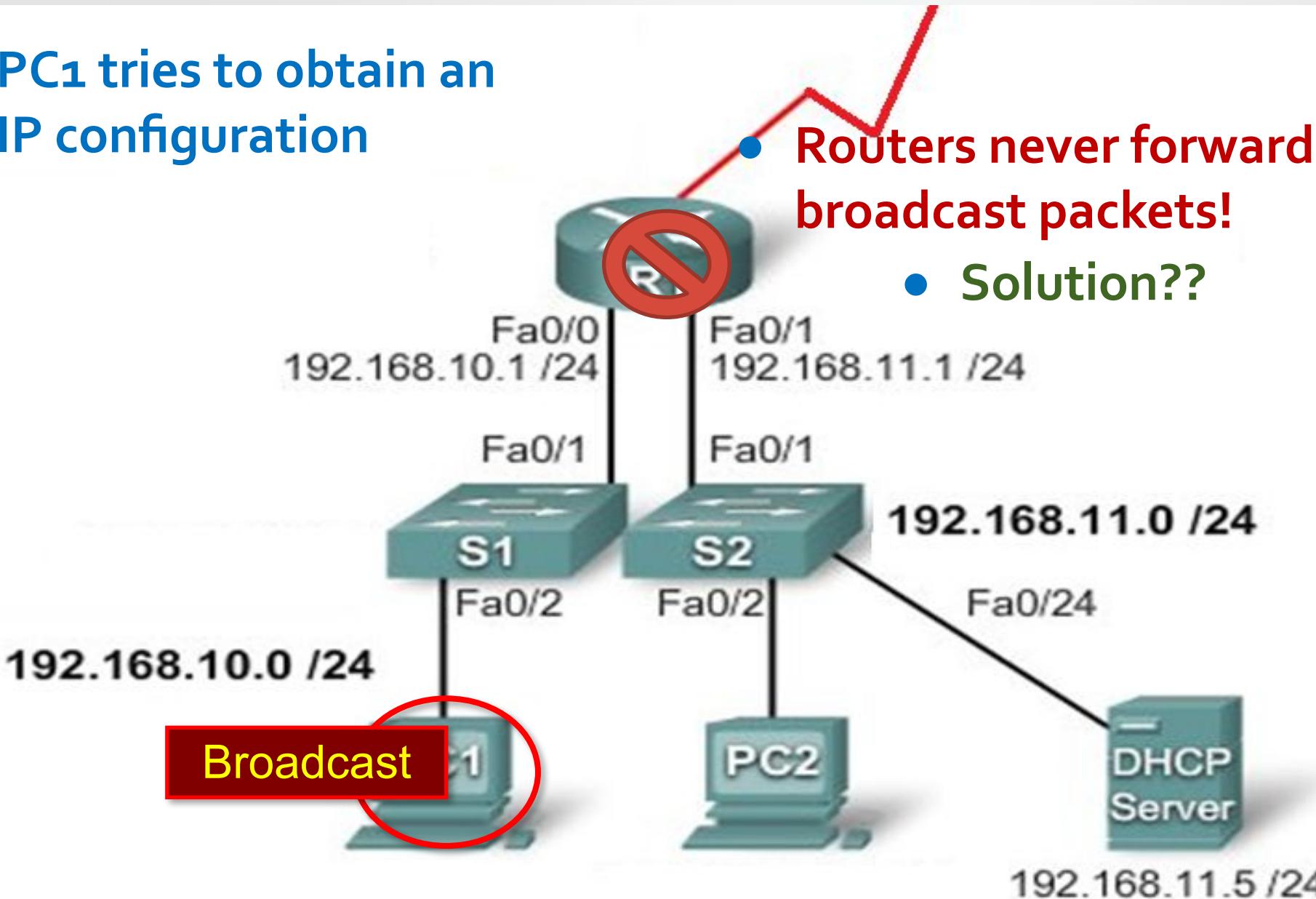
DHCP related issues

What is the problem here?

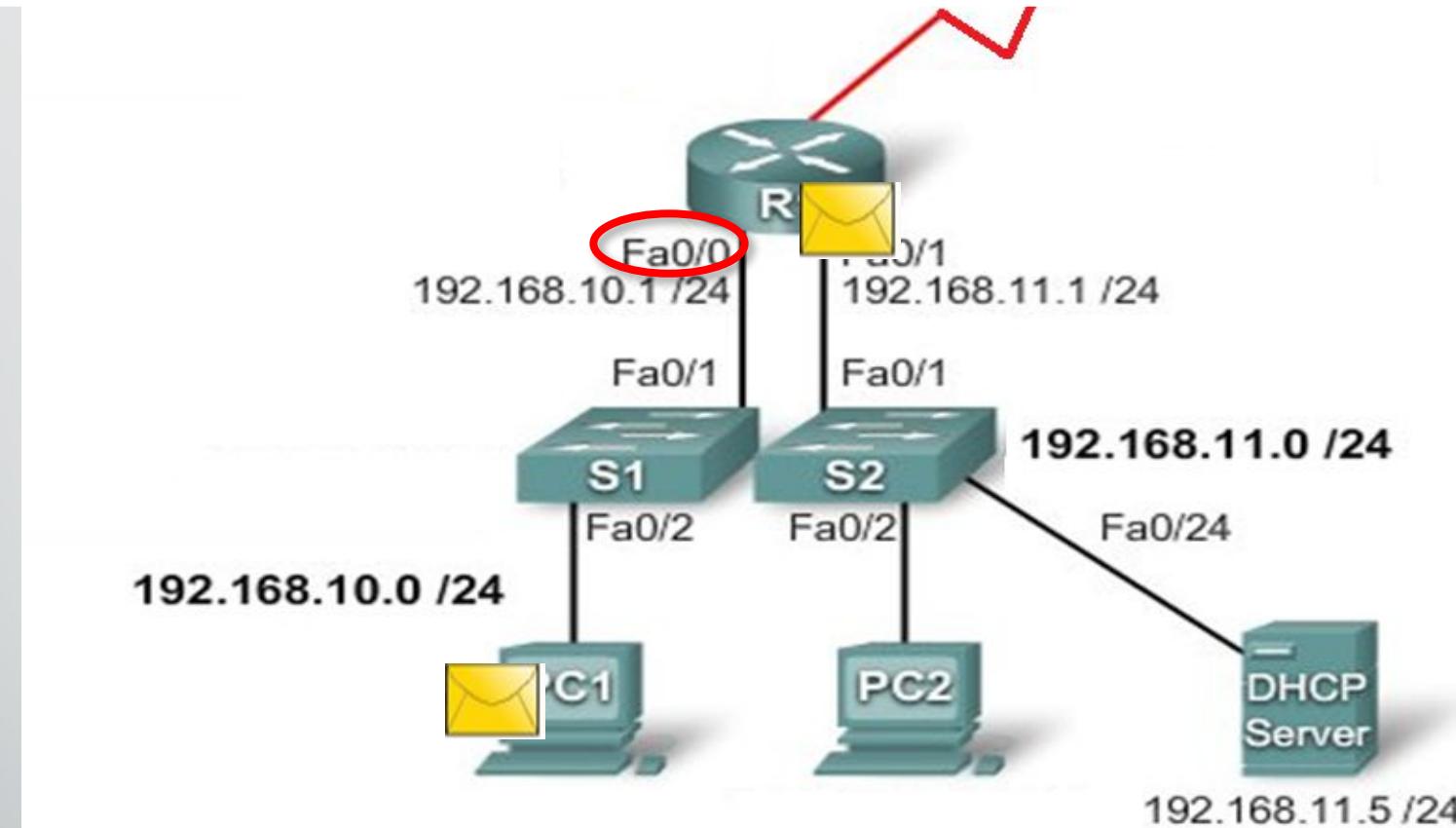


Problem with DHCP Server not in the same network

- PC1 tries to obtain an IP configuration



Dest MAC	Source MAC	Dest IP	Source IP	Dest Port	Source Port	DATA
DHCP Server	R1 Fa0/1 Mac	192.168.11.5	0.0.0.0	67	68	DATA

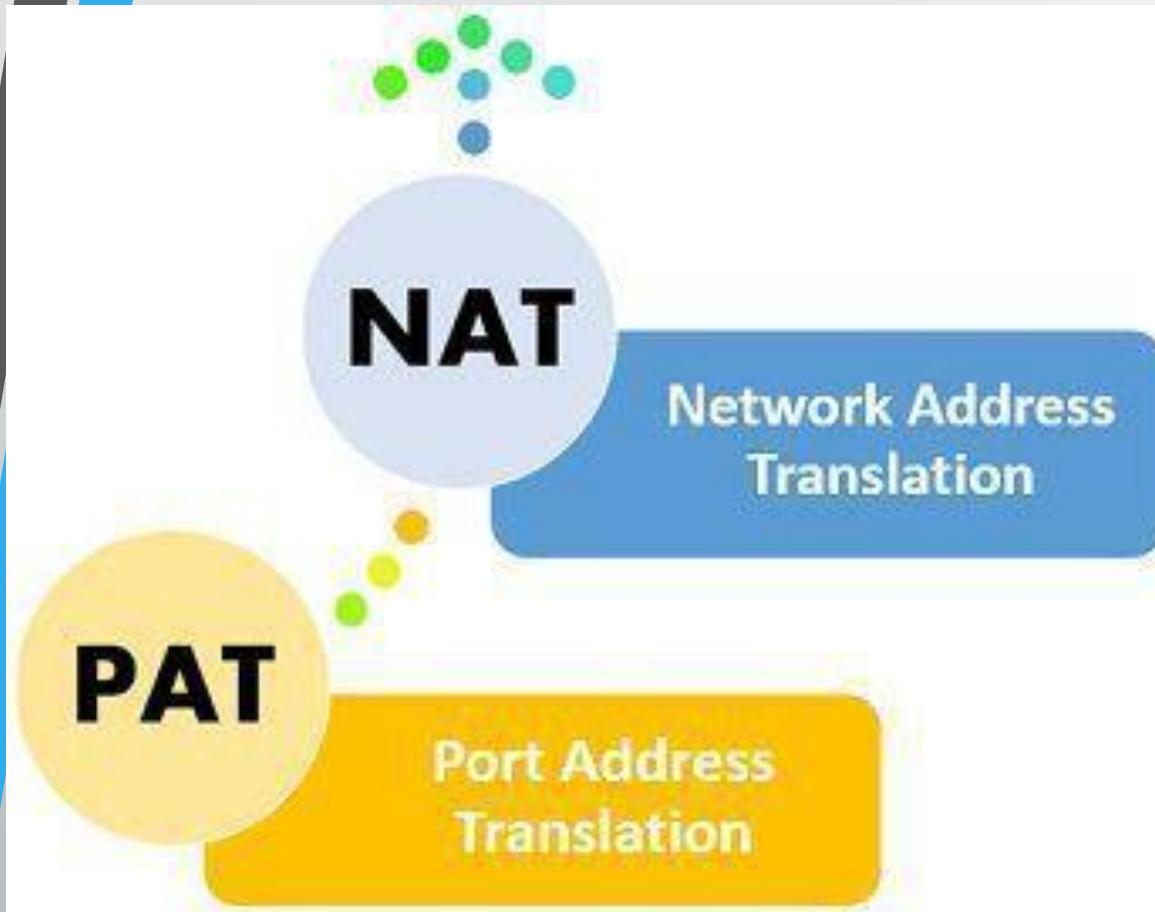


Known as
DHCP Relay

- Configure **R1 Fa0/0** (*the interface that receives the PC1 broadcasts*) to **relay DHCP broadcasts** to the DHCP server, use the following commands:

R1(config)#interface fa0/0

R1(config-if)#ip helper-address 192.168.11.5



How many devices share one IP address

Why do we need to share??



Category of IP Addresses

- **Two Categories**

- Private IP addresses
- Public IP addresses

- **Private IP Addresses:**

- Used **inside** homes, offices, universities
- **Cannot** be used on the internet
- Safe and reusable
- Assigned manually or via DHCP

Example : Separate three IP ranges

Private IP address space		
From	To	
10.0.0.0	10.0.0.0/8	10.255.255.255
172.16.0.0	172.16.0.0/12	172.31.255.255
192.168.0.0	192.168.0.0/16	192.168.255.255

Category of IP Addresses

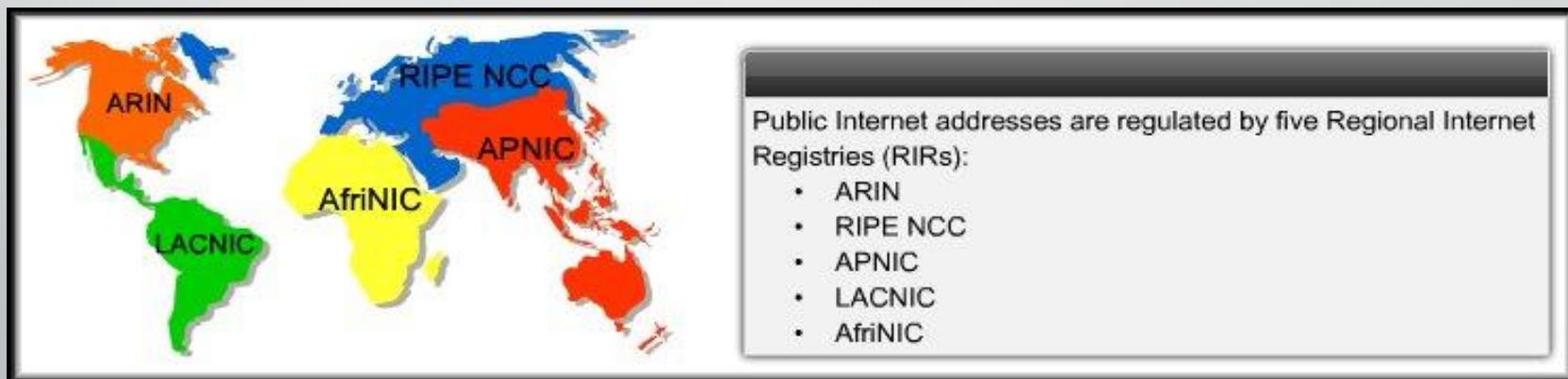
- **Public IP Addresses:**

- Used **on the internet**
 - Must be unique globally
 - Provided by ISP
 - Expensive and limited
-
- **Example :** Any IP address not within the above private ranges can be considered a public IP address.



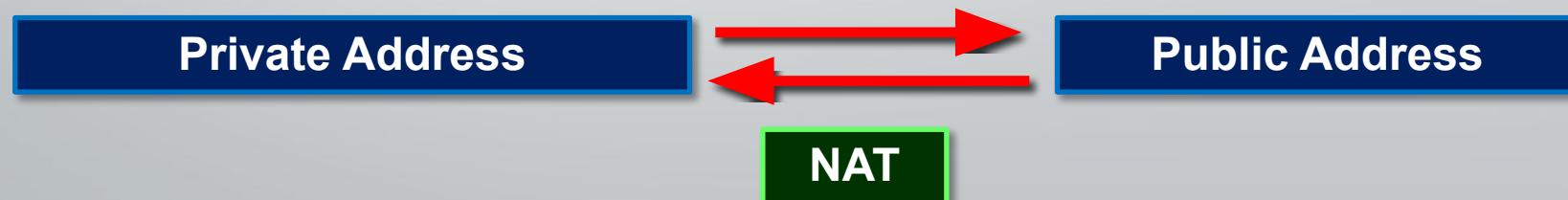
Public Addresses

- Must be unique worldwide
- Given by ISPs and regulated by global organizations called **Regional Internet Registries (RIRs)**.
- Organizations that owns the public IP can use it on their network.



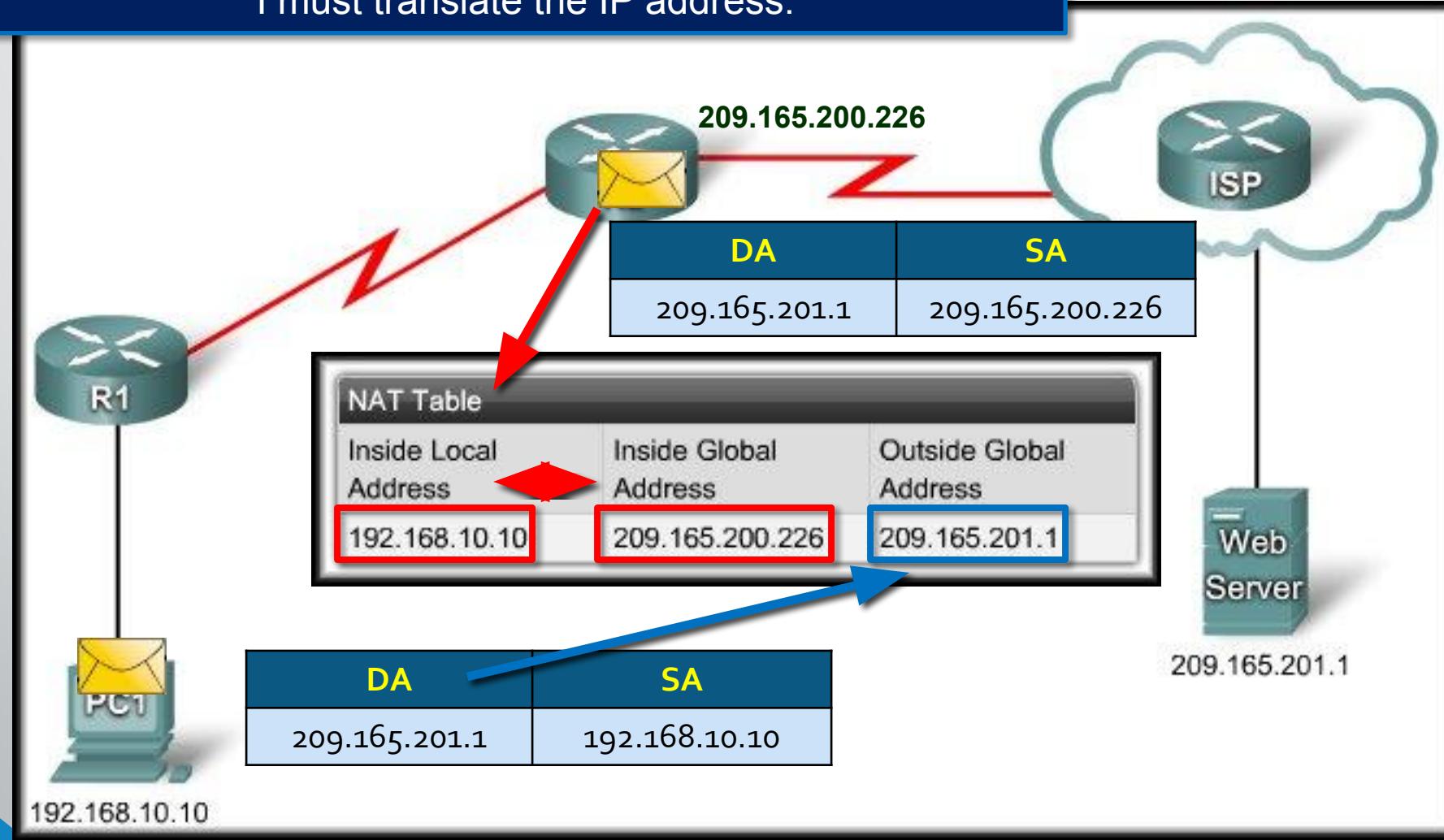
WHY??

- Why categorise into Public and Private IP addresses?
- How does using Private IP addresses help us save IP addresses?
- Private addresses cannot be routed in the Internet— Do we want this?



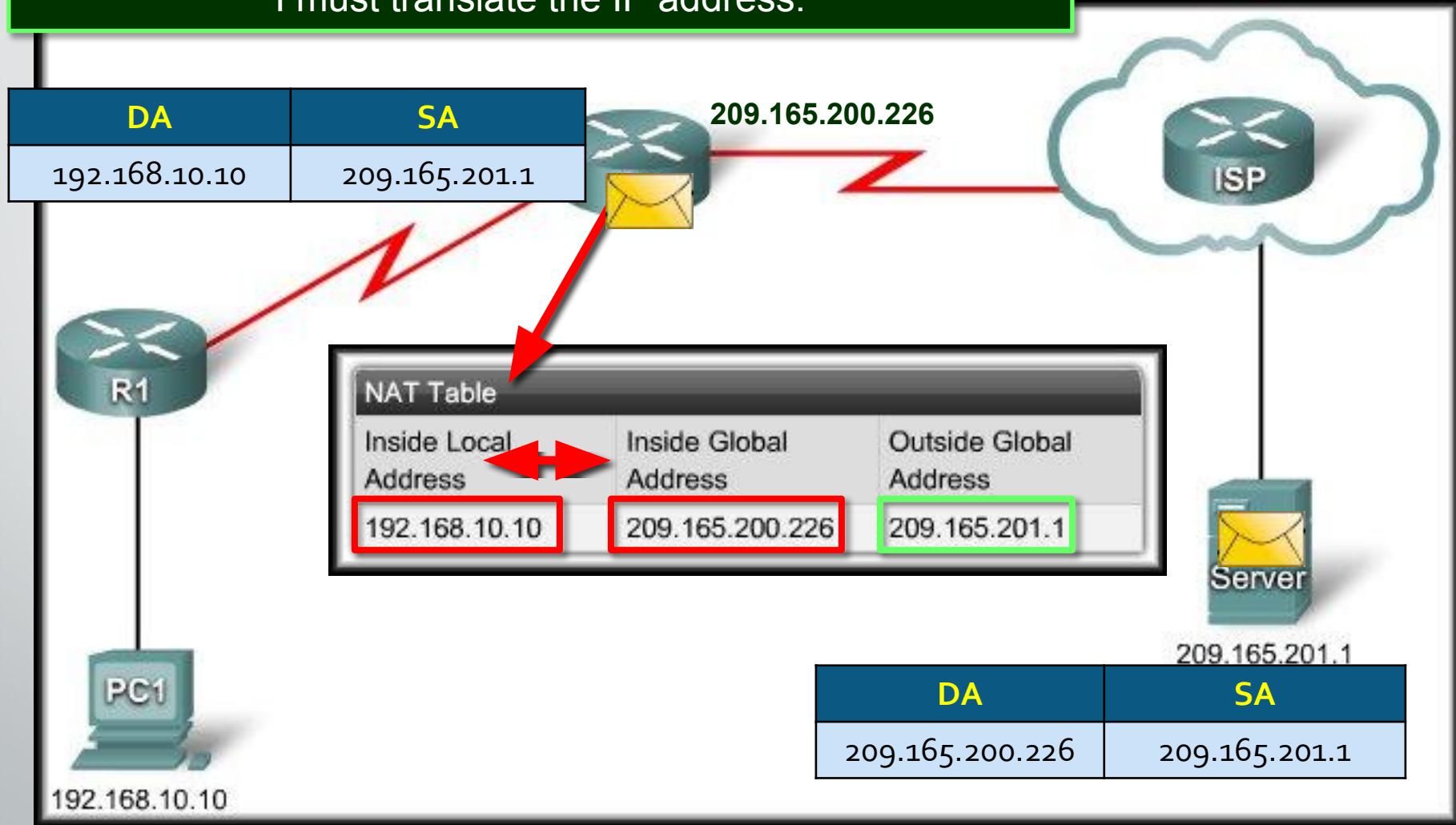
Example: NAT; Sending

R2: I have a packet for the **outside network**.
 I must translate the IP address.



Example: NAT; Receiving

R2: I have a packet for the **inside network**.
 I must translate the IP address.



Advantages of NAT

- Helps save official IP addresses
- Keeps internal network settings consistent, even when public IP configurations change.
- keeps user and device IPs private from the outside internet, enhancing security.

Disadvantages of NAT

- NAT **increases delays**.
- End-to-end IPv4 **traceability** is lost.
- **Can cause problems** for some protocols, such as Ipsec, VPN

Main issue: Does not **scale**

PAT (NAT Overload)

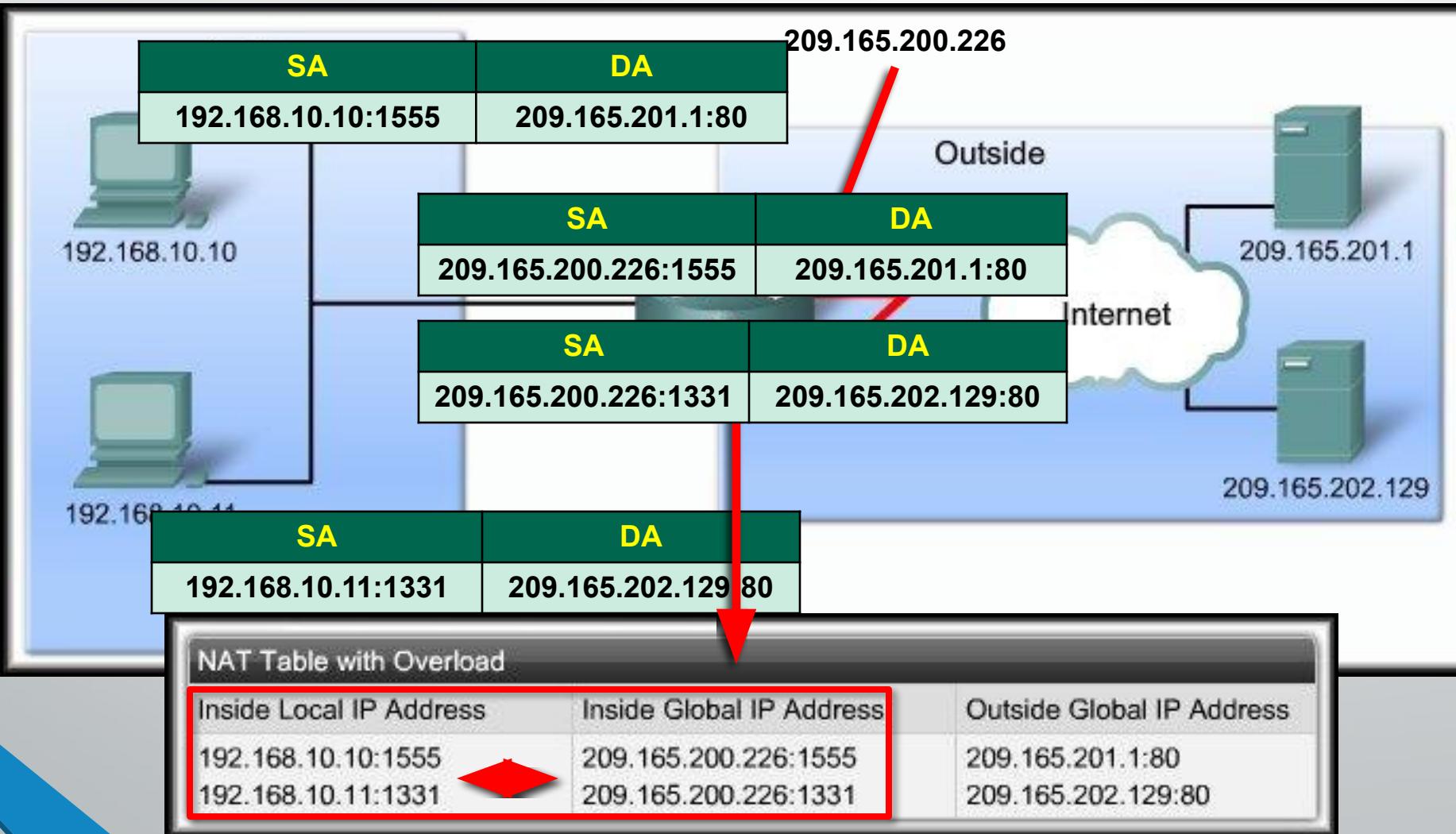
NAT Overload (PAT)

- Port Address Translation (PAT) = Real-world NAT
- Allows many devices to share one public IP
- Uses port numbers to differentiate the devices
- Router keeps a table:

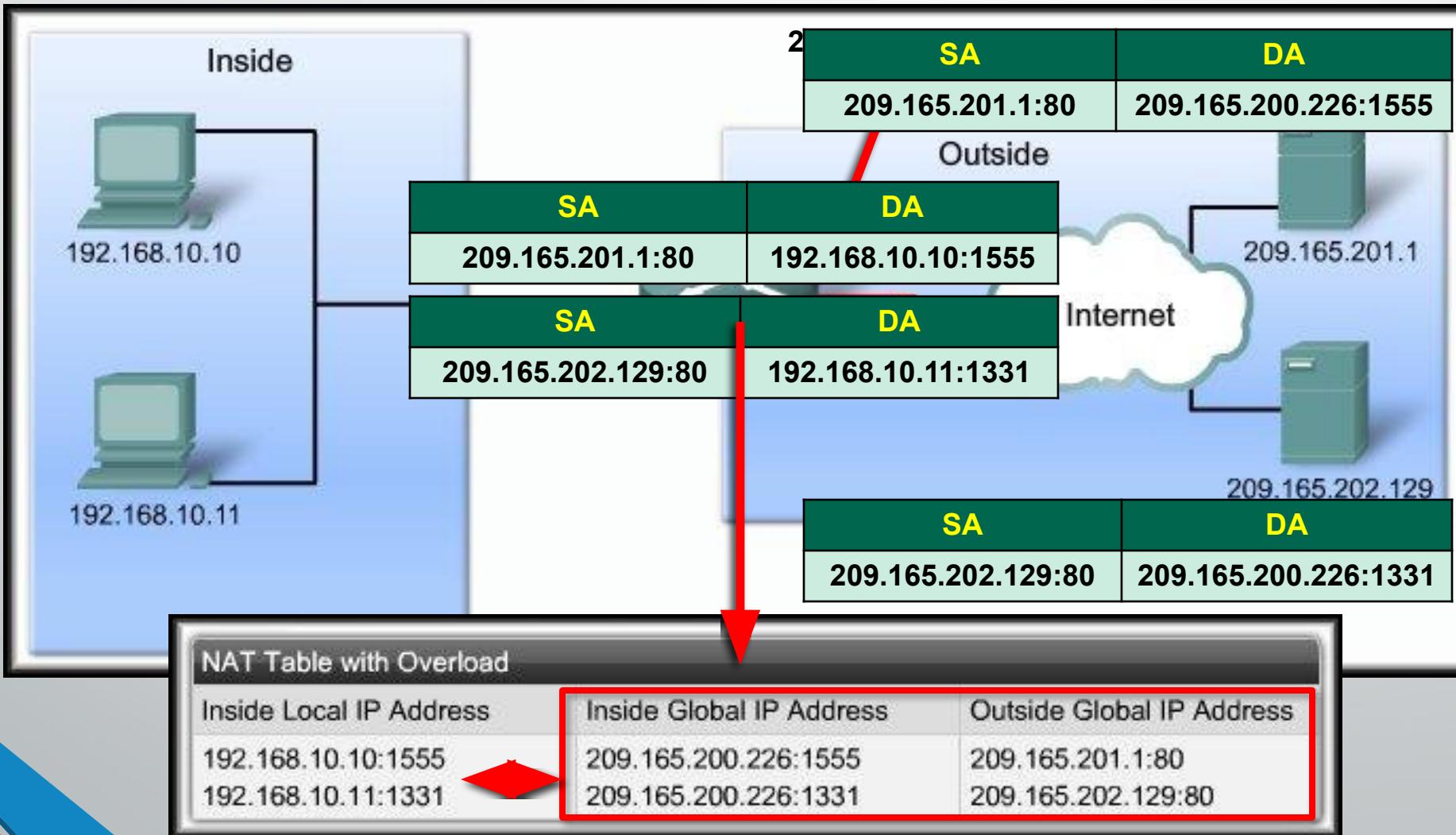
Private IP + Port → Public IP + New Port

- Each connection becomes unique because of the port
- PAT changes both the IP address and the port number.

PAT Operation

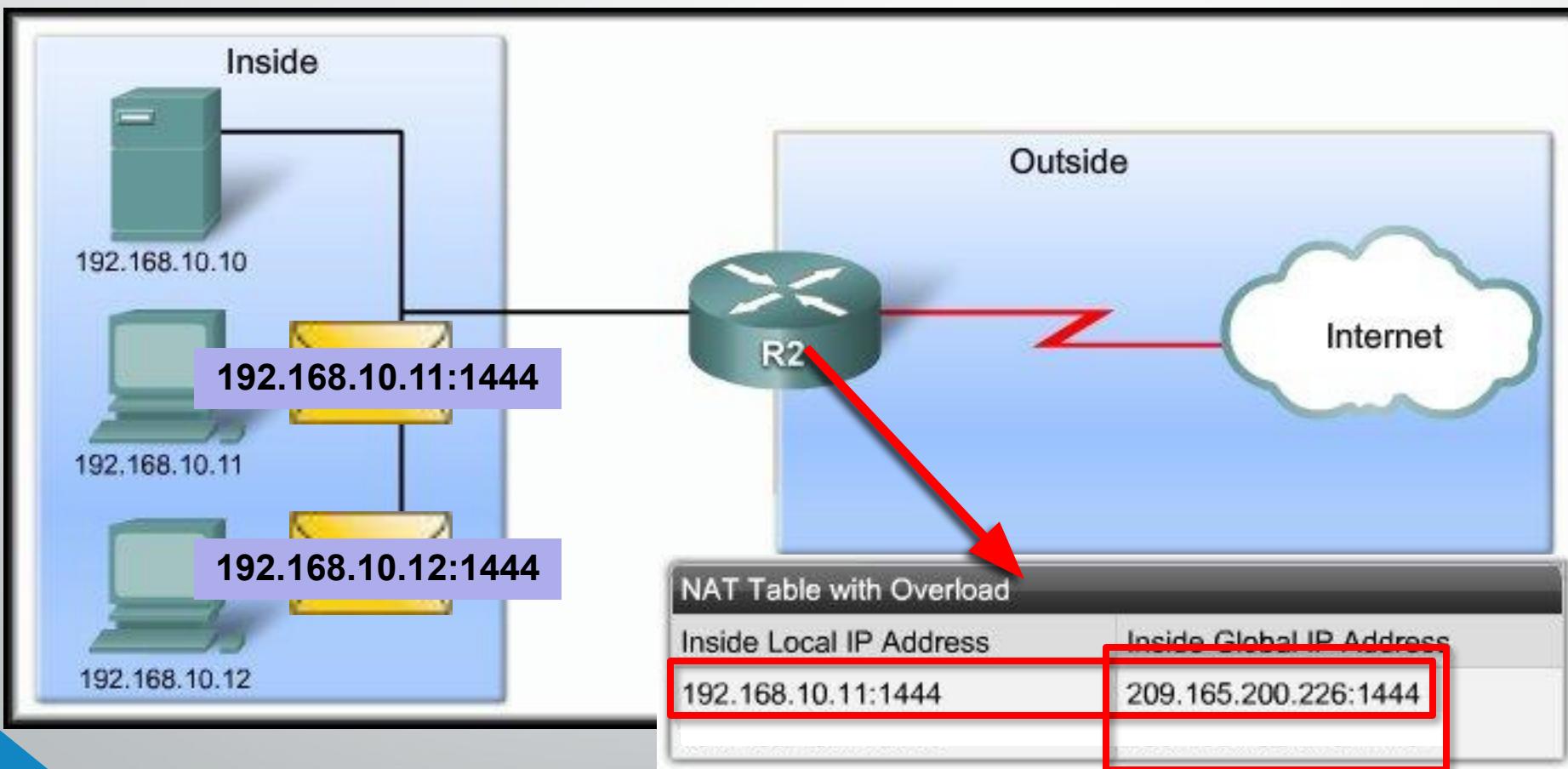


PAT Operation



PAT Operation

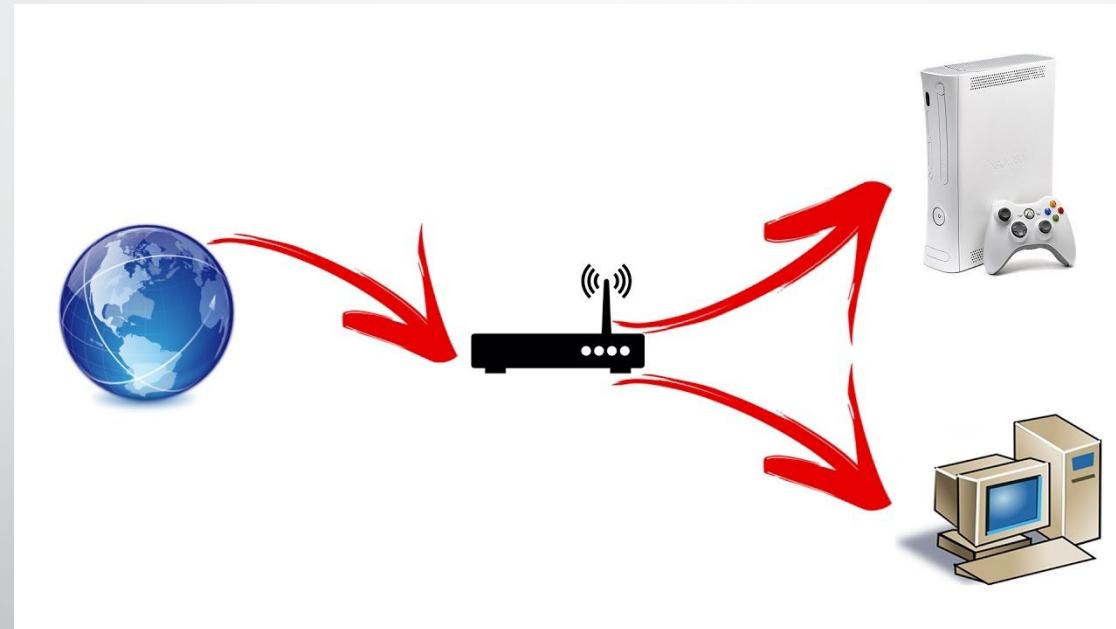
- **NEXT AVAILABLE PORT NUMBER**



Packets without Ports

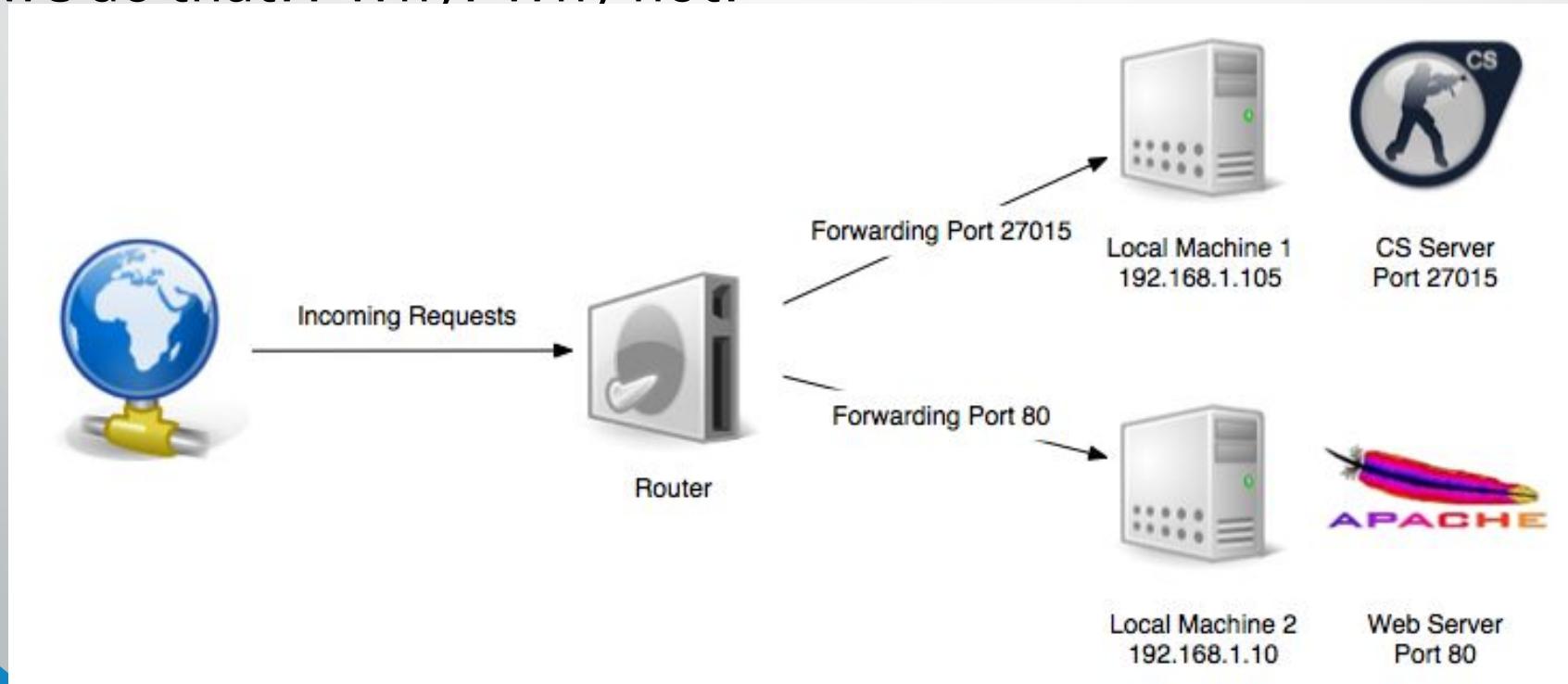
- Some protocols (like **ICMP**) do **not** have **TCP/UDP port numbers**
- PAT still needs a way to identify each connection
- ICMP uses a **Query ID** to match request reply
- PAT uses this **Query ID** the same way it uses port numbers

Port Forwarding



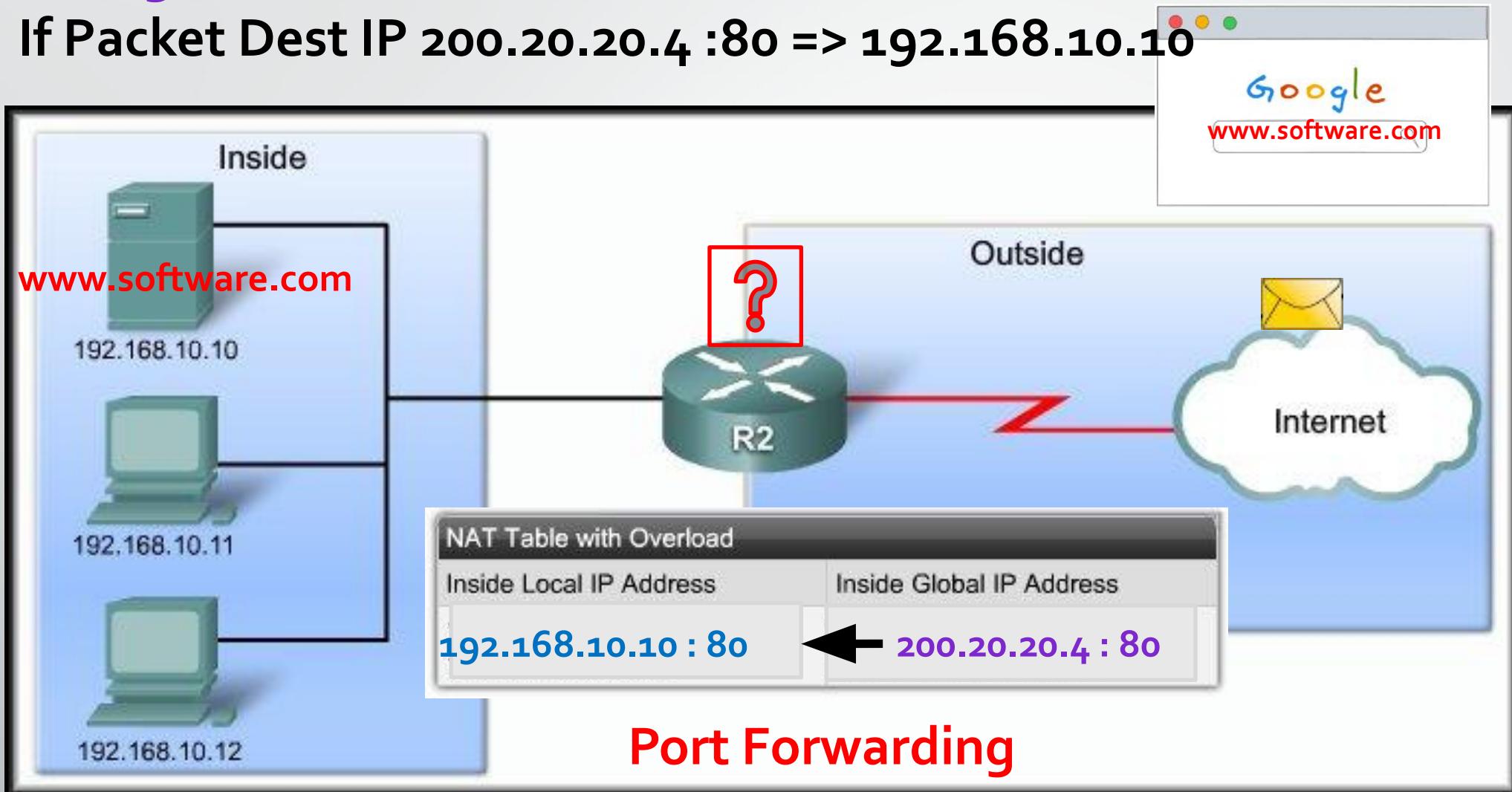
Port Forwarding

- Sometimes we need access to services hosted on private IP addresses (like home security cameras or personal web servers) **from the internet.**
- Can we do that?? Why? Why not?



Configure in Router :

If Packet Dest IP 200.20.20.4 :80 => 192.168.10.10



One Public IP : 200.20.20.4

DNS Records for www.software.com =>
200.20.20.4

Port Forwarding

- Used when a server inside the network has a **private IP**
- Router maps **PublicIP:Port** to the **correct PrivateIP:Port** inside the network.
- Allows Internet users to access inside services

Port Forwarding

Access from outside

112.12.136.14 : 27105 ==> 192.168.1.105:27015



Incoming Requests



Router

Forwarding Port 27015



Local Machine 1
192.168.1.105



CS Server
Port 27015

Forwarding Port 80



Local Machine 2
192.168.1.10



Web Server
Port 80

Public IP : **112.12.136.14**

The End