Example

An organization is granted the block 130.34.12.64/26. The organization needs four subnetworks, each with an equal number of hosts. Design the subnetworks and find the information about each network.

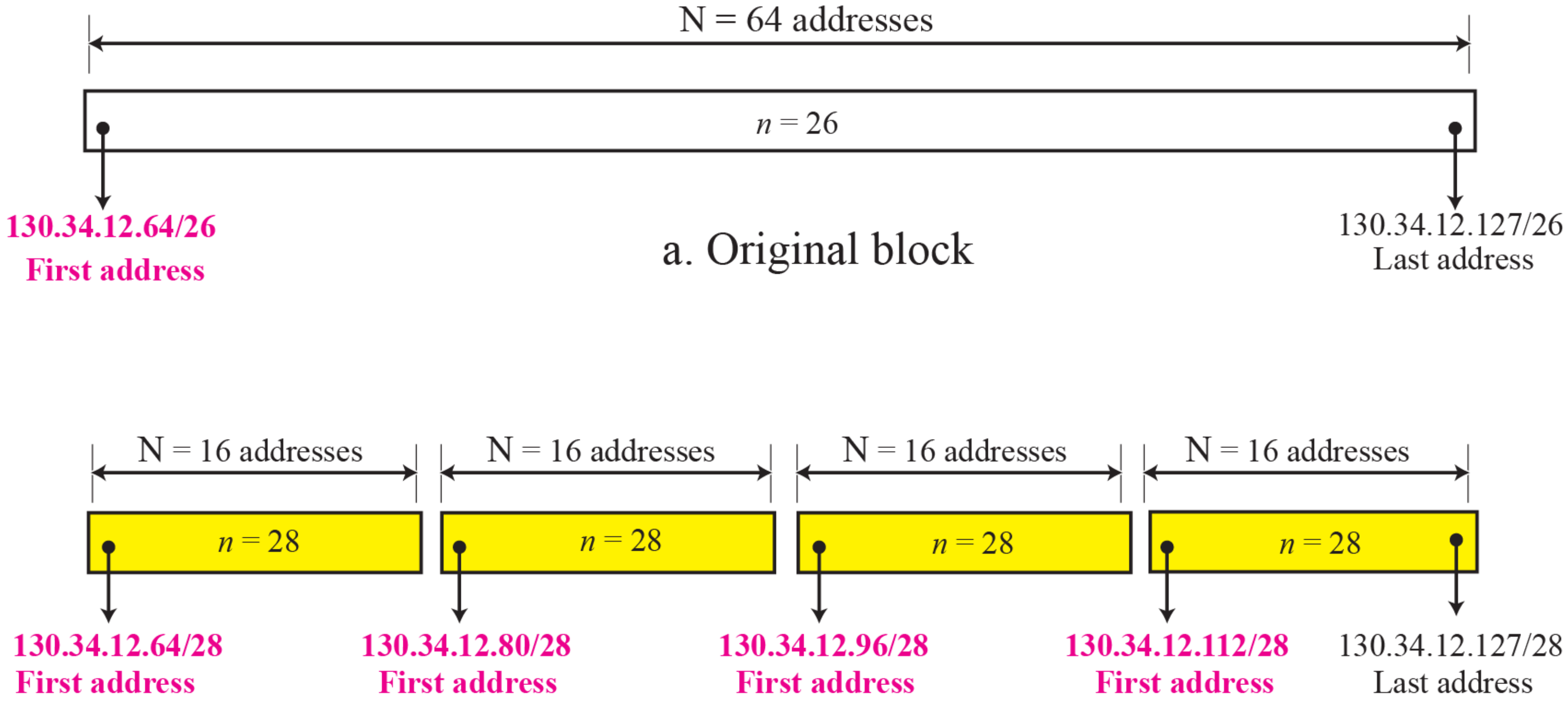
Solution

The number of addresses for the whole network can be found as $N = 2^{32-26} = 64$. The first address in the network is 130.34.12.64/26 and the last address is 130.34.12.127/26. We now design the subnetworks:

1. We grant 16 addresses for each subnetwork to meet the first requirement (64/16 is a power of 2).
2. The subnetwork mask for each subnetwork is:

$$n_1 = n_2 = n_3 = n_4 = n + \log_2 (N/N_i) = 26 + \log_2 4 = 28$$

3. We grant 16 addresses to each subnet starting from the first available address. Figure shows the subblock for each subnet. Note that the starting address in each subnetwork is divisible by the number of addresses in that subnetwork.



b. Subblocks

Example

An organization is granted a block of addresses with the beginning address 14.24.74.0/24. The organization needs to have 3 subblocks of addresses to use in its three subnets as shown below:

- ❑ One subblock of 120 addresses.
- ❑ One subblock of 60 addresses.
- ❑ One subblock of 10 addresses.

Solution

There are 2^{32-24} = 256 addresses in this block. The first address is 14.24.74.0/24; the last address is 14.24.74.255/24.

a. The number of addresses in the first subblock is not a power of 2. We allocate 128 addresses. The subnet mask is 25. The first address is 14.24.74.0/25; the last address is 14.24.74.127/25.

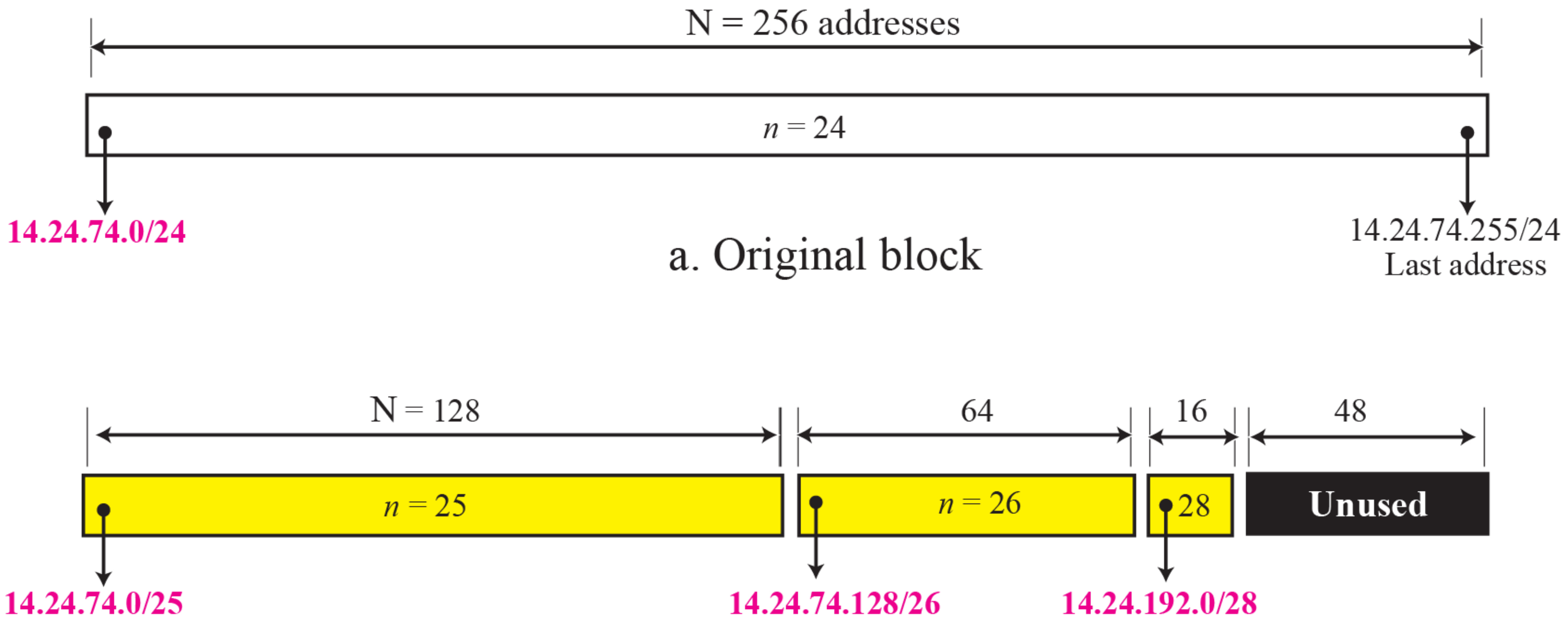
Example

b. The number of addresses in the second subblock is not a power of 2 either. We allocate 64 addresses. The subnet mask is 26. The first address in this block is 14.24.74.128/26; the last address is 14.24.74.191/26.

c. The number of addresses in the third subblock is not a power of 2 either. We allocate 16 addresses. The subnet mask is 28. The first address in this block is 14.24.74.192/28; the last address is 14.24.74.207/28.

d. If we add all addresses in the previous subblocks, the result is 208 addresses, which means 48 addresses are left in reserve. The first address in this range is 14.24.74.209. The last address is 14.24.74.255.

e. Figure shows the configuration of blocks. We have shown the first address in each block.

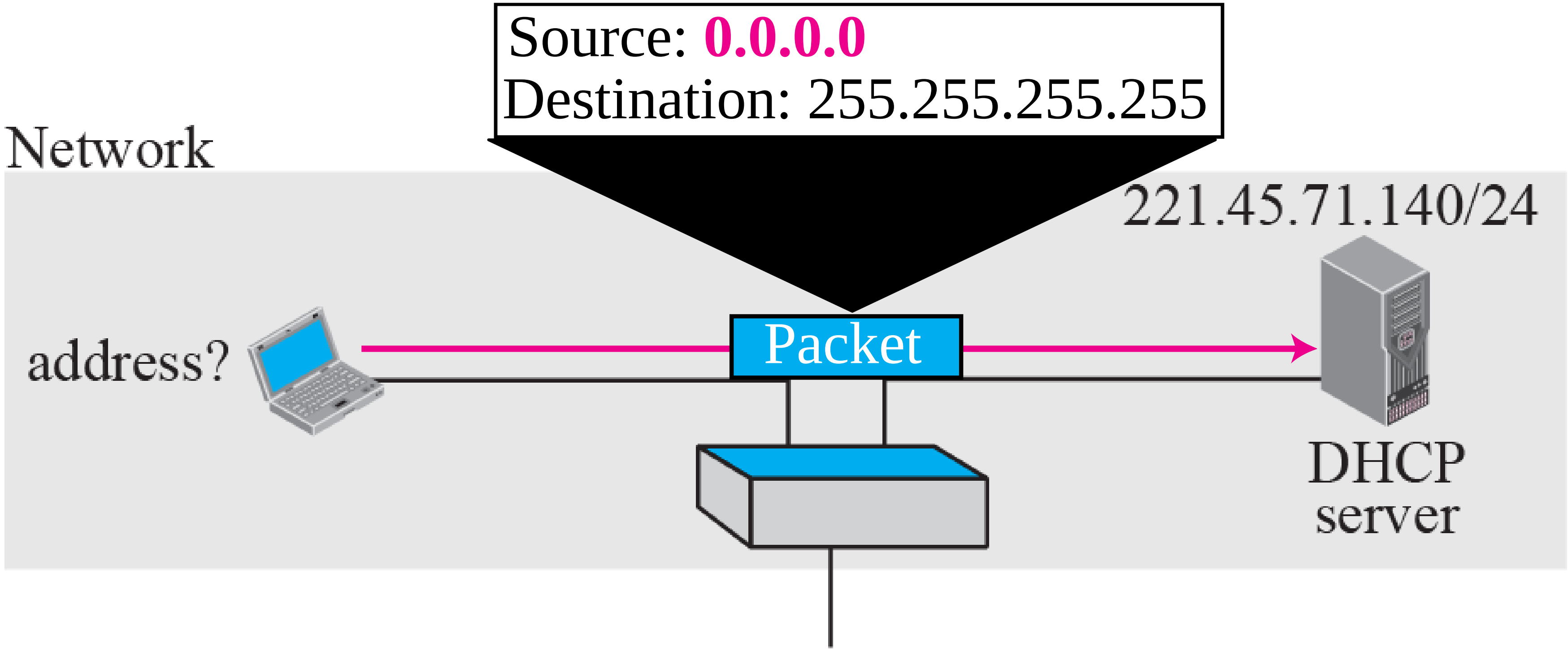


a. Original block

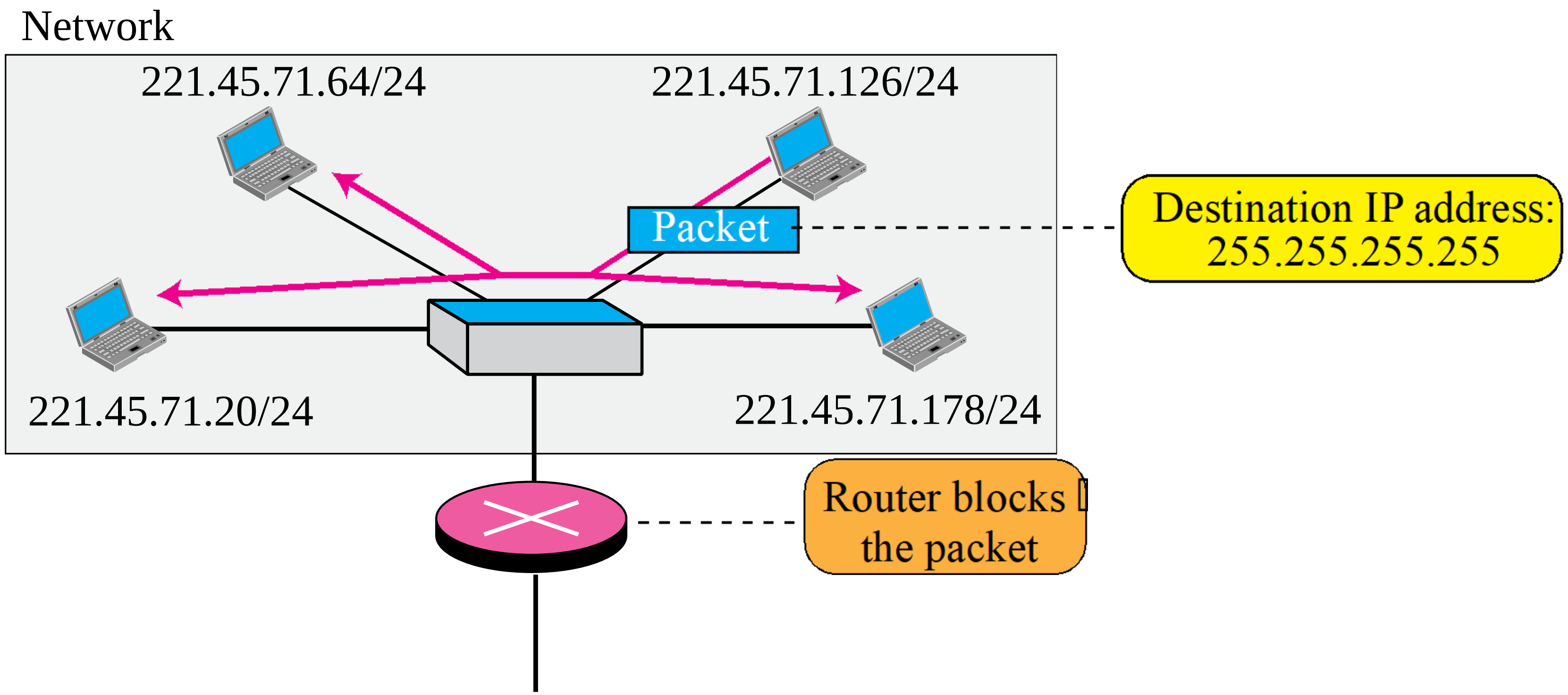
b. Subblocks

Special Address

Example of using the all-zero address



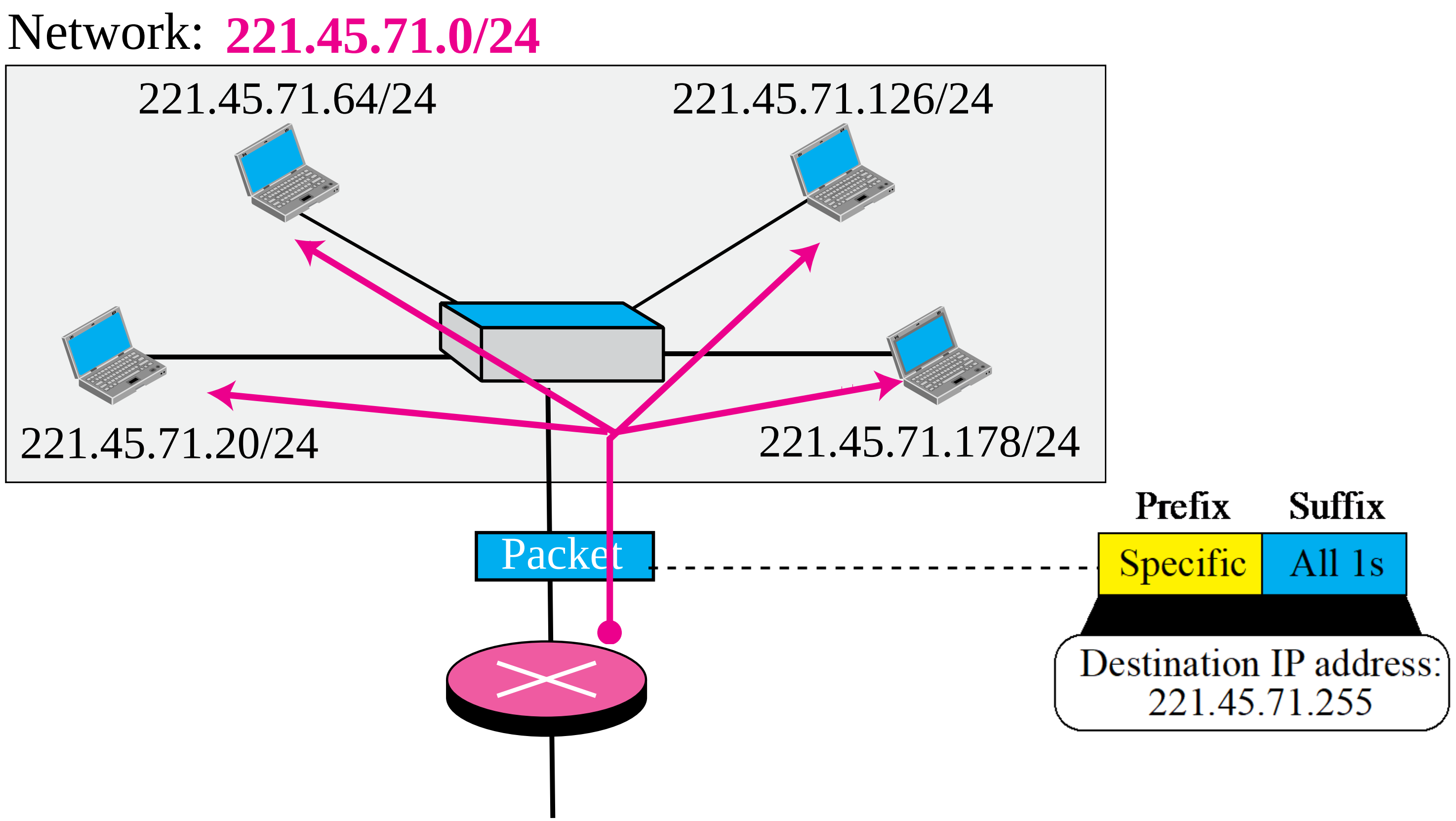
Example of limited broadcast address



Example of loopback address

- 127.0.0.0 to 127.255.255.255 or 127.0.0.0/8 is loopback address block.
- With loopback address you can send packet to yourself.
- Used for troubleshooting
- Check if TCP/IP protocol suite is working properly.
- Generally we use ping 127.0.0.1 to test it.

Example of a directed broadcast address



DHCP: Dynamic Host Configuration Protocol

IP addresses: how to get one?

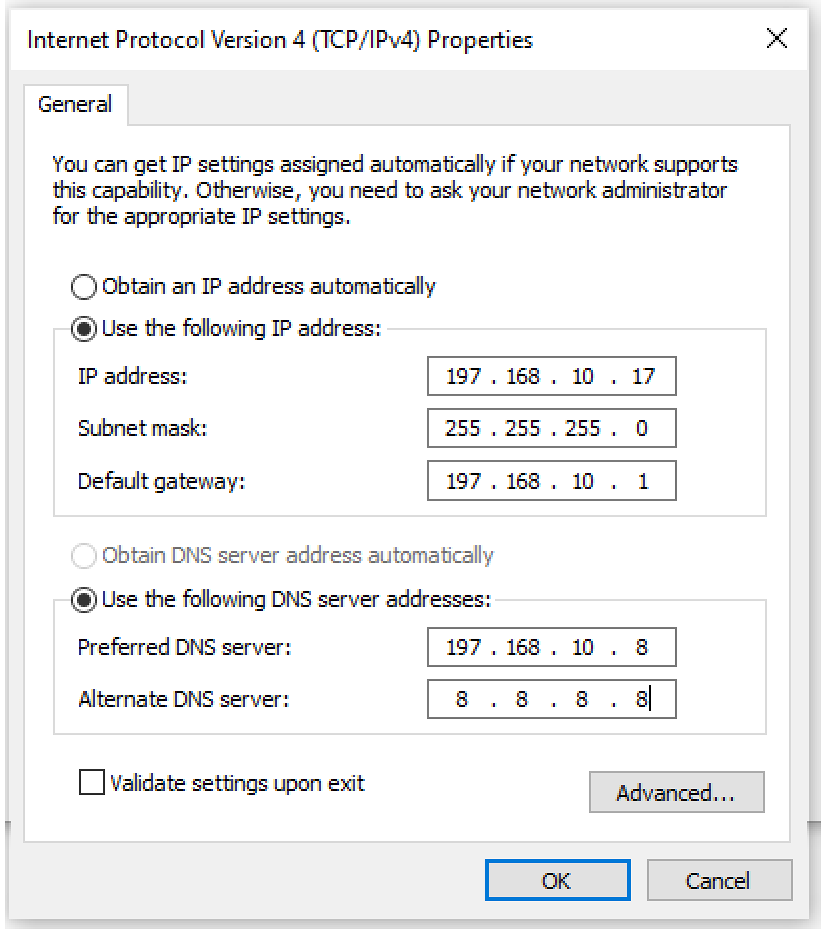
That's actually two questions:

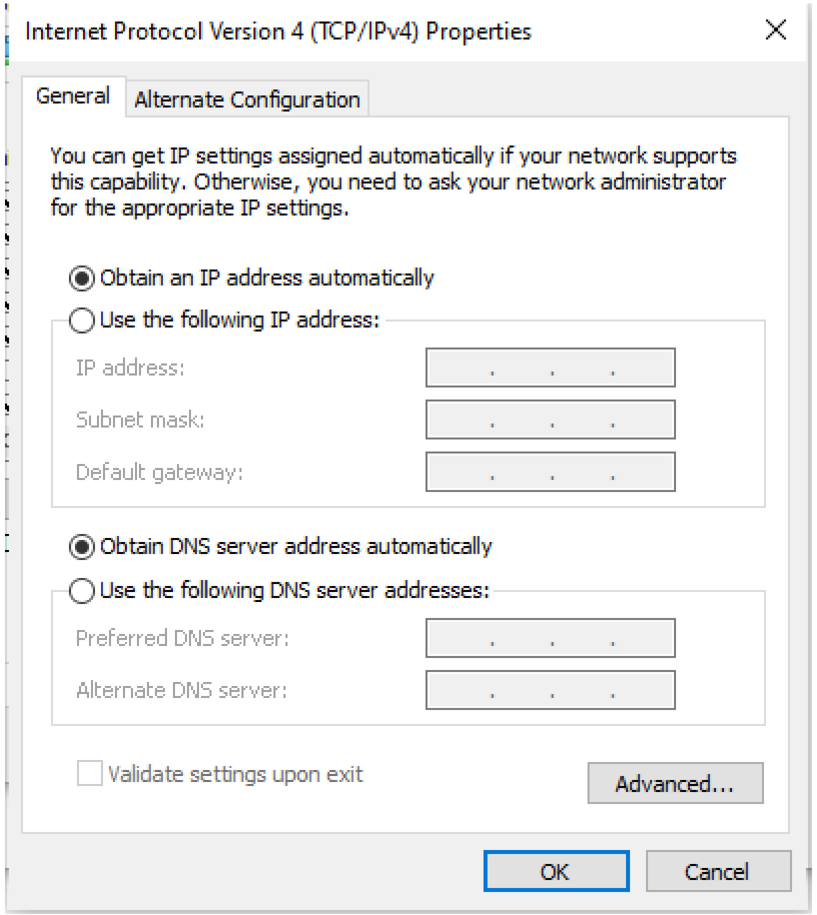
1. Q: How does a *host* get IP address within its network (host part of address)?
2. Q: How does a *network* get IP address for itself (network part of address)

How does *host* get IP address?

- hard-coded by sysadmin in config file (e.g., /etc/rc.config in UNIX)
- DHCP: Dynamic Host Configuration Protocol: dynamically get address from as server
  - "plug-and-play"

IP addresses: how to get one?





IP Cont..

```
Wireless LAN adapter Wi-Fi:

   Connection-specific DNS Suffix  . : iitbhilai.ac.in
   Description . . . . . . . . . . . : Qualcomm QCA9377 802.11ac Wireless Adapter
   Physical Address. . . . . . . . . : B0-68-E6-82-D9-8D
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   Link-local IPv6 Address . . . . . : fe80::80d1:147e:1fc0:c043%9(Preferred)
   IPv4 Address. . . . . . . . . . . : 10.3.54.107(Preferred)
   Subnet Mask . . . . . . . . . . . : 255.255.192.0
   Lease Obtained. . . . . . . . . . : 29 September 2020 09:39:45
   Lease Expires . . . . . . . . . . : 29 September 2020 18:28:38
   Default Gateway . . . . . . . . . : 10.3.0.1
   DHCP Server . . . . . . . . . . . : 10.1.72.7
   DHCPv6 IAID . . . . . . . . . . . : 162556134
   DHCPv6 Client DUID. . . . . . . . : 00-01-00-01-24-F3-49-C3-D8-D0-90-5B-50-B5
   DNS Servers . . . . . . . . . . . : 192.168.10.87
                                       192.168.10.72
```

DHCP: Dynamic Host Configuration Protocol

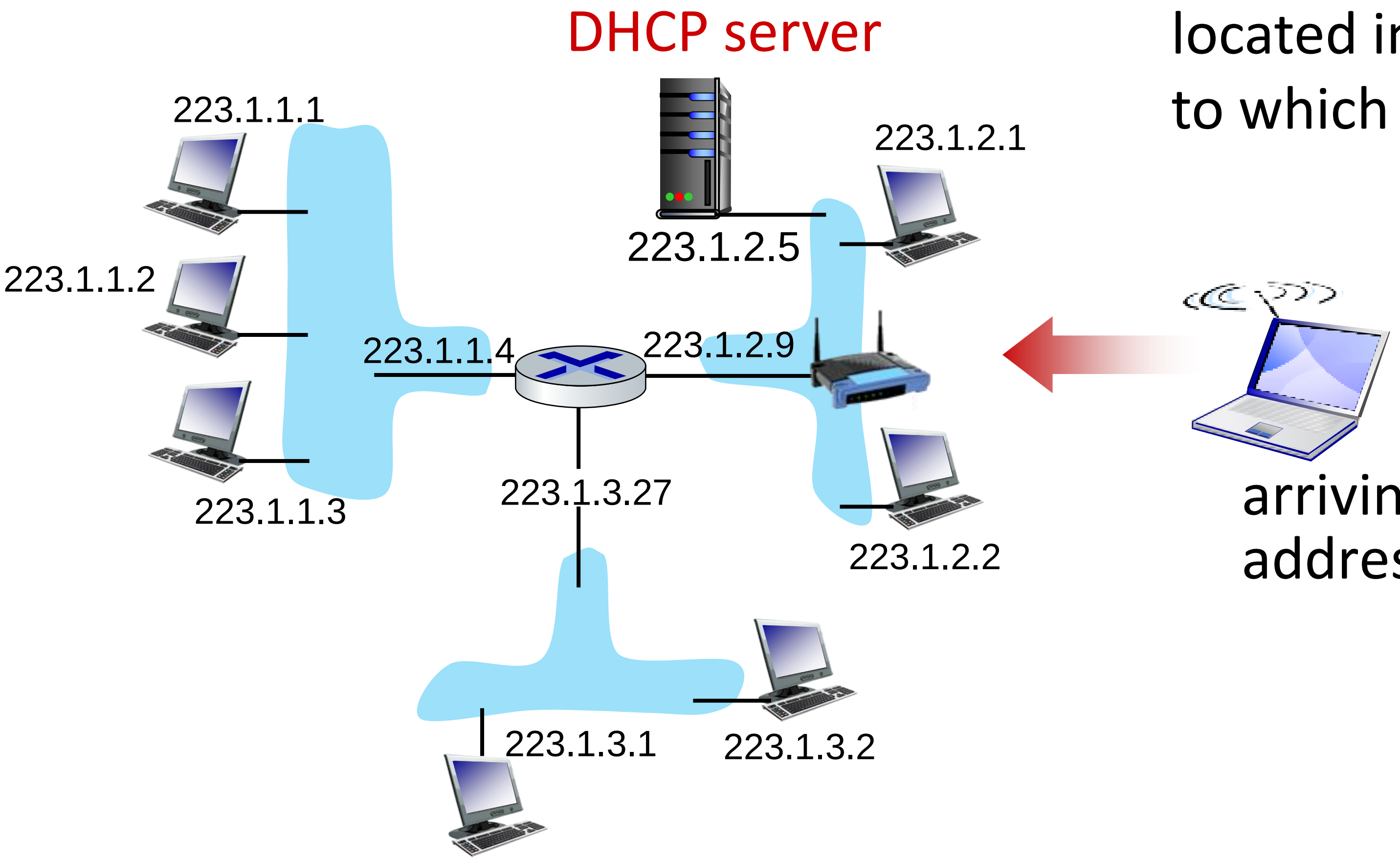
goal: host *dynamically* obtains IP address from network server when it "joins" network

- can renew its lease on address in use
- allows reuse of addresses (only hold address while connected/on)
- support for mobile users who join/leave network

DHCP overview:

- host broadcasts DHCP discover msg [optional]
- DHCP server responds with DHCP offer msg [optional]
- host requests IP address: DHCP request msg
- DHCP server sends address: DHCP ack msg

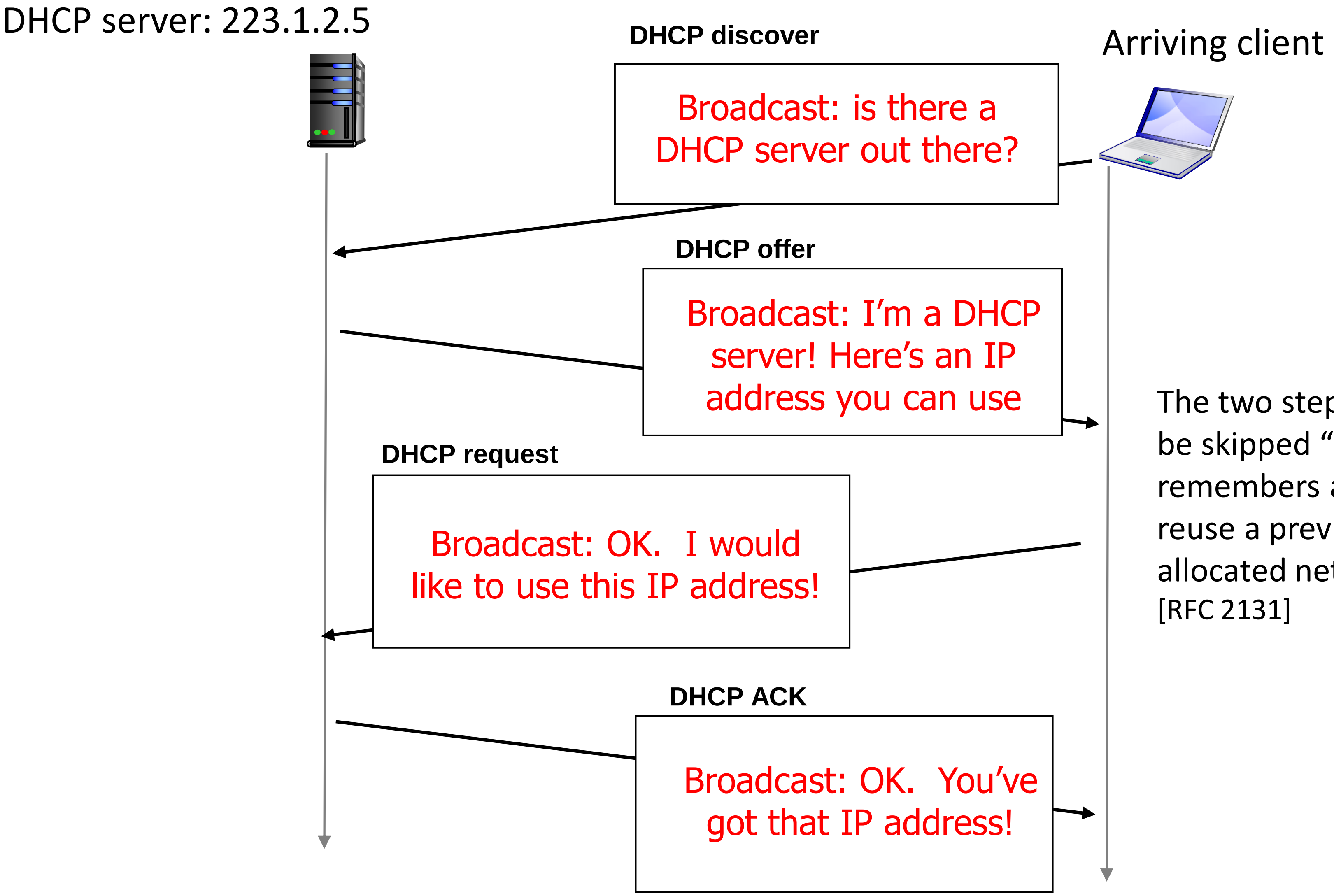
DHCP client-server scenario



Typically, DHCP server will be co-located in router, serving all subnets to which router is attached

arriving DHCP client needs address in this network

DHCP client-server scenario



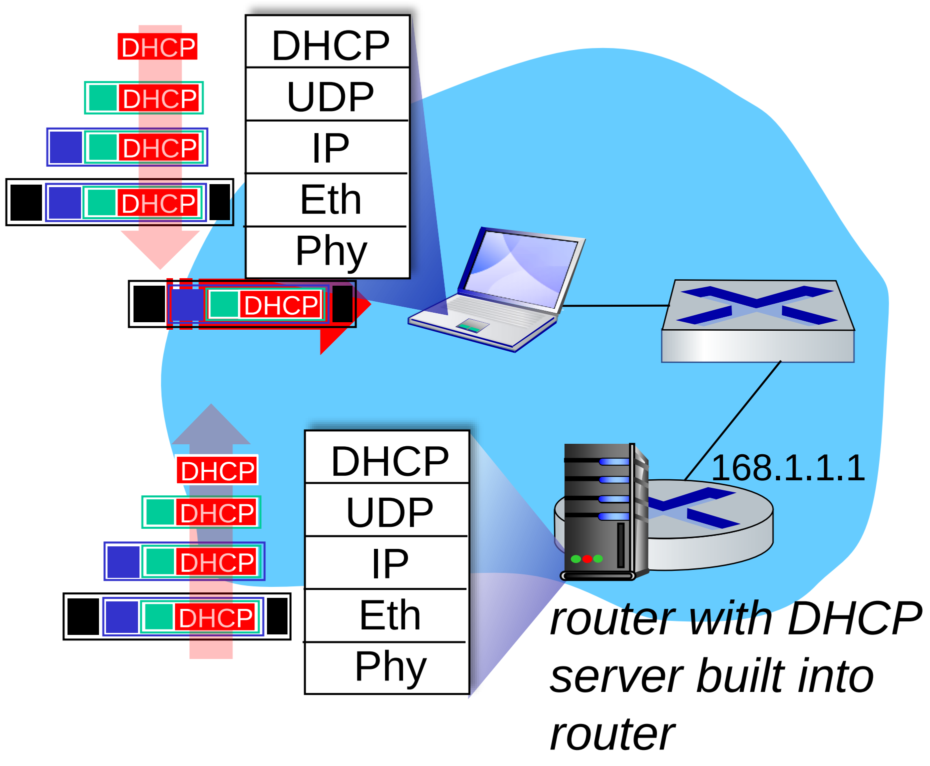
The two steps above can be skipped "if a client remembers and wishes to reuse a previously allocated network address" [RFC 2131]

DHCP: more than IP addresses

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

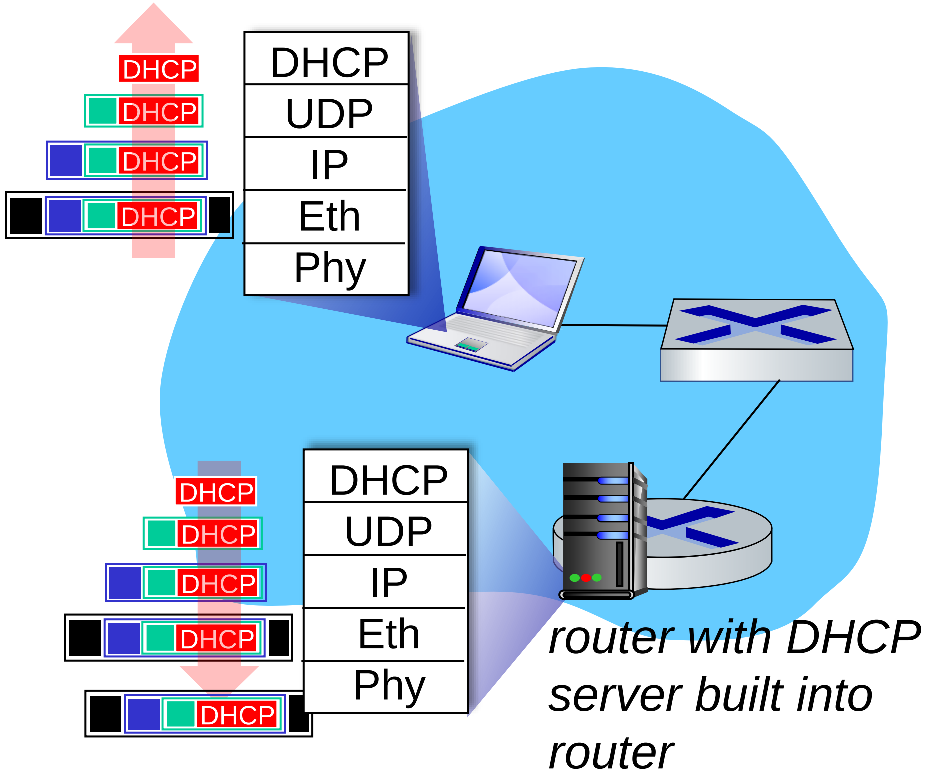
- address of first-hop router for client
- name and IP address of DNS sever
- network mask (indicating network versus host portion of address)

DHCP: example



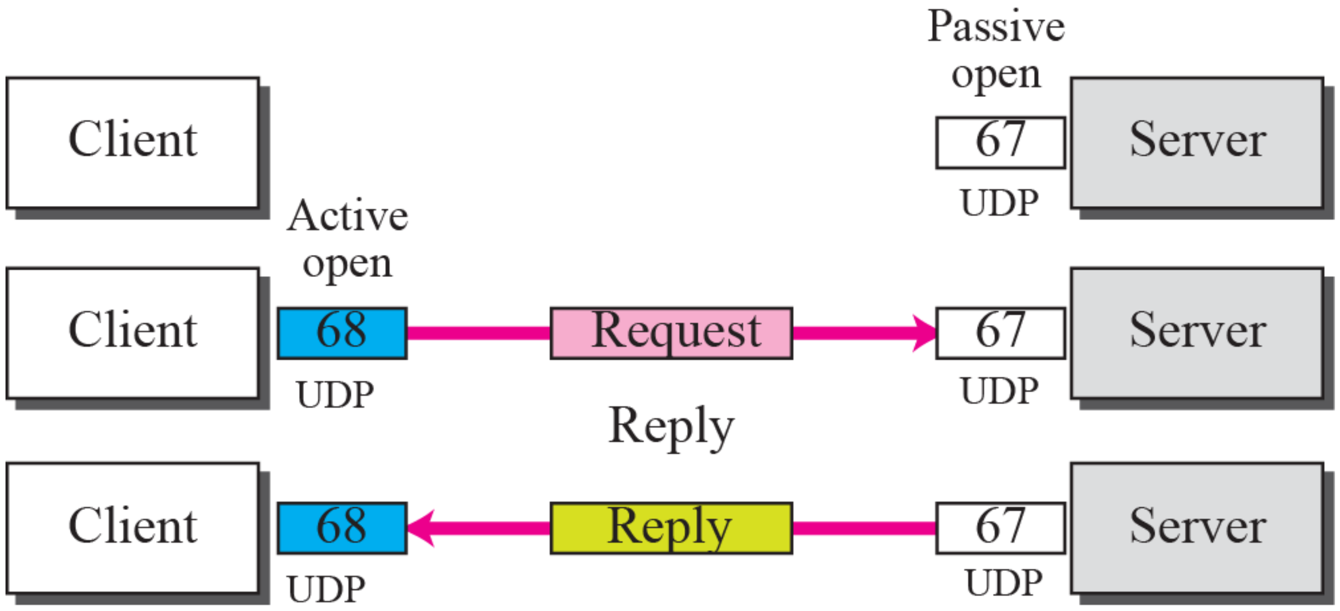
- Connecting laptop will use DHCP to get IP address, address of first-hop router, address of DNS server.
- DHCP REQUEST message encapsulated in UDP, encapsulated in IP, encapsulated in Ethernet
- Ethernet frame broadcast (dest: FFFFFFFFFFFF) on LAN, received at router running DHCP server
- Ethernet demux'ed to IP demux'ed, UDP demux'ed to DHCP

DHCP: example



- DCP server formulates DHCP ACK containing client's IP address, IP address of first-hop router for client, name & IP address of DNS server
- encapsulated DHCP server reply forwarded to client, demuxing up to DHCP at client
- client now knows its IP address, name and IP address of DNS server, IP address of its first-hop router

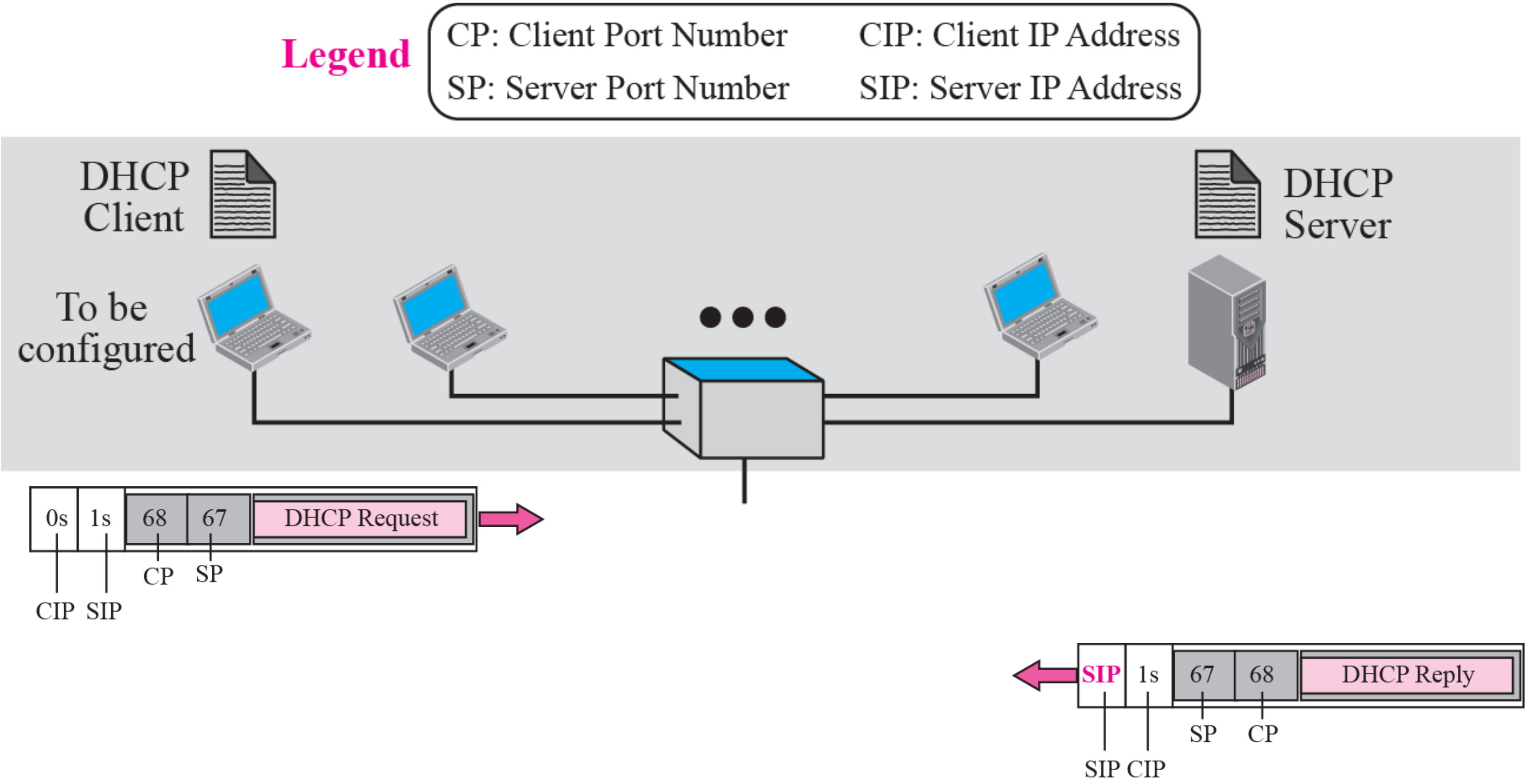
Use of UDP ports



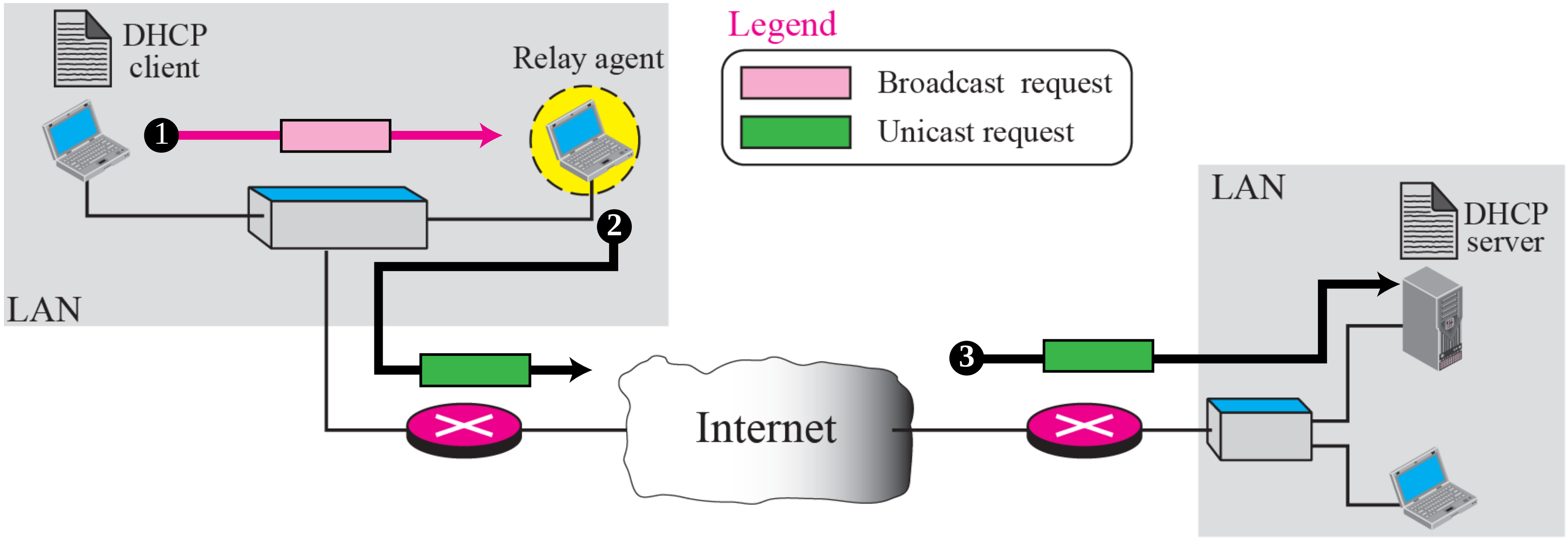
DHCP Operation

The DHCP client and server can either be on the same network or on different networks. Let us discuss each situation separately.

Client and server on the same network



Client and server on two different networks



IP addresses: how to get one?

Q: how does *network* get subnet part of IP address?

A: gets allocated portion of its provider ISP's address space

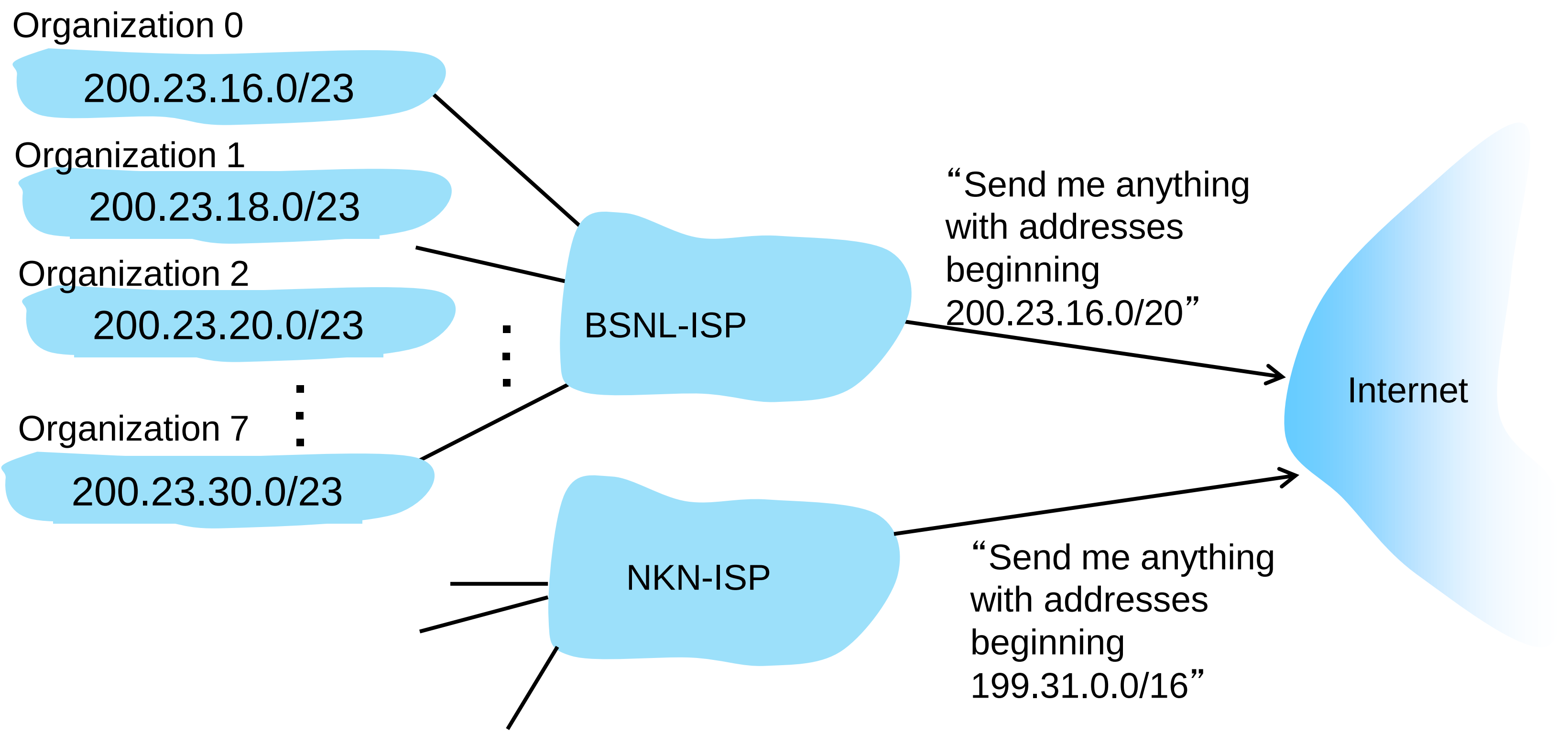
ISP's block	11001000 00010111 00010000 00000000	200.23.16.0/20

ISP can then allocate out its address space in 8 blocks:

Organization 0	11001000 00010111 00010000 00000000	200.23.16.0/23
Organization 1	11001000 00010111 00010010 00000000	200.23.18.0/23
Organization 2	11001000 00010111 00010100 00000000	200.23.20.0/23
...	....	....
Organization 7	11001000 00010111 00011110 00000000	200.23.30.0/23

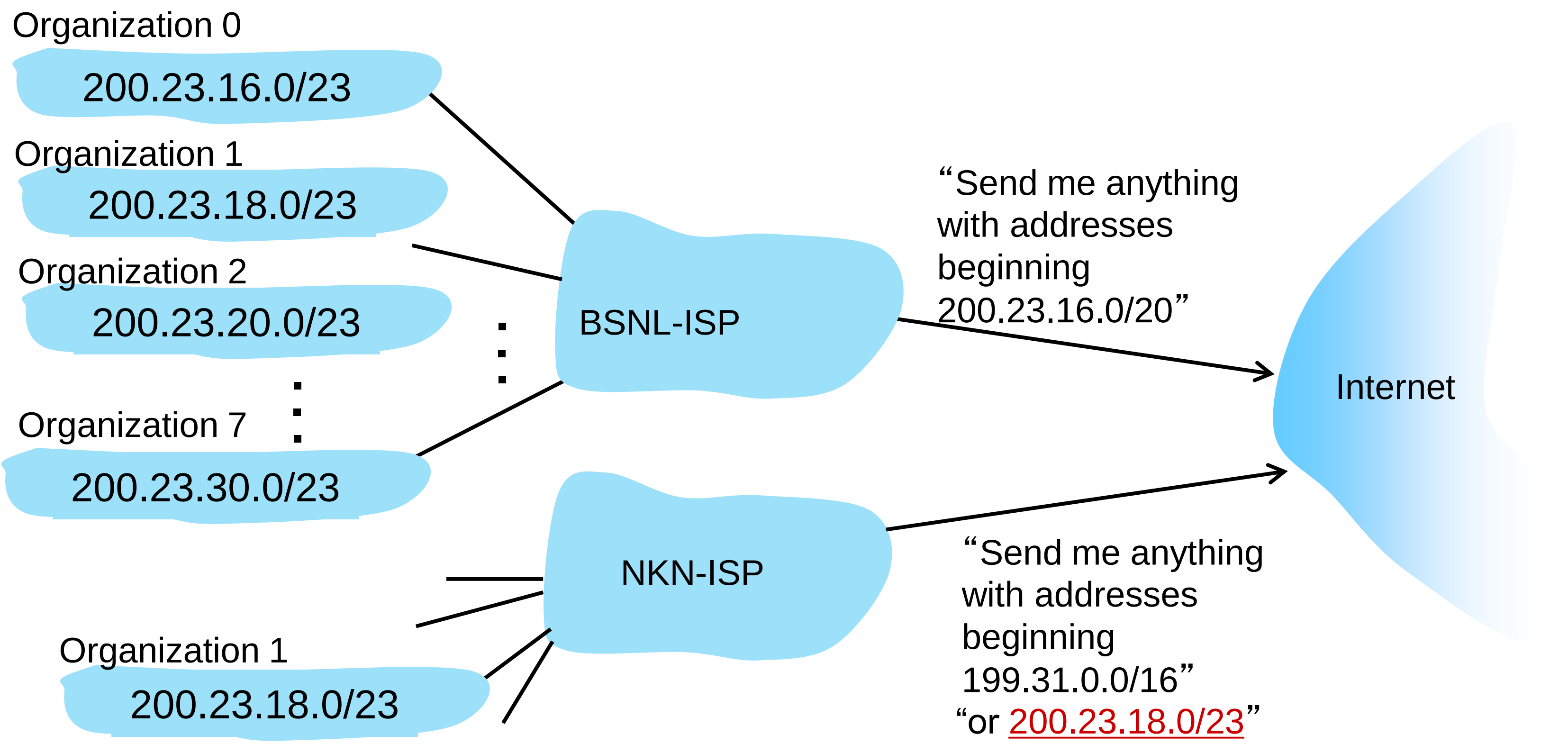
Hierarchical addressing: route aggregation

hierarchical addressing allows efficient advertisement of routing information:



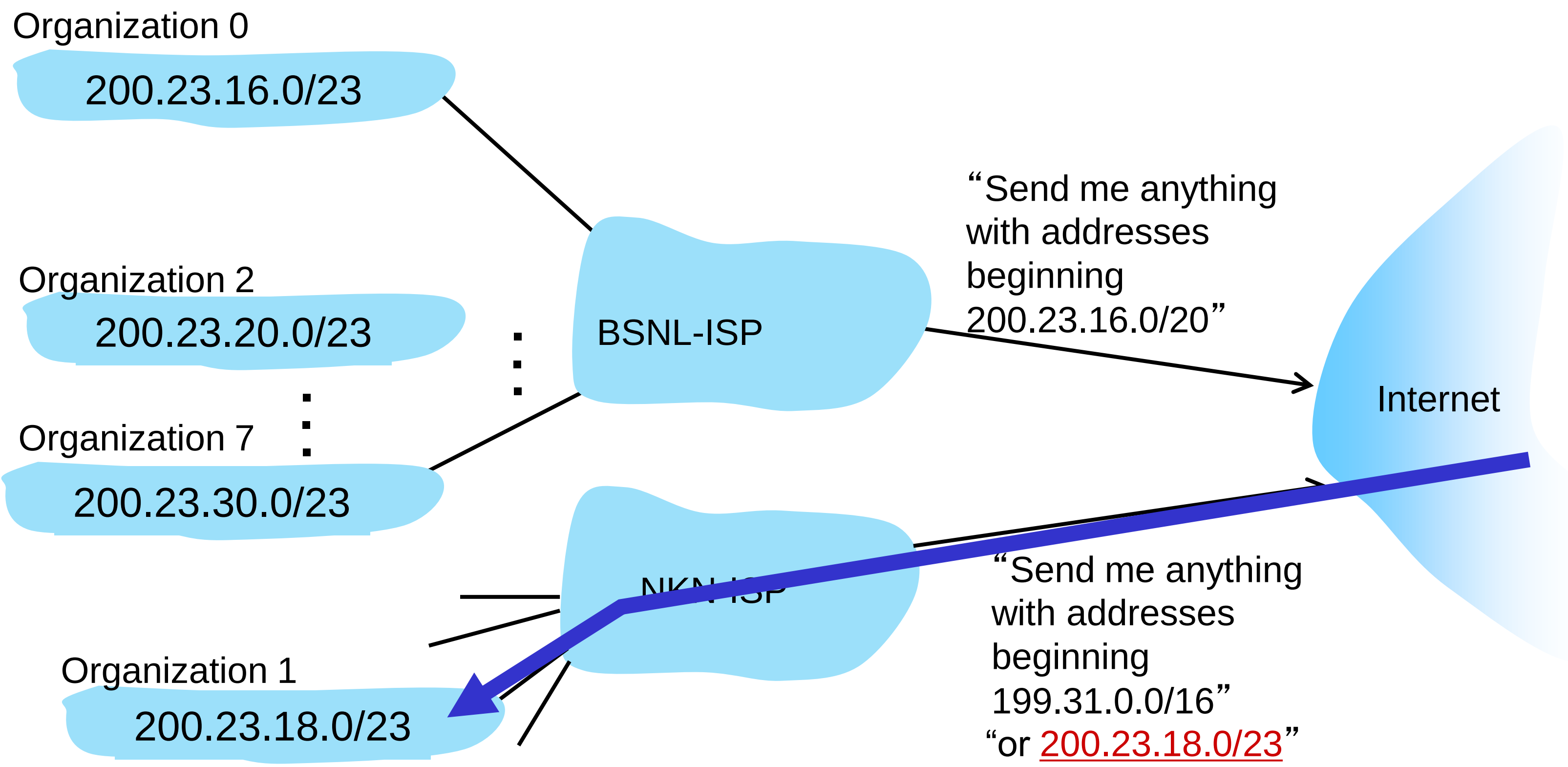
Hierarchical addressing: more specific routes

- Organization 1 moves from BSNL-ISP to NKN-ISP
- NKN-ISP now advertises a more specific route to Organization 1



Hierarchical addressing: more specific routes

- Organization 1 moves from BSNL-ISP to NKN-ISP
- ISPs-R-Us now advertises a more specific route to Organization 1



IP addressing: last words ...

Q: how does an ISP get block of addresses?

A: ICANN: Internet Corporation for Assigned Names and Numbers http://www.icann.org/

- allocates IP addresses, through 5 regional registries (RRs) (who may then allocate to local registries)
- manages DNS root zone, including delegation of individual TLD (.com, .edu , …) management

Q: are there enough 32-bit IP addresses?

- ICANN allocated last chunk of IPv4 addresses to RRs in 2011
- NAT (next) helps IPv4 address space exhaustion
- IPv6 has 128-bit address space

Public Internet addresses are regulated by five Regional Internet Registries (RIRs):

- ARIN
- RIPE
- APNIC
- LACNIC
- AfriNIC