CS 31006: Computer Networks – Moving From End-to-End To Per Hop

Department of Computer Science and Engineering

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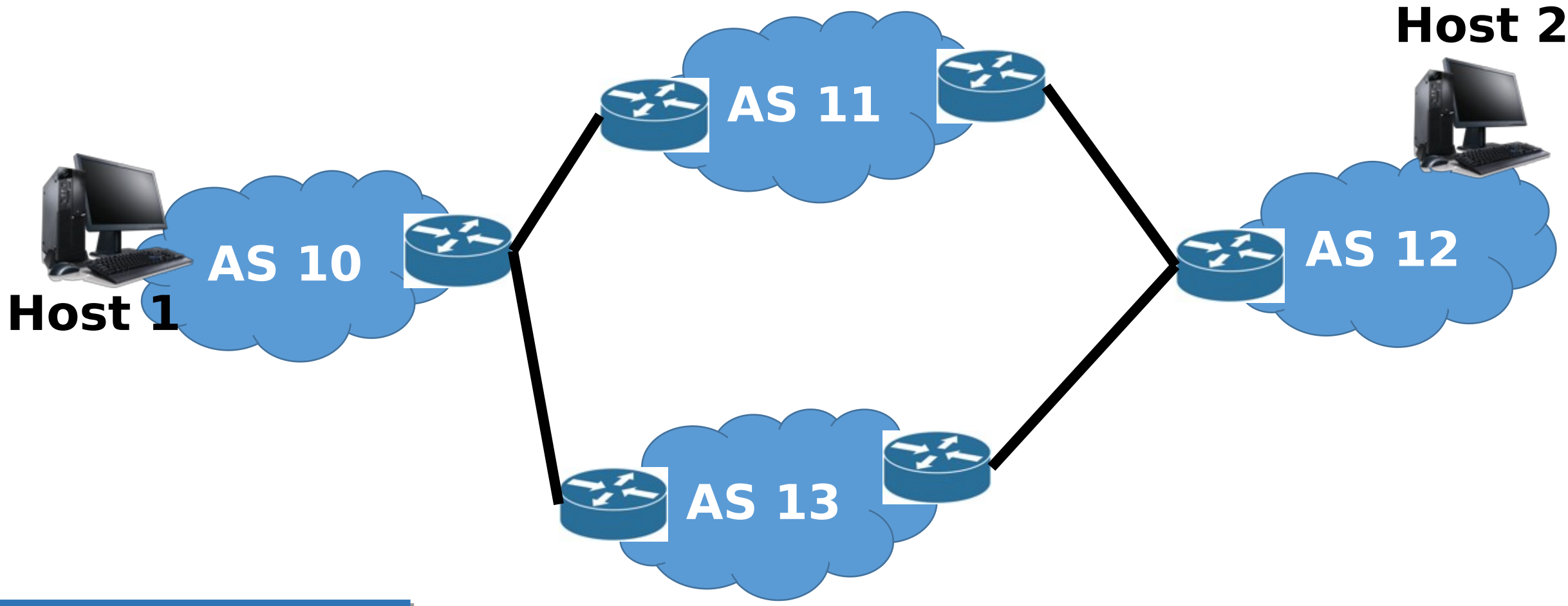
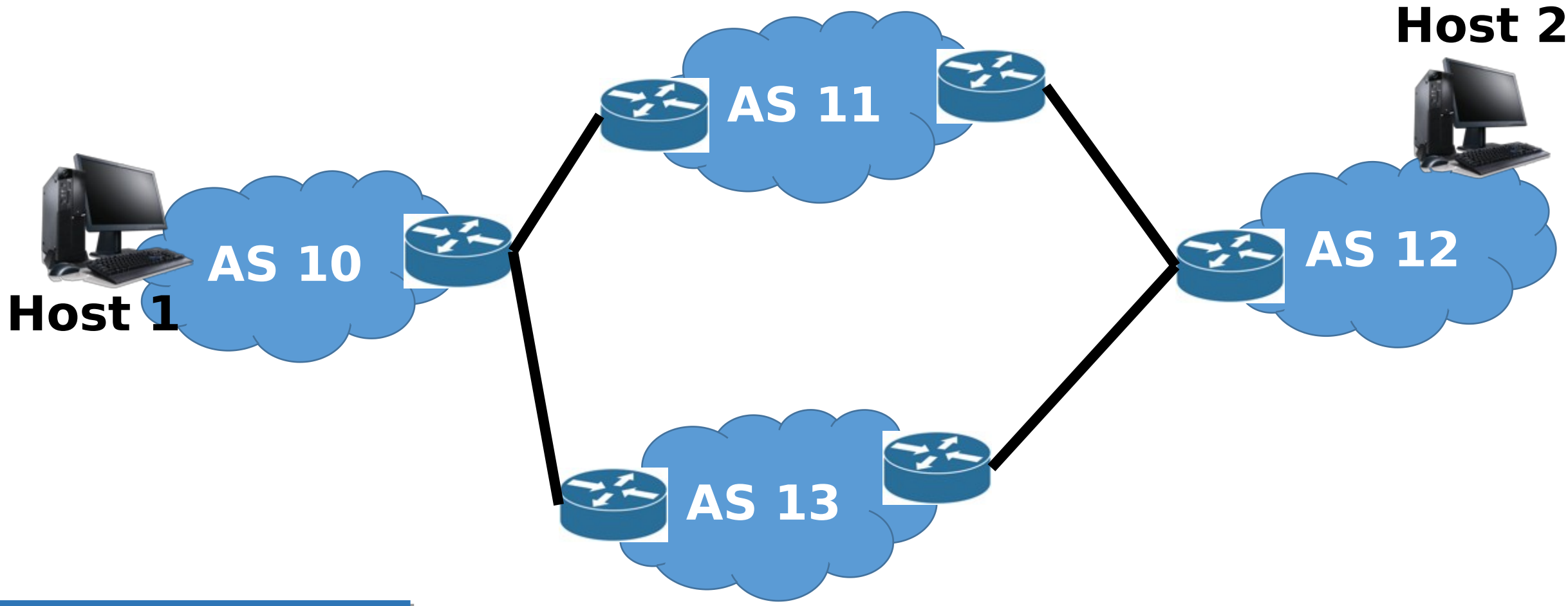
IP Addressing – Basic Principles

- **We need to forward data packets from one network to another network via different intermediate networks.**



IP Addressing – Basic Principles

- **The address should identify a network as well as a host inside a network**

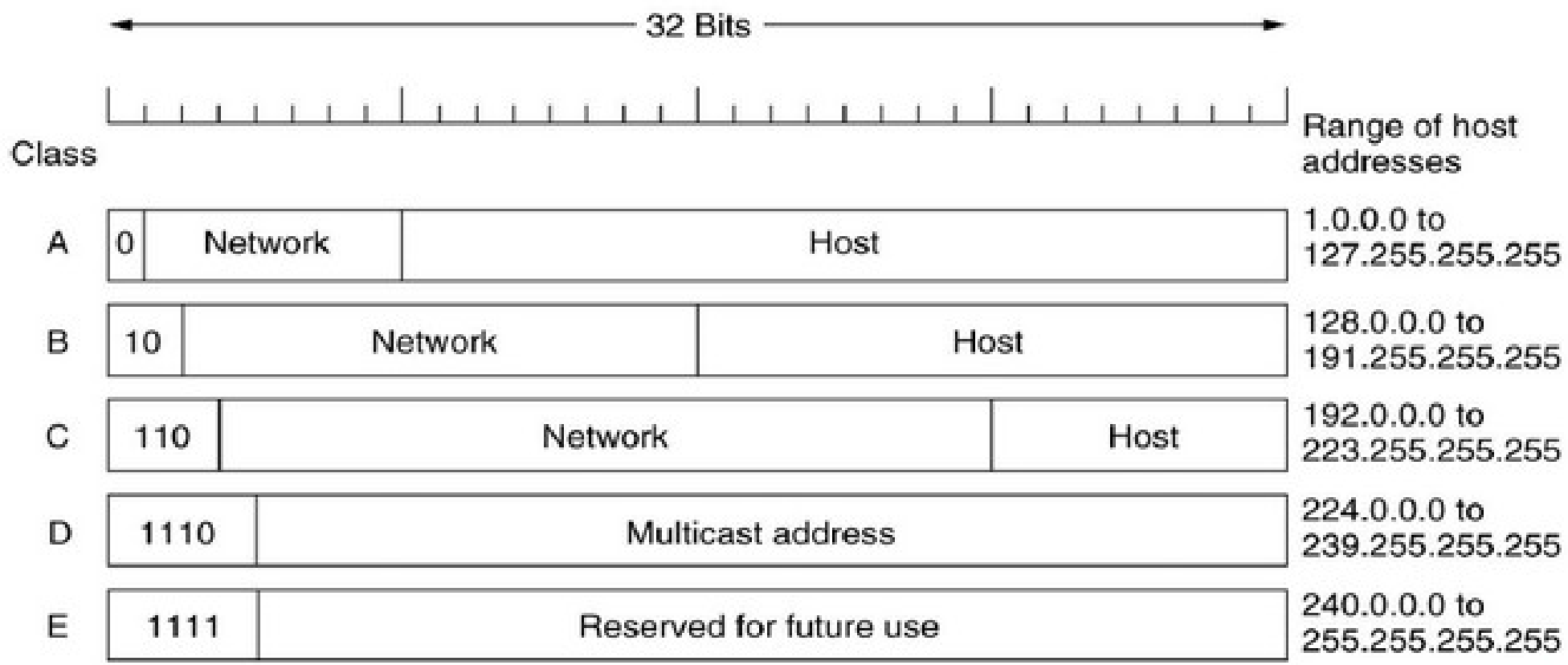


IP Addressing

- Divide the address space (32 bit in IPv4) among network address and host address

- **The old age – Classful addressing:** Fixed number of bits for network address and host address

Classful Addressing



- **How to identify a class –** use the first few bits
  - **0 – Class A, 10 – Class B, 110 – Class C, 1110 – Class D, 1111 – Class E**

Network Address and Broadcast Address

- **Network address –** identify a network
  - All 0’s in the host address part
  - **Ex-1 (Class A):** 01111110.00000000.00000000.00000000 (126.0.0.0)
  - **Ex-2 (Class B):** 10111101.11101001.00000000.00000000 (189.233.0.0)

- **Broadcast address –** send the data to **all the hosts** of a network
  - All 1’s in the host address part
  - **Ex-1 (Class A)**: 01111110.11111111.11111111.11111111 (126.255.255.255)
  - **Ex-2 (Class B):** 10111101.11101001.11111111.11111111

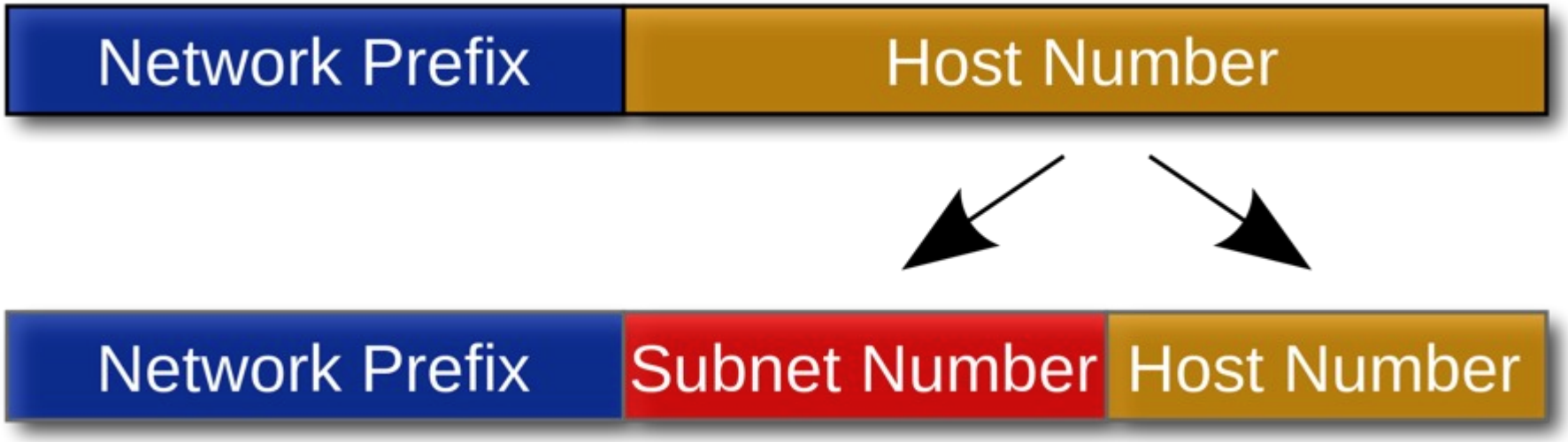
Subnetting and Supernetting – Classless Inter-domain Routing (CIDR)

- **You have 255 hosts in a network. Which IPv4 address class will you use – Class C or Class B ?**
  - **Class C – not possible**
  - **Class B – huge address space is lost (using only 255 addresses out of possible 2^{16}-2 addresses)**

- Split a large network or combine multiple small networks for efficient use of address space
  - **Subnetting** – divide a large network into multiple small networks
  - **Supernetting** – combine multiple small networks into a single large network

- **Subnet mask –** denote the number of bits in the network address field

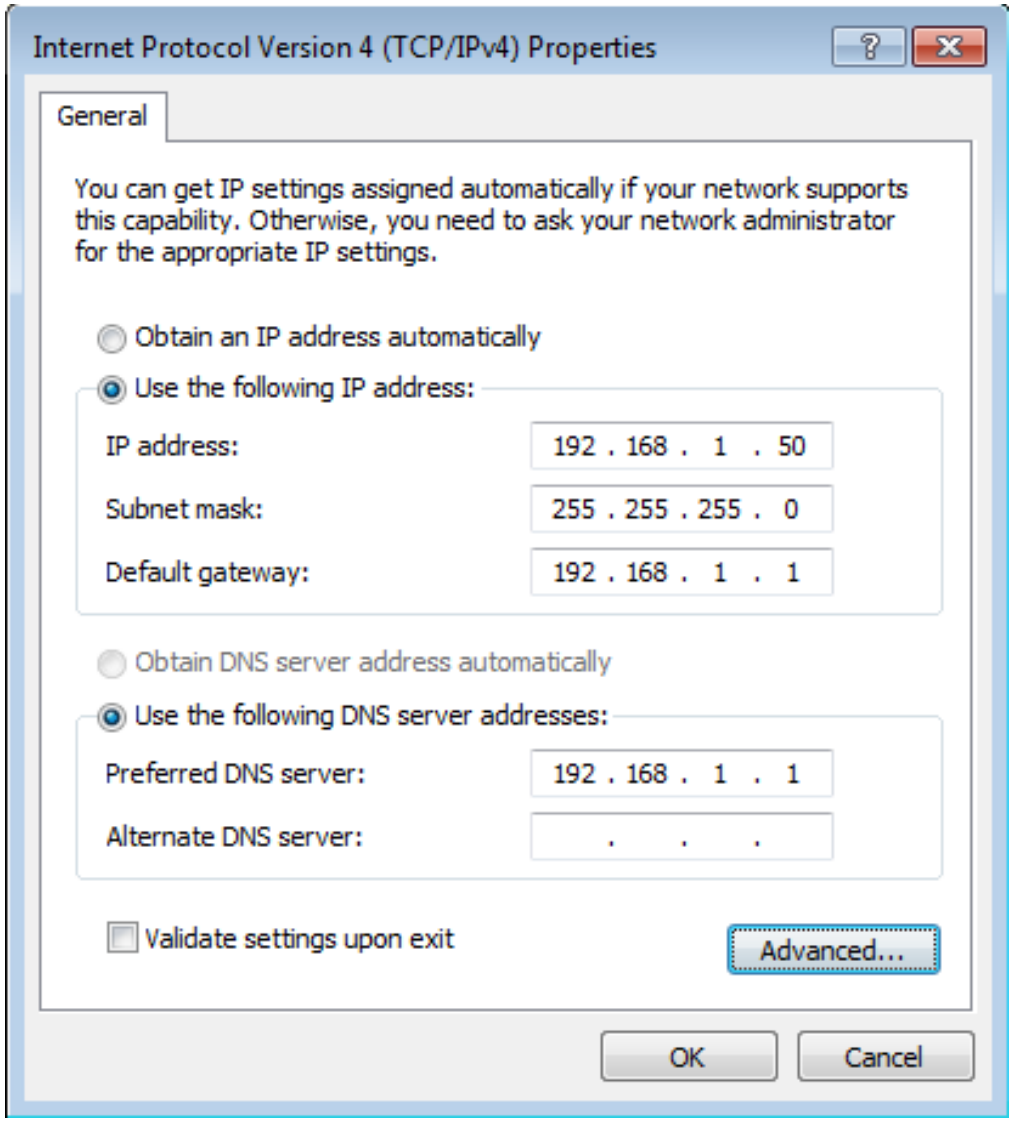
Divide a Network into Subnets

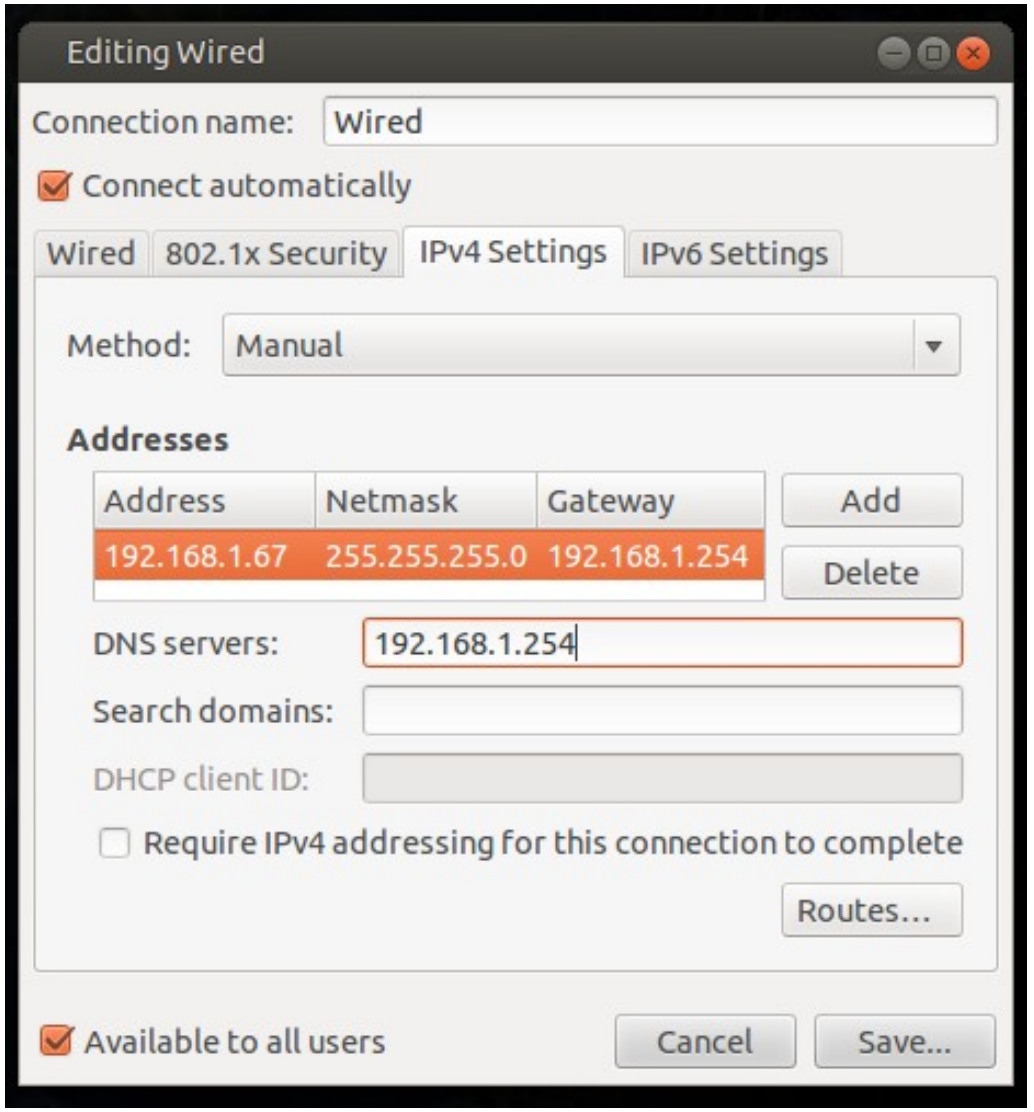


CIDR – Addressing Format

- We write the IP address as 191.180.83.235/12 in CIDR notation
  - The first 12 bits are the network address and rest (32-12)=20 bits are for host address

CIDR - Manual IP Setting in the OS

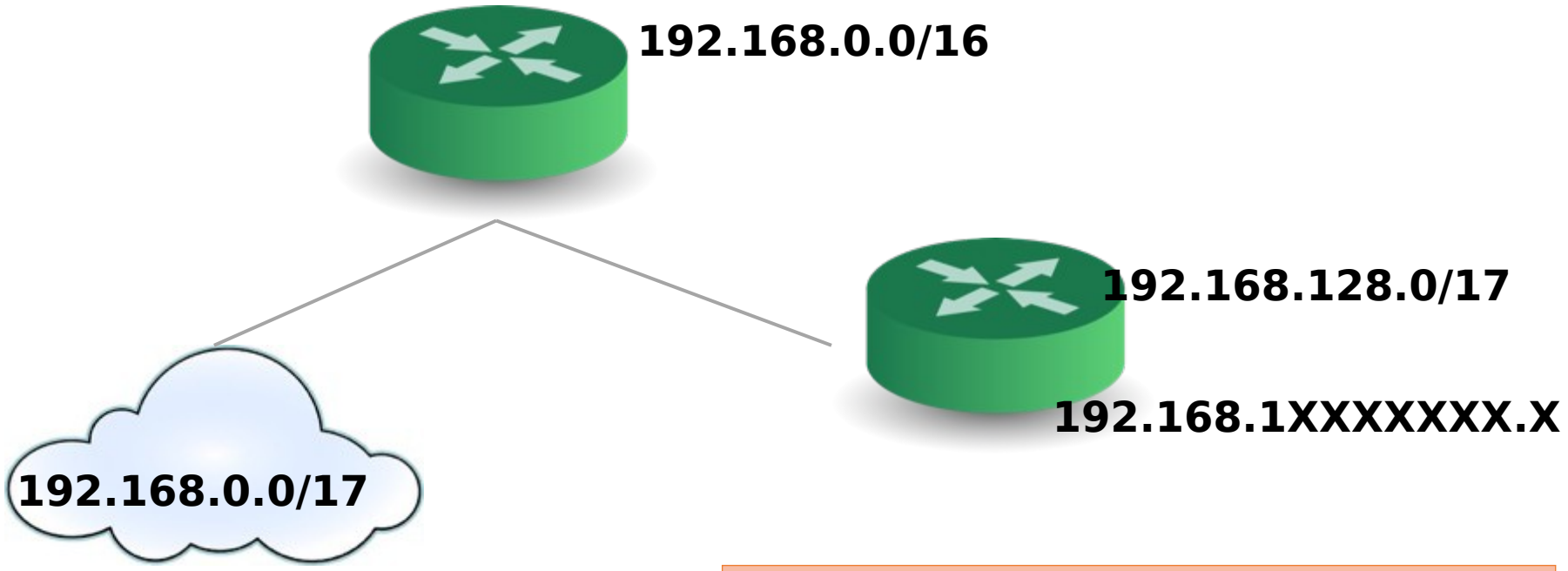




Divide a Network into Subnets

- Let the IP address of a network is 203.110.0.0/16
- We want to divide this network into three subnets
- We need 3 bits for subnets – **why not 2 bits?**
  - Subnet 1 – 100, Subnet 2– 101, Subnet 3 – 110
- Rest 13 bits are used for addressing the hosts of those subnets.
- The subnets are – 203.110.128.0/19, 203.110.160.0/19, 203.110.192.0/19

All Zero and All One Subnets



The network address for the subnet and the original network is identical – Subnet Zero

Broadcast address for this subnet is 192.168.255.255, broadcast address for the original network is also 192.168.255.255 – All-One Subnet

We normally avoid "all zero" and "all one" subnets.

CIDR Example

CSE – 2000 Hosts

VGSOM – 500 Hosts

EE – 500 Hosts

203.110.0.0/1

CIDR Example

CSE – 2000 Hosts

VGSOM – 500 Hosts

EE – 500 Hosts

11 bit hosts

9 bit hosts

9 bit hosts

203.110.0.0/1

CIDR Example

- Address space – 203.110.0.0/19
  - 13 bits are available to serve all the hosts of IITKGP network
  - We need to divide these address space among 3 subnets
- CSE – 11 bits, VGSOM – 9 bits, EE – 9 bits for host address
- We have 2 bits left for identifying three subnets **– Is this possible?**
  - Avoid “all zero” and ”all one” subnets
- Let us apply CIDR – Combine VGSOM and EE Networks together

CIDR Example

CSE – 2000 Hosts

VGSOM – 500 Hosts

EE – 500 Hosts

11 bit hosts

9 bit hosts

9 bit hosts

10 bit hosts

203.110.0.0/1

CIDR Example

CSE – 11 bits, VGSOM+EE – 10 bits

- Network address – 203.110.0.0/19, 203.110.000**XX**XXX.XXXXXXXX
- CSE network address 203.110.00010XXX.XXXXXXXX (203.110.16.0/21)
- VGSOM+EE network address 203.110.00001XXX.XXXXXXXX (203.110.8.0/21)

CIDR Example

CSE – 2000 Hosts

VGSOM – 500 Hosts

EE – 500 Hosts

11 bit hosts

203.110.16.0/21

9 bit hosts

10 bit hosts

203.110.8.0/21

9 bit hosts

203.110.0.0/1

CIDR Example

VGSOM – 9 bits, EE – 9 bits

- Network address – 203.110.8.0/21, 203.110.000**01**XXX.XXXXXXXX
- VGSOM network address 203.110.00001**10**X.XXXXXXXX (203.110.12.0/23)
- EE network address 203.110.00001**01**X.XXXXXXXX (203.110.10.0/23)

CIDR Example

CSE – 2000 Hosts

VGSOM – 500 Hosts

EE – 500 Hosts

11 bit hosts

203.110.16.0/21

9 bit hosts

203.110.12.0/23

9 bit hosts

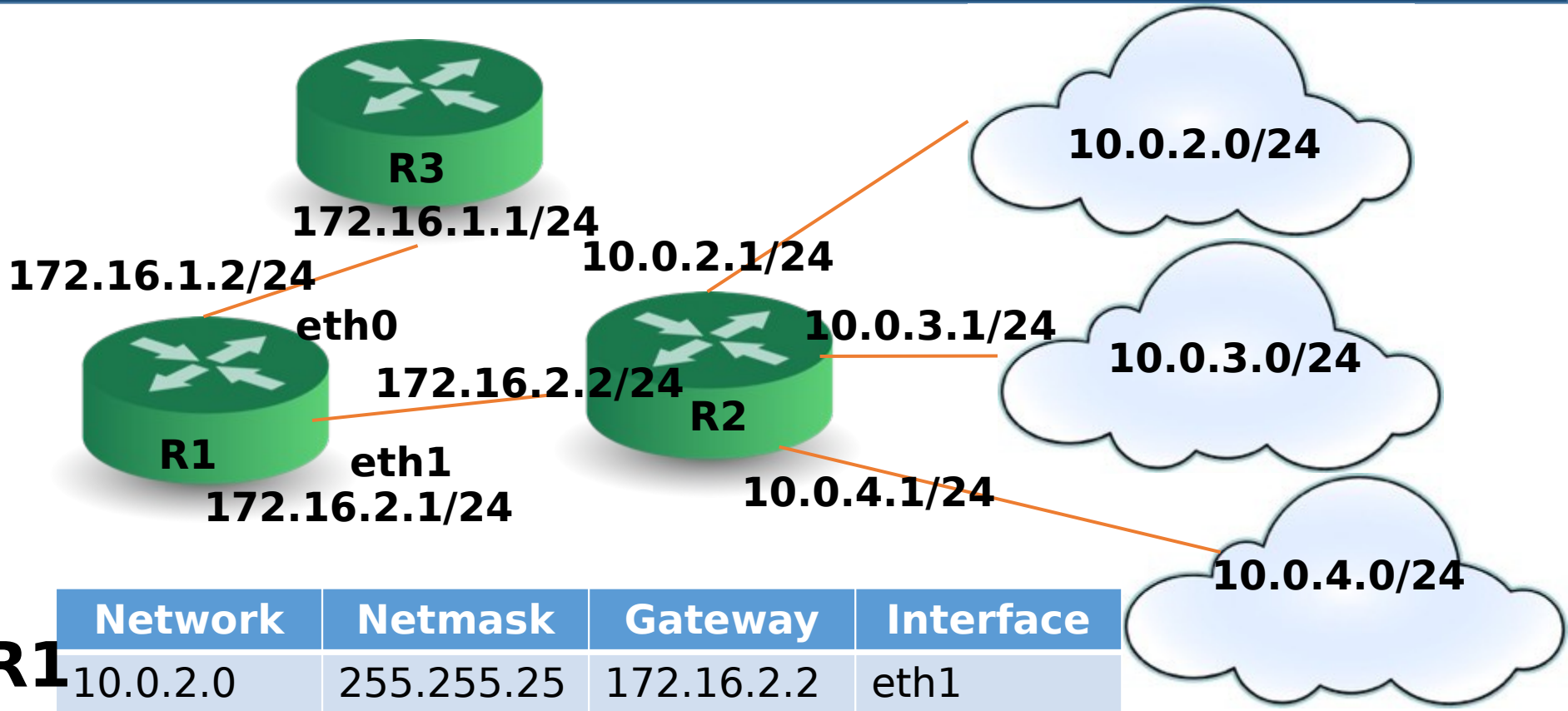
203.110.10.0/23

10 bit hosts

203.110.8.0/21

203.110.0.0/1

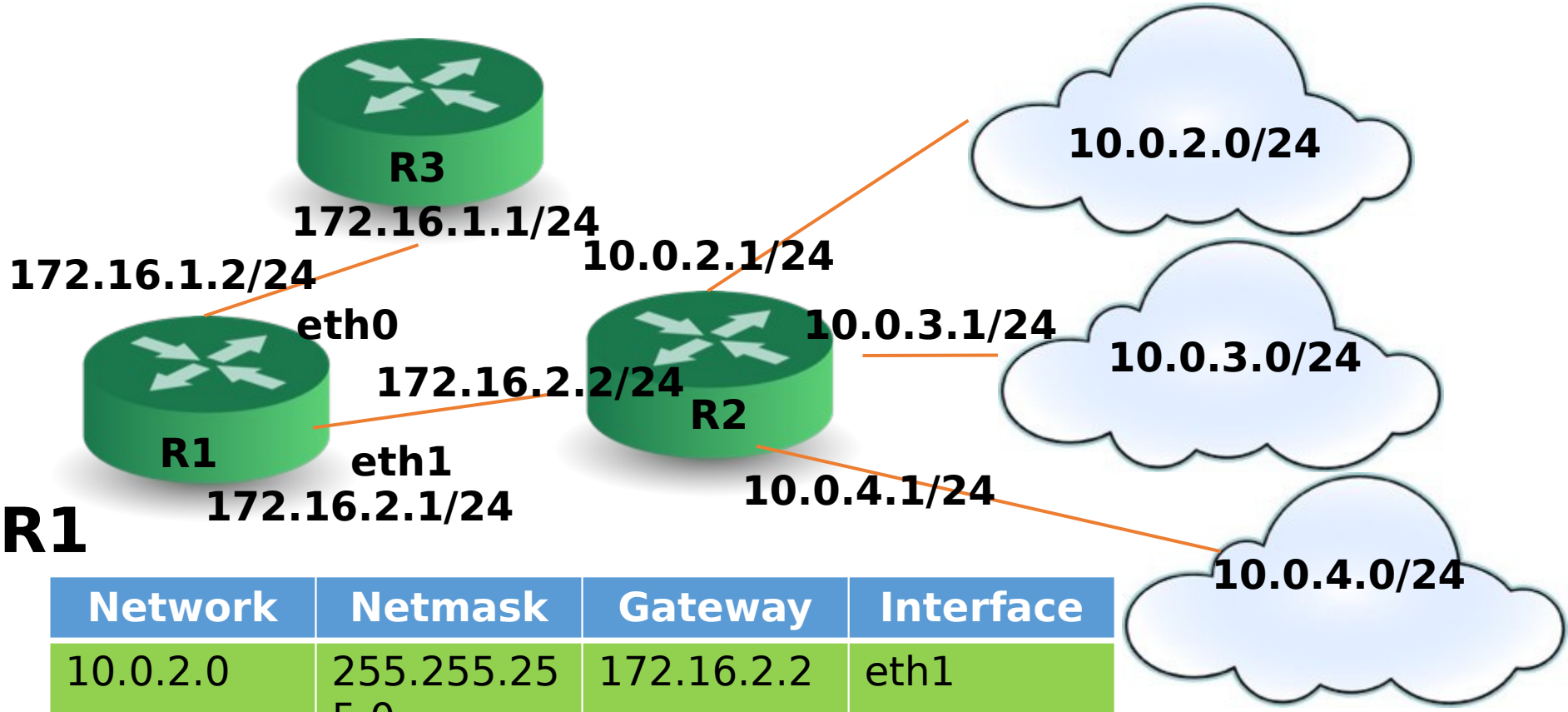
CIDR – Routing Table Construction



outing Table for R1

Network	Netmask	Gateway	Interface
10.0.2.0	255.255.255.0	172.16.2.2	eth1
10.0.3.0	255.255.255.0	172.16.2.2	eth1
10.0.4.0	255.255.255.0	172.16.2.2	eth1
0.0.0.0	0.0.0.0	172.16.1.1	eth0

CIDR – Routing Table Construction

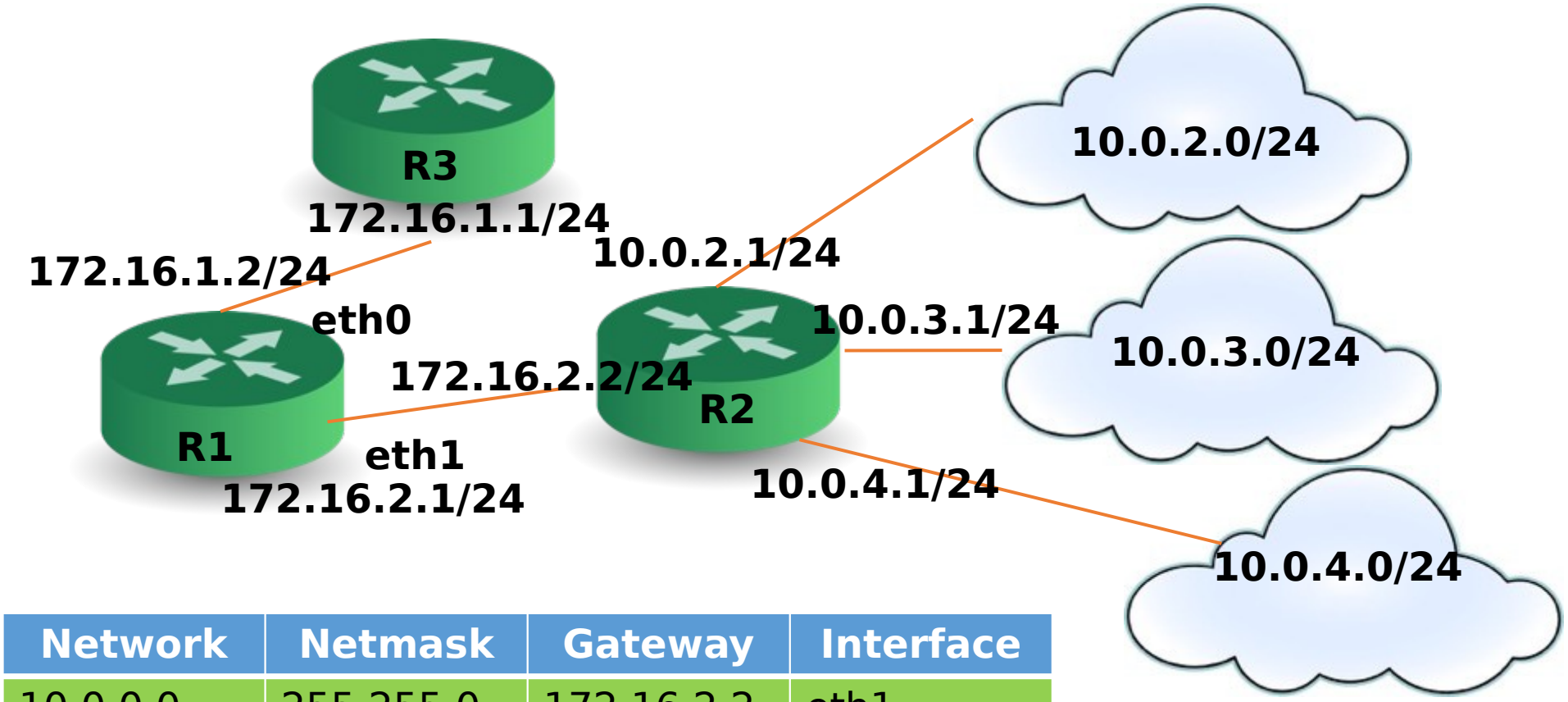


outing Table for R1

Compaction of routing table is possible

Network	Netmask	Gateway	Interface
10.0.2.0	255.255.255.0	172.16.2.2	eth1
10.0.3.0	255.255.255.0	172.16.2.2	eth1
10.0.4.0	255.255.255.0	172.16.2.2	eth1
0.0.0.0	0.0.0.0	172.16.1.1	eth0

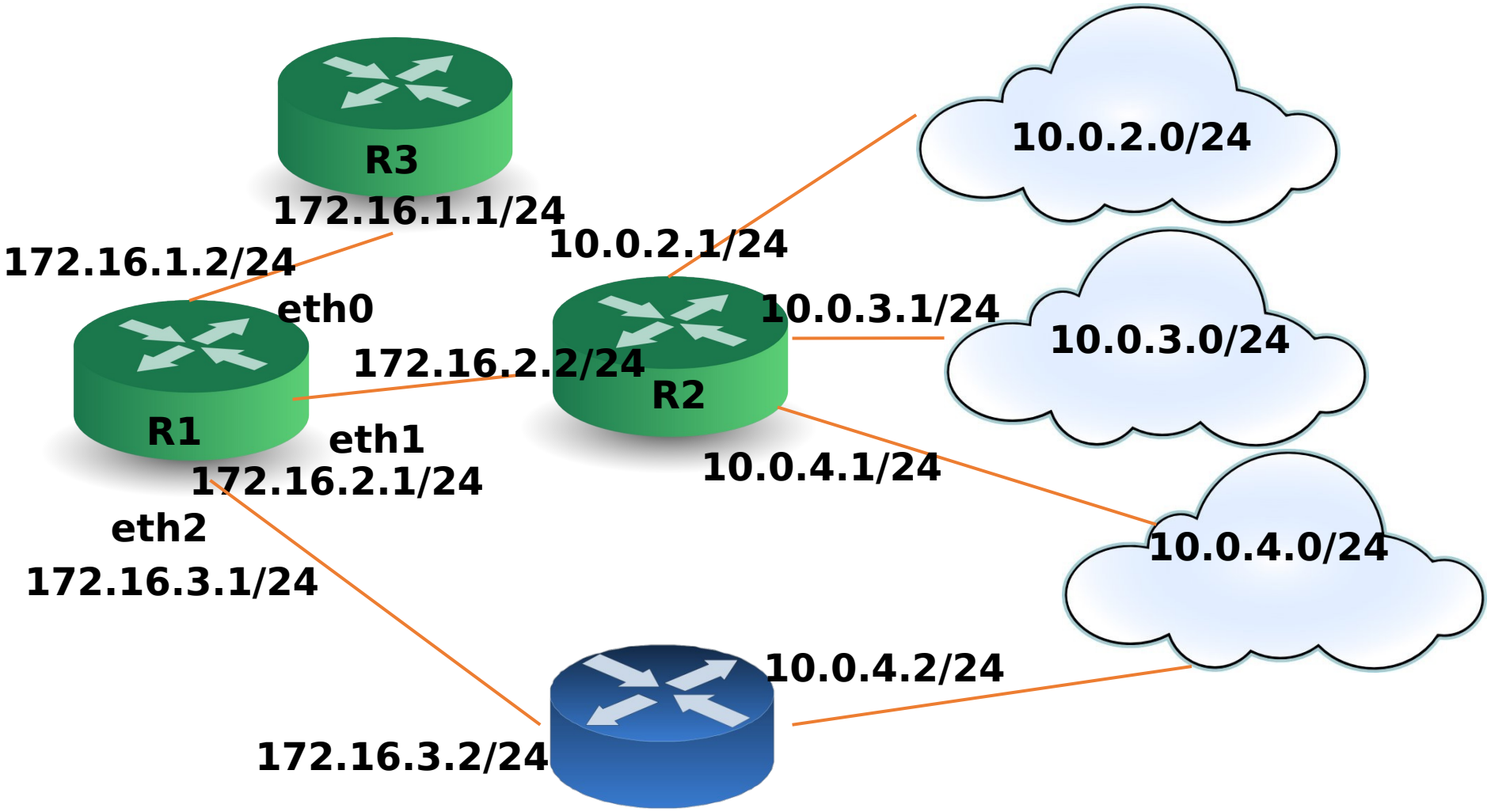
CIDR – Routing Table Construction



Network	Netmask	Gateway	Interface
10.0.0.0	255.255.0.0	172.16.2.2	eth1
0.0.0.0	0.0.0.0	172.16.1.1	eth0
172.16.1.0	255.255.255.0	172.16.1.1	eth0
172.16.2.0	255.255.25	172.16.2.2	eth1

Compact Routing Table for R1

CIDR – Problem of Multihoming



CIDR – Longest Prefix Match

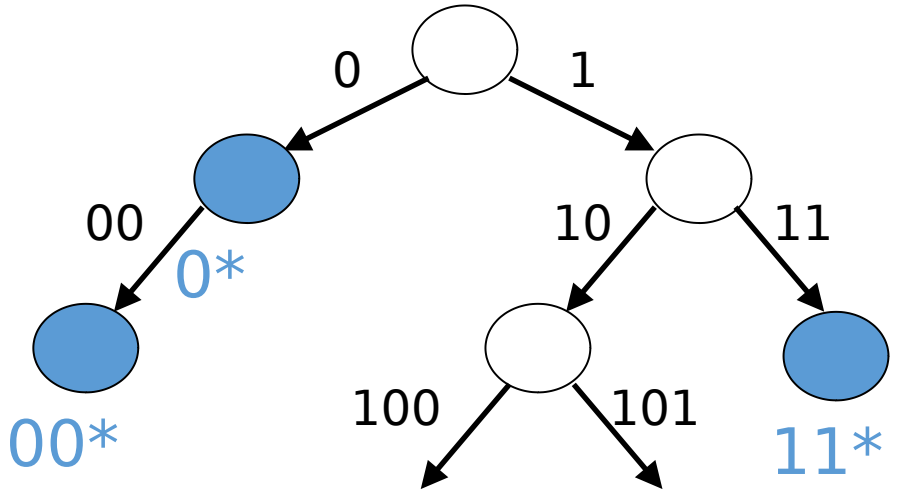
Supernetting is not always perfect !
There is always a possibility of duplicate entries

Network	Netmask	Gateway	Interface
10.0.0.0	255.255.0.0	172.16.2.2	eth1
10.0.4.0	255.255.255.0	172.16.3.2	eth2
0.0.0.0	0.0.0.0	172.16.1.1	eth0
172.16.1.0	255.255.255.0	172.16.1.1	eth0
172.16.2.0	255.255.25	172.16.2.2	eth1

Where to forward 10.0.4.8 ?

CIDR – Longest Prefix Match

- Use **Patricia Tree** (a compact representation of trie) for matching prefixes.



Next, we'll look how to construct the routing table for the Internet …