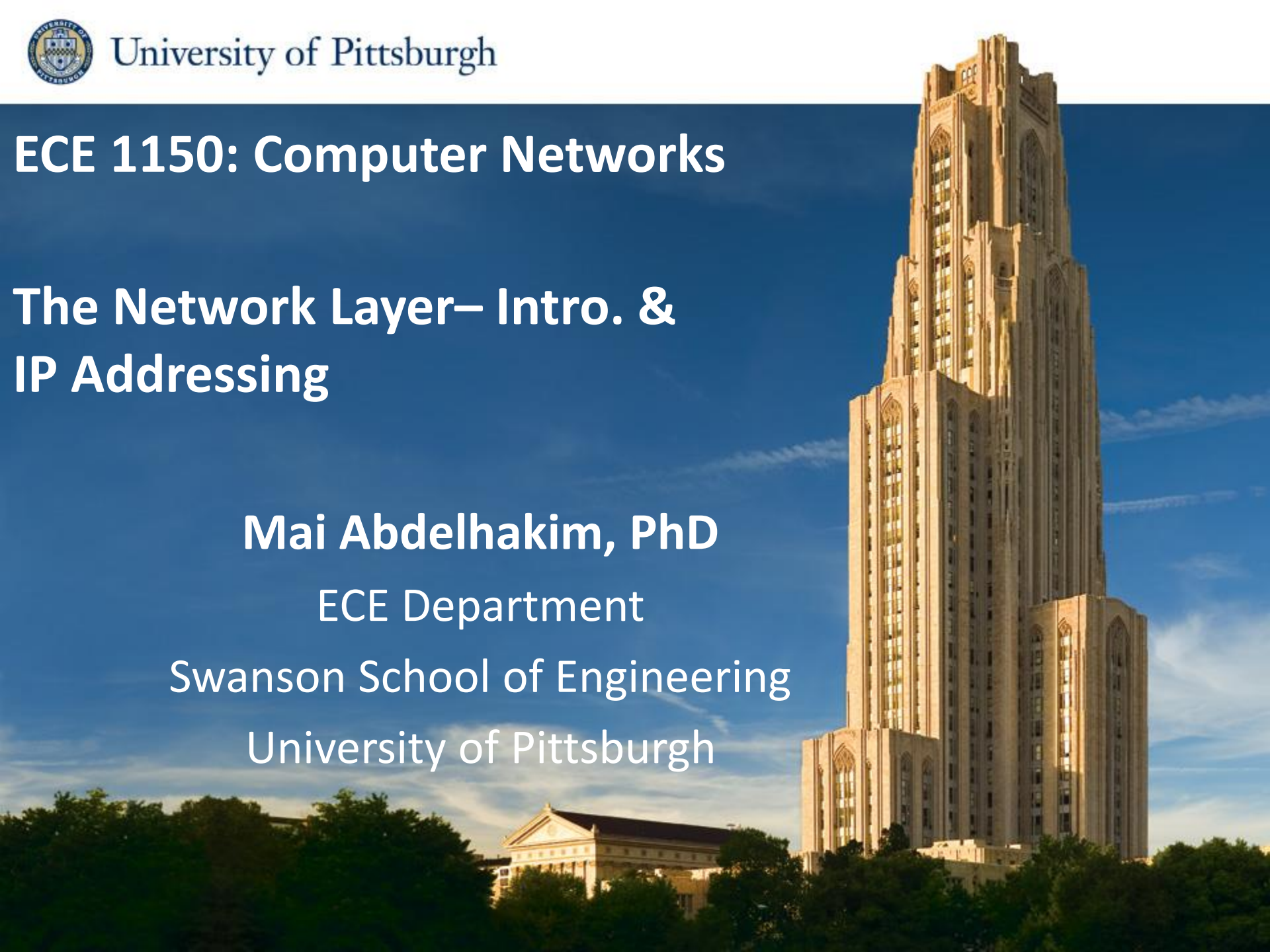

University of Pittsburgh

ECE 1150: Computer Networks

The Network Layer– Intro. & IP Addressing

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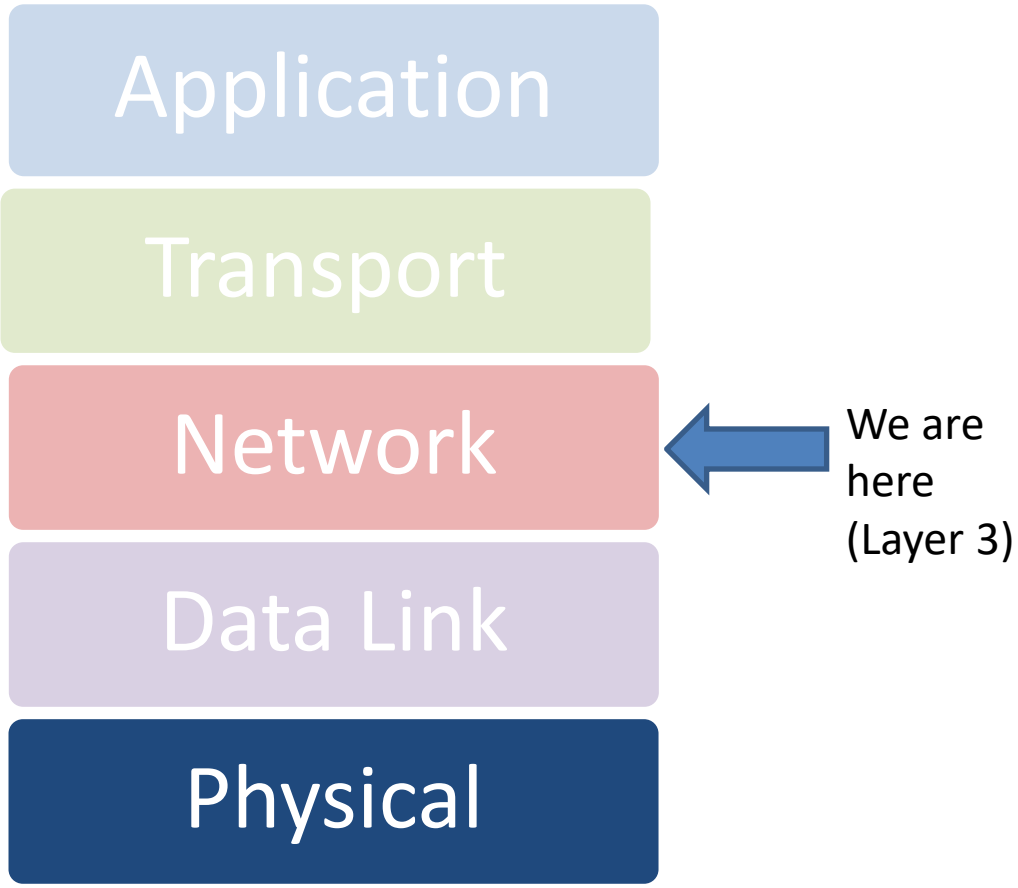
Topics

- The Network layer of the Internet – IP (Internet Protocol)
  - Main Functions
  - Header at network layer
  - IP addresses:
    - Address classes
    - Classless inter-domain routing
  - Routing

The Network Layer

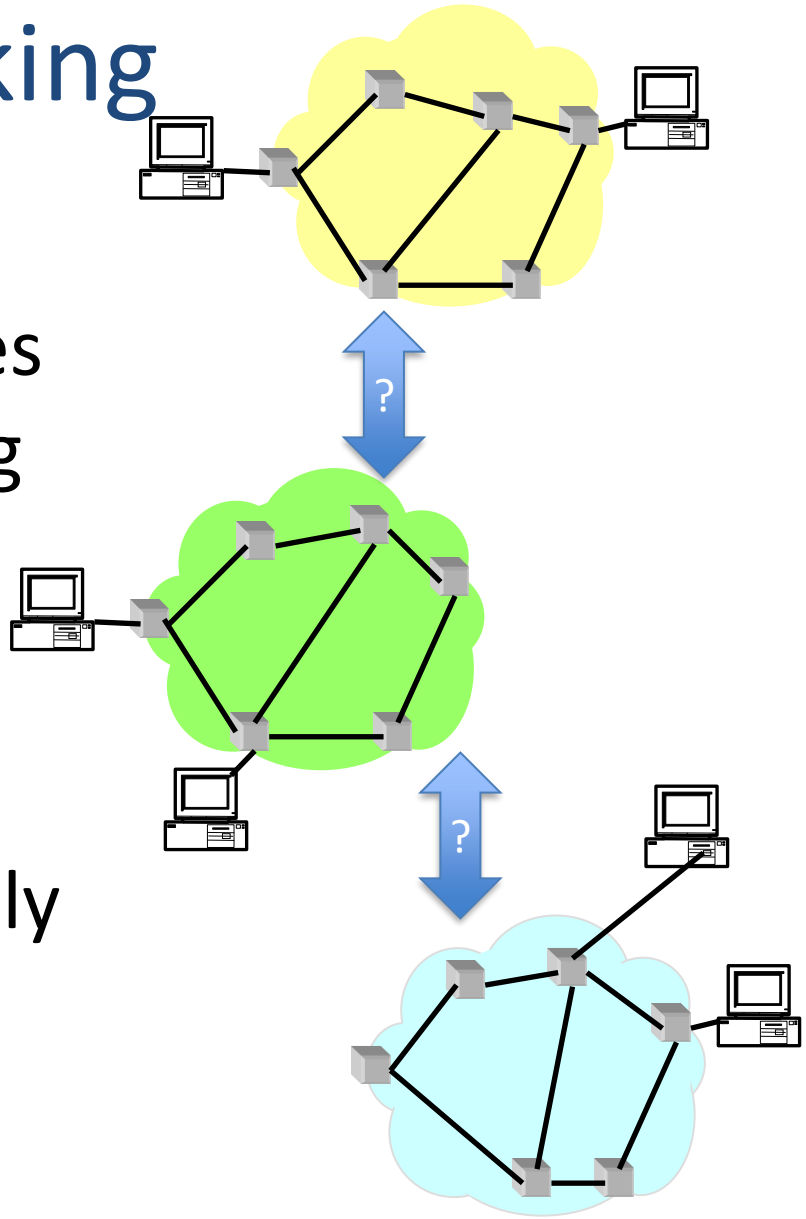
- Network Layer
  - **Layer 3** in the Internet model
  - Responsible for **addressing** and **routing** of message
- RFC = Request for Comments – specifies internet related standards
  - **Developed by IETF – Internet Engineering Task Force**



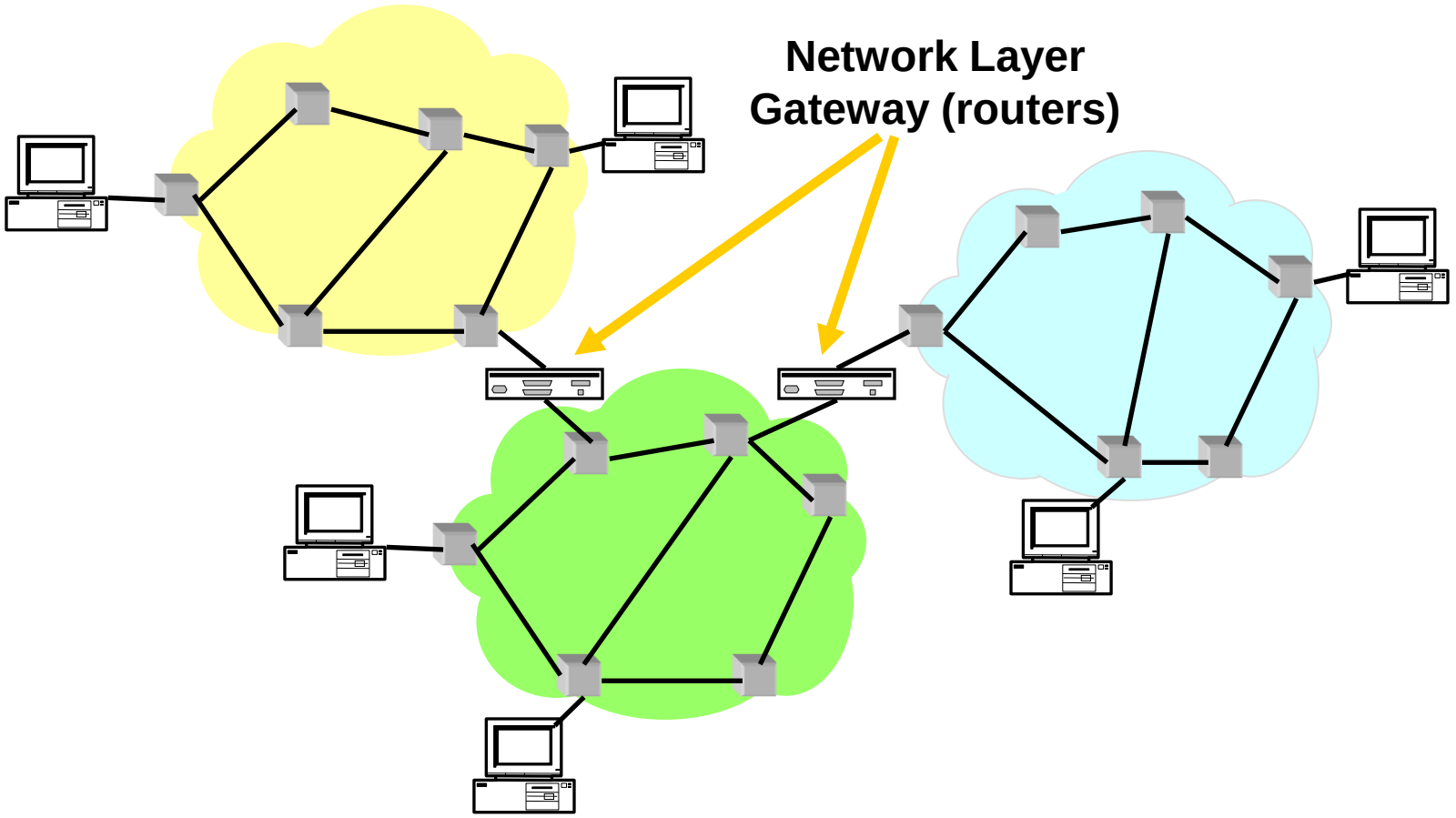
Internetworking

- Before Internet: Only nodes on the same network using same technology could communicate

- How to allow independently owned and administered networks to interconnect?



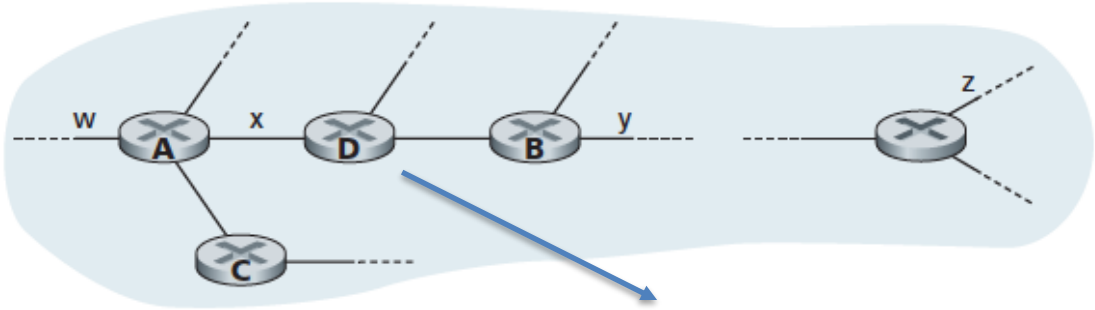
Internet Solution to Internetworking



- **Gateways** called *"**routers**"* can route packets between different LANs using the Internet protocol

Routing Protocols Build Routing Tables

- Routing Protocols: mechanism used by routers exchange information about their connections and select best route for each packet
  - Routers periodically exchange messages to determine the best routes
- Each router builds and maintains **routing table**
  - For each network destination **IP** address, the best next hop towards this destination is identified and stored in routing table



Routing table in router D

Destination Subnet	Next Router	Number of Hops to Destination
w	A	2
y	B	2
z	B	7
x	—	1

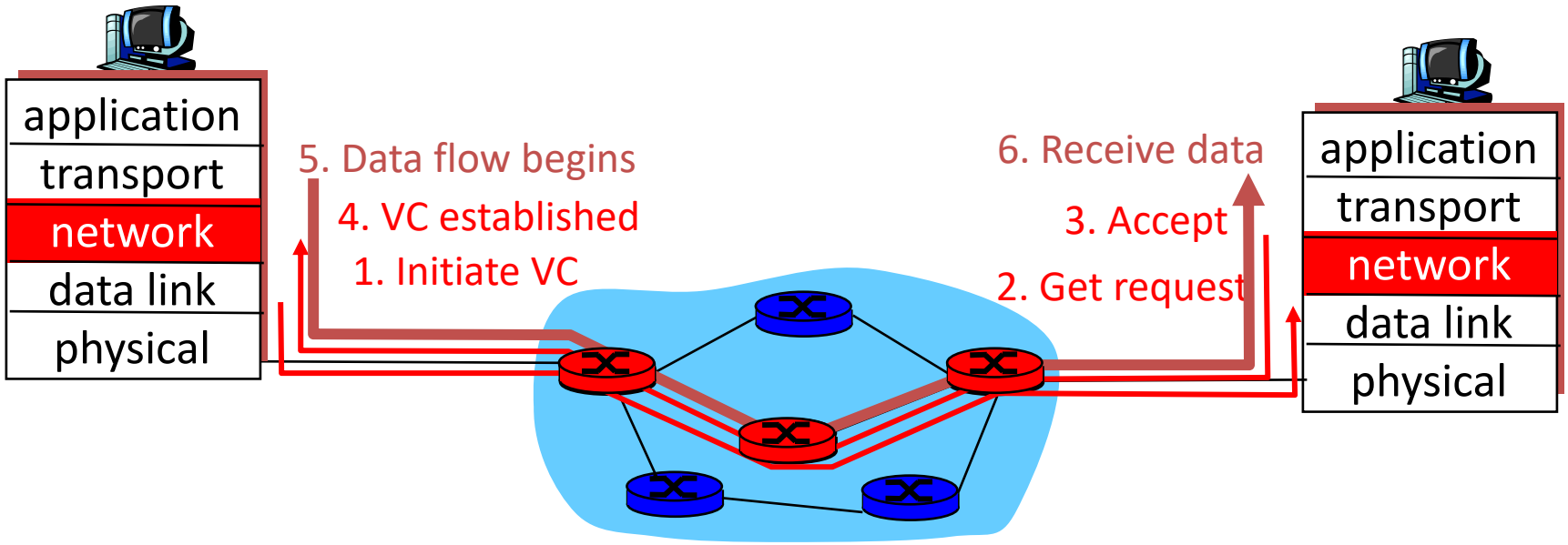
Two Ways for Packet switching

- **Connection Oriented: virtual circuit packet switching**
  - **All packets go on same route**

- **Connection-less: datagram packet switching**
  - **Route each packet independently** through the network

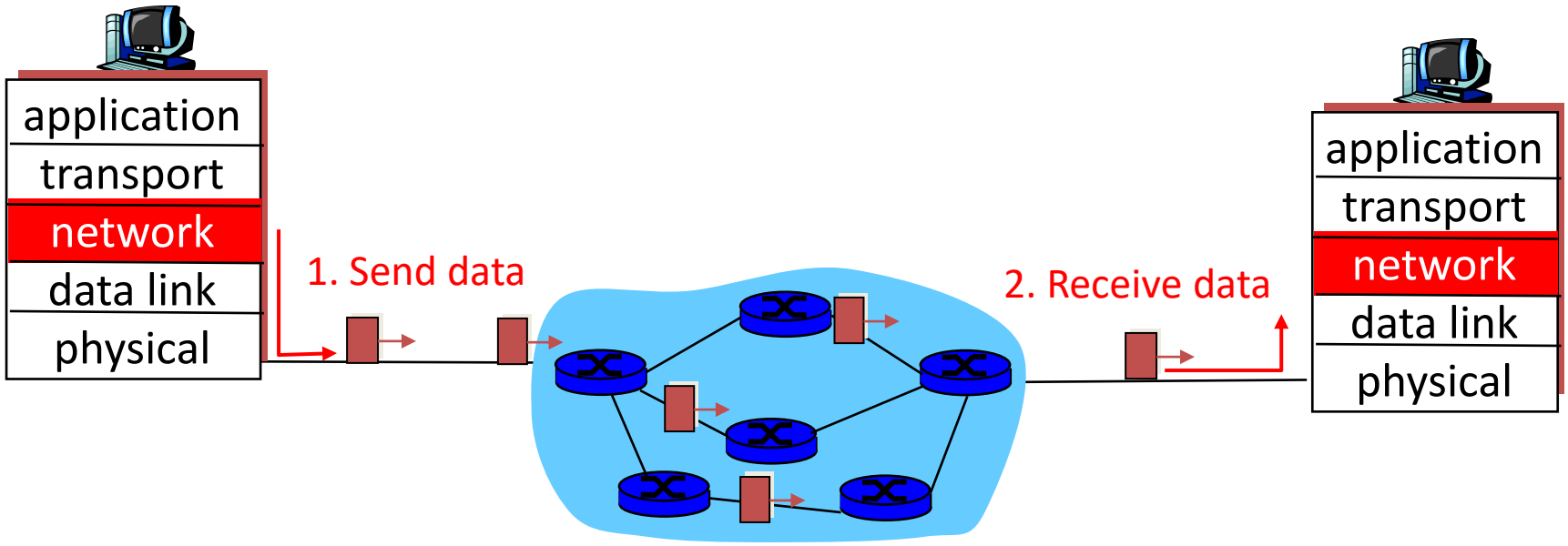
Connection Oriented Service

- Before data flows, end hosts establish connection called virtual Circuit (VC)
- Needs signaling protocol to setup, teardown VC
- Each packet has **VC ID in header** – decision based on ID
  - Used in WAN standards: ATM, frame-relay, X.25



Datagram (IP) Networks

- Packet between same source-destination pair may follow a different routing path
  - Packets forwarded using destination host address
- No setup needed at network layer
- Used in Internet



Network Protocols

- IPv4 Packet
  - 160-192 bits (20-24 bytes) of overhead
  - Options field: rarely used

IP Datagram Format

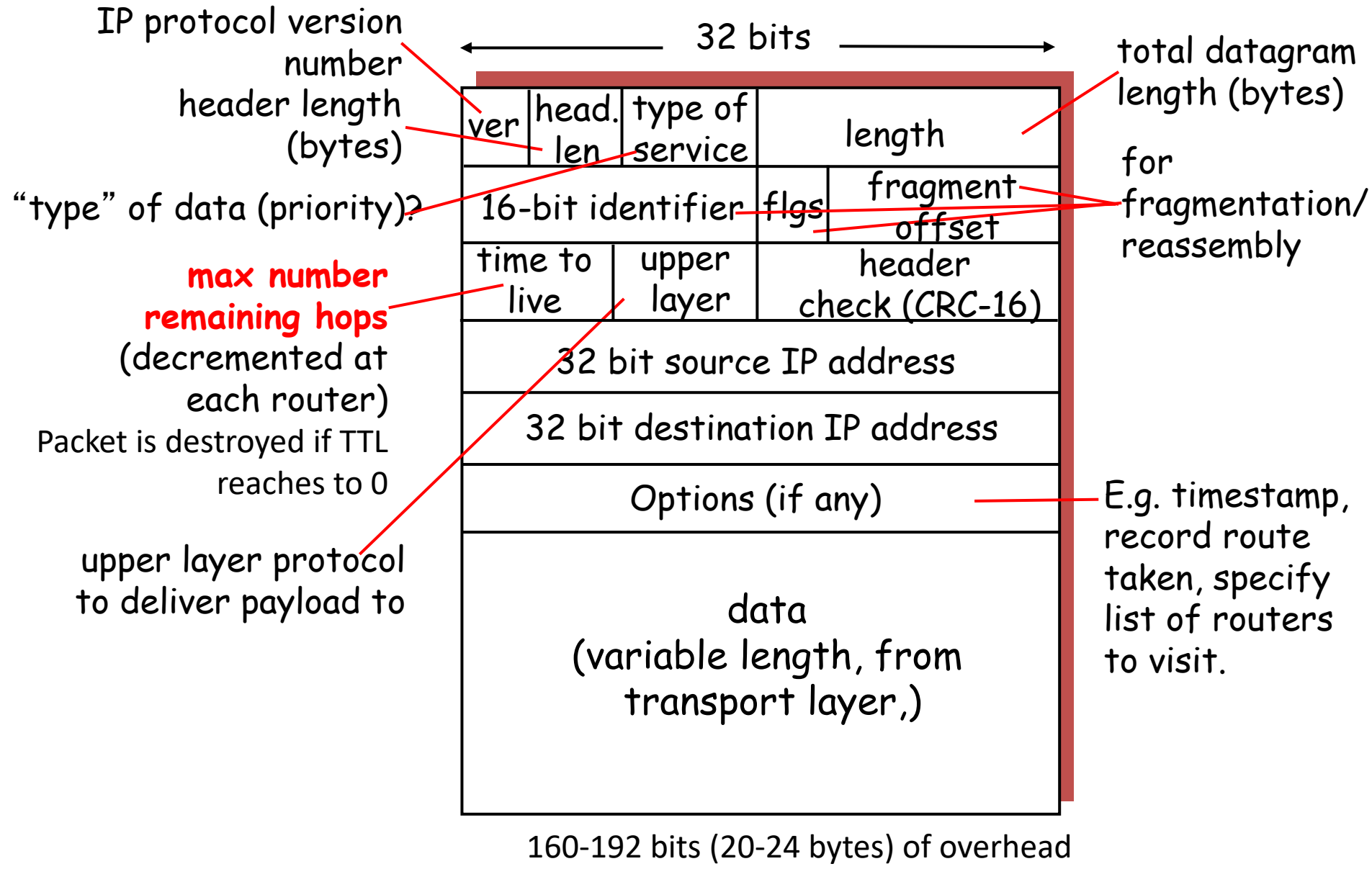
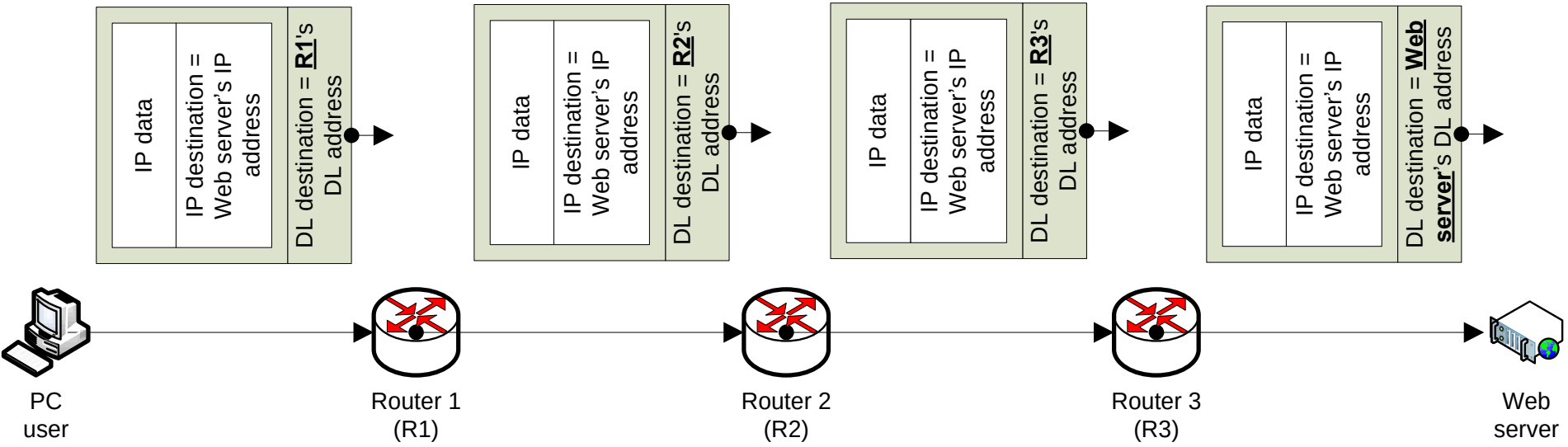


Figure modified from Agrawal

Why Need Addressing at Network and Link Layers?



- Data Link(DL) Layer address is addressing over a link ➔ Changes every link (every hop)
  - Source address is address of device transmitting over a link
  - Destination address is the address of the device receiving at end of a link
- IP (network layer) addressing is end-to-end
  - IP destination address is that of the final destination
  - Does not change throughout transmission

Internet (IP) Addresses

- **IP addresses** are **assigned by network administrators**
  - Provides flexibility in addressing

- The current addresses consist of **32 bit binary** numbers (IPv4)
  - Theoretically up to 2^{32} = 4.29 billion addresses
  - IPV6 expands the address space

IP Addresses

- Binary numbers are hard to remember, so use decimal equivalents
- IP addresses are written in **dotted decimal notation**
  - 32 bit addresses broken into 4 numbers, each of 8 bits
  - Each block converted to decimal representation
  - Decimals are separated by dots

  - **E.g. 136.142.185.57**
    - **Decimal to Binary**
      - **10001000 10001110 10111001 00111001**

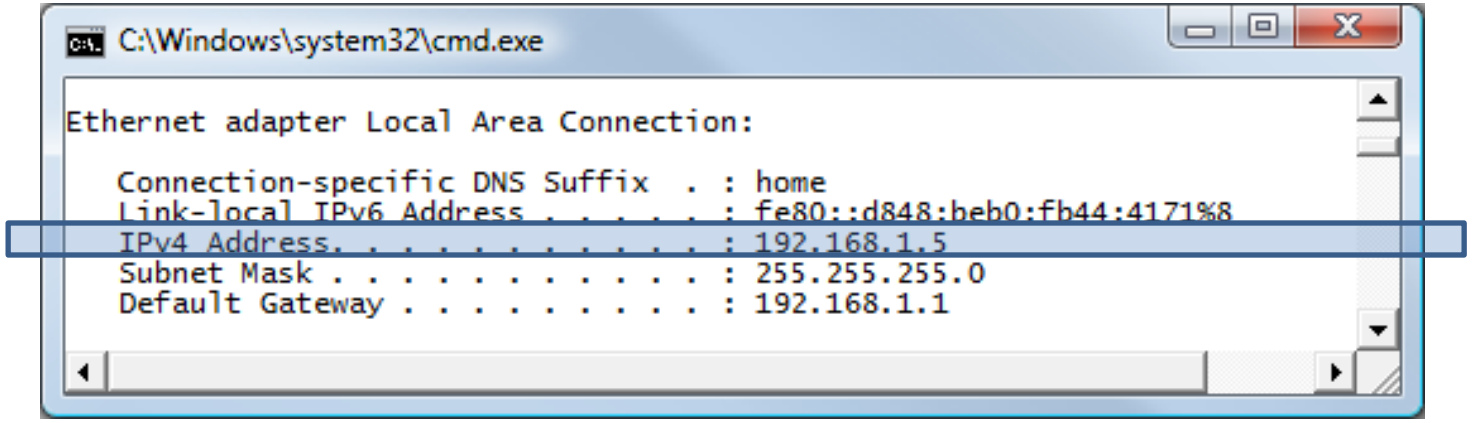
IP Addresses (dotted decimal notation)

- Examples

Recall Decimal to binary video link on Canvas.

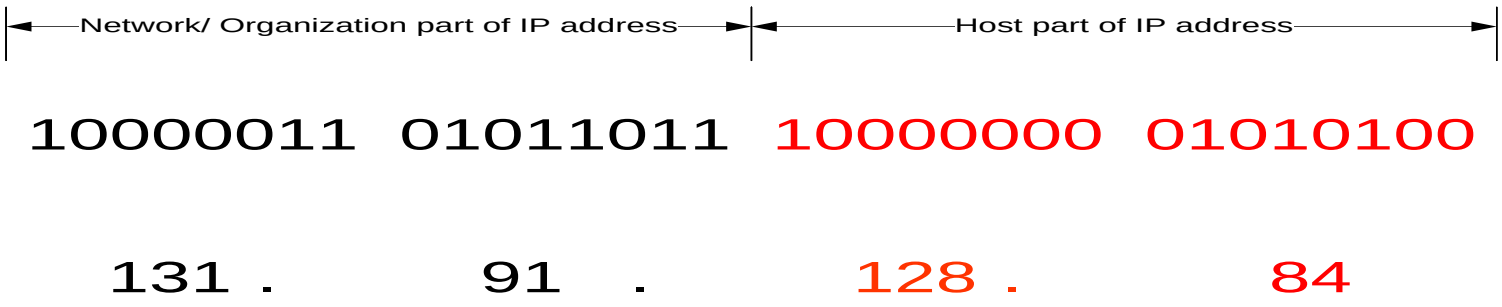
11000000 10101000 00000001 00000101

192 . 168 . 1 5



IP Addresses – 2 Part Structure

- IP address has **network part** and **host part**
- **Network part:** The first few bits **define organization** to which the address belongs
- **Host part:** Remaining bits are unique to the **computer (host) within the organization**
  - Host part is generally broken further into subnets (discussed later)



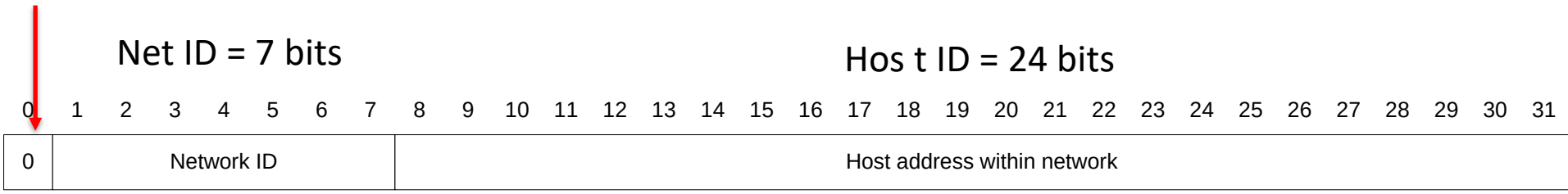
Florida Atlantic University Network ID

IP Address Classes (Old Technique)

- **Addresses are allocated in blocks (chunks)**
- **Defined 3 address classes**
  - Allowed **three possible network sizes**
- An organization could request from ISP an **address block** depending on its needs
  - **Class A** for the largest organizations
    - Need to support huge number of devices (hosts)
  - **Class B** for organizations like Universities
  - **Class C** for small businesses

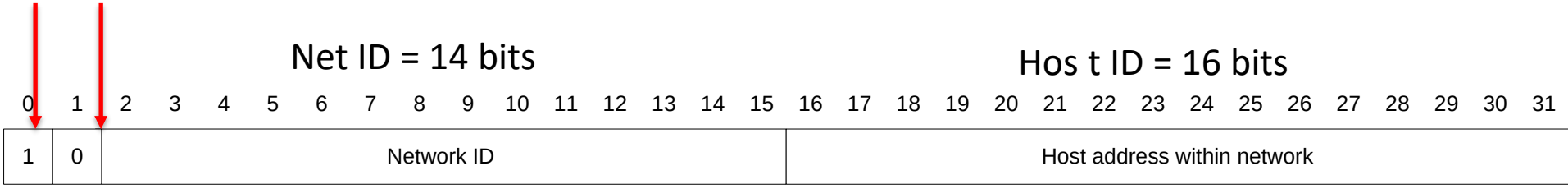
Address Classes

First bit is always ‘0’ for class A



Class A addresses

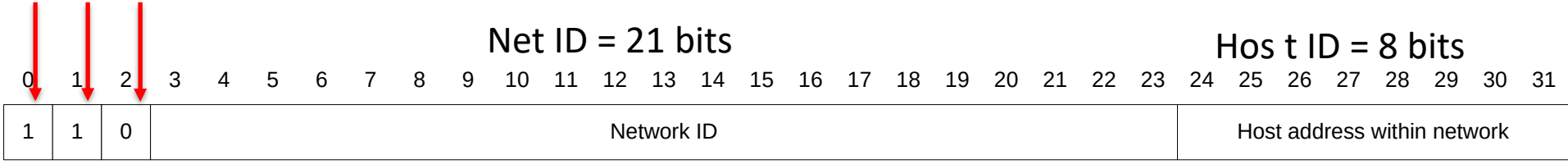
First two bits are ‘1 0’ for class B



65k hosts

Class B addresses

First three bits are ‘1 1 0’ for class C



256 hosts

Class C addresses

CIDR: **Classless Inter-Domain Routing**

- What if you need 2000 addresses in your organization
  - Get 8 blocks of class C (complex to handle) or one class B (waste addresses)
- **CIDR: Stands for Classless Inter-Domain Routing**
  - **Eliminates address classes**
  - CIDR aims to solve unavailability of address **blocks of reasonable size**
  - Defined in RFC 1519

CIDR

- With CIDR
  - **Choose any number of bit for the network part** of the **IP** address block

- If we need 2000 addresses,
  - we want IP address with 11 bits in host ID part (2^{11}=2048)
  - Thus, the network ID part is 21 bits
    - 32 - 11=21 bits
      - » 32 is the **total length of IP**

CIDR Notation

- With CIDR, **a number along with the IP address to specify how many bits are in the network ID part**
  - The number denotes the number of bits in the network part of the address
  - E.g. 73.5.0.0/ 17
    - The number after the dash is the number of bits for network ID (17 bits)

CIDR Notation

- If an organization has CIDR address of: 73.5.0.0**/ 17**,

  Means that the network part of IP address is 17 bits, hence the host part is 32-17

  - First 17 bits of the address are the network part
  - Called a /17 network
  - The remaining 15 bits (32-17) identify the host
  - So, the network can have 2^{15} = 32,768 computers

Key takeaways

- IP frame format
- IP address classes
- CIDR: Classless Inter-Domain Routing