

# MOBILE COMPUTING

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Prof. Jongwon Yoon



**Intelligent Machines Lab.**

# Course description

- This course aims to provide an overview of wireless networking and an in-depth knowledge on Internet protocols.
- Students will learn the fundamentals of wireless networking and acquire hands-on experience with various network protocols.
- **Prerequisite: Computer Networks**
- Textbook: TCP/IP Illustrated, Vol.1, W. Richard Stevens  
available at <http://www.pcvr.nl/tcpip/>  
인터넷프로토콜, 김효곤, 홍릉출판사  
Reference: TCP/IP Guide, Charles M. Kozierok  
available at [http://www.tcpipguide.com/free/t\\_toc.htm](http://www.tcpipguide.com/free/t_toc.htm)

# Intro

- Class material will be posted on every Monday @9AM
- About 10 HWs (due next Monday @8:59AM)
- HWs and Exams are usually tough. Think carefully.
- Email: [jongwon@hanyang.ac.kr](mailto:jongwon@hanyang.ac.kr)
- Office hours: Every Monday @9:30-10:30AM
- Evaluation:
  - HW 25%
  - Discussion 10%
  - Midterm1 (10/4) 20%
  - Midterm2 (11/13) 20%
  - Final (12/20) 25%
- Total < 40% will FAIL

# Why mobile computing?



2005

2013



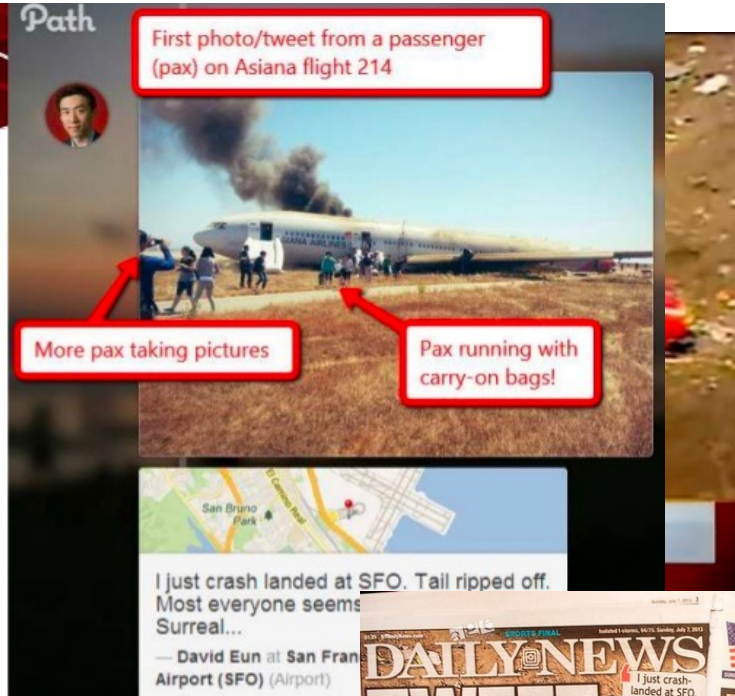


# Why mobile computing?

First photo from a passenger hits Twitter, via Path

David Eun, a Samsung executive was the first passenger to post a photo of the burning wreckage, 18 mins after the crash.

<https://path.com/p/1lwrZb>



2013.7.6 11:28AM

2013.7.7 Morning



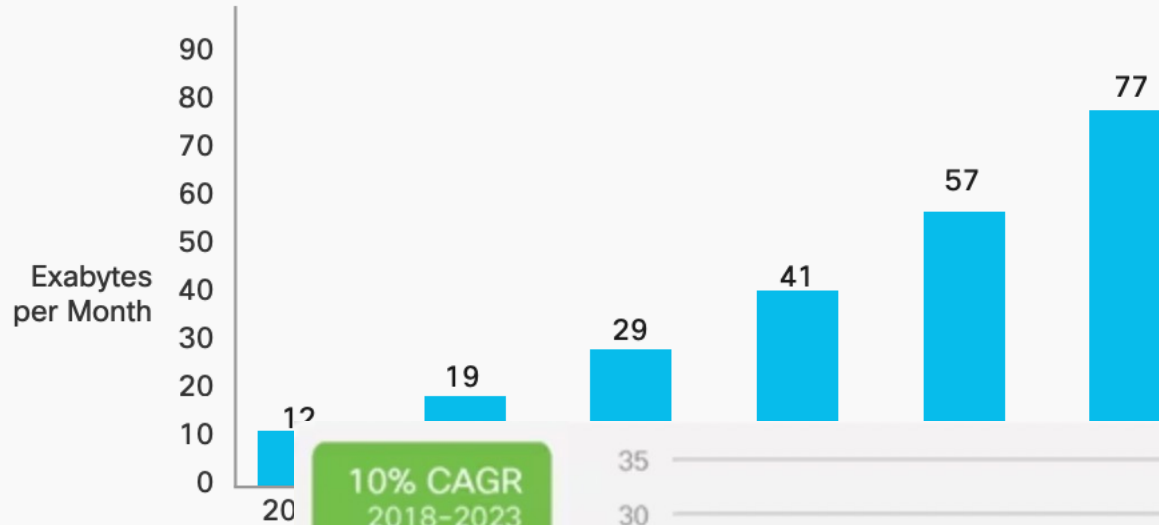
# Why mobile computing?



# Why mobile computing?

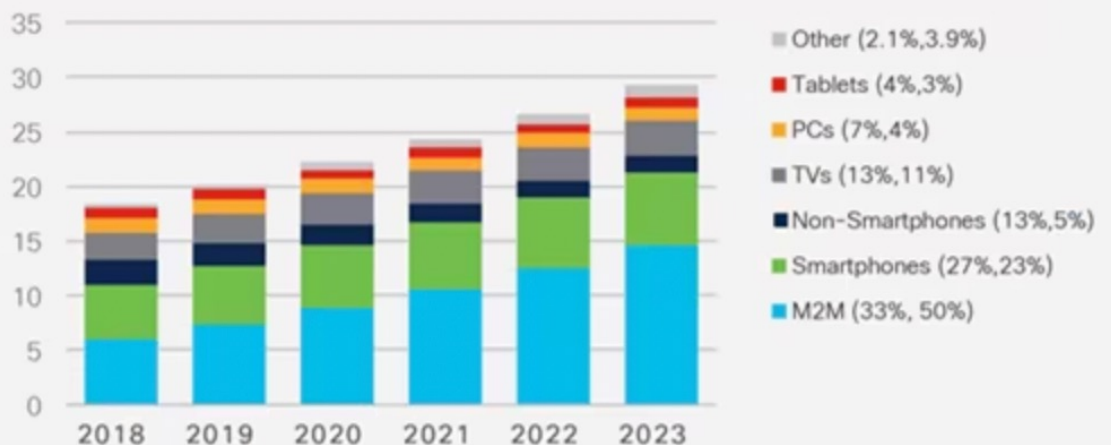
1 exabytes = 1,000,000,000,000,000,000 bytes

**46% CAGR  
2017-2022**



**10% CAGR  
2018-2023**

Billions of  
Devices



\* Figures (n) refer to 2018, 2023 device share

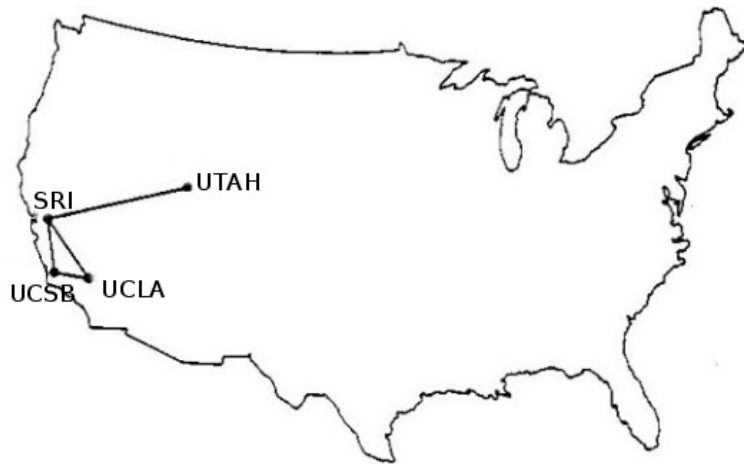
Global mobile  
growth by device

# Mobile computing?

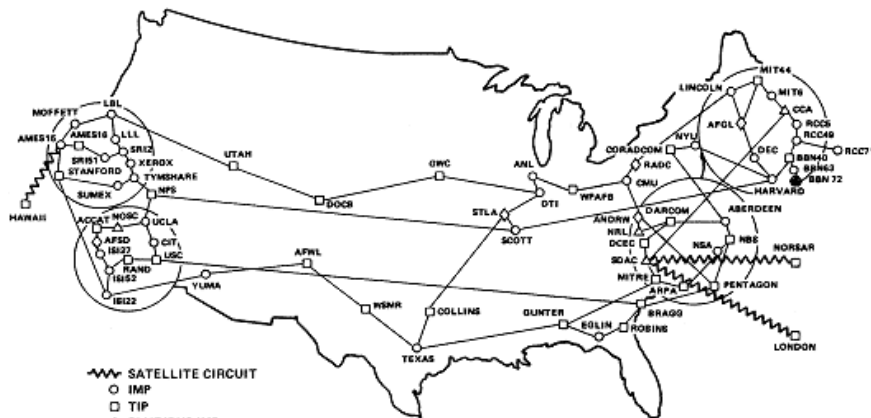
- Mobile computing is a technology that allows **transmission of data, voice and video** via a **computer** or any other **wireless device** without having to be connected to a physical link.
- Mobile computing encompasses a number of technologies and devices, such as wireless LANs, laptops, cell and smart phones, tablet PCs and etc.
- Any electronic device that helps you organize your life, communicate with coworkers or friends, or do your job more efficiently is part of mobile computing.



# Historical Maps of Computer Networks

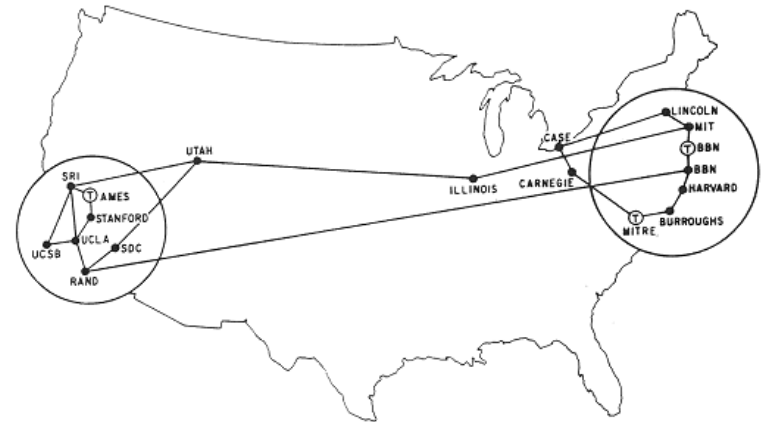


1000 ARPA NET  
ARPANET GEOGRAPHIC MAP, OCTOBER 1980

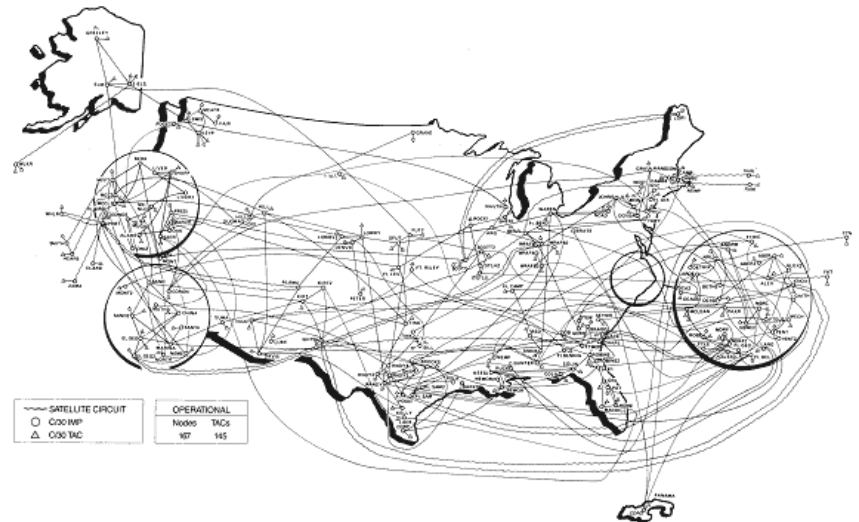


SATELLITE CIRCUIT  
 IMP  
 TIP  
 PLURIBUS IMP  
 PLURIBUS TIP  
 C30

(NOTE: THIS MAP DOES NOT SHOW ARPA'S EXPERIMENTAL SATELLITE CONNECTIONS)  
NAMES SHOWN ARE IMP NAMES, NOT (NECESSARILY) HOST NAMES

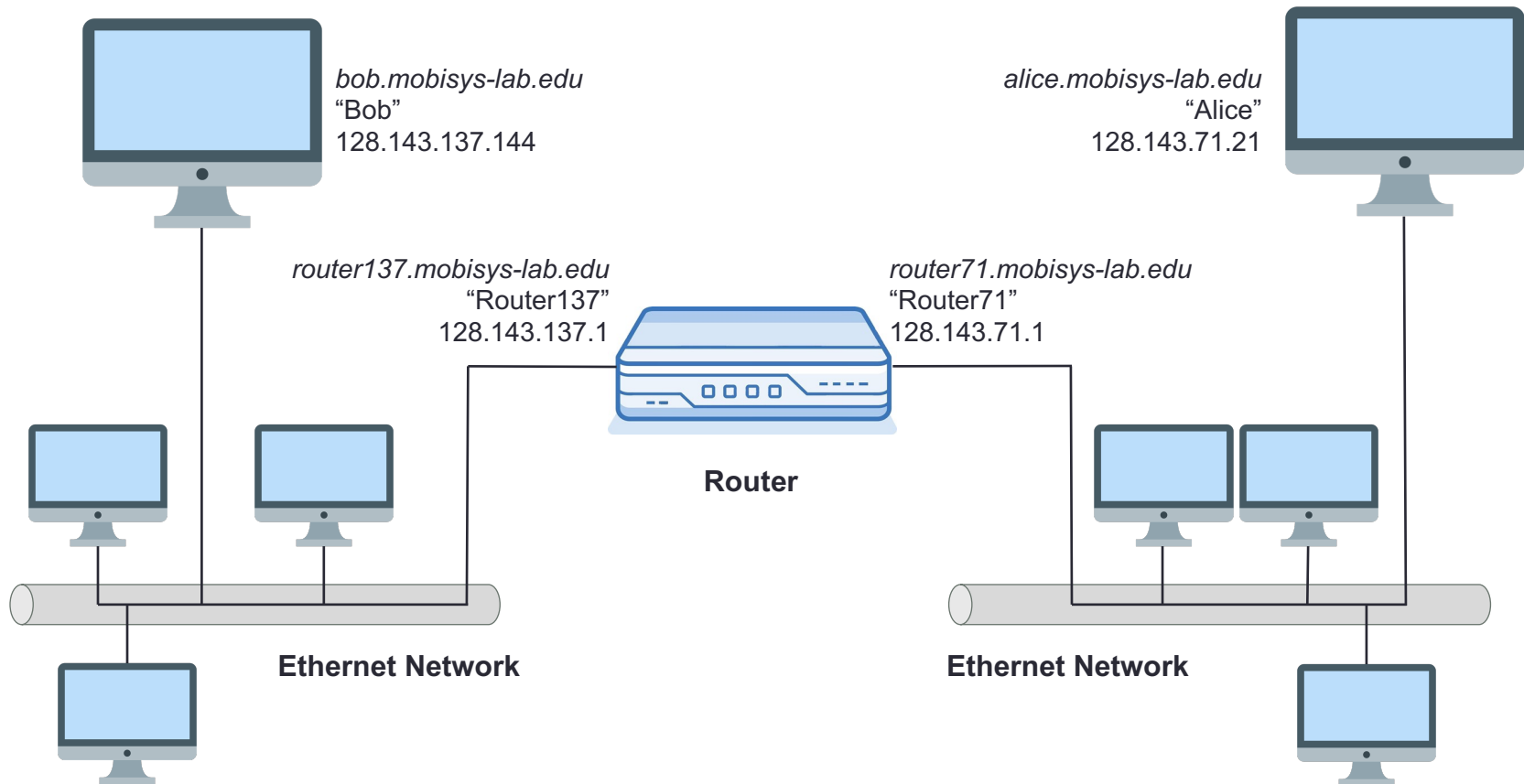


MAP 4 September 1971

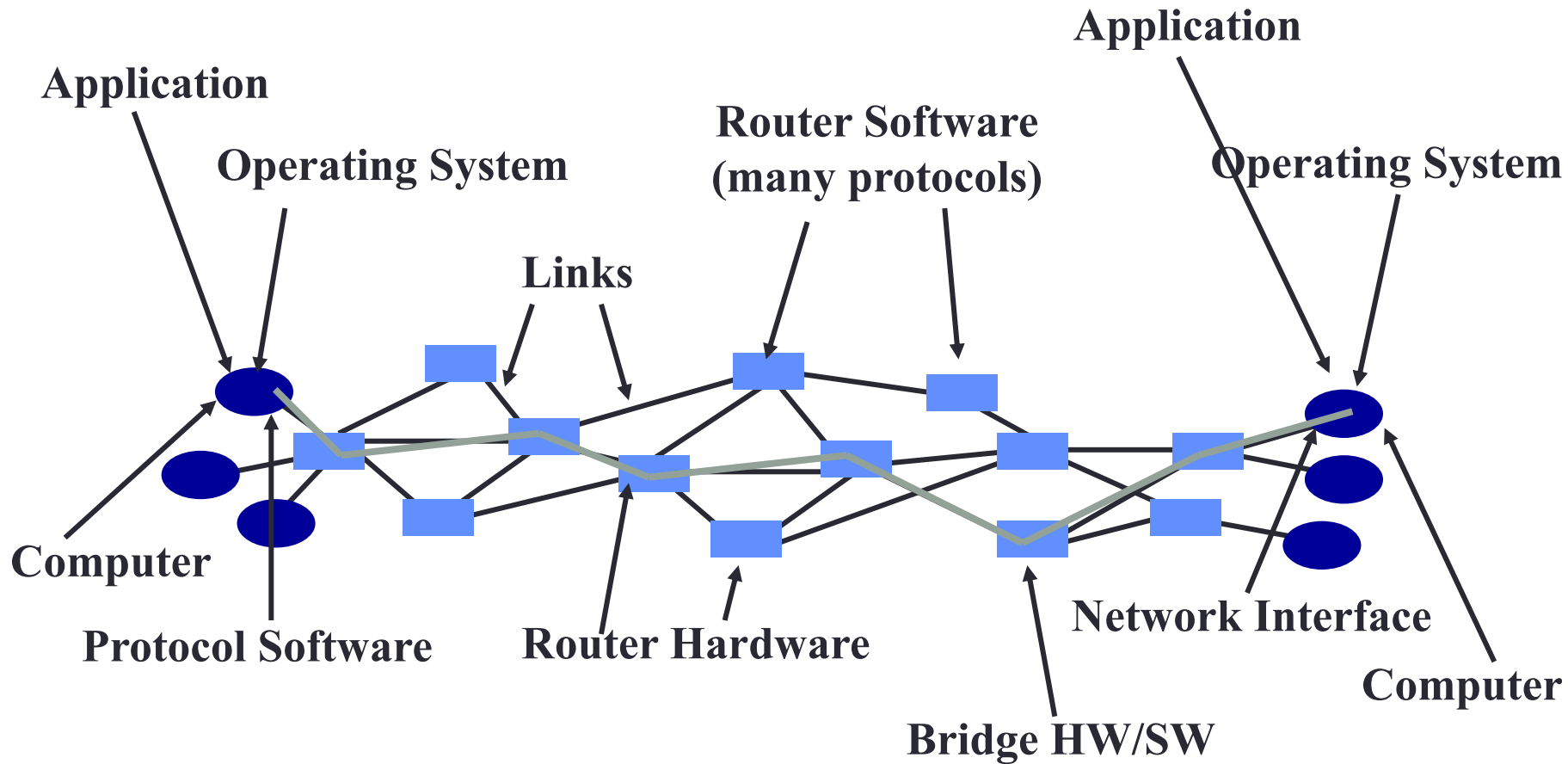


SATELLITE CIRCUIT  
 CDS IMP  
 CDS TAC  
 OPERATIONAL  
 Nodes TACs  
 IMP VES

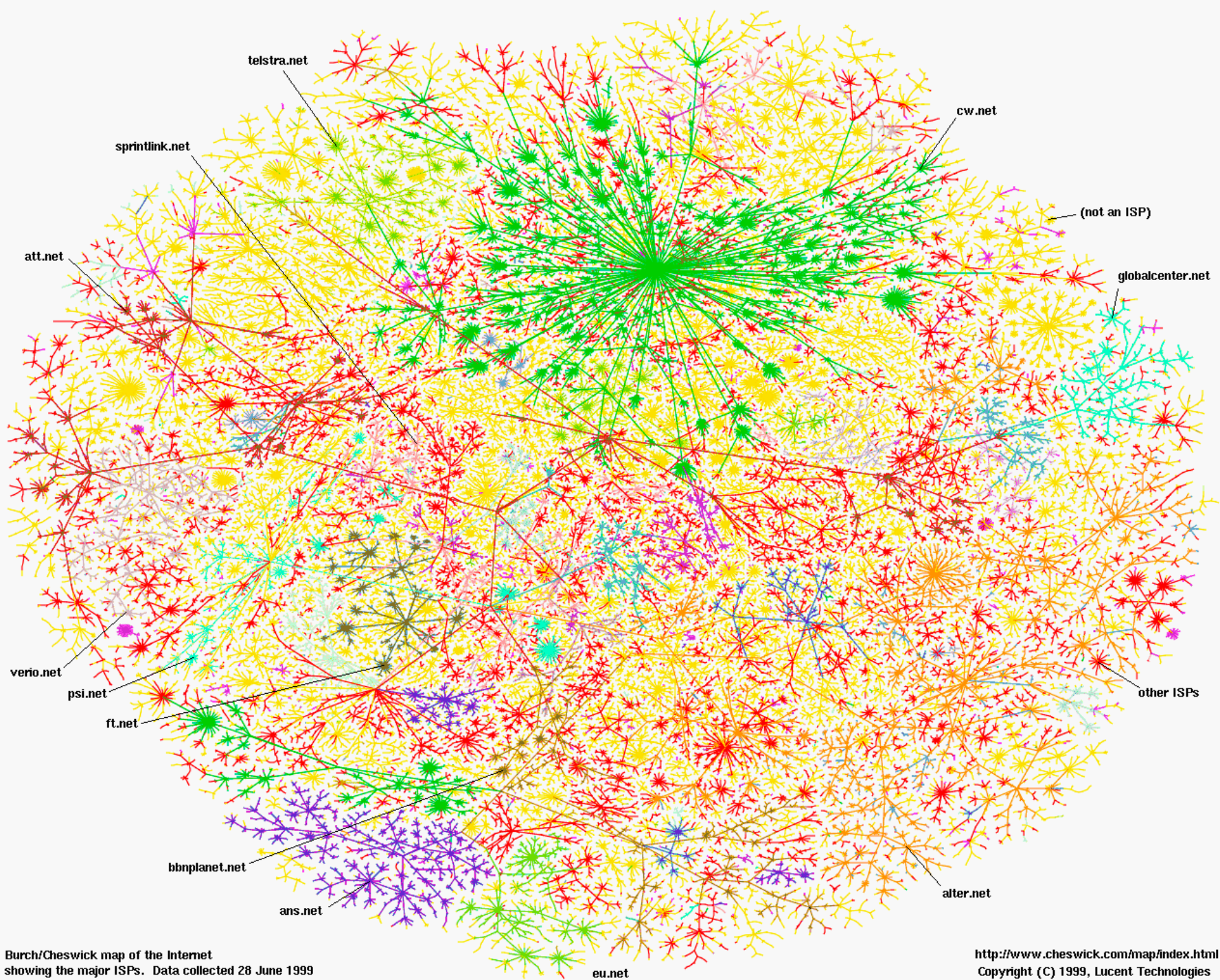
# Sending packets from Bob to Alice



# Too many network components







# Too many components 2

- Links: copper, fiber, air, carrier pigeon
- Running Ethernet, token ring, SONET, FDDI
- Routers speaking BGP, OSPF, RIP, ...
- Hosts running FreeBSD, Linux, Windows, Mac OS X, ...
- People using Chrome, Mozilla, Explorer, Opera, ...  
and it changes all the time
- Protocols hide this stuff with simple abstractions.

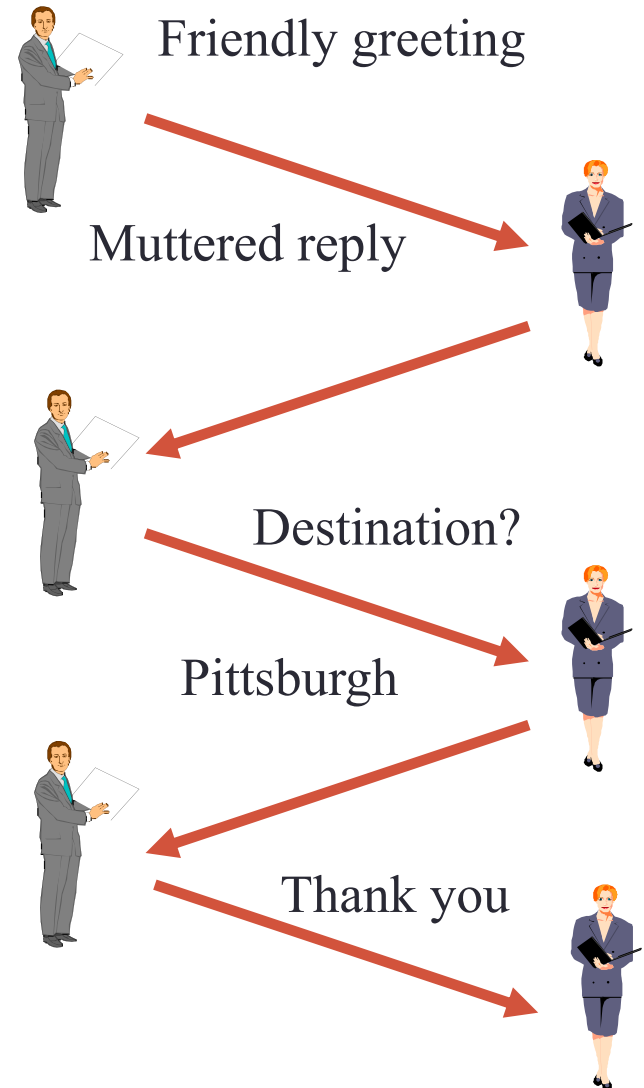
# Protocol

- **Protocol** is the special set of **rules** that **end points** in a telecommunication connection use when they communicate.
- **Protocols** specify interactions between the communicating entities.
- **Internet Protocol (IP)** is the principal communications protocol in the **Internet protocol suite** for relaying datagrams across network boundaries.
- Its routing function enables internetworking, and essentially establishes the **Internet**.



# Protocols

- An agreement between parties on who communication should take place.
- Protocols may have to define many aspects of the communication.
- Syntax:
  - Data encoding, language, etc.
- Semantics:
  - Error handling, termination, ordering of requests, etc.
- Protocols at hardware, software, *all* levels!
- Syntax: English, ascii, lines delimited by “\n”



# More on Protocols

- Protocols are the key to interoperability.
  - Networks are very heterogeneous:

<b>Computer: x86</b>	<b>Hardware</b>
<b>Ethernet: 3com</b>	<b>Hardware/link</b>
<b>Routers: cisco, etc.</b>	<b>Network</b>
<b>App: Email</b>	<b>Application</b>

- The hardware/software of communicating parties are often not built by the same vendor
- Yet they can communicate because they use the same protocol
- Protocols exist at many levels.
  - Application level protocols, e.g. access to mail, web access, ..
  - Protocols at the hardware level allow two boxes to communicate over a link, e.g. the Ethernet protocol

# Interfaces

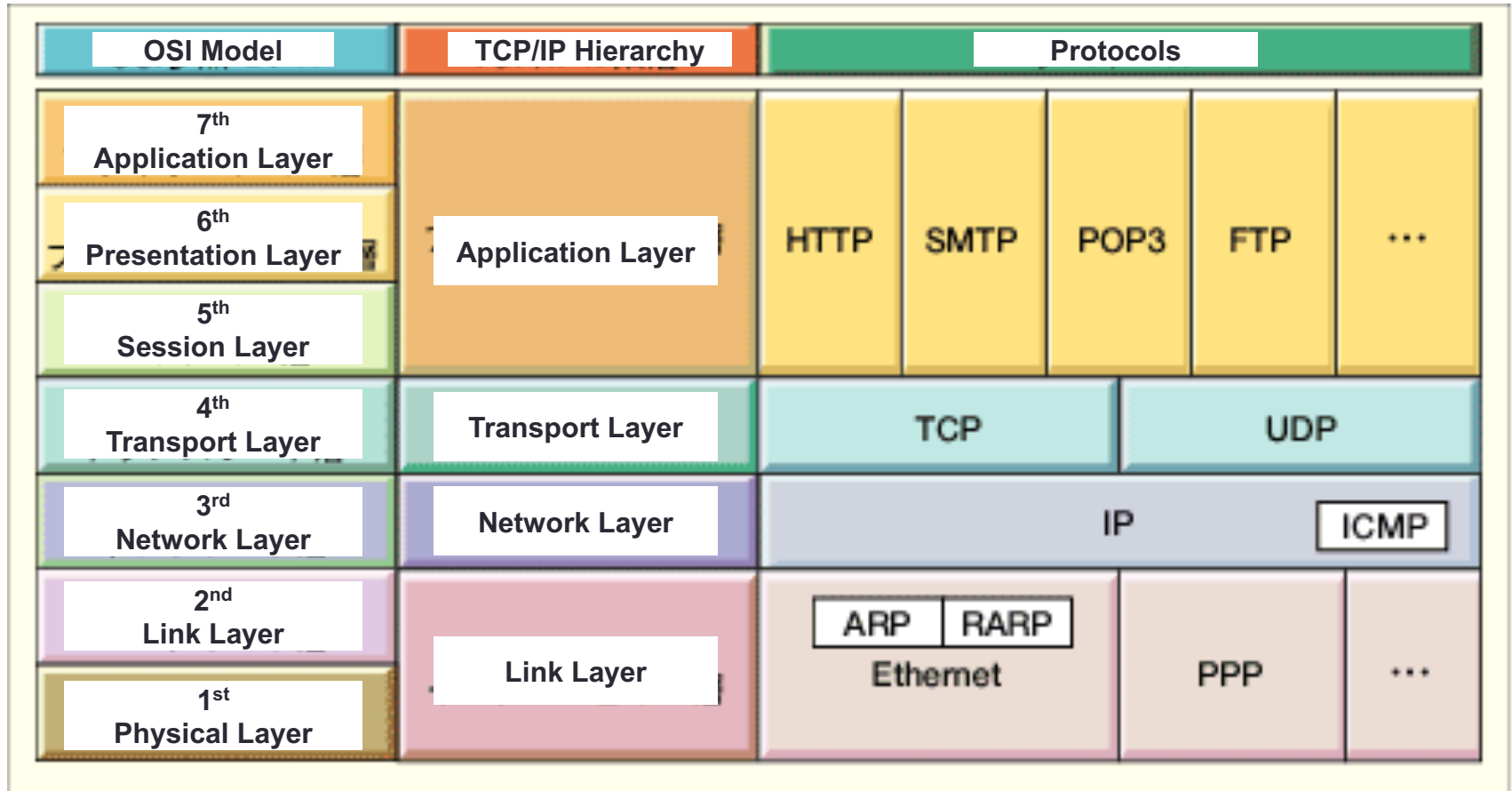
- Each protocol offers an interface to its users, and expects one from the layers on which it builds
  - Syntax and semantics strike again
    - Data formats
    - Interface characteristics, e.g. IP service model
- Protocols build upon each other
  - Add value
    - E.g., a reliable protocol running on top of IP
  - Reuse
    - E.g., OS provides TCP, so apps don't have to rewrite

# Communication Architecture

- The complexity of the communication task is reduced by using multiple protocol layers:
  - Each protocol is implemented independently
  - Each protocol is responsible for a specific subtask
  - Protocols are grouped in a hierarchy
- A structured set of protocols is called a communications architecture or protocol suite

# OSI and Protocol Stack

OSI: Open Systems Interconnect



Link Layer : includes device driver and network interface card

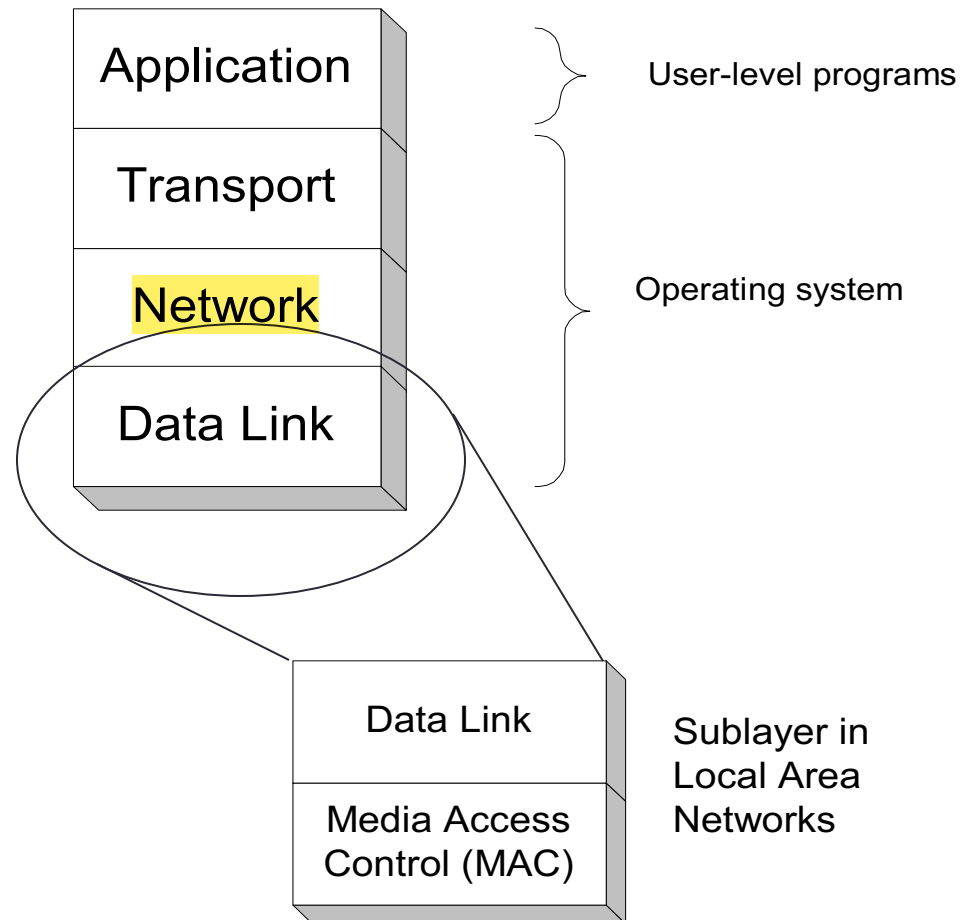
Network Layer : handles the movement of packets, i.e. Routing

Transport Layer : provides a reliable flow of data between two hosts

Application Layer : handles the details of the particular application

# TCP/IP Protocol Suite

- The TCP/IP protocol suite is the protocol architecture of the **Internet**
- The TCP/IP suite has four layers: **Application**, **Transport**, **Network**, and **Data Link Layer**
- **End systems** (hosts) implement all four layers.
- Routers (Gateways) only have the bottom two layers.

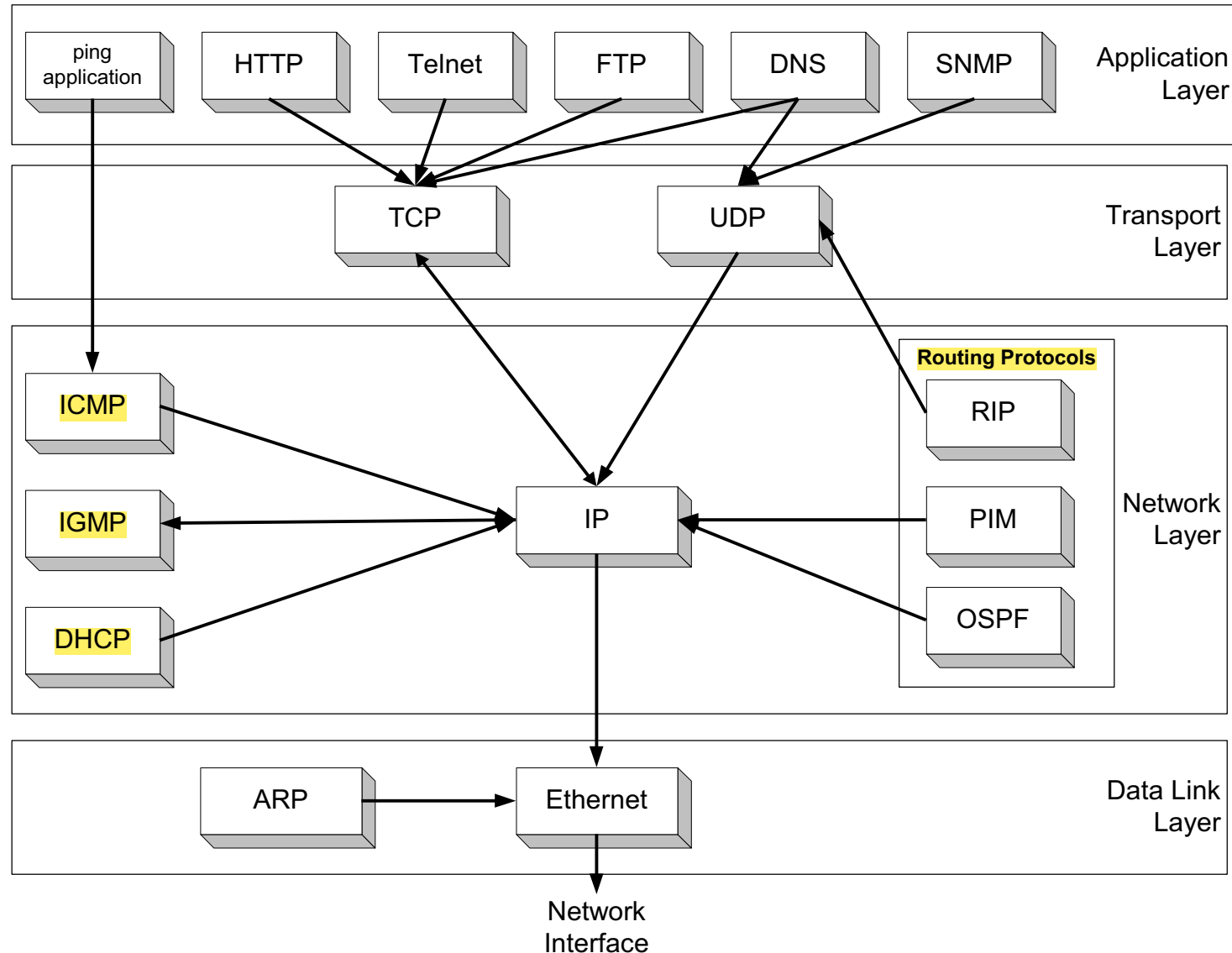




# Functions of the Layers

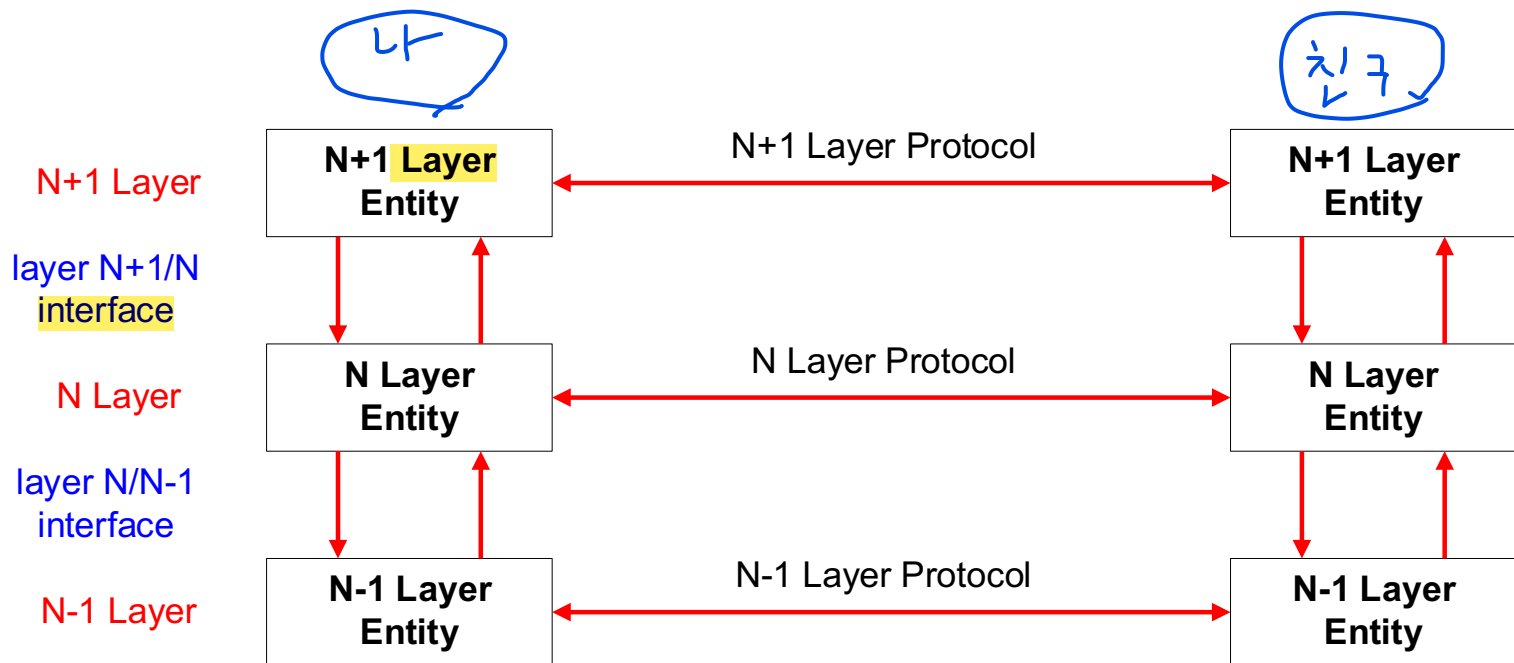
- **Data Link Layer**
  - **Service:** Reliable transfer of frames over a link  
Media Access Control on a LAN
  - **Functions:** Framing, media access control, error checking
- **Network Layer**
  - **Service:** Move packets from source host to destination host
  - **Functions:** Routing, addressing
- **Transport Layer**
  - **Service:** Delivery of data between hosts
  - **Functions:** Connection establishment/termination, error control, flow control
- **Application Layer**
  - **Service:** Application specific (delivery of email, retrieval of documents, reliable transfer of file)  
HTML
  - **Functions:** Application specific

# Assignment of Protocols to Layers



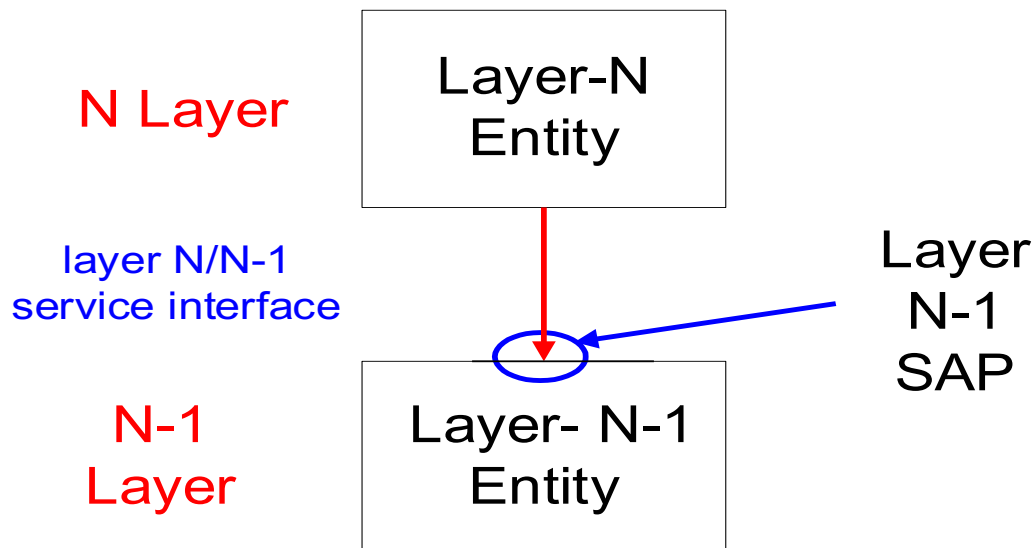
# Layered Communications

- An entity of a particular layer can only communicate with:
  1. a **peer layer entity** using a common protocol (**Peer Protocol**)
  2. **adjacent layers** to provide services and to receive services



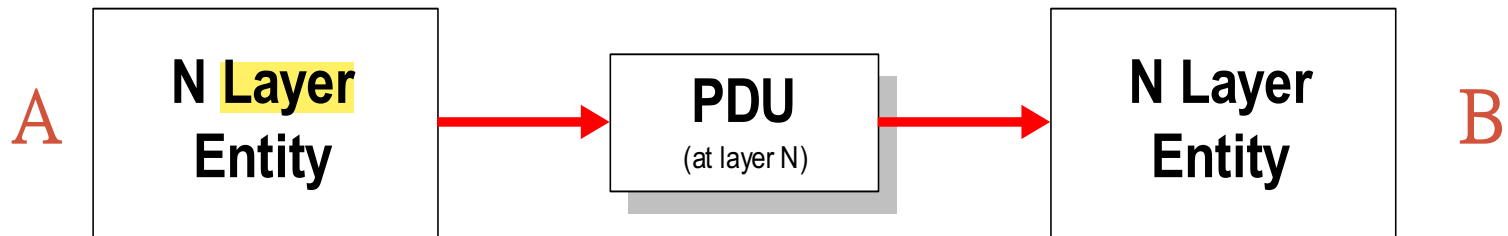
# Service Access Points

- A service user accesses services of the service provider at Service **Access Points (SAPs)**
- A SAP has an address that uniquely identifies where the service can be accessed



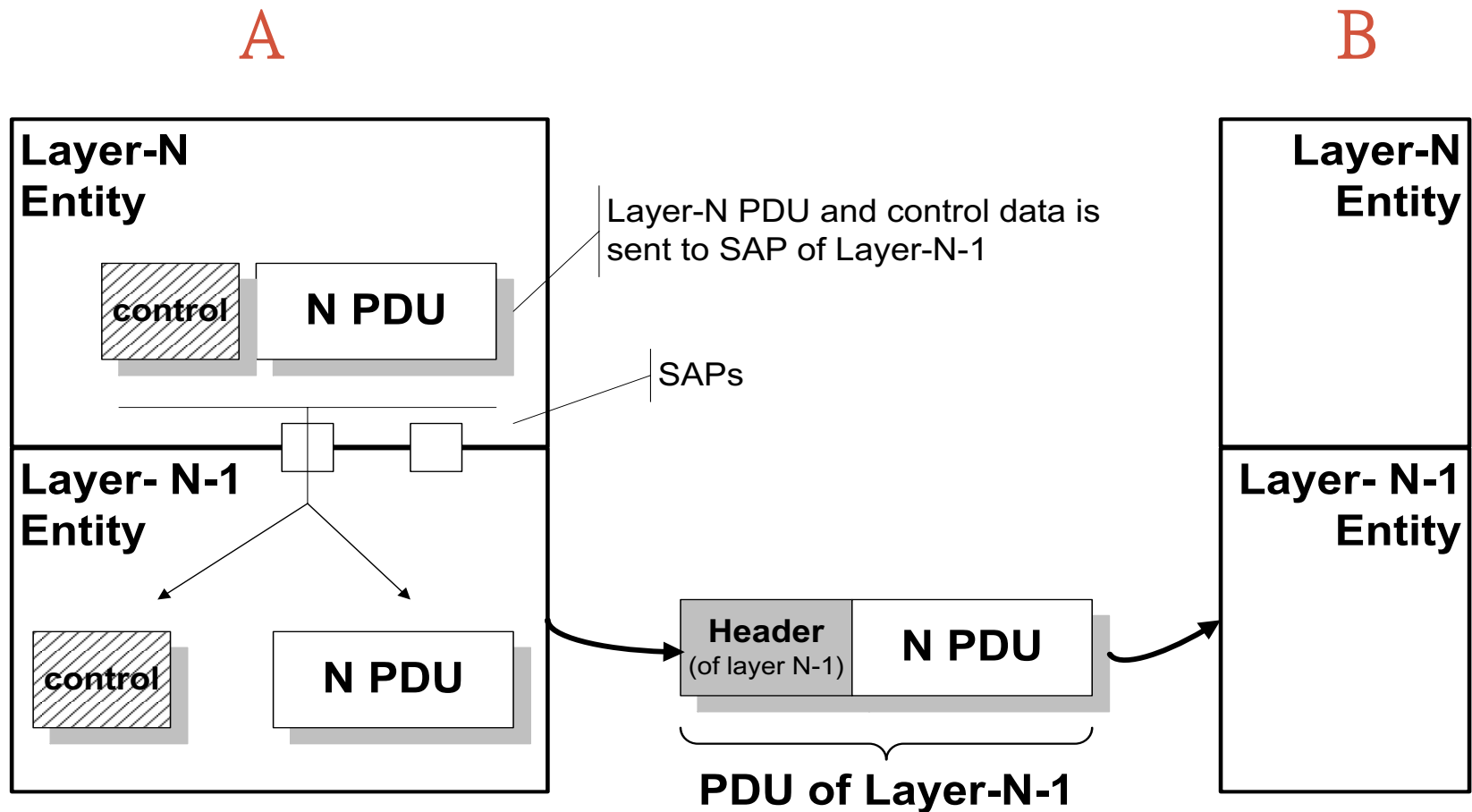
# Exchange of Data

- The unit of data send between peer entities is called a **Protocol Data Unit (PDU)**
- For now, let us think of a PDU as a single packet



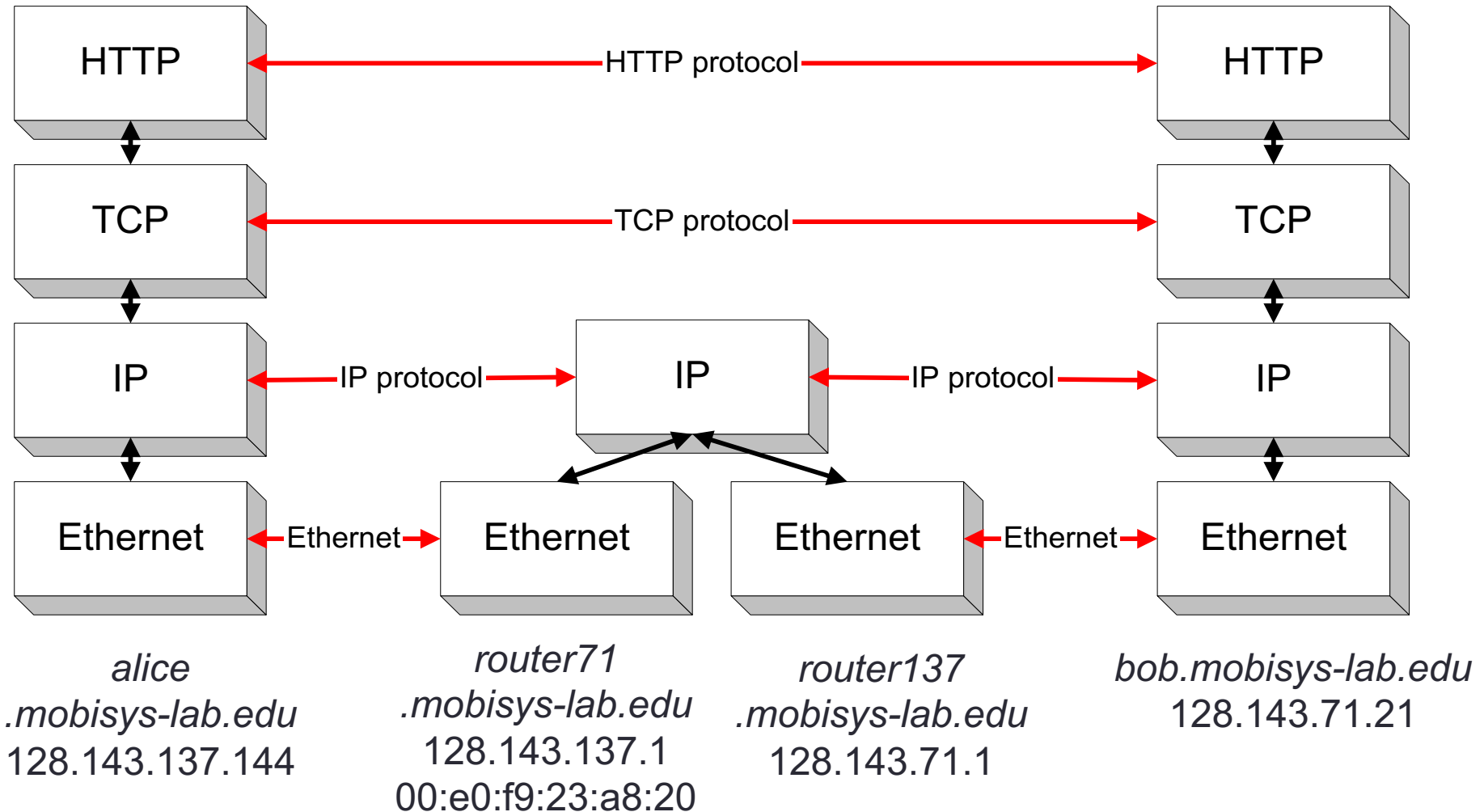
- **Scenario:** Layer-N at A sends a layer-N PDU to layer-N at B
- What actually happens:
  - A' s layer-N passes the PDU to one the SAPs at layer-N-1
  - Layer-N-1 entity at A constructs its own (layer-N-1) PDU which it sends to the layer-N-1 entity at B
  - **PDU at layer-N-1 = layer-N-1 Header + layer –N PDU**

# Exchange of Data

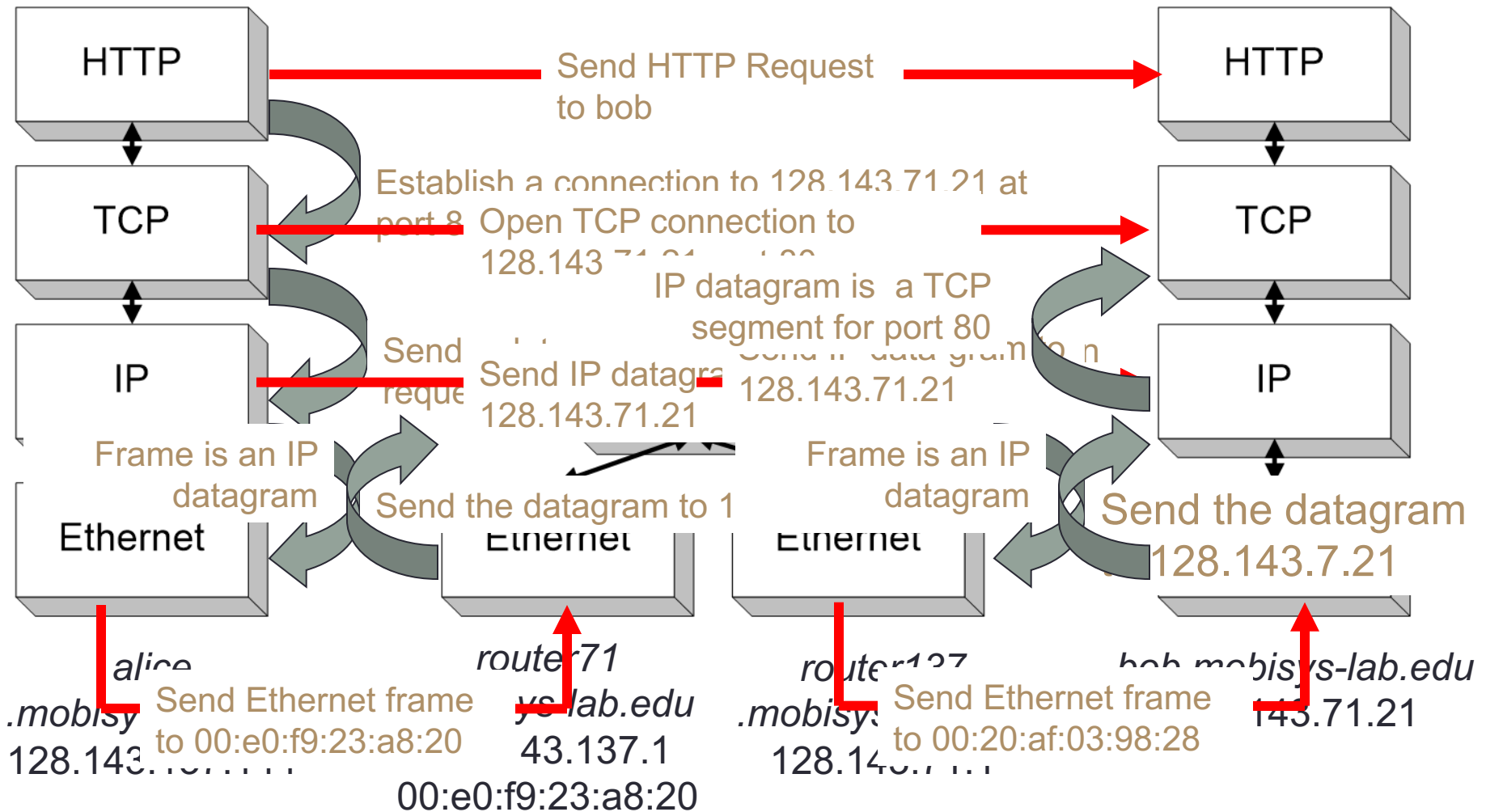




# Layers in the Example

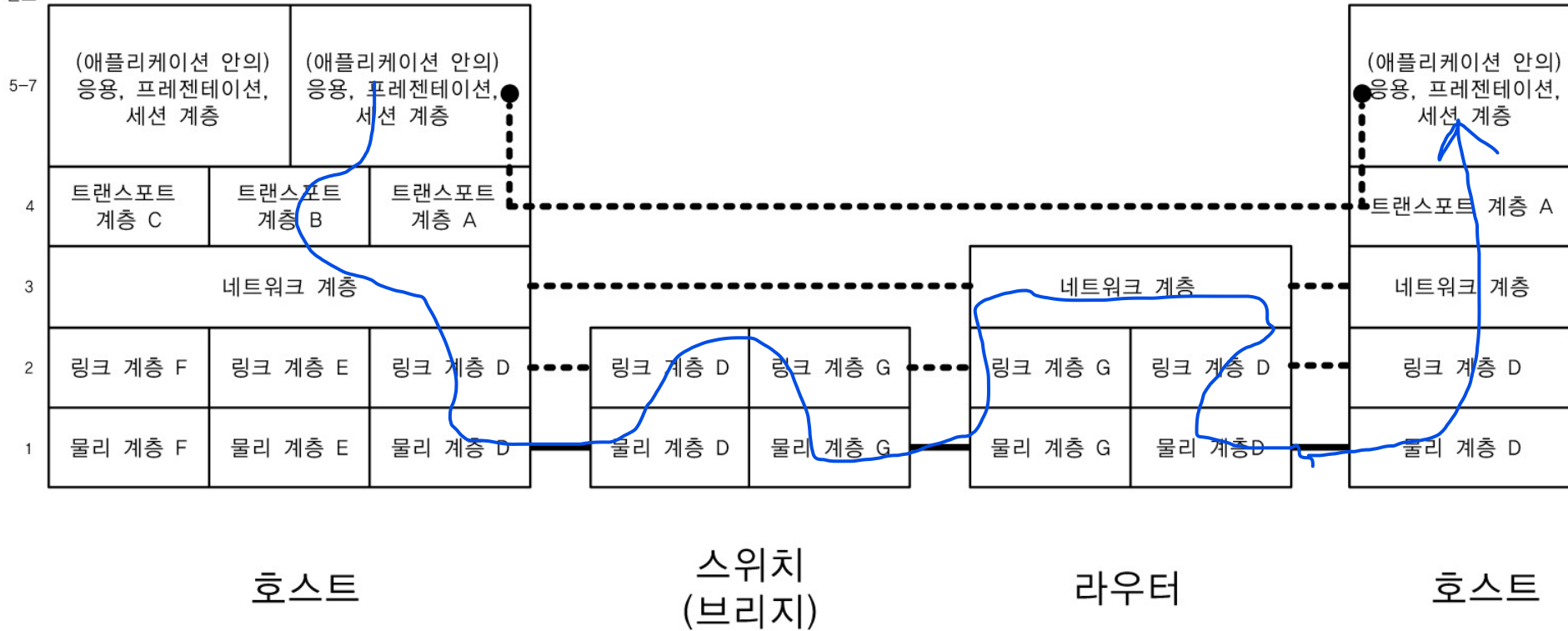


# Layers in the Example



# Layers in the Example

계층  
번호

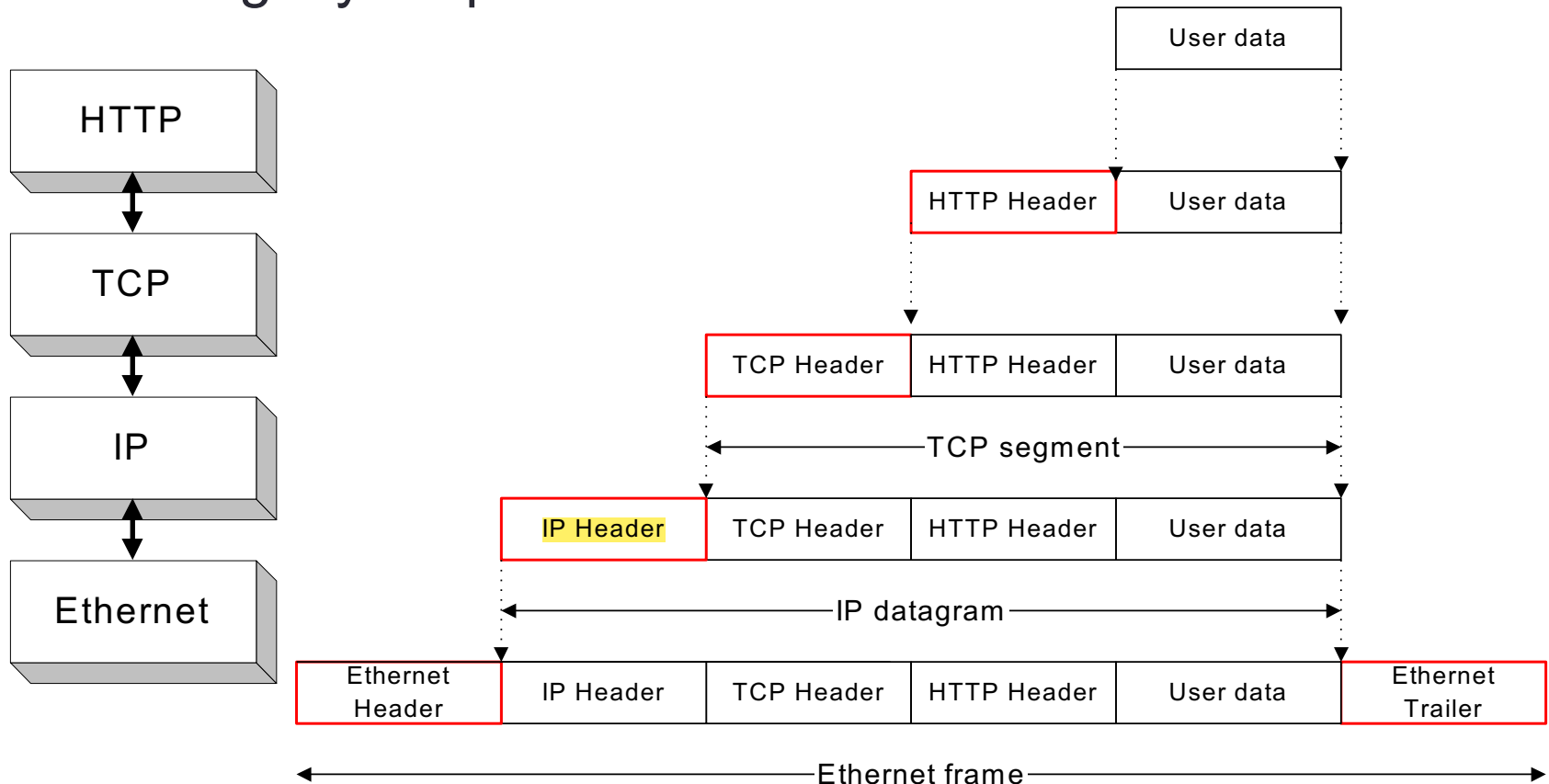


# Layers and Services

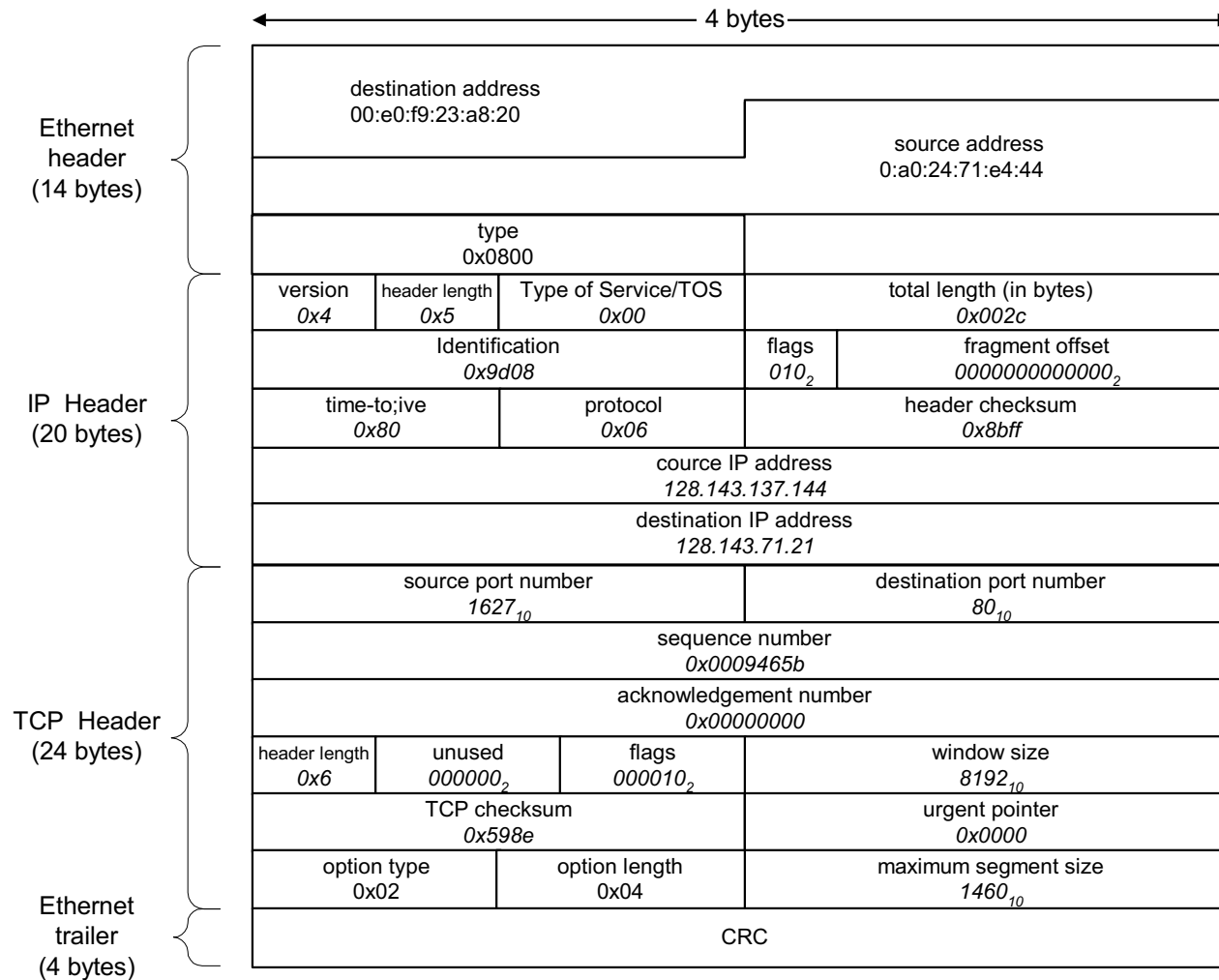
- Service provided by TCP to HTTP:
  - reliable transmission of data over a logical connection
- Service provided by IP to TCP:
  - unreliable transmission of IP datagrams across an IP network
- Service provided by Ethernet to IP:
  - transmission of a frame across an Ethernet segment
- Other services:
  - DNS: translation between domain names and IP addresses
  - ARP: Translation between IP addresses and MAC addresses

# Encapsulation and Demultiplexing

- As data is moving down the protocol stack, each protocol is adding layer-specific control information

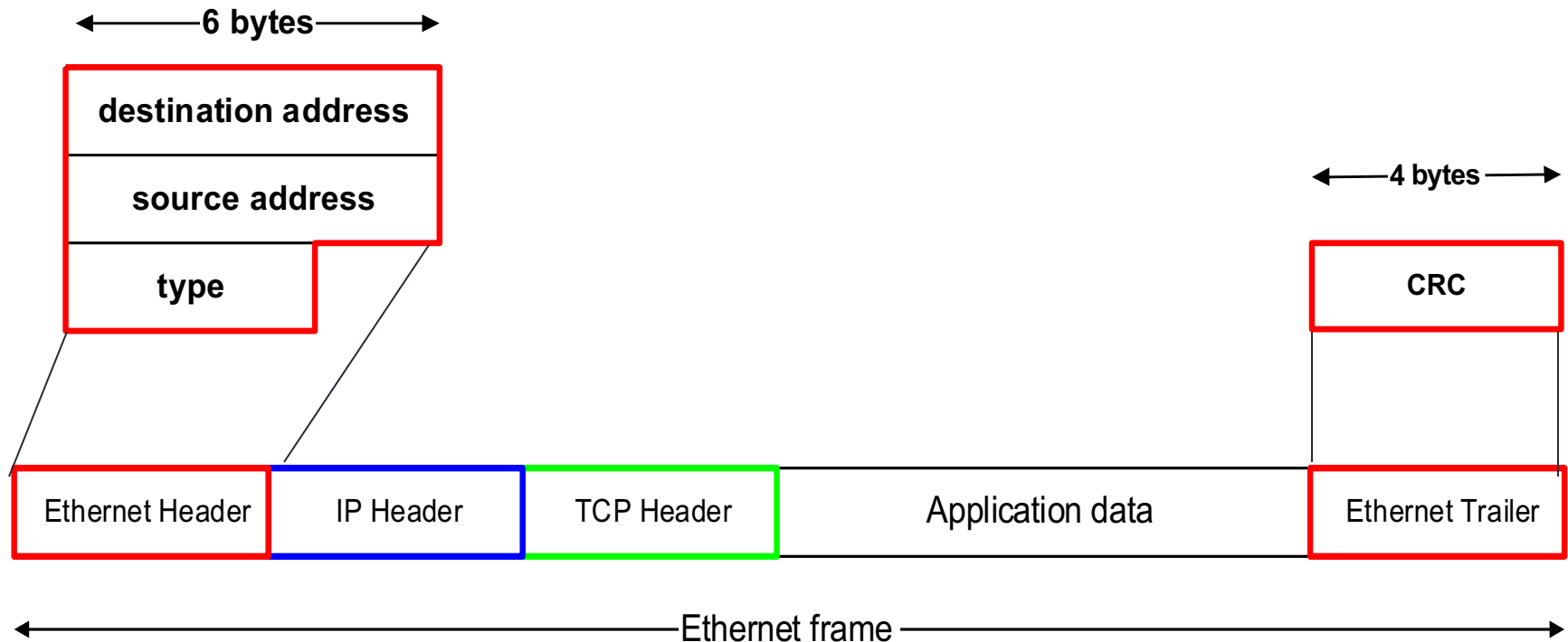


# Parsing the information in the frame

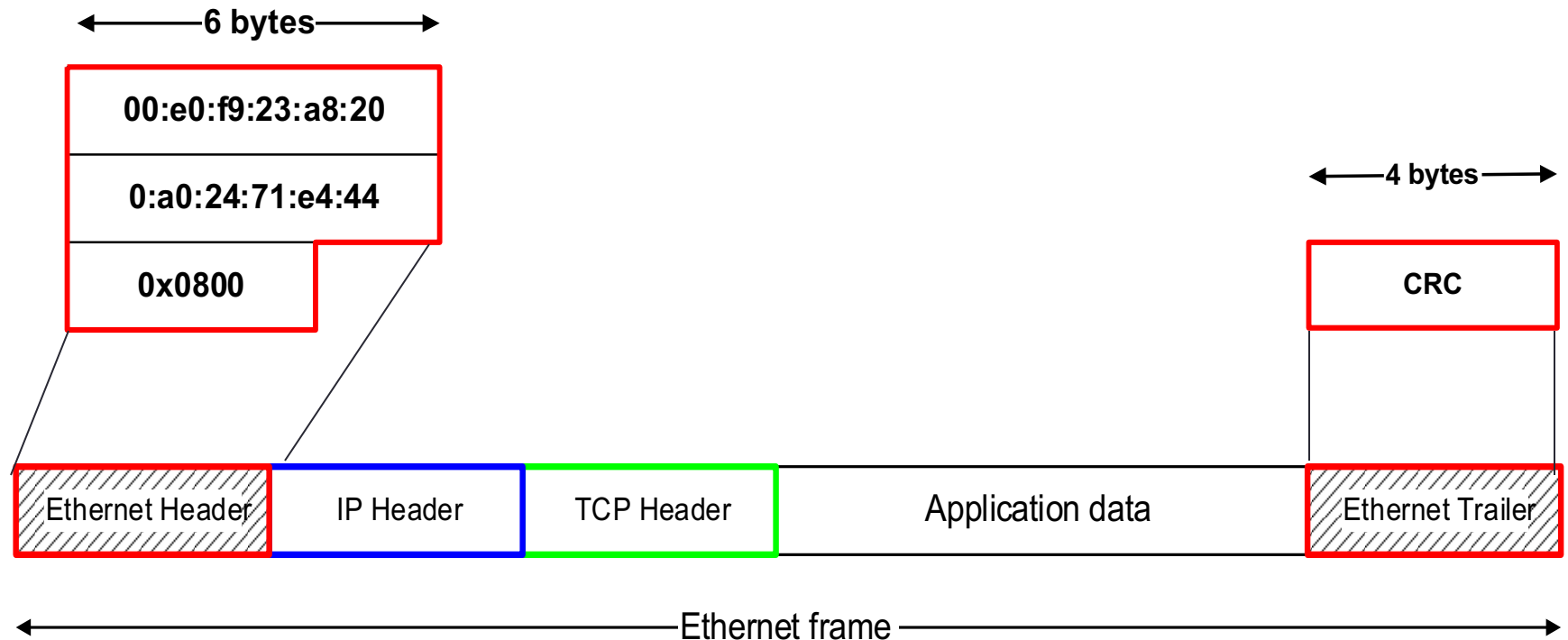




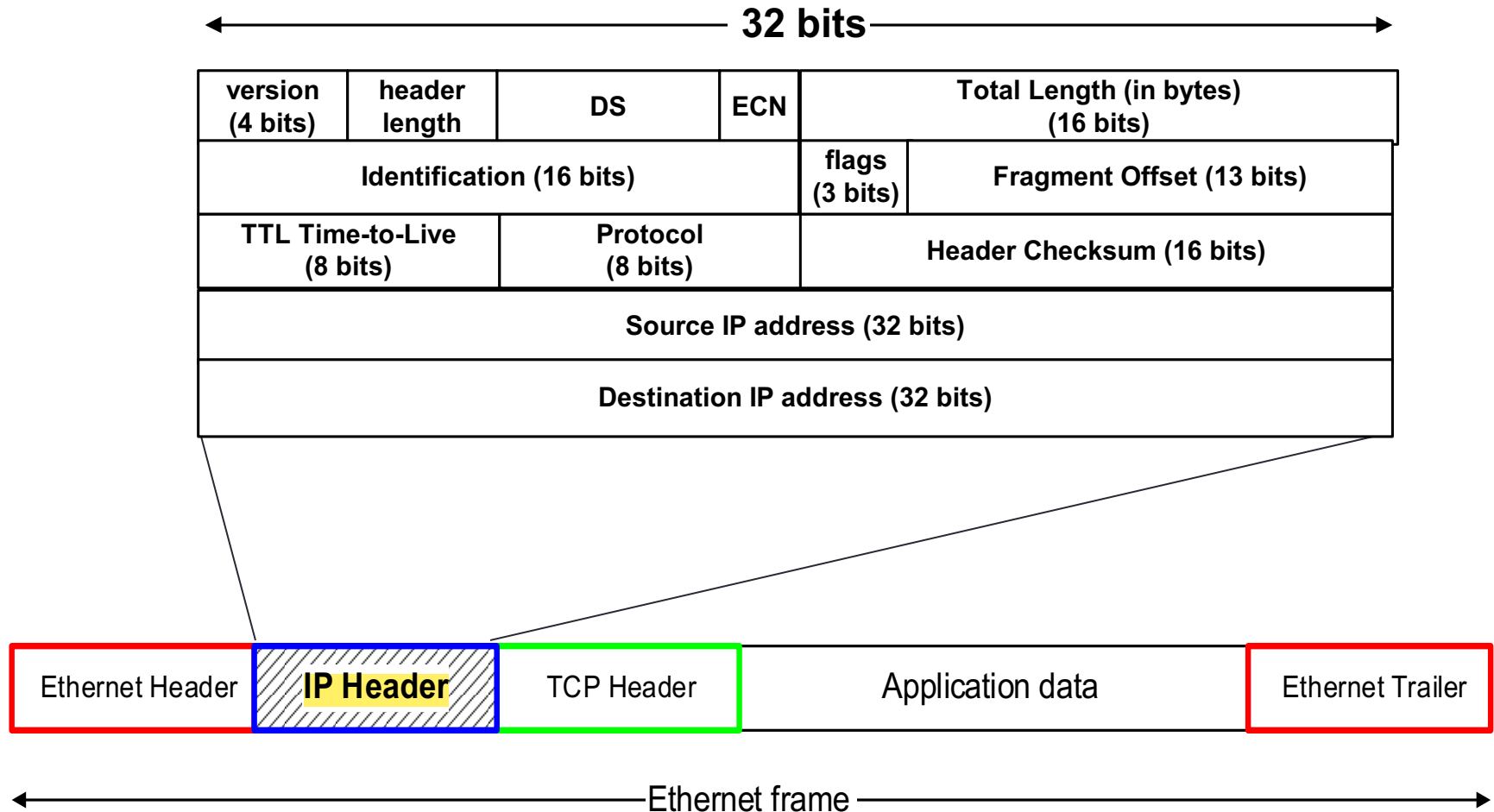
# Encapsulation and Demultiplexing



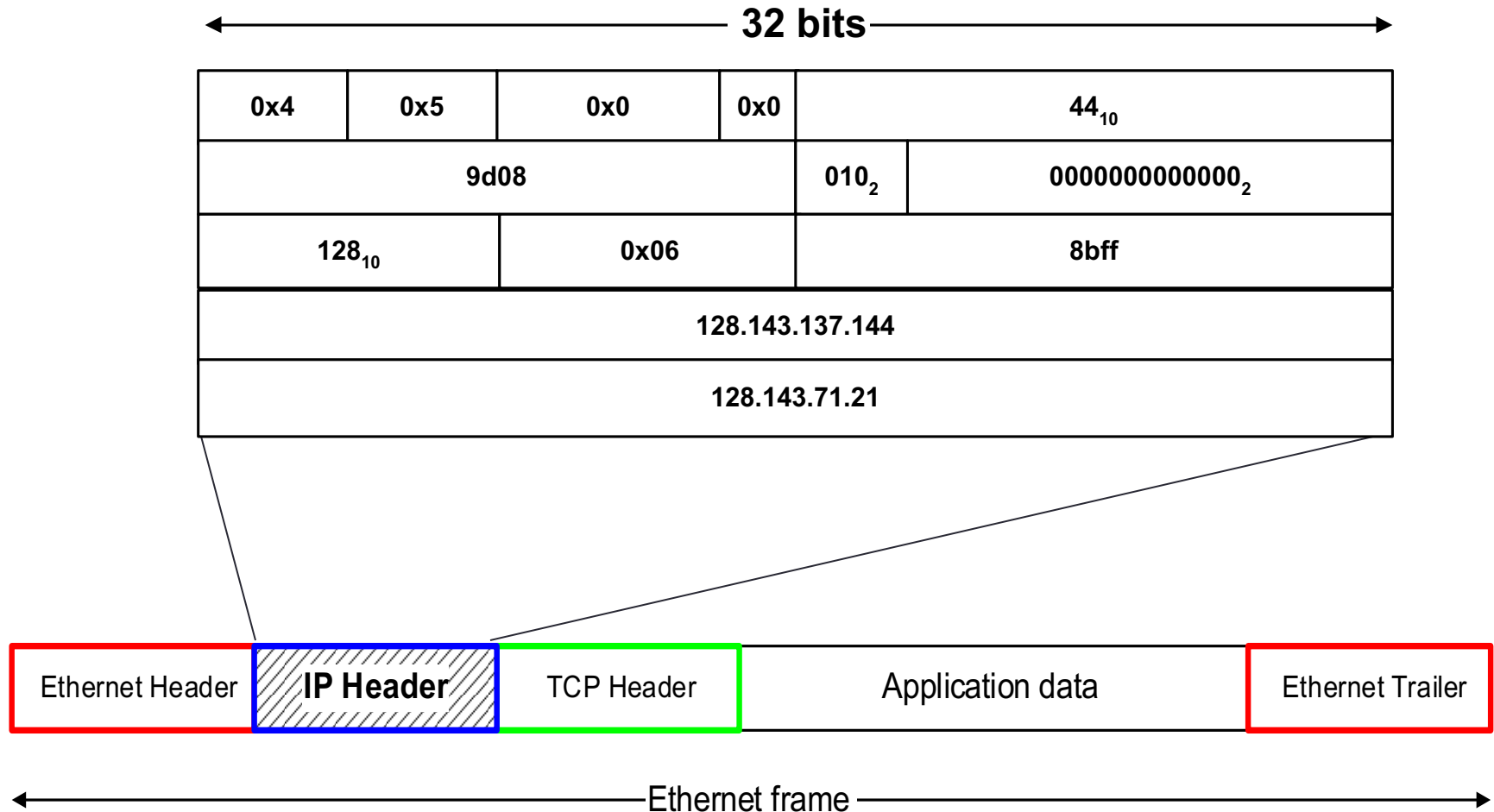
# Encapsulation and Demultiplexing: Ethernet Header



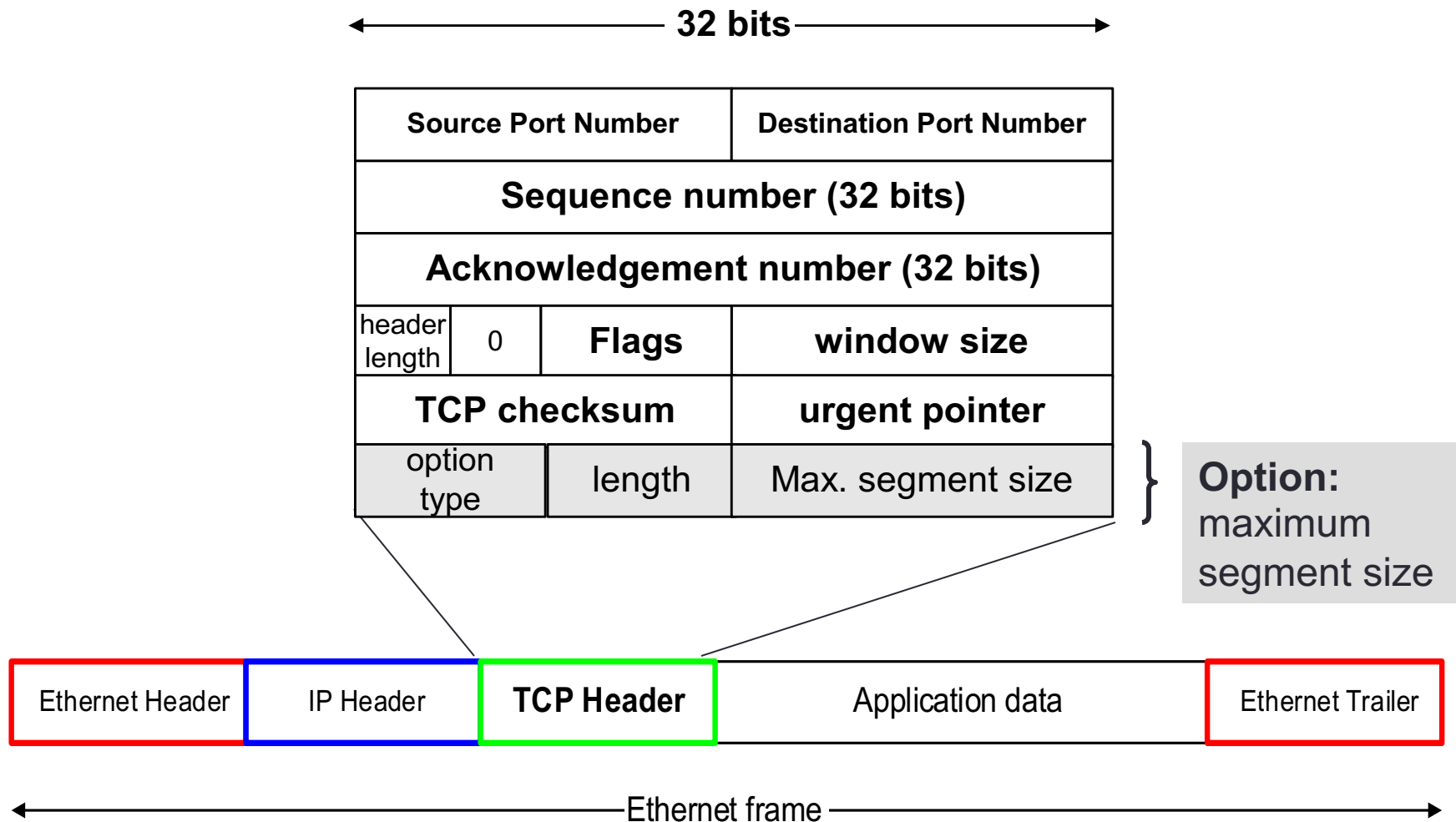
# Encapsulation and Demultiplexing: IP Header



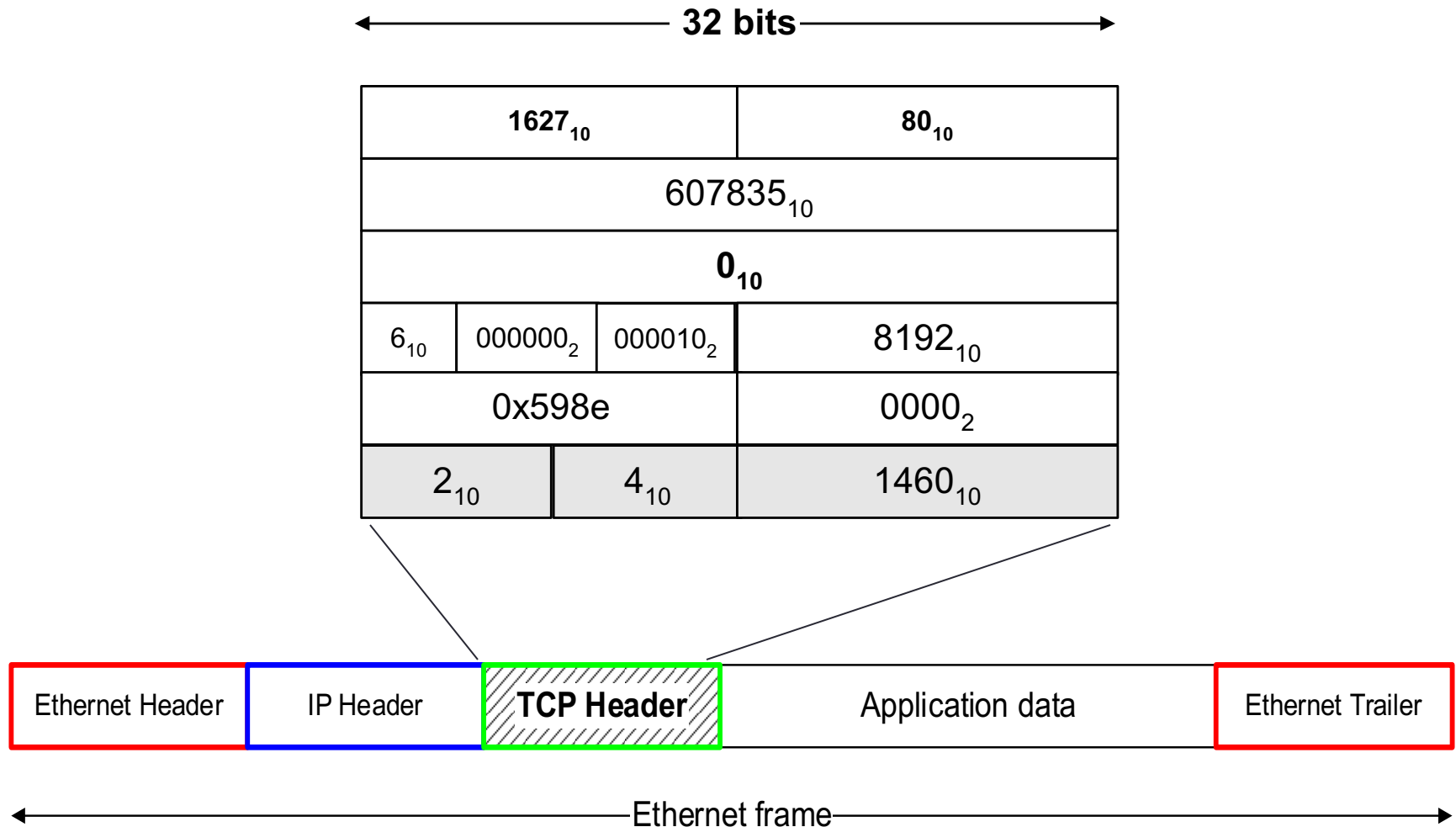
# Encapsulation and Demultiplexing: IP Header



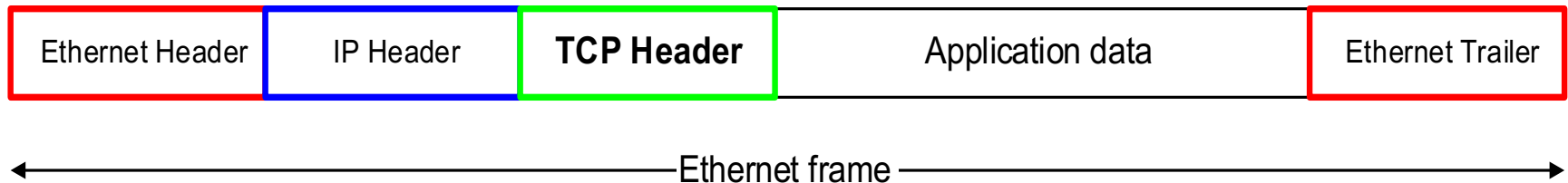
# Encapsulation and Demultiplexing: TCP Header



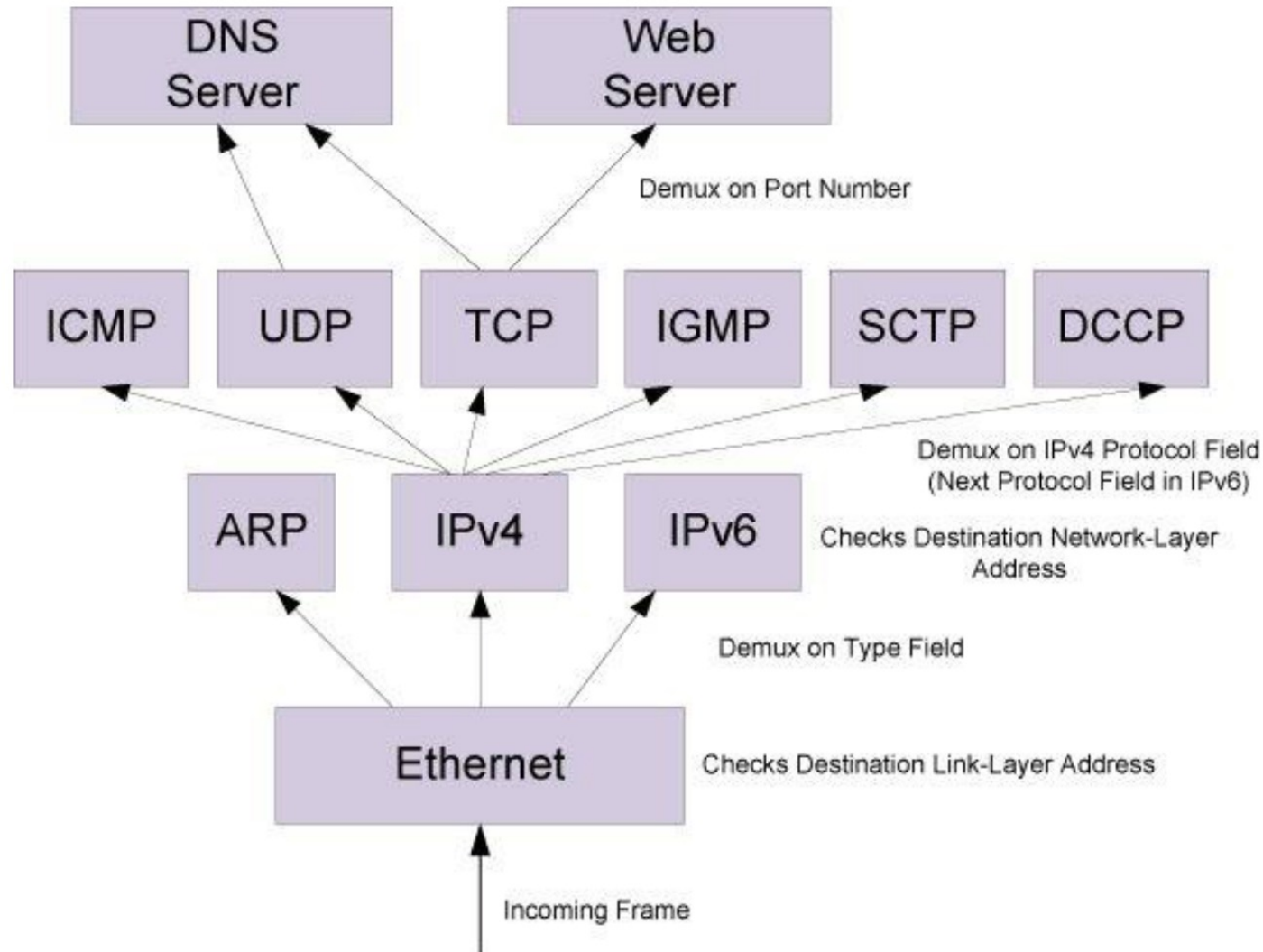
# Encapsulation and Demultiplexing: TCP Header



# Encapsulation and Demultiplexing: Application data



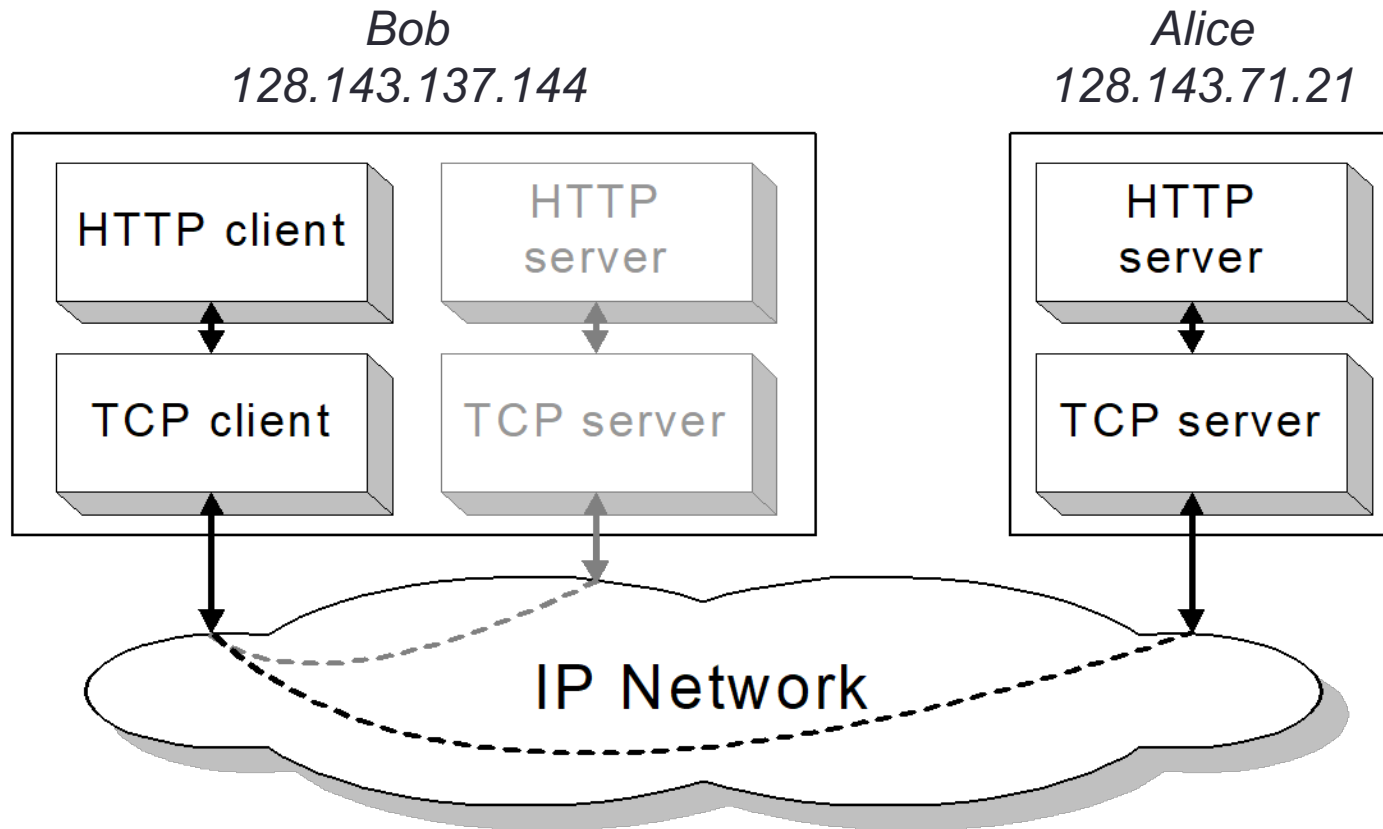
# Demultiplexing



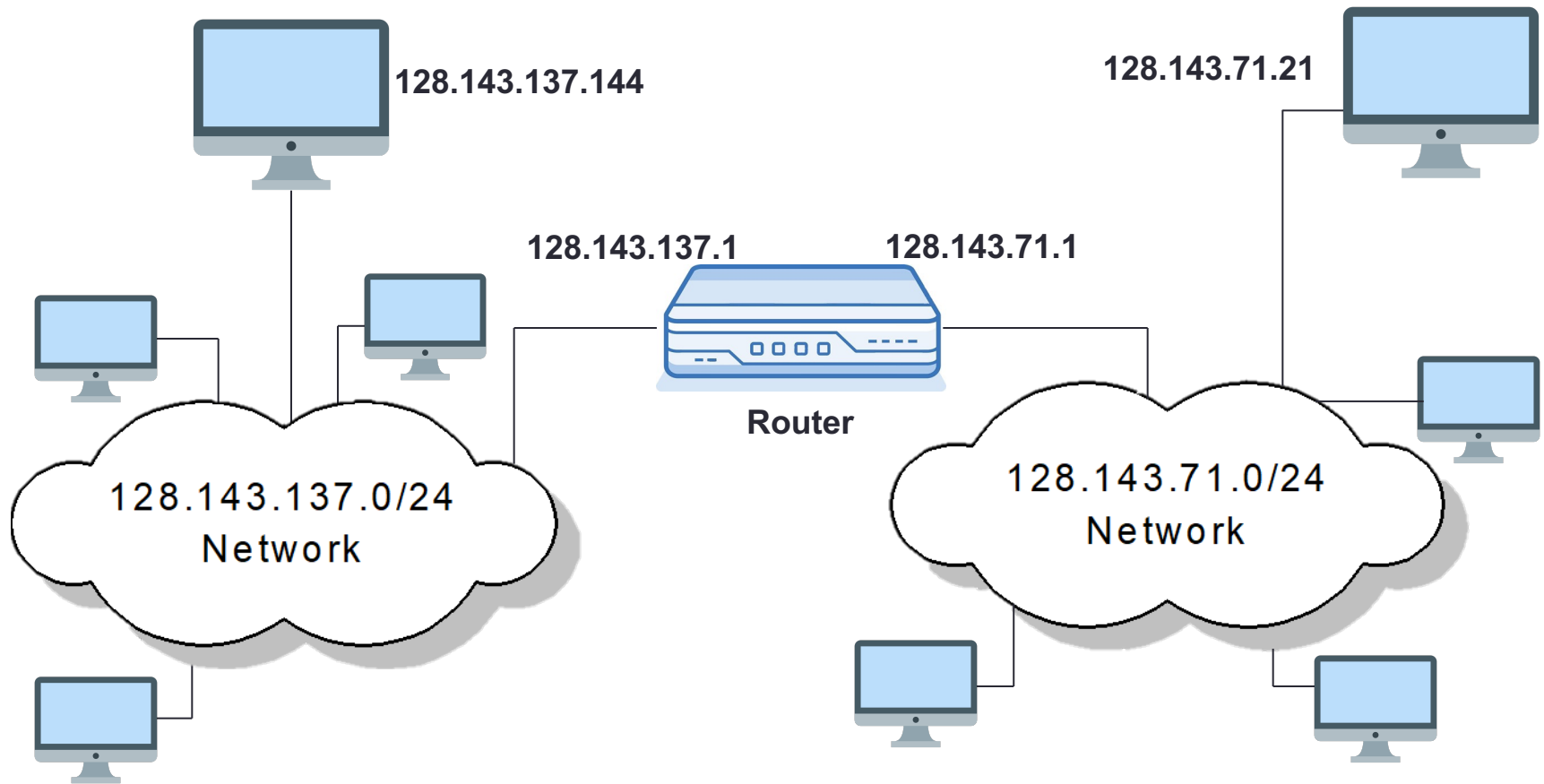


# Different views of networking

- Different Layers of the protocol stack have a different view of the network. This is HTTP's and TCP's view of the network.

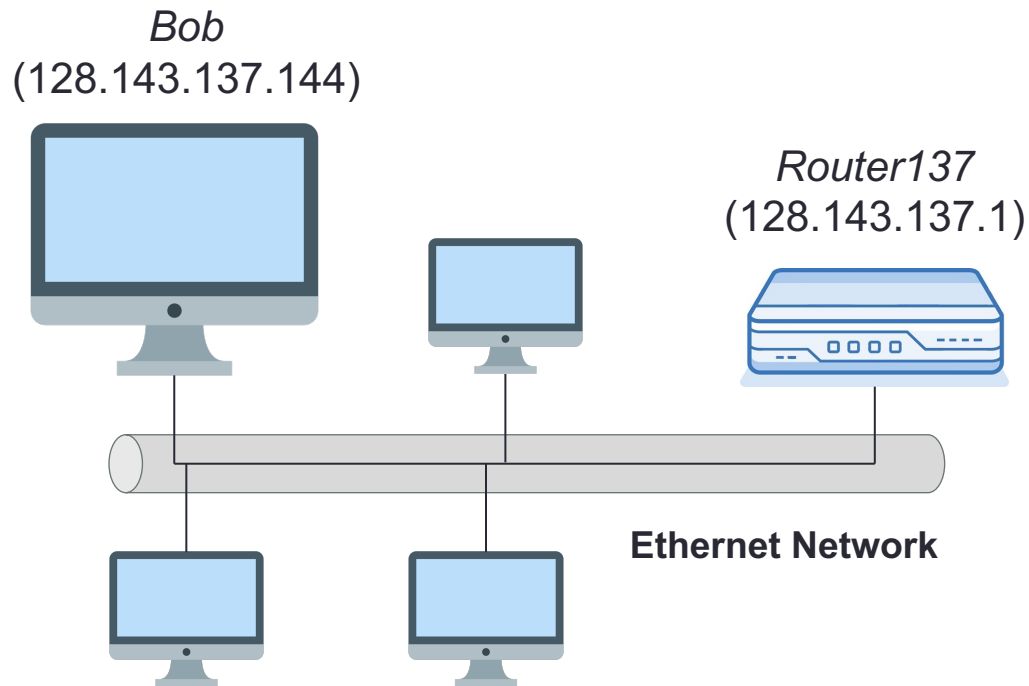


# Network view of IP protocol

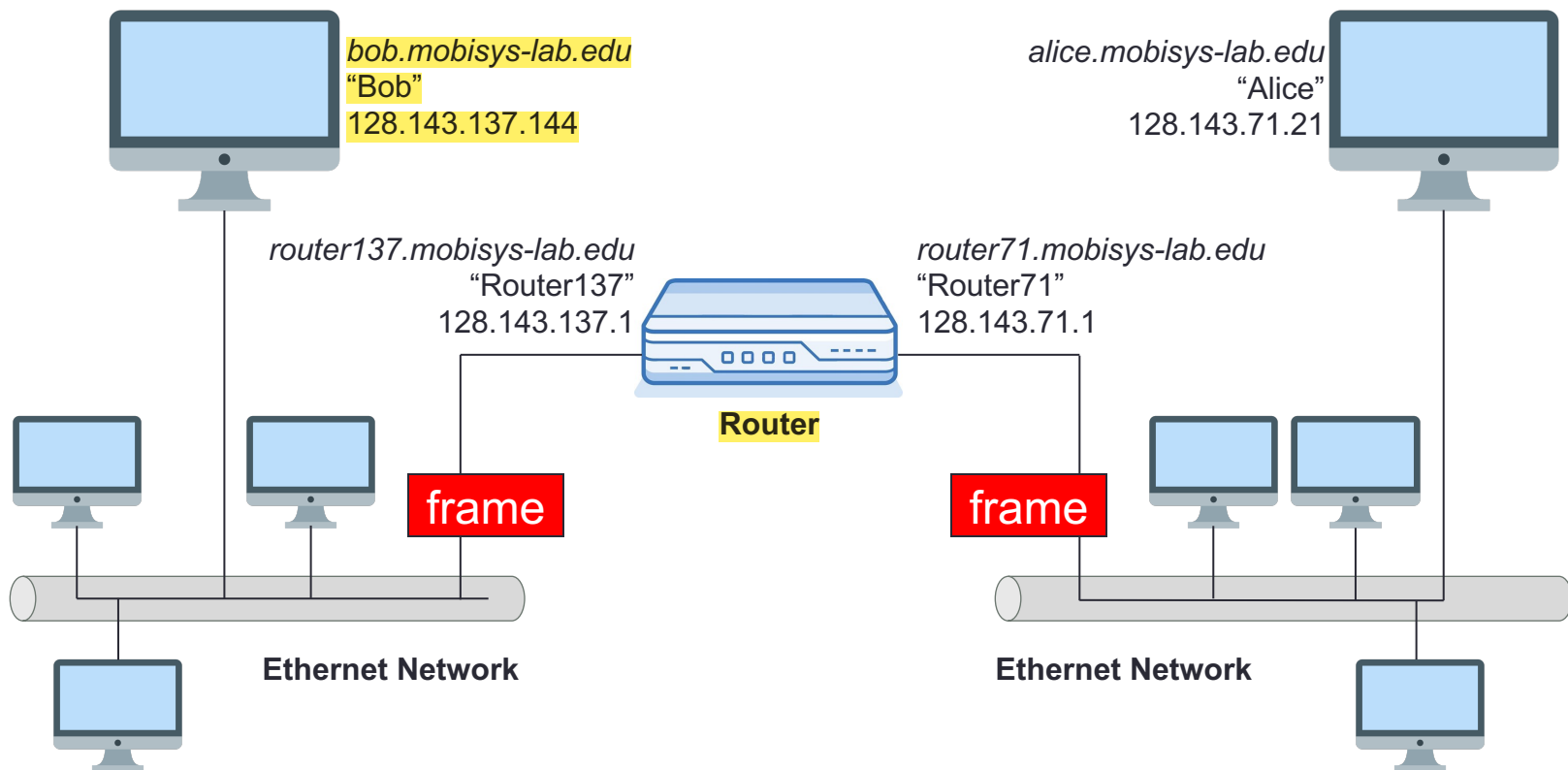


# Network View of Ethernet

- Ethernet's view of the network



# Sending packets from Bob to Alice



# Sending packet

128.143.71.21 is **not** on my local network

The

128.143.71.21 is on my local network.  
Therefore, I can send the packet directly.

DNS: What is the IP address of  
"bob.mobisys-lab.edu"?  
ARP: What is the MAC  
address of 128.143.137.1?

ARP: What is the MAC  
address of 128.143.71.21?

128.143.137.1 is 00:e0:f9:23:8:20

