Business Data Networks and Security 11th edition Panko Solutions Manual

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Mirai used Telnet and SSH to probe potential victims. Many devices allow remote access via Telnet and SSH. A window on the attacker's screen allows the attacker to type keystrokes on the victim device as if was his or her own device.

Significant Changes Since the Last Edition

This chapter is pretty much a total rewrite. The last edition introduced single networks and then showed how the Internet links them together. This is historically correct, but it proved cleaner to jump into the Internet right away and introduce single networks in the context of data links to connect routers.

In Edition 10, Chapter 1 introduced network architectures. To lighten Chapter 1 in this edition, network architectures are moved to Chapter 2. However, the new first chapter uses terms such as "physical processes" and "transport processes" to make it easier to cover layered standards architectures in the next chapter.

The chapter introduces the Point-to-Point Protocol.

The section on residential access routers, Internet core routers, and Wi-Fi access points is new. I have also been careful to depict corporate access routers and residential access routers differently.

Network speeds are moved to Chapter 3 to lighten and focus Chapter 1. Students already know basic bits per second speed notation enough to put off the details to a later chapter.

Cloud computing is moved to Chapter 11. It fits better with the application architectures section of that chapter.

In general, this edition replaces semi-realistic icons for routers, switches, and other devices, with basic Cisco Systems symbols. It has proven surprisingly helpful in reducing distractions because it reduces the visual complexity of figures.

Chapter 2: Network Standards

Role in the Book

- ✓ Chapter 1 looked at the Internet and single networks. I mentioned a number of standards, which are also called protocols.
- ✓ Chapter 2 focuses on the nature of standards. Standards are absolutely essential to networking, and a holistic and deep understanding of standards concepts and principles is required of graduates.
- ✓ This chapter tackles layered standards architectures. It uses terms that were introduced in the first chapter: physical, data link, internet, transport, and application processes. It shows how they form the Hybrid TCP/IP-OSI Standards Architecture that dominates in real corporations today.

Flow

- ✓ The opening caselet looks at the novel creation of early Internet standards and the sometimes zany ways in which the Internet Engineering Task Force still creates standards. Be sure to have students look at the small section on April Fool's Day RFCs. BTW, members of the Network Working Group were only a few years older than undergraduate students.

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- ✓ The body of the chapter begins with a look the role of standards and protocols. In this book, we use the terms interchangeably.
- ✓ Standards architectures introduces the concept of network standards architecture. It focuses on the implications of the fact that two different standards agencies create most networking protocols today and have different standards architectures for creating standards. The chapter then introduces the Hybrid TCP/IP-OSI hybrid standards architecture that corporations overwhelmingly use today. Some networking textbooks focus on the complex OSI architecture as the "true" architecture. That is out of touch with professional practice.
- ✓ Message ordering is about turn-taking in conversations. The section looks at the simple message ordering in HTTP and the complex message ordering in TCP. The section discusses connection orientation and reliability, which are implemented in TCP but not in HTTP.
- ✓ Message Syntax in Standards looks at how messages are structured. It presents the general header-data field-trailer syntax for standards. It then shows syntax for a number of critical standards such as IPv4, TCP, and UDP that students will see throughout the course. Students will see many message syntaxes in the book, so it is important to distinguish between them. The syntaxes of different standards are easy to confuse. It is important to do comparing and contrasting frequently.
- ✓ Application programs must create application messages that consist entirely of 1s and 0s. Yet applications deal with many types of information, including text, binary numbers, and alternatives (chicken, fish, or vegetables) that are not 1s and 0s. This section goes in some depth into encoding for these three types of information. Of course, there are many more types.
- ✓ Protocols in this Chapter compare the main protocols we have seen in this chapter. In a discussion similar to the game, "Which of these is not like the other?" We look at why TCP is so different from other standards.

Opportunities to Enrich the PowerPoint Presentation

OK, this one is pretty much a straight lecture chapter, and it is a tough one. There are a lot of things to present, and there is again the problem of frameworks with multiple pieces that must be learned simultaneously. It's good to spend time looking for analogies and frequent recaps.

The Hard Parts

If a student has not mastered different physical, data link, internet, transport, and application concepts, this chapter is going to be brutal. They will have a hard time learning layered standards architectures. This will hurt them throughout the course. I do a lot of recapping.

Message syntax is a problem because the chapter presents several standards and discusses their different syntaxes. It is so easy for students to get lost. Frequently remind them of the flow when you discuss individual standards.

Encoding, text, integers, and alternatives to binary requires students to master three encoding methods that each take some time to learn. The hardest is encoding alternatives because students tend not to work enough examples to really get it down. These need to be mastered

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because we will use these concepts frequently in the course, especially encoding alternatives. For example, it comes back big time in network subnetting in Chapter 9.

More Information

There is no additional information for this chapter at this time.

Significant Changes Since the Last Edition

The last edition presented standards architectures in the first chapter. This edition moves this to Chapter 2, although preliminary concepts such a data link processes are covered in Chapter 1. This was done to lighten Chapter 1.

Previous editions of the book introduced the IEEE 802.3 standard for Ethernet. This edition focuses on the Ethernet Ⅱ syntax. While the 802.3 frame may be "more official," the Internet Protocol calls for the use of Ethernet Ⅱ frames, and this is indeed industry practice. Ethernet Ⅱ is the frame syntax that students will usually encounter overwhelmingly in the field. A modest benefit is that the Ethernet Ⅱ frame is easier to understand than the 802.3 frame.

Although it may not feel that way, Chapter 2 in this edition is somewhat simplified. For example, the number of message syntaxes it presents has been reduced. The HTTP request and response message syntaxes, for example, are now in Chapter 11, which focuses on applications.

Chapter 3: Network Management

Role in the Book

Chapters 1 and 2 looked at how networks operate. Beyond that, our graduates will have to design and manage networks. That requires additional skills. Chapter 3 focuses heavily on the core concept of traffic analysis in design. It covers centralized network management with SMPT and the potentially revolutionary potential of software-defined networking.

Content Flow

- ✓ Network Quality of Service (QoS) is about goals. Today, networks need to work *well*. QoS metrics define what that means. Network staffs often must define and achieve service-level agreements for the levels of QoS they will provide.
- ✓ Network Design struggles with the issue of what speeds individual transition links will provide between locations. Beyond this, companies will try many different combinations of switch, router, and firewall locations and connection links among them. A basic course cannot cover these well. Most network transmission lines are multiplexed, so multiplexing is described.
- ✓ Momentary traffic peaks will still occur in well-designed networks because traffic volume is stochastic. The book presents alternatives for dealing with this unavoidable issue.
- ✓ Centralized Network Management is necessary to manage networks with hundreds or thousands of switches and routers. Traveling to them individually to install, configure, and troubleshoot them would be horrendously expensive and slow. Network managers work from central locations. They use tools like Ping, Traceroute, and especially SNMP to give them

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2

NETWORK STANDARDS

Last Name: _____

First Name: _____

Due Date: _____

INSTRUCTIONS

Homework files are in Word for Windows format.
You download them from the book's website.
In a chapter, your teacher may assign you questions to complete.
To begin typing your answer, click after the right angle brackets.

HOW INTERNET STANDARDS COME TO BE

1. a) What are IETF standards called? (Spell out the name and give the acronym.)

   >>>

   b) What factors in the Internet's informal development process lead to rapid standards development and low-cost products?

   >>>

INTRODUCTION

2. a) Distinguish between standards and protocols.

   >>>

   b) What is a network standard?

   >>>

   c) What is interoperability?

   >>>

   d) What are the benefits of standards?

   >>>

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CREATING STANDARDS

3. a) What standards agency creates Internet standards?

   >>>

   b) What other two standards agencies work together to create network standards?

   >>>

   c) Which standards agency(ies) is(are) especially important for internet processes?

   >>>

   d) For physical transmission processes?

   >>>

   e) For data link processes?

   >>>

   f) For transport processes?

   >>>

   g) For Internet supervisory processes?

   >>>

4. a) Why do standards architectures have multiple layers?

   >>>

   b) To what does a standards layer provide services?

   >>>

   c) If you change a standard at one layer, do standards at other layers need to be changed?

   >>>

   d) Why may it be advantageous to change a standard if the standard at the layer below it is upgraded?

   >>>

5. a) What are the standards agencies for OSI? Just give the abbreviations.

   >>>

   b) Distinguish between ISO and OSI.

   >>>

   c) What is the standards agency for TCP/IP? (Give both the name and the abbreviation.)

   >>>

   d) What standards architecture do most organizations actually use in practice?

   >>>

   e) At which layers of this architecture are IETF standards dominant?

   >>>

   f) At which layers are ISO and ITU-T standards dominant?

   >>>

   g) Why does it usually not matter what standards agency creates an application layer standard?

   >>>

6. a) What layer or layers govern(s) transmission media?

   >>>

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b) Application programs?

>>>

c) Transmission through a single network?

>>>

d) Transmission through the Internet?

>>>

e) Application message fragmentation?

>>>

7. a) At what layer will you find standards for routers?

>>>

b) Wireless access points?

>>>

c) Packets?

>>>

d) Switches?

>>>

e) Frames?

>>>

f) IP addresses?

>>>

g) Routes?

>>>

h) EUI-48 addresses?

>>>

i) Data links?

>>>

8. a) If two hosts are connected by five networks, how many packets will there be when one host sends a packet to the other host? (Hint: draw a picture.)

>>>

b) How many frames?

>>>

c) How many routers?

>>>

d) If every host and router connects with a point-to-point connection, how many physical links will there be?

>>>

MESSAGE ORDERING (PLUS RELIABILITY AND CONNECTION ORIENTATION) IN STANDARDS

9. a) In HTTP, which application program initiates an interaction?

>>>

b) Is HTTP a connectionless protocol?

>>>

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c) Is HTTP a reliable protocol?

>>>

10. a) What do we call TCP messages?

>>>

b) Describe the three-step opening in TCP.

>>>

c) Is every TCP segment acknowledged?

>>>

d) What is noteworthy about control segments?

>>>

11. a) Is TCP connection-oriented or connectionless?

>>>

b) What benefits do sequence numbers bring?

>>>

c) How many segments are transmitted to open a connection?

>>>

12. a) What kind of message does the destination host send if it receives an error-free segment?

>>>

b) What kind of message does the destination host send if it does not receive a segment during a TCP connection?

>>>

c) What kind of message does the destination host send if it receives a segment that has an error during a TCP connection?

>>>

d) Under what conditions will a source host TCP process retransmit a segment?

>>>

13. a) What are the four steps in the four-way close?

>>>

b) When the side that initiates the close sends its FIN segment, does it stop transmitting more TCP segments? Explain.

>>>

MESSAGE SYNTAX IN STANDARDS

14. a) What are the three general parts of messages?

>>>

b) What higher-layer content does the data field contain?

>>>

c) What is the definition of a header?

>>>

d) Is there always a data field in a message?

>>>

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e) What is the definition of a trailer?

>>>

f) Are trailers common?

>>>

g) Distinguish between headers and header fields.

>>>

15. a) List the first bit number on each IPv4 header row in 2-12, not including options. (Remember that the first bit in Row 1 is Bit 0.)

>>>

b) What is the bit number of the first bit in the Destination IP Address Field in IPv4?

>>>

c) Describe how the internet process checks an arriving packet for errors.

>>>

d) What does the receiving internet process do if it finds an error?

>>>

e) What does it do if it does not find an error?

>>>

f) Is IP reliable or unreliable? Explain.

>>>

g) Is IP a connectionless or connection-oriented protocol?

>>>

16. a) What are 1-bit fields called?

>>>

b) If someone says that a flag field is set, what does this mean?

>>>

c) If the ACK bit is set, what other field must have a value?

>>>

d) Why are sequence numbers good?

>>>

e) What is the purpose of the Acknowledgment Number Field?

>>>

f) Do SYN segments have data fields?

>>>

g) Can a single TCP segment both send information and provide an acknowledgment?

>>>

17. a) What are the four fields in a UDP header?

>>>

b) Describe the third.

>>>

c) Describe the fourth.

>>>

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d) UDP does error detection and discarding but does not do the retransmission of damaged or lost datagrams. Is UDP reliable? Explain.

>>>

18. a) What type of port numbers do servers use for common server programs?

>>>

b) What type of port numbers do clients use when they communicate with server programs?

>>>

c) What is the range of port numbers for each type of port?

>>>

d) How are ephemeral port numbers generated?

>>>

e) Why are they called ephemeral?

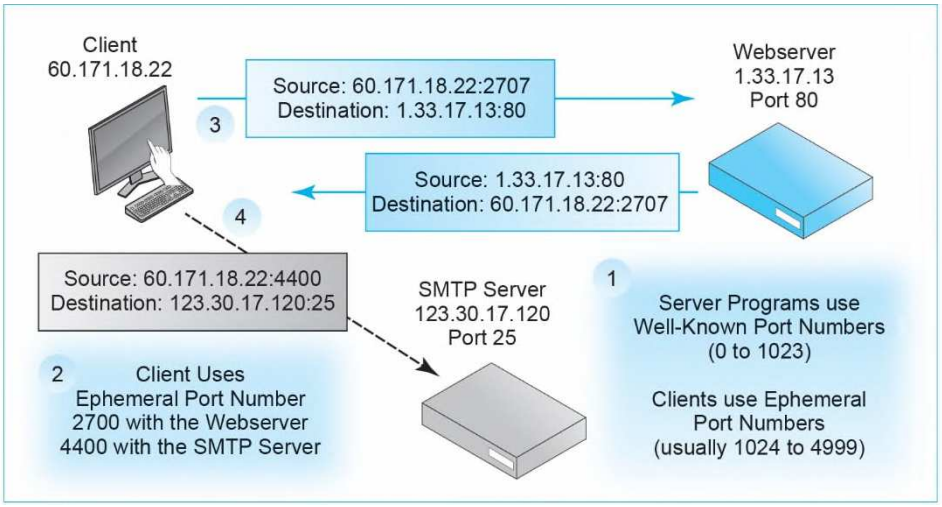
>>>

19. a) What is the syntax of a socket?

>>>

b) In Figure 2-16, when the client transmits to the mail server, what is the source socket?

>>>



c) What is the destination socket?

>>>

d) When the SMTP server transmits to the client host, what is the source socket?

>>>

e) What is the destination socket?

>>>

20. a) How is the syntax of Ethernet II frames depicted?

>>>

b) In what field is the IP packet carried in Ethernet II frames?

>>>

c) Why does this version of the book deal with Ethernet II frames?

>>>

d) How does the receiving data link layer process know what is in the data field of an Ethernet II frame?

>>>

e) Why is Ethernet unreliable despite having a Frame Check Sequence Field that is used to check for errors?

>>>

ENCODING APPLICATION MESSAGES INTO BINARY

21. a) What is encoding?

>>>

b) At what layer is the encoding of application messages done?

>>>

22. a) What is alphanumeric information?

>>>

b) Explain how many bytes it will take to transmit “Go team” without the quotation marks. (Answer: 7)

>>>

c) Explain how many bytes it will take to transmit “Hello World!” without the quotation marks.

>>>

d) Go to a search engine and find a converter to represent characters in ASCII. What are the 7-bit ASCII codes for “Hello world!” without the quotation marks? (Check: H is 1001000.) Show this in a table with two columns. The first will show letters or other keyboard characters. The second will show the ASCII code for that character.

Letter	ASCII
H	1001000

23. Answer the following questions without using a calculator or a computer.

a) What is an integer?

>>>

b) Is 4,307 an integer?

>>>

c) Is 45.7 an integer?

>>>

d) To encode a decimal number into binary, is the first bit position on the right in Figure 2-20 a 0 or 1?

>>>

e) Convert the decimal number 6 to binary without using a computer. (Answer 110.)

>>>

f) Convert decimal 0 to binary.

>>>

g) Convert decimal 15 to binary.

>>>

h) Convert 62 to binary.

>>>

i) This time using Excel or a decimal to binary converter, convert 128 to binary. (Answer: 10000000).

>>>

j) Also using Excel or a decimal to binary converter, convert 255 to binary.

>>>

k) Convert the binary number 100 to decimal. (Answer: 4.)

>>>

l) Convert the binary number 1111 to decimal.

>>>

m) Convert the binary number 10110 to decimal.

>>>

n) Convert the binary number 100100 to decimal.

>>>

24. a) How many alternatives can you represent with a 4-bit field? (Answer: 16.)

>>>

b) For each bit you add to an alternatives field, how many additional alternatives can you represent?

>>>

c) How many alternatives can you represent with a 10-bit field? (With 8 bits, you can represent 256 alternatives.)

>>>

d) If you need to represent 129 alternatives in a field, how many bits long must the field be? (Answer: 8.)

>>>

e) If you need to represent 18 alternatives in a field, how many bits long must the field be?

>>>

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f) Come up with three examples of things that should be encoded with 3 bits.

>>>

25. a) In TCP, port number fields are 16 bits long. How many possible port numbers are there?

>>>

b) IPv6 addresses are 128 bits long. How many IPv6 addresses are there? Just represent the formula for calculating the value.

>>>

c) The IP version number field is 4 bits long. How many possible versions of IP can there be?

>>>

d) UDP length fields are 16 bits long. This field gives the number of bytes in the data field. How many bytes long may a UDP data field be?

>>>

e) ASCII has a 7-bit code. How many keyboard characters can it represent?

>>>

PROTOCOLS IN THIS CHAPTER

26. a) What protocols that we saw in this chapter are reliable?

>>>

b) Why aren't all protocols reliable?

>>>

END-OF-CHAPTER QUESTIONS

2-1. How do you think TCP would handle the problem if an acknowledgment were lost, so that the sender retransmitted the unacknowledged TCP segment, therefore causing the receiving transport process to receive the same segment twice?

>>>

2-2 a) Compute the minimum number of TCP segments required to open a connection, send an HTTP request and response message, and close the connection. Justify this number by creating a table showing each message and its sequence number. (Hint: Do the table in Excel and paste it into your homework document.)

Step	Sender	Segment
1	BROWSER	SYN
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

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12	
13	
14	
15	

b) Repeat the question, this time if the HTTP response message is damaged during transmission.

Step	Sender	Segment
1	BROWSER	SYN
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

2-3 Compute the minimum number of TCP segments required to open a connection, send an HTTP request and response message, and close the connection if the HTTP response message must be fragmented across ten packets. Justify this number by creating a table showing each message and its sequence number. (Hint: Do the table in Excel and paste it into your homework document.)

Step	Sender	Segment
1	B	SYN
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		

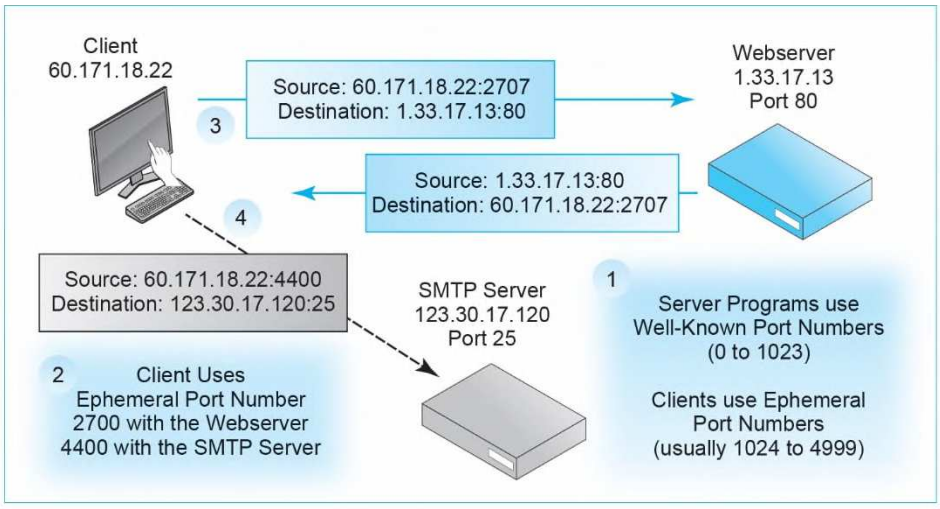
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16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
25

>>>

2-4. a) In Figure 2-16, what will be the value in the destination port number field if a packet arrives for the e-mail application? (Yes, this is a repeat question from earlier.)

>>>



b) When the HTTP program on a webserver sends an HTTP response message to a client PC, in what field of what message will it place the value 80?

>>>

2-5. Do the following without using a calculator or computer, but check your answers with a calculator or a computer. a) Convert 6 to binary.

>>>

b) Convert 47 to binary.

>>>

c) Convert 100 to binary.

>>>

d) Convert 110100 to decimal.

>>>

e). Convert 001100 to decimal.

>>>

2-6. Do the following without using a calculator or a computer, but check your answers with a calculator or a computer. You need to represent 1,026 different city names. How many bits will this take if you give each city a different binary number? Explain your answer.

>>>

2-7. a) The port number fields in TCP and UDP are 16 bits long. How many port numbers can they represent?

>>>

b) In IP, the Time to Live Field is 8 bits in size. How many values can it represent?

>>>

c) How many values can a flag field represent?

>>>

2-8. Consult the Wikipedia Webpage April Fools' Day Request for Comments (https://en.wikipedia.org/wiki/April_Fools%27_Day_Request_for_Comments). Select one of the RFCs listed on the page and write a paragraph on its claimed purpose. (Don't just pick the first few.)

>>>

2-9. What was the most surprising thing you learned in this chapter?

>>>

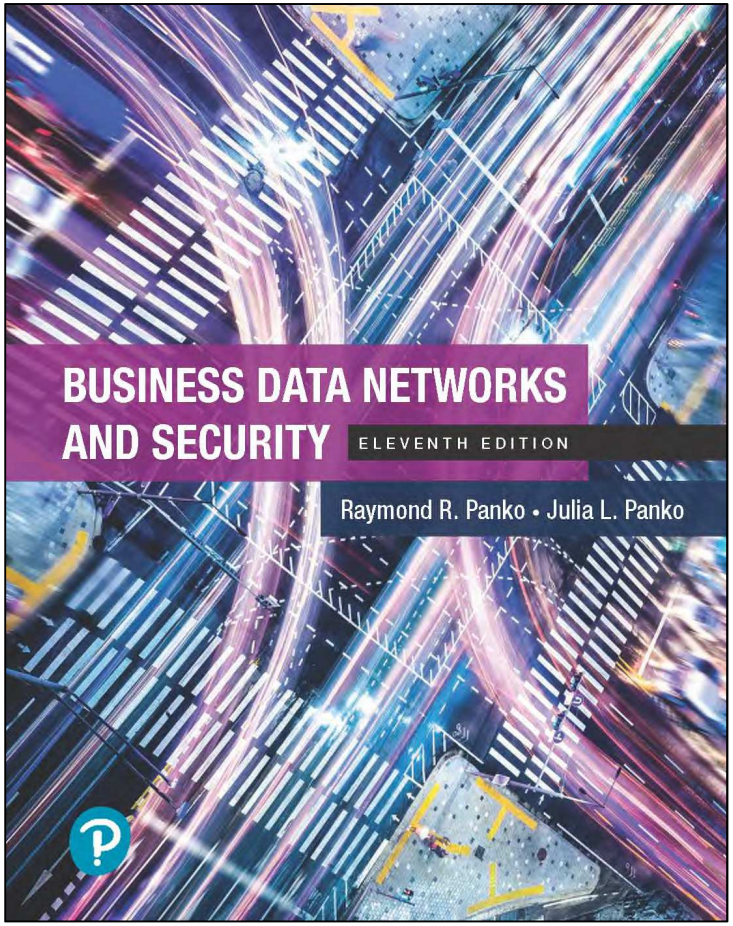
2-10. What was the most difficult material for you in this chapter?

>>>

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Business Data Networks and Security

Eleventh Edition



Chapter 2

Network Standards

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Learning Objectives (1 of 2)

- Explain how Internet standards are made and why this approach is valuable.
- Provide the definitions of network standards and protocols; articulate their importance.
- Explain the OSI, TCP/IP, and Hybrid TCP/IP-OSI architectures and their standards agencies.
- Explain the purpose of each standards layer in the Hybrid TCP/IP-OSI architecture, what is standardized at each layer, and which standards agency dominates standards at each layer.

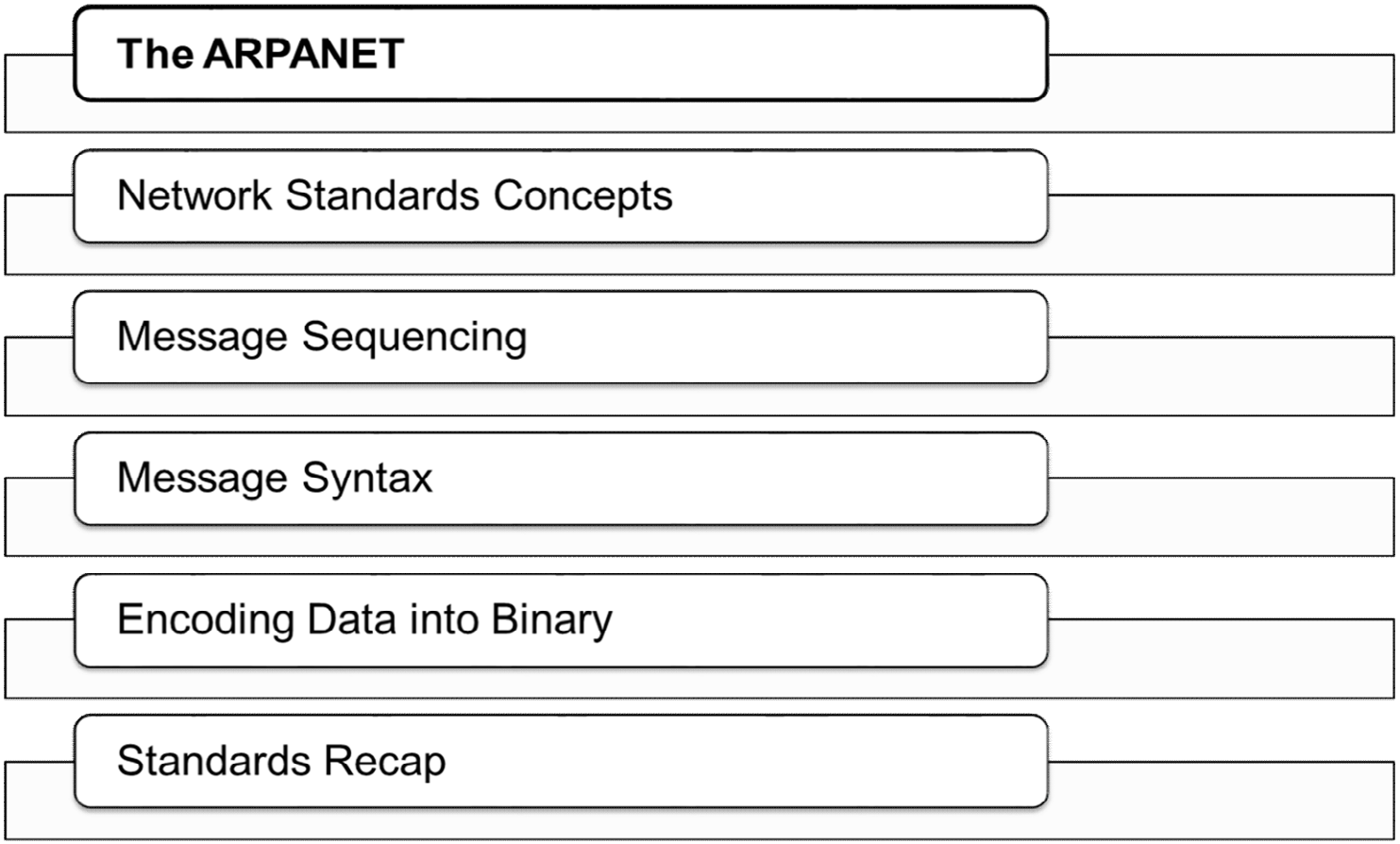
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Learning Objectives (2 of 2)

- Explain message ordering in general and in HTTP and TCP.
- Explain message syntax in general and in IP packets, TCP segments, UDP datagrams, and Ethernet frames.
- Demonstrate how application programs encode alphanumeric, decimal, and alternative data into bits (1s and 0s) before passing their messages to the transport layer.

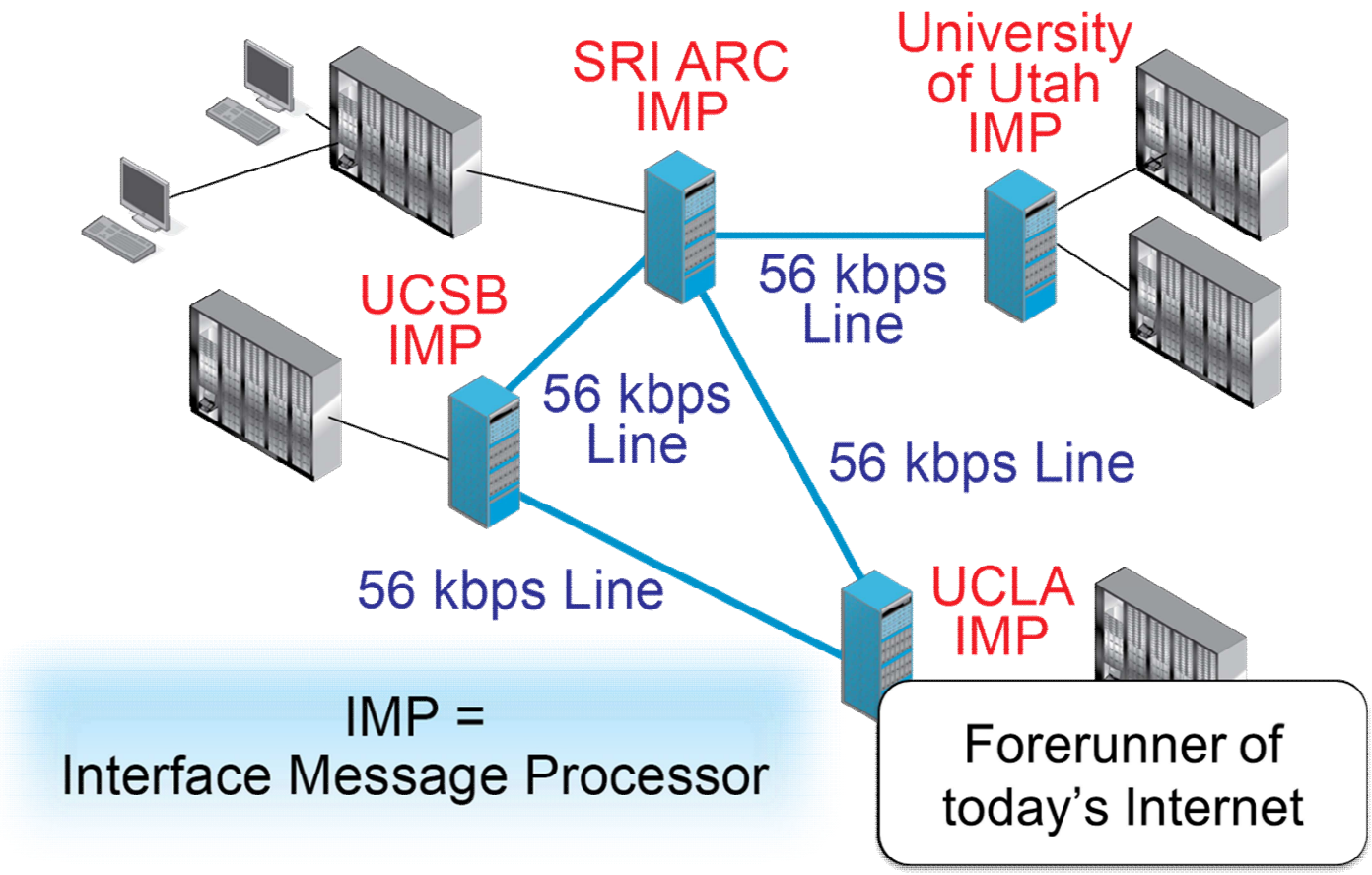
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The ARPANET



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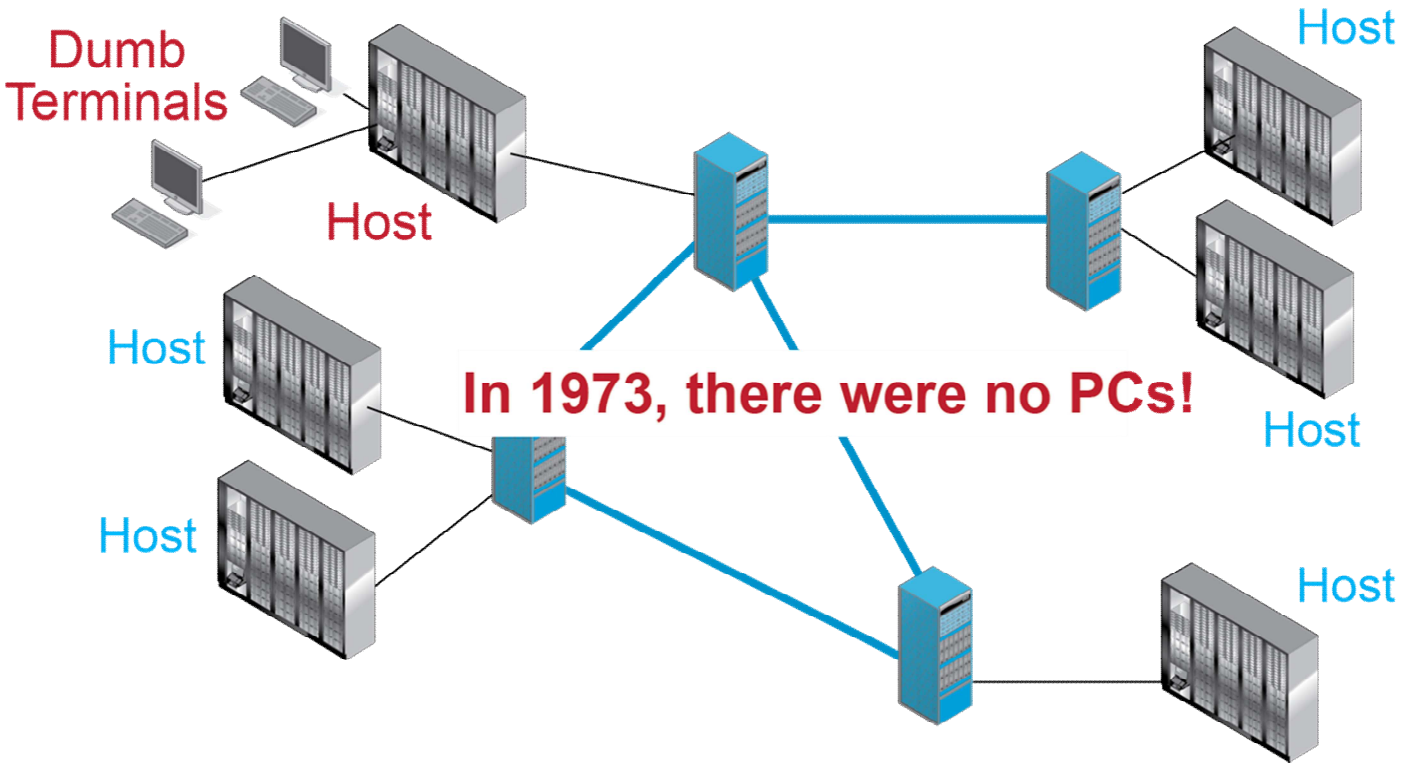
2.1 The Early ARPANET (1 of 2)



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2.1 The Early ARPANET (2 of 2)

Hosts were large computers then Users worked at dumb terminals



When PCs arrived, had to change all the documents or call PCs hosts

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The Network Working Group

- Informal group created to set application and other standards for the ARPANET
- Called their documents, including standards, Requests for Proposals (RFPs)
  - Mostly graduate students, professors, and engineers, who did not have a mandate for creating standards, so used the term RFC
  - RFC 791 was the Internet Protocol
- Evolved into the Internet Engineering Task Force (IETF), which continued the practice

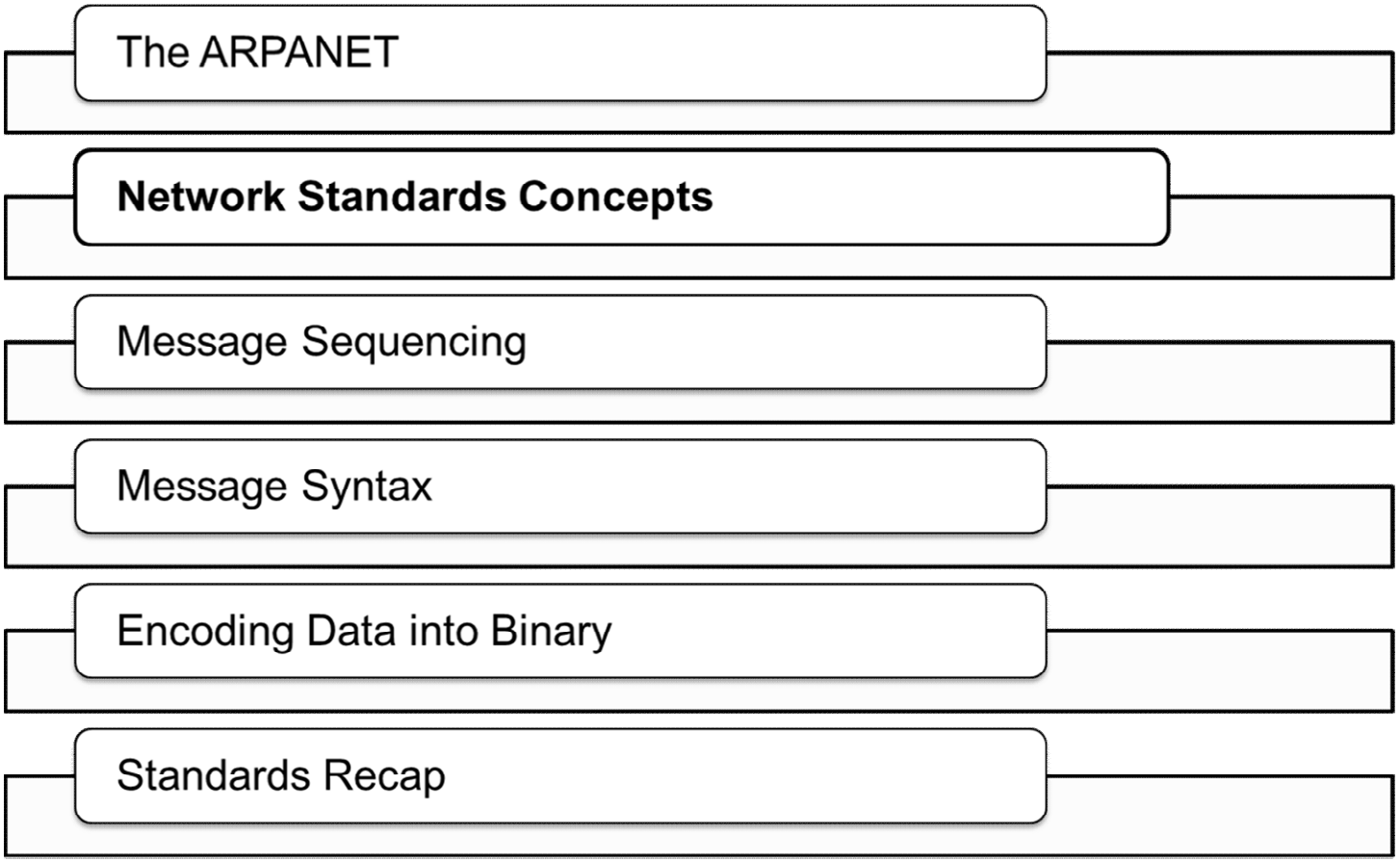
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The Network Working Group / IETF

- Informality led to informal standards development
  - No formal voting, but hummed to give assent anonymously
  - Rough consensus was the norm
- Created simple standards based on actual running code
  - Overall, created inexpensive and ready-to-use standards
  - Other standards agencies were slow dinosaurs
- Joke RFCs on April 1 of most years

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Network Standards Concepts



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2.2 Network Standards (1 of 2)



Network Standards (Protocols) are rules of operation that specify how two hardware or software processes work together by exchanging messages.

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2.2 Network Standards (2 of 2)



Standards permit interoperability among vendors.
This creates competition.
Competition lowers prices.
Competition encourages growth in functionality.

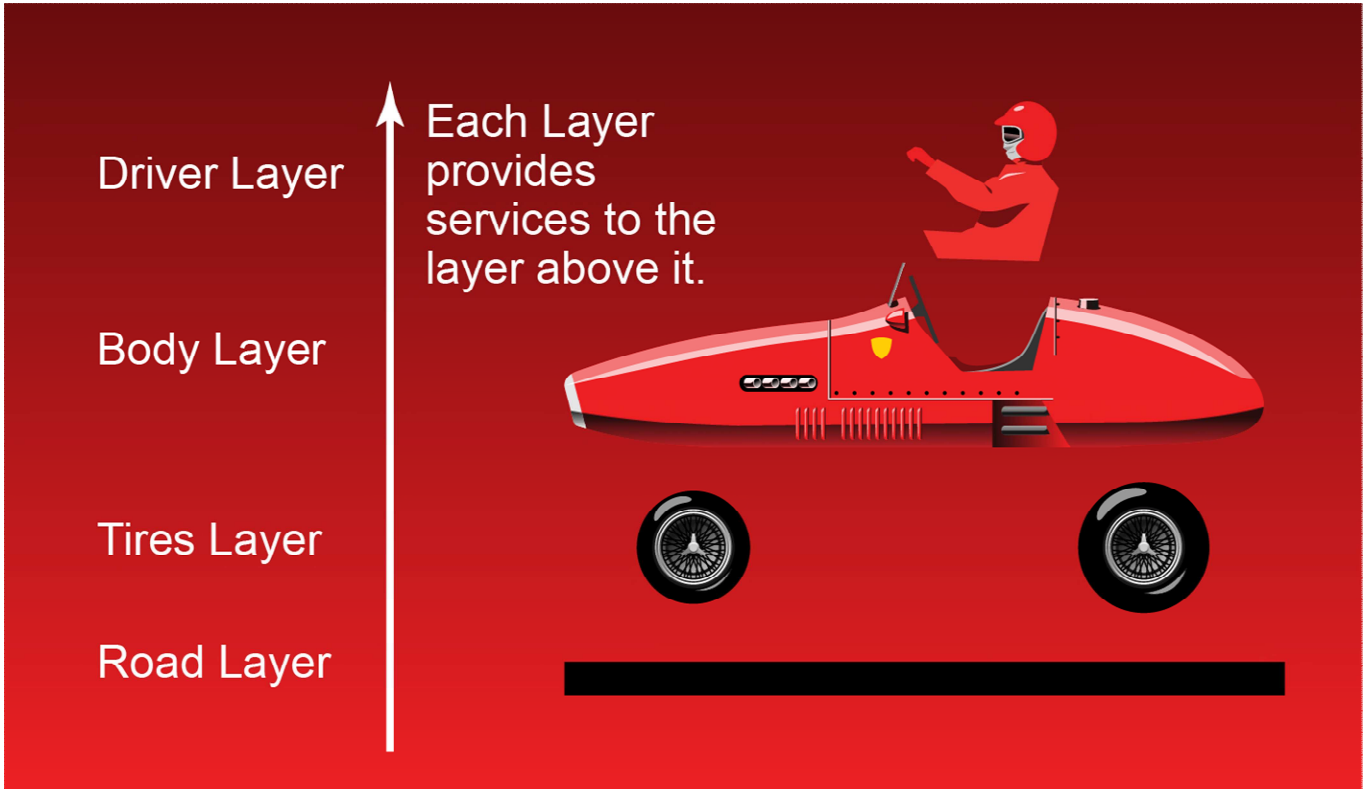
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2.3 Major Standards Agencies

Standards Agency(ies)	Creates
Internet Engineering Task Force (IETF)	Standards for the Internet, especially internet processes, transport processes, and Internet supervisory standards (DNS, etc.)
ISO and ITU-T	A variety of network standards, especially for physical and data link processes

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2.4 Layers in Automobile Travel



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2.5 Layering Benefits (1 of 2)

- Specialization in design
  - For the road layer, soil analysis, strength of paving materials, etc.
  - For the wheels layer, tensile strength, wear for different compounds, etc.

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2.5 Layering Benefits (2 of 2)

- The ability to change one layer while not changing others
  - If add auto parking at the car body level, need not adopt it at the driver level
  - However, can change the driver layer to take advantage of it if desired
  - Upgrade layers as desired
  - It would be too expensive to upgrade all standards every time a standard changed

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2.6 Standards Agencies and Architectures (1 of 3)

OSI Architecture (ITU-T and ISO) Layer Number and Name	TCP/IP Architecture (IE Nu Na	Hybrid TCP/IP–OSI	Standards Come Mostly From
7. Application	4.		Various Standards Architectures
6. Presentation			
5. Session			
4. Transport	3.		TCP/IP (IETF)
3. Network	2.		TCP/IP (IETF)
2. Data Link	1. Ac		OSI (ITU-T and ISO)
1. Physical	Pr		OSI (ITU-T and ISO)

The standards architecture of ISO and ITU-T is OSI

Note:
OSI is a standards architecture

ISO is a standards organization

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2.6 Standards Agencies and Architectures (2 of 3)

OSI Architecture (ITU-T and ISO) Layer Number and Name	TCP/IP Architecture (IETF) Layer Number and Name	Hybrid TCP/IP–OSI Sta Arc Lay and	Standards Come Mostly
7. Application	4. Application	5. A	
6. Presentation			
5. Session			s
4. Transport	3. Transport	4. T	F)
3. Network	2. Internet	3. I	F)
2. Data Link	1. Subnet Access Protocol	2. D	
1. Physical		1. P	

TCP/IP is the standards architecture of the IETF

TCP is a standard

IP is a standard

TCP is a standards architecture

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2.6 Standards Agencies and Architectures (3 of 3)

What organizations actually use is a 5-layer Hybrid TCP/IP-OSI standards architecture

Application standards come from various standards organizations.

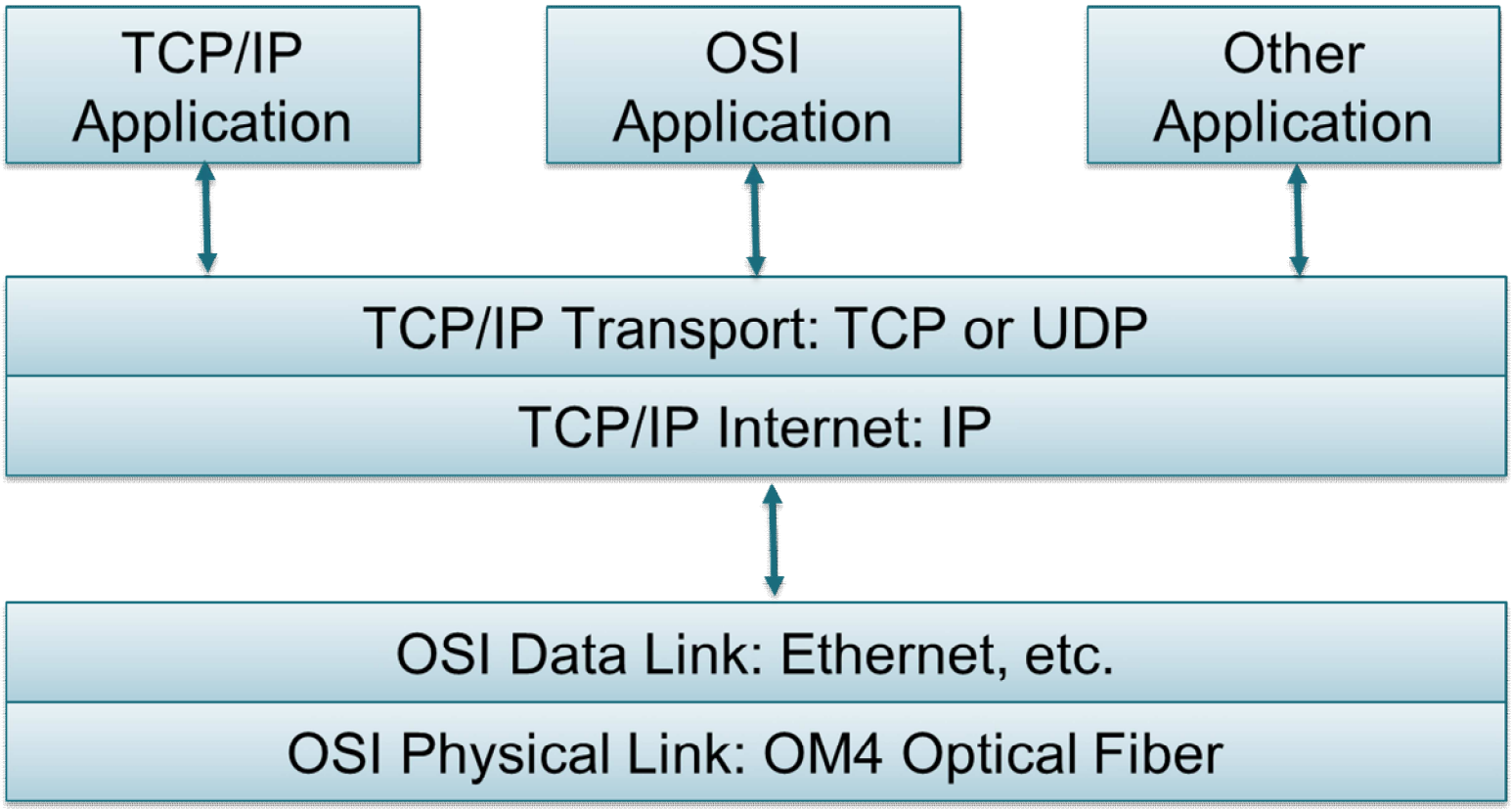
Internet and data link standards come from TCP/IP

Physical and data link layer standards come from OSI

Hybrid TCP/IP–OSI Standards Architecture Layer Number and Name	Standards Come Mostly From
5. Application	Various Standards Architectures
4. Transport	TCP/IP (IETF)
3. Internet	TCP/IP (IETF)
2. Data Link	OSI (ITU-T and ISO)
1. Physical	OSI (ITU-T and ISO)

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2.6 Processes from Different Architectures Can Work Together



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2.7 Layers Recap (1 of 6)

Broad Function	Layer	Layer Name
Interoperability of application programs	5	Application
Transmission across an internet	4	Transport
	3	Internet
Transmission across a single network	2	Data Link
	1	Physical

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2.7 Layers Recap (2 of 6)

1. Physical layer
   - Physical layer standards govern transmission between adjacent devices connected by a transmission medium, regardless of who the two vendors are

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2.7 Layers Recap (3 of 6)

2. Data link layer
   - Data link layer standards govern the transmission of frames across a single switched, wireless, or point-to-point network
   - Data link layer standards govern frame organization and switch operation
   - As in all other layers, the devices can come from different vendors

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2.7 Layers Recap (4 of 6)

3. Internet layer
   - Internet link layer standards govern the transmission of packets across the Internet—typically by sending them through several routers along the route
   - Internet layer standards govern packet organization and routing
   - Hosts and routers can be from different vendors

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2.7 Layers Recap (5 of 6)

4. Transport layer
   - Transport layer standards govern aspects of end-to-end communication between two end hosts that are not handled by the internet layer, including reliability and application message fragmentation
   - These standards allow hosts to work together even if the two computers are from different vendors or have different internal designs

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2.7 Layers Recap (6 of 6)

5. Application layer
   - Application layer standards govern how two applications work with each other, even if they are from different vendors

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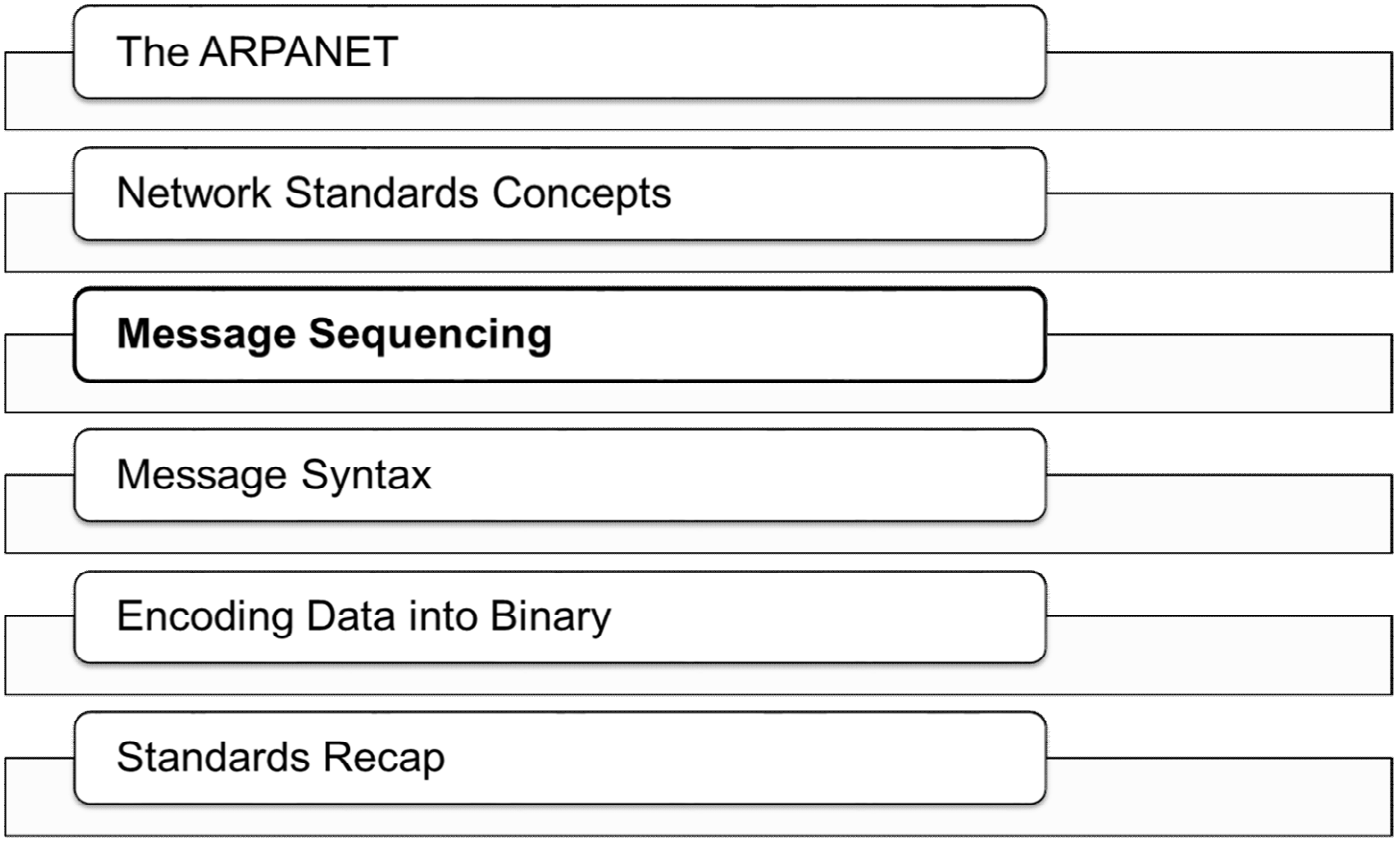
2.8 Repeated Concepts at Layers 2 and 3

	Layer 2	**Layer 3**
Layer Name	Data Link	Internet
Message	Frame	Packet
Forwarding Device	Switch	Router
Span	Single Network	The Internet as a whole
Path Name	Data Link	Route
Destination Address in Header	Data Link Layer (DLL) address; often, but not always EUI-48 addresses	IP addresses

Common source of confusion

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Message Sequencing



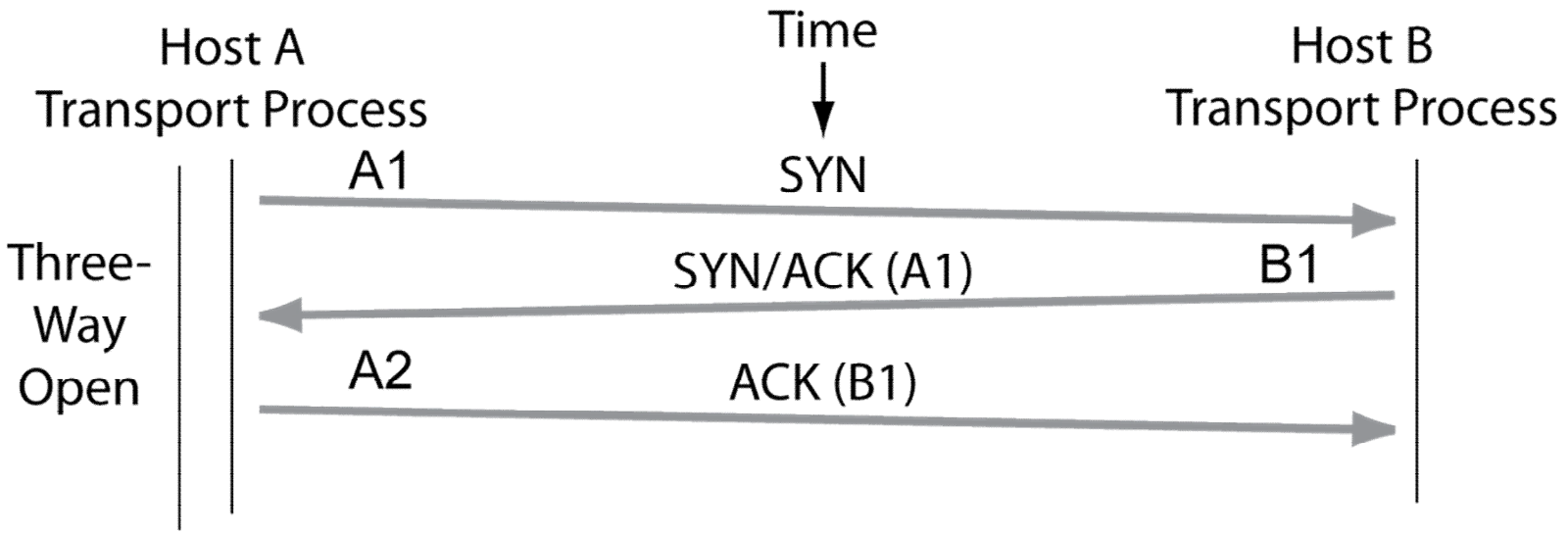
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2.9 Simple HTTP Request-Response Cycle



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2.10 TCP Session (1 of 4)



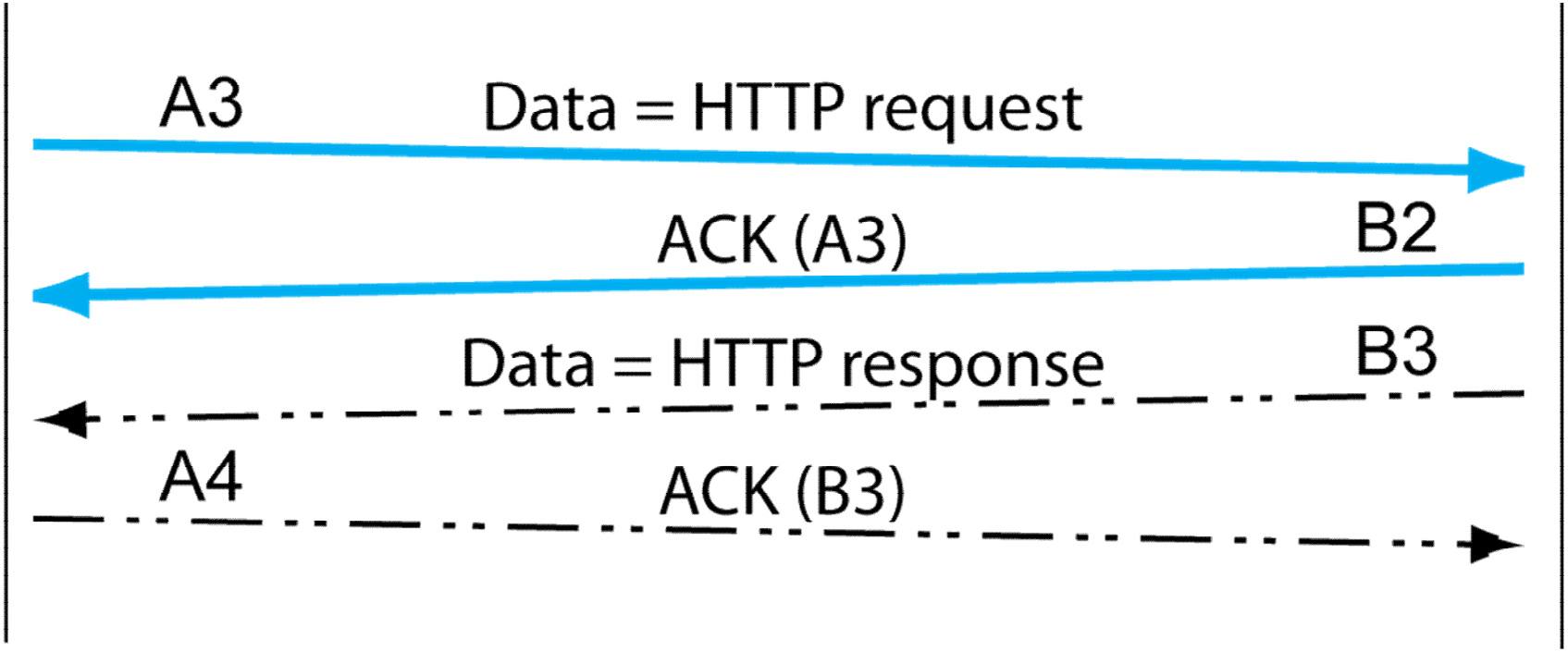
Three TCP segments are used to open a connection

SYN indicates a desire or willingness to communicate

All segments are acknowledged except for pure ACKs

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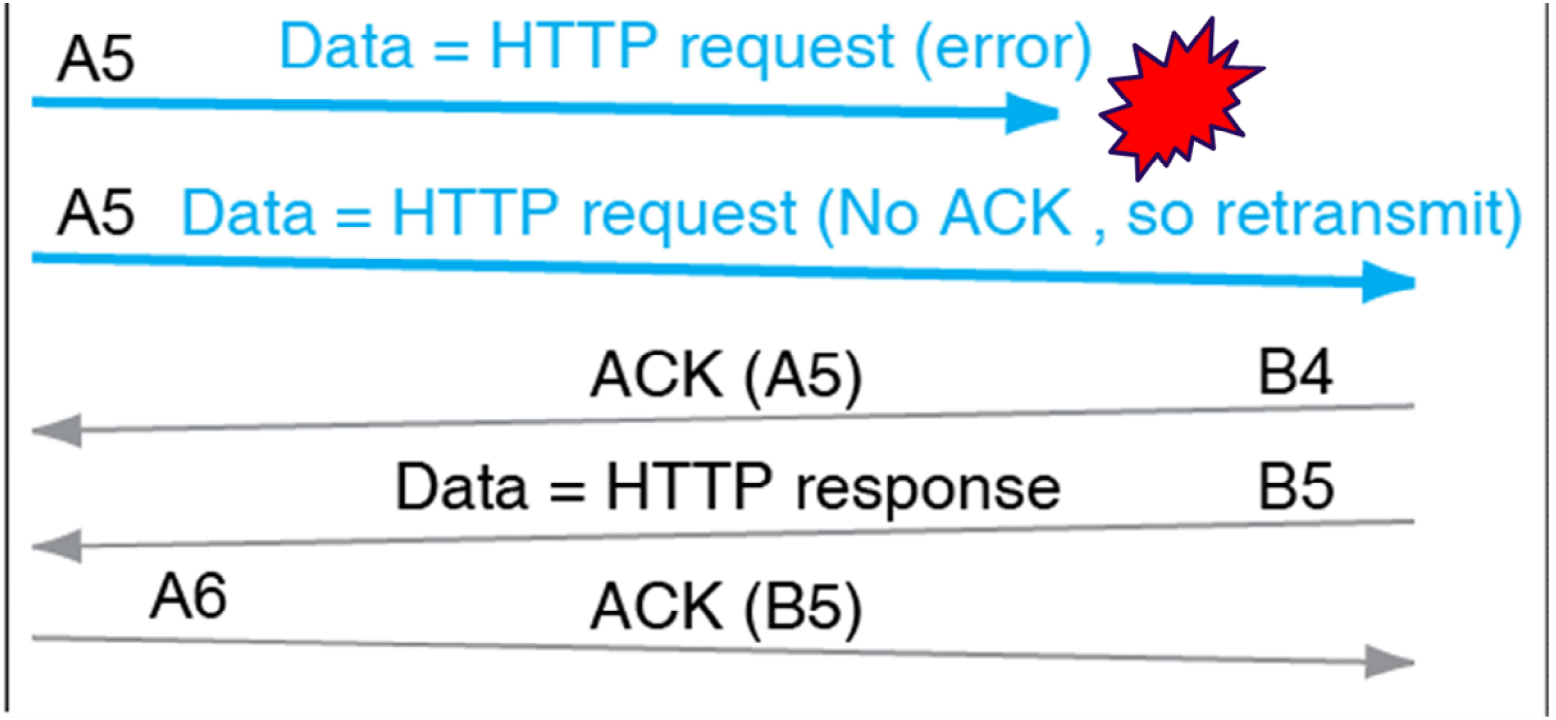
2.10 TCP Session (2 of 4)



First HTTP request and response cycle No error

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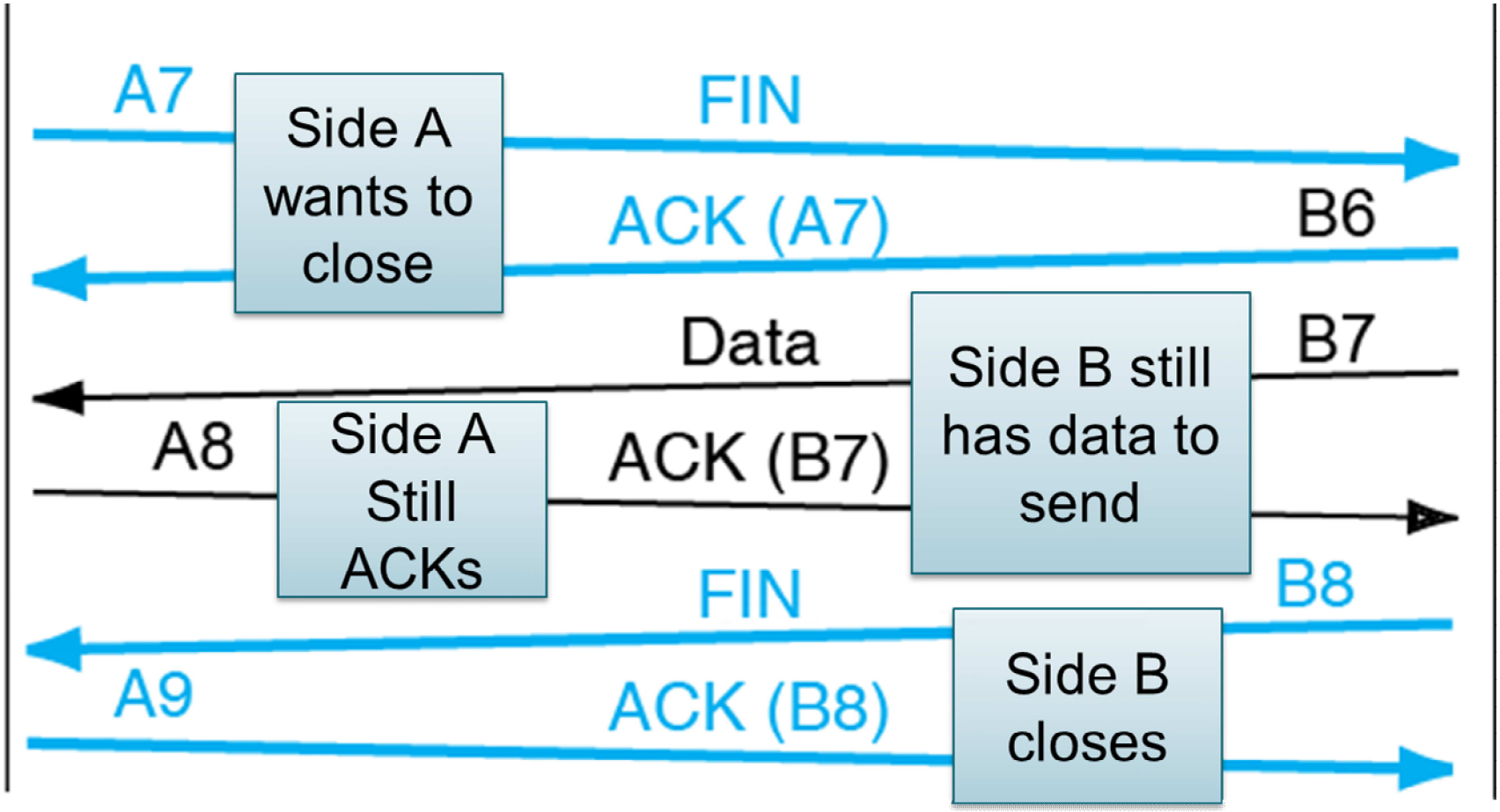
2.10 TCP Session (3 of 4)



Error in the next HTTP request-response cycle

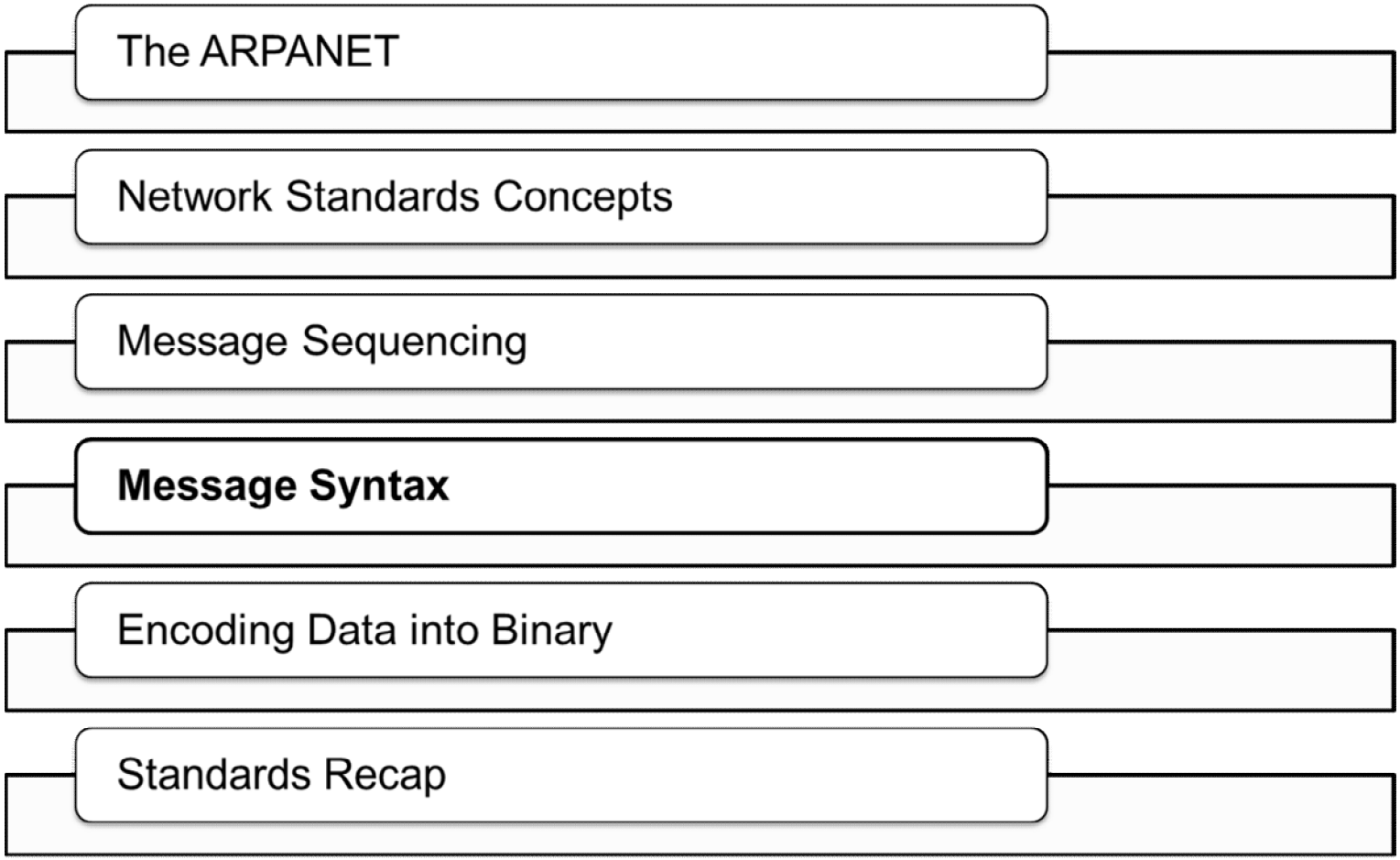
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2.10 TCP Session (4 of 4)



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Message Syntax



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2.11 Headers, Data Fields, and Trailers (1 of 2)

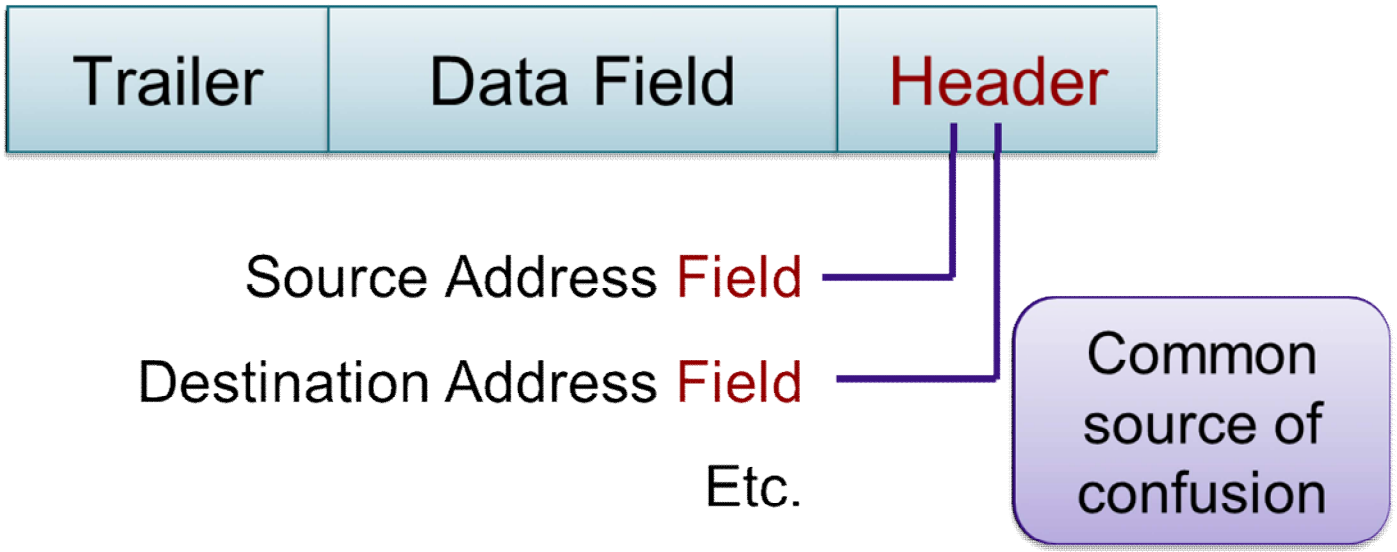
- Data field
  - The information carried by message
- Header
  - Everything that comes before the data field
- Trailer
  - Everything that comes after the data field



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2.11 Headers, Data Fields, and Trailers (2 of 2)

- Fields
  - The header and trailer may be further divided into fields such as the source and destination address fields.



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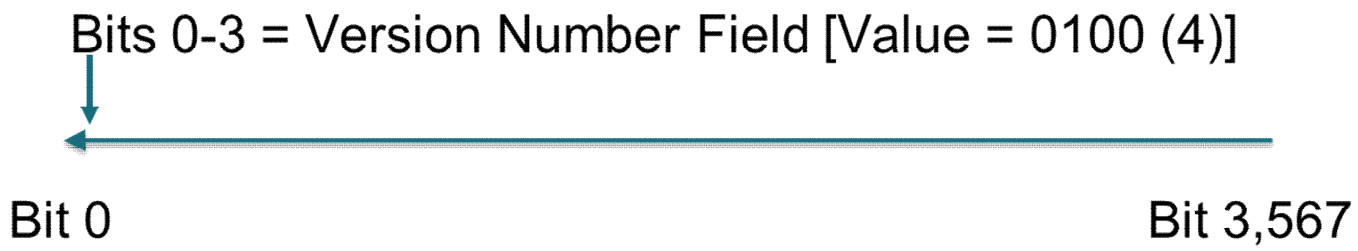
The Syntax of Important Message Types (1 of 5)

- **IPv4**
- TCP Segments
- UDP Datagrams
- Port Numbers and Sockets in TCP and UDP
- Ethernet II Frames

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IPV4 Packet Syntax

- A packet is a long string of bits
  - The first bit to arrive is Bit 0
  - Fields are consecutive groups of bits
  - Version number field is first four bits
  - Packets with thousands of bits are difficult to draw because the line would go for miles



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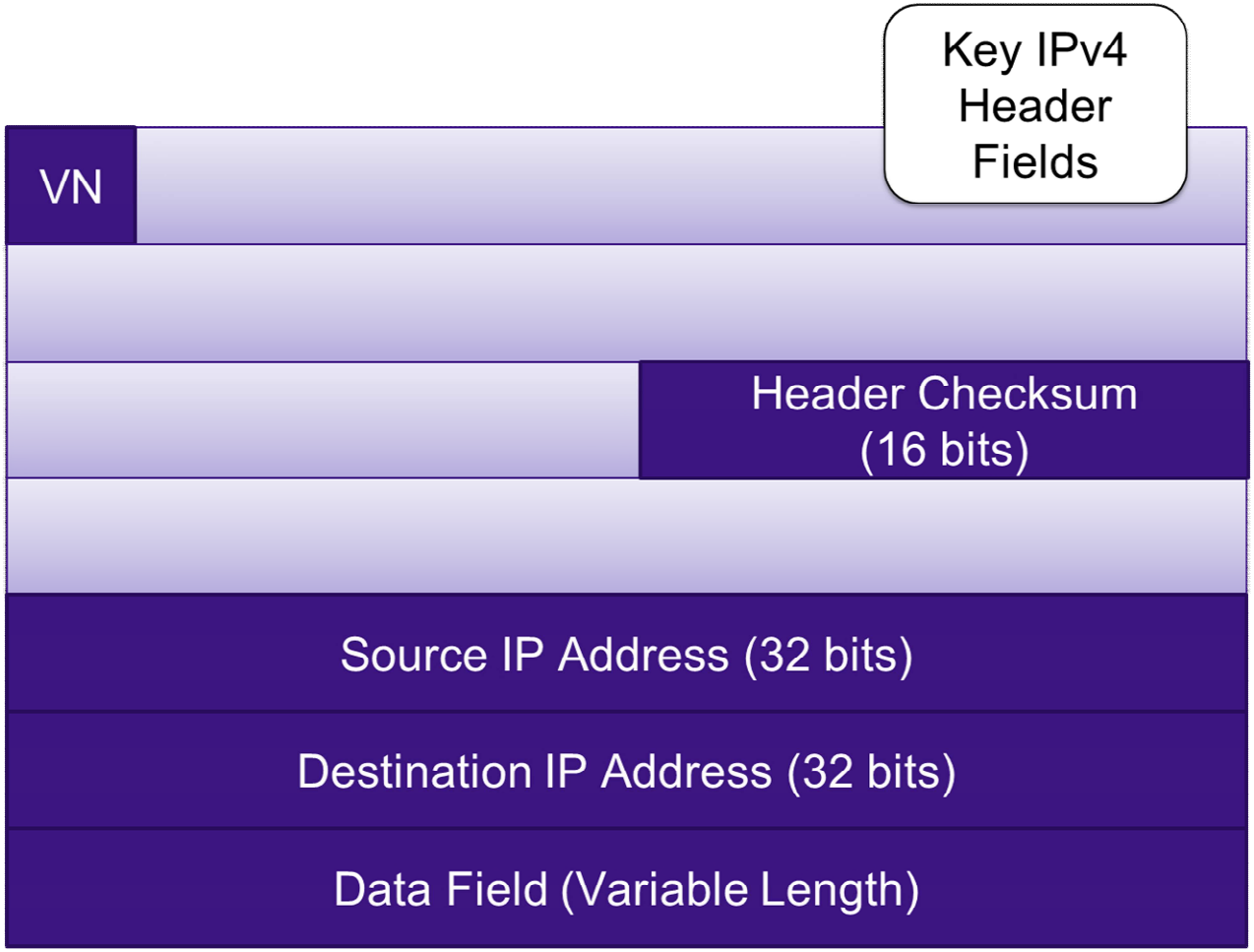
2.12 IPV4 Packet Syntax (1 of 5)

- So the IETF represents them with 32 bits per line
- The first bit is zero instead of one
- First line has bits 0 through 31

Line	First Bit	Last Bit
1	0	31
2	32	63
3	64	95
4	96	127
…	…	…

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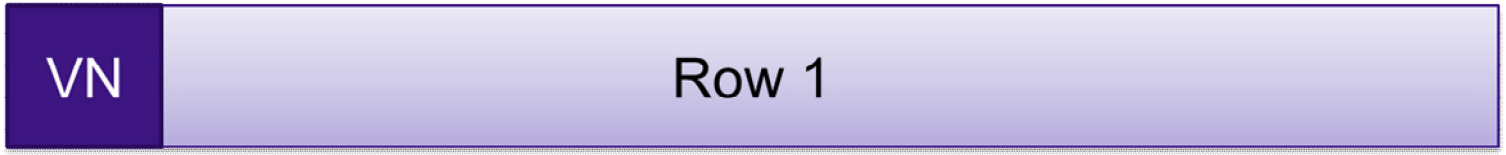
2.12 IPV4 Syntax



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2.12 IPV4 Packet Syntax (2 of 5)

- Version Number Field
  - Version of the IP Protocol
  - First 4 bits of the first row
  - Version 4 (0100) was the first version used
  - Version 6 (0110) is the current growing version
  - Comes first because subsequent fields in v4 and v6 are different



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2.12 IPV4 Packet Syntax (3 of 5)

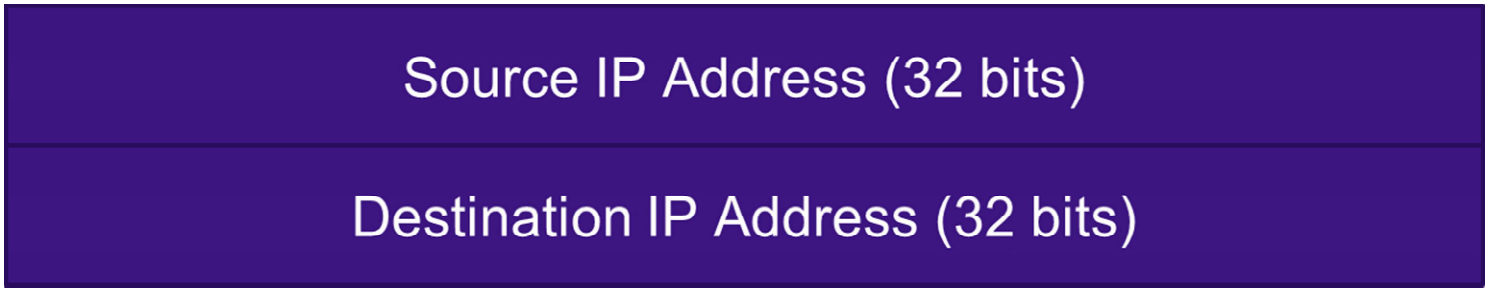
- Header Checksum Field
  - To check for errors in the header (not whole packet)
  - Sender calculates value based on bits in the header
  - Receiver redoes the calculation
  - If the sent and recalculated values are different, receiver discards the packet because something has gone wrong
  - No retransmission for lost or damaged packets
  - So IPv4 is not a **reliable** protocol



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2.12 IPV4 Packet Syntax (4 of 5)

- IP Address Fields
  - Source and destination IP addresses
  - Each is 32 bits long (one line)



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2.12 IPV4 Packet Syntax (5 of 5)

- Data Field
  - The Information being carried
  - Variable length
  - Usually very long compared to the header



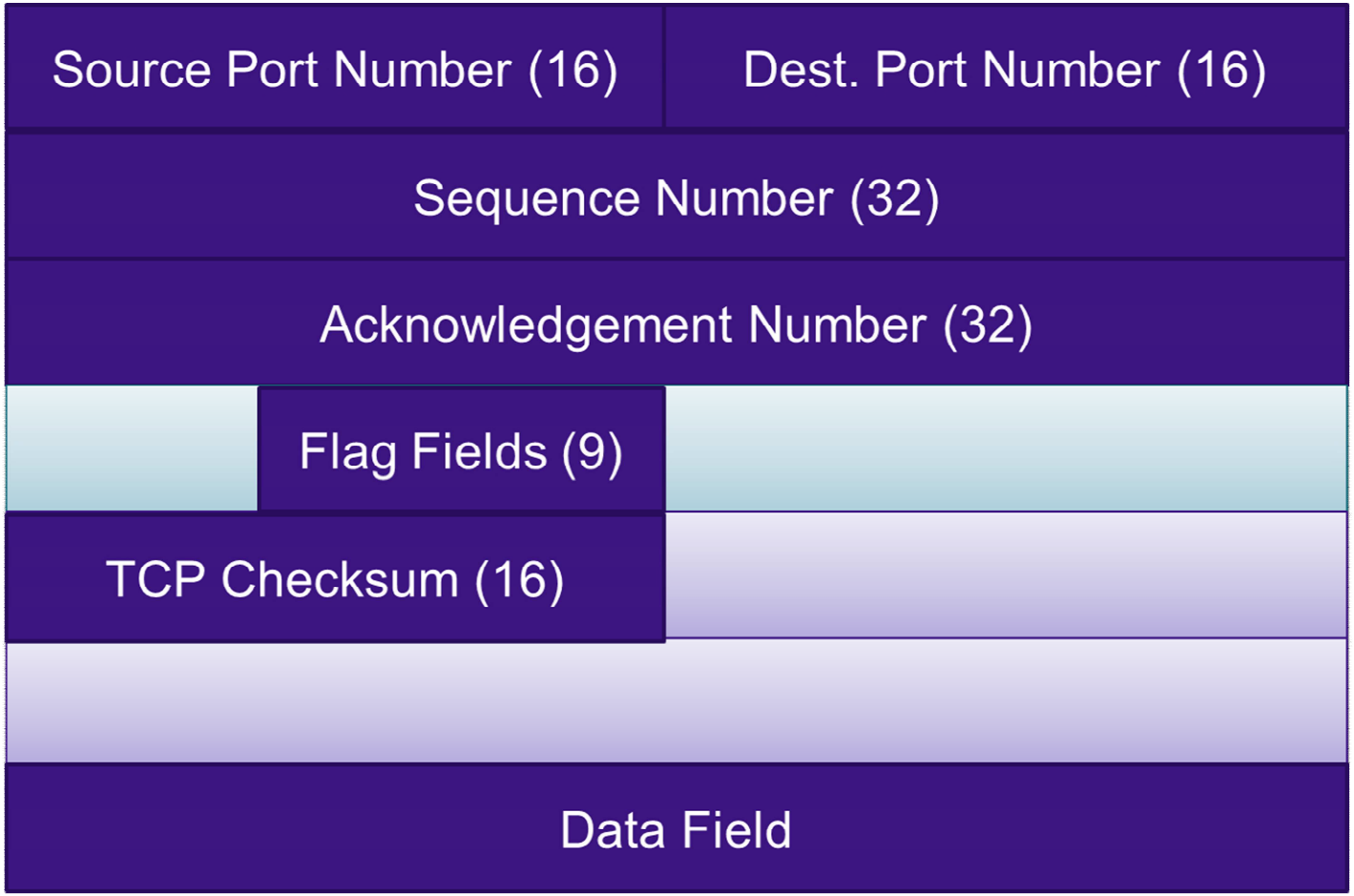
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The Syntax of Important Message Types (2 of 5)

- IPv4
- **TCP Segments**
- UDP Datagrams
- Port Numbers and Sockets in TCP and UDP
- Ethernet II Frames

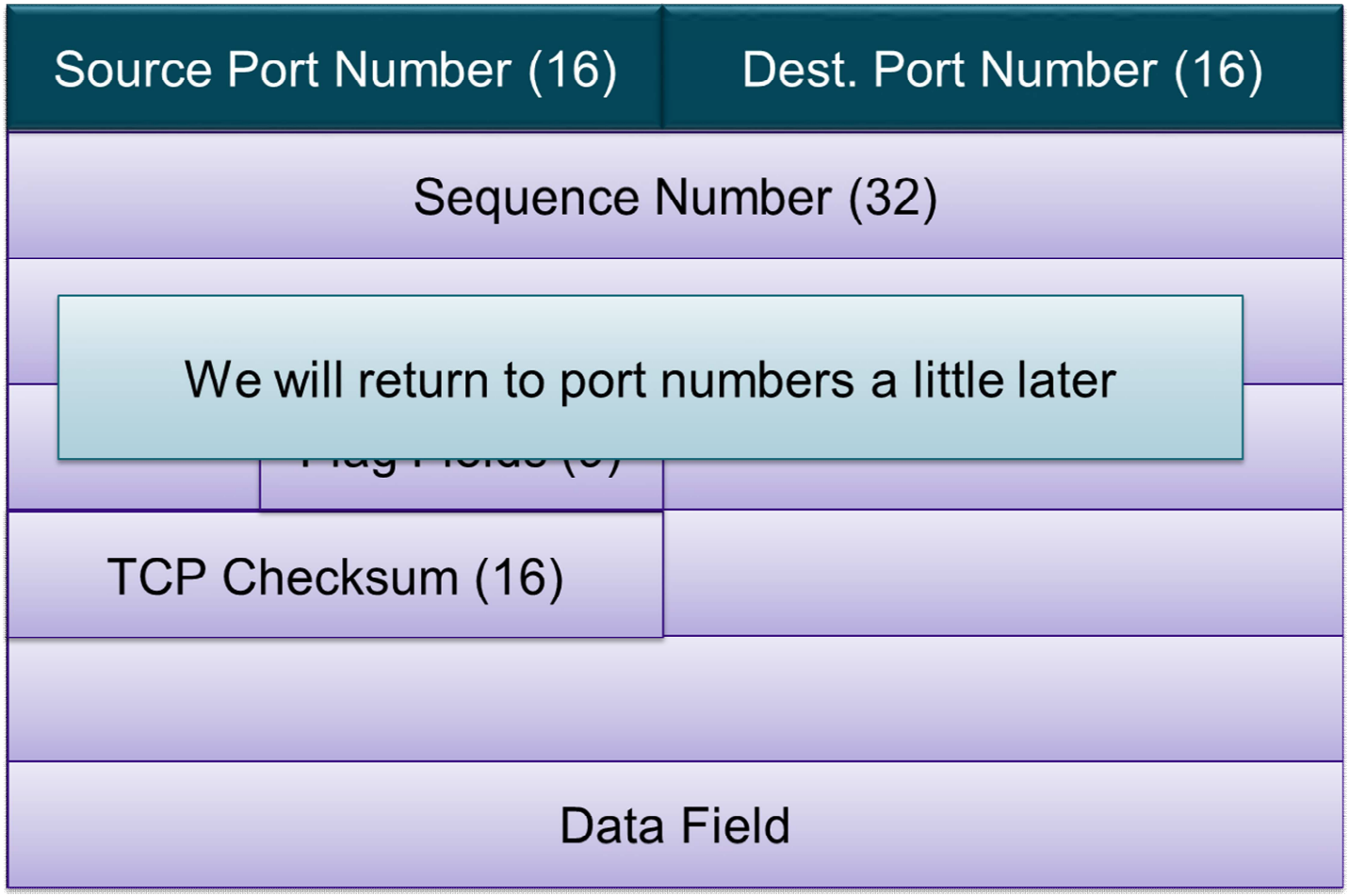
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2.13 TCP Segment Syntax (1 of 5)



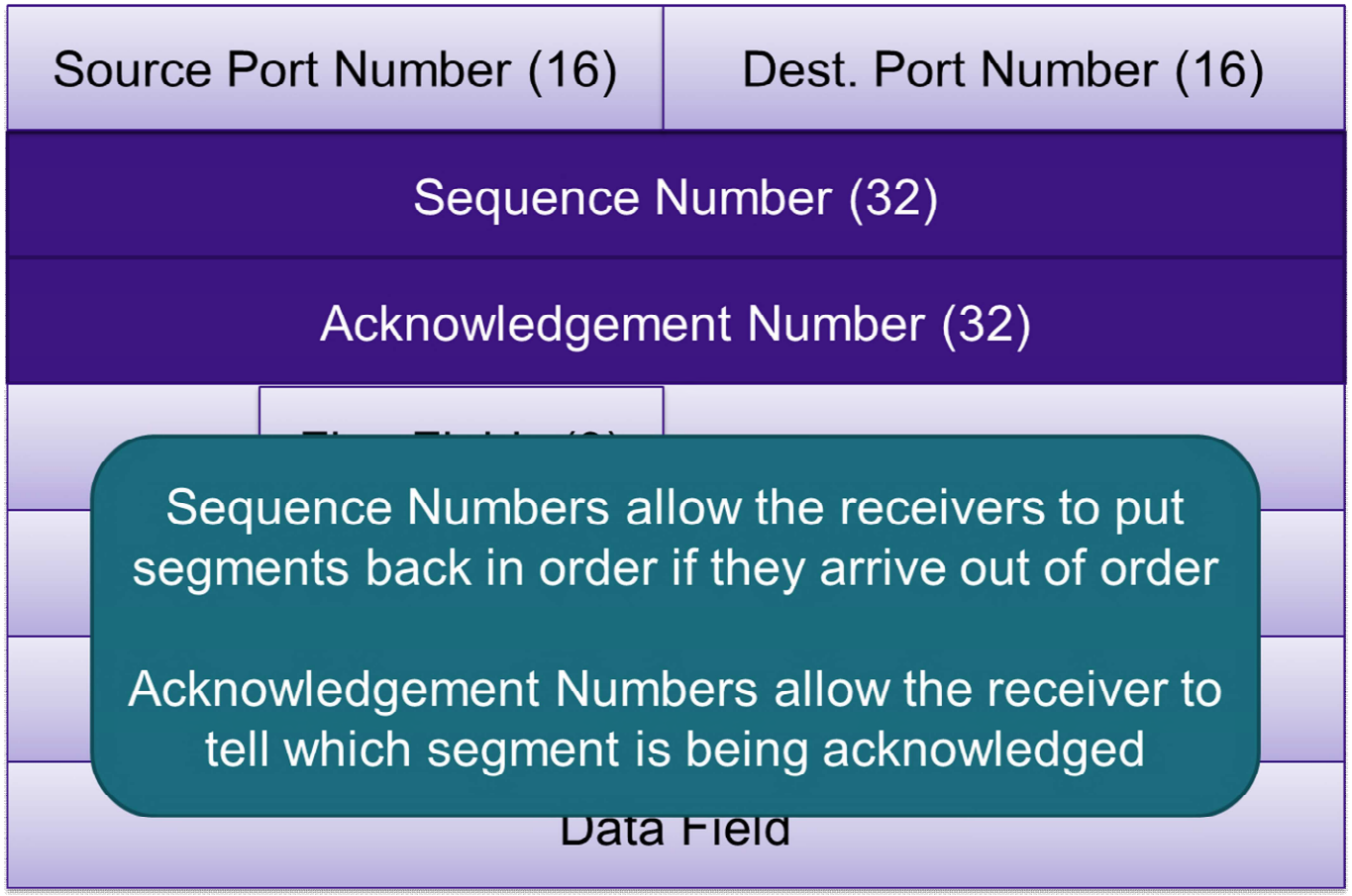
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2.13 TCP Segment Syntax (2 of 5)



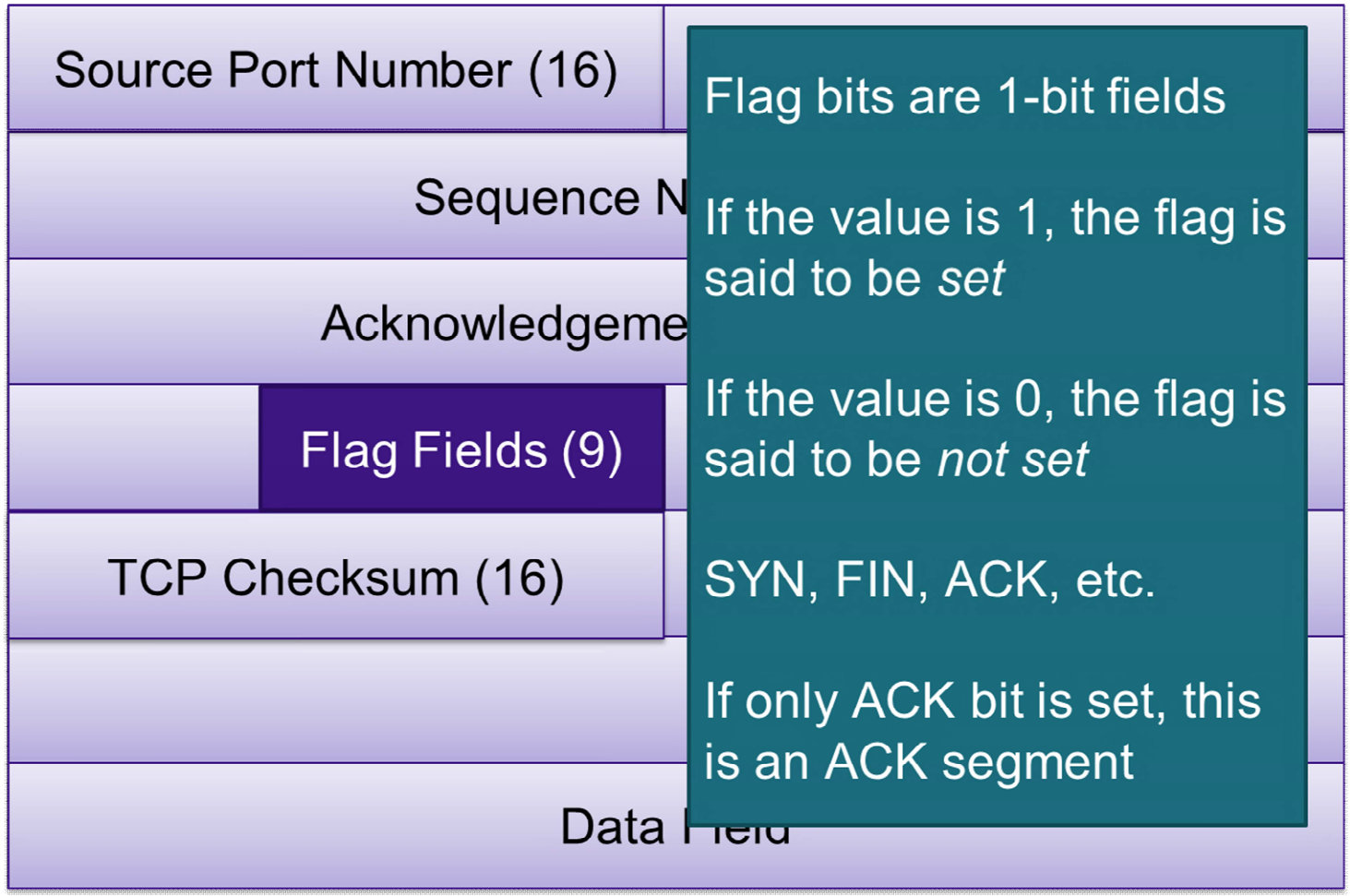
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2.13 TCP Segment Syntax (3 of 5)



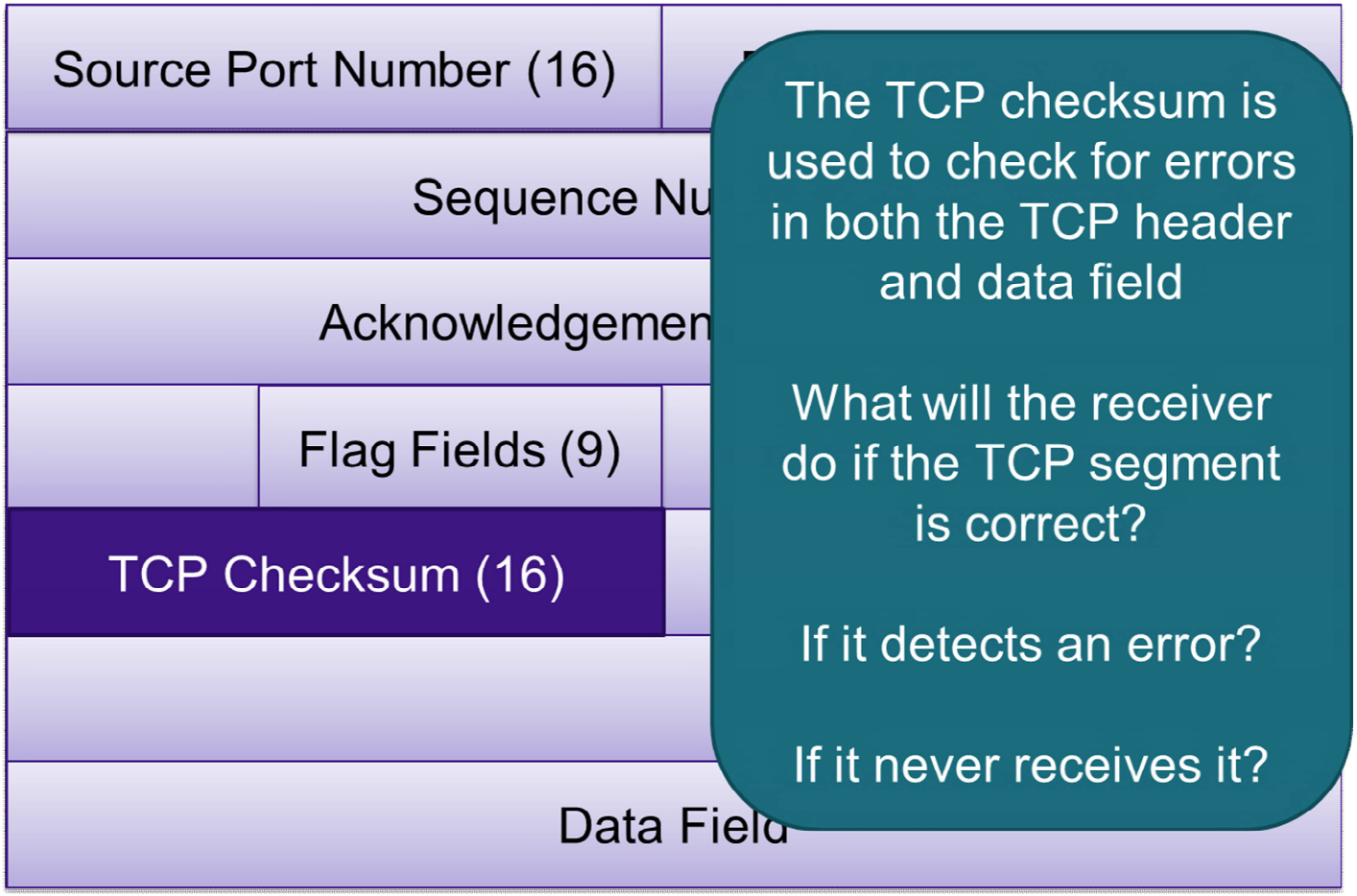
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2.13 TCP Segment Syntax (4 of 5)



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2.13 TCP Segment Syntax (5 of 5)



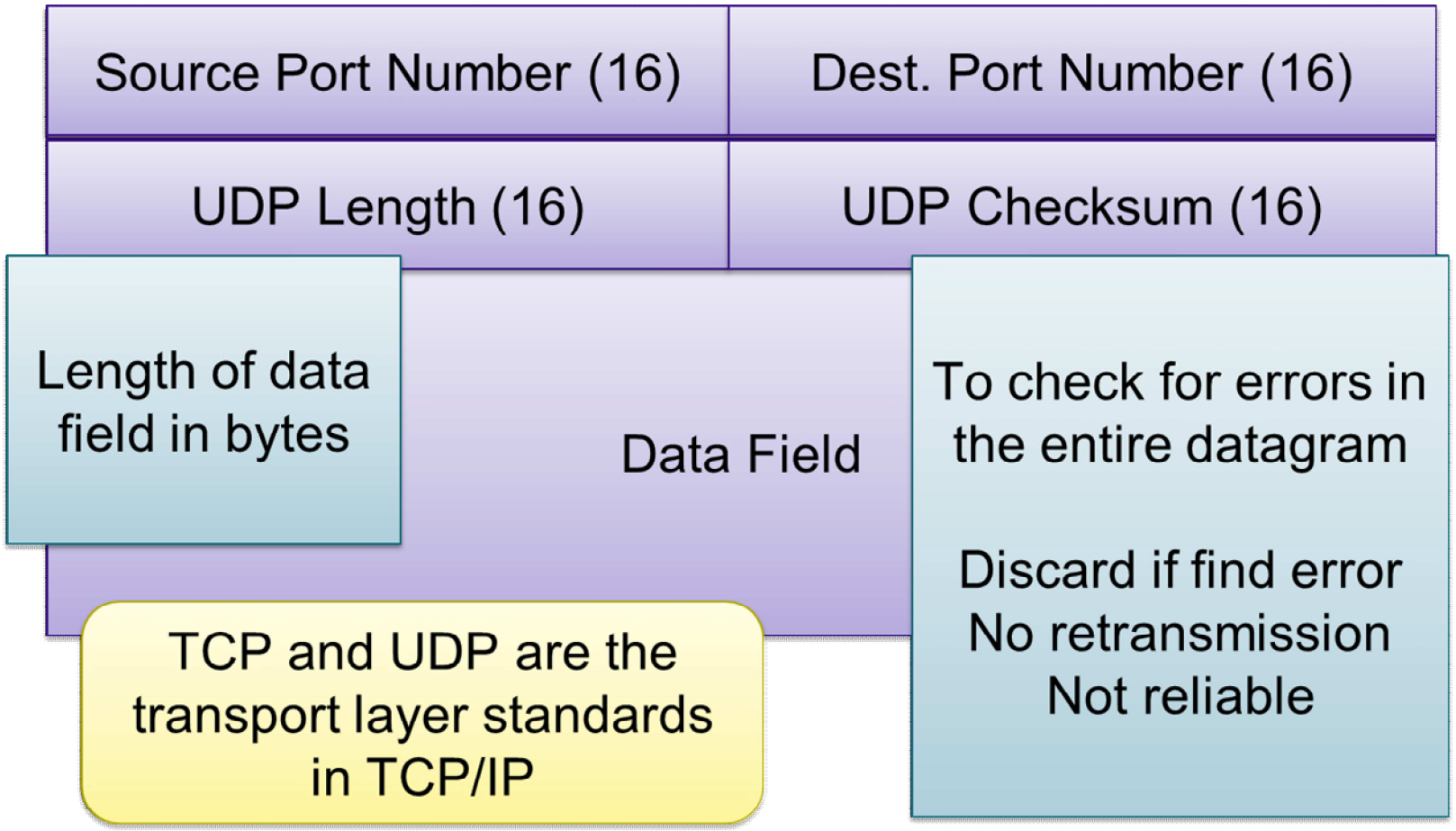
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The Syntax of Important Message Types (3 of 5)

- IPv4
- TCP Segments
- **UDP Datagrams**
- Port Numbers and Sockets in TCP and UDP
- Ethernet II Frames

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2.14 UDP Datagram Syntax



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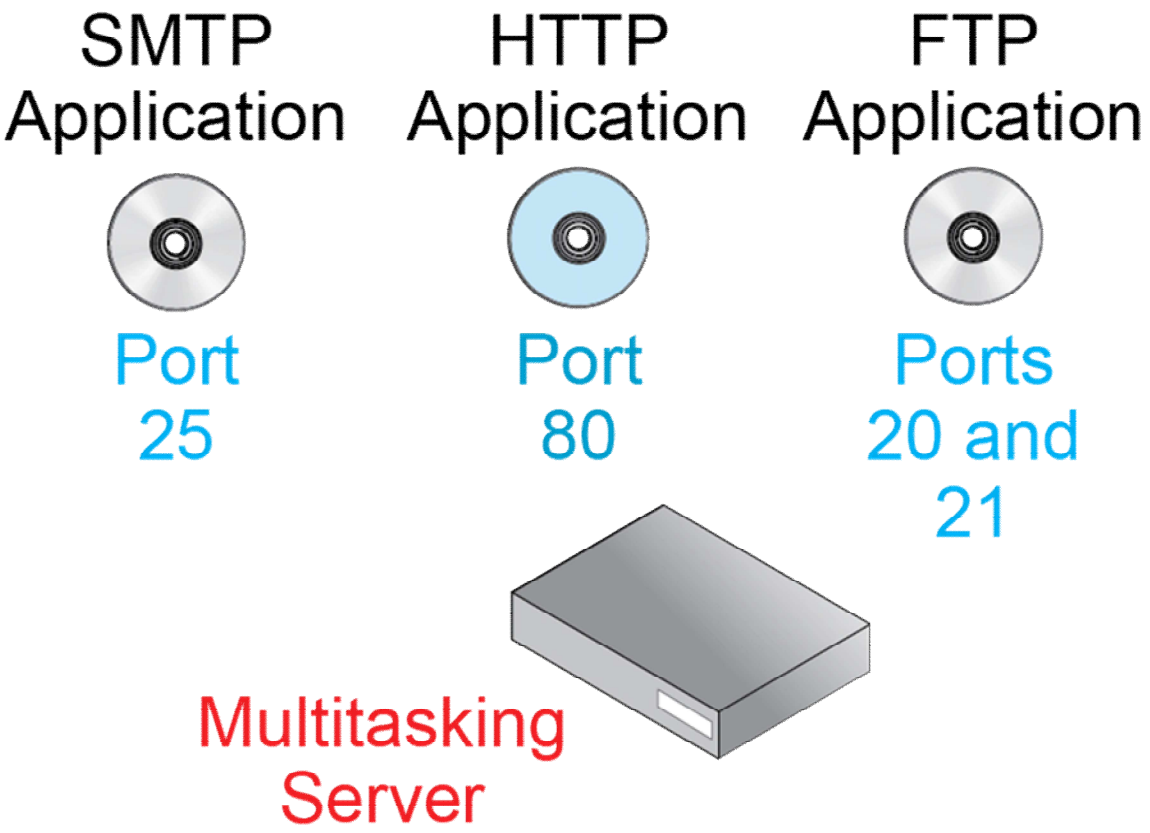
The Syntax of Important Message Types (4 of 5)

- IPv4
- TCP Segments
- UDP Datagrams
- **Port Numbers and Sockets in TCP and UDP**
- Ethernet II Frames

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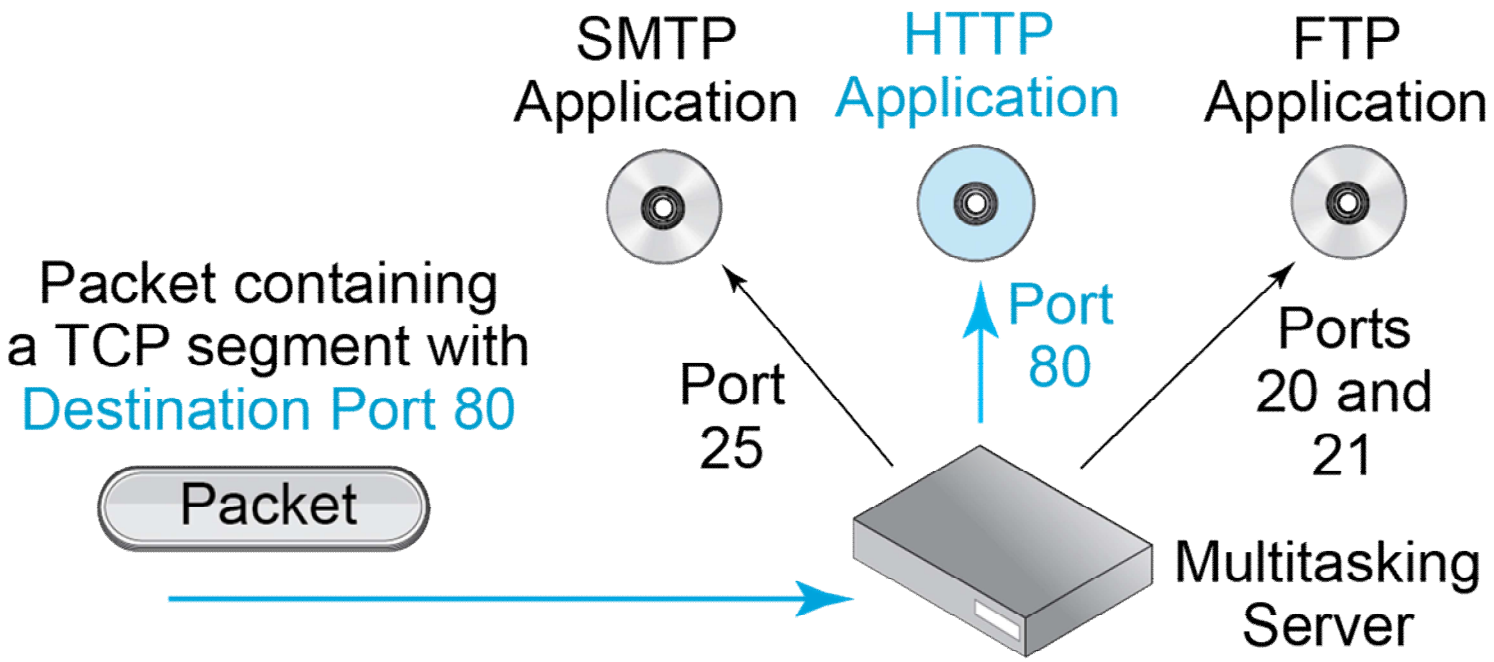
2.15 Server Port Numbers (1 of 3)

Servers are multitasking computers that can run multiple applications. They assign each application a different port number.



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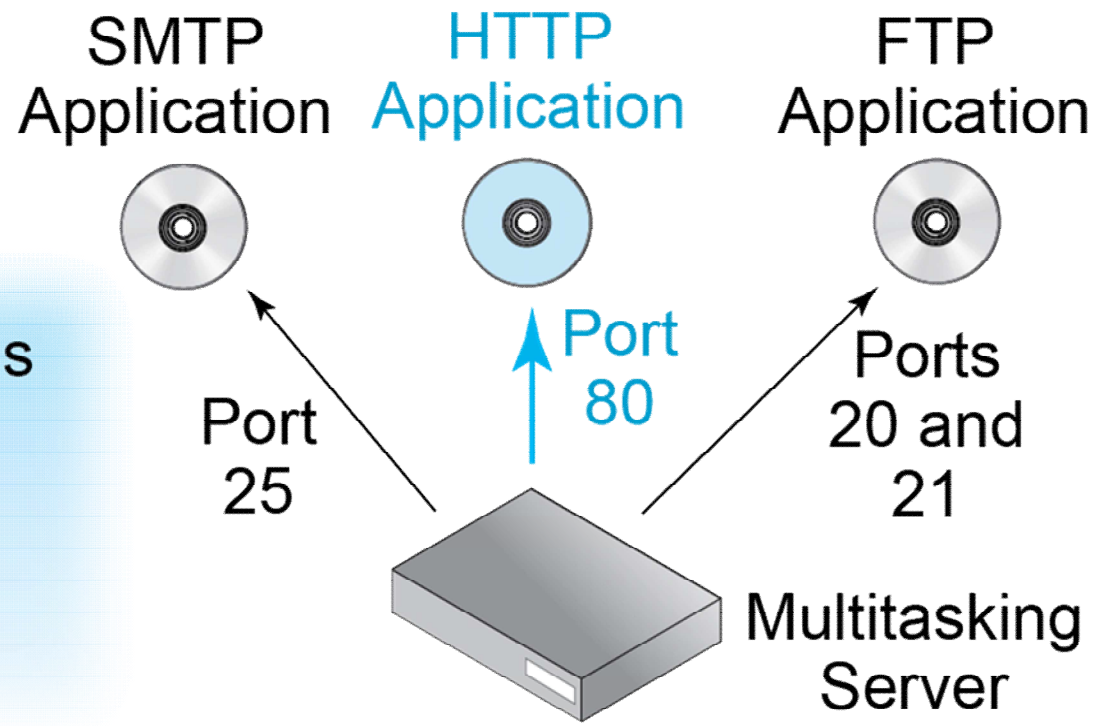
2.15 Server Port Numbers (2 of 3)



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2.15 Server Port Numbers (3 of 3)

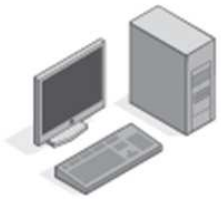
Server Programs Normally Use Well-Known Port Numbers (0 to 1023)



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2.16 Client Port Numbers and Sockets (1 of 4)

Client
60.171.18.22
Port 2707



Clients use Ephemeral
Port Numbers
(usually 1024 to 4999)
New ephemeral port number
for each connection

Webserver
1.33.17.13
Port 80



Server Programs use
Well-Known Port Numbers
(0 to 1023)

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2.17 TCP and UDP Sockets

IP Address	Port Number	Socket
60.171.18.22	2707	60.171.18.22:2707
123.30.17.120	80	123.30.17.120:80
60.171.18.22	4400	60.171.18.22:4400
1.33.17.13	25	1.33.17.13:25

Socket is an IP address, a colon, and a port number
It is a particular program on a particular server or a particular connection on a particular client

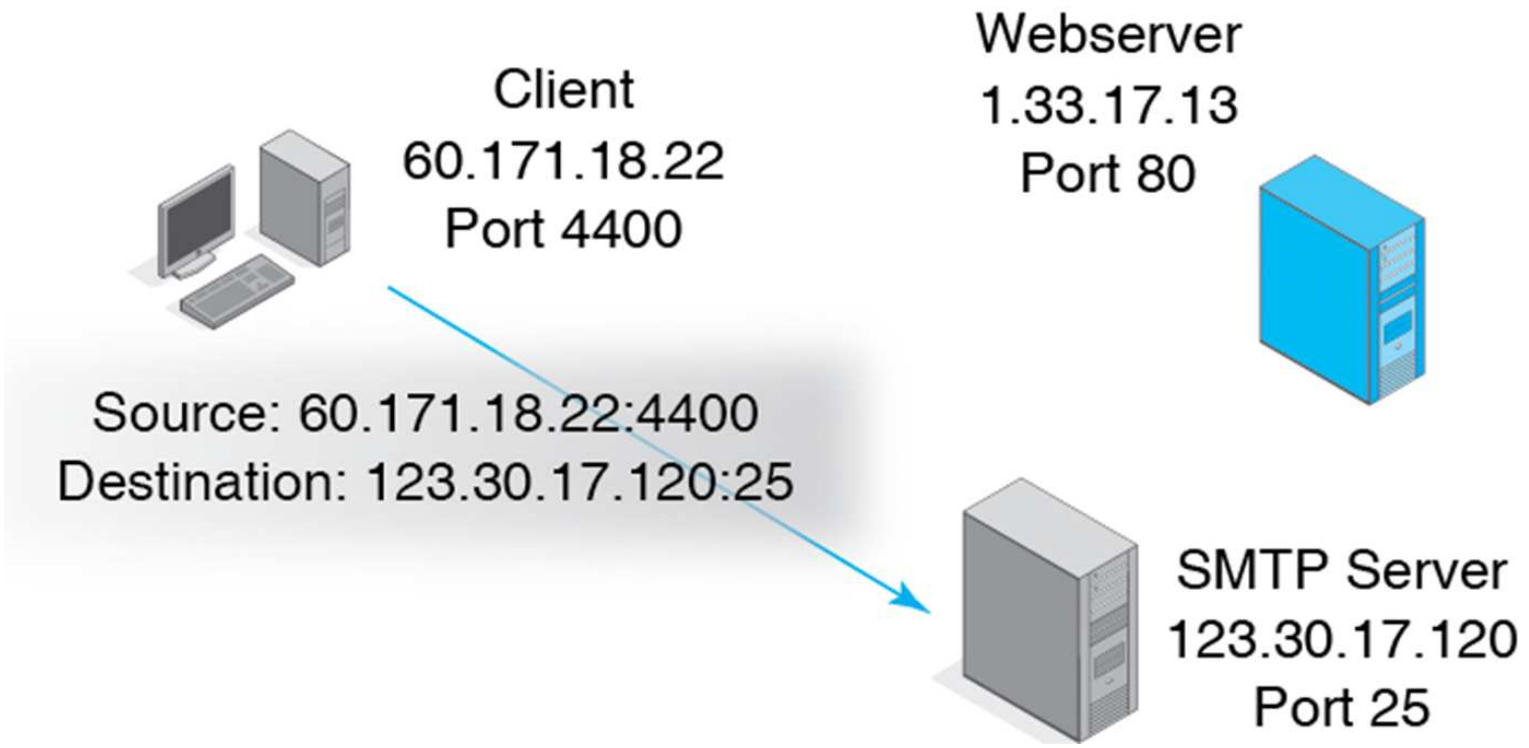
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2.16 Client Port Numbers and Sockets (2 of 4)



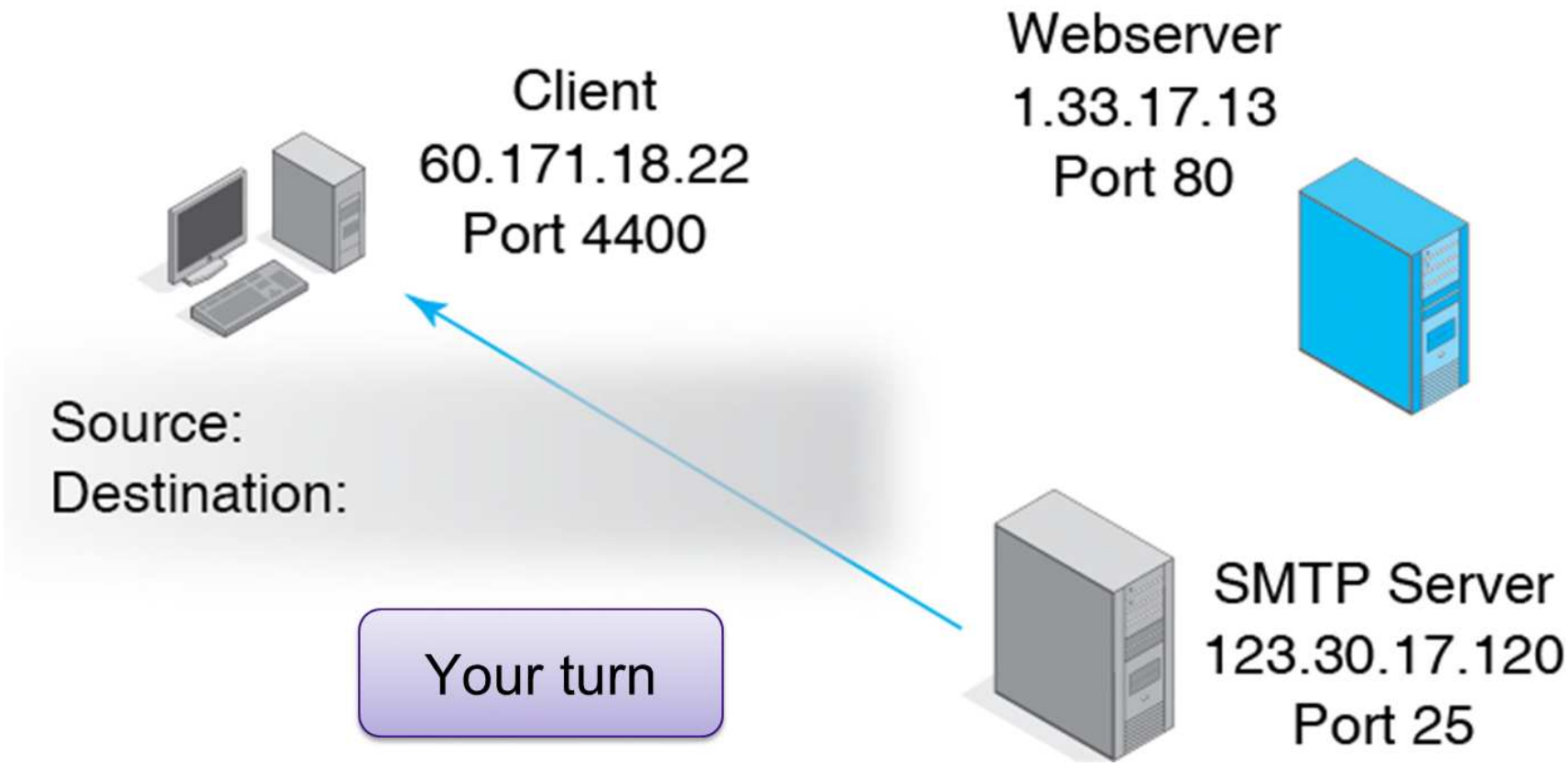
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2.16 Client Port Numbers and Sockets (3 of 4)



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2.16 Client Port Numbers and Sockets (4 of 4)



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The Syntax of Important Message Types (5 of 5)

- IPv4
- TCP Segments
- UDP Datagrams
- Port Numbers and Sockets in TCP and UDP
- **Ethernet II Frames**

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2.18 Ethernet II Frame (1 of 8)

Field (bits or octets)

Destination Address (48 bits)

Source EUI-Address (48 bits)

Tag Protocol ID (2 octets) Optional

Tag Control Information (2 octets) (optional)

Length (2 octets)

EtherType (2 octets)

IP Packet (variable)

PAD (variable; may not be present)

Frame Check Sequence (4 octets)

In Ethernet, standards are set by the IEEE, not the IETF

Ethernet, frames are shown as a sequence of fields in arrival order, not 32 bits per line like IETF standards

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2.18 Ethernet II Frame (2 of 8)

Field (bits or octets)

Destination Address (48 bits)

Source EUI-Address (48 bits)

Tag Protocol ID (2 octets) Optional

Tag Control Information (2 octets) (optional)

Length (2 octets)

EtherType (2 octets)

IP Packet (variable)

PAD (variable; may not be present)

Frame Check Sequence (4 octets)

An octet is a group of 8 bits

Yes, that is the same as a byte

However, the term octet is used often in networking, so you need to know it

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2.18 Ethernet II Frame (3 of 8)

Field (bits or octets)

Destination Address (48 bits)

Source EUI-Address (48 bits)

Tag Protocol ID (2 octets) Optional

Tag Control Information (2 octets) (optional)

Length (2 octets)

EtherType (2 octets)

IP Packet (variable)

PAD (variable; may not be present)

Frame Check Sequence (4 octets)

Ethernet addresses are 48 bits long

They EUI-48 addresses

Formerly called MAC addresses

Expressed in hexadecimal notation (discussed in Chapter 5)

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2.18 Ethernet II Frame (4 of 8)

Field (bits or octets)

Destination Address (48 bits)

Source EUI-Address (48 bits)

Tag Protocol ID (2 octets) Optional

Tag Control Information (2 octets) (optional)

Length (2 octets)

EtherType (2 octets)

IP Packet (variable)

PAD (variable; may not be present)

Frame Check Sequence (4 octets)

The Length field is 2 octets long (16 bits)

Tells the length of the data field in bytes

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2.18 Ethernet II Frame (5 of 8)

Field (bits or octets)

Destination Address (48 bits)

Source EUI-Address (48 bits)

Tag Protocol ID (2 octets) Optional

Tag Control Information (2 octets) (optional)

Length (2 octets)

EtherType (2 octets)

IP Packet (variable)

PAD (variable; may not be present)

Frame Check Sequence (4 octets)

EtherType field describes the contents of the data field

0800 = IPv4 packet

86DD= IPv6 packet

These values are in hexadecimal notation, which, again, we will see in Chapter 5

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2.18 Ethernet II Frame (6 of 8)

Field (bits or octets)

Destination Address (48 bits)

Source EUI-Address (48 bits)

Tag Protocol ID (2 octets) Optional

Tag Control Information (2 octets) (optional)

Length (2 octets)

EtherType (2 octets)

IP Packet (variable)

PAD (variable; may not be present)

Frame Check Sequence (4 octets)

Next comes the data field, which contains the packet

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2.18 Ethernet II Frame (7 of 8)

Field (bits or octets)

Destination Address (48 bits)

Source EUI-Address (48 bits)

Tag Protocol ID (2 octets) Optional

Tag Control Information (2 octets) (optional)

Length (2 octets)

EtherType (2 octets)

IP Packet (variable)

PAD (variable; may not be present)

Frame Check Sequence (4 octets)

Frame Check Sequence Field is used to check for errors

Sender calculates a value based on other fields

If the receiver calculates the same value, there have been no errors

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2.18 Ethernet II Frame (8 of 8)

Field (bits or octets)

Destination Address (48 bits)

Source EUI-Address (48 bits)

Tag Protocol ID (2 octets) Optional

Tag Control Information (2 octets) (optional)

Length (2 octets)

EtherType (2 octets)

IP Packet (variable)

PAD (variable; may not be present)

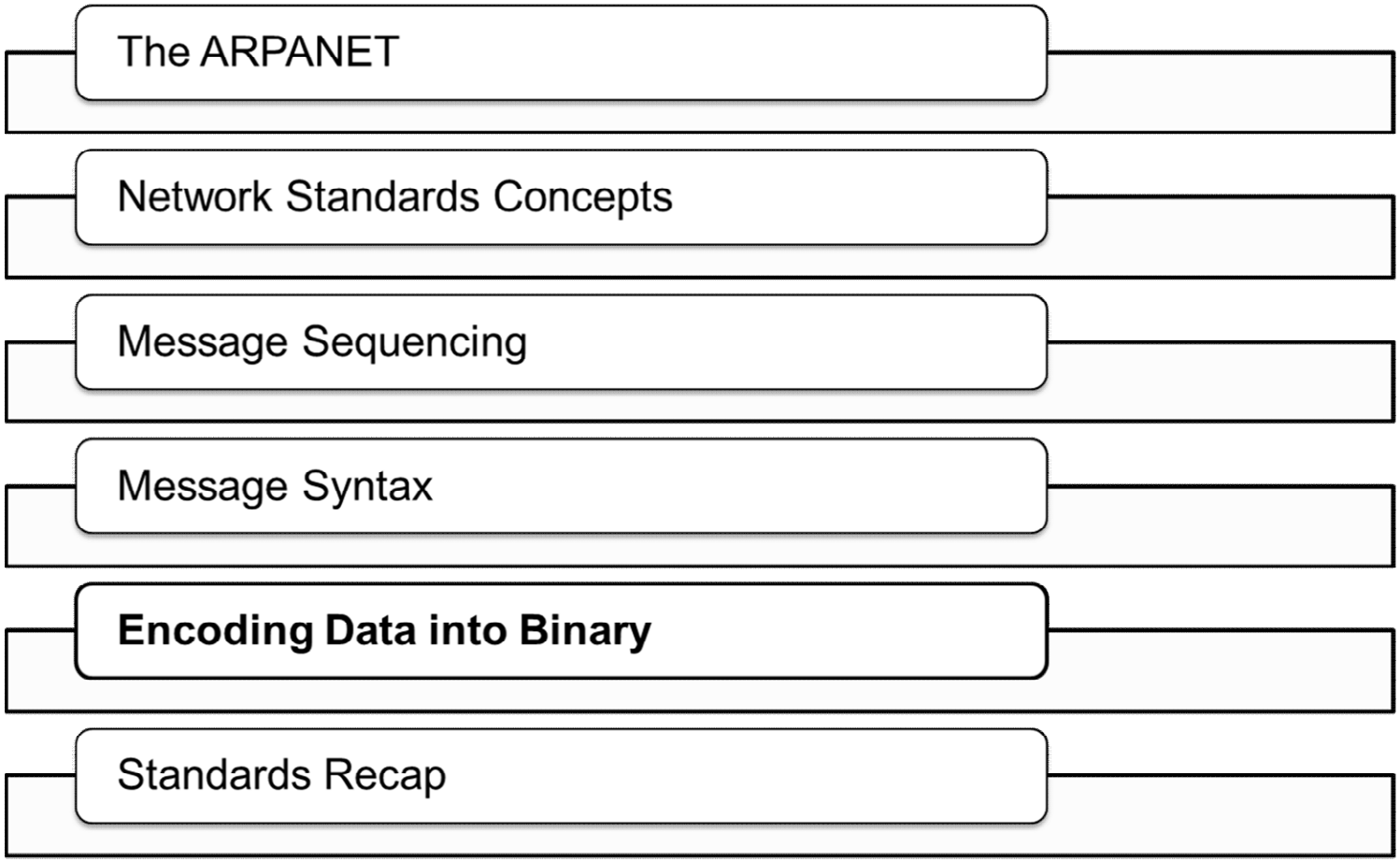
Frame Check Sequence (4 octets)

If there is an error, the receiving data link layer process discards the frame

There is no retransmission for discarded frames, so Ethernet is **unreliable**

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Encoding Data into Binary (1 of 2)



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Encoding Data into Binary (2 of 2)

- An application can store data in many formats—text, sounds, numbers, etc.
- These must be stored as binary data to be transmitted
- It is the application's job to convert data into binary formats
- This conversion is called encoding
- We will look at a few types of encoding here

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2.19 Encoding Text as Binary

Category	Example	7-Bit ASCII Code	8th bit in Byte
Upper-Case	A	1000001	Unused
Lower-Case	a	1100001	Unused
Digits (0-9)	3	0110011	Unused
Punctuation	Period	0101110	Unused
Punctuation	Space	0100000	Unused
Control Codes	Carriage Return	0001101	Unused
Control Codes	Line Feed	0001010	Unused

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2.20 Encoding Decimal to Binary

0	Decimal number	11						
1	Bit position, b (begins with 0 from right)	6	5	4	3	2	1	0
2	Position Exponent	2^6	2^5	2^4	2^3	2^2	2^1	2^0
3	Position value, 2^b	64	32	16	8	4	2	1

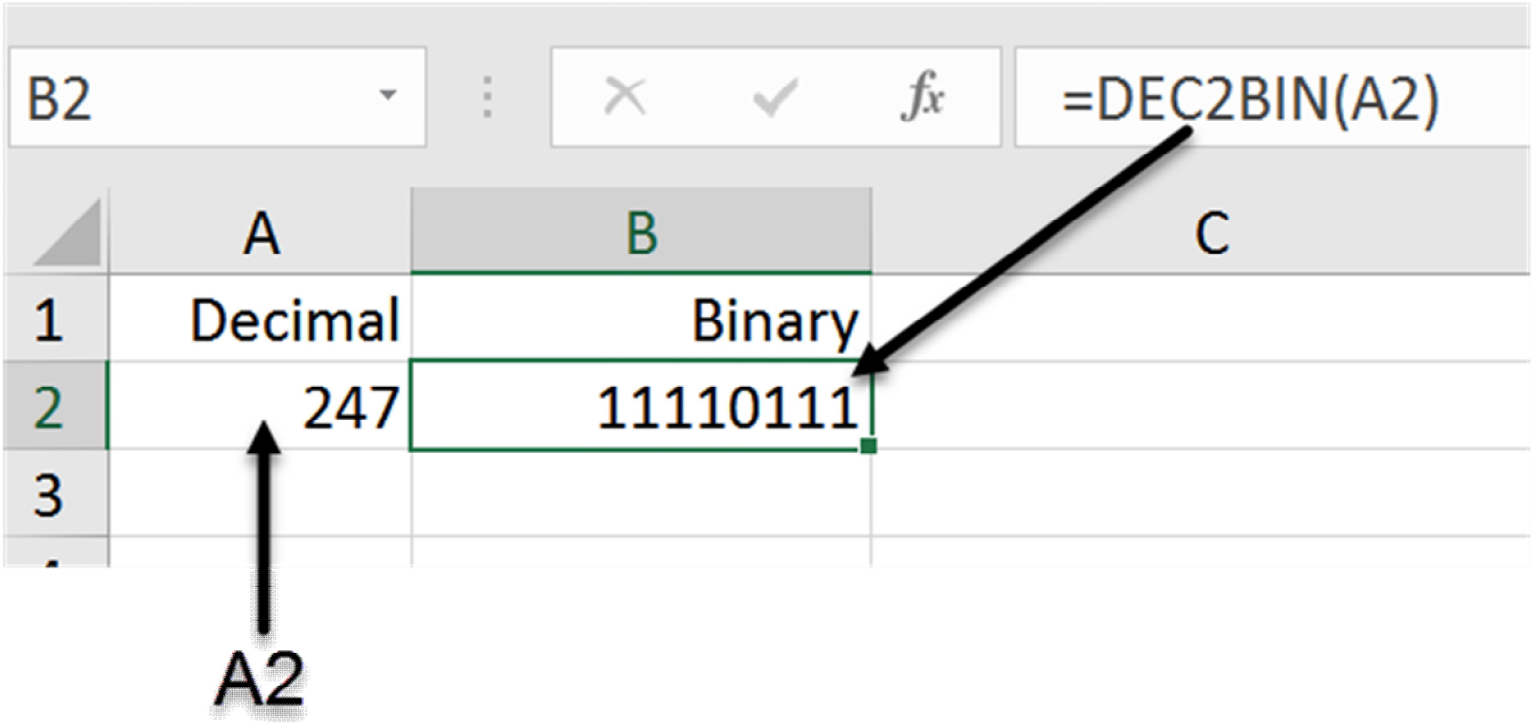
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2.20 Encoding Decimal as Binary

3	Position value, 2^b	64	32	16	8	4	2	1
4	Available positions <= 11	-	-	-	x	x	x	x
5	Combination that produces 11	-	-	-	1	0	1	1
6	The number in binary	1011						

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2.21 Converting Decimal to Binary in Excel



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2.22 Converting Binary to Decimal

Binary number	1010				
Bit position, b	4	3	2	1	0
Position Exponent	2^4	2^3	2^2	2^1	2^0
Position value, 2^b	16	8	4	2	1
Binary number	0	1	0	1	0
Decimal Equivalents	0	8	0	2	0
Decimal Representation	$1010 = 1*8 + 1*2 = 10$				

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2.23 Number of Alternative $a = 2^b$ (1 of 4)

Bits in Field (b)	Number of Alternatives that can be Encoded (a)	Possible Bit Sequences	Examples
1	$2^1 = 2$	0, 1	Yes or No, Connection-oriented or connectionless, etc.
2	$2^2 = 4$	00, 01,10, 11	North, South, East, West; Red, Green, Blue, Black

$a = 2^b$

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2.23 Number of Alternative $a = 2^b$ (2 of 4)

Bits in Field (b)	Number of Alternatives that can be Encoded (a)	Possible Bit Sequences	Examples
4	$2^4 = 16$	0000, 0001, 0010, …	Top 10 security threats: 3 bits would give 8 alternatives. Not enough, 4 bits works. 6 values go unused
8	$2^8 = 256$	00000000, 00000001, …	One byte per color gives 256 possible colors levels

$a = 2^b$

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2.23 Number of Alternative $a = 2^b$ (3 of 4)

Bits in Field (b)	Number of Alternatives that can be Encoded (a)	Possible Bit Sequences	Examples
16	$2^{16} = 65,536$	0000000000000000, 0000000000000001, '…	Two bytes per color gives 65,536 color levels
32	$2^{32} = 4,294,967,296$	0000000000000000 0000000000000000, etc.	Number of Internet Protocol Version 4 addresses

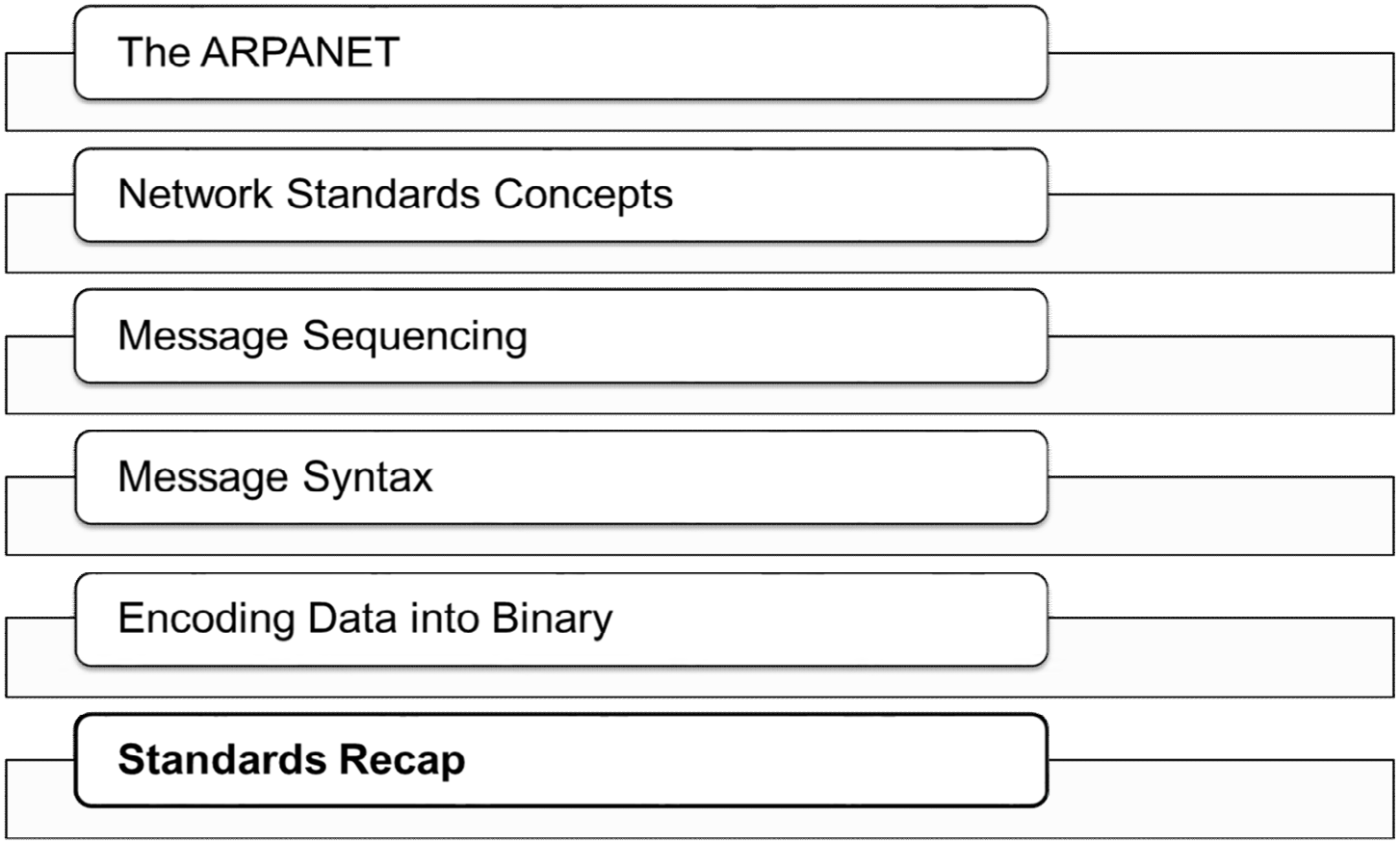
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2.23 Number of Alternative $a = 2^b$ (4 of 4)

- Each added bit **doubles** the number of alternatives
  - 8 bits = 256 alternatives
  - 9 bits = 512 alternatives
  - 10 bits = 1,024
- Each subtracted bit halves the number of alternatives
  - 4 bits = 16 alternatives
  - 3 bits = 8 alternatives
- From the above
  - How many alternatives can you have with 7 bits?
  - How many alternatives can you have with 17 bits?

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Standards Recap



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2.24 Protocols in This Chapter

Layer	Protocol	Reliable or Unreliable?	Connection-Oriented or Connectionless
5	HTTP	Unreliable	Connectionless
4	TCP	Reliable	Connection-Oriented
4	UDP	Unreliable	Connectionless
3	IP	Unreliable	Connectionless
2	Ethernet	Unreliable	Connectionless

Which of these is not like the others?

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