Chapter 2

Network Standards

Standards Govern Message Exchanges

Network Standards (Protocols)

Message Order, Semantics, and Syntax

Test Your Understanding

1. a) Give the definition of network standards that this chapter introduced.

   Network standards govern the exchange of messages between hardware or software processes on different host computers, including message order, semantics, syntax, reliability, and connection orientation.

   b) What three things about message exchanges do network standards govern?

   Message order, semantics, and syntax

   c) Give an example not involving networking in which the order in which you do things can make a big difference.

   Answers will vary

   Example: Installing a printer on a computer (when to power it on, etc.)

   d) Distinguish between syntax and semantics.

   Syntax governs the organization of messages.

   Semantics defines the meaning of messages.

Syntax: General Message Organization

Test Your Understanding

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

   The three general parts of messages are the header, the data field, and the trailer.

   b) What does the data field contain?

   The data field contains the content delivered by the message.

   c) What is the definition of a header?

The header is everything that comes before the data field.

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

No, there is not always a data field in a message.

e) What is the definition of a trailer?

The trailer is everything that comes after the data field.

f) Are trailers common?

No, trailers are not common. <When a trailer exists, it is usually at the data link layer, and not even all data link standards use them.>

g) Distinguish between headers and header fields.

The header is everything that comes before the data field. A header field is a subdivision of the header.

Reliability and Connections

Reliability

Test Your Understanding

3. a) What is reliability?

Reliability is the condition wherein errors are corrected by resending lost or damaged messages.

b) How does TCP implement reliability?

TCP implements reliability with its use of acknowledgements (ACKs). The receiver acknowledges every correctly received TCP segment. The original sender retransmits any segments that are not acknowledged.

c) In TCP, what is the receiver's role in reliability?

In TCP, the receiver's role in reliability is to send back an ACK segment for every correct TCP segment it receives.

d) In TCP, what is the sender's role in reliability?

In TCP, the sender's role in reliability is to resend a segment for which it does not receive an acknowledgement.

e) What is the disadvantage of reliability?

It places a heavy load on computers.

Connection-Oriented and Connectionless Protocols

Connectionless and Unreliable Protocols Dominate

Test Your Understanding

4. a) Distinguish between connectionless and connection-oriented protocols.

Connection-oriented services have explicit openings and closings. In contrast, connectionless services do not establish connections before transmitting or close the connection after they have finished transmitting.

b) Which can have sequence numbers?

Connection-oriented service can have sequence numbers.

c) What are the advantages that sequence numbers bring to connection-oriented protocols?

Thanks to sequence numbers, the parties can tell when a message is lost. (There will be a gap in the sequence numbers.)

Acknowledgements can refer to specific messages according to the sequence numbers of these messages.

Long messages can be fragmented into many smaller messages that can fit inside of packets. The fragments will be given sequence numbers so that they can be assembled at the other end. **Fragmentation** followed by **reassembly** is an important concept in networking.

Messages can refer to an earlier message by sequence number. This is important in database-based transaction processes where several messages must be exchanged to make a purchase, record a transaction, or do some other common business task.

d) Explain fragmentation and reassembly.

The sender divides a message into a number of fragments small enough to fit into individual packets.

Each fragment is given a sequence number.

The receiver reassembles the fragments by sequence number into the original message.

e) What is the disadvantage of connection-oriented protocols?

They are expensive, placing a heavy load on networks and computers.

f) Are most protocols connectionless or connection-oriented?

Most are connectionless.

g) Are most protocols reliable or unreliable?

Most are unreliable

Layered Standards Architectures

Architectures

Test Your Understanding

5. a) What is a network architecture?

   A network architecture is a broad plan that specifies everything necessary for two application programs on different networks on an internet to be able to work together effectively.

   b) What is the most popular network architecture today?

   The most popular standards architecture for networking today is the Hybrid TCP/IP–OSI Architecture.

   c) In layered standards architectures, to what layer or layers does a layer provide service?

   In layered standards architecture, each layer provides services to the layer above it.

6. Why do standards architectures break down the standards development process into layers?

   First, it is a good strategy to break up a major task into individual, more manageable, pieces.

   Second, breaking down the standards development process into layers allows team members to be assigned individual tasks that suit their skills—for example having specialists in a particular application create application layer standards without having to worry about physical layer standards.

   Third, layering means that development at one layer is freed of concerns at other layers.

   Fourth, layering allows standards to be updated or changed at various layers independently.

Layer 1 and Layer 2 Standards for Switched Networks (Switched LANs and WANs)

Physical Links

Test Your Understanding

7. a) What devices does a physical link connect?

   A physical link connects adjacent devices connected by a transmission medium—a computer to a switch, a switch to a switch, or a switch to a router.

   b) What is a data link?

   A data link is the path that a frame takes across a single switched network.

c) Five switches separate two computers on a switched network. How many physical links are there between the two computers?

There are six physical links between the two computers.

d) How many data links are there between them?

There is one data link between them.

e) What do data link layer standards govern?

Data link layer standards govern the transmission of frames across a single switched network—typically by sending them through several switches along the data link. Data link standards also govern frame organization, reliability, and other matters.

f) Which layers govern switched LAN transmission?

The physical and data link layers govern switched LAN transmission. (A switched LAN is a single switched network.) Students need to do some thinking here. They know from Chapter 1 that a switched LAN is a single switched network. They know from this chapter that single switched networks involve the physical and data link layers and only these layers.

g) Which layers govern switched WAN transmission?

The physical and data link layers govern switched WAN transmission.

Standards for Routed Network Transmission (Layers 3 and 4)

Test Your Understanding

8. a) What do the internet and transport layers do collectively?

Collectively, the internet and transport layers govern the communication between two end hosts across an internet.

b) Distinguish between what the internet and transport layer standards govern.

Internet layer standards govern the transmission of packets across an internet—typically by sending them through several routers along the route. Internet layer standards also govern packet organization and other matters.

Transport layer standards govern the aspects of end-to-end communication between two end hosts that are not handled by the internet layer.

c) What is the main internet layer standard?

The Internet Protocol (IP).

d) What errors does the transport layer usually fix?

The transport layer usually fixes all errors created at the transport layer or lower layers.

e) What does it mean in this book if *internet* is spelled with a lower-case *i*?

It refers to a single routed network or to the internet layer.

Test Your Understanding

9. a) What do application layer standards govern?

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

   b) Which layer has the most standards? Why is this the case?

   The application layer has the most standards.

   This is the case because there are many different applications, each with its own standard.

Layers 1 (Physical) and 2 (Data Link) in Ethernet

Ethernet Physical Layer Standards

Test Your Understanding

10. What does the sending physical layer process do with the bits of the frame?

    It translates them into signals.

Ethernet Frames

Test Your Understanding

11. What is an octet?

    An octet is a collection of eight bits. <This is the same as a byte.>

12. a) How many bits long are Ethernet addresses?

    Ethernet addresses are 48 bits long.

    b) When are Ethernet addresses set on NICs?

    Ethernet addresses are set on NICs at the factory before the card ships.

    c) In what notation are Ethernet addresses typically written for human reading?

    Ethernet addresses are typically written in hexadecimal notation for human reading.

    d) What device in an Ethernet network besides the destination host reads the Ethernet address?

    Switches between the source and destination hosts read the Ethernet address.

    e) What is its purpose in reading the Ethernet address?

    The switch's purpose in doing so is to look up the Ethernet address in the switching table so that the switch can decide which port number to select to send the frame back out.

13. Where is the IP packet carried in an Ethernet frame?

    The Ethernet data field usually contains an IP packet.

14. a) How many *bits* long is the Ethernet frame check sequence field?

The Ethernet frame check sequence field is 32 bits long.

b) What is the purpose of the Ethernet frame check sequence field?

Its purpose is to allow the receiver to detect whether errors have occurred during transmission.

c) How does the receiving NIC use the value in the frame check sequence field?

The receiving NIC recomputes the frame check sequence number and compares its result with the value contained in the frame check sequence field. If the two do not match, the receiving NIC knows that an error must have occurred during transmission.

d) What happens if a receiving NIC detects an error?

If a receiving NIC detects an error, the NIC's data link layer process simply discards the frame. There is no request for retransmission.

e) Does this error detection and discarding process make Ethernet a reliable standard? Explain.

This error detection and discarding process does not make Ethernet a reliable standard, because there is no error correction.

Ethernet Is Unreliable and Connectionless

Test Your Understanding

15. a) Is Ethernet connectionless or connection-oriented? Explain.

Ethernet is connectionless. NICs send Ethernet frames without opens, closes, acknowledgements, or sequence numbers.

b) Is Ethernet reliable or unreliable? Explain.

Ethernet is unreliable. Errors are detected, but they are not corrected.

Layer 3: The Internet Protocol (IP)

Layer 2 versus Layer 3

Test Your Understanding

16. a) Four switched networks are involved in transmissions from the source to the destination host. How many packets will there be along the way when the source host transmits a packet?

There will be one packet.

b) How many frames will there be along the way?

There will be four frames.

c) How many routes will there be along the way?

There will be one route.

d) How many data links will there be along the way?

There will be four data links.

e) How many destination IP addresses will there be?

There will be one destination IP address (that of the destination host).

f) How many data link layer destination addresses will there be?

There will be four data link layer destination addresses.

g) In the data link layer destination address field of the frame in the first switched network, the destination address is the destination address of which device?

The data link layer address of the router that connects the first and second switched networks will be the Layer 2 data link layer destination address of the frame. <Actually, the data link layer address of the port into which the frame arrives. Each port on the router has a different data link layer address.>

h) What will be the destination IP address of the packet contained in that frame?

The IP address of the destination host.

The IP Packet

Test Your Understanding

17. a) How many octets long is an IP header if there are no options? (Look at Figure 2-12.)

If there are no options, the IP header will be 20 octets.

b) What is the bit number of the first bit in the destination address field? (Remember that the first bit in binary counting is Bit 0.)

128. <The first bit on each line is 0, 32, 64, 96, and 128.>

c) How long are IP addresses?

IP addresses are 32 bits long.

d) You have two addresses: B7-23-DD-6F-C8-AB and 217.42.18.248. Specify what kind of address each address is.

B7-23-DD-6F-C8-AB is an Ethernet address.

217.42.18.248 is an IP address.

e) What device in an internet besides the destination host reads the destination IP address?

Each router along the way reads the destination IP address.

f) What is this device's purpose in doing so?

The router reads the IP address in order to learn how to forward the IP packet to the next router or to the destination host itself.

IP Characteristics

Test Your Understanding

18. a) Is IP connectionless or connection-oriented?

IP is connectionless.

b) Is IP reliable or unreliable?

IP is unreliable.

Layer 4: The Transport Layer

Layers 3 and 4

Test Your Understanding

19. Ten routers separate two hosts. a) How many internet layer processes will be active on the two hosts and the routers between them?

There will be 12, one on each router and host.

b) How many transport layer processes will be active? (The answer is not directly in the book. You will have to think about this one a little.)

Two will be active: one each on the source and the destination hosts.

c) Which layers are hop-by-hop layers? (The physical layer is not considered to be either a hop-by-hop or an end-to-end layer.)

The internet and data link layers are hop-by-hop layers.

d) Which layers are end-to-end layers? (The physical layer is not considered to be either a hop-by-hop or an end-to-end layer.)

The application and transport layers are end-to-end layers.

TCP: A Reliable Protocol

Test Your Understanding

20. a) Why are most standards unreliable?

Most standards are unreliable because reliability is expensive. It takes a great deal of processing power to test for errors and to implement retransmission. It also places a heavy burden on internet traffic because of acknowledgements and the other supervisory traffic needed to implement reliability.

b) For what two reasons is making TCP reliable a good choice?

Making TCP reliable is a good choice because TCP operates at the highest level below the application layer, so TCP can provide error-free data to the application program without each lower layer having to do error correction.

In addition, TCP is an end-to-end layer, so error correction only has to be done on the two hosts.

The User Datagram Protocol (UDP)

Test Your Understanding

21. Compare TCP and UDP in terms of layer of operation, connection-orientation, reliability, and burden (traffic and processing on devices).

    Both protocols work at the transport layer. While TCP is connection-oriented and reliable, so it is burdensome on the two hosts and on the network, UDP is connectionless and unreliable, so it places a lighter load on the two hosts and the network.

The Only Protocols at the Transport Layer

Test Your Understanding

22. At the transport layer, what are the only TCP/IP protocols?

    TCP and UDP.

Layer 5: HTTP and Other Application Standards

Test Your Understanding

23. a) Is the application layer standard always HTTP?

    No, the application layer standard is not always HTTP.

    b) Which layer has the most standards?

    The standard at the application layer standard is always HTTP.

    c) At which layer would you find standards for instant messaging? (The answer is not explicitly in this section.)

    Instant messaging is an application, so one would expect to find standards for instant messaging at the application layer.

Vertical Communication on Hosts, Switches, and Routers

Layered Communication on the Source Host

Test Your Understanding

24. a) When a layer creates a message, what does it usually do immediately afterward?

When a layer creates a message, it usually passes the message down to the next-lower layer immediately.

b) What does the layer below it usually do after receiving the next-higher-layer message?

After receiving the next-higher-layer message, a layer usually encapsulates the received message in the data field of its own message. It then adds a header and, sometimes, a trailer.

<Why "usually?" First, TCP may first have to fragment the application message into several TCP messages (segments).>

<Second, as we will see in Chapter 8, when TCP receives the first application message to a destination host, what it does depends on whether there is a connection open to the TCP process on the destination host. If there is a connection open, the TCP process will encapsulate the application message and pass it on immediately. However, if no connection is open, the TCP process will open a connection. After it opens a connection to that host and application, it will deliver the message.>

c) What is encapsulation?

Encapsulation is placing a message in the data field of another message.

d) With 'Web communication using HTTP, what message does IP encapsulate in packet data fields?

IP encapsulates the TCP segment (alternatively, a TCP header and HTTP message).

25. a) What are the two steps after a layer process creates its layer message?

When a layer N creates its message, the layer process passes the message down to the next-lower (N - 1) layer.

The N - 1 layer encapsulates the message in the data field of the Layer N - 1 message and adds a Layer N - 1 header and (at the data link layer only) perhaps a layer N - 1 trailer. The Layer N - 1 process repeats the cycle.

b) What is the final frame if SMTP (an e-mail protocol that requires TCP) is used at the application layer and if Frame Relay (which has a header and a trailer) is used instead of Ethernet at the data link layer?

The final frame will be a Frame Relay header, an IP header, a TCP header, an SMTP message, and a Frame Relay trailer.

c) What is the final frame if SNMP (which requires UDP) is used at the application layer and if the ATM data link layer protocol (which has a header but no trailer) is used instead of Ethernet at the data link layer?

The final frame will be an ATM header, an IP header, a UDP header, and an SNMP message.

On the Destination Host

Test Your Understanding

26. a) Which host decapsulates—the sending host or the receiving host?

The receiving host decapsulates.

b) Describe what each layer's process does on the receiving host when the host receives an Ethernet frame containing an HTTP message.

The physical layer process turns the signals into the bits of the frame and passes the frame to the data link layer.

The data link layer process checks the Ethernet frame for errors. If there are no errors, it decapsulates the IP packet and passes the packet up to the internet layer process.

The internet layer process checks the IP packet header for errors. If there are no errors, it decapsulates the TCP segment and passes the segment up to the transport layer process.

The transport layer process checks the TCP segment for errors. If there are no errors, it decapsulates the HTTP message and passes this message up to the HTTP application layer process.

On Switches and Routers along the Way

Test Your Understanding

27. a) Why are switches called Layer 2 devices?

Switches are called Layer 2 devices because the highest layer in switching is the data link layer (Layer 2).

b) Why are routers called Layer 3 devices?

Routers are called Layer 3 devices because the highest layer in routing is the internet layer (Layer 3).

c) Do routers first encapsulate or decapsulate? (The answer is not explicitly in the text. Look at Figure 2-17.)

Routers first decapsulate packets from incoming frames, then encapsulate packets in new frames for sending out another port.

Layering on a Source Router

Test Your Understanding

28. a) Why is there no transport or application content to the final frame in Figure 2-18?

The internet layer initiates the ICMP message transmission. Higher layers are not involved at all, so there are no higher-layer messages or headers.

b) To create the frame in the figure, at what layer do you begin?

Layer 3

c) At what layer is an ICMP message?

Layer 3

Combining Vertical and Horizontal Communication

Test Your Understanding

29. To what software process is the transport layer message addressed?

To the transport layer process on the destination host.

Major Standards Architectures

TCP/IP and OSI Architectures

Test Your Understanding

30. a) What is a standards architecture?

A standards architecture is a family of related standards that collectively allow an application program on one machine on an internet to communicate with another application program on another machine on that same internet.

b) What are the two dominant network standards architectures?

The two dominant network standards architectures are OSI and TCP/IP.

c) Are they competitors?

Although OSI and TCP/IP sometimes are viewed as competitors, they actually work together in most corporate networks.

Test Your Understanding

31. a) What standards agencies are responsible for the OSI standards architecture? Just give the acronyms.

The standards agencies responsible for the OSI standards architecture are the International Organization for Standardization (ISO) and the International Telecommunications Union–Telecommunications Standards Sector (ITU-T).

b) At which layers do OSI standards dominate usage?

OSI is dominant at the physical and data link layers.

c) Name and describe the functions of OSI Layer 5.

OSI Layer 5 is the OSI session layer. It initiates and maintains a connection between application programs on different computers. It is especially good for database applications. If communication fails during a transaction, the entire transaction does not have to be done over—only the work since the last rollback point.

d) Name and describe the intended use of OSI Layer 6.

OSI Layer 6 is the OSI presentation layer. It is designed to handle data formatting differences between two computers, as well as compression and encryption.

e) How is the OSI presentation layer actually used?

The OSI presentation layer is actually used as a category for data file formats.

f) Beginning with the physical layer (Layer 1), give the name and number of the OSI layers.

1. Physical
2. Data link
3. Network
4. Transport
5. Session
6. Presentation
7. Application

TCP/IP

Test Your Understanding

32. a) Which of the following is an architecture: TCP/IP, TCP, or IP?

TCP/IP is an architecture.

b) Which of the following are standards: TCP/IP, TCP, or IP?

TCP and IP are standards.

c) What is the standards agency for TCP/IP?

The standards agency for TCP/IP is the Internet Engineering Task Force (IETF).

d) Why have this agency's standards been so successful?

IETF TCP/IP standards have been successful because they tend to be simple standards that can be implemented quickly and inexpensively. <Not primarily because of the use of these standards on the Internet.>

e) What are most of this agency's documents called?

Most of this agency's documents are called requests for comment (RFCs).

f) At which layers is TCP/IP dominant?

TCP/IP is dominant at the internet and transport layers.

g) How dominant is TCP/IP today at these layers compared with OSI's dominance at the physical and data link layers?

TCP's dominance at these layers is not nearly universal, as OSI's dominance at the physical and data link layers is.

The Application Layer

Test Your Understanding

33. a) Is any standards architecture dominant at the application layer?

No standards architecture is dominant at the application layer, although IETF protocols are widely used.

b) Do almost all applications run over TCP/IP standards at the internet and transport layers?

Yes.

TCP/IP *and* OSI: The Hybrid TCP/IP–OSI Standards Architecture

Test Your Understanding

34. a) What layers of the hybrid TCP/IP–OSI standards architecture use OSI standards?

The physical and data link layers of the hybrid TCP/IP–OSI standards architecture use OSI standards.

b) What layers use TCP/IP standards?

The internet and transport layers primarily use TCP/IP standards.

c) Do switched LAN standards come from OSI or TCP/IP? Explain. (The answer is not explicitly in this section.)

Switched LAN standards come from OSI because switched LANs are single switched networks.

d) Do switched WAN standards come from OSI or TCP/IP? Explain. (Again, the answer is not explicitly in this section.)

Switched WAN standards come from OSI because WANs are single switched networks even if they are very large.

A Multiprotocol World at Higher Layers

Test Your Understanding

35. a) Under what circumstances might you encounter IPX/SPX standards?

You might encounter IPX/SPX standards if Novell NetWare servers were being used.

b) SNA standards?

You might encounter SNA standards if IBM mainframe computers were communicating over the network.

c) AppleTalk standards?

You might encounter AppleTalk standards if Apple Macintoshes were communicating over the network.

Conclusion

Synopsis

End-of-Chapter Questions

Basic Thought Questions

1. ~~To open a TCP connection to the transport layer process on Host B, the TCP process on host A sends a TCP SYN segment. What will the final frame be that Host A sends if Host A is on a Frame Relay (FR) switched network? FR frames have both headers and trailers. The application layer process is not at all involved in the connection-opening attempt.~~

   ~~FR-H IP-H TCP-H FR-T~~

   ~~Note that there is no TCP message. Start with the TCP header at L4.~~

   ~~Then add the IP header (there is no IP trailer) at L3~~

   ~~Then add the FR header and trailer at L2~~

2. Figure 2-11 shows the fields in an Ethernet frame. Ethernet is the dominant standard for switched LANs. However, there are many other data link standards. One example is the Point-to-Point Protocol (PPP). This protocol is used at the data link layer to connect two routers with a point-to-point leased line from the telephone company. PPP frames begin and end with a one-octet flag field containing the content 01111110. These unambiguously signal the start of a new frame and the end of that frame, respectively. The second two octets always have the values 11111111 and 00000011. These are the address and control fields, respectively. They exist for historical reasons that are no longer important. Obviously, there is no need for an address field in a point-to-point connection, and the function of the control field has been replaced by the advanced use of the data field for supervisory communication. The next two octets form the protocol field, which describes the contents of the data field. If the PPP frame is delivering a packet, the protocol field contains the value 8021h. In PPP, this data field is called the information field. It can be up to 1500 octets long, although a shorter value can be negotiated. Next comes the frame check sequence field. As in Ethernet, this field is used to detect errors. If the receiver detects an error, it simply discards the frame. There are no acknowledgements.

   a) Which fields form the PPP header?

   Start flag, address field, control field, and protocol field form the PPP header

b) Which fields form the PPP trailer?

Frame check sequence field, stop flag form the PPP trailer

c) Figure 2-15 shows the final frame when an HTTP application transmits an application message over an Ethernet switched network. Give the final frame if PPP is used instead of Ethernet. Just say *PPP header* and *PPP trailer*. Do not give details regarding the fields that make up the PPP header and trailer.

PPP header, IP header, TCP header, HTTP message, *PPP trailer*.

d) Give the final frame if the application is SNMP, which requires UDP at the transport layer. The protocol is still PPP at the data link layer. Again, just say *PPP header* and *PPP trailer*. Do not give details regarding the fields that make up the PPP header and trailer.

PPP header, IP header, UDP header, SNMP message, PPP trailer

e) When TCP sends a pure acknowledgement, it transmits a TCP message that only has a header. The application layer is not involved at all in the acknowledgement process. Give the final frame when the packet travels over an Ethernet LAN.

Ethernet header, IP header, TCP header, Ethernet trailer

3. a) In Figure 2-19, how many switched networks, physical links, data links, and routes are shown? b) In Figure 2-19, how many data link, internet, transport, and application processes in total are involved in the transmission?

3 switched networks.

6 physical links.

3 data links. (one in each switched network)

1 route.

b) Figure 2-19, how many data link, internet, transport, and application **processes** in total are involved in the transmission?

9 data link processes (one on each host and switch and two on each router).

4 internet layer processes (one each on the two hosts and the two routers).

2 transport processes (one each on the source and destination hosts).

2 application processes (one each on the source and destination hosts).

4. Ethernet stations need Ethernet addresses. Do Ethernet switches need to have Ethernet addresses too when they forward frames? Explain your reasoning.

No. For frame forwarding, Ethernet switches merely look at frame Ethernet destination addresses and pass on the frames. This does not require switches to have Ethernet addresses themselves.

<However, for managed switches, there has to be a way for switches to talk to one another. This does require each to have an Ethernet address.>

Even Harder Thought Questions

1. Normally, only the transport layer standard is reliable. However, in Chapter 5, we will see that 802.11 wireless LAN standards at the data link layer are reliable. Why do you think this is so? (Hint: Review the logic in Figure 2-13 for clues.)

Radio transmission has high error rates, making frame-by-frame error correction highly valuable. In contrast, physical transmissions on wire or optical fiber have very low error rates, so error correction at the data link layer for every frame makes no sense.

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

   Both segments would have the same sequence number. The receiving transport process would realize this and drop the duplicate.

3. You can place both TCP/IP clients and servers and IPX clients and servers on the same Ethernet network, and each client will talk to its server. How do you think this is possible? (Hint: Consider the Ethernet frame in Figure 2-11.)

   Consider the Ethernet frame. Packets are carried in the data field. Ethernet frames do not care what architecture the packets come from. They simply deliver packets. Therefore, there is no problem if different frames going between different pairs of devices carry different packets in their data fields.

   To give an analogy, in a single freight train, different freight cars can carry different goods.

4. How can you make a connectionless protocol reliable? (Try to answer this one, but you may not be able to do so.)

   You do not have sequence and acknowledgement numbers.

   So you have to send one message, then stop and wait for an acknowledgement before sending the next messages.

   This is very slow compared with being able to send many messages before getting acknowledgements, as TCP can do.

5. Spacecraft exploring the outer planets need reliable data transmission. However, the acknowledgements would take hours to arrive. This makes an ACK-based reliability approach unattractive. Can you think of another way to provide reliable data transmission to spacecraft? (Try to answer this one, but you may not be able to do so.)

   Spacecraft transmission uses forward error correction (FEC), in which messages are sent with redundant bits. There is enough redundancy in messages to allow the receiver to correct most errors during transmission.

   <FEC also is used in wireless LAN transmission because of the high error rates in wireless transmission.>

Perspective Questions

1. What was the most surprising thing you learned in this chapter?
2. What was the most difficult material for you in this chapter?

Getting Current

Go to the book website's New Information and Errors pages for this chapter to get new information since this book went to press and for corrections to any errors in the text.

