Layered Standards Architectures

Chapter 2

Panko's *Business Data Networks and Telecommunications, 5th edition*

Why Layers

- Breaking up large tasks into smaller tasks and assigning tasks to different individuals is common in all fields
- Specialization in standards design (EEs for physical layer, application specialists for application layer, etc.)
- Simplification in standards design for individual standards
- If you change a standard at one layer, you do not have to change standards at other layers

OSI, TCP/IP, and Other Standards Architectures

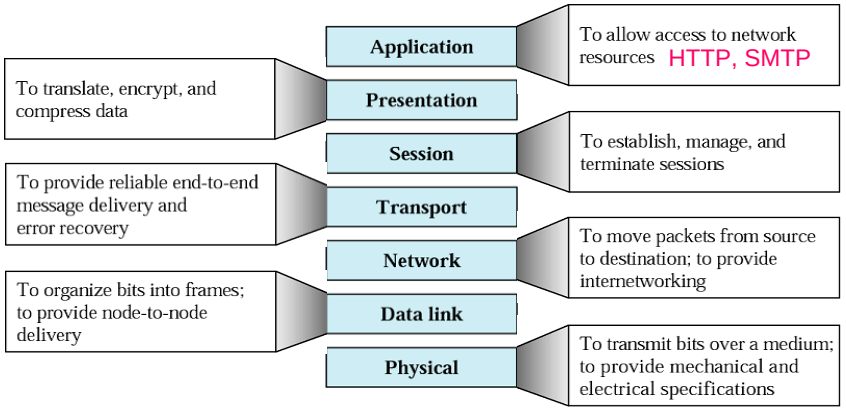
ISO/OSI Model

- OSI(Open Systems Interface) Model :
  - developed by ISO
    - International Organization for Standardization
  - Open system means that
    - it can communicate with any other systems that follows the specified standards (semantics, syntaxs, timing)
  - seven layers

ISO/OSI Model, Continued

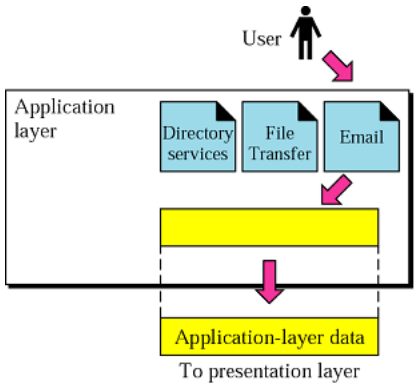
Application	第七層 應用層
Presentation	第六層 展示層
Session	第五層 會議層
Transport	第四層 傳輸層
Network	第三層 網路層
Data link	第二層 資料連結層
Physical	第一層 實體層

ISO/OSI Model, Continued

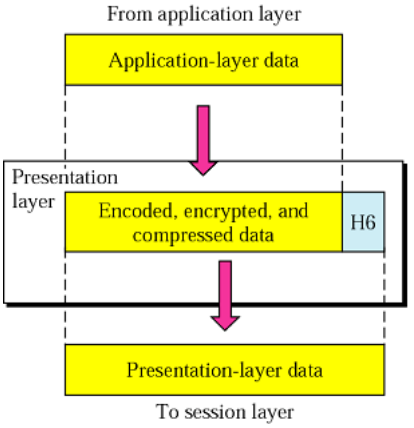


ISO/OSI Model - Application Layer Downward

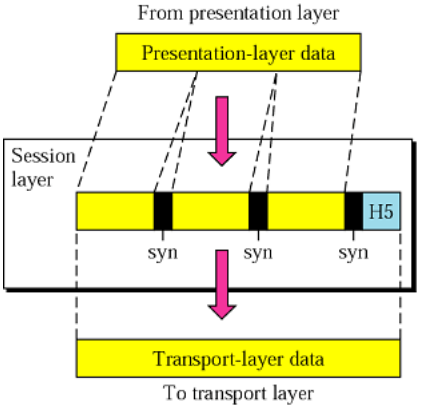
The application layer governs how two applications work with each other, even if they are from different vendors



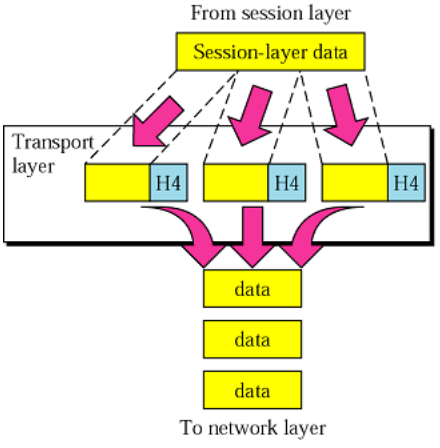
ISO/OSI Model - Presentation Layer Downward



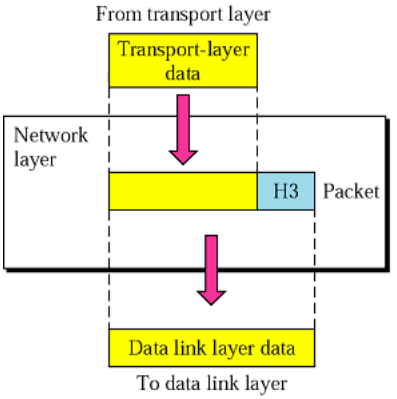
ISO/OSI Model - Session Layer Downward



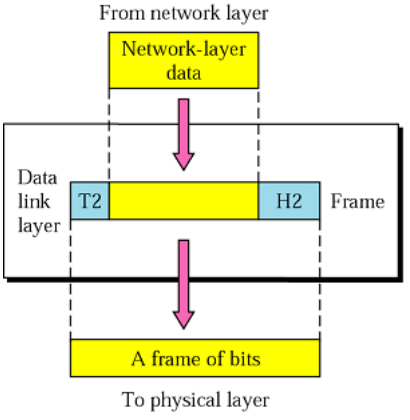
ISO/OSI Model - Transport Layer Downward



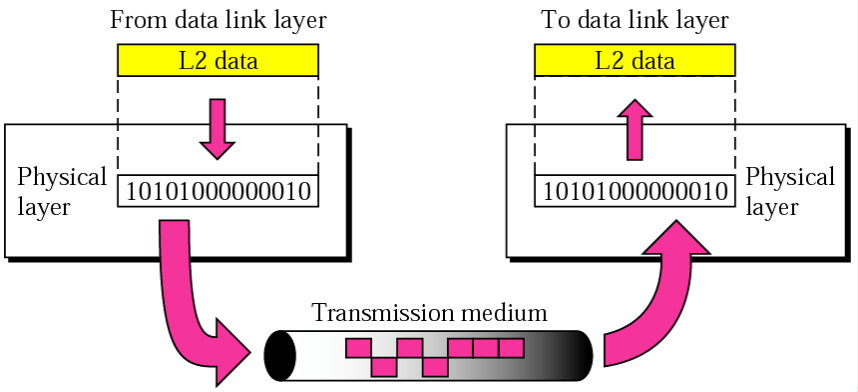
ISO/OSI Model - Network Layer Downward



ISO/OSI Model - Data Link Layer Downward

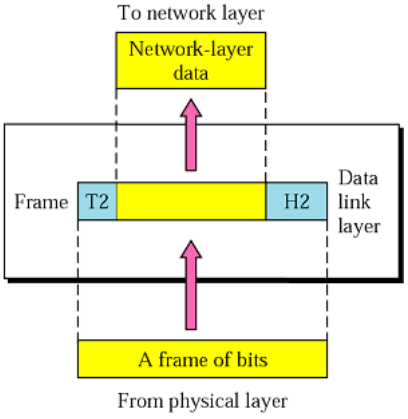


ISO/OSI Model - Physical Layer Downward and Upward

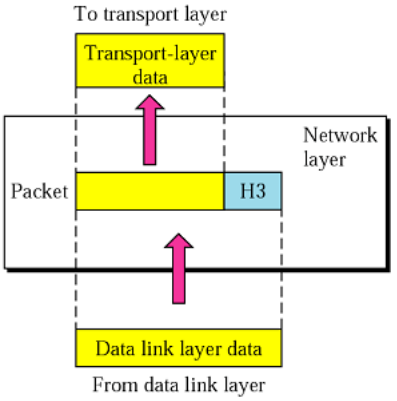


SerDes: Serialize and Deserialize

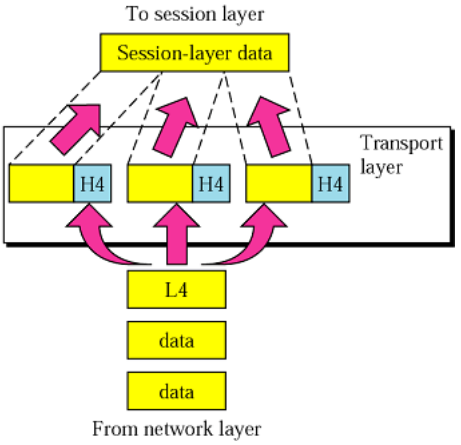
ISO/OSI Model - Data Link Layer Upward



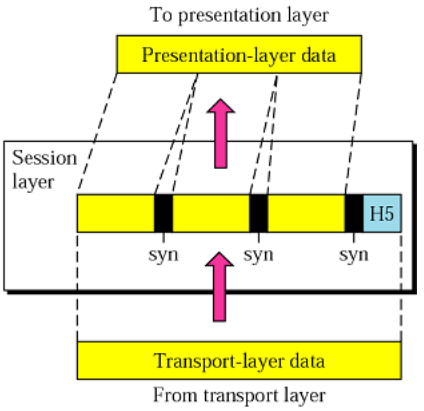
ISO/OSI Model - Network Layer Upward



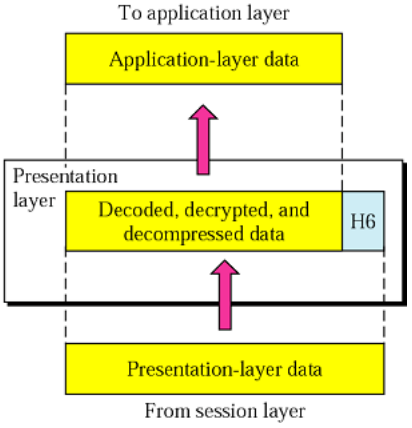
ISO/OSI Model - Transport Layer Upward



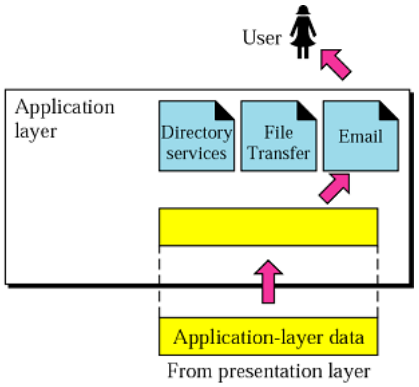
ISO/OSI Model - Session Layer Upward



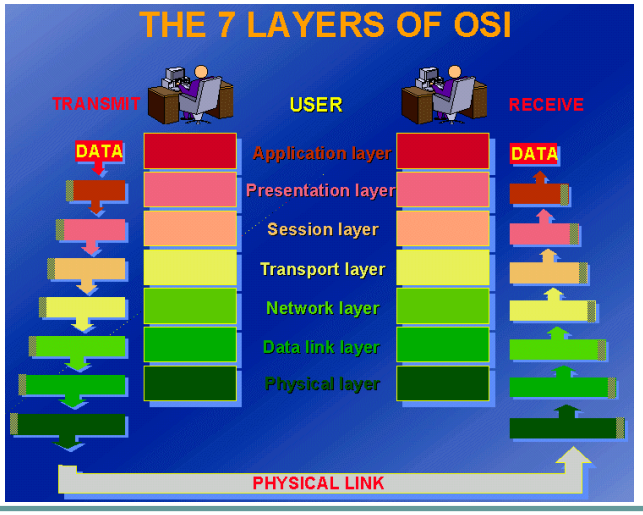
ISO/OSI Model - Presentation Layer Upward



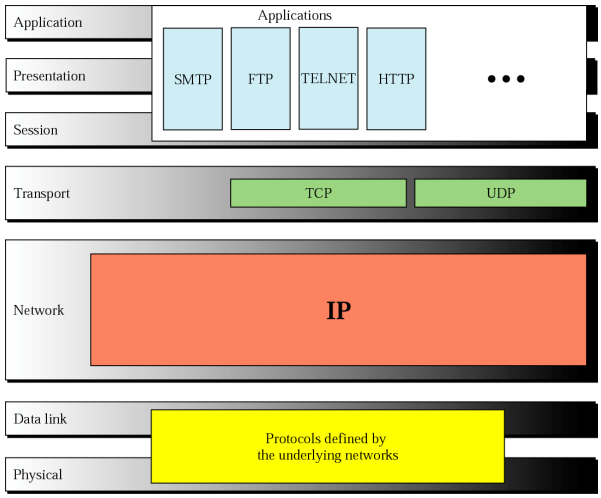
ISO/OSI Model - Application Layer Upward



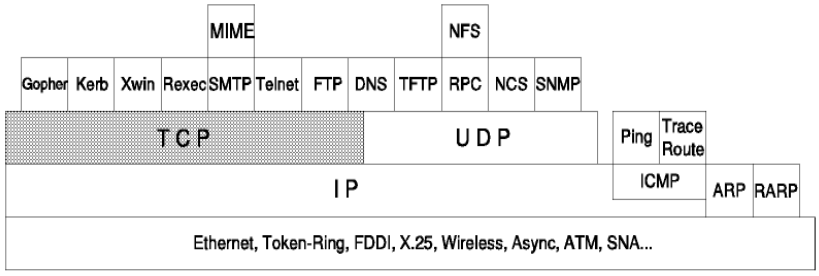
ISO/OSI Model, Continued



TCP/IP Model



TCP/IP Model, Continued



OSI and TCP/IP

	OSI	TCP/IP
Standards Agency(ies)	ISO (International Organization for Standardization) ITU-T (International Telecommunications Union—Telecommunications Standards Sector)	IETF (Internet Engineering Task Force)

OSI and TCP/IP, Continued

	OSI	TCP/IP
Dominance	Nearly 100% at physical and data link layers	70% to 80% at the Internet and transport layers. Also strong at the application layer
Documents are Called	Various	Mostly RFCs (requests for comment)

Figure 2-19: OSI and TCP/IP, Continued

- Do not confuse OSI (the architecture) with ISO (the organization)
- The acronyms for ISO and ITU-T do not match their names, but these are the official names and acronyms

Figure 2-20: The Hybrid TCP/IP-OSI Architecture

TCP/IP	OSI	Hybrid TCP/IP-OSI	Broad Purpose
Application	Application	Application (Layer 5)	Applications
	Presentation		
	Session		
Transport	Transport	Transport (Layer 4)	Internetworking
Internet	Network	Internet (Layer 3)	
Use OSI Standards Here	Data Link	Data Link (Layer 2)	Communication within a single LAN or WAN
	Physical	Physical (Layer 1)	

Figure 2-20: The Hybrid TCP/IP-OSI Architecture, Continued

- Notes:
  - The Hybrid TCP/IP-OSI Architecture is used on the Internet and dominates internal corporate networks
  - OSI standards are used almost universally at the physical and data link layers (which govern communication within individual networks)
  - TCP/IP is used for 70% to 80% of all corporate traffic at the internet and transport layers and is used heavily at the application layer.

Figure 2-7: TCP/IP-OSI Architecture

Layer	Specific Purpose	General Purpose
Application (5)	Application-application interworking	Application-application interworking
Transport (4)	Host-host communication	Transmission across an internet
Internet (3)	Packet delivery across an internet	
Data Link (2)	Frame delivery across a network	Transmission across a single network (LAN or WAN)
Physical (1)	Device-device connection	

Figure 2-7: TCP/IP-OSI Architecture, Continued

- Physical and Data Link Layer Standards Govern Communication Through a Single Network
- LAN or WAN

Figure 2-7: TCP/IP-OSI Architecture, Continued

- Physical Layer
  - Physical layer standards govern transmission between adjacent devices connected by a transmission medium

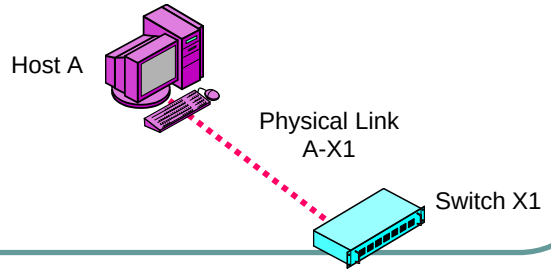


Figure 2-7: TCP/IP-OSI Architecture, Continued

- Data Link Layer
  - Data link layer standards govern the transmission of frames across a single network—typically by sending them through several switches along the data link
  - Data link layer standards also govern frame organization, timing constraints, and reliability

Figure 2-8: Physical and Data Link Layer Standards

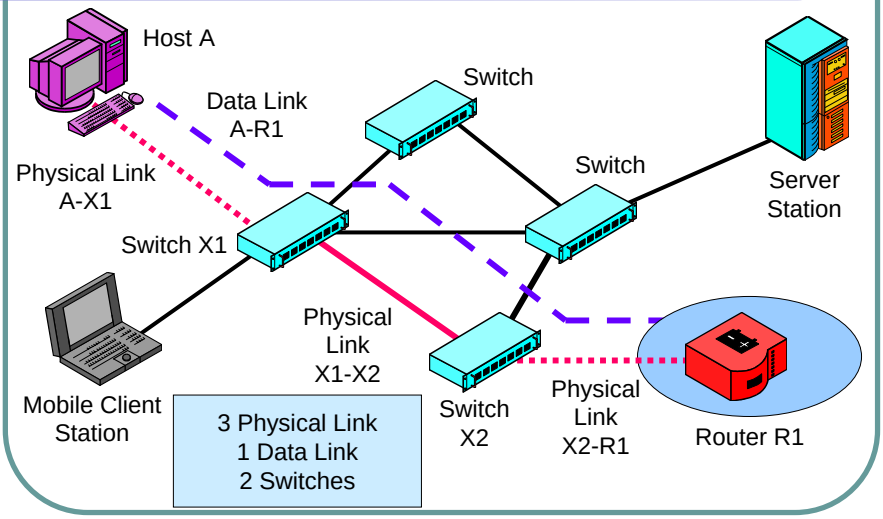


Figure 2-7: TCP/IP-OSI Architecture, Continued

- Internet and Transport Layers
  - An internet is a group of networks connected by routers so that any application on any host on any network can communicate with any application on any other host on any other network
  - Internet and transport layer standards govern communication across an internet composed of two or more single networks

Figure 2-7: TCP/IP-OSI Architecture, Continued

- Internet Layer
  - 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, timing constraints, and reliability

Figure 2-9: Internet and Data Link Layer Standards

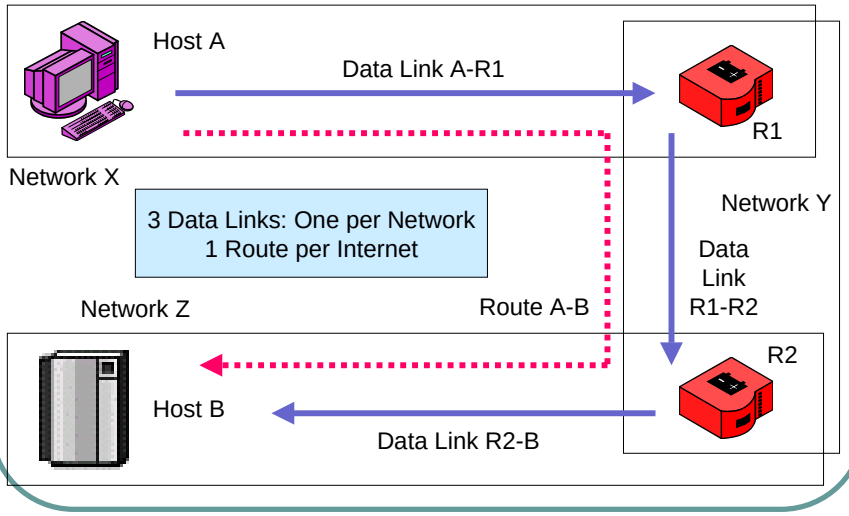


Figure 2-9: Internet and Data Link Layer Standards, Continued

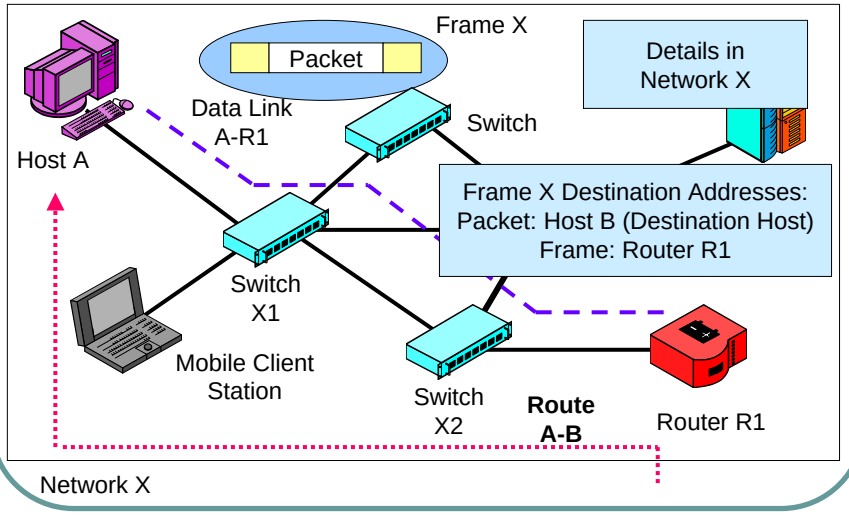
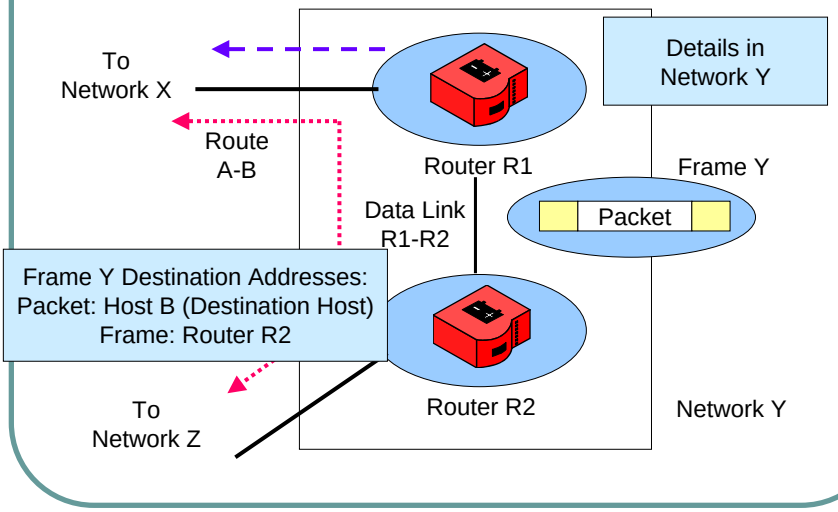
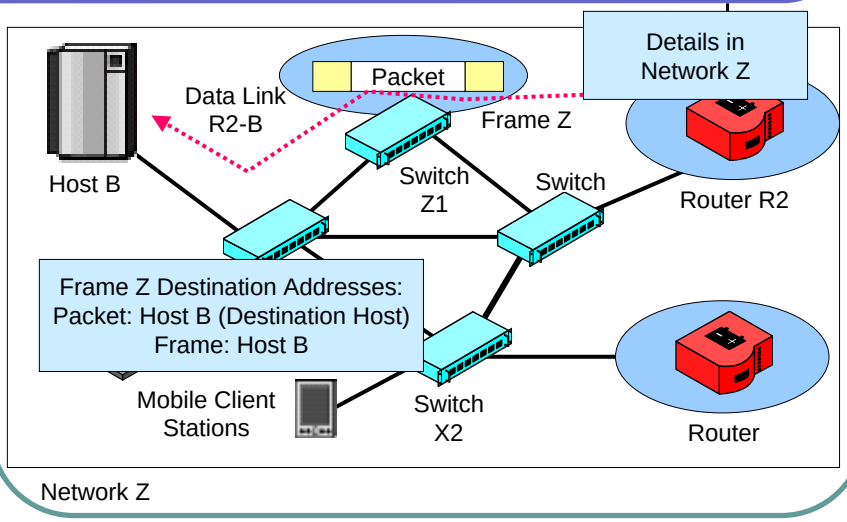


Figure 2-9: Internet and Data Link Layer Standards, Continued



37

Figure 2-9: Internet and Data Link Layer Standards, Continued



38

Frames and Packets

- In an internet with hosts separated by N networks, there will be:
  - 2 hosts
  - One route (between the two hosts)
  - N frames (one in each network)
  - N-1 routers (change frames between each pair of networks)

Figure 2-7: TCP/IP-OSI Architecture, Continued

- Transport Layer
  - Transport layer standards govern aspects of end-to-end communication between two end hosts that are not handled by the data link layer
  - These standards also allow hosts to work together even if the two computers are from different vendors and have different internal designs

Figure 2-10: Internet and Transport Layer Standards

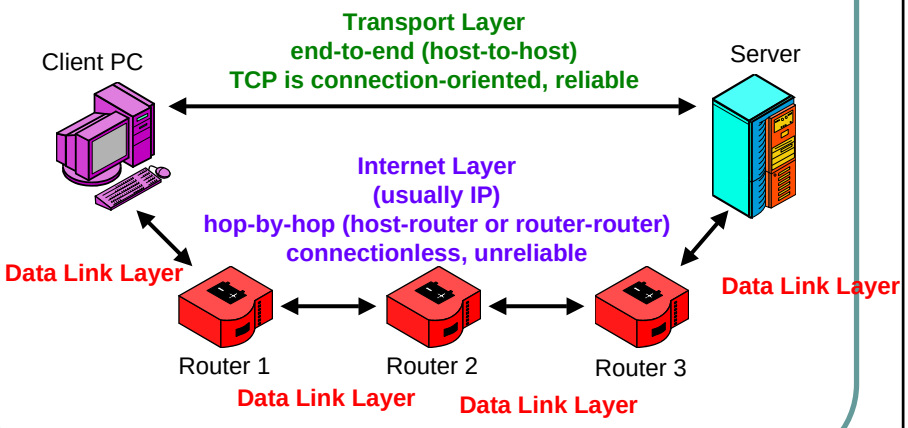
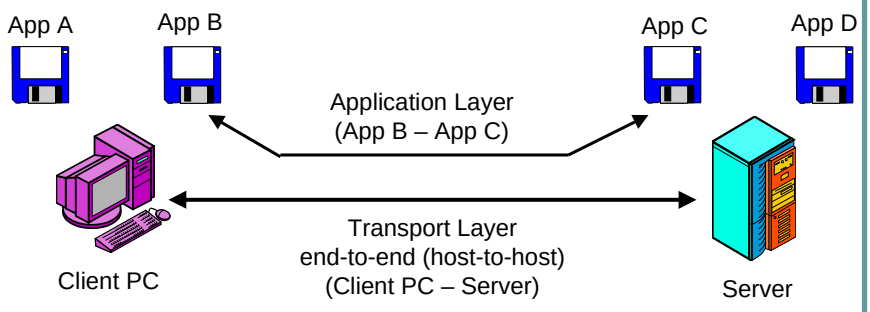


Figure 2-7: TCP/IP-OSI Architecture, Continued

- Application Layer
  - The application layer governs how two applications work with each other, even if they are from different vendors

Transport and Application Layer Standards



Most hosts are multitasking machines
that run multiple applications simultaneously.
Hosts need to communicate; So do pairs of applications

Figure 2-21: OSI Session Layer

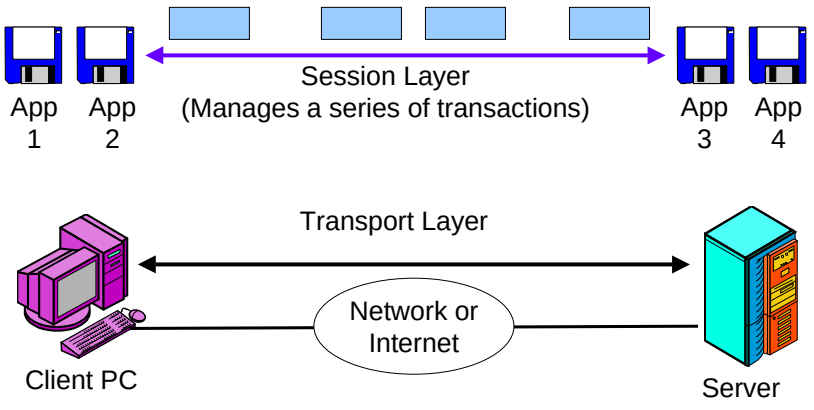
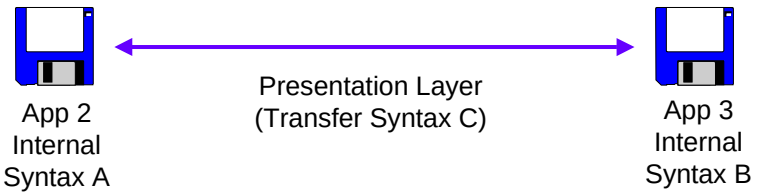


Figure 2-21: OSI Session Layer, Continued

- OSI Session Layer
  - Manages a series of transactions closely
  - If there is a connection break, only have to retransmit transactions since the last rollback point
- TCP/IP Has No Session Layer
  - The few applications that need to manage transaction series closely provide their own mechanisms
  - In HTTP, cookies provide continuity across applications

Figure 2-22: OSI Presentation Layer



Presentation standards also include compression standards and data formatting standards (jpeg, etc.)

Figure 2-22: OSI Presentation Layer, Continued

- OSI Presentation Layer
  - Transfer syntax
  - Layer for application standards, such as jpeg
- TCP/IP Has No Presentation Layer
  - MIME at least allows the sender to indicate the format of file delivered in a message

Other Major Standards Architectures

- IPX/SPX
  - Used by older Novell NetWare file servers
  - Popular option for newer Novell NetWare file servers
- SNA (Systems Network Architecture)
  - Used by IBM mainframe computers
- AppleTalk
  - Used by Apple Macintoshes

Messages

Figure 2-1: How Standards Govern Interactions

- Standards
  - Govern the Exchange of Messages
  - Messages must be governed by strict rules
    - Semantics
    - Syntax
    - Timing

網路傳輸協定要素

Figure 2-1: How Standards Govern Interactions, Continued

- Message Semantics (Meaning)
  - Only a few message types are allowed because computers do not have the intelligence to handle open-ended communication
  - In HTTP, request and response messages

訊息所代表的意義

Figure 2-2: Hypertext Transfer Protocol (HTTP) Interactions

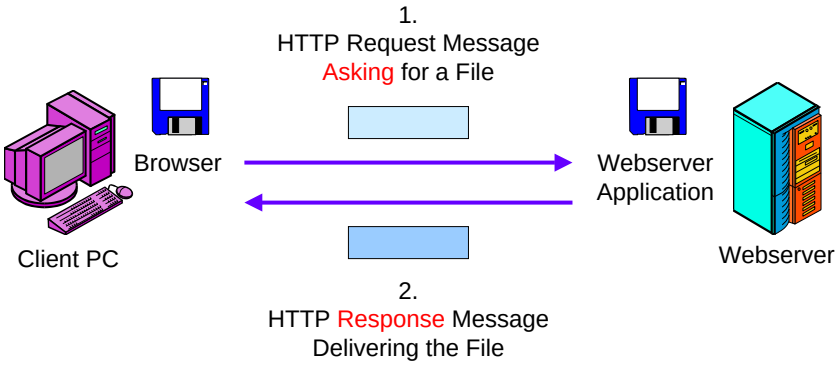
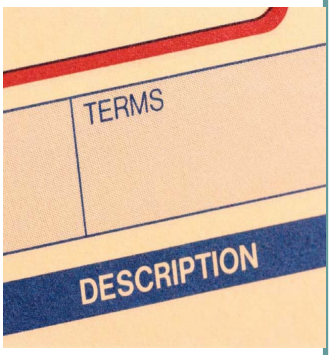


Figure 2-1: How Standards Govern Interactions, Continued

- Message Syntax (Organization)
  - Rigidly structured
    - In HTTP, lines of text (Figure 2-3)
    - Most lines are of the form "Keyword: Information"



訊息格式需事先制定

Figure 2-3: Syntax of HTTP Request and Response Messages

- [CRLF]
  - Carriage return and line feed (starts a new line)
- HTTP Request Message
  - GET /reports/project1/final.htm HTTP/1.1[CRLF]
  - Host: voyager.cba.Hawaii.edu[CRLF]

Figure 2-3: Syntax of HTTP Request and Response Messages, Continued

- HTTP Response Message
  - HTTP/1.1 200 OK[CRLF]
  - Date: Tuesday, 20-MAR-2004 18:32:15 GMT[CRLF]
  - Server: *name of server software*[CRLF]
  - MIME-version: 1.0[CRLF]
  - Content-type: text/plain[CRLF]
  - [CRLF]
  - *File to be downloaded*

Figure 2-1: How Standards Govern Interactions, Continued

- Message Syntax (Organization)
  - General Message Organization (Figure 2-4)
  - Primary components
    - Data Field (content to be delivered)
    - Header (everything before the data field)
    - Trailer (everything after the data field)
  - Header and trailer are further divided into fields

Figure 2-4: General Message Organization

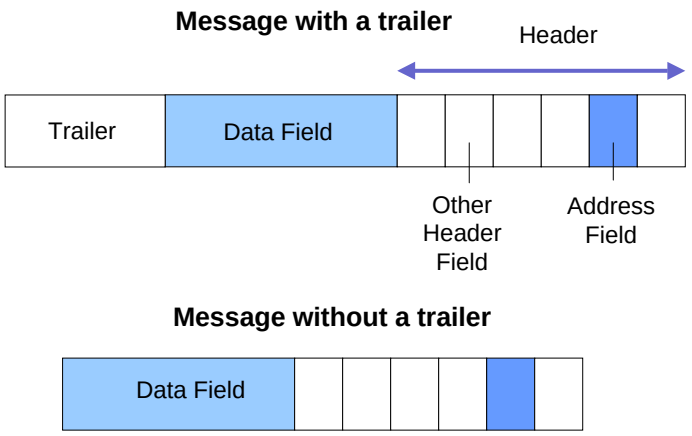
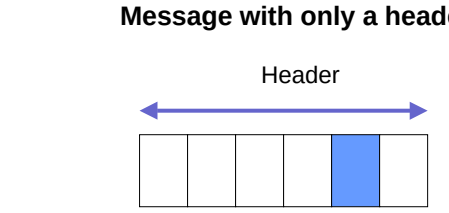


Figure 2-4: General Message Organization, Continued



e.g. TCP supervisory messages are pure headers

Figure 2-1: How Standards Govern Interactions, Continued

- Message Timing Constraints
  - When may a process transmit? At any time? Only when some event happens?
  - Turn-taking in conversations
  - In client/server computing, server cannot respond unless it receives a request
  - Many more complex examples exist (for instance, in TCP later in this chapter)

Connection-Oriented and Connectionless Protocols

Figure 2-5: Connectionless and Connection-Oriented Protocols

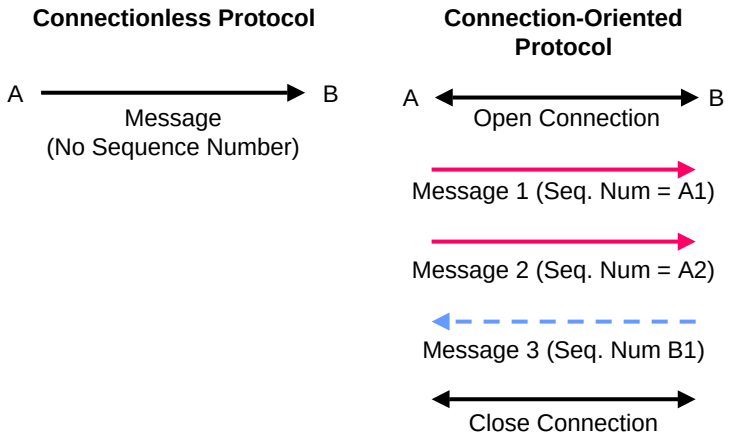
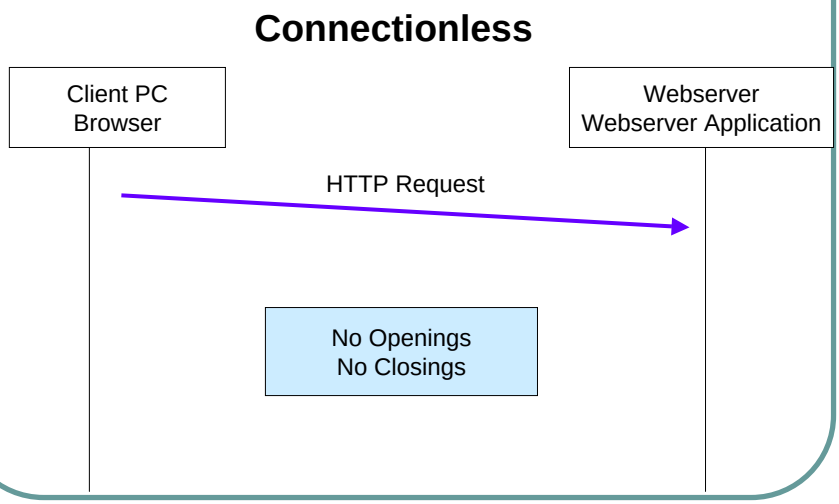


Figure 2-5: Connectionless and Connection-Oriented Protocols, Continued



Connection-Oriented

- Open
- Communication
- Acknowledgement
- Close

Figure 2-6: Transmission Control Protocol (TCP) Session

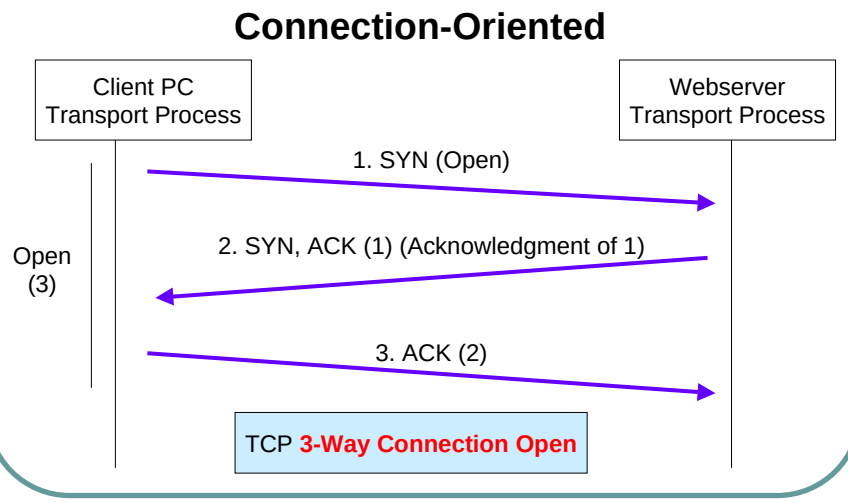


Figure 2-6: Transmission Control Protocol (TCP) Session, Continued

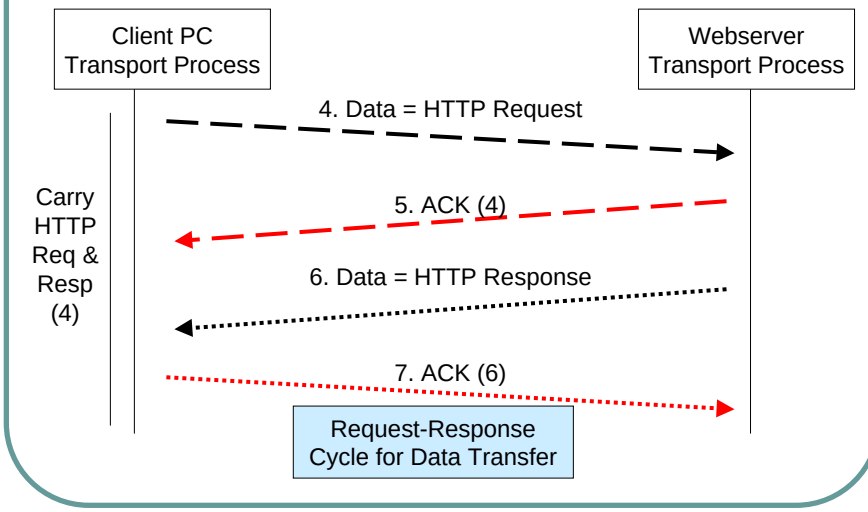


Figure 2-6: Transmission Control Protocol (TCP) Session, Continued

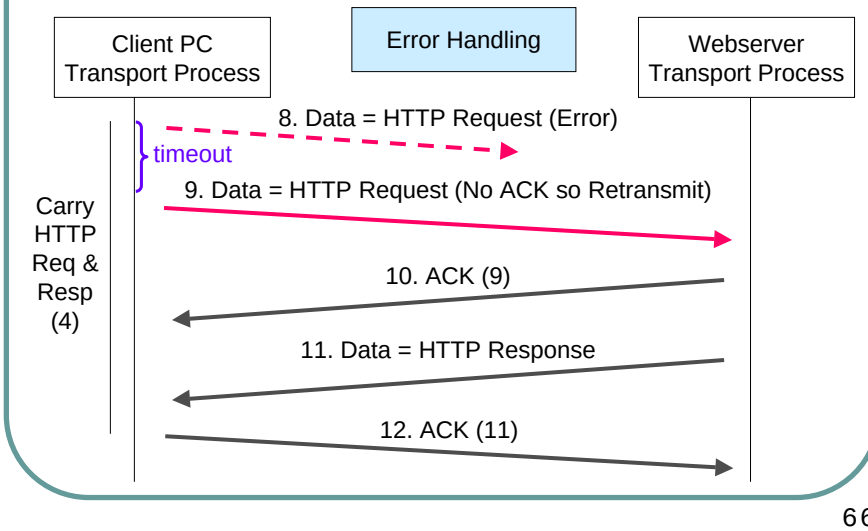
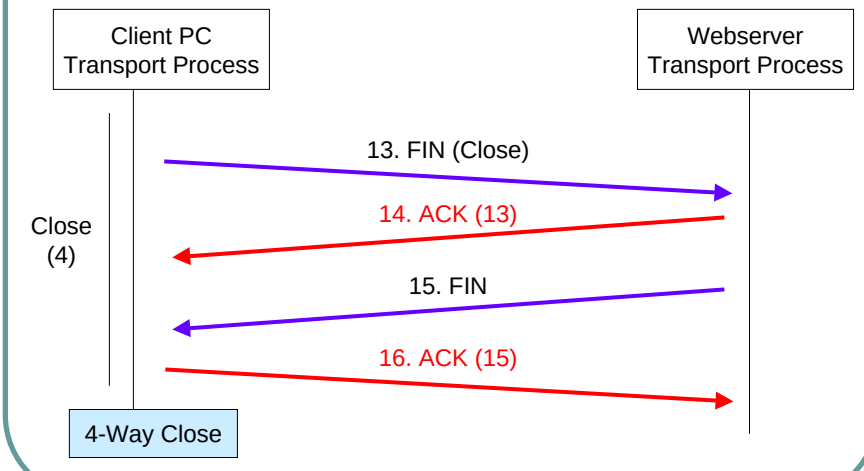


Figure 2-6: Transmission Control Protocol (TCP) Session, Continued

- If acknowledgements are not sent by the receiver, the sender retransmits the TCP segment
- This gives reliability
- Note: An ACK may be combined with the next message if the next message is sent quickly enough

Figure 2-6: Transmission Control Protocol (TCP) Session, Continued



Syntax Examples

Octets

- Field lengths may be measured in octets
- An octet is a group of eight bits
- In computer science, an octet is called a byte

Octet

Figure 2-12: Ethernet Frame

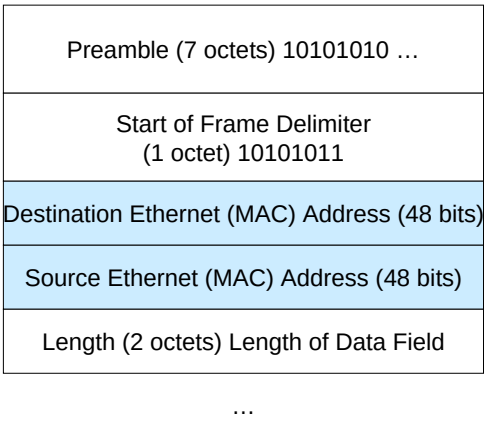


Figure 2-12: Ethernet Frame, Continued

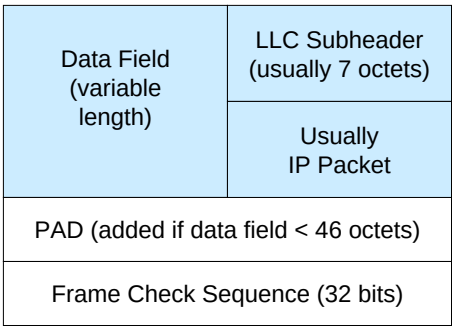


Figure 2-12: Ethernet Frame, Continued

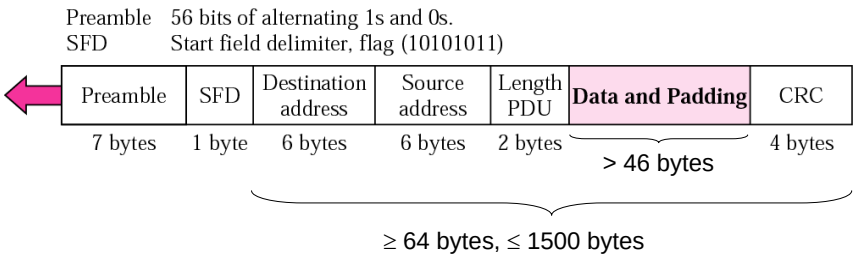


Figure 2-12: Ethernet Frame, Continued

Frame Check Sequence (32 bits)

- Sender computes the frame check sequence field value based on contents of other fields
  - Receiver recomputes the field value
- If the values match, there have been no errors
- If the values do not match, there is an error
  - The receiver simply discards the frame
- Unreliable: error detection but not error correction

Figure 2-13: Ethernet Switching Decision

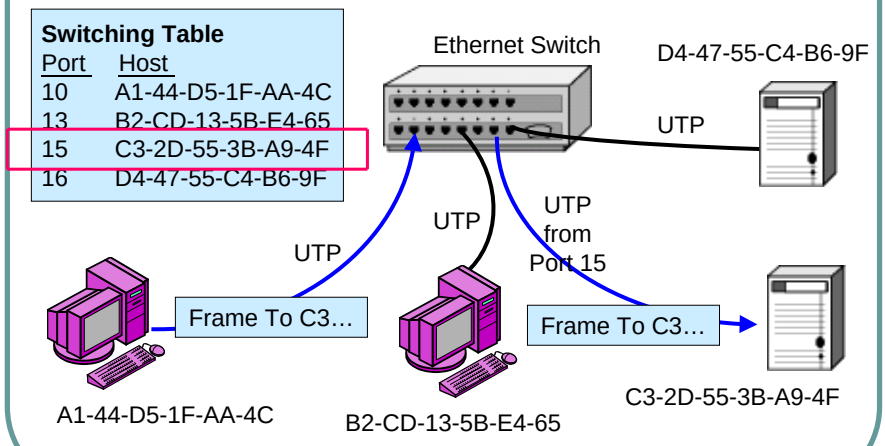
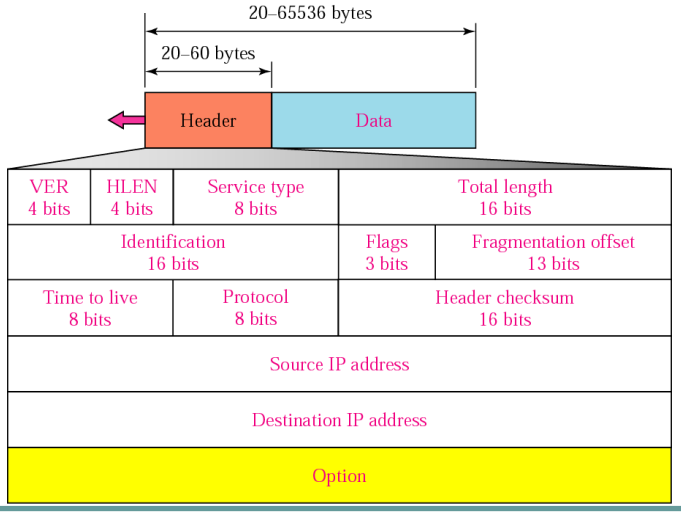


Figure 2-14: Internet Protocol (IP) Packet



Vertical Communication

Figure 2-15: Layered Communication on the Source Host

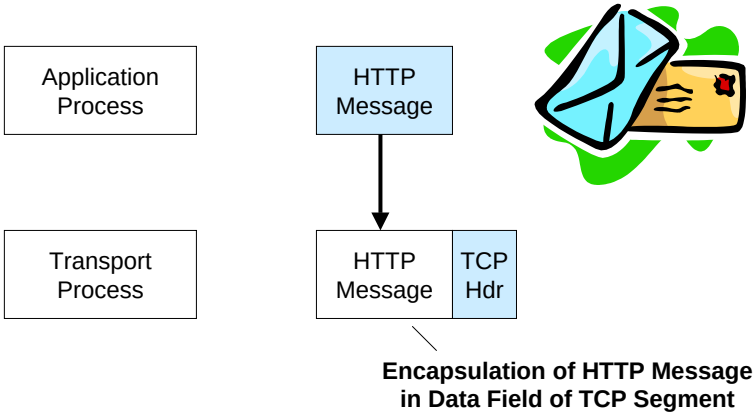


Figure 2-15: Layered Communication on the Source Host, Continued

- When a layer process (N) creates a message, it passes it down to the next-lower-layer process (N-1) immediately
- The receiving process (N-1) will encapsulate the Layer N message, that is, place it in the data field of its own (N-1) message

Figure 2-15: Layered Communication on the Source Host, Continued

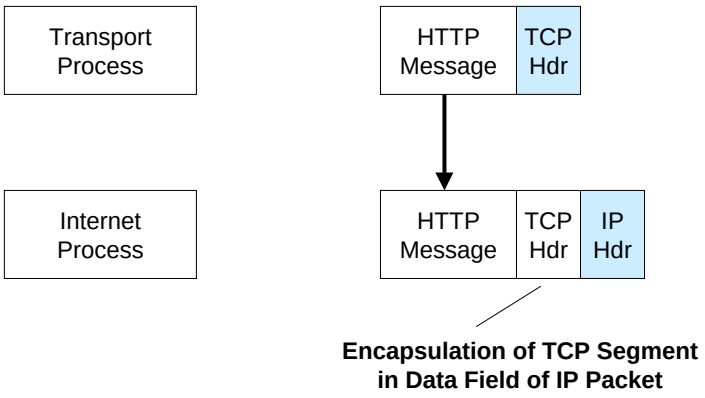


Figure 2-15: Layered Communication on the Source Host, Continued

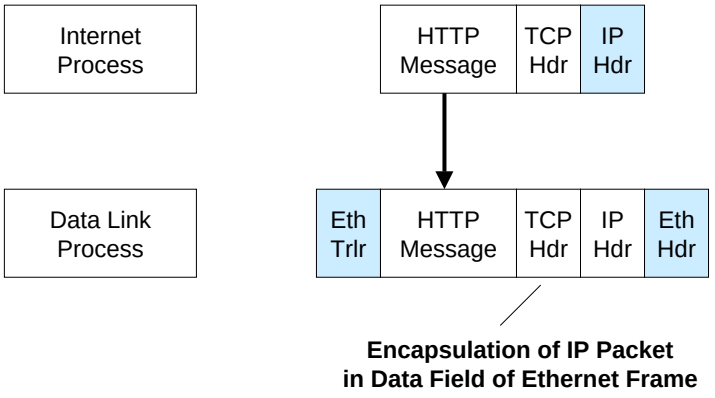


Figure 2-15: Layered Communication on the Source Host, Continued

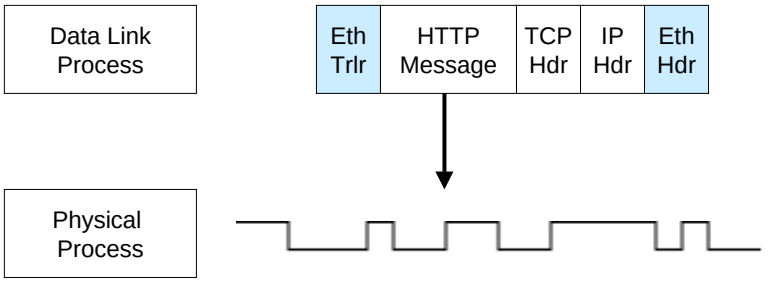


Figure 2-15: Layered Communication on the Source Host, Continued

The following is the final frame for a packet carrying an HTTP message on an Ethernet LAN

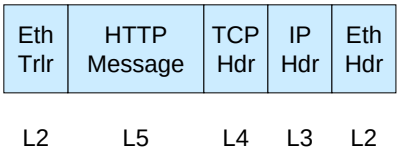
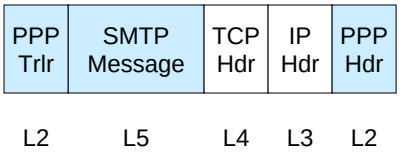


Figure 2-15: Layered Communication on the Source Host, Continued

The following is the final frame for a packet carrying an SMTP (e-mail) message on PPP telephone modem connection

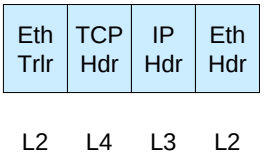


Note: HTTP is NOT the application layer message, as it is in webservice.

PPP replaces Ethernet.

Figure 2-15: Layered Communication on the Source Host, Continued

The following is the final frame for a packet carrying a supervisory TCP segment:



Supervisory TCP segments are initiated by the Transport layer process (Layer 4), so Layer 5 is not involved.

TCP supervisory messages consist entirely of headers. The header carries supervisory information, so no TCP data field exists in supervisory TCP messages.

Figure 2-16: Decapsulation on the Destination Host

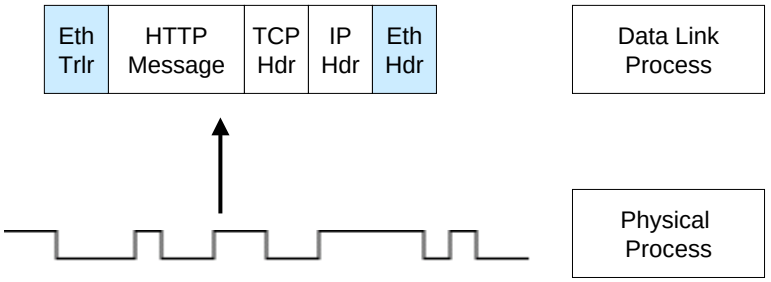


Figure 2-16: Decapsulation on the Destination Host, Continued

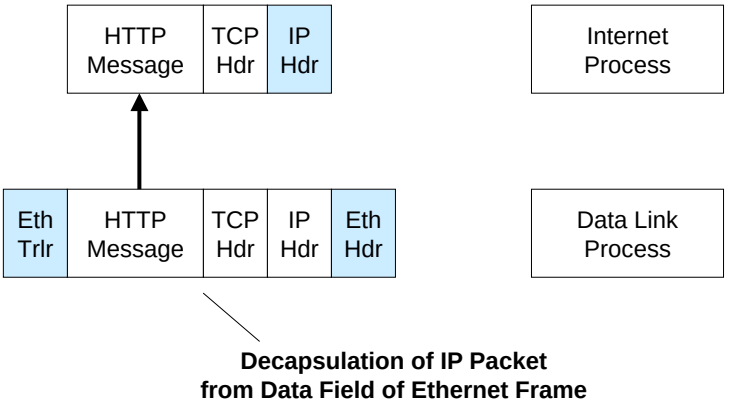


Figure 2-16: Decapsulation on the Destination Host, Continued

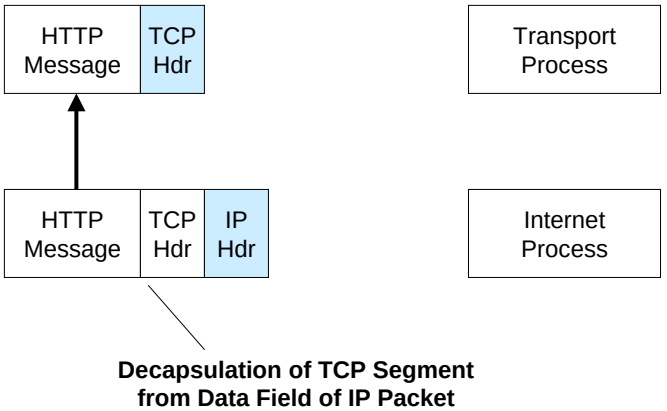
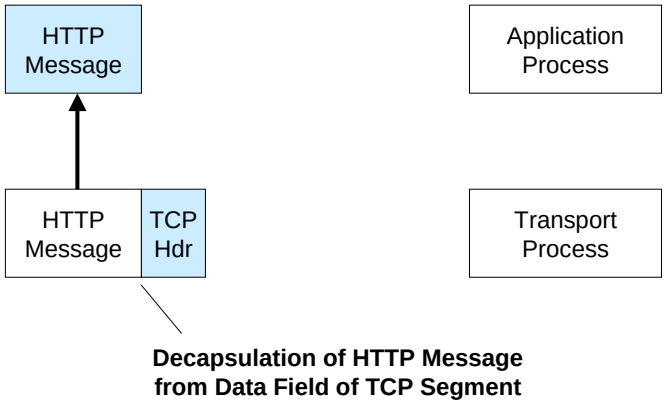


Figure 2-16: Decapsulation on the Destination Host, Continued



Sample Frame - captured using sniffer

```
00000000: 00 30 88 01 24 a0 00 e0 18 b1 a0 71 88 64 11 00
00000010: 36 58 01 dc 00 21 45 00 01 da 21 91 40 00 80 06
00000020: 6b 38 cb 43 d5 c3 cb 48 00 05 05 dc 00 50 24 da
00000030: 95 6d 25 97 e6 02 50 18 ff ff d2 1f 00 00 47 45
00000040: 54 20 2f 6d 61 69 6e 2e 68 74 6d 20 48 54 54 50
00000050: 2f 31 2e 31 0d 0a 41 63 63 65 70 74 3a 20 69 6d
00000060: 61 67 65 2f 67 69 66 2c 20 69 6d 61 67 65 2f 78
00000070: 2d 78 62 69 74 6d 61 70 2c 20 69 6d 61 67 65 2f
00000080: 6a 70 65 67 2c 20 69 6d 61 67 65 2f 70 6a 70 65
00000090: 67 2c 20 61 70 70 6c 69 63 61 74 69 6f 6e 2f 78
000000a0: 2d 73 68 6f 63 6b 77 61 76 65 2d 66 6c 61 73 68
000000b0: 2c 20 61 70 70 6c 69 63 61 74 69 6f 6e 2f 76 6e
000000c0: 64 2e 6d 73 2d 65 78 63 65 6c 2c 20 61 70 70 6c
000000d0: 69 63 61 74 69 6f 6e 2f 6d 73 77 6f 72 64 2c 20
000000e0: 61 70 70 6c 69 63 61 74 69 6f 6e 2f 76 6e 64 2e
000000f0: 6d 73 2d 70 6f 77 65 72 70 6f 69 6e 74 2c 20 2a
00000100: 2f 2a 0d 0a 41 63 63 65 70 74 2d 4c 61 6e 67 75
00000110: 61 67 65 3a 20 7a 68 2d 74 77 0d 0a 41 63 63 65
00000120: 70 74 2d 45 6e 63 6f 64 69 6e 67 3a 20 67 7a 69
00000130: 70 2c 20 64 65 66 6c 61 74 65 0d 0a 49 66 2d 4d
00000140: 6f 64 69 66 69 65 64 2d 53 69 6e 63 65 3a 20 54
00000150: 68 75 2c 20 32 36 20 41 75 67 20 32 30 30 34 20
00000160: 30 30 3a 35 31 3a 34 31 20 47 4d 54 3b 20 6c 65
00000170: 6e 67 74 68 3d 31 38 32 36 0d 0a 55 73 65 72 2d
```

Ethernet Frame
PPPOE
IP
TCP
HTTP

Figure 2-17: Layered End-to-End Communication

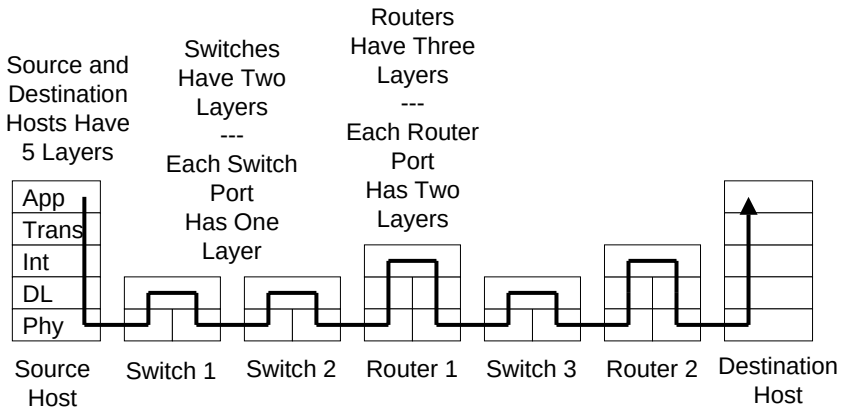


Figure 2-18: Protocols

- Protocols are standards that govern interactions between hardware and software processes at the same layer but on different hosts

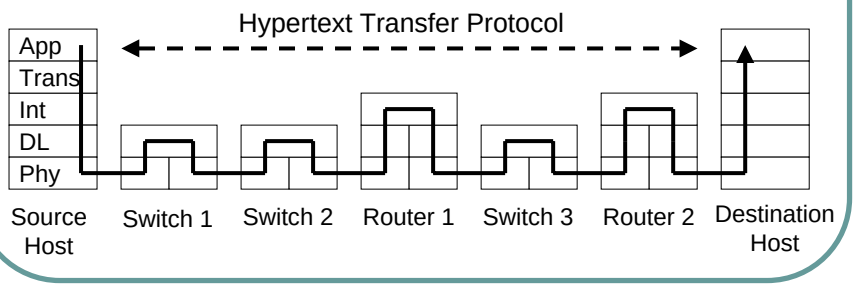


Figure 2-18: Protocols, Continued

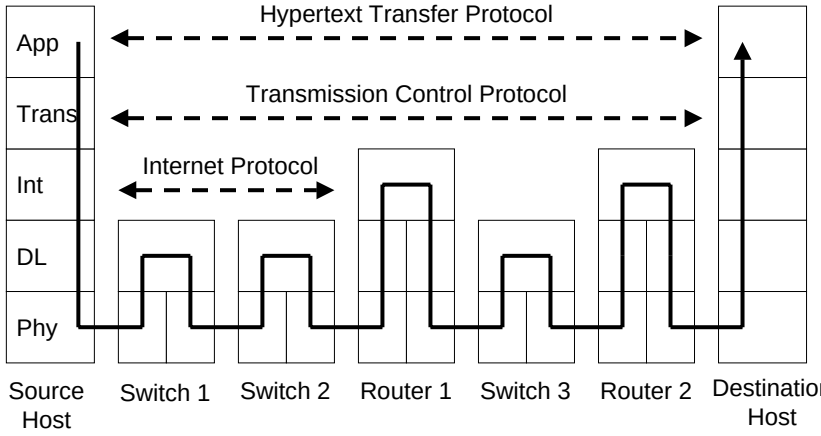
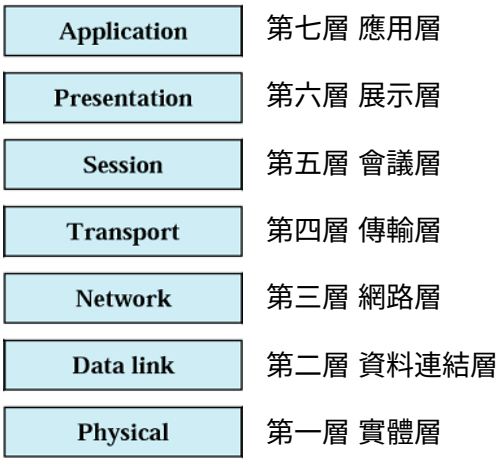


Figure 2-24: Characteristics of Protocols Discussed in the Chapter

Layer	Protocol	Connection-Oriented /Connectionless	Reliable/ Unreliable	Strong / Weak Timing Constraints
5 (App)	HTTP	Connectionless	Unreliable	Weak
4 (Trans)	TCP	Connection-oriented	Reliable	Strong
3 (Internet)	IP	Connectionless	Unreliable	Weak
2 (DL)	Ethernet	Connectionless	Unreliable	Weak

Topics Covered

- OSI model



Topics Covered

- Layered Standards Architecture
  - Physical layer (between adjacent devices)
  - Data link layer (across a switched network)
  - Internet layer (across an internet)
  - Transport layer (host-to-host)
  - Application layer (application-to-application)

Topics Covered

- Other Standards Architectures
  - IPX/SPX
  - SNA
  - AppleTalk

Topics Covered

- Standards govern the semantics, syntax and timing of message exchanges
  - Data field, header, and trailer
  - Header and trailer subdivided into fields
- HTTP: Text request and response messages
- Connection-oriented versus connectionless
- TCP connections
  - 3-way opens, data exchanges, 4-way closes

Topics Covered

- Reliability
  - In TCP, receiver sends ACKs
  - Senders retransmit non-acknowledged segments
- TCP/IP-OSI Architecture
  - OSI is 100% dominant at Layers 1 and 2
  - TCP/IP is 70% to 80% dominant at Layers 3 and 4
  - TCP/IP is used heavily at Layer 5

Topics Covered

- Ethernet Packet
  - Source and destination addresses are 48 bits long
  - Switches base output port decisions on 48-bit Ethernet addresses
  - Unreliable: if detects an error, drops the frame
- Internet Protocol (IP)
  - 32-bit addresses
  - Show 32 bits on each line
  - Unreliable: checks headers for errors but discards

Topics Covered

- Vertical Communication on the Source Host
  - Layer process send message to the next-lower layer
  - Encapsulation
  - Final frame
- Vertical Communication on the Destination Host
  - Decapsulation and passing up

Topics Covered

- Not All Devises Have All Layers
  - Hosts: all five
  - Routers: three
  - Switches: two
- Protocols
  - Standards that govern interactions between hardware and software practices at the same layer but on different hosts