Networking Principles

Adapted from From:

DistributedSystems: Concepts and Design, Coulouris, Dollimore and Kindberg - Edition 4, © Addison-Wesley 2005

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What's in the data?

For effective communication

- same language, same conventions

For computers:

- electrical encoding of data
- where is the start of the packet?
- which bits contain the length?
- is there a checksum? where is it? how is it computed?
- what is the format of an address?
- byte ordering

Protocols

These instructions and conventions are known as **protocols**

Protocols exist at different *levels*

understand format of address and how to compute checksum

humans vs. whales
different wavelengths

versus

request web page

French vs. Hungarian

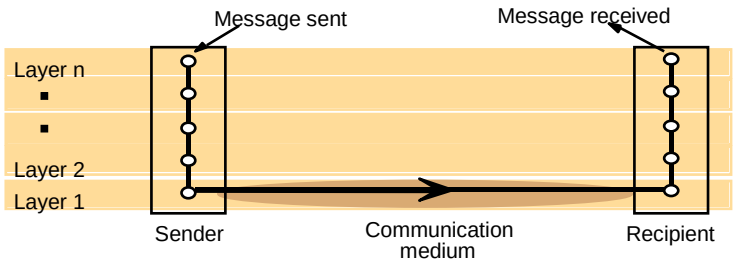
Layering

To ease software development and maximize flexibility:

- Network protocols are generally organized in **layers**
- Replace one layer without replacing surrounding layers
- Higher-level software does not have to know how to format an Ethernet packet

  … or even know that Ethernet is being used

Conceptual layering of protocol software



Most popular model of guiding (not specifying) protocol layers is the

OSI reference model

Adopted and created by ISO (International Standards Organization)
7 layers of protocols

OSI Reference Model: Layer 1

Transmits and receives raw data to communication medium.

Does not care about contents.

voltage levels, speed, connectors

Examples: RS-232, 10BaseT

OSI Reference Model: Layer 2

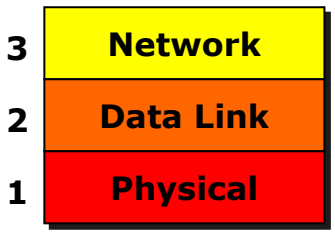
Detects and corrects errors.

Organizes data into packets before passing it down. Sequences packets (if necessary).

Accepts acknowledgements from receiver.

Examples: Ethernet MAC, PPP

OSI Reference Model: Layer 3

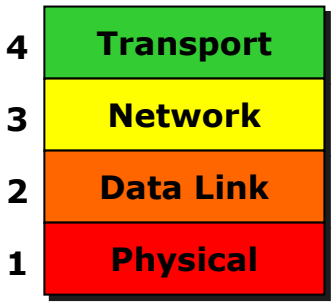


Relay and route information to destination.

Manage journey of packets and figure out intermediate hops (if needed).

Examples: IP, X.25

OSI Reference Model: Layer 4

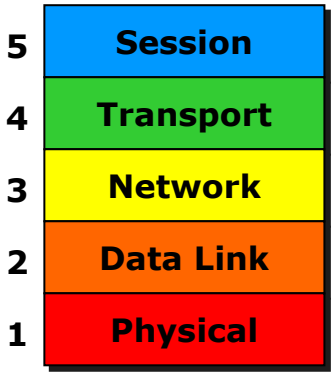


Provides a consistent interface for end-to-end (application-to-application) communication. Manages flow control.

Network interface is similar to a mailbox.

Examples: TCP, UDP

OSI Reference Model: Layer 5



Services to coordinate dialogue and manage data exchange.

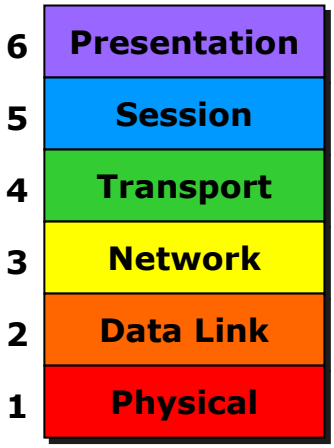
Software implemented switch.

Manage multiple logical connections.

Keep track of who is talking: establish & end communications.

Examples: HTTP 1.1, SSL, NetBIOS

OSI Reference Model: Layer 6



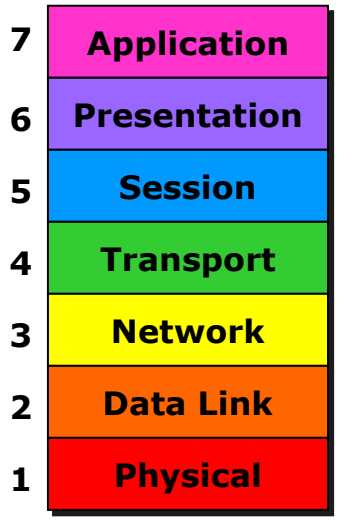
Data representation

Concerned with the meaning of data bits

Convert between machine representations

Examples: XDR, ASN.1, MIME, MIDI

OSI Reference Model: Layer 7



Collection of application-specific protocols

Examples:
email (SMTP, POP, IMAP)
file transfer (FTP)
directory services (LDAP)

Protocol layers in the ISO Open Systems Interconnection (OSI) model

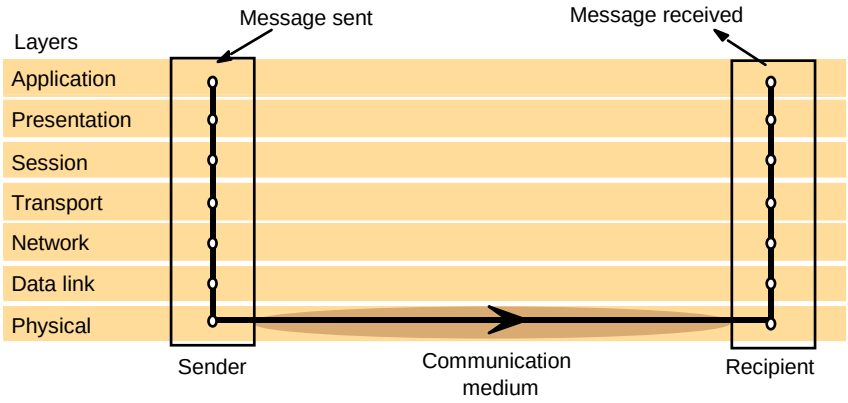
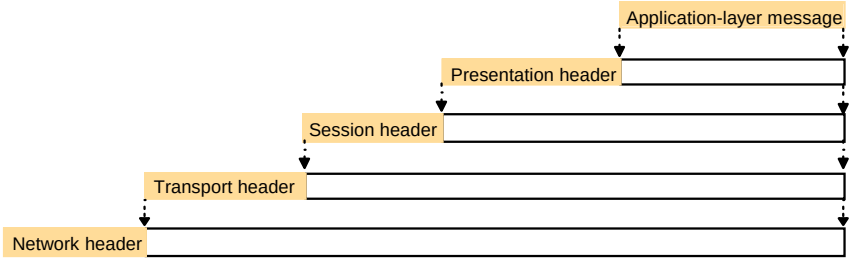


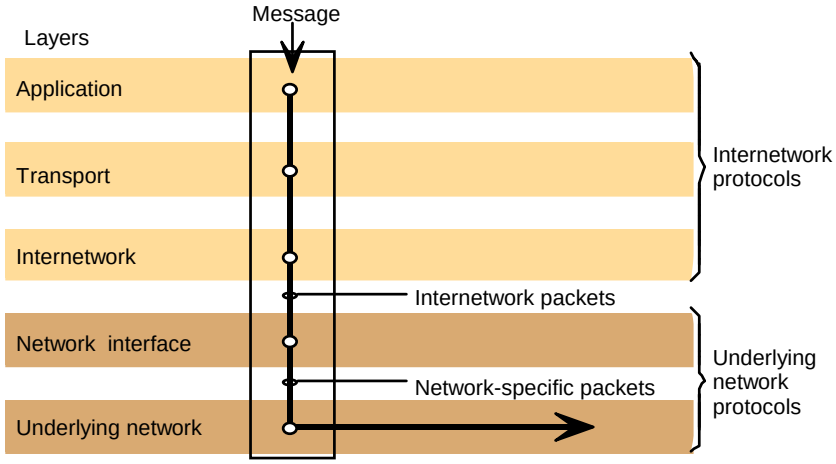
Figure 3.5
OSI protocol summary

Layer	*Description*	*Examples*
Application	Protocols that are designed to meet the communication requirements of specific applications, often defining the interface to a service.	HTTP,FTP, SMTP, CORBA IIOP
Presentation	Protocols at this level transmit data in a network representation that is independent of the representations used in individual computers, which may differ. Encryption is also performed in this layer, if required.	Secure Sockets (SSL),CORBA Data Rep.
Session	At this level reliability and adaptation are performed, such as detection of failures and automatic recovery.	
Transport	This is the lowest level at which messages (rather than packets) are handled. Messages are addressed to communication ports attached to processes, Protocols in this layer may be connection-oriented or connectionless.	TCP, UDP
Network	Transfers data packets between computers in a specific network. In a WAN or an internetwork this involves the generation of a route passing through routers. In a single LAN no routing is required.	IP, ATM virtual circuits
Data link	Responsible for transmission of packets between nodes that are directly connected by a physical link. In a WAN transmission is between pairs of routers or between routers and hosts. In a LAN it is between any pair of hosts.	Ethernet MAC, ATM cell transfer, PPP
Physical	The circuits and hardware that drive the network. It transmits sequences of binary data by analogue signalling, using amplitude or frequency modulation of electrical signals (on cable circuits), light signals (on fibre optic circuits) or other electromagnetic signals (on radio and microwave circuits).	Ethernet base- band signalling, ISDN

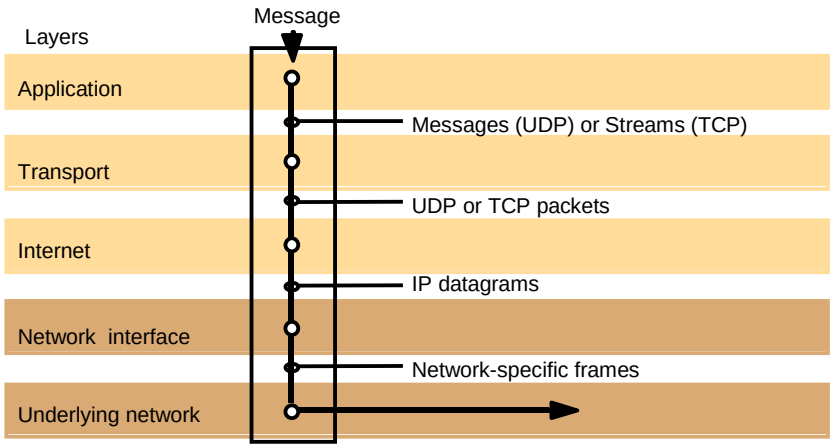
Encapsulation as it is applied in layered protocols



Internetwork layers

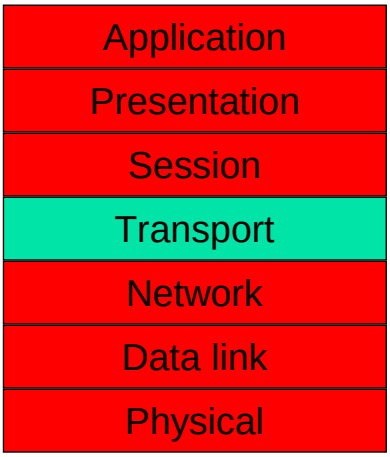


TCP/IP layers



Transport Layer

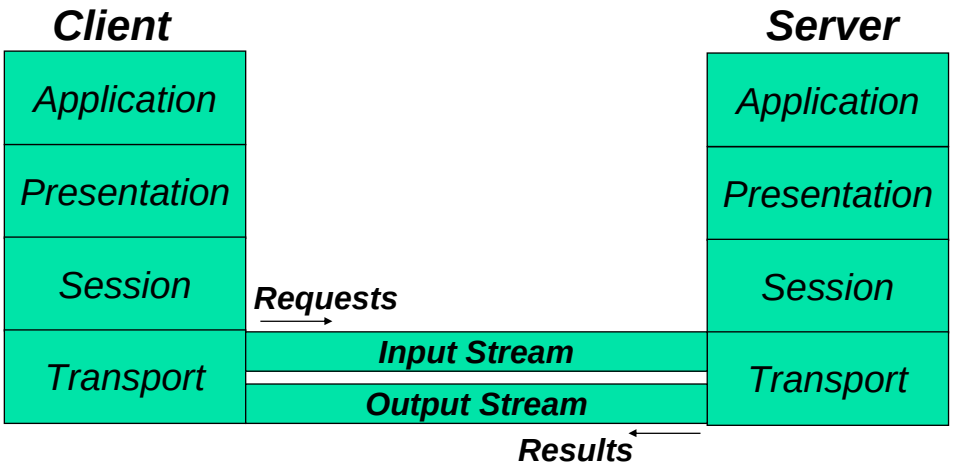
- Level 4 of ISO/OSI reference model.
- Concerned with the transport of information through a network.
- Two facets in UNIX/Windows networks:
  - TCP and
  - UDP.



Transmission Control Protocol (TCP)

- Provides bi-directional stream of bytes between two distributed components.
- UNIX rsh, rcp and rlogin are based on TCP.
- Reliable but slow protocol.
- Buffering at both sides de-couples computation speeds.

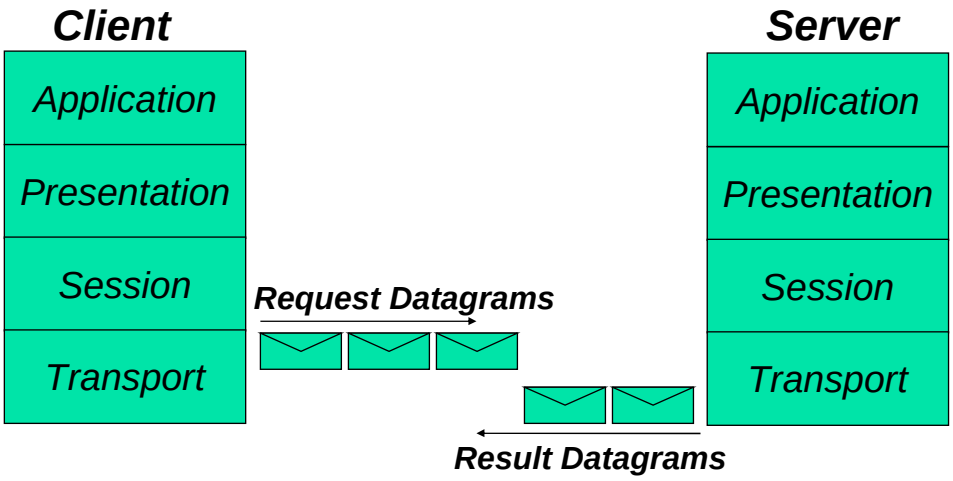
TCP for Request Implementation



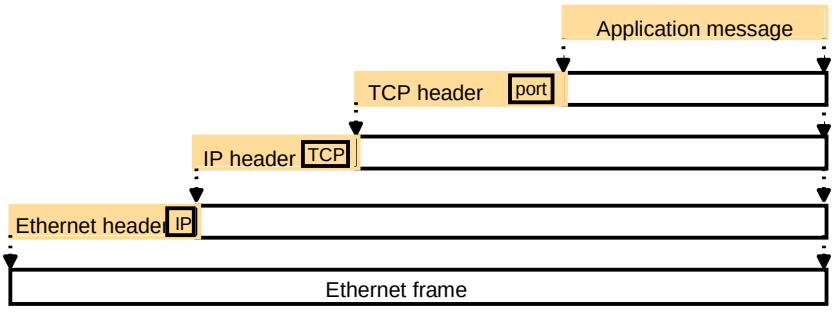
User Datagram Protocol (UDP)

- Enables a component to pass a message containing a sequence of bytes to another component.
- Other component is identified within message.
- Unreliable but very fast protocol.
- Restricted message length.
- Queuing at receiver.
- UNIX rwho command is UDP based.

UDP for Request Implementation



Encapsulation in a message transmitted via TCP over an Ethernet



The programmer's conceptual view of a TCP/IP Internet