Chapter 4 Communication

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Network Communication Protocols

- Interprocess communication in distributed systems is based on **message passing** offered by the underlying network
- All communications between processes use standard rules that govern the format, contents, and meaning of messages sent and received. These rules are formalized in **protocols**.

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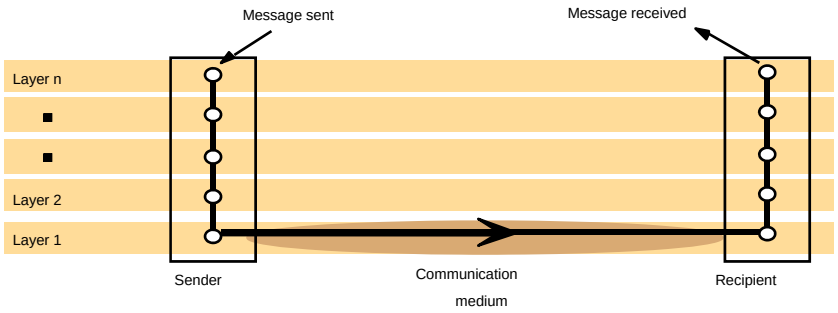
Layering of Protocols

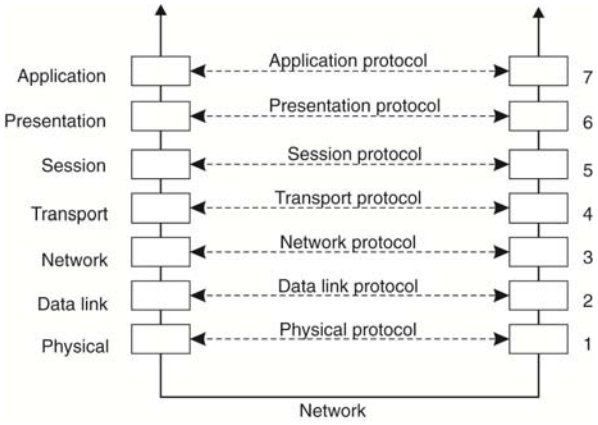


- Protocols are organized into layers
- A protocol is implemented by a pair of software modules located in the sending and receiving computers

The OSI Model

- The **Open Systems Interconnection model** (**OSI**) is a conceptual model that standardizes the internal functions of a communication system
  - Developed by the International Standards Organization (ISO) in 1980s
- The OSI model defines 7 layers, gives them standard names, and specifies the functionality of each layer
- The protocols developed as part of the OSI model were never widely used. However, the model itself is quite useful for understanding computer networks

The OSI Model



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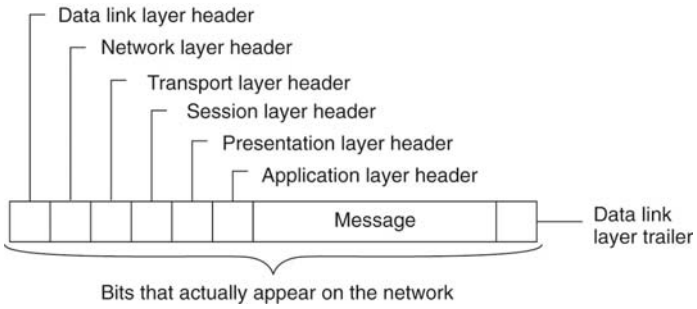
Data Flow Between Layers

- At sending side, layer N accepts packet from layer N+1 and encapsulates it in a layer N packet before passing it to layer N-1
- At receiving side, layer N accepts packet from layer N-1 and removes the layer N header before passing it to layer N+1



A typical message as it appears on the network.

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Functionality of OSI Layers (1)

- **Application layer** protocols are designed to meet the communication requirements of the specific applications
  - Examples: HTTP for Web, SMTP for Email
- **Presentation layer** protocols transmit data in a network representation that is independent of the representations used in individual computers, which may differ. Encryption is performed in this layer, if required.
  - Examples: TLS, CORBA common data representation
- **Session layer** establishes, manages, and terminates the connections between local and remote applications. It also performs failure detection and automatic recovery
  - Examples: SIP

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Functionality of OSI Layers (2)

- **Transport layer** delivers application messages from source process to destination process
  - Examples: TCP, UDP
- **Network layer** transfers data packets from source host to destination host. Routing is performed at this layer.
  - Examples: IP, ATM virtual circuits
- **Data link layer** is responsible for transmission of packets between nodes that are directly connected by a physical link
  - Examples: Ethernet MAC, Wi-Fi MAC, PPP
- **Physical layer** is responsible for transmitting raw bits over a physical link
  - Examples: Ethernet baseband signaling, ISDN

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The Internet Architecture

- The protocols used in the Internet are organized into five layers
  - **Application layer**
  - **Transport layer**
  - **Network layer**
  - **Data link layer**
  - **Physical layer**
- The presentation layer is integrated with the application layer
- The session layer is integrated with the transport layer

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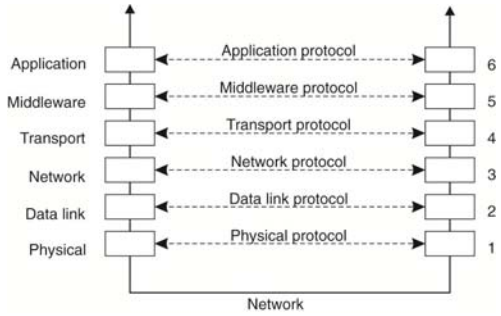
Middleware Layer

- Middleware provides common services that can be used by many different applications; such services are implemented by middleware protocols
- Example middleware protocols
  - Protocols supporting high-level communication services, e.g., RPC, RMI, multicast
  - Security protocols, e.g., authentication protocols, authorization protocols
  - Distributed commit protocols for transactions
  - Distributed locking protocols for mutual exclusion



An adapted reference model for networked communication

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Types of Communication

- Middleware can offer different types of communication to applications
  - Transient vs. persistent
  - Synchronous vs. asynchronous

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Transient vs. Persistent Communication

- **Persistent communication**: messages are stored by the communication middleware until receiver can accept it
  - Receiving application need not be executing when the message is submitted.
  - Example: Email
- **Transient communication**: a message will be discarded if the middleware cannot deliver it due to a transmission error or because the receiver is not executing
  - Example: TCP, UDP

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Synchronous vs. Asynchronous Communication

- **Asynchronous communication**: sender continues execution immediately after submitting its message for transmission
  - The message is stored by the middleware upon submission
- **Synchronous communication**: sender is blocked until its request is known to be accepted, that is,
  - The middleware notifies acceptance of the message, *or*
  - The message has been delivered to the receiver, *or*
  - The receiver has processes the message & returned a response

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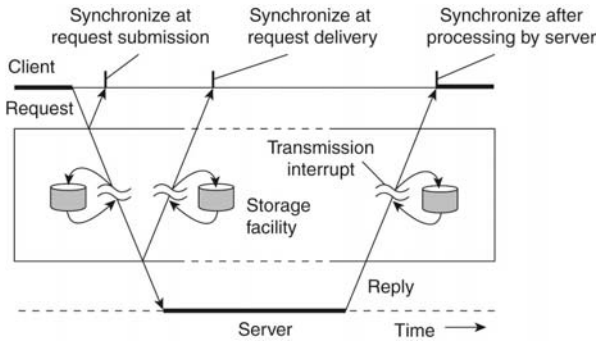

Three points where synchronization can take place.

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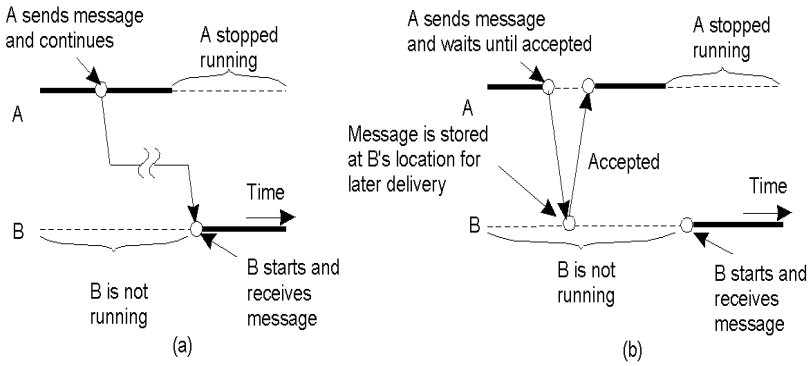
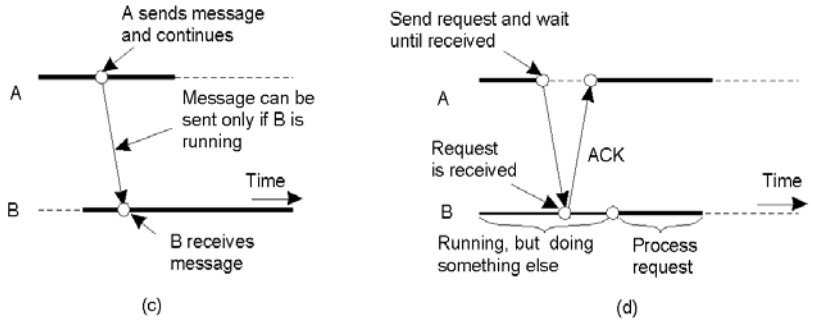
Persistence and Synchrony Combinations (1)



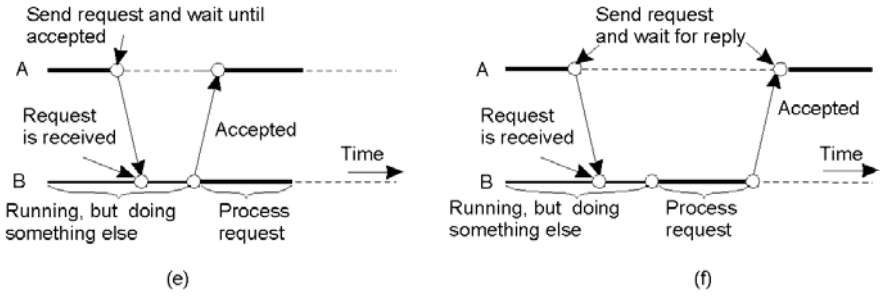
(a) Persistent asynchronous communication (e.g., email). (b) Persistent synchronous communication

Persistence and Synchrony Combinations (2)



(c) Transient asynchronous communication (e.g., TCP, UDP). (d) Receipt-based transient synchronous communication.

Persistence and Synchrony Combinations (3)



(e) Delivery-based transient synchronous communication (e.g., asynchronous RPC). (f) Response-based transient synchronous communication (e.g., RPC).