Distributed Systems
Communication (II)

[2] **Communication (II)**

1. Layered Protocols
2. Remote Procedure Call
3. Remote Object Invocation
4. **Message-oriented Communication**
5. **Stream-oriented Communication**

[3] **Persistence and Synchronicity in Communication (1)**

Assumption – communication system organized as follows:

- applications are executed on hosts,
- each host connected to one communication server,
- buffers may be placed either on hosts or in the communication servers of the underlying network,
- example: an e-mail system.

persistent vs **transient** communication,

asynchronous communication – sender continues immediately after it has submitted its message for transmission,

synchronous communication – the sender blocked until its message is stored in a local buffer at the receiving host or actually delivered to the receiver.

[4] **Persistence and Synchronicity in Communication (2)**

Client/server computing generally based on a model of **synchronous communication**:

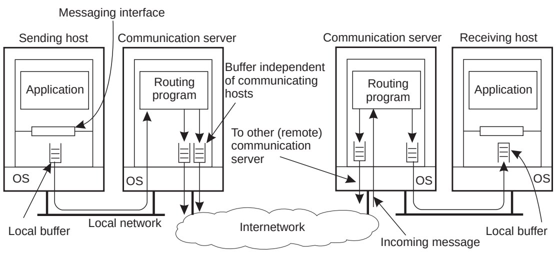
- client and server to be active at the time of communication,
- client issues request and blocks until reply received,

- server essentially waits only for incoming requests and subsequently processes them.

Drawbacks of synchronous communication:

- client cannot do any other work while waiting for reply,
- failures to be dealt with immediately (the client is waiting),
- in many cases the model simply not appropriate (mail, news).

[5] **Persistence and Synchronicity in Communication (3)**



General organization of a communication system in which hosts are connected through a network.

- queued messages sent among processes,
- sender not stopped in waiting for immediate reply,
- fault tolerance often ensured by middleware.

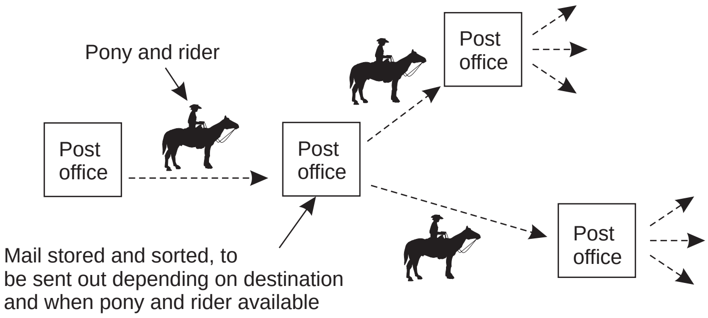
[6] **Persistence and Synchronicity in Communication (4)**

Persistent vs. transient communication

Persistent communication
A message is stored at a communication server as long as it takes to deliver it at the receiver.

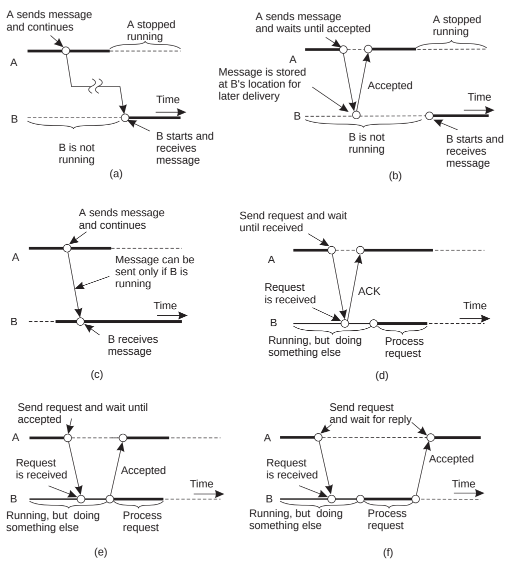
Transient communication
A message is discarded by a communication server as soon as it cannot be delivered at the next server or at the receiver.

[7] **Persistence and Synchronicity in Communication (5)**



Persistent communication of letters back in the days of the Pony Express.

[8] **Persistence and Synchronicity in Communication (6)**



Different forms of communication:

a. persistent asynchronous,

b. persistent synchronous,

c. transient asynchronous,

d. receipt-based transient synchronous,

e. delivery-based transient synchronous,

f. response-based transient synchronous,

[9] **Message-Oriented Transient Communication**

– socket interface introduced in Berkeley UNIX,

- another transport layer interface: XTI, X/Open Transport Interface, formerly called the Transport Layer Interface (TLI), developed by AT&T

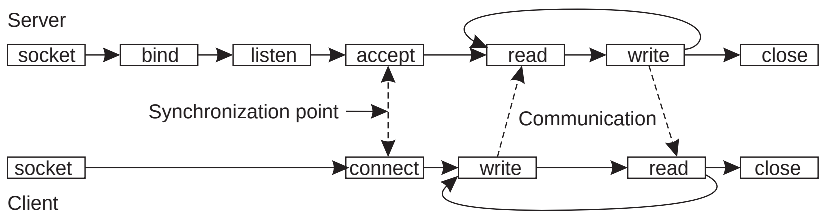
socket
Communication endpoint to which an application write data that are to be sent over the underlying network and from which incoming data can be read.

[10] **Berkeley Sockets (1)**

Primitive	Meaning
Socket	Create a new communication endpoint
Bind	Attach a local address to a socket
Listen	Announce willingness to accept connections
Accept	Block caller until a connection request arrives
Connect	Actively attempt to establish a connection
Send	Send some data over the connection
Receive	Receive some data over the connection
Close	Release the connection

Socket primitives for TCP/IP.

[11] **Berkeley Sockets (2)**



Connection-oriented communication pattern using sockets.

[12] **The Message-Passing Interface (MPI) (1)**

MPI
Group of message-oriented primitives that would allow developers to easily write highly efficient applications.

Sockets insufficient because:

- at the wrong level of abstraction supporting only send and receive primitives,
- designed to communicate using general-purpose protocol stacks such as TCP/IP, not suitable in high-speed interconnection networks, such as those used in COWs and MPPs (with different forms of buffering and synchronization).

[13] **The Message-Passing Interface (MPI) (2)**

MPI assumptions:

- communication within a known group of processes,
- each group with assigned id,
- each process withing a group also with assigned id,
- all serious failures (process crashes, network partitions) assumed as fatal and without any recovery,
- a (groupID, processID) pair used to identify source and destination of the message,
- only receipt-based transient synchronous communication (d) not supported, other supported.

[14] **The Message-Passing Interface (3)**

Primitive	Meaning
MPI_bsend	Append outgoing message to a local send buffer
MPI_send	Send a message and wait until copied to local or remote buffer
MPI_ssend	Send a message and wait until receipt starts
MPI_sendrecv	Send a message and wait for reply
MPI_isend	Pass reference to outgoing message, and continue
MPI_issend	Pass reference to outgoing message, and wait until receipt starts
MPI_recv	Receive a message; block if there is none
MPI_irecv	Check if there is an incoming message, but do not block

Some of the most intuitive message-passing primitives of MPI.

[15] **The Message-Oriented Persistent Communication**

Message-queueing systems = Message-Oriented Middleware (MOM)

The essence of MOM systems:

- offer the intermediate-term storage capacity for messages,
- target to support message transfers that are allowed to take minutes instead of seconds or milliseconds,
- no guarantees about when or even if the message will be actually read,
- the sender and receiver can execute completely independently.

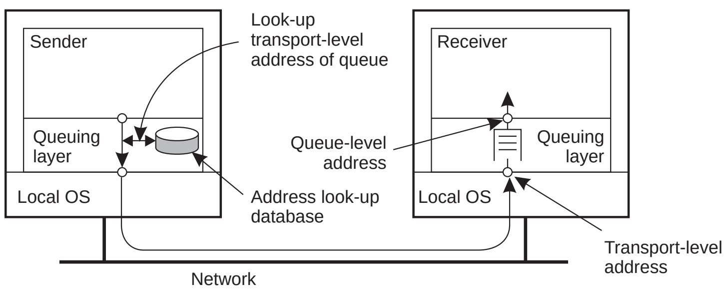
[16] **Message-Queuing Model**

Primitive	Meaning
Put	Append a message to a specified queue
Get	Block until the specified queue is nonempty, and remove the first message
Poll	Check a specified queue for messages, and remove the first. Never block
Notify	Install a handler to be called when a message is put into the specified queue

Basic interface to a queue in a message-queuing system.

Most queuing systems also allow a process to install handlers as callback functions.

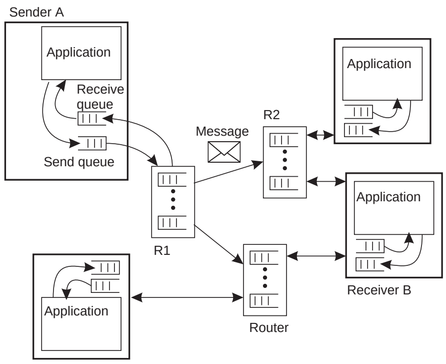
[17] **Architecture of Message-Queuing Systems (1)**



The relationship between queue-level addressing and network-level addressing.

source queue, destination queue, a database of queue names to network locations mapping.

[18] **Architecture of Message-Queuing Systems (2)**



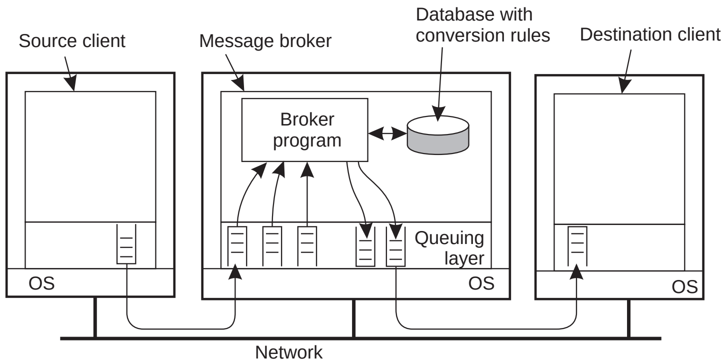
The general organization of a message-queuing system with routers:

- may grow into overlay network,
- may need dynamic routing schemes.

Queue managers:

- normally interact directly with applications,
- some operate as routers or relays.

[19] **Message Brokers**

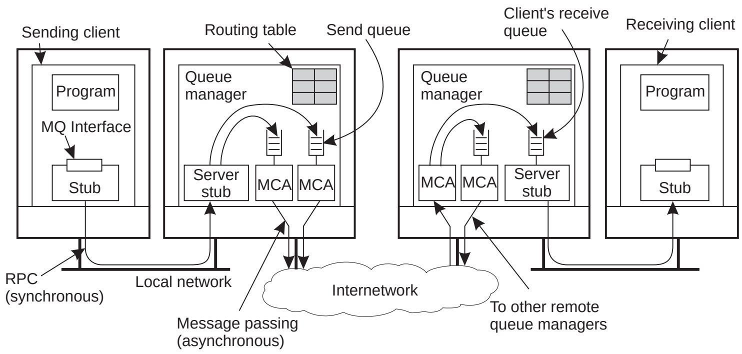


The general organization of a message broker in a message-queuing system.
Message broker
Acts as an application-level gateway in a message-queuing system. Its main purpose it to convert incoming messages to a format that can be understood by the destination application. It may provide routing capabilities.

[20] **Notes on Message-Queuing Systems**

- with message brokers it may be necessary to accept a certain loss of information during transformation,
- at the heart of a message broker lies a database of conversion rules,
- general message-queuing systems are not aimed at supporting only end users,
- they are set up to enable persistent communication,
- range of applications:
  - e-mail, workflow, groupware, batch processing,
  - integration of a collection of databases or database applications.

[21] **Example: IBM MQSeries**



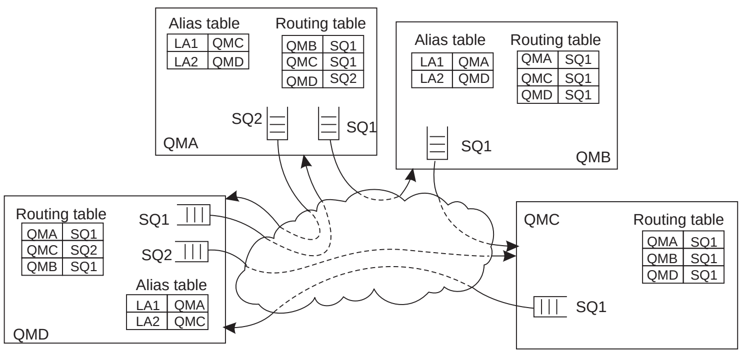
General organization of IBM's MQSeries message-queuing system.

[22] **Channels**

Attribute	Description
Transport type	Determines the transport protocol to be used
FIFO delivery	Indicates that messages are to be delivered in the order they are sent
Message length	Maximum length of a single message
Setup retry count	Specifies maximum number of retries to start up the remote MCA
Delivery retries	Maximum times MCA will try to put received message into queue

Some attributes associated with message channel agents.

[23] **Message Transfer (1)**



The general organization of an MQSeries queuing network using routing tables and aliases. By using logical names, in combination with name resolution to local queues, it is possible to put a message in a remote queue.

[24] **Message Transfer (2)**

Primitive	Description
MQopen	Open a (possibly remote) queue
MQclose	Close a queue
MQput	Put a message into an opened queue
MQget	Get a message from a (local) queue

Primitives available in an IBM MQSeries MQI.

[25] **Stream-Oriented Communication**

- forms of communication in which timing plays a crucial role,
- example:
  - an audio stream built up as a sequence of 16-bit samples each representing the amplitude of the sound wave as it is done through PCM (Pulse Code Modulation),
  - audio stream represents CD quality, i.e. 44100Hz,
  - samples to be played at intervals of exactly 1/44100,
- which facilities a distributed system should offer to exchange time-dependent information such as audio and video streams?
  - support for the exchange of time-dependent information = **support for continuous media**,
  - **continuous** (representation) media vs. **discrete** (representation) media.

[26] **Support for Continuous Media**

In continuous media :

– temporal relationships between data items fundamental to correctly interpreting the data,

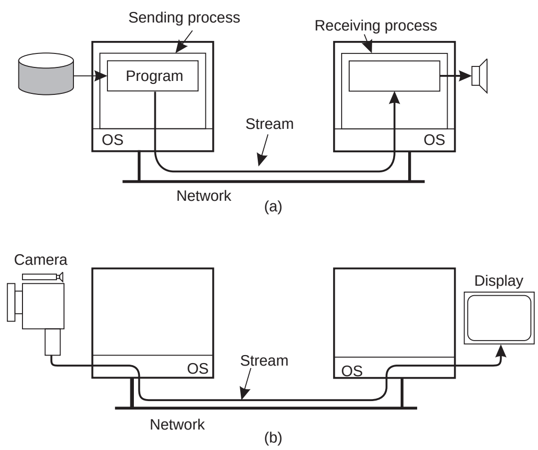
– timing is crucial.

Asynchronous transmission mode
Data items in a stream are transmitted one after the other, but there are no further timing constraints on when transmission of items should take place.

Synchronous transmission mode
Maximum end-to-end delay defined for each unit in a data stream.

Isochronous transmission mode
It is necessary that data units are transferred on time. Data transfer is subject to bounded (delay) jitter.

[27] **Data Stream (1)**



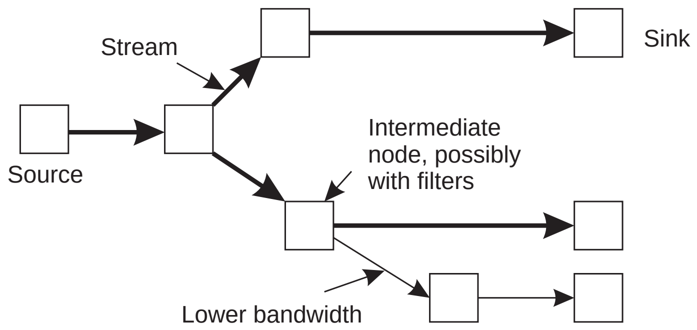
a. Setting up a stream between two processes across a network,

b. Setting up a stream directly between two devices.

– stream sequence of data units, may be considered as a virtual connection between a source and a sink,

– simple stream vs. complex stream (consisting of several related sub-streams).

[28] **Data Stream (2)**



An example of multicasting a stream to several receivers.

- problem with receivers having different requirements with respect to the quality of the stream,
- **filters** to adjust the quality of an incoming stream, differently for outgoing streams.

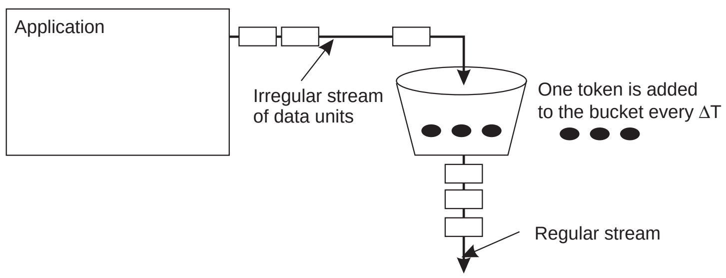
[29] **Specifying QoS (1)**

Characteristics of the Input	Service Required
Maximum data unit size (bytes) Token bucket rate (bytes/sec) Token bucket size (bytes) Maximum transmission rate (bytes/sec)	Loss sensitivity (bytes) Loss interval (μsec) Burst loss sensitivity (data units) Minimum delay noticed (μsec) Maximum delay variation (μsec) Quality of guarantee

A flow specification.

Time-dependent requirements among other **Quality of Service (QoS)** requirements.

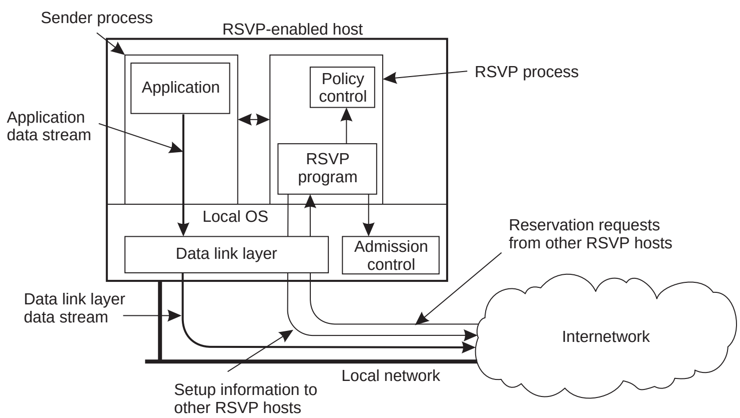
[30] **Specifying QoS (2)**



The principle of a token bucket algorithm.

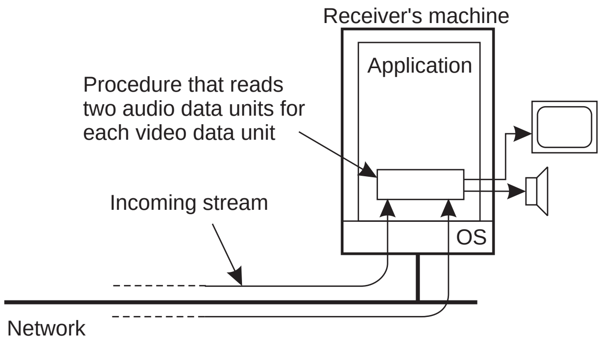
- tokens generated at a constant rate,
- tokens buffered in a bucket which has limited capacity.

[31] **Setting Up a Stream**



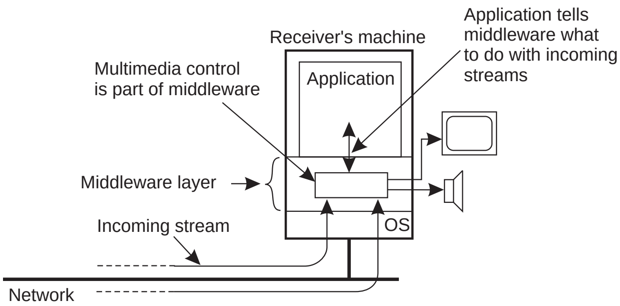
The basic organization of RSVP (Resource reSerVation Protocol), transport-level protocol for resource reservation in a distributed system.

[32] **Synchronization Mechanisms (1)**



The principle of explicit synchronization on the level data units.
Given a complex stream, how to keep the different substreams in synch?

[33] **Synchronization Mechanisms (2)**



The principle of synchronization as supported by high-level interfaces.

Multiplex of all substreams into a single stream and demultiplexing at the receiver. Synchronization is handled at multiplexing/demultiplexing point (MPEG).