Message-Queuing Systems

- **Message-queuing (MQ) systems** (also referred to as **Message–Oriented Middleware**) support asynchronous persistent communication
  - Asynchronous: sender continues execution immediately after submitting its message for transmission
  - Persistent: messages are stored by the MQ system until receiver can accept it
- MQ systems are mainly used for **Enterprise Application Integration (EAI)**, i.e., integration between applications within a given enterprise
- Example middleware: IBM's WebSphere MQ, Microsoft's MSMQ, Oracle's Streams Advanced Queuing

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Message-Queuing Model (1)

- Applications communicate by inserting messages in queues, which are provided by the MQ system
- Each application has its own queue to which other applications can send messages
- Each queue has a system-wide unique name; Every message contains the name of the destination queue
- A sender is given the guarantee that its message will be inserted in the recipient's queue
  - No guarantees are given about when or if the message will be read, which is determined by the behavior of the recipient

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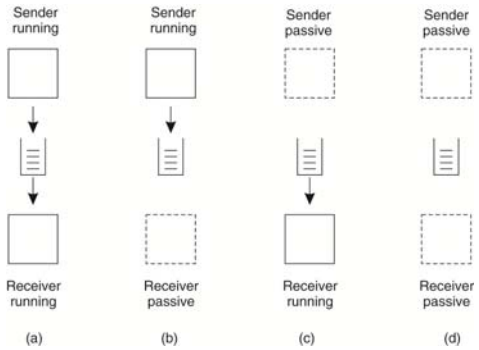
Message-Queuing Model (2)

- Communication is loosely coupled in time: Sender and receiver can execute independently of each other



Four combinations for loosely-coupled communications using queues.

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Basic Interface Offered to Applications

Primitive	Meaning
Put	Append a message to a specified queue (nonblocking)
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

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General Architecture of a MQ System (1)

- Applications can only put messages into and read messages from **local queues**
  - A **local queue** is a queue on the same machine or on a machine nearby (e.g., on the same Ethernet) that can be effectively reached through an RPC
- Sender's local queue is called the **source queue**; the receiver's local queue is called the **destination queue**
- The MQ system is responsible for transferring messages from their source queue to their destination queue

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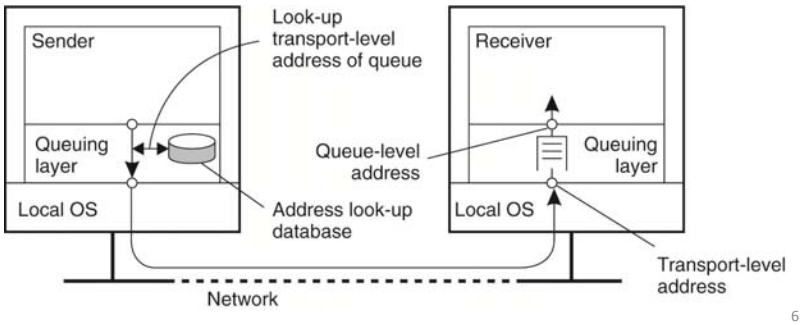
General Architecture of a MQ System (2)

- Every message contains the name of the destination queue
- A MQ system maintains a mapping of queue names to network locations in order to transfer messages to their destination queue
  - The mapping is maintained in a (possibly distributed) database



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General Architecture of a MQ System (3)

- Queues are managed by queue managers
  - A queue manager interacts directly with the application that is sending or receiving a message
- One way to map queue names to network locations is to have each queue manager maintain a copy of the queue-to-location mapping
  - A message can be directly sent to the destination queue manager
  - This is unscalable: every queue manager must be updated when queues are added or removed

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General Architecture of a MQ System (4)

- A scalable solution is to employ a few special queue managers that operate as **routers**, or **relays**
- A message is first transferred from the source queue to the nearest router; the router then forwards the message toward its destination queue
- How does a router know where to forward a message?
  - Each router maintains a routing table that maps destination queue names to next-hop routers
  - Forwarding decision is made by consulting the routing table
- This is scalable
  - Queue managers only need to know where the nearest router is
  - When queues are added or removed, only routing tables stored in routers need to be updated

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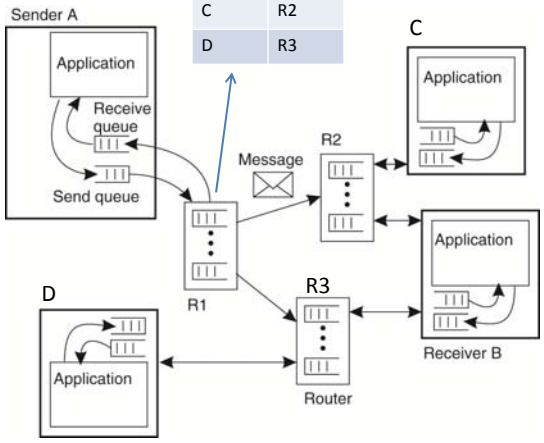
R1's routing table

Queue Name	Next-Hop
B	R2
C	R2
D	R3



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

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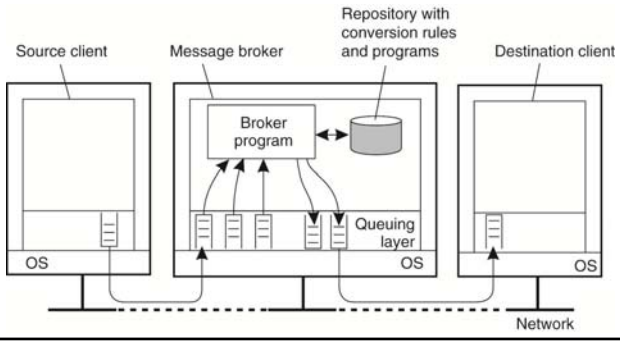
Message Brokers

- A MQ system is often used to integrate different applications into a single coherent distributed information system
- Different applications may have different message formats; message brokers can be used to handle conversion between different message formats (e.g., converting from one byte order to another, converting from one external data representation to another)
  - A message broker maintains a repository of rules and programs that can transform a message of one type to a message of another type



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MQ Systems vs Email Systems

- Both MQ systems and email systems support asynchronous persistent communication
- There are a few differences
  - No routing in email systems: messages are sent directly from the source mail server to the destination mail server
  - MQ systems are more general purpose than email: MQ systems enable communication between processes; email systems support only end users

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Example: IBM's Websphere MQ

- All queues are managed by queue managers, which handle outgoing and incoming messages
- Queue managers are linked together to form a certain topology and route messages toward their destination queue
- Queue managers and applications can run on the same machine or on separate machines
  - If on separate machines, the application communicates with the queue manager using RPC

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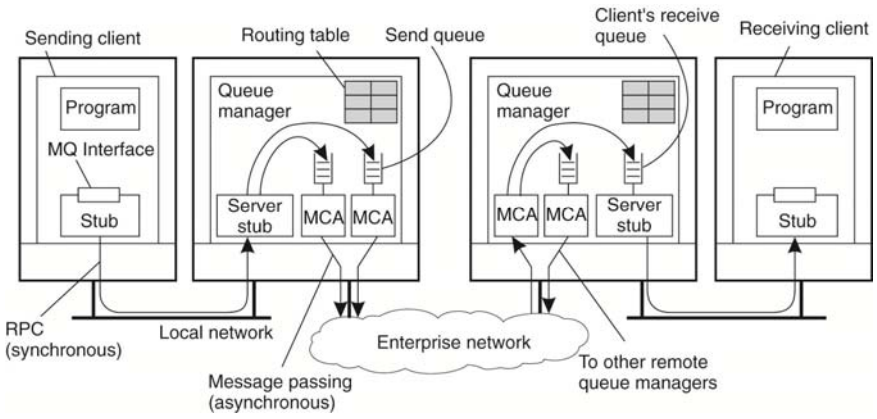

General organization of IBM's message-queuing system.

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Message Channels

- Queue managers are pairwise connected through **message channels**
  - A message channel is a unidirectional, reliable connection (e.g., a TCP connection) between a sending and a receiving queue manager, through which queued messages are transported
  - Each message channel has one associated send queue that contains the messages to be sent on the channel
- At each endpoint of a channel is a **message channel agent (MCA)**
  - The sending MCA is responsible for wrapping messages in the send queue into transport-level packets and sending them
  - The receiving MCA is responsible for receiving packets, unwrapping them, and storing unwrapped messages into the appropriate queue

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Message Transfer

- Each message carries a destination address consisting of the name of the destination queue manager and the name of the destination queue
- Each queue manager has a routing table (maintained manually)
  - A table entry is a pair (destQM, sendQ), where destQM is the name of a destination queue manager and sendQ is the name of a local send queue
  - The entry means that a message for destQM should be appended to sendQ
  - Note: Each message channel has exactly one send queue, so sendQ effectively specifies to which queue manager the message is to be forwarded
- **Aliases** can be used to allow applications to use the same logical name for a queue even if the queue manager of that queue changes
  - An alias defined within a queue manager M1 is another name for a queue manager M2, which is only available to applications interfacing to M1
  - Changing the name of a queue manager requires that we change its alias table entry and routing table entry in all queue managers. However, applications are not affected.

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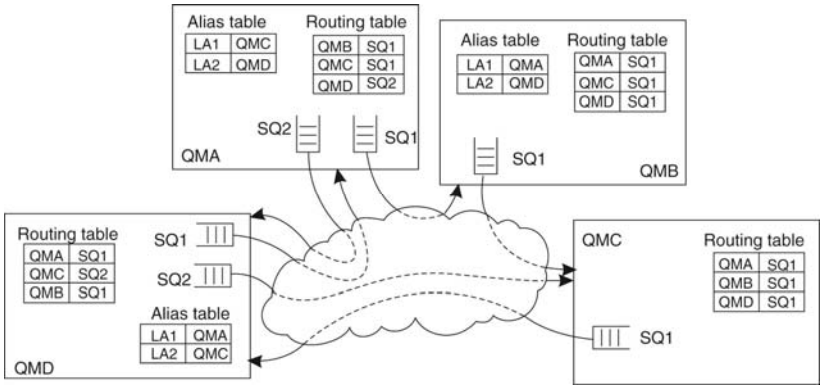

The general organization of an MQ queuing network using routing tables and aliases.

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