CSci 5105

Introduction to Distributed Systems

Communication: MPI, MoM

MPI

- Message Passing Library Interface Standard
- For parallel computers, clusters, and heterogeneous networks
- Communication modes: *standard*, *synchronous*, *buffered*, and *ready*
- Designed to permit the development of portable parallel software libraries

MPI Communication API

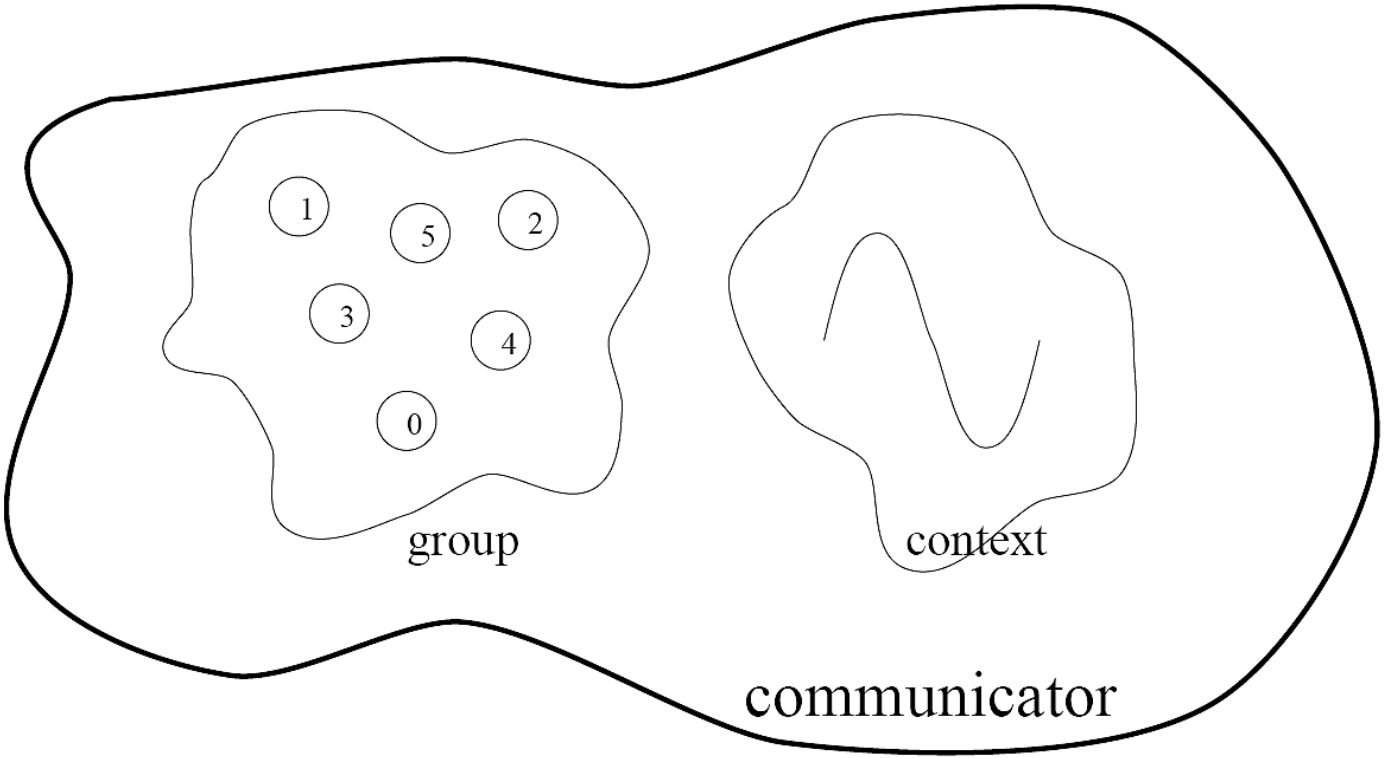
Primitive	Meaning
MPI_send	Send a message and wait until copied to local or remote buffer
MPI_ssend	Send a message and wait until receipt starts
MPI_sendrecv	Send a message and wait for reply
MPI_isend	Pass reference to outgoing message, and continue
MPI_issend	Pass reference to outgoing message, and 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

Example: Startup

```
#include <mpi.h>
#include <stdio.h>
int main(int argc, char *argv[])
{
   int rank, size;
   MPI_Init(&argc, &argv);
   MPI_Comm_rank(MPI_COMM_WORLD, &rank);
   MPI_Comm_size(MPI_COMM_WORLD, &size);
   printf("I am %d of %d\n", rank, size);
   MPI_Finalize();
   return 0;
}
```

MPI Abstractions

- Group: is the set of processes that communicate with one another
- Communicator: each communicator is associated with a group and a context



MPI Simple?

- Despite over 100 options …
- Many parallel programs can be written using just these six functions
  - MPI_INIT
  - MPI_FINALIZE
  - MPI_COMM_SIZE
  - MPI_COMM_RANK
  - MPI_SEND
  - MPI_RECV

```c
#include <stdio.h>
#include <mpi.h>

// No error checking
int main(int argc, char *argv[])
{
  const int tag = 42;          // Message tag
  int id, ntasks, source_id, dest_id, st, i;
  MPI_Status status;
  int msg[2]; // Message array

  MPI_Init(&argc, &argv); // Initialize MPI
  MPI_Comm_size(MPI_COMM_WORLD, &ntasks); // Get # of tasks
  MPI_Comm_rank(MPI_COMM_WORLD, &id);  // Get id

  if (ntasks < 2) {
    printf("You have to use at least 2 processors to run this
            program\n");
    MPI_Finalize();   // Quit if there is only one processor
    exit(0);
  }
```

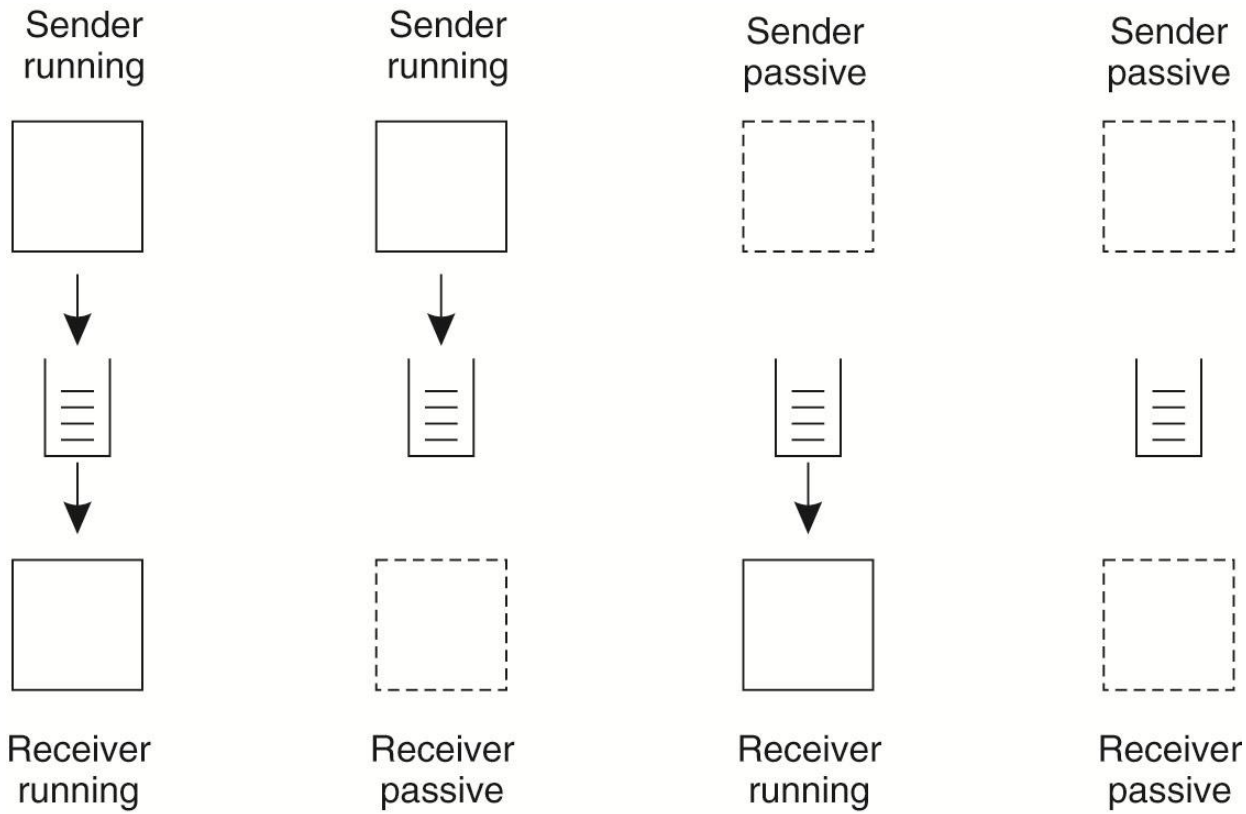
```
  if (id == 0) {  /* Process 0 (the receiver) does this */
    for (i=1; i<ntasks; i++) {
      MPI_Recv(msg, 2, MPI_INT, MPI_ANY_SOURCE, tag,
               MPI_COMM_WORLD, &status); // Receive a message
      source_id = status.MPI_SOURCE; // Get id of sender
    }
  }
  else {    // Processes 1 to N-1 (the senders) do this
    msg[0] = id; // Put own identifier in the message
    msg[1] = ntasks;          // and total number of processes
    dest_id = 0; // Destination address
    MPI_Send(msg, 2, MPI_INT, dest_id, tag, MPI_COMM_WORLD);
  }

  MPI_Finalize();           // Terminate MPI
  exit(0);
  return 0;
}
```

Motivation

- RPC and lower-level protocols assume sender/receivers run at the same time
- Suppose they are not?
- Need persistent communication
  - delay ~ of minutes is ok
- For users *and* applications

Scenarios

- Four possibilities

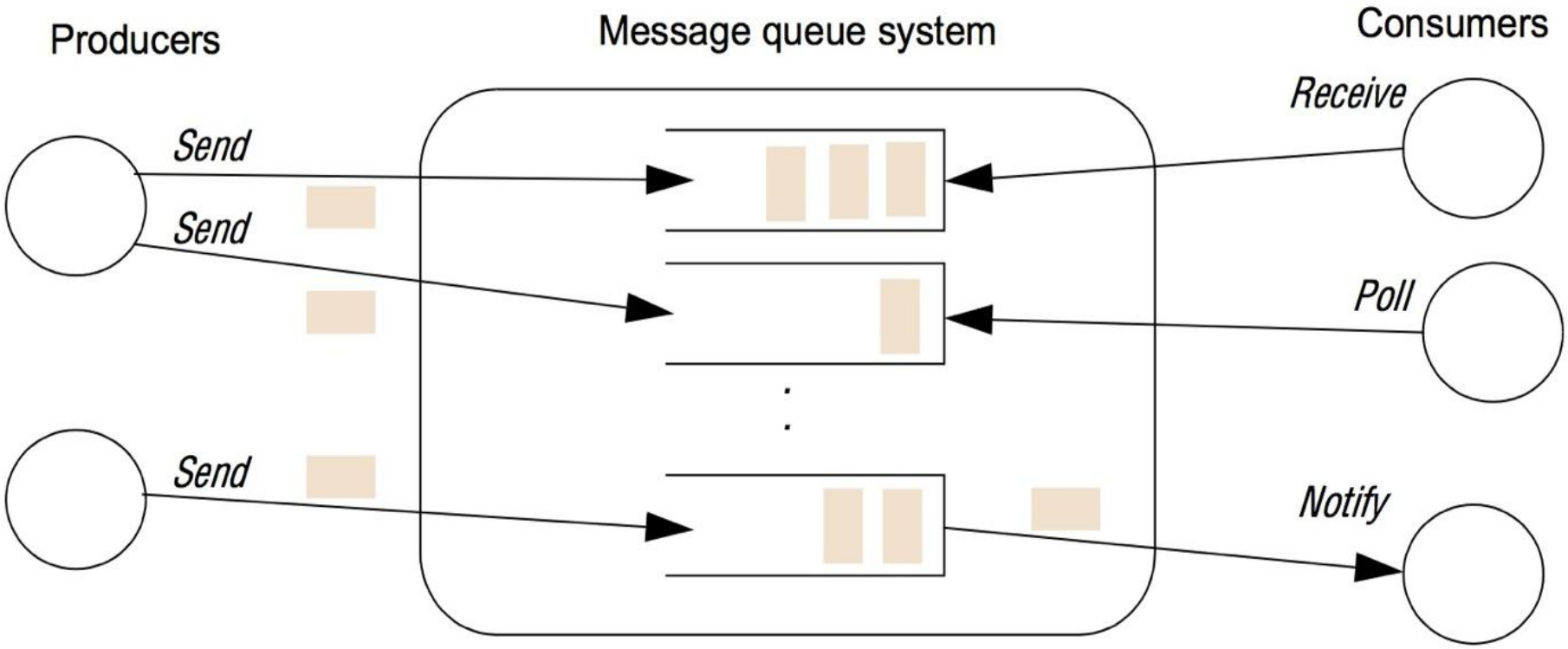


Message-Queuing Model

- Need a persistent queue
- Basic interface

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

Message-Queuing Model

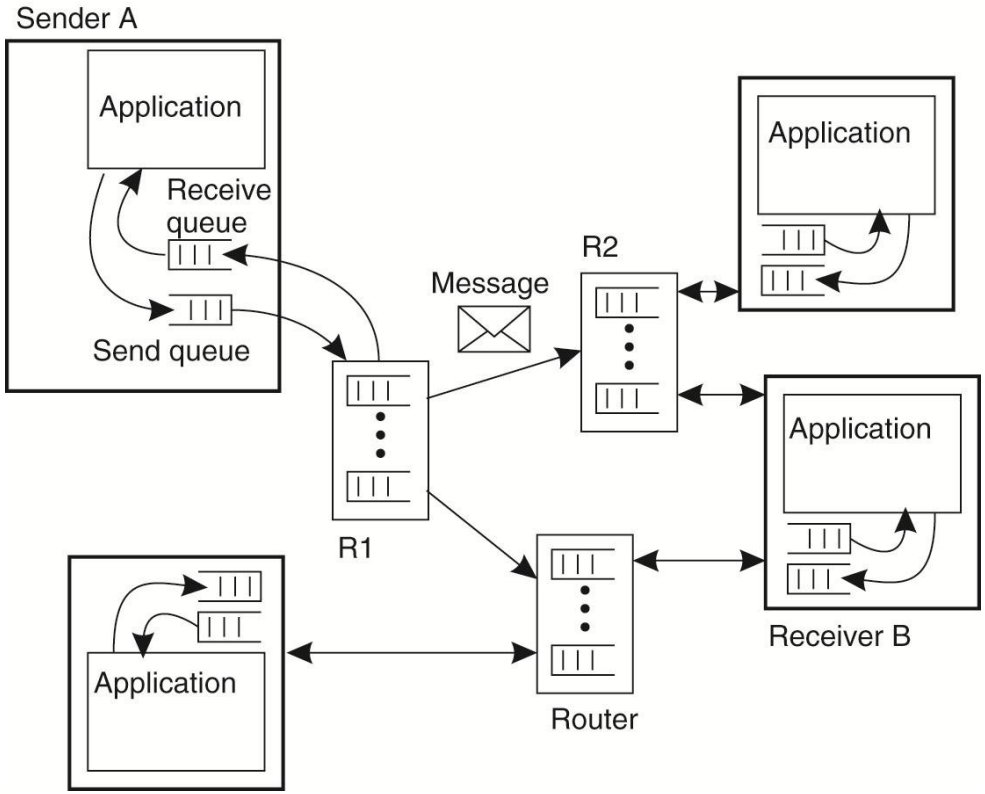


Generalization

- Senders don’t care who they are sending to!
- Receivers don’t care who they are receiving from!

Architecture of a Message-Queuing System

- Series of queues with lookup services
- Automatic routing from source to destination queue

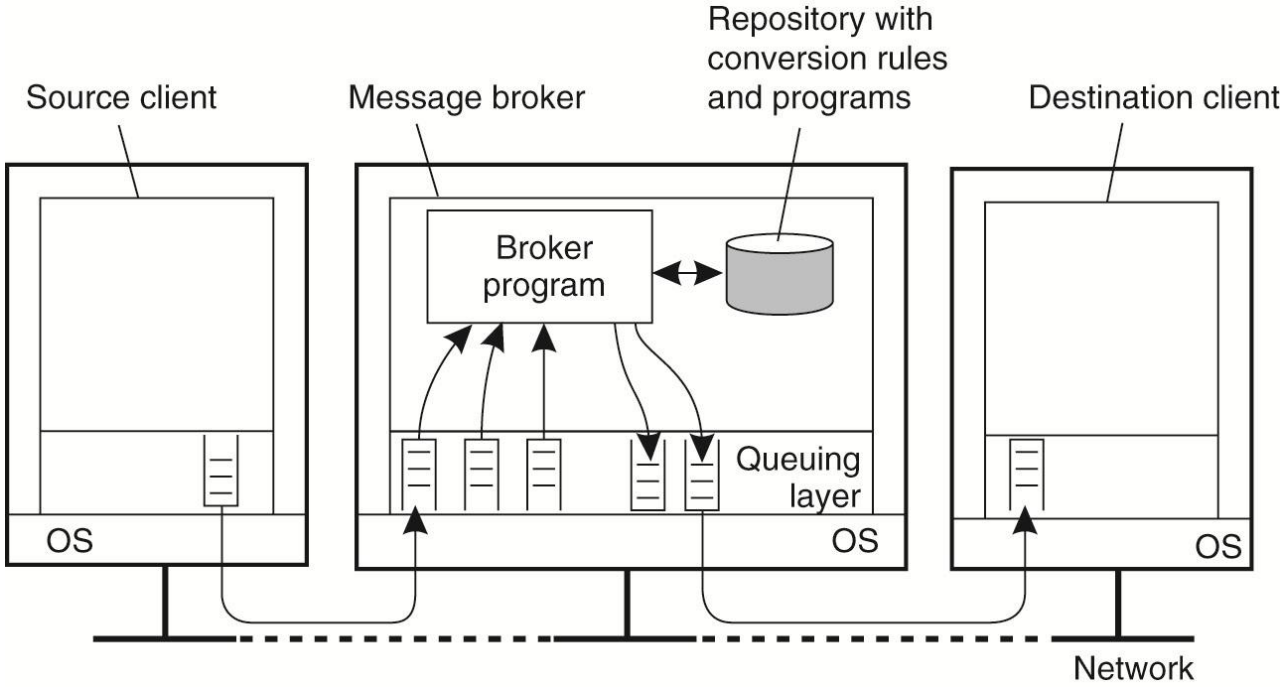


Relays

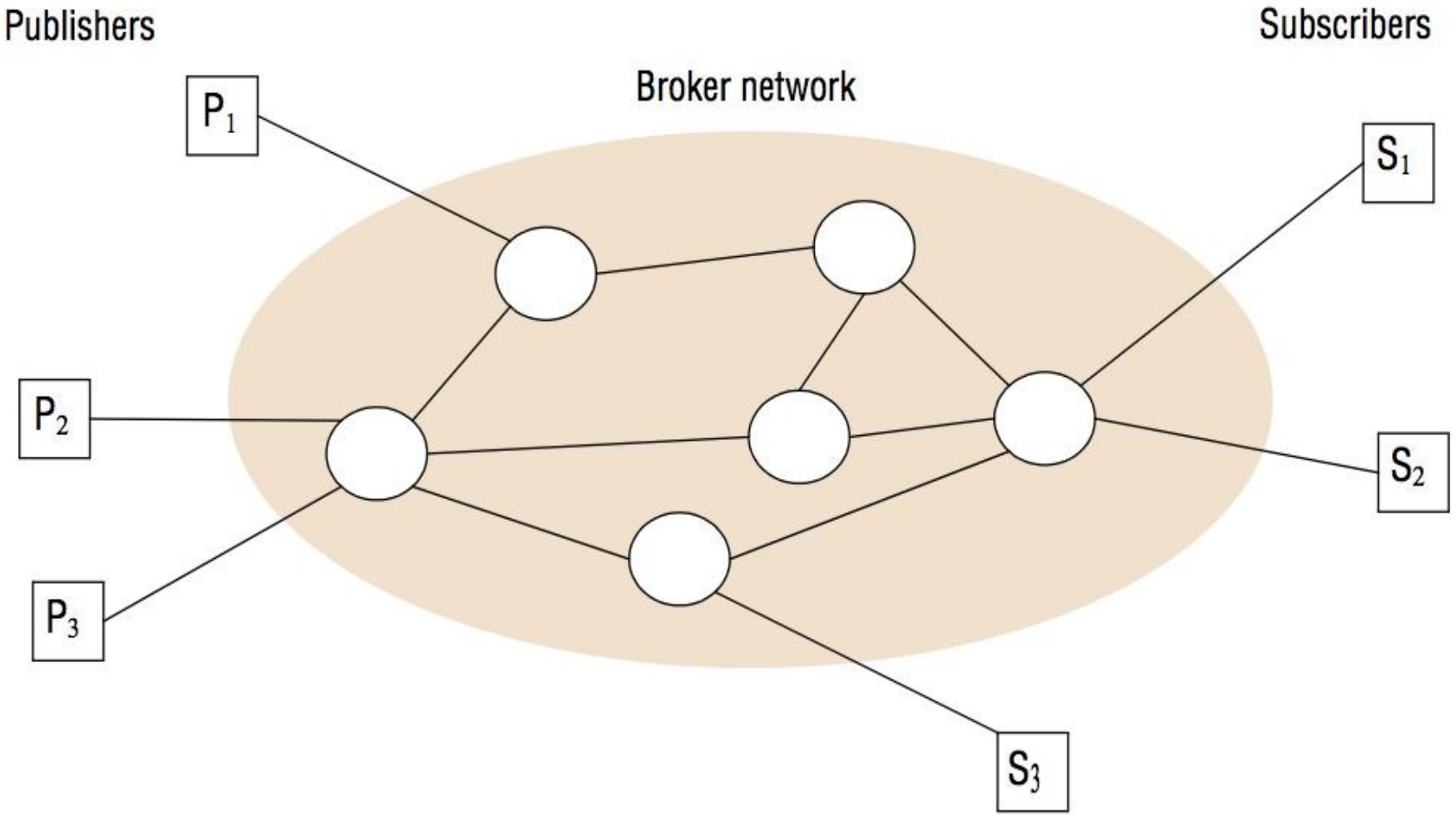
- Scalability
- Static routing
- Provide messaging features
  - logging
  - multicast
  - format transformation

Brokers

- Connect new applications
- Message formats are not compatible
- Application-gateway is needed to perform transformation for receiving clients



A network of brokers

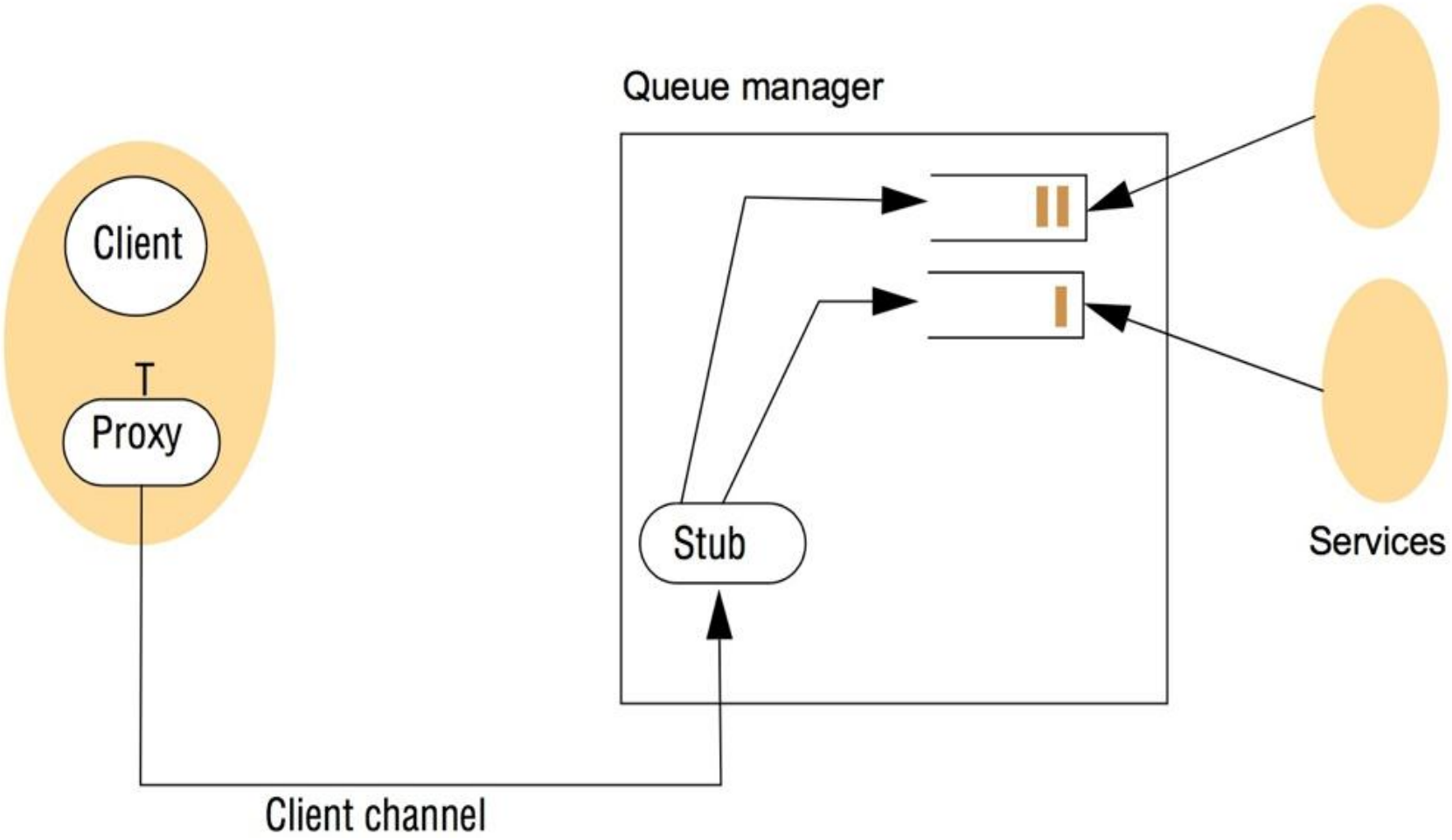


IBM's WebSphere

- Message channels (MCA) connect message queues
- Specify specific behaviors

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

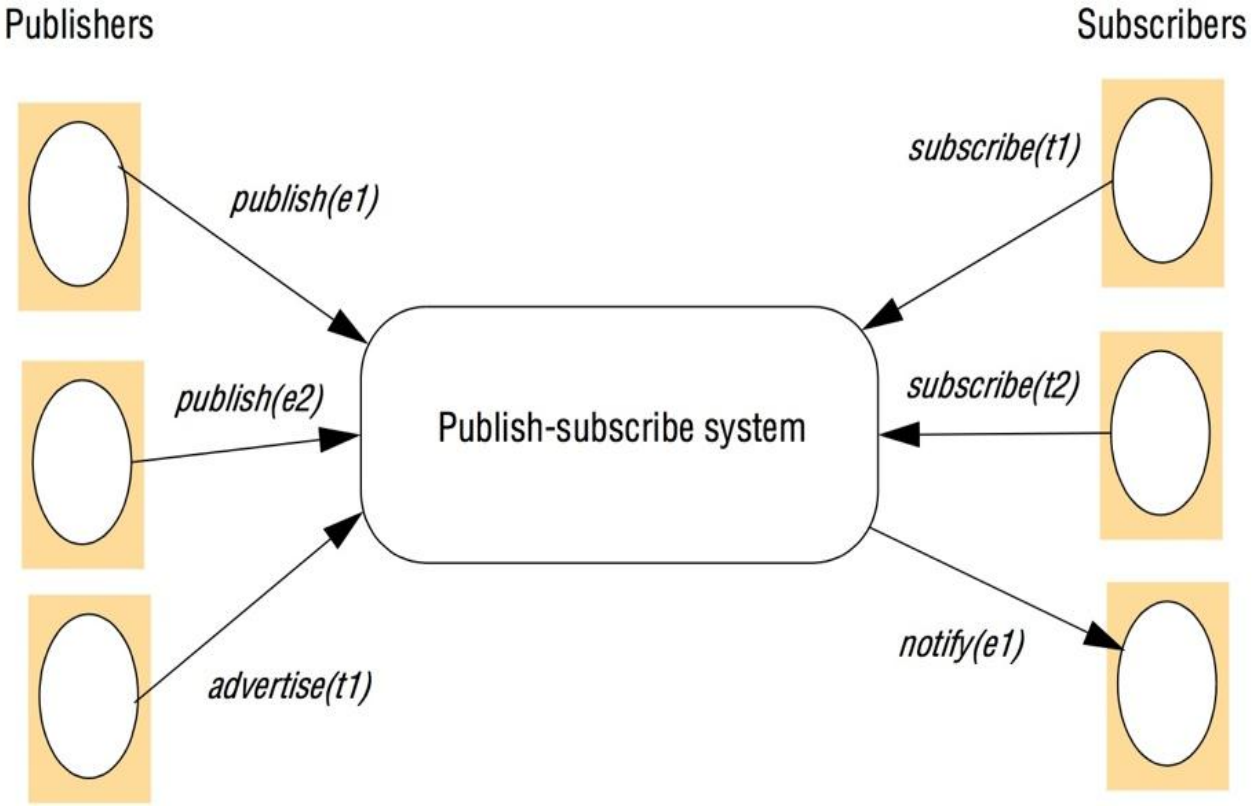
Programming in WebSphere



Use Cases?

- Application integration
- E-commerce
  - Past: an order went to a single application to process
  - Future: split order into multiple sub-orders and send to different vendors
- Different database query formats

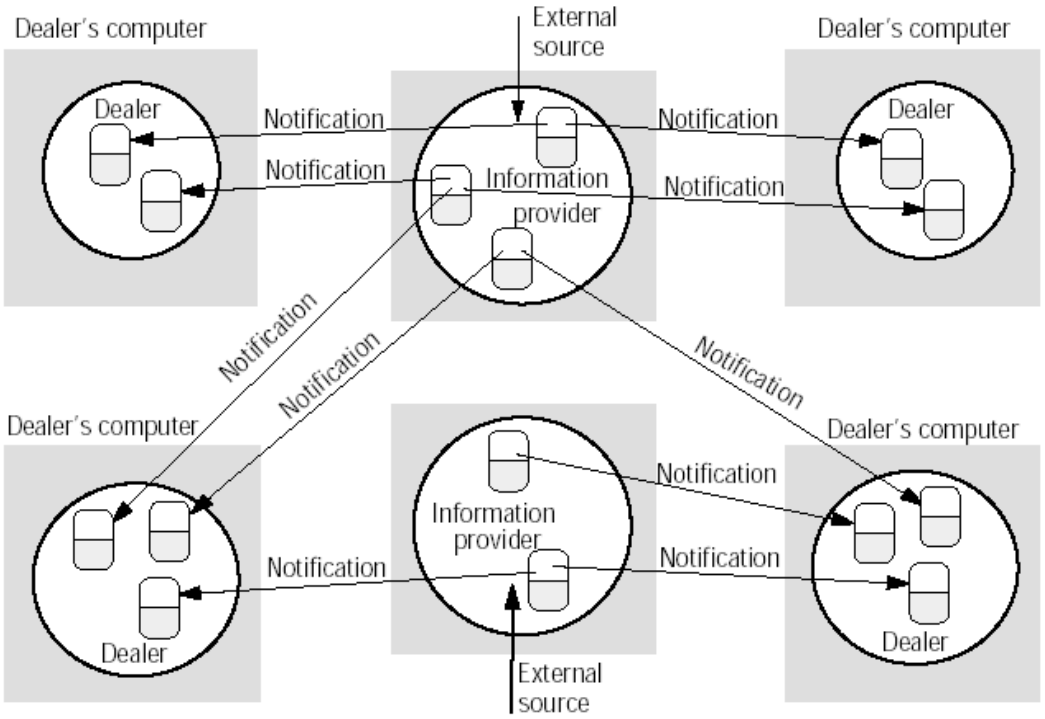
Publish Subscribe



subscribe to a message with particular attributes

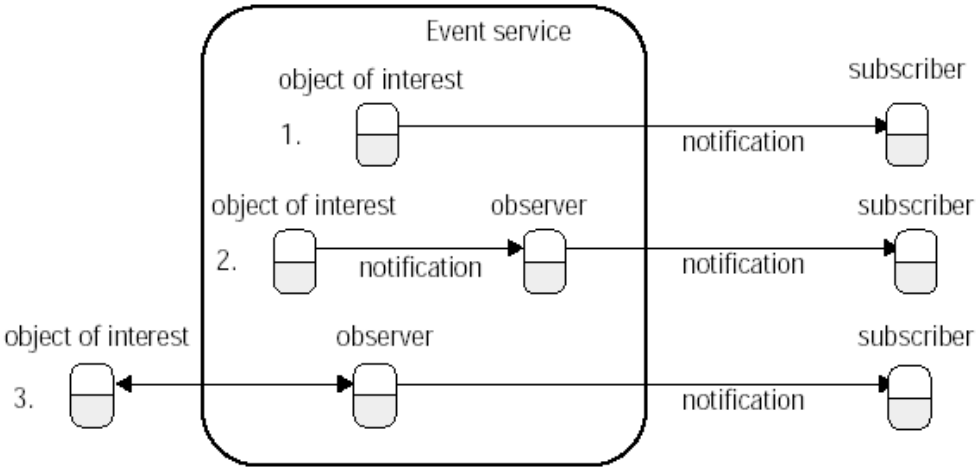
Example: Stock Quotes

- Stricter semantics on notification delivery
- Dealers for same stock should get same information



Finer-grain: Object-Based

Figure 5.10 Architecture for distributed event notification



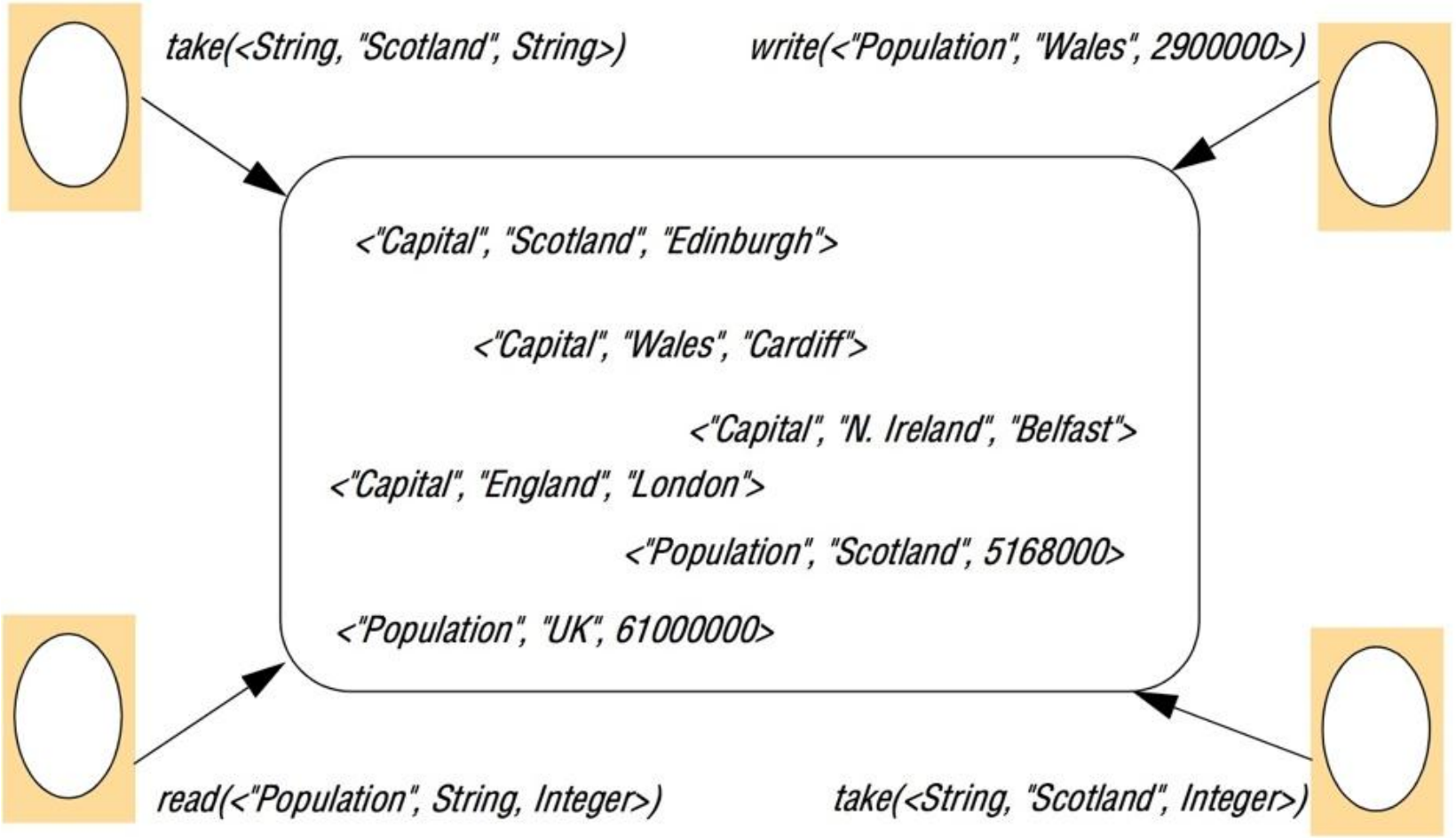
events occur at an object of interest

notification: “event object”

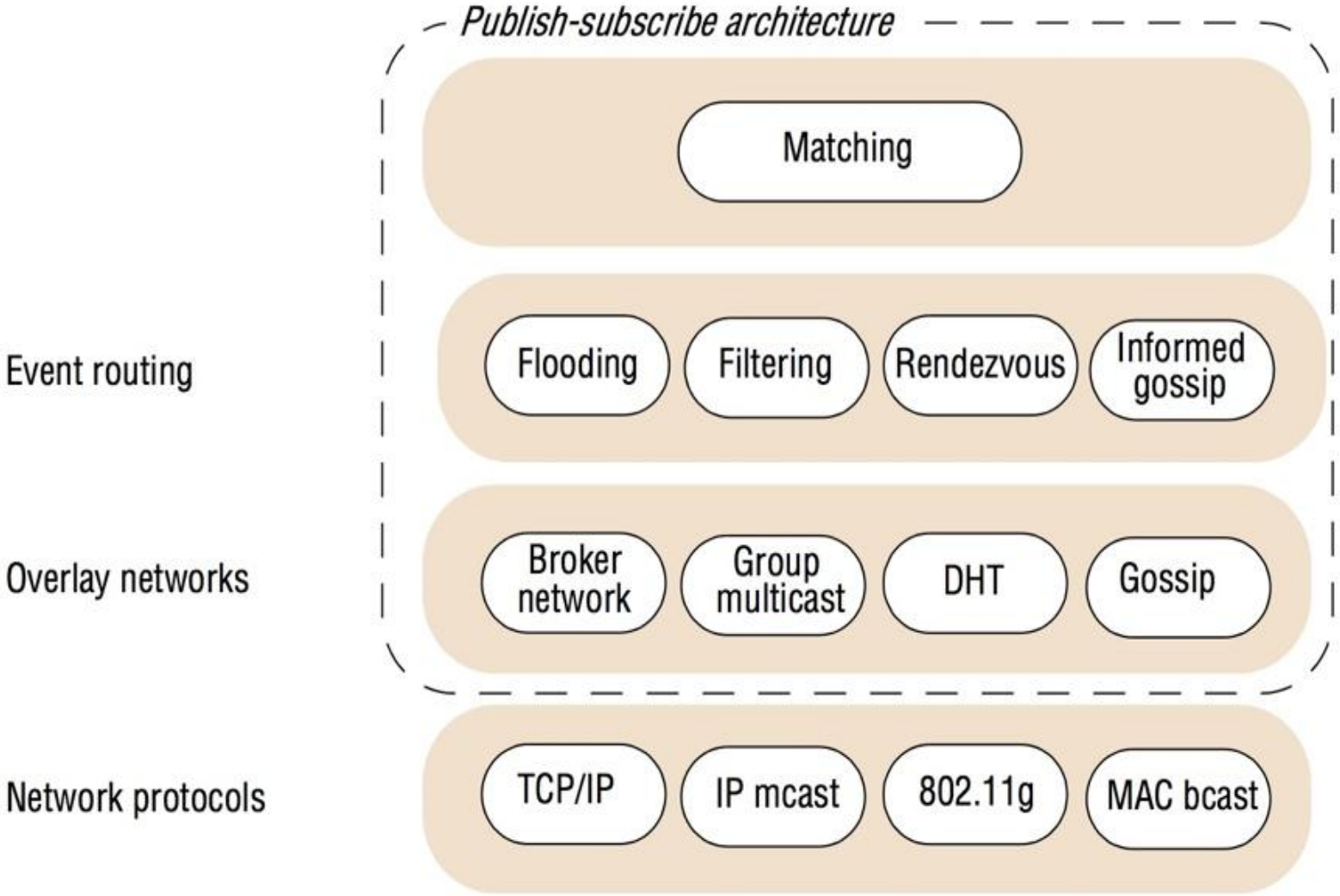
observers propagate notifications

delivery semantics: real-time, reliable, …

Programming Model: Tuple Space



Pub-Sub Architecture



How does information propagate?

- Flooding
  - information is sent to all nodes
  - discard at destination
- Filtering (network)
  - brokers filter only if subscribers upstream
- Filtering (source)
  - flood subscriptions
  - filter at source

Propagation

- Advertisements
  - producers propagate advertisements towards subscribers
- Rendezvous
  - set of brokers responsible for specific portions of the event space

Next Time

Next topic: Streaming and Multicast

Read Chapters 4.4 - 4.5 TVS