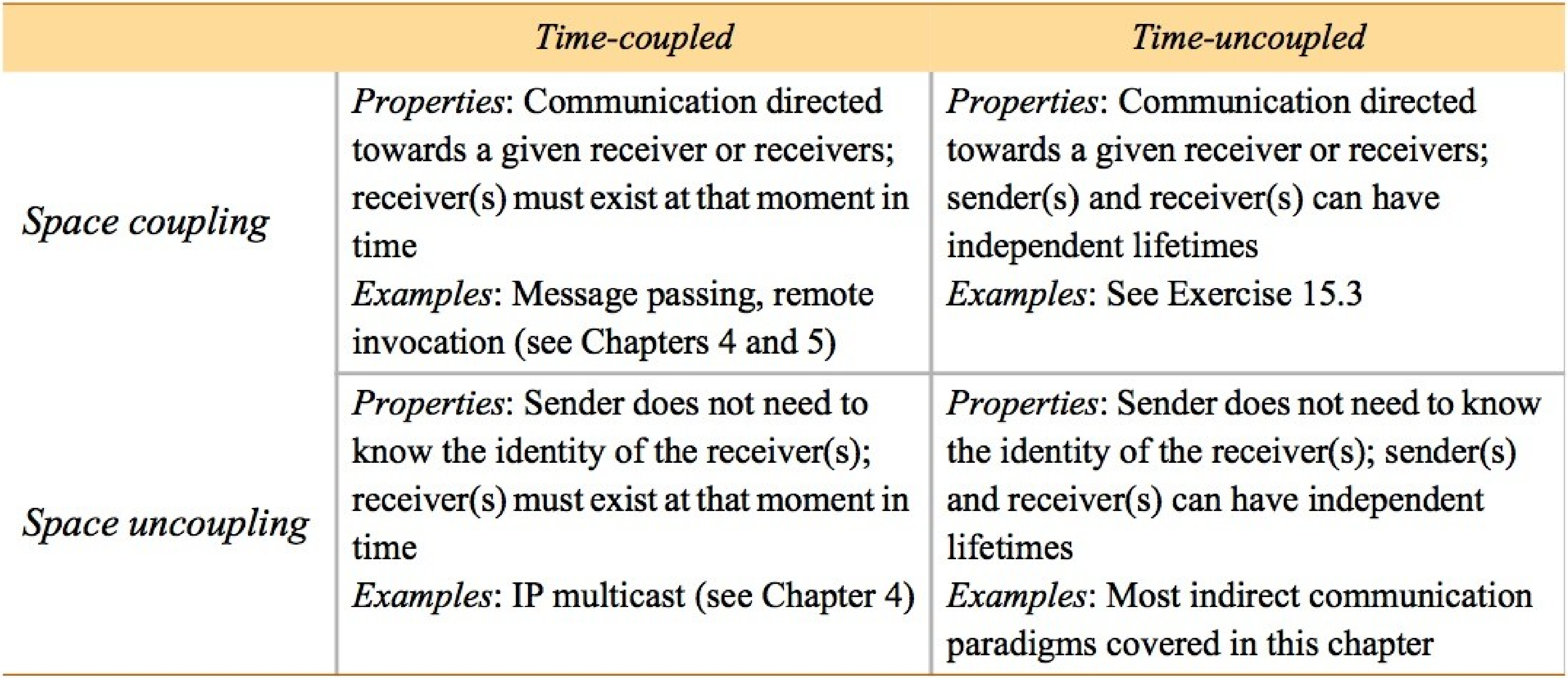
Slides for Chapter 6:
Indirect Communication

Figure 6.1
Space and time coupling in distributed systems



	Time-coupled	*Time-uncoupled*
Space coupling	*Properties*: Communication directed towards a given receiver or receivers; receiver(s) must exist at that moment in time *Examples*: Message passing, remote invocation (see Chapters 4 and 5)	*Properties*: Communication directed towards a given receiver or receivers; sender(s) and receiver(s) can have independent lifetimes *Examples*: See Exercise 15.3
Space uncoupling	*Properties*: Sender does not need to know the identity of the receiver(s); receiver(s) must exist at that moment in time *Examples*: IP multicast (see Chapter 4)	*Properties*: Sender does not need to know the identity of the receiver(s); sender(s) and receiver(s) can have independent lifetimes *Examples*: Most indirect communication paradigms covered in this chapter

Figure 6.2
Open and closed groups

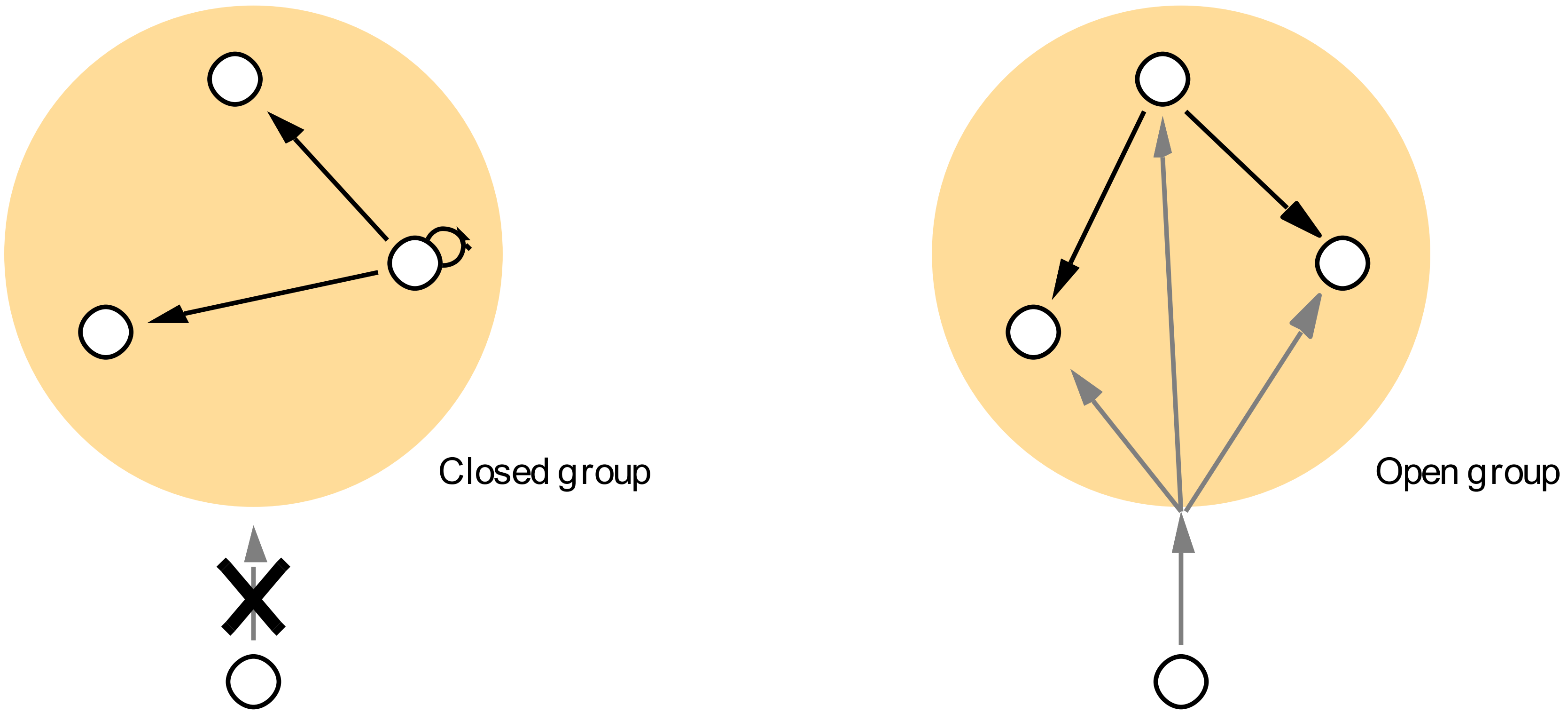


Figure 6.3
The role of group membership management

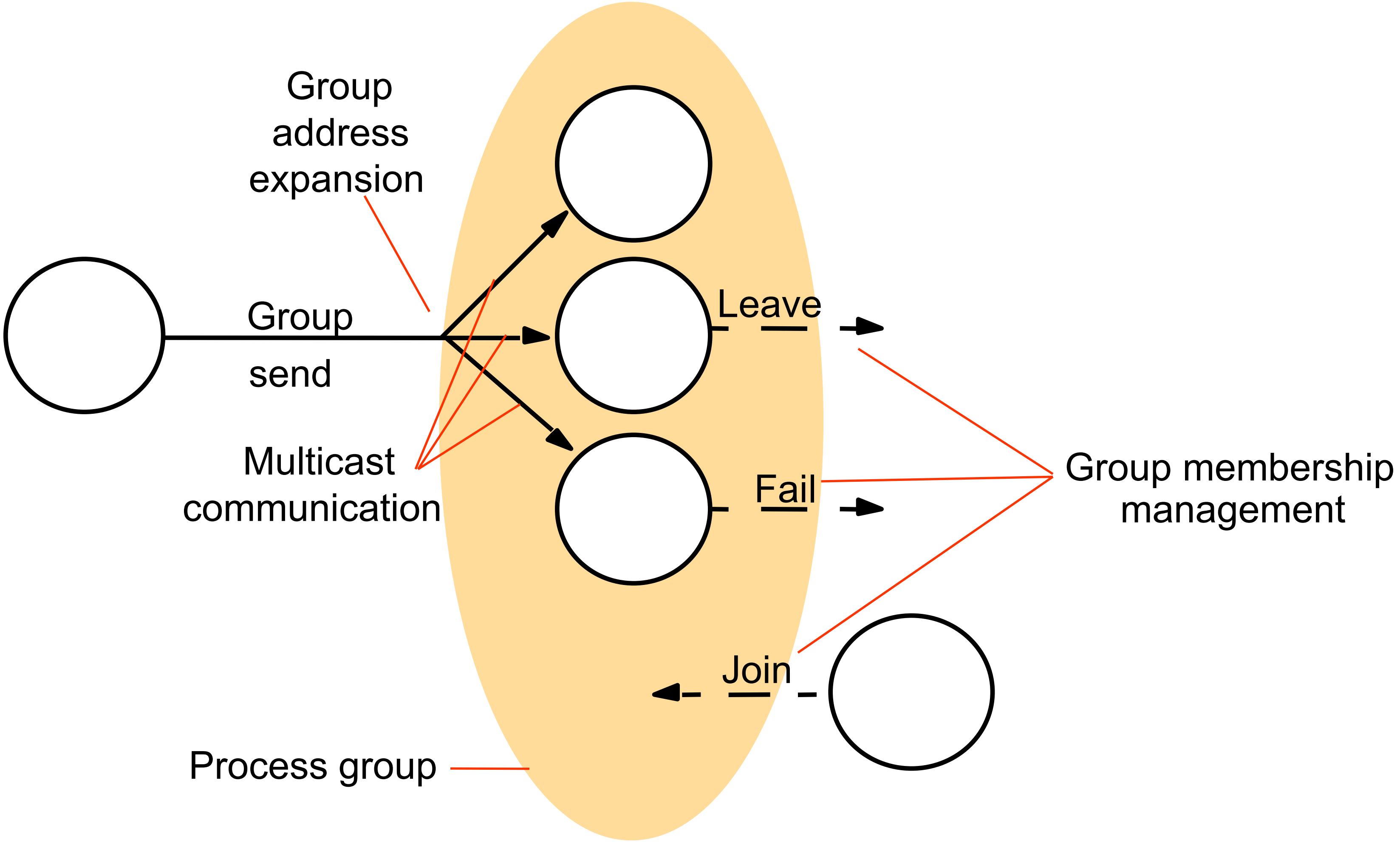


Figure 6.4
The architecture of JGroups

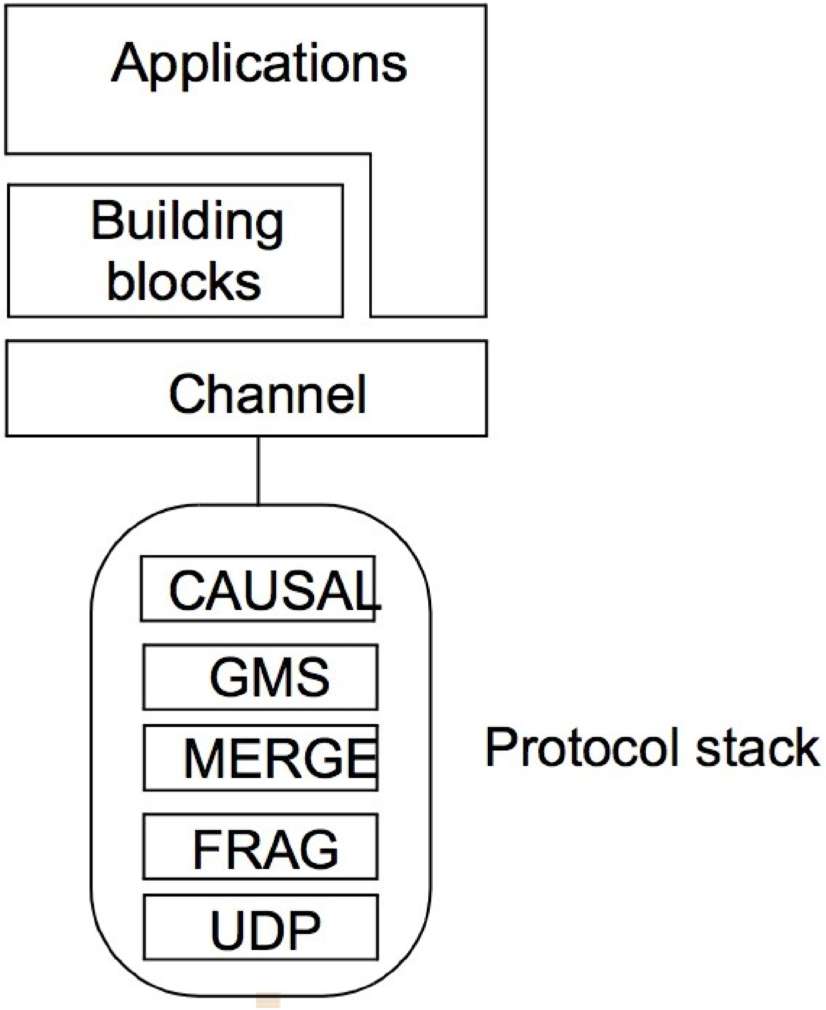


Figure 6.5
Java class *FireAlarmJG*

```
import org.jgroups.JChannel;
public class FireAlarmJG {
public void raise() {
    try {
        JChannel channel = new JChannel();
        channel.connect("AlarmChannel");
        Message msg = new Message(null, null, "Fire!");
        channel.send(msg);
    }
    catch(Exception e) {
    }
}
```

Figure 6.6
Java class *FireAlarmConsumerJG*

```
import org.jgroups.JChannel;

  public class FireAlarmConsumerJG {
     public String await() {
    try {
          JChannel channel = new JChannel();
          channel.connect("AlarmChannel");
          Message msg = (Message) channel.receive(0);
          return (String) msg.GetObject();
    } catch(Exception e) {
          return null;
    }
  }
}
```

Figure 6.7
Dealing room system

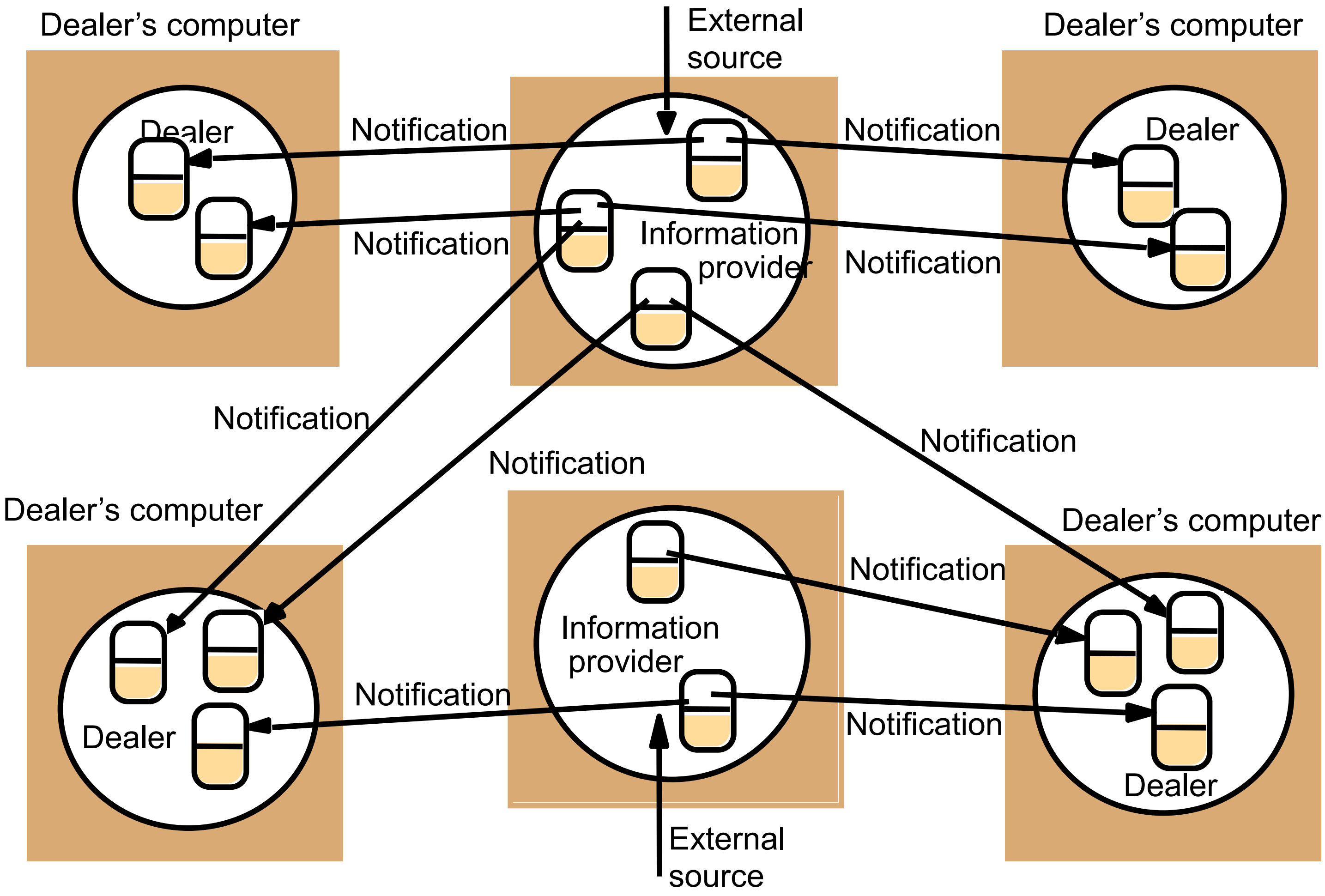


Figure 6.8
The publish-subscribe paradigm

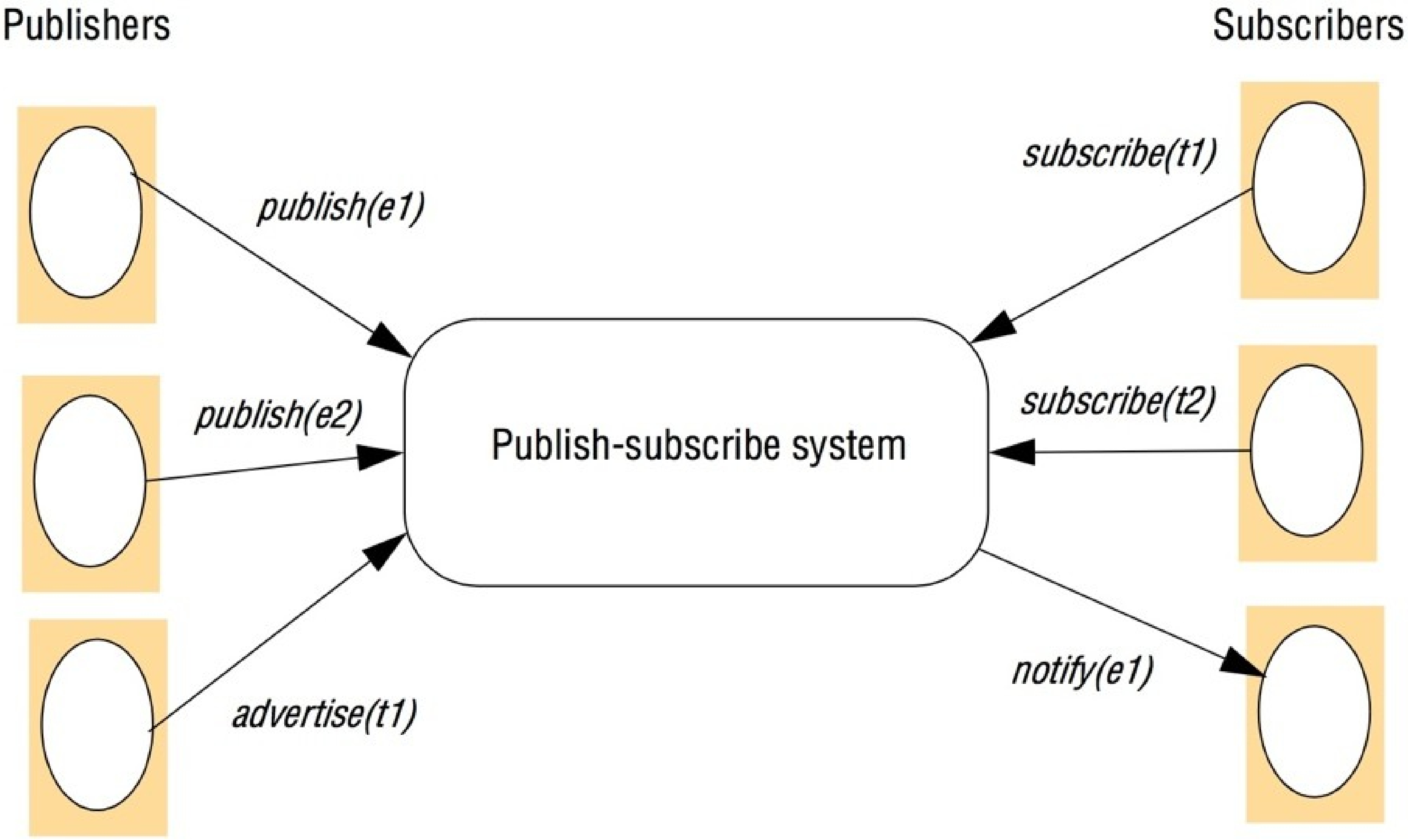


Figure 6.9
A network of brokers

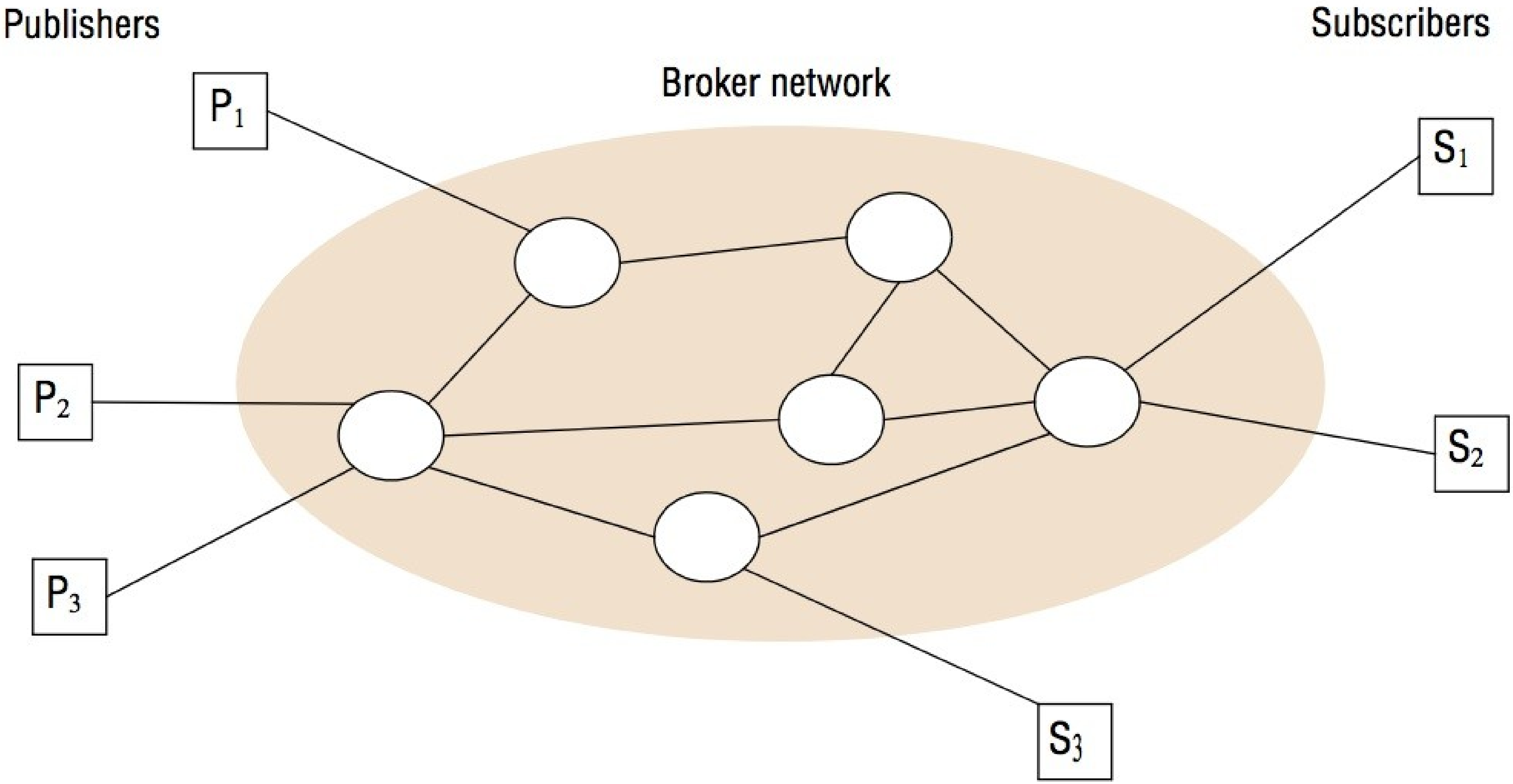


Figure 6.10
The architecture of publish-subscribe systems

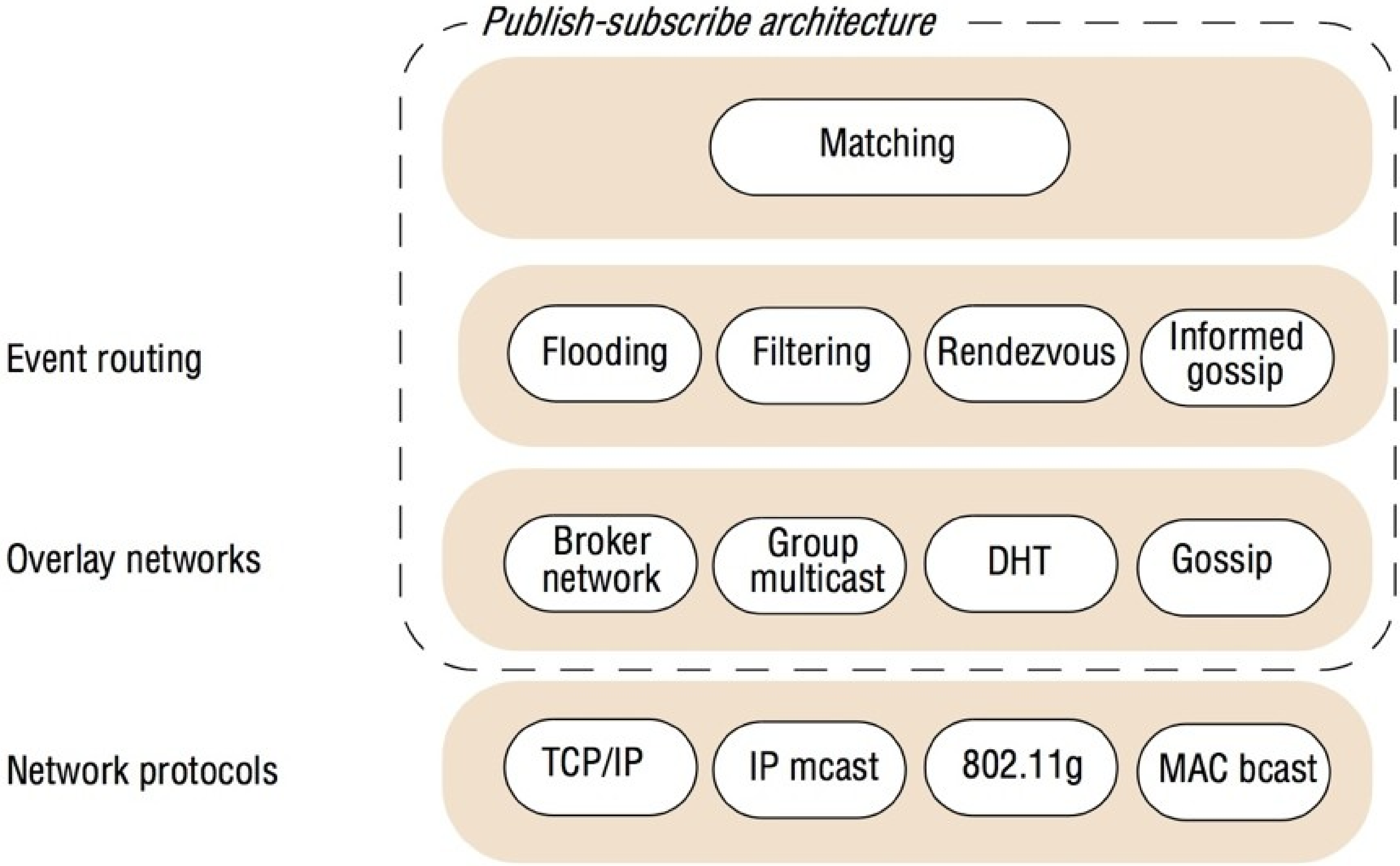


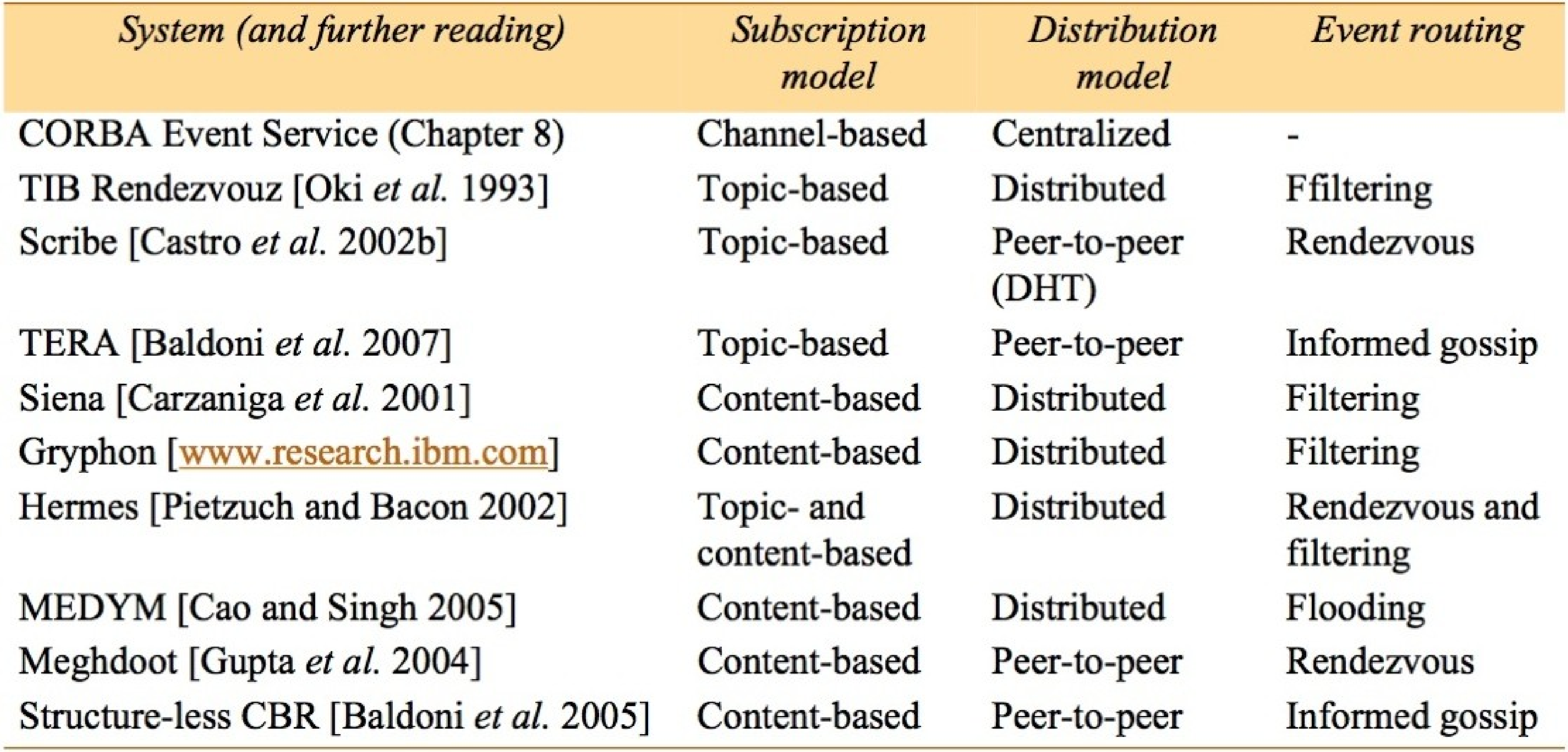
Figure 6.11
Filtering-based routing

```
upon receive publish(event e) from node x
    matchlist := match(e, subscriptions)
    send notify(e) to matchlist;
    fwdlist := match(e, routing);
    send publish(e) to fwdlist - x;
upon receive subscribe(subscription s) from node x
    if x is client then
        add x to subscriptions;
    else add(x, s) to routing;
    send subscribe(s) to neighbours - x;
```

Figure 6.12
Rendezvous-based routing

```
upon receive publish(event e) from node x at node i
    rvlist := EN(e);
    if i in rvlist then begin
        matchlist :=match(e, subscriptions);
        send notify(e) to matchlist;
    end
    send publish(e) to rvlist - i;
upon receive subscribe(subscription s) from node x at node i
    rvlist := SN(s);
    if i in rvlist then
        add s to subscriptions;
    else
        send subscribe(s) to rvlist - i;
```

Figure 6.13
Example publish-subscribe system



System (and further reading)	*Subscription model*	*Distribution model*	*Event routing*
CORBA Event Service (Chapter 8)	Channel-based	Centralized	-
TIB Rendezvouz [Oki *et al.* 1993]	Topic-based	Distributed	Ffiltering
Scribe [Castro *et al.* 2002b]	Topic-based	Peer-to-peer (DHT)	Rendezvous
TERA [Baldoni *et al.* 2007]	Topic-based	Peer-to-peer	Informed gossip
Siena [Carzaniga *et al.* 2001]	Content-based	Distributed	Filtering
Gryphon [www.research.ibm.com]	Content-based	Distributed	Filtering
Hermes [Pietzuch and Bacon 2002]	Topic- and content-based	Distributed	Rendezvous and filtering
MEDYM [Cao and Singh 2005]	Content-based	Distributed	Flooding
Meghdoot [Gupta *et al.* 2004]	Content-based	Peer-to-peer	Rendezvous
Structure-less CBR [Baldoni *et al.* 2005]	Content-based	Peer-to-peer	Informed gossip

Figure 6.14
The message queue paradigm

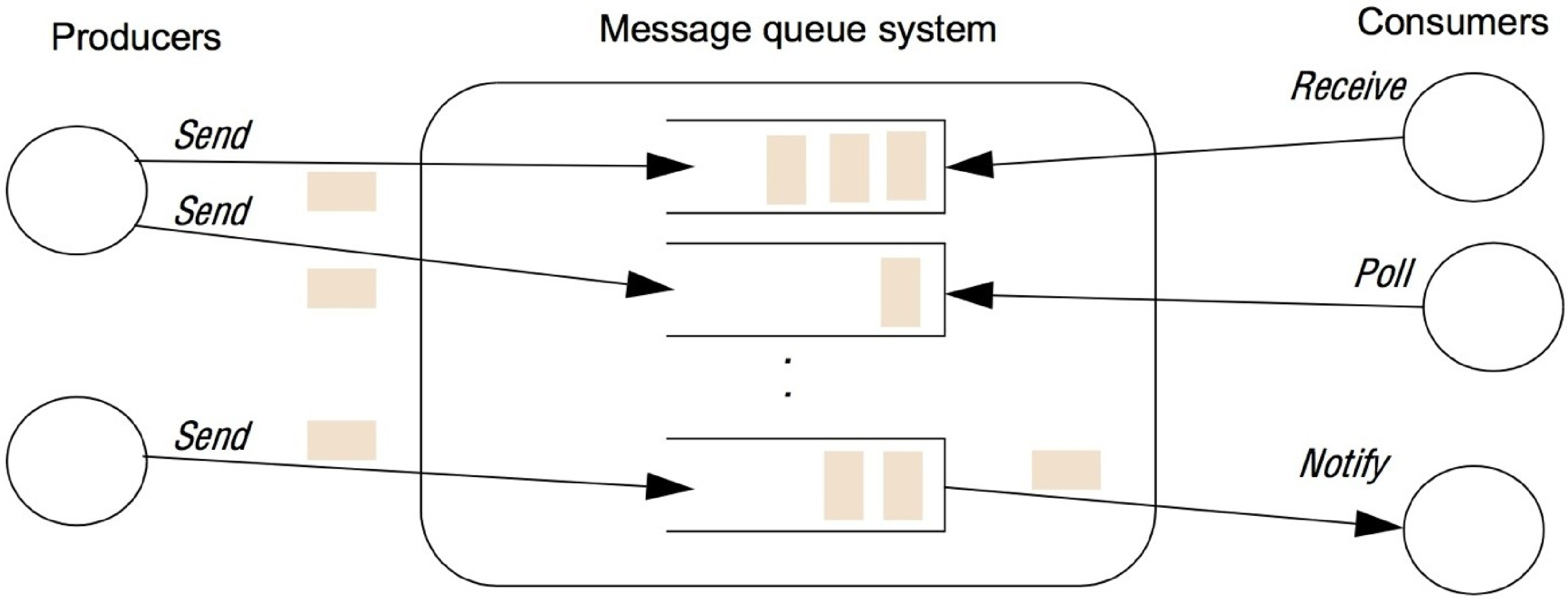


Figure 6.15
A simple networked topology in WebSphere MQ

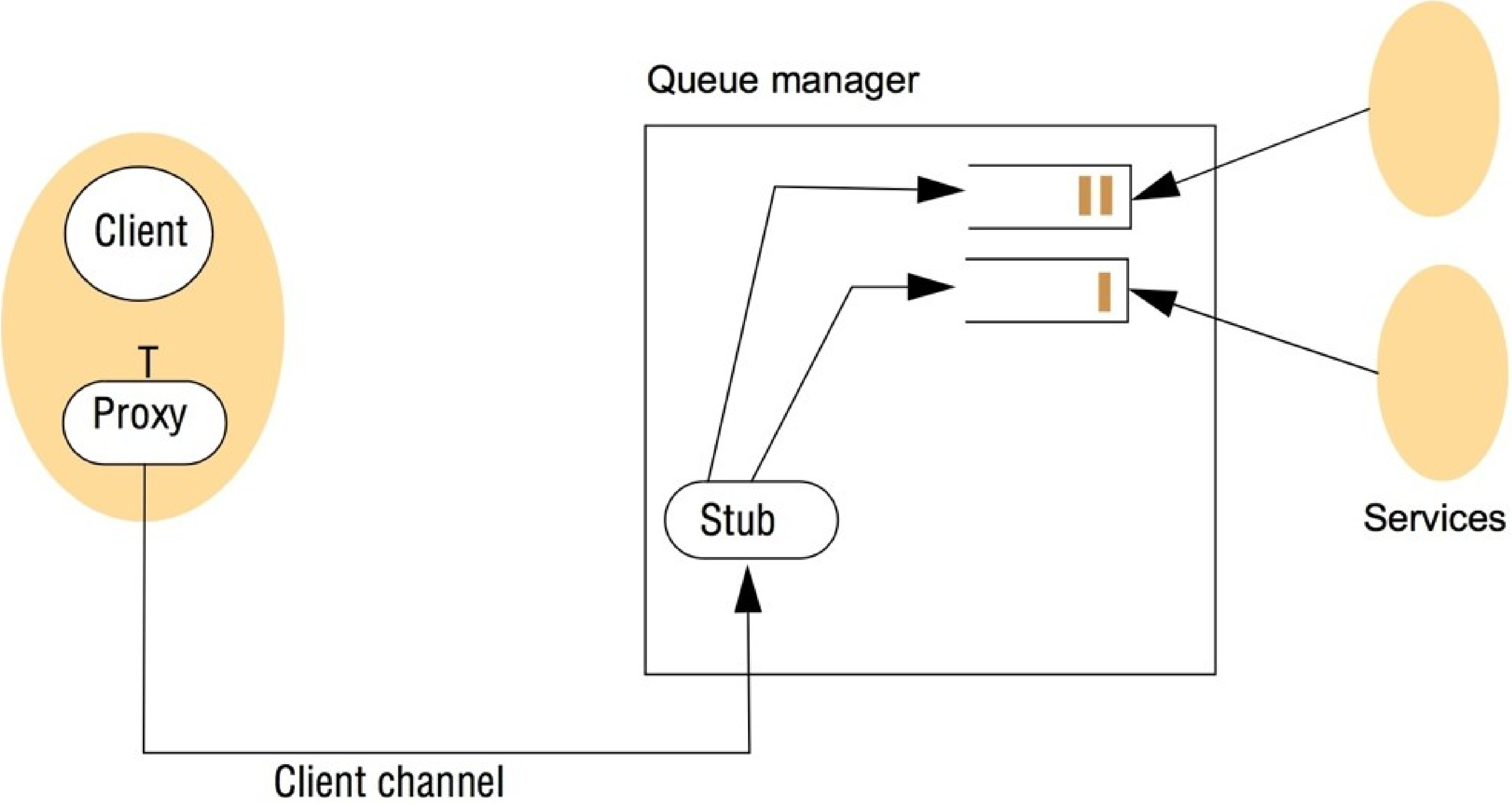


Figure 6.16
The programming model offered by JMS

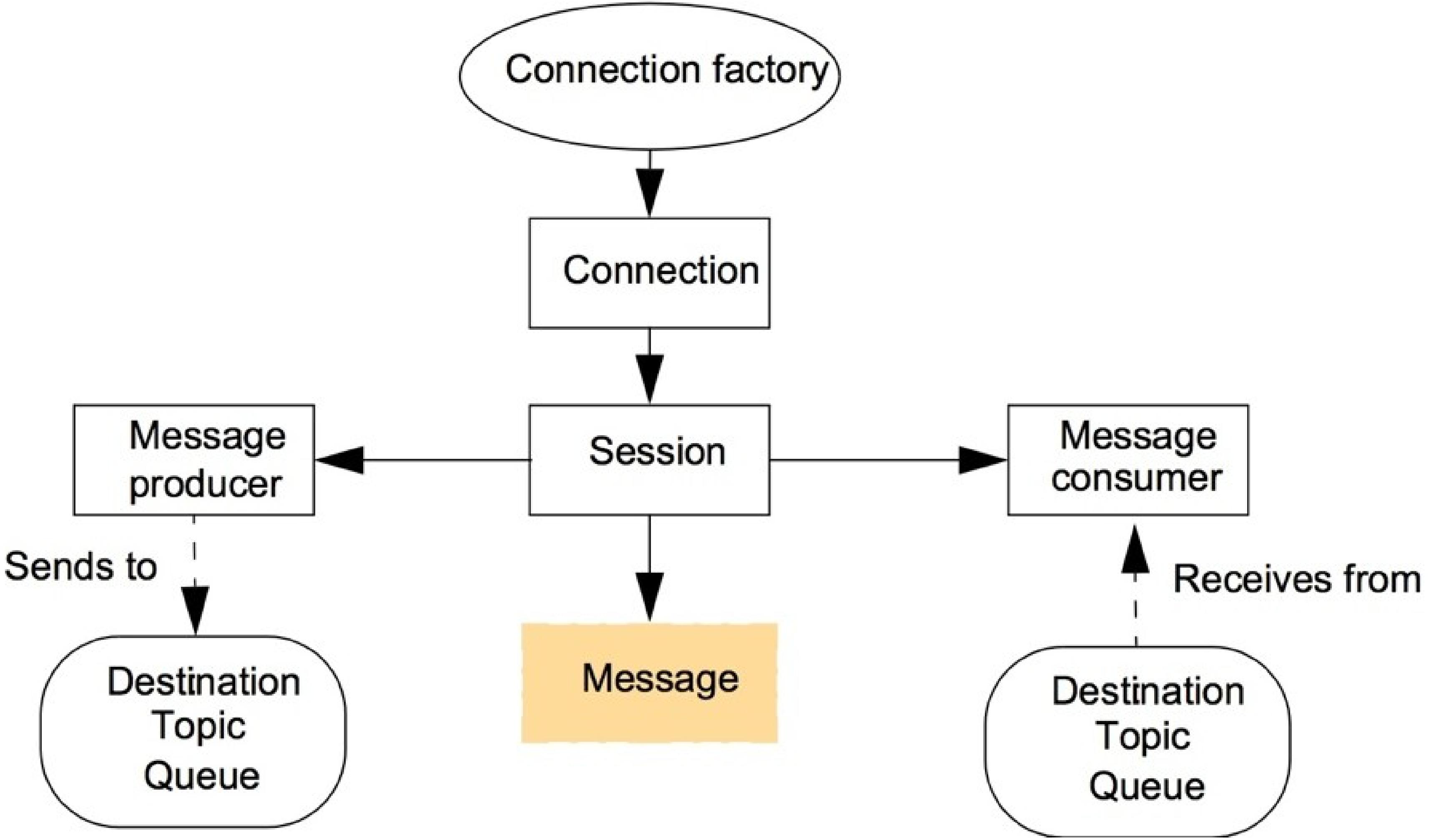


Figure 6.17
Java class *FireAlarmJMS*

```
import javax.jms.*;
import javax.naming.*;
public class FireAlarmJMS {

public void raise() {
     try {
          Context ctx = new InitialContext();
          TopicConnectionFactory topicFactory =
          (TopicConnectionFactory)ctx.lookup ("TopicConnectionFactory");
          Topic topic = (Topic)ctx.lookup("Alarms");
          TopicConnection topicConn =
               topicConnectionFactory.createTopicConnection();
          TopicSession topicSess = topicConn.createTopicSession(false,
               Session.AUTO_ACKNOWLEDGE);
          TopicPublisher topicPub = topicSess.createPublisher(topic);
          TextMessage msg = topicSess.createTextMessage();
           msg.setText("Fire!");
          topicPub.publish(message);
          } catch (Exception e) {
          }
}
```

Figure 6.18
Java class *FireAlarmConsumerJMS*

```
import javax.jms.*;  import javax.naming.*;
public class FireAlarmConsumerJMS
public String await() {
     try {
          Context ctx = new InitialContext();
          TopicConnectionFactory topicFactory =
               (TopicConnectionFactory)ctx.lookup("TopicConnectionFactory");
            Topic topic = (Topic)ctx.lookup("Alarms");
            TopicConnection topicConn =
                   topicConnectionFactory.createTopicConnection();
            TopicSession topicSess = topicConn.createTopicSession(false,
                        Session.AUTO_ACKNOWLEDGE);
            TopicSubscriber topicSub = topicSess.createSubscriber(topic);
            topicSub.start();
            TextMessage msg = (TextMessage) topicSub.receive();
            return msg.getText();
            } catch (Exception e) {
                         return null;
   }
}
```

Figure 6.19
The distributed shared memory abstraction

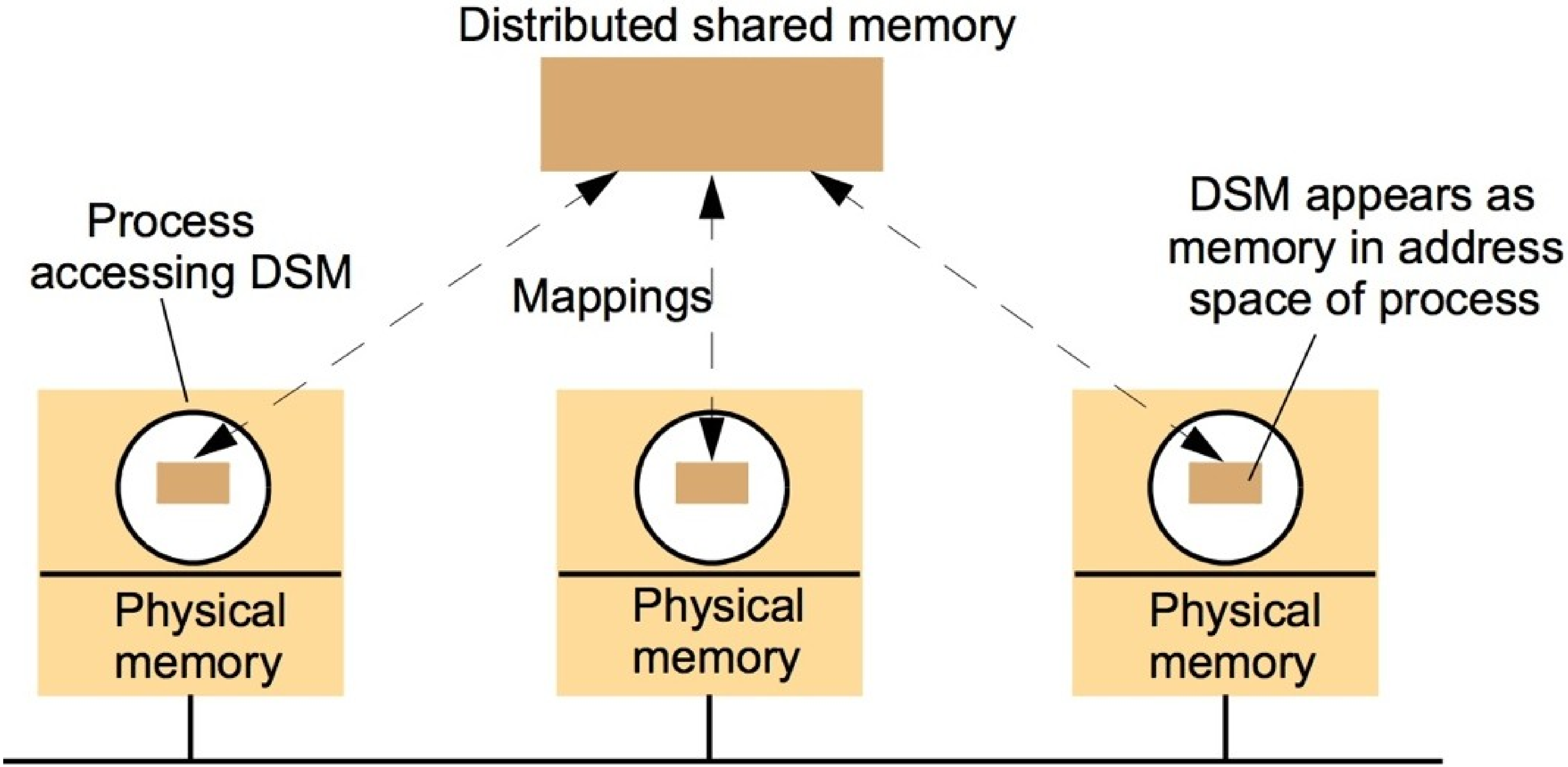
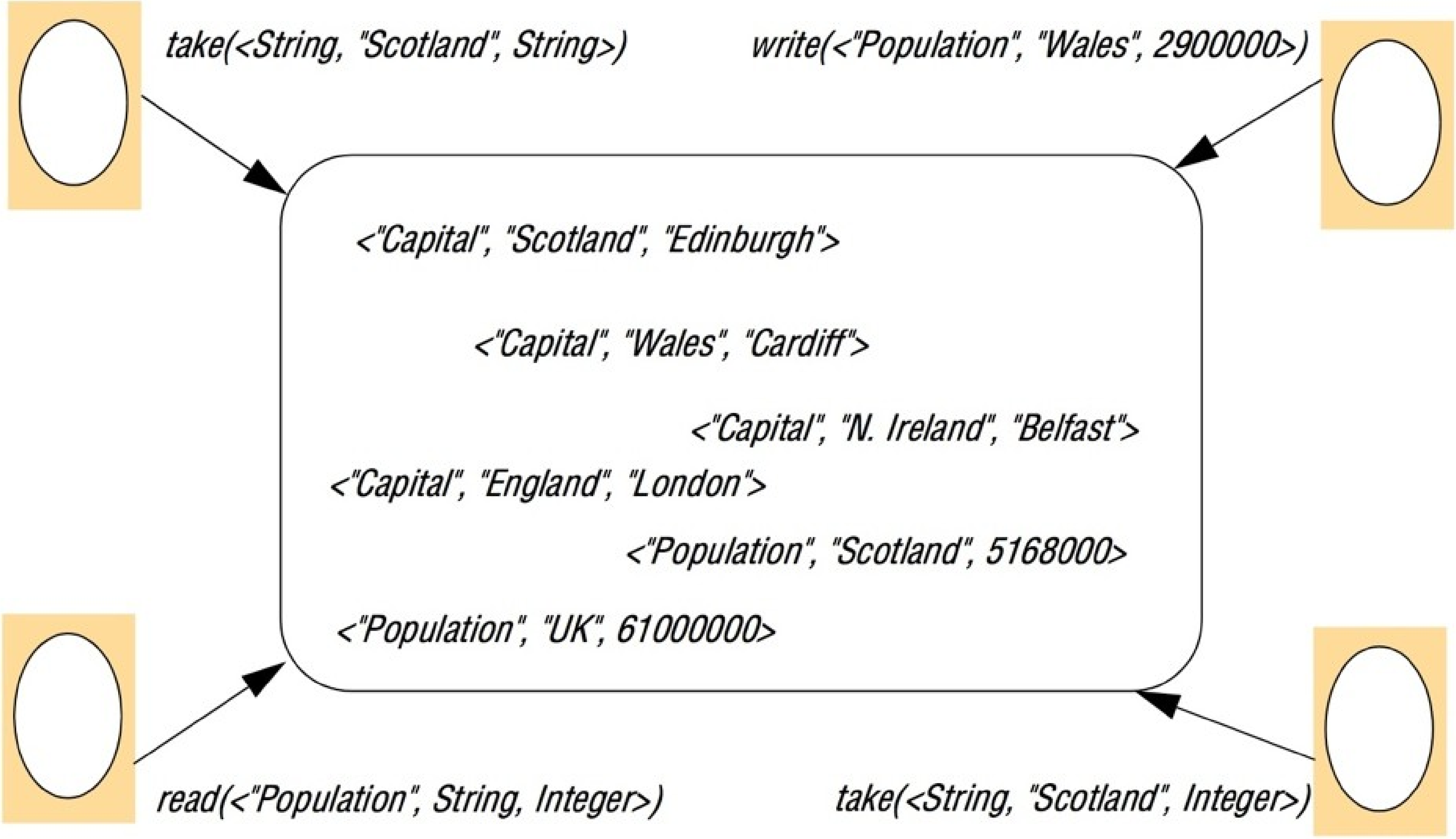


Figure 6.20
The tuple space abstraction



take(<String, "Scotland", String>)

write(<"Population", "Wales", 2900000>)

<"Capital", "Scotland", "Edinburgh">

<"Capital", "Wales", "Cardiff">

<"Capital", "N. Ireland", "Belfast">

<"Capital", "England", "London">

<"Population", "Scotland", 5168000>

<"Population", "UK", 61000000>

read(<"Population", String, Integer>)

take(<String, "Scotland", Integer>)

Figure 6.21 (1)
Replication and the tuple space operations [Xu and Liskov 1989]

write

1. The requesting site multicasts the *write* request to all members of the view; 2. On receiving this request, members insert the tuple into their replica and acknowledge this action;
3. Step 1 is repeated until all acknowledgements are received.

read

1. The requesting site multicasts the *read* request to all members of the view;
2. On receiving this request, a member returns a matching tuple to the requestor;
3. The requestor returns the first matching tuple received as the result of the operation (ignoring others); 4 Step 1 is repeated until at least one response is received.

continued on next slide

Figure 6.21 (continued)
Replication and the tuple space operations [Xu and Liskov 1989]

take Phase 1: Selecting the tuple to be removed

1. The requesting site multicasts the *take* request to all members of the view;
2. On receiving this request, each replica acquires a lock on the associated tuple set and, if the lock cannot be acquired, the *take* request is rejected;
3. All accepting members reply with the set of all matching tuples;
4. Step 1 is repeated until all sites have accepted the request and responded with their set of tuples and the intersection is non-null;
5. A particular tuple is selected as the result of the operation (selected randomly from the intersection of all the replies);
6. If only a minority accept the request, this minority are asked to release their locks and phase 1 repeats.

Phase 2: Removing the selected tuple

1. The requesting site multicasts a *remove* request to all members of the view citing the tuple to be removed;
2. On receiving this request, members remove the tuple from their replica, send an acknowledgement and release the lock;
3. Step 1 is repeated until all acknowledgements are received.

Figure 6.22
Partitioning in the York Linda Kernel

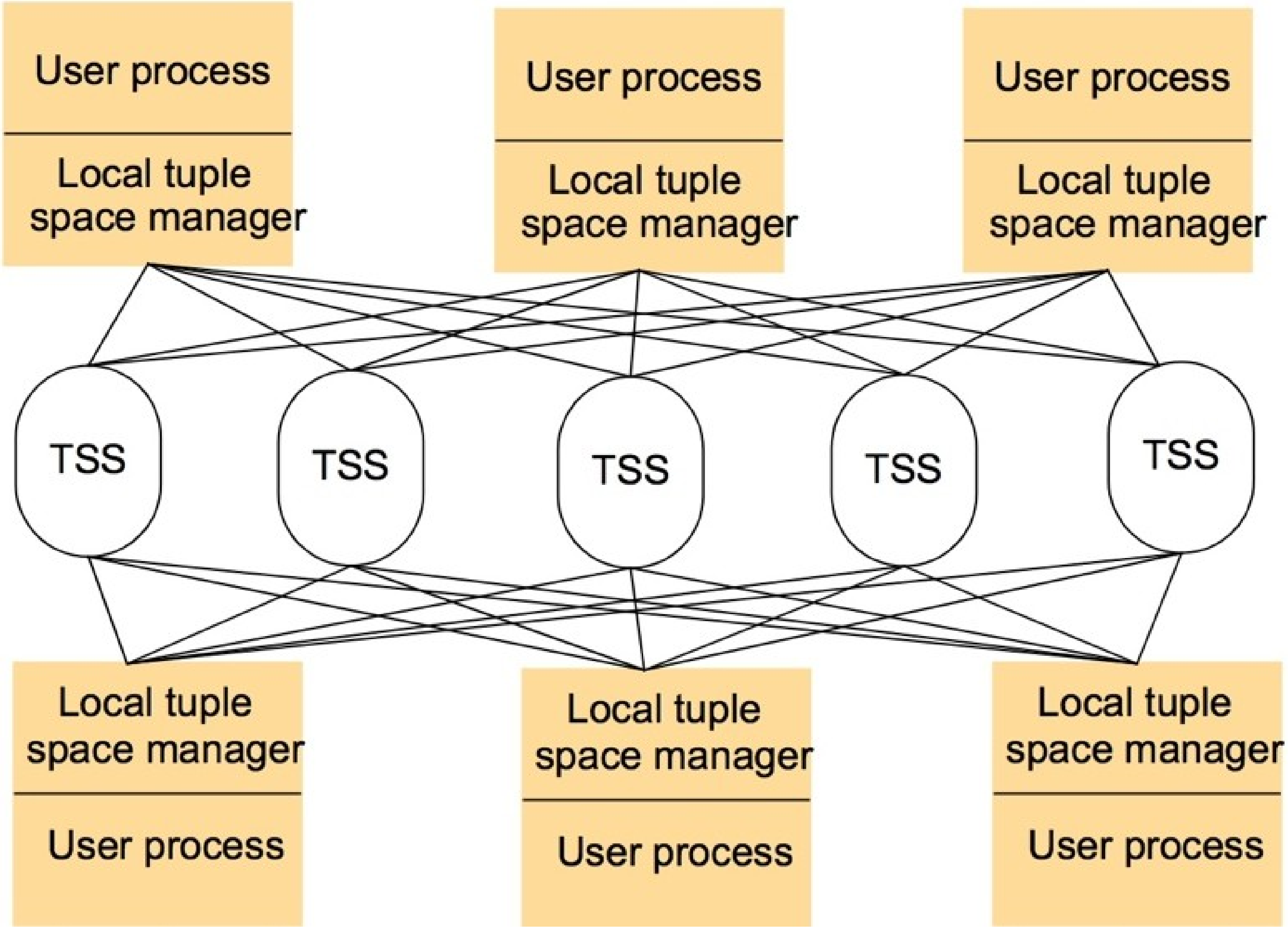
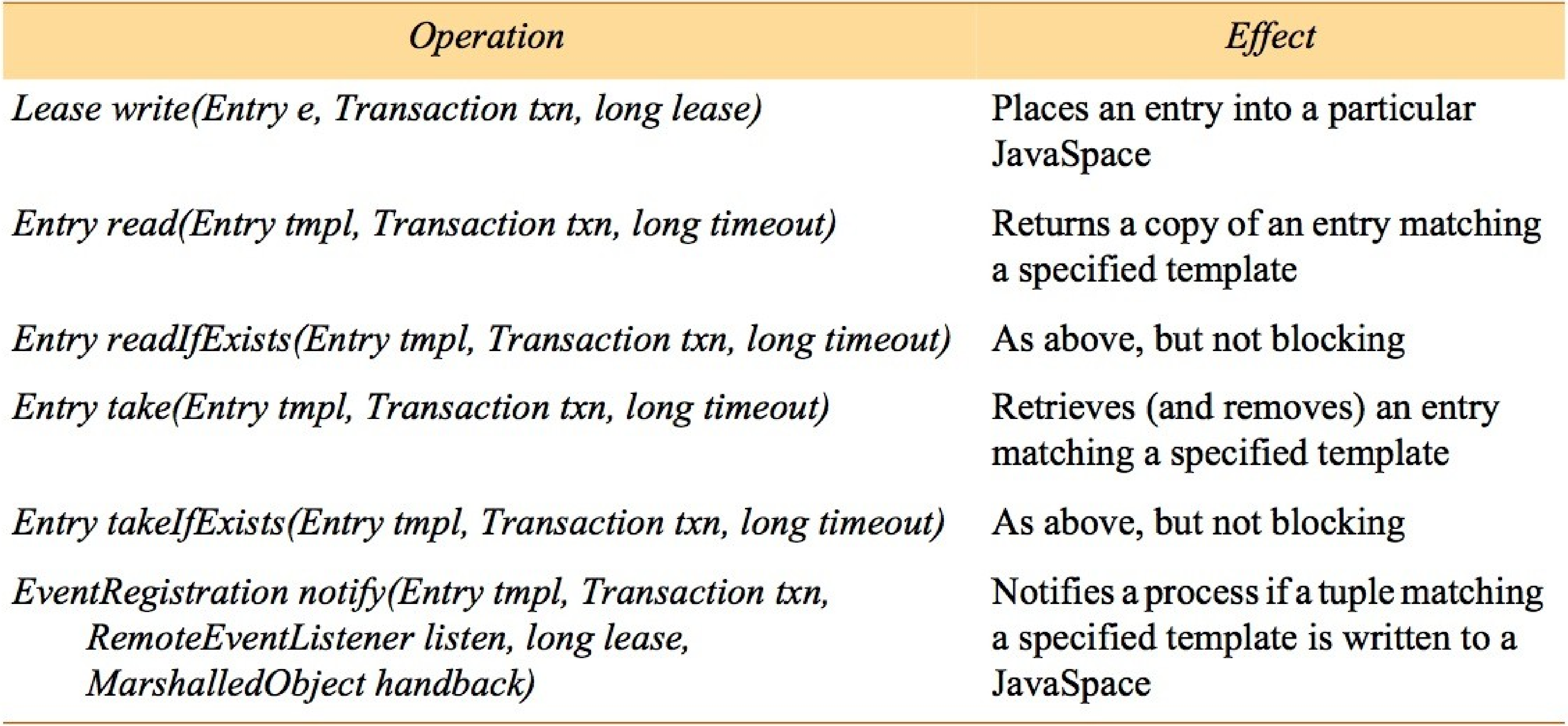


Figure 6.23
The JavaSpaces API



Operation	*Effect*
Lease write(Entry e, Transaction txn, long lease)	Places an entry into a particular JavaSpace
Entry read(Entry tmpl, Transaction txn, long timeout)	Returns a copy of an entry matching a specified template
Entry readIfExists(Entry tmpl, Transaction txn, long timeout)	As above, but not blocking
Entry take(Entry tmpl, Transaction txn, long timeout)	Retrieves (and removes) an entry matching a specified template
Entry takeIfExists(Entry tmpl, Transaction txn, long timeout)	As above, but not blocking
EventRegistration notify(Entry tmpl, Transaction txn, RemoteEventListener listen, long lease, MarshalledObject handback)	Notifies a process if a tuple matching a specified template is written to a JavaSpace

Figure 6.24
Java class *AlarmTupleJS*

```
import net.jini.core.entry.*;
public class AlarmTupleJS implements Entry {
    public String alarmType;
        public AlarmTupleJS() { }
    }
    public AlarmTupleJS(String alarmType) {
        this.alarmType = alarmType;}
    }
}
```

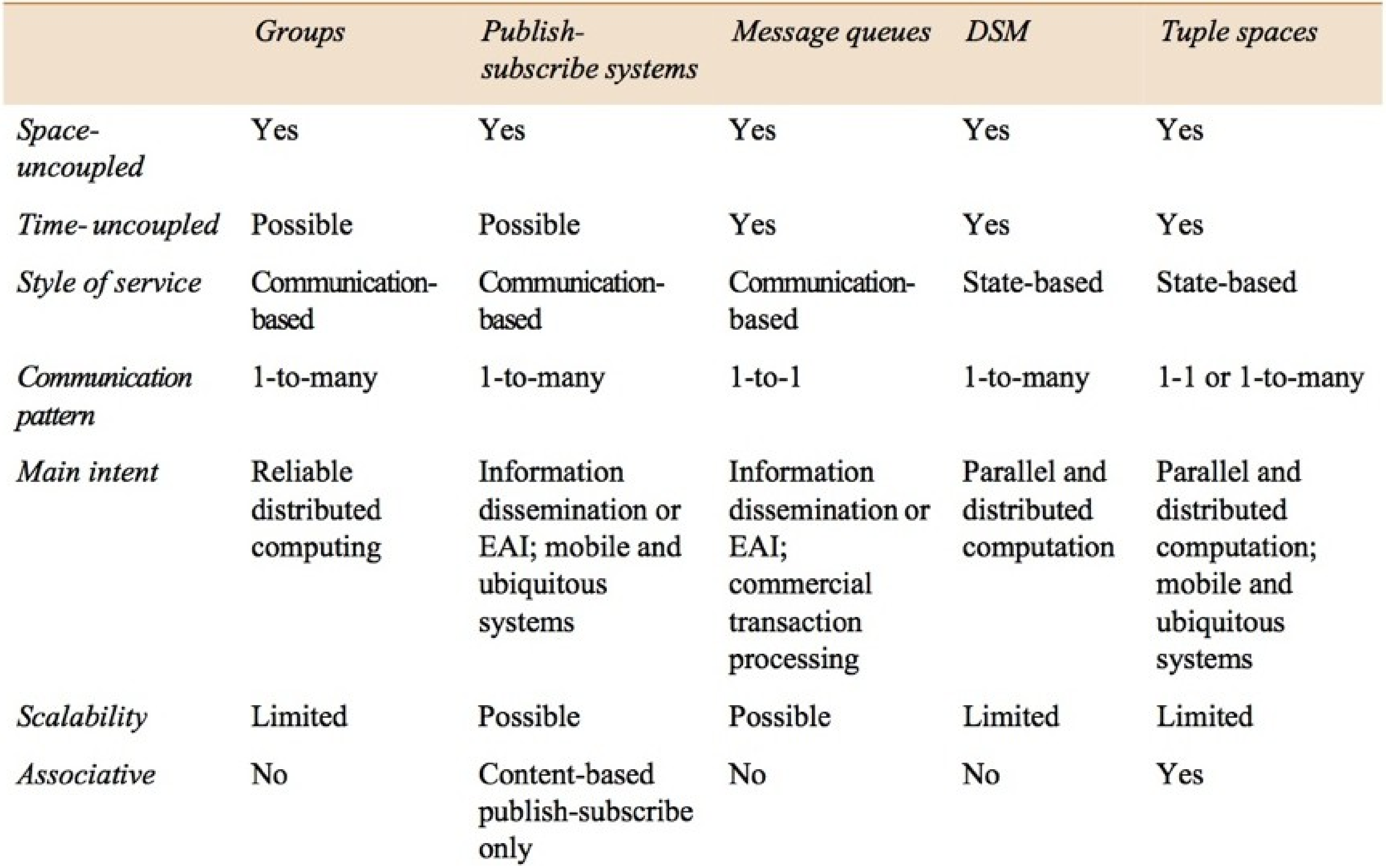
Figure 6.25
Java class *FireAlarmJS*

```
import net.jini.space.JavaSpace;
public class FireAlarmJS {
public void raise() {
    try {
        JavaSpace space = SpaceAccessor.findSpace("AlarmSpace");
        AlarmTupleJS tuple = new AlarmTupleJS("Fire!");
        space.write(tuple, null, 60*60*1000);
     catch (Exception e) {
    }
  }
}
```

Figure 16.26
Java class *FireAlarmReceiverJS*

```
import net.jini.space.JavaSpace;
public class FireAlarmConsumerJS {
public String await() {
      try {
                  JavaSpace space = SpaceAccessor.findSpace();
                  AlarmTupleJS template = new AlarmTupleJS("Fire!");
                  AlarmTupleJS recvd = (AlarmTupleJS) space.read(template, null,
                              Long.MAX_VALUE);
                  return recvd.alarmType;
      }
              catch (Exception e) {
                  return null;
                 }
          }
}
```

Figure 6.27
Summary of indirect communication styles



	Groups	*Publish-subscribe systems*	*Message queues*	*DSM*	*Tuple spaces*
Space-uncoupled	Yes	Yes	Yes	Yes	Yes
Time-uncoupled	Possible	Possible	Yes	Yes	Yes
Style of service	Communication-based	Communication-based	Communication-based	State-based	State-based
Communication pattern	1-to-many	1-to-many	1-to-1	1-to-many	1-1 or 1-to-many
Main intent	Reliable distributed computing	Information dissemination or EAI; mobile and ubiquitous systems	Information dissemination or EAI; commercial transaction processing	Parallel and distributed computation	Parallel and distributed computation; mobile and ubiquitous systems
Scalability	Limited	Possible	Possible	Limited	Limited
Associative	No	Content-based publish-subscribe only	No	No	Yes