Programming models 2

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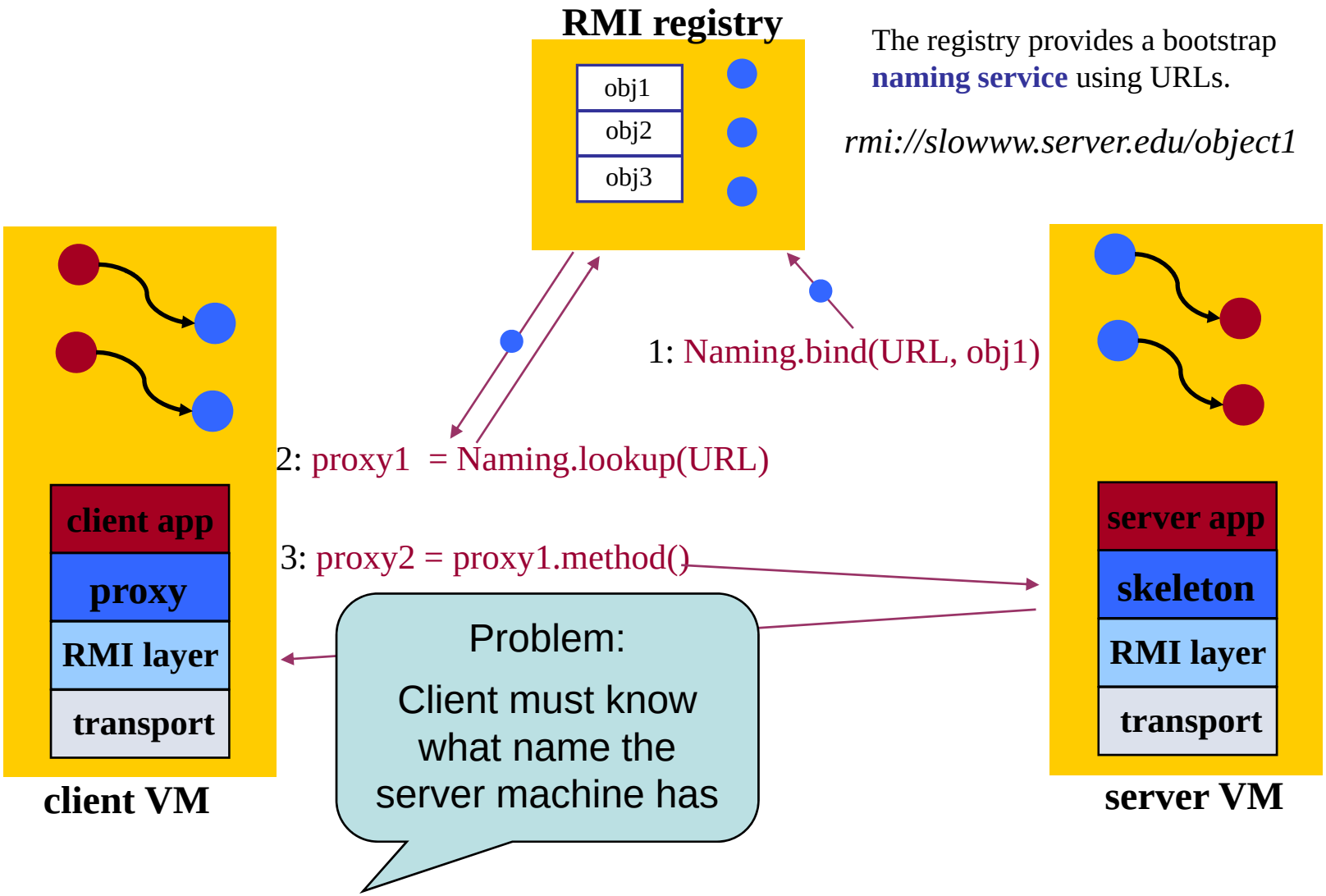
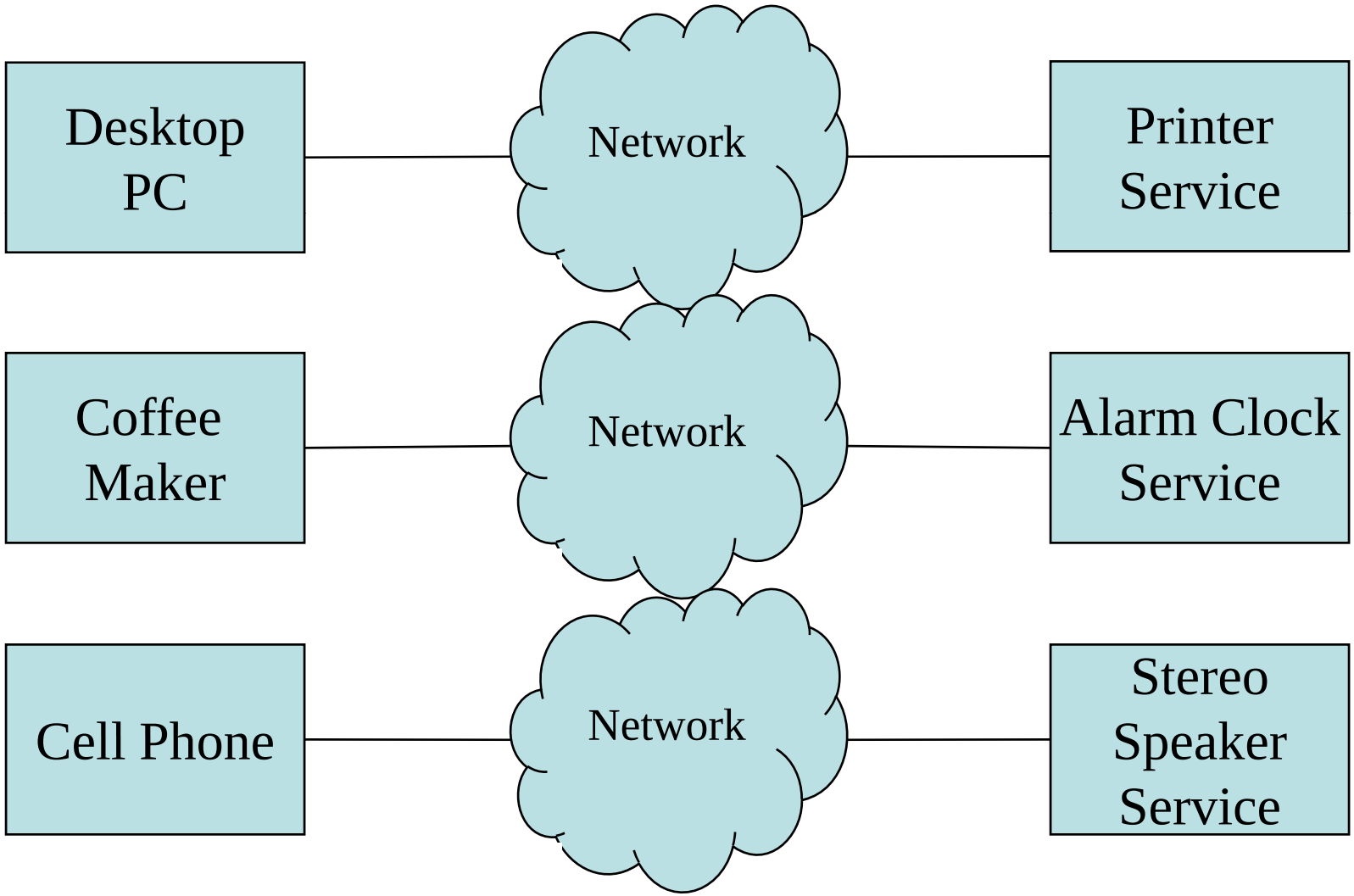
Registry = NameServer



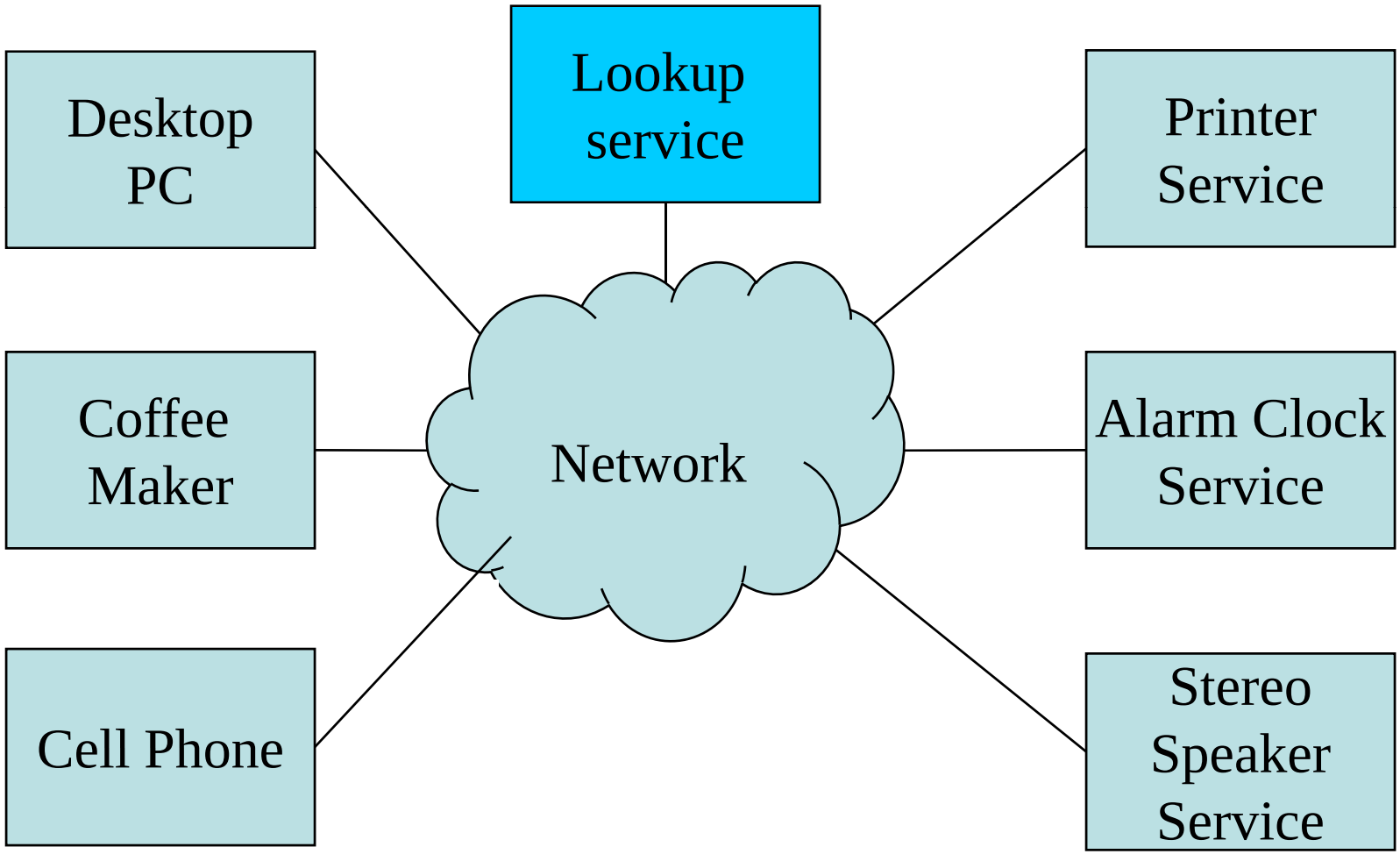
Motivation

- Example scenarios
  - "Find all nearby color duplex printers"
  - "Start brewing coffee five minutes before my alarm clock goes off"
  - "Let my cell phone use the car speakers“
- Coordination framework
  - Simple, seamless, and scalable interoperability
  - Network "plug and play" with minimum admin
  - Networked software and hardware provide *services*
  - Any device can find and use existing services

One Way Scenarios Might Be Done Today



What Jini Proposes



Spontaneous networking

- Jini enables clients to automatically discover services at runtime
- Associative search
  - Not by name lookup (e.g. http://some.url:port)
  - Instead: find a service that does this or that
- Loose coupling
  - Services and clients can join and leave the system (Jini federation) at any time without causing system failure

Jini and Java

Jini Services	• JavaSpaces™ • Transaction Managers • Printing, Storage, Databases...
Jini Infrastructure	• Discovery • Lookup Service
Jini Programming Model	• Leasing • Distributed Events • Transactions
Java 2 Platform	• Java RMI • Java VM

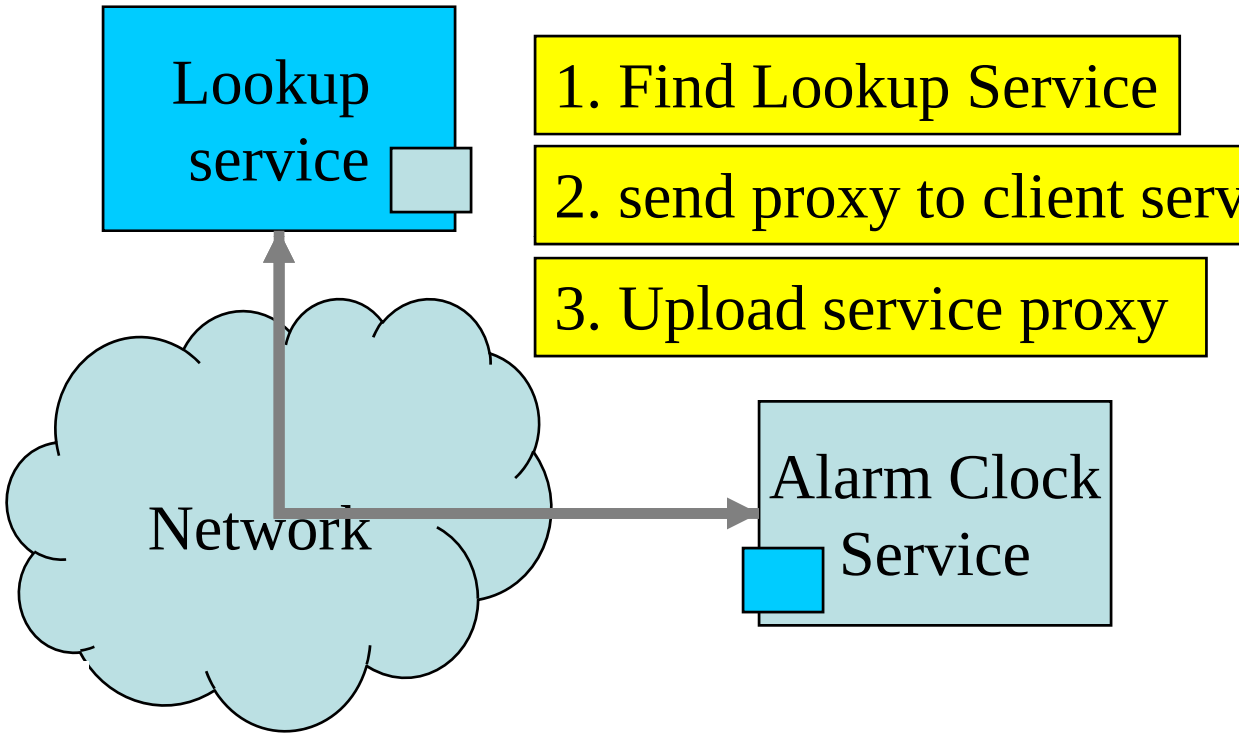
Service Interface

- Everything is a service on the network.
- Interfaces define **what** a service offers, not **how** it implements it
- Java interfaces gives strong typing
- The `ServiceItem` Java object represents a service registration:
  - A unique service ID
  - The service proxy object
  - A set of optional Java attribute objects
    - (e.g. location, status, vendor, etc)
- Services are found in the lookup service by template matching described by a `ServiceTemplate` object

Discovery, join, lookup protocols

- **Join protocol**
  - Services register with lookup services
  - Registration is a Java object
- **Discovery protocol**
  - Clients and services **find lookup services** by multicasting requests at predefined IP multicast address or direct addressing **(PULL)**
  - Lookup service may advertise its existence by periodic multicasting its presence **(PUSH)**
- **Lookup protocol**
  - Clients send a search request to lookup services
  - Specify service type and properties as a Java object
  - Lookup service finds and returns matching services
  - Returned is a Java object (ServiceItem) that carries the service proxy

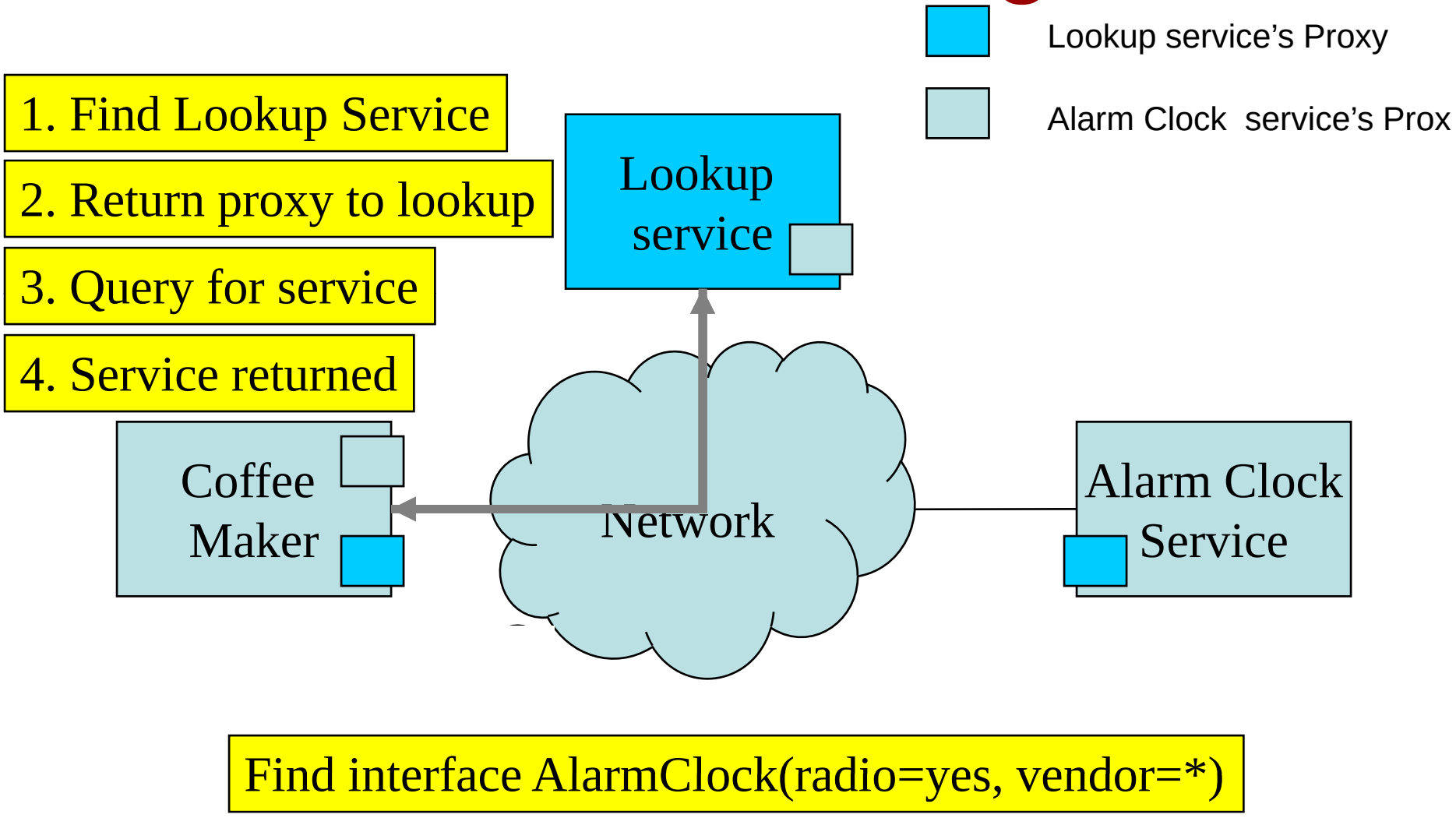
Service Registration



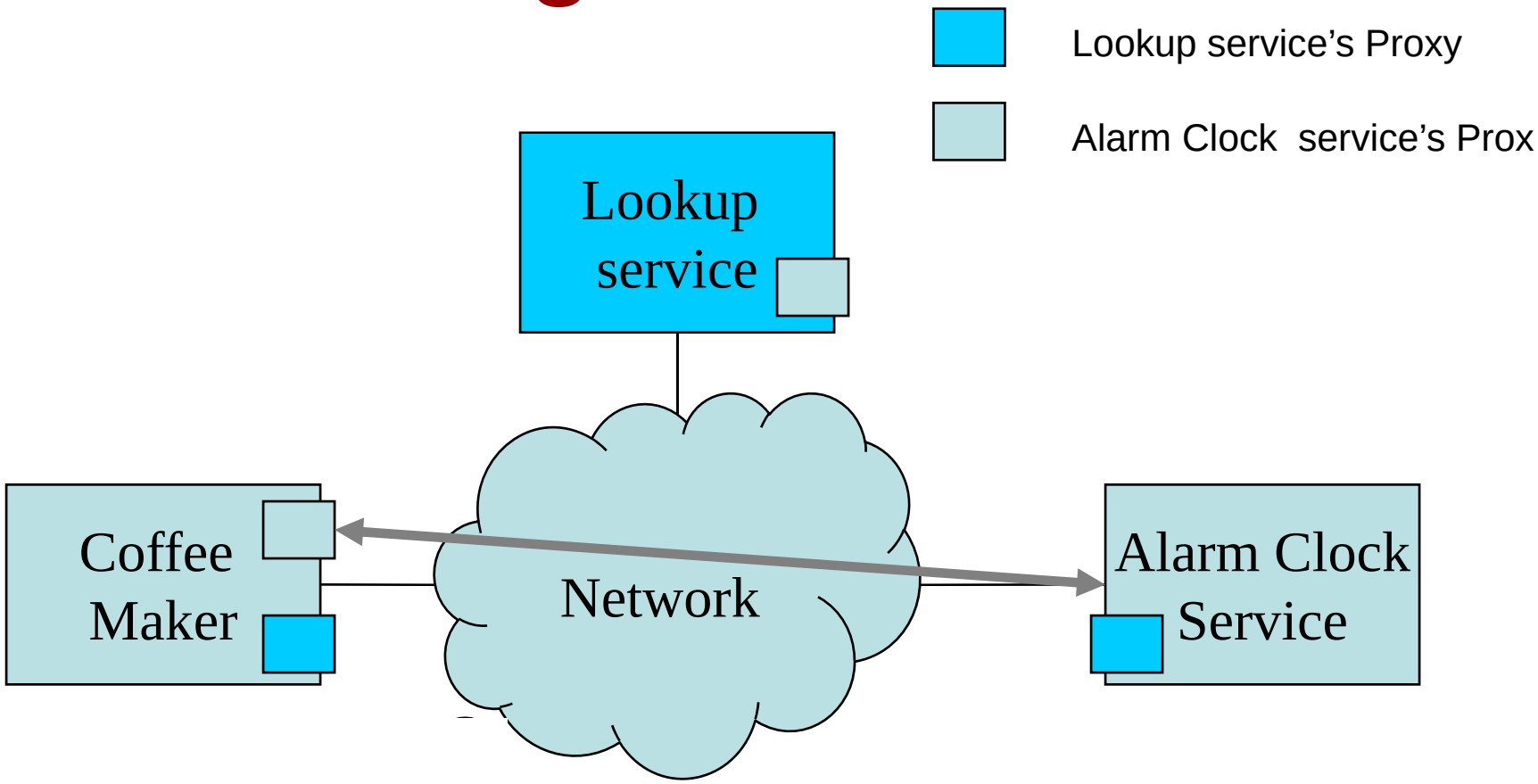
Lookup service's Proxy Object

Alarm Clock service's Proxy Object

Service Leasing

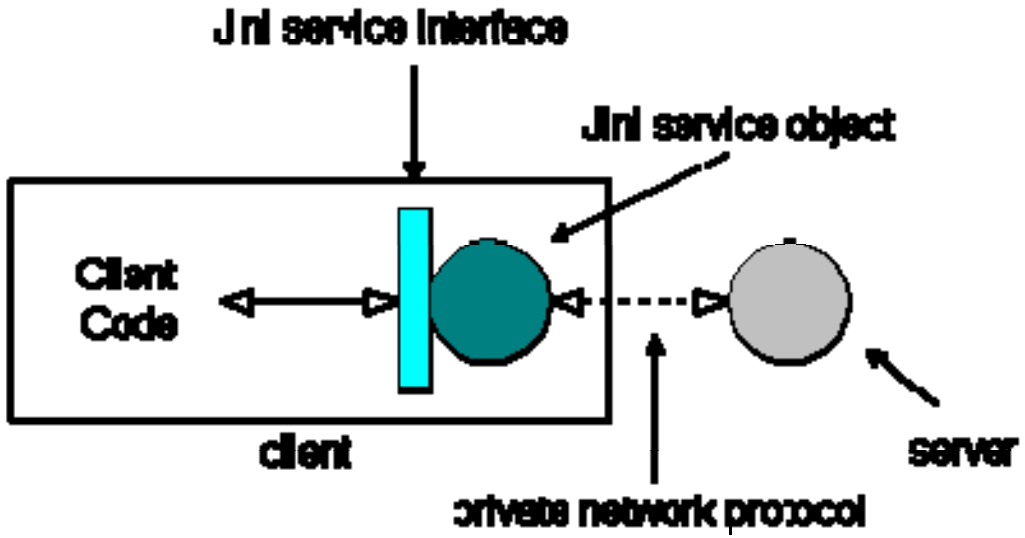


Using Services



Can use any protocol to communicate to service (or proxy can contain service itself!)

The role of the proxy



- The proxy is a Java object downloaded from the service
- Hides communication between proxy and service
  - Costumizable, dedicated protocol **(transparent)**
    - Protocol independent (TCP/IP, HTTP, SOAP, etc.)
    - Replication
  - Updatable
  - protocol
  - Interact directly with physical devices

Leasing

- What happens if a service dies?
  - It must be de-registered at the lookup service
  - May crash, or “forget” to do so
- **A lease is a time period during which the grantor of the lease promises that the holder of the lease will have access to some resource**
  - Eg. The lookup service stores a service registration
- A client requests a lease from the provider (lease grantor) and must periodically renew it.
- Expired or non-renewed lease results in removing lease and freeing up resources

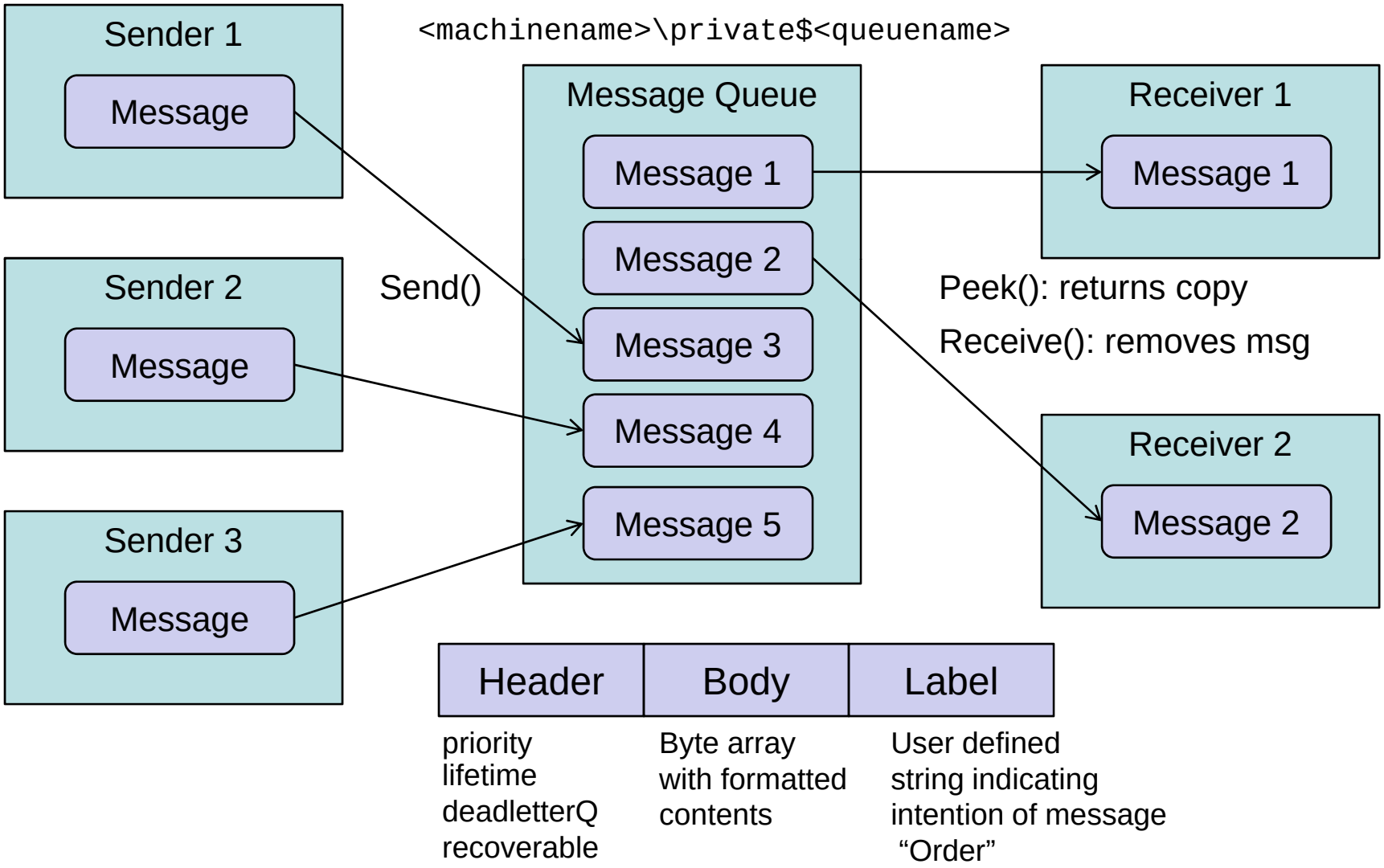
Microsoft Message Queue (MSMQ)

Messaging-Oriented Middleware, .NET/COM style

MSMQ:
Microsoft Message Queueing

- Specification for messaging on **Microsoft OS**
  - currently at 4.0 (Vista, 3.0 XP)
- Captures essence of messaging
  - Synchronous or asynchronous operation
  - Loosely- or strongly-coupled operation
  - Transacted send/receive
  - Prioritized delivery
  - Deadline-based delivery
  - Delivery filtering
- Several language bindings, including C#
  - `System.Messaging` namespace
  - `System.Messaging.dll` assembly

MSMQ: MS Message Queues



Programming Model

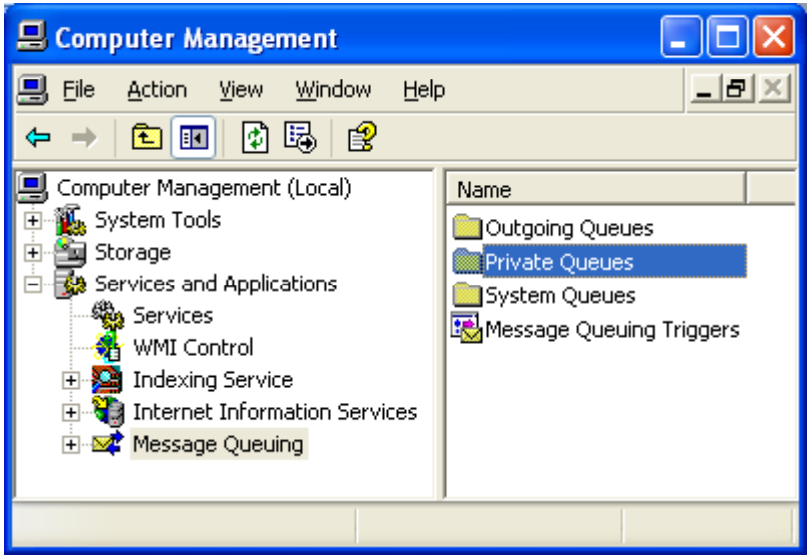
- The MessageQueue object is just wrapper around native queue
  - Queue must already exist on machine.

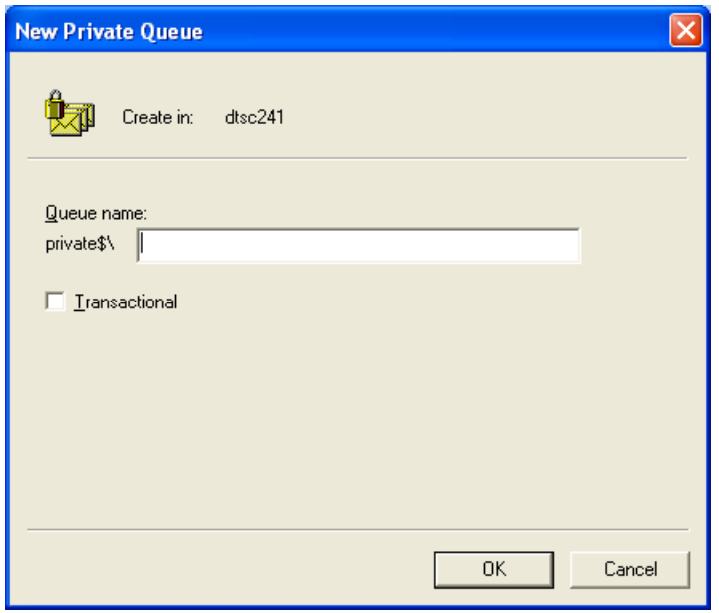
```
using System.Messaging;
string queueName = @".\private$\myqueue";
if (MessageQueue.Exists(queueName))
{
  MessageQueue myQ = new MessageQueue(queueName);

  Message msg = new Message
  ("Hello World!");
   myQ.Send(msg,"greetingmsg");

  myQ.close()
}
```

```
myQ.Formatter = new XmlMessageFormatter
    (new Type[]{ typeof(string) });

 Message msg = myQ.Peek();
 Message msg2 = myQ.Receive();
Console.WriteLine((string)(msg.Body));
}
```

Queues

- Creating the Queue administratively:
  - Message Queuing, under Services and Applications
  - right-click folder to create New queue





- Creating the Queue programatically :
  - **`MessageQueue.Create(name)`**

Queues

- Domain Mode (public queues via Active Directory)
- Work Group mode (private Queues)

- Independent Client vs. Dependent client (Active Dir)

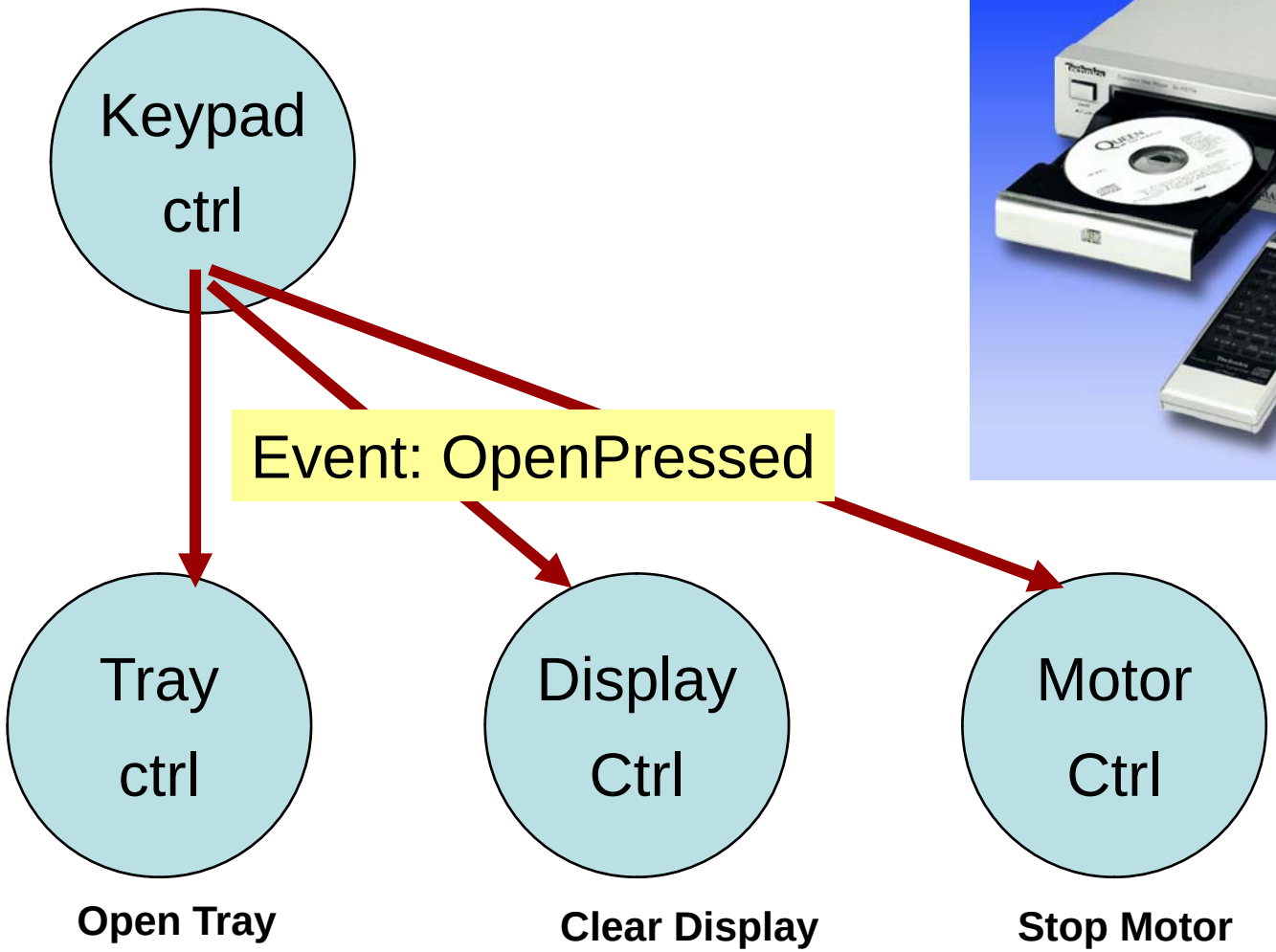
- System Queues
  - Journal queues
    - stores copies of messages sent to/through/from this machine
    - allows for better quality-of-service guarantees for messages
    - read-only (can't be directly sent to); much like database logs
  - Dead-letter queues
    - final resting place of undeliverable messages
    - one each for transactional and non-transactional O's
    - read-only (can only be read and deleted, not sent to)
  - Connector queues
    - used for store-and-forward messaging in route

Event Based Systems

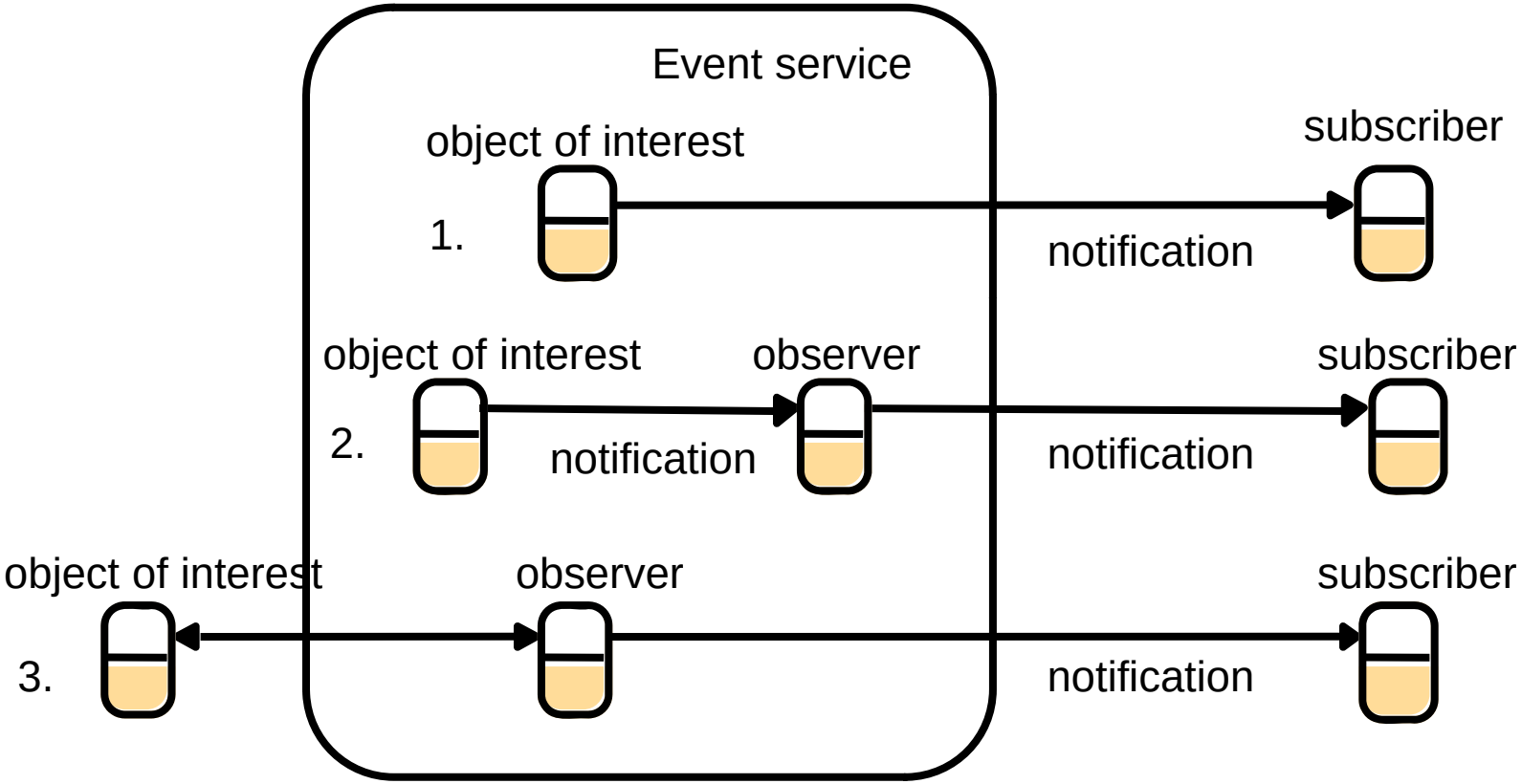
Event driven programming

- Programming principle based on the idea that objects should react on events (state change, either concretely or abstractly) happening in other objects.
- Objects ***publishes*** information about events that other objects might be interested in knowing about.
- Objects can ***subscribe*** to receive information about when an event occur.

Event Programming



Architecture for distributed event notification



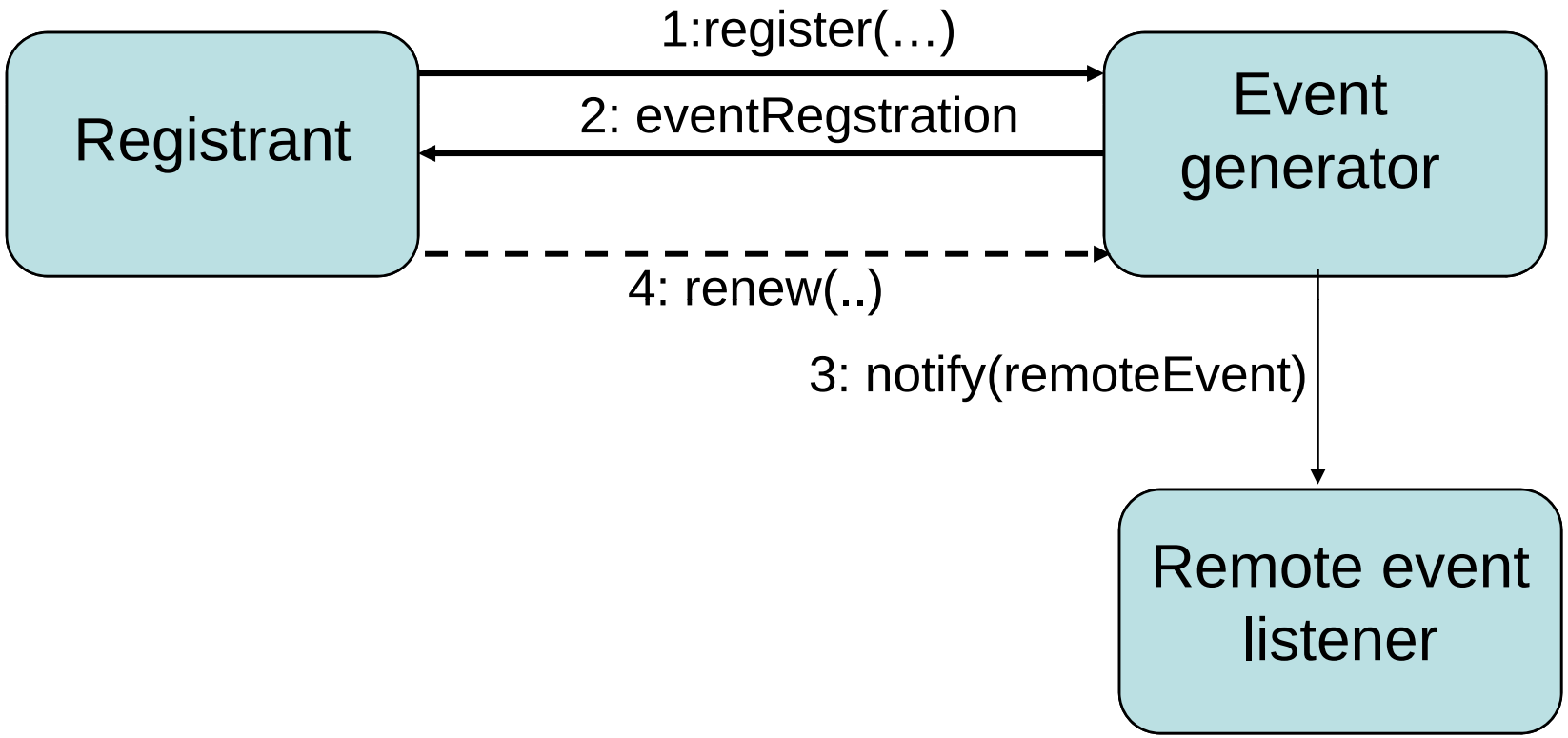
1. OOI directly notifies subscriber
2. OOI nofies subscriber via observer
3. Observer queries (polls) OOI and notifies subscriber

Remote Events

- **Remote events more expensive to send than local events**
- **Remote events propagate slowly**
- **Remote events may not arrive in order sent**
- **Remote events may not arrive at all (or at all subscribers)**
- **What does sender do if receiver has crashed -- keep trying? How long?**

Jini Remote Events

Jini Remote Events



Jini Events

- ***Event generators:*** An object, that allows other objects to subscribe to its events and generates notification (via RMI).
- ***Remote event listeners:*** An object that can receive notifications.
- ***Remote events:*** An object that is passed by value to remote event listeners (a notification).
- ***Third-party agents:*** Objects that may be interposed between an object of interest and a subscriber *(observers).*
- Subscriptions are subject to leasing

RemoteEventListener interface

```
public interface RemoteEventListener extends
    Remote,
    java.util.EventListener
{
    void notify(RemoteEvent theEvent)
        throws UnknownEventException,
    RemoteException;
}
```

RemoteEvent Class

```
public class RemoteEvent extends java.util.EventObject {
    public RemoteEvent(    Object source,
                           long event ID,
                           long SeqNum,
                           MarshalledObject handback) {…}
    )

public Object getSource( )  {…}
    public long getID( )  {…}
    public long getSequenceJumber( )  {…}
    public MarshalledObject getRegitrationObject  {…}
}
```

source+eventID+SeqNum uniquely identifies event occurrence:

$\Rightarrow$ **Notify is IDEMPOTENT**

Example *EventGenerator*

```
public interface EventGenerator extends Remote  {
    public EventRegistration register(  long evID,
                                        MarshalledObject handback,
                                        RemoteEventListenter toInform,
                                        long leaseLength)
                throws UnknownEventException, RemoteException;
}
```

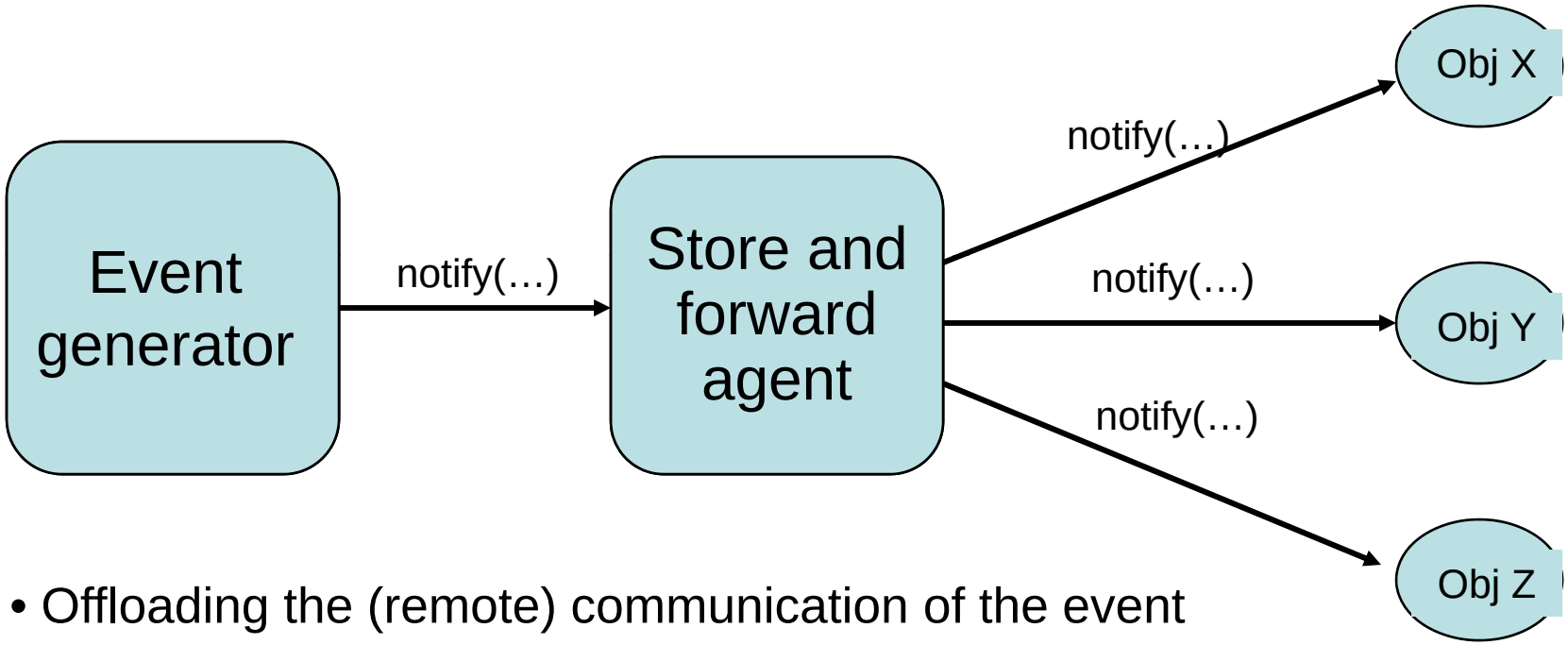
The *EventRegistration* Class

```
public class EventRegistration implements java.io.Serializable
{
    public EventRegistration(    long eventID,
                                 Object eventSource,
                                 Lease eventLease,
                                 long seqNum)  {…}
    public long getID( )  {…}
    public Object getSource( ) {…}
    public Lease getLease( )  {…}
    public long getSequenceNumber( )  {…}
}
```

3rd party objects (Observers)

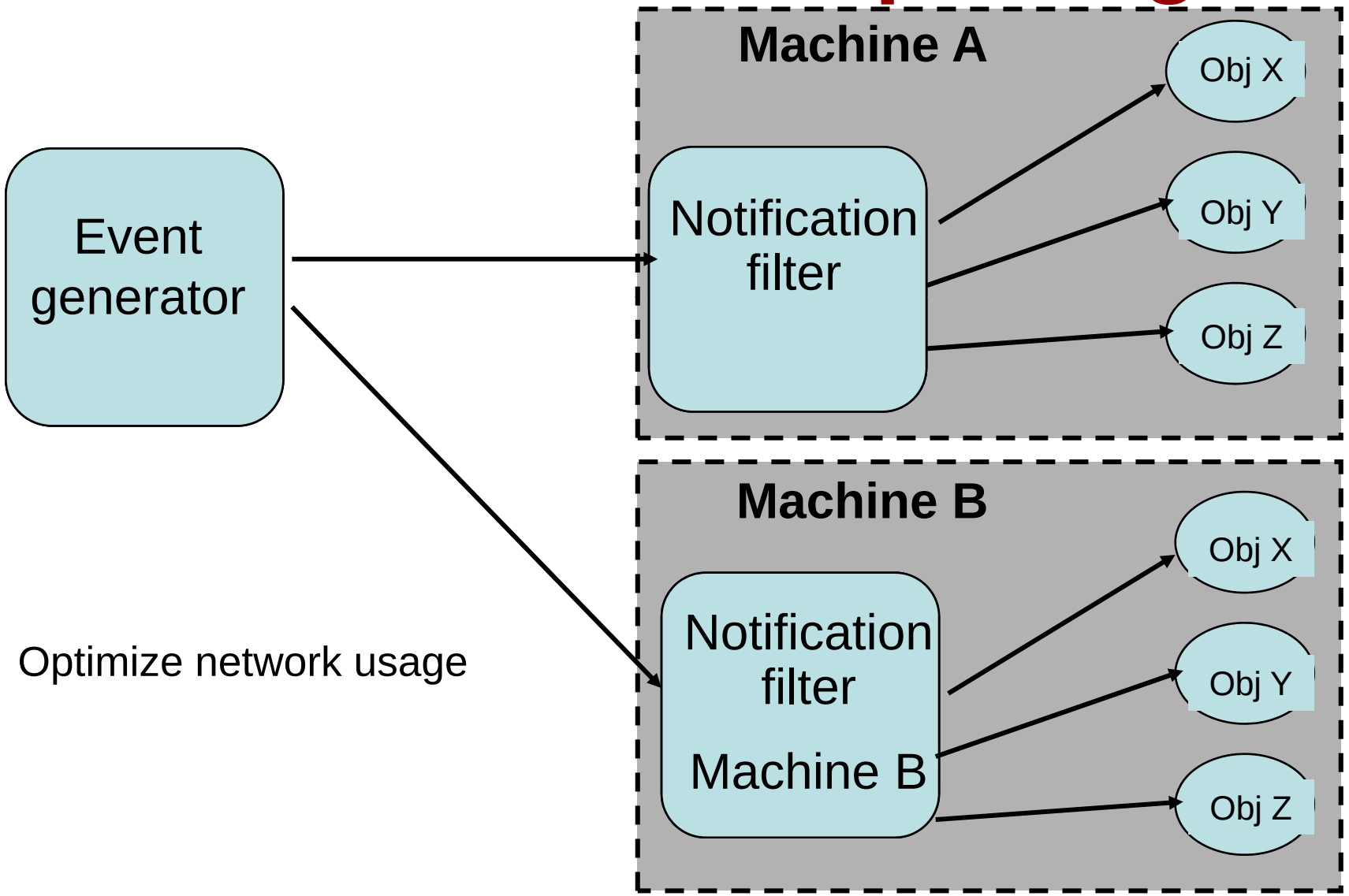
- Store-and-forward agents
- Notification filters
- Notification mailboxes

Store and forward agent



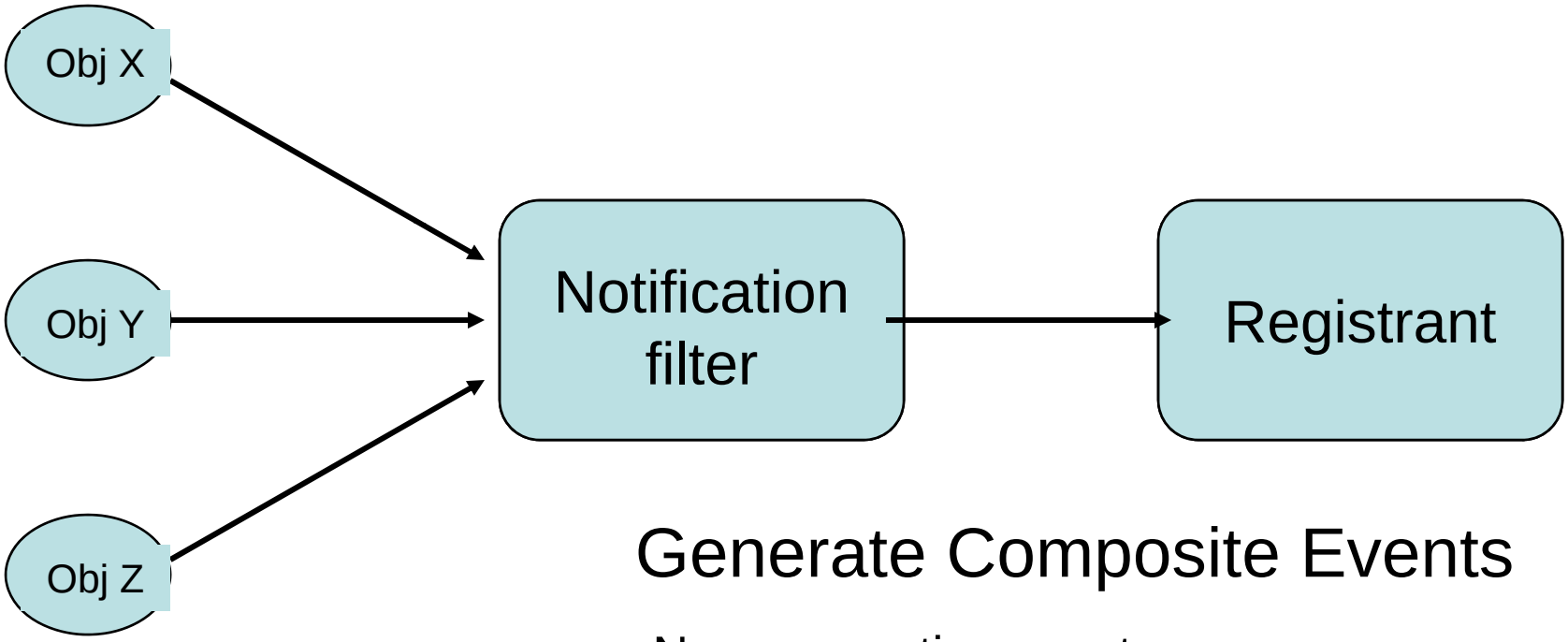
- Offloading the (remote) communication of the event generator.
- Delivery policies (eg retry policies)
- reliable Multicast, hardware multicast

Notification Multiplexing



Optimize network usage

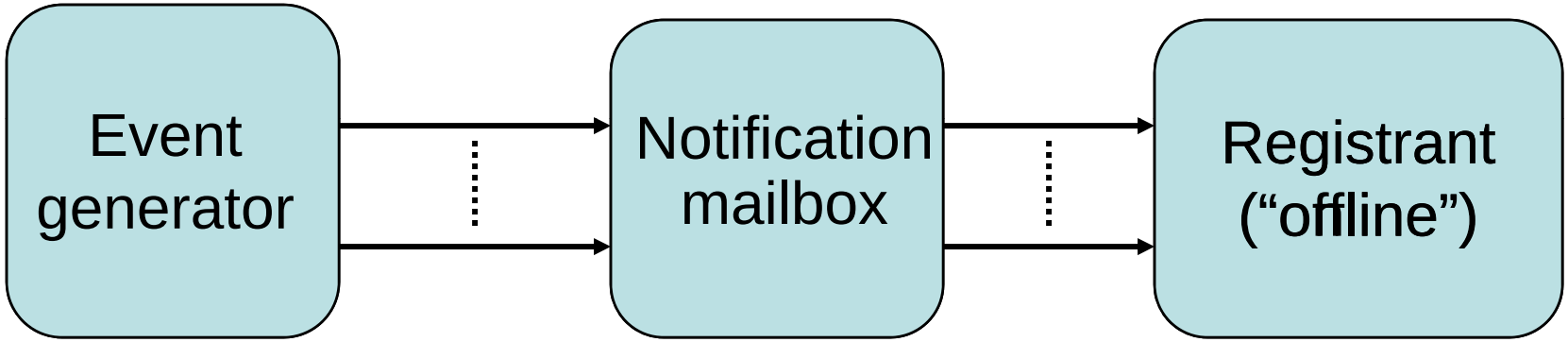
Notification Demultiplexing



Generate Composite Events

- N consequetive events
- N different events
- An event at each source

Notification mailbox

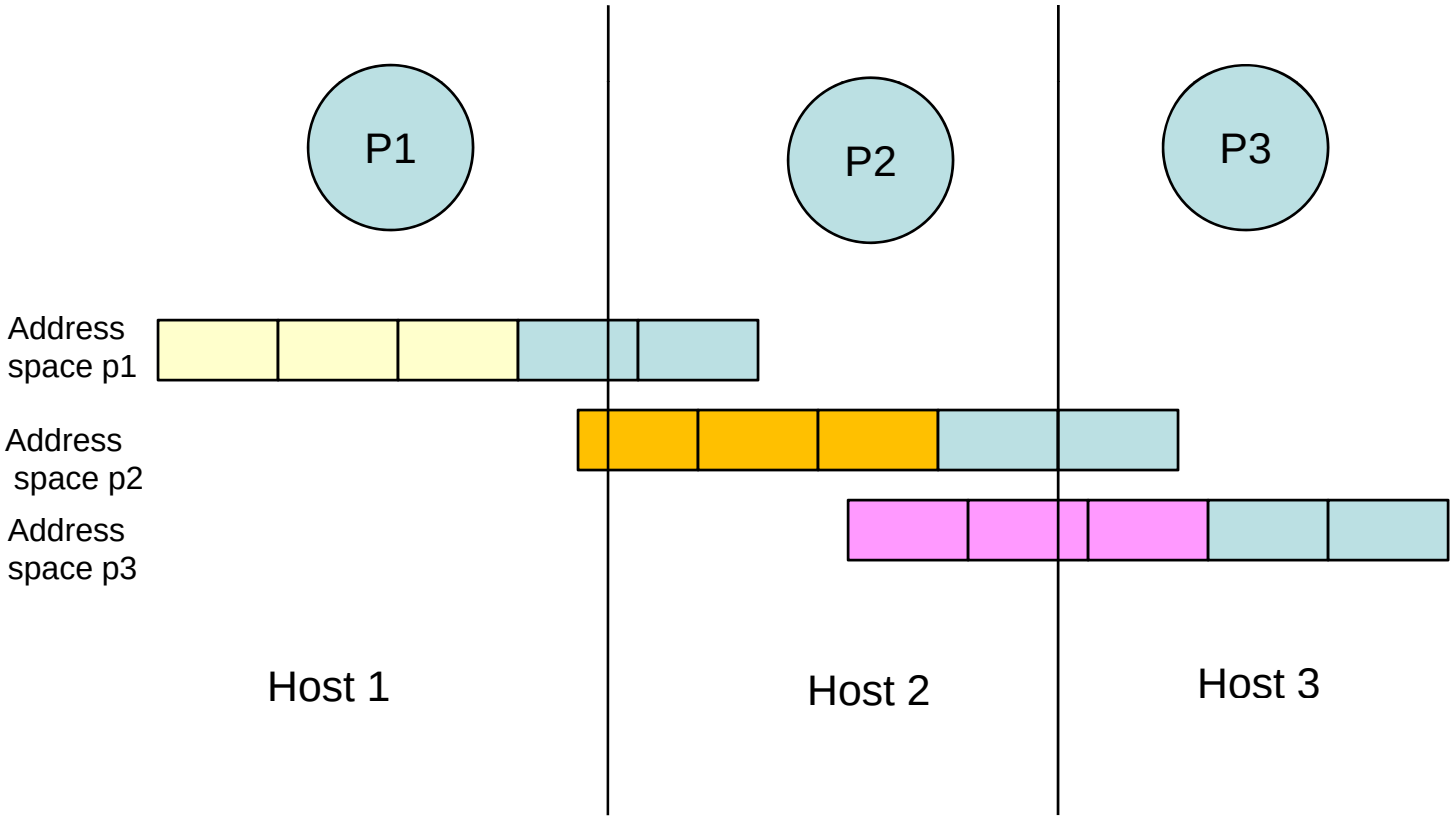


1) Mailbox stores events until registrant comes “online”.

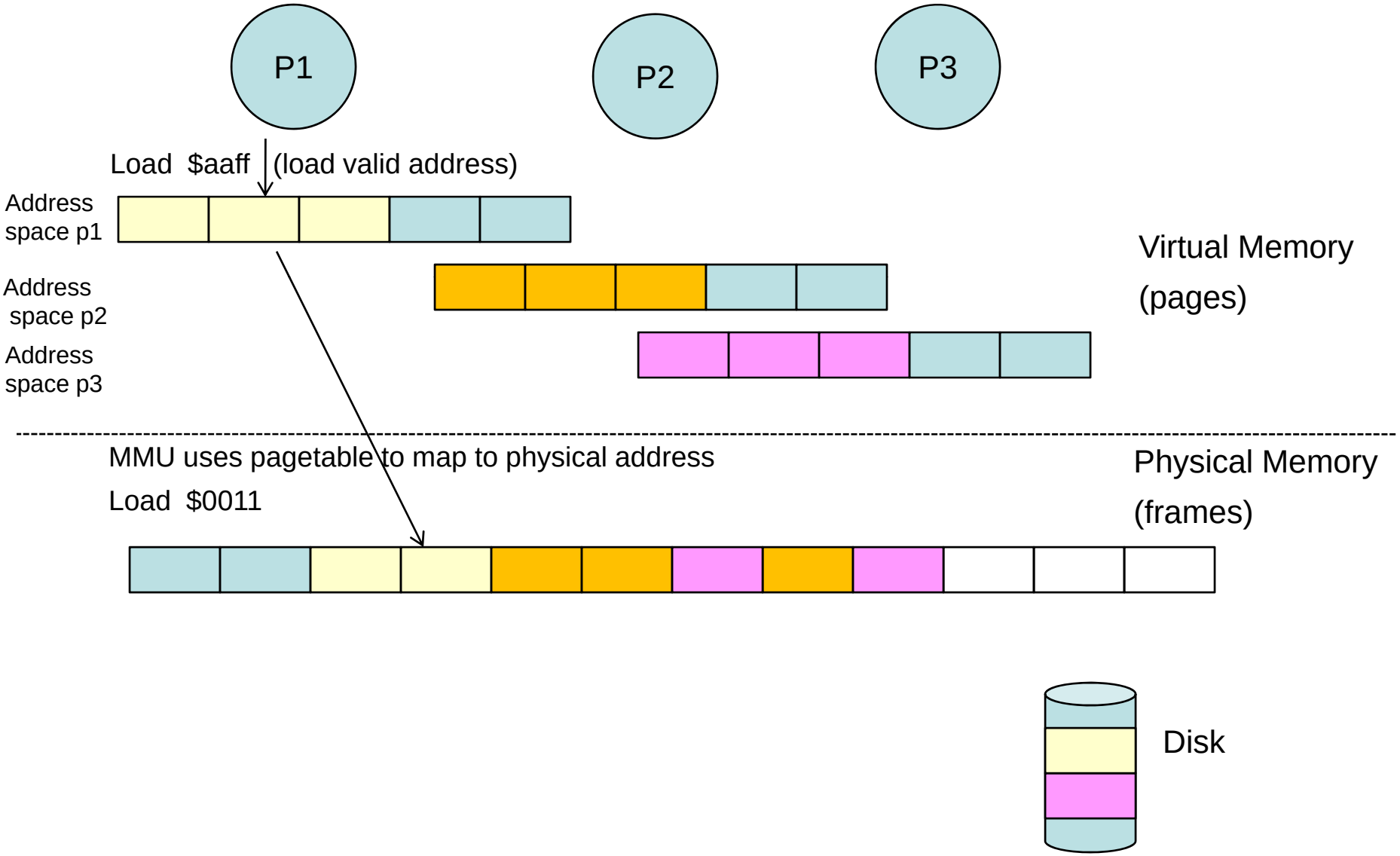
2) When registrant comes “online” the stored events are delivered.

Distributed Shared Memory

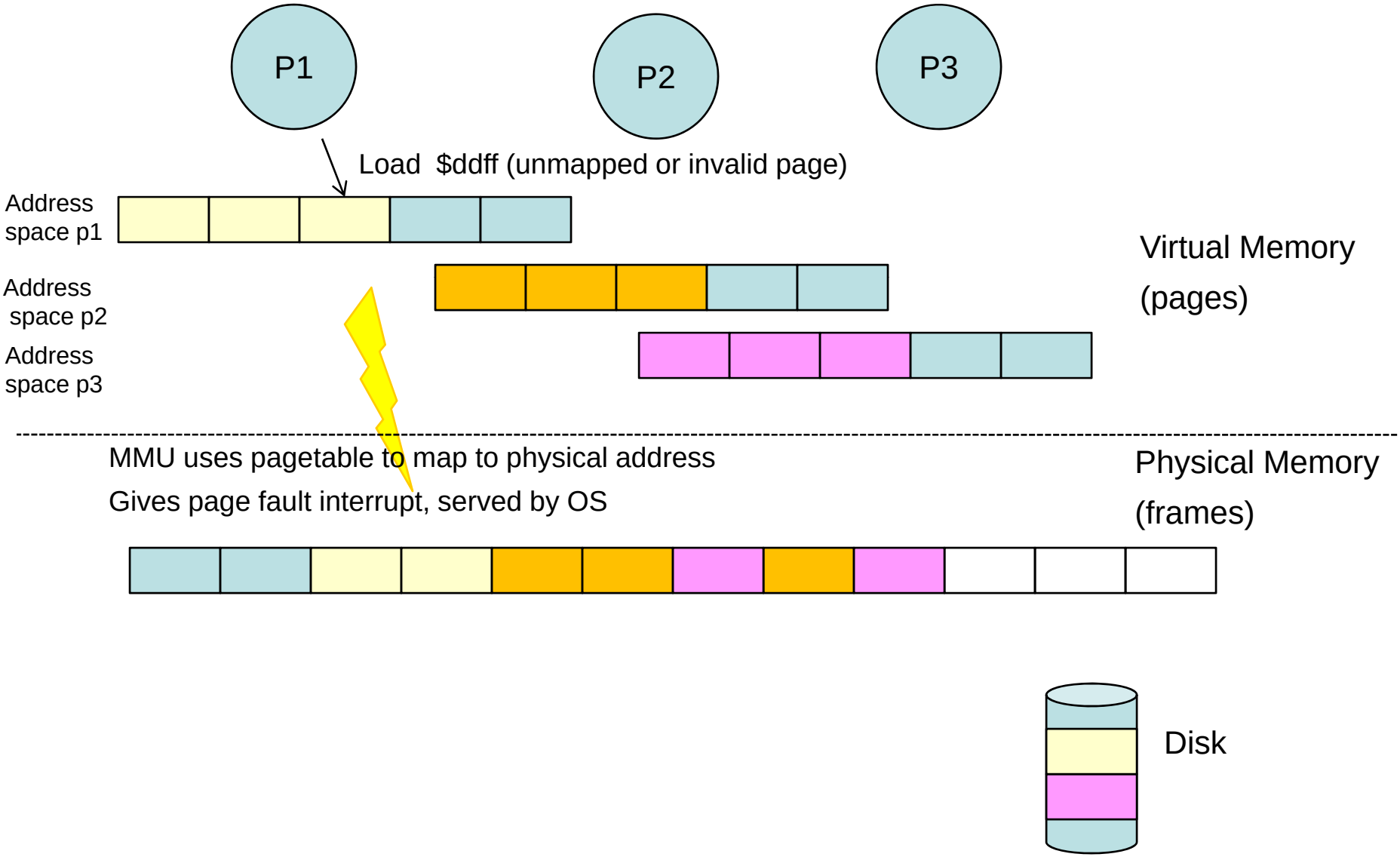
•Give processes the *illusion* that they are running on a shared memory machine, even though they run on different machines and that their memories are physically distributed



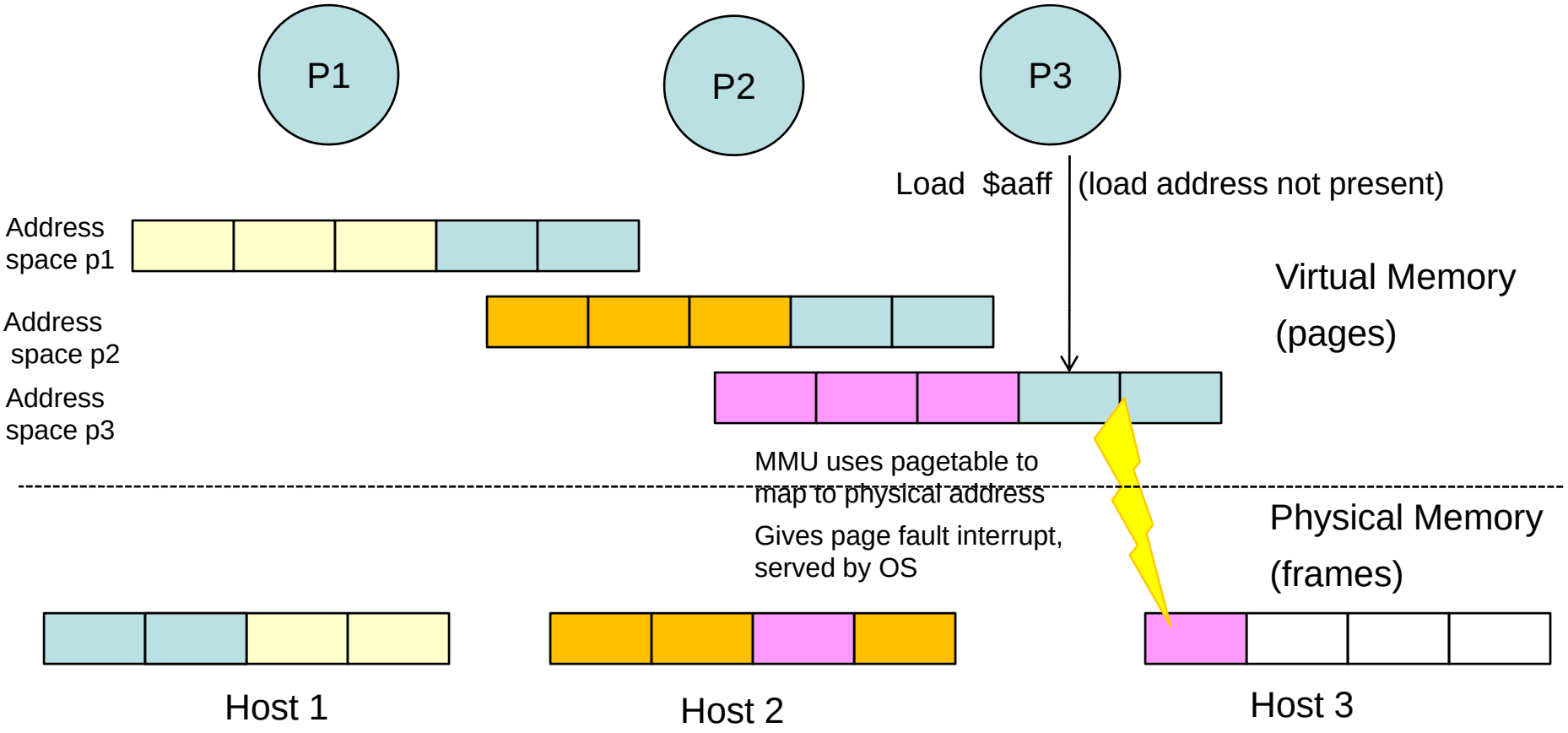
Virtual Memory 1



Virtual Memory 2

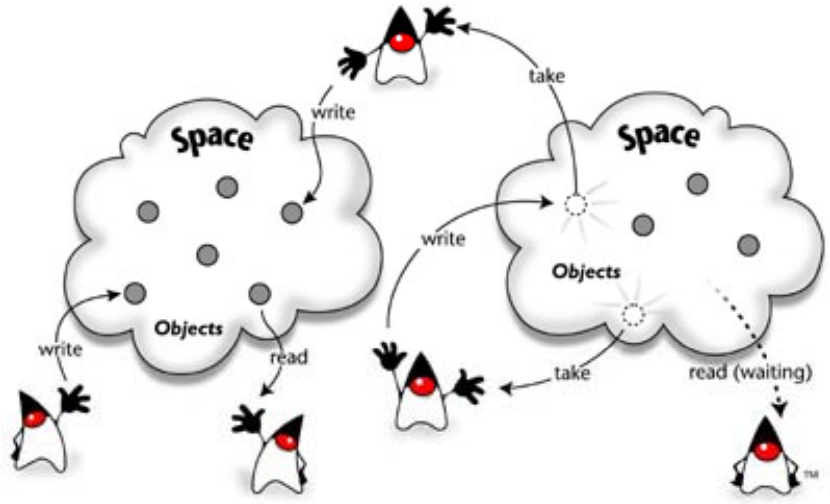


Distributed Shared Memory 2



Memory Consistency when writes occur???!!

=> Coherency Protocols



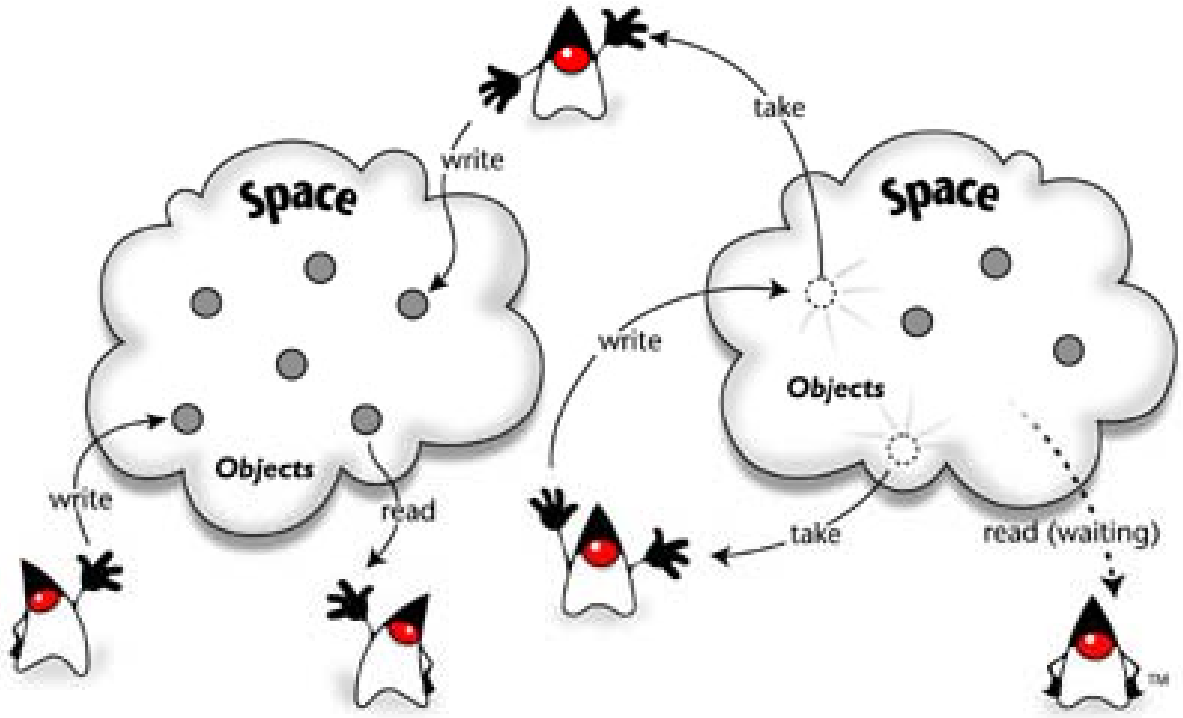
Linda (and JavaSpaces)

David Gelernter, yale University.

Linda

- Program Concurrency by using uncoupled processes with shared data space
- Add concurrency into a sequential language by adding:
  - Simple operators
  - Runtime kernel (language-independent)
  - Preprocessor (or compiler)

Basic Idea



- Have a shared memory space (“tuple space”)
  - Processes can **add**, **read**, and **take** away values from this space
- Bag of processes, each looks for work it can do by matching values in the tuple space
- Implicit load balancing, synchronization, messaging, etc.

Tuples

	Conventional Memory	Linda/JavaSpaces
Unit	Bit	Logical Tuple (23, “test”, false)
Access Using	Address (variable)	Selection of values
Operations	read, write	**in, out, read** JavaSpaces: read, write, take **Immutable**

Tuple Space Operations

- **out** (*t*) – add tuple *t* to tuple space
- **in** (*s*) $\rightarrow$ *t* – returns and removes tuple t matching template s
- **read** (*s*) $\rightarrow$ *t* – same as **in**, except doesn't remove *t*.

- Originally also **Eval**(f(42),g(45));
- Operations are atomic (even if space is distributed)

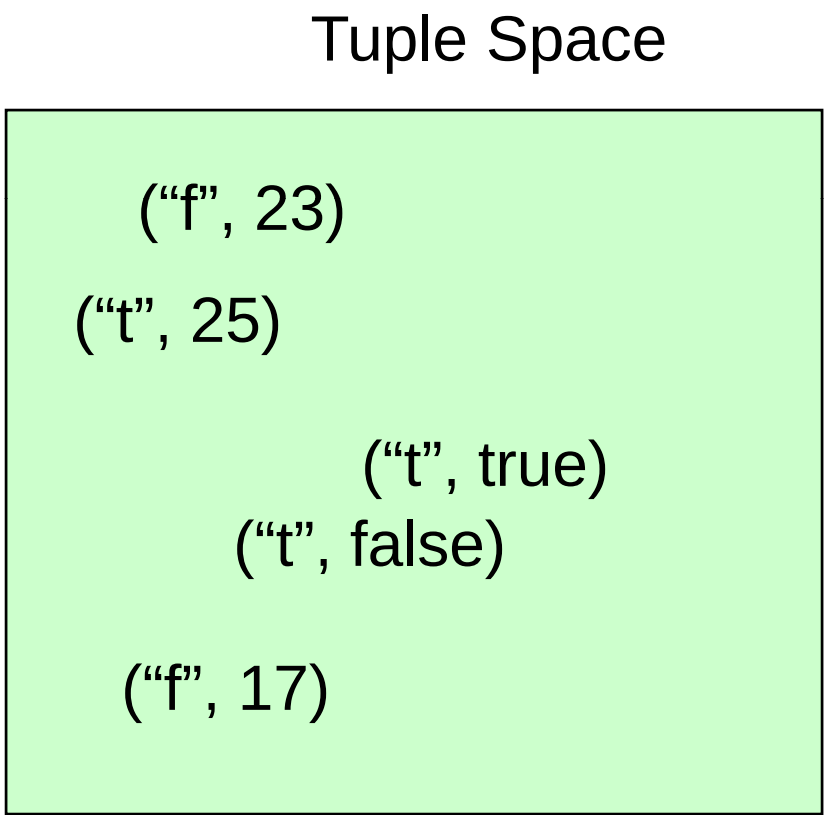
Meaning of in

in (“f”, int n)

in (“f”, 23)

in (?string s,? int n)

in (“cookie”)



Counting Semaphore

- Create (int n, String resource)

  for (i = 0; i < n; i++) **out** (*resource*);
- Down (String resource)

  in (*resource*)
- Up (String resource)

  out (*resource*)

Distributed Ebay

- OfferItem (String item, int min bid, int timeout):

  out (item, minbid, “owner”);

  sleep (timeout);

  in (item, ? bid, ? bidder);

  if (bidder ≠ “owner”) SOLD!

- Bid (String bidder, String item, int bid):

  in (item, ? highbid, ? highbidder);

  if (bid > highbid) **out** (item, bid, bidder)

  else **out** (item, highbid, highbidder)

Further Reading

- Jini Specification

  http://www.sun.com/jini/specs
- Jini Developers

  http://jini.org
- Universal Plug and Play

  http://www.upnp.org

END