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Centre International de Mathématiques Pures et Appliquées
International Center for Pure and Applied Mathematics

A CIMPA-UNSA-INRIA-UNESCO-VIETNAM SCHOOL ON

Objects and Network

Part : Distributed Objects Courses

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SUMMARY

Distributed Objects:

- RMI
- Distributed GC
- CORBA

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Distributed Objects

Copying remote objects:

sockets + persistence $\Rightarrow$ transport of objects by copy (and creation of new instances)

Sharing remote objects:

References to a remote object from different network places to the **same** object
to invoke its methods and/or to modify its instance variables.

GOALS:

- To simplify the protocol.
  The object interface becomes the new protocol.
- To distribute applications.

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Implementation difficulties

- Referential transparency
- Garbage Collector
- Typechecking for copied objects
- Remote exceptions

jdk 1.1 proposes a basic mechanism, called RMI (*Remote Method Invocation*) to manipulate remote objects.

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RMI

- remote objects : running in another Java abstract machine
- method call : to keep the same object model
  a remote method call has the **same** syntax!!!
- using remote object : Just to need to implement the `Remote` interface.
  Parameters and results are given by copy (`Serializable`)
- naming service : localization by URL
- communication : rmi protocol

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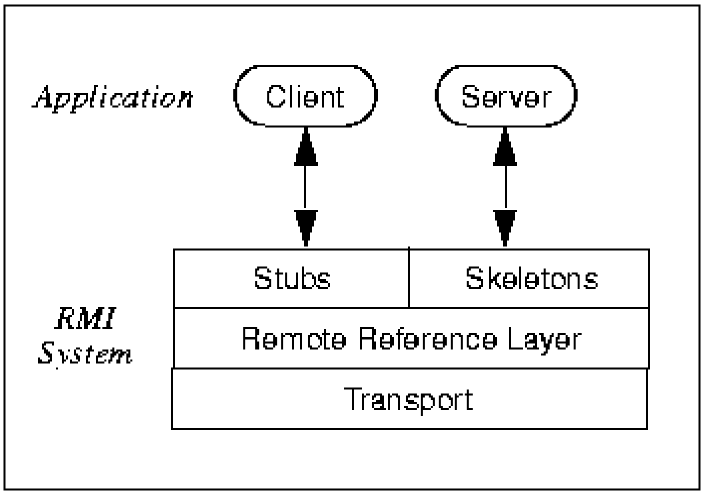
Architecture



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Server

The server part is more complicated for the following services :

- GC for distributed objects
- replication for remote objects
- activation for persistent objects

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Packages

packages are :

- `java.rmi` : for client side
- `java.rmi.server` : for server side
- `java.rmi.registry` : to manage `Registry`
- `java.rmi.dgc` : for the distributed GC

The remote objects interface extends the `Remote` interface and adds some methods, which can throw `RemoteException`.

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Packages description

in java.rmi

- `Remote` Interface : to identify remote objects (empty)
- `Naming` class : main `static` methods
  void `bind`(String, Remote)
  void `rebind`(String,Remote)
  String[] list(String)
  Remote `lookup`(String)
  void `ubind`(String)
  They can throw a lot of exceptions.
- `RMISecurityManager` class: default security
- a lot of exceptions : `RemoteException`,...

in java.rmi.server

- `UnicastRemoteObject` class : support for point-to-point active object references

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Example : Remote Points

Interface:

```
import java.rmi.*;
public interface PointRMI extends Remote {

  void moveto (int a, int b) throws RemoteException;

  void rmoveto (int dx, int dy) throws RemoteException;

  void display() throws RemoteException;

  double distance() throws RemoteException;

}
```

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Remote interfaces implementation

Interface implementation:

```
  import java.rmi.*;
  import java.rmi.server.UnicastRemoteObject;

public class PointD extends UnicastRemoteObject
                     implements PointRMI {

  int x,y;
  PointD(int a, int b) throws RemoteException {x=a;y=b;}
  PointD() throws RemoteException {x=0;y=0;}

  public void moveto (int a, int b)
    throws RemoteException
  { x=a; y=b;}

  public void rmoveto (int dx, int dy)
    throws RemoteException
  { x = x + dx; y = y + dy;}

  public void display()
   throws RemoteException
  { System.out.println("(" + x + "," + y + ")");}

  public double distance()
    throws RemoteException
  { return Math.sqrt(x*x+y*y);}
}
```

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Compilation

- interface and classes : `javac` PointRMI.java PointD.java
- *stubs* and *skeletons* : `rmic` PointD

`rmic PointD` will create the files : `PointD_Stub.class` (for clients) and `PointD_Skel.class` (for servers).

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Creation and registration

The points server will create `PointD` instances and will registry them (`rebind`) to the `rmiregistry` daemon which manages the rmi protocol.

```
import java.rmi.*;
import java.rmi.server.UnicastRemoteObject;

public class Creation {

  public static void main (String args[]) {
    System.setSecurityManager(new RMISecurityManager());
    try {
      PointD p0 = new PointD();
      PointD p1 = new PointD(3,4);
      Naming.rebind("//etretat.lip6.fr/point0",p0);
      Naming.rebind("//etretat.lip6.fr/point1",p1);
      System.out.println("Distributed Objects 'p0'" +
           " and 'p1' are registried");
    }
    catch (Exception e) { e.printStackTrace();
    }
  }
}
```

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Server running

Naming service:

```
$ rmiregistry&
```

Server:

```
$  java Creation
Distributed Objects 'p0'
and 'p1' are registried
```

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A client

```
import java.rmi.*;
public class ClientP {
  public static void main( String argv[]) {
    String url0="rmi://etretat.lip6.fr/point0";
    String url1="rmi://etretat.lip6.fr/point1";
 try {
   PointRMI p0 = (PointRMI)Naming.lookup(url0);
   PointRMI p1 = (PointRMI)Naming.lookup(url1);
   p0.display(); p1.display();
   p0.rmoveto(7,12);
   p1.rmoveto(5,6);
   p0.display(); p1.display();
   if (p0.distance() == p1.distance())
     System.out.println("same distance!!!");
   else
       System.out.println("different distance");
   }
 catch (Exception e) {
     System.err.println("exception : " +
                         e.getMessage());
     e.printStackTrace();
} } }
```

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Client running

first execution:

```
(0,0)
(3,4)
(7,12)
(8,10)
different distance
```

second execution:

```
(7,12)
(8,10)
(14,24)
(13,16)
different distance
```

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Concurrent calls

may or not may execute in a separate thread

- **same** client virtual machine :
  no guarantees to execute method invocation in different threads
- **different** client virtual machines :
  calls will execute in different threads

To use `synchronized` methods for the remote objects!!!

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Concurrent Clients

```
etr: java ClientP C1 & \
     java ClientP C2 & java ClientP C3
[2] 32212
[3] 32213
C3.p0(112,192)
C1.p0(112,192)
C1.p1(83,100)
C1.p0(119,204)
C1.p1(88,106)
C3.p1(88,106)
C3.p0(126,216)
C3.p1(93,112)
C1 : different distance
[2]    Done                    java ClientP C1
C3 : different distance
C2.p0(126,216)
C2.p1(93,112)
C2.p0(133,228)
C2.p1(98,118)
C2 : different distance
[3]    Done                    java ClientP C2
```

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Exceptions

Different cases:

- daemon doesn't run

```
exception : Connection refused to host;
...
```

- object doesn't registry

```
exception : point0
java.rmi.NotBoundException: point0
```

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Communication port

Default port for the rmi service is : 1099,
but the rmiregistry can be running on another port :

```
rmiregistry 2000&
```

this new port must be used for the URL :

```
//youpou.lip6.fr:2000
```

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Distributed GC

What is the problem?:

cleans the external reference to an object (in the server side)

- if a client doesn't use it
- need to be fault tolerant
  - when a client disappears (long time)
  - if a client disappears and appears again

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Java solution

in `java.rmi.dgc` package :

A reference to a remote object is leased for a period of time by the client holding the reference.

- The lease period starts when the dirty call is received.
- It is the client's responsibility to renew the leases, by making additional dirty calls, on the remote references it holds before such leases expire.
- If the client does not renew the lease before it expires, the distributed garbage collector assumes that the remote object is no longer referenced by that client.

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Interface DGC

```
package java.rmi.dgc;

import java.rmi.server.ObjID;

public interface DGC extends java.rmi.Remote {

        Lease dirty(ObjID[] ids, long sequenceNum, Lease lease)
                throws java.rmi.RemoteException;

        void clean(ObjID[] ids, long seqNum, VMID vmid,
boolean strong)
                throws java.rmi.RemoteException;
}
```

For each exported remote object in the local virtual machine, the garbage collector maintains a reference list – a list of clients that hold references to it.

The clean call removes the vmid from the reference list of each remote object indicated in *ids*.

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CORBA

Common Object Request Broker Architecture : standard (OMG - 1990) allows :

- to be independent from languages
- to have more complete registrying services
- to be independent from constructors
  a lot of ORBs (including free ORBs)

To be independent :

- from constructors, CORBA specifies IIOP (open protocol)
- from languages : CORBA specifies the IDL language.

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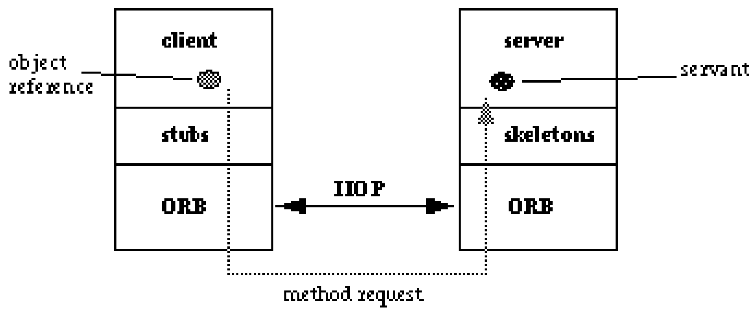
Architecture



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IDL

Interface Definition Language allows to describe visible *methods* and *fields* from objects.
Accept simple or multiple interface inheritance.

Point.idl:

```
interface Point {
  void moveto(in int a, in int b);
  void rmoveto(in int dx, in int dy);
  void display();
  double distance();
}
```

From this description, the IDL compiler (given with ORBs), generates *stub* and *skeletons* fro the server, and that for different languages (Smalltalk, C++, Java ...)

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CORBA and Java

Java IDL: classes, libraries and tools to use CORBA object from Java, contains :

- an ORB
- a naming service (`tnameserv`)
- `idltojava` compiler

Java IDL conforms to IIOP 1.0 (Internet InterORB Protocol).

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Java IDL : development process

1. To define the remote interface : Point.idl
2. To compile the remote interface, which generates Java version of the interface, and class code files for the *stubs* and *skeletons*
3. To implement the server, by using *skeletons* to implement remote interface, server code includes the ORB starting and waits for invocation.
4. To implement the client, by using *stubs* : to start its ORB
   look up the server using the name service, to obtain a reference to remote object and to call its method.
5. To start the applications
   to start the name service, then to start the server, then to run the clients

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RMI and CORBA

same ideas (RMI technology was inspired by CORBA) :

- interfaces definition
- stubs and skeletons elaboration

CORBA is a standard (OMG = 500 companies), RMI not
CORBA gives a better registration services

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RMI *vs* CORBA

	RMI	CORBA
version	JDK1.1.6	JDK 1.2 **Beta 4**
communication	Java machines	IIOP
services	minimal	better
performances	bad	variable
DGC	yes	no
cost	free licence	javatoidl ??
old programs	not	possible
usage	simpler	more complex