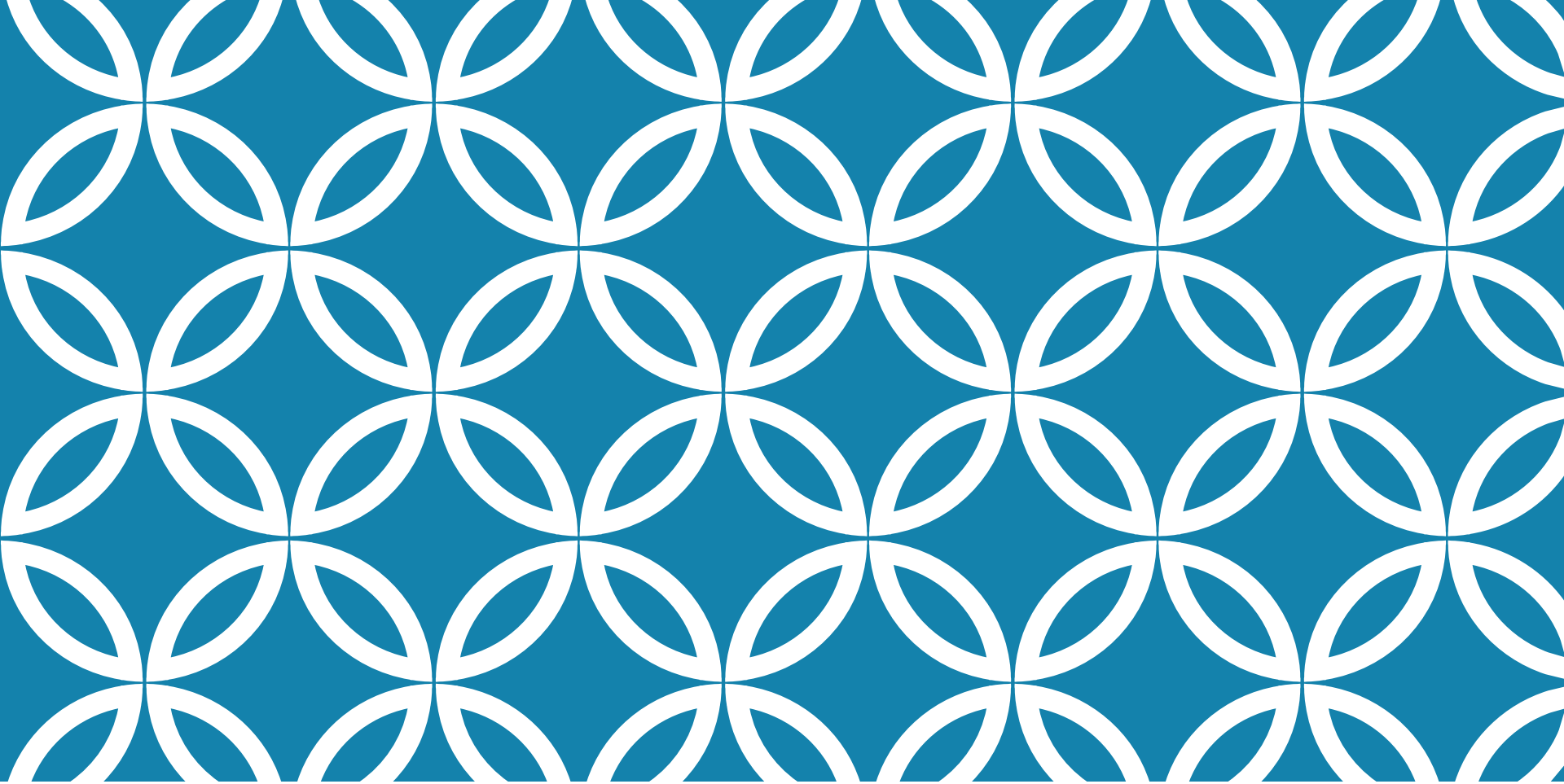


RMI PROGRAMMING

October 2019

WHAT IS RMI?

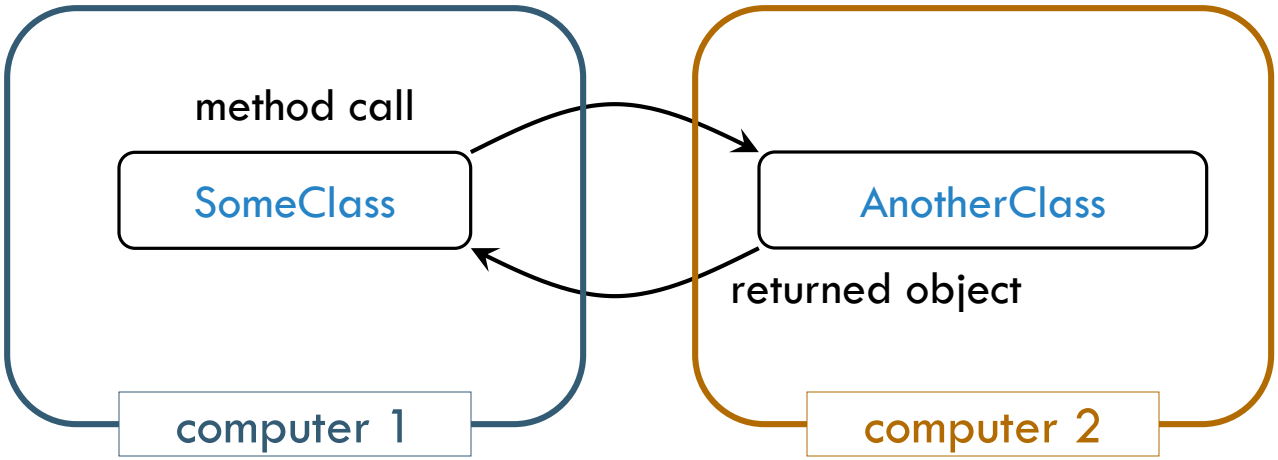
Remote Method Invocation

- A **true distributed computing application interface** for Java, written to provide easy access to objects existing on remote virtual machines

- **Provide access to objects** existing on remote virtual machines

"THE NETWORK IS THE COMPUTER"

Consider the following program organization:



If the network **is** the computer, we ought to be able to put the two classes on different computers

RMI is one technology that makes this possible

WHAT IS RMI? CONT.

Remote Method Invocation

- Remote objects can be treated similarly to local objects
- Handles marshalling, transportation, and garbage collection of the remote objects
- Became part of the JDK with version 1.1

WHAT IS RMI NOT?

Not an all-purpose ORB architecture like CORBA and DCOM (but close …)

Not language independent

- Limited only to Java and Perl
- Interfaces to remote objects are defined using ordinary Java **interfaces** (rather than having to use a special purpose interface definition language)
- Can provide more advanced features like serialization and security

TERMINOLOGY

A remote object is an object on another computer

The client object is the object making the request (sending a message to the other object)

The server object is the object receiving the request

As usual, “client” and “server” can easily trade roles (each can make requests of the other)

The rmiregistry is a special server that looks up objects by name

- Hopefully, the name is unique!

rmic is a special compiler for creating stub (client) and skeleton (server) classes

WHAT IS NEEDED FOR RMI

Java makes RMI (Remote Method Invocation) *fairly* easy, but there are some extra steps

To send a message to a remote "server object,"

- The "client object" has to *find* the object : do this by looking it up in a registry

WHAT IS NEEDED FOR RMI

- The client object then has to marshal the parameters (prepare them for transmission)
  - Java requires Serializable parameters
  - The server object has to unmarshal its parameters, do its computation, and marshal its response
- The client object has to *unmarshal* the response

PROCESSES

For RMI, you need to be running *thr*ee processes

- The Client
- The Server
- The Object Registry, rmiregistry, which is like a DNS service for objects

You also need TCP/IP active

INTERFACES

Interfaces define **behavior**

Classes define **implementation**

Therefore,

- In order to use a remote object, the client must know its behavior (interface), but does not need to know its implementation (class)
- In order to provide an object, the server must know both its interface (behavior) and its class (implementation)

In short,

- The interface must be available to both client and server
- The class of any transmitted object must be on both client and server
- The class whose method is being used should only be on the server

CLASSES

A Remote class is one whose instances can be accessed remotely

- On the computer where it is defined, instances of this class can be accessed just like any other object
- On other computers, the remote object can be accessed via object handles

CLASSES

A Serializable class is one whose instances can be marshaled (turned into a linear sequence of bits)

- Serializable objects can be transmitted from one computer to another

It is probably not a good idea for an object to be both remote and serializable

CONDITIONS FOR SERIALIZABILITY

If an object is to be serialized:

- The class must be declared as public
- The class must implement Serializable
  - However, Serializable does not declare any methods
- The class must have a no-argument constructor
- All fields of the class must be **serializable**: either primitive types or Serializable objects
  - Exception: Fields marked transient will be ignored during serialization

REMOTE INTERFACES AND CLASS

A Remote class has two parts:

- The interface (used by both client and server):
  - Must be **public**
  - Must extend the interface java.rmi.Remote
  - Every method in the interface must declare that it throws java.rmi.RemoteException (other exceptions may also be thrown)

REMOTE INTERFACES AND CLASS

- The class itself (used only by the server):
  - Must implement the Remote interface
  - Should extend java.rmi.server.UnicastRemoteObject
  - May have locally accessible methods that are not in its Remote interface

REMOTE VS. SERIALIZABLE

A Remote object lives on another computer (such as the Server)

- You can send messages to a Remote object and get responses back from the object
- All you need to know about the Remote object is its interface
- Remote objects don't pose much of a security issue

You can transmit a *copy* of a Serializable object between computers

- The receiving object needs to know how the object is implemented; it needs the class as well as the interface
- There is a way to transmit the class definition
- Accepting classes ***does* pose a security issue**

SECURITY

It isn't safe for the client to use somebody else's code on some random server

- System.setSecurityManager(new RMISecurityManager());
- The security policy of RMISecurityManager is the same as that of the default SecurityManager
- Your client program should use a more conservative security manager than the default

SECURITY

Most discussions of RMI assume you should do this on both the client and the server

- Unless your server also acts as a client, it isn't really necessary on the server

See:

- `http://fragments.turtlemeat.com/rmi.php`
- `http://docs.oracle.com/javase/tutorial/rmi/running.html`

THE SERVER CLASS

The class that defines the server object should extend:
UnicastRemoteObject

- This makes a connection with exactly one other computer
- If you must extend some other class, you can use exportObject() instead
- Sun does *not* provide a MulticastRemoteObject class

The server class needs to register its server object:

- String url = "rmi://" + ***host*** + ":" + ***port*** + "/" + ***objectName***;
  - The default port is 1099
- Naming.rebind(url, ***object***);

Every remotely available method must throw a RemoteException (because connections can fail)

Every remotely available method should be synchronized

HELLO WORLD SERVER: INTERFACE

```
import java.rmi.*;

public interface HelloInterface extends Remote

{
   public String say() throws RemoteException;
}
```

HELLO WORLD SERVER: CLASS

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

public class Hello extends UnicastRemoteObject
                                implements HelloInterface {
      private String message; // Strings are serializable


      public Hello (String msg) throws RemoteException {
            message = msg;
   }

      public String say() throws RemoteException {
            return message;
   }
}
```

REGISTERING THE HELLO WORLD SERVER

```
class HelloServer {
   public static void main (String[] argv) {
       try {
              Naming.rebind("rmi://localhost/HelloServer",
                                  new Hello("Hello, world!"));
              System.out.println("Hello Server is ready.");
       }
       catch (Exception e) {
          System.out.println("Hello Server failed: " + e);
       }
   }
}
```

THE HELLO WORLD CLIENT PROGRAM

```
class HelloClient {
   public static void main (String[] args) {
      HelloInterface hello;
      String name = "rmi://localhost/HelloServer";
      try {
          hello =(HelloInterface)Naming.lookup(name);
          System.out.println(hello.say());
       }
       catch (Exception e) {
          System.out.println("HelloClient exception: " +
e);
       }
    }
}
```

RMIC

The class that implements the remote object should be compiled as usual

Then, it should be compiled with rmic:

- rmic Hello

This will generate files Hello_Stub.class and Hello_Skel.class

These classes do the actual communication

- The "**Stub**" class must be *copied* to the client area
- The "**Skel**" was needed in SDK 1.1 but is no longer necessary

TRYING RMI

In three different terminal windows:

1. Run the registry program:
   - rmiregistry
2. Run the server program:
   - java HelloServer
3. Run the client program:
   - java HelloClient

- If all goes well, you should get the “Hello, World!” message

SUMMARY

1. Start the registry server, rmiregistry

2. Start the object server
    1. The object server registers an object, with a name, with the registry server

SUMMARY

1. Start the client
    1. The client looks up the object in the registry server
2. The client makes a request
    1. The request actually goes to the Stub class
    2. The Stub classes on client and server talk to each other
    3. The client's Stub class returns the result