# Мрежово програмиране
# Разпределени системи
# Отдалечено извикване на методи

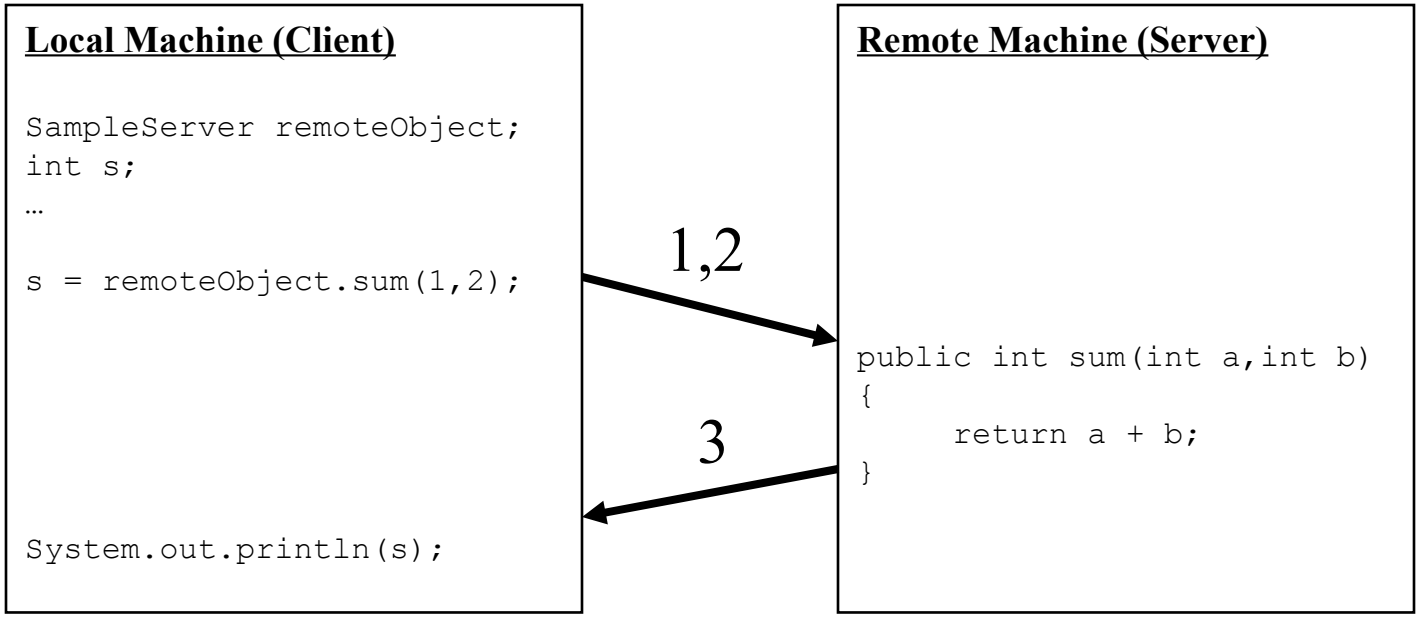
**доц. д-р Йордан Денев**
**denev@fmi.uni-sofia.bg**

Използван; http://www.comp.hkbu.edu.hk/~jng/comp3320/rmi.html

# Java Remote Object Invocation (RMI)

RMI applications often comprise two separate programs, a server and a client. A typical server program creates some remote objects, makes references to these objects accessible, and waits for clients to invoke methods on these objects.

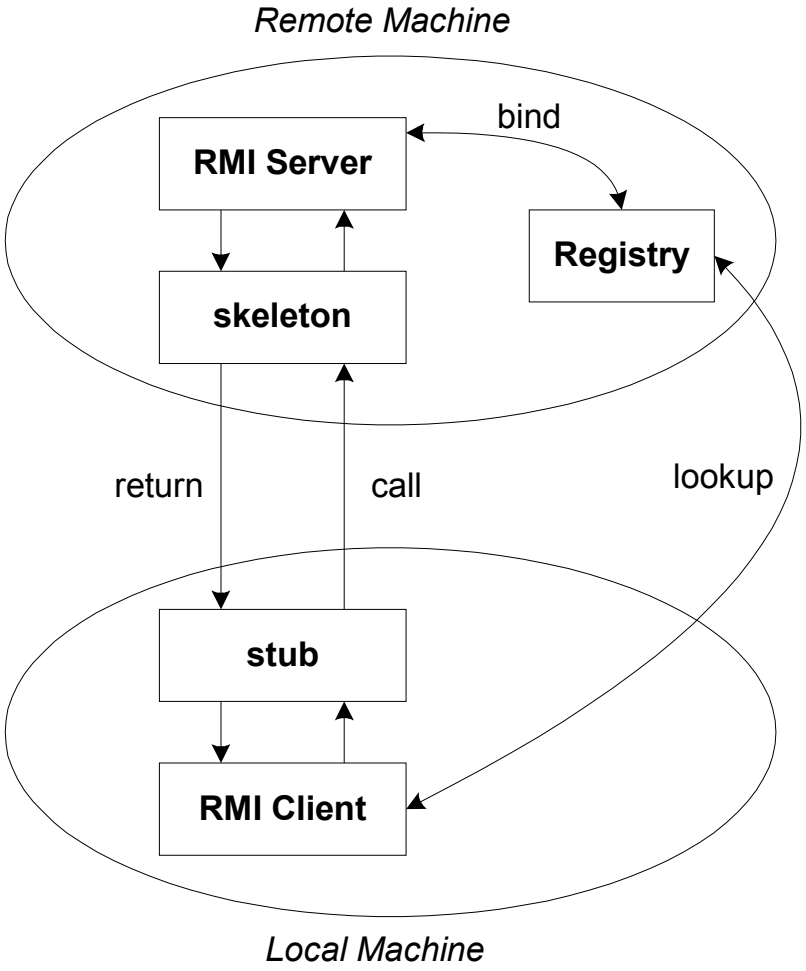
A typical client program obtains a remote reference to one or more remote objects on a server and then invokes methods on them. RMI provides the mechanism by which the server and the client communicate and pass information back and forth.


Local Machine (Client)
SampleServer remoteObject;
int s;
…
s = remoteObject.sum(1,2);
System.out.println(s);
1,2
3
Remote Machine (Server)
public int sum(int a,int b)
{
return a + b;
}

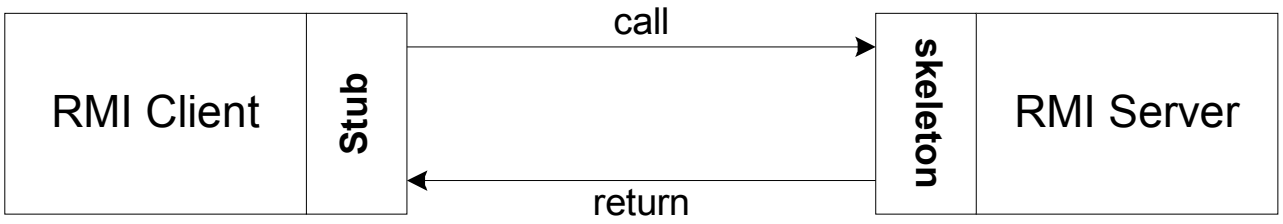
- **Locate remote objects.** Applications can use various mechanisms to obtain references to remote objects. For example, an application can register its remote objects with RMI's simple naming facility, the RMI registry. Alternatively, an application can pass and return remote object references as part of other remote invocations.
- **Communicate with remote objects.** Details of communication between remote objects are handled by RMI. To the programmer, remote communication looks similar to regular Java method invocations.
- **Load class definitions for objects that are passed around.** Because RMI enables objects to be passed back and forth, it provides mechanisms for loading an object's class definitions as well as for transmitting an object's data.

# The General RMI Architecture

- The server must first bind its name to the registry
- The client lookup the server name in the registry to establish remote references.
- The Stub serializing the parameters to skeleton, the skeleton invoking the remote method and serializing the result back to the stub.



# The Stub and Skeleton




- A client invokes a remote method, the call is first forwarded to stub.
- The stub is responsible for sending the remote call over to the server-side skeleton
- The stub opening a socket to the remote server, marshaling the object parameters and forwarding the data stream to the skeleton.
- A skeleton contains a method that receives the remote calls, unmarshals the parameters, and invokes the actual remote object implementation.

# Steps for Developing an RMI System

1. Define the remote interface

   A remote interface specifies the methods that can be invoked remotely by a client. Clients program to remote interfaces, not to the implementation classes of those interfaces. The design of such interfaces includes the determination of the types of objects that will be used as the parameters and return values for these methods.

2. Develop the remote object by implementing the remote interface.

   Remote objects must implement one or more remote interfaces. The remote object class may include implementations of other interfaces and methods that are available only locally. If any local classes are to be used for parameters or return values of any of these methods, they must be implemented as well.

3. Develop the client program.

   Clients that use remote objects can be implemented at any time after the remote interfaces are defined, including after the remote objects have been deployed.
4. Compile the Java source files.
5. Generate the client stubs and server skeletons.
6. Start the RMI registry.
7. Start the remote server objects.
8. Run the client

# Step 1: Defining the Remote Interface

- To create an RMI application, the first step is the defining of a remote interface between the client and server objects.

```
/* SampleServer.java */
import java.rmi.*;

public interface SampleServer extends Remote
{
  public int sum(int a,int b) throws RemoteException;
}
```

# Step 2: Develop the remote object and its interface

- The server is a simple unicast remote server.
- Create server by extending `java.rmi.server.UnicastRemoteObject`.
- The server uses the RMISecurityManager to protect its resources while engaging in remote communication.

```
/* SampleServerImpl.java */
import java.rmi.*;
import java.rmi.server.*;
import java.rmi.registry.*;

public class SampleServerImpl extends UnicastRemoteObject
                              implements SampleServer
{
  SampleServerImpl() throws RemoteException
  {
     super();
  }
```

- Implement the remote methods

```
/* SampleServerImpl.java */
  public int sum(int a,int b) throws RemoteException
  {
     return a + b;
  }
}
```

- The server must bind its name to the registry, the client will look up the server name.
- Use `java.rmi.Naming` class to bind the server name to registry. In this example the name call “SAMPLE-SERVER”.
- In the main method of your server object, the RMI security manager is created and installed.

```
/* SampleServerImpl.java */
  public static void main(String args[])
  {
      try
      {
        System.setSecurityManager(new RMISecurityManager());
        //set the security manager
        //create a local instance of the object
        SampleServerImpl Server = new SampleServerImpl();
        //put the local instance in the registry
        Naming.rebind("//localhost/SAMPLE-SERVER" , Server);

        System.out.println("Server waiting.....");
      }
      catch (java.net.MalformedURLException me)        {
        System.out.println("Malformed URL: " +
   me.toString());    }
      catch (RemoteException re)  {
         System.out.println("Remote exception: " +
   re.toString());  }
  }
```

# Step 3: Develop the client program

- In order for the client object to invoke methods on the server, it must first look up the name of server in the registry. You use the `java.rmi.Naming` class to lookup the server name.
- The server name is specified as URL in the from ( rmi://host:port/name )
- Default RMI port is 1099.
- The name specified in the URL must exactly match the name that the server has bound to the registry. In this example, the name is “SAMPLE-SERVER”
- The remote method invocation is programmed using the remote interface name (`remoteObject`) as prefix and the remote method name (`sum`) as suffix.

# Step 3: Develop the client program

```
import java.rmi.*;
import java.rmi.server.*;
public class SampleClient
{
   public static void main(String[]  args)
   {
      // set the security manager for the client
      System.setSecurityManager(new RMISecurityManager());
      //get the remote object from the registry
      try
        {
          System.out.println("Security Manager loaded");
          String url = "//localhost/SAMPLE-SERVER";
          SampleServer remoteObject = (SampleServer)Naming.lookup(url);
          System.out.println("Got remote object");
          System.out.println(" 1 + 2 = " + remoteObject.sum(1,2) );
         }
```

```
catch (RemoteException exc) {
          System.out.println("Error in lookup: " + exc.toString()); }
        catch (java.net.MalformedURLException exc) {
          System.out.println("Malformed URL: " + exc.toString());   }
        catch (java.rmi.NotBoundException exc)  {
          System.out.println("NotBound: " + exc.toString());
        }
   }
}
```

# Step 4 & 5: Compile the Java source files & Generate the client stubs and server skeletons

- Assume the program compile and executing at elpis on ~/rmi
- Once the interface is completed, you need to generate stubs and skeleton code. The RMI system provides an RMI compiler (`rmic`) that takes your generated interface class and procedures stub code on its self.

```
elpis:~/rmi> set CLASSPATH=”~/rmi”
elpis:~/rmi> javac SampleServer.java
elpis:~/rmi> javac SampleServerImpl.java
elpis:~/rmi> rmic SampleServerImpl

elpis:~/rmi> javac SampleClient.java
```

# Step 6: Start the RMI registry

- The RMI applications need install to Registry. And the Registry must start manual by call `rmiregisty`.
- The `rmiregistry` us uses port 1099 by default. You can also bind rmiregistry to a different port by indicating the new port number as : `rmiregistry <new port>`

```
elpis:~/rmi> rmiregistry
```

- *Remark: On Windows, you have to type in from the command line:*

```
> start rmiregistry
```

# Steps 7 & 8: Start the remote server objects & Run the client

- Once the Registry is started, the server can be started and will be able to store itself in the Registry.
- Because of the grained security model in Java 2.0, you must setup a security policy for RMI by set `java.security.policy` to the file `policy.all`

```
elpis:~/rmi> java -Djava.security.policy=policy.all
   SampleServerImpl

elpis:~/rmi> java -Djava.security.policy=policy.all
   SampleClient
```

# Java Policy File

- In Java 2, the java application must first obtain information regarding its privileges. It can obtain the security policy through a policy file. In above example, we allow Java code to have all permissions, the contains of the policy file policy.all is:

```
grant {
 permission java.security.AllPermission;
};
```

- Now, we given an example for assigning resource permissions:

```
grant {
 permission java.io.filePermission "/tmp/*", "read",
 "write";
 permission java.net.SocketPermission
 "somehost.somedomain.com:999","connect";
 permission java.net.SocketPermission "*:1024-
 65535","connect,request";
 permission java.net.SocketPermission "*:80","connect";
};
```

# Comment for the Java Policy File

1. allow the Java code to read/write any files only under the /tmp directory, includes any subdirectories
2. allow all java classes to establish a network connection with the host “somehost.somedomain.com” on port 999
3. allows classes to connection to or accept connections on unprivileged ports greater than 1024 , on any host
4. allows all classes to connect to the HTTP port 80 on any host.

- *You can obtain complete details by following links:*

`http://java.sun.com/products//jdk/1.2/docs/guide/security/spec/security-spec.doc3.html`