Remote Method Invocation

Network Programming Paradigms

- Sockets programming: design a protocol first, then implement clients and servers that support the protocol.
- RMI: Develop an application, then move some objects to remote machines.
  - Not concerned with the details of the actual communication between processes – everything is just method calls.

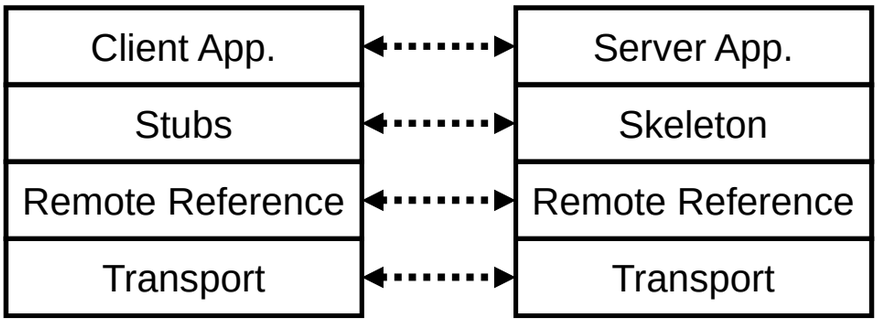
Call Semantics

- Method Call Semantics – what does it mean to make a call to a method?
  - How many times is the method run?
  - How do we know the method ran at all?
- RMI does a great job of providing *natural* call semantics for remote objects/methods.
  - Simply a few additional Exceptions that you need to handle.

Finding Remote Objects

- It would be awkward if we needed to include a hostname, port and protocol with every remote method invocation.
- RMI provides a *Naming Service* through the RMI Registry that simplifies how programs specify the location of remote objects.
  - This naming service is a JDK utility called **`rmiregistry`** that runs at a well known address (by default).

RMI Adds a few layers



Remote Object References

- The client acquired a reference to a remote object.
  - This part is different from creating a local object.
- The client calls methods on the remote object
  - No (syntactic) difference!
  - Just need to worry about a few new exceptions.

Overview of RMI Programming

- Define an `interface` that declares the methods that will be available remotely.
- The *server* program must include a `class` the implements this `interface`.
- The *server* program must create a remote object and register it with the naming service.
- The *client* program creates a remote object by asking the naming service for an object reference.

Server Details – extending Remote

- Create an interface the extends the `Remote` interface.
  - This new interface includes all the public methods that will be available as remote methods.

```
public interface MyRemote extends Remote {
  public int foo(int x) throws RemoteException;
  public String blah(int y) throws RemoteException;
  . . .
}
```

Server Details – Implementation Class

- Create a class that implements the interface.
  - The class should also extend **`UnicastRemoteObject`***
- This class needs a constructor that throws `RemoteException` !
- This class is now used by rmic to create the stub and skeleton code.

*It doesn't have to extend `UnicastRemoteObject`, there is another way…

Remote Object Implementation Class

```
public class MyRemoteImpl extends
  UnicastRemoteObject implements MyRemote {

    public MyRemoteImpl() throws RemoteException {
    }

    public int foo(int x) {
      return(x+1);
    }
    public String blah(int y) {
      return("Your number is " + y);
    }
}
```

Generating stubs and skeleton

- Compile the remote interface and implementation:

```
> javac MyRemote.java MyRemoteImpl.java
```

- Use `rmic` to generate
  `MyRemoteImpl_stub.class, MyRemoteImpl_skel.class`

```
> rmic MyRemoteImpl
```


Server Detail – main()

- The server `main()` needs to:
  - create a remote object.
  - register the object with the Naming service.

```
public static void main(String args[]) {
  try {
     MyRemoteImpl r = new MyRemoteImpl();
     Naming.bind("joe",r);
  } catch (RemoteException e) {
     . . .
```

Client Details

- The client needs to ask the naming service for a reference to a remote object.
  - The client needs to know the hostname or IP address of the machine running the server.
  - The client needs to know the name of the remote object.
- The naming service uses URLs to identify remote objects.

Using The Naming service

- **`Naming.lookup()`** method takes a string parameter that holds a URL indicating the remote object to lookup.

  `rmi://hostname/objectname`

- **`Naming.lookup()`** returns an **`Object`**!
- **`Naming.lookup()`** can throw
  - **`RemoteException`**
  - **`MalformedURLException`**

Getting a Remote Object

```
try {
  Object o =
      naming.lookup("uri://monica.cs.rpi.edu/joe");

  MyRemote r = (MyRemote) o;

  . . . Use r like any other Java object! . . .
} catch (RemoteException re) {
  . . .
} catch (MalformedURLException up) {
   throw up;
}
```


Starting the Server

- First you need to run the Naming service server:

  `start rmiregistry`

- Now run the server:

  `java ServerMain`

Sample Code