

CMSC 433 – Programming Language
Technologies and Paradigms
Spring 2003

Java RMI
April 15, 2003

Distributed Computing

- Programs that cooperate and communicate over a network
 - e-mail
 - web server and web client
 - SETI @Home

Key Features of Distrib. Comp.

- Machines are not all the same
 - But all adhere to same communication protocol
- Network is “slow”
 - Sending a message takes a lot of time
- Network is unreliable
 - Machines may join and leave with no warning
 - Part of the network may fail

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Different Approaches to Distributed Computation

- Connecting via sockets
 - E.g., project 3
 - custom protocols for each application
- RPC/DCOM/CORBA/RMI
 - make what looks like a normal function call
 - function actually invoked on another machine
 - Arguments are *marshalled* for transport
 - Value is *unmarshalled* on return

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Remote Method Invocation

- Easy way to get distributed computation
- Have stub for remote object
 - calls to stub get translated into network call
- Arguments and return values are passed over network
 - Java takes care of the details

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A Simple Example

```
class ChatServerImpl ... { // runs on one mach.
    public void receive(String s) {
        System.out.println(s);
    }
    ...
}
class Chatter { // runs on another mach.
    public static void main(String args[]) {
        ChatServer c = // get remote object;
        BufferedReader br = new BufferedReader(new
            InputStreamReader(System.in));

        while (true) {
            System.out.print("> ");
            c.receive(br.readLine());
        }
    }
} }
```

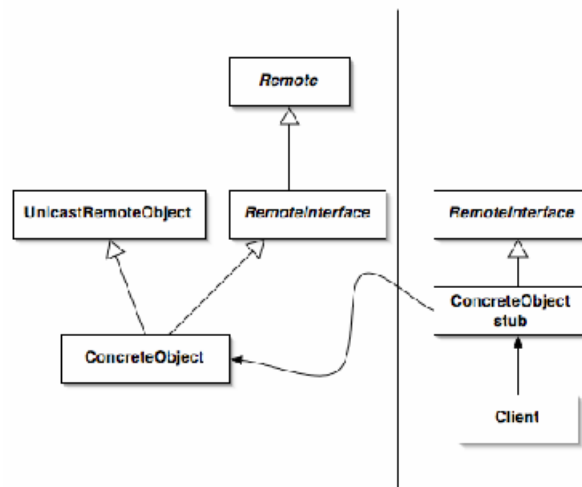
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Remote Objects

- Object should
 - extend `java.rmi.server.UnicastRemoteObject`
 - Constructor declared to throw `RemoteException`
 - implement a *remote interface*
 - A remote interface extends `java.rmi.Remote`
 - All methods in a remote interface throw `RemoteException`
 - “Something bad happened on the network”
 - Side note: actually, don’t need to extend `UnicastRemoteObject`, but it’s much easier

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Remote Interfaces



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Stubs

- Client only sees the RemoteInterface
 - ConcreteObject can have other methods
- Remote objects represented using stub
 - Stub sends arguments over network
 - Stub receives result back from network

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Compiling Stubs with rmic

- Generates stub code for a class
 - For 1.1, also generates skeleton class
 - Stub on client side communicates with skeleton on remote side
 - skeleton not needed for 1.2+
 - And 1.2+ generates position-independent code
 - Use -v1.2 if you can (e.g., for project 5)
- Generates stubs for all methods declared in the class's Remote interface
 - other methods don't get a stub

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Passing Arguments

- To pass an argument to a remote method
 - (or return a result from a remote method)
 - it must be either
 - a primitive type (int, double, etc.),
 - Serializable (e.g., String), or
 - Remote (i.e., implement a sub-interface of Remote)
 - Primitives passed as you'd expect

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Passing Serializable vs. Remote

- Serializable objects passed by value
 - Same Serializable in different calls materializes different objects at receiver
- Remote objects passed by reference
 - Same Remote object in different calls yields same stub object, which passes arguments back to same remote object

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Stub Code

- Objects contain both data and code
 - When you receive a remote object, you need the stub for that remote object
- Solution #1: All clients have stub code on their classpath
 - Or stub code for another class with same remote interface

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Downloading Code

- Solution #2: Provide a *code base* where stub code for objects can be downloaded

```
java -Djava.rmi.server.codebase=<url> ...
```

 - Specifies location of classes originating from this server
 - url can be, e.g., http:// or file:/

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Security Manager

- Downloading code (even stub code) from the internet is potentially risky
 - Need to limit what downloaded code could do
 - Must install a Security Manager before you download any code from RMI code bases

- Can use

```
System.setSecurityManager(  
    new RMISecurityManager());
```

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Policy Files

- In addition to security manager, need to specify a security policy

```
grant {  
    permission java.net.SocketPermission  
        "*:1024-65535", "connect,accept";  
    permission java.net.SocketPermission "*:80",  
        "connect";  
};
```

- Set security policy when JVM started
 - `java -Djava.security.policy=<file name>`

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Getting the First Remote Object

- Can make objects available in RMI registry
 - Each object has a name (that you specify)
 - Registry listens on a port (1099 default)
- Naming.lookup(url) gets object from reg.
 - E.g., Naming.lookup(“rmi://localhost/Chat”);
 - Use to get first reference to remote object
 - Don’t need to lookup for objects returned by remote methods

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Starting an RMI Registry

- Method 1: Separate RMI registry process
 - Command `rmiregistry`
 - Run with stubs in classpath, or specify codebase
 - Listens on port 1099 by default
- Method 2: Start in same JVM
 - `LocateRegistry.createRegistry(int port)`
 - Advantage: dies when your program dies
 - No registries lying around on machine

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Advertising Remote Objects

- Call `Naming.{bind/unbind/rebind}` to place objects in registry
 - E.g., `Naming.bind("rmi://localhost/Chat");`
- Can bind/unbind/rebind name on localhost
- Can lookup name on any host

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Example: RMI Chat Server

- Server
 - runs the chat room
- Client
 - participant in chat room
 - receives messages from others in room
- Connection
 - uniquely identifies a client
 - used to speak in chat room

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Server

```
interface Server extends Remote {  
  
    Connection logon(String name, Client c)  
        throws RemoteException;  
  
}
```

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Connection

```
interface Connection extends Remote {  
  
    /** Say to everyone */  
    void say(String msg)  
        throws RemoteException;  
  
    / ** Say to one person */  
    void say(String who, String msg)  
        throws RemoteException;  
  
    String [] who()  
        throws RemoteException;  
  
    void logoff()  
        throws RemoteException;  
}
```

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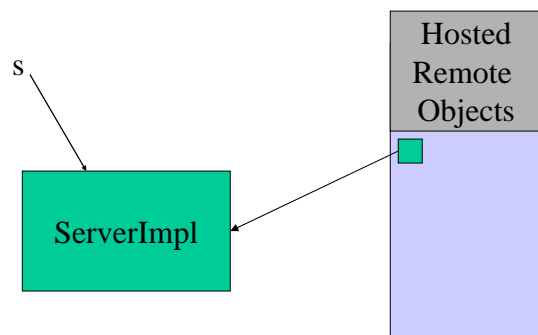
Client

```
interface Client extends Remote {  
  
    void said(String who, String msg)  
        throws RemoteException;  
  
    void whoChanged(String [] who)  
        throws RemoteException;  
}
```

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Server's Remote Object creation

```
Server s = new ServerImpl();
```



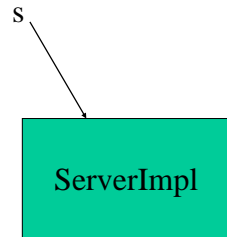
*Object added to table
because it implements
extension of **Remote**
interface*

Server

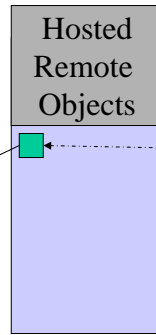
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Remote Object registry

```
Naming.rebind("ChatServer", s);
```



Server



ChatServer



RMI Registry

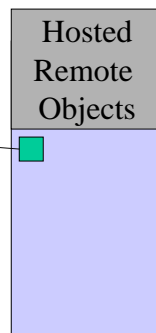
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Client's Remote Object creation

```
Client c = new ClientImpl();
```



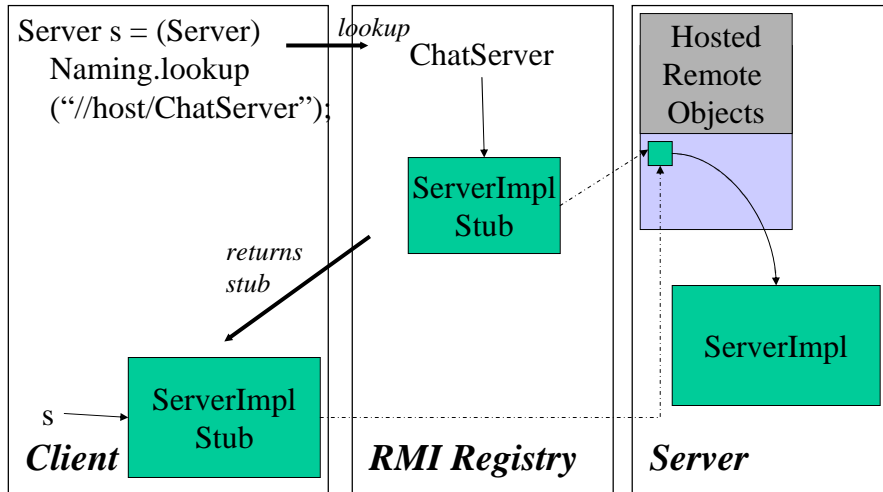
Client



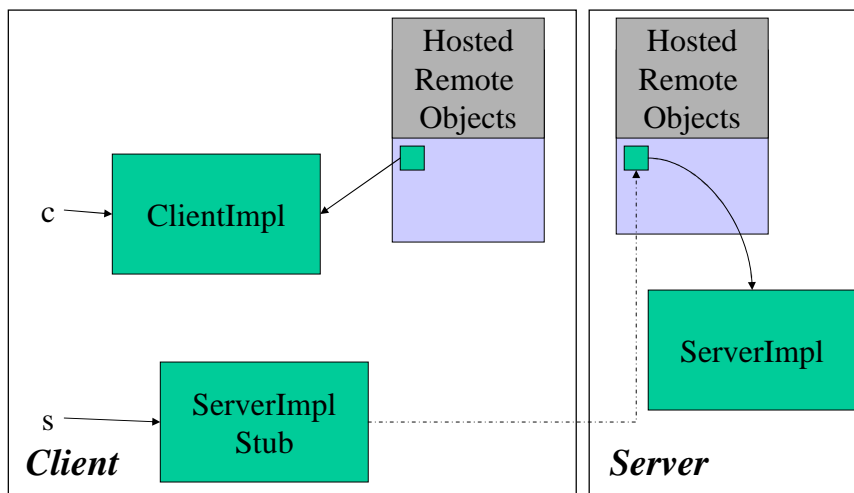
*Client object also implements extension of **Remote** interface*

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Client looks up Server

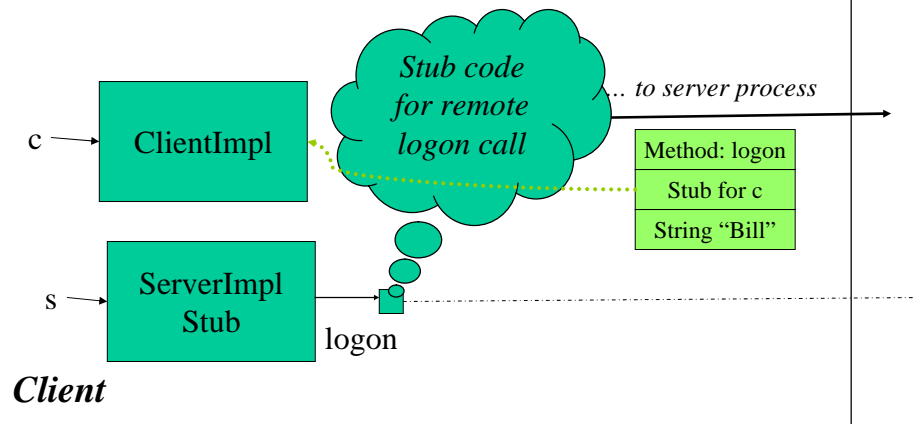


After lookup finished



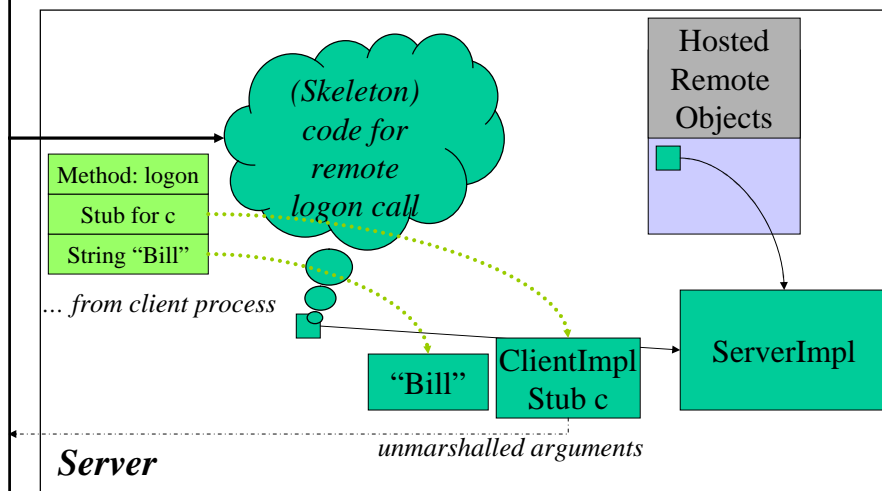
Invokes remote Server method

```
Connection conn = s.logon("Bill", c);
```



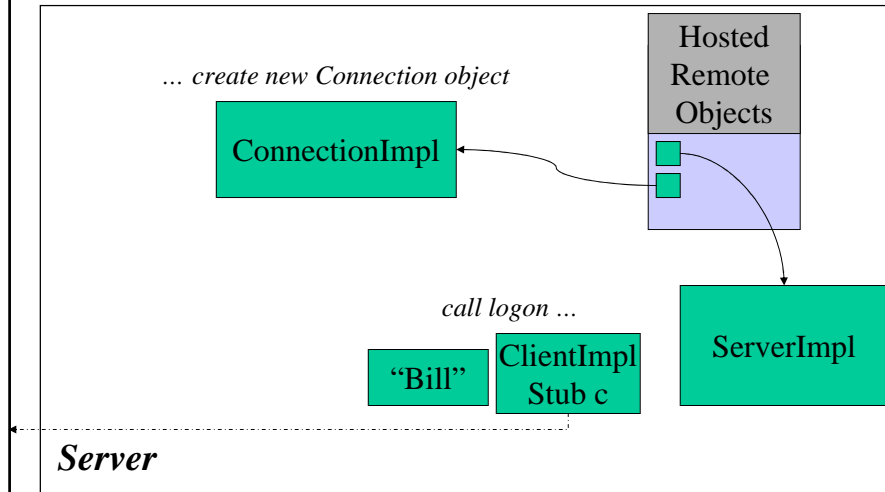
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Receives remote call



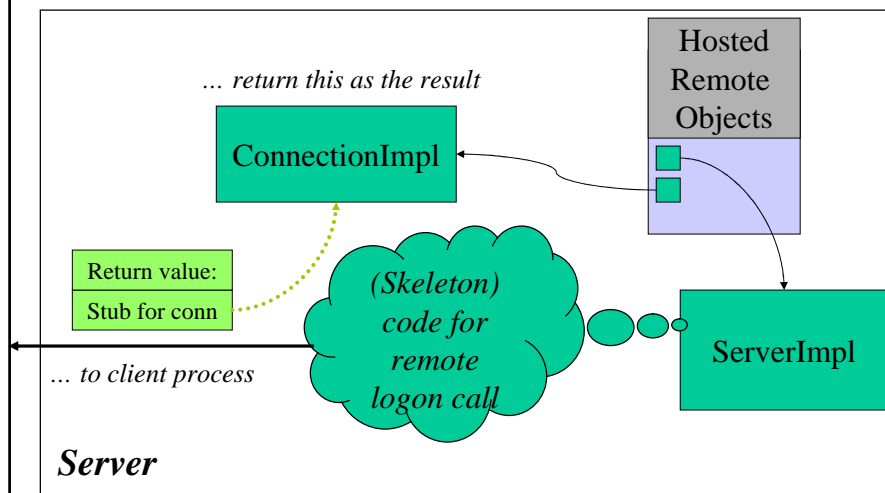
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Executes the call



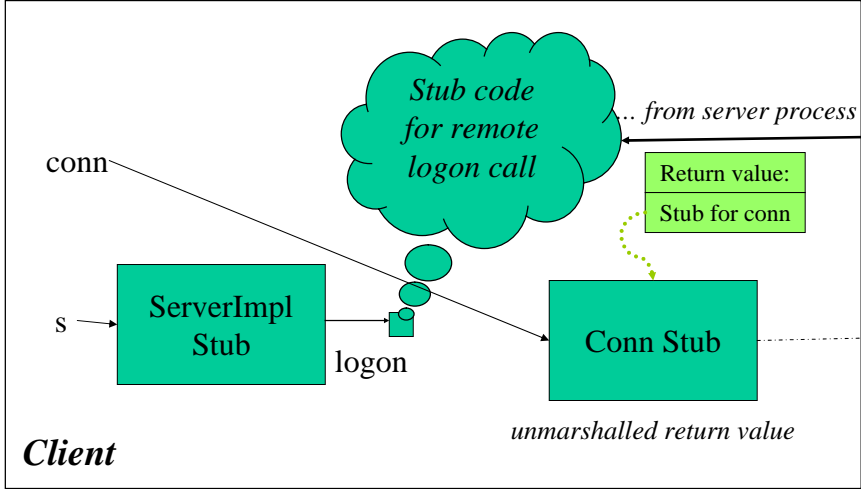
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Returns the result



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Receives the result



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