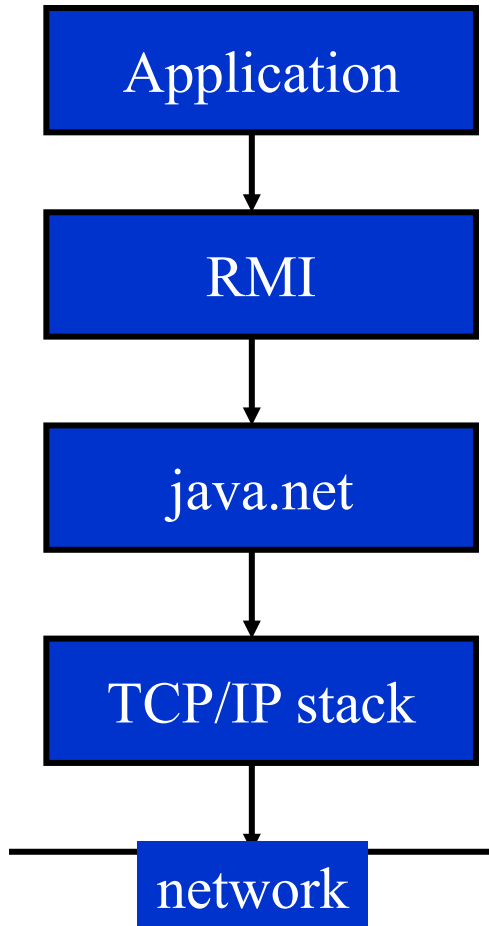


Lab 10

Remote Method Invocation

Java RMI Example

Java RMI



- Java RMI is a projection of RPC onto Java Object Model;
- Support seamless remote invocation on objects in different virtual machines;
- Support callbacks from server to applets
- Preserve the safety provided by the Java runtime environment;
- Less rich object services infrastructure.

Java RMI - Example

- The files needed for creating a Java RMI application are:
 - A **remote interface** defines the remote interface provided by the service. Usually, it is a single line statement specifies the service function (**HelloInterface.java**). (An interface is the skeleton for a public class.)
 - A **remote object** implements the remote service. It contains a constructor and required functions. (**Hello.java**)
 - A **client** that invokes the remote method. (**HelloClient.java**)
 - The **server** offers the remote service, installs a security manager and contacts rmiregistry with an instance of the service under the name of the remote object. (**HelloServer.java**)

HelloInterface.java

- **import java.rmi.*;**

```
public interface HelloInterface extends  
Remote {  
    public String say(String msg) throws  
    RemoteException;  
}
```

Hello.java

- **import** java.rmi.*;
import java.rmi.server.*;

```
public class Hello extends UnicastRemoteObject implements
HelloInterface {
    private String message;
    public Hello(String msg) throws RemoteException {
        message = msg;
    }
    public String say(String m) throws RemoteException {
        return new StringBuffer(m).reverse().toString() + "\n" +
message;
    }
}
```

HelloClient.java

```
• import java.rmi.*;

public class HelloClient {
    public static void main(String args[]) {
        String path = "//localhost/Hello";
        try {
            if(args.length < 1)
                System.out.println("usage: java HelloClient <host:port> <string>
\n");
            else
                path = "//" + args[0] + "/Hello";
            HelloInterface hello = (HelloInterface)Naming.lookup(path);
            for(int i = 1; i < args.length; ++i)
                System.out.println(hello.say(args[i]));
        } catch(Exception e) {
            System.out.println("Hello Client exeption: " + e);
        }
    }
}
```

HelloServer.java

- **import** java.rmi.*;
import java.rmi.server.*;

```
public class HelloServer {  
    public static void main(String args[]) {  
        if(System.getSecurityManager()==null) {  
            System.setSecurityManager(new SecurityManager());  
        }  
        try {  
            Naming.rebind("Hello", new Hello("Hello, world!"));  
            System.out.println("server is running...");  
        } catch(Exception e) {  
            System.out.println("Hello server failed: " + e.getMessage());  
        }  
    }  
}
```


rmi.policy

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

# Steps to Build a RMI application

- **Write the following Java code:**
  - **Interface** - HelloInterface.java
  - **Implementation class** – Hello.java
  - **Client** – HelloClient.java
  - **Server** – HelloServer.java
- **Compile the code**  
**javac** Hello.java HelloClient.java HelloInterface.java  
HelloServer.java
- **Generate Stub and Skeleton class files**  
**rmic** Hello

# Steps to Build a RMI application

- **Make security policy**  
`rmi.policy`
- **Start the RMI registry** (in a separate window or in the background)  
`rmiregistry &`
- **Start the server** in one window or in the background with the security policy  
`java -Djava.security.policy=rmi.policy HelloServer`
- **Run the client** in another window  
`java -Djava.security.policy=rmi.policy HelloClient`  
`127.0.0.1:1099 testing`

# Test Hello Example

- **Write the following Java code:**

```
SeongHwanui-MacBook-Pro:Hello jihwankim$ ls
Hello.java HelloInterface.java rmi.policy
HelloClient.java HelloServer.java _
```

- **Compile the code**

```
SeongHwanui-MacBook-Pro:Hello jihwankim$ javac Hello.java HelloClient.java
HelloInterface.java HelloServer.java
SeongHwanui-MacBook-Pro:Hello jihwankim$ ls
Hello.class HelloClient.java HelloServer.class
Hello.java HelloInterface.class HelloServer.java
HelloClient.class HelloInterface.java rmi.policy
```

- **Generate Stub and Skeleton class files**

```
SeongHwanui-MacBook-Pro:Hello jihwankim$ rmic Hello
SeongHwanui-MacBook-Pro:Hello jihwankim$ ls
Hello.class HelloInterface.class Hello_Stub.class
Hello.java HelloInterface.java rmi.policy
HelloClient.class HelloServer.class
HelloClient.java HelloServer.java
```

# Test Hello Example

- **Start the RMI registry** (in a separate window or in the background)

```
[SeongHwanui-MacBook-Pro:Hello jihwankim$ rmiregistry &]
```

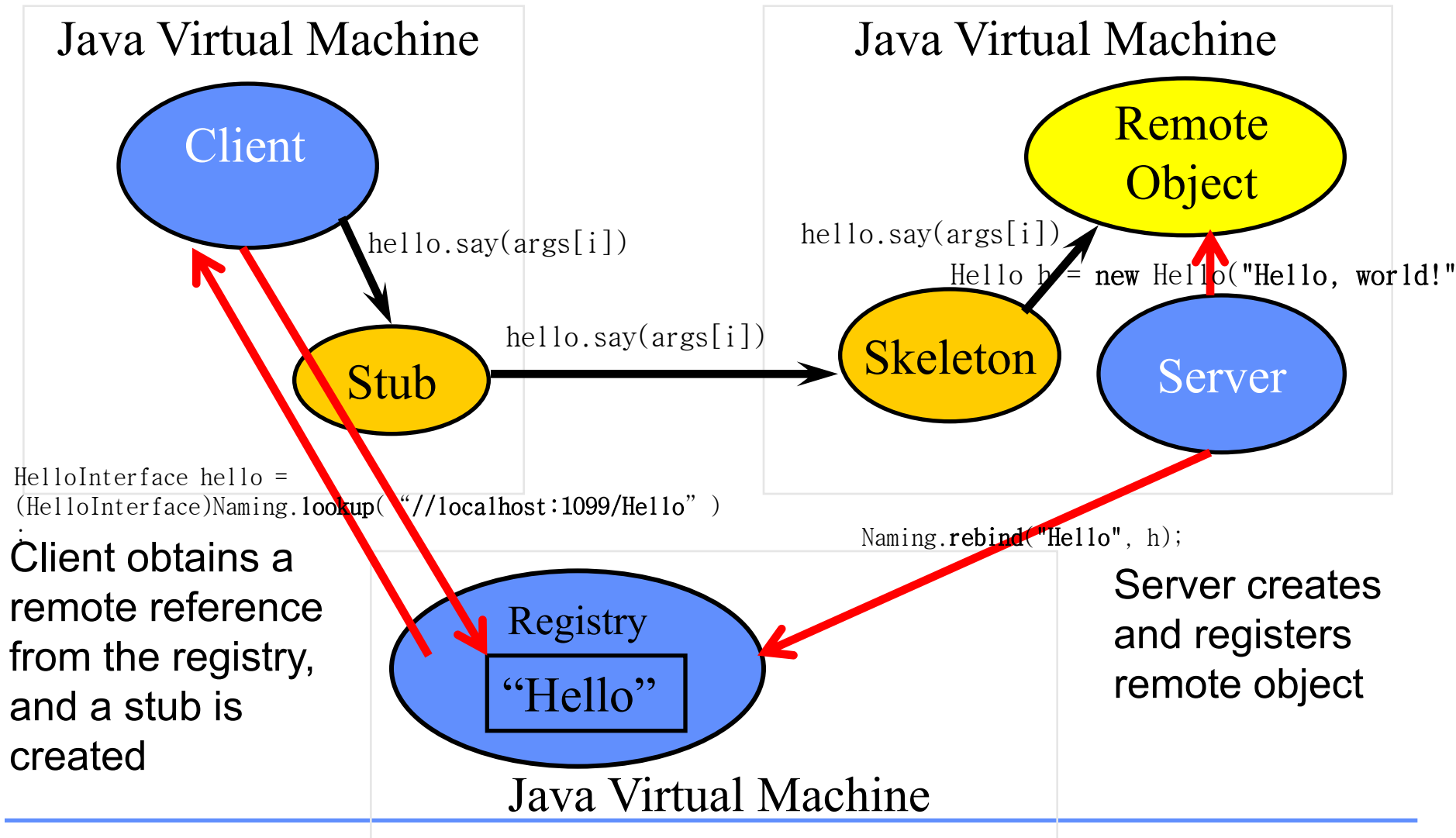
- **Start the server** in one window or in the background with the security policy

```
[SeongHwanui-MacBook-Pro:Hello jihwankim$ java -Djava.security.policy=rmi.policy HelloServer
server is running...]
```

- **Run the client** in another window

```
[SeongHwanui-MacBook-Pro:Hello jihwankim$ java -Djava.security.policy=rmi.policy HelloClient 127.0.0.1:1099 testing
gnitset
Hello, world!]
```

# Hello Example



# Procedure of Implementation

- Step 1: Make Interface of Remote Object for service
- Step 2: Make both Remote Object and Server program
- Step 3: Generate Stub/Skeleton
- Step 4: Make a Client program using Remote Object
- Step 5: Execute RMI Registry
- Step 6: Execute both Server program and Client program

# Step 1: Make Interface of Remote Object

- Interface of Bank
  - Extends Remote
- Three abstract method
  - getBalance()
  - Deposit(int amount)
  - Withdraw(int amount)



# Bank.java

- **import java.rmi.\*;**

```
public interface Bank extends Remote {
 public int getBalance() throws RemoteException;
 public int deposit(int amount) throws
RemoteException;
 public int withdraw(int amount) throws
RemoteException;
}
```

---

## Step 2: Make Remote Object and Server program

- Implementation of Bank Interface
  - All method of remote interface should be implemented
  - Use `java.rmi.server.UnicastRemoteObject`

# BankImpl.java

- ```

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

public class BankImpl extends UnicastRemoteObject implements Bank {
    private int total;
    public BankImpl(int total) throws RemoteException {
        this.total = total;
    }

    public int getBalance() throws RemoteException {
        return total;
    }

    public int deposit(int amount) throws RemoteException {
        total += amount;
        return getBalance();
    }

    public int withdraw(int amount) throws RemoteException {
        total -= amount;
        return getBalance();
    }

    public static void main(String[] args) throws Exception {
        if (System.getSecurityManager() == null) {
            System.setSecurityManager(new SecurityManager());
        }
        BankImpl bankip = new BankImpl(10000);
        Naming.rebind("//localhost/BankIp", bankip);
        System.out.println("bank was rebinded with name BankIp");
    }
}

```

Method of Naming Class

- Public static void bind(String name, Remote obj);
 - Bind given name with object
- Public static String[] list (String name)
 - Return a name list from RMI Registry
- Public static Remote lookup(String name)
 - Return the reference of remote object which is bound to name
- Public void rebind(String name, Remote obj)
 - Ignore previous binding. Bind given name with object
- Public static void unbind(String name);
 - Release current binding

Compile java code

- **Write the following Java code:**

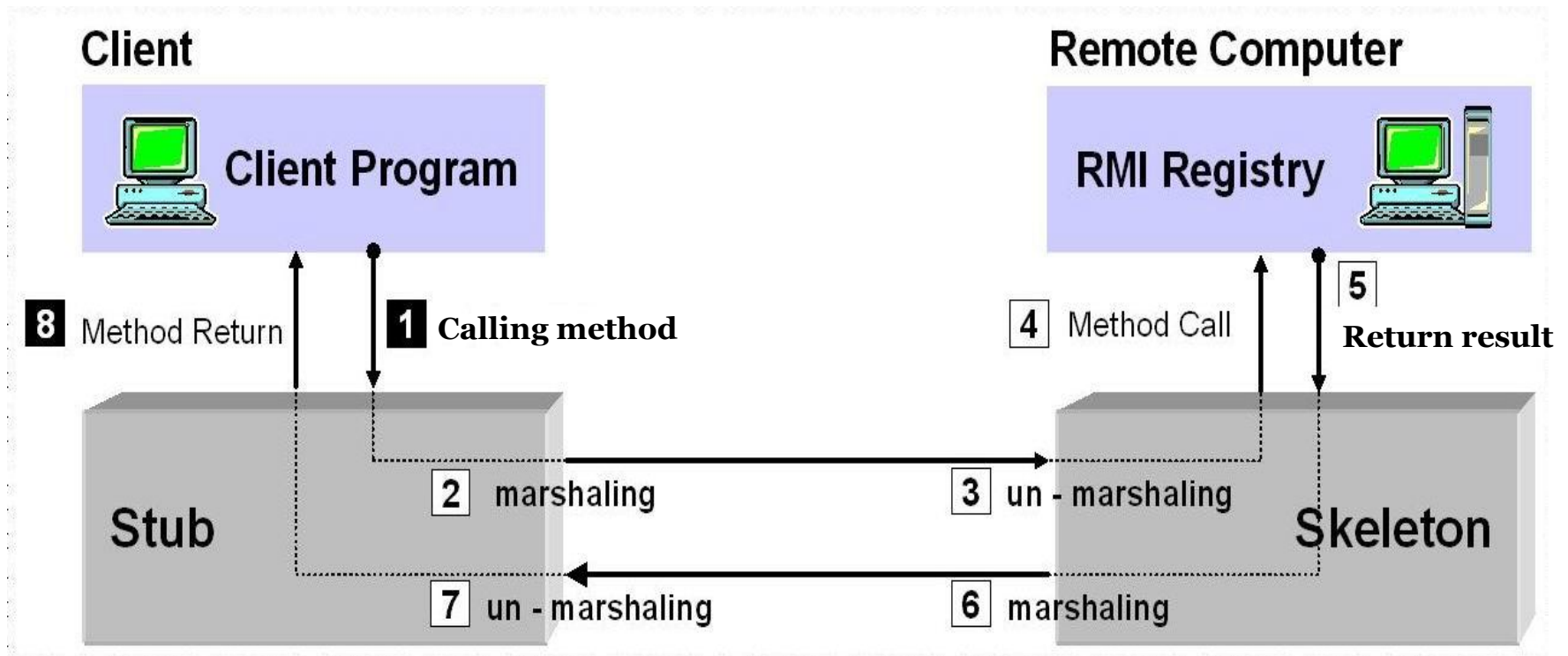
```
SeongHwanui-MacBook-Pro:Bank jihwankim$ ls  
Bank.java      BankClient.java BankImpl.java  rmi.policy
```

- **Compile the code**

```
SeongHwanui-MacBook-Pro:Bank jihwankim$ javac Bank.java BankClient.java BankImpl.java
```

Step 3: Generation of Stub/Skeleton

- Stub and Skeleton



Step 3: Generation of Stub/Skeleton

- **Generate Stub and Skeleton class files**

```
SeongHwanui-MacBook-Pro:Bank jihwankim$ rmic BankImpl
Warning: generation and use of skeletons and static stubs for JRMP
is deprecated. Skeletons are unnecessary, and static stubs have
been superseded by dynamically generated stubs. Users are
encouraged to migrate away from using rmic to generate skeletons and static
stubs. See the documentation for java.rmi.server.UnicastRemoteObject.
```

```
[SeongHwanui-MacBook-Pro:Bank jihwankim$ ls
Bank.class          BankClient.java    BankImpl_Stub.class
Bank.java           BankImpl.class     rmi.policy
BankClient.class    BankImpl.java
```

Step 4: Client program

- BankClient
 - Get remote reference from RMI Registry in server
 - Calling methods by using remote reference

BankClient.java

- **import** java.rmi.*;

```
public class BankClient {  
    public static void main(String[] args) throws Exception {  
        int balance = 0;  
        Bank bank = (Bank)Naming.lookup("//localhost/BankIp");  
        System.out.println("Bank was given from server");  
        balance = bank.getBalance();  
        System.out.println("current balance: " + balance);  
        balance = bank.deposit(1000);  
        System.out.println("deposit 1000\ncurrent balance: " + balance);  
        balance = bank.withdraw(5000);  
        System.out.println("withdraw 5000\ncurrent balance: " +  
balance);  
    }  
}
```

Step 5: Execute RMI Registry

- Two way of execution
 - Execution with default: rmiregistry
 - Execution with specific port number: rmiregistry port#
- **Start the RMI registry** (in a separate window or in the background)

```
[SeongHwanui-MacBook-Pro:Bank jihwankim$ rmiregistry]
```

Step 6: Execute Server and Client appl.

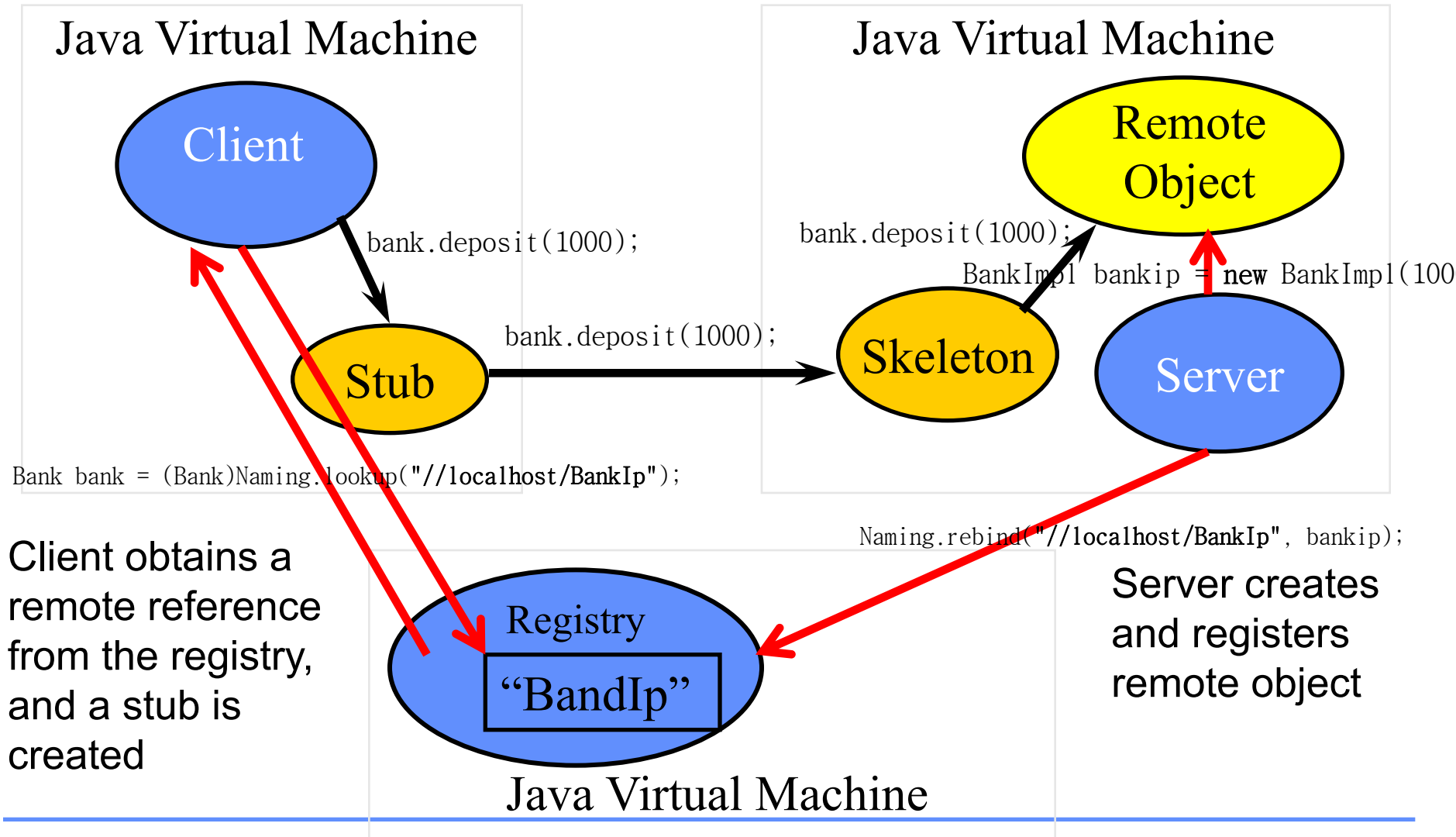
- **Start the server** in one window or in the background with the security policy

```
SeongHwanui-MacBook-Pro:Bank jihwankim$ java -Djava.security.policy=rmi.policy BankImpl  
bank was rebinded with name BankIp
```

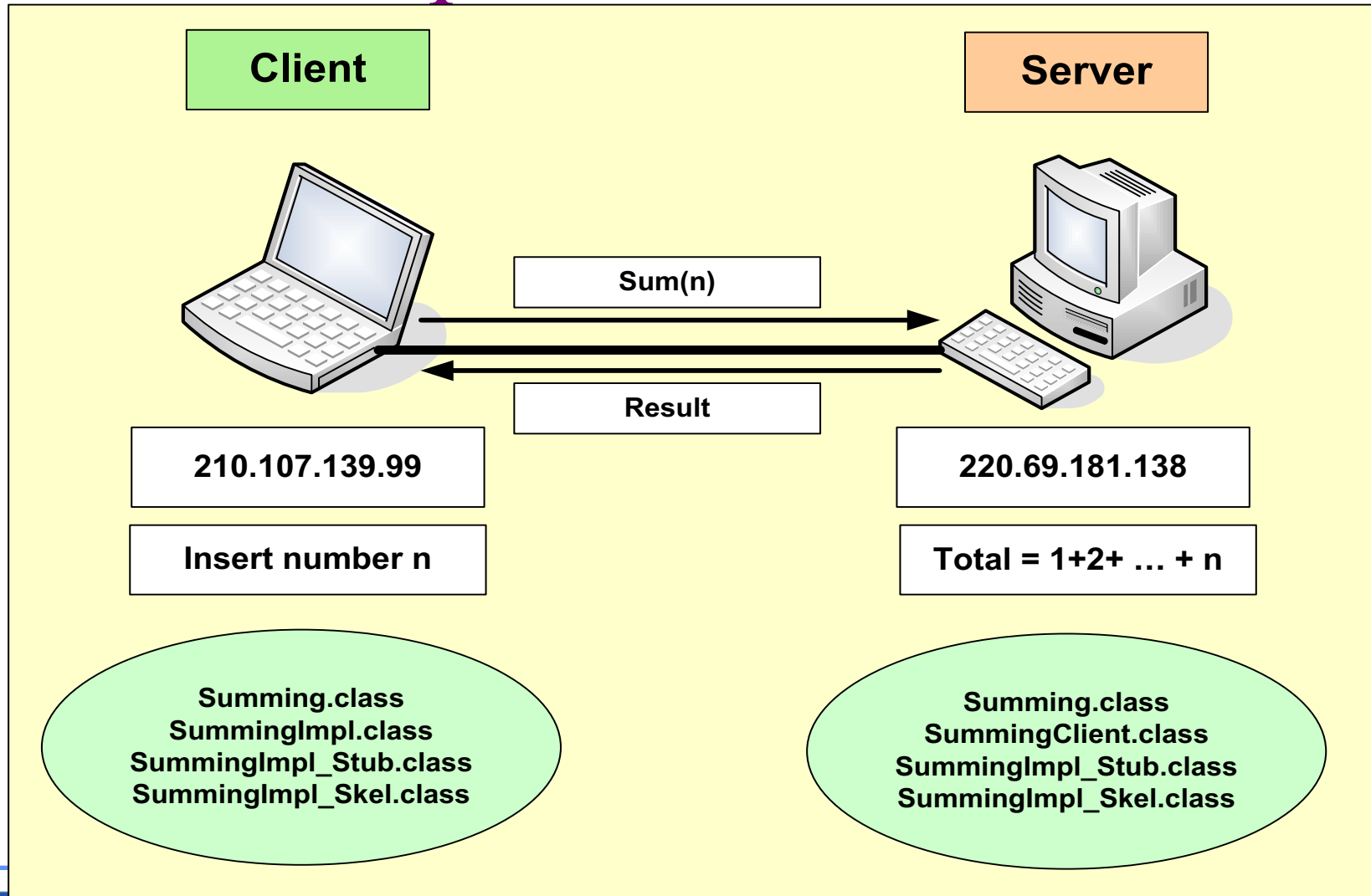
- **Run the client** in another window

```
SeongHwanui-MacBook-Pro:Bank jihwankim$ java -Djava.security.policy=rmi.policy  
BankClient  
Bank was given from server  
current balance: 10000  
deposit 1000  
current balance: 11000  
withdraw 5000  
current balance: 6000
```

Bank Example



Example 2: Sum method



Interface Implementation

```
import java.rmi.*;  
public interface Summing extends Remote {  
    int sum(int max) throws RemoteException;  
}
```

SummingImpl.java

- **import** java.rmi.*;
import java.rmi.server.*;

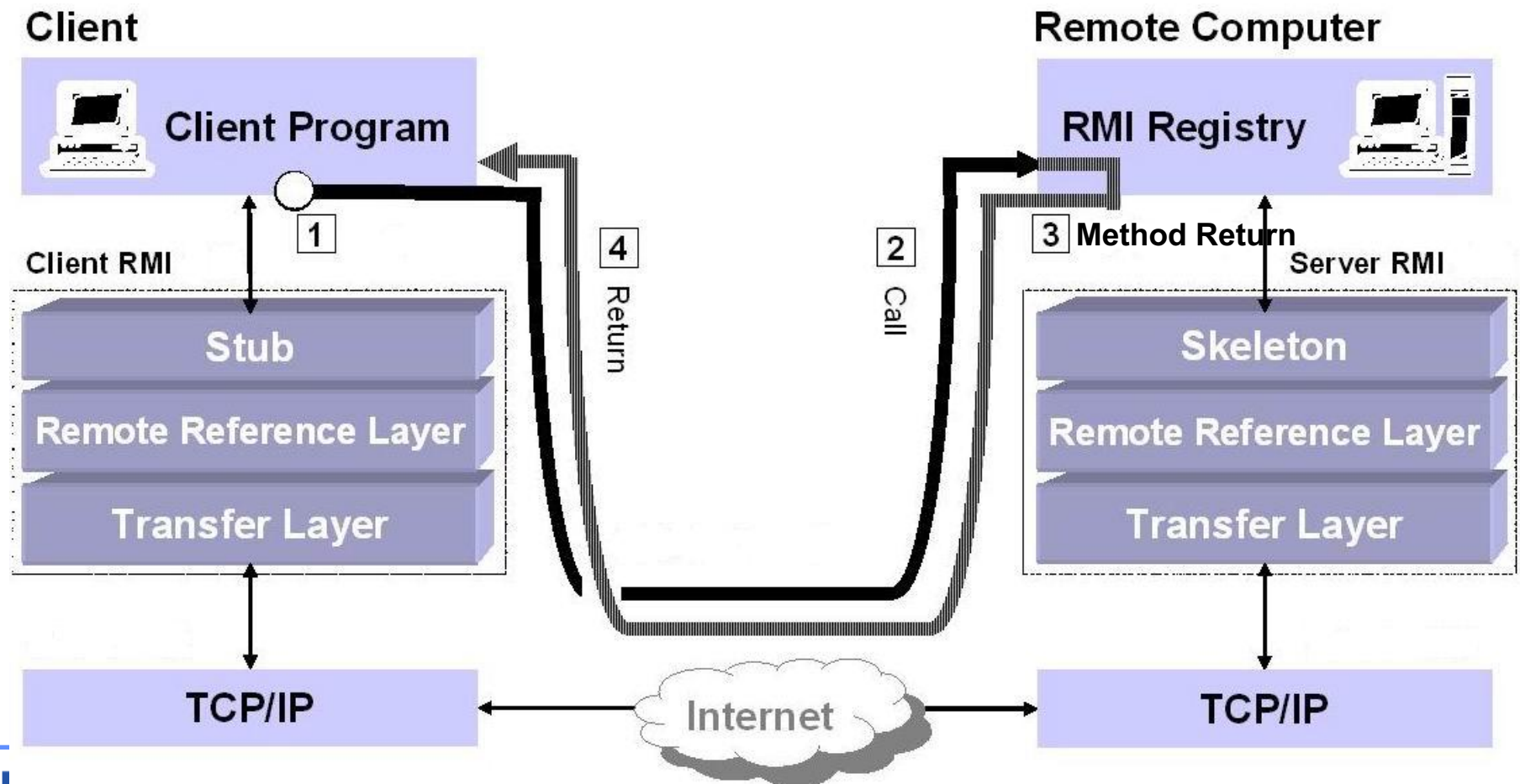
```
public class SummingImpl extends UnicastRemoteObject implements Summing {  
    public SummingImpl() throws RemoteException {  
    }  
  
    public int sum(int max) throws RemoteException {  
        if(max <= 0) return 0;  
        else return (max + sum(max - 1));  
    }  
  
    public static void main(String[] args) throws Exception {  
        if (System.getSecurityManager() == null) {  
            System.setSecurityManager(new SecurityManager());  
        }  
  
        SummingImpl s = new SummingImpl();  
        Naming.rebind("SumServer", s);  
        System.out.println("Summing was rebounded with name SumServer");  
    }  
}
```

SummingClient.java

- **import** java.rmi.*;

```
public class SummingClient {  
    public static void main(String args[]) {  
        if(args.length < 2) {  
            System.out.println("usage: java HelloClient <host:port> <string> \n");  
            System.exit(1);  
        }  
  
        try {  
            String serverURL = "rmi://" + args[0] + "/SumServer";  
            Summing s = (Summing) Naming.lookup(serverURL);  
            System.out.println("Your Input = " + args[1]);  
            int max = Integer.parseInt(args[1]);  
            System.out.println("The sum 1 to " + max + " is " + s.sum(max));  
        } catch(Exception e) {  
            System.out.println("Sum Client exeption: " + e);  
        }  
    }  
}
```


Procedure of execution



Server Side

```
[SeongHwanui-MacBook-Pro:Summing jihwankim$ ls
Summing.class          SummingClient.java    SummingImpl_Stub.class
Summing.java           SummingImpl.class
SummingClient.class    SummingImpl.java
```

```
[SeongHwanui-MacBook-Pro:Summing jihwankim$ rmiregistry
```

```
SeongHwanui-MacBook-Pro:Summing jihwankim$ java -Djava.security.policy=rmi.policy SummingImpl
Summing was rebound with name SumServer
```

Result

```
[SeongHwanui-MacBook-Pro:Summing jihwankim$ java -Djava.security.policy=rmi.policy  
SummingClient 127.0.0.1:1099 100  
Your Input = 100  
The sum 1 to 100 is 5050  
[SeongHwanui-MacBook-Pro:Summing jihwankim$ java -Djava.security.policy=rmi.policy  
SummingClient 127.0.0.1:1099 1000  
Your Input = 1000  
The sum 1 to 1000 is 500500
```

Transaction Processing using Java RMI

(On-Line Transaction Processing System)

Real-life example

< apple online shopping mall for electronic device >

The screenshot shows the Apple Store website interface. At the top, there is a navigation bar with the Apple logo and links to '애플스토어' (Apple Store), 'Mac', 'iPod + iTunes', '다운로드' (Downloads), and '고객지원' (Customer Support). Below this, a search bar and a welcome message '애플스토어 방문을 환영합니다' (Welcome to the Apple Store) are visible. The main content area displays a grid of products with their names and prices in Korean Won (₩). On the left, there are sidebars for 'Shop Mac', 'Shop iPod', and '인기 액세서리' (Popular Accessories). On the right, there is a '신제품' (New Products) list and an '인기 제품' (Popular Products) list.

Apple Store
080-3404-622
검색

애플스토어 방문을 환영합니다

도움말 | 계정 | 장바구니

신제품

- iPod nano
- iPod touch
- iPod classic
- iPod shuffle
- Apple In-Ear Headphones
- Apple Earphones
- iPod nano Armband
- iMac
- AirPort Express Base Station
- MacBook
- MacBook Pro
- Belkin Leather Folio for iPod touch
- Toast 9 Titanium by Roxio

인기 제품

Mac

1. MacBook
2. iMac
3. MacBook Air
4. MacBook Pro
5. Time Capsule - 1 TB
6. Apple Wireless Keyboard

Shop Mac
Shop iPod
Mac 액세서리
Mac 소프트웨어
iPod 액세서리

교육 할인 스토어
국가별 애플 스토어

인기 액세서리
For Mac

- AirPort & 무선 네트워크
- Audio & 스피커
- 디지털 카메라 & 비디오
- 메모리
- 마우스 & 키보드
- Notebook 케이스
- 휴대용 장치
- 프린터

NEW
iPod shuffle
₩53,000 부터

NEW
iPod nano
₩180,000 부터

NEW
iPod classic
₩300,000

NEW
iPod touch
₩280,000 부터

Apple TV
₩319,000 부터

MacBook
₩1,190,000 부터

MacBook Air
₩2,190,000 부터

MacBook Pro
₩2,190,000 부터

Mac mini
₩690,000 부터

iMac
₩1,350,000 부터

Mac Pro
₩3,150,000

iPod touch
상상할 수 있는 모든 즐거움을 한 손에.

새로운 iPod nano
이제 8GB와 16GB입니다.

하나면 됩니다.
iPod classic.

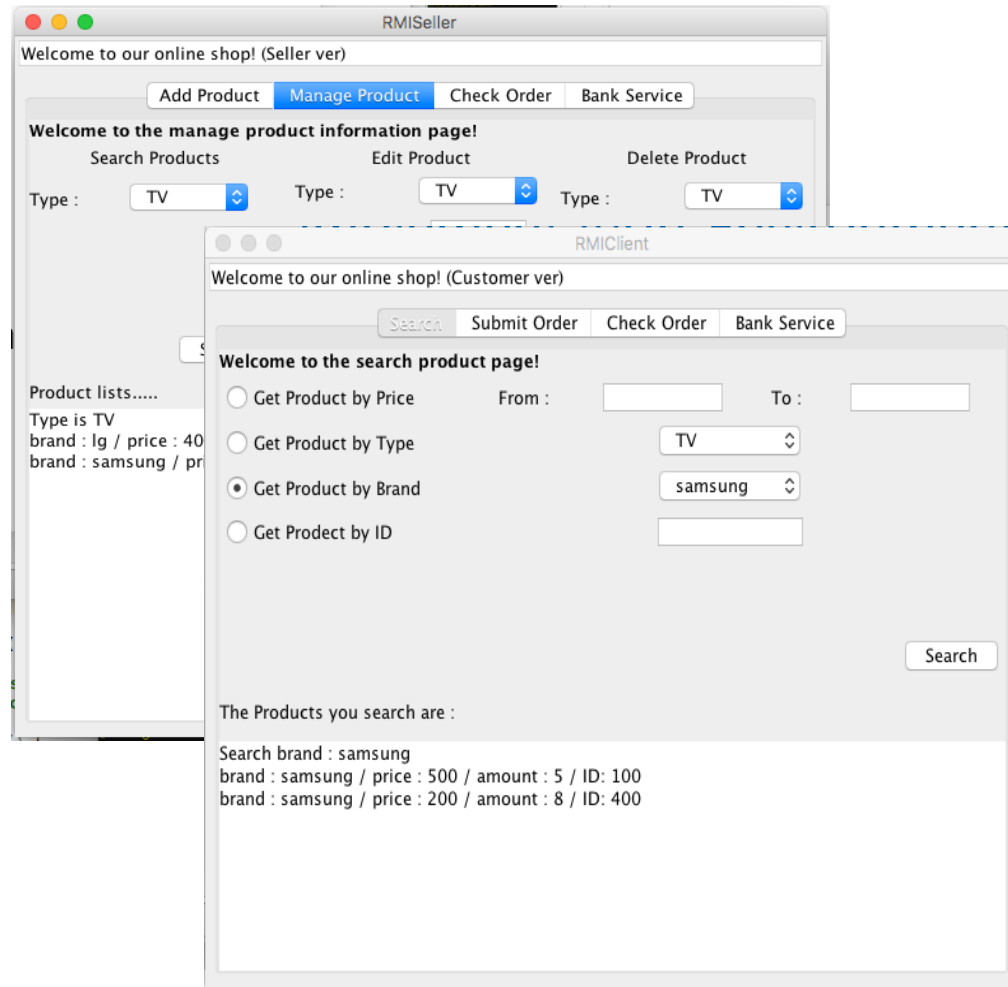
implementation environment

- Integrated Development Environment
 - IntelliJ
- Language
 - JAVA 1.8
- Communication method
 - Remote Method Invocation (RMI)
- Library
 - Swing : Seller and Buyer interface

Mini on-line Shopping Mall

- In online shopping mall practices, Transaction middleware is used for elevating efficiency of whole process , such as buy and sell, accounting, inventory and etc.
- **System components**
 - ❖ **Customer :**
GUI for customers to complete the whole transaction process.
 - ❖ **Seller:**
GUI for sellers to complete the whole transaction process and management information of products.
 - ❖ **Shop server**
information of products and customer information
 - ❖ **Bank server**
Store user account and guarantee safe transaction

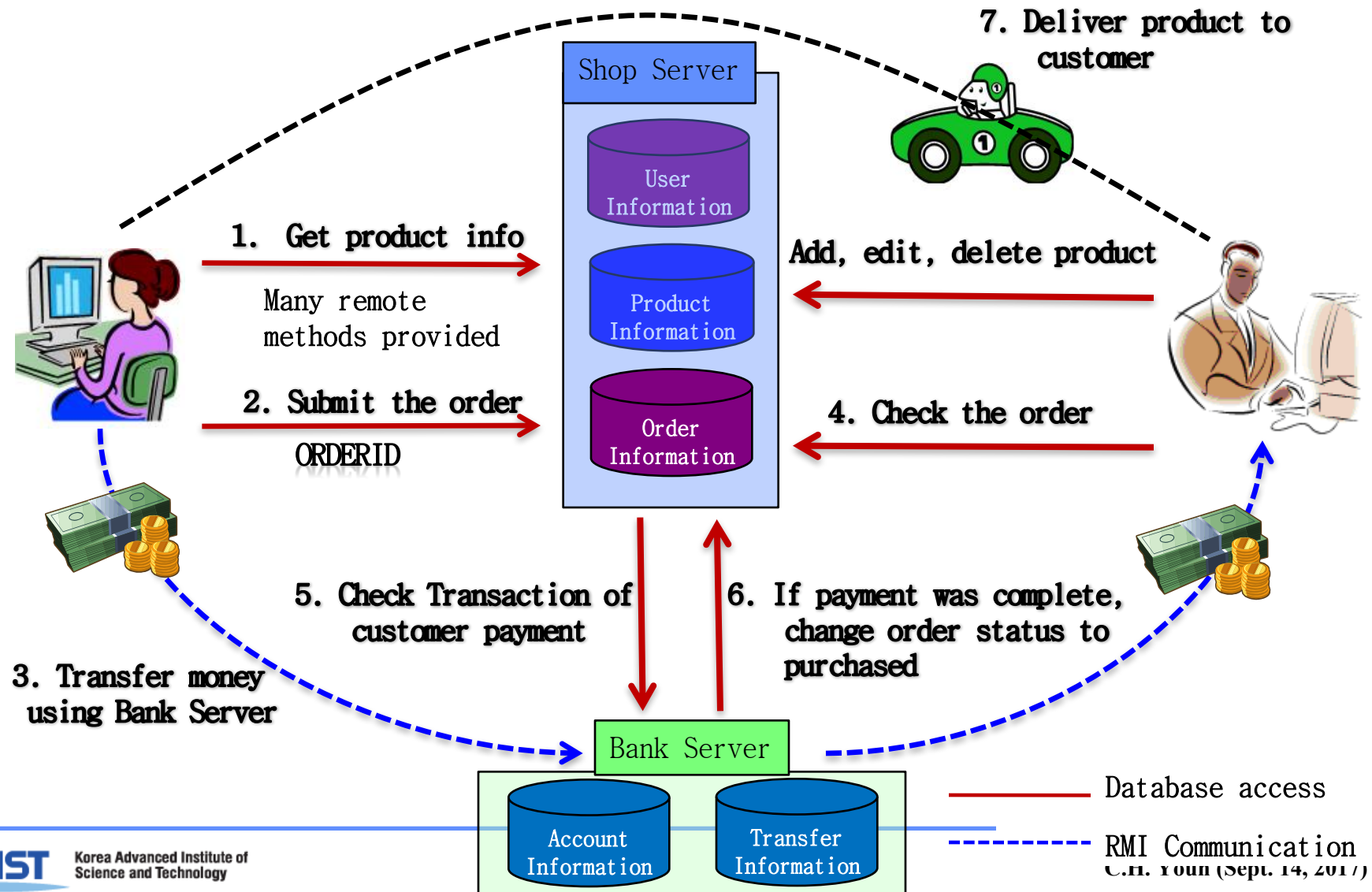
Transaction middleware using RMI



- ❖ User friendly GUI
 - Using JAVA Swing Library
 - Using IntelliJ IDE
- ❖ JAVA RMI for method invocation
 - Bank server
 - Shop server

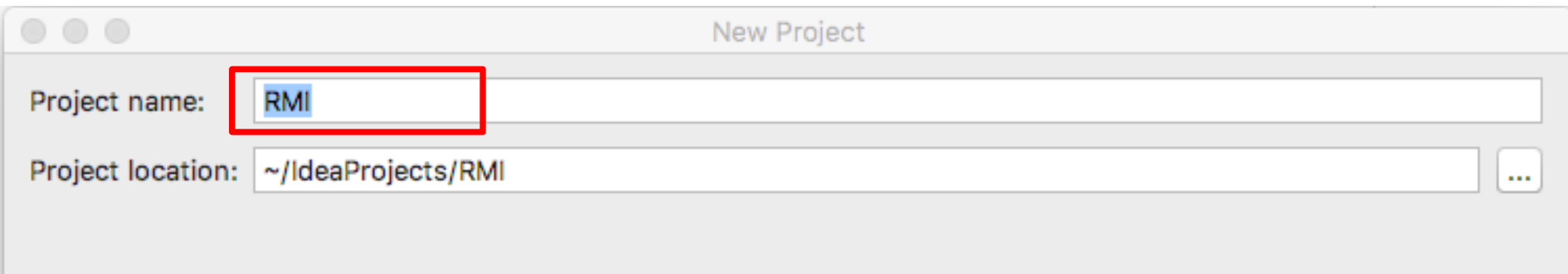
< Simple transaction middleware GUI>

Implement scenario

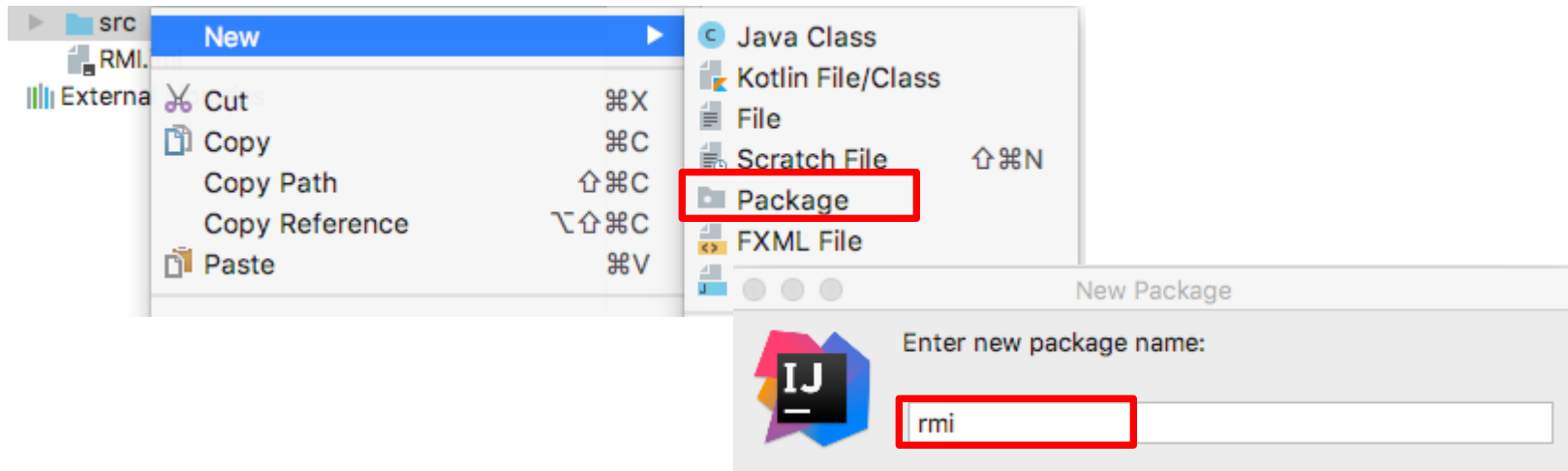


Make IntelliJ Project

1. Project name as RMI



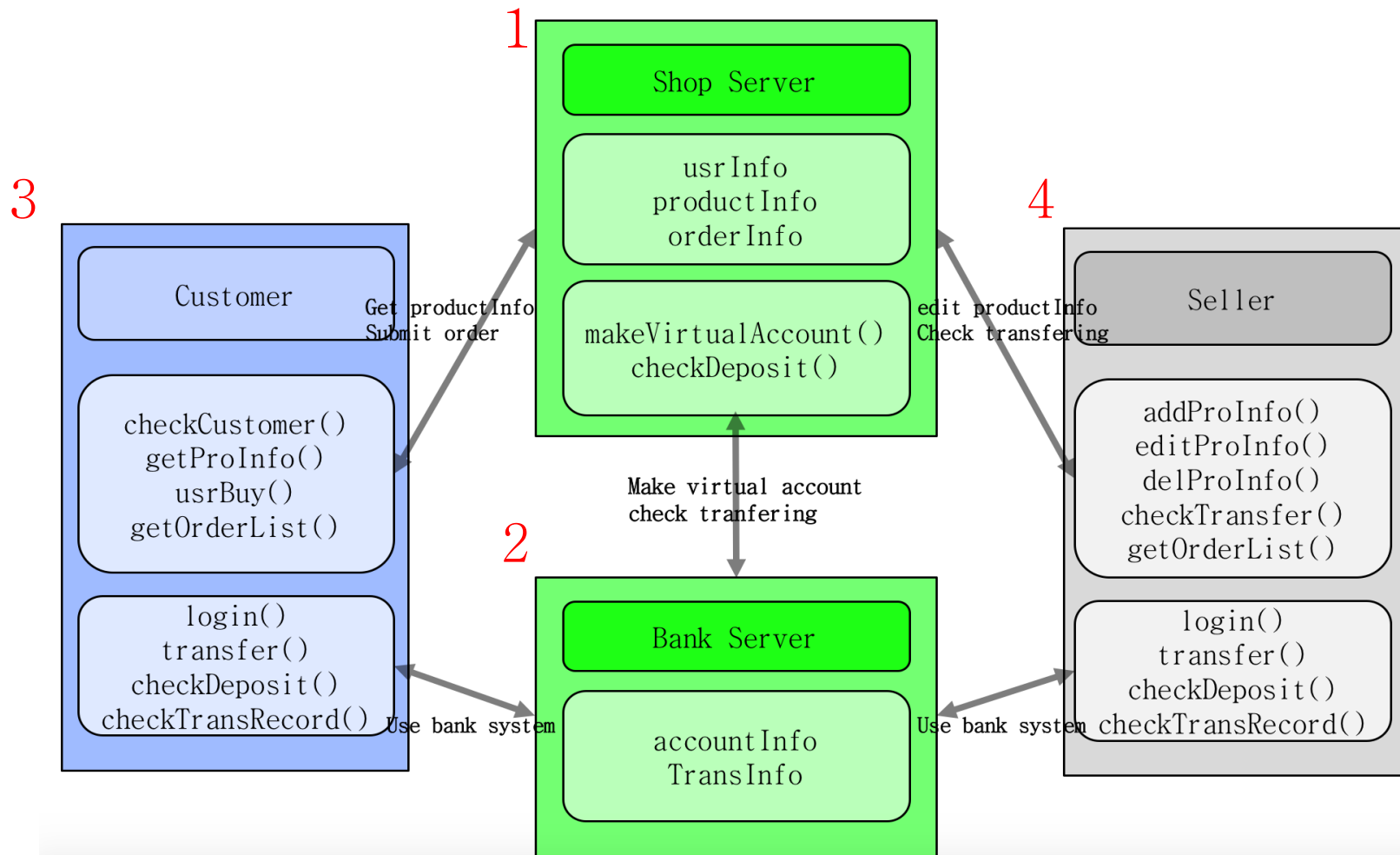
2. Make package name as rmi



Procedure of implement a RMI program

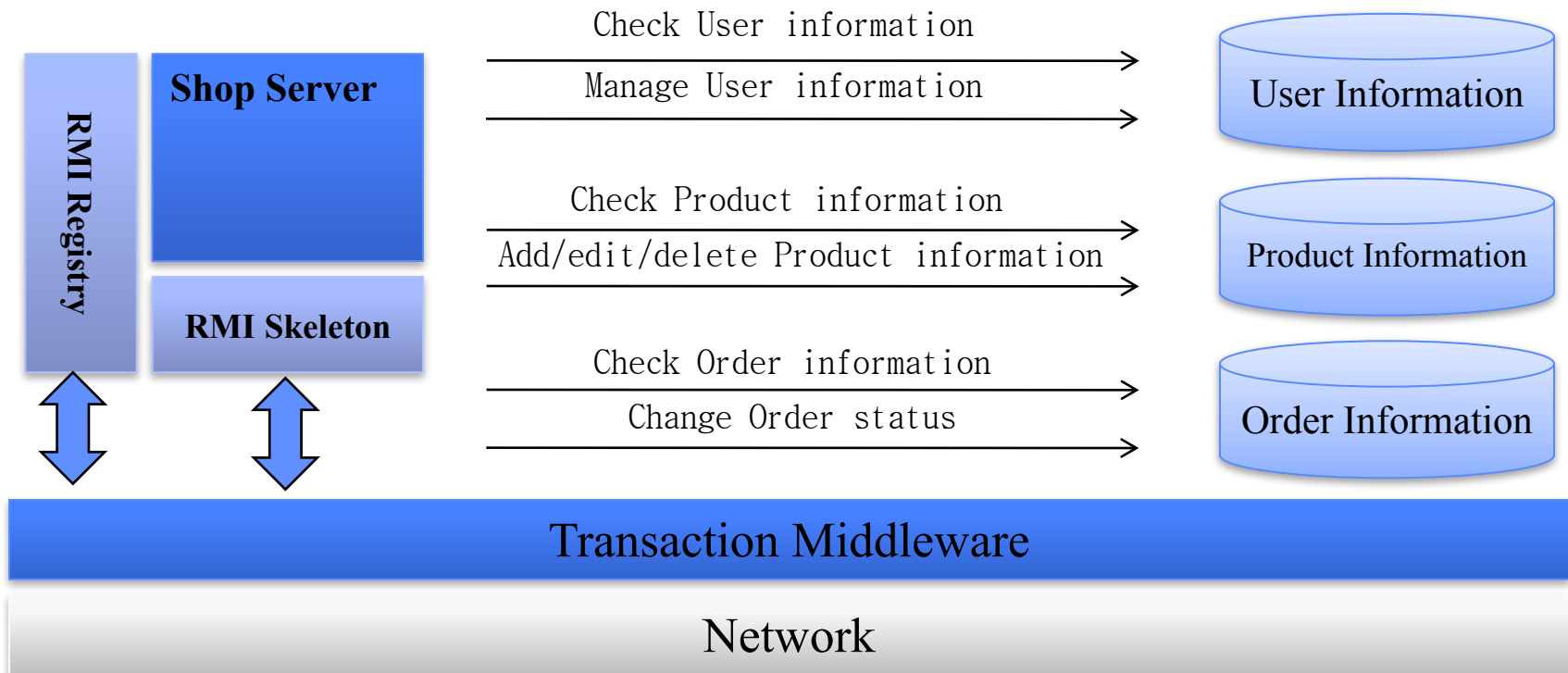
1. Make interface of remote object for service
2. Make both remote object and server program
3. Generate stub/skeleton
4. Make a client program using remote object
5. Execute RMI registry
6. Execute both server and client program

System architecture



Order of Implementation

Shop Server



Shop Server

- To implement Shop Server, you need to create and define the **information objects** that will be stored on the Shop server and managed.
 - User Information
 - Product Information
 - Order Information

Shop Server(1) – User Information

UsrInfo.java

```
package rmi;

import java.util.ArrayList;

class UsrInfo implements java.io.Serializable{

    String usrName;
    int usrPwd;
    ArrayList<OrderInfo> usrOrder;

    UsrInfo() { }

    UsrInfo(String usrName, int usrPwd) {
        this.usrName = usrName;
        this.usrPwd = usrPwd;
        this.usrOrder = new ArrayList<OrderInfo>();
    }
}
```

Shop Server(2) – Product Information

ProdcutInfo.java

```
package rmi;
```

```
public class ProductInfo implements java.io.Serializable {
```

```
    public String brand;
```

```
    public int price;
```

```
    public int amount;
```

```
    public String ID;
```

```
    ProductInfo() { }
```

```
    ProductInfo(String brand, int price, int amount, String ID) {
```

```
        this.brand = brand;
```

```
        this.price = price;
```

```
        this.amount = amount;
```

```
        this.ID = ID;
```

```
    }
```

```
    @Override
```

```
    public String toString() {
```

```
        return String.format("brand : %s / price : %d / amount : %d / ID: %s", brand,  
price, amount, ID);
```

```
    }
```

```
}
```


Shop Server(3) – Order Information

OrderInfo.java

```
package rmi;

class OrderInfo implements java.io.Serializable{
    private static int orderCount = 1;
    int orderID;
    int virtualAccount;
    String usrAdr;
    String proID;
    int amount;
    int totalPrice;
    String purchased;

    OrderInfo() { }

    OrderInfo(int virtualAccount, String usrAdr, String proID, int amount, int totalPrice, String purchased) {
        this.orderID = orderCount++;
        this.virtualAccount = virtualAccount;
        this.usrAdr = usrAdr;
        this.proID = proID;
        this.amount = amount;
        this.totalPrice = totalPrice;
        this.purchased = purchased;
    }

    boolean notPurchasedOrder () {
        return this.purchased.equals("not purchased");
    } // check purchased or not to know what order was not purchased.

    @Override
    public String toString() {
        return String.format("OrderID : %d / VirtualAccount: %d / Address : %s / Product ID : %s / amount : %d / price : %d / purchased : %s", orderID, virtualAccount, usrAdr, proID, amount, totalPrice, purchased);
    }
}
```

1. Make interface of remote object for service Shop.java

```
package rmi;
```

```
import java.rmi.Remote;
```

```
import java.rmi.RemoteException;
```

```
import java.util.ArrayList;
```

```
import java.util.HashMap;
```

```
public interface Shop extends Remote {
```

```
    Boolean checkCustomer(String usrName, int usrPwd) throws RemoteException;
```

```
    ArrayList<ProductInfo> getProInfoByPrice(int from, int to) throws RemoteException;
```

```
    HashMap<String, ProductInfo> getProInfoByType(String type) throws RemoteException;
```

```
    ArrayList<ProductInfo> getProInfoByBrand(String brand) throws RemoteException;
```

```
    ProductInfo getProInfoByID(String ID) throws RemoteException;
```

```
    OrderInfo usrBuy(String usrName, String usrAdr, String type, String proID, int amount)
    throws RemoteException;
```

```
    UsrInfo getOrderList(String usrName) throws RemoteException;
```

```
    void addProInfo(String type, String brand, int price, int amount, String ID) throws
    RemoteException;
```

```
    void editProInfo(String type, String ID, int price, int amount) throws RemoteException;
```

```
    void delProInfo(String type, String ID) throws RemoteException;
```

```
    HashMap<String, UsrInfo> checkTransfer() throws RemoteException;
```

```
}
```

2. Make both remote object and server program

ShopImpl.java

```

public class ShopImpl extends UnicastRemoteObject implements Shop {
    Bank b; // create Bank object
    HashMap<String, HashMap<String, ProductInfo>> proList = new HashMap<>();
    HashMap<String, UsrInfo> usrList = new HashMap<>();
    HashMap<Integer, Account> orderAccount = new HashMap<>();

    public ShopImpl() throws RemoteException, NotBoundException, MalformedURLException {
        super();
        this.b = (Bank) Naming.lookup("rmi://localhost:1099/TestBank"); // ShopServer try rmi connection with Bank Object.

        proList.put("TV", new HashMap<>());
        proList.put("MP3", new HashMap<>());
        proList.put("COM", new HashMap<>());
        proList.put("PHONE", new HashMap<>());
        proList.get("TV").put("100", new ProductInfo("samsung", 500, 5, "100"));
        proList.get("TV").put("110", new ProductInfo("lg", 400, 3, "110"));
        usrList.put("123", new UsrInfo("123", 123));
        usrList.put("456", new UsrInfo("456", 456));
    }

    .....

    @Override
    public HashMap<String, UsrInfo> checkTransfer() throws RemoteException {
        for (String key : usrList.keySet()) {
            for (int i = 0; i < usrList.get(key).usrOrder.size(); i++) {
                if (usrList.get(key).usrOrder.get(i).notPurchasedOrder()) {
                    if (b.checkDeposit(usrList.get(key).usrOrder.get(i).virtualAccount) == usrList.get(key).usrOrder.get(i).totalPrice) { // call object BankImpl's
                        checkDeposit method
                        b.transfer(orderAccount.get(usrList.get(key).usrOrder.get(i).orderId).accName,
                        orderAccount.get(usrList.get(key).usrOrder.get(i).orderId).accPwd, 456, b.checkDeposit(usrList.get(key).usrOrder.get(i).virtualAccount));
                        // call object BankImpl's transfer method
                        usrList.get(key).usrOrder.get(i).purchased = "purchased";
                    }
                }
            }
        }
        return usrList;
    }
}

```

2. Make both remote object and server program ShopServer.java

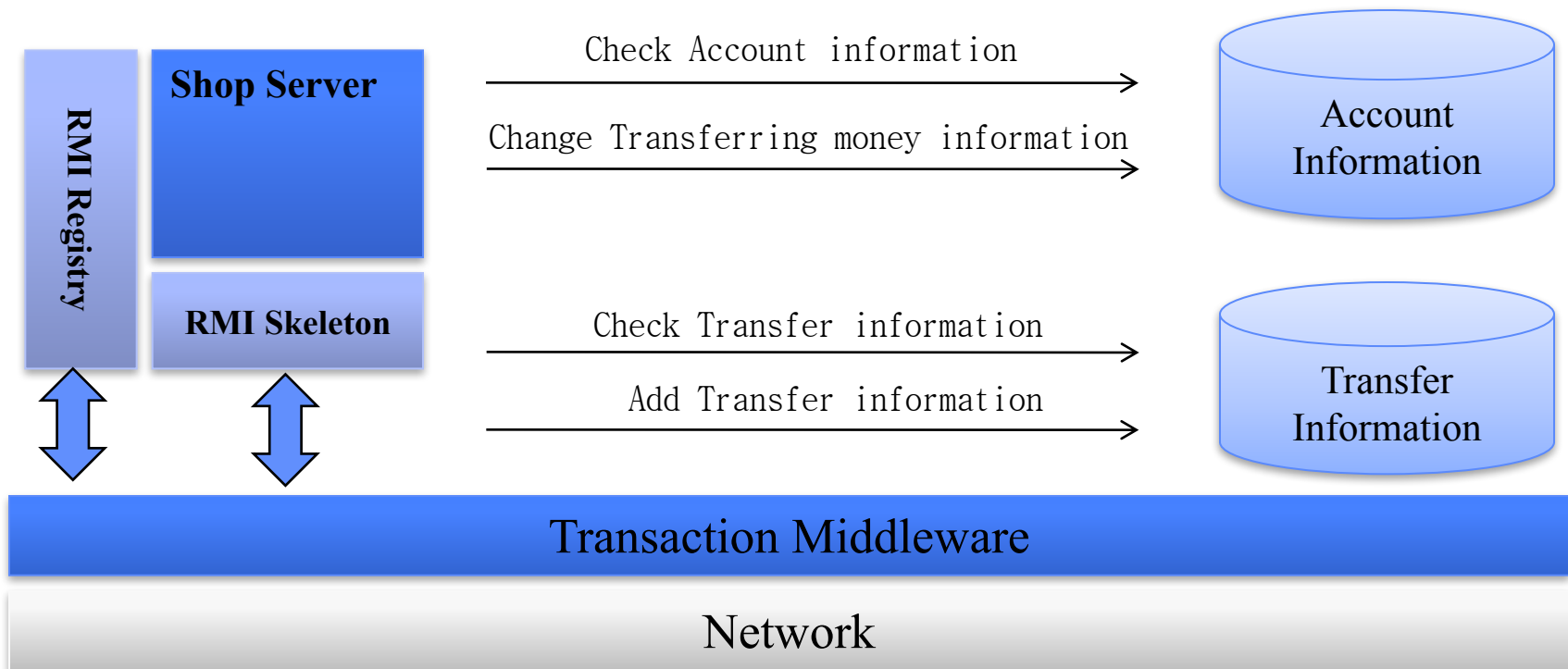
```
package rmi;

import java.rmi.Naming;
import java.lang.SecurityManager;

public class ShopServer {
    public static void main(String[] args) throws Exception {
        if(System.getSecurityManager()==null) {
            System.setSecurityManager(new SecurityManager());
        }

        ShopImpl s = new ShopImpl();
        Naming.rebind("rmi://localhost:1099/TestShop", s);
        System.out.println("Binding ShopImpl object s name as TestShop");
    }
}
```

Bank Server



Bank Server

- To implement Bank Server, you need to create and define the **information objects** that will be stored on the Bank server and managed.
 - Account Information
 - Transfer Information

Bank Server(1) – Account Information

AccountInfo.java

```
package rmi;

import java.util.ArrayList;

class Account implements java.io.Serializable{
    int accName;
    int accPwd;
    int deposit;
    ArrayList<TransInfo> transRecord;

    Account() { }

    Account(int accName, int accPwd, int deposit) {
        this.accName = accName;
        this.accPwd = accPwd;
        this.deposit = deposit;
        this.transRecord = new ArrayList<TransInfo>();
    }
}
```

Bank Server(2) – Transfer Information

TransInfo.java

```
package rmi;
```

```
import java.sql.Timestamp;
```

```
import java.text.SimpleDateFormat;
```

```
class TransInfo implements java.io.Serializable{
```

```
    int sendAccName;
```

```
    int receiveAccName;
```

```
    int transAmount;
```

```
    Timestamp timestamp;
```

```
    TransInfo() { }
```

```
    TransInfo(int sendAccName, int receiveAccName, int transAmount) {
```

```
        this.sendAccName = sendAccName;
```

```
        this.receiveAccName = receiveAccName;
```

```
        this.transAmount = transAmount;
```

```
        this.timestamp = new Timestamp(System.currentTimeMillis());
```

```
    }
```

```
    @Override
```

```
    public String toString() {
```

```
        String time = new SimpleDateFormat("MM/dd/yyyy HH:mm:ss").format(this.timestamp);
```

```
        return String.format("Send Account : %d / Receive Account: %d / Amount : %d / Time : %s",
```

```
sendAccName, receiveAccName, transAmount, time);
```

```
    }
```

```
}
```


1. Make interface of remote object for service

Bank.java

```
package rmi;
```

```
import java.rmi.Remote;
```

```
import java.rmi.RemoteException;
```

```
import java.util.ArrayList;
```

```
public interface Bank extends Remote{
```

```
    public boolean login(int name, int pwd) throws RemoteException;
```

```
    public Account makeVirtualAccount(int accPwd) throws RemoteException;
```

```
    public boolean[] transfer(int name, int pwd, int obj, int num) throws
```

```
    RemoteException;
```

```
    public int checkDeposit(int name) throws RemoteException;
```

```
    public ArrayList<TransInfo> checkTransRecord(int name) throws
```

```
    RemoteException;
```

```
}
```

2. Make both remote object and server program

BankImpl.java

```

public class BankImpl extends UnicastRemoteObject implements Bank {
    HashMap<Integer, Account> accountList = new HashMap<>(); // hashmap accountList consist of <accName, Account> to find Account using
    accName.

    public BankImpl() throws RemoteException {
        super();
        accountList.put(123, new Account(123, 123, 5000));
        accountList.put(456, new Account(456, 456, 5000));
    }

    @Override
    public boolean login(int name, int pwd) throws RemoteException {
        /*
        proving login user is bank's customer using account ID(name), password(pwd).
        */
        boolean check = true;

        if (accountList.get(name) != null) {
            if (accountList.get(name).accPwd == pwd)
                check = false;
        }

        return check;
    }

    .....

    @Override
    public ArrayList<TransInfo> checkTransRecord(int name) throws RemoteException {
        /*
        Check transfer records.
        */
        return accountList.get(name).transRecord;
    }
}

```

2. Make both remote object and server program BankServer.java

```
package rmi;
```

```
import java.rmi.Naming;
```

```
import java.lang.SecurityManager;
```

```
public class BankServer {
```

```
    public static void main(String[] args) throws Exception {
```

```
        if(System.getSecurityManager()==null) {
```

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

```
        }
```

```
        BankImpl b = new BankImpl();
```

```
        Naming.rebind("rmi://localhost:1099/TestBank", b);
```

```
        System.out.println("Binding BankImpl object b name as TestBank");
```

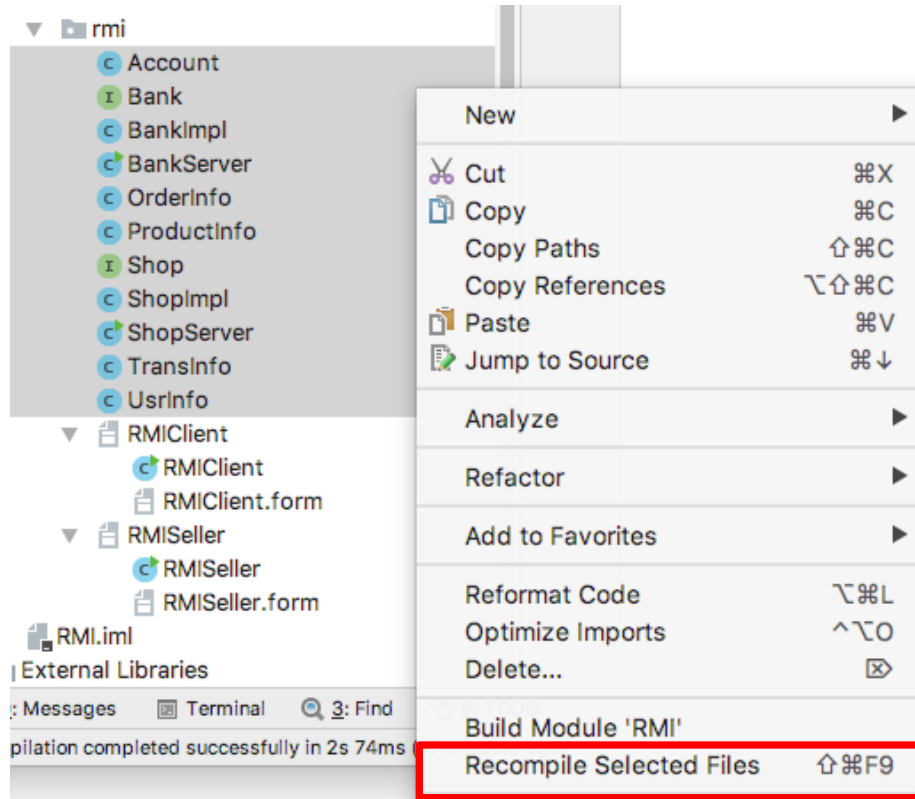
```
    }
```

```
}
```

3. Generate stub/skeleton

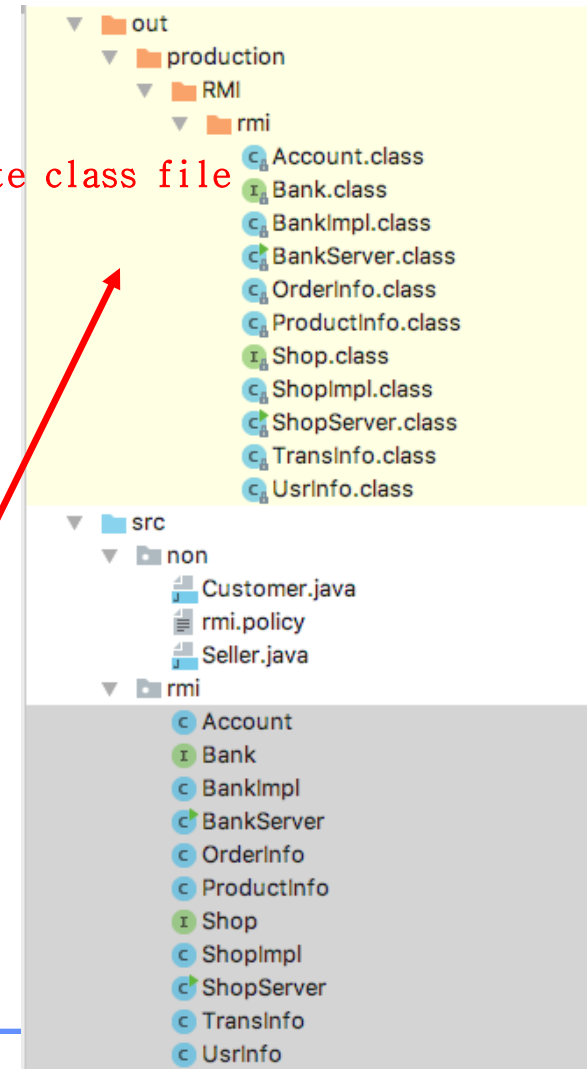
• Compile the code

1. Select all
java file



2. Recompile
Selected Files

3. Create class file



3. Generate stub/skeleton

- Open terminal, and move to directory including “rmi” package

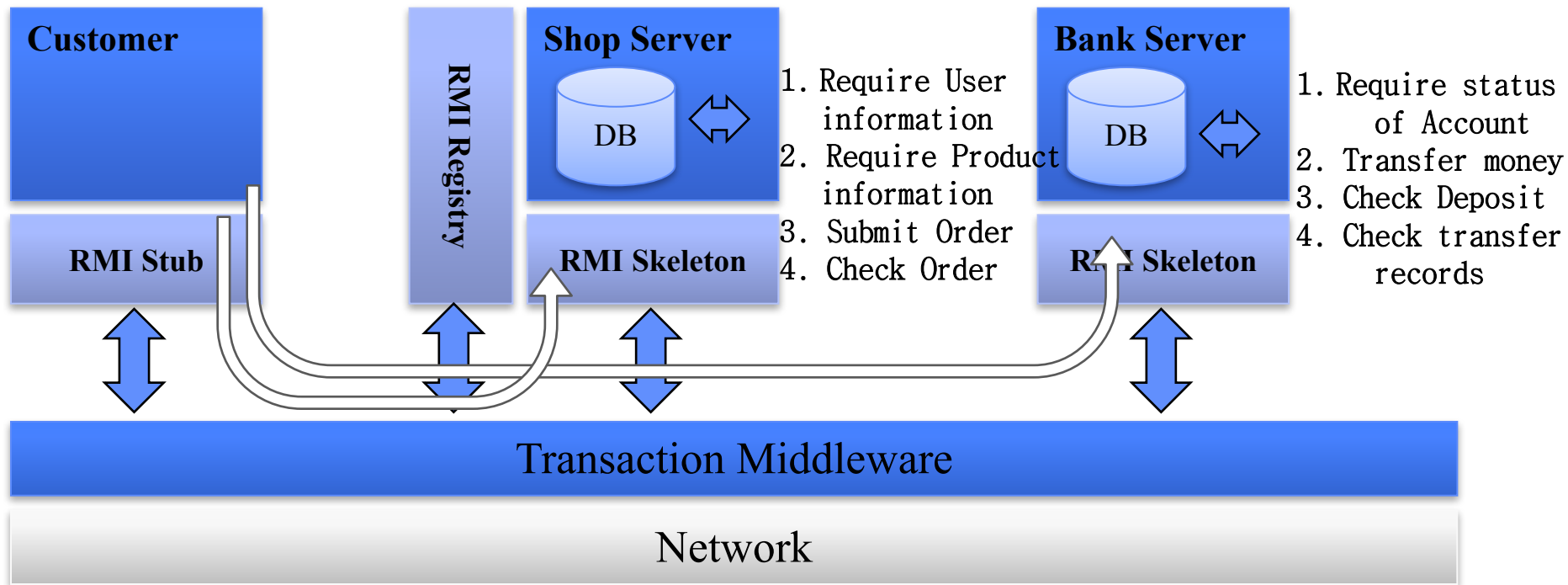
```
[SeongHwanui-MacBook-Pro:~ jihwankim$ cd IdeaProjects/RMI/out/production/RMI/
[SeongHwanui-MacBook-Pro:RMI jihwankim$ ls
rmi
```

- Generate stub/skeleton

```
[SeongHwanui-MacBook-Pro:RMI jihwankim$ rmic rmi.ShopImpl rmi.BankImpl
Warning: generation and use of skeletons and static stubs for JRMP
is deprecated. Skeletons are unnecessary, and static stubs have
been superseded by dynamically generated stubs. Users are
encouraged to migrate away from using rmic to generate skeletons and static
stubs. See the documentation for java.rmi.server.UnicastRemoteObject.
```

```
[SeongHwanui-MacBook-Pro:RMI jihwankim$ cd rmi/
[SeongHwanui-MacBook-Pro:rmi jihwankim$ ls
Account.class      OrderInfo.class    ShopServer.class
Bank.class          ProductInfo.class  TransInfo.class
BankImpl.class      Shop.class         UserInfo.class
BankImpl_Stub.class ShopImpl.class
BankServer.class    ShopImpl_Stub.class
```

Customer Client



4. Make a client program using remote object RMIClient.java

- **public** RMIClient() **throws** Exception {
 /*
 RMIClient's init method
 */
 super("Online Shop (Only Customer)");
 if(System.getSecurityManager()==**null**) {
 System.setSecurityManager(**new** SecurityManager());
 }
 Shop i = (Shop)Naming.lookup("rmi://localhost:1099/TestShop");
 Bank b = (Bank) Naming.lookup("rmi://localhost:1099/TestBank");
}

4. Make a client program using remote object

RMIClient.java

```

• submitOrderButton.addActionListener(new ActionListener() {
    @Override
    public void actionPerformed(ActionEvent e) {
        OrderInfo orderInfo = new OrderInfo();
        String usrName = submitNameText.getText();
        String type = submitTypeBox.getSelectedItem().toString();
        String ID = submitIDText.getText();
        String usrAdd = submitAddText.getText();
        boolean loginCheck = true;

        if (checkEmpty(usrName) && checkEmpty(submitPwdText.getText()) && checkEmpty(ID) && checkEmpty(usrAdd) &&
            checkEmpty(submitAmountText.getText())) {
            int usrPwd = Integer.parseInt(submitPwdText.getText());
            int amount = Integer.parseInt(submitAmountText.getText());

            try {
                loginCheck = i.checkCustomer(usrName, usrPwd); //call object InfoImpl's checkCustomer method
            } catch (RemoteException e1) {
                e1.printStackTrace();
            }

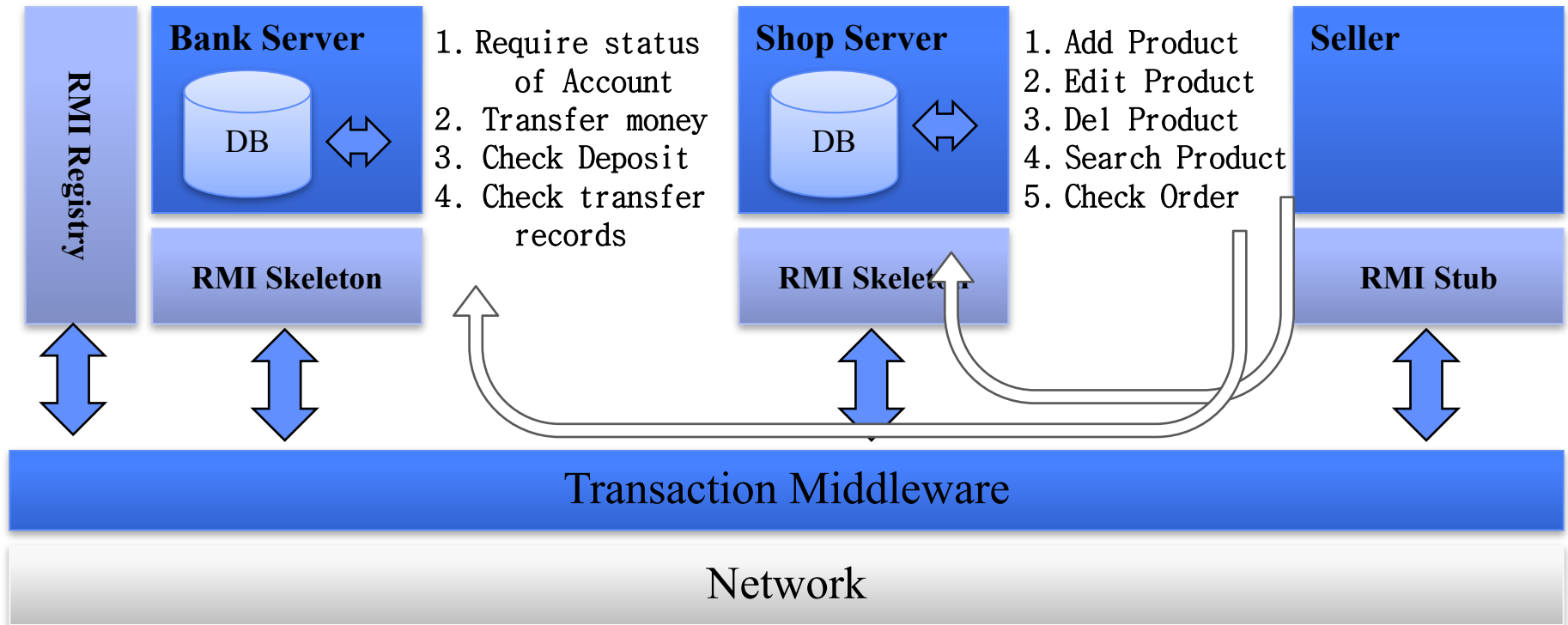
            if (!loginCheck) {
                try {
                    orderInfo = i.usrBuy(usrName, usrAdd, type, ID, amount); //call object InfoImpl's usrBuy method
                } catch (RemoteException e1) {
                    e1.printStackTrace();
                }
            }
        }
    }
}

```

Login to Shop Server

Submit order to Shop Server

Seller Client



4. Make a client program using remote object RMISeller.java

- **public RMISeller() throws Exception {**
 */**
 RMISeller's init method
 **/*
 super("Online Shop (Seller ver)");
 if(System.getSecurityManager()==null) {
 System.setSecurityManager(**new** SecurityManager());
 }

 Shop i = (Shop)Naming.lookup(**"rmi://localhost:1099/TestShop"**);
 Bank b = (Bank) Naming.lookup(**"rmi://localhost:1099/TestBank"**);

4. Make a client program using remote object

RMISeller.java

• **bankSendButton**.addActionListener(new ActionListener() {

 @Override

 public void actionPerformed(ActionEvent e) {

 boolean loginCheck = true;

 boolean transferCheck = true;

 boolean objAccCheck = false;

 boolean[] checks = new boolean[2];

 if (checkEmpty(**bankAccNameText**.getText()) && checkEmpty(**bankAccPwdText**.getText()) && checkEmpty(**bankTransObjText**.getText())
 && checkEmpty(**bankTransAmountText**.getText())) {

 int accName = Integer.parseInt(**bankAccNameText**.getText());

 int accPwd = Integer.parseInt(**bankAccPwdText**.getText());

 int objAcc = Integer.parseInt(**bankTransObjText**.getText());

 int amount = Integer.parseInt(**bankTransAmountText**.getText());

 try {

 loginCheck = **b.login(accName, accPwd);** //call object BankImpl's login method

 } catch (RemoteException e1) {

 e1.printStackTrace();

Login to Bank Server

 }

 if (!loginCheck) {

 try {

 checks = **b.transfer(accName, accPwd, objAcc, amount);** //call object BankImpl's transfer method

 } catch (RemoteException e1) {

 e1.printStackTrace();

Transfer money using bank service

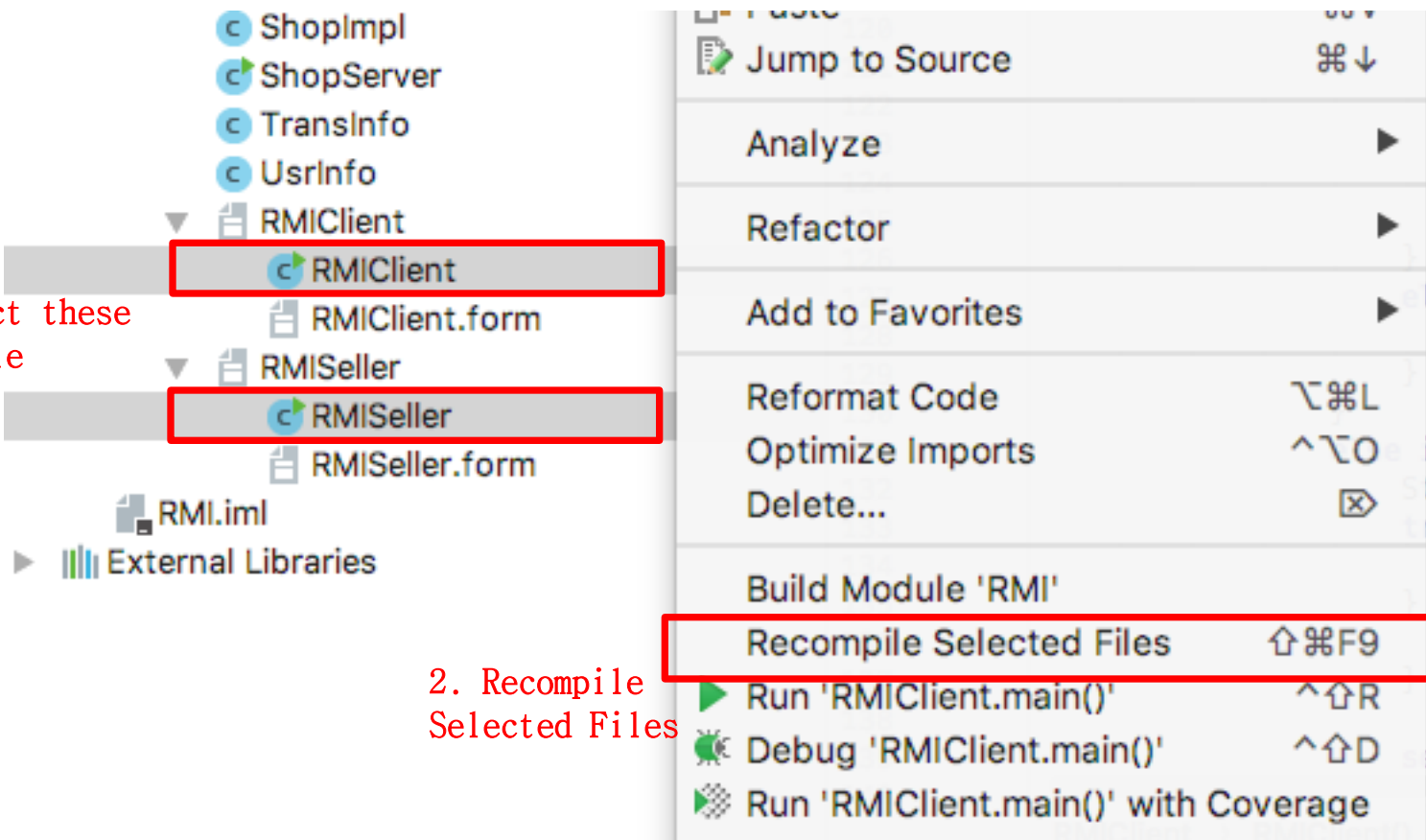
 }

 transferCheck = checks[0];

 objAccCheck = checks[1];

4. Compile both Customer and Seller Client

1. Select these java file



2. Recompile Selected Files

The screenshot shows an IDE's project view on the left with the following structure:

- ShopImpl
- ShopServer
- TransInfo
- UserInfo
- RMIClient (expanded)
 - RMIClient (highlighted in a red box)
 - RMIClient.form
- RMISeller (expanded)
 - RMISeller (highlighted in a red box)
 - RMISeller.form
- RMI.iml
- External Libraries

The context menu for the selected 'RMISeller' file includes the following options:

- Jump to Source
- Analyze
- Refactor
- Add to Favorites
- Reformat Code
- Optimize Imports
- Delete...
- Build Module 'RMI'
- Recompile Selected Files (highlighted in a red box)
- Run 'RMIClient.main()'
- Debug 'RMIClient.main()'
- Run 'RMIClient.main()' with Coverage

5. Execute RMI registry

- Make RMI security policy file

```
[SeongHwanui-MacBook-Pro:RMI jihwankim$ ls  
com          rmi          rmi.policy
```

- Execute RMI registry

```
[SeongHwanui-MacBook-Pro:RMI jihwankim$ rmiregistry 1099
```

6. Execute both server and client program

- **Run BankServer**

```
SeongHwanui-MacBook-Pro:RMI jihwankim$ java -Djava.security.policy=rmi.policy  
rmi.BankServer  
Binding BankImpl object b name as testBank
```

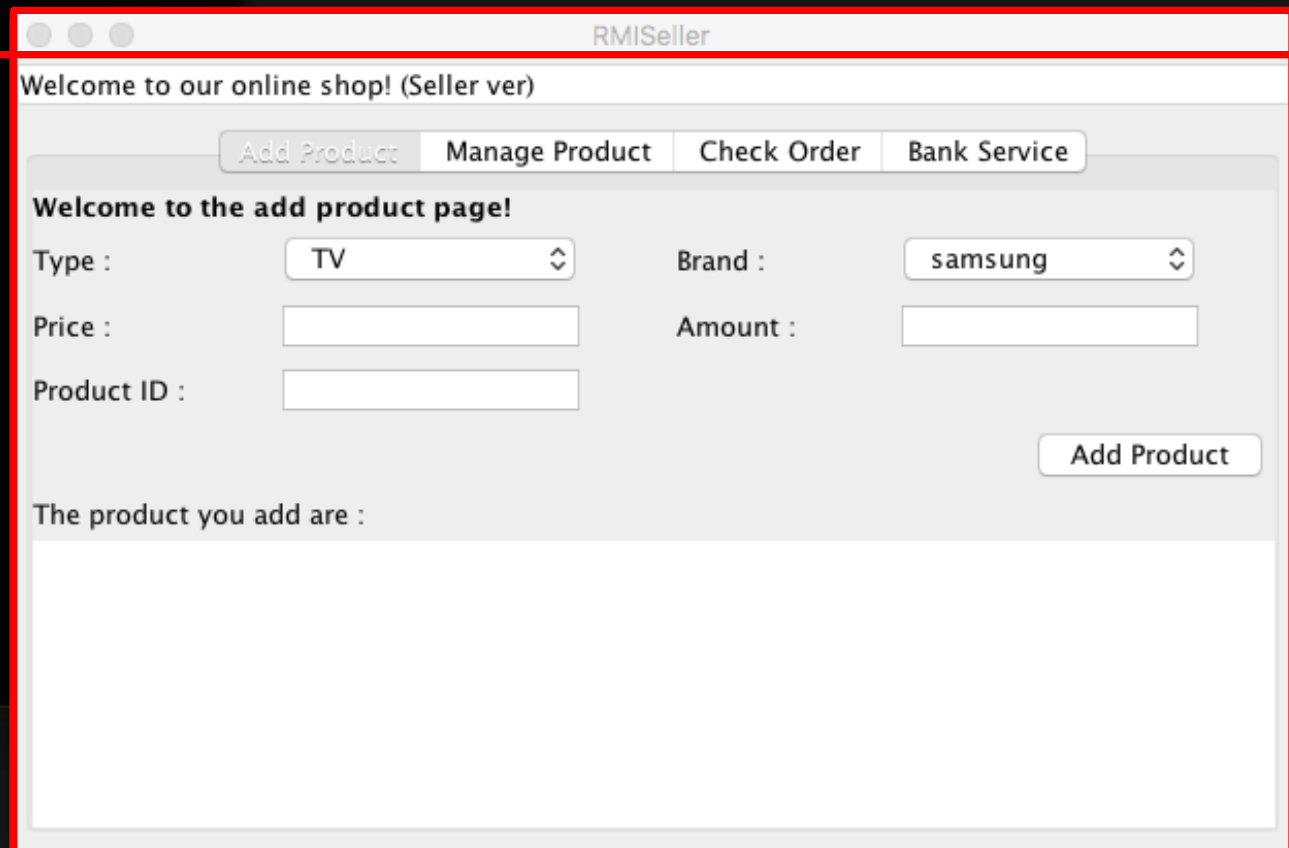
- **Run ShopServer**

```
SeongHwanui-MacBook-Pro:RMI jihwankim$ java -Djava.security.policy=rmi.policy  
rmi.ShopServer  
Binding ShopImpl object s name as Test Shop
```

6. Execute both server and client program

- **Run Seller**

```
SeongHwanui-MacBook-Pro:RMI jihwankim$ java -Djava.security.policy=rmi.policy  
rmi.RMISeller
```

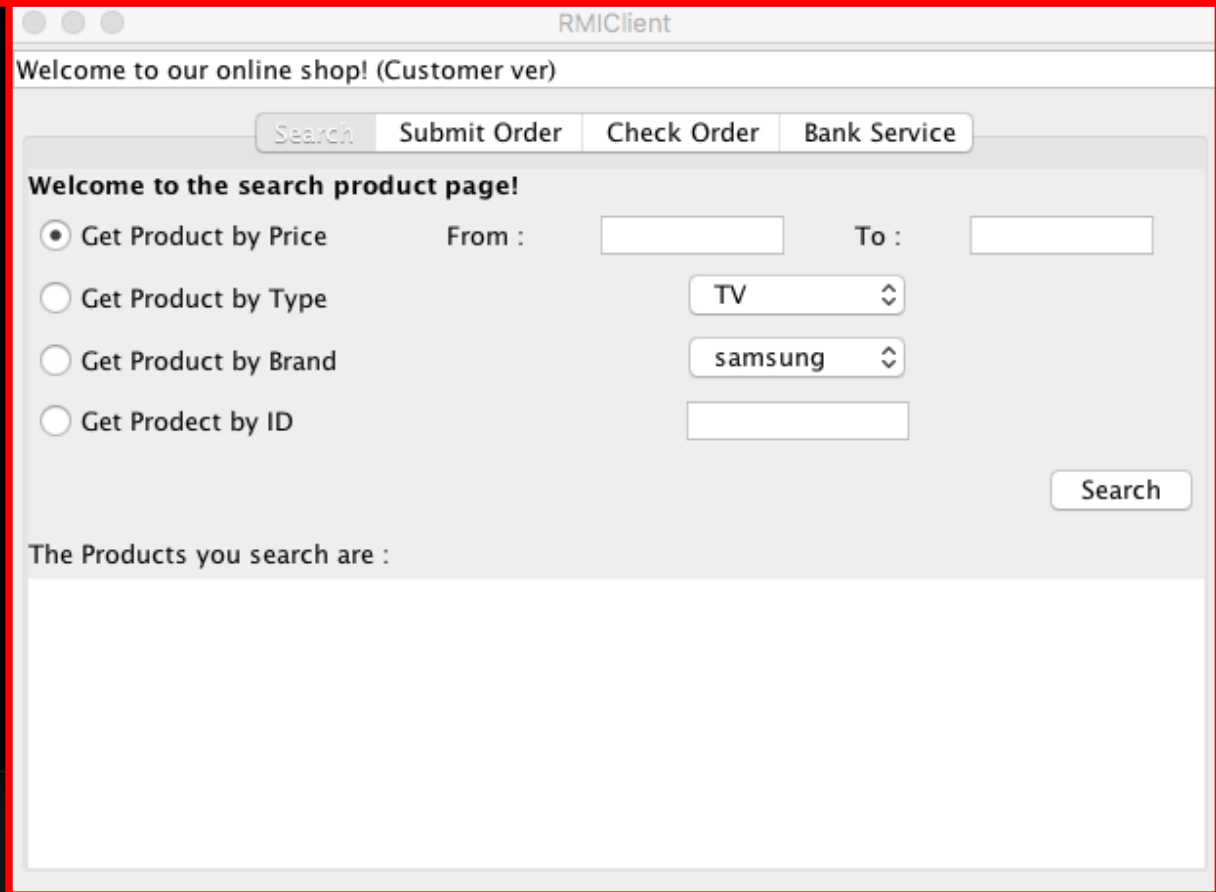


The screenshot shows a Java Swing window titled "RMISeller". The window has a title bar with standard macOS window controls. Below the title bar, there is a header area with the text "Welcome to our online shop! (Seller ver)". Below this, there are four tabs: "Add Product", "Manage Product", "Check Order", and "Bank Service". The "Add Product" tab is currently selected. The main content area of the "Add Product" tab has the heading "Welcome to the add product page!". Below this heading, there are four input fields: "Type :" with a dropdown menu showing "TV", "Brand :" with a dropdown menu showing "samsung", "Price :" with a text input field, and "Amount :" with a text input field. Below these, there is a "Product ID :" label and an empty text input field. To the right of these fields, there is an "Add Product" button. At the bottom of the window, there is a label "The product you add are :" followed by a large empty text area.

6. Execute both server and client program

- **Run Customer**

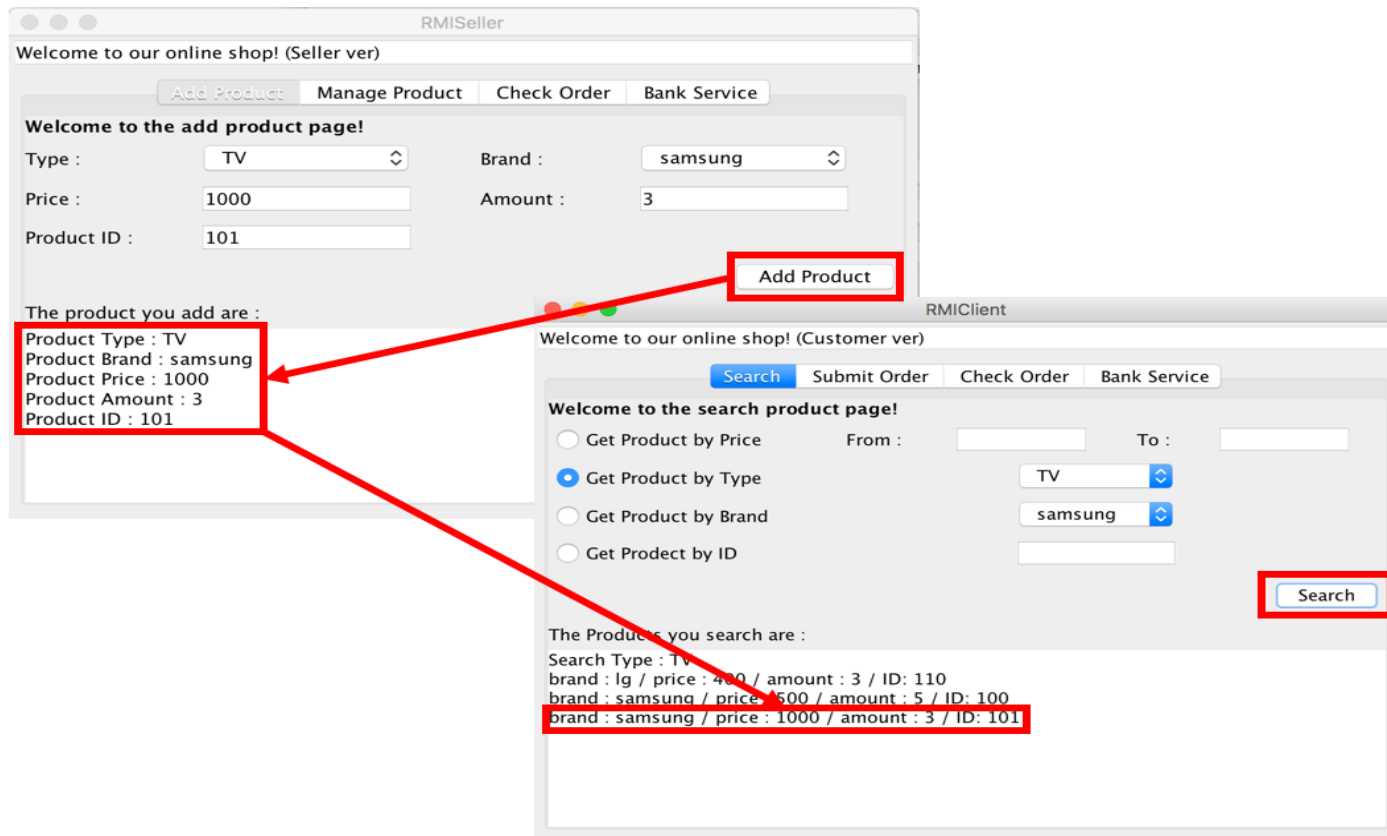
```
SeongHwanui-MacBook-Pro:RMI jihwankim$ java -Djava.security.policy=rmi.policy  
rmi.RMIClient
```



The screenshot shows a Java Swing window titled "RMIClient". Inside the window, there is a header bar with four buttons: "Search", "Submit Order", "Check Order", and "Bank Service". Below this, a message says "Welcome to our online shop! (Customer ver)". The main content area is titled "Welcome to the search product page!". It contains four radio buttons for search criteria: "Get Product by Price" (selected), "Get Product by Type", "Get Product by Brand", and "Get Product by ID". To the right of the "Get Product by Price" option are two input fields labeled "From :" and "To :". Below the "Get Product by Type" option is a dropdown menu showing "TV". Below the "Get Product by Brand" option is a dropdown menu showing "samsung". Below the "Get Product by ID" option is an empty input field. A "Search" button is located at the bottom right of the search section. Below the search section, there is a label "The Products you search are :" followed by a large empty text area.

Demo on-line shopping mall

- Seller → method addProInfo(InfoImpl) / Customer → method getProInfoByType(InfoImpl)



Demo on-line shopping mall

- Customer → method `usrBuy(InfoImpl)`
`getOrderList(InfoImpl)` `makeVirtualAccount(BankImpl)`

The screenshot shows a Java Swing window titled "RMIClient". Inside, there's a header "Welcome to our online shop! (Customer ver)". Below it are four buttons: "Search", "Submit Order", "Check Order", and "Bank Service". The "Submit Order" button is highlighted with a red box and an arrow pointing to the order summary below. The order summary is also enclosed in a red box and contains the following text:

Welcome to the order submit page! After submit the order, next step is payment.

User Name : 123 User Password : 123
Product Type : TV Amount : 2
Product ID : 100 Address : Seoul

The order you submit is :
OrderID : 1 / VirtualAccount: 737 / Address : Seoul / Product ID : 100 / amount : 2 / price : 1000 / purchased : not purchased
You have to transfer 1000 to account number 737

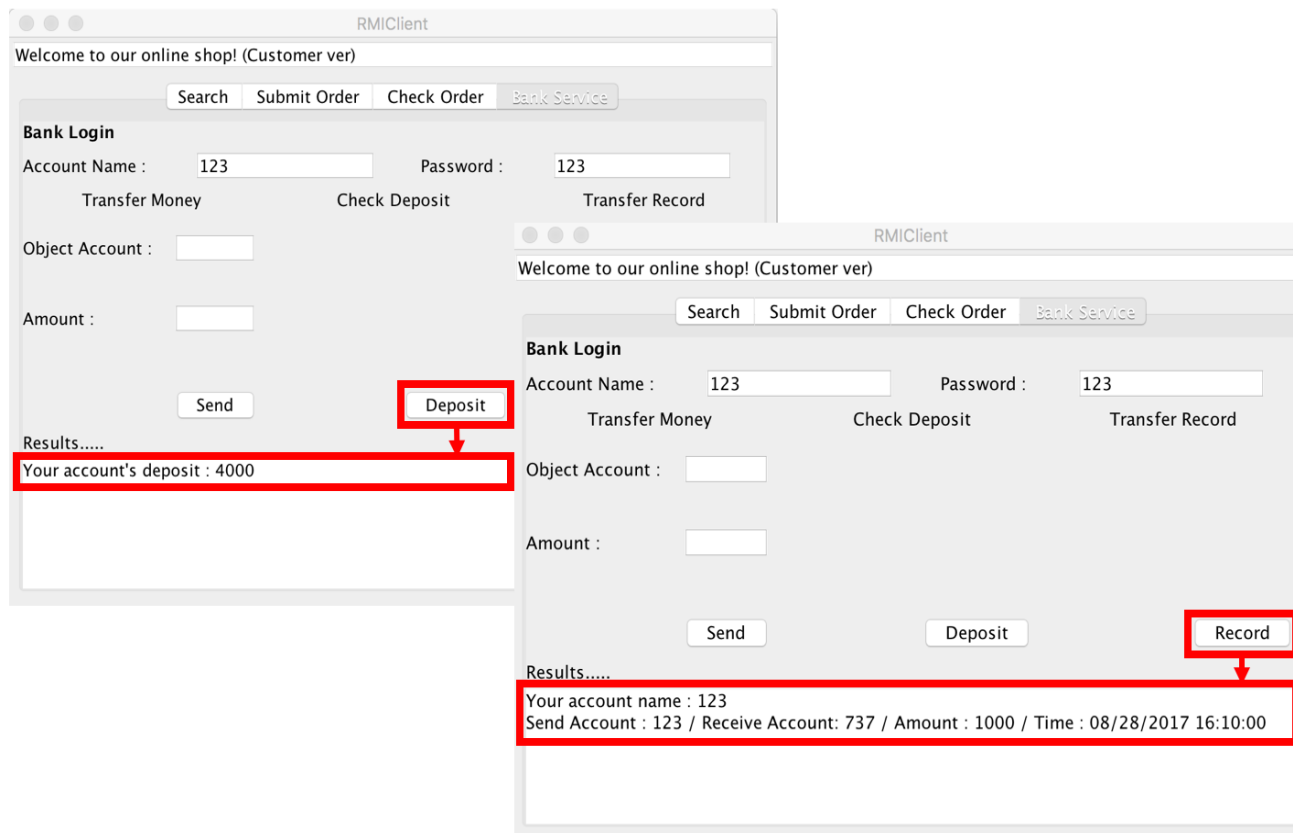
Demo on-line shopping mall

- Customer → method login(BankImpl)
transfer(BankImpl)

The screenshot shows a Java Swing window titled "RMIClient". Inside, there's a label "Welcome to our online shop! (Customer ver)". Below it are four buttons: "Search", "Submit Order", "Check Order", and "Bank Service". The "Bank Service" button is selected. Underneath, the "Bank Login" section has two input fields: "Account Name : 123" and "Password : 123", both highlighted with a red rectangle. Below these are three tabs: "Transfer Money", "Check Deposit", and "Transfer Record". The "Transfer Money" tab is active, showing "Object Account : 737" and "Amount : 1000". A red arrow points from the "Send" button (also highlighted with a red rectangle) to the "Results....." section. The results section, also highlighted with a red rectangle, displays: "Transfer Success!", "Your account : 123", "Object account : 737", and "Amount transfer money : 1000".

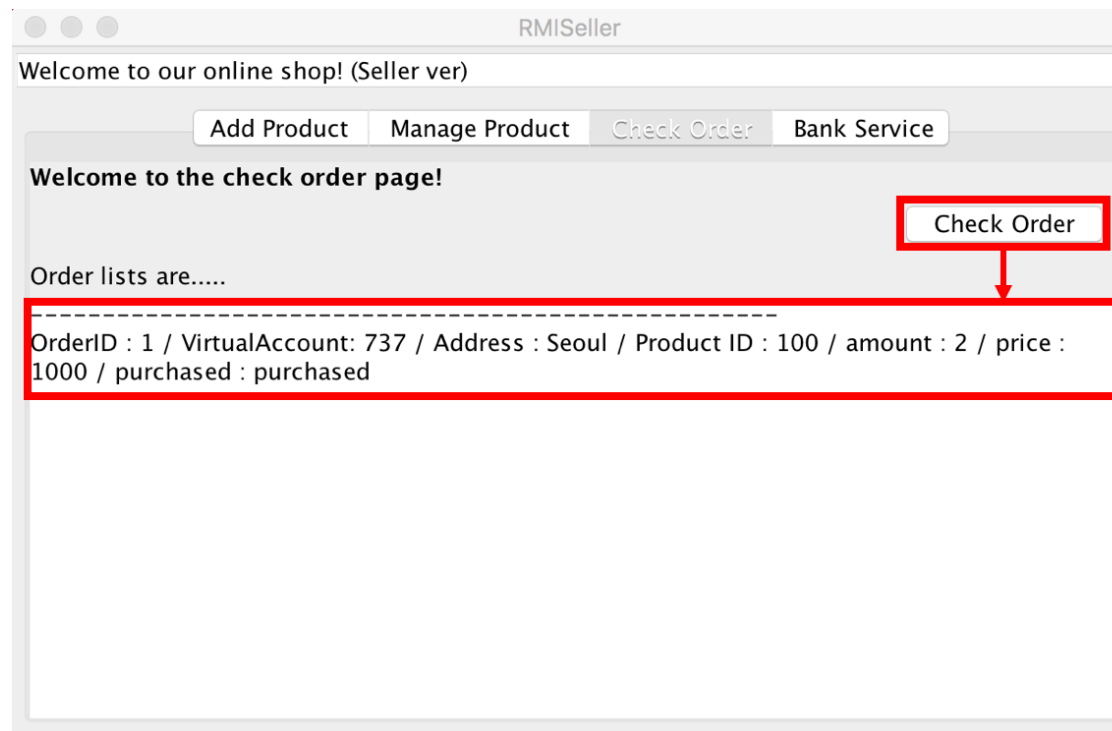
Demo on-line shopping mall

- Customer → method `checkDeposit(BankImpl)`
`checkTransRecord(BankImpl)`



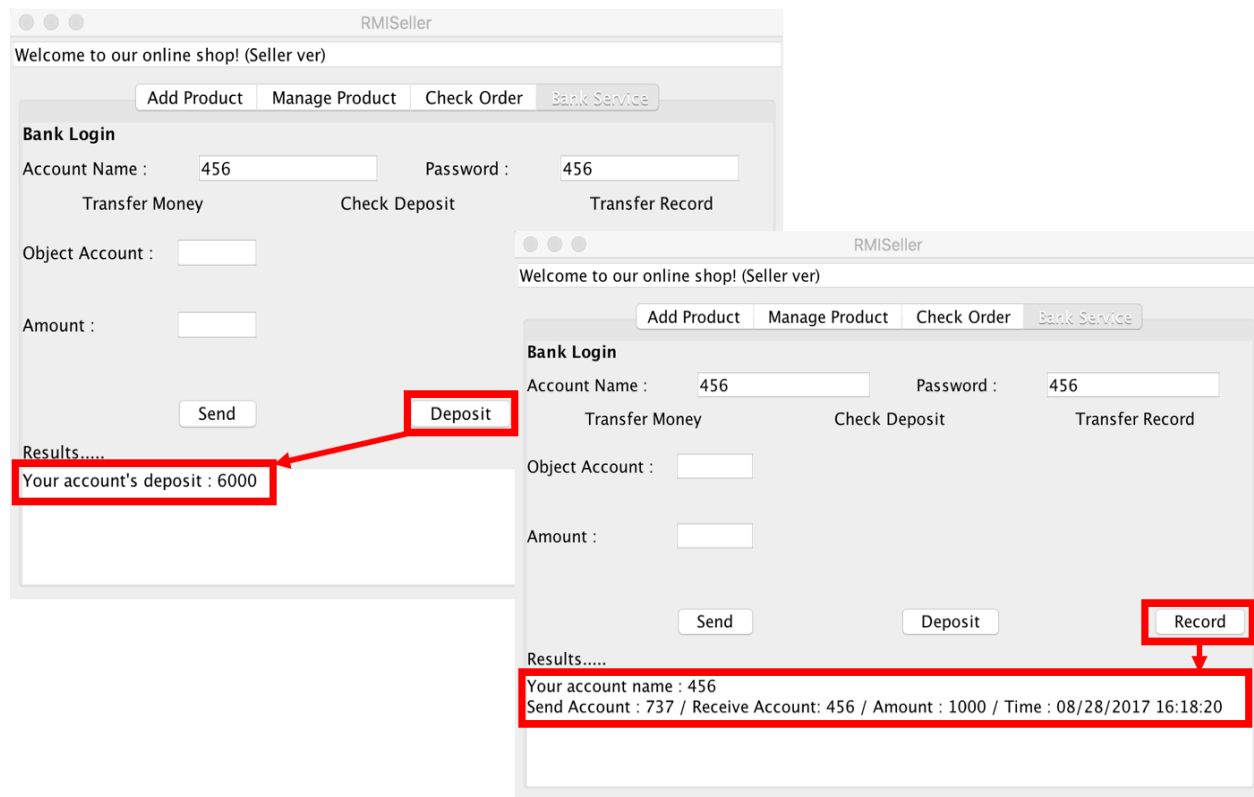
Demo on-line shopping mall

- Seller → method checkOrder(InfoImpl)



Demo on-line shopping mall

- Seller → method login(BankImpl)
checkDeposit(BankImpl) checkTransRecord(BankImpl)



Lab 10. Building OOM

- Comparison with Message-oriented Middleware
 - Explain the structural differences between OOM and MOM
 - Compare the two middleware in terms of performance, scalability, ease of development, complexity and etc.
- Build a Mini on-line Shopping Mall program on your PC
 - Illustrate how client, shop, bank and seller works, step by step.
 - Describe the operating procedures and object lifecycle of each entity from the perspective of server, client, and rmiregistry.