Implementing Classes

Advanced Programming

ICOM 4015

Lecture 3

Reading: Java Concepts Chapter 3

Chapter Goals

- To become familiar with the process of implementing classes
- To be able to implement simple methods
- To understand the purpose and use of constructors
- To understand how to access instance fields and local variables
- To appreciate the importance of documentation comments

Black Boxes

- A black box magically does its thing
- Hides its inner workings
- Encapsulation: the hiding of unimportant details
- What is the right *concept* for each particular black box?

Continued…

Black Boxes

- Concepts are discovered through abstraction
- Abstraction: taking away inessential features, until only the essence of the concept remains
- In *object-oriented programming* the black boxes from which a program is manufactured are called objects

Levels of Abstraction: A Real-Life Example

- **Black boxes in a car: transmission, electronic control module, etc.**

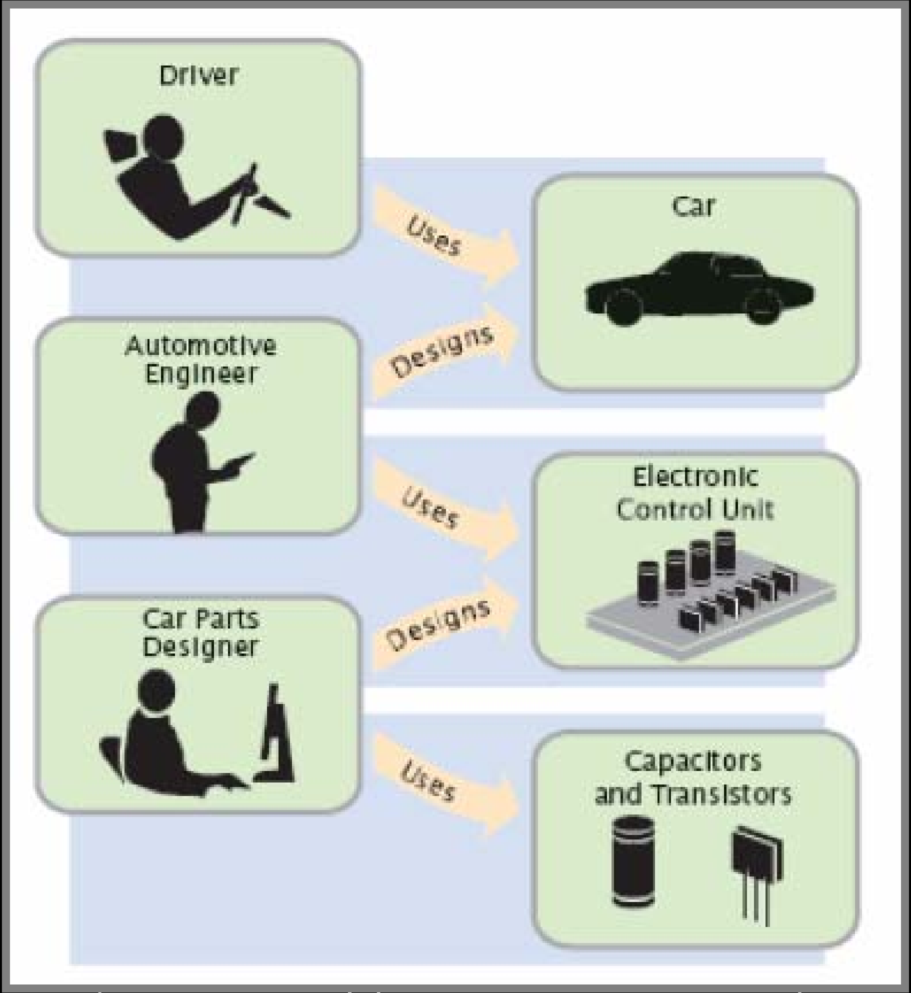


Figure 1: Levels of Abstraction in Automobile Design

Levels of Abstraction: A Real- Life Example

- **Users of a car do not need to understand how black boxes work**
- **Interaction of a black box with outside world is well-defined**
  - Drivers interact with car using pedals, buttons, etc.
  - Mechanic can test that engine control module sends the right firing signals to the spark plugs
  - For engine control module manufacturers, transistors and capacitors are black boxes magically produced by an electronics component manufacturer

Continued…

Levels of Abstraction: A Real- Life Example

- **Encapsulation leads to efficiency:**
  - Mechanic deals only with car components (e.g. electronic control module), not with sensors and transistors
  - Driver worries only about interaction with car (e.g. putting gas in the tank), not about motor or electronic control module

Levels of Abstraction: Software Design

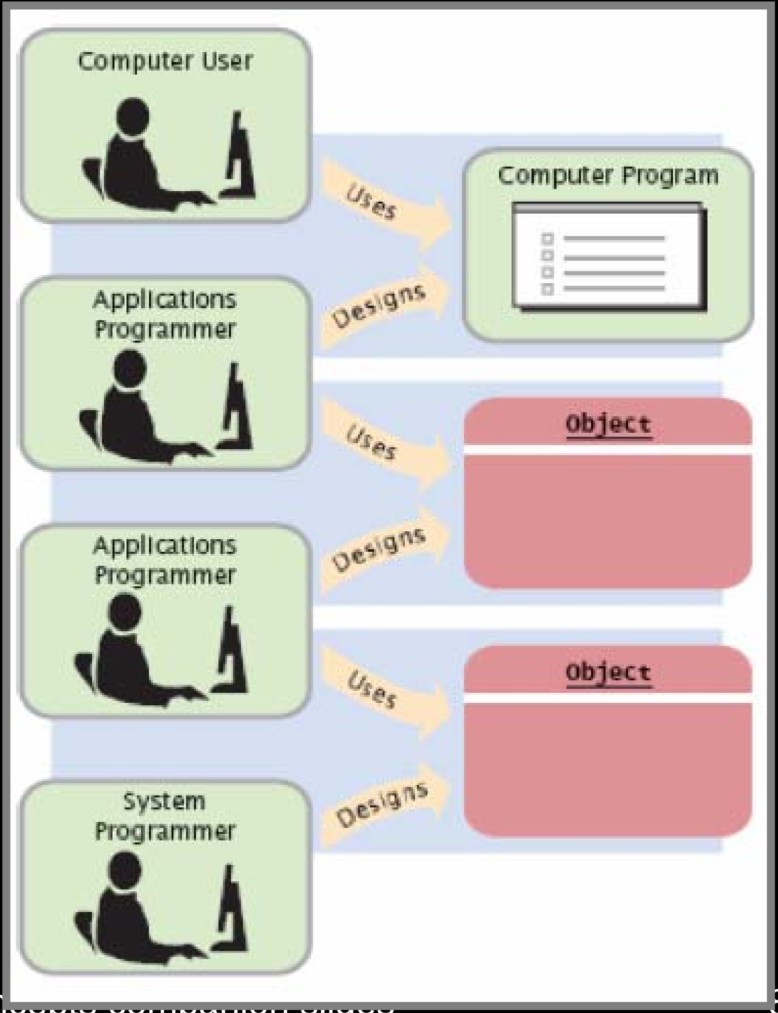


Figure 2:
Levels of Abstraction in Software Design

Levels of Abstraction: Software Design

- Old times: computer programs manipulated primitive types such as numbers and characters
- Manipulating too many of these primitive quantities is too much for programmers and leads to errors
- Solution: Encapsulate routine computations to software black boxes

Continued…

Levels of Abstraction: Software Design

- Abstraction used to invent higher-level data types
- In object-oriented programming, objects are black boxes
- Encapsulation: Programmer using an object knows about its behavior, but not about its internal structure

Continued…

Levels of Abstraction: Software Design

- In software design, you can design good and bad abstractions with equal facility; understanding what makes good design is an important part of the education of a software engineer
- First, define behavior of a class; then, implement it

Self Check

1. In Chapters 1 and 2, you used `System.out` as a black box to cause output to appear on the screen. Who designed and implemented `System.out`?
2. Suppose you are working in a company that produces personal finance software. You are asked to design and implement a class for representing bank accounts. Who will be the users of your class?

Answers

1. The programmers who designed and implemented the Java library
2. Other programmers who work on the personal finance application

Designing the Public Interface of a Class

- **Behavior of bank account (abstraction):**
  - deposit money
  - withdraw money
  - get balance

Designing the Public Interface of a Class: Methods

- Methods of **`BankAccount`** class:

```
deposit
withdraw
getBalance
```

- We want to support method calls such as the following:

```
harrysChecking.deposit(2000);
harrysChecking.withdraw(500);
System.out.println(harrysChecking.getBalance());
```

Designing the Public Interface of a Class: Method Definition

- access specifier (such as `public`)
- return type (such as `String` or `void`)
- method name (such as `deposit`)
- list of parameters (`double amount` for `deposit`)
- method body in `{ }`

Continued…

Designing the Public Interface of a Class: Method Definition

Examples

```
public void deposit(double amount) { . . . }
public void withdraw(double amount) { . . . }
public double getBalance() { . . . }
```

Syntax 3.1: Method Definition

```
accessSpecifier returnType methodName(parameterType
 parameterName, . . .)
{
   method body
}
```

Example:

```
   public void deposit(double amount)
   {
       . . .
   }
```

Purpose:

To define the behavior of a method

Designing the Public Interface of a Class: Constructor Definition

- A constructor initializes the instance variables
- Constructor name = class name

```
public BankAccount()
{
   // body--filled in later
}
```

Continued…

Designing the Public Interface of a Class: Constructor Definition

- Constructor body is executed when new object is created
- Statements in constructor body will set the internal data of the object that is being constructed
- All constructors of a class have the same name
- Compiler can tell constructors apart because they take different parameters

Syntax 3.2: Constructor Definition

```
   accessSpecifier ClassName(parameterType parameterName, . . .)
   {
       constructor body
   }
```

Example:

```
    public BankAccount(double initialBalance)
   {
      . . .
   }
```

Purpose:

To define the behavior of a constructor

`BankAccount` Public Interface

- The public constructors and methods of a class form the *public interface* of the class.

```
public class BankAccount
{
   // Constructors
   public BankAccount()
   {
      // body--filled in later
   }
   public BankAccount(double initialBalance)
   {
      // body--filled in later
   }

   // Methods
   public void deposit(double amount)
```

Continued…

BankAccount Public Interface

```
    {
       // body--filled in later
    }

    public void withdraw(double amount)
    {
       // body--filled in later
    }
    public double getBalance()
    {
       // body--filled in later
    }
    // private fields--filled in later
}
```

Syntax 3.3: Class Definition

```
accessSpecifier class ClassName
 {
    constructors
    methods
    fields
 }
```

Example:

```
 public class BankAccount
 {
    public BankAccount(double initialBalance) { . . . }
    public void deposit(double amount) { . . . }
   . . .
 }
```

Purpose:

To define a class, its public interface, and its implementation details

Self Check

1. How can you use the methods of the public interface to *empty* the `harrysChecking` bank account?
2. Suppose you want a more powerful bank account abstraction that keeps track of an *account number* in addition to the balance. How would you change the public interface to accommodate this enhancement?

Answers

1.
```
harrysChecking.withdraw(harrysChecking.getBalance())
```

2. Add an `accountNumber` parameter to the constructors, and add a `getAccountNumber` method. There is no need for a `setAccountNumber` method–the account number never changes after construction.

Commenting on the Public Interface

```
/**
   Withdraws money from the bank account.
   @param amlount the amount to withdraw
*/
public void withdraw(double amount)
{
   // implementation filled in later
}
```

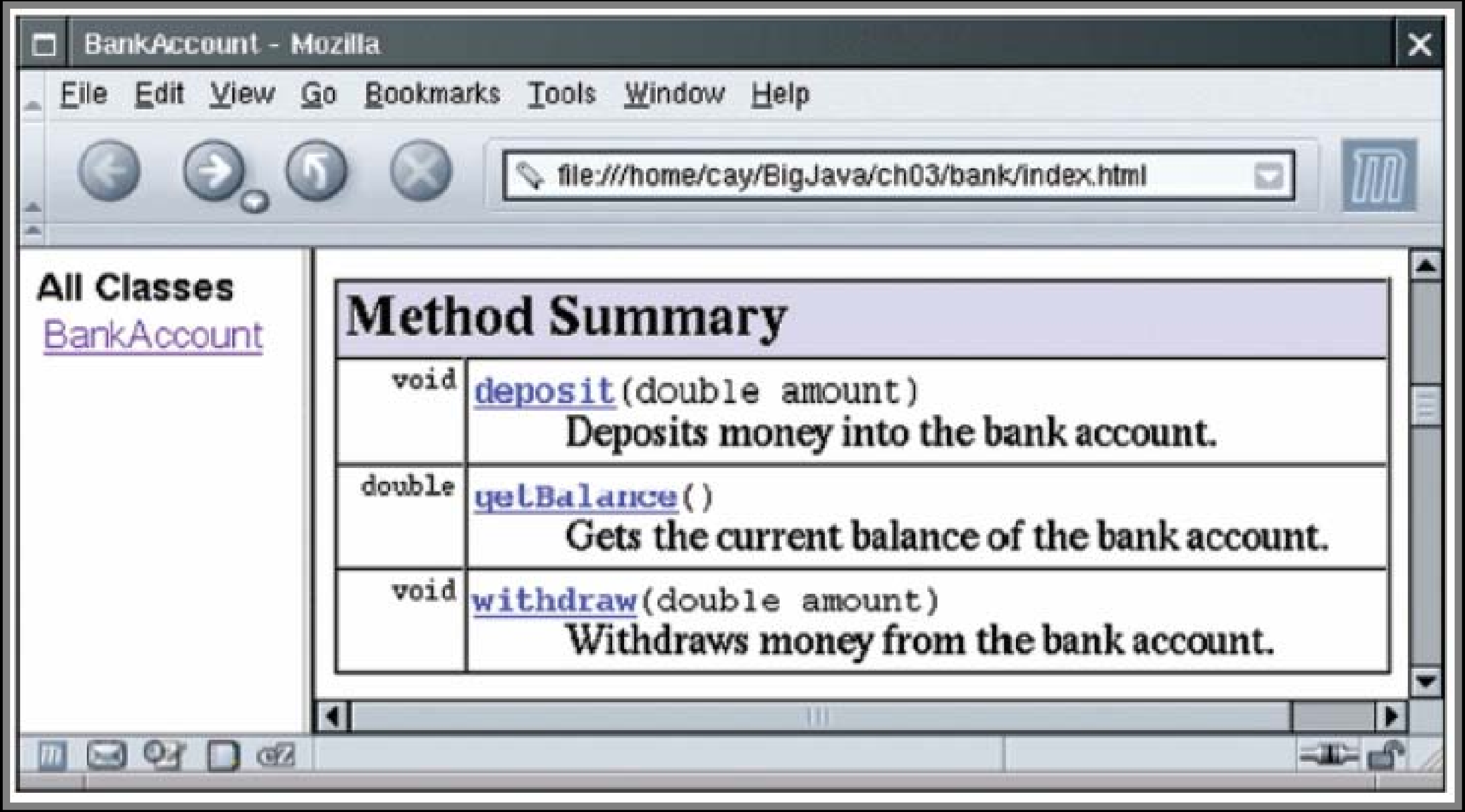
```
/**
   Gets the current balance of the bank account.
   @return the current balance
*/
public double getBalance()
{
   // implementation filled in later
}
```

Class Comment

```
/**
   A bank account has a balance that can
   be changed by deposits and withdrawals.
*/
public class BankAccount
{
   . . .
}
```

- **Provide documentation comments for**
  - every class
  - every method
  - every parameter
  - every return value.

Javadoc Method Summary

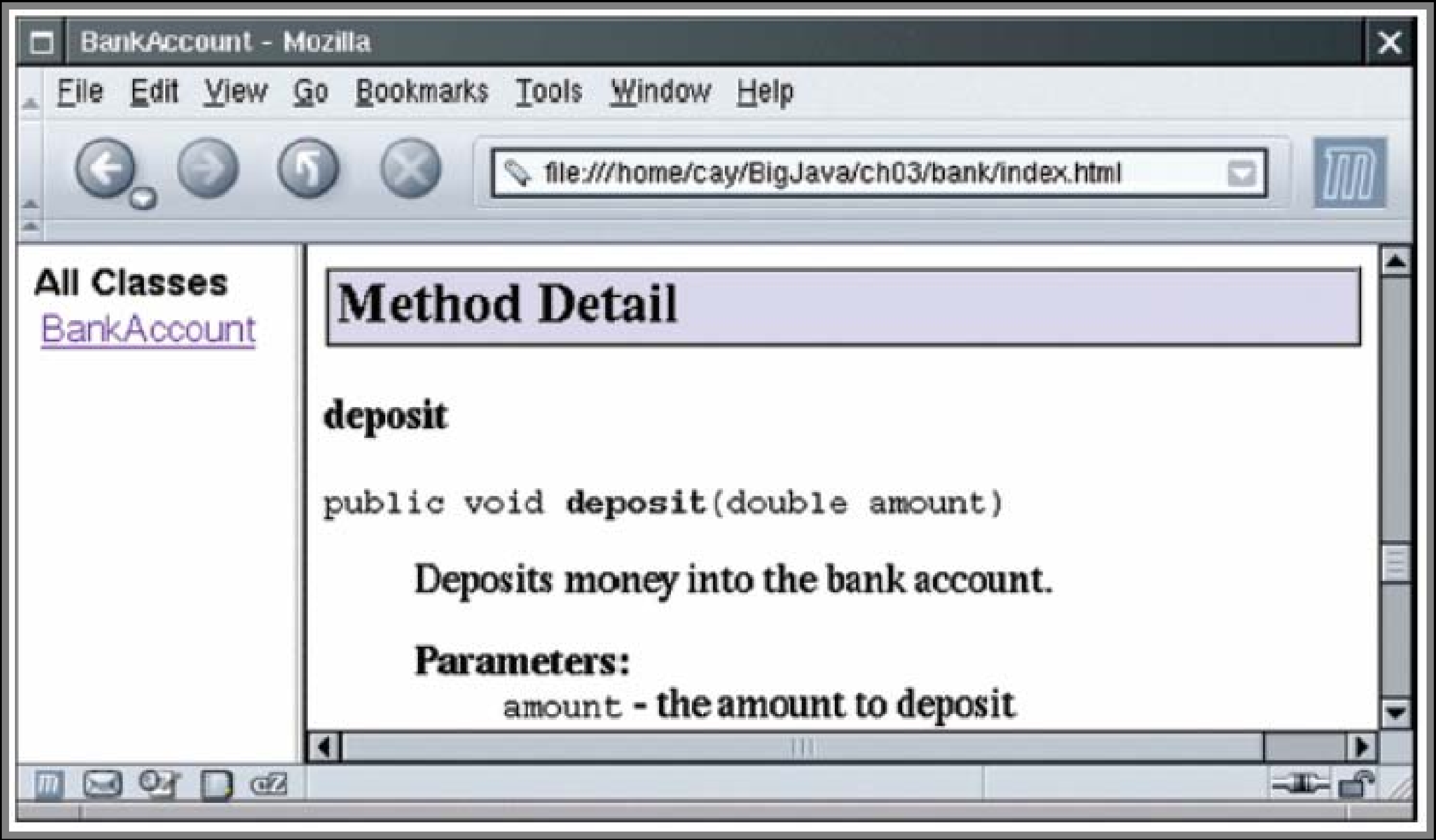

BankAccount - Mozilla
File Edit View Go Bookmarks Tools Window Help
file:///home/cay/BigJava/ch03/bank/index.html
All Classes
BankAccount

Method Summary

void	deposit(double amount) Deposits money into the bank account.
double	getBalance() Gets the current balance of the bank account.
void	withdraw(double amount) Withdraws money from the bank account.

Figure 3:
A Method Summary Generated by `javadoc`

Javadoc Method Detail


BankAccount - Mozilla
File Edit View Go Bookmarks Tools Window Help
file:///home/cay/BigJava/ch03/bank/index.html
All Classes
BankAccount

Method Detail

deposit

```
public void deposit(double amount)
```

Deposits money into the bank account.

Parameters:

`amount` - the amount to deposit

Figure 4:
Method Detail Generated by `javadoc`

Self Check

1. **Why is the following documentation comment questionable?**

```
/**
   Each account has an account number.
   @return the account number of this account.
*/
int getAccountNumber()
```

Answers

1.

```
/**
   Constructs a new bank account with a given initial balance.
   @param accountNumber the account number for this account
   @param initialBalance the initial balance for this account
*/
```

1. **The first sentence of the method description should describe the method–it is displayed in isolation in the summary table**

Instance Fields

- An object stores its data in instance fields
- Field: a technical term for a storage location inside a block of memory
- Instance of a class: an object of the class
- The class declaration specifies the instance fields:

```
public class BankAccount
{
   . . .
   private double balance;
}
```

Instance Fields

- **An instance field declaration consists of the following parts:**
  - access specifier (such as `private`)
  - type of variable (such as `double`)
  - name of variable (such as `balance`)
- **Each object of a class has its own set of instance fields**
- **You should declare all instance fields as private**

Instance Fields

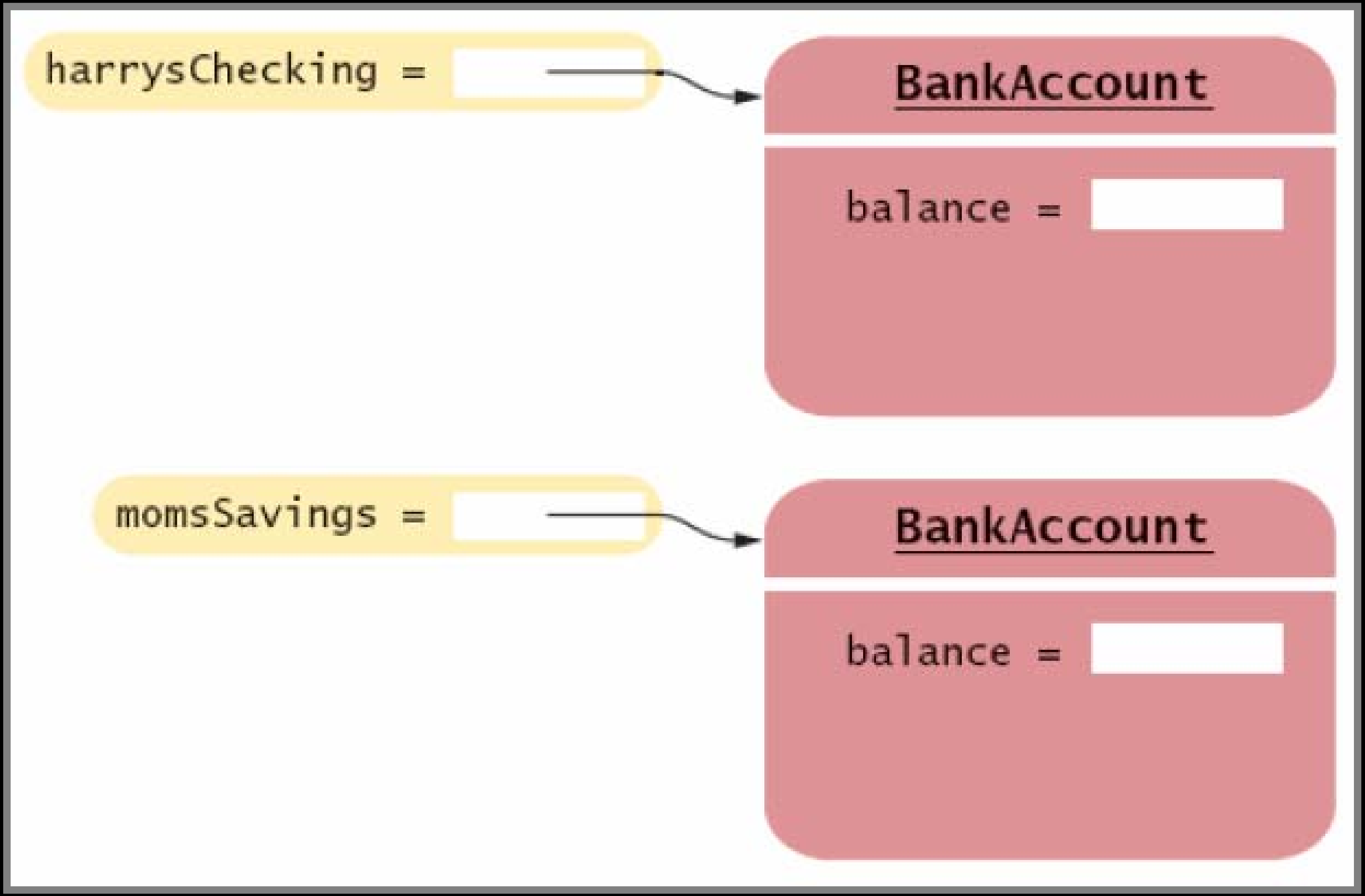


Figure 5:
Instance Fields

Syntax 3.4: Instance Field Declaration

```
 accessSpecifier class ClassName
{
   . . .
   accessSpecifier fieldType fieldName;
   . . .
}
```

Example:

```
 public class BankAccount
 {
    . . .
    private double balance;
    . . .
 }
```

Purpose:

To define a field that is present in every object of a class

Accessing Instance Fields

- **The deposit method of the `BankAccount` class can access the `private` instance field:**

```
public void deposit(double amount)
{
   double newBalance = balance + amount;
   balance = newBalance;
}
```

Continued…

Accessing Instance Fields

- **Other methods cannot:**

```
public class BankRobber
{
   public static void main(String[] args)
   {
     BankAccount momsSavings = new BankAccount(1000);
     . . .
     momsSavings.balance = -1000; // ERROR
   }
}
```

- **Encapsulation = Hiding data and providing access through methods**

Self Check

1. Suppose we modify the `BankAccount` class so that each bank account has an account number. How does this change affect the instance fields?
2. What are the instance fields of the `Rectangle` class?

Answers

1. An instance field

```
private int accountNumber;
```

needs to be added to the class

2.

```
private int x;
private int y;
private int width;
private int height;
```

Implementing Constructors

- Constructors contain instructions to initialize the instance fields of an object

```
public BankAccount()
{
   balance = 0;
}
public BankAccount(double initialBalance)
{
   balance = initialBalance;
}
```

Constructor Call Example

-
  ```
  BankAccount harrysChecking = new BankAccount(1000);
  ```
  - Create a new object of type `BankAccount`
  - Call the second constructor (since a construction parameter is supplied)
  - Set the parameter variable `initialBalance` to 1000
  - Set the `balance` instance field of the newly created object to `initialBalance`
  - Return an object reference, that is, the memory location of the object, as the value of the `new` expression
  - Store that object reference in the `harrysChecking` variable

Implementing Methods

- Some methods do not return a value

```
public void withdraw(double amount)
{
   double newBalance = balance - amount;
   balance = newBalance;
}
```

- Some methods return an output value

```
public double getBalance()
{
   return balance;
}
```

Method Call Example

-
  ```
  harrysChecking.deposit(500);
  ```
  - Set the parameter variable `amount` to 500
  - Fetch the `balance` field of the object whose location is stored in `harrysChecking`
  - Add the value of `amount` to `balance` and store the result in the variable `newBalance`
  - Store the value of `newBalance` in the `balance` `instance` field, overwriting the old value

Syntax 3.5: The `return` Statement

```
 return expression;
```
or
```
return;
```

Example:
```
 return balance;
```

Purpose:

To specify the value that a method returns, and exit the method immediately. The return value becomes the value of the method call expression.

File BankAccount.java

```java
/**
   A bank account has a balance that can be changed by
   deposits and withdrawals.
*/
public class BankAccount
{
   /**
      Constructs a bank account with a zero balance.
   */
   public BankAccount()
   {
      balance = 0;
   }

   /**
      Constructs a bank account with a given balance.
      @param initialBalance the initial balance
   */
```

Continued…

File BankAccount.java

```java
    public BankAccount(double initialBalance)
    {
       balance = initialBalance;
    }

    /**
       Deposits money into the bank account.
       @param amount the amount to deposit
    */
    public void deposit(double amount)
    {
       double newBalance = balance + amount;
       balance = newBalance;
    }

    /**
       Withdraws money from the bank account.
       @param amount the amount to withdraw
```

Continued…

File BankAccount.java

```
   */
   public void withdraw(double amount)
   {
      double newBalance = balance - amount;
      balance = newBalance;
   }

   /**
      Gets the current balance of the bank account.
      @return the current balance
   */
   public double getBalance()
   {
      return balance;
   }

   private double balance;
}
```

Self Check

1. How is the `getWidth` method of the `Rectangle` class implemented?
2. How is the `translate` method of the `Rectangle` class implemented?

Answers

1.
```
public int getWidth()
{
   return width;
}
```

1. **There is more than one correct answer. One possible implementation is as follows:**

```
public void translate(int dx, int dy)
{
   int newx = x + dx;
   x = newx;
   int newy = y + dy;
   y = newy;
}
```

Testing a Class with JUnit

- Import Junit TestCase and Assert classes
- Wite a testing subclass of TestCase
- Create testing objects in setUp() method
- Cleanup code in tearDown() method
- Write one method for each test
- Run testing class as Junit from Eclipse

Continued…

Testing a Class with JUnit

```
import junit.framework.Assert;
import junit.framework.TestCase;

public class BankAccountTest extends TestCase {
   private BankAccount account1;
   private BankAccount account2;
   protected void setUp(){
      account1 = new BankAccount();
      account2 = new BankAccount(0);
   }
   protected void tearDown(){
      // No cleanup needed
   }
```

Continued…

Testing a Class with JUnit

```
    public void testConstructors() {
       Assert.assertTrue((0.0 == account1.getBalance())
       Assert.assertTrue(account1.getBalance() ==
                                account2.getBalance());
    }
    public void testDeposit() {
       account1.deposit(100.00);
       Assert.assertTrue(account1.getBalance() == 100.00);
    }

    // ... More tests here
}
```

Continued…

Systematic Testing Principles

- Test incrementally
- Test each module independently
- Test from simple to complex modules
- Know what output to expect
- Verify boudary cases
- Verify conservation properties of methods
- Incrementally build a test suite
- Re-run test suite after every code change

Categories of Variables

- **Categories of variables**
  - Instance fields (`balance` in `BankAccount`)
  - Local variables (`newBalance` in `deposit` method)
  - Parameter variables (`amount` in `deposit` method)
- **An instance field belongs to an object**
- **The fields stay alive until no method uses the object any longer**

Categories of Variables

- In Java, the *garbage collector* periodically reclaims objects when they are no longer used
- Local and parameter variables belong to a method
- Instance fields are initialized to a default value, but you must initialize local variables

Lifetime of Variables

```
harrysChecking.deposit(500);
double newBalance = balance + amount;
balance = newBalance;
```

- **Objects live until no longer “referred to”**
- **Local and parameter variables die when method ends**
- **Instance fields live until object dies**

Continued…

Lifetime of Variables

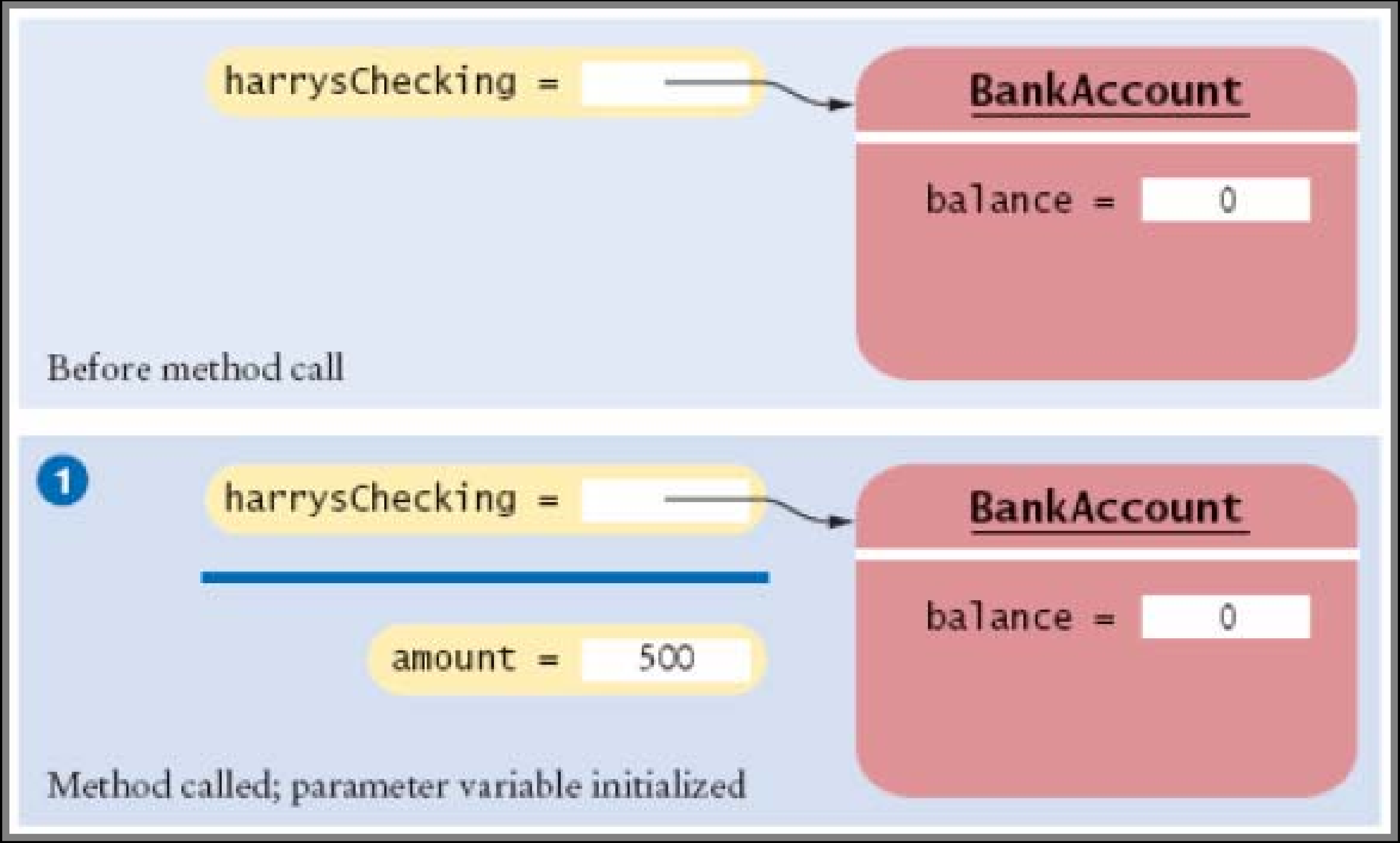


Figure 7:
Lifetime of Variables

Continued…

Lifetime of Variables

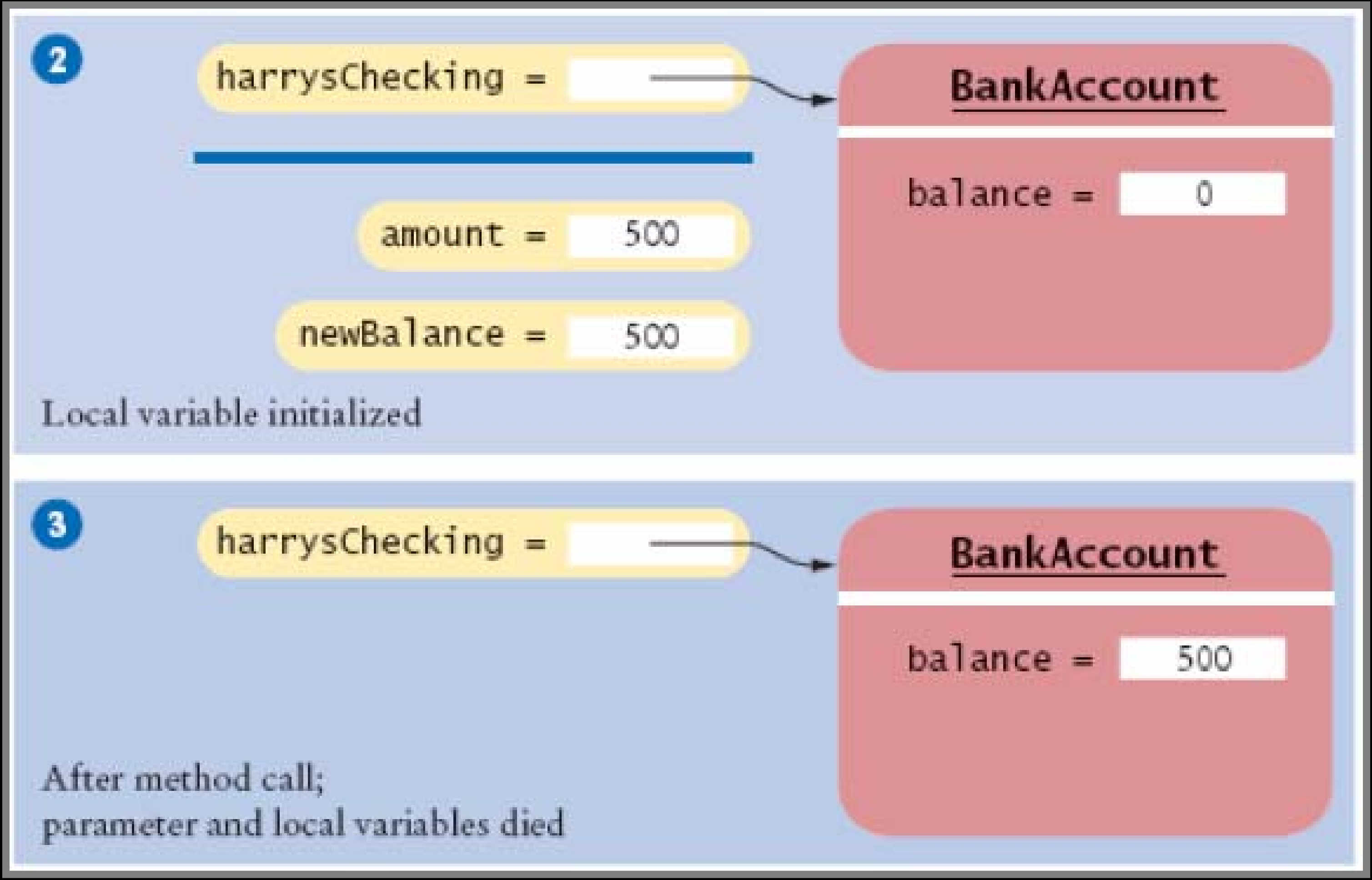


Figure 7:
Lifetime of Variables

Self Check

1. What do local variables and parameter variables have in common? In which essential aspect do they differ?

Answers

1. **Variables of both categories belong to methods–they come alive when the method is called, and they die when the method exits. They differ in their initialization. Parameter variables are initialized with the call values; local variables must be explicitly initialized.**

Continued…

Implicit and Explicit Method Parameters

- The implicit parameter of a method is the target object on which the method is invoked
- The `this` reference denotes the implicit parameter

Implicit and Explicit Method Parameters

- **Use of an instance field name in a method denotes the instance field of the implicit parameter**

```
public void withdraw(double amount)
{
   double newBalance = balance - amount;
   balance = newBalance;
}
```

Implicit and Explicit Method Parameters

- **`balance` is the balance of the target object to the left of the dot:**

```
momsSavings.withdraw(500)
```

means

```
double newBalance = momsSavings.balance - amount;
momsSavings.balance = newBalance;
```

Implicit Parameters and `this`

- Every method has one implicit parameter
- The implicit parameter is always called `this`
- Exception: Static methods do not have an implicit parameter (more on Chapter 9)

```
double newBalance = balance + amount;
// actually means
double newBalance = this.balance + amount;
```

Implicit Parameters and `this`

- When you refer to an instance field in a method, the compiler automatically applies it to the `this` parameter

```
momsSavings.deposit(500);
```

Implicit Parameters and `this`

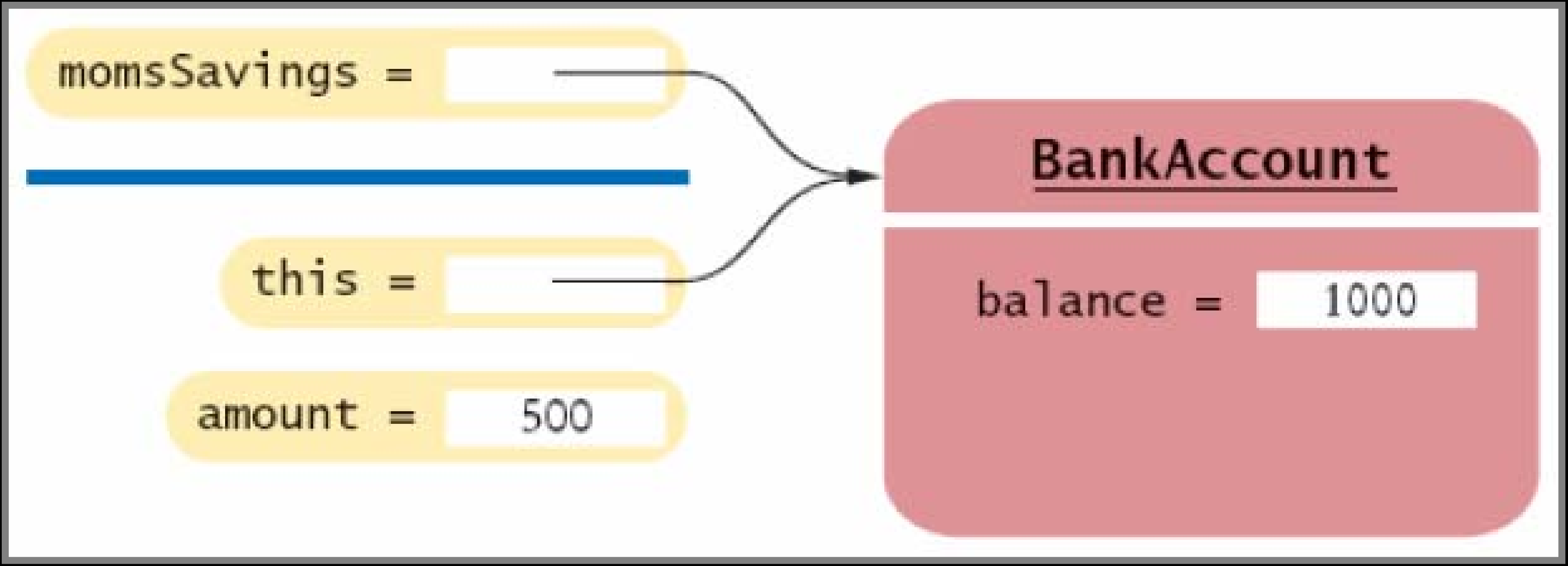


Figure 8:
The Implicit Parameter of a Method Call

Self Check

1. How many implicit and explicit parameters does the `withdraw` method of the `BankAccount` class have, and what are their names and types?
2. In the `deposit` method, what is the meaning of `this.amount`? Or, if the expression has no meaning, why not?
3. How many implicit and explicit parameters does the main method of the `BankAccountTester` class have, and what are they called?

Answers

1. One implicit parameter, called `this`, of type `BankAccount`, and one explicit parameter, called `amount`, of type `double`.
2. It is not a legal expression. this is of type `BankAccount` and the `BankAccount` class has no field named `amount`.
3. No implicit parameter–the method is static–and one explicit parameter, called `args`.

Electronic Voting Machines

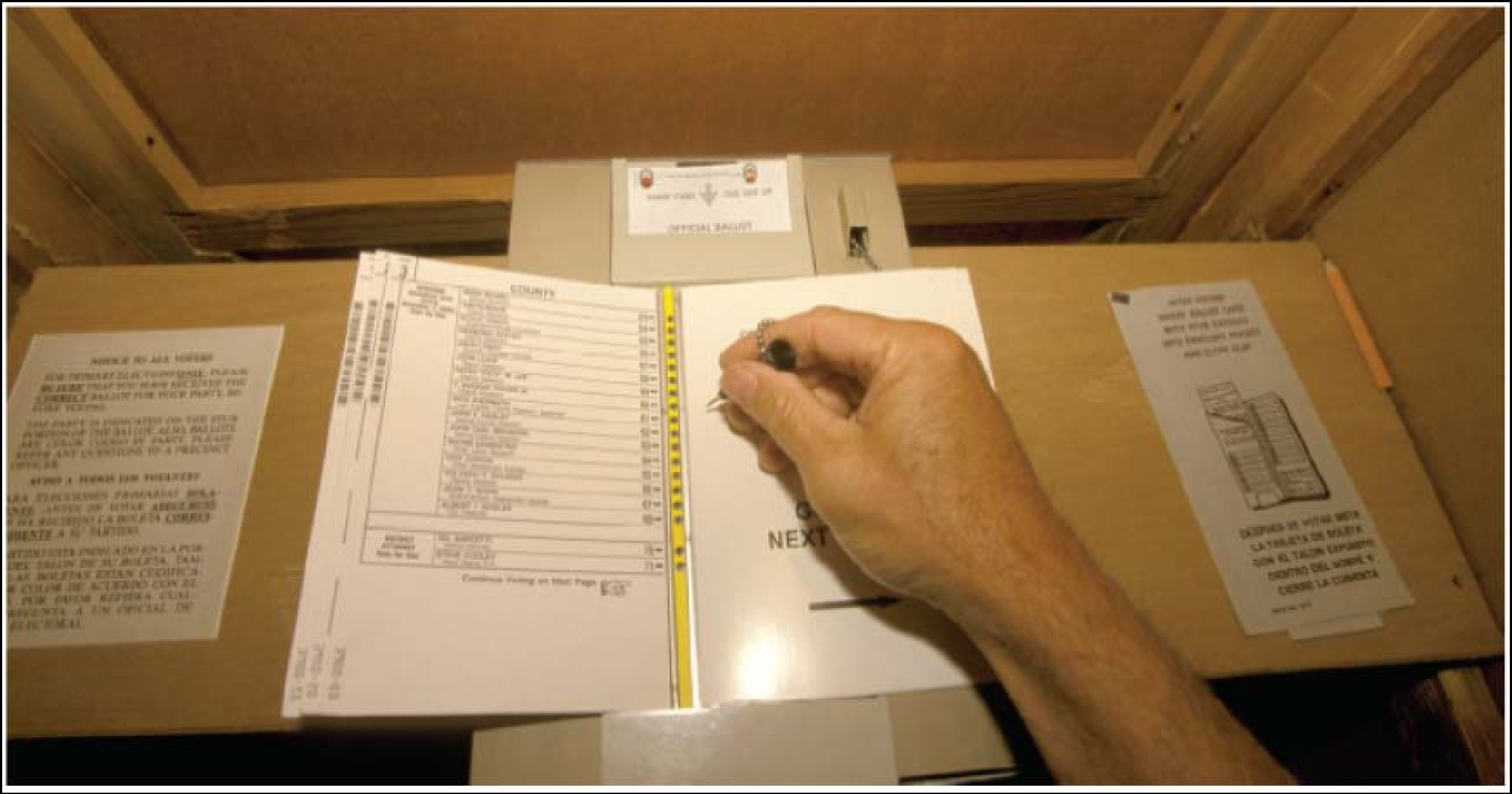


Figure 9:
Punch Card Ballot

Electronic Voting Machines

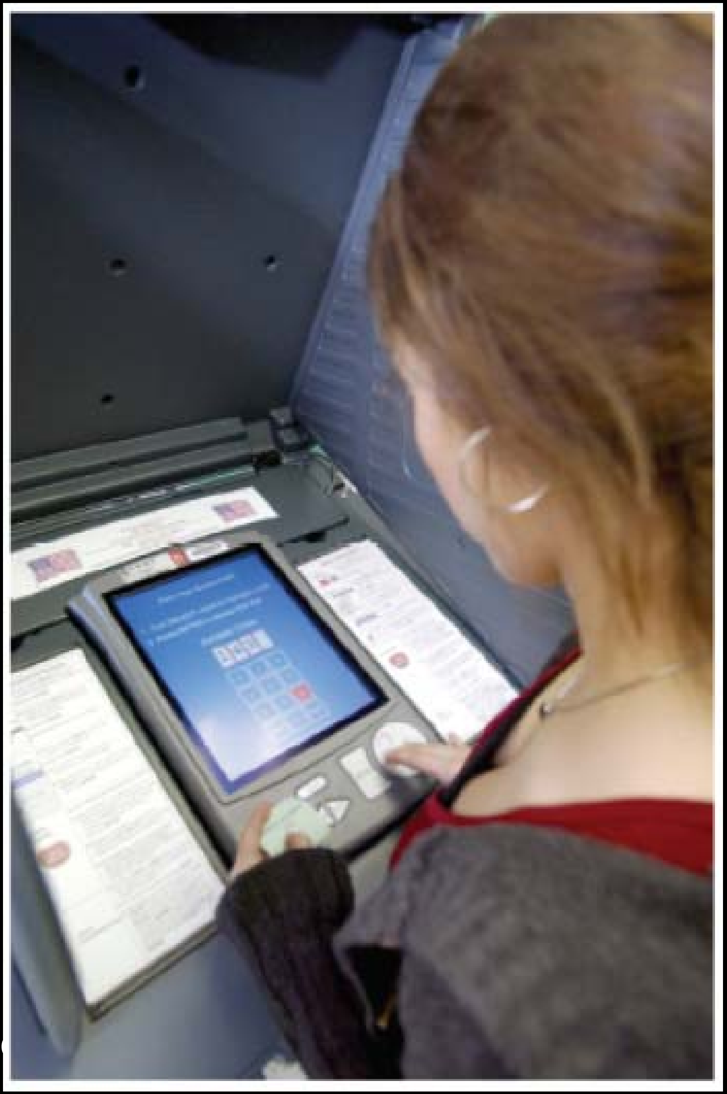


Figure 10:
Touch Screen Voting Machine