Tutorial

Object-Oriented Concepts for Distributed Systems I (OODS I)

Part I: Java

1 Organization

A.1 Part I: Java

- Java language, Packages, Applets and Applications
- Inheritance, Interfaces, Inner Classes, Abstract Classes, Final Classes and Methods, Exceptions
- AWT, Threads

A Organization

A.1 Part II: Distributed Programming

- Streams, Sockets
- Serialization, Classloader
- RMI
- ORB

A Organization

A.1 Part III: CORBA

- ...

A Organization

A.1 Part IV: Jini

- ...

A Organization

- You don’t have to hand in programming assignments that are labeled with "0 points" (e.g., assignment 1).
- We will reserve part of the CIP pool for OODS.
- A tutor will answer your questions and help you with the practical programming work in the CIP pool.

2 Overview of Todays Tutorial

- Introduction to the Java System and Language
  - Java vs. C
  - Classes and Objects
  - Methods and Constructors
  - Packages
  - Encapsulation
- Applets and Applications

3 What's Java all about?

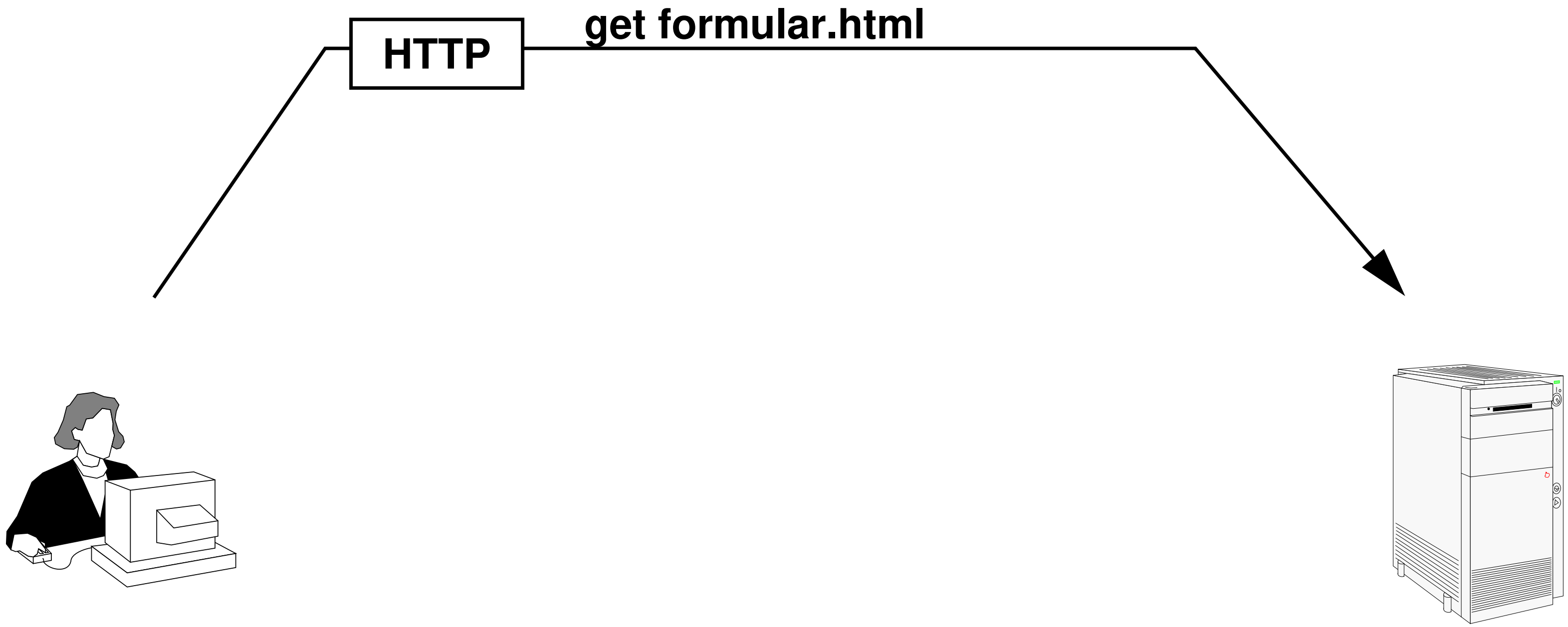
◆ At first sight:

- a language to create cool animations for web pages

3.1 ... but more importantly

- an object-oriented language which is
  - simple
  - portable
  - robust
- a secure run-time system
  - execute arbitrary programs without any risk of damages
  - control access to local resources (e.g. files) and to the network

3.2 Java and the World Wide Web



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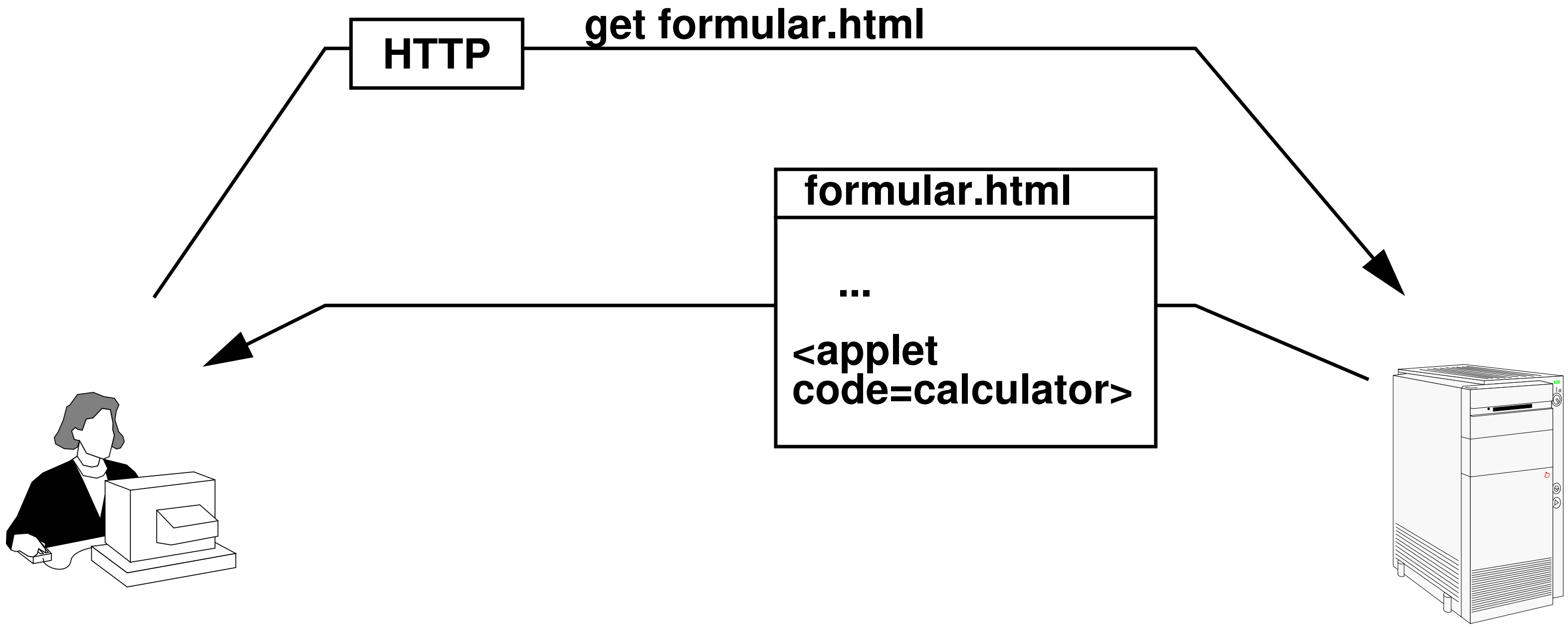

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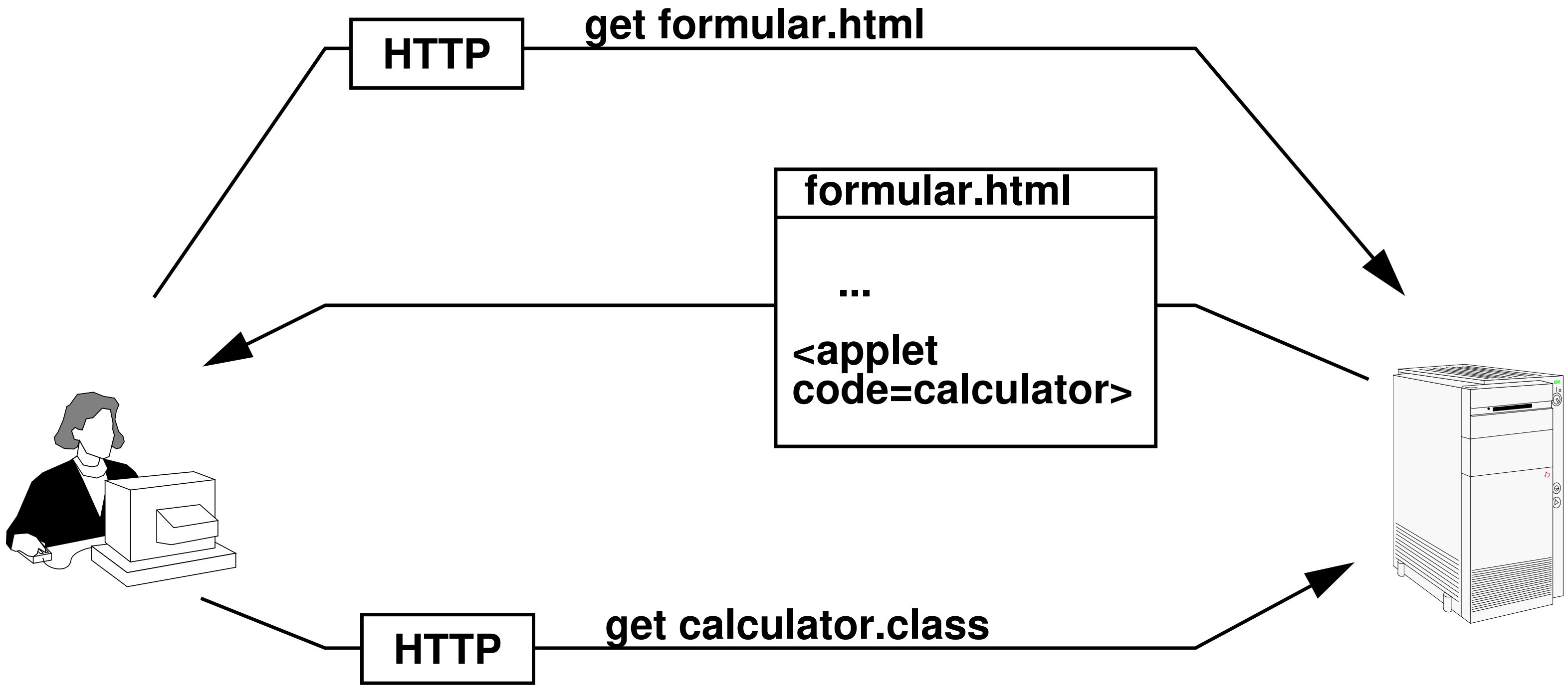

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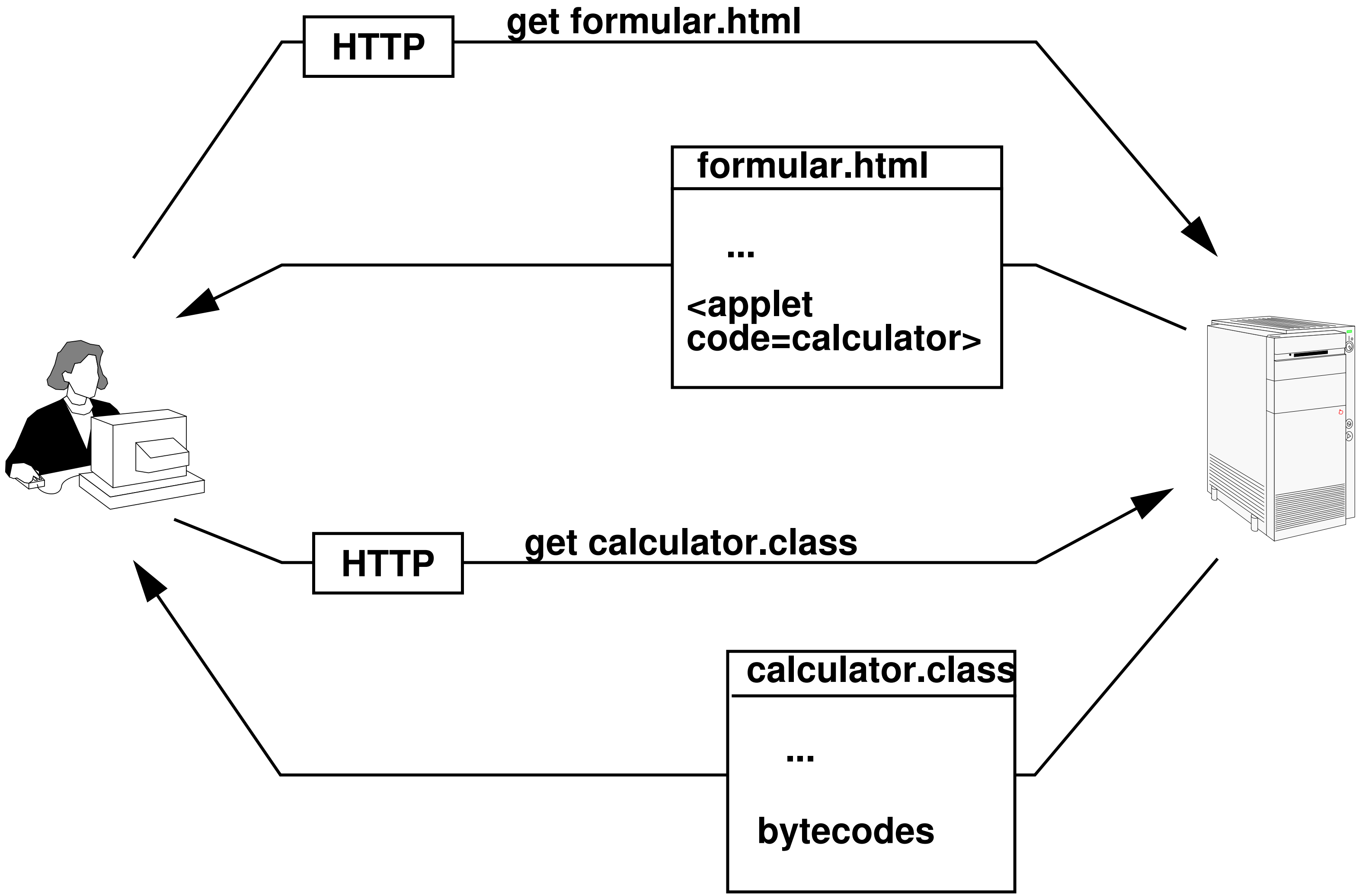
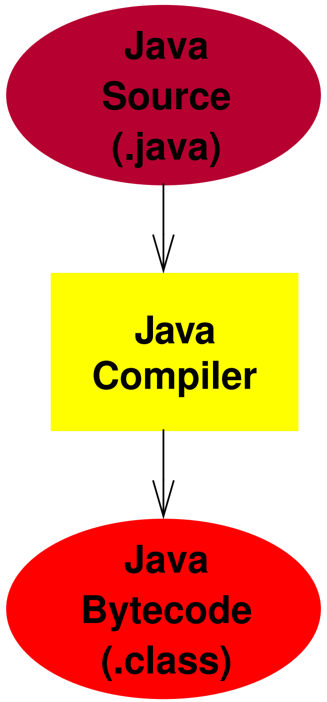
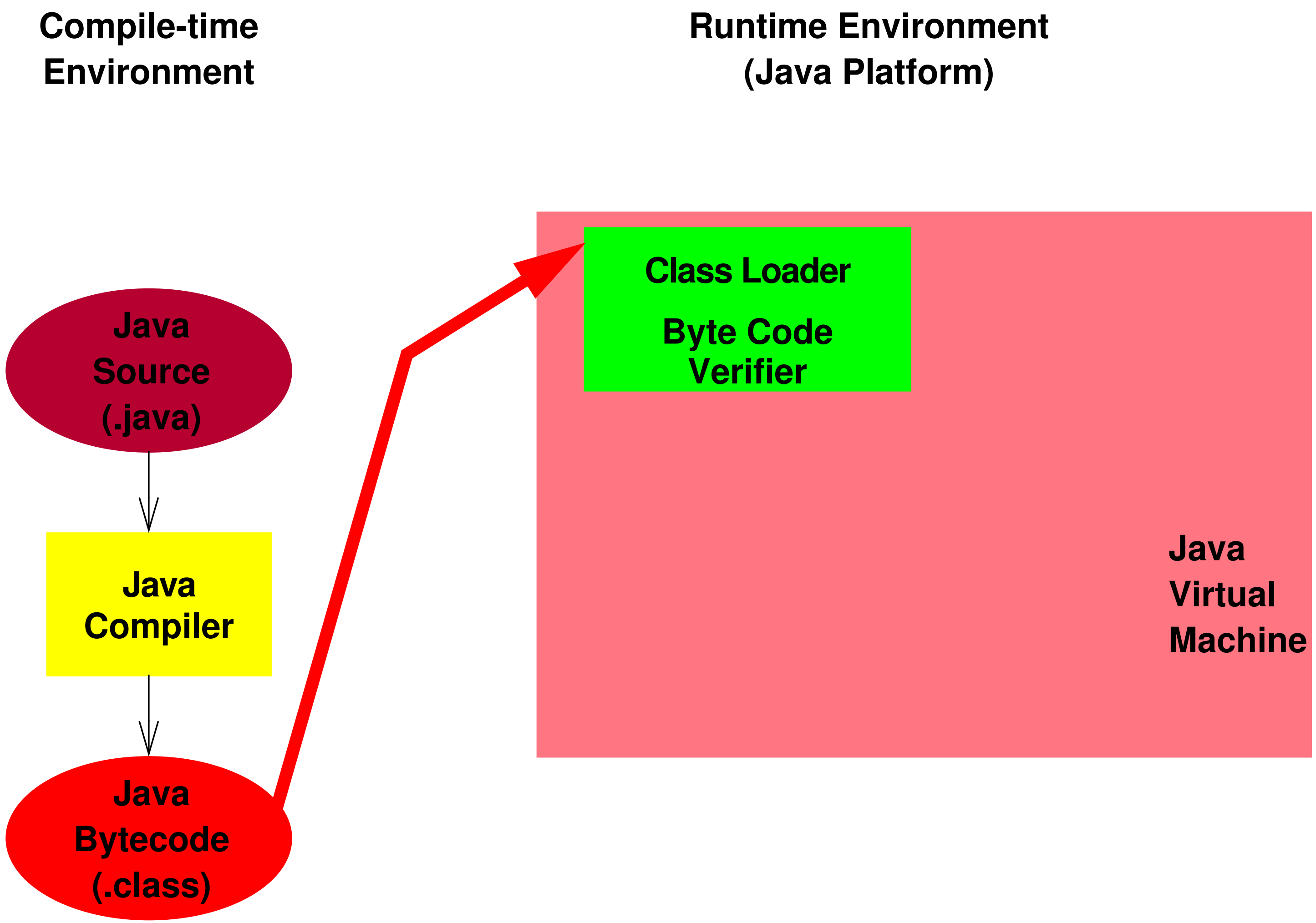


3.3 The Java System

Compile-time Environment



The Java System



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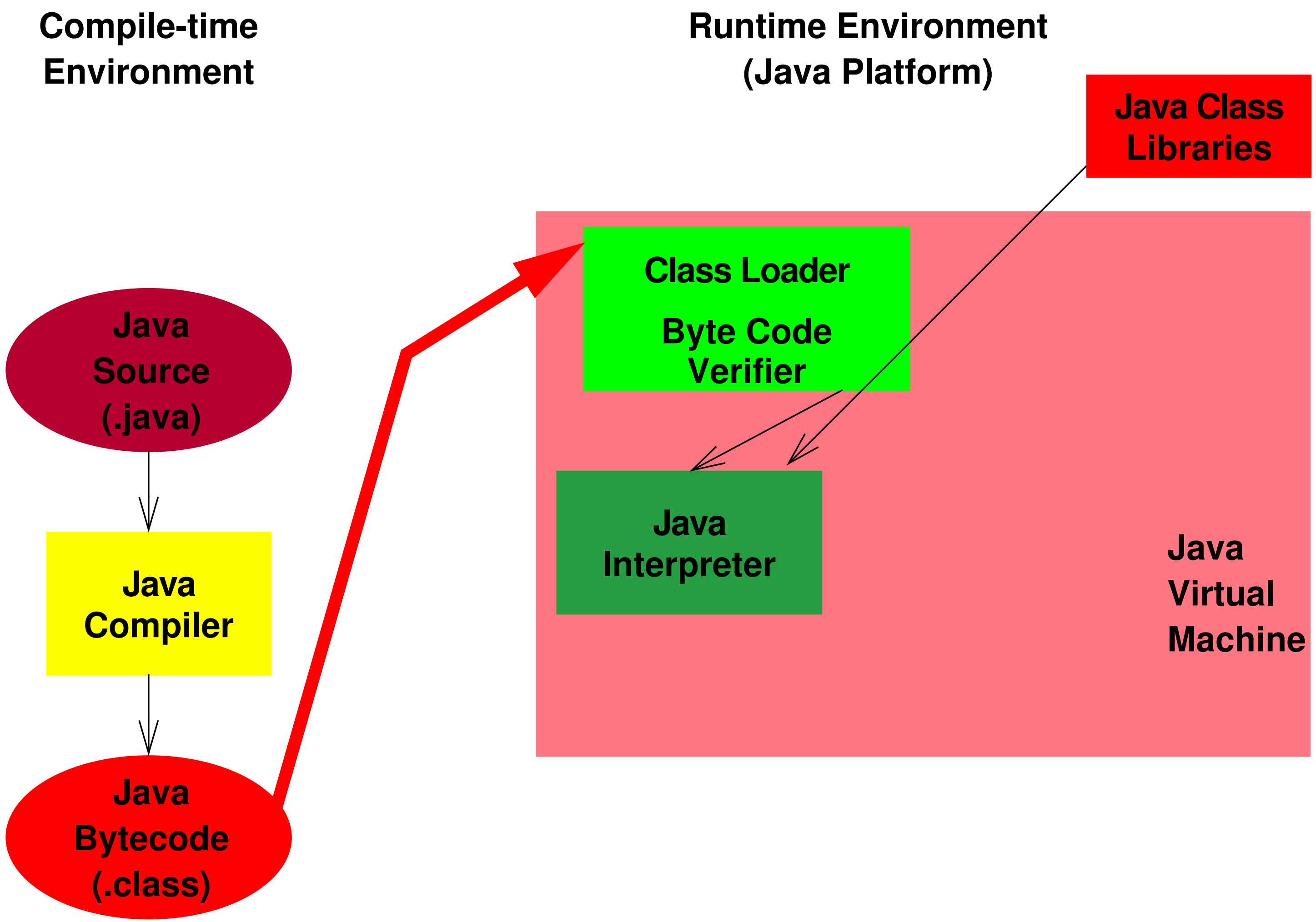
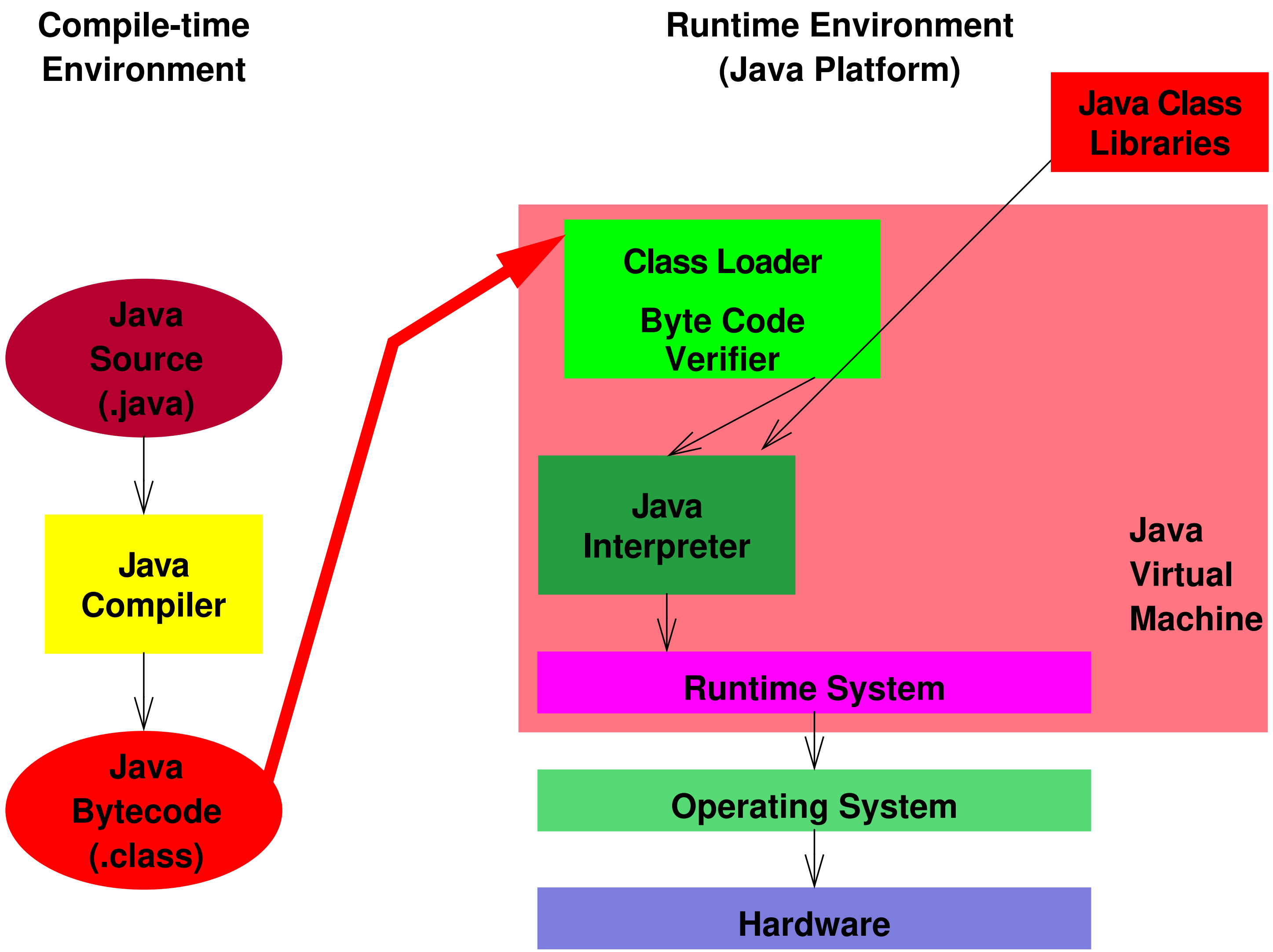


The Java System



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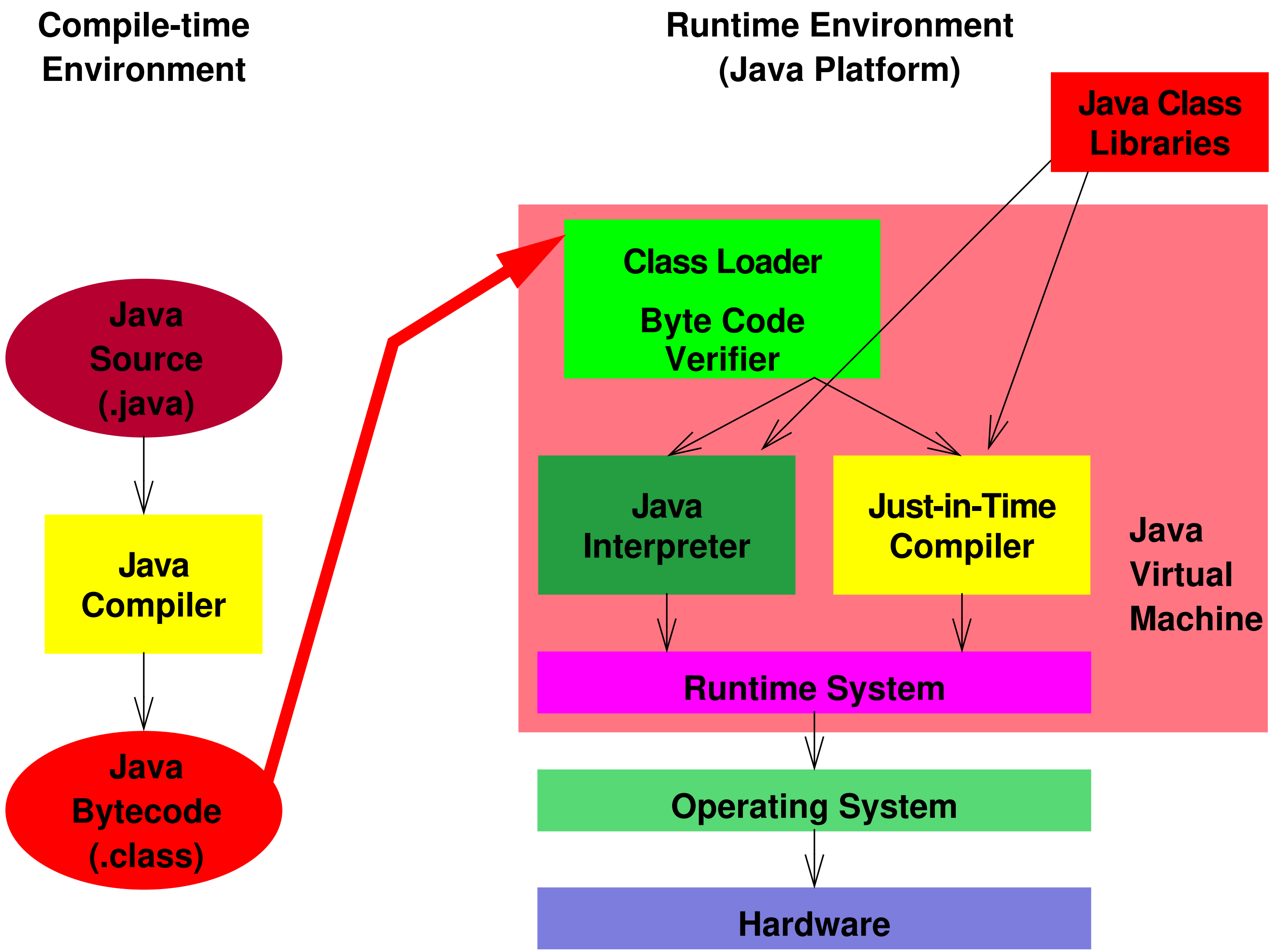


4

Java vs. C/C++

- no pre-processor (#define)
- no typedef, union, enum, struct
- no pointer arithmetic
- no functions or procedures
- no global variables

4.1 Data types

- Primitive data types:
  - byte, short, int, long (8/16/32/64 bit)
  - float, double (32/64 bit)
  - char (Unicode, 16 bit)
  - boolean (true, false)
  - "ordinary" operators: +,-,+=,<<,...

- Differences to C:
  - no "unsigned"
  - special "boolean" type and Unicode-char type
  - no **`while (x--)`**, use **`while (x-- != 0)`**
  - no **`if (ptr)`**, use **`if (ptr != null)`**

4.2 Comments

- one line comment

```
// this is a comment
```

- multi-line comment

```
/* This comment
 * uses multiple
 * lines.
 */
```

- documentation comment (generate docs with the **`javadoc`** tool)

```
/** This comment
 *  contains program
 *  documentation.
 */
```

4.3 Control structures

- Control structures as in C:
  - for (... ; ... ; ...) { ... }
  - while (...) { ... }   or   do { ... } while (...);
  - switch (...) { case .... }
  - if ....
  - return, break, continue

- Differences to C:
  - no goto
  - labelled break und continue:

```
outerloop: for ( .... ) { // this is "outerloop"
    while ( .... ) {
        if ( ... ) break outerloop;// leave outerloop
    }
}
```

4.4 Strings

- Good support for string handling
- Data type **`String`**

```
String hello = "Hello";
```

- Concatenation with "+"

```
String world = "World";
String greeting = hello + " " + world + "!";
System.out.println(greeting);
```

Output:

Hello World!

4.4 Strings (2)

- Concatanation works also with int ,float,...

```
String test = "Result: " + (2 + 3);
```

Contents of test: "**`Result: 5`**"

- **Important: Strings are constant.**

5 Arrays

- Declaration with ***`type`* `name[]`** or ***`type`* `[] name`**
- Allocation with **`new`**, no free neccessary (garbage collector)

```
int numbers[] = new int[100];
```

- Element access as in in C: **`name[index]`**

```
for (int n=0; n<100; n++) numbers[n] = n;
```

- Atomatic range checking

5.1 Arrays (2)

- Declaration und initialization

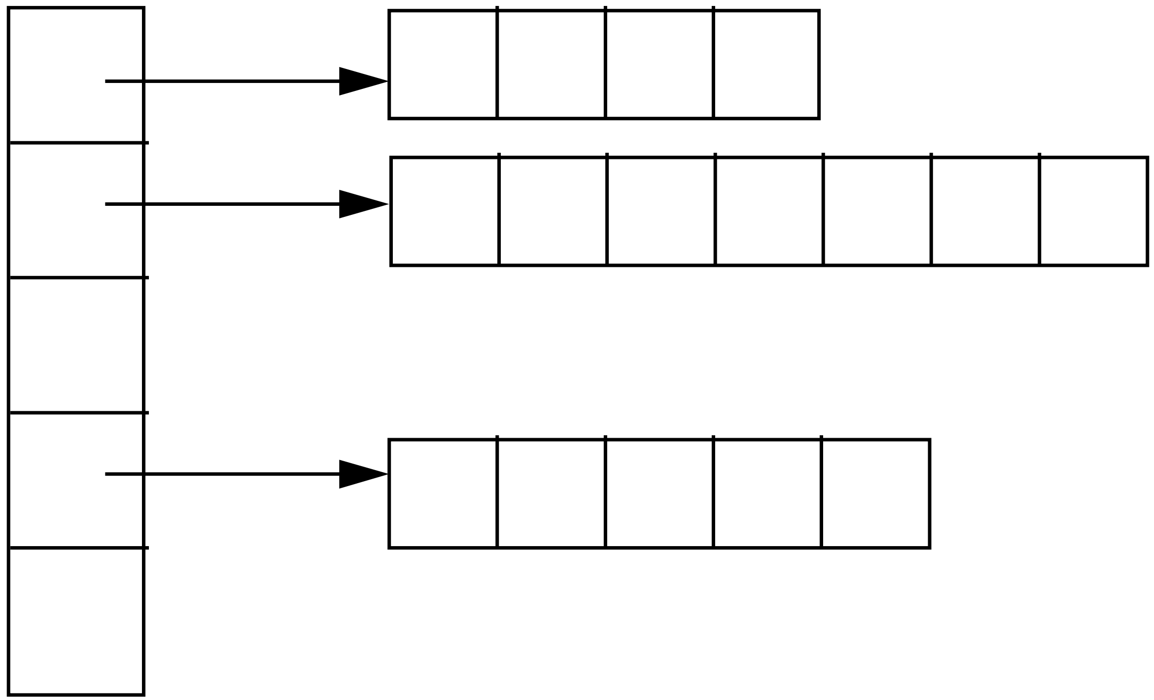
```
int [] firstPrimes = { 2, 3, 5, 7 };
```

- Access to array length with **`length`**

```
for(int i=0; i<firstPrimes.length; i++) {
    System.out.println(firstPrimes[i]);
}
```

5.2 Multi-Dimensional Arrays

- Array elements can be arrays



```
int [][] matrix = new int[5][4];
```

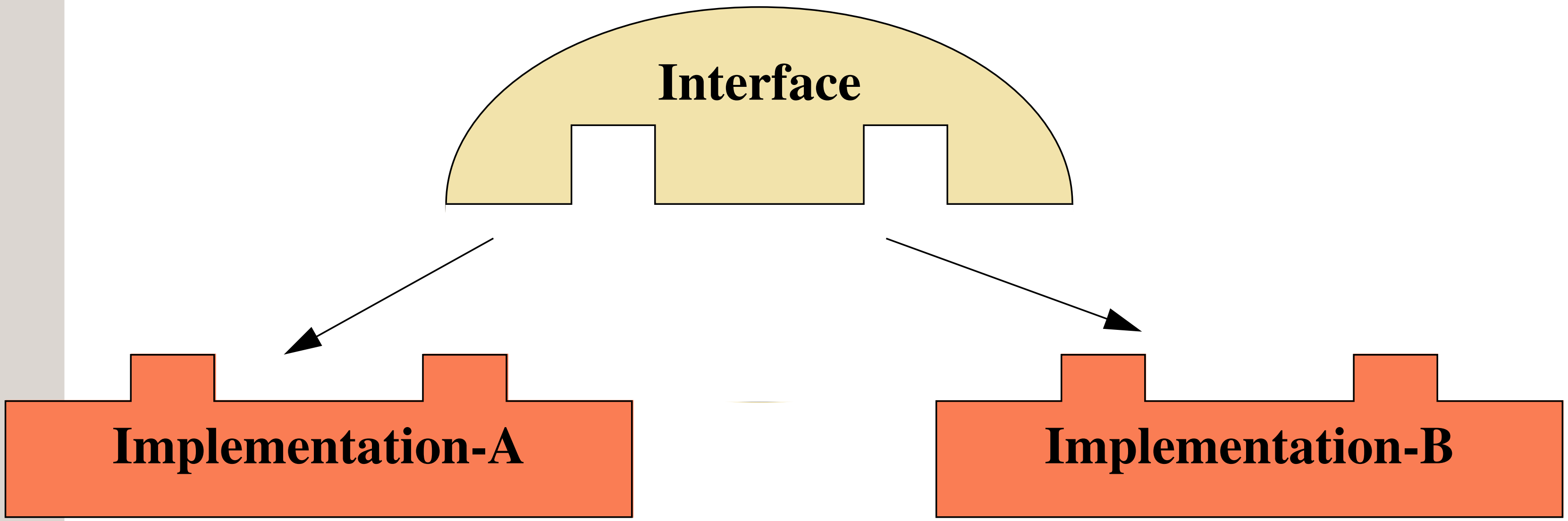
- fundamental concepts of object-oriented programming:

abstraction

encapsulation

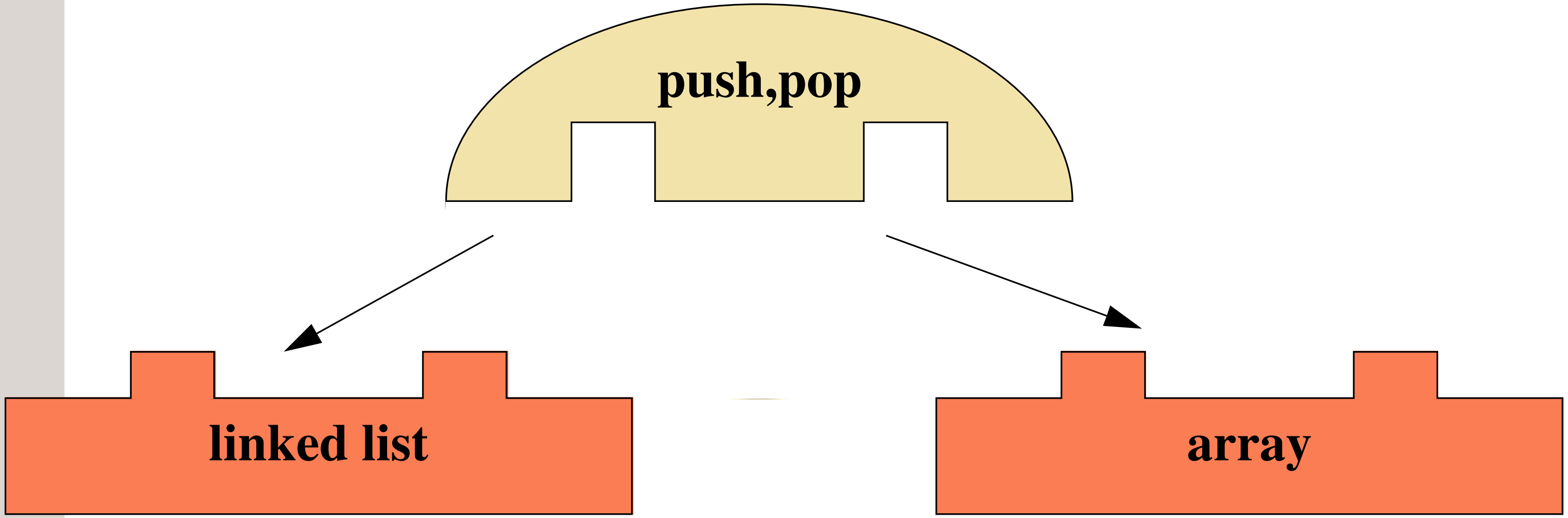
6.1 Abstraction

- Separation
  - interface (what can be done) and
  - implementation (how is it done)

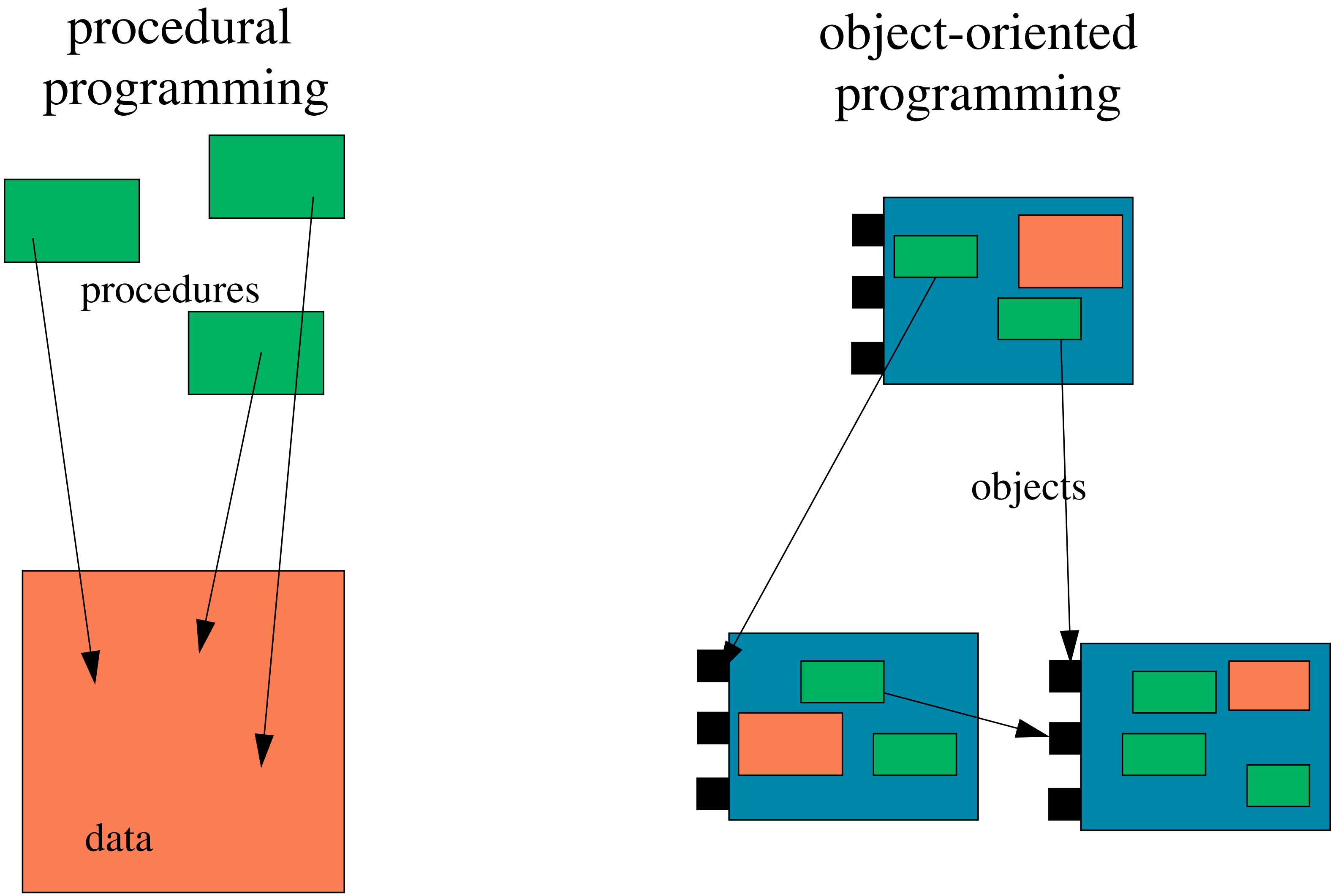


6.1 Abstraction

- Example: stack
  - interface: push, pop
  - implementation: linked list, array

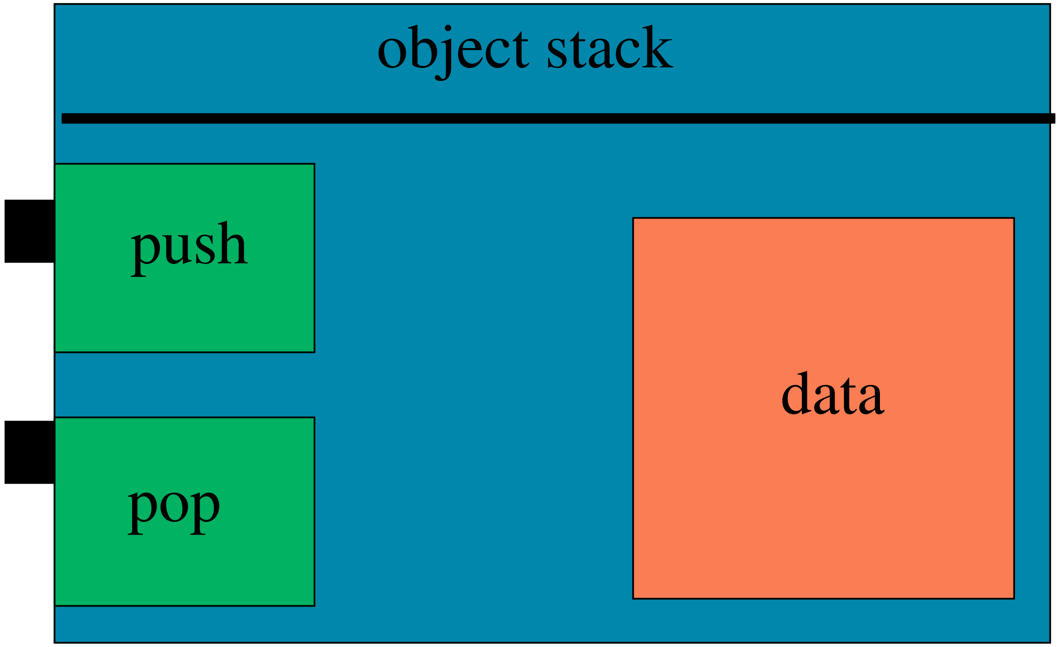


Encapsulation



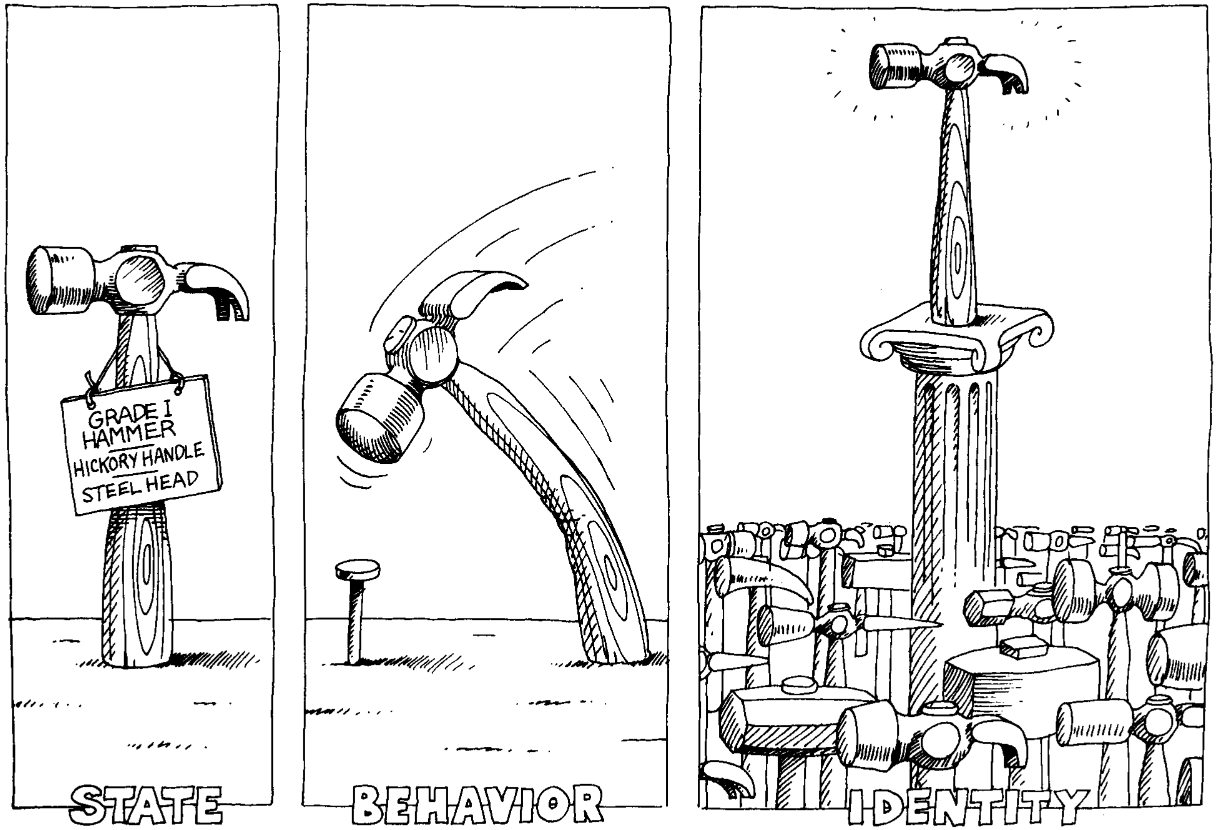
6.2 Encapsulation

- Objects: encapsulated data structure, consisting of
  - Data (instance variables, attributes)
  - Methods (operations)



- Encapsulation helps building abstractions

6.3 Properties of Objects



6.4 The Class

- objects are *instances* of a class
- the class determines internal structure and interface of the objects

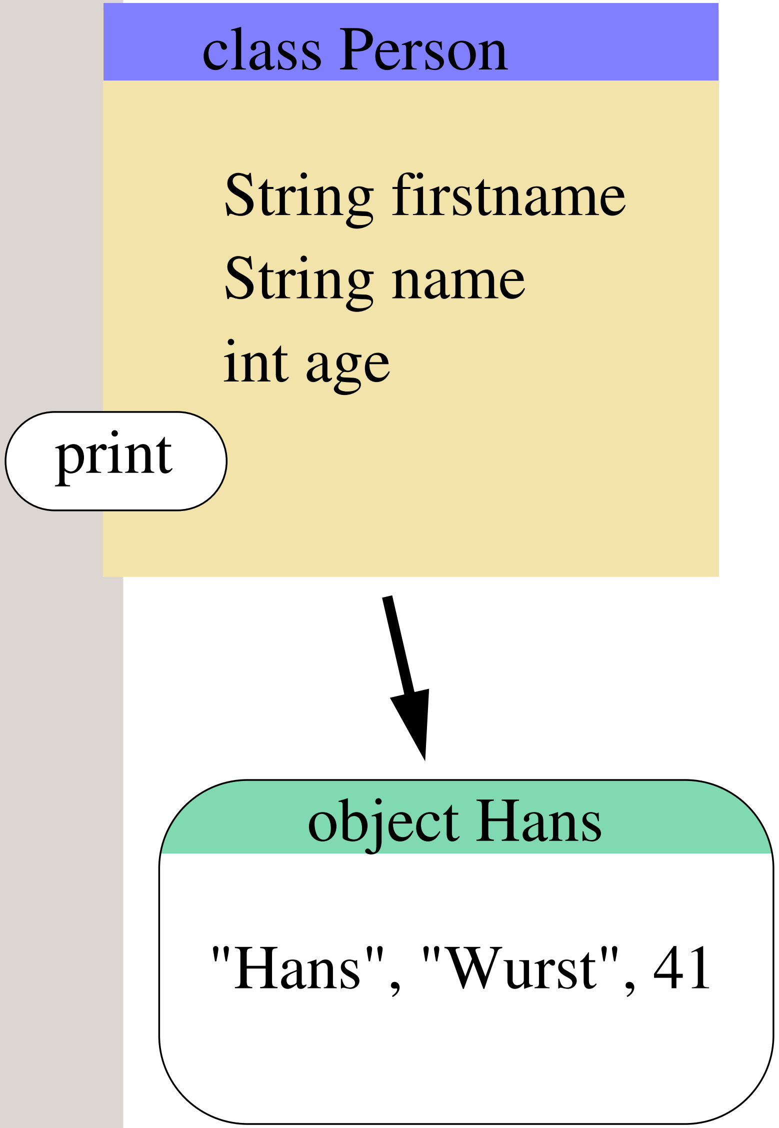
6.5 Class - Example

class Person

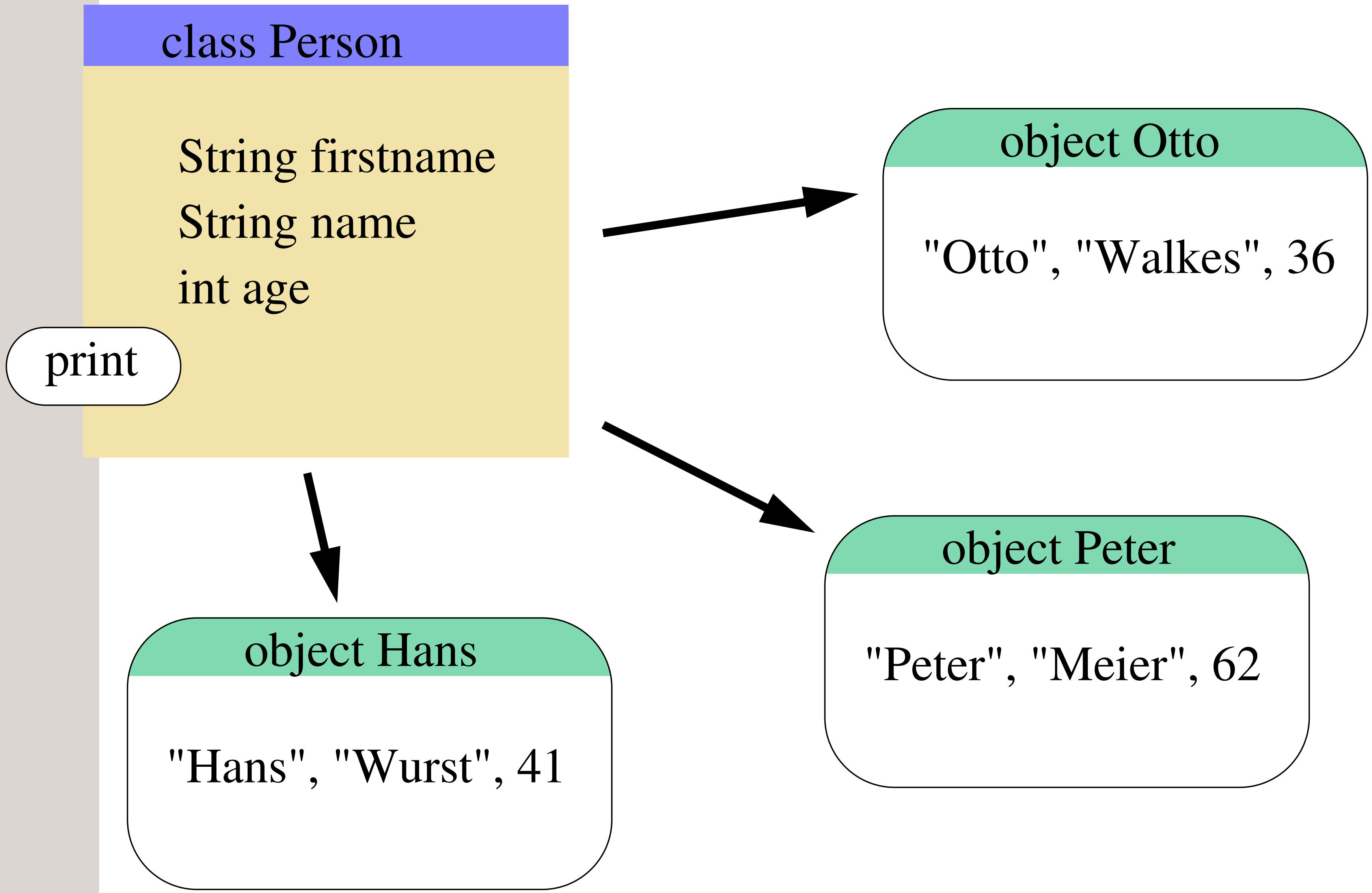
String firstname
String name
int age

print

Class - Example



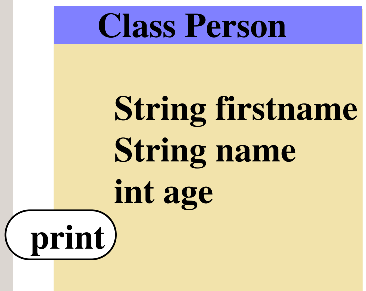
6.5 Class - Example



6.6 Class - Example

- Class definition

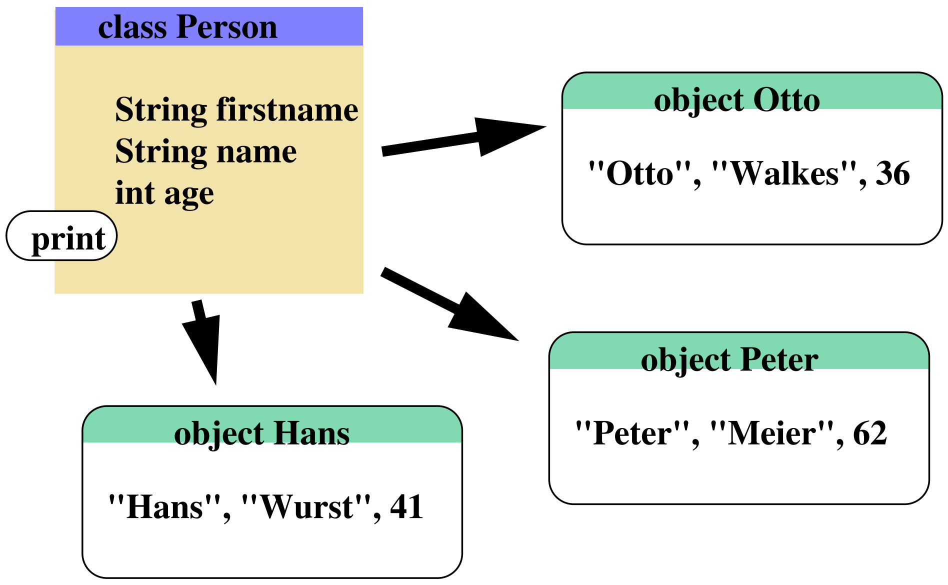
```
class Person {
    String firstname;
    String name;
    int age;
    void print() {
     System.out.println("Name:" + firstname + name +
                        "Age:" + age);
    }
}
```



6.7 Object creation

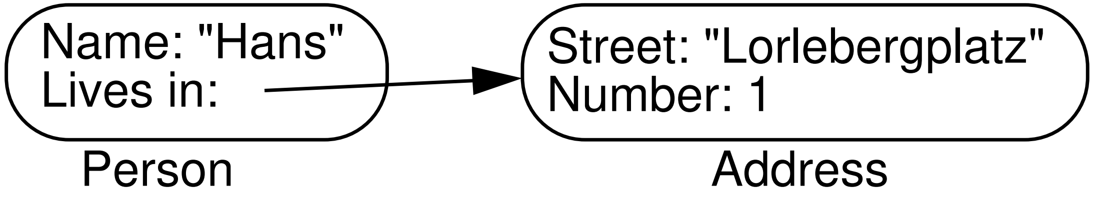
- object creation (instantiation)

```
Person otto = new Person();
otto.firstname = "Otto";
otto.name = "Walkes";
otto.age = 36;
otto.print();
```

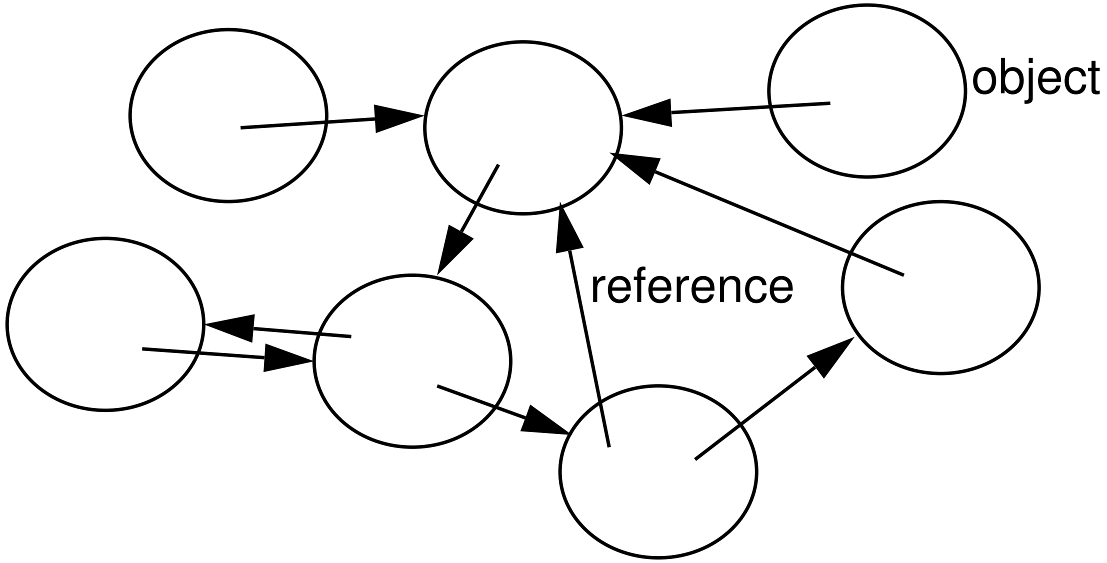


6.8 The object web

- objects can reference other objects
  - ◆ e.g. a person can reference an address



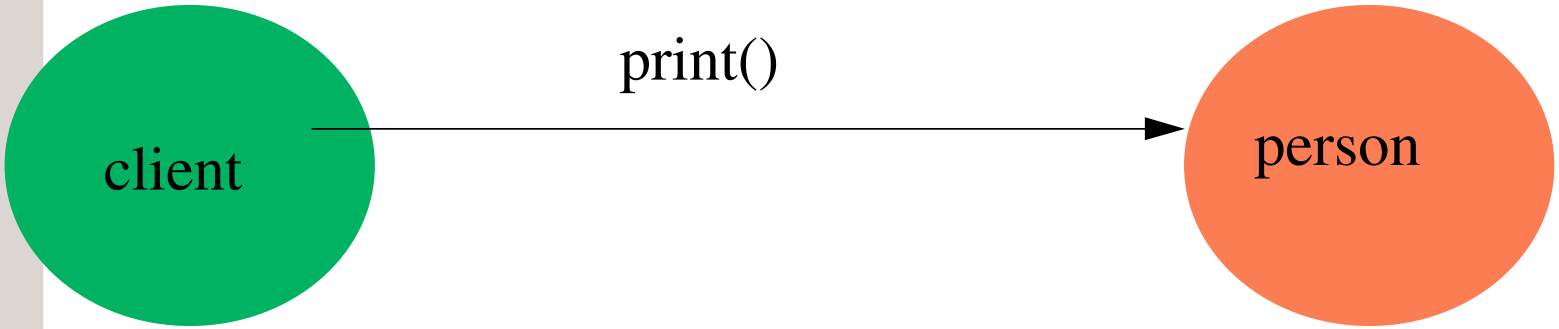
- snapshot of the state of an object-oriented program



6.9 Messages / Methods

- objects communicate through messages
  - ◆ object itself determines its behaviour
  - ◆ object semantics not spread over whole program
- message = method call at an object

```
person.print()
```



- object-oriented program: several objects are communicating to fulfill a specific task

7 Methods and Variables

- Method can access 3 different kinds of variables:
  - parameters (arguments)
  - local variables
  - instance variables

```
class Point {
   int xPosition, yPosition;
   ...
   void move(int x, int y) {
      int i;
      ...
   }
}
```

instance variables

parameters

local variables

7.1 Method-Call Semantics

- object parameters are passed by reference
- primitive types (int, float, etc.) are passed by value

```
void meth(int a, Person k)
    a = 5;
    k.setAge(25);
```

Variables

- Parameters and local variables must have different names
- Parameters and local variables hide instance variables

```
class Test {
    int a;
    void m(int a) {
        a = 5; // does not change instance variable a
    }
}
```

7.3 Variables

- Access to instance variable with
  - *instanceName.variableName*

```
class Person {
    String firstname;
    String name;
    int age;

    boolean sameName(Person otherPerson) {
        if (name == otherPerson.name) return true;
        return false;
    }
}
```

instance variable *instance variable*

7.4 The *this*-Parameter

- every method has an *implicit* parameter **`this`**
- **`this`**: reference to the message-receiver object

```
class Person {
    String name;
    ...
    void print() {
        System.out.println(this.name);
    }
}
```

- **`this`** can be omitted if there are no ambiguities
- Example ambiguity

```
class Person {
    ...
    boolean compare(String name) { return this.name == name; }
}
```

Object Initialization

- creating an object means reserving memory
- this memory must be initialized
- one possibility
  - calling an initialization method
  - bad, because error prone

8.1 Constructors

- initialize the object
- name of constructor = name of class
- are invoked automatically after object creation

8.1.1 Constructors - Example

- Initializing a Person with name and age

```
class Person {
    String name;
    int age;

    Person(String name, int age) {
        this.name = name;
        this.age = age;
    }
    ...
}
```

8.1.2 Constructors

- more than one constructor possible

```
class Person {
    String name;
    int age;

    Person(String name, int age) {
        this.name = name;
        this.age = age;
    }
    Person(String name) {
        this.name = name;
        this.age = 18;
    }
    ...
}
```

8.1.3 Constructors

- Invocation of a different constructor with **`this(...)`**

```
class Person {
    String name;
    int age;

    Person(String name, int age) {
        this.name = name;
        this.age = age;
    }
    Person(String name) {
        this(name,18);
    }
    ...
}
```

8.2 Direct Initialization

- Instance variables can be initialized directly

```
class Person {
    String name;
    int age = 18;
    ...
}
```

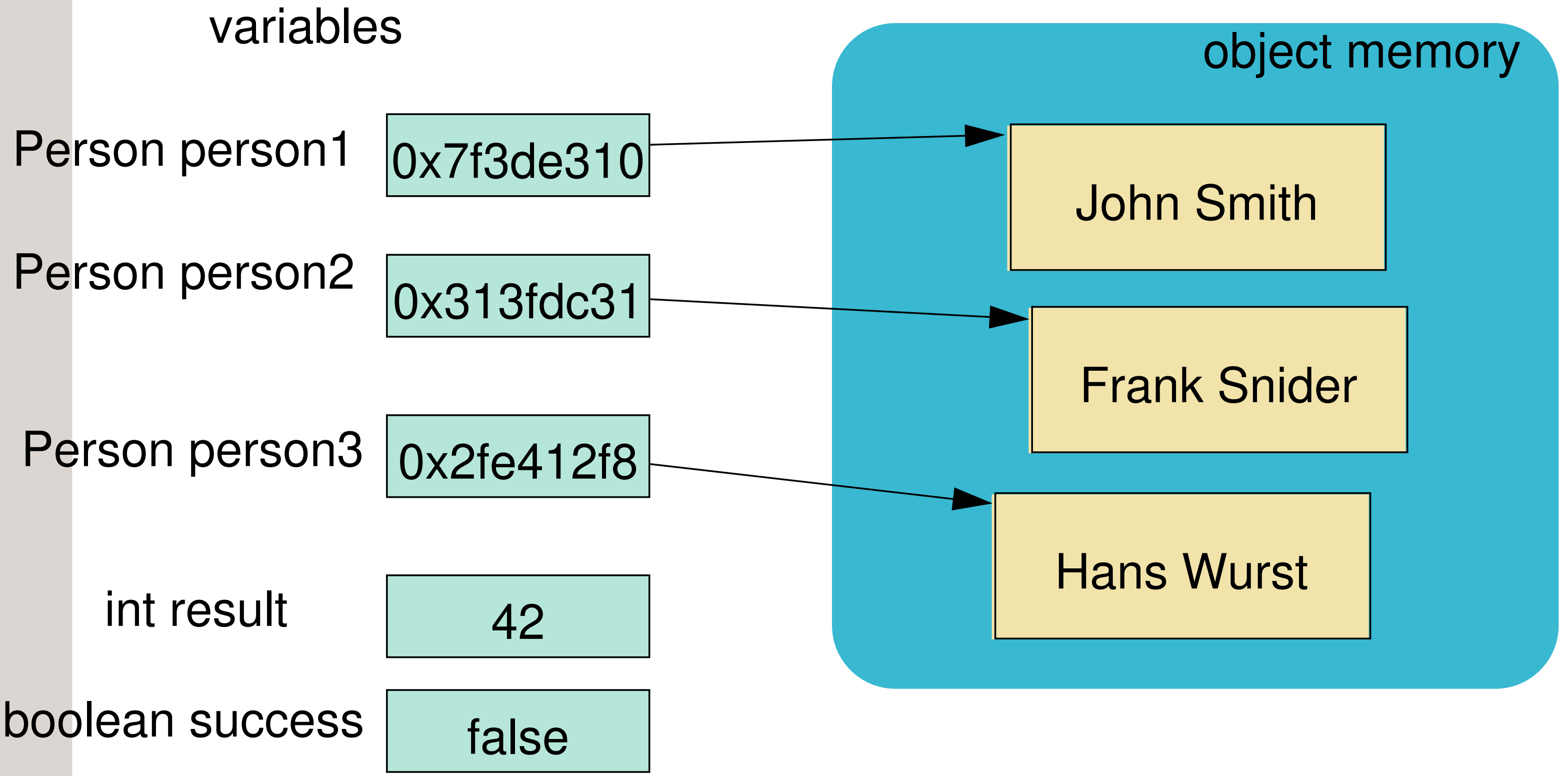
- Initialization is executed at the beginning of every constructor
- Initialization is done in the order of declaration
- Method calls are possible

```
class Customer {
    String name;
    int number = CustomerNumbers.createNew();
    ...
}
```

9 Objects and References

- Java variables do not name objects but references

```
Person p;   // declaration of a reference to an object
            // of class Person
p.print(); // error: method call at the null reference
```



9.1 Objects and References (2)

- = assignes a reference to a variable
- == compares two references
- a variable of primitive type can never be assigned a reference
- a variable of reference type can never be assigned a value of primitive type

```
Person p;   // declaration of a reference variable
int i=42;   // declaration and initialization of
            // a primitive type variable
p = i;      // error: assignment between reference and
            // primitive type
```

10 Equality and Identity

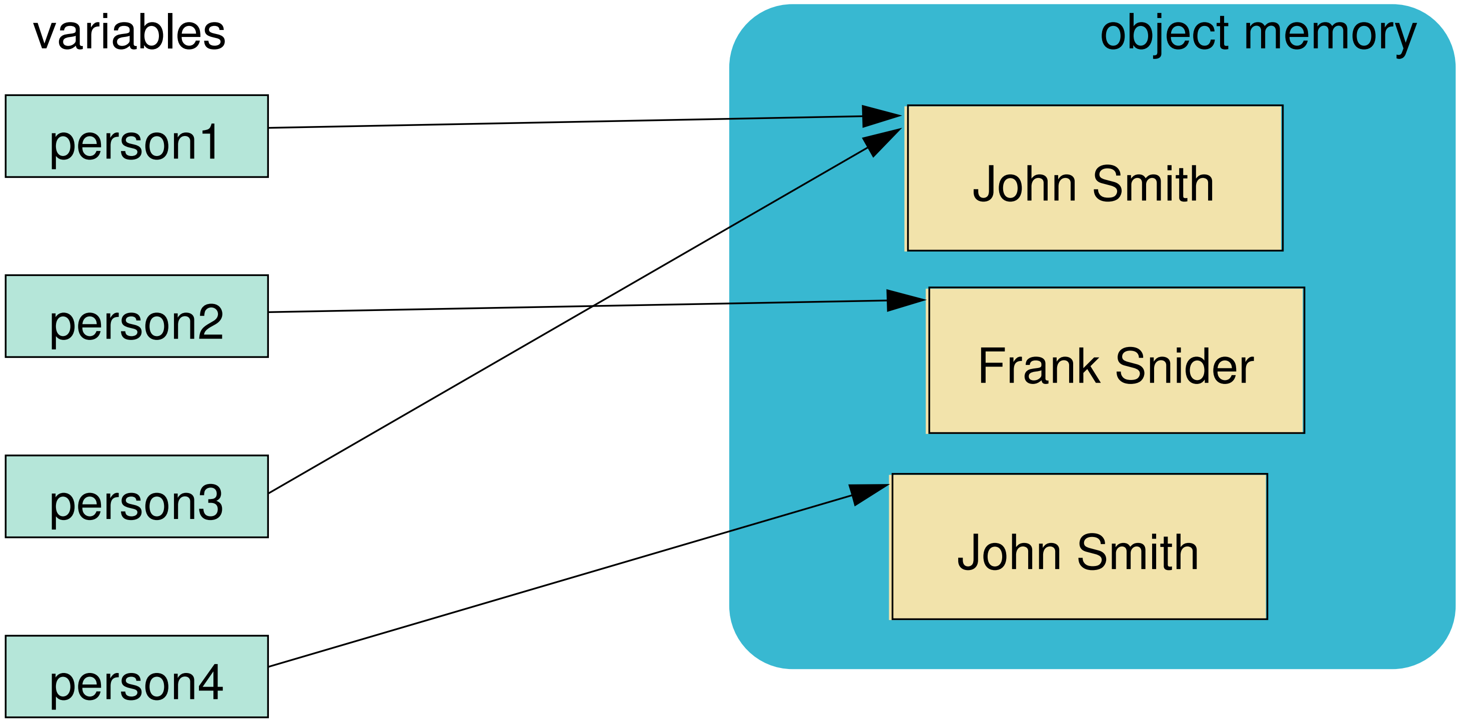
- there is a difference between *equal objects* and *identical objects*

```
class Date {
  int day,month,year;
  Date(int day, int month, int year) {
    this.day = day; this.month = month; this.year = year;
  }
}
...
Date d = new Date(1,3,98);
Date d1 = new Date(1,3,98);
Date d2 = d;
```

- d and d1 are equal
- d und d2 are identical

10.1 Identity and References

- Identity: same reference
- Equality: contents of referenced object is the same



- Which persons are identical, which are equal?

10.2 Test of Equality and Identity

- Identity can be tested using the == operator

```
if (d == d1) { ... }
```

- Equality can be tested calling the **`equals`** method

```
if (d.equals(d1)) { ... }
```

- you have to implement the **`equals`**-method

```
class Date {
    ...
  public boolean equals(Object o) {
    if (! (o instanceof Date)) return false;
    Date d = (Date)o;
   return d.day == day && d.month == month && d.year == year;
  }
}
```

10.2 Test of Equality and Identity

- Java requires: if two objects are equal, then they must have the same hash code

```
class Date {
    ...
  public int hashcode() {
    return day + month + year;
  }
}
```

11 Packages

- Package: program unit (module) with
  - unique name (e.g. **`java.lang`** or **`java.awt.image`**)
  - consits of one or more classes
  - used to partition the name space
- Packages
  - **`public`** classes are available outside the package
  - private classes are only available within their own package
- Visibility of methods/variables can be restricted to the own package
  - Example: **`protected`** = visible only in subclasses or in other classes of the same package

11.1 Classes and Visibility

- A class can be public or not public.
- Classes without the **`public`** declaration are only visible within the same package.

```
public class X { ... }

class X { ... }
```

- A public class must be defined in an own file.
  file name := class name + ".java"
  Example: Class **`X`** must be defined in the file **`X.java`**.

11.2 Keyword: package

- Packages are declared with **`package`**

```
package test;
public class TestClass ...
```

- **`package`** must be the first statement in a file
- you can create a hierarchie of packages

```
package test.unittest1;
```

11.3 Keyword: import

- Classes of other packages can be used with **`import`**:

```
import java.util.*; // use all classes from package java.util
import java.io.File;// use class File from package java.io
```

- classes are searched using the package name as a directory
- Example:
  - Package **`bank`** with class **`Customer`**
  - Use it with **`import bank.Customer`**
  - Bytecode file is searched as **`bank/Customer.class`**
- Package **`java.lang.*`** is imported automatically
- Using classes without import: give full class name, including package

11.4 Packages and the CLASSPATH

- classes are looked up using the CLASSPATH environment variable
- Example:
  - package **`bank`** with class **`Customer`**
  - use this class with **`import bank.Customer;`**
  - compiler,interpreter look for the bytecode file **`bank/Customer.class`**
  - **`CLASSPATH`** contains **`/proj/test:/tmp`**
  - Looking for
    - **`/proj/test/bank/Customer.class`**
    - **`/tmp/bank/Customer.class`**
  - you can specify target directory when compiling
    - **`javac -d /proj/test Customer.java`**

11.5 Package Example

File
`editor/shapes/X.java`

```
package editor.shapes;
public class X {
    public void test() {
        System.out.println("X");
    }
}
```

File
`editor/filters/Y.java`

```
package editor.filters;
import editor.shapes.*;
class Y {
    X x;
    void test1() { x.test();}
}
```

File
`editor/filters/Z.java`

```
package editor.filters;
class Z {
    editor.shapes.X x;
    void test1() { x.test();}
}
```

11.6 Java Core Packages

- `java.lang`: Language support (Thread, String,...)
- `java.io`: Input-/Output support (Files, Streams,...)
- `java.net`: Network support (Sockets, URLs, ...)
- `java.awt`: Abstract Windowing Toolkit
- `java.applet`: Applet support
- `java.util`: Utility classes (Random), data structures (Vector, Stack)
- `java.rmi`: Remote Method Invocation
- `java.beans`: Beans component architecture
- `java.sql`: database access
- `java.security`: cryptographic support

11.6 Java Core Packages

- Look in the documentation to find out more about them!

`http://www4/Services/Doc/Java/jdk-1.1/api/packages.html`

12 Encapsulation

- *Encapsulation* is one of the principles of object-oriented programming
- Encapsulation is used to hide unnecessary information (*information hiding*)

12.1 Encapsulation in Java

- Visibility:
  public, default, protected, private protected, private

- Can be applied to methods and instance variables
  - **`public`**: globally visible
  - default: visible in the same class and the same package
  - **`protected`**: visible in this class, subclasses, and within the same package
  - **`private`**: only visible within the same class

- visibility modifier must be specified with *each* method and instance variable

12.2 Encapsulation

- without encapsulation:

```
class Person {
    public String name;// "name" can be modified/read globally
}
```

- better:

```
class Person {
    private String name;// only Person can access "name"
    public String getName() {// access method
        return name;
    }
}
```

Applications and Applets

- Applications
  - ◆ are started like normal programs
  - ◆ have full access to local resources (disk, network, OS, ...)
- Applets
  - ◆ can be integrated in web pages
  - ◆ access to local resources is limited

13.1 Applications

- An application needs a main method

```
class MyApplication {
    public static void main(String[] args) {
        ...
    }
}
```

- Applications are started by invoking the Java interpreter with the main class (the class containing the **`main()`** method)

```
> set path=( /local/java-1.1/bin $path)
> setenv CLASSPATH /proj/i4oods/golm/assignment1
> java MyApplication
```

13.2 Applets

- Applets are started via an HTML file
- Applets are referenced with HTML tag: **APPLET**
  - Specification of applet class
  - Specification of applet size
  - Optionally some parameters (name and value)

```
<APPLET
    CODE="MyApplet.class"
    width=200
    height=200
>
</APPLET>
```

- **.class** file and **.html** file must be located in the same directory

13.3 Applets

- Class specified in html file must be *subclass of* **`Applet`** (**`MyApplet extends Applet`**)
- Course of events:

1. Applet class (**`MyApplet`**) is loaded.
2. Class is instantiated.
3. Method **`init()`** is called at the **`MyApplet`** object.
4. Method **`start()`** is called.
5. The the applet runs.
6. Method **`paint()`** is called when the applet area must be painted.
7. Method **`stop()`** is called when the applet disappears from the user.
8. When the browser is exited or the applet is removed from the browser cache then method **`destroy()`** is called.

13.4 Applets Example

```java
import java.awt.*;
import java.applet.*;

public class MyApplet extends Applet {
  String s;

  public void init() {
    s = "Hello World";
  }

  public void paint(Graphics g) {
    g.drawString(s, 10, 10);
  }
}
```

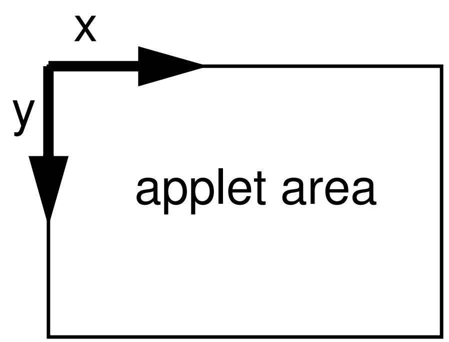
13.4 Applets

- Applets can be tested with netscape (Version# >= 4.06) (/local/netscape/bin/netscape)
- Better for testing: appletviewer
- Invocation with: **`appletviewer test.html`**
  - ◆ you need to include java in your path:

```
set path=( /local/java-1.1/bin $path)
```

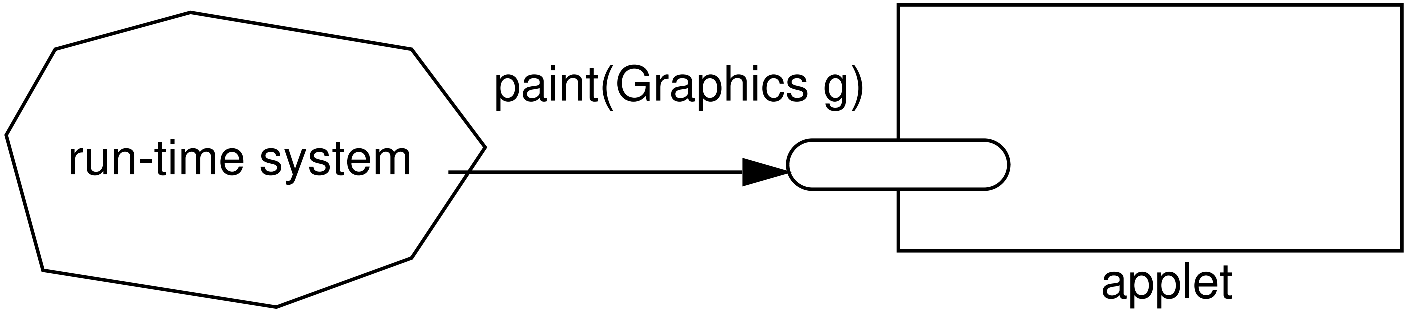
13.5 Mouse Events

- Event handlers of the Applet class
  - **`boolean mouseDown(Event e, int x, int y)`**
    user pressed the mouse button at position (x,y)
  - **`boolean mouseDrag(Event e, int x, int y)`**
    user moved the mouse to (x,y) while pressing the mouse button
- the Event object contains further information about the event
  - check if Shift key was pressed with **`shiftDown()`**
- Return true to indicate that you handled the event
- (x,y) coordinates

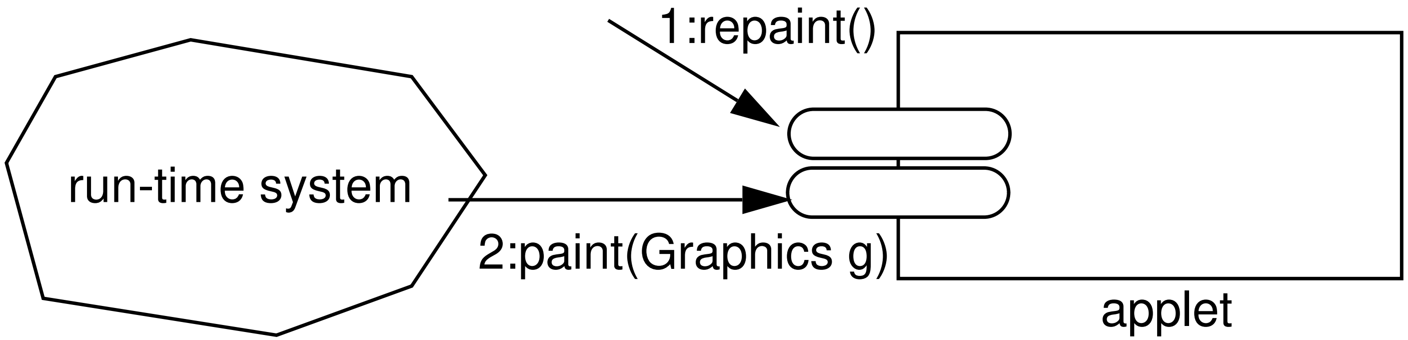


13.6 Applet Painting

- if the Applet must be drawn, the system calls the paint method



- you can tell the system, that paint() must be called by invoking repaint()



13.7 The Graphics Object

- is passed to the paint() method of the Applet as a parameter

```
import java.awt.*;
import java.applet.*;

public class SampleApplet extends Applet {
     ...
   public void paint(Graphics g) {
     ...
   }
}
```

- is used for drawing
  - drawRect(int x, int y, int w, int h)
  - drawOval(int x, int y, int w, int h)
  - ...

13.8 Further Information

- Look at the OODS Homepage:
  `http://www4/Lehre/WS00/V_OODS1/Tutorial/`