Java Review

Lecture 2
CS2110 Fall 2008

Announcements

- Assignment 1 has been posted
  - Due Wednesday, September 10, 11:59pm
  - Materials available in CMS
- Check that you are in CMS
  - Report any problems to your Section TA (email is fine)
- It's *really* a good idea to start on A1 and check CMS *this week* (well before the assignment is due)
- Available help
  - Consulting will start very soon—watch for announcements
  - Instructor & TA office hours are in effect
- Check daily for announcements
  http://courses.cs.cornell.edu/cs2110

More Announcements

- Sections start this week
  - Section material will be useful for A1

- Dexter out of the country 9/3 - 9/7 (Nottingham, England)
  - 9/4 guest lecturer: Juan Altmeyer Pizzorno

Today — A Smorgasbord

- A brief (biased) history of programming languages
- Review of some Java/OOP concepts
- Java tips, trick, and pitfalls
- Debugging and experimentation

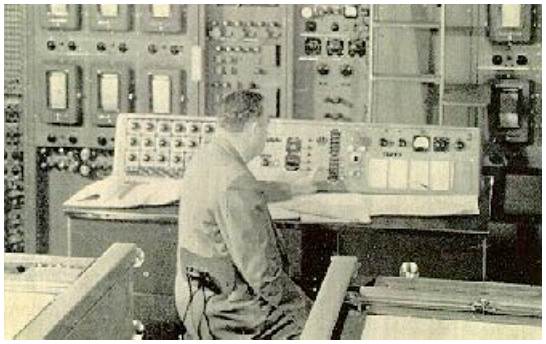
Machine Language

- Used with the earliest electronic computers (1940s)
  - Machines use vacuum tubes instead of transistors
- Programs are entered by setting switches or reading punch cards
- All instructions are numbers

- Example code

```
0110 0001 0000 0110
Add  Reg1          6
```

- An idea for improvement
  - Use words instead of numbers
  - Result: Assembly Language



Assembly Language

- Idea: Use a program (an *assembler*) to convert assembly language into machine code
- Early assemblers were some of the most complicated code of the time (1950s)

- Example code

```
ADD R1 6
MOV R1 COST
SET R1 0
JMP TOP
```

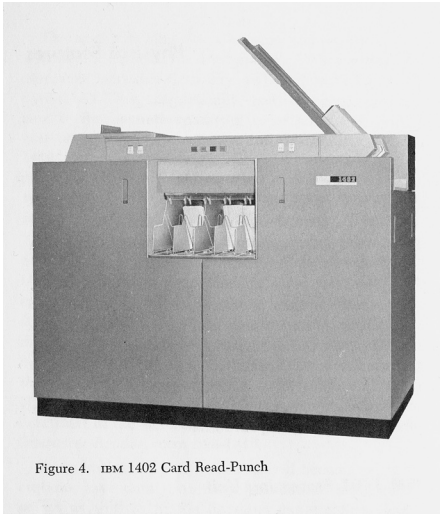
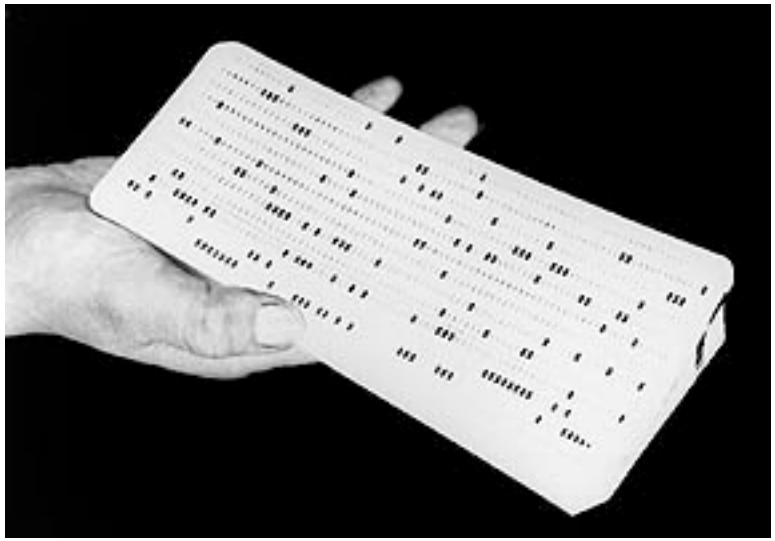


Figure 4. IBM 1402 Card Read-Punch



- Idea for improvement
  - Let's make it easier for humans by designing a high-level computer language
  - Result: high-level languages

High-Level Language

- Idea: Use a program (a *compiler* or an *interpreter*) to convert high-level code into machine code
- Pro
  - Easier for humans to write, read, and maintain code
- Con
  - The resulting program will never be as efficient as good assembly-code
    - Waste of memory
    - Waste of time
- The whole concept was initially controversial
  - FORTRAN (mathematical FORmula TRANslating system) was designed with efficiency very much in mind

FORTRAN

- Initial version developed in 1957 by IBM

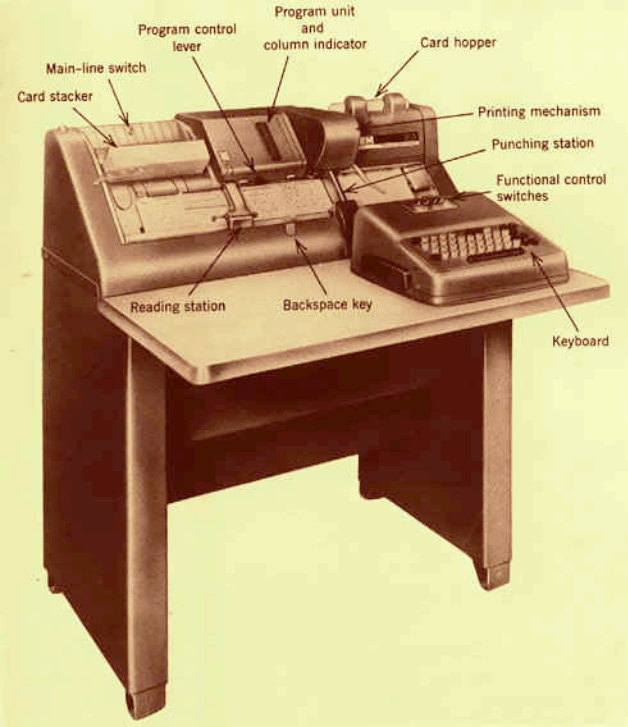


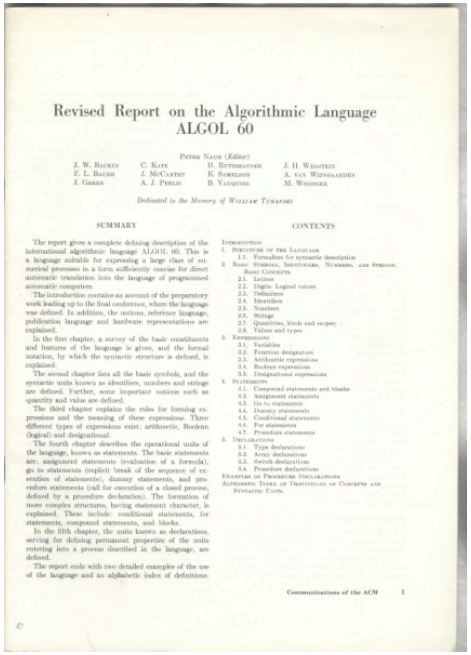
FIGURE 4.11 IBM 026 Keypunch (Courtesy IBM).

- Example code

```
C       SUM OF SQUARES
        ISUM = 0
        DO 100 I=1,10
        ISUM = ISUM + I*I
  100 CONTINUE
```

- FORTRAN introduced many high-level language constructs still in use today
  - Variables & assignment
  - Loops
  - Conditionals
  - Subroutines
  - Comments

ALGOL



Revised Report on the Algorithmic Language
ALGOL 60

PETER NAUR (Editor)

J. W. BACKUS, F. L. BAUER, J. GREEN, C. KATZ, J. MCCARTHY, A. J. PERLIS, H. RUTISHAUSER, K. SAMELSON, B. VAUQUOIS, J. H. WEGSTEIN, A. VAN WIJNGAARDEN, M. WOODGER

Dedicated to the Memory of WILLIAM TURANSKI

SUMMARY

CONTENTS

- ALGOL
  = ALGOrithmic Language
- Developed by an international committee
- First version in 1958 (not widely used)
- Second version in 1960 (widely used)

- Sample code

```
comment Sum of squares
begin
    integer i, sum;
    for i:=1 until 10 do
        sum := sum + i*i;
end
```

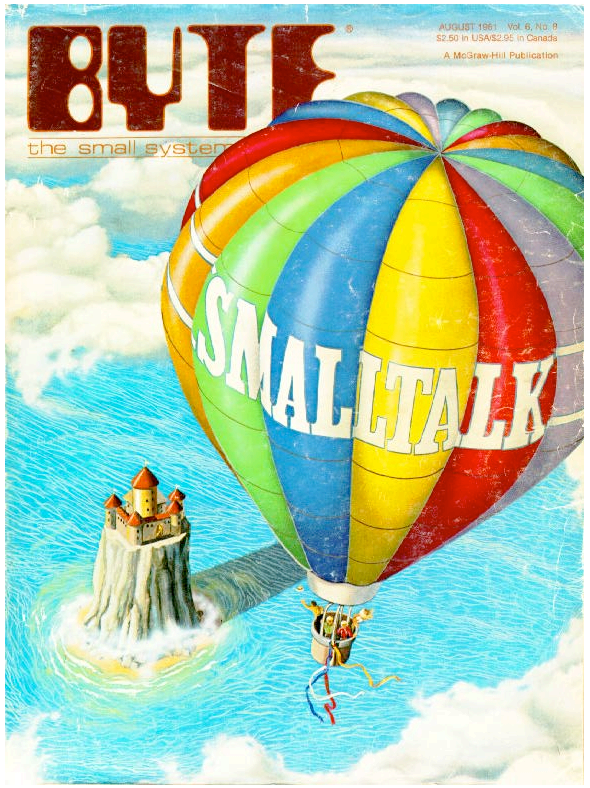
- ALGOL 60 included *recursion*
  - Pro: easier to design clear, succinct algorithms
  - Con: too hard to implement; too inefficient

COBOL

- COBOL = COmmon Business Oriented Language
- Developed by the US government (about 1960)
  - Design was greatly influenced by Grace Hopper
- Goal: Programs should look like English
  - Idea was that *anyone* should be able to read and understand a COBOL program
- COBOL included the idea of *records* (a single data structure with multiple *fields*, each field holding a value)

Simula & Smalltalk

- These languages introduced and popularized *Object Oriented Programming* (OOP)
  - Simula was developed in Norway as a language for simulation in the 60s
  - Smalltalk was developed at Xerox PARC in the 70s
- These languages included
  - Classes
  - Objects
  - Subclasses & Inheritance



Java – 1995

- Java includes
  - Assignment statements, loops, conditionals from FORTRAN (but syntax from C)
  - Recursion from ALGOL
  - Fields from COBOL
  - OOP from Simula & Smalltalk

We will assume you already know something about ...

- Classes and objects
- Static vs instance fields and methods
- Primitive vs reference types
- Private vs public vs package
- Constructors
- Method signatures
- Local variables
- Arrays
- Subtypes and Inheritance, Shadowing

Constructors

- Called to create new instances of a class
- Default constructor initializes all fields to default values (`0` or `null`)

```
class Thing {
   int val;

   Thing(int val) {
      this.val = val;
   }

   Thing() {
      this(3);
   }
}
```

```
Thing one = new Thing(1);
Thing two = new Thing(2);
Thing three = new Thing();
```

Static Initializers

- Run once when class is loaded
- Used to initialize static objects

```
class StaticInit {

   static Set<String> courses = new HashSet<String>();

   static {
      courses.add("CS 2110");
      courses.add("CS 2111");
   }

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

Static vs Instance Example

```
class Widget {
    static int nextSerialNumber = 10000;
    int serialNumber;

    Widget() {
        serialNumber = nextSerialNumber++;
    }

    public static void main(String[] args) {
        Widget a = new Widget();
        Widget b = new Widget();
        Widget c = new Widget();
        System.out.println(a.serialNumber);
        System.out.println(b.serialNumber);
        System.out.println(c.serialNumber);
    }
}
```

A Common Pitfall

local variable shadows field

```
class Thing {
    int val;

    boolean setVal(int v) {
        int val = v;
    }
}
```

- you would like to set the instance field **`val = v`**
- but you have declared a new local variable **`val`**
- assignment has no effect on the field **`val`**

A Common Pitfall

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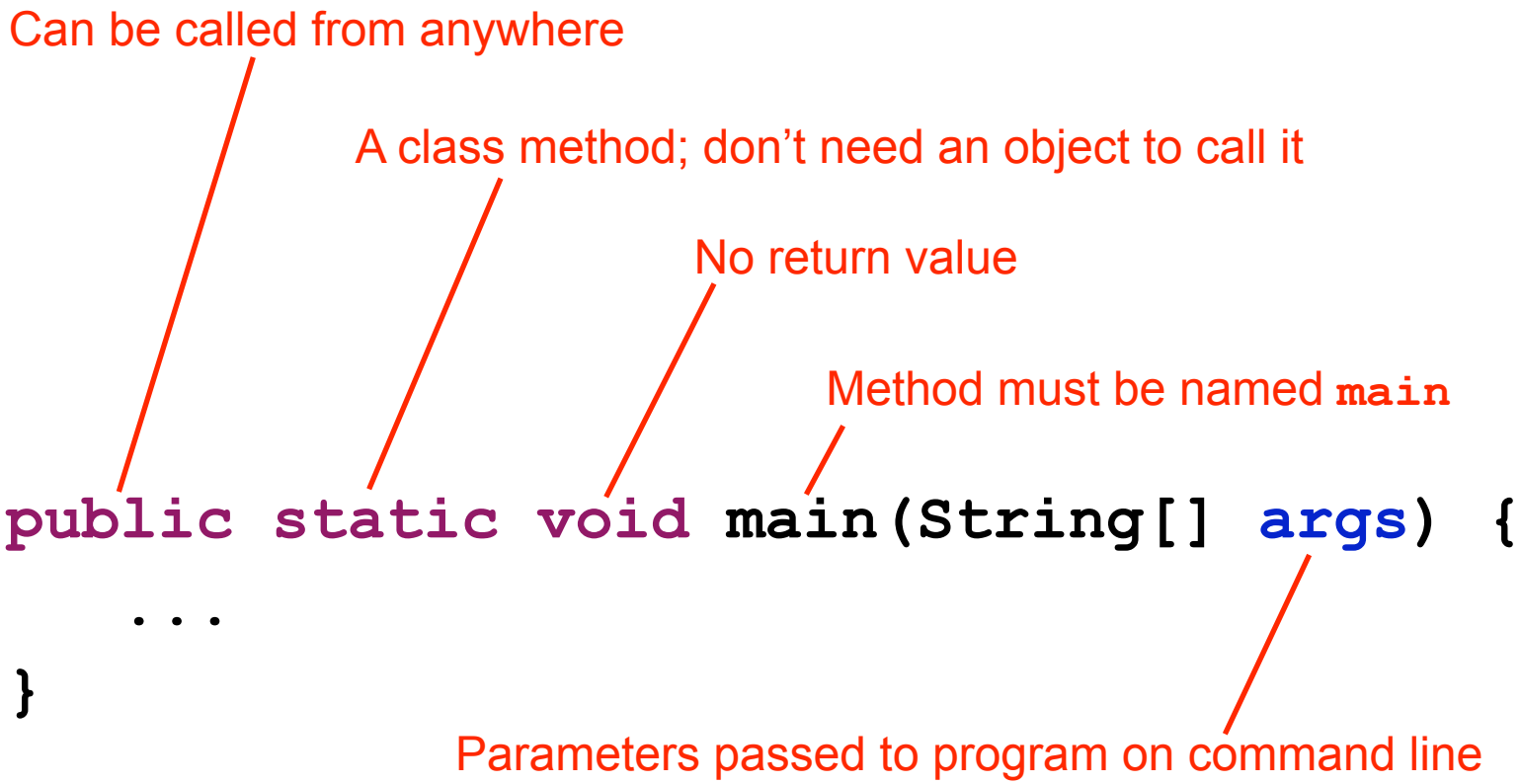
The `main` Method



Names

- Refer to my static and instance fields & methods by (unqualified) name:
  - `serialNumber`
  - `nextSerialNumber`
- Refer to static fields & methods in another class using name of the class
  - `Widget.nextSerialNumber`
- Refer to instance fields & methods of another object using name of the object
  - `a.serialNumber`
- Example
  - `System.out.println(a.serialNumber)`
    - `out` is a static field in class `System`
    - The value of `System.out` is an instance of a class that has an instance method `println(int)`
- If an object must refer to itself, use `this`

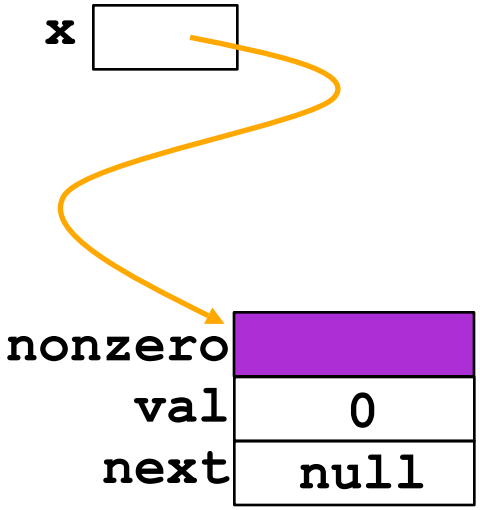
Overloading of Methods

- A class can have several methods of the same name
  - But all methods must have different *signatures*
  - The *signature* of a method is its name plus types of its parameters
- Example: **`String.valueOf(...)`** in Java API
  - There are 9 of them:
    - `valueOf(boolean);`
    - `valueOf(int);`
    - `valueOf(long);`
    - `...`
  - Parameter types are part of the method's signature

Primitive vs Reference Types

- Primitive types
  - `int`, `short`, `long`, `float`, `byte`, `char`, `boolean`, `double`
  - Efficient
  - 1 or 2 words
  - Not an `Object`—*unboxed*

- Reference types
  - Objects and arrays
  - `String`, `int[]`, `HashSet`
  - Usually require more memory
  - Can have special value `null`
  - Can compare `null` with `==`, `!=`
  - Generates `NullPointerException` if you try to dereference `null`

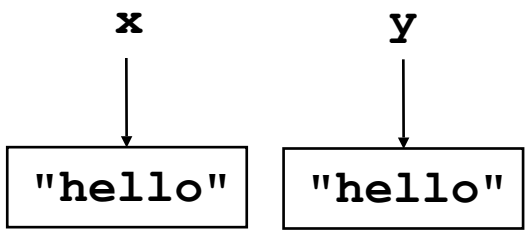


== vs equals( )

- `==` tests whether variables hold identical values (shallow equality)
- Works fine for primitive types
- For reference types (e.g., `String`), you usually want to use `equals()` (deep equality)

- Two different strings with value `"hello"`

```
x = "hello";
y = "hello";
x == y?
```



- To compare object *contents*, override `Object.equals()`

```
boolean equals(Object x);
```

- But if you do this, must also override `Object.hashCode()` (more on this later)

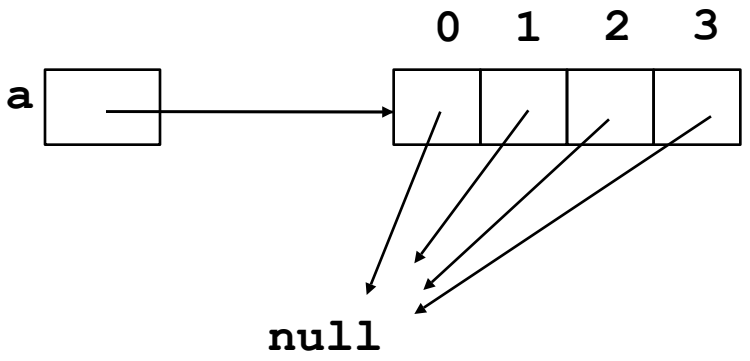
== vs equals( )

```
"xy" == "xy"                    "xy".equals("xy")

"xy" == "x" + "y"               "xy".equals("x" + "y")

"xy" == new String("xy")        "xy".equals(new String("xy"))
```

Arrays

- Arrays are reference types
- Array *elements* can be reference types or primitive types
  - E.g., `int[]` or `String[]`
- If `a` is an array, `a.length` is its length
- Its elements are `a[0]`, `a[1]`, ..., `a[a.length-1]`
- The length is fixed

```
String[] a = new String[4];
```




```
a.length = 4
```

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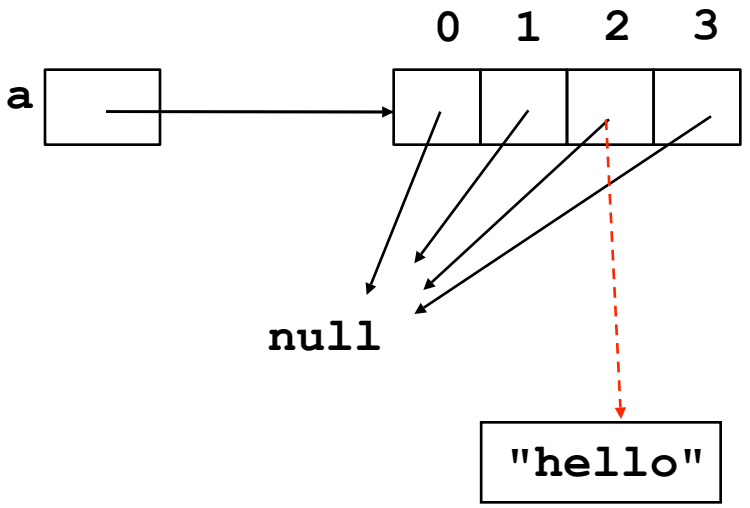
```
String[] a = new String[4];
a[2] = "hello"
```

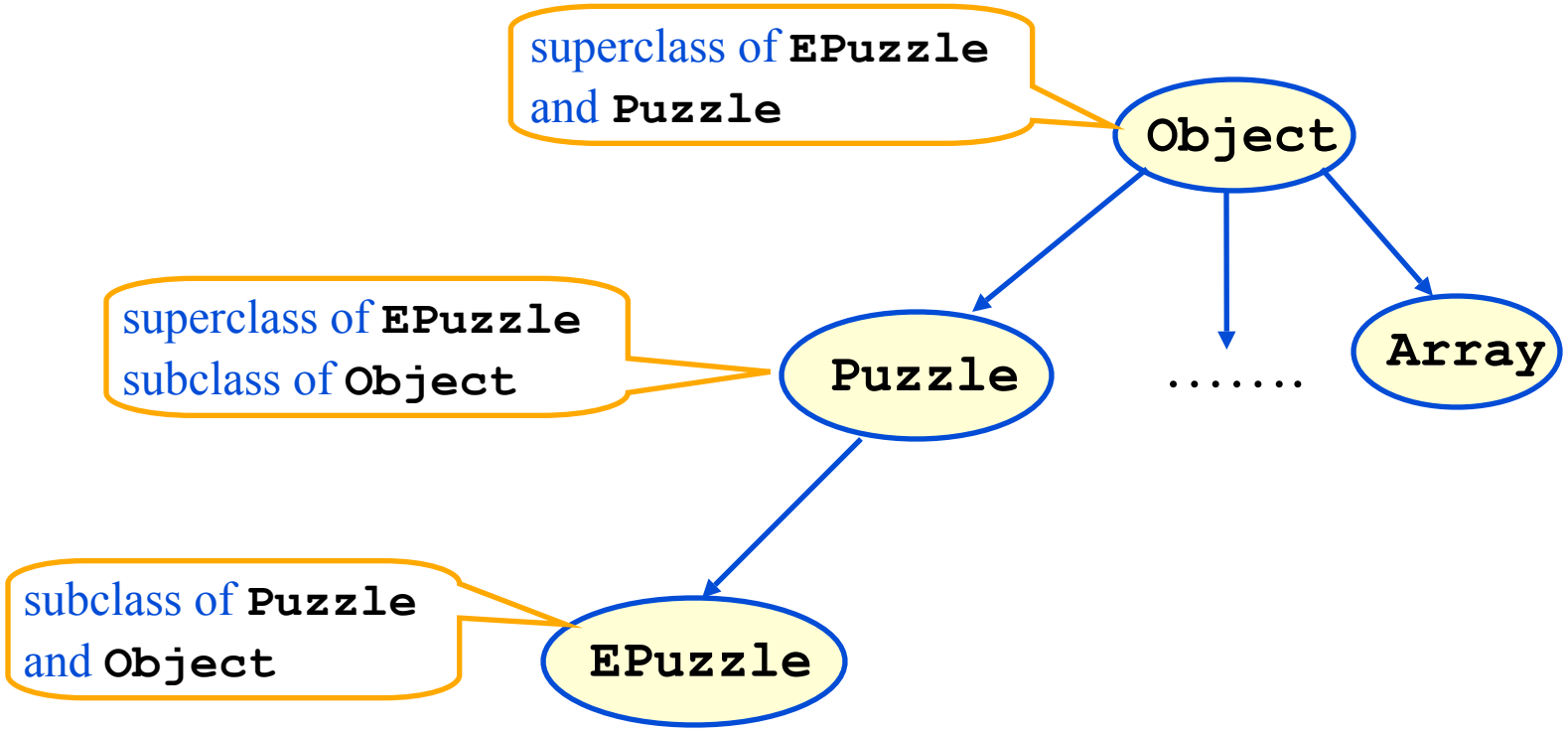


`a.length = 4`

Accessing Array Elements Sequentially

```
public class CommandLineArgs {

   public static void main(String[] args) {

      System.out.println(args.length);

      // old-style
      for (int i = 0; i < args.length; i++) {
         System.out.println(args[i]);
      }

      // new style
      for (String s : args) {
         System.out.println(s);
      }
   }
}
```

Class Hierarchy



Every class (except `Object`) has a unique immediate superclass, called its *parent*

Overriding

- A method in a subclass overrides a method in superclass if:
  - both methods have the same name,
  - both methods have the same signature (number and type of parameters and return type), and
  - both are static methods or both are instance methods
- Methods are dispatched according to the runtime type of the object

Accessing Overridden Methods

- Suppose a class `S` overrides a method `m` in its parent
- Methods in `S` can invoke the overridden method in the parent as

```
super.m()
```

- In particular, can invoke the overridden method in the overriding method!

- Caveat: cannot compose super more than once as in `super.super.m()`

Unexpected Consequence

An overriding method cannot have more restricted access than the method it overrides

```
class A {
   public int m() {...}
}

class B extends A {
   private int m() {...} //illegal!
}

A supR = new B(); //upcasting
supR.m(); //would invoke private method in
class B at runtime!
```

Shadowing

- Like overriding, but for fields instead of methods
  - Superclass: variable `v` of some type
  - Subclass: variable `v` perhaps *of some other type*
  - Method in subclass can access shadowed variable using `super.v`
- Variable references are resolved using *static binding* (i.e., at compile-time), not *dynamic binding* (i.e., not at runtime)
  - Variable reference `r.v` uses the *static type* (declared type) of the variable `r`, not the *runtime type* of the object referred to by `r`
- Shadowing variables is bad medicine and should be avoided

Array VS ArrayList VS HashMap

- Three extremely useful constructs (see Java API)
- **`Array`**
  - Storage is allocated when array created; cannot change
- **`ArrayList`** (in **`java.util`**)
  - An "extensible" array
  - Can append or insert elements, access i^{th} element, reset to 0 length
- **`HashMap`** (in **`java.util`**)
  - Save data indexed by keys
  - Can lookup data by its key
  - Can get an iteration of the keys or the values

`HashMap` Example

- Create a **`HashMap`** of numbers, using the names of the numbers as keys:

```
Map<String, Integer> numbers
    = new HashMap<String, Integer>();
numbers.put("one", new Integer(1));
numbers.put("two", new Integer(2));
numbers.put("three", new Integer(3));
```

To retrieve a number:

```
Integer n = numbers.get("two");
```

- returns **`null`** if the **`HashMap`** does not contain the key
  - Can use **`numbers.containsKey(key)`** to check this

Generics and Autoboxing

- Old (pre-Java 5)

```
Map numbers = new HashMap();
numbers.put("one", new Integer(1));
Integer s = (Integer)numbers.get("one");
```

- New (generics)

```
Map<String, Integer> numbers =
    new HashMap<String, Integer>();
numbers.put("one", new Integer(1));
Integer s = numbers.get("one");
```

- New (generics + autoboxing)

```
Map<String, Integer> numbers =
    new HashMap<String, Integer>();
numbers.put("one", 1);
int s = numbers.get("one");
```

Experimentation and Debugging

- Don't be afraid to experiment if you are not sure how things work
  - Documentation isn’t always clear
  - *Interactive Development Environments* (IDEs), e.g. Eclipse, make this easier
- Debugging
  - Do not just make random changes, hoping something will work
  - Think about what could cause the observed behavior
  - Isolate the bug
  - An IDE makes this easier by providing a *Debugging Mode*
    - Can set breakpoints, step through the program while watching chosen variables