Comp 401 Initialization and Inheritance

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Prerequisite

- Inheritance Abstract Classes

.

More Inheritance

AREGULARCOURSE

```
public class ARegularCourse extends ACourse implements Course {
        int courseNum;
        public ARegularCourse (String theTitle, String theDept, int
theCourseNum) {
                super (theTitle, theDept);
                courseNum = theCourseNum;
        }
        public int getNumber() {
                return courseNum;
        }
}
```

Alternative ARegularCourse

```
public class ARegularCourse extends ACourse implements Course {
        int courseNum;
        public ARegularCourse (String theTitle, String theDept, int
theCourseNum) {
                courseNum = theCourseNum;
                super (theTitle, theDept);
        }
        public int getNumber() {
                return courseNum;
        }
}
```

Super call must be first statement in constructor but not other methods.

Subclass may want to override initialization in super class

Superclass vars initialized before subclass vars, which can use the former

Subclass vars not visible in superclass

Alternative ARegularCourse

```
public class ARegularCourse extends ACourse implements Course {
        int courseNum;
        public ARegularCourse (String theTitle, String theDept, int
theCourseNum) {
                courseNum = theCourseNum; ✗
        }
        public int getNumber() {
                return courseNum;
        }
}
```

No super call()!

ACourse

```
public abstract class ACourse extends Object  {
        String title, dept;
        public ACourse (String theTitle, String theDept) {
                title = theTitle;
                dept = theDept;
        }
        public String getTitle() {
                return title;
        }
        public String getDepartment() {
                return dept;
        }
}
```

Missing super call

Every class including Object has constructor

Equivalent ACourse

```
public abstract class ACourse extends Object  {
        String title, dept;
        public ACourse (String theTitle, String theDept) {
                super();
                title = theTitle;
                dept = theDept;
        }
        public String getTitle() {
                return title;
        }
        public String getDepartment() {
                return dept;
        }
}
```

Automatically inserted

Alternative ARegularCourse

```
public class ARegularCourse extends ACourse implements Course {
        int courseNum;
        public ARegularCourse (String theTitle, String theDept, int theCourseNum) {
                courseNum = theCourseNum;
        }
        public int getNumber() {
                return courseNum;
        }
}
```

No super call()!

Alternative ARegularCourse

```
public class ARegularCourse extends ACourse implements Course {
		int courseNum;
		public ARegularCourse (String theTitle, String theDept, int theCourseNum) {
				super();
				courseNum = theCourseNum;
		}
		public int getNumber() {
				return courseNum;
		}
}
```

✗

Automatically inserted

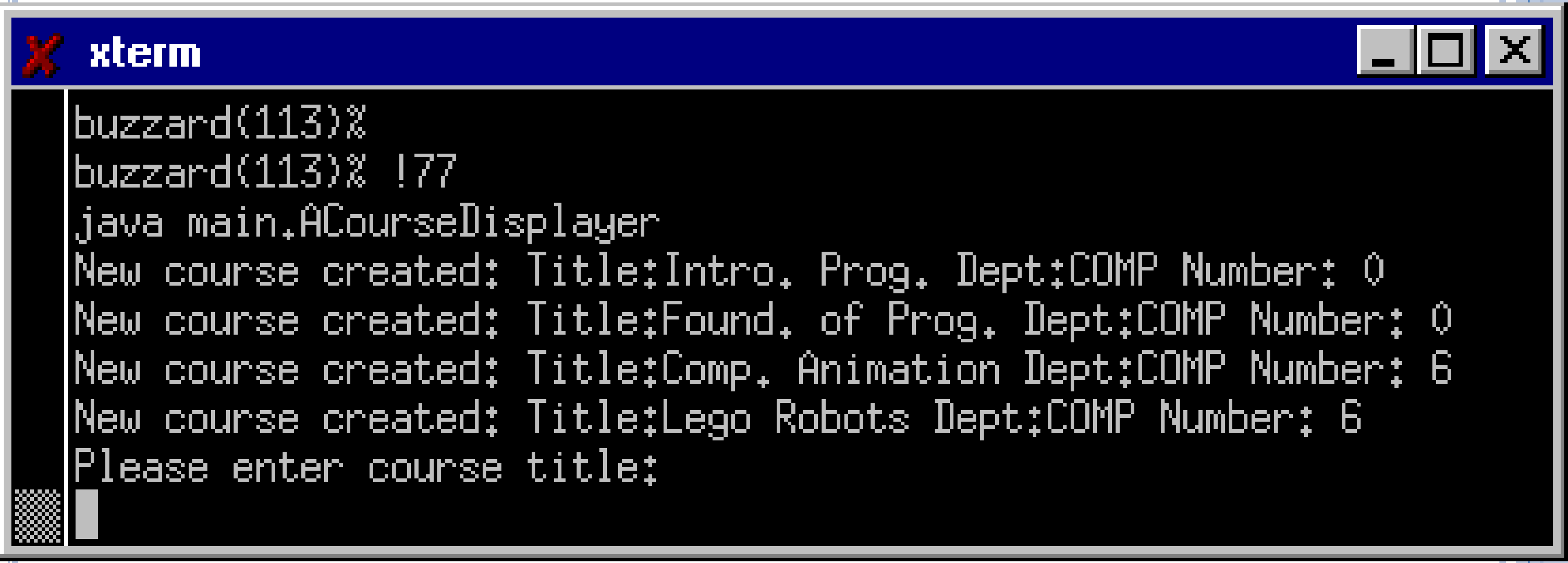
Java complains superclass does not have parameterless constructor

Advanced Initialization

ABSTRACT METHODS IN CONSTRUCTORS

```
public abstract class ACourse  implements Course {
    String title, dept;
    public ACourse (String theTitle, String theDept) {
            title = theTitle;
            dept = theDept;
            // "innocuous" debugging statement added to ACourse
            System.out.println("New course created: " + "Title:" + title + "
    Dept:"+ dept + " Number: " + getNumber())           ;
        }
   public String getTitle() {
            return title;
    }
    public String getDepartment() {
            return dept;
    }
    abstract public int getNumber();
}
```

Abstract methods in constructors



```
buzzard(113)%
buzzard(113)% !77
java main.ACourseDisplayer
New course created: Title:Intro. Prog. Dept:COMP Number: 0
New course created: Title:Found. of Prog. Dept:COMP Number: 0
New course created: Title:Comp. Animation Dept:COMP Number: 6
New course created: Title:Lego Robots Dept:COMP Number: 6
Please enter course title:
```

getNumber() called before subclass constructor in ARegularCourse has initialized variables.

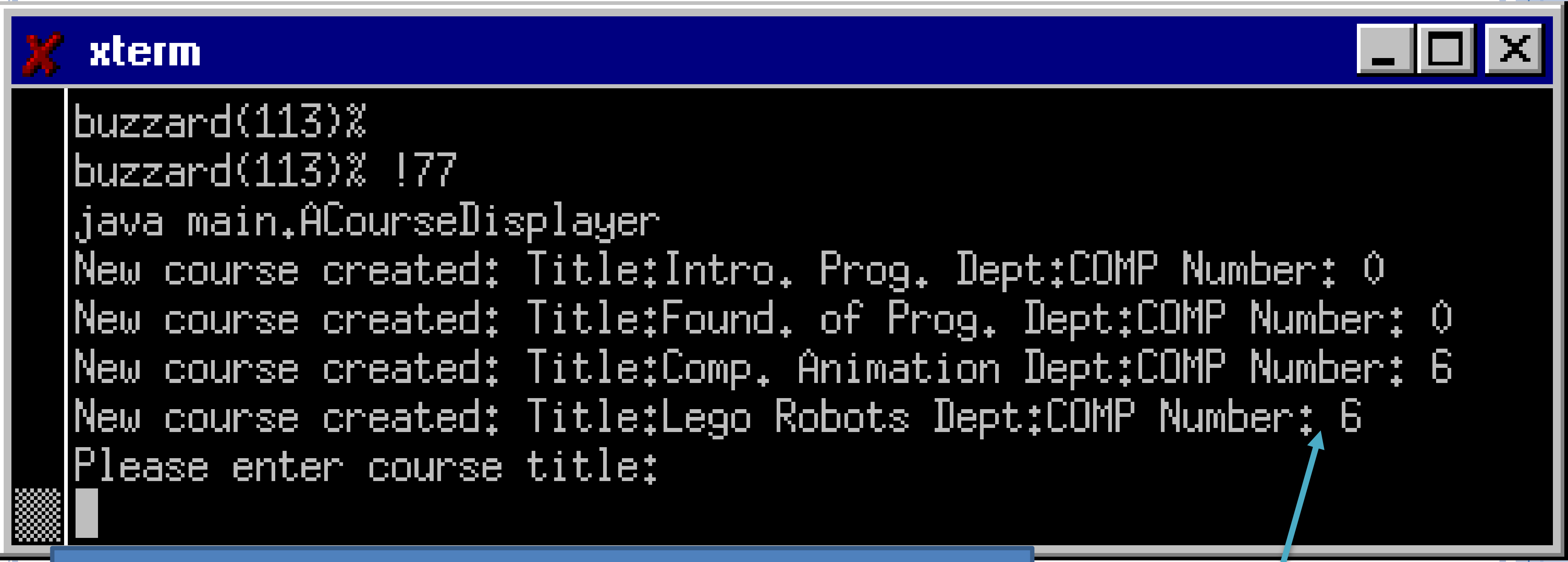
Abstract methods in constructors

- Beware of abstract methods being called in constructors.
- They may access uninitialized variables in subclasses!

Initializing declaration

```
public class ARegularCourse extends ACourse {
    int courseNum = 99;
    public ARegularCourse (String theTitle, String theDept, int
   theCourseNum) {
         super (theTitle, theDept);
         courseNum = theCourseNum;
    }
    public int getNumber() {
         return courseNum;
    }
}
```

Initializing declarations



```
buzzard(113)%
buzzard(113)% !77
java main.ACourseDisplayer
New course created: Title:Intro. Prog. Dept:COMP Number: 0
New course created: Title:Found. of Prog. Dept:COMP Number: 0
New course created: Title:Comp. Animation Dept:COMP Number: 6
New course created: Title:Lego Robots Dept:COMP Number: 6
Please enter course title:
```

Initializations in declarations processed after superclass constructor returns

Try stepping into a constructor in a debugger.

Why correct value?

Constant initializations

- Done when constants allocated memory.
- (Should be) shared by all instances.
- When class is loaded in memory.
- Not when an instance created.

Processing of new

```
(new ARegularCourse ("Intro. Prog.",  "COMP", 14));
```

- The variables declared in ARegularCourse and Course are allocated space but not initialized.
- The constructor of ARegularCourse is called.
- It calls the constructor of ACourse in its first statement.

Processing of new

- The initializations in the declarations of the variables of ACourse are processed. In this case there are no initializations.
- The constructor of ACourse is started.
- The two instance variables of ACourse are assigned parameter values, “Intro. Prog.” And “COMP”.
- The values of these variables are printed.
- The method getNumber() of ARegularCourse is called and the default value of courseNum is printed.

Processing of new

- The constructor of ACourse returns.
- The initializations in the declarations of the variables of ARegularCourse are processed. In this case, courseNum is assigned the value 0.
- Execution resumes in the constructor of ARegularCourse.The courseNum variable is assigned the parameter value, 14.
- The constructor of ARegularCourse returns.
- The new statement completes, returning the new instance to its caller.

Multiple Constructors

```
public abstract class ACourse  implements Course {
            String title = “COMP”;
            String dept = “Topics in Computer Science”;
            public ACourse (String theTitle, String theDept) {
                        title = theTitle;
                        dept = theDept;
                        System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
            }
            public ACourse () {
                        System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
            }
            public String getTitle() {return title;}
            public String getDepartment() {return dept;}
            abstract public int getNumber();
}
```

How to remove code duplication?

CONSTRUCTOR CALLING CONSTRUCTOR

```
public abstract class ACourse  implements Course {
        String title = “COMP”;
        String dept = “Topics in Computer Science”;
        public ACourse (String theTitle, String theDept) {
                title = theTitle;
                dept = theDept;
                System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
        }
        public ACourse () {
                this (title, dept);
        }
        public String getTitle() {return title;}
        public String getDepartment() {return dept;}
        abstract public int getNumber();
}
```

This implies constructor of same class

Equivalent Code

```
public abstract class ACourse  implements Course {
          String title = “COMP”;
          String dept = “Topics in Computer Science”;
          public ACourse (String theTitle, String theDept) {
                    super();
                    title = theTitle;
                    dept = theDept;
                    System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
          }
          public ACourse () {
                    this (title, dept);
          }
          public String getTitle() {return title;}
          public String getDepartment() {return dept;}
          abstract public int getNumber();
}
```

No super

Super may have side effects, so cannot call super() before this()

Java complains that instance variables not initialized

Constructor calling Constructor

```
public abstract class ACourse  implements Course {
            String title = “COMP”;
            String dept = “Topics in Computer Science”;
            public ACourse (String theTitle, String theDept) {
                        title = theTitle;
                        dept = theDept;
                        this();
            }
            public ACourse () {
                         System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
            }
            public String getTitle() {return title;}
           public String getDepartment() {return dept;}
            abstract public int getNumber();
}
```

Java complains that this() must be first call, as it results in super() being called

Constructor calling Constructor

```
public abstract class ACourse  implements Course {
		String title, dept;
		final String DEFAULT_DEPT = “COMP”;
		final String DEFAULT_TITLE = “Topics in Computer Science”;
		public ACourse (String theTitle, String theDept) {
				title = theTitle;
				dept = theDept;
				System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
		}
		public ACourse () {
				this (“COMP”, “Topics in Computer Science”);
		}
		public String getTitle() {return title;}
		 public String getDepartment() {return dept;}
		abstract public int getNumber();
}
```

No complaints.

Constructor calling Constructor

```
 ;
public abstract class ACourse  implements Course {
          String title, dept;
          final String DEFAULT_DEPT = "COMP";
          final String DEFAULT_TITLE = "Topics in Computer Science";
          public ACourse (String theTitle, String theDept) {
                    title = theTitle;
                    dept = theDept;
                    System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
          }
          public ACourse () {
                    this (DEFAULT_DEPT, DEFAULT_TITLE );
          }
          public String getTitle() {return title;}
          public String getDepartment() {return dept;}
          abstract public int getNumber();
}
```

Java complains that instance vars cannot be accessed.

Possible constructor call semantics

- Rule so far: each constructor calls superclass constructor.
- Problem: then super class initialized multiple times.
  - Not a problem if each initialization yields the same result.
  - Can have multiple constructors doing different initializations.
  - Same constructor may do different things on different invocations or may have side effects.

Actual Semantics

- A constructor may call another constructor as first statement.
- Super not called in that case.
- Only last call in constructor chain calls super.
- Hence no danger of super being initialized multiple times.
- But danger that constructor parameters may be uninitialized.
- Literal parameters ok.
- Constructor call must be first statement.
- Otherwise code executed before superclass initialized

Solution: Init Method

```
 ;
public abstract class ACourse  implements Course {
            String title, dept;
            final String DEFAULT_DEPT = “COMP”;
            final String DEFAULT_TITLE = “Topics in Computer Science”;
            public ACourse (String theTitle, String theDept) {
                        init (theTitle, theDept)
            }
            public ACourse () {
                         init (DEFAULT_DEPT, DEFAULT_TITLE);
            }
            void init (String theTitle, String theDept) {
                        title = theTitle;
                        dept = theDept;
                        System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
             }
            public String getTitle() {return title;}
             public String getDepartment() {return dept;}
            abstract public int getNumber();
}
```

Allowing Init After Construction

```
 ;
public abstract class ACourse  implements Course {
        String title = “Topics in Computer Science”;;
        String dept = “COMP”;
        public ACourse (String theTitle, String theDept) {
                init (theTitle, theDept)
        }
        public ACourse () {
                 init (DEFAULT_DEPT, DEFAULT_TITLE);
        }
        public void init (String theTitle, String theDept) {
                title = theTitle;
                dept = theDept;
                System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
         }
        public String getTitle() {return title;}
         public String getDepartment() {return dept;}
        abstract public int getNumber();
}
```

ARegularCourse

```
 ;
public class ARegularCourse extends ACourse {
		int courseNum;
		public ARegularCourse (String theTitle, String theDept, int 
theCourseNum) {
				super (theTitle, theDept);
				courseNum = theCourseNum;
		}
		public ARegularCourse () {
		}
		public int getNumber() {
				return courseNum;
		}
}
```

courseNum **uninitialized,** as init method only in super class

```
Course course =new ARegularCourse();
course.init("Meaning of Life", "PHIL");
```

ARegularCourse with Init

```
;
public class ARegularCourse extends ACourse {
		int courseNum;
		public ARegularCourse (String theTitle, String theDept, int
theCourseNum) {
				super (theTitle, theDept);
				courseNum = theCourseNum;
		}
		public ARegularCourse () {
		}
		public int getNumber() {
				return courseNum;
		}
		public  void init (String theTitle, String theDept, int theCourseNum) {
				courseNum = theCourseNum;
		}

}
```

Super class init not called

```
Course course =new ARegularCourse();
Course.init("Meaning of Life", "PHIL", 999);
```

AREGULARCOURSE WITH INIT

```
;
public class ARegularCourse extends ACourse {
        int courseNum;
        public ARegularCourse (String theTitle, String theDept, int
theCourseNum) {
                super (theTitle, theDept);
                courseNum = theCourseNum;
        }
        public ARegularCourse () {
        }
        public int getNumber() {
                return courseNum;
        }
        public  void init (String theTitle, String theDept, int theCourseNum) {
                init(theTitle, theCourseNum);
                courseNum = theCourseNum;
        }
}
```

Super class init called.

```
Course course =new ARegularCourse();
Course.init("Meaning of Life", "PHIL", 999);
```

Two ways to construct

- Initialized construction
  - **new** ARegularCourse (“Intro. Prog”, “COMP”, 14);
- Construction and then initialization
  - (**new** ARegularCourse()).init(“Intro Prog.”, “COMP”, 14)

Parameterized Constructors

- Can create multiple parameterized constructors
  - To initializes some subset of instance variables.
  - Use default values assigned by initializing declarations for the rest.

```
public ACourse (String theTitle) {
    title = theTitle;
}
```

- Add an init method for each parameterized constructor

Init methods

- Allows initialization after object is created.
- Initializer can be different from creator
  - Abstract class may initialize
  - Concrete factory method may instantiate.
- Init methods can be in interfaces
- Init method(s) recommended but not required

AFreshmanSeminar

```
public class AFreshmanSeminar extends ACourse {
        public AFreshmanSeminar (String theTitle, String theDept) {
                super (theTitle, theDept);
                title = theTitle;
        }
        public int getNumber() {
                return SEMINAR_NUMBER;
        }
}
```

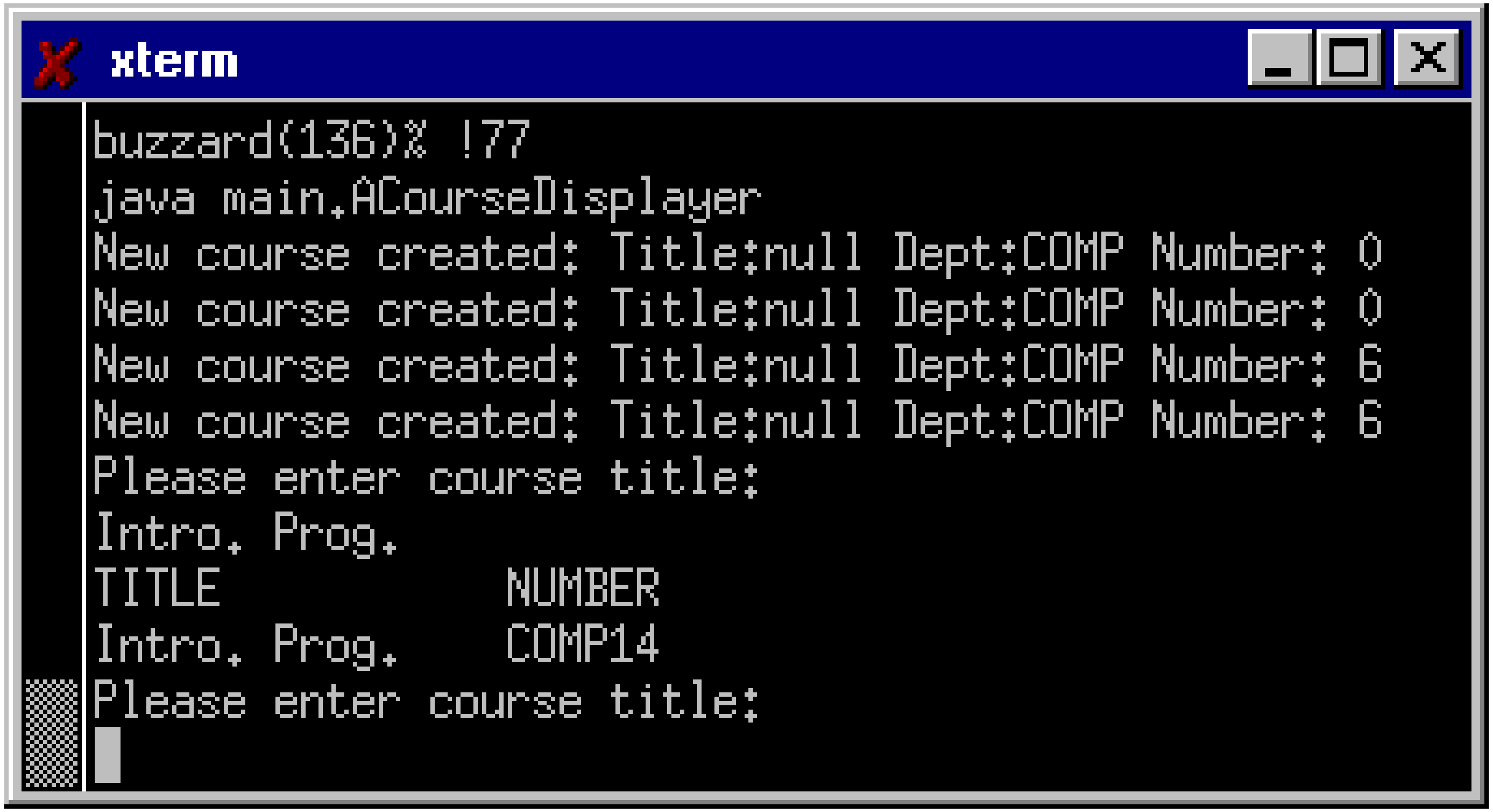
Allowed since in same package

Abstract Course

```
 ;
public abstract class ACourse {
		String title, dept;
		public ACourse (String theTitle, String theDept) {
				//title = theTitle;
				dept = theDept;
				// "innocuous" debugging statement added to ACourse
				System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber()
		}
		public String getTitle() {
				return title;
		}
		public String getDepartment() {
				return dept;
		}
		abstract public int getNumber();
}
```

No longer necessary

Display Abstract Course



```
buzzard(136)% !77
java main.ACourseDisplayer
New course created: Title:null Dept:COMP Number: 0
New course created: Title:null Dept:COMP Number: 0
New course created: Title:null Dept:COMP Number: 6
New course created: Title:null Dept:COMP Number: 6
Please enter course title:
Intro. Prog.
TITLE           NUMBER
Intro. Prog.    COMP14
Please enter course title:
```

Abstract Course

```
 ;
public abstract class ACourse {
		String title, dept;
		public ACourse (String theTitle, String theDept) {
			//title = theTitle;
			dept = theDept;
			// "innocuous" debugging statement added to ACourse
			System.out.println("New course created: " + "Title:" + title+ " 
Dept:"+ dept + " Number: " + getNumber()
		}
		public String getTitle() {
			return title;
		}
		public String getDepartment() {
			return dept;
		}
}
```

Accesses Uninitialized variable

Redefining SuperClass Variables

```
 ;
public class ARegularCourse extends ACourse {
        int courseNum;
        String title;
        public ARegularCourse (String theTitle, String theDept, int
theCourseNum) {
                super (theTitle, theDept);
                courseNum = theCourseNum;
                title = theTitle;

        }
        public int getNumber() {
                return courseNum;
        }
}
```

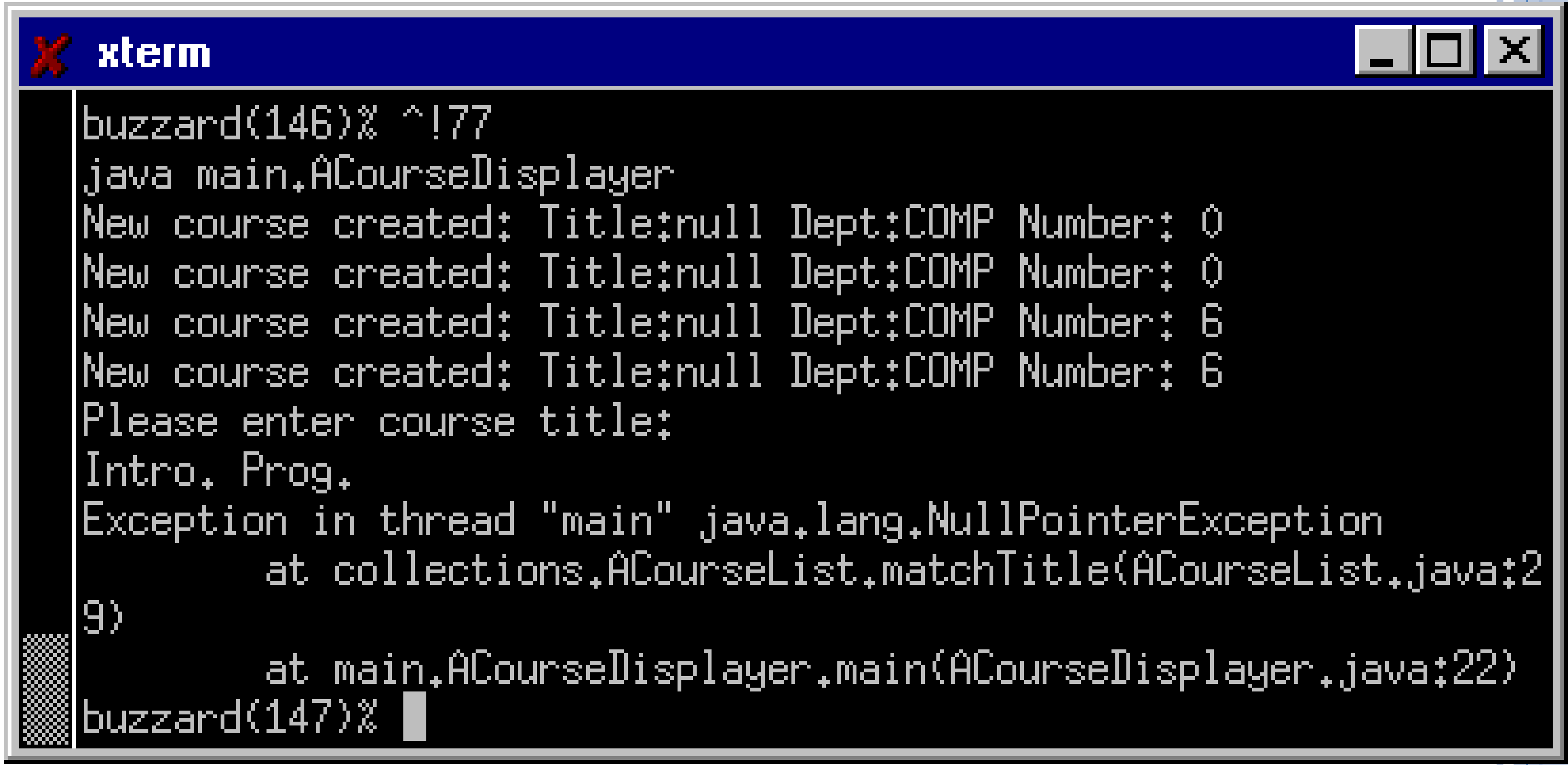
Refers to overriding variable

Overriding variable legal in Java

Alternative AFreshmanSeminar

```
 ;
public class AFreshmanSeminar extends ACourse {
        String title;
        public AFreshmanSeminar (String theTitle, String theDept) {
                super (theTitle, theDept);
                title = theTitle
        }
        public int getNumber() {
                return SEMINAR_NUMBER;
        }
}
```

Redeclaring superclass variables



```
buzzard(146)% ^!77
java main.ACourseDisplayer
New course created: Title:null Dept:COMP Number: 0
New course created: Title:null Dept:COMP Number: 0
New course created: Title:null Dept:COMP Number: 6
New course created: Title:null Dept:COMP Number: 6
Please enter course title:
Intro. Prog.
Exception in thread "main" java.lang.NullPointerException
        at collections.ACourseList.matchTitle(ACourseList.java:2
9)
        at main.ACourseDisplayer.main(ACourseDisplayer.java:22)
buzzard(147)% 
```

Abstract Course

```
 ;
public abstract class ACourse  implements Course {
        String title, dept;
        public ACourse (String theTitle, String theDept) {
                //title = theTitle;
                dept = theDept;
                System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber()
        }
        public String getTitle() {
                return title;
        }
        public String getDepartment() {
                return dept;
        }
        abstract public int getNumber();
}
```

Equals accesses uninitialized variable

Re-declaring subclass variables

- Happens accidentally when class is re-factored manually to move subclass variables to super-classes.
- Original variable in subclass remains.
- Beware!
- Use Eclipse refactor→move command when possible.

Extra Slides

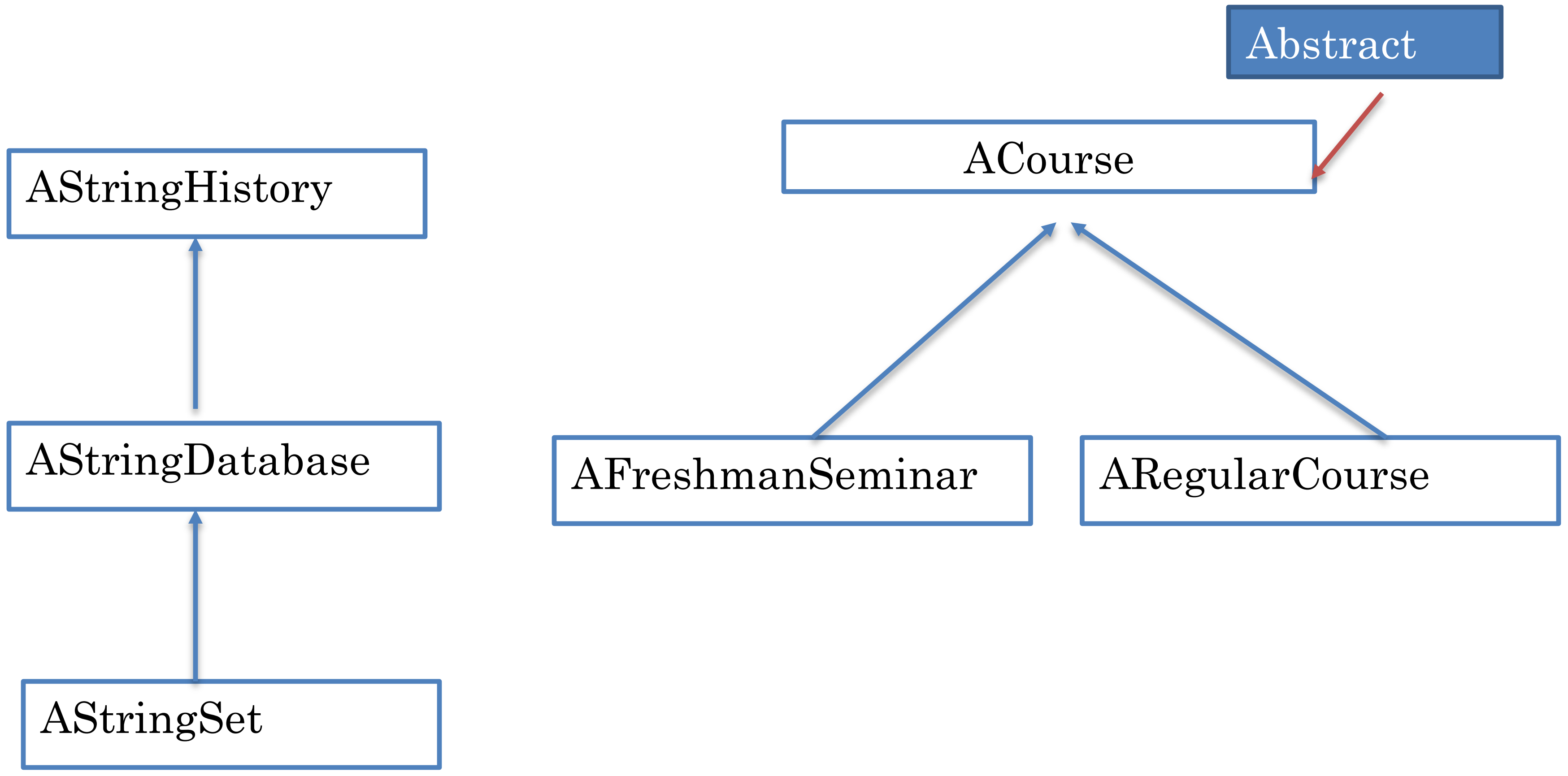
Cannot always get rid of manual dispatch/instancof

```
static void print (Course course) {
    if (course instanceof  ARegularCourse)
          printHeader ((ARegularCourse) course);
     else if (course instanceof  AFreshmanSeminar))
          printHeader ((AFreshmanSeminar) course);
    System.out.println(
          course.getTitle() + "      " +
          course.getDepartment()  +
          course.getNumbert() );
}
static void printHeader (ARegularCourse course) {
          System.out.print("Regular Course: ");
}
static void printHeader (AFreshmanSeminar course) {
          System.out.print("Freshman Seminar: ");
}
```

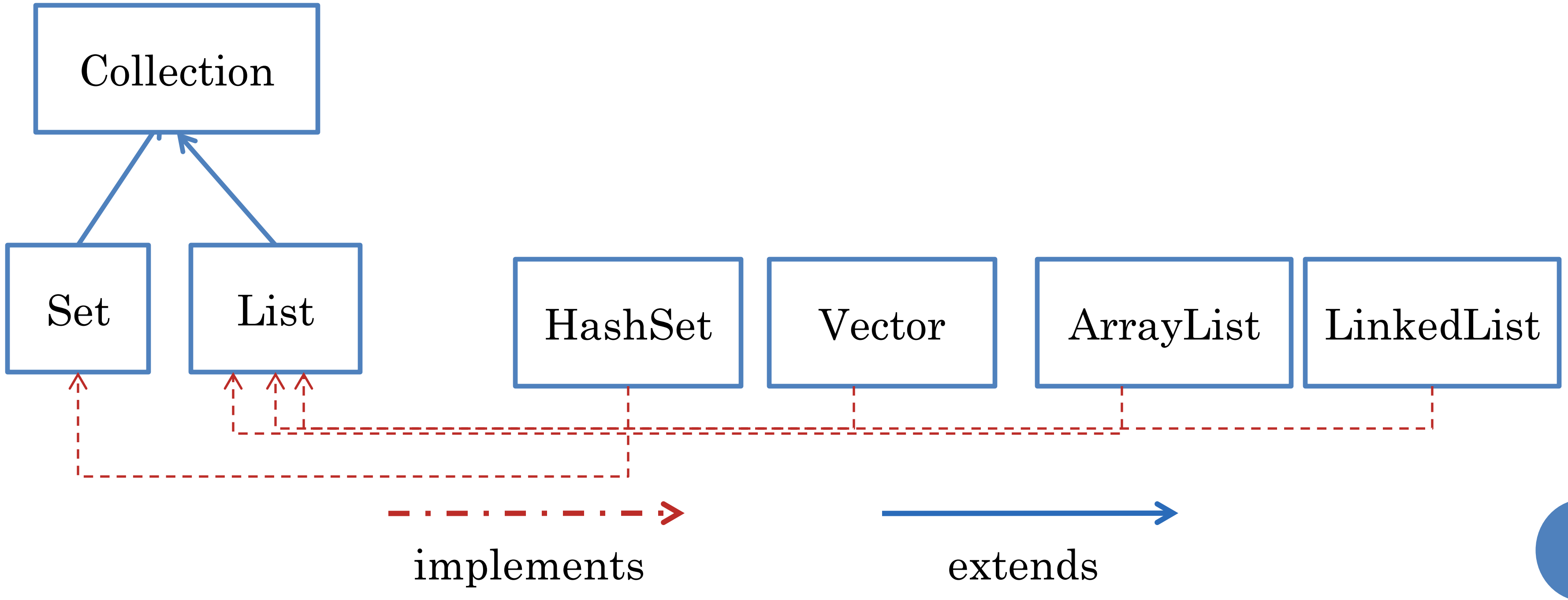
Multiple Inits

```
 ;
public abstract class ACourse  implements Course {
            String title = “Topics in Computer Science”;;
            String dept = “COMP”;
            public ACourse (String theTitle, String theDept) {
                        init (theTitle, theDept);
                        init();
            }
            public ACourse () { init ();}
            public void init (String theTitle, String theDept) {
                        title = theTitle;
                        dept = theDept;
             }
            void init() {
                         System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
            }
            public String getTitle() {return title;}
             public String getDepartment() {return dept;}
            abstract public int getNumber();
}
```

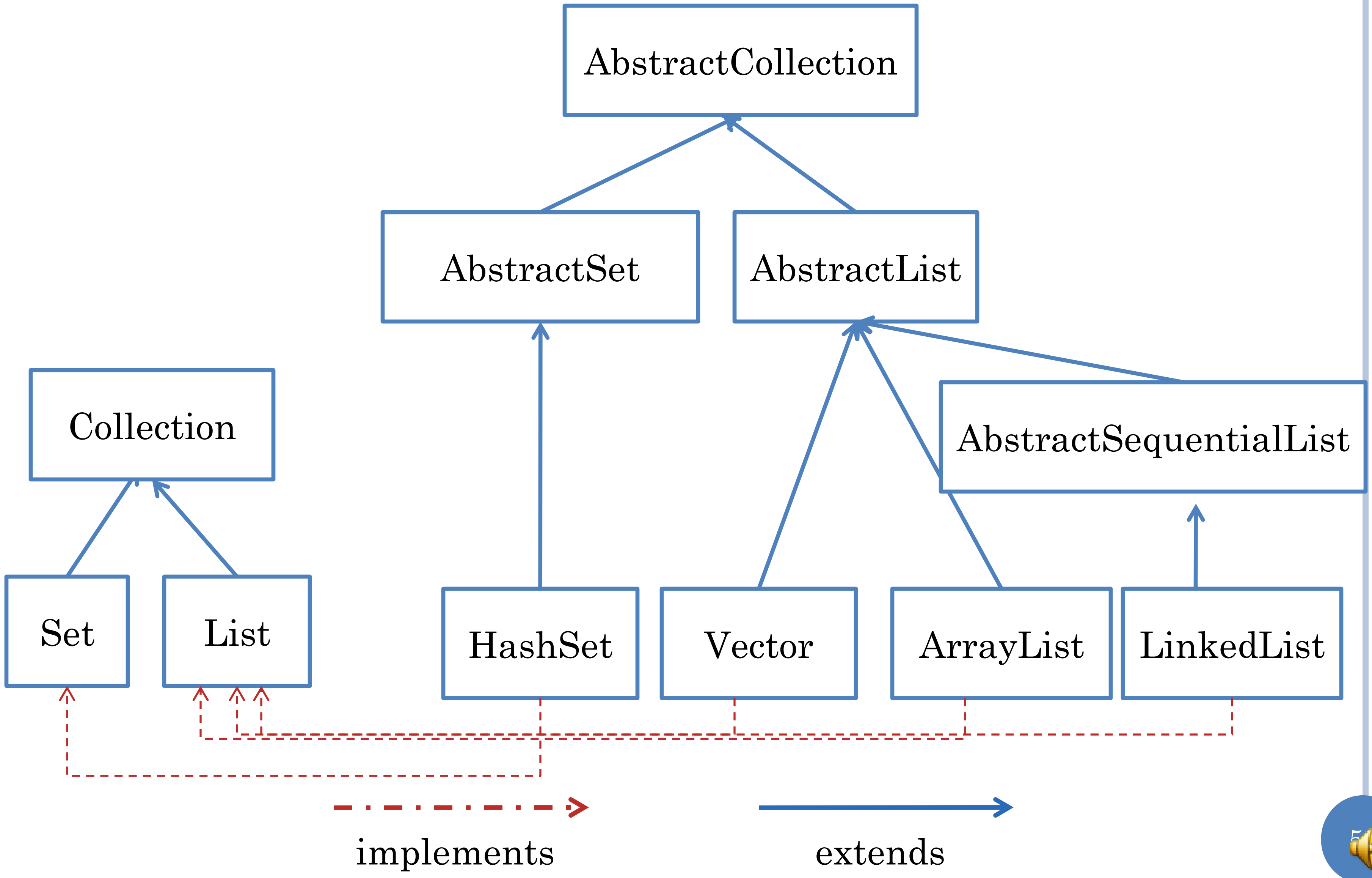
Some SuperTypes in Examples



ABSTRACT CLASSES IN JAVA.UTIL?



Abstract Classes in java.util



Polymorphism vs. Overloading and Dynamic Dispatch

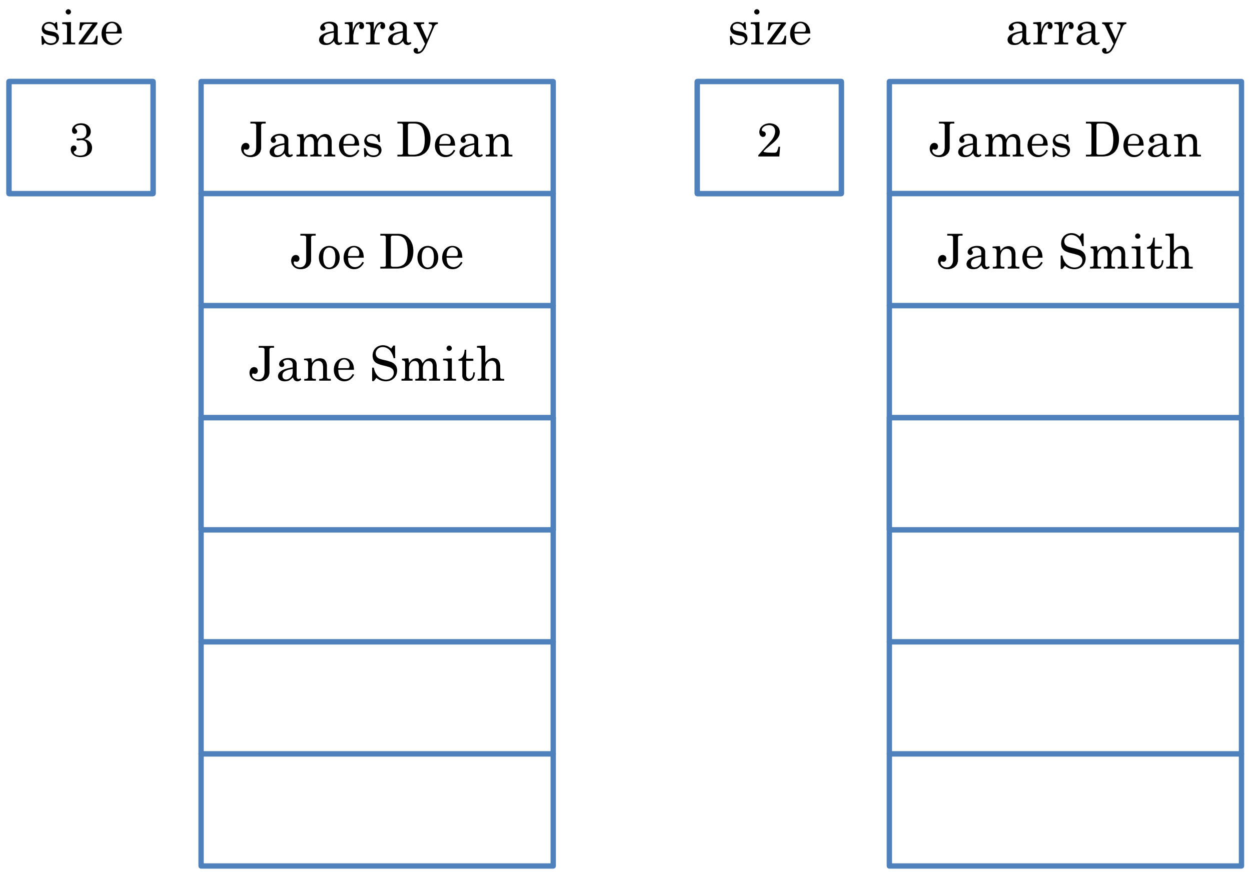
- Create polymorphic code when you can
  - In overloading and dynamic dispatch, multiple implementations associated with each method name.
  - In polymorphic case, single implementation.
    - Use interfaces rather than classes as types of parameters
    - Use supertypes rather than subtypes as types of parameters
- Polymorphism vs. Overloading
  - Polymorphism: single `print (Course course)`
  - Overloading: `print (ARegularCourse course)` and `print (AFreshmanSeminar course)` with same implementation.
- Polymorphism vs. Dynamic Dispatch
  - Polymorphism: single `getTitle()` in `ACourse`
  - Dynamic dispatch: `getTitle()` in `AFreshmanSeminar()` and `getTitle()` in `ARegularCourse()` with same implementation.

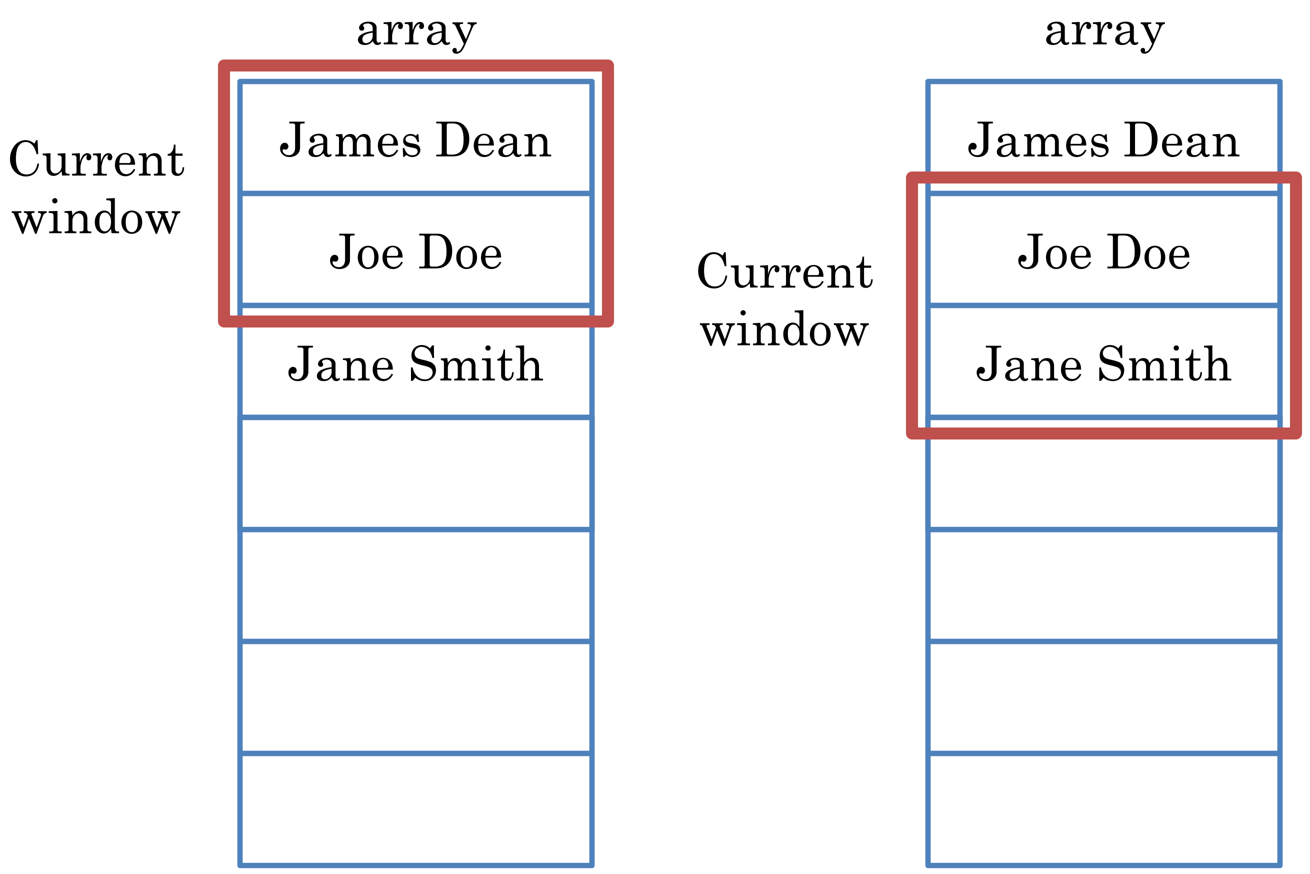
Polymorphism vs. Overloading and Dynamic Dispatch

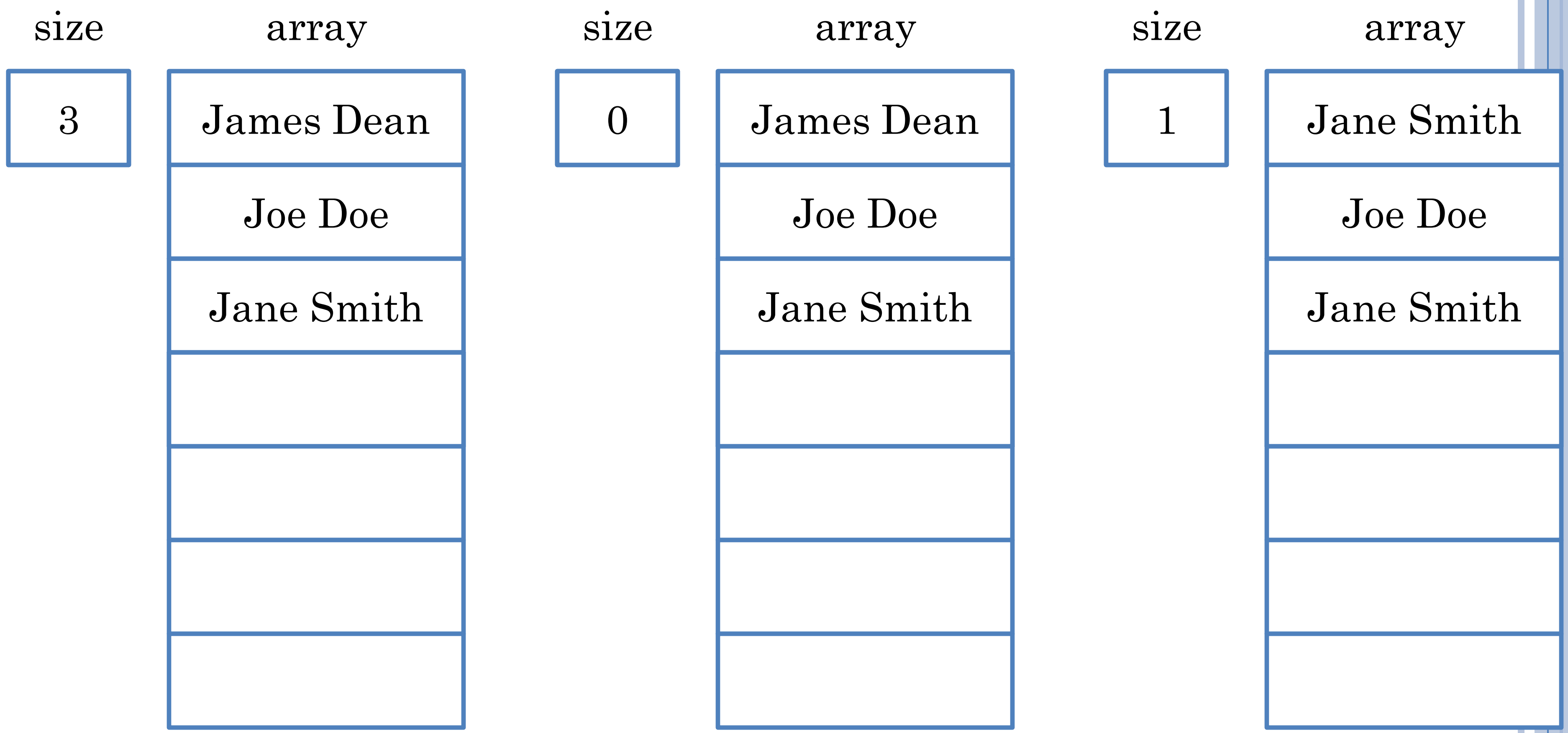
- Cannot always create polymorphic method.
  - `getNumber()` for `ARegularCourse` and `AFreshmanSeminar` do different things.
  - `print(Course course)` and `print (CourseList courseList)` do different things.
- When polymorphism not possible try overloading and dynamic dispatch.

Overloading vs. dynamic dispatch

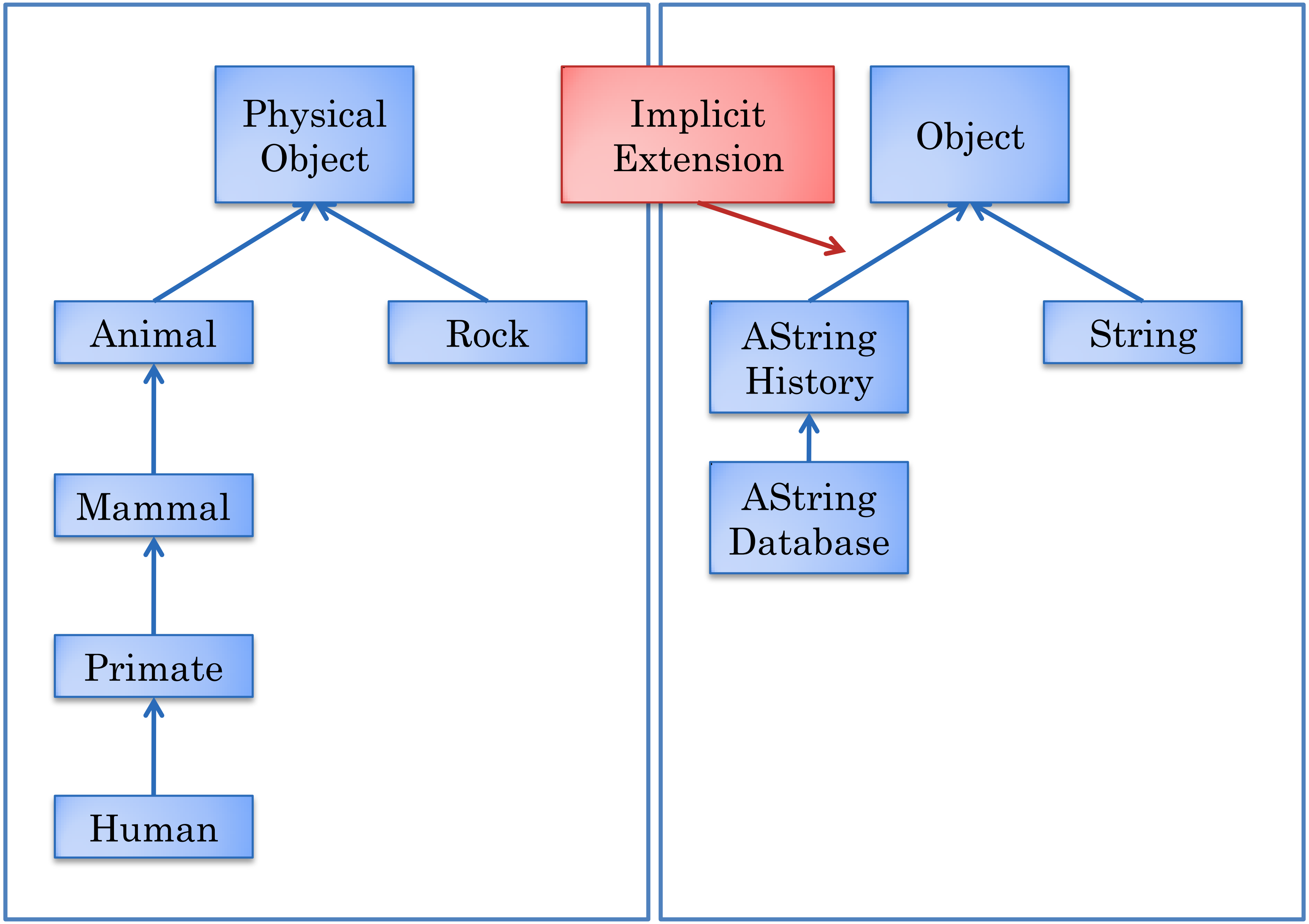
- Overloading:
  - Object is parameter
- Dynamic dispatch:
  - Object is target
- Method in object class vs. external class
  - Program decomposition issue
  - `print(Course)`, `print (CourseList)` definitions overloaded
  - `AFreshmanSeminar.getCourseNumber()`, `ARegularCourse.getCourseNumber()` dynamically dispatched
- Overload resolution looks at multiple parameter types
  - More general and used for that reason also
- Dynamic dispatch is done at runtime
  - Can be used for that reason


size
array
3
James Dean
Joe Doe
Jane Smith
size
array
2
James Dean
Jane Smith


array
Current window
James Dean
Joe Doe
Jane Smith
array
Current window
James Dean
Joe Doe
Jane Smith


size
array
3
James Dean
Joe Doe
Jane Smith
size
array
0
James Dean
Joe Doe
Jane Smith
size
array
1
Jane Smith
Joe Doe
Jane Smith

Physical and Computer Inheritance



Different Types

```
public void addElement(Object element) {
          if (isFull())
                 System.out.println("Adding item to a full history");
          else {
                 contents[size] = element;
                 size++;
          }
 }
```

```
public void addElement(String element) {
         if (member(element)) return;
         super.addElement(element);
 }
```

Signature of Overridden method should be identical in overriding class, otherwise considered different method

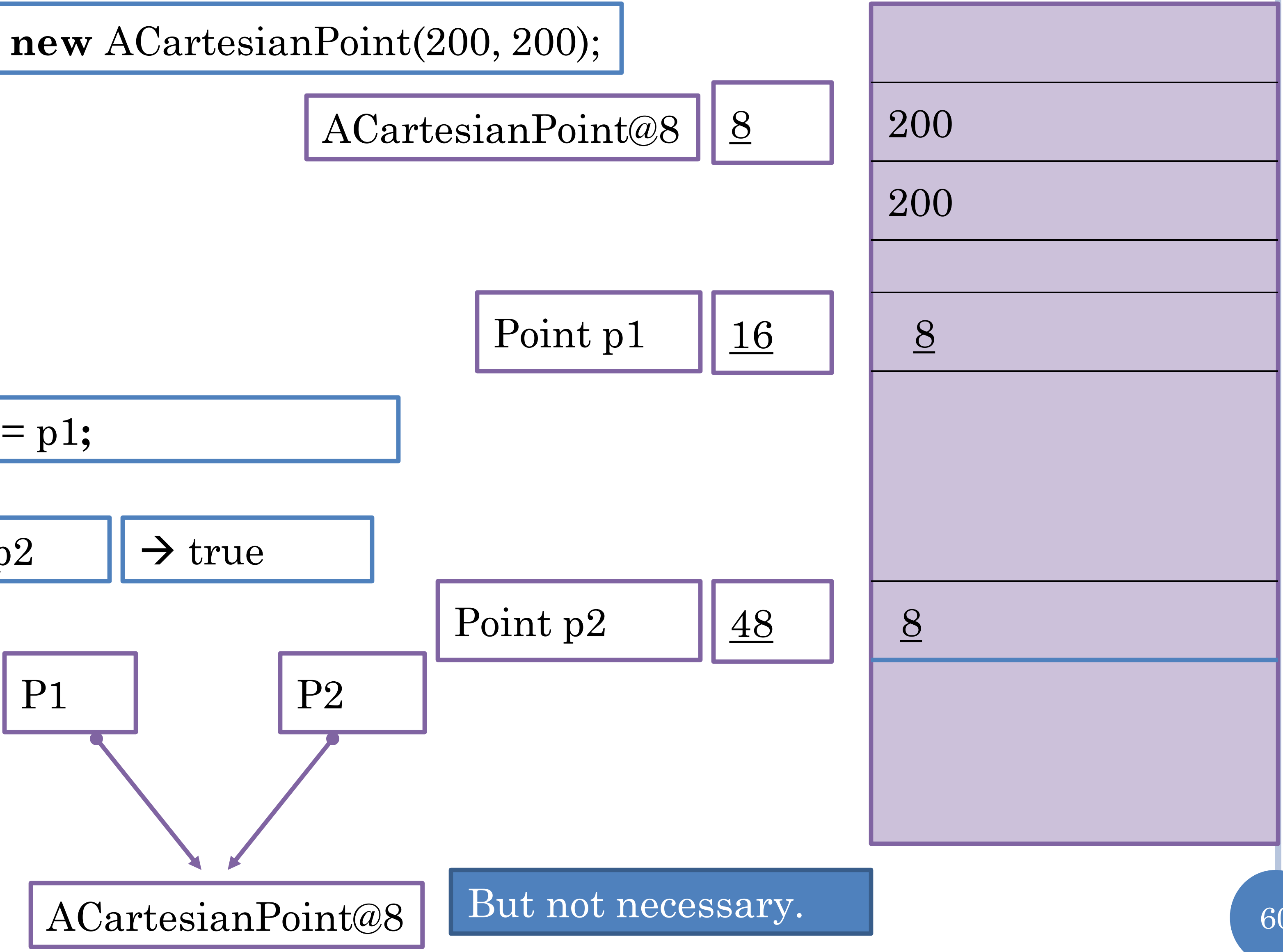
== for Objects

```
Point p1 = new ACartesianPoint(200, 200);
```

```
Point p2 = p1;
```

```
p2 == p2
```

→ true



But not necessary.

Abstract Course

```
 ;
public abstract class ACourse {
        String title, dept;
        public ACourse (String theTitle, String theDept) {
                super();
                title = theTitle;
                dept = theDept;
        }
        public String getTitle() {
                return title;
        }
        public String getDepartment() {
                return dept;
        }
}
```

Does not implement an interface

ANOTHER COURSE

```
 ;
public abstract class ACourse implements Course {
        String title, dept;
        public ACourse (String theTitle, String theDept) {
                super();
                title = theTit
                dept = theDe
        }
        public String getTitl
                return title;
        }
        public String getDepartment() {
                return dept;
        }
        abstract public int getNumber();
}
```

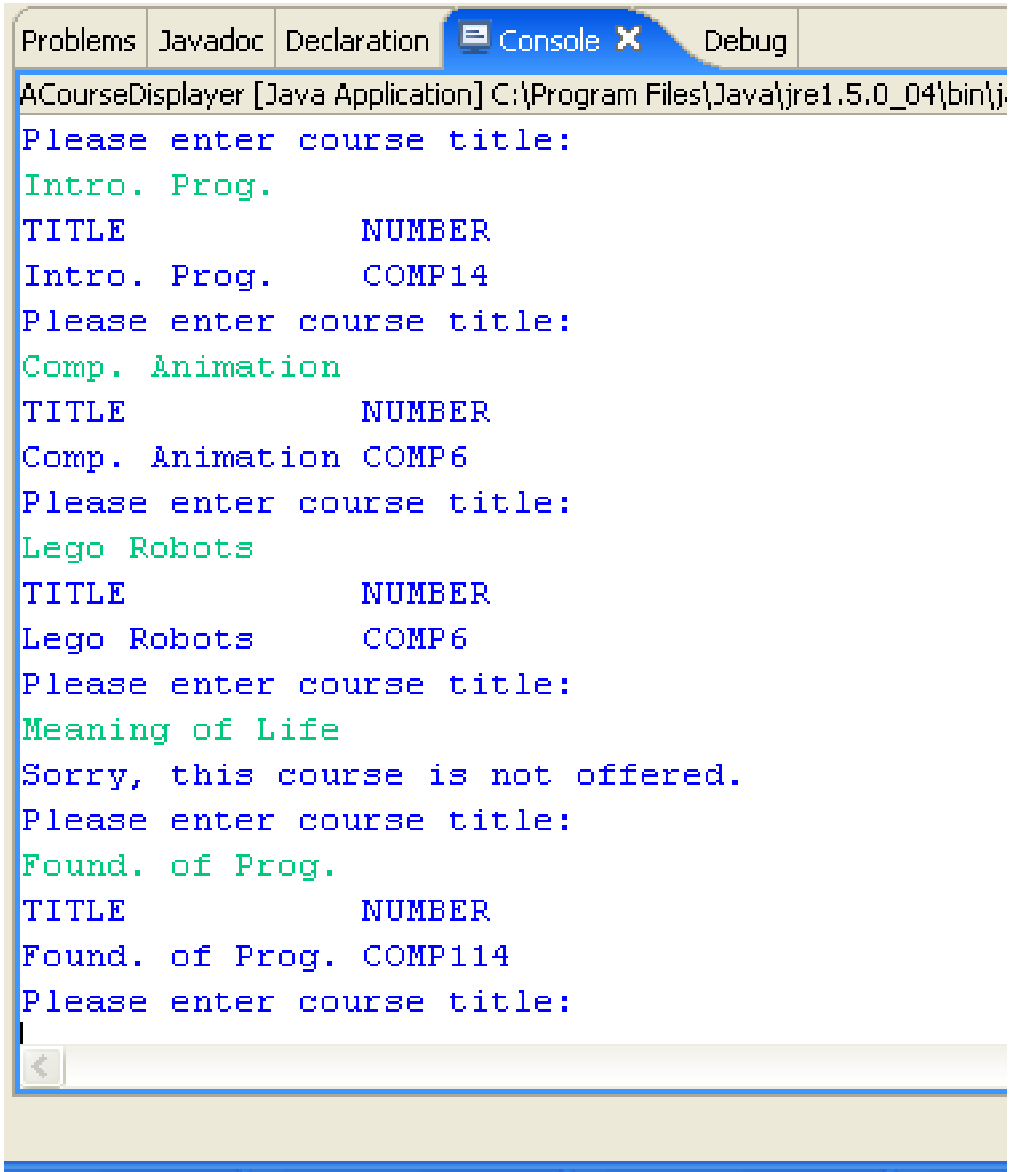
```
 ;
public interface Course {
        public String getTitle();
        public String getDepartment();
        public int getNumber();
}
```

Abstract Method

Abstract method

- Declared only in abstract classes
- Keyword: **abstract**
- No body
- Each (direct or indirect) subclass must implement abstract methods defined by an abstract class.
- Much like each class must implement the methods defined by its interface(s).

Course Displayer User Interface



```
ACourseDisplayer [Java Application] C:\Program Files\Java\jre1.5.0_04\bin\j
Please enter course title:
Intro. Prog.
TITLE           NUMBER
Intro. Prog.    COMP14
Please enter course title:
Comp. Animation
TITLE           NUMBER
Comp. Animation COMP6
Please enter course title:
Lego Robots
TITLE           NUMBER
Lego Robots     COMP6
Please enter course title:
Meaning of Life
Sorry, this course is not offered.
Please enter course title:
Found. of Prog.
TITLE           NUMBER
Found. of Prog. COMP114
Please enter course title:
```

Main class: Filling List

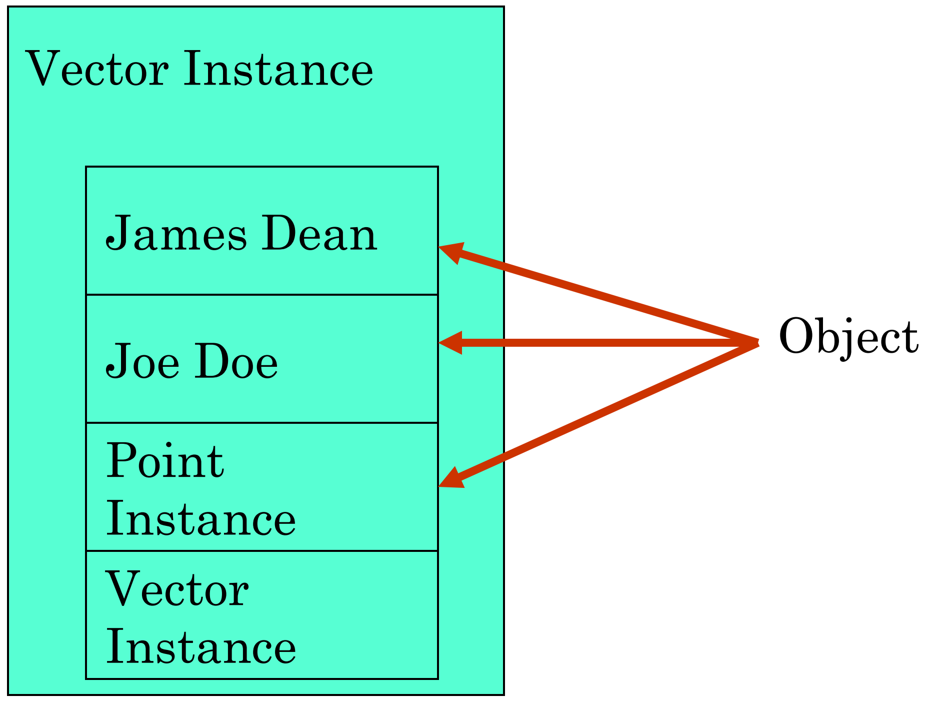
```
		static CourseList courses = new ACourseList();
		static void fillCourses() {
				courses.addElement(new ARegularCourse ("Intro. Prog.", 
"COMP", 14));
				courses.addElement(new ARegularCourse ("Found. of 
Prog.", "COMP", 114));
				courses.addElement(new AFreshmanSeminar("Comp. 
Animation", "COMP"));
				courses.addElement(new AFreshmanSeminar("Lego 
Robots",  "COMP"));
		}
```

Java Vectors, Array Lists and Iterators

- Just like collections we defined
- Except they can store and iterate arbitrary objects

Vectors (java.util.Vector)

Vector v;



```
v = new Vector();
v.addElement("James Dean")
v.addElement("Joe Doe")
v.addElement(new ACartesianPoint(5, 5))
v.addElement(new Vector())
```

~~v.addElement(5)~~

Important Methods of Class Vector

- **public final int** size()
- **public final** Object elementAt(int index)
- **public final void** addElement(Object obj)
- **public final void** setElementAt(Object obj, int index)
- **public final void** insertElementAt(Object obj, **int** index)
- **public final boolean** removeElement(Object obj)
- **public final void** removeElementAt(**int** index)
- **public final int** indexOf(Object obj)
- **public final** Enumeration elements()

Methods of Interface Enumeration (java.util.Enumeration)

- **public boolean** hasMoreElements();
- **public** Object nextElement();

```
Enumeration elements = vector.elements();
while ( elements.hasMoreElements())
    System.out.println(elements.nextElement();
```

Methods of Interface Enumeration (java.util.Enumeration)

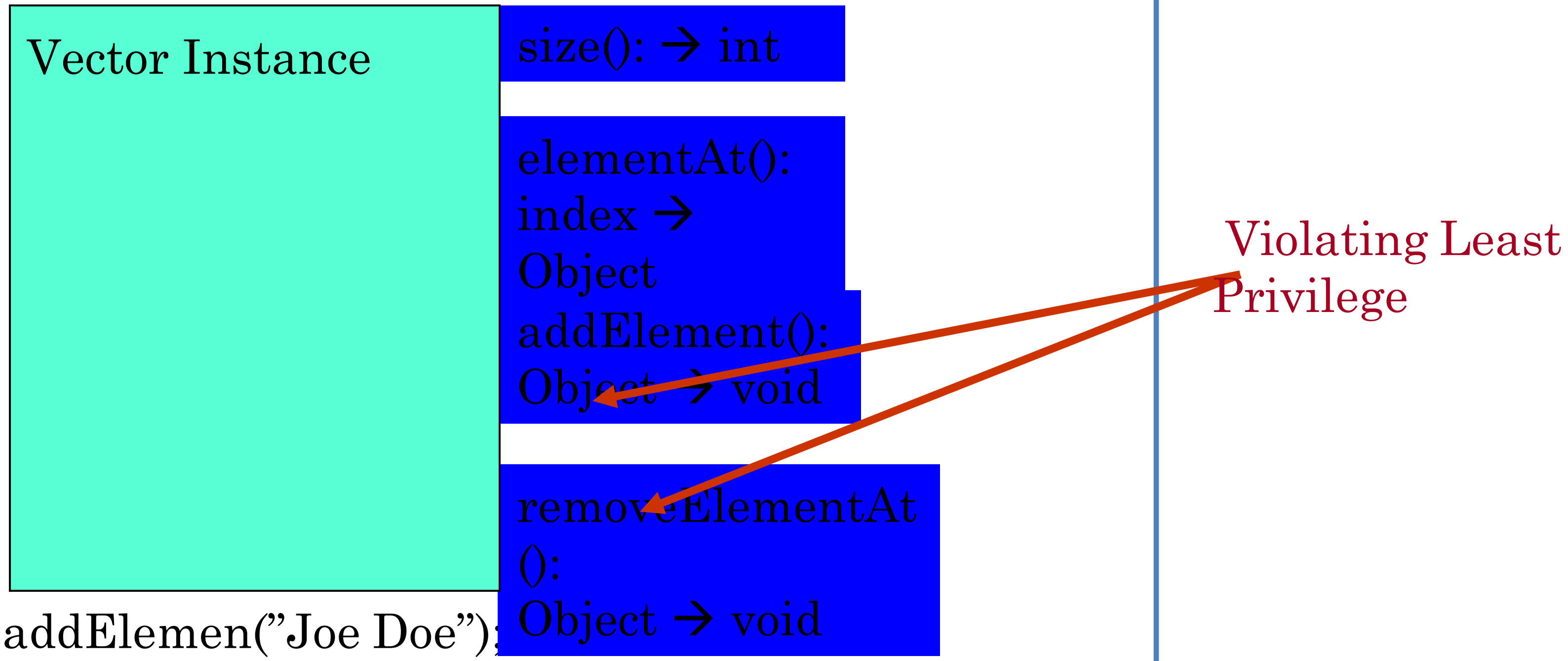
- **public boolean** hasMoreElements();
- **public** Object nextElement();

```
for (Enumeration elements =        vector.elements();
           elements.hasMoreElements();)
   System.out.println(elements.nextElement();
```

Using Vector Directly

String history user

Vector v = new Vector();



Vector Instance
size(): → int
elementAt(): index → Object
addElement(): Object → void
removeElementAt(): Object → void
Violating Least Privilege

v.addElemen(”Joe Doe”);

v.addElement(“John Smith”**);**

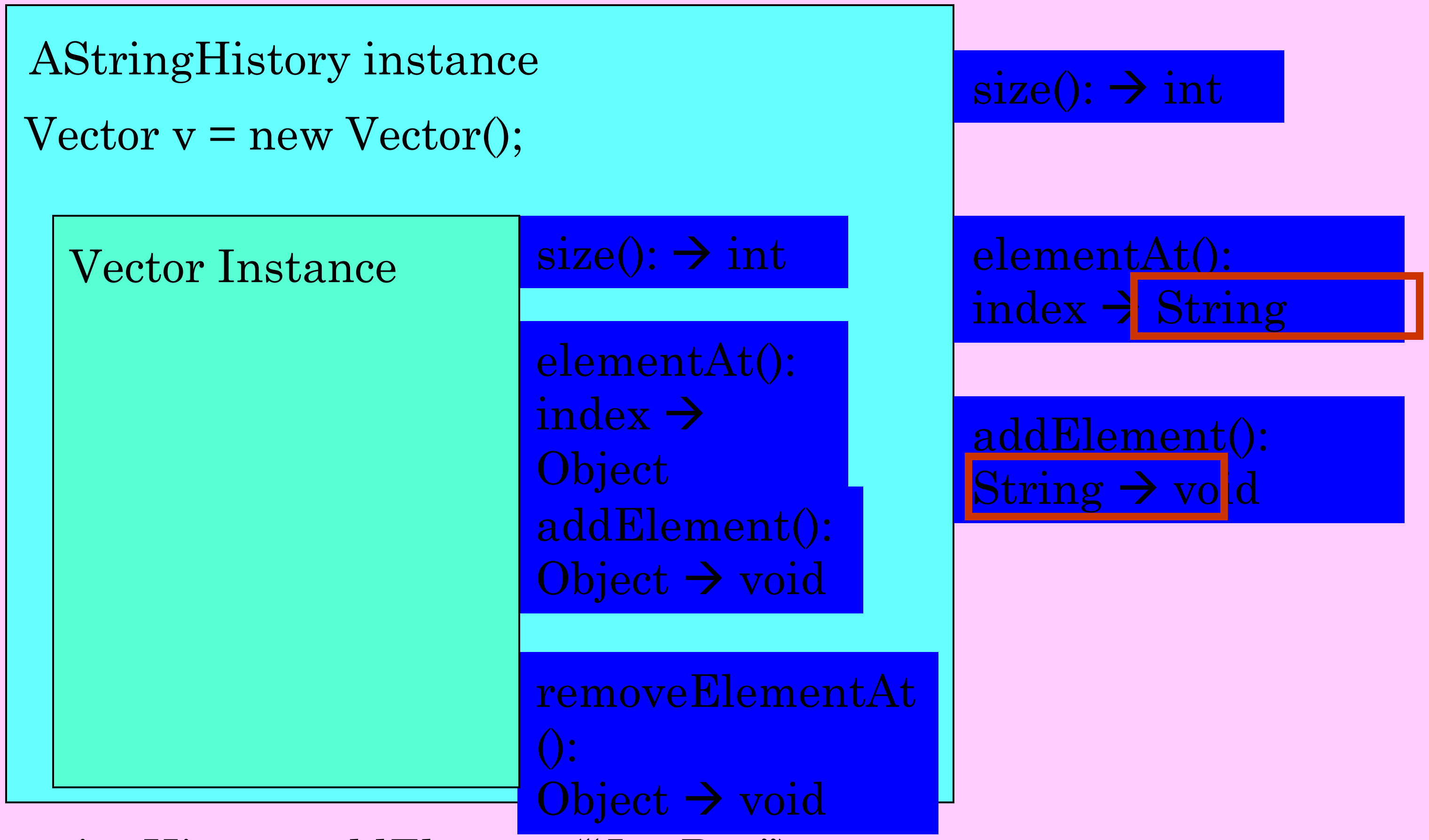
v.addElement(**new** Vector());

v.removeElementAt(0);

Encapsulating Vector

String history user

```
StringHistory stringHistory = new AStringHistory()
```



AStringHistory instance
Vector v = new Vector();
Vector Instance
size(): → int
elementAt(): index → Object
addElement(): Object → void
removeElementAt(): Object → void
size(): → int
elementAt(): index → String
addElement(): String → void

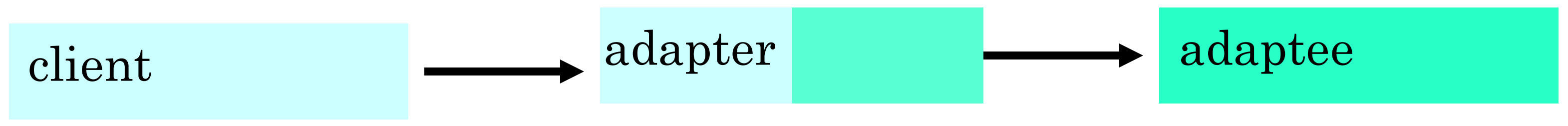
```
stringHistory.addElement("Joe Doe");
stringHistory.addElement(new Vector())
```

Encapsulating Vector

```
import java.util.Vector;
public class AStringHistory implements
   StringHistory {
   Vector contents = new Vector();
   public void addElement (String s) {
         contents.addElement(s);
   }
   public String elementAt (int index) {
         return (String) contents.elementAt(index);
   }
   public int size() {
         return contents.size();
   }
}
```

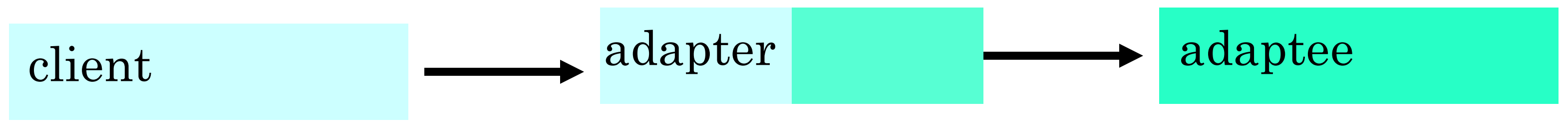
Simply converts types

Adapter Pattern



- Degree of adaptation undefined.
- Methods offered to client
  - Adapted name
  - Adapted type

ADAPTER PATTERN



- Degree of adaptation undefined.
- Methods offered to client
  - Adapted name
  - Adapted type

Parser Structure

- Each production associated with a parser method.
- Parser method returns object associated with LHS of production.
- Usually at start of method execution
  - Prefix of unconsumed input should be legal phrase derived from LHS
  - Unless calling method consumed one ore more tokens of the phrase to choose an alternative rule
- Such a parser called: recursive descent parser
- Illustrates top-down programming

Alternative ARegularCourse

```
 ;
public class ARegularCourse extends ACourse {
        int courseNum;
        public ARegularCourse (String theTitle, String theDept, int
theCourseNum) {
                super (theTitle, theDept);
                courseNum = theCourseNum;
        }
        public int getNumber() {
                return courseNum;
        }
}
```

Implementation of abstract method

Implicitly implements interfaces implemented by superclass

ALTERNATIVE AFRESHMANSEMINAR

```
 ;
public class AFreshmanSeminar extends ACourse {
        public AFreshmanSeminar (String theTitle, String theDept) {
                super (theTitle, theDept);
        }
        public int getNumber() {
                return SEMINAR_NUMBER;
        }
}
```

Implementation of abstract method

Implicitly implements interfaces implemented by superclass

Alternative AFreshmanSeminar

```
 ;
public class AFreshmanSeminar extends ACourse {
        public AFreshmanSeminar (String theTitle, String theDept) {
                super (theTitle, theDept);
                title = theTitle;
        }
        public AFreshmanSeminar () {     }

        public int getNumber() {
                return SEMINAR_NUMBER;
        }
}
```

```
new AFreshmanSeminar (“Lego Robots”, “COMP”);
```

```
new AFreshmanSeminar();
```

Multiple Constructors

```
 ;
public abstract class ACourse  implements Course {
            String title, dept;
            final String DEFAULT_DEPT = “COMP”;
            final String DEFAULT_TITLE = “Topics in Computer Science”;
            public ACourse (String theTitle, String theDept) {
                        title = theTitle;
                        dept = theDept;
                        System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber()
            }
            public ACourse () {
                         dept = DEFAULT_DEPT;
                         title = DEFAULT_TITLE;
                         System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber())          ;
            }
            public String getTitle() {return title;}
            public String getDepartment() {return dept;}
            abstract public int getNumber();
}
```

Code Duplication

```
 ;
public abstract class ACourse  implements Course {
        String title, dept;
        final String DEFAULT_DEPT = “COMP”;
        final String DEFAULT_TITLE = “Topics in Computer Science”;
        public ACourse (String theTitle, String theDept) {
                title = theTitle;
                dept = theDept;
                System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber()
        }
        public ACourse () {
                dept = DEFAULT_DEPT;
                title = DEFAULT_TITLE;
                System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber())        ;
        }
        public String getTitle() {return title;}
         public String getDepartment() {return dept;}
        abstract public int getNumber();
}
```

How to remove code duplication?

CONSTRUCTOR CALLING CONSTRUCTOR

```
 ;
public abstract class ACourse  implements Course {
        String title, dept;
        final String DEFAULT_DEPT = “COMP”;
        final String DEFAULT_TITLE = “Topics in Computer Science”;
        public ACourse (String theTitle, String theDept) {
                title = theTitle;
                dept = theDept;
                System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
        }
        public ACourse () {
                this (DEFAULT_DEPT, DEFAULT_TITLE );
        }
        public String getTitle() {return title;}
         public String getDepartment() {return dept;}
        abstract public int getNumber();
}
```

this implies constructor of same class.

Equivalent Code

```
 ;
public abstract class ACourse  implements Course {
        String title, dept;
        final String DEFAULT_DEPT = “COMP”;
        final String DEFAULT_TITLE = “Topics in Computer Science”;
        public ACourse (String theTitle, String theDept) {
                super();
                title = theTitle;
                dept = theDept;
                System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: "          ber());
        }
        public ACourse () {
                 this (DEFAULT_DEPT, DEFAULT_TITLE );
        }
        public String getTitle() {return title;}
         public String getDepartment() {return dept;}
        abstract public int getNumber();
}
```

super()?

Super may have side effects, so cannot call super() before this()

Constructor calling Constructor

```
 ;
public abstract class ACourse  implements Course {
        String title, dept;
        final String DEFAULT_DEPT = “COMP”;
        final String DEFAULT_TITLE = “Topics in Computer Science”;
        public ACourse (String theTitle, String theDept) {
                title = theTitle;
                dept = theDept;
                System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
        }
        public ACourse () {
                this (DEFAULT_DEPT, DEFAULT_TITLE );
        }
        public String getTitle() {return title;}
         public String getDepartment() {return dept;}
        abstract public int getNumber();
}
```

Java complains that instance vars cannot be accessed.

Multiple Constructors

```
 ;
public abstract class ACourse  implements Course {
            String title, dept;
            final String DEFAULT_DEPT = “COMP”;
            final String DEFAULT_TITLE = “Topics in Computer Science”;
            public ACourse (String theTitle, String theDept) {
                        title = theTitle;
                        dept = theDept;
                        System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber()
            }
            public ACourse () {
                        dept = DEFAULT_DEPT;
                        title = DEFAULT_TITLE;
                        System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber())         ;
            }
            public String getTitle() {return title;}
            public String getDepartment() {return dept;}
            abstract public int getNumber();
}
```

Code Duplication

```
 ;
public abstract class ACourse  implements Course {
            String title, dept;
            final String DEFAULT_DEPT = “COMP”;
            final String DEFAULT_TITLE = “Topics in Computer Science”;
            public ACourse (String theTitle, String theDept) {
                        title = theTitle;
                        dept = theDept;
                        System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber()
            }
            public ACourse () {
                         dept = DEFAULT_DEPT;
                         title = DEFAULT_TITLE;
                         System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber())        ;
            }
            public String getTitle() {return title;}
             public String getDepartment() {return dept;}
            abstract public int getNumber();
}
```

How to remove code duplication?

Constructor calling Constructor

```
 ;
public abstract class ACourse  implements Course {
          String title, dept;
          final String DEFAULT_DEPT = “COMP”;
          final String DEFAULT_TITLE = “Topics in Computer Science”;
          public ACourse (String theTitle, String theDept) {
                    title = theTitle;
                    dept = theDept;
                    System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
          }
          public ACourse () {
                    this (DEFAULT_DEPT, DEFAULT_TITLE );
          }
          public String getTitle() {return title;}
           public String getDepartment() {return dept;}
          abstract public int getNumber();
}
```

this implies constructor of same class.

EQUIVALENT CODE

```
 ;
public abstract class ACourse  implements Course {
        String title, dept;
        final String DEFAULT_DEPT = “COMP”;
        final String DEFAULT_TITLE = “Topics in Computer Science”;
        public ACourse (String theTitle, String theDept) {
                super();
                title = theTitle;
                dept = theDept;
                System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: "              ber());
        }
        public ACourse () {
                 this (DEFAULT_DEPT, DEFAULT_TITLE );
        }
        public String getTitle() {return title;}
         public String getDepartment() {return dept;}
        abstract public int getNumber();
}
```

super()?

Super may have side effects, so cannot call super() before this()

Constructor calling Constructor

```
 ;
public abstract class ACourse  implements Course {
        String title, dept;
        final String DEFAULT_DEPT = “COMP”;
        final String DEFAULT_TITLE = “Topics in Computer Science”;
        public ACourse (String theTitle, String theDept) {
                title = theTitle;
                dept = theDept;
                System.out.println("New course created: " + "Title:" + title
+ " Dept:"+ dept + " Number: " + getNumber());
        }
        public ACourse () {
                this (DEFAULT_DEPT, DEFAULT_TITLE );
        }
        public String getTitle() {return title;}
         public String getDepartment() {return dept;}
        abstract public int getNumber();
}
```

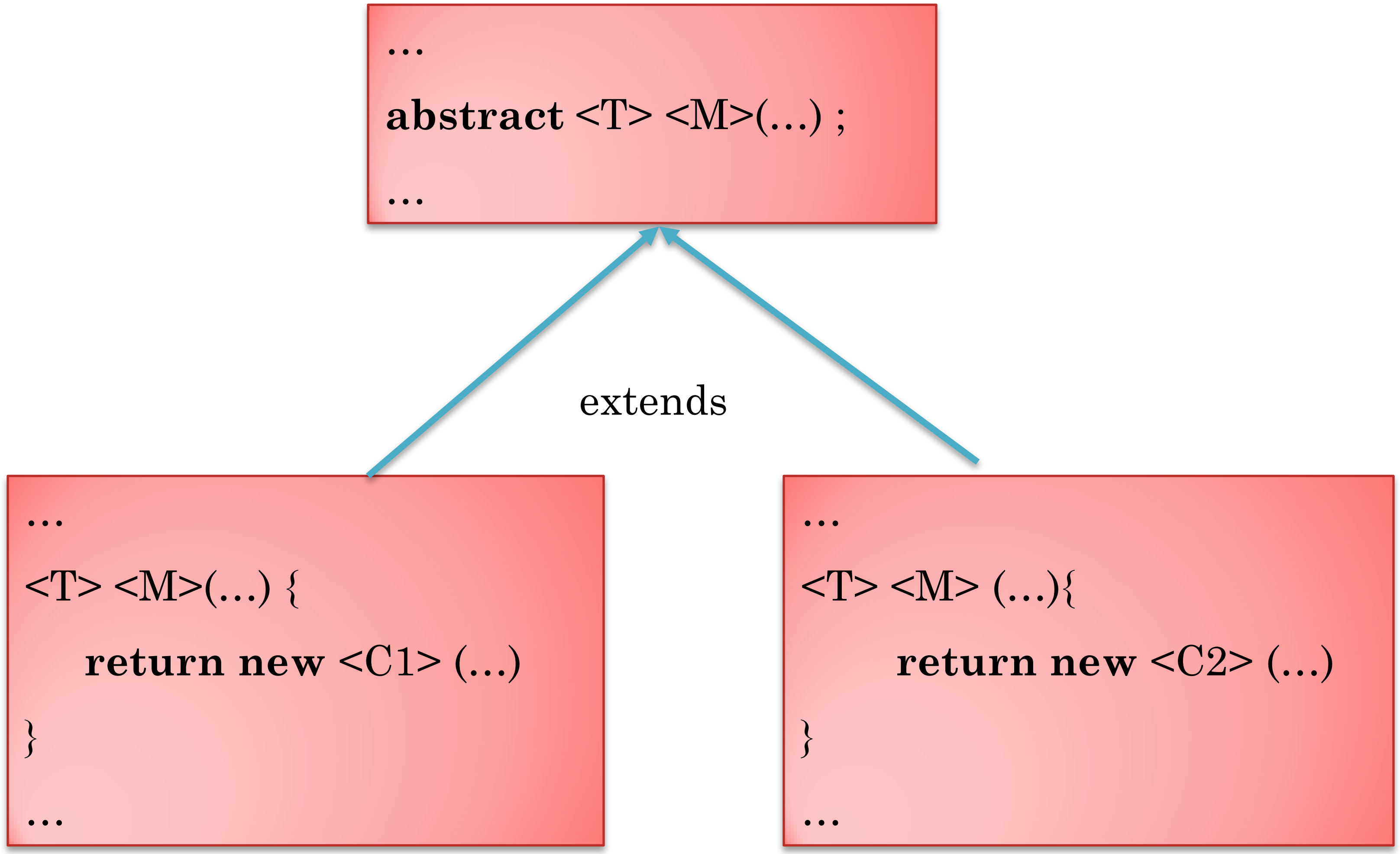
Java complains that instance vars cannot be accessed.

Abstract Method Example

```
 ;
public abstract class ACourse {
        String title, dept;
        public ACourse (String theTitle, String theDept) {
                super();
                title = theTitle;
                dept = theDept;
        }
        public String getTitle() {
                return title;
        }
        public String getDepartment() {
                return dept;
        }
        abstract public int getNumber();
}
```

Abstract Method

Factory Abstract Method



```
…
abstract <T> <M>(…) ;
…
```

```
…
<T> <M>(…) {
    return new <C1> (…)
}
…
```

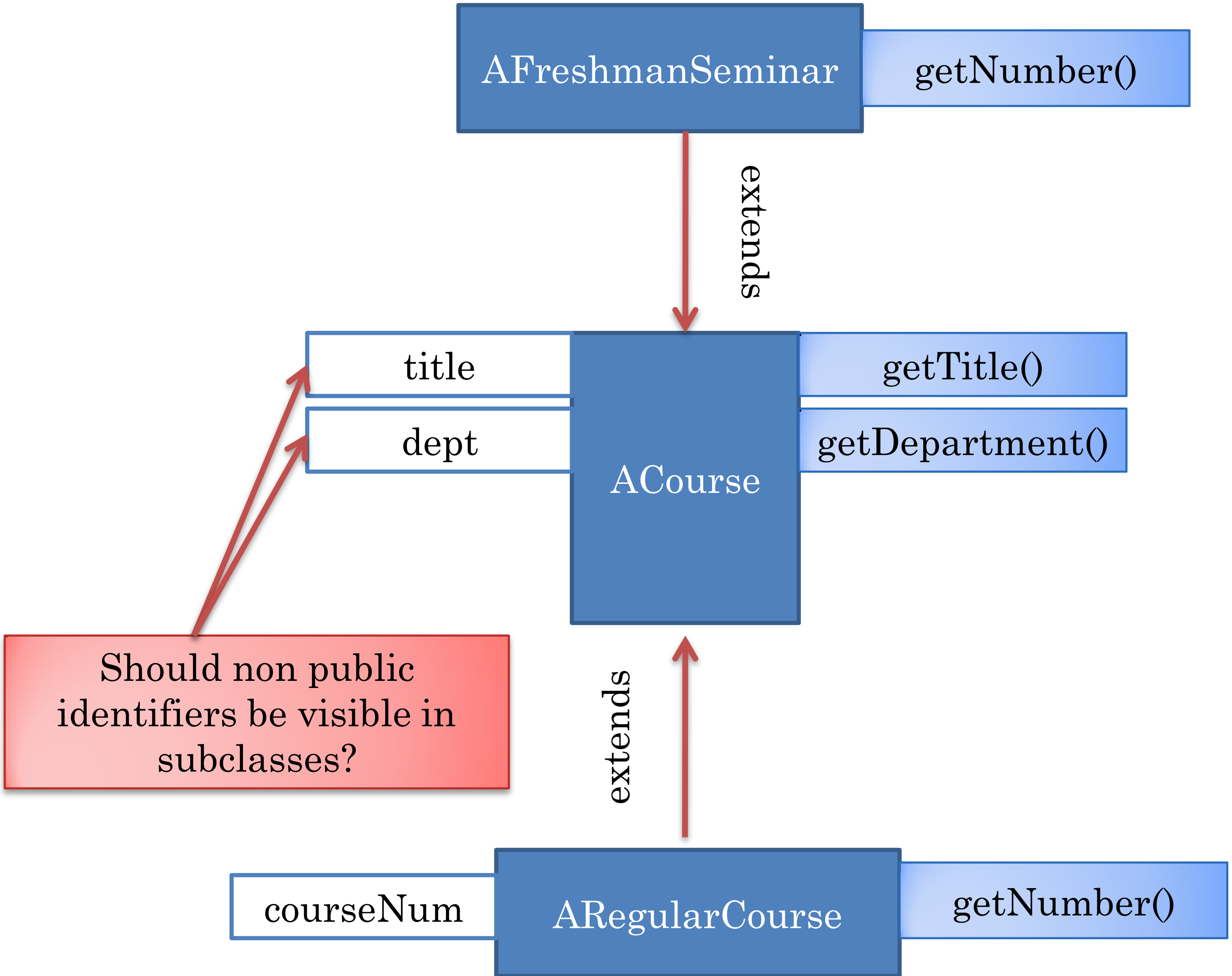
```
…
<T> <M> (…){
        return new <C2> (…)
}
…
```

Abstract method that returns an instance of some type T – like a factory, it creates and initializes an object.

Init methods

- Allows initialization after object is created.
- Initializer can be different from creator
- Init methods can be in interfaces
- Init method(s) recommended but not required

Visibility of SuperClass Members



Access control on variables and Inheritance, Packages

- **public**: accessible in all classes.
- **protected**: accessible in all subclasses of its class and all classes in its package.
- **default**: accessible in all classes in its package.
- **private**: accessible only in its class.

ACCESSING SUPERCLASS VARIABLES

```
 ;
public class ARegularCourse extends ACourse {
	int courseNum;
	public ARegularCourse (String theTitle, String theDept, int
theCourseNum) {
		super (theTitle, theDept);
		courseNum = theCourseNum;
		title = theTitle;

	}
	public int getNumber() {
		return courseNum;
	}
}
```

Access allowed since in same package