

CMSC 132: Object-Oriented Programming II



Unified Modeling Language (UML)

Department of Computer Science
University of Maryland, College Park

UML (Unified Modeling Language)

- **UML is a modeling language for**
 - **Specifying**
 - **Visualizing**
 - **Constructing**
 - **Documenting**
- object-oriented software**

Motivation

- **Software growing larger & complex**
 - **Difficult to describe and analyze**
- **Use UML to help**
 - **Visualize design of software**
 - **Provide abstract model of software**

Goals

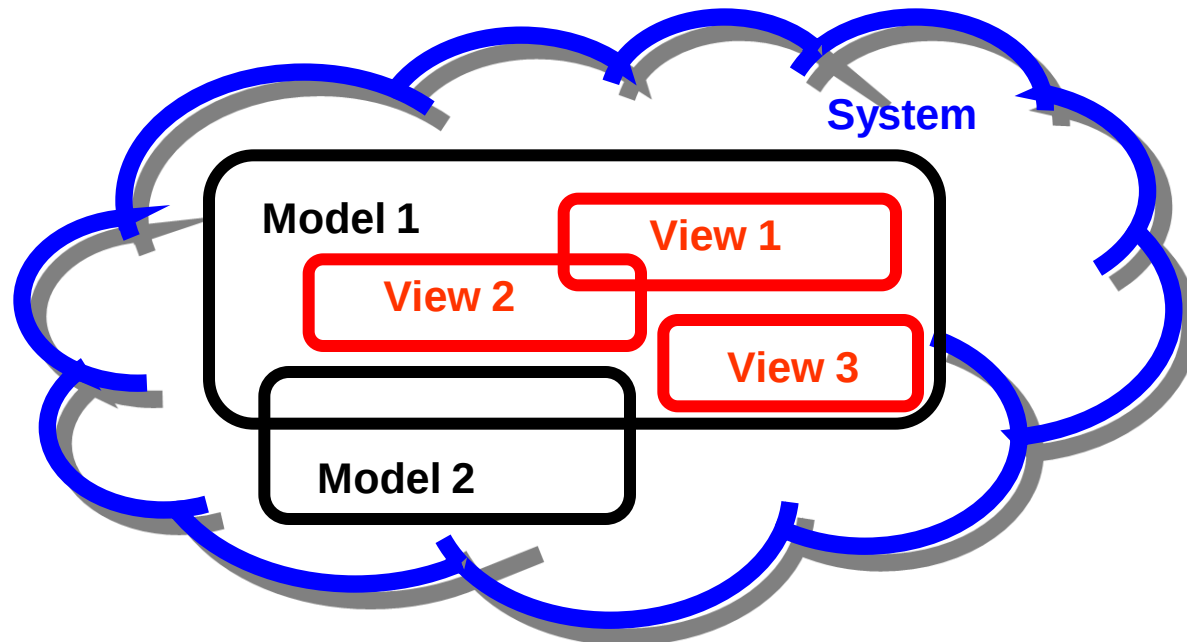
- **Provide a software “blueprint”**
 - Simple yet clear abstraction for software
- **Describe software design**
 - Clearly
 - Concisely
 - Correctly

History of UML

- **Started in 1994**
- **Combines 3 leading OO methods**
 - **OMT** (James Rumbaugh)
 - **OOSE** (Ivar Jacobson)
 - **Booch** (Grady Booch)

UML Diagrams

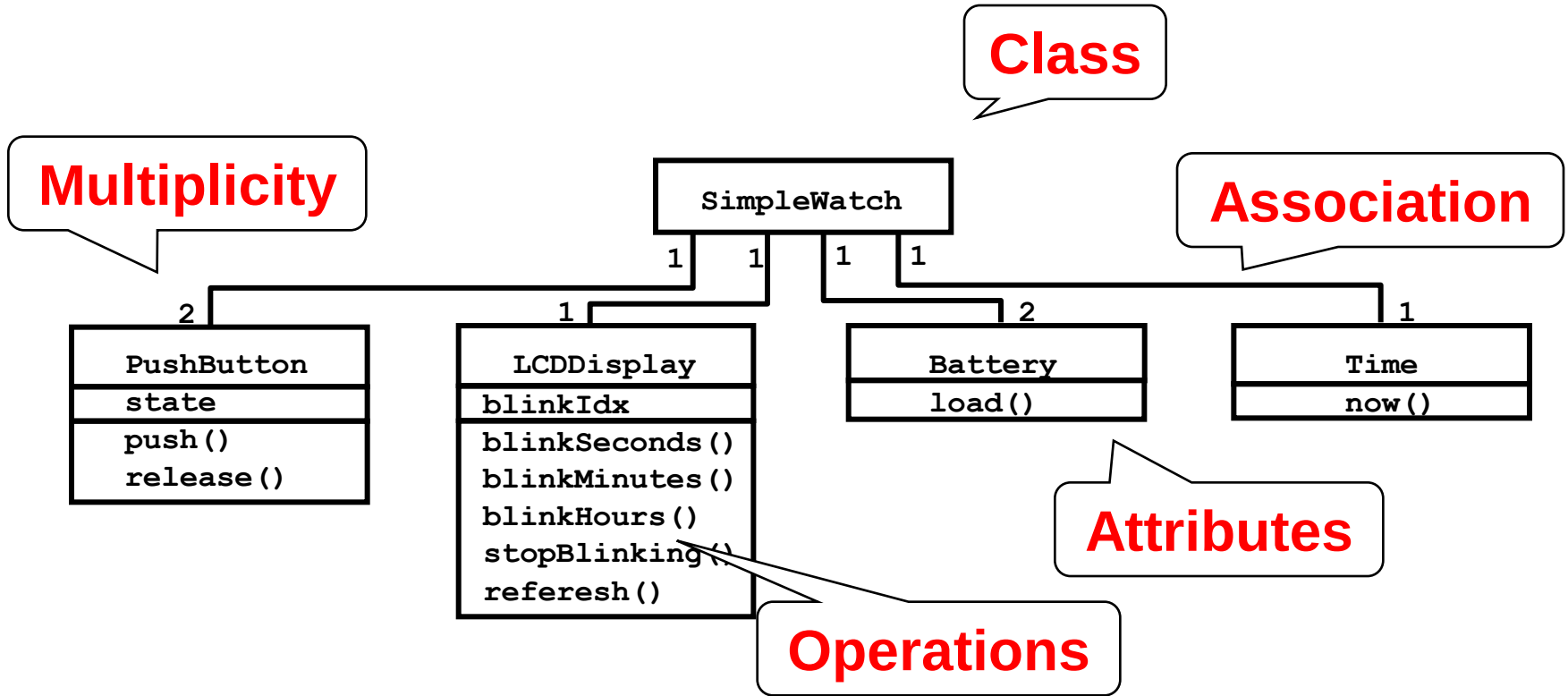
- UML provides a number of **diagrams** that
 - Describe a **model** of all or part of system
 - From a particular point of **view**
 - With varying level of abstraction
 - Using certain set of notations



Class Diagram

- Represents (static) structure of system
- A class diagram displays
 - Information for class
 - Relationships between classes

Class Diagram

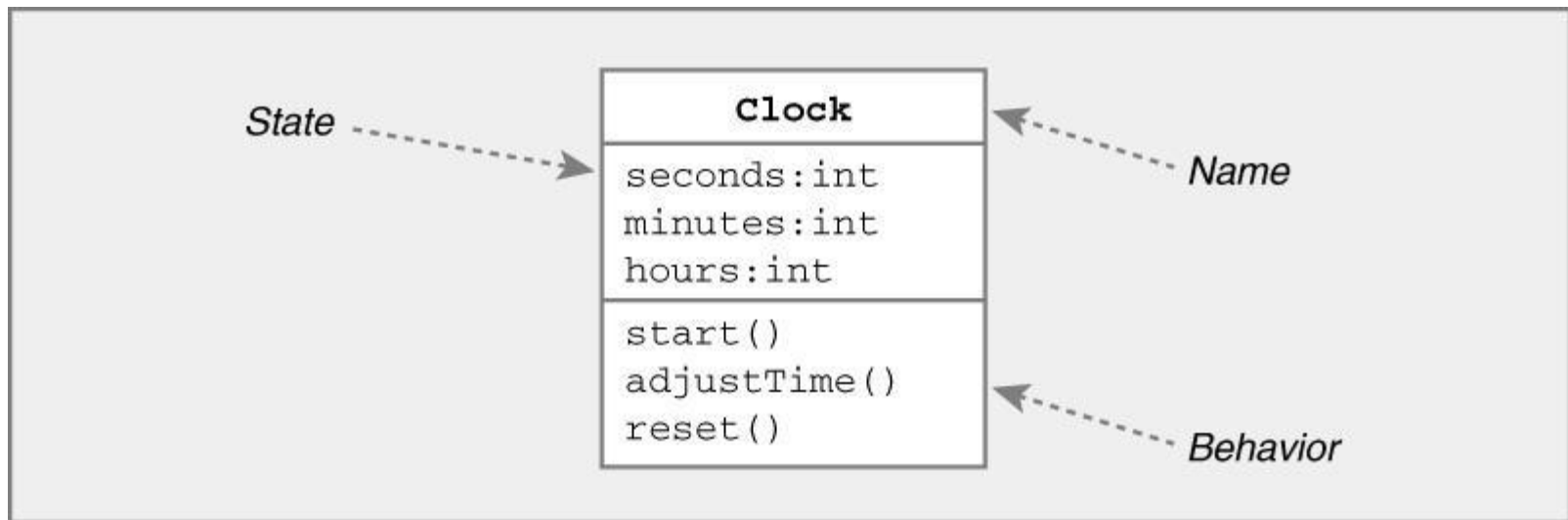


Class diagrams represent structure of system

Class Diagrams

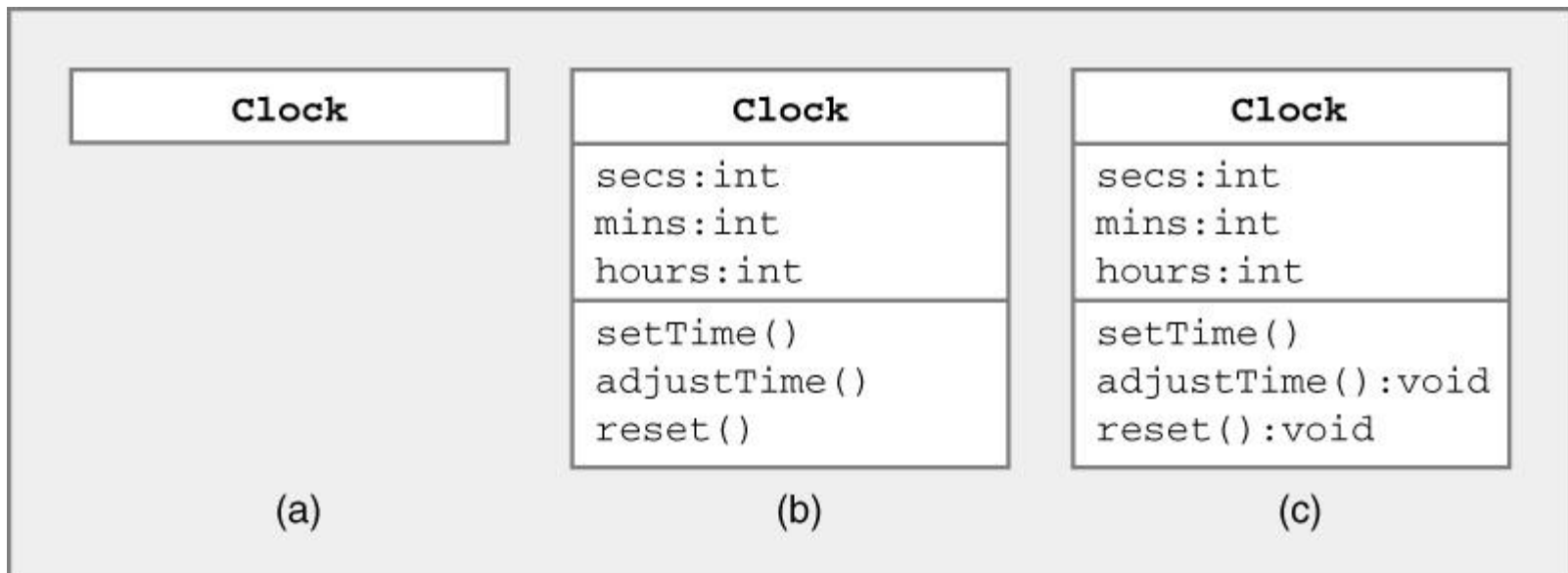
■ Information for class contains

- Name
- State
- Behavior



Class Diagram

- Class name is required
- Other information optional
 - State, behavior
 - Types, visibility...



UML Class Diagrams ↔ Java Code

- Different representation of **same** information
 - Name, state, behavior of class
 - Relationships between classes
- Should be able to derive one from the other
- Motivation
 - UML ⇒ Java
 - Implement code based on design written in UML
 - Java ⇒ UML
 - Create UML to document design of existing code

Java → UML : Clock Example

■ Java

```
class Clock { // name
```

```
// state
```

```
int seconds;
```

```
int minutes;
```

```
int hours;
```

```
// behavior
```

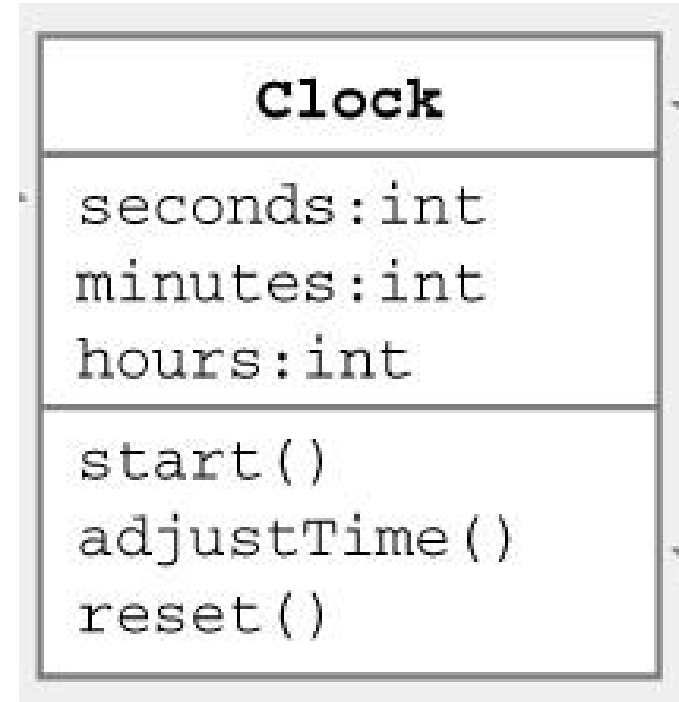
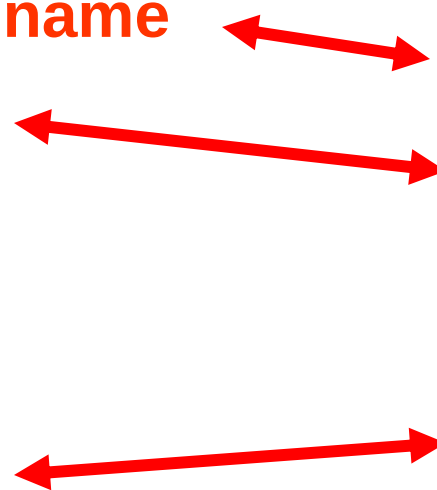
```
void start();
```

```
void adjustTime();
```

```
void reset();
```

```
}
```

Java Code



Class Diagram

UML Class Diagram Notation

■ **Type** ⇒ type name preceded by colon :

■ **Visibility** ⇒ prefix symbol

+ public

- private

protected

~ package

■ **Static** ⇒ underline

■ **Types of relationships**

■ **Generalization**

■ Inheritance

■ Implementation

■ **Association**

■ Dependency

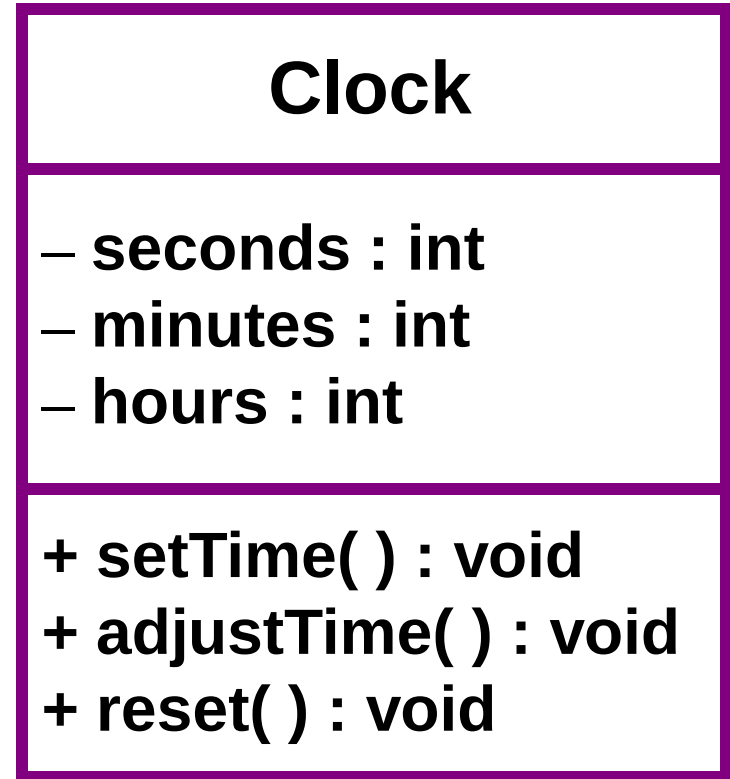


Java → UML : Clock Example

■ Java

```
class Clock { // name
    // state
    private int seconds;
    private int minutes;
    private int hours;
    // behavior
    public void setTime( );
    public void adjustTime(int value);
    public void reset( );
}
```

Java Code



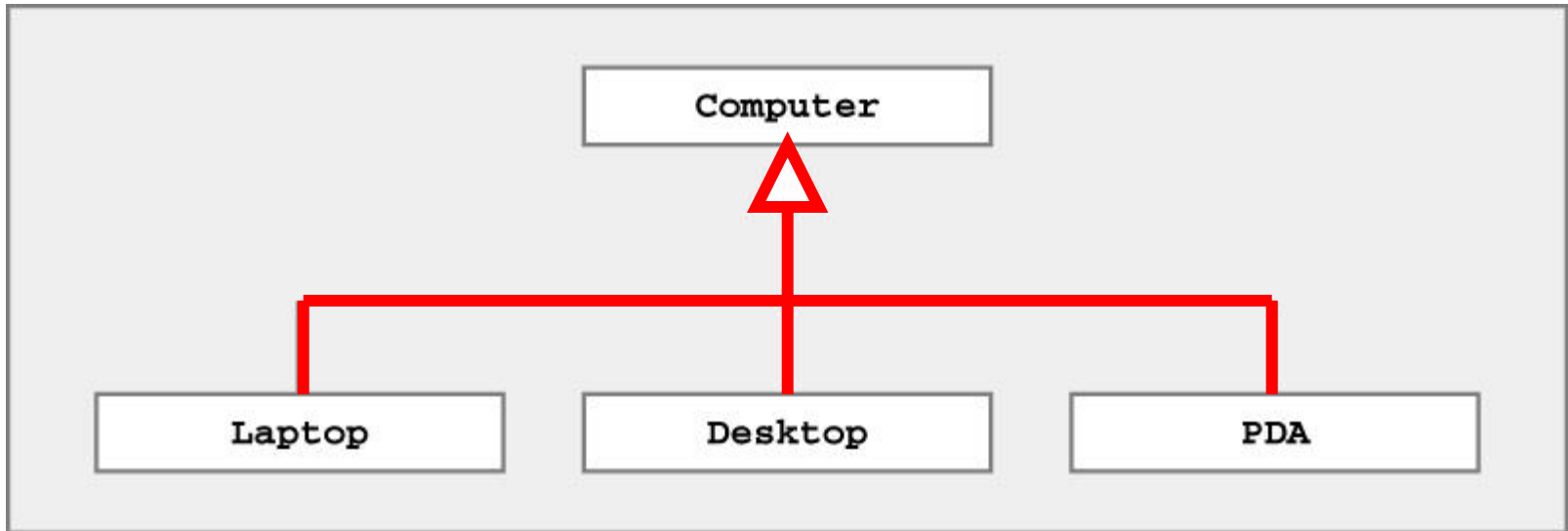
Class Diagram

Generalization

- Denotes inheritance between classes
 - Can view as “is a” relationship
- Example
 - Lecturer is a person (Lecturer extends Person class)
- Types of generalization
 - Subclass extends superclass
 - Solid line ending in (open) triangle 
 - Class implements interface
 - Dotted line ending in (open) triangle 

Generalization Example

■ Inheritance



**Laptop, Desktop, PDA inherit
state & behavior from Computer**

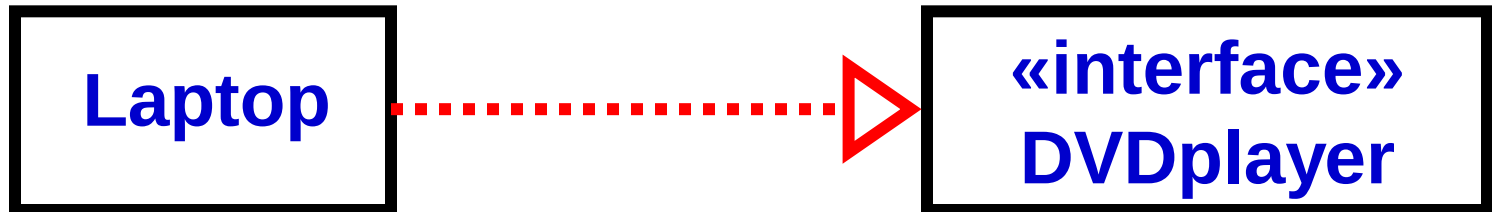
Generalization Example

- Abstract Classes are represented by italicizing the name



Abstract class Shape

- Interfaces are prefaced with <<interface>>



Laptop implements DVDplayer interface

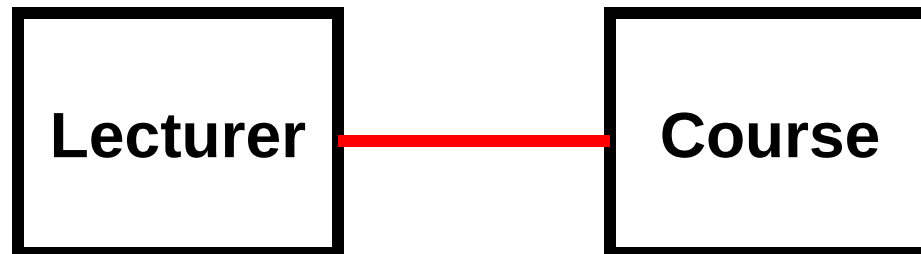
Association

- Denotes interaction between two classes

- Example

 - Lecturer teaches course

 - Indicates relationship between Lecturer & Course

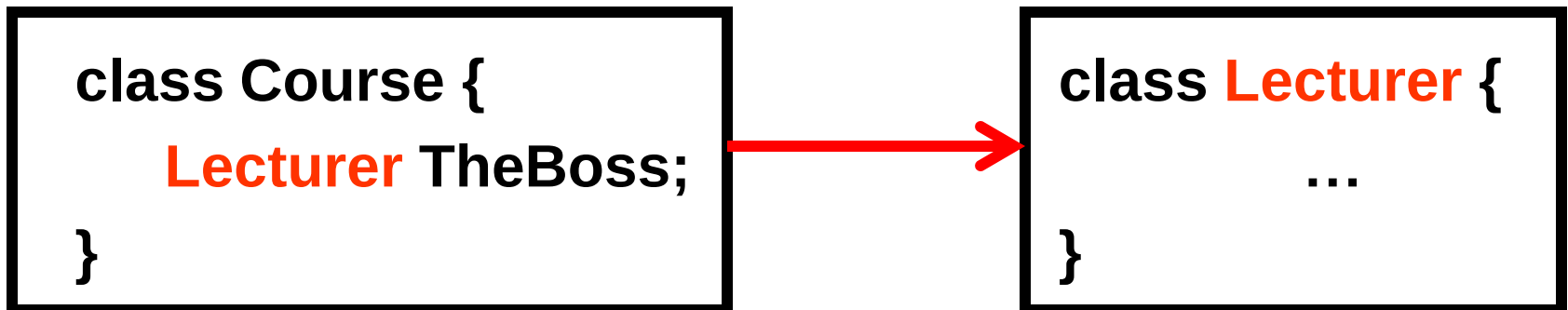


Association w/ Navigation

■ Navigation information

- Relationship between classes may be directional
 - Only class A can send messages to class B
- Arrowhead indicates direction of relationship

■ Example

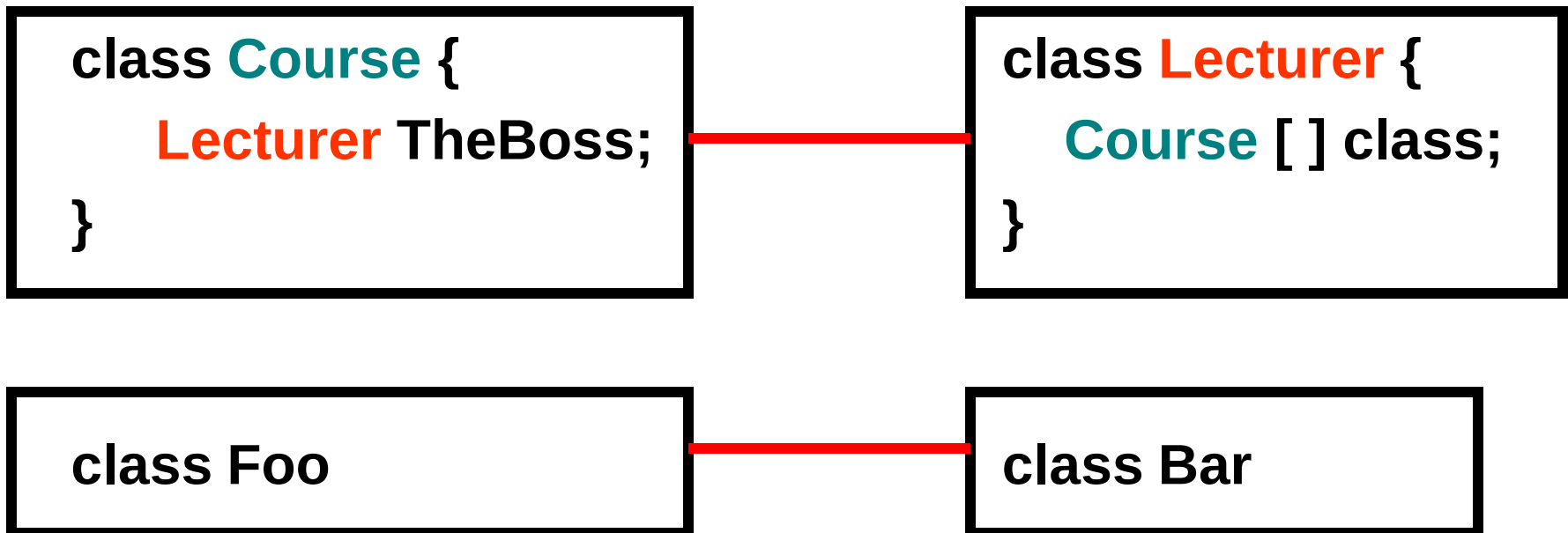


Association w/o Navigation

■ Undirected edge

- Relationship between classes may be bi-directional
- Direction of relationship may be unknown

■ Examples



Permanent Association

■ Permanent / structural association

- Class A contains reference to class B in data field
- Can view as “has a” relationship
- Also referred to as composition

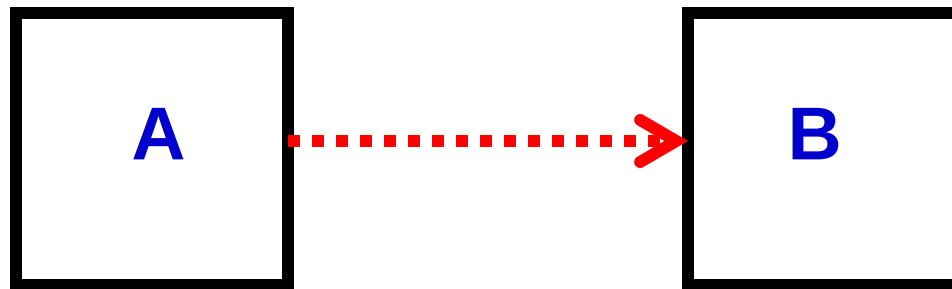
■ Example



A has a B

Temporary Association (Dependency)

- A **transitory** relationship between classes
 - Always directed (class A depends on B)
 - Indicates change in class B may affect class A
 - Can view as “**uses a**” relationship
 - Represented by dotted line with arrowhead
- Example



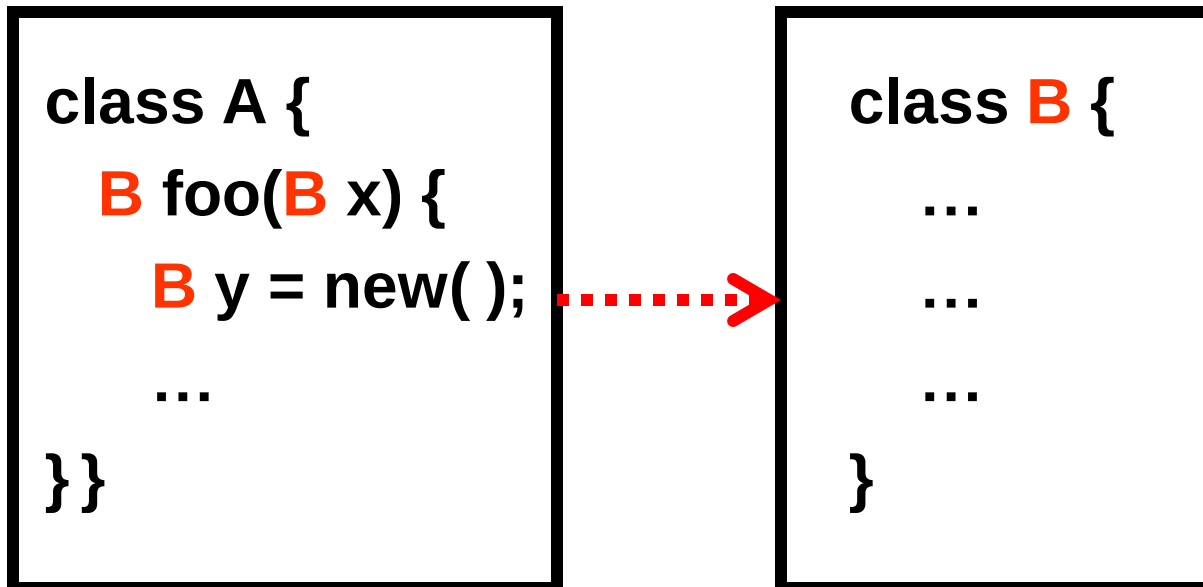
A depends on B

Dependency

■ Dependence may be caused by

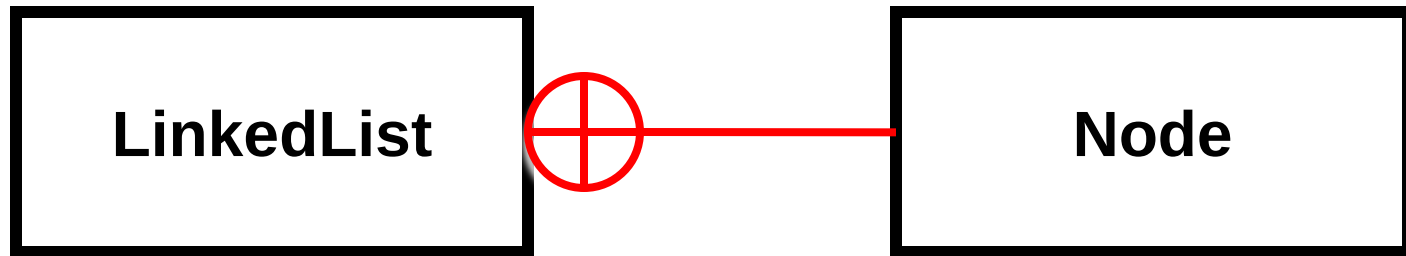
- Local variable
- Parameter
- Return value

■ Example



Inner/Nested Classes

- **Anchor (cross inside a circle) associated with enclosing class**



UML Examples

■ Read UML class diagram

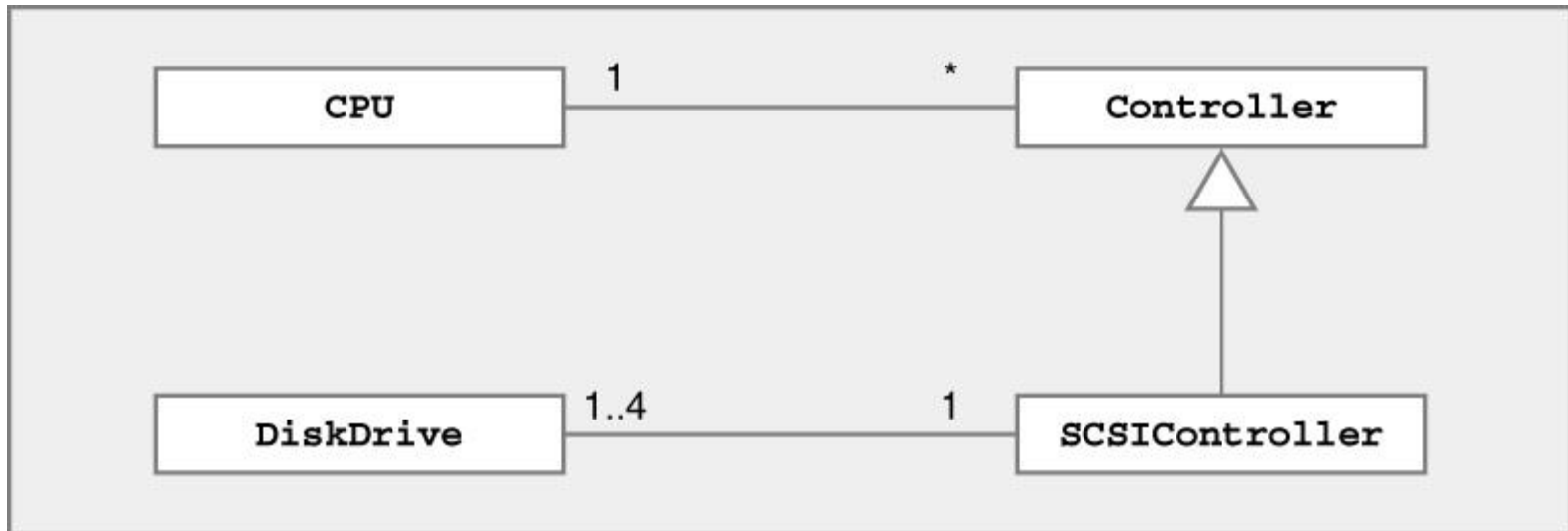
- Try to understand relationships
- Practice converting to / from Java code

■ Examples

- Computer disk organization
- Banking system
- Home heating system
- Printing system

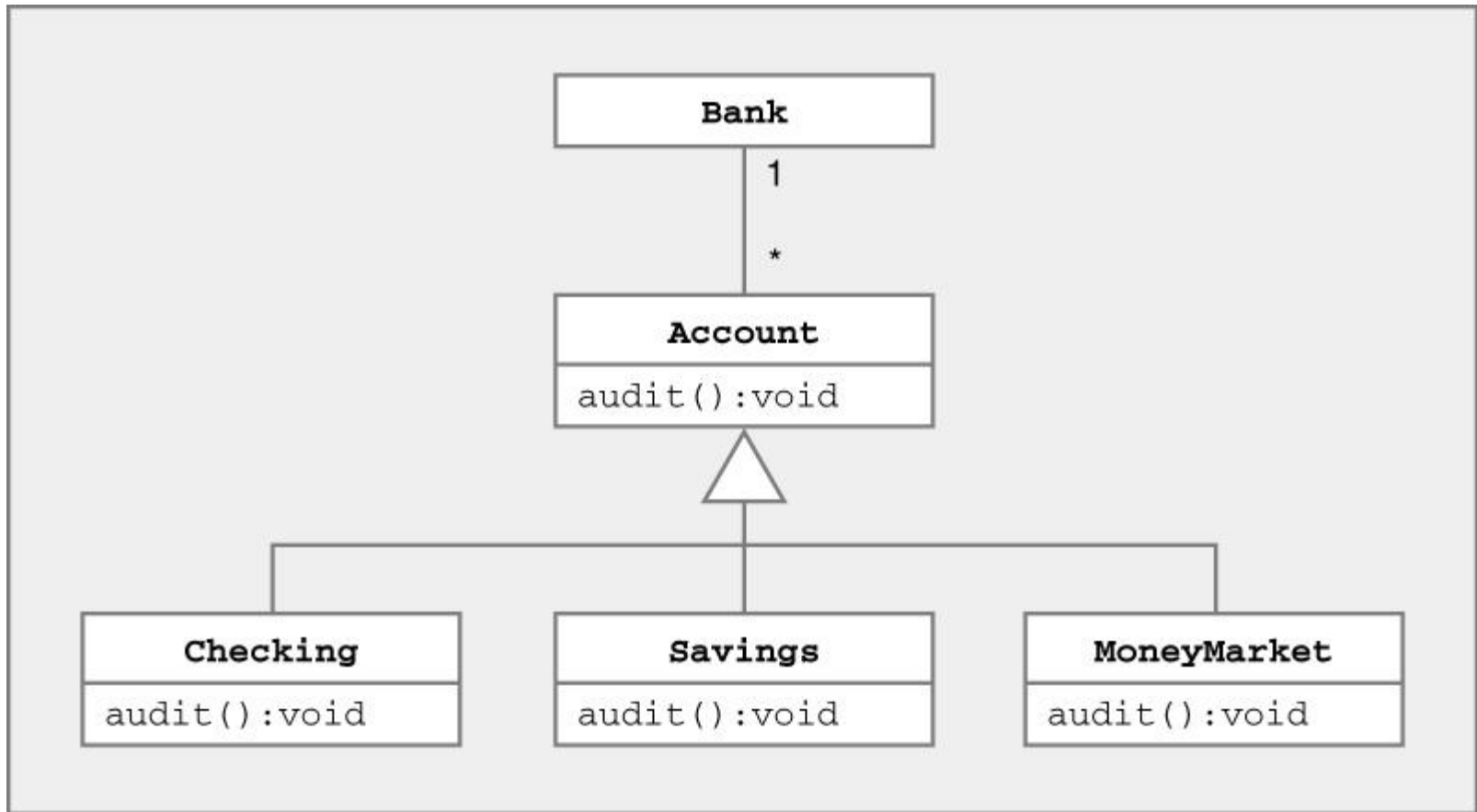
UML Example – Computer System

- Try to read & understand UML diagram



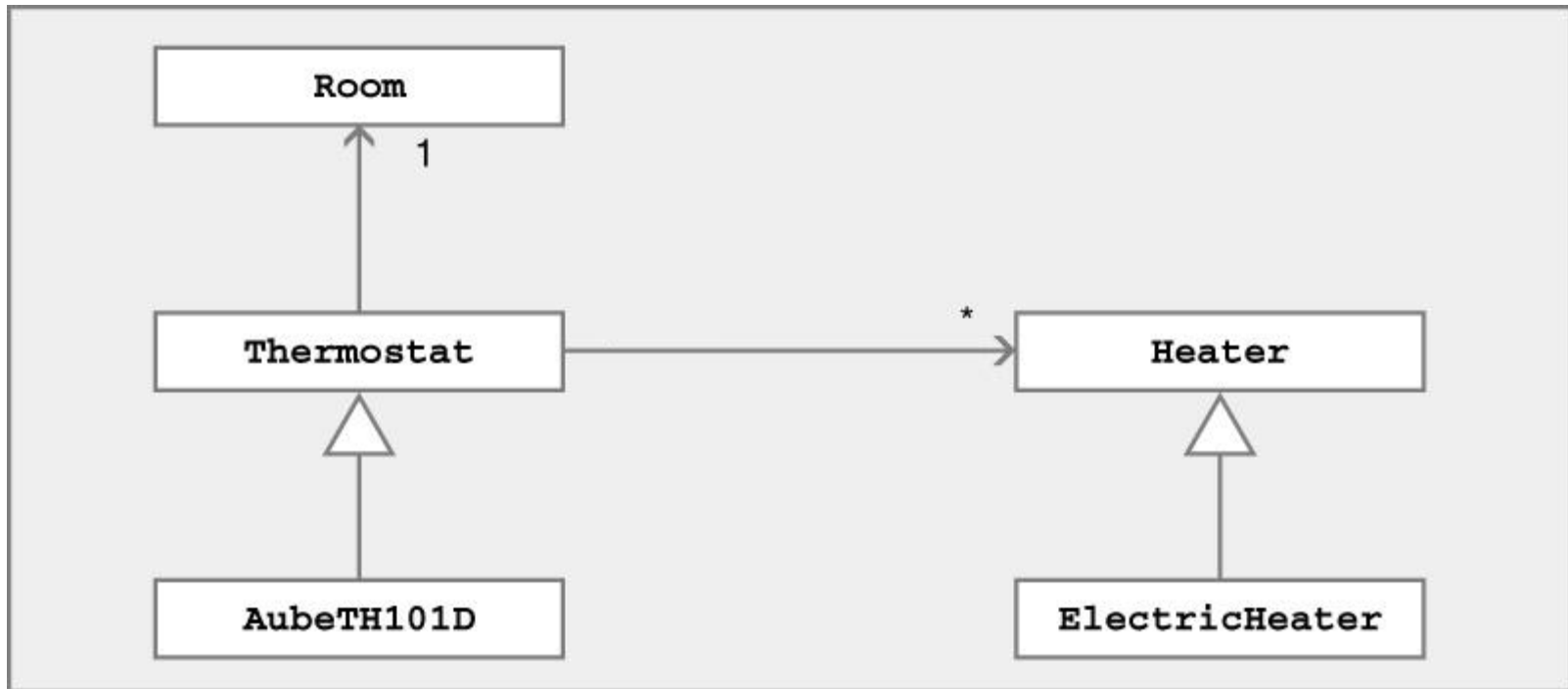
- CPU is associated with Controllers
- DiskDrive is associated with SCSIController
- SCSIController is a (type of) Controller

UML Example – Banking System



- **Bank associated with Accounts**
- **Checking, Savings, MoneyMarket are type of Accounts**

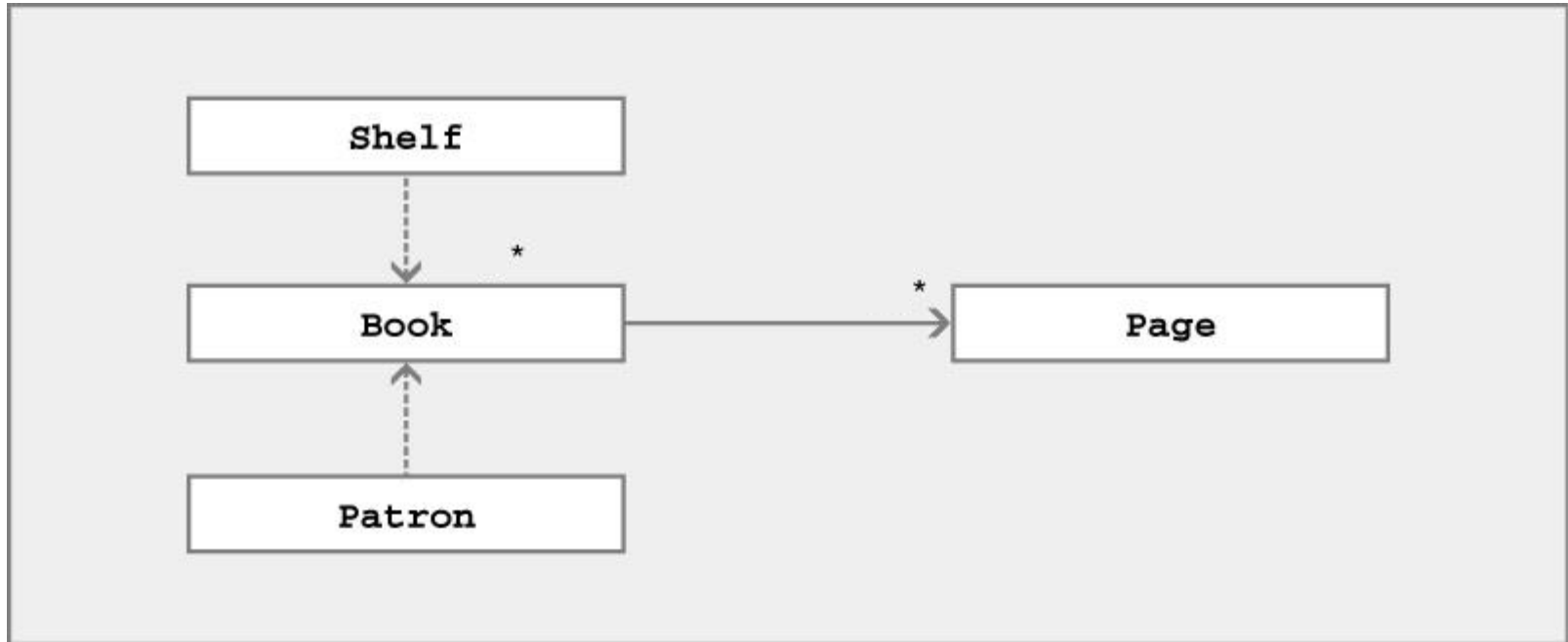
UML Example – Home Heating System



- Thermostat associated with (has a) Room
- Thermostat associated with (has a) Heater
- ElectricHeater is a specialized Heater
- AubeTH101D is a specialized Thermostat

UML Example – Library System

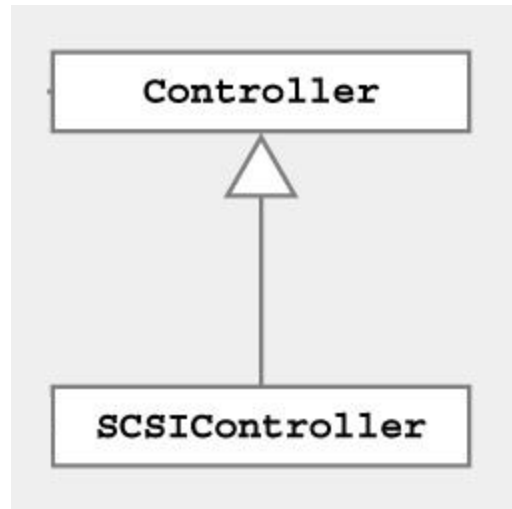
- Try to read & understand UML diagram



- Books are associated with (has some) Pages
- Patron & Shelf depend on (temporarily use) Books

UML → Java : Computer System

■ UML

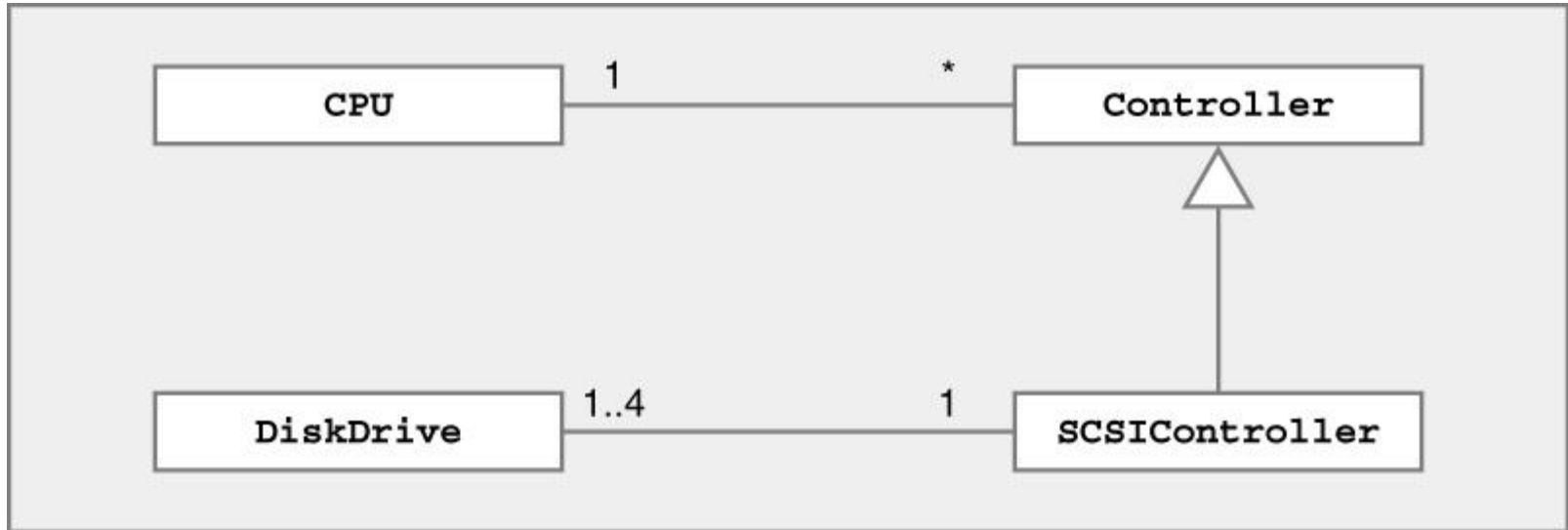


■ Java

```
class Controller {  
}  
class SCSIController extends Controller {  
}
```

UML → Java : Computer System

■ UML



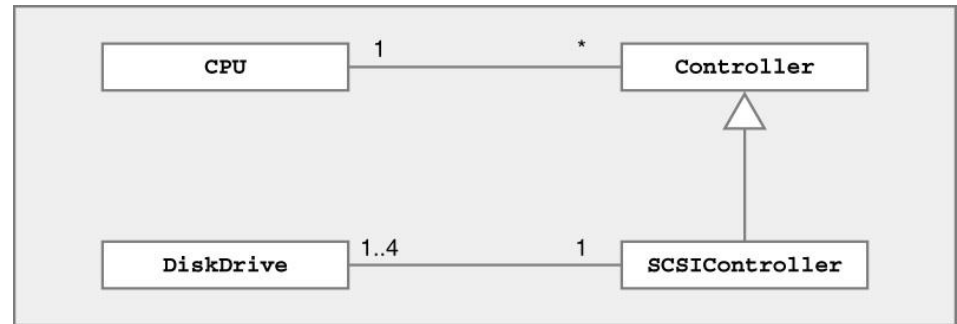
■ Java

- Design code using all available information in UML...

UML → Java : Computer System

■ Java

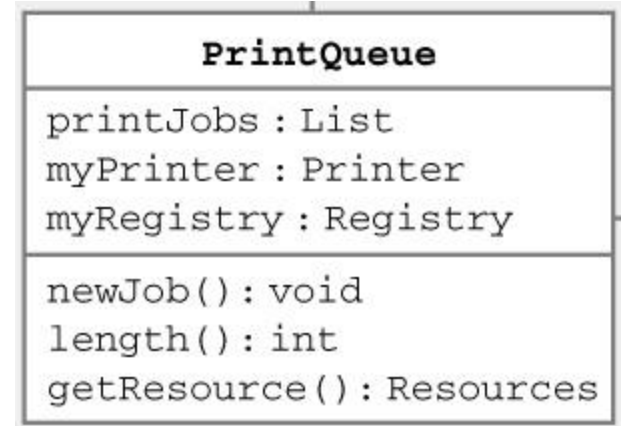
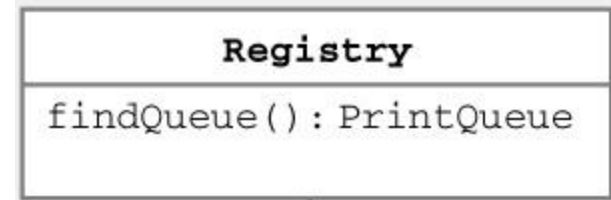
```
class CPU {  
    Controller myCtrls[ ];  
}  
class Controller {  
    CPU myCPU;  
}  
class SCSIController extends Controller {  
    DiskDrive myDrive[4];  
}  
Class DiskDrive {  
    SCSIController mySCSI;  
}
```



Java → UML : Printing System

■ Java

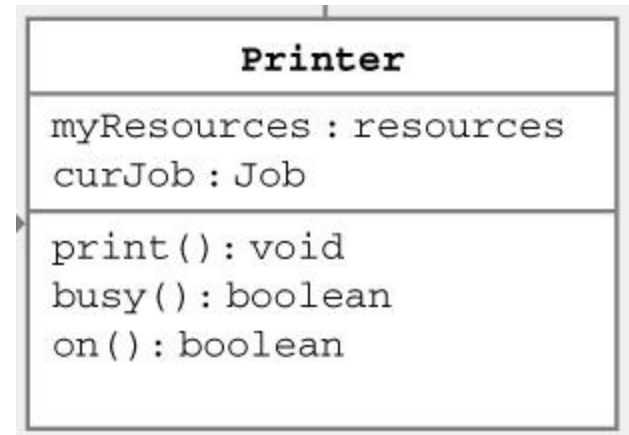
```
class Registry {  
    PrintQueue findQueue();  
}  
class PrintQueue {  
    List printJobs;  
    Printer myPrinter;  
    Registry myRegistry;  
    void newJob();  
    int length();  
    Resources getResource();  
}
```



Java → UML : Printing System

■ Java

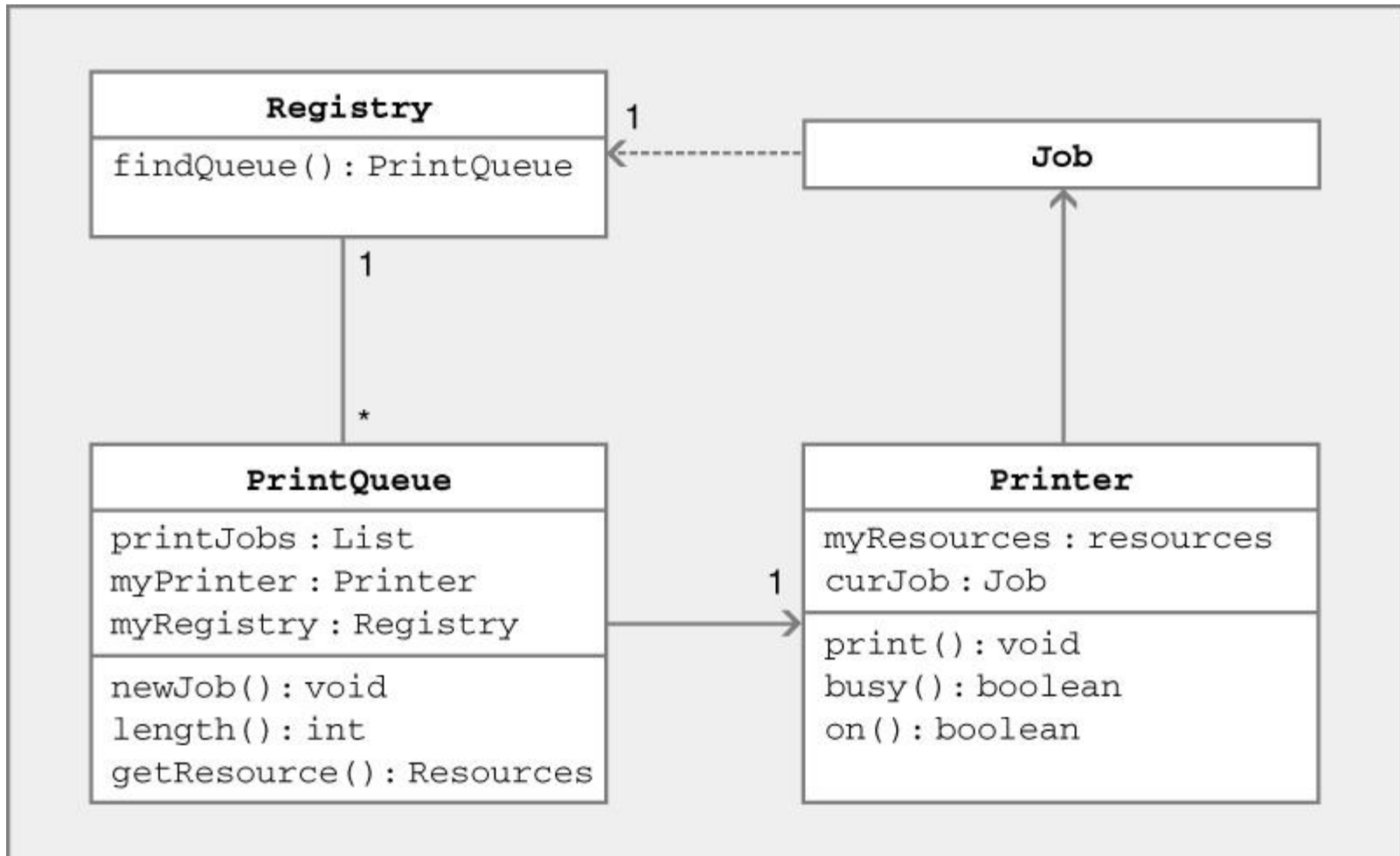
```
Class Printer {  
    Resources myResources;  
    Job curJob;  
    void print();  
    boolean busy();  
    boolean on();  
}  
class Job {  
    Job(Registry r) {  
        ...  
    }  
}
```



Java → UML : Printing System

■ Java

■ All together



UML Tools

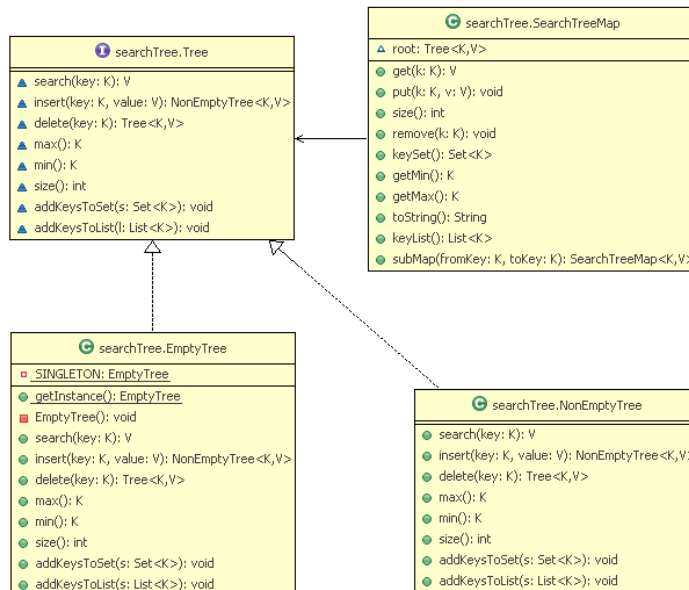
■ Can automatically generate

■ UML diagrams from code

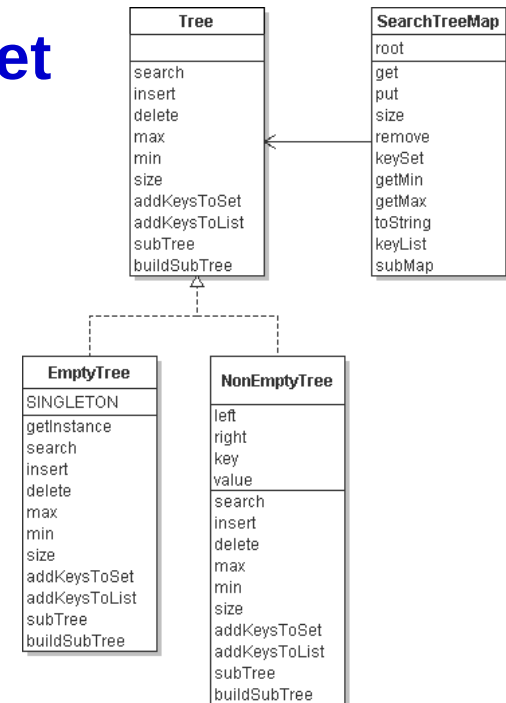
■ Code from UML diagrams

■ Examples

■ AmaterasUML



■ Violet



Amateras UML Editor

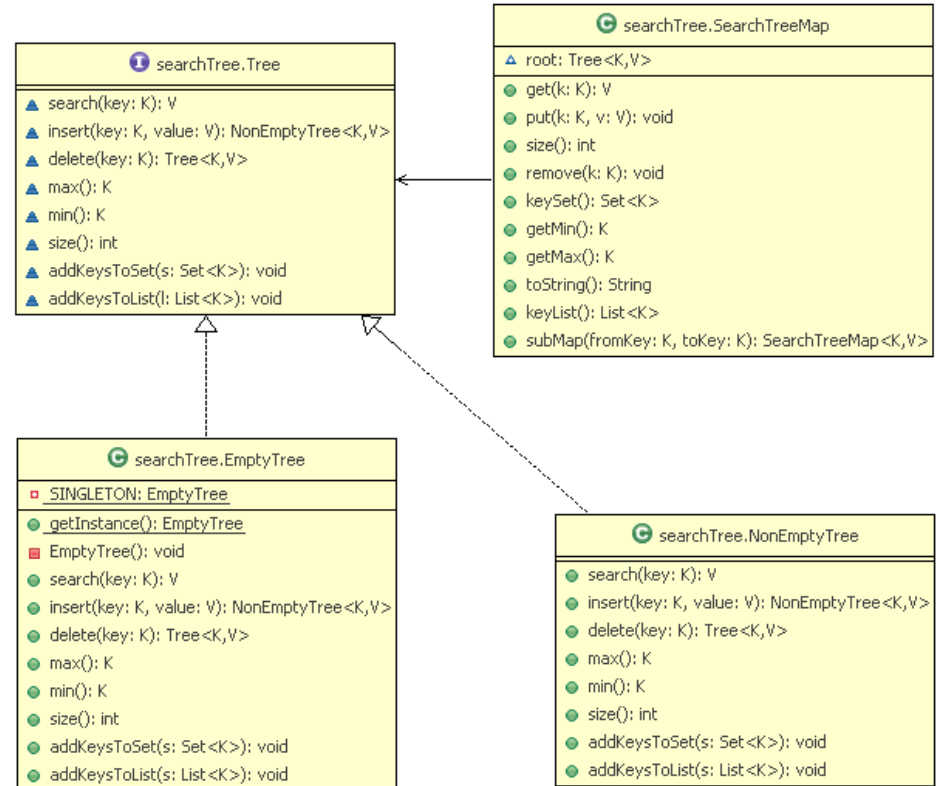
■ Drag-n-drop classes into UML diagram

■ Auto creates class w/ attributes & methods

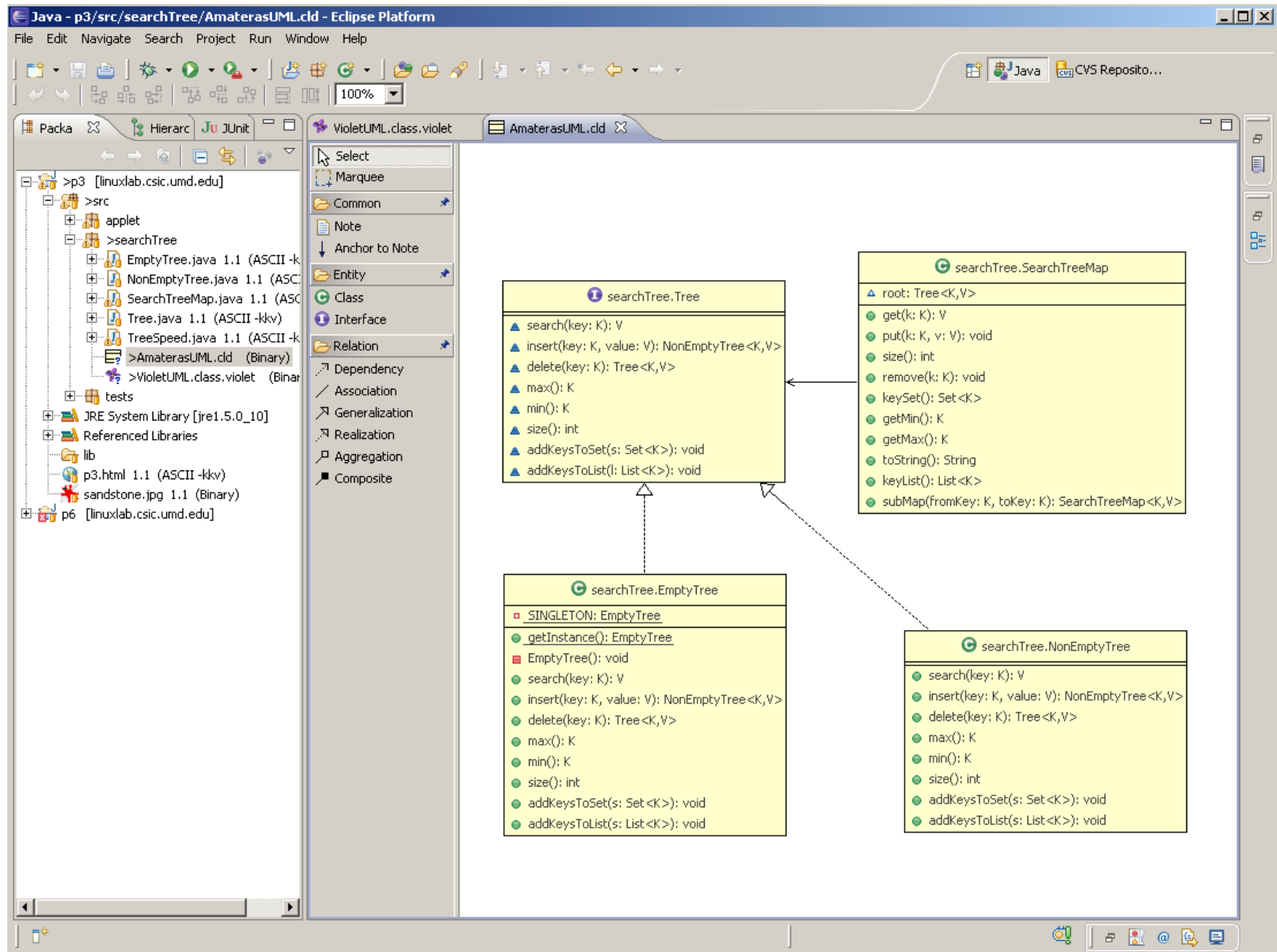
■ Add links manually

■ No directed associations

■ Use undirected association + directed dependency together

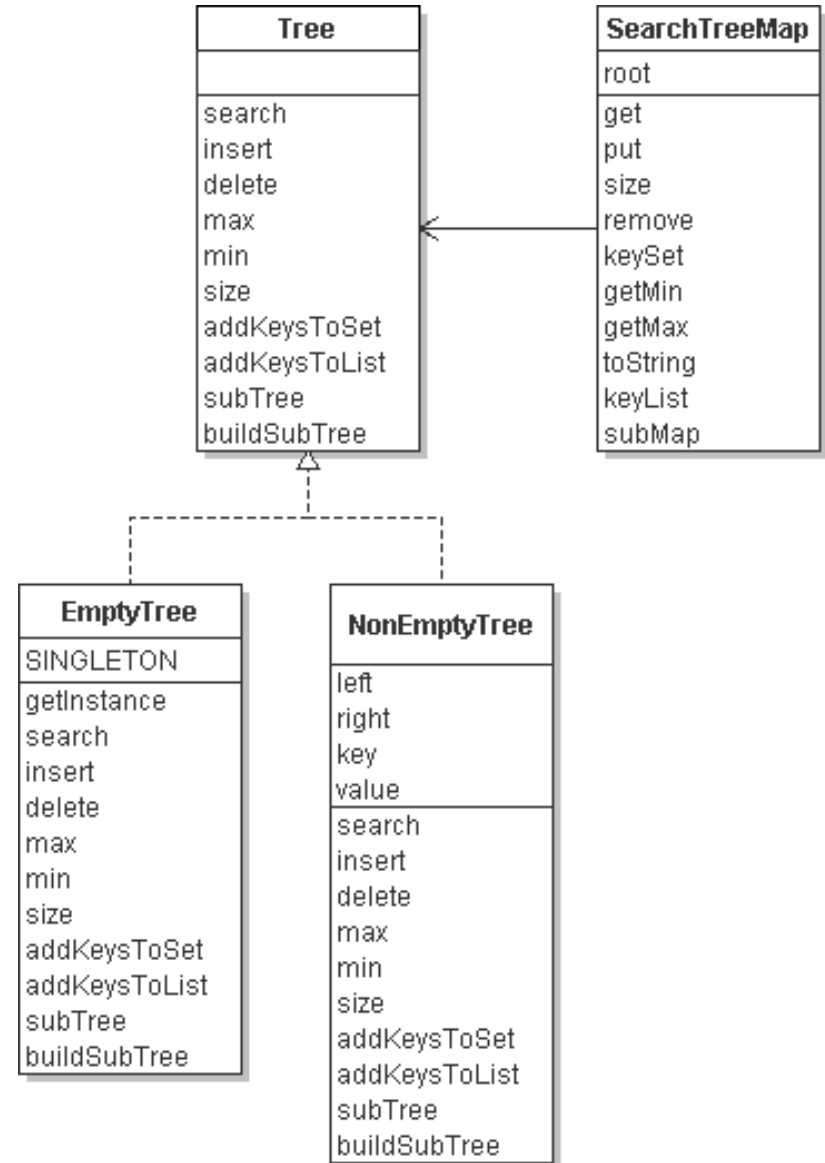


Amateras UML Editor – Eclipse Plugin

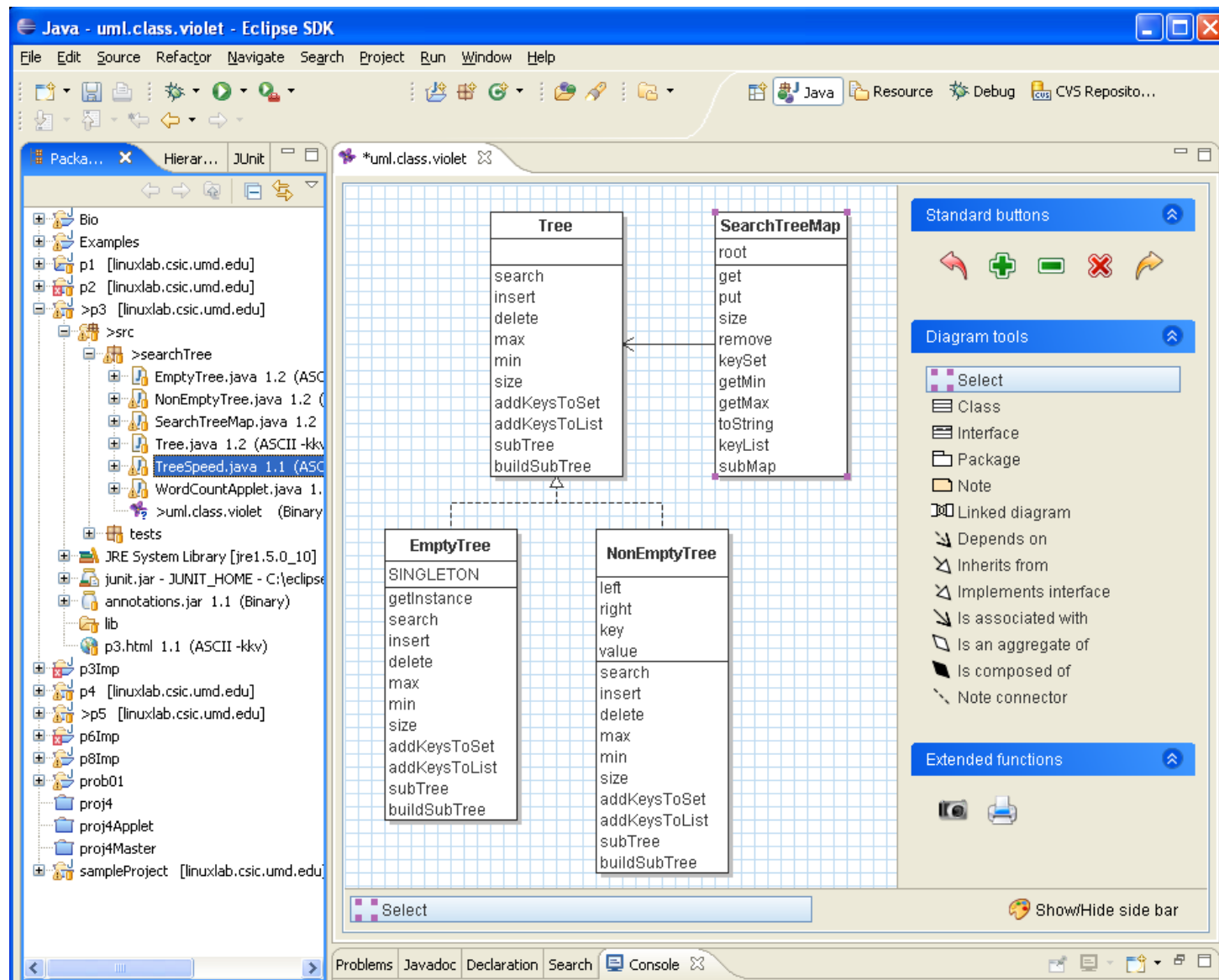


Violet UML Editor

- Drag-n-drop classes into UML diagram
 - Auto creates class w/ attributes & methods
- Add links manually
 - No undirected associations
 - Use directed association in **both** directions instead



Violet UML Editor – Eclipse Plugin



UML Summary

- UML → modeling language
- Visually represents design of software system
- We focused on **class diagrams**
 - Contents of a class
 - Relationship between classes
- You should be able to
 - Draw UML class diagram given Java code
 - Write Java code given UML class diagram