CMSC 132:
Object-Oriented Programming II

Unified Modeling Language (UML)

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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

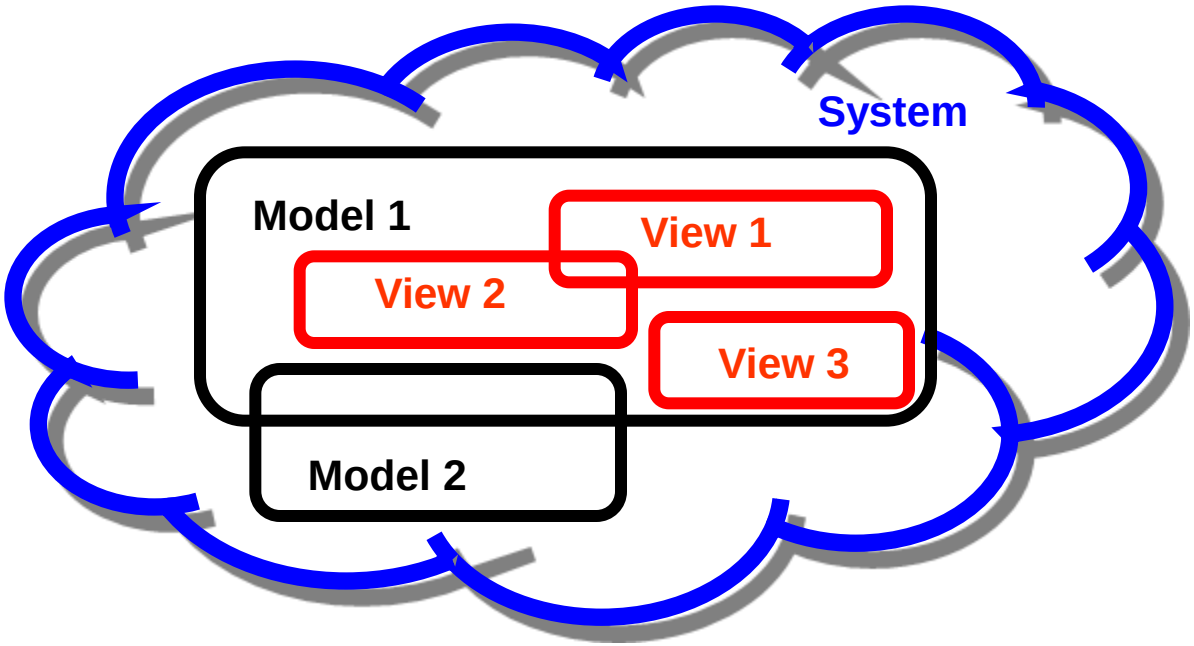
- Provide a software “blueprint”
  - Simple yet clear abstraction for software
- Describe software design
  - Clearly
  - Concisely
  - Correctly

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

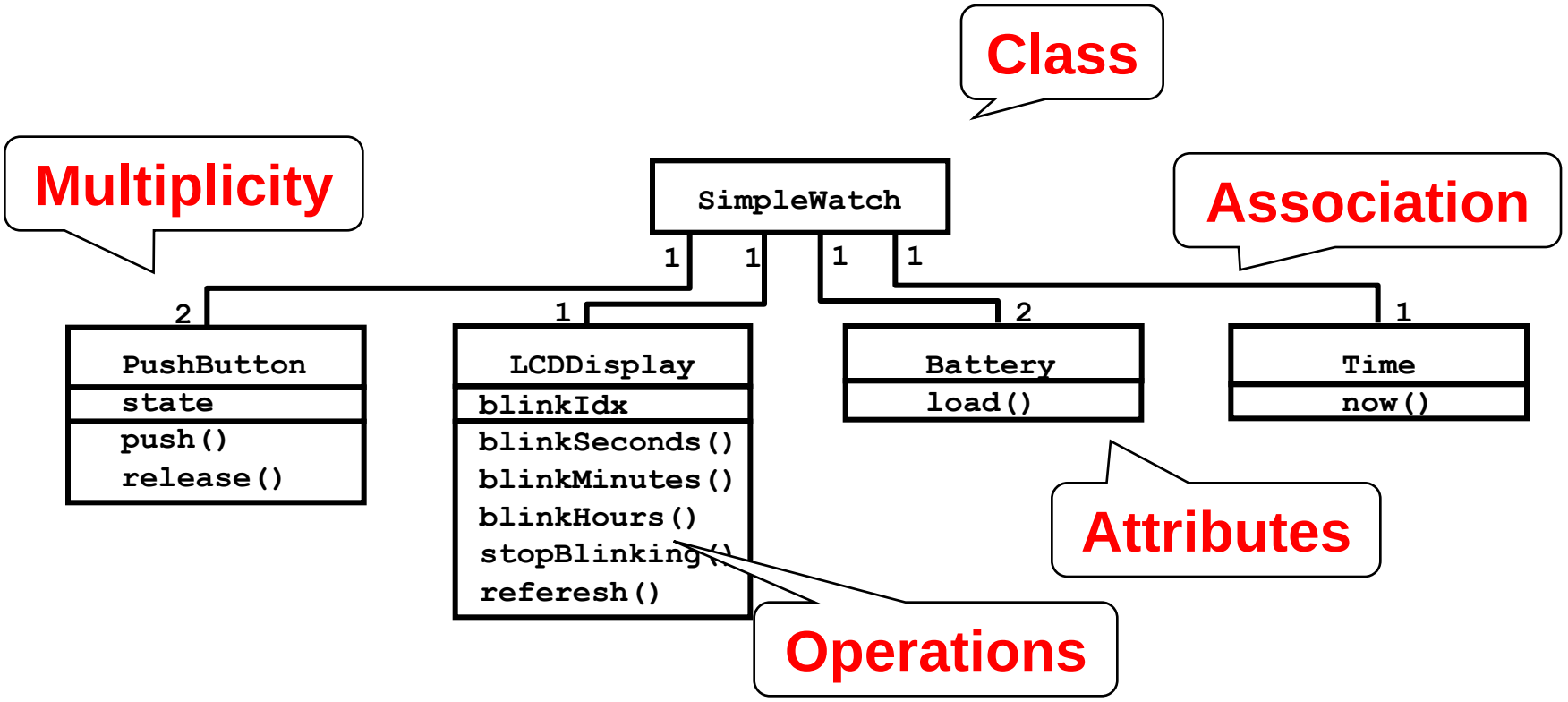


Class Diagram

- **Represents (static) structure of system**

- **A class diagram displays**
  - **Information for class**
  - **Relationships between classes**

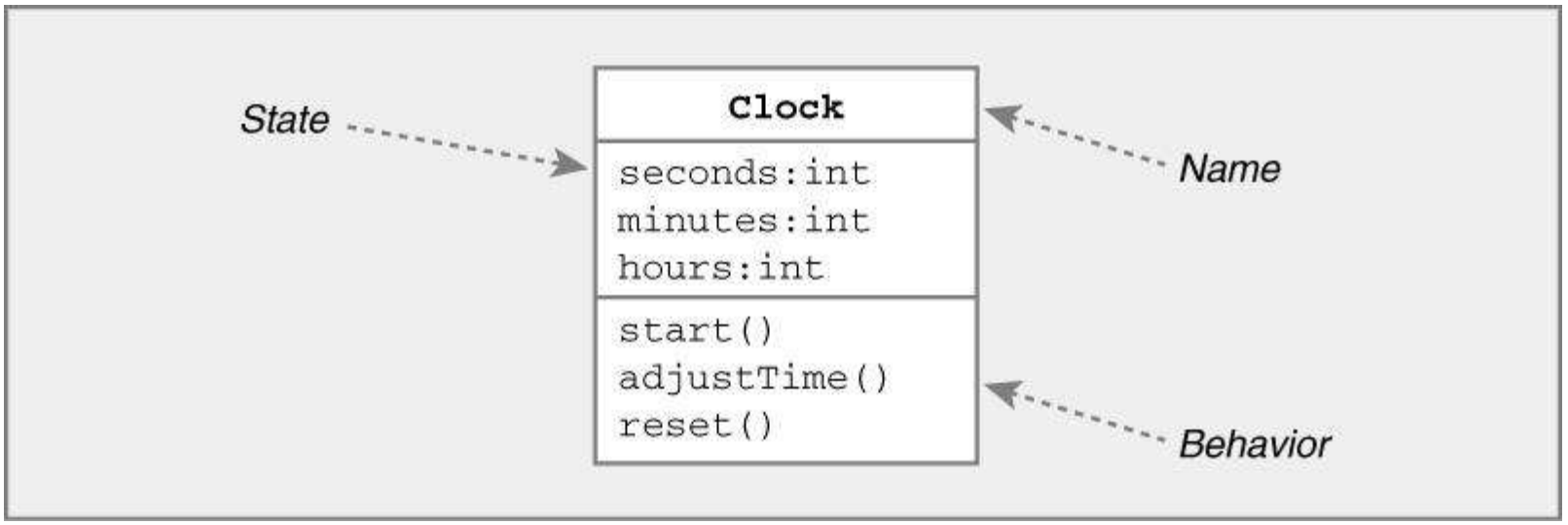
Class Diagram



Class diagrams represent structure of system

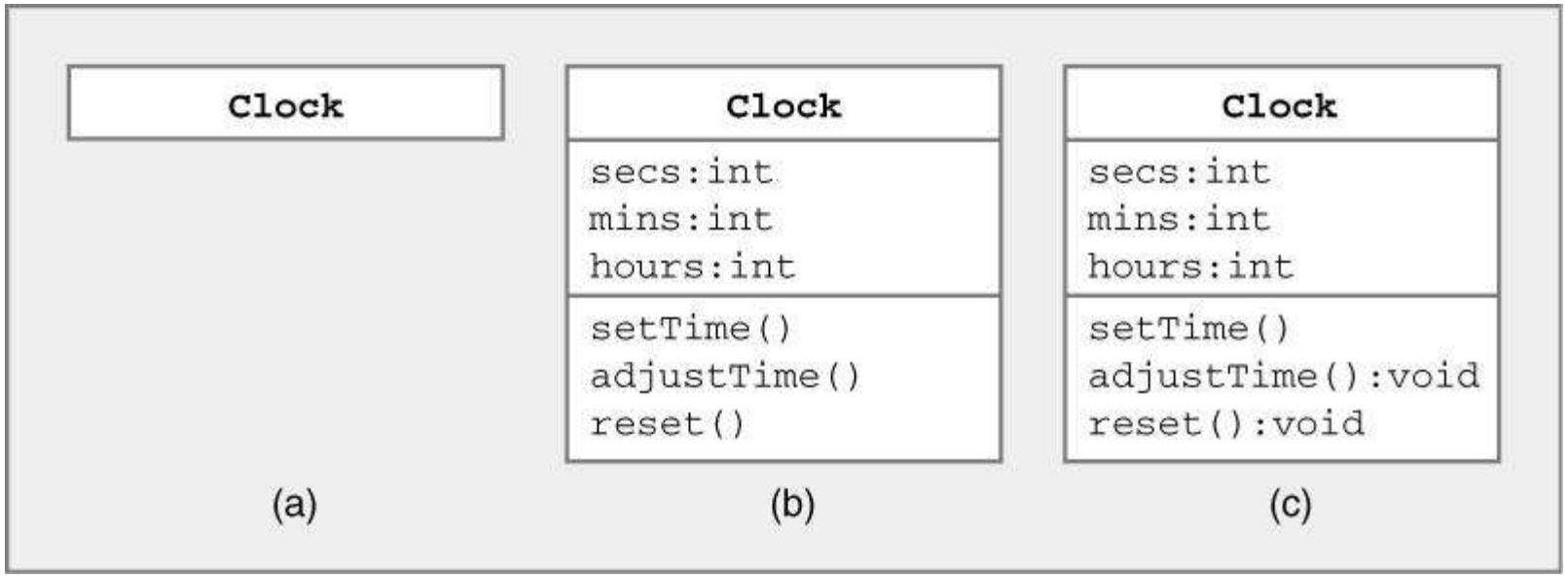
Class Diagrams

- **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

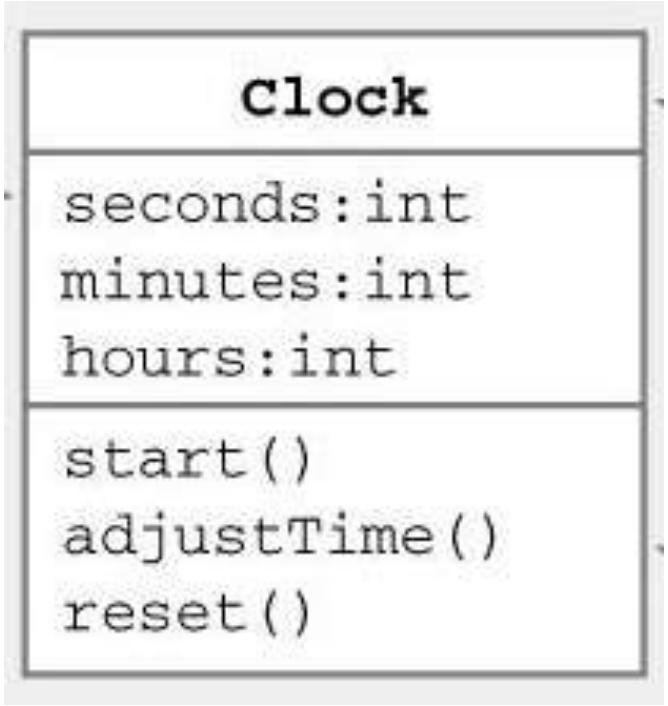
- Different representation of same information
  - Name, state, behavior of class
  - Relationships between classes
- Should be able to derive one from the other
- Motivation
  - UML ⇒ Java
    - Implement code based on design written in UML
  - Java ⇒ UML
    - Create UML to document design of existing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

Java → UML : Clock Example

- **Java**

```
class Clock { // name
   // state
   int seconds;
   int minutes;
   int hours;
   // behavior
   void start();
   void adjustTime();
   void reset();
}
```

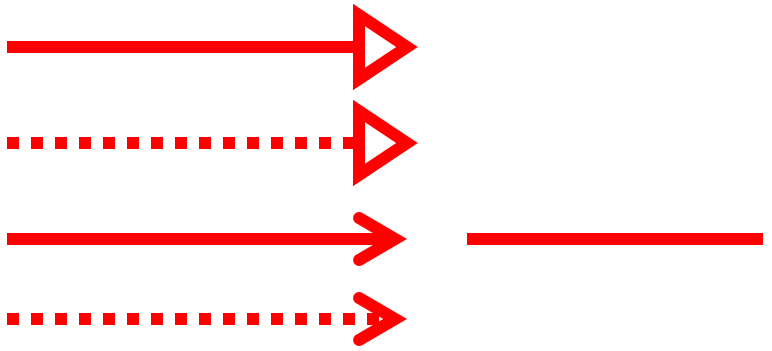
Java Code



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

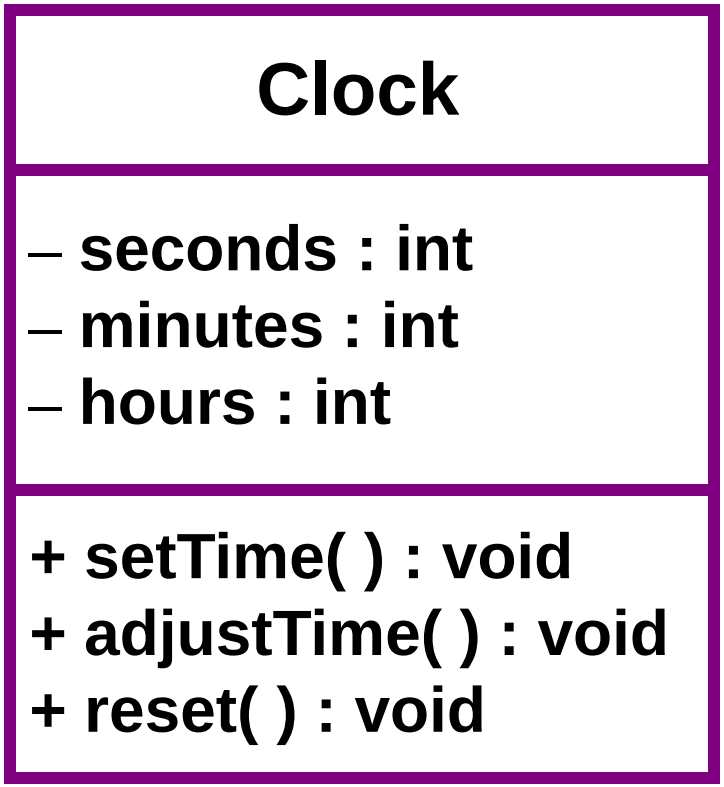


Java → UML : Clock Example

- **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



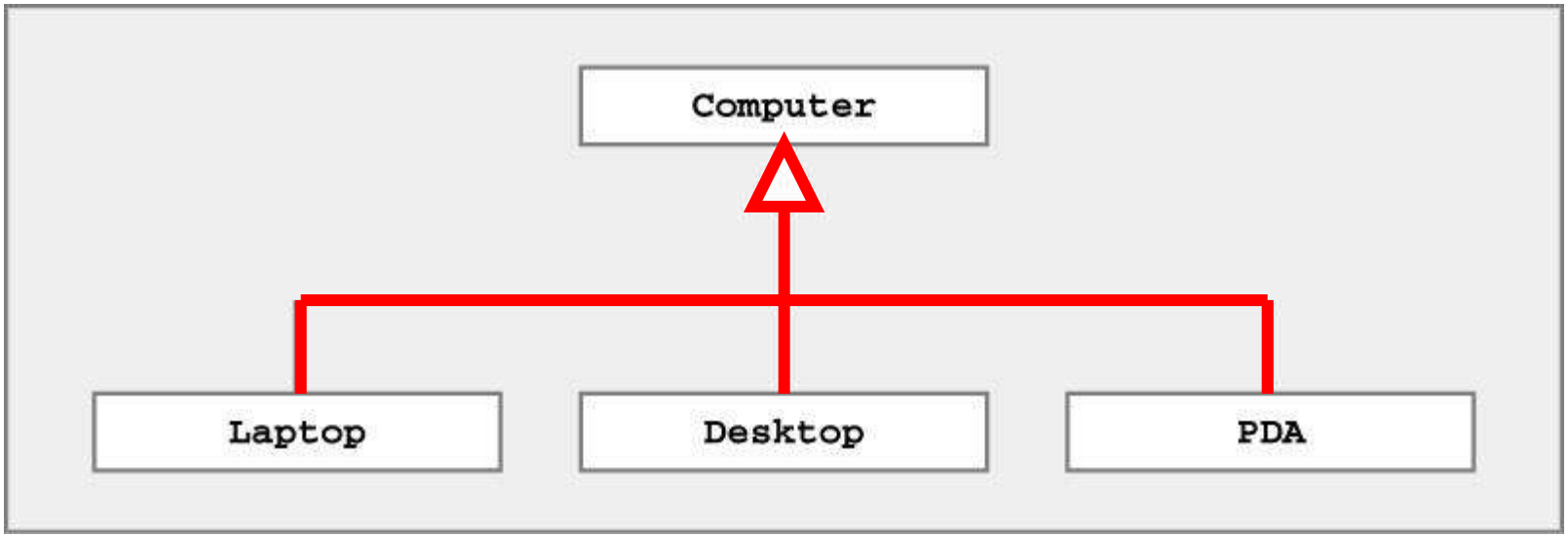
Class Diagram

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**



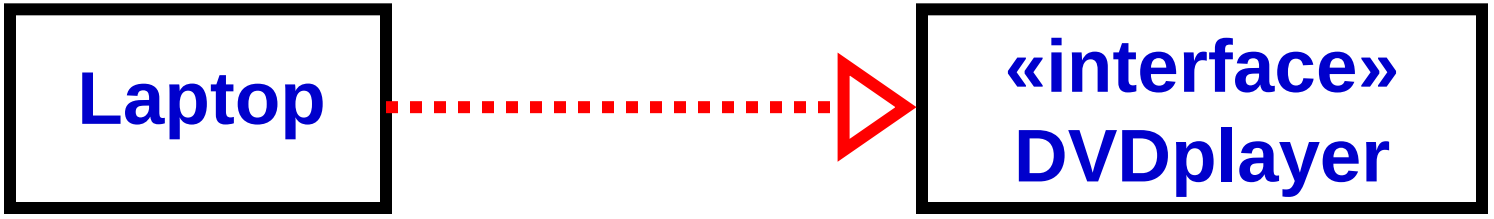
Laptop, Desktop, PDA inherit state & behavior from Computer

Generalization Example

- **Abstract Classes are represented by italicizing the name**

Abstract class Shape

- **Interfaces are prefaced with <<interface>>**

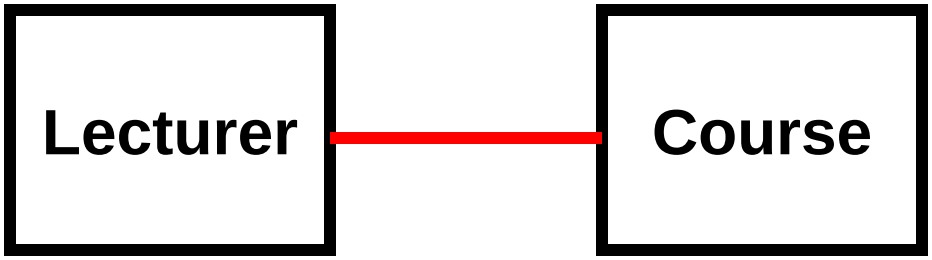


Laptop implements DVDplayer interface

Association

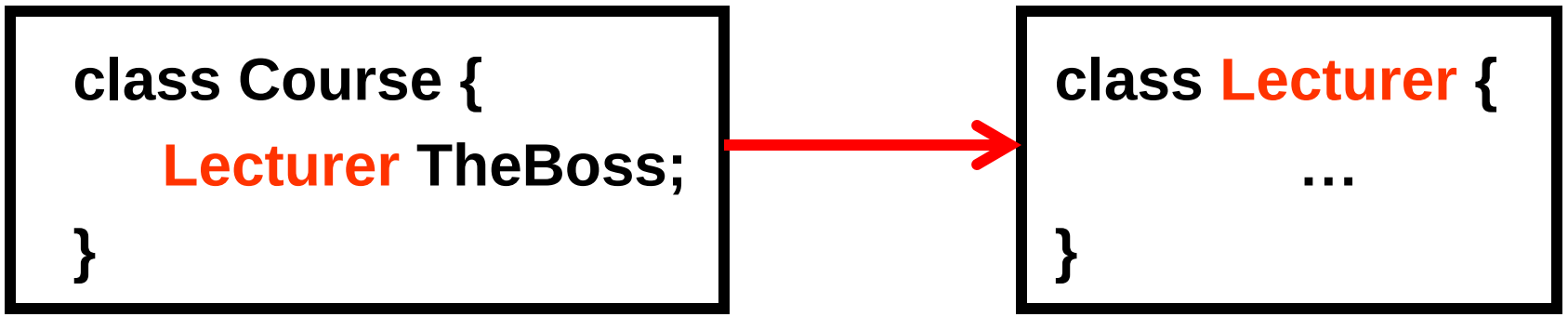
- Denotes interaction between two classes

- Example
  - Lecturer teaches course
    - Indicates relationship between Lecturer & Course



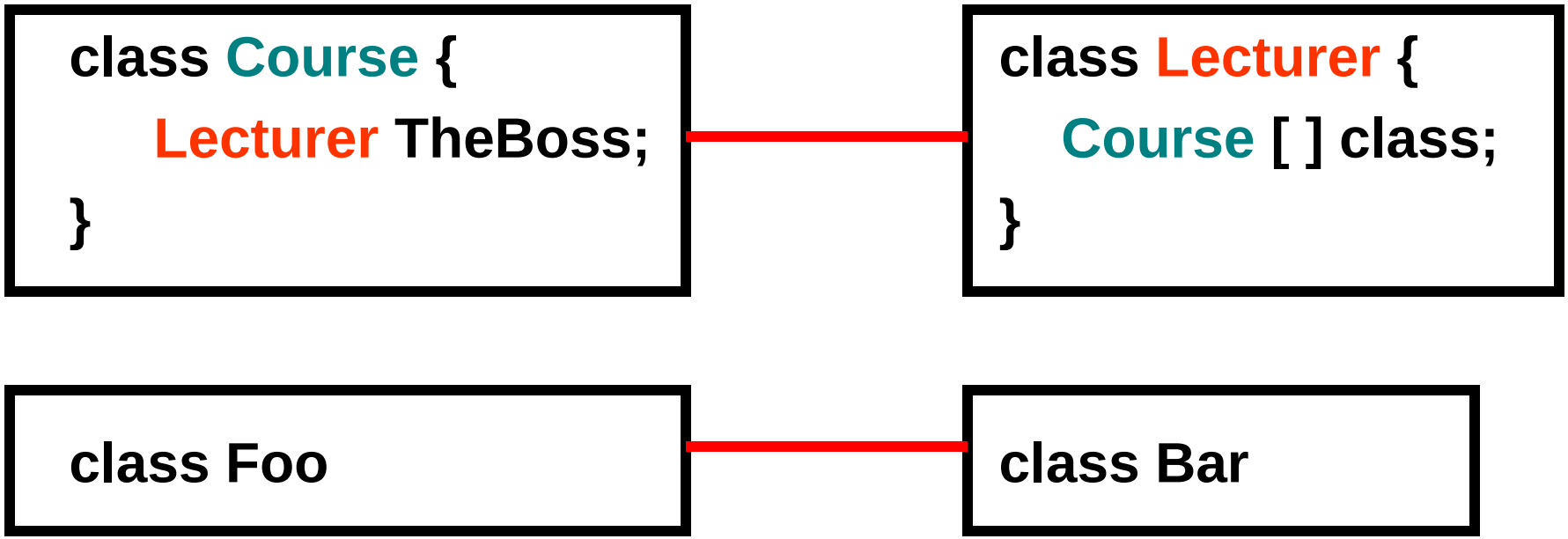
Association w/ Navigation

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



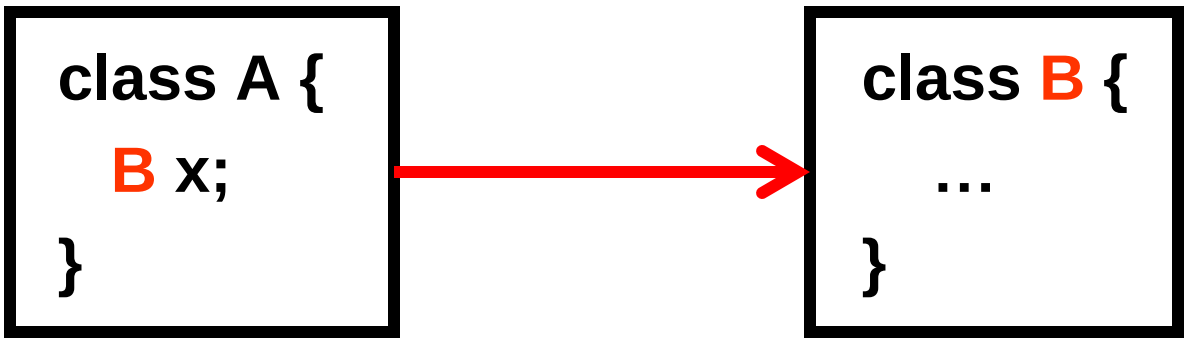
Association w/o Navigation

- **Undirected edge**
  - **Relationship between classes may be bi-directional**
  - **Direction of relationship may be unknown**
- **Examples**



Permanent Association

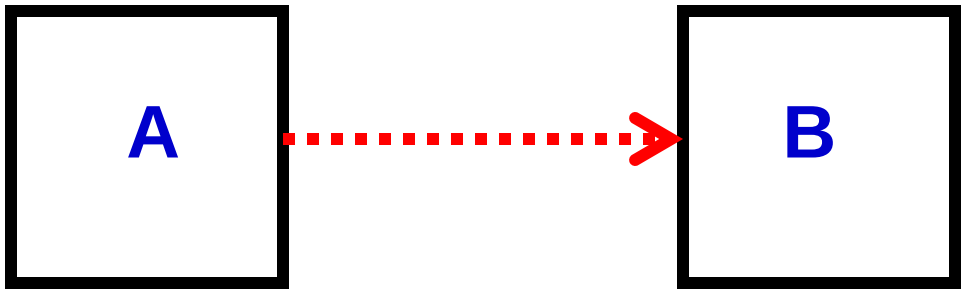
- **Permanent / structural association**
  - Class A contains reference to class B in data field
  - Can view as "has a" relationship
  - Also referred to as composition
- **Example**



A has a B

Temporary Association (Dependency)

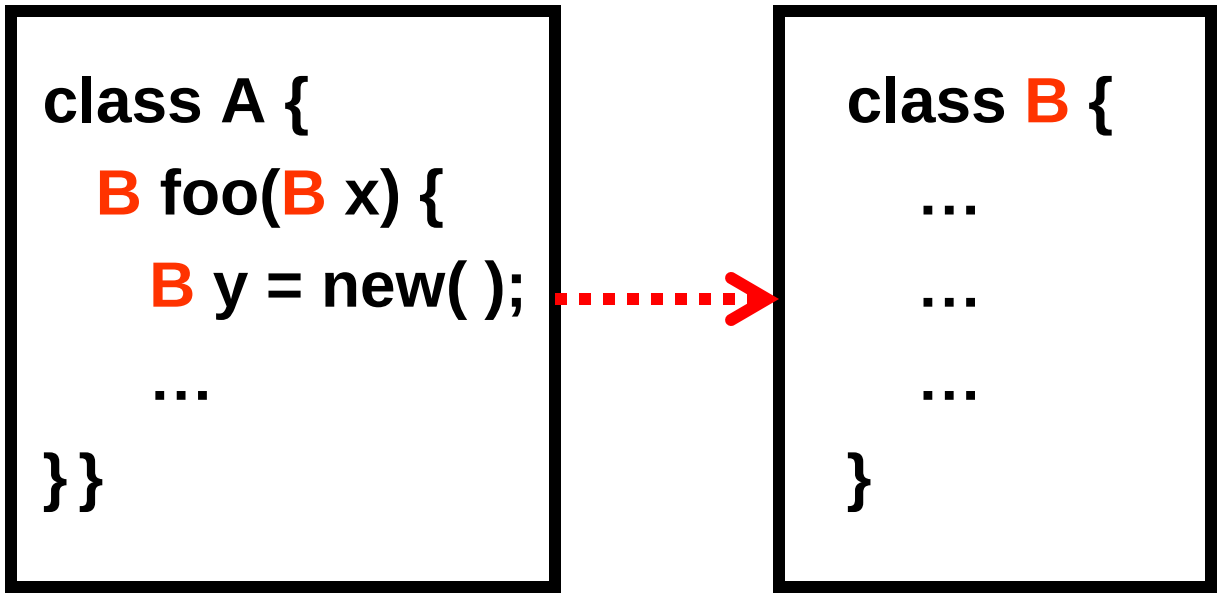
- A transitory relationship between classes
  - Always directed (class A depends on B)
  - Indicates change in class B may affect class A
  - Can view as "uses a" relationship
  - Represented by dotted line with arrowhead
- Example



A depends on B

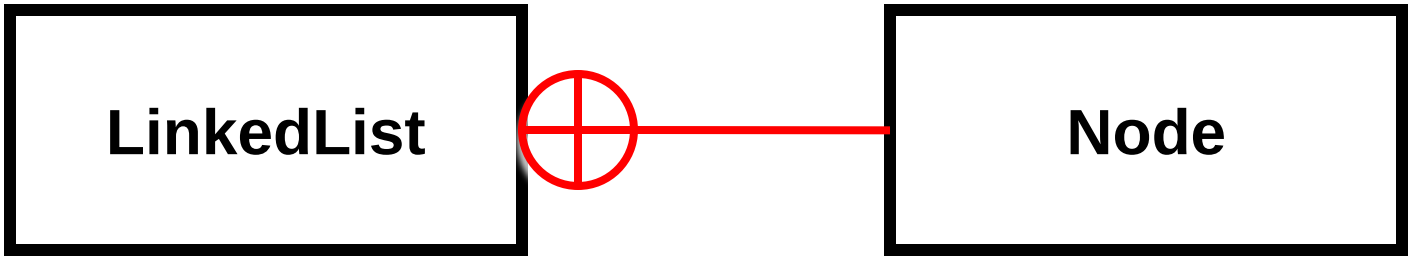
Dependency

- Dependence may be caused by
  - Local variable
  - Parameter
  - Return value
- Example



Inner/Nested Classes

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

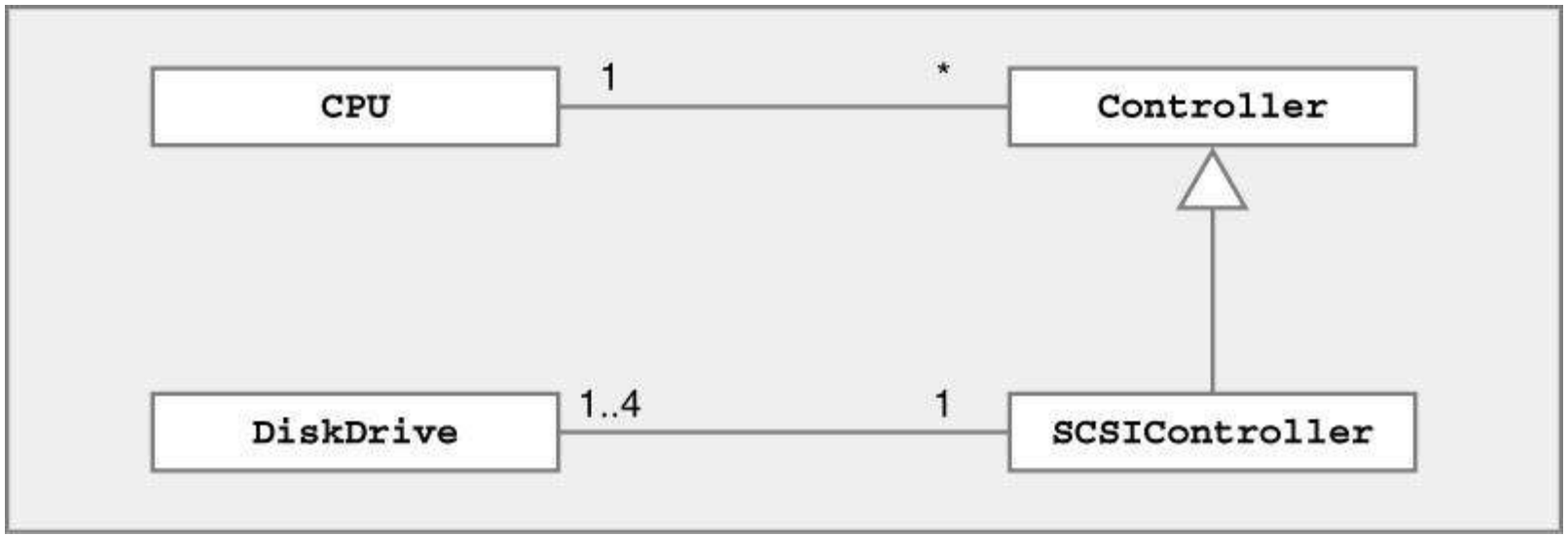


UML Examples

- **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**

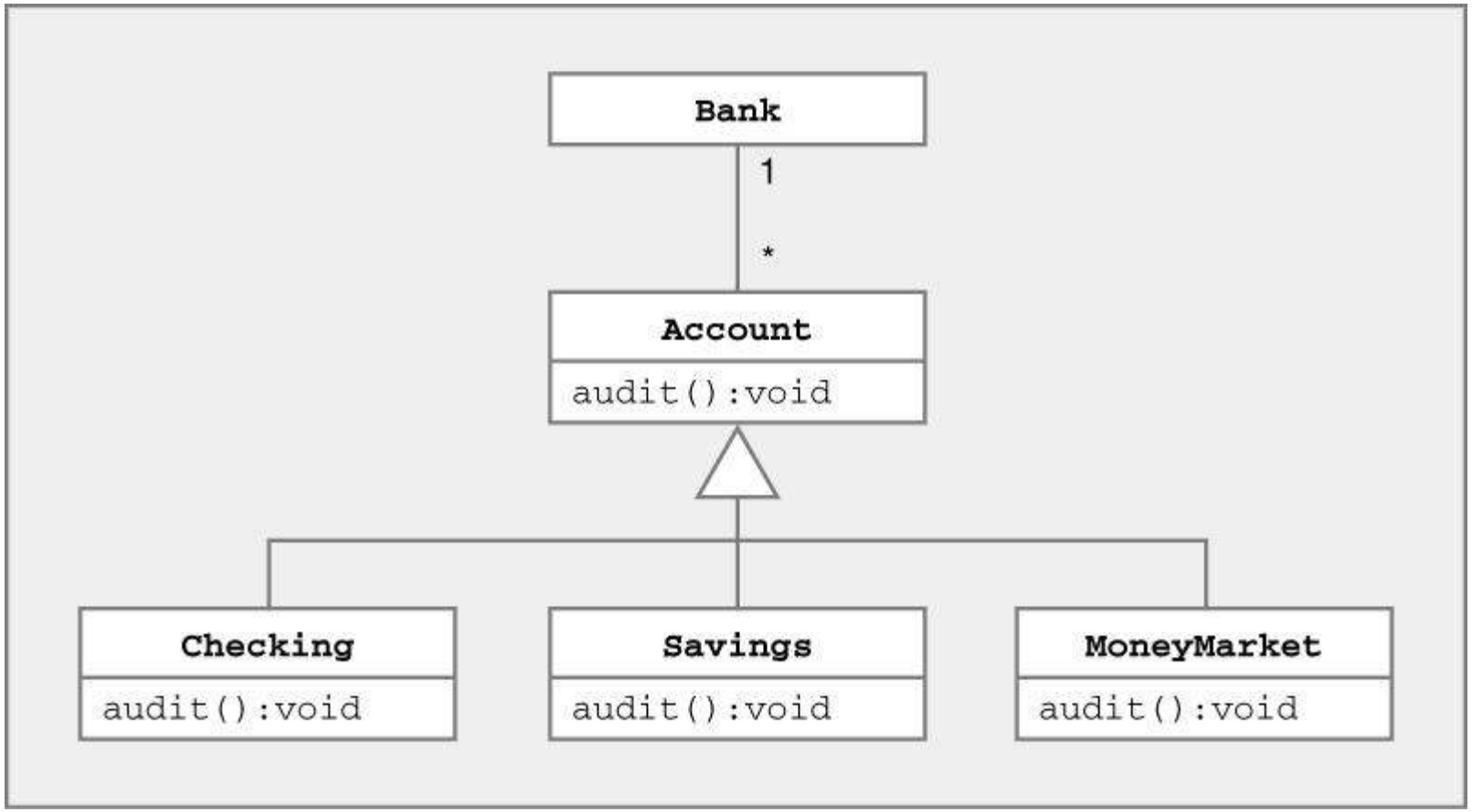
UML Example – Computer System

- **Try to read & understand UML diagram**



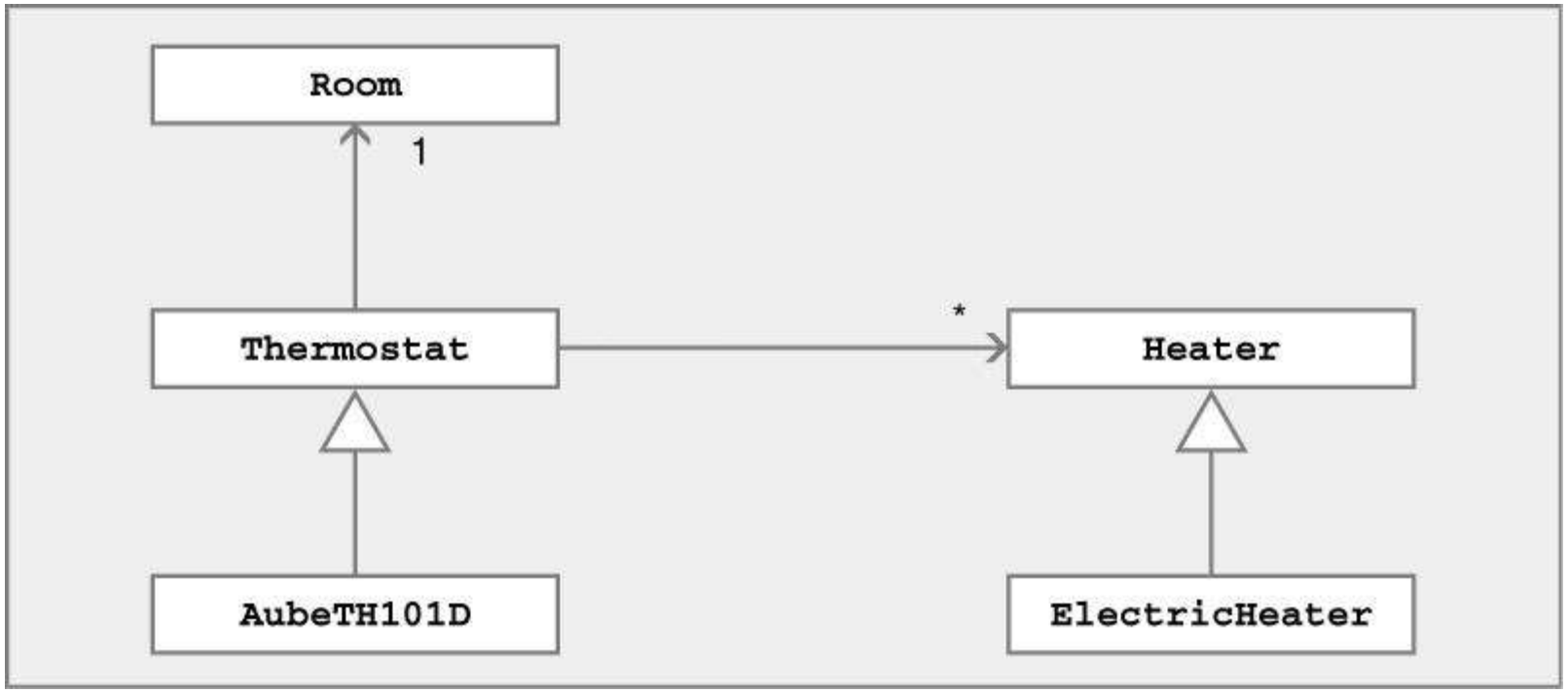
- **CPU is associated with Controllers**
- **DiskDrive is associated with SCSIController**
- **SCSIController is a (type of) Controller**

UML Example – Banking System



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

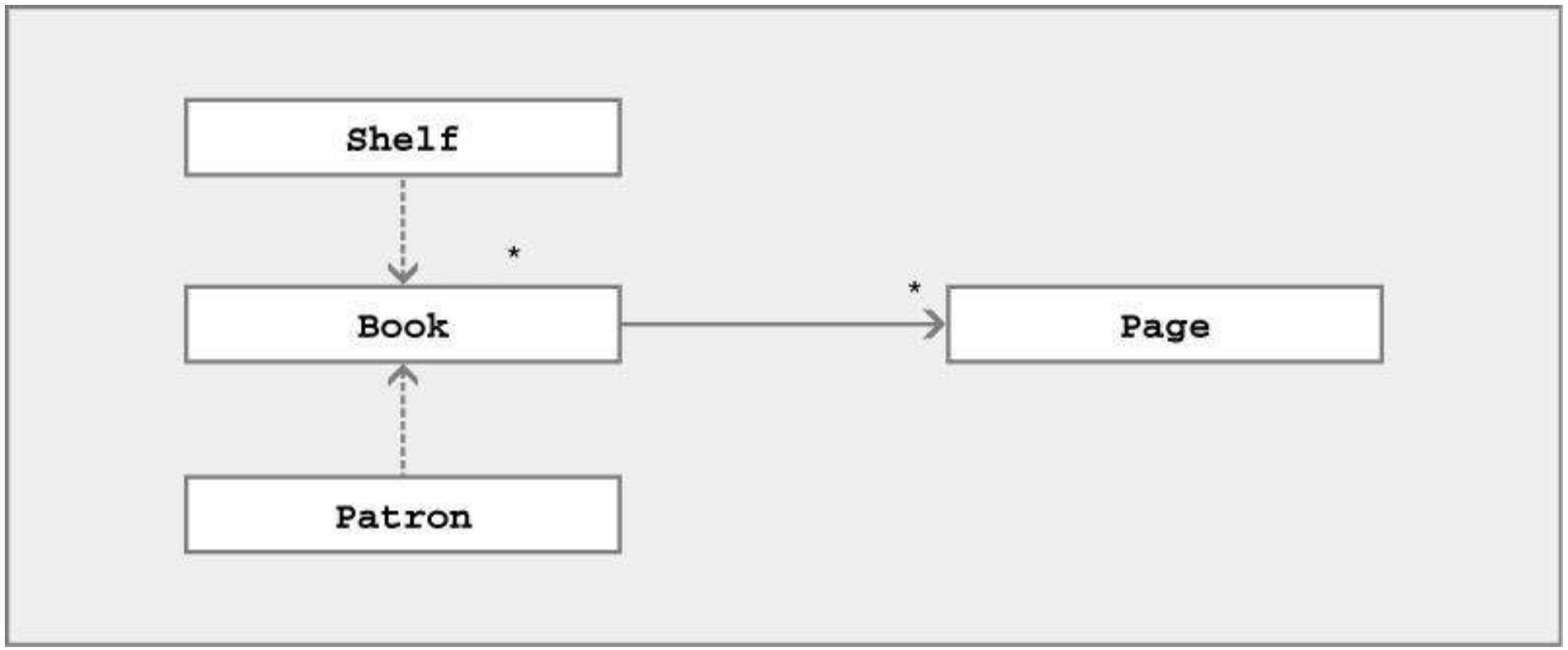
UML Example – Home Heating System



- 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

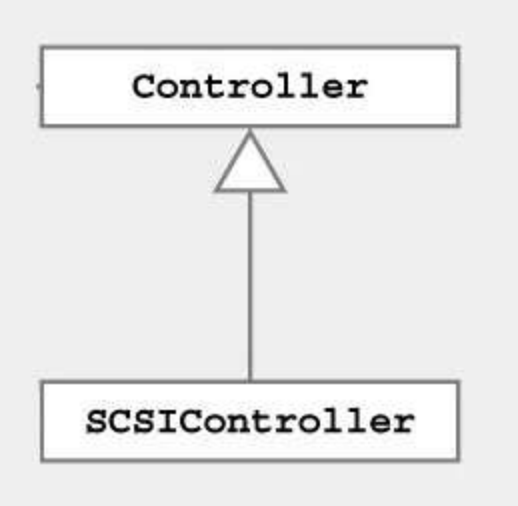
- **Try to read & understand UML diagram**



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

UML → Java : Computer System

- **UML**

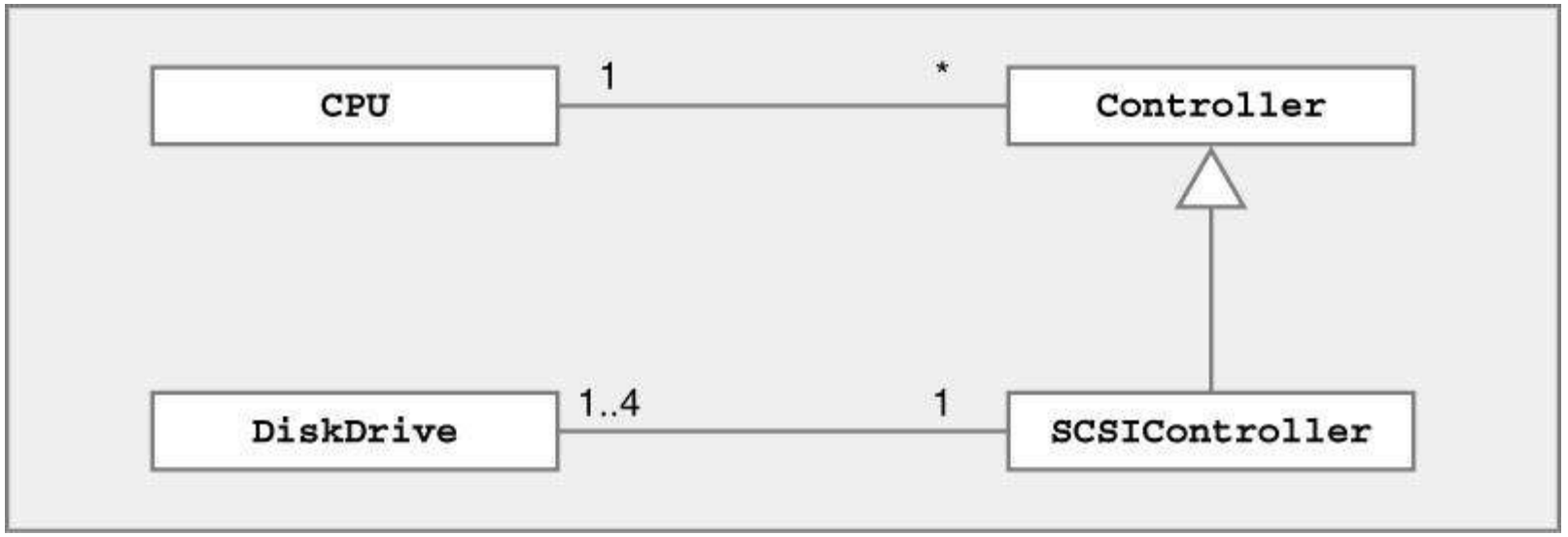


- **Java**

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

UML → Java : Computer System

- **UML**

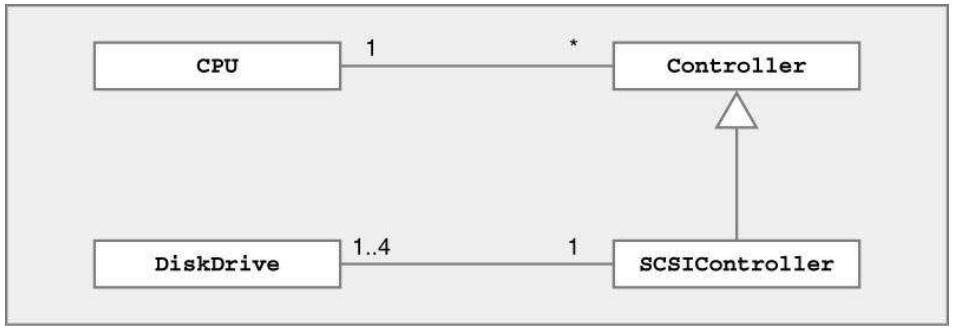


- **Java**
  - **Design code using all available information in UML…**

UML → Java : Computer System

- **Java**

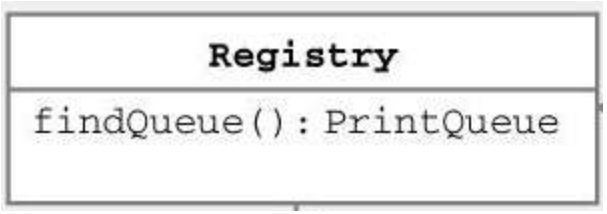
```
class CPU {
    Controller myCtlrs[ ];
}
class Controller {
    CPU myCPU;
}
class SCSIController extends Controller {
    DiskDrive myDrive[4];
}
Class DiskDrive {
     SCSIController mySCSI;
}
```

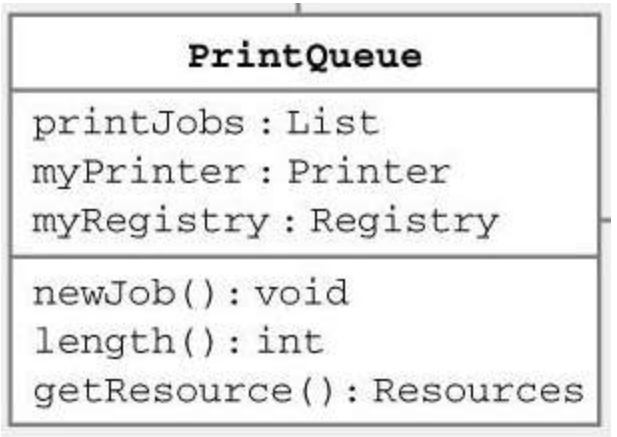


Java → UML : Printing System

- **Java**

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

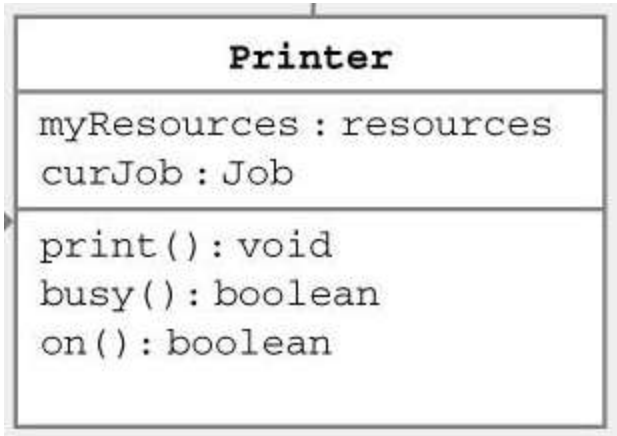




Java → UML : Printing System

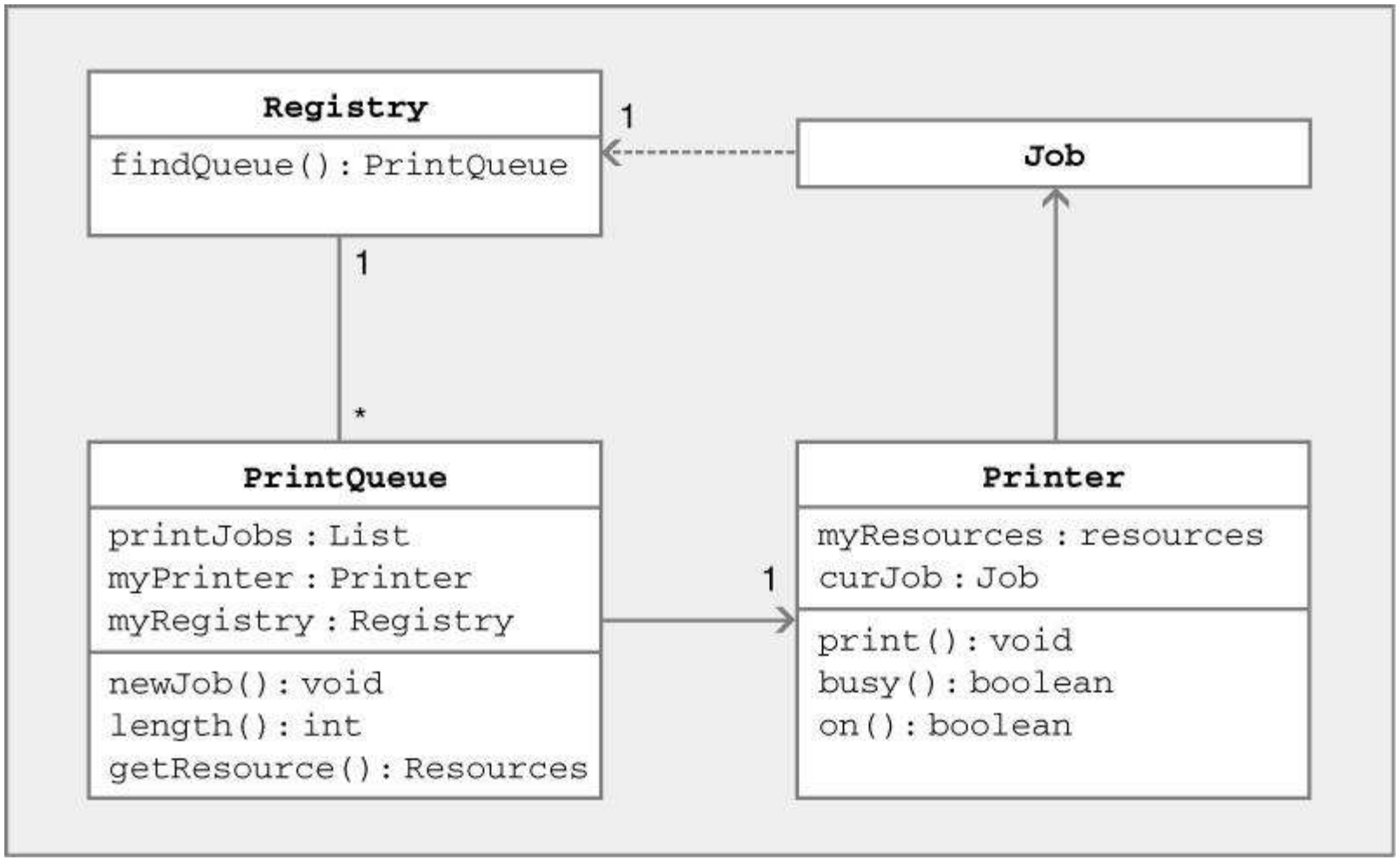
- **Java**

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



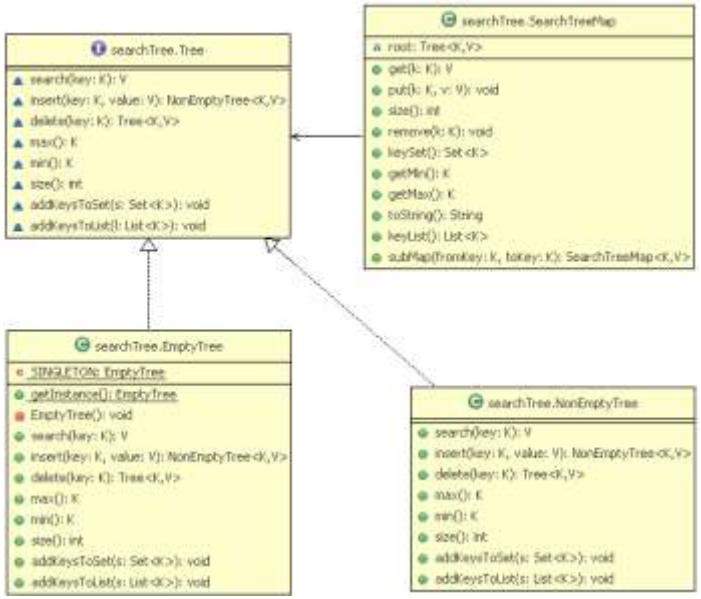
Java → UML : Printing System

- **Java**
  - **All together**

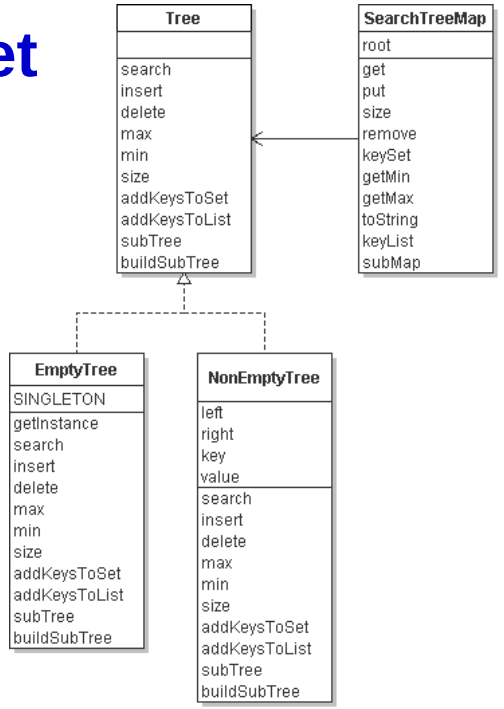


UML Tools

- Can automatically generate
  - UML diagrams from code
  - Code from UML diagrams
- Examples
  - AmaterasUML

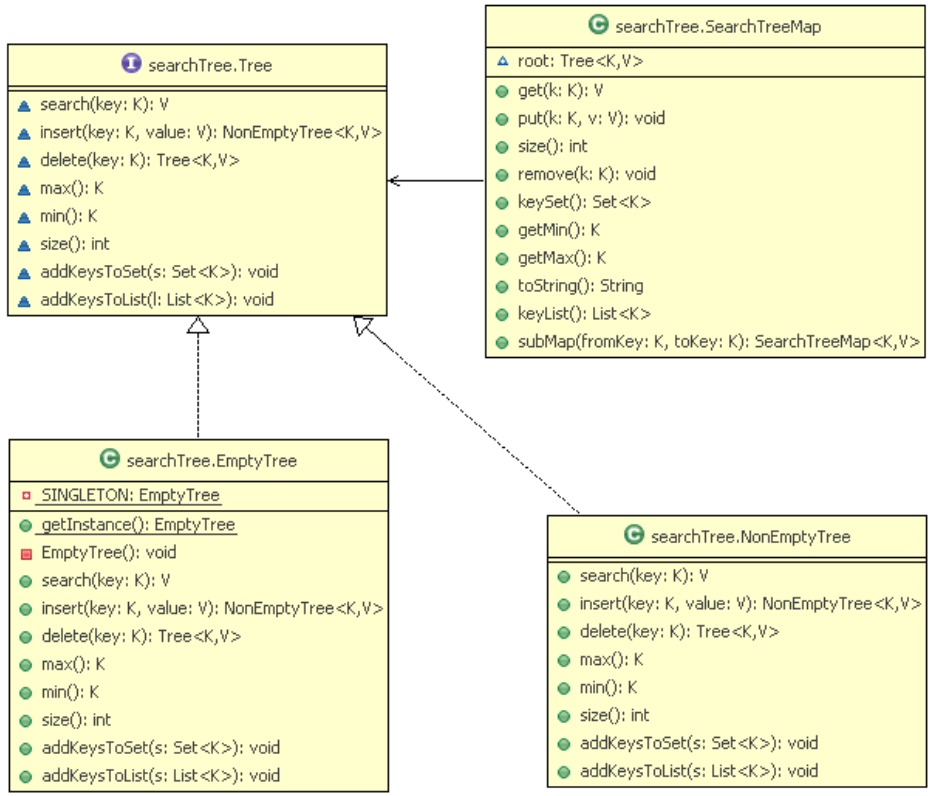


- Violet

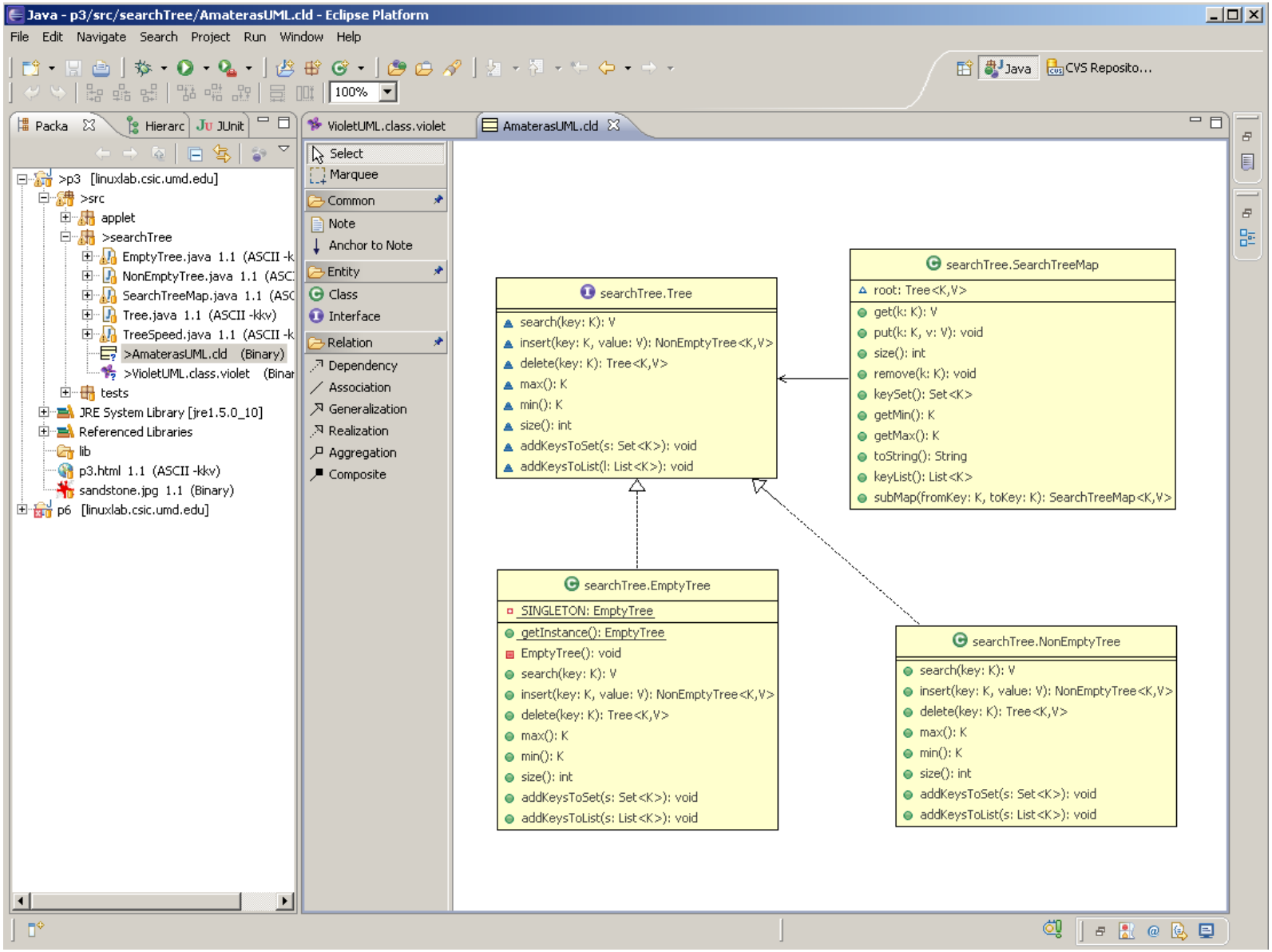


Amateras UML Editor

- 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

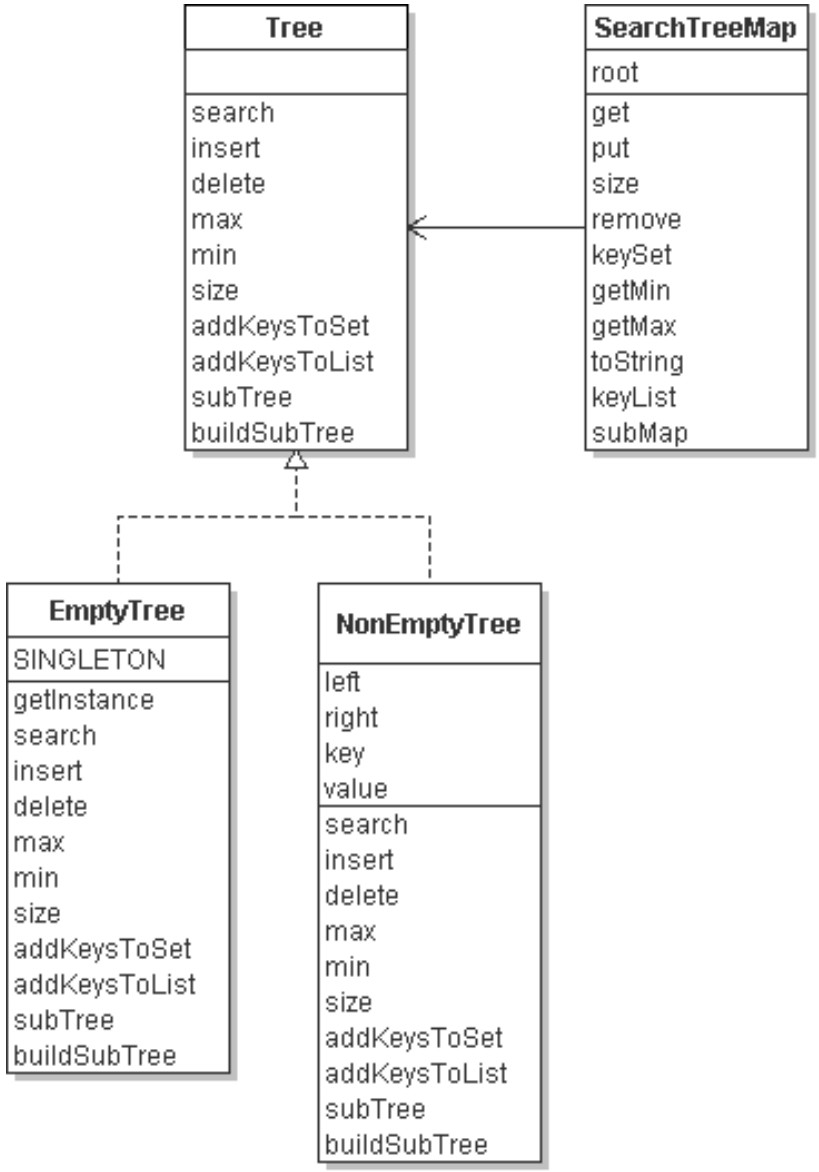


Amateras UML Editor – Eclipse Plugin

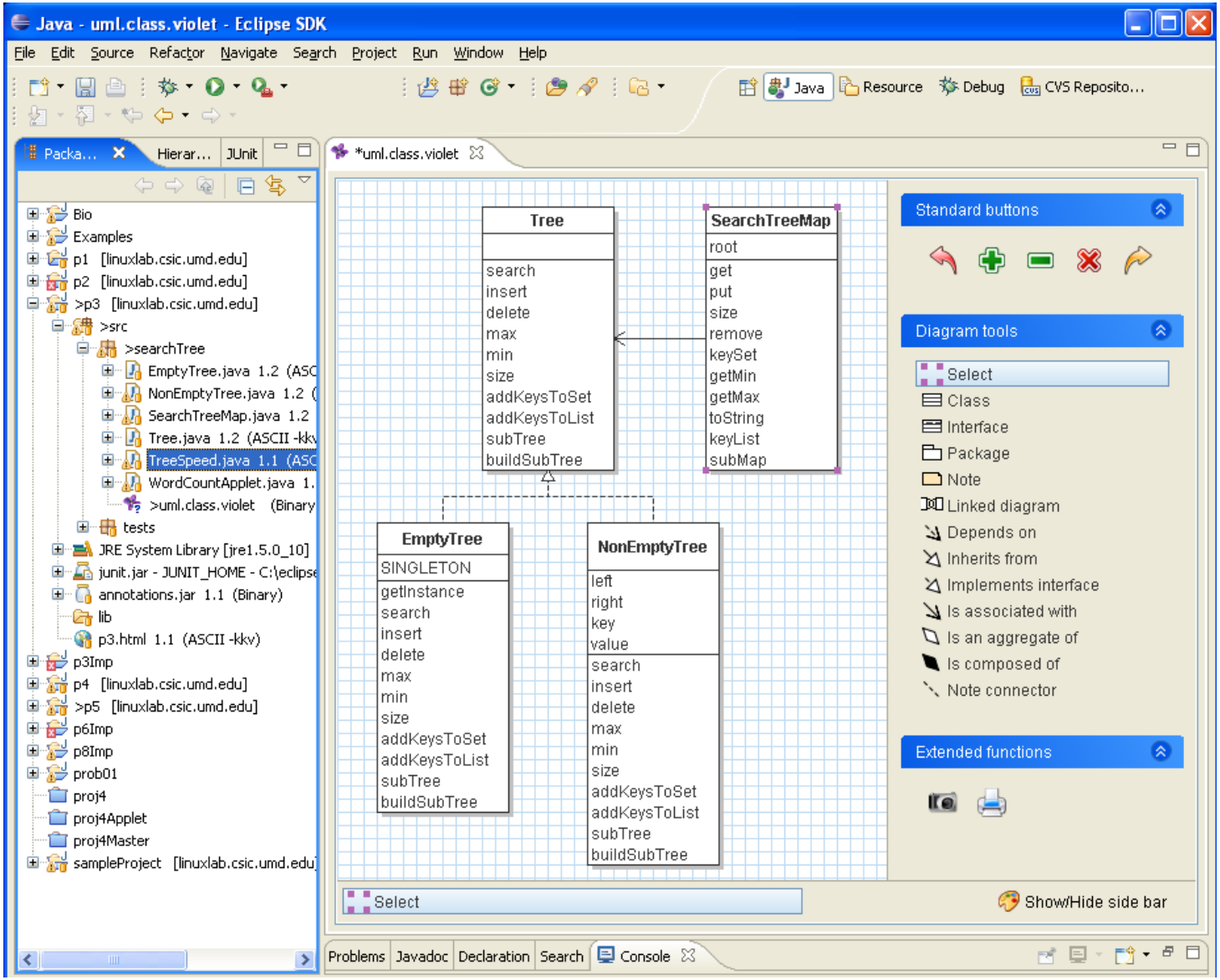


Violet UML Editor

- **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