CS3342 Software Design

Lecture 01 Introduction to Software Engineering and Design

What is Software

- Software is a set of items or objects that form a "**configuration**" that includes
  - **programs** (i.e., source code, executable code) which are instructions
  - **documents** (requirements, design document, test plan, user guide, etc.) 'describe the program'
  - **data structure** that 'enable program' to work.
- Software is the **Product** that SW engineers design and build
  - produces, manages, acquires, modifies, displays, or transmits information
- Software is **logical rather than physical**
- Software is a **vehicle for delivering a product/service**
  - **Supports or directly** provides system **functionality** (e.g., banking system, inventory control, CRM)
  - **Controls** other programs (e.g., an operating system)
  - Enable communications (e.g., networking software)
  - Helps build other software (e.g., software tools)
- Quality of software
  - It works(must do the task correctly and completely), thus the first step in the development process is to understand the SW REQUREMENT
    - Format of input and output
    - Processing details
    - Performance
    - Error and handling procedures
    - Standards
  - Can be read and easily understood: document the code
  - Can be modified: accommode for new requirements and changes
  - Completed in time and within budget
- Software vs. Hardware
  - software is engineered not manufactured
  - software doesn't wear out
  - software is complex
  - Software is custom build (most of them) except software like *Excel, PowerPoint,* etc.
- Software Costs
  - Software costs often dominate system costs (cost of software on a PC are often greater than the hardware cost)

    - Software costs more to **maintain** than it does to **develop**. For systems with a long life, maintenance costs could be several times of development costs
- **The IEEE Definition of Software Engineering**
    - “The application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software; that is, the application of engineering to software.”
    - Software Engineering is the process of solving **users problems** by the systematic development and evolution of large, high-quality software systems within cost, time and other constraints
- Task in SE
    - Feasibility Study
    - Requirements Analysis
    - Design
    - Programming**
    - Unit test
    - Integration and system test
    - User training
    - Changeover
    - Maintenance
    - And many more...
- **Software professionals** are characterized
    - by a relevant education and continued learning;
    - they have a holistic or system life-cycle focus;
    - they work to industry standards;
    - and they have a balanced approach to technical risk.
- **Why do software project fail**
    - Poor communication(internal and external)
    - Resistance to change
    - Not reviewing project progress on a regular basis
    - Unclear Requirements
    - Unrealistic expectations
    - The absence of a good project manager
    - Moving the goalposts too often
    - not enough resource

Lec 02 Software Process

Part one :

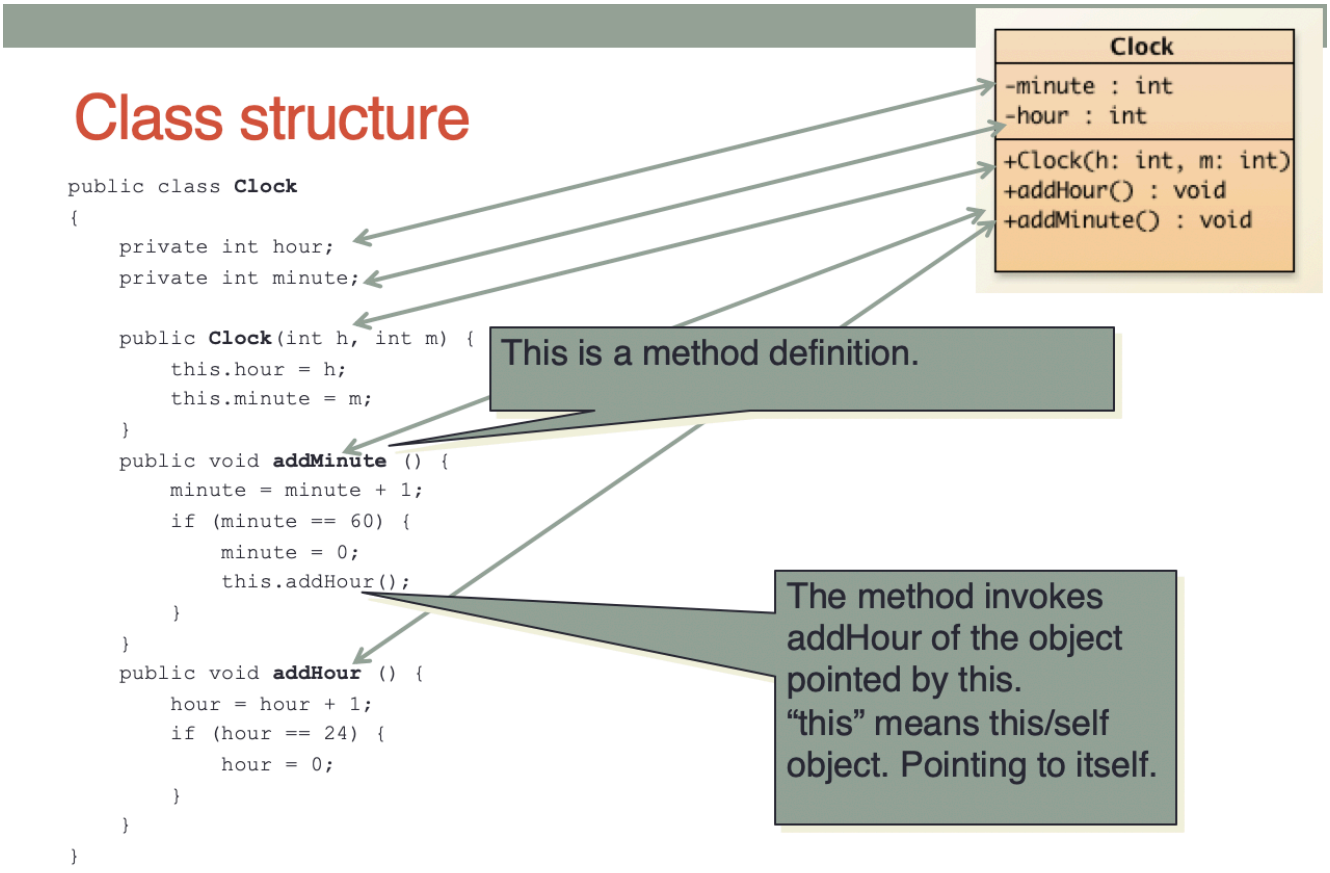
- Object : thing from real world which can be quantified to mean one specific item
    - an **instance** of class
    - entity that has a state and a set of operations on that state (**a set of object attribute**)
    - Operation: provide services to other obj which request these services
- Class : represent all objects of the same kind
    - A set of related objects

    - Declarations of the attributes and services associated with an object of that class
    - represents some useful concept that existing in the **problem/solution domains**
    - may inherit attributes and operations from other classes
- OO
    - OO Programming has become the **standard programming** methodology for software engineers.
    - OO Programming is a **software programming paradigm** using “objects”, with instances of a class.
    - In OO programming, you would design the program with the **data parts in mind, contextual information rather than procedures.**
    - E.g Designing a smart phone… : What kind of information/data to be stored/used?
- Advantage of OO
    - **Easier to maintain** : Objs may be understood as stand-alone entities
    - **reuse**
        - Objects are potentially **reusable** components.
        - For some systems, there may be an obvious mapping from real world entities to system objects.
- Rules to Name Classes

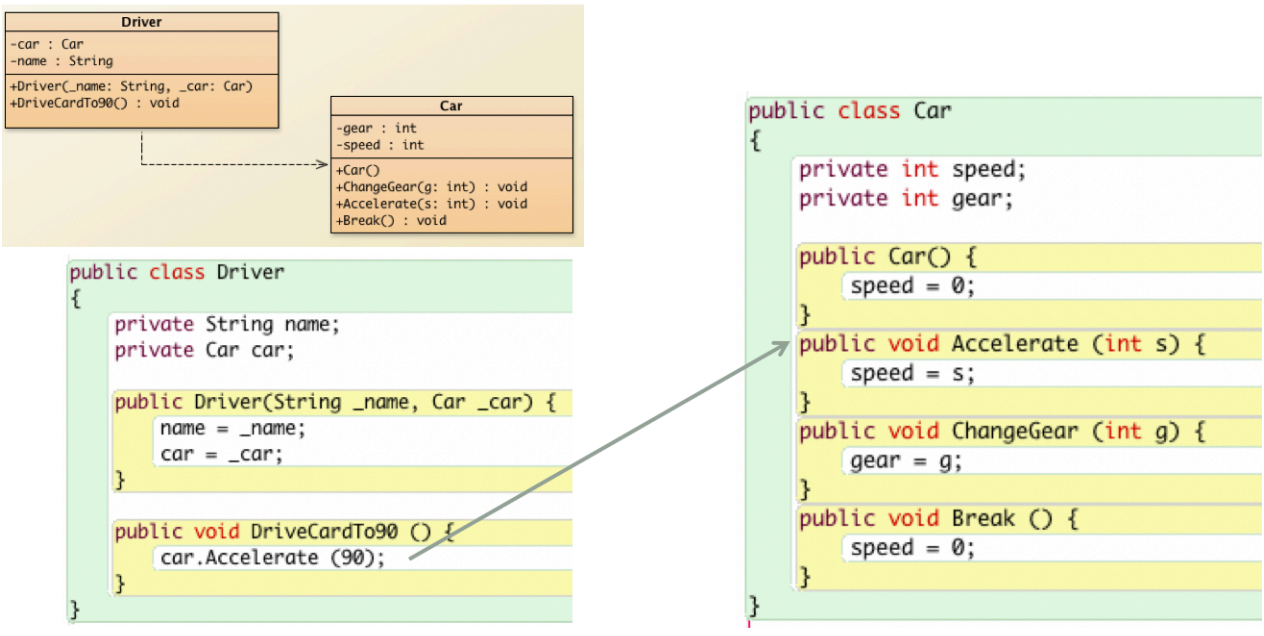
	Some Good Examples
Singular	Account, Chart,
Informative	Clock, Watch,
Concrete	Flowchart, Photo, Video
Non-confusing	Chinese language, Programming language, Digital Clock, Analog Clock

    - notice to model *real world* objects correctly, every attribute of the class instance must be assigned with a concrete value at any time.

- UML

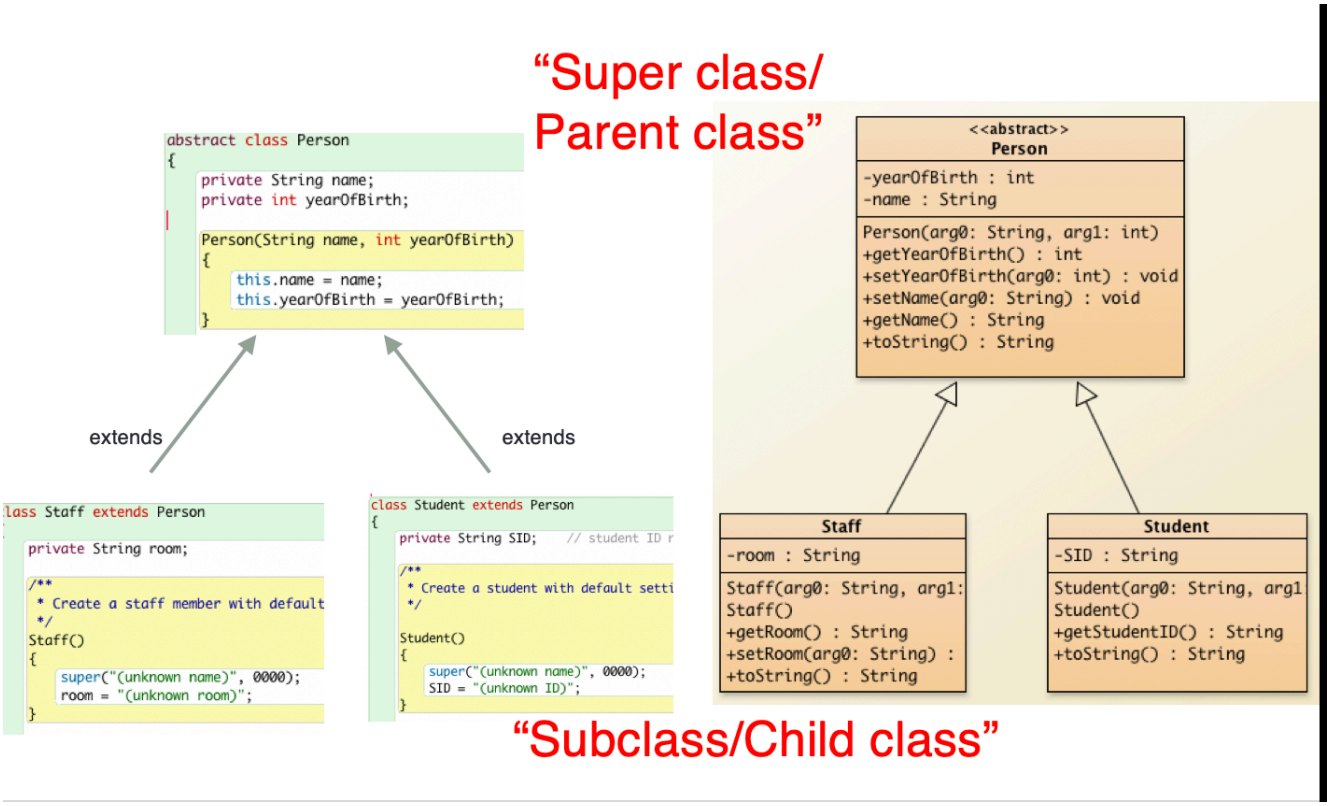


  - Operations :
    - **change the value** of some attribute of an obj(set)
    - **Queries** (get)
  - Reference
    - Objects communicate by *message passing*: request from one object to another asking the second object to execute one of its methods.



- State of Object
  - Objects can be in different **states**.

    - State will change under the influence of outside circumstances
    - Use a interface and create difference states class to implement the interface
- Object Inheritance : Tool to reuse the code
    - subclass "is a (kind of)" superclass
    - generalization and inheritance
        - ***Generalisation*** is implemented as ***inheritance*** in OO programming languages
        - *Classes* may be arranged in a *class hierarchy* where one class (a *super-class*) is a *generalisation* of one or more other classes (*sub-classes*)
    - Sub-class inherits (all **attributes/operations/relationships**), and add attributes and operations, relationships, **redifine(override**) inherited operations
    - **Point from subclass to superclass**
    - Do not use too often which causes difficulties of management



- Advantage of Inheritance
    - It is *an abstraction mechanism* to classify entities
    - It *supports **reuse*** （often exist in the exam） both at the design and programming level
    - It provides a mechanism to extend or refine a class: by adding or overriding methods (or *operations*) and by adding attributes
    - The inheritance diagram is a *source of organisational knowledge about domains and systems*
- Information Hiding in OO
    - *Information hiding* enhances **maintainability** because implementation details are **invisible** outside an object
    - OO languages allow an attribute to be described as **private** (invisible outside the object)
        - (-) minus-sign : private, (+) plus-sign : public
- Benefits of information hiding

- change cannot affect other part of the system
- a system consists of essentially **independent** classes
- they **communicate by sending messages**
- **objects do talking to each other**

Part two:

Software process

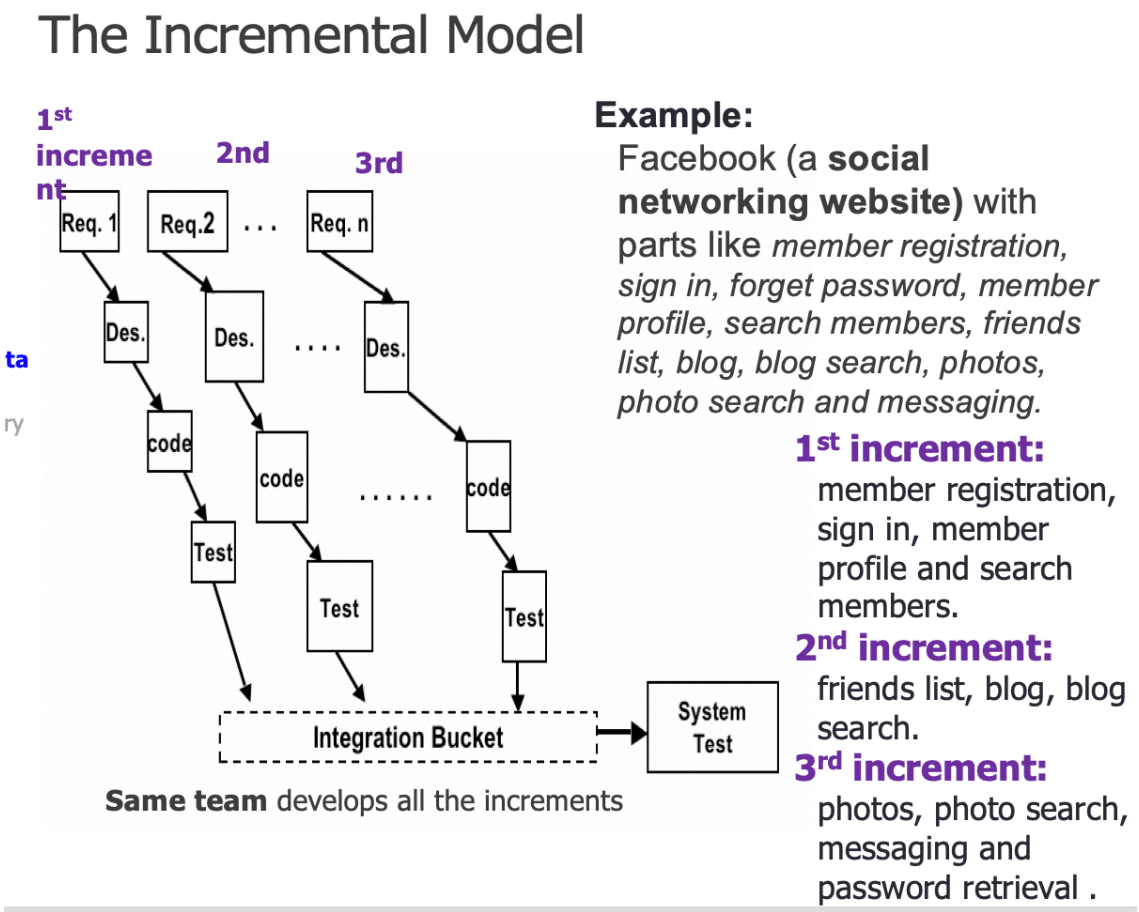
- Software process: A series of predictable steps, road maps, that help us to create a timely, and high-quality result (defines tasks of activities that take place during the process)
  - defines who is responsible for:
    - What?
    - when and how?
    - to reach a goal
  - Process defines tasks and activities within a schedule
  - start with understanding the business requirements

SW Process Model (Life cycle)

- Software process model
  - An abstract representation of a process
  - It describe **a process**
  - guides the software developement team
  - with a set of key activities
- Phases and components : (e.g. design phase, test phase) and each phase has 3 components:
  - set of **activities**： define, design, implement, test and maintain
  - set of **deliverables**(可交付产品): what to produce
  - Quality control **measures**: what to use to evaluate/assess deliverables
- Process Model
  - **Waterfall Model**: Follows a systematic, sequential approach to SW development that begins at the system level and progresses through analysis, design, code and testing.
    - The "god parent" of models, linear sequence of phases
    - pure model : **no phases overlap**
    - Pros: Easy; Structured; Provide a template into which methods for **analysis, design, code, testing and maintenance** can be placed.
    - Cons:
      - Sequential, does not reflect reality
      - Does not produce a prototype
      - *Little feedback from users* until it might be too late. Therefore cannot adapt to users' needs, lack of intelligence and adaptability
      - *Problems in the specification may be found very late (at* Coding or integration)
      - It can *take a long time* before the first version is out
      - Risky: Integration and testing occur at the end => to late

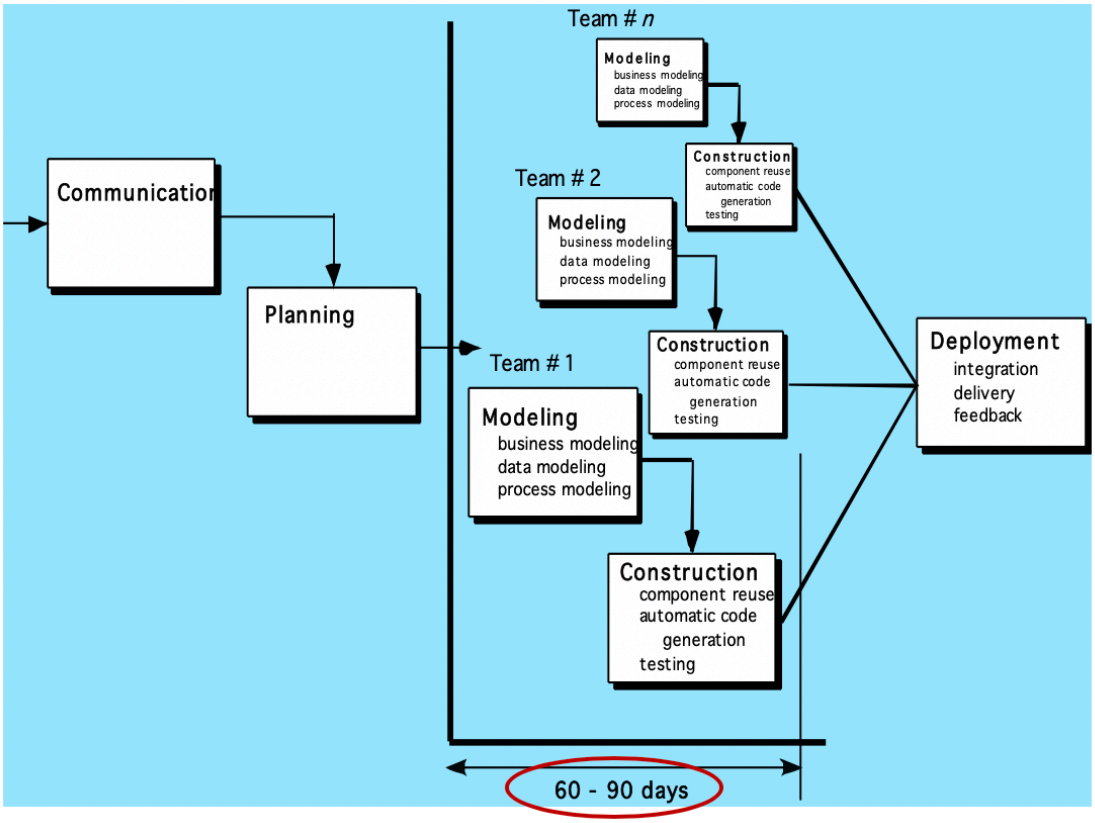
- When to use:
  - simple proj
  - limited amout of time
  - requirements are well understood
  - Use well-understood technologies

- Incremental Process Models
  - Goal : provide quick basic functionality to the users
  - Process is not linear
  - **Requirements are well defined**
  - Software is completed **in small increments**
  - The system "Grows" in a number of small steps
  - 2 types:
    - Incremental Model



      - First build provides the **CORE** functionalities
      - Each increment “deliverable” **adds a new** functionality.
      - This is repeated until the product is complete
      - It combines characteristics of the waterfall model and the iterative nature of the prototyping model
      - When to use: software **can be broken into increments** and each increment represent a solution
    - RAD (The Rapid Application Developement) Model

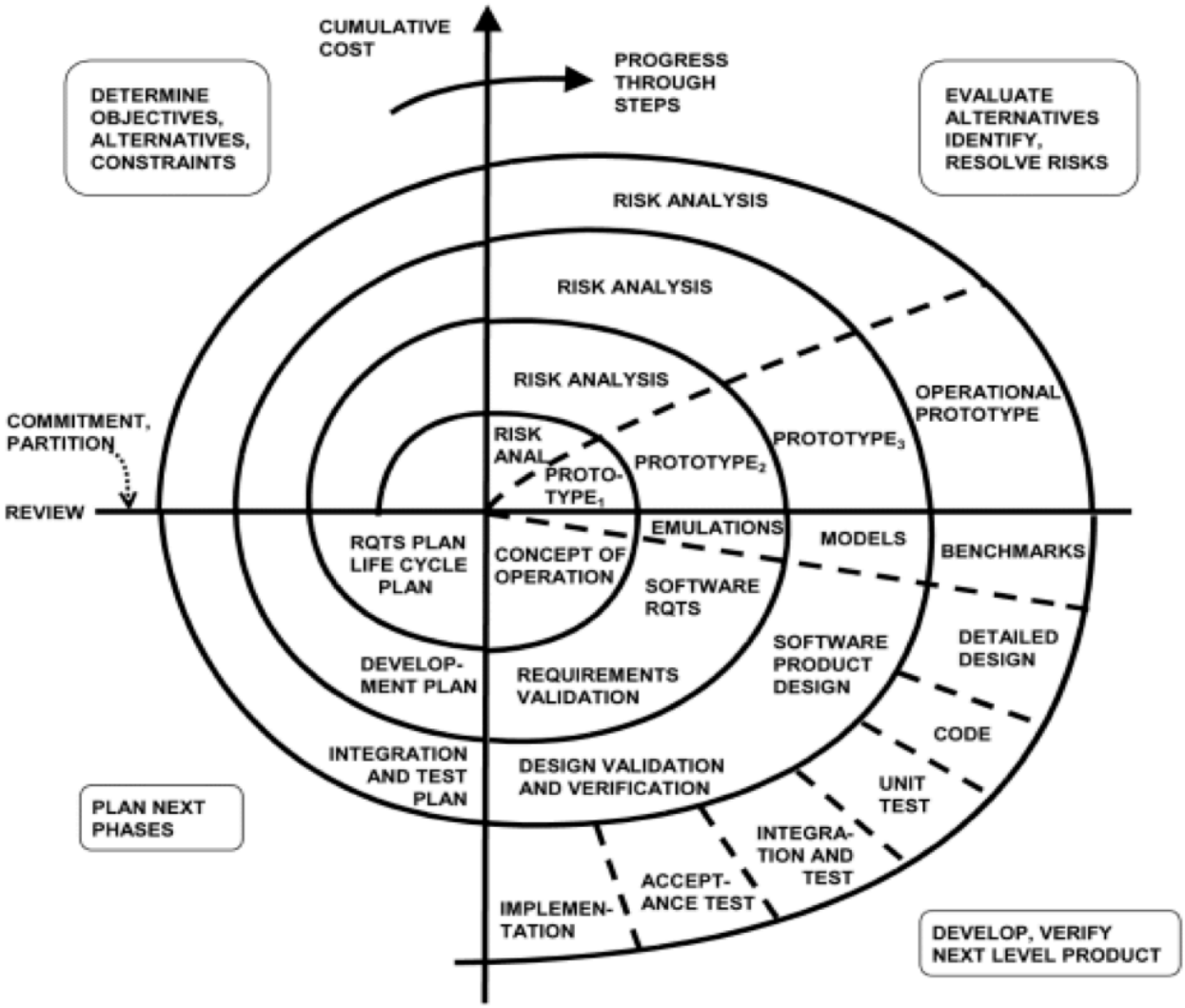
RAD Model



- Builds on the Incremental model with emphases on **short development cycle**.
- A **speed waterfall** model
- Components are built using this model as a fully functional units in a relatively short time
- It **assumes that the system can be modularized(模块化)**
- Involves multiple teams!
- RAD will fail if we don't have strong and skillful teams

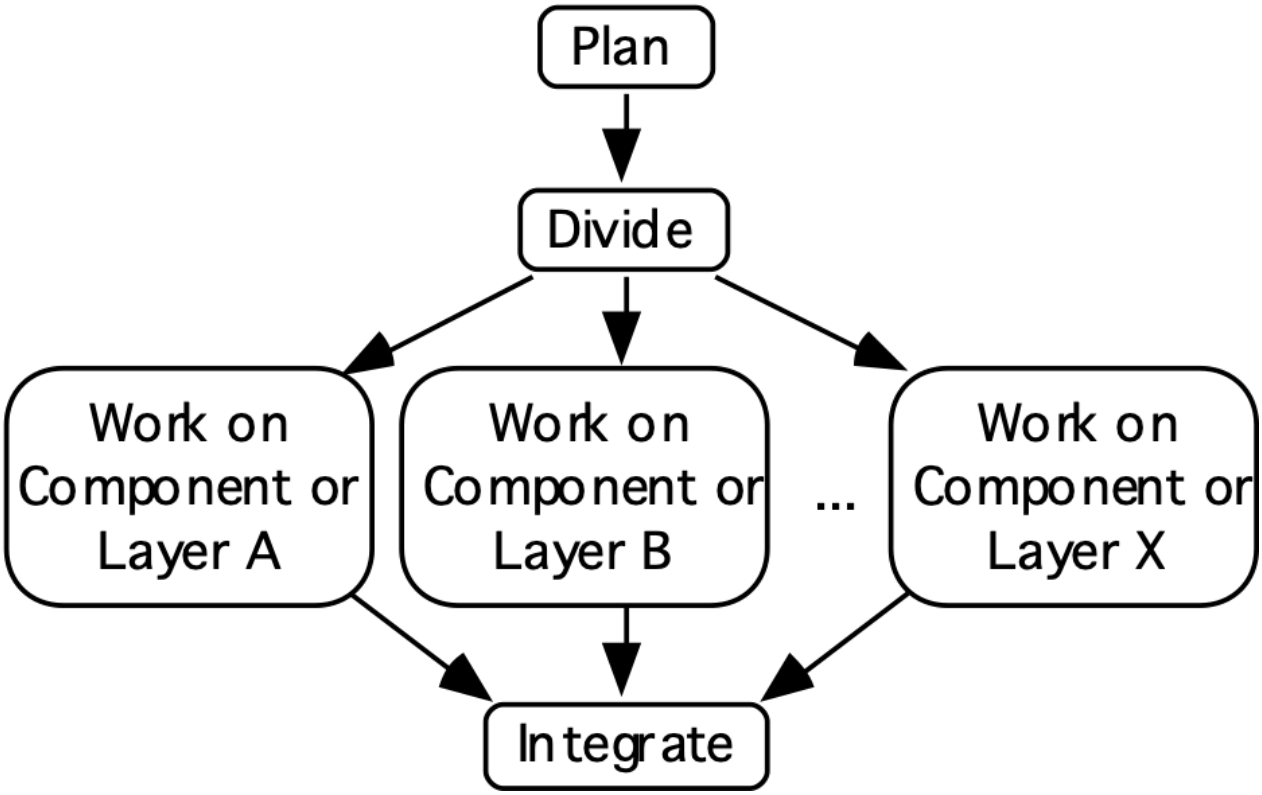
- Evolutionary(演变) Process Models
  - **Specification,development and validation** activities are carried out *concurrently*(同时) with *rapid feedback across these activities*
  - **Core requirements are well understood but additional requirements are evolving and changing fast**
    - Design most prominent(重要的) parts first
    - Usually via a visual prototype
    - Good for situations with:
      - Rapidly **changing requirements**
      - Non-committal customer(非承诺客户)
      - Vague(模糊) problem domain
    - **Advantages**
      - Do not require **full** knowledge of the requirements
      - **Iterative** (software gets more complex with each iteration)
      - Divide project into **builds** (standalone software package - binaries)

        - Allows ***feedback***, show user something sooner
        - Use to develop more complex systems
        - Provide steady, visible progress to customer
    - **Disadvantages**
        - Time estimation is difficult
        - Project completion date may be unknown
- **Prototyping Model**
    - Start with what is known about requirements.
    - Complete a quick design.
    - Build the prototype by focusing on what will be seen by the user.(write interface first??)
    - Use the prototype to show the user and help refining(提炼) requirements.
    - Better communication
    - Advantage
        - Prototype can serve as a way for identifying requirements.
        - It is developed very quickly.
    - Disadvantage
        - Customer might think that the prototype is the final product and forget the lack of quality i.e. PERFORMANCE, RELIABILITY.
    - **When to use?**:
        - When the customer define general objectives for the SW but does NOT identify details about INPUT, OUTPUT, or processing requirements.
        - The developer is unsure of the efficiency of an algorithm, human machine interaction, etc(no implementation detail)
- Spiral(螺旋) Model
    - Iterative (like Prototype) and controlled (like waterfall)
    - Software is developed using evolutionary releases(演变发行)
    - Complexity increase with each release
    - A spiral process rather than as a sequence of activities with backtracking
    - *Each loop* in the spiral represents *a phase in the process*.
    - *No fixed phases* such as req. specification or design - loops in the spiral are chosen depending on what is required—*more flexible*
    - Emphasize risk analysis and management (Risks are explicitly assessed and resolved throughout the process)
- The Spiral Model



- Each addresses a set of "risks": Start small, explore risks, prototype, plan, repeat
- Number of spirals is variable
- Advantage:
  - Can be combined with other models(as long as it can be divided into spirals)
  - risk orientation provides early warning of problems
- Disadvantages
  - More complex
  - requires more management
- When to use
  - very large projects, mission critical systems
  - When technical skills must be evaluated at each step

- Concurrent Engineering Model(paralllel development)



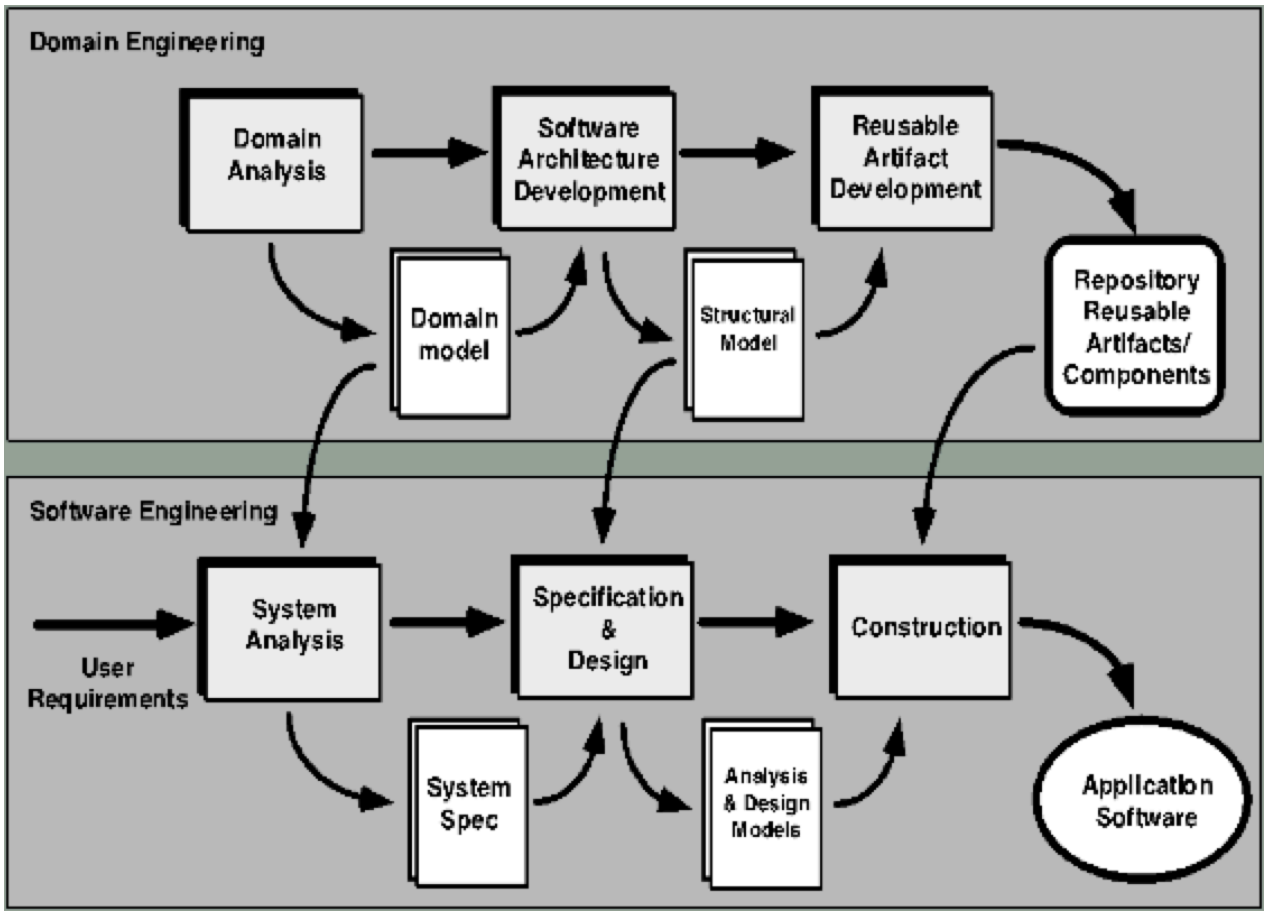
    - It explicitly use the **divide and conquer** principle.
    - Each team works on its own component, typically following a spiral or evolutionary approach.
    - There has to be some initial planning, and periodic integration.
- Other Process Model: Component based software engineering(CBSE)
    - When **reuse** is a development objective
    - Based on systematic reuse where systems are integrated from existing components or COTS (Commercial-off-the-shelf) systems. (E.g., data conversion, encryption, device drivers, data mining modules)
    - The main difference is that CBSE emphases(依靠) on **composing** solutions from prepackaged software components or classes
    - Key questions: Are commercial off-the-shelf components and internally-developed reusable components are available to implement the requirement; Are the interfaces for available components compatible within the architecture of the system to be built?
    - First rule of CBSE: never build what you can buy!

      Because: it becomes solution oriented, built based on features available in the components, not from customer requirements (problem-oriented).
    - Design principles:
        - Components are independent so do not interfere with each other
        - Component implemnations are hidden
        - Communication is through well-defined interfaces;(method calls)
        - Component platforms are shared and reduce development efforts/costs
    - Component: Provide a service without regard to where the component is executing or its programming language
        - The *component interface* is published and all interactions are through the published interface;
        - An independent, executable entity

    - The services offered by a component are made available through an interface API
- Component characteristics

Standardised	Component standardisation means that a component that is used in a CBSE process has to conform to some standardised component model. This model may define component interfaces, component meta-data, documentation, composition and deployment.
Independent	A component should be independent – it should be possible to compose and deploy it without having to use other specific components. In situations where the component needs externally provided services, these should be explicitly set out in a 'requires' interface specification.
Composable	For a component to be composable, all external interactions must take place through publicly defined interfaces. In addition, it must provide external access to information about itself such as its methods and attributes.
Deployable	To be deployable, a component has to be self-contained and must be able to operate as a stand-alone entity on some component platform that implements the component model. This usually means that the component is a binary component that does not have to be compiled before it is deployed.
Documented	Components have to be fully documented so that potential users of the component can decide whether or not they meet their needs. The syntax and, ideally, the semantics of all component interfaces have to be specified.

- Considerations



- step(1): Build up a component library
- step(2): Develop a new system based on components

Lecture 03 OOFundamental-Part II & Roles of Variables & UML Class Diagram

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OOFundamental II

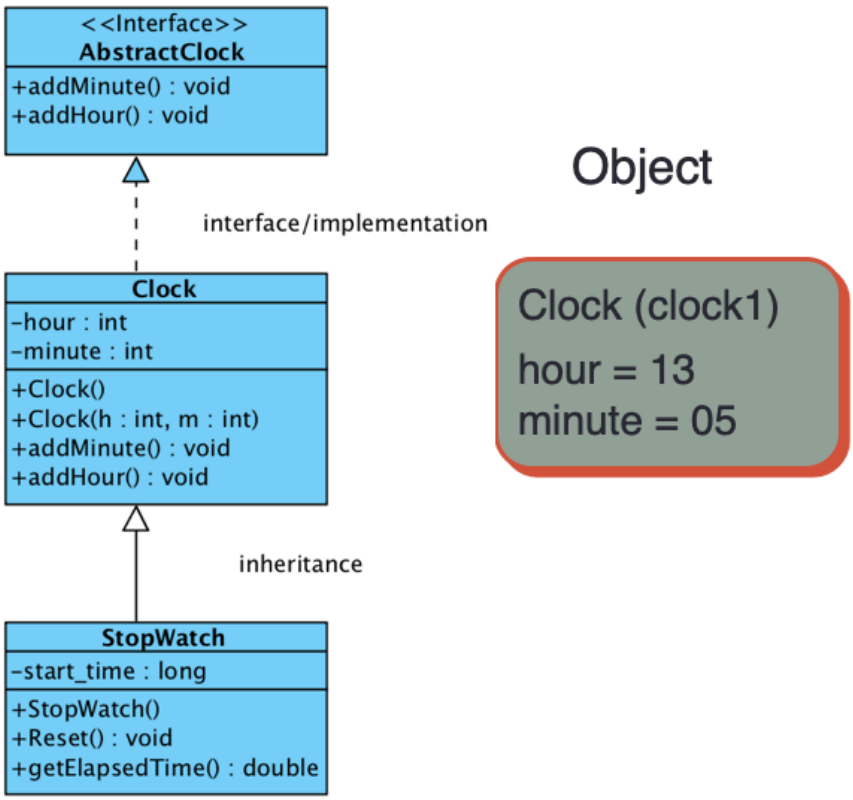
- Abstraction

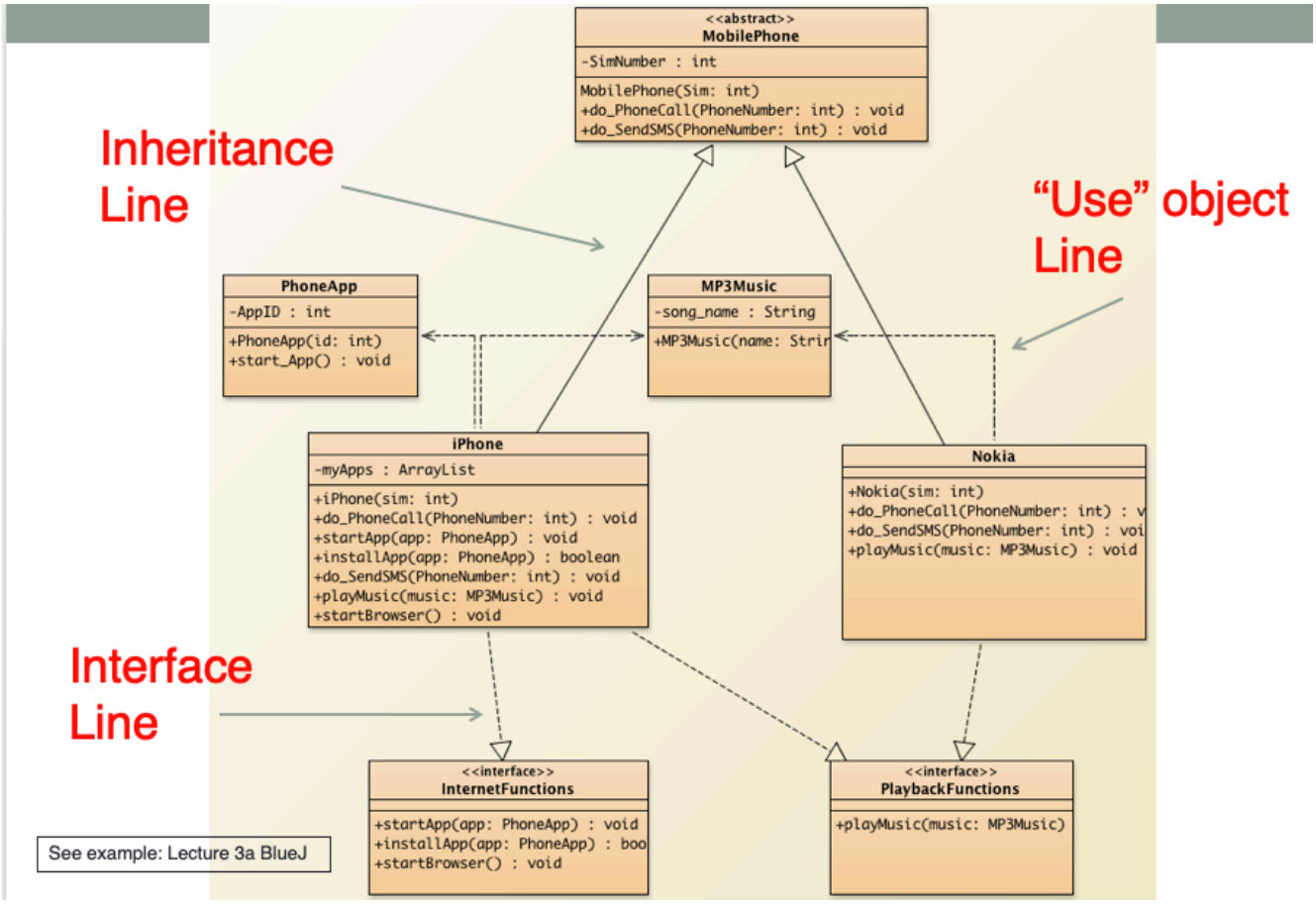
Example

Modeling Clock

```
public class Clock implements AbstractClock
{
    private int hour;
    private int minute;

    public Clock () { hour = 0; minute = 0;}

    public Clock(int h, int m) {
        this.hour = h;
        this.minute = m;
    }

    public void addMinute () {
        minute = minute + 1;
        if (minute == 60) {
            minute = 0;
            this.addHour();
        }
    }

    public void addHour () {
        hour = hour + 1;
        if (hour == 24) {
            hour = 0;
        }
    }
}
```

See example: Lecture 3a BlueJ





- Abstract class<<abstract>>, … extends…
  - A special kind of class that cannot be instantiated (create object).
  - Can have "default" implementations, subclasses can modify.
  - Enforce certain characteristics and hierarchies for all the subclasses.
  - Support Multiple Inheritance: NO. Can only inherit from one abstract class
- Interface<<interface>>, … implements…
  - An interface is NOT a class. It is an entity, and has no implementation.
  - Only the definition of the methods without the body.
  - Cannot have "default" implementation, subclasses MUST implement them.
  - Support Multiple Inheritance : Yes, can implement different Interfaces

- Polymorphism(and dynamic binding)

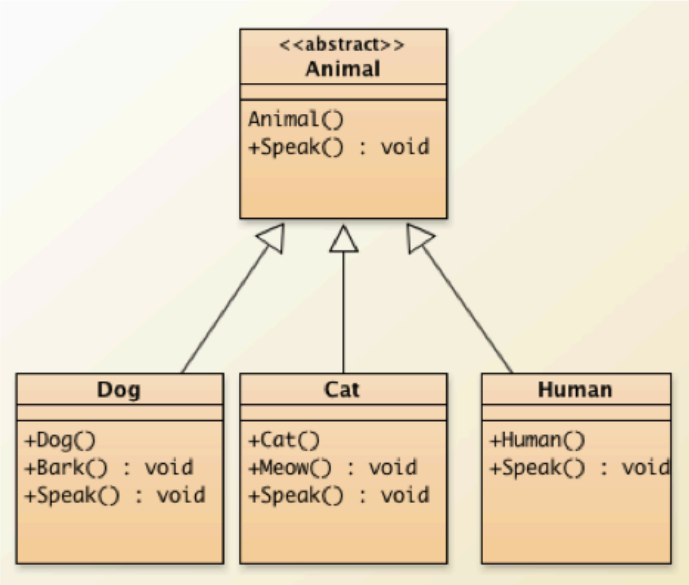
Example Polymorphism

```
abstract class Animal
{
    public abstract void Speak();
}
```

```
public class Dog extends Animal
{
    public void Speak()
    {
        Bark();
    }
    public void Bark()
    {
        System.out.println ("I am a Dog and I can Speak : Woof Woof!");
    }
}
```

```
public class Cat extends Animal
{
    public void Speak()
    {
        Meow();
    }
    public void Meow()
    {
        System.out.println ("I am a Cat and I can Speak : Meow Meow!");
    }
}
```

```
public class Human extends Animal
{
    public void Speak()
    {
        System.out.println ("I am a Human and I can Speak : Hello Word!");
    }
}
```



See example: Lecture 3b BlueJ

- Polymorphism is an OO feature that allows a subclass to provide a specific implementation of a method that is already provided by one of its superclasses.
- Method overriding is an important feature that facilitates polymorphism in the design of object-oriented programs.

Roles of Variables

- If a variable has **multiple purposes** to be used at the same time, the logic becomes less obvious: It is easier to introduce bugs in our program if we are unable to consistently maintain the value of the variable for all purpose
- The "Role" of a variable: is a way for developer to represent *meta-level programming knowledge*. Ten of them are very common in programs
  - **Constant/Fixed value**: A variable which is initialized without any calculation whose value does not change thereafter
    - Purpose: write once and read only
    - Example: read the radius of a circle, then print the area of the circle
      - variable ***r*** is a *fixed value, gets its value once,* never changes after that
      - (e.g., the variable PI in the following example).
    - "final" in Java or "const" in C/C++

```
public class AreaOfCircle {
   public static void main(String[] args) {
    float PI = 3.14F; // PI is a constant
    float r = 0.0;
      System.out.print("Enter circle radius: ");
     r = UserInputReader.readFloat();
     System.out.println(“Circle area is " + PI * r * r);
  }
}
```

- **Stepper**: A variable stepping through values that can be predicted as soon as the succession starts.(increment or, i++)
  - Purpose: Goes through a sequence of values systematically

```
public class MultiplicationTable {
   public static void main(String[] args) {
  int multiplier;
  for (multiplier = 1; multiplier <= 10; multiplier++)
    System.out.println(multiplier + " * 3 = "
      + multiplier * 3);
  }
}
```

- **Most-recent holder**: A variable holding the latest value encountered in going through a succession of values.
  - Most recent member of a group, or simply latest input value
    - e.g.: when asking the user for an input until input value is valid
    - s in the following example

```
public class AreaOfSquare {
   public static void main(String[] args) {
  float s = 0.0;
  while (s <= 0) {
    System.out.print("Enter side of square: ");
    s = UserInputReader.readFloat();
  }
  System.out.println(“Area of square is " + s * s);
  }
}
```

- **Gatherer**: A variable accumulating the effect of individual values in going through a succession of values.

- Purpose: Accumulates values seen so far: accepts integers, then calculates mean
- Variable sum is a gatherer

```
public class MeanValue {
    public static void main(String[] argv) {
  int count=0;
  float sum=0, number=0;
  while (number != -999) {
     System.out.print("Enter a number, -999 to quit: ");
       // number is most recent holder
     number = UserInputReader.readFloat();
     if (number != -999) { sum = sum + number; count++; }
  }
  if (count>0)
        System.out.println("The mean is " + sum / count);
   }
}

```

- **One-way flag**: A two-valued variable that cannot get its initial value once its value has been changed.
  - Purpose: serve as a Boolean variable (true or false)
  - Example: sum input numbers and report if any negative numbers

```
public class SumTotal {
   public static void main(String[] argv) {
  int number=1, sum=0;
  boolean neg = false;  //one-way flag
  while (number != 0) {
      System.out.print("Enter a number, 0 to quit: ");
      number = UserInputReader.readInt(); sum += number;
     if (number < 0) neg = true;
  }
  System.out.println("The sum is " + sum);
  if (neg)
        System.out.println(“There were negative numbers.");
   }
}

```

- **Temporary**: A variable holding some value for a very short time only.
  - Keep values that are only needed for very short period(e.g. separated by a few lines of code)
    - e.g.: output two numbers in size order, swapping if necessary

```
public class Swap {
   public static void main(String[] args) {
  int number1, number2, tmp;
  System.out.print("Enter num: ");
  number1 = UserInputReader.readInt();
  System.out.print("Enter num: ");
  number2 = UserInputReader.readInt();
  if (number1 > number2) {
    tmp = number1;
    number1 = number2;
    number2 = tmp;
  }
  System.out.println("Order is " + number1 + "," + number2 + ".");
   }
}

```

- **Organizer:** An array which is only used for rearranging its elements after initialization. (container)
  - An array[] for containing and rearranging elements
  - e.g.: input ten characters and output in reverse order

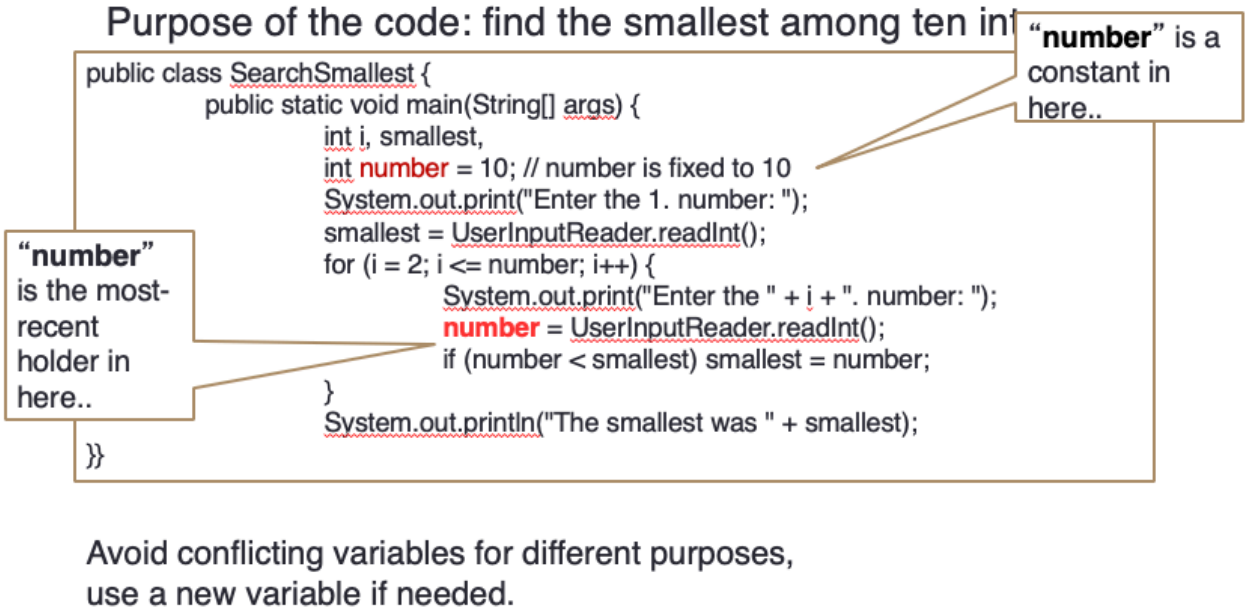
```
public class Reverse {
   public static void main(String[] args) {
  char[] word = new char[10]; // organizer
  char tmp; int i;
  System.out.print("Enter ten letters: ");
  for (i = 0; i < 10; i++) word[i] = UserInputReader.readChar();
  for (i = 0; i < 5; i++) {
    tmp = word[i];
    word[i] = word[9-i];
    word[9-i] = tmp;
  }
  for (i = 0; i < 10; i++) System.out.print(word[i]);
  System.out.println();
  }}
```

- **Transformation**: A variable that always gets its new value from the same calculation from value(s)of other variable(s).
  - Purpose: Compute value in new unit
  - e.g.: `speed = distance/time`

```java
public class Growth {
   public static void main(String[] args) {
  float capital, interest; int i;
  System.out.print("Enter capital (positive or negative): ");
  capital = UserInputReader.readFloat();
  for (i = 1; i <=10; i++) {    //stepper
       interest = 0.05 * capital; //transformation
       capital += interest;   //gatherer
       System.out.println("After "+i+" years interest is "
    + interest + " and capital is " + capital);
  }
   }
}
```

Solution:

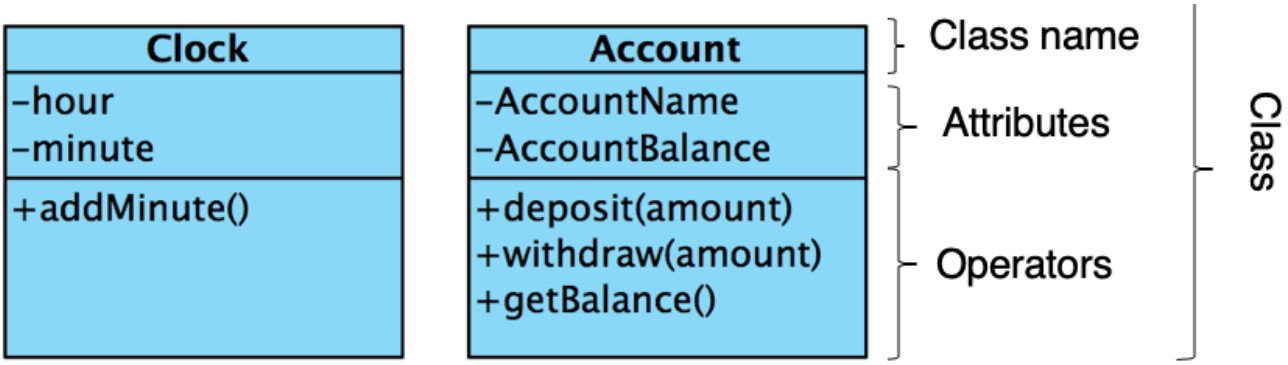
What's wrong about the usage of "number"?



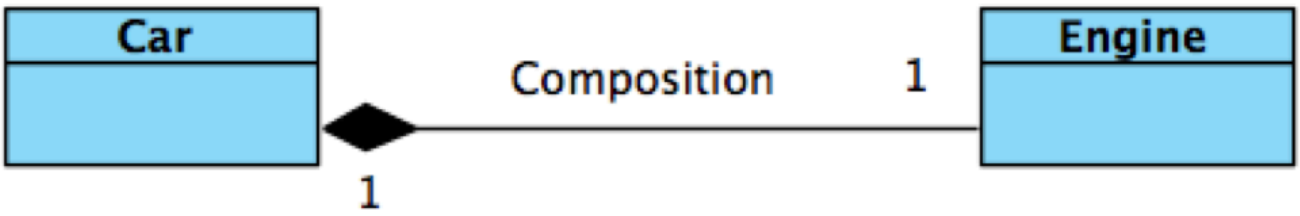
Avoid conflicting variables for different purposes, use a new variable if needed.

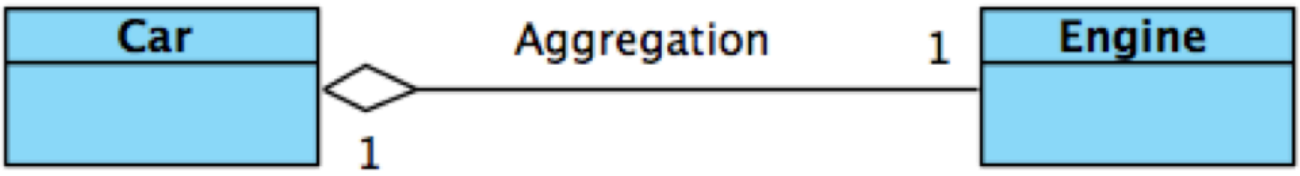
UML Class Diagram

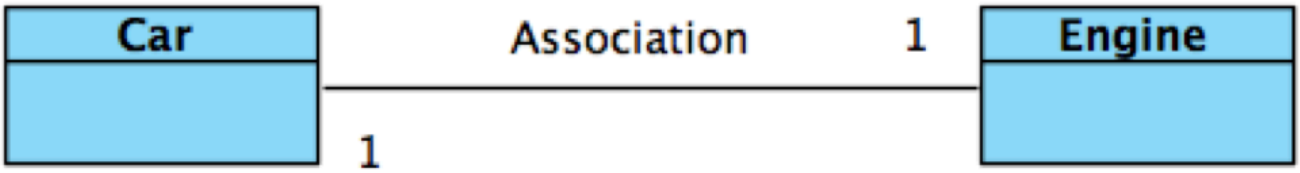
- Class diagram: Used to visualize object-oriented classes and their relationships in our system



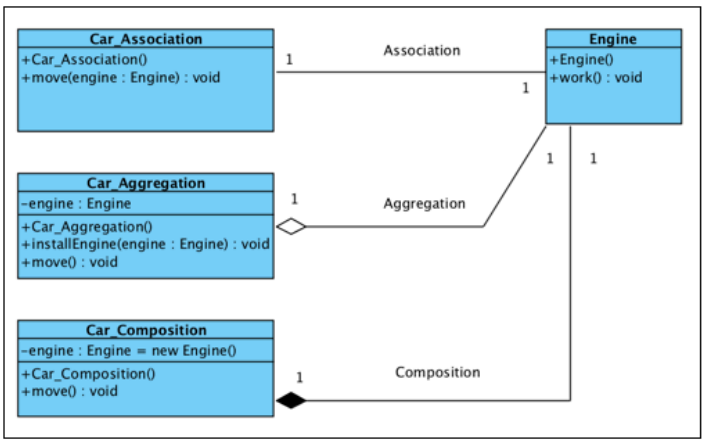
- Class linkages

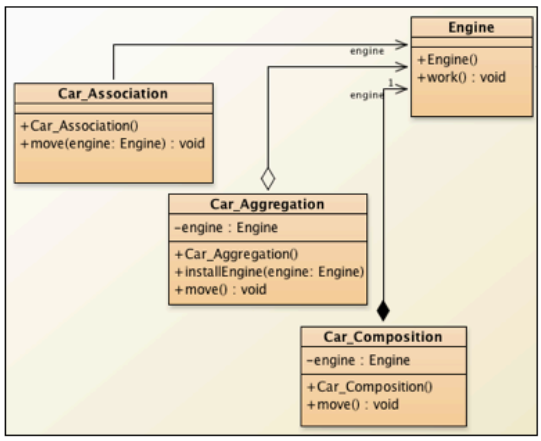


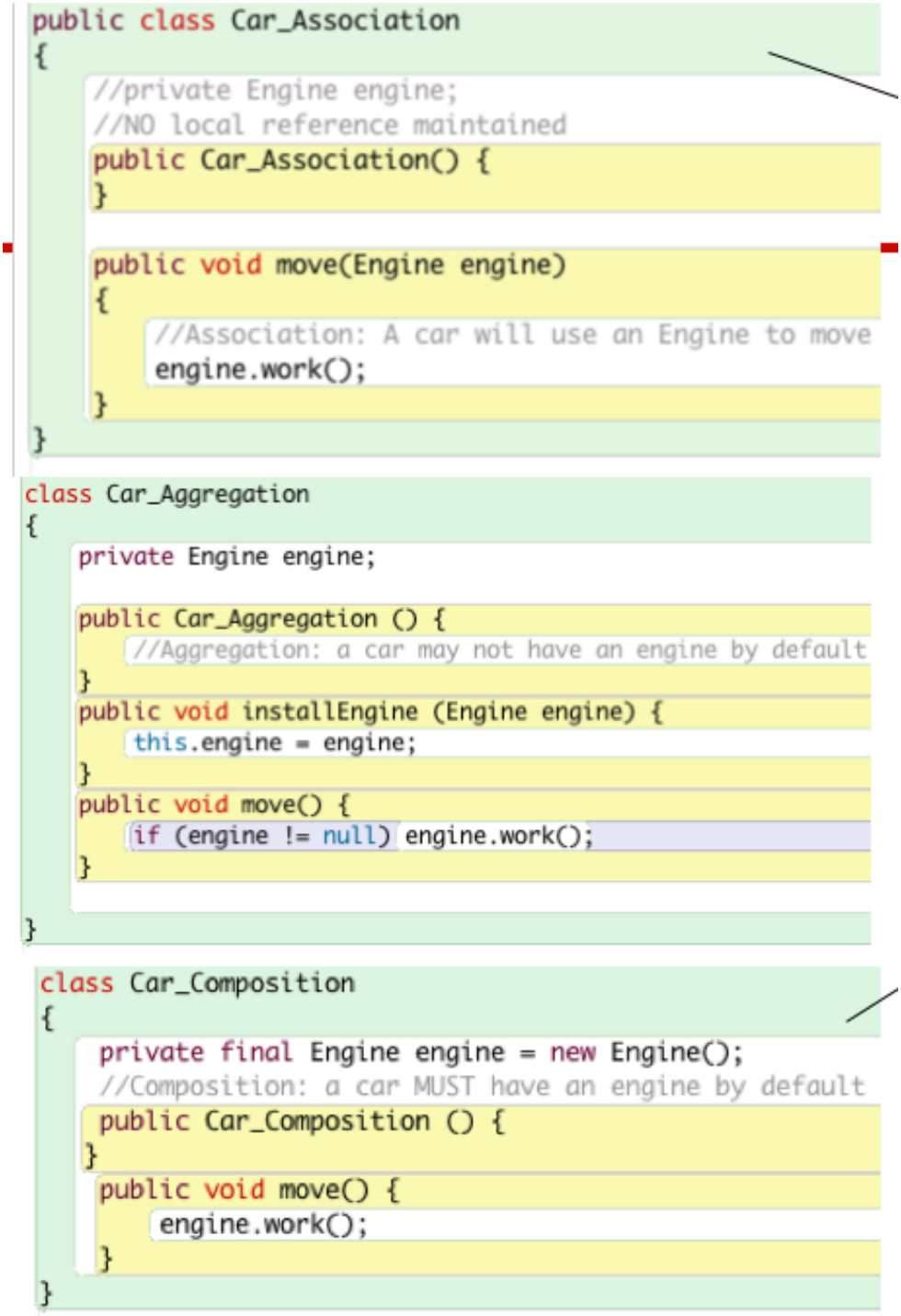




  - Composition
    - A has B(Must/compulsory, i.e. B must be included)
    - Implementation: Class_A contains a fixed local variable links to Class_B
  - Aggregation
    - A has B(B is Optional, can be included later)
    - Implementation: Class_A contains a changale local variable links to Class_B
  - Association
    - A uses B(may be as a parameter, can define B at runtime, more dynamic)
      - ***Class_A*** DO NOT contain a local variable links to ***Class_B***
      - ***Class_A*** uses ***Class_B*** as (input/output) ***Parameter*** directly.
- Example:







```
public class Car_Association
{
    //private Engine engine;
    //NO local reference maintained
    public Car_Association() {
    }

    public void move(Engine engine)
    {
        //Association: A car will use an Engine to move
        engine.work();
    }
}
```

```
class Car_Aggregation
{
    private Engine engine;

    public Car_Aggregation () {
        //Aggregation: a car may not have an engine by default
    }
    public void installEngine (Engine engine) {
        this.engine = engine;
    }
    public void move() {
        if (engine != null) engine.work();
    }

}
```

```
class Car_Composition
{
    private final Engine engine = new Engine();
    //Composition: a car MUST have an engine by default
    public Car_Composition () {
    }
    public void move() {
        engine.work();
    }
}
```

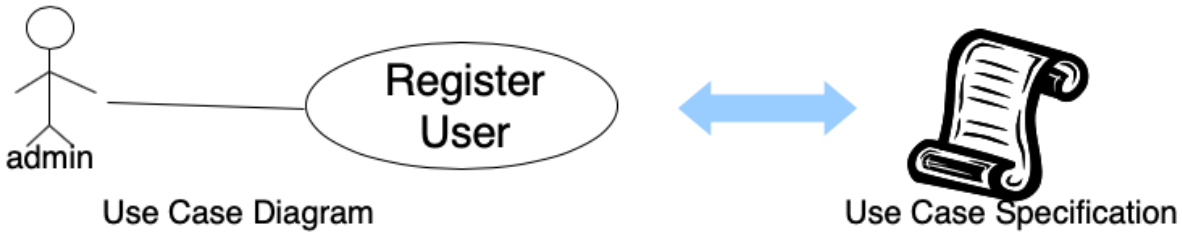
- Association & Mutiplicity

Multiplicity	Multiplicity Notation	Association with Multiplicity	Association Meaning
Exactly 1	1 or *leave blank*	Employee — works for 1 — Department Employee — works for — Department	An employee works for one and only one department.
Zero or one	0..1	Employee — has 0..1 — Spouse	An employee has either one or no spouse.
Zero or More	0..* or *	Customer — makes 0..* — Payment Customer — makes * — Payment	A customer can make no payment up to many payments.
One or more	1..*	University — offers 1..* — Course	A university offers at least 1 course up to many courses.
Specific range	7..9	Team — has scheduled 7..9 — Game	A team has either 7, 8, or 9 games scheduled

Lecture 04 Software Requirement Modeling with Use-cases

Introduction

- Use Cases: Typically, a use case is a **contract** of an interaction between the system and an actor.
  - The Actor can be a human or an external system / machine.
  - A full use-case model comprise of:
    - A Use Case Diagram, describing relations between use-cases (system tasks, roles) and actors (external parties).
    - Use Case Specifications (usually one per each use case) Documents describe the use case in details



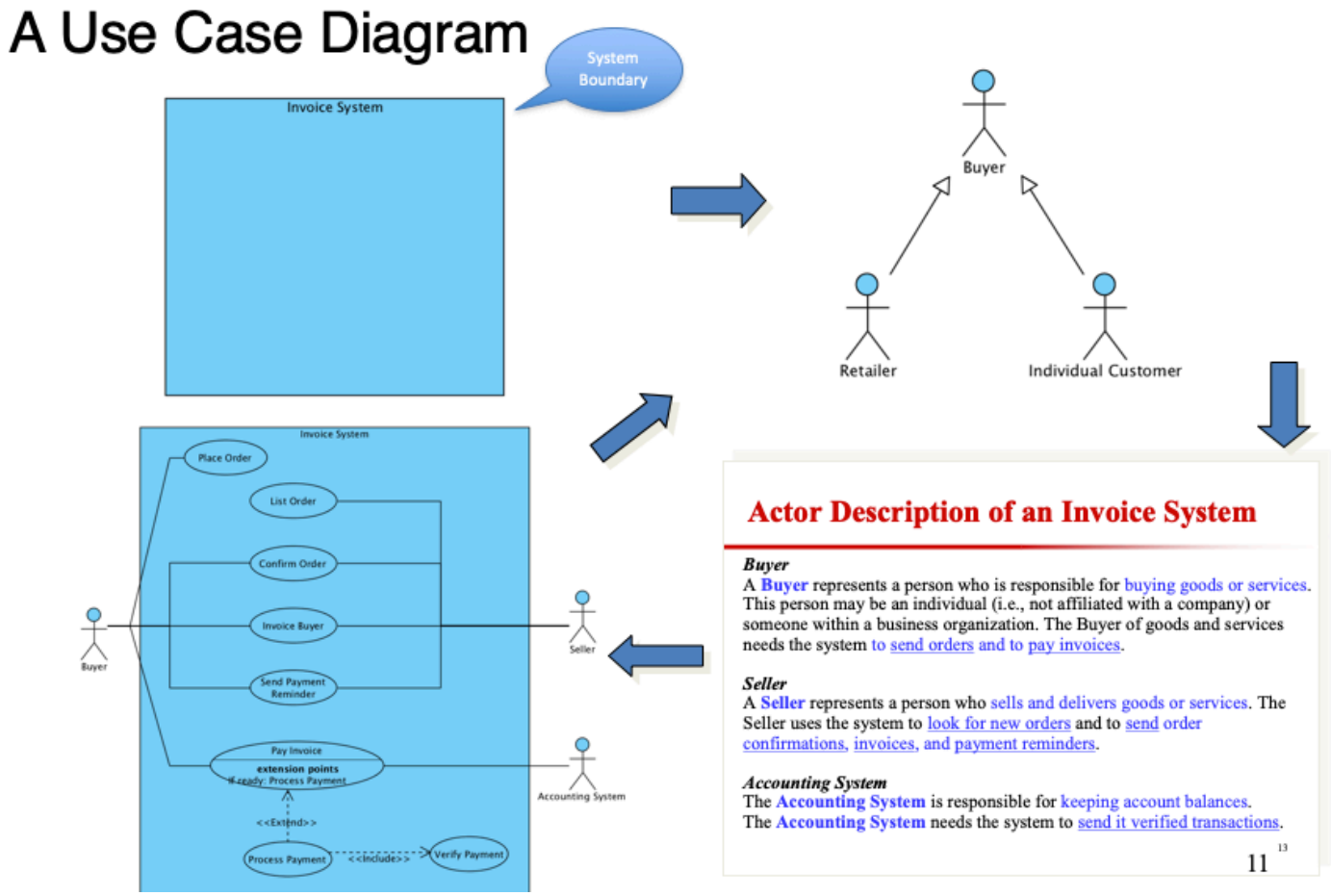
- Use cases as means of communication: simulate about what the system should do
  - mainly with people who are outside of the development team.

    The objective of *use case analysis* is to **model** the system and describe

    - how users interact with this system
    - when trying to achieve their objectives.
    - “It is one of the key activities in requirements analysis”
- Use Case Diagram Objective:
    - Create a semi-formal model of the functional requirements (what the system does..)
    - Analyze and define:
        - Scope (What are the main functions?)
        - External parties (who will interact with the system?)
        - External interfaces (how they are related?)
        - Scenarios and reactions (One Big Picture)

Use Case Diagram

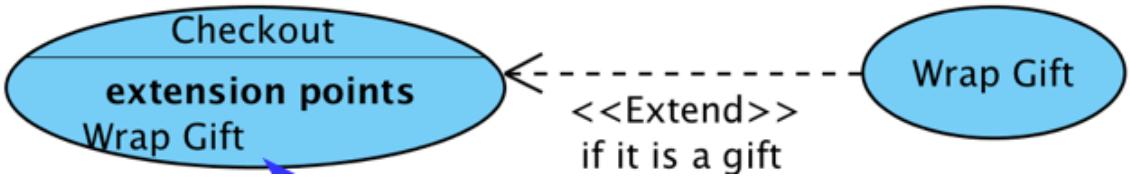
- Steps to build an Use-Case Model
    - Choose the ***system boundary*** – what are you modeling? System? Business organization?
    - Identify the ***primary actors*** – they have user goals fulfilled by using the services of the system
    - For each primary actor, ***identify their user goals*** – define what they want to do with the system. Describe their goals at the correct level
    - ***Define use cases*** that satisfy user goals. Name each according to its goal. [You may find out other actors, which we call secondary actors of ***that particular*** use case.]



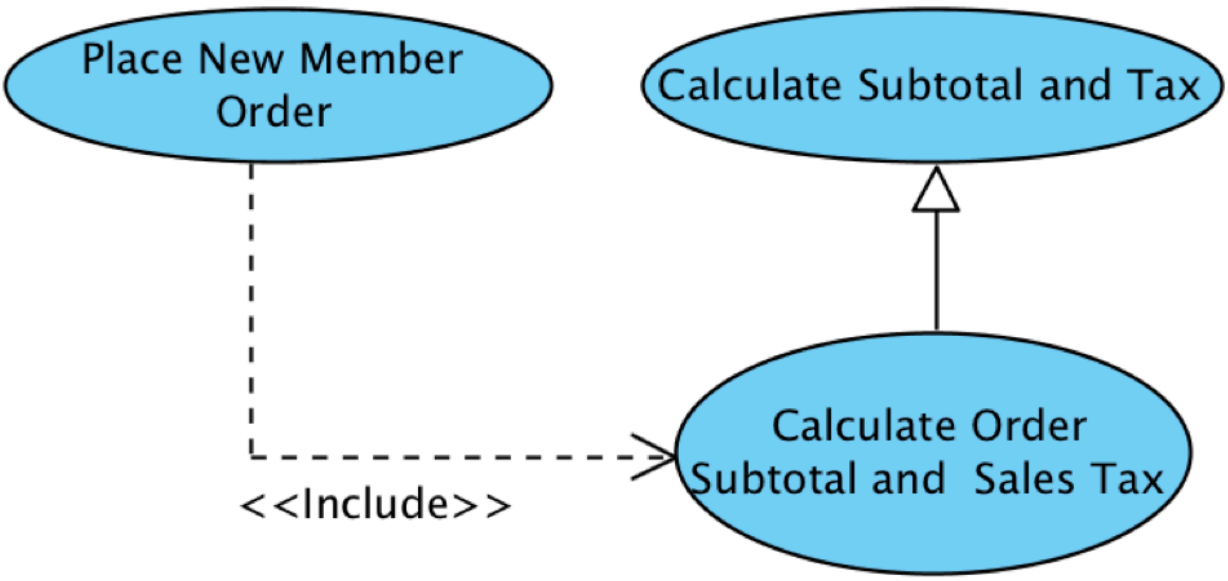
- Actors(provides input and takes output): External objects that produce/consume data:
    - must serve as sources and destinations for data

- must be **external to the system**
- **Primary actor** : interacts directly with the system
- **Secondary actor**: interacts indirectly with the system or support the use case to complete a use case for the primary actor
- Use case is User-centric

- Basic Types of Relationship in Use Case Model
  - Include(Allow one to express **commonality** between several different use cases)
    - Can be included in other use cases: very different use cases can share sequence of actions and enable you to avoid repeating details in multiple use cases
    - Shows the performing of a lower-level task with a lower-level goal
    - e.g. "place order" includes "validate user"
  - Extend - Graphical representation
    - Conditional flow (IF...THEN...)
    - show **optional** behaviour or handle **exception**



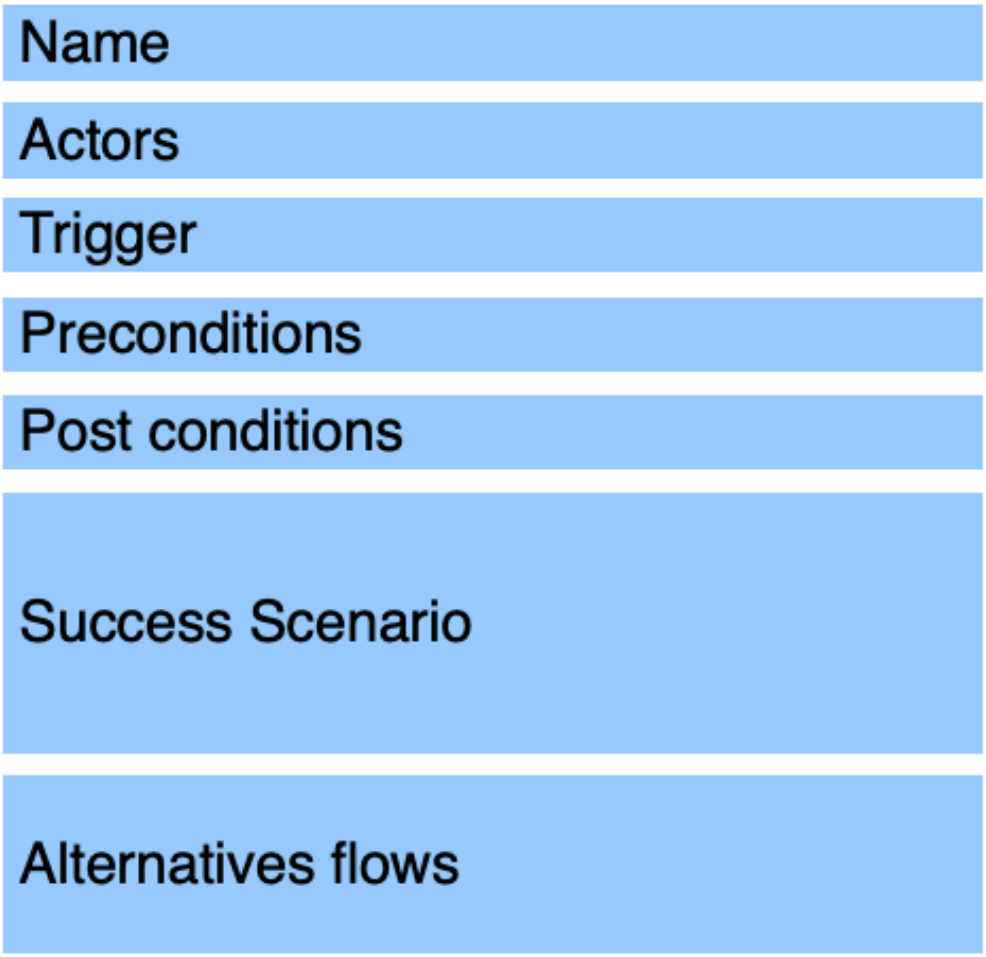
  - Association: Instances of the actor and instances of the use case communicate with each other(**Only** relationship between actors and use cases)
  - Generalization: A generalization from use case A to use case B indicates that A inherits B



  - Actors can also be generalized: Child actor inherit all use-cases associations

Writing Use Cases

- Contents in a single use case:

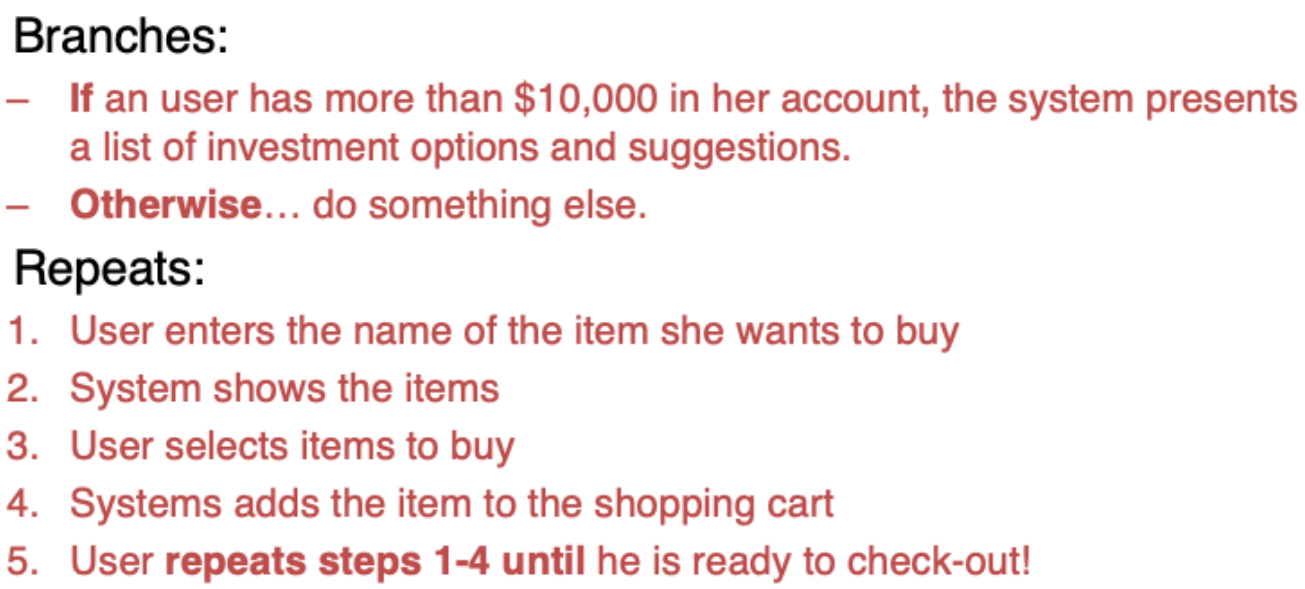


  - **Name**: Give a short, descriptive name to the use case.
  - **Purpose**: State clearly the purpose of the use case. Give a short informal description.
  - **Actors**: List the actors who can perform this use case.
  - **Pre-conditions**: Describe the state of the system before the use case.(need to be true before running)
  - **Flow of Events**
    - interactions between actors and the system
    - business logic
  - **Not allowed paths** (if any)
  - **Alternative paths** (if any)
  - **Exceptions** (if any)
  - **Post-conditions**: State of the system in following completion.(outcome condition of the use case)
  - **Extension Points**
  - **Triggers** : What starts the use-case
  - **success senario**: main story-line of the use-case
    - written under the assumption that everything is okay, no errors or problems

        - Composed of a sequence of action steps

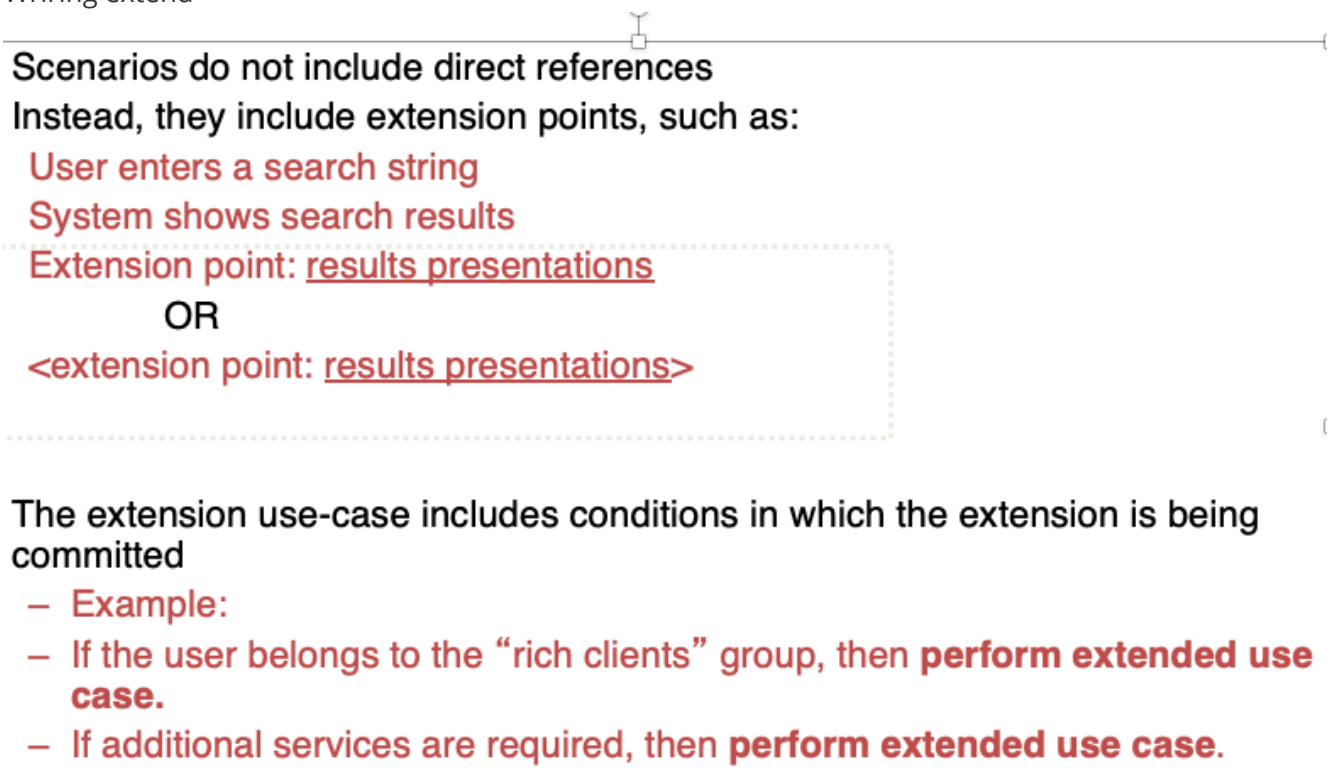
Guidelines for Effective Use Cases

- Guide lines
    - simple grammar
    - one side is doing something in a single step
    - write from an "objective" point of view
    - any step should lead to some progress



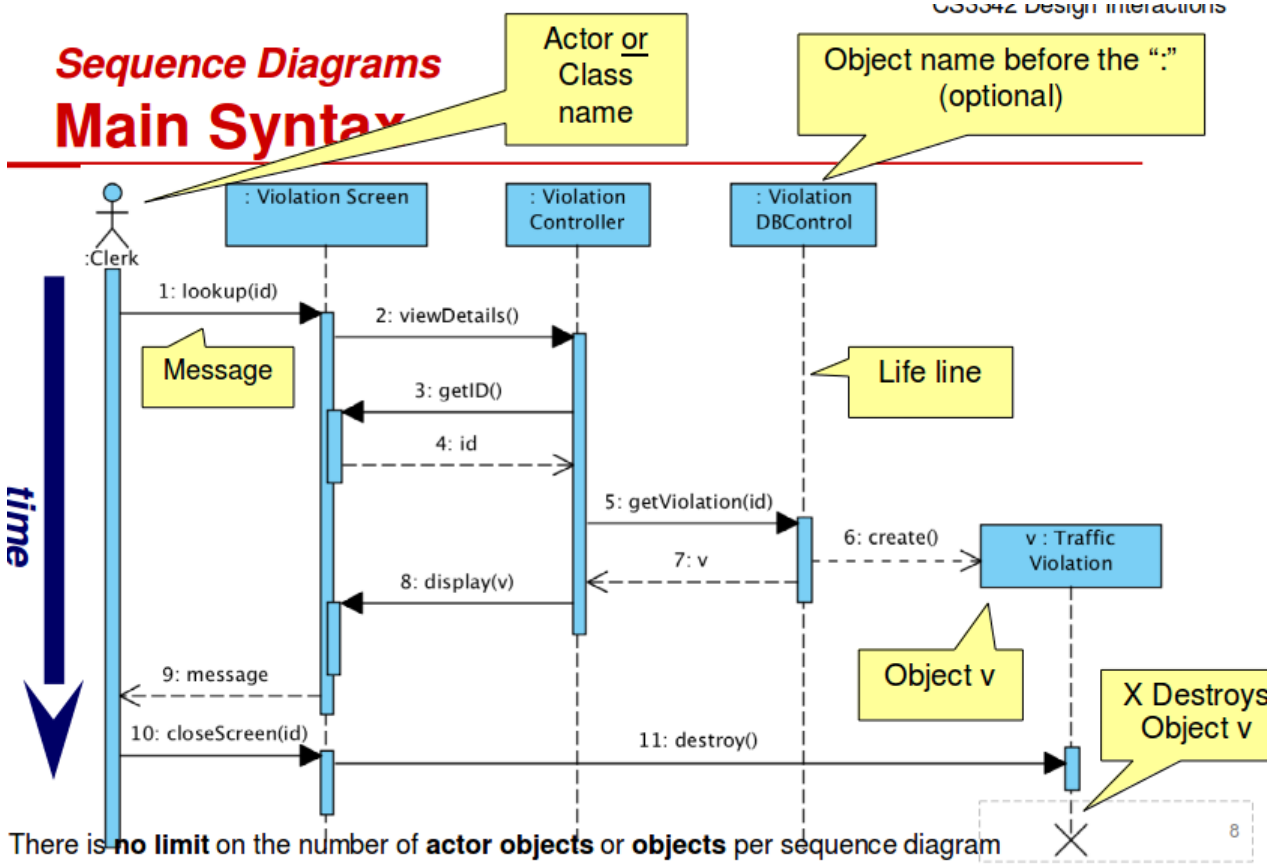
- Common Mistakes:
    - complex diagram
    - No system box
    - no actor
    - too many details(implementation, UI ...)
- Alternative Flows: used to describe exceptional functionality
    - Errors:
        - “Case did not eject properly”
        - “Any network error occurred during steps 4-7”
        - “Any type of error occurred”
    - Unusual or rare cases
        - “Credit card is defined as stolen”
        - “User selects to add a new word to the dictionary”
    - Endpoints: “The system detects no more open issues”
    - Shortcuts : “The user can leave the use-case by clicking on the “ESC” key
- Writing include: add a reference as a step
    - system shows homepage
    - User executes <include: login to the system>

- Wriring extend

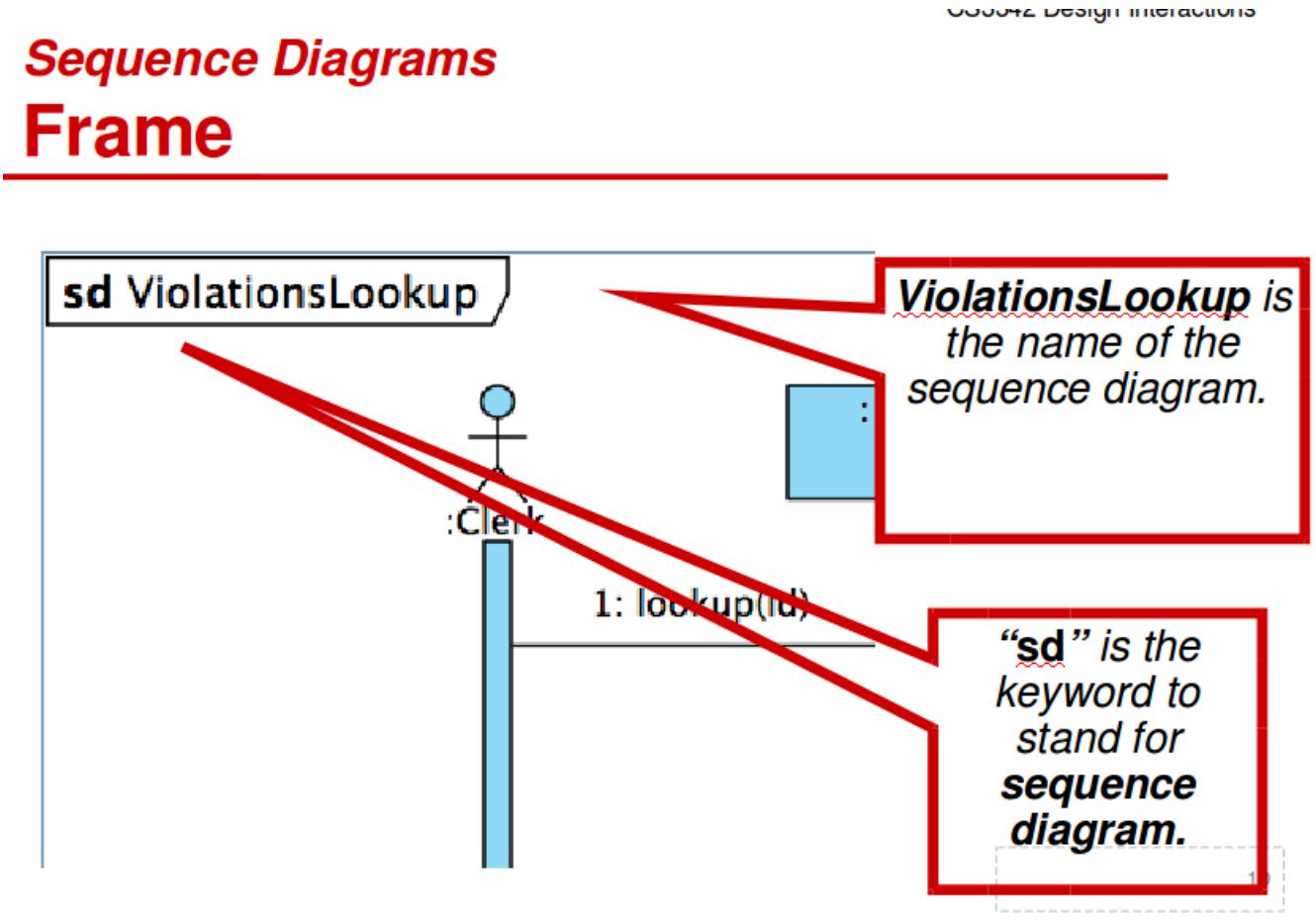


Lecture 05 Sequence Diagram

- Sequence diagram: Things between implementation and request
  - execution sequence between objects: class methods calling each others
  - when to use centralized or delegation of responsibility and express them in sequence
  - shows objects or actors(**not** classes or the system itself) as vertical dotted lines
  - events as horizontal arrows from the sender object to the receiver object



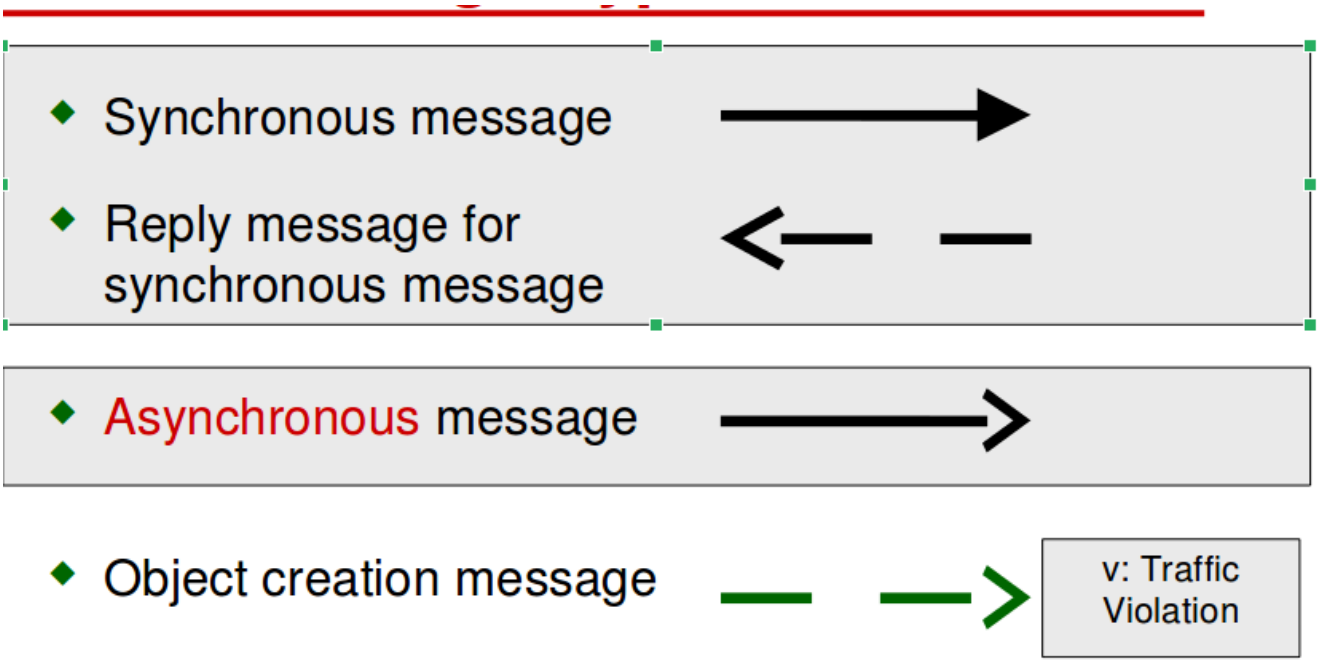
- Basic components



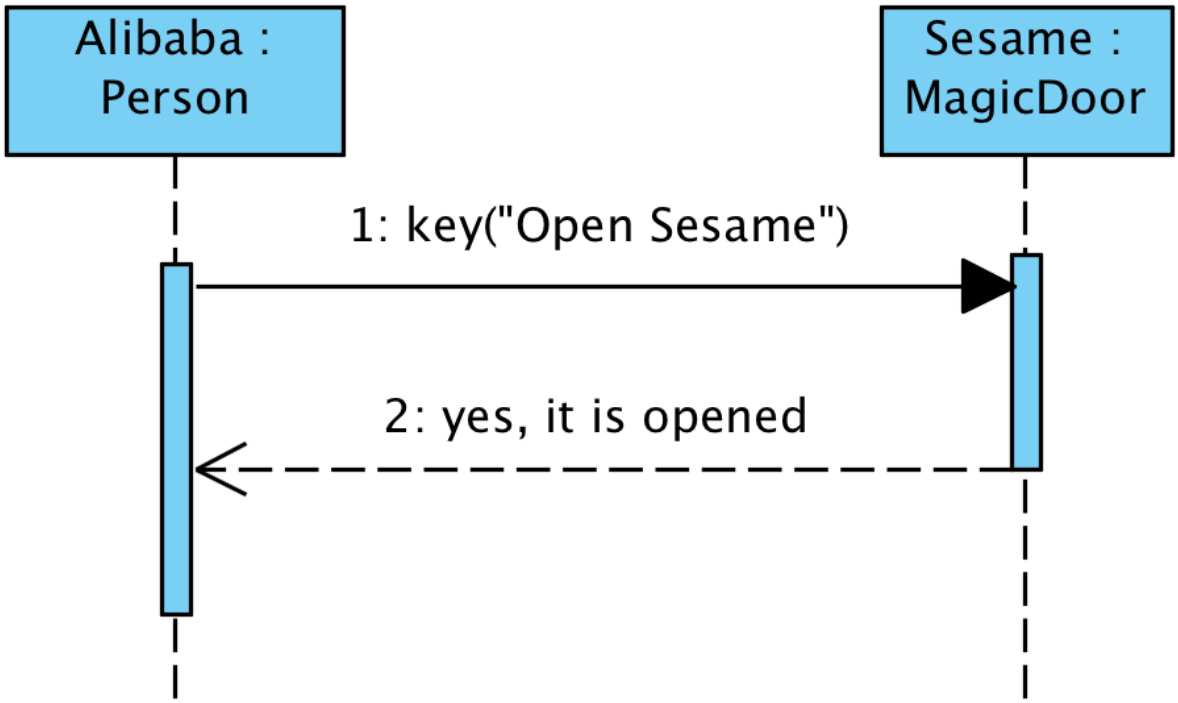
  - **Frame**: define the scope of a sequence diagram
  - **Object, message, life-line, condition,execution occurrence** are basic elements to compose a

sequence diagram

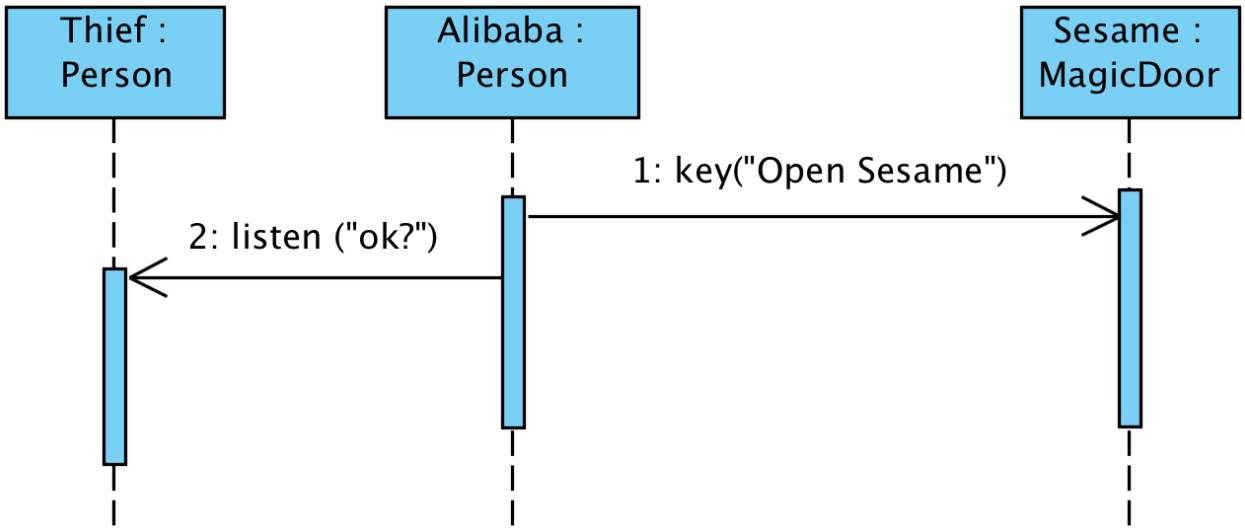
- Message:



  - Messages, written with horizontal arrows with the message name written above them, display interaction. Solid arrow heads represent synchronous calls, open arrow heads represent asynchronous messages, and dashed lines represent reply messages.[1]
  - If a caller sends a synchronous message, it must **wait until the message is done**, such as invoking a subroutine. If a caller sends an asynchronous message, it **can continue**(bg demo run 1 1) processing and doesn't have to wait for a response.
    - synchronous

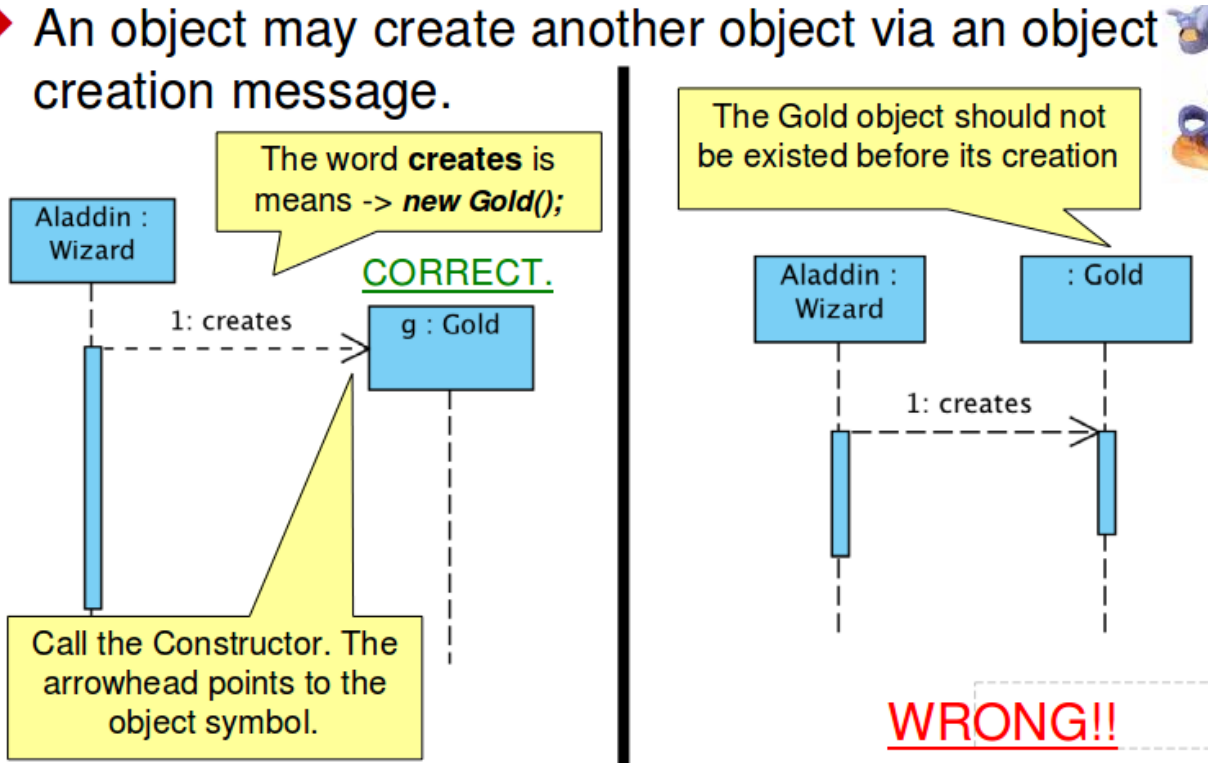


    - Asynchronous(do not pair with return)

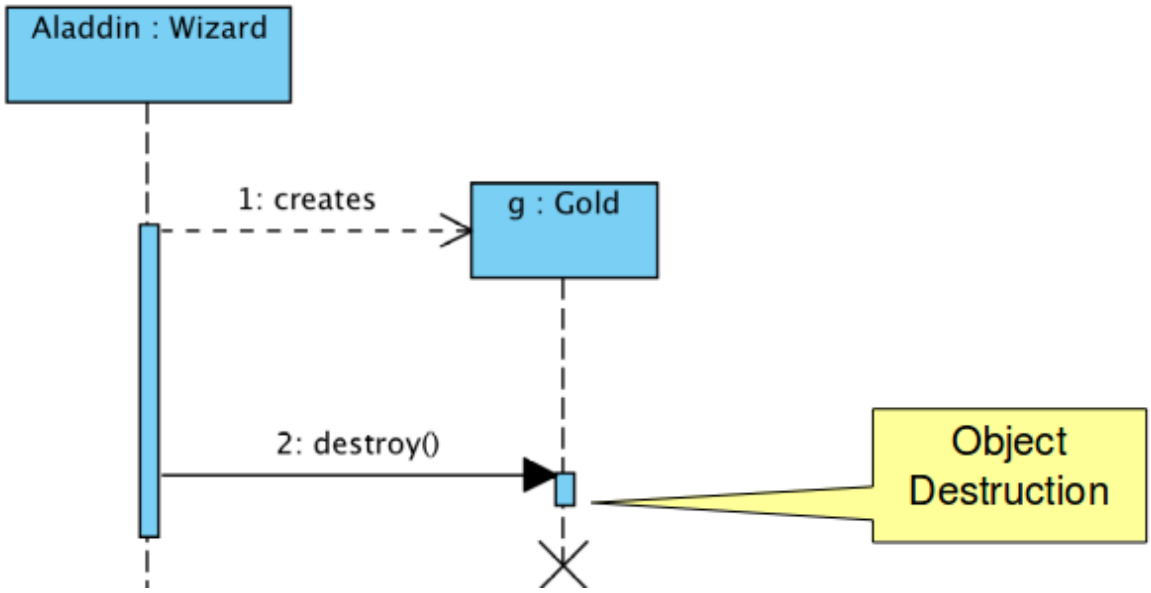


- Asynchronous calls are present in multithreaded applications, event-driven applications and in message-oriented middleware.
- Activation boxes, or method-call boxes, are opaque rectangles drawn on top of lifelines to represent that processes are being performed in response to the message (ExecutionSpecifications in UML).

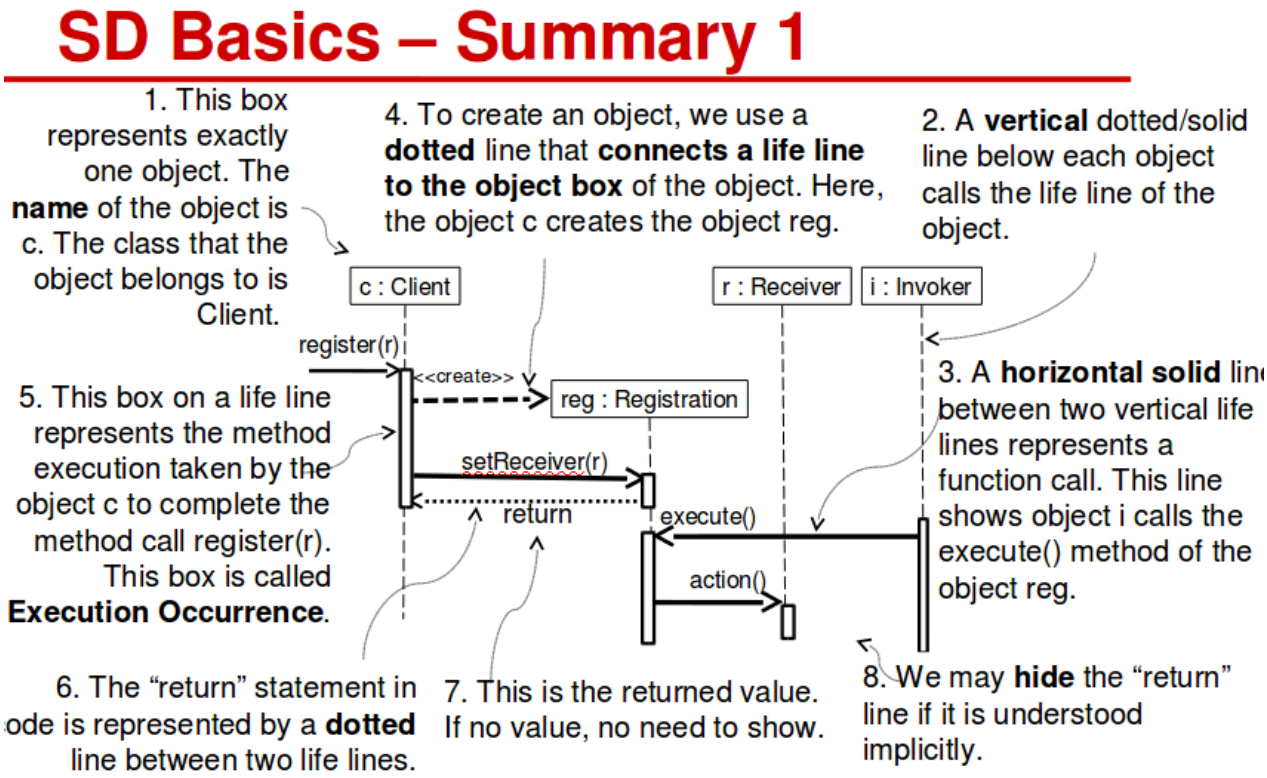
- okay without return values(optional) => reduce line in the diagram(when return val is obvious)
- Object Creation message(make the lifeline correct)



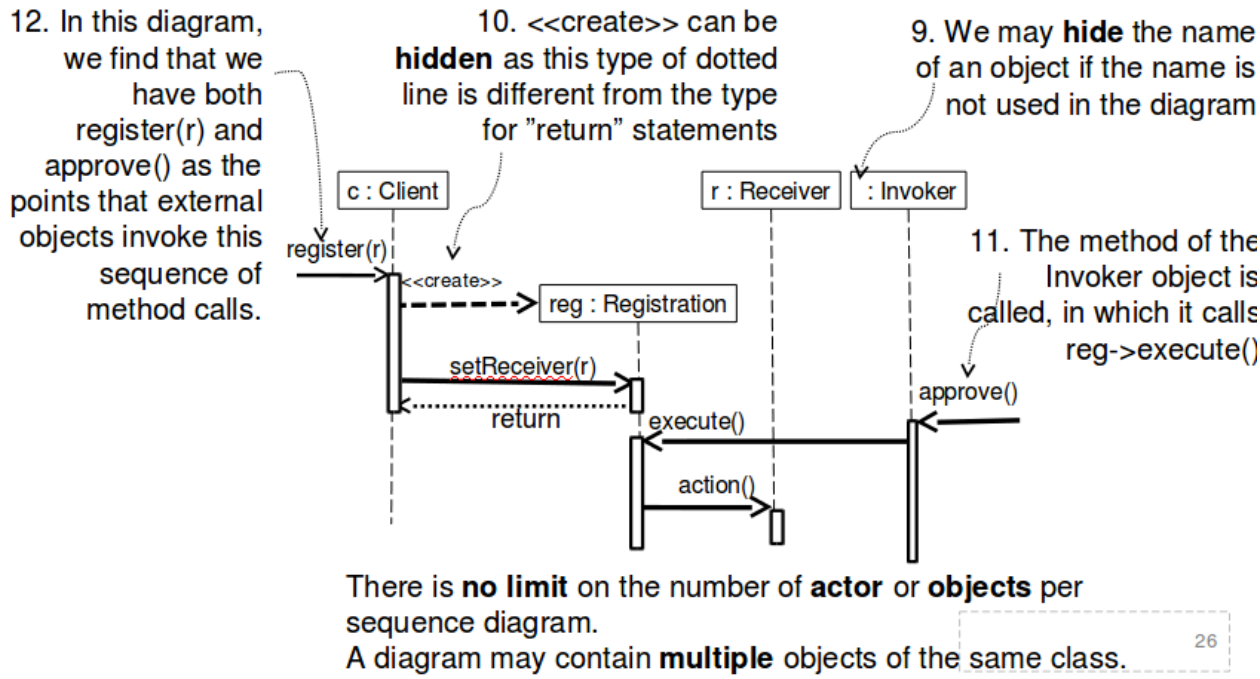
- Object Destruction
  - c++ : call destructor
  - java: garbage collection


Aladdin : Wizard
1: creates
g : Gold
2: destroy()
Object Destruction

- summary

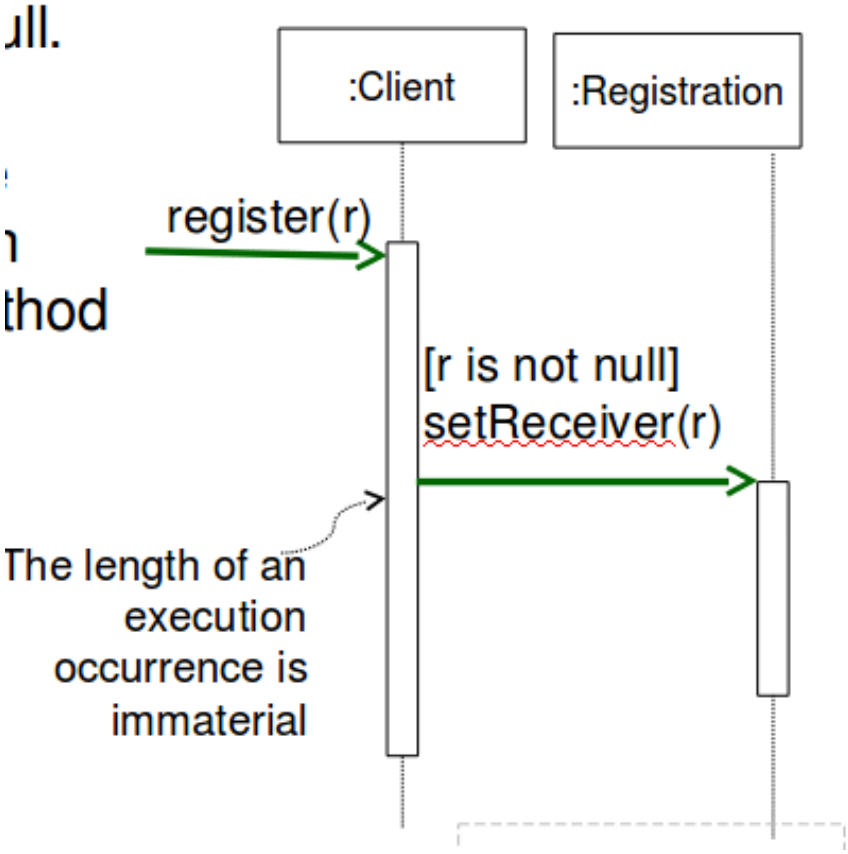

SD Basics – Summary 1
1. This box represents exactly one object. The name of the object is c. The class that the object belongs to is Client.
4. To create an object, we use a dotted line that connects a life line to the object box of the object. Here, the object c creates the object reg.
2. A vertical dotted/solid line below each object calls the life line of the object.
c : Client
r : Receiver
i : Invoker
register(r)
<<create>>
reg : Registration
3. A horizontal solid lin between two vertical life lines represents a function call. This line shows object i calls the execute() method of the object reg.
5. This box on a life line represents the method execution taken by the object c to complete the method call register(r). This box is called Execution Occurrence.
setReceiver(r)
return
execute()
action()
6. The "return" statement in ode is represented by a dotted line between two life lines.
7. This is the returned value. If no value, no need to show.
8. We may hide the "return" line if it is understood implicitly.

SD Basic – Summary 2



SD with Complexity

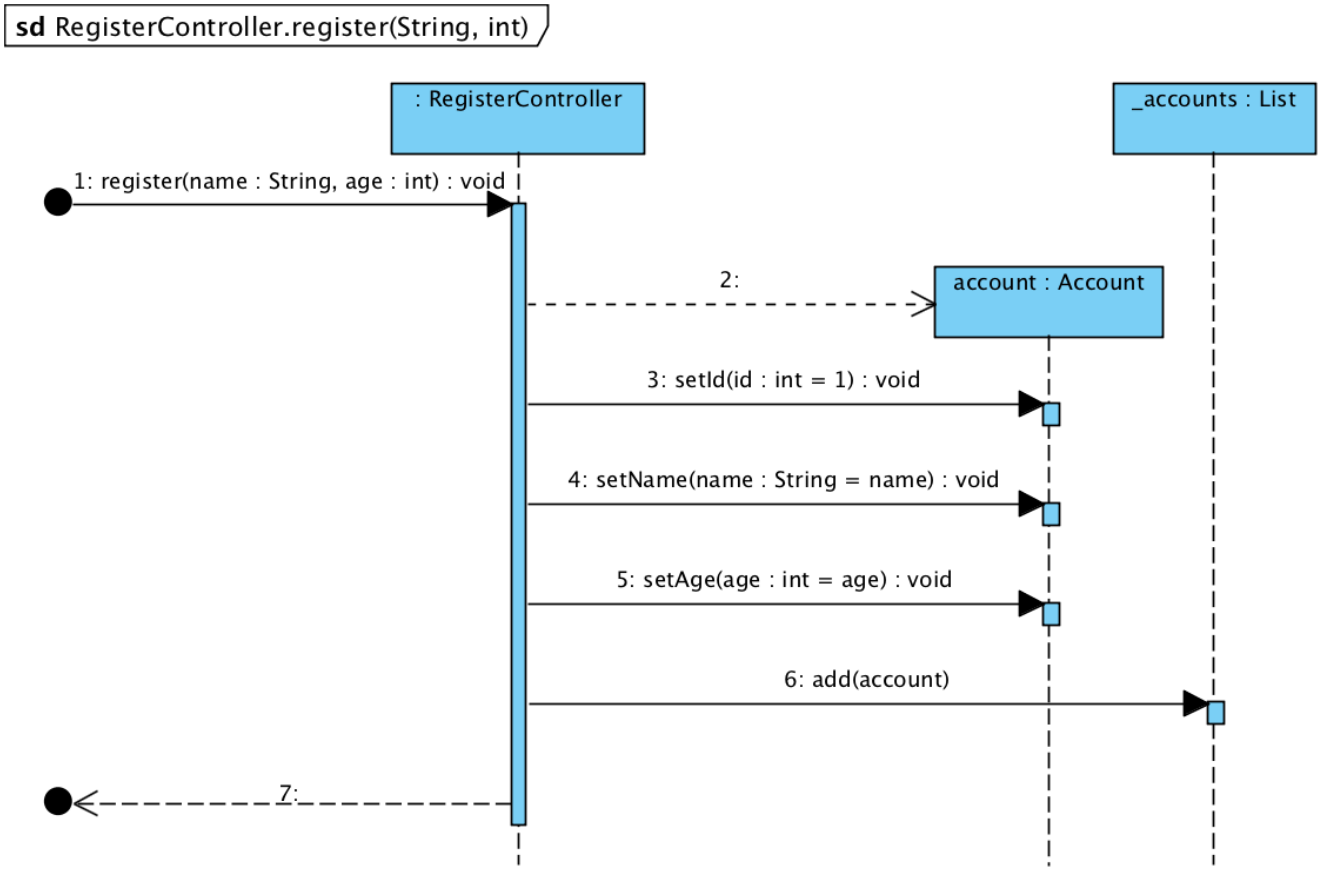
- Condition(event occurs when satisfies condition)



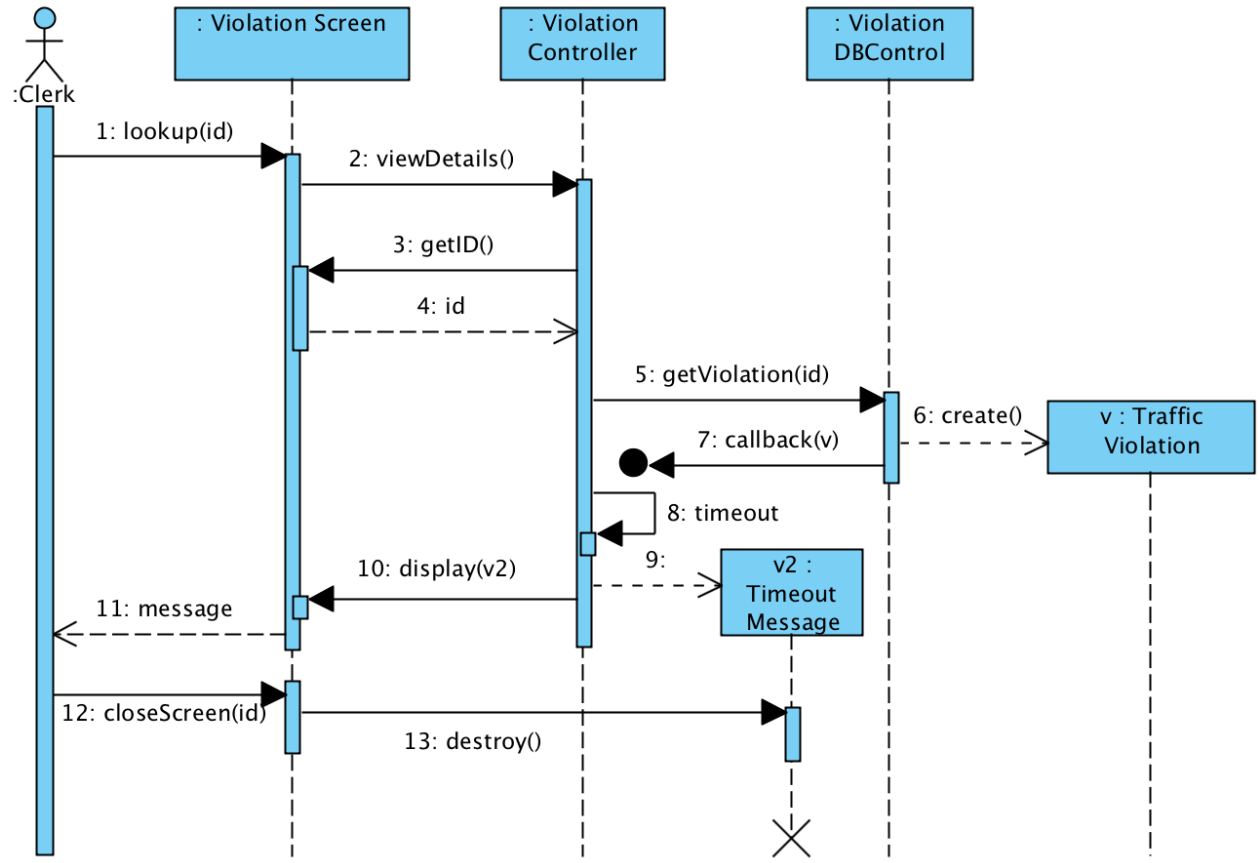
  - [condition] methodName() when initiate an event

- Lost and found

```
public void register(String name, int age){ // found
    Account acc = new Account();
    acc.setId(1);
    acc.setName(name);
    acc.setAge(age);
    _accound.add(account);  //loss
}
```

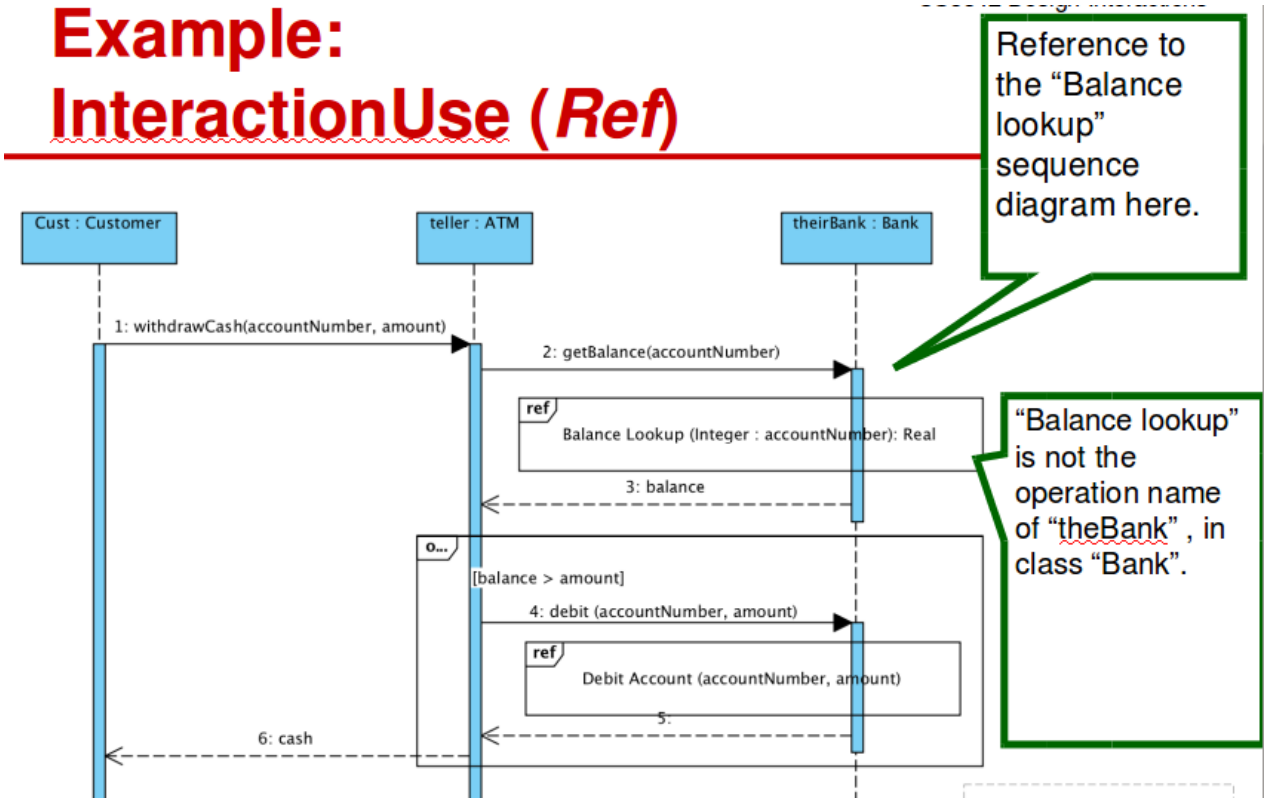


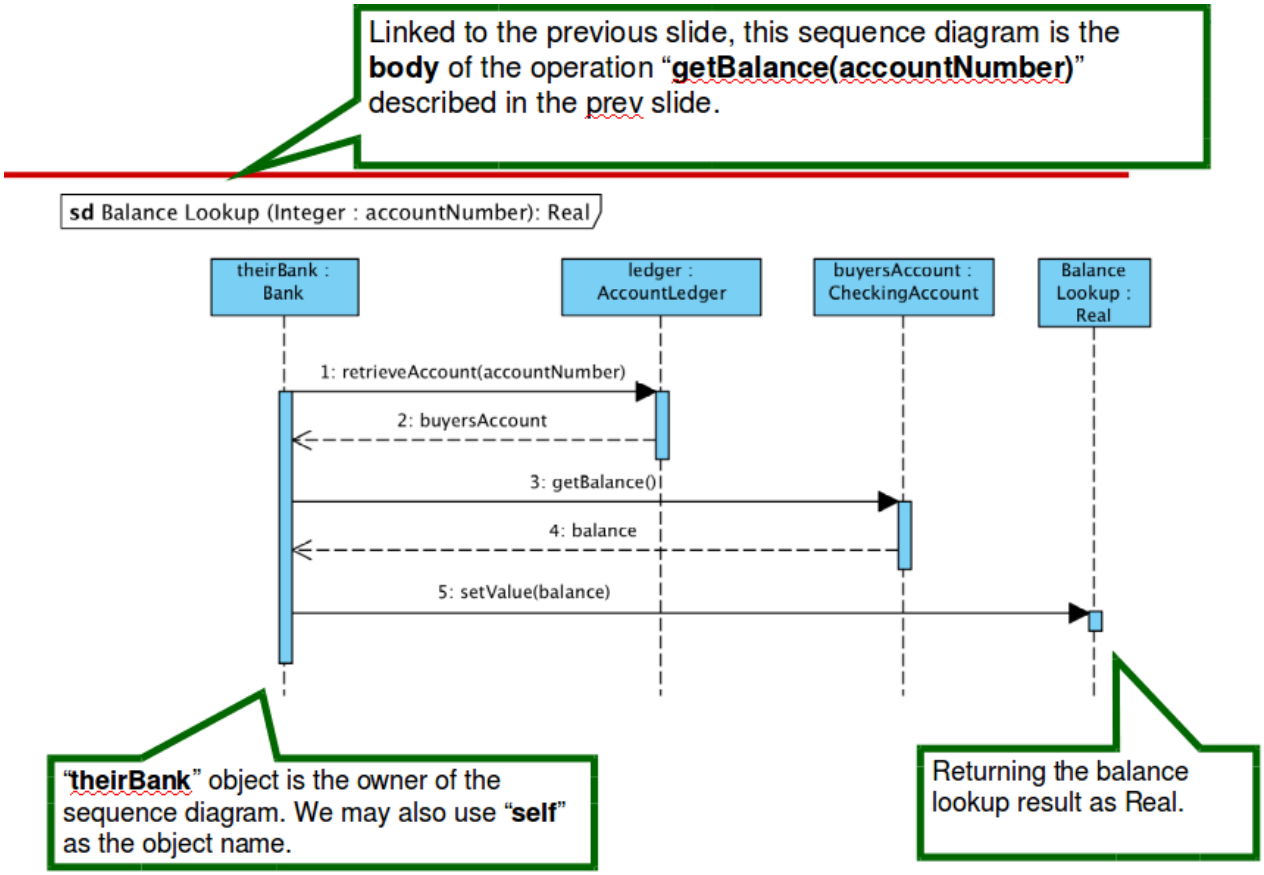
  - Lost message: are those that are either sent but not arrived, or which go to a recipient not shown on the current diagram. (connecting to other functions in another diagram)
  - Found message: are those that arrived from an unknown source, or from a sender not shown on the current diagram. (They are denoted going to or coming from an endpoint element.)
  - Enhanced Version



- No one destructs Traffic Violation obj, memory leaks

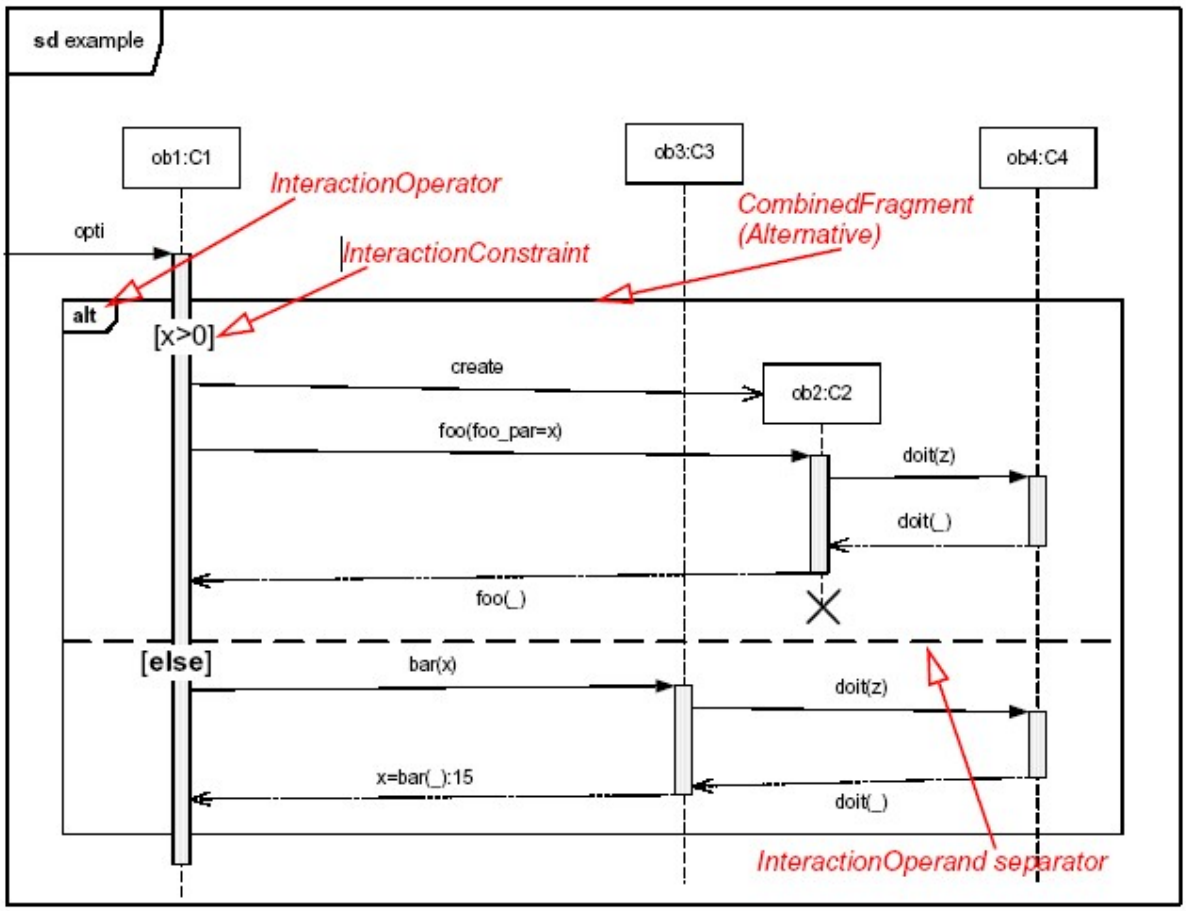
- Condition/control logics: if then else, for breaks, fragmentations
  - Reference of interactionUSe(ref): Fragment refers/points to another sequence diagram





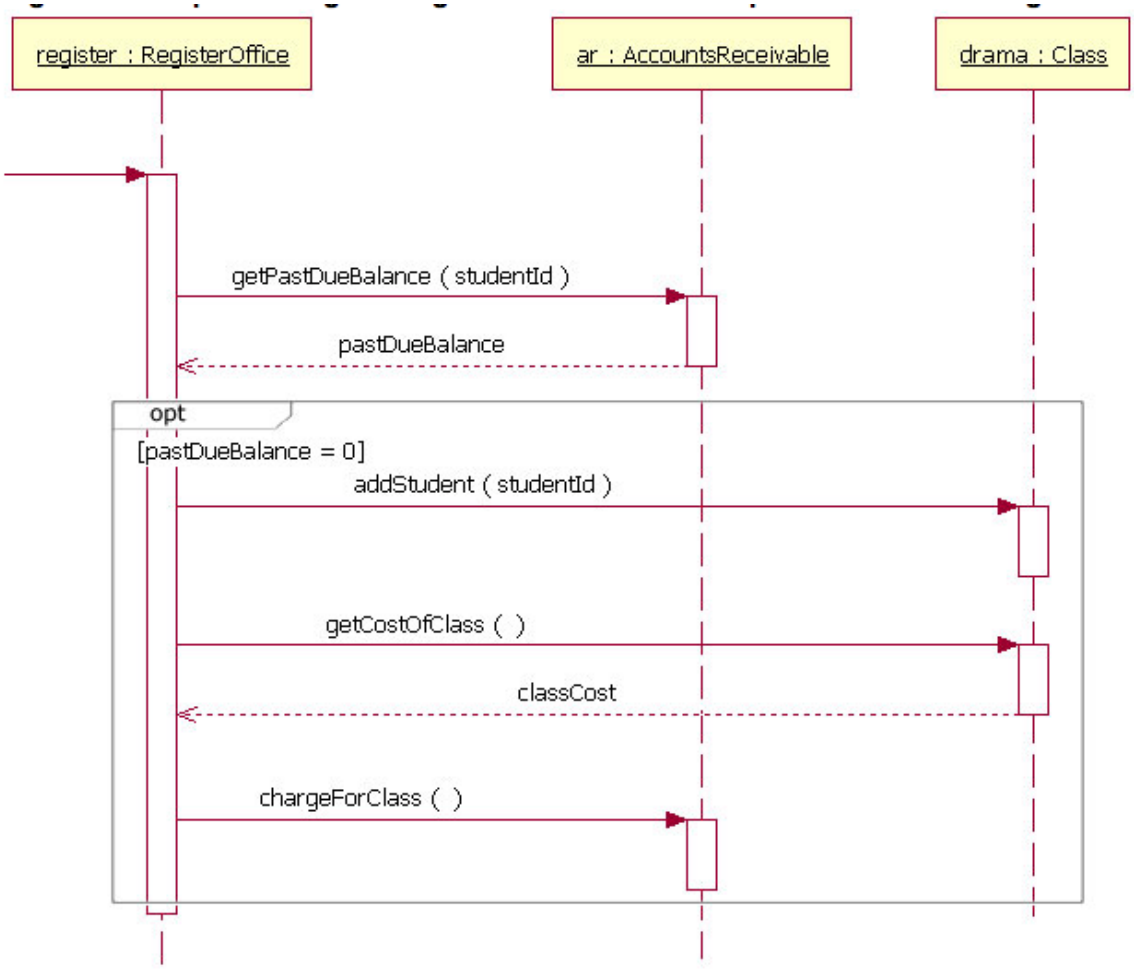
- Interaction scenario of objects
- short hand for copying the contents(inline in cpp)
  - To be accurate the copying must take into account substituting parameters with arguments and connect the formal gates with the actual ones.

- CombinedFragments: Control information of sequence diagram(modeling simple combinations)
  - alt(alternatives): similar to switch: at most one operands

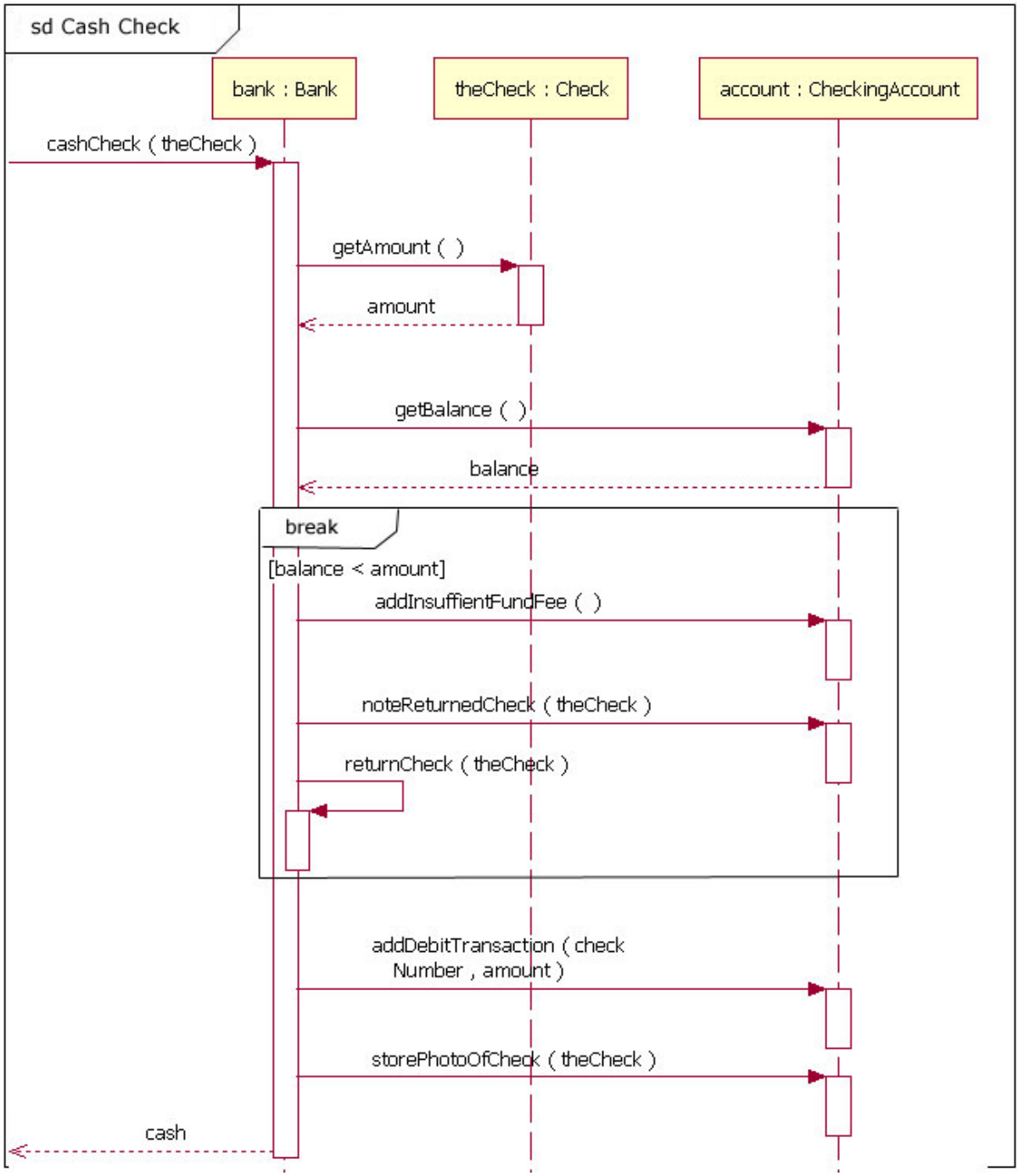


- use "else " for unnamed case

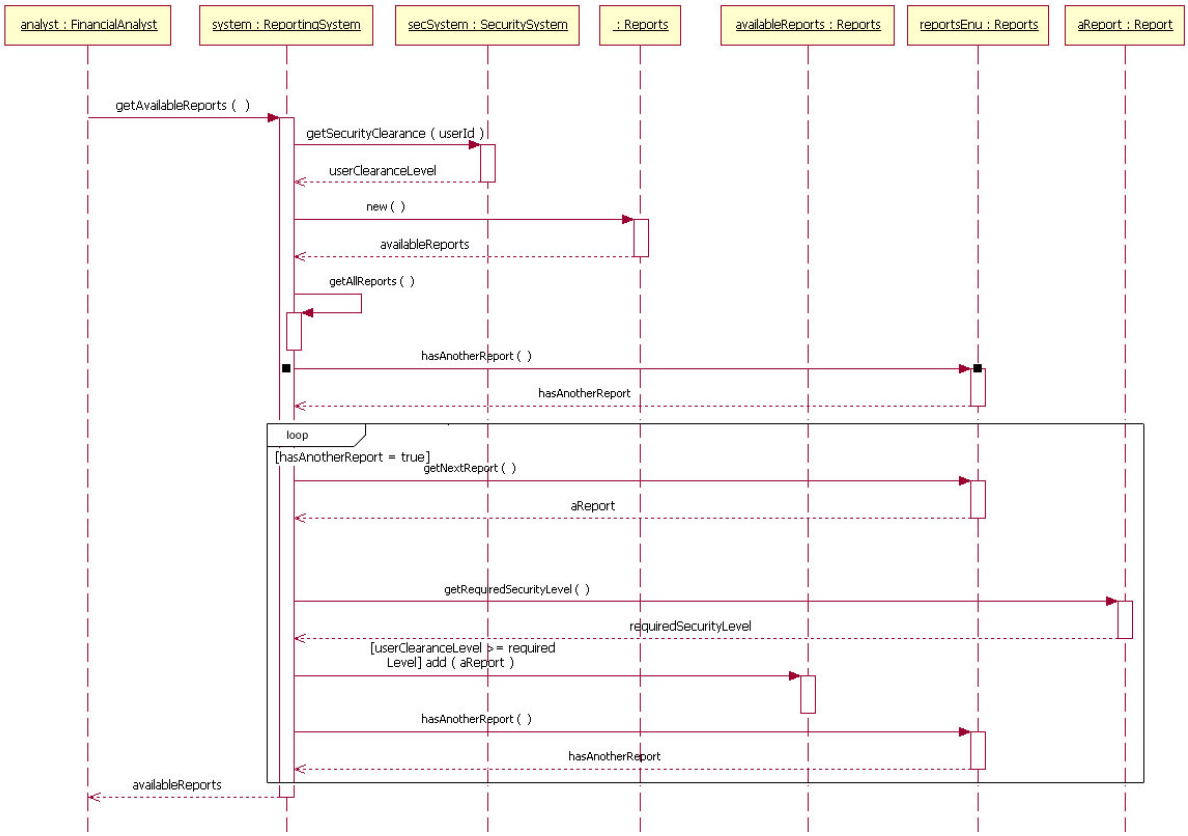
- opt(option): if satisefy run, else skip(no else)



- Break(break): similar to cpp(if satisifies break, run the code, other wise, do not run the code)

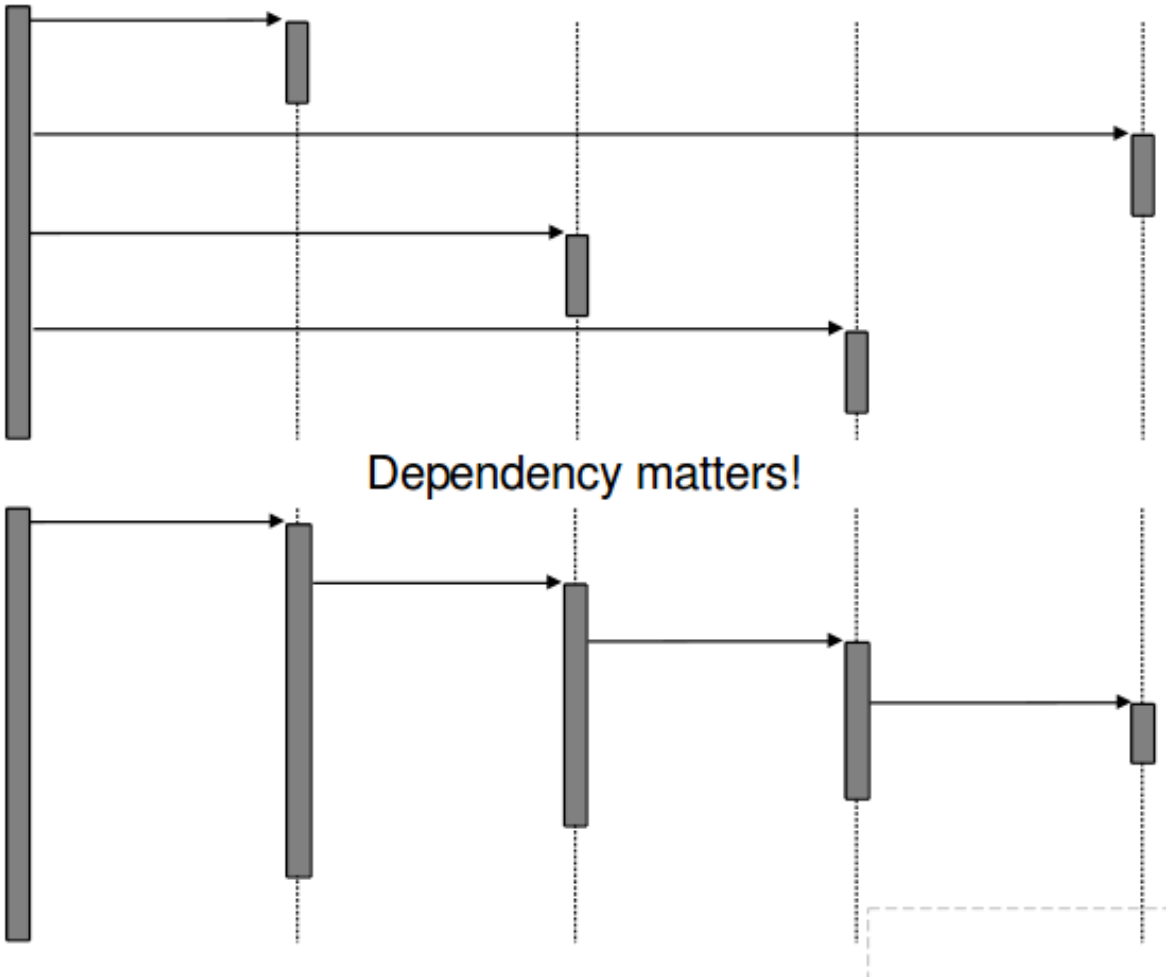


- Iteration(loop)



    - loop(min,max) // where min max define the range of iterations
    - loop(3) minimum of 3 iterations , equivalent to loop(3,*)

- Case study
    - how to determine the well structured sequence : 2 implementations:
        - Fork diagram(centralized control): Appropriate when the operations can change order or new operations could be inserted
        - Stair Diagram(decentralized control): Appropriate when the operations have a **strong connection** and will **always** be performed in the **same order**



- A **strong connection** exists among the operations if the objects:
  - form a "consists-of" hierarchy(country-state-city)
  - Information hierarchy(document-chapter-section)
  - represent a fixed procedural sequence such as advertisement-order-invoice-delivery-payment
  - form a (conceptual) inheritance hierarchy(animal-mammal-cat)
- Reverse Engineering SD

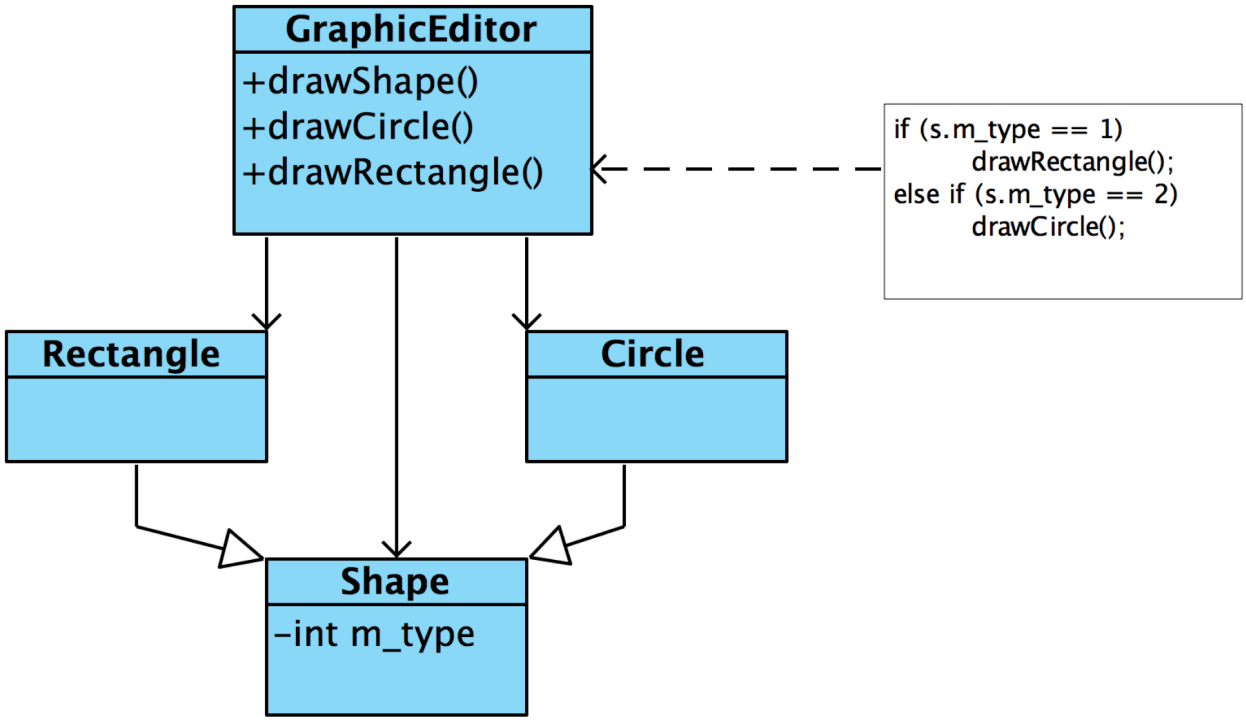
Lecture 06 Software Design Principles

- Reason of writing code that functions well:
  - Development(add new functionality) <=> Maintenance(Fix bug, improve the algorithm , porting a program from one platform to another(iOS->android)
  - Programs are so large that, if functionalities in a real-life program is not well-designed, a small change in a program is extremely painful!

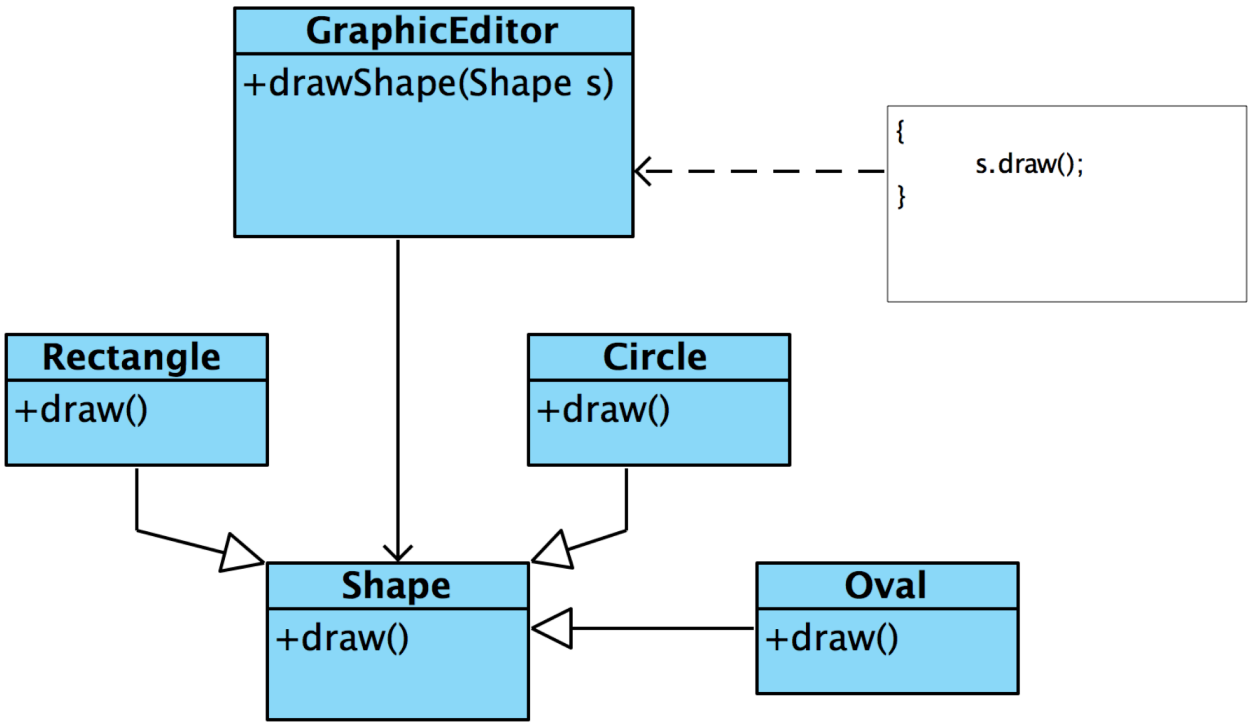
Reveiw Basic OO concepts

Learn OO Design Principles

- Class Design Principles
  - Open-Closed Principle (OCP)
  - Liskov Substitution Principle (LSP)
  - Dependency Inversion Principle (DIP)
  - Single Responsibility Principle (SRP)
  - Interface Segregation Principle (ISP)
  - Law of Demeter Principle (LoD)
  - or SOLID
- OCP(open-closed principle)
  - open for extension closed for modification(core should not be changed, important attrs shouldn't be directly accessible)
  - ***Modules should be written so they can be extended without requiring them to be modified***
  - Bad design



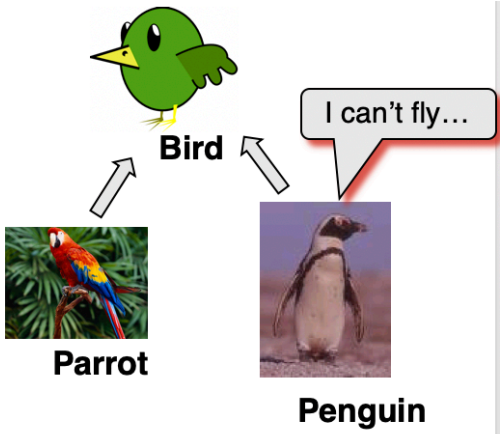
  - Improved



- **Get rid of IF…THEN…ELSE**
- **make all obj-data, variables with in an obj private**
  - **Maintaining** public variable/data is always risky, because it may “open” the module for other objects to perform some harmful tasks.
  - They may produce a **rippling effect** requiring maintenance at many unexpected locations, due to code dependencies.
  - Errors are difficult to be located and fixed. : Fixes may cause undesirable errors elsewhere because of such data dependencies.
- Implementation:
  - class abstraction(java interface, abstract class,virtual class in cpp)
  - Polyorphism

- Liskov Substitution Principle
  - Key word: Substitutability / Replaceable
  - Definition/Measure of subtyping relation
  - Strong behavioural subtyping
  - An extension of OCP
    - Ensure that new derived subclasses only extending the **base-class**
    - **without changing their behaviour**
  - **Derived subclasses must be completely substitutable for their parent class**(can be changed to other set of implementations)

```java
class Penguin extends Bird
{
    public void fly()
    {
        // override and print
        System.out.println ("Penguins don't fly");
    }
}
class PlayPet
{
    PlayPet()
    {
        Bird mypet;
        mypet = new Parrot();
        mypet.fly ();  // my pet "is-a" bird, so can fly()

        mypet = new Penguin();
        mypet.fly ();  // BAD if it is a genguin!
    }

    public void PlayWithBird (Bird bird)
    {
        bird.fly(); // OK if it is a parrot
        // BAD if it is a genguin!
    }
}
```



- Should never model no-op operations:
  - "*Penguins don't fly*"
- Think about **Substitutability (LSP)** in our class design carefully.

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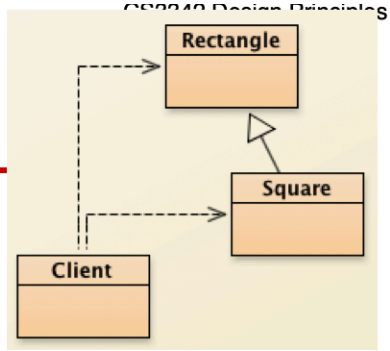
- **Understand class relationships before you design**
  - Don't guess, have a deeper understanding.
  - Lack of understanding before designing the inheritance hierarchy is likely to beach LSP, which is undesirable.
  - Make sure subclasses can be used to "replace" their parent class.
  - Subclass could have additional features.
  - Subclass **should not inherit features don't exist in the actual context**! (see last example, penguin don't fly.).
- e.g.: Rectangle / Square

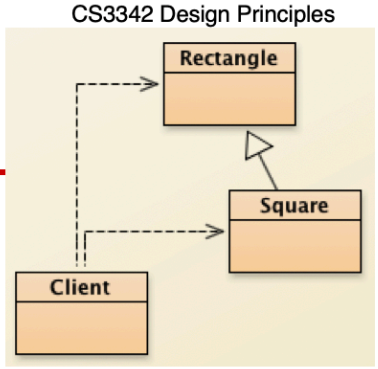
Rectangle / Square



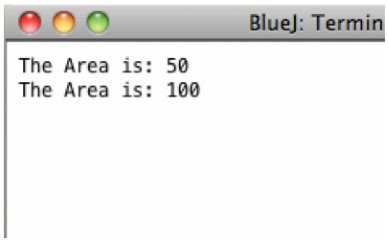

```java
public class Rectangle
{
    protected int width;
    protected int height;

    public Rectangle(){
        width = 0;
        height = 0;
    }

    public void setWidth (int w){
        width = w;
    }
    public void setHeight (int h){
        height = h;
    }
    public int getWidth ()  { return width; }
    public int getHeight () { return height; }
    public int getArea () {
        return width * height;
    }
}
```

```java
public class Square extends Rectangle
{
    public Square()
    {

    }

    public void setWidth (int w)
    {
        width = w;
        height = w;
    }
    public void setHeight (int h)
    {
        width = h;
        height = h;
    }
}
```

Rectangle / Square




```
public class Client
{
    private Rectangle r;

    public Client()
    {
        //Test #1
        r = new Rectangle ();
        CalculateArea (r);
        // This will correctly display Area is 50;

        r = new Square ();
        CalculateArea (r);
        // This will wrongly Area is 100 for a square sized 5;
    }

    public void CalculateArea (Rectangle r)
    {
        r.setWidth (5);
        r.setHeight (10);
        System.out.println ("The Area is: "+ r.getArea());

    }
}
```

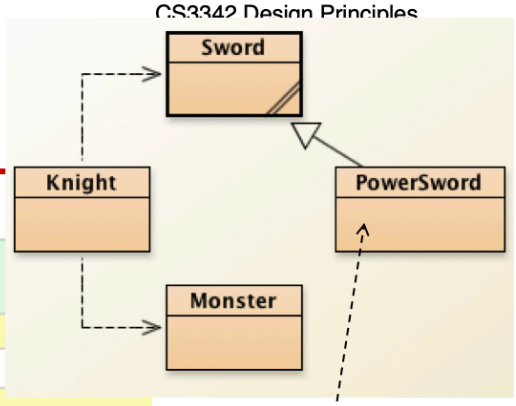


    - different output because of the bad inherance
- Dependency Inversion Principle(DIP)
    - A specific form of decoupling software modules
    - direction of dependency matters
    - *High-level modules* ***should not*** depend on **Low**-level modules.: Both should depend on abstractions.
    - Abstractions should not depend on details.: Details should depend on abstractions.

- e.g. powersword:

CS3342 Design Principles

Violating DIP



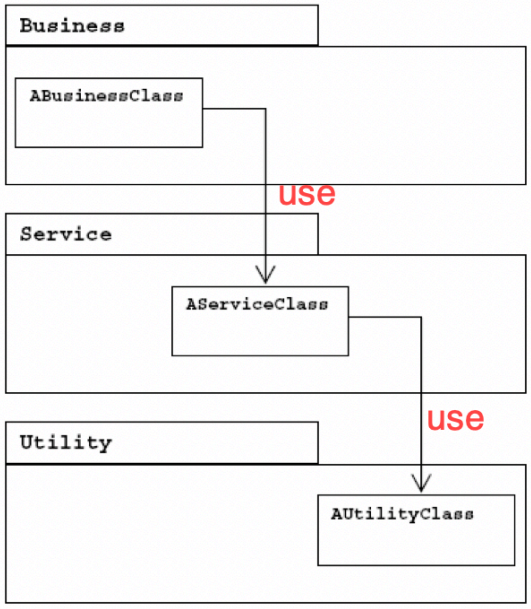

```
public class Knight
{
    public Knight()  { } // Constructor

    public void Kill (Monster m, Sword s)
    {  //A Knight kills Monster (m) with a Sword (s)

        if (s.getClass().getName() == "PowerSword") {
            PowerSword ps = (PowerSword) s;
            ps.firePowerCombo(m);
        }
        else
            s.attack(m);
    }
}
```

Indicates the presence of a particular subclass, and its method name, bad idea!

- highlevel knight should not depend on the low level existence of power sword => should depends on dinamic-binding
- high level class should provide interface for low level to implement

CS3342 Design Principles

DIP Violation

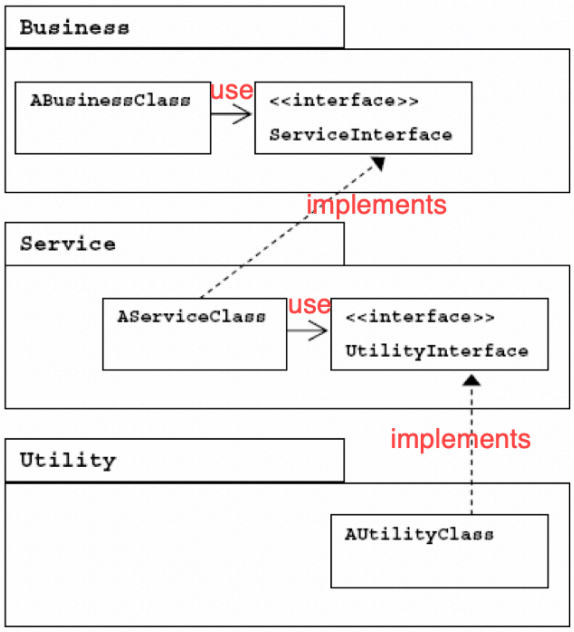


- **All classes** in the diagram on the left are **concrete classes**.
- *ABussinessClass* in the business (top) layer depends on *AServiceClass* in the service (middle) layer. Similarly, *AServiceClass* depends on a *AUtilitvClass* in the utility (bottom) layer,
  - e.g., the code of *ABussinessClass* calls a method of *AServiceClass*, and
- Thus, the above business class depends transitively on the classes at the bottom layer.
- This is ***poor*** in design because changes in low level modules may lead to changes in high-level modules.
- Also, high-level modules will be more difficult to reuse in other contexts

AServiceClass implements ServiceInterface { …}

AUtilityClass implements AServiceClass { …}

Compliance to DIP



- We can ***invert*** the dependencies by using interfaces declared in the upper layer.
- Now, the *Business* layer no longer depends on any concrete class in the *Service layer*
- The entire Business layer can be reused.
- Thus, Dependency Inversion

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Learn General Software Coding Best Practices

Lecture 05 Software Design Principles Part II

Single Responsibility Principle

Week 9

- Software Design Pattern:
  - A “General” and **“Reusable”** solution to a commonly occurring software design problem.
  - A design **“Template”** can be used in many situations.
  - **Best practices** collected from professional programmers.
- Observer Pattern (For broadcasting messages to subscribers)
  - Needs to “Notify/update ALL its dependents”
    - Defines one-to-many dependency amongst objects so that when one object changes its state, all its dependents are notified.
    - Broadcasting
  - Needs to **separate presentation layer with the data layer**, i.e. separate views and data.
    - Change in one view automatically reflects in other views. Any changes in the application data will be reflected in all views.
-