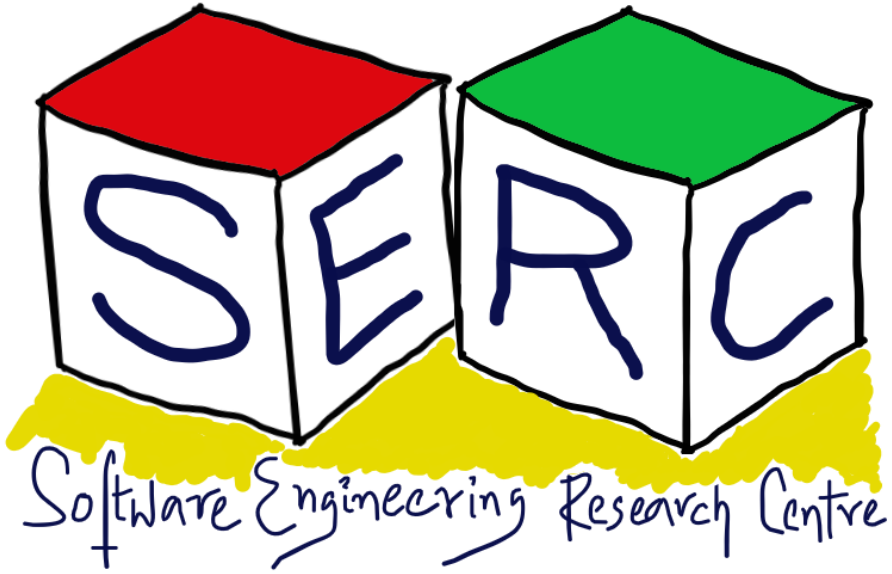
Software Modeling: An Overview

CS6.401 Software Engineering



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Acknowledgements

The materials used in this presentation have been gathered/adapted/generate from various sources as well as based on my own experiences and knowledge

-- Karthik Vaidhyanathan

Sources:

1. Introduction to MDE, Ludovico Iovino, GSSI, Italy
2. UML@Classroom, An Introduction to Object-Oriented Modeling by Martina Seidl, Marion Scholz, Christian Huemer and Gerti Kappel
3. UML Modelling lecture, Dr. Raghu, IIIT Hyderabad

Source: Googe images

Modeling Languages

Modeling Languages

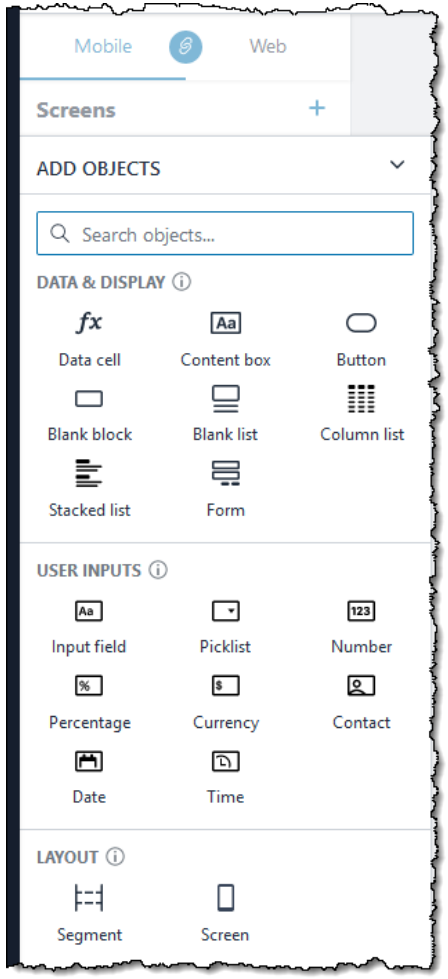
Largely classified into two types

- Domain-Specific Languages (DSLs)
  - Languages designed to model a certain domain
  - Examples: HTML, SQL, etc.

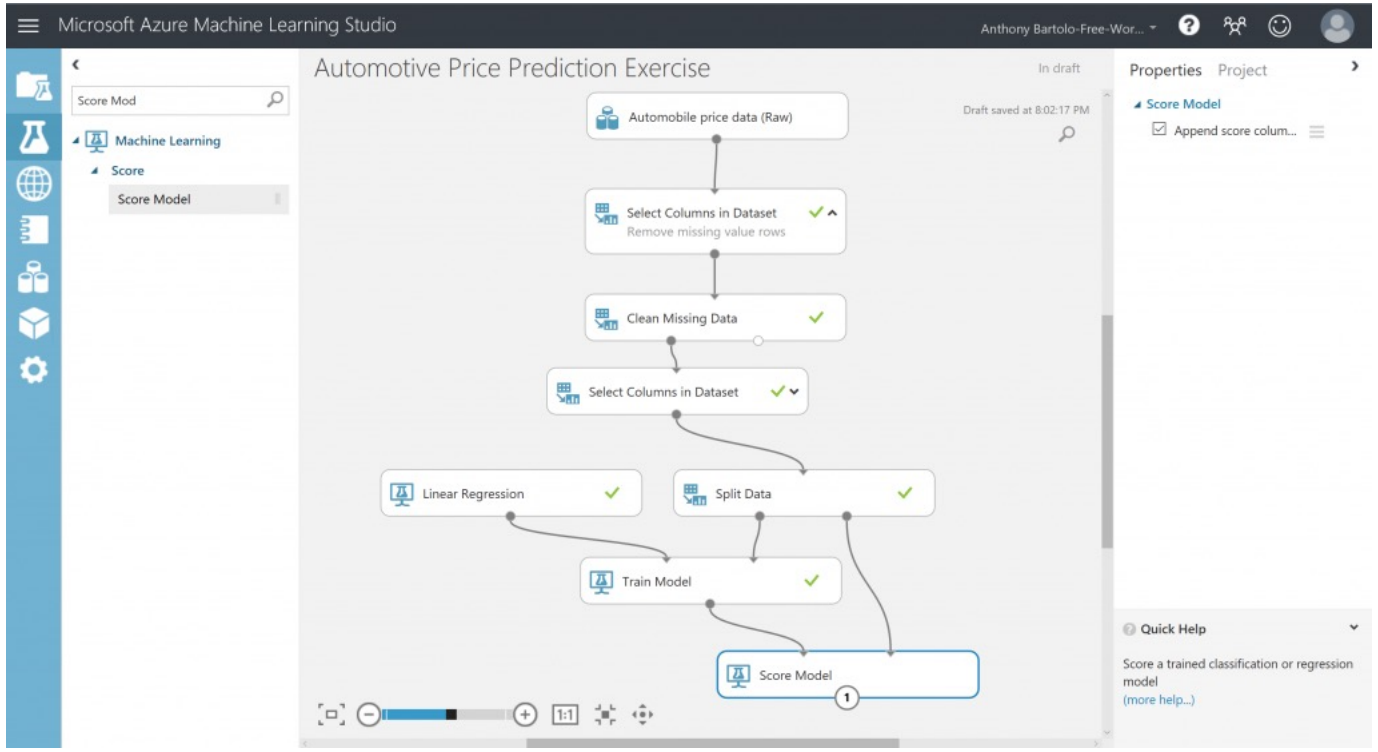
- General Purpose Modeling Languages (GPLs)
  - Languages can be applied to any domain for modeling
  - Examples: **UML**, XML, etc.

Wait is this similar to low code/no code?

Some Examples



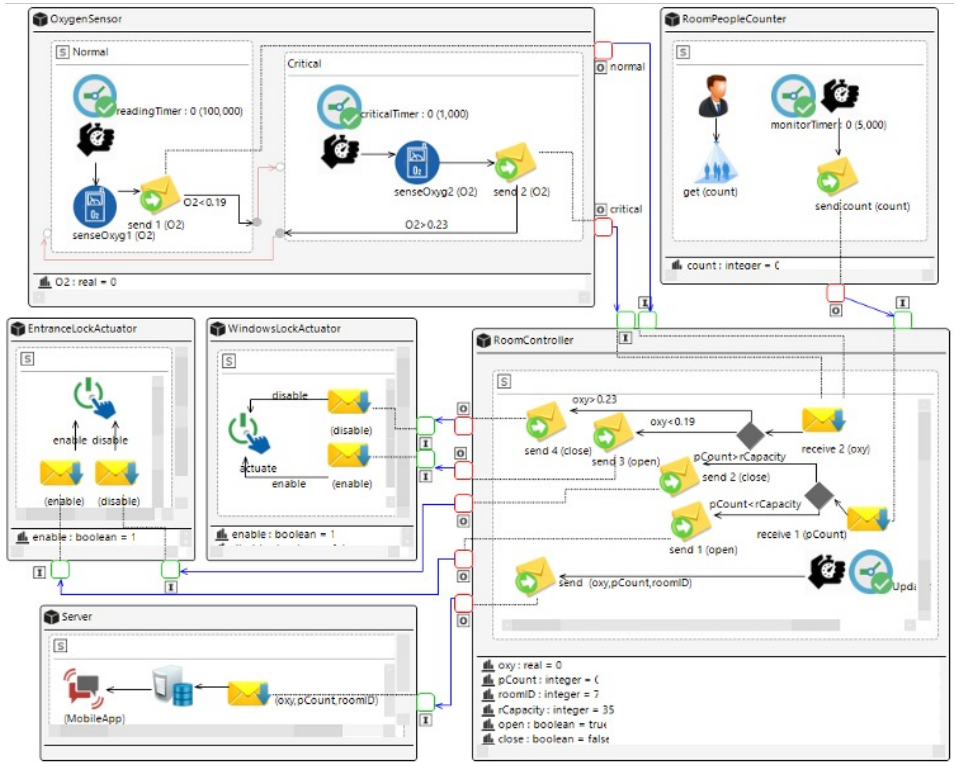
AWS Honeycode



Azure Machine Learning Studio

Source: AWS, Azure (Microsoft Tech Community)

Some Examples - We can create our own too



CAPS modeling for IoT

```
configuration Robot
{
    instance robot : RobotControl
    instance sdist : DistanceSensor
    instance scoll : CollisionSensor
    instance motion : MotionControl
    instance left_wheel : WheelControl
    instance right_wheel : WheelControl

    connector robot.rangefinder => sdist.data
    connector robot.bumper => scoll.data
    connector robot.platform => motion.ctrl
    connector motion.left => left_wheel.ctrl
    connector motion.right => right_wheel.ctrl
}
```

ThingML modeling

Source: CAPS.disim.univaq.it, ThingML presentation@Models2018

In the Context of Our Course (GPL – UML)

Unified Modeling Language (UML): Brief History

- No common language to model until 1996
- GPL developed by industry consortium in 1997
  - Introduction of OOP in IT dates back to 1960's
  - Required a standard representation: **OMG**
  - Three Amigos: Grady Booch, Ivar Jacobson and James Rumbaugh
- Based on multiple prior visual modeling languages
- Goal was to have a single language that could cover large number of SE tasks
- Current version of UML: 2.5.1 (as of Dec 2017)

https://www.omg.org/spec/UML/

Image source: Wikimedia commons

Unified Modeling Language (UML)

- Notation for OO Modeling
  - Use object orientation as basis
  - Model a system as collection of objects that interact with each other

- Graphical diagrams as a way to model systems
  - More clear (imprecise) than natural language (too detailed)
  - Capture an overall view of the system
  - Independent of language or technology

What UML is not?

- Not an OO Method or Process
- Not a visual programming language
- Not a tool specification

UML Diagrams

- 14 different diagrams
- Structure diagrams

for capturing static aspects of system

- Behavior diagrams

for capturing dynamic aspect of system

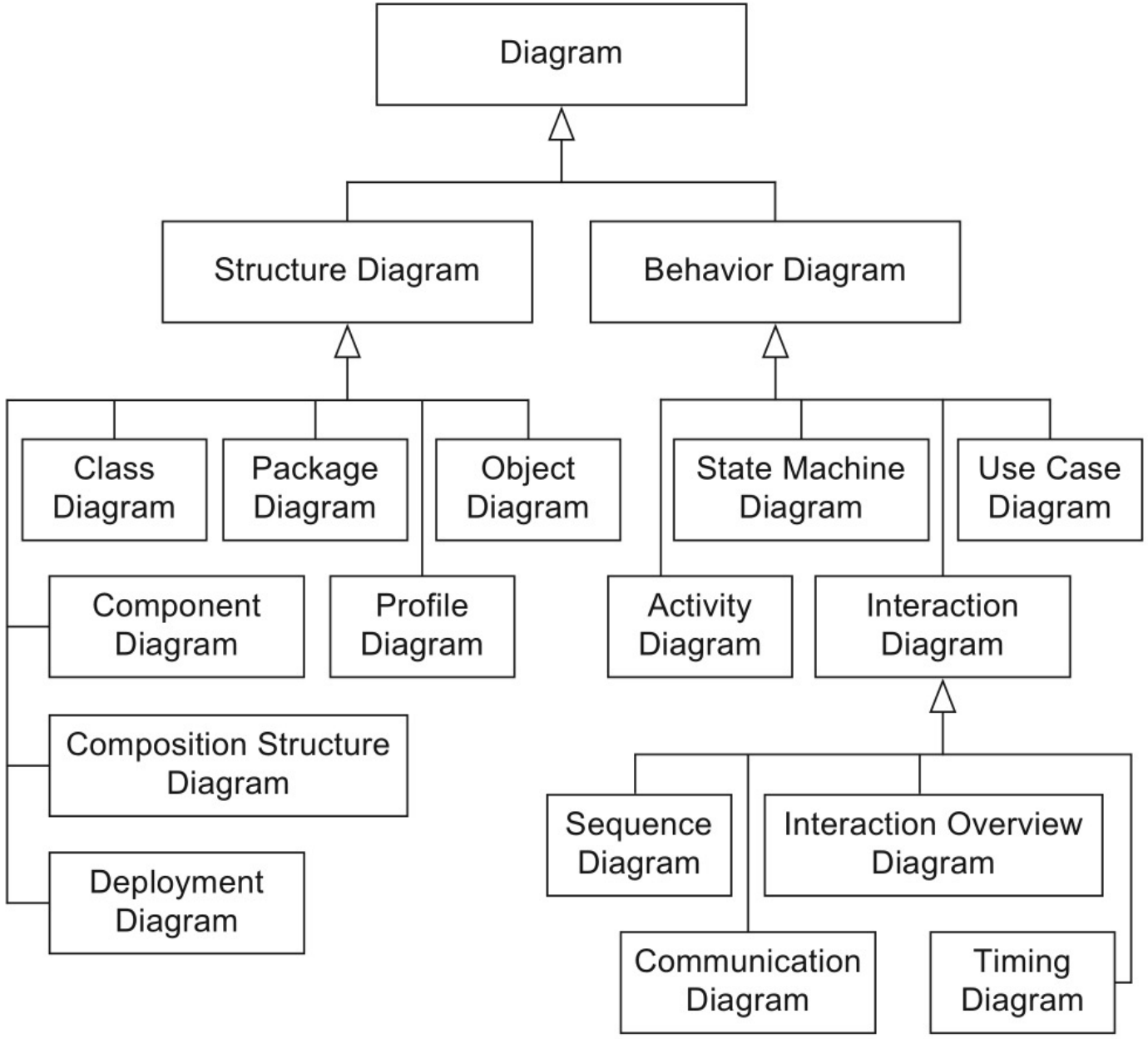


Image source: UML@classroom

Static Vs Dynamic Models

Static Model

- Describes the static structure of a system
- One of the most common diagrams: *class diagrams*

Dynamic Model

- Captures the dynamic behavior of a system
- Developed with help of state chart diagrams, sequence diagrams, etc.

In this unit: class diagram (static) and sequence diagram (dynamic)

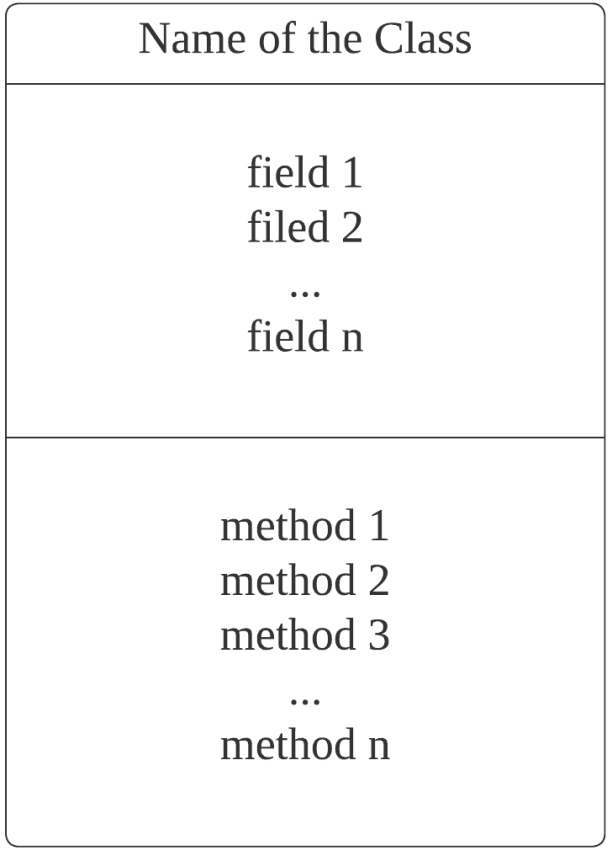
UML Class Diagram

UML Class Diagram

- Most common diagram in OO modeling
- Captures the static structure of a system
- Intuitively it is like a graph
  - Nodes represent the classes
  - Links represent the relationship among classes
    - Inheritance
    - Association (aggregation, composition)
    - Dependency

UML Class Diagram: Notation

Consists of three compartments



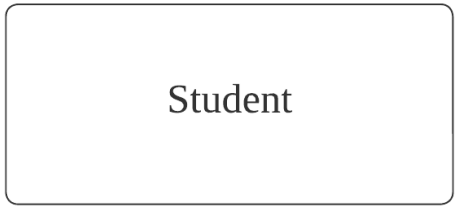
Class name - Pascal Casing, Singular noun, domain vocabulary

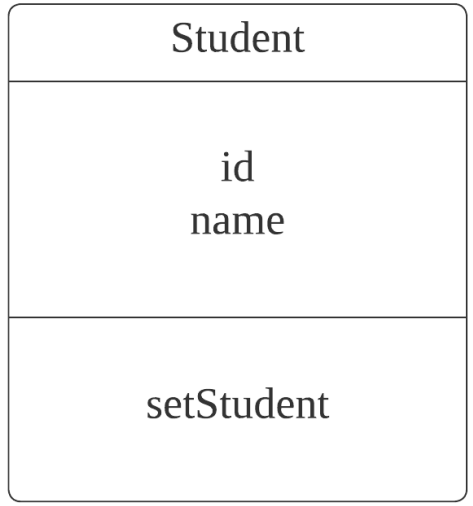
Fields/Attributes (state) - camel casing, name and type at basic level

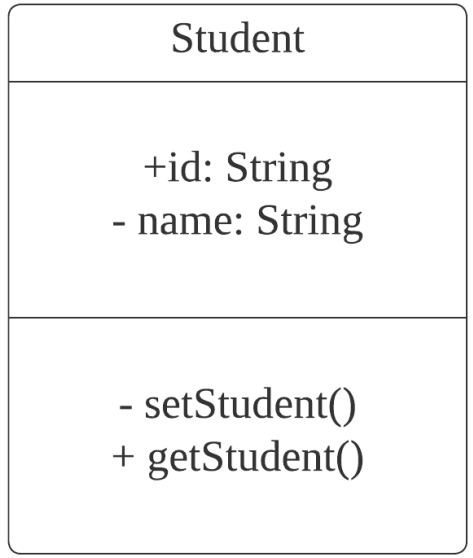
Methods/operations (behavior) – camel casing, name, parameters, return value

UML Class Diagram: Always make use of abstraction

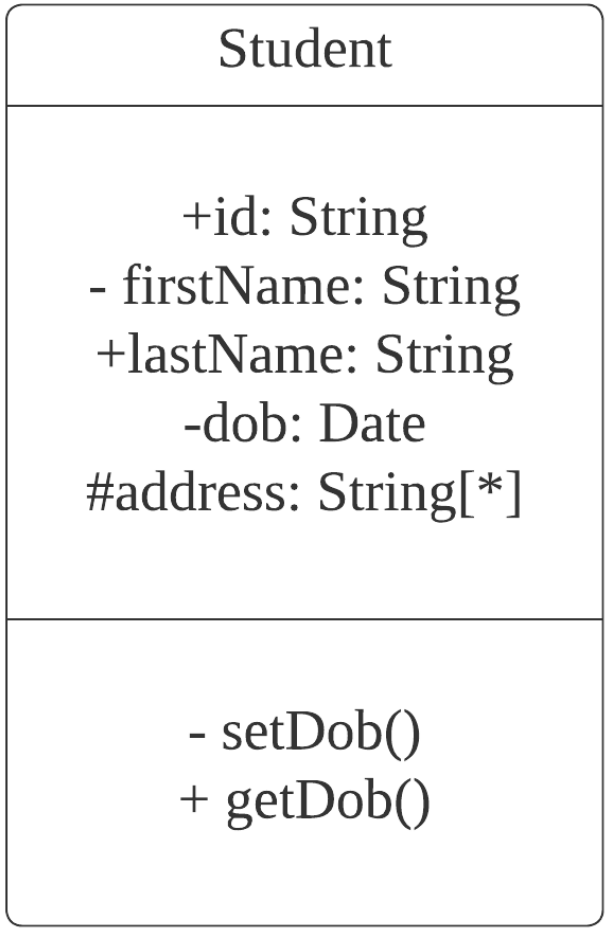
- Model has to be clear and understandable
- Detail with respect to the stage of software development process
- More low-level analysis and development requires detailed information







UML Class Diagram: Specifying Attributes and Methods



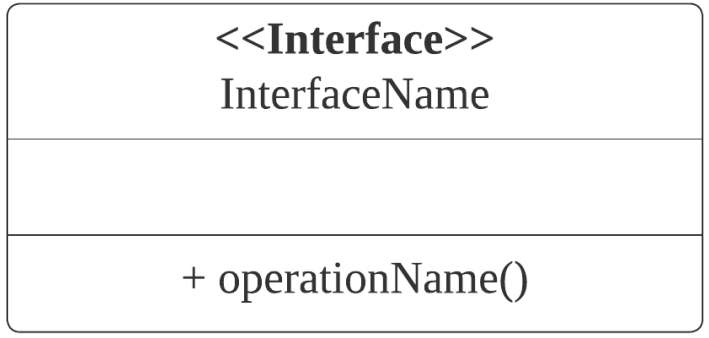
Name and Symbol	Description
public (+)	Access by objects of any class
Private (-)	Access only within the object
Protected (#)	Access by objects of same classes or sub-classes
Package (~)	Access by objects of the classes which are in same package

Create a class diagram for the following code

```java
public class Course {
    public String courseName;
    public String courseId;
    private String roomNumber;
    protected int count;

    public String getCourseName() {
        return courseName;
    }

    public String getCourseId() {
        return courseId;
    }

    private String getRoomNumber() {
        return roomNumber;
    }
```

Interface and Notation for Interfaces

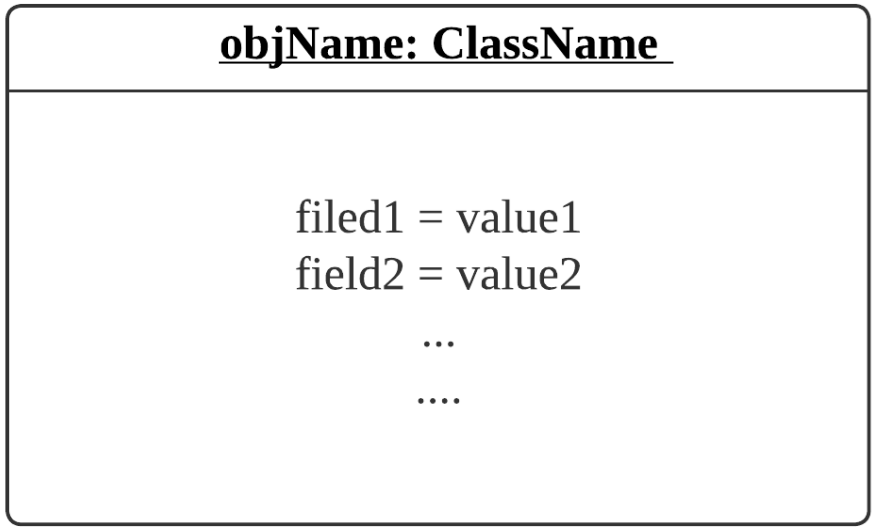
- In simple terms it's a contract mechanism – What to do!
- Mechanism to achieve abstraction, group classes, enforcer – No instance variables only constants
- Class can implement an interface – "implements" keyword (Java)

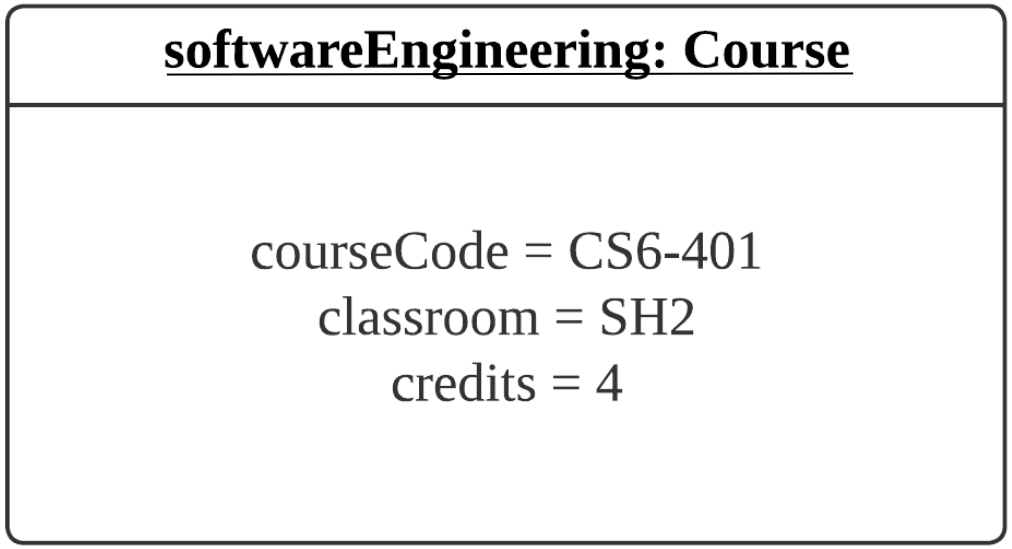


- Vehicles can implement Gear interface

Notation for Objects

- Box with one or two compartments
- Remember to mention the class name

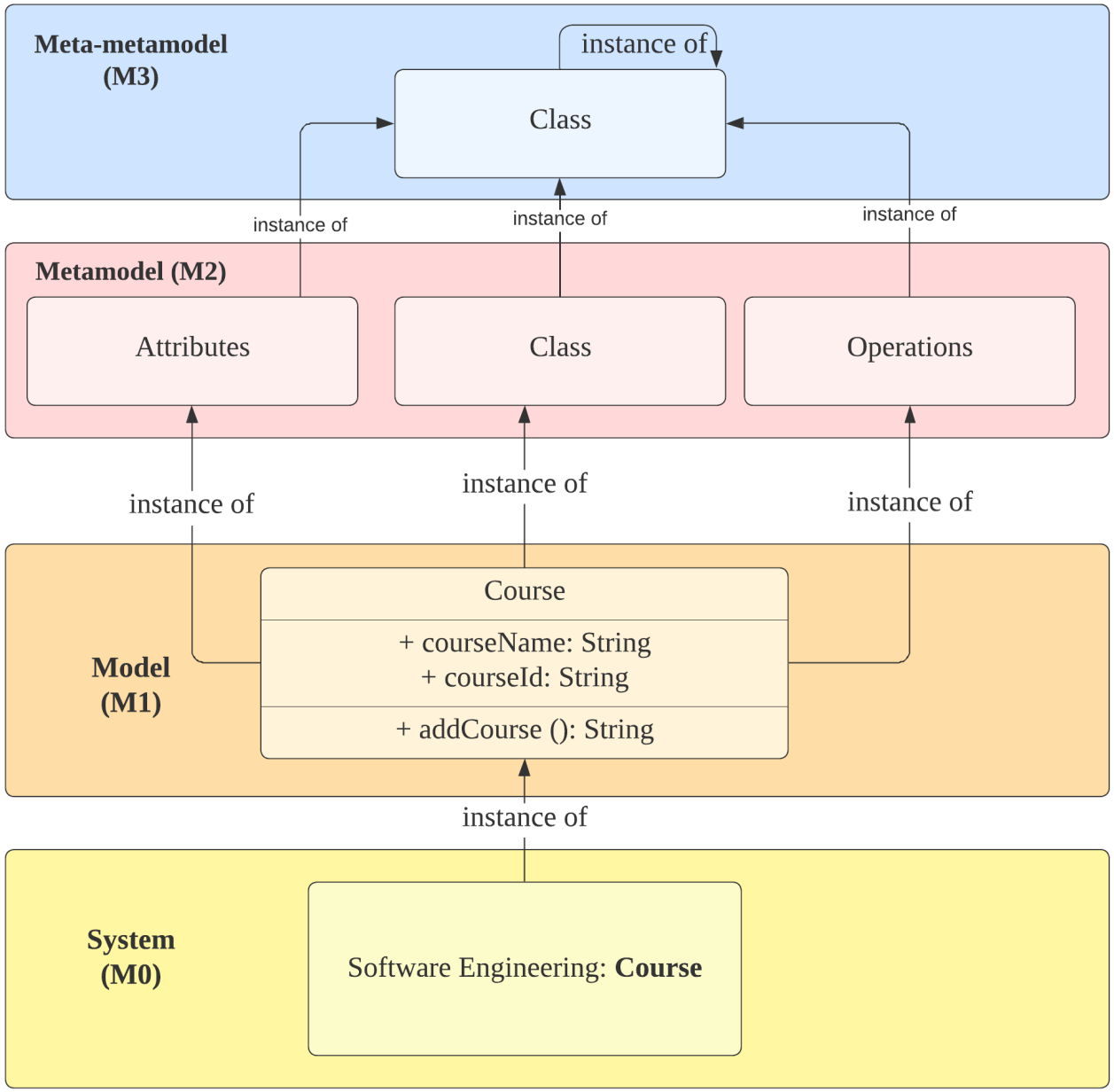




First part has object name and corresponding class name
Second part has list of fields and values

Models and Meta models

- Models of models
- Defines the rules for the different models
- For eg: a class needs to be defined in a particular way



Modeling Relationships using UML

Three main relationships between classes

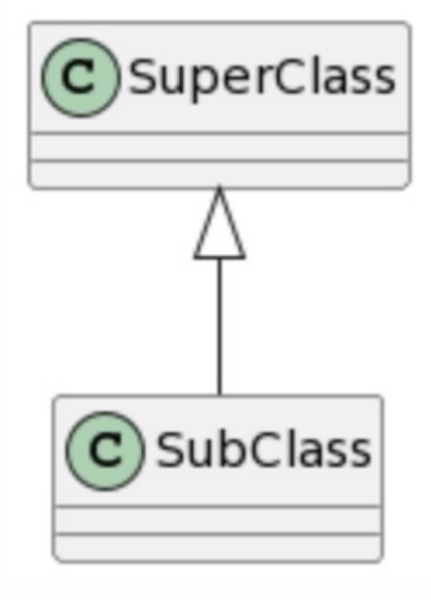
- Dependency
  - Class A uses Class B
- Associations (has-a)
  - Class A affects Class B
  - Types: Aggregation and Composition
- Generalization (Is-a)
  - Class A is a kind of Class B

Inheritance in Java

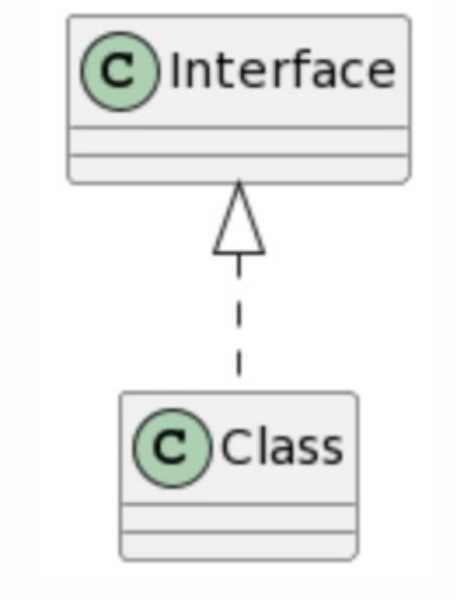
- Object acquires properties and behavior of parent object
- Create new classes based on existing classes
  - Derive classes from existing classes (”extends” keyword)
  - Parent class/super class – Class from which other classes are derived
  - Child class/sub class – Class that is derived from existing class
- **Object** class is the parent class for every class in java (java.lang.package)
- Eg: Vehicle class can be parent of car, bikes, etc.
  - Each car, bike can themselves be parent class for child classes – **How?**

Inheritance in UML

- UML provides easy ways to represent inheritance
  - Extension is called *specialization (sub class) and generalization (supper class)*
  - Implementation is called *realization*

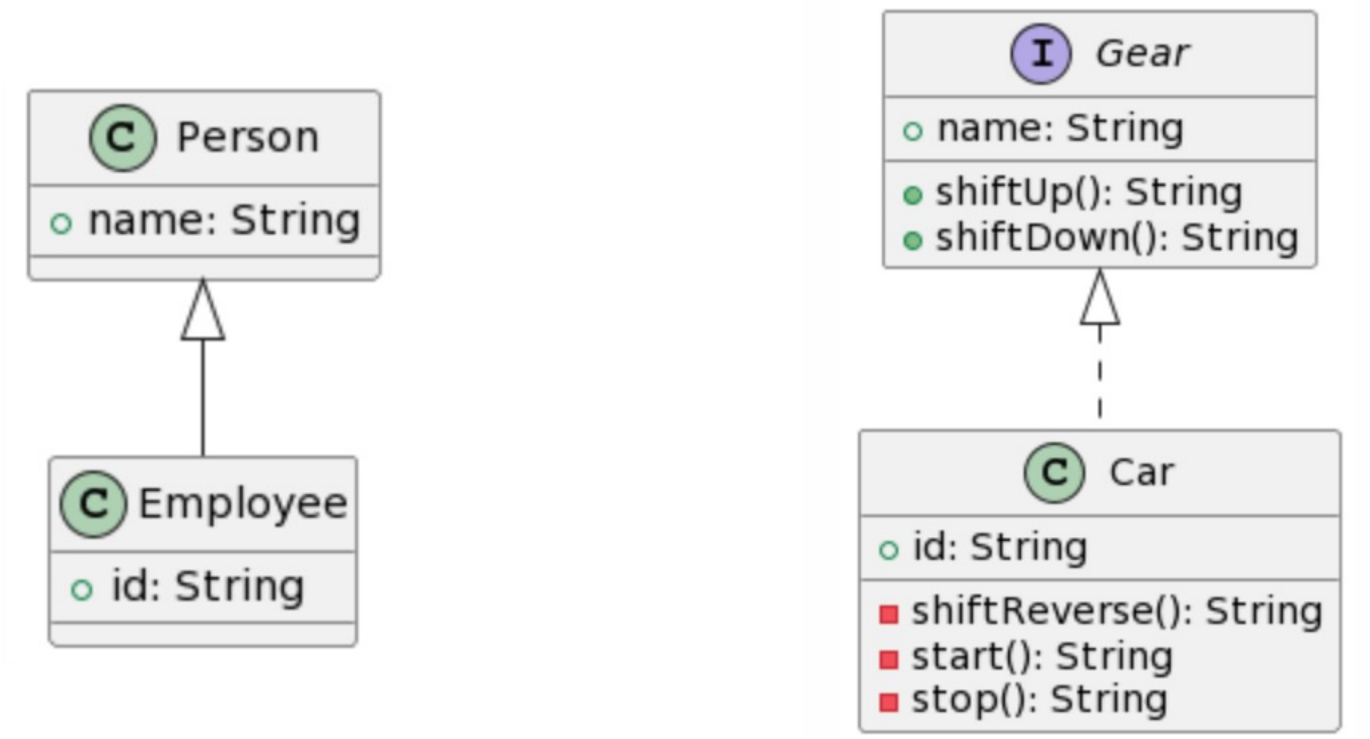


Extension of classes



Realization of interfaces

More Concrete Example



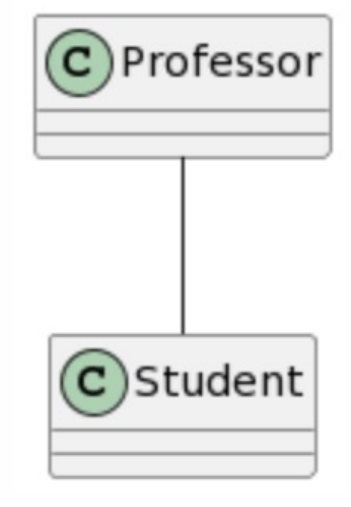
Time to be Creative

Draw a UML diagram showing possible inheritance relationship between different types of students in the class. What will be the abstract class (es)?

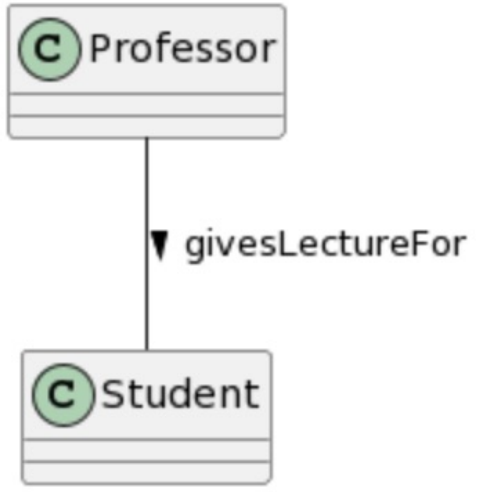
Hint: We have B.Tech, M.Tech, …..

Association

- Model links between instances of classes
- Identify the communication partners
- Use association names and reading directions (solid arrowhead) for labeling



What kind?

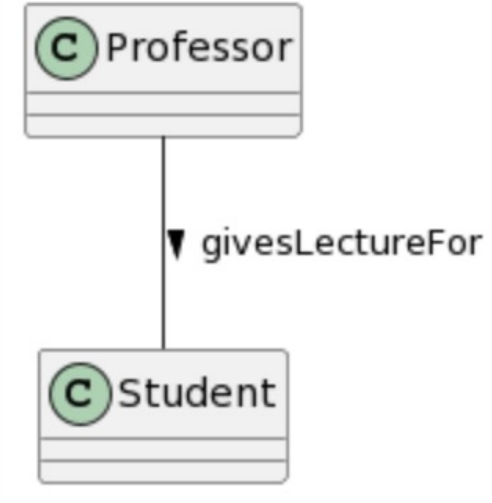


What about multiplicity?

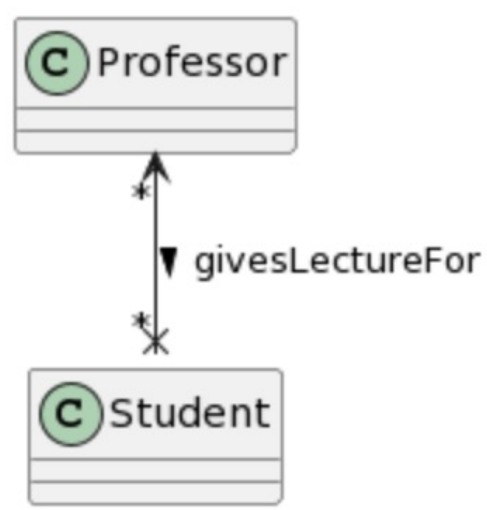
Professors gives lecture

Association – Navigability and Multiplicity

- Cardinality of the class in relation to the another - Multiplicity
- Navigation from one to another is possible – Navigability
- Navigability - Indicates who can access what (not reading direction)
- Usual assumption: Bidirectional navigability



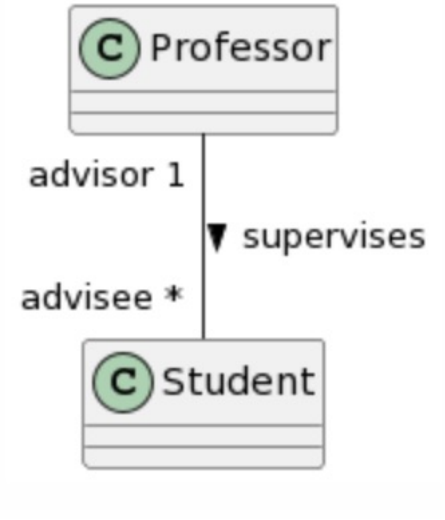
Bidirectional



Professor class cannot access public parameters/methods of student

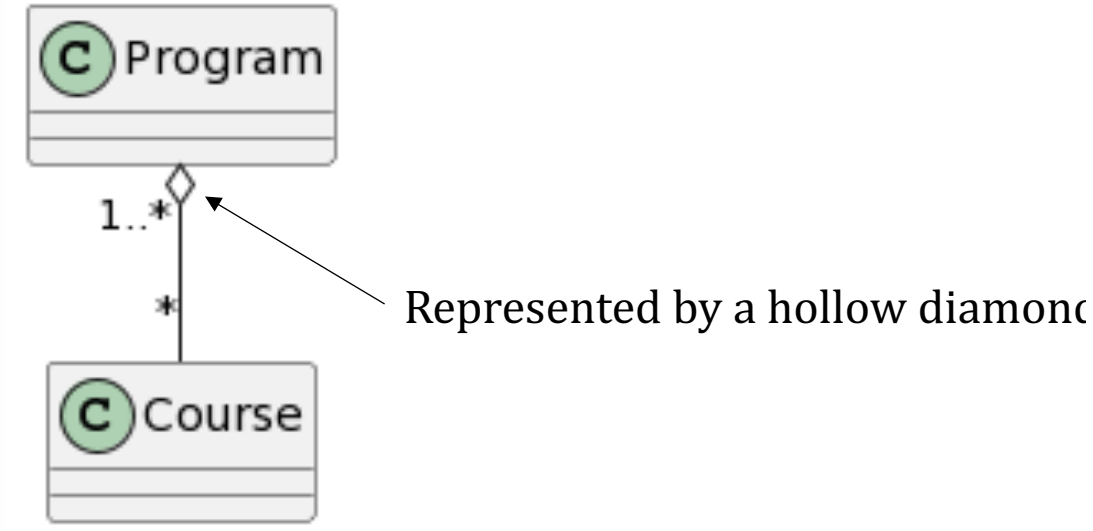
Association – Few more things

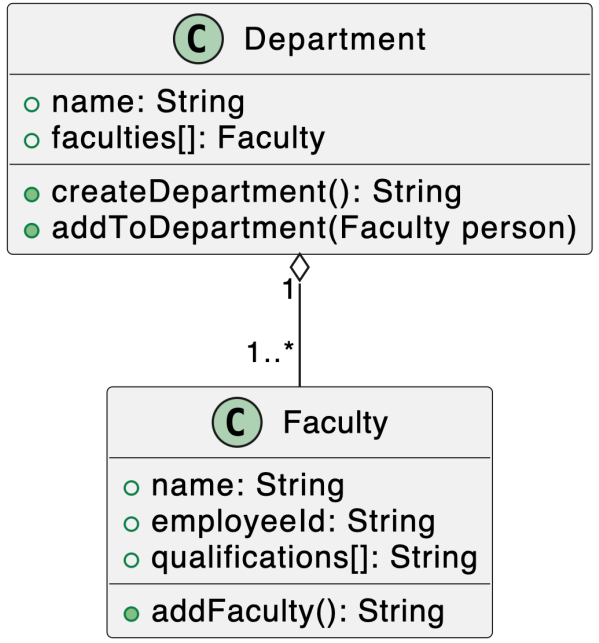
- May have optional role name
- Multiplicity specification is not always mandatory
  - min…max: closed (inclusive) range of integers
  - n: single integer
  - 0..*: entire set of non-negative integers



Aggregation

- Special form of association - Parts-whole relationship
- Used to express that a class is part of another (hollow diamond)
- Combination of independent objects (eg: Program and course)

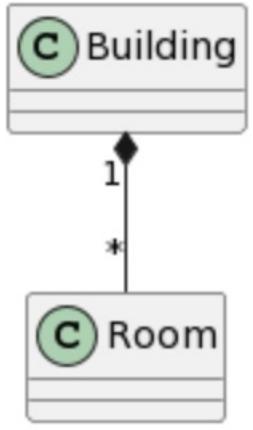




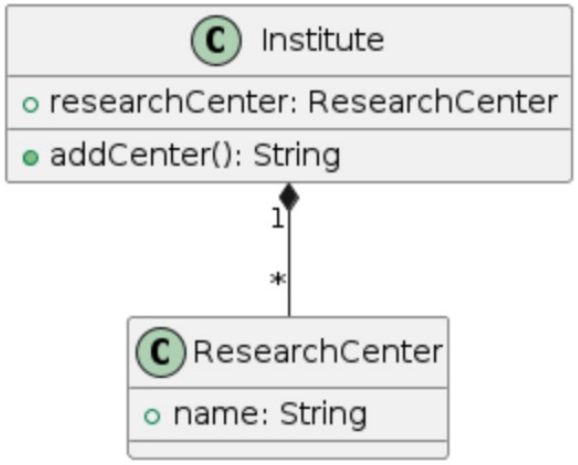
Another example

Composition

- Dependency between composite objects and its parts
- If the composite object is deleted, the parts are also deleted
- One part can be contained in at most one composite object at a time
  - Max multiplicity at the aggregating end is 1 (closed diamond representation)



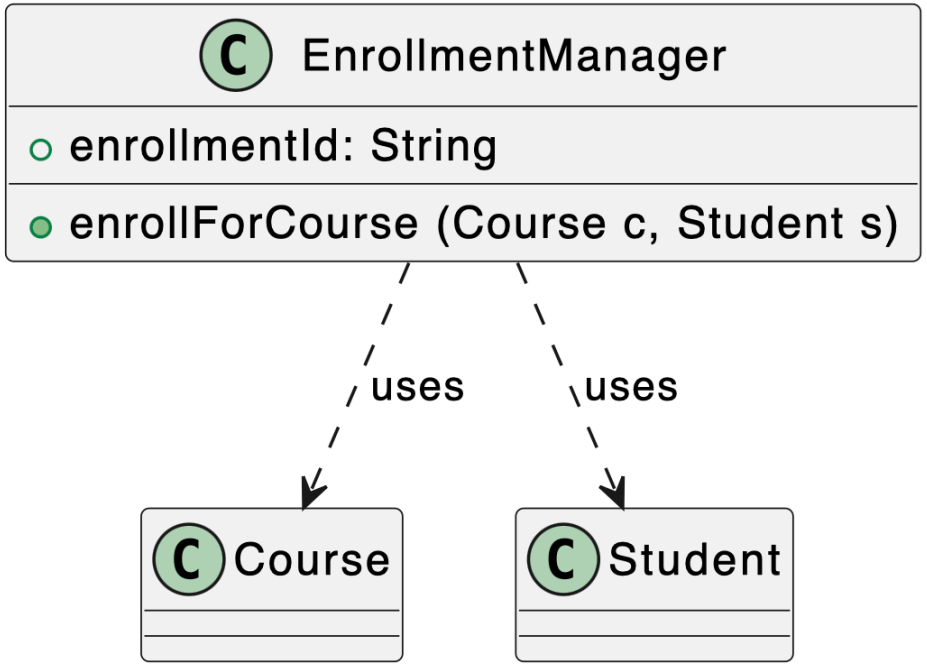
Building is composed of multiple rooms



Adding centers from Institute

Dependency

- One class uses another class <<uses> relationship
- There is no conceptual link between the objects of the classes
- One may refer the other or vice versa



Time to be Creative

Let’s revisit the case this time with class diagrams:

we want to build a course management portal (think of moodle), what could be some of the classes the corresponding attributes and methods? Can you think of some interfaces?

Modeling the Dynamic Aspects: Sequence Diagram [Interaction Diagram]

Sequence Diagram

- Captures the dynamic behavior
- Two dimensional-diagram
  - Horizontal: Involved interaction
  - Vertical: Chronological order of the interaction
- Interaction => sequence of event specifications

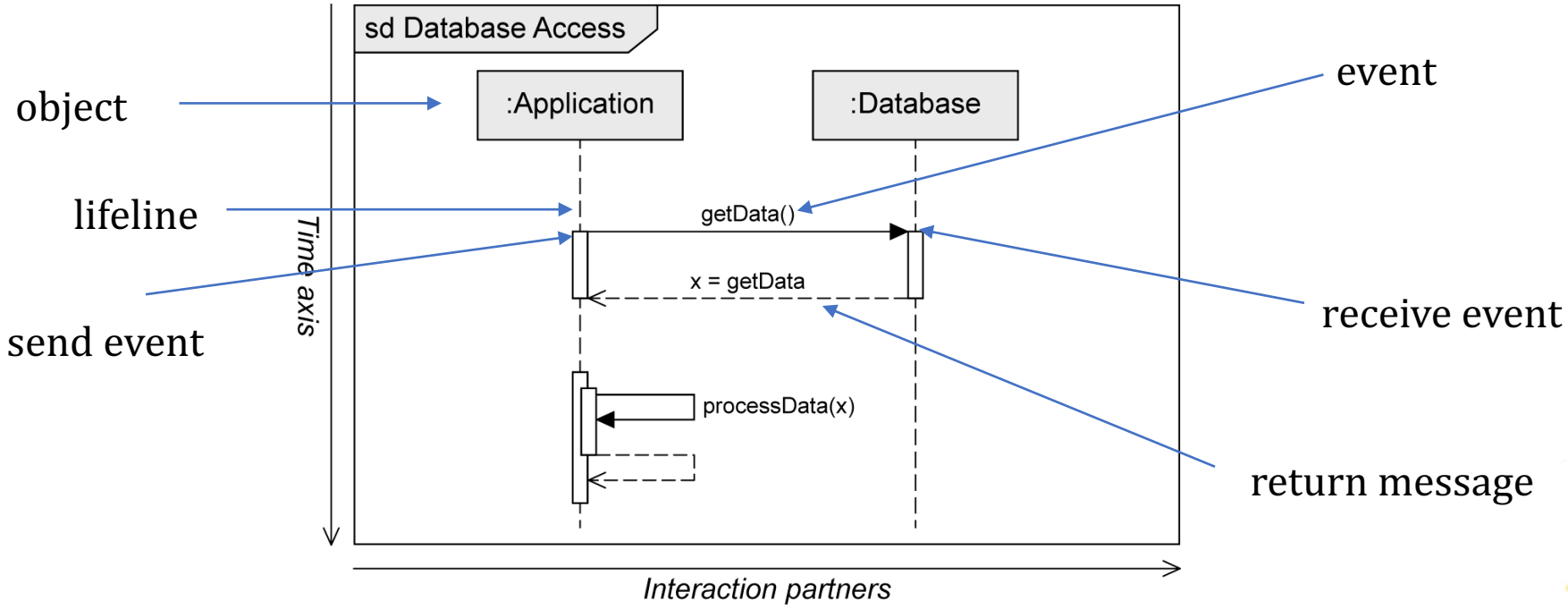
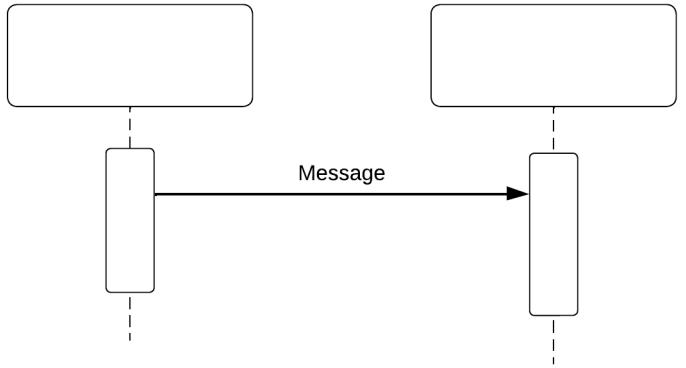


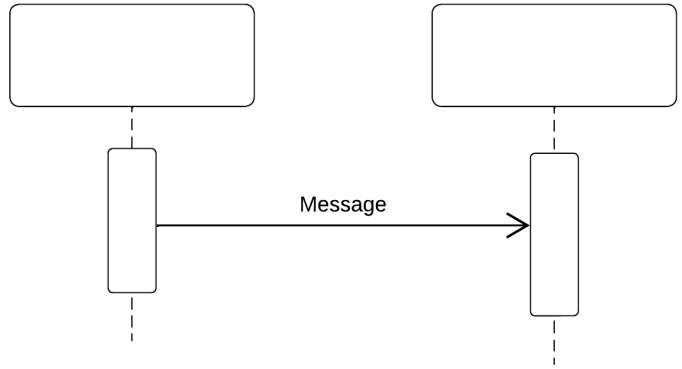
Image source: uml@classroom

Sequence Diagram – Main Message types

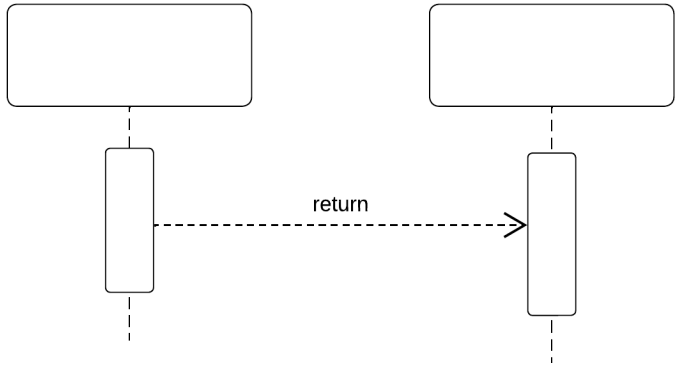
- Synchronous Message
  - Sender waits till the return message is received before next



- Asynchronous Messages
  - Sender does not wait for response message

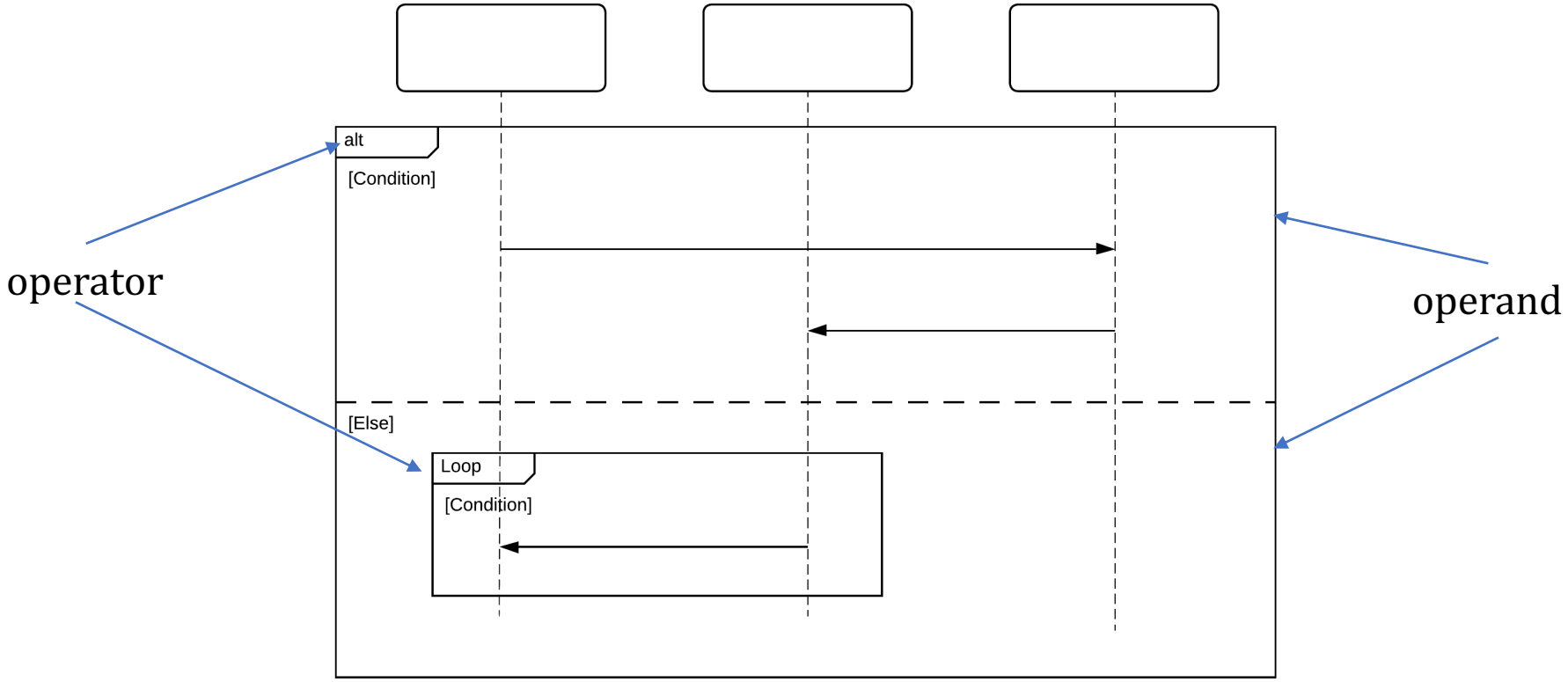


- Response message
  - Not mandatory in obvious situations



Sequence Diagram – Combined Fragments

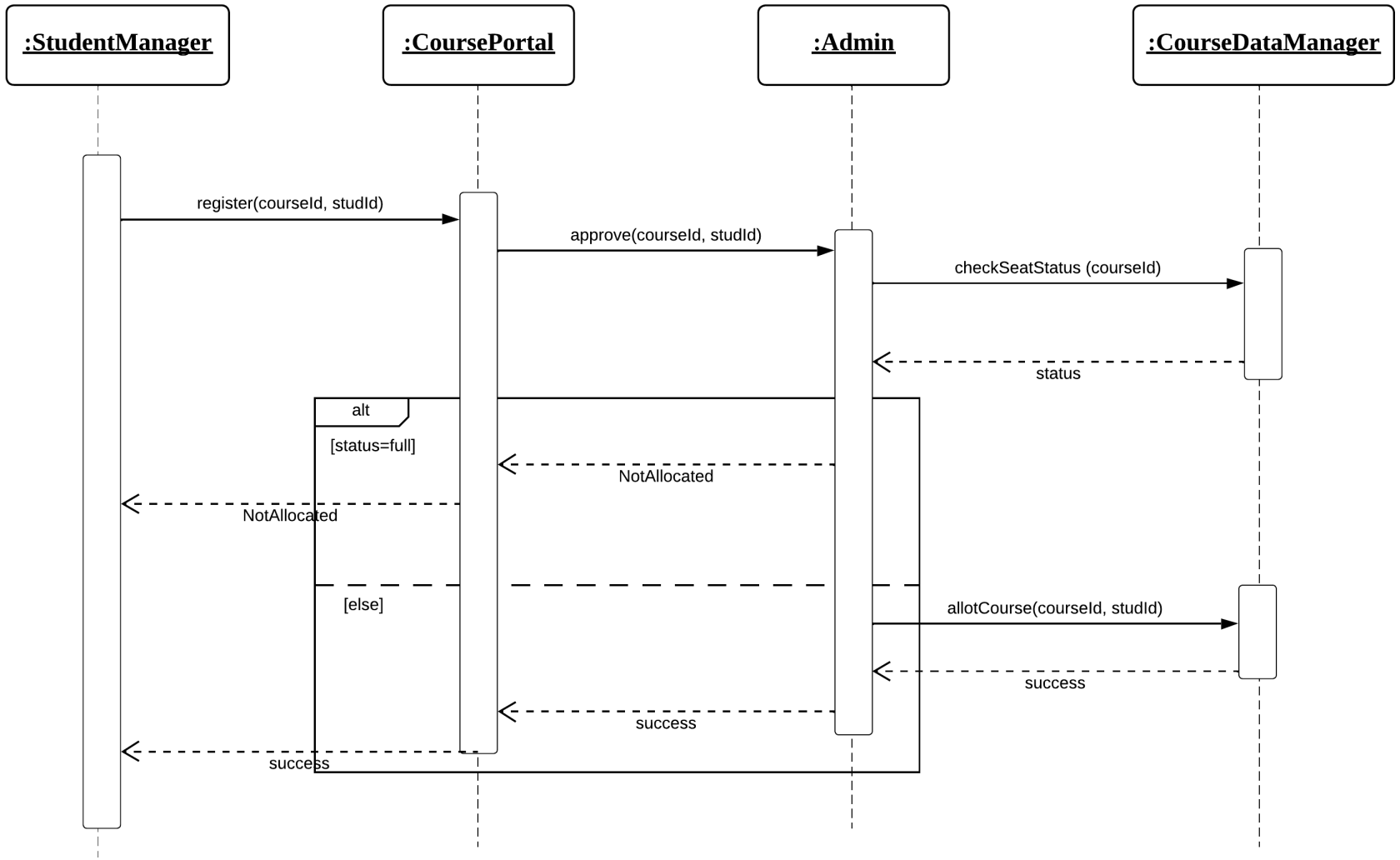
- Model control structures explicitly
- UML sequence diagram supports 12 operators. Three groups
  - Branches and loops, Concurrency and order, Filters and Assertions



Different Operators

Name and Operator	Use
Alternative (alt)	Express alternative execution (if-else)
Optional (opt)	Fragment executes based on guard condition (if)
Break (break)	Execution of a fragment when break condition is met
Loop (loop)	Repeated execution of a fragment
Sequential (seq)	Weak ordering (default model)
Strict (strict)	Interaction with strict order
Parallel (par)	Concurrent execution of sub-scenarios
Critical (critical)	Atomic interactions (no other interactions can affect)
Ignore (ignore)	Irrelevant messages (insignificant messages at runtime)
Consider (consider)	Important messages of the interactions
Negate (neg)	Model invalid interactions, undesirable situations
Assert (assert)	To assert certain interactions (mandatory)

Sequence Diagram – Example



Thank You

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