ÖZYEĞİN UNIVERSITY

CS105
Introduction to Object-Oriented Programming

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Class Diagrams

Outline

- UML (Unified Modeling Language)
  - Goals of UML
  - Characteristics of UML
- Conceptual Modelling
- Uses for UML
- UML Class Diagram
  - Purpose of Class Diagrams
  - Benefits of Class Diagrams
- Vital components of a Class Diagram
- Relationships between classes
- Class Diagram Examples

UML (Unified Modeling Language)

- a standardized general-purpose, graphical modeling language in the field of Software Engineering.
- used to specify, visualize, construct, and document the artifacts (major elements) of the software system.
- helps in designing and characterizing, especially those software systems that incorporate the concept of Object orientation.
- describes the working of both the software and hardware systems.

Goals of UML

- Since it is a general-purpose modeling language, it can be utilized by all the modelers.
- UML came into existence after the introduction of object-oriented concepts to systemize and consolidate the object-oriented development, due to the absence of standard methods at that time.
- The UML diagrams are made for business users, developers, ordinary people, or anyone who is looking forward to understand the system, such that the system can be software or non-software.
- UML is a simple modeling approach that is used to model all the practical systems.

Characteristics of UML

- **The UML has the following features:**

- It is a generalized modeling language.
- It is distinct from other programming languages like C++, Python, etc.
- It is interrelated to object-oriented analysis and design.
- It is used to visualize the workflow of the system.
- It is a pictorial language, used to generate powerful modeling artifacts.

Conceptual Modeling

- A conceptual model is composed of several interrelated concepts

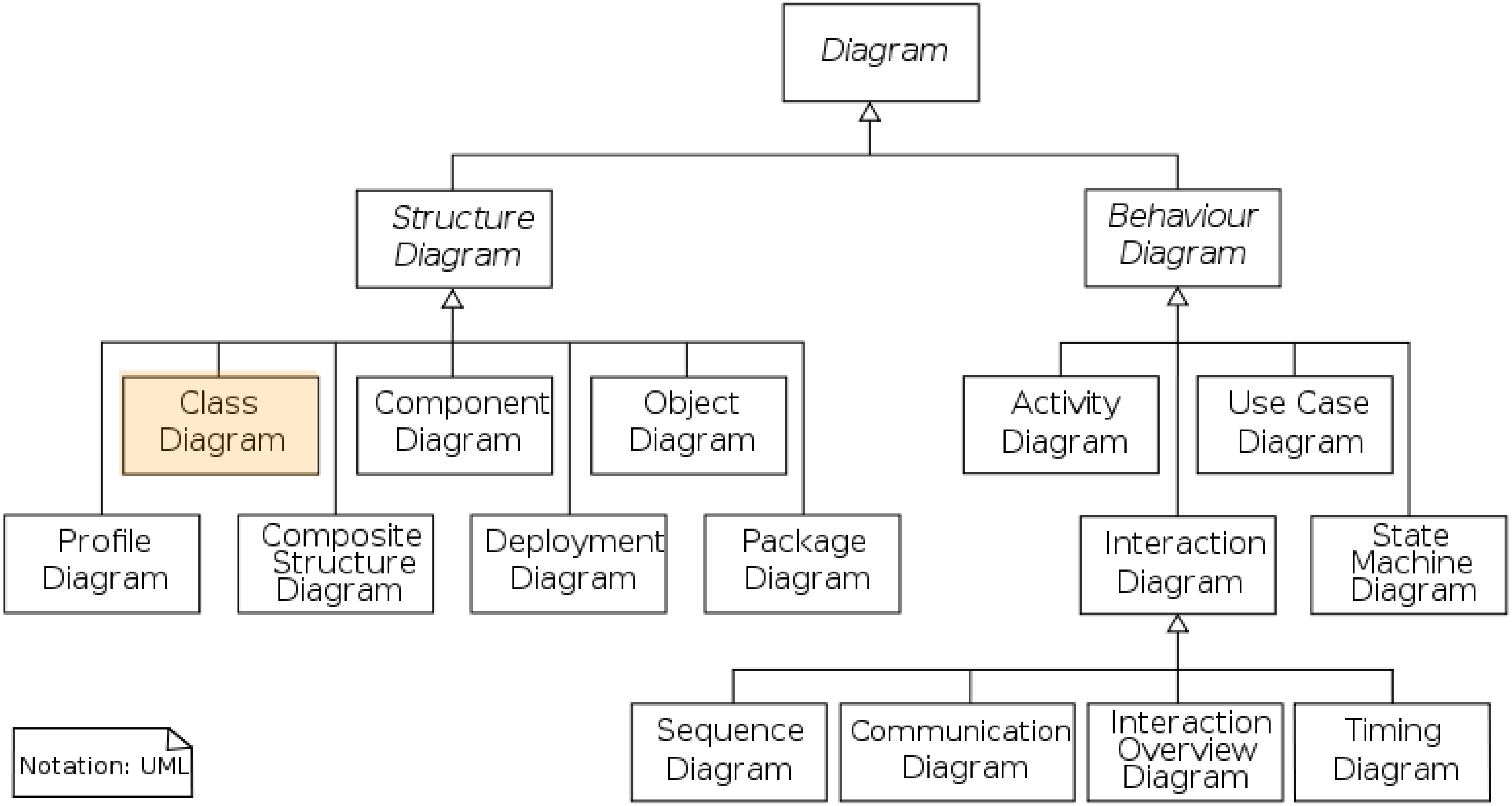
- makes it easy to understand the objects and how they interact with each other.

- This is the first step before drawing UML diagrams.
- Following are some object-oriented concepts that are needed to begin with UML:

Conceptual Modeling

- Following are some object-oriented concepts that are needed to begin with UML:
  - Object:
    - An object is a real world entity.
    - There are many objects present within a single system.
    - It is a fundamental building block of UML.
  - Class:
    - a software blueprint for objects, which means that it defines the variables and methods common to all the objects of a particular type.
  - Abstraction:
    - the process of portraying the essential characteristics of an object to the users while hiding the irrelevant information.
    - Basically, it is used to envision the functioning of an object.
  - Inheritance:
    - the process of deriving a new class from the existing ones.
  - Polymorphism:
    - a mechanism of representing objects having multiple forms used for different purposes.
  - Encapsulation:
    - binds the data and the object together as a single unit, enabling tight coupling between them.

UML Diagrams



Uses for UML

- **As a sketch:**
  - to communicate aspects of system
    - forward design: doing UML before coding
    - backward design: doing UML after coding as documentation
    - often done on whiteboard or paper
    - used to get rough selective ideas
- **As a blueprint:**
  - a complete design to be implemented
    - sometimes done with CASE (Computer-Aided Software Engineering) tools
- **As a programming language:**
  - with the right tools, code can be auto-generated and executed from UML
    - only good if this is faster than coding in a "real" language

UML Class Diagram

- What is a UML class diagram?
  - –a picture of the classes in an OO system, their fields and methods, and connections between the classes that interact or inherit from each other.
    - shows the attributes, classes, functions, and relationships to give an overview of the software system.
    - constitutes class names, attributes, and functions in a separate compartment that helps in software development.
- What are some things that are not represented in a UML class diagram?
  - –details of how the classes interact with each other
  - –algorithmic details;
    - how a particular behavior is implemented

Purpose of Class Diagrams

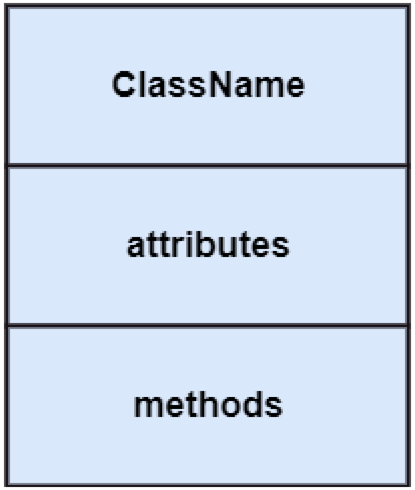
- to build a static view of an application.
  - It is the only diagram that is widely used for construction, and it can be mapped with object-oriented languages.
  - It is one of the most popular UML diagrams.
- Following are the purpose of class diagrams given below:
  - It analyses and designs a static view of an application.
  - It describes the major responsibilities of a system.
  - It is a base for component and deployment diagrams.
  - It incorporates forward and reverse engineering.

Benefits of Class Diagrams

- It can represent the object model for complex systems.
- It reduces the maintenance time by providing an overview of how an application is structured before coding.
- It provides a general schematic of an application for better understanding.
- It represents a detailed chart by highlighting the desired code, which is to be programmed.
- It is helpful for the stakeholders and the developers.

Vital components of a Class Diagram

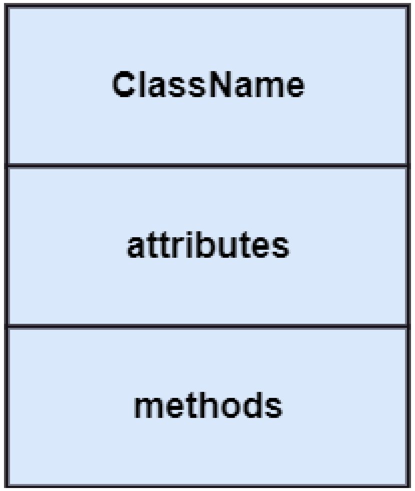
- The class diagram is made up of three sections:
  - Upper Section:
    - encompasses the name of the class.
      - A class is a representation of similar objects that shares the same relationships, attributes, operations, and semantics.
    - rules that should be taken into account while representing a class:
      - Capitalize the initial letter of the class name.
      - Place the class name in the center of the upper section.
      - A class name must be written in bold format.
      - The name of the abstract class should be written in italics format.

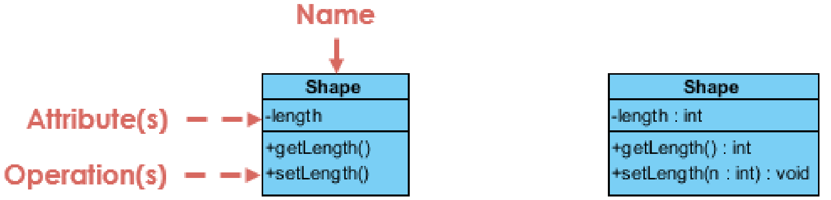


Vital components of a Class Diagram

- The class diagram is made up of three sections:
  - –Middle Section:
    - constitutes the attributes, which describe the quality of the class.

      visibility name : *type* [*count*] = *default_value*
    - The attributes have the following characteristics:
      - –The attributes are written along with its visibility factors, which are
        - public (+), private (-), protected (#), and package/default (~), derived (/).
          - derived attribute: not stored, but can be computed from other attribute values
      - –The accessibility of an attribute class is illustrated by the visibility factors.
      - –A meaningful name should be assigned to the attribute, which will explain its usage inside the class.
        - underline <u>static attributes</u>
      - –attribute example:
        - - balance : double = 0.00





Class without signature

Class with signature

Vital components of a Class Diagram

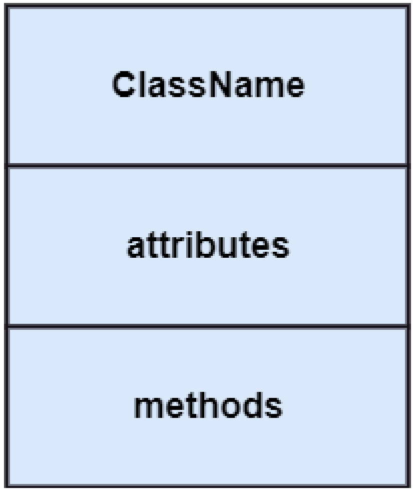
- The class diagram is made up of three sections:
  - –Lower Section:
    - The lower section contain methods or operations.

      visibility name (*parameters*) : *return_type*

      - underline static methods

      –method example:

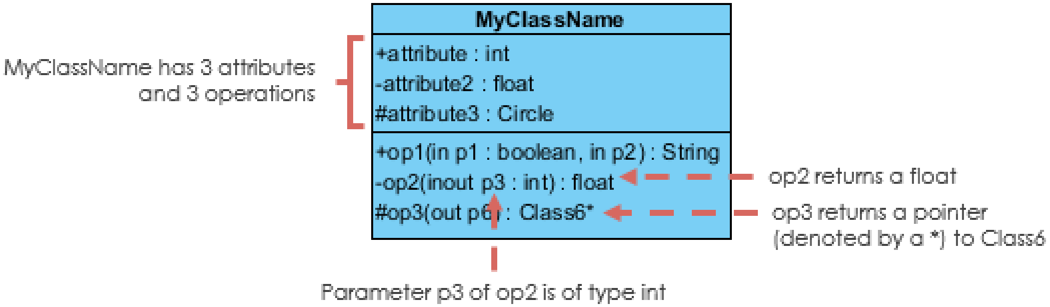
      + distance(p1: Point, p2: Point): double
    - The methods are represented in the form of a list, where each method is written in a single line.
    - omit *return_type* on constructors and when return type is void
    - It demonstrates how a class interacts with data.



ClassName

attributes

methods



MyClassName

+attribute : int
-attribute2 : float
#attribute3 : Circle

+op1(in p1 : boolean, in p2) : String
-op2(inout p3 : int) : float
#op3(out p6) : Class6*

MyClassName has 3 attributes and 3 operations

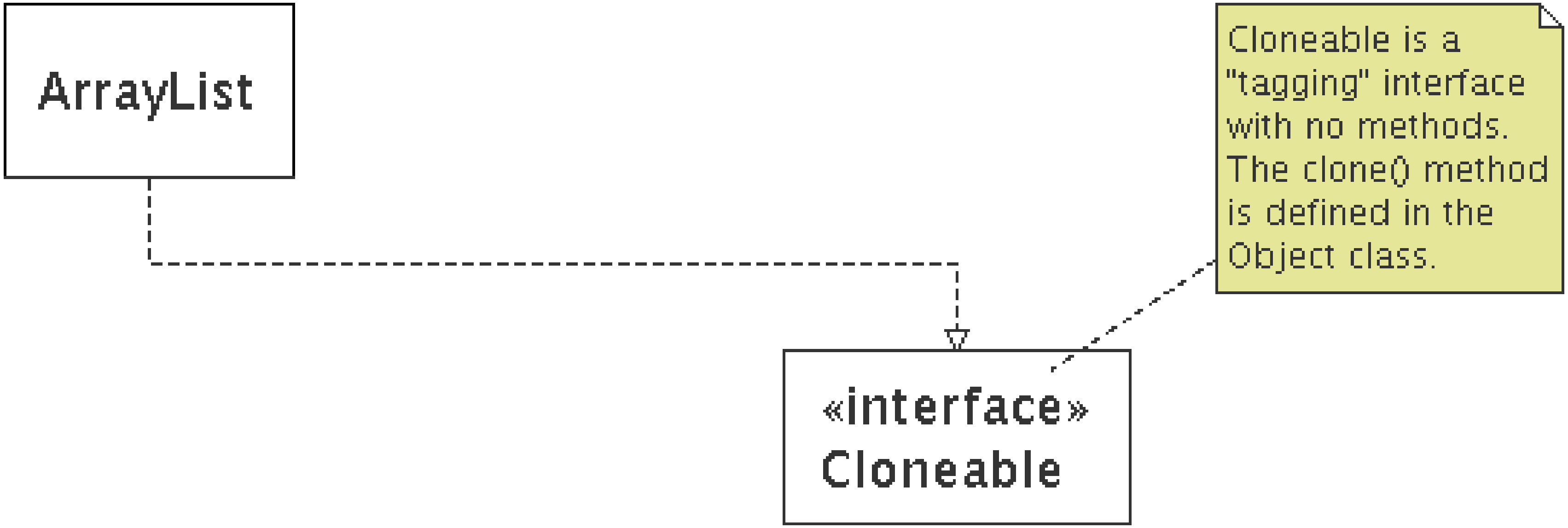
op2 returns a float

op3 returns a pointer (denoted by a *) to Class6

Parameter p3 of op2 is of type int

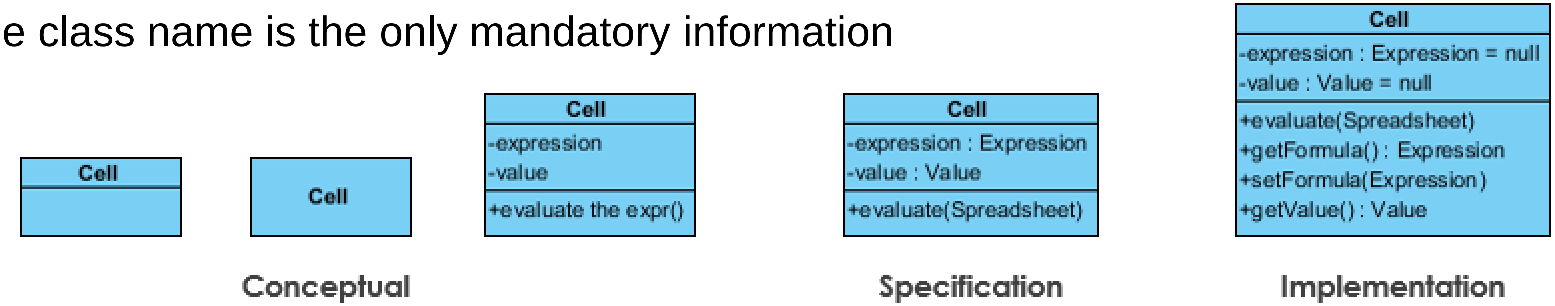
Comments

- represented as a folded note, attached to the appropriate class/method/etc by a dashed line


ArrayList
«interface»
Cloneable
Cloneable is a "tagging" interface with no methods. The clone() method is defined in the Object class.

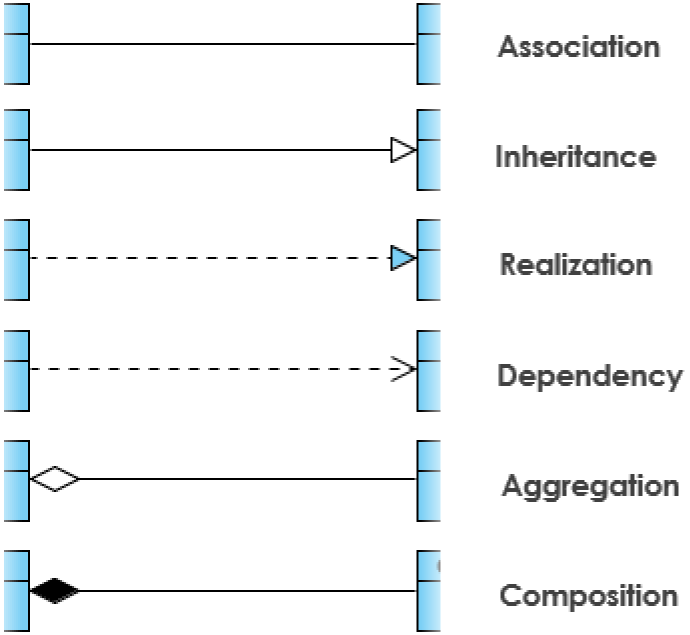
Perspectives of Class Diagram

- The choice of perspective depends on how far along you are in the development process.
- A diagram can be interpreted from various perspectives:
  - –Conceptual:
    - represents the concepts in the domain
  - –Specification:
    - focus is on the interfaces of Abstract Data Type (ADTs) in the software
  - –Implementation:
    - describes how classes will implement their interfaces
- the class name is the only mandatory information



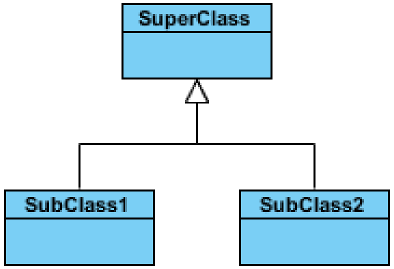
Relationships between classes

- A class may be involved in one or more relationships with other classes.
- A relationship can be one of the following types:

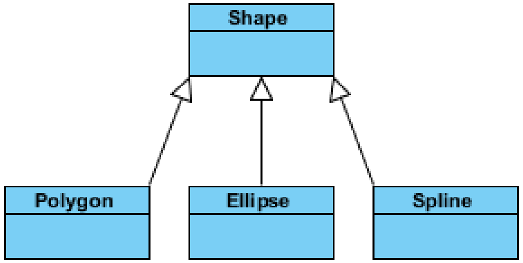


Relationships between classes

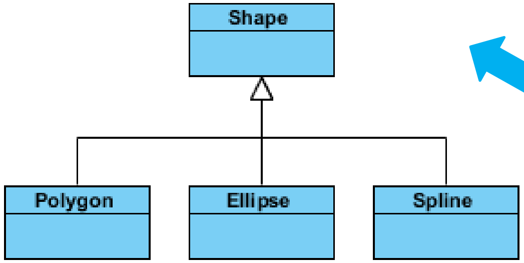
- **Generalization (Inheritance):**
  - –a relationship between a parent class (superclass) and a child class (subclass).
  - –Represents an "is-a" relationship.
  - –An abstract class name is shown in italics.



  - –inheritance between classes
    - The child class is inherited from the parent class.
      - –SubClass1 and SubClass2 are specializations of SuperClass
    - inheritance example with two styles.
      - –they are semantically equivalent.



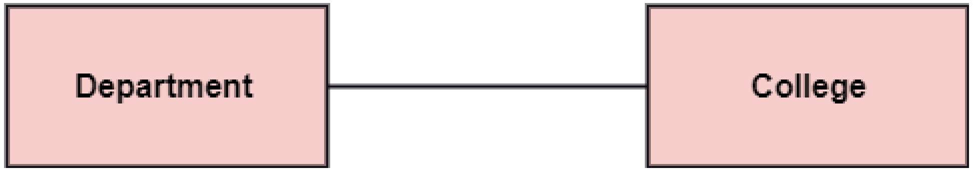
Style 1: Separate target



Style 2: Shared target

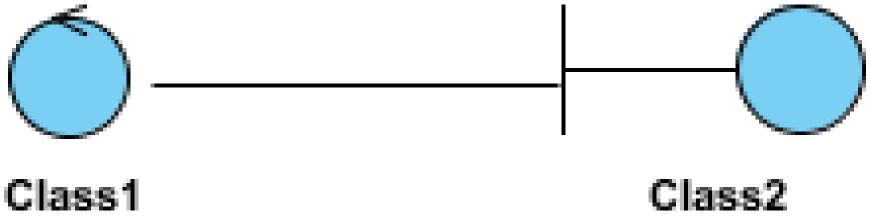
Relationships between Classes

- **Association:**
  - –describes a static or physical connection between two or more objects.
  - –depicts how many objects are there in the relationship.
  - –a usage relationship
    - aggregation
    - Composition
    - dependency
  - –For example, a department is associated with the college.



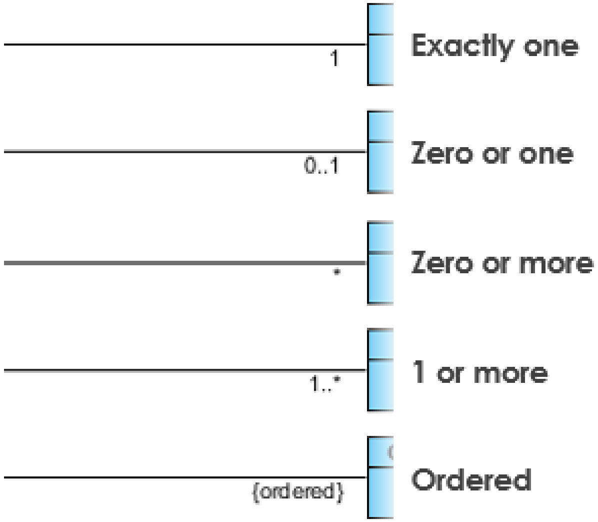
Relationships between Classes

- **Association:**
  - –Simple association
    - A structural link between two peer classes.
    - There is an association between Class1 and Class2
      - –The figure below shows an example of simple association.
        - There is an association that connects the <<control>> class Class1 and <<boundary>> class Class2.
          - The relationship is displayed as a solid line connecting the two classes.



Relationships between Classes

- **Association:**
  - –Multiplicity (Cardinality)
    - expressed in terms of:
      - –one to one
      - –one to many
      - –many to many

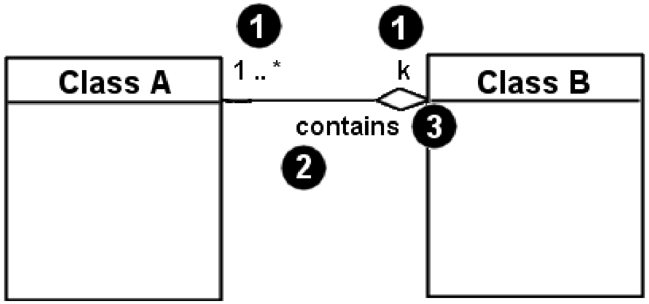


- Associational (usage) relationships

1. multiplicity (how many are used)

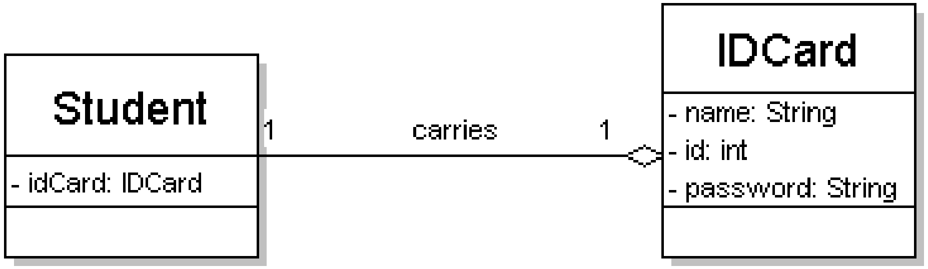
*	⇒ 0, 1, or more
1	⇒ 1 exactly
2..4	⇒ between 2 and 4, inclusive
3..*	⇒ 3 or more

2. name (what relationship the objects have)
3. navigability (direction)



Multiplicity of associations

- one-to-one
  - –each student must carry exactly one ID card



Student

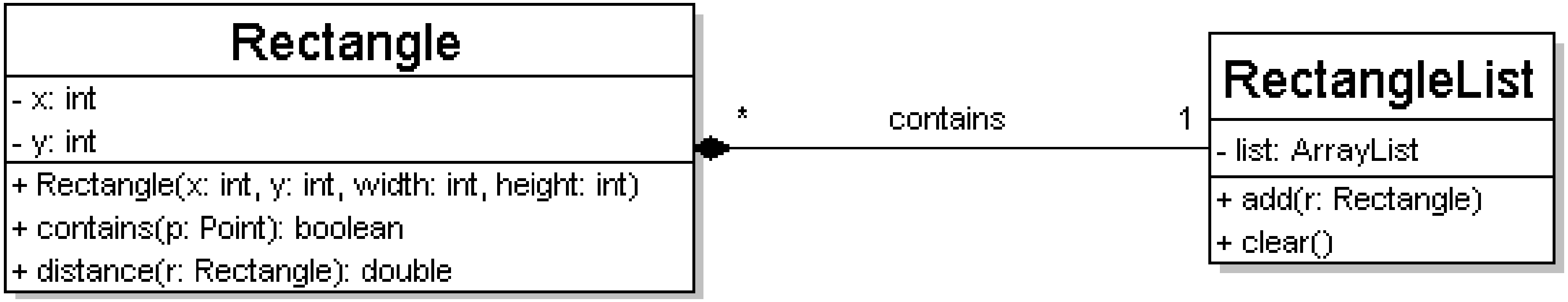
- idCard: IDCard

1 carries 1

IDCard

- name: String
- id: int
- password: String

- one-to-many
  - –one rectangle list can contain many rectangles



Rectangle

- x: int
- y: int

+ Rectangle(x: int, y: int, width: int, height: int)
+ contains(p: Point): boolean
+ distance(r: Rectangle): double

* contains 1

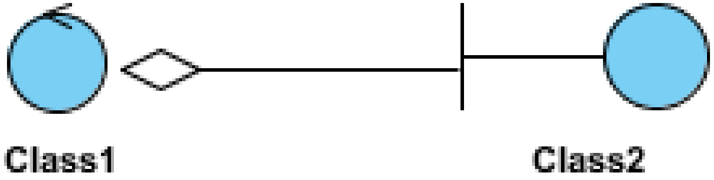
RectangleList

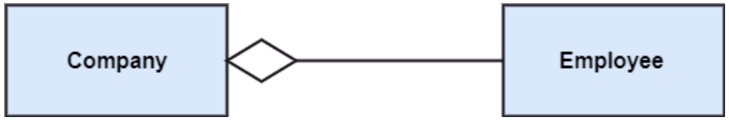
- list: ArrayList

+ add(r: Rectangle)
+ clear()

Relationships between Classes

- **Association:**
  - –Aggregation
    - A special type of association.
    - It represents an “is part of" relationship.
      - –Class2 is part of Class1.
      - –Many instances (denoted by the *) of Class2 can be associated with Class1.
      - –Objects of Class1 and Class2 have separate lifetimes.
        - The figure below shows an example of aggregation.
          - The relationship is displayed as a solid line with a unfilled diamond at the association end, which is connected to the class that represents the aggregate.

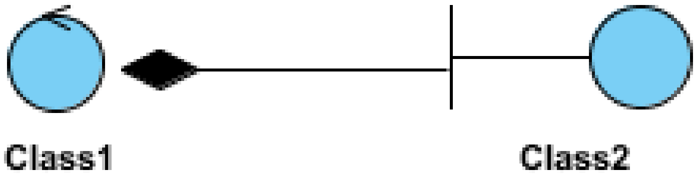


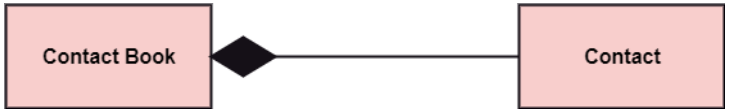


The company encompasses a number of employees, and even if one employee resigns, the company still exists.

Relationships between Classes

- **Association:**
  - –Composition
    - A stronger version of aggregation,
      - –where parts are destroyed when the whole is destroyed
      - –Objects of Class2 live and die with Class1
      - –Class2 cannot stand by itself.
    - It represents an "is entirely made of" relationship.
      - The figure below shows an example of composition.
        - The relationship is displayed as a solid line with a filled diamond at the association end, which is connected to the class that represents the whole or composite.

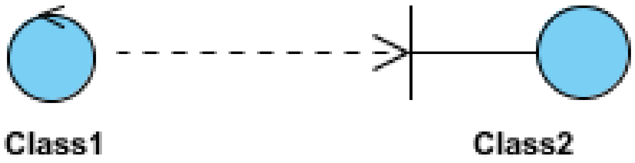


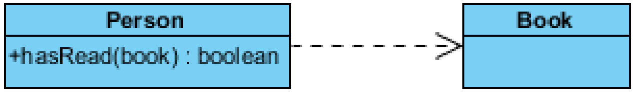


A contact book consists of multiple contacts, and if you delete the contact book, all the contacts will be lost.

Relationships between Classes

- **Association:**
  - –Dependency
    - A special type of association that forms a weaker relationship.
      - –symbolized by a dotted line
    - A semantic relationship between two or more classes,
      - –where a change in one class cause changes in another class,
        - but not the other way around
        - The figure below shows an example of dependency.
          - The relationship is displayed as a dashed line with an open arrow.

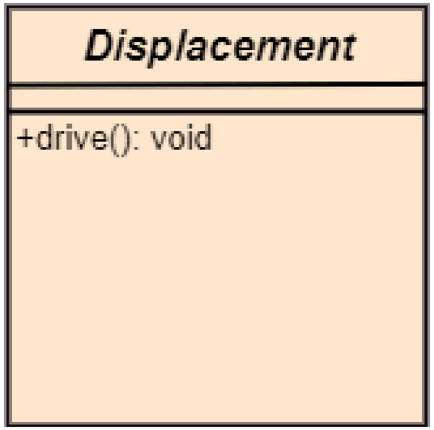




The Person class might have a hasRead method with a Book parameter that returns true if the person has read the book (perhaps by checking some database).

Abstract Classes

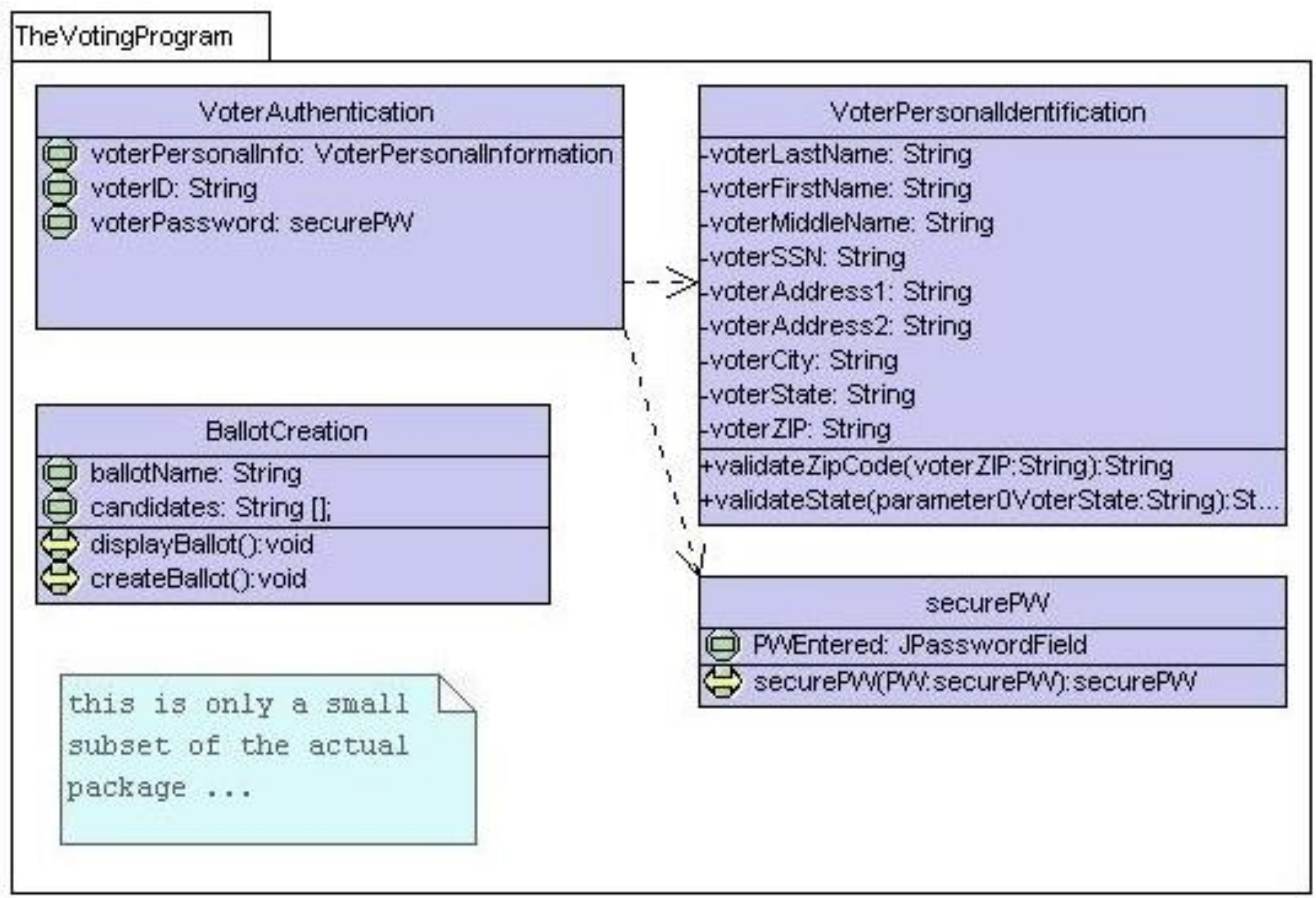
- In the abstract class, no objects can be a direct entity of the abstract class.
- can neither be declared nor be instantiated.
  - It is used to find the functionalities across the classes.
- written in italics.
- It is best to use the abstract class with multiple objects.
  - Assume that we have an abstract class named displacement with a method declared inside it, and that method will be called as a drive ().
    - This abstract class method can be implemented by any object, for example, car, bike, scooter, cycle, etc.



How to draw a Class Diagram?

- The class diagram is used most widely to construct software applications.
  - It not only represents a static view of the system but also all the major aspects of an application.
  - A collection of class diagrams as a whole represents a system.
- Key points to keep in mind while drawing a class diagram:
  - Give a meaningful name to the class diagram.
  - Objects and their relationships should be acknowledged in advance.
  - Attributes and methods of each class must be known.
  - A minimum number of desired properties should be specified
    - more number of the unwanted property will lead to a complex diagram.
  - Notes can be used as and when required by the developer to describe the aspects of a diagram.
  - The diagrams should be redrawn and reworked as many times to make it correct before producing its final version.

Class Diagram Example: Voting Program



TheVotingProgram

VoterAuthentication

voterPersonalInfo: VoterPersonalInformation
voterID: String
voterPassword: securePW

VoterPersonalIdentification

-voterLastName: String
-voterFirstName: String
-voterMiddleName: String
-voterSSN: String
-voterAddress1: String
-voterAddress2: String
-voterCity: String
-voterState: String
-voterZIP: String

+validateZipCode(voterZIP:String):String
+validateState(parameter0VoterState:String):St...

BallotCreation

ballotName: String
candidates: String [];

displayBallot():void
createBallot():void

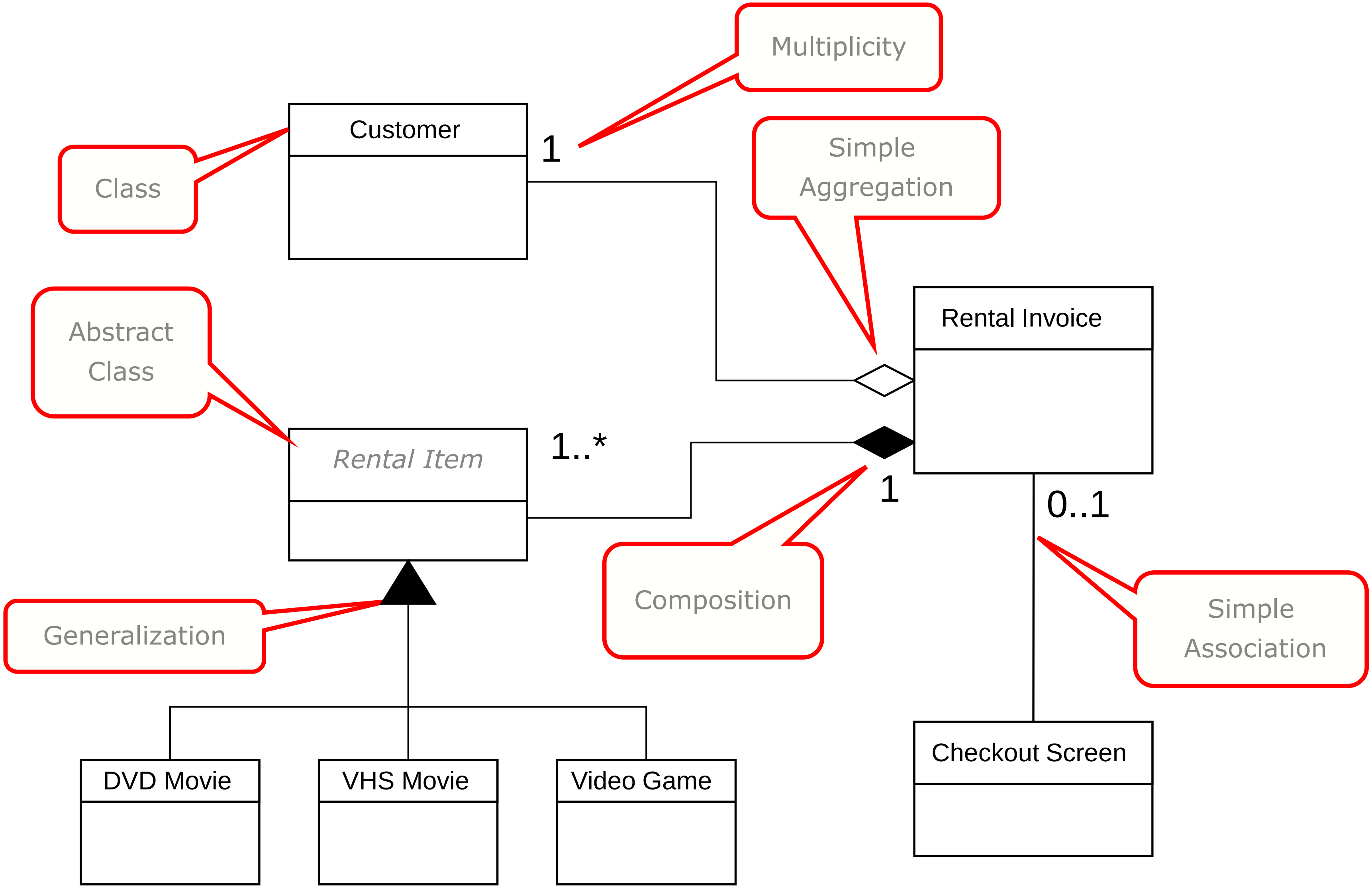
securePW

PWEntered: JPasswordField

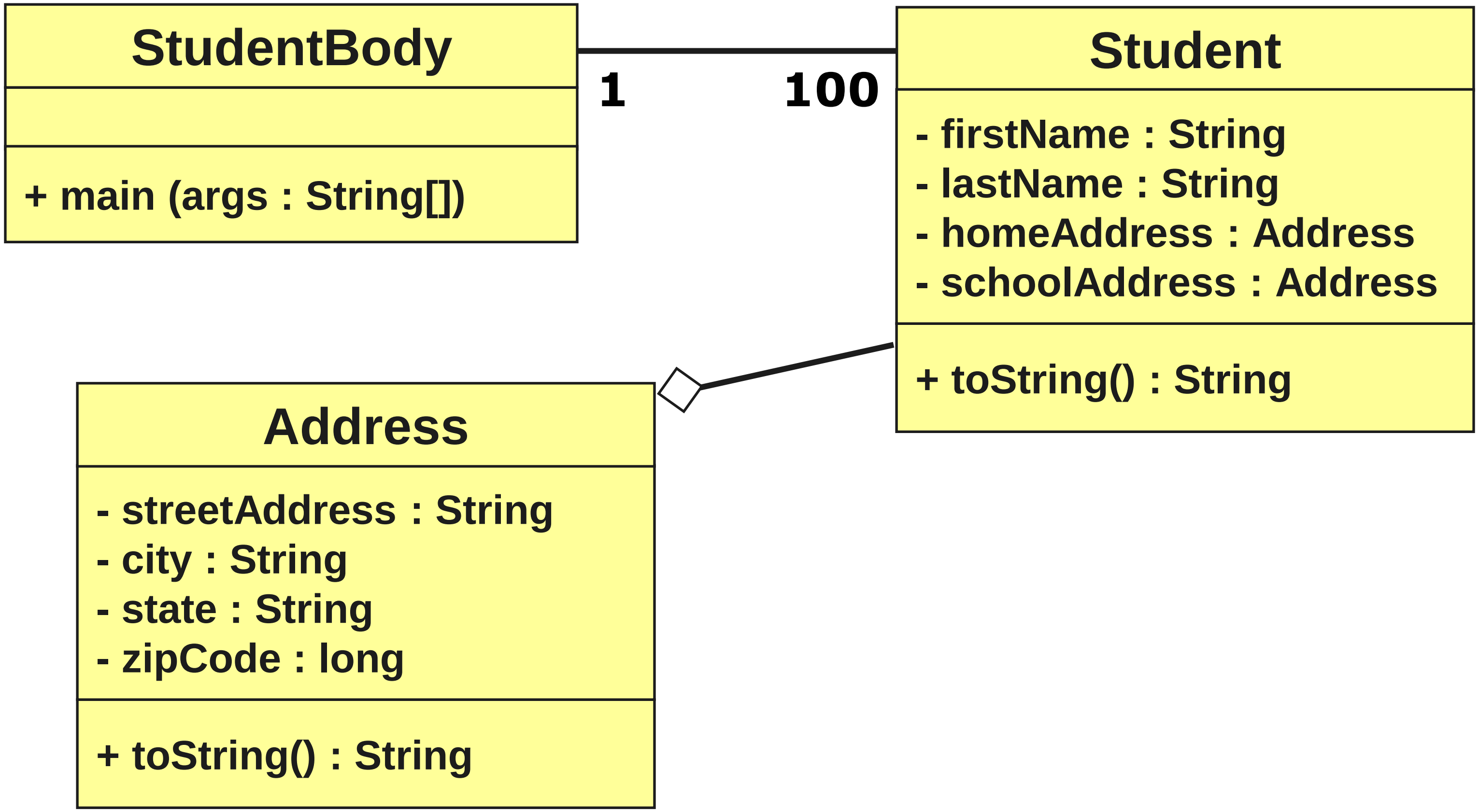
securePW(PW:securePW):securePW

this is only a small subset of the actual package ...

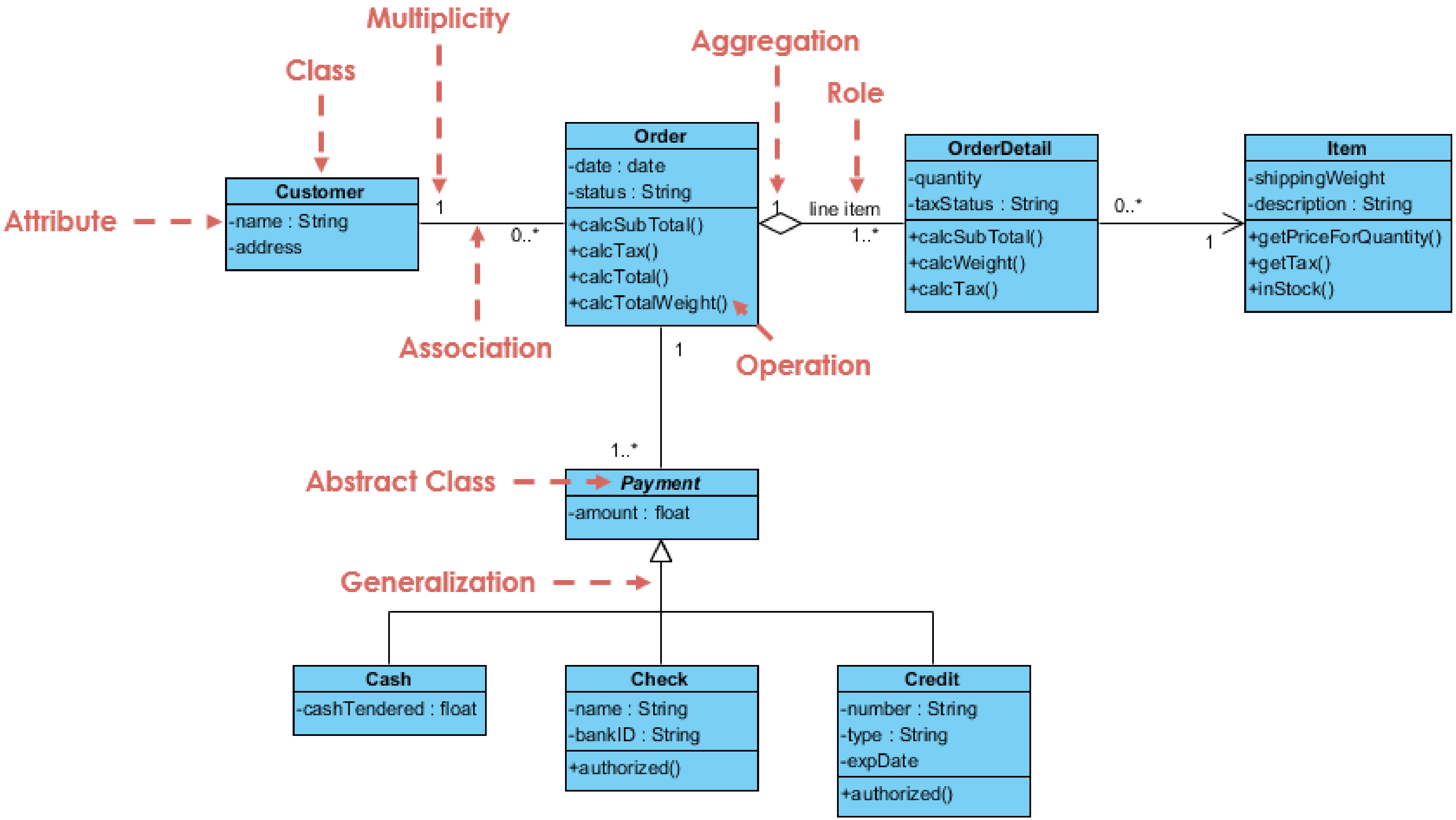
Class Diagram Example: Rental System



Class Diagram Example: Student Record



Class Diagram Example: Order System



Customer
-name : String
-address

Order
-date : date
-status : String
+calcSubTotal()
+calcTax()
+calcTotal()
+calcTotalWeight()

OrderDetail
-quantity
-taxStatus : String
+calcSubTotal()
+calcWeight()
+calcTax()

Item
-shippingWeight
-description : String
+getPriceForQuantity()
+getTax()
+inStock()

Payment
-amount : float

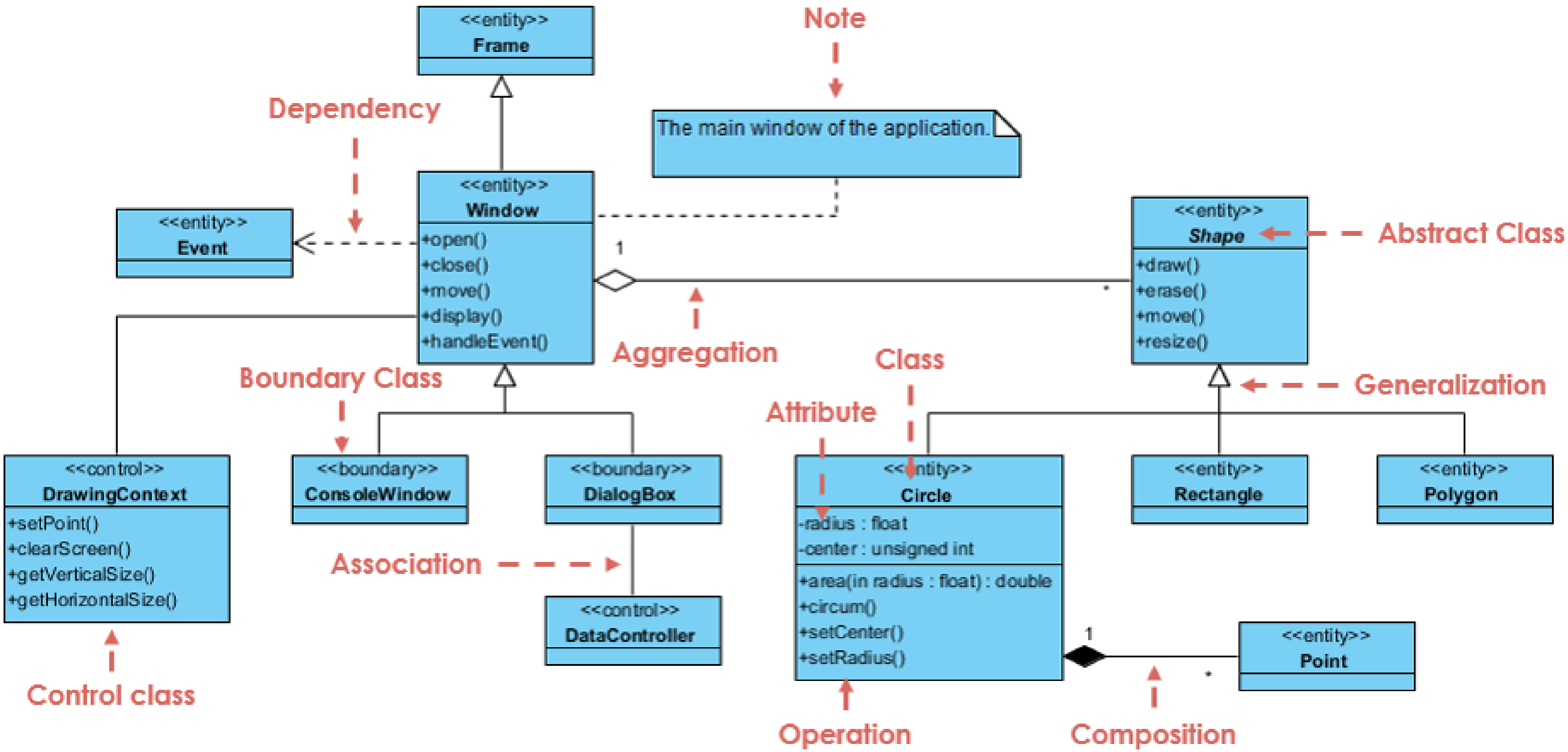
Cash
-cashTendered : float

Check
-name : String
-bankID : String
+authorized()

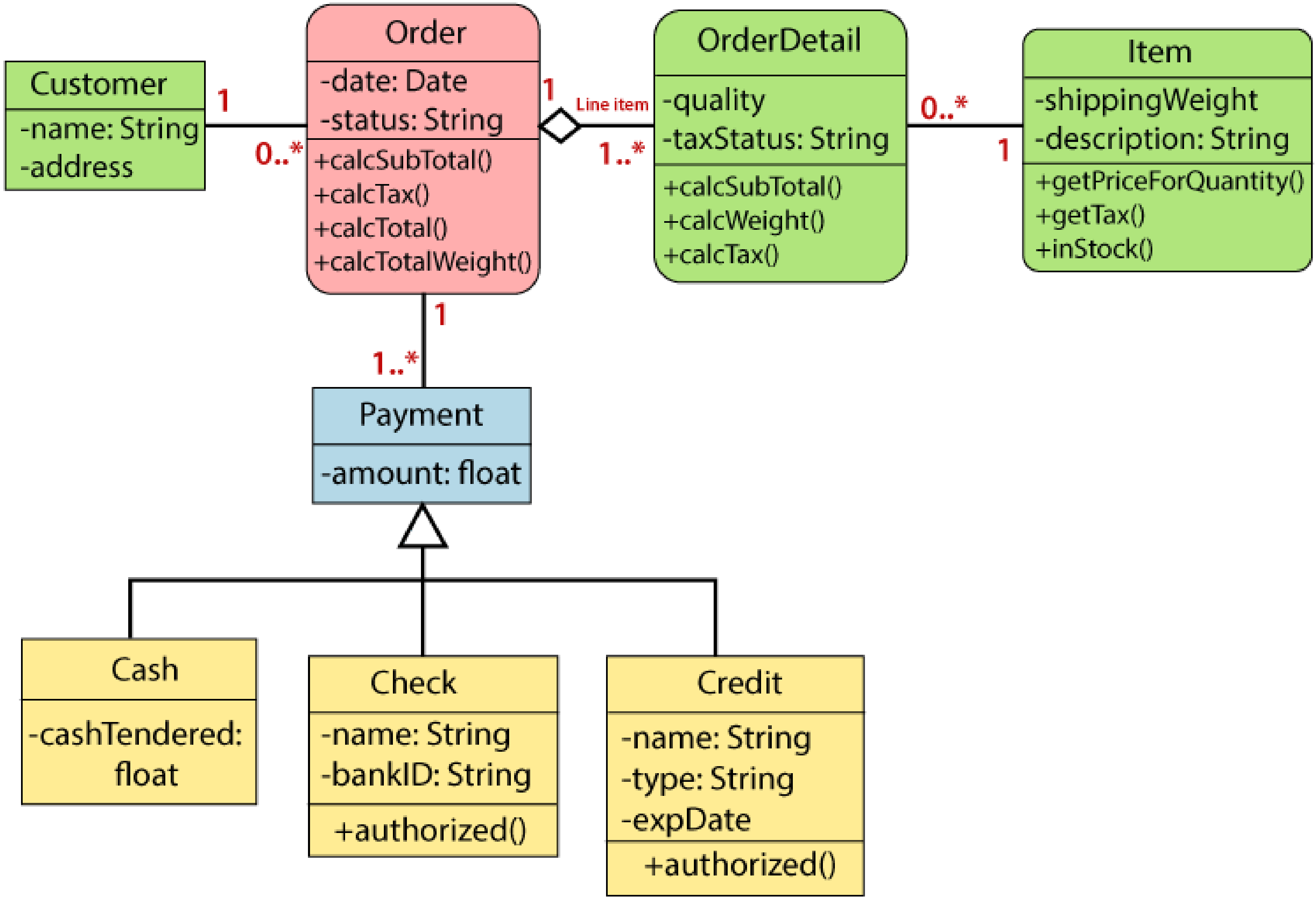
Credit
-number : String
-type : String
-expDate
+authorized()

Class Diagram Example: GUI

- A class diagram may also have notes attached to classes or relationships.



Class Diagram Example: Sales Order System



Tools for creating UML diagrams

- ClickUp
  - https://clickup.com/
- Violet
  - http://horstmann.com/violet/
- Rational Rose
  - https://www.ibm.com/support/pages/ibm-rational-rose-enterprise-7004-ifix001
- Visual Paradigm UML Suite
  - http://www.visual-paradigm.com/
- SmartDraw
  - https://www.smartdraw.com/
- EdrawMax
  - https://www.edrawsoft.com/
- Lucidchartx
  - https://www.lucidchart.com/

  ⋮

    - there are many others, but most are commercial

Any Questions?