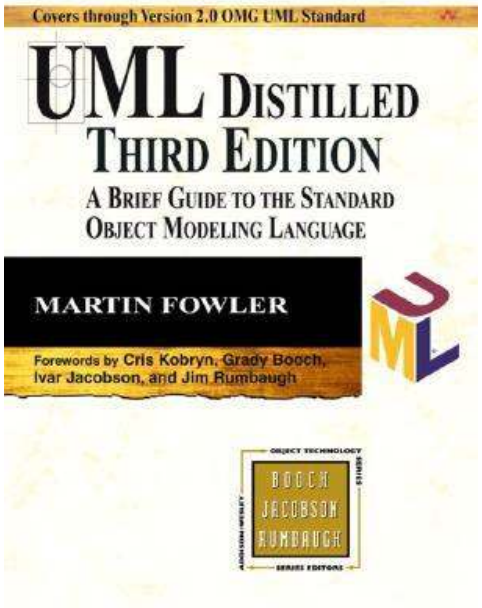


Design and UML Class Diagrams

Suggested reading:

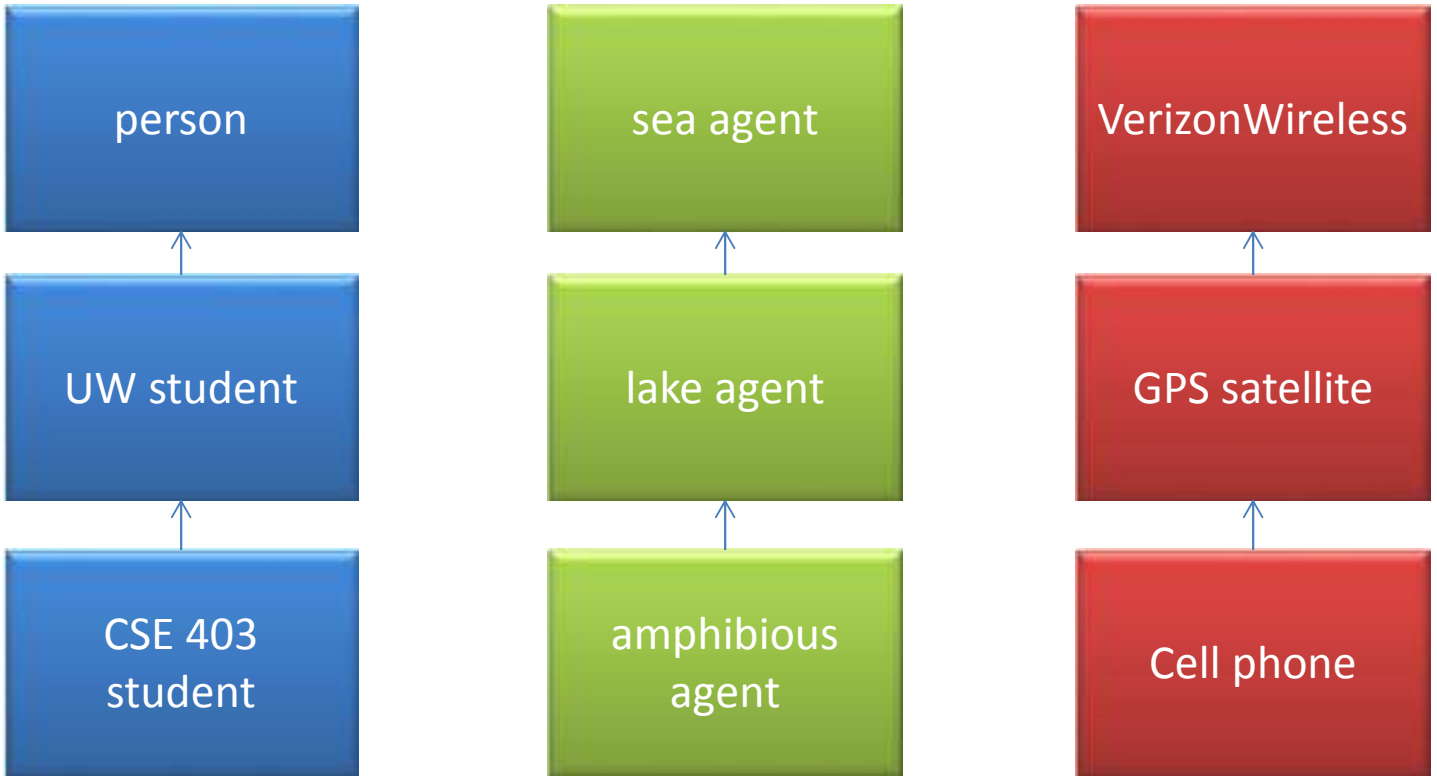
Practical UML: A hands on introduction for developers

http://dn.codegear.com/article/31863

UML Distilled Ch. 3, by M. Fowler

How do people draw / write down software architectures?

Example architectures



Big questions

- What is UML?
  - Why should I bother? Do people really use UML?
- What is a UML class diagram?
  - What kind of information goes into it?
  - How do I create it?
  - When should I create it?

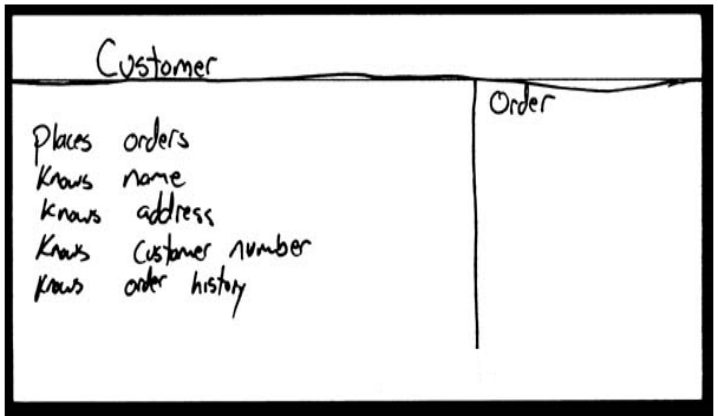
Design phase

- **design**: specifying the structure of how a software system will be written and function, without actually writing the complete implementation

- a transition from "what" the system must do, to "how" the system will do it
  - What classes will we need to implement a system that meets our requirements?
  - What fields and methods will each class have?
  - How will the classes interact with each other?

How do we design classes?

- class identification from project spec / requirements
  - nouns are potential classes, objects, fields
  - verbs are potential methods or responsibilities of a class
- CRC card exercises
  - write down classes' names on index cards
  - next to each class, list the following:
    - **responsibilities**: problems to be solved; short verb phrases
    - **collaborators**: other classes that are sent messages by this class (asymmetric)
- UML diagrams
  - class diagrams (today)
  - sequence diagrams
  - ...



What is UML?

- UML: pictures of an OO system
  - programming languages are not abstract enough for OO design
  - UML is an open standard; lots of companies use it

- What is legal UML?
  - a *descriptive* language: rigid formal syntax (like programming)
  - a *prescriptive* language: shaped by usage and convention
  - it's okay to omit things from UML diagrams if they aren't needed by team/supervisor/instructor

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

In an effort to promote Object Oriented designs, three leading object oriented programming researchers joined ranks to combine their languages:

- Grady Booch (BOOCH)
- Jim Rumbaugh (OML: object modeling technique)
- Ivar Jacobsen (OOSE: object oriented software eng)

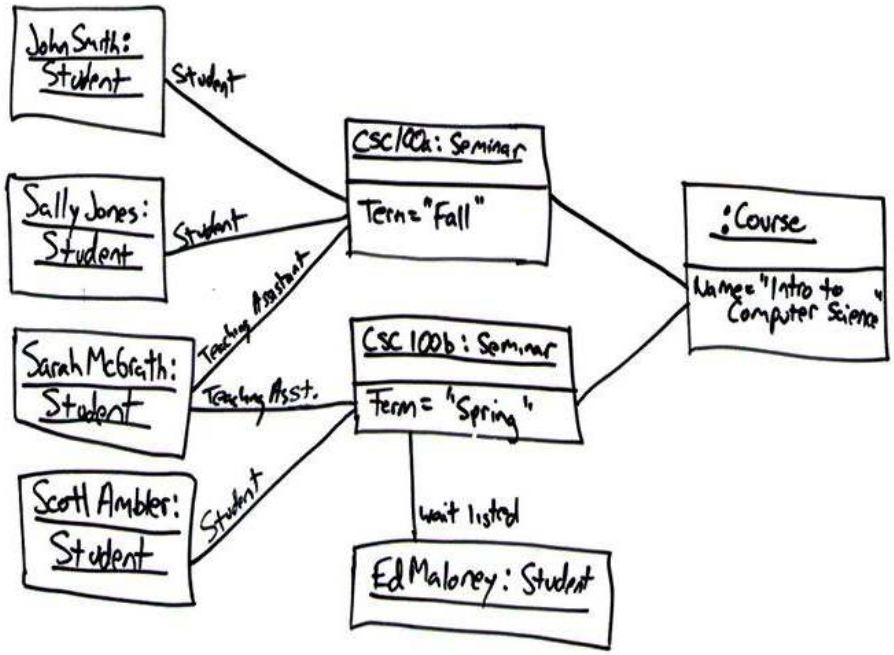
and come up with an industry standard [mid 1990's].

UML – Unified Modeling Language

- Union of all Modeling Languages
  - Use case diagrams
  - Class diagrams
  - Object diagrams
  - Sequence diagrams
  - Collaboration diagrams
  - Statechart diagrams
  - Activity diagrams
  - Component diagrams
  - Deployment diagrams
  - ….
- Very big, but a nice standard that has been embraced by the industry.

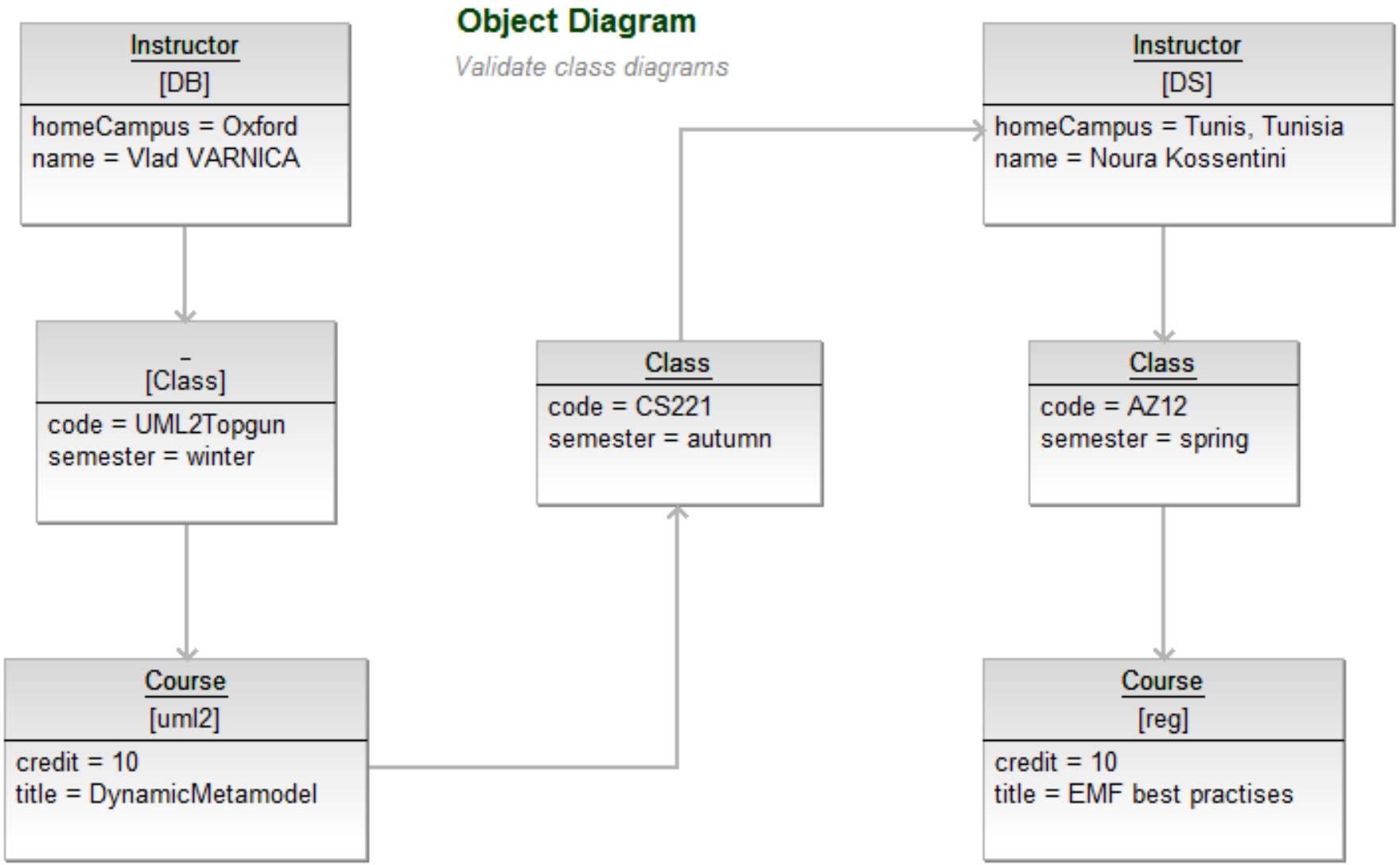
Object diagram (≠ class diagram)

- individual objects (heap layout)
  - objectName : type
  - attribute = value
- lines show field references



- Class diagram:
  - summary of all possible object diagrams

Object diagram example

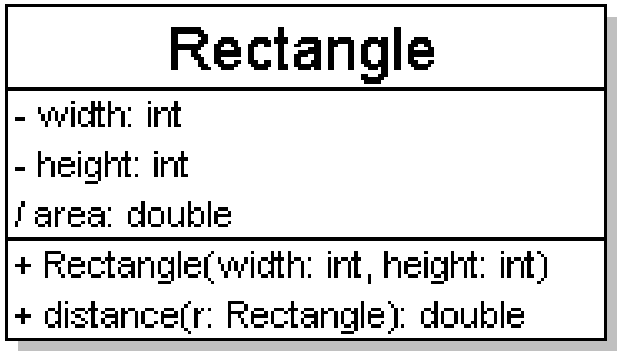


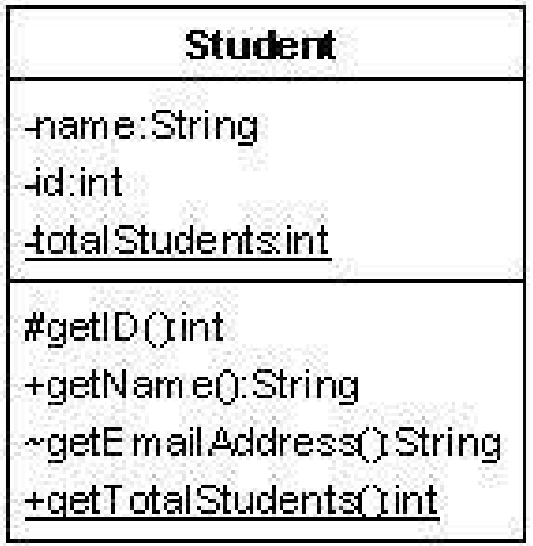
UML class diagrams

- **UML class diagram**: a picture of
  - the classes in an OO system
  - their fields and methods
  - connections between the classes
    - that interact or inherit from each other
- Not represented in a UML class diagram:
  - details of how the classes interact with each other
  - algorithmic details; how a particular behavior is implemented

Diagram of one class

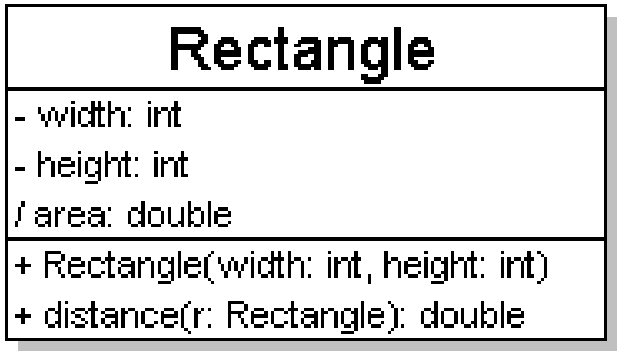
- class name in top of box
  - write <<interface>> on top of interfaces' names
  - use *italics* for an *abstract class* name
- attributes (optional)
  - includes fields of the object
- operations / methods (optional)
  - may omit trivial (get/set) methods
    - but don't omit any methods from an interface!
  - should not include inherited methods

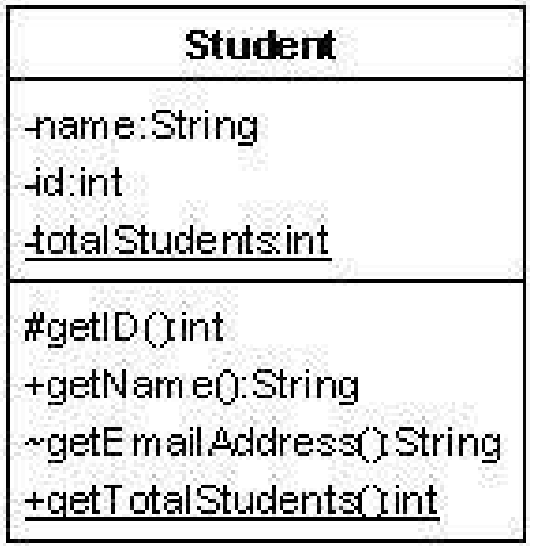




Class attributes (= fields)

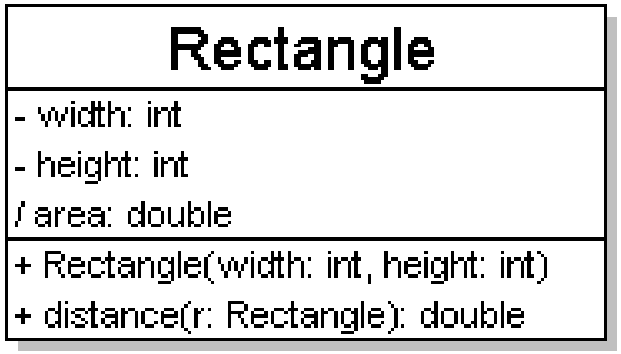
- attributes (fields, instance variables)
  - *visibility name* : *type* [*count*] = *default_value*
  - visibility:
    - \+ public
    - # protected
    - - private
    - ~ package (default)
    - / derived
  - underline static attributes
  - **derived attribute**: not stored, but can be computed from other attribute values
    - "specification fields " from CSE 331
  - attribute example:
    - balance : double = 0.00

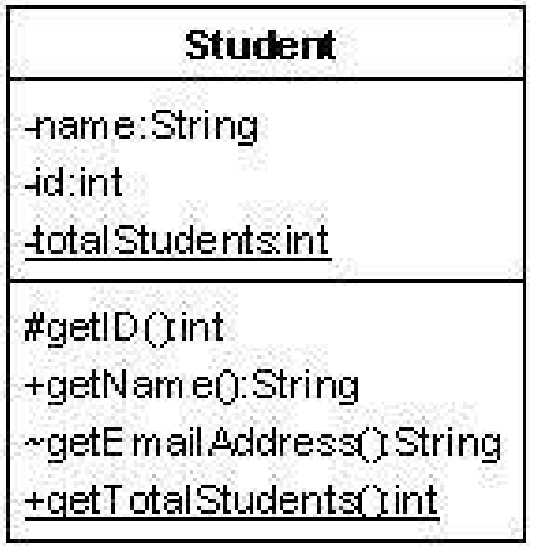




Class operations / methods

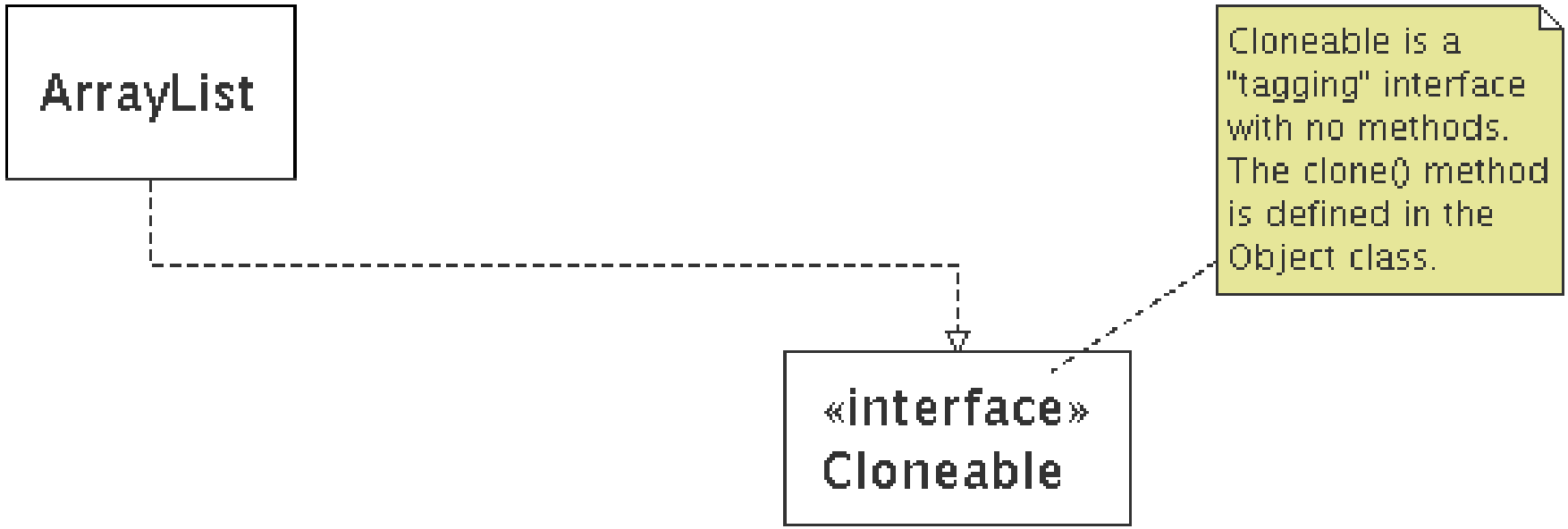
- operations / methods
  - *visibility name* (*parameters*) : *return_type*
  - visibility:
    - \+ public
    - # protected
    - \- private
    - ~ package (default)
  - underline static methods
  - parameter types listed as (name: type)
  - omit *return_type* on constructors and when return type is void
  - method example:
    + distance(p1: Point, p2: Point): double





Comments

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



Relationships between classes

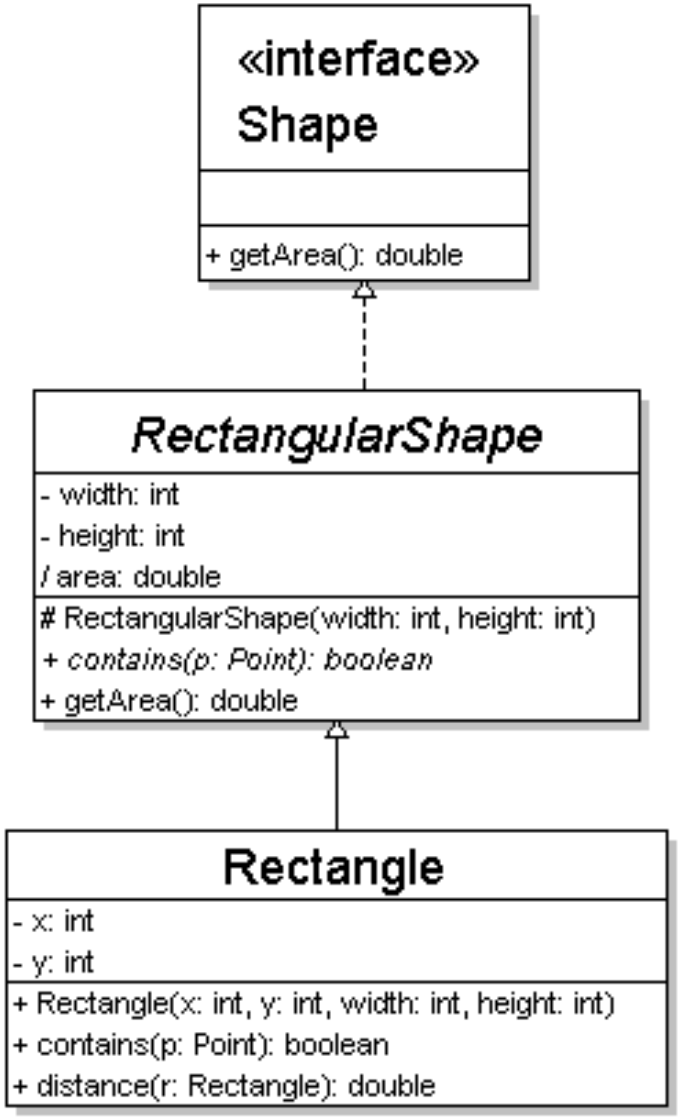
- **generalization**: an inheritance relationship
  - inheritance between classes
  - interface implementation

- **association**: a usage relationship
  - dependency
  - aggregation
  - composition

Generalization (inheritance) relationships

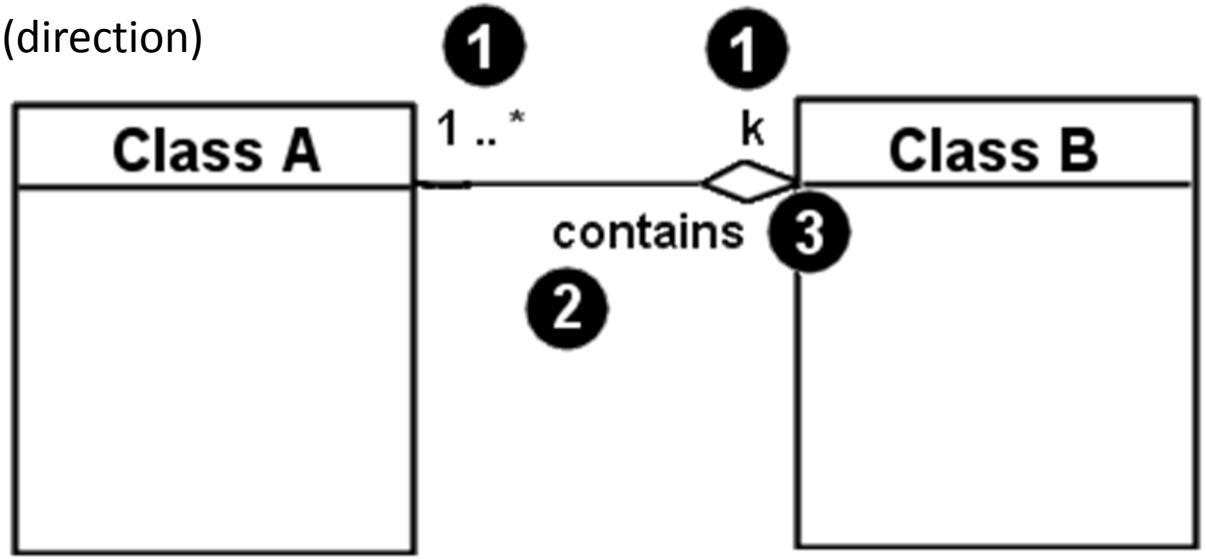
- hierarchies drawn top-down
- arrows point upward to parent
- line/arrow styles indicate whether parent is a(n):
  - class:
    solid line, black arrow
  - abstract class:
    solid line, white arrow
  - interface:
    dashed line, white arrow

- often omit trivial / obvious generalization relationships, such as drawing the Object class as a parent



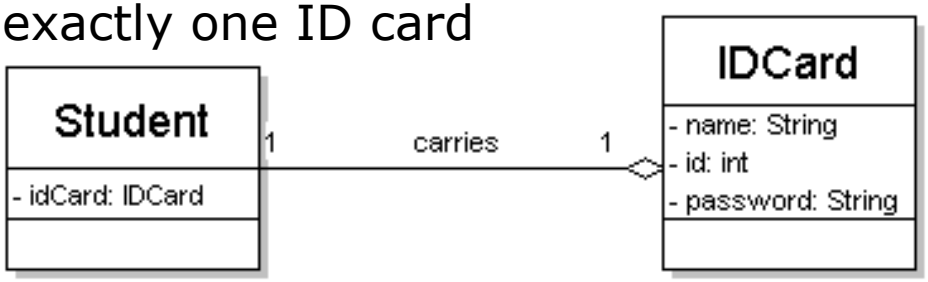
Associational relationships

- 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 (also written as “3..”)
  2. name (what relationship the objects have)
  3. navigability (direction)

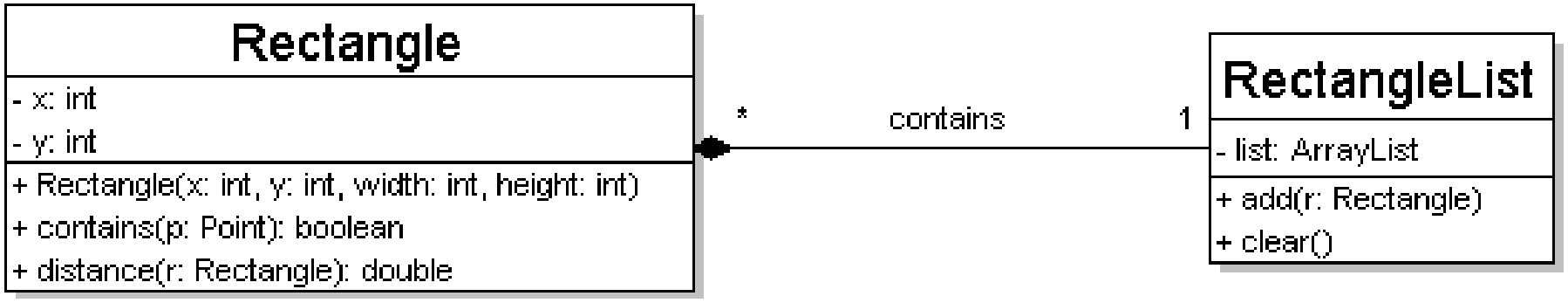


Multiplicity of associations

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

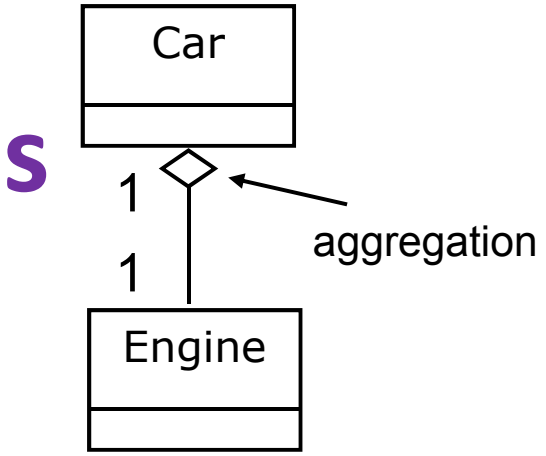


- one-to-many
  - one rectangle list can contain many rectangles

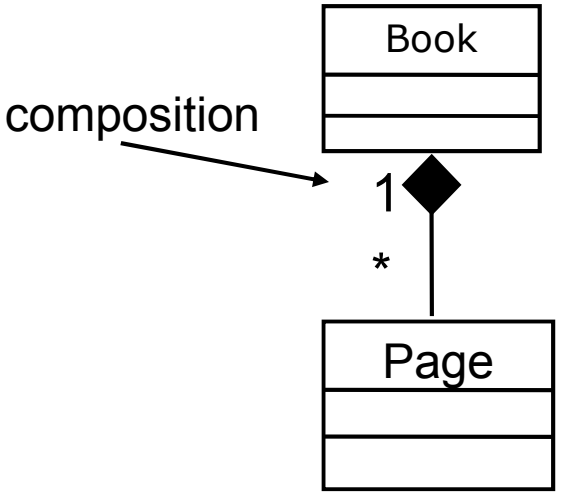


Association types

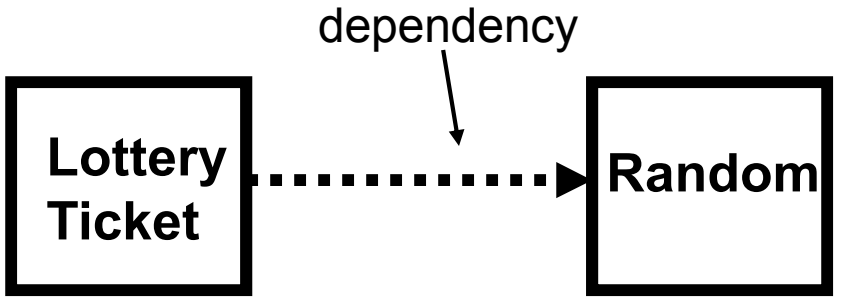
- **aggregation**: "is part of"
  - symbolized by a clear white diamond



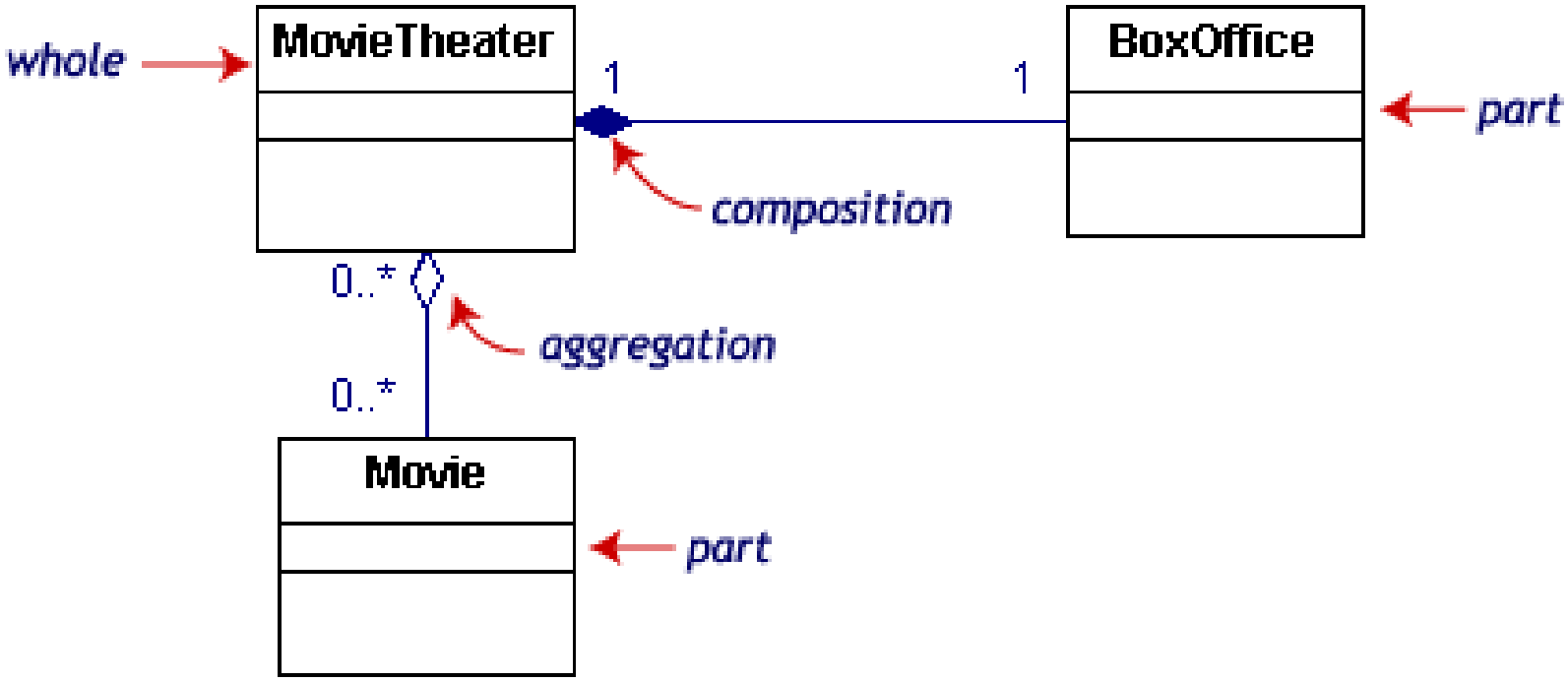
- **composition**: "is entirely made of"
  - stronger version of aggregation
  - the parts live and die with the whole
  - symbolized by a black diamond



- **dependency**: "uses temporarily"
  - symbolized by dotted line
  - often is an implementation detail, not an intrinsic part of that object's state



Composition/aggregation example

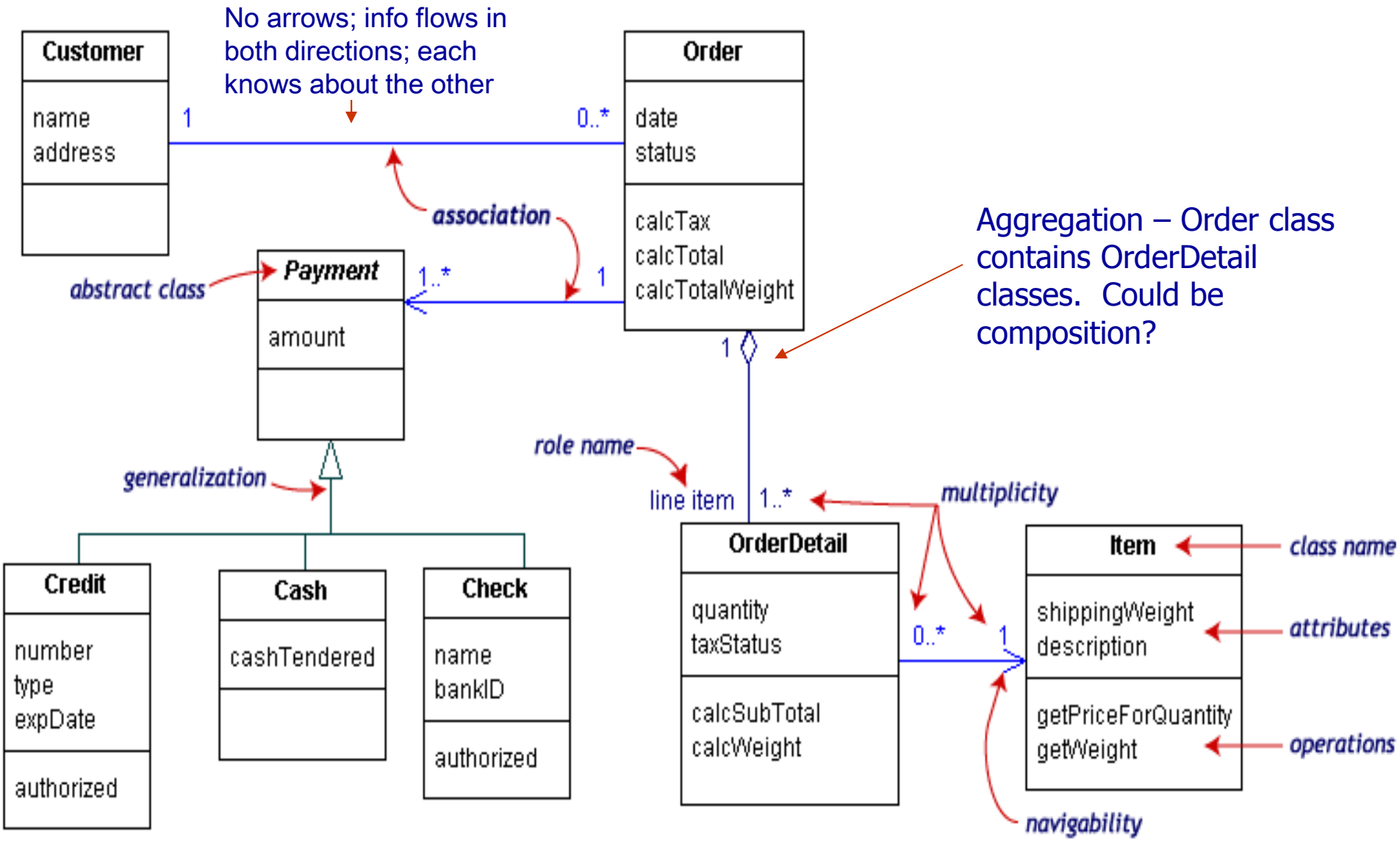


If the movie theater goes away

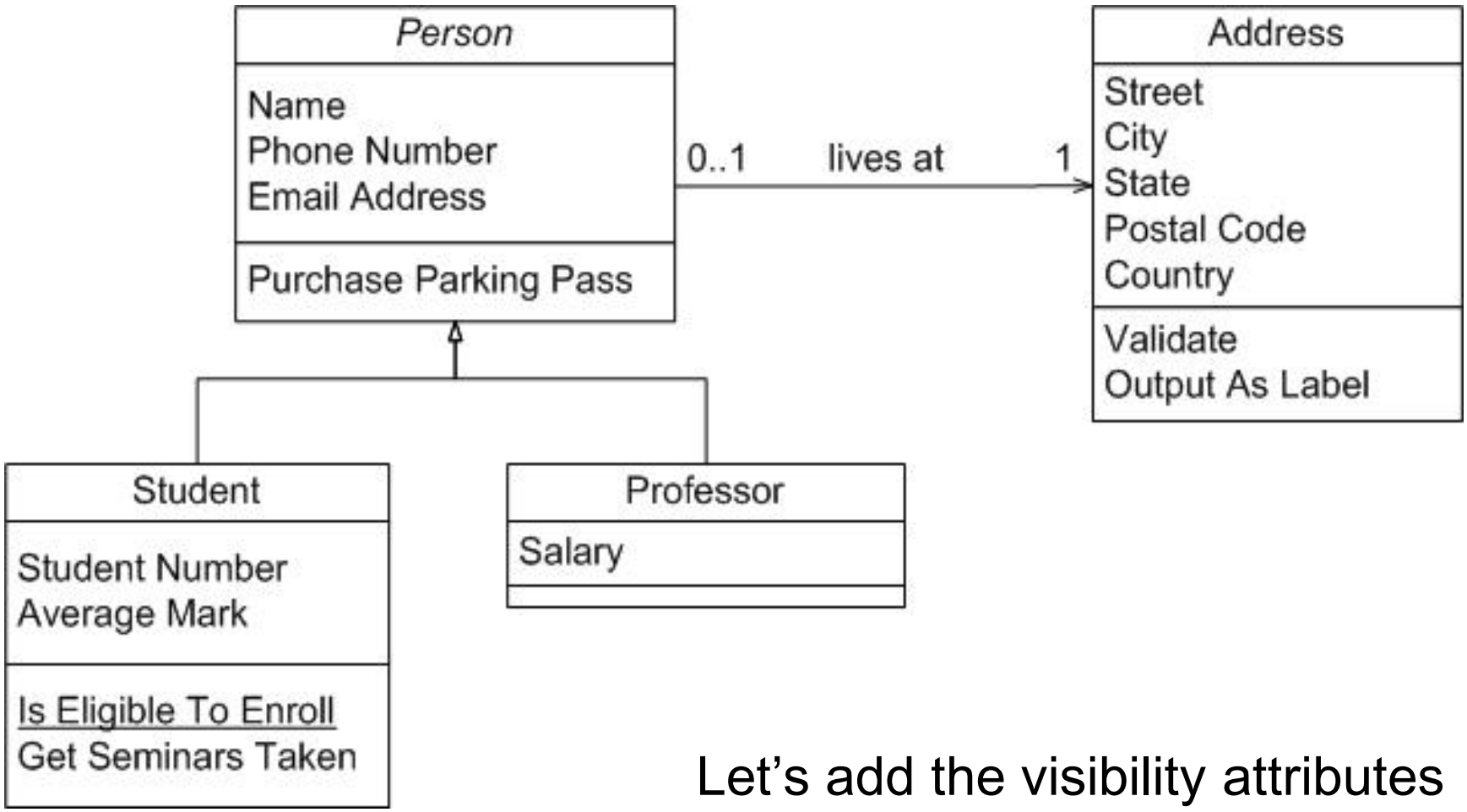
so does the box office => composition

but movies may still exist => aggregation

Class diagram example

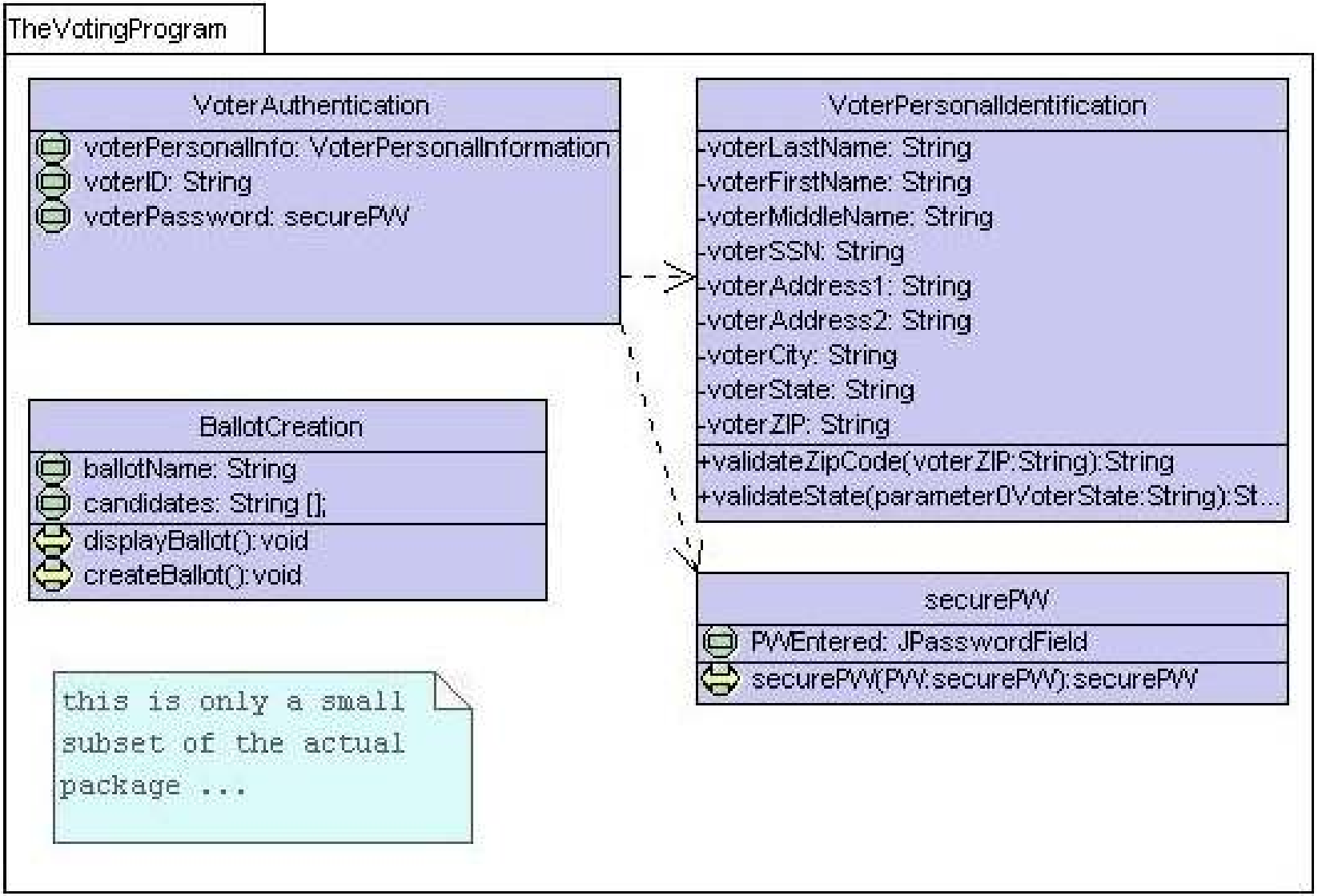


UML example: people

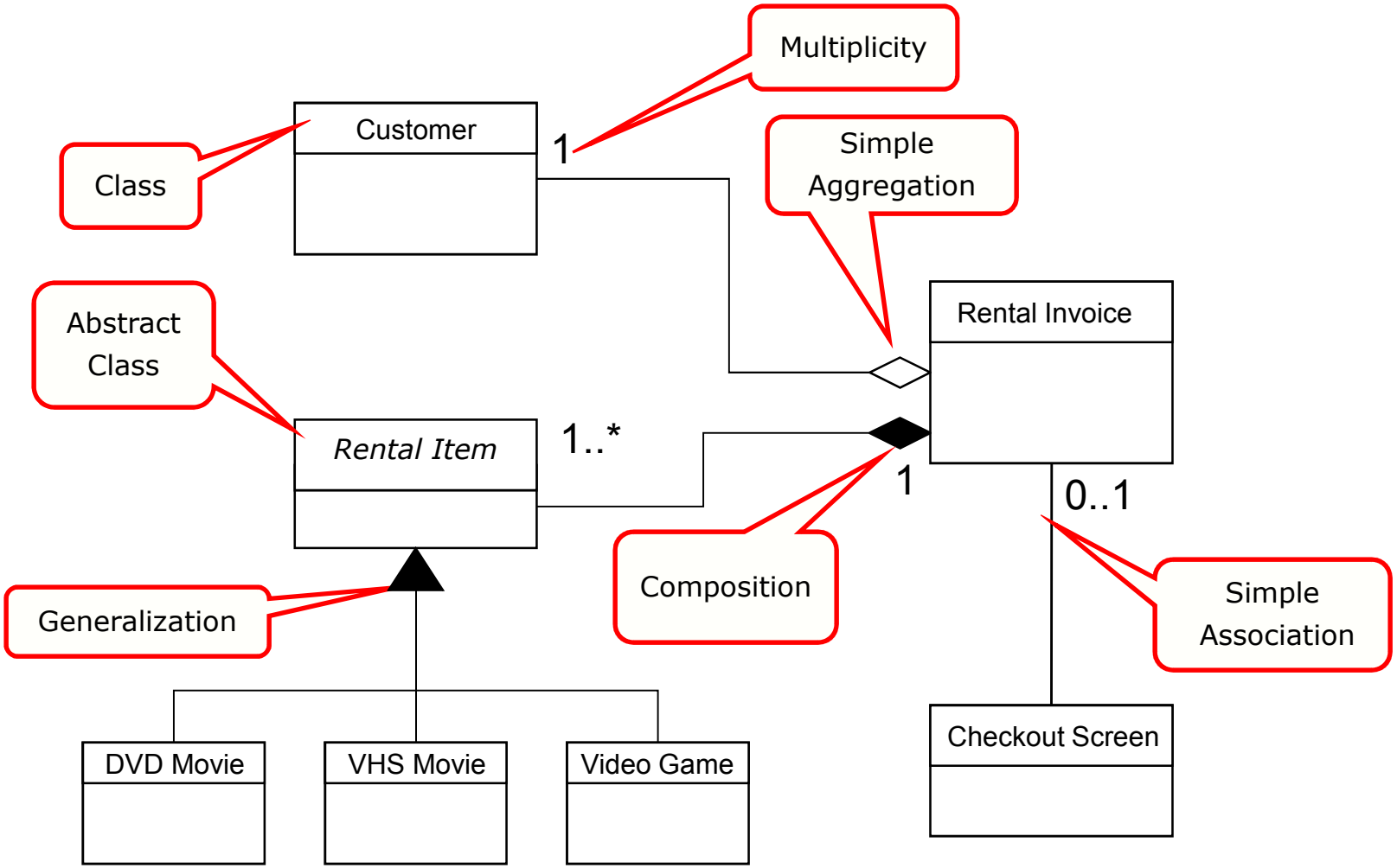


Let's add the visibility attributes

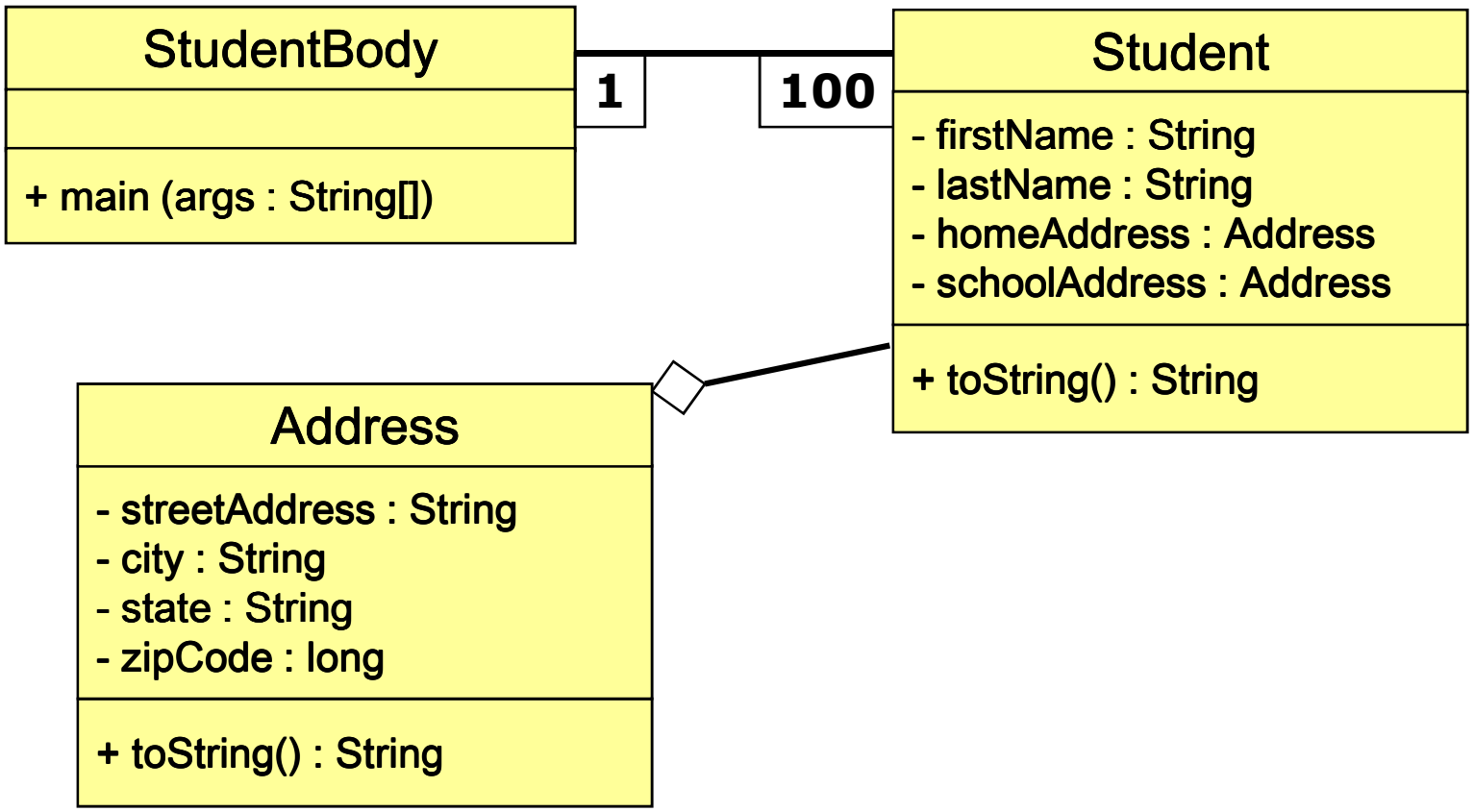
Class diagram: voters



Class diagram example: video store



Class diagram example: student



Tools for creating UML diagrams

- Violet (free)
  - http://horstmann.com/violet/
- Rational Rose
  - http://www.rational.com/
- Visual Paradigm UML Suite (trial)
  - http://www.visual-paradigm.com/
  - (nearly) direct download link:
    http://www.visual-paradigm.com/vp/download.jsp?product=vpuml&edition=ce

(there are many others, but most are commercial)

Design exercise: Texas Hold ‘em poker game

- 2 to 8 human or computer players
- Each player has a name and stack of chips
- Computer players have a difficulty setting: easy, medium, hard
- Summary of each hand:
  - Dealer collects ante from appropriate players, shuffles the deck, and deals each player a hand of 2 cards from the deck.
  - A betting round occurs, followed by dealing 3 shared cards from the deck.
  - As shared cards are dealt, more betting rounds occur, where each player can fold, check, or raise.
  - At the end of a round, if more than one player is remaining, players' hands are compared, and the best hand wins the pot of all chips bet so far.
- What classes are in this system? What are their responsibilities? Which classes collaborate?
- Draw a class diagram for this system. Include relationships between classes (generalization and associational).

Class diagram pros/cons

- Class diagrams are great for:
  - discovering related data and attributes
  - getting a quick picture of the important entities in a system
  - seeing whether you have too few/many classes
  - seeing whether the relationships between objects are too complex, too many in number, simple enough, etc.
  - spotting dependencies between one class/object and another

- Not so great for:
  - discovering algorithmic (not data-driven) behavior
  - finding the flow of steps for objects to solve a given problem
  - understanding the app's overall control flow (event-driven? web-based? sequential? etc.)