CSE 403: Software Engineering, Fall 2016

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UML Class Diagrams

Emina Torlak
emina@cs.washington.edu

Outline

- Designing classes
- Overview of UML
- UML class diagrams
    - Syntax and semantics
    - Examples

design phase: from requirements to code

Software design

- **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 to design classes?

Identify classes and interactions from project requirements:

- **Nouns** are potential classes, objects, and fields
- **Verbs** are potential methods or responsibilities of a class
- **Relationships** between nouns are potential interactions (containment, generalization, dependence, etc.)

How to design classes?

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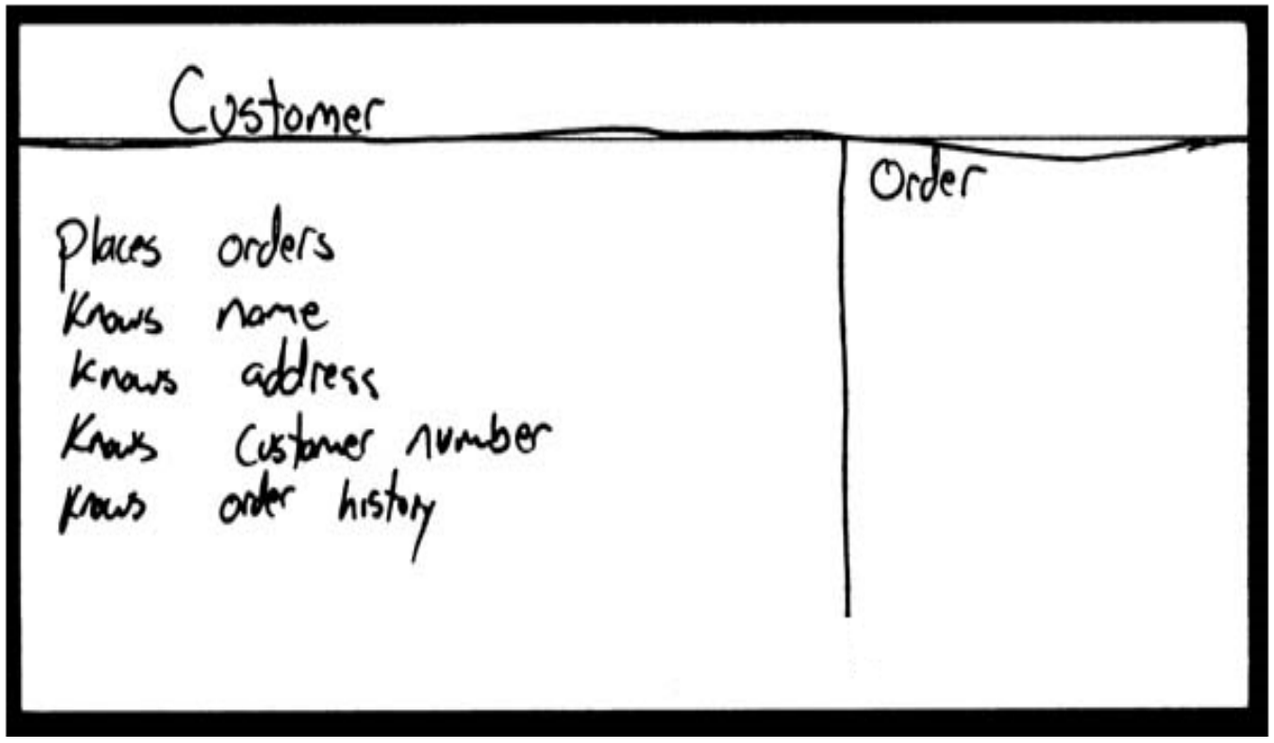
- Which nouns in your project should be classes?
- Which ones are fields?
- What verbs should be methods?
- What are potential interactions between your classes?

Describing designs with CRC cards

CRC (class-responsibility-collaborators) cards

- on top of the card, write down the name of the class
- below the name, list the following:
  - **responsibilities**: problems to be solved; short verb phrases
  - **collaborators**: other classes that are sent messages by this class



Describing designs with UML diagrams

- Class diagram (today)
    - Shows classes and relationships among them.
    - A static view of the system, displaying what interacts but not what happens when they do interact.
- Sequence diagram (next lecture)
    - A dynamic view of the system, describing how objects collaborate: what messages are sent and when.

basics

describing designs with UML: an overview

What is UML?

- Pictures or views 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

UML: Unified Modeling Language

- Union of Many Languages
  - Use case diagrams
  - Class diagrams
  - Object diagrams
  - Sequence diagrams
  - Collaboration diagrams
  - Statechart diagrams
  - Activity diagrams
  - Component diagrams
  - Deployment diagrams
  - ….

A very big language!

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 diagrams

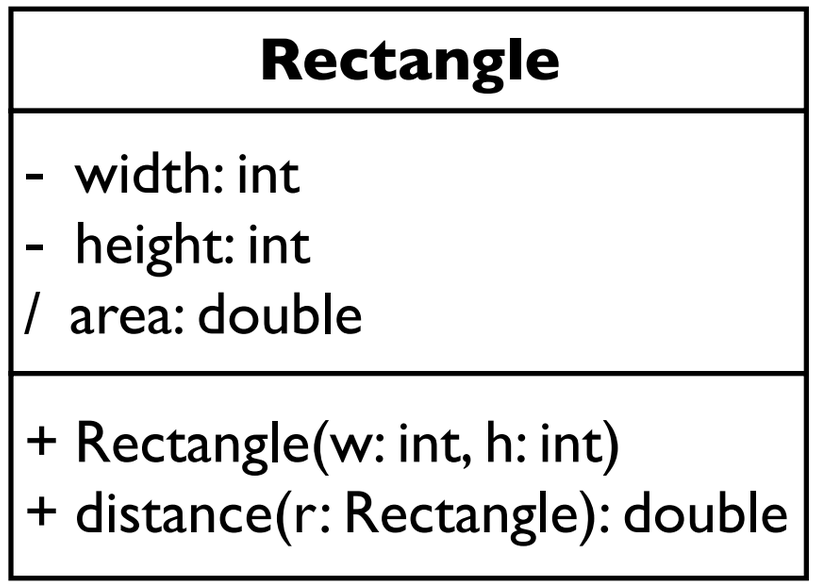
What is a UML class diagram?

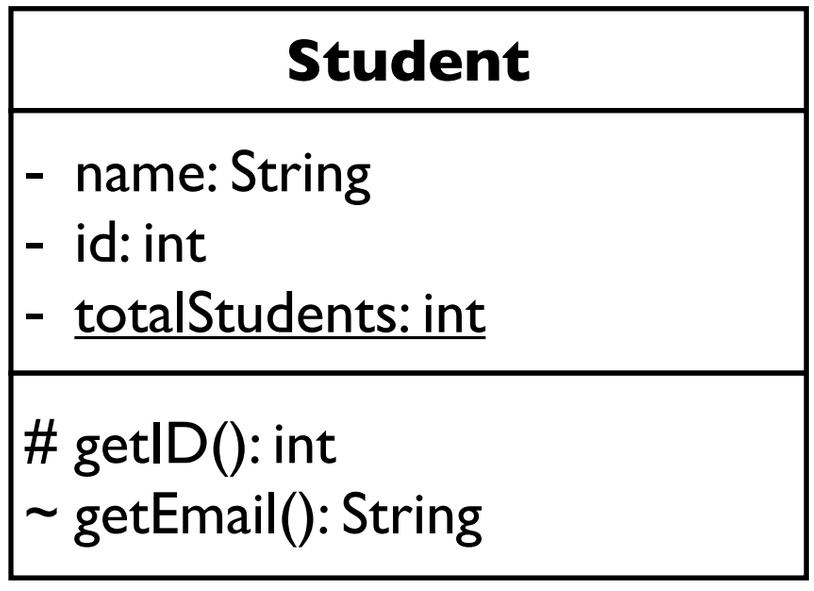
- A UML class diagram is a picture of
  - the classes in an OO system
  - their fields and methods
  - connections between the classes that interact or inherit from each other

- 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 a single class

- Class name
  - write «interface» on top of interfaces' names
  - use *italics* for an abstract class name
- Attributes (optional)
  - fields of the class
- 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, instance variables)

visibility name : type [count] = default_value

- visibility
  - \+ public
  - \# protected
  - \- private
  - ~ package (default)
  - / derived
- **derived attribute**: not stored, but can be computed from other attribute values
  - "specification fields" from CSE 331
- underline static attributes

Rectangle
- width: int - height: int / area: double
+ Rectangle(w: int, h: int) + distance(r: Rectangle): double

Student
- name: String - id: int - totalStudents: int
getID(): int ~ getEmail(): String

Class operations / methods

visibility name(parameters) : return_type

- visibility
  - \+ public
  - \# protected
  - \- private
  - ~ package (default)
- parameters listed as name : type
- underline static methods
- omit return_type on constructors and when return type is void

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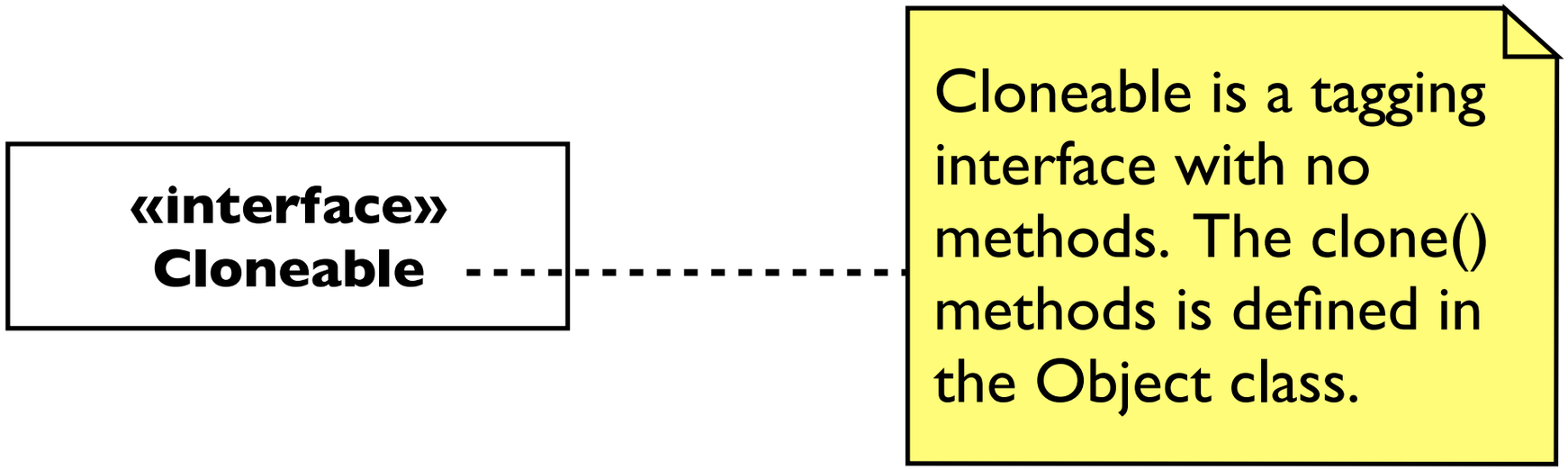
Comments

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

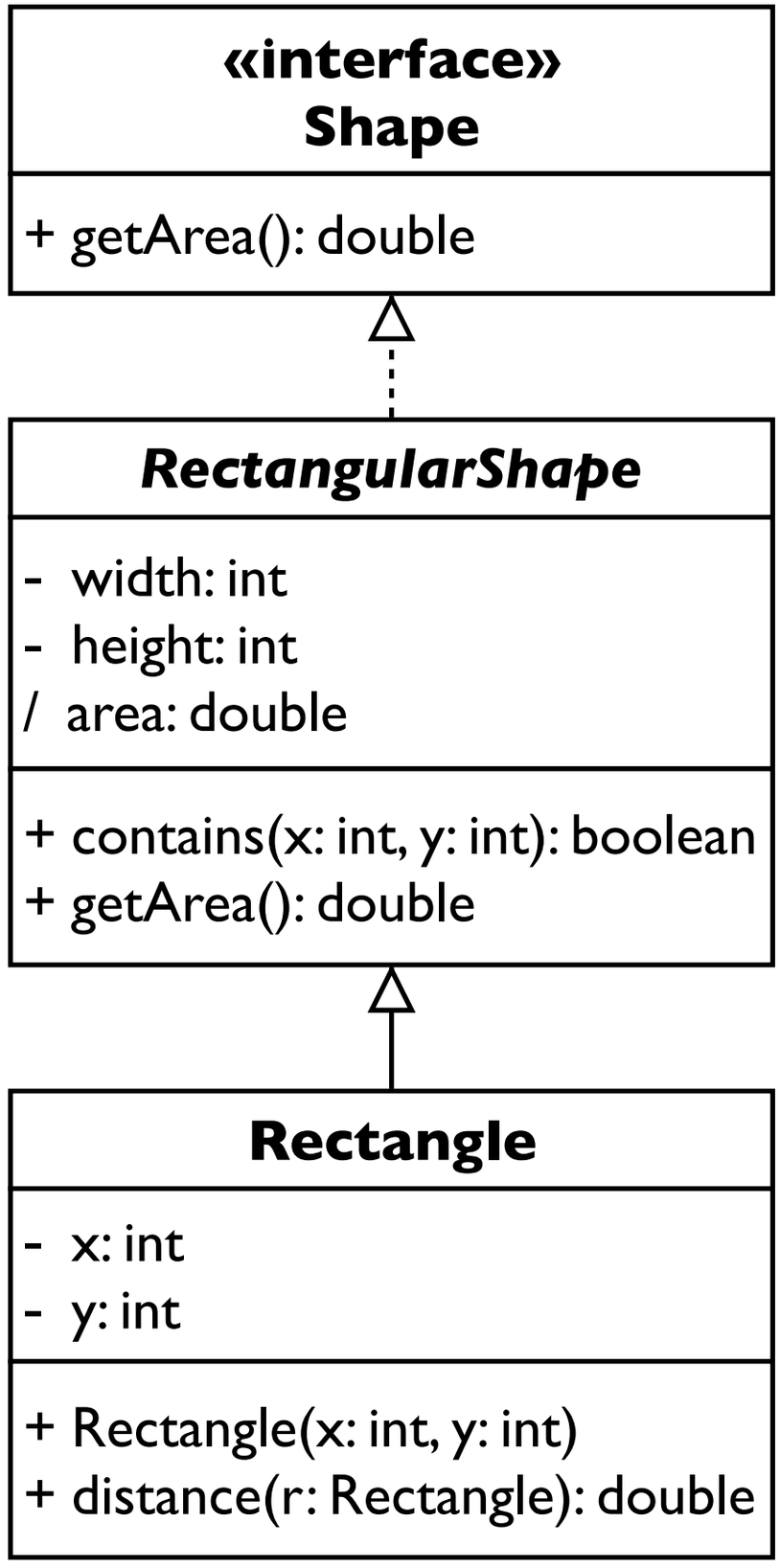


Relationships between classes

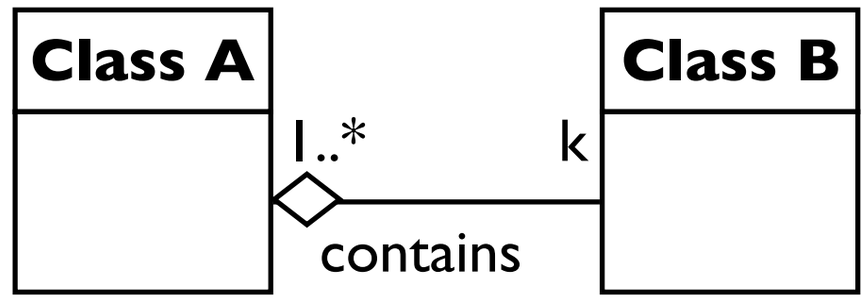
- **Generalization**: an inheritance relationship
    - inheritance between classes
    - interface implementation
- **Association**: a usage relationship
    - dependency
    - aggregation
    - composition

Generalization relationships

- Hierarchies drawn top-down
- Arrows point upward to parent
- Line/arrow styles indicate if 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

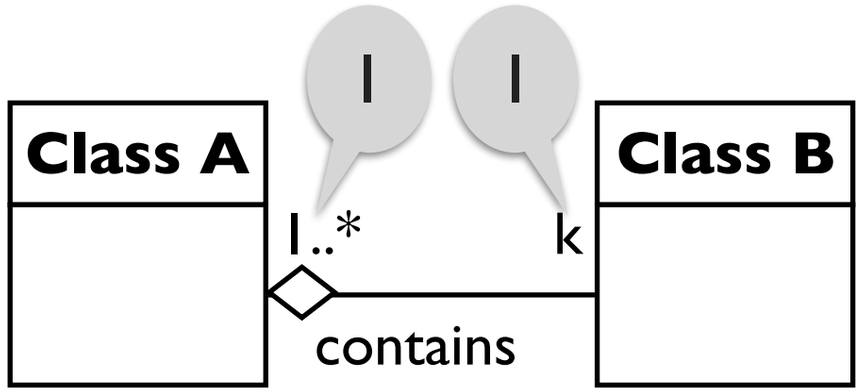


Associational (usage) relationships



Associational (usage) relationships

1. Multiplicity (how many are used)
   - * (zero or more)
   - 1 (exactly one)
   - 2..4 (between 2 and 4, inclusive)
   - 3..* (3 or more, * may be omitted)



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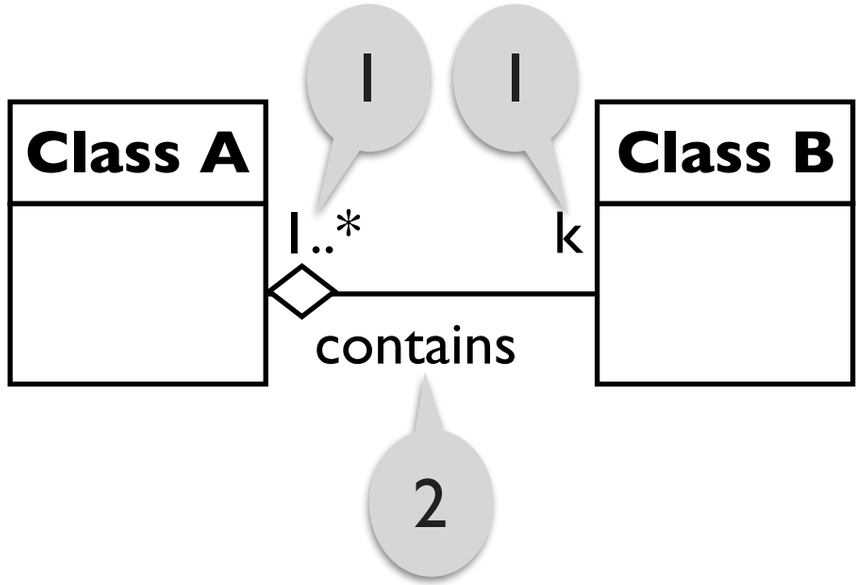

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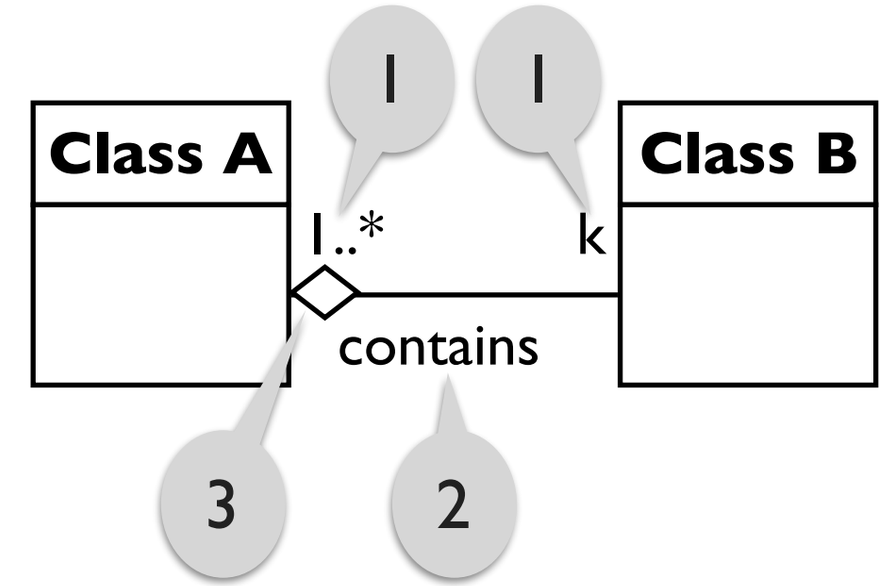
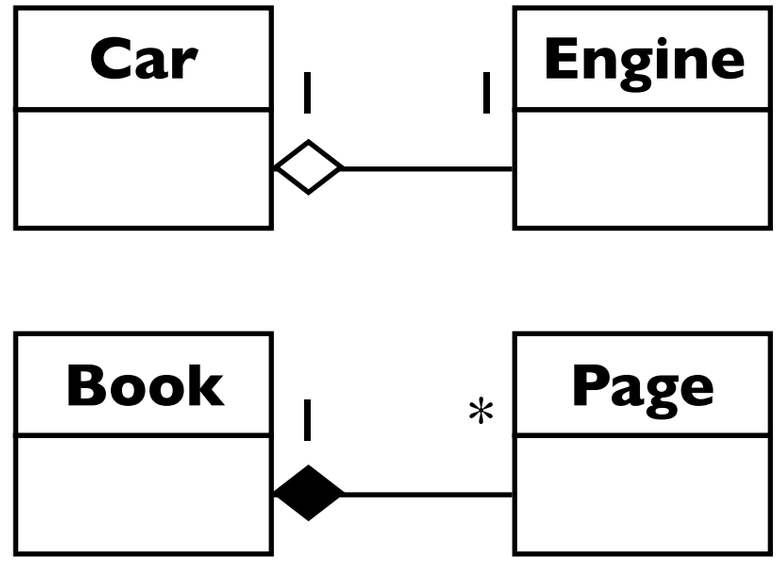
2. Name (what relationship the objects have)
3. Navigability (direction)

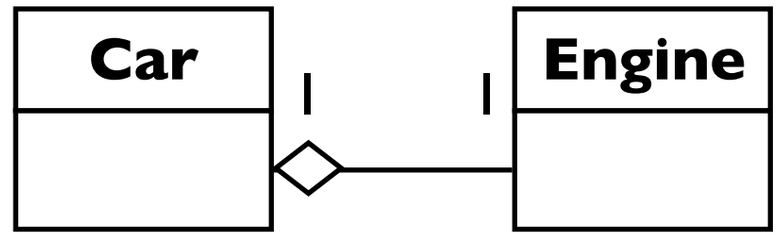


Association multiplicities

- One-to-one
  - Each car has exactly one engine.
  - Each engine belongs to exactly one car.
- One-to-many
  - Each book has many pages.
  - Each page belongs to exactly one book.

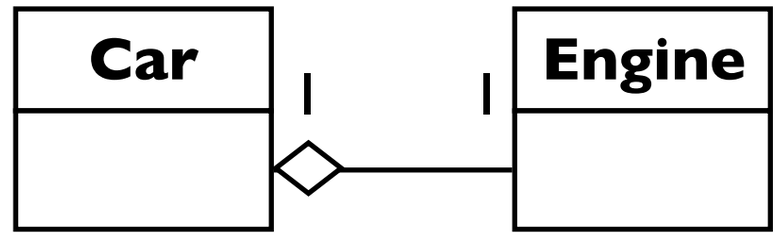


Association types



Association types

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



Association types

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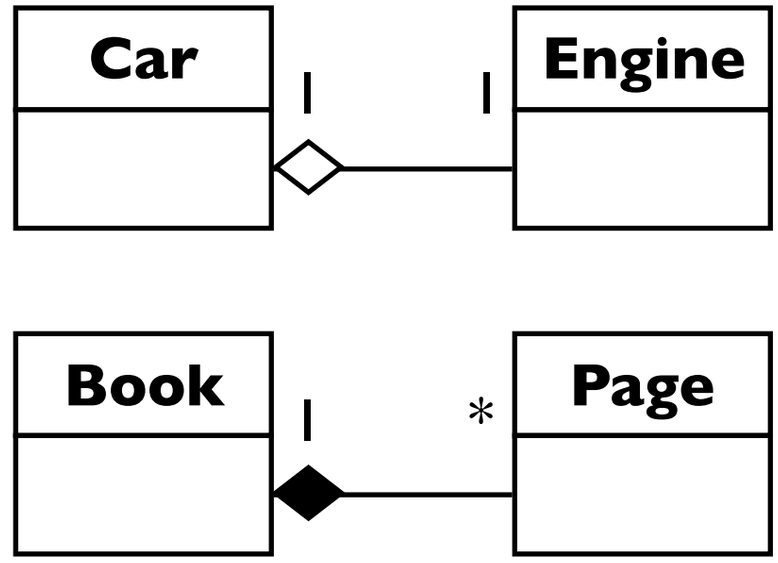
- **Composition**: "is entirely made of"
  - stronger version of aggregation
  - the parts live and die with the whole
  - symbolized by a black diamond



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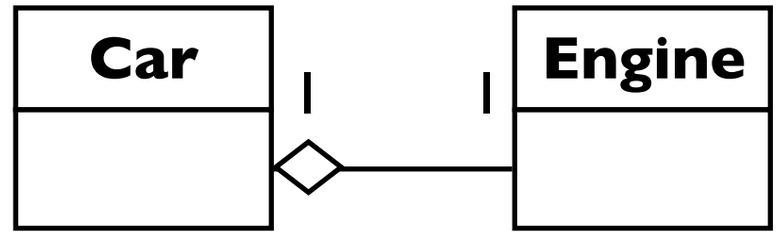
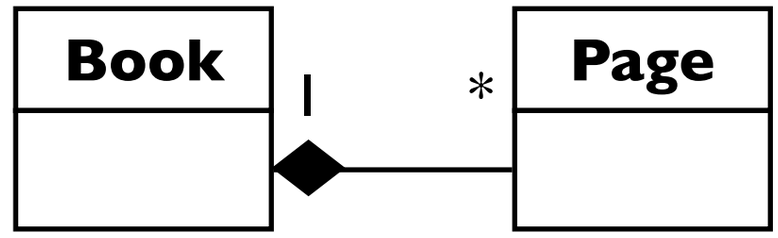
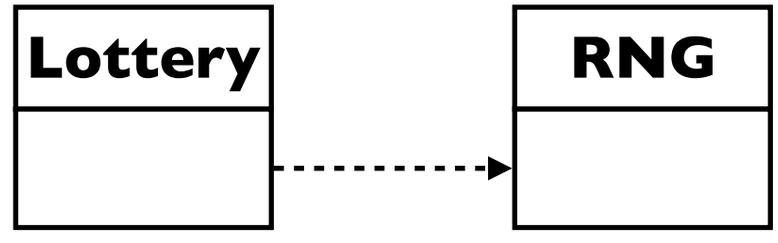
- **Dependency**: "uses temporarily"
  - symbolized by dotted line
  - often is an implementation detail, not an intrinsic part of the object's state

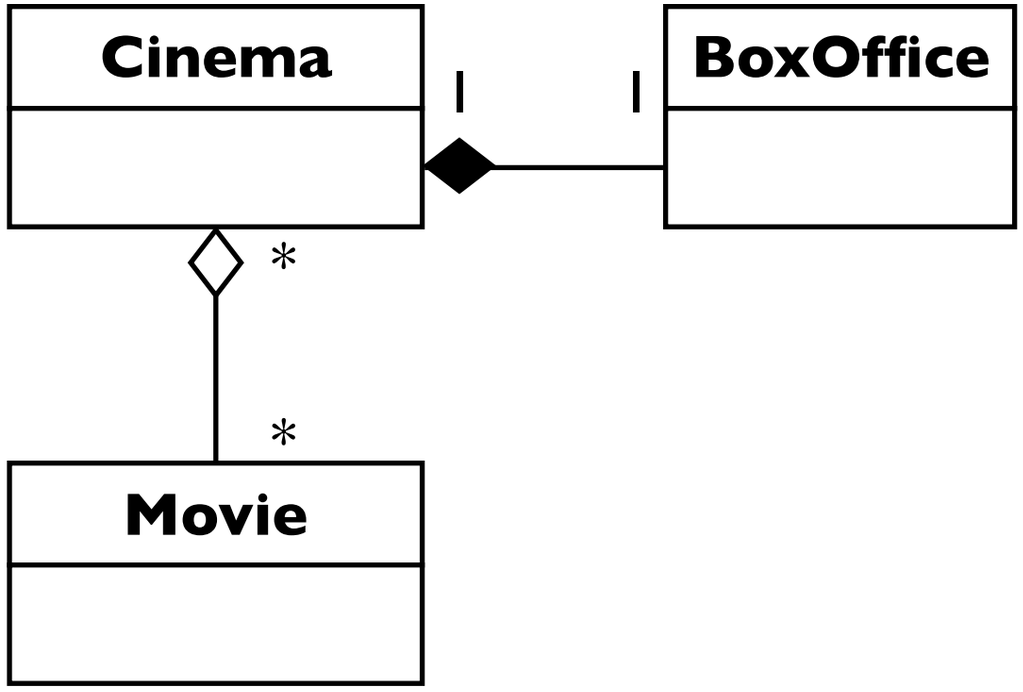




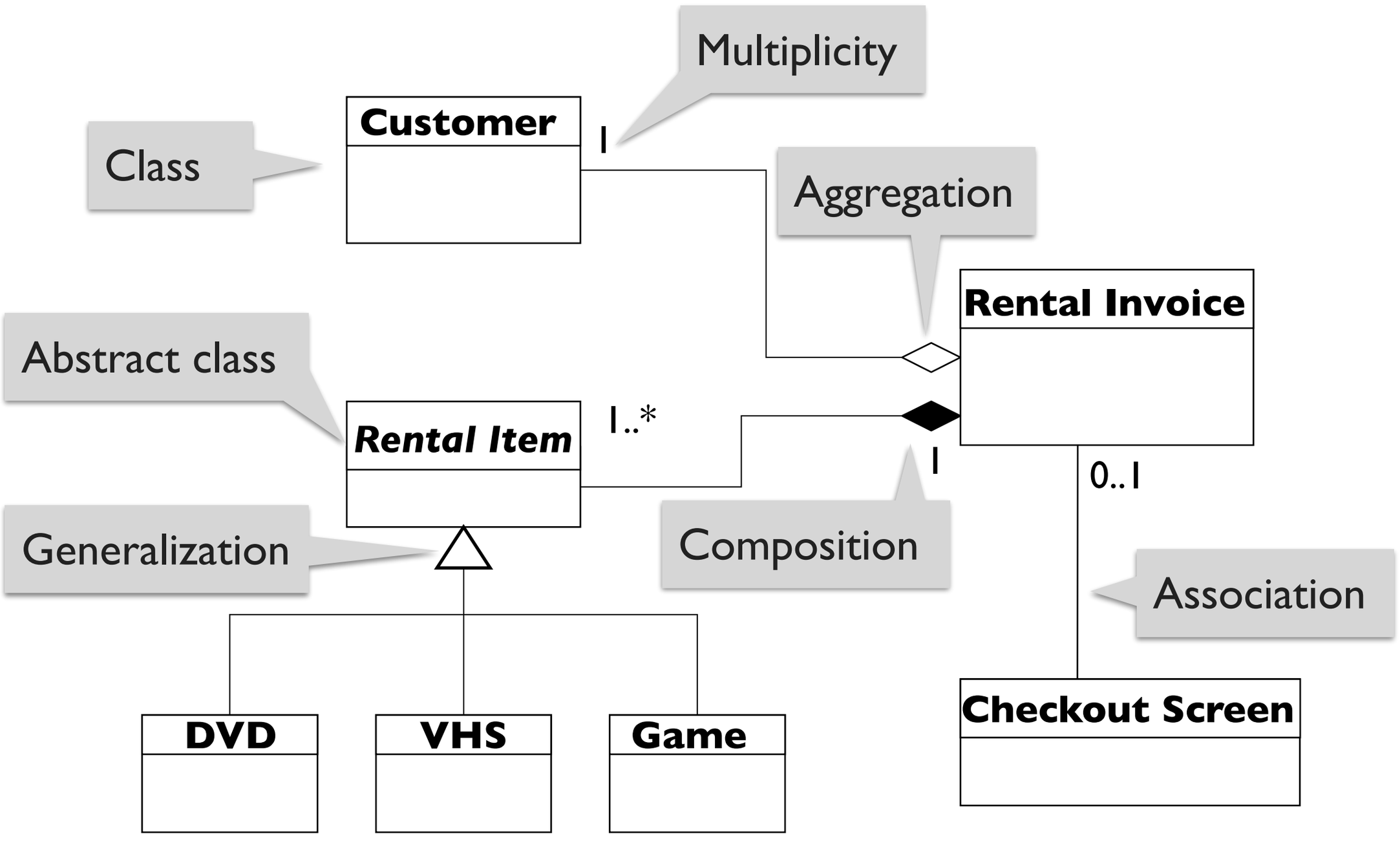


Aggregation / composition example

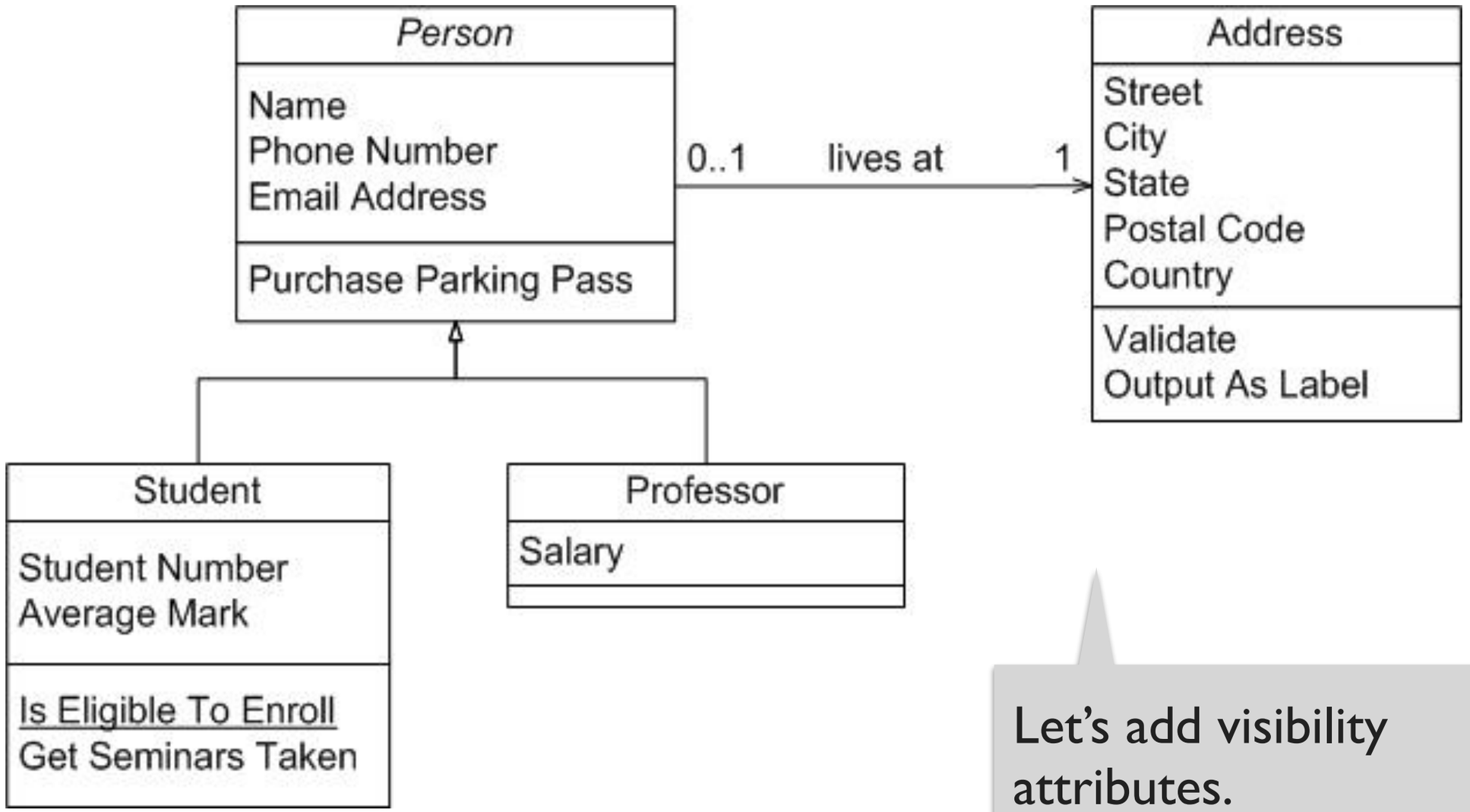
- If the cinema goes away
    - so does the box office: composition
    - but movies may still exist: aggregation



Class diagram example: video store

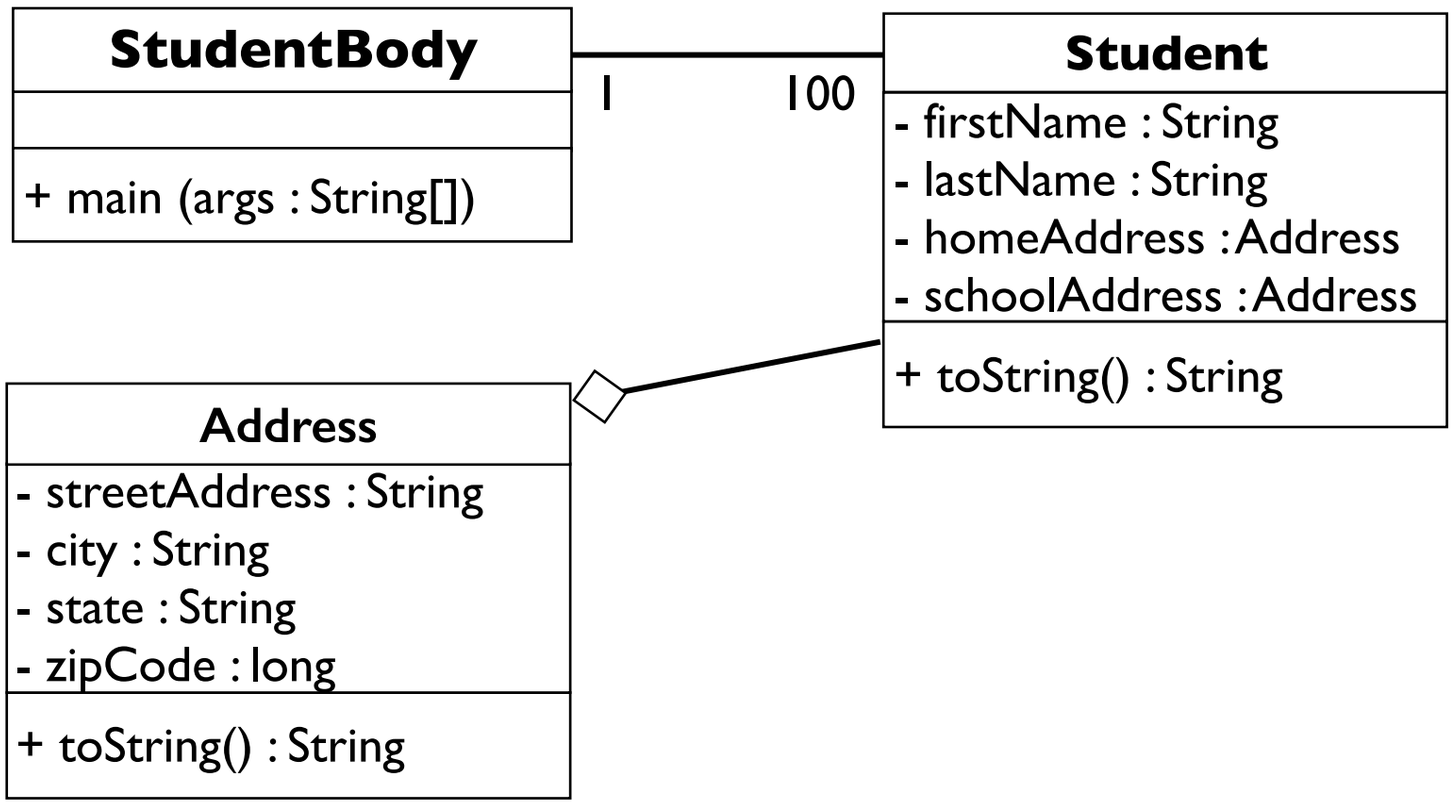


Class diagram example: people



Let's add visibility attributes.

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/
- There are many others, but most are commercial

What (not) to use class diagrams for

What (not) to use class diagrams for

- 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

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  - 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.)

Summary

- A design specifies the structure of how a software system will be written and function.
- UML is a language for describing various aspects of software designs.
- UML class diagrams present a static view of the system, displaying classes and relationships between them.