Inf2-SEPP:
Lecture 9 Part 2: UML class diagrams

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This lecture

Class diagrams

- Notation:
  - Classes: representation, attributes and operations
  - Associations: representation, rolenames, multiplicity, navigability
  - Generalisation
  - Interfaces
  - Abstract classes and operations
  - Static attributes and operations
- An approach for identifying objects and classes

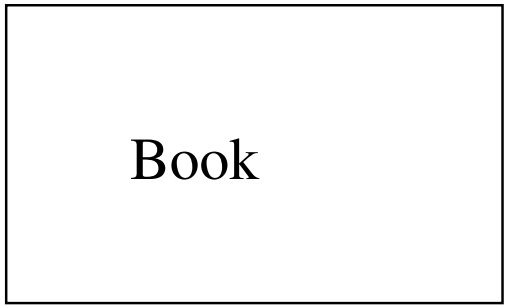
Class diagrams: introduction

Part of UML

Used to represent the static design of the system, i.e. classes and their relationships.

Important! As for use case diagrams, we must respect the notation imposed by UML, which has a (fairly) precise meaning.

Representing classes



UML explicitly separates concerns of actual symbols used vs meaning:

- The rectangle and text form an example of a corresponding **presentation element**.
- A class as design entity is an example of a **model element**

Allows same class to appear in multiple diagrams, maybe using different presentation.

Identifying classes from a system description

Simplest and best: look for noun phrases!

Then abandon things which are:

- redundant
- outside scope
- vague
- attributes
- operations and events
- implementation classes.

(May need to add some back later, especially implementation classes: point is to avoid incorporating premature design decisions into your conceptual level model.)

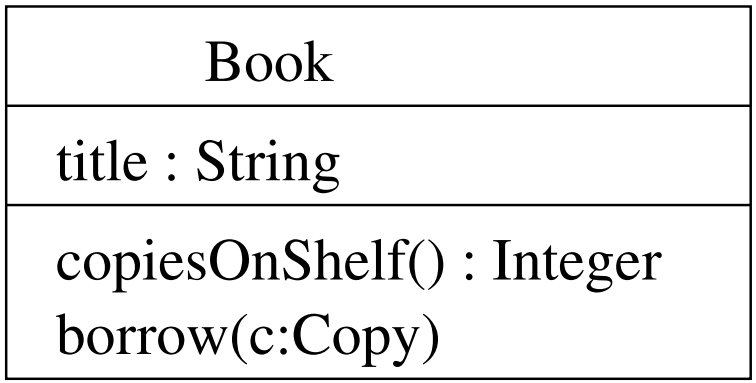
Identifying classes from a system description: example

Books and Journals: The library contains books and journals. It may have several copies of a given book. Some of the books are for short term loans only. All other books may be borrowed by any library member for three weeks. Members of the library can normally borrow up to six items at a time, but members of staff may borrow up to 12 items at one time. Only members of staff may borrow journals.

- *Eliminate*: library, short term loan, member of the library, week, time
- *Left with*: item, book, journal, copy (of book), library member, member of staff.

Showing attributes and operations in classes (optional)

Compartments for *attributes* and *operations* can be added

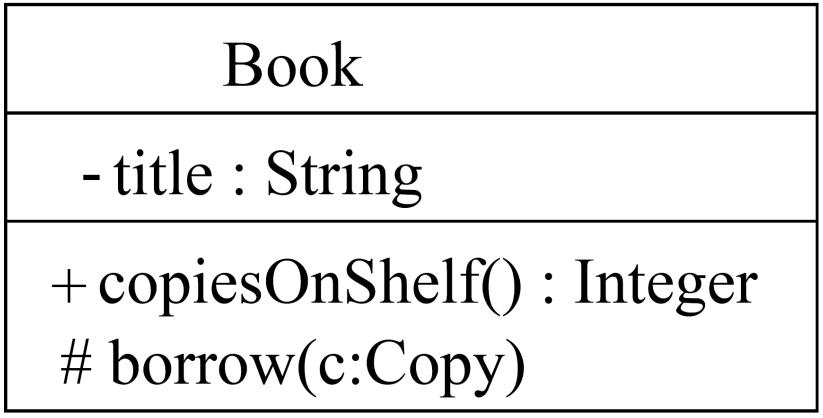


Syntax for types can be adapted for different programming languages.

Types and operation argument names are optional.

Choosing attributes and operations involves conceptual approach (what makes sense in the real world?) and pragmatic approach (what can help meet requirements?)

Showing visibility in classes (optional)

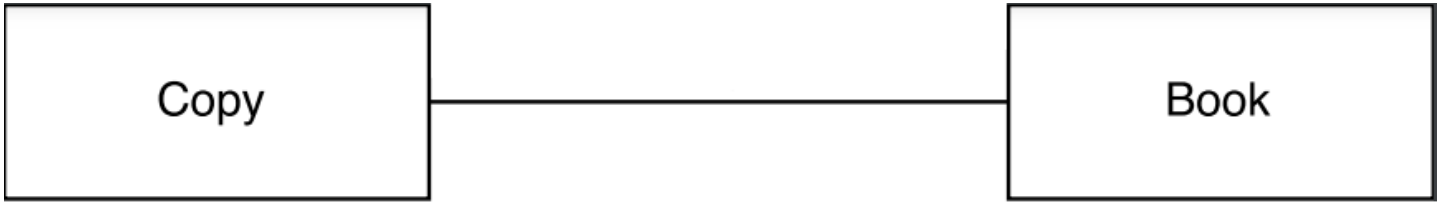


Can show whether an attribute or operation is

- public (visible from everywhere) with $+$
- private (visible only from inside objects of this class) with $-$

(Or protected ($\#$), package ($\sim$) or other language dependent visibility.)

Representing association between classes



Two classes are associated if some object of the first *has to know* about some object of the second.

An object is an instance of a class.

A link is an instance of an association.

Each link consists of a pair of objects, each an instance of the class at each end of the association.

E.g. $\langle$ Copy 3 of War and Peace, War and Peace $\rangle$

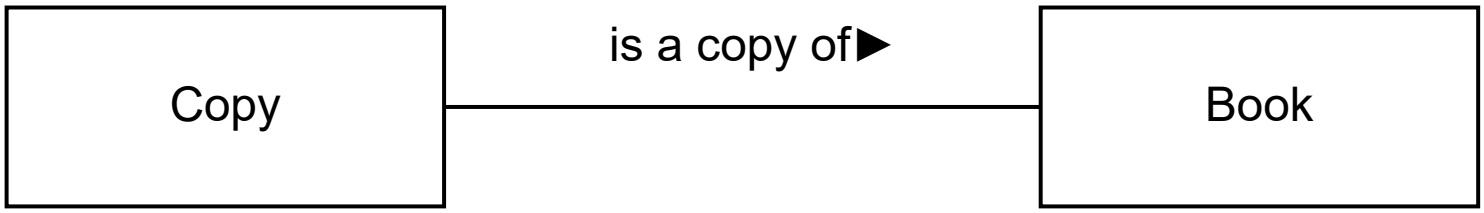
Detailed meaning of an association

Classes A and B are associated if:

- An object of class A sends a message to (i.e. calls an operation in) an object of class B
- An object of class A creates (i.e. calls a constructor of) an object of class B
- An object of class A has an attribute whose values are objects/ collections of objects of class B
- An object of class A receives a message (i.e. performs an operation) with an object of class B as an argument.

Choosing associations also involves a conceptual and a pragmatic approach.

Showing association name and direction (both optional)

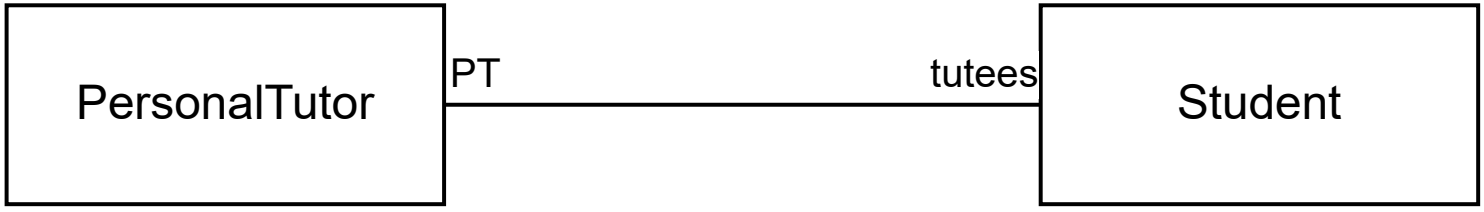


The name is recommended, even if optional. It is useful to clarify the relationship between the objects of the classes.

The direction arrow can improve readability, especially in complex diagrams where reading an association may not be left to right.

Showing rolenames on associations (optional)

Rolenames show the roles that objects play in an association.

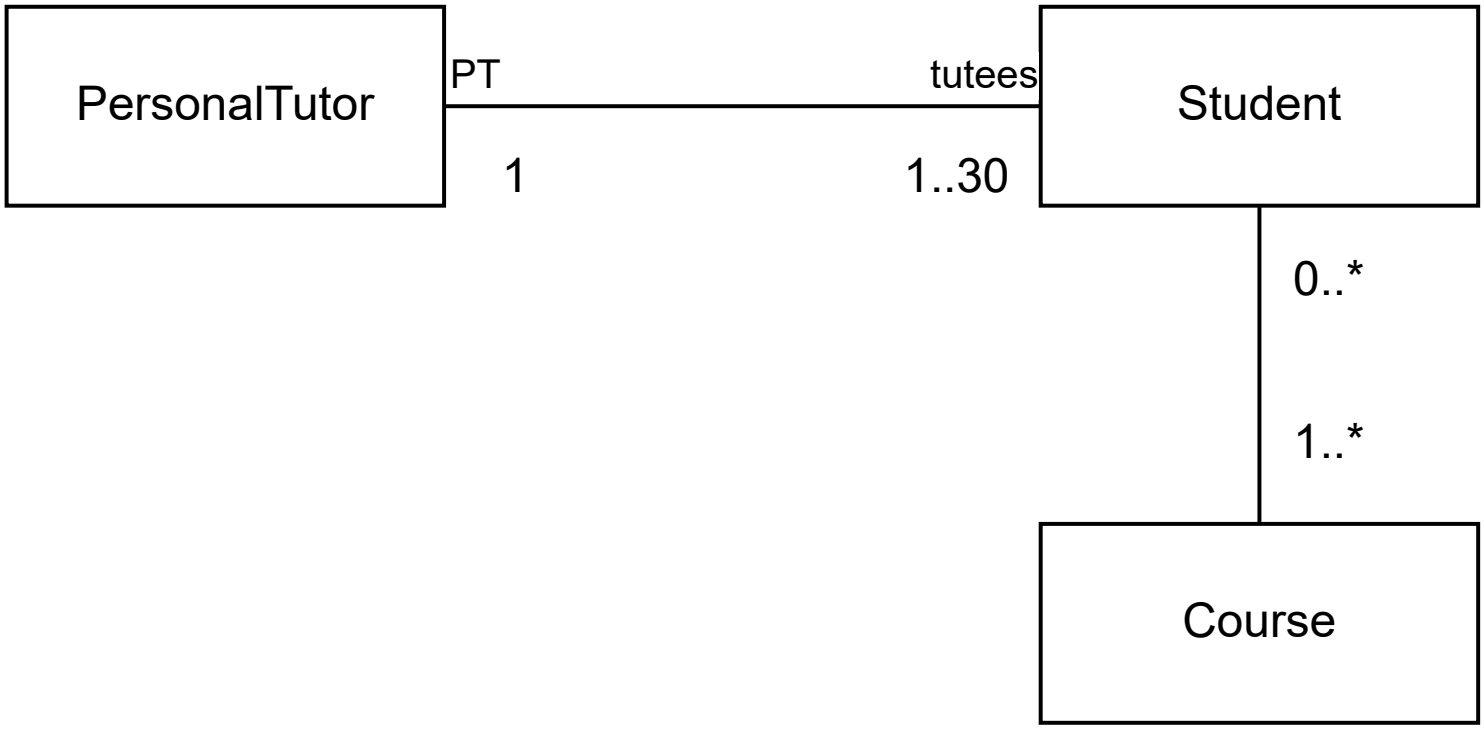


The above association shows that

- students are tutees of a personal tutor
- a personal tutor is a PT for some students

Can use visibility notation $+$ $-$ etc on role names too.

Showing association multiplicities (optional)



For each personal tutor there are between 1 and 30 students

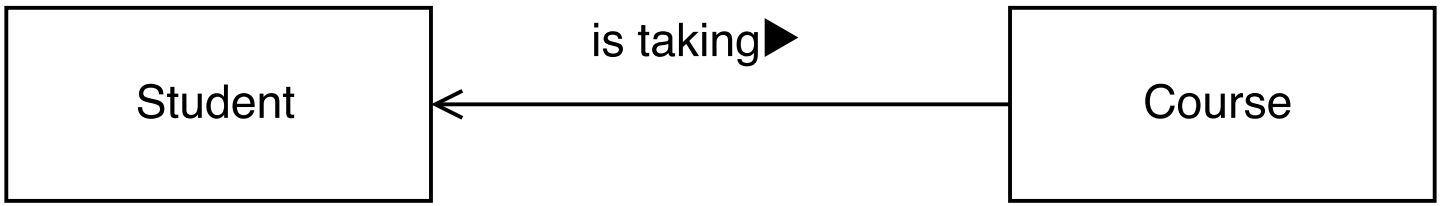
For each student there is exactly one personal tutor

* for unknown number: each student takes one or more courses.

0..* often abbreviated as *

Showing association navigability (optional)

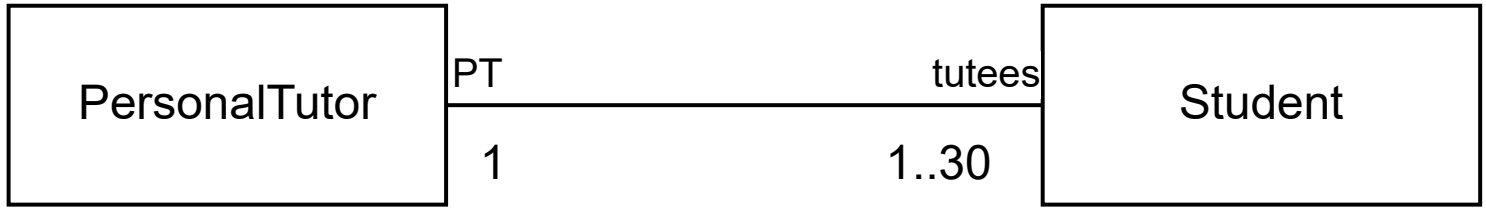
Adding an arrow at the end of an association shows that some object of the class at one end can access some object of the class at the other end, e.g. to send a message.



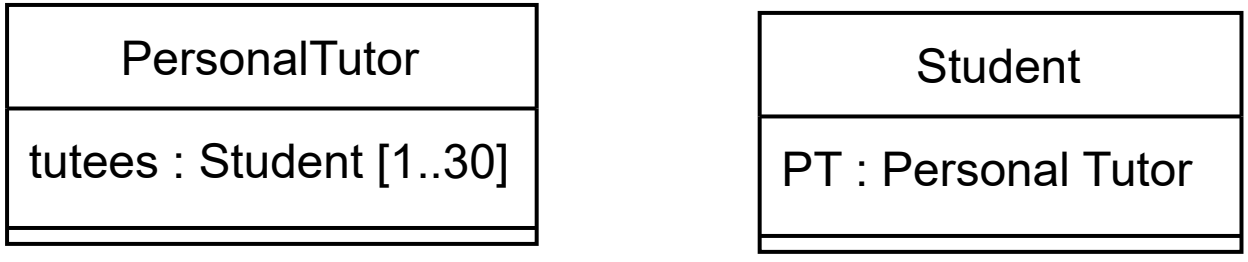
Use $\times$ near an association end to show non-navigability

Direction of navigability has nothing to do with direction in which you read the association name

Attributes vs associations



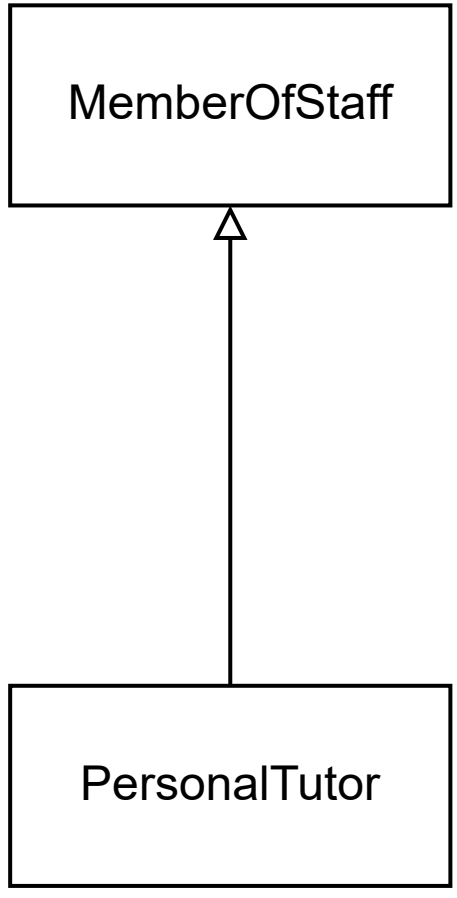
One way (not the only one!) of realising the above association is:



Don't show both association and attributes, as it is redundant!

Attribute preferred if attribute type is primitive or predefined Java class, or library class. Otherwise, association is better!

Representing class generalisation



Usually, corresponds to implementation with inheritance.

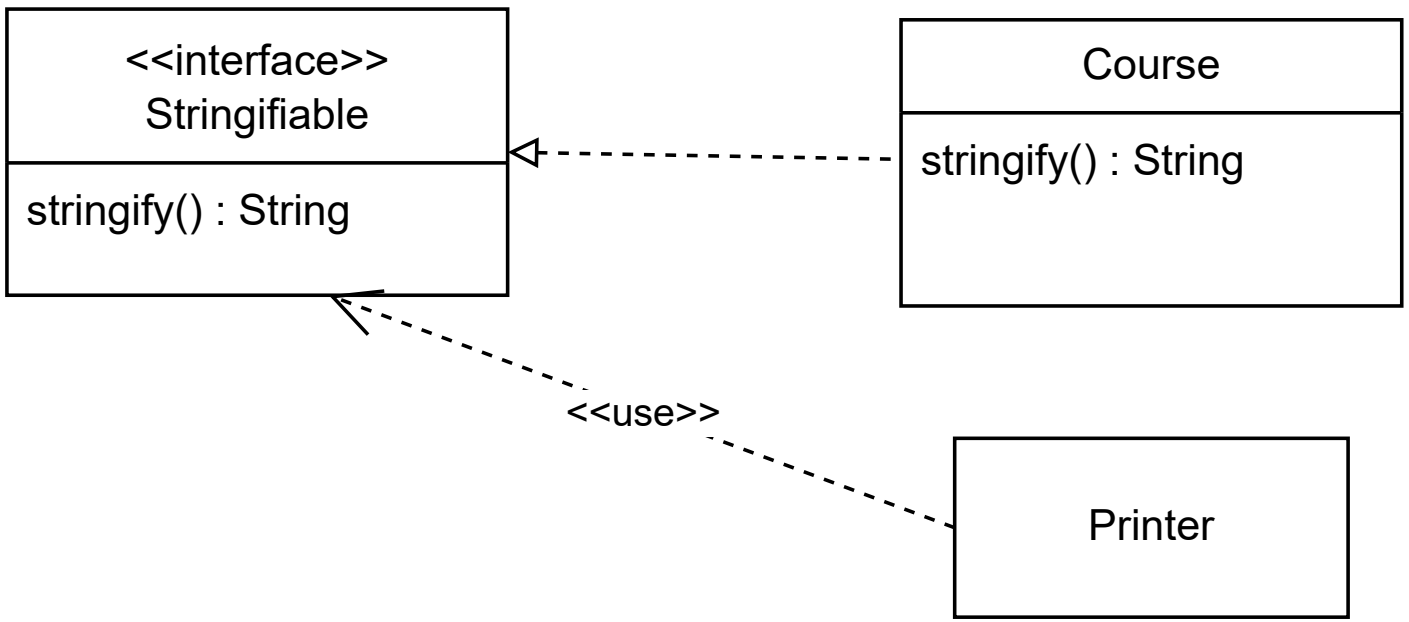
Usually can read as *is a*: e.g., a personal tutor *is a* member of staff

Representing interfaces and realisation

In UML an interface is just a collection of operations, that can be *realised* by a class.

E.g. The Course class realises the Stringifiable interface

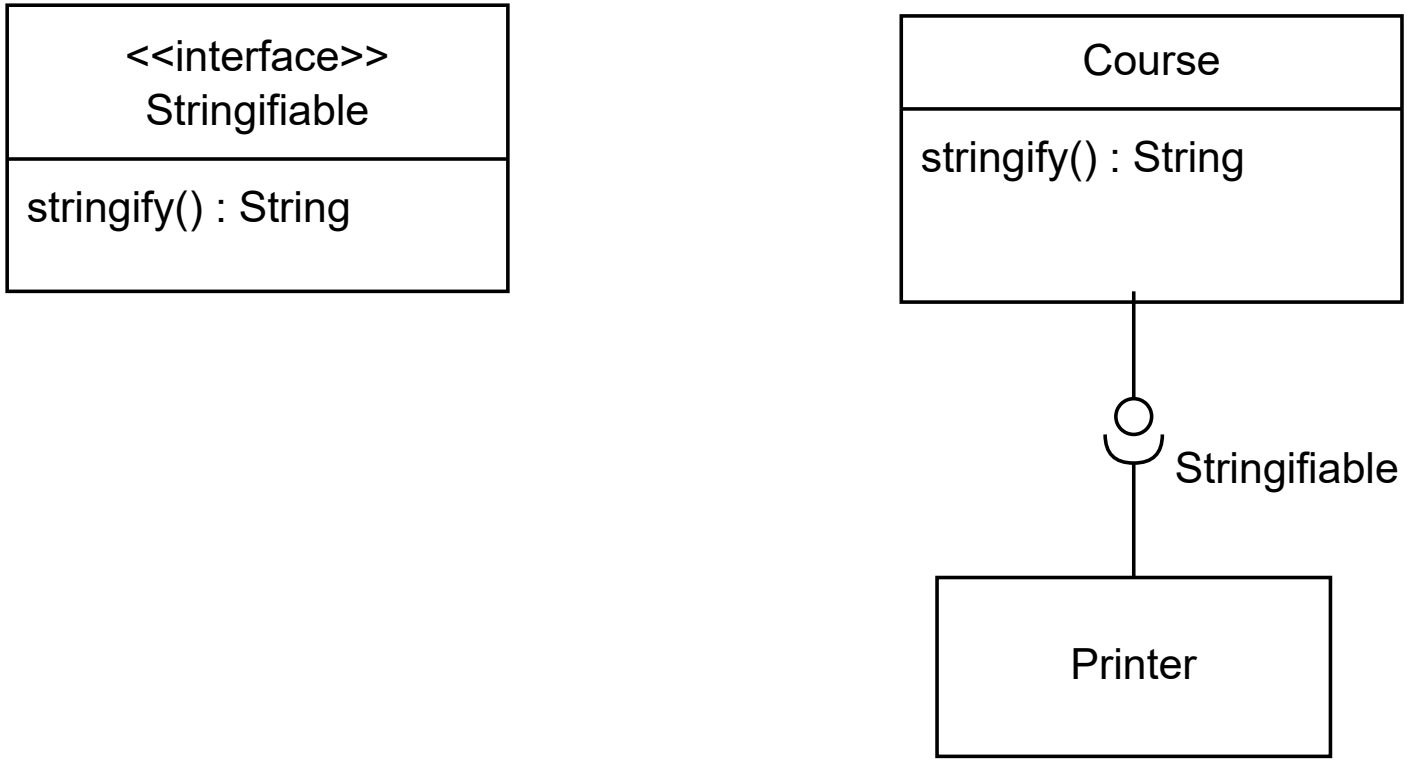
The Printer class interacts with the Stringifiable interface (i.e. some object of it interacts with whatever object will be implementing the interface).



Representing interfaces and realisation: alternative notation

The Course class realises the Stringifiable interface

The Printer class interacts with the Stringifiable interface (i.e. some object of it interacts with whatever object will be implementing the interface).



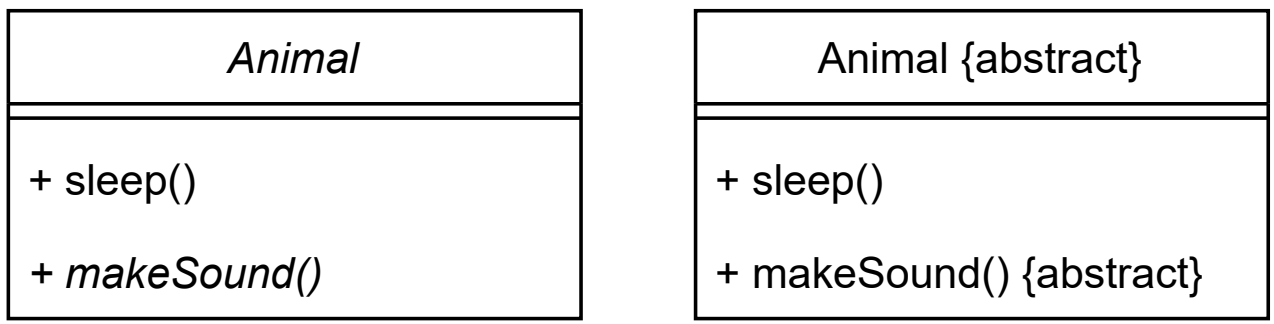
Representing abstract classes and operations

In UML, an abstract class is one that is intended to be used by subclasses, and does not have instances.

Abstract operations can only be present in abstract classes. They must be defined by subclasses.

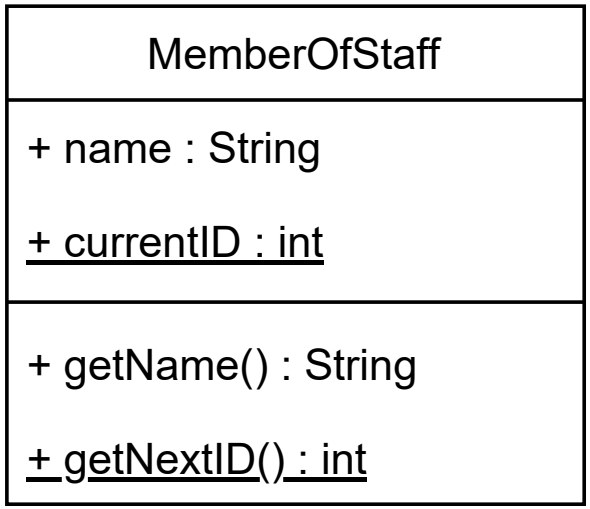
An abstract class may have both abstract and regular operations.

Two notation alternatives provided below



Representing static attributes and operations

In UML, a static attribute or operation is an attribute or operation belonging to a class rather than the instances of the class.



Reading

Stevens

- Recommended: Ch 2: Object concepts
- Essential: Ch 3: Introductory case study 3, until section 3.5
- Essential: Ch 5: Essentials of class models, until section 5.6
- Essential: Ch 6: More on class models sections 6.1.2, 6.1.3, 6.2, 6.6