UML class diagrams

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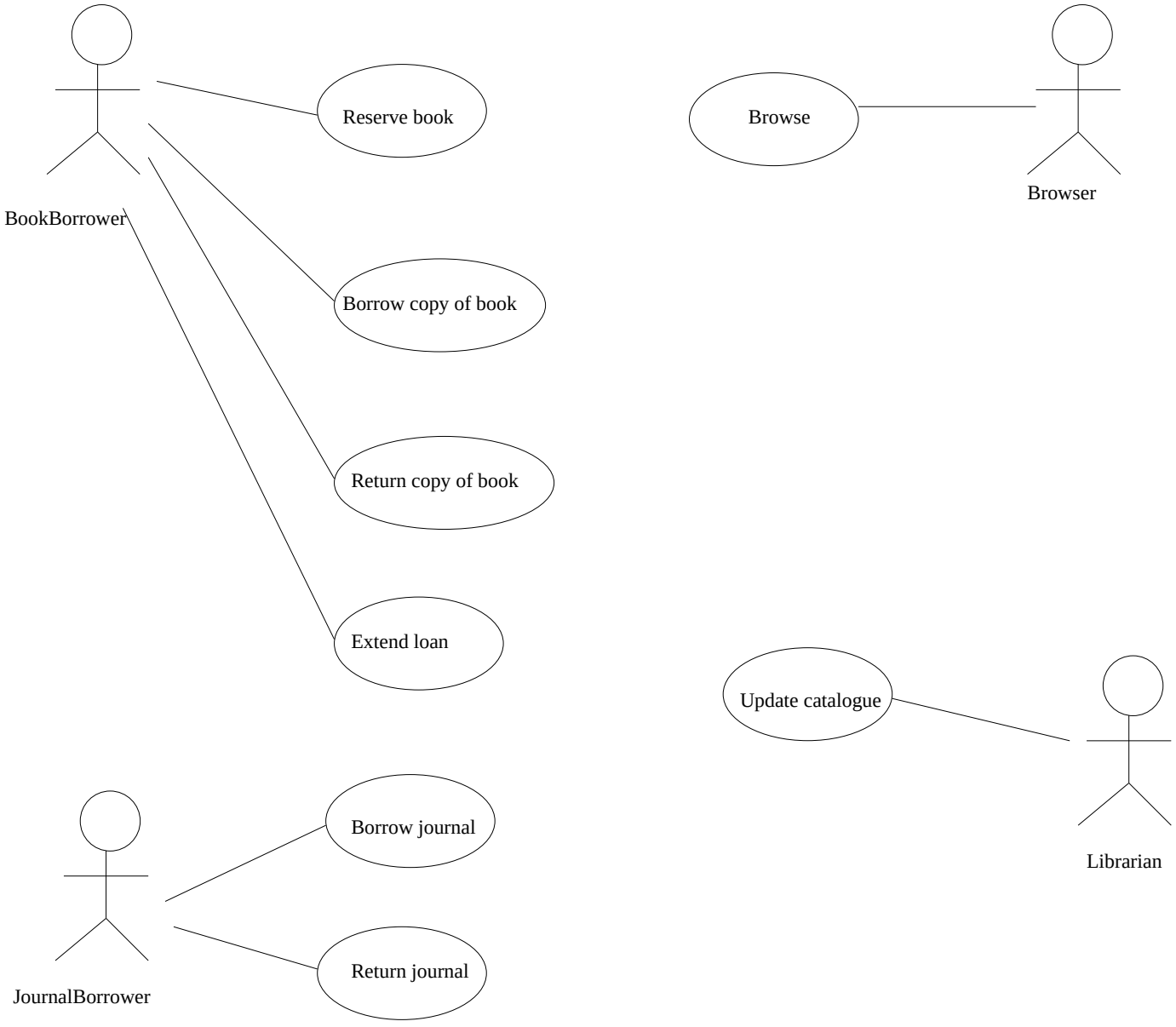
The Unified Modeling Language

UML is a graphical language for recording aspects of the requirements and design of software systems.

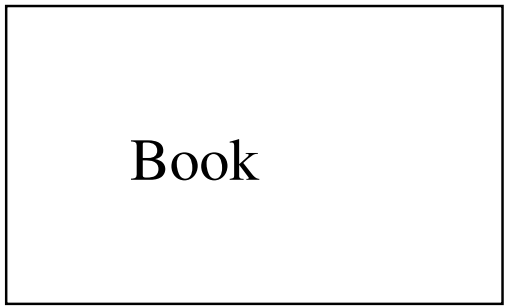
It provides many diagram types; all the diagrams of a system together form a UML model. Three important types of diagram:

1. *Use-case diagram*. Already seen in requirements lecture.
2. *Class diagram*. Today.
3. *Sequence diagram*. In the future.

Reminder: a simple use case diagram



A class



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

UML explicitly separates concerns of actual symbols used vs meaning.

Many other things can be model elements: use cases, actors, associations, generalisation, packages, methods,...

An object

This pattern generalises: always show an instance of a classifier using the same symbol as for the classifier, labelled instanceName : classifierName.

Classifiers and instances

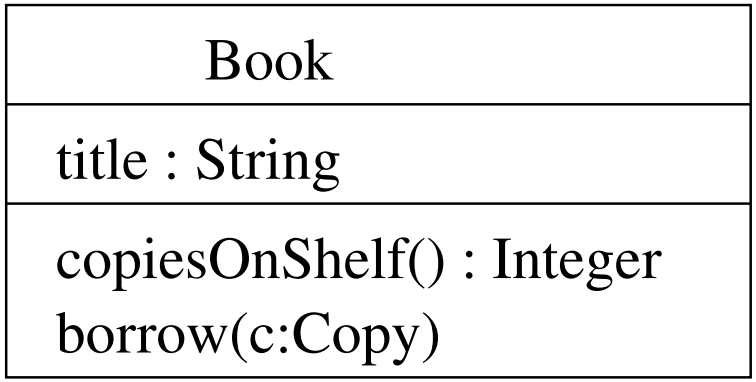
An aspect of the UML metamodel that it's helpful to understand up front.

An **instance** is to a **classifier** as an object is to a class: instance and classifier are more general terms.

In the metamodel, Class inherits from Classifier, Object inherits from Instance.

UML defines many different classifiers. E.g., UseCase and Actor are classifiers.

Showing attributes and operations



Syntax for signature of operations (argument and return types) adaptable for different programming languages. May be omitted

Compartments

We saw the standard:

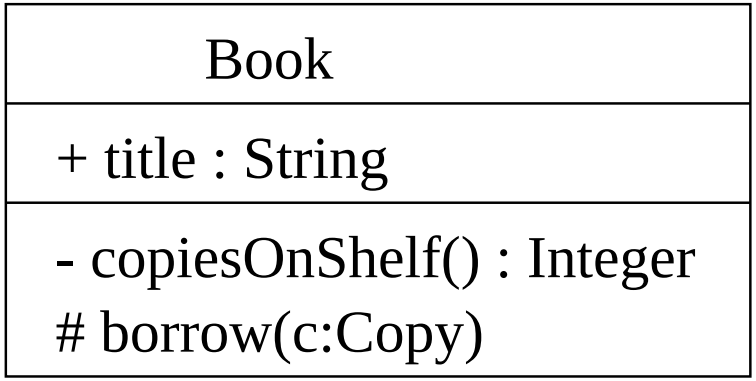
- a compartment for attributes
- a compartment for operations, below it

They can be suppressed in diagrams.

They are omitted if empty.

You can have extra compartments labelled for other purposes, e.g., responsibilities of the class...

Visibility

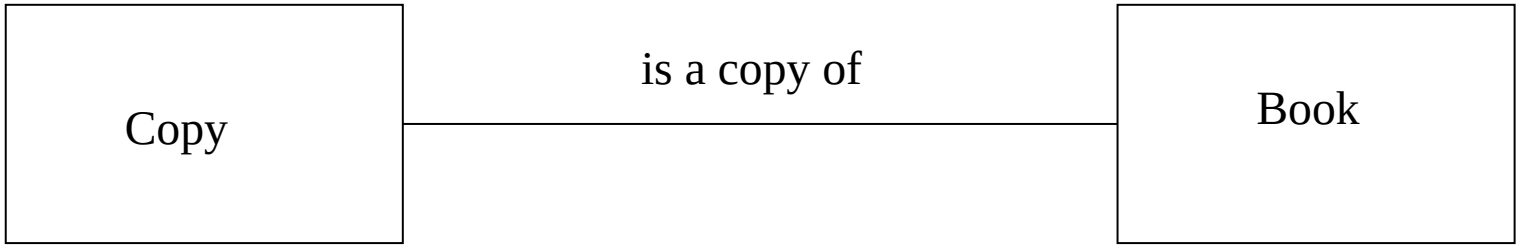


Can show whether an attribute or operation is

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

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

Association between classes

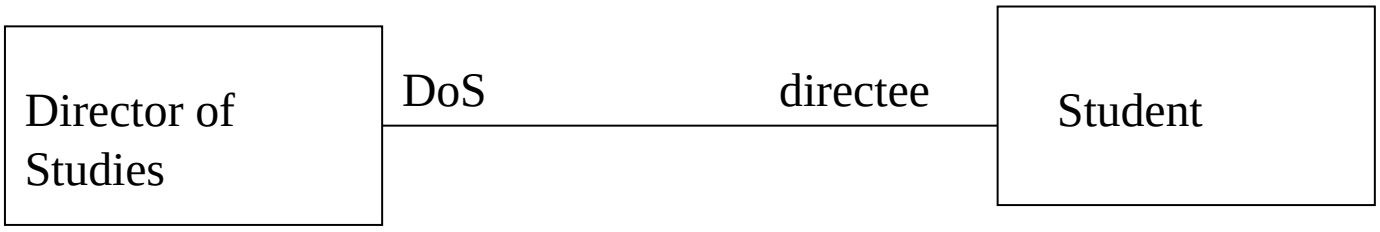


This generalises: association between classifiers is always shown using a plain line. (Recall the associations between actors and use cases!)

An instance of an association connects objects (e.g. Copy 3 of War and Peace with War and Peace).

An **object diagram** contains objects and links: occasionally useful.

Rolenames on associations



Can show the role that one object plays to the other.

Useful when documenting the class: e.g. a *class invariant* for DirectorOfStudies could refer to the associated Student objects as self.directee (a set, if there can be more than one).

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

Class invariants

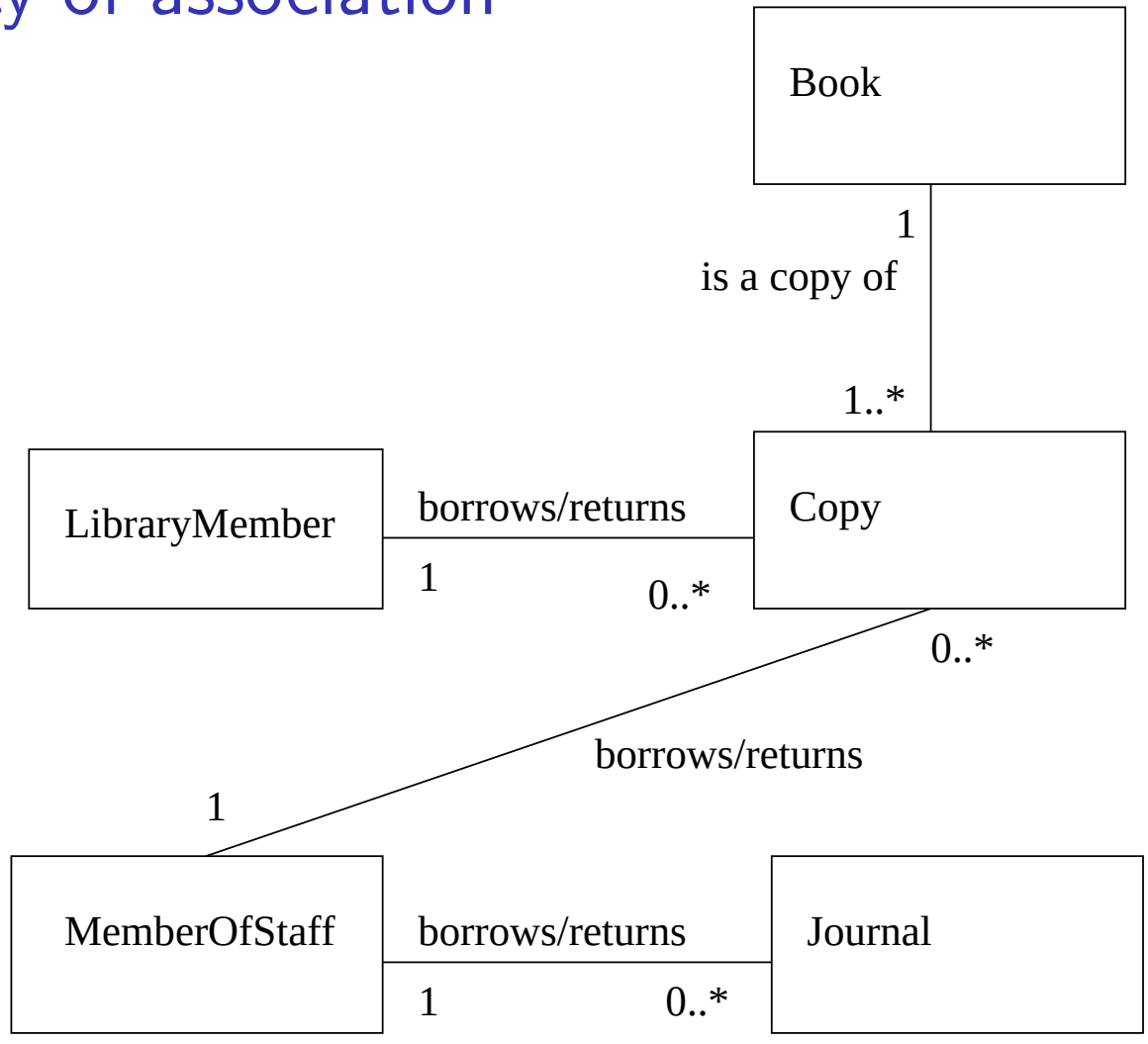
A class invariant is a statement which is supposed to be true of every object of the class, all the time - a "sanity check".

Very useful to make these explicit. Can be included as comments on class diagrams, and in code.

May be formal, e.g. `x + y = z`, or informal, e.g. "the attribute `docstring` describes the action of the button in concise English".

If formal, it can be useful to have class invariants automatically checked.

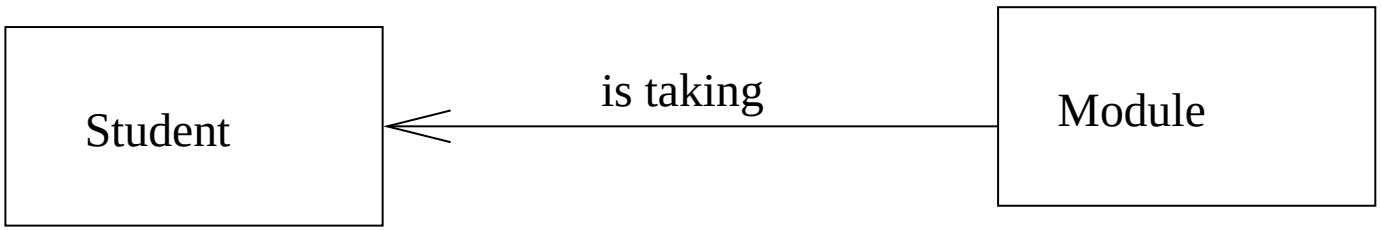
Multiplicity of association



Commas for alternatives, *two* dots for ranges, * for unknown number. E.g. each Copy is a copy of exactly one Book; there must be at least one Copy of every Book.

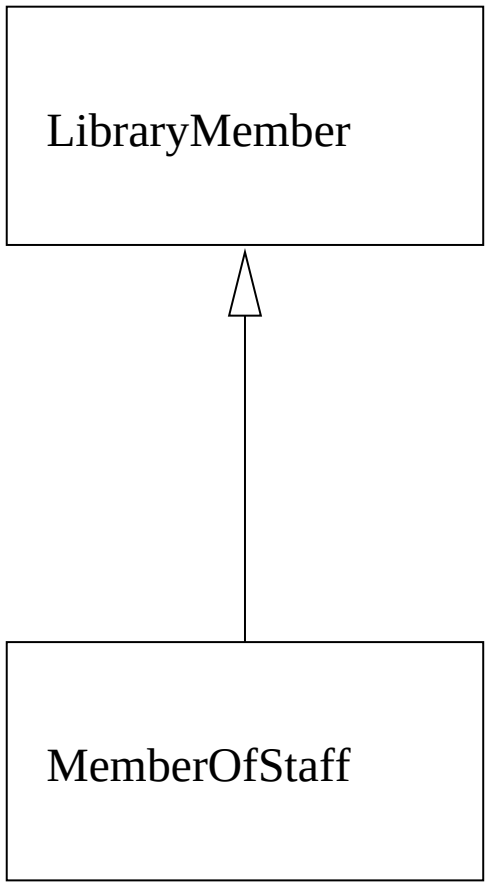
Navigability

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.



Crucial to understanding the coupling of the system. NB direction of navigability has nothing to do with direction in which you read the association name.

Generalisation



This generalises: generalisation between classifiers is always shown using this arrow.

Usually, but not necessarily, corresponds to implementation with inheritance.

Abstract operations and classes

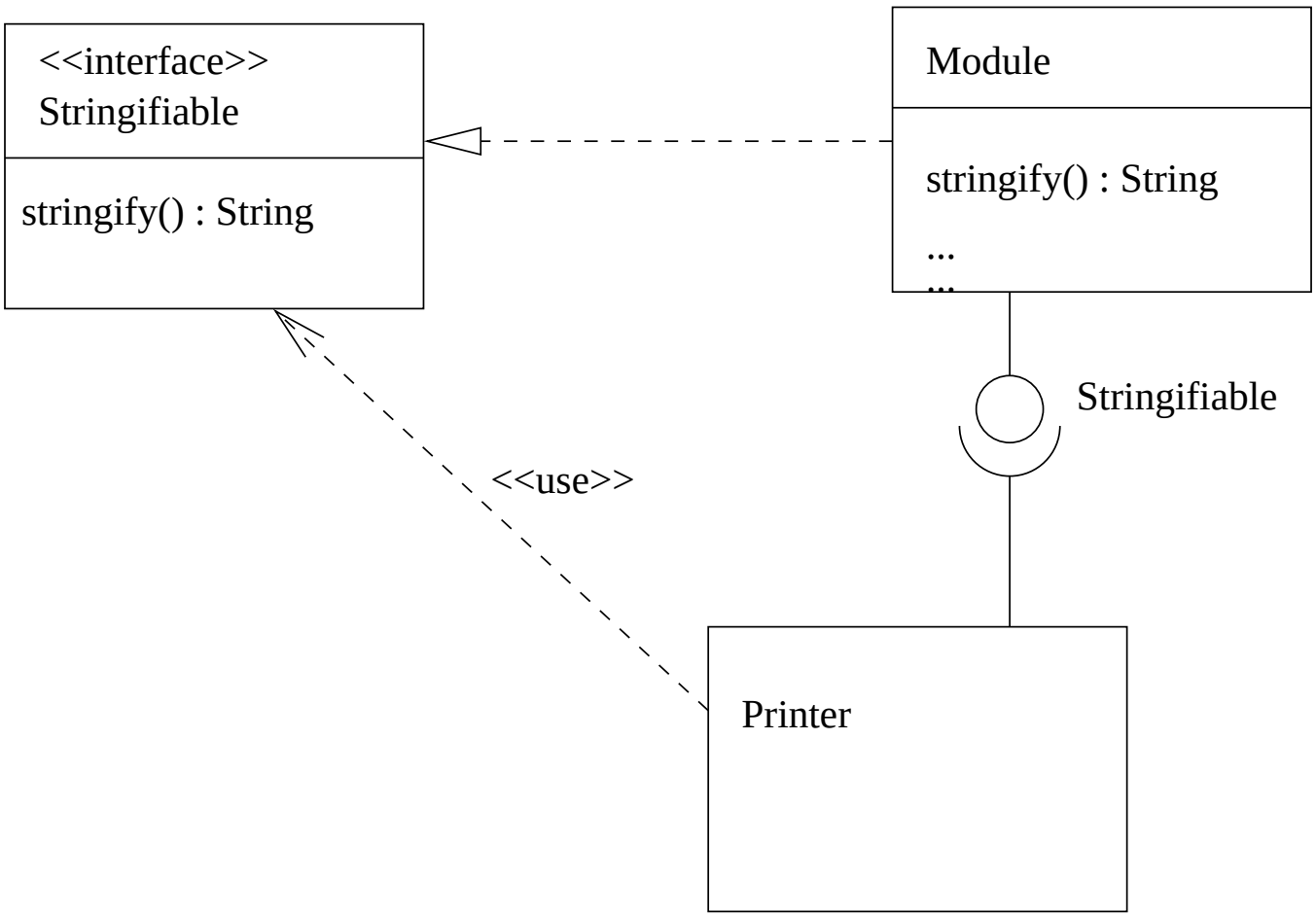
An operation of a class is abstract if the class provides no implementation for it: thus, it is only useful if a subclass provides the implementation.

A class which cannot be instantiated directly – for example, because it has at least one abstract operation – is also called abstract. Java...

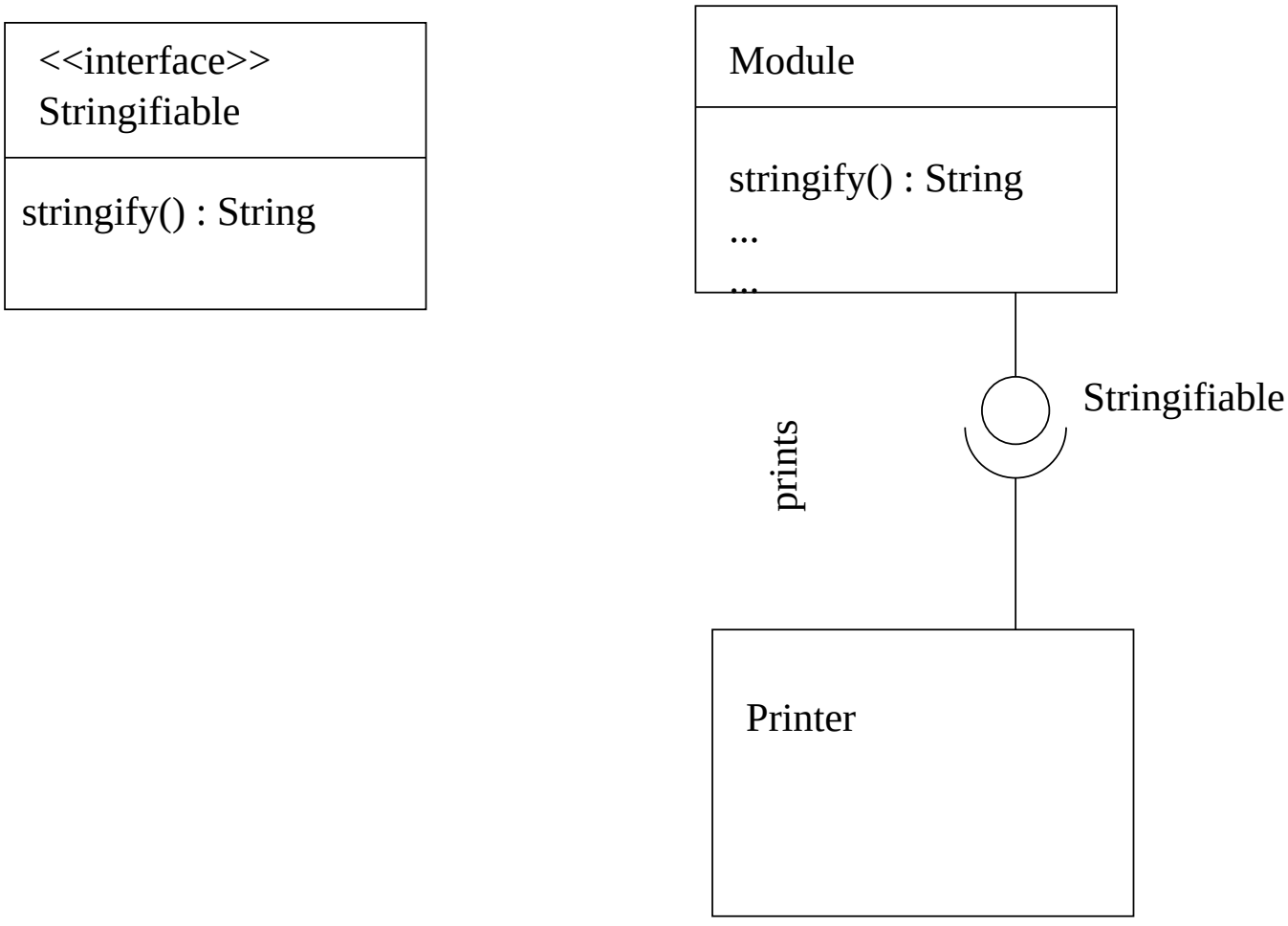
Can show *abstract* operation or class using italics for the name, and/or using the *property* $\{abstract\}$.

Interfaces

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



Simpler diagram: WRITE ONCE



Many things other than classes can realise interfaces: can use the lollipop symbol on e.g. components, actors.

Identifying objects and classes

Simplest and best: look for noun phrases in the system description!

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.)

Similarly, can use verb phrases to identify operations and/or associations

Reading

Suggested: Stevens

- Ch 2: Object concepts
- Ch 3: The LIbrary case study
  - Includes basics of how to identify classes
- Ch 5: Essentials of class models
  - Includes use of CRC cards for class design
- Ch 6: For abstract classes and interfaces