All the UML you need to know

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Introduction

This page describes the elements of the UML that I expect my students to know. By no means does this document attempt to portray all of the UML. Those elements described herein are those that I have found useful in practice and those that I have seen featured in formal and informal written communication. That is, these are the minimum features that I consider to represent UML literacy.

Sequence Diagrams

This document is being written in Fall 2011, and we already talked about these in class. I'm not going to invest the time in reiterating the same content here, since you have it in your notes already.

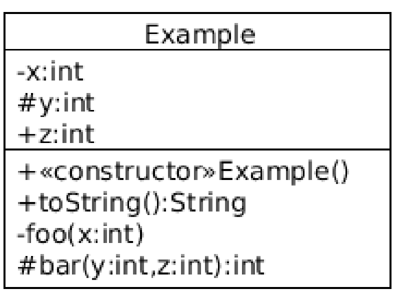
Class Diagrams

Classes and interfaces

A **class** is represented by a box with up to three sections: the top contains the class name; the middle contains the fields; the bottom contains the methods. Consider the following Java class definition, a ridiculously-designed example that will serve to demonstrate core UML data representations. (Note that if you're one of my students and you ever turn in programs as nonsensical as this, expect to be harassed.)

```
public class Example {
  private int x;
  protected int y;
  public int z;
  public Example() { ... }
  public String toString() { ... }
  private void foo(int x) { ... }
  protected int bar(int y, int z) { ... }
}
```

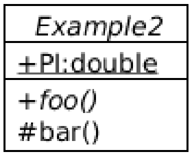
This can be represented with the following class diagram.



The fields and methods are annotated to indicate their access level: plus (+) for public, minus (-) for private, and hash (#) for protected. UML conventially uses Algol-style naming, so variables are given as *name*:*type* and methods are given as *name*(*params*):*type*, where each parameter is, of course, a variable. In UML, metadata is often represented through stereotypes, which are always listed in guillemet. For example, the fact that our `Example()` method is a constructor is identified via the «constructor» stereotype.

Static members in class diagrams are underlined, and abstract elements are italicized. Here is another code and diagram example.

```
public abstract class Example2 {
  public static final double PI = 3.14;
  public abstract void foo() { ... }
  protected void bar() { ... }
}
```



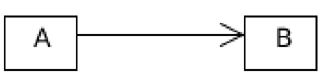
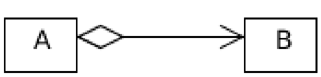
Interfaces are given the «interface» annotation, as shown below.

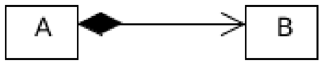
```
public interface FooListener {
  public void foo();
}
```

Keep in mind that UML is a communication tool, and you can omit details that are not necessary for expressing your message. For example, I frequently skip the middle box in UML classes since they deal with data representation, and I'm usually more interested in capturing the relationships among classes.

Relationships

It is the messages sent among objects that give a system dynamic behavior, and these are represented in UML through the relationships among classes. There are four kinds of relationships that I use regularly, shown in the following table in order of increasing specificity. That is, the relationships lower on the table subsume all those above them.

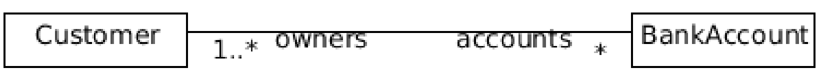
Relationship	Depiction	Interpretation
Dependency		`A` depends on `B` This is a very loose relationship and so I rarely use it, but it's good to recognize and be able to read it.
Association		An `A` sends messages to a `B` Associations imply a direct communication path. In programming terms, it means instances of `A` can call methods of instances of `B`, for example, if a `B` is passed to a method of an `A`.
Aggregation		An `A` is made up of `B` This is a part-to-whole relationship, where `A` is the whole and `B` is the part. In code, this essentially implies `A` has fields of type `B`.
Composition		An `A` is made up of `B` with lifetime dependency

		That is, `A` aggregates `B`, and if the `A` is destroyed, its `B` are destroyed as well.

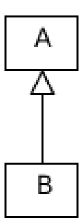
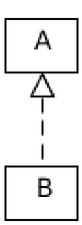
A useful annotation on these relationships is *multiplicity*, which tells you how many of each object is involved in the relationship. This can be a constant ("1"), unbounded ("*", *i.e.*, zero or more), or a range ("2..*"). Where multiplicity is not explicit, "1" is assumed. You can also annotate a relationship with *roles* to further describe the relationship; these roles may translate into fields in the implementation. For example, the relationship between a player and its achievements might be represented as follows:

(The reader may wonder what actual data structure is used to hold the achievements: is it an array, or a linked list, or something else? At this level of modeling, that's probably not important. You could use UML to show that `Player` aggregates a `java.util.LinkedList`, and that this list aggregates `Achivement` objects, but unless that's essential to your reader, you're best to skip it.)

Directionality is another important aspect of relationships. All of my examples above have been unidirectional, but relationships may also be bidirectional. This is shown by omitting the arrowhead. For example, the following diagram shows a case where a customer may have any number of bank accounts, and a bank account can be owned by one or more customers. Note that you could use the open diamond annotation to show aggregation if you were interpreting this as a part-to-whole on either or both sides. (This proves the fact that you cannot write a UML tutorial without a bank account example. QED.)



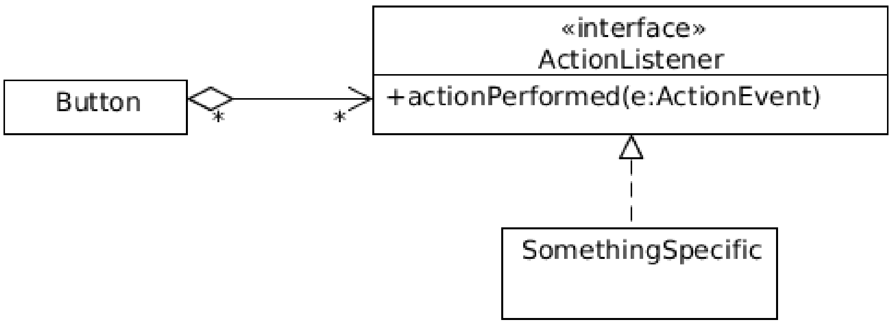
Two other important relationships deal with the relationship among classes, shown in the table below.

Relationship	Depiction	Interpretation
Generalization		`A` generalizes `B` Equivalently, `B` is a subclass of `A`. In Java, this is `extends`.
Realization		`B` realizes (the interface defined in) `A` As the parenthetical name implies, this is used to show that a class realizes an interface. In Java, this is `implements`, and so it would be common for `A` to have the «interface» stereotype.

Note that it's not mandatory to draw these with vertical alignment, but I do recommend it to improve readability. Most readers will conceptualize the upper class as more general and the lower class as more specific; if you were to invert your relationship, you would be causing unnecessary cognitive dissonance.

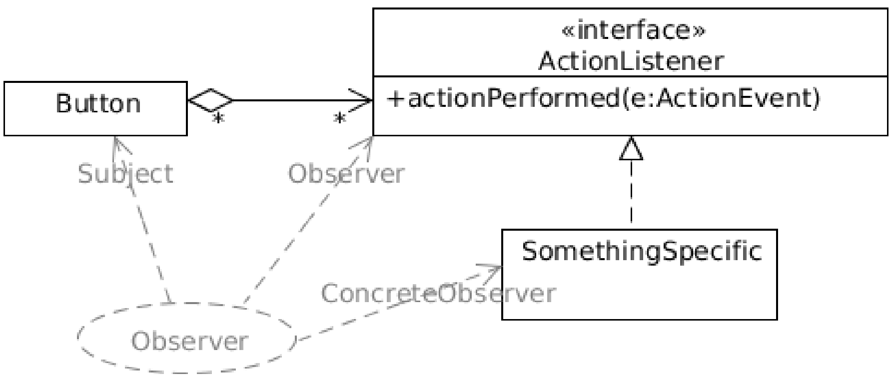
Multiple representations, plus collaboration notation

In a good OO design, you have cross-module dependencies on interfaces, not implementations. As a result, you might frequently encounter cases as shown below, where a `Button` sends messages through the `ActionListener` interface



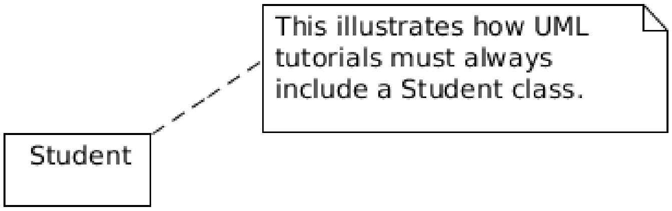
If what you're trying to express is that information gets to `SomethingSpecific` from `Button`, then you can use the ball-and-socket notation instead, as shown below. This says that the communication between `Button` and `SomethingSpecific` happens through the `ActionListener` interface.

On the other hand, if the important thing to show is that this is a reification of the [observer design pattern](), then you can use a UML collaboration to show this. As always, it all comes down to knowing what you want to say and then using the notation to your advantage.



Miscellaneous

You can put a note on any part of a UML diagram. Connect the note to the relevant bit with a dashed line, as shown in the example below.



Concluding Remarks

The UML is a massive specification, and I've only showed one or two kinds of diagrams above. These are the diagrams I encounter most often in research, on the Web, and in print. For your next steps, I would recommend learning state machine diagrams, activity diagrams, and use case diagrams. One of the most useful UML resources I have found online is Allen Holub's UML Quick Reference—great for getting a refresher or a birds-eye view on a diagram type.

All of the diagrams above were created with UMLet, an amazing and free tool for rapidly creation of UML diagrams.
