Modeling with UML
Chapter 2, part 2

CS 4354
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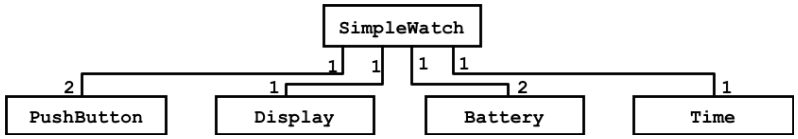
Class diagrams

- Used to describe the internal structure of the system.
- Also used to describe the application domain.
- They describe the system in terms of
  - ✦Classes, an abstract representation of a set of objects
  - ✦Attributes, properties of the objects in a class
  - ✦Operations that can be performed on objects in a class
  - ✦Associations that can occur between objects in various classes

Class diagram for a simple watch

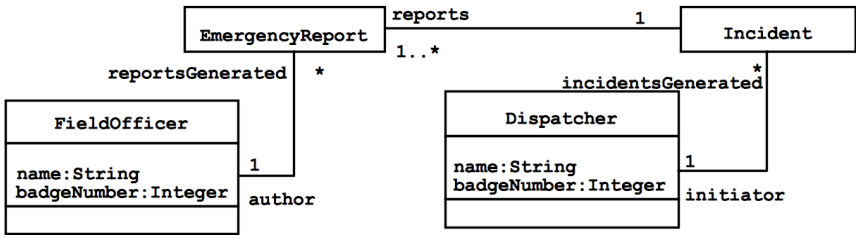


- Boxes are classes
- Lines show associations (between objects)
- Numbers show how many objects must be associated

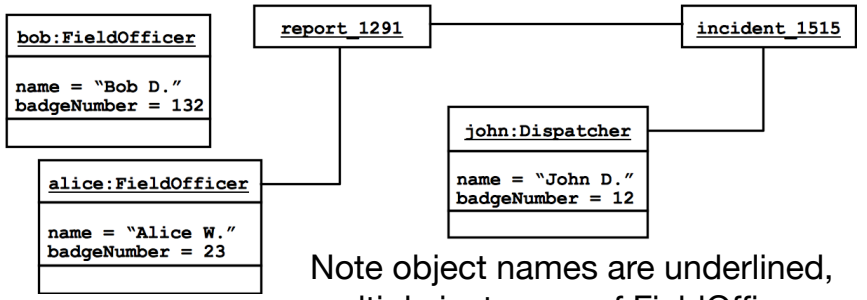
Class Diagrams: details

- Can represent classes OR objects
- Classes (and objects) are boxes composed of three compartments:
  - ✦Top compartment: name
  - ✦Center compartment: attributes (may be omitted for simplicity/delay)
  - ✦Bottom compartment: operations (may be omitted for simplicity/delay)
- Conventions:
  - ✦Object names (when used) are underlined to indicate they are instances
  - ✦Class names start with uppercase letter
  - ✦Named objects start with lowercase

UML class diagram: **classes** that participate in the ReportEmergency use case.



UML object diagram: **objects** that participate in the warehouseOnFire scenario.



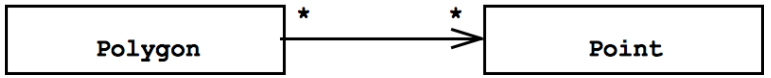
Note object names are underlined, multiple instances of FieldOfficer.

These kinds of diagrams are not commonly used.

Associations and links

- A link represents a connection between two objects.
- Associations are relationships between classes and represent the fact that links may (or do) exist between object instances.
  - ✦Links and associations are noted with a line between the boxes.
- Associations can be symmetrical (bidirectional) or asymmetrical (unidirectional).
  - ✦Unidirectional association is indicated by using a line with an arrow
  - ✦The arrow indicated in which direction navigation is supported.
  - ✦If the line has no arrows, it's assumed to be bidirectional.

Example of a unidirectional association

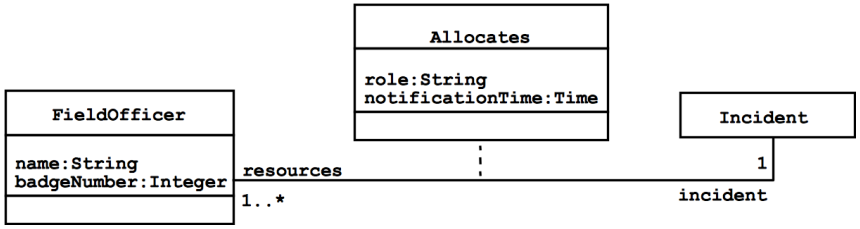


This system supports navigation from the Polygon to the Point, but not vice versa. Given a specific Polygon, it is possible to query all Points that make up the Polygon. But a given Point does not know which Polygon(s) it belongs to.

*Note: the diagram in the book is wrong

Association class

- Association class: an association with attributes and/or operations
- Depicted by a class symbol that contains the attributes and operations and is connected to the association symbol with a dashed line.



These kinds of classes are not commonly used.

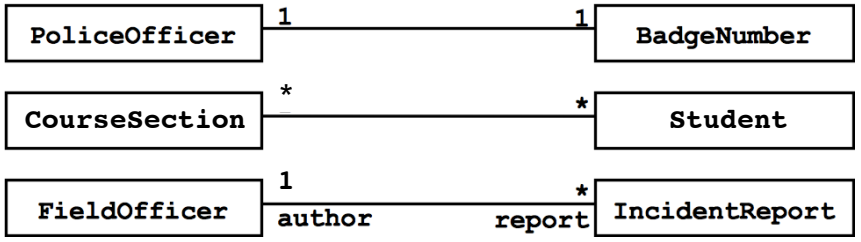
Roles

- Each end of an association can be labeled by a role.
- Allows us to distinguish among the multiple associations originating from a class.
  - ✦An employee can belong to a department and be the head of the department.
- Roles clarify the purpose of the association.
- Previous slide:
  - ✦The FieldOfficers allocated to a given incident are called resources.

Multiplicity

- Multiplicity: a set of integers labeling one end of an association
- Indicates how many links can originate from an instance of the class at the other end of the association.
- * is shorthand for 0..n, called “many”
- Most associations belong to one of these three types:
  - ✦A **one-to-one** association has a multiplicity 1 on each end.
  - ✦A **one-to-many** association has a multiplicity 1 on one end and 0..n (*) or 1..n on the other.
  - ✦A **many-to-many** association has a multiplicity 0..n or 1..n on both ends.

Examples of multiplicity



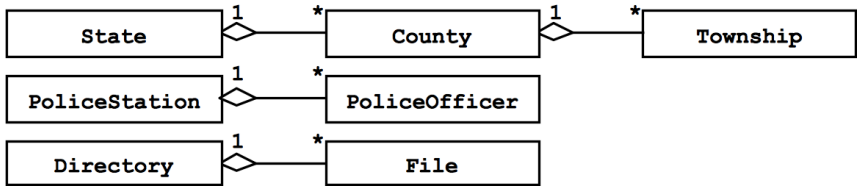
A CourseSection contains many Students
A Student is enrolled in many CourseSections

How many reports can a FieldOfficer write?
How many authors of a report can there be?

Aggregation and Composition

- Aggregation is a kind of association that specifies a whole/part relationship between the aggregate (whole) and component part.
  - ✦Useful to denote hierarchical relationships (directory contains files)
  - ✦Specified with an open diamond on the aggregate (whole) side.
- Composition is a special case of aggregation where the composite object has sole responsibility for the life cycle of the component parts.
  - ✦The composite is responsible for the creation and destruction of the component parts.
  - ✦An object may be part of only one composite.
  - ✦Specified with a closed diamond on the composite (whole) side.

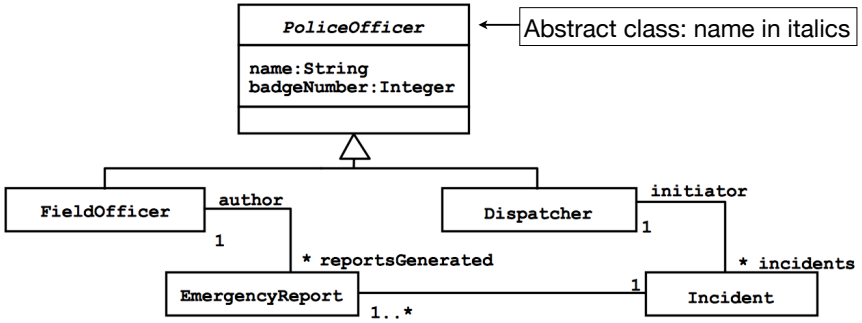
Examples of a aggregations



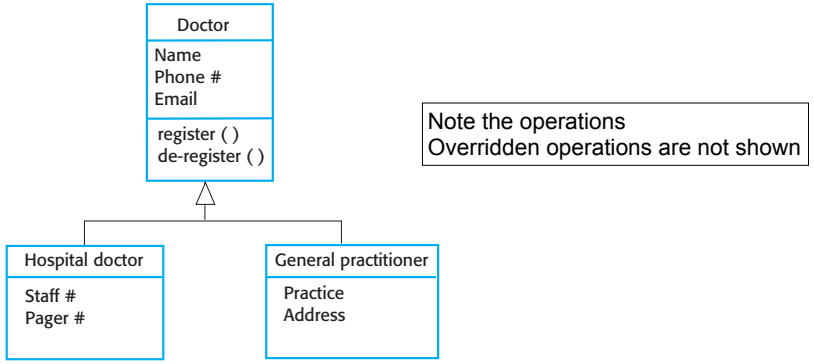
Could any of these be composites?
- can a County belong to more than one State?
- can a County exist without a State?

Inheritance

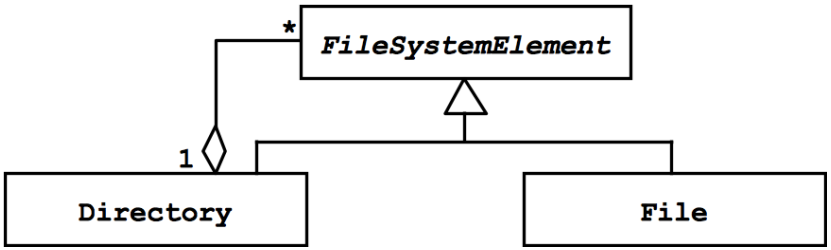
- Inheritance is a relationship between a base class and a more refined class.
  - ✦ the refined class has attributes and operations of its own, as well as the attributes and operations of the base class (it inherits them).



Inheritance example



Example of a hierarchical file system



Class diagram with an interface

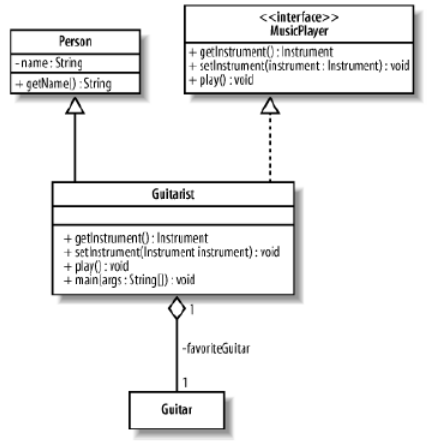
This diagram says that objects:

a) Persons have a name

b) Guitarists have a name

c) Guitars have a name

d) MusicPlayers have a name



When and how to use Class Diagrams

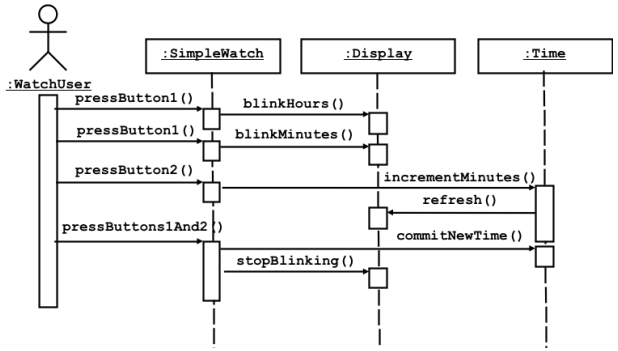
- All the time.
- Try to keep them simple, don't use unnecessary notation.
  - ✦ Especially if you are using them to model the application domain.
  - ✦ If you want to specify the implementation very specifically, you will use more of the notation.
- Don't draw models for every part of the program (at least not all in great detail)
- Focus first on concepts, then add detail as the design process continues.

Sequence Diagrams

- Represent the dynamic behavior of the system
- Describe patterns of communication among a set of interacting objects.
- An object interacts with another object by sending **messages**.
  - ✦The message must be an operation of the receiving object.
- Arguments may be passed along with a message
  - ✦they correspond to the parameters of the receiver's operation.

A Sequence diagram should be consistent with any existing class diagrams (this is where the messages (operations) are specified).

Sequence diagram for a simple watch

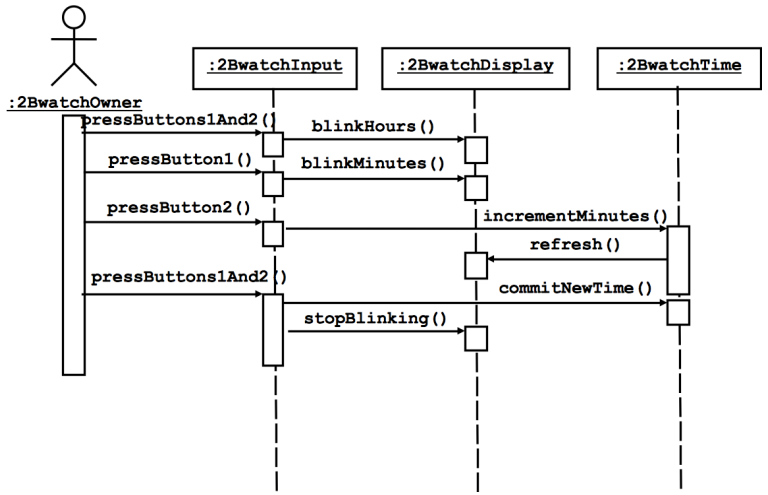


- Actor and objects (not classes) across the top
- Vertical lines are time lines of the objects
- Labeled arrows are messages sent to another object

Sequence Diagrams

- Objects across the top (horizontal axis)
- Time goes down (vertical axis)
- Diagram components:
  - ✦Solid horizontal arrows: messages
  - ✦Labels on arrows: message names (arguments optional)
  - ✦Return arrows (at end of operation, going back) are optional
  - ✦Vertical rectangle: an activation (lifetime) of an operation
  - ✦Interactions involving actors may not be operations.

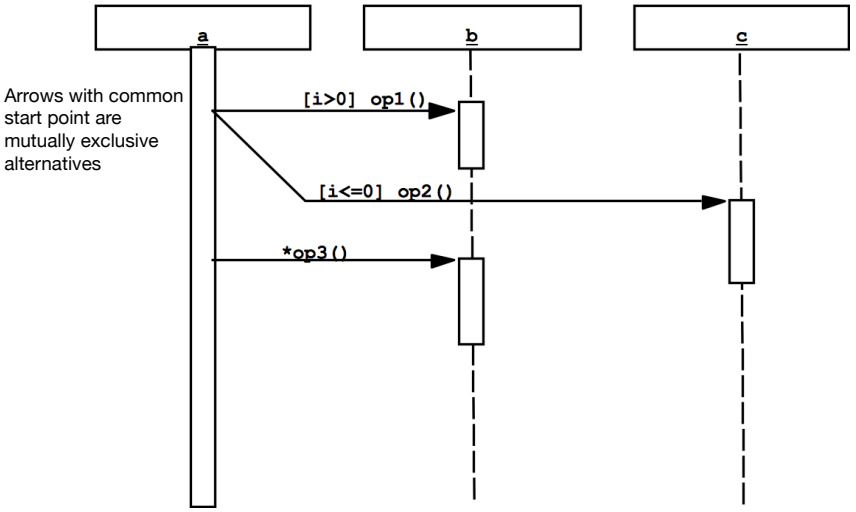
Sequence diagram: setting the time on 2Bwatch.



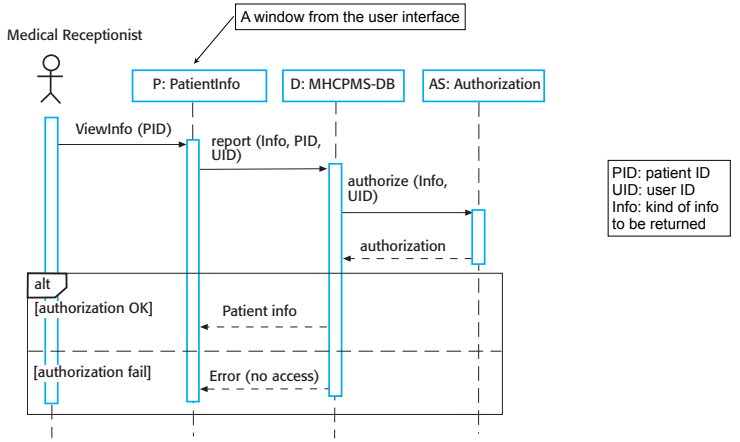
Sequence Diagrams: iteration and branching

- Notation for iteration (loops)
  - ✦Repeated message has an asterisk (see next slide: *op3())
    - ➡Optional: indicate basis of iteration in brackets: *[for all order lines] op3()
- Notation for conditions (alternatives)
  - ✦Conditional message is marked with a guard (see next slide) OR
  - ✦Alternative message(s) in a partitioned box labeled “alt”
    - ➡each partition has a guarded message (see next next slide)
  - ✦May be easier to draw a separate diagram for each alternative
- If you really want to model control flow, you should use an activity diagram instead.

Conditions and iterators in sequence diagrams.

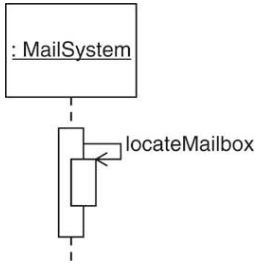


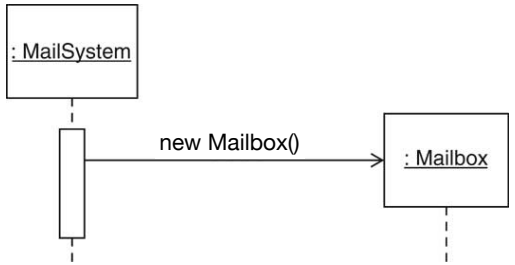
Using alt box to show branching.

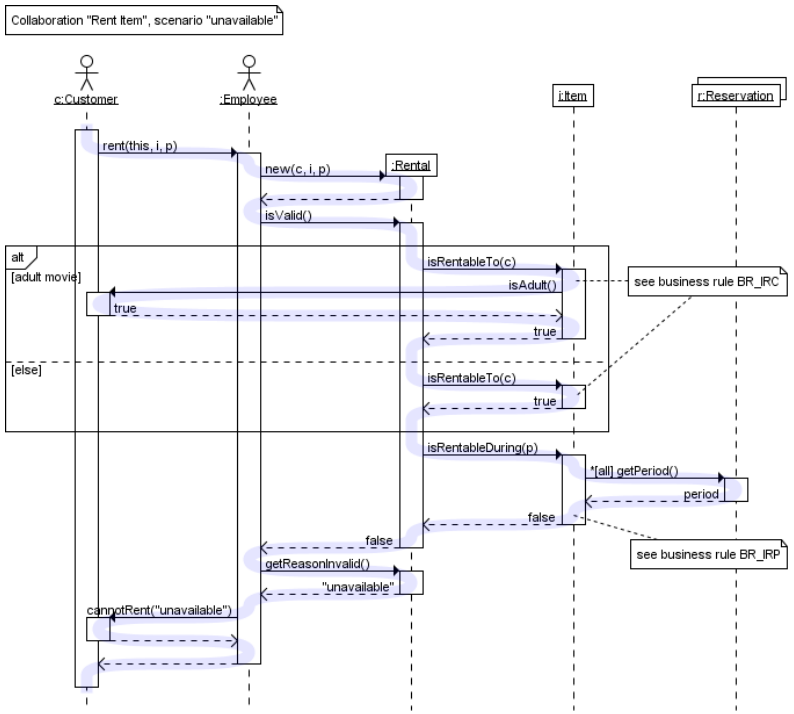


Sequence Diagrams: additional notations

- Self-call (operation calls itself)
  - ✦Message arrow back to original activation:
- Creating new instances:
  - ✦"new Class()" message points to object's box:







When and how to use Sequence Diagrams

- When you want to look at the behavior of several objects within a single use case.
- When the order of the method calls in the code seems confusing.
- When you are trying to determine which class should contain a given method.
  - ✦to uncover the responsibilities of the classes in the class diagrams
  - ✦to discover even new classes
- During Object-Oriented Design, sequence diagrams and the class diagram are often developed in tandem.