Evolution of Object-Oriented Development Methods

- Mid to late 1980s
  - Object-Oriented Languages (esp. C++) were very much in vogue
  - However, there was little guidance on how to divide a problem into OO classes.
- 1990: Object Modeling
  - All at around the same time, many were borrowing an argument from structured design:
    - The best organization for a software systems is one that is cohesive in the problem domain, not in the solution space
      - Tends to isolate changes
      - Tends to make the program easier to understand
  - Developed methods for applying this concept to OO design.
    - Rumbaugh, Coad, Wirfs-Brock, Booch, Jacobson …

Object Modeling Method

- Step 1: OOA
  - Analyze the problem domain
    - Identify problem domain classes and relationships between classes
    - Identify attributes and methods
    - Identify states and transitions
    - Sample object structures and interactions
  - Not programming! Abstracting the real-world.
- Step 2: OOD
  - Use the OOA as the core of a solution to:
    - User interface design
    - Database design
    - OO program design

UML

- Unified Modeling Language
  - In early 90s, there were many competing graphical notations all used for OOA.
  - Three of the major players got together in Booch's company
    - Rational Software Corporation
      - Booch, Rumbaugh, Jacobson
    - Merged their ideas to produce
      - UML (public domain)
      - Associated tools (mainly Rational Rose)
      - Rational Software Process (public domain)
      - Acquired other companies (Purify, Quantify, …)

Uses for UML

- OOA
  - A visual language for, in the problem domain,
    - capturing knowledge about a subject
    - expressing knowledge for the purposes of communication
- OOD
  - A visual language for, in the solution space,
    - capturing design ideas
    - communicating design ideas

- Related, but distinct usages
- Must supplement both with written explanations

This Course and UML

- You will use UML for assignments
  - Unfortunately, many of my slides are in OMT, as is the Design Patterns book.
- UML
  - Has its warts
  - Good enough when augmented by written explanation
- Cover only the most useful subset of UML
  - Mainly class/object/use case/sequence charts.

Books on UML

- You must acquire reference materials on UML
  - Some of these lecture materials prepared from
    - UML In A Nutshell (O'Reilly) by Sinan Si Alhir
  - Also
    - The Unified Modeling Language User Guide
      - Booch et. al.
  - Also
    - Reference materials off the Web
- Object Modeling books:
  - Object Oriented Analysis and Design
    - Booch et.al.
  - Designing Object-Oriented Software
    - Wirfs-Brock et. al.
  - Object-Oriented Modeling and Design
    - Rumbaugh et. al.
  - Object-Oriented Analysis
    - Coad and Yourdon

UML Definition

- OMG-endorsed standard (Object Management Group)
  - UML Semantics Document
    - “inside-view”
    - specifies semantics of constructs
  - UML Notation Guide
    - “outside-view”
    - specifies notation for expressing constructs
  - Object Constraint Language specification document
    - definition of a (textual) language for expressing logical constraints

UML is For

- For Problems
  - Specifying
  - Visualizing
  - Promoting Understanding
  - Documenting
- For Problem Solving
  - Capturing Attempts
  - Communicating Attempts
  - Leveraging Knowledge
- For Solutions
  - Specifying
  - Visualizing
  - Evaluating
  - Constructing
  - Documenting

Parts of UML

- Class Diagrams
  - models
- Object Diagrams
  - example models
- Use Case Diagrams
  - document who can do what in a system
- Sequence Diagrams
  - shows interactions between objects used to implement a use case
- Collaboration Diagrams
  - same as above, different style
- Statechart Diagrams
  - possible states and responses of a class and what transitions them
- Activity Diagrams
  - describe the behaviour of a class in response to internal processing
- Component Diagrams
  - Organization of and dependencies amongst software implementation components
- Deployment Diagrams
  - Describe the mapping of software implementation components onto processing nodes

The World Out There

- The real world is impenetrably complex
  - e.g., a complete model of you would include DNA, behaviour specifications, total history, parents' history, influences, …
  - for a particular problem, abstracting you as
    - last name
    - first name
    - student number
    - course
    - final grade

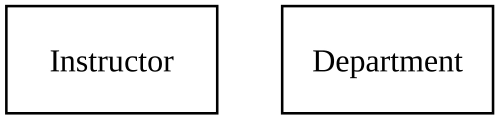
    may be enough.
- The Object-Oriented paradigm is one method for simplifying the world.

Objects [Rumbaugh]

- An object is
  A concept, abstraction, or thing
  with crisp boundaries and
  meaning for the problem at hand
- Objects
  - promote understanding of the real world
  - provide a practical basis for computer implementation
- Decomposition of a problem into objects depends on
  - Judgment
  - The nature of the problem being solved
    - Not only the domain: two analyses of the same domain will turn out differently depending upon the kind of programs we wish to produce.

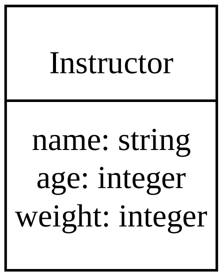
Classes

- A class describes a group of objects with similar properties.
  - ***Class***: Instructor
    - ***Object***: David Penny
    - ***Object***: Matthew Zaleski
  - ***Class***: Department
    - ***Object***: Department of Computer Science
    - ***Object***: Department of Electrical Engineering



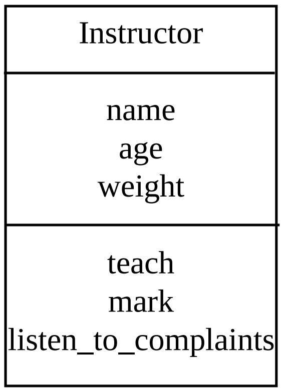
Attributes

- Data values held by the objects of a class



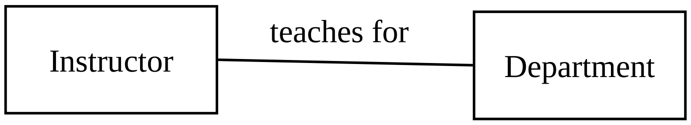
Operations

- A function or a transformation that may be applied to or by objects in a class.
  - Not often used (not often terribly useful) in an OOA



Links and Associations

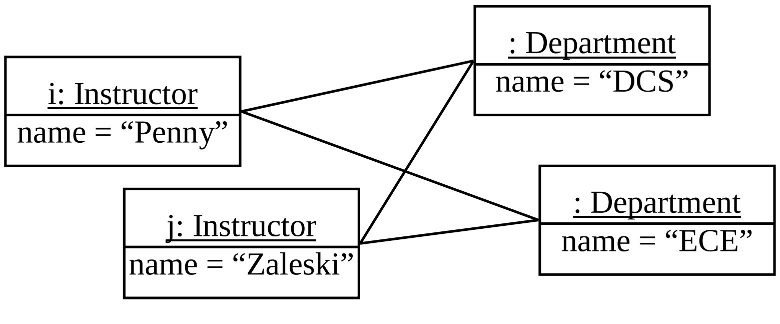
- The means for establishing relationships among objects and classes.
  - **link**: a connection between two object instances
  - **association**: a collection of links with common structure and semantics.



- By default, read association names left to right and top to bottom (override with ◄ or ►)

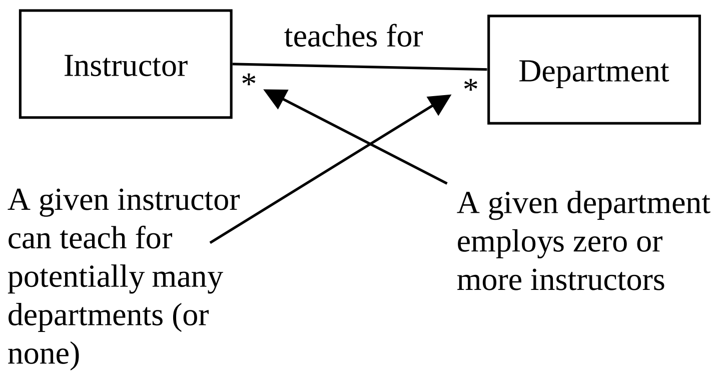
Object Diagrams

- Models instances of things contained in class diagrams.
- Shows a set of objects and their links at a point in time
- Useful preparatory to deciding on class structures.
- Useful in order to better explain more complex class diagrams by giving instance examples.



Multiplicity

- Used to indicate the number of potential instances involved in the association when the other associated classes are fixed.

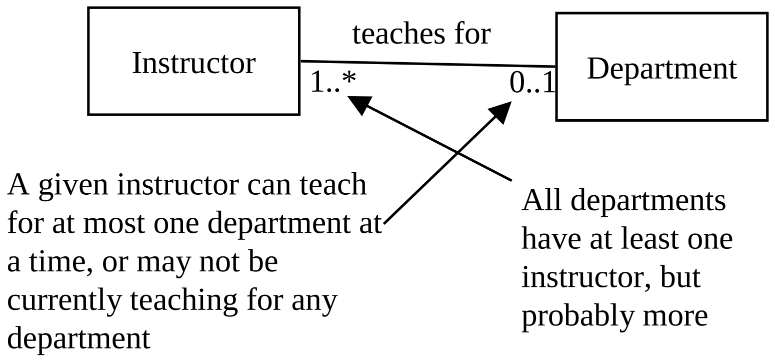


A given instructor can teach for potentially many departments (or none)

A given department employs zero or more instructors

Multiplicities Carry Important Messages

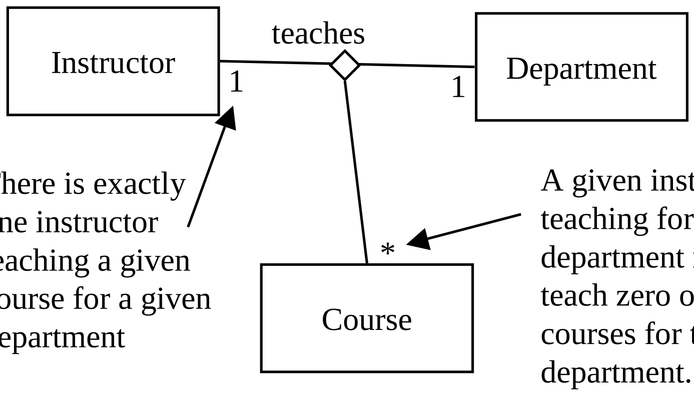
- Used to indicate the number of potential instances involved in the association when the other associated class is fixed.



A given instructor can teach for at most one department at a time, or may not be currently teaching for any department

All departments have at least one instructor, but probably more

N-Ary Associations

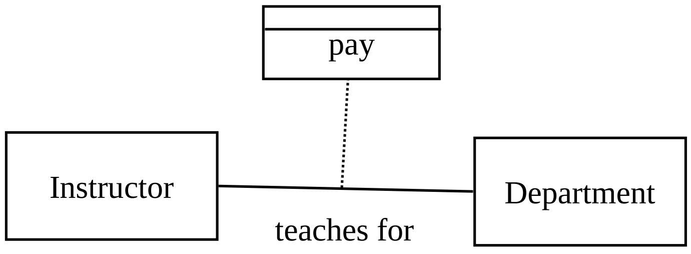


There is exactly one instructor teaching a given course for a given department

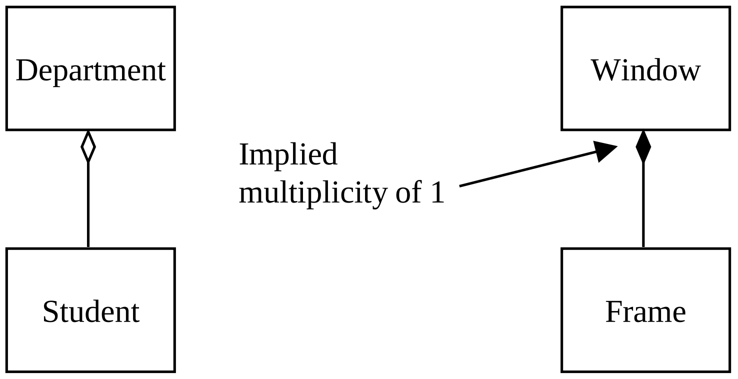
A given instructor teaching for a given department may teach zero or more courses for that department.

Try to avoid them!

Attributes on Associations



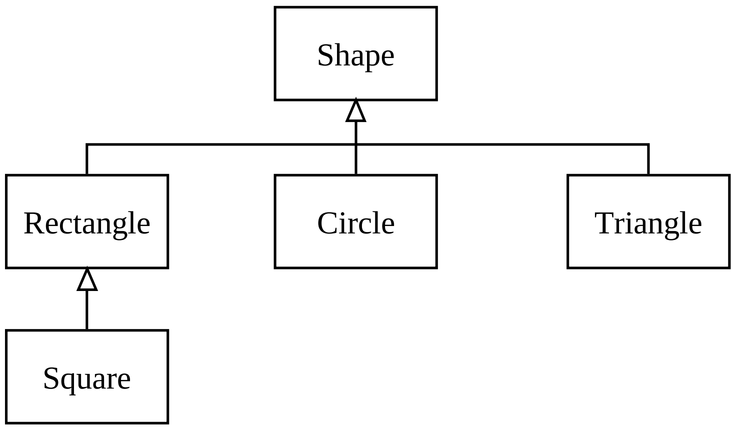
Aggregation Indicators (Part-Of)



Aggregation
(no associated semantics)

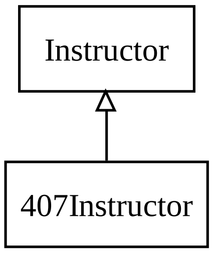
Composition
(strong ownership,
coincident lifetime)

Generalization (a.k.a. Inheritance, is-a)



Avoiding Morphing Classes

- Analysis shown below may not be a good choice, as objects of class 407Instructor may teach other things and different things next term.
- Avoid situations where objects will need to morph classes



Example

- We are asked to build a system for keeping track of the time our workers spend working on customer projects.
- We divide projects into activities, and the activities into tasks. A task is assigned to a worker, who could be a salaried worker or an hourly worker.
- Each task requires a certain skill, and resources have various skills at various level of expertise.

Steps

- Analyze the written requirements
  - Extract nouns: make them classes
  - Extract verbs: make them associations
  - Draw the OOA UML class diagrams
  - Determine attributes
  - Draw object diagrams to clarify class diagrams
- Determine the system’s use cases
  - Identify Actors
  - Identify use case
  - Relate use cases
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  - One per use case
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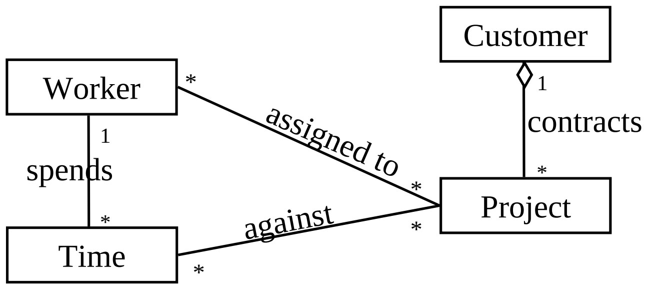

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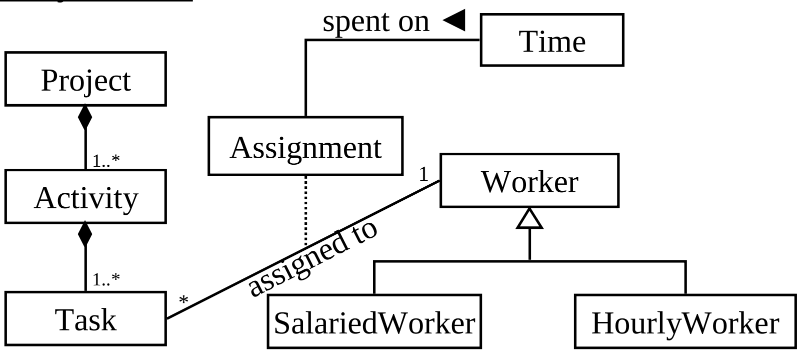
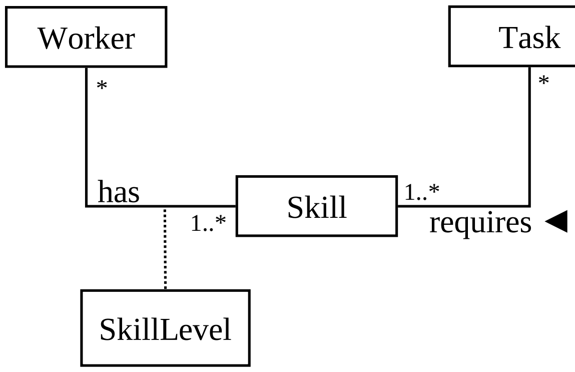


Example

- Each task requires a certain skill, and workers have various skills at various level of expertise.



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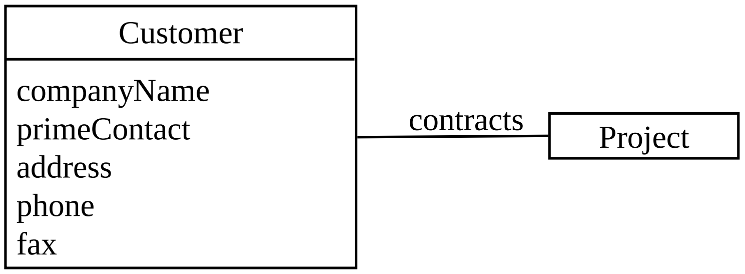
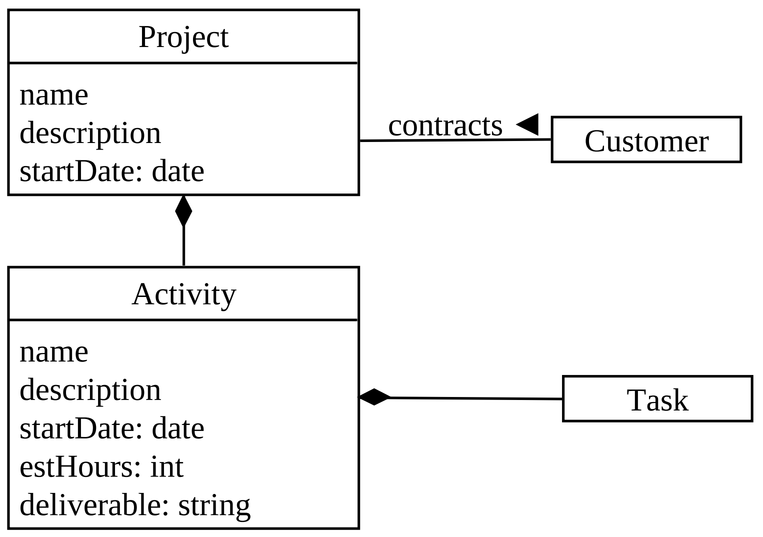


N.B.

- Project has no attribute in Customer
  - association is enough
- no database id for Customer shown
  - in an OOA, only include an id if visible to users
  - may include such things during database design or OOD

Example



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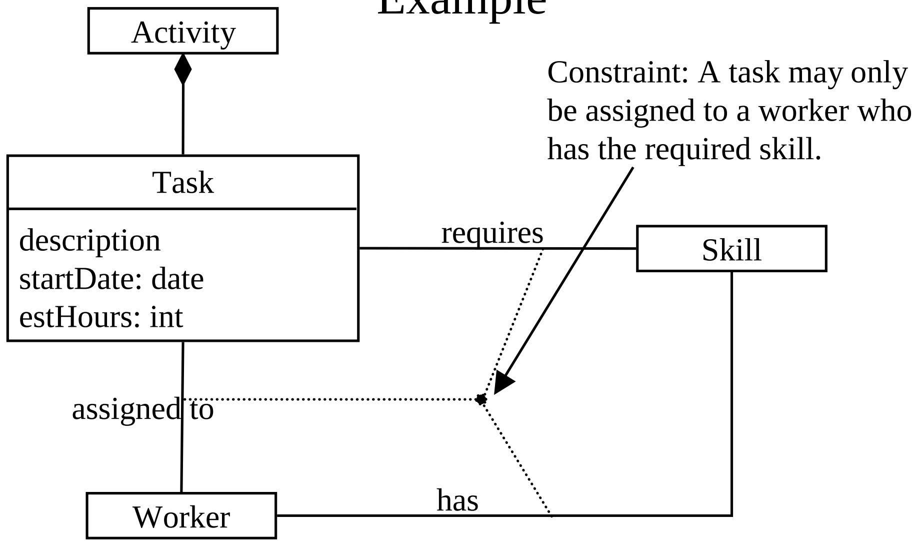
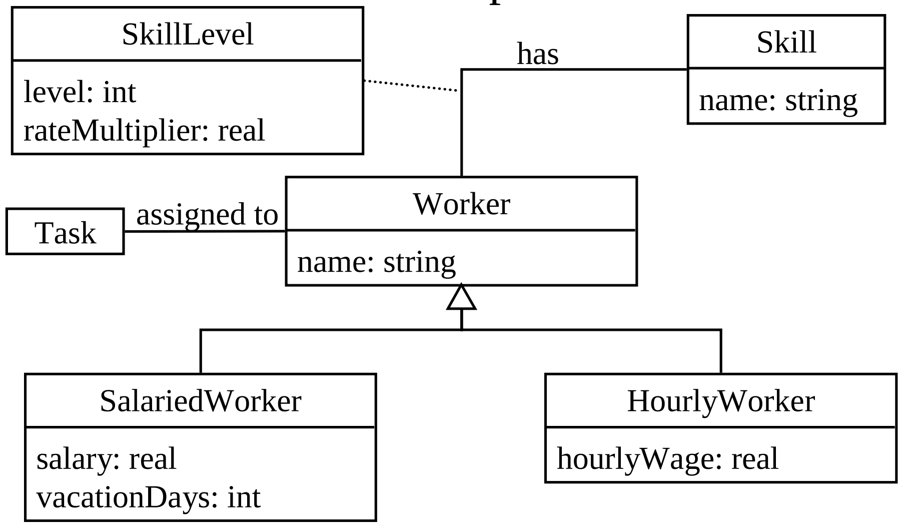

Constraint: A task may only be assigned to a worker who has the required skill.

Example



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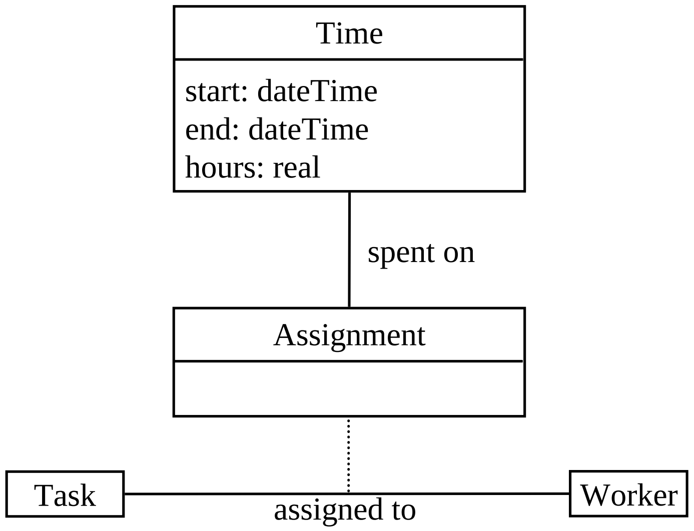

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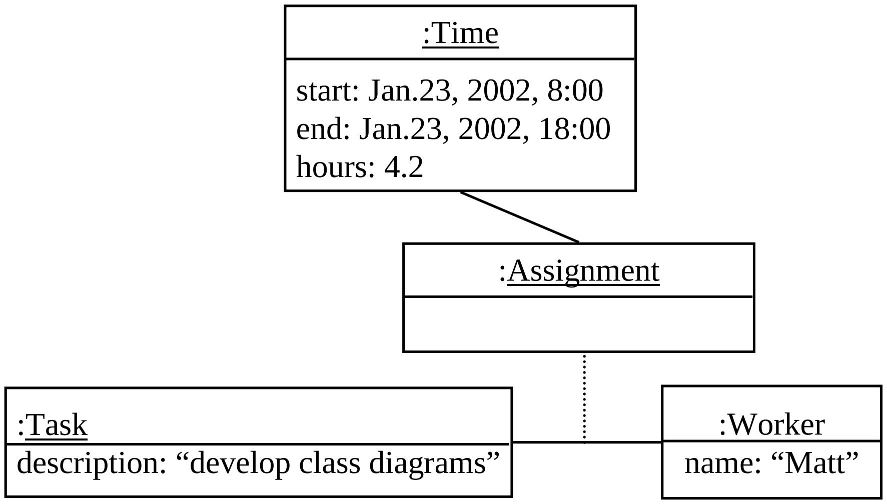
Object Diagrams



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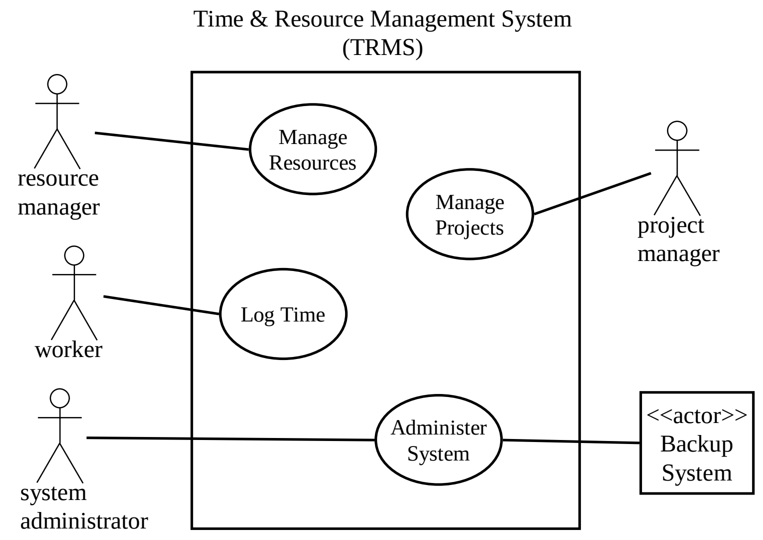
Use Cases

- Actors:
  - Represent users of a system
    - human users
    - other systems
- Use cases
  - Represent functionality or services provided by a system to its users

Use Case Diagrams



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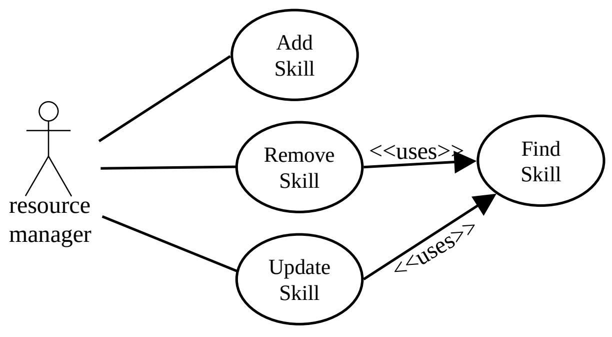
Resource Manager Use Cases



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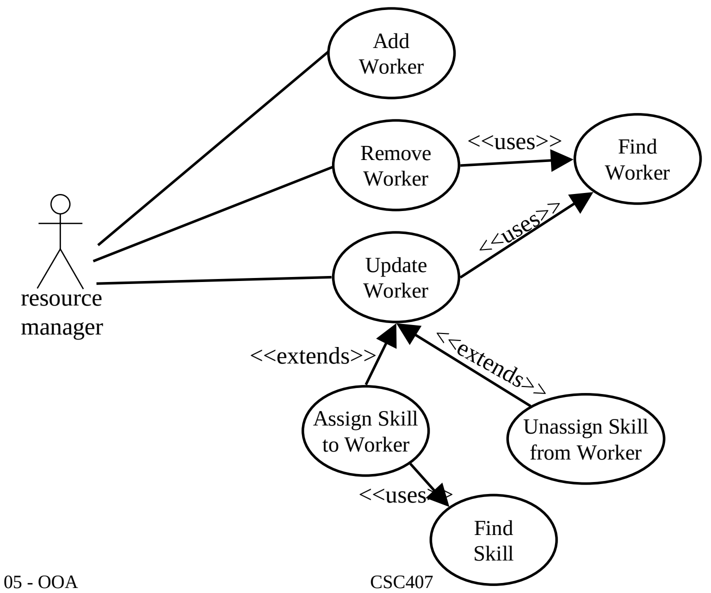
More Resource Manager Use Cases



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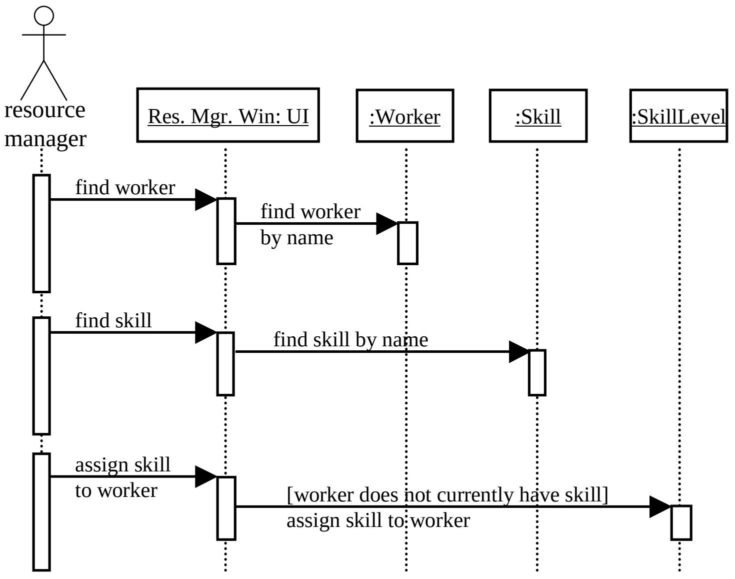
Sequence Diagram – Assign Skill to Worker Use Case



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Add Methods

- Read sequence diagrams to identify necessary methods

Worker
name: string

+ static Worker findWorker(String name);
+ static list of Workers getWorkers();

In Design

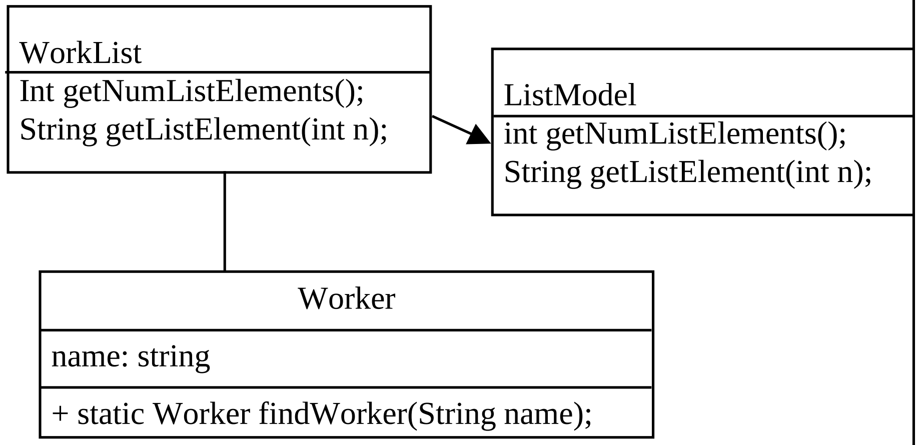
- Bring methods closer to implementation

Worker
name: string

+ static Worker findWorker(String name);
+ static int getNWorkers();
+ static Worker getWorker(int);

In Design

- Bring methods closer to implementation


WorkList
Int getNumListElements();
String getListElement(int n);
ListModel
int getNumListElements();
String getListElement(int n);
Worker
name: string
+ static Worker findWorker(String name);