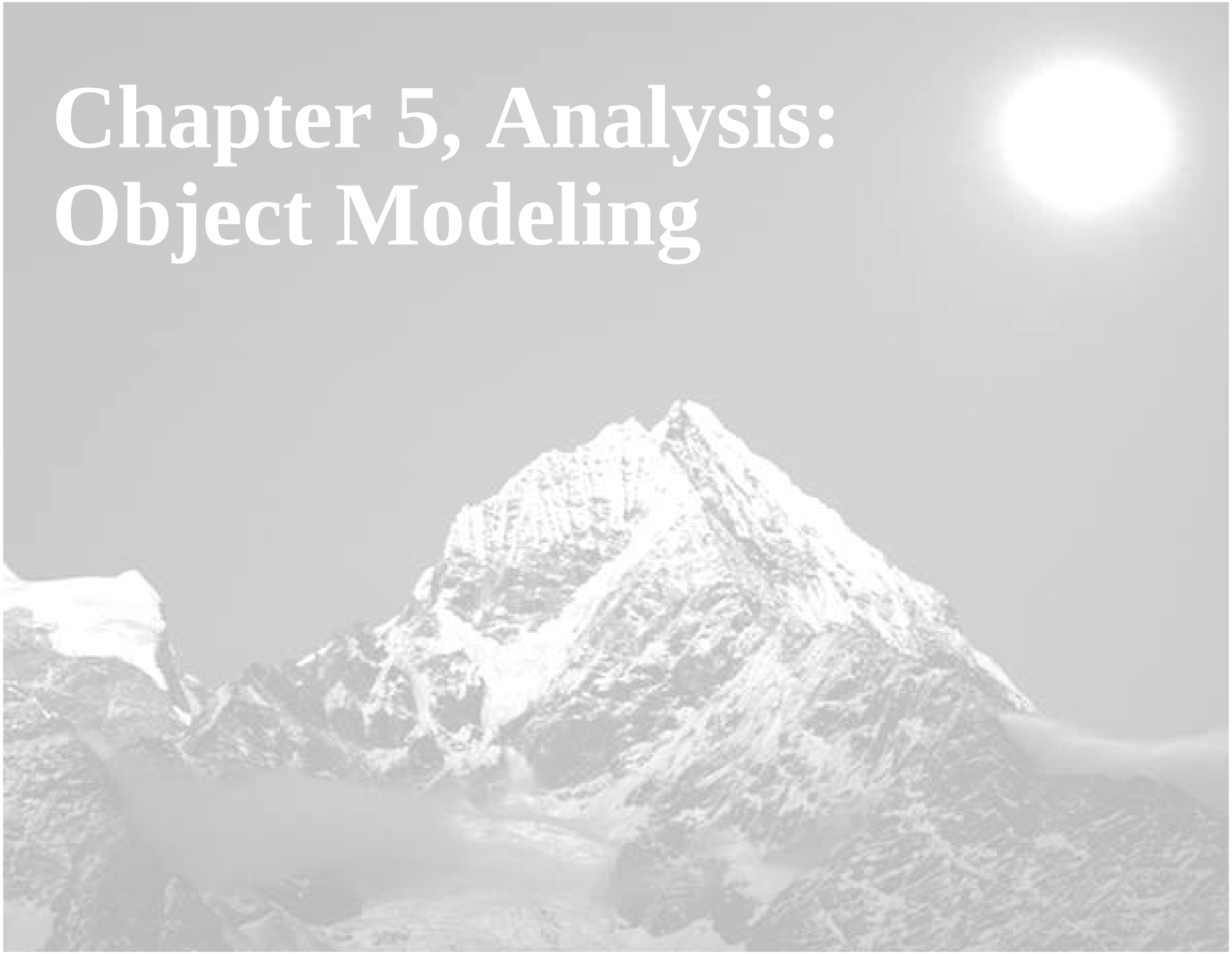
Object-Oriented Software Engineering
Conquering Complex and Changing Systems

Chapter 5, Analysis: Object Modeling



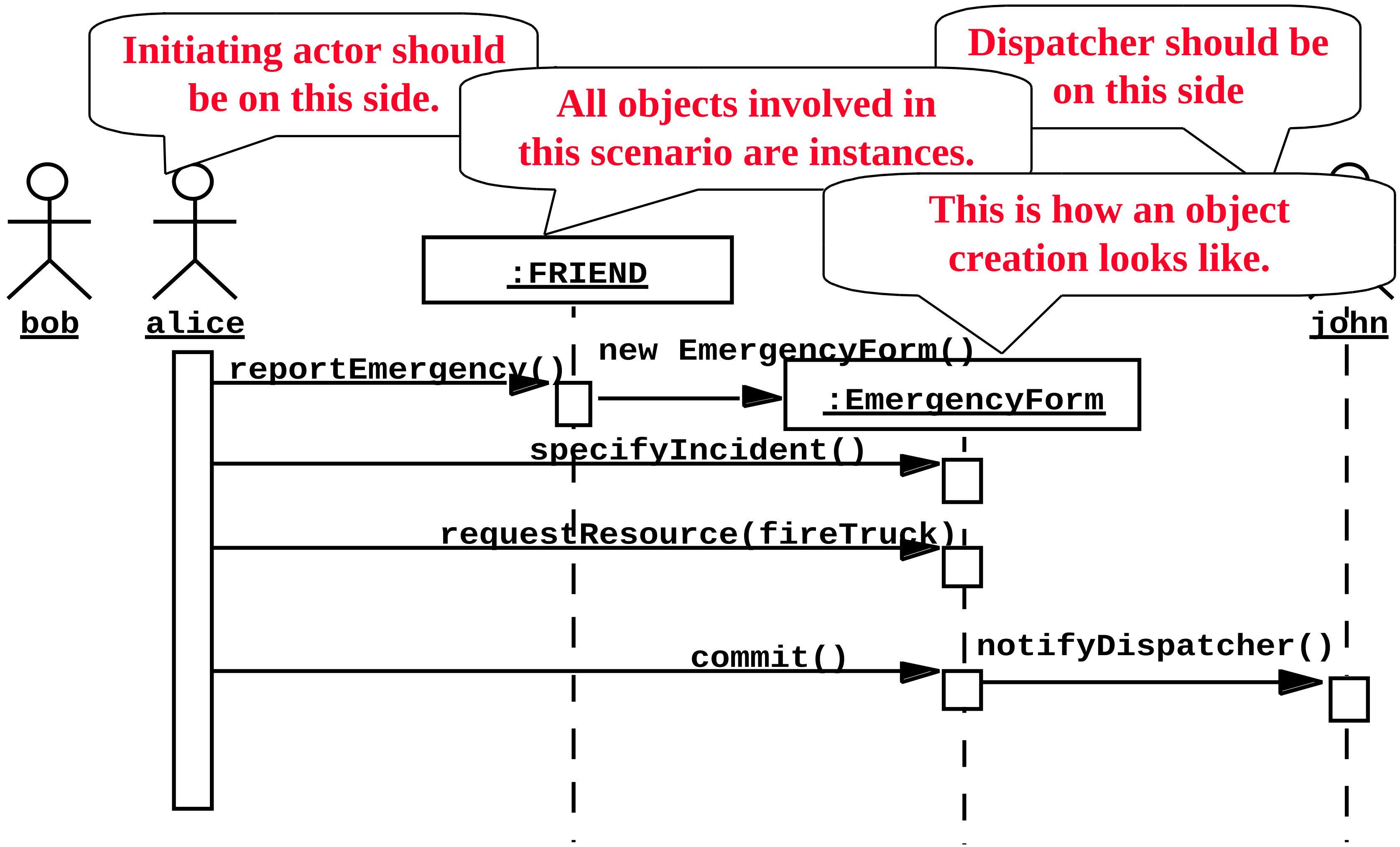
Exercise 2.6

Draw a sequence diagram for the `warehouseOnFire` scenario (as described in the requirements elicitation lecture).

Include the objects bob, alice, john, system, and instances of other classes you may need.

Draw only the first five message sends.

Solutions to exercise 2.6



Note: this exercise can have many other acceptable solutions.

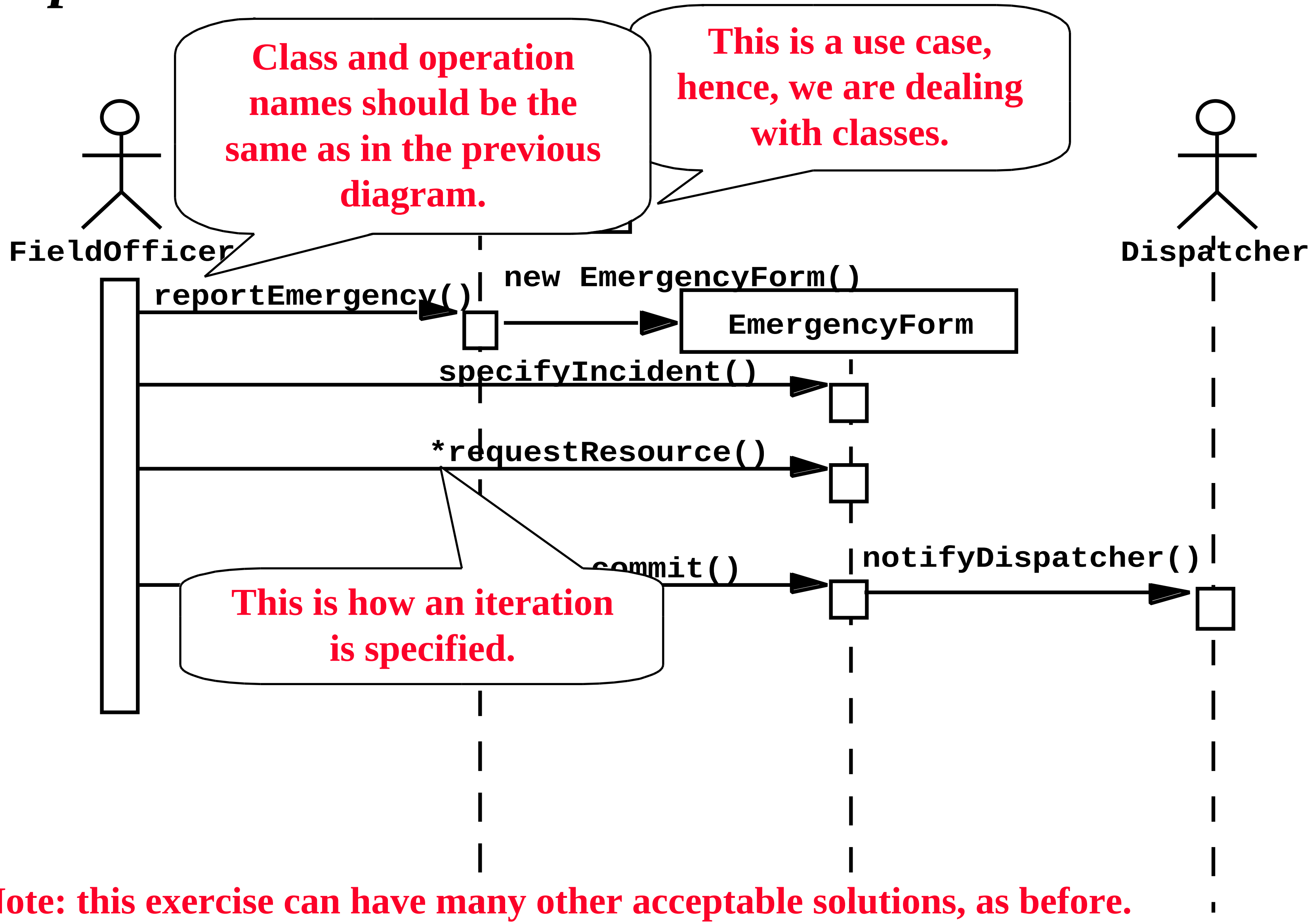
Exercise 2.7

Draw a sequence diagram for the `ReportIncident` use case (as described in the requirements elicitation lecture).

Make sure it is consistent with the sequence diagram of the previous exercise.

Draw only the first five message sends.

Sample solution to exercise 2.7

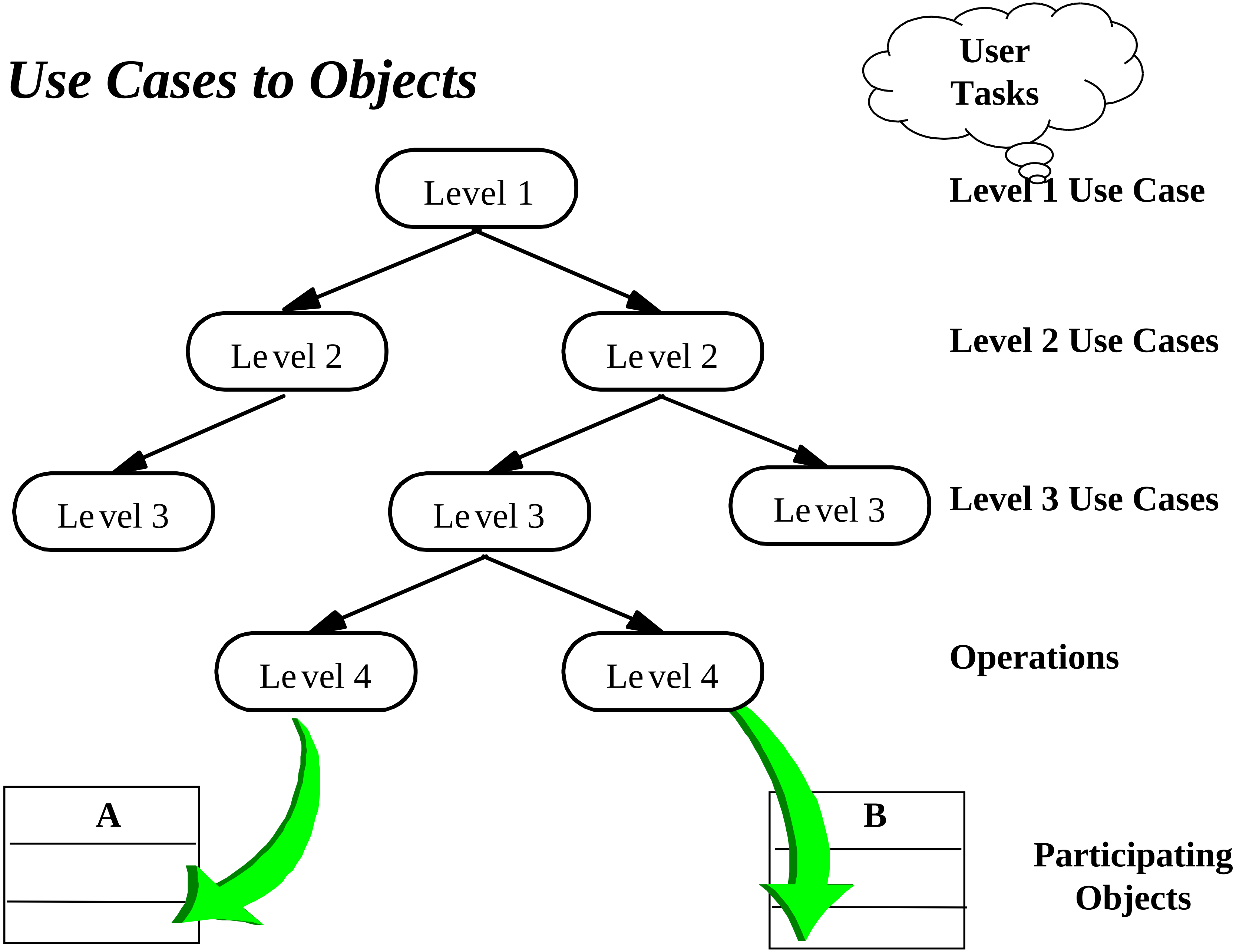


Note: this exercise can have many other acceptable solutions, as before.

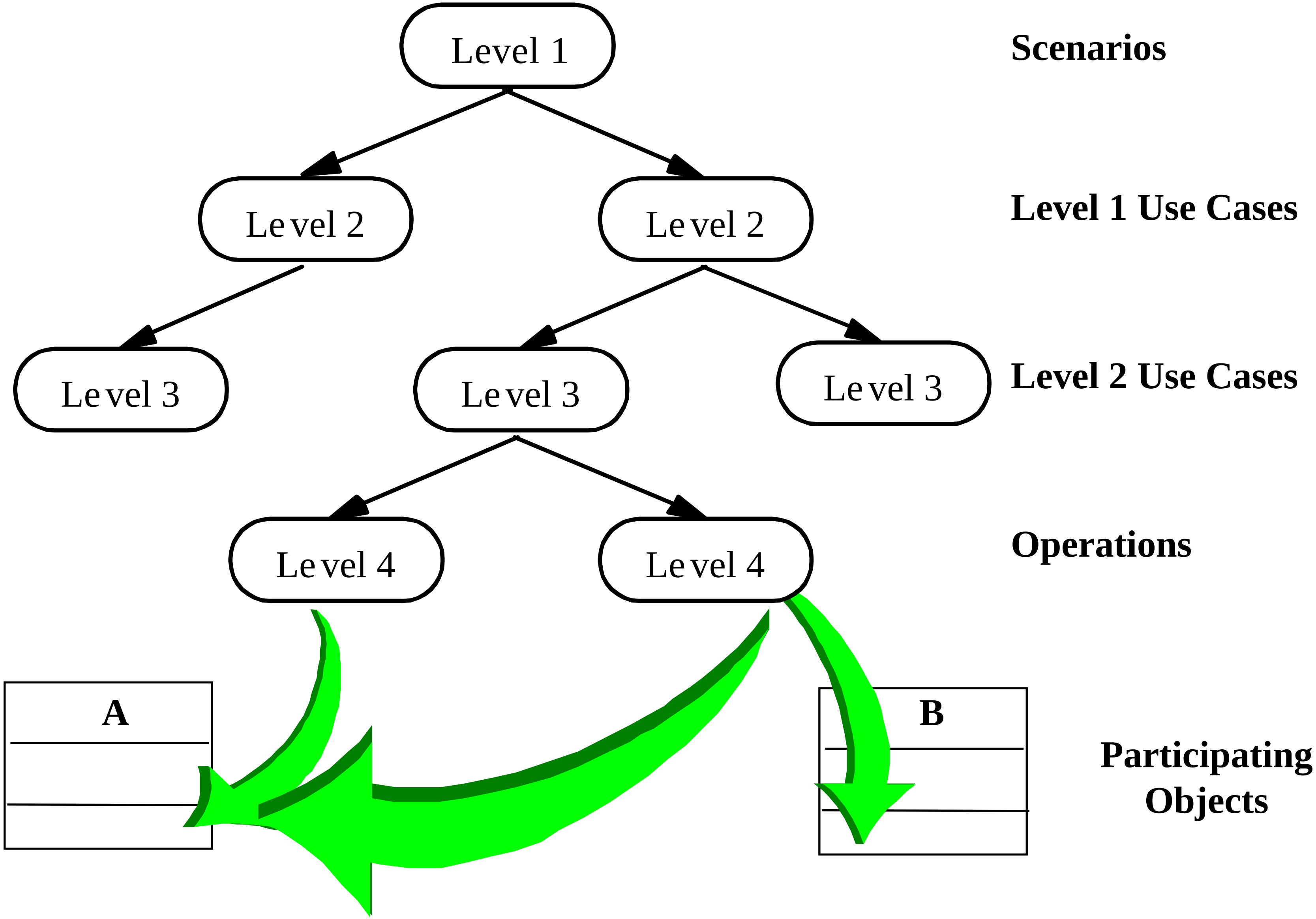
Outline

- From use cases to objects
- Object modeling
- Class vs instance diagrams
- Attributes
- Operations and methods
- Links and associations
- Examples of associations
- Two special associations
  - **Aggregation**
  - **Inheritance**

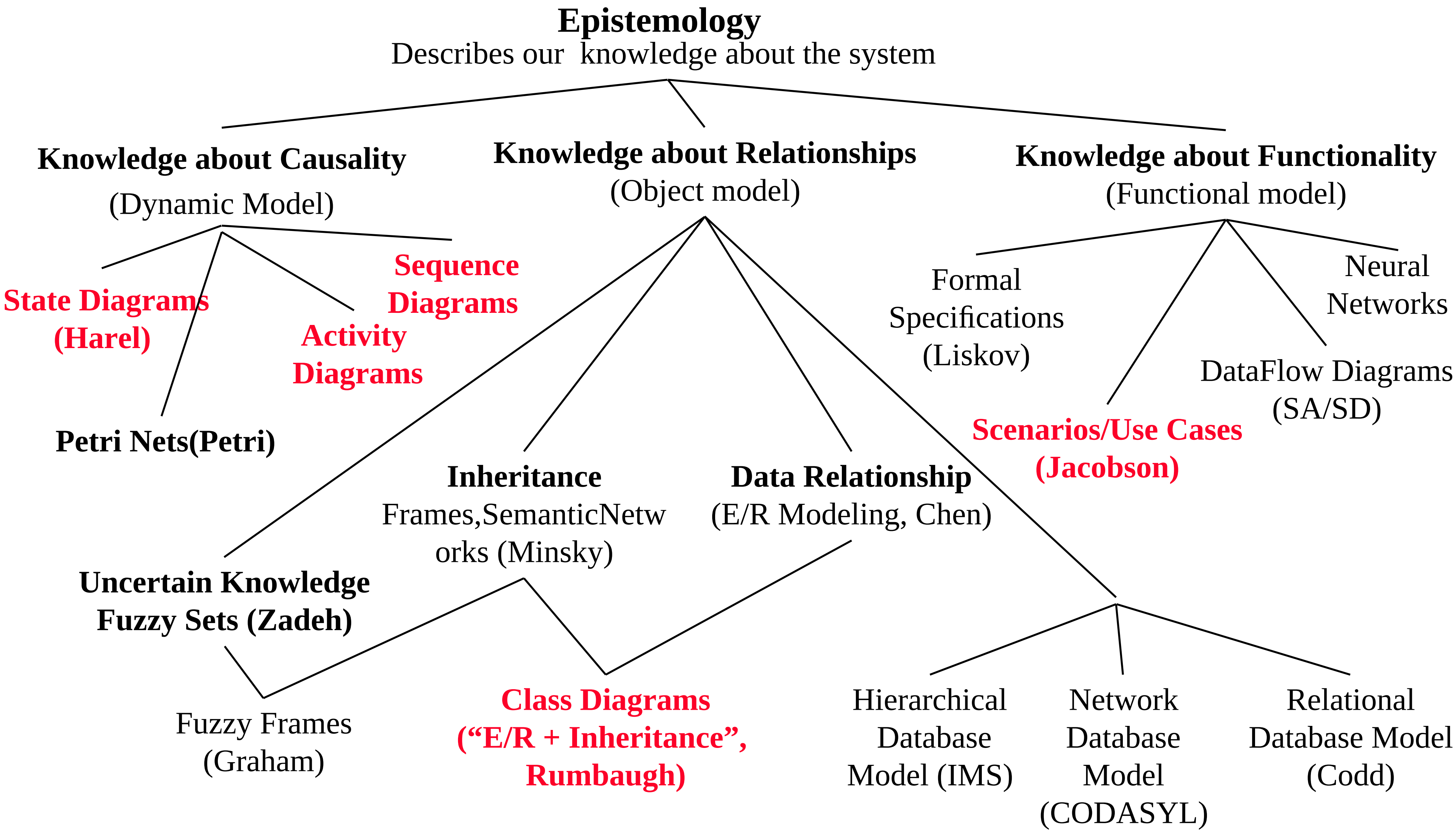
From Use Cases to Objects



From Use Cases to Objects: Why Functional Decomposition is not Enough



How do we describe complex systems (Natural Systems, Social Systems, Artificial Systems)?



Definition: Object Modeling

- Main goal: Find the important abstractions
- What happens if we find the wrong abstractions?
  - **Iterate and correct the model**
- Steps during object modeling
  - **1. Class identification**
    - **Based on the fundamental assumption that we can find abstractions**
  - **2. Find the attributes**
  - **3. Find the methods**
  - **4. Find the associations between classes**
- Order of steps
  - **Goal: get the desired abstractions**
  - **Order of steps secondary, only a heuristic**
  - **Iteration is important**

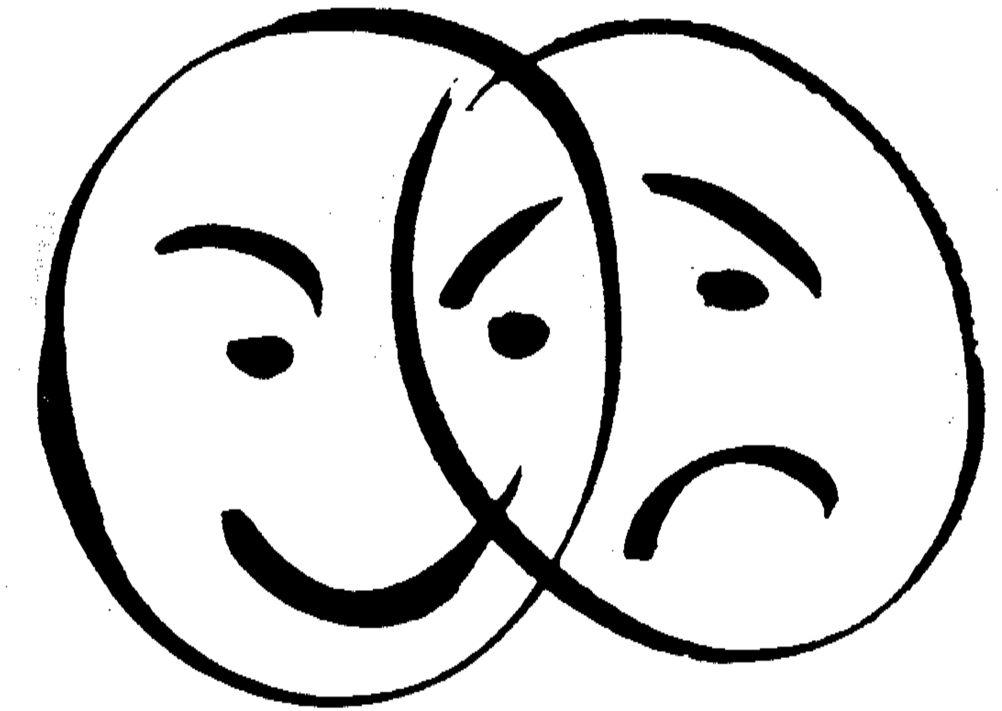
Class Identification

- Identify the boundaries of the system
- Identify the important entities in the system
- Class identification is crucial to object-oriented modeling
- Basic assumption:
  - **1. We can find the classes for a new software system (Forward Engineering)**
  - **2. We can identify the classes in an existing system (Reverse Engineering)**
- Why can we do this?
  - **Philosophy, science, experimental evidence**

Class identification is an ancient problem

- Objects are not just found by taking a picture of a scene or domain
- The application domain has to be analyzed.
- Depending on the purpose of the system different objects might be found
  - **How can we identify the purpose of a system?**
  - **Scenarios and use cases**
- Another important problem: Define system boundary.
  - **What object is inside, what object is outside?**

What is This?



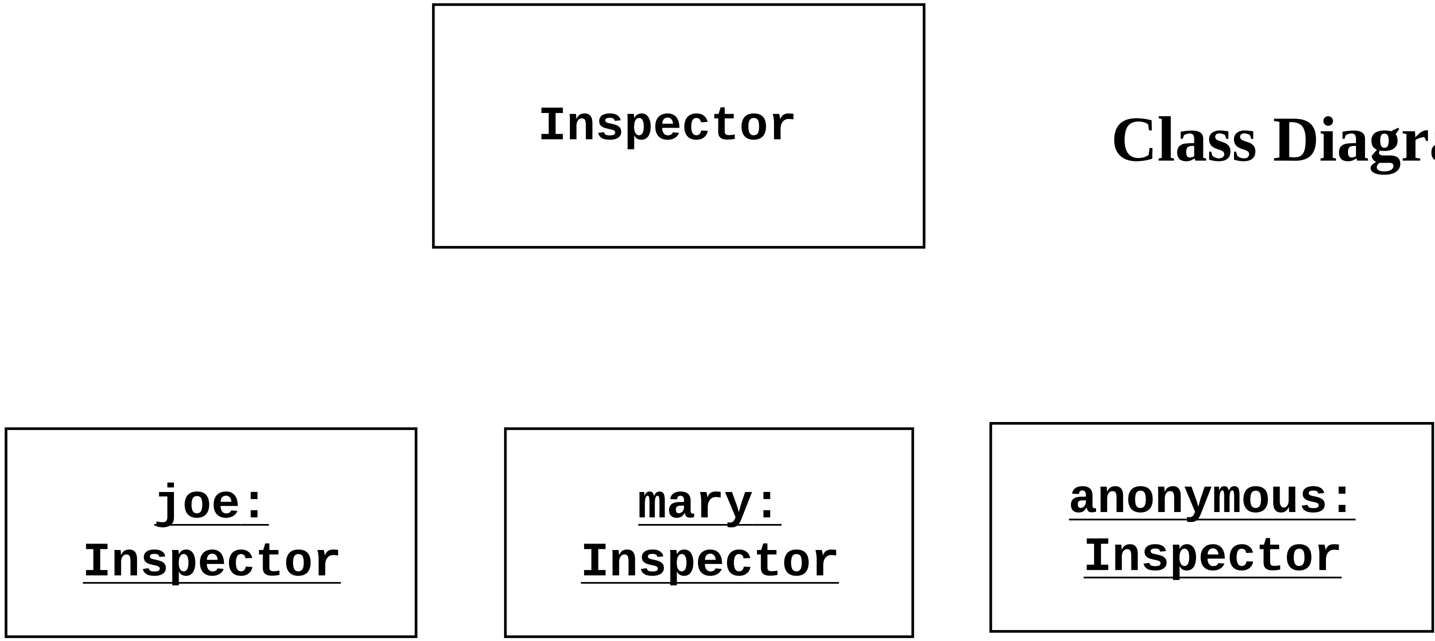
Pieces of an Object Model

- Classes
- Associations (Relations)
  - **Part of- Hierarchy (Aggregation)**
  - **Kind of-Hierarchy (Generalization)**
- Attributes
  - **Detection of attributes**
  - **Application specific**
  - **Attributes in one system can be classes in another system**
  - **Turning attributes to classes**
- Methods
  - **Detection of methods**
  - **Generic methods: General world knowledge, design patterns**
  - **Domain Methods: Dynamic model, Functional model**

Object vs Class

- Object (instance): Exactly one thing
  - **The lecture on November 2 on Software Engineering from 14:30 -16:00**
- A class describes a group of objects with similar properties
  - **IETM, Author, Corrosion, Work order**
- *Object diagram:* A graphic notation for modeling objects, classes and their relationships ("associations"):
  - ***Class diagram:* Template for describing many instances of data. Useful for taxonomies, patters, schemata...**
  - ***Instance diagram:* A particular set of objects relating to each other. Useful for discussing scenarios, test cases and examples**
- Together-J: CASE Tool for building object diagrams, in particular class diagrams
  - **Tutorial on November 10**

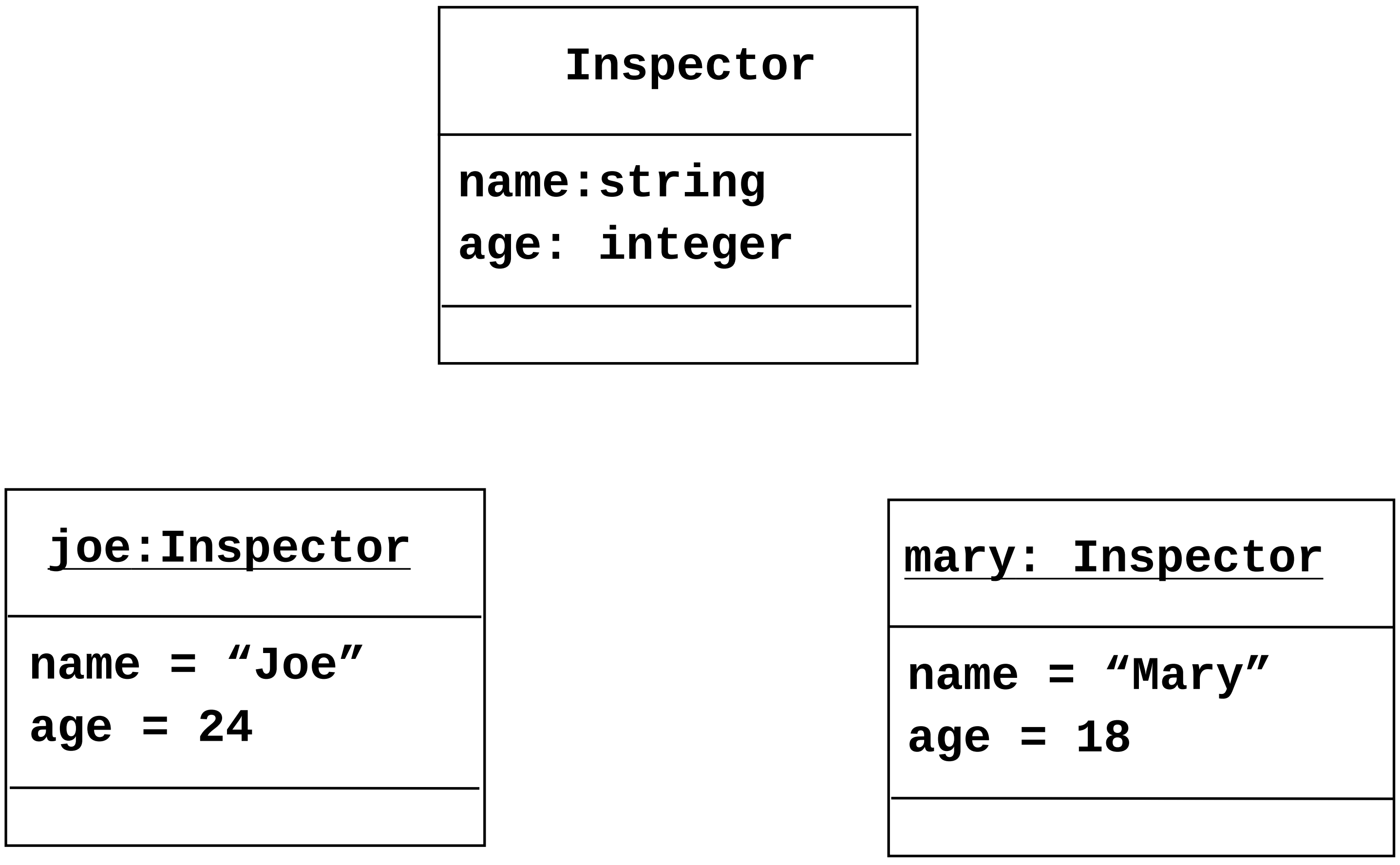
UML: Class and Instance Diagrams



Class Diagram

Instance Diagram

Attributes and Values



Operation, Signature or Method? What when?

- ***Operation*:** A function or transformation applied to objects in a class. All objects in a class share the same operations *(Analysis Phase)*
- ***Signature*:** Number & types of arguments, type of result value. All methods of a class have the same signature *(Object Design Phase)*
- ***Method*:** Implementation of an operation for a class *(Implementation Phase)*

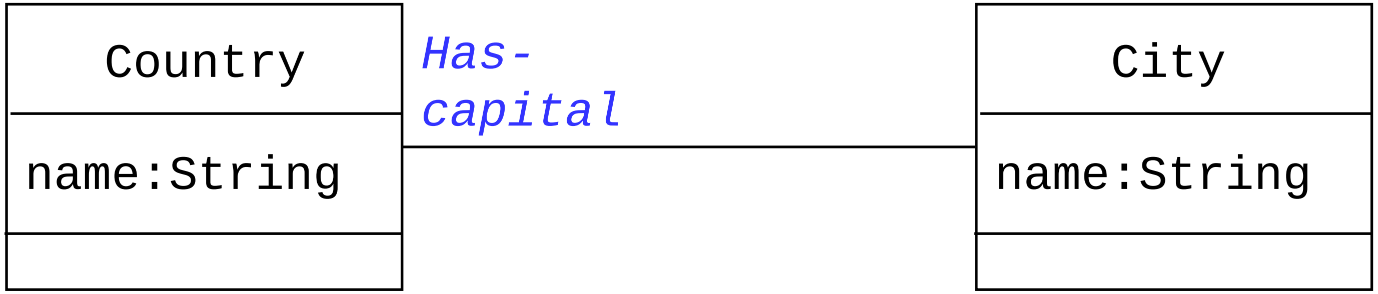
  Polymorphic operation: The same operation applies to many different classes.

Workorder
File_name: String Size_in_bytes: integer Last_update: date Stickies: array[max]
print() delete() open() close() write() read()

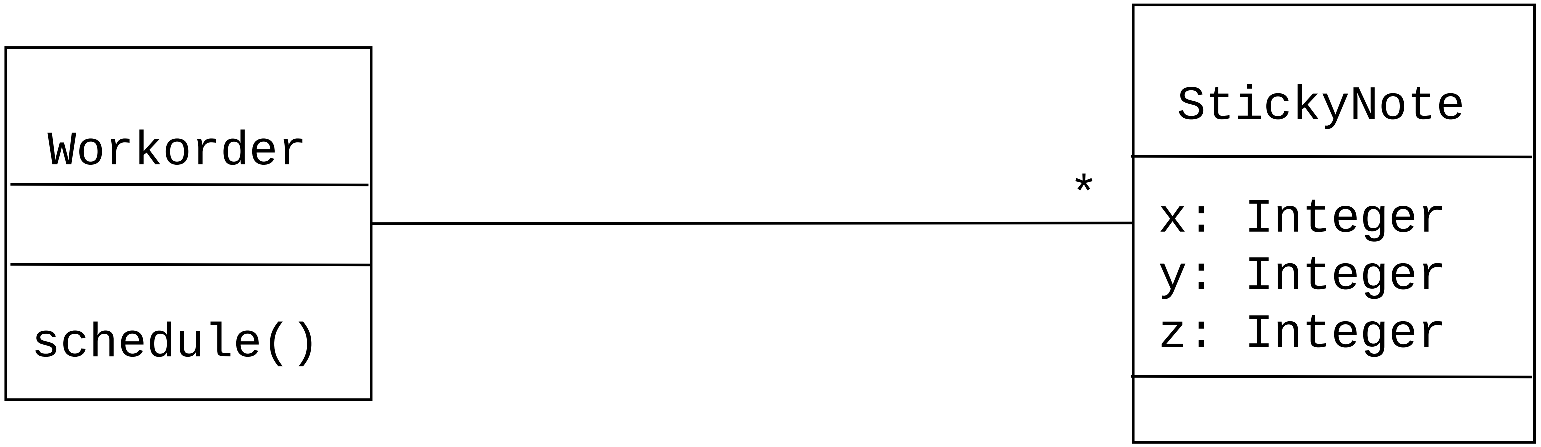
Links and Associations

- Links and associations establish relationships among objects and classes.
- **Link:**
  - **A connection between two object instances. A link is like a tuple.**
  - **A link is an instance of an association**
- **Association:**
  - **Basically a bidirectional mapping.**
  - **One-to-one, many-to-one, one-to-many,**
  - **An association describes a set of links like a class describes a set of objects.**

1-to-1 and 1-to-many Associations



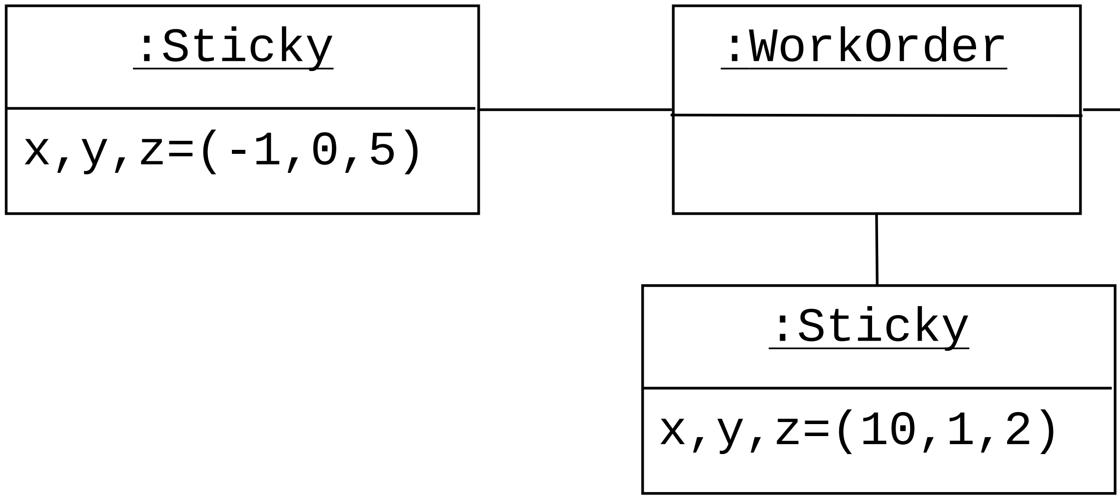
One-to-one association



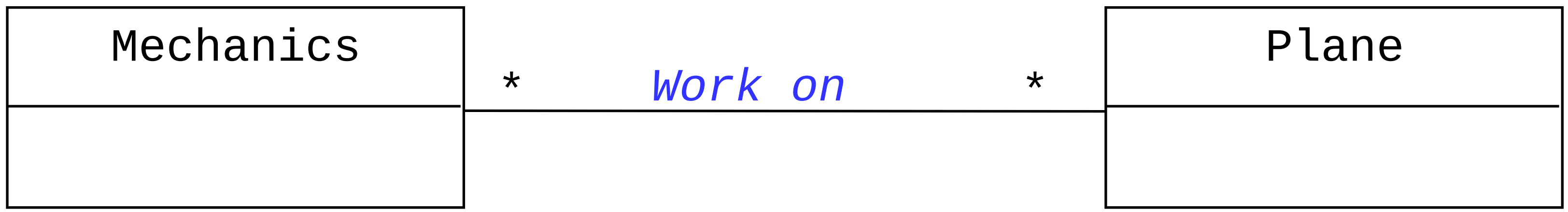
One-to-many association

Object Instance Diagram

Example for 1-to-many



Many-to-Many Associations

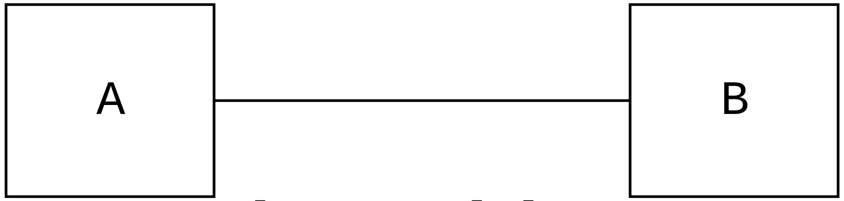


Roles in Associations

- Client Role**:**
  - **An object that can operate upon other objects but that is never operated upon by other objects.**
- Server Role:
  - **An object that never operates upon other objects. It is only operated upon by other objects.**
- Agent Role:
  - **An object that can both operate upon other objects and be operated upon by other objects. An agent is usually created to do some work on behalf of an actor or another agent.**

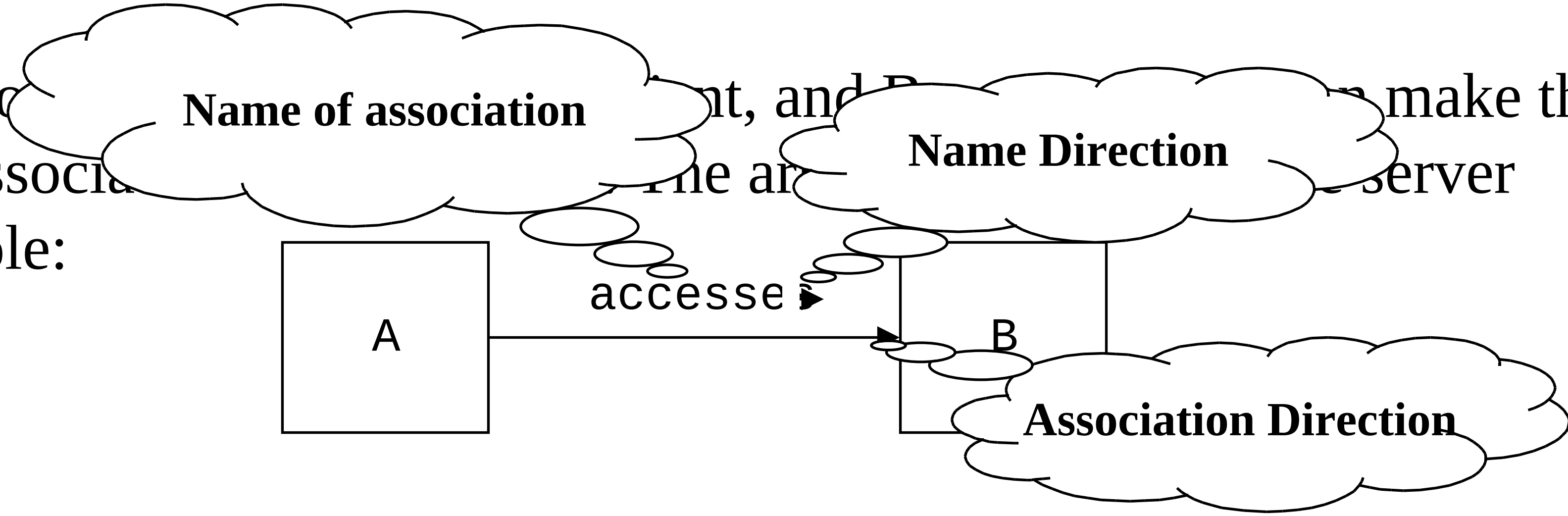
Do UML associations have direction?

- **A association between two classes is by default a bi-directional mapping.**



  - **Class A can access class B and class B can access class A**
  - **Both classes play the agent role.**

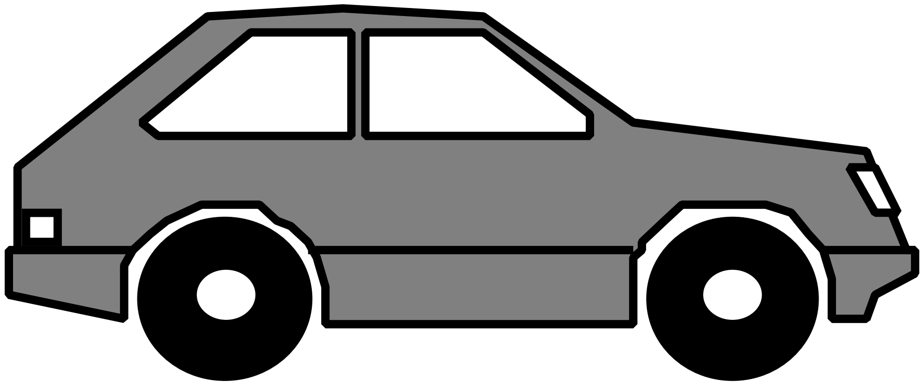
If yo nt, and B make the associa The ar server role:



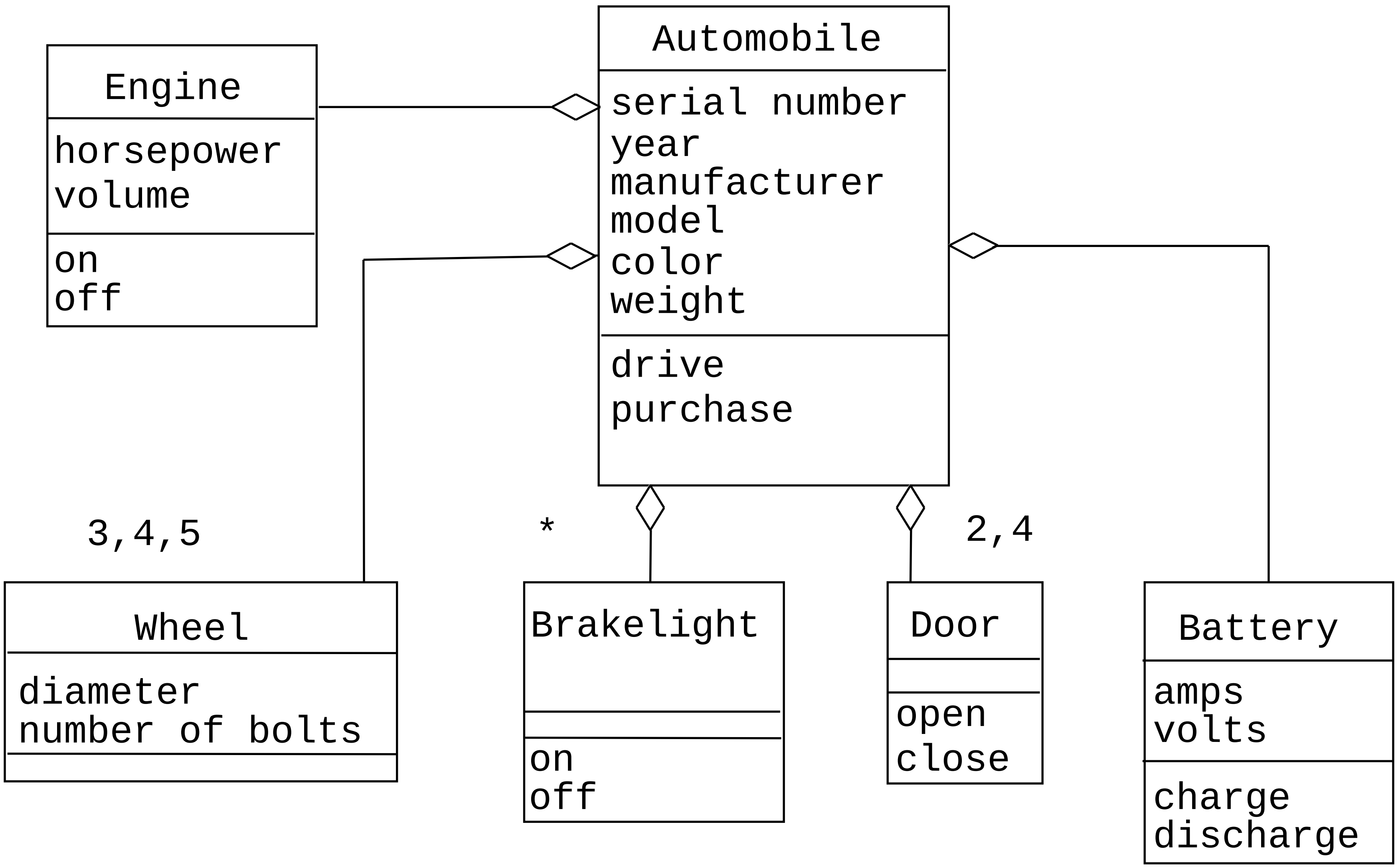
Class A (the “client”) accesses class B (“the server”). B is also called *navigable*

Aggregation

- Models "part of" hierarchy
- Useful for modeling the breakdown of a product into its component parts (sometimes called bills of materials (BOM) by manufacturers)
- UML notation: Like an association but with a small diamond indicating the assembly end of the relationship.

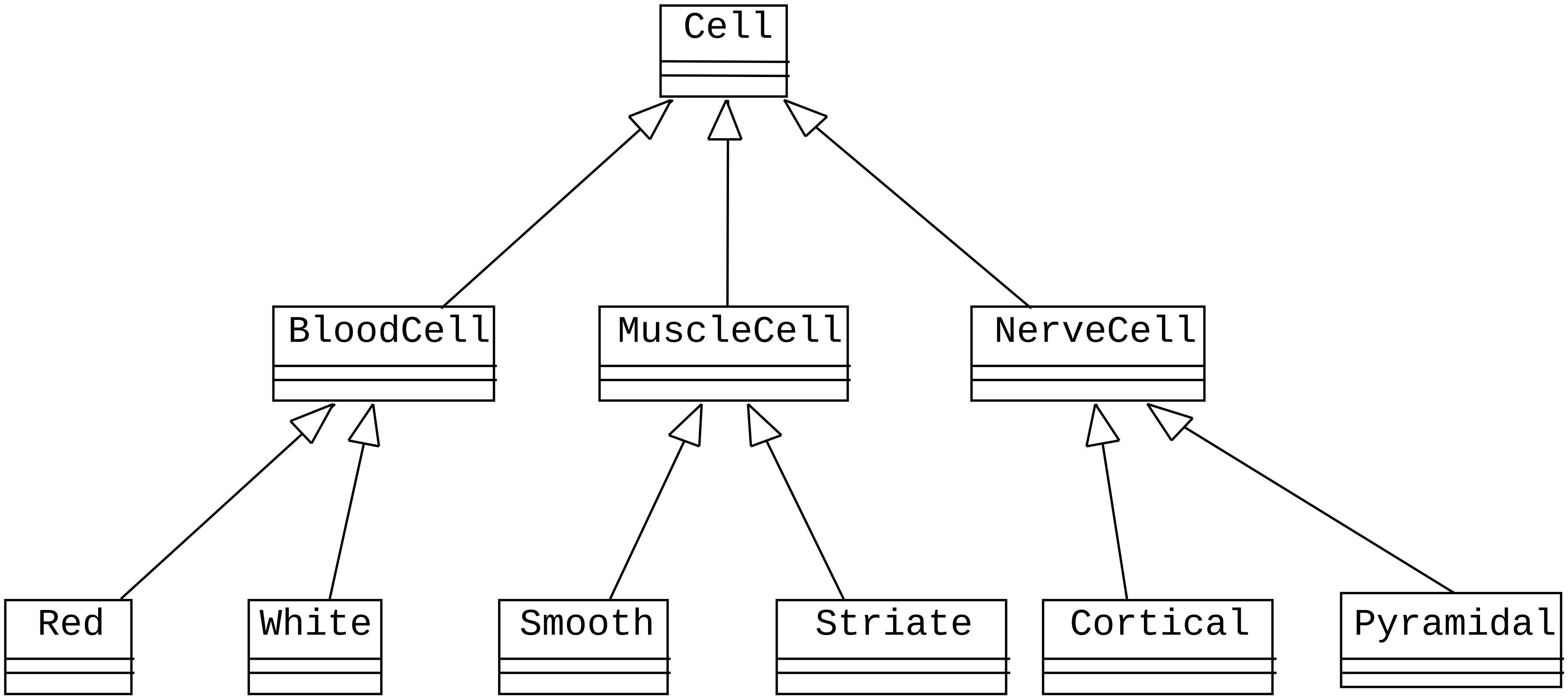


Aggregation



Inheritance

- Models "kind of" hierarchy
- Powerful notation for sharing similarities among classes while preserving their differences
- UML Notation: An arrow with a triangle



Aggregation vs Inheritance

- Both associations describe trees (hierarchies)
  - **Aggregation tree describes a-part-of relationships (also called and-relationship)**
  - **Inheritance tree describes "kind-of" relationships (also called or-relationship)**
- Aggregation relates instances (involves two or more *different* objects)
- Inheritance relates classes (a way to structure the description of a *single* object)

Other Associations

- Uses:
  - **A subsystem uses another subsystem (System Design)**
- Contains:
  - **Sometimes called “spatial aggregation”**
  - **... contains ...**
  - **Example: A UML package contains another UML package**
- Parent/child relationship:
  - **... is father of ...**
  - **... is mother of ...**
- Seniority:
  - **... is older than ...**
  - **... is more experienced than ...**

Odds and Ends

- Hoererschein for the book:
  - **Participating Bookstores: If you say you are taking this class, you get 10% off at:**
    - **Buchladen am Obelisk (Barerstrasse),**
    - **Kanzler (Gabelsbergerstrasse),**
    - **Lachner (Theresienstrasse)**
- Solution to last exercise
- Finding a superclass

Object Types11/2/00

- Entity Objects
  - **Represent the persistent information tracked by the system (Application domain objects, "Business objects")**
- Boundary Objects
  - **Represent the interaction between the user and the system**
- Control Objects:
  - **Represent the control tasks performed by the system**
- Having three types of objects leads to models that are more resilient to change.
  - **The boundary of a system changes more likely than the control**
  - **The control of the system change more likely than the application domain**
- Object types originated in Smalltalk:
  - **Model, View, Controller (MVC) => Observer Pattern**

Example: 2BWatch Objects

- UML provides several mechanisms to extend the language
- UML provides the stereotype mechanism to present new modeling elements

<<entity>>
Year

<<control>>
ChangeDateControl

<<boundary>>
ButtonBoundary

<<entity>>
Month

<<boundary>>
LCDDisplayBoundary

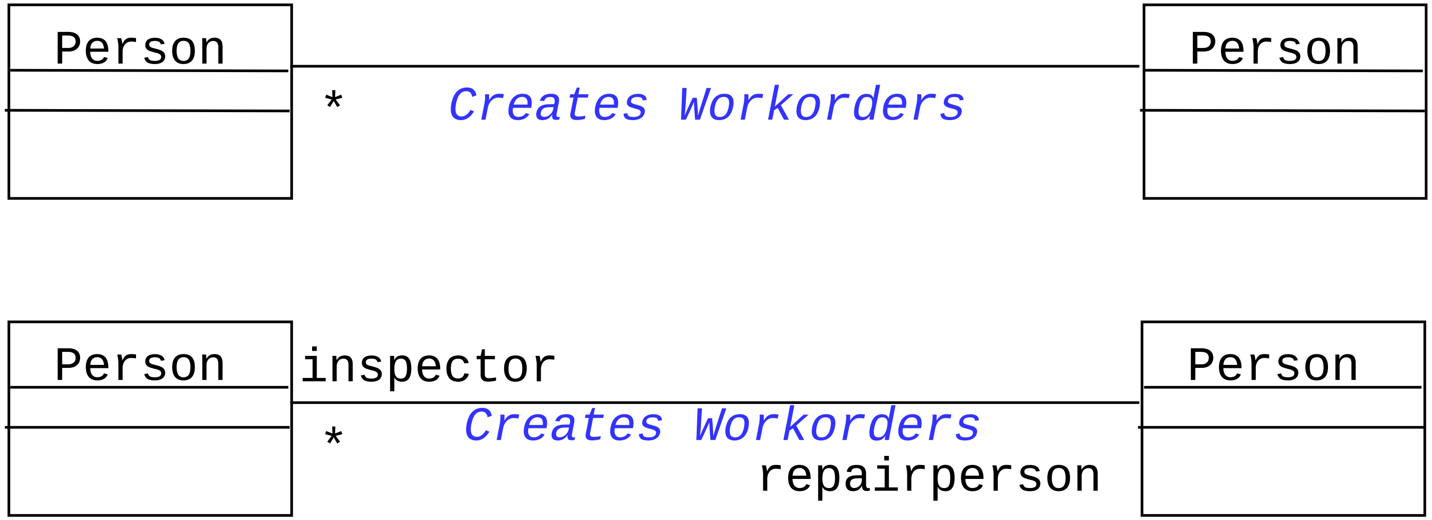
<<entity>>
Day

Roles

- A role name is the name that uniquely identifies one end of an association.
- A role name is written next to the association line near the class that plays the role.
- When do you use role names?
  - **Necessary for associations between two objects of the same class**
  - **Also useful to distinguish between two associations between the same pair of classes**
- When do you not use role names?
  - **If there is only a single association between a pair of distinct classes, the names of the classes serve as good role names**

Example of Role

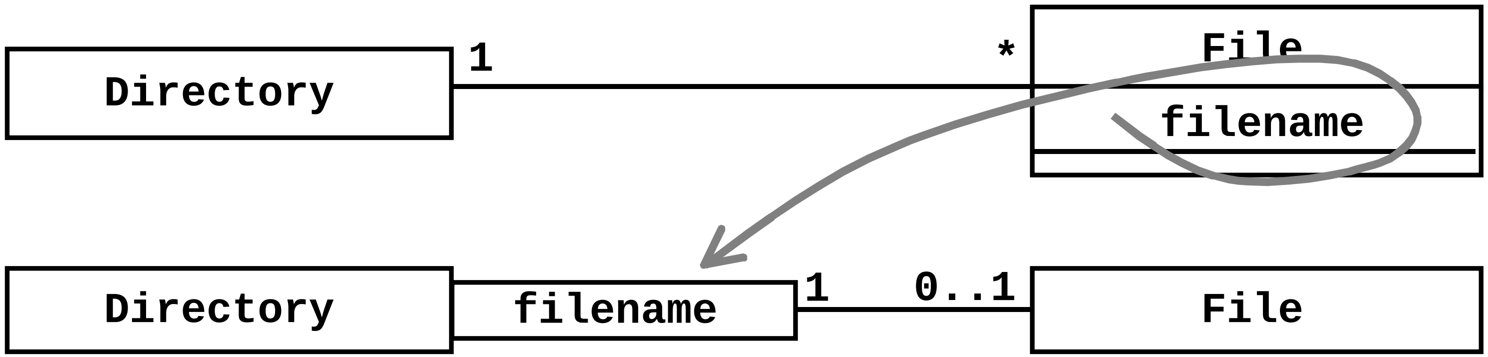
Problem Statement : A person assumes the role of repairer with respect to another person, who assumes the role of inspector with respect to the first person.



Qualification

- The qualifier improves the information about the multiplicity of the association between the classes.
- It is used for reducing 1-to-many multiplicity to 1-1 multiplicity

Without qualification: A directory has many files. A file belongs only to one directory.



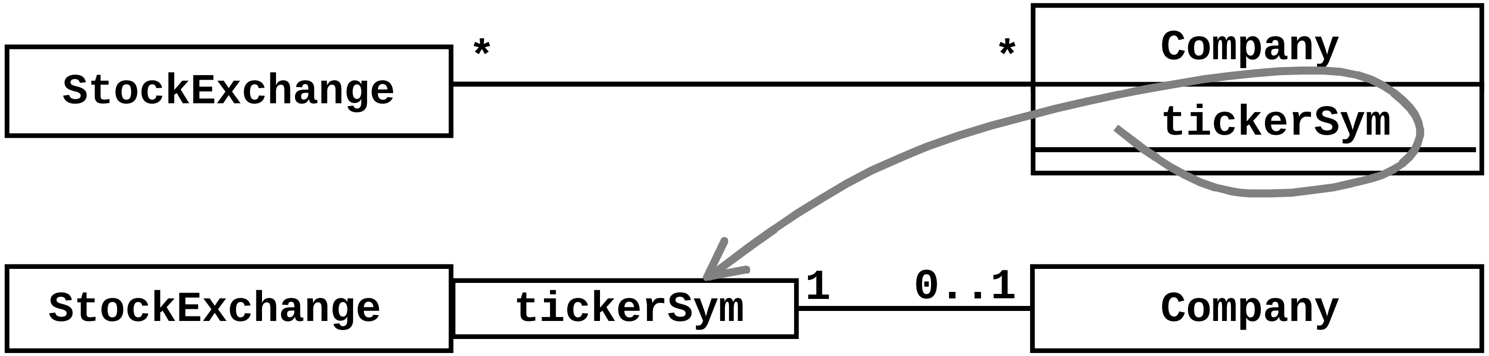
With qualification: A directory has many files, each with a unique name

Example

Problem Statement : A stock exchange lists many companies. However , a stock exchange lists only one company with a given ticker symbol. A company may be listed on many stock exchanges, possibly with different ticker symbols.

Find company with ticker symbol AAPL, DCX.

Use of Qualification reduces multiplicity



How do you find classes?

- Learn about problem domain: Observe your client
- Apply general world knowledge and intuition
- Take the flow of events and find participating objects in use cases
- Apply design patterns
- Try to establish a taxonomy
- Do a textual analysis of scenario or flow of events (Abbott Textual Analysis, 1983)
- Nouns are good candidates for classes

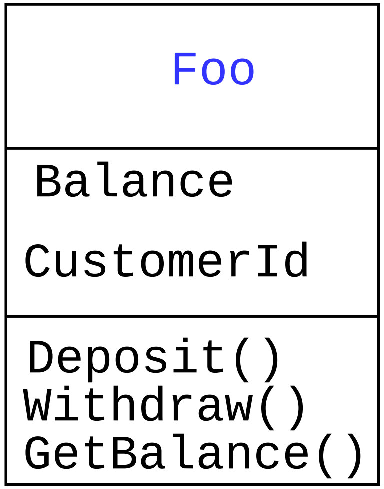
Mapping parts of speech to object model components [Abbot 1983]

Part of speech	*Model component*	*Example*
Proper noun	object	Jim Smith
Improper noun	class	Toy, doll
Doing verb	method	Buy, recommend
being verb	inheritance	is-a (kind-of)
having verb	aggregation	has an
modal verb	constraint	must be
adjective	attribute	3 years old
transitive verb	method	enter
intransitive verb	method (event)	depends on

Example: Scenario from Problem Statement

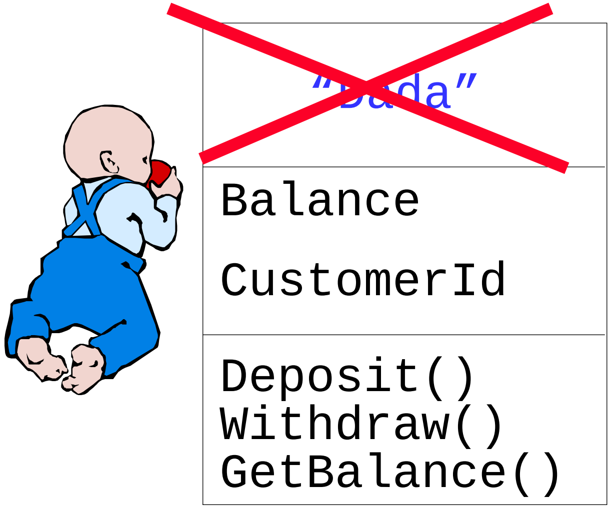
- Jim Smith enters a store with the intention of buying a toy for his 3 year old child.
- Help must be available within less than one minute.
- The store owner gives advice to the customer. The advice depends on the age range of the child and the attributes of the toy.
- Jim selects a dangerous toy which is unsuitable for the child.
- The store owner recommends a more yellow doll.

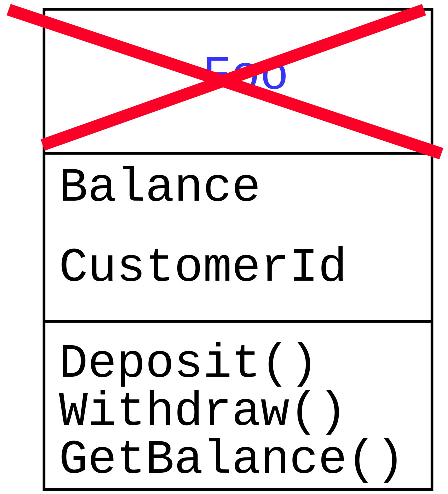
Object Modeling in Practice: Class Identification

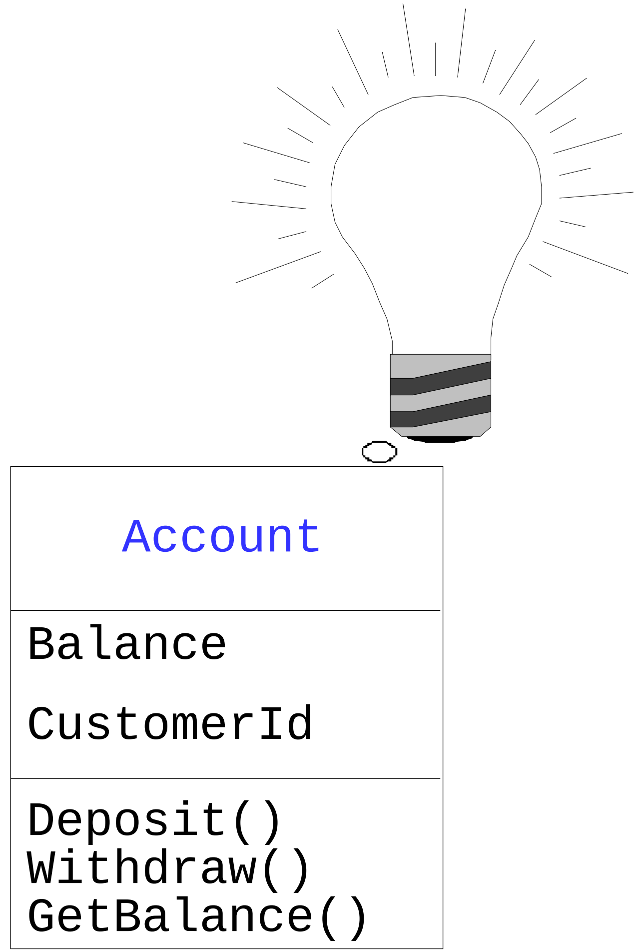


Class Identification: Name of Class, Attributes and Methods

Object Modeling in Practice: Encourage Brainstorming

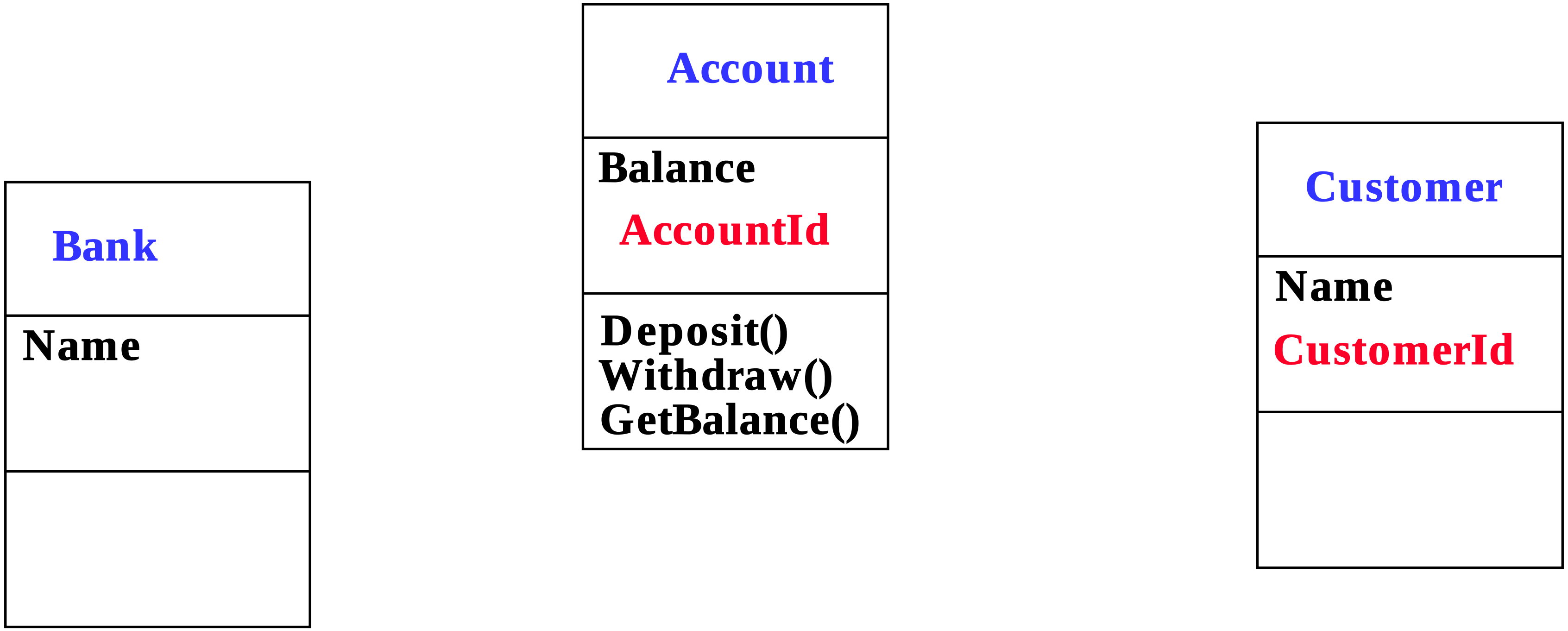






Naming is important!

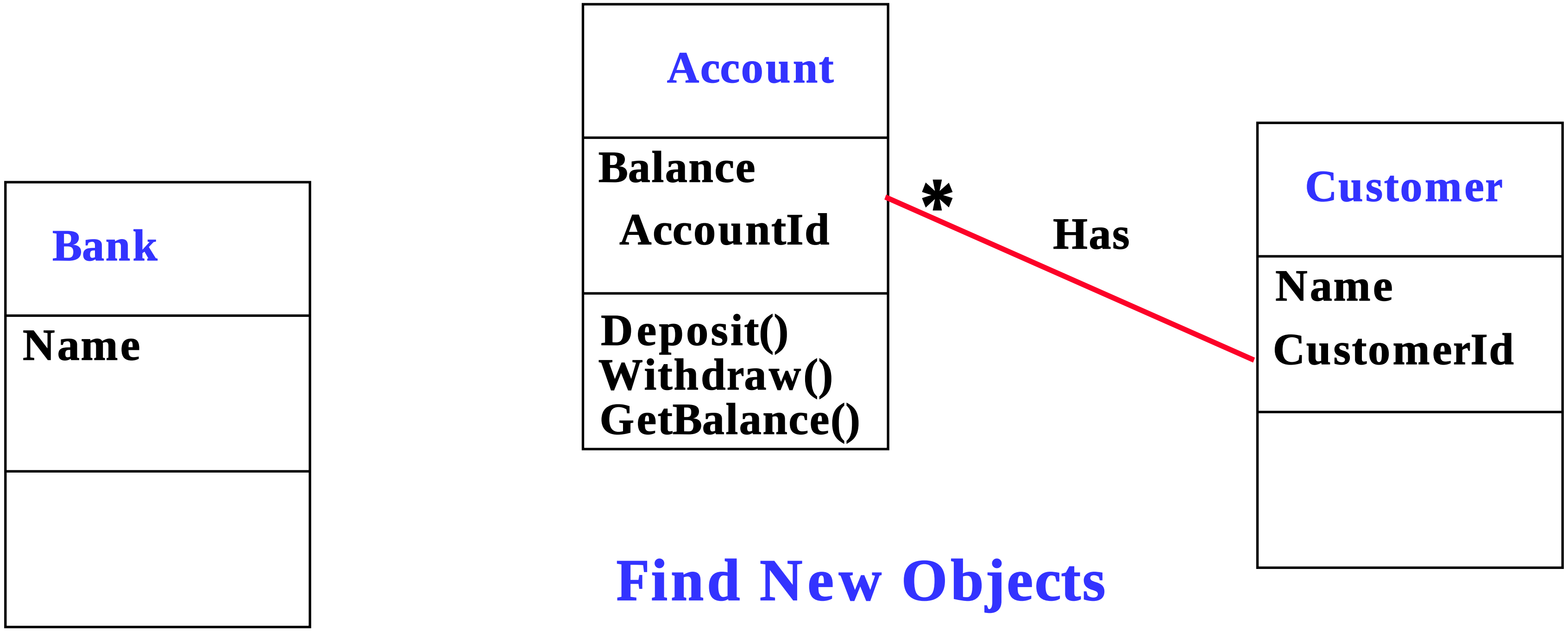
Object Modeling in Practice



Find New Objects

Iterate on Names, Attributes and Methods

Object Modeling in Practice: A Banking System



Find New Objects

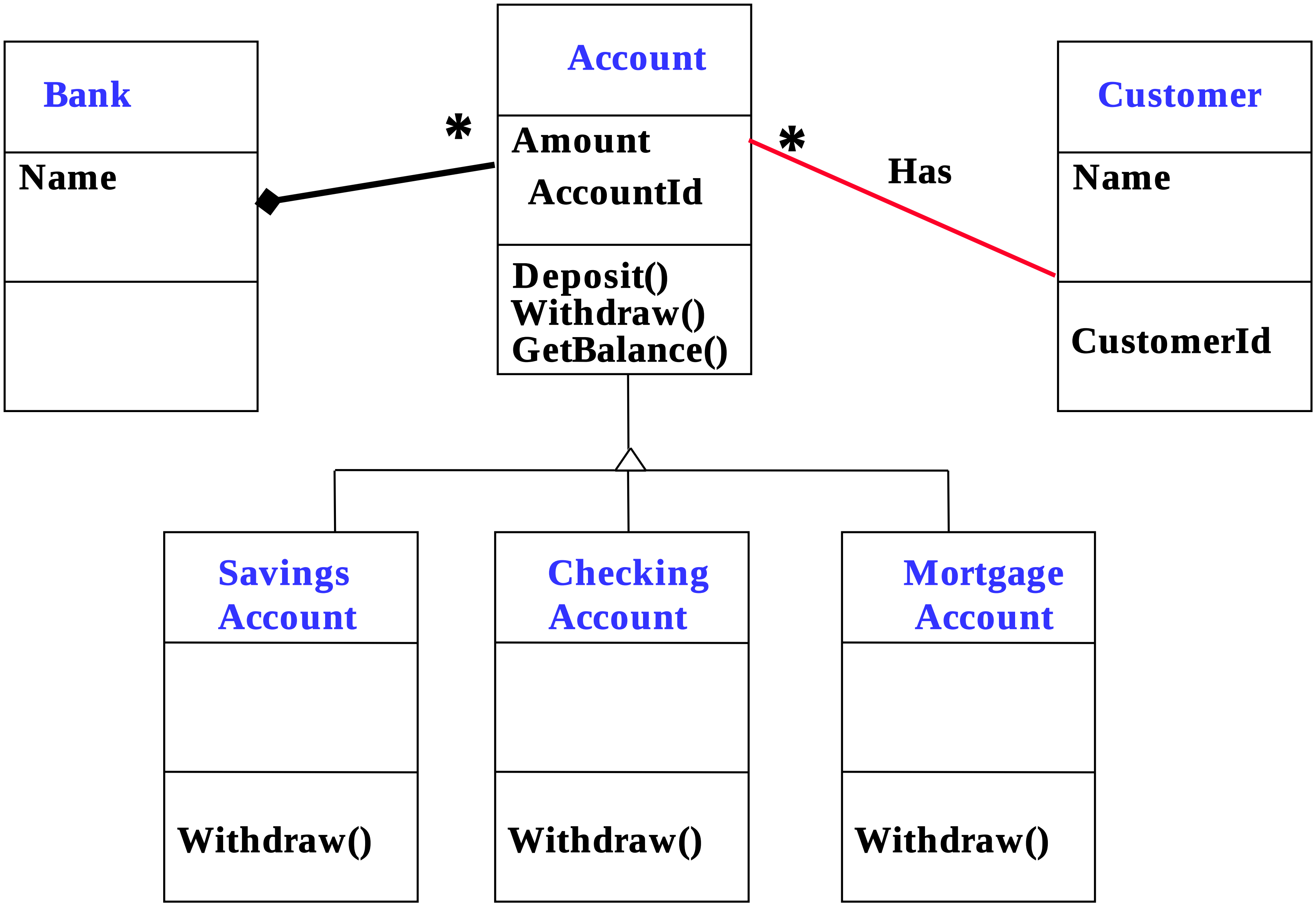
Iterate on Names, Attributes and Methods

Find Associations between Objects

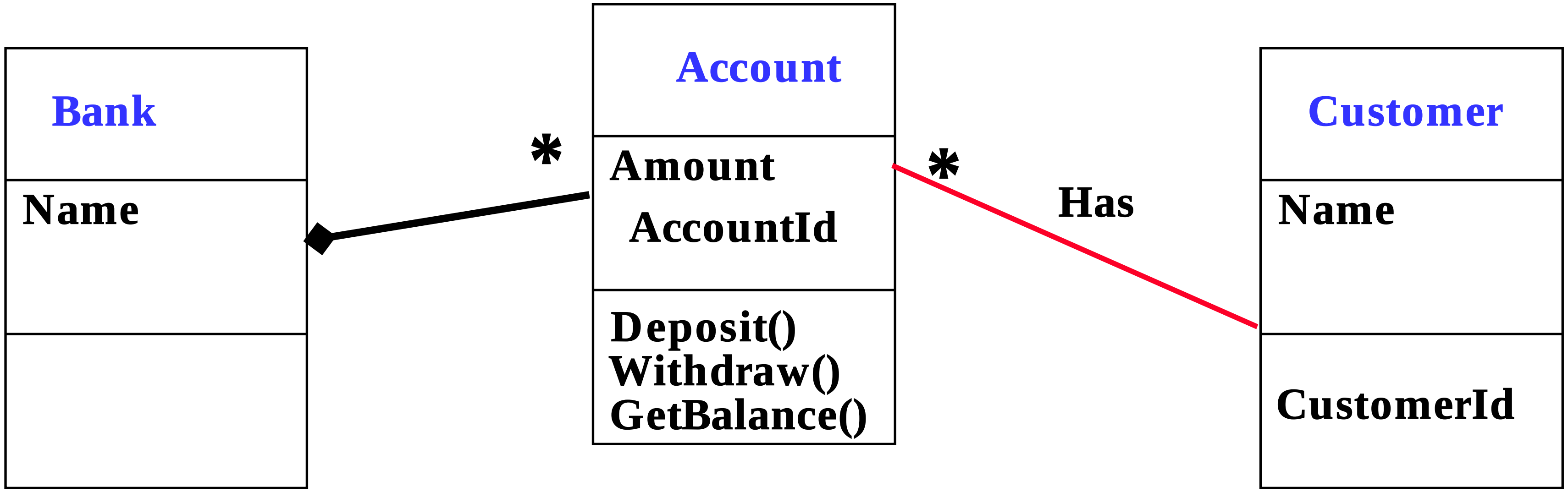
Label the assocations

Determine the multiplicity of the assocations

Object Modeling in Practice: Categorize!

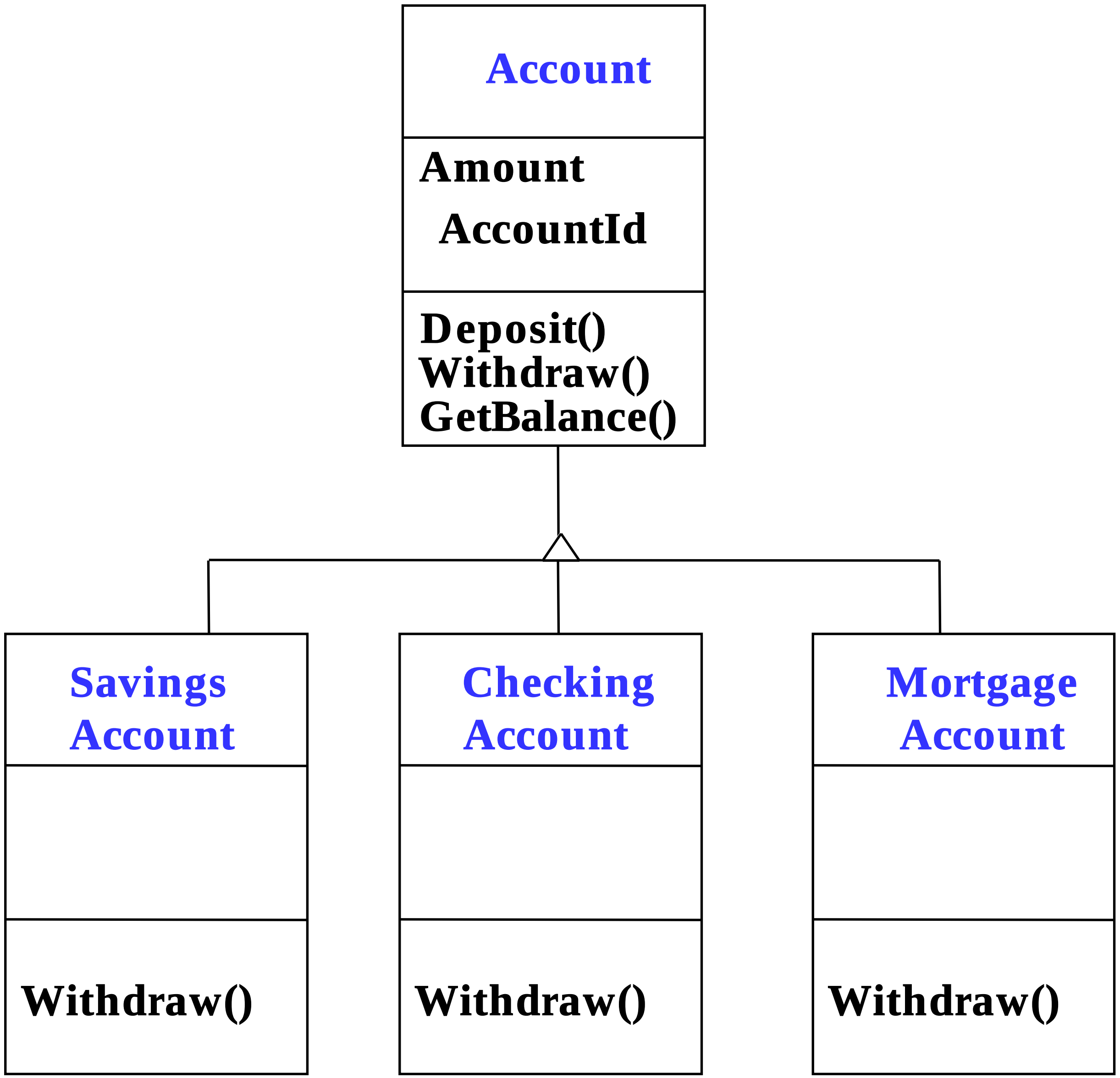


Avoid Ravioli Models



Don't put too many classes into the same package: 7+-2 (or even 5+-2)

Avoid Ravioli Models: Put Taxonomies in a separate View

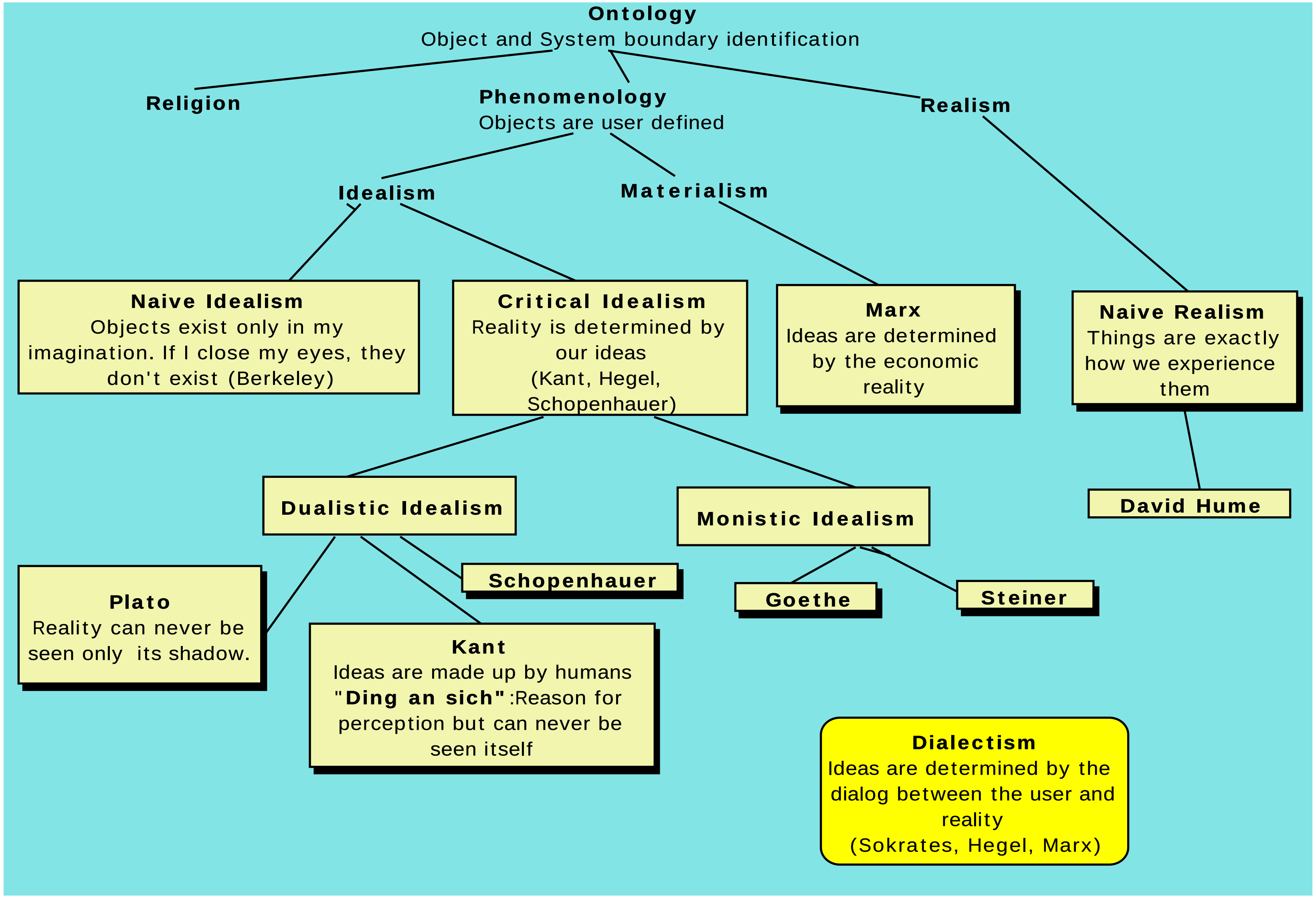


Object Modeling in Practice: Heuristics

- Explicitly schedule a team meeting for object identification
- Try to differentiate between entity, boundary and control objects
- Find associations and their multiplicity
  - **Unusual multiplicities usually lead to new objects or categories**
- Identify Aggregation
- Identify Inheritance: Look for a Taxonomy, Categorize

- Allow time for brainstorming , Iterate, iterate

Software Engineers are not the only System Analysts



What is a Software Engineer?

- From the point of view of phenomenology, Software Engineers are dialectic monistic idealists:
  - ***Idealists:***
    - **They accept that ideas (called requirements or "customer's wishlist") are different from reality.**
    - **The reality might not yet exist ("Vaporware is always possible ")**
  - ***They are monistic:***
    - **They are optimistic that their ideas can describe reality.**
  - ***Dialectic:***
    - **They do this in a dialogue with the customer**

Summary

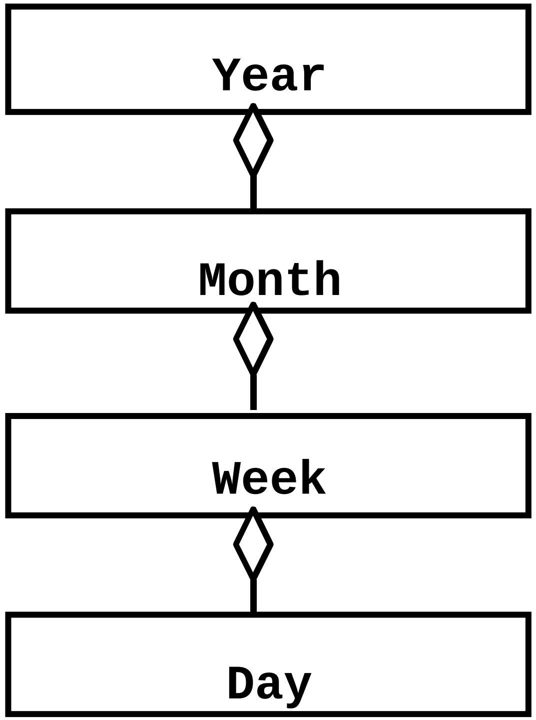
In this lecture, we reviewed the construction of the object model from use case model. In particular, we described:

- Identification of objects
- Refinement of objects with attributes and operations
- Generalization of concrete classes
- Identification of associations
- Reduction of multiplicity using qualification.

In the next lecture, we describe the construction of the dynamic model from the use case and object models.

Exercises

5.6 Consider the object model below (adapted from [Jackson, 1995]):



Given your knowledge of the Gregorian calendar, list all the problems with this model. Modify it to correct each of them.

Exercises (cont'd)

5.7 Consider the object model of the previous exercise. Using association multiplicity ***only***, can you modify the model such that a developer unfamiliar with the Gregorian calendar could deduce the number of days in each month? Identify additional classes if necessary.

Next Steps

- For all students:
  - **Tomorrow: Requirements Elicitation Tutorial (REQ/QOC)**
  - **Next Thursday: Configuration Management**
  - **Next Friday: TogetherJ Tutorial**

- For STARS students:
  - **GUI Mockup due tomorrow on Notes Bboard**
    - **2-3 slides + name of presenter for each team**
  - **GUI Mockup review on Monday 14:15**