Object Oriented

UML Class Diagram

CSC207 – Software Design

Remember from the midterm . . .

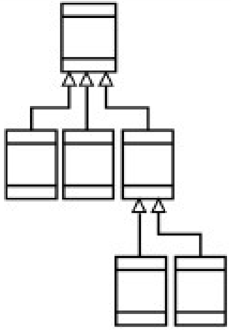
7 - Design a software system, in terms of interfaces, which contain headers of public methods, for the following problem statement: (20)

- Customers order products from an online store; their orders will be processes by the closest store to their address, and their bills will be issued. After the payment is done, items will be shipped to the customer address.

the Unified Modelling Language (UML)

- Standardized general-purpose modeling language
  - Used to specify, visualize, construct, and document the design of an object-oriented system under development
  - Offers a way to visualize various elements of a system such as activities, actors, business processes, database schemas, logical components, programming language statements, and reusable software components.
  - Combines techniques from data modeling(entity relationship diagrams), business modeling (work flows), object modeling, and component modeling
- Booch, Rumbaugh & Jacobson are principal authors
  - Still evolving (currently version 2.3)
  - Attempt to standardize the proliferation of OO variants
- Is purely a notation
  - No modelling method associated with it!
  - Was intended as a design notation
  - Can be used anywhere in the software development cycle
- Has become an industry standard
  - But is primarily promoted by IBM/Rational (who sell lots of UML tools, services)
- Has a standardized meta-model
  - Use case diagrams , Class diagrams, Message sequence charts, Activity diagrams, State Diagrams , Module Diagrams, …

Modeling Notations

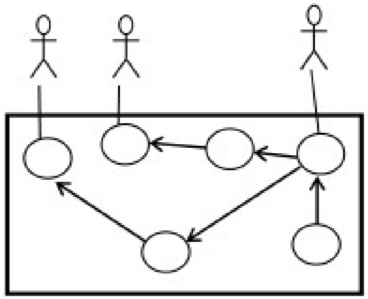


UML Class Diagrams

information structure

relationships between data items

modular structure for the system

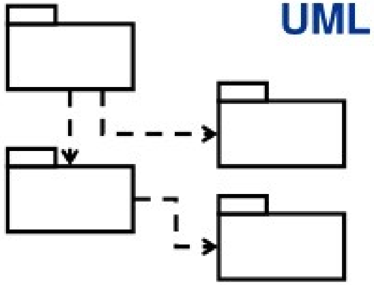


Use Cases

user's view

Lists functions

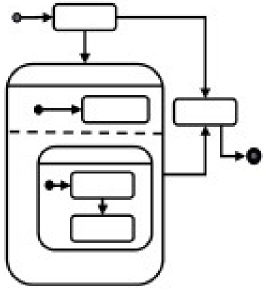
visual overview of the main requirements



UML Package Diagrams

Overall architecture

Dependencies between components

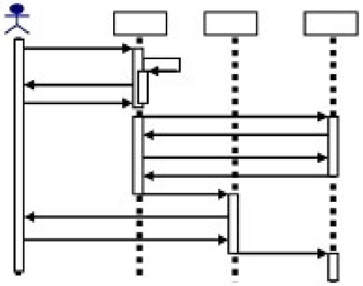


(UML) Statecharts

responses to events

dynamic behavior

event ordering, reachability, deadlock, etc

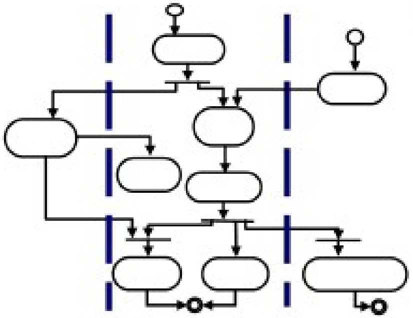


UML Sequence Diagrams

individual scenario

interactions between users and system

Sequence of messages



Activity diagrams

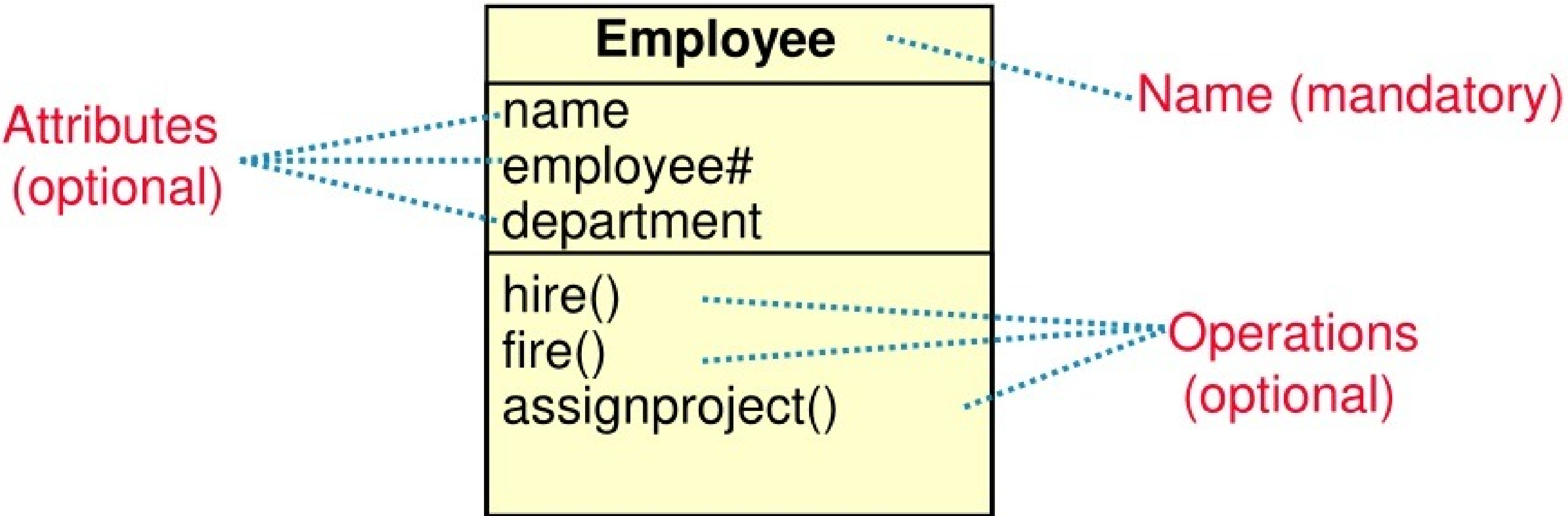
business processes;

concurrency and synchronization;

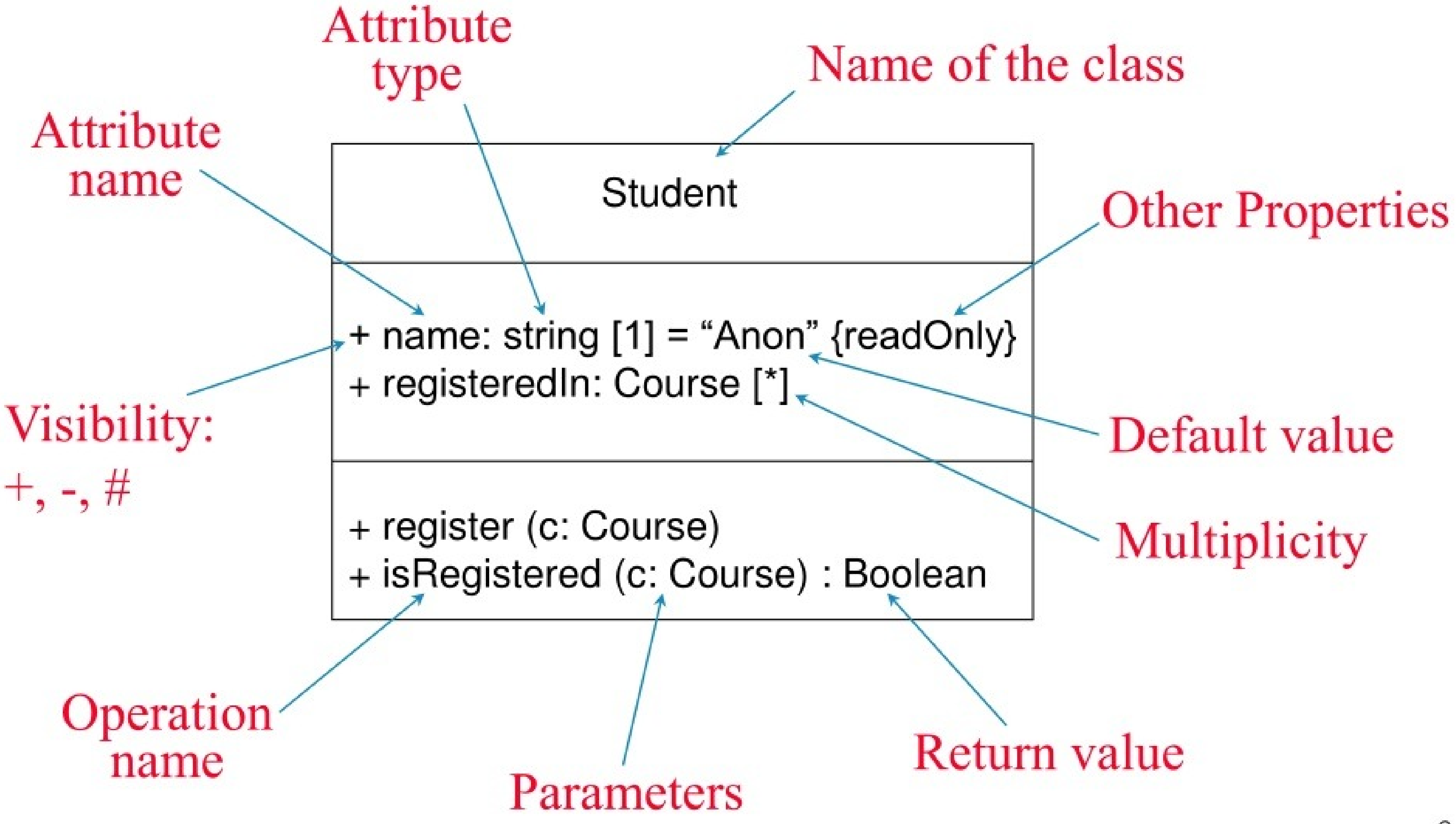
dependencies between tasks;

What are classes?

- A class describes a group of objects with
  - similar properties (attributes),
  - common behaviour (operations),
  - common relationships to other objects,
  - and common meaning ("semantics").
- Examples
  - Employee: has a name, employee# and department; an employee is hired, and fired; an employee works in one or more projects



The full notation…



Attribute type

Name of the class

Attribute name

Student

Other Properties

+ name: string [1] = “Anon” {readOnly}
+ registeredIn: Course [*]

Visibility:
+, -, #

Default value

+ register (c: Course)
+ isRegistered (c: Course) : Boolean

Multiplicity

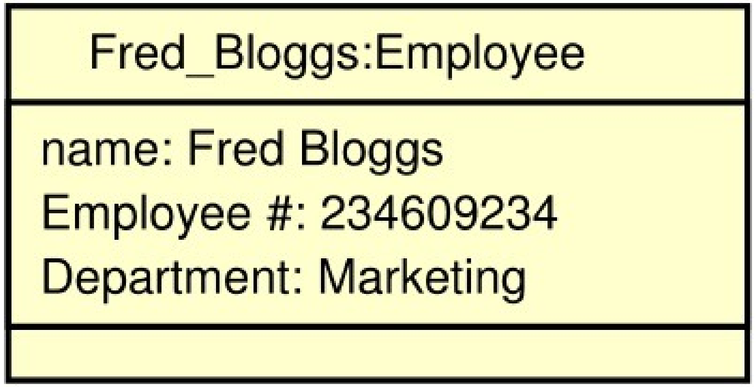
Operation name

Parameters

Return value

Objects vs. Classes

- The instances of a class are called objects.
  - Objects are represented as:



Fred_Bloggs:Employee

name: Fred Bloggs
Employee #: 234609234
Department: Marketing

  - The relation between an Object and its Class is called "*Instantiation*"
  - Two different objects may have identical attribute values (like two people with identical name and address)
  - Note: Make sure attributes are associated with the right class
    - E.g. you don't want both managerName and manager# as attributes of Project! (…Why??)

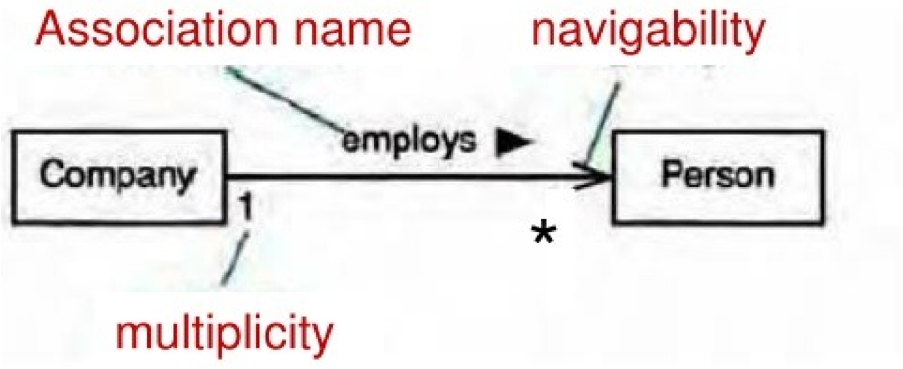
Relationships

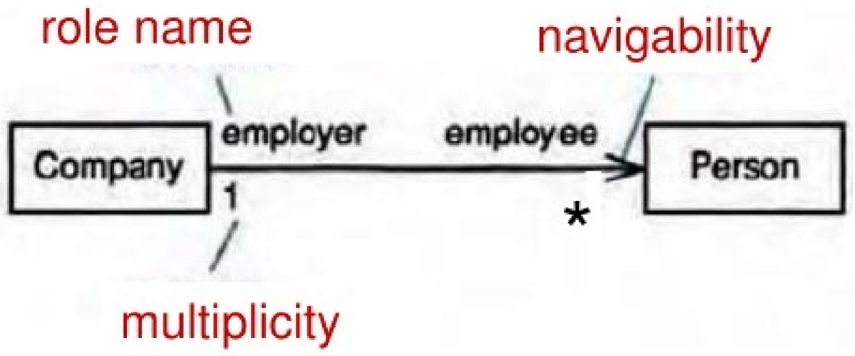
- Objects do not exist in isolation from one another
  - A relationship represents a connection among things.
  - E.g. Fred_Bloggs:employee is associated with the KillerApp:project object
  - But we will capture these relationships at the class level (why?)

- Class diagrams show classes and their relationships
  - In UML, there are different types of relationships:
    - Association
    - Aggregation and Composition
    - Generalization
    - Dependency
    - Realization

Association

- Associations may optionally have the following:
  - Association name
    - may be prefixed or postfixed with a small black arrowhead to indicate the direction in which the name should be read;
    - should be a verb or verb phrase;
  - Role names
    - on one or both association ends;
    - should be a noun or noun phrase describing the semantics of the role;
  - Multiplicity
    - The number of objects that can participate in an instantiated relation
  - Navigability





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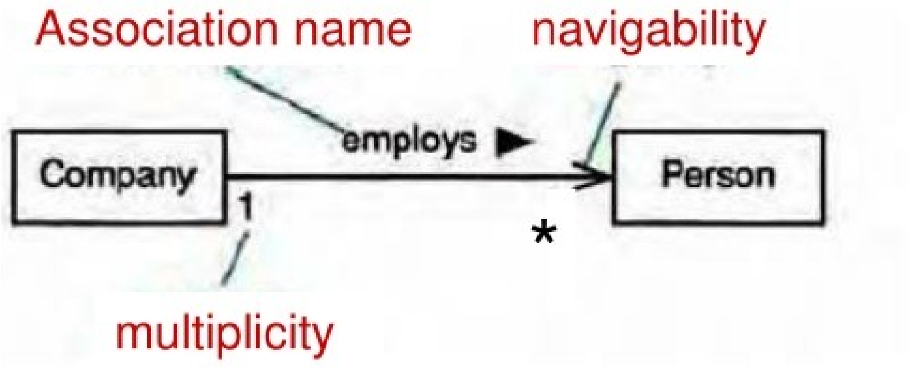
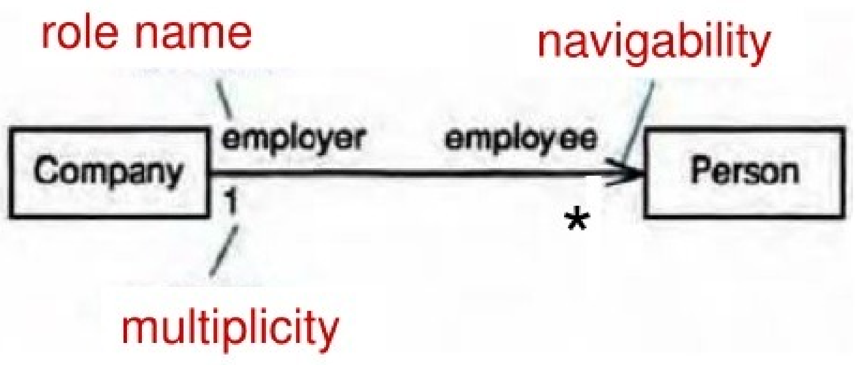
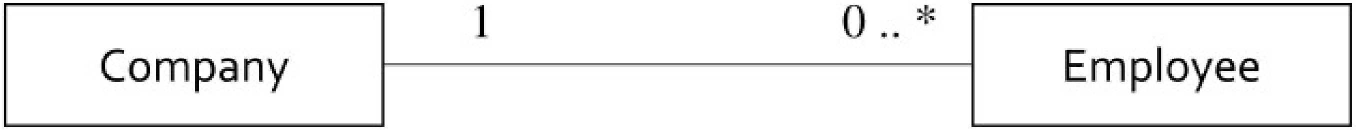




Association Multiplicity

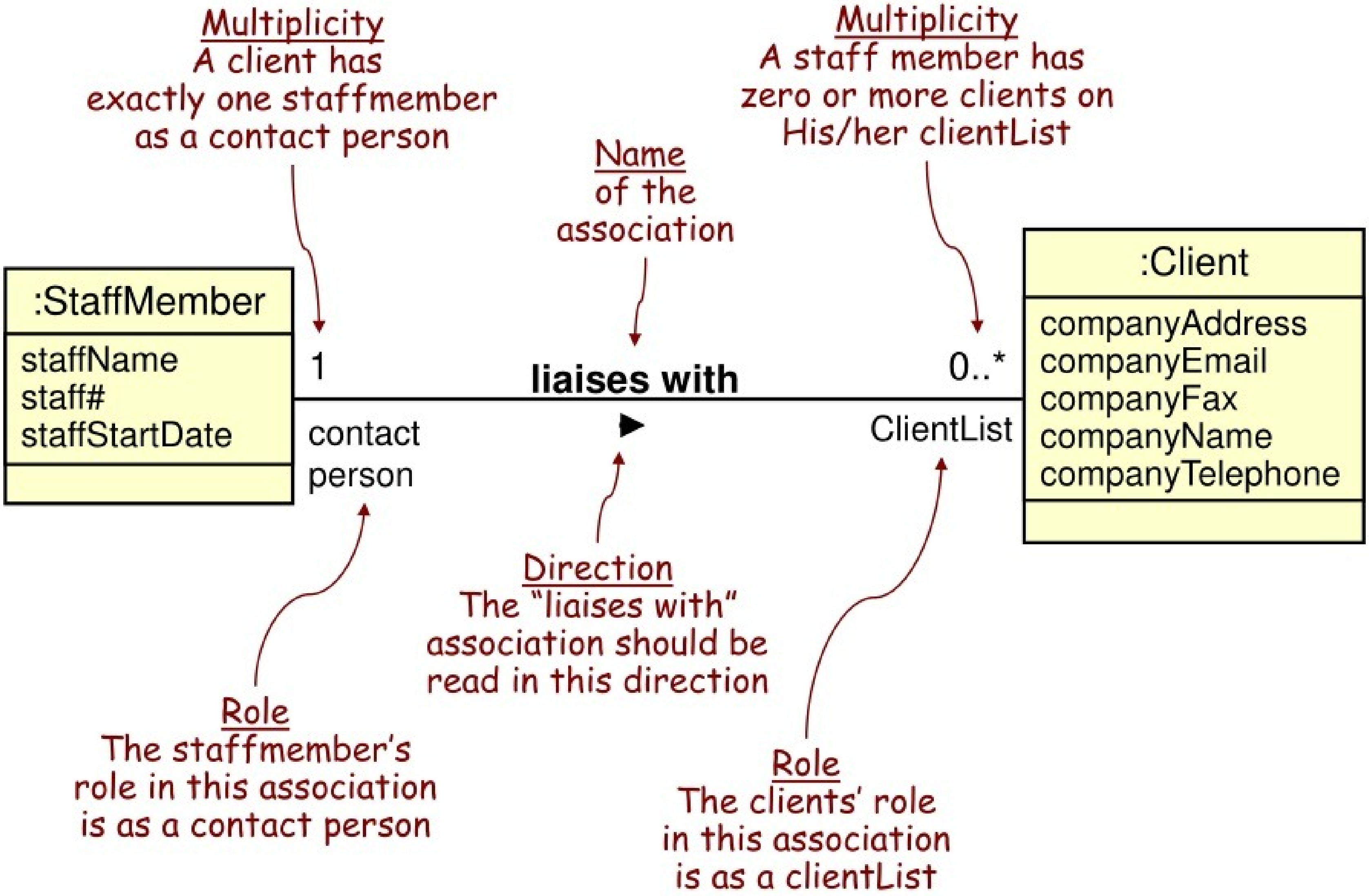
- **Ask questions about the associations:**
  - **Can a company exist without any employee?**
    - **If yes, then the association is optional at the Employee end - zero or more (0..*)**
    - **If no, then it is not optional - one or more (1..*)**
    - **If it must have only one employee - exactly one (1)**
  - **What about the other end of the association?**
    - **Can an employee work for more than one company?**
    - **No. So the correct multiplicity is one.**



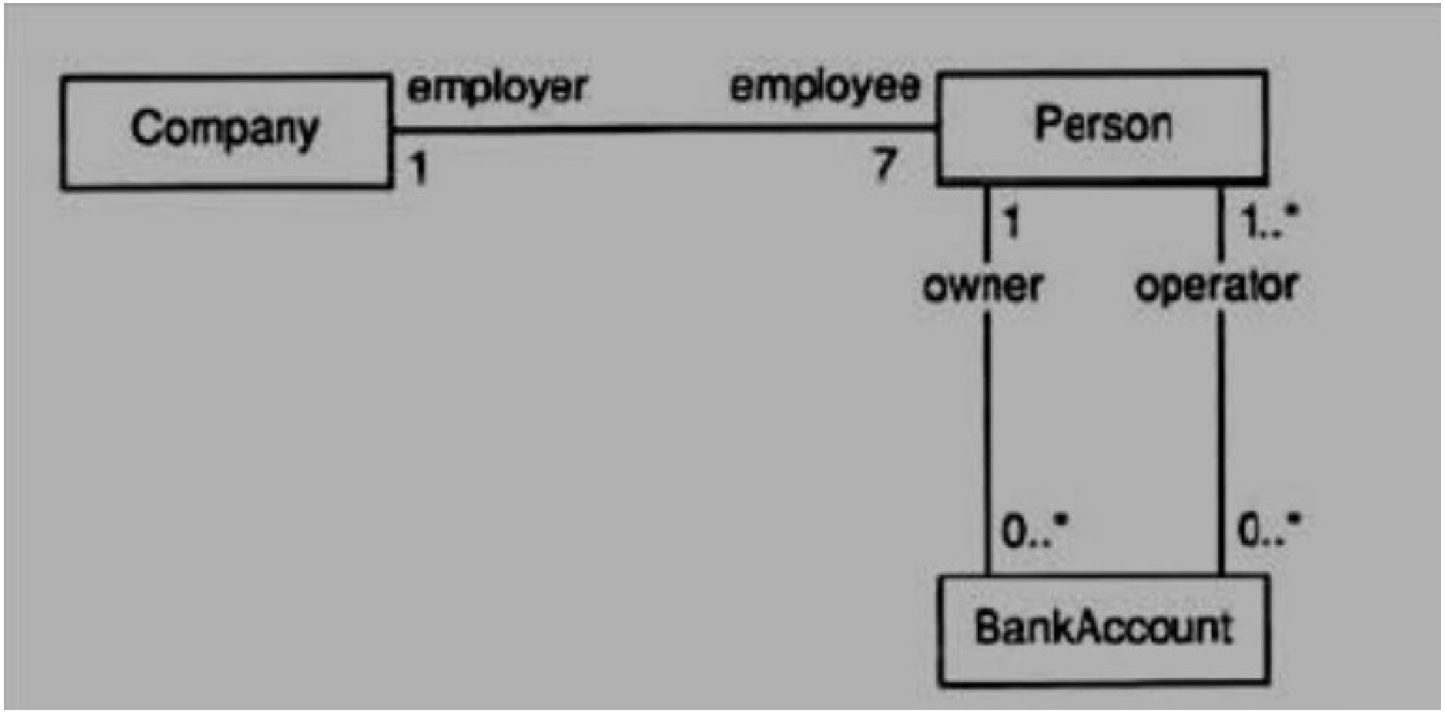
- **Some examples of specifying multiplicity:**

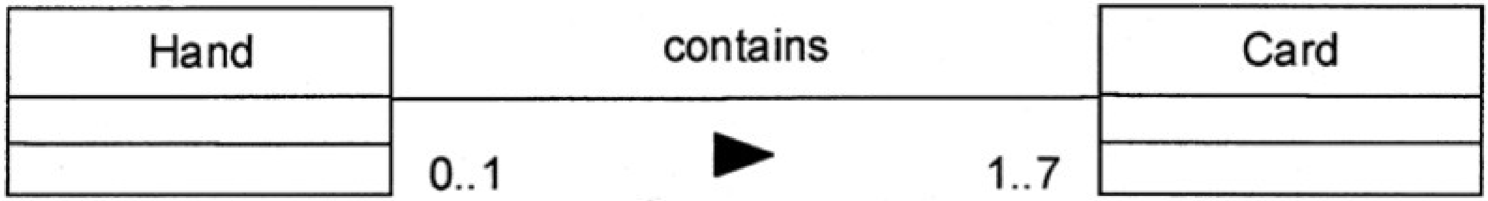
Optional (0 or 1)	0..1	
Exactly one	1	= 1..1
Zero or more	0..*	= *
One or more	1..*	
A range of values	2..6	

Class associations

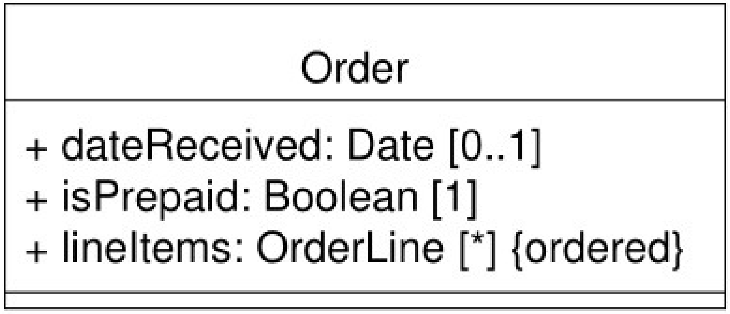


More Examples



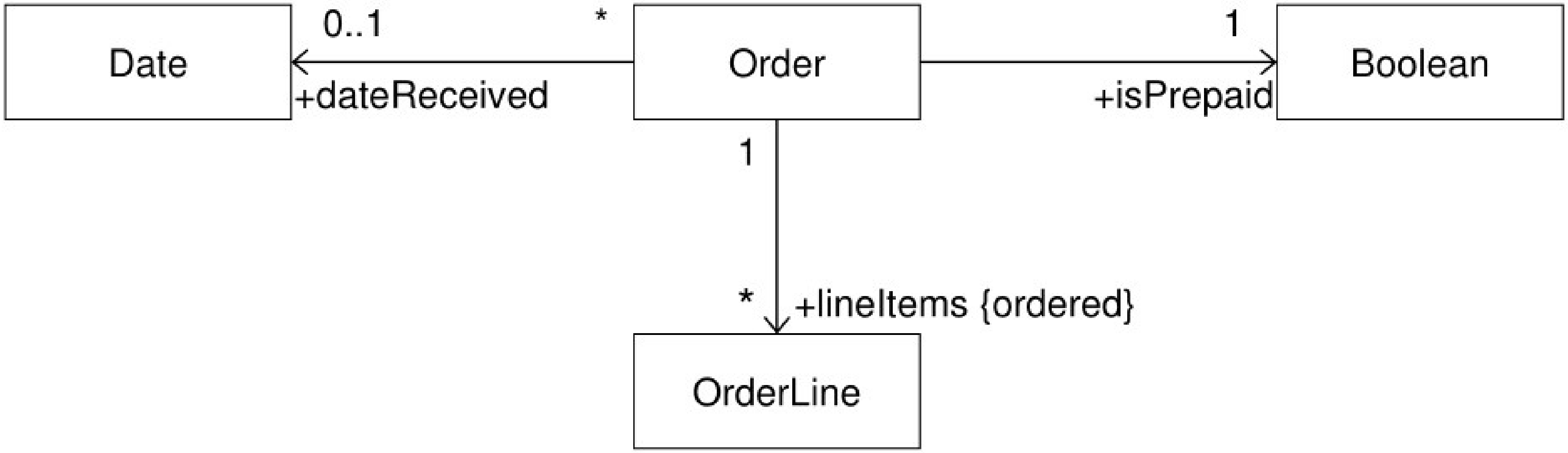


Navigability / Visibility



Order

+ dateReceived: Date [0..1]
+ isPrepaid: Boolean [1]
+ lineItems: OrderLine [*] {ordered}



Date

0..1

+dateReceived

*

Order

1

+isPrepaid

Boolean

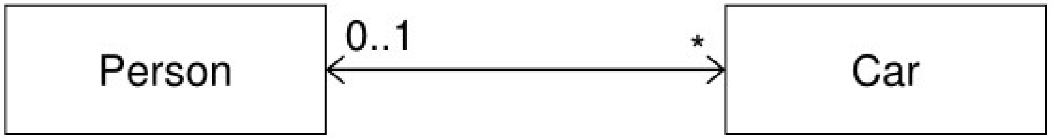
1

*

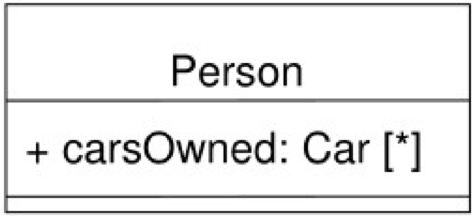
+lineItems {ordered}

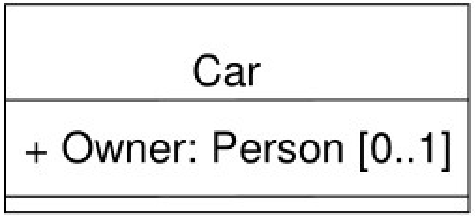
OrderLine

Bidirectional Associations



How implement it?





Implementation Complexities !

Generalization

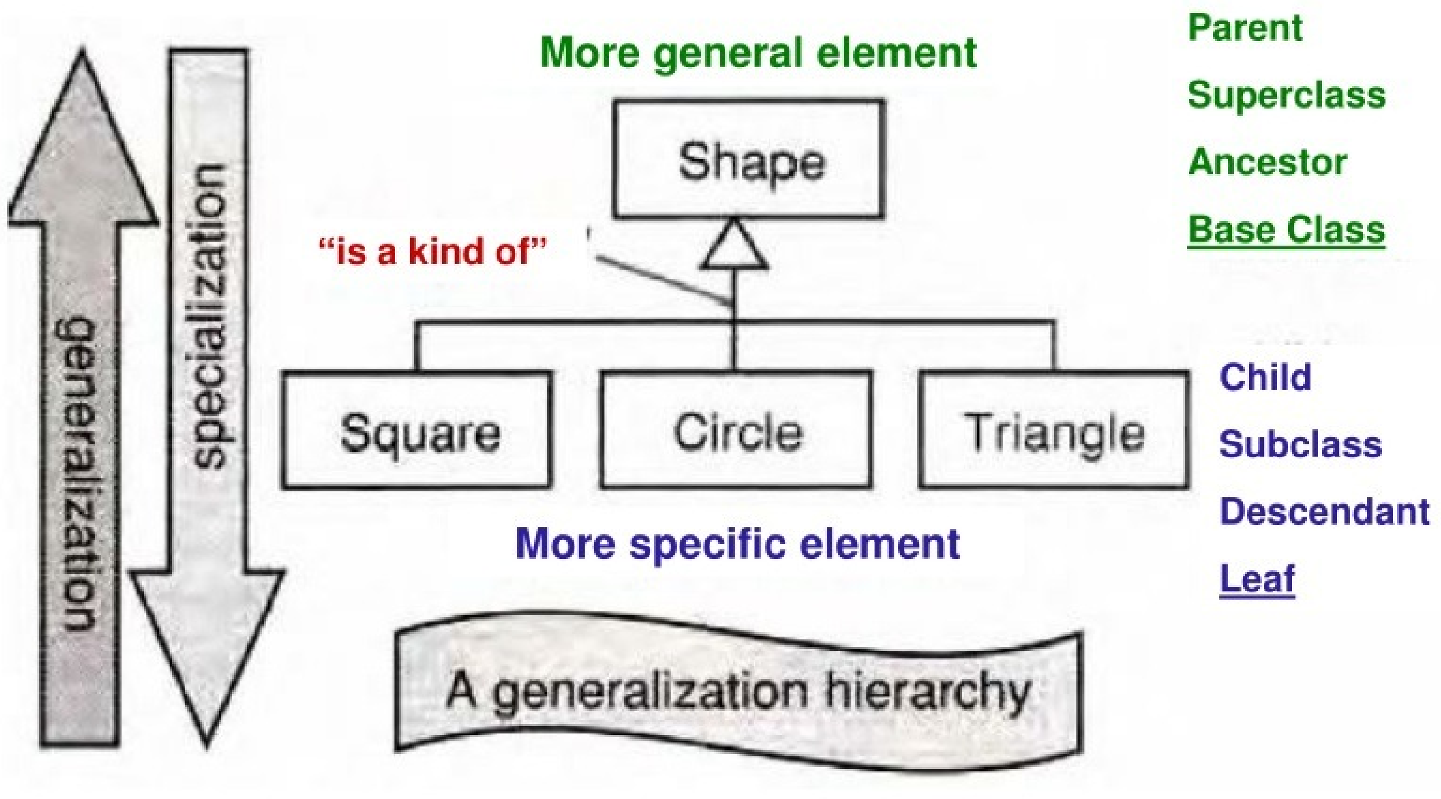
- Generalization is a relationship between a more general thing and a more specific thing:

  - the more specific thing is consistent in every way with the more general thing.

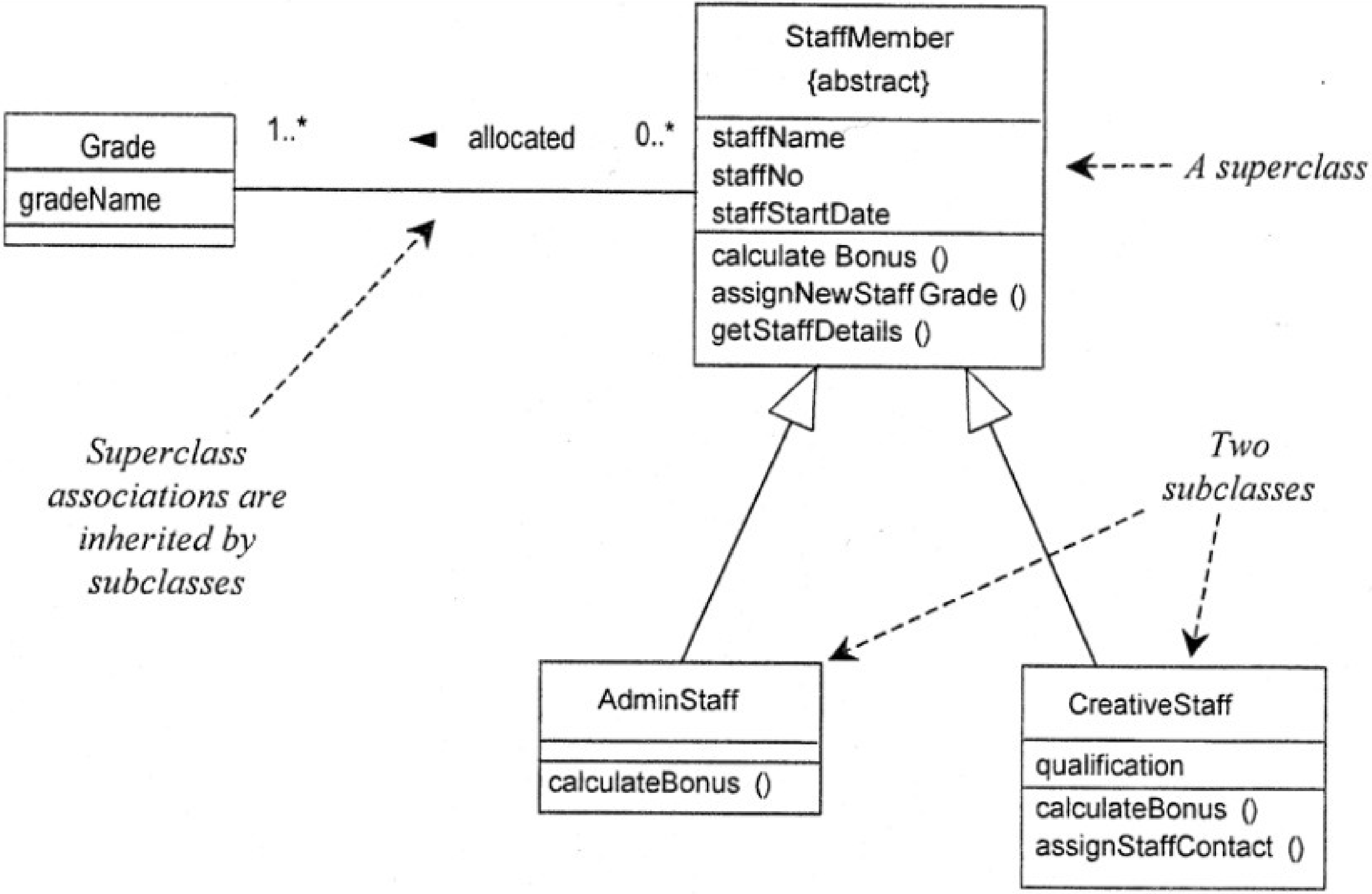
  - the substitutability principle states that you can substitute the more specific thing anywhere the more general thing is expected.

Generalization/Specialization

- Generalization hierarchies may be created by generalizing from specific things or by specializing from general things.



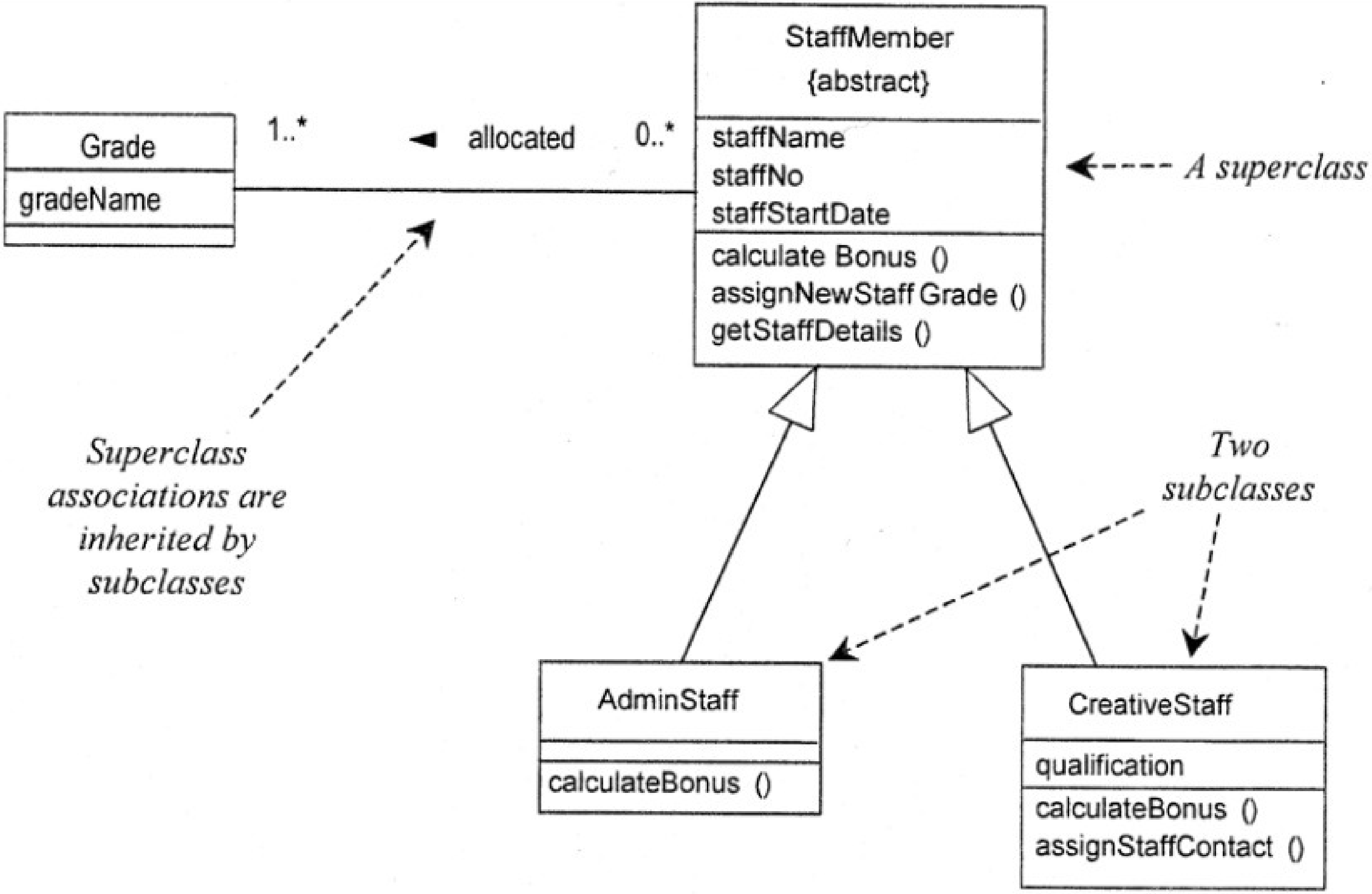
Inheritance



Notes:

- A subclass may override an inherited aspect
  - e.g. AdminStaff & CreativeStaff have different methods for calculating bonuses
- A Subclass may add new features
  - qualification is a new attribute in CreativeStaff
- Superclasses may be declared {abstract}, meaning they have no instances
  - Implies that the subclasses cover all possibilities
  - e.g. there are no other staff than AdminStaff and CreativeStaff

Inheritance



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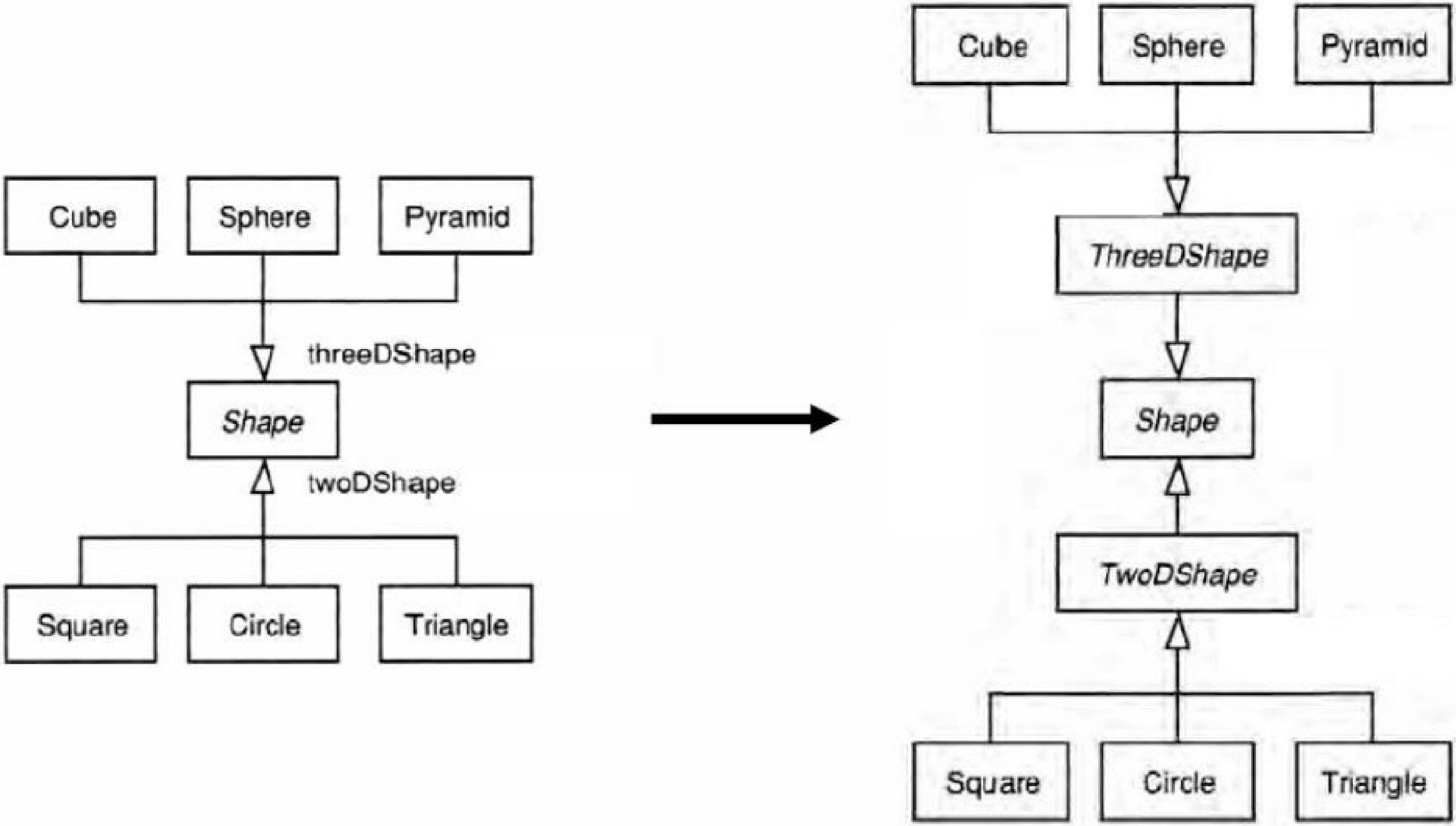
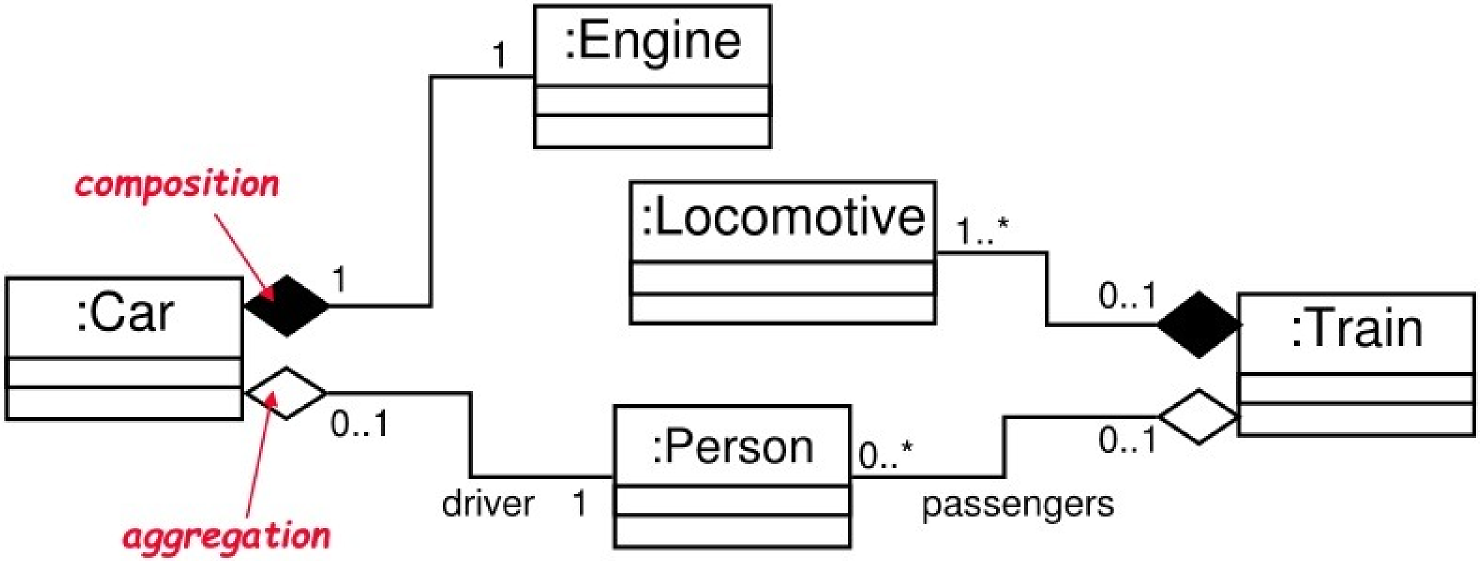
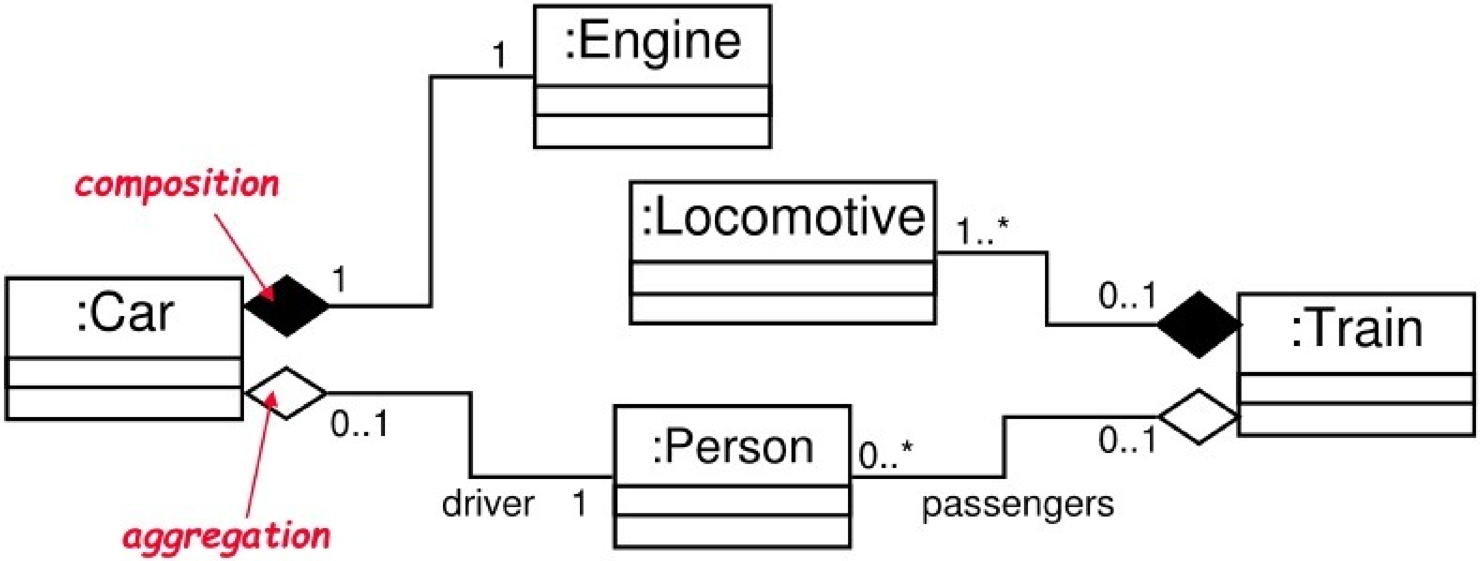
Generalization Sets: Implementation



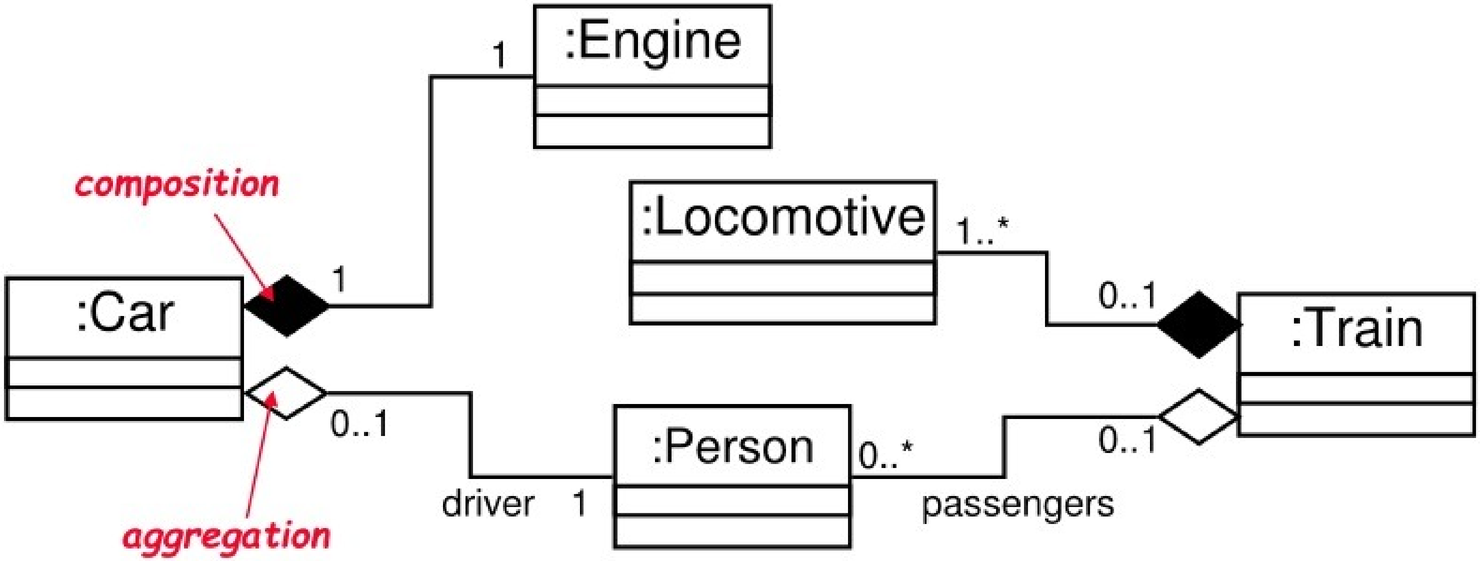
Aggregation and Composition



Aggregation and Composition



Aggregation and Composition



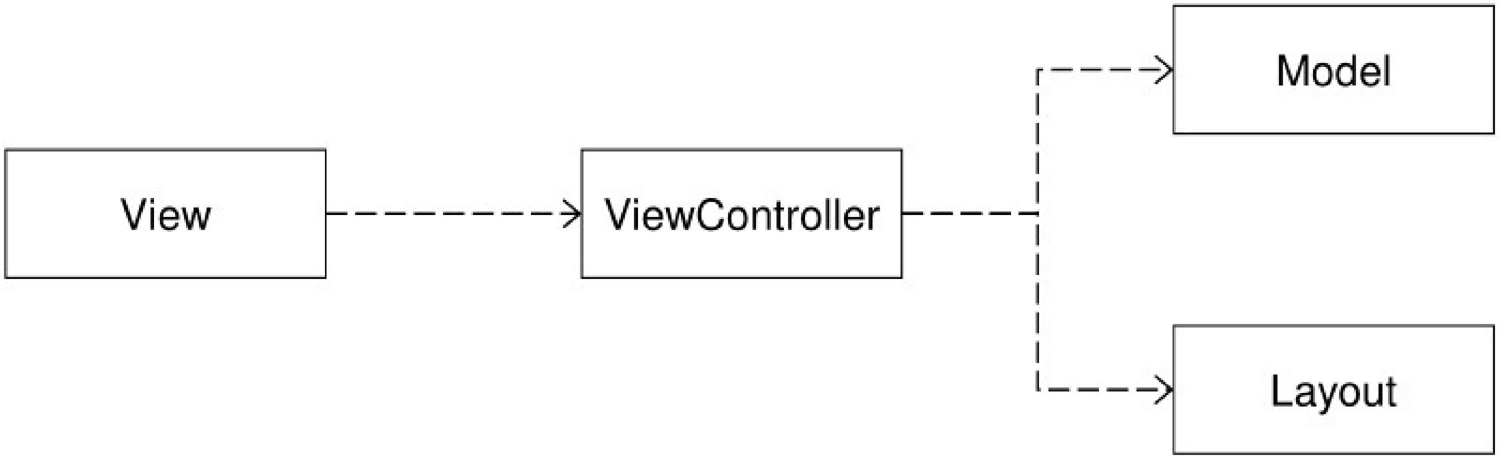
Class Activity

- Draw the UML class diagram which represents a file system – containing files and directories

Dependency

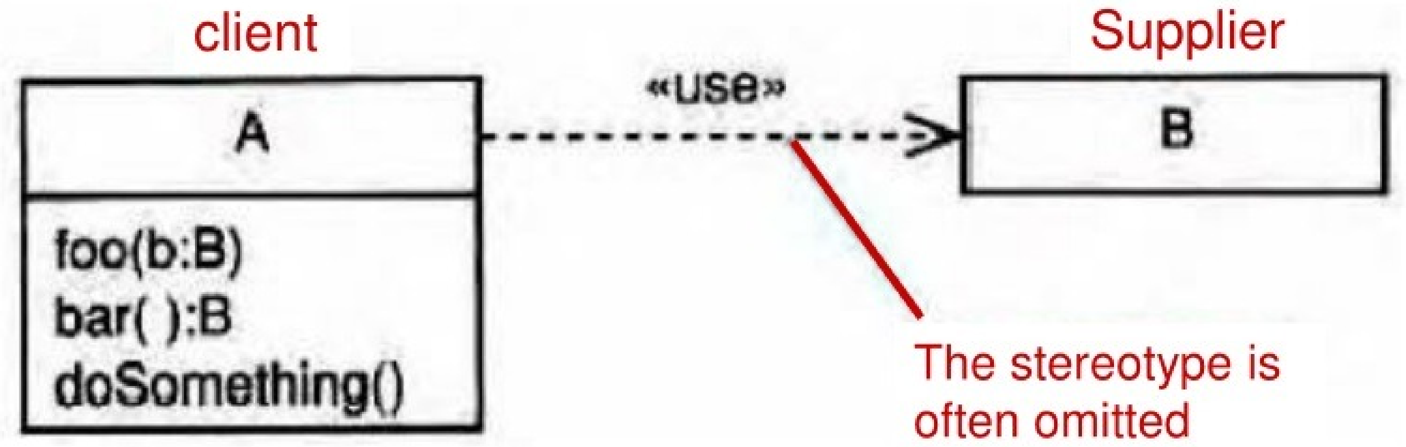
Dependencies are relationships in which a change to the supplier affects, or supplies information to, the client.

- The client depends on the supplier in some way.
- Dependencies are drawn as a dashed arrow from client to supplier.



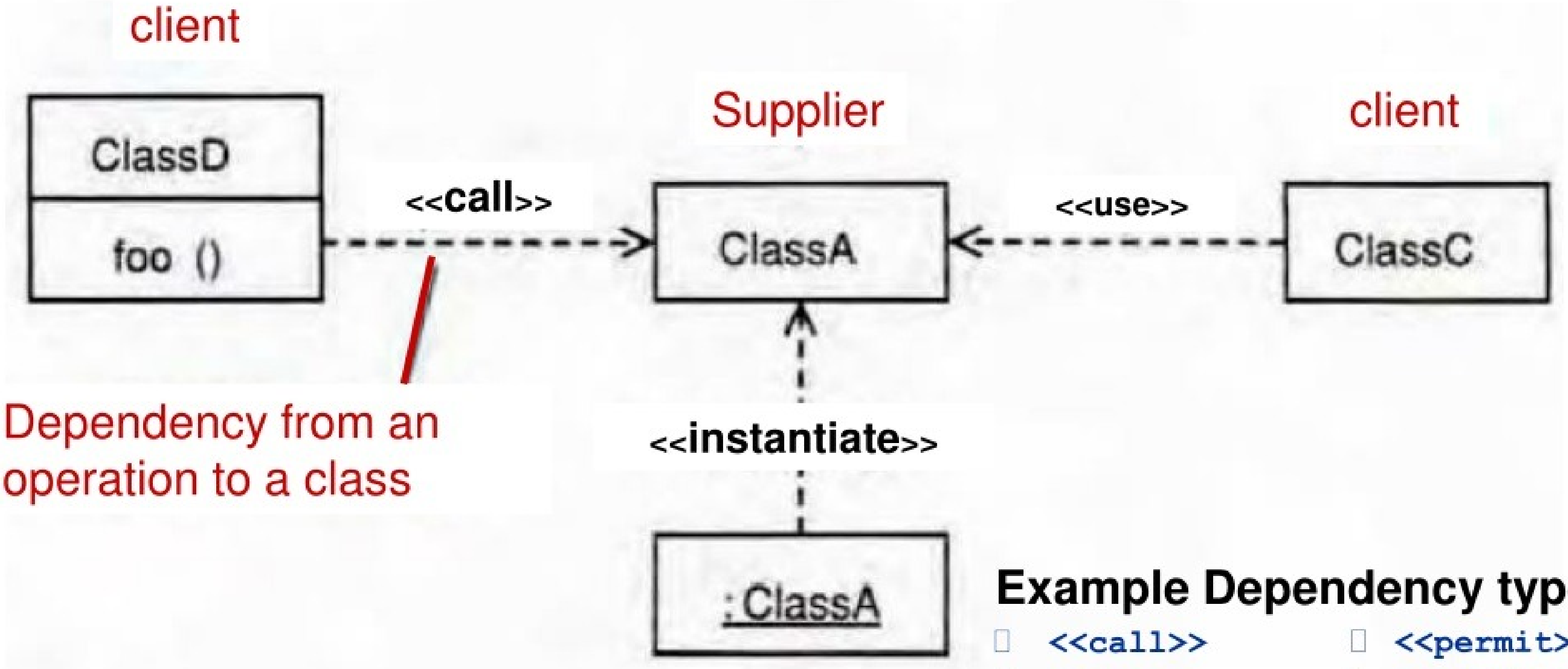
Usage Dependencies

- «use»-the client makes use of the supplier in some way -this is the catch-all.
- «call»-the client operation invokes the supplier operation.
- «parameter»-the supplier is a parameter or return value from one of the client's operations.
- «instantiate»-the client is an instance of the supplier.



The stereotype is often omitted

Dependencies: Example

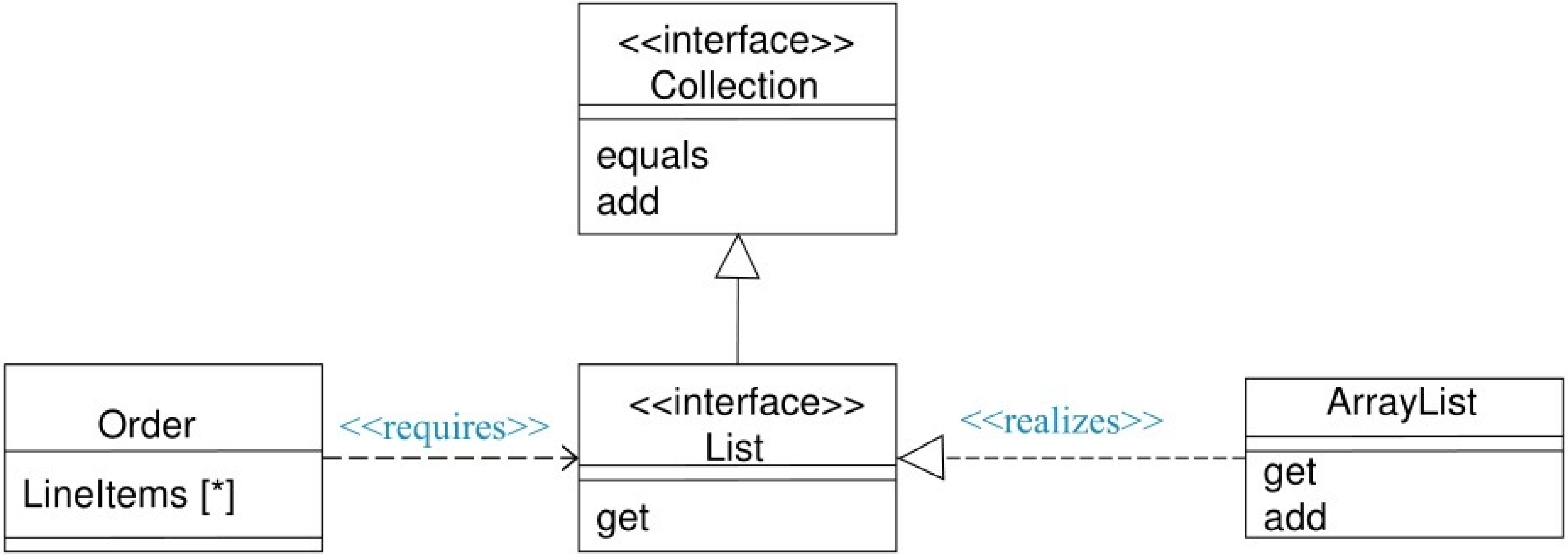


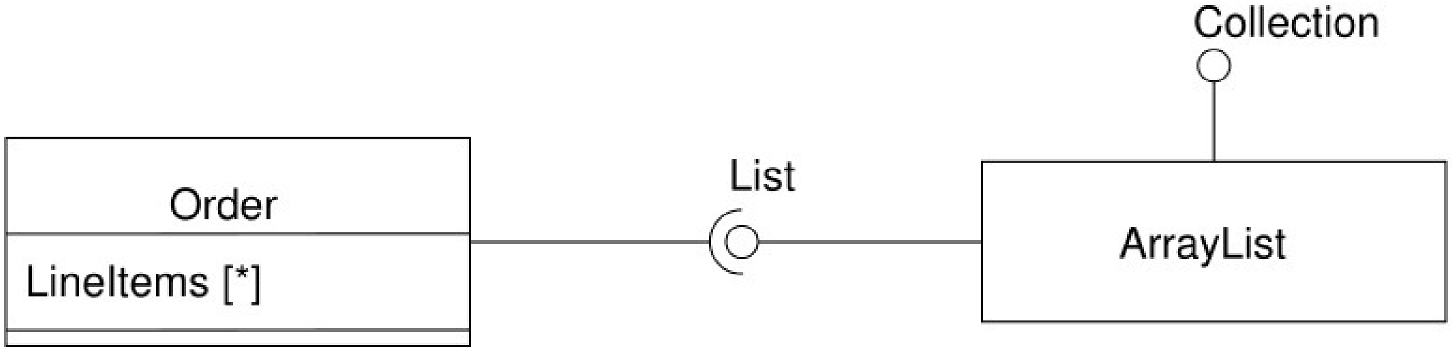
Dependency from an operation to a class

Example Dependency types:

- <<call>>
- <<use>>
- <<create>>
- <<derive>>
- <<instantiate>>
- <<permit>>
- <<realize>>
- <<refine>>
- <<substitute>>
- <<parameter>

Interfaces


<<interface>>
Collection
equals
add
Order
LineItems [*]
<<requires>>
<<interface>>
List
get
<<realizes>>
ArrayList
get
add

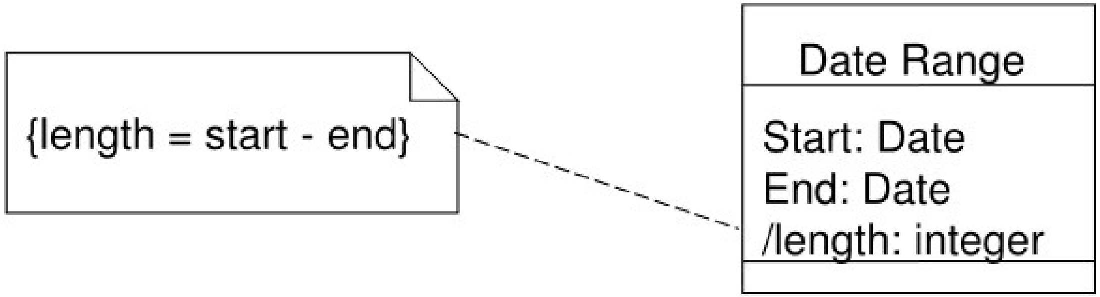

Collection
Order
LineItems [*]
List
ArrayList

Annotation

Comments

- -- can be used to add comments within a class description

Notes



Constraint Rules

- Any further constraints {in curly braces}
- e.g. {time limit: length must not be more than three months}

What UML class diagrams can show

- **Division of Responsibility**
  - Operations that objects are responsible for providing
- **Subclassing**
  - Inheritance, generalization
- **Navigability / Visibility**
  - When objects need to know about other objects to call their operations
- **Aggregation / Composition**
  - When objects are part of other objects
- **Dependencies**
  - When changing the design of a class will affect other classes
- **Interfaces**
  - Used to reduce coupling between objects

Good Analysis Classes

- What makes a good analysis class?
  - Its name reflects its intent.
  - It is a crisp abstraction that models *one specific element of the problem domain*.
  - It maps to a clearly identifiable feature of the problem domain.
  - It has a small, well-defined set of *responsibilities*:
    - a responsibility is a contract or obligation that a class has to its clients;
    - a responsibility is a semantically cohesive set of operations;
    - there should only be about three to five responsibilities per class.
  - It has high cohesion – all features of the class should help to realize its intent.
  - It has low coupling – a class should only collaborate with a small number of other classes to realize its intent.

Bad Analysis Classes

- What makes a bad analysis class?
  - A functoid- a class with only one operation.
  - An omnipotent class -a class that does everything (classes with "system" or "controller" in their name *may* need closer scrutiny).
  - A class with a deep inheritance tree -in the real world inheritance trees tend to be shallow.
  - A class with low cohesion.
  - A class with high coupling.
  - Many very small classes in a model – merging should be considered.
  - Few but large classes in a model – decomposition should be considered.

Class Identification Techniques

- Noun/Verb Analysis (Grammatical Parsing)
- CRC Analysis
- Use-Case-Based Analysis
- Real-World Analysis

Noun/verb analysis (*Grammatical Parsing*)

1. Collect as much relevant information about the problem domain as possible; suitable sources of information are:
    - The requirements model
    - The use case model
    - The project glossary
    - Any other document (architecture, vision documents, etc.)

2. Analyze the documentation:
    - Look for **nouns or noun phrases** -these are candidate classes or attributes.
    - Look for **verbs or verb phrases** -these are candidate responsibilities or operations.
        - Always think about running methods on objects.

          e.g. given Number objects "x" and "y"

          x.add(y) is more OO than x = add(x, y)

3. Make a tentative allocation of the attributes and responsibilities to the classes.

Some OO Jargons !

Static Methods.

- But not all methods in Java are called on objects,... what's going on here?

- Some times methods are required that don't run against a specific object.
  - Initial program method ("main")
  - Factory methods
  - Methods that are not object specific

- Any methods or fields that are not related to a specific object are declared as ***"Static".*** They are class methods or fields

Static

- A static field is one that is the same for all objects. E.g. static pi.

- A static method is one that is the same for all objects.

- Static methods can’t refer to none static fields. Why?

- Static methods don’t need to be called on a particular objects. (Classname.method())

Nested Class

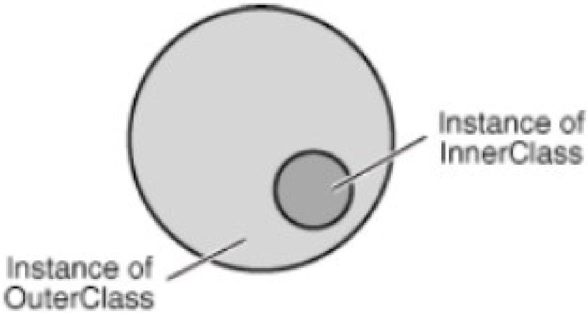
- A nested class is one that is declared inside another class.
  - a member of the enclosing class
  - private, public, protected, or *default*
  - may be static

Static Nested Class

- Does not need an instance of outer class
- Essentially just an outer class that is
- declared inside another outer class can be private
- sometimes called top-level nested class

```
OuterClass.StaticNestedC n = new OuterClass.StaticNestedC();
```

Inner Classes



- non static nested class
- declared within an instance of the outer class
- has access to private members of outer class

```
OuterClass.InnerClass innerObject = outerObject.new InnerClass();
```

Why Bother?

- Logical Grouping of Classes
- Encapsulation
- More readable and maintainable code

Example

```
public class DataStructure {
    //create an array
    private final static int SIZE = 15;
    private int[] arrayOfInts = new int[SIZE];
    public DataStructure() {
        //fill the array with ascending integer values
        for (int i = 0; i < SIZE; i++) {
            arrayOfInts[i] = i;
    }
}
```

Add an EvenIterator

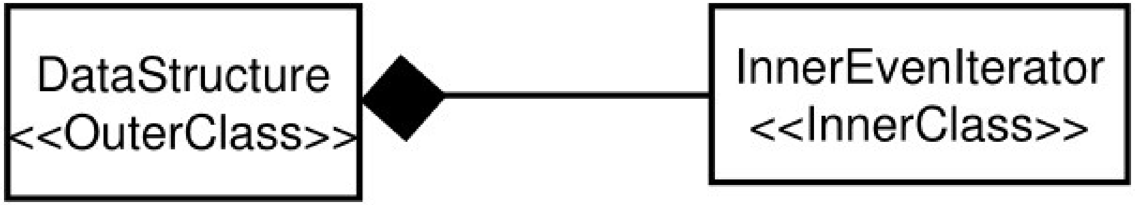
```
public void printEven() {
    //print out values of even indices of the array
    InnerEvenIterator iterator = this.new
         InnerEvenIterator();
    while (iterator.hasNext()) {
         System.out.println(iterator.next() + " ");
    }
}
```

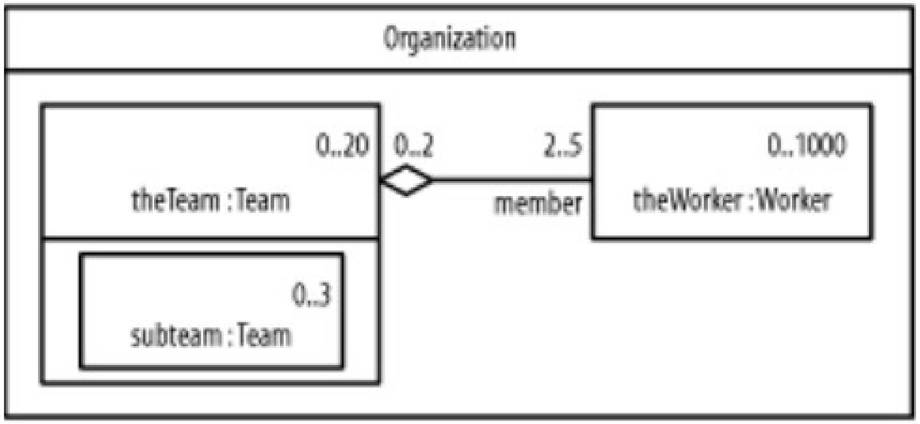
```
private class InnerEvenIterator {
    private int next = 0;
    public boolean hasNext() {
        //check if a current element is the last in the array
        return (next <= SIZE - 1);
    }

    public int next() {
        //record a value of an even index of the array
        int retValue = arrayOfInts[next];
        //get the next even element
        next += 2;
        return retValue;
    }
}
```

How to model Inner classes in UML?

- Aggregation





Local Classes

- member class that is declared within a body of a method or instance initializer
- scoping rules make this useful

Anonymous Classes

- A local class that has no name
- One statement declares and creates an object for the class
  - – new parentClassName (params) { body}
  - – new interfaceName() { body}