Object Oriented Design

Class Diagrams

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Lecture 03

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Section Contents

1. The Object Model
   - Core Concept
   - Objects
   - Object Graph
   - Classes
   - UML Diagrams

- Programming languages and design languages both tell us about programs
- These facts are expressed at different levels of abstraction
- Both are based on the abstract idea of running programs that we will call **the object model**

- The object model is not a specific UML model
  - It refers to how we think about programming in OOP
- The fundamental concept in the object model is that **computation takes place in and between objects**
  - Individual objects are responsible for maintaining part of the systems data
  - Individual objects are responsible for implementing part of the systems functionality

- Objects are often represented as an area in memory containing some data
- One important points is that much data is represented in the relationships between objects
- In the object model, objects are often viewed as a graph of connected objects
- These object communicate by **sending messages**

- It is normally too complicated to write programs by defining individual objects
  - OOP can be done without classes in some languages
- Classes are used to define the common responsibilities of objects
- These classes describe **how an object can be used**

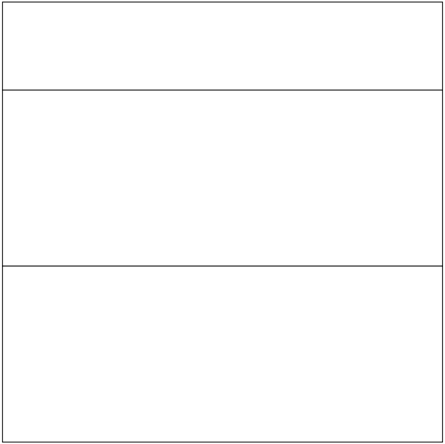
- There are two main types of UML diagram
  - **Static** diagrams describe the properties the object network can have
  - **Dynamic** diagrams describe what happens in the object network

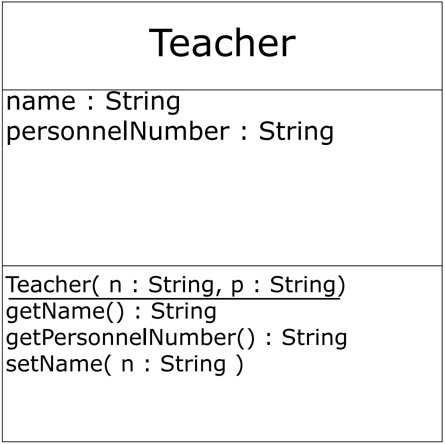
Section Contents

2 Representing Classes in UML

- An Empty Class
- A Teacher Class
- Notes
- Visibility

- Class diagrams in UML are made up of classes, their information and the connections between them
- For every class, we can represent three things:
  1. The **name** of the class
  2. The **attributes** it contains
  3. The **operations** it can perform





Teacher

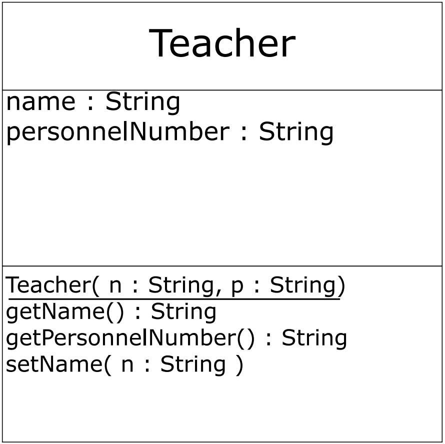
name : String
personnelNumber : String

Teacher(n : String, p : String)
getName() : String
getPersonnelNumber() : String
setName(n : String)

```
public class Teacher {
    String name;
    String personnelNumber;

    Teacher(String n, String p){
        name = n;
        personnelNumber = p;
    }

    String getName(){
        return name;
    }
    String getPersonnelNumber(){
        return personnelNumber;
    }
    void setName(String n){
        name = n;
    }
}
```



Teacher

name : String
personnelNumber : String

Teacher(n : String, p : String)
getName() : String
getPersonnelNumber() : String
setName(n : String)

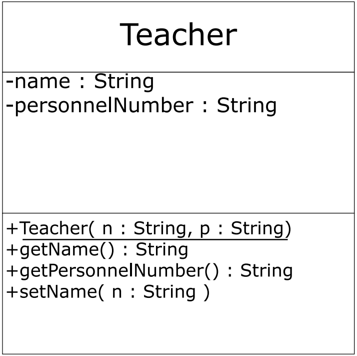
- The attributes section is basically a list of the instance variables in class
  - But this does not include complex objects
- The operations section is a list of the names, return types and parameters for all of the methods in the class
  - But this does not tell us what they do or how
  - Constructors are underlined

- We can represent the visibility of attributes and operations
- There are the same 4 levels as in Java
    - public $+$
    - package $\sim$
    - protected $\#$
    - private -
- The symbol is placed before the name of the attribute or operation

```java
public class Teacher {
    private String name;
    private String personnelNumber;

    public Teacher(String n, String p){
        name = n;
        personnelNumber = p;
    }

    public String getName(){
        return name;
    }
    public String getPersonnelNumber(){
        return personnelNumber;
    }
    public void setName(String n){
        name = n;
    }
}
```



Teacher

-name : String
-personnelNumber : String

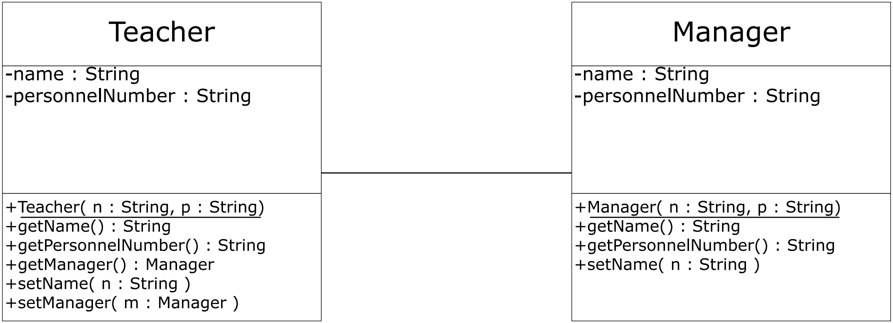
+Teacher(n : String, p : String)
+getName() : String
+getPersonnelNumber() : String
+setName(n : String)

Section Contents

3 Associations

- Instance Variables
- Annotations - Association Name
- Annotation - Role Name
- Annotation - Multiplicity
- Annotation - Navigability
- Example

- Attributes in a UML class do not include the instance variables that are complex objects
- These are instead represented as connections between classes
- The connections are called **associations**
- They are shown as a line connecting two classes
  - Can be annotated with **name**, **role name**, **multiplicity**, and/or **navigability**



Teacher

-name : String
-personnelNumber : String

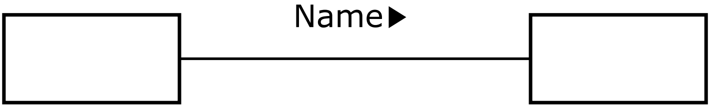
+Teacher(n : String, p : String)
+getName() : String
+getPersonnelNumber() : String
+getManager() : Manager
+setName(n : String)
+setManager(m : Manager)

Manager

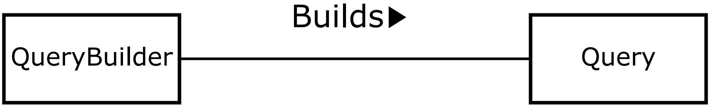
-name : String
-personnelNumber : String

+Manager(n : String, p : String)
+getName() : String
+getPersonnelNumber() : String
+setName(n : String)

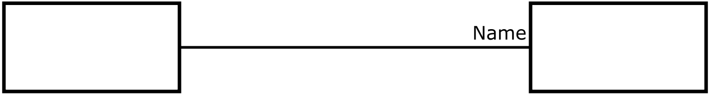
- The name of an association is shown above the line approximately in the middle



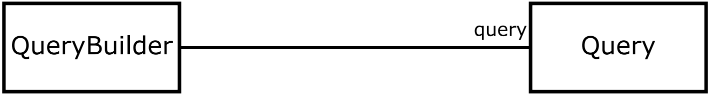
- The name usually explains the association in some way
- The triangle shows the direction the association should be read



- The concept of **role name** or association end name is supposed to describe the role played by classes in the relationship
- In reality, it is most commonly used to show the name of the instance variable used to implement the association

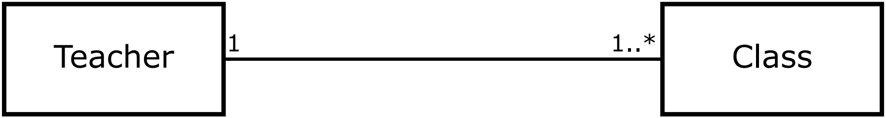


- The name is placed at the opposite end of the association to the class it belongs to



- Role names may also include visibility

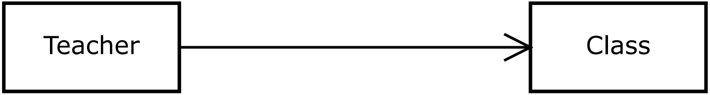
- The multiplicity on an association tells us how many objects are connected
- You will normally see one of the following options
  - Zero or Many **(0..*)** or **(*)**
  - Zero or One **(0..1)**
  - Only One **(1)**
  - One or Many **(1..*)**
- The multiplicity is placed at the opposite end of the association from the class it applies to



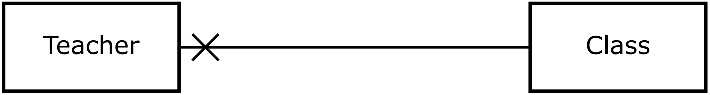
- The multiplicities above give us the following facts
  - Each teacher may be teaching one or more classes
  - Each class is taught by exactly one teacher

- Navigability is the concept of which directions the association can be used in
- More specifically, it tells us which objects can communicate
    - Communication is done by calling methods
- If navigability is not shown, then we do not know what is possible

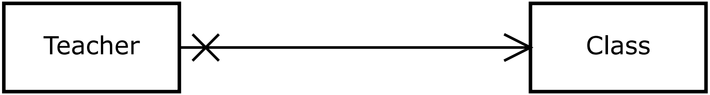
- This diagram shows that Teacher can communicate with Class

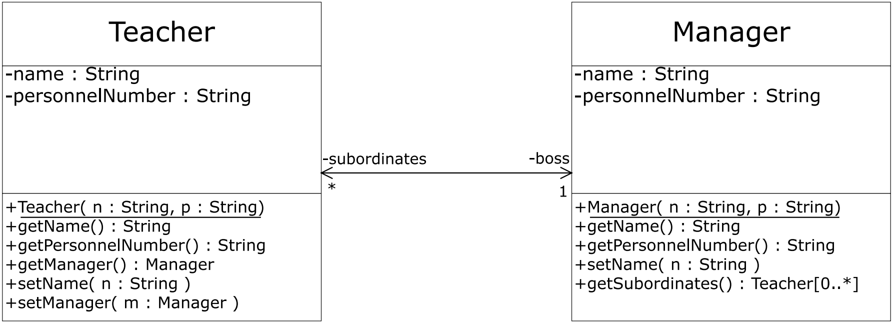


- This diagram shows that Class cannot communicate with Teacher



- This diagram shows both of the above





Teacher

-name : String
-personnelNumber : String

+Teacher(n : String, p : String)
+getName() : String
+getPersonnelNumber() : String
+getManager() : Manager
+setName(n : String)
+setManager(m : Manager)

-subordinates *

-boss 1

Manager

-name : String
-personnelNumber : String

+Manager(n : String, p : String)
+getName() : String
+getPersonnelNumber() : String
+setName(n : String)
+getSubordinates() : Teacher[0..*]

```java
public class Teacher {
    private String name;
    private String personnelNumber;
    private Manager boss;

    public Teacher(String n, String p){ ... }

    public String getName(){ ... }
    public String getPersonnelNumber(){ ... }
    public Manager getManager(){ ... }

    public void setName(String n){ ... }
    public void setManager(Manager m){ ... }
}
```

```java
public class Manager {
    private String name;
    private String personnelNumber;
    private List<Teacher> subordinates;

    public Manager(String n, String p){ ... }

    public String getName(){ ... }
    public String getPersonnelNumber(){ ... }
    public void setName(String n){ ... }
}
```

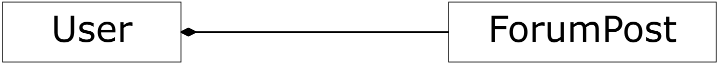
Section Contents

4 Aggregation and Composition

- Composition
- Aggregation
- Example of Composition and Aggregation Relationships

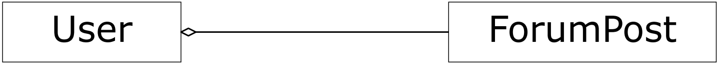
- UML allows us to define some different types of associations
- These will not always result in differences in the actual code
- But they will give some information about how objects in the relationship should be used
- These different types of association are know as **aggregation** and **composition**

- Composition is shown by adding a filled diamond to the association

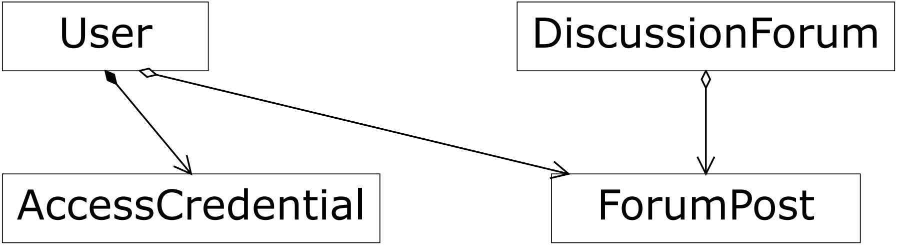


- Composition implies a level of ownership or possession (I.e. the `User` object owns the `ForumPost` object)
- When objects share a composition relationship, they may be **created together** and should be **destroyed together**
- An object may only be part of one composition

- Aggregation is shown by adding a hollow diamond to the association



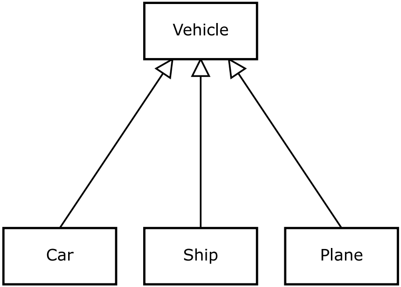
- Aggregation is similar to composition, but weaker and poorly defined
- In principle there is still a relationship where one object is considered part of another
- However, with aggregation an object may be part of multiple aggregations

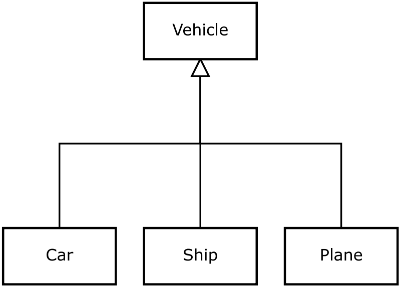

User
DiscussionForum
AccessCredential
ForumPost

Section Contents

5 Generalisation and Specialisation
- Generalisation Example
- Generalisation Implementation

- The relationship between classes we know as inheritance is called generalisation or specialisation in UML
- It is called **generalisation** in the direction of the superclass
  - The superclass is more general than the subclass
- It is called **specialisation** in the direction of the subclass
  - The subclass is more specialised than the superclass


Vehicle
Car
Ship
Plane


Vehicle
Car
Ship
Plane

```
public class Vehicle {
    ...
}
```

```
public class Car extends Vehicle {
    ...
}
```

```
public class Ship extends Vehicle {
    ...
}
```

Section Contents

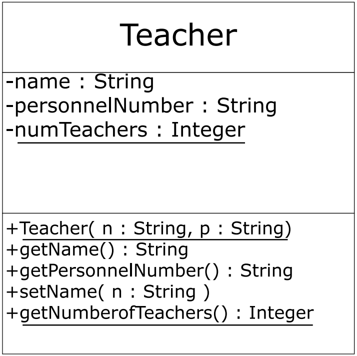
6 Class Members
- Static Members

- UML allows us to show when variables or methods belong to the class
- This is done by underlining the attribute or method
- Constructors are also considered as belonging to the class in UML

```java
public class Teacher {
    private String name;
    private String personnelNumber;
    private static int numTeachers;

    public Teacher(String n, String p){ ... }

    public String getName(){ ... }
    public String getPersonnelNumber(){ ... }
    public void setName(String n){ ... }
    public static int getNumberofTeachers(){ ... }
}
```



Teacher

-name : String
-personnelNumber : String
-numTeachers : Integer

+Teacher(n : String, p : String)
+getName() : String
+getPersonnelNumber() : String
+setName(n : String)
+getNumberofTeachers() : Integer

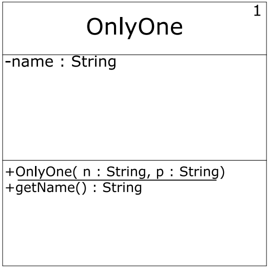
Section Contents

7 Singletons

- Class Multiplicity
- Showing a Class is a Singleton
- Implementing Class as a Singleton
- Using A Singleton Object
- When to use a Singleton

- Multiplicity can also be applied to an individual class
- This can describe how many objects may be created based on this class
- The only important case is where classes are limited to a single instance
- Classes like this are known as **singletons**

- A class that is limited to a single instance is shown by adding a 1 to the top right hand corner



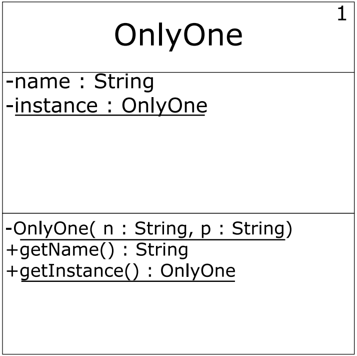
The Singleton Pattern

```java
public class OnlyOne {
    private String name;
    private static OnlyOne instance;

    private OnlyOne(){

    }

    public static OnlyOne getInstance(){
        if (instance == null){
            instance = new OnlyOne();
        }
        return instance;
    }
    public String getName(){
        return name;
    }
}
```



1

OnlyOne

-name : String
-instance : OnlyOne

-OnlyOne(n : String, p : String)
+getName() : String
+getInstance() : OnlyOne

- When we want to use a singleton object, we cannot construct it like a normal object
- Instead, we must use the static `getInstance` method
- E.g. `OnlyOne oo = OnlyOne.getInstance();`

- Having an object that can be accessed from everywhere in our code can simplify things, but it also can have down sides
- Disadvantages:
  - We need to consider concurrency
  - Singletons make testing harder
  - They can hide dependencies in our code
- Typical uses:
  - Logging
  - Caches
  - Read-only application state

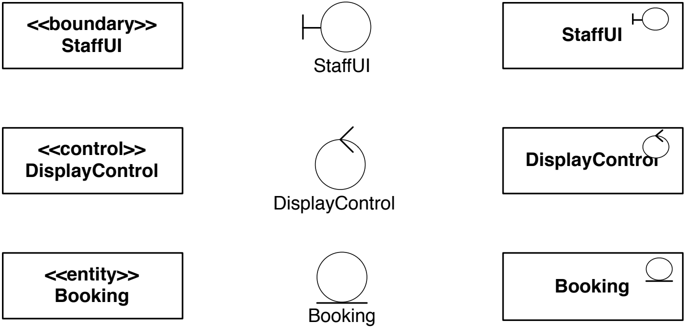
Section Contents

8 Types of Classes

- Boundary, Control and Entity objects

- UML distinguishing between **boundary**, **control** and **entity** objects
  - Entity objects are responsible for maintaining data
  - Boundary objects are those which interact with external users
  - Control objects ensure the interactions in the program happen correctly
- These are ordinary classes with an additional description of their role in the system
  - Represented in UML by stereotypes

- The stereotype can be written in the class icon, but distinctive icons are also defined for the three types of class


<<boundary>>
StaffUI
StaffUI
StaffUI
<<control>>
DisplayControl
DisplayControl
DisplayControl
<<entity>>
Booking
Booking
Booking