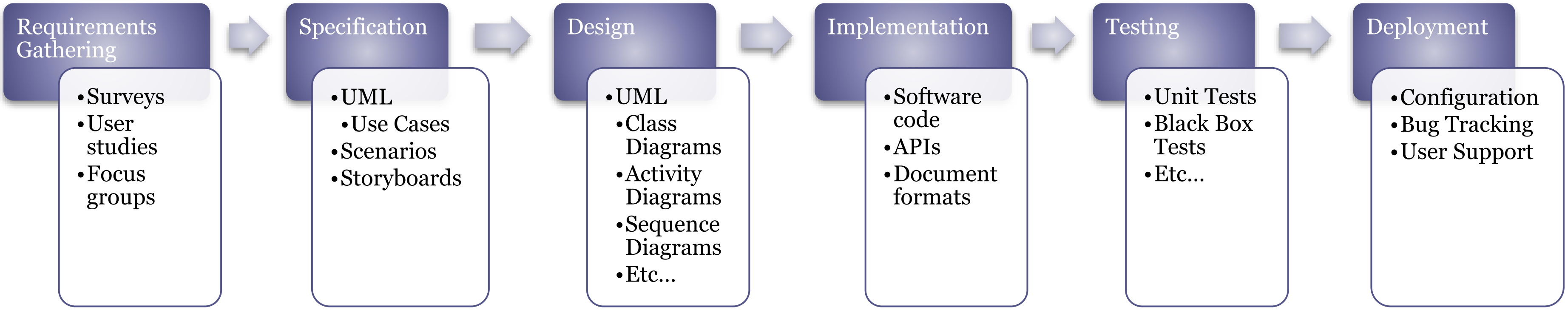
OOAD: Big Picture



Requirements Gathering

- Surveys
- User studies
- Focus groups

Specification

- UML
  - Use Cases
- Scenarios
- Storyboards

Design

- UML
  - Class Diagrams
  - Activity Diagrams
  - Sequence Diagrams
  - Etc…

Implementation

- Software code
- APIs
- Document formats

Testing

- Unit Tests
- Black Box Tests
- Etc…

Deployment

- Configuration
- Bug Tracking
- User Support

This is rarely a straightforward progression – in reality there are lots of iterations and points of feedback

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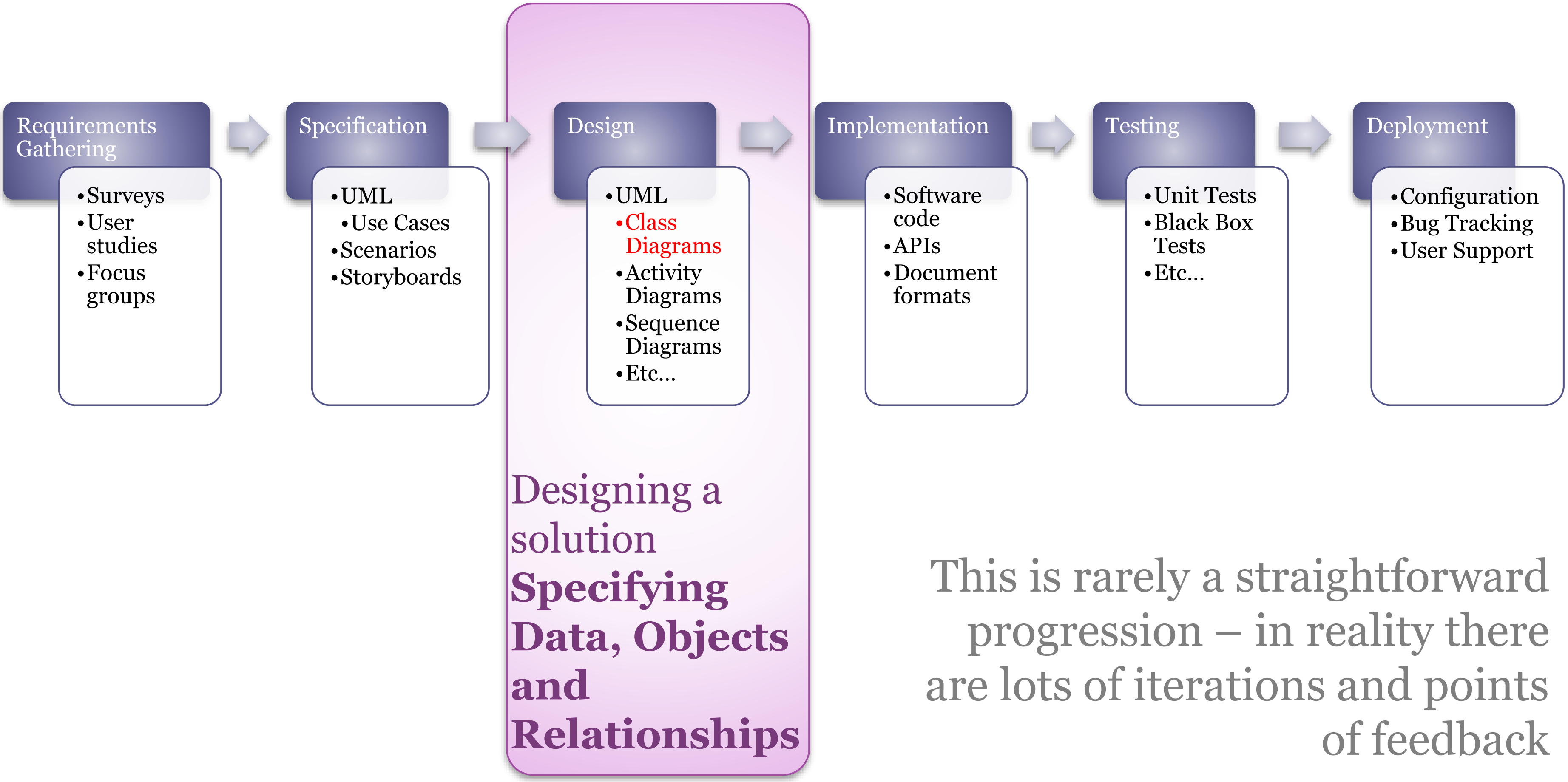

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Designing a solution

Specifying Data, Objects and Relationships

This is rarely a straightforward progression – in reality there are lots of iterations and points of feedback

UML Class Diagrams

Lecture 8

Types of Diagram

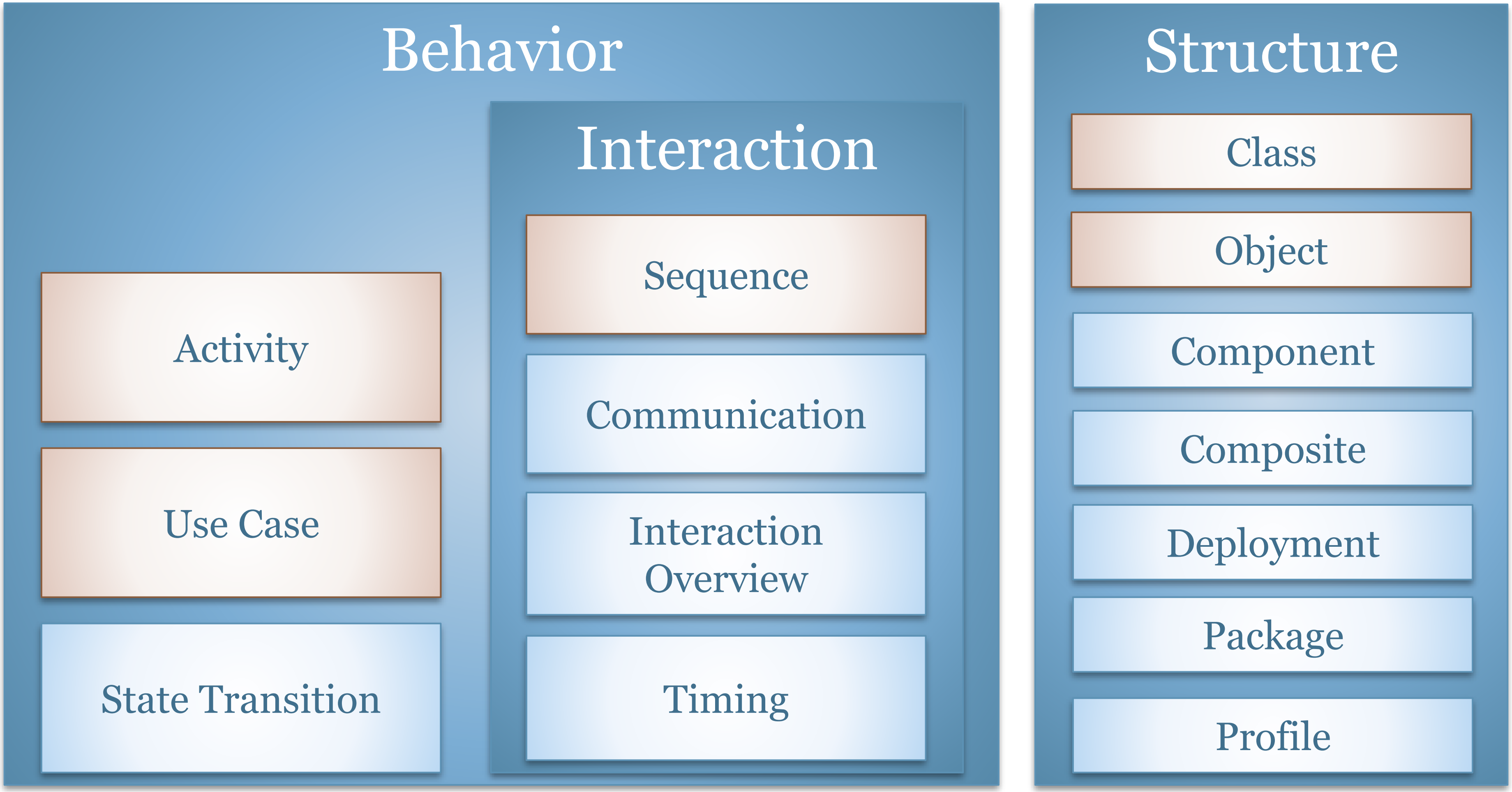
Structure Diagrams

- Provide a way for representing the data and static relationships that are in an information system
- you are connecting different parts together to get the final design

Behavioral Model

- Behavioral modeling refers to a way to model the system based on its functionality.

Two Types of Diagram



Behavior

- Activity
- Use Case
- State Transition

Interaction

- Sequence
- Communication
- Interaction Overview
- Timing

Structure

- Class
- Object
- Component
- Composite
- Deployment
- Package
- Profile

What is UML Class Diagrams

- What is a UML class diagram? Imagine you were given the task of drawing a family tree. The steps you would take would be:
    - Identify the main members of the family
    - Identify how they are related to each other
    - Find the characteristics of each family member
    - Determine relations among family members
    - Decide the inheritance of personal traits and characters

Basics of UML Class Diagrams

- A software application is comprised of classes and a diagram depicting the relationship between each of these classes would be the class diagram.
- A class diagram is a pictorial representation of the detailed system design

Relationship between Class Diagram and Use Cases

- How does a class diagram relate to the use case diagrams that that we learned before?

Relationship between Class Diagram and Use Cases

- When you designed the use cases, you must have realized that the use cases talk about "what are the requirements" of a system.
- The aim of designing classes is to convert this "what" to a "how" for each requirement
- Each use case is further analyzed and broken up that form the basis for the classes that need to be designed

Elements of a Class Diagram

- A class diagram is composed primarily of the following elements that represent the system's business entities:
  - **Class:** A class represents an entity of a given system that provides an encapsulated implementation of certain functionality of a given entity. These are exposed by the class to other classes as *methods*
  - Apart from functionality, a class also has properties that reflect unique features of a class. The properties of a class are called *attributes*.

Naming Convention

Class naming: Use **singular** names

- because each class represents a generalized version of a singular object.

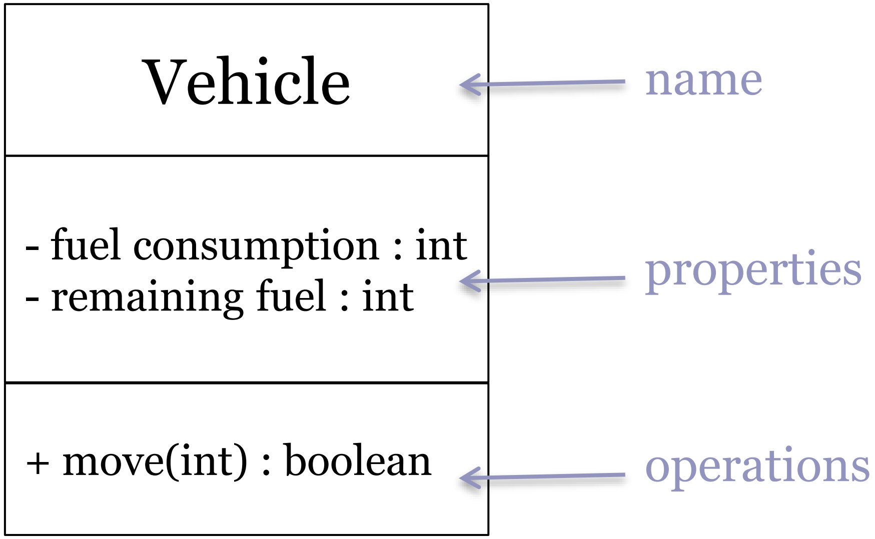
Classes

We need to store several sorts of data about vehicles, including their fuel consumption and level of remaining fuel. Vehicles can move a given distance assuming that they have enough fuel.

- What is the name of the class?
- What are its properties?
- What are its operations?

Classes

We need to store several sorts of data about vehicles, including their fuel consumption and level of remaining fuel. Vehicles can move a given distance assuming that they have enough fuel.

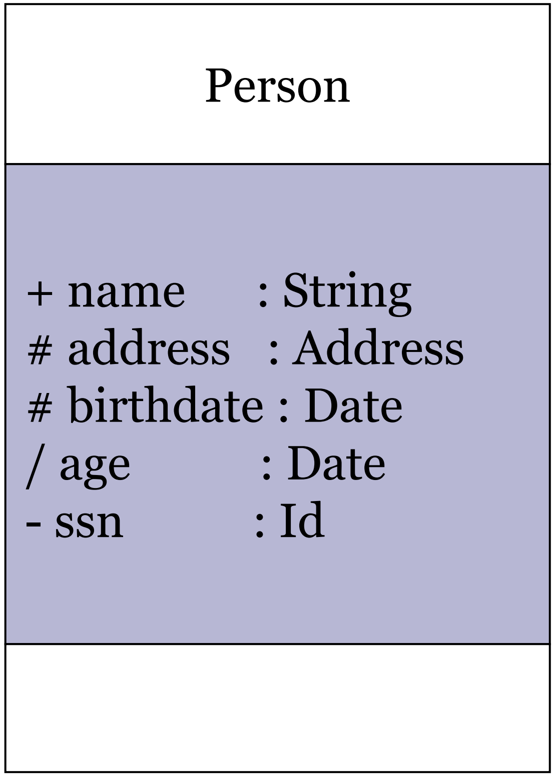


Vehicle

- fuel consumption : int
- remaining fuel : int

+ move(int) : boolean

Class Attribute


Person

+ name : String
# address : Address
# birthdate : Date
/ age : Date
- ssn : Id

attributeName : Type

"-" **private**

"#" **protected**

"+" **public**

"~" **package**

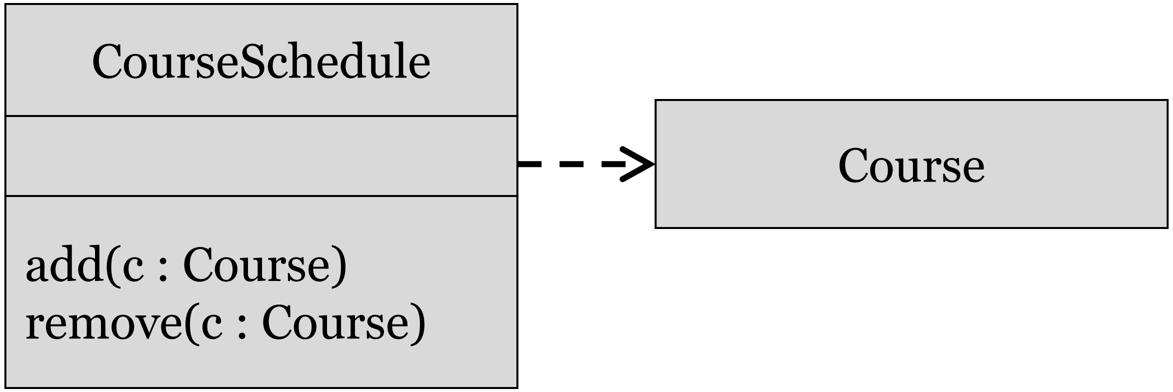
"/" **derived**

Relationships

- In UML, object interconnections (logical or physical), are modeled as relationships.
- There are three kinds of relationships in UML:
  - Dependencies
  - Generalizations
  - Associations

Dependency

- Dependency is represented when a reference to one class is passed in as a method parameter to another class.



```
public class A {

        public void doSomething(B b) {
```

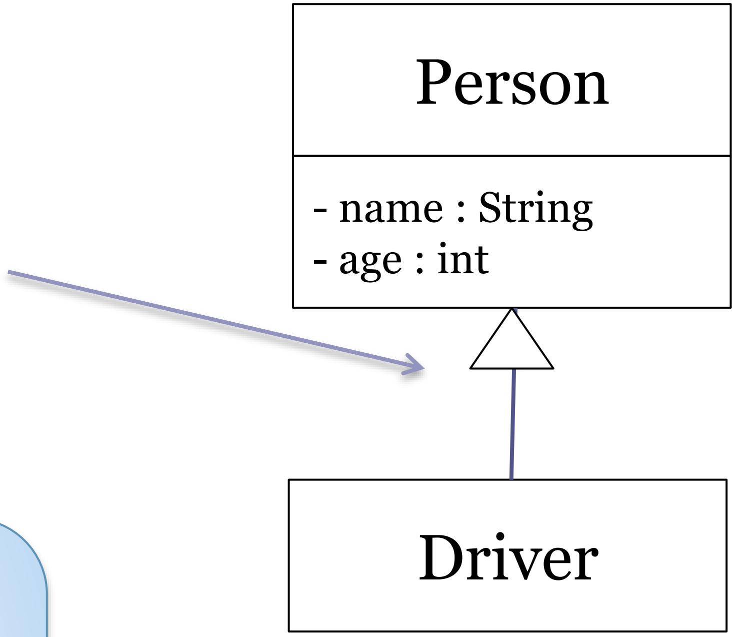
Generalization

Drivers are a type of person. Every person has a name and an age.

UML Class Diagrams: Generalization

Drivers are a type of person. Every person has a name and an age.

Note: we use a special kind of arrowhead to represent generalization



Person

- name : String
- age : int

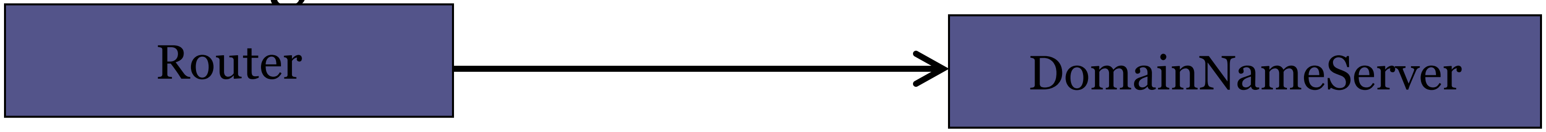
Driver

```
public Person  {
...
} // class Person
public class Driver extends Person{
....
} // class Driver
```

We assume that Driver **inherits** all the properties and operations of a Person (as well as defining its own)

One-way Association

- We can constrain the association relationship by defining the *navigability* of the association.
- In one way association, We can navigate along a single direction only
- Denoted by an arrow towards the server object
- Here, a *Router* object requests services from a *DNS* object by sending messages to (invoking the operations of) the server. The direction of the association indicates that the server has no knowledge of the *Router*.



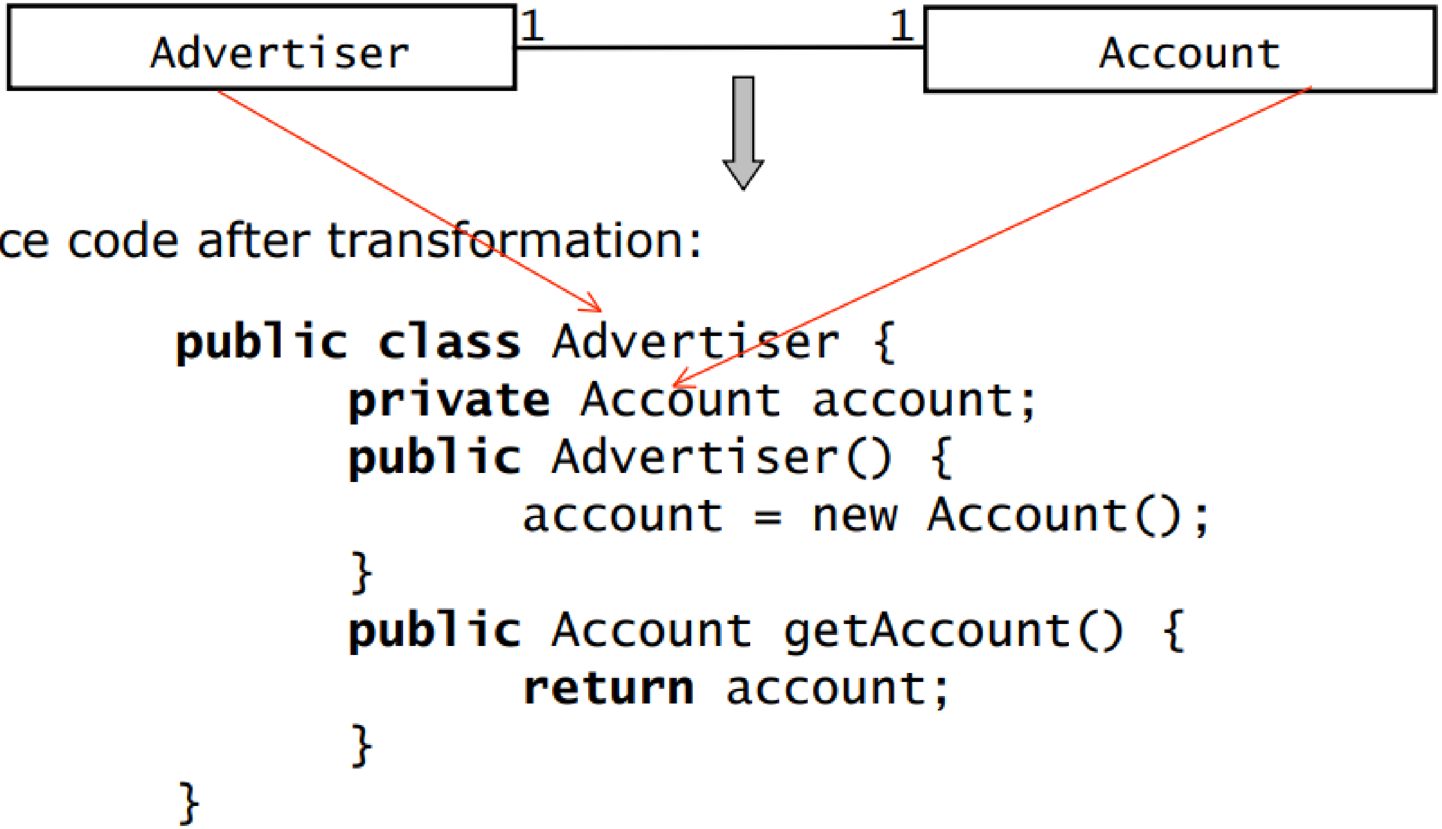
One way Association-Person-Address

```
class Person {
string Name;
Address addr;
int Age;
public:
Person(){..}
~Person{..}
void setAddress(Address* a)
{
addr = a; //shallow copy
}
};
```

```
class Address {

string Street;
long postalCode;
string Area;
…..
}
```

One way Association



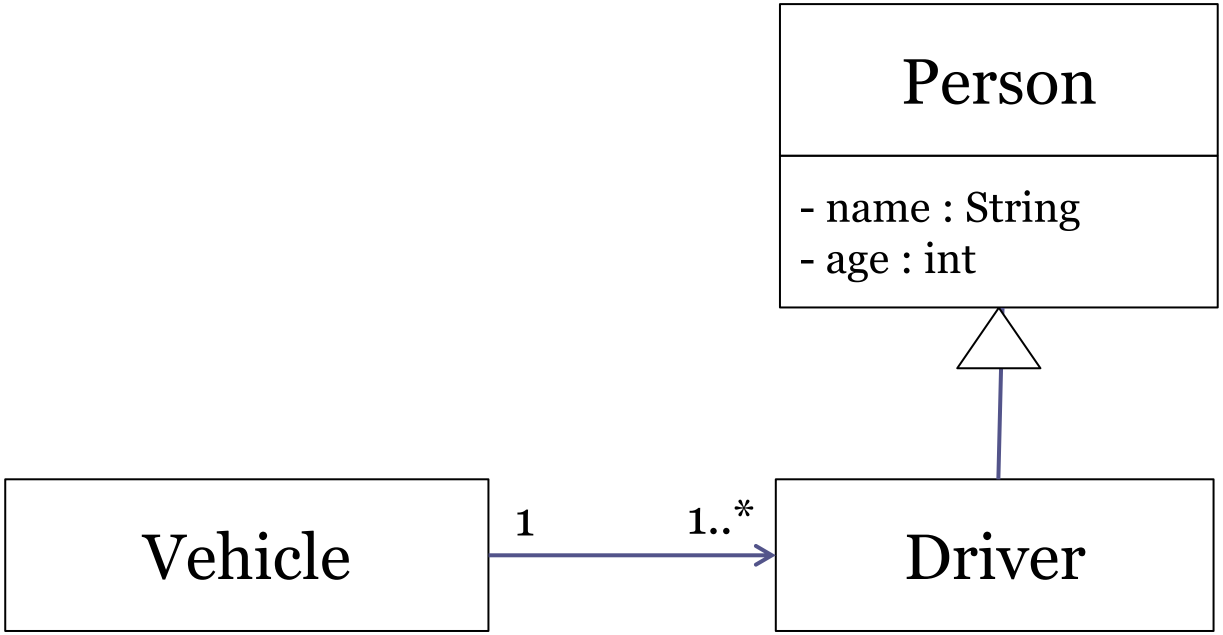
Source code after transformation:

```
public class Advertiser {
        private Account account;
        public Advertiser() {
                account = new Account();
        }
        public Account getAccount() {
                return account;
        }
}
```

One to one Relationship

Composition

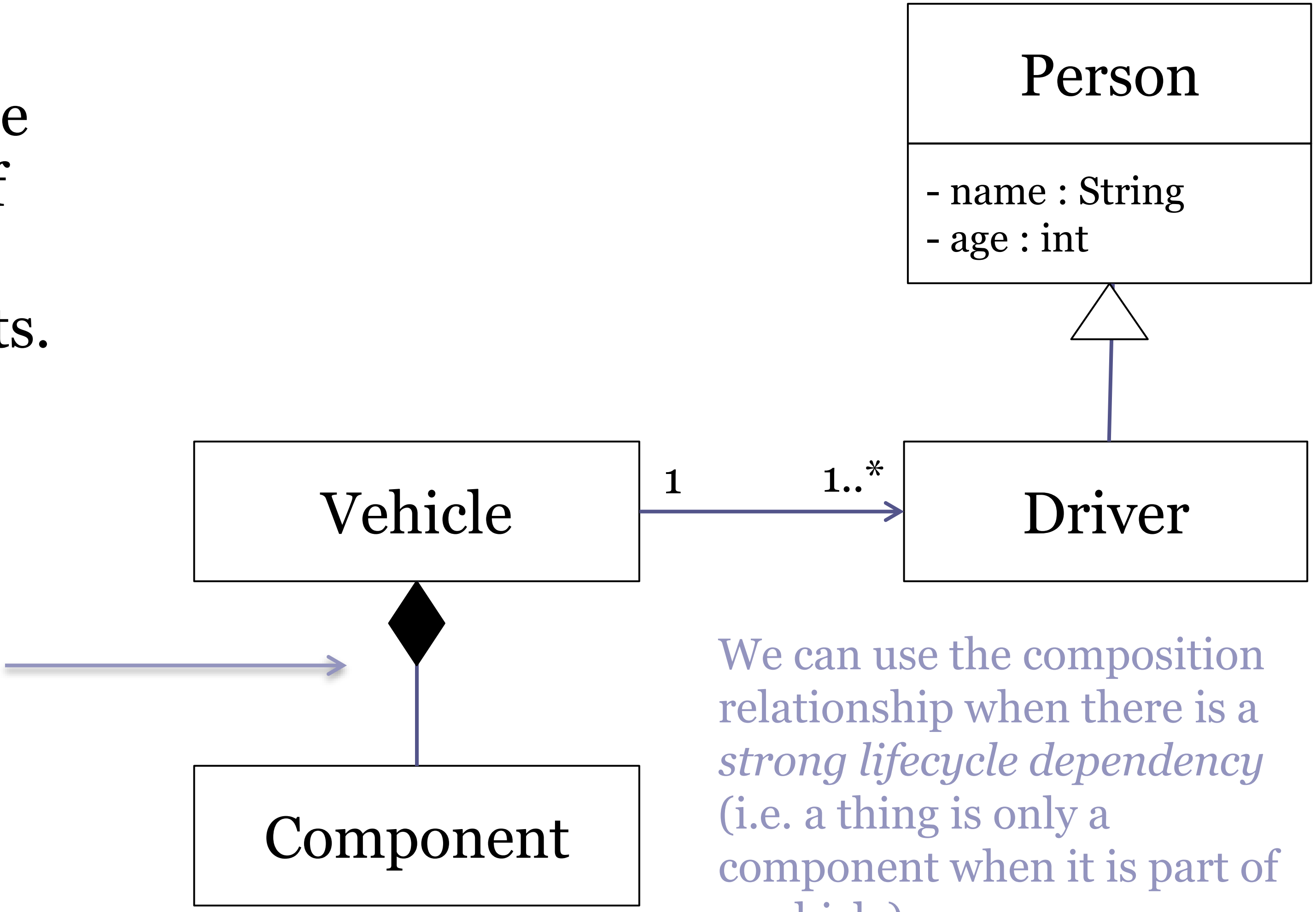
Vehicles are made up of many components.



Composition

Vehicles are made up of many components.

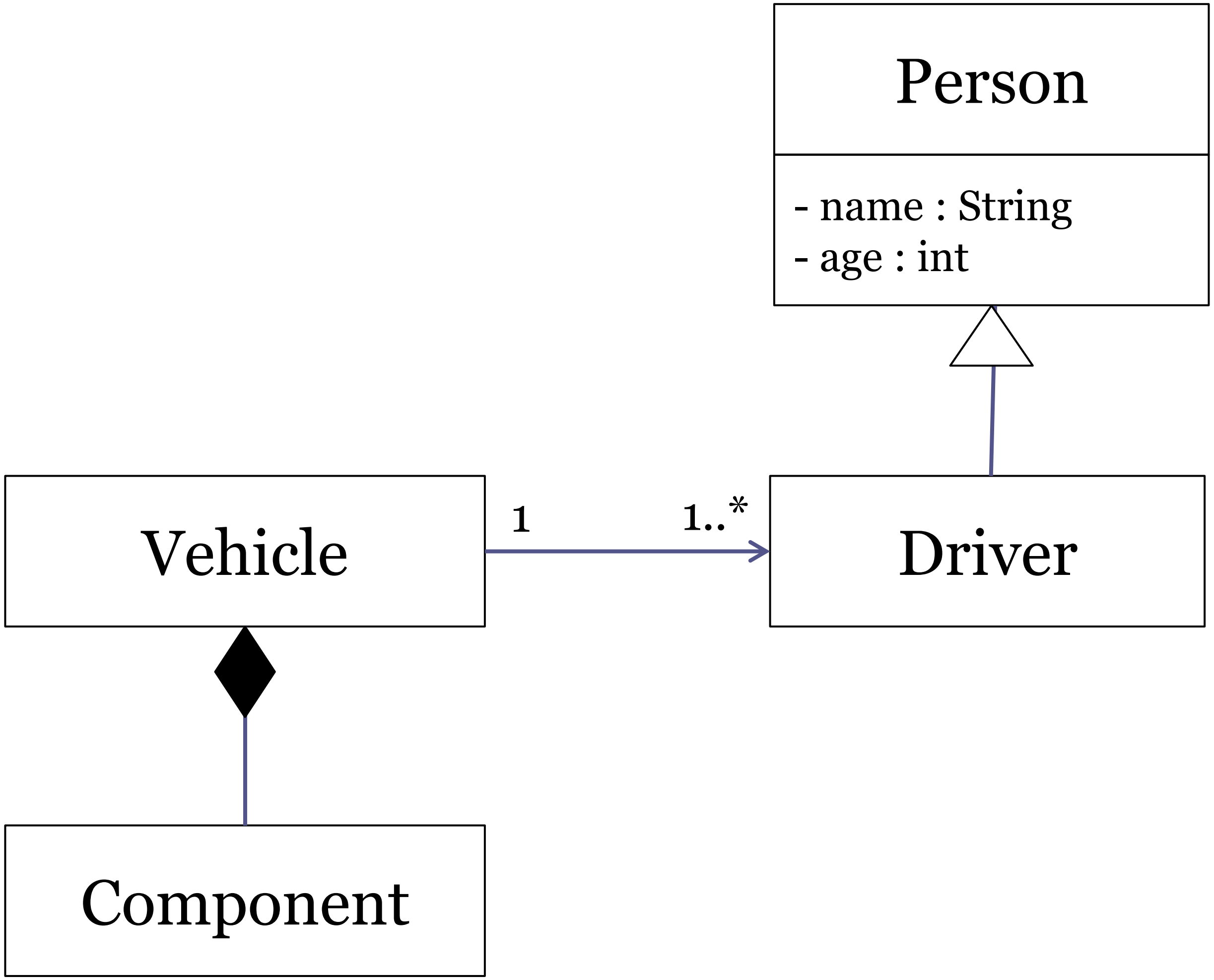
Note: we use a solid diamond to represent composition



We can use the composition relationship when there is a *strong lifecycle dependency* (i.e. a thing is only a component when it is part of a vehicle)

Aggregation

Vehicles are managed in a collection called a Fleet.



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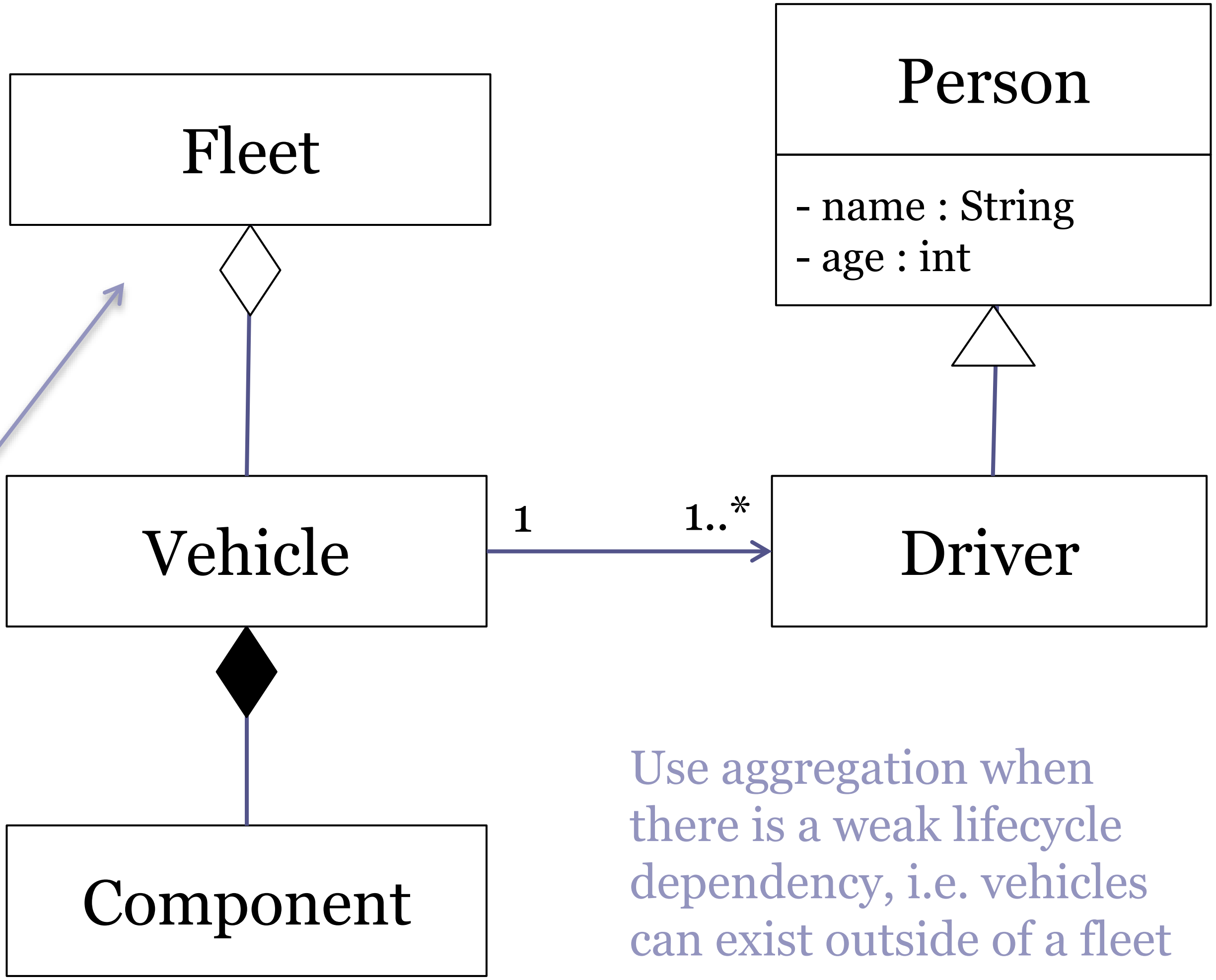
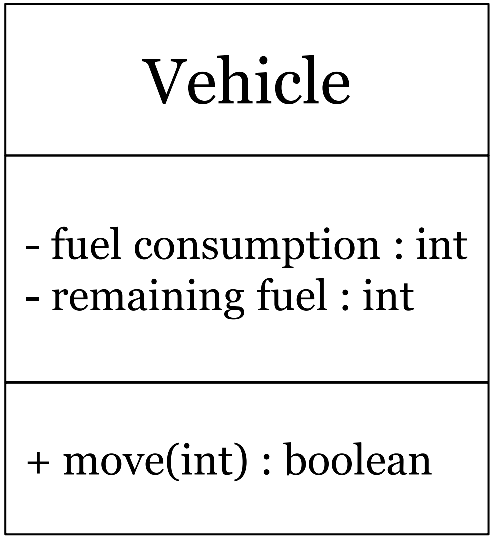


Note: we use an empty diamond to represent aggregation

Use aggregation when there is a weak lifecycle dependency, i.e. vehicles can exist outside of a fleet

Two Way Associations

Vehicles always have at least one driver. Each driver must have a single vehicle.



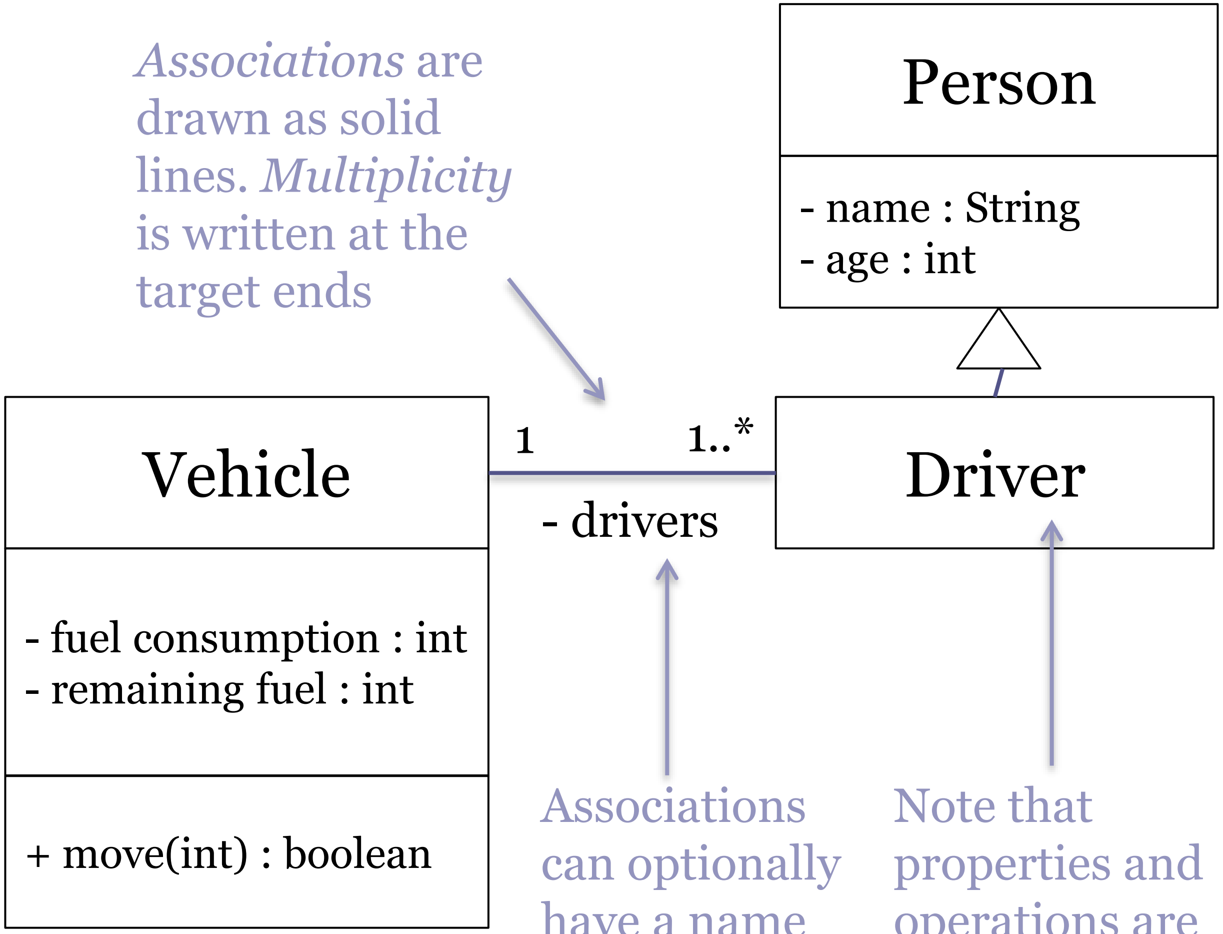
Vehicle

- fuel consumption : int
- remaining fuel : int

+ move(int) : boolean

Two way Associations

Vehicles always have at least one driver. Each driver must have a single vehicle.



Associations are drawn as solid lines. *Multiplicity* is written at the target ends

Person

- name : String
- age : int

Vehicle

- fuel consumption : int
- remaining fuel : int

+ move(int) : boolean

1

1..*

- drivers

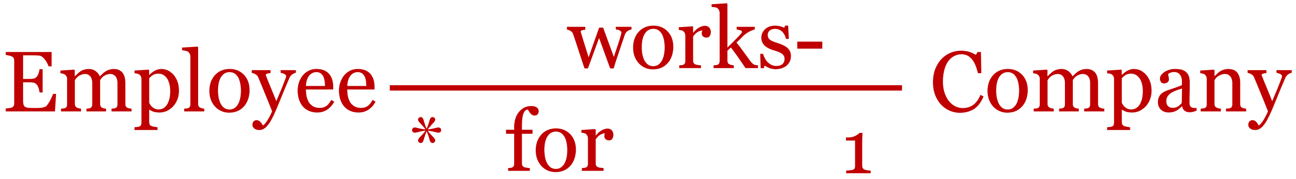
Driver

Associations can optionally have a name and visibility

Note that properties and operations are optional

Two-way Association(Bidirectional)

- We can navigate in both directions
- Denoted by a line between the associated objects



Employee

works-for

*

1

Company

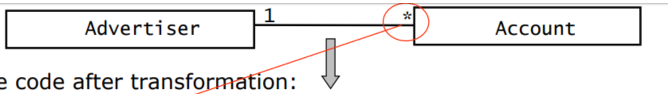
- Employee works for company
- Company employs employees

Two way Association-Contractor-Project

```
class Contractor
{
private:
string Name;
Project MyProject;
...
};
```

```
class Project
{
string Name;
Contractor person;
....
};
```

Bidirectional Association

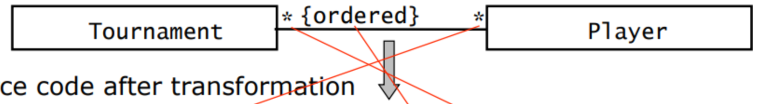


Source code after transformation:

```
public class Advertiser {
   private Set accounts;
   public Advertiser() {
         accounts = new HashSet();
   }
   public void addAccount(Account a) {
         accounts.add(a);
         a.setOwner(this);
   }
   public void removeAccount(Account a)
   {
         accounts.remove(a);
         a.setOwner(null);
   }
}
```

```
public class Account {
   private Advertiser owner;
   public void setOwner(Advertiser
   newOwner) {
      if (owner != newOwner) {
            Advertiser old = owner;
            owner = newOwner;
            if (newOwner != null)

   newOwner.addAccount(this);
            if (oldOwner != null)

   old.removeAccount(this);
      }
   }
}
```

One to many

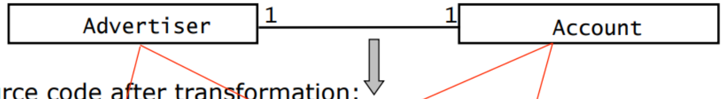


Source code after transformation

```
public class Tournament {
   private List players;
   public Tournament() {
         players = new ArrayList();
   }
   public void addPlayer(Player p)
   {
         if (!players.contains(p)) {
               players.add(p);
               p.addTournament(this);
         }
   }
}
```

```
public class Player {
   private List tournaments;
   public Player() {
         tournaments = new
   ArrayList();
   }
   public void
   addTournament(Tournament t) {
         if
   (!tournaments.contains(t)) {
            tournaments.add(t);
            t.addPlayer(this);
         }
   }
}
```

many to many

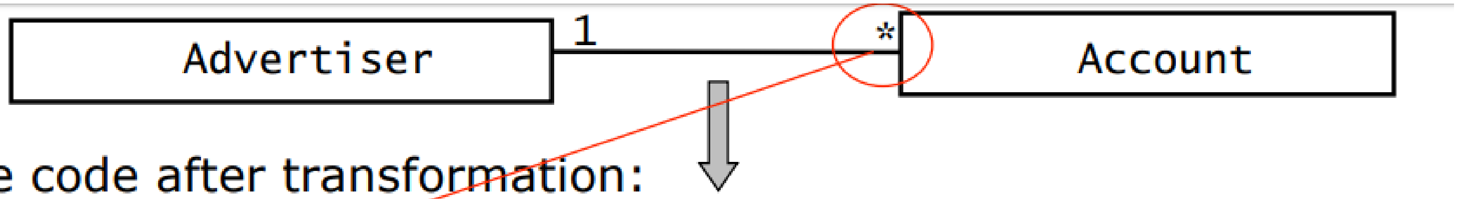


Source code after transformation:

```
public class Advertiser {
/* account is initialized
 * in the constructor and never
 * modified. */
  private Account account;
  public Advertiser() {
        account = new
  Account(this);
  }
  public Account getAccount() {
        return account;
  }
}
```

```
public class Account {
  /* owner is initialized
   * in the constructor and
   * never modified. */
  private Advertiser owner;
  publicAccount(owner:Advertiser) {
        this.owner = owner;
  }
  public Advertiser getOwner() {
        return owner;
  }
}
```

One to one



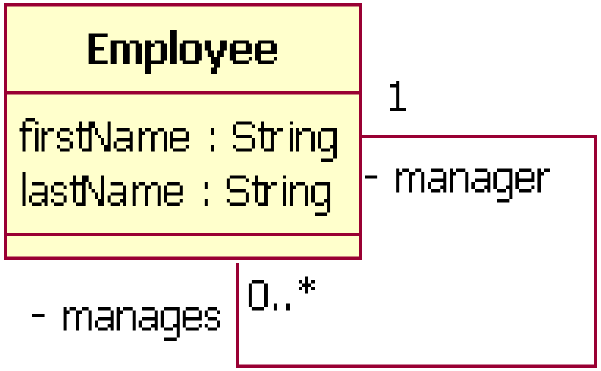
Source code after transformation:

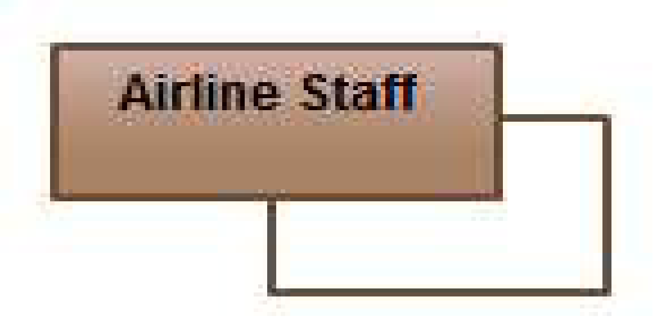
```
public class Advertiser {
   private Set accounts;
   public Advertiser() {
         accounts = new HashSet();
   }
   public void addAccount(Account a) {
         accounts.add(a);
         a.setOwner(this);
   }
   public void removeAccount(Account a)
   {
         accounts.remove(a);
         a.setOwner(null);
   }
}
```

```
public class Account {
   private Advertiser owner;
   public void setOwner(Advertiser
   newOwner) {
      if (owner != newOwner) {
            Advertiser old = owner;
            owner = newOwner;
            if (newOwner != null)

   newOwner.addAccount(this);
            if (oldOwner != null)

   old.removeAccount(this);
      }
   }
}
```

Self Association

A class can have a *self association/ reflexive Association*.





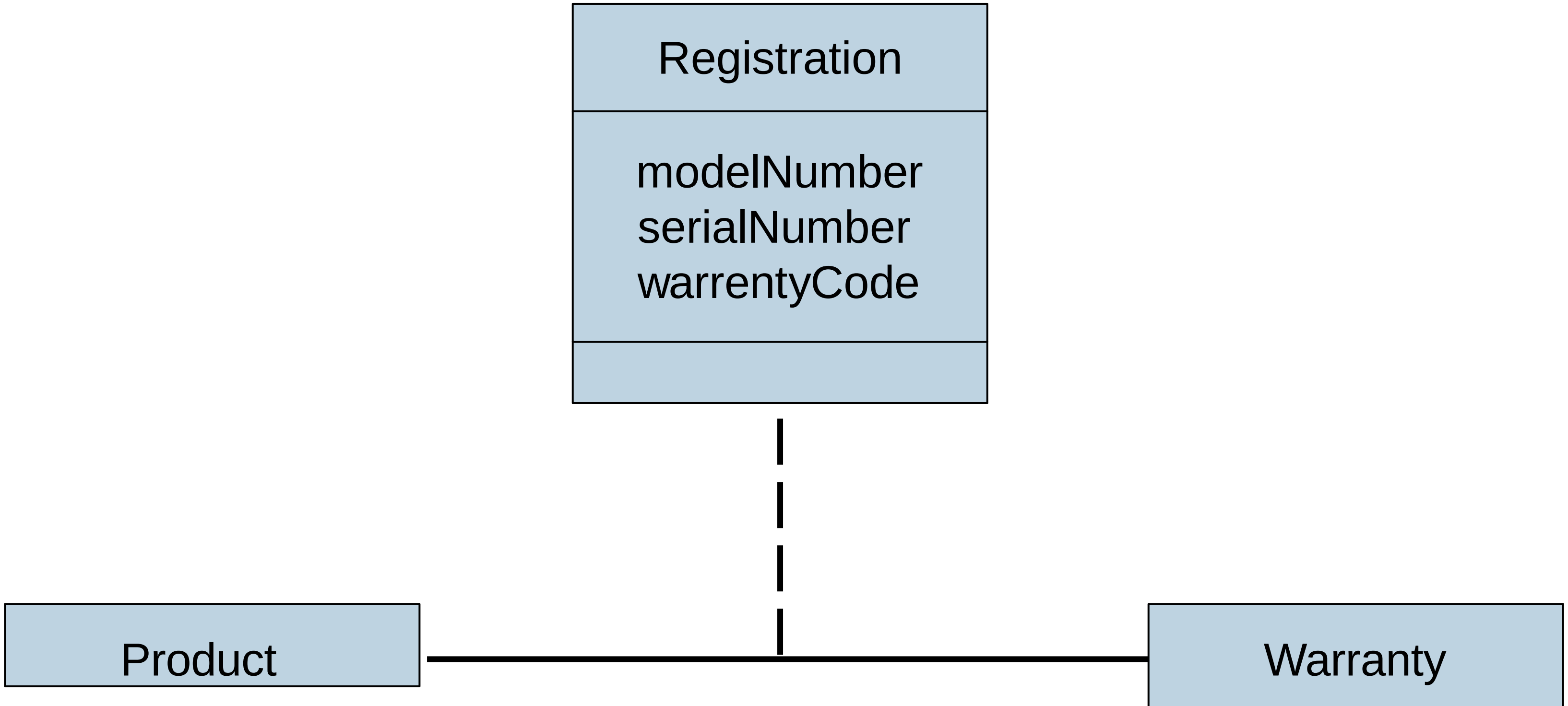
Two instances of the same class:
Pilot
Aviation engineer

Self Association

```
class Course
{
private:
    std::string m_name;
    Course *m_prerequisite;

public:
    Course(std::string &name, Course *prerequisite=nullptr):
        m_name(name), m_prerequisite(prerequisite)
    {
    }

};
```

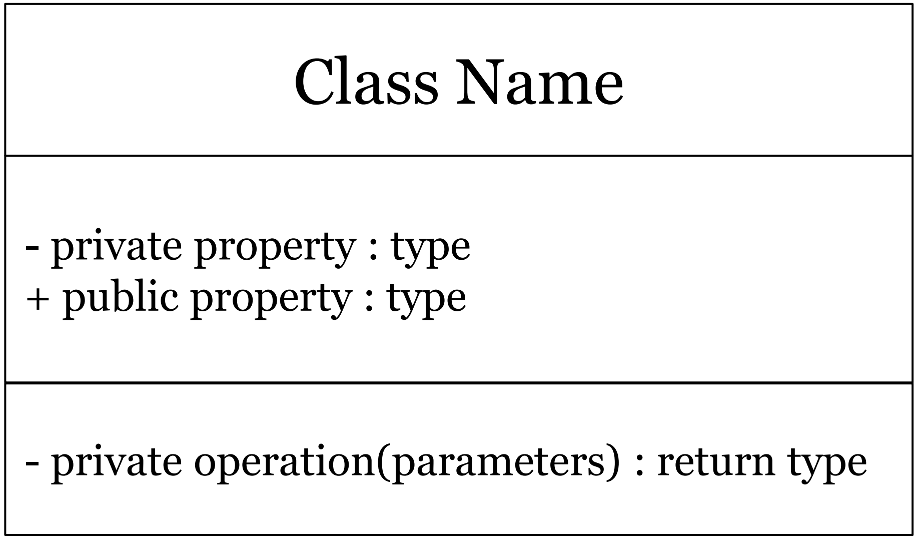
Association Class

- Associations can also be objects themselves, called link classes or an association classes.
- A link is an instance of an association.



UML Class Diagrams

Class

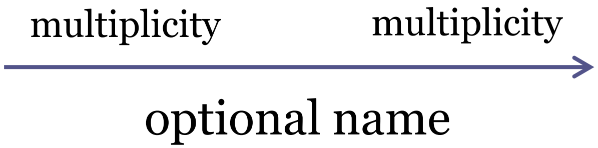


Class Name

- private property : type
+ public property : type

- private operation(parameters) : return type

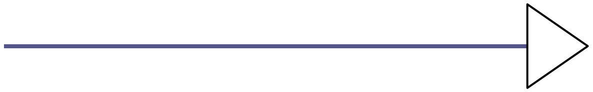
Association



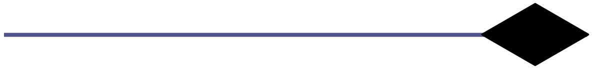
multiplicity multiplicity

optional name

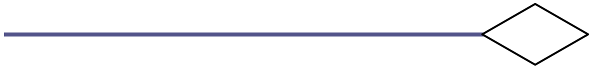
Generalization (Inheritance)



Composition (strong)

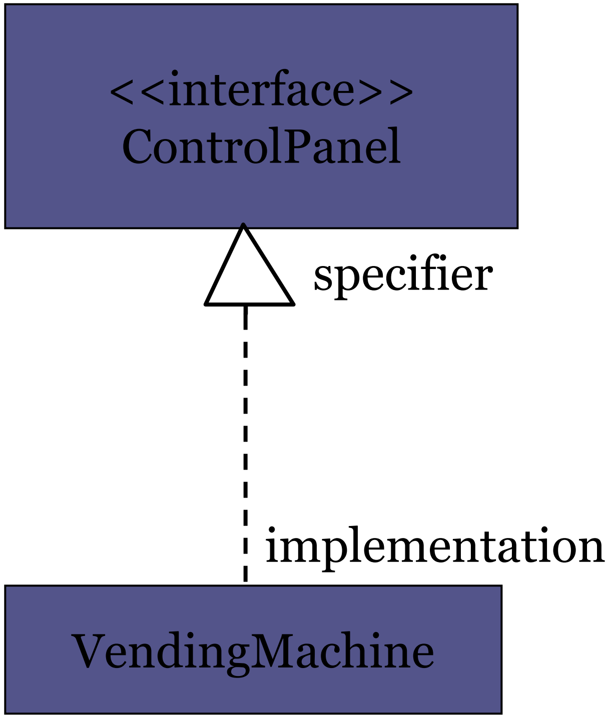


Aggregation (weak)



Interface Realization Relationship

A *realization* relationship connects a class with an interface that supplies its behavioral specification. It is rendered by a dashed line with a hollow triangle towards the specifier.

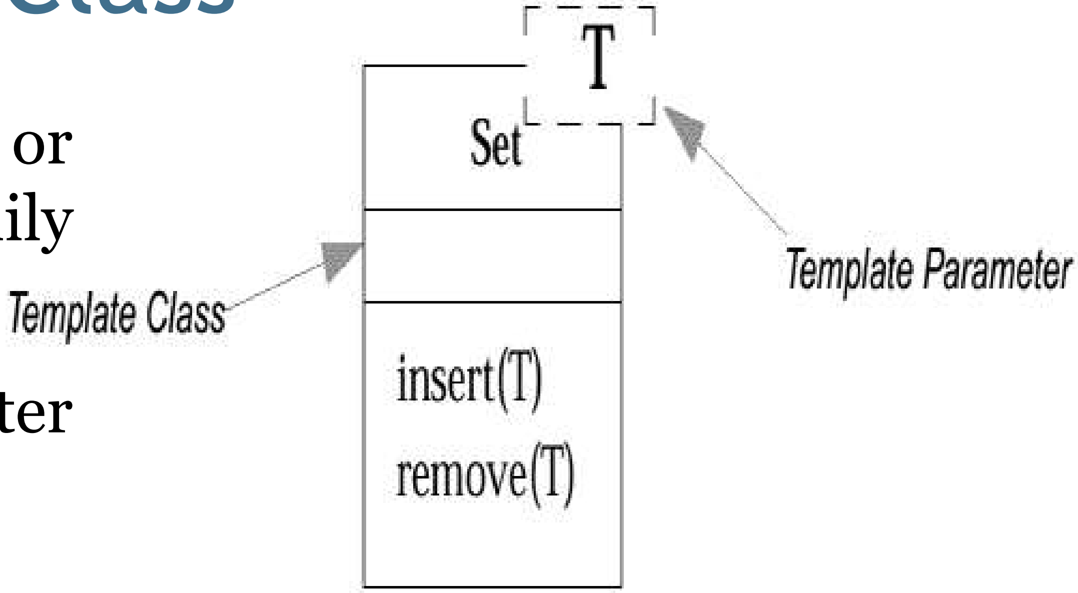


```
public interface A {
} // interface A
public class B implements A {
} // class B
```

Parameterized Class

A *parameterized class* or *template* defines a family of potential elements.

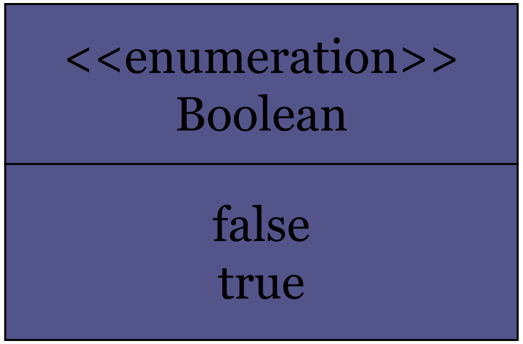
To use it, the parameter must be bound.



```
class Set <T> {
void insert (T newElement);
void remove (T anElement);
```

Enumeration

An *enumeration* is a user-defined data type that consists of a name and an ordered list of enumeration literals.

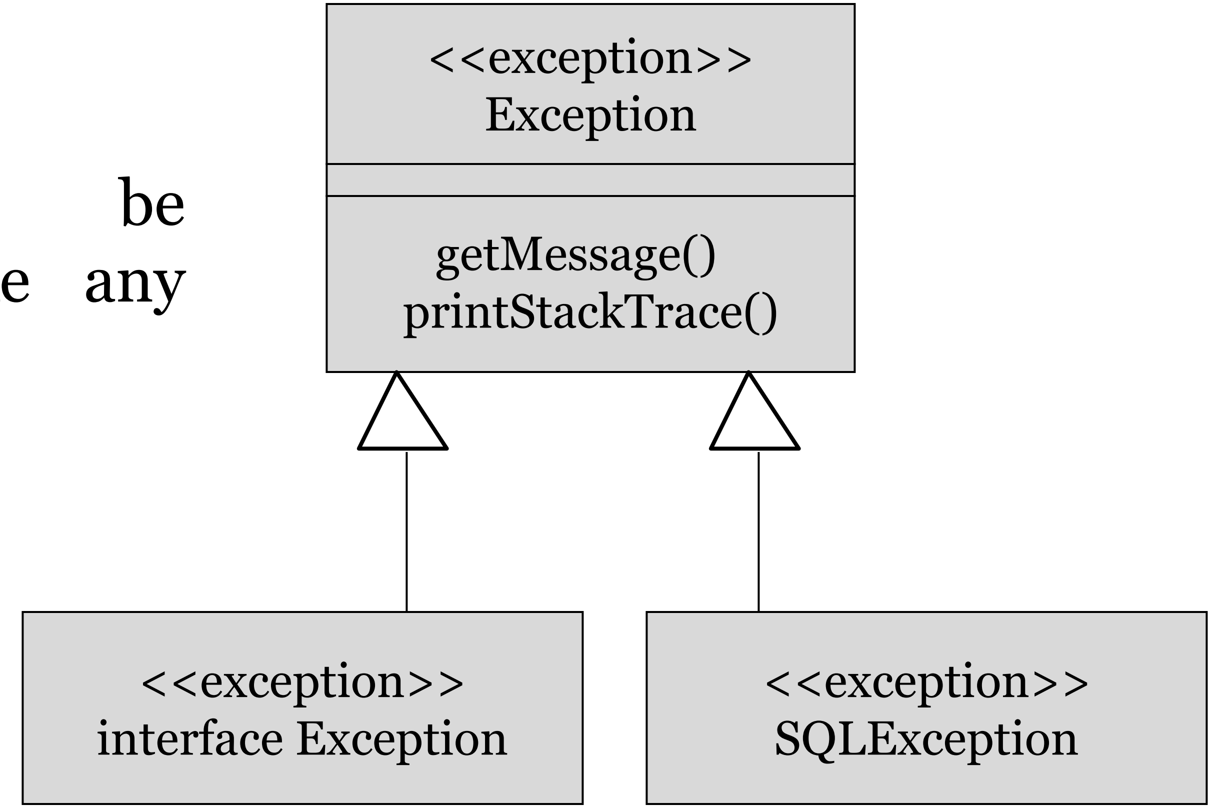


<<enumeration>>
Boolean

false
true

Exceptions

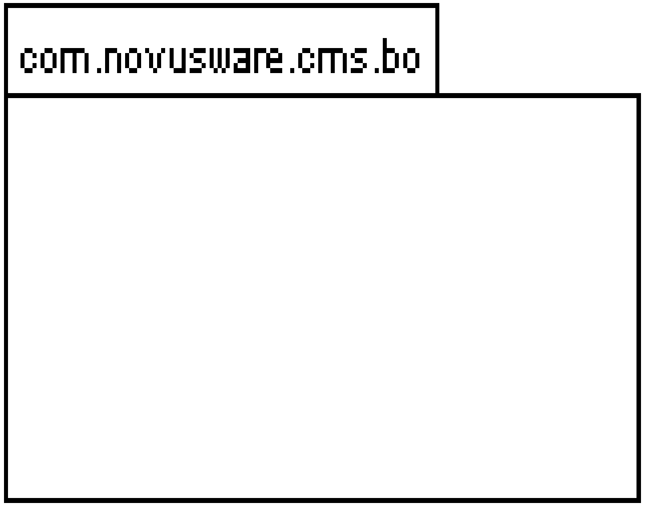
Exceptions can be modeled just like any other class.



Package

provides the ability to group together classes and/or interfaces that are either similar in nature or related.

Grouping these design elements in a package element provides for better readability of class diagrams, especially complex class diagrams.



Library System

Books and Journals: The library contains books and journals. Some of the books are for short term loans only. All other books may be borrowed by any library member for three weeks. Members of the library can normally borrow 1 or more items at a time, members of staff may also borrow items a. Only members of staff may borrow journals up to 12 at a time.

How might we model…

Students and staff are both members of the University. Staff can be either academic, support or research staff.

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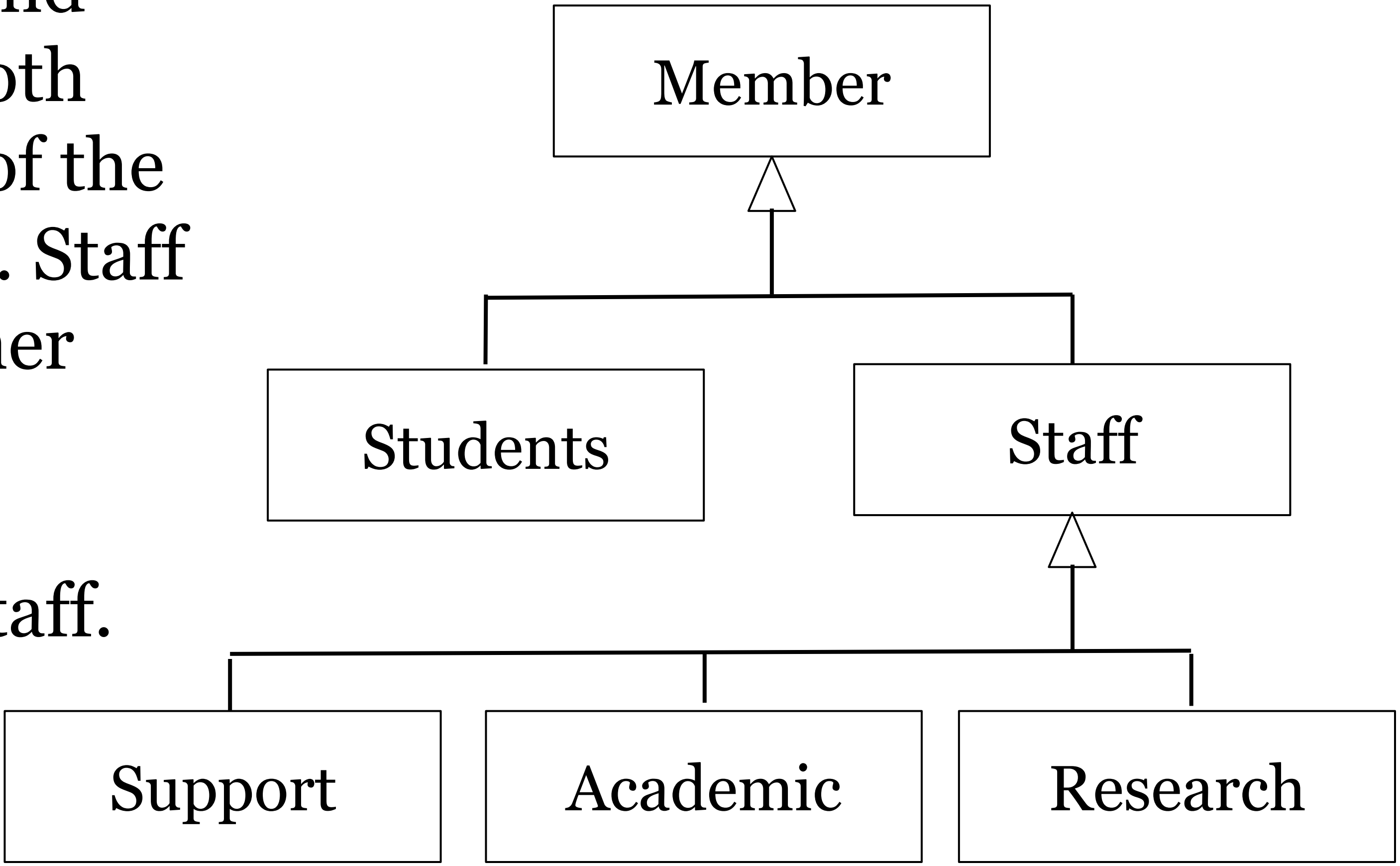
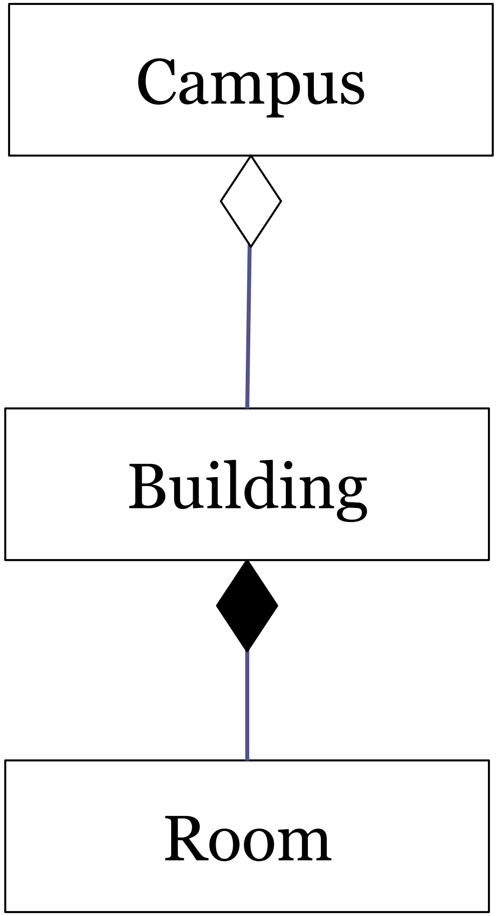


How might we model…

A campus is made up of many buildings. A building is made of many rooms.

How might we model…

A campus is made up of many buildings. A building is made of many rooms.



How might we model…

A Race has many competitors. Each competitor may have a trainer. Both types of person have a name, but competitors also have a number.

How might we model…

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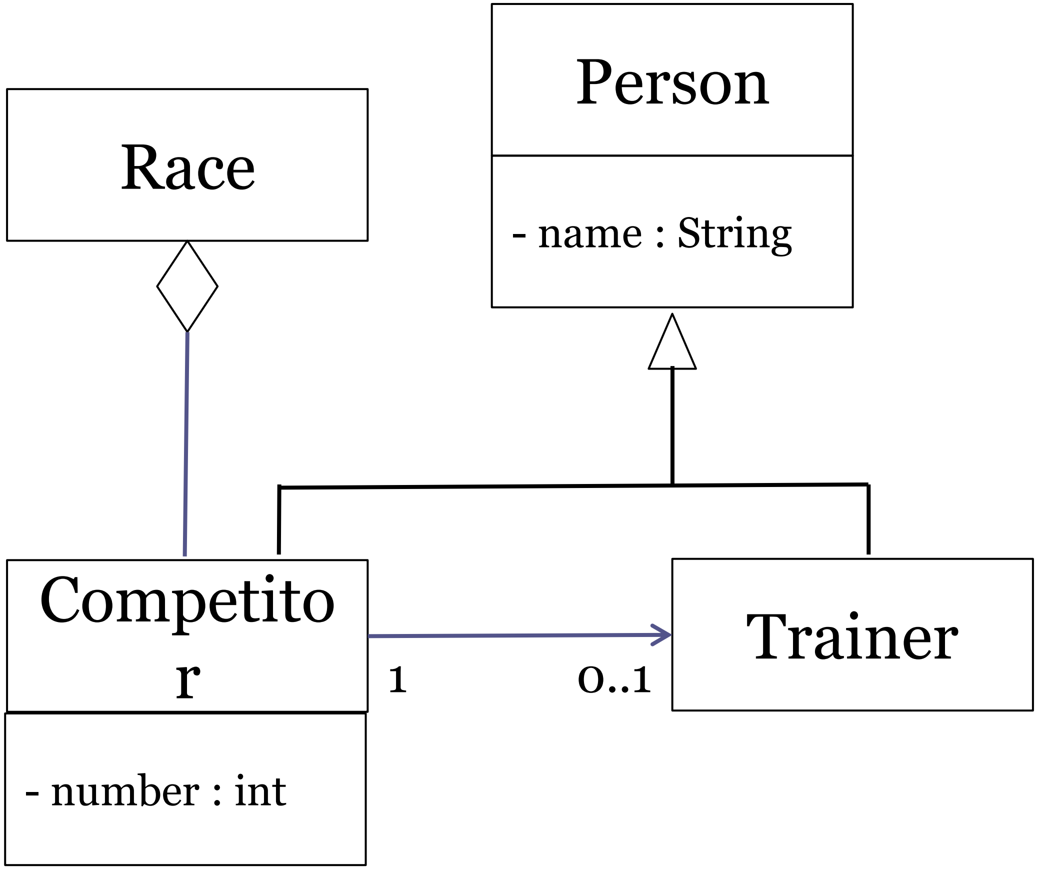

Home Work Exercises

University Team Management

- In the SAD course at Fast University, students are member of teams.
- Each team has 2 or 3 members.
- Each team completes 0 to 3 assignments.
- Each student takes exactly two midterm test.
- Computer Science students have a single account on Coding Development facility , while each engineering student has an account on the Engineering facility.
- Each assignment and midterm is assigned a mark.

University System

- A Fast university offers degrees to students.
- The university consists of faculties each of which consists of one or more departments.
- Each degree is administered by a single department.
- Each student is studying towards a single degree.
- Each degree requires one to 20 courses.
- A student enrolls in 1-5 courses (per term).
- A course cab be either graduate or undergraduate, but not both.
- Likewise, students are graduates or undergraduates but not both.

Library System

- This application will support the operations of a technical library for an R&D organization. This includes the searching for and lending of technical library materials, including books, videos, and technical journals. Users will enter their company ids in order to use the system; and they will enter material ID numbers when checking out and returning items. Each borrower can be lent up to five items. Each type of library item can be lent for a different period of time (books 4 weeks, journals 2 weeks, videos 1 week). If returned after their due date, the library user's organization will be charged a fine, based on the type of item(books $1/day, journals $3/day, videos $5/day).Materials will be lent to employees with no overdue lendable, fewer than five articles out, and total fines less than $100.