OBJECT LANGUAGE AND THEORY

12. CLASS DIAGRAMS

1

Objectives

- Describe the static view of the system and show how to capture it in a model.
- Demonstrate how to read and interpret a class diagram.
- Model an association and aggregation and show how to model it in a class diagram.
- Model generalization on a class diagram.

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Content

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1.1. Classes in the UML

- A class is represented using a rectangle with three compartments:
  - The class name
  - The structure (attributes)
  - The behavior (operations)

```
Professor
- name
- employeeID : UniqueId
- hireDate
- status
- discipline
- maxLoad

+ submitFinalGrade()
+ acceptCourseOffering()
+ setMaxLoad()
+ takeSabbatical()
+ teachClass()
```

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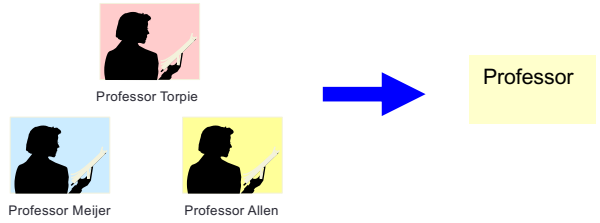
Classes and Objects

- A class is an abstract definition of an object
  - It defines the structure and behavior of each object in the class.
  - It serves as a template for creating objects.
- Classes are not collections of objects



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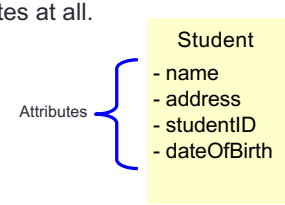
What Is an Attribute?

- An attribute is a named property of a class that describes the range of values that instances of the property may hold.
  - A class may have any number of attributes or no attributes at all.



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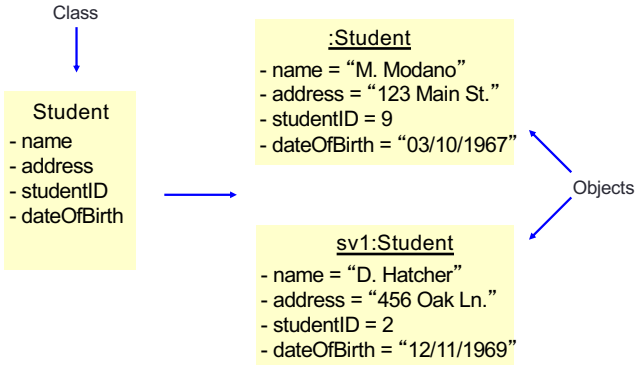
Attributes in Classes and Objects



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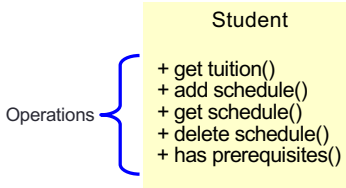
What Is an Operation?

- A service that can be requested from an object to effect behavior. An operation has a signature, which may restrict the actual parameters that are possible.
- A class may have any number of operations or none at all.



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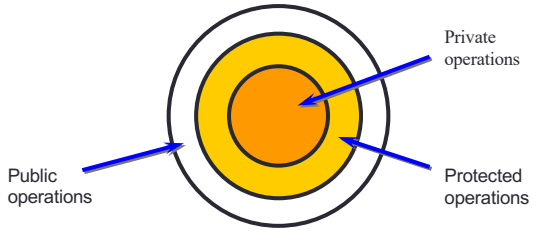
Member Visibility

- Visibility is used to enforce encapsulation
- May be public, protected, or private



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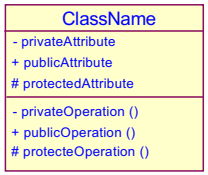
How Is Visibility Noted?

- The following symbols are used to specify export control:
  - + Public access
  - # Protected access
  - - Private access



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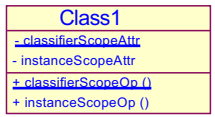
Scope

- Determines number of instances of the attribute/operation
  - Instance: one instance for each class instance
  - Classifier: one instance for all class instances
- Classifier scope is denoted by underlining the attribute/operation name



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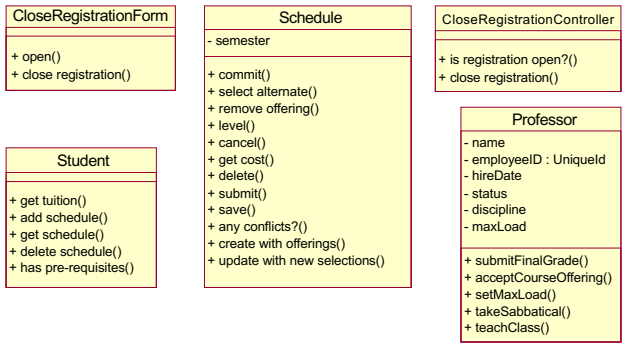
1.2. What Is a Class Diagram?

- Static view of a system



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Static Structure vs. Dynamic Behavior

- **Static aspects:** Software component and how they are related to one another
- **Dynamic aspects:** How the components interact with one another and/or change state internally over time.

static

vs

dynamic

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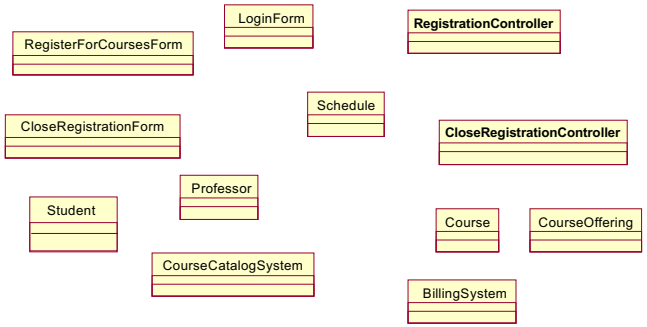
Example: Class Diagram

- Is there a better way to organize class diagrams?



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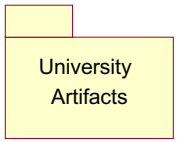
Review: What Is a Package?

- A general purpose mechanism for organizing elements into groups.
- A model element that can contain other model elements.
- A package can be used:
  - To organize the model under development
  - As a unit of configuration management



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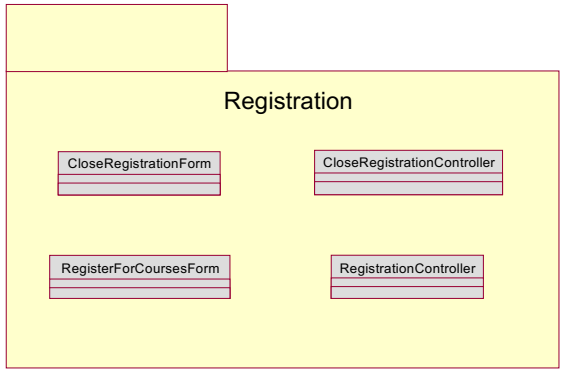
Example: Registration Package



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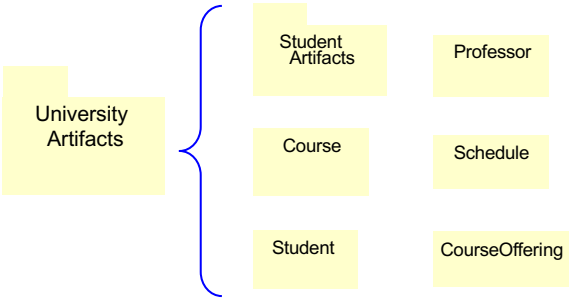
A Package Can Contain Classes

- The package, University Artifacts, contains one package and five classes.



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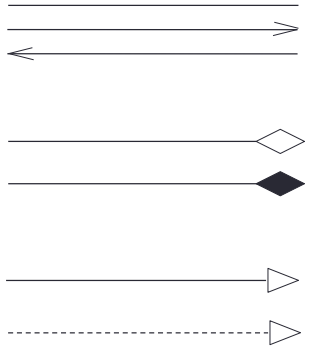
Class Relationships

- Association
- Aggregation
  - Composition
- Generalization
- Realization



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Content

1. Class diagrams
2. Association
3. Aggregation and Composition
4. Generalization

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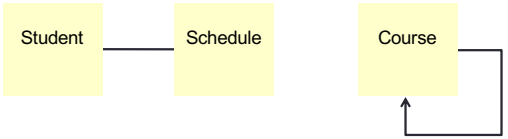
What Is an Association?

- The semantic relationship between two or more classifiers that specifies connections among their instances.
- A structural relationship specifying that objects of one thing are connected to objects of another thing.



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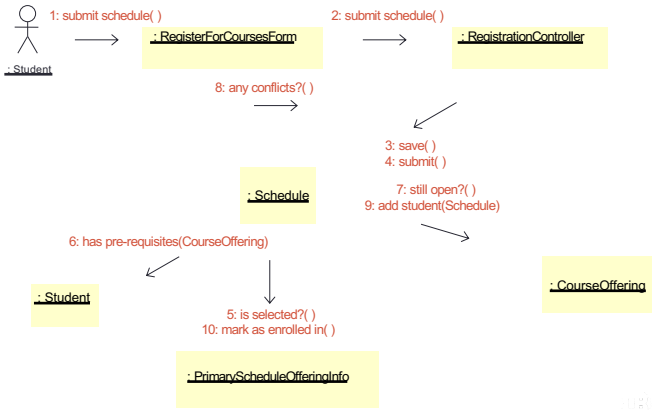
Example: What Associations?



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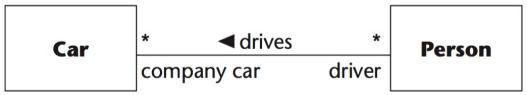
Role



- Role
  - Useful technique for specifying the context of a class and its objects
  - Optional
- Role name
  - String placed near the end of the association next to the class to which it applies
  - Indicates the role played by the class in terms of the association.
  - Part of the association and not part of the classes

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What Is Multiplicity?

- Multiplicity is the number of instances one class relates to ONE instance of another class.
- For each association, there are two multiplicity decisions to make, one for each end of the association.
  - For each instance of Professor, many Course Offerings may be taught.
  - For each instance of Course Offering, there may be either one or zero Professor as the instructor.

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Multiplicity Indicators

Unspecified	
Exactly One	1
Zero or More	0..*
Zero or More	*
One or More	1..*
Zero or One (optional value)	0..1
Specified Range	2..4
Multiple, Disjoint Ranges	2, 4..6

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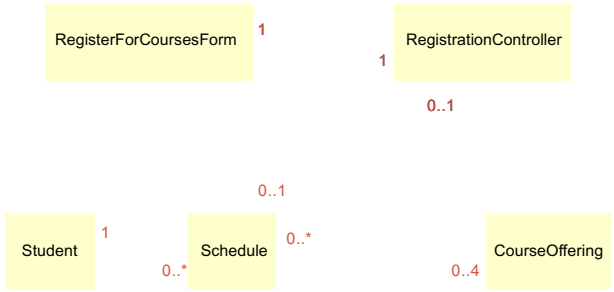
Example: Multiplicity



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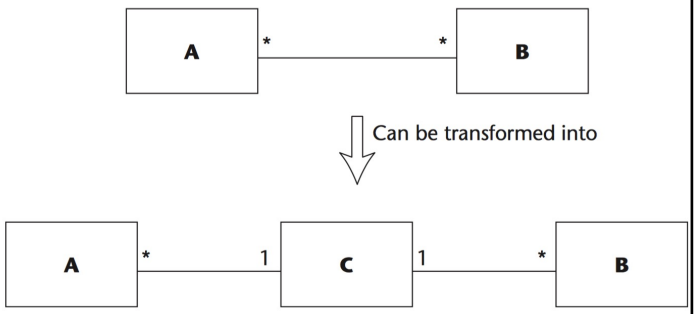
Many-to-many association



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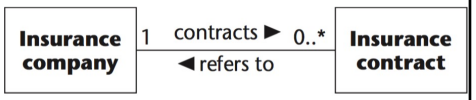
Java implementation




```java
//InsuranceCompany.java file
public class InsuranceCompany
{
   // Many multiplicity can be implemented using Collection
   private List<InsuranceContract> contracts;


   /* Methods */
}
// InsuranceContract.java file
public class InsuranceContract
{
   private InsuranceCompany refers_to;

   /* Methods */
}
```

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Content

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What Is an Aggregation?

- A special form of association that models a whole-part relationship between the aggregate (the whole) and its parts.
  - An aggregation is an "is a part-of" relationship.
- Multiplicity is represented like other associations.

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What is Composition?

- A special form of aggregation with strong ownership and coincident lifetimes of the part with the aggregate
  - Also called composition aggregate
- The whole "owns" the part and is responsible for the creation and destruction of the part.
  - The part is removed when the whole is removed.
  - The part may be removed (by the whole) before the whole is removed.

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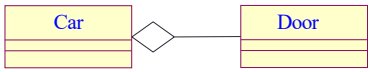
Examples: Association Types

- Association
  - use-a
  - Objects of one class are associated with objects of another class

- Aggregation
  - has-a/is-a-part
  - Strong association, an instance of one class is made up of instances of another class



- Composition
  - Strong aggregation, the composed object can't be shared by other objects and dies with its composer
  - Share life-time

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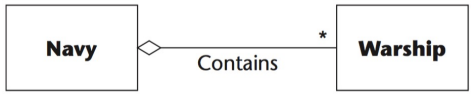
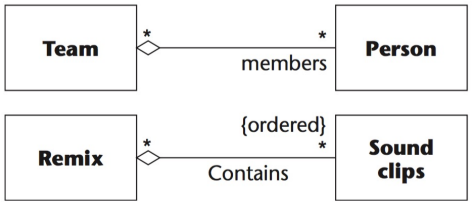
Aggregation Example



- A *shared aggregation* is one in which the parts may be parts in any wholes



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Aggregation – Java implementation

```
class Car {
    private List<Door> doors;
    Car(String name, List<Door> doors) {
        this.doors = doors;
    }

    public List<Door> getDoors() {
        return doors;
    }
}
```

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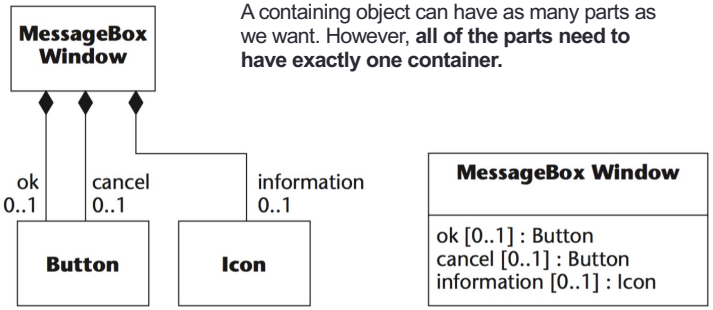
Composition Example

- A compound aggregate is shown as attributes in a class



A containing object can have as many parts as we want. However, **all of the parts need to have exactly one container.**

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Aggregation – Java implementation

```
final class Car {
    private Engine engine;

    void setEngine(Engine engine) {
        this.engine = engine;
    }

    void move() {
        if (engine != null)
            engine.work();
    }
}
```

```
class Engine {
    // starting an engine
    public void work() {
        System.out.println("Engine of car has been started ");
    }
}
```

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Composition – Java implementation

```
final class Car {
    private final Engine engine;

    Car(EngineSpecs specs) {
        engine = new Engine(specs);
    }

    void move() {
        engine.work();
    }
}
```

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Composition – Java implementation

```
class Person {
   private final Brain brain;

   Person(Brain humanBrain) {
      brain = humanBrain;
   }
}
```

```
Brain b = new Brain();
// or we have an instance of Brain in other scopes
// not exactly in this scope

Person p1 = new Person(b);
Person p2 = new Person(b);
```

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Composition – Java implementation

```
public class House {
   private final Room room;

   public House() {
      room = new Room();
   }
}
```

The child **cannot exist independent** of the parent

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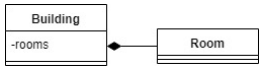
Composition – Java implementation




```
class Building {
   class Room {}
   private final List<Room> rooms;
   public Building() {
      rooms = new ArrayList<Room>();
      rooms.add(new Room());
      rooms.add(new Room());
   }
}
```

The objects' lifecycles are tied. If the whole is destroyed, the part will also be destroyed with it.

Note that doesn't mean that the whole can't exist without any of its parts. E.g., we can tear down all the walls inside a building, hence destroy the rooms. But the building will still exist

```
class Building {
   List<Room> rooms;

   interface Room {
      void doInRoom();
   }
   Room createAnonymousRoom() {
      return new Room() {
         @Override
         public void doInRoom() {}
      };
   }

   Room createInlineRoom() {
      class InlineRoom implements Room {
         @Override
         public void doInRoom() {}
      }
      return new InlineRoom();
   }

   Room createLambdaRoom() {
      return () -> {};
   }
   // …
}
```

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Content

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Review: What Is Generalization?

- A relationship among classes where one class shares the structure and/or behavior of one or more classes.
- Defines a hierarchy of abstractions where a subclass inherits from one or more superclasses.
  - Single inheritance
  - Multiple inheritance
- Is an "is a kind of" relationship.

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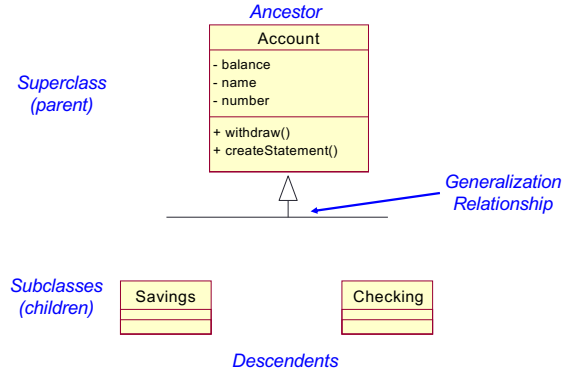
Example: Single Inheritance

- One class inherits from another.



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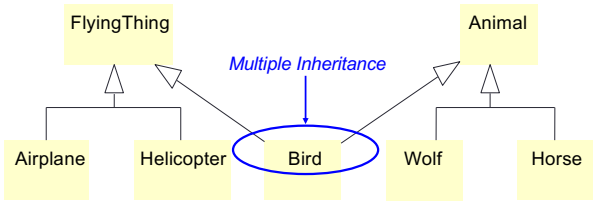
Example: Multiple Inheritance

- A class can inherit from several other classes.



Use multiple inheritance only when needed and always with caution!

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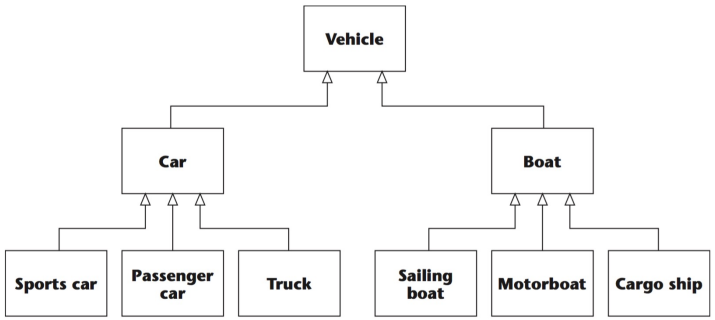
Inheritance Tree Example



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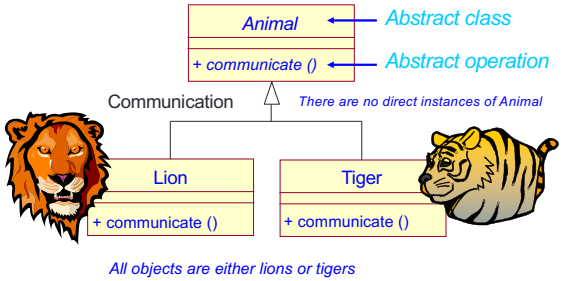
Abstract and Concrete Classes

- Abstract classes cannot have any objects
- Concrete classes can have objects



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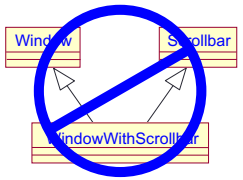
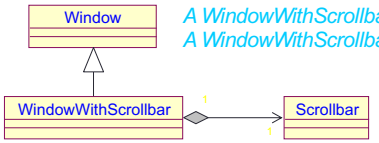
Generalization vs. Aggregation





A WindowWithScrollbar "is a" Window
A WindowWithScrollbar "contains a" Scrollbar

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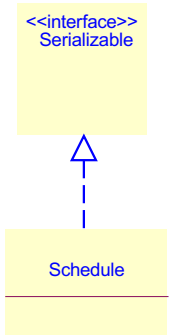
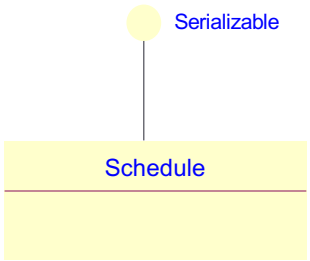
Interfaces and Realizes Relationships



Normal presentation



Icon presentation

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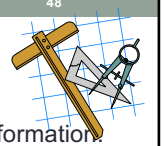
Exercise



Document a class diagram using the following information:

- A class diagram containing the following classes: Personal Planner Profile, Personal Planner Controller, Customer Profile, and Buyer Record.
- Associations drawn using the following information:
  - Each Personal Planner Profile object can be associated with up to one Personal Planner Controller object.
  - Each Personal Planner Controller object must be related to one Personal Planner Profile.
  - A Personal Planner Controller object can be associated with up to one Buyer Record and Customer Profile object.
  - An instance of the Buyer Record class can be related to zero or one Personal Planner Controller.
  - Zero or one Personal Planner Controller objects are associated with each Customer Profile instance.

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