

Elements of Unified Modeling Language

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Corso di Programmazione++

Roma, 22 June 2009

Today's Lecture

- Introduction to UML
 - object modeling language
- Class diagrams
- Relations between classes
- Suggestions for further reading

Object Oriented Analysis (OOA)

- Build a system composed of objects
- Behavior of system defined by collaboration between objects through sending messages to each other
- State of system defined by states of individual collaborating objects
- Does not take into account implementations constraints such as distribution and persistency
- Result of OOA is a conceptual model focused on ideas and concepts to be implemented

Object Oriented Design (OOD)

- Start from conceptual model provided by OOA and add implementation constraints, e.g. specific programming language
- Treat the objects as instances of collection of classes within a class hierarchy
- Typically four stages in Design:
 - Identify classes and objects
 - Identify their responsibilities
 - Identify their relationship
 - Provide class interface and implementation

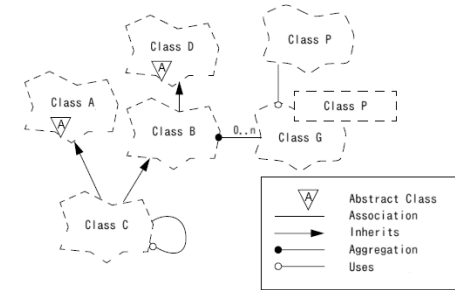
Object Modeling Language

- Standardized set of symbols and relations between them to model object oriented design
- Visual and graphical representation provides higher level of abstraction important in early analysis and design stage
 - Focus on interaction and relation between objects
 - Define interface rather than internal structure
- Software modeling tools can be used to implement code from visual modeling diagrams

Brief History of Object Modeling Language

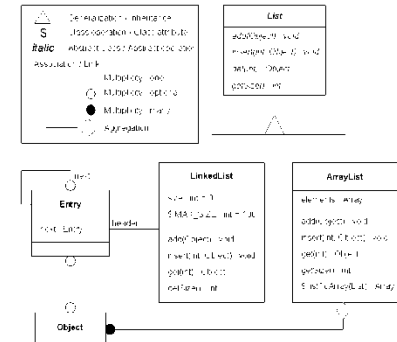
■ Booch Method

- Developed by Grady Booch
- Better for design



■ Object modeling technique (OMT)

- Developed by Jim Rumbaugh
- Better for analysis



■ Objectory

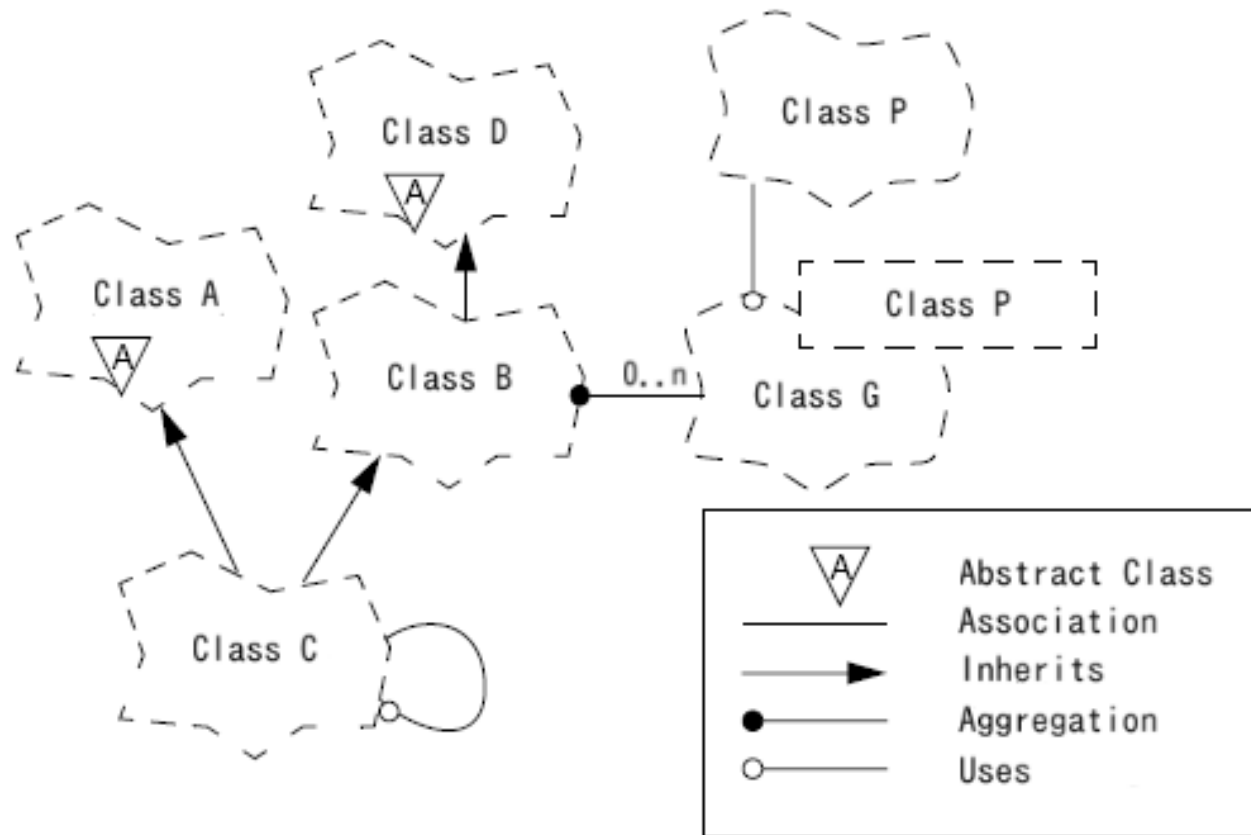
- Developed by Ivar Jacobsen
- Treat Use Cases
 - Use case: interaction between system and end user to achieve a specific goal



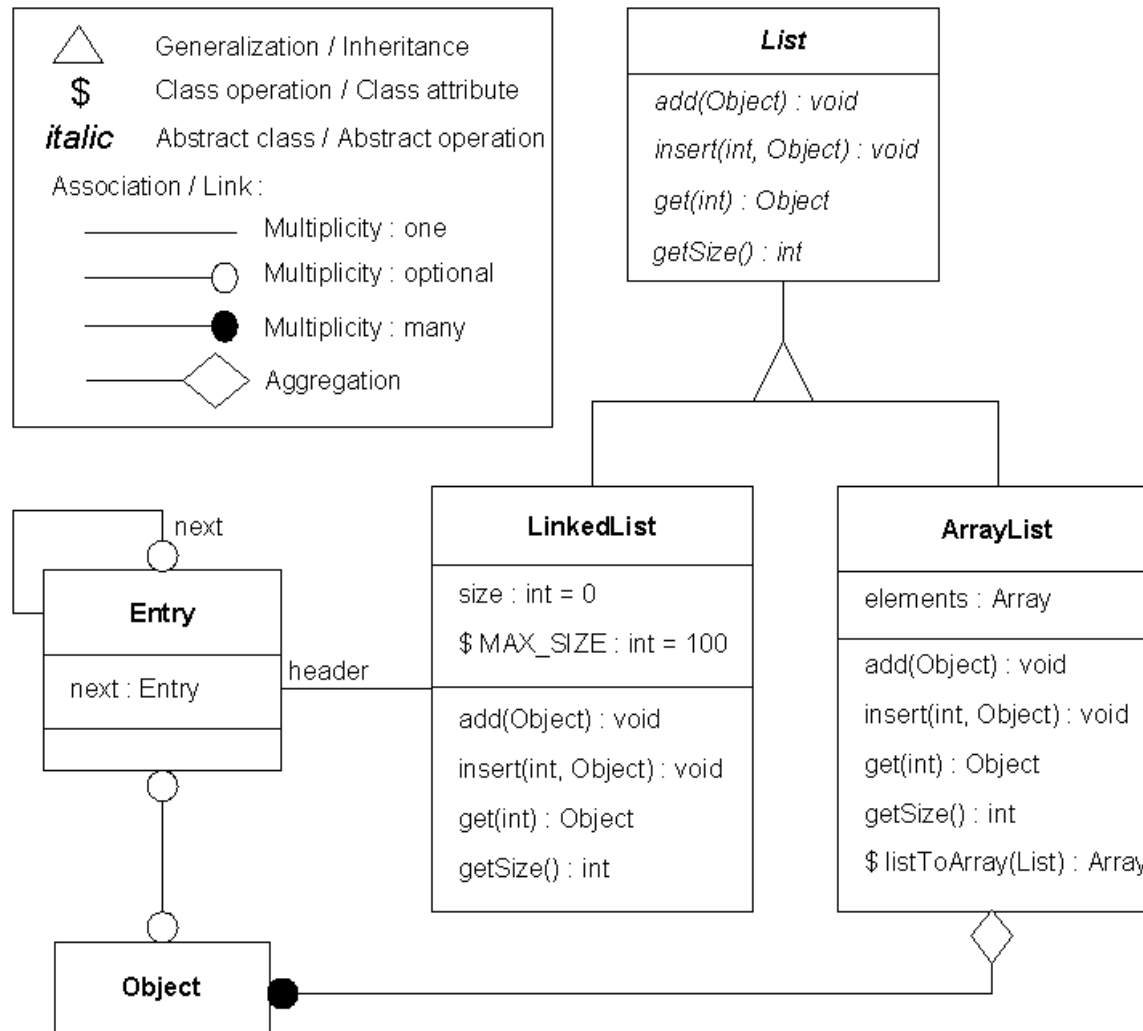
■ Class-Responsibility-Collaboration Cards

- Proposed by Ward Cunningham

Booch Method



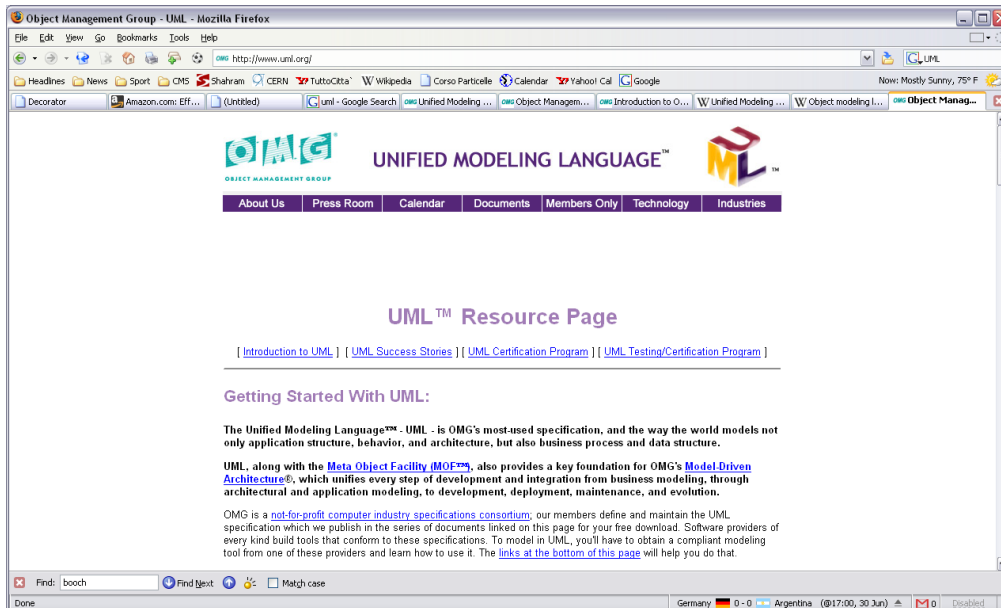
Object Modeling Technique



Unified Modeling Language (UML)



- Many approaches on the market by mid 1990s
- Object Management Group (OMG) called for development of a unified approach
- Consortium including Booch, Jacobsen, and Rumbaugh has developed what today is called Unified Modeling Language



<http://www.uml.org/>

Unified Modeling Language (UML)

Unified Modeling Language - Wikipedia, the free encyclopedia - Mozilla Firefox

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Unified Modeling Language

From Wikipedia, the free encyclopedia

The **Unified Modeling Language (UML)** is a non-proprietary, [object modeling](#) and [specification language](#) used in [software engineering](#). UML includes a standardized graphical notation that may be used to create an abstract model of a system: the *UML model*. UML is an extensible modeling language. If a concept you need is not present in the base language, you may introduce it by defining a [stereotype](#).

UML is officially defined at the [Object Management Group](#) (OMG) by the UML metamodel – a [Meta-Object Facility](#) metamodel (MOF). Like other MOF-based specifications, the UML meta-model and UML models may be serialized in [XMI](#). UML is a General Purpose [Modeling language](#). While UML was designed to specify, visualize, construct, and document [software-intensive](#) systems, UML is not restricted to modeling software. UML has its strengths at higher, more [architectural](#) levels and has been used for modeling hardware (engineering systems) and is commonly used for [business process modeling](#), [systems engineering](#) modeling, and representing [organizational structure](#) among many other domains.

UML has been important in the early ages of [Model Driven Engineering](#) or [model-driven architecture](#). By establishing a consensual agreement on the various graphical shapes commonly used to represent common concepts like classes, inheritance, aggregation, states, transitions, etc. UML has allowed software designers to concentrate on more fundamental issues.

In the initial [MDA](#) view, [PIMs](#) and [PSMs](#) may be expressed in the UML language. It is also possible to transform a UML model serialized in [XMI](#) into a [Java](#) or [EJB](#) implementation by using a [Model Transformation Language](#) or [MTL](#). The standard way recommended by [OMG](#) for achieving this is to use the newly defined [QVT](#) standard. UML has also an optional graph navigation and constraint language called [OCL](#); in its navigational aspect this has a similar relationship to UML as [XPath](#) has to [XML](#).

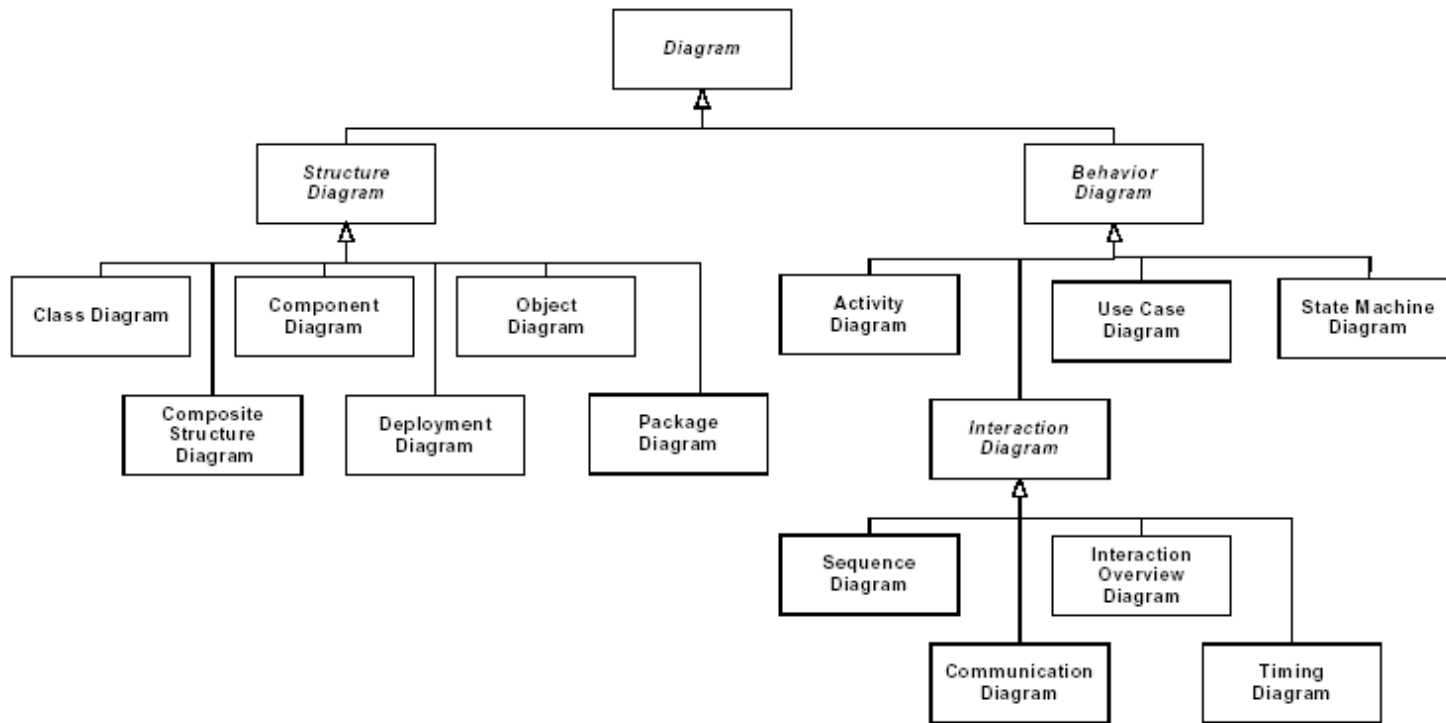
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- 1 History
- 2 Methods
- 3 Modeling
- 4 Diagrams

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UML Diagrams

- Thirteen diagrams in UML 2.0 organized



Categories of Diagrams

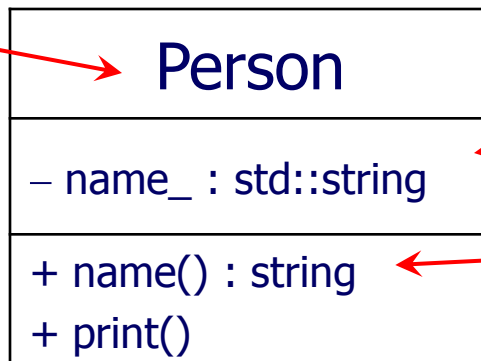
- **Structure diagrams:** emphasize what things must be in the system
 - Class diagram
 - Component diagram
 - Object diagram
 - Composite structure diagram
 - Deployment diagram
 - Package diagram
- **Behavior diagrams:** emphasize what must happen in the system
 - Activity diagram
 - Use case diagram
 - State Machine diagram
- **Interaction Diagrams:** subset of behavior diagrams, emphasize flow of control and data among the things in the system
 - Sequence diagram
 - Collaboration (UML 1.x)/Communication diagram (UML 2.0)
 - Interaction overview diagram (UML 2.0)
 - Timing diagram (UML 2.0)

Class Diagram

- Type of static structure diagram describing structure of a system by showing
 - system's classes
 - relationships between classes
- Graphical representation: box with 3 compartments for
 - Name of class
 - attributes or data members
 - operations or methods

```
class Person {  
    public:  
        Person(const std::string& name);  
        ~Person();  
        std::string name() const { return name_; }  
        void print() const;  
  
    private:  
        std::string name_;  
};
```

Name
of class



Attributes

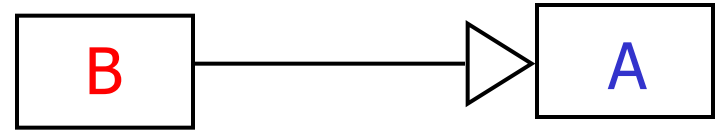
Operations

+ public
- private
protected

Relations between Classes

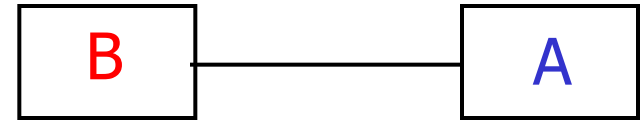
- Generalization or Inheritance

- an is-a relationship



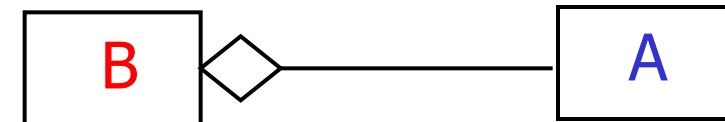
- Association

- can be mutual or uni-directional



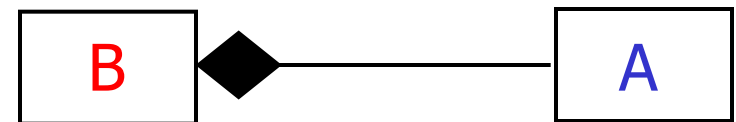
- Aggregation

- Whole/part relationship. no lifetime control



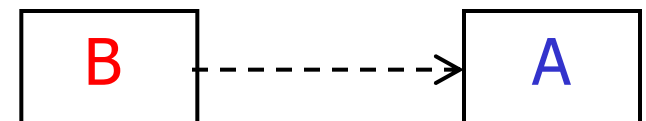
- Composition

- Aggregation with lifetime control



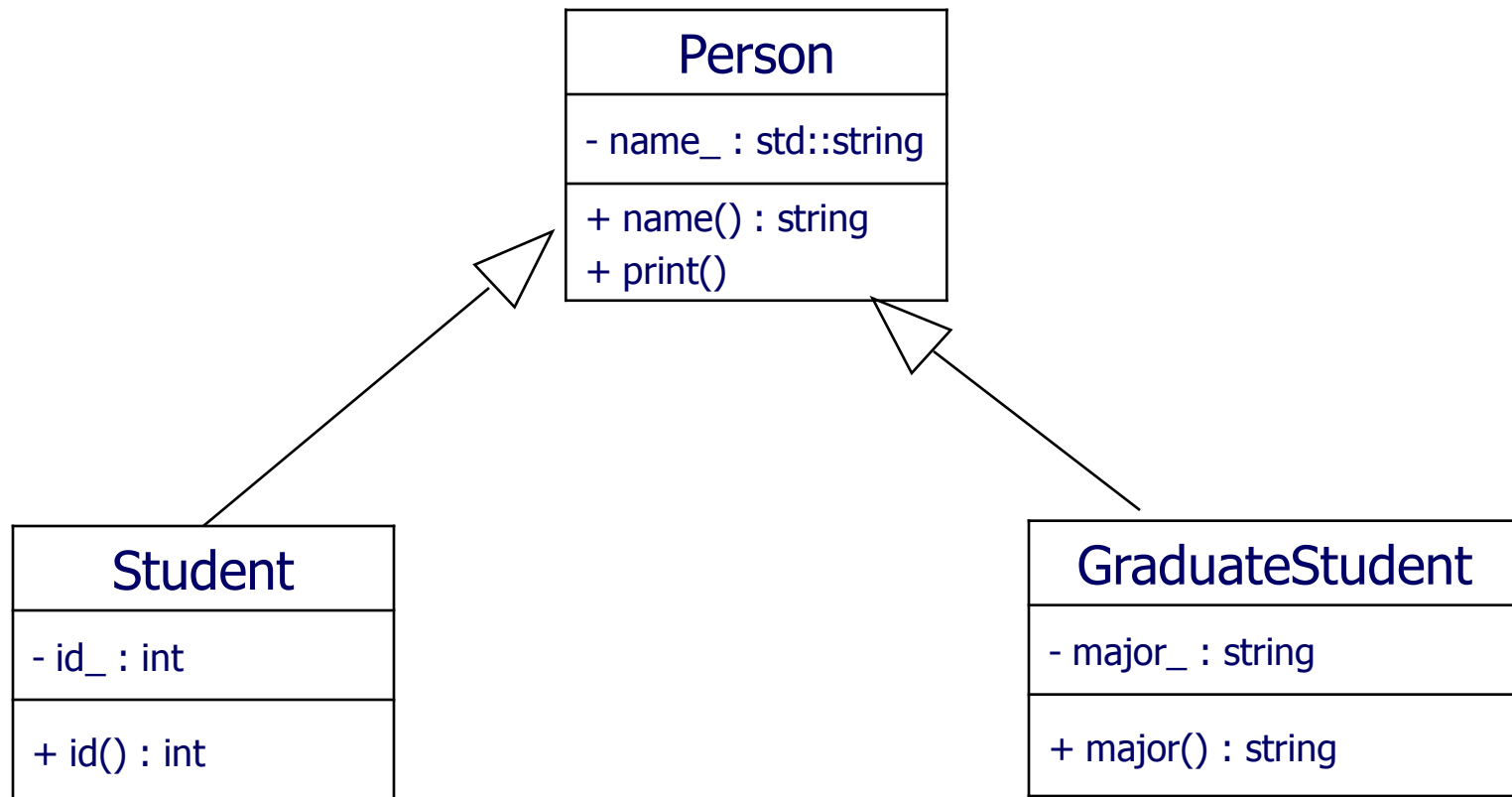
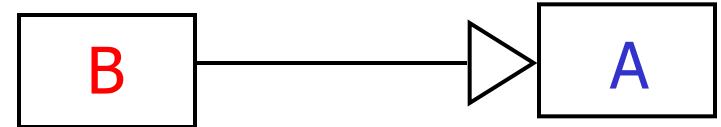
- Dependence

- uni-directional association
- only B knows about A



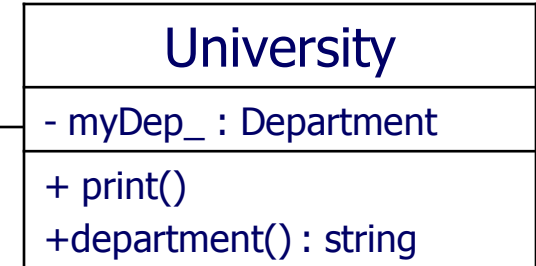
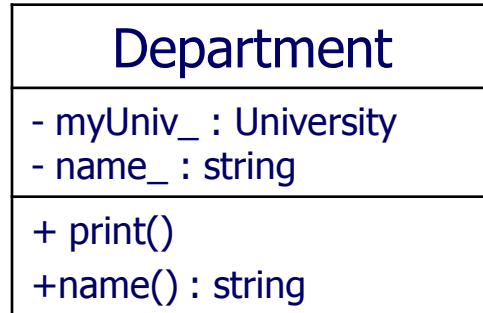
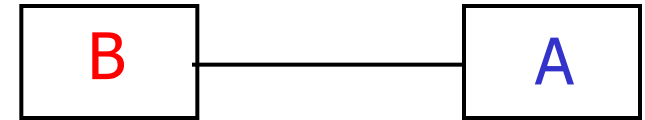
Generalization or Inheritance

- Is-A relationship between A and B: B is also an A
 - relationship between a base class (super-type, parent) and a derived class (sub-type, child)



Association

- A and B exchange messages
 - Call methods of each other

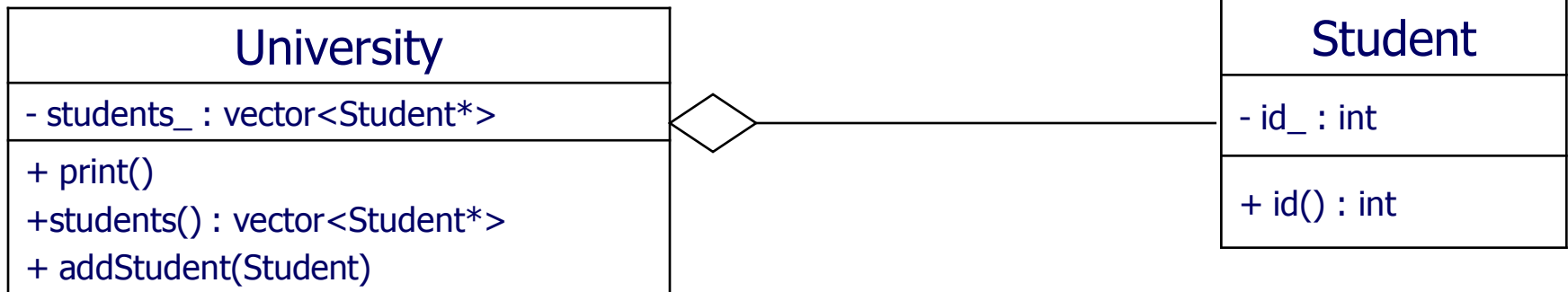
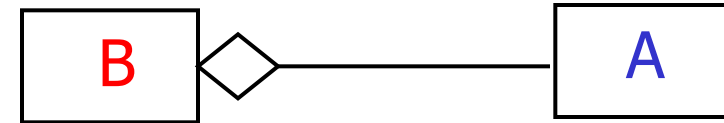


```
class Department {  
  
    private:  
        University* myUniversity_;  
  
    public:  
        void print() {  
            cout << "My University is: : <<  
                << myUniv_->name ()  
                << endl;  
        }  
  
}
```

```
class University {  
  
    private:  
        Department* myDep_;  
  
    public:  
        string department() {  
            return myDep_->name ();  
        }  
  
}
```


Aggregation

- Whole/part association with no lifetime control
 - B contains a pointer to A
 - B does not control lifetime of A
 - A exists regardless of B



```
class University {
private:
    vector<Student*> students_;

public:
    vector<Student*> students() {
        return students_;
    }
    void addStudent(Student* s) {
        students_>push_back(s);
    }
}
```

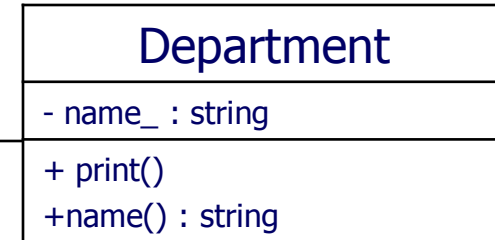
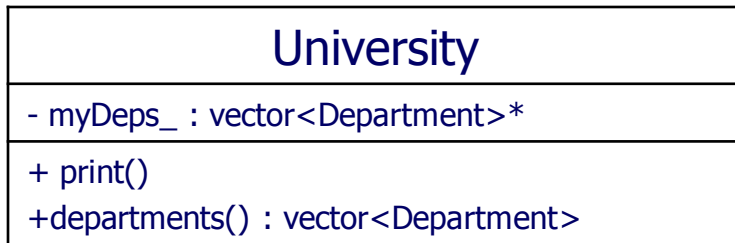
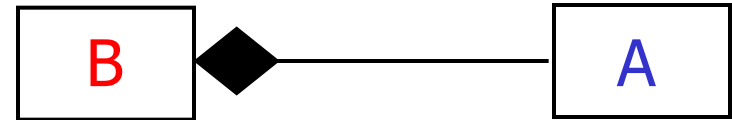
All instances of Student exist regardless of the instance of University

Only keeps pointers but does not control lifetime of objects pointed to

Composition

- Whole/part association with lifetime control

- B contains instance of A
- B is responsible for creation of its copies of A and their destruction
- B can transfer ownership of it's a to others

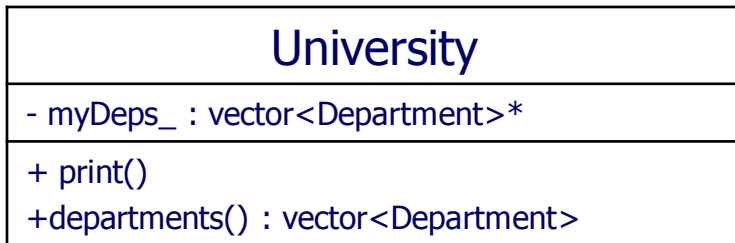
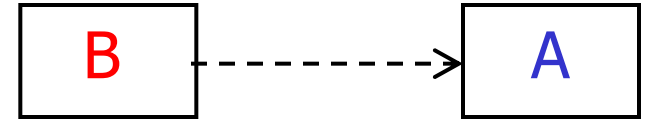


```
class University {  
    private:  
        vector<Department>* deps_;  
  
    public:  
        University() {  
            deps_ = new vector<Department>;  
            deps_>push_back("physics");  
        }  
        ~University() { delete deps_; }  
  
        vector<Departments> departments() {  
            return *deps_;  
        }  
}
```

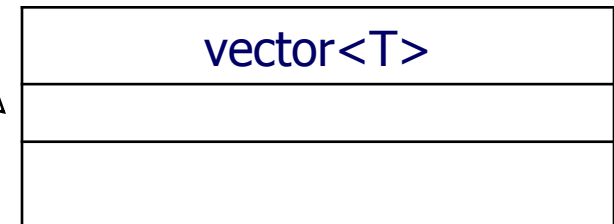
```
class Department {  
    private:  
        string name_;  
  
    public:  
        string name() { return name_; }  
}
```

Dependence

- B knows about A but A has no knowledge of B
 - Mostly when A is used in definition of A

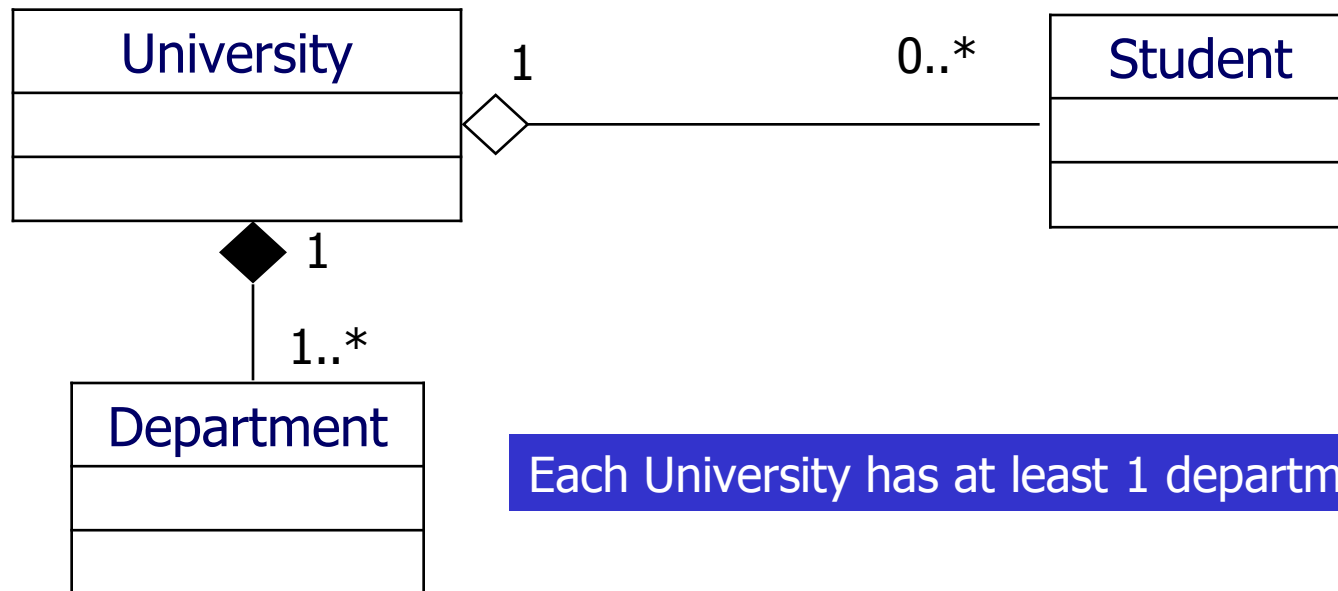


```
class University {  
    private:  
        vector<Department>* deps_;  
    public:  
        University() {  
            deps_ = new vector<Department>;  
            deps_>push_back("physics");  
        }  
        ~University() { delete deps_; }  
        vector<Departments>* departments() {  
            return *deps_;  
        }  
}
```



Multiplicity (a.k.a Cardinality)

- Multiplicity of a role describes number of instances participating in the association
 - * or 0..* : zero to many
 - 1..* : one to many
 - 0..1 : zero or one
 - 1 : one and only one
 - n..m : n or m



University might have no student

Each University has at least 1 department

Additional Readings

- Few very good books to improve your skills and learn more about object oriented programming techniques
- [Effective C++](#) : 55 Specific Ways to Improve Your Programs and Designs, Scott Meyers
- [More Effective C++](#): 35 New Ways to Improve Your Programs and Designs, Scott Meyers
- [Design Patterns](#): Elements of Reusable Object-Oriented Software, E. Gamma et al.
- [Learning UML 2.0](#), K. Hamilton, R. Miles

