COMP2012H

Inheritance: Introduction
Example: University Admin Info

- Let's implement a system for maintaining university administration information.

  - Teacher and Student are two completely separate classes. Their implementation uses separate code.

  - However, they share many methods and members that are implemented in the same way: handling name, address, and department.

  - Why do we implement the same function twice?

  - This is not good software reuse!
Example: U. Admin Info – Student.hpp

```cpp
#define accounting 0
#define business 1
#define engineering 2
#define mathematics 3
#define unknown 4

typedef int Department;

class Student
{
    private:
        string name;
        string address;
        Department dept;
        Course* enrolled;
        int num_courses;
    public:
        Student(string n, string a, Department d) :
            name(n), address(a), dept(d), enrolled(NULL), num_courses(0) { }
        void set_name(const char* name);
        void set_address(const char* adr);
        void set_department(Department dept);
        string get_name() const;
        string get_address() const;
        Department get_department() const;
        bool enroll_course(const string&);
        bool drop_course(const Course&);
};
```
enum Department { accounting, business, engineering, mathematics, unknown };  
class Student  
{
    private:
        string name;
        string address;
        Department dept;
        Course* enrolled;
        int num_courses;
    public:
        Student(string n, string a, Department d) :
            name(n), address(a), dept(d), enrolled(NULL), num_courses(0) { };
        void set_name(const char* name);
        void set_address(const char* adr);
        void set_department(Department dept);
        string get_name() const;
        string get_address() const;
        Department get_department() const;
        bool enroll_course(const string&);  
        bool drop_course(const Course&);
};
enum Rank { instructor, assistant_prof, associate_prof, professor, dean };
class Teacher
{
  private:
    string name;
    string address;
    Department dept;
    Rank rank;
  public:
    Teacher(string n, string a, Department d, Rank r) :
      name(n), address(a), dept(d), rank(r) { }
    void set_name(const char* name);
    void set_address(const char* adr);
    void set_department(Department dept);
    void set_rank(Rank rank);
    string get_name() const;
    string get_address() const;
    Department get_department() const;
    Rank get_rank() const;
};
Things to Consider

• We want a way to say that Student and Teacher both have the same members: name, address, dept, but yet require them to keep a separate copy of these members.

• We want to share the code for set_name, etc., between Student and Teacher as well.

• We want this code to act like member functions (to permit consistency of state of the objects), so they cannot be written as global functions.
Solution 1: Re-use by Copying

• Copy the code from one class to the other class, and change the class names.
  – This is very error prone.
  – It is also a maintenance nightmare.
  – What if we find a bug in the code in one class?
  – What if we want to improve the code? Perhaps by introducing a new class `Address`.

• “REUSE by COPYING” is a bad idea!
Inheritance

- Inheritance enables code reuse.
- Inheritance is the ability to define a new class based on an existing class with a hierarchy.
- The derived class *inherits* the data members and member methods) of the base class.
- New members and methods can be added to the derived class.
- Since the new class only has to implement the behavior that is different from the base class, we can reuse the code for the base class.
- “Inheritance” is the traditional term, but C++ calls it “derivation”.

Inheritance
class Person
{
    private:
        string name;
        string address;
        Department dept;

    public:
        Person(string n, string a, Department d) :
            name(n), address(a), dept(d) { }
        void set_name(const char* name);
        void set_address(const char* adr);
        void set_department(Department dept);
        string get_name() const;
        string get_address() const;
        Department get_department() const;
};
```cpp
Solution 2: By Inheritance – Student.hpp

class Student : public Person
{
    private:
        Course* enrolled;
        int num_courses;

    public:
        Student(string n, string a, Department d) :
            Person(n, a, d), enrolled(NULL), num_courses(0) { }

        bool enroll_course(const string&);
        bool drop_course(const Course&);
};
```
Solution 2: By Inheritance – Teacher.hpp

class Teacher : public Person
{

private:
    Rank rank;

public:
    Teacher(string n, string a, Department d, Rank r) :
        Person(n, a, d), rank(r) { }

    void set_rank(Rank rank);
    Rank get_rank() const;

};
Inheritance

- Person is the base class of Student.

- Student is a derived class of Person.

- The effect is that Student inherits all data members and methods from Person.

- The data members of Student are the data members of Person (name, address, dept), plus the extra data members declared in the definition of Student (enrolled, num_courses).
Example: Inherited Members

```cpp
void some_func(Person& person, Student& student)
{
    cout << person.get_name() << endl;
    cout << student.get_name() << endl;

    student.set_department(engineering);
    Department dept = person.get_department();
    student.enroll_course("COMP151");
    person.enroll_course("COMP001"); // Error!
}
```
“Is-a” Relationship

• Inheritance implements the is-a relationship.
  – Recall: membership (composition) implements the has-a relationship.

• Since Student inherits from Person,
  – every object of type Student can be used like an object of type Person
  – all methods of Person can be called on a Student object

• In other words, a Student object definitely is a Person object under all circumstances.

• In general: a derived class object can be treated like a base class object under all circumstances.
Example: Derived Objects as Base Class Object

```cpp
bool print_mailing_label(const Person& person)
{
    string name = person.get_name();
    string adr = person.get_address();

    // code to print the label
}
```

- Since a **Student is a Person**, we can print a mailing label for a student like this:

```cpp
Student student("Tom", "Sai Kung", mathematics);
print_mailing_label(student);
```
Direct and Indirect Inheritance

- Let's add a new class `PG_Student`:

```cpp
class PG_Student : public Student
{
  private:
    Topic research_topic;
  public:
    PG_Student(string n, string a, Department d) :
      Student(n, a, d), research_topic(NONE) {} 
    void set_topic(const Topic& x) { research_topic = x; }
};
```

- `PG_Student` is directly derived from `Student`.
- It is **indirectly derived** from `Person`.
- So a `PG_Student` object is a `Person` object.
- `Person` is called an **indirect base class** for `PG_Student`. 