Programming Language Concepts

Object Oriented Prog: Relations

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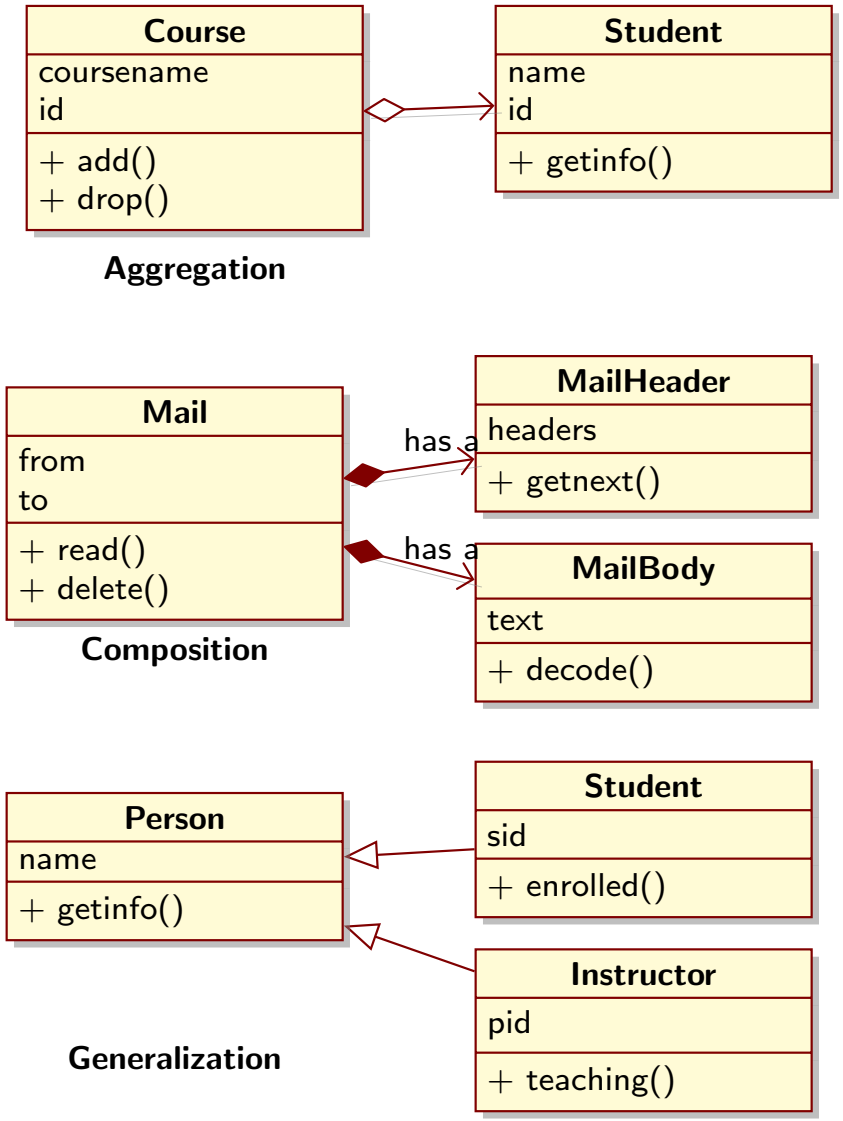
Bilgisayar Mühendisliği

Outline

Class Relations

- In Object Oriented paradigm objects interact in order to solve a problem.
- Basic class relations:
  - Aggragate ("has a")
  - Composition ("has a")
  - Generalization (inheritance, "is a")
- Other associations/relations exist.
- When two classes have such a relation, one depends on the other.



Aggragate

- Class A can have 0 or more instance of class B
- Lifetime of class B objects are independent of class A
- Catalog relationship. In terms of references.
- Members of class B are regular objects in scope of A they are not in scope of A. So private members ... ?

```
class Course {
 char name[40];
 int no;
 List students;
public:
 void register(Student &a) {
   student.insert(&a);
 };
} ceng242 ;
```

```
void Student {
 char name[30];
 int no;
public:
 void add(Course &c) {
   c.register(*this);
 }
};
```

Composition

- Class A can have 0 or more instance of class B
- Lifetimes of class B objects depend on the class A object
- Class B objects are destroyed when A is destroyed.
- Members of class B are regular objects in scope of A
  they are not in scope of A as in aggragate.

```
class FrameBox {
 Shape frame;
 String text;
 double coordx,coordy;
public:
 Framebox(Frame &f,
          String &t) {
  ...}
  void draw() {
    frame.draw(); text.draw();
} ceng242 ;
```

```
class Shape {
 enum Type {Circle,Rect} type;
 double sizex, sizey;
public:
 void draw();
};

class String {
...
};
```

Framebox

Shape `frame`		
	`Type type`	sizeof(int)
	`double coordx`	sizeof(double)
	`double coordy`	sizeof(double)
String `text`		
	`...`	...
`double coordx`	sizeof(double)	
`double coordy`	sizeof(double)	

- Container class vs. contained classes
- Composition nests storage of contained classes into container class.
- `frame` and `text` are regular object variables in member functions of `Framebox`
- Integrity of contained objects?

```
class Student {
 char name[40];
 int id;
public:
 Student() { name[0]=0; id=0;}
 void setnameid(const char *s,int i);
 ...
};

class StudentArr {
  Student *content;
public:
  StudentArr(int size) {
      content=new Student[size];
  }
  ~StudentArr() { delete [] content;}
  Student &operator[](int i) {
      return content[i];
  }
}
...
StudentArr a(10);
a[5].setnameid("onur",55717);
```

Integrity of Contained Objects

```
class A {
  int x;
public:
  A(int a) { x=a;}
};
class B {
  int y;
public:
  B(int a) { y=a;}
};
```

```
class C {
  int c;
  A a;
  B b;
public:
  C(int x,y,z):a(x),b(y) {
       c=z; /*can refer a,b */
  }
  ~C() { /*can refer a,b */}
};
```

- When constructors called? Tip: Container class constructor may refer to the contained objects.
- When destructors called? Tip: Container class destructor may refer to the contained objects.

- Constructors of contained objects called just before the body of container constructor executed.
- Destructors of contained objects called just after the container destructor called.
- Container constructor can pass arguments to member object constructors.

```
ACons(int x):c(x),b(x+2),a(x+1) {...}
```

- The list of comma separated initializers between the column and opening brace is called member initializer list. It defines how members are initialized in constructor syntax.
- The order of member initializer list is irrelevant. Member object constructors are called in declaration order. For definition:

```
class ACons { int a, b, c; ...}
```

call order will be `a(x+1); b(x+2); c(x)`, then body of the constructor is executed.

- `friend` declaration can be used if the objects need to access others private member.

Generalization/Inheritance

- Class Circle is a Shape but has extra features.
- It has all members of Shape plus specific ones.
- Circle extends Shape
- Shape is super class of Circle
- Shape is more general, Circle has more information

```
class Shape {
 double x,y;
public:
 Shape(double a, double b);
 void draw();
};

class Circle: public Shape {
 double radius;
public:
 void draw();
};

class Square: public Shape {
 double width;
public:
 void draw();
};
```

Circle

Shape `double x`	sizeof(double)
`double y`	sizeof(double)
`double radius`	sizeof(double)

- There is an inherent Shape object in each Circle object.
- Env(Circle) = Env(Shape) ∪ Members specific to Circle
- All members are inherited. They are in the scope of the subclass.
- How about their accessibility, protection?
- Two new thing: protected label, derivation label
- A subclass can access protected members of the upper classes.
- derivation label is a filter defining how members of superclass interpreted when used through subclass (object of subclass or further derivations from subclass)

```
class A {
private:   int a;
protected: int b;
public:    int c;
   void Amember() { ① }
} Aobj ;
class B: DLABEL A { // DLABEL=public|protected|private
   void Bmember() { ② };
} Bobj;
... Aobj.③ ;
... Bobj.④ ;
class C: public B {
    void Cmember() { ⑤ } };
```

	①	②	③
a			
b			
c			

	④			⑤		
DLABEL	a	b	c	a	b	c
private						
protected						
public						

- DLABEL is only significant outside of the derived class
- protection is minimum of original label and DLABEL

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```

	①	②	③
a	√	×	×
b	√	√	×
c	√	√	√

	④			⑤		
DLABEL	a	b	c	a	b	c
private	×	×	×	×	×	×
protected	×	×	×	×	√	√
public	×	×	√	×	√	√

- DLABEL is only significant outside of the derived class
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- The inherent superclass object should have a valid value.
- Constructors/Destructors should be called

```
class A {
  int x;
public:
  A(int a) { x=a;}
  ~A() { ... }
};
class B : public A {
  int y;
public:
  B(int a):A(a) { y=a;}
  ~B() { ... }
};
```

- Base class constructors are called just before the class constructor
  Base class destructor is called just after the class destructor
- Similar to contained objects, member initializer list can contain base class initializers as well. The order of execution will be:
  1. base classes in order of appearance in declaration
  2. member objects in order of appearance.

Member Hiding

- members of the subclass hides member of the superclass with same name
- but superclass member still exists
- Scope operator can be used to access the member

```
class A {
protected:
  int x;
public:
  int get() {return x};
} Aobj;
class B : public A {
  int x;
public:
  int get() {return x+A::x}
} Bobj;
...
cout << Bobj.get() << Bobj.A::get() ;
```

Multiple Inheritance

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  A boat with diesel engine, a car with electrical engine or hybrid engine

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- Land vehicle+Water vehicle $\rightarrow$ Hoovercraft
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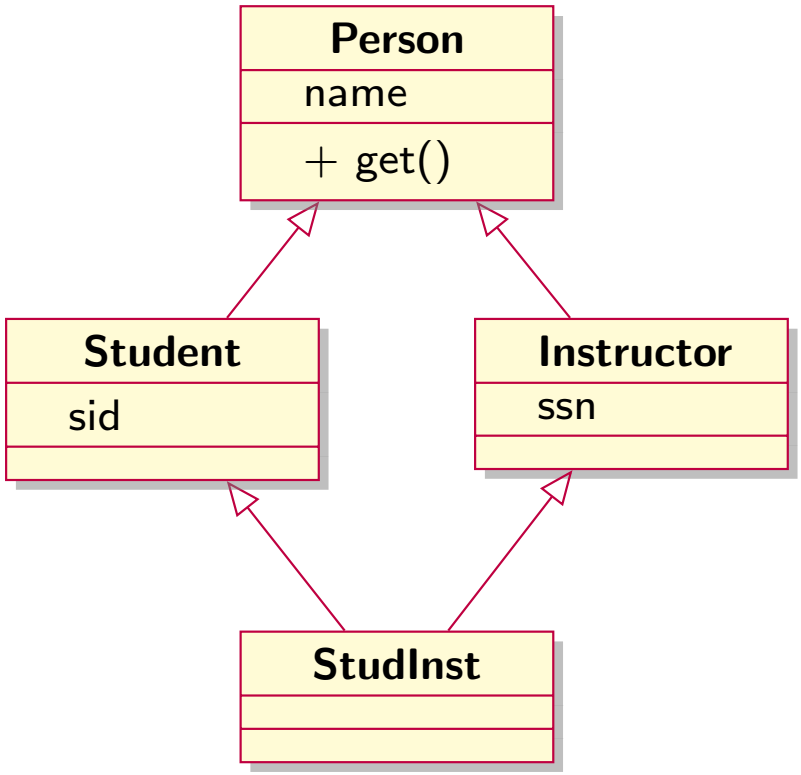
- A class hierarchy for vehicle types, a class hierarchy for engines:
  A boat with diesel engine, a car with electrical engine or hybrid engine
- Multiple inheritance is necessary in some rare cases. C++ provides it, Java avoids it and uses Interfaces for essential functionality similar to multiple inheritance.

```
class Shape {
  int x,y;
public:
  Shape(int a, int b) { x=a; y=b;}
  ~Shape() { ... }
};
enum LineStyle {None, Solid, Dashed, Dotted, Double}
enum FillStyle {None, Full, Half, Pattern}
class ShapeAttr {
  LineStyle ls; double lw; FillStyle fill;
public:
  ShapeAttr(LineStyle a, double b, FillStyle c) {
        ls=a;lw=b;fill=c;}
  ~ShapeAttr() { ... }
};

class Circle: public Shape, public ShapeAttr {
  int radius;
public:
  Circle(int a, int b, int c, LineStyle d,
     double e, FillStyle f):Shape(a,b),ShapeAttr(d,e,f) {
         radius=c;
  }
}
```

Diamond Problem

- Multiple inheritance may cause same super class duplicated in the resulting class



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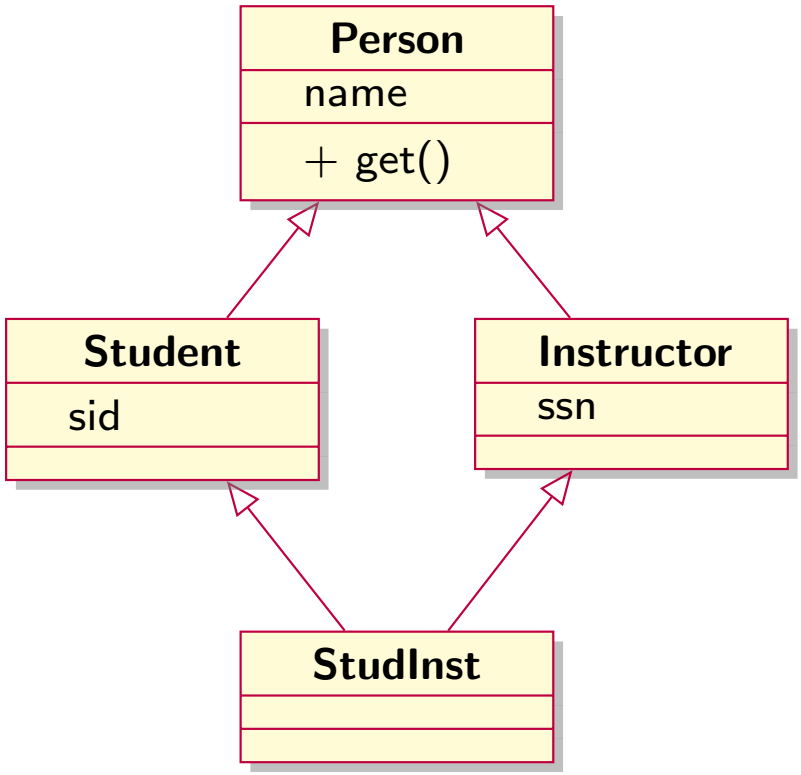
  StudInst contains two Person's get() call refers to which one? What's the name ?



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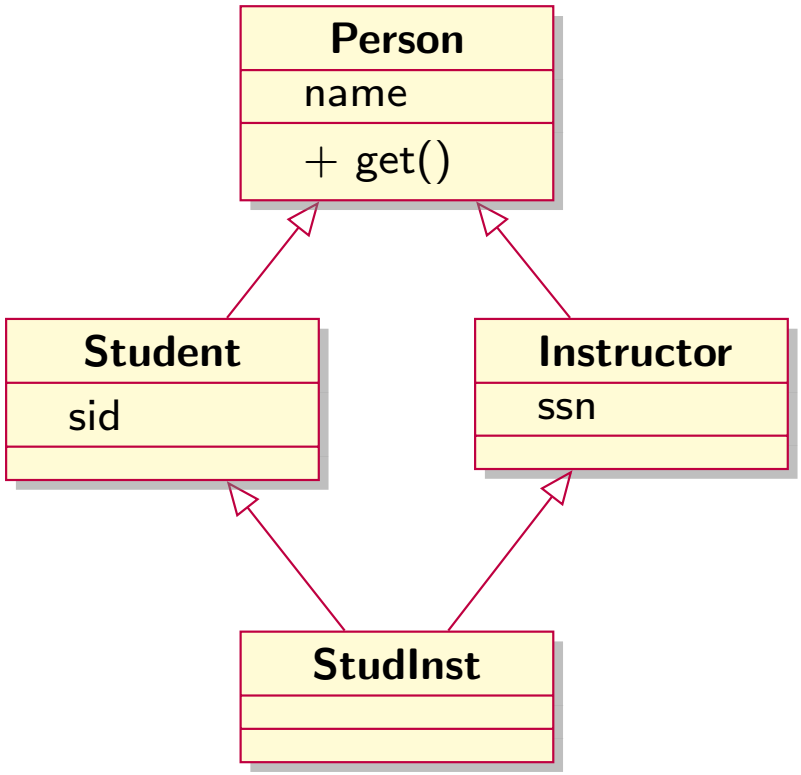

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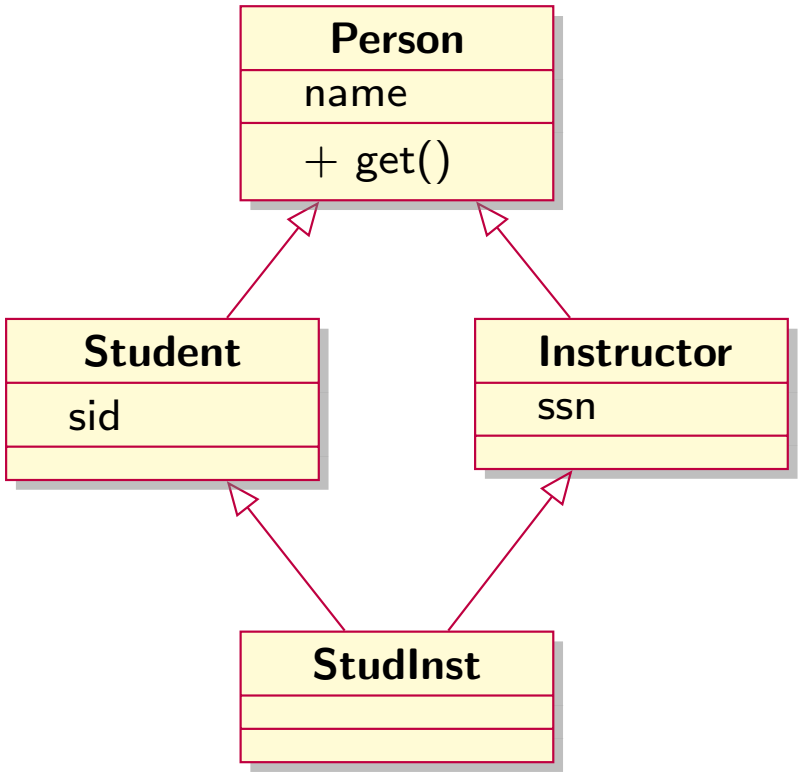
  StudInst contains two Person's get() call refers to which one? What's the name ?
- Ambiguity can be solved by scope operator:
  Student::name vs Instructor::name
- But a person with two names? Do we need that redundancy?
  NO!



Virtual base class

- virtual keyword used
  in inheritance gets only a single copy of base class in subclasses.

```
class Person {
        char name[40];
public: Person(char *s) {...}
};
class Student: virtual Person {
        int id;
public: Student(char *s, int i):Person(s) {...}
};
class Instructor: virtual Person {
        int ssn;
public: Instructor(char *s, int i):Person(s) {...}
};
class StudInst:public Student, public Instructor {
public: StudInst(char *s, int a, int b)
         :Person(s),Student(s,a),Instructor(s,b) {...}
};
```

- virtual keyword is for subclasses
- It is an overloaded keyword. We also have virtual member functions which is completely different.
- Multiple inheritence is not essential feature in OOP.
- There are ways to live without it. Assume two hierarchies with M and N classes. First is under Vehicle, second is Engine
- Bridge pattern Put a Engine* member in Vehicle
- Nested classes Create all M×N possibilities derived from Vehicle
- Such cases are rare and primary advantage of inheritance is Polymorphism