Konzepte objektorientierter Programmierung

Prof. Dr. Peter Müller

Werner Dietl

Software Component Technology

Exercises 4: Components

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Swiss Federal Institute of Technology Zurich

Core Concepts: Summary

- Core concepts of the OO-paradigm
  - Object model
  - Interfaces and encapsulation
  - Classification and polymorphism
- Core concepts are **abstract concepts** to meet the new requirements
- To apply the core concepts we need ways to **express them in programs**
- **Language concepts** enable and facilitate the application of the core concepts

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Subtyping

- **Substitution principle**
  Objects of subtypes can be used wherever objects of supertypes are expected

- **Subtype polymorphism**
  Program parts working with supertype objects work as well with subtype objects

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Inheritance versus Subtyping

- **Subtyping** expresses **classification**
- **Inheritance** is a means of **code reuse**
- Inheritance is **usually coupled** with subtyping
  - Terminology: **Subclassing** = Subtyping + Inheritance

- Issues
  - Subtyping without inheritance
  - Inheritance without subtyping

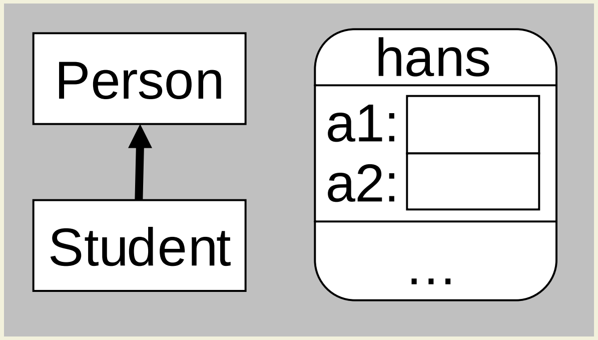
Rules for Subtyping: Summary

- Subtype objects must **fulfill contracts** of supertypes, but
  - Subtypes can have **stronger invariants**
  - Overriding methods of subtypes can have
    weaker preconditions
    stronger postconditions
    than corresponding supertype methods

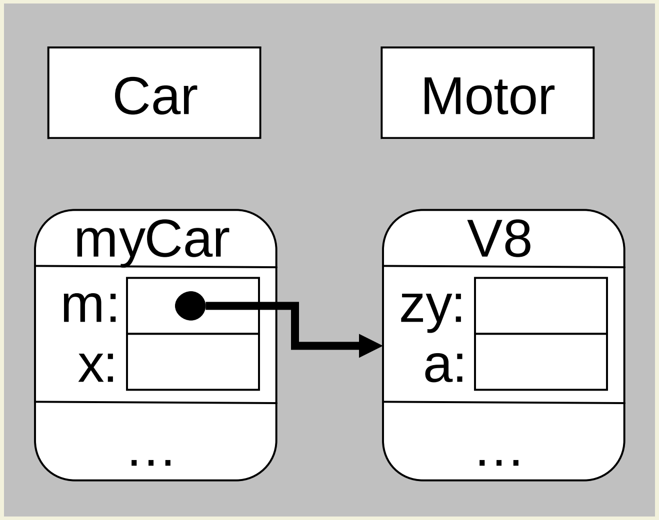
- Concept is called **Behavioral Subtyping**
- Consequence of substitution principle

Main Forms of Reuse "in the Small"

- Inheritance
  - Subclassing establishes **"is-a" relation**
  - Enables subtype **polymorphism**
  - Only **one object** at runtime



- Aggregation
  - Establishes **"has-a" relation**
  - **No subtyping** in general
  - **Two objects** at runtime



Homework – Exercise 6 – Set

```
public void add( Object o ) {
  assert true : "Any state allowed."; // pre
  …
  assert isElem( o ) : "Element not
   successfully inserted!"; // post
}

public void remove( Object o ) {
  assert isElem( o ) : "Element must be
   contained in the set!"; // pre
  …
  assert !isElem( o ) : "Element was not
   removed successfully!"; // post
}
```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Homework – Exercise 6 – Set

```
public boolean isElem( Object o ) {
  assert true :
   "Any state allowed."; // pre
  ...
}

public int size() {
  assert true : "Any state allowed."; // pre
  ...
  assert s == set_impl.size() :
   "Inconsistent size value!"; // post
}
```

Homework – Exercise 6 – BoundedSet

```
public void add( Object o ) {
  assert size() < max : "Size >= max!"; // pre
  …
  assert isElem( o ) : "Element not successfully
   inserted!"; // post
  assert size() <= max : "Size > max!"; // invariant
}

public void remove( Object o ) {
  assert isElem( o ) : "Element must be contained in
   the set!"; // pre
  …
  assert !isElem( o ) : "Element was not removed
   successfully!"; // post
  assert size() <= max : "Size > max!"; // invariant
}
```

Homework – Exercise 6 – BoundedSet

```
public boolean isElem( Object o ) {
  assert true : "Any state allowed."; // pre
  …
  assert size() <= max : "Size > max!"; // invariant
}

public int size() {
  assert true : "Any state allowed."; // pre
  …
  assert s == set_impl.size() : "Inconsistent size
   value!"; // post
  assert s <= max : "Size > max!"; // invariant
}
```

Homework – Exercise 7

- ObjectList:

```
// requires type( obj ) <= Object
void insert( Object obj ) …
```

- IntegerList:

```
// requires type( obj ) <= Integer
void insert( Object obj ) …
```

➔ `IntegerList` no subtype of `ObjectList`, because the precondition gets stronger!

Homework – Exercise 7

- So should `ObjectList` be a subclass of `IntegerList?`
- Contract of the `insert` method would get weaker!
- Integerlist:

```
// ensures type( res ) <= Integer
Object get( int idx ) …
```

- ObjectList:

```
// ensures type( res ) <= Object
Object get( int idx ) …
```

➔ Postcondition gets weaker, which is not allowed!

Homework – Exercise 8

- `List<Object>` substituted method signatures:
  `void insert( Object obj )`
  `Object get( int idx )`
- `List<Integer>` substituted method signatures:
  `void insert( Integer obj )`
  `Integer get( int idx )`
- As before, the two possible subtype relationships would violate behavioral subtyping
- Java forbids subtype
- Eiffel does not check and might create a CAT call

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Aggregation

- Java always stores references to other objects
- In e.g. C++ the developer has the choice to either safe a reference to the aggregate object or include it in its own body
- “has-a” and “part-of” aggregation
- Let’s look at the pros and cons a bit
- `Address` and `FullAddress` store information
- `Address` > `FullAddress`
- A `Person` uses an `Address` object to store its information

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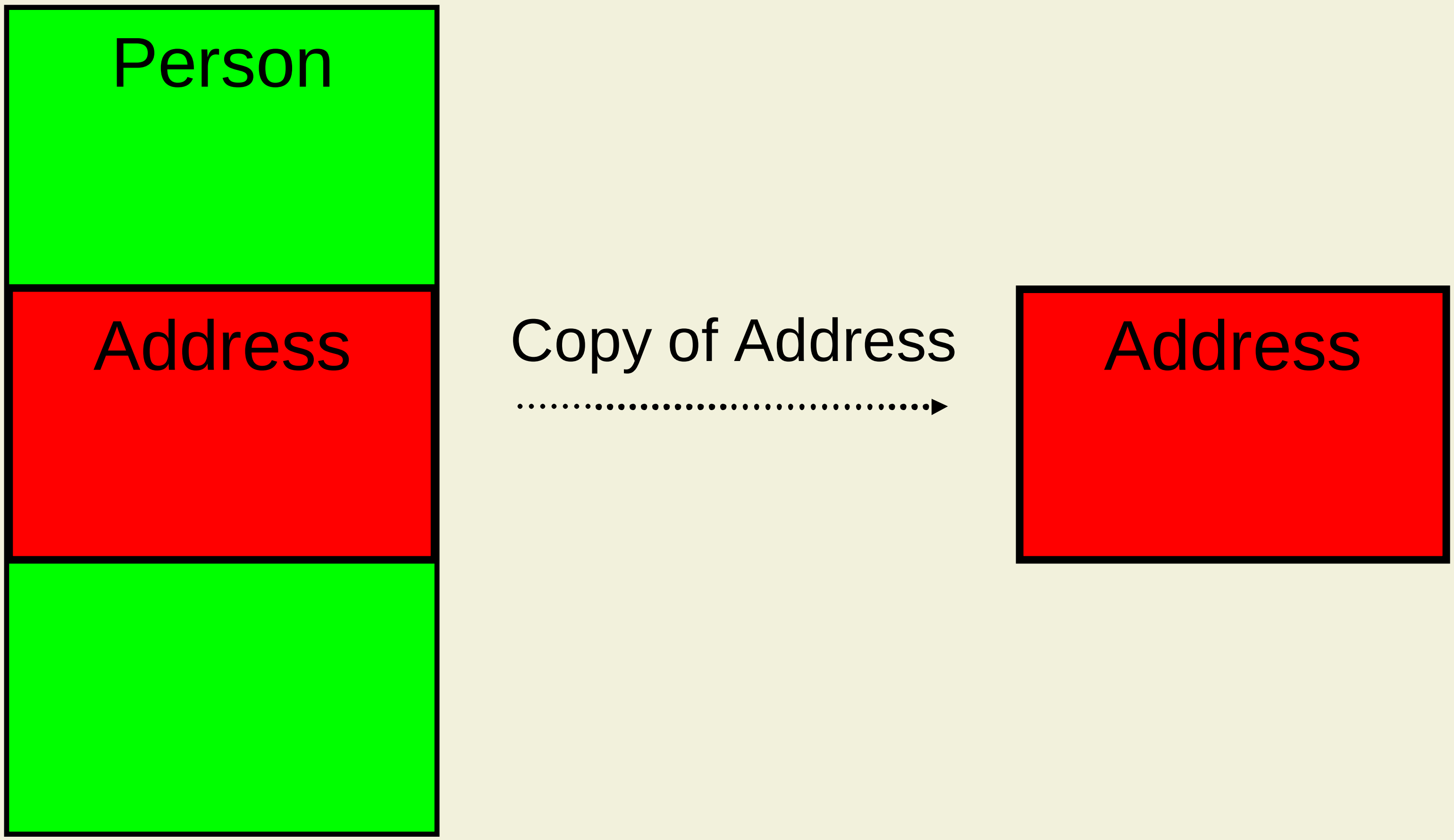
Part-of Aggregation



Part-of Aggregation in C++

```
class Person {
  Person(…) { … }

   void setAddress( const Address &a ) {
   addr = a; }
   Address getAddress() {
   return addr; }

   Address addr;
};
```

Copy-Constructor of Address is called!

Problem with Part-of Aggregation

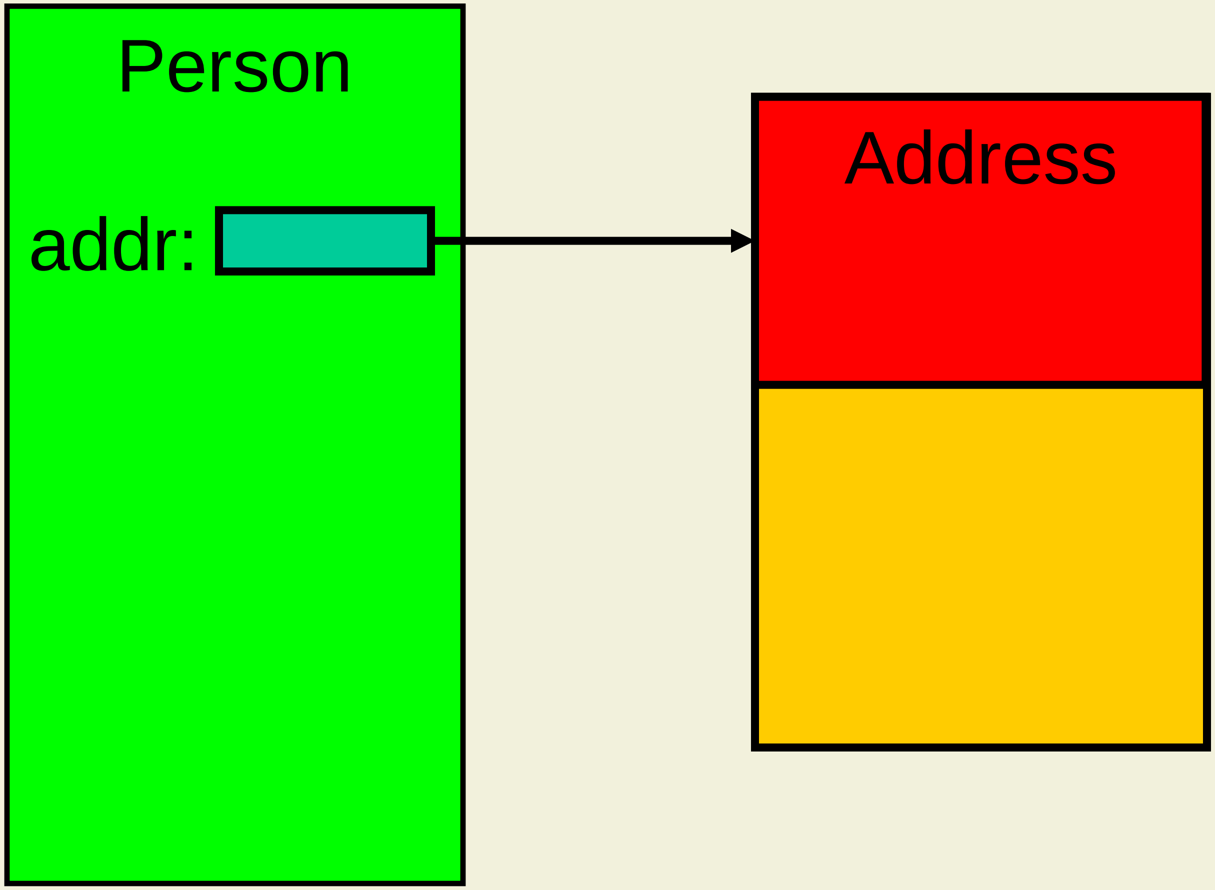
```
Person p( … );
FullAddress a( … );

cout << "Person after construction: " << endl;

cout << p.getAddress().getID() << endl;

p.setAddress( a );

cout << "Person after asssigning a
  FullAddress: " << endl;
cout << p.getAddress().getID() << endl;
```

Only the Address information is copied!
System not extendible by subtyping!

Advantages of Part-of Aggregation

- It is a bit harder for the programmer to create unwanted aliases to the aggregate
- It might be more efficient

Has-a Aggregation



Has-a Aggregation in C++ (Always in Java)

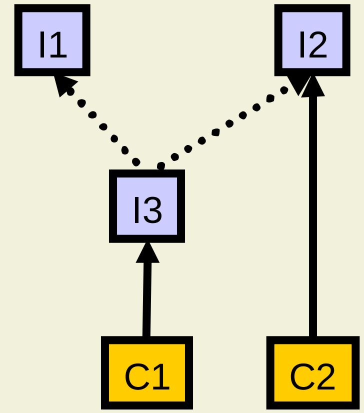
```
class Person {
  Person(…) { addr = new Address(…); }

  void setAddress( Address *a ) {
  addr = a; }
  Address *getAddress() {
  return addr; }


  Address *addr;
};
```

Reference to Address is stored/returned!

Pros & Cons of Has-a Aggregation

- The aggregate can be exchanged at runtime with a different object, even of a different subtype
- Dynamic change of behavior possible
- Recursive data structures like linked-lists only possible with has-a aggregation
- Problems with multiple references to the same object difficult to handle

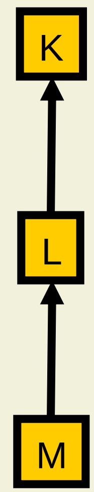
Another Casting Example




```
interface I1 {}          interface I2 {}
interface I3 extends I1, I2 {}

class C1 implements I3 {}
class C2 implements I2 {}

class Conv {
  public static void main( String argv[] ) {
1     C1 c1 = new C1();
2     I2 i2 = (I2) c1;
3     String s = (String) i2;          Compilation Error!
4     C2 c2 = (C2) i2;                 ClassCastException
5     I1 i1 = (I1) i2;
6     I3 i3 = new I3();                Compilation Error!
7     i1 = (I1) c1;
  }
}
```

What’s this programs output?

```
class K {
  K() { System.out.println("K"); }

  public static void main(String[] args) { new M(3); }
}

class L extends K {
  L() { System.out.println("L"); }
}

class M extends L {
  M(int p) { System.out.println("M"); }
}
```



K
L
M

What's this programs output?

```
class K {
  K(int p) { System.out.println("K"); }

  public static void main(String[] args) { new M(3); }
}

class L extends K {
  L(int p) { System.out.println("L"); }
}

class M extends L {
  M(int p) { System.out.println("M"); }
}
```

Compilation Error!

Dynamic Type Information

```
class A {
  void m() {
   if( this instanceof A )
     System.out.println("I'm an A!");
   if( this instanceof B )
     System.out.println("I'm a B!");
  }}
class B extends A {
  public static void main(String[] args) {
   A a = new B();
   a.m();
  }
}
```

```
I'm an A!
I'm a B!
```

Object Comparison

```
class D {
  private int x;
  public D( int p ) { x = p; }

  public boolean equals( Object o ) {
  if( o instanceof D ) {
    return ((D)o).x == this.x;
  } else {
    return false;
}}}
```

Questions?