

Konzepte objektorientierter Programmierung

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Chair of Programming Methodology

Exercises 1: Introduction



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Who's talking?

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Course homepage:

`http://pm.ethz.ch/teaching/as2008/KOOP`

1. Introduction for the Exercises

- Content
- Examination
- Simulating OO in C – Alternatives

Content

- Exercises present...
 - ... more examples
 - ... other programming languages
 - ... research papers
 - Exercises open for questions regarding the lecture
-
- You are encouraged to bring your laptop!

Examination

- Written exam in the exam period
- Exam will be in English
- Content of lectures and exercises
- Type: 2V 1U
- Credits for Students: 5
- Credits for PhDs: 4 (with exam) or 3 (without exam)

Systematic Look at Simulating OO in C

- Subtyping
- Attribute and Method Access
- Inheritance
- Dynamic Binding
- Overriding
- Calling Overridden Methods
- Multiple Subtyping

```
public class Student
    extends Person {

    public Student(String name,
                    int reg ) {
        super( name );
        this.reg_num = reg;
    }

    public void print() {
        super.print();
        System.out.println(
            "No: " + reg_num);
    }

    protected int reg_num;
}
```

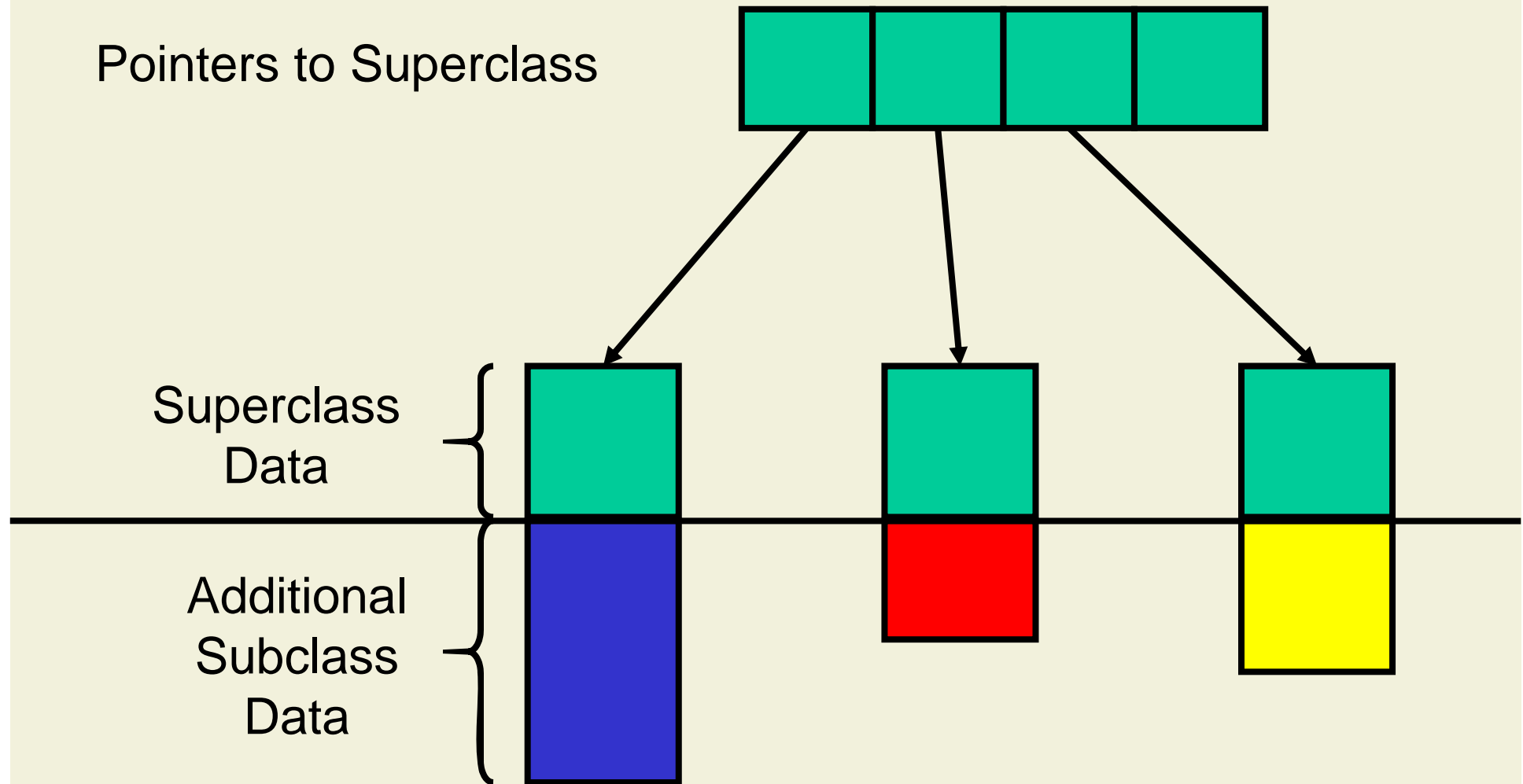
Simulating OO in C – Lecture Example

- Use a `struct` for each class and function pointers for methods
- Each subclass needs to exactly copy the base class attribute and method layout
- We can change function parameters to the subtype structure
- Dynamic method binding works, because whichever method is at the named memory location will be executed

```
struct sPerson {  
    String *name;  
  
    void      (*print)( Person* );  
    String*   (*lastName)( Person* );  
};
```

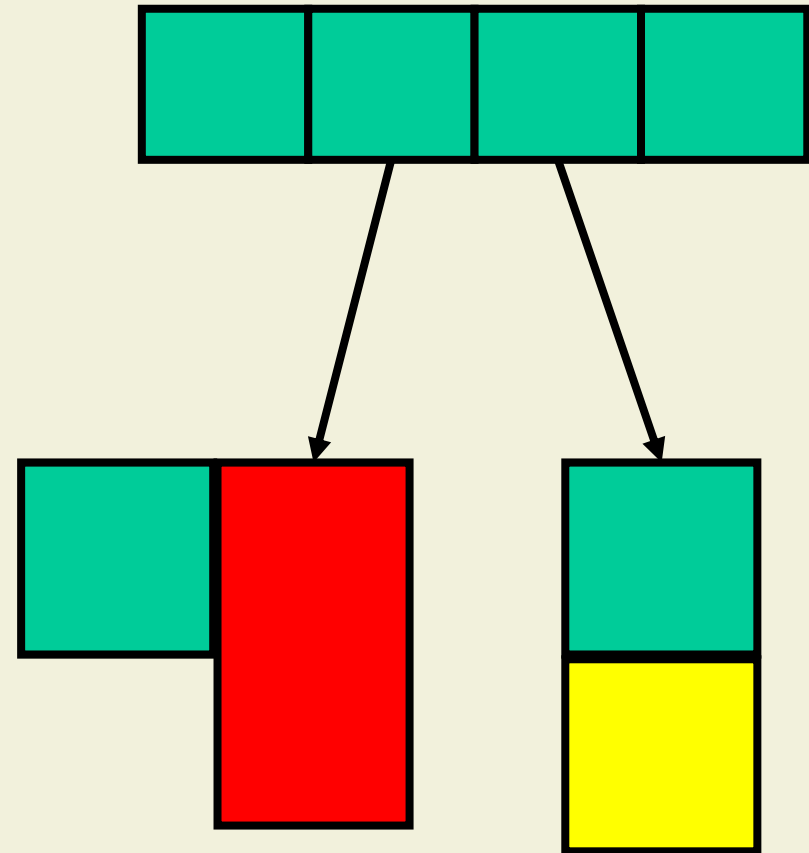
How does this work?

Pointers to Superclass



How can this go wrong?

- Lack of Type Safety!
- If there is an incorrect structure in the array (e.g. order of elements was changed)
- It is interpreted as though it is of the superclass type
- Lots of trouble possible: access to invalid data, arbitrary function calls



Example of incorrect behavior

- We have a new Animal structure:

```
struct sAnimal {  
    void (*print)(Animal*);  
    void (*bite)(Animal*);  
    String *name;  
};
```

- It also has a print method
- Therefore we try to put it into the Person array and pass it to the printAll method
- The bite method is called!
- A lot worse could happen!

printall result:

----- 0 -----

Name: Max Gans

No: 777

----- 1 -----

Name: Karl Heinrich Huber

----- 2 -----

Name: Meister Klug

No of PhDs: 2

----- 3 -----

**Animal Fifi bites your arm
off!**

Bye.

Example of wrong behavior:

What we think to have:

```
struct sPerson {  
    String *name;  
    void (*print)(Person*);  
    String* (*lastName)(Person*);  
};
```

What there really is:

```
struct sAnimal {  
    void (*print)(Animal*);  
    void (*bite)(Animal*);  
    String *name;  
};
```

Why didn't the compiler catch this?

```
d = ProfC("Meister Klug", 2);  
a = AnimalC("Fifi");  
test[2] = (Person*) d;  
test[3] = (Person*) a;
```

Note: It's not simply that print is the second item in Person, therefore we call the second item in Animal!
The data layout in memory is important.

Analysis of this Solution

- Subtyping only by imposing the same data layout
- Member access via struct
- Inheritance only by explicitly calling other functions
- Dynamic Binding because of same data layout
- Multiple subtyping not possible

- Very error prone and tedious to write

OO in C – Alternative Implementation

- Basic idea: reuse the struct of the superclass
- Person is the same as in the last example
- Child classes simply use the superclass structure as the first data member:

```
struct sStudent {  
    Person pers;  
  
    int reg_num;  
};
```

- Easy for multiple levels of single subtyping

How do we access the components?

- Nice and clean with component access:

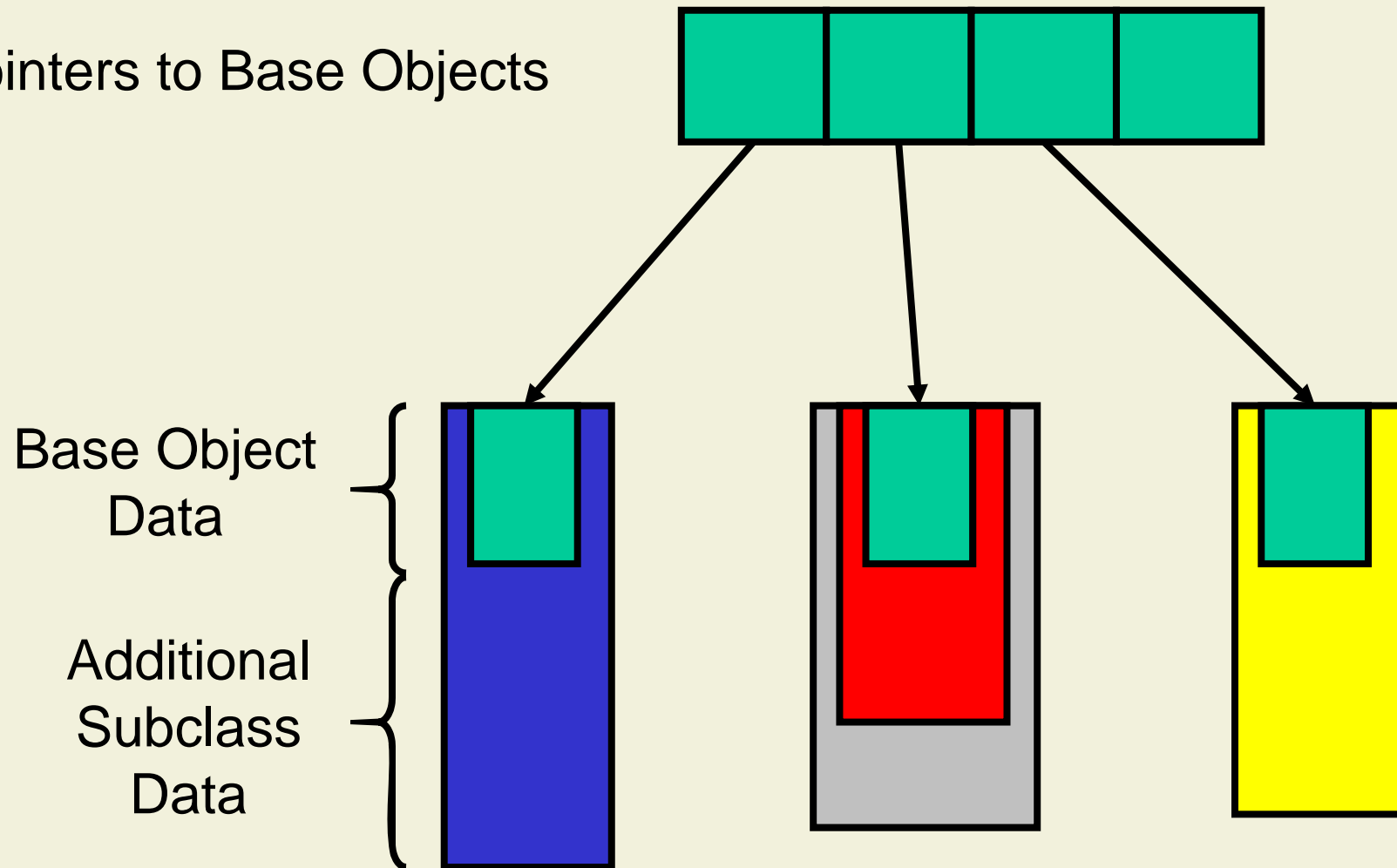
```
initStudent( &(amp;this->stud), n, reg );  
this->stud.pers.print =  
    (void (*)(Person *)) printGraduate;
```

- Flatten the hierarchy by a cast:

```
initStudent( (Student *) this, n, reg );  
((Person *) this)->print =  
    (void (*)(Person *)) printBachelor;
```

How does this work?

Pointers to Base Objects



Analysis of this Solution

- Subtyping still only by imposing the same data layout
- But by reusing the existing structures we do not have to type as much and are less likely to make errors
- Member access via struct, either with casts or subcomponent access
- Inheritance only by explicitly calling other functions
- Dynamic Binding because of same data layout
- Multiple subtyping not possible
- Basic lack of type safety, structures are cast around as programmer thinks is best

Other Solutions

- The mapping of OO into C could be spun even further
- The first C++ and Objective-C compilers created C-code instead of binary code
- The Eiffel compiler also creates C code
- For some historical comments also see OOSE 34.4 pages 1106 ff.

Java Solution Revisited

- Java provides all the language constructs needed for Object-Oriented programming
- Keyword `class` introduces a new data structure consisting of attributes and methods
- Classes can inherit from each other:

```
public class Graduate extends Student {
```
- Similar to including the structure of the superclass in the new class
- Safe types with subtyping, no need for insecure casting

Java Solution Revisited

- Polymorphic method calls
- Encapsulation
- Information Hiding
- Many other advantages that we will hear of later