Script generated by TTT

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FAKULTÄT FÜR INFORMATIK

Programming Languages

Mixins

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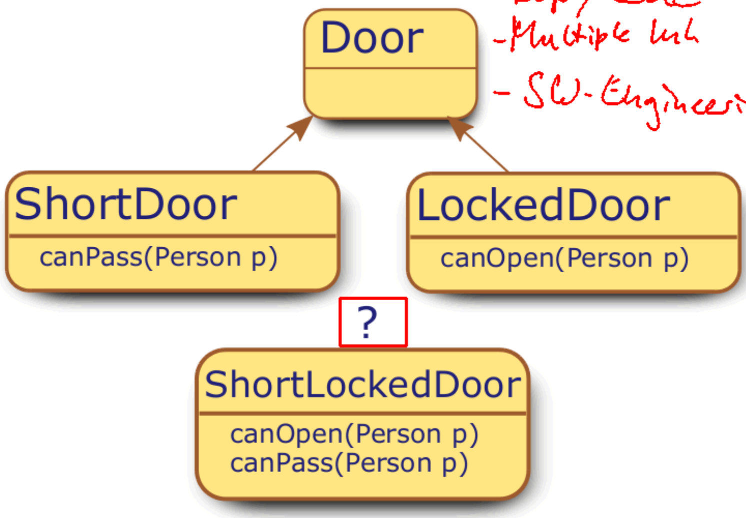
"What advanced techiques are there besides multiple implementation inheritance?"

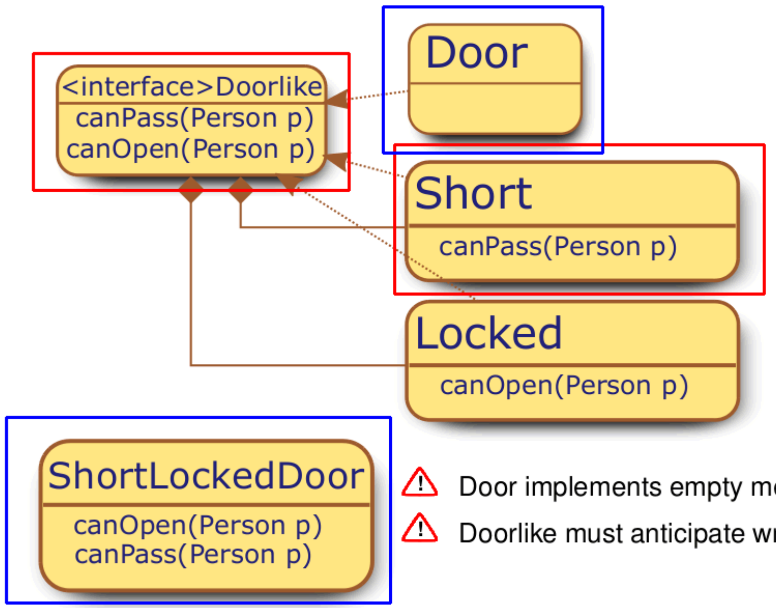
Outline

The Adventure Game



- Kopy Code
- Multiple Inh
- SW-Engineering !

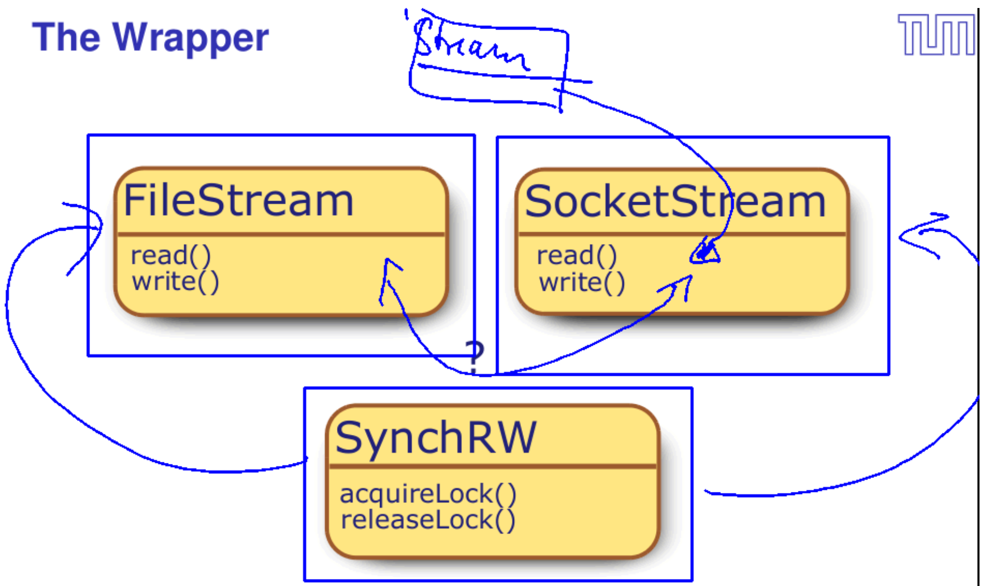
The Adventure Game



⚠ Door implements empty methods

⚠ Doorlike must anticipate wrappers

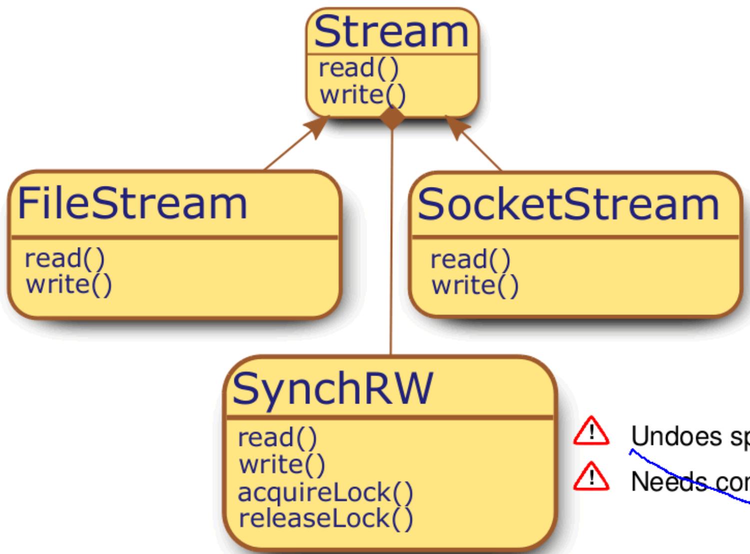
The Wrapper



⚠ Cannot inherit from both seperately

⚠ Creating new wrapping Classes duplicates code

The Wrapper



⚠ Undoes specialization

⚠ Needs common ancestor

"Let's go back to the basics of inheritance"

Abstract model for Smalltalk-Inheritance

Smalltalk inheritance is the archetype for inheritance in mainstream languages like Java or C#.

- Types of Classes abstracted to maps from identifiers to qualified methods
- $\Delta(P) \rightsquigarrow$ the increment Δ can delegate calls to its parent P via keyword (in Smalltalk via `super`)
- The combination operator $\oplus$ merges maps, prefering the left argument

In Smalltalk-like inheritance, a subtype clause is defined as $\Delta \triangleright P = \Delta(P) \oplus P$

Example: `Doors`

$$Door = \{canPass \mapsto \bot, canOpen \mapsto \bot\}$$

$$LockedDoor = (\{canOpen \mapsto LockedDoor.canOpen\}(Door)) \oplus Door$$

Excursion: Beta-Inheritance

Beta-style inheritance is designed to provide security from replacement of a method by a different method.

- methods in parent overwrite methods in subclass
- `inner` as keyword to delegate control to subclass ($\rightsquigarrow$ `super`)
- $\rightsquigarrow$ parent arranges the exact spot, where the subclass can take over

Example (equivalent syntax):

```
class Person {
  String name ="Axel Simon";
  public virtual String toString(){ return name+inner(); };
};
class Graduate extends Person {
  public extended String toString(){ return ", Ph.D."; };
};
```

In Beta-like Inheritance, a subtype clause is defined as $\boxed{\Delta \triangleleft P} = \boxed{P(\boxed{\Delta})} \oplus \boxed{\Delta}$

Excursion: CLOS-Inheritance

CLOS(Common Lisp Object System)-style inheritance offers multiple implementation inheritance featuring linearization.

- methods in childs overwrite methods in parents
- `super` as keyword to delegate control to direct parent ($\rightsquigarrow$ linearization)

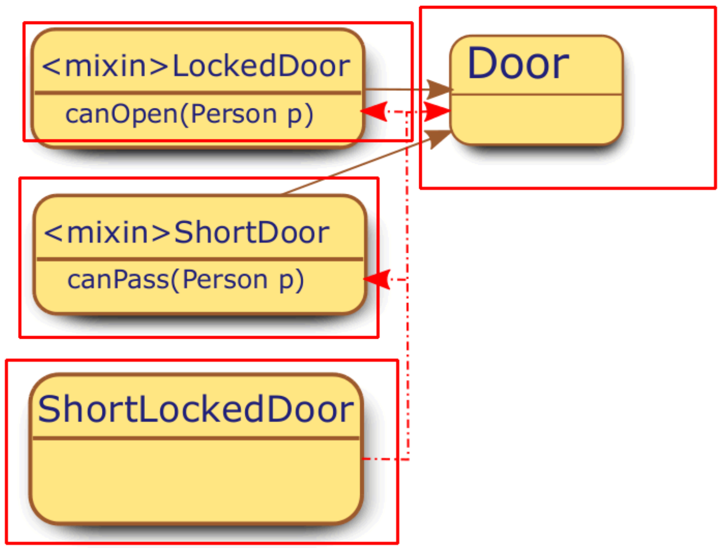
Example (equivalent syntax):

```
class Person {
  String name ="Axel Simon";
  public String toString(){ return name; }
}
class Graduate extends Person {
  public String toString(){ return super.toString()+", Ph.D."; }
}
class Doctor extends Person {
  public String toString(){ return "Dr. "+super.toString(); }
}
class ResearchingDoctor extends Doctor,Graduate {}
```

CLOS-like Multiple-Inheritance sybtype clause: $\boxed{\Delta_1 \triangleright (\Delta_2 \triangleright (\ldots \triangleright P)}\ldots)$

"So what do we really want?"

Adventure Game with Mixins



Adventure Game with Mixins

```
class Door {
  boolean canOpen(Person p) { return true; };
  boolean canPass(Person p) { return true; };
}
mixin Locked extends Door {
  boolean canOpen(Person p){
    if (!p.hasItem(key)) return false; else return super.canOpen(p);
  }
}
mixin Short extends Door {
  boolean canPass(Person p){
    if (p.height()>1) return false; else return super.canPass(p);
  }
}
class ShortDoor = Short(Door);
class LockedDoor = Locked(Door);
mixin ShortLocked = Short compose Locked;
class ShortLockedDoor  = Short(Locked(Door));
class ShortLockedDoor2 = ShortLocked(Door);
```


Back to the blackboard!

Abstract model for Mixins

Mixin

A Mixin M is a *curried second order type operation*, more precisely: Let Δ be a constant map from identifiers to fully qualified identifiers, then M is

$$\backslash\lambda.\Delta \triangleright \lambda = \backslash\lambda.\Delta(\lambda) \oplus \lambda$$

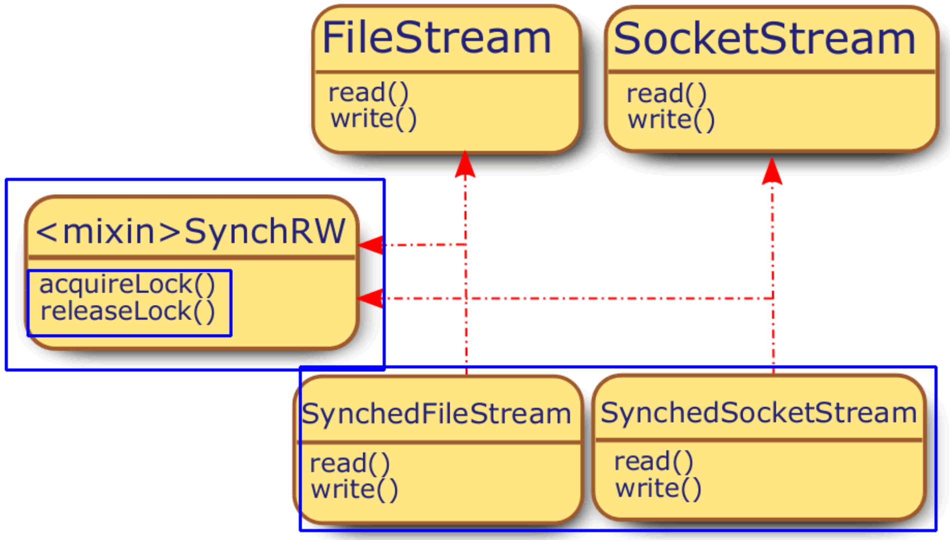
Example: `Doors`

$$\boxed{Door} = \{canPass \mapsto Door.canPass, canOpen \mapsto Door.canOpen\}$$
$$Locked = \{canOpen \mapsto Locked.canOpen\}$$
$$Short = \{canPass \mapsto Locked.canPass\}$$
$$ShortLocked_M = Short_M\ Locked_M = \boxed{\boxed{\backslash\lambda}\ Short \triangleright (Locked \triangleright \lambda)}$$

Let Δ be the Mixin Ms map. Then, M is connected to a class C via parameter binding:

$$MC = \Delta \triangleright C = \Delta(C) \oplus C$$

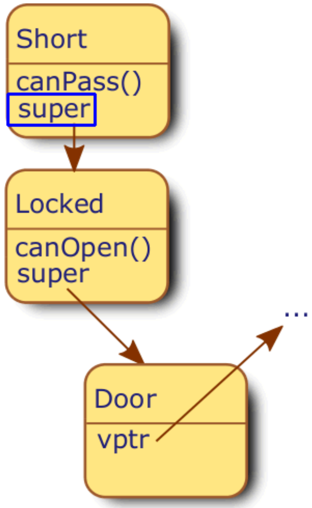
Wrapper with Mixins



Implementing Mixins

```
class Door {
 boolean canOpen(Person p)...
 boolean canPass(Person p)...
}
mixin Locked extends Door {
 boolean canOpen(Person p)...
}
mixin Short extends Door {
 boolean canPass(Person p)...
}
class ShortDoor
    = Short(Door);
class ShortLockedDoor
    = Short(Locked(Door));
...

ShortDoor d
    = new ShortLockedDoor();
```



⚠ `super`-References not statically resolvable

"Surely multiple inheritance is powerful enough to simulate mixins?"

Simulating Mixins in C++

```
template <class Super>
class SyncRW : public Super {
  public: virtual int read(){
    acquireLock();
    int result = Super::read();
    releaseLock();
    return result;
  };
  virtual void write(int n){
    acquireLock();
    Super::write(n);
    releaseLock();
  };
  // ... acquireLock & releaseLock
};
```


Simulating Mixins in C++

```
template <class Super>
class LogOpenClose : public Super {
   public: virtual void open(){
    Super::open();
    log("opened");
   };
   virtual void close(){
    Super::close();
    log("closed");
   };
   protected: virtual void log(char*s) { ... };
};
class MyDocument : public SyncRW<LogOpenClose<Document>> {};
```


Simulating Mixins in C++

```
template <class Super>
class SyncRW : public Super {
  public: virtual int read(){
    acquireLock();
    int result = Super::read();
    releaseLock();
    return result;
  };
  virtual void write(int n){
    acquireLock();
    Super::write(n);
    releaseLock();
  };
  // ... acquireLock & releaseLock
};
```


Simulating Mixins in C++

```
template <class Super>
class LogOpenClose : public Super {
   public: virtual void open(){
    Super::open();
    log("opened");
   };
   virtual void close(){
    Super::close();
    log("closed");
   };
   protected: virtual void log(char*s) { ... };
};
class MyDocument : public SyncRW<LogOpenClose<Document>> {};
```

True Mixins vs. C++ Mixins

True Mixins

- `super` natively supported
- Mixins as Template do not offer composite mixins
- C++ Type system not modular
- ⇝ Mixins have to stay source code
- Hassle-free simplified version of multiple inheritance

C++ Mixins

- Mixins reduced to templated superclasses
- Can be seen as coding pattern

Common properties of Mixins

- Linearization is necessary
- ⇝ Exact sequence of Mixins is relevant

"Ok, ok, show me a language with native mixins!"

Ruby

```ruby
class Person
  attr_accessor :size
  def initialize
    @size = 160
  end
  def hasKey
    true
  end
end
class Door
  def canOpen (p)
    true
  end
  def canPass(person)
    person.size < 210
  end
end
```

```ruby
module Short
  def canPass(p)
    p.size < 160 and super(p)
   end
end
module Locked
  def canOpen(p)
    p.hasKey() and super(p)
  end
end

class ShortLockedDoor < Door
  include Short
  include Locked
end

p = Person.new
d = ShortLockedDoor.new
puts d.canPass(p)
```


Lessons Learned

Lessons Learned

1. Formalisms to model inheritance
2. Mixins provide soft multiple inheritance
3. Multiple inheritance can not compensate `super` reference
4. Full extent of mixins only when mixins are 1st class language citizens

Further reading...

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