Script generated by TTT

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TECHNISCHE UNIVERSITÄT MÜNCHEN
FAKULTÄT FÜR INFORMATIK

Programming Languages

Multiple Inheritance

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Winter term 2015

Outline

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"Wouldn't it be nice to inherit from several parents?"

Interface vs. Implementation inheritance

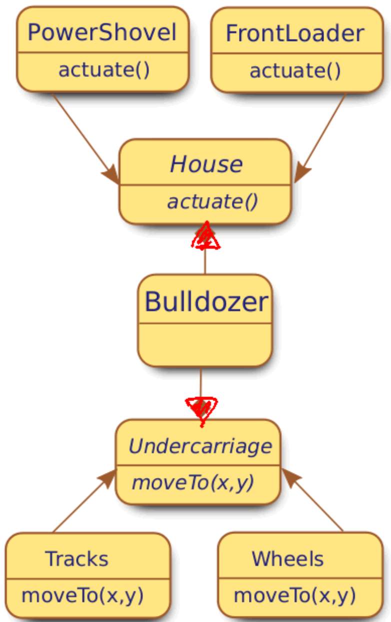
The classic motivation for inheritance is implementation inheritance

- *Code reusage*
- Child specializes parents, replacing particular methods with custom ones
- Parent acts as library of common behaviours
- Implemented in languages like C++ or Lisp

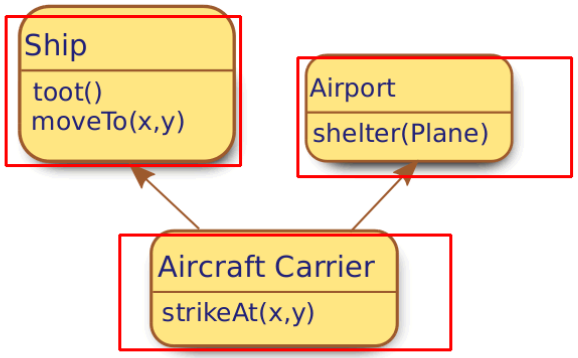
Code sharing in interface inheritance inverts this relation

- *Behaviour contract*
- Child provides methods, with signatures predetermined by the parent
- Parent acts as generic code frame with room for customization
- Implemented in languages like Java or C#

Interface Inheritance



Implementation inheritance



"So how do we lay out objects in memory anyway?"

Excursion: Brief introduction to LLVM IR

Low Level Virtual Machine as reference semantics:

```
;(recursive) struct definitions
%struct.A = type { i32, %struct.B, i32(i32)* }
%struct.B = type { i64, [10 x [20 x i32]], i8 }

;(stack-) allocation of objects
%a = alloca %struct.A
;adress computation for selection in structure (pointers):
%1 = getelementptr %struct.A* %a, i64 0, i64 2
;load from memory
%2 = load i32(i32)* %1
;indirect call
%retval = call i32 (i32)* %2(i32 42)
```

Retrieve the memory layout of a compilation unit with:

```
clang -cc1 -x c++ -v -fdump-record-layouts -emit-llvm source.cpp
```

Retrieve the IR Code of a compilation unit with:

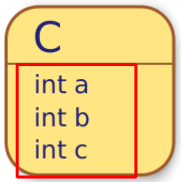
```
clang -O1 -S -emit-llvm source.cpp -o IR.llvm
```


Object layout

```
class A {
  int a; int f(int);
};
class B : public A {
  int b; int g(int);
};
class C : public B {
  int c; int h(int);
};

...

C c;
c.g(42);
```




```
%class.C = type { %class.B, i32 }
%class.B = type { %class.A, i32 }
%class.A = type { i32 }
```

```
%c = alloca %class.C
%1 = bitcast %class.C* %c to %class.B*
%2 = call i32 @_g(%class.B* %1, i32 42) ; g is statically known
```


Translation of a method body

```
class A {
  int a; int f(int);
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class B : public A {
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};
class C : public B {
  int c; int h(int);
};
int B::g(int p) {
  return p+b;
};
```

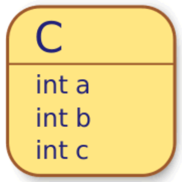


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%class.C = type { %class.B, i32 }
%class.B = type { %class.A, i32 }
%class.A = type { i32 }
```

```
define i32 @_g(%class.B* %this, i32 %p) {
  %1 = getelementptr %class.A* %this, i64 0, i32 1
  %2 = load i32* %1
  %3 = add i32 %2, %p
  ret i32 %3
}
```

Translation of a method body

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C
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int b
int c

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Single-Dispatching implementation choices

Single-Dispatching needs runtime action:

1. Manual search run through the super-chain (Java Interpreter ⇝ last talk)

```
call i32 @__dispatch(%class.C* %c,i32 4711)
```


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```
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2. Caching the dispatch result (⇝ Hotspot/JIT)

```
%1 = getelementptr(%class.C* %c, i64 0, i32 0)
%2 = load i32* %1
assert (%2==%class.D)
call i32 @_f(%class.C* %c, i32 42)
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3. Precomputing the dispatching result in tables
   1. Full 2-dim matrix
   2. 1-dim Row Displacement Dispatch Tables

A	B			F			
1	1	2	...	8	9		7

	f()	g()	h()	i()	j()	k()	l()	m()	n()
A	1								
B	1	2							
C	3		4						
D	3	2	4	5					
E						6		7	
F					8	9		7	

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   3. Virtual Tables
      (⇝ LLVM/GNU C++,this talk)

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Object layout – virtual methods

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class A {
  int a; virtual int f(int);
         virtual int g(int);
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};
class B : public A {
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class C : public B {
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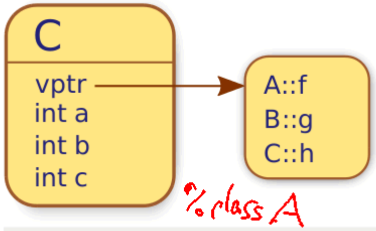


```
%class.C = type { %class.B, i32, [4 x i8] }
%class.B = type { [12 x i8], i32 }
%class.A = type { i32 (...)**, i32 }
```

```
%c.vptr = bitcast %class.C* %c to i32 (%class.B*, i32)*** ; vtbl
%1 = load (%class.B*, i32)*** %c.vptr     ; dereference vptr
%2 = getelementptr %1, i64 1              ; select g()-entry
%3 = load (%class.B*, i32)** %2           ; dereference g()-entry
%4 = call i32 %3(%class.B* %c, i32 42)
```


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	f()	g()	h()	i()	j()	k()	l()	m()	n()
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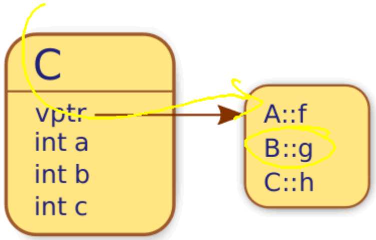


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```


"So how do we include several parent objects?"

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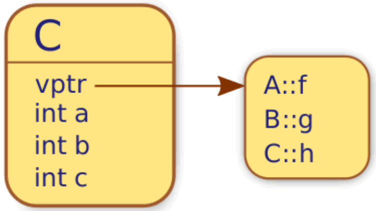


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