Compiler aided optimization of the pimpl-idiom

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Pimpl-idiom

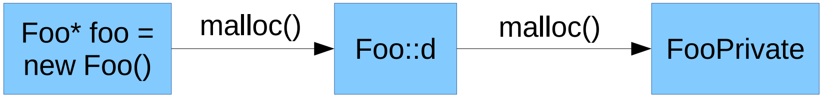
- Used to keep binary compatibility in C++ libraries
- Heavily used by e.g. Qt and KDE
- **Problem:** requires extra memory allocations

Example

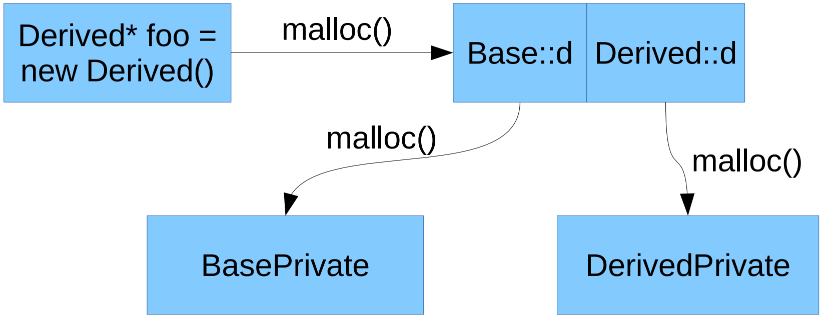
```
//foo.h
class Foo {
public:
   Foo(const char* s);
   // ...
private:
   FooPrivate* d;
};

// foo.cpp
class FooPrivate {
   // data members
}
Foo::Foo(const char* s) : d(new FooPrivate(s)) {}
```

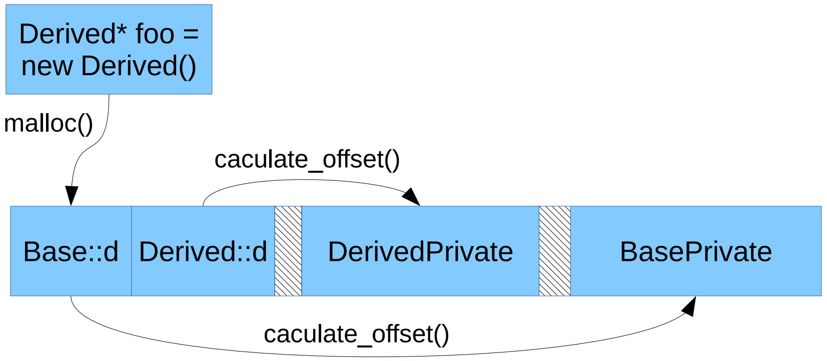
Pimpl overhead



Even more overhead with inheritance



Optimized layout



Solution

- One large `malloc()` call and then use *placement new*
- **Must** retain binary compatibility
- Could be done at the library level
  - Error-prone and hard to debug
  - Requires changing every `new` expression!
- **Better:** Let clang do the work for us

Solution

```
//foo.h
class Foo {
public:
  Foo(const char* s);
  // ...
private:
  [[clang::pimpl]] FooPrivate* d; // only need to add one attribute
};

// foo.cpp
class FooPrivate {
  // data members
}
Foo::Foo(const char* s) : d(new FooPrivate(s)) {}
```

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- Generate three static data members per class
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- Let original constructor delegate to new one and pass `nullptr` for the `dpointer` parameter
- Add custom `operator delete` to private class
- Replace every `new Foo(args)` expression by

```
void* buffer = ::operator new(Foo::totalSize);
Foo* foo = new (buffer) Foo(args,buffer + sizeof(Foo) + align);
```

Conclusion

- Over 50% speedup in allocation-heavy benchmark
- Total memory usage reduced by about 3%

- Code at `https://github.com/a-richardson/clang`
- Questions $\rightarrow$ alr48@cam.ac.uk