Miscellaneous

Object-Oriented Programming with C++

Named casts

- The C-style cast is:
  - dangerous because it can do (logically different) conversion.
  - not search friendly
- If you must cast things, use a named cast:
  - `static_cast` (less likely to make mistakes)
  - `dynamic_cast`
  - `reinterpret_cast`
  - `const_cast`
  - …

Named casts

```
double d = 7.1;
int a;

a = d;                          // implicit

a = (int) d;                    // explicit

a = static_cast<int>(d); // exact meaning
```

Named casts

```
int a = 7;
double* p;

p = (double*) &a; // ok (but a is not a double)

p = static_cast<double*>(&a); // error

p = reinterpret_cast<double*>(&a); // ok: I really
                                   // mean it
```

Named casts

```
const int c = 7;
int* q;

q = &c; // error

q = (int*)&c; // ok (but is *q2=2 really allowed?)

q = static_cast<int*>(&c); // error

q = const_cast<int*>(&c); // I really mean it
```

Named casts

```
struct A {
  virtual void f() {}
};
struct B : public A {};
struct C : public A {};

int main()
{
  A *pa = new B;
  C *pc = static_cast<C*>(pa);  // OK: but *pa is B!

  return 0;
}
```

Named casts

```
struct A {
  virtual void f() {}
};
struct B : public A {};
struct C : public A {};

int main()
{
  A *pa = new B;
  C *pc = static_cast<C*>(pa);  // OK: but *pa is B!
  C *pc = dynamic_cast<C*>(pa); // return nullptr

  return 0;
}
```

Named casts

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struct A {
  // virtual void f() {}
};
struct B : public A {};
struct C : public A {};

int main()
{
  A *pa = new B;
  C *pc = static_cast<C*>(pa);  // OK: but *pa is B!
  C *pc = dynamic_cast<C*>(pa); // Error!

  return 0;
}
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Named casts

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struct A {
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struct B : public A {};
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int main()
{
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  C *pc = static_cast<C*>(pa);  // OK: but *pa is B!

  return 0;
}
```

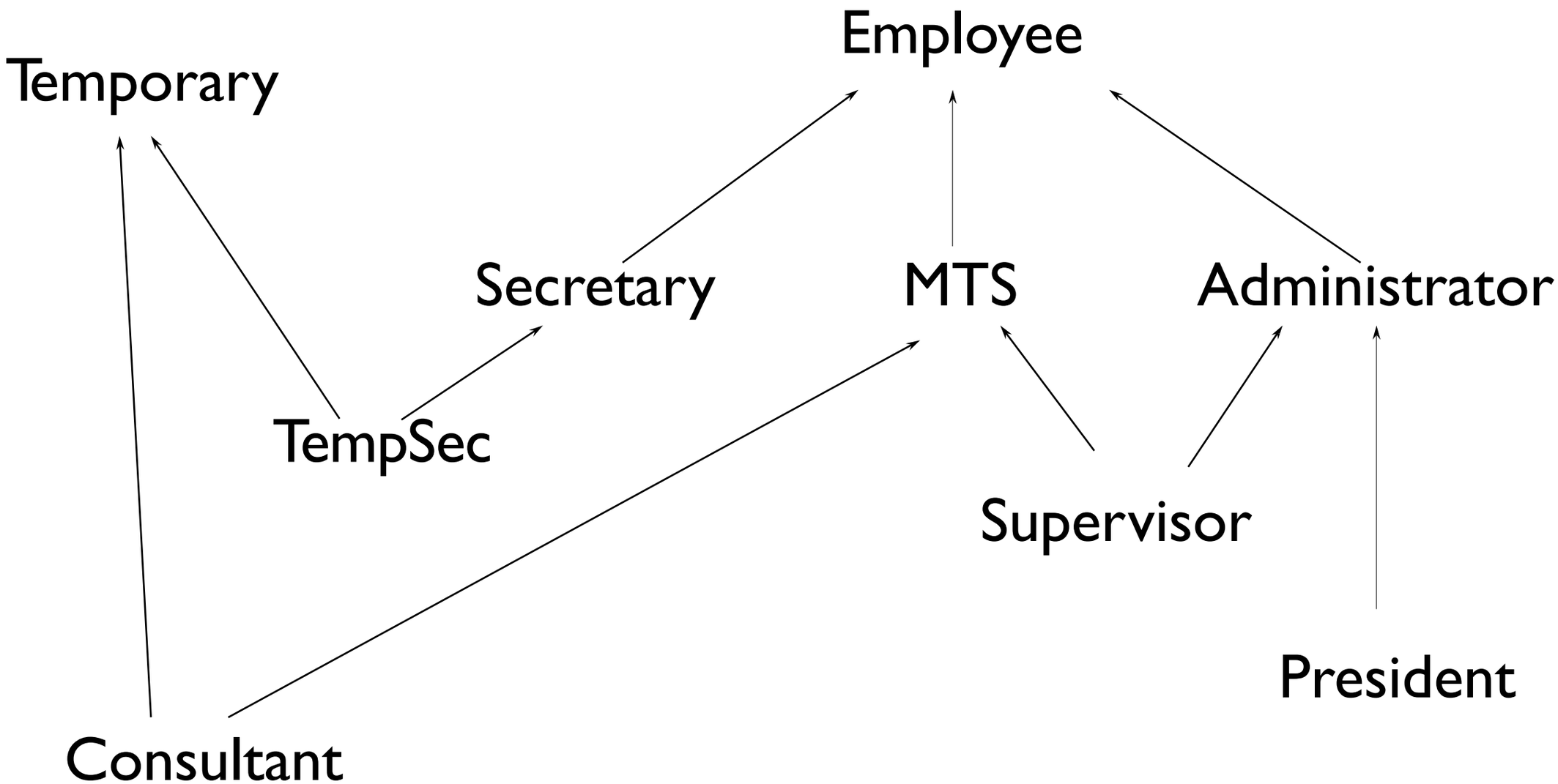
Named casts

```
struct A {
  // virtual void f() {}
};
struct B : public A {};
struct C : public A {};
struct D {};

int main()
{
  A *pa = new B;
  D *pd = static_cast<D*>(pa);  // Error!

  return 0;
}
```

Multiple inheritance



Mix and match

```
class Employee {
protected:
     String name;
     EmpID id;
};
```

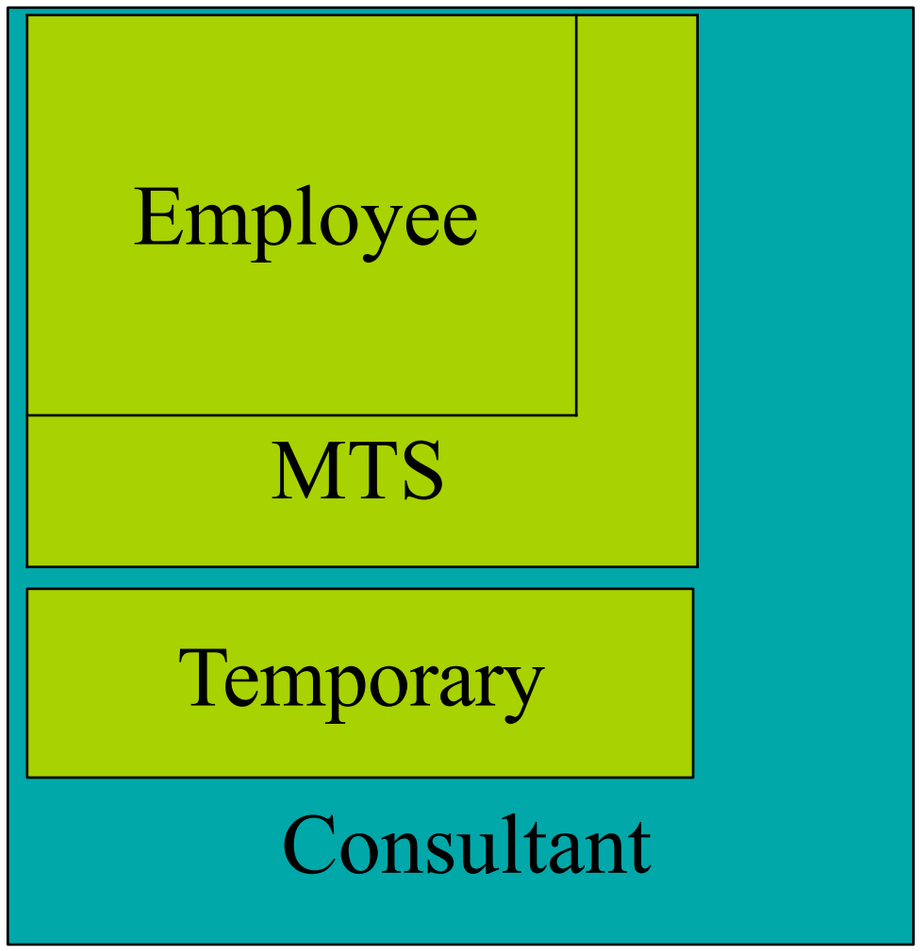
```
class MTS : public Employee {
protected:
     Degrees degree_info;
};

class Temporary {
protected:
     Company employer;
};
```

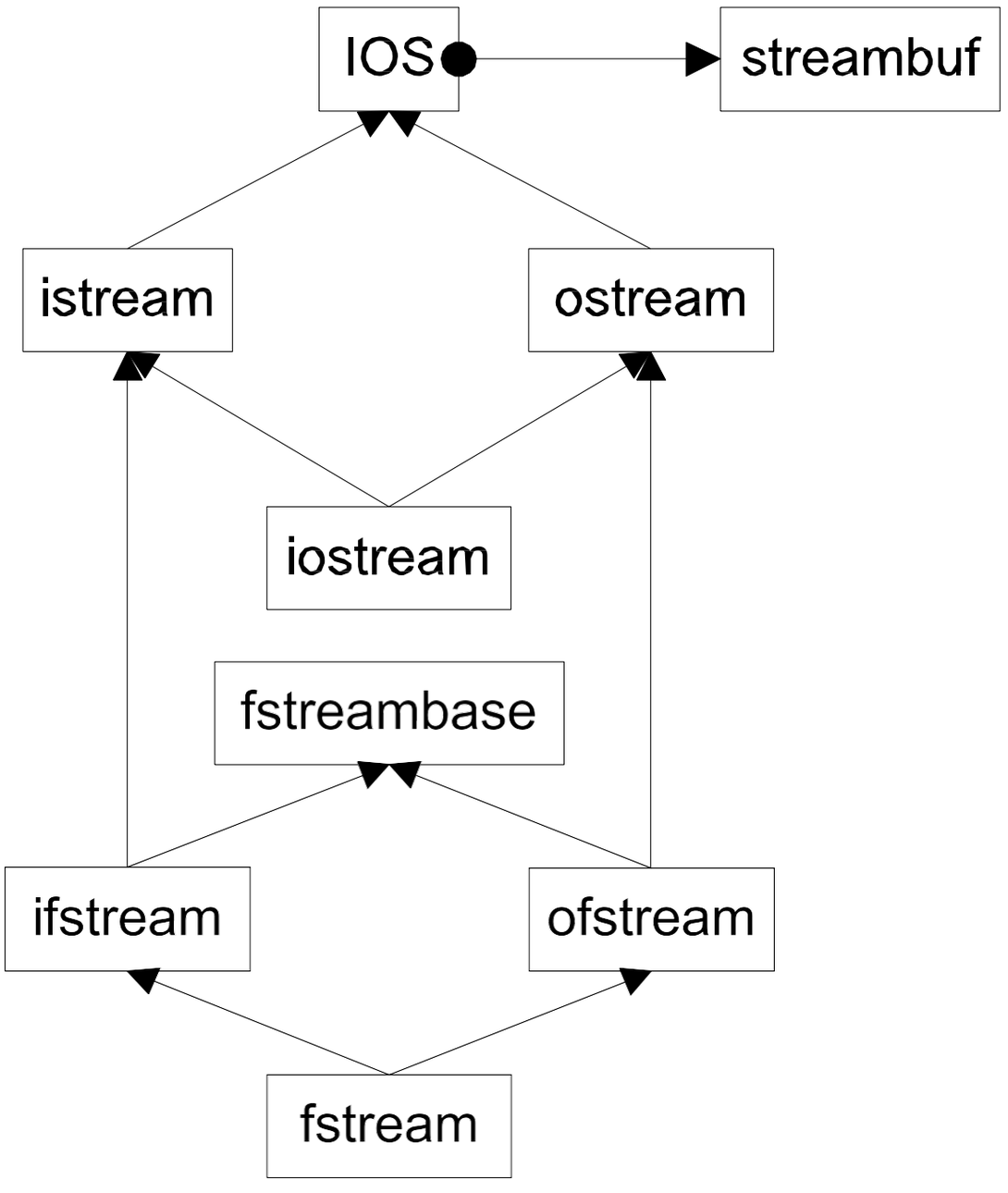
```
class Consultant:
   public MTS,
   public Temporary {
…
};
```

- Consultant picks up the attributes of both `MTS` and `Temporary`.
  - name
  - id
  - degree_info
  - employer

MI complicates data layouts

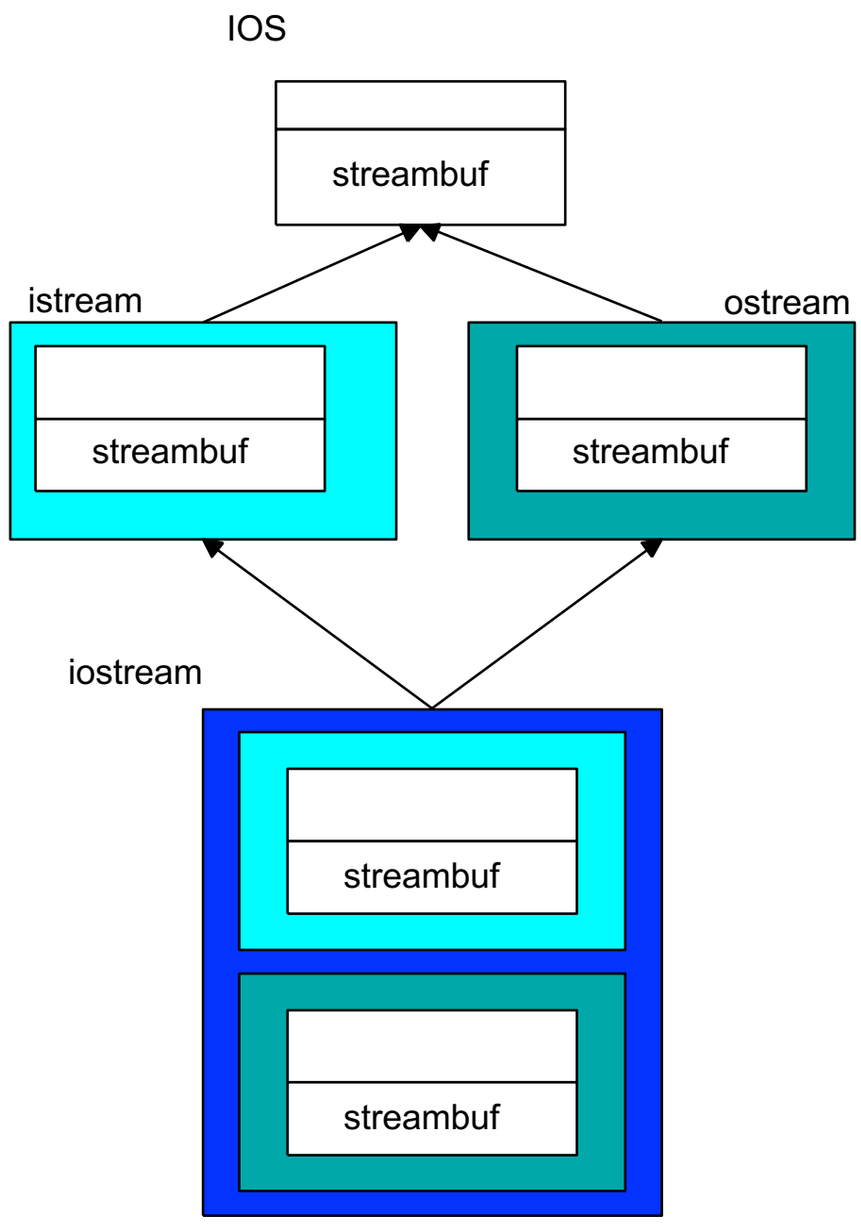


iostream package



Vanilla MI

- Members are duplicated
- Derived class has access to full copies of each base class
- This ***can*** be useful!
  - –Multiple links for lists
  - –Multiple streambufs for input and output



More on MI ...

```
struct B1 { int m_i; };
struct D1 : public B1 {};
struct D2 : public B1 {};
struct M : public D1, public D2 {};
```

```
int main() {
   M m; // OK
   B1* p = &m; // ERROR: which B1???
   B1* p1 = dynamic_cast<D1*>(&m); // OK
   B1* p2 = dynamic_cast<D2*>(&m); // OK
}
```

`B1` is a *replicated* sub-object of `M`.

Replicated bases

- Normally replicated bases aren't a problem (usage of B1 by D1 and D2 is an implementation detail).
- Replication becomes a problem if replicated data makes for confusing logic:

```
M m;
m.m_i++; // ERROR: D1::B1.m_i or D2::B1.m_i?
```

Safe uses

- Protocol classes

Protocol / Interface classes

- Abstract base class with
  - All non-static member functions are *pure* virtual except destructor
  - Virtual destructor with empty body
  - No non-static member variables, inherited or otherwise
    - May contain static members

Example interface

- Unix character device

```
class CDevice {
public:
    virtual ~CDevice() {}
    virtual int read(...) = 0;
    virtual int write(...) = 0;
    virtual int open(...) = 0;
    virtual int close(...) = 0;
    virtual int ioctl(...) = 0;
};
```

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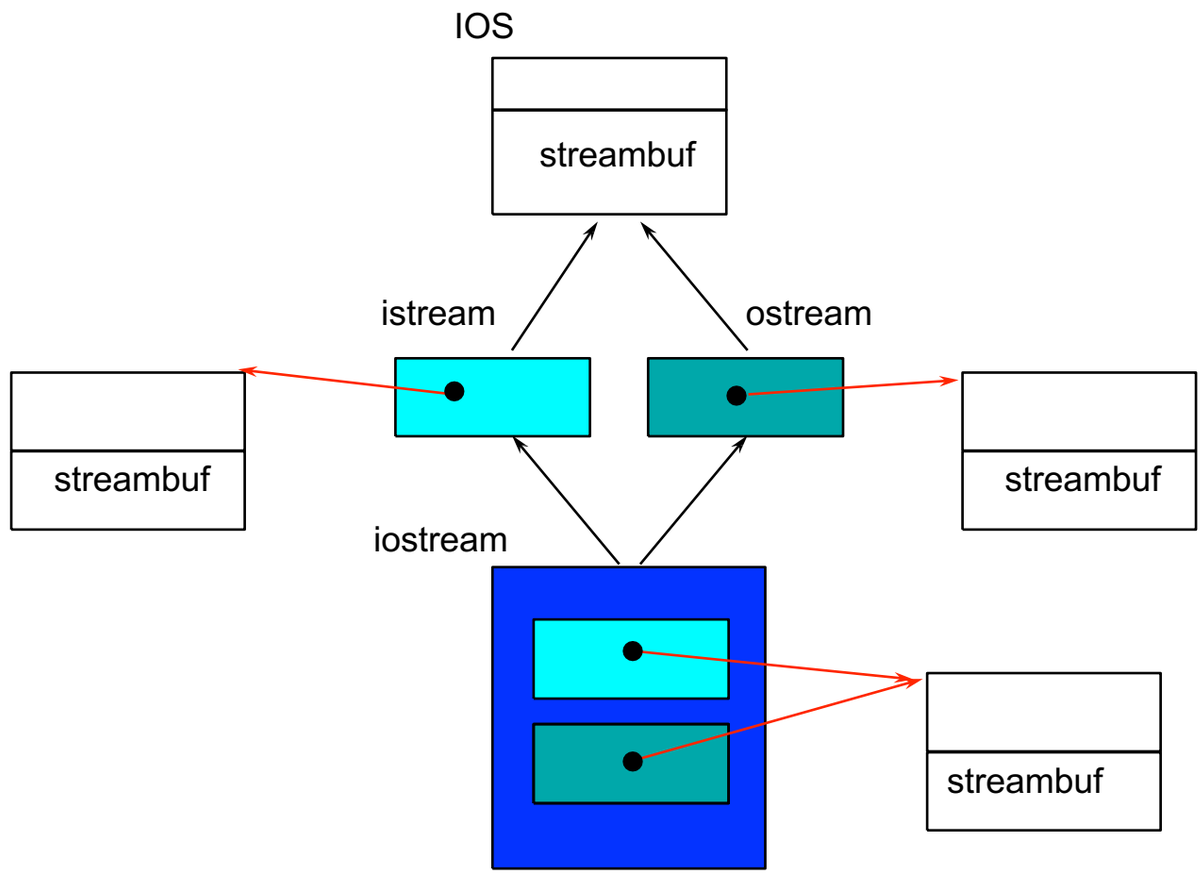
- How do you avoid having two `streambufs`?
- Base classes can be ***virtual***
  - To C++ people, "virtual" means "indirect"
- Virtual member functions have dynamic binding
  - They use pointer indirection
- Virtual base classes are represented indirectly
  - They use pointer indirection

Using virtual base classes

- Virtual base classes are ***shared***
- Derived classes have a single copy of the virtual base
- Full control over sharing
  - –Up to you to choose
- Cost is in complications



has-a ●→

is-a →

Virtual bases

```
struct B1 { int m_i; };

struct D1 : virtual public B1 {};

struct D2 : virtual public B1 {};

struct M : public D1, public D2 {};

int main() {

    M m;  // OK

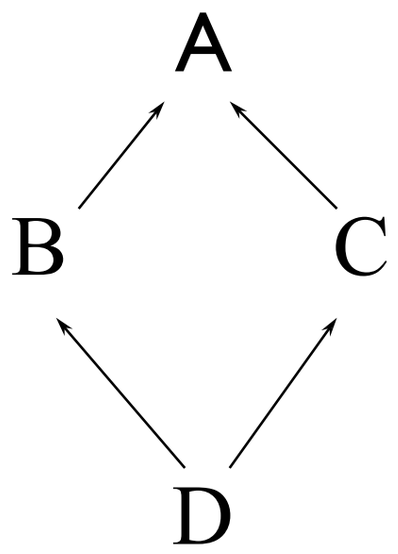
    m.m_i++; // OK, there is only one B1 in m

    B1* p = new M; // OK

}
```

Complications of MI

- Name conflicts
  - –Dominance rule
- Order of construction
  - –Who constructs virtual base?
- Virtual bases not declared when you need them



- Code in virtual bases called more than once
- Compilers are still iffy
- Moral:
  - – Use sparingly
  - – Avoid diamond patterns
    - expensive
    - hard

Virtual bases

- Use of virtual base imposes some runtime and space overhead.
- If replication isn't a problem then you don't need to make bases virtual.
- Abstract base classes (that hold no data except for a vptr) can be replicated with no problem – virtual base can be eliminated.

TIPS for MI

- In general, SAY

NO

Avoiding name clashes

- Including duplicate names at global scope is a problem:

```
// old1.h
   void f();
   void g();

// old2.h
   void f();
   void g();
```

Avoiding name clashes (cont)

- Wrap declarations in namespaces.

```
// old1.h
namespace old1 {
    void f();
    void g();
}

// old2.h
namespace old2 {
    void f();
    void g();
}
```

Namespace

- Expresses a logical grouping of classes, functions, variables, etc.
- A namespace is a scope just like a class
- Preferred when name encapsulation is needed

```
namespace Math {
   double abs(double);
   double sqrt(double);
   int trunc(double);
   ...
} // Note: No terminating end colon!
```

Defining namespaces

- Place namespaces in include files:

Defining namespaces

- Place namespaces in include files:

```
// Mylib.h
namespace MyLib {
    void foo();
    class Cat {
    public:
        void Meow();
    };
}
```

Defining namespace functions

- Use normal scoping to implement functions in namespaces.

```
// MyLib.cpp
#include "MyLib.h"

void MyLib::foo() { cout << "foo\n"; }
void MyLib::Cat::Meow() {
    cout << "meow\n";
}
```

Using names from a namespace

- Use scope resolution to qualify names from a namespace.
- Can be tedious and distracting.

```
#include "MyLib.h"
int main()
{
    MyLib::foo();
    MyLib::Cat c;
    c.Meow();
}
```

`using`-declarations

- Introduces a local synonym for name
- States in one place where a name comes from.
- Eliminates redundant scope qualification:

```
int main() {
    using MyLib::foo;
    using MyLib::Cat;
    foo();
    Cat c;
    c.Meow();
}
```

`using`-directives

- Makes *all* names from a namespace available.
- Can be used as a notational convenience.

```
int main() {
    using namespace std;
    using namespace MyLib;
    foo();
    Cat c;
    c.Meow();
    cout << "hello" << endl;
}
```

Ambiguities

- Using-directives may create *potential* ambiguities.
- Consider:

```
// Mylib.h
namespace XLib {
    void x();
    void y();
}

namespace YLib {
    void y();
    void z();
}
```

Ambiguities (cont)

- Using-directives only make the names available.
- Ambiguities arise only when you make calls.
- Use scope resolution to resolve.

```
int main() {
  using namespace XLib;
  using namespace YLib;
  x();          // OK
  y();          // Error: ambiguous
  XLib::y(); // OK, resolves to XLib
  z();          // OK
}
```

Namespace aliases

- Namespace names that are too short may clash
- Names that are too long are hard to work with
- Use aliasing to create workable names
- Aliasing can be used to version libraries.

```
namespace supercalifragilistic {
    void f();
}
namespace short_ns = supercalifragilistic;
short_ns::f();
```

Namespace composition

- Compose new namespaces using names from other ones.
- Using-declarations can resolve potential clashes.
- Explicitly defined functions take precedence.

```
namespace first {
  void x();
  void y();
}
namespace second {
  void y();
  void z();
}
```

Namespace composition (cont)

```
namespace mine {
    using namespace first;
    using namespace second;
    using first::y; // resolve clashes
    void mystuff();
    ...
}
int main() {
    mine::x();
    mine::y(); // call first::y()
    mine::mystuff();
}
```

Namespace selection

- Compose namespaces by selecting a few features from other namespaces.
- Choose only the names you want rather than all.
- Changes to “orig” declaration become reflected in “mine”.

```
namespace mine {
  using orig::Cat; // use Cat class from orig
  void x();
  void y();
}
```

Namespaces are open

- Multiple namespace declarations add to the same namespace.
  - Namespace can be distributed across multiple files.

```
//header1.h
namespace X {
    void f();
}

// header2.h
namespace X {
    void g(); // X how has f() and g();
}
```