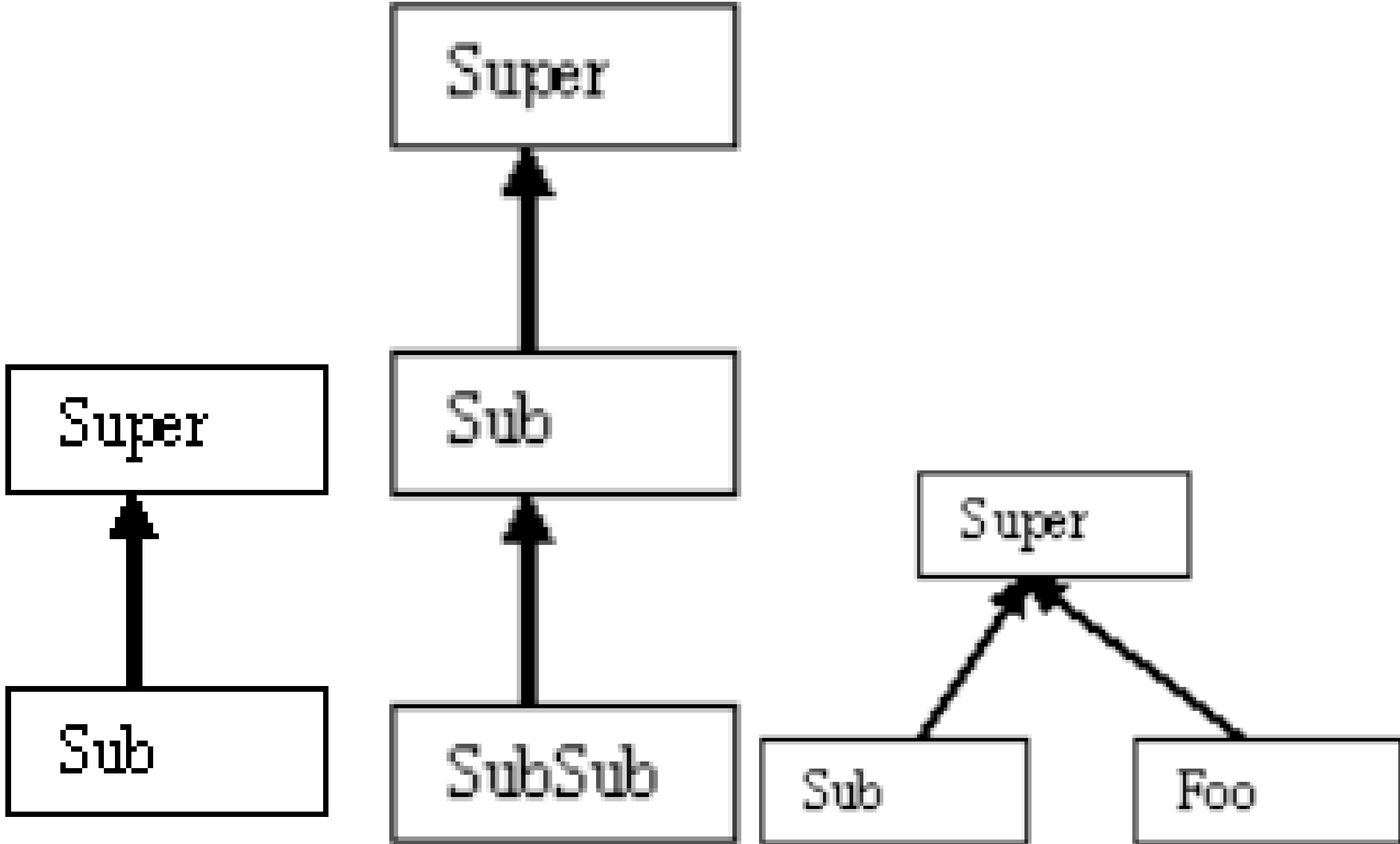
Inheritance

See also: Chapter 10

Basic Inheritance Syntax

```
class Super
{
    public:
        Super();

        void someMethod();

    protected:
        int mProtectedInt;

    private:
        int mPrivateInt;
};
```

```
class Sub : public Super
{
    public:
        Sub();

        void otherMethod();
};
```


Super
Sub
Super
Sub
SubSub
Super
Sub
Foo

Using Subclasses – Just like normal classes!

```
Sub mySub;

mySub.someMethod();   // b/c Sub is a Super
mySub.otherMethod();  // because Sub declares it


Super mySuper;
mySuper.otherMethod(); // BUG! Super is not a Sub
```

Pointers and References with Subclasses

- Can point/refer to a class or any of its subclasses
- Can only (directly) access methods/members of the declared class
- Mechanism that allows polymorphism (later)

```
// Create a sub, and store it in a super pointer.
Super* superPointer = new Sub();
```

What I Can Do As a Subclass?

- Define my own methods and members.

- Access `public` and `protected` data of my superclass as though they were my own, but I can't access `private` data:

```
void Sub::otherMethod()
{
    cout << "I can access superclass' mProtectedInt."
    cout << "Its value is " << mProtectedInt; // OK!
    cout << "But not private: " << mPrivateInt; // BUG!
}
```

- Change the behavior of my superclass' methods by *overriding* them.

The `virtual` Keyword

In order to be properly overridable, a method must be virtual in the superclass. My suggestion: **make *everything* virtual except ctors and static methods!**

```
class Super
{
  public:
      Super();

      virtual void someMethod(); // now with overridability!

  protected:
         int mProtectedInt;

  private:
         int mPrivateInt;
};
```

Overriding a Method

```
// Super.cpp
void Super::someMethod()
{
    cout << "This is Super's someMethod()." << endl;
}


// Sub.h
class Sub : public Super
{
 public:
  Sub();

  virtual void someMethod(); // Override Super someMethod()
  virtual void otherMethod();
};
```

```
// Sub.cpp
void Sub::someMethod()
{
    cout << "This is Sub's someMethod()." << endl;
}
```

What will each of these print?

```
Super mySuper;
mySuper.someMethod();

Sub mySub;
mySub.someMethod();

Sub mySub;
Super& ref = mySub;
ref.someMethod();
```

Slicing: Reason #28 Why Java Programmers Complain about C++

Even though a pointer or reference to a Super can actually refer to a Sub, non-pointer/ref objects will be sliced:

```
Sub mySub;
Super assignedObject = mySub; // Assign Sub to a Super.

assignedObject.someMethod();  // Calls Super's someMethod()
```

Subclasses lose their uniqueness when cast to a superclass. They retain their uniqueness when access by a pointer or reference to the superclass.

Example of Subclassing for Code Reuse

```
// WeatherPrediction.h

/**
 * Predicts the weather using proven new-age
 * techniques given the current temperature
 * and the distance from Jupiter to Mars. If
 * these values are not provided, a guess is
 * still given but it's only 99% accurate.
 */
class WeatherPrediction
{
    public:
        virtual void setCurrentTempFahrenheit(int inTemp);
        virtual void setPositionOfJupiter(int
                                     inDistanceFromMars);
```

```
    /**
     * Gets the prediction for tomorrow's temperature
     */
    virtual int getTomorrowTempFahrenheit();

    /**
     * Gets the probability of rain tomorrow. 1 means
     * definite rain. 0 means no chance of rain.
     */
    virtual double getChanceOfRain();

    /**
     * Displays the result to the user in this format:
     * Result: x.xx chance. Temp. xx
     */
    virtual void showResult();

    protected:
        int mCurrentTempFahrenheit;
        int mDistanceFromMars;
};
```

Modify this class so that:

- It works with Celsius
- The output is nicer

```
// MyWeatherPrediction.h
class MyWeatherPrediction : public WeatherPrediction {
    public:
        virtual void setCurrentTempCelsius(int inTemp);
        virtual int getTomorrowTempCelsius();
        virtual void showResult();   // override

    protected:
        static int convertCelsiusToFahrenheit(int
                        inCelsius);
        static int convertFahrenheitToCelsius(int
                        inFahrenheit);
};
```

```
void MyWeatherPrediction::setCurrentTempCelsius(int inTemp)
{
    int fahrenheitTemp = convertCelsiusToFahrenheit(inTemp);
    setCurrentTempFahrenheit(fahrenheitTemp);
}

int MyWeatherPrediction::getTomorrowTempCelsius()
{
    int fahrenheitTemp = getTomorrowTempFahrenheit();
    return convertFahrenheitToCelsius(fahrenheitTemp);
}
```

The new methods *wrap* existing methods defined in the superclass. You can also add completely new, unrelated functionality in the same way.

```
void MyWeatherPrediction::showResult()
{
    cout << "Tomorrow's temperature will be " <<
            getTomorrowTempCelsius() << " C (" <<
            getTomorrowTempFahrenheit() << " F)" << endl;

    cout << "The chance of rain is " << (getChanceOfRain()
           * 100) << " percent" << endl;

    if (getChanceOfRain() > 0.5) {
        cout << "Bring an umbrella!" << endl;
    }
}
```

This method *replaces* the superclass version.

Call Your Parents at Least Once a Month

Here's how C++ constructs a class:

1. If there is a superclass, construct it first.
2. Construct non-static data members in the order of declaration.
3. Execute the body of the constructor.

```
class Something {
    public:
        Something() { cout << "2"; }
};

class Parent {
    public:
        Parent() { cout << "1"; }
};

class Child : public Parent {
    public:
        Child() { cout << "3"; }

    protected:
        Something mDataMember;
};

int main(int argc, char** argv) {
    Child myChild;
}
```

Superclasses with Non-Zero-Arg Constructors

If your parent class has a zero-arg constructor, it will be called automatically. If it doesn't, or if you want to use a different parent constructor, call it on the initializer list:

```
// Super.h
class Super
{
    public:
        Super(int i);
};

// Sub.cpp
Sub::Sub() : Super(7)
{
    // Do Sub's other initialization here.
}
```

You can also pass arguments of one constructor into another:

```
Sub::Sub(int i) : Super(i)
{
    // Do Sub's other initialization here.
}
```

However, you should not pass a data member, because it won't be initialized:

```
Sub::Sub() : Super(mSubDataMember) // BUG!
{
    // Do Sub's other initialization here.
}
```

Destructors, Parents, and Children

- Destruction happens in the reverse order of construction.
- Destructors should *always* be virtual!
- Each class only cleans up its own data. Let your parent clean up theirs.

Referring to Parent Data

- Implied (see earlier weather example)
- Explicit

```
class Book
{
    public:
        virtual string getDescription() { return "Book"; }
};

class Paperback : public Book
{
    public:
        virtual string getDescription() {
            // avoid infinite loop!
            return "Paperback " + Book::getDescription();
        }
};
```

```
class Romance : public Paperback
{
    public:
        virtual string getDescription() {
           return "Romance " + Paperback::getDescription();
        }
};

class Technical : public Book
{
    public:
        virtual string getDescription() {
           return "Technical " + Book::getDescription();
        }
};
```

Casting and Subclassing

Upcasting:

```
Super mySuper = mySub;  // SLICE!
Super& mySuper = mySub; // No slice!
```

Downcasting, if you absolutely must:

```
void presumptuous(Super* inSuper) {
   Sub* mySub = static_cast<Sub*>(inSuper);  // BAD!
   // Proceed to access Sub methods on mySub.
}

void lessPresumptuous(Super* inSuper) {
    Sub* mySub = dynamic_cast<Sub*>(inSuper); // OK!
    if (mySub != NULL) {
     // Proceed to access Sub methods on mySub.
    }
}
```

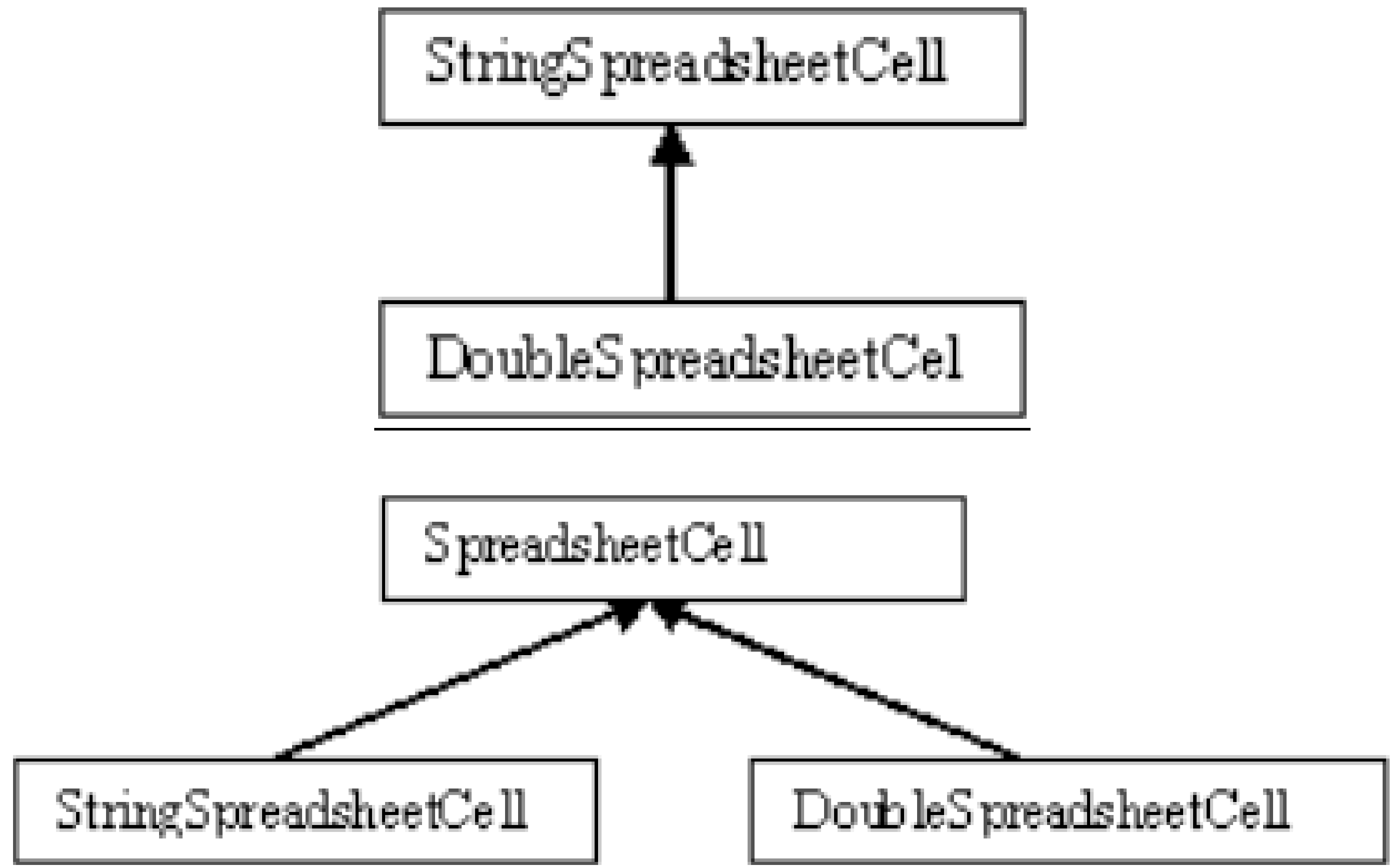
Crosscasting == BAD!

Inheritance for Polymorphism

Polymorphism lets you use objects with a common parent interchangeably.

```
class SpreadsheetCell {
    public:
        SpreadsheetCell();

        virtual void set(double inDouble);
        virtual void set(const std::string& inString);
        virtual std::string getString();

    protected:
        static std::string doubleToString(double inValue);
        static double stringToDouble(const std::string&
                                                  inString);

        double      mValue;
        std::string mString;
};
```

Class Hierarchy Design Approaches



The SpreadsheetCell hierarchy is *polymorphic* because:

- Both subclasses support the same interface (set of methods) defined by the base class.
- Code that uses a SpreadsheetCell can call any of its methods without knowing (or caring) whether the StringSpreadsheetCell implementation will be used or the DoubleSpreadsheetCell will.
- Through virtual methods, the appropriate implementation will be called, as long as we use pointers or references.
- A collection (vector?) of SpreadsheetCells can be created that stores both String cells and double cells.

Defining the Base Class

- All cells need to be able to set with a string and return a string, even cells that actually contain doubles.

- You can never create a generic SpreadsheetCell. It must always be a StringSpreadsheetCell or a DoubleSpreadsheetCell.

```
class SpreadsheetCell  // an "abstract class"
{
    public:
        SpreadsheetCell() {};
        virtual ~SpreadsheetCell() {};

        virtual void set(const std::string& inString) = 0;

        virtual std::string getString() const = 0;
};
```

```
class StringSpreadsheetCell : public SpreadsheetCell {
    public:
        StringSpreadsheetCell();
        virtual void set(const std::string& inString);

        virtual std::string getString() const;
    protected:
        std::string mValue;
};

StringSpreadsheetCell::StringSpreadsheetCell()
          : mValue("#NOVALUE"){}

void StringSpreadsheetCell::set(const string& inString) {
    mValue = inString;
}

string StringSpreadsheetCell::getString() const {
    return mValue;
}
```

```
class DoubleSpreadsheetCell : public SpreadsheetCell
{
    public:
        DoubleSpreadsheetCell ();
        virtual void set(double inDouble);
        virtual void set(const std::string& inString);

        virtual std::string getString() const;

    protected:
        static std::string doubleToString(double inValue);
        static double stringToDouble(const std::string&
                                        inValue);
        double mValue;
};
```

```
DoubleSpreadsheetCell::DoubleSpreadsheetCell():mValue(-1){}

void DoubleSpreadsheetCell::set(double inDouble)
{
    mValue = inDouble;
}

void DoubleSpreadsheetCell::set(const string& inString)
{
    mValue = stringToDouble(inString);
}

string DoubleSpreadsheetCell::getString() const
{
    return doubleToString(mValue);
}
```

Result: Each class is self-centered. StringSpreadsheetCell only worries about storing string values. DoubleSpreadsheetCell only worries about storing doubles. No more split personality!

Using Polymorphic Objects

```
int main(int argc, char** argv) {
    SpreadsheetCell* cellArray[3];

    cellArray[0] = new StringSpreadsheetCell();
    cellArray[1] = new StringSpreadsheetCell();
    cellArray[2] = new DoubleSpreadsheetCell();

    cellArray[0]->set("hello");
    cellArray[1]->set("10");
    cellArray[2]->set("18");

    cout << "Array values are [" <<
        cellArray[0]->getString() << "," <<
        cellArray[1]->getString() << "," <<
        cellArray[2]->getString() << "]" << endl;
}
```

Grid<SpreadsheetCell*> mySpreadsheet;

Multiple Inheritance

```
class Baz : public Foo, public Bar
{
    // Etc.
};
```

- Baz is a Foo
- Baz is a Bar
- Baz can be cast to a Foo or a Bar

What if both superclasses have a method with the same name?

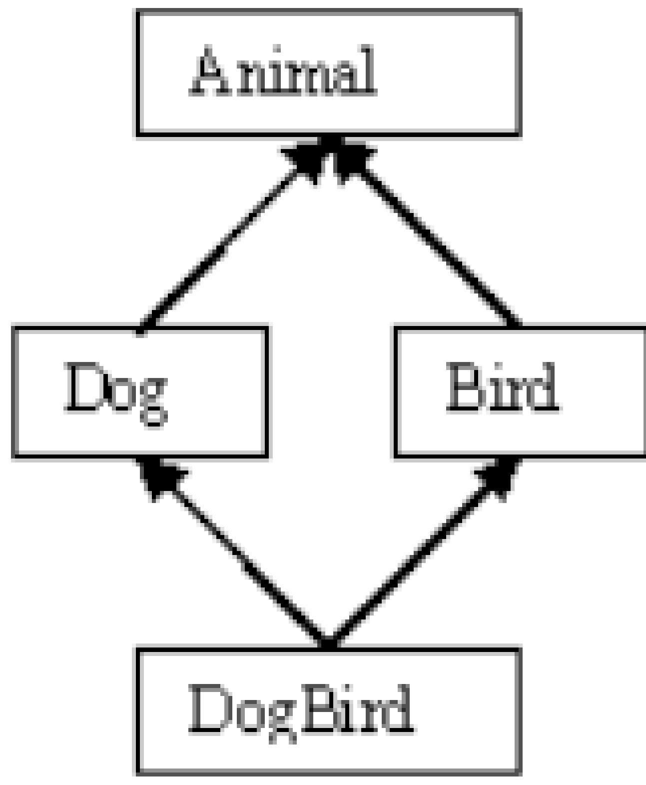
The compiler will give an error, unless you explicitly say which parent you are referring to by casting or using the following syntax:

```
myBaz.Foo::someMethod();
```

Or inside of a Baz method:

```
void Baz::doSomething() {
    Foo::someMethod();
}
```

What if Two Parents Have a Parent in Common?



Solution: virtual base classes (see book)

Can you…

change the return type in a method you override?

You *can* if it's a subclass of the original return type, but you probably *shouldn't*.

change the arguments in the overridden version?

You *can* if you use default args to make it compatible, but you probably *shouldn't*.

override a static method?

No. It will compile, but static methods are bound to the declared type at compile time. Static methods are *not virtual!*

override some versions of a method, but not others?

You *can*, but it's bad style. The other versions will be superficially hidden.

override protected or private methods?

You bet! It's very common.

change the default arguments when I override?

You *can*, but this has very strange consequences. You *shouldn't*.

make a public method private by overriding it?

Only *superficially*. You can't truly prevent access to it.

make a private method public by overriding it?

Yes, but only by creating a new public method that calls the private one.

See Chapter 10 for further discussions of these questions!

Subclassing and Well Behaved Classes

- If you write a copy constructor for the subclass, you must explicitly "chain" to the copy constructor for the superclass.
- If you write operator= for the subclass, you should call operator= on the superclass.

```
Sub::Sub(const Sub& inSub) : Super(inSub) {}

Sub& Sub::operator=(const Sub& inSub) {
    if (&inSub == this) {
        return *this;
    }
    Super::operator=(inSub) // Call parent's operator=.

    // Do necessary assignments for subclass.
    return (*this);
}
```

Run Time Type Identification (RTTI)

```
#include <typeinfo>

// should really be a method on Animal!
void speak(const Animal& inAnimal)
{
    if (typeid(inAnimal) == typeid(Dog&)) {
        cout << "Woof!" << endl;
    } else if (typeid(inAnimal) == typeid(Bird&) {
        cout << "Chirp!" << endl;
    }
}


void logObject(Loggable& inLoggableObject)
{
    logfile << typeid(inLoggableObject).name() << " ";
    logfile << inLoggableObject.getLogMessage() << endl;
}
```