UNIVERSITY OF OREGON

CIS 330:

```
   __  __      _                         __   ______    __ ______
  / / / /___  (_)  __   ____ _____  ____/ /  / ____/  _/_// ____/__    __
 / / / / __ \/ / |/_/  / __ `/ __ \/ __  /  / /     _/_/ / /  __/ /___/ /_
/ /_/ / / / / />  <   / /_/ / / / / /_/ /  / /___ _/_/  / /__/_  __/_  __/
\____/_/ /_/_/_/|_|   \__,_/_/ /_/\__,_/   \____//_/    \____/ /_/   /_/
```

Lecture 16: exceptions, Virtual function table

May 18th, 2018

Hank Childs, University of Oregon

Project 3E

- You will need to think about how to accomplish the data flow execution pattern and think about how to extend your implementation to make it work.
- This prompt is vaguer than some previous ones
  - … not all of the details are there on how to do it

Project 3E

```
    blender.SetInput(tbconcat2.GetOutput());
    blender.SetInput2(reader.GetOutput());

    writer.SetInput(blender.GetOutput());

    reader.Execute();
    shrinker1.Execute();
    lrconcat1.Execute();
    tbconcat1.Execute();
    shrinker2.Execute();
    lrconcat2.Execute();
    tbconcat2.Execute();
    blender.Execute();

    writer.Write(argv[2]);
}
```

```
    blender.SetInput(tbconcat2.GetOutput());
    blender.SetInput2(reader.GetOutput());

    writer.SetInput(blender.GetOutput());

    blender.GetOutput()->Update();
    writer.Write(argv[2]);
}
```

Project 3E

- Worth 3% of your grade
- Assigned today, due May 23

New Stuff: Exceptions

Exceptions

- C++ mechanism for handling error conditions
- Three new keywords for exceptions
  - try: code that you "try" to execute and hope there is no exception
  - throw: how you invoke an exception
  - catch: catch an exception … handle the exception and resume normal execution

Exceptions

```
fawcett:330 childs$ cat exceptions.C
#include <iostream>
using std::cout;
using std::endl;

int main()
{
    try
    {
        cout << "About to throw 105" << endl;
        throw 105;
        cout << "Done throwing 105" << endl;
    }
    catch (int &theInt)
    {
        cout << "Caught an int: " << theInt << endl;
    }
}
fawcett:330 childs$ g++ exceptions.C
```

Exceptions: catching multiple types

```
fawcett:330 childs$ cat exceptions2.C
#include <iostream>
using std::cout;
using std::endl;

int main()
{
    try
    {
        cout << "About to throw 105" << endl;
        throw 105;
        cout << "Done throwing 105" << endl;
    }
    catch (int &theInt)
    {
        cout << "Caught an int: " << theInt << endl;
    }
    catch (float &theFloat)
    {
        cout << "Caught a float: " << theFloat << endl;
    }
}
fawcett:330 childs$ g++ exceptions2.C
fawcett:330 childs$ ./a.out
About to throw 105
Caught an int: 105
```

Exceptions: catching multiple types

```
fawcett:330 childs$ cat exceptions3.C
#include <iostream>
using std::cout;
using std::endl;

int main()
{
    try
    {
         cout << "About to throw 10.5" << endl;
         throw 10.5;
         cout << "Done throwing 10.5" << endl;
    }
    catch (int &theInt)
    {
         cout << "Caught an int: " << theInt << endl;
    }
    catch (float &theFloat)
    {
         cout << "Caught a float: " << theFloat << endl;
    }
}
fawcett:330 childs$ g++ exceptions3.C
fawcett:330 childs$ ./a.out
About to throw 10.5
terminate called after throwing an instance of 'double'
Abort trap
```

Exceptions: catching multiple types

```
fawcett:330 childs$ cat exceptions4.C
#include <iostream>
using std::cout;
using std::endl;

int main()
{
    try
    {
        cout << "About to throw 10.5" << endl;
        throw 10.5;
        cout << "Done throwing 10.5" << endl;
    }
    catch (int &theInt)
    {
        cout << "Caught an int: " << theInt << endl;
    }
    catch (float &theFloat)
    {
        cout << "Caught a float: " << theFloat << endl;
    }
    catch (double &theDouble)
    {
        cout << "Caught a double: " << theDouble << endl;
    }
}
```

```
fawcett:330 childs$ g++ exceptions4.C
fawcett:330 childs$ ./a.out
About to throw 10.5
Caught a double: 10.5
fawcett:330 childs$
```

Exceptions: throwing/catching complex types

```
class MyExceptionType  { };

class MemoryException : public MyExceptionType {};
class FailedAllocationException : public MemoryException {};
class NULLPointerException : public MemoryException {};

class FloatingPointException : public MyExceptionType {};
class DivideByZeroException : public FloatingPointException {};
class OverflowException : public FloatingPointException {};
```

```
void Foo();

int main()
{
    try
    {
        Foo();
    }
    catch (MemoryException &e)
    {
        cout << "I give up" << endl;
    }
    catch (OverflowException &e)
    {
        cout << "I think it is OK" << endl;
    }
    catch (DivideByZeroException &e)
    {
        cout << "The answer is bogus" << endl;
    }
}
```

Exceptions: cleaning up before you return

```
void Foo(int *arr);

int *
Foo2(void)
{
    int  *arr = new int[1000];
    try
    {
        Foo(arr);
    }
    catch (MyExceptionType &e)
    {
         delete [] arr;
         return NULL;
    }

    return arr;
}
```

Exceptions: re-throwing

```
void Foo(int *arr);

int *
Foo2(void)
{
    int  *arr = new int[1000];
    try
    {
        Foo(arr);
    }
    catch (MyExceptionType &e)
    {
        delete [] arr;
        throw e;
    }

    return arr;
}
```

Exceptions: catch and re-throw anything

```
void Foo(int *arr);

int *
Foo2(void)
{
    int  *arr = new int[1000];
    try
    {
        Foo(arr);
    }
    catch (...)
    {
         delete [] arr;
         throw;
    }

    return arr;
}
```

Exceptions: declaring the exception types you can throw

```
int *
MyIntArrayMemoryAllocator(int num) throw(FloatingPointException)
{
    int  *arr = new int[num];
    if (arr == NULL)
        throw DivideByZeroException();

    return arr;
}
```

Exceptions: declaring the exception types you can throw ... not all it is cracked up to be

```
int *
MyIntArrayMemoryAllocator(int num) throw(FloatingPointException)
{
    int  *arr = new int[num];
    if (arr == NULL)
        throw MemoryException();

    return arr;
}
```

This will compile ... compiler can only enforce this as a run-time thing.

As a result, this is mostly unused (I had to read up on it)

But: "standard" exceptions have a "throw" in their declaration.

std::exception

- c++ provides a base type called “std::exception”
- It provides a method called “what”

```
// using standard exceptions
#include <iostream>
#include <exception>
using namespace std;

class myexception: public exception
{
  virtual const char* what() const throw()
  {
    return "My exception happened";
  }
} myex;

int main () {
  try
  {
    throw myex;
  }
  catch (exception& e)
  {
    cout << e.what() << '\n';
  }
  return 0;
}
```

Source: cplusplus.com

Exceptions generator by C++ standard library

exception	description
bad_alloc	thrown by new on allocation failure
bad_cast	thrown by dynamic_cast when it fails in a dynamic cast
bad_exception	thrown by certain dynamic exception specifiers
bad_typeid	thrown by typeid
bad_function_call	thrown by empty function objects
bad_weak_ptr	thrown by shared_ptr when passed a bad weak_ptr

Source: cplusplus.com

3F

Project 3F in a nutshell

- Logging:
  - infrastructure for logging
  - making your data flow code use that infrastructure
- Exceptions:
  - infrastructure for exceptions
  - making your data flow code use that infrastructure

The webpage has a head start at the infrastructure pieces for you.

Warning about 3F

- My driver program only tests a few exception conditions
- Your stress tests later will test a lot more.
  - Be thorough, even if I'm not testing it

3F timeline

- Assigned tonight, due Saturday May 26th

3F: warning

- 3F will almost certainly crash your code
  - It uses your modules wrong!
- You will need to figure out why, and add exceptions
  - gdb will be helpful

Review: Access Control

Two contexts for access control

```
class A : public B {
    public:
        A() { x=0; y=0; };
        int foo() { x++; return foo2(); };
    private:
        int x, y;
        int foo2() { return x+y; };
};
```

defines how a class inherits from another class

defines access controls for data members and methods

Inheritance ("class A : public B")

- public → "is a"
  - (I never used anything but public)
- private → "implemented using"
  - (I have never used this, but see how it could be useful)
- protected → the internet can not think of any useful examples for this

Access Control

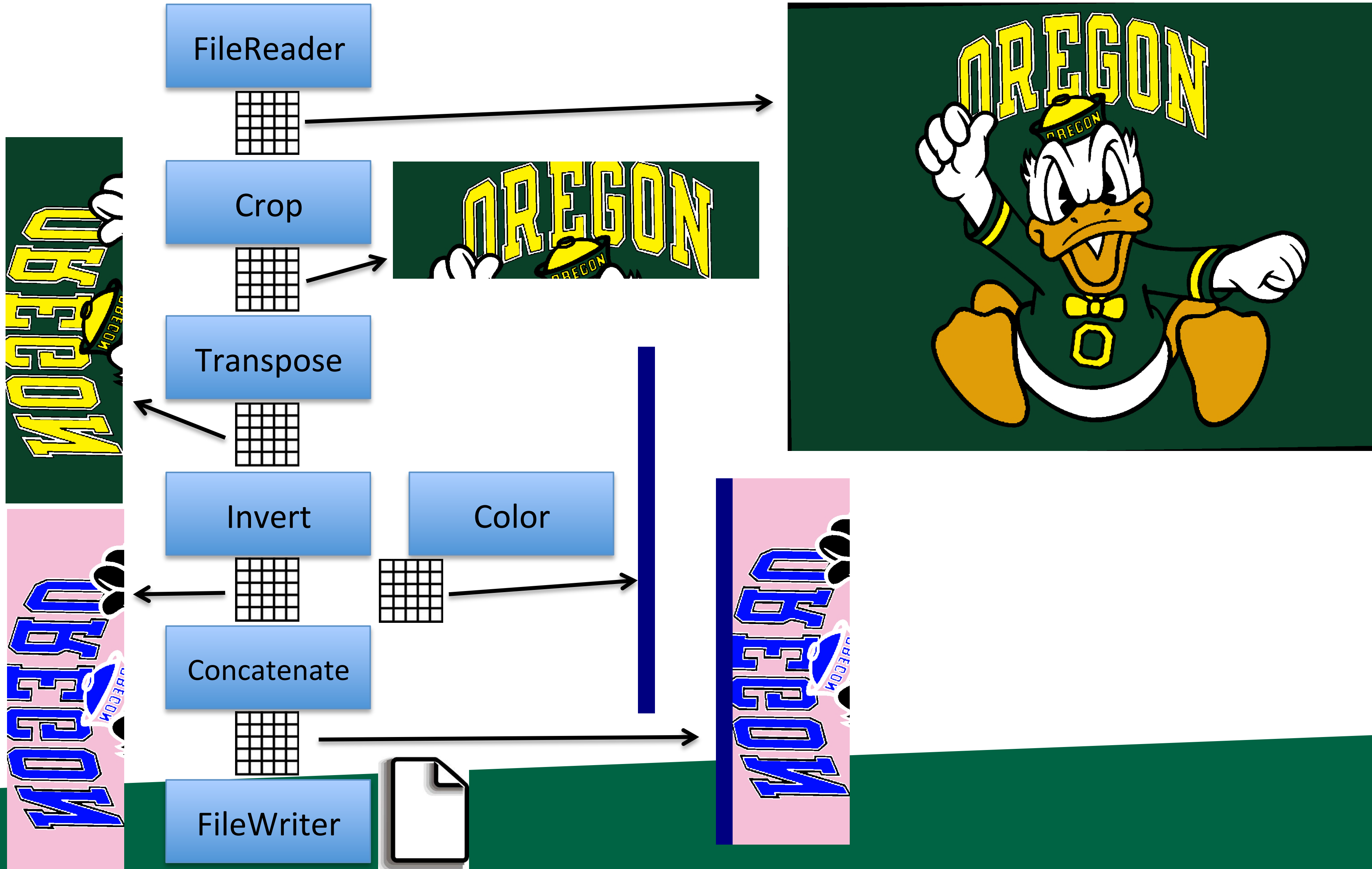
```
class Hank
{
  public/private/protected:
    BankAccount hanksId;
};
```

Access control type	Who can read it
private	Only Hank class
public	Anyone
protected	Those who inherit from Hank

Class Vs Struct

- Class:
  - Default inheritance is private
    - That’s why you add public (class A : public B)
  - Default access control is private
- Struct:
  - Default inheritance is public
    - That’s why you don’t have to add public (struct A : B)
  - Default access control is public

Example of data flow (image processing)



How C++ Does Methods

"this": pointer to current object

- From within any struct's method, you can refer to the current object using "this"

```
TallyCounter::TallyCounter(int c)
{
    count = c;
}

     <------>

TallyCounter::TallyCounter(int c)
{
    this->count = c;
}
```

How methods work under the covers (1/4)

```
class  MyIntClass
{
  public:
                  MyIntClass(int x) { myInt = x; };

    friend void   FriendIncrementFunction(MyIntClass *);
    int           GetMyInt() { return myInt; };

  protected:
    int           myInt;
};

void
FriendIncrementFunction(MyIntClass *mic)
{
    mic->myInt++;
}

int main()
{
    MyIntClass MIC(12);
    FriendIncrementFunction(&MIC);
    FriendIncrementFunction(&MIC);
    cout << "My int is " << MIC.GetMyInt() << endl;
}
```

```
fawcett:330 childs$ g++ this.C
fawcett:330 childs$ ./a.out
My int is 14
fawcett:330 childs$
```

How methods work under the covers (2/4)

```
class  MyIntClass
{
  public:
                   MyIntClass(int x) { myInt = x; };

    friend void    FriendIncrementFunction(MyIntClass *);
    int            GetMyInt() { return myInt; };

  protected:
    int            myInt;
};

void
FriendIncrementFunction(MyIntClass *mic)
{
    mic->myInt++;
}

int main()
{
    MyIntClass MIC(12);
    FriendIncrementFunction(&MIC);
    FriendIncrementFunction(&MIC);
    cout << "My int is " << MIC.GetMyInt() << endl;
}
```

Addr.	Variable	Value
0x8000	MIC/ myInt	12

Addr.	Variable	Value
0x8000	MIC/ myInt	12
0x8004	mic	0x8000

How methods work under the covers (3/4)

```
class  MyIntClass
{
  public:
                    MyIntClass(int x) { myInt = x; };

    friend void     FriendIncrementFunction(MyIntClass *);
    void            IncrementMethod(void);
    int             GetMyInt() { return myInt; };

  protected:
    int             myInt;
};

void
FriendIncrementFunction(MyIntClass *mic)
{
    mic->myInt++;
}

void
MyIntClass::IncrementMethod(void)
{
    this->myInt++;
}

int main()
{
    MyIntClass MIC(12);
    FriendIncrementFunction(&MIC);
    MIC.IncrementMethod();
    cout << "My int is " << MIC.GetMyInt() << endl;
}
```

```
fawcett:330 childs$ g++ this.C
fawcett:330 childs$ ./a.out
My int is 14
fawcett:330 childs$
```

How methods work under the covers (4/4)

The compiler secretly slips "this" onto the stack whenever you make a method call.

It also automatically changes "myInt" to this->myInt in methods.

```
class  MyIntClass
{
}

{
    mic->myInt++;
}

void
MyIntClass::IncrementMethod(void)
{
    this->myInt++;
}

int main()
{
    MyIntClass MIC(12);
    FriendIncrementFunction(&MIC);
    MIC.IncrementMethod();
    cout << "My int is " << MIC.GetMyInt() << endl;
}
```

Addr.	Variable	Value
0x8000	MIC/ myInt	12

Addr.	Variable	Value
0x8000	MIC/ myInt	12
0x8004	mic	0x8000

Addr.	Variable	Value
0x8000	MIC/ myInt	13
0x8004	this	0x8000

Virtual Function Tables

Virtual functions

- Virtual function: function defined in the base type, but can be re-defined in derived type.
- When you call a virtual function, you get the version defined by the derived type

Virtual functions: example

```
128-223-223-72-wireless:330 hank$ cat virtual.C
#include <stdio.h>

struct SimpleID
{
   int id;
   virtual int GetIdentifier() { return id; };
};

struct ComplexID : SimpleID
{
   int extraId;
   virtual int GetIdentifier() { return extraId*128+id; };
};

int main()
{
   ComplexID cid;
   cid.id = 3;
   cid.extraId = 3;
   printf("ID = %d\n", cid.GetIdentifier());
}
128-223-223-72-wireless:330 hank$ g++ virtual.C
128-223-223-72-wireless:330 hank$ ./a.out
ID = 387
```

Picking the right virtual function

```
class A
{
  public:
    virtual const char *GetType() { return "A"; };
};

class B : public A
{
  public:
    virtual const char *GetType() { return "B"; };
};

int main()
{
    A a;
    B b;

    cout << "a is " << a.GetType() << endl;
    cout << "b is " << b.GetType() << endl;
}

fawcett:330 childs$ g++ virtual.C
fawcett:330 childs$ ./a.out
```

It seems like the compiler should be able to figure this out ...
it knows that a is of type A
and
it knows that b is of type B

??????

Picking the right virtual function

```
class A
{
  public:
    virtual const char *GetType() { return "A"; };
};

class B : public A
{
  public:
    virtual const char *GetType() { return "B"; };
};

void
ClassPrinter(A *ptrToA)
{
    cout << "ptr points to a " << ptrToA->GetType() << endl;
}

int main()
{
    A a;
    B b;

    ClassPrinter(&a);
    ClassPrinter(&b);
}

fawcett:330 childs$ g++ virtual2.C
fawcett:330 childs$ ./a.out
```

??????

So how to does the compiler know?

How does it get "B" for "b" and "A" for "a"?

Virtual Function Table

- Let C be a class and X be an instance of C.
- Let C have 3 virtual functions & 4 non-virtual functions
- C has a hidden data member called the "virtual function table"
- This table has 3 rows
  - Each row has the correct definition of the virtual function to call for a "C".
- When you call a virtual function, this table is consulted to locate the correct definition.

Showing the existence of the virtual function pointer with sizeof()

```
class A
{
  public:
    virtual (
};

class B : public A
{
  public:
    virtual (
};

class C
{
  public:
    const char *GetType() { return "C"; };
};

int main()
{
    A a;
    B b;

    cout << "Size of A is " << sizeof(A) << endl;
    cout << "Size of a pointer is " << sizeof(int *) << endl;
    cout << "Size of C is " << sizeof(C) << endl;
}
```

empty objects have size of 1? why?!?

Answer: so every object has a unique address.

```
fawcett:330 childs$ ./a.out
Size of A is 8
Size of a pointer is 8
Size of C is 1
```

what will this print?

Virtual Function Table

- Let C be a class and X be an instance of C.
- Let C have 3 virtual functions & 4 non-virtual functions
- Let D be a class that inherits from C and Y be an instance of D.
  - Let D add a new virtual function
- D's virtual function table has 4 rows
  - Each row has the correct definition of the virtual function to call for a "D".

More notes on virtual function tables

- There is one instance of a virtual function table for each class
  - Each instance of a class shares the same virtual function table
- Easy to overwrite (i.e., with a memory error)
  - And then all your virtual function calls will be corrupted
  - Don’t do this! ;)

Virtual function table: example

CIS 330: Project #2C
Assigned: April 17th, 2014
Due April 24th, 2014
(which means submitted by 6am on April 25th, 2014)
Worth 6% of your grade

Please read this entire prompt!

Assignment: You will implement subtypes with C.

1) Make a union called ShapeUnion with the three types (Circle, Rectangle, Triangle).
2) Make a struct called FunctionTable that has pointers to functions.
3) Make an enum called ShapeType that identifies the three types.
4) Make a struct called Shape that has a ShapeUnion, a ShapeType, and a FunctionTable.
5) Modify your 9 functions to deal with Shapes.
6) Integrate with the new driver function. Test that it produces the correct output.

Virtual function table: example

```
class Shape
{
    virtual double GetArea() = 0;
    virtual void   GetBoundingBox(double *) = 0;
};

class Rectangle : public Shape
{
  public:
                   Rectangle(double, double, double, double);
    virtual double GetArea();
    virtual void   GetBoundingBox(double *);
  protected:
    double minX, maxX, minY, maxY;
};

class Triangle : public Shape
{
  public:
                   Triangle(double, double, double, double);
    virtual double GetArea();
    virtual void   GetBoundingBox(double *);
  protected:
    double pt1X, pt2X, minY, maxY;
};
```

Questions

- What does the virtual function table look like for a Shape?

```
typedef struct
{
    double (*GetArea)(Shape *);
    void   (*GetBoundingBox)(Shape *, double *);
} VirtualFunctionTable;
```

- What does Shape's virtual function table look like?
  - Trick question: Shape can't be instantiated, precisely because you can't make a virtual function table
    - abstract type due to pure virtual functions

Questions

- What is the virtual function table for Rectangle?

```
c->ft.GetArea = GetRectangleArea;
c->ft.GetBoundingBox = GetRectangleBoundingBox;
```

- (this is a code fragment from my 2C solution)

Calling a virtual function

- Let X be an instance of class C.
- Assume you want to call the 4th virtual function
- Let the arguments to the virtual function be an integer Y and a float Z.
- Then call:

The 4th virtual function has index 3 (0-indexing)

```
(X.vptr[3])(&X, Y, Z);
```

The pointer to the virtual function pointer (often called a vptr) is a data member of X

Secretly pass “this” as first argument to method

Inheritance and Virtual Function Tables

```
class A
{
  public:
```

This whole scheme gets much harder with multiple inheritance, and you have to carry around multiple virtual function tables.

```
    virtual void Foo2();
};
```

A	
	Location of Foo1

	Location of Foo1
Foo2	Location of Foo2

```
class C : public B
{
  public:
    virtual void Foo1();
    virtual void Foo2();
    virtual void Foo3();
};
```

Same as B's
This is how you can treat a C as a B

C	
Foo1	Location of Foo1
Foo2	Location of Foo2
Foo3	Location of Foo3

Virtual Function Table: Summary

- Virtual functions require machinery to ensure the correct form of a virtual function is called
- This is implemented through a virtual function table
- Every instance of a class that has virtual functions has a pointer to its class's virtual function table
- The virtual function is called via following pointers
  - Performance issue

Now show Project 2D in C++

- Comment:
  - C/C++ great because of performance
  - Performance partially comes because of a philosophy of not adding “magic” to make programmer’s life easier
  - C has very little pixie dust sprinkled in
    - Exception: ‘\0’ to terminate strings
  - C++ has more
    - Hopefully this will demystify one of those things (virtual functions)

vptr.C

```
fawcett:vptr childs$ cat vptr.C
#include <iostream>
using std::cerr;
using std::endl;

class Shape
{
  public:
     int s;
     virtual double GetArea() = 0;
     virtual void   GetBoundingBox(double *) = 0;
};

class Triangle : public Shape
{
  public:
     virtual double GetArea() { cerr << "In GetArea for Triangle" << endl; return 1;};
     virtual void GetBoundingBox(double *) { cerr << "In GetBBox for Triangle" << endl; };
};

class Rectangle : public Shape
{
  public:
     virtual double GetArea() { cerr << "In GetArea for Rectangle" << endl; return 2; };
     virtual void GetBoundingBox(double *) { cerr << "In GetBBox for Rectangle" << endl; };
};

struct VirtualFunctionTable
{
     double (*GetArea)(Shape *);
     void (*GetBoundingBox)(Shape *, double *);
};


int main()
{
    Rectangle r;
    cerr << "Size of rectangle is " << sizeof(r) << endl;

    VirtualFunctionTable *vft = *((VirtualFunctionTable**)&r);
    cerr << "Vptr = " << vft << endl;
    double d = vft->GetArea(&r);
    cerr << "Value = " << d << endl;

    double bbox[4];
    vft->GetBoundingBox(&r, bbox);
}
```

Pitfalls

Pitfall #1

```
void AllocateBuffer(int w, int h, unsigned char **buffer)
{
    *buffer = new unsigned char[3*w*h];
}

int main()
{
    int w = 1000, h = 1000;
    unsigned char *buffer = NULL;
    AllocateBuffer(w, h, &buffer);
}
```

This is using call-by-value, not call-by-reference.

Pitfall #2

```
struct Image
{
    int width;
    int height;
    unsigned char *buffer;
};

Image *ReadFromFile(char *filename)
{
    Image *rv = NULL;

    /*  OPEN FILE, descriptor = f */
    /*    ...      */
    /*   set up width w,  and height h */
    /*    ...      */

    rv = malloc(sizeof(Image));
    rv->width  = w;
    rv->height = h;
    fread(rv->buffer, sizeof(unsigned char), w*h, f);
}
```

Pitfall #3

- int *s = new int[6*sizeof(int)];

Pitfall #4

```
int main()
{
    // new black image
    int height = 1000, width = 1000;
    unsigned char *buffer = new unsigned char[3*width*height];
    for (int i = 0 ; i < sizeof(buffer) ; i++)
    {
        buffer[i] = 0;
    }
}
```

- Assume:

  int *X = new int[100];
- What is sizeof(X)?
- What is sizeof(*X)?

Pitfall #5

```
/* struct definition */
struct Image
{
   /* data members */
};

/* prototypes */
void WriteImage(Image *, const char *);


/* main */
int main()
{
    Image *img = NULL;
    /* set up Image */
    const char *filename = "out.pnm";
    WriteImage(img, filename);
}

/* WriteImage function */
void WriteImage(char *filename, Image *img)
{
   /* code to write img to filename */
}
```

```
fawcett:330 childs$ g++ write_image.c
Undefined symbols:
  "WriteImage(Image*, char const*)", referenced from:
      _main in ccSjC6w2.o
ld: symbol(s) not found
collect2: ld returned 1 exit status
```

(not-a-)Pitfall #6

```
unsigned char* Image::getPixel(int i, int j) {
    int pixStart = 3*i*this->width+3+j;
    unsigned char *pixel = new unsigned char[3];
    pixel[0] = this->data[pixStart];
    pixel[1] = this->data[pixStart + 1];
    pixel[2] = this->data[pixStart + 2];
    return pixel;
}
```

```
unsigned char* Image::getPixel(int i, int j) {
    int pixStart = 3*i*this->width+3+j;
    return this->data+pixStart;
}
```

Top requires memory allocation / deletion, and does extra copy.

Pitfall #7

- For objects on the stack, the destructors are called when a function goes out of scope
  - You may have a perfectly good function, but it seg-faults on return
- Especially tricky for main
  - program ran to completion, and crashed at the very end

Pitfall #8

```
#include <stdlib.h>

class Image
{
  public:
                       Image() { width = 0; height = 0; buffer = NULL; };
    virtual           ~Image() { delete [] buffer; };

    void               ResetSize(int width, int height);
    unsigned char     *GetBuffer(void) { return buffer; };

  private:
    int width, height;
    unsigned char *buffer;
};

void
Image::ResetSize(int w, int h)
{
    width  = w;
    height = h;
    if (buffer != NULL)
        delete [] buffer;
    buffer = new unsigned char[3*width*height];
}
```

```
int main()
{
    Image img;
    unsigned char *buffer = img.GetBuffer();
    img.ResetSize(1000, 1000);
    for (int i = 0 ; i < 1000 ; i++)
        for (int j = 0 ; j < 1000 ; j++)
            for (int k = 0 ; k < 1000 ; k++)
             buffer[3*(i*1000+j)+k] = 0;
}
```

Bonus Topics

Backgrounding

- “&”: tell shell to run a job in the background
  – Background means that the shell acts as normal, but the command you invoke is running at the same time.
- “sleep 60” vs “sleep 60 &”

When would backgrounding be useful?

Suspending Jobs

- You can suspend a job that is running

  Press “Ctrl-Z”
- The OS will then stop job from running and not schedule it to run.
- You can then:
  - make the job run in the background.
    - Type “bg”
  - make the job run in the foreground.
    - Type “fg”
      - like you never suspended it at all!!

Web pages

- ssh –l <user name> ix.cs.uoregon.edu
- cd public_html
- put something in index.html
- → it will show up as

  http://ix.cs.uoregon.edu/~<username>

Web pages

- You can also exchange files this way
  - scp file.pdf <username>@ix.cs.uoregon.edu:~/public_html
  - point people to http://ix.cs.uoregon.edu/~<username>/file.pdf

Note that ~/public_html/dir1 shows up as http://ix.cs.uoregon.edu/~<username>/dir1

("~/dir1" is not accessible via web)