333 Section 7 - C++ Casting and Inheritance

C++ Smart Pointers

`std::shared_ptr` – Uses reference counting to determine when to delete a managed raw pointer

- Most commonly used type of smart pointer in practice
- `std::weak_ptr` – Used in conjunction with `shared_ptr` but does **not** contribute to reference count

`std::unique_ptr` – Uniquely manages a raw pointer

- Used when you want to declare unique ownership of a pointer
- Disabled `cctor` and `op=`

Exercise 1 - **"Smart" LinkedList**
Consider the `IntNode` struct below. Convert the `IntNode` struct to be "smart" by using `shared_ptr`.

```
#include <memory>
using std::shared_ptr;

struct IntNode {
  IntNode(int* val, IntNode* node): value(val), next(node) {}

  ~IntNode() { delete value; }

  int* value;
  IntNode* next;
};
```

After the conversion, draw a memory diagram with the reference count for blocks of memory.

```
#include <iostream>

using std::cout;
using std::endl;

int main() {
  shared_ptr<IntNode> head =
      shared_ptr<IntNode>(new IntNode(new int(351), nullptr));
  head->next = shared_ptr<IntNode>(new IntNode(new int(333),
                                                          nullptr));
  shared_ptr<IntNode> iter = head;
  while (iter != nullptr) {
    cout << *(iter->value) << endl;
    iter = iter->next;
  }
}
```

Inheritance in C++

Inheritance

A **Derived** class inherits from a **base** class (*Similar to*: A subclass inherits from a superclass)

- The public interface of a derived class Inherits all **non-private** member variables and functions (**except** for ctor, cctor, dtor, op=)
- Aside: We will be only using **public** inheritance in CSE 333

Inheritance in HW3

Base Class: HashTableReader (Protected)	Derived Classes
• list<IndexFileOffset_t> LookupElementPositions(HTKey_t hash_val) const; • FILE* file_; • IndexFileOffset_t offset_; • BucketListHader header_;	• IndexTableReader – Reads index table • DocIDTableReader – Reads DocID Table • DocTableReader – Reads DocTable • FileIndexReader – Reads File's Index

Style Considerations

- Use virtual **only once** when first defined in the base class
- All derived classes of a base class should use override to get the compiler to check that a function overrides a virtual function from a base class
- Use virtual for destructors of a base class of a base class – Guarantees all derived classes will use dynamic dispatch to ensure use of appropriate destructors

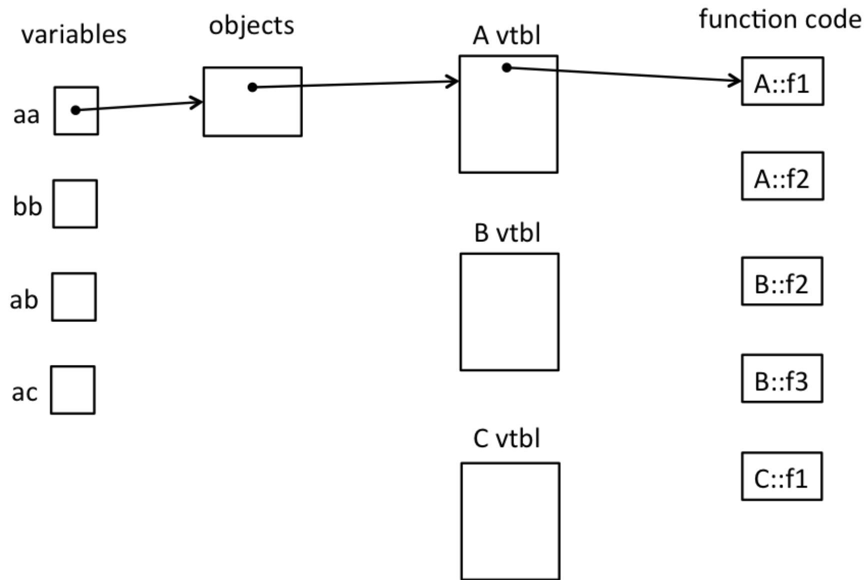
Exercise 3:
Consider the program on the following page, which does compile and execute with no errors, except that it leaks memory (which doesn't matter for this question).

(a) Complete the diagram on the next page by adding the remaining objects and all of the additional pointers needed to link variables, objects, virtual function tables, and function bodies. Be sure that the order of pointers in the virtual function tables is clear (i.e., which one is first, then next, etc.). One of the objects and a couple of the pointers are already included to help you get started.

(b) Write the output produced when this program is executed. If the output doesn't fit in one column in the space provided, write multiple vertical columns showing the output going from top to bottom, then successive columns to the right

```
#include <iostream>
using namespace std;

class A {
 public:
  virtual void f1() { f2(); cout << "A::f1" << endl; }
  void f2() { cout << "A::f2" << endl; }
};
class B : public A {
 public:
  virtual void f3() { f1(); cout << "B::f3" << endl; }
  virtual void f2() { cout << "B::f2" << endl; }
};
class C : public B {
 public:
  void f1() { f2(); cout << "C::f1" << endl; }
};
```




```
int main() {
  A* aa = new A();
  B* bb = new B();
  A* ab = bb;
  A* ac = new C();
  aa->f1();
  cout << "---" << endl;
  bb->f1();
  cout << "---" << endl;
  bb->f2();
  cout << "---" << endl;
  ab->f2();
  cout << "---" << endl;
  bb->f3();
  cout << "---" << endl;
  ac->f1();
  return EXIT_SUCCESS;
}
```

Output:

Bonus:

Virtual holidays! Consider the following C++ program, which does compile and execute successfully.

```
#include <iostream>
using namespace std;

class One
{ public:
        void m1() { cout << "H"; }
virtual  void m2()  {  cout  <<  "l";  }
virtual void m3() { cout << "p"; }
};

class Two: public One {
public:
  virtual void m1() { cout << "a"; }
          void m2() { cout << "d"; }
  virtual void m3() { cout << "y"; }
         void m4() { cout << "p";}
};

class Three: public Two
{
  public:
         void m1() { cout << "o"; }
         void m2() { cout << "i"; }
         void m3() { cout << "s"; }
         void m4() { cout << "!"; }
   };
```

```
int main() {
    Two t;
    Three th;
    One *op = &t;
    Two *tp = &th;
    Three *thp = &th;

    op->m1();
    tp->m1();
    op->m3();
    op->m3();
    tp->m3();

    op->m1();
    thp->m1();
    op->m2();
    thp->m2();
    tp->m2();
    tp->m1();
    tp->m3();
    thp->m3();
    tp->m4(); cout <<
    endl;
};
```

(a) (8 points) On the next page, complete the diagram showing all of the variables, objects, virtual method tables (vtables) and functions in this program. Parts of the diagram are supplied for you. **Do not remove** this page from the exam.

(b) (6 points) What does this program print when it executes?

(c) (6 points) Modify the above program by removing and/or adding the virtual keyword in appropriate place(s) so that the modified program prints HappyHolidays! (including the ! at the end). Draw a line through the virtual keyword where it should be deleted and write in virtual where it needs to be added. Do not make any other changes to the program. Any correct solution will receive full credit.

(cont.) Draw your answer to part (a) here. Complete the vtable diagram below. Draw arrows to show pointers from variables to objects, from objects to vtables, and from vtable slots to functions. Note that there may be more slots provided in the blank vtables than you actually need. Leave any unused slots blank.