COMP6771
Advanced C++ Programming

Week 2
Part 1: Scopes, Namespaces, I/O, Strings, and Casting

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This Week

- Scopes and Namespaces
- I/O
- std::string
- Casting
- Arrays
- Standard Template Library
- STL Containers
- Iterators

Scope

- Scope: the part of a program where a name is valid
- In the same scope, an entity (object, type, function or template) referred to by a name must be unique
- Scope rules used by compiler to determine if a reference to a identifier is legal or not at a particular point
- Five scopes (the first 3 are the same in C):
  1. local (blocks/compound statements delimited by { })
  2. function prototype (each parameter list is distinct)
  3. function (only applies to goto labels)
  4. namespace
  5. class scope

Scope

- A scope starts from its point of declaration
- Java programmers take note!

```
1 int i = j; // error: j not in scope
2 int j = i; // ok
3
4 void f() {
5   g();     // error: g not in scope
6 }
7 void g() {
8   f();     // ok
9 }
```

Local Scope

```
1 void f() {
2   int i;
3   for (int i = 1; i <= N; ++i)
4   {...}
5   for (int i = 1; i <= N; ++i)
6   {...}
7 }
```

- The name i refers to three distinct entities
- A name is visible from declaration to its closing }
- A local name can be hidden

Statements in Local Scope

- Like in Java, this is ok (and recommended):

```
1 for (unsigned int i = 0; i < s.size(); ++i) {
2     // i declared in the scope { } of for
3 }
```

- But, unlike in Java, this is also ok:

```
1 if (int i = compute_value())
2   // do something
3 else
4   j = i;  // ok: i in if in scope
5 k = i;     // error: out of scope
```

Prototype Scope

```
1 void f(int, int);
2 void f(int a, int b);
3 void f(int a, int a);
```

- The three declarations are equivalent
- a name is visible until its closest ',' or)
- the parameter names are only placeholders

Function Scope

```
1 for (int i = 0; i < 10; i++) {
2   if (a[i] == key) goto found;
3 }
4 found:
5 ...
```

- found is visible in the entire function body

Never use goto

Namespaces

- Namespace scope: part of program for packaging names
- To avoid name clashes with multiple, independently developed libraries:

```
1 namespace VendorOne {
2   class Matrix {...}
3   const double pi = 3.14;
4   void inverse (matrix &);
5   ...
6 }
```

```
1 namespace VendorTwo {
2   class Matrix {...}
3   const double pi = 3.14;
4   void inverse (matrix &);
5   ...
6 }
```

- Can be nested or aggregated
- Namespaces have the same feel as Java's packages
- The names in the C++ standard library are defined in std

Namespaces (Cont'd)

- Two special cases:
- Global scope: the outermost namespace scope of a file
- File scope: the namespace scope in a file (unnamed)

```
1 // file1.cpp:
2 namespace {
3   int i = 3;
4 }
```

```
1 // file2.cpp:
2 namespace {
3   int i = 10;
4 }
```

  - The scope automatically opened by compiler
  - Preferred over the use of static names in C:

```
1 // file1.c:
2 static int i = 3;
```

```
1 // file2.c:
2 static int i = 10;
```

Namespaces (Cont'd)

- using directive: makes the namespace members visible as if they were declared outside the namespace at the location where the namespace definition is located
  (e.g., `using namespace std;`)
- using declaration: Introduce a name into the scope where using declaration appears

```
std::cout << "hello" << std::endl;
using std::cout;
cout << "there" << endl;
```

- Scope resolution operator ::

Use "using directive" with care since it may pollute the global namespace

Namespace Clashes

```
1  namespace X {
2    int i, j, k;
3  };
4
5  int k;
6
7  int main() {
8    int i = 0;
9    using namespace X; // make names from X accessible!
10   i++;               // local i
11   j++;               // X::j
12   k++;               // error: X::k or global k?
13   ::k++;             // the global k
14   X::k++;            // X::k
15 }
```

Namespace Clashes

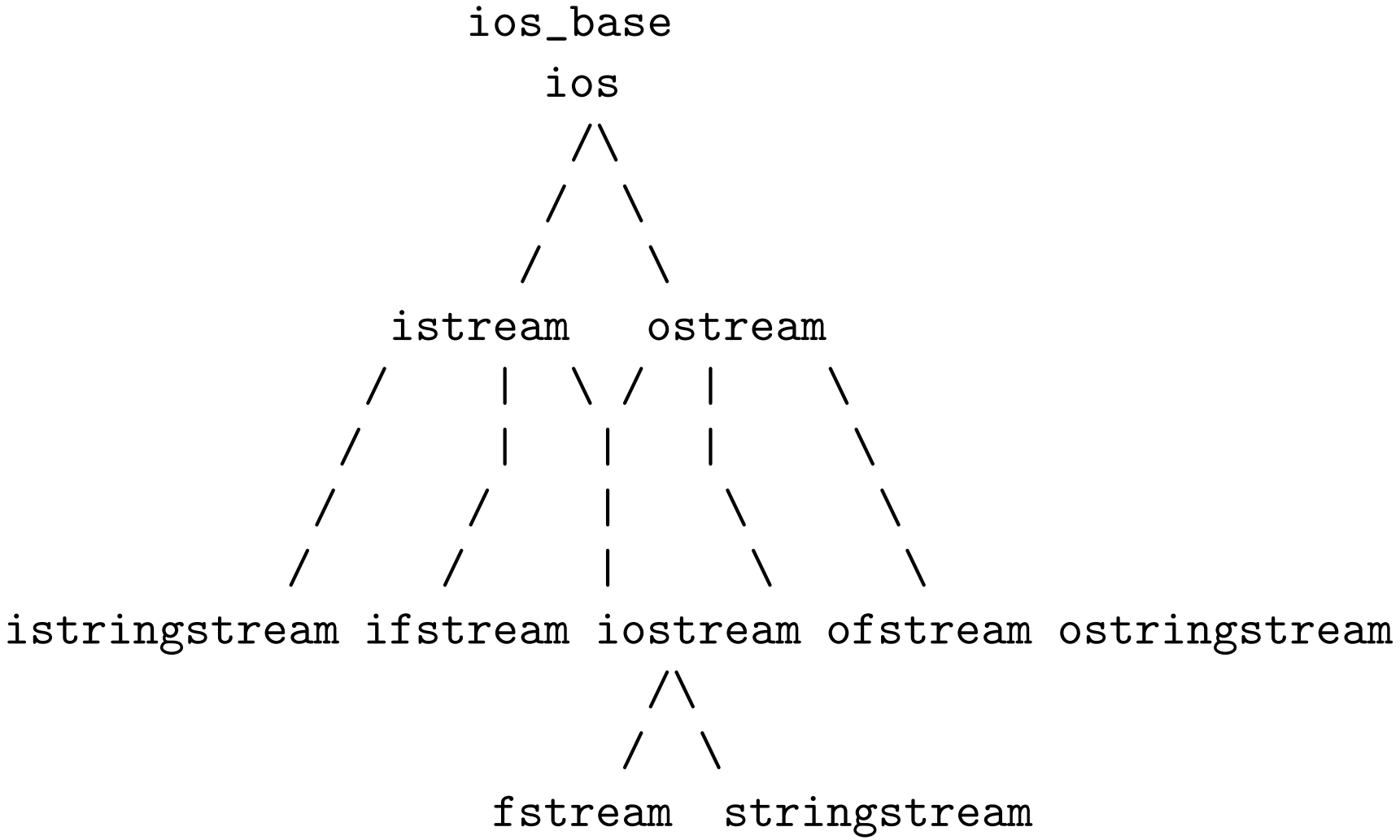
```
1  namespace X {
2    int i, j, k;
3  };
4
5  int k;
6
7  int main() {
8    int i = 0;
9    X::i;          // error: i declared twice
10   using X::j;
11   using X::k;          // hides the global k
12   j++;                 // X::j
13   k++;                 // X::k
14 }
```

Namespace Style

- Don't put "using namespace std;" into header files.
- Generally avoid "using namespace std;" as it pollutes the scope.
- You may (with care) use specific namespace directives, e.g. "using std::cout;" —but even this is not recommended. See http://stackoverflow.com/a/1453605

C++ Input/Output Streams

- Class hierarchy:



- Will not cover this topic in detail

Predefined Stream Objects

- cin - the standard input (often the keyboard)
- cout - the standard output (often the terminal window)
- cerr - the standard error (often the terminal window).

```
1 int i,
2 float f;
3 std::string s;
4 std::complex c;
5
6 std::cin >> i >> f >> s >> c;
7 std::cout << i << f << s << c << std::endl;
8 std::cerr << i << f << s << c << std::endl;
9
```

<< and >> are pre-defined to work with built-in types and those in the library

Input and Output on Files

Input:

```
1  #include <iostream>
2  #include <fstream>
3
4  int i;
5  std::ifstream fin;
6  fin.open("data.in");
7  while (fin >> i) {
8    std::cout << i << std::endl;
9  }
10 fin.close();
```

Output:

```
1  std::ofstream fout;
2  fout.open("data.out");
3  ...
4  fout << i;
5  ...
6  fout.close()
```

Formatting

```
1  #include <iostream>
2  #include <iomanip> // to use the setprecision manipulator
3
4  int main() {
5    std::cout << 1331 << std::endl;
6    std::cout << "In hex " << std::hex << 1331 << std::endl;
7    std::cout << 1331.123456 << std::endl;
8    std::cout.setf(std::ios::scientific, std::ios::floatfield);
9    std::cout << 1331.123456 << std::endl;
10   std::cout << std::setprecision(3) << 1331.123456 << std::endl;
11   std::cout << std::dec << 1331 << std::endl;
12   std::cout.fill('X');
13   std::cout.width(8);
14   std::cout << 1331 << std::endl;
15   std::cout.setf(std::ios::left, std::ios::adjustfield);
16   std::cout.width(8);
17   std::cout << 1331 << std::endl;
18   return 0;
19 }
```

Formatting (Cont'd)

The output is:

```
1331
In hex 533
1331.12
1.331123e+03
1.331e+03
1331
XXXX1331
1331XXXX
```

std::string

The C++ standard library provides a useful `string` type.

1. Prefer C++ `string` operations to C-style functions
2. Use iterators and `[]` for speed
3. Use `at()` when you need range checking
4. Use `find()` operations to locate values in a `string`
5. Append to `string` to add characters efficiently
6. be mindful of the character with the value 0; this is a valid character in C++, but it is treated as a terminator in C
7. Use `isalpha()`, `isdigit()`, etc. for character classification

Please refer to §3.2 of your textbook for the details.

Strings

Here is a simple example:

```
1  #include <iostream>
2  #include <string>
3
4  int main() {
5    std::cout << "Please enter your first name: ";
6    std::string name;
7    std::cin >> name;
8
9    const std::string greeting = "Hello, " + name + "!";
10   std::cout << greeting << std::endl;
11
12   return 0;
13 }
```

Strings

What if we wanted to say hello to multiple people?

```
1  #include <iostream>
2  #include <string>
3
4  int main() {
5    std::string name, greeting;
6
7    std::cout << "Please enter your first name: ";
8    while(std::cin >> name) {
9        greeting = "Hello, " + name + "!";
10       std::cout << greeting << std::endl << std::endl;
11       std::cout << "Please enter your first name: ";
12   }
13
14   return 0;
15 }
```

What happens if we input a blank name? What about multiple names? When does the `while` loop stop?

The `string` Interface

The standard library `string` is a surprisingly complex entity and it provides a rich interface.

- element access: iterators, `[]` and `at()`
- constructors: empty, string, C-style string, substring
- error handling (exceptions): `out_of_range()`
- assignment (copy): `=`
- concatenation and appending: `+`, `+=`, `insert()`, `append()`

Uninitialised `strings`

The default initialiser for `string` is the empty string.

Classes

In C++ we define a new type by defining a *class*.

- Pre-defined classes/types in the library: vector, string, ...
- User-defined classes, e.g.

```
class Book {
  public:
    std::string isbn();
    ...
  private:
    std::string isbn;
    unsigned int units_sold;
    double revenue;
};
```

Objects

- An object is a region of memory with a type
- Two kinds of objects
  - an class object (i.e., an instance of a class)
  - an non-class object

All variables are identified with named objects:

```
1 int i = 1;          // an int object
2 std::string s = "abc";  // a string object
3 std::vector<int> v(5); // a vector of 5 int's
4           // i.e., a vector object holding 5 int objects
```

- C++ is case-sensitive
- A name must be declared before it is used
- Read §2.2 about default initialisation.

What is a Variable Definition?

A variable is a construct that:

- provides named storage
- has a specific type
- is an *lvalue*
- must be defined (or declared) before it is used
- should NOT be used as an *rvalue* before it is initialised

§2.2.3 covers naming guidelines and conventions.
§2.2.1 covers initialisation issues.

Initialization

```
1  int main() {
2    int i1 {1};     // {}-list preferred (C++11)
3    int i2 = {1};
4    int i3 = 1;
5    int i4(1);
6
7    int j1{};           // the default value used
8    int j2 = int{};     // a temporary containing the default value
9  }
```

Will look at initialser lists later

Read §2.2 about default initialisation.

Strong Static Type Checking

Strong Static Typing

Type-checking happens during compilation. Compiler will produce type-mismatch errors if types are used illegally. Types must be known at compile time!

Example:

```
1 float f;
2 float *pf = &f;   // ok
3 int *pi = &f;     // error int pointer can't point to a float
```

Type Conversions

- Implicit, i.e., compiler-directed conversions
- Explicit, i.e., programmer-specified conversions

Promotion: value-preserving conversions

```
1 int b = true;  // a bool converted to an int
2 long l = 1;    // an int converted to a long
```

Caution

Type convert with care. Potential for data loss without any warning.

```
1 int pi = 3.14;  // pi has value 3. No compilier warning.
```

Static Casting

Three ways of static casting:

```
1 double myDouble = 3.14;
2 int cast1 = (int)myDouble;  // c-style
3 int cast2 = int(myDouble);
4 int cast3 = static_cast<int>(myDouble);  // recommended
```

Example, int division:

```
1 int i = 5, j = 2;
2 int slopeInt = i / 5;
3 double slopeDouble = static_cast<double>(i) / j;
```

reinterpret_cast

Low level reinterpretation of the bit pattern.

Example, convert and modify a pointer address to a long.

```
1  #include <iostream>
2
3  // Returns a hash code based on an address
4  unsigned short hash(void *p) {
5    unsigned long val = reinterpret_cast<unsigned long>(p);
6    return ( unsigned short )(val ^ (val >> 16));
7  }
8
9  int main() {
10   int a[20];
11   for (int i = 0; i < 20; i++)
12     std::cout << hash(a + i) << std::endl;
13 }
```

const_cast

- Removes low level const, i.e., 'casts away the const'.
- Avoid doing this if you can.
- Used mostly for portability:

```
3rd Party code:

// You know that this function doesn't modify fooPtr
printFoo(Foo* fooPtr)  ...

Your code:

// Your code has made an effort to use Foo* in
// contexts where writability is needed and
// const Foo* in all other contexts.

const Foo* f = &constFoo;
printFoo(<const_cast<Foo *>(f);
```