# HIGH-LEVEL PROGRAMMING 2

Namespaces

by Prasanna Ghali

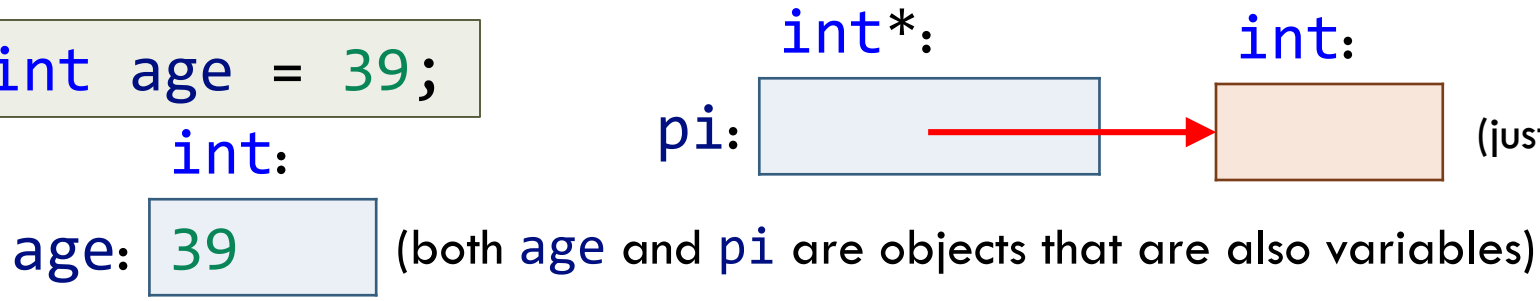
# Objects, Variables, Types …



- *Type* is set of values and set of operations on those values
- *Object* is region of memory that has a type
  - Every object has a type so we know what kind of information can be placed in that object
- *Variable* is a named object

```
int *pi = static_cast<int*>( malloc(sizeof(int)) );
```

```
int age = 39;
```



# Several Kinds of Scopes



- There're several kinds of scopes that we use to control where our names are used:
  - *Global* or *file scope*: area of text outside any other scope
  - *Function scope*: area of text in function body including parameters
  - *Local scope*: between `{ ... }` braces of a block in a function
  - *Statement scope*: e.g., in a `for` statement

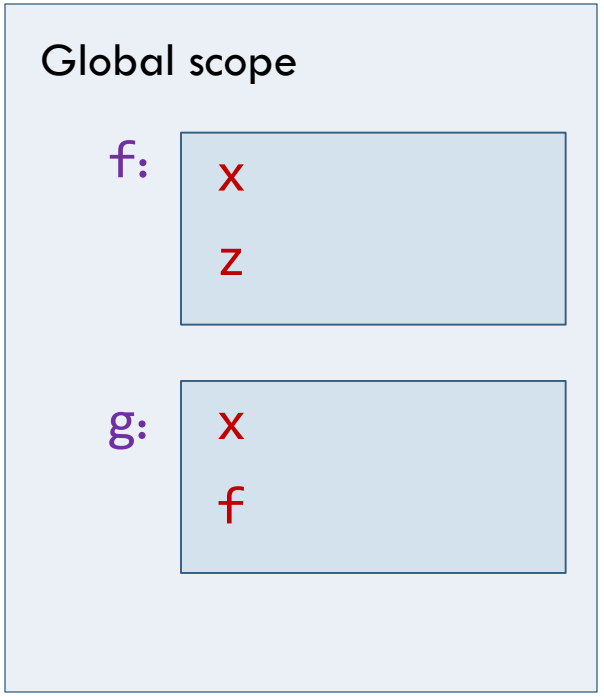
# Main Purpose of Scope



- Main purpose of a scope is to keep names local, so they won't interfere with names declared elsewhere

```
void f(int x) // f is global; x is local to f
{
  int z {x+7}; // z is local to f
}

int g(int x) // g is global; x is local to g
{
  int f {x+2}; // f is local to g
  return 2*f;
}
```



# Scoping Rule



- Compiler will associate *closest declaration of a name* when references are made to variables, types, and functions with same name

# Scope: Examples (1/4)



```
void f1(int param) { // scope of param starts here
  int a{2};          // scope of a starts here
  int b{10};         // scope of b starts here

  while (a < 10) {
    int x;           // scope of x starts here

    x = param * a++; // OK, param and a both in scope

    if (x == 5)
      b = 11;     // OK, b in scope
  }               // scope of x ends here

  x = 3;        // ERROR! x not in scope
}  // scope of a, b and param end here
```

# Scope: Examples (2/4)



```
int x{1};   // scope of global x starts here

void f2(int param) {  // scope of param starts here
  int a{2};    // scope of a starts here
  int param;   // ERROR! param already defined

  while (a < 10) {
    int x{2};    // scope of second x starts here
    double a;    // OK. Different scope, different (second) a
    float param; // OK. Different scope, different param

    if (x == 5) {
      int x;     // OK. Different scope, different (third) x
      int param; // OK. Different scope, different param
    } // scope of third x and param ends here
  }   // scope of second x, second a and param ends here
}     // scope of first a and param ends here
```

# Scope: Examples (3/4)



```
int a;  // Memory for a is allocated before program starts
        // Value of a is 0 (global variable)

void f3(int param) {
  int b;  // Memory for b is allocated when function starts
          // b is uninitialized (local variable)
  b = a * param; // OK, a and param in scope
}

int main() {
  int x;  // Memory for x is allocated when main starts
          // x is uninitialized (because it is local variable)

  f3(x);  // Memory for copy of x is allocated when f3 starts
          // Memory for copy of x is deallocated when f3 returns
}
// Memory for a is deallocated when program ends
```

# Scope: Examples (4/4)



In C, we're declaring type `struct S`
while in C++, we're declaring type `S`

```
struct S { // S is global
  int x; // x is local to type S
  int y; // y is local to type S
};

int f(S x) { // f is global; x is local to f
  int y {x.x+x.y}; // y is local to f
  return y;
}
```

Can also be:

```
int f(struct S x) {
 /*...*/
}
```

# Namespaces



- C++ provides language feature, `namespace`, exclusively for expressing scoping
- Why and how?

# Why Namespaces? (1/2)



- We use blocks to organize code within function
- We use structures to organize data and types into a type
- Both do two things for us:
  - They give us a name to refer to what we've defined
  - They allow us to define a number of "entities" without worrying that their names clash with other names in our program

# Why Namespaces? (2/2)



- What we lack is a way to organize our functions, data, and types to prevent *name clashes* with names introduced by other programmers [in their source files] and by third-party C/C++ libraries [such as OpenGL and UDK]

# Name Clashes (1/2)



- By default, in C/C++, names defined in global scope in a source file have *external linkage*
  - This means that compiler will export such names to linker
- If program contains multiple definitions with same name [having external linkage], C/C++ require these definitions to be similar
  - Otherwise, linker signals *name clash*

# Name Clashes (2/2)



- Individual source files compile but linker fails!!!
- External linkage implies program consisting of many source files must have *one and only one definition of name defined in global scope*

```
// mine.cpp
int x {10};

int main() {
  printf("mine:  %d\n", x);
  extern void foo();
  foo();
}
```

```
// yours.cpp
int x {20};

void foo() {
  printf("yours: %d\n", x);
}
```

# What is a Namespace? (1/4)



- What we lack is a way to organize our functions, data, and types to prevent *name clashes* with names introduced by other programmers [in their source files] and by third-party C++ libraries [such as UDK]
- C++ mechanism for grouping of declarations is called a *namespace*
  - Namespace is a block that attaches an extra name – the namespace name – to every entity name that is declared within it

# What is a Namespace? (2/4)



```
// in graphics.cpp ...
struct Color { /* ... */ };
struct Line { /* ... */ };
struct Shape { /* ... */ };
void draw(Shape *) { /* ... */ }
void xform() { /* ... */ }
// ...
void gui() { /* ... */ }
```

```
// in graphics.cpp ...
namespace Graphics_Lib {
  struct Color { /* ... */ };
  struct Line { /* ... */ };
  struct Shape { /* ... */ };
  void draw(Shape *) { /* ... */ }
  void xform() { /* ... */ }
  // ...
  void gui() { /* ... */ }
}
```

This is how you define a namespace.
No semicolon is required after closing brace in namespace definition!!!

By enclosing names `Color`, `Line`, ... in namespace `Graphics_Lib` in my source file, name clashes are prevented if you use the same names in your source files

# What is a Namespace? (3/4)



Full name of each entity is the namespace name followed by *scope resolution operator*, `::`, followed by the entity name, as in:

`Graphics_Lib::gui` means "name `gui` in namespace scope `Graphics_Lib`"

```
// in graphics.cpp ...
namespace Graphics_Lib {
    struct Color { /* ... */ };
    struct Line { /* ... */ };
    struct Shape { /* ... */ };
    void draw(Shape *) { /* ... * /}
    void xform() { /* ... */ }
    // ...
    void gui() { /* ... */ }
}
```

# What is a Namespace? (4/4)



```
// in graphics.cpp ...
namespace Graphics_Lib {
  struct Color { /* ... */ };
  struct Line { /* ... */ };
  struct Shape { /* ... */ };
  void draw(Shape *) { /*...*/ }
  void xform() { /* ... */ }
  // ...
  void gui() { /* ... */ }
}
```

```
// in yours-graphics.cpp ...
namespace Better_Graphics_Lib {
  struct Color { /* ... */ };
  struct Line { /* ... */ };
  struct Shape { /* ... */ };
  void draw(Shape *) { /* ... */ }
  void xform() { /* ... */ }
  // ...
  void gui() { /* ... */ }
}
```

Different namespaces can contain entities with the same name, but the entities are differentiated because they're *qualified* by different namespace names, as in:

`Graphics_Lib::Shape` is a different entity compared to `Better_Graphics_Lib::Shape`

# Global Namespace (1/3)



- *Global namespace* applies by default if a namespace hasn't been defined

```
#include <iostream>

int global_int{10};

int main() {
  std::cout << global_int << '\n';
}
```

All names within global namespace are just as you declare them, without a namespace being attached

# Global Namespace (2/3)



- To explicitly access names defined in global namespace, you use scope resolution operator without left operand

```
#include <iostream>

int global_int{10};

int main() {
  std::cout << ::global_int << '\n';
}
```

# Global Namespace (3/3)



- Explicit use of scope resolution operator to access names in global namespace only really required if there is a more local declaration with same name that *hides the global name*

```
#include <math.h>

double zip_a_dee(int pow) {
  return ::pow(3.141592, pow);
}
```

Recall that pow is a function declared in C standard library header math.h!!!

# Global Namespace and C Standard Library (1/2)



- For compatibility with C standard library, C++ standard library provides headers just as in C source files

Just as in C code, C standard library names are also in global scope in C++ code if they're exposed by including header files with `.h` suffix

```
#include <stdio.h>
#include <stdlib.h>

int main() {
  int *pi { (int*) malloc(sizeof(int)) };
  *pi = 39;
  ::printf("*pi: %d\n", *pi);
}
```

# Global Namespace and C Standard Library (2/2)



- For compatibility with C standard library, C++ standard library provides headers just as in C source files

Don't do this!!!
Will be deprecated in future C++ versions!!!

```
#include <stdio.h>
#include <stdlib.h>

int main() {
  int *pi { (int*) malloc(sizeof(int)) };
  *pi = 39;
  printf("*pi: %d\n", *pi);
}
```

# Namespace std and C++ Standard Library



Standard header declares global variables that control reading from and writing to standard streams stdout, stdin, and stderr

Namespaces are C++ mechanisms that introduce new scopes to avoid conflicts between names in large programs.
std is namespace for virtually all names in C++ standard library

```
#include <iostream>

int main() {
  std::cout << "Hello World\n";
}
```

:: is *scope resolution operator*.
std::cout means "name cout in namespace scope std"

Global variable of type std::ostream is instantiated at program startup and its purpose is to write characters to standard stream stdout

# Namespace std and C Standard Library



- Facilities of C standard library in header *name.h* provided in C++ standard library header *cname*:

```
#include <cstdio>
#include <cstdlib>

int main() {
  int *pi { (int*) std::malloc(sizeof(int)) };
  *pi = 39;
  std::printf("*pi: %d\n", *pi);
}
```

Do this!!!
Names in these headers are within namespace std

# C Standard Library and HLP2 Assessments



- Unless explicitly specified by assessment specification, expect zero grade for assessments that rely on C standard library for I/O, dynamic memory allocation/deallocation, …

# Defining a Namespace [Revisited]



- Namespace block doesn't have to be contiguous

```
namespace Math {
  double const sqrt2{1.4142135};
}

namespace Graphic_Lib {
  struct Color { /* ... */ };
}

namespace Math {
  double square(double x) {
    return x*x;
  }
}
```

You can extend a namespace scope by adding a second namespace block with same name

Namespaces can be spread across files too!!!

# Functions and Namespaces



- For function to exist within a namespace, it is sufficient for function declaration to appear in a namespace block

```
namespace Math {
  double const sqrt2{1.4142135};
  double square(double x);
}
```

We've two options for defining function square

```
// option 1: enclose in
// namespace block
namespace Math {
  double square(double x) {
    return x*x;
  }
}
```

```
// option 2: use qualified name
// of function
double Math::square(double x) {
  return x*x;
}
```

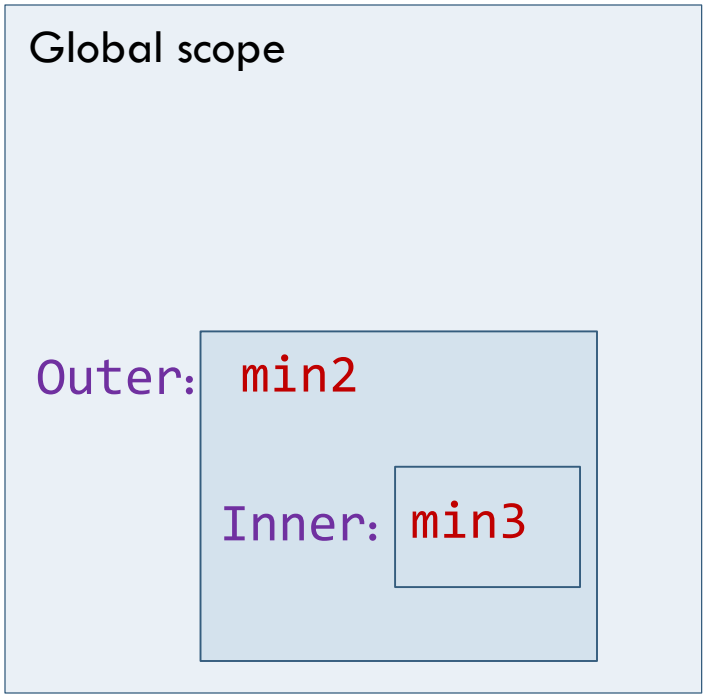
# Nested Namespaces (1/2)



- You can define one namespace inside another

```
namespace Outer {
  int min2(int x, int y) {
    return x < y ? x : y;
  }

  // option 1: explicit nesting
  namespace Inner {
    int min3(int x, int y, int z) {
      return min2(x, min2(y, z));
    }
  }
}
```



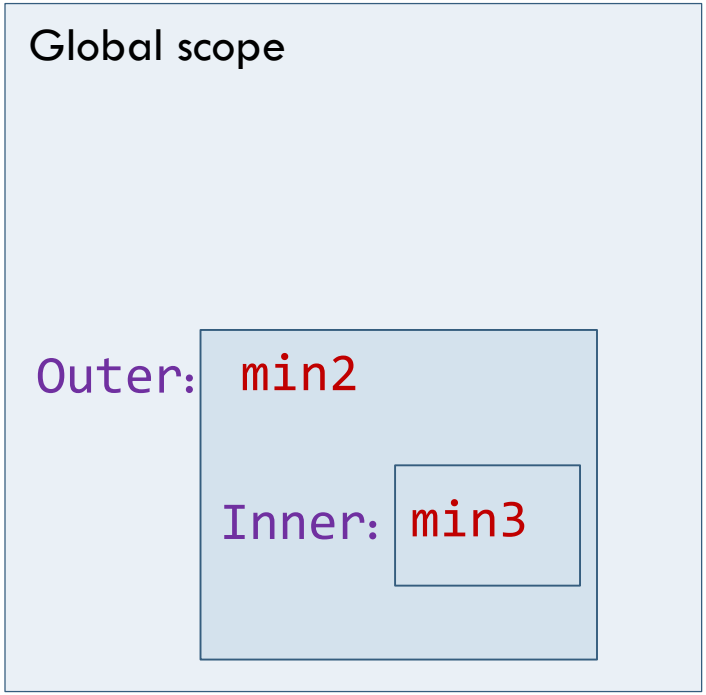
# Nested Namespaces (2/2)



- You can add something to nested namespace directly with this compact system:

```
namespace Outer {
  int min2(int x, int y) {
    return x < y ? x : y;
  }
}

// option 2: direct nesting
namespace Outer::Inner {
  int min3(int x, int y, int z) {
    return min2(x, min2(y, z));
  }
}
```



# Anonymous [or Unnamed] Namespaces (1/3)



- Anonymous namespace looks like this:

```
namespace {
  int global_int{10};

  int update(int i) {
    return global_int = i;
  }

  int add(int i) {
    return i+global_int;
  }
}
```

Why use anonymous namespaces?

# Anonymous [or Unnamed] Namespaces (2/3)



- One good reason is that variables and functions declared in anonymous namespaces in a source file have *internal linkage*!!!

```
namespace {
  int global_int{10};

  int update(int i) {
    return global_int = i;
  }

  int add(int i) {
    return i+global_int;
  }
}
```

```
// equivalent to declarations
// in anonymous namespace
static int global_int{10};

static int update(int i) {
  return global_int = i;
}

static int add(int i) {
  return i+global_int;
}
```

# Anonymous [or Unnamed] Namespaces (3/3)



- Second good reason is that anonymous namespaces can be used to declare types that can only be referenced from one source file

```
namespace {
  // type S is "private" to this source file
  struct S { int x, y; };

  // function print is also "private" to this source file
  void print(S const *ps) {
    std::cout << ps->x << ',' << ps->y << '\n';
  }
}
```

# Namespace Aliases (1/3)



- Long namespace names may be unduly cumbersome to use

```
namespace Programming {
  namespace AdvancedProgramming {
    int foo{11}, bar{12};
    int f1(int x)  { return x / 2; }
  }

  namespace IntroductoryProgramming {
    int foo{21}, bar{22};
    int Div2(int x) {return x / 2; }
  }
}

int main() {
  std::cout << Programming::AdvancedProgramming::foo;
  std::cout << Programming::IntroductoryProgramming::Div2(8);
}
```

# Namespace Aliases (2/3)



- You can create *aliases* to shorten namespace names

```
namespace Programming {
  namespace AdvancedProgramming {
    int foo{11}, bar{12};
    int f1(int x)  { return x / 2; }
  }

  namespace IntroductoryProgramming {
    int foo{21}, bar{22};
    int Div2(int x) {return x / 2; }
  }
}

namespace PAP = Programming::AdvancedProgramming;
namespace PIP = Programming::IntroductoryProgramming;

int main() {
  std::cout << PAP::foo;
  std::cout << PIP::Div2(8);
}
```

# using Declaration



- Allows you to use a *specific name* without its namespace qualification

```
namespace Stuff {
  int foo {11}; // Stuff::foo
  int bar {12}; // Stuff::bar
}

using Stuff::foo;

void f1() {
  Stuff::foo = 21;  // ok: using qualified name
  foo = 22;         // ok: namespace not required
  using Stuff::bar; // make bar available in this scope only
  bar = 30;         // ok
  //int bar = 5;    // error: redeclaring name bar
}
```