Programming with C++

COMP2011: C++ Function III — Declaration, Definition, Overloading, and Default Arguments

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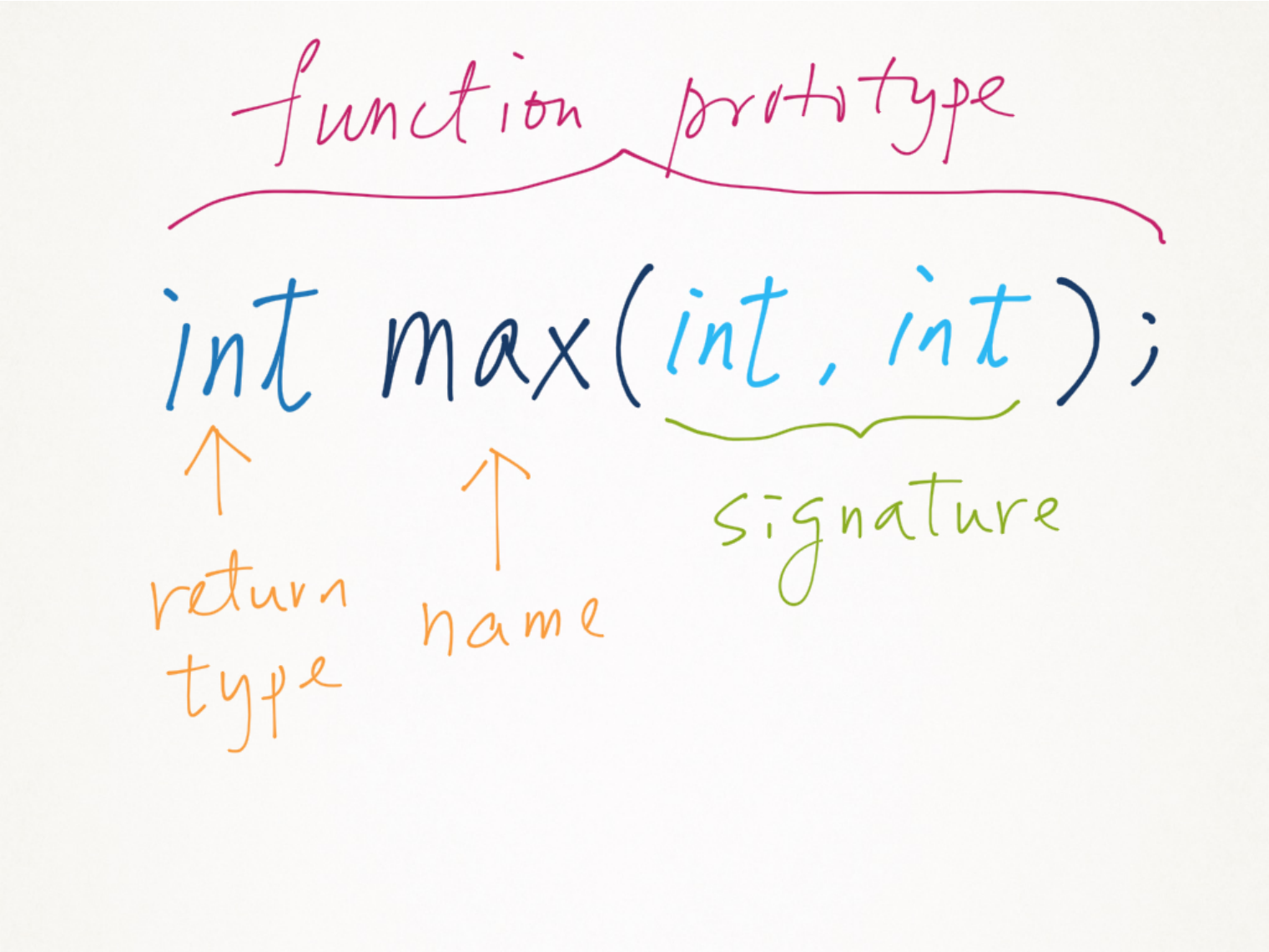
Part I

Function Declaration and Function Definition

Some Function Terminology



Function Prototype

A function prototype consists of

1. function name
2. return data type
3. the number of formal parameters
4. the data type of the formal parameters

Example: Function Prototypes

```
// int factorial(int n)  ...
int factorial(int);

// float euclidean_distance(float x1,float y1,float x2,float y2)  ...
float euclidean_distance(float, float, float, float);

/* void print_tree(int tree_height, char tree_symbol,
                   char trunk_symbol, char pot_symbol)  ...  */
void print_tree(int, char, char, char);
```

Function Prototype ..

- The identifier names of the formal parameters are not part of the signature as the names are immaterial.

Example: Variable Names are Immaterial in a Function Prototype

```
/* All the following 3 function definitions are equivalent */

int max(int x, int y) { return (x > y) ? x : y; }

int max(int a, int b) { return (a > b) ? a : b; }

int max(int f, int g) { return (f > g) ? f : g; }
```

- A function prototype describes the interface of the function: what parameters it takes in and what value it returns.
- Technically, a function prototype is also called the application programming interface (API).

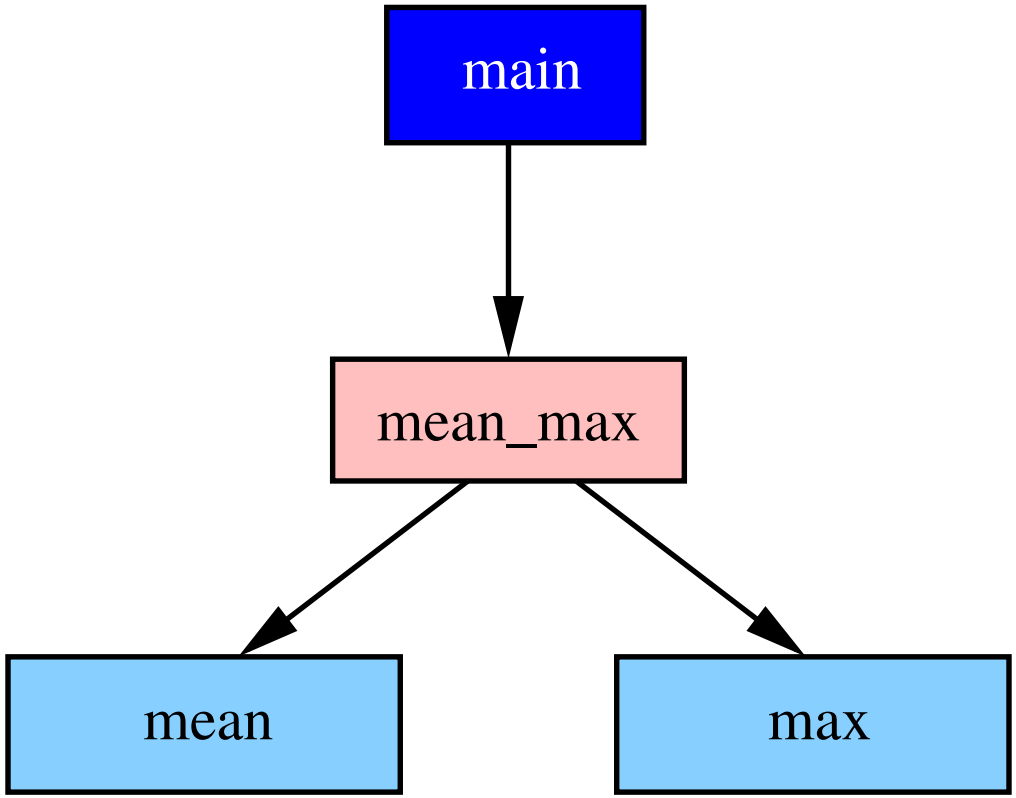
Function Declaration vs. Definition

- A function is declared by writing down its interface — its function prototype.
- A function is defined by writing down its function header *plus* its function body.
- A function definition will ask the compiler to generate machine codes according to the C++ codes in its function body.
- A function declaration just informs the compiler about the function's interface *without* generating any machine codes.
- A function may be declared many times, but a function can be defined only once.
- Of course, when a function is defined, it is also declared.
- But, simply declaring a function does **not** define the function.

Function Declaration vs. Definition ..

- In C++, all functions must be declared before they can be used, so that the compiler can
  - make sure the exact number of arguments are passed.
  - do type checking on the arguments passed to the function.
- That is, if function A wants to call function B, function B must be
  - declared/defined before, or
  - declared inside function A before calling function B.
- However, a function need not be defined before it can be used, although it must be defined eventually somewhere in the whole program in order that the program can be compiled to an executable.

Example: A Program with 3 Levels of Functions



Example: Declare Functions by Defining the Functions

```
#include <iostream>      /* File: fcn-prototype1.cpp */
using namespace std;

int max(int x, int y) { return (x > y) ? x : y; }
int mean(int x, int y) { return (x + y)/2; }

void mean_max(int x, int y, int& mean_num, int& max_num)
{
    mean_num = mean(x, y);
    max_num = max(x, y);
}

int main()
{
    int average, bigger;

    mean_max(6, 4, average, bigger);
    cout << "mean = " << average << endl << "max = " << bigger << endl;
    return 0;
}
```

Example: Declare Functions Globally

```
#include <iostream>     /* File: fcn-prototype2.cpp */
using namespace std;

void mean_max(int, int, int&, int&); // main only needs to know mean_max

int main()
{
    int average, bigger;
    mean_max(6, 4, average, bigger);
    cout << "mean = " << average << endl << "max = " << bigger << endl;
    return 0;
}

int max(int, int);      // mean_max needs to know max and mean
int mean(int, int);

void mean_max(int x, int y, int& mean_num, int& max_num)
{
    mean_num = mean(x, y);
    max_num = max(x, y);
}

int max(int x, int y) { return (x > y) ? x : y; }
int mean(int x, int y) { return (x + y)/2; }
```

Example: Declare Functions Locally

```
#include <iostream>     /* File: fcn-prototype3.cpp */
using namespace std;

int main()
{
    void mean_max(int, int, int&, int&);
    int average, bigger;

    mean_max(6, 4, average, bigger);
    cout << "mean = " << average << endl << "max = " << bigger << endl;
    return 0;
}

void mean_max(int x, int y, int& mean_num, int& max_num)
{
    int max(int, int);
    int mean(int, int);

    mean_num = mean(x, y);
    max_num = max(x, y);
}

int max(int x, int y) { return (x > y) ? x : y; }
int mean(int x, int y) { return (x + y)/2; }
```

Example: Forward Function Declaration

```
#include <iostream>      /* File: odd-even.cpp */
using namespace std;

bool even(int);

bool odd(int x) { return (x == 0) ? false : even(x-1); }

bool even(int x) { return (x == 0) ? true : odd(x-1); }

int main()
{
    int x;
    cin >> x;             // Assume x > 0

    cout << boolalpha << odd(x) << endl;
    cout << boolalpha << even(x) << endl;

    return 0;
}
```

Part II

Function Overloading

Signature of a Function

- Recall that in C++, all functions are global. That means, in general, all functions can "see" each other.
- Just as we use one's signature to identify the person, we identify a function by its name and signature.
- A function's signature is the list of formal parameters without their identifier names.
- No two C++ functions can have the same name *and* same signature but different return type.
- BUT two C++ functions can have the same name *but* different signature $\Rightarrow$ function overloading.

Example: No 2 Function Prototypes Differ Only in Return Type

```
// The following 2 function definitions of
// pick_one cannot appear in the same program

int pick_one(int x, float y) { return x; }
float pick_one(int x, float y) { return y; }
```

Function Overloading

C++ allows several functions to have the same name but different types of input parameters.

Example: Overloaded Functions

```
int max(int x, int y) { return (x > y) ? x : y; }
int max(int x, int y, int z) { return max(max(x,y), z); }
double max(double a, double b) { return (a > b) ? a : b; }

void swap(int& a, int& b) { int temp = a; a = b; b = temp; }
void swap(float& a, float& b) { float temp = a; a = b; b = temp; }
void swap(double& a, double& b) { double temp = a; a = b; b = temp; }

int absolute(int a) { return (a < 0) ? -a : a; }
int absolute(int& a) { return (a = (a < 0) ? -a : a); }
```

Question: How can you call the following version of absolute( )?

```
int absolute(int&);
```

Example: Invalid Function Overloading

```
/* Identifier names of formal parameters are immaterial */

int max(int x, int y) { return (x > y) ? x : y; }
int max(int a, int b) { return (a > b) ? a : b; }



/* Return type is not part of the signature */

void swap(int& a, int& b) { int temp = a; a = b; b = temp; }
int swap(int& a, int& b) { int temp = a; a = b; b = temp; return a; }
```

Overloaded Function Resolution

- When an overloaded function is called, C++ will determine exactly which function among those with the same name should be called — function resolution.
- Function resolution is done by comparing the types of
  - actual parameters passed in a function call, and
  - formal parameters in the function definition.

  and find the best match in the following order:

1. exact match
2. match after some type promotion
   - `char/bool/short --> int`
   - `float --> double`
3. match after some standard type conversion
   - between integral types
   - between floating types
   - between integral and floating types
4. match after some user-defined type conversion (later)

Example: Function Resolution

```
int test(int a, double b);
int test(double a, int b);
```

- If you make the following function call: `test(3, 4.6)`, the compiler will pick the first version.
- If you make the following function call: `test('a', 4.6)`, the compiler will again pick the first version by converting 'a' to an int.
- If you make the following function call: `test(3.2, 4.6)`, it can either
  - match to the first version by narrowing conversion of the first parameter to int.
  - match to the second version by narrowing conversion of the second parameter to int.
  - since neither one is more preferable than the other one
    $\Rightarrow$ compilation error!

Default Function Argument

- Sometimes, we would like a function to have certain default behaviour, but still allow the user to change it.
- C++ allows the user to call a function with fewer arguments if all he wants is its default behaviour, and with more arguments if he wants some particular behaviour of the function.
- A function may have more than 1 default argument.
- But all default arguments must be specified at the end of the formal parameter list.

```
/* The following 2 prototypes are equivalent */
void func(int x, float& y, char gender = 'M', bool alive = true);
void func(int, float&, char = 'M', bool = true);
```

- The default argument(s) may be specified in a function declaration or function definition, but not both.
  - usually we put it on the function declaration. Why?
- A function with default arguments looks like several overloaded functions, but it is not.

Example: cin.getline( ) Again

- The true getline function header is:

  cin.getline(char s[ ], int max-num-char, char terminator='\n');

- Thus, you may call it as

  cin.getline(char s[ ], int max-num-char);

  and the default terminator is the newline character.

Example: Different getline Calls

```
const int MAX_LINE_LEN = 1000;
char s[MAX_LINE_LEN+1];

cin.getline(s, sizeof(s));       // terminator = newline
cin.getline(s, sizeof(s), '.'); // terminator = full stop
```

Example: Increment with Default Argument

```
#include <iostream>     /* File: increment-default-arg.cpp */
using namespace std;

int increment(int x, int step = 1)
{
    return (x + step);
}

int main()
{
    cout << increment(10) << endl;
    cout << increment(10, 5) << endl;

    return 0;
}
```