High Level Programming

Functions

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Functions

- Functions in C++ have many similarities with C
- The main exceptions are the following
  - Argument passing
    - By value, address (pointer), reference
  - Varying parameters
    - Number of parameters
  - Overloading
  - Default arguments
  - Pointers to functions

Argument passing

- In C++ functions may have 3 different types of parameters
  - By value
  - By address (pointer)
  - By reference
- The last one is not present in C

In C, these were parameters by reference

Arguments by value

- For the arguments passed by value
  - We provide a value to the function parameter when the function is called
    - The local parameter is equivalent to a local variable
    - This variable holds a **copy** of the parameter
  - Changes to the local parameter will not affect the original variable

When a parameter is passed by value, a copy of the argument's value is made and passed to the function. Any modifications made to the parameter within the function do not affect the original argument.

```
void foo(int x) {
    x = 10; // Modifying the parameter (local copy)
}

int main() {
    int num = 5;
    foo(num); // Passing num by value
    // num remains unchanged after the function call
    return 0;
}
```

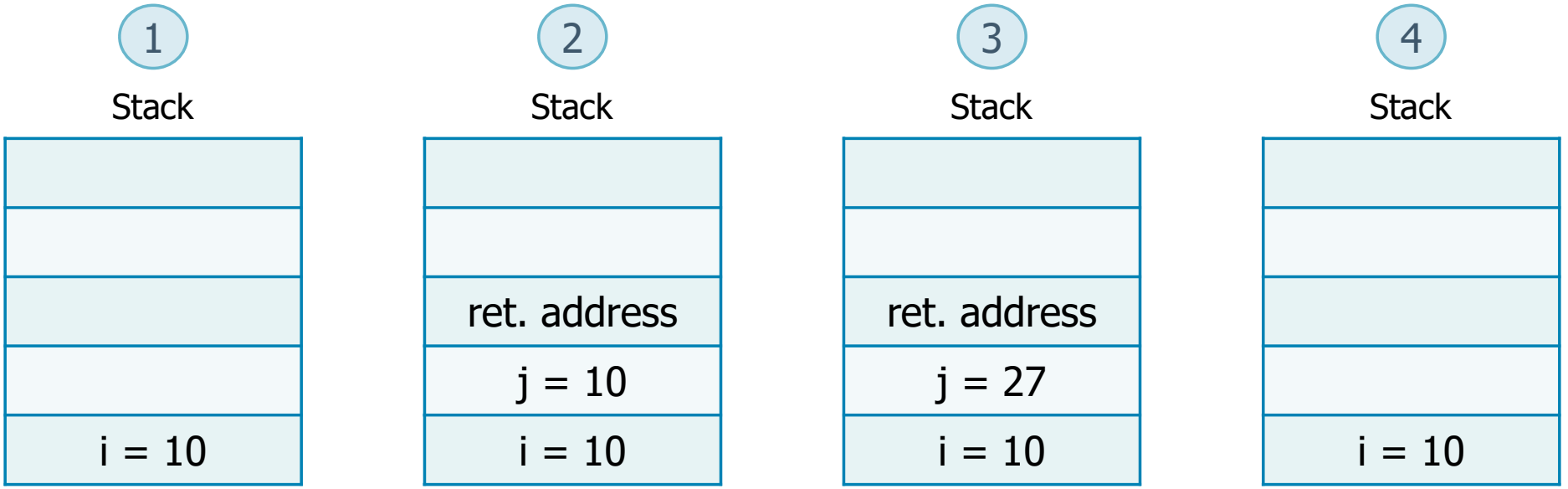
Example

```
int main() {
  int i=10;
  f(i);
  return i;
}
```

```
void f(int j) {
  j=27;
  return;
}
```

The value of i becomes the (initial) the value of j

The value of j is lost



Arguments by address

- Pointers behave like any other type
  - To pass a pointer "by value," we copy the pointer
    - After the copy, the two pointers are distinct
    - However, the pointer may give indirect access to the object to which it points
  - By dereferencing the address, the function may access and modify the original data
    - Passing a **pointer by value** implies passing the pointed **object by reference**
    - Again, a copy of the address is done, not a copy of the data referenced by the address
  - Unfortunately, an address can be **nullptr**, thus a variable by reference can be **invalid**

When a parameter is passed by address, a memory address (pointer) pointing to the argument's location in memory is passed to the function. This allows the function to directly access and modify the original argument.

```
void bar(int* ptr) {
    *ptr = 10; // Modifying the value at the memory location pointed by ptr
}

int main() {
    int num = 5;
    bar(&num); // Passing the address of num
    // num is modified to 10 by the function call
    return 0;
}
```

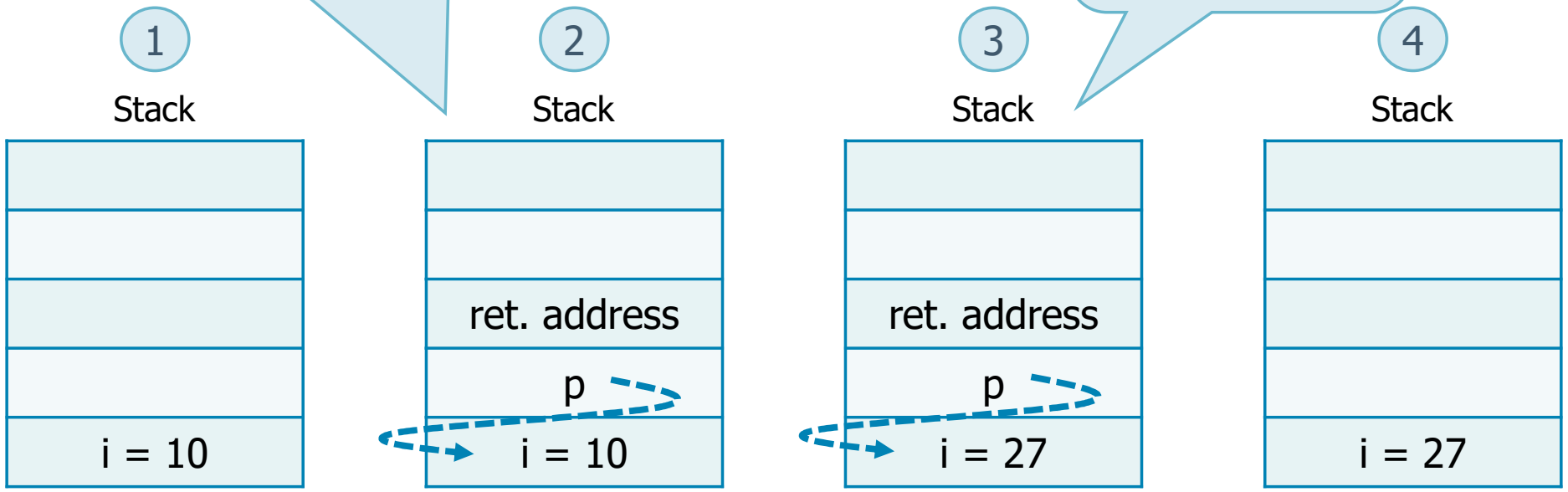
Example

```
int main() {
  int i=10;      1
  f(&i);         2
  return i;      4
}
```

```
void f(int *p) {
  if (p!=nullptr)   3
    *p = 27;
}
```

The new location does not contain an integer but a pointer

Access to the location referenced by the pointer p



Arguments by reference

New parameter passing strategy

- With a parameter by
  - Value, we may need to **copy** a lot of memory, and we cannot modify extern objects
  - Address, we can have **null** pointers
- With a parameter by **reference**, we pass a pointer to a verified variable
  - The parameter is accessed directly without dereferencing the pointer
    - The syntax is simpler
  - We never have **nullptr** pointers

Passing by Address (Pointer):
When passing arguments by address (using pointers), there is indeed a risk of encountering null pointers if the pointer being passed is not properly initialized or if it's assigned the value of nullptr.
If the pointer is null and the function dereferences it without proper validation, it can lead to undefined behavior, such as a segmentation fault or access violation.

When passing arguments by reference, there is no risk of encountering null references because references must always be bound to valid objects.
References in C++ cannot be null or uninitialized; they must always refer to an existing object.
Therefore, passing by reference eliminates the possibility of null pointers.

Example

```
int main() {
  int i=10;
  f(i);
  return i;
}
```

1 2 4

No &

```
void f(int &r) {
  r = 27;
}
```

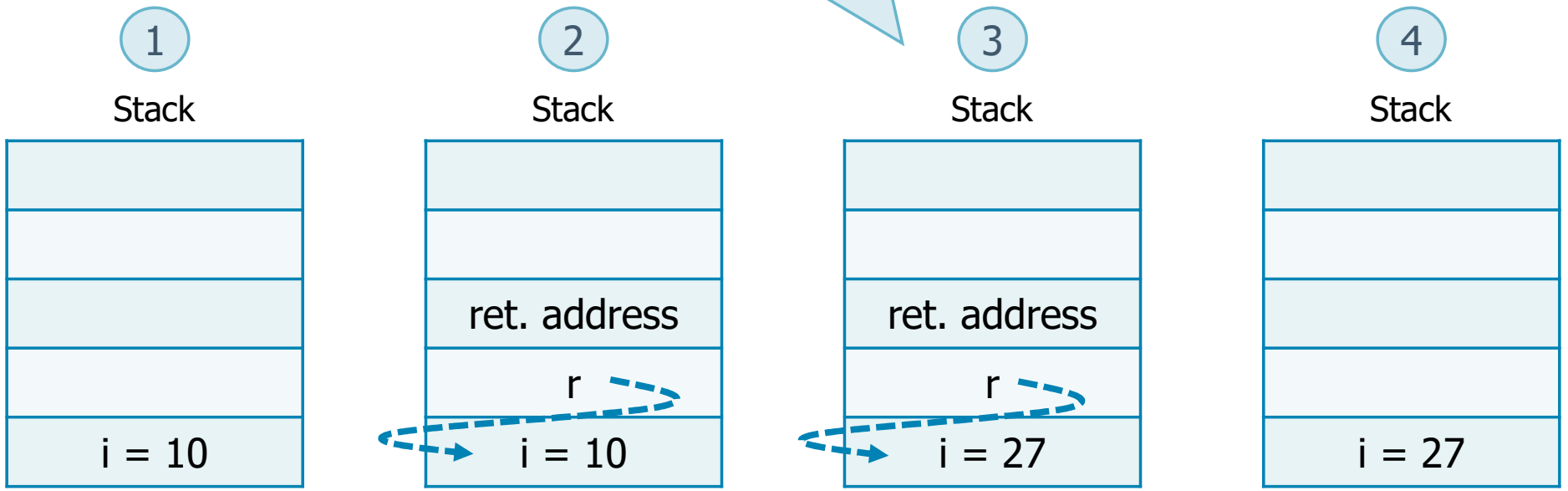
3

No * but &

r is another name for i

The code is "by value"
The effect is "by reference"

Here we don't need to check if nullptr cuz reference are always bound to valid objects.



Examples

```
void reset (int &i) {
  i=0;
}

...

int j=10;
reset (j);
cout << j;
```

Passed by reference

The value is 0

We will see strings in Unit 04

```
bool is_shorter (const string &s1, const string &s2) {
  return s1.size() < s2.size();
}

...

if (is_shorted (s1, s2)) ...
```

It can be inefficient to copy large objects. Moreover, some objects cannot be copied. In those cases, we can use references

Example

The classical **swap** function

```
void swap(int &x, int &y) {
  int z = x;
  x = y;
  y = z;
}

int main() {
  int firstNum = 10;
  int secondNum = 20;

  cout << "Before swap: " << "\n";
  cout << firstNum << secondNum << "\n";

  // Call the function swap
  swap(firstNum, secondNum);

  cout << "After swap: " << "\n";
  cout << firstNum << secondNum << "\n";

  return 0;
}
```

Constant parameters

- Parameters that the function does not change should be defined as constant
  - Not doing that would give the impression that the function does modify the parameter

```
void find_char (string &s) { ... }
...
find_char ("hello word");
```

This is an error
We must define the string as const

```
void find_char (const string &s) { ... }
```

Check documentation for more details

Varying parameters

- Like in C it is possible to write functions with a variable number of parameters
- In the C++ standard this is possible using two strategies
  - If all arguments have the same type, it is possibile to use the library **initializer_list**
  - Otherwise, it is possibile to use a special parameter type called **ellipsis**

Reported for the sake of completeness. You may ignore it !

Overloading

- In C++, it is possible to have multiple definitions for the same function in the same scope
- Overloaded functions have
  - The same name
  - Different parameter lists
  - Appear in the same scope region
- Overloading
  - Eliminates the necessity to remind different names
  - Is implemented by the compiler
    - The compiler calls the function that best matches the actual argument list

Overloading

- The definitions of the function must differ from each other for
  - The types of its arguments
  - The number of its arguments
  - You **cannot** overload function declarations that differ only by the return type

Function overloading is a feature in C++ that allows you to define multiple functions with the same name but with different parameter lists. These functions can have the same or different return types, but they must differ in the number or types of their parameters. When you call an overloaded function, the compiler determines which version of the function to invoke based on the arguments provided.

Examples

- The following functions perform the same action but on different object types
  - Definitions (and declarations)

```
void print (char c) { ... }
void print (char *s) { ... }
void print (int v[], int n) { ... }
```

  - Function calls

```
print ('A');
print ("string"):
print (v, size);
```

Example

Function overloading

```
int plus_func(int x, int y) {
  return x + y;
}

double plus_func(double x, double y) {
  return x + y;
}

int main() {
  int my1 = plus_func(8, 5);
  double my2 = plus_func(4.3, 6.26);
  cout << "Int: " << my1 << "\n";
  cout << "Double: " << my2;
  return 0;
}
```

Default arguments

- Functions may have parameters that have a particular value in most, but not all, calls
- In those cases, we can declare that value as a default argument
  - Each parameter can have a single default value in a given scope
  - If a parameter has a default argument, **all** the parameter that follow it **must** also have a default value

Example

- The following functions perform the same action but on different object types
  - Declarations

```
void myf (int i, int j, char c);
void myf (int i, int j, char c='a');
void myf (int i, int j=20, char c='a');
void myf (int i=10, int j=20, char c='a');
void myf (int i=10, int j=20, char c);
```

No default

Error: If a parameter has a default value all parameters that follow it must have a default value

Example

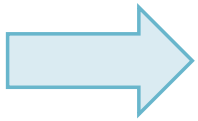
- The following functions perform the same action but on different object types
  - Declarations

```
void myf (int i, int j, char c);
void myf (int i, int j, char c='a');
void myf (int i, int j=20, char c='a');
void myf (int i=10, int j=20, char c='a');
void myf (int i=10, int j=20, char c);
```

Error

  - Calls

```
myf ();
myf (12):
myf (12, 34):
myf (12, 34, 'z');
```



```
myf (10, 20, 'a');
myf (12, 20, 'a'):
myf (12, 34, 'a'):
myf (12, 34, 'z');
```

Example

Default arguments

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

int sum(int x, int y, int z=0, int w=0) {
  return (x + y + z + w);
}

int main() {
  cout << sum(10, 15) << endl;
  cout << sum(10, 15, 25) << endl;
  cout << sum(10, 15, 25, 30) << endl;
  return 0;
}
```

Output

```
25
50
80
```

Pointers to functions

- A function pointer is just like any other pointer but is denotes a function
- The name of a function is automatically converted into the function pointer
- Function pointer can be
  - Passed to a function as a parameter
  - Returned by a function

Reported for the sake of completeness. Some example may follow.