

C Pointers and parameter passing

Victor Eijkhout, Susan Lindsey

Fall 2021

last formatted: October 21, 2021

Pointers and addresses

C and F pointers

C++ and Fortran have a clean reference/pointer concept: a reference or pointer is an 'alias' of the original object

C/C++ also has a very basic pointer concept:
a pointer is the address of some object
(including pointers)

If you're writing C++ you should not use it.
(until you get pretty advanced)
if you write C, you'd better understand it.

1. Memory addresses

If you have an `int i`, then `&i` is the address of `i`.

An address is a (long) integer, denoting a memory address. Usually it is rendered in hexadecimal notation.

Code:

```
int i;  
cout << "address of i, decimal: "  
      << (long)&i << endl;  
cout << "address of i, hex      : "  
      << std::hex << &i << endl;
```

Output

[pointer] coutpoint:

```
address of i, decimal  
      : 140732703427524  
address of i, hex  
      : 0x7ffee2cbcbc4
```

2. Same in C

Using purely C:

Code:

```
int i;  
printf("address of i: %ld\n",  
      (long)(&i));  
printf(" same in hex: %lx\n",  
      (long)(&i));
```

Output

[pointer] printfpoint:

```
address of i:  
      140732690693076  
same in hex: 7  
      ffee2097bd4
```

3. Address types

The type of '`&i`' is `int*`, pronounced 'int-star', or more formally: 'pointer-to-int'.

You can create variables of this type:

```
int i;  
int* addr = &i;  
// exactly the same:  
int *addr = &i;
```

Now `addr` contains the memory address of .

4. Dereferencing

Using `*addr` 'dereferences' the pointer: gives the thing it points to; the value of what is in the memory location.

Code:

```
int i;  
int* addr = &i;  
i = 5;  
cout << *addr << endl;  
i = 6;  
cout << *addr << endl;
```

Output

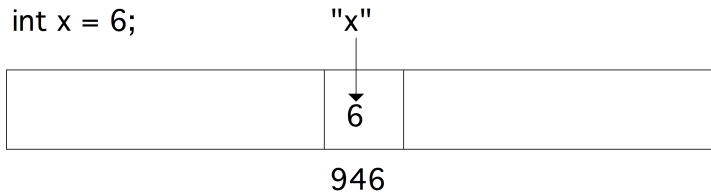
[pointer] cintpointer:

5

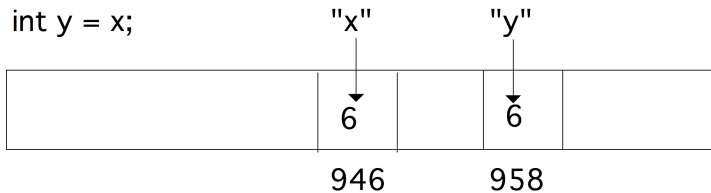
6

5. illustration

int x = 6;

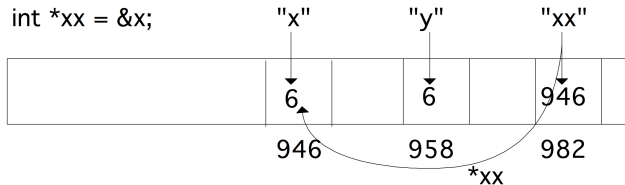


int y = x;

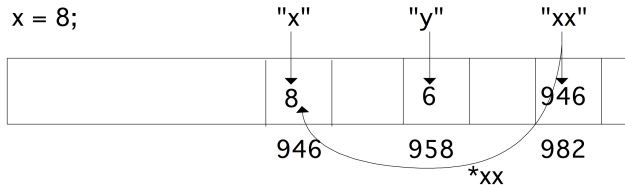


6. illustration

int *xx = &x;



x = 8;



7. Star stuff

Equivalent:

- `int* addr`: `addr` is an int-star, or
- `int *addr`: `*addr` is an int.

Addresses and parameter passing

8. C++ pass by reference

C++ style functions that alter their arguments:

```
void inc(int &i) { i += 1; }  
int main() {  
    int i=1;  
    inc(i);  
    cout << i << endl;  
    return 0;  
}
```

9. C-style pass by reference

In C you can not pass-by-reference like this. Instead, you pass the address of the variable *i* by value:

```
void inc(int *i) {  
    *i += 1;  
}  
  
int main() {  
    int i=1;  
    inc(&i);  
    cout << i << endl;  
    return 0;  
}
```

Now the function gets an argument that is a memory address: *i* is an int-star. It then increases **i*, which is an int variable, by one.

Exercise 1

Write another version of the *swap* function:

```
void swap( /* something with i and j */ {  
    /* your code */  
}  
  
int main() {  
    int i=1,j=2;  
    swap( /* something with i and j */ );  
    cout << "check that i is 2: " << i << endl;  
    cout << "check that j is 1: " << i << endl;  
    return 0;  
}
```

Hint: write C++ code, then insert stars where needed.

Arrays and pointers

10. Array and pointer equivalence

Array and memory locations are largely the same:

Code:

```
double array[5] = {11,22,33,44,55};  
double *addr_of_second = &(array[1]);  
cout << *addr_of_second << endl;  
array[1] = 7.77;  
cout << *addr_of_second << endl;
```

Output

[pointer] arrayaddr:

22

7.77

11. Array passing to function

When an array is passed to a function, it behaves as an address:

Code:

```
void set_array( double *x,int size) {  
    for (int i=0; i<size; i++)  
        x[i] = 1.41;  
};  
  
/* ... */  
double array[5] = {11,22,33,44,55};  
set_array(array,5);  
cout << array[0] << "..." << array  
[4] << endl;
```

Output

[pointer] arraypass:

1.41....1.41

Note that these arrays don't know their size, so you need to pass it.

Multi-dimensional arrays

12. Multi-dimensional arrays

After

```
double x[10][20];
```

a row `x[3]` is a `double*`, so is `x` a `double**`?

Was it created as:

```
double **x = new double*[10];  
for (int i=0; i<10; i++)  
    x[i] = new double[20];
```

No: multi-d arrays are contiguous.

Dynamic allocation

13. Problem with static arrays

Create an array with size depending on something:

```
if ( something ) {  
    double ar[25];  
} else {  
    double ar[26];  
}  
ar[0] = // there is no array!
```

This Does Not Work

14. Declaration and allocation

Now dynamic allocation:

```
double *array;  
if (something) {  
    array = new double[25];  
} else {  
    array = new double[26];  
}
```

Don't forget:

```
free(array);
```

15. Allocation, C vs C++

C allocates in bytes:

```
double *array;  
array = (double*) malloc( 25*sizeof(double) );
```

C++ allocates an array:

```
double *array;  
array = new double[25];
```

Don't forget:

```
delete(array);
```

16. De-allocation

Memory allocated with *malloc* / *new* does not disappear when you leave a scope. Therefore you have to delete the memory explicitly:

```
free(array);  
delete(array);
```

The C++ *vector* does not have this problem, because it obeys scope rules.

17. Memory leak1

```
void func() {  
    double *array = new double[large_number];  
    // code that uses array  
}  
int main() {  
    func();  
};
```

- The function allocates memory
- After the function ends, there is no way to get at that memory
- \Rightarrow memory leak.

18. Memory leaks

```
for (int i=0; i<large_num; i++) {  
    double *array = new double[1000];  
    // code that uses array  
}
```

Every iteration reserves memory, which is never released: another memory leak.

Your code will run out of memory!