

C Pointers and parameter passing

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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:

```
1 int i;  
2 cout << "address of i, decimal: "  
3     << (long)&i << '\n';  
4 cout << "address of i, hex      : "  
5     << std::hex << &i << '\n';
```

Output:

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

2. Same in C

Using purely C:

Code:

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

Output:

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

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 *i*.

4. Dereferencing

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

Code:

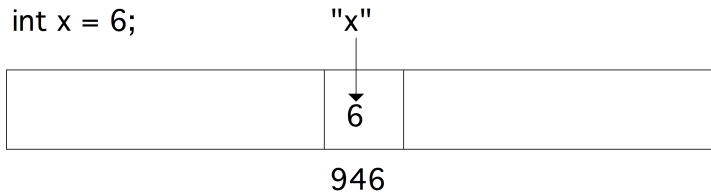
```
1 int i;  
2 int* addr = &i;  
3 i = 5;  
4 cout << *addr << '\n';  
5 i = 6;  
6 cout << *addr << '\n';
```

Output:

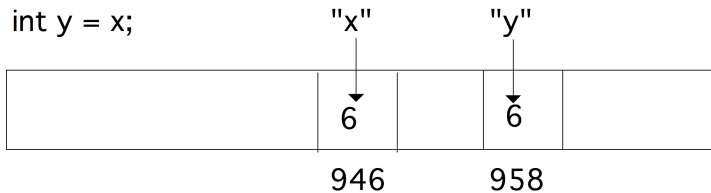
```
5  
6
```

5. illustration

int x = 6;

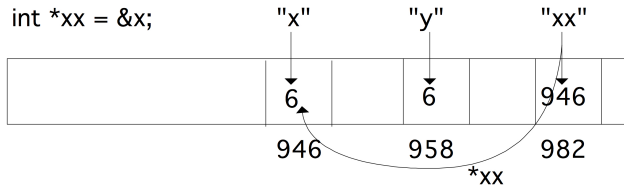


int y = x;

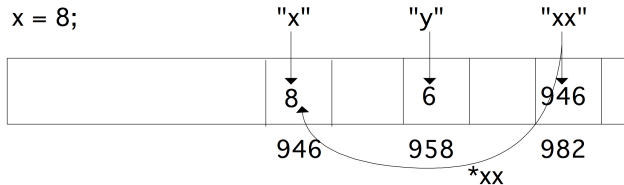


6. illustration

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:

```
1 double array[5] = {11,22,33,44,55};  
2 double *addr_of_second =  
    &(array[1]);  
3 cout << *addr_of_second << '\n';  
4 array[1] = 7.77;  
5 cout << *addr_of_second << '\n';
```

Output:

```
22  
7.77
```


11. Array passing to function

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

Code:

```
1 void set_array( double *x,int size)
  {
2   for (int i=0; i<size; i++)
3     x[i] = 1.41;
4 };
5  /* ... */
6  double array[5] =
   {11,22,33,44,55};
7  set_array(array,5);
8  cout << array[0] << "...." <<
   array[4] << '\n';
```

Output:

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:

```
delete 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:

```
free(array); // C  
delete array; // C++
```

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!