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.
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. C style:

```
Code:

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

```
Output
[pointer] printfpoint:

make[2]: ‘printfpoint’ is up to d
```

and C++:

```
Code:

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

```
Output
[pointer] coutpoint:

make[2]: ‘coutpoint’ is up to dat
```

2. 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;
```

3. Dereferencing

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

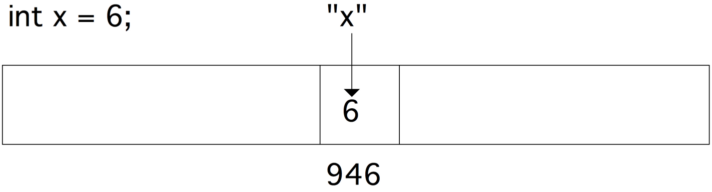
Code:

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

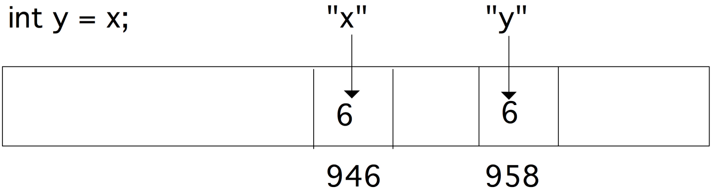
```
Output
[pointer] cintpointer:

make[2]: 'cintpointer' is up to d
```

4. illustration

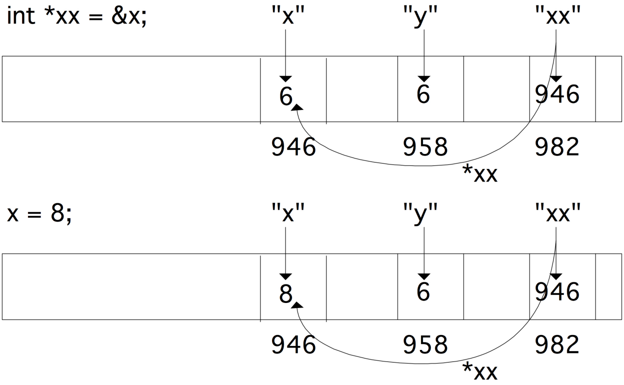
int x = 6;



int y = x;



5. illustration



6. Star stuff

Equivalent:

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

Addresses and parameter passing

7. 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;
}
```

8. 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

9. 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:

make[2]: ‘arrayaddr’ is up to dat
```

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:

make[2]: 'arrayaddr' is up to dat
```

Multi-dimensional arrays

11. 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

12. Problem with static arrays

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

13. Declaration and allocation

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

(Size in doubles, not in bytes as in C)

14. De-allocation

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

```
delete(array);
```

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

15. 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.

16. 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!