Pointers and references

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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.

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:

```
address of i: 140732689254188
 same in hex: 7ffee1f3872c
```

and C++:

Code:

```
int i;
cout << "address of i, decimal: "
```

Output:

```
address of i, decimal: 140732799797020
```

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;
```

Dereferencing

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

Code:

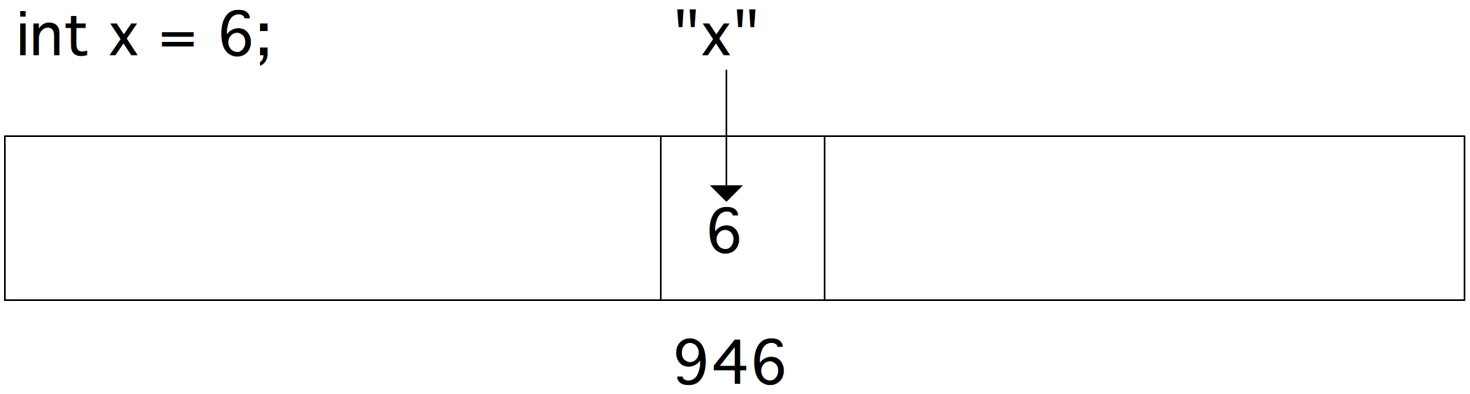
```
int i;
int* addr = &i;
i = 5;
cout << *addr << endl;
i = 6;
cout << *addr << endl;
```

Output:

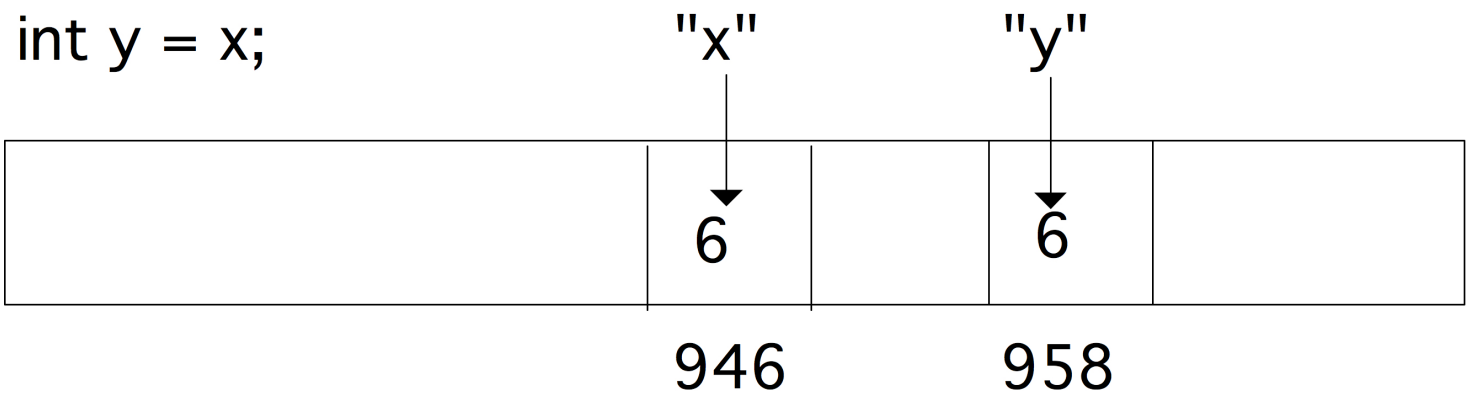
```
5
6
```

illustration

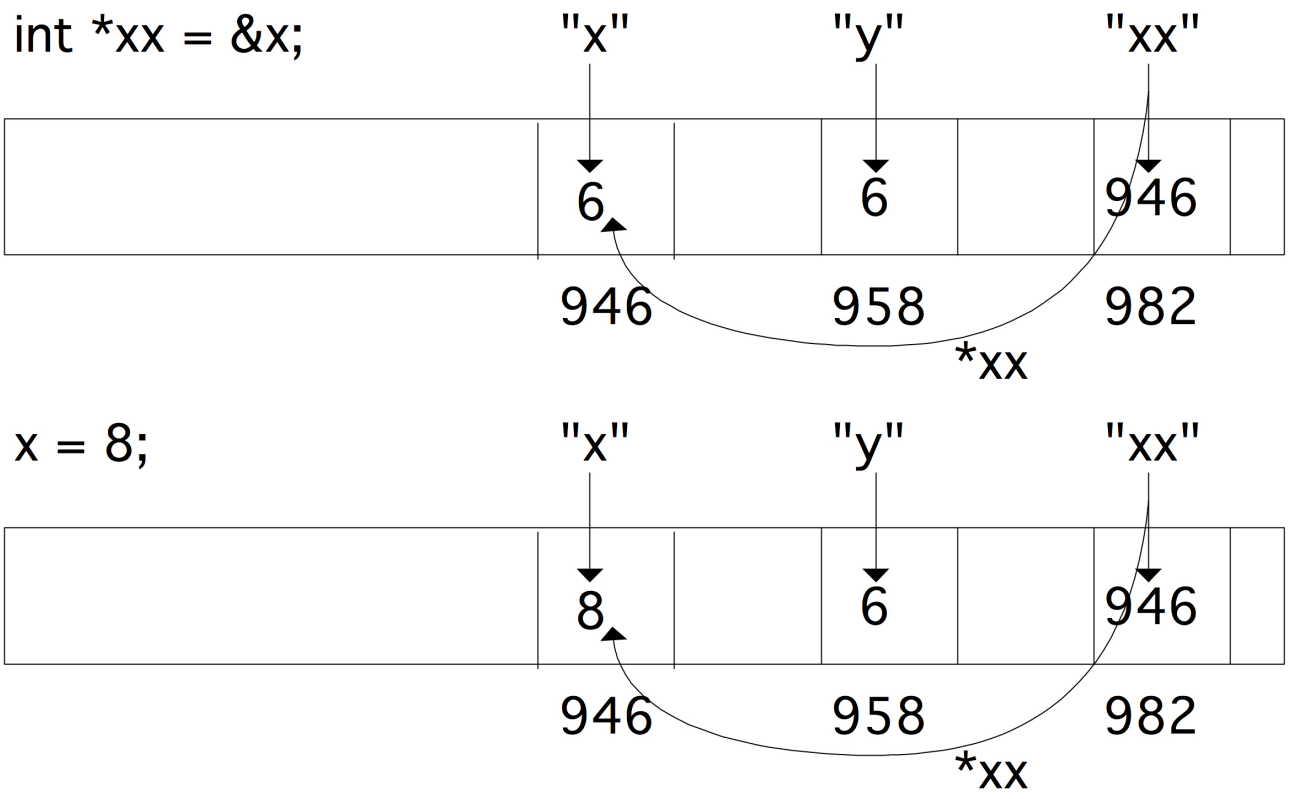
int x = 6;



int y = x;



illustration



Star stuff

Equivalent:

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

Arrays and pointers

Array and pointer equivalence

Array and memory locations are largely the same:

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

Multi-dimensional arrays

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.

Pointers and parameter passing

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;
}
```

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 swapij( /* something with i and j */ {
  /* your code */
}
int main() {
  int i=1,j=2;
  swapij( /* 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.

Reference: change argument

```
void f( int &i ) { i += 1; };
int main() {
  int i = 2;
  f(i); // makes it 3
```

Reference: save on copying

```
class BigDude {
private:
   vector<double> array(5000000);
}
int main() {
   BigDude big;
   f(big); // whole thing is copied
```

Instead write:

```
void f( BigDude &thing ) { .... };
```

Prevent changes:

```
void f( const BigDude &thing ) { .... };
```

Dynamic allocation

Problem with static arrays

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

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)

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.

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*.

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!