Pointers

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- Special case of bounded-size natural numbers
  - Maximum memory limited by processor word-size
  - 2^{32} bytes = 4GB, 2^{64} bytes = 16 exabytes

- A pointer is just another kind of value
  - A basic type in C++ `int *ptr;`

The variable “ptr” is a pointer to an “int”.

Pointer Operations in C++

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- Creation
  - `&` *variable* — Returns variable's memory address
- Dereference
  - `*` *pointer* — Returns contents stored at address
- Indirect assignment
  - `*` *pointer* = *val* — Stores value at address

- Of course, still have...

- Assignment
  - *pointer* = *ptr* — Stores pointer in another variable

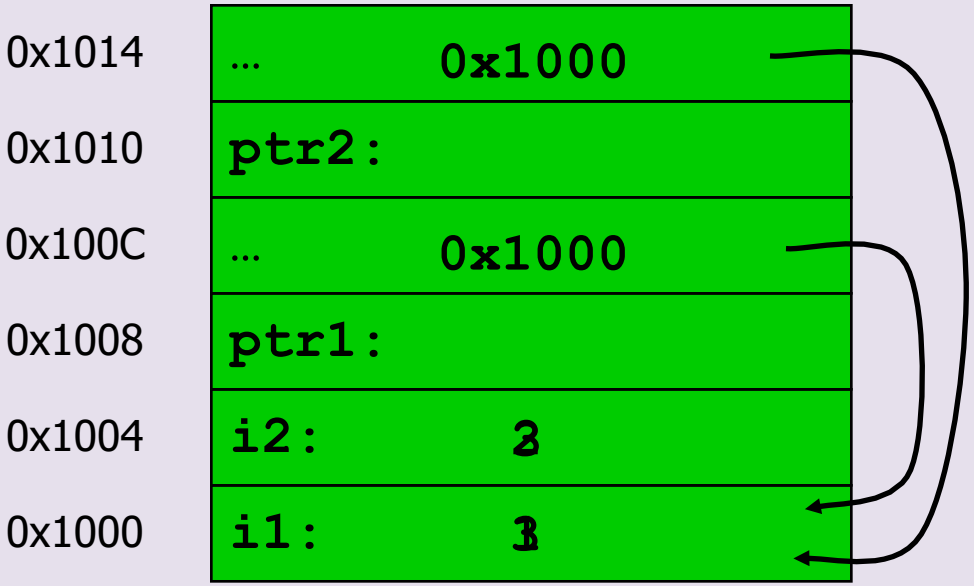
Using Pointers

```
int  i1;
int  i2;
int *ptr1;
int *ptr2;

i1 = 1;
i2 = 2;

ptr1 = &i1;
ptr2 = ptr1;

*ptr1 = 3;
i2 = *ptr2;
```



Using Pointers (cont.)

```
int  int1     = 1036;   /* some data to point to  */
int  int2     = 8;

int *int_ptr1 = &int1;  /* get addresses of data  */
int *int_ptr2 = &int2;

*int_ptr1 = int_ptr2;

*int_ptr1 = int2;
```

What happens?

Type check warning: `int_ptr2` **is not an** `int`

`int1` **becomes 8**

Using Pointers (cont.)

```
int  int1     = 1036;   /* some data to point to  */
int  int2     = 8;

int *int_ptr1 = &int1;  /* get addresses of data  */
int *int_ptr2 = &int2;

int_ptr1 = *int_ptr2;

int_ptr1 = int_ptr2;
```

What happens?

Type check warning: `*int_ptr2` **is not an** `int *`

Changes `int_ptr1` **– doesn't change** `int1`

Example

```
int x = 1, y = 2, z[10];
int *ip;                // ip is a pointer to an int, so it can point
                        // to x, y, or an element of z
ip = &x;                // ip now points at the location where x is stored
y = *ip;                // set y equal to the value pointed to by ip, or y = x
*ip = 0;                // now change the value that ip points to to 0,
                        // so now x = 0 but notice that y is unchanged
ip = &z[0];             // now ip points at the first location in the array z

*ip = *ip + 1;          // the value that ip points to (z[0]) is incremented
```

```
int x, *y, z, *q;
x = 3;
y = &x;                 // y points to x
printf("%d\n", x);      // outputs 3
printf("%d\n", y);      // outputs x's address, will seem like a random number
printf("%d\n", *y);     // outputs what y points to, or x (3)
printf("%d\n", *y+1);   // outputs 4 (print out what y points to + 1)
printf("%d\n", *(y+1));//this outputs the item after x in memory – what is it?
z = *(&x);              // z equals 3 (what &x points to, which is x)
q = &*y;                // q points to x, just like y; note *& and &* cancel out
```

Pointer Arithmetic

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pointer + number *pointer – number*

E.g., *pointer* + 1 adds something to a pointer

```
char   *p;
char    a;
char    b;

p = &a;
p += 1;
```

In each, p now points to b
(Assuming compiler doesn't reorder variables in memory)

```
int   *p;
int    a;
int    b;

p = &a;
p += 1;
```

Adds 1*sizeof(char) to the memory address

Adds 1*sizeof(int) to the memory address

Pointer arithmetic should be used cautiously

The Simplest Pointer in C++

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- Special constant pointer `NULL`
  - Points to no data
  - Dereferencing illegal – causes *segmentation fault*

Pointer as Parameters

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

void swap(int *a, int *b)
{ int temp;
  temp = *a;
  *a = *b;
   *b = temp;
}

int main ()
{
  int m=3,n=4;
  cout<< m <<" " << n<<endl;
  swap(&m,&n);
  cout<< m <<" " << n<<endl;
  return 0;
}
```

Summary

- Address-of Operator (&)
- Dereference operator (*)
- Declaring pointers
- Pointer initialization
- Pointer arithmetics

Pointer Vs Arrays

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Pointers and arrays are strongly related. In fact, pointers and arrays are interchangeable in many cases.

Pointer Vs Arrays

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

double calMean(int *arr, int size)
{
  int    i, sum = 0;
  double mean;

  for (i = 0; i < size; ++i)
  {
    sum += arr[i];
   }

  mean = double(sum) / size;

  return mean;
}

int main ()
{
   // an int array with 5 elements.
   int score[5] = {1000, 12, 111, 170, 150};
   double mean;
    // pass pointer to the array as an argument.
   mean = calMean( score, 5 ) ;
    // output the returned value
   cout << "Mean value is: " << mean << endl;

   return 0;
}
```

Pointer Vs Arrays

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However, pointers and arrays are not completely interchangeable.

```
#include <iostream>

using namespace std;
const int MAX = 3;

int main ()
{
   int  var[MAX] = {10, 100, 200};

   for (int i = 0; i < MAX; i++)
   {
      *var = i;     // This is a correct syntax
      var++;        // This is incorrect.
   }
   return 0;
}
```

Pointer Vs Arrays

- The sizeof operator
  a) sizeof(array) returns the amount of memory used by all elements in array
  b) sizeof(pointer) only returns the amount of memory used by the pointer variable itself

- The & operator
  a) &array is an alias for &array[0] and returns the address of the first element in array
  b) &pointer returns the address of pointer

- A string literal initialization of a character array
  a) char array[] = “abc” sets the first four elements in array to ‘a’, ‘b’, ‘c’, and ‘\0’
  b) char *pointer = “abc” sets pointer to the address of the “abc” string (which may be stored in read-only memory and thus unchangeable)

- Pointer variable can be assigned a value whereas array variable cannot be.

```
int  a[10];
int  *p;
p=a;  /*legal*/
a=p;  /*illegal*/
```

- Arithmetic on pointer variable is allowed.

```
p++;  /*Legal*/
a++;  /*illegal*/
```