C Introduction

CS 2130: Computer Systems and Organization 1

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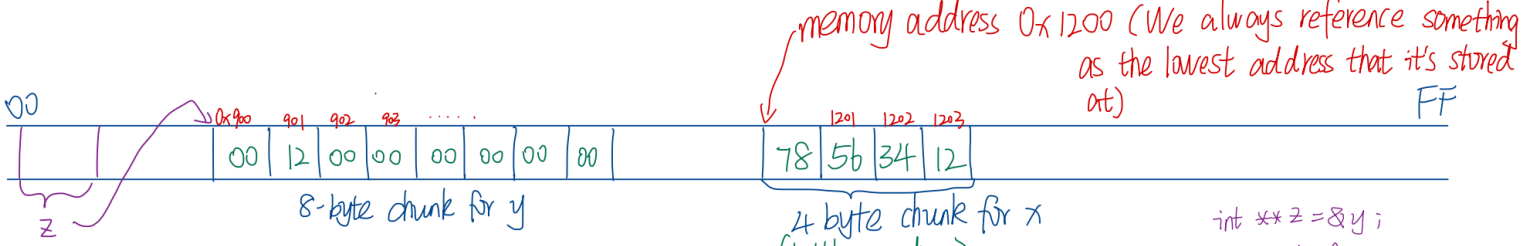
Announcements

- Homework 6 due
- Homework 7 **due Monday at 11:59pm** on Gradescope
- Quiz 7 available today on Gradescope, due Sunday
- Exam 2 next Friday

Data Types in C

Pointers - how C uses addresses!

- Hold the address of a position in memory
- Need to know the kind of information stored at that location



int x = 0x12345678

int *y;

y = &x, (I want y point to x, which means store the address of x in y).

int **z = &y;

*z : dereference z

**z: dereference *z

**z = 0x00000000;
(set x to 0x00000000)

*z = 25; (Warning: you're trying to assign an integer to a pointer)
(But later, when you use it as an address, may seg Fault).

y = 0xABCDEF01; (I'm changing the pointer) → I may don't want to do this. Sometimes seg fault?

*y = 25; (When I use an asterisk, it will say is follow the pointer on y, follow the address to the place in memory that y points to and change that value)

Using Compilers

Arrays

Array: 0 or more values of same type stored contiguously in memory

- Declare as you would use: `int myarr[100];`
- `sizeof(myarr)` = 400 — 100 4-byte integers
- `myarr` treated as pointer to first element
- Can declare array literals:

```
int y[5] = {1, 1, 2, 3, 5}
```

Pointers and Arrays

`*x` and `x[0]` are equivalent

- Pointer to single value and pointer to first value in array
- Treat array as pointer to the first value (lowest address)
- Indexing into array: `x[n]` and `*(x+n)`
  - If `x` is an `int *`, then `x+1` points to **next int** in memory
  - Adding 1 to pointer adds `sizeof()` the type we're pointing to

Pointers and Arrays

Consider: **int **a**

Pointers

- All pointers are the same size: address size in underlying ISA
- Two special int types (defined using typedef)
  - `size_t` - integer the size of a pointer (unsigned)
  - `ssize_t` - integer the size of a pointer (signed)
  - With our compiler and ISA, these are both variants of `long`

Pointers

Consider the following code:

```
int x = 10;
int *y = &x;
int *z = y + 2;
long w = ((long)z) - ((long)y);
```

Why is `w` = 8?

Other Types and Values

- Literal values - integer literals are implicitly cast
  - `unsigned long very_big = 92233720368547758O8uL`
  - `u` for unsigned, `L` for long
- `enum` - named integer constants (in ascending order)
  - ```
    enum { a, b, c, d=100, e };
    int foo = e;
    ```
- `void` - a byte with no meaning or "nothing"
  - Pointers: `void *p`
  - Return values: `void myfunction();`
- Casting - changing type, converting
  - Integer: zero- or sign-extend or truncate to space
  - Int to float: convert to nearby representable value
  - Float to int: truncate remainder (no rounding)
    ```

Structures

`struct` - Structures in C

- Act like Java classes, but no methods and all public fields
- Stores fields adjacently in memory (but may have padding)
- Compiler determines padding, use `sizeof()` to get size
- Name of the resulting type includes word `struct`

```
struct foo {
    long a;
    int b;
    short c;
    char d;
};

struct foo x;
x.b = 123;
x.c = 4;
```

Structure Literals

```
struct a {
    int b;
    double c;
};

/* Both of the following initialize b to 0 and c to 1.0 */
struct a x = { 0, 1.0 };
struct a y = { .b = 0, .c = 1.0 };
```

typedef

`typedef` - give new names to any type!

- Fairly common to see several names for same data type to convey intent
- Ex: `unsigned long` may be `size_t` when used in sizes
- Examples:

```
typedef int Integer;
Integer x = 4;
typedef double ** dpp;
```

- Used with *anonymous structs*:

```
typedef struct { int x; double y; } foo;
foo z = { 42, 17.4 };
```

Struct Example

```
typedef struct {
    long x;
    long y;
    long *array;
    long length;
} foo;
```

Struct Example

```
long sum2(foo *arg) {
    long ans = arg->x;
    for(long i = 0; i < arg->length; i += 1)
        ans += arg->y * arg->array[i];
    return ans;
}
```

```
sum2:
    movq    (%rdi), %rax
    movq    24(%rdi), %r8
    testq   %r8, %r8
    jle     .LBB1_3
    movq    8(%rdi), %rdx
    movq    16(%rdi), %rsi
    xorl    %edi, %edi
.LBB1_2:
    movq    (%rsi,%rdi,8), %rcx
    imulq   %rdx, %rcx
    addq    %rcx, %rax
    incq    %rdi
    cmpq    %rdi, %r8
    jne     .LBB1_2
.LBB1_3:
    retq
```

Struct Example

```
long sum1(foo arg) {
    long ans = arg.x;
    for(long i = 0; i < arg.length; i += 1)
        ans += arg.y * arg.array[i];
    return ans;
}
```

```
sum1:
    movq    8(%rsp), %rax
    movq    32(%rsp), %r8
    testq   %r8, %r8
    jle     LBB0_3
    movq    16(%rsp), %rdx
    movq    24(%rsp), %rsi
    xorl    %edi, %edi
.LBB0_2:
    movq    (%rsi,%rdi,8), %rcx
    imulq   %rdx, %rcx
    addq    %rcx, %rax
    incq    %rdi
    cmpq    %rdi, %r8
    jne     .LBB0_2
.LBB0_3:
    retq
```