CS 61C Spring 2019 — C Basics

Discussion 1: January 30, 2019

# 1 C

C is syntactically similar to Java, but there are a few key differences:

1. C is function-oriented, not object-oriented; there are no objects.
2. C does not automatically handle memory for you.
   - Stack memory, or *things allocated the way you're accustomed to*: data is garbage immediately after the *function in which it was defined* returns.
   - Heap memory, or *things allocated with* `malloc`, `calloc`, *or* `realloc` *commands*: data is freed only when the programmer explicitly frees it!
   - In any case, allocated memory always holds garbage until it is initialized!
3. C uses pointers explicitly. `*p` tells us to use the value that `p` points to, rather than the value of `p`, and `&x` gives the address of `x` rather than the value of `x`.

   On the left is the memory represented as a box-and-pointer diagram.

   On the right, we see how the memory is really represented in the computer.

| | |
|---|---|
| 0xFFFFFFFF | |
| | ... |
| 0xF93209B0 | x=0x61C |
| 0xF93209AC | 0x2A |
| | ... |
| 0xF9320904 | p |
| 0xF9320900 | pp |
| | ... |
| 0x00000000 | |

| | |
|---|---|
| 0xFFFFFFFF | |
| | ... |
| 0xF93209B0 | 0x61C |
| 0xF93209AC | 0x2A |
| | ... |
| 0xF9320904 | 0xF93209AC |
| 0xF9320900 | 0xF9320904 |
| | ... |
| 0x00000000 | |

   Let's assume that **`int`**`* p` is located at `0xF9320904` and **`int`** `x` is located at `0xF93209B0`. As we can observe:

   - `*p` should return `0x2A` ($42_{10}$).
   - `p` should return `0xF93209AC`.
   - `x` should return `0x61C`.
   - `&x` should return `0xF93209B0`.

   Let's say we have an **`int`** `**pp` that is located at `0xF9320900`.

1.1 What does `pp` evaluate to? How about `*pp`? What about `**pp`?

1.2 The following functions are syntactically-correct C, but written in an incomprehensible style. Describe the behavior of each function in plain English.

(a) Recall that the ternary operator evaluates the condition before the `?` and returns the value before the colon (`:`) if true, or the value after it if false.

```
int foo(int *arr, size_t n) {
    return n ? arr[0] + foo(arr + 1, n - 1) : 0;
}
```

(b) Recall that the negation operator, `!`, returns 0 if the value is non-zero, and 1 if the value is 0. The `~` operator performs a *bitwise not* (NOT) operation.

```
int bar(int *arr, size_t n) {
    int sum = 0, i;
    for (i = n; i > 0; i--)
        sum += !arr[i - 1];
    return ~sum + 1;
}
```

(c) Recall that `^` is the *bitwise exclusive-or* (XOR) operator.

```
void baz(int x, int y) {
    x = x ^ y;
    y = x ^ y;
    x = x ^ y;
}
```

# 2 Programming with Pointers

2.1 Implement the following functions so that they work as described.

(a) Swap the value of two **int**s. *Remain swapped after returning from this function.*

```
void swap(
```

(b) Return the number of bytes in a string. *Do not use* `strlen`.

```
int mystrlen(
```

2.2 The following functions may contain logic or syntax errors. Find and correct them.

(a) Returns the sum of all the elements in `summands`.

```c
int sum(int* summands) {
    int sum = 0;
    for (int i = 0; i < sizeof(summands); i++)
        sum += *(summands + i);
    return sum;
}
```

(b) Increments all of the letters in the `string` which is stored at the front of an array of arbitrary length, `n >= strlen(string)`. Does not modify any other parts of the array's memory.

```c
void increment(char* string, int n) {
    for (int i = 0; i < n; i++)
        *(string + i)++;
}
```

(c) Copies the string `src` to `dst`.

```c
void copy(char* src, char* dst) {
    while (*dst++ = *src++);
}
```

(d) Overwrites an input string `src` with "61C is awesome!" if there's room. Does nothing if there is not. Assume that `length` correctly represents the length of `src`.

```c
void cs61c(char* src, size_t length) {
    char *srcptr, replaceptr;
    char replacement[16] = "61C is awesome!";
    srcptr = src;
    replaceptr = replacement;
    if (length >= 16) {
        for (int i = 0; i < 16; i++)
            *srcptr++ = *replaceptr++;
    }
}
```

# 3 Memory Management

3.1 For each part, choose one or more of the following memory segments where the data could be located: **code, static, heap, stack**.

(a) Static variables

(b) Local variables

(c) Global variables

(d) Constants

(e) Machine Instructions

(f) Result of `malloc`

(g) String Literals

3.2 Write the code necessary to allocate memory on the heap in the following scenarios

(a) An array `arr` of $k$ integers

(b) A string `str` containing $p$ characters

(c) An $n \times m$ matrix `mat` of integers initialized to zero.

Suppose we've defined a linked list **`struct`** as follows. Assume `*lst` points to the first element of the list, or is `NULL` if the list is empty.

```
struct ll_node {
    int first;
    struct ll_node* rest;
}
```

3.3 Implement `prepend`, which adds one new `value` to the front of the linked list.

```
void prepend(struct ll_node** lst, int value)
```

3.4 Implement `free_ll`, which frees all the memory consumed by the linked list.

```
void free_ll(struct ll_node** lst)
```