Discussion 1: January 30, 2019

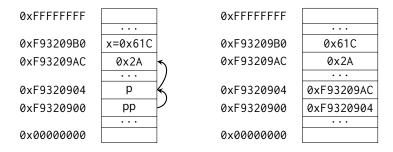
## 1 C

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.



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.

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.

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

(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.

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

(c) Copies the string src to dst.

```
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.

## 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\_11, which frees all the memory consumed by the linked list.

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