CSC 209 Review 8 Solution

August 28, 2020

1. I need to create a wrapper function `my_malloc` that does the following:

   - ask `my_malloc` it to allocate `n` bytes
   - call `malloc`
   - test `malloc` doesn't have a null pointer
   - return pointer from `malloc`

   The solution to this problem is:

```c
void *my_malloc(int n) {
    void *p;

    p = malloc(n);

    if (!p) {
        printf("ERROR: Malloc allocation failed");
    }

    return p;
}
```

   Notes

   - Learned that void function can return value
   - **Dynamic Storage Allocation**
     - Allows to allocate storage during program execution
     - Allows to create data structures and shink and grow array as needed
     - e.g. `malloc`, `calloc`, `realloc`
   - **Memory Allocation Functions**
     - `malloc` - Allocates a block of memory but doesn't initialize it
       - doesn't initialize the allocated memory

    - more efficient than `calloc`
    - accessing the content → segmentation fault (accessing value at invalid mem. location) or garbage values
  - `calloc` - Allocates a block of memory and clears it
    - allocates memory and initializes the memory block to zero
    - accessing the content of blocks would return 0
  - `realloc` - Resizes a previously allocated block of memory
- **Null Pointer**
  - is returned when it fails to allocate a block of memory large enough to satisfy the request

Example

```
p = malloc(10000);
if (p == NULL) {
  /* allocation failed; take appropriate action */
}
```

2. I need to write a function named `duplicate` that uses dynamic storage allocation to create a copy of a string.

   The requirements of the function are

   - `duplicate` allocates space for a string of the same length as `str`
   - `duplicate` copies the contents of str into the new string
   - `duplicate` returns a pointer to it
   - `duplicate` returns a null pointer if the memory allocation fails

   The solution to this problem is:

```c
#include <stdio.h>
#include <stdlib.h>  // malloc
#include <string.h>  // strlen

char *duplicate(const char *str);

int main(void) {
    char s[] = "hello world", *p;

    p = duplicate (s);
```

```
11
12          printf("Duplicate: %s\n", p);
13
14          free(p);
15          return 0;
16      }
17
18
19      char *duplicate(const char *str) {
20          char *p, *q;
21          const char *r;
22
23          int n = strlen(str);
24
25          p = (char *)malloc(n + 1);
26
27          if (!p) {
28              return p;
29          }
30
31          r = str;
32          q = p;
33          while (r < str + n) {
34              *q = *r;
35              q++;
36              r++;
37          }
38
39          *q = '\0';
40
41          return p;
42      }
```

Correct Solution:

```
1       #include <stdio.h>
2       #include <stdlib.h>  // malloc
3       #include <string.h>  // strlen
4
5       char *duplicate(const char *str);
6
7       int main(void) {
8           char s[] = "hello world", *p, *q;
9           ;
10          p = duplicate (s);
11
12          printf("Duplicate: %s\n", p);
13
14          free(p);
15          return 0;
16      }
17
```

```
18
19    char *duplicate(const char *str) {
20        char *p, *q;
21        const char *r;
22
23        int n = strlen(str);
24
25        p = (char *)malloc(n + 1);
26
27        if (!p) {
28            p = ((void*)0);
29            return p;
30        }
31
32        r = str;
33        q = p;
34        while (r < str + n) {
35            *q = *r;
36            q++;
37            r++;
38        }
39
40        *q = '\0';
41
42        return p;
43    }
```

Note

- Null pointer has value `((void*)0)`
- `const` tag in parameter prevetns the function from modifying what it's pointer variable is pointing to.
  - value is modifiable
  - changes the parameter to pass by value

3.

```
1   int *create_array(int n, int initial_value) {
2       int *array;
3
4       array = malloc(n * sizeof(int));
5
6       if (array == NULL) {
7           return array;
8       }
9
10      for(int i = 0; i < n; i++){
11          array[i] = initial_value;
12      }
13
14      return array
15  }
```

Notes

- **Dynamically Allocated Arrays**
  - **Syntax:**

```
int *a;
a = malloc(n * sizeof(int));
```

  - returns null pointer if allocation fails

4.

```c
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

struct point {int x, y;};
struct rectangle {struct point upper_left, lower_right;};

int main(void) {

    struct rectangle *p;

    p = malloc(sizeof(struct rectangle));

    p->upper_left.x = 10;
    p->upper_left.y = 25;
    p->lower_right.x = 20;
    p->lower_right.y = 15;

    printf("%d %d %d %d",
        p->upper_left.x,
        p->upper_left.y,
        p->lower_right.x,
        p->lower_right.y
    );

    return 0;
}
```

Notes

- -> doesn't carry over to accessing nested members. Only works when struct is a pointer

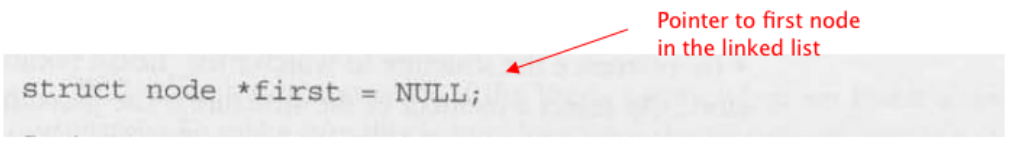
  Example

  `p->upper_left.x`

- **Linked Lists**
  - **Declaring Node Type**

* **Syntax (Node structure):**

```
struct node {
  int value;            /* data stored in the node  */
  struct node *next;    /* pointer to the next node */
};
```



– **Creating a Node**

* **Syntax (Allocating using malloc):**

```
struct node *new_node;
new_node = malloc(sizeof(struct node));
```

* Assigning value

```
(*new_node).value = 10;
```

– **-> Operator**

* is a short form of `(*STRUCT_NAME).MEMBER_NAME`

Example

```
(*new_node).value = 10;
```

Is the same as

```
new_node->value = 10;
```

5. `b)` and `c)` are legal

6.
```
1  struct node *delete_from_list(struct node *list, int n)
2  {
3      struct node *curr, *to_be_freed;
4
5      for (curr = list; curr != NULL && curr->value != n; curr = curr
   ->next) {
6          if (curr->next != NULL && curr->next->value == n) {
7              to_be_freed = curr->next;
8              curr->next = curr->next->next;
9              free(to_be_freed);
10
11             return list;
12         }
13     }
```

```
14
15
16          return list;
17
18      }
```

Notes

- **Searching a Linked List**
  - **Syntax:** `for (p = first; p != NULL; p = p ->next)`

    Example:

```
struct node *search_list(struct node *list, int n)
{
  struct node *p;

  for (p = list; p != NULL; p = p->next)
    if (p->value == n)
      return p;
  return NULL;
}
```

- **Deleting Node from a List**
  - Steps
    1. Locate the node to be deleted
       - **Syntax (Searching for the node of value `n` to be deleted):**

```
for (cur = list, prev = NULL;
     cur != NULL && cur->value != n;
     prev = cur, cur = cur->next)
  ;
```

    2. Alter the previous node so that it "bypasses" the deleted node

```
if (cur == NULL)
  return list;
if (prev == NULL)
  list = list->next;
else
  prev->next = cur->next;
```

3. Call `free` to reclaim the space occupied by the deleted code

```
free(cur);
```

Putting together, we have

```
struct node *delete_from_list(struct node *list, int n)
{
  struct node *cur, *prev;

  for (cur = list, prev = NULL;
       cur != NULL && cur->value != n;
       prev = cur, cur = cur->next)
    ;
  if (cur == NULL)
    return list;                /* n was not found */
  if (prev == NULL)
    list = list->next;          /* n is in the first node */
  else
    prev->next = cur->next;     /* n is in some other node */
  free(cur);
  return list;
}
```

7. The statement is incorrect because it removes the current node before its pointer moves to the next node.

   As a result, the remaining nodes cannot be removed, and this is not good.

   To fix the problem, the pointer `p` must move to the next before removing the current node, as shown below:

```
1    struct node *to_be_freed;
2
3    for (p = first; p != NULL;) {
4        to_be_freed = p;
5        p = p->next;
6        free(p);
7    }
```

8.

```
1    int contents[100];
2    int top = 0;
3
4    void make_empty(void) {
5
6    }
```

```
7
8     void is_empty(void) {
9
10    }
11
12    void push (int i) {
13
14    }
15
16    int pop(void) {
17
18    }
```