CS 537
Section 3: Quiz and Memory in C

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Quiz 1

- You have 15 minutes.
- Please answer all three questions

Project 0

- Average was 10 our of 20
- Common problems:
  - Incorrectly handling errors: lots of people don't read in the rest of the line when the line is too long
  - Extra lines
  - Memory corruption (garbage characters)
  - lots of people copied code to allocate an array and didn't convert from integers to characters
  - people didn't free memory
  - Allocated too much memory

```
char **reversed = (char **)malloc(FILE_MAX * LINE_MAX * sizeof(char *));
    for(i = 0; i < FILE_MAX; i++)
        reversed[i] = (char *)malloc(LINE_MAX * sizeof(char));
```

  - People wrote their own routines when not necessary (e.g. strlen() for length of a line)
  - Inefficiency: reading through whole file multiple times; once to count length, another time to read lines

Memory Debugging

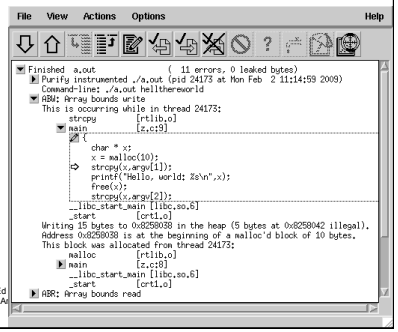
```
int main(int argc, char * argv[])
{
  char * x;
  x = malloc(10);
  strcpy(x,argv[1]);
  printf("Hello, world: %s\n",x);
  free(x);
  strcpy(x,argv[2]);
  printf("Bye, world: %s\n",x);

  return(0);
}
```

What happens if you run this program?

- It works correctly?
- It crashes?
- [try it]

Purify

```
manaslu(4)% purify gcc -g z.c
manaslu(5)% ./a.out hellthereworld
Hello, world: hellthereworld
Segmentation fault
```



Valgrind

```
[swift] gcc -g z.c
[swift] valgrind ./a.out hellothereworld
==858== Memcheck, a memory error detector.
==858== ERROR
==858==
==858== Invalid write of size 1
==858==    at 0x26DB0: strcpy+160 (in /usr/local/lib/
   valgrind/x86-darwin/vgpreload_memcheck.so)
==858==    by 0x1F84: main+50 (z.c:9)
==858==  Address 0x3ec35a is 0 bytes after a block of size
   10 alloc'd
==858==    at 0x22E53: malloc+99 (in /usr/local/lib/
   valgrind/x86-darwin/vgpreload_memcheck.so)
==858==    by 0x1F6A: main+24 (z.c:8)
```


Pointers in C

- Pointers are addresses
  - `char * c = malloc(10 * sizeof(char));`
  - c now contains the **address** of some memory
- '*' operator returns what is at an address
  - *c returns the character at address c
- p[n] operator returns what is at address:
  - p + n * sizeof(*p) – the size of the type p points to
- two dimensional arrays:
  - int **p;
  - p[n] = what is at p+n*sizeof(int *); call this q: a pointer to integers
  - q[m] = what is at q + m*sizeof(int); an integer

Data types in C

- structures: like a class without functions

```
struct node {
    int value;
    char name[10];
};
struct node node_instance;
struct node * ptr_to_node;
```

- typedef: give a name to another type

```
typedef struct node node_type;
typedef struct node * ptr_node_type;
```

- Recursive structures

```
struct node {
    int value;
    struct node * next;
};
```


Rules for allocating memory

- Call malloc() for any data returned from a function:

```
char * reverse(char * line) {
    char tmp[100];
    for (int j=0, i = strlen(line); i >= 0; i--)
        tmp[j++] = line[i];
    return(tmp)
```

- Call free() when you are done:

```
char * output;
fgets(line,MAX_LEN,file);
output = reverse(line);
free(output);
```


Data Structures in C – Linked List

- Linked Lists

```
typedef struct node_s {
   char field_n;
   struct node *next;
 } node, node_ptr;

 node_ptr my_ptr, ptr;
 struct header {
   node_ptr first, last;
 } my_list;
```

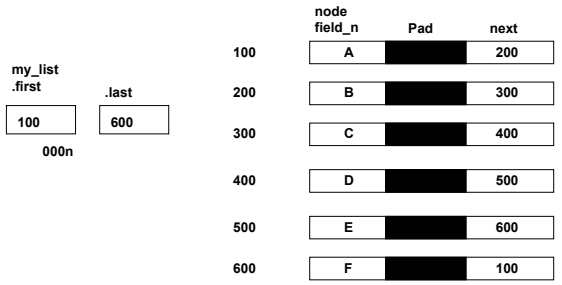

Allocating a List

```
int i;
/* allocate the first list record */
my_ptr = (node_ptr)malloc( sizeof(node));
if (!my_ptr) exit(1);
my_list.first = my_ptr;
my_list.last = my_ptr;
my_ptr->field_n = 'A';
my_ptr->next = my_list.first;  /* makes the list circular */
```

Allocating a List

```
/* allocate records 2 through 6 to the list */
for (i=2; i <= 6; i++)
{
  my_ptr = (node_ptr)malloc(sizeof(node));
      if(!my_ptr) exit(1);
  ptr = my_list.last;        // find end of list
  my_list.last = my_ptr;
  ptr->next = my_ptr;        // update ptr in former last
  my_ptr->field_n = ptr->field_n + 1; // move to next char
  my_ptr->next = my_list.first; // make circular again
}
```


Layout in Memory



Freeing a list

```
ptr = my_list.first;
while (my_list.first != NULL ) {
  my_ptr = my_list.first;
  my_list.first = my_ptr->next;
  if (my_list.last == my_ptr)
    my_list.last = NULL;
  free(my_ptr);
}
```


Memory Manipulation Functions

Header File:

```
<string.h>
```

```
void *memcpy (void *dest, const void *src, size_t n);
void *memmove(void *dest, const void *src, size_t n);
int memcmp (const void *s1, const void *s2, size_t n);
void *memset (void *s, int c, size_t n);
```

Memory Manipulation Functions

```
/* memcpy.c: memcpy example */
#include <stdio.h>
#include <string.h>

void main(void)
{
   char src[ ] = "*************************";
   char dest[ ] = "abcdefghijlkmnopqrstuvwxyz01234";
   char *ptr;
   printf("destination before memcpy: %s\n", dest);
   ptr = (char *) memcpy(dest, src, strlen(src));
   if (ptr)
      printf("destination after memcpy: %s\n", dest);
   else
      printf("memcpy failed\n");  }
```

Memory Manipulation Functions

```
/* memmove.c memmove example */

#include <string.h>
#include <stdio.h>

void main(void)
{
  char dest [80] = “abcdefghijklmnopqrstuvwxyz012345” ;

  printf ( “dest prior to memmove: %s\n”, dest);
  memmove (&dest[5], &dest[26], 6);
  printf (“dest after memmove: %s\n”, dest);
}
```

Memory Manipulation Functions

```
/* memset.c: memset example */

#include <string.h>
#include <stdio.h>
#include <mem.h>

void main(void)
{
  char buffer[  ] = "Hello world\n";

  printf("Buffer before memset: %s\n", buffer);
  memset(buffer, '*', strlen(buffer) - 1);
  printf("Buffer after memset:  %s\n", buffer);
}
```

Memory Manipulation Functions

```
char *buf1 = "aaa”,  *buf2 = "bbb”,  *buf3 = "ccc";
int stat;
stat = memcmp(buf2, buf1, strlen(buf2));
if (stat > 0)
   printf("buffer 2 is greater than buffer 1\n");
else
   printf("buffer 2 is less than buffer 1\n");
stat = memcmp(buf2, buf3, strlen(buf2));
if (stat > 0)
   printf("buffer 2 is greater than buffer 3\n");
else
   printf("buffer 2 is less than buffer 3\n");
```