SOFTWARE DESIGN & IMPLEMENTATION

COSC 50 – Winter 2021

Memory functions

STANDARD C LIBRARY

Memory functions provide the flexibility needed to handle dynamic memory allocation at runtime.

- p = malloc(n)
  allocates n bytes of heap memory; the memory contents remain uninitialized.

- p = calloc(count, size)
  allocates count*size bytes of heap memory and initializes it all to zero; this call is appropriate when you want to allocate an array of count items, each of size bytes.

- p = realloc(p, n)
  where p is a pointer to previously allocated heap memory; it expands (or shrinks) its allocation to a total of n bytes.

- free(p)
  where p is a pointer to previously allocated heap memory; that portion of heap memory is released for future use.

Stack

…
char * p;
…
p = malloc(26);

	02931000
	0239ec41
	0000992f
	0000c000
	0000c000

Heap

0000c000	11	23	0	57	0	0	0	0	11	40	5f	5f	5f	73	74	61	|.#.W......@___sta|
0000c010	63	6b	5f	63	68	6b	5f	67	75	61	72	64	0	51	72	0	|ck_chk_guard.Qr.|
0000c020	90	40	5f	5f	5f	73	74	64	69	6e	70	0	90	40	64	79	|.@___stdinp..@dy|
0000c030	6c	64	5f	73	74	75	62	5f	62	69	6e	64	65	72	0	90	|ld_stub_binder..|
0000c040	73	0	11	40	5f	5f	5f	73	74	61	63	6b	5f	63	68	6b	|s..@___stack_chk|
0000c050	5f	66	61	69	6c	0	90	0	73	8	11	40	5f	63	61	6c	|_fail...s..@_cal|
0000c060	6c	6f	63	0	90	0	73	10	11	40	5f	66	65	6f	66	0	|loc...s..@_feof.|
0000c070	90	0	73	18	11	40	5f	66	67	65	74	63	0	90	0	73	|...s..@_fgetc...s|
0000c080	20	11	40	5f	66	72	65	65	0	90	0	73	28	11	40	5f		.@_free...s(.@_|

Stack

...
char * p;
...
p = calloc(26, sizeof(char);

	02931000
	0239ec41
	0000992f
	0000c000
	0000c000

Heap

0000c000	11	23	0	57	0	0	0	0	11	40	5f	5f	5f	73	74	61	|.#.W......@___sta|
0000c010	63	6b	5f	63	68	6b	5f	67	75	61	72	64	0	51	72	0	|ck_chk_guard.Qr.|
0000c020	90	40	5f	5f	5f	73	74	64	69	6e	70	0	90	40	64	79	|.@___stdinp..@dy|
0000c030	6c	64	5f	73	74	75	62	5f	62	69	6e	64	65	72	0	90	|ld_stub_binder..|
0000c040	73	0	11	40	5f	5f	5f	73	74	61	63	6b	5f	63	68	6b	|s..@___stack_chk|
0000c050	5f	66	61	69	6c	0	90	0	73	8	11	40	5f	63	61	6c	|_fail...s..@_cal|
0000c060	6c	6f	63	0	90	0	73	10	11	40	5f	66	65	6f	66	0	|loc...s..@_feof.|
0000c070	90	0	73	18	11	40	5f	66	67	65	74	63	0	90	0	73	|...s..@_fgetc...s|
0000c080	20	11	40	5f	66	72	65	65	0	90	0	73	28	11	40	5f	| .@_free...s(.@_|

calloc( )

```
…
int * p;

…
⇒  p = calloc( 4, sizeof(int);
   *p = 100;
```

	0000c000
	0239ec41
	0000992f
	0000c000
	0000c000

Memory is allocated here and set to NULL

Heap

0000c000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|................|
0000c010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|................|
0000c020	90	40	5f	5f	5f	73	74	64	69	6e	70	0	90	40	64	79	|.@___stdinp..@dy|
0000c030	6c	64	5f	73	74	75	62	5f	62	69	6e	64	65	72	0	90	|ld_stub_binder..|
0000c040	73	0	11	40	5f	5f	5f	73	74	61	63	6b	5f	63	68	6b	|s..@___stack_chk|
0000c050	5f	66	61	69	6c	0	90	0	73	8	11	40	5f	63	61	6c	|_fail...s..@_cal|
0000c060	6c	6f	63	0	90	0	73	10	11	40	5f	66	65	6f	66	0	|loc...s..@_feof.|
0000c070	90	0	73	18	11	40	5f	66	67	65	74	63	0	90	0	73	|...s..@_fgetc...s|
0000c080	20	11	40	5f	66	72	65	65	0	90	0	73	28	11	40	5f	| .@_free...s(.@_|

```
…
int * p;
…
p = calloc( 4, sizeof(int);
*p = 100;
```

Stack

0000c000
0239ec41
0000992f
0000c000
0000c000

Heap

0000c000	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|d...............|
0000c010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|................|
0000c020	90	40	5f	5f	5f	73	74	64	69	6e	70	0	90	40	64	79	|.@___stdinp..@dy|
0000c030	6c	64	5f	73	74	75	62	5f	62	69	6e	64	65	72	0	90	|ld_stub_binder..|
0000c040	73	0	11	40	5f	5f	5f	73	74	61	63	6b	5f	63	68	6b	|s..@___stack_chk|
0000c050	5f	66	61	69	6c	0	90	0	73	8	11	40	5f	63	61	6c	|_fail...s..@_cal|
0000c060	6c	6f	63	0	90	0	73	10	11	40	5f	66	65	6f	66	0	|loc...s..@_feof.|
0000c070	90	0	73	18	11	40	5f	66	67	65	74	63	0	90	0	73	|...s..@_fgetc...s|
0000c080	20	11	40	5f	66	72	65	65	0	90	0	73	28	11	40	5f	| .@_free...s(.@_|

0000c000	
0239ec41	
0000992f	
7fff2072	
07f8a8b1	

```
int *p, *q;
p = calloc( 4, sizeof(int));
q = malloc( sizeof(int));
*(p+1) = 100
free(p);
p = calloc( p, 2*sizeof(int));
free(q);
```

Heap

0000c000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|................|
0000c010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|................|
0000c020	90	40	5f	5f	5f	73	74	64	69	6e	70	0	90	40	64	79	|.@___stdinp..@dy|
0000c030	6c	64	5f	73	74	75	62	5f	62	69	6e	64	65	72	0	90	|ld_stub_binder..|
0000c040	73	0	11	40	5f	5f	5f	73	74	61	63	6b	5f	63	68	6b	|s..@___stack_chk|
0000c050	5f	66	61	69	6c	0	90	0	73	8	11	40	5f	63	61	6c	|_fail...s..@_cal|
0000c060	6c	6f	63	0	90	0	73	10	11	40	5f	66	65	6f	66	0	|loc...s..@_feof.|
0000c070	90	0	73	18	11	40	5f	66	67	65	74	63	0	90	0	73	|...s..@_fgetc...s|
0000c080	20	11	40	5f	66	72	65	65	0	90	0	73	28	11	40	5f	| .@_free...s(.@_|

Stack

0000c000
0000c020
0000992f
7fff2072
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Heap

0000c000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|................|
0000c010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|................|
0000c020	90	40	5f	5f	5f	73	74	64	69	6e	70	0	90	40	64	79	|.@___stdinp..@dy|
0000c030	6c	64	5f	73	74	75	62	5f	62	69	6e	64	65	72	0	90	|ld_stub_binder..|
0000c040	73	0	11	40	5f	5f	5f	73	74	61	63	6b	5f	63	68	6b	|s..@___stack_chk|
0000c050	5f	66	61	69	6c	0	90	0	73	8	11	40	5f	63	61	6c	|_fail...s..@_cal|
0000c060	6c	6f	63	0	90	0	73	10	11	40	5f	66	65	6f	66	0	|loc...s..@_feof.|
0000c070	90	0	73	18	11	40	5f	66	67	65	74	63	0	90	0	73	|...s..@_fgetc...s|
0000c080	20	11	40	5f	66	72	65	65	0	90	0	73	28	11	40	5f	| .@_free...s(.@_|

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Heap

0000c000	0	0	0	0	0	0	0	0	64	0	0	0	0	0	0	0	|.........d.......|
0000c010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|................|
0000c020	90	40	5f	5f	5f	73	74	64	69	6e	70	0	90	40	64	79	|.@___stdinp..@dy|
0000c030	6c	64	5f	73	74	75	62	5f	62	69	6e	64	65	72	0	90	|ld_stub_binder..|
0000c040	73	0	11	40	5f	5f	5f	73	74	61	63	6b	5f	63	68	6b	|s..@___stack_chk|
0000c050	5f	66	61	69	6c	0	90	0	73	8	11	40	5f	63	61	6c	|_fail...s..@_cal|
0000c060	6c	6f	63	0	90	0	73	10	11	40	5f	66	65	6f	66	0	|loc...s..@_feof.|
0000c070	90	0	73	18	11	40	5f	66	67	65	74	63	0	90	0	73	|...s..@_fgetc...s|
0000c080	20	11	40	5f	66	72	65	65	0	90	0	73	28	11	40	5f	| .@_free...s(.@_|

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0000c000	0	0	0	0	0	0	0	0	64	0	0	0	0	0	0	0	|.........d.......|
0000c010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|................|
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0000c030	6c	64	5f	73	74	75	62	5f	62	69	6e	64	65	72	0	90	|ld_stub_binder..|
0000c040	73	0	11	40	5f	5f	5f	73	74	61	63	6b	5f	63	68	6b	|s..@___stack_chk|
0000c050	5f	66	61	69	6c	0	90	0	73	8	11	40	5f	63	61	6c	|_fail...s..@_cal|
0000c060	6c	6f	63	0	90	0	73	10	11	40	5f	66	65	6f	66	0	|loc...s..@_feof.|
0000c070	90	0	73	18	11	40	5f	66	67	65	74	63	0	90	0	73	|...s..@_fgetc...s|
0000c080	20	11	40	5f	66	72	65	65	0	90	0	73	28	11	40	5f		.@_free...s(.@_|

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```

Heap

0000c000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|................|
0000c010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	|................|
0000c020	90	40	5f	5f	5f	73	74	64	69	6e	70	0	90	40	64	79	|.@___stdinp..@dy|
0000c030	6c	64	5f	73	74	75	62	5f	62	69	6e	64	65	72	0	90	|ld_stub_binder..|
0000c040	73	0	11	40	5f	5f	5f	73	74	61	63	6b	5f	63	68	6b	|s..@___stack_chk|
0000c050	5f	66	61	69	6c	0	90	0	73	8	11	40	5f	63	61	6c	|_fail...s..@_cal|
0000c060	6c	6f	63	0	90	0	73	10	11	40	5f	66	65	6f	66	0	|loc...s..@_feof.|
0000c070	90	0	73	18	11	40	5f	66	67	65	74	63	0	90	0	73	|...s..@_fgetc...s|
0000c080	20	11	40	5f	66	72	65	65	0	90	0	73	28	11	40	5f	| .@_free...s(.@_|