

CS241 – 09 Thanks for the Heap Memory !

Where is the heap stored in process memory?
(And why is it so far away from the stack?)

```
void* malloc(unsigned int numbytes) {  
    // sbrk increases the process's data  
    segment by n bytes  
    void* ptr = sbrk(numbytes);  
    if(ptr == (void*) -1)  
        return NULL; // no memory for you!  
    return ptr;  
}  
void free(void*mem) { /* do nothing */}
```

What is (was) sbrk?

What are the challenges of writing malloc?

How do I store the linked list of allocated blocks and holes?

What is calloc and realloc?

Placement Strategies - Best Fit, Worst Fit, First Fit Allocation

Suppose the heap is managed with a linked list. Each node in the list is either allocated or free. The list is sorted by address. When `malloc()` is called, the list is searched for a free segment that is big enough (depending on the allocation algorithm), that segment is divided into an allocated segment (at the beginning) and a free segment. When `free()` is called, the corresponding segment should merge with its neighboring segments, if they are also free. A process has a heap of 13KB, which is initially unallocated. During its execution, the process issues the following memory allocate/de-allocate calls (`pA... pE` are `void*` pointers). In all cases, break ties by choosing the earliest segment. Also, assume all algorithms allocate memory from the beginning of the free segment they choose.

```
pA = malloc(3KB)
pB = malloc(4KB)
pC = malloc(3KB)
free(pB)
pD = malloc(3KB)
free(pA)
pE = malloc(1KB)
```

For simplicity, assume the memory begins at address 0, and ignore the memory used by the linked list itself. Show the heap allocation after the above calls, using best-fit, worst-fit and first-fit algorithms respectively.

Best Fit:

0K	1K	2K	3K	4K	5K	6K	7K	8K	9K	10K	11K	12K

Starting address of pD= ____ K and pE = ____ K

Worst Fit:

0K	1K	2K	3K	4K	5K	6K	7K	8K	9K	10K	11K	12K

Starting address of pD = ____ K and pE = ____ K

First Fit:

0K	1K	2K	3K	4K	5K	6K	7K	8K	9K	10K	11K	12K

Starting address of pD = ____ K and pE = ____ K

What is Fragmentation? What happens if heap memory is severely fragmented?

Best Fit outcome?

Worst Fit outcome?

First Fit outcome?