System Level Programming

A5

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November 22, 2019

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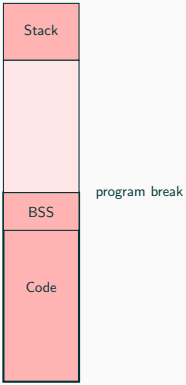
Dynamic Memory

```
int inputsize = 200;
int *buffer = malloc(inputsize * sizeof(int));
memcpy(buffer, input, inputsize)
// do something very important
free(buffer);
```

- Where in the memory is this buffer located?
- How can it be increased/decreased at runtime?

Memory of a process



Virtual memory space

- Linear address space for each process

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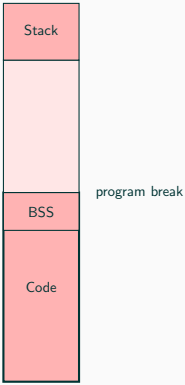

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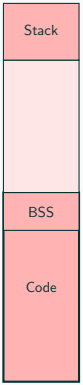
Code

- Segment for the binary code



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Code

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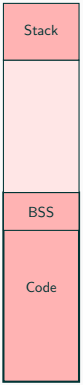
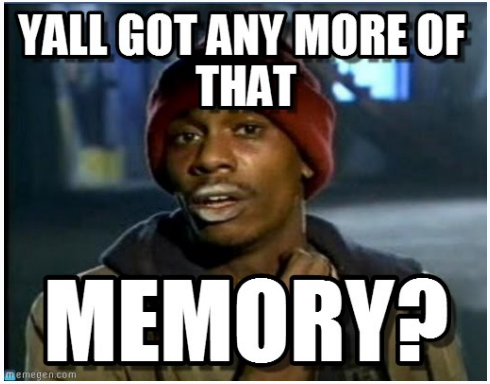
BSS

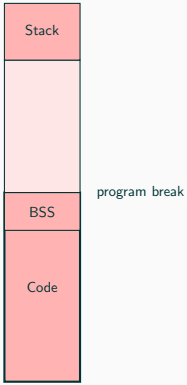
- Global/static variables with known size at compile time

Memory of a process



program break



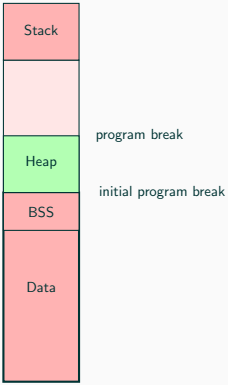


Program break

- end of data segment

Program break can be increased and decerased

Heap



After increasing the program break (brk)

- Usable memory between end of BSS and brk

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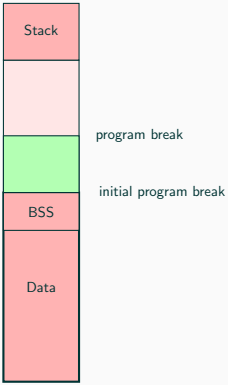

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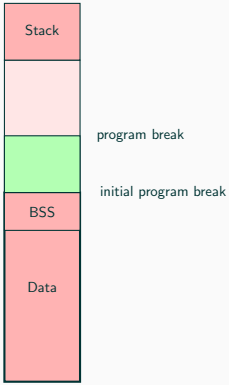

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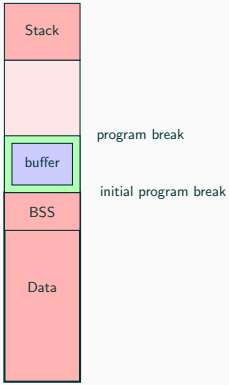

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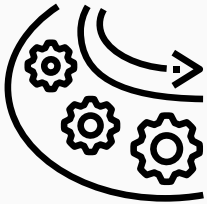
- Why don't we use this for our buffer?



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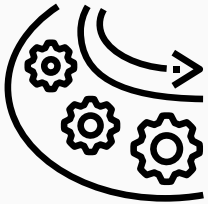

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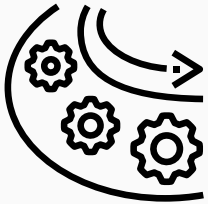

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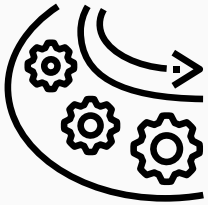

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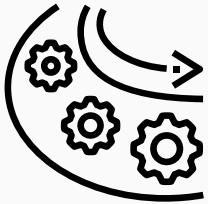

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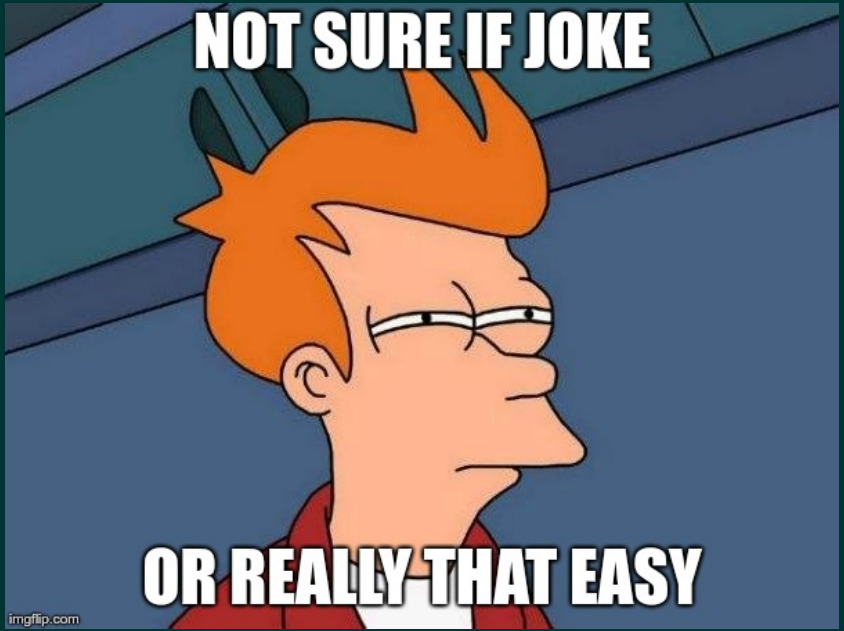
  - `sbrk(0)` returns current location of the break

A straight forward solution?

```
void *malloc(size_t size){
  return sbrk(size)
}
```


NOT SURE IF JOKE
OR REALLY THAT EASY
imgflip.com

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Because ...

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void* u = malloc(100);

free(t);
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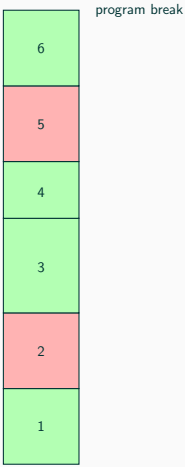
It's not that easy, but not much harder!

Goals

- Efficient usage of memory
- Reuse of freed memory areas
- Avoid fragmentation of heap segment

Decrease program break if possible

- If there is free memory area just below the break
- Decrease the program break



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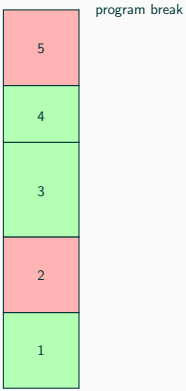

Merge free memory areas

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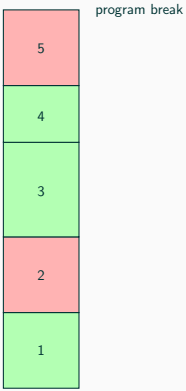

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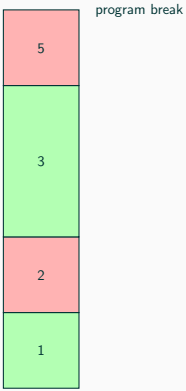
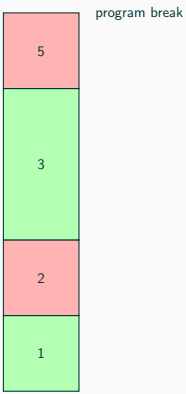


Reuse free memory areas

- When new memory is `malloc`ed
- Search for a free memory area $\geq$ requested size and split it



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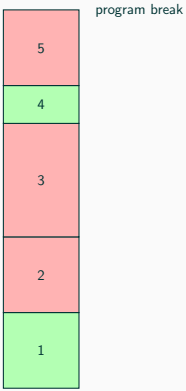

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Any ideas how to organize this information?

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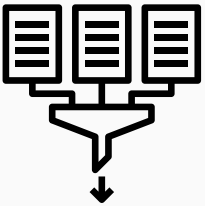
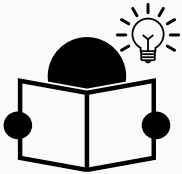
GOOD MEMORY
YOU HAVE
memegenerator.net



- Choose a structure to organise the memory areas
- Decrease program break if possible
- Avoid heap fragmentation
  - Split large free memory areas to the needed size
  - Bonus: Merge free neighboring memory areas
- Detect overflows, double frees and out of memory
- Your implementation has to conform to POSIX (manpage)

cf. assignment page for further details



Make use of pointer arithmetic

- `int* p; p+5;` $\longrightarrow$ address in `p` is increased by `5*sizeof(int)`

How many bytes does a pointer need?

- Correct use of `sizeof`

Double-Linked-List of memory areas

Be careful to test the right malloc implementation ;)

Debugging with `printf`?