Memory management

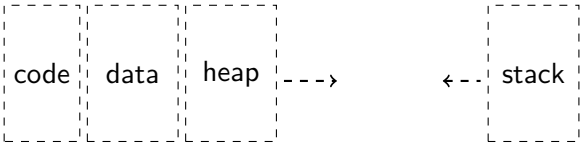
Johan Montelius

KTH

2019

virtual memory and segmentation

virtual memory and segmentation



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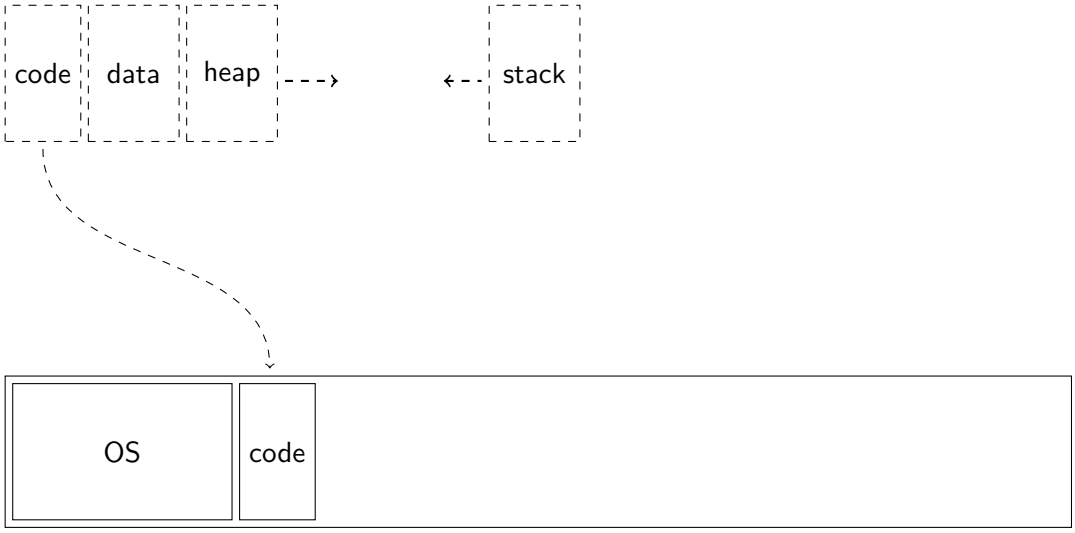

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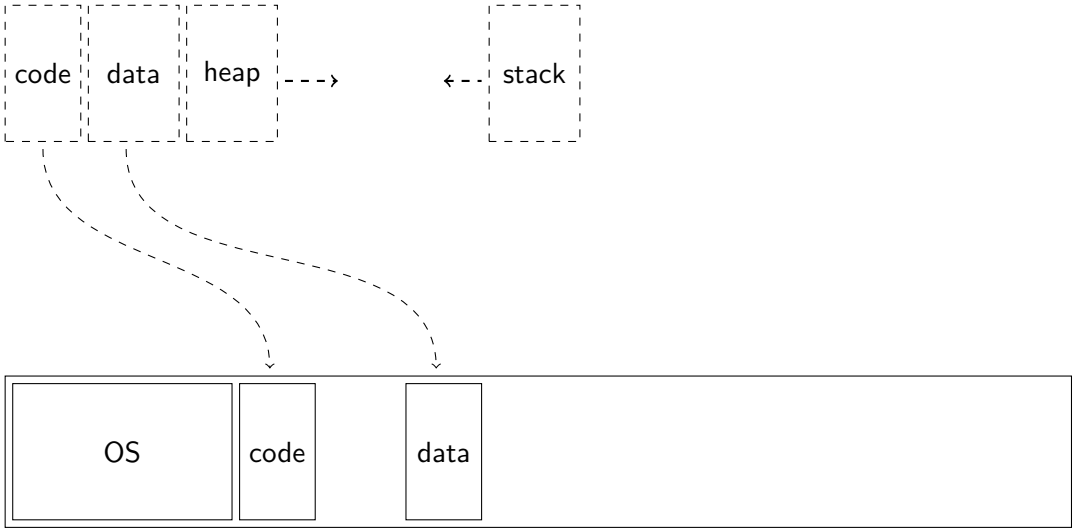

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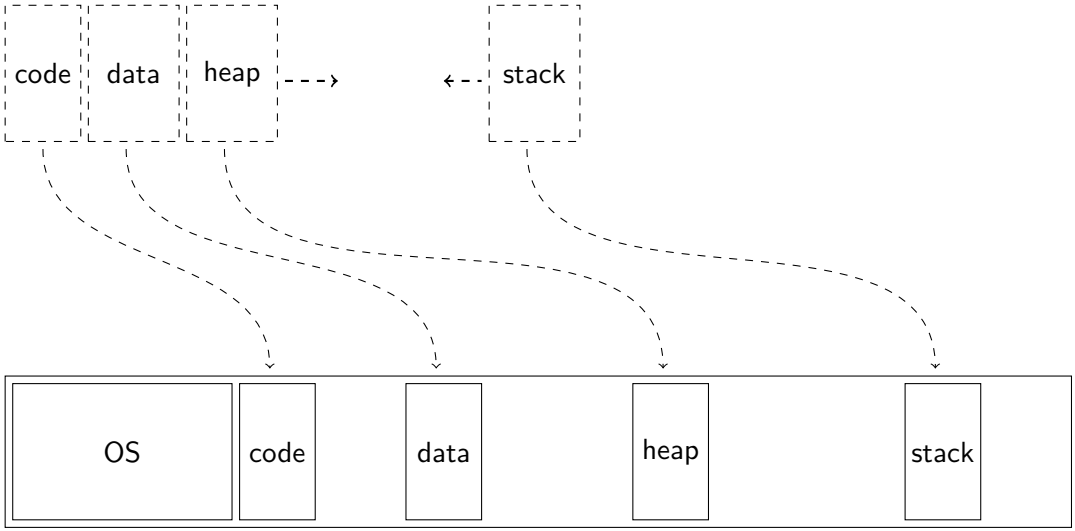

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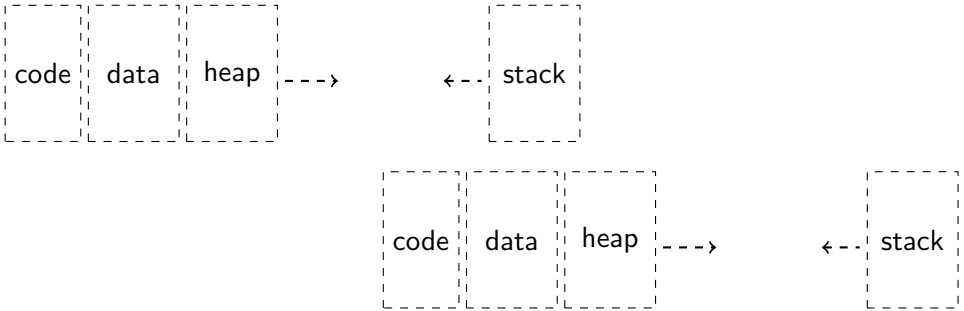

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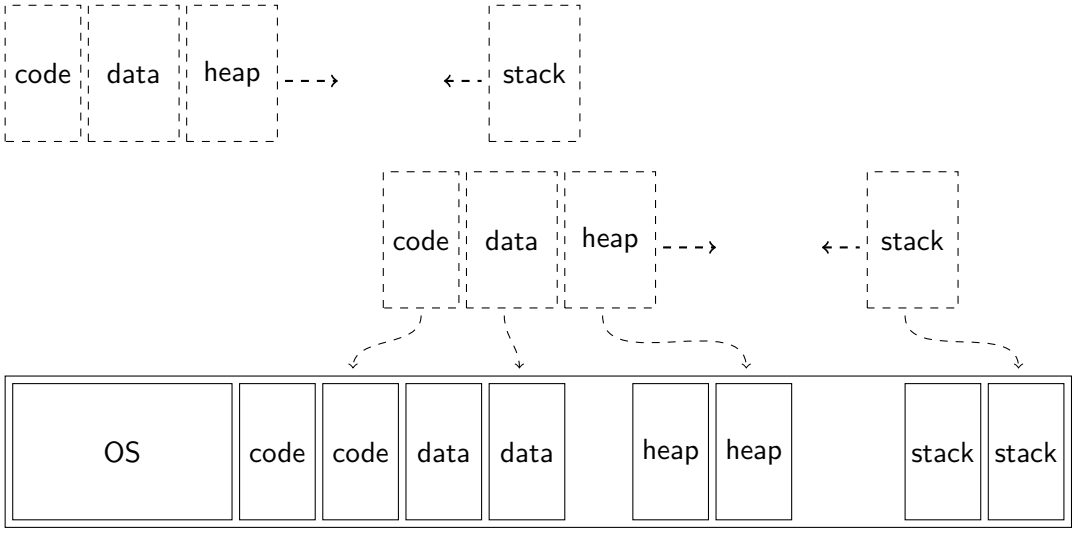

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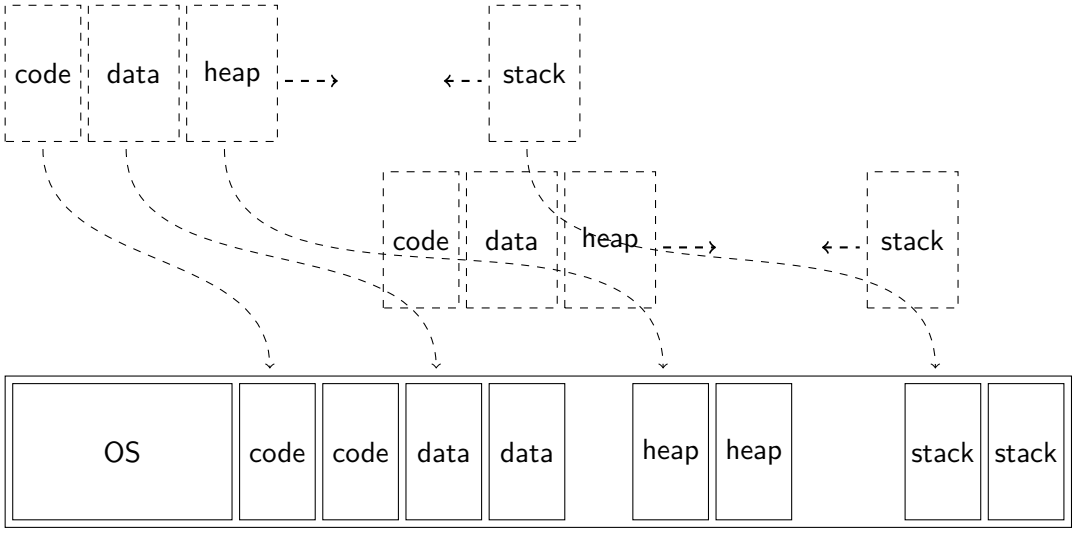
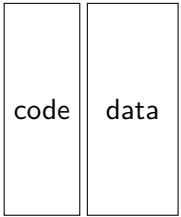


the process view



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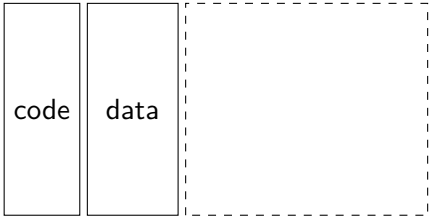

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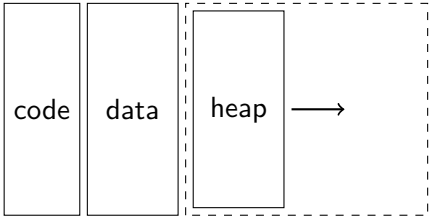

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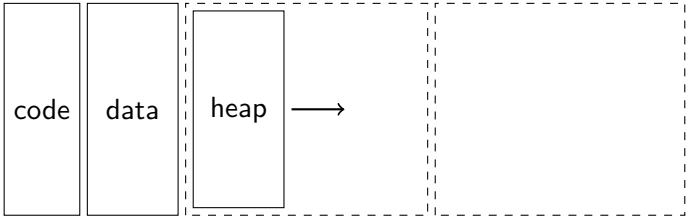

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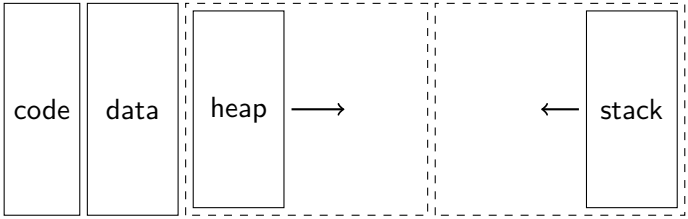

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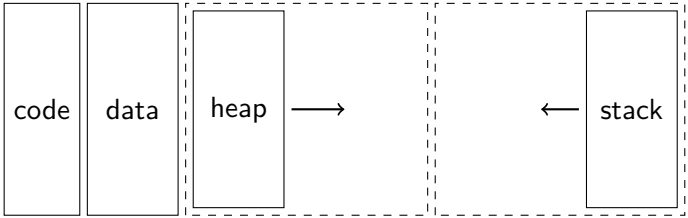

How do we obtain more memory for the heap data structures?

Linux system call

brk() and sbrk() change the location of the program break, which defines the end of the process's heap segment

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#include <unistd.h>

int brk(void *addr);
void *sbrk(intptr_t incr);
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sbrk() increments the program's heap space by increment bytes. It returns the previous program break.

Calling sbrk() with an increment of 0 can be used to find the current location of the program break.

C program - not the way to do it

```
#include <stdlib.h>
#include <unistd.h>

int *allocate_array_please(int size) {

  return (int*)sbrk(size * sizeof(int));
}
```

a growing heap

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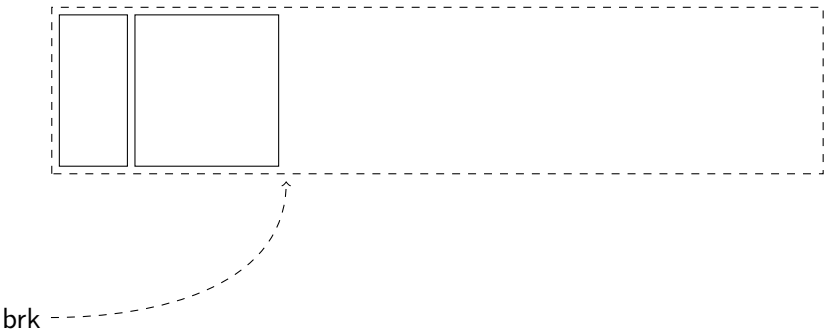

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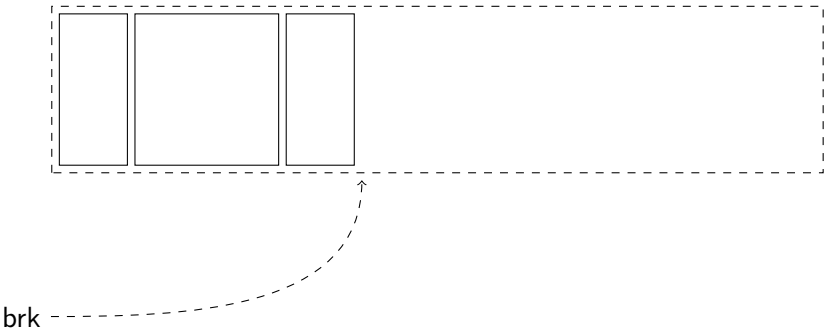

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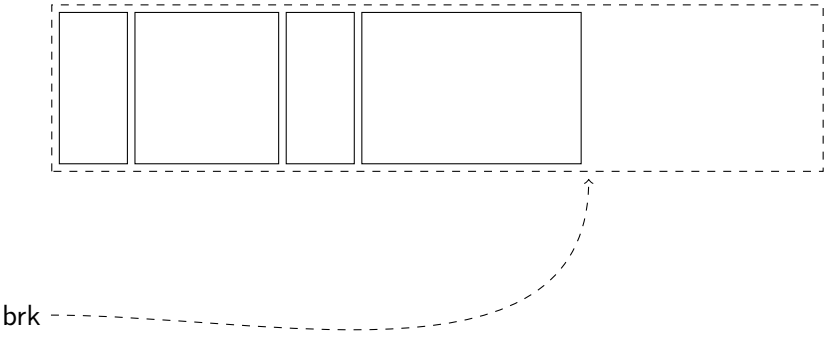

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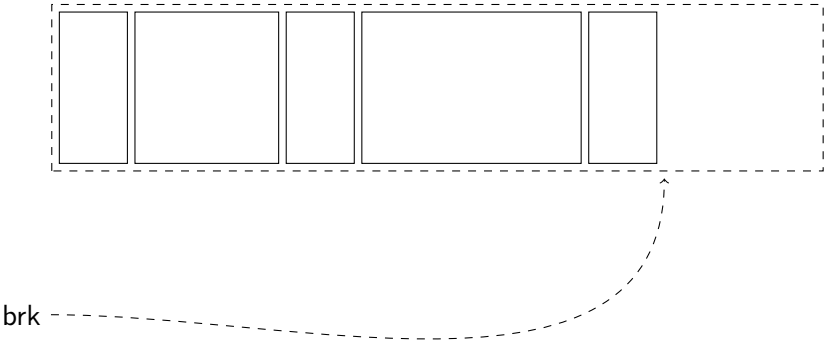

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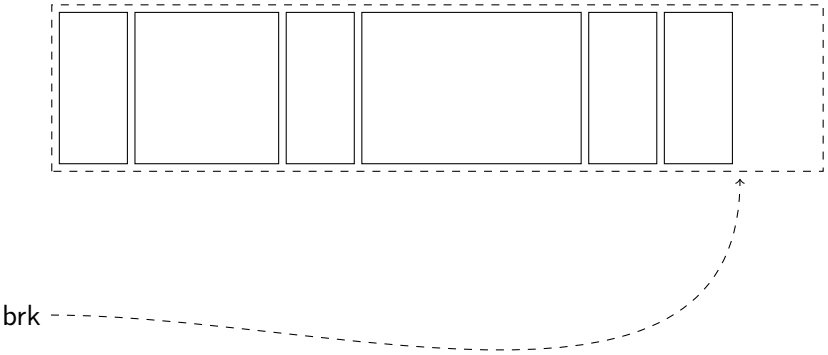

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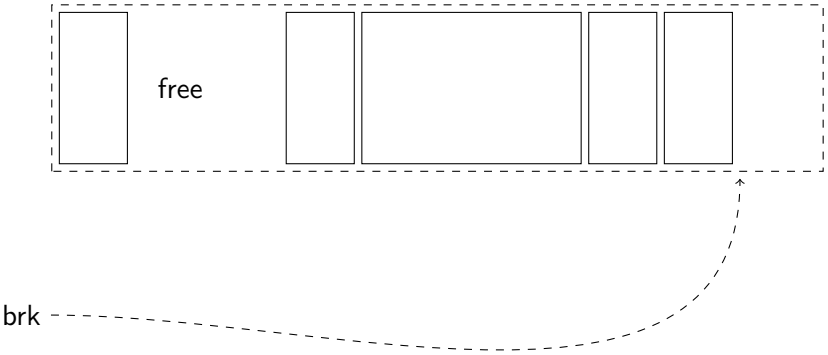

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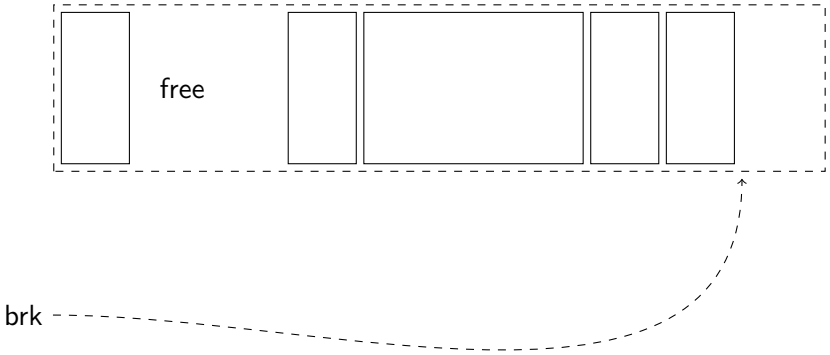

How do we reuse allocated memory?

C program

```
#include <stdlib.h>

int global = 42;

int main(int argc, char *argv[]) {

  if(argc < 2) return -1;

  int n = atoi(argv[1]);

  int on_stack[5] = {1,2,3,4,5};

  int *on_heap = malloc(sizeof(int)*n);

    :

}
```

The malloc() function allocates size bytes and returns a pointer to the allocated memory. The memory is not initialized.

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#include <stdlib.h>

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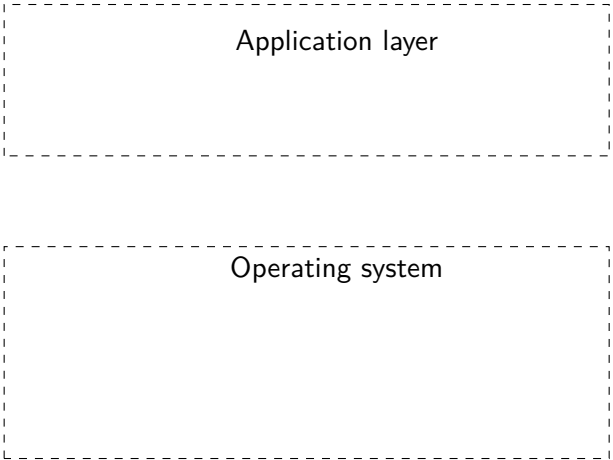
The free() function frees the memory space pointed to by ptr, which must have been returned by a previous call to malloc(), ..

:

The operating system



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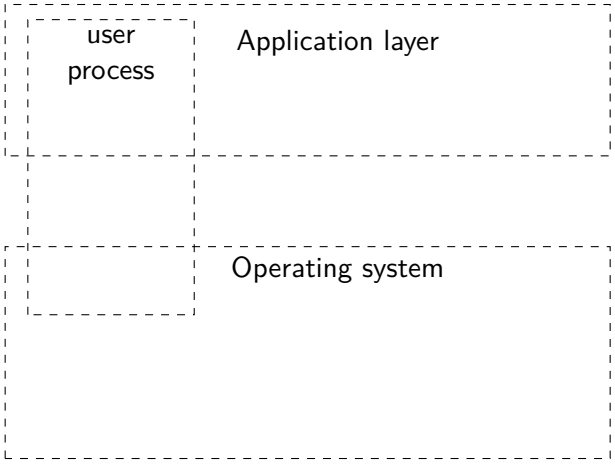

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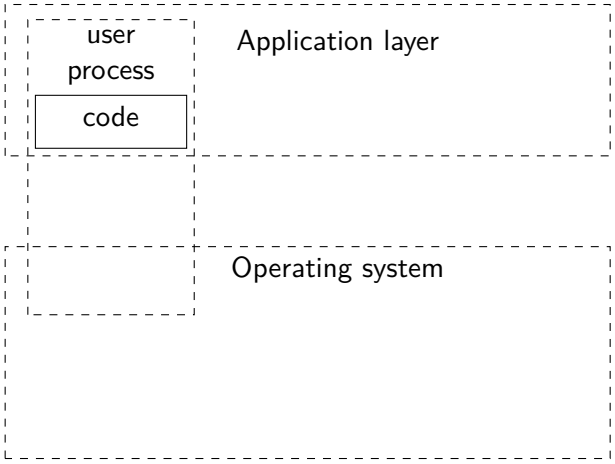

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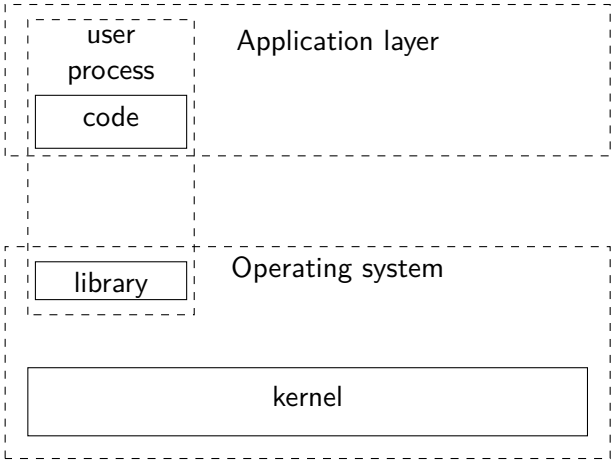

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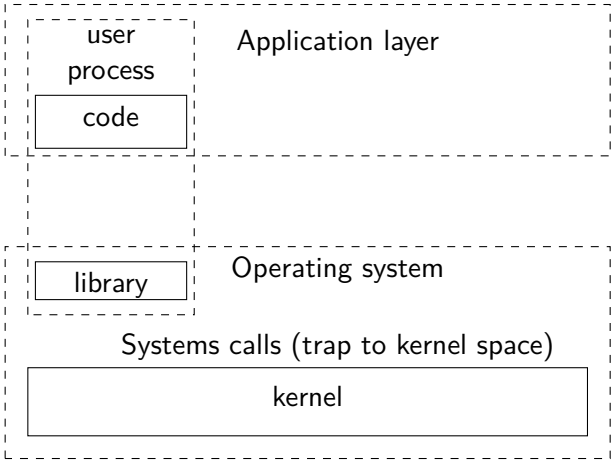

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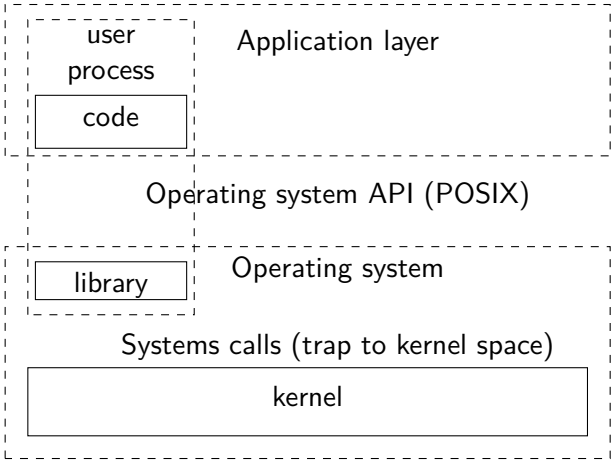

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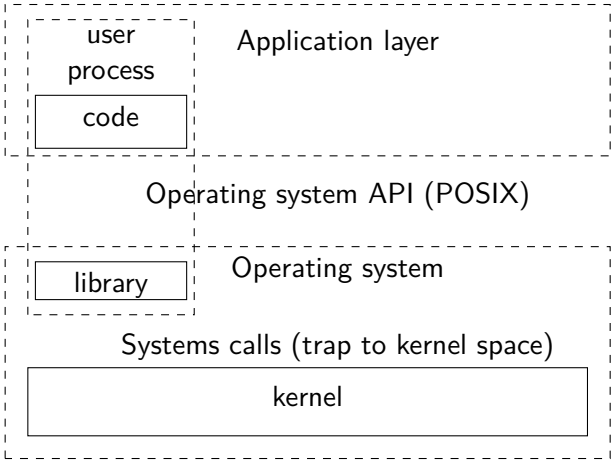

Library is often just a wrapper for the system call - sometimes more complex.

Memory hierarchy

User space program

Memory hierarchy

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Library routines

malloc() / free()

Memory hierarchy

User space program

Library routines — malloc() / free()

System calls — sbrk() / brk()

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`char a[10]` `structs person {int age; char name[20]}`

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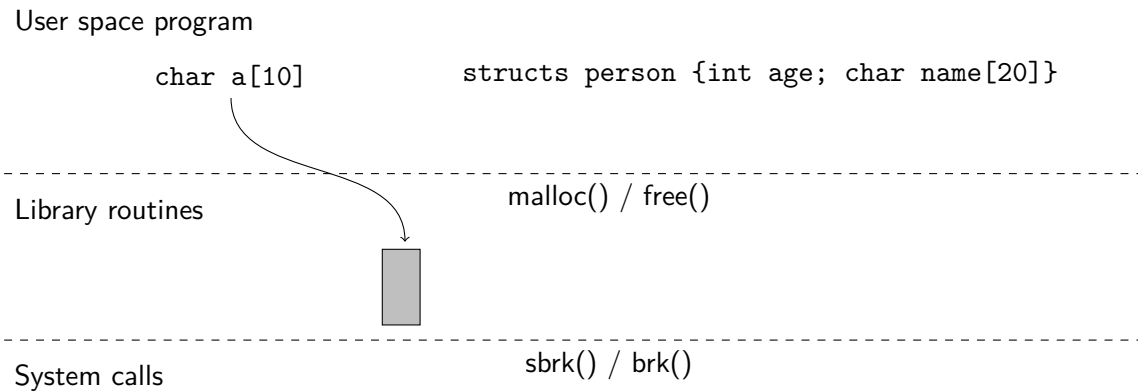

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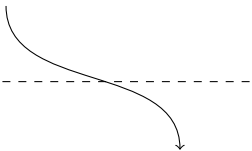

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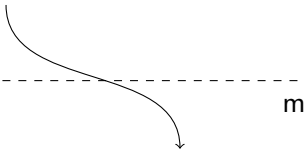

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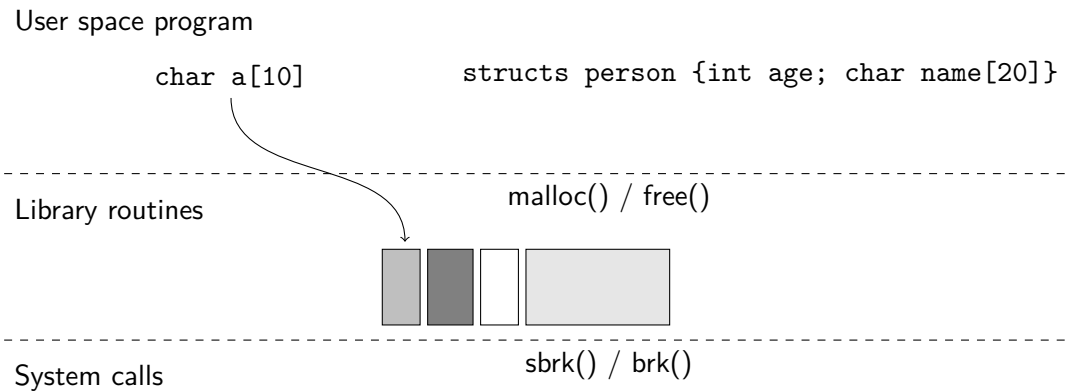

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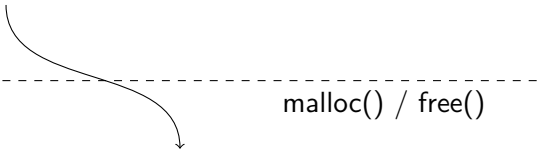

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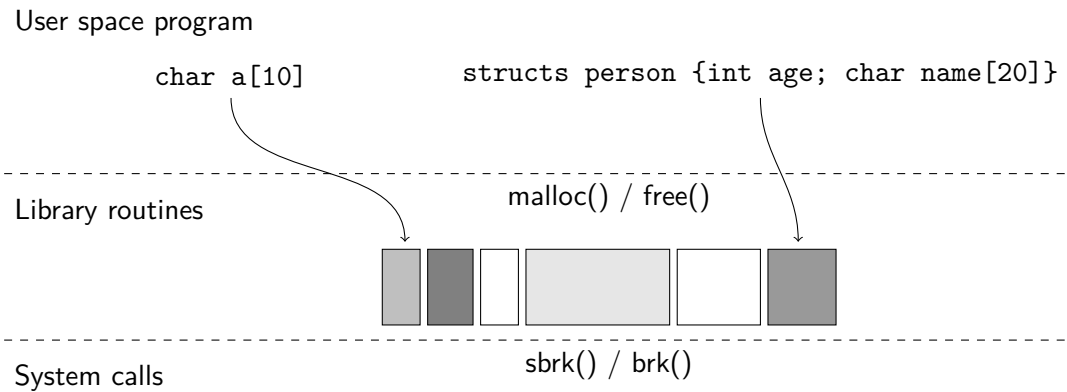

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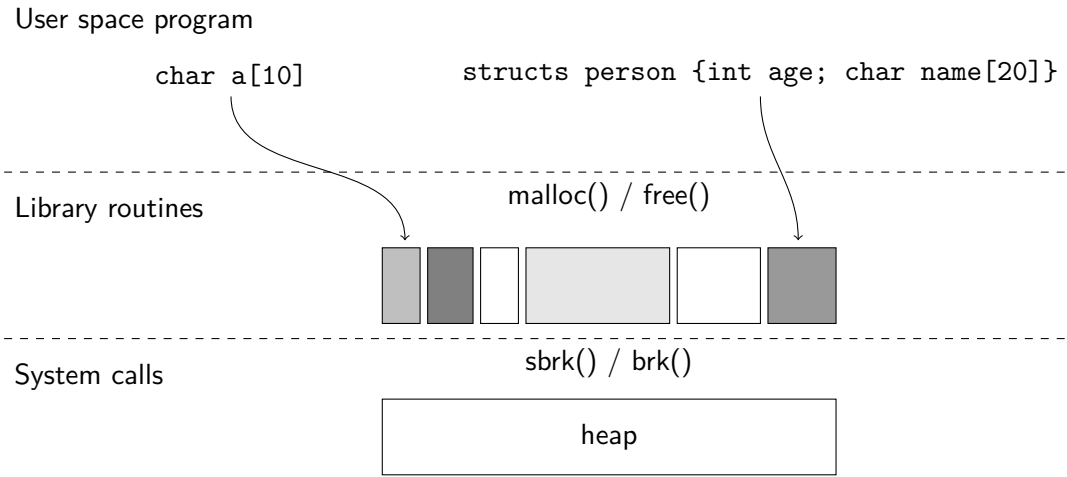

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A list of free blocks

Assume each free block holds a header containing: the size and a pointer to the next block.

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typefdef struct __node_t {
  int    size;
  struct __node_t *next;
}
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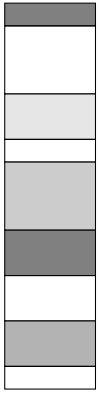

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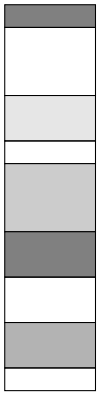

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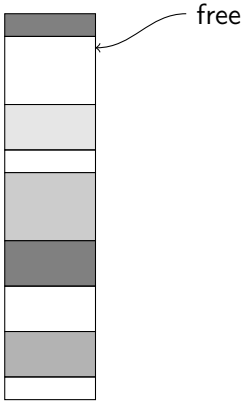

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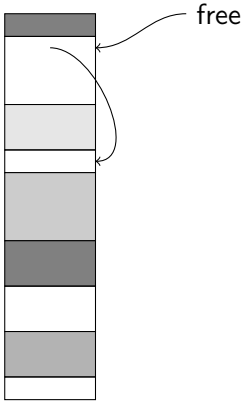

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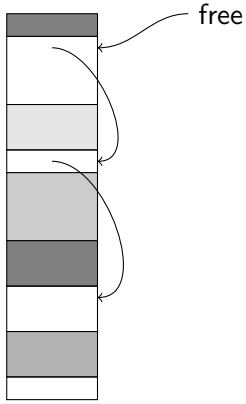

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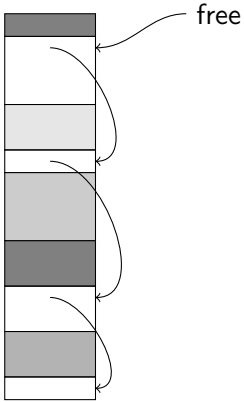

pick a suitable block

When we malloc we first search the free-list for a suitable block.

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char *buf = malloc(20)
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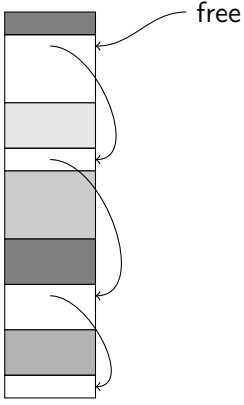

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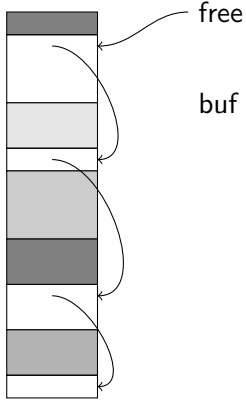

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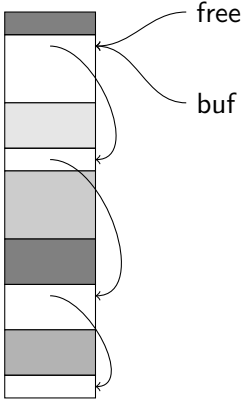

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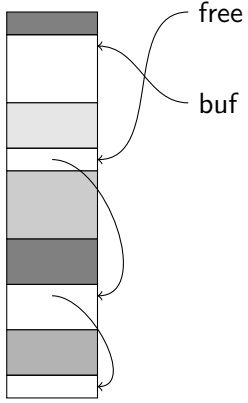

return a block

How do we return a block?

```
free(this)
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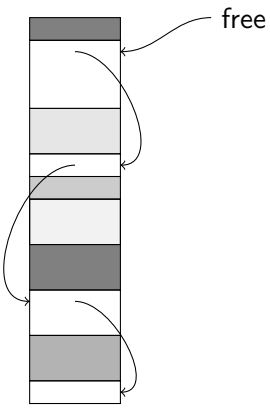

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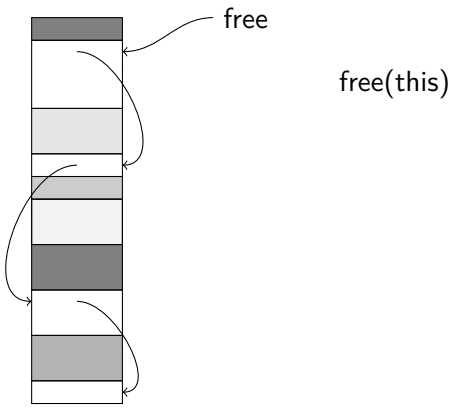

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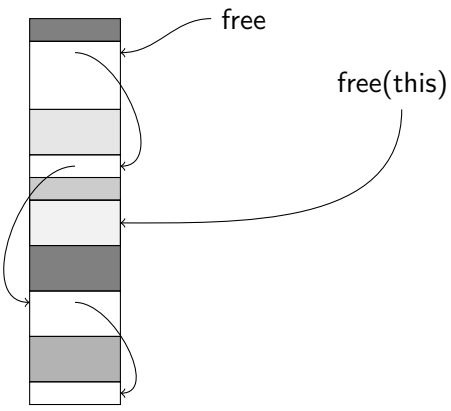

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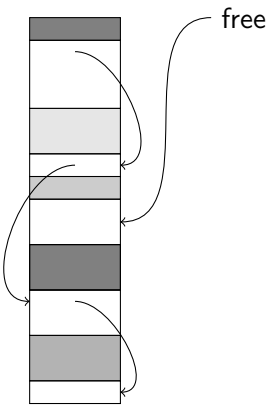

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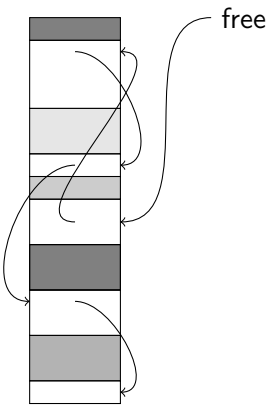

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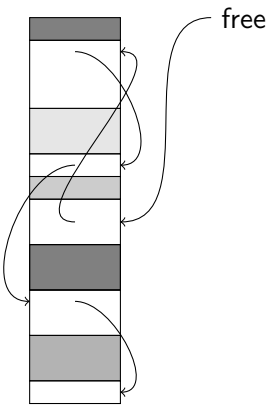

What's the problem?

hidden information

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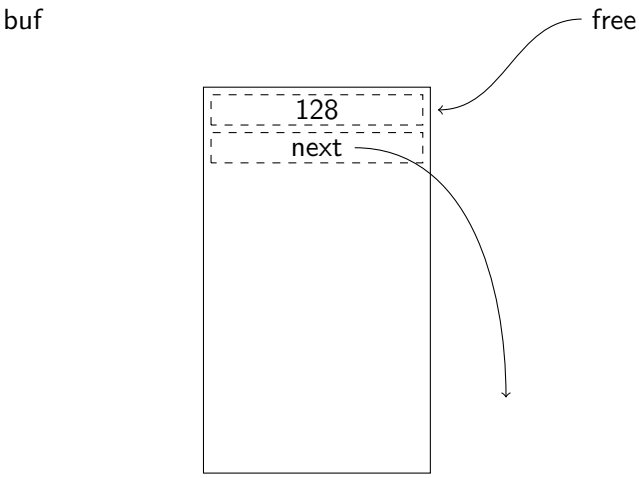

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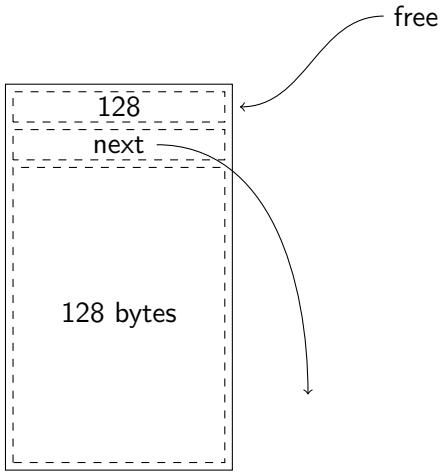

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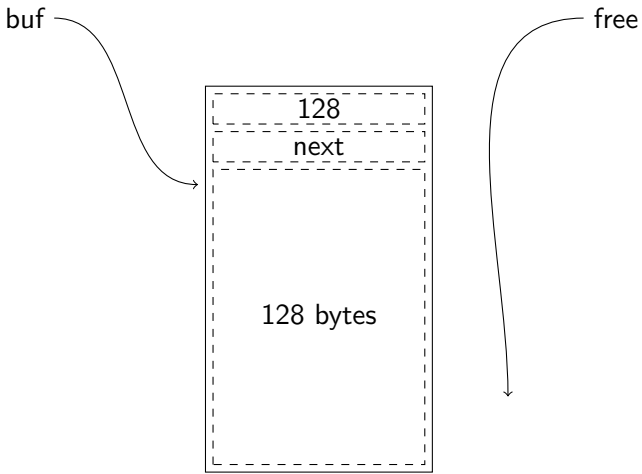

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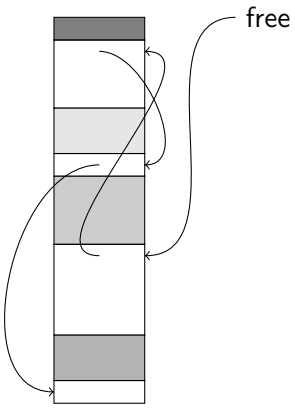

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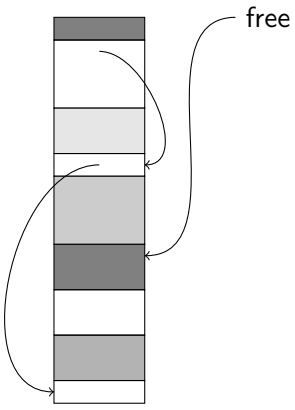

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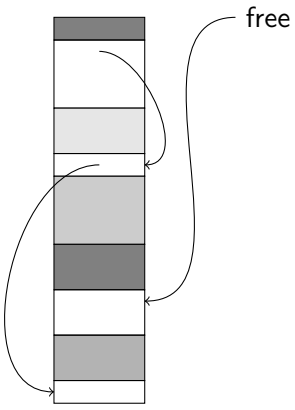

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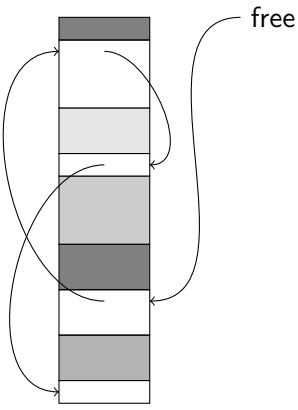

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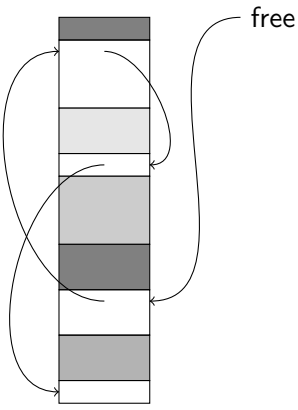

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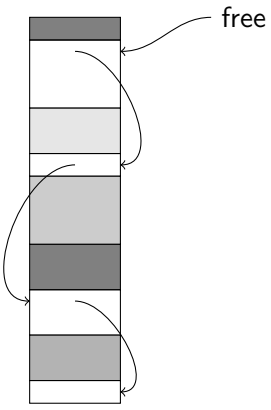

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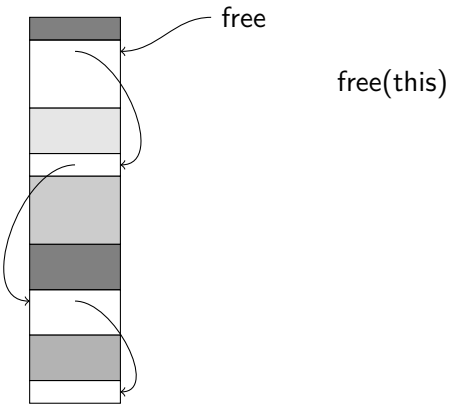

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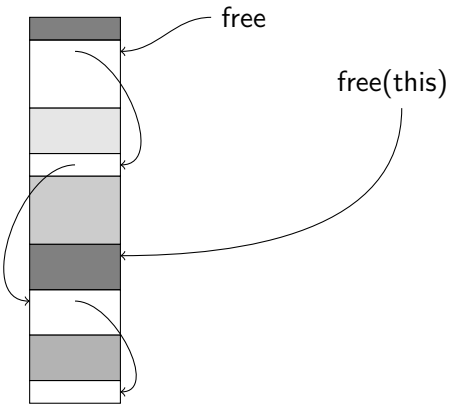

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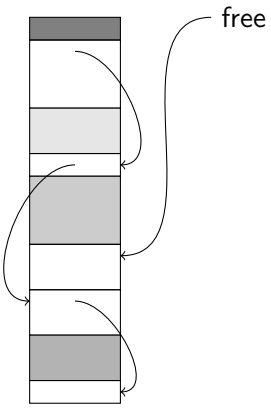

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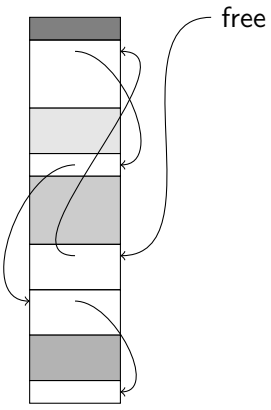

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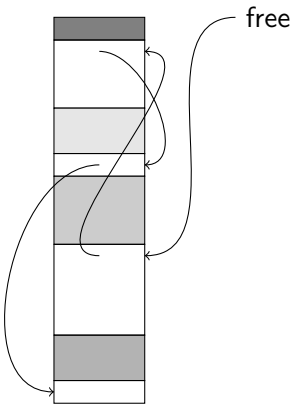

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You should know the pros and cons of these strategies.

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We can build our own allocator that is optimized for a given application.

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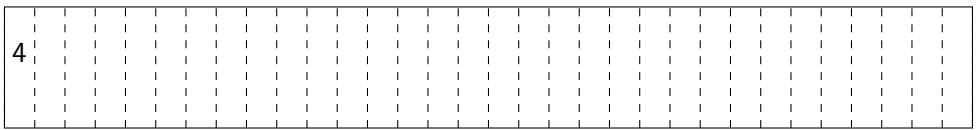

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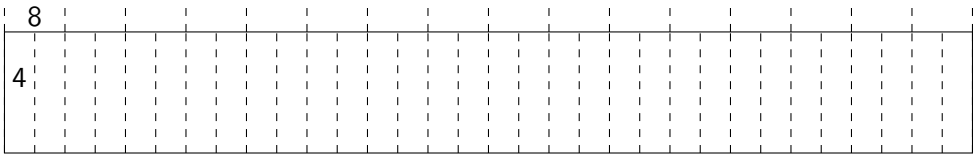

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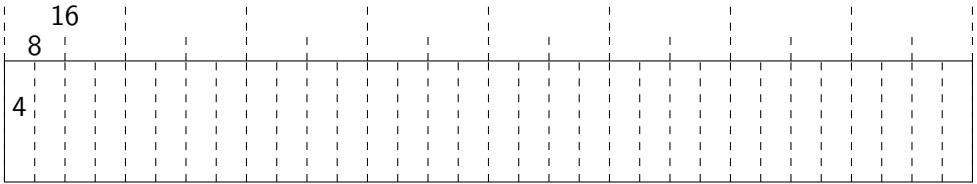

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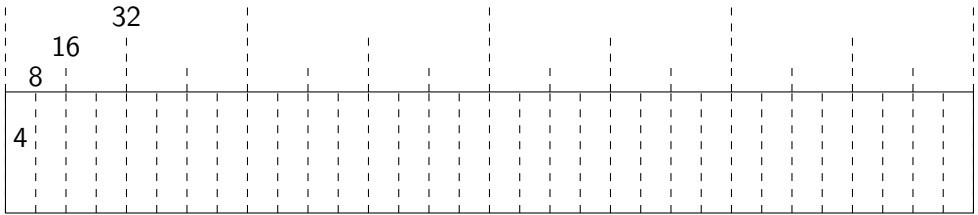

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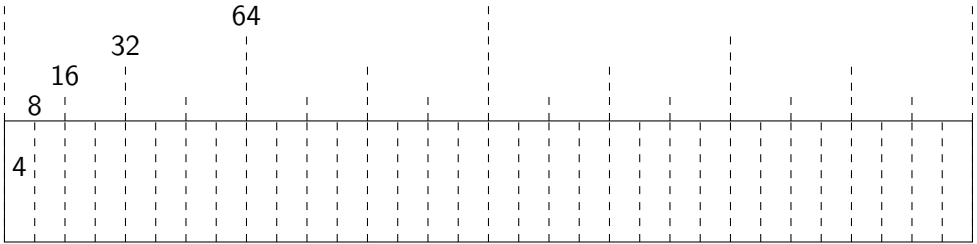

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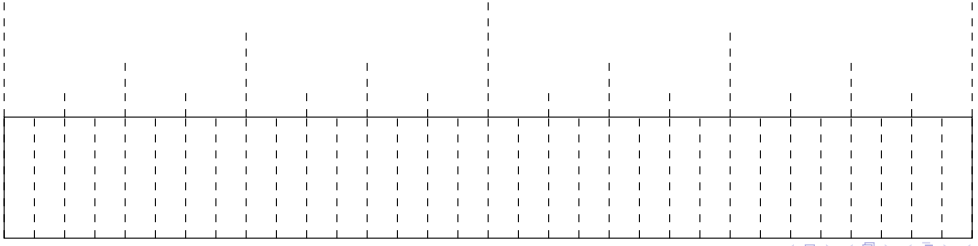

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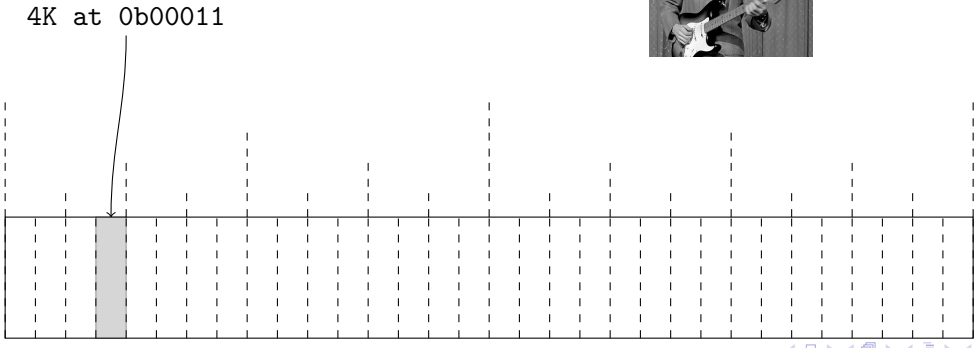

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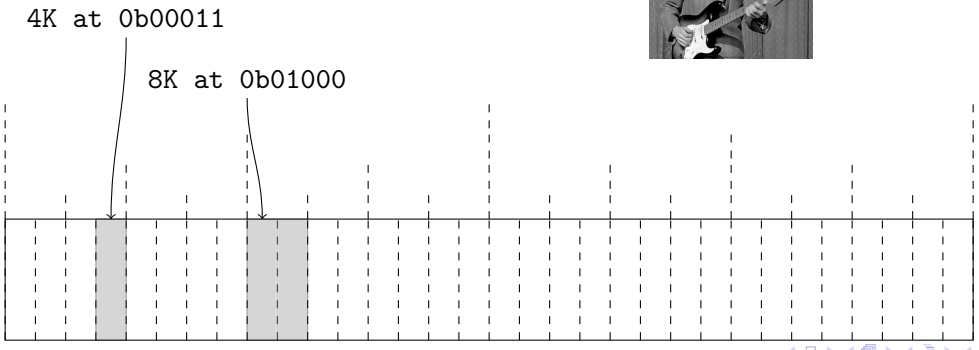

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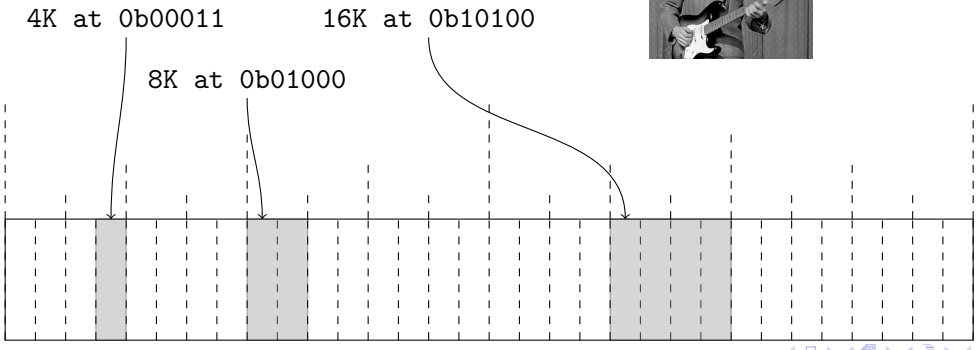

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Linux uses Buddy allocations when managing physical memory - check `/proc/buddyinfo`.

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Originally from 4.2BSD, default in OSX where malloc() uses mmap() to allocate memory.

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