COMPUTER SYSTEMS AND ORGANIZATION

Allocators and Header Files

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ENGINEERING

1. Locations in memory (More Details)
2. Malloc Examples
3. Allocators Implementing Malloc
4. Creating our own C library
5. Header files
6. Files IO operations
7. Memory Errors Next time.

STACK VS HEAP

	Permissions	Contents	Managed by
Stack	Read/Write	Local vars etc	Compiler
Heap	Read/Write	Dynamic structures	Programmer: malloc/free
Statics	Read/Write	Global Vars	Compiler
Literals	Read	String Literals	Compiler
Text	Execute	Instructions	Compiler

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SCANF (INPUT)

```
int scanf(const char *format, ...)
```

1. ... Indicates that the function accepts variable length arguments
2. char *: This contains the *format specifiers*

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SCANF EXAMPLES

```
int a;

printf("Enter a number: ");
scanf("%d", &a);
```


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SCANF EXAMPLES

```
int a;
int b;

printf("Enter two numbers ");
scanf("%d %d", &a, &b);
```


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DON'T DO THIS

```
#include <stdio.h>
#include <stdlib.h>
#define MAXN 15213

int array[MAXN]

int main(){
      int i, n;
      scanf("%d, &n);
      If (n > MAXN){
           app_error("Input file too big");
      }
      for( i = 0; i <n; i++){
         scanf("%d". &array[i]);
       }
}
```

Draw the stack.

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DO THIS INSTEAD

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

int main(){
      int *array, i, n;
      scanf("%d, &n);
      array =  (int *) malloc(n*sizeof(int));
      for( i = 0; i <n; i++){
         scanf("%d". &array[i]);
       }
}
```


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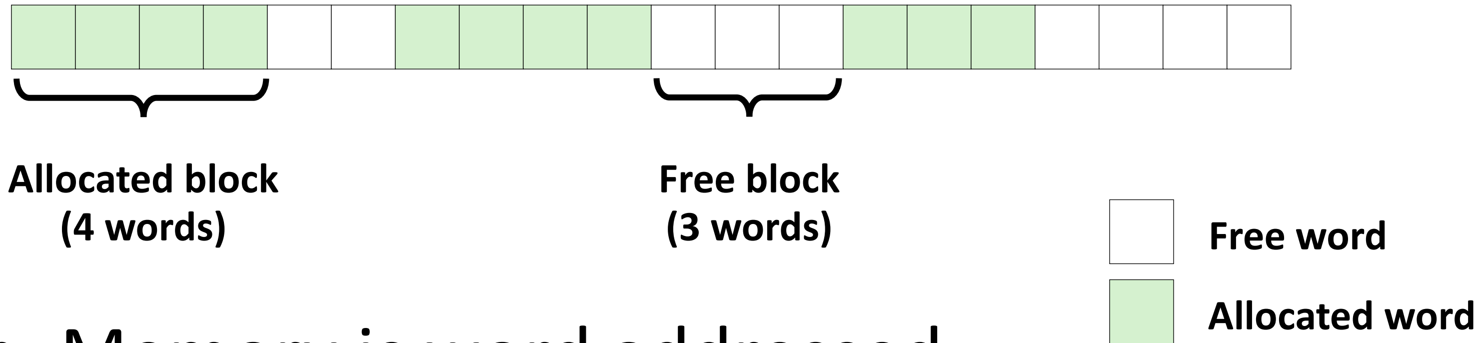
WE'LL ASSUME WORD ADDRESS NOT BYTE ADDRESS



- Memory is word addressed.
- Words are int-sized.

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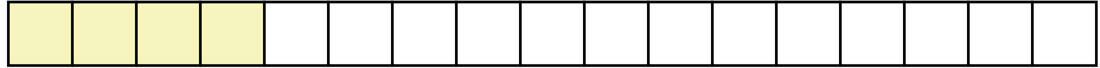
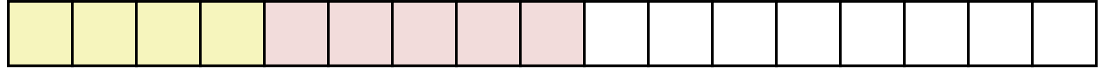
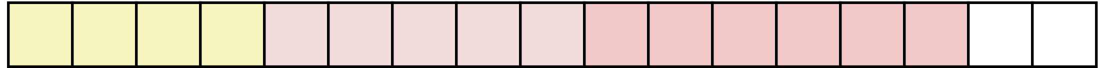
`p1 = malloc(4)`



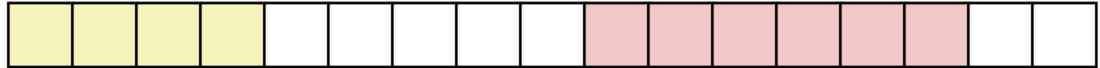
`p2 = malloc(5)`



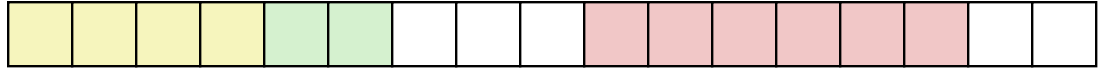
`p3 = malloc(6)`



`free(p2)`



`p4 = malloc(2)`



LET'S TALK ABOUT HOW WE COULD BUILD AND ALLOCATOR

Allocators

- Can't control the number or size of allocated blocks
- Must allocate blocks from free memory
- Can manipulate and modify only free memory
- Can't move the allocated blocks once they are `malloc`'d

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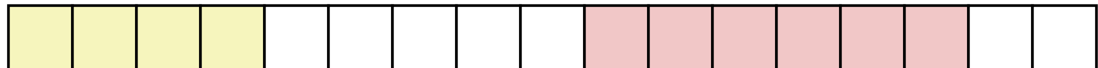
ALSO, WANT TO REDUCE FRAGMENTATION

`p1 = malloc(4)`

`p2 = malloc(5)`

`p3 = malloc(6)`

`free(p2)`



`p4 = malloc(6)`

Oops! (what would happen now?)

Malloc turns NULL (No space left ☹)

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IMPLEMENTATION CHALLENGES

1. How do we know how much memory to free given just a pointer?

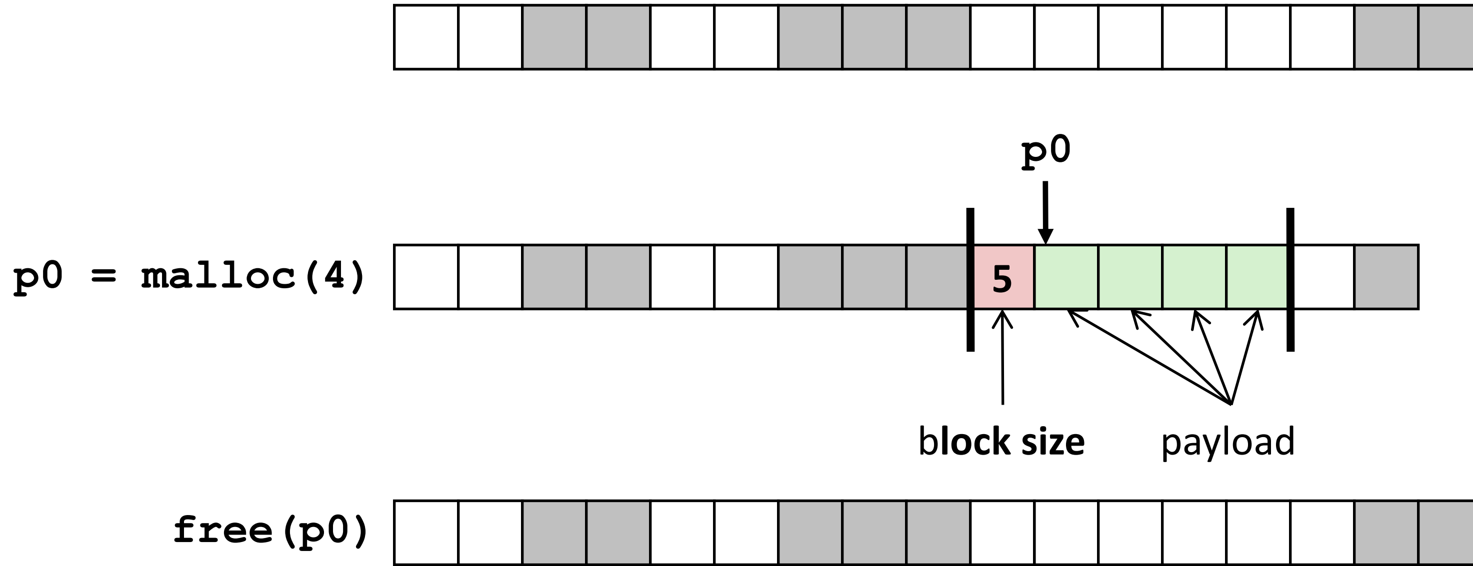
2. How do we keep track of the free blocks?

3. How do we pick a block to use for allocation?
    1. Best Fit
    2. Next Fit
        1. Sadly both still have fragmentation.

KNOWING HOW MUCH TO FREE

Keep the length of a block in the word preceding the block.

This word is often called the ***header field*** or ***header***



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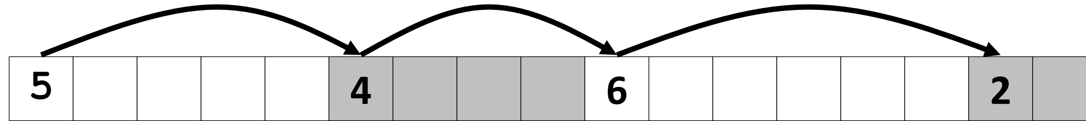
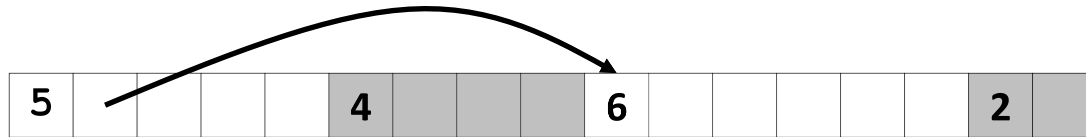
KEEP TRACK OF FREE BLOCKS

Method 1: *Implicit list* using length—links all blocks



Method 2: *Explicit list* among the free blocks using pointers



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GNU nano 6.3 crypto.c

```
/**
This is library runs implements
Simple Crypto Library (Don't write your own crypto libraries)
//For onetime pad the key needs  to be random and they same lenght
// as the message this is a bad implementation of one-time pad
//Because the key is reused for different parts of the message
*/
#include <string.h>
#include <stdio.h>

void encrypt(char * input_string, const char * key ){
        int length_of_key = strlen(key);
        for (int i = 0; i < strlen(input_string); i++){
                input_string[i] =  input_string[i] ^ key[i%length_of_key];
        }
}
```


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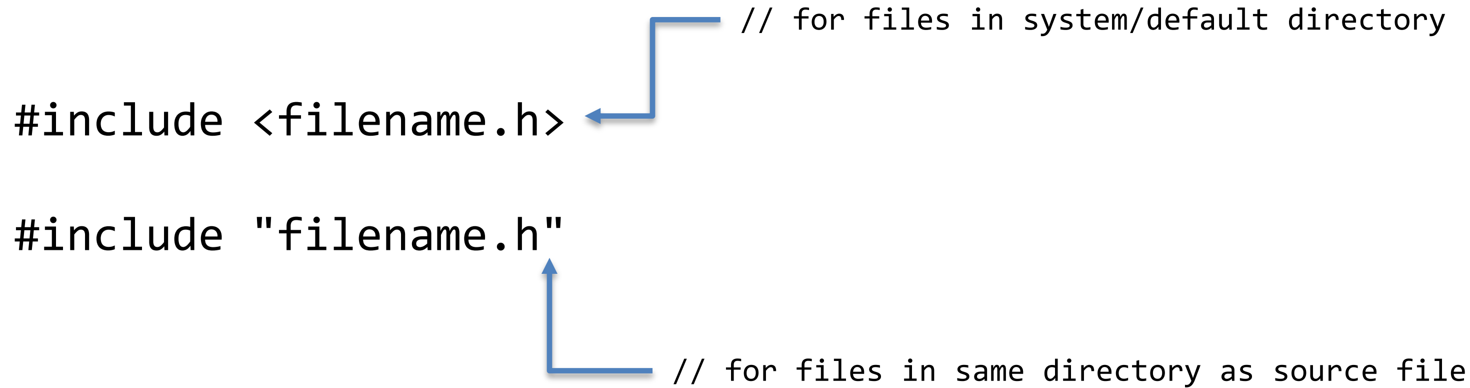
HEADER FILES



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WHY DO HEADER FILES EXIST?

You can think of header files as an API that provides the method definition that tells us so we can use a library

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EXAMPLE HEADER FILES

```
#ifndef EXAMPLE_HEADER_FILE
#define EXAMPLE_HEADER_FILE

----- Contents of Header file.


#endif
```

Header Guard

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EXAMPLE HEADER FILES

```
#ifndef EXAMPLE_HEADER_FILE
#define EXAMPLE_HEADER_FILE

/** Encrypts a string using a key
@param input_string String to be encrypted
@part key key to use for encryption.
**/
#include<string.h>
  void encrypt(char * input_string, const char * key );


#endif
```


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USING THE LIBRARY

```
  GNU nano 6.3                         main.c                          Modified
#include <stdio.h>
#include <string.h>
#include "crypto.h"




int main(){
        char * message = strdup("A secure, connected and intelligent future");
        char * key = strdup("Love");
        encrypt(message, key);
}
```


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FILE IO

```
FILE *fopen( const char * filename, const char * mode );
```


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FILE IO

r	Opens an existing text file for reading purposes.
w	Opens a text file for writing. If it does not exist, then a new file is created. Here your program will start writing content from the beginning of the file.
a	Opens a text file for writing in appending mode. If it does not exist, then a new file is created. Here your program will start appending content in the existing file content.
r+	Opens a text file for both reading and writing.
w+	Opens a text file for both reading and writing. It first truncates the file to zero length if it exists, otherwise creates a file if it does not exist.
a+	Opens a text file for both reading and writing. It creates the file if it does not exist. The reading will start from the beginning but writing can only be appended.

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WHAT IS THIS FILE TYPE

```
FILE *fopen( const char * filename, const char * mode );
```

Let's look at the header file. (It is open source)

Notice that NULL is defined.

https://www.gnu.org/software/m68hc11/examples/stdio_8h-source.html

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FILE IO

```
int fclose( FILE *fp );
```


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FIO EXAMPLE

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

int main()
{
    // file pointer variable to store the value returned by
    // fopen
    FILE* fptr;

    // opening the file in read mode
    fptr = fopen("filename.txt", "r");

    // checking if the file is opened successfully
    if (fptr == NULL) {
        printf("The file is not opened. The program will "
               "now exit.");
        exit(0);
    }

    return 0;
}
```