Memory and C Programming

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What is Memory?

What is Memory?

- I can’t recall…

I remember now:

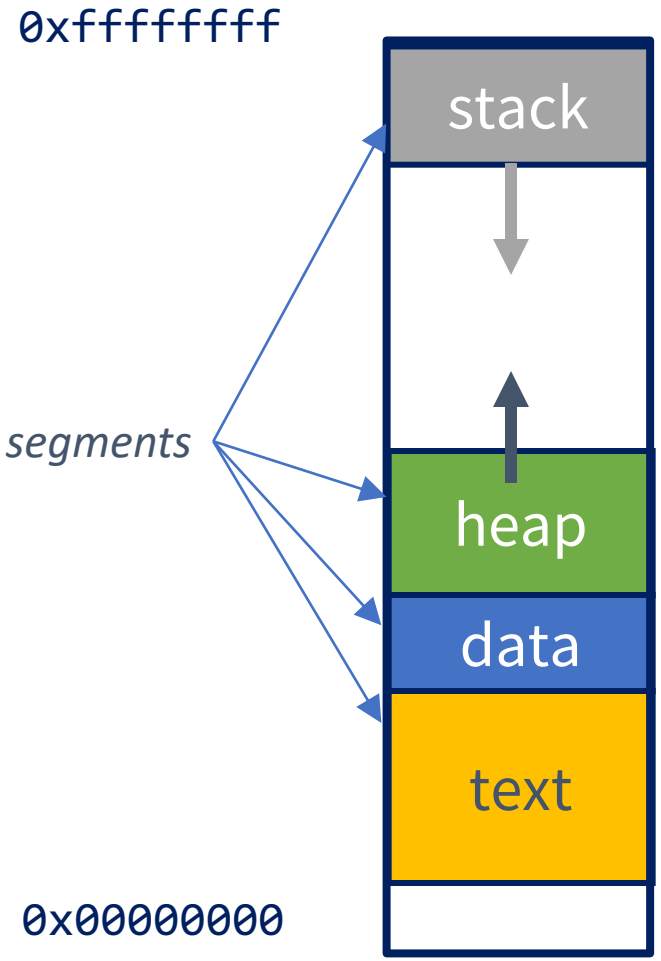
- Memory is an array of bytes
- An index into this array is called an ”address”
- A variable holding an address is called a “pointer”

Types of memory

- Code: machine instructions (read-only)
- Read-only data (string constants etc.)
- Global variables
- Heap: dynamically allocated memory
- Stack

You can store your data in global variables, on the heap, or on the stack

Logical view of process memory



call stack

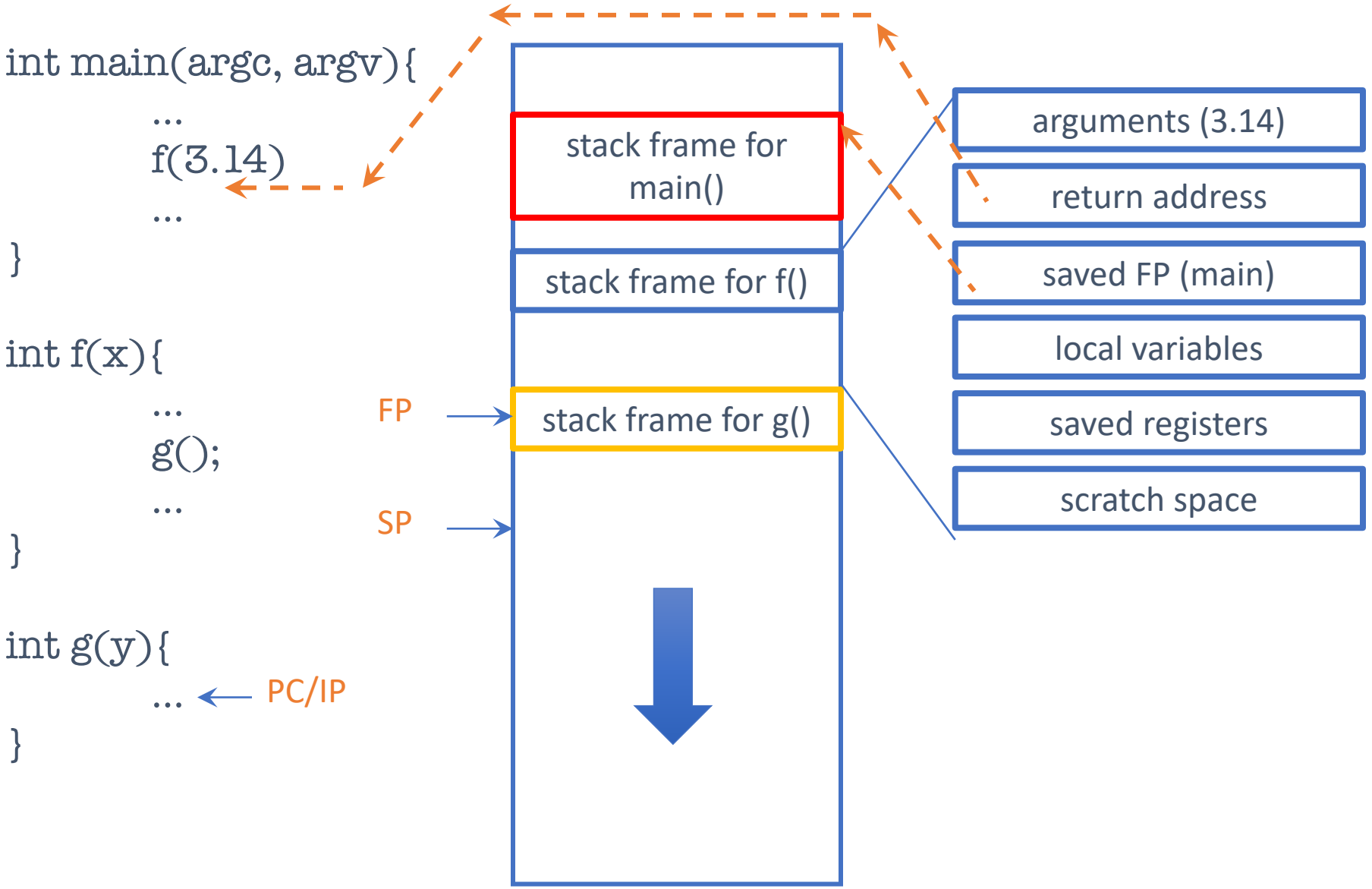
heap used for memory allocation (malloc)

data segment contains global variables

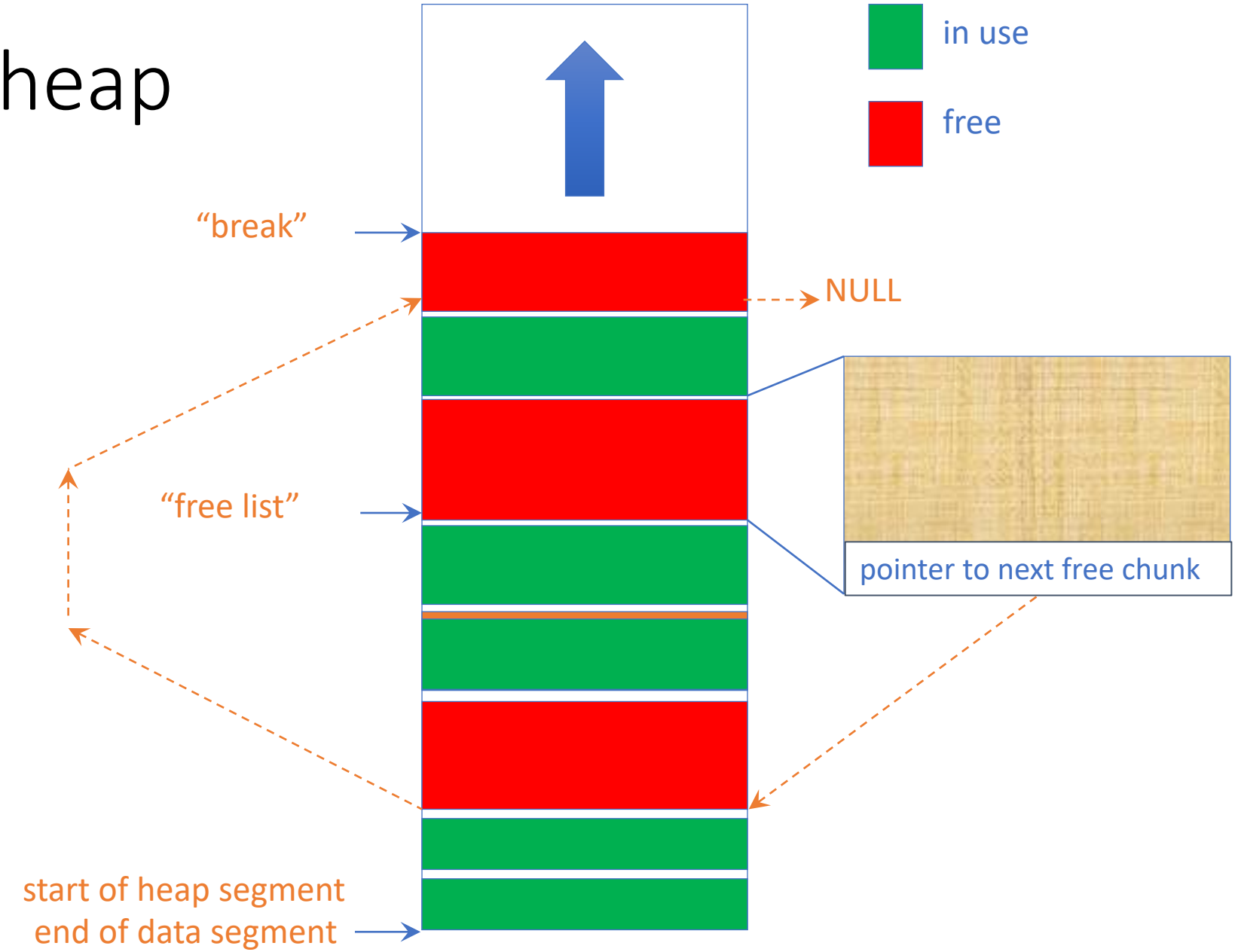
read-only text segment contains code and constants

How many bits in an address for this CPU?
Why is address 0 not mapped?

Review: stack (aka call stack)



Review: heap


in use
free
"break"
NULL
"free list"
pointer to next free chunk
start of heap segment
end of data segment

Three types of data memory

	Global	Heap	Stack
allocated	at start of process	using malloc()	at start of function call
initial state	as specified or 0 otherwise	junk (or 0)	as specified or junk otherwise
released	at end of process	using free()	at end of function call

C Programming

- Like Java programming, but
  - no garbage collection
  - no type safety
  - no object-orientation, polymorphism, container types, …
- Instead:
  - ”structs” (instead of classes)
  - pointers (instead of references)
  - malloc/free (instead of **new** and garbage collection)

Hello World

```
#include <stdio.h>


int main()
{
        printf(“Hello World\n”);
        return 0;
}
```

Structs

```
struct square
{
        int width, height;
};

typedef struct square square_t;
```

Pointers

```
void f()
{
        square_t sq1, sq2;          // on the stack!
        square_t* ptr = &sq1;       // a pointer

        ptr->width = 300;

        …
```

malloc/free

```
void f()
{
        square_t* ptr = malloc( sizeof(square_t) );

        ptr->width = 300;
        …
        free(ptr);
        …
```

Project P0

- Implement a queue *and* a test program
- Must be done by each student individually
  - by Wednesday February 7, so you have almost two weeks
  - but start today if only to find out how hard it is to get started on this!
    - you don't want to find this out too late
- Tar file with instructions (README file) on CMS

On Testing

- Testing is at least as important as implementing the data structure itself
- Don’t be satisfied with a simple “it compiles and I can do a simple access”
  - think about corner cases, and check those
    - dequeue from an empty queue
    - removing the first entry of a queue
    - removing the last entry of a queue
    - …

Linux…

- All projects should be done in a Linux / x86 environment
  - MacOSX on x86 or M1/M2 works pretty well too, but debugging tools quite different
- Learn to use
  - C compiler: cc (or gcc or clang)
  - Debugging tools: valgrind, gdb
  - Code project tools: make
  - Code repo: git
    - use private github repo on github.coecis.cornell.edu
- Running Linux
  - Can install Linux on your laptop
    - dual boot or virtual machine (Vmware, VirtualBox, Hyper-V, …)
  - Remote access
    - CSUGlab machines