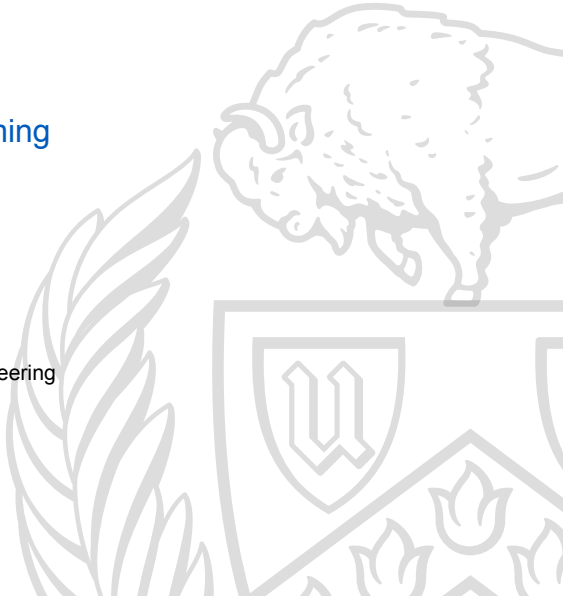
Midterm Review

CSE 220: Systems Programming

Ethan Blanton

Department of Computer Science and Engineering

University at Buffalo



Logistics

Your midterm will be on UBlearns during this lecture time.

You must take a time lapse according to the post on Piazza.

- Don't freak out about it
- Do your best, move things around if you have to
- Improvise if you must

Plan to log in a few minutes early.

The midterm will not open until 9:10.

Resources

You may use:

- K&R, CS:APP
- Lecture slides
- Lab and assignment handouts (not code!)
- Your own notes that you personally took from the above[1]

You must absolutely not use:

- GitHub
- Stack Overflow
- Chegg
- Friends/family/neighbors/tutors/@thingskatedid

[1] Accommodations from AR may allow a notetaker.

Introduction to C

- C is a high level language used in systems programming.
- Architectural details are important in C.
- The C/POSIX model is:
  - A dedicated machine for each program
  - Sequential execution of program instructions
  - Data is stored in accessible, addressed memory
- We explored some trivial C programs.

Variables, Strings, and Loops

- C is a typed language
- Every variable has a type
- Variable values must match the type
- Variables have scope, and cannot be used outside that scope
- Arrays are contiguous memory locations
- Array syntax uses `[]`
- C strings are arrays of characters
- Every C string is terminated with a zero byte
- For loop syntax
- For loops are very flexible

Conditionals and Control Flow

- All nonzero values are true conditions in C.
- All Boolean expressions use 1 for true.
- The `bool` keyword holds only 0 or 1.
- C uses short-circuit evaluation of Boolean logic.
- `if` and `switch` implement conditionals.
- Use blocks for if and else!
- Control flow is implemented with comparisons and jumps.

Memory and Pointers

- Memory locations are identified by addresses.
- Addresses are integers.
- Our system's memory is like one large array.
- POSIX processes appear to have their own dedicated memory.
- Pointers hold addresses and have types.
- Unix processes are divided into sections.
- Pointers and arrays are closely related, but not the same.

Programming Practices

- Cultivate good work habits
- Design your programs purposefully
- Use your tools!
- Practice good style and form
- Debug with a plan

The only way to become a good programmer is to write programs.

A Tour of Computer Systems

- Architectural details matter
  - Bus widths
  - Numeric properties
  - Performance details
- C and POSIX are just one possible system
- All systems have those details
- Software correctness can be critically important

Memory Allocation

- The heap is where you manually allocate memory.
- The C standard library contains a flexible allocator.
- Heap allocations are sized by the programmer.

Integers and Integer Representation

- The CPU and memory deal only in words
- Buses and registers have native word widths
- Integers have different:
  - Bit widths
  - Endianness
  - Sign representation
- Ones' and two's complement representation

Alignment, Padding, and Packing

- Integers, pointers, and floating point numbers are scalar types.
- Arrays and structures are aggregate types.
- Structures can contain members of mixed type.
- Scalar types must be aligned.
- Aggregate types must align for scalars.
- Allocation normally aligns to the largest type.
- Pointer arithmetic uses stride in computations.
- `void *` has a stride of 1.
- The `void *` type can be used for raw memory manipulation
- Casting `void *` to another type is convenient
- Math on `void *` is by byte

Floating Point Numbers

- Numbers can have fractional portions
- Both fixed and floating point representations can be calculated in both binary and decimal
- IEEE 754 standardizes a floating point representation
- Floating point numbers have fixed precision, but variable magnitude

Bitwise Operations

- C can manipulate individual bits in memory.
- Bit operations can be subtle and tricky!
- Signedness matters.
- Bit manipulations can force endianness or other representations.

Process Anatomy

- POSIX programs are laid out in sections
- The stack grows downward
- Automatic variables are allocated on the stack
- Stack frames track function calls
- Items removed from the stack are not cleared
- Stack-allocated arguments are how C is call-by-value

License

To retrieve a copy of this material, or related materials, see `https://www.cse.buffalo.edu/~eblanton/`.