CS3210: Tutorial Session 2

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Overview

- Goal: Understand C and GDB
- Part1: C Programming
- Part2: GDB
- Part3: In-class Exercises

Revised Tutorial Format

- Recommended by Dr. Andersen to modify tutorial format after feedback from first session
- Will attempt this modified format
  - 30 minutes lecture
  - 10-20 minutes demo / walkthrough
  - 30 minutes group / individual exercises

Part 1: C Programming Review

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- Bitwise Operations
- Pointers
- Review of the prep quiz

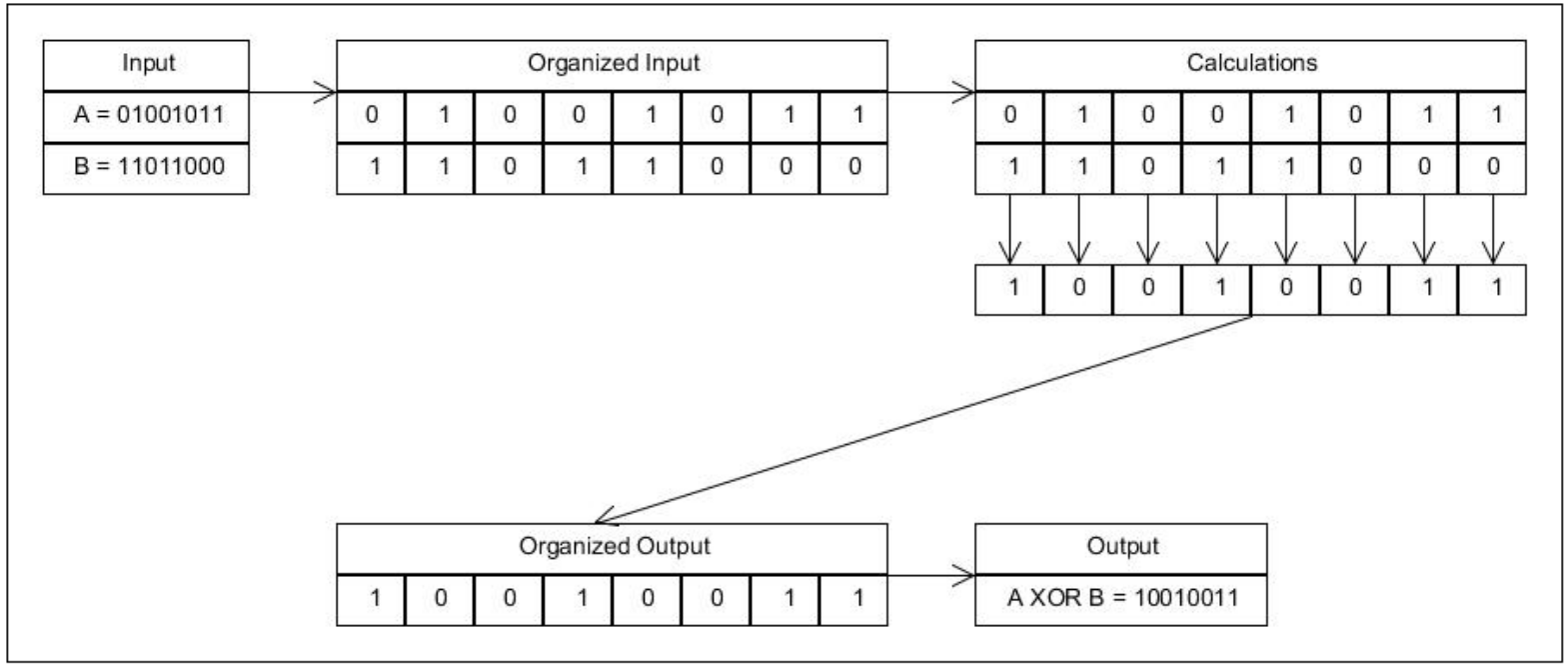
Features of C

- Few keywords
- Structure, unions
- Macro preprocessor
- Pointers - memory, arrays
- External standard library - I/O, etc..
- Lacks (directly)
    - Exceptions, garbage-collection, OOP, polymorphism

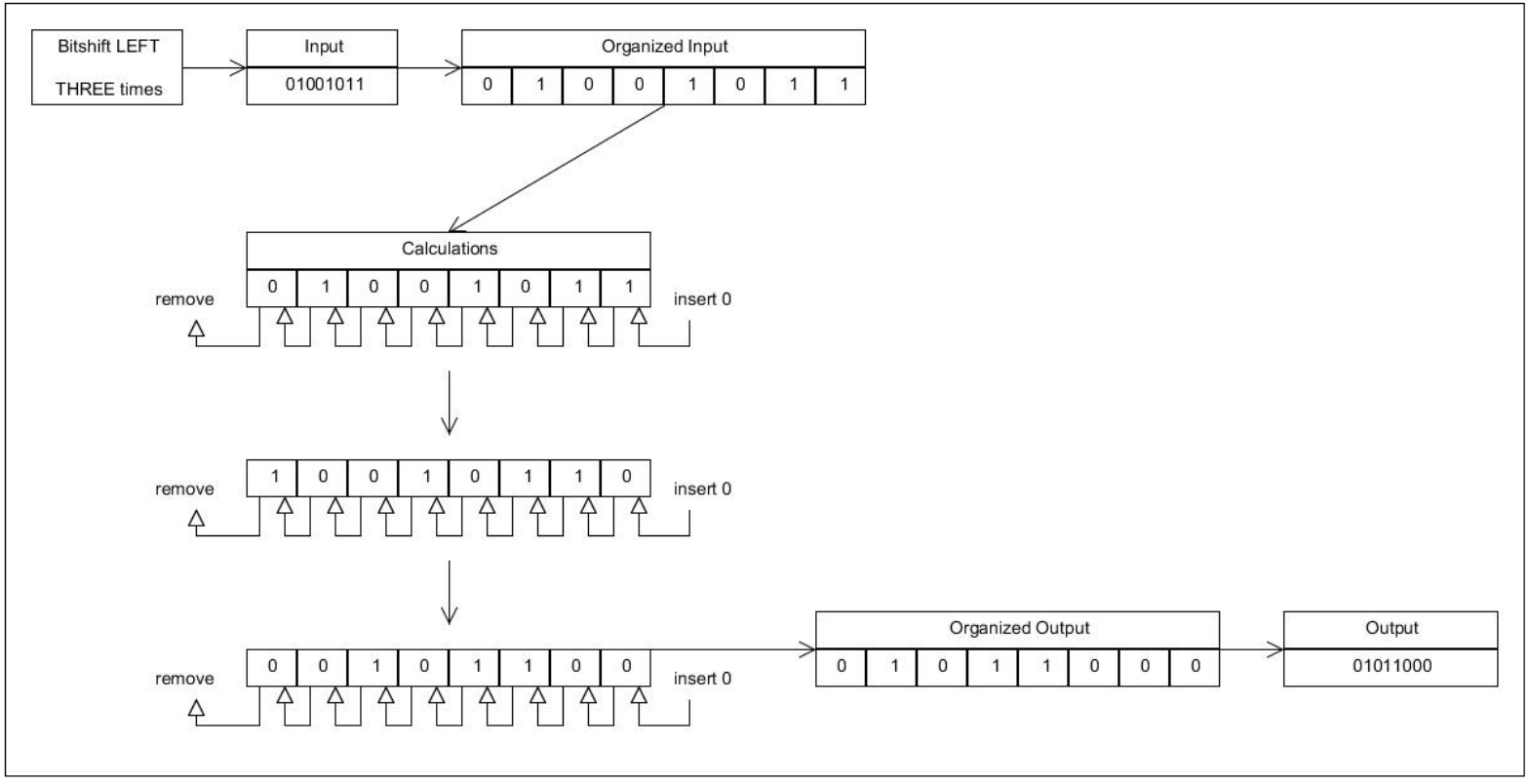
Bitwise Operators in C

- & --- bitwise AND
- | --- bitwise inclusive OR
- ^ --- bitwise exclusive OR
- << --- left shift
- >> --- right shift
- ~ --- one's complement(unary)

Bitwise XOR


Input
A = 01001011
B = 11011000
Organized Input
0 1 0 0 1 0 1 1
1 1 0 1 1 0 0 0
Calculations
0 1 0 0 1 0 1 1
1 1 0 1 1 0 0 0
1 0 0 1 0 0 1 1
Organized Output
1 0 0 1 0 0 1 1
Output
A XOR B = 10010011

Bitwise shift (left and right)



Bitwise Operations - Example

```
unsigned getbits(unsigned x, int p, int n)
{
    return (x >> (p+1-n)) & ~(~0 << n);
}
```

- Let's say x=3210, p=10, n=4

p+1-n → 10+1-4 = 7

1100 1000 1010_2 >> 7 → 0000 0001 1001

~(~0 << 4) → ~(1111 1111 1111) → 0000 0000 1111

0000 0001 1001 & 0000 0000 1111 → 0000 0000 1001 → 9

Pointers

- Pointers are variables that contain **memory addresses** as their values
- A variable name directly references a value
- A pointer indirectly references a value
    - Referencing a value through a pointer is called indirection
- A pointer variable must be declared before it can be used

Concept of address and pointers

- Memory can be conceptualized as a linear set of data locations
- Variables reference the contents of these locations
- Pointers have a value of the address of a given location

How to read a declaration

Definition	Code
1. p is a variable	const int* **p**;
2. p is a pointer variable	const int***** **p**;
3. p is a pointer variable to an integer	const **int*** **p**;
4. p is a pointer variable to a constant integer	**const int*** **p**;

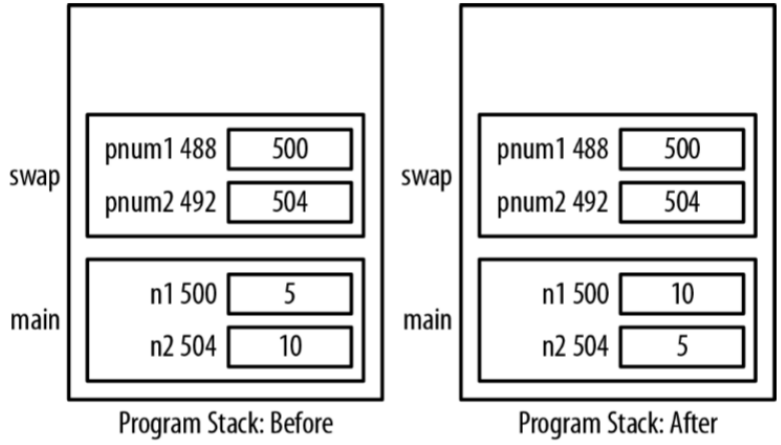
Example (1)

```
int main(){
      int n1 = 5;
      int n2 = 10;
      swap(&n1, &n2);
      return 0;
}
```

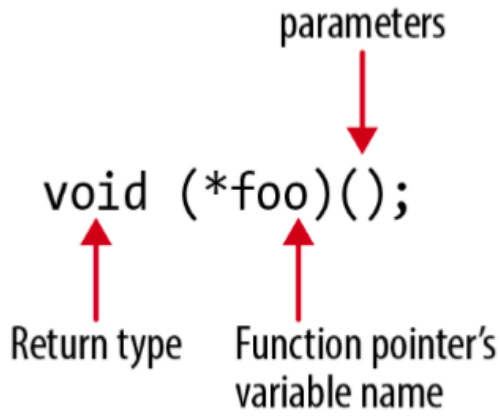
What should swap() look like?

Example (1) - Answer and Result

```
int swap(int* pnum1, int* pnum2){
      int tmp;
      tmp = *pnum1;
      *pnum1 = *pnum2;
      *pnum2 = tmp;
}
```



Function pointer declaration




```
// Example
int (*f1)(double);  // passed a double, returns an int
void (*f2)(char*);  // passed a pointer to char and returns void
```

Example (2)

```
int add(int num1, int num2){
    return num1 + num2;
}
int subtract(int num1, int num2){
    return num1 - num2;
}
int (*fptrOperation)(int,int);
int compute(fptrOperation op, int num1, int num2){
    return op(num1, num2);
}
//usage
printf("%d\n", compute(add,5,6);
printf("%d\n", compute(sub,5,6);
```

Part 2: GDB

- Introduction of GDB
- How GDB works
- How GDB interact with QEMU

Introduction to GDB

- GDB is the GNU program debugger
- GDB allows you
  - set a breakpoint in your program at any given point
  - examine the program state when stopped
  - change things in your program

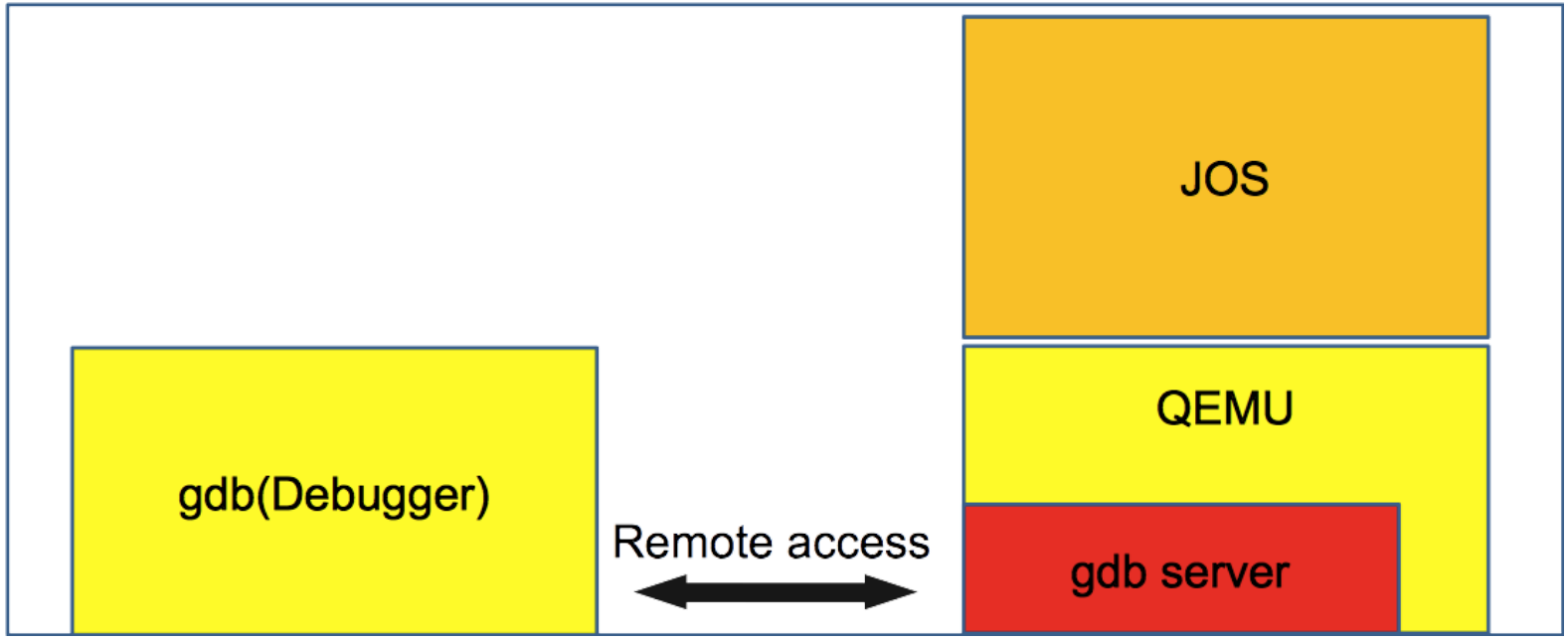
GDB structure

- User interface
  - Several actual interfaces, plus supporting code
- Symbol side
  - Object file readers, debugging info interpreters, symbol table management, etc.
- Target side
  - Execution control, stack frame analysis, and physical target manipulation

GDB debugger

- Kernel support
  - Debugger support has to be part of the OS kernel
  - Kernel able to read and write memory that belongs to each and every process
- Debugger-debuggee synchronization
  - Signal
- Hardware Breakpoint -Built-in debugging feature
- Software Breakpoint

GDB interaction with QEMU



Example: make qemu-gdb

- Open cs3210-lab/lab/Makefile
  - .gdbinit
  - target remote localhost:26000

Basic commands of GDB

- run / r / r arg1 arg2 arg3
  - Start program execution from the beginning of the program
- continue / c
  - Continue execution to next break point
- Kill
  - Stop program execution
- quit / q
  - Exit gdb

GDB: break execution

```
break function-name/line-#/ClassName::functionName
break filename:function/filename:line-#
break *address
break line-# if condition
clear function/line-#
delete br-#
enable br-#
disable br-#
```

GDB: line and instruction execution

- step / s / si / s # / si #
  - Step into
- next / n / ni / n # / ni #
  - Do not enter functions (step over)
- Until / until line-#
  - Continue processing until you reach a specified line number
- Where
  - Show current line number and which function you are in
- Disassemble 0x[start] 0x[end]

GDB: examine variables

- x 0xaddress
- x/nfu 0xaddress
- print variable-name
- p/x , p/d , p/u , p/o
  - Hex, signed integer, unsigned integer, octal
- p/t variable , x/b address
  - Binary
- p/a , x/w
  - Hex address, 4 bytes of memory pointed by address

Part3: In-class exercises

```
git clone git://tc.gtisc.gatech.edu/cs3210-pub
```

```
or
```

```
git pull in your cs3210-pub directory
```

```
cd cs3210-pub/tut/tut2
```

- Open README and follow all the steps
- Have a fun :-)