CS061: Machine Organization & Assembly Language Lab 8

Agenda

1. Presentation:
    a. Programming Assignment 4 Review
    b. Printing out decimal numbers
    c. Counting Bits + Parity Checking
    d. Lab Descriptions

2. Work Time / Questions / Demos

PA 4

- Take in a 5-digit decimal number: “12345”
- Store it to a register.
  - E.g. R4 = 12345
- Concepts:
  - Input Validation: handling when users enter in incorrect input.
  - Number Parsing:
    - Converting digit character to digit. E.g. ‘9’ (57) -> 9
    - Appending digit to a base 10 number. E.g. ‘32’ -> 30 + 2

Printing out Numbers

- How to print out numbers from a register?
  - The reverse of Programming Assignment 4!
  - E.g. R0 = 12345. Print out “12345”

- Say we have R0 = 13.
  - Must print left to right!
  - Print ‘1’ first then print ‘3’!
  - Console will display it as “13”!

- Does that mean we need to get the 1 (from 13) first?
  - No, just have to *print* it first!
  - Can get the 3 (from 13) first!

Isolating Digits

- How to get the 1 (from 13)?

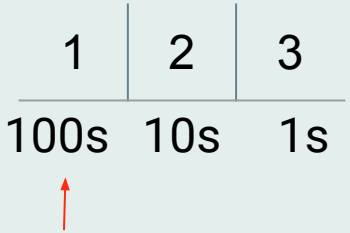
1	3
10s	1s

- In 13, there is 1 instance of 10.
  - i.e. Can subtract 10 **once** from 13.
    - E.g. 13 - 10 = 3 (Positive)
    - E.g. 13 - 10 - 10 = -3 (Negative).
  - Tells you value of the 10s place!

- Can do this for all digits!
  - For 5 digits, there's 10,000s, 1,000s, 100s, 10s, 1s

Isolating Digits Ex.

Counter: 1



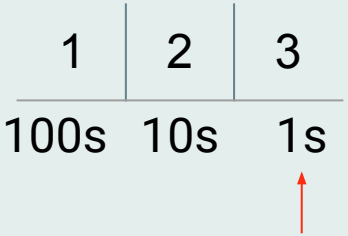
Output: “1”

- Setup:
  - Counter (to represent value in a digit place - e.g. 100s place, 10s place, etc)
    - Can reuse the counter too.
    - Initialize counter to 0.

1. 123 - 100 = 23
   - Result not negative, so continue!
   - Increment counter.

2. 23 - 100 = -23
   - Result negative!
   - Hence there’s only 1 in the 100s place!
   - Print counter value! (Counter: 1)

Isolating Digits Ex.



Output: “123”

- Reset counter! (Counter = 0)
- 23 - 10 = 13
  - Counter++ (Counter = 1)
- 13 - 10 = 3
  - Counter++ (Counter = 2)
- 3 - 10 = -3
  - Negative (don’t change counter)
  - Print counter value!

- Reset counter!
- 3 - 1 = 2
  - Counter++ (Counter = 1)
- 2 - 1 = 1
  - Counter++ (Counter = 2)
- 1 - 1 = 0
  - Counter++ (Counter = 3)
- 0 - 1 = -1
  - Negative (don’t change counter)
  - Print counter value!

Division/Modulo Method

- Can divide/modulo by 10!
  - Need an extra stack for this!

- E.g. 123 / 10 = 12 rem 3
  - Push 3 onto the stack.
- 12 / 10 = 1 rem 2
  - Push 2 onto the stack.
- 1 / 10 = 0 rem 1
  - Push 1 to stack

- How to divide by 10?
  - No instruction in LC-3!
  - Can find out how many times you can subtract the number by 10!

- E.g. 123 - (10 * x) = y
  - x = 12, y = 3

Pop off stack to print number in order:

- Pop and print (Prints 1) Console: “1”
- Pop and print (Prints 2) Console: “12”
- Pop and print (Prints 3) Console: “123”

Counting Bits

- How to count the number of 1s (or even 0s) in a binary number?
  - E.g. in **11011010** = 5 bits that are 1s.
- Very similar to Programming Assignment 3!

Remember this?

Pseudocode:

```
for(i = 15 downto 0):
     if (msb is a 1):
          print a 1
     else:
          print a 0
     shift left
```

- Shift Left Review:
  - 0101 (5) -> 1010 (10)
  - Adding a number to itself will bit shift it to the left!

- Instead of printing, just increment a counter if the MSB is a 1!

Why count bits?

- Counting bits is useful in something called “**parity checking**”!
  - **Parity**: Being even or odd.
- Parity checking is good for **error detection**.

- Suppose we’re trying to send 8-bits across a network:
  - E.g. sending ‘11011101’
- How to know if the bits were sent correctly?
  - Can send the bits + a parity bit:
  - E.g. ‘11001101’ and ‘1’ = ‘110011011’
- Count the parity bit in the number:
  - ‘110011011’ has 6 ones.
  - If parity count is even, then its correct (in the case of even parity)!

Character	Sender	Parity Bit	Receiver	Parity	
“E”	1000101	1	10001011	Even	
“A”	1000001	0	10000010	Even	
“C”	1000011	1	11100111	Even	
“q”	1110001	0	11100000	Odd	Error!

Christopher Kalodikis - “Parity Check” (Youtube)

Exercise 1

- Do the reverse of assignment 4!
- Two sub-routines.

- LOAD_FILL_VALUE_3200:
  - Load a hardcoded value into a register!

- OUTPUT_AS_DECIMAL_3400:
  - Print out register value to console!
  - See previous slides for help!
  - **Must handle negative numbers!**

- Test Harness (Main Program):
  - Call LOAD_FILL_VALUE_3200 sub-routine.
  - Add 1 to the value.
  - Call OUTPUT_AS_DECIMAL_3400 sub-rotuine.

Exercise 2

- Count number of 1s in a binary number!

- Create a sub-routine:
  - Parameter (Rx): Value to count.
  - Post-condition: Count number of 1s in the binary form of Rx.
  - Return Value (Ry): Number of 1s.

- Test Harness (Main Program):
  - Ask user to input a character.
  - Call sub-routine on the ASCII value of the character entered (e.g. ‘A’ -> 65)
  - **Print out “The number of 1’s in ‘<char>’ is: x”**
  - E.g. “The number of 1’s in ‘A’ is: 2”

Exercise 3

- How to right-shift a value?
- No coding required for this exercise: just think of the algorithm!

- Right-shifting:
  - ‘1011’ -> ‘0101’

- Can we:
  - Subtract the number from itself? *Nope*
  - Can we divide the number by 2? *Yes - but **impractical** for large numbers.*

- Can we left-rotate?
  - Left-rotating: Left-shifting but adding MSB back to number.
  - E.g. ‘1011’:
    - MSB is ‘1’
    - Left-shift: ‘0110’
    - Add MSB: ‘0111’
  - How can we use left-rotating to right shift?

Demo Info

- **Lab Grade Breakdown:**
  - 3 points for attendance.
  - 7 points for demoing (+1 bonus point demo'd before/during Friday).
  - 3 point penalty if lab is demo'd during the next lab session.

- **Tips before you demo:**
  - ***Understand your code!*** (Know what each line does & the input/output)
  - ***Test your code!*** (Check for correct output and that there are no errors)