CSM 61C Spring 2019

Midterm Review

Mentoring 4: February 10, 2019

1 Number Representation

1.1 What is the range of integers represented by a n-bit binary number? Your answers should include expressions that use 2^n.

(a) Unsigned:

(b) Two's Complement:

(c) One's Complement:

(d) Bias (with bias b):

1.2 How many unique integers can be represented in each case?

(a) Unsigned:

(b) Two's Complement:

(c) One's Complement:

(d) Bias (with bias b):

2 C Memory Locations

2.1 Consider the following C program:

```
int a = 5;
int main()
{
    int b = 0;
    char* s1 = cs61c;
    char s2[] = cs61c;
    char* c = malloc(sizeof(char) * 100);
    return 0;
};
```

For each of the following values, state the location in the memory layout where they are stored. Answer with code, static, heap, or stack.

(a) `s1`

(b) `s2`

(c) `s1[0]`

(d) `s2[0]`

(e) `c[0]`

(f) `a`

2.2 Consider the C code here, and assume the malloc call succeeds. Rank the following values from 1 to 5, with 1 being the least, right before bar returns. Use the memory layout from class; Treat all addresses as unsigned numbers.

```
#include <stdlib.h>

int FIVE = 5;

int bar(int x) {
    return x * x;
}

int main(int argc, char *argv[]) {
    int *foo = malloc(sizeof(int));
    if (foo) free(foo);
    bar(10); //  snapshot just before it returns
    return 0;
}
```

```
foo:   _______
&foo:  _______
FIVE:  _______
&FIVE: _______
&x:    _______
```

3 Linked Lists

3.1 Fill out the declaration of a singly linked linked-list node below.

```
typedef struct node {
    int value;
    _____________ next; // pointer to the next element
} sll_node;
```

3.2 Let's convert the linked list to an array. Fill in the missing code.

```
int* to_array(sll_node *sll, int size) {
    int i = 0;
    int *arr = ________________;
    while (sll) {
        arr[i] = ____________;
        sll = ____________;
        _______;
    }
    return arr;
}
```

3.3 Finally, complete the function `delete_even()` that will delete every second element of the list. For example, given the lists below:

```
Before: Node 1  Node 2  Node 3  Node 4
After: Node 1  Node 3
```

Calling `delete_even()` on the list labeled "Before" will change it into the list labeled "After". All list nodes were created via dynamic memory allocation.

```
void delete_even(sll_node *s11) {
    sll_node *temp;
    if (!sll || !sll->next) {
        return;
    }
    temp = _________;
    sll->next = _________;
    free(_________);
    delete_even(_________);
}
```

4 RISC-V to C

4.1 Assume we have two arrays input and result. They are initialized as follows:

```
int *input = malloc(8*sizeof(int));
int *result = calloc(8, sizeof(int));
for (int i = 0; i < 8; i++) {
    input[i] = i;
}
```

You are given the following RISC-V code. Assume register x10 holds the address of input and register x12 holds the address of result.

```
    add x8, x0, x0
    addi x5, x0, 8
    addi x11, x0, 0
    addi x12, x0, 0
Loop:
    beq x5, x11, Done
    lw x6, 0(x10)
    add x8, x8, x6
    slli x7, x5, 2
    add x7, x7, x12
    sw x8, 0(x7)
    addi x5, x5, -1
    addi x10, x10, 4
    j Loop
Done:
    // exit
    .

// sizeof(int) == 4
int sum = 0;
```

4.2 What is the end array stored starting at register x12?

5 Advanced RISC-V

5.1 You are given the following RISC-V code:

```
Loop:   andi t2 t1 1
        srli t3 t1 1
        bltu t1 a0 Loop
        jalr s0 s1 MAX_POS_IMM
```

(a) What is the value of the byte offset that would be stored in the immediate field of the bltu instruction?

(b) What is the binary encoding of the bltu instruction? Please use hexadecimal to represent your answer.

5.2 As a curious 61C student, you question why there are so many possible `opcodes`, but only 47 instructions. Thus, your propose a revision to the standard 32-bit RISC-V instruction formats where each instruction has a unique `opcode` (which still is 7 bits). You believe this justifies taking out the `funct3` field from the `R`, `I`, `S`, and `SB` instructions, allowing you to allocate bits to other instruction fields except the `opcode` field.

(a) What is the largest number of registers that can now be supported in hardware?

(b) With the new register size, how far can a `jal` instruction jump to (in halfwords)?

(c) Assume register `s0 = 0x1000 0000`, `s1 = 0x4000 0000`, `PC = 0xA000 0000`. Lets analyze the instruction `jalr s0, s1, MAX_POS_IMM` where `MAX_POS_IMM` is the maximum possible positive immediate for `jalr`. Using the register sizes defined above, what are the values in registers `s0`, `s1`, and `pc` after the instruction executes?