UC Berkeley : CS61C (Garcia & Lustig) : Midterm part 1 : 2014-10-10

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Question 1: ***Running in circles*** (25 min, 18 pts)

A *nibble* is half of a byte (4 bits). You'd like to implement **LoadNibble** in MAL MIPS, a function that takes one **uint32_t** argument **N** and returns the **N**th nibble of memory in the lowest 4 bits of the return register (the other 28 bits should be 0). Note: The **N**th nibble immediately follows the **N-1**th nibble without overlapping; see box . The MIPS instruction **srlv** ("shift right variable") might be useful here; it operates like the **shamt**-based right-shift, except that its 3rd *register* argument is the variable amount to shift by.

a) What fraction of all the nibbles of memory can you access? **1/2**

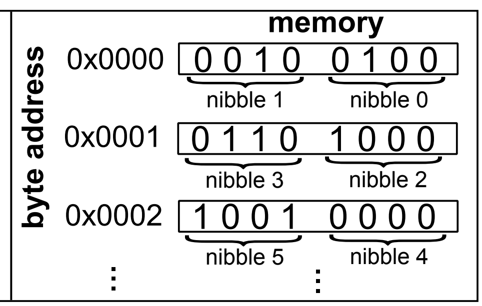
b) Implement **LoadNibble** by filling in the blanks:

```
LoadNibble: srl   $t0   $a0   1     # figure out which byte contains that nibble
            lbu   $a1   0($t0)
            andi  $a0   $a0   0x1
sll $a0 $a0 2 # we needed this!
gone1:      srlv  $v0   $a1   $a0
gone2:      andi  $v0   $v0   0xF

            jr $ra
```

for N=2, **LoadNibble** returns **0b1000**

for N=5, **LoadNibble** returns **0b1001**



c) We want to rewrite **LoadNibble** to make use of a helper function **Helper** that will take two arguments. The first is an index **i** from 0-1 and the second is a byte **B**. **Helper** returns the **i**th nibble in **B** placed in the lowest 4 bits of the return value (the rest 0s).

E.g., **Helper(0, 0b01100100)** → **0b0100** and **Helper(1, 0b01100100)** → **0b0110**

We decide we don't need the two MIPS instructions labeled "**gone1**" and "**gone2**". What would you replace these instructions (and the **sll**) with to call **Helper** and implement **LoadNibble** successfully? Write the replacement below. Follow calling conventions and complete it in the fewest lines possible.

```
addiu $sp $sp -4          # this line may not be necessary
sw $ra 0($sp)             # this line may not be necessary
______________            # this line may not be necessary
jal   Helper   # j works too, all other lines blank (since $ra = LoadNibble's caller)!
lw  $ra 0($sp)            # this line may not be necessary
addiu $sp  $sp   4        # this line may not be necessary
______________            # this line may not be necessary
```

Question 2: *I can C clearly now, the rain is gone...* (25 min, 18 pts)

A) Fill in the blank to complete this function that parses a string of *octal digits* (base 8) into a **uint64_t**. For example, calling **parse_octal("71")** should return the number 57. Do not use the comma operator, nested assignment, prefix/postfix operators, or function calls. You may assume that the given number "fits" into a **uint64_t**. (**Hint:** The backside of the MIPS green sheet may help.)

```
uint64_t parse_octal(char *s) {
        uint64_t r = 0;
        while(*s){          r*8 + (*s - '0')
                r = ____________________________________;
                s++;
        }
        return r;
}
```

B) We have the following data *packed tightly (no padding)* into the struct **data**, and some more code below:

```
struct {
        int16_t a;
        char b[2+(UNKNOWN_LENGTH*4)];
        int32_t c;
        int32_t d;
} data;
```

Fill in the blanks with an equivalent expression using only the pointer **s**, pointer arithmetic, casting, and the function **strlen()**. You may <u>**NOT**</u> use **UNKNOWN_LENGTH**. Assume **sizeof(char) = 1**.

```
/* … Some code here that fills in data.b with the longest string possible … */
char *s  = data.b; /* s is a char, so it counts by 1 byte by default if in parens */
                          s-1 /* or (s-2) */
*( (int16_t *) ________________________________________ ) = -1;  // data.a = -1;
                        (s+strlen(s)+1+4)
*( (int32_t *) ________________________________________ ) = -1;  // data.d = -1;
```

C) Here we have a *LR-tree*, defined as a node with two arrays of child pointers: two left children and two right children. Each node also contains a pointer to its parent node, a unique integer ID value, and a string name field. Root nodes will have a **NULL** parent pointer, and leaf nodes will have arrays of **NULL** children pointers.

```
struct lr_tree{
  char *name;
  uint64_t ID;
  struct lr_tree *left_children[2];
  struct lr_tree *right_children[2];
  struct lr_tree *parent;
};
```

Fill in the blanks to complete this function that frees a LR-tree if called with the root of the tree. You must free **ALL** data associated with this LR-tree! You might not need all of the blanks, in which case use the most minimal number of blanks possible. Do not use the comma operator, nested assignment, or prefix/postfix operators.

```
void free_lr_tree (struct lr_tree *p) {
                  p != NULL
        if (______________________________________________ ){
                for(size_t x = 0; x < 2; x++) {
                        free_lr_tree(p->left_children[x]);
                        ______________________________________;
                        free_lr_tree(p->right_children[x]);
                        ______________________________________;
                }
                free(p->name);
                ______________________________________;
                free(p);
                ______________________________________;

                ______________________________________;
        }
}
```