University of Arizona, Department of Computer Science

CSc 340 Foundations of Computer Systems — Homework 3

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Due Tuesday, March 27

1. Write a C function `ackerman(x,y)` that implements Ackerman's Function:

$$\begin{aligned} A(0,y) &= y+1 \\ A(x+1,0) &= A(x,1) \\ A(x+1,y+1) &= A(x,A(x+1,y)) \end{aligned}$$

2. Write a C procedure that takes an integer array A as input and prints out the following information:
   (a) The *maximum* and *minimum* values in A,
   (b) The *median* element of A,
   (c) The (real) *average* of the elements of A,
   (d) The *mode* of the elements of A, i.e. the most frequently occuring value.

3. Explain briefly the kind of hazards caused by the following pair of statements and which two stages in the pipeline get involved in the hazard: (assuming a MIPS architecture and pipelining)
   (a)
   ```
   lw $s2, addr
   addu $s1, $s2, $s3
   ```
   (b)
   ```
   lw $s1,addr
   beqz $s1, next
   ```

4. Reschedule the Mips assembly code given below to avoid hazards. Hint: You need to fill in the branch delay slot with some instruction, if not use a `nop`.

```
loop: lw     $s0, 0($t0)
      lw     $s1, 0($t1)
      mul    $s0, $s0, $s1
      add    $s2, $s0, $s2
      addi   $t0, $t0, 0x8
      addi   $t1, $t1, 0x8
      sub    $s3, $s4, $t0
      bnez   $s3, loop
```