Introduction to Computer Science

Midterm Examination, April 17, 2002

102 points in 2 pages

1. Convert each of the following base ten representation to its equivalent two's complement representation in which each value is represented in seven bits: (8 points)

   (a) 12 (b) -12 (c) -1 (d) 8

2. Convert each of the following two's complement representations to its equivalent base ten representation: (8 points)

   (a) 01111 (b) 01010 (c) 10101 (d) 11111

3. Perform each of the following additions assuming the bit strings represent values in two's complement notation. Represent the results in two's complement notation. Identify each case in which the answer is incorrect because of overflow. (8 points)

   (a) 01111 + 00001 (b) 01010 + 10101

   (c) 11111 + 11111 (d) 01000 + 01000

4. Code the following values using the eight-bit floating-point format described in Fig. 1. Indicate each case in which a truncation error occurs. (8 points)

   (a) $7\ ^{1}/_{2}$ (b) $-3\ ^{3}/_{4}$ (c) $^{3}/_{32}$ (d) $^{31}/_{32}$

5. Decode the following bit patterns using the floating-point format described in Fig. 1. (8 points)

   (a) 01011100 (b) 11001000 (c) 01101000 (d) 10111001

6. Perform each of the following additions, interpreting the bit patterns using the floating-point format described in Fig. 1. Code the answer in the same floating-point format. Identify those cases in which truncation errors occur. (8 points)

   (a) 01011100 + 01101000 (b) 01101010 + 00111000

   (c) 01111000 + 00011000 (d) 01011000 + 01011000

7. Suppose the machine described in Appendix C communicates with a printer using the technique of memory mapped I/O. Suppose also that address FF is used to send characters to the printer, and address FE is used to receive information about the printer's status. In particular, suppose the least significant bit at the address FE indicates whether the printer is ready to receive another character (with a 0 indicating "not ready" and a 1 indicating "ready'). Starting at address 00, write a machine language routine that waits until the printer is ready for another character and then send the character represented by the bit pattern in register 5 to the printer. (8 points)

8. List in chronological order the major events that take place when a process is interrupted. (8 points)

9. Use pseudo code to design an algorithm that, given two strings of characters, tests whether the first string appears as a substring somewhere in the second. (8 points)

10. Explain the following terms briefly. (30 points, 3 points for each term)
    (a) The program counter
    (b) The machine cycle
    (c) The bootstrap booting process
    (d) The shells of Operating systems
    (e) The three necessary conditions for deadlock
    (f) The four layers of the Internet software
    (g) The two basic differences between TCP and UDP
    (h) Stepwise refinement
    (i) Activations of a recursive algorithm
    (j) The big-theta notation

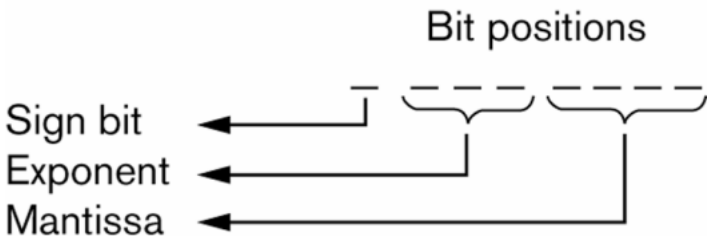

Fig. 1. Floating-point notation format. Note that a 0 in the sign bit mean that the value is nonnegative, and a 1 mean that the value is negative. Meanwhile, the exponent field is interpreted using the three-bit excess method.

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1. (a) 0001100 (b) 1110100 (c) 1111111 (d) 0001000
2. (a) 15 (b) 10 (c) -11 (d) -1
3. (a) 10000, overflow (b) 11111 (c) 11110 (d) 10000, overflow
4. (a) 01111111 (b) 11101111 (c) 00011100 (d) 01001111, truncation error
5. (a) 3/2 (b) -1/2 (c) 2 (d) -9/32
6. (a) 01101110 (b) 01101011 (c) 01111000, truncation error (d) 01101000
7. Algorithm:

   Step 1. Load R0 the constant 00 // for comparison with the flag bit
   Step 2. Load R1 the constant 01 // as a mask to check the flag bit
   Step 3. Load R2 the content of address FE // prepare to check the flag bit
   Step 4. And R1, R2 to R3 // extract the flag bit
   Step 5. Jump to step 3 if R3 equals R0 // not ready
   Step 6. Store R5 to address FF // write content of R5 to printer
   Step 7. Halt

   Machine program

Address	Contents
00	20
01	00
02	21
03	01
04	12
05	FE
06	83
07	12
08	B3
09	04
0A	35
0B	FF
0C	C0
0D	00

8. (1). The timer circuit generates an interrupt signal
   (2). The CPU completes its current machine cycle
   (3). The CPU saves its position in the current process
   (4). The CPU begins executing the interrupt handler, which is stored at a predetermined location in main memory and is part of the dispatcher
   (5). The dispatcher preempt the current process
   (6). The dispatcher allows the scheduler to update the process table
   (7). The dispatcher selects the process from the process table that has the highest priority among the ready process
   (8). The dispatcher restarts the timer circuit
   (9). The dispatcher allows the selected process to begin its time slice

9. **procedure** IsSubstr(string1, string2) // check if string1 is a substring of string2
   assign length1 **the value** the length of string1**;**
   assign length2 **the value** the length of string2**;**
   if (string1 or string2 is null or length1 larger than length2) **return** false
   assign m **the value** 1 // m as an index for string2
   while (m not greater then length2) **do** (
      // search in string2 for the first character of string1
      while (the m'th character of string2 does not equal the first character of string1
            and m no greater than length2)
         do (assign m the value m+1),
      if (m greater than length2) **return** false,
      assign m **the value** m+1,
      assign n **the value** 2, // n as an index for string1

      // check matches with the remaining characters of string1
      while (n not greater than length1 and m not greater than length2
            and the n'th character of string1 equals the m'th character of
            string2) **do** (
         assign n **the value** n+1,
         assign m **the value** m+1
      ),

      if (n greater than length1) **return** true, // match with string1 found
      assign m **the value** m+1,
)
   return false

10. (a) The program counter is a special purpose register containing the address of the next instruction to be executed

(b) The machine cycle is an algorithm that the control unit repeats to perform a computer's job. It consists of three steps: fetch an instruction from the main memory, decode the instruction, and execute the instruction.

(c) The bootstrap booting process is the process to start the operating system. The process automatically executes the bootstrap program, which is a small program stored in a read-only memory part of main memory, when the machine is turned on. It directs the CPU to transfer the material from a predetermined location in mass storage into the volatile area of main memory. In most cases this material is the operating system. Once the operating system has been placed in main memory, the bootstrap directs the CPU to execute a jump instruction to the area of memory. At this point, the operating system takes over and begins controlling the machine's activities.

(d) The shell is the portion of an operating system that defines the interface between the operating system and its users.

(e) (1) There is competition for nonsharable resources.
(2) The resources are requested on a partial basis.
(3) Once a resource has been allocated, it can not be forcibly retrieved.

(f) (1) Application layer: software units that must communicate with each other across the internet.
(2) Transport layer: divides long messages from the application layer into segments of a size compatible with the underlying network layer and adds sequence numbers and the destination address to each segment. The resulting units are known as packets.
(3) Network layer: responsible for seeing that the packets it receives from Transport layer are properly forwarded from one network within the Internet to another until they reach their final destinations.
(4) Link layer: deals with the communication details particular to the individual network in which the machine resides.

(g) (1) A TCP transport layer establishes a connection before sending data, while a transport layer based on UDP does not establish such a connection prior to sending data.
(2) TCP transport layers at the origin and the destination work together by means of acknowledgements and segment retransmissions to confirm that all segments are successfully transferred to the destination, whereas UDP does not offer such retransmission services, or said to be an unreliable protocol.

(h) Stepwise refinement is essentially the problem-solving technique that one first views the problem at hand in terms of several subproblems such that one is able to approach the overall solution in terms of steps. In turn, the stepwise refinement proposes that these steps be decomposed into smaller steps. Continue this process until the original problem has been reduced to a collection of easily solved subproblems.

(i) Activations are multiple copies of a recursive algorithm itself. They appear and disappear, as the algorithm advances. Of those activations existing at any given time, only one is actively progressing. The others are waiting for another activation to terminate before it can continue.

(j) The big-theta notation is used to classify algorithms according to the shape of the graphs representing its resource consumption with respect to the input data size. For example, the insertion sort algorithm is classified as a $\Theta(n^2)$ algorithm through its computation time analysis.