ENGINEERING TRIPOS PART IIA

Tuesday 20 April 2010 9 to 10.30

Module 3F5

COMPUTER AND NETWORK SYSTEMS

Answer not more than ***three*** *questions.*

All questions carry the same number of marks.

The ***approximate*** *percentage of marks allocated to each part of a question is indicated in the right margin.*

There are no attachments.

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS
Engineering Data Book
CUED approved calculator allowed

You may not start to read the questions printed on the subsequent pages of this question paper until instructed that you may do so by the Invigilator

1 (a) What are the advantages and disadvantages of virtual memory? [20%]

(b) Explain how the main disadvantage can be reduced by using a Translation Lookaside Buffer (TLB). [10%]

(c) Assuming a 32-bit virtual address, a 30-bit physical address, with 4kB pages, sketch the design of a 2-way set-associative TLB with a block size of 2 and a total of 32 blocks. [40%]

(d) Assume a MUX or testing equality takes two gate delays and that a table lookup takes six gate delays. If each gate causes a delay of 0.5ns, how long does your design of TLB take to compute a physical address?

Assuming that the memory cache has the same performance, how fast could the processor be clocked assuming a pipelined design? [20%]

(e) What difference would be made if the cache indexed *virtual* addresses? What are the disadvantages of such a design? [10%]

2 (a) What is meant by a data hazard? [10%]

(b) What is the difference between *caller* save and *callee* save? [10%]

(c) The assembler code below shows a function which counts how many bits are set in an integer. For example, the integer 23 has the binary representation 10111 and hence if the value 23 were passed to `bitcount`, it would return the value 4.

```
# Function bitcount
# takes integer argument in register 4
# counts the number of bits set in this register
# and returns the result in register 2

bitcount:
    add $2,$0,$0          # store 0 in register 2 which will hold the result
    addi $20, $0, 32      # store 32 in register 20 (this is a loop counter)

loop:
    andi $21, $4, 1       # AND register 4 with 1 and store in register 21
                          # register 21 is now 1 if lowest bit of register 4 was set
    beq $21, $0, notset   # if the result is zero jump to notset:

    addi $2, $2, 1        # if we got here we found a bit set so add 1 to register 2

notset:
    srl $4, $4, 1         # shift register 4 right by one bit so we can test the next bit
    addi $20, $20, -1     # subtract 1 from register 20 (the loop counter)
    bgtz $20, loop        # if reg 20 has not reached zero yet, go round the loop again

    jr $31                # return from function (the result is in register 2)
```

Assuming no data forwarding, identify the data hazards in this code. Can any of these hazards be avoided by reordering the instructions? [30%]

(d) By convention, registers 2 and 3 are used for the result of a function, registers 4–7 are used for the arguments of a function, registers 8–15 are caller save and registers 16–23 are callee save.

Following this convention, which registers would need to be saved by the function bitcount? Would it be possible to use different registers to avoid this? [20%]

(cont.

(e) Write a function in MIPS assembly code which takes two integers as arguments (in registers 4 and 5), counts how many bits are set in both of them and returns the sum of those numbers in register 2. Your function should use the bitcount function already given. Minor errors in syntax will not be penalised, but you should clearly state what each instruction does. [30%]

3 (a) What are the three main features of the synchronous digital hierarchy (SDH) which helped to correct the defects in the older pleisiochronous digital hierarchy (PDH) used in modern telephone networks. Explain why these three features make SDH a far superior telephone network structure. [25%]

(b) Describe how an ideal SDH wide area network would be constructed across a country such as the United Kingdom and describe each component used to create such a wide area network.

Why is such a wide area network topology not possible in reality? [30%]

(c) The evolution of SDH also gave us integrated services digital network (ISDN) protocols and in particular the asynchronous transfer mode (ATM) protocol. Explain the basic structure of ATM and show how it was made compatible with the SDH system. [25%]

(d) Why is this SDH network now being replaced by internet using the voice over internet protocol set? [20%]

4 (a) Describe in detail the main differences between a circuit switch and a packet switch in terms of the requirements of a telecommunications network and a computer data network. [25%]

(b) One of the first packet switched protocols to be popular in the 1980s was X.25. Explain why the X.25 packet switched network protocol was successful and why it eventually evolved into frame relay. Identify the key features which were retained in the new frame relay protocol. [30%]

(c) One of the most important local area network (LAN) protocols in today's computer networks is the 802.3 standard, ethernet. Describe the original features of the 802.3 ethernet protocol for a coaxial cable based LAN. Why did this protocol evolve into the protocol that is in use today? [30%]

(d) Given how the protocols have evolved in parts b) and c) above, compare the relevant features of modern day frame relay and ethernet. [15%]

END OF PAPER