ENGINEERING TRIPOS PART IIA

Tuesday 21 April 2009 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	SPECIAL REQUIREMENTS
Single-sided script paper	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) In the context of a pipelined datapath, what is meant by a *branch hazard*? How might branch hazards be resolved? [20%]

(b) In the pipelined MIPS datapath in Fig. 1, three instructions are flushed from the pipeline whenever a `beq` branch is taken. Sketch a modified hardware schematic that reduces this penalty to a single instruction. Discuss how your design might affect the pipeline's clock speed. [40%]

(c) "Assume branch not taken" strategies, as employed in Fig. 1, are particularly ineffective with branches at the ends of loops. Consider the following two alternative strategies, which are different forms of dynamic branch prediction.

- For each branch instruction, start with the "branch not taken" prediction. Reverse the prediction for this branch every time the prediction is wrong.
- As above, but reverse the prediction for the branch every time the prediction is wrong twice in a row.

Consider a loop branch that is taken nine times in a row, then is not taken once, with this pattern repeating every time the loop is executed. What are the asymptotic prediction accuracies of the two schemes? Suggest how each of the schemes might be implemented in hardware. [40%]

(cont.

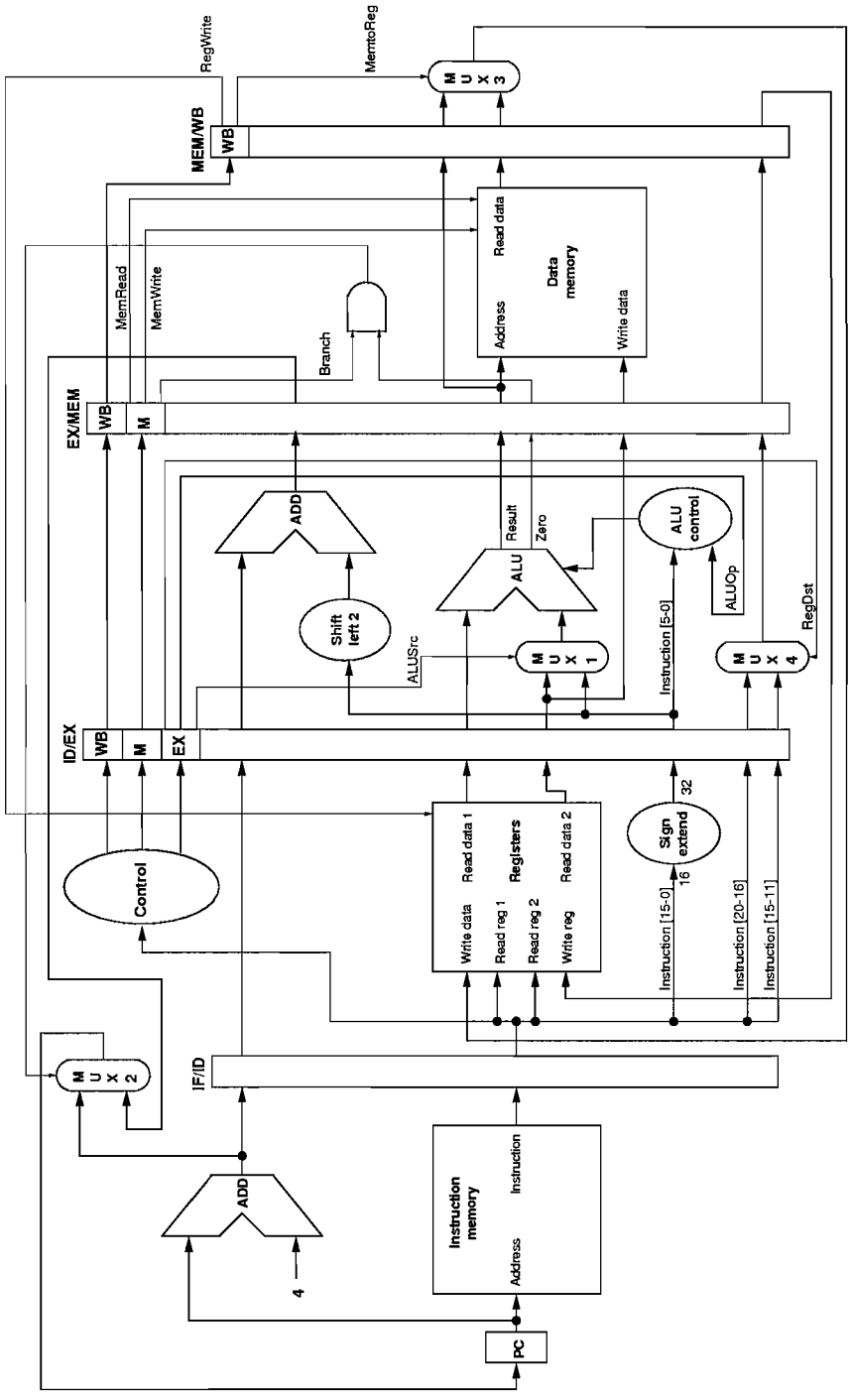

Fig. 1

(TURN OVER

2 (a) Distinguish between the *latency* and *bandwidth* of an I/O system. What factors contribute to the latency of hard disk I/O? [10%]

(b) Estimate the bandwidth of modern examples of the following I/O devices: keyboard, hard disk, ethernet adapter, graphics card. [10%]

(c) A prototype database application makes frequent references to a large file. The developer notices that the execution speed is limited by the disk I/O, while most of the system's physical memory remains unused. How might a file system cache improve this application's performance? What issues do you anticipate when implementing such a cache within the operating system? [30%]

(d) What advantages do PCI-express and Serial ATA enjoy over PCI and Parallel ATA? [30%]

(e) PCI-express and Serial ATA employ a line code in which groups of 8 data bits are coded into 10-bit symbols before transmission over the link. The encoded data stream has the following characteristics.

- In the long run, there are equal numbers of 1s and 0s.
- In any group of 20 bits, the difference between the numbers of 1s and 0s is at most two.
- There are never more than five 1s or 0s in a row.

Explain why each of these characteristics is desirable. [20%]

3 (a) Explain the role of *justification bits* and *bit stuffing* in the plesiochronous digital hierarchy (PDH). Use the example of time division multiplexing of telephone circuits to illustrate your explanation. Why does this process limit the scalability of PDH? [25%]

(b) Describe how the evolution of the synchronous digital hierarchy (SDH) removed the need for bit stuffing. What are the key features of SDH that allowed this to happen? Use the example of a first order synchronous transport module (STM-1) to illustrate these features. [25%]

(c) Explain why the STM-1 frame is described as a two dimensional table. Why does this tabular format result in a data rate of 155 Mbits/second? Assuming no bit stuffing, how many bytes would a multiplex of 32 phone channels occupy in the payload of an STM-1 frame? What is the data rate of an STM-64 multiplex? [20%]

(d) Discuss how an internet protocol (IP) packet might be transported over SDH. Indicate what sort of problems would be encountered in this process. [30%]

4 (a) Give a brief description of how the internet evolved from the early experiments in the UK and the US. What features of the early internet were important in it becoming a globally accepted phenomenon? [33%]

(b) The mapping of the transmission control protocol/internet protocol (TCP/IP) stack onto the open systems interconnect (OSI) reference model is not a simple one. Briefly describe the mapping, assuming that the TCP/IP is being used over twisted pair ethernet. Identify two features of TCP/IP that are not in the correct OSI layer. [33%]

(c) Discuss the suitability of using the internet protocol (IP) for voice services. What role might the transmission control protocol (TCP) take in this process? How has this idea evolved into services such as voice over IP (VoIP)? [34%]

END OF PAPER

Part IIA 2009

Module 3F5: Computer and Network Systems

Numerical Answers

1. (c) First scheme 80%, second scheme 90%.