2003 Paper 2 Question 10

Structured Hardware Design

In a specialist data communication network, digital data is sent between nodes using air pressure in pipes. Each node has a small number of pipes leading to each of its near neighbours. Each pipe may be either at atmospheric pressure or at some slightly higher pressure under control of, and detected by, transducers, fitted at each end of every pipe. The time for a pressure change to propagate down a given pipe depends on the length of the pipe and can vary from 1 to 10 milliseconds. Variations in the manufacturing of the transducers can sometimes add up to a further millisecond to the time taken to change the pressure or detect that it has changed.

For peer-to-peer data transfer, nine pipes run between each connected neighbour. They are used as eight data pipes and one clock pipe, with data on the eight data pipes being latched into a broadside register at the receiving end on each positive pressure change on the clock pipe.

(a) Design a timing diagram for reliable, continuous data transfer between a pair of nodes. [5 marks]

(b) What is the approximate, maximum, continuous data transfer rate achievable between adjacent nodes? (Assume all pipes between any pair of nodes are roughly the same length and allow a reasonable timing margin for safety.) [5 marks]

A data packet structure is now imposed on the system, whereby packets of 8 bytes of data may be sent by a node to a neighbour from time to time. Pipes are used bi-directionally, but only changing direction between packets. All pipes are to be at atmospheric pressure when there is no data to send.

(c) Suggest how the start and end of a packet can be determined. [5 marks]

(d) What will happen if both ends of a link decide to transmit to each other at the same time? Should an extra pipe be used to help solve this problem? [5 marks]