

Department of Electrical Engineering, IIT Delhi

ELL782 Computer Architecture: Minor I Examination

(Closed book/Closed Notes) Time: 1 hour

Maximum Marks: 28

"Thou shalt not covet thy neighbour's answers"

1. **Accumulating Knowledge!** Consider the problem of single-node accumulation on a hypercube. There are p processors, and the following piece of pseudo-code is written for processor k . Please note the following restriction: in each of the two blanks where you have to fill a bitwise logical operation, you are allowed to use at most two of { AND, OR NOT }, and not any other Boolean operator. On your answer sheet, write the contents of the blanks in the pseudo-code, below.
- (7 × 2 marks)

```

mask = ____;
for (phase = ____; phase >= 1; phase--)
{
    phase_max = 2^phase;
    if (0 <= k <= ____) /* insert a function of phase_max */
    {
        sender = k ____ mask; /* insert bitwise logical operation(s) */
        wait(&data, sender);
        accumulate(data);
    }
    else if (____ <= k <= ____) /* insert functions of phase_max */
    {
        receipient = k ____ mask; /* insert bitwise logical operation(s) */
        send(data, receipient);
    }
    mask = mask >> 1;
}

```

2. **Personalised treatment: No getting 'hyper' on this!** Consider the problem of one-to-all-personalised broadcast (single node scatter) on a hypercube. Assume that node 0 has data for each node k , $1 \leq k \leq (p-1)$. Assume store-and-forward routing. Assume that in one time interval, a pair of nodes can only have an information transfer in one direction, and that all operations are blocking in nature (they wait for completion of the operation).

(a) Assume all processors equally powerful, and all links to have the same bandwidth. Show the set of all operations that will take place at every time interval, for a hypercube with 16 nodes. An arrow represents flow of information between a pair of nodes. For instance, use the following notation to send a packet consisting of personalised messages for nodes 3, 6 and 7 from node

Ⓐ to node Ⓒ, in a suitable phase: Ⓐ $\xrightarrow[\text{phase}]{\boxed{3,6,7}}$ Ⓒ. Con-

sider the following restriction: the communication phases start with the LSB, and go on in steps, all the way to the MSB. Assume that initially, node 0000 starts with a packet $[0, 1, 2 \dots 15]$, and that node k does not need to send k to itself. Each node will pick and choose from what it receives/has, and send a suitably modified packet onward to a neighbouring node, in a phase.

(4 marks) \angle

(b) Now, write suitable pseudo-code for a non-ideal case, using the notation in the previous question. At the start of each communication operation, a sender has a packet called **remaining**. From this, it creates a packet data suitably, to send it to a recipient, and updates its copy of **remaining**, in case it has to be a sender, in the next phase, as well. A variable **packet_size** holds the value of the size of the packet, for each transmission. Have suitable initialisations for **remaining**, **mask** and **packet_size**.

(10 marks)