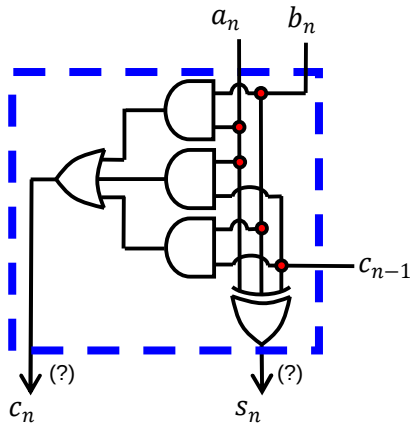
EE6402 Real-Time DSP Design and Applications

Continuous Assessment 2

Please write your **name** and **matriculation number** in your solution, then submit (any format) to NTULearn by **31/3/23**. Penalties apply for late submission. *Please do not copy or let others copy your solutions*. – Anamitra Makur

If your matriculation number is $\mathrm{A}d_6d_5d_4d_3d_2d_1d_0\mathrm{B}$, where A and B denote letters, and d_0 to d_6 denote decimal digits, then use your digits in the following questions.

Q1. A full adder is shown on the right. All 2-input gates have d_0 nanosecond (ns) delay, while all 3-input gates have d_1 ns delay, depending on your matriculation number. [10]



(i) Find the delays (in ns) to compute both full adder outputs, sum s_n and carry c_n.

(ii) Draw a diagram of a 3-bit ripple carry adder using this full adder, and show the delays (in ns) to compute all sum and carry outputs.

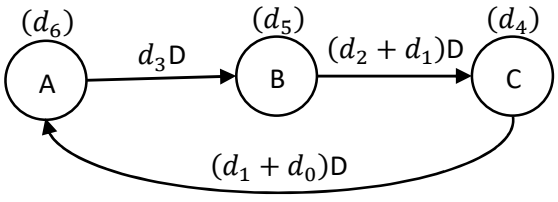
(iii) Find a formula for the maximum delay (in ns) of a *N*-bit ripple carry adder using this full adder. (Maximum = all sum/carry computations should be completed.)

Q2. A recursive filter $y(n) = \frac{d_2+2}{12}x(n) - \frac{d_3+2}{12}y(n-1)$ has to be implemented in pipelining, where the multiplier coefficients depend on your matriculation number. The multipliers have 2 latches but the adders have no latch (non-pipelined adders). [10]

(i) Rewrite the filter output $y(n)$ without using $y(n-1)$ for such a pipelining.

(ii) Draw the pipelined structure. Since the multipliers of $x(n)$ also have two latches, the output of your diagram is not $y(n)$. What is the output?

Q3. The data flow graph of a system is shown on the right. Computation time of each node is shown above each node, and the delays of each edge is shown above each edge. These values depend on your matriculation number. [10]



(i) Find the iteration bound of the graph.

(ii) Perform unfolding on the system with an unfolding factor of 2. Clearly draw the final data flow graph with all nodes and all edges with corresponding delays.

(iii) Find the iteration bound of the final data flow graph after unfolding.