IN3160 Oblig 9

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I am not delivering timing summary reports, since it was stated in discourse that it was not required.

Task 1:

Adding two binary numbers end up with a maximum of 1 overflow bit. Take the worst case as an example where every bit gets shifted one place to the left:

$$\begin{array}{rr} & 1111\ 1111\ 1111\ 1111 \\ + & 1111\ 1111\ 1111\ 1111 \\ \hline = & 1\ 1111\ 1111\ 1111\ 1110 \end{array}$$

Therefore, the answer is **a)** 17 bits.

Task 2

Multiplying the two numbers ends up with a less obvious amount of bits. Lets take the worst case, do a multiplication in base 10, and converting to binary.

$$(1111\ 1111\ 1111\ 1111)_2 = (65\ 535)_{10}$$

$$(65\ 535)_{10} \cdot (65\ 535)_{10} = (4\ 294\ 836\ 225)_{10}$$

$$(4\ 294\ 836\ 225)_{10} = (FFFE0001)_{16} = (1111\ 1111\ 1111\ 1110\ 0000\ 0000\ 0000\ 0001)_2$$

The end result of the worst case multiplication is **b)** 32 bits.

Task 3

Say all four numbers are FFFF. a + b results in 17 bits. c + d results in 17 bits. Using the result from Task 1:

$$\begin{array}{rr} & 1\ 1111\ 1111\ 1111\ 1110 \\ + & 1\ 1111\ 1111\ 1111\ 1110 \\ \hline = & 11\ 1111\ 1111\ 1111\ 1100 \end{array}$$

The addition of these two 17 bit sums will then result in 3FFFC which is **c)** 18 bits.

Task 4

We assume that all the numbers are FFFF, including e. We then end up with multiplying 18 bits with 16 bits. The multiplication goes like this:

$$(3\ FFFC)_{16} \cdot (FFFF)_{16} = (262\ 140)_{10} \cdot (65\ 535)_{10}$$

$$= (17\ 179\ 344\ 900)_{10} = (3\ FFF8\ 0004)_{16}$$

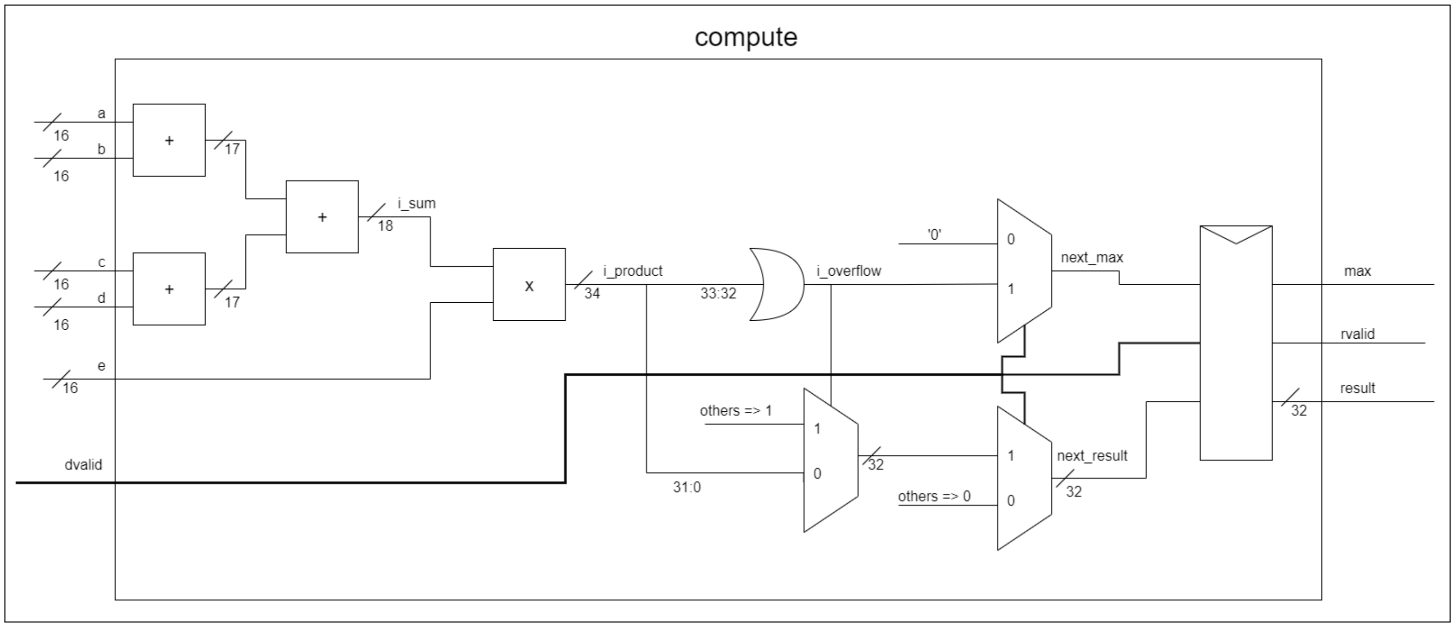
$$= (11\ 1111\ 1111\ 1111\ 1000\ 0000\ 0000\ 0000\ 0100)_2$$

The resulting binary number is **d)** 34 bits.

Task 5

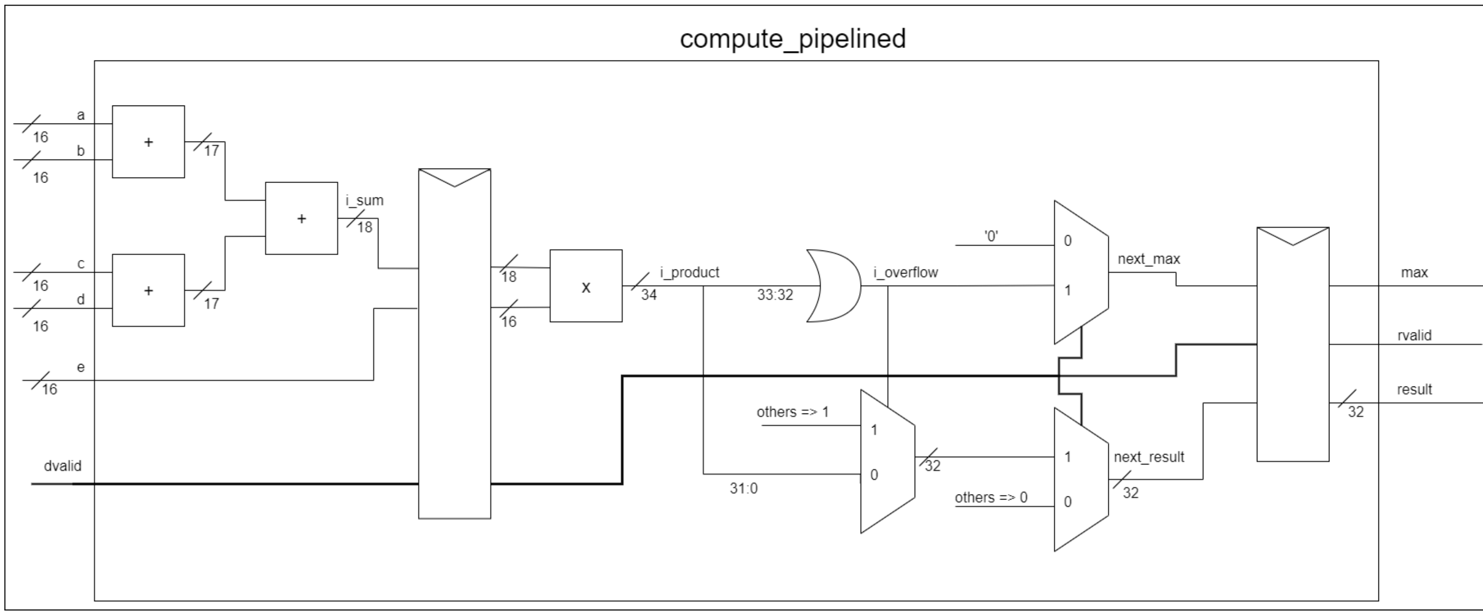
a)

Datapath diagram for the module compute:



b)

Datapath diagram for the module compute_pipelined:



Task 7

Since there is 1 flip-flop per flip-flopped bit, we have 32 flip-flops for result, 1 flip-flop for rvalid, and 1 flip-flop for max, with a total of 34 flip-flops for the module compute. I have not used the synthesized design to get this information.

Task 8

We have 32 flip-flops for result, 1 flip-flop for rvalid, and 1 flip-flop for max, just like with the module compute. In addition, there are the flip-flops used for the pipeline. 18 flip-flops for i_sum, 16 flip-flops for e, and 1 flip-flop for dvalid. With a total of 34 + 18 + 16 + 1 = 69 flip-flops for the module compute_pipelined. I have not used the synthesized design to get this information.