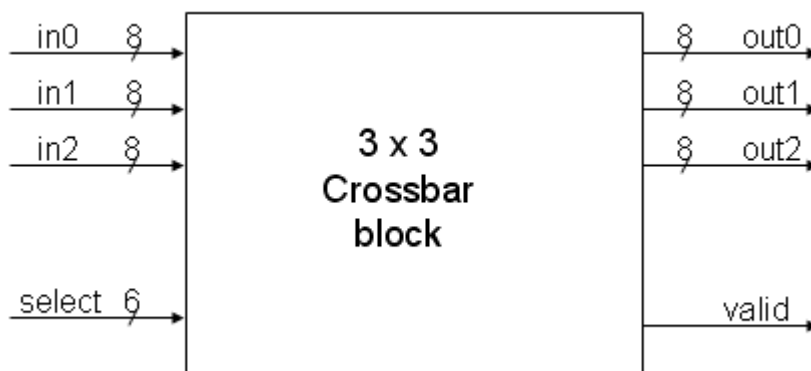
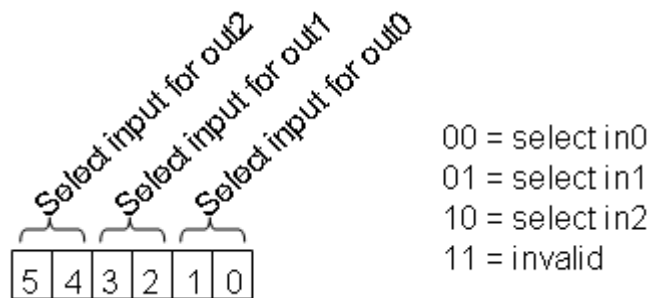


6.1) Implement a 4x4 crossbar

A crossbar is a switch matrix that is very useful in telecommunication applications. An NxN crossbar consists on N inputs and N outputs. The purpose of a crossbar is to re-route the signal from any input port to any output port. This is done via the crossbar configuration signal. In this problem, we will call the configuration signal "select," as shown in the figure below.



A 3x3 crossbar block diagram
This is not the same size as your problem.



The meaning of the select input byte

This is a 3x3 crossbar example. Each input and output port are 8-bit wide. The output port is selected via a 2-bit part of the select signal.

The crossbar configuration is considered valid only if every input port has a map to an output port. A crossbar will continue to function for any select signal, but if the select signal is not properly assigned to have every input map to every output, the valid signal will not be asserted. Here is an example of select, crossbar operation, and valid signal:

select signal	Crossbar function	valid output
10_01_00	out0 is in0 out1 is in1 out2 is in2	1, because every input is mapped to an output
01_10_01	out0 is in1 out1 is in2 out2 is in1	0, because in0 is not mapped to any output
10_00_01	out0 is in1 out1 is in0 out2 is in2	1, because every input is mapped to an output
10_10_10	out0 is in2 out1 is in2 out2 is in2	0, because in0, and in1 are not mapped to any output port
11_10_00	out0 is in0 out1 is in2 out2 is 0	0, because out2 is invalid.

The following is specification for the 3x3 crossbar module:

```

module crossbar (in0, in1, in2, select,
                out0, out1, out2, valid);
    input [7:0] in0, in1, in2;
    input [5:0] select;
    output [7:0] out0, out1, out2;
    output valid;

    // Add code here

endmodule

```

Design a 4x4 crossbar. Modify the specification from the 3x3 crossbar module above. Your inputs are in0, in1, in2, in3, and select (How many bits are required for select?). Your outputs are out0, out1, out2, out3 and valid(a 1-bit signal). Show your crossbar's block diagram and the meaning of the select input. Your score also depends on adequate testing stimuli.

Many crossbars exist on both the telephone line network and the internet today. For example, if 0 = Bangkok, 1 = Chiang Mai, 2 = Khon Kaen, then we can route the data or telephone calls from and to these 3 cities using a

crossbar.

Real life crossbars tend to be much larger than your design, they can be as big as 256x256 or bigger, depending on the applications.

The hardest problem in telecommunication is left out from this problem though, and that is, how to generate the right "select" signal, given the current network traffic load. The select signal has to be chosen carefully to maximize the utilization of available network capacity.

Some hint: multiplexers are your friends.