COMP2611: Computer Organization

Combinational logic circuits in Logisim

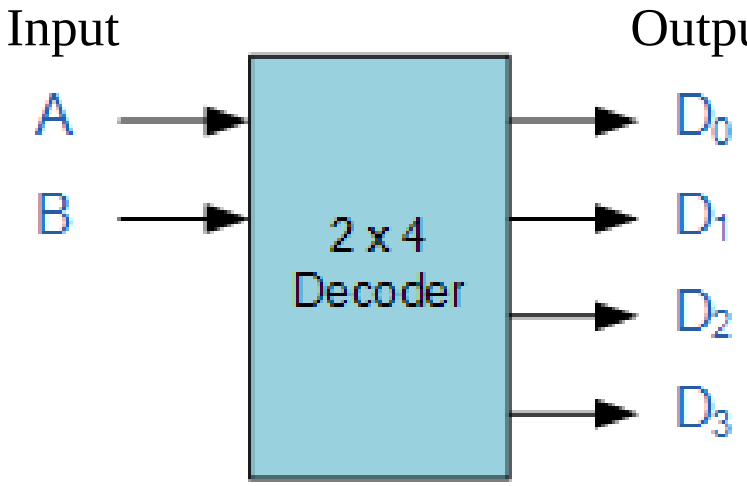
Content

- Today we will learn:
  - How to design and build a 2-to-4 decoder;
  - How to automatically build circuits in Logisim;
  - How to design and build a 4-bit multiplexer;

2-to-4 Decoder

- A **decoder** (**N-to-2^N decoder**) is a logical block with an N-bit input and 2^N 1-bit outputs. The output corresponding to the input bit pattern is true while all other outputs are false.

- Truth table

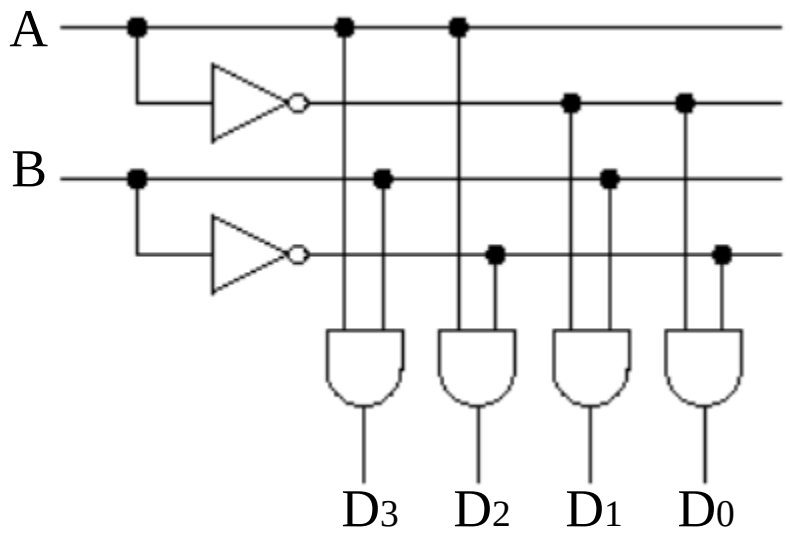


A	B	D_0	D_1	D_2	D_3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

2-to-4 Decoder

- Logic expression and circuit design

$$D_0 = \bar{A} \cdot \bar{B}$$
$$D_1 = \bar{A} \cdot B$$
$$D_2 = A \cdot \bar{B}$$
$$D_3 = A \cdot B$$



- You can try to build a 2-to-4 decoder based on our circuit design in Logisim now.

Question: Is there anyway to make the building of circuits more efficient?

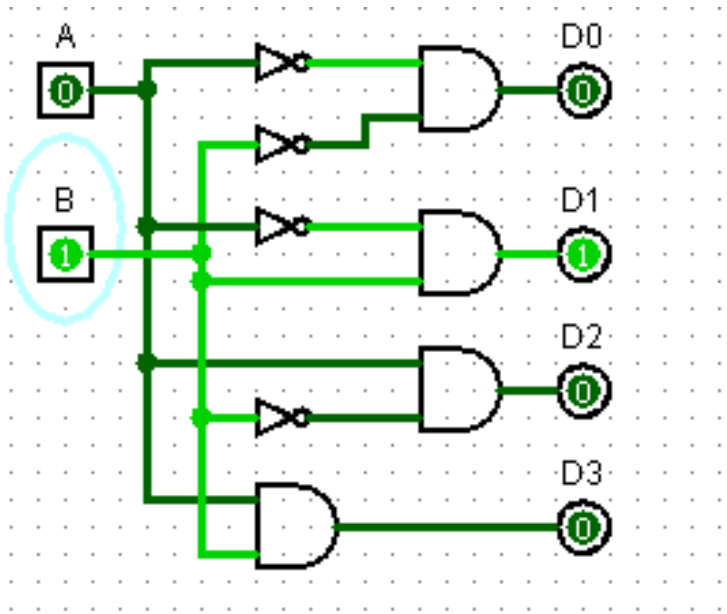
Yes, there is☺

Auto build feature of Logisim 1/2

- Just for your interest, Logisim can auto-build your designed circuit. For example, to build a 2-to-4 decoder, you just need enter the logic expression to Logisim and let Logisim build the circuit automatically.
- To do that, click "Project", "Analyze Circuit";
- Then click the "Inputs" tab, enter "A", "B" separately as inputs;
- Now click the "Outputs" tab, enter "D_0", "D_1", "D_2", "D_3" as outputs;
- click the "Expression" tab and choose the output "D_0", type the expression (replace AND operator with a space) as: ~A ~B
- Then click "Enter" tab at the lower right corner. Do the similar things for output "D_1", "D_2" and "D_3".

Auto build feature of Logisim 2/2

- Finally click "Build Circuit" at the bottom, Logisim will build the circuit. You can poke to check its correctness.



THIS IS JUST FOR YOUR INTEREST ONLY, DON'T USE IT TO CHEAT! THIS TOOL WILL NOT BE AVAILABLE ON THE DATES OF THE QUIZ!

Questions?

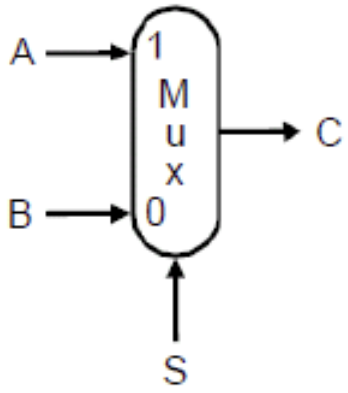
- At this point can you
  - Build a 2-to-4 decoder in Logisim?
  - poke the input values to check the correctness?
  - Use the auto-build features in Logisim?

- If there is any question, it is good to be sorted out at this point, before we go on to discuss more complicated combinational circuits.

4-input Multiplexer

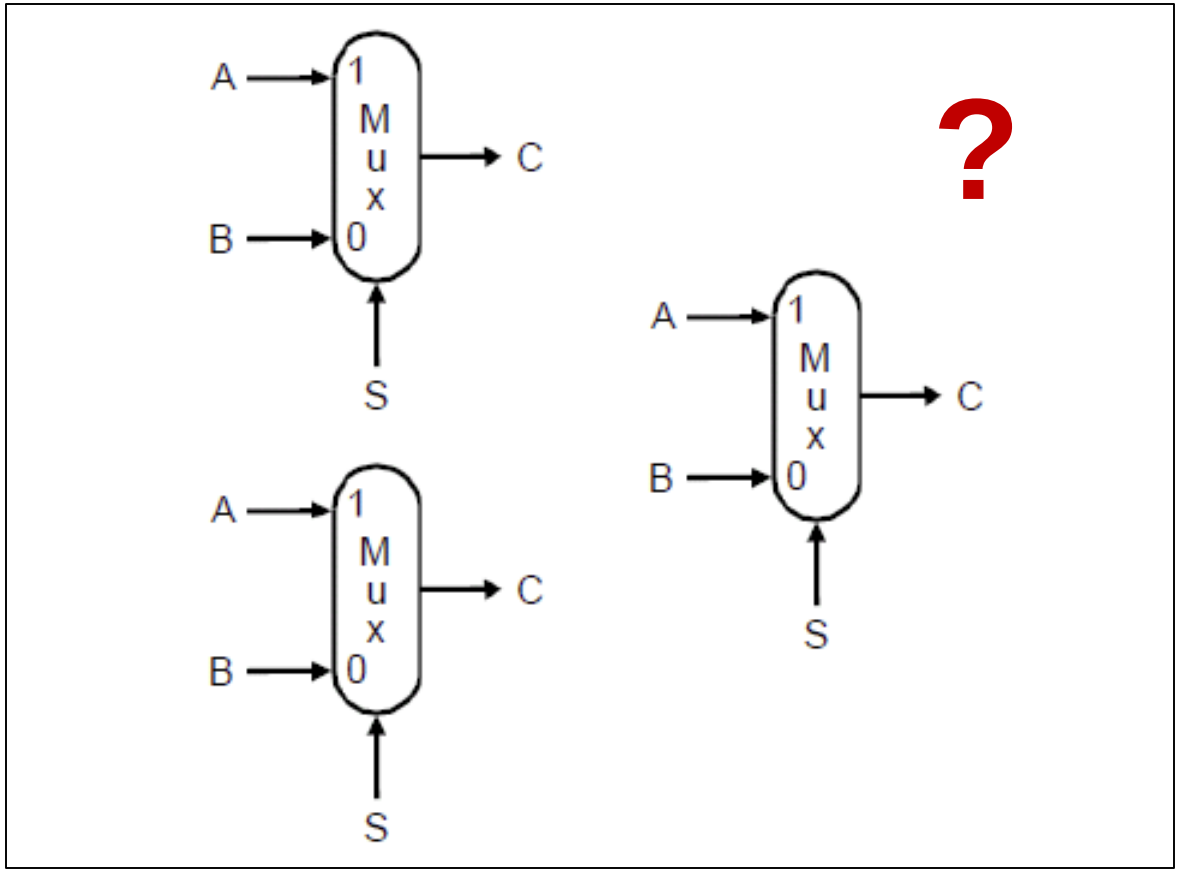
- A **multiplexer** selects one of the data inputs as output by a control input value.
- Remember the 2-input multiplexer we built during lab1, now we will reuse it as a *model* to build a 4-input multiplexer.
- Question: how many 2-input multiplexers do we need?

2-input multiplexer: forward A to output if S=1;
forward B to output if S=0.



4-input Multiplexer

- The answer is 3.
- But how to connect them together? How about the control input?



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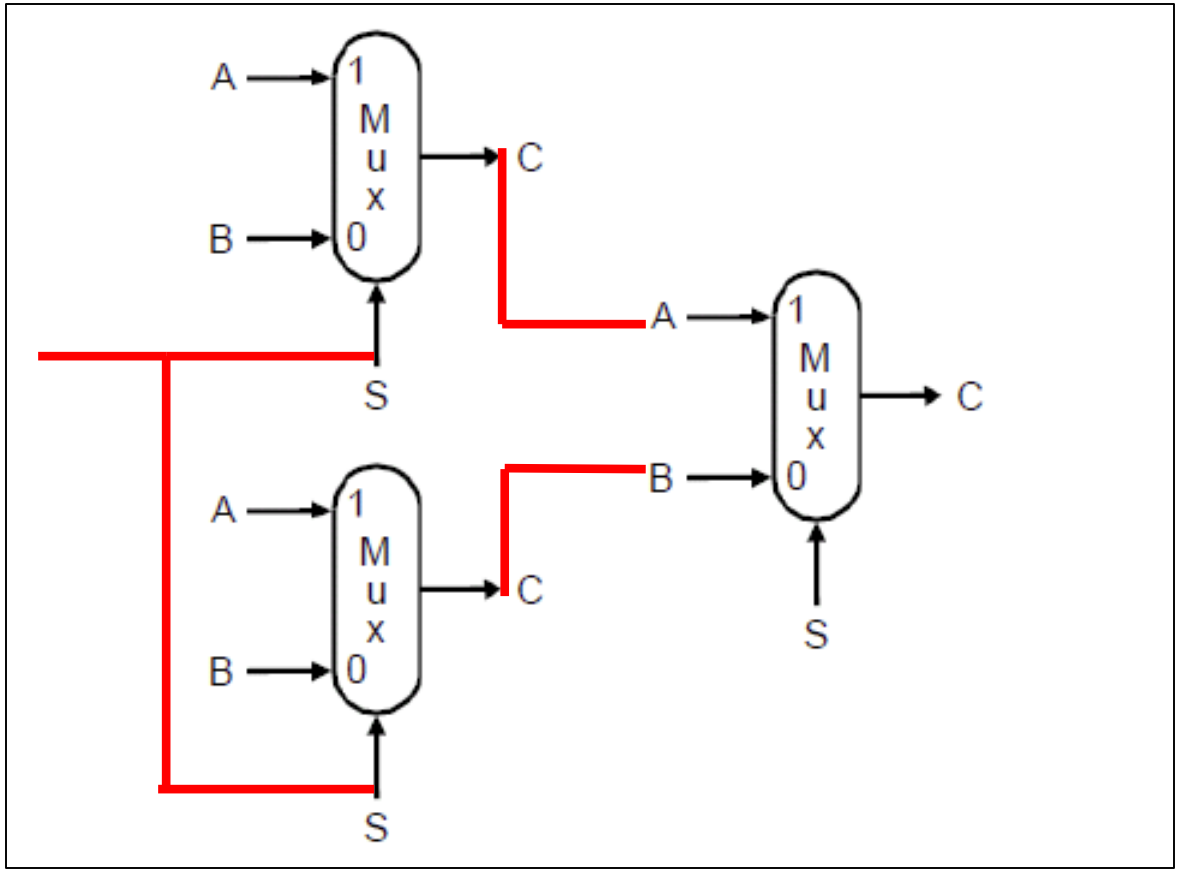
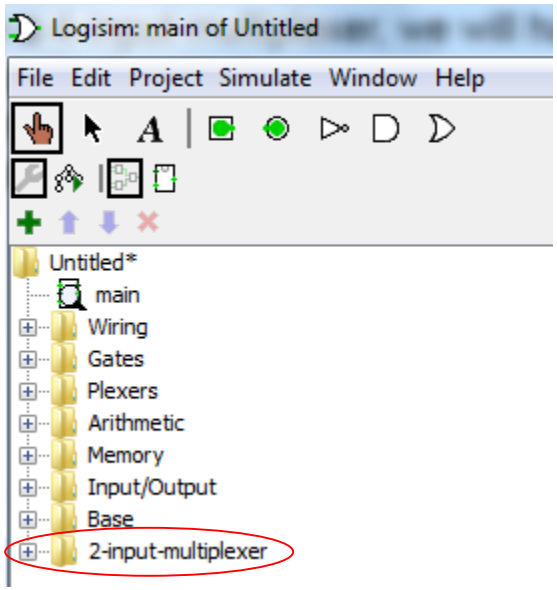


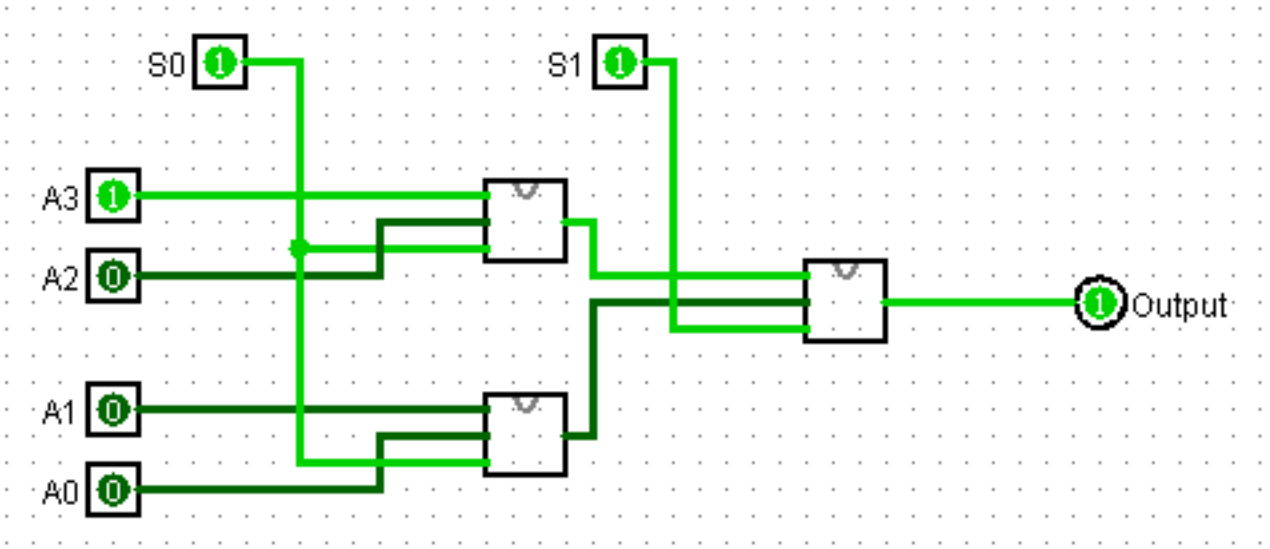
4-input Multiplexer

- In a 4-input multiplexer, we will have 4 data inputs, 2 control inputs, 1 output;
- And we reuse the 2-input multiplexer we built before as a model to make the job easier.
- To enable such reuse, click “Project”, “Load Library”, “Logisim Library” and choose the .circ file (e.g. 2-input-multiplexer.circ) you saved before.
- The circuit will appear as a new folder in the bottom of the explorer pane. You just need to click such older to access the circuit model.



4-input Multiplexer

4-input multiplexer in Logisim by reusing the models we built before.



4-input Multiplexer

A possible design of a 4-input multiplexer if the models are not reused.