Remember to bring this along to your lab!

CS2100 Computer Organisation
Lab #8: Using Logisim I

(Week 11: 28 October – 1 November 2024)

[This document is available on Canvas and course website https://www.comp.nus.edu.sg/~cs2100]

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Lab Group: 7

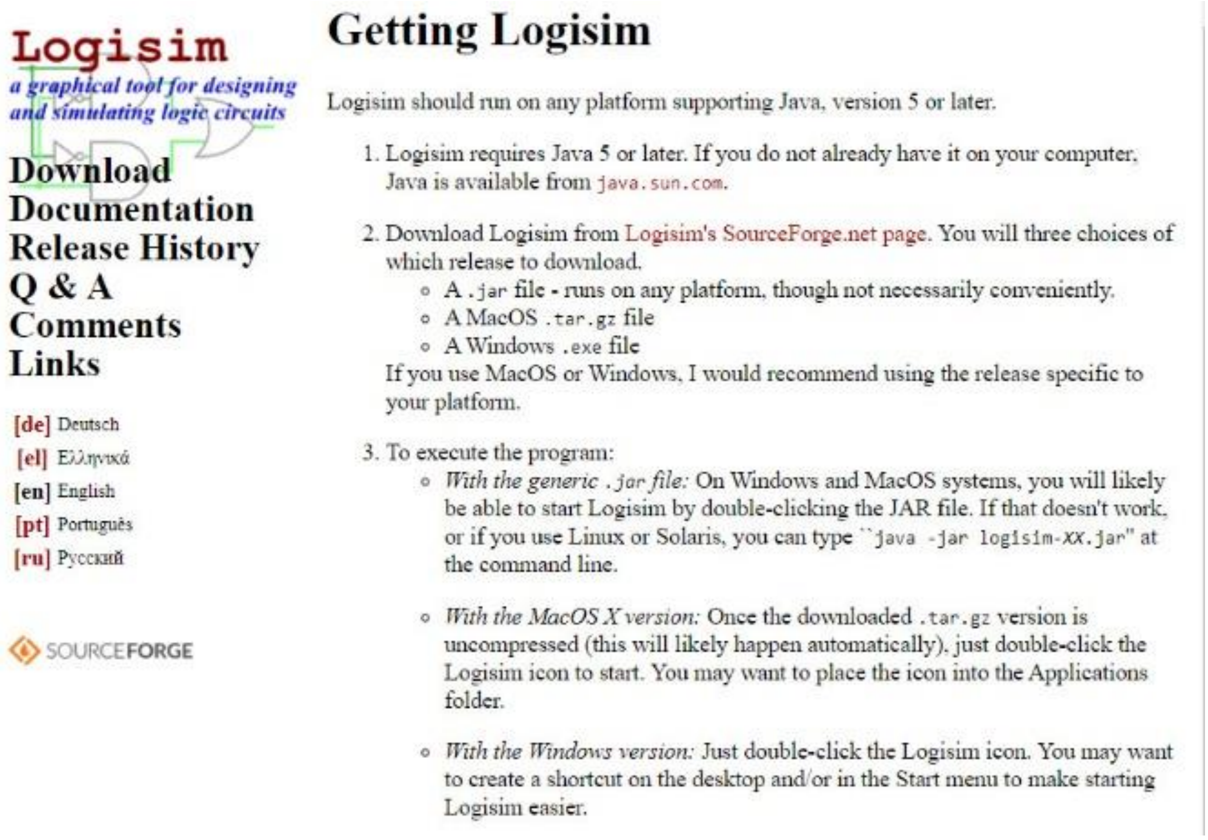
Important: You should complete the report before you come for your lab or you may not have enough time to complete it. For Thursday lab groups, please see point 11.

Objective:

You will learn to use **logisim** to analyse a simple circuit and create a 4-bit parallel adder.

Preparation (before the lab):

1. Download **logisim** from the website: http://www.cburch.com/logisim/download.html (Logisim has been installed in the computers in the labs.)



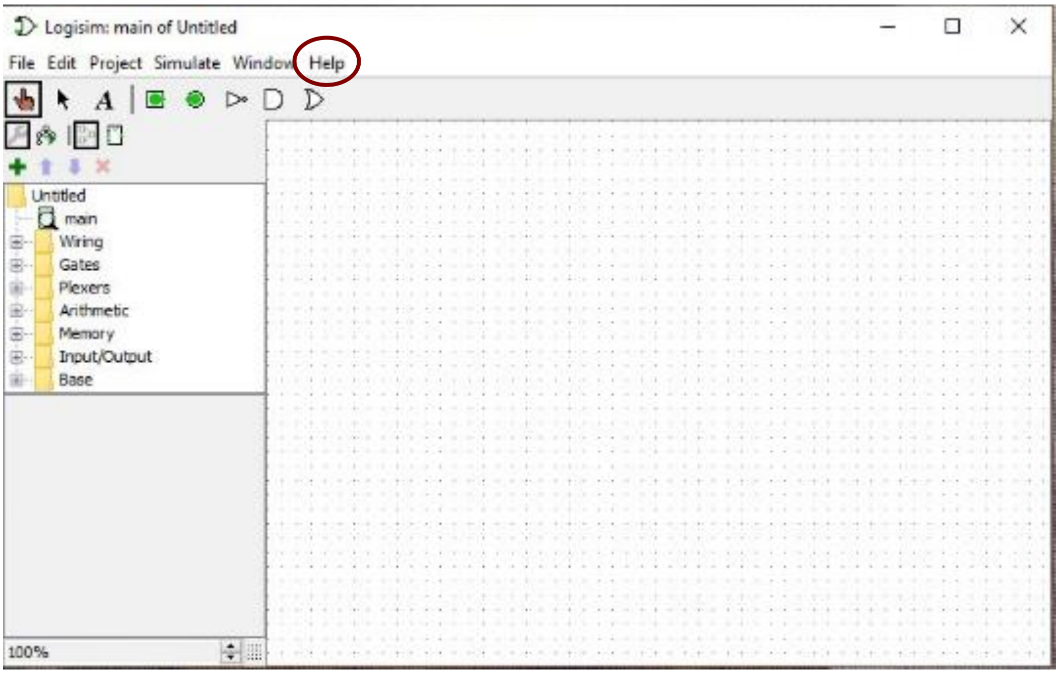
Getting Logisim

Logisim should run on any platform supporting Java, version 5 or later.

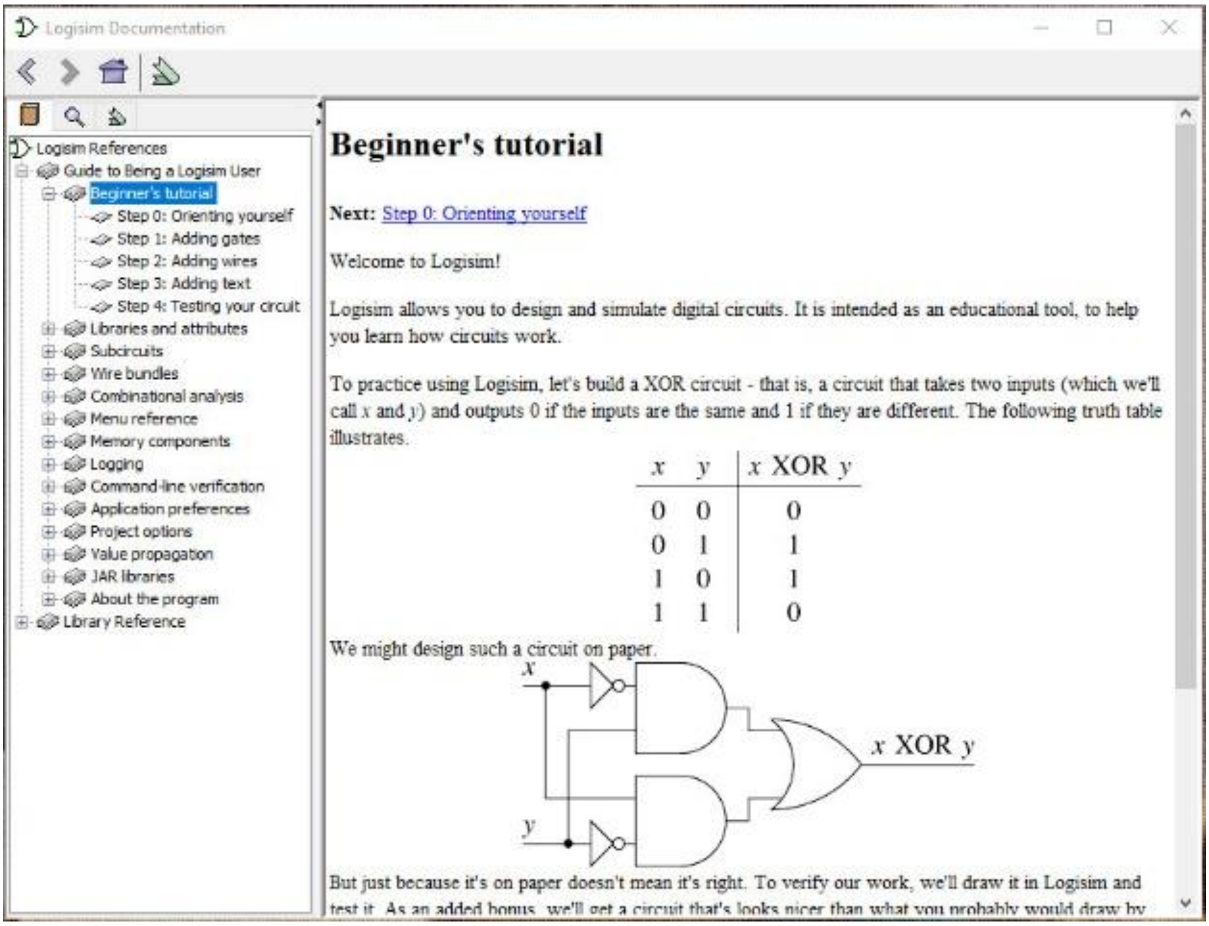
1. Logisim requires Java 5 or later. If you do not already have it on your computer, Java is available from `java.sun.com`.
2. Download Logisim from Logisim's SourceForge.net page. You will three choices of which release to download.
   - A `.jar` file - runs on any platform, though not necessarily conveniently.
   - A MacOS `.tar.gz` file
   - A Windows `.exe` file

   If you use MacOS or Windows, I would recommend using the release specific to your platform.
3. To execute the program:
   - *With the generic `.jar` file:* On Windows and MacOS systems, you will likely be able to start Logisim by double-clicking the JAR file. If that doesn't work, or if you use Linux or Solaris, you can type ``java -jar logisim-XX.jar" at the command line.
   - *With the MacOS X version:* Once the downloaded `.tar.gz` version is uncompressed (this will likely happen automatically), just double-click the Logisim icon to start. You may want to place the icon into the Applications folder.
   - *With the Windows version:* Just double-click the Logisim icon. You may want to create a shortcut on the desktop and/or in the Start menu to make starting Logisim easier.

2. Run **logisim** and you will see this screen:



3. Click on "Help" → "Tutorial" and read "Beginner's tutorial". Familiarise yourself with the basic working of the software. Go through the 5 steps in the tutorial and create some simple circuits yourself.



Beginner's tutorial

Next: Step 0: Orienting yourself

Welcome to Logisim!

Logisim allows you to design and simulate digital circuits. It is intended as an educational tool, to help you learn how circuits work.

To practice using Logisim, let's build a XOR circuit - that is, a circuit that takes two inputs (which we'll call x and y) and outputs 0 if the inputs are the same and 1 if they are different. The following truth table illustrates.

x	y	x XOR y
0	0	0
0	1	1
1	0	1
1	1	0

We might design such a circuit on paper.

But just because it's on paper doesn't mean it's right. To verify our work, we'll draw it in Logisim and test it. As an added bonus, we'll get a circuit that's looks nicer than what you probably would draw by

Procedure:

1. Download the file **lab8.circ** from Canvas or the CS2100 website.

2. Open **lab8.circ** in Logisim. Select the "Poke" tool 👆 and then click on the inputs *X*, *Y* and *Z* to toggle their values, and observe the changes in the outputs.

3. What is the name of the circuit? [1 mark]

   Answer: Full adder

4. The circuit has two outputs *S* and *C*, but they are not labelled. Add the labels correctly. Show your labTA. [2 marks]

   For Thursday lab groups, as you have no physical lab that day, you do not need to do this. 2 marks will be awarded to you if you submit your report. See point 11 below.

5. Click "Project" → "Analyze Circuit". Click on "Table", and fill in the table below with what you have observed. (If you find that the outputs do not appear in the same column-order as in the table below, you can change the order by clicking on "Outputs".) [2 marks]

X	*Y*	*Z*	*C*	*S*
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

6. Still at "Project" → "Analyze Circuit". Click on "Minimized". Below the K-map of an output you should see the simplified SOP expressions for that output. Write down the simplified SOP expressions for the two outputs *S* and *C*. [2 marks]

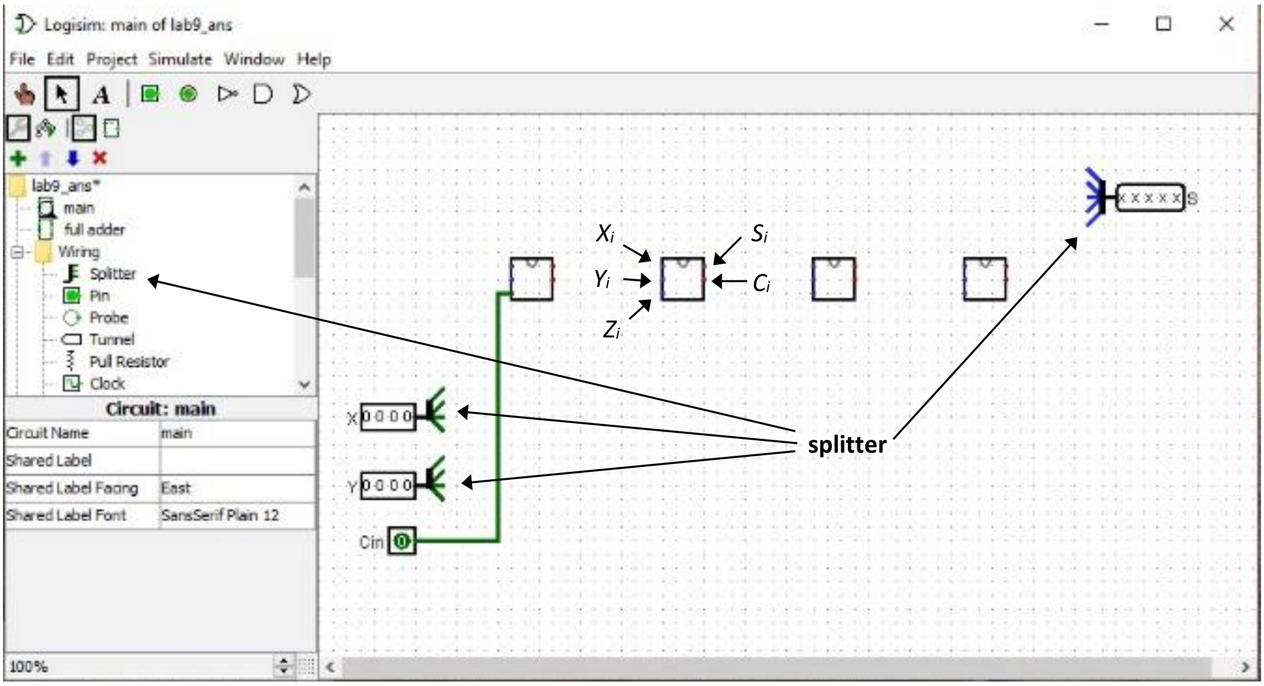
   $S = x' \cdot y' \cdot z + x' \cdot y \cdot z' + x \cdot y' \cdot z' + x \cdot y \cdot z$

   $C = y \cdot z + x \cdot z + x \cdot y$

7. Currently, the circuit you have is in the "main" circuit. Now, click on "Project" → "Add circuit...". A pop-up menu will appear asking for the circuit name. Enter the name with the answer you have for part 3 above. This will create a new entry with that name just below "main". Let's refer to this name as xxxx here for the subsequent parts.

8. Transfer the circuit you have in “main” (using the select button ↖ and click and hold the left mouse button to select the whole circuit, then press **ctrl-x** to cut) and paste it into the newly created “xxxx” circuit (click on “xxxx” – making sure the magnifying glass is over it – and press **ctrl-v** to paste).

9. Go back to the “main” circuit (which should be empty now). Create a **4-bit parallel adder** here by using 4 copies of the xxxx circuit you have created earlier. A partial diagram is shown below.
   - Each xxxx is represented by a block diagram. The labels are indicated in one of the block diagrams below for your reference.
   - The 4-bit inputs *X* and *Y* are created by clicking on the input pin button 🟩 and specifying 4 data bits in the attribute table. Likewise, the 5-bit output *S* is created by clicking on the output pin button ● and specifying 5 data bits in the attribute table.
   - Splitters (refer to the Logisim tutorial, “Wire bundles” → “Splitters” for more details) are used to route the different bits in the inputs and outputs.



Circuit: main	
Circuit Name	main
Shared Label	
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10. <u>Show the completed 4-bit parallel adder circuit to your labTA</u>. [8 marks]

11. For Thursday lab groups (B19 – B27), you are to email your (a) lab report and (b) your logisim file (.circ) to your labTA, by 31 October 2024, Wednesday, 3pm.

Report: 5 marks
Demonstration: Part 4 (2 marks), Part 10 (8 marks)
Total: 15 marks