TC-PRCS2

Assignment 3: Combinatorial Logic Simulator

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Question 1. Research combinatorial Logic:

A: Give the definition of combinatorial logic

Combinatorial logic refers to a digital logic function made of logic gates (AND, OR, NOT, etc.) in which all outputs of the function are directly related to the current combination of values on its inputs. Any changes to the signals being applied to the inputs will immediately have an affect on the outputs.

B: Give two examples of what can be computed with combinatorial logic.

Some examples of common combinational logic circuits include: Adders (half and full) and multiplexers. If you look further you'll find that encoders and decoders are also good examples of combinational circuits.

Question 2. Project Design:

A: Create class diagram for your version of the interface and basic logic components.

See UML Class diagram V1.

B: Draw a sequence diagram for producing a truth table for an XOR-gate.

See Sequence diagram XOR Gate.

C: Create an application that simulates the required gates.

See Code.

D: Add a custom exception "InvalidPinException": thrown when any of the logic gates receive input on a non-existing pins.

See custom exception class: "InvalidPinException"**.**

E: Update your class diagram and include the exception.

See UML Class diagram V2.

Question 3. Research half-adder:

A: Give the definition of a half-adder.

A half adder is a type of adder, an electronic circuit that performs the addition of numbers. The half adder is able to add two single binary digits and provide the output plus a carry value. It has two inputs, called A and B, and two outputs S (sum) and C (carry). The common representation uses a XOR logic gate and an AND logic gate. See figure 1.

A half adder is used to add two single-digit binary numbers and results into a two-digit output. It is named as such because putting two half adders together with the use of an OR gate results in a full adder. In other words, it only does half the work of a full adder.

B: Write down in your own words what a half-adder is, what it is used for and what its limits are.

From what I understand, A half adder is an electronic circuit comprised of an XOR-gate and an AND-gate. The two inputs you receive will be translated to two different outputs. The carry and the Sum. The reason its called a half adder is because it doesn't have the full capabilities of a full adder. It can also be made using only NOT-gates, AND-gate and an OR-gate. The circuit is used to perform the addition of numbers.

C: Draw the circuit diagram of a half-adder.

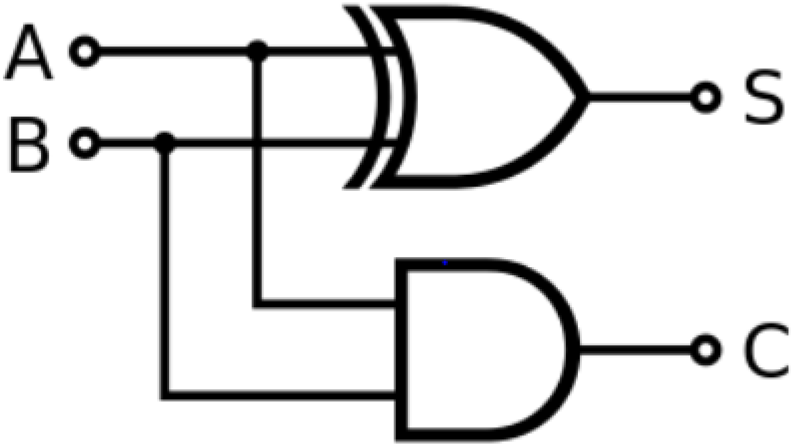
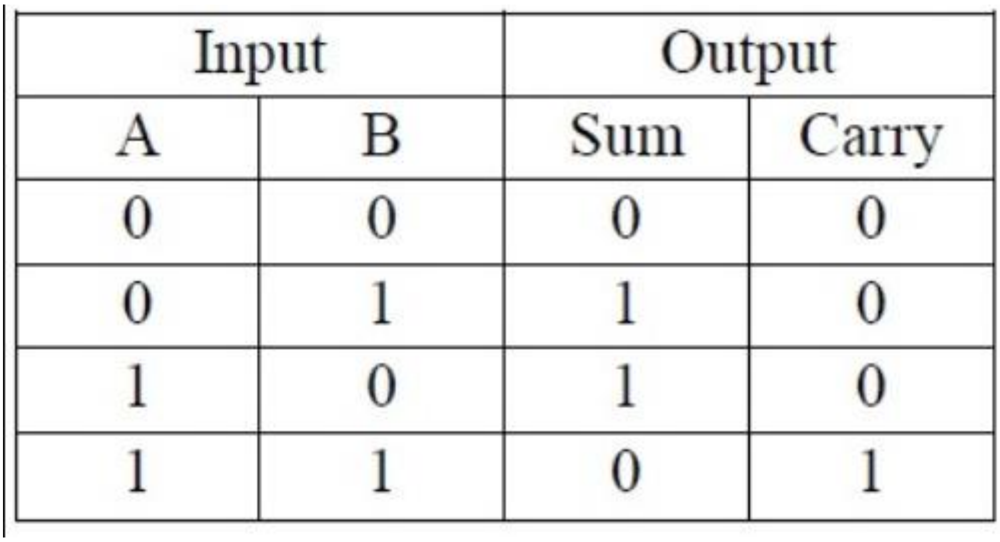


Figure 1: Half adder circuit

D: Describe its inputs and outputs.

The inputs of a half adder are like any other inputs within a computer. They are binary values. Meaning they can only be 0 or 1. The outputs are dependant on which gate they pass through. In other words, the output will be of an AND gate if they pass through the AND gate. The same goes for the XOR gate. The results will be that of a XOR gate. If you have two 1’s as your input than the output for the AND gate will be 1 while the output of the XOR gate will be 0. See table 1.

E: Draw a truth table for a half-adder.



Input		Output	
A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Table1: Half adder truth table.

Question 4. Research Composition:

A: Give the definition of composition in the context of object-oriented programming.

It is one of the many fundamental concepts in object-oriented programming. It describes a class that makes a references to one or many objects from other classes in instance variables. This allows you to model a sort of “Has a” relationship between objects.

B: Write down what the advantages and disadvantages of composition are.

Some advantages include the fact that we can reuse code from these classes. It is used to design clean APIs

Some disadvantages include the fact that in order to program composition you require more code and time than if you weren't to use it. The behaviour of the system may be more difficult to understand just by looking at the source code. Since it isn't static, the interaction between the objects happens more in run-time rather than in compile time.

C: Program the half adder using composition.

See code.

D: Add a custom exception "ConnectionAlreadyCreated": thrown when a connection from an output to an input already exists.

See custom exception class: "ConnectionAlreadyCreated".

E: Update your class diagram and include the exception.

See Class diagram V3.

F: Add the half adder to your program and include a demonstration of it.

See code.

References

[1] PCMag. (n.d.). *Definition of combinational logic*. PCMAG. https://www.pcmag.com/encyclopedia/term/combinational-logic

[2] Storr, W. (2022). Combinational Logic Circuits. *Basic Electronics Tutorials*. https://www.electronics-tutorials.ws/combination/comb_1.html#:~:text=Examples%20of%20common%20combinational%20logic,in%20the%20next%20few%20tutorials.

[3] Techopedia. (2020, November 13). *What is a Half Adder? - Definition from Techopedia*. https://www.techopedia.com/definition/7509/half-adder#:~:text=A%20half%20adder%20is%20a,)%20and%20C%20(carry).

[4] Janssen, T. (2023). OOP Concepts for Beginners: What is Composition? *Stackify*. https://stackify.com/oop-concepts-composition/#:~:text=Composition%20is%20one%20of%20the,regularly%20in%20the%20real%20world.