

Boolean Algebra

CS 2130: Computer Systems and Organization 1

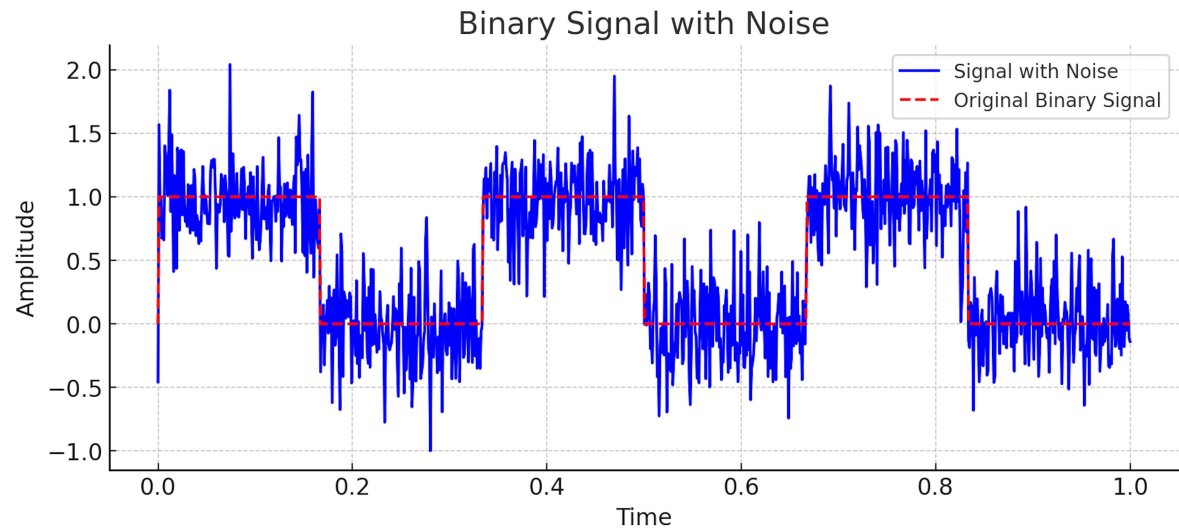
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Announcement

1. If you need to switch labs:
 - Form will be coming soon
 - Must be justified (i.e. class conflicts)
 - Very limited space to make swaps
2. Quiz 1 opens tonight, due Sunday 11:59pm
3. For the Exams: The question types will be similar to those used in **Spring 2023**

Why only 0 and 1?

Claude Shannon

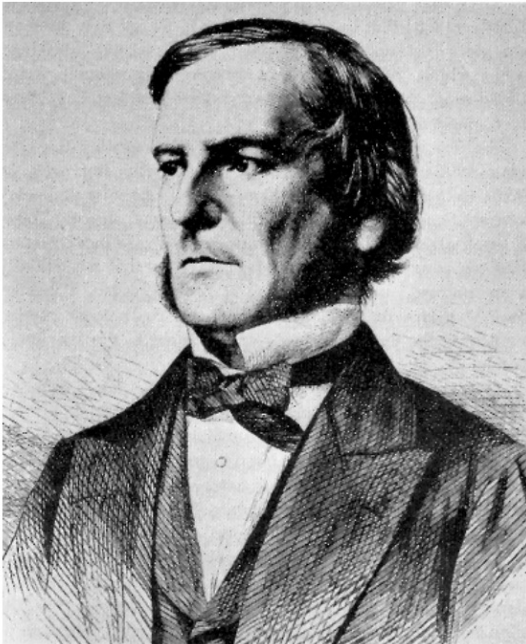


Vocabulary

- bit – either a 0 or 1
- binary - a system that has only two positions
- trinary - a system that has only three positions
- quaternary - a system that has only four positions
- ...
- decinary - ...
- decimal - system that has ten positions

Boolean Algebra

George Boole



In Boolean Algebra, we live in a world with only two values:

- **True or False**
- **Yes or No**
- **1 or 0**

Boole showed that you could build an entire algebraic system using only these two values.

And that system uses three basic operations: **AND, OR, and NOT.**"

Putting Them Together

Overall idea:

- Only need two things (Shannon)
- We can do math with two things (Boole)

Now we need a physical device that deals in two levels

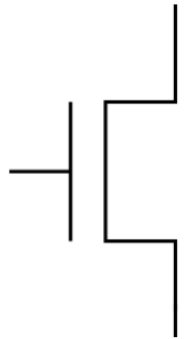
Transistors

Electricity (conceptually) - involves flow of electrons or other charged carriers through a conductive material

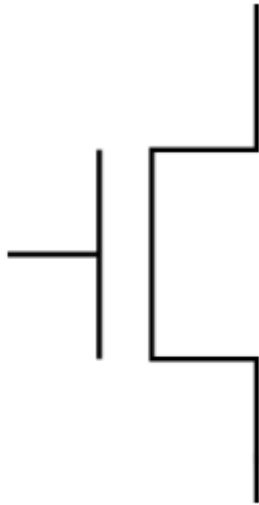
- current - rate of flow
- voltage - pressure of flow

Transistors act like an electrically-triggered switch

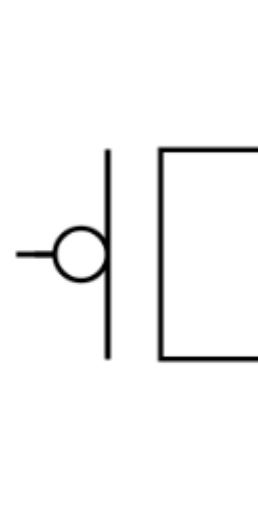
- No voltage, no current
- Apply voltage to allow current to flow
- The amount of voltage needed to open the gate is boundary between 0 and 1
- Central technique for how we are going to build binary computers



Transistors

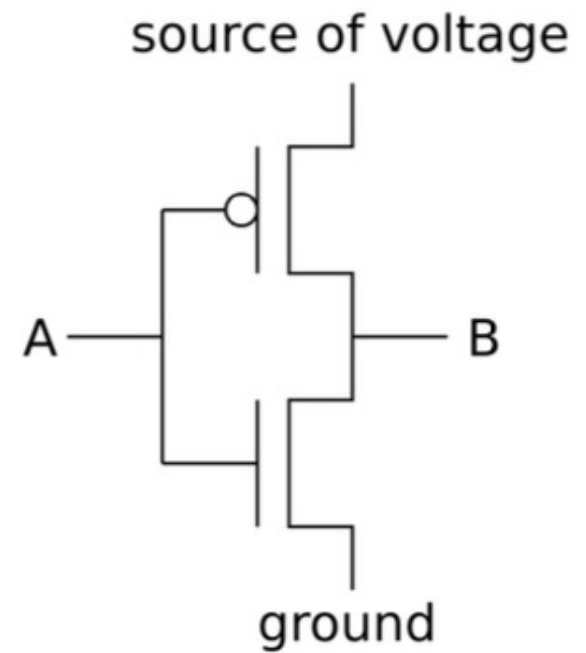


Push to close

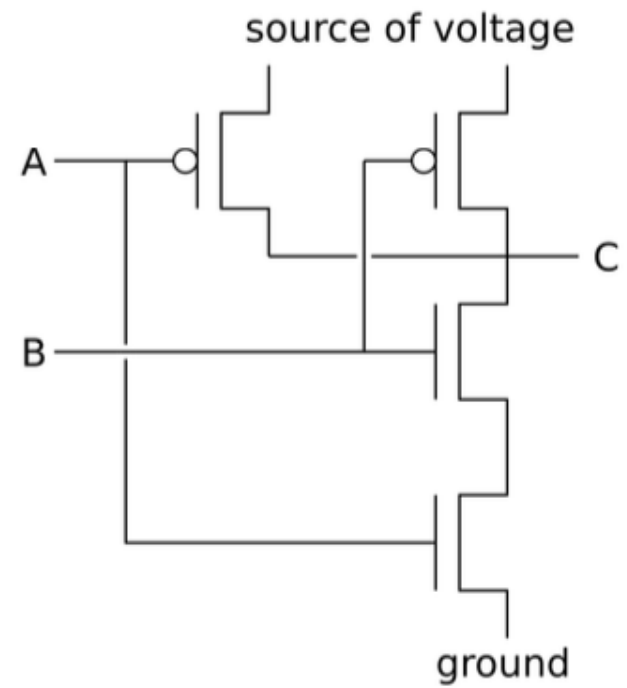


Push to open

Circuit Diagram



Circuit Diagram



Other Gates

Reading: <https://uva-cs.github.io/cso1-f25/readings/bool.html>

Building Up

Where we are now

- World with only 2 states: 0 and 1
- Re-developed Boolean logic: and, or, not

Gives us everything Boole talked about

- We can do a lot of interesting things!
- Next: build higher level ideas: the trinary operator

Trinary Operator

General idea

```
if ( ... ) {  
    ...  
} else {  
    ...  
}
```

Trinary operator (expression if)

Python:

`x=b if a else c`

Java:

`x=a?b:c`

Multiplexer (mux)

How can we build a mux out of what we have learned so far?

$x = a ? b : c$

Can be built from and, or, and not

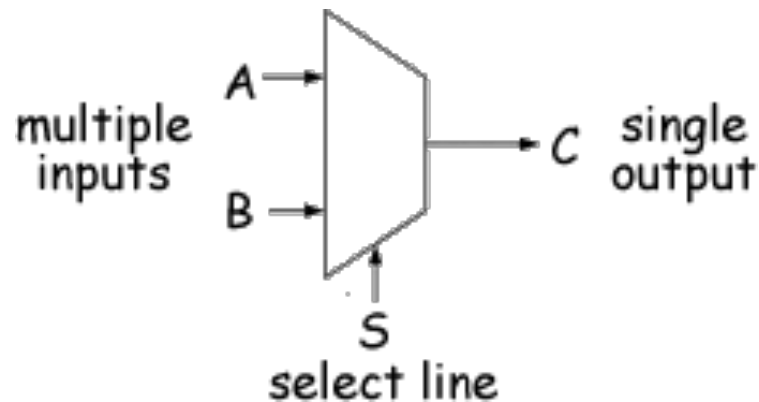
- Can be built using transistors
- Can physically put it in silicon!

Mux will be the key when constructing a computer out of gates and circuits!

Multiplexer (mux)

$x = a ? b : c$

A multiplexer (mux) is commonly drawn as a trapezoid in circuit diagrams.



2-bit Multiplexer (mux)

2-bit values instead of 1-bit values

Any Questions?