

Binary Arithmetic

CS 2130: Computer Systems and Organization 1

August 29, 2022

Course Content

Where do I go to find course material?

- Collab: central hub for 2130 this semester
 - Course website for all content
 - Lecture recordings on Panopto
 - Q&A discussion on Piazza
 - Submit assignments through Gradescope
- Community and online TA office hours on Discord

Expectations and Evaluations

Covid-19 Policies

- Masks are always welcome in class (I will be wearing one)
- No eating or drinking in the classroom
- Attendance is **not** required, but engagement is
 - Watch lecture videos
- If you don't feel well, stay home, it will be okay
 - Will work with you—if you stay home—to ensure no effect to grade

This is a Large Class

How can you get your questions answered?

- Piazza (!!)
 - If you know an answer to someone else's question, answer it!
 - We're in it together for the semester
- Discord
- TAs (office hours and labs)
- My office hours

Speaking of Office Hours!

TA Office Hours

- In-person office hours in the evening
- Online office hours throughout the day
- More information on Wednesday!

Office Hour poll

Professor Hott

Who am I? Why teach 2130?



Professor Hott

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The collage features several key elements:

- University of Virginia Crest:** A green shield with a white crown and a white monogram.
- Hillside Town:** A photograph of a town built on a hillside with white buildings and red roofs.
- University of Virginia Logo:** A blue shield with an orange building icon and the text "UNIVERSITY of VIRGINIA".
- Network Diagrams:** Three diagrams illustrating social networks: a circular one with colored segments, a large orange radial one, and a smaller blue one.
- snac Website Screenshot:** A screenshot of the "Social Networks and Archival Context" website. It shows a search bar, a "All Types" dropdown, and a grid of historical figures with their names and dates:
 - Goddard, Arabella, 1836-1922
 - Thomas, Cyrus, 1825-1919
 - Wilson, William Bauchop, 1862-1934
 - Lindquist, Roy E. (Roy Ernest), 1907-1986

Questions?

So far...

So far, we have discussed:

- `and`, `or`, `not`, 0 and 1

So far...

So far, we have discussed:

- and, or, not, 0 and 1
- nand, nor, xor

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So far, we have discussed:

- **and, or, not**, 0 and 1
- **nand, nor, xor**
- Transistors and how to make these gates (high level)

So far...

So far, we have discussed:

- **and**, **or**, **not**, 0 and 1
- **nand**, **nor**, **xor**
- Transistors and how to make these gates (high level)

Now let's build something powerful

Trinary Operator

General idea

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

- Python: `x = b if a else c`

Trinary Operator

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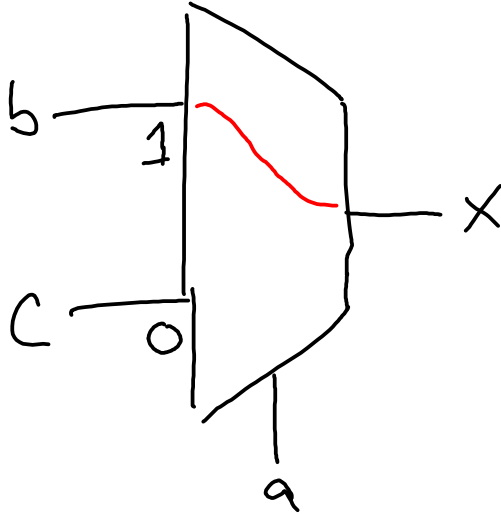
a	b	c	x
0			c
1			b

Trinary operator

- Python: `x = b if a else c`
- Java: `x = a ? b : c`

Multiplexer (mux)

$$x = a ? b : c$$



Multiplexer (mux)

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

$$x = a ? b : c$$

a	b	c	x
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

$$\begin{aligned} & (!a \& !b \& c) | \\ & (!a \& b \& c) | \\ & (a \& b \& !c) | \\ & (a \& b \& c) \end{aligned}$$

Multiplexer (mux)

Can be built from **and**, **or**, and **not**

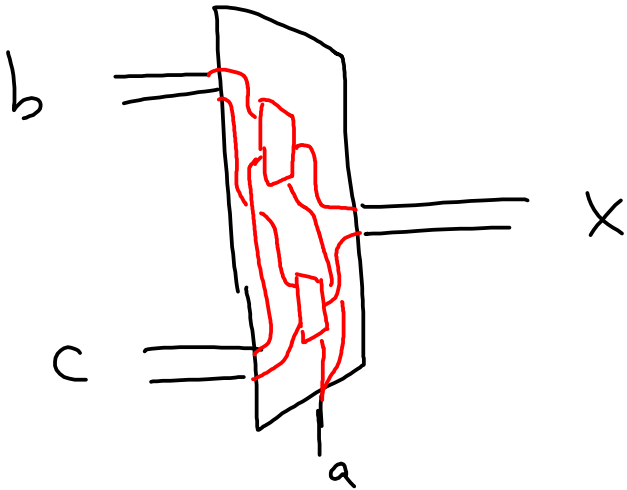
- Can be built using transistors
- Can physically put it in silicon!

Questions?

More bits!

2-bit Multiplexer (mux)

2-bit values instead of 1-bit values

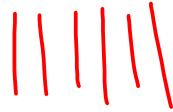


Multi-bit Values

- So far, only talking about 2 things
- Numbers, strings, objects, ...

Numbers

From our oldest cultures, how do we mark numbers?



Numbers

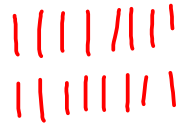
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Numbers

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- **unary** representation: make marks, one per "thing"
 - Awkward for large numbers, ex: CS 2130?
 - Hard to tell how many marks there are
- Update: group them!
- Romans used new symbols: V L C D M

Numbers

From our oldest cultures, how do we mark numbers?

- Arabic numerals
 - Positional numbering system

$$\begin{array}{ccccccc} & & 10^3 & 10^2 & 10^1 & & 10^0 \\ & & 1000^3 & 100^2 & 10^1 & 1 & \\ 7 & \text{---} & 2 & 1 & 3 & 0 & \\ 7 \cdot 10^0 & & 2 \cdot 1000 & + & 1 \cdot 100 & + & 3 \cdot 10 & + & 0 \cdot 1 \end{array}$$

0
1
2
3
4
5
6
7
8
9

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- Arabic numerals
 - Positional numbering system
 - The **10** is significant:
 - 10 symbols, using 10 as base of exponent
 - The **10** is *arbitrary*
 - We can use other bases! π , 2130, 2, ...

Base-8 Example

Try to turn 134_8 into base-10: