Mux, Binary Arithmetic

CS 2130: Computer Systems and Organization 1

Xinyao Yi Ph.D.
Assistant Professor

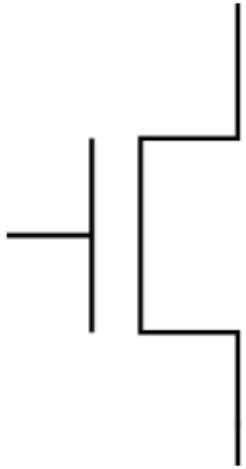
UNIVERSITY of VIRGINIA | ENGINEERING

Announcement

- **Lab grading clarification:** If you do not attend labs, the maximum score you can receive is **50%**, not 90%.
- **Slides updates:**
  - The annotated slides have been published on the course webpage.
  - Please note that in the future, I may occasionally make small updates on the slides after class—for example, adding more detailed explanations if many students found certain concepts difficult. I will let you know about any such changes at the beginning of the next class.

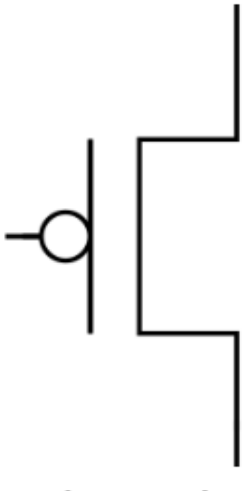
From Last Class…

Transistors



n-type transistor: Push to close

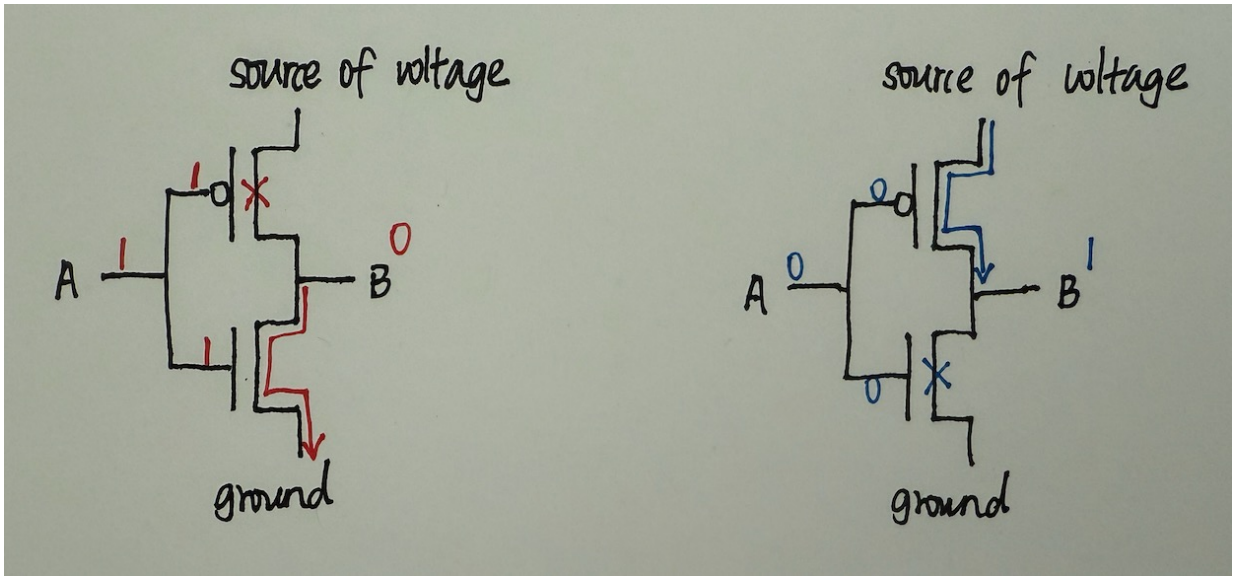
- If we apply voltage, it switches **on**—current flows.
- If there's no voltage, it stays **off**.

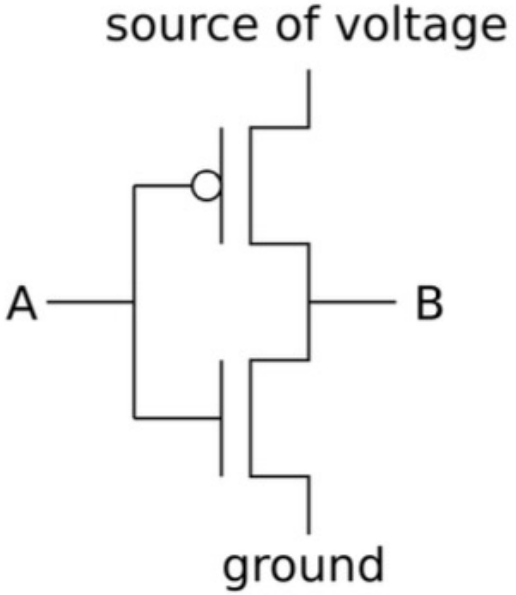


p-type transistor: Push to open

- If we apply voltage, it actually switches **off**—it blocks the current.
- If there's no voltage, it stays **on**.

Circuit Diagram

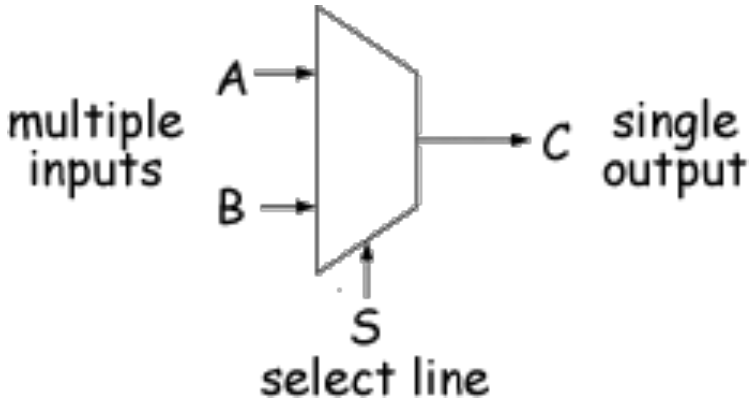




Multiplexer (mux)

x=a ? b : c

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



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2-bit Multiplexer (mux)

2-bit values instead of 1-bit values

Multi-bit Values

So far, only talking about 2 things: 0 and 1

Next:

Numbers, strings, objects, ...

Numbers

From our oldest cultures, how do we mark numbers?

- 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:

Numbers

Arabic numerals

- Positional numbering system

Numbers

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- The 10 is significant:
  - 10 symbols, using 10 as base of exponent

Numbers

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:

Bases

We will discuss a few in this class

- Base-10 (decimal) - talking to humans
- Base-8 (octal) - shows up occasionally
- Base-2 (binary) - most important! (we've been discussing 2 things!)
- Base-16 (hexadecimal) - nice grouping of bits

Binary

2 digits: 0, 1

Try to turn 1100101_2 into base-10

Binary

Any downsides to binary?

Turn 2130_{10} into base-2:

hint: find largest power of 2 and subtract

Long Numbers

How do we deal with numbers too long to read?

Long Numbers

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- Group them by 3 (right to left)

Long Numbers

How do we deal with numbers too long to read?

- Group them by 3 (right to left)
- In decimal, use commas: ,
- Numbers between commas: 000 – 999
- Effectively base-1000

Long Numbers in Binary - Readability

- Typical to group by 3 or 4 bits
- No need for commas *Why?*

100001010010

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- How many do we need for groups of 3?

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- We can use a separate symbol per group
- How many do we need for groups of 3?
- Turn each group into decimal representation
- Converts binary to **octal**

100001010010

Long Numbers in Binary - Readability

- Groups of 4 more common
- How many symbols do we need for groups of 4?

100001010010

Long Numbers in Binary - Readability

- Groups of 4 more common
- How many symbols do we need for groups of 4?
- Converts binary to **hexadecimal**
- Base-16 is very common in computing

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Hexadecimal

Need more than 10 digits. What next?

1110

Hexadecimal Exercise

Consider the following hexadecimal number:

852dab1e

Is it even or odd?

Using Different Bases in Code

	Old Languages	New Languages
binary		
octal		
decimal		
hexadecimal		

Any Questions?