

# Circuits and Code

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## CS 2130: Computer Systems and Organization 1

**Xinyao Yi** Ph.D.  
Assistant Professor

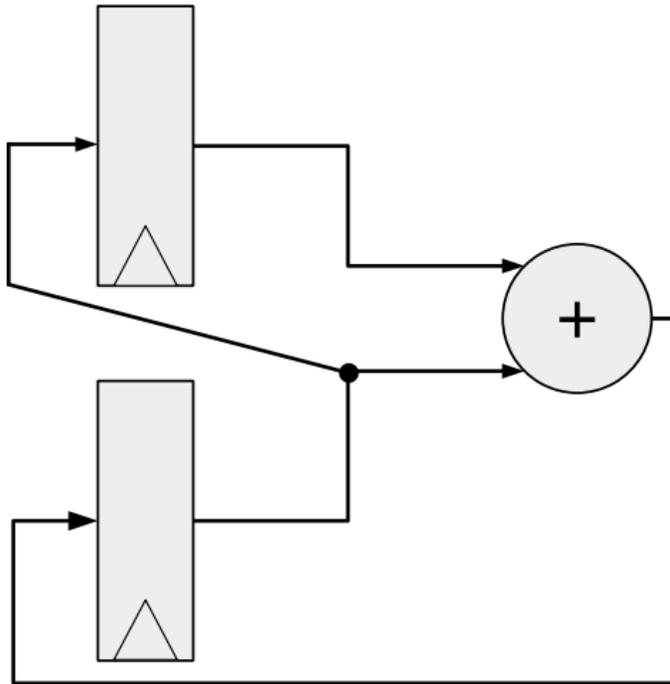
## Announcements

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- Homework 1 due tonight
- Homework 2 available today, due next Monday

## Another Counter

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# Common Model in Computers

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## Code to Build Circuits from Gates

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Write code to build circuits from gates

- Gates we already know:  $\&$ ,  $|$ ,  $\wedge$ ,  $\sim$
- Operations we can build from gates:  $+$ ,  $-$
- Others we can build:

## Code to Build Circuits from Gates

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- Operations we can build from gates:  $+$ ,  $-$
- Others we can build:
- Ternary operator:  $? :$

## Equals

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Equals: =

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Equals: =

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- Ex:  $z = x * y$
- What about the following?  
 $x = 1$   
 $x = 0$
- **Single assignment:** each variable can only be assigned a value once

## Subtraction

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$$z = x + \sim y + 1$$

$$a = \sim y$$

$$b = a + 1$$

$$z = x + b$$

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- `!=` - same as `==` without not of output
- `<` - consider  $x < 0$
- `>`, `<=`, `=>` are similar

## Indexing

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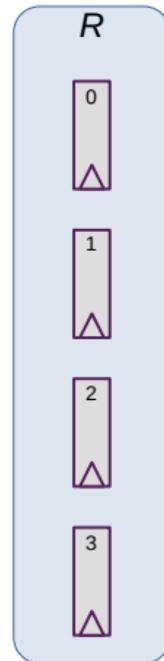
Indexing with square brackets: [ ]

- **Register bank (or register file)** - an array of registers
  - Can programmatically pick one based on index
  - I.e., can determine which register while running
- Two important operations:
  - $x = R[i]$  - Read from a register
  - $R[j] = y$  - Write to a register

## Reading

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$x = R[i]$  - connect output of registers to  $x$  based on index  $i$



## Aside: 4-input Mux

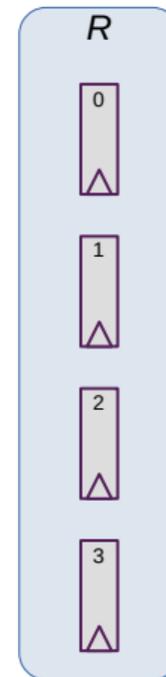
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How do we build a 4-input mux? How many wires should  $i$  be?

## Writing

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$R[j] = y$  - connect  $y$  to input of registers based on index  $j$



## Aside: Creating $== 0$ gates

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How do we build gates that check for  $j == w$ ?

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Need one more thing to build computers

## Memory and Storage

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### Registers

≈ KiB

- 6 gates each, ≈ 24 transistors
- Efficient, fast
- Expensive!
- Ex: local variables

*These do not persist between power cycles*

## Memory and Storage

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Memory

≈ GiB

- Two main types: SRAM, DRAM
- DRAM: 1 transistor, 1 capacitor per bit
- DRAM is cheaper, simpler to build
- Ex: data structures, local variables

*These do not persist between power cycles*

## Memory and Storage

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Disk

≈ GiB-TiB

- Two main types: flash (solid state), magnetic disk
- Magnetic drive
  - Platter with physical arm above and below
  - Cheap to build
  - Very slow! Physically move arm while disk spins
- Ex: files

*Data on disk does persist between power cycles*

Putting it all together  
Next time!