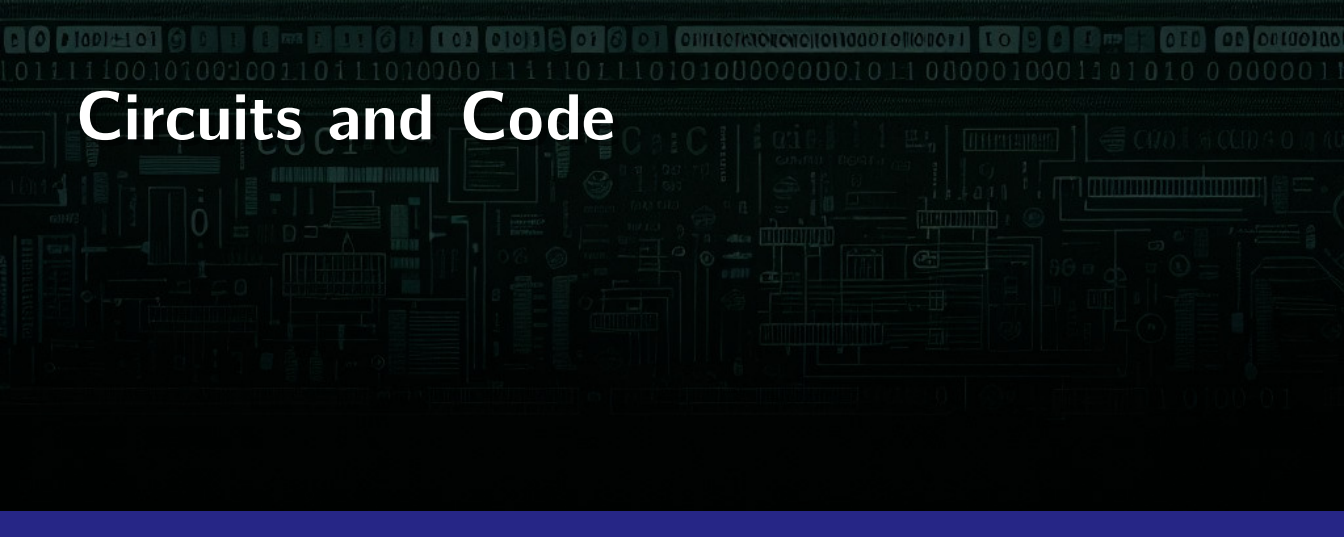


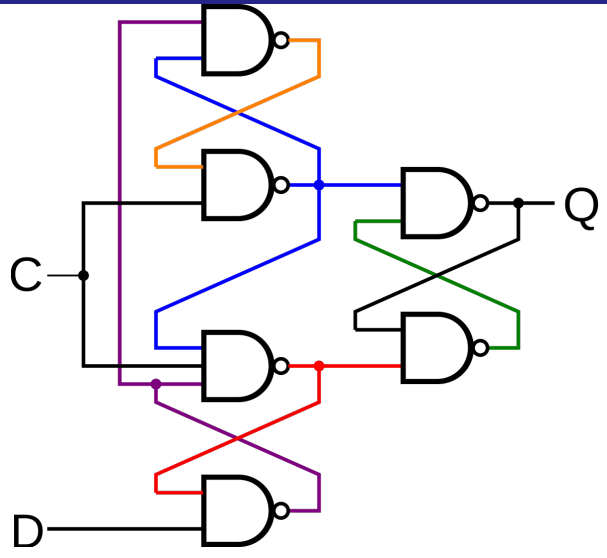
Circuits and Code

CS 2130: Computer Systems and Organization 1
September 15, 2025

Announcements

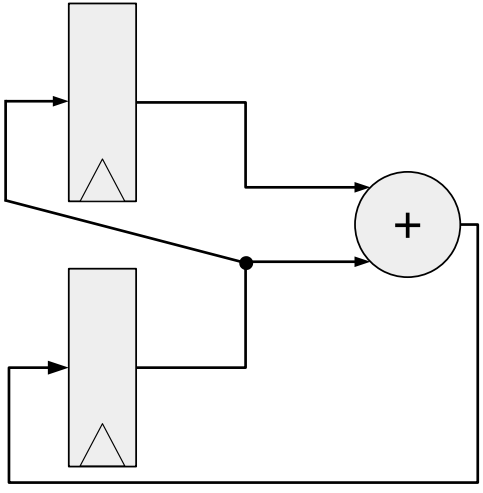
- Homework 1 due tonight
- Homework 2 available today, due next Monday

1-bit Register Circuit

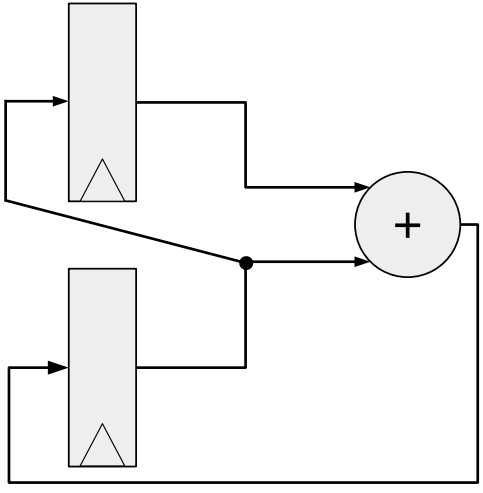


Building a Counter

Another Circuit



Another Circuit



Common Model in Computers

Code to Build Circuits from Gates

Write code to build circuits from gates

- Gates we *already* know: `&`, `|`, `^`, `~`
- Operations we can build from gates: `+`, `-`
- Others we can build:

Code to Build Circuits from Gates

Write code to build circuits from gates

- Gates we *already* know: `&`, `|`, `^`, `~`
- Operations we can build from gates: `+`, `-`
- Others we can build:
- Ternary operator: `?  :`

Equals

Equals: `=`

- Attach with a wire (i.e., connect things)
- Ex: `z = x * y`

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- What about the following?

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x = 1
x = 0
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Equals

Equals: `=`

- Attach with a wire (i.e., connect things)
- Ex: `z = x * y`
- What about the following?
  ```
  x = 1
  x = 0
  ```
- **Single assignment**: each variable can only be assigned a value once

Subtraction

```
z = x + ~y + 1
```

```
a = ~y
b = a + 1
z = x + y
```

Comparisons

Each of our comparisons in code are straightforward to build:

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Each of our comparisons in code are straightforward to build:

- == - xor then nor bits of output
- != - same as == without not of output
- < - consider `x < 0`
- >, <=, => are similar

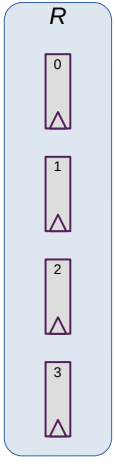
Indexing

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

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

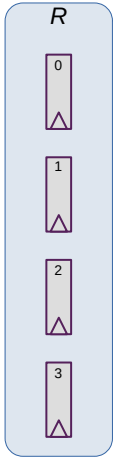


Aside: 4-input Mux

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

Writing

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



Aside: Creating ==0 gates

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

Need one more thing to build computers

Memory and Storage

Registers ≈ KiB

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

These do not persist between power cycles

Memory and Storage

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

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!