Circuits and Code

CS 2130: Computer Systems and Organization 1

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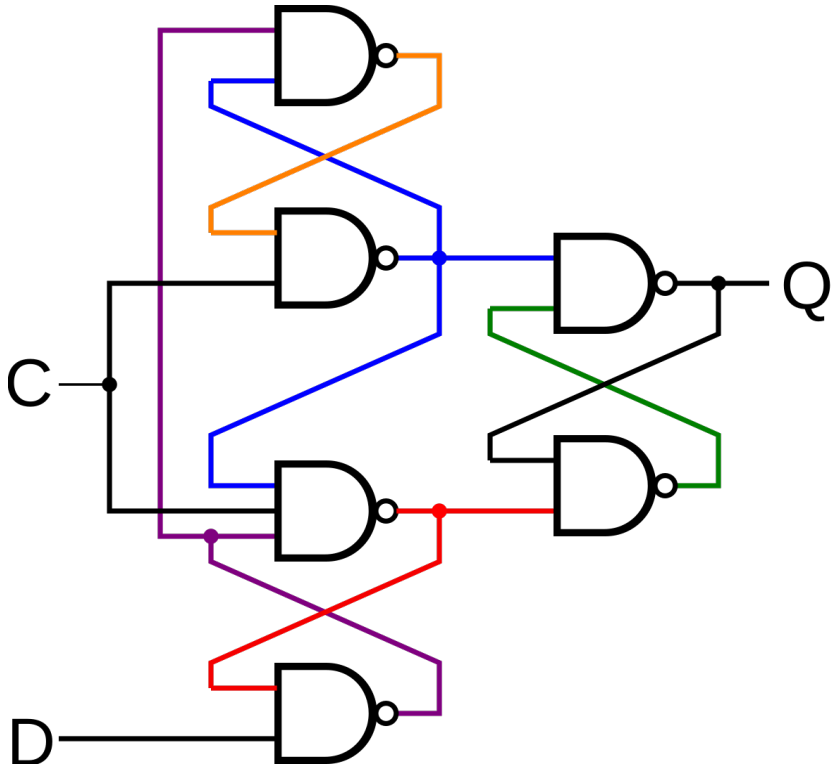
Announcements

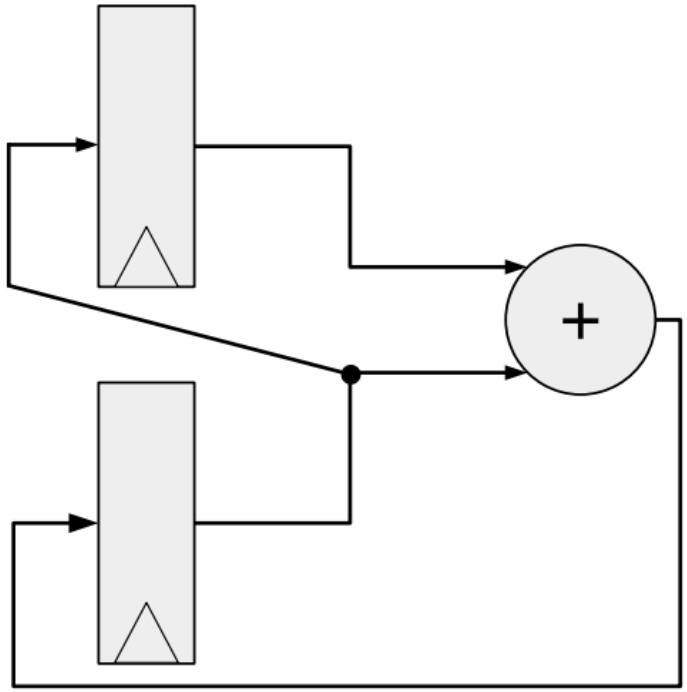
- Homework 1 due tonight
- Homework 2 available today, due next Monday

1-bit Register Circuit



Building a Counter

Another Counter



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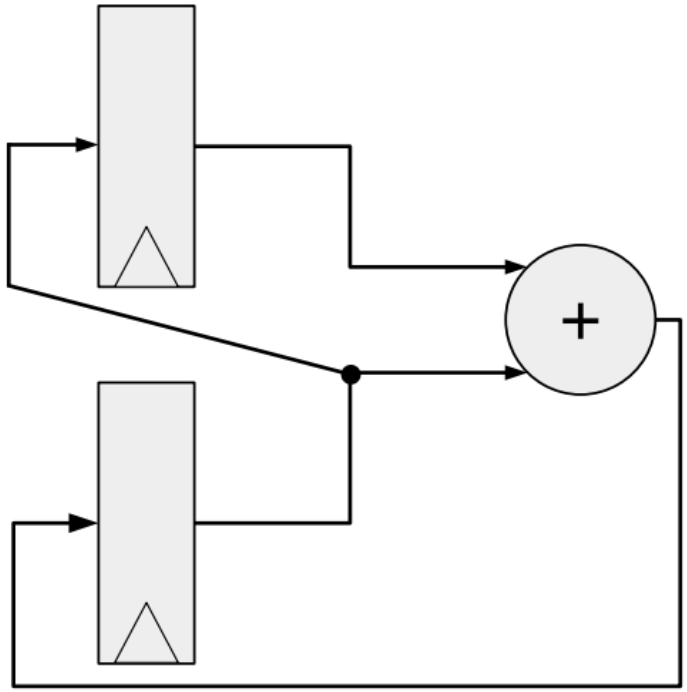

Common Model in Computers

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:

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- 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 = 0

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- Ex: z = x * y
- What about the following?

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  x = 0
- **Single assignment:** each variable can only be assigned a value once

Subtraction

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

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

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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

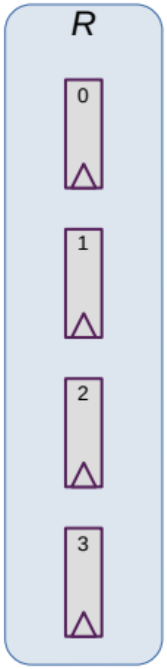
Indexing

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*

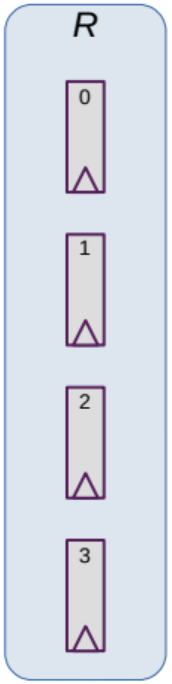


Aside: 4-input Mux

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!