CMSC 11: Introduction to Computer Science

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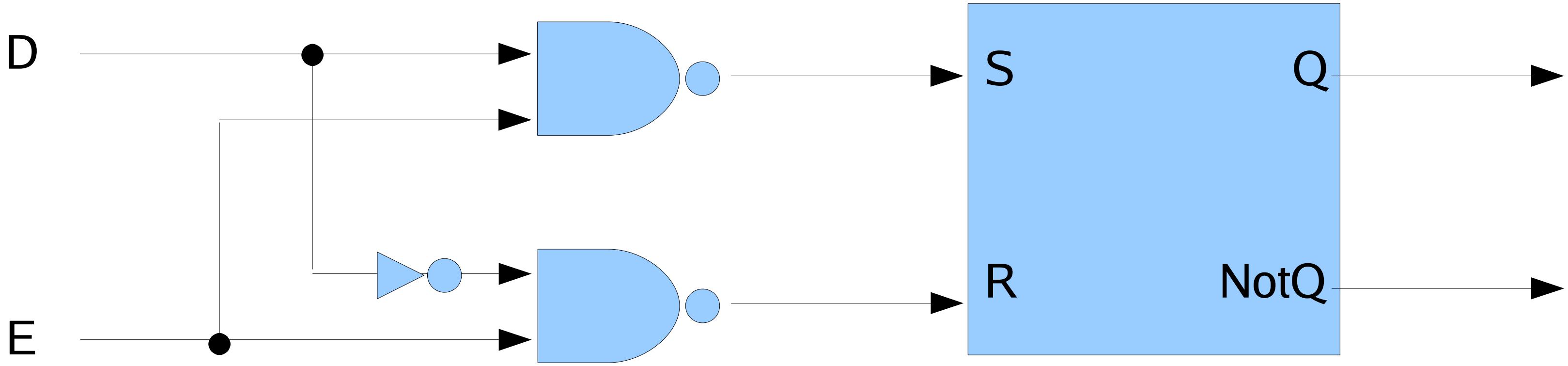
Review

- Gated Flip-Flop



- Registers
- Parallel Registers
- Time

Memory

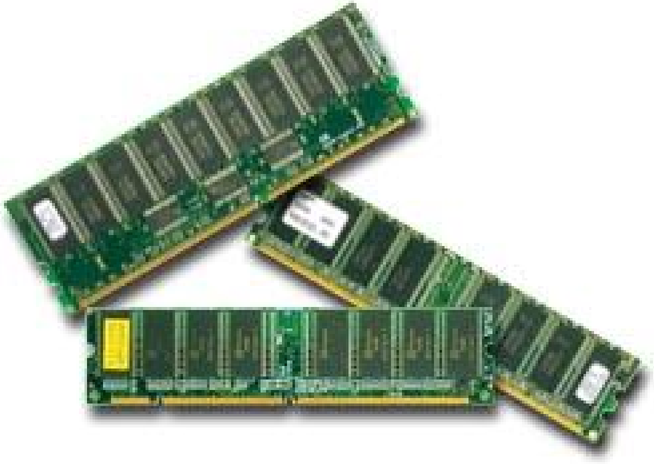
- Research has produced a bewildering array of memory types and technologies

Card memories, tape memories, drum, disk, bubble, optical, core, charge-coupled device, and semiconductor memories, volatile, non-volatile, dynamic, static, destructive and non-destructive, read-write, read-only, programmable, erasable... pant, pant, pant, ... whew, have I forgotten anything?

I don’t remember!

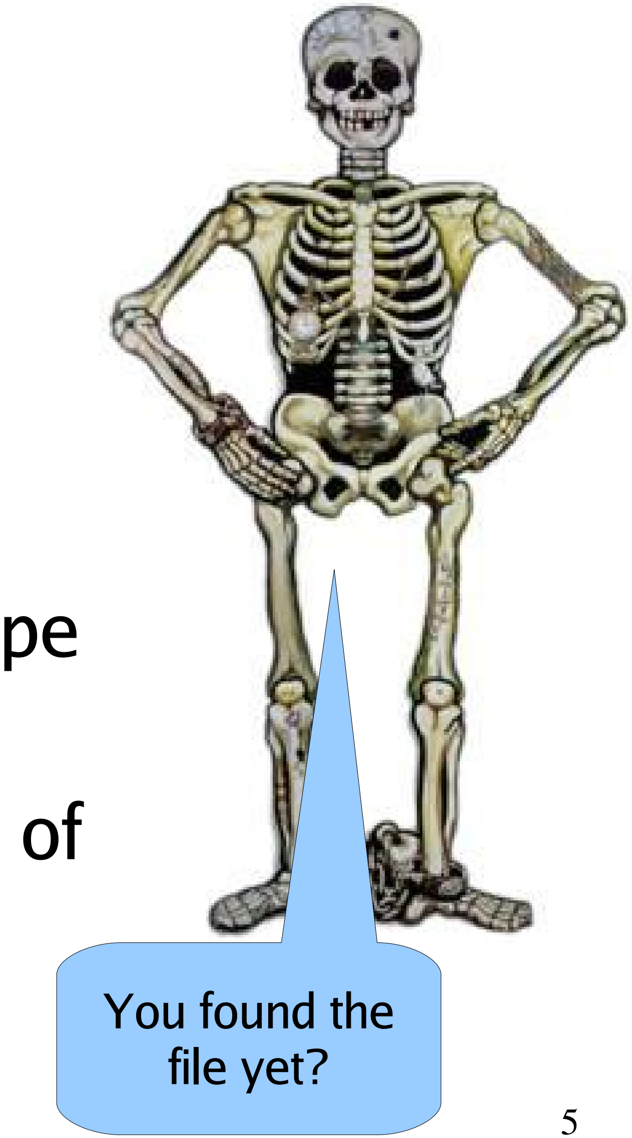
Electronic vs. Electromechanical

- Eletronic Memories
  - no moving parts
  - as fast as the rest of the computer
  - ideal for computer's main or internal memory
  - can store up to 2 billion bytes
  - Examples
    - RAM
    - Flash card
    - Memory card
    - SIM



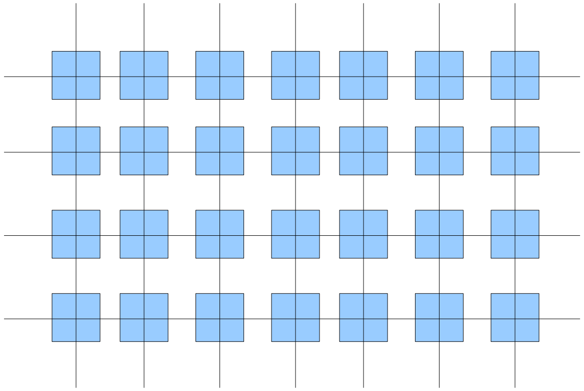
Electronic vs. Electromechanical

- Electromechanical
  - have moving parts
  - Examples
    - disk, CDs
    - reels of tape
  - slow: How slow? Depends on the type of memory
  - Used for secondary storage outside of the machine
  - Can store up to 100 billion bytes



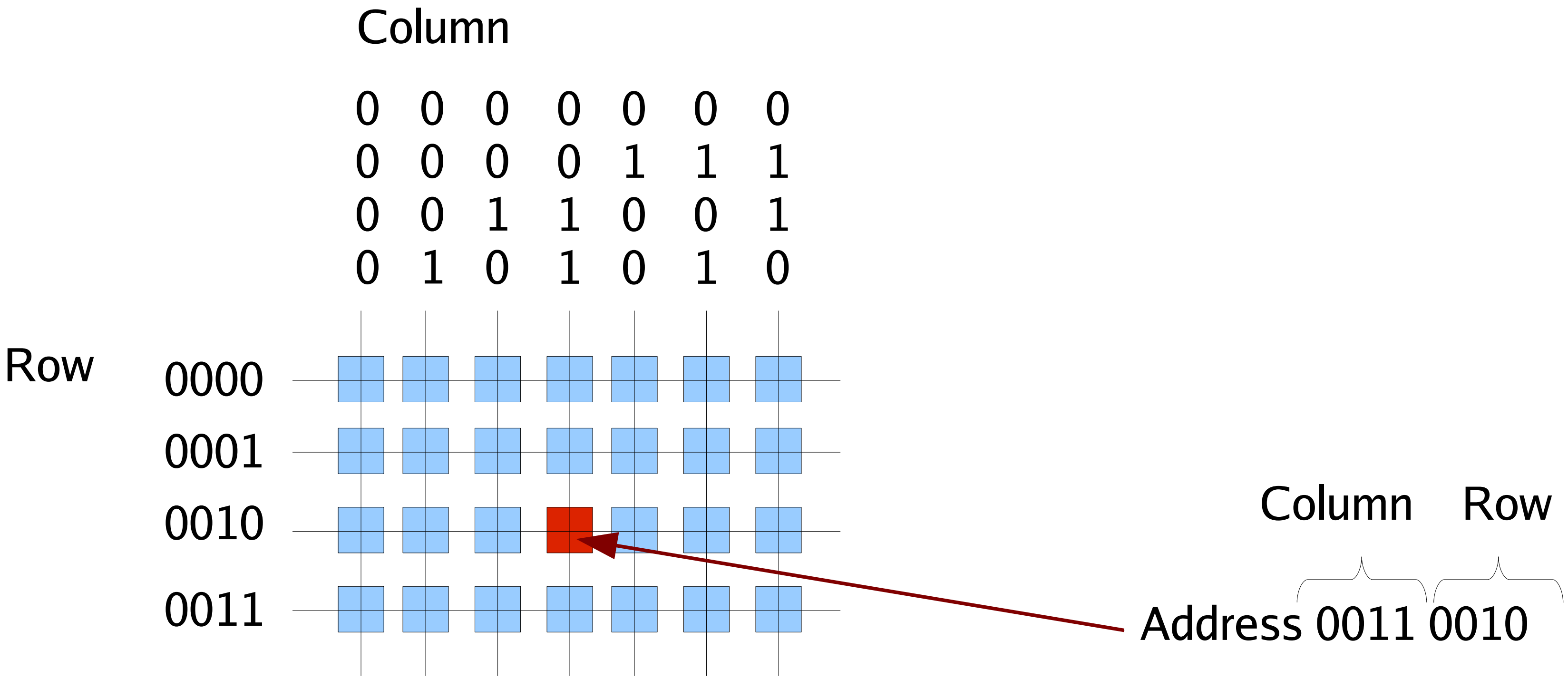
Internal Memory

- Can be thought of as a simple grid
- With a cell at each intersection
- Depending on the computer, each cell can hold one byte, two bytes, or more



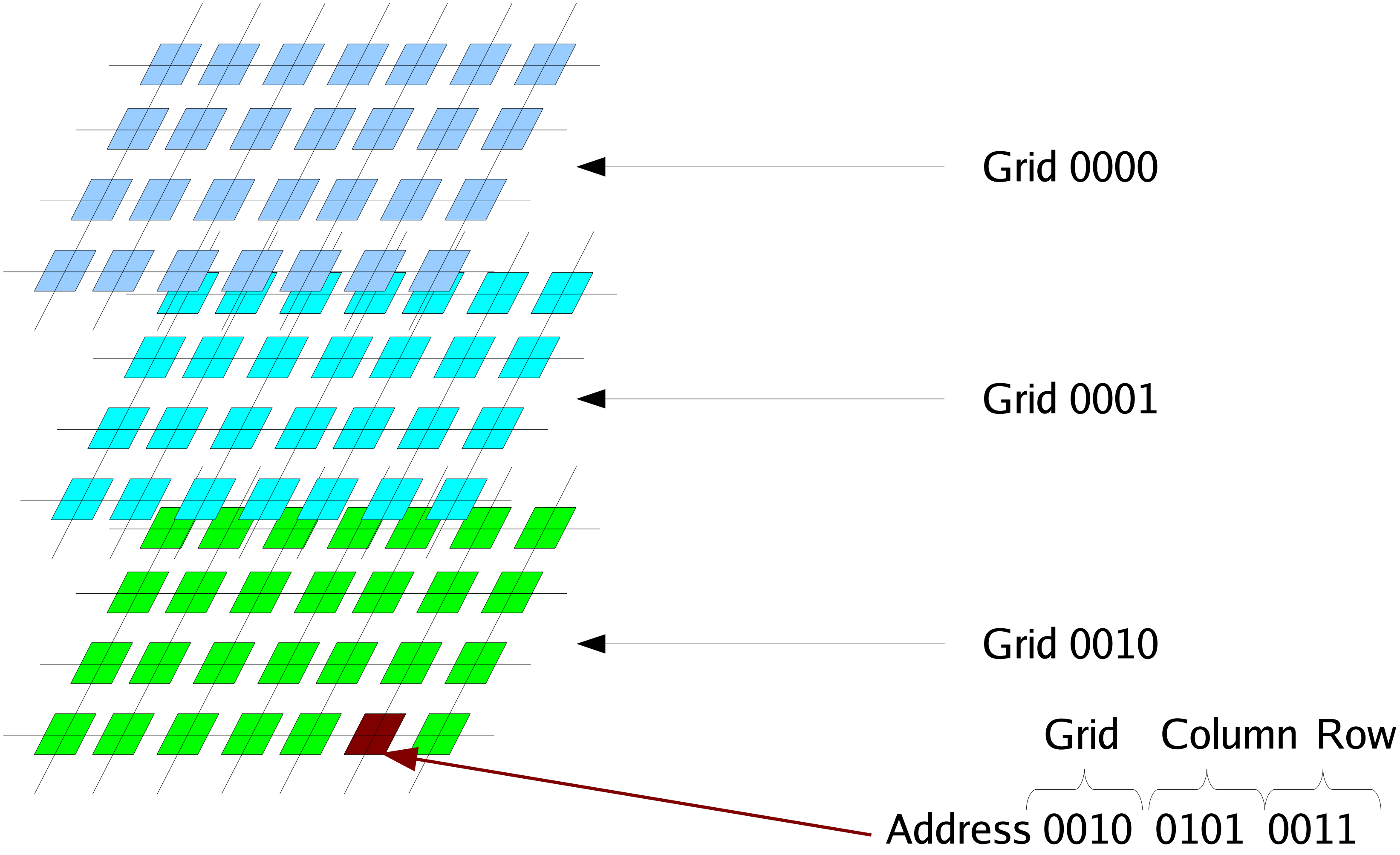
Internal Memory

- Every cell has a unique ADDRESS
- ... specifying where it sits in the grid



Internal Memory

- In practice, there may be many such grids



Grid 0000

Grid 0001

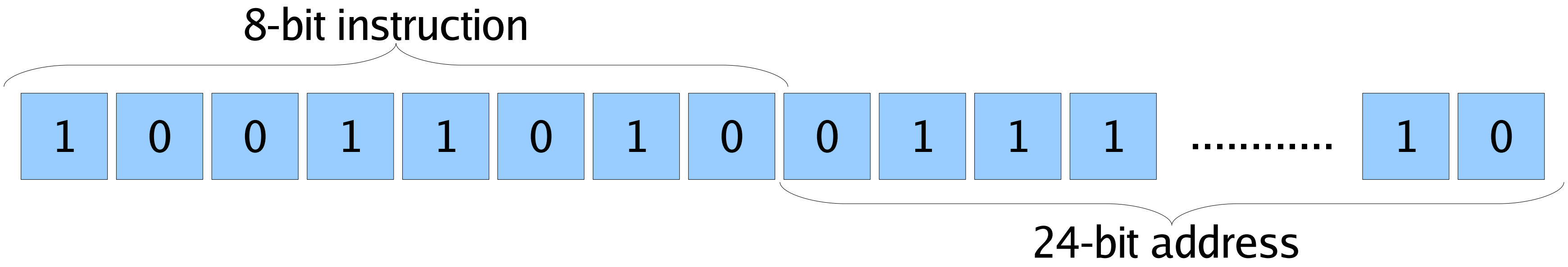
Grid 0010

Grid Column Row

Address 0010 0101 0011

Memory Address

- What is the maximum number of cells the computer can address?
- Depends on the length and structure of the computer’s **words**.
- Example: a 32-bit computer
  - First 8 bits is interpreted as instruction
  - Remaining 24 bits as the address

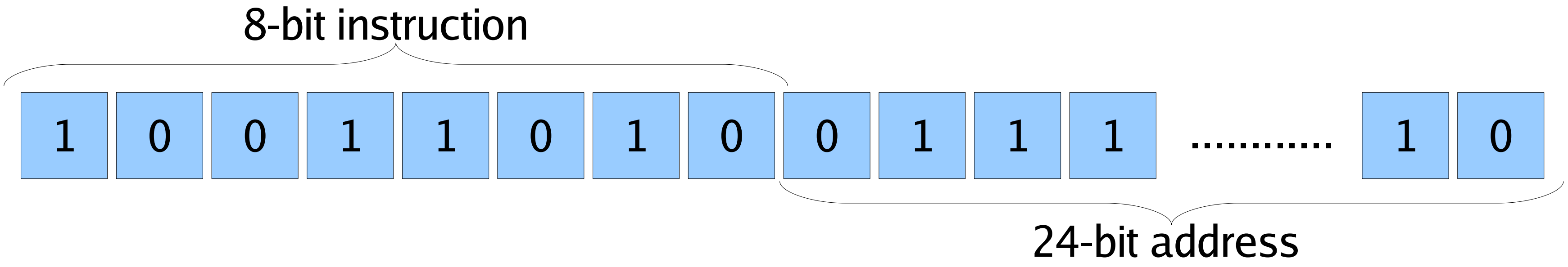


8-bit instruction

1 0 0 1 1 0 1 0 0 1 1 1 ………… 1 0

24-bit address

32-bit addressing

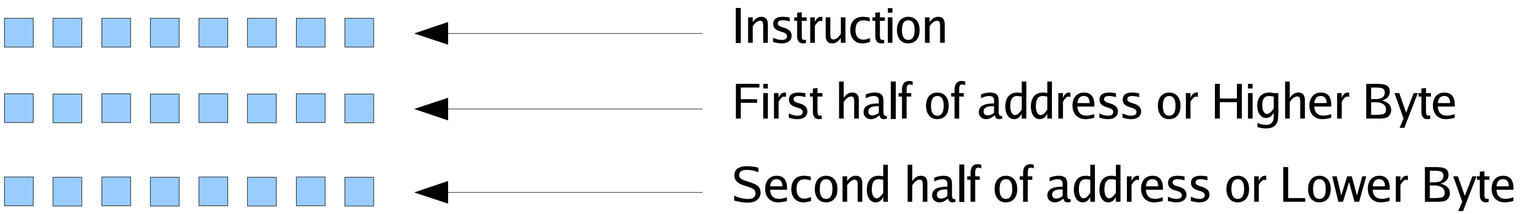


- In this case, addresses can be anything between
  - 000000000000000000000000 and
  - 111111111111111111111111 = $2^{24} - 1$
- giving 2^{24} possible memory cells

16,777,216 cells to be exact!

8-bit addressing

- An 8-bit microcomputer, on the other hand, might process 3 bytes in succession
  - First 8 bits for instruction
  - Second 8 bits for first half of address
  - Third 8 bits for thesecond half of address
- Here, the address is 16 bits long giving 2^{16} = 65,536 possible addresses



Instruction

First half of address or Higher Byte

Second half of address or Lower Byte

Hexadecimal

- To make addresses shorter and more readable, they are often expressed in **HEXADECIMAL**
- ... or base-16 numerals
- $10_{hex} = 16_{decimal}$
- $100_{hex} = 16^2 = 256$
- $1000_{hex} = 16^3 = 4096$

Hexadecimal

- Just as base-10 numbers require the digits 0-9, so hex needs digits from 0 to fifteen
- The extras are represented by the letters A-F

Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Hex	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

- For example $4A0D_{\text{hex}}$ =

$$\left.\begin{array}{rrl} & 4 & \text{x } 16^3 \\ + & 10 & \text{x } 16^2 \\ + & 0 & \text{x } 16 \\ + & 13 & \text{x } 1 \end{array}\right\} 18{,}957_{\text{decimal}}$$

Hexadecimal

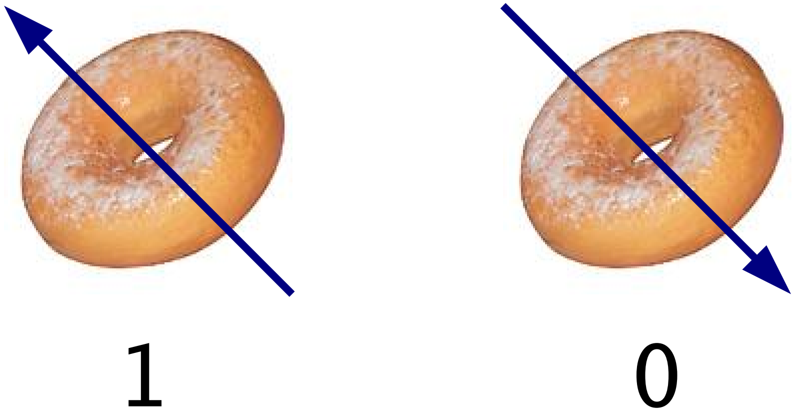
- To convert binary to hex:
  - group the binary number into nibbles, starting from the right
  - Convert each nibble into a hex digit
- Example: 101111001011011

$$\underbrace{101}_{5}\quad\underbrace{1110}_{C}\quad\underbrace{0101}_{5}\quad\underbrace{1011}_{B}$$

- To convert hex to binary, just reverse the process.

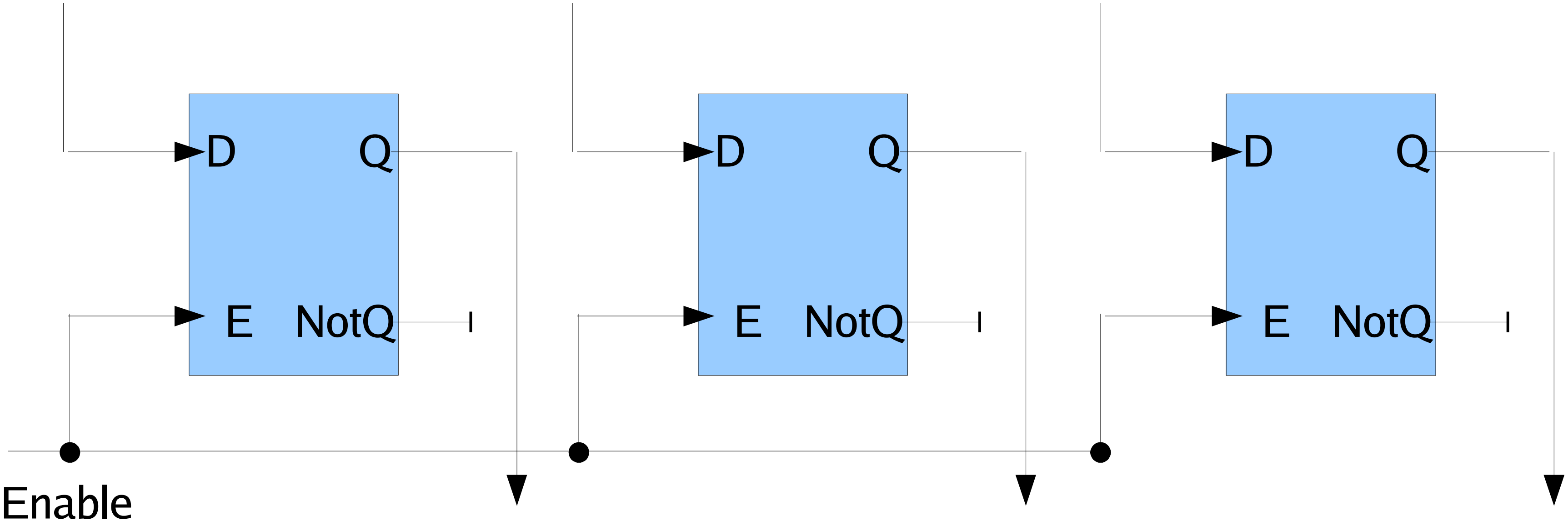
Types of Internal Memory

- From the hardware point of view, there are three main types of internal memory
  - CORE
    - memories use little magnetic doughnuts (cores)
    - each can be electrically magnetized in one of two directions, representing 0 and 1.



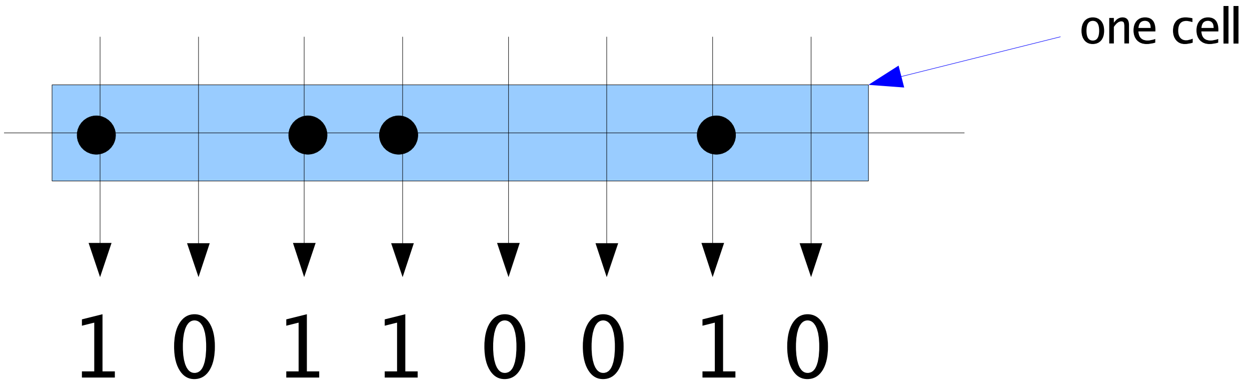
Types of Internal Memory

- RAM
  - Uses flip-flops to store bits
  - Each memory cell is essentially a parallel register
  - Stands for Random Access Memory
    - meaning: any cell can be accessed directly



Types of Internal Memory

- ROM
  - Indicates a 1 or 0 at each grid point by the presence of absence of an electric connection there
  - Stands for Read-Only Memory



ROM vs. RAM

- The practical difference between them is that
  - you can only READ what's in ROM
  - while with RAM, you can read things out or write them in with equal ease.