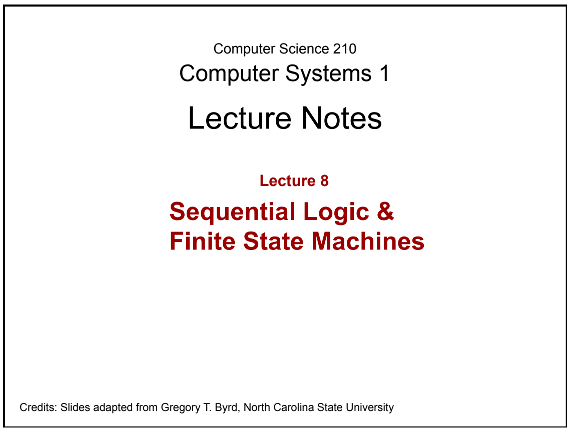


Computer Science 210

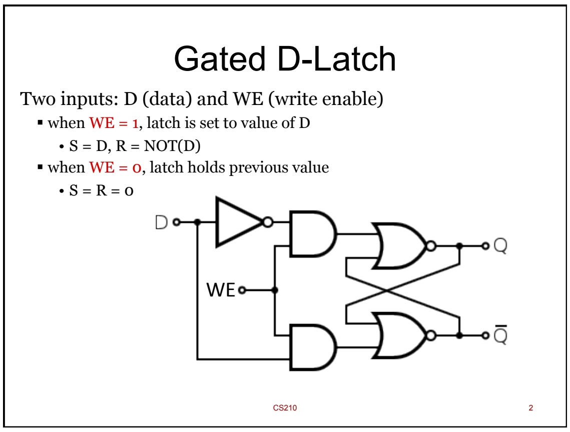
Computer Systems 1

Lecture Notes

Lecture 8

Sequential Logic & Finite State Machines

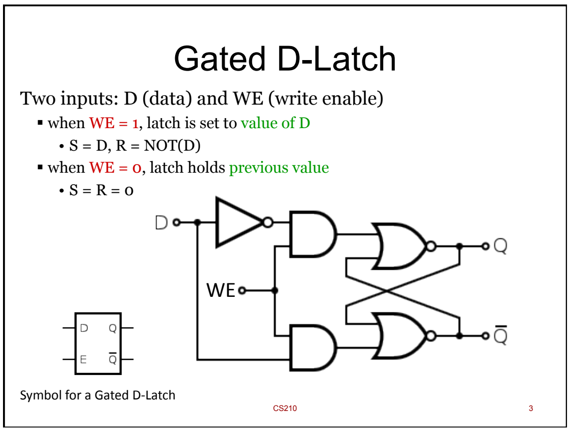
Credits: Slides adapted from Gregory T. Byrd, North Carolina State University



Gated D-Latch

Two inputs: D (data) and WE (write enable)

- when WE = 1, latch is set to value of D
  - S = D, R = NOT(D)
- when WE = 0, latch holds previous value
  - S = R = 0



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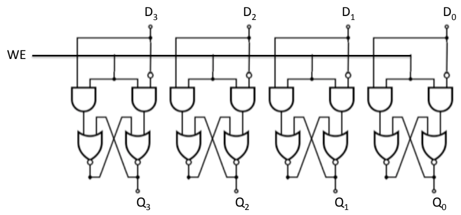
Symbol for a Gated D-Latch

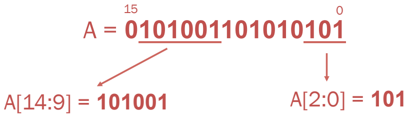


Representing Multi-bit Values

Number bits from right (0) to left (n-1)

– a convention

Use brackets to denote range:
D[l:r] denotes bit **l** to bit **r**, from *left* to *right*


$$A = 0\underline{101001}101010\underline{101}$$

A[14:9] = **101001**

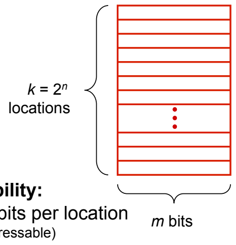
A[2:0] = **101**

•May also see A<**14:9**>,
especially in hardware block diagrams.

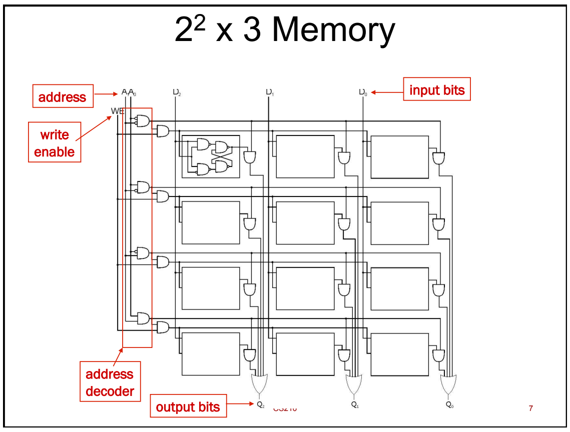
Memory

Now that we know how to store bits,
we can build a memory – a logical *k* × *m* array of stored bits.

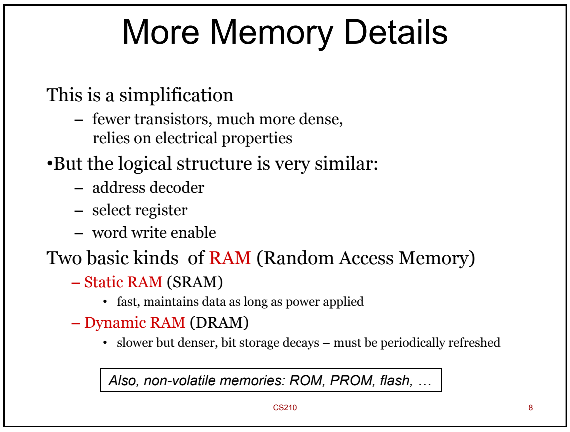
Address Space:
number of locations
(usually a power of 2)



Addressability:
number of bits per location
(e.g., byte-addressable)



2^2 x 3 Memory



More Memory Details

This is a simplification

- fewer transistors, much more dense, relies on electrical properties

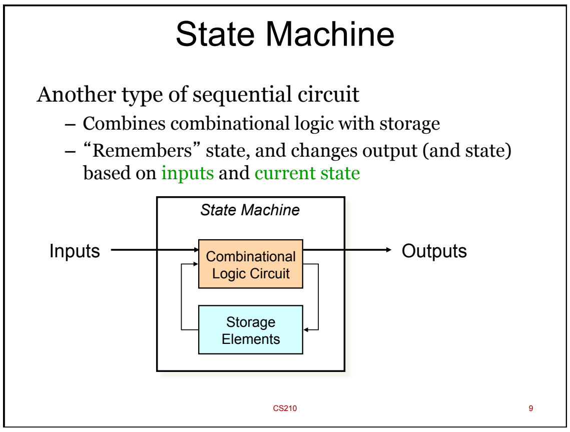
•But the logical structure is very similar:

- address decoder
- select register
- word write enable

Two basic kinds of RAM (Random Access Memory)

- Static RAM (SRAM)
  - fast, maintains data as long as power applied
- Dynamic RAM (DRAM)
  - slower but denser, bit storage decays – must be periodically refreshed

Also, non-volatile memories: ROM, PROM, flash, …



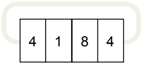
State Machine

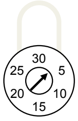
Another type of sequential circuit

- Combines combinational logic with storage
- “Remembers” state, and changes output (and state) based on inputs and current state

Combinational vs. Sequential

- Two types of “combination” locks





Combinational
Success depends only on the values, not the order in which they are set.

Sequential
Success depends on the sequence of values (e.g, R-13, L-22, R-3).

State

The state of a system is a snapshot of all the relevant elements of the system at the moment the snapshot is taken.

- Examples:
  - The state of a tic-tac-toe (Noughts & Crosses) game can be represented by the placement of X’s and O’s on the board.
  - The state of a cricket game can be represented by the scoreboard
    - Number of runs & wickets, overs remaining, etc.

State of a Turnstile

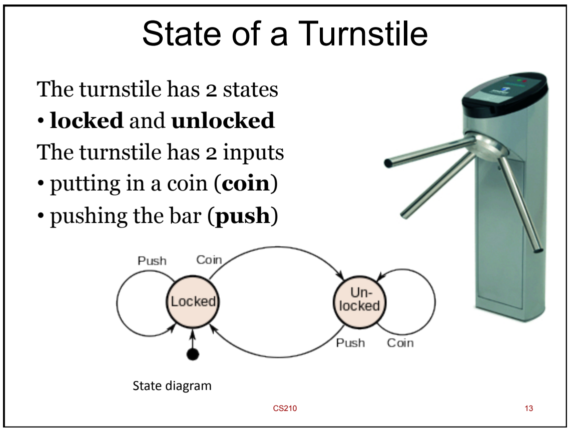
The turnstile has 2 states

- **locked** and **unlocked**

The turnstile has 2 inputs

- putting in a coin (**coin**)
- pushing the bar (**push**)

Current State	Input	Next State	Output
Locked	coin	Unlocked	Release turnstile so customer can push through
	push	Locked	None
Unlocked	coin	Unlocked	None
	push	Locked	When customer has pushed through lock turnstile



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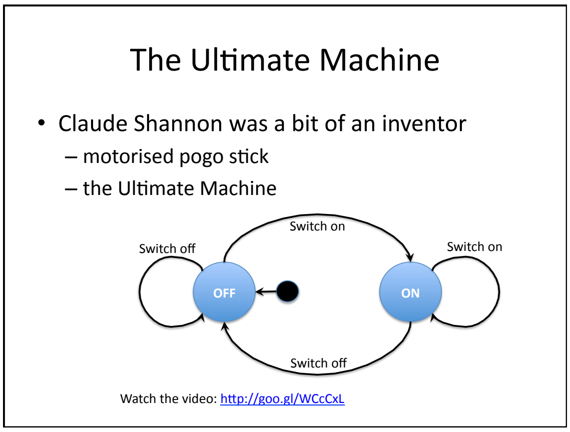
State diagram



The Ultimate Machine

- Claude Shannon was a bit of an inventor
  - motorised pogo stick
  - the Ultimate Machine

Watch the video: http://goo.gl/WCcCxL