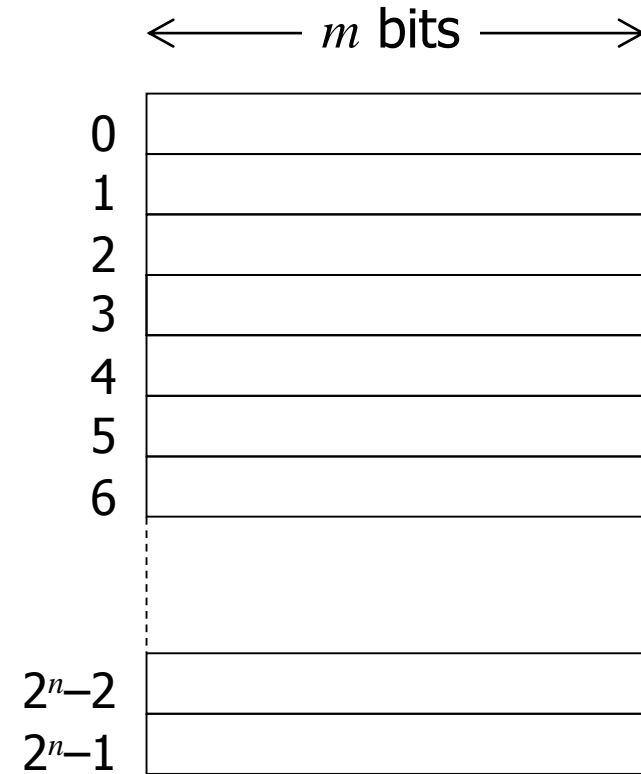# Memory types

CMPE 311

General Concepts

- A memory is an array of storage locations
  - Each with a unique address
  - Like a collection of registers, but with optimized implementation
- Address is unsigned-binary encoded
  - n address bits $\Rightarrow 2^n$ locations
- All locations the same size
  - $2^n \times m$ bit memory

$\xleftarrow{\hspace{2cm}} m \text{ bits} \xrightarrow{\hspace{2cm}}$

0
1
2
3
4
5
6

2^n-2
2^n-1

Memory Sizes

- Use power-of-2 multipliers
  - Kilo (K): $2^{10} = 1,024 \approx 10^3$
  - Mega (M): $2^{20} = 1,048,576 \approx 10^6$
  - Giga (G): $2^{30} = 1,073,741,824 \approx 10^9$
- Example
  - 32K × 32-bit memory
  - Capacity = 1,024K = 1Mbit
  - Requires 15 address bits
- Size is determined by application requirements

Basic Memory Operations
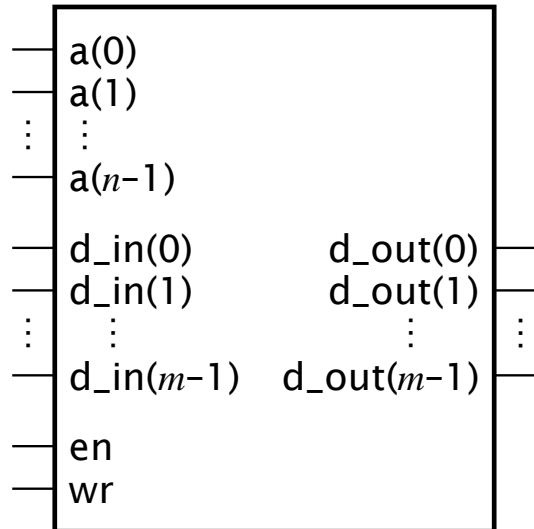
- a inputs: unsigned address
- d_in and d_out
  - Type depends on application
- Write operation
  - en = 1, wr = 1
  - d_in value stored in location given by address inputs
- Read operation
  - en = 1, wr = 0
  - d_out driven with value of location given by address inputs
- Idle: en = 0

Synchronous SRAM (SSRAM)

- Clocked storage registers for inputs
    - address, data and control inputs
    - stored on a clock edge
    - held for read/write cycle

- **Flow-through SSRAM**
  - no register on data output
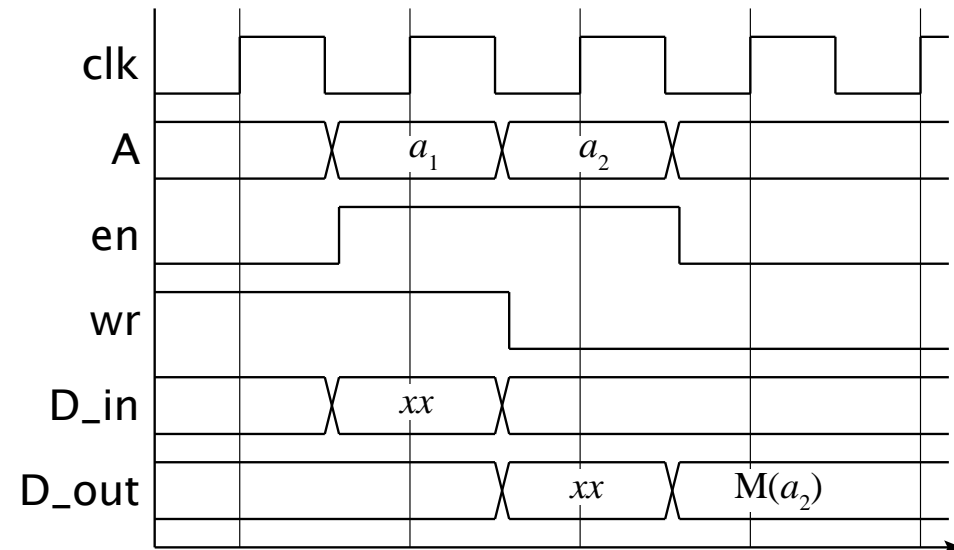
Memory Types

- Volatile and non-volatile
  - Volatile: only maintains its data while the device is powered, Ex: RAM
  - Non volatile: can maintain stored information even after having been power cycled (turned off and back on), Ex: ROM, Flash

- Random-Access Memory (RAM)
  - Can read and write
  - Static RAM (SRAM)
    - Stores data so long as power is supplied
    - Asynchronous SRAM: not clocked
    - Synchronous SRAM (SSRAM): clocked
  - Dynamic RAM (DRAM)
    - Needs to be periodically refreshed

- Read-Only Memory (ROM),

- Programmable read only memory (PROM)

- Erasable PROM (EPROM)

- Electronically Erasable PROM (EEPROM)

Electrically erasable programmable read-only memory (EEPROM)

- remove the biggest drawbacks of EPROMs: ease of programmability.
- The chip does not have to removed to be rewritten.
- The entire chip does not have to be completely erased to change a specific portion of it.
- Changing the contents does not require additional dedicated equipment.
- EEPROM chips are too slow to use in many products that make quick changes to the data stored on the chip.

Flash

- **Flash memory**, a type of EEPROM that uses **in-circuit wiring** to erase by applying an electrical field to the entire chip or to predetermined sections of the chip called **blocks**. Flash memory works much faster than traditional EEPROMs because it writes data in chunks, usually 512 bytes in size, instead of 1 byte at a time

Memory Comparison table

Memory type	Read speed	Volatility	density	rewrite
SRAM	+++	-	-	++
DRAM	+	- -	++	++
EPROM	+	+		-
EEPROM	+	+		+
Flash	+	+	+	+