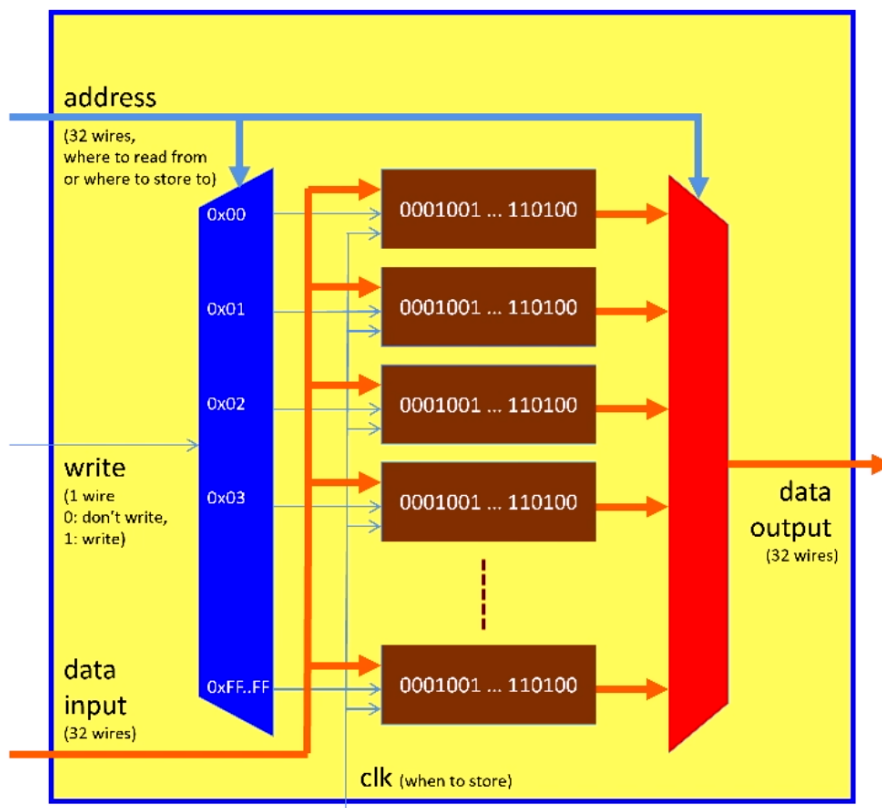


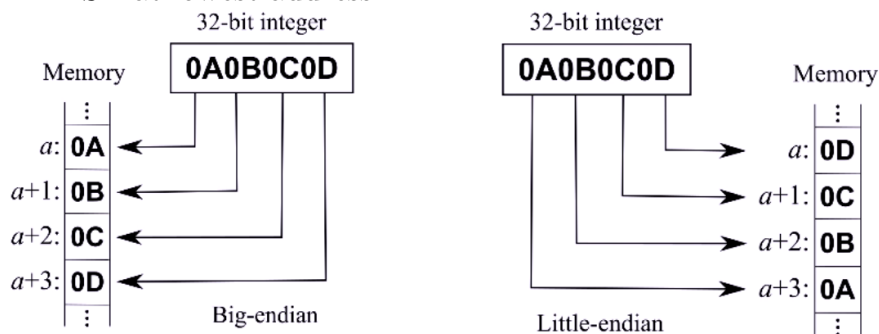
Memory

- Random Access Memory
 - store data at arbitrary (random) location in memory



Endianes

- little endian
 - LSB at lowest address
- big endian
 - MSB at lowest address



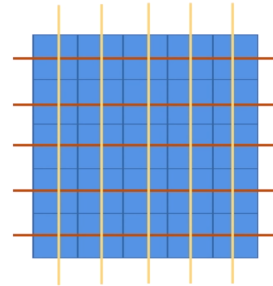
Building Memory

- standard flip flops, decoders and multiplexer would be expensive
 - able to write/read value to each FF in each cycle

- not necessary for most memory
- single port to read/write memory
 - read/write one cell at a time

Basic Idea of Memory Design

- A bitline connects all memory cells of a column vertically (yellow)
- A wordline connects all memory cells of a row horizontally
- This basic structure is used for all kinds of memories:
 - Non-volatile memory (NVM)
 - Static memory (SRAM)
 - Dynamic memory (DRAM)
 - DDR memory



- Each memory type is for different trade-offs with respect to size, speed, ...

• DRAM

- A DRAM cell just consists of a single transistor and a capacitance that stores the data value
- In steady state (no access) all bitlines and wordlines are disconnected from the power supply (i.e. they are floating)

Writing a cell:

- Set corresponding bitline to the desired storage value
- Set corresponding wordline to high
- This charges the capacitance of the desired cell to the desired storage value

Reading a cell:

- Pre-charge the corresponding bitline to the desired voltage value
- Disconnect the bitline
- Set the corresponding wordline to high
- The bitline keeps its value, if the stored value is high or is pulled to low, if the stored value is zero