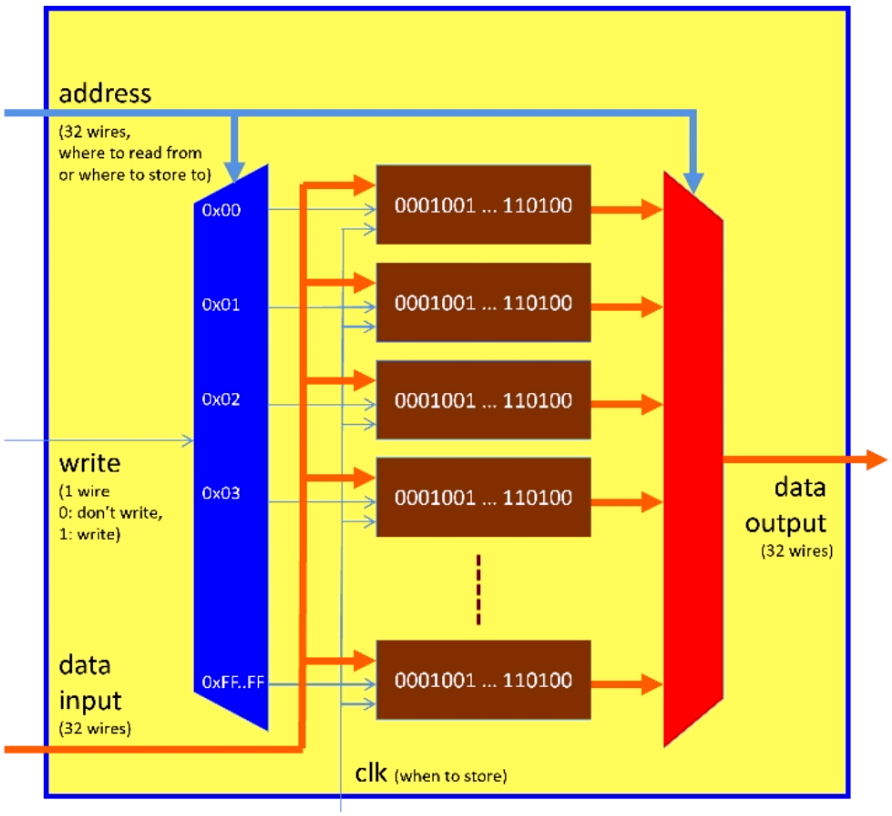
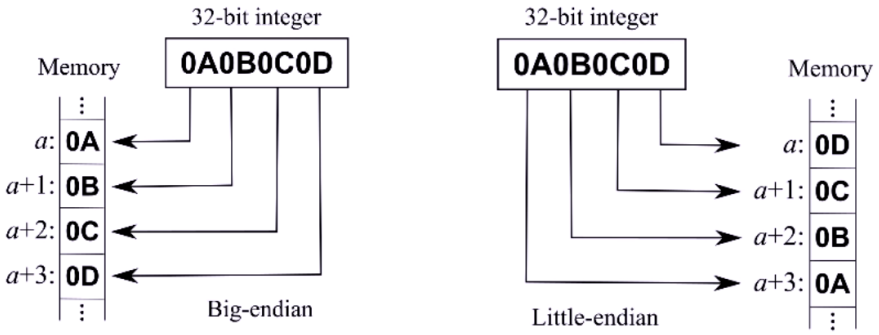
Memory

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

Endianes

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

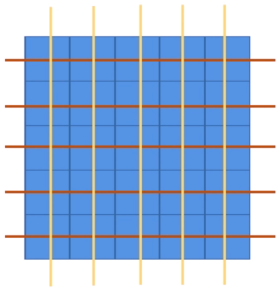
Building Memory

- 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