

Computer Architecture and Organization

INTERNAL MEMORY

Lecture 5

Dr.Shada Mabgar

Memory Basics

- *A memory* is just like a human brain.
- *Memory* is the workspace for the processor.
- It is a **temporary** storage area .
- Memory storage is considered **temporary** because the data and programs remain there only as long as the computer has electrical power or is not reset.
- Before the computer is **shut down** or **reset**, any data that has been changed should be saved to a more permanent storage device (usually a hard disk) so it can be reloaded into memory in the future.

Memory Basics

- The **main memory** in a system is a collection of chips or modules containing chips that are usually plugged into the motherboard.
- These chips or modules vary in their electrical and physical designs and must be compatible with the system into which they are being installed to function properly.

Memory Basics

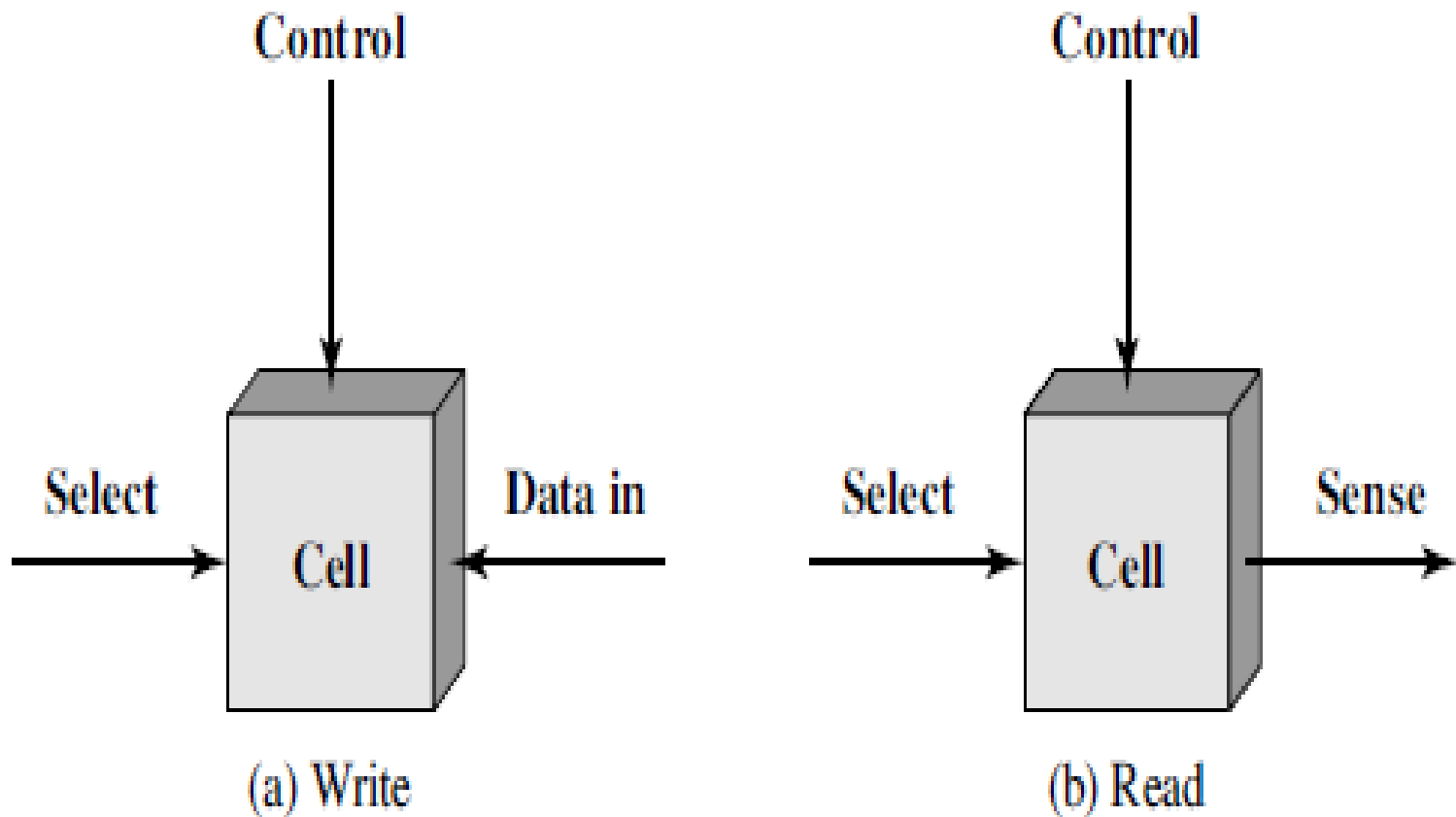
- The memory is divided into large number of small parts called **cells**.
- Each **location or cell** has a unique address which varies from zero to memory size minus one.
- For example if computer has 64k words, then this memory unit has $64 * 1024 = 65536$ memory locations. The address of these locations varies from 0 to 65535.

Memory Basics

The **cell** has three functional terminals capable of carrying an electrical signal.

- The select terminal, as the name suggests, selects a memory cell for a read or write operation.
- The control terminal indicates read or write.
- For writing, the other terminal provides an electrical signal that sets the state of the cell to 1 or 0. For reading, that terminal is used for output of the cell's state.

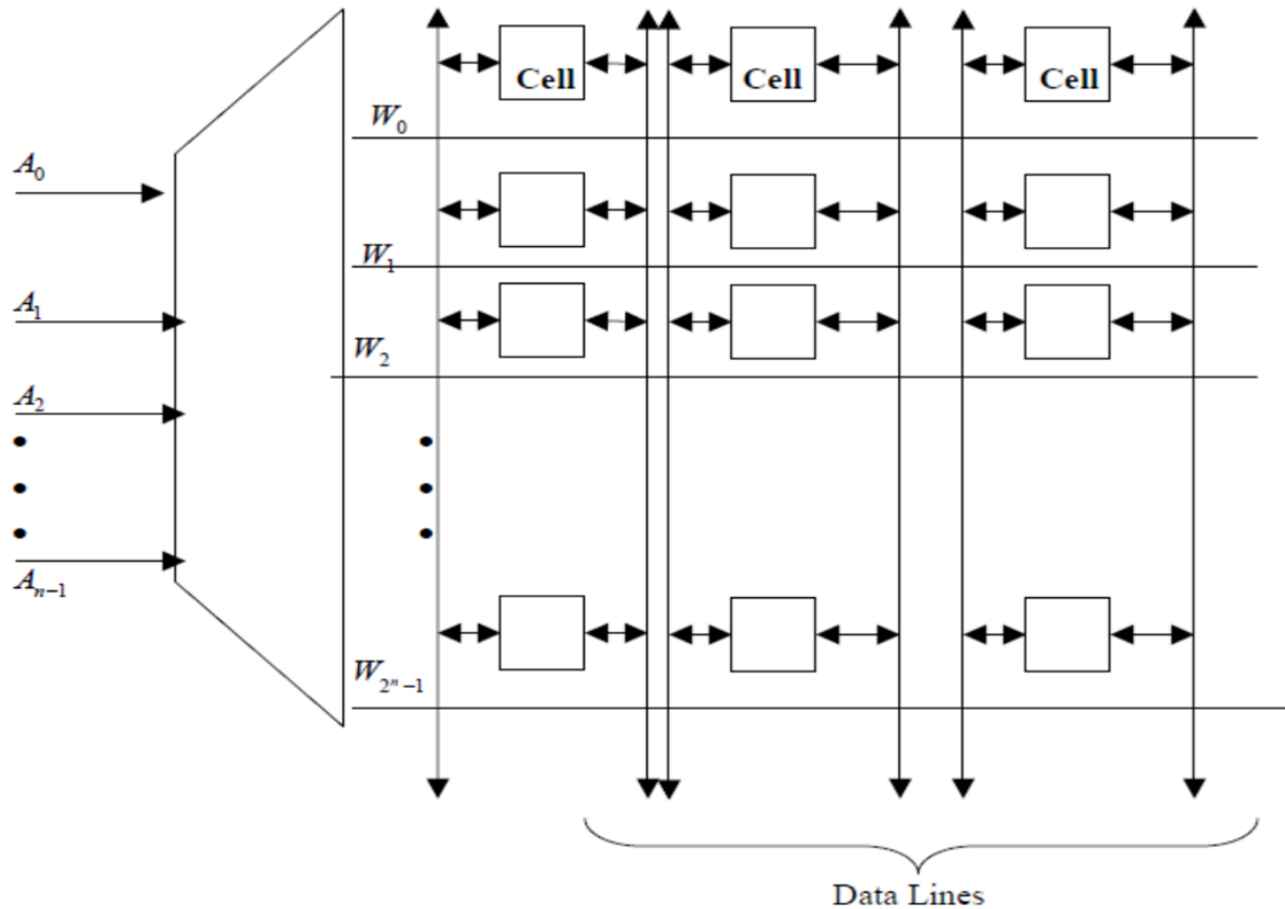
Memory Basics



Memory Basics

- typical internal main memory structure as consisting of rows and columns of basic cells.
- Each cell is capable of storing one bit of information.
- Address lines $A_{n-1}A_{n-2}\dots A_1A_0$ are used as inputs to the address decoder in order to generate the word select lines $W_{2^n-1}\dots W_1W_0$.
- A given word select line is common to all memory cells in the same row.
- At any given time, the address decoder activates only one word select line while deactivating the remaining lines.

Internal Organization of a Memory Chip



Main Memory

- Main memory is called **RAM** (Random Access Memory) .
- Randomly (as opposed to sequentially) access any location in memory.
- The information stored in this type of memory is lost when the power supply to the PC or laptop is switched off.
- The information stored in RAM can be checked with the help of BIOS.
- **RAM** is the hardware location in a computer where the operating system, application programs, and data in current use are kept so that they can be quickly reached by the computer's processor .

Basic Memory Operations

Steps in a Typical **Write Cycle** :

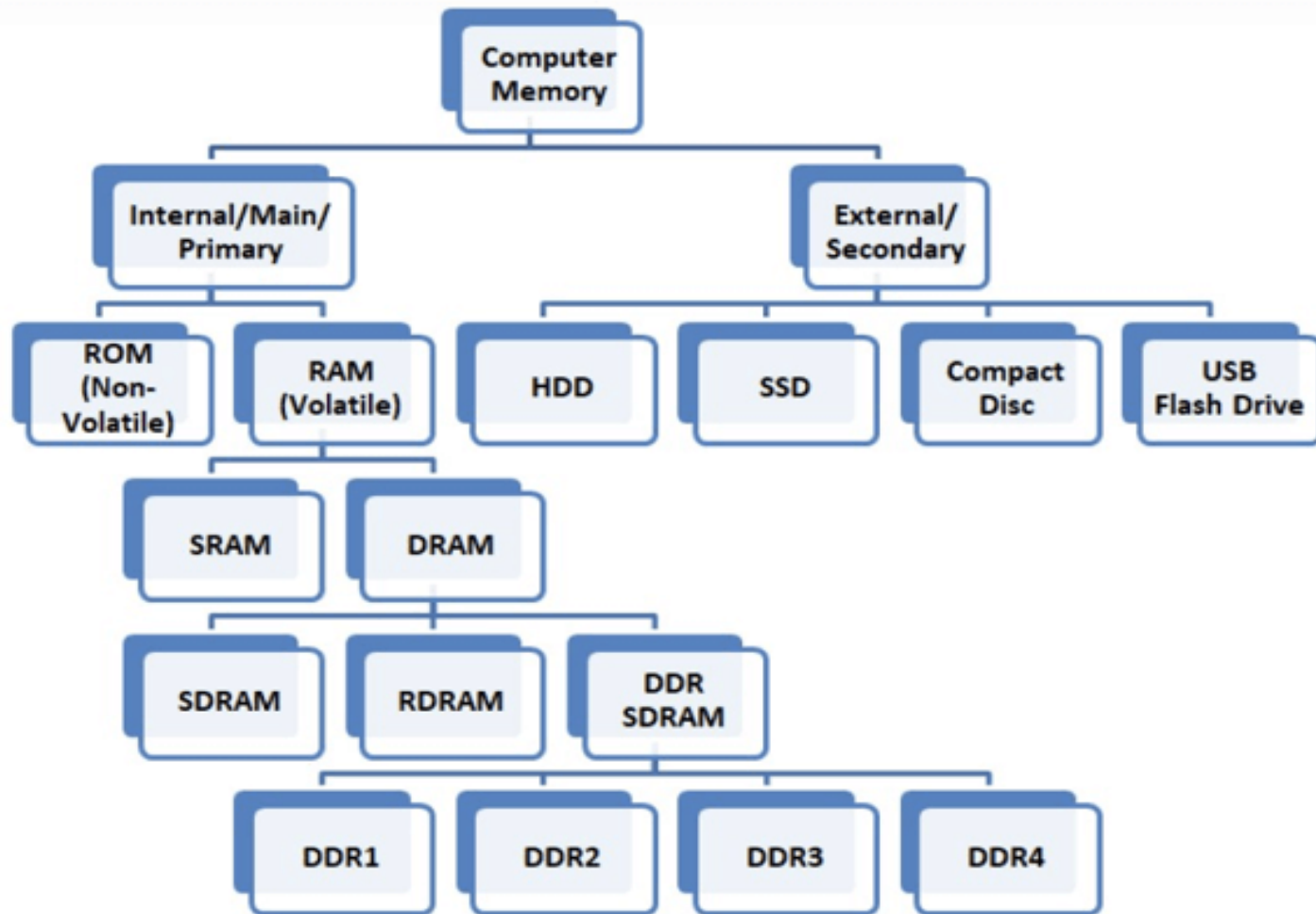
1. Place the address of the location to be written on the **address bus** .
2. Place the data to be written on the **data bus**.
3. Activate the memory write control signal on the **control bus** .
4. Wait for the memory to store the data at the addressed location .
5. Drop the memory write signal to terminate the write cycle.

Basic Memory Operations

Steps in a Typical **Read Cycle** :

1. Place the address of the location to be read on the **address bus** .
2. Activate the memory read control signal on the **control bus** .
3. Wait for the memory to retrieve the data from the addressed memory location and place them on the **data bus** .
4. Read the data from the **data bus** .
5. Drop the memory read control signal to terminate the read cycle .

TYPES OF RAM



Types of RAM

TYPES OF RAM

Two main types of **RAM** are :

- **Static RAM (SRAM)**
- **Dynamic RAM (DRAM)**

The only type of memory you normally need to purchase and install in a system is DRAM. The other types are built in to the motherboard (ROM), processor (SRAM), and other components such as the video card, hard drives, and so on.

DRAM

- The characteristics of **DRAM** chips (and therefore most types of RAM in general) is that they store data dynamically, which really has **two meanings**:
 - 1- One meaning is that the information can be written to RAM repeatedly at any time .
 - 2- The other has to do with the fact that **DRAM** requires the data to be refreshed (essentially rewritten) every few milliseconds or so;
- Each bit uses a single capacitor and single transistor circuit.

SRAM

- The **static** RAM does not require the periodic refreshing .
- Fastest form of **RAM** but also the most expensive. Due to its cost it is not used as main memory but rather for cache memory.
- Each bit requires a 6-transistor circuit.

DRAM & SRAM

Table Comparing DRAM and SRAM

Type	Speed	Density	Cost
DRAM	Slow	High	Low
SRAM	Fast	Low	High

Types of DRAM

- **FPM DRAM** - Fast Page Mode Dynamic Random Access Memory
- **SDRAM**- Synchronous Dynamic access Memory
- **RDRAM**- Rambus Dynamic Random Access Memory
- **VRAM – Video RAM**- optimized for video adapters .
These chips have two ports so that video data can be written to chips at the same time the video adapter regularly reads the memory to refresh the monitor's current display.

Types of RAM

- **EDO RAM** - **E**xtended **D**ata **O**utput **R**andom **A**ccess **M**emory - It doesn't wait for the completion of the processing of the first bit before continuing to the next one. As soon as the address of the first bit is located, EDO DRAM begins looking for the next bit.
- **Flash Memory** :is an electrically erasable and programmable permanent type of memory. It uses a one-transistor memory to store a bit. It offers low power consumption and helps to reduce the cost. It is mainly used in digital cameras, MP3 players, etc

Types of DRAM

- **DDR SDRAM** - **D**ouble **D**ata **R**ate **S**ynchronous **D**ynamic **R**andom **A**ccess **M**emory - It is just like **SDRAM**.
- The only difference between the two is the data is transferred twice as quickly as standard **SDRAM**.
- **DDR** memory achieves the doubling in performance by transferring twice per transfer cycle: **once at the leading (falling) edge and once at the trailing (rising) edge of the cycle.**

Types of DRAM

SDR

1 transfer
per clock cycle

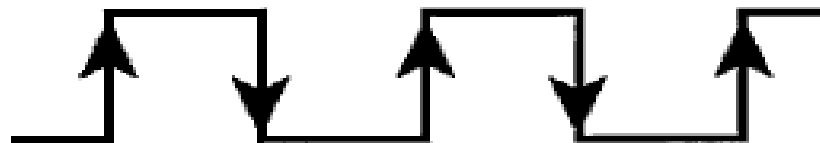


Clock Freq = 100MHz

Data Freq = 100MHz

DDR

2 transfers
per clock cycle



Clock Freq = 100MHz

Data Freq = 200MHz

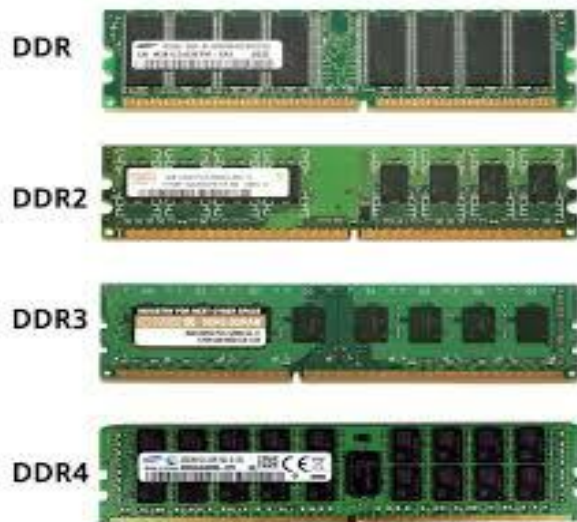
SDR (single data rate) versus DDR (double data rate) cycling.

Types of RAM

Performance Comparison of RAM Types

Standard	Time in Market	Internal Rate	Bus Clock(MHZ)	Perfectch	Data rate(MT/s)	Tranfer rate(GB/s)	Voltage
SDRAM	1993	100-166	100-166	1n	100-166	0.8-1.3	3.3
DDR	2000	133-200	133-200	2n	266-400	2.1-3.2	2.5/2.6
DDR2 SDRAM	2003	133-200	266-400	4n	533-800	4.2-6.4	1.8
DDR3	2007	133-200	533-800	8n	1066-1600	8.5-14.9	1.35/1.5
DDR 4	2014	133-200	1066-1600	8n	2133-3200	17-21.3	1.2

Types of DDR



DDR 400 / DDR2 800 / DDR3 1600



Types of DRAM

❑ Fast Page Mode DRAM

- Standard DRAM is accessed through a technique called paging.
- Normal memory access requires that a row and column address be selected, which takes time.
- Paging enables faster access to all the data within a given row of memory by keeping the row address the same and changing only the column.
- Memory that uses this technique is called Page Mode or Fast Page Mode memory.
- Other variations on Page Mode were called Static Column or Nibble Mode memory.

Types of DRAM

❑ SDRAM - Synchronous DRAM

- A type of DRAM that runs in synchronization with the memory bus.
- Delivers information in very high-speed bursts using a high-speed clocked interface.
- Removes most of the latency involved in asynchronous DRAM because the signals are already in synchronization with the motherboard clock.

Types of DRAM

❑ RDRAM- Rambus DRAM

- It is a type of **RAM** made by **Rambus** and is the fastest type of computer memory available.
- Typical **SDRAM** can transfer data at speeds up to **133 MHz**, while standard **RDRAM** can crank it up over **1 GHz**.
- An improvement to **RDRAM** called **Direct Rambus (DRDRAM)** allows for even faster data transfer rates. **DRDRAM** uses a 16-bit bus rather than the 8-bit bus DRAM uses, which means it can handle 8 operations at once and can transfer data at a speeds of **1.6 GHz**.

ROM MEMORY

- **Read-only memory (ROM)** is a type of storage medium that permanently stores data on personal computers (PCs) and other electronic devices.
- It contains the programming needed to start a PC, which is essential for boot-up.
- It performs major input/output tasks and holds programs or software instructions.
- Because ROM is read-only, it cannot be changed; it is permanent and **non-volatile**, meaning it also holds its memory even when power is **removed**.

TYPES OF ROM

- **PROM – Programmable Read Only Memory-** semiconductor memory which can only have data written to it once -is nonvolatile .
- **EPROM – Erasable Programmable Read Only Memory-** semiconductor memory can be programmed and then erased at a later time.
- **EEPROM – Electrically Erasable Programmable Read Only Memory-** data can be written to it and can be erased using electrical voltage .
- **Flash memory** –Data can be written to it and it can be erased .first introduced in the mid-1980s, flash memory is intermediate between **EPROM** and **EEPROM**.

ROM MEMORY

- Because **ROM** cannot be changed and is read-only, it is mainly used for **firmware**.
- **Firmware** is software programs or sets of instructions that are embedded into a hardware device. It supplies the needed instructions on how a device communicates with various hardware components.
- **Firmware** includes **BIOS**, erasable programmable **ROM (EPROM)** and the **ROM** configurations for software.
- **ROM** may also be referred to as **maskROM (MROM)**.
- **MaskROM** is a read-only memory that is static ROM and is programmed into an integrated circuit by the manufacturer..