Memory and Storage

- Main Memory
  - Fast Access
  - Directly Accessible by CPU
  - Usually RAM or ROM
- Secondary Storage
  - Access Via I/O Subsystem
  - Normally Disk Storage

Structure of Memory

- An Array of "Registers"
- Each "Register" is a Memory Location

```
b_7 b_6 b_5 b_4 b_3 b_2 b_1 b_0
```

- Register N (Location N)
- Register N-1 (Location N-1)
- Register N-2 (Location N-2)
  
- Register 1 (Location 1)
- Register 0 (Location 0)
Structure of Memory

- Data is Organized in Words
  - Contains the Maximum Number of Bits the CPU Can Utilize
    - Larger Words Imply the Ability to Deal with Larger Numbers
    - Smaller CPU's Must Make Multiple Fetches to Memory
  - Processors Are Classified According to Word Size
- Words Are Stored in Memory Locations
- Memory Locations Have an Address
  - This is Equivalent to the Register Number
  - Also, The Location

Random-Access Memory (Read-Write)

- Memory Locations Can be Accessed in Any Order (i.e., Randomly)
- An Address is Decoded into a Memory Location By a n-to-2^n Decoder
- Dynamic RAM's
  - Data Are Stored in Small Capacitors
  - Must Be Refreshed Periodically
- Static RAM's
  - Data Are Stored in Flip Flop's
  - No Refresh Is Necessary
- Non-Volatile RAM's
  - Do Not Lose Their Contents After Power is Turned Off
  - May Be Dynamic or Static RAM's
Physics Structure of Static RAMs

Basic Cell for Static RAMs

<table>
<thead>
<tr>
<th>In</th>
<th>R/W</th>
<th>S</th>
<th>$Q_{t+1}$</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>$Q_t$</td>
<td>-</td>
</tr>
<tr>
<td>0</td>
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</tr>
</tbody>
</table>
Basic Cell for Static RAMs

Physical Structure of Dynamic RAMs
Read-Only Memory

- Memory Contents Are Fixed (Permanently Programmed)
  - Permanent Changes Are Often Made at a Device Level
  - Burning A Silicon Fuse
  - Causing Physical Material Changes By High Voltage
- Programmable Read-Only Memory (PROM)
- Erasable Programmable ROM (EPROM)
- Electrically Alterable ROM (EAROM)

Sequential Access Memory

- Data Must Be Accessed in a Sequence With Other Data
- Direct Access
  - The Computer Can Directly Access the Storage Medium
  - Occurs Via a Transducer
  - Via the I/O Subsystem
  - DASD is the IBM Acronym for Disk Storage
- Indirect Access
  - Tape Subsystem
  - Intermediate System Is Required
Structure of Disk Drives

Disk Types

- **Constant Angular Velocity (CAV)**
  - Rotational Speed Remains Constant
  - Data Density Varies
    - High Near Spindle
    - Low Near Perimeter
  - Applications
    - Most Hard Disks
    - Many Flexible Disks

- **Constant Linear Velocity (CLV)**
  - Rotational Speed Varies
  - Data Density Is Constant
    - Some Flexible Disks
    - CD/ROMs
Programmable Logic Device

- Allows the development of inexpensive "custom" chip functions
- Types of PLDs
  - PROM
    - Form of Memory Device
    - Program the Truth Table of a Function
  - Programmable Logic Array (PLA)
    - Standard Chip
    - Based on Minterm Structure of Boolean Expressions
    - Inputs Connected by Fuses to AND/OR gates
  - PAL
    - Similar to PLAs
    - Easier to Program than a PLA

Structure of PLAs
Programmable Logic Arrays

- Procedure
  - Write Combinational Logic as Sum of Minterms
  - Program Minterms in First Array
  - Program Sums in Second Array
  - Programming by Burning Fuses
- Programmable Array Logic (PAL)
  - Like PLA
  - OR is not Programmable