11.3 SC Memories: Types and Architectures

Reading Assignment: pp. 1028-1030

Digital Computers use many different types of memory.

Q:

A: HO: Computer Memory

HO: Semiconductor Memories
Computer Memory

Digital Memory → Required for storing data and program instructions.

Memory Types:

- Volatile OR Non-volatile
- Main-Memory OR Mass-storage
- Read/Write OR Read Only (ROM)
- Random Access OR Serial
- Dynamic (DRAM) OR Static (SRAM)

```
Memory
  └── Main
      ├── RAM
      │    └── Dynamic
      └── ROM
      └── Static
  └── Mass
      └── Serial
          └── Tape
              └── Disk
```
General performance parameters (Read/write):

<table>
<thead>
<tr>
<th></th>
<th>Speed</th>
<th>Cost/bit</th>
<th>Volatility</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRAM</td>
<td>faster</td>
<td>$$$</td>
<td>Yes</td>
</tr>
<tr>
<td>DRAM</td>
<td>fast</td>
<td>$$</td>
<td>Yes</td>
</tr>
<tr>
<td>Serial</td>
<td>slow</td>
<td>$</td>
<td>No</td>
</tr>
</tbody>
</table>

As a result, there is no perfect computer memory—most computers will use several memory types!
Semiconductor Memories

Typically, integrated circuit memory is formed by creating multiple storage cells—each storing the value of just a single bit.

These storage cells are arranged into a two dimensional matrix. In other words, they are formed in rows and columns!

Typically, the number of rows is much greater than the number of columns. In other words, the length of each row (in bits) is much smaller than the length of each column.
Generally, the length of each row (i.e., the number of columns), is some small multiple of 1 byte (1 byte = 8 bits). For example, each row might be 1 byte (8 bits), 4 bytes (32 bits), or 16 bytes (128 bits) long!

Generally, the length of each column (i.e., the number of rows), is some large power of 2 (e.g., $2^{14}$, $2^{16}$, $2^{20}$).

Thus, we can say that typically a semiconductor memory is an arrangement of $2^M$ rows, with each row consisting of $2^N$ storage cells.

Or, we can say that a typical semiconductor memory is a matrix with $2^N$ columns, with each column consisting of $2^M$ storage cells.
Note then that each row can be uniquely identified with a $M$-bit binary word (e.g., row 5 of 16 $\rightarrow$ 0101).

Likewise, each column can be uniquely identified with an $N$-bit binary word.

Thus, we can uniquely select a storage cell by selecting the row and the column that it resides in. In other words, each storage cell can be uniquely identified by a binary word of length $MN$.

By selecting a specific row and column (by setting the proper $M$-bit and $N$-bit words), a memory device is said to enable one specific memory cell.
We can do one of two things to an enabled memory cell:

1. **We can read it** - In other words, we sense the state of that memory cell. We answer the question, is that bit high or low?

2. **We can write to it** - In other words, we place the memory cell in a desired state—we tell the memory cell the value of the bit that we want it to remember.

We “read” the value of a memory cell using **sense amplifiers**, and we “write” to them using line **drivers**.