Topics

- Levels, virtual machines, machine languages and interpretation,

- How the levels evolved over time and how they continue to evolve,

- Moore’s law, Nathan’s law and Richard Hamming’s observation about hardware and software development
Zeroth Generation – Mechanical Computers

- Pascal
  - 1st working calculating machine

- Babbage
  - Analytical engine was general-purpose

- Aiken
  - 1st American general-purpose computer (Mark I)
Harvard Architecture

- Design where physically separate data paths exist to transfer instructions and data
- Based on Mark I, which stored instructions on punched tape and data in relay latches

First Generation – Vacuum Tubes

- COLOSSUS
  – World’s 1st electronic digital computer
- ENIAC
  – Start of modern computer history
- IAS machine
  – John von Neumann at Princeton Institute of Advanced Studies
The von Neumann Architecture

- Parallel binary arithmetic
- Stored program and data
- Still basis of most digital computers

Figure 1-5: The original von Neumann machine.

Second Generation – Transistors

- Transistors invented in 1948 at Bell Labs
- PDP-8 had a single bus
- Seymour Cray designed 6600 and later supercomputers

Figure 1-4: The PDP-8 machine.
Third Generation – Integrated Circuits

- Silicon integrated circuit invented in 1958 by Robert Noyce
  - Allowed smaller, faster, cheaper computers

- IBM’s family of computers
  - Single product line

- Multiprogramming
  - Several programs in memory to utilize idle time

Fourth Generation – VLSI

- 1st personal computers sold in kits
  - All assembly and programming required

- Birth of Apple computers

- Rise of Microsoft

- IBM PC and “Attack of the Clones”
Next Generation?

- Quantum (molecular) computing
- Organic compounds/materials
- Your breakthrough invention???

Moore’s Law

The number of transistors on a chip doubles every 18 months

*Gordon E. Moore, Intel co-founder*

- Empirical observation
- Self-fulfilling prophecy
Nathan’s First Law of Software

Software is a gas. It expands to fill the container holding it.

*Nathan Myhrvold, Microsoft Corp.*

Hamming’s Observation

A change of an order of magnitude in quantity causes a change in quality.

*Richard Hamming, Bell Labs*

<table>
<thead>
<tr>
<th>Type</th>
<th>Price ($)</th>
<th>Example application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disposable computer</td>
<td>1</td>
<td>Greeting cards</td>
</tr>
<tr>
<td>Embedded computer</td>
<td>10</td>
<td>Watches, cars, appliances</td>
</tr>
<tr>
<td>Game computer</td>
<td>100</td>
<td>Home video games</td>
</tr>
<tr>
<td>Personal computer</td>
<td>1K</td>
<td>Desktop or portable computer</td>
</tr>
<tr>
<td>Server</td>
<td>10K</td>
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<td>Collection</td>
<td>100K</td>
<td>Departmental minisupercomputer</td>
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<tr>
<td>Mainframe</td>
<td>1M</td>
<td>Batch data processing in a bank</td>
</tr>
<tr>
<td>Supercomputer</td>
<td>10M</td>
<td>Long range weather prediction</td>
</tr>
</tbody>
</table>

*Figure 1.9. The current spectrum of computers available. The prices should be taken with a grain (or better yet, a metric ton) of salt.*
Two Design Strategies

- Build more computer at constant price
- Build same computer cheaper