The High Walls Have Crumpled

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Economy

- Creation of Wealth
- Distribution of Wealth
Technology

- Application of Scientific Knowledge to the Solution of Practical Problems
Education

- Discovery of Knowledge
- Production of Human Resources
Economy: Creation of Wealth

- Labor Force = Wealth
- Natural Resources = Wealth
- Technology = Wealth
Labor Force = Wealth

- Large Population
- Slaves
- Expatriates, Migrant Workers
- Sweatshops
- Steam Engine: First Industrial Revolution
Natural Resources = Wealth

- Gold, Coal, Iron, Oil, etc.
- Territory, Colony
- Cartels
Technology = Wealth

- Aerospace, Communication, Information, Medical, ....
- Fashion, Music, Literature, ....
- Knowledge
- Talents
Labor Force $\rightarrow$ Wealth

Reduction
Natural Resources ➔ Wealth

Depletion
Technology $\iff$ Wealth

Mutual Enhancement
Semiconductor Industry

- Design
  - Tools: design simulation emulation
  - Equipment: $3.4 billion

- Fabrication
  - Equipment: $16.8 billion

- Packaging
  - Equipment: $2.0 billion

- Test
  - Equipment: $5.2 billion

Total:
- IC: $200 billion
Making Sausages

Piglet → Pig → Pork → Sausages → Packaging
High Tech Industry

- Rapid advancement in technology
- Low cost products
- Unbounded market needs
- Short product life
- Capital intensive
- Brain power intensive
Rapid Advancement in Technology
( Semiconductor Industry )

Thickness of skin is 100 µm
Diameter of a piece of hair is 50 µm
Finger nails grow by 1 µm in 10 minutes
Low Cost
(Semiconductor Industry)

- A transistor cost $30 in 1960
- 8080 (5,000 tx) cost $150 in 1974
  - 3 cents/tx
- Pentium-II (7,500,000 tx) cost $225 in 1997
  - 0.003 cents/tx

- 1,000 fold decrease from 1960 to 1974
- 1,000,000 fold decrease from 1960 to 1997
Cheaper and Better Systems
Greater and Greater Market Needs

<table>
<thead>
<tr>
<th>Year</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
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</thead>
<tbody>
<tr>
<td>¥ X</td>
<td>2.1</td>
<td>9.9</td>
<td>18.5</td>
<td>31.3</td>
<td>60</td>
<td>68</td>
<td>67</td>
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<tr>
<td>ASP</td>
<td>17,550</td>
<td>13,975</td>
<td>11,050</td>
<td>9,230</td>
<td>6,094</td>
<td>5,460</td>
<td>4,924</td>
</tr>
</tbody>
</table>

- 1997: 528 ¥ à DVD¼ ü
- 2001: 5,500 ¥ à DVD¼ ü
- 2002: 16,000 ¥ à DVD¼ ü

Introduction to the graph:
- Vertical axis: ¥
- Two lines: ¥ and ASP

Notes:
- The graph shows a significant increase in ¥ and ASP over the years.
- The percentage changes indicate a steady increase in market needs.
- The data for 1997 and 2001 highlight the significant growth in DVD sales.
Technology

- rapid advancement in technology
- miniaturization, low cost
- cheaper, smaller, faster systems
- greater market needs

Moore’s Law
Rapid Advancement in Technology

The High Walls Have Crumpled
Programmable Logic

ASIC
Optical, Electro-mechanical

Electrical
Design

Manufacturing
Tools

Design
Rapid Advancement in Manufacturing Technology
Design Technology
Test Technology

The High Walls Have Crumpled
What does an engineer do?
Putting things together!

Integration!

\[ \int x \, dx \]
A Microelectronic System-on-a-Chip (SOC)
- A Microelectronic System on a Chip (SoC)
- It used to be
  - System-in-a-Package  Multi-chip Module
  - System-on-a-Board  Printed Circuit Board
  - System-in-a-Cabinet
  - System-in-a-Room
System-on-a-Chip

Hardware

Digital Circuits
- Interface Circuits
- Memories
- Analog Circuits
- Input-Output Devices

Software: Operating Systems
Application Programs
System-on-a-Chip (SoC)
(An Example of Technology Advancement)

- rapid advancement in technology
- miniaturization, low cost
- cheaper, smaller, faster systems
- greater market needs
Integration – Advantages

- Improvement in Performance
- Reduction in Size
- Reduction in Cost
- Easy to Assemble
- Energy Efficient
Heterogeneity – New/Old Technical Issues

- Design Objectives
- System Integration
- Design Complexity: Reusable Components (Intellectual Properties)
- Hardware/Software Co-Design
- Analog and Mixed Signal Circuit and System Design
- Processing
Design Objectives

- Digital Circuits : Speed
- Memories : Density
- Mixed Signal Circuits : Compatibility
- Analog Circuits : Precision
- Input-Output Devices : Sensitivity, Size, Power
Design Objectives

- Design for Manufacturing
- Design for Testability
- Design for Performance
- Design for Low Power
- Design for Low Cost
- Design for Time-to-Market
System Integration

- Platform-based
  - Memory
  - Processor
    - I/O
  - Cores
    - IP
    - Glue
    - Core

- Core-based

- Synthesis-based
  - CU
  - DP
## Design Complexity: Reusable Components (Intellectual Properties, IP)

<table>
<thead>
<tr>
<th>IP</th>
<th>Subroutine</th>
<th>Reusable Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft IP</td>
<td>Algorithm</td>
<td>HDL Description</td>
</tr>
<tr>
<td>Firm IP</td>
<td>C++ Program</td>
<td>Gate-Level Netlist</td>
</tr>
<tr>
<td>Hard IP</td>
<td>Binary Code</td>
<td>Silicon Block</td>
</tr>
</tbody>
</table>
IP – New Design Methodology

- Export (IP creation)
  - implementation, documentation, test, customer support,…

- Import (IP selection)
  - catalog, evaluation, qualification,…

- Compatibility
  - protocols, interfaces,…

- IP Protection
  - water mark, finger printing, encryption,…

- Design reuse cost minimization
  - enhancements, process migration, version control,…
IP – New Business Model

IP Provider
- Library
- Documentation
- Quality Assurance
- Standardization
- Services

IP Vendor
- Business Model
- Legal Issues
- Security

IP Integrator
- Exploration
- Methodology
- Environment
- Standardization

IP Tool Provider
Hardware-Software Co-Design – New Design Methodology

- Partitioning
- Co-specification, co-analysis, co-design, co-simulation, co-verification
- Interface synthesis
Analog and Mixed Signal System and Circuits

- Design
- A/D, D/A Conversion
Processing

- Processing Technology
- Yield:
  Product of Yields of Components

\[0.9 \times 0.9 \times 0.9 = 0.729\]
System-on-a-Chip

New Technology Advancement

- Will push semi-conductor technology forward
- Will invigorate the economy
- Will demand human resources from universities
Concluding Remarks

A Peaceful, Prosperous, and Happy World

Economy

Education  Technology