Introduction

Chapter 1

The Digital Computer

- Machine to carry out instructions
  - A program
- Instructions are simple
  - Add numbers
  - Check if a number is zero
  - Copy data between memory locations
- Primitive instructions in machine language

Languages, Levels, and Virtual Machines (1)

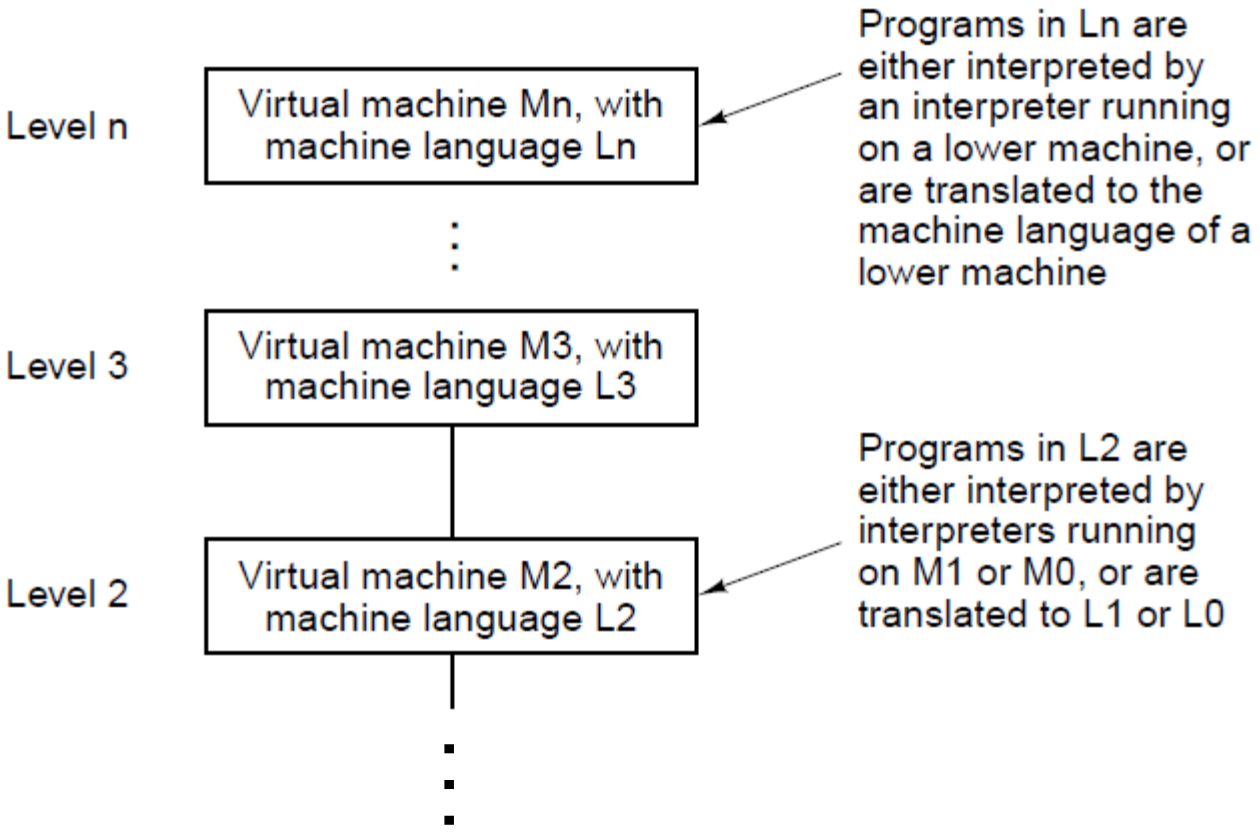

Figure 1-1. A multilevel machine.

Languages, Levels, and Virtual Machines (2)

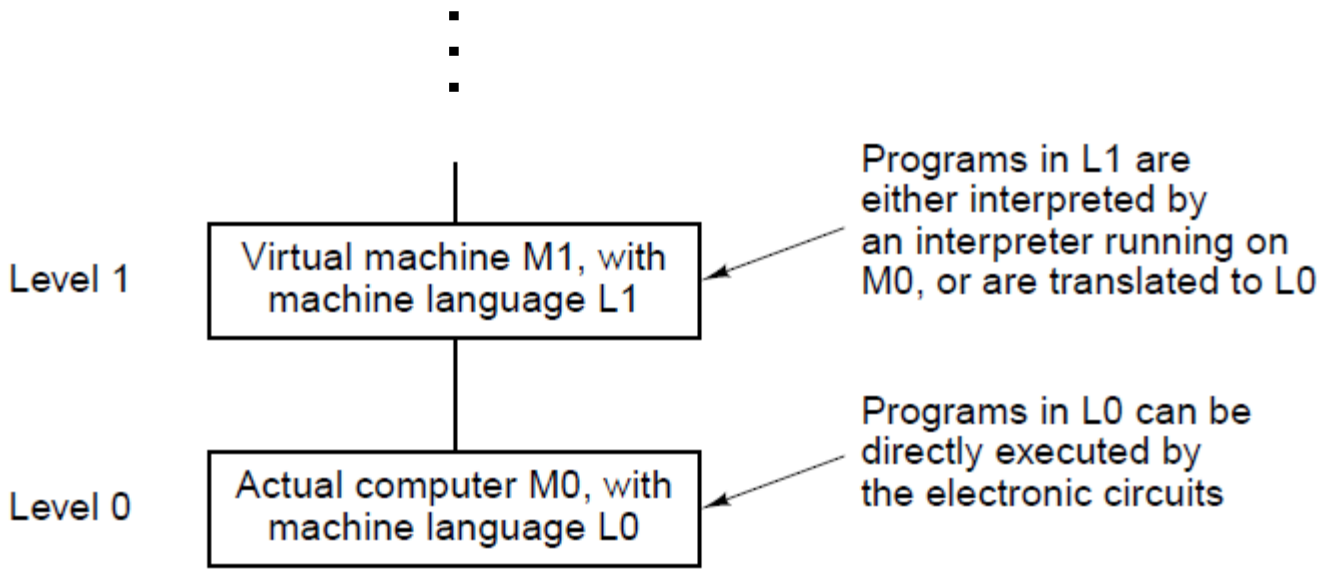

Figure 1-1. A multilevel machine.

Contemporary Multilevel Machines (1)

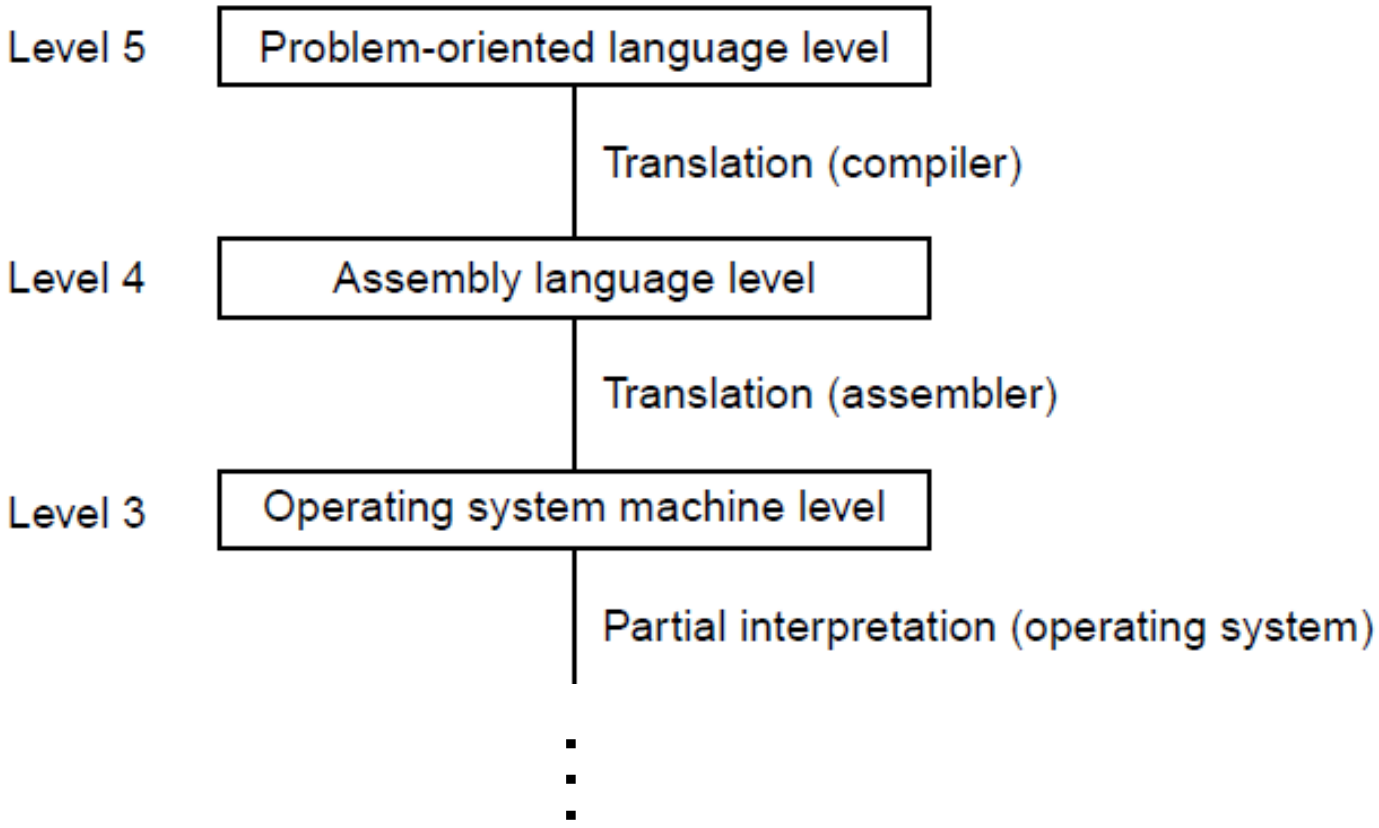

Figure 1-2. A six-level computer. The support method for each level is indicated below it (along with the name of the supporting program).

Contemporary Multilevel Machines (2)

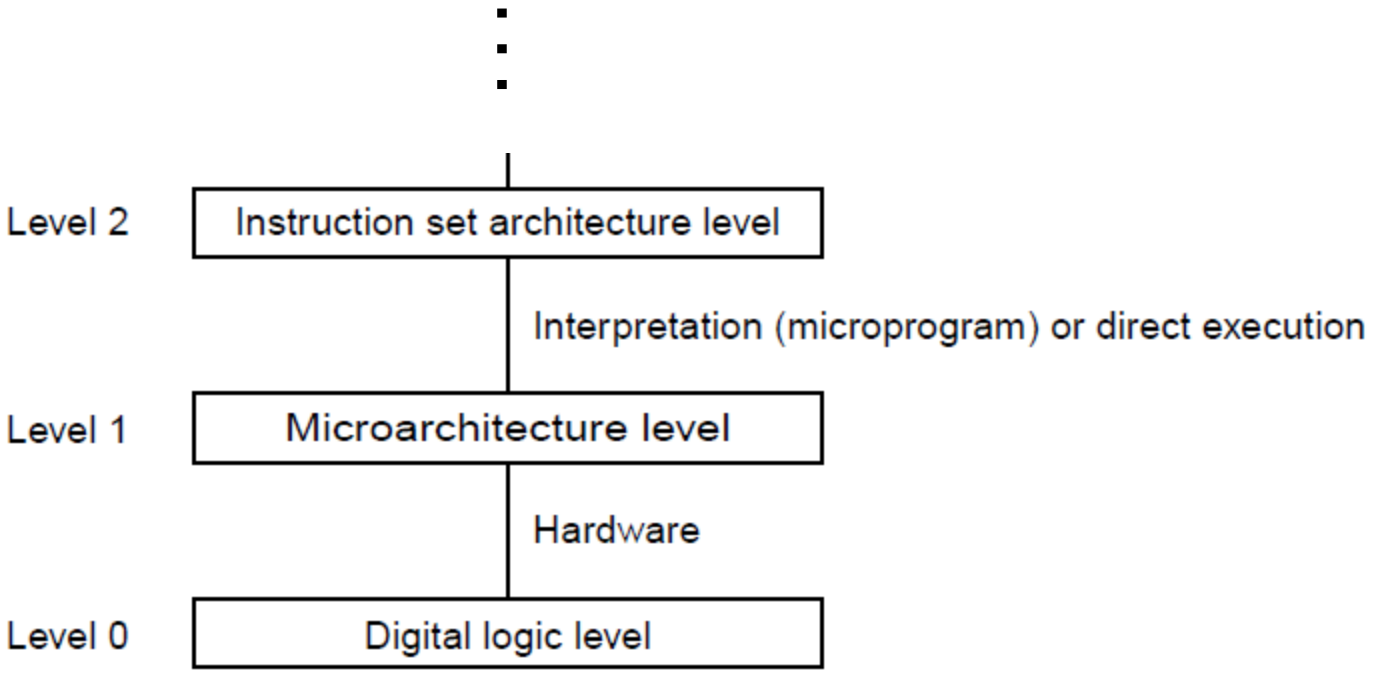

Figure 1-2. A six-level computer. The support method for each level is indicated below it (along with the name of the supporting program).

Evolution of Multilevel Machines

- Invention of microprogramming
- Invention of operating system
- Migration of functionality to microcode
- Elimination of microprogramming

Operating System Tasks

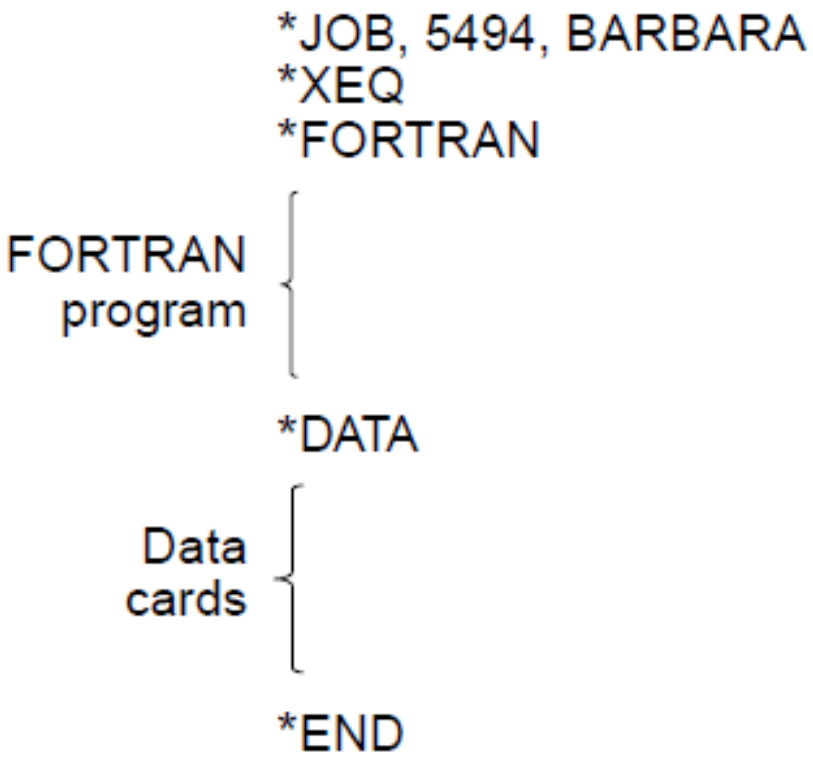

Figure 1-3. A sample job for the FMS operating system.

Increased Functionality in Microcode (1)

- Instructions for integer multiplication and division
- Floating-point arithmetic instructions
- Instructions for calling and returning from procedures
- Instructions for speeding up looping
- Instructions for handling character strings
- Indexing and indirect addressing
- Relocation facilities
- Interrupt systems
- Process switching
- Processing audio, image, multimedia files

Milestones (1)

Year	Name	Made by	Comments
1834	Analytical Engine	Babbage	First attempt to build a digital computer
1936	Z1	Zuse	First working relay calculating machine
1943	COLOSSUS	British gov't	First electronic computer
1944	Mark I	Aiken	First American general-purpose computer
1946	ENIAC	Eckert/Mauchley	Modern computer history starts here
1949	EDSAC	Wilkes	First stored-program computer
1951	Whirlwind I	M.I.T.	First real-time computer
1952	IAS	Von Neumann	Most current machines use this design
1960	PDP-1	DEC	First minicomputer (50 sold)
1961	1401	IBM	Enormously popular small business machine

⋮

Figure 1-4. Some milestones in the development of the modern digital computer.

Milestones (2)

Year	Name	Made by	Comments
1962	7094	IBM	Dominated scientific computing in the early 1960s
1963	B5000	Burroughs	First machine designed for a high-level language
1964	360	IBM	First product line designed as a family
1964	6600	CDC	First scientific supercomputer
1965	PDP-8	DEC	First mass-market minicomputer (50,000 sold)
1970	PDP-11	DEC	Dominated minicomputers in the 1970s
1974	8080	Intel	First general-purpose 8-bit computer on a chip
1974	CRAY-1	Cray	First vector supercomputer
1978	VAX	DEC	First 32-bit superminicomputer
1981	IBM PC	IBM	Started the modern personal computer era

⋮

Figure 1-4. Some milestones in the development of the modern digital computer.

Milestones (3)

Year	Name	Made by	Comments
1983	Lisa	Apple	First personal computer with a GUI
1985	386	Intel	First 32-bit ancestor of the Pentium line
1985	MIPS	MIPS	First commercial RISC machine
1985	XC2064	Xilinx	First field-programmable gate array (FPGA)
1987	SPARC	Sun	First SPARC-based RISC workstation
1989	GridPad	Grid Systems	First commercial tablet computer
1990	RS6000	IBM	First superscalar machine
1992	Alpha	DEC	First 64-bit personal computer
1992	Simon	IBM	First smartphone
1993	Newton	Apple	First palmtop computer (PDA)
2001	POWER4	IBM	First dual-core chip multiprocessor

Figure 1-4. Some milestones in the development of the modern digital computer.

Computer Generations

- Zeroth Generation Mechanical Computers (1642 – 1945)
- First Generation Vacuum Tubes (1945 – 1955)
- Second Generation Transistors (1955 – 1965)
- Third Generation Integrated Circuits (1965 – 1980)
- Fourth Generation Very Large Scale Integration (1980 – ?)
- Fifth Generation Low-Power and Invisible Computers

von Neumann Machine

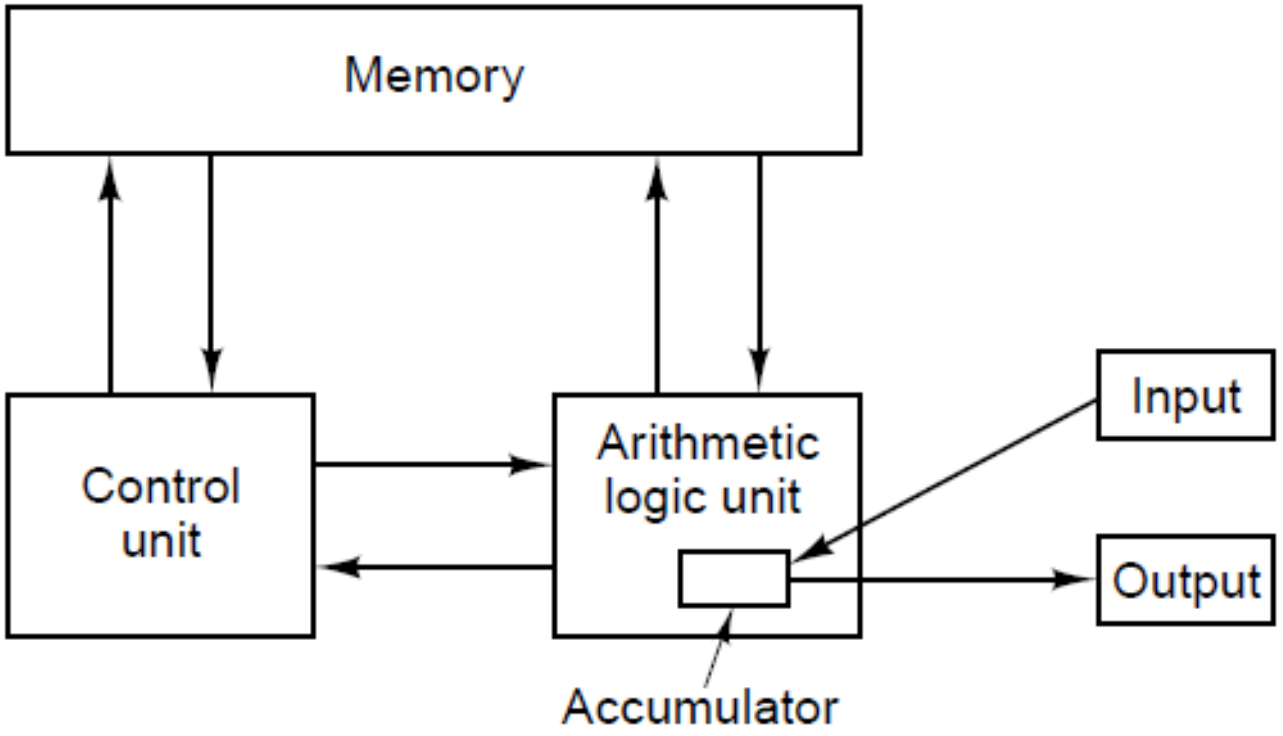

Figure 1-5. The original von Neumann machine.

PDP-8 Innovation – Single Bus

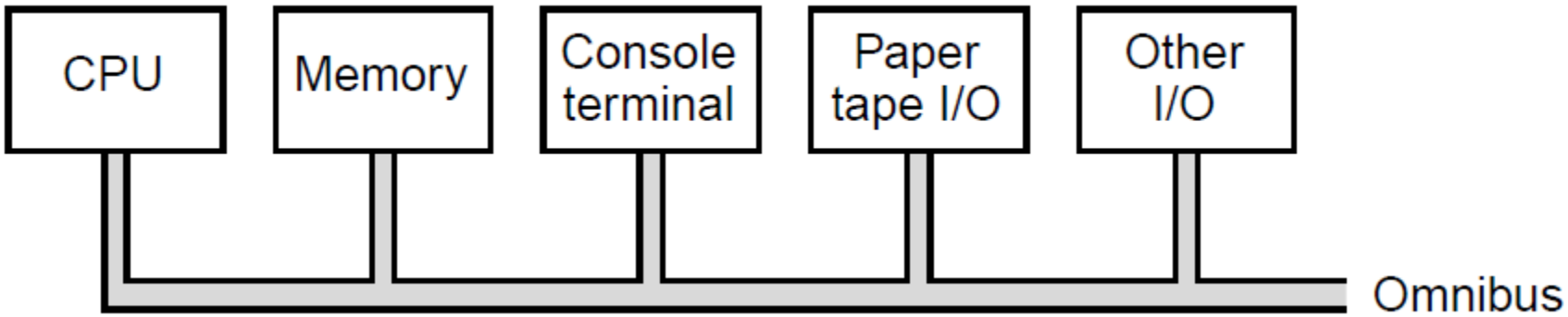

Figure 1-6. The PDP-8 omnibus.

IBM 360

Property	Model 30	Model 40	Model 50	Model 65
Relative performance	1	3.5	10	21
Cycle time (in billionths of a sec)	1000	625	500	250
Maximum memory (bytes)	65,536	262,144	262,144	524,288
Bytes fetched per cycle	1	2	4	16
Maximum number of data channels	3	3	4	6

Figure 1-7. The initial offering of the IBM 360 product line.

Technological and Economic Forces

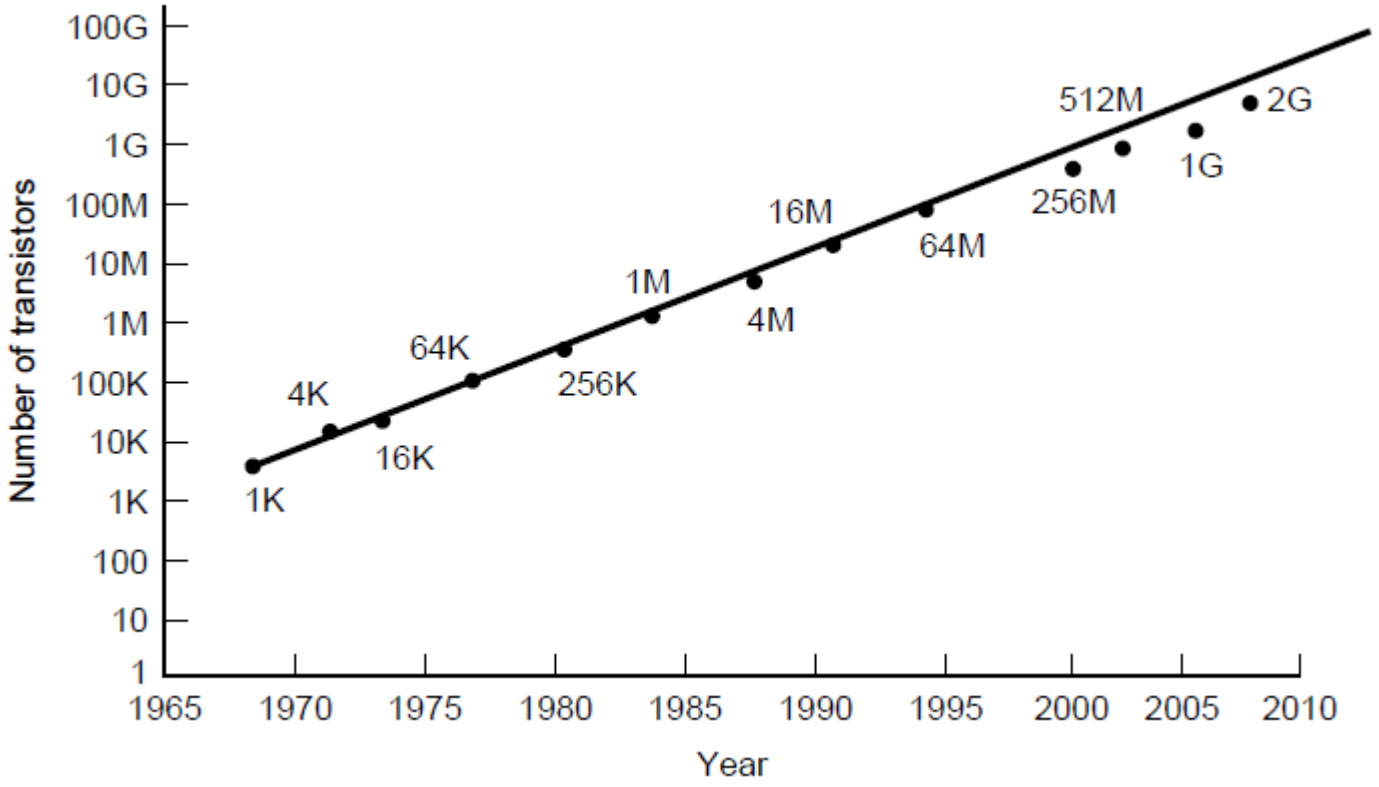

Figure 1-8. Moore's law predicts a 60 percent annual increase in the number of transistors that can be put on a chip. The data points given above and below the line are memory sizes, in bits.

The Computer Spectrum (1)

Type	Price ($)	Example application
Disposable computer	0.5	Greeting cards
Microcontroller	5	Watches, cars, appliances
Mobile and game computers	50	Home video games and smartphones
Personal computer	500	Desktop or notebook computer
Server	5K	Network server
Mainframe	5M	Batch data processing in a bank

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.

The Computer Spectrum (2)

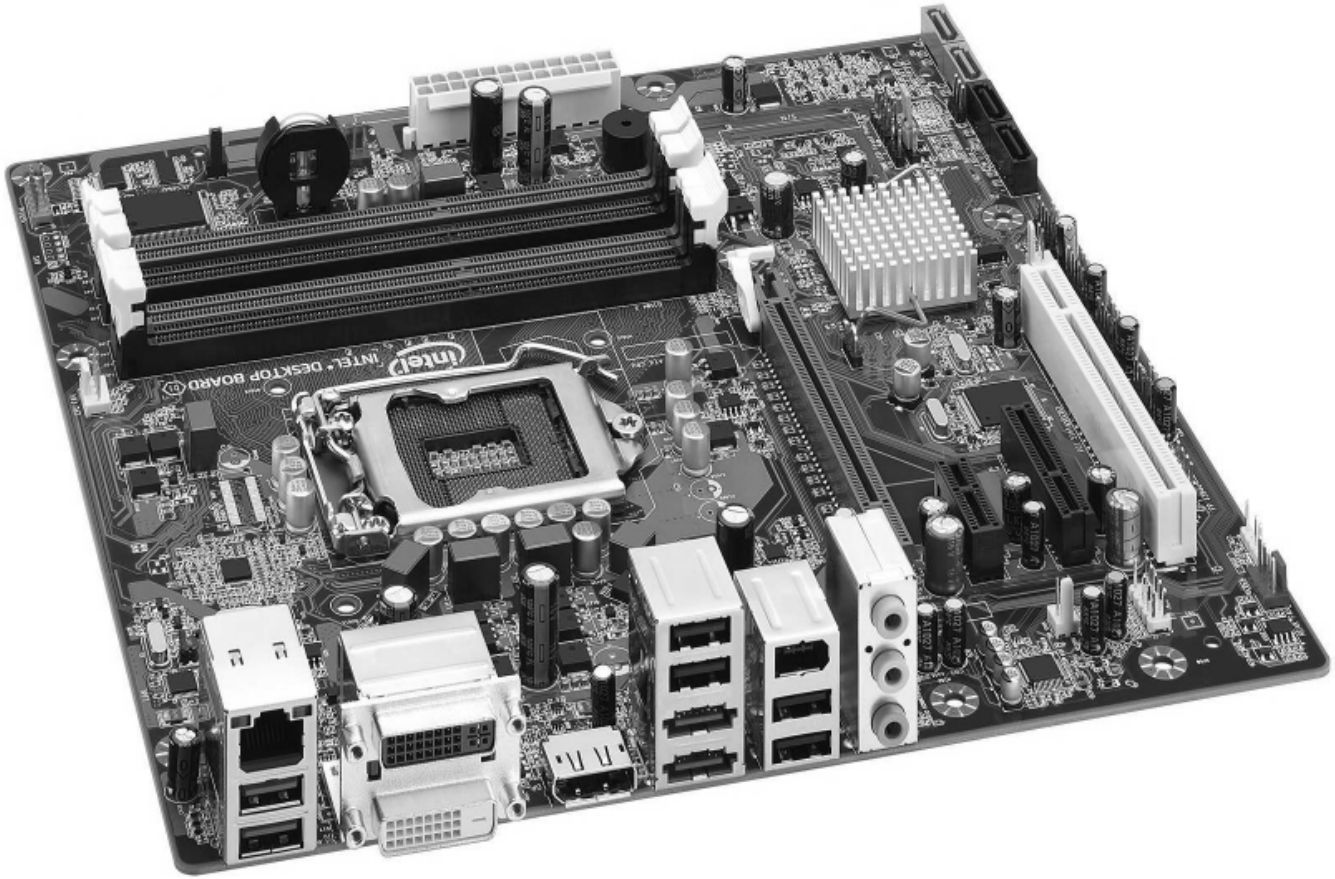

Figure 1-10. A printed circuit board is at the heart of every personal computer. This one is the Intel DQ67SW board. © 2011 Intel Corporation. Used by permission.

Microcontrollers

- Appliances
- Communications gear
- Computer peripherals
- Entertainment devices
- Imaging devices
- Medical devices
- Military weapon systems
- Shopping devices
- Toys

Introduction to the x86 Architecture (1)

Chip	Date	MHz	Trans.	Memory	Notes
4004	4/1971	0.108	2300	640	First microprocessor on a chip
8008	4/1972	0.108	3500	16 KB	First 8-bit microprocessor
8080	4/1974	2	6000	64 KB	First general-purpose CPU on a chip
8086	6/1978	5–10	29,000	1 MB	First 16-bit CPU on a chip
8088	6/1979	5–8	29,000	1 MB	Used in IBM PC
80286	2/1982	8–12	134,000	16 MB	Memory protection present
80386	10/1985	16–33	275,000	4 GB	First 32-bit CPU
80486	4/1989	25–100	1.2M	4 GB	Built-in 8-KB cache memory

⋮

Figure 1-11. Key members of the Intel CPU family. Clock speeds are measured in MHz (megahertz), where 1 MHz is 1 million cycles/sec.

Introduction to the x86 Architecture (2)

Chip	Date	MHz	Trans.	Memory	Notes
Pentium	3/1993	60–233	3.1M	4 GB	Two pipelines; later models had MMX
Pentium Pro	3/1995	150–200	5.5M	4 GB	Two levels of cache built in
Pentium II	5/1997	233–450	7.5M	4 GB	Pentium Pro plus MMX instructions
Pentium III	2/1999	650–1400	9.5M	4 GB	SSE Instructions for 3D graphics
Pentium 4	11/2000	1300–3800	42M	4 GB	Hyperthreading; more SSE instructions
Core Duo	1/2006	1600–3200	152M	2 GB	Dual cores on a single die
Core	7/2006	1200–3200	410M	64 GB	64-bit quad core architecture
Core i7	1/2011	1100–3300	1160M	24 GB	Integrated graphics processor

Figure 1-11. Key members of the Intel CPU family. Clock speeds are measured in MHz (megahertz), where 1 MHz is 1 million cycles/sec.

Introduction to the x86 Architecture (3)

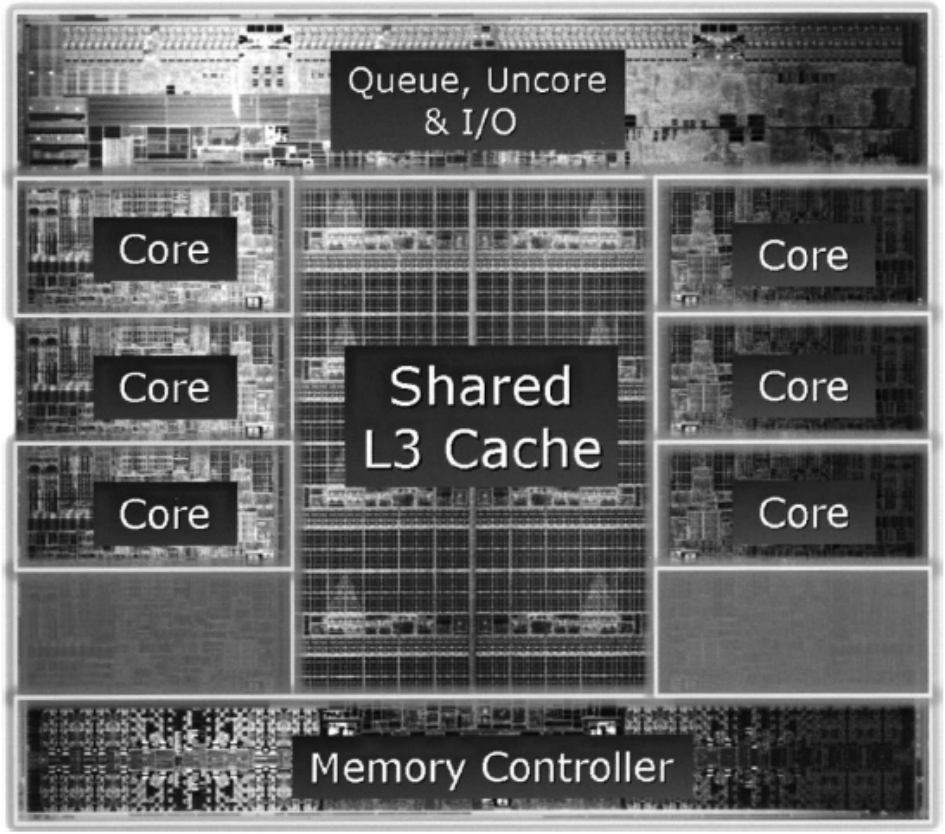

Figure 1-12. The Intel Core i7-3960X die. The die is 21 by 21 mm and has 2.27 billion transistors. © 2011 Intel Corporation. Used by permission.

Introduction to the x86 Architecture (4)

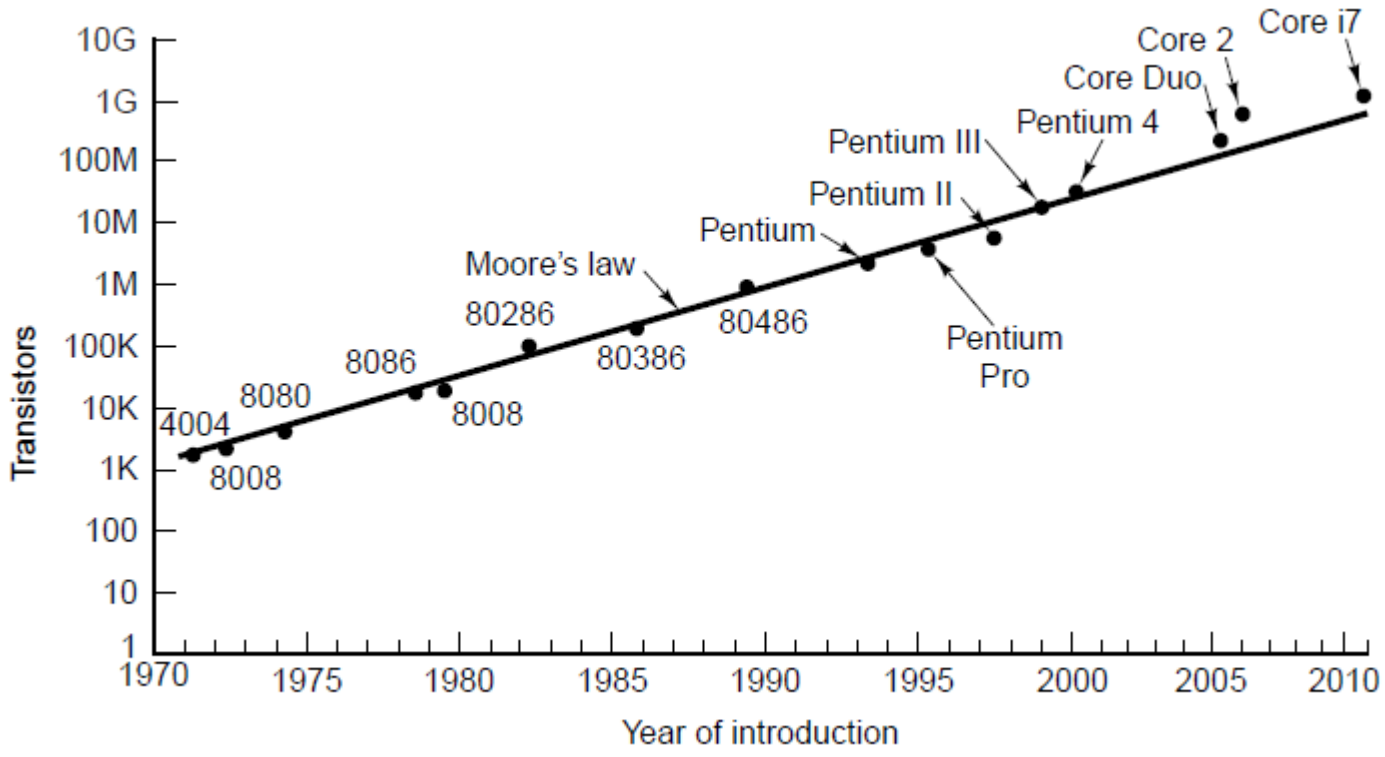

Figure 1-13. Moore's law for (Intel) CPU chips.

Introduction to the ARM Architecture

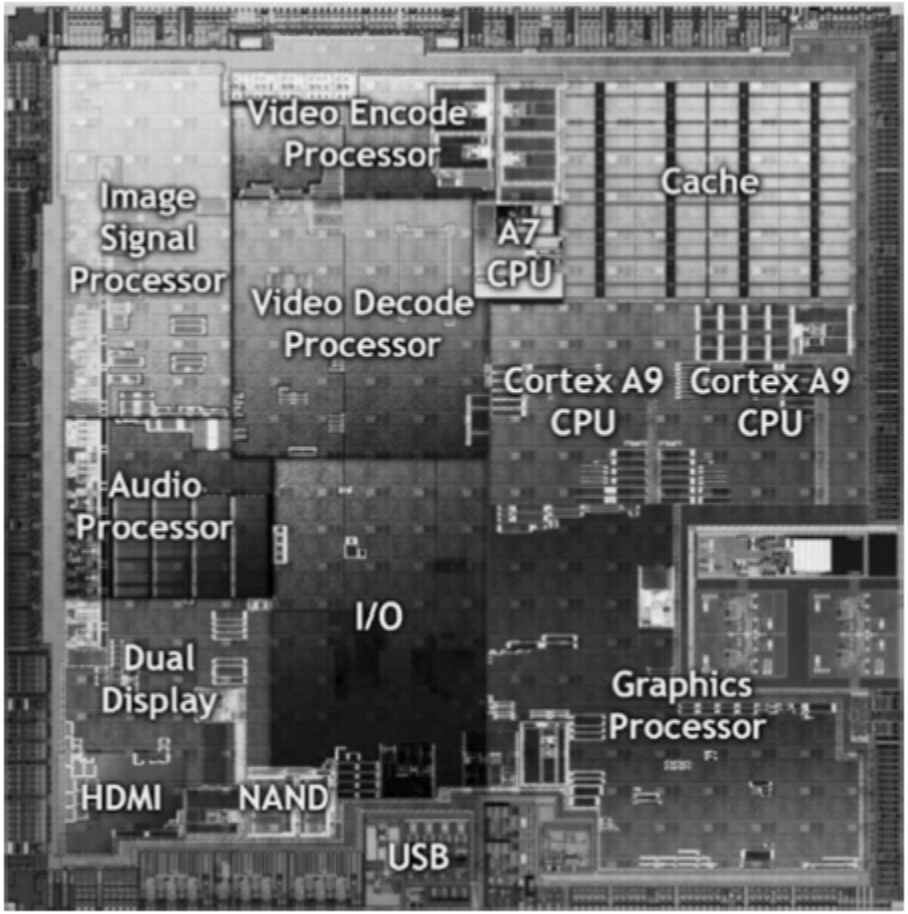

Figure 1-14. The Nvidia Tegra 2 system on a chip.

Introduction to the AVR Architecture

Chip	Flash	EEPROM	RAM	Pins	Features
tinyAVR	0.5–16 KB	0–512 B	32–512 B	6–32	Tiny, digital I/O, analog input
megaAVR	8–256 KB	0.5–4 KB	0.25–8 KB	28-100	Many peripherals, analog out
AVR XMEGA	16–256 KB	1–4 KB	2–16 KB	44–100	Crypto acceleration, USB I/O

Figure 1-15. Microcontroller classes in the AVR family.

Peripherals in the Atmel megaAVR-168

- Three timers
- Real-time clock with oscillator
- Six pulse-width modulation channels
- Eight analog-to-digital conversion channels
- Universal serial receiver/transmitter
- I2C serial interface
- Programmable watchdog timer
- On-chip analog comparator
- Power brown-out detector
- Internal programmable clock oscillator

Metric Units

Exp.	Explicit	Prefix	Exp.	Explicit	Prefix
10^{-3}	0.001	milli	10^{3}	1,000	kilo
10^{-6}	0.000001	micro	10^{6}	1,000,000	mega
10^{-9}	0.000000001	nano	10^{9}	1,000,000,000	giga
10^{-12}	0.000000000001	pico	10^{12}	1,000,000,000,000	tera
10^{-15}	0.000000000000001	femto	10^{15}	1,000,000,000,000,000	peta
10^{-18}	0.000000000000000001	atto	10^{18}	1,000,000,000,000,000,000	exa
10^{-21}	0.000000000000000000001	zepto	10^{21}	1,000,000,000,000,000,000,000	zetta
10^{-24}	0.000000000000000000000001	yocto	10^{24}	1,000,000,000,000,000,000,000,000	yotta

Figure 1-16. The principal metric prefixes.

End

Chapter 1