Chapter 5
Moore's Law: Fast, Cheap Computing and What It Means for the Manager

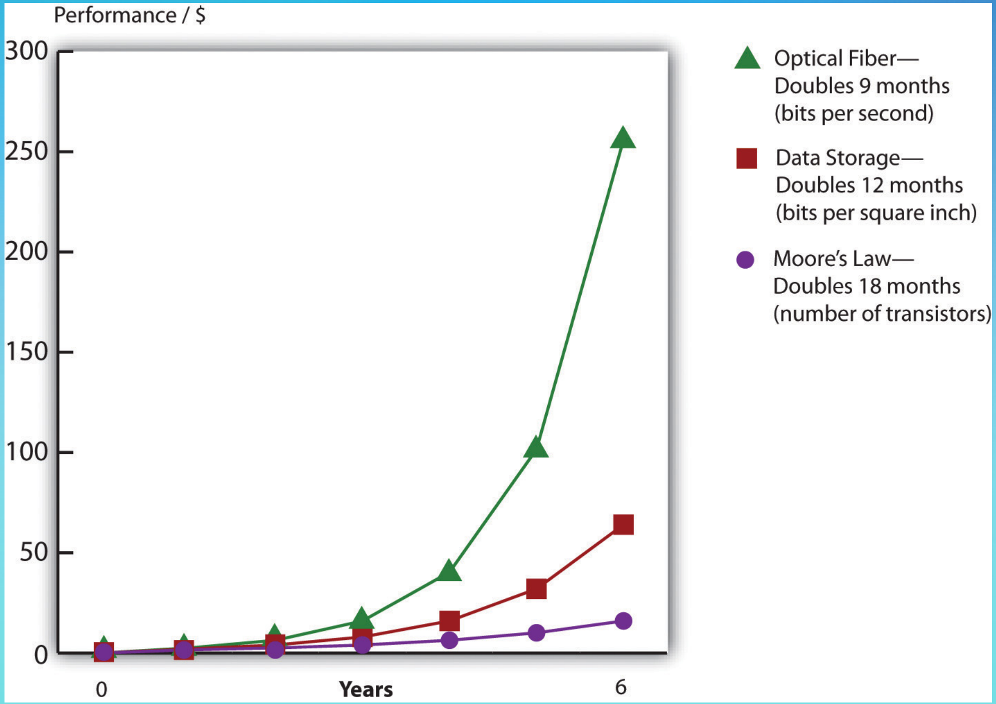
Some Definitions

- **Moore's Law**: Chip performance per dollar doubles every eighteen months
- **Microprocessor**: The part of the computer that executes the instructions of a computer program
- **Random-access memory (RAM)**: The fast, chip-based volatile storage in a computing device
- **Volatile memory**: Storage (such as RAM chips) that is wiped clean when power is cut off from a device
- **Nonvolatile memory**: Storage that retains data even when powered down (such as flash memory, hard disk, or DVD storage)

Some Definitions

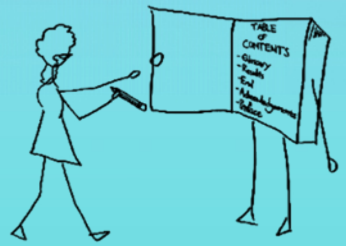
- **Flash memory:** Nonvolatile, chip-based storage, often used in mobile phones, cameras, and MP3 players
- **Solid state electronics:** Semiconductor-based devices
- **Semiconductors:** A substance such as silicon dioxide used inside most computer chips that is capable of enabling as well as inhibiting the flow of electricity
- **Optical fiber line:** A high-speed glass or plastic-lined networking cable used in telecommunications

Figure 5.1 - Advancing Rates of Technology (Silicon, Storage, Telecom)



Get Out Your Crystal Ball

- When technology gets cheap, **price elasticity** kicks in
- The five waves of computing over the previous five decades:
  - 1960s – Mainframe computers
  - 1970s – Minicomputers
  - 1980s – PCs
  - 1990s – Internet computing
  - Present – Ubiquitous computing



Ambient Devices and the Fifth Wave

- Ambient Devices is a "fifth wave" firm that's embedding computing and communications devices into everyday products to make them more useful and smarter
- Ambient's ability to pull off this little miracle is evidence of how quickly new markets, spawned by Moore's Law, can come into being
- Ambient has expanded the product line to several low-cost appliances designed to provide information at a glance

Get Out Your Crystal Ball

- One of the most agile surfers of this fifth wave is Apple, Inc.
  - A firm with a product line that is now so broad that in January 2007, it dropped the word "Computer" from its name
  - The high-end iPod increased song capacity by forty times in six years while dropping in cost by fifty dollars
- The change in hard drive prices isn't directly part of Moore's Law, the faster and cheaper phenomenon applies to storage
  - Example: Amazon

Bits and Bytes

- Computers express data as bits that are either one or zero
- Eight bits form a byte
- A kilobyte refers to roughly a thousand bytes, or a thousand characters
  - Megabyte = 1 million
  - Gigabyte = 1 billion
  - Terabyte = 1 trillion
  - Petabyte = 1 quadrillion
  - Exabyte = 1 quintillion bytes

Bits and Bytes

- Storage is listed in bytes
- Telecommunication capacity (bandwidth) is listed in bits per second (bps)

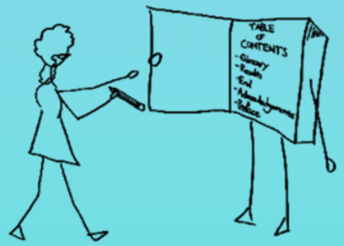


Table 5.3 - Bytes Defined

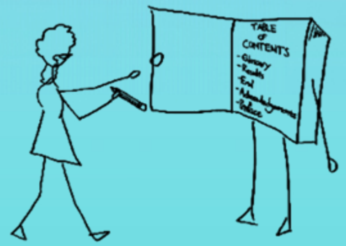
	Managerial Definition	Exact Amount	To Put It in Perspective
1 Byte	One keyboard character	8 bits	1 letter or number = 1 byte
1 Kilobyte (KB)	One thousand bytes	2^{10} bytes	1 typewritten page = 2 KB
			1 digital book (Kindle) = approx. 500—800 KB
1 Megabyte (MB)	One million bytes	2^{20} bytes	1 digital photo (7 megapixels) = 1.3 MB
			1 MP3 song = approx. 3 MB
			1 CD = approx. 700 MB
1 Gigabyte (GB)	One billion bytes	2^{30} bytes	1 DVD movie = approx. 4.7 GB
			1 Blu-ray movie = approx. 25 GB

Table 5.3 - Bytes Defined

	Managerial Definition	Exact Amount	To Put It in Perspective
1 Terabyte (TB)	One trillion bytes	2^{40} bytes	Printed collection of the Library of Congress = 20 TB
1 Petabyte (PB)	One quadrillion bytes	2^{50} bytes	eBay data warehouse (2010) = 10 PBC. Monash, "eBay Followup—Greenplum Out, Teradata > 10 Petabytes, Hadoop Has Some Value, and More," October 6, 2010. Note eBay plans to increase this value 2.5 times by the end of 2011.
1 Exabyte (EB)	One quintillion bytes	2^{60} bytes	
1 Zettabyte (ZB)	One sextillion bytes	2^{70} bytes	Amount of data consumed by U.S. households in 2008 = 3.6 ZB

Get Out Your Crystal Ball

- If you are producing products with a significant chip-based component, the chips inside that product rapidly fall in value
  - It is great when it makes your product cheaper and opens up new markets for your firm
  - It can be deadly if you overproduce and have excess inventory sitting on shelves for long periods of time
- Moore's Law impacts mundane management tasks too



The Death of Moore's Law?

- Moore's Law is possible because the distance between the pathways inside silicon chips gets smaller with each successive generation
  - Since the pathways are closer together, electrons travel shorter distances
  - If electrons travel half the distance to make a calculation, that means the chip is twice as fast
- This shrinking can't go on forever
  - Three interrelated forces—size, heat, and power—threaten to slow down Moore's Law's advance

The Death of Moore's Law?

- Microsoft, Yahoo!, and Google have all built massive data centers in the Pacific Northwest in order to benefit from cheap hydroelectric power
  - The chief eco officer at Sun Microsystems has claimed that computers draw four to five percent of the world's power
  - Google's chief technology officer has said that the firm spends more to power its servers than the cost of the servers themselves
- Chips can't get smaller forever because chip pathways can't be shorter than a single molecule and actual physical limit may be higher

Buying Time

- **Multicore microprocessors**: Microprocessors with two or more (typically lower power) calculating processor cores on the same piece of silicon
  - For many applications, the multicore chips will outperform a single speedy chip, while running cooler and drawing less power
- Multicore processors are now mainstream
  - Today, most PCs and laptops sold have at least a two-core (dual-core) processor
  - Intel has demonstrated chips with upwards of fifty cores

Buying Time

- Multicore processors can run older software written for single-brain chips
  - They usually do this by using only one core at a time
- In order to take full advantage of multicore chips, applications need to be rewritten to split up tasks so that smaller portions of a problem are executed simultaneously inside each core
- Writing code for execution in a multicore environment is challenging

Buying Time

- Another approach that's breathing more life into Moore's Law moves chips from being paper-flat devices to built-up 3-D affairs
- By building up as well as out, firms are radically boosting speed and efficiency of chips

Bringing Brains Together: Supercomputing and Grid Computing

- **Supercomputers**: Computers that are among the fastest of any in the world at the time of their introduction
- Supercomputing was once the domain of governments and high-end research labs
- Modern supercomputing is done via massively parallel processing
  - **Massively parallel**: Computers designed with many microprocessors that work together, simultaneously, to solve problems

Bringing Brains Together: Supercomputing and Grid Computing

- **Grid computing**: A type of computing that uses special software to enable several computers to work together on a common problem as if they were a massively parallel supercomputer
- Multicore, massively parallel, and grid computing are all related in that each attempts to lash together multiple computing devices so that they can work together to solve problems

E-waste: The Dark Side of Moore's Law

- The dark side to Moore's Law is discarded tech junk, referred to as electronic waste or e-waste
- Recycling is a solution to the problem

E-waste: The Dark Side of Moore's Law

- There is a disconnect between consumers and managers who want to do good and those efforts that are actually doing good
- The following points show how difficult addressing this problem will be
  - The complexities of the modern value chain
  - The vagaries of international law
  - The nefarious actions of those willing to put profits above principle
- The process of recycling is extremely labor intensive
- Disregard of ethical recycling imperatives can tarnish a brand

E-waste: The Dark Side of Moore's Law

- **E-waste:** Discarded, obsolete technology
  - It contains mainstream recyclable materials like plastics and aluminum
  - It contains small bits of increasingly valuable metals such as silver, platinum, and copper
- Recycling of e-waste is extremely labor intensive
- Managers must consider and plan for the waste created by their products, services, and technology used by the organization