

## Digital Information Storage

DBC340

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### Storing data in a digital computer

- All computers are based on the concept of "digital".
- What does *digital* mean?

### Bits/Bytes prefixes

Prefix	Abbr.	Size
Kilo	K	$2^{10} = 1,024$
Mega	M	$2^{20} = 1,048,576$
Giga	G	$2^{30} = 1,073,741,824$
Tera	T	$2^{40} = 1,099,511,627,776$
Peta	P	$2^{50} = 1,125,899,906,842,624$
Exa	E	$2^{60} = 1,152,921,504,606,846,976$
Zetta	Z	$2^{70} = 1,180,591,620,717,411,303,424$
Yotta	Y	$2^{80} = 1,208,925,819,614,629,174,706,176$ (that's a yotta bytes!)

How do hard disk companies "cheat you"?

## Agenda

- Bits and bytes
- Bandwidth (moving bits in time)
- Using 0's and 1's to represent other #'s
- Assigning #'s to keyboard characters
- Representing pictures as #'s
- Representing sound as #'s
- Addendum: the RGB color scheme

### Bits and Bytes

- A single 0 or 1 is called a **bit**.
- With one bit, you can't do a whole lot
  - The power of computers comes from working with millions, billions, or even trillions of bits per second!
- The word **byte** implies a sequence of 8 bits (a block of 4 bits is called a nybble)
- Standard abbreviations for bits and bytes
  - Lowercase "b" means bits
  - Uppercase "B" means bytes

### Where are these bits/bytes used?

- Here are some examples

- Ports:



- Processor 64 bit CPU versus 32 bit CPU
  - Process 8 bytes at a time vs. 4 bytes

Processor Name	32- or 64-bit
Intel Core Solo	32 bit
Intel Core Duo	32 bit
Intel Core 2 Duo	64 bit
Intel Quad-Core Xeon	64 bit

## Where are these bits/bytes used?

- Primary Memory (RAM)
  - 4GB (two 2GB SO-DIMMs) of 1066MHz DDR3 memory; two SO-DIMM slots support up to 8GB
- Secondary Hard disks
  - 250GB, 320GB, or 500GB 5400-rpm Serial ATA hard drive; optional 320GB or 500GB 7200-rpm hard drive, or 32GB or 256GB solid-state drive<sup>1</sup>
- Other places as well...
  - All models: NVIDIA GeForce 9400M graphics processor with 256MB of DDR3 SDRAM shared with main memory<sup>1</sup>

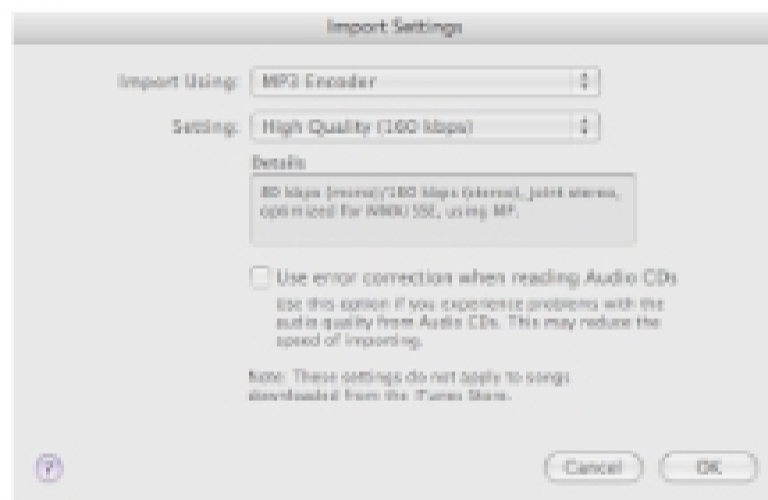


## Moving bits in time ("bandwidth")

- Two standard ways to introduce time into the discussion
  - State **Hz** (i.e., **cycles per sec**) rate, with each cycle moving some # of bits
    - e.g., "DDR-400" memory cards have the following specs:
      - Data Transfer Rate: 400 MHz
      - # of bits moved at a time: 64 bits
    - What data bandwidth does that imply?
      - $64 \text{ bits} \times 400 \text{ M cycles/sec} = 25,600 \text{ M bits /sec}$
      - $= 3,200 \text{ MB/sec}$
    - 3,200 MB/sec is in fact the "Peak Transfer Rate" of DDR-400 memory
  - We sometimes see the more directly stated **Bits/sec** (or **bytes/sec**) values
    - ...see example on next slide

## Moving bits in time ("bandwidth")

- From iTunes



## How many mp3 songs?

- Does 7,000 songs make sense? (Apple assume 4 min/song)
- Each song takes 9 MB
- Apple-assumed 128 Kbps MP3 = 16 KB / sec \* 4 min = 16 KB/sec \* 240 sec = 3840 KB = 3.84 MB
- 32,000 MB / 3.84 MB/song = approx. 8,000 songs



### Audio

- Frequency: 16,000 Hz to 20,000 Hz
- Audio formats supported: AAC @ 128 Kbps, Protected AAC (from iTunes Store), MP3 @ 128 Kbps, MP3 VBR, Audible (formats 1, 2), and 3x Apple Lossless, AIF, and WAV

### Capacity

- 11 GB or 14 GB flash drive<sup>2</sup>
- 14 GB up to 7,000 or 14,000 songs in 128 Kbps AAC format<sup>2</sup>

Makes sense... Apple conservatively estimates 7,000 due to other issues (wasted space on the drive, space consumed by software and file "meta data")

## Moving bits in time ("bandwidth")

- From Comcast

**The New Comcast High-Speed Internet**

Types of service (download/upload speeds)

Performance: 10 Mbps/3 Mbps (up to 15 Mbps/3 Mbps with PowerBoost)

Speed: 10 Mbps/3 Mbps (up to 20 Mbps/3 Mbps with PowerBoost)

Ultra: 20 Mbps/6 Mbps (up to 30 Mbps/7 Mbps with PowerBoost)

Extreme: 30 Mbps/10 Mbps

- From QWest

**Shop Internet Services**

Service

- Connection speeds up to 1.5 Mbps
- Connection speeds up to 7 Mbps
- Connection speeds up to 12 Mbps
- Connection speeds up to 20 Mbps

Internet: Wired/Local/Phone

Special Offers

Remember: Mbps (lowercase "b") means mega bits per second

## Moving bits in time ("bandwidth")

- Wireless networking

**Netgear WNDR37 Wireless Router** 54Mbps, 802.11g, 4 Port

Item Number: N326-0470

Model: WNDR37

Availability: Order Today, Ships Today

Price: **\$44.99**

Protect Your Investment

Choose from selected service plans as low as \$14.99

Quantity: 1

**ADD TO CART**

- Approx. how many megabytes should you theoretically (i.e., perfect connection, no other users, etc.) be able to transfer wireless per second, using this router?

## Be an informed consumer of IT

- For example, consider interface bandwidths
  - USB2 : 480 Mbps
  - Firewire-400 : 400 Mbps
- The latest
  - USB3 : 5,000 Mbps
  - Thunderbolt (Apple/Intel collaboration) : 10,000 Mbps
- Important concept: these speeds are virtually never realized due to **bottlenecks**
  - e.g., digital camera with photos/video on 300 Mbps Flash card, connected to your computer via 10,000 Mbps Thunderbolt. What bandwidth will you realize?

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## Using 0's and 1's to represent other #'s

- Using 0's and 1's and a scheme that we devise, we can create correspondences between these bits and our real-world stuff (our "normal" numbers, text, and pictures)
- For example, consider the **binary counting** scheme in contrast with our more familiar **decimal counting** scheme.
- Consider the bits: 1 1 0 0 1

	1	1	0	0	1
Binary counting scheme	A 16 ( $2^4$ )	A 8 ( $2^3$ )			A one
Decimal counting scheme	A 10000 ( $10^4$ )	A 1000 ( $10^3$ )			A one

## Using 0's and 1's to represent other #'s

- Therefore, looking at the string of values 1 1 0 0 1, using...
  - Decimal counting, we interpret that string as meaning the quantity eleven thousand and one
  - Binary counting, we interpret that string as meaning twenty five

	1	1	0	0	1
Binary scheme	A 16 ( $2^4$ )	A 8 ( $2^3$ )			A one
Decimal scheme	A 10000 ( $10^4$ )	A 1000 ( $10^3$ )			A one

Sum = twenty five

Sum = eleven thousand & one

## Using 0's and 1's to represent other #'s

- Let's consider a **byte**'s worth of bits
- Minimum possible value: 0 0 0 0 0 0 0 0.
  - This byte represents the value \_\_\_\_\_?
- Maximum possible value: 1 1 1 1 1 1 1 1.
  - This byte represents the value \_\_\_\_\_?
  - Mathematically, this is  $2^8 - 1$ .
- Let's consider **two bytes** worth of bits
  - Consider the string **11111111 11111111**
    - What number does this represent?
    - $2^{16} - 1$  is ?

## Using 0's and 1's to represent other #'s

- Let's consider another **byte**
- Consider: 0 1 0 0 1 1 0 0.
  - This byte represents what value?

