Topics

- ECC
- I/O
- Floating point numbers

Error Correcting Code Function

What is the function $f$?
Error Correcting Code (ECC)

http://www.wikipedia.org/wiki/Error-correcting_code

- Generic name for the formatted field
  - Hamming codes
  - Cyclic Redundancy Codes (CRC)
  - Reed-Muller codes
  - Reed-Solomon codes (arguably most powerful codes)
    - http://www.wikipedia.org/wiki/Reed-Solomon_error_correction

Coding Theory

k-bit Data

\[ \begin{array}{c}
2^k \\
\text{possibilities}
\end{array} \xrightarrow{\text{Generator (mapping) Function}} \begin{array}{c}
\text{Valid Codewords} \\
\begin{bmatrix}
2^k \\
\text{with } d_{\text{min}}
\end{bmatrix}
\end{array} \]

\[ [m_0, \ldots, m_{k-1}] \begin{bmatrix}
g_{0,0} & \cdots & g_{0,n-1} \\
\vdots & \ddots & \vdots \\
g_{k-1,0} & \cdots & g_{k-1,n-1}
\end{bmatrix} = [c_0, \ldots, c_{n-1}] \]
Hamming Code Generator Matrix

Parity bits

\[
\begin{bmatrix}
1 & 1 & 0 & 0 & 0 & 0 \\
1 & 0 & 1 & 1 & 0 & 0 \\
1 & 0 & 1 & 0 & 1 & 0 \\
1 & 1 & 0 & 1 & 0 & 0 \\
1 & 1 & 0 & 1 & 1 & 0
\end{bmatrix}
= \begin{bmatrix}
c_0 & c_1 & c_2 & c_3 & c_4 & c_5 \\
0 & 1 & 1 & 1 & 0 & 0
\end{bmatrix}
\]

Encode 11002 with even parity

\[
\begin{bmatrix}1 & 1 & 0 & 0\end{bmatrix} \begin{bmatrix}
1 & 1 & 0 & 0 & 0 & 0 \\
1 & 0 & 1 & 1 & 0 & 0 \\
0 & 1 & 0 & 1 & 0 & 1 \\
1 & 1 & 0 & 1 & 0 & 0 \\
1 & 1 & 0 & 1 & 1 & 0
\end{bmatrix} = \begin{bmatrix}0 & 1 & 1 & 1 & 1 & 0 & 0\end{bmatrix}
\]

Decoding Theory

\[\begin{bmatrix}r_0 & \cdots & r_{n-1}\end{bmatrix} \mathbf{H}^T = \begin{bmatrix}s_0 & \cdots & s_{n-k-1}\end{bmatrix}\]
Hamming Code Parity Matrix

- For syndrome bit $s_0$
  
  $r_4 \oplus r_5 \oplus r_6 \oplus r_7$

- For syndrome bit $s_1$
  
  $r_2 \oplus r_3 \oplus r_6 \oplus r_7$

- For syndrome bit $s_2$
  
  $r_1 \oplus r_3 \oplus r_5 \oplus r_7$

\[
H^T = \begin{bmatrix}
0 & 0 & 1 \\
0 & 1 & 0 \\
0 & 1 & 1 \\
1 & 0 & 0 \\
1 & 0 & 1 \\
1 & 1 & 0 \\
1 & 1 & 1
\end{bmatrix}
\]

Computer Organization

- ALU
- Control
- Memory
- Input
- Output

**Figure 1.5.** The original von Neumann machine.
Modern Components

- CPU
- Memory
  - Primary
  - Secondary
- I/O

Typical Home Computer

- Other components
  - Printer
  - Modem
  - Etc.

Fig. 2-1. The organization of a simple computer with one CPU and two I/O devices.
Bus Arbitration

![Diagram of bus arbitration](image)

Figure 3-39. (a) A centralized one-level bus arbiter using daisy chaining. (b) The same arbiter, but with two levels.

I/O Component Compatibility

- Peripheral Component Interconnection (PCI)
  - For high-bandwidth (fast) devices
- Industry Standard Architecture (ISA)
  - For slower devices
Implementation

- North Bridge
  - Connects CPU to memory & video

- South Bridge
  - Connects North Bridge to everything else

Input Devices

- Keyboard
  - Click versus non-click

- Mice
  - How many buttons? One, two, or three

- Joystick
  - From Atari to PS2

- Rollerball
  - Old school Centipede arcade game

- Touch screen
  - Stylus

- Etc.
Monitors – CRT

- Electron gun
- Grid
- Spot on screen
- Vacuum
- Vertical deflection plate
- Horizontal scan
- Vertical retrace
- Horizontal retrace

Fig. 2-31. (a) Cross section of a CRT. (b) CRT scanning pattern.

Monitors – Flat Panel

- Liquid crystal
- Rear glass plate
- Rear electrode
- Rear polaroid
- Light source
- Dark
- Bright
- Front glass plate
- Front electrode
- Front polaroid
- Notebook computer
- Grooves on the rear and front plates are perpendicular to one another.

Fig. 2-32. (a) The construction of an LCD screen. (b) The grooves on the rear and front plates are perpendicular to one another.
Printers

- Dot matrix
  - Cheap, slow, durable
- Inkjet
  - Low-cost home printing
- Laser
  - High-quality documents and images
- Color
  - Uses reflected light (CYMK) cartridges

Modems

- Three types of transmission
  - Amplitude (b)
  - Frequency (c)
  - Phase (d)
Data Precision with Intel Inside

TOP 10 REASONS TO BUY A PENTIUM

- 9.9999973251 Your old PC is too accurate.
- 8.9999163362 Provides really good alibi when the IRS calls.
- 7.9999414610 Attracted by Intel's new 'You don't need to know what's inside' ad campaign.
- 6.999831538 It redefines computing -- and mathematics!
- 5.999835137 You've always wondered what it would be like to be a plaintiff.
- 4.9999999021 Current paperweight not big enough.
- 3.9998245917 Takes concept of floating point to a whole new level.
- 2.9991523619 You always round off to the nearest hundred anyway.
- 1.9999103517 Got a great deal from Jet Propulsion Laboratory!

And the number one reason to buy a Pentium:

- 0.9999999998 It'll probably work!

Representing Real Numbers

Figure B-1. The real number line can be divided into seven regions.

- Regions 2, 4, and 6 are OK
- Must find a way to handle regions 1, 3, 5, and 7
IEEE Floating Point Standard 754

- Provided designers with a correct model
- Allowed FP data to be exchanged among different computer systems
- Defines three formats
  - Single precision (32 bits)
  - Double precision (64 bits)
  - Extended precision (80 bits)
    - Only occurs within FP units

IEEE Numerical Types

- Underflow handled gracefully
  - Use denormalized numbers instead of jumping to zero
- Overflow becomes infinity
- Includes Not a Number (NaN)
Overflow Using Two’s Complement

• When the leftmost bits of the operands are the same, the leftmost bit of the answer must also be the same, otherwise overflow has occurred.

OR…looked at another way…

• The carry-in bit to the leftmost bit must be the same as the carry-out bit from the leftmost bit.