Lab, finish bit manipulation, and errors

10/28/15
Announcements

• HW 4 extended until tonight

• New assignment (finishing chat client), due next Wednesday

• Reading:
  – For Friday: Section 6.4
  – For Monday: Section 6.5
Ideas for organizing the chat client

```c
int main(int argc, char** argv) {
    if(argc == 3)  // prog name, handle, port number
        server(...);
    else
        client(...);
}
```
Ideas for organizing the chat client

```c
int main(int argc, char** argv) {
    if(argc == 3) // prog name, handle, port number
        server(...);
    else
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}
```

Open socket like echo server.
```c
receive_and_send_handle();
while(not done) {
    receive_and_print();
    read_and_send();
}
```

Open socket like echo client.
```c
send_and_receive_handle();
while(not done) {
    read_and_send();
    receive_and_print();
}
```
Chat protocol

- Messages are terminated with 0s:
  
  ```
  send(sock, mesg, strlen(mesg)+1, 0);
  ```

  ```
  while(didn’t receive a 0) {
      recv(...)
  }
  ```
Recall: Bit operations

• Shifting: \( 4 \ll 1 \) gives 8

\[
\begin{array}{c}
0100 \\
1000
\end{array}
\]
(can also shift other direction with \( >> \))

• Bitwise and: \& (gives 1 where both args are 1)

\[
\begin{array}{c}
6 & 12 \\
0110 & 1100
\end{array}
\]
gives 4

\[
\begin{array}{c}
0100
\end{array}
\]

• Bitwise or: | (gives 1 where either arg is 1)
What expression will tell you whether the 8s bit (the 3\textsuperscript{rd} bit) of variable $x$ is on?

A. $x \& 8$
B. $x \& 3$
C. $x \& (1 \ll 3)$
D. $(x \gg 3) \& 1$
E. Not exactly one of the above
What expression will tell you whether the 8s bit (the 3rd bit) of variable x is on?

A. \( x \& 8 \)
B. \( x \& 3 \)
C. \( x \& (1 << 3) \)
D. \( (x >> 3) \& 1 \)
E. Not exactly one of the above (A, C, and D)
What expression will tell you whether the $k^{th}$ bit of variable $x$ is on?

A. $(x \& (1 << k)) == x$
B. $(x \& (1 << k)) == 1$
C. $(x | (1 << k)) == x$
D. $(x | (1 << k)) == 1$
E. Not exactly one of the above
What expression will tell you whether the $k^{th}$ bit of variable $x$ is on?

A. $(x \& (1 << k)) == x$
B. $(x \& (1 << k)) == 1$
C. $(x \mid (1 << k)) == x$
D. $(x \mid (1 << k)) == 1$
E. Not exactly one of the above
Error detection and correction
Introduction to coding theory
Introduction to coding theory

Sender

Message

Transmission Medium

Recipient

Message + Error
Introduction to coding theory

Sender

Message

Encoding

Transmission

Medium

Recipient

Decoding

Codeword

Codeword + Error

Message
Error model

• Our choice: arbitrary bit flips
  – 1 or more bits of codeword have their value switched

• Alternate models:
  – independent random errors
  – burst errors (many bits in a row)
Hamming distance

- The *Hamming distance* between 2 words is the number of bits in which they differ
What is the Hamming distance between 0110 and 1010?

A. 0
B. 1
C. 2
D. 3
E. 4
What is the Hamming distance between 0110 and 1010?

A. 0
B. 1
C. 2
D. 3
E. 4
Hamming distance

• The *Hamming distance* between 2 words is the number of bits in which they differ

• A code has distance $d$ if every pair of codewords has Hamming distance $\geq d$
What is the distance of a code with codewords \{000, 011, 101, 111\}?

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Hamming distance

- The *Hamming distance* between 2 words is the number of bits in which they differ
- A code has distance $d$ if every pair of codewords has Hamming distance $\geq d$
- To detect $d$ errors, use a code w/ distance $\geq d+1$
  
  Example: adding a parity bit
Hamming distance

• The *Hamming distance* between 2 words is the number of bits in which they differ

• A code has distance \( d \) if every pair of codewords has Hamming distance \( \geq d \)

• To detect \( d \) errors, use a code w/ distance \( \geq d+1 \)

• To correct \( d \) errors, use a code w/ distance \( \geq 2d+1 \)
Hamming code (1950)

• Encodes 4 bit messages into 7 bit code words
• It has distance 3 (i.e. can correct single errors)

(Other Hamming codes have different parameters)
Review: Matrix multiplication

\[
\begin{pmatrix}
1 & 2 \\
3 & 4
\end{pmatrix}
\begin{pmatrix}
5 & 6 \\
7 & 8
\end{pmatrix}
= 
\begin{pmatrix}
1*5 + 2*7 & 1*6 + 2*8 \\
3*5 + 4*7 & 3*6 + 4*8
\end{pmatrix}
= 
\begin{pmatrix}
19 & 22 \\
43 & 50
\end{pmatrix}
\]
Encoding

(Message) \[
\begin{pmatrix}
1 & 1 & 1 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 1 & 1 & 0 & 0 \\
0 & 1 & 0 & 1 & 0 & 1 & 0 \\
1 & 1 & 0 & 1 & 0 & 0 & 1 \\
\end{pmatrix}
\]
= Codeword (mod 2)
What is the encoding of $(1100)$?

A. $(01010000)$
B. $(0101110)$
C. $(01111000)$
D. $(0110011)$
E. None of the above
What is the encoding of (1 1 0 0)?

A. (0 1 0 1 0 0 0)
B. (0 1 0 1 1 1 0)
C. (0 1 1 1 1 0 0)
D. (0 1 1 0 0 1 1)
E. None of the above
Decoding

• Multiply by

\[
\begin{pmatrix}
0 & 0 & 1 \\
0 & 1 & 0 \\
0 & 1 & 1 \\
1 & 0 & 0 \\
1 & 0 & 1 \\
1 & 1 & 0 \\
1 & 1 & 1
\end{pmatrix}
\]

• If result is all 0s, no error occurred
• If not, then result is bit number in binary