

Error Detection With Parity Bits

Information Theory Lab 8

Objective

Understand the use of parity bits for error detection, in particular the detection of 1 error based on 1 parity bit.

Theoretical notions

Given a set of N bits b_1, \dots, b_N , a parity bit p is defined as the **modulo-2 sum** of their values:

$$p = b_1 \oplus b_2 \oplus \dots \oplus b_N.$$

The parity bit can be used for detection of a single error:

- when transmitting a group of bits, compute and send their parity bit as well
- when receiving a group of bits and their parity bit, compute the parity bit of the first bits again and compare with the parity bit received:
 - a. If they are the same, decide that no error has happened;
 - b. If they differ, an error has been detected.

This scheme represents an 1-error detection code.

In the C language, modulo-2 sum is done by the bitwise XOR operation (\wedge).

Exercises

1. Write a C program that computes and appends the parity bit for every byte in a data file. The program shall be called as follows:

```
Parity.exe input.dat output.dat
```

- The arguments are:

- `input.dat`: the input file
 - `output.dat`: the output file produced by the program (12.5% larger than the input)
 - The program should consist of the following steps:
 - declare two large vectors of `unsigned char`, for input and output bits
 - open the input file and read everything into the input vector
 - for every group of 8 bits from the input vector:
 - * copy them to the output vector
 - * compute the parity bit
 - * append it to the output vector
 - write the output vector to the output data file
2. Write a second C program that checks the parity bit for every byte in a data file. The program shall be called as follows:

`ParityCheck.exe input.dat output.dat`

- The arguments are:
 - `input.dat`: the input file, which should be the output of the first program
 - `output.dat`: the output file
 - The program should consist of the following steps:
 - declare two large vectors of `unsigned char`, for input and output bits
 - open the input file and read everything into the input vector
 - for every group of 9 bits from the input vector:
 - * copy the first 8 bits to the output vector
 - * compute the parity bit of all the 9 bits
 - if result is 0, all OK, do nothing
 - if result is 1, display a message “Error detected in group number %d”
 - write the output vector to the output data file
3. Run the first program to produce the output file, for some input file. Use the `Frrhed` program supplied to introduce 1 error into some locations in the output file (just 1 error every 9 bits). Call the second program and observe if the errors are detected.

Program design

1. The bit operation macro definitions are available in `bitmacros.h`.

For quick access to a bit number i in a large array, use the following macros:

```
#define VECREAD_BIT(v,i) (READ_BIT((v[(i)/8]),(i)%8))
#define VECWRITE_BIT(v,i,val) (WRITE_BIT((v[(i)/8]),(i)%8, val))
```

Final questions

1. How could we make the code detect 1 error in every 4 bits? How about 1 error in every 2 bits? What is the downside?