A NOVEL APPROACH FOR ERROR DETECTION AND CORRECTION USING GATED CORRECTION METHOD

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Abstract

Data communication is the process of exchanging information between sender and receiver. The basic objective of a communication system is to transmit data which is free of error. Advancement in technology has made various revolutions in data communication, with which come greater chances that the data to be sent becomes corrupted. The data is transferred from various transmission impairments and during this period various factors affect the signal, the data received at the receiver is different from the data transmitted. As digital signals exist in two states either high or low, the error occurred will change its state. In today's advance world different techniques have been made to detect and remove error in the data. The paper delivers a simple error correction and detection method which can detect and correct single, multiple and burst error simply by using XNOR and COMPLEMENT. In the proposed method key is calculated and is send as a redundant bits at the receiver different operations are made to get the data that was originally sent. This error correction is a step ahead of hamming code. This paper also discusses the shortcomings of hamming code.

Keywords: Data communication, transmission impairments, error correction and detection, xnor, complement, hamming code, gated data.

Introduction

In communication system the data is sent through a channel. During transmission there exists a greater possibility of an error and a high bit is changed to low and a low bit is changed to high or vice versa [1-3]. The error occurred during transmission can be single bit, multiple bit or burst error. Single bit error occurs when only one bit is changed from high to low and vice versa figure 1, multiple bit error occurs when more than one bit is changed figure 2. In burst error consecutive multiple numbers of bits are changed figure 3. Different efforts have been made to detect and correct the error occurred during transmission [4-9]. Error correcting code are more complicated than error detecting codes also the error correction requires more redundant bit then error correction. The main purpose of error correction technique is that the received data is an exact copy of the transmitted signal.

1	0	0	1	1	1	0	0

⇩

1	0	1	0	1	1	0	0

Figure 1 Single bit error

1	0	0	1	1	0	1	1

⇩

1	1	0	1	1	1	0	1

Figure 2 Multiple bit error

1	1	0	0	1	0	1	1

⇩

1	0	1	0	0	0	1	1

Figure 3 Burst error

Hamming Code

It is one of the power full methods for error correction in data communication. Redundant Bits (r) are calculated so that it can represent the states (the number by which the size of the bits can be represented in binary) of the bits(m) also the left hand side of the equation i.e. 2^r is greater than m+r+1 where m is the number of bits. Then the r bits are appended with the original bits, then the r bits are inserted by the formula 2^n. The binary position of each bit is calculated, and then the r bits are filled with either 1 or 0 depending upon the number of 1's.

o $2^r \geq m+r+1$

o If m=7, r=4 as $16 \geq 7+4+1$

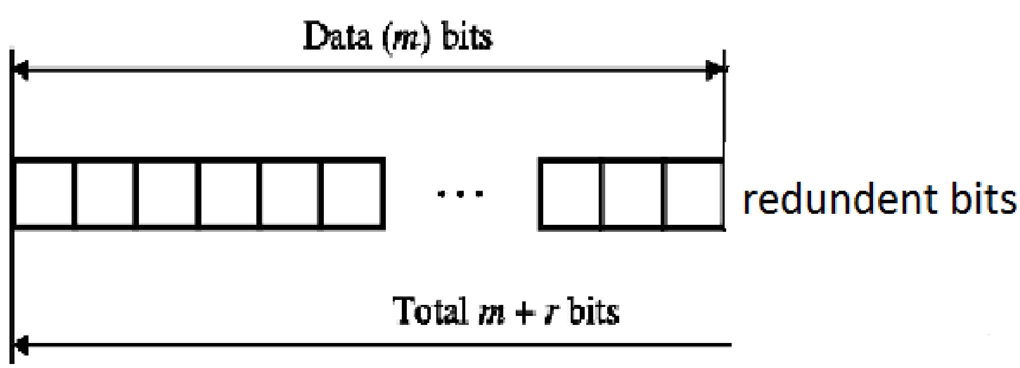
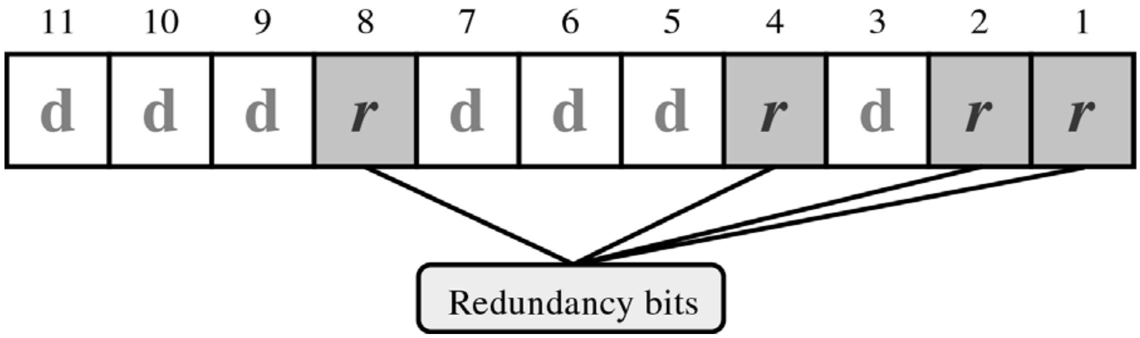


Figure 5 Redundant Bits



1	0	1	0	1	1	0	0

Error at 8th position

0	0	1	0	1	1	0	0

$2^r \geq m+r+1$

$2^4 > 10+4+1$

$16 > 15$

0	0	1	R8	0	1	1	R4	0	0	R2 R1
1100	1101	1001	1001	1000	0111	0110	0101	0100	0011	0010 0001

0	0	1	1	0	1	1	0	0	0	0 0
1100	1101	1001	1001	1000	0111	0110	0101	0100	0011	0010 0001

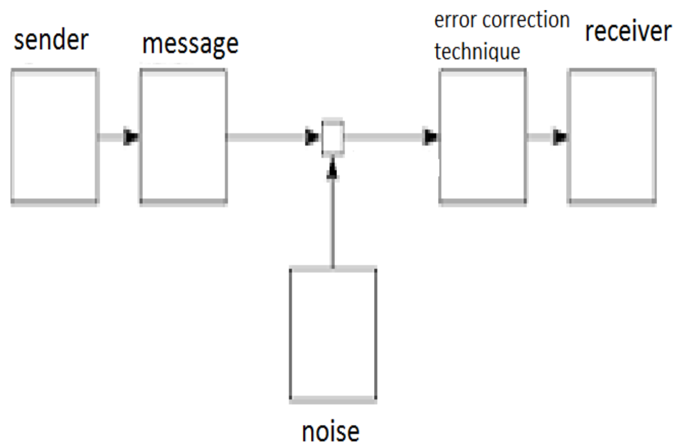
If error has occurred at 8th position, we calculate the states and the number of the bits in which the states can be represented. For the above example there are 8 states and hence we need 4 bits to represent the states which also obeys the 2^r > m+R+1. We then plug in the redundant bits into the table and find their values. Later on we get the position of the bit where the error has occurred.

Methodology

Now we discuss the steps and procedure for simple error correction. The following steps are involved at transmitter site and at the receiver side.

Transmitter/ Receiver side

The detection of the error can be determined by any of the pre defined methods for error detection. At the transmitter the data along with the key is sent to the receiver. The key is calculated by taking the complement of the data to be sent. At the receiver the received data is complemented, and then the key and the complemented data is xnor'ed, we call the result as gated data. At last the gated data and the received data are xnor'ed again this gives us the original data that the sender wants to send.



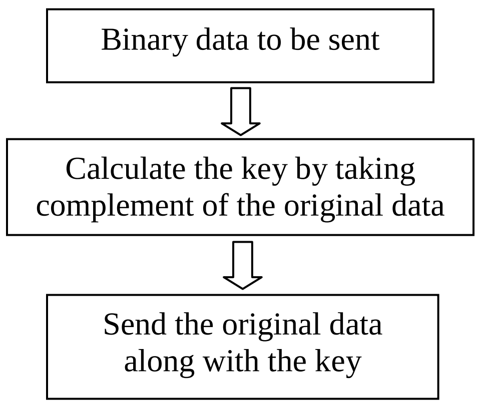


Figure 6: Steps at Transmitter End.

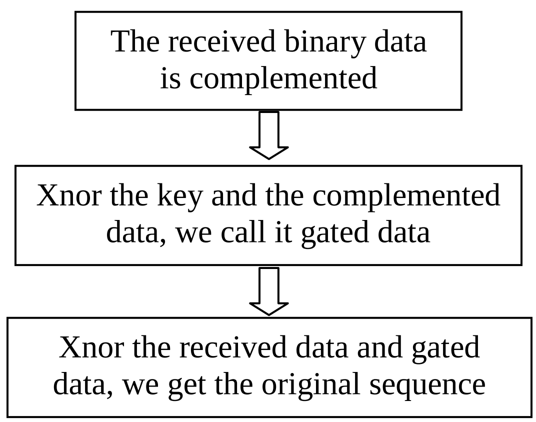


Figure7: Steps at Receiver End.

Single bit error

Single bit error occurs when a single bit i.e. 1 is changed to 0 or a 0 is changes to 1. The proposed method can easily tackle single bit error without any drawback. The fig shows that a single bit error has occurred and a 1 is change to 0. Then the complement of the data is sent as a key as shown we then xnor the complement of the received data and key which gives us gated data. Then by again taking xnor with the gated data and the received data gives us the original signal as shown in the below figure.

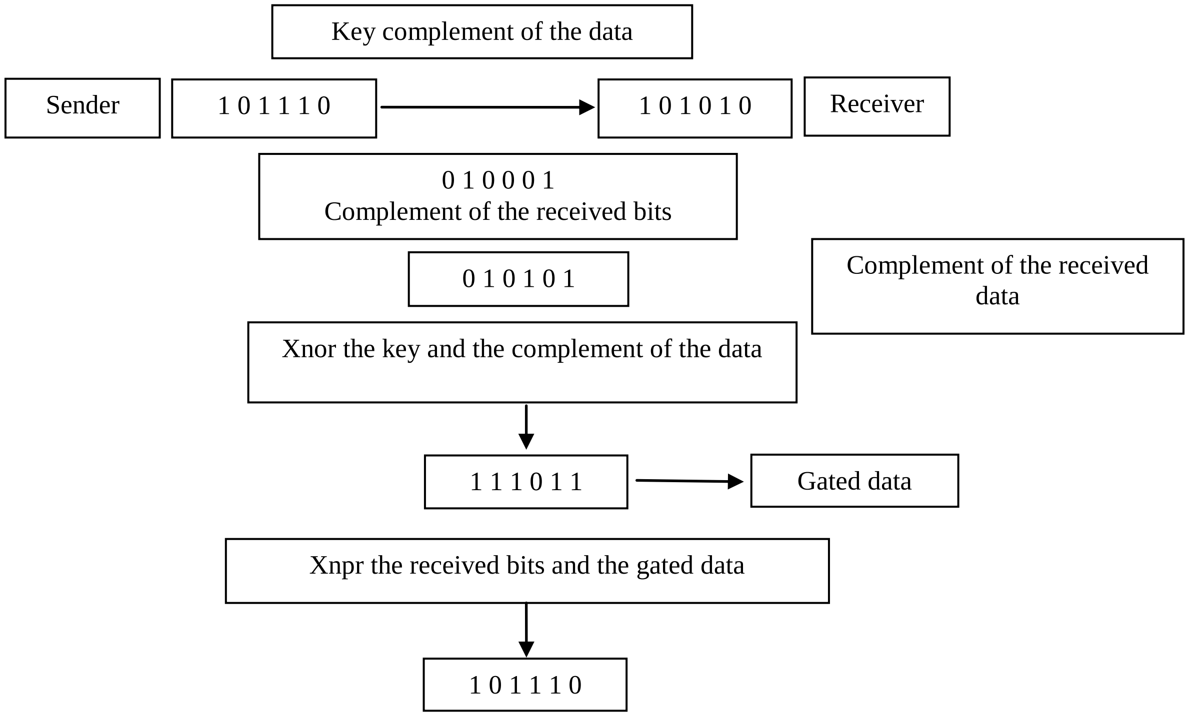


Figure 8: Representing the steps involved when a single bit error is produced

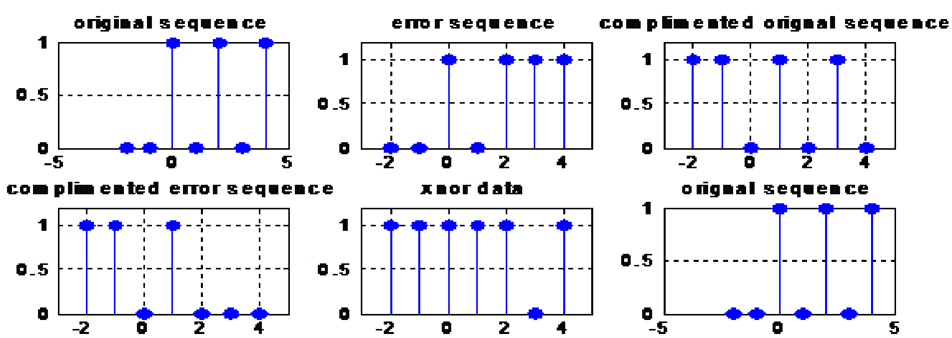


Figure 9: Single bit error

Multiple Errors

Burst error occurs when multiple bits are changed. The proposed method can easily tackle multiple bit error without any drawback. The fig show that a multiple bit error has occurred and a 1 is change to 0 and 0 is changed to 1 as shown in the figure. Then the complement of the data is sent as a key, we then xnor the complement of the received data and key which gives us gated data. Then by again taking xnor with the gated data and the received data gives us the original signal as shown in the below figure.

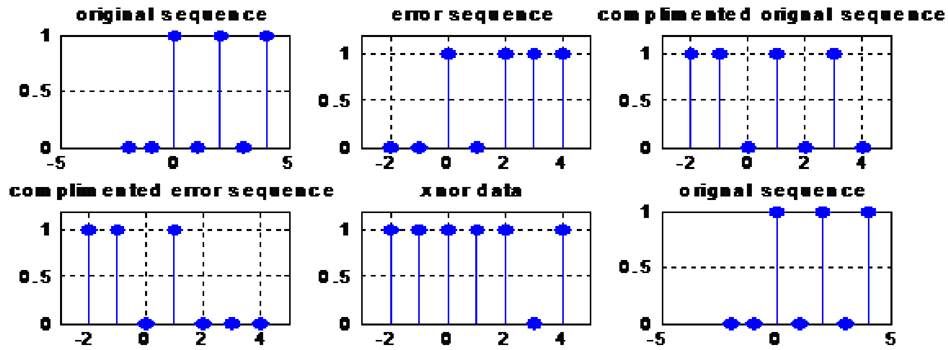


Figure 10: Multiple Bit Error.

Burst Error

Burst error occurs when a sequence of bits are changed. The proposed method can easily tackle multiple bit error without any drawback. The fig show that a multiple bit error has occurred and a 1 is change to 0 and 0 is changed to 1 as shown in the figure. Then the complement of the data is sent as a key, we then xnor the complement of the received data and key which gives us gated data. Then by again taking xnor with the gated data and the received data gives us the original signal as shown in below figure.

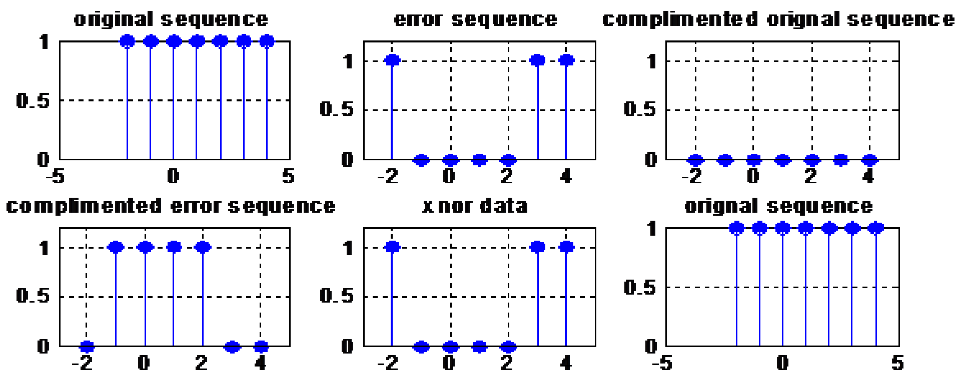


Figure 11: Burst error.

Discussion

Error correcting code are more complicated than error detecting codes also the error correction requires more redundant bit then error correction. From the above discussion the proposed method simple and is a step head of hamming code which is one of the error correction method the hamming code performs well when a single bit error occurs but it fails when multiple bits error occurs and also when burst error occurs another drawback of the hamming code is that it is time consuming, whereas from the above simulations the proposed method is robust and can easily correct single, multiple and burst errors.

Short Comings of Method

The short coming of the proposed method is that it fails to correct the data when the key is changed which is of less probability. The short coming of the proposed method can be fixed if the key is send twice and is compared.

Conclusion

The proposed method is a simple error correction method and is compared with the hamming code. The simulation showed that the proposed method is simple and robust compared to hamming code, the paper also discussed the method was successful in determining multiple and burst error, also the short coming of this proposed method and a solution to problem is provided.

References

[1] “Data Communication and Networking” 4th edition by Behrouz A.Forouzan (Chapter 10th page 267)

[2] “Modern Digital and Analog Communication Systems” 3rd edition by B.P Lathi (Chapter 16th page 728)

[3] “Logic and Computer Design Fundamentals” 2nd edition (Chapter 2nd page 74)

[4] “Data and Computer Communication” 8th edition by William Stalling

[5] "Mathematical Challenge April 2013 Error-correcting codes" (PDF). Swiss Quant Group Leadership Team. April 2013.

[6] https://www.researchgate.net/publication/236202666_Simple-Error-Detection-Method

[7] MacKay, David J.C. (September 2003). In-formation Theory, Inference and Learning Algorithms. Cambridge: Cambridge University Press. ISBN 0-521-64298-1.

[8] Moon, Todd K. (2005). Error Correction Coding. New Jersey: John Wiley & Sons. ISBN 978-0-471-64800-0.

[9] Peterson, W. W. and Brown, D. T. (January 1961). "Cyclic Codes for Error Detection". Proceedings of the IRE 49 (1): 228–235.doi:10.1109/JRPROC. 1961.287814.