ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 4, Issue 1, January 2017

Performance Study on the Suitability of Reed Solomon Codes in Communication Systems

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Abstract: This paper examines a coding which uses Reed-Solomon (RS) codes. Communication has got many applications such as telephonic conversations in which the messages are encoded into the communication channel and then decoding it at the receiver end. During the transfer of message, the data might get corrupted due to lots of disturbances in the communication channel. Reed Solomon codes are type of burst error detecting codes which has got many applications due to its burst error detection and correction nature. Reed-Solomon is designed for applications such as digital wrapper, Digital video and Digital Audio. The module will encode the incoming data blocks of 239, 8 bits at a time and output the original data set with the appended redundancy data of 16 bits. Reed Solomon codes is a member of the family of non binary Bose-Choudhuri-Hocquenqhen (BCH) codes. The fading identity of the wireless channel, errors normally take place in busty form.

Keywords: Audio, Digital, Cryptology, Reed-Solomon codes, Spread spectrums.

INTRODUCTION

R-S codes[1] are the main class of error detecting codes initiated by the scientist Irving S. Reed and Gustavo Solomon. R-S codes run on the information by distributing the message stream into the block of data and adding redundancy per block relying only on the current inputs. These codes having the ability to rectify both burst errors and deletion. The fundamental block diagram for the communication system is as shown in the Figure 1.

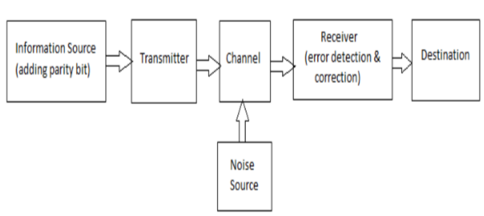

Fig. 1: Block diagram of Communication System

CHARACTERISTIC OF R-S CODE

R-S codes are subgroup of B-C-H codes and are linear block codes. A R-S code is described as R-S (n,k) along s-bit symbol i.e. the encoder consider k data symbols of s-bits each and adds parity symbols to make an n-symbol codeword. An R-S decoder can correct up to ‘r’ symbols that contain errors in a codeword, where, $2r = (n-k)$ .The following diagram shows a typical R-S code word shown in Fig.2.

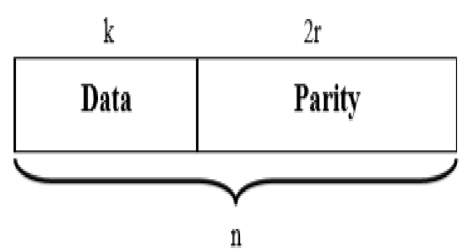

Fig. 2: Typical Reed Solomon Codeword

Reed-Solomon codes[2] are block-based error correcting codes with a wide range of applications in digital communications and storage. Reed-Solomon codes are used to correct errors in many systems including:

- Storage devices (including tape, Compact Disk, DVD, barcodes, etc)
- Wireless or mobile communication (including cellular telephones, microwave links, etc)
- Satellite communications
- Digital television
- High-speed modems such as ADSL

REED-SOLOMON ENCODING AND DECODING

- The capacity of a binary channel is increased by adding extra bits to this data.
- The quality of digital data. The process of adding redundant bits is known as channel encoding.
- In many situations, errors are not distributed at random but occur in bursts.
- Scratches, dust or fingerprints on a compact disc (CD) introduce errors on neighboring data.
- Bits. Cross-interleaved Reed-Solomon codes (CIRC) are particularly well-suited for detection and correction of burst.[3]
- Redistributes the data over many blocks of code. The double encoding has the first code declaring erasures and the second code corrects them.

BLOCK DIAGRAM

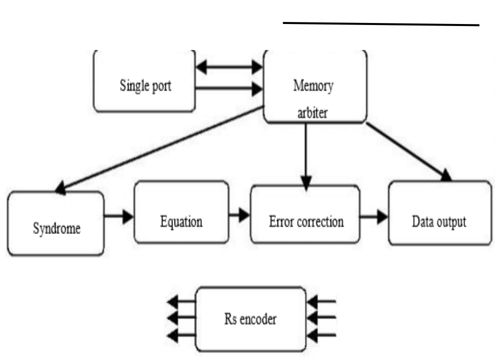

Fig. 3: RS code Encoding and Decoding

The Fig.3 Shows the RS code decoding and encoding block diagram. The Reed-Solomon encoder takes a block of digital data and adds extra "redundant" bits. Errors occur during transmission or storage for a number of reasons (for example noise or interference, scratches on a CD, etc). The Reed-Solomon decoder processes each block and attempts to correct errors and recover the original data. The number and type of errors that can be corrected depends on the characteristics of the Reed Solomon code.

ERROR DETECTION AND CORRECTION

When data is stored or transmitted we cannot ignore encoding. The field of mathematics that deals with sending data, a digital bit stream, over a noisy channel is called coding theory. This field of cryptology was born out of necessity, a sense of survival. After the war, before governments could render the research obsolete, the people behind cryptology research showed that cryptology and eventually the theory of error detecting and correcting could be put into practical use. We can see that the field of cryptology[4] is adjacent to and oftentimes overlapping with the field of coding theory. Firstly, some pioneers and their achievements are addressed. Physical damage like dust or scratches or material impurities can cause erasures or burst errors in the data stream. With forward error correction techniques, like Reed-Solomon codes these interrupts in the data stream can be detected and corrected.

Consider an (n, k) = (255, 247) R-S code, where each symbol is made up of m = 8 bits (such symbols are typically referred to as bytes). Since n - k = 8, indicates that it can correct any four symbol errors in a block of 255. Imagine the presence of a noise burst, lasting for 25-bit durations and disturbing one block of data during transmission of data block disturbed by 25-bit noise burst. In this example, notice that a burst of noise that lasts for a duration of 25 contiguous bits must disturb exactly four symbols. The R-S decoder for the (255, 247) code will correct any four-symbol errors without regard to the type of damage suffered by the symbol. In other words, when a decoder corrects a byte, it replaces the incorrect byte with the correct one, whether the error was caused by one bit being corrupted or all eight bits being corrupted. Thus if a symbol is wrong, it might as well be wrong in all of its bit positions. This gives an R-S code a tremendous burst-noise advantage over binary codes, even allowing for the interleaving of binary codes. In this example, if the 25-bit noise disturbance had occurred in a random fashion rather than as a contiguous burst, it should be clear that many more than four symbols would be affected

REED SOLOMON CODES: PROPERTIES

The properties of Reed-Solomon codes[5] make them especially well-suited to applications where errors occur in bursts. This is because

• It does not matter to the code how many bits in a symbol are in error, if multiple bits in a symbol are corrupted it only counts as a single error. Alternatively, if a data stream is not characterized by error bursts or drop-outs but by random single bit errors, a Reed-Solomon code[6] is usually a poor choice. More effective codes are available for this case.

• Designers are not required to use the "natural" sizes of Reed Solomon code blocks. A technique known as shortening can produce a smaller code of any desired size from a larger code. For example, the widely used (255,251) code can be converted to a (160,128) and not transmitting them. At the decoder, the same portion of the block is loaded locally with binary zeroes.

• Its capability to correct both burst errors and erasures makes it the best choice for the designer to use it as the encoding and decoding too.

APPLICATIONS OF REED-SOLOMON CODES

Digital Audio Disc:

It can safely be claimed that Reed-Solomon codes are the most frequently used digital error control codes in the world. This claim rests firmly on the fact that the digital audio disc or compact disc uses Reed-Solomon codes for error correction[7] and error concealment. Reed-Solomon codes make the sound quality of the compact disc really impressive.

Deep Space Telecommunication:

Solomon codes are used in several of NASA and ESA's planetary exploration missions. They begin by noting that Reed-Solomon codes were not an obvious choice for deep space telecommunication systems because the deep space channel does not usually induce burst errors in transmitted data.

Error Control for Systems with Feedback:

Such applications include mobile data transmission systems and high-reliability military communication systems along with their powerful error correction capabilities.

SPREAD SPECTRUM

Spread-spectrum[8] systems can be grouped into two basic types: frequency hopping spread spectrum (FH/SS) and direct sequence spread spectrum (DS/SS). An FH/SS system modulates information onto a carrier that is systematically moved from frequency to frequency. Frequency hopping has been used in military communications systems as a powerful jamming. Direct-sequence spread spectrum (DSSS)[9] is a spread-spectrum modulation technique primarily used to reduce overall signal interference. The direct-sequence modulation makes the transmitted signal wider in bandwidth than the information bandwidth. After the de spreading or removal of the direct-sequence modulation in the receiver, the information bandwidth is restored, while the unintentional and intentional interference is substantially reduced.

FUTURE SCOPE

The commercial world is becoming increasingly demandable for mobiles; while simultaneously need reliable, rapid access to sales, marketing, and accounting information. Unfortunately the mobile channel is a nasty environment in which to communicate, with deep fades an ever-present phenomenon. Reed-Solomon codes[10] are the single best solution; there is no other error control system that can match their reliability performance in the mobile environment. The optical channel provides another set of problems altogether. Shot noise and a dispersive, noisy medium plague line-of-sight optical system, creating noise bursts that are best handled by Reed-Solomon codes.

CONCLUSION

As optical fibers see increased use in high-speed multiprocessors, we can expect to see Reed-Solomon codes used there as well. In more specialized, single-use applications such as the occasional deep space probe; Reed-Solomon codes will continue to be used to force communication system performance ever closer to the line drawn by Shannon. Reed-Solomon (R-S) codes, a powerful class of Non-binary block codes, particularly useful for correcting burst errors. Because coding efficiency increases with code length, R-S codes have a special attraction. Reed Solomon codes are the single best solution; there is no other error control system that can match their reliability performance in the mobile environment. The optical channel provides another set of problems altogether. Shot noise and a dispersive, noisy medium plague line-of-sight optical system, creating noise bursts that are best handled by Reed-Solomon codes.

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