Research Paper Summary IEEE TIT 2013/01 - 2013/09

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May 23, 2018

Zigzag Codes: MDS Array Codes With Optimal Rebuilding

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2013/03

Abstract - Maximum distance separable (MDS) array codes are widely used in storage systems to protect data against erasures. We address the rebuilding ratio problem, namely, in the case of erasures, what is the fraction of the remaining information that needs to be accessed in order to rebuild exactly the lost information? It is clear that when the number of erasures equals the maximum number of erasures that an MDS code can correct, then the rebuilding ratio is 1 (access all the remaining information). However, the interesting and more practical case is when the number of erasures is smaller than the erasure correcting capability of the code. For example, consider an MDS code that can correct two erasures: What is the smallest amount of information that one needs to access in order to correct a single erasure? Previous work showed that the rebuilding ratio is bounded between $\frac{1}{2}$ and $\frac{3}{4}$; however, the exact value was left as an open problem. In this paper, we solve this open problem and prove that for the case of a single erasure with a two-erasure correcting code, the rebuilding ratio is $\frac{1}{2}$. In general, we construct a new family of r-erasure correcting MDS array codes that has optimal rebuilding ratio of $\frac{1}{r}$ in the case of a single erasure. Our array codes have efficient encoding and decoding algorithms (for the cases $r = 2$ and $r = 3$, they use a finite field of size 3 and 4, respectively) and an optimal update property.

Index Terms - Distributed storage, network coding, optimal rebuilding, RAID

On Generalized Reed-Solomon Codes Over Commutative and Noncommutative Rings

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2013/09

Abstract -In this paper, we study generalized Reed-Solomon codes (GRS codes) over commutative and noncommutative rings, we show that the classical Welch-Berlekamp and Guruswami-Sudan decoding algorithms still hold in this context, and we investigate their complexities. Under some hypothesis, the study of noncommutative GRS codes over finite rings leads to the fact that GRS codes over commutative rings have better parameters than their noncommutative counterparts. Also, GRS codes over finite fields have better parameters than their commutative rings counterparts. But we also show that given a unique decoding algorithm for a GRS code over a finite field, there exists a unique decoding algorithm for a GRS code over a truncated power series ring with a better asymptotic complexity. Moreover, we generalize a lifting decoding scheme to obtain new unique and list decoding algorithms designed to work when the base ring is, for example, a Galois ring or a truncated power series ring or the ring of square matrices over the latter ring.

Index Terms-Algebra, algorithm design and analysis, decoding, error correction, Reed-Solomon codes.