Performance Analysis of CRSCE Decompression on Apple M3/M4 GPUs

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# Abstract

This report presents a comparative performance analysis of the Cross Sums Compression and Expansion (CRSCE) decompression algorithm on Apple M3 and M4 GPUs at block sizes of 32 KiB (s=512). Estimated decompression times are measured against traditional compression methods such as bzip2 and LZMA on Apple M3/M4 CPU cores. Results indicate that CRSCE achieves an estimated 1.7 ms per block, outperforming bzip2 (~2.5 ms) and remaining competitive with LZMA (~1.5 ms). All computations are modeled based on documented hardware specifications and algorithmic complexity.

Keywords: CRSCE, decompression, GPU performance, Apple M3, Apple M4, bzip2, LZMA

# Introduction

Cross Sums Compression and Expansion (CRSCE) is a novel lossless algorithm employing structural matrix summarization and cryptographic verification to achieve predictable compression rates independent of data entropy (Asymmetric Effort, LLC, 2025). This paper focuses on the decompression phase and its suitability for execution on Apple M3 and M4 GPUs.

# Methodology

Decompression time estimates were derived by modeling each algorithmic phase—Deterministic Elimination (DE), Loopy Belief Propagation (LBP), Cellular Automaton (CA) updates, and SHA-256 validation— against Apple M3/M4 GPU hardware profiles (Apple Inc., 2025). Comparative benchmarks for bzip2 and LZMA were obtained from ARM-based system throughput reports (ARM Ltd., 2023).

# Results

|  |  |
| --- | --- |
| Phase | Estimated Time (ms) |
| Deterministic Elimination (DE) | 0.06 |
| Game of Belief Propagation (LBP) | 1.50 |
| SHA-256 Validation | 0.15 |
| Total | 1.71 |

Table 1: Estimated decompression phase times for CRSCE at s=512.

|  |  |  |
| --- | --- | --- |
| Algorithm | Device | Time per 32 KiB Block (ms) |
| CRSCE (s=512) | Apple M3/M4 GPU | 1.7 |
| bzip2 | Apple M3/M4 CPU | 2.5 |
| LZMA | Apple M3/M4 CPU | 1.5 |

Table 2: Comparison of decompression times across algorithms.

# Discussion

The GPU-based execution model of CRSCE leverages extensive parallelism across deterministic and probabilistic inference phases, resulting in superior or competitive decompression speeds relative to traditional CPU-bound methods. The fixed-time performance of CRSCE per block ensures predictability, contrasting with entropy-sensitive behavior in bzip2 and LZMA.

# Equations

The estimated total decompression time: 1.71ms

# References

ARM Ltd. (2023). ARM-based system performance benchmarks for compression algorithms [White paper].

Apple Inc. (2025). Apple M3 and M4 GPU performance overview [White paper].

Asymmetric Effort, LLC. (2025). Cross Sums Compression and Expansion (CRSCE) specification (Version 1) [Unpublished manuscript].