Implicit-Storing and Redundant-Encoding-of-Attribute Information in Error-Correction-Codes

Memory Organization

* Error:

- Logical Memory Model: table of addresses and data

- Physical Memory Organization: multi-level hierarchy, arrays with multiple blocks, each block with many words

* Store Extra Information without overheads

- Basic Idea
  - Extend the logical capacity of a memory array without increasing its physical capacity
- HOW
  - Encode the extra information in the ECC
  - Using shortened codes
- Extra information is erased
  - Infers the extra information on reads: Multiple decodings use codeword with fewer errors

Implicit-Storing (IS)

- Extra hardware
  - 5 XOR gates and 5 Inverters
- Miss-correct some uncorrectable data errors
- Savings in Area and Energy
  - Cache: 3.75% DRAM: 11.11%

Implementation of 1-bit Implicit-Storing

Overhead of Implicit Storing

Redundant Encoding of Attributes

- Encode the same attribute in multiple codewords of a block
- Read multiple correlated locations and produce their codewords
- The decoder uses many codewords to determine data and implicit bit
- When to use REA: when an error is detected

Extra Information in Memory

- Extra information in memory locations useful for:
  - Reliability, ECC bits
  - Security, Taint Bits
  - Performance, Full/Empty Bits
  - Energy, Subblock Dirty bits
- Extra overheads: area, energy, delay

Implicit-Storing:

- * encode in ECC extra information
  - extend the logical capacity of a memory array without increasing its physical capacity
  - minimal area and energy overheads
  - low performance overhead
  - reduction in the code strength

Redundant Encoding of Attributes:

- redundantly encode the same attributes in multiple codewords
- minimize the reduction of the code strength
- minimal impact on performance

Background

- Error:
- Erasure: a specific bit position of the data with unknown value
- Shortened codes: number of protected bits is smaller than max number that can be protected
  - k check bits can protect for p bits.
  - SECDED, for k=8
    - p = 2^k - k extra bits => p = 120 bits
  - Data 64 bits => Can protect 56 bits

Implementation of 1-bit Implicit-Storing

- Missing bit value is X.
- Syndrome
  - from checker that assumes missing bit is X
  - from checker that assumes missing bit is X'
- Syndrome
  - Design constraints/locality
  - over multiple codewords/attribute

Decoder Decision

- Correct Decision
- No error, Detect odd & Correct
- Detect odd & Unreconstructable
- Detect even & Unreconstructable

Correct Decision

- YES, YES, YES
- Implicit-Storing (IS & REA (IREA))

IS & REA (IREA)