Improving Oblivious RAM Protocol through Novel Eviction and Access Strategies

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Overview

1. Background
   a. Definition of ORAM
   b. Previous ORAMs
2. Path ORAM II (Ring)
3. Future Directions
   a. Onion ORAM
   b. Optimization and Improvement

What is an ORAM?

- Oblivious Random Access Memory
- Trusted client, untrusted server

Desired Specifications:

- All accesses must be hidden
- Ideally a usable product with reasonable runtimes

Why is access pattern important?

- Information can be gained from data access pattern
    - frequently accessed files are considered more important
    - financial data, medical information

Background

a	b	c	d	e	f

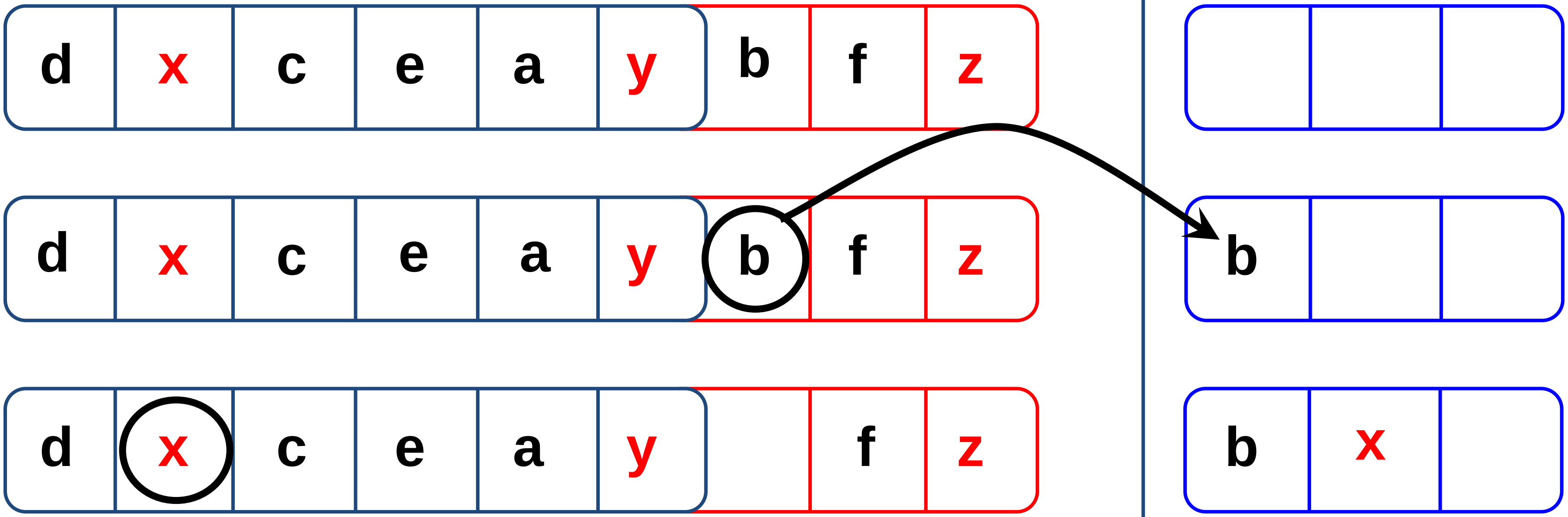
Encryption:

ɐ	q	ɔ	p	ǝ	ɟ

Goldreich 1987 ORAM

Server

Client

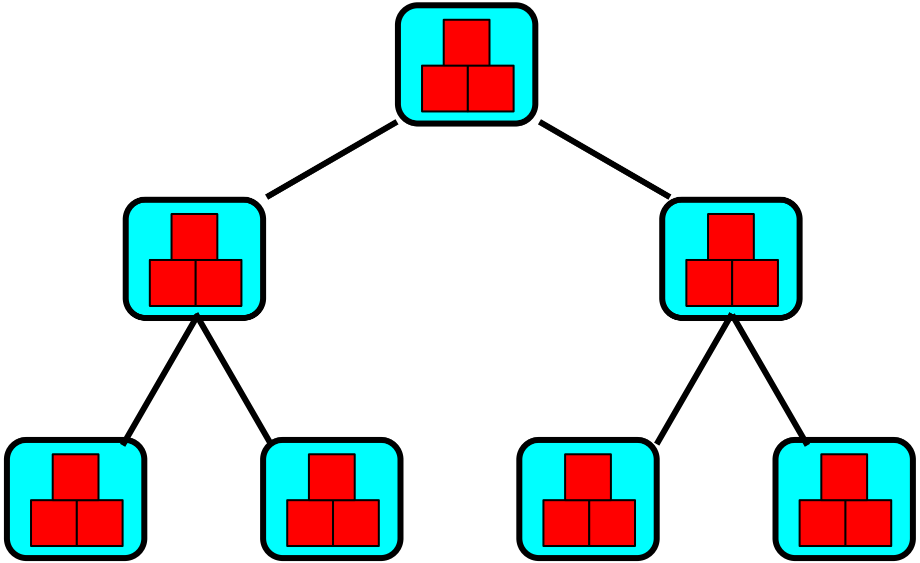


d	x	c	e	a	y	b	f	z			
d	x	c	e	a	y	b	f	z	b		
d	x	c	e	a	y		f	z	b	x	

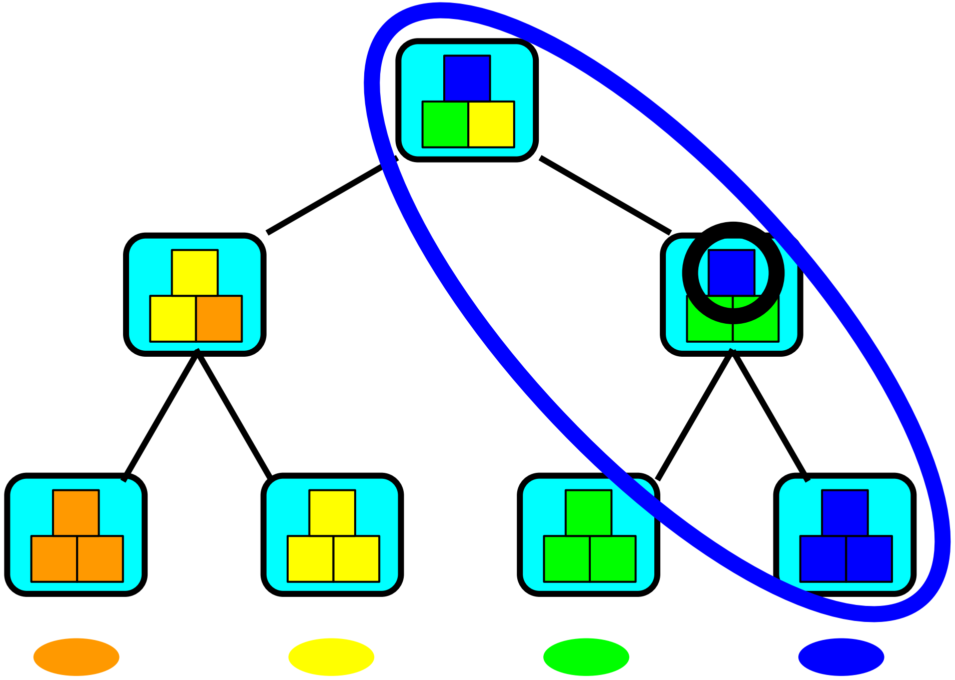
Problems with Goldreich Approach

- It’s still very inefficient - complexity $O(\sqrt{N})$
- Shuffling is also inefficient
- With large amounts of data, it’s virtually unusable

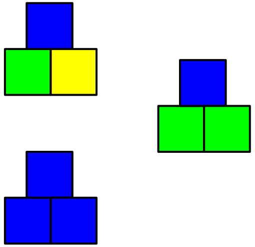
Path ORAM Overview



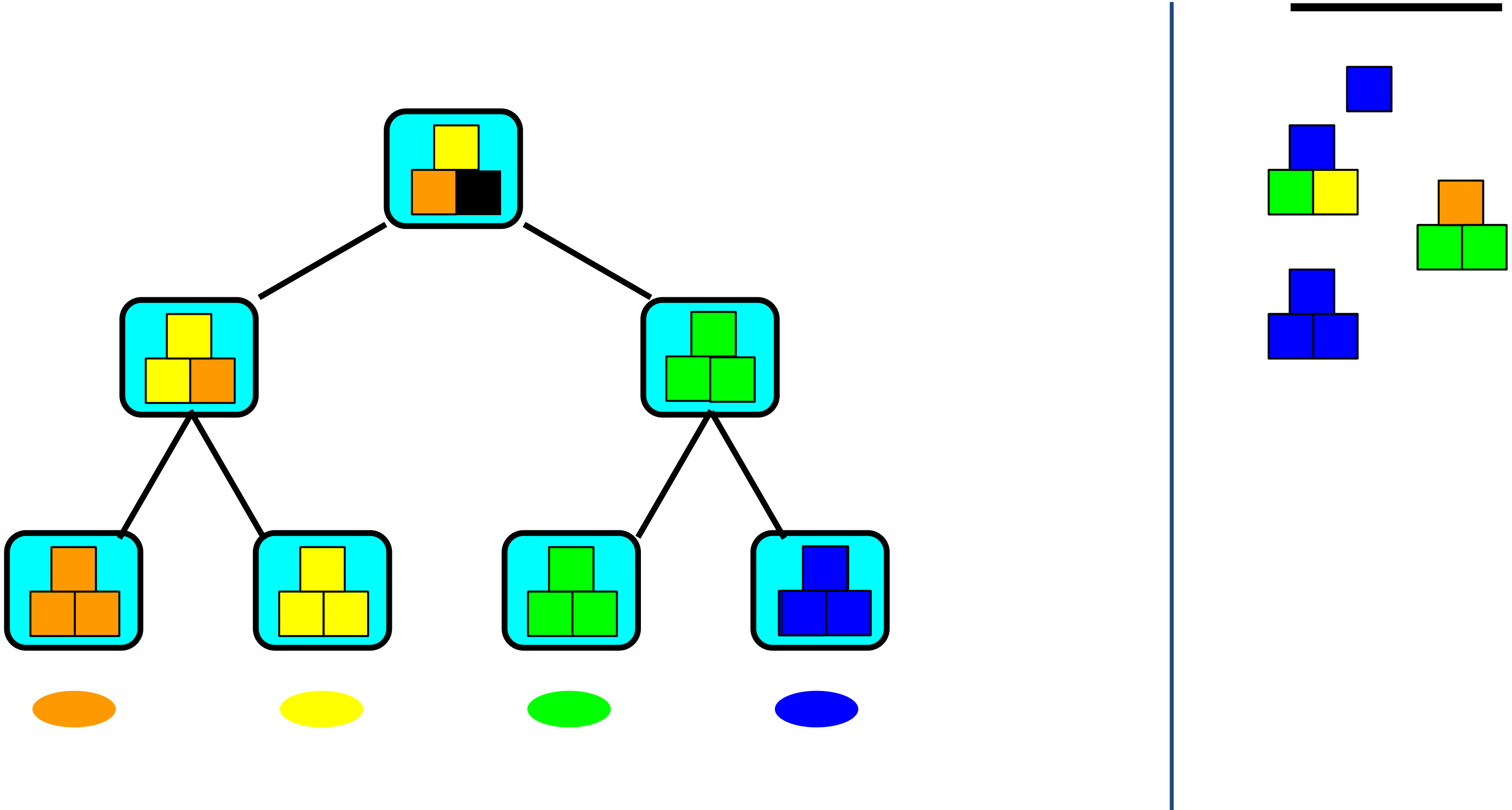
Path ORAM: Access



Stash



Path ORAM: Eviction



Path ORAM: Overall

- Much more efficient: O(log N)
- Still can be improved...

Path ORAM II: Ring ORAM

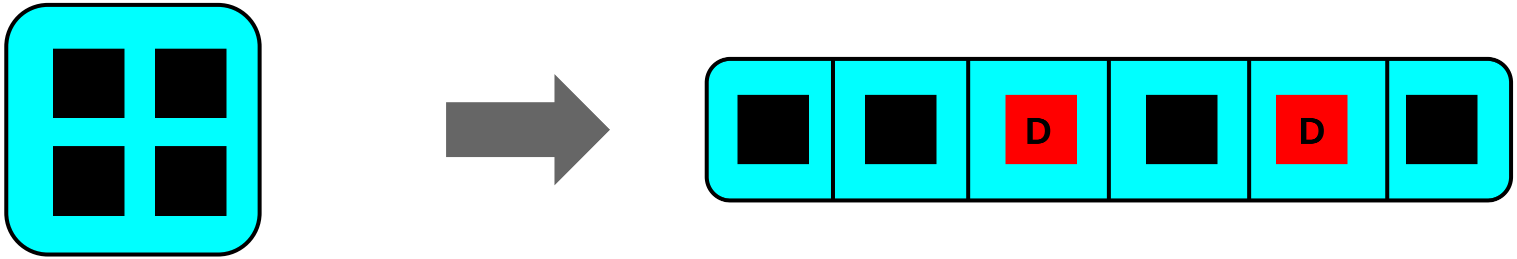
Ring ORAM: Overview

- Improvement on Path ORAM

- Improves by:
    - Decreasing bandwidth
    - Improve eviction quality

Ring ORAM: Buckets

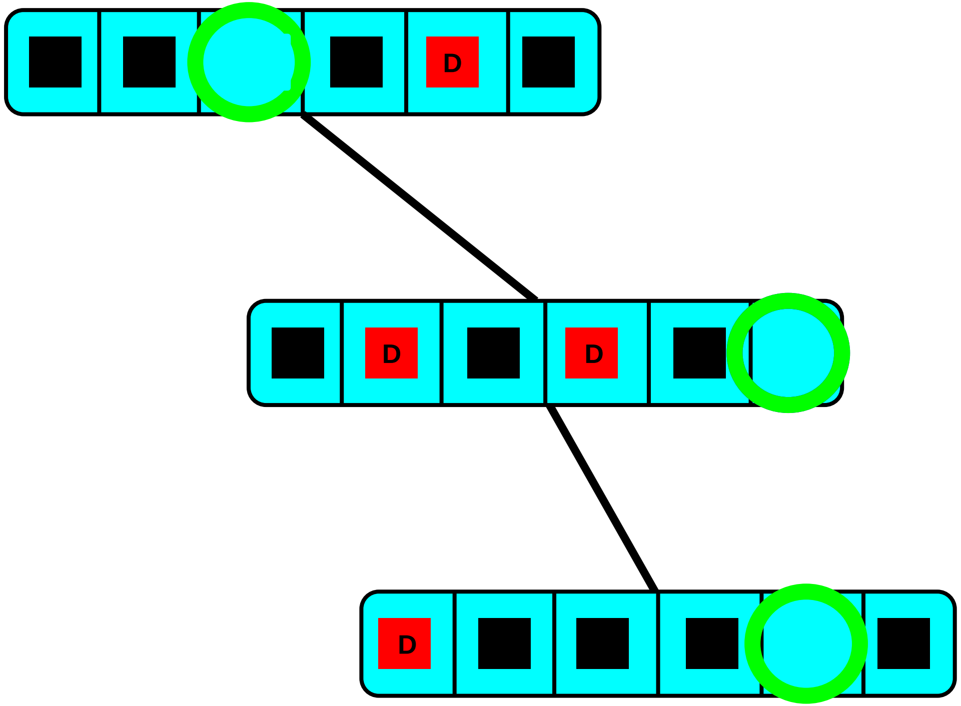
- Use Goldreich Approach:



Path ORAM Bucket

Ring ORAM Bucket

Ring ORAM: Access



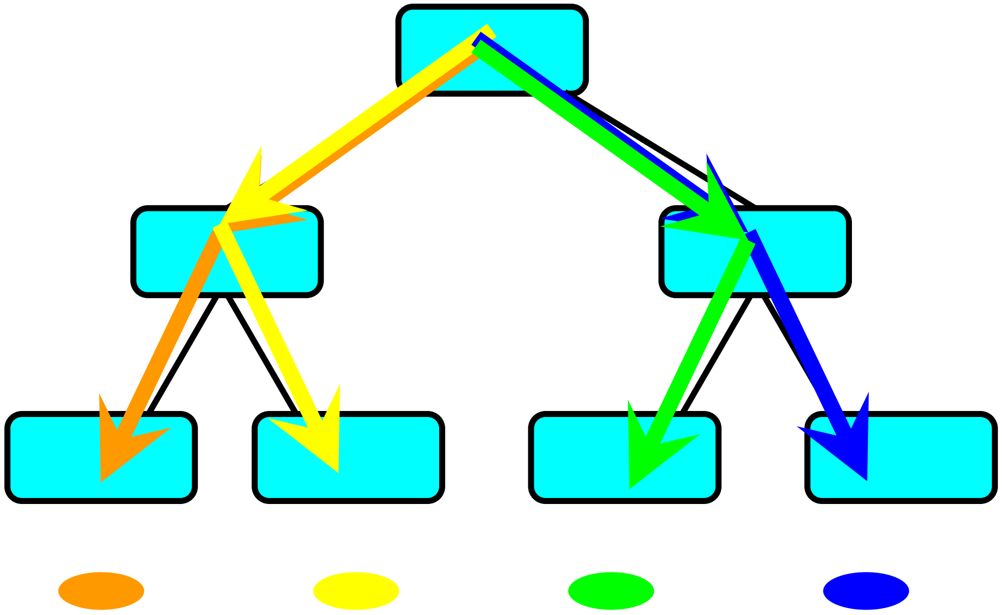
Stash

Ring ORAM: Eviction

Two Changes from Path ORAM:

- Only evict every Ath Access
- Evict along more efficient path

Optimized Eviction Paths



Our Ring ORAM Results

Z-value: 5

ORAM size: 127

Ring ORAM speed: 0.021916

Final Stash Size: 4

Table of Efficiencies

ORAM Protocol	**Bandwidth Efficiency**
Naive Linear Scan	O(N)
Goldreich (1987)	O(√N)
Path (2013)	O(lg N) (~8 lg N)
Ring (2014)	O(lg N) (~3 lg N)
?????	O(1)

FUTURE WORK

Onion Oram

Onion ORAM Details

- Breaks log N bound
- Server computation

Onion ORAM: Overview

- Server computes on encrypted data

- How?
  - Additive Homomorphic Encryption
  - Guaranteed progress of blocks

Onion ORAM protocol

E(0 1 0 0 0 0)

Data!

Onion ORAM layers

- Many layers of encryption
- Bounding layers is key
- Eviction - move all blocks to leaf

Onion ORAM efficiency

- Bandwidth cost: Constant order - O(b)

- Server Computation: O(B λ log N)

- Very Costly!

Optimizations and Improvements

- Onion ORAM multi-eviction
- Skipping layers in eviction phase
- NTRU vs Damgård-Jurik

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Onion (2015)	O(1) constant