# SIEVE: An Efficient Eviction Policy for Bufferpool Data


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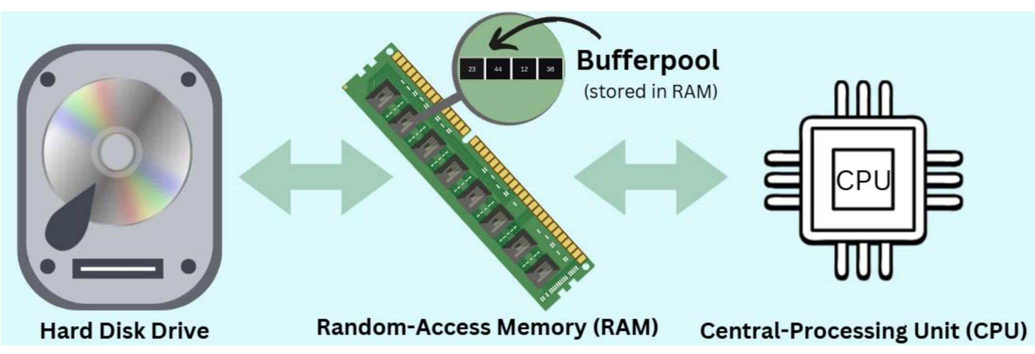
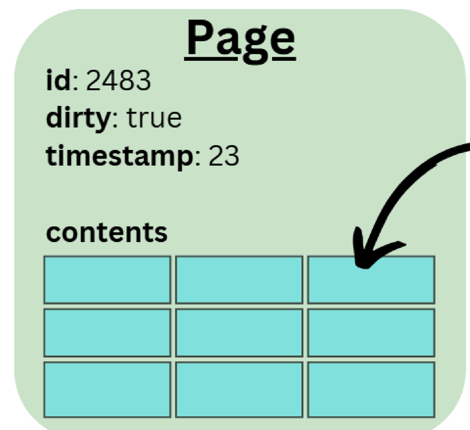
## Introduction

### Background

- The bufferpool is a region of the computer's RAM with limited space that stores the most relevant, frequently accessed data files by a user
- Cache eviction policies are algorithms that are used to strategically determine which data files to remove when the bufferpool is full and a new page is requested
- Present-day **modern** and **classic** policies such as **ARC, FIFO, or LRU** often face a trade-off between efficiency and simplicity
- Adapting to more efficient eviction policies helps ensure **optimal energy storage**, **minimum cost**, and the **consistency of data files**




### Objective

- This research study explores a new implementation of the recently-discovered **SIEVE policy** to determine future implications of SIEVE in various workloads
- The SIEVE implementation is compared to the implementations of **LRU** (classic policy) and **CLFRU** (modern policy) to explore differences in performance metrics across workloads

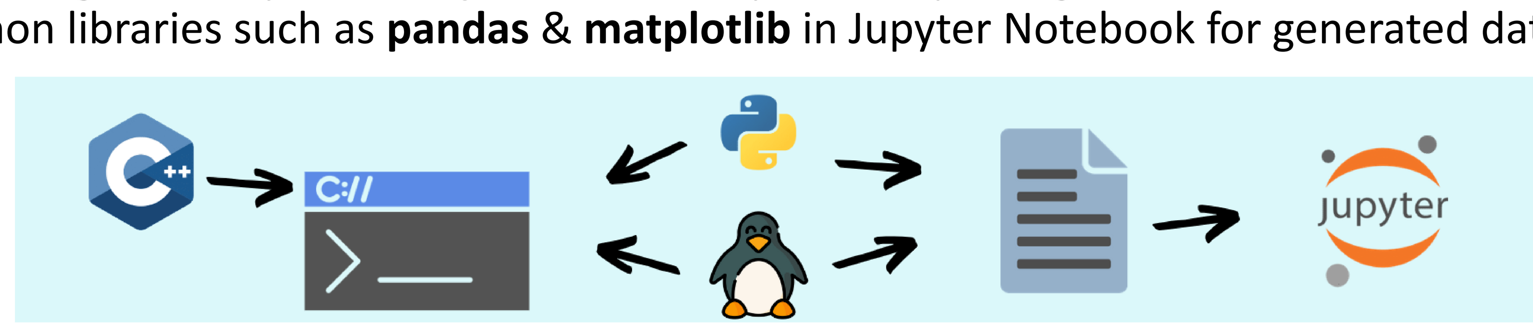
## Methods

**Part 1: Implementing Cache Eviction Policies + Read/Write Simulator (C++)**

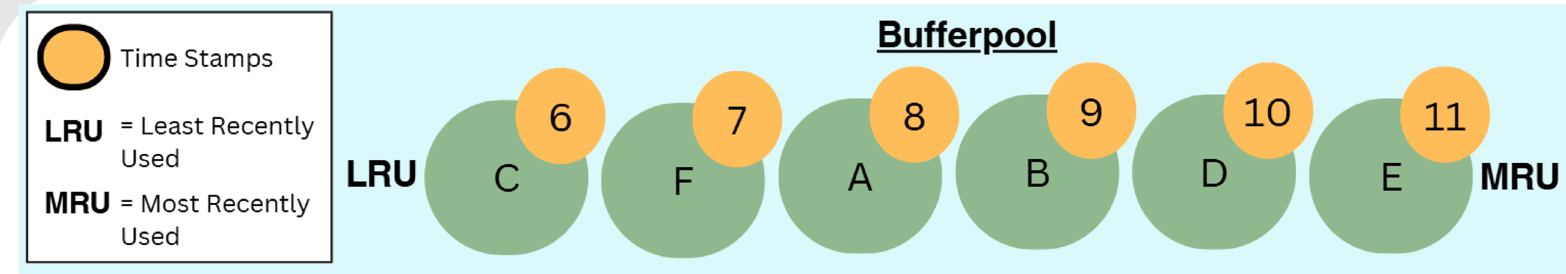
- Implemented algorithms for CFLRU, LRU, and SIEVE using VS Code + WSL
- Implementation included **workload generator**, **executor**, and **parameter** prerequisite files which were compiled using a Makefile under the target **Buffermanager**
- Executor included a **simulation** of fetching & executing read/write requests
- Each call to the Buffermanager generated metrics on the **hit rate, miss rate, read IO, write IO, and policy execution time**

**Part 2: Building a Compiler for Data Collection (Python)**

- 2 Compilers: first compiler varied **disk & bufferpool sizes** & the **number of page requests;** second compiler tracked metrics across algorithms resulting from different **workload skews** and **read/write ratios**
- Each compiler generated a CSV file with data sets for each combination of parameter values by calling repeated requests on the Buffermanager through **terminal command-prompts**
- Incorporated **Regex** and Python **Subprocess** in compilers for parsing data
- Utilized Python libraries such as **pandas** & **matplotlib** in Jupyter Notebook for generated data visualization



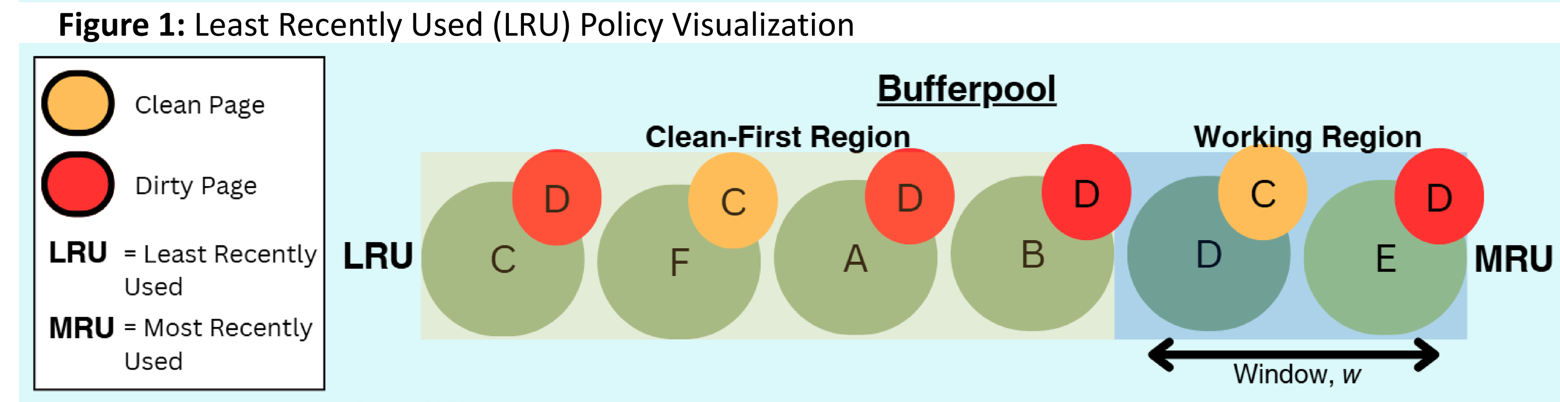

## Eviction Policies




**Each time page a is requested:**

- If the page is in the bufferpool, the page is moved to the front (MRU) and its timestamp is updated
- If the page is not in the bufferpool, the least-recently used page is evicted
  - The requested page is added in the front as the most-recently used

**Figure 1:** Least Recently Used (LRU) Policy Visualization

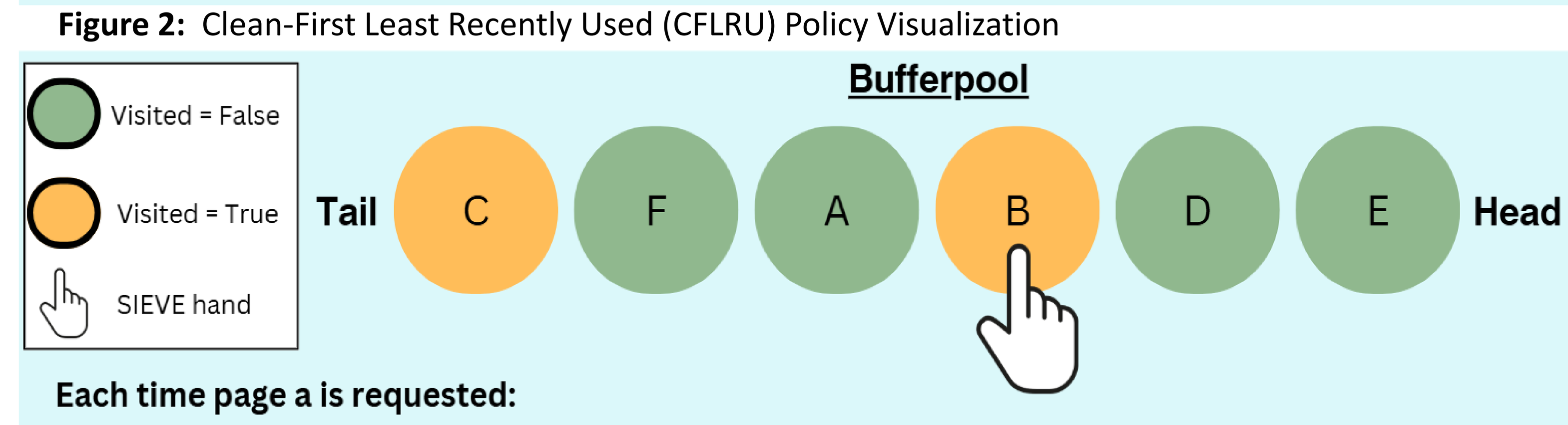



**Same as LRU with a few differences:**

- Pages are only evicted from the clean-first region
- First LRU *clean* page that is found is evicted; if clean-first region has no clean pages, the first LRU dirty page is evicted
- Window size (*w*) is determined with parameter *n*

**Window Size (*w*)** = *Buffer Size / n*

**Figure 2:** Clean-First Least Recently Used (CFLRU) Policy Visualization




**Each time page a is requested:**

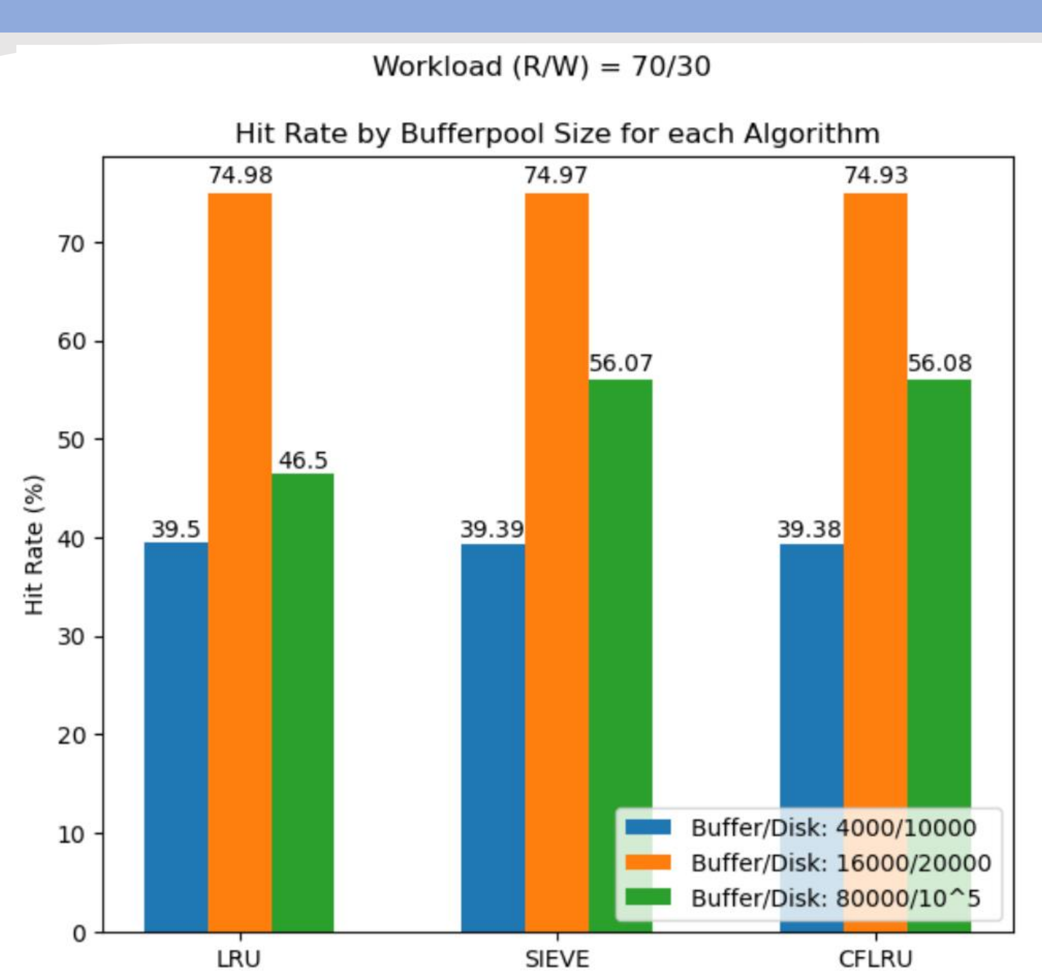
- If the SIEVE hand points to a visited page, the page is changed to false
- If hand points to an unvisited page, the page is evicted; the requested page is added to the head
- Hand moves one right (tail to head) for each request

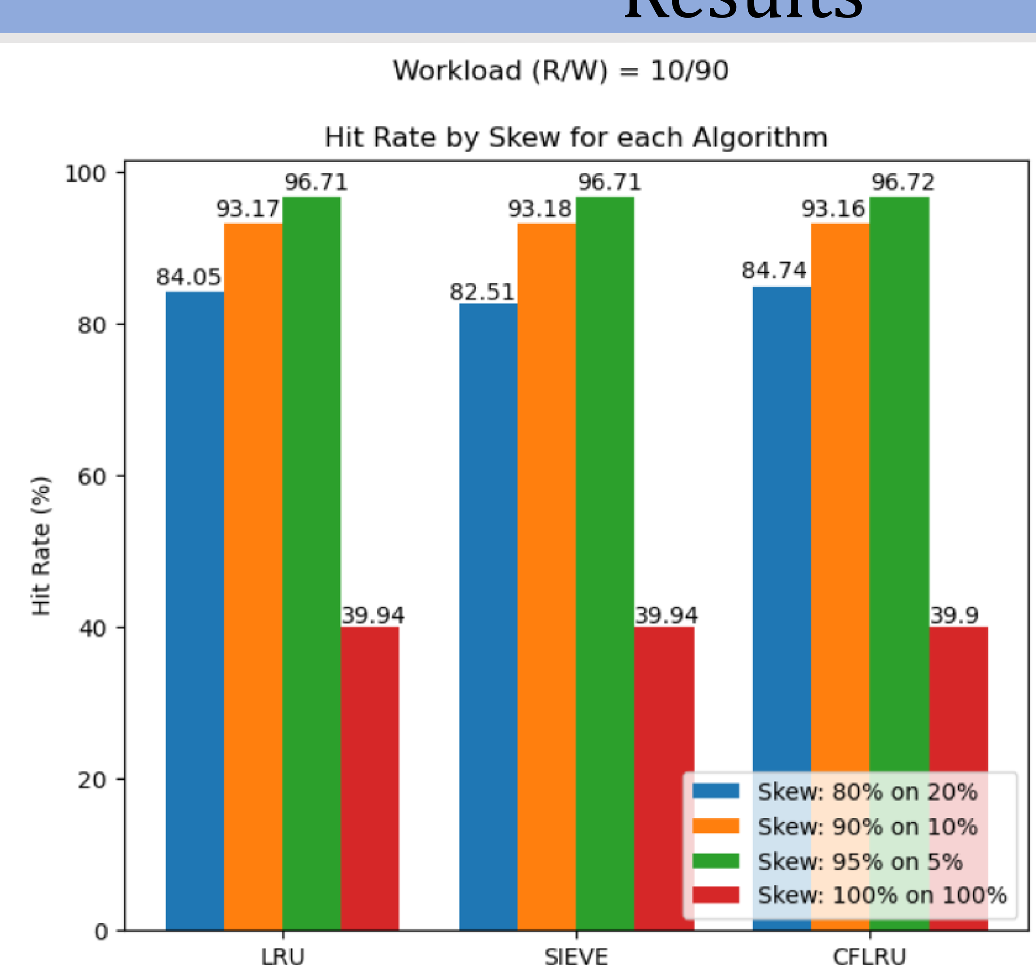
**Figure 3:** SIEVE Policy Visualization

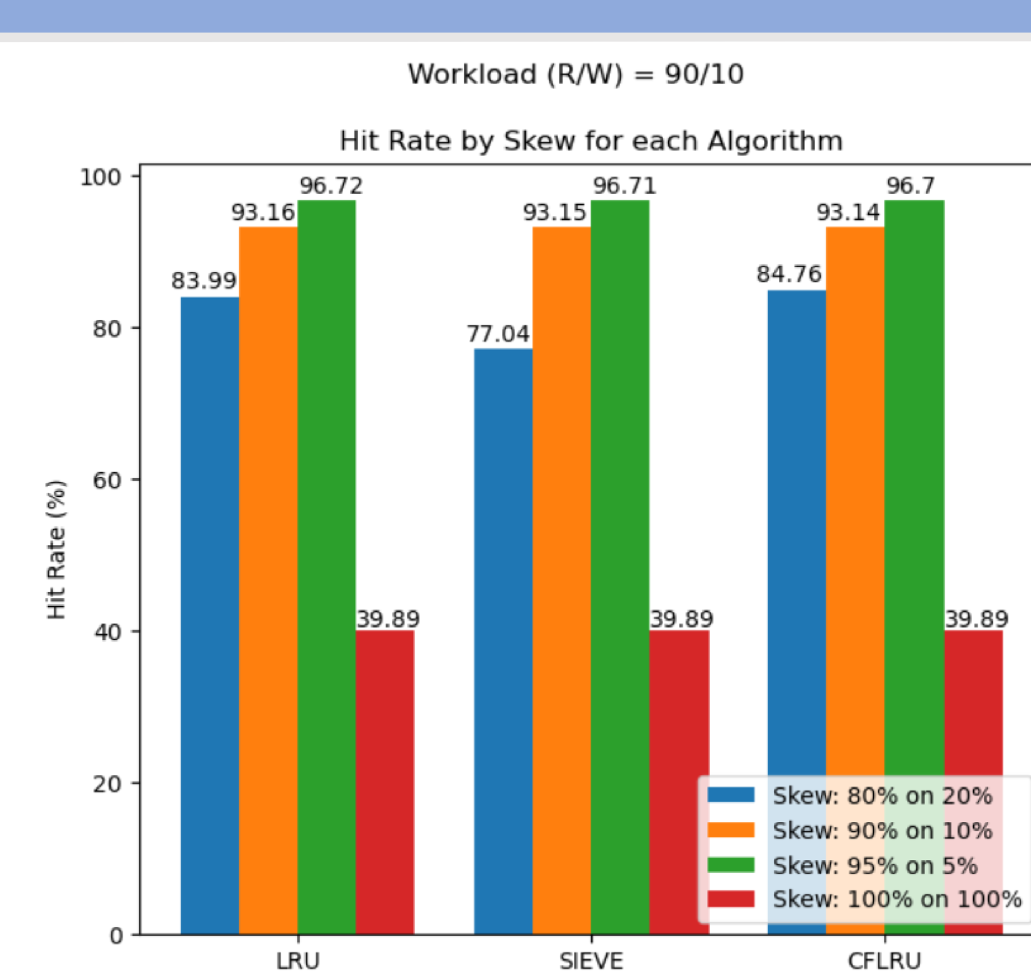
## Parameters

| Parameter | Compiler 1 | | | Compiler 2 | | | | |
|---|---|---|---|---|---|---|---|---|
| Bufferpool Size; Disk Size | 4,000; 10,000 | 16,000; 20,000 | 80,000; 10^5 | 4,000; 10,000 | | | | |
| Number of Requests | 10^5 | 2 * 10^5 | 10^6 | 10^6 | | | | |
| Read/Write Ratio | 70/30 | | | 10/90 | 30/70 | 50/50 | 70/30 | 90/10 |
| Workload Skew (% accesses on % pages) | 100%, 100% | | | 80%, 20% | 90%, 10% | 95%, 5% | 100%, 100% | |

## Results




Skewed workloads refer to the % of accesses on a % of pages in the bufferpool (e.g., 80% on 20% means 80% of accesses are done on 20% of the bufferpool data)

## Conclusions

- SIEVE performs significantly better (+9.57%) compared to LRU within larger environments that encompass larger bufferpool/disk sizes (e.g., Buffer, Disk sizes of 80,000, 10^5)
- SIEVE and CFLRU have comparable hit rates in macroenvironments; however, CFLRU takes over 161 times the processing speed of SIEVE --> SIEVE is more efficient in HDDs
- SIEVE outperforms LRU in hit rate on write-heavy workloads (R/W = 10/90); however, it underperforms when enacted in read-heavy workloads (R/W = 90/10)

**Future Implications**

- The SIEVE policy can be implemented in larger environments with a higher number of request operations, which may improve long-term efficiency for cache eviction
- Implementing the SIEVE policy can be integral in write-heavy systems such as applications for logging systems or financial transactions

## References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[3] Zhang, Y.; Yang, J.; Yue, Y.; Vigfusson, Y.; Rashmi, K. V. SIEVE Is Simpler than LRU: An Efficient Turn-Key Eviction Algorithm for Web Caches. In Proceedings of the 21st USENIX Symposium on Networked Systems Design and Implementation (NSDI 24); 2023.


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https://github.com/s-prshah/cache_eviction_simulation