Evaluation of Pointer Swizzling Techniques for DBMS Buffer Management

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Pointer Swizzling as in “In-Memory Performance for Big Data”

Subsection 1

Locate Pages in the Buffer Pool without Pointer Swizzling

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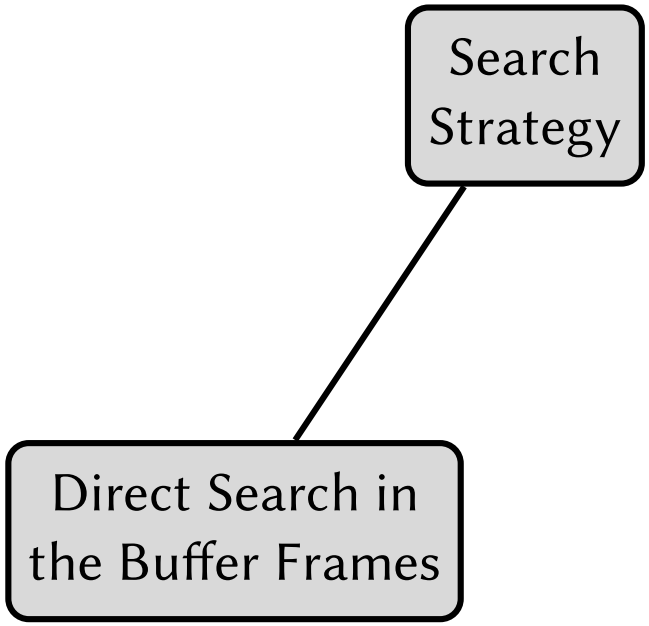

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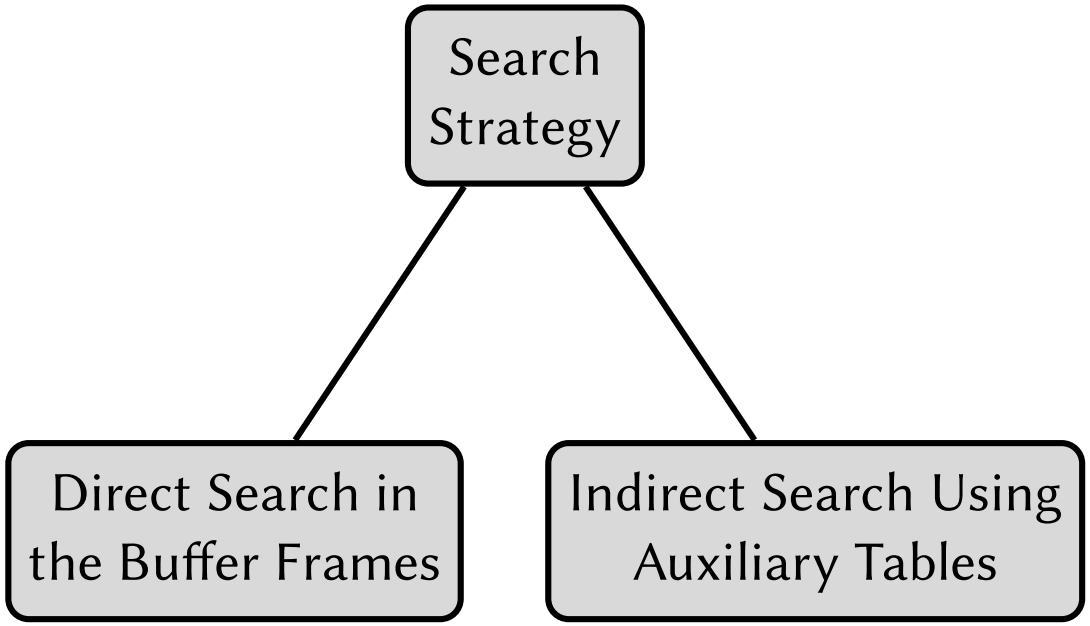

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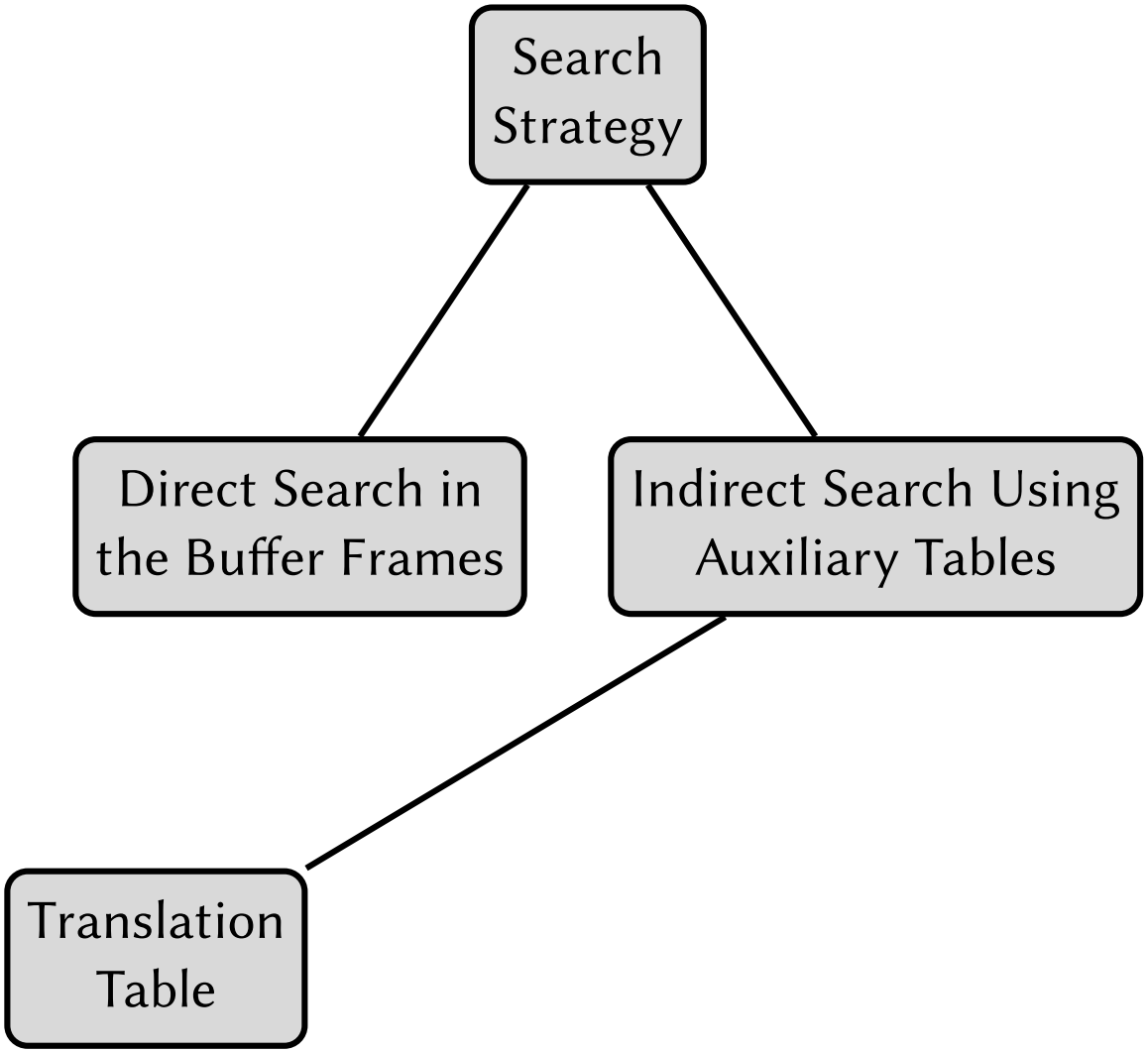

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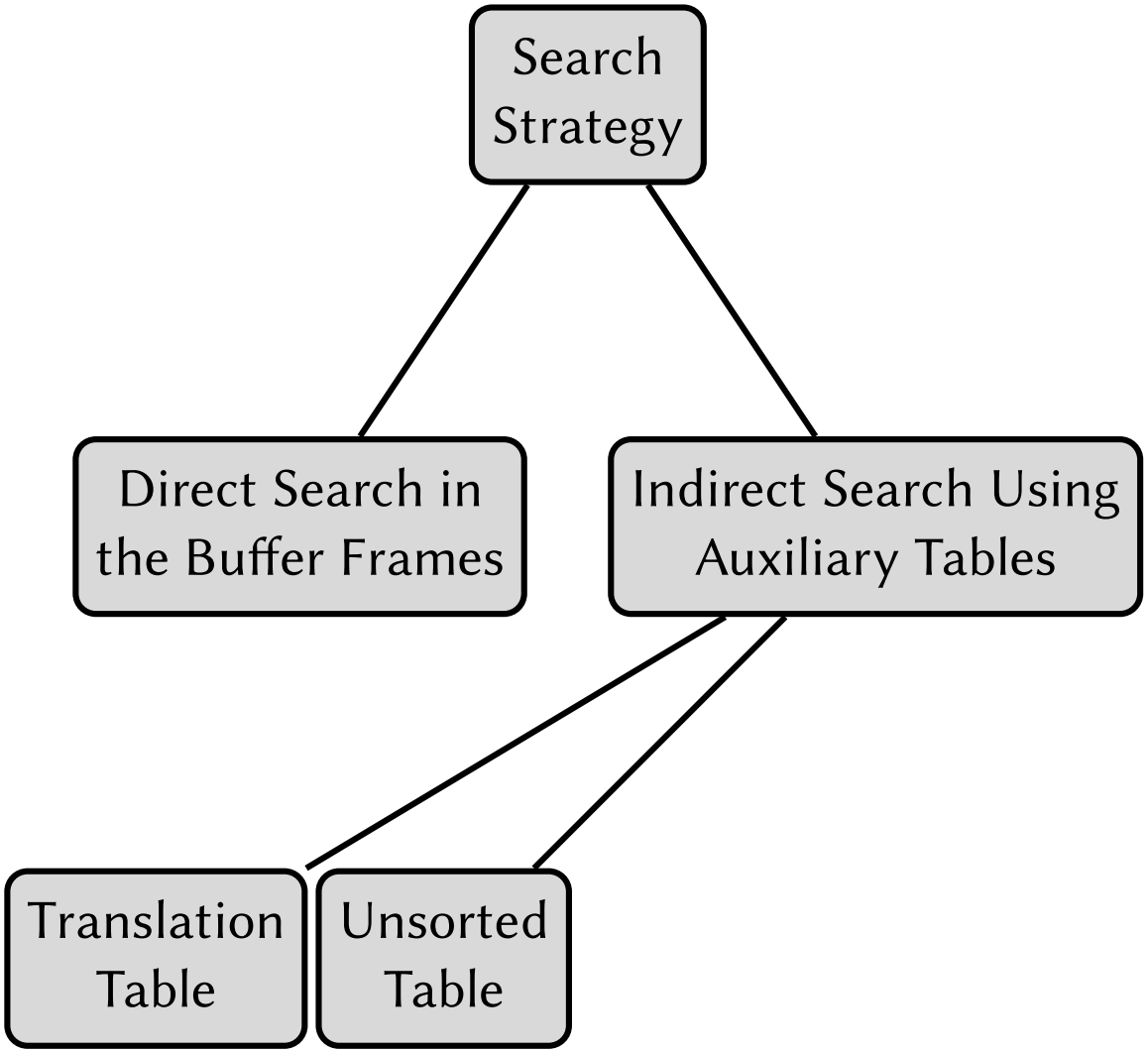

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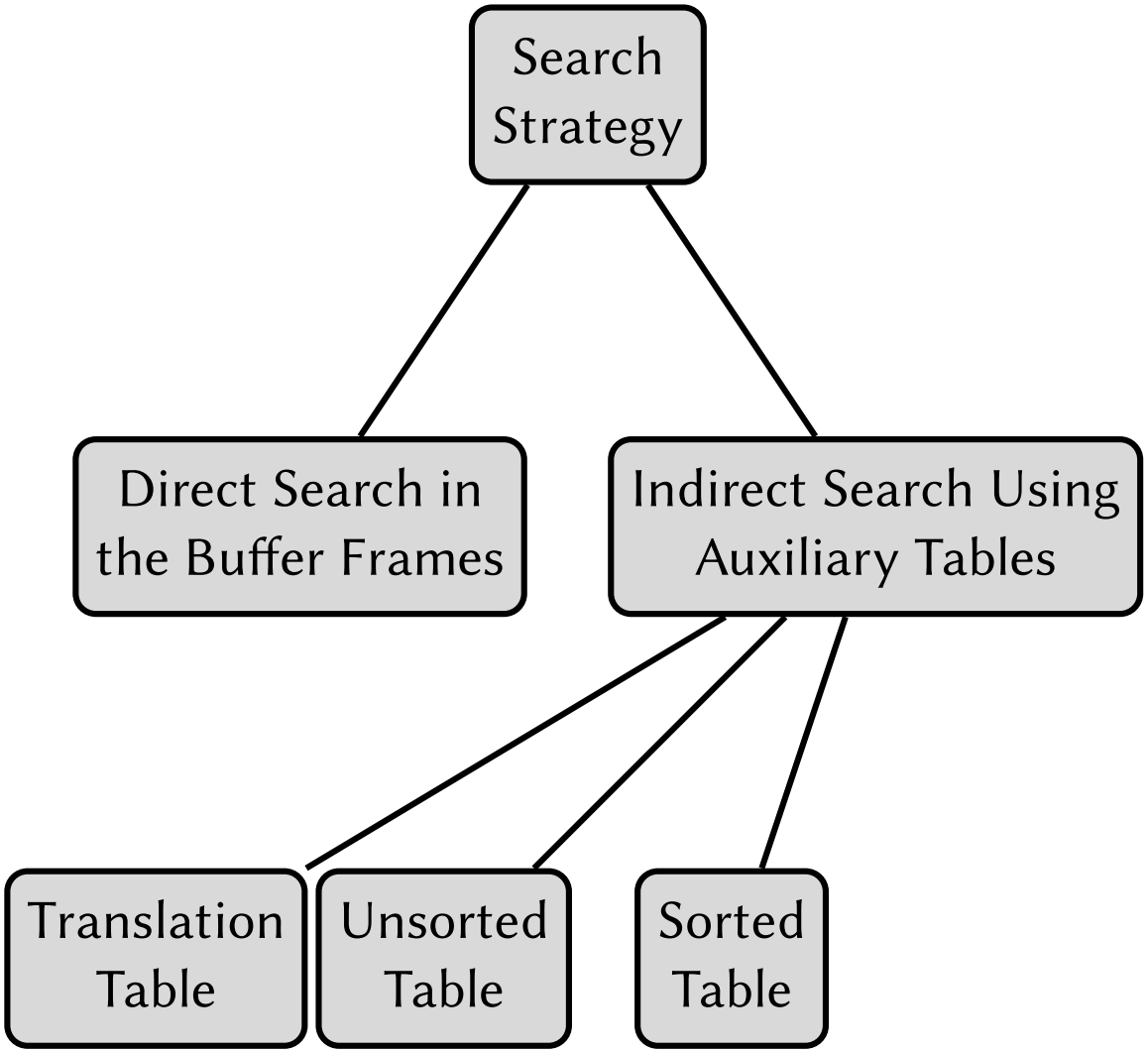

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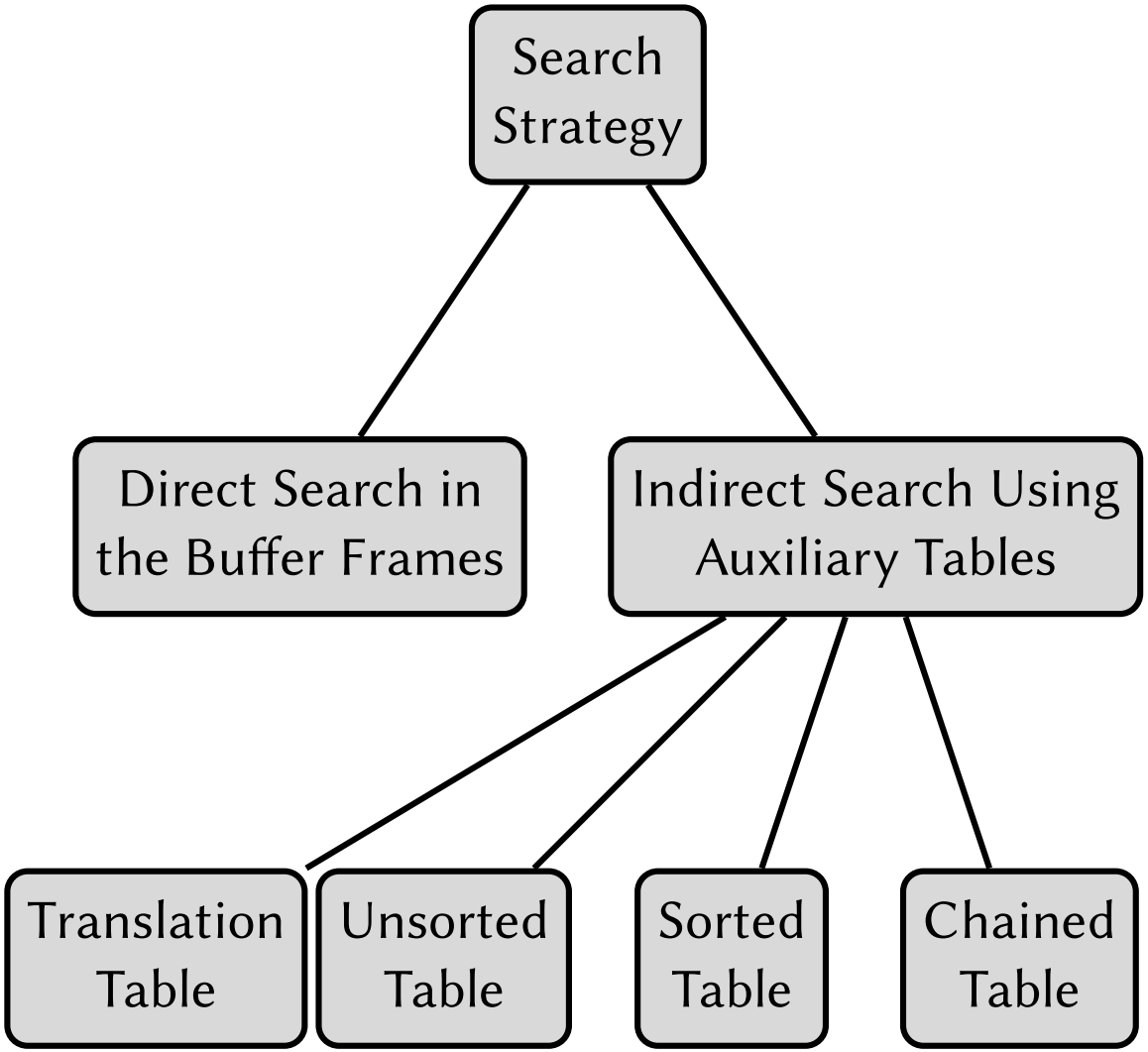

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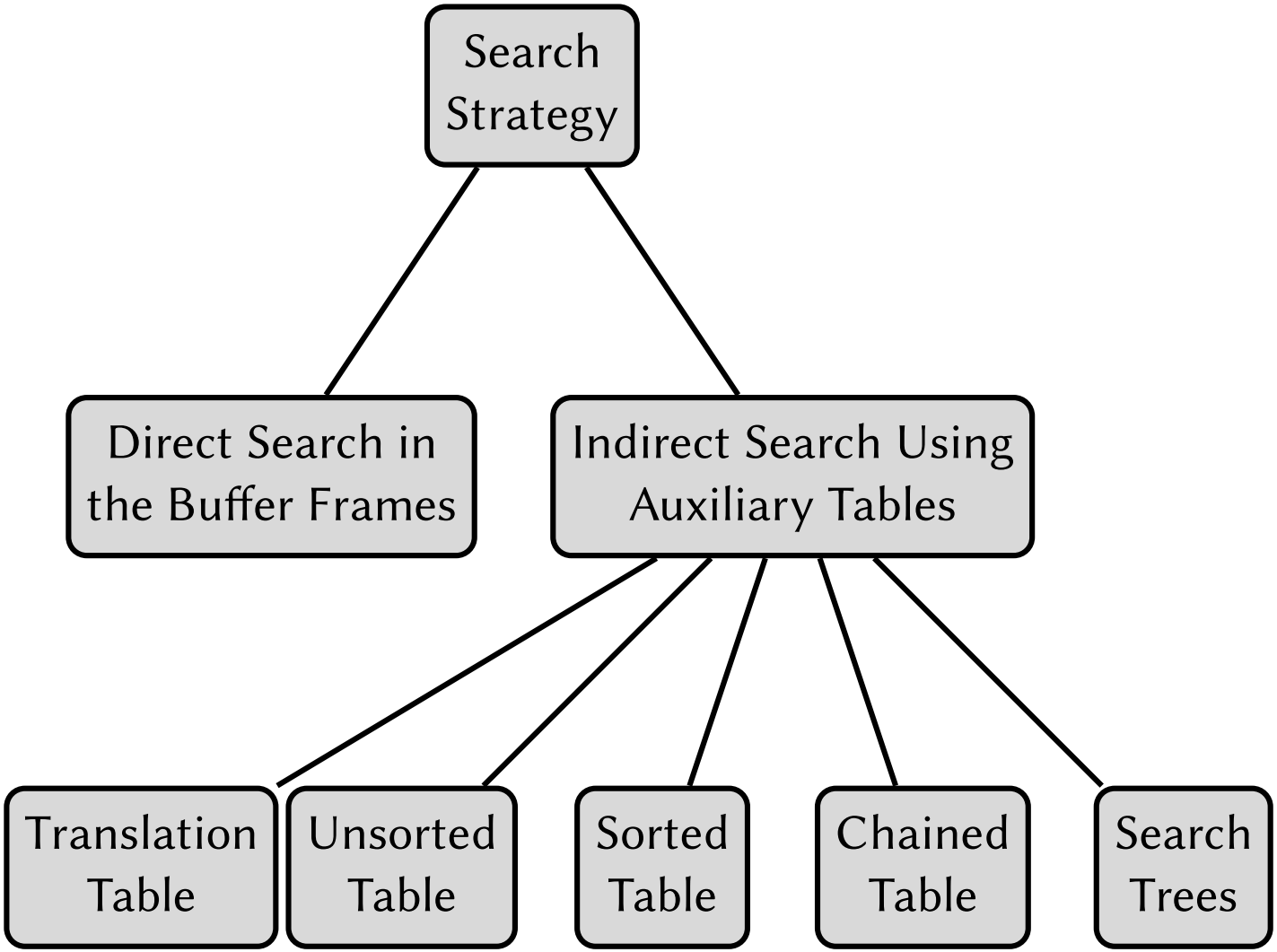

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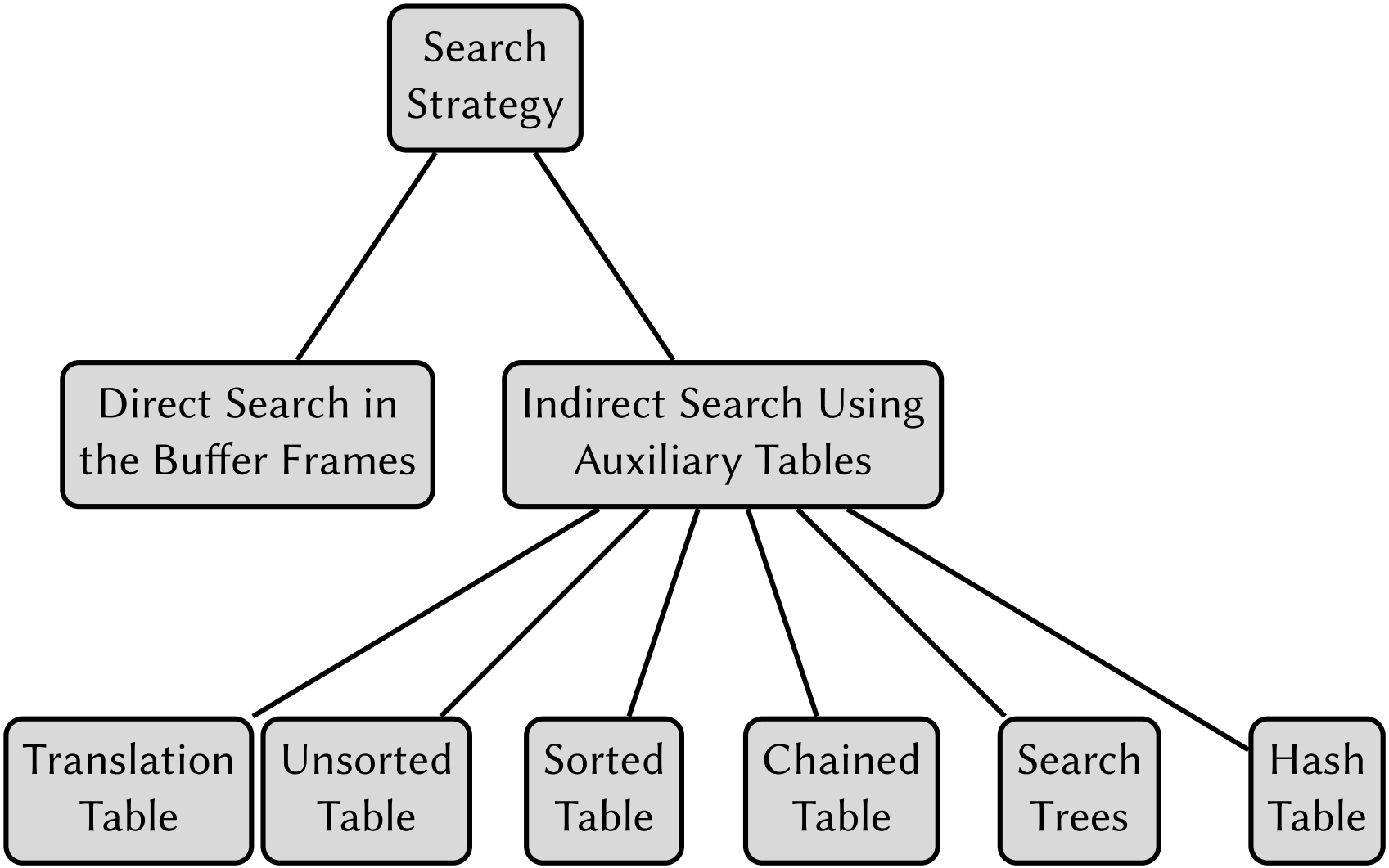

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- Auxiliary data structure of size $S_{\text{pace}} \in \mathcal{O}\left(n\right)$

0	1	2	3	4	5	6	7	8
7785	**6977**	**4347**	**3380**	**5610**	**6376**	**4877**	**3332**	**3354**

Figure: An unsorted table used to map buffer frames to page IDs.

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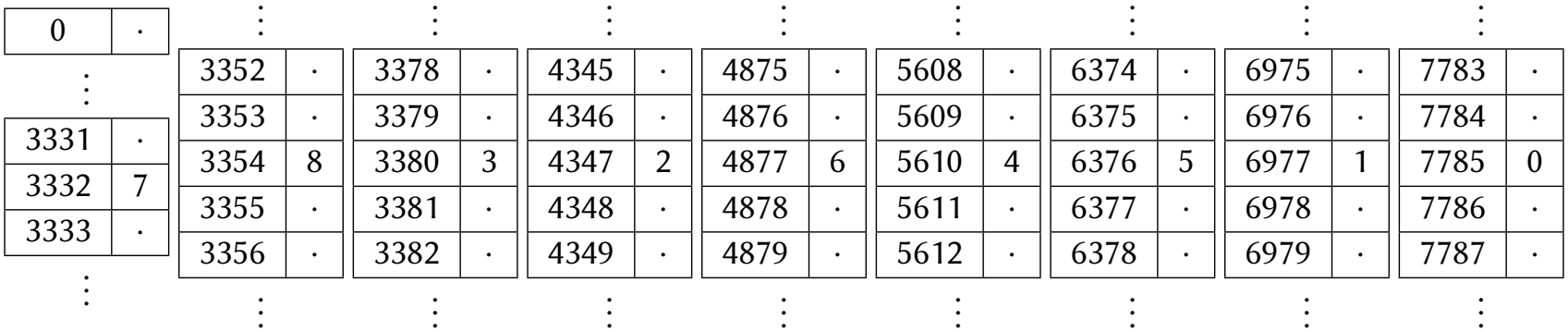

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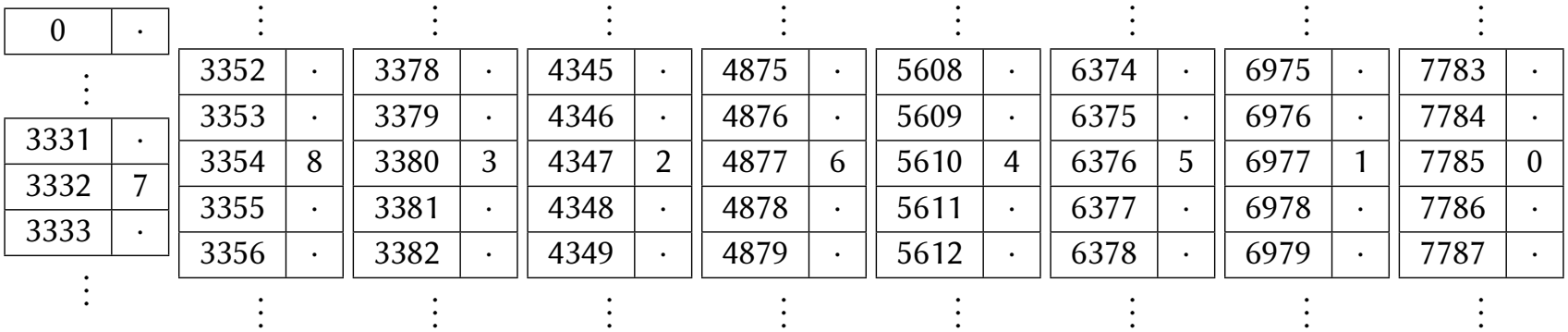

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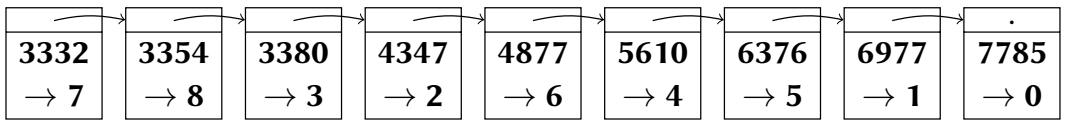

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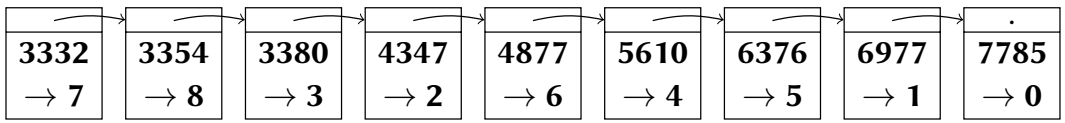

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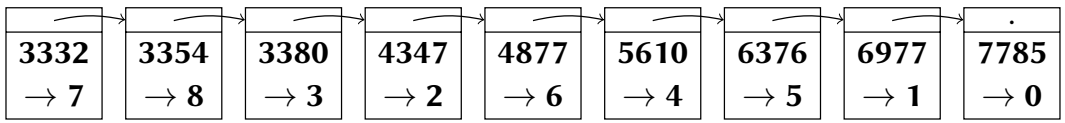
- Binary search requires more links!



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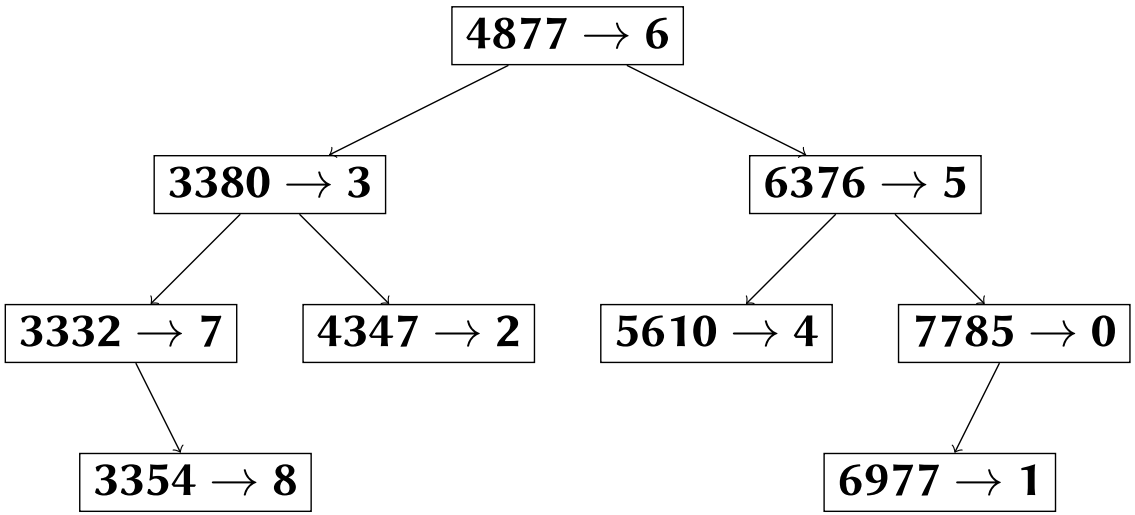

Figure: A balanced search tree used to map page IDs to buffer frames.

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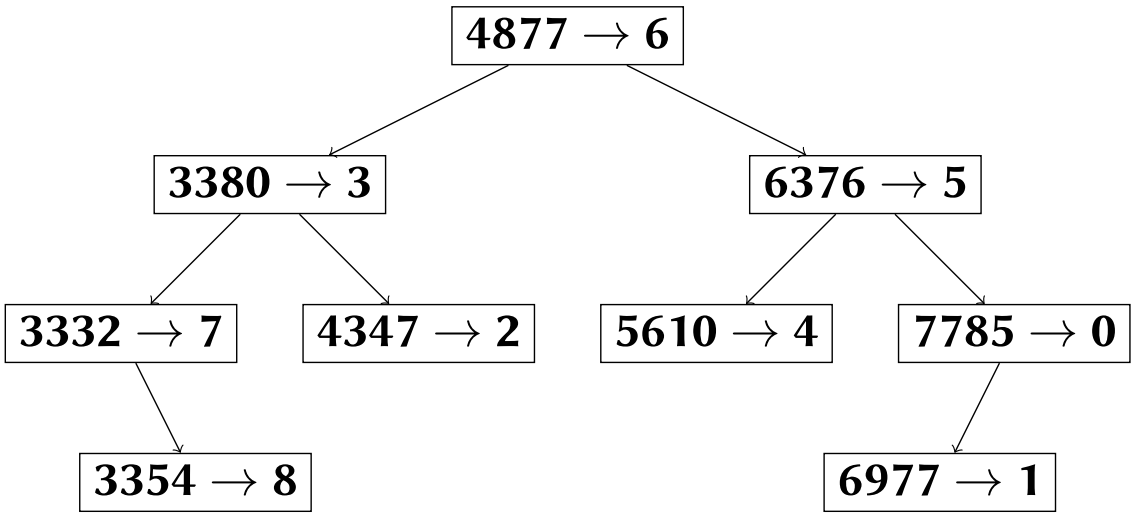

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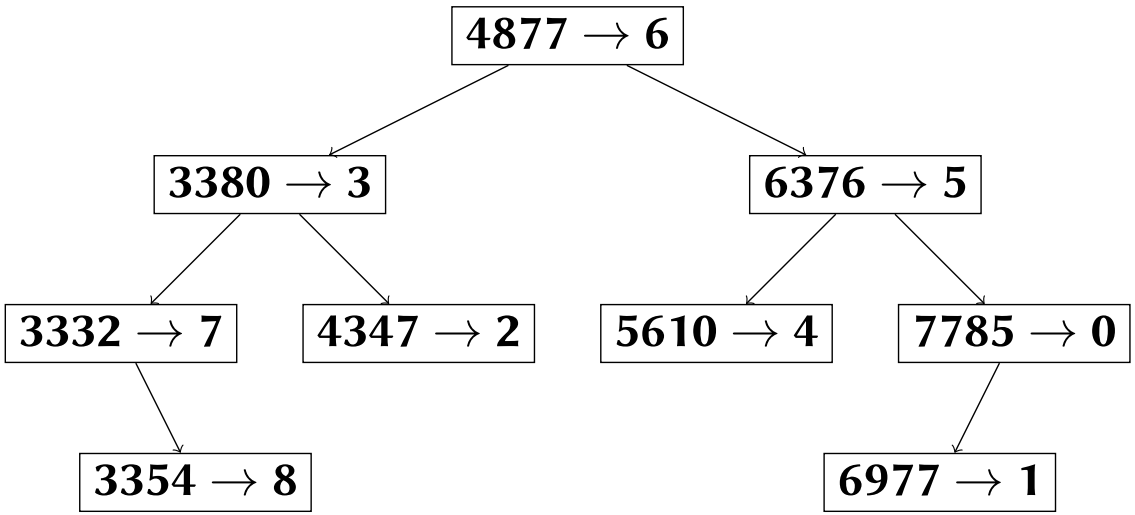

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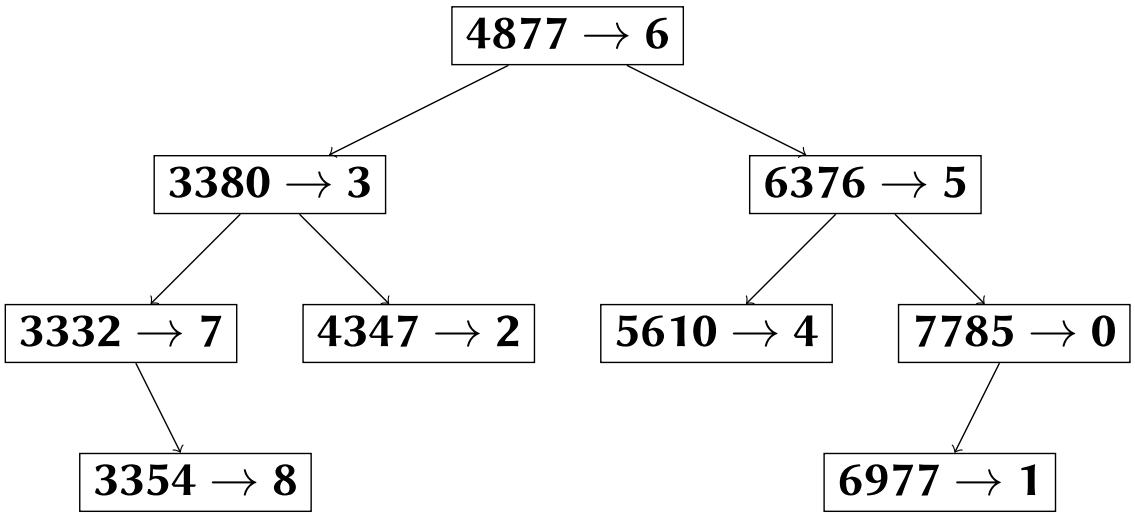
- The worst case costs and the worst cases vary between the different search tree data structures



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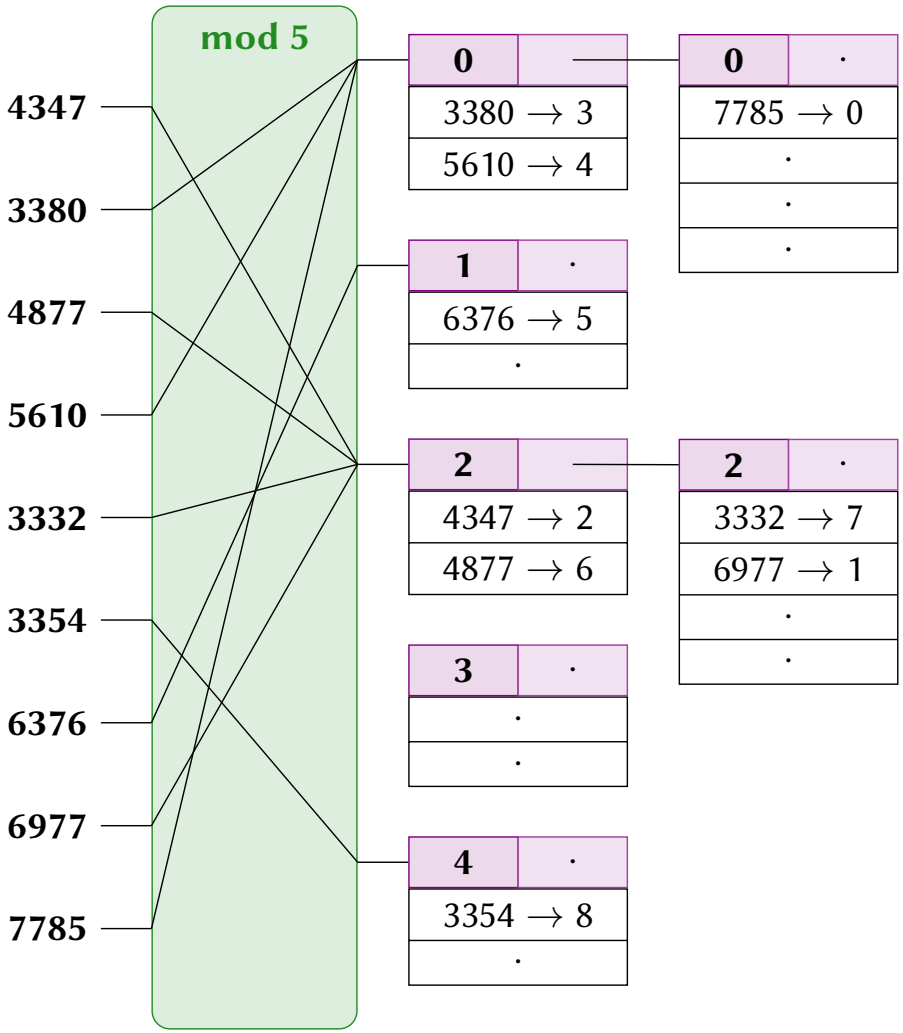
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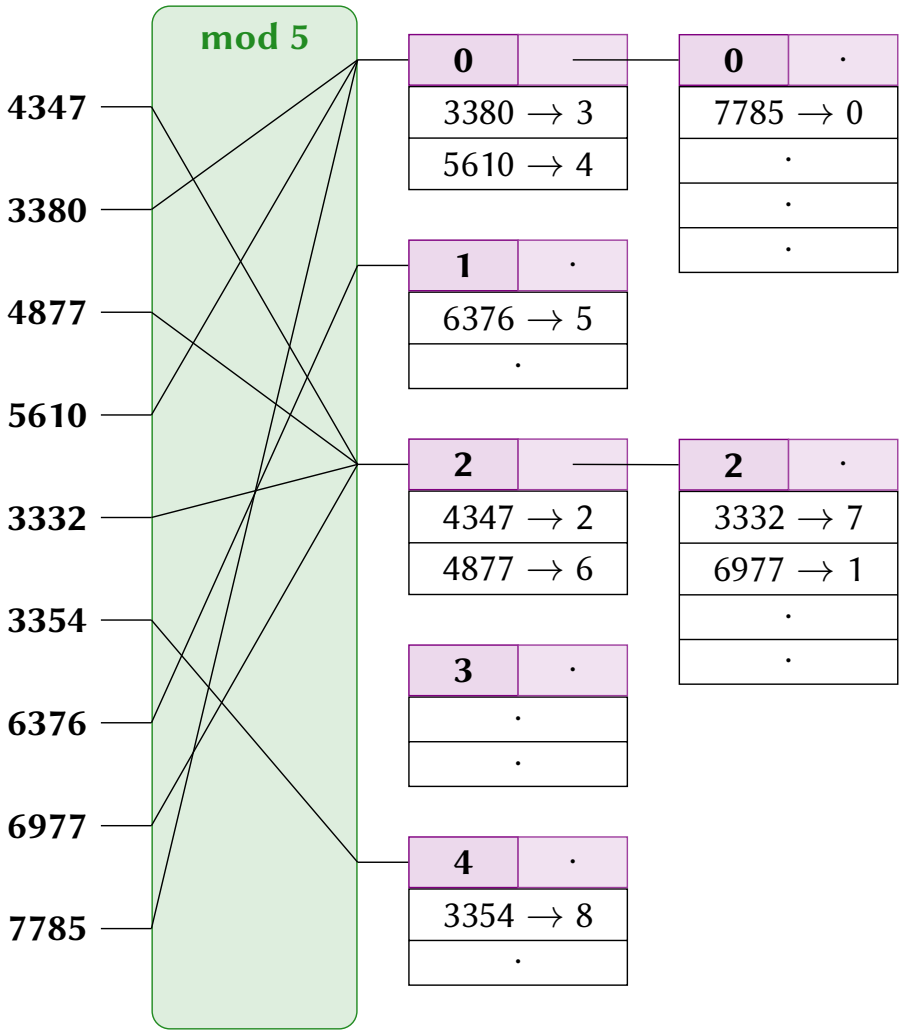

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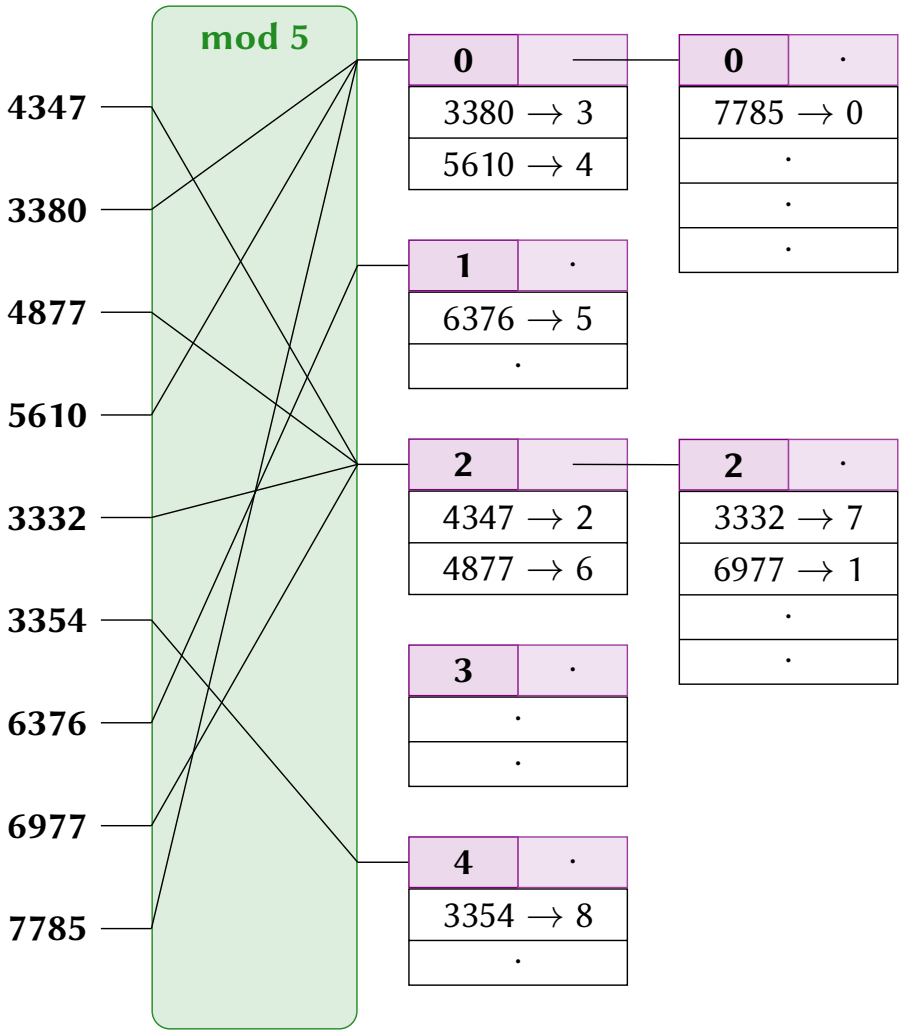

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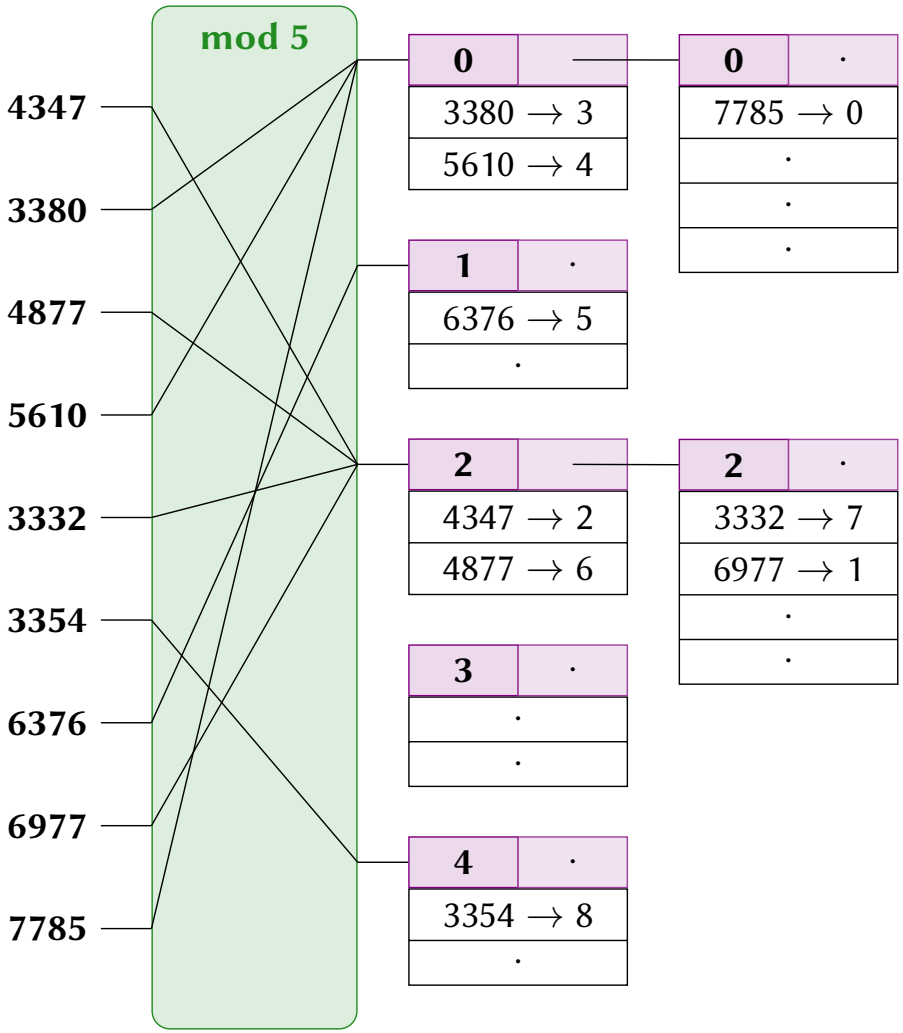

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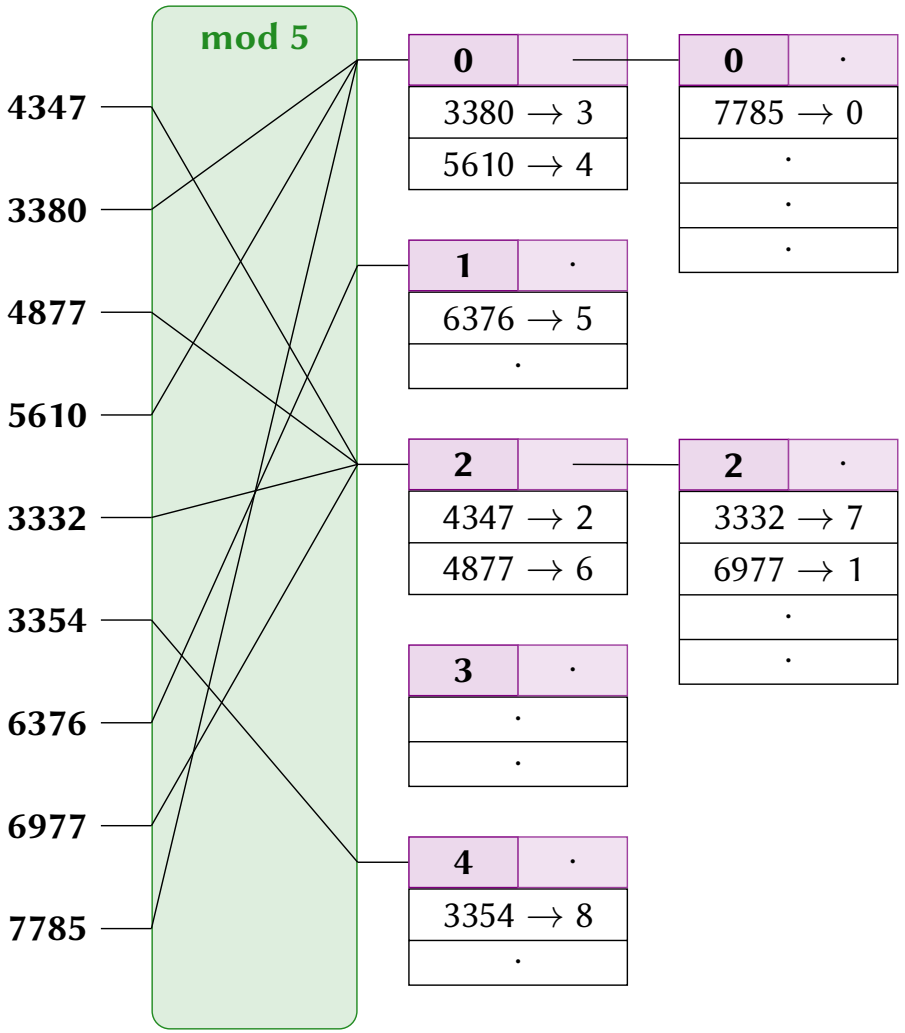

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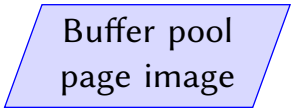

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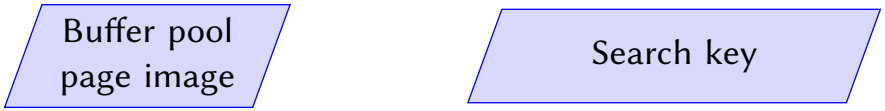

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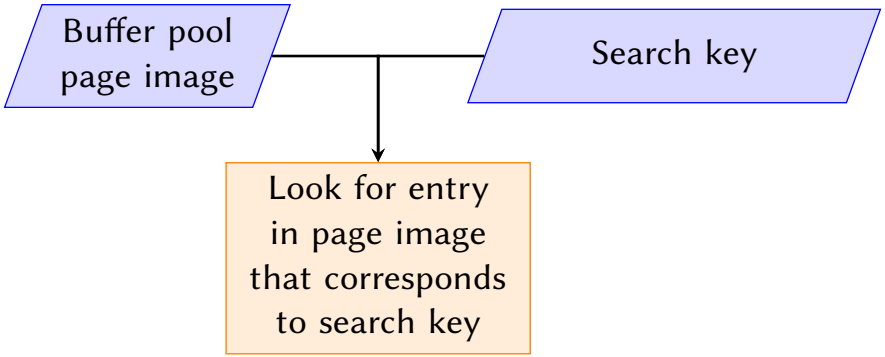

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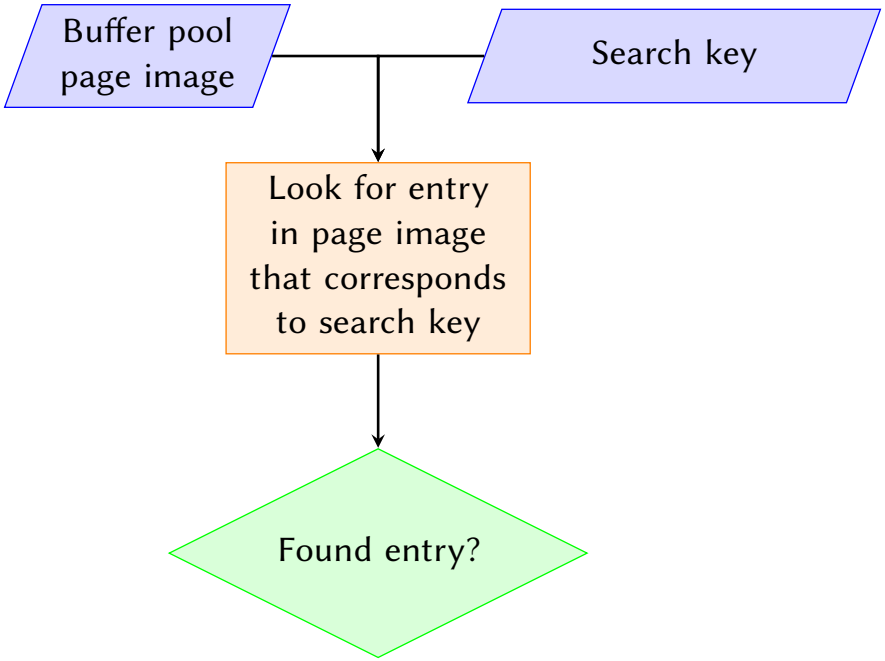

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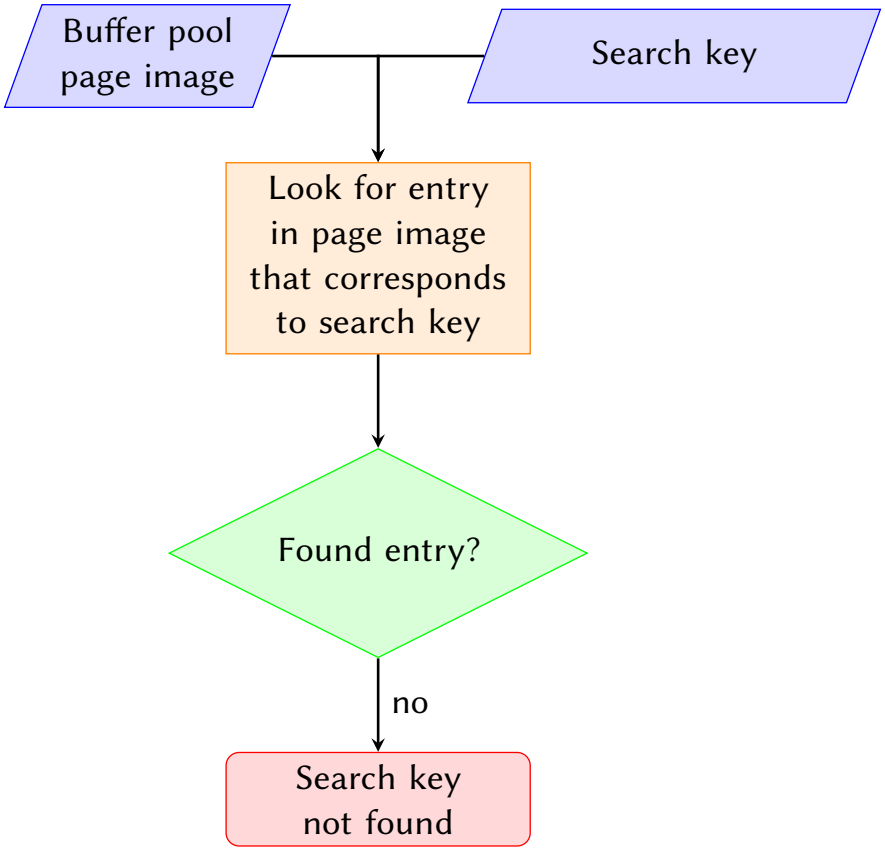

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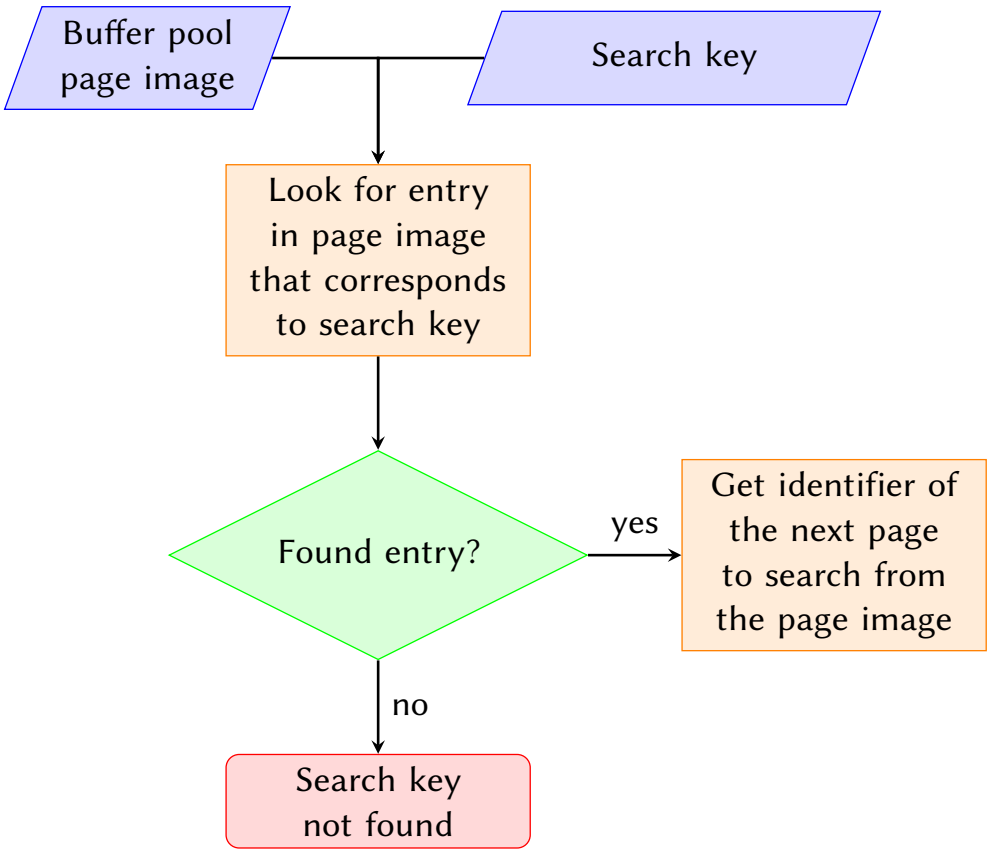

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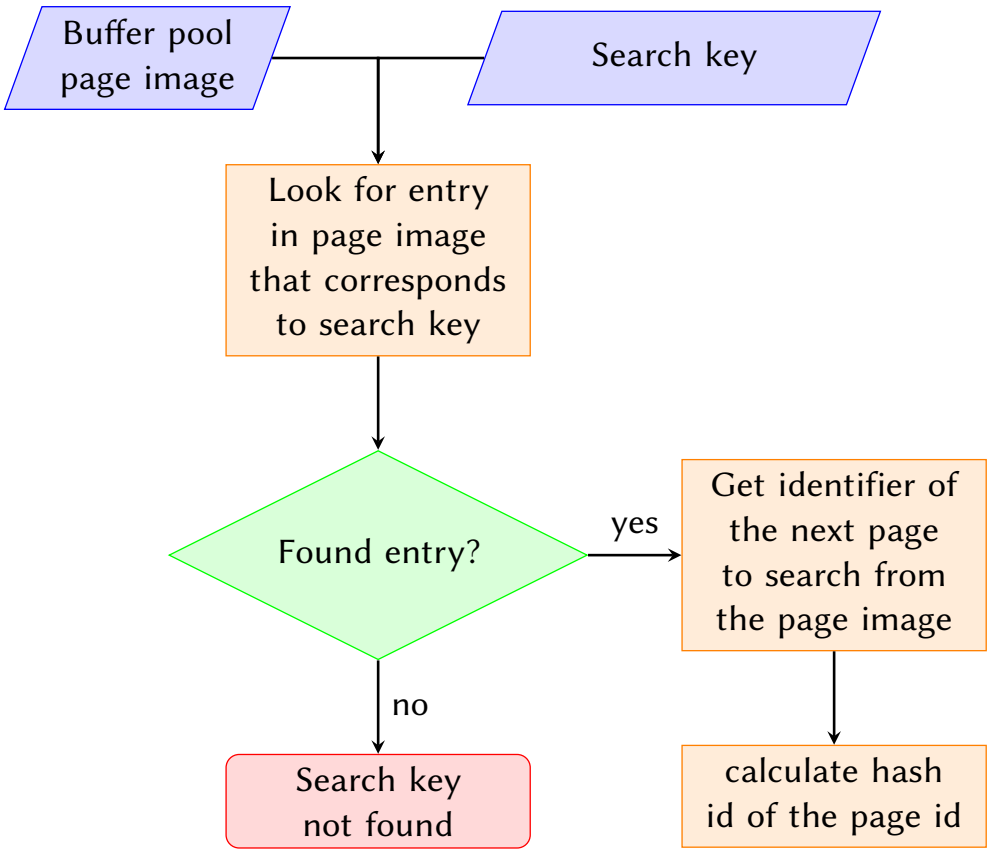

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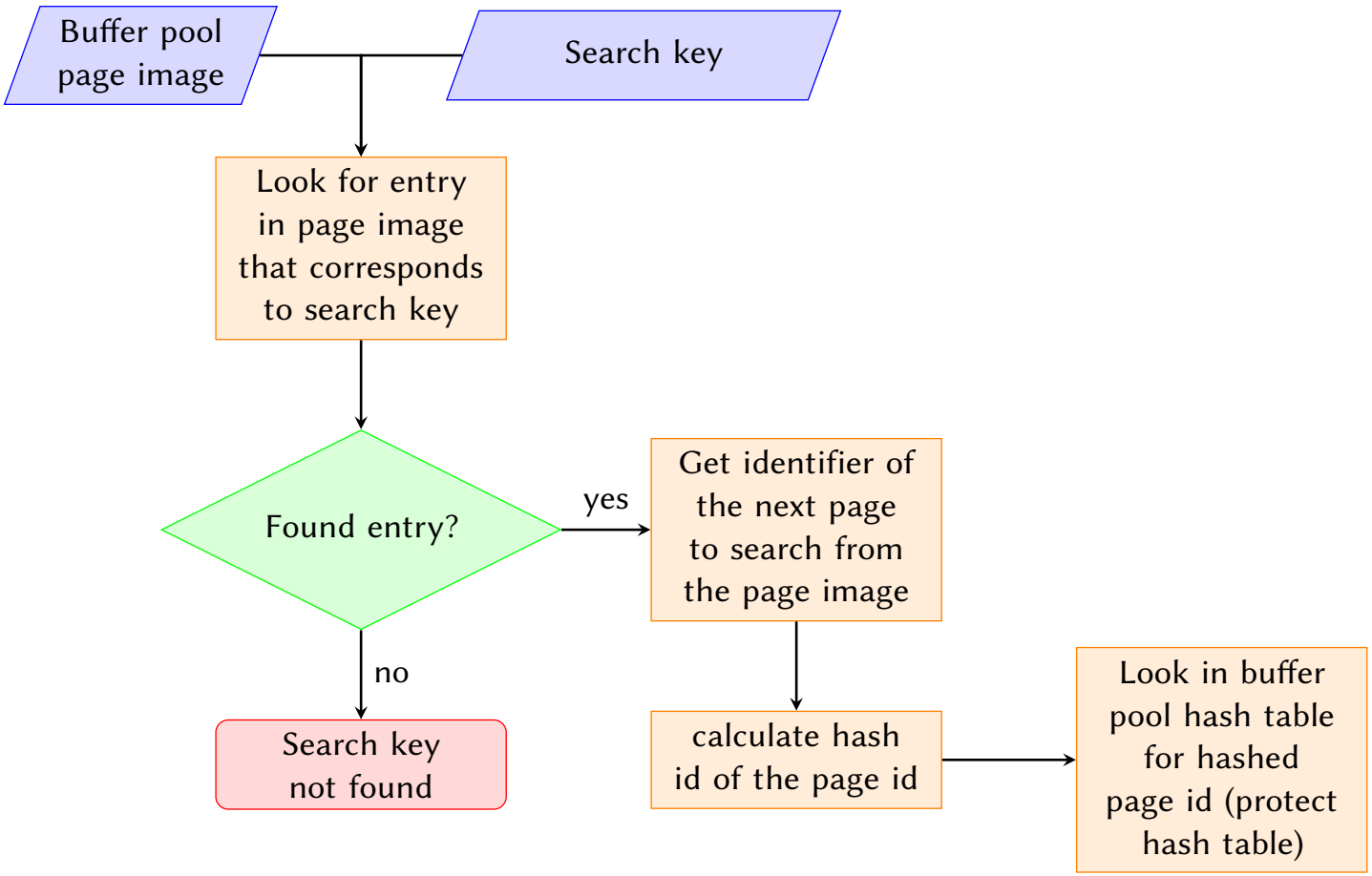

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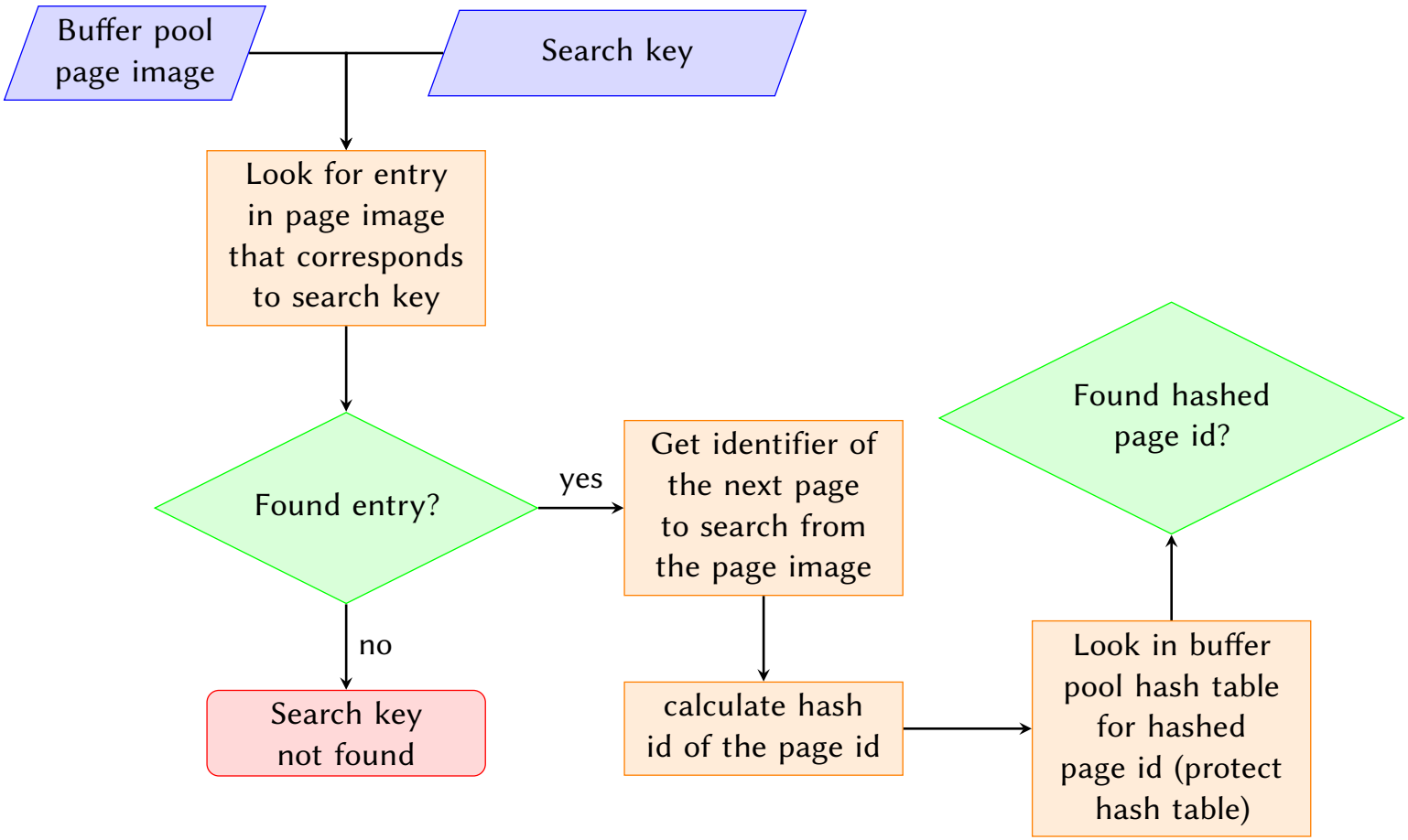

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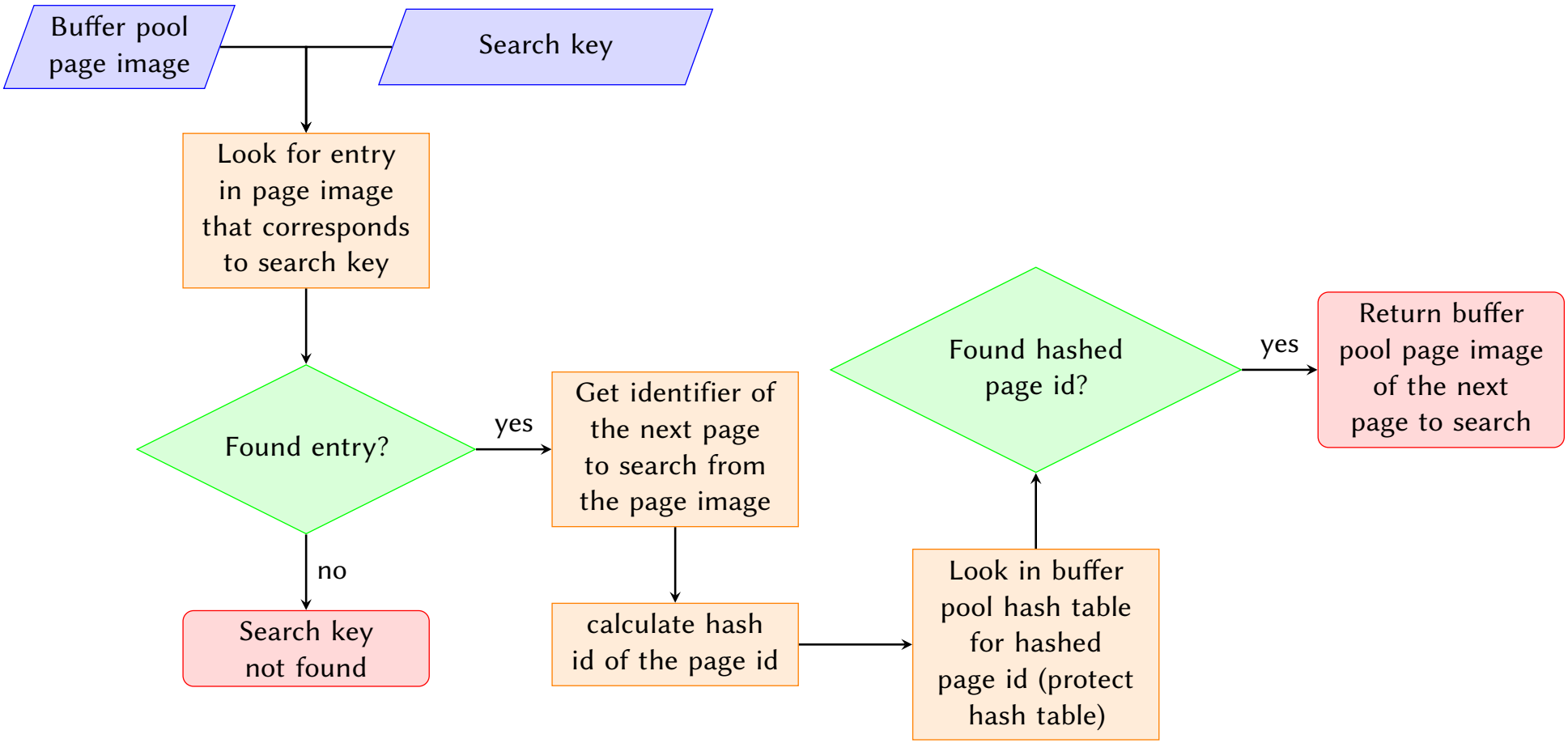

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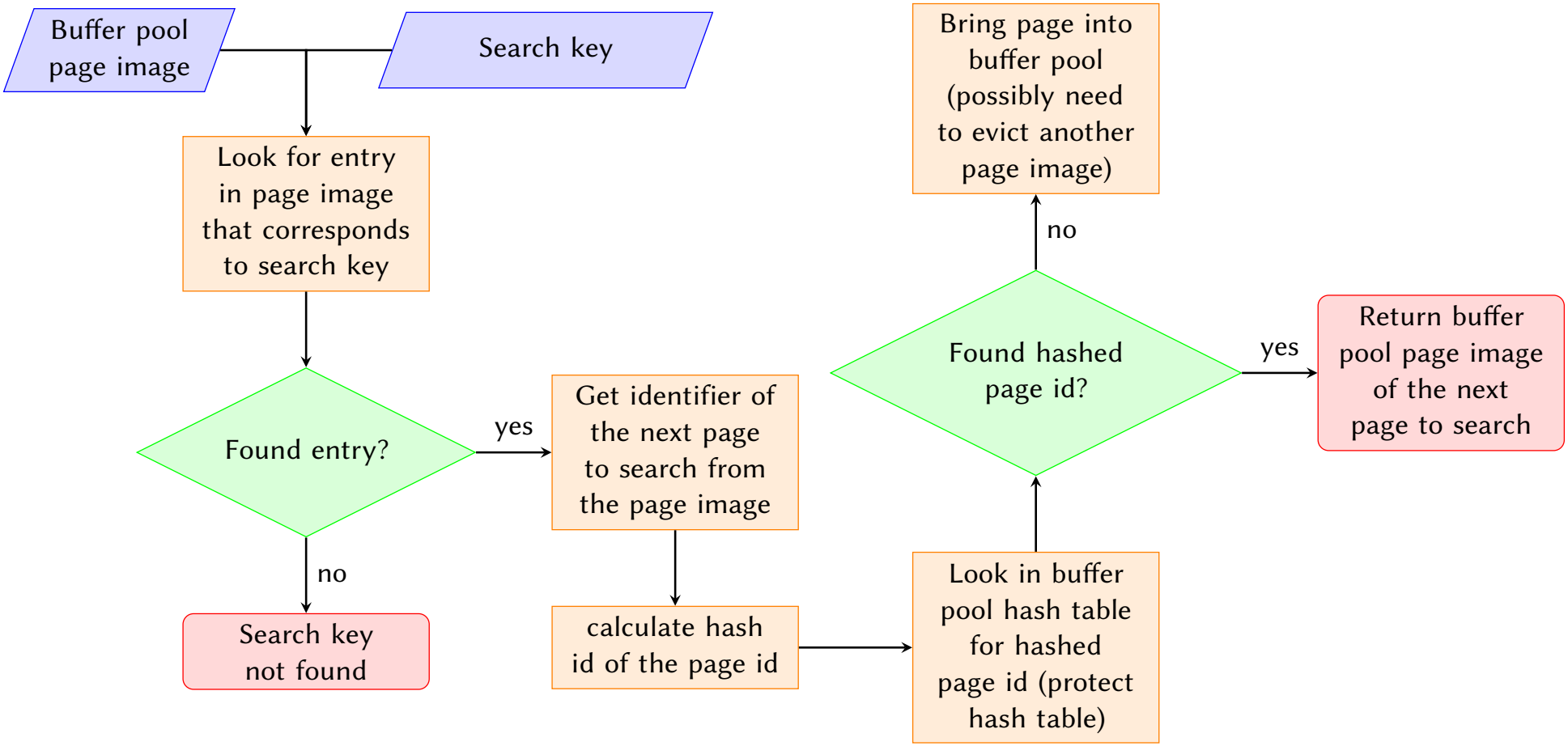

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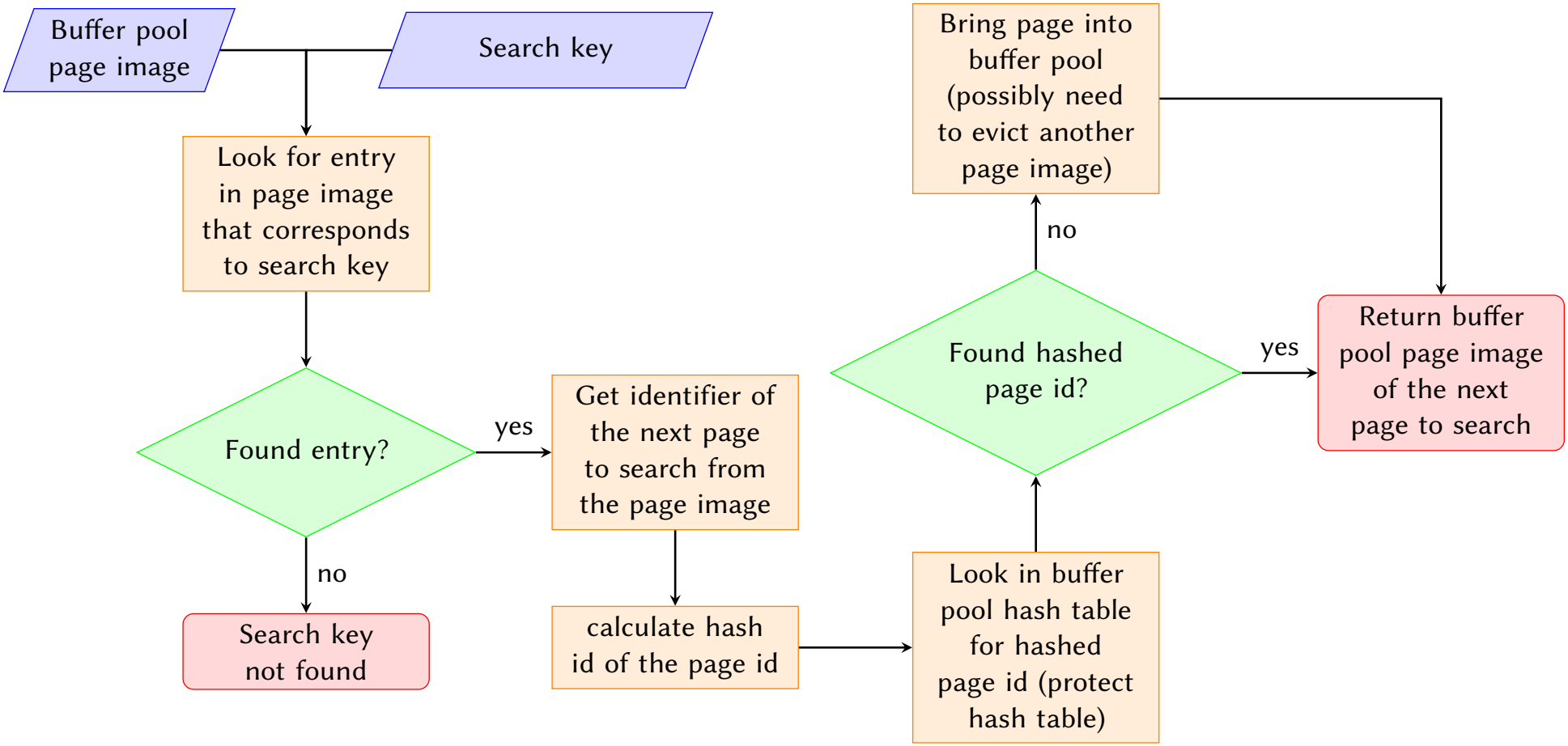

Subsection 2

Locate Pages in the Buffer Pool with Pointer Swizzling

Pointer Swizzling

Definition

To swizzle a pointer means to transform the address of the persistent object referenced there to a more direct address of the transient object in a way that this transformation could be used during multiple indirections of this pointer ([Mos92]).

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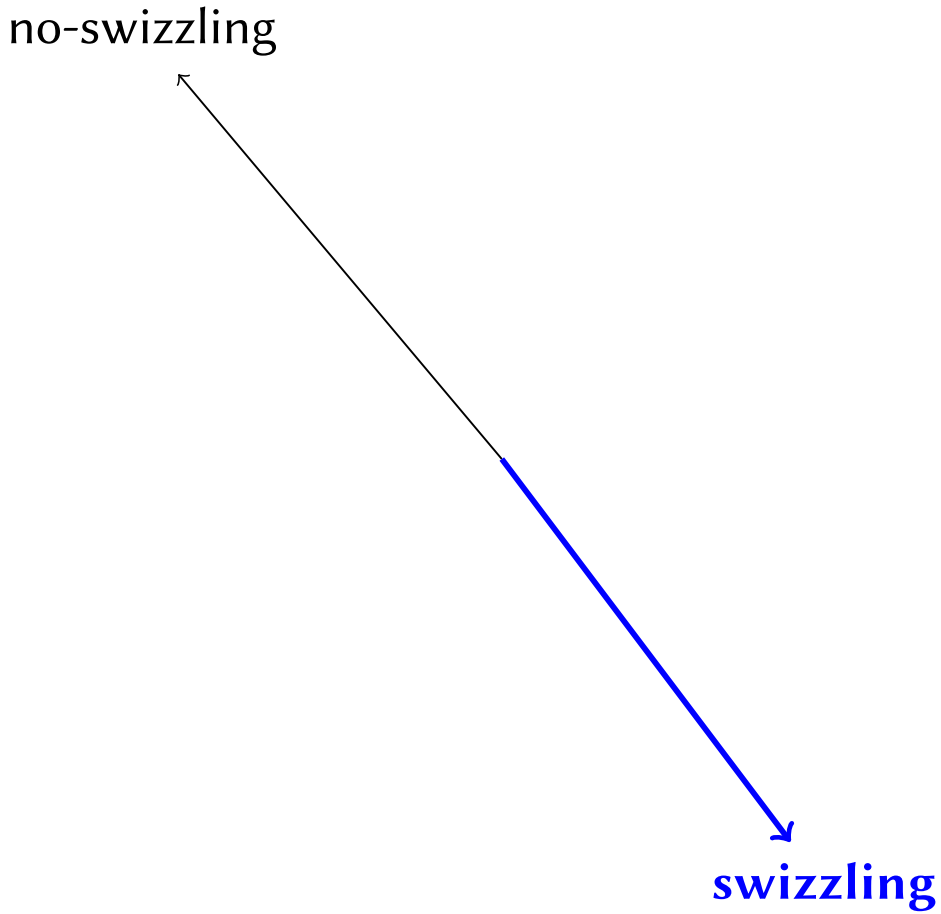

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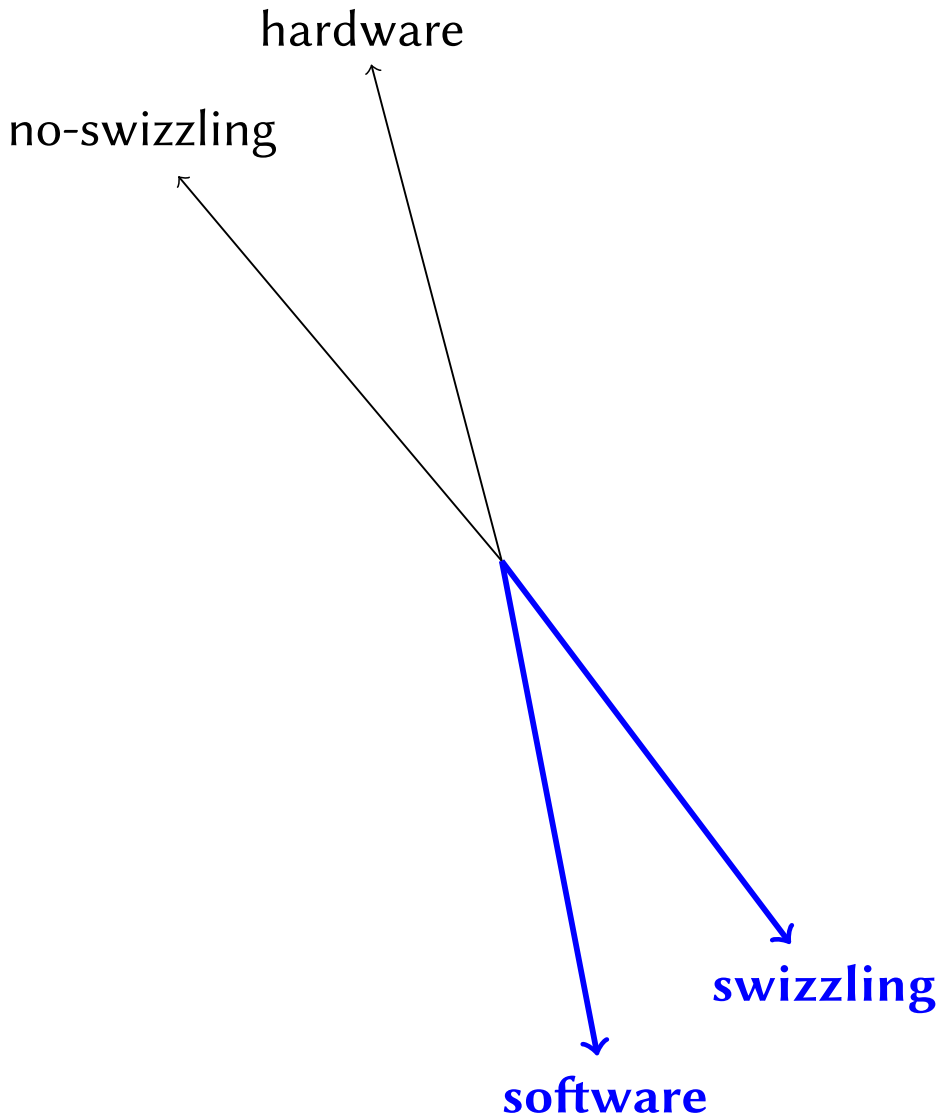

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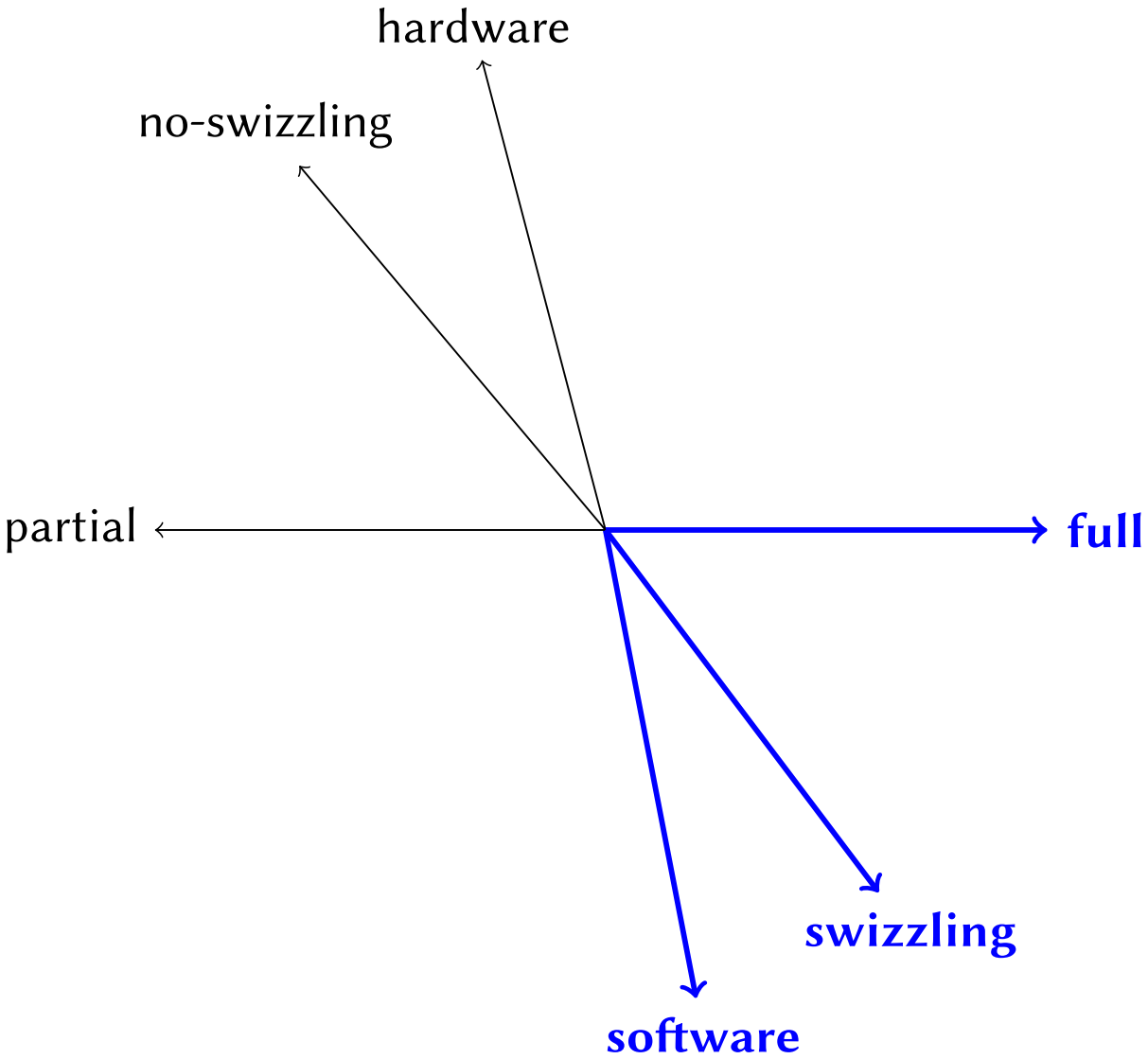

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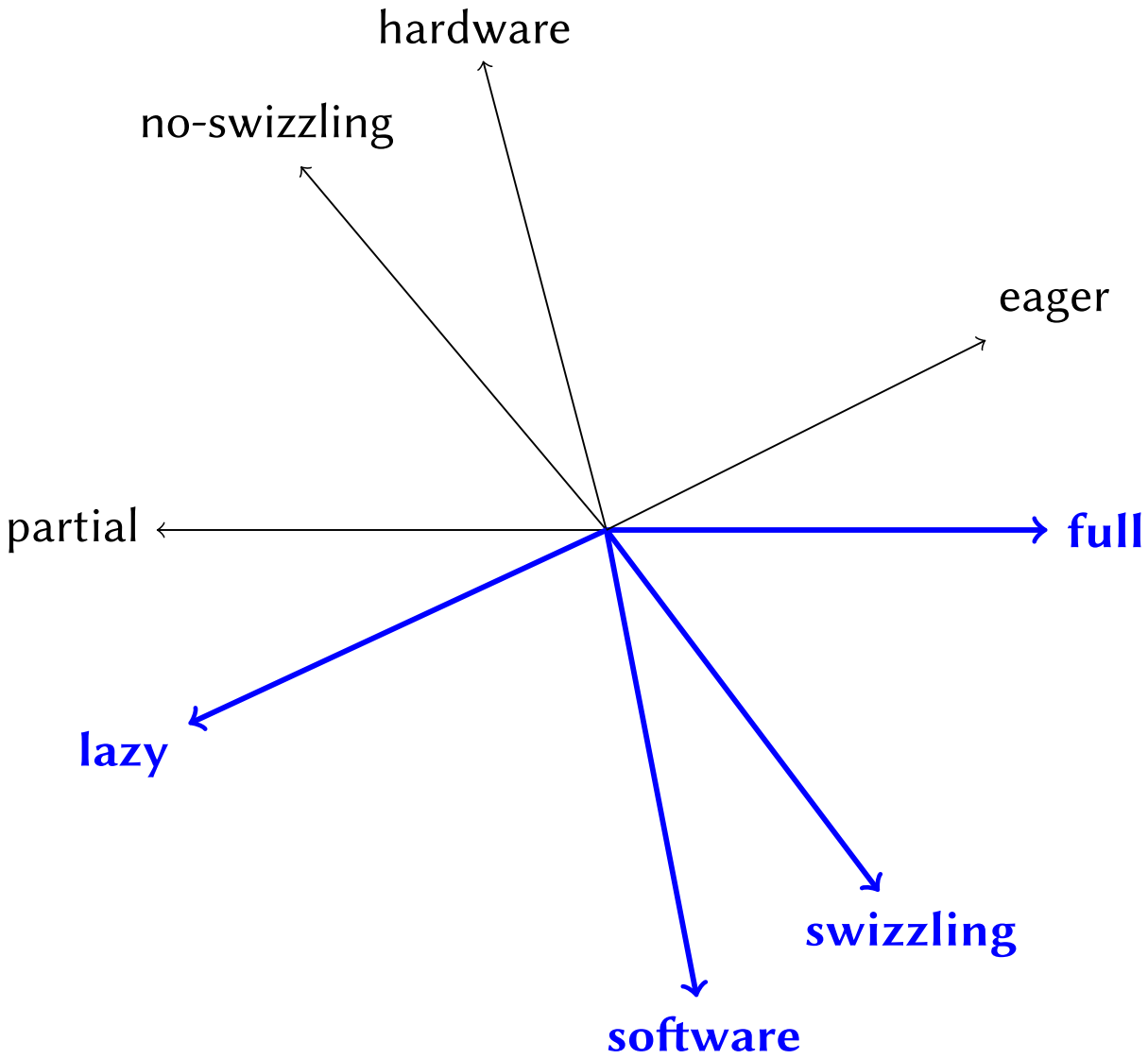

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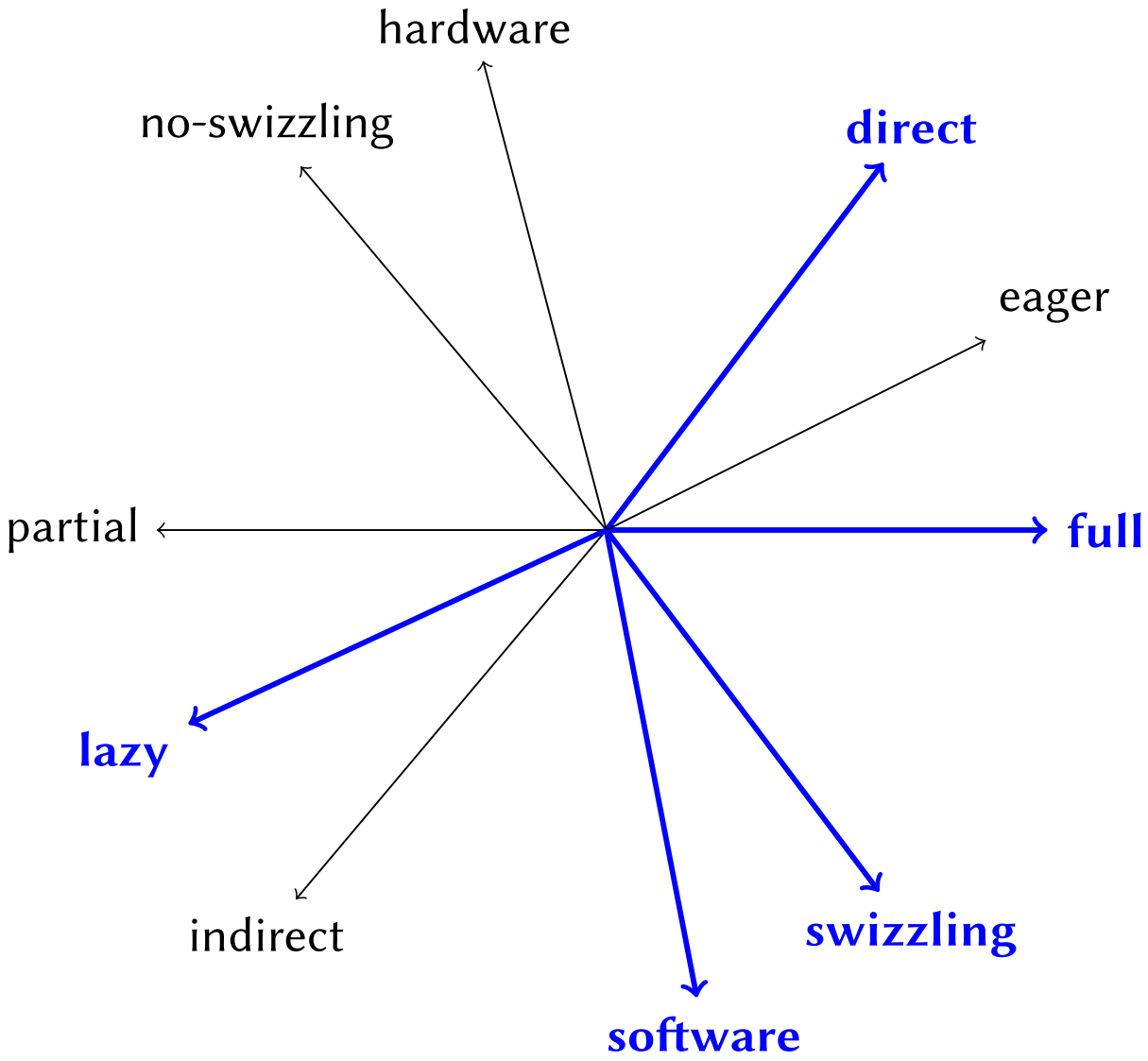

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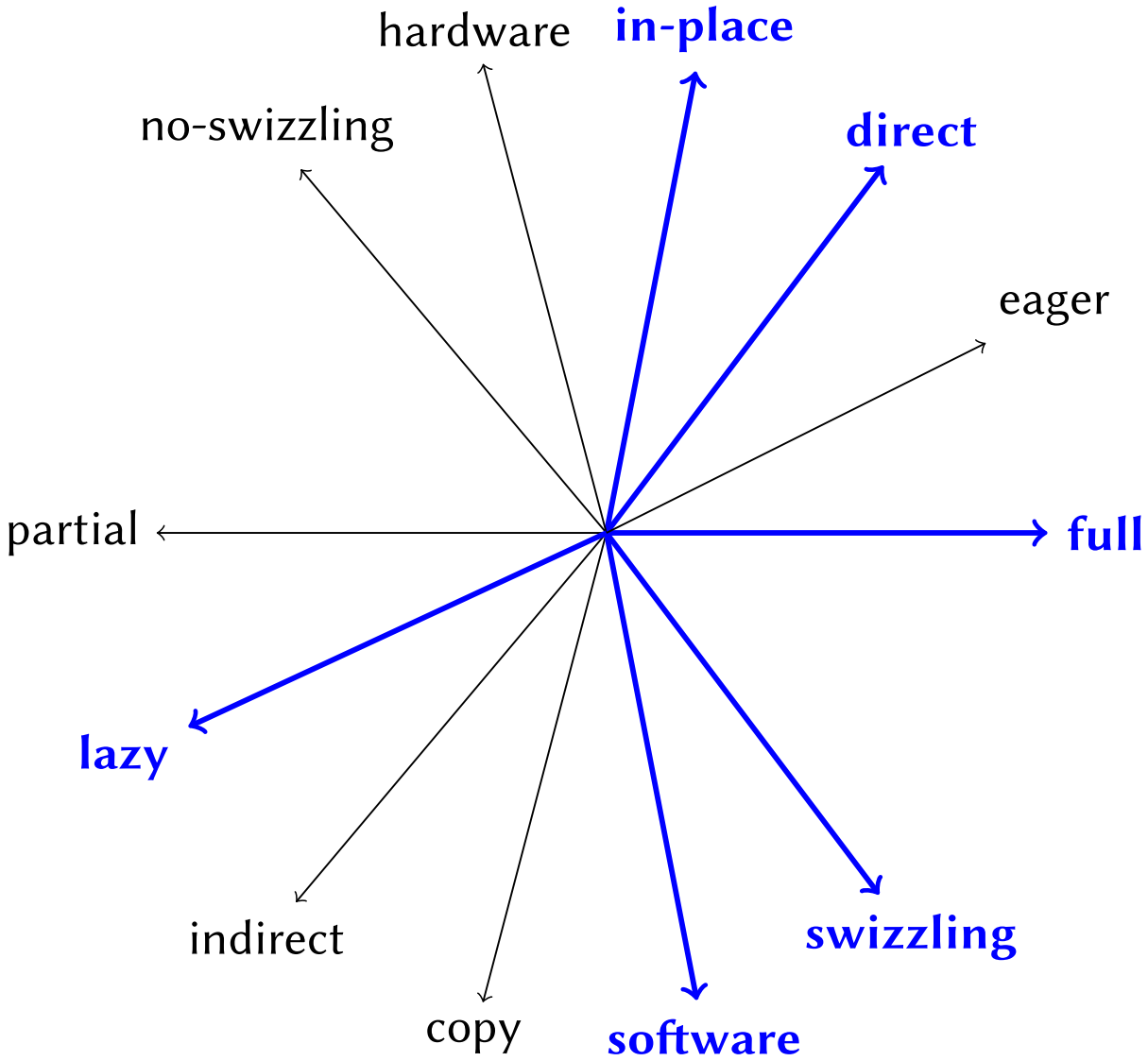

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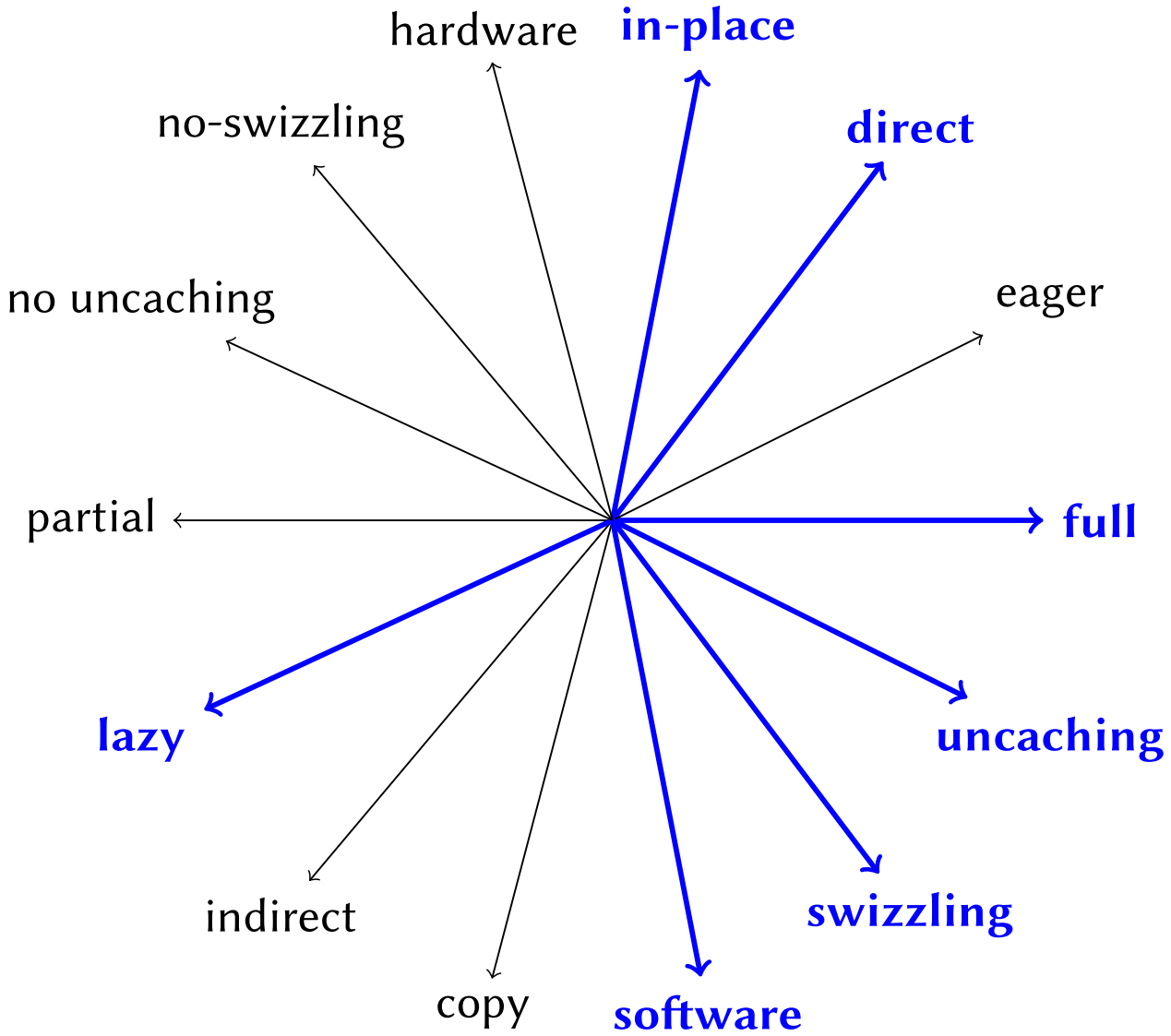

Locate Pages in Buffer Pool w/ Pointer Swizzling ([Gra+14])

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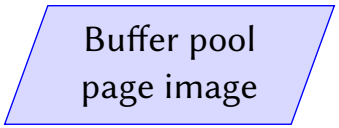

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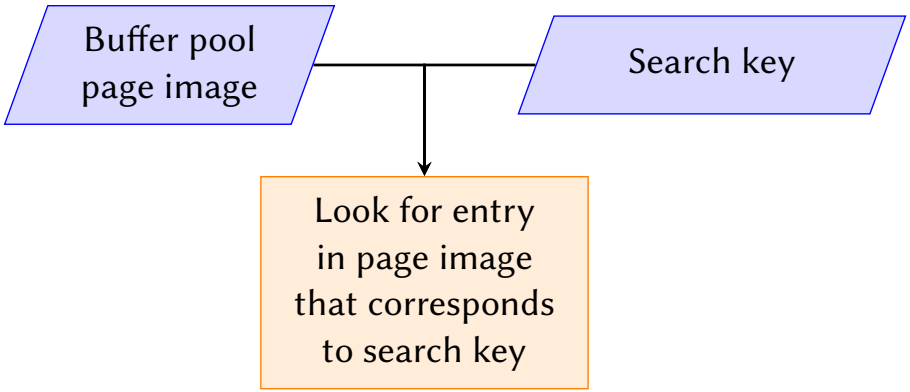

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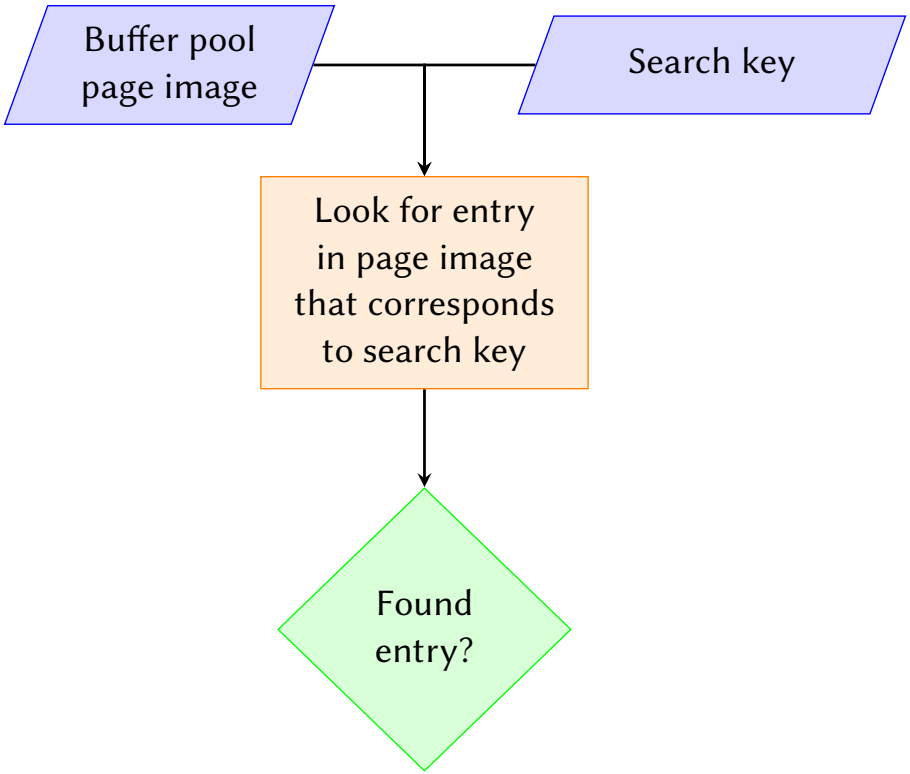

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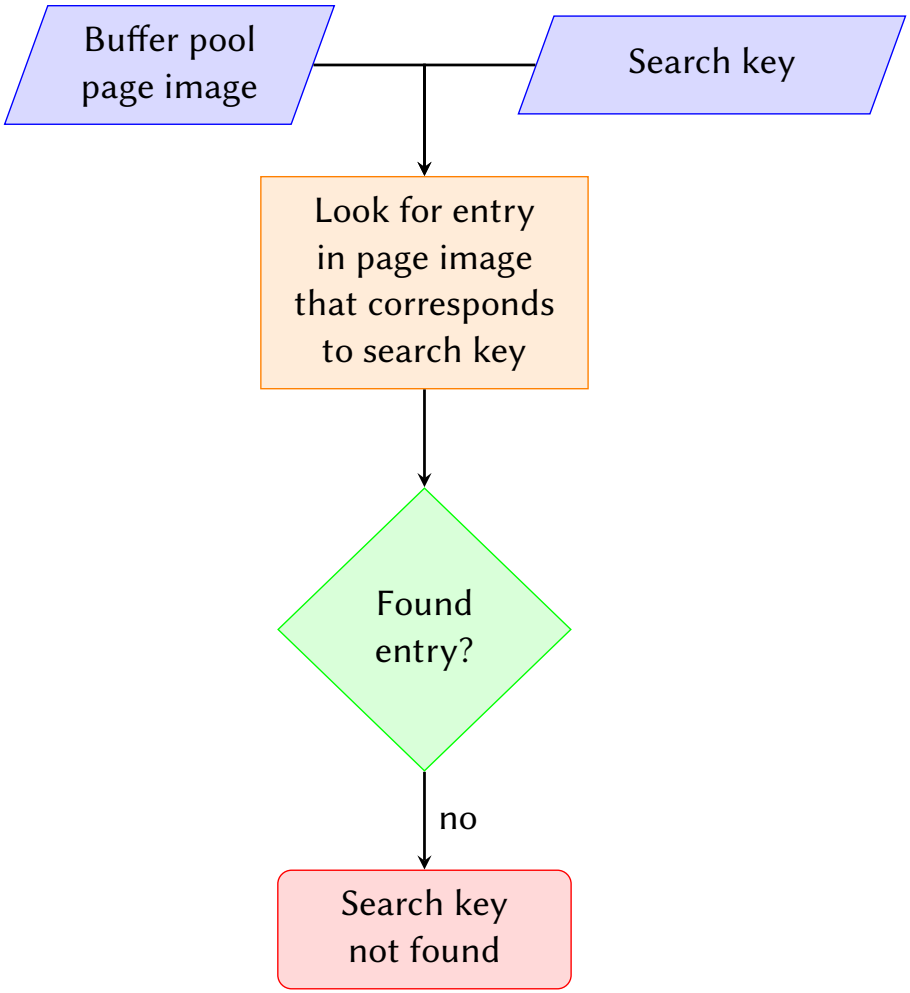

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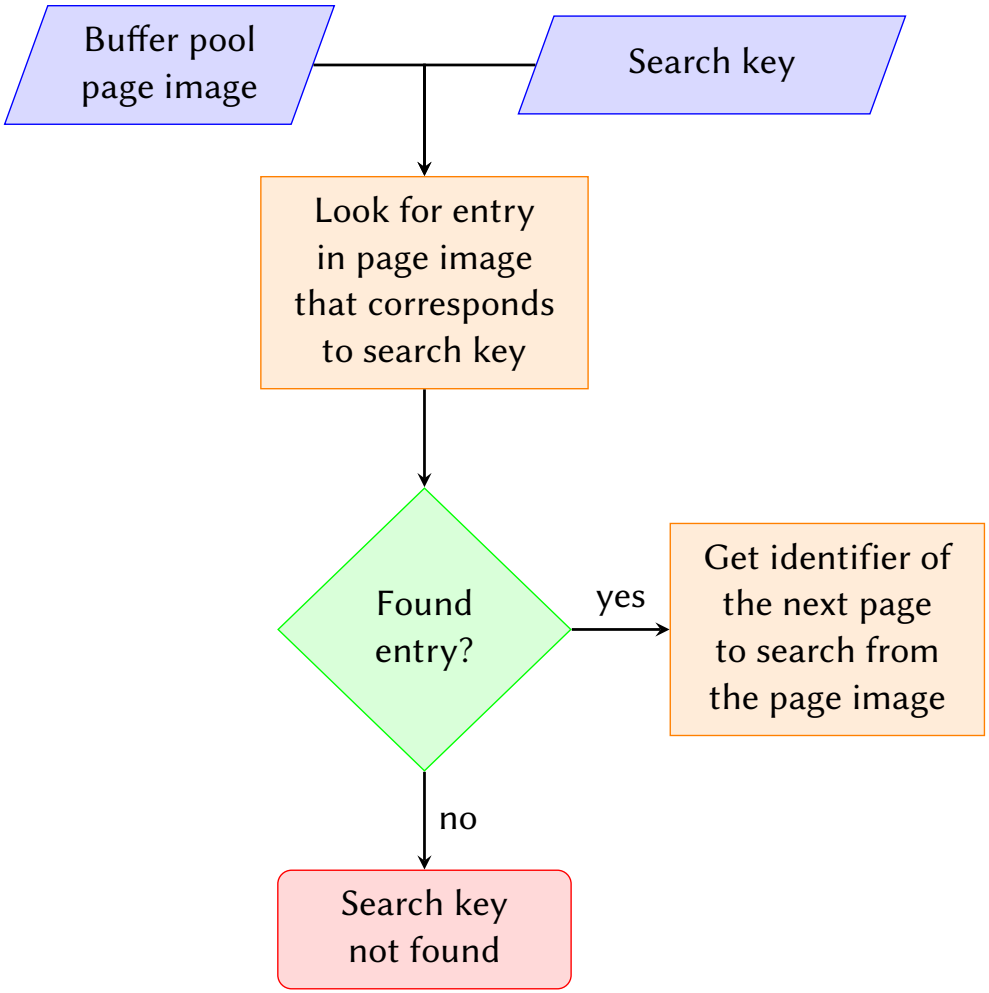

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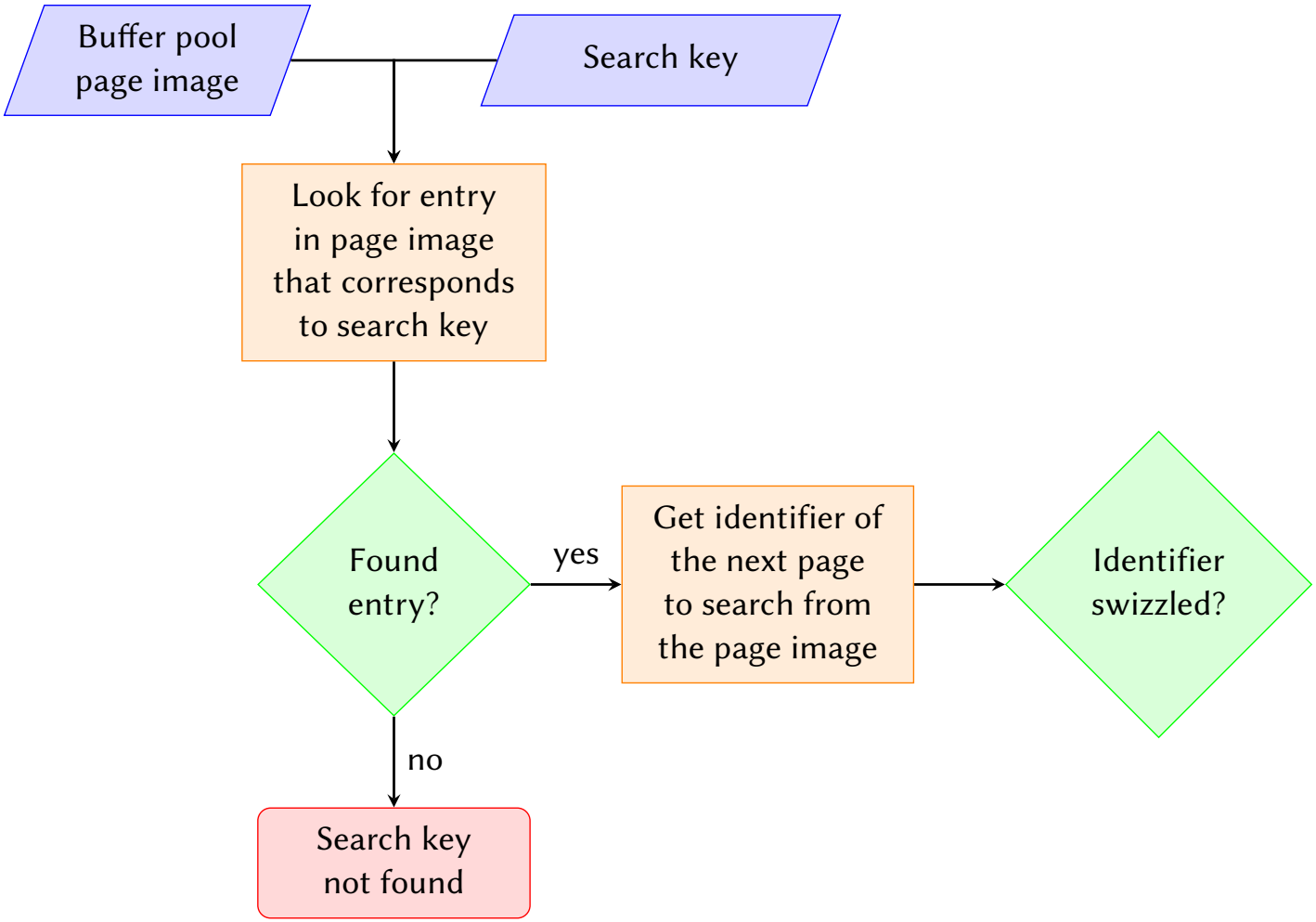

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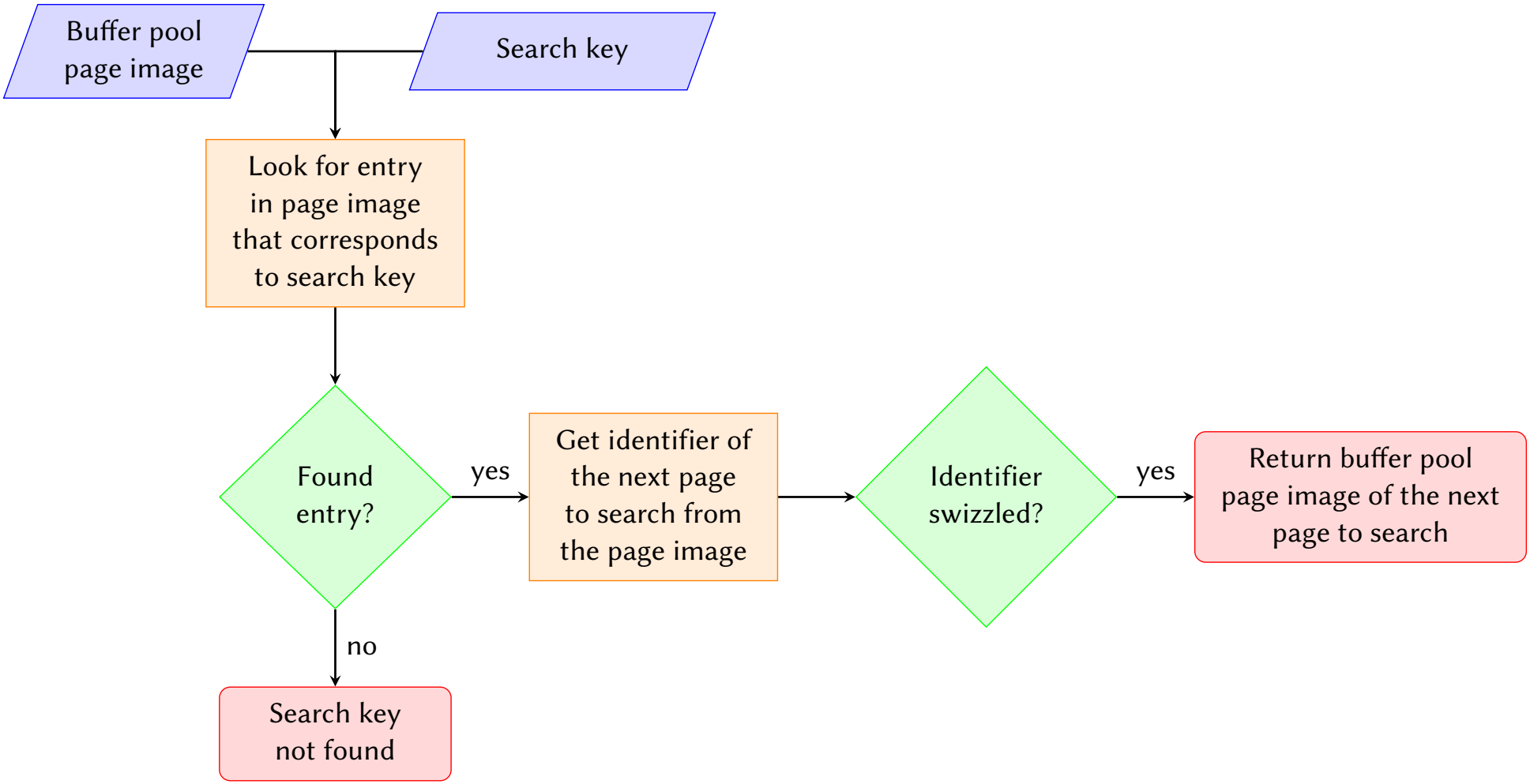

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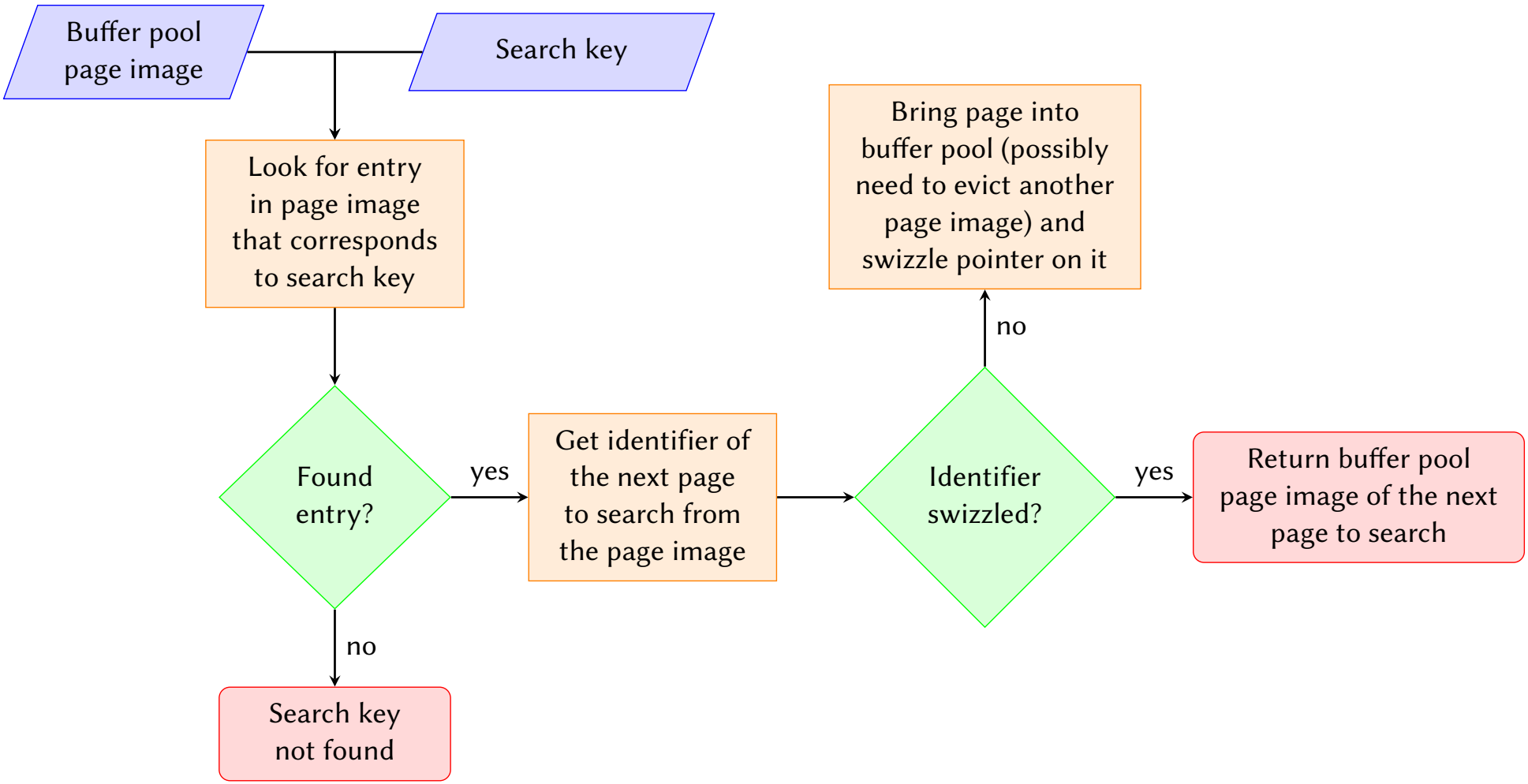

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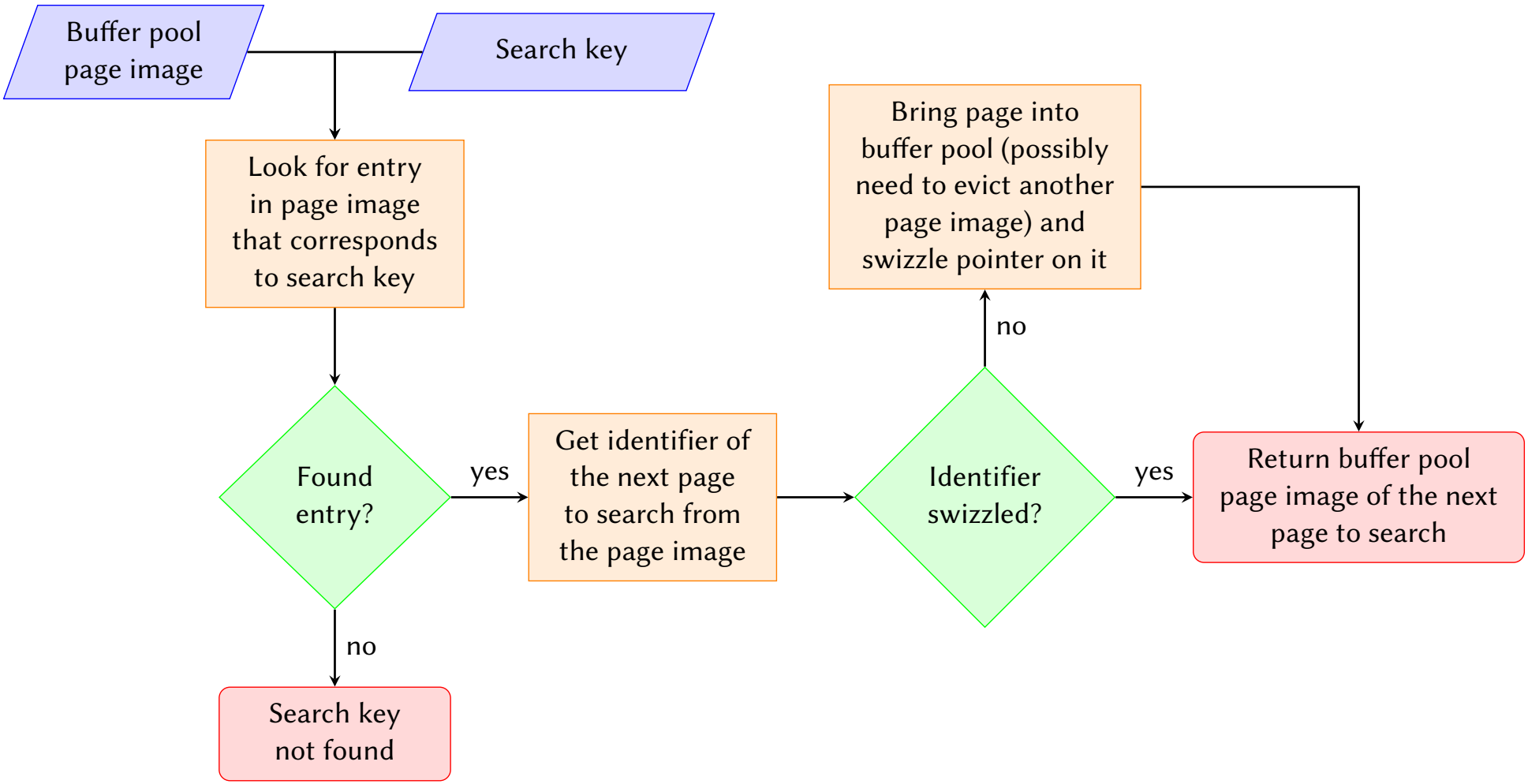


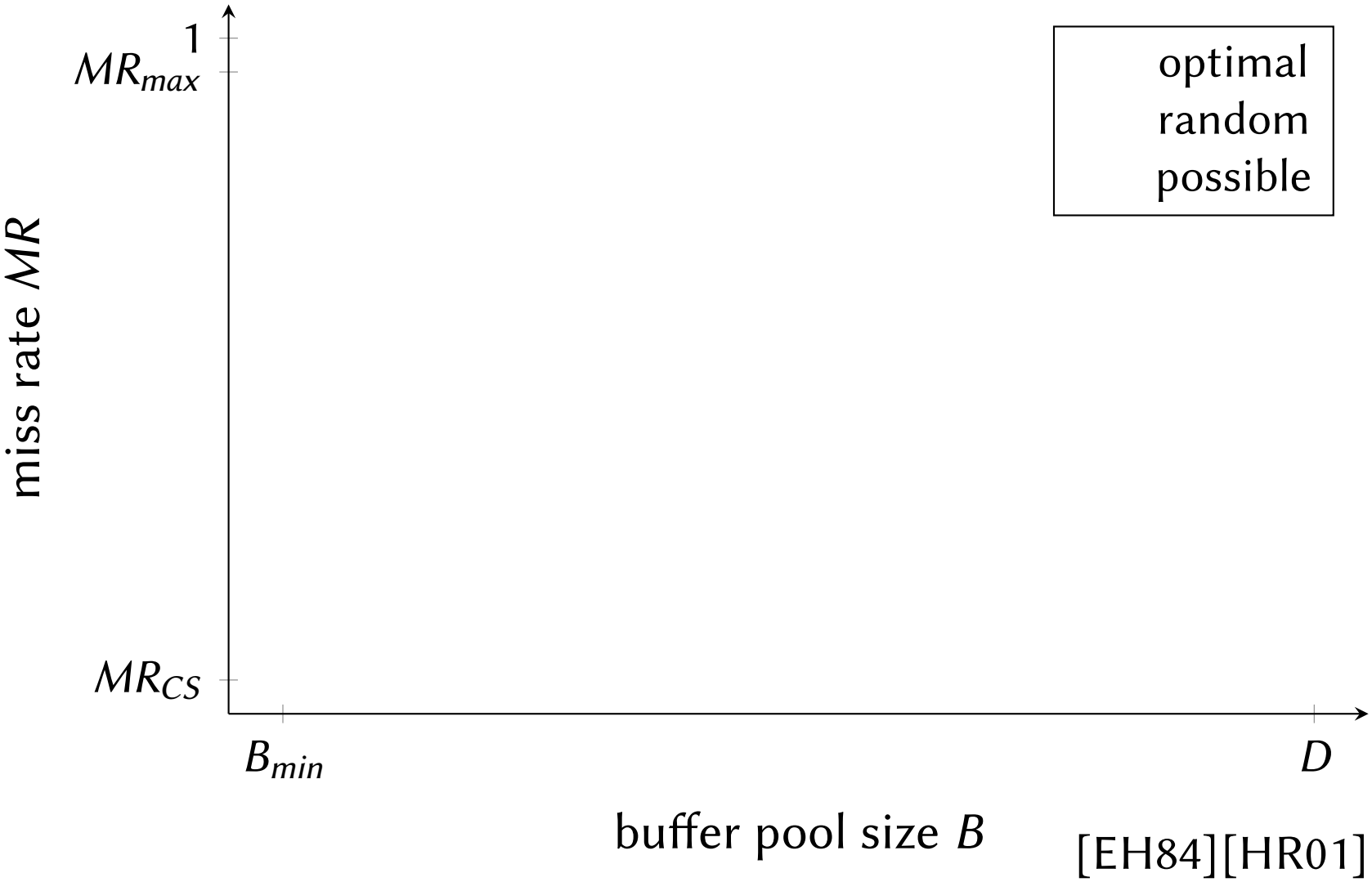
Section 2

Performance Evaluation of the Buffer Management Utilizing Pointer Swizzling

Subsection 1

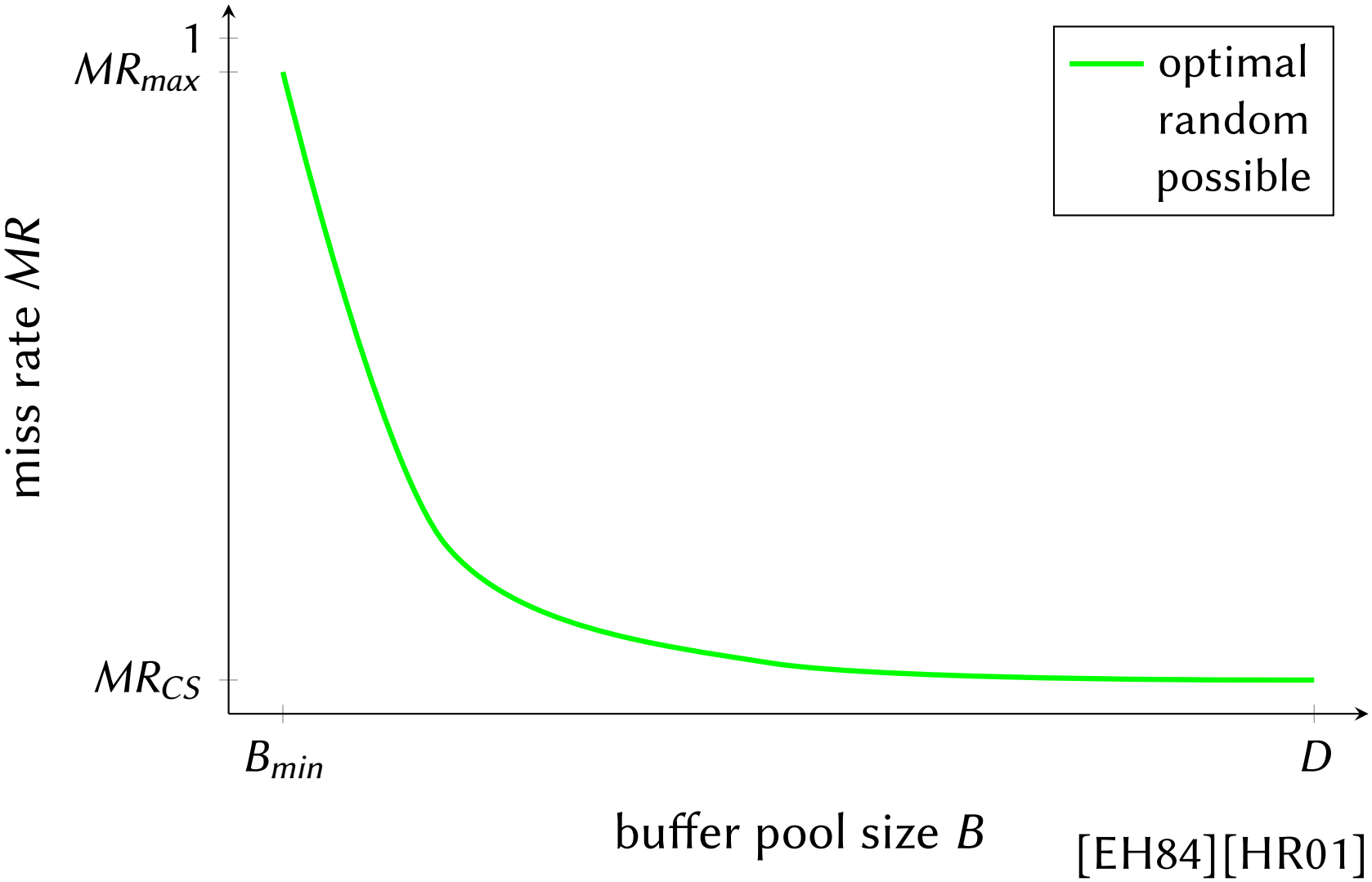
Expected Performance

Performance of Different Buffer Pool Sizes



[EH84][HR01]

Performance of Different Buffer Pool Sizes



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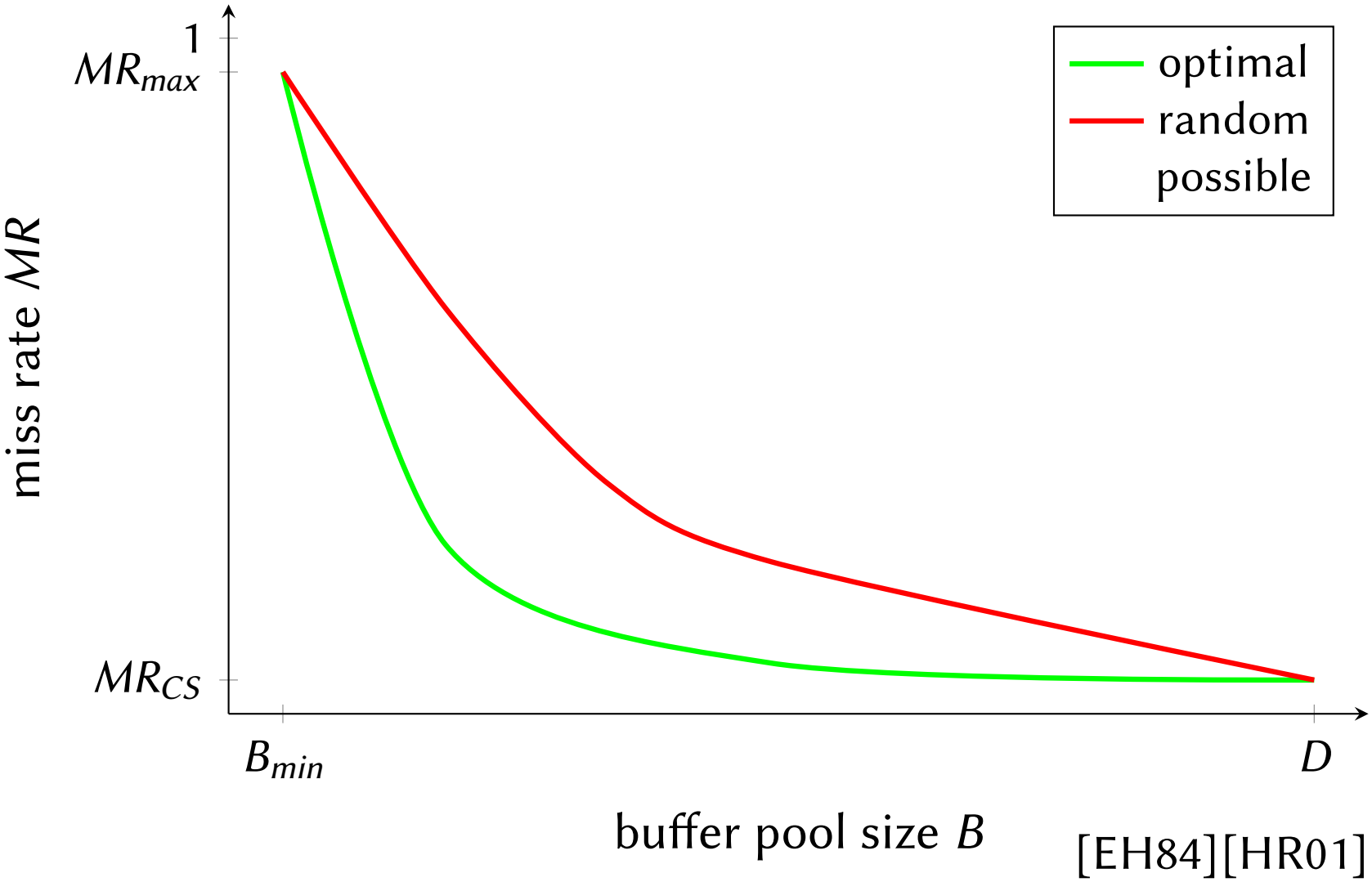

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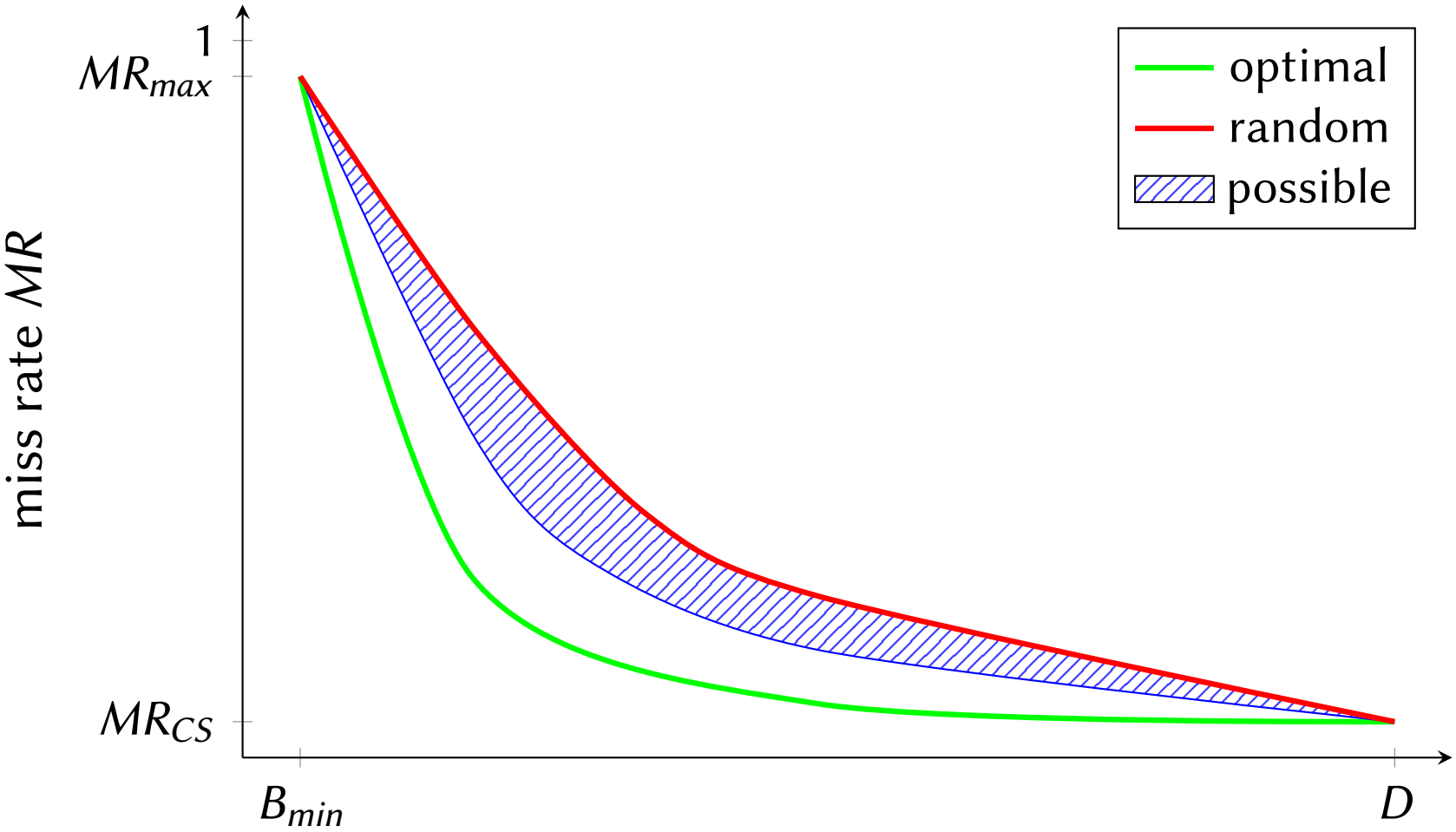
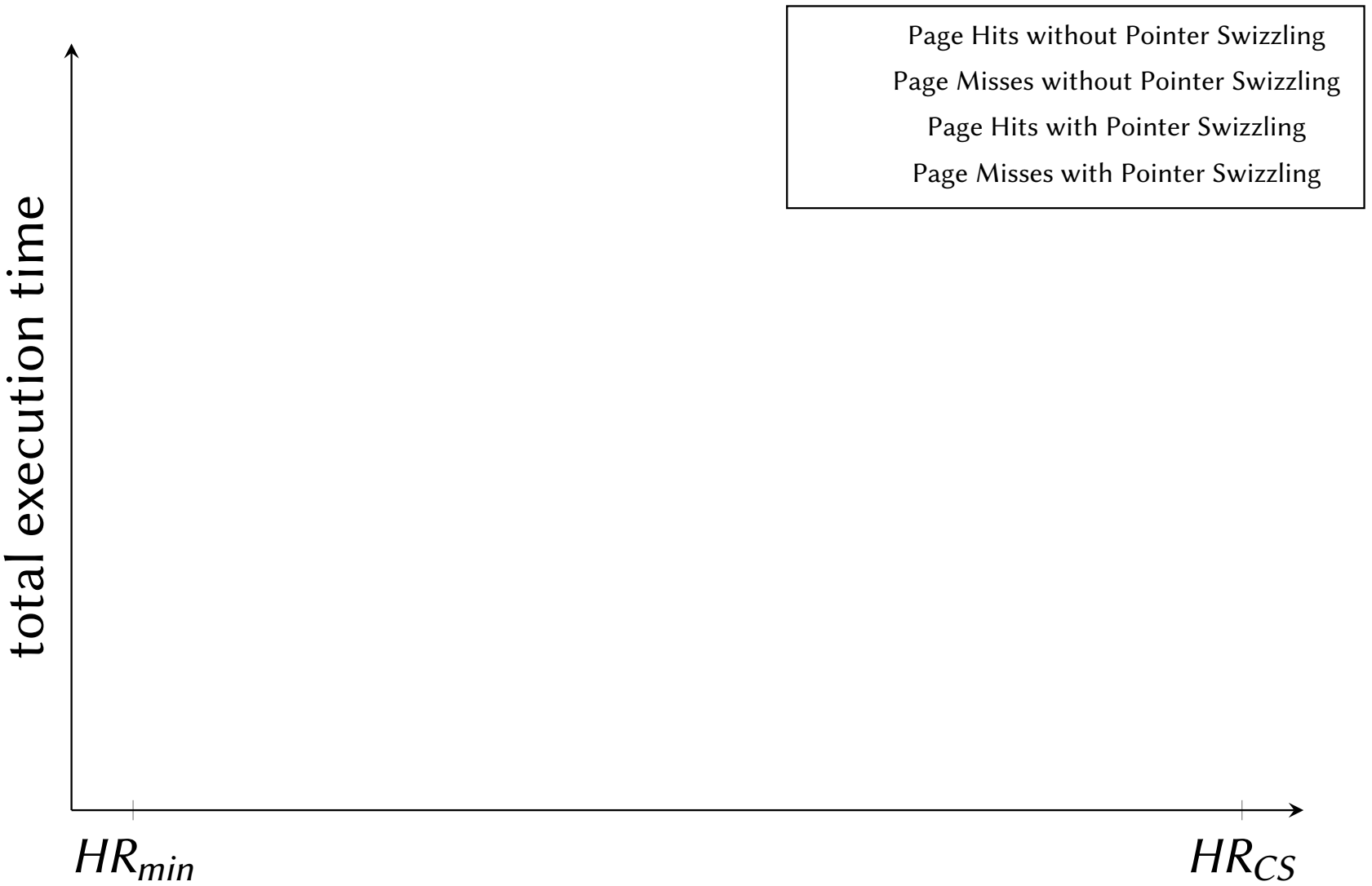


[EH84][HR01]

Buffer Management with and without Pointer Swizzling



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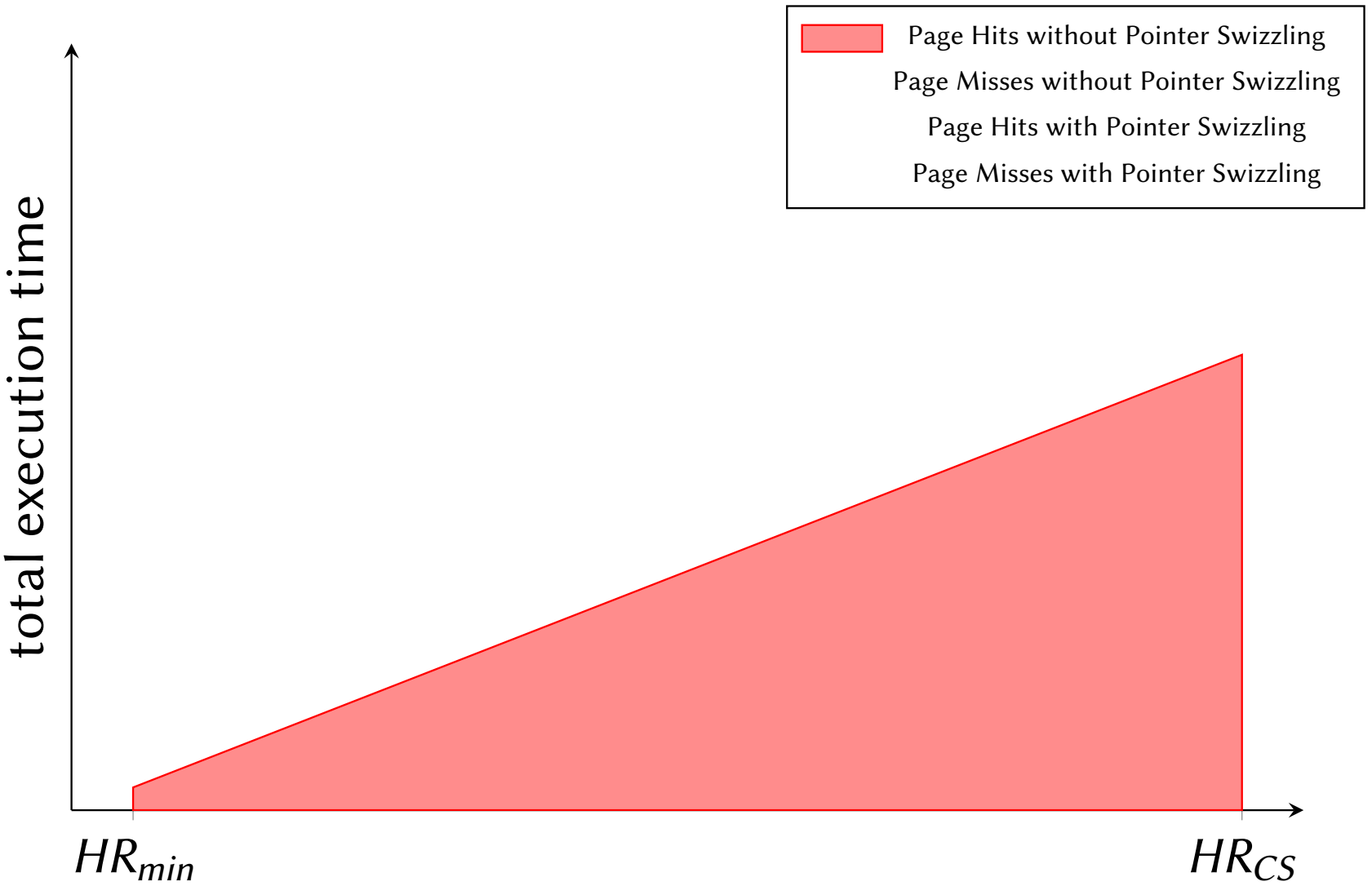

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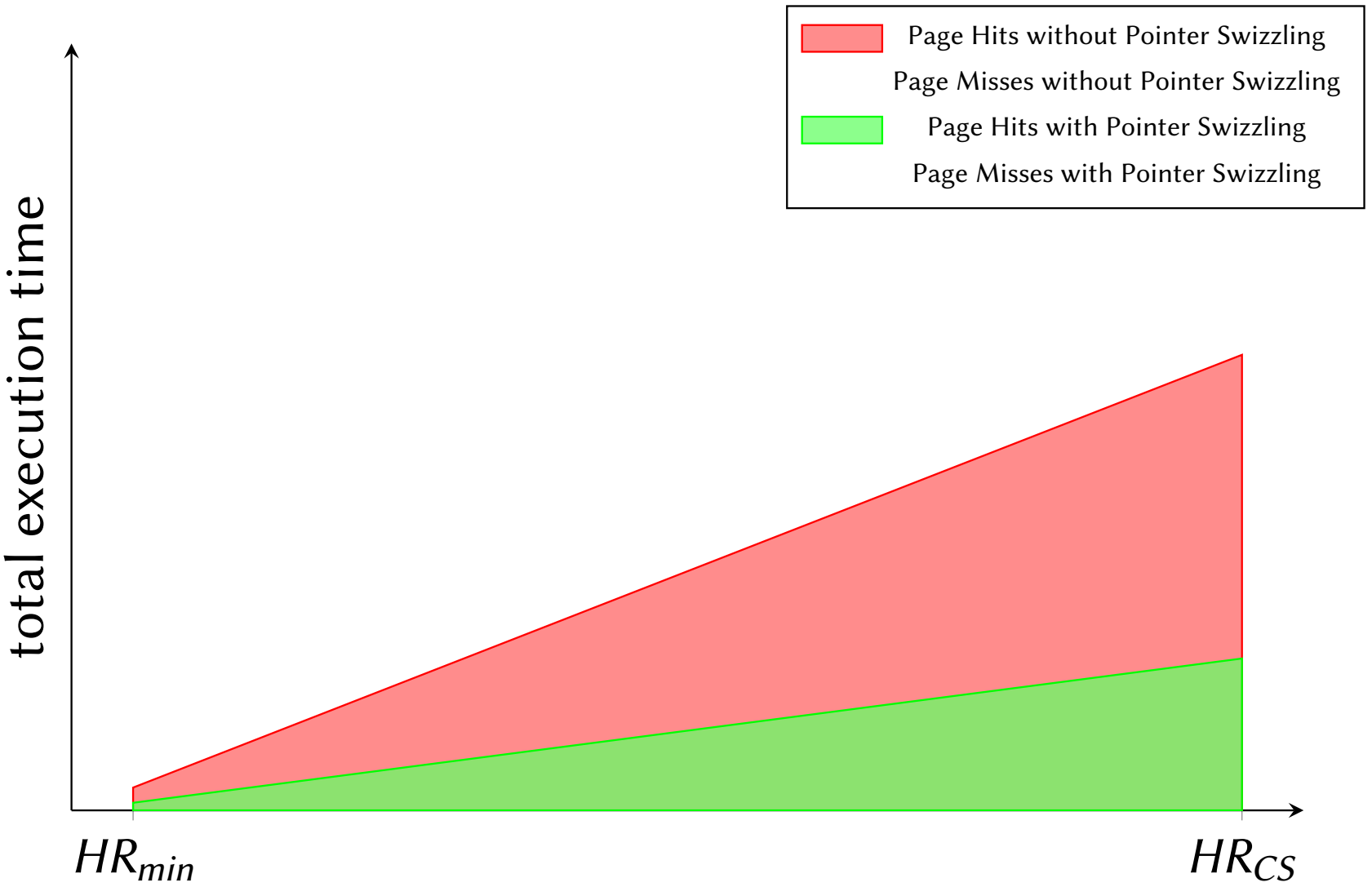

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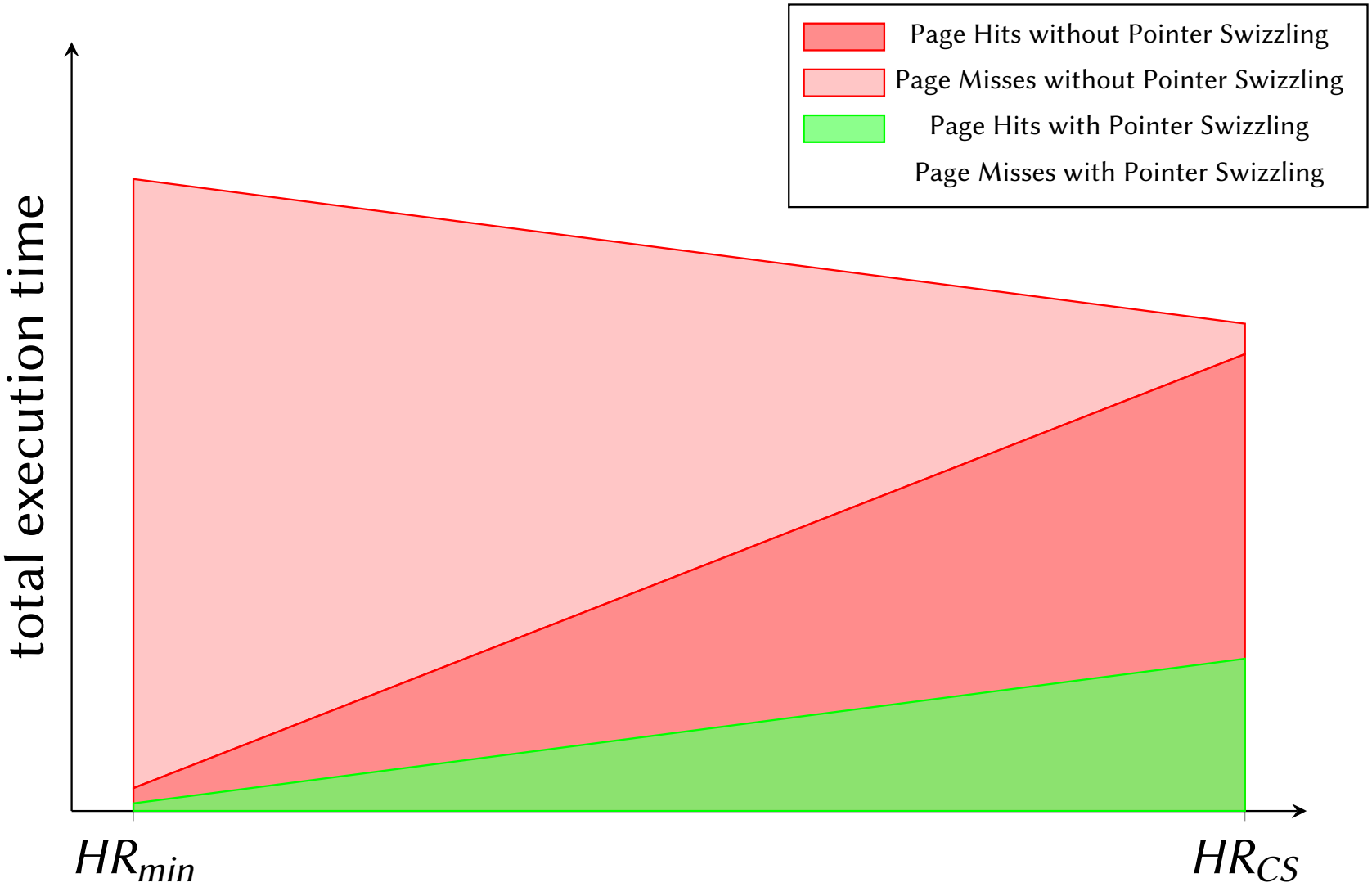

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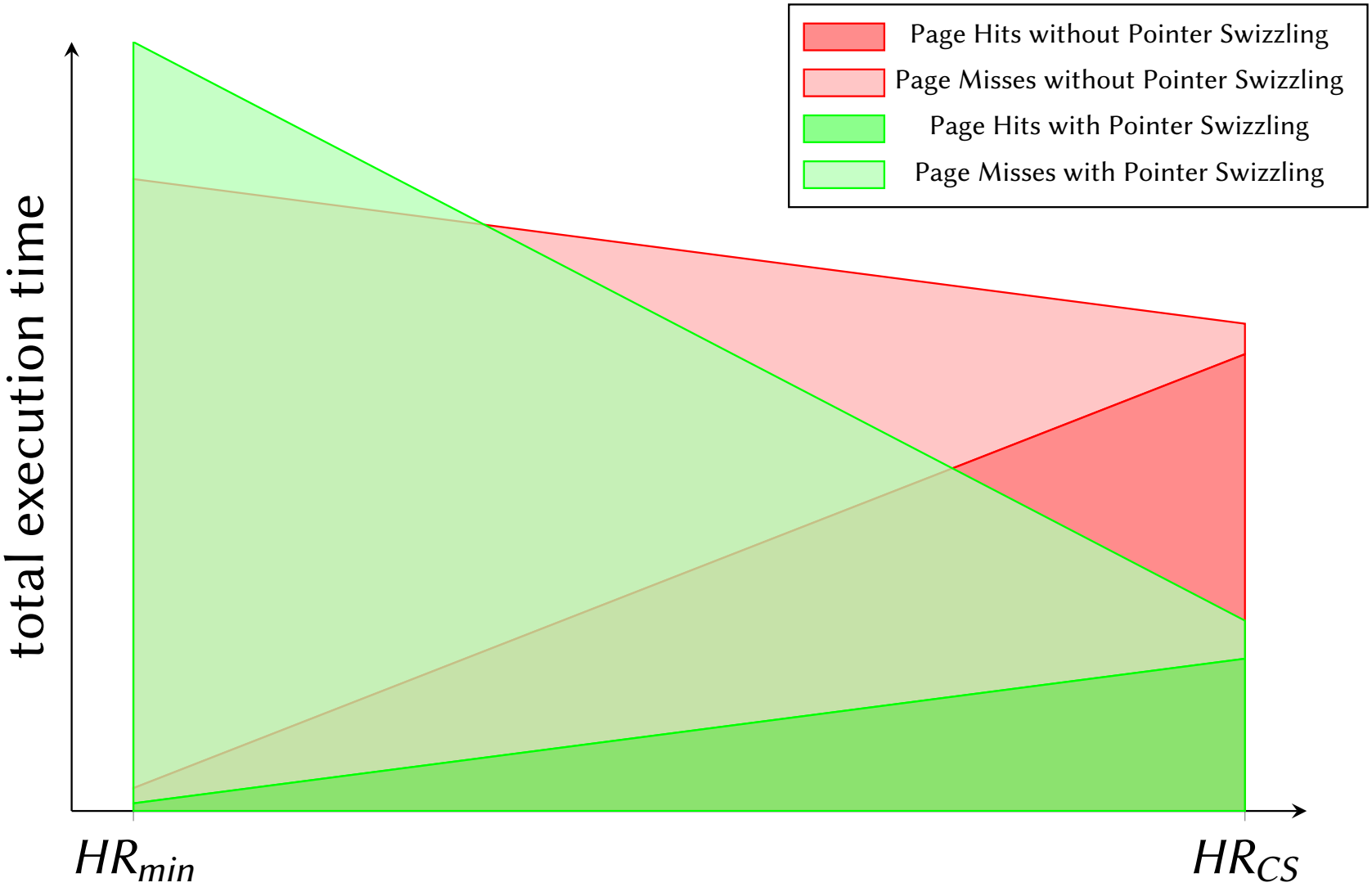

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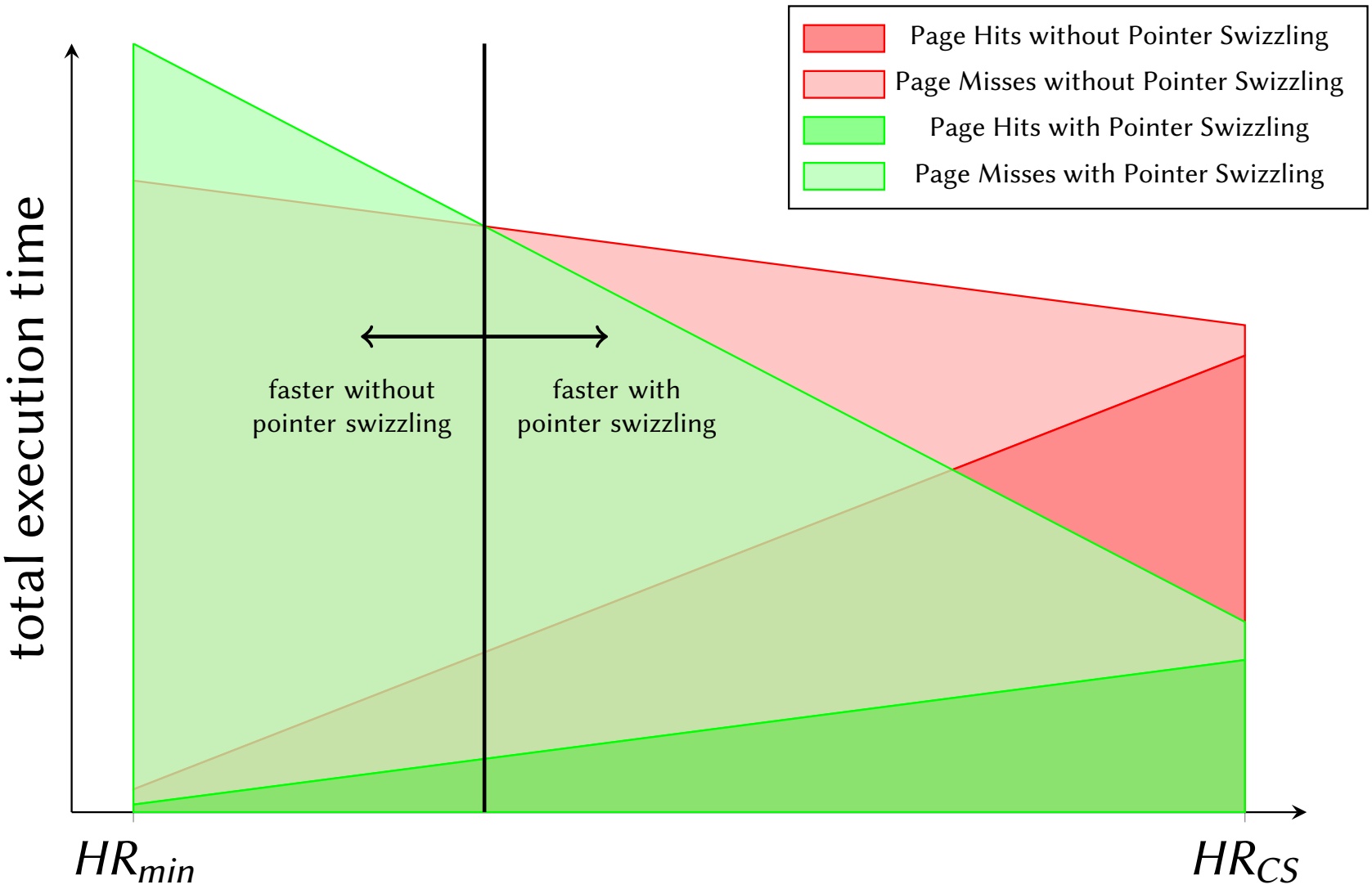
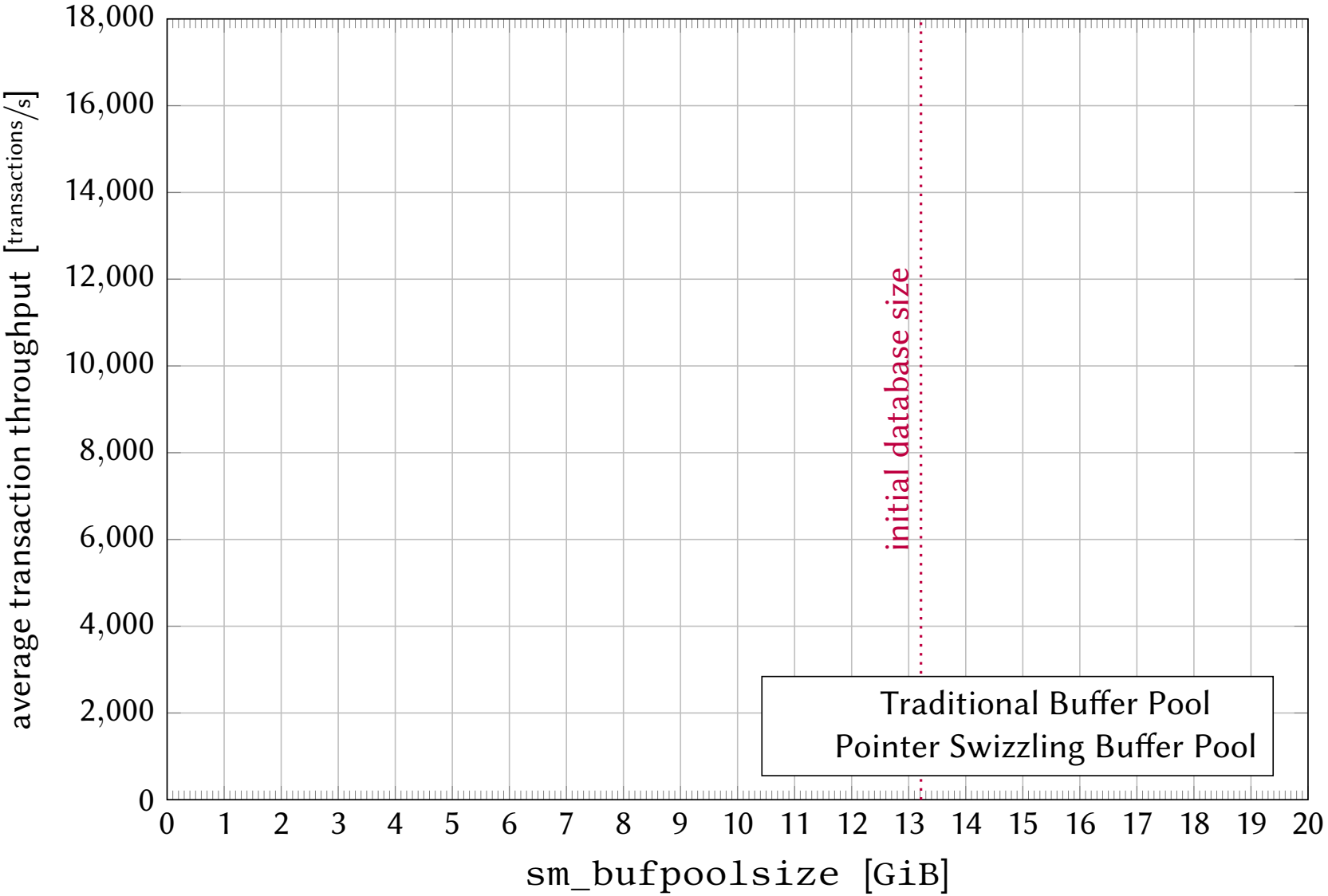


Subsection 2

Measured Performance

Transaction Throughput (TPC-C)



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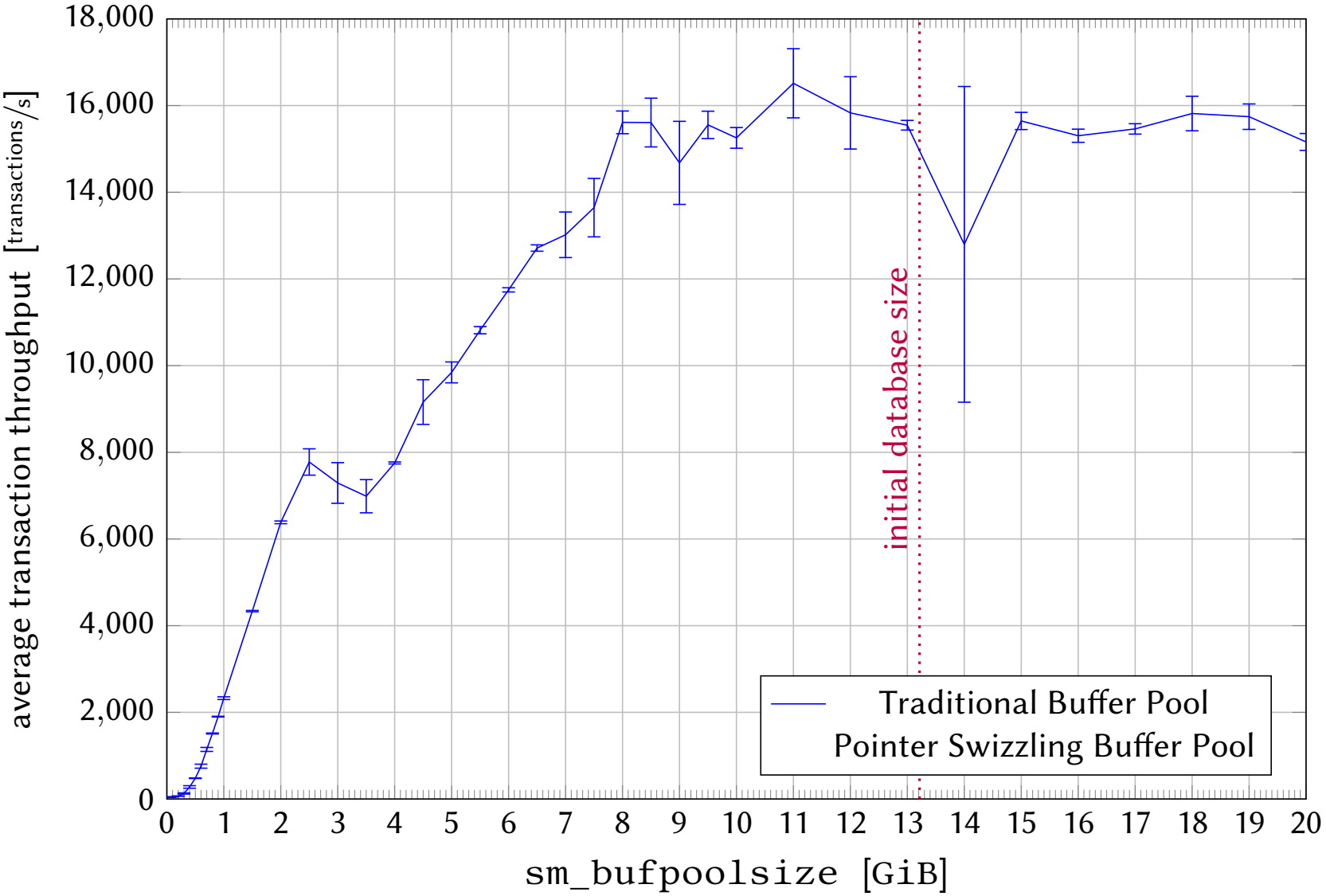

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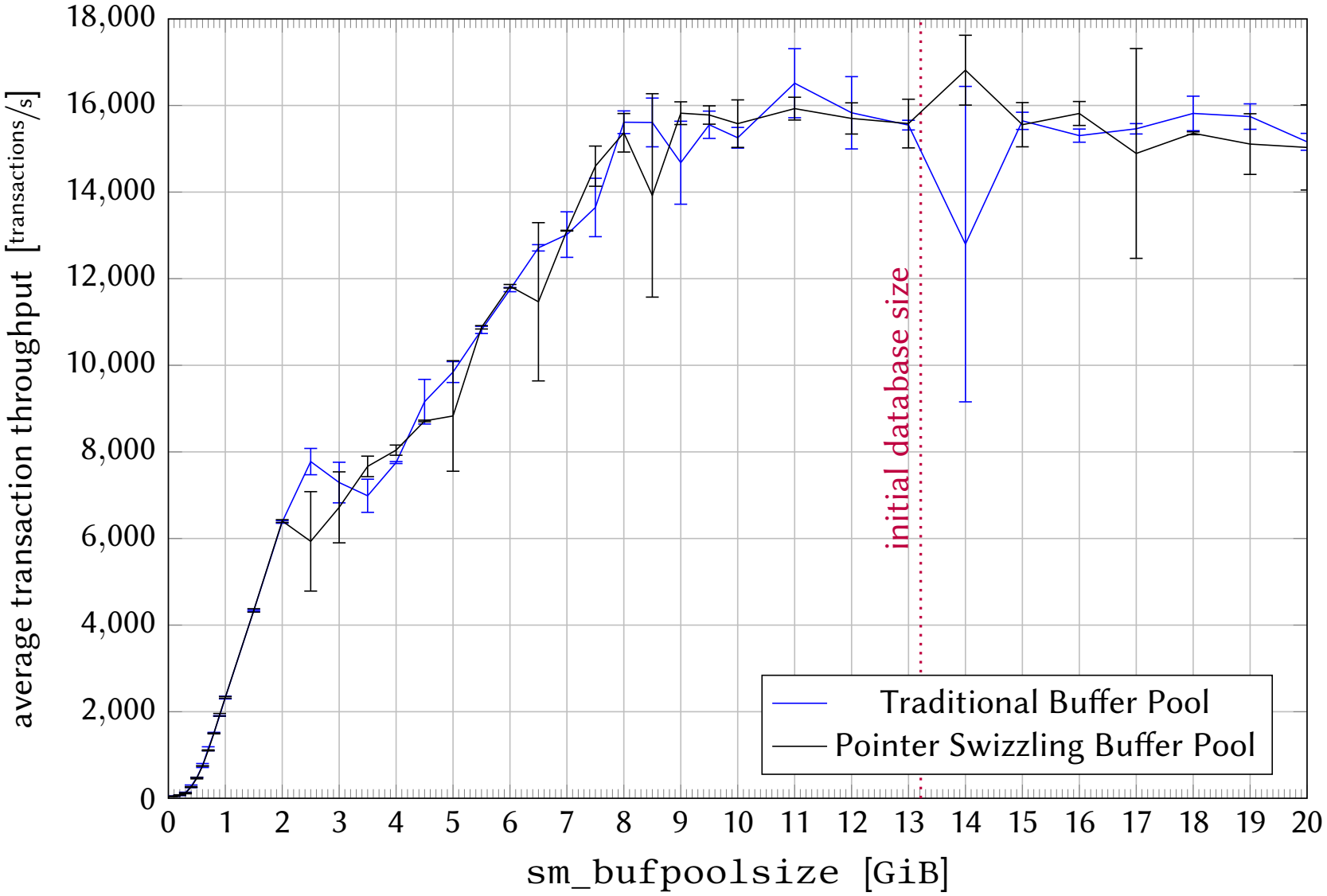
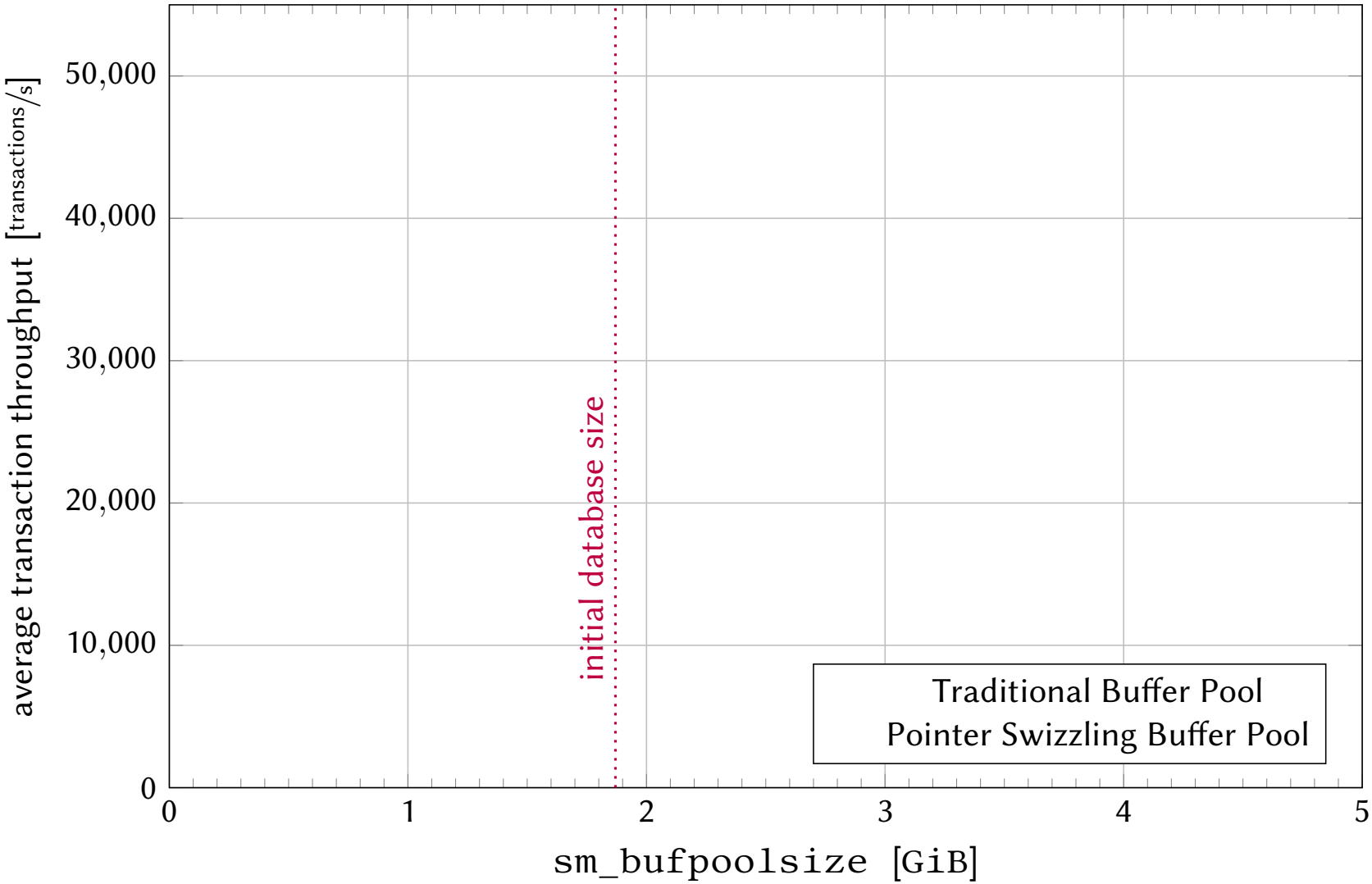


Transaction Throughput (TPC-B)



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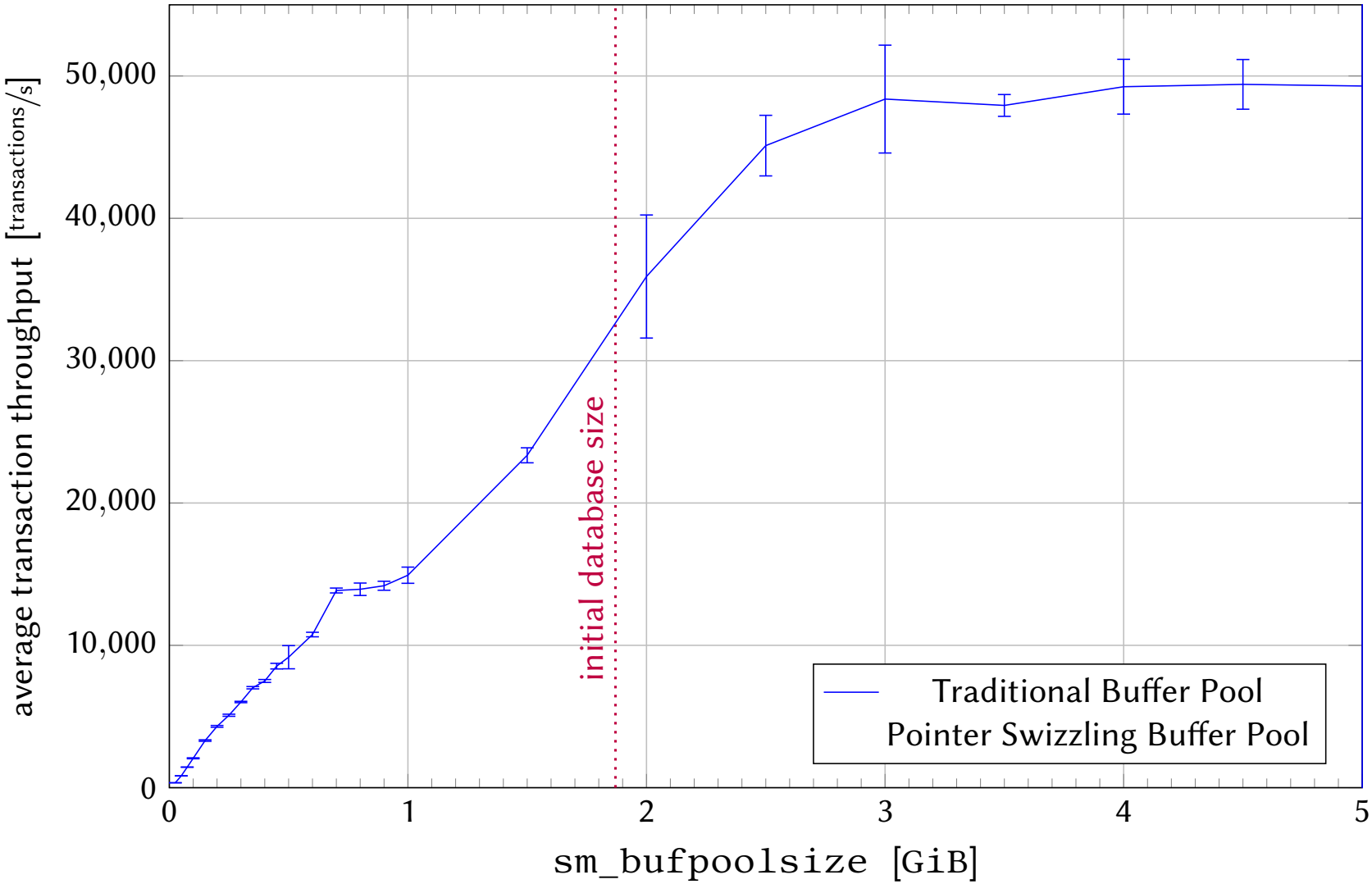

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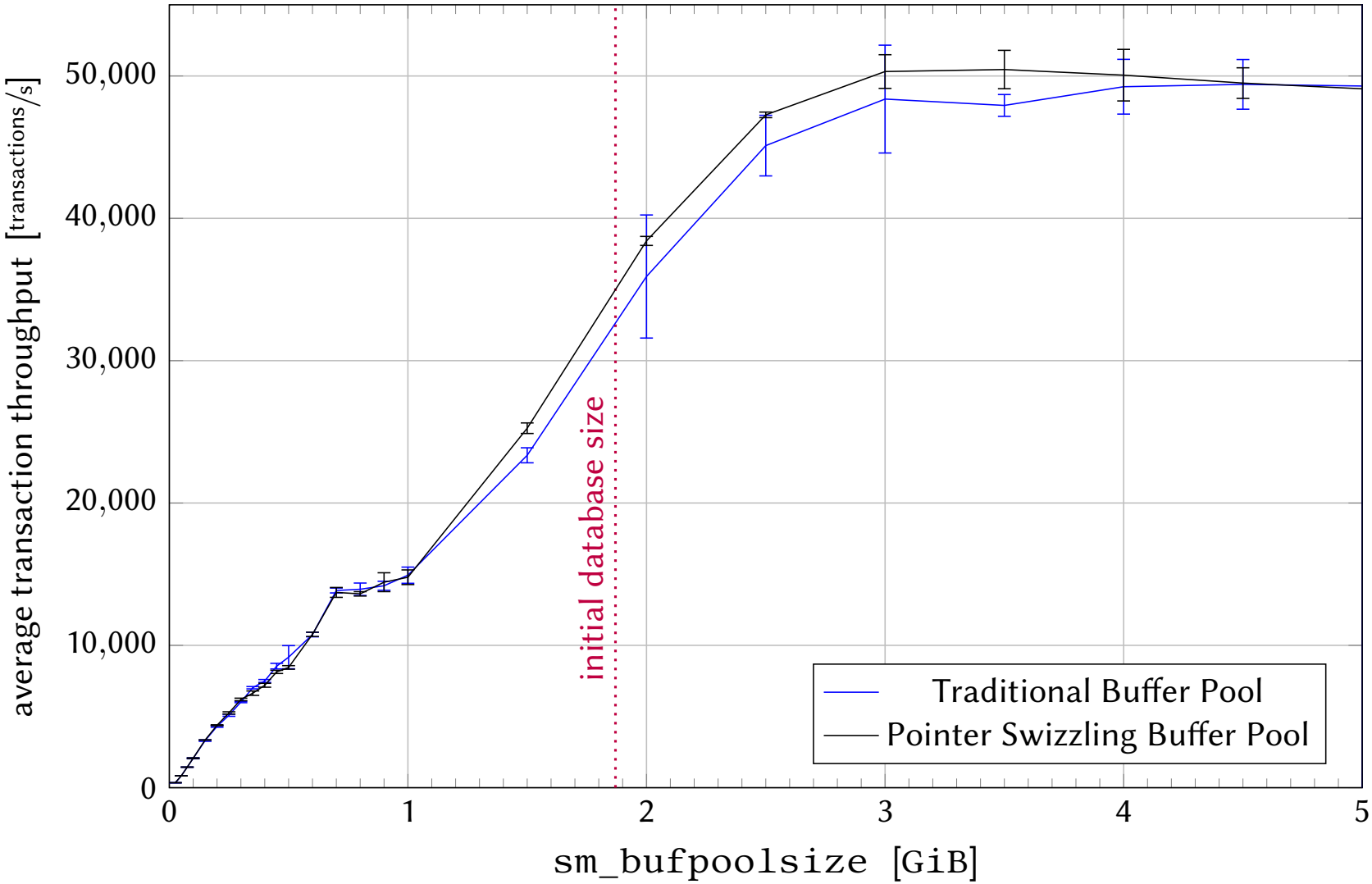
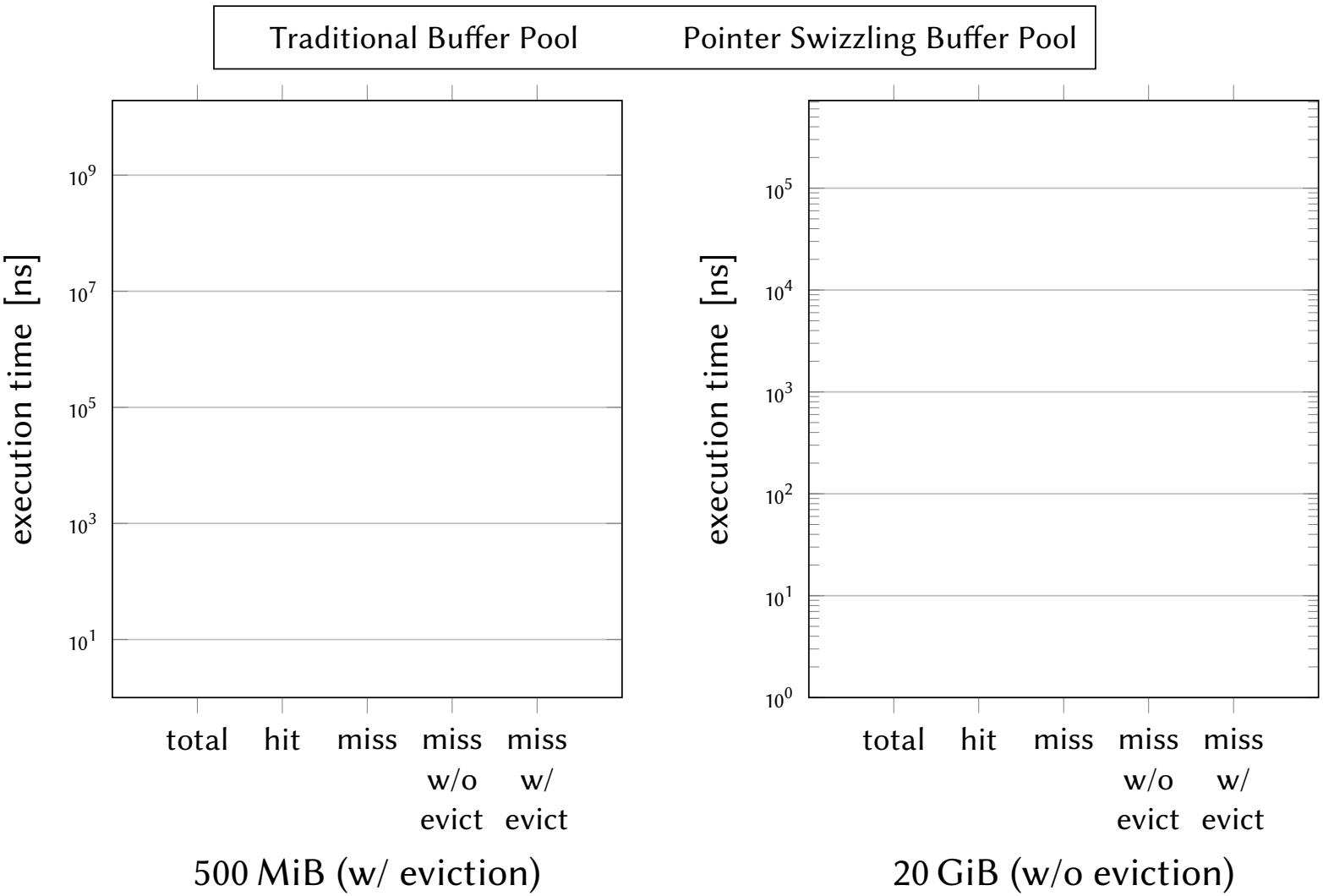


Buffer Pool Performance Acquiring Shared Latches



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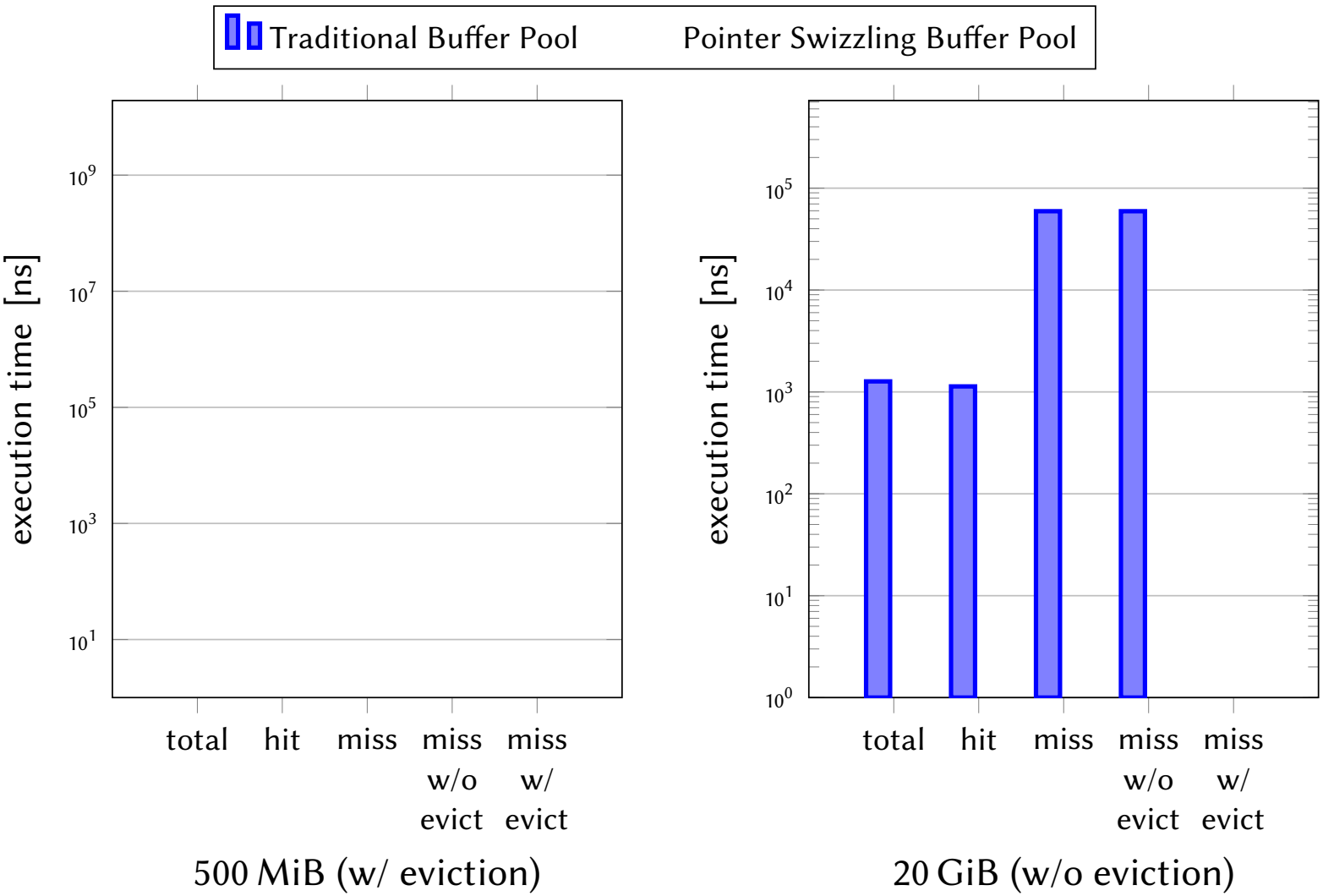

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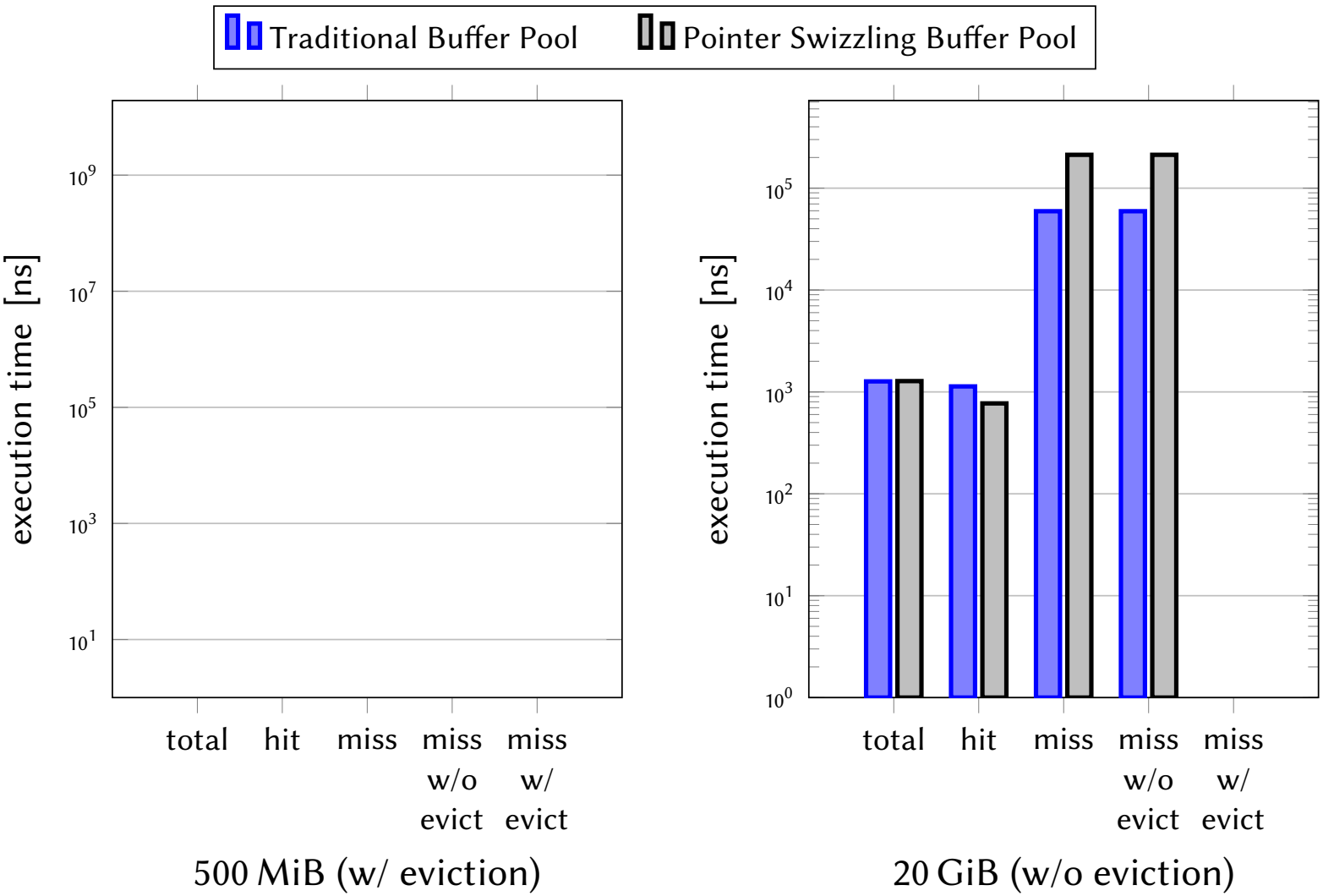

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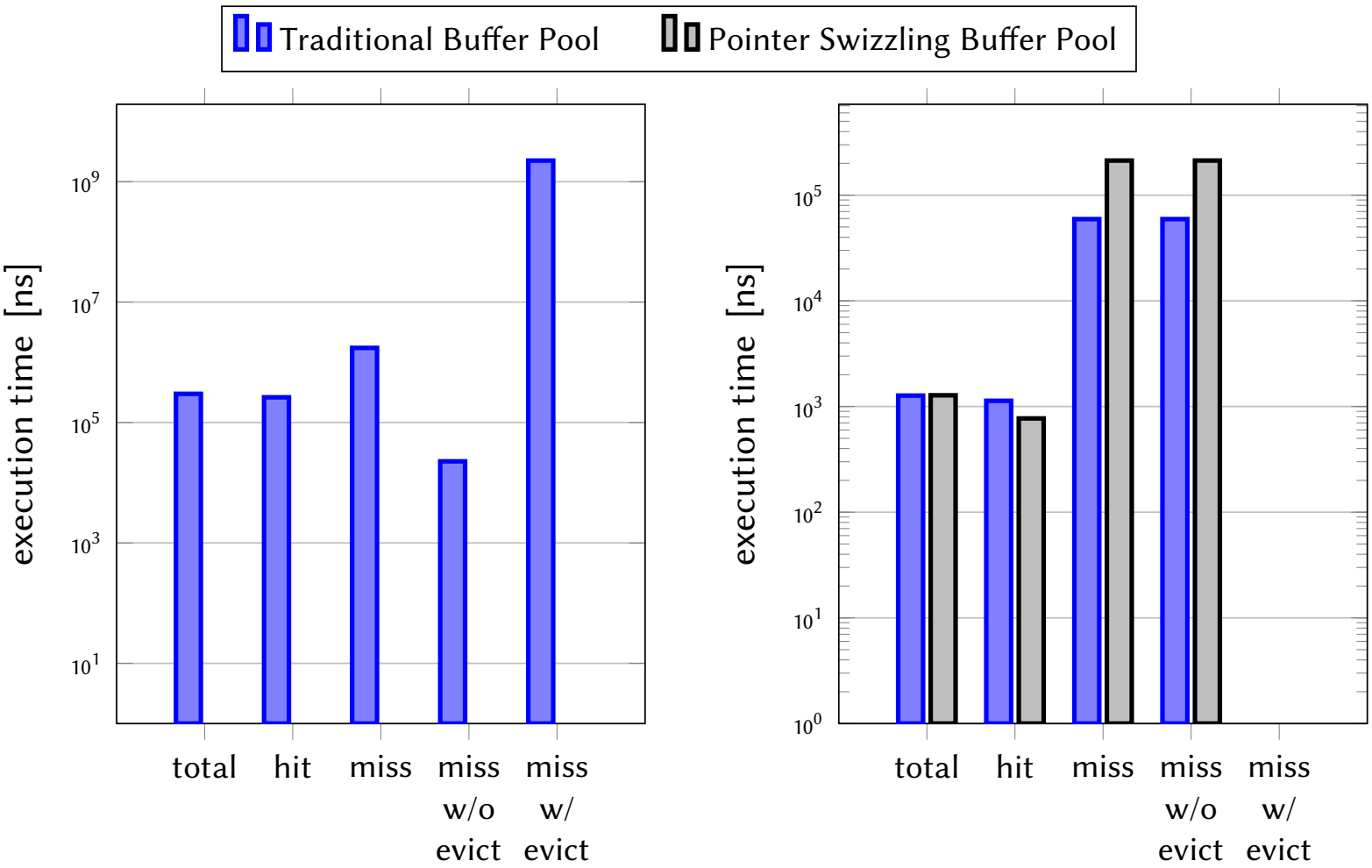

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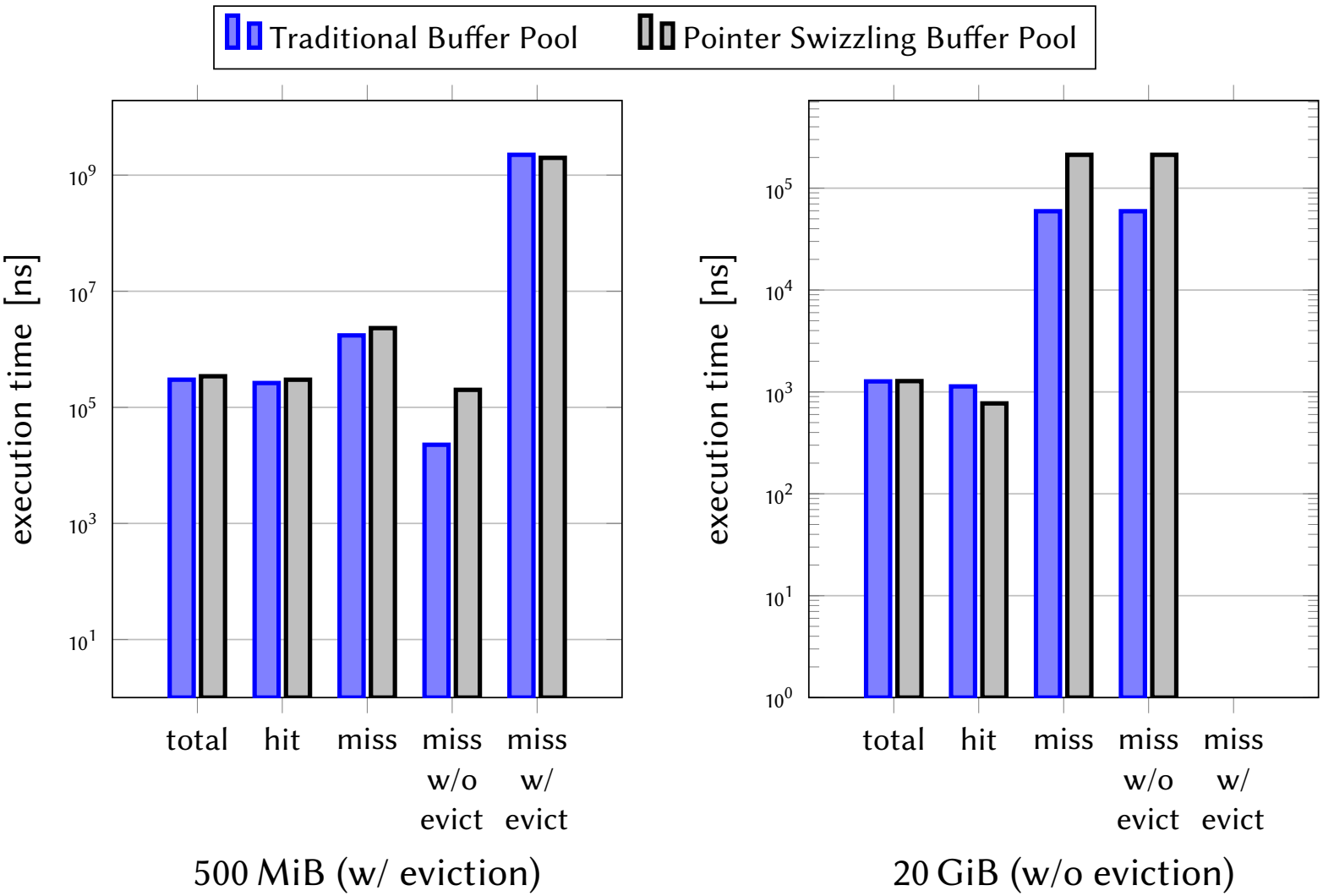

Subsection 3

Conclusion

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Overall Performance

Conclusion

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Buffer Pool Performance

- A page hit is faster when pointer swizzling is activated.
- A page miss is slower when pointer swizzling is activated.
- After the cold start phase, activated pointer swizzling will improve the buffer pool performance for large buffer pools.

Section 3

Page Eviction Strategies in the Context of Pointer Swizzling

Motivation not to Analyze Different Page Eviction Strategies

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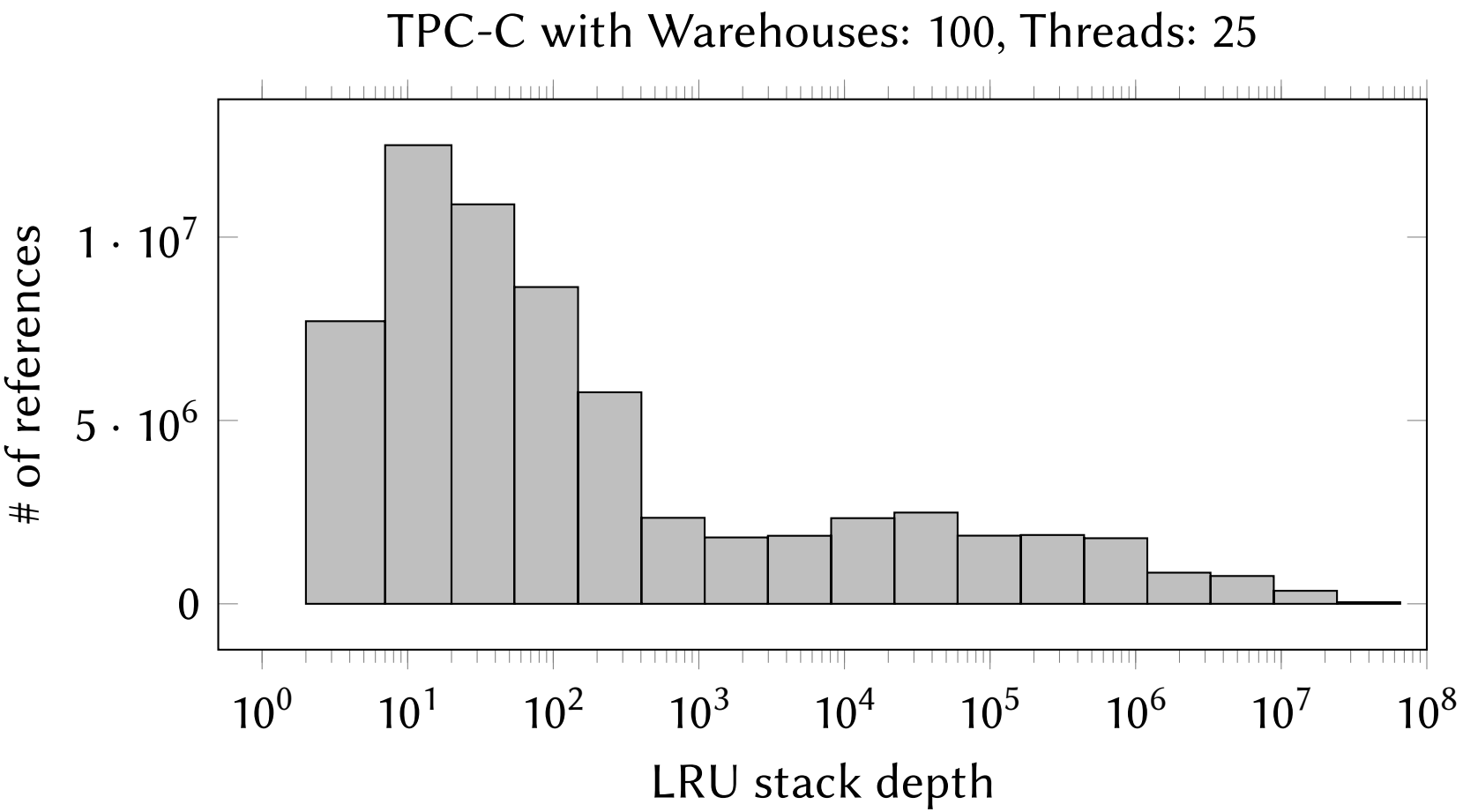
- Even LRU results in decent hit rates



But ...

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- Huge access time gap $\Longrightarrow$ Every saved page miss significantly improves the performance
- Pointer swizzling even amplifies that effect

Subsection 1

Probable pitfalls when Implementing a Page Eviction Strategy for a DBMS Buffer Manager

General Problems Concerning DBMS Buffer Managers

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- A page pinned for refix cannot be evicted but a long timespan in which a page is pinned could make it a candidate for eviction.
- Dirty pages cannot be evicted but a page being dirty for a long timespan due to the update propagation using write-back policy could make it a candidate for eviction.

Additional Problem When Using Pointer Swizzling

Additional Problem When Using Pointer Swizzling

- A page containing swizzled pointer cannot be evicted but a page unfixed before the last unfix of one of its child pages could make it a candidate for eviction before its child pages got evicted.

Solutions

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Solutions

- Check each of the restrictions before the eviction of a page.
- Update the statistics of the eviction strategy during an unfix, too.
- Update the statistics of the eviction strategy during an pin and unpin, too.
- Use write-thru for update propagation or a page cleaner decoupled from the buffer pool as proposed in [SHG16].
- Use a page eviction strategy that takes into account the content of pages (like the structure of an B tree).

Subsection 2

Evaluated Page Replacement Strategies

RANDOM

Overview

RANDOM

Overview

- Simplest page eviction strategy

RANDOM

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RANDOM

Overview

- Simplest page eviction strategy
- Evicts a random page that can be evicted
- Won't evict frequently used pages as they're latched all the time

GCLOCK

Overview

GCLOCK

Overview

- Slight enhancement of the CLOCK algorithm: *generalized CLOCK*

GCLOCK

Overview

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  - $\boldsymbol{k = 1}$: CLOCK

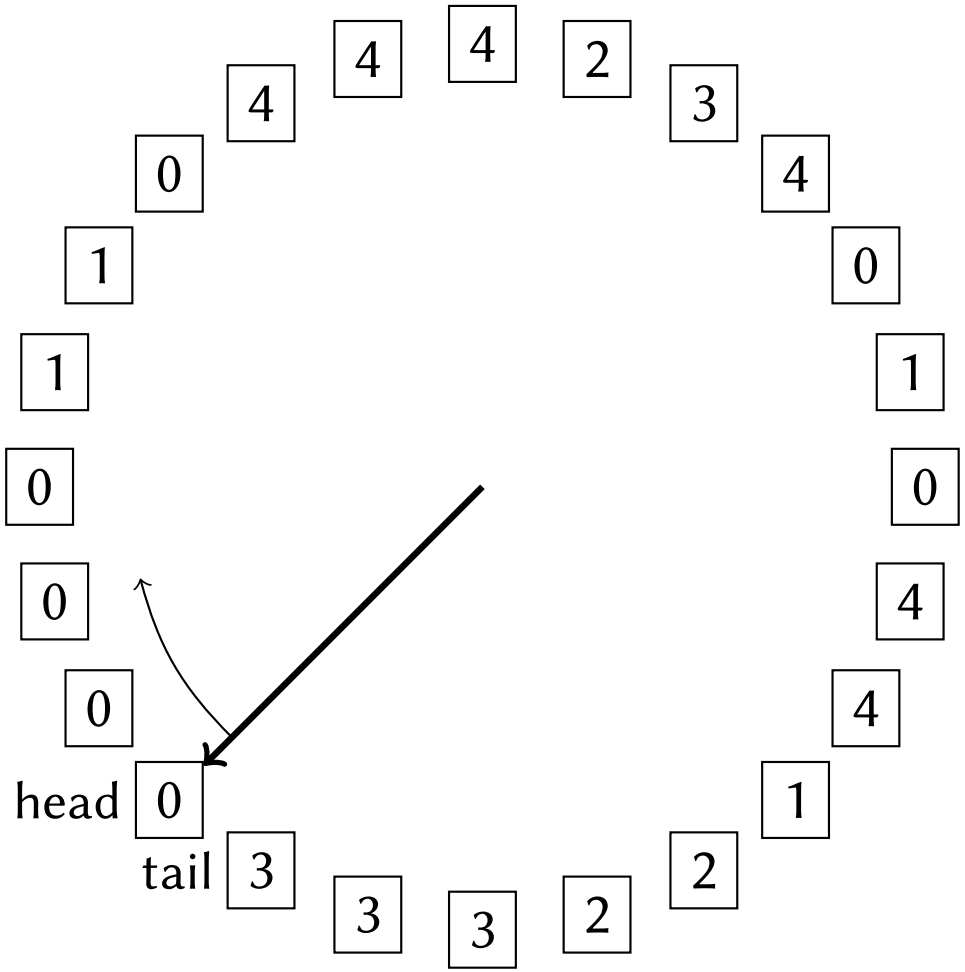
GCLOCK

Overview

- Slight enhancement of the CLOCK algorithm: *generalized CLOCK*
- Uses finer-grained statistics about the recency of page references
- Parameter k defines granulation of statistics
  - $\boldsymbol{k = 1}$**:** CLOCK
  - $\boldsymbol{k = \#}$**frames:** Similar to LRU

GCLOCK

Example



GCLOCK

Advantage of Higher k-Values

GCLOCK

Advantage of Higher k-Values

Advantages of Lower k-Values

GCLOCK

Advantage of Higher k-Values

- More detailed statistics about page references
  $\Longrightarrow$ Higher hit rate
  $\Longrightarrow$ Higher performance

Advantages of Lower k-Values

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Advantages of Lower k-Values

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$\Longrightarrow$ Trade-off between CPU- and I/O-optimization

CAR

Overview

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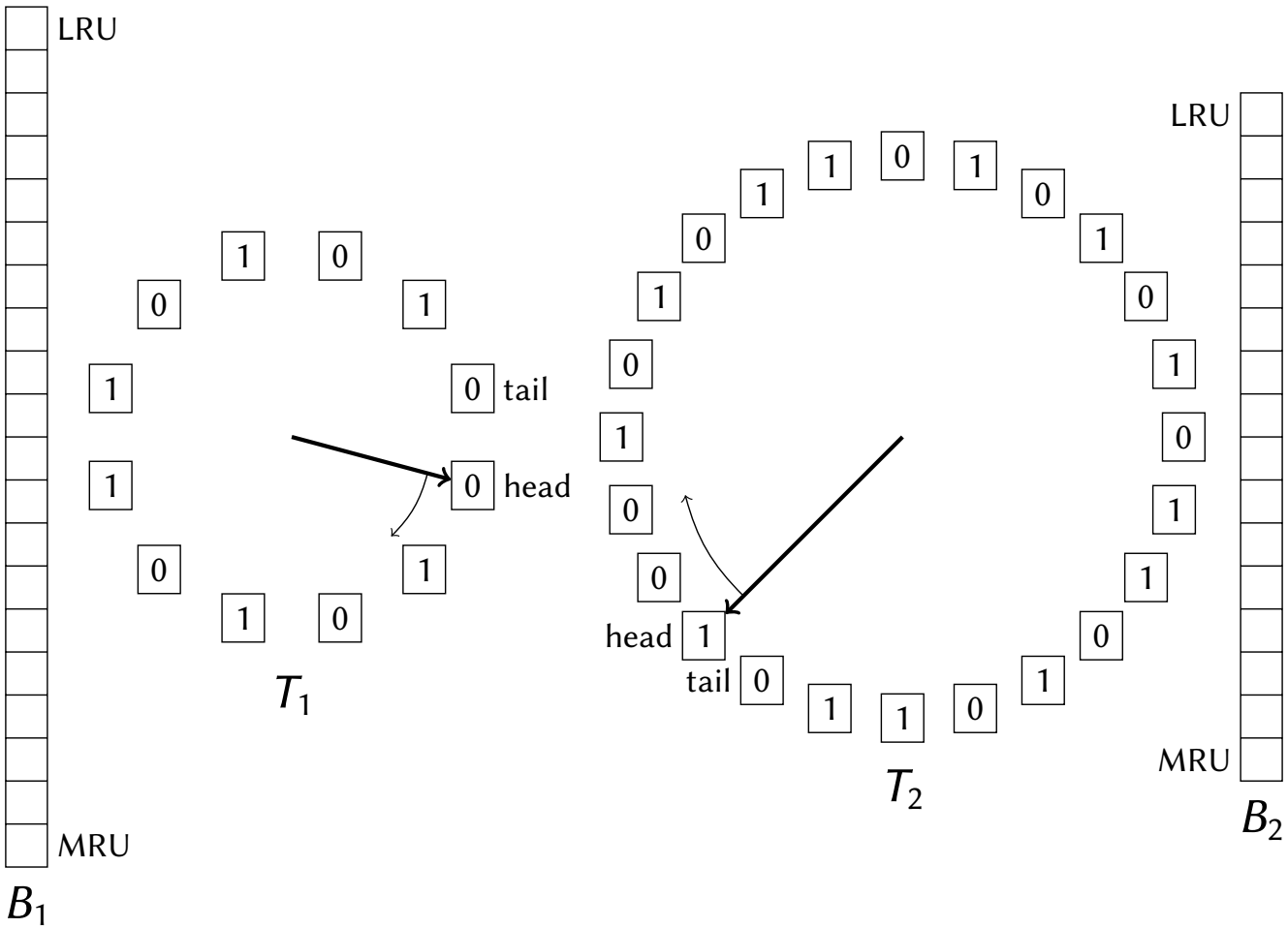
  - Scan-resistence

CAR

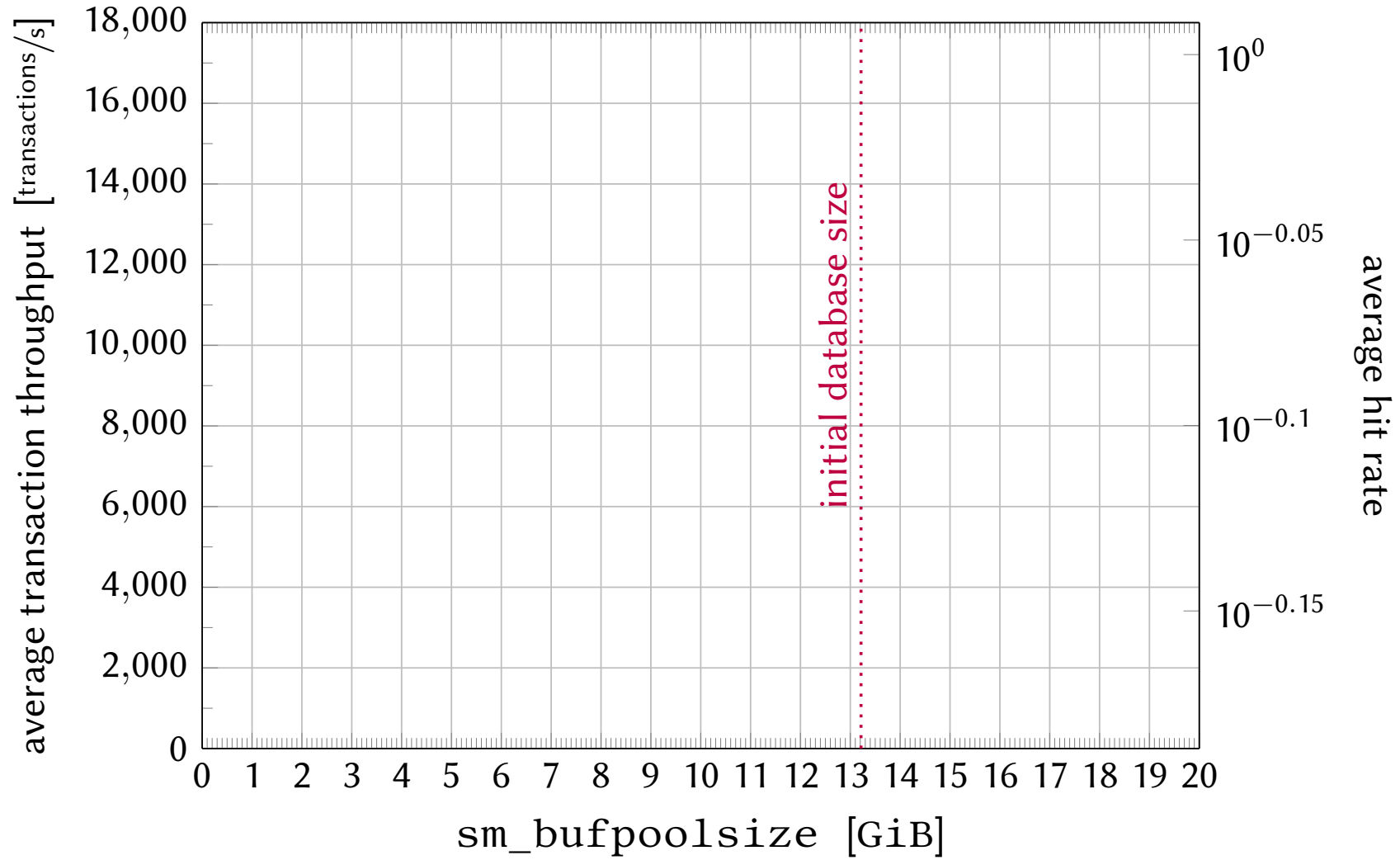
Example



Subsection 3

Performance Evaluation

Buffer Pool Without Pointer Swizzling (TPC-C)



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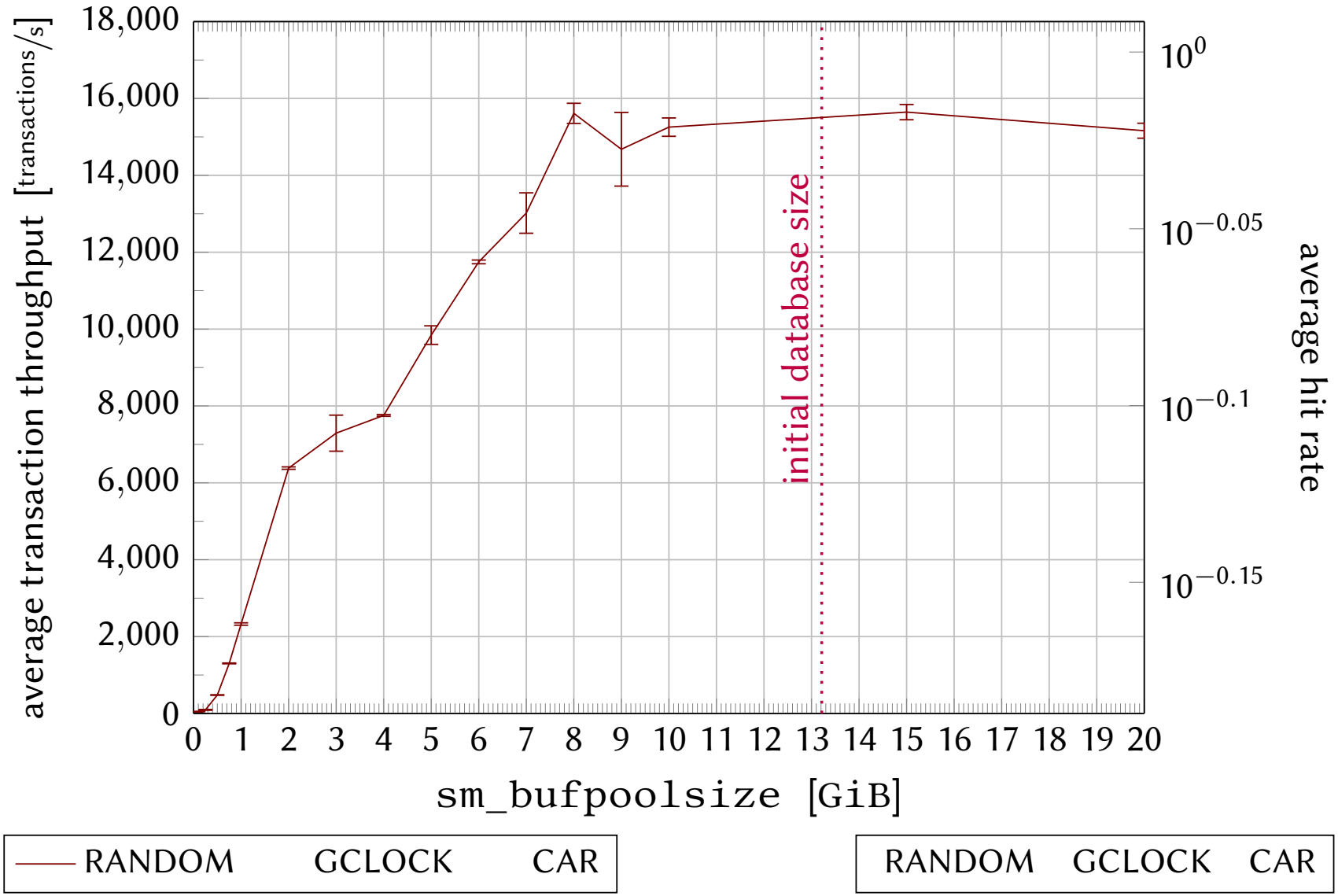

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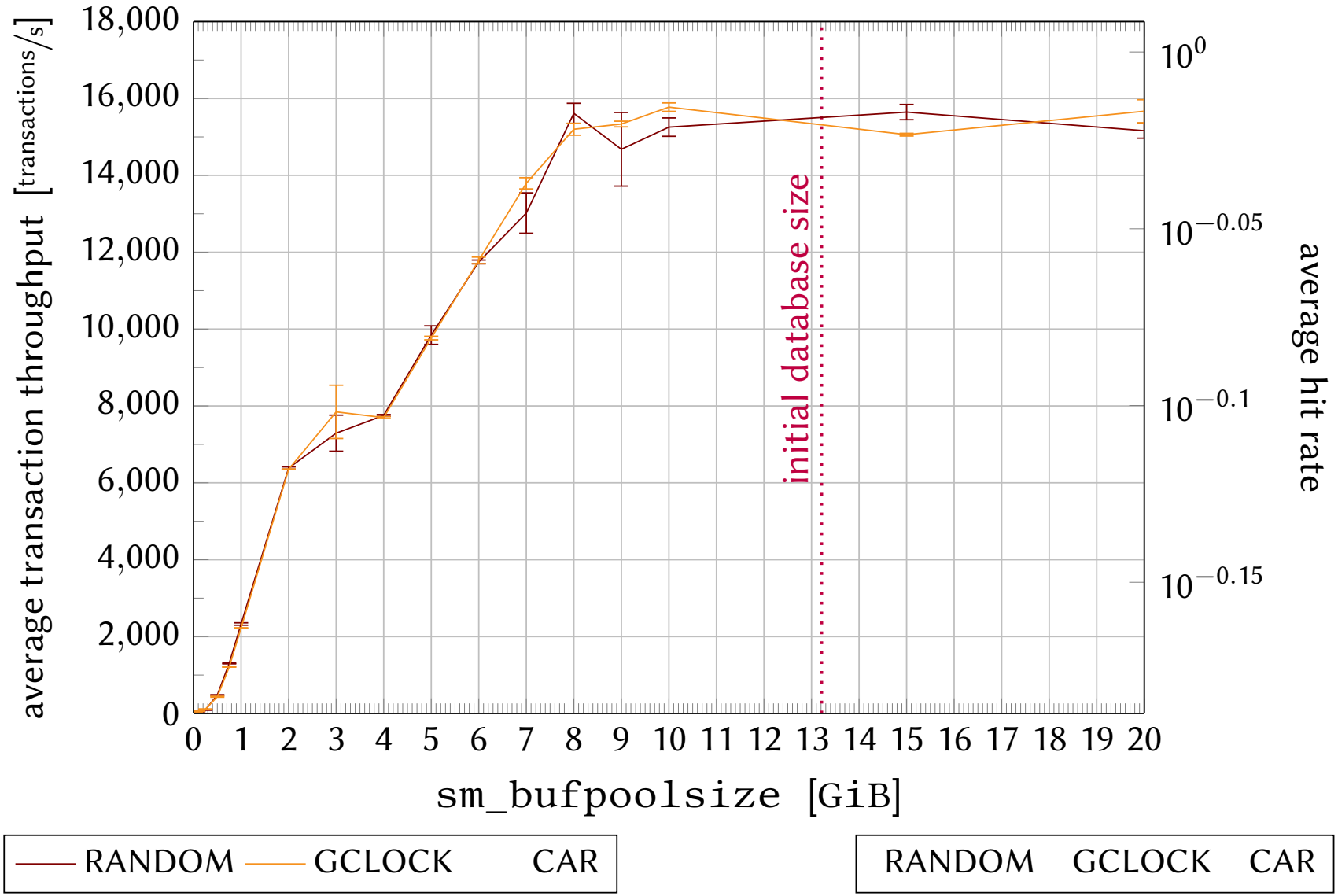

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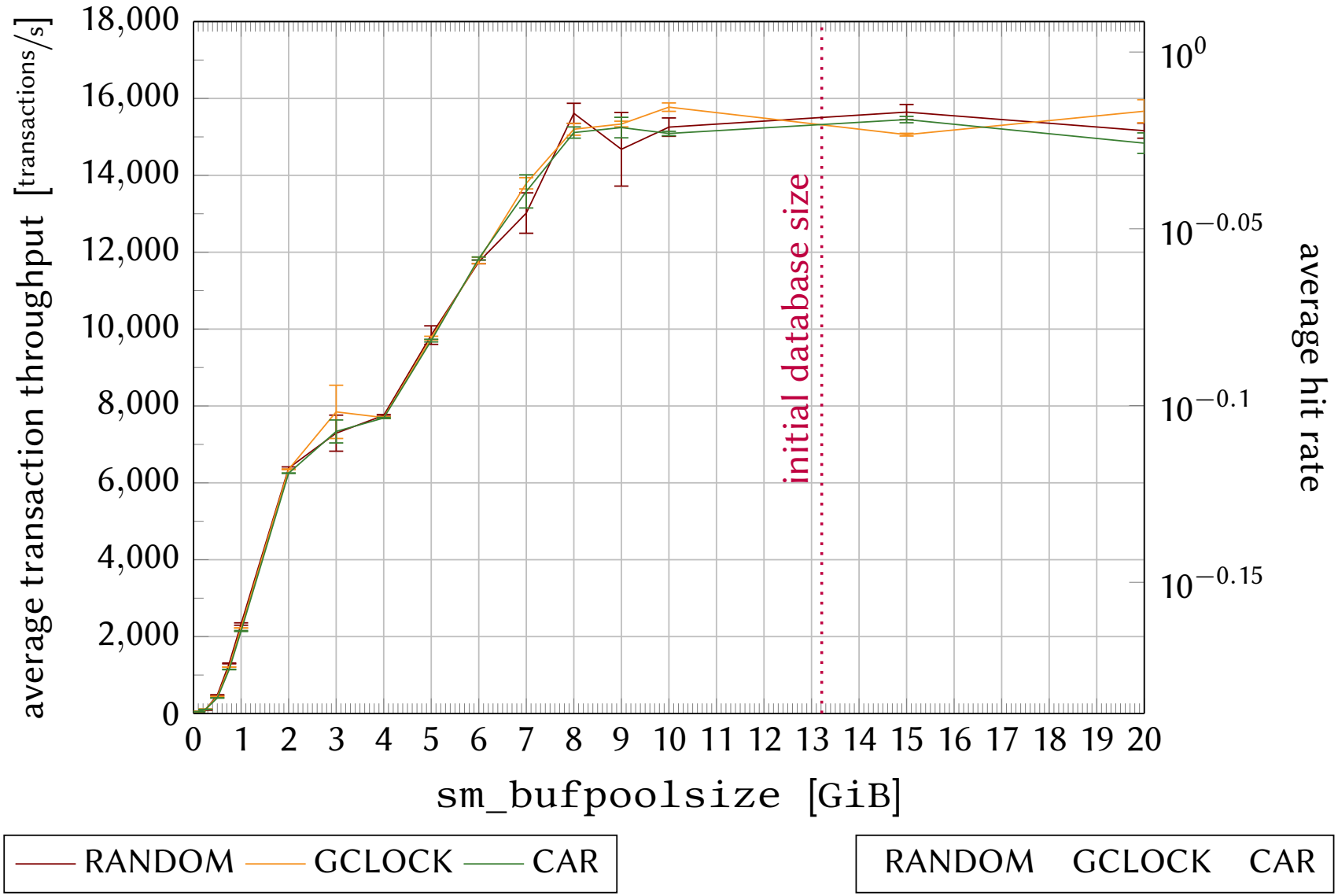

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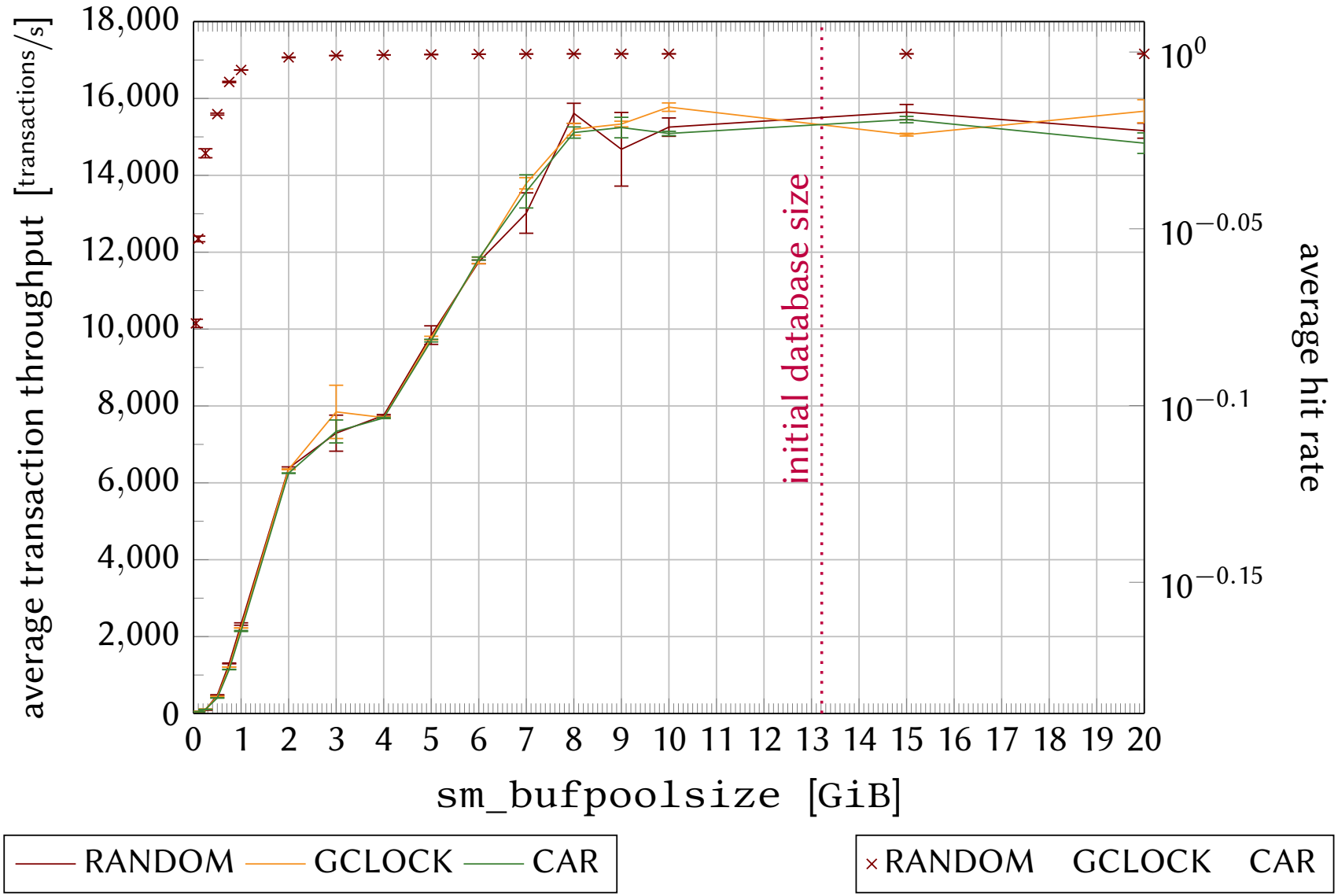

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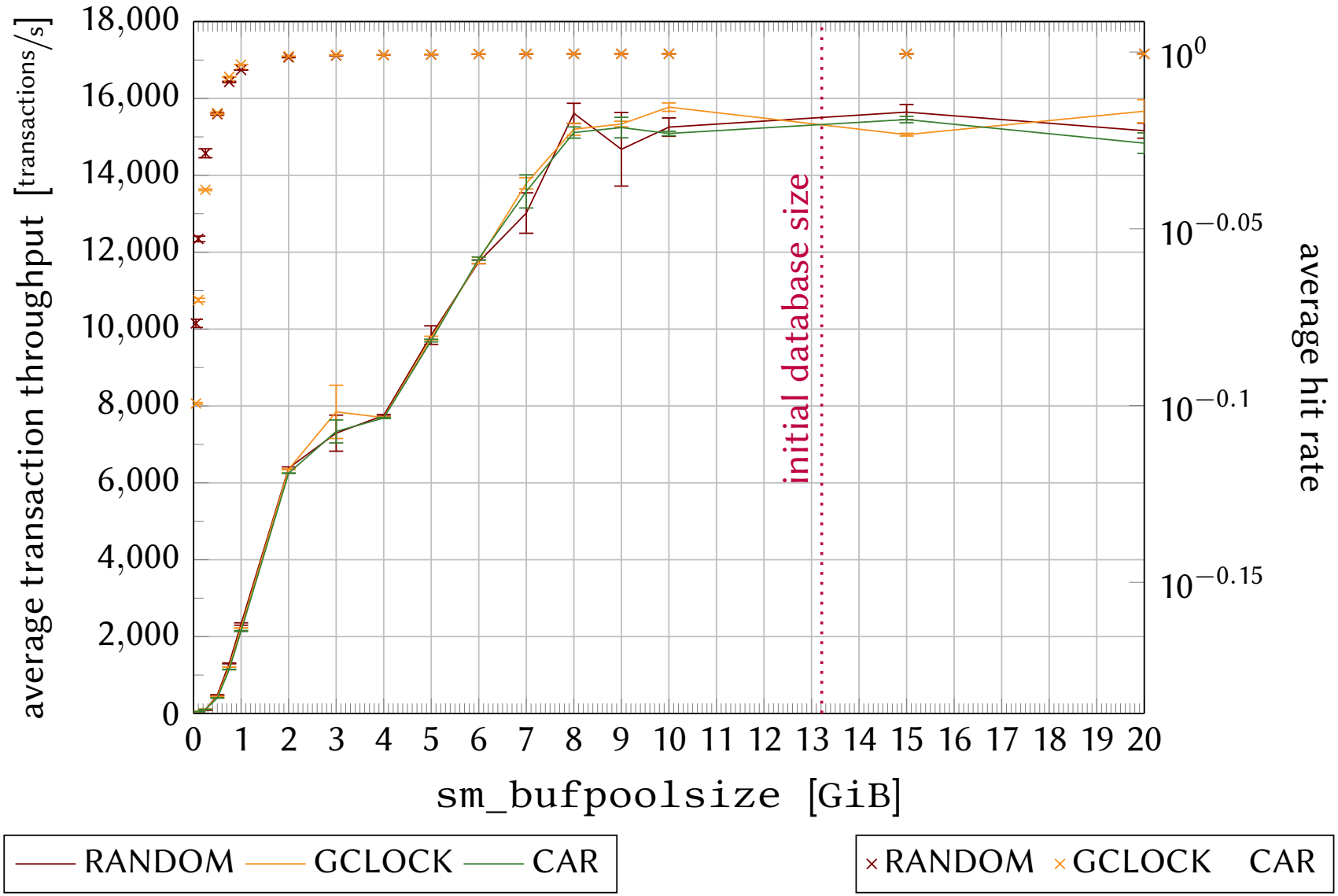

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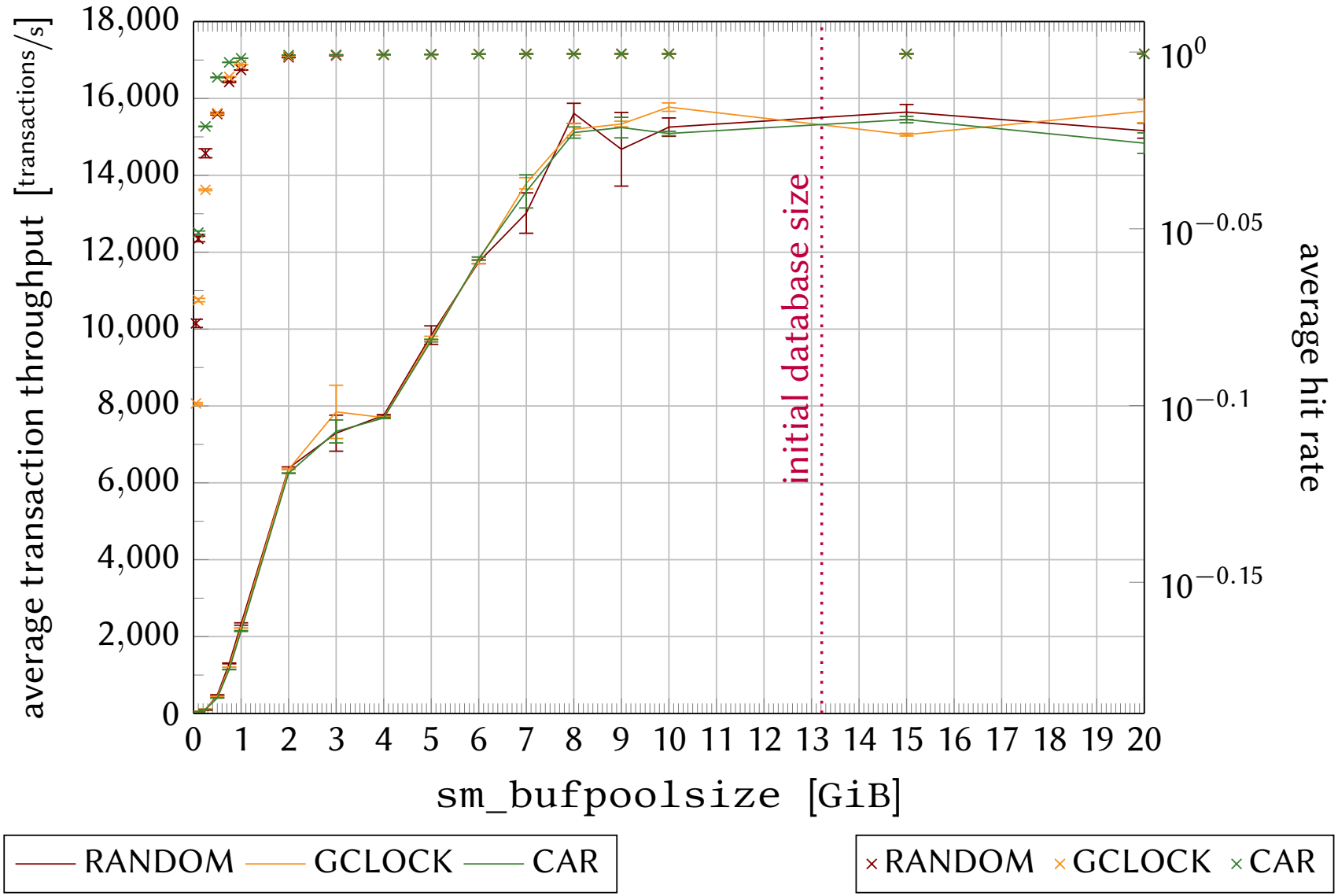

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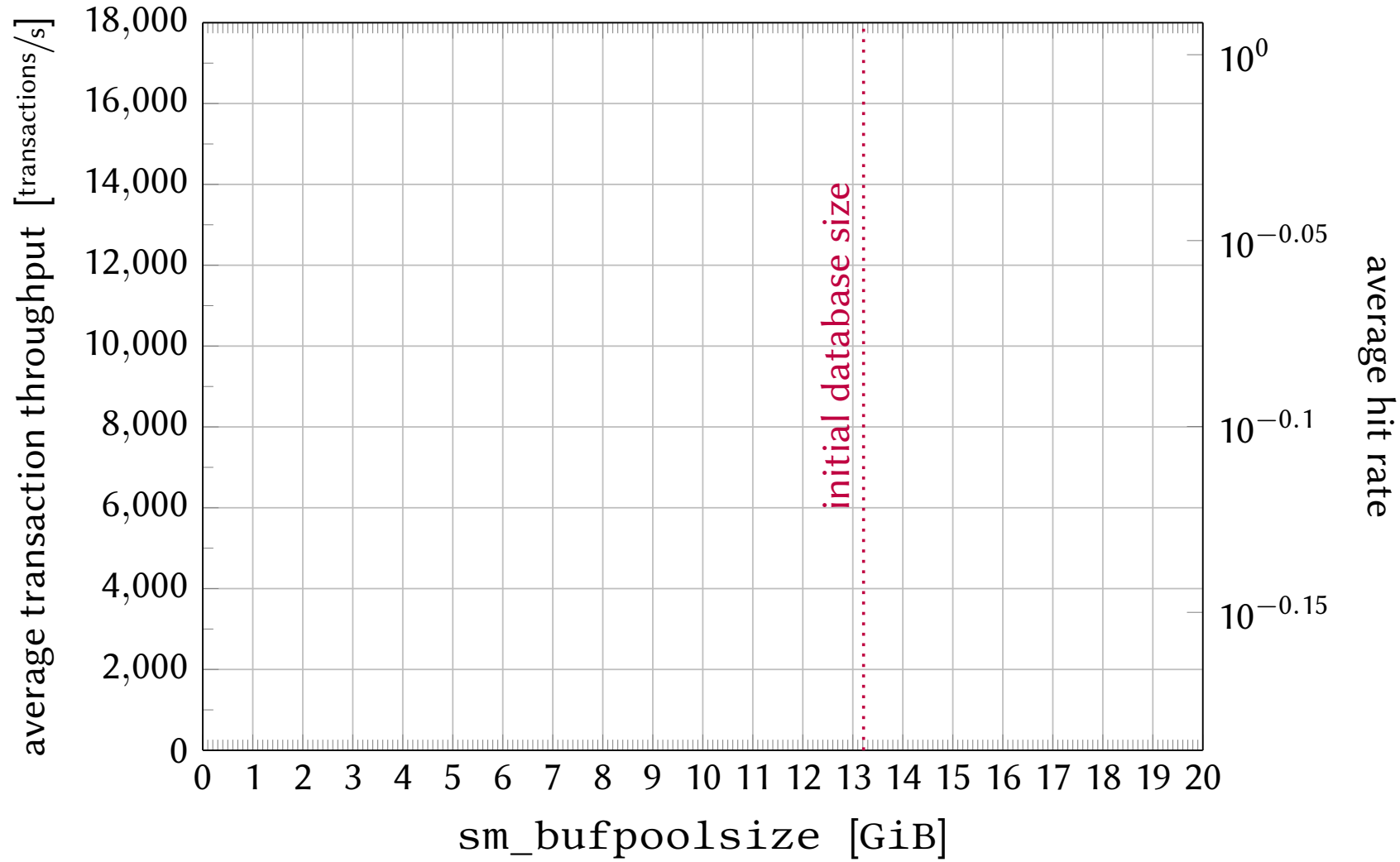

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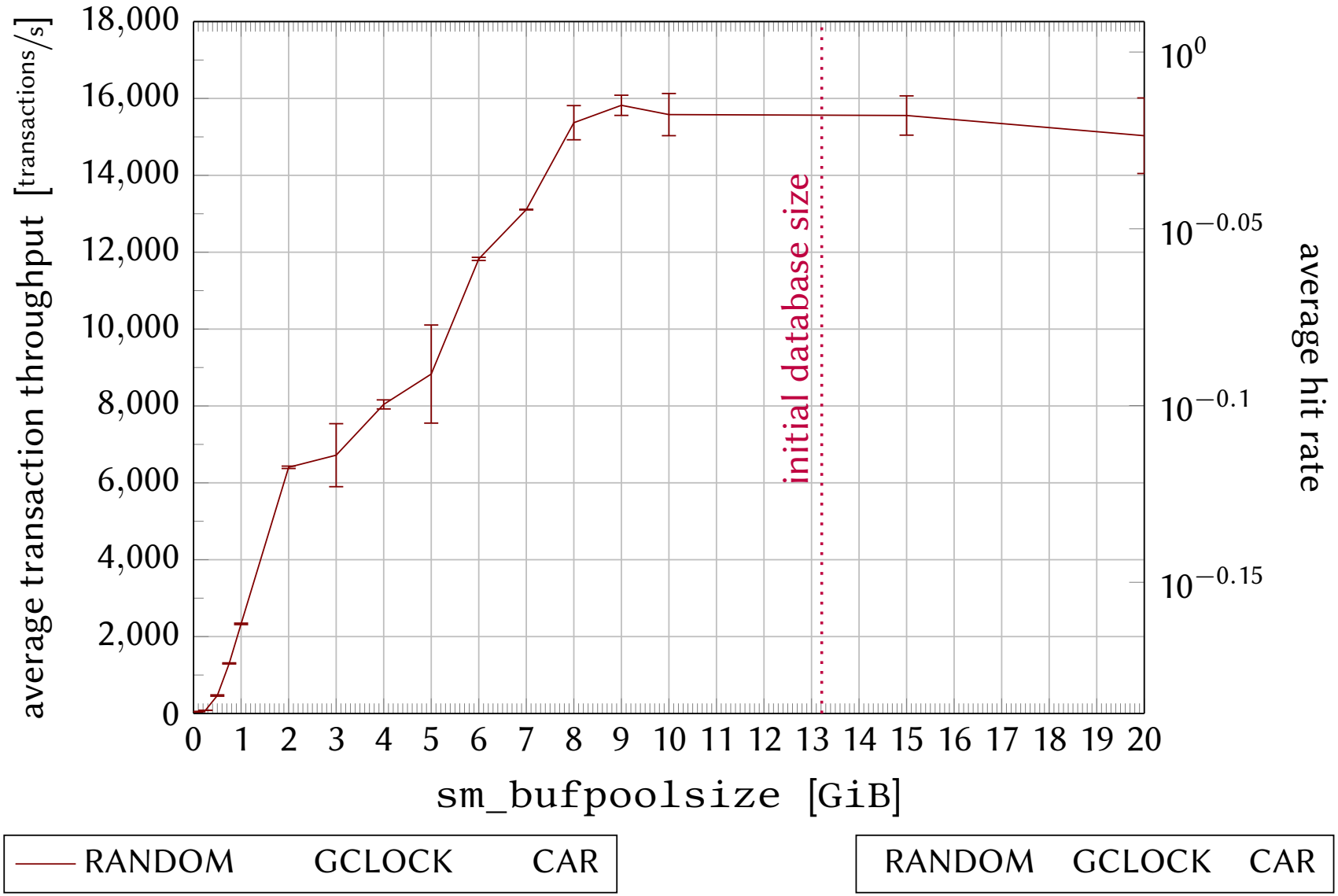

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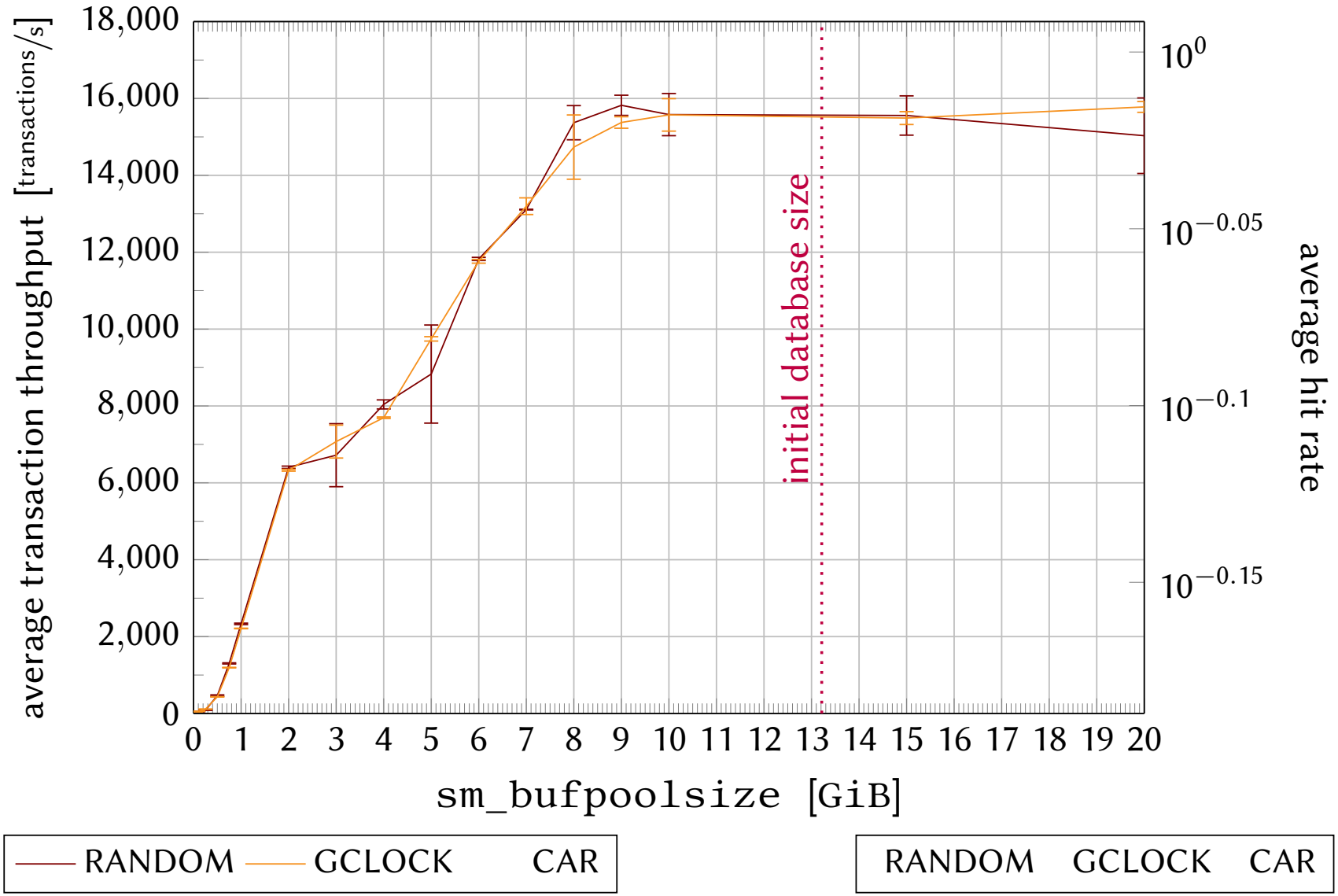

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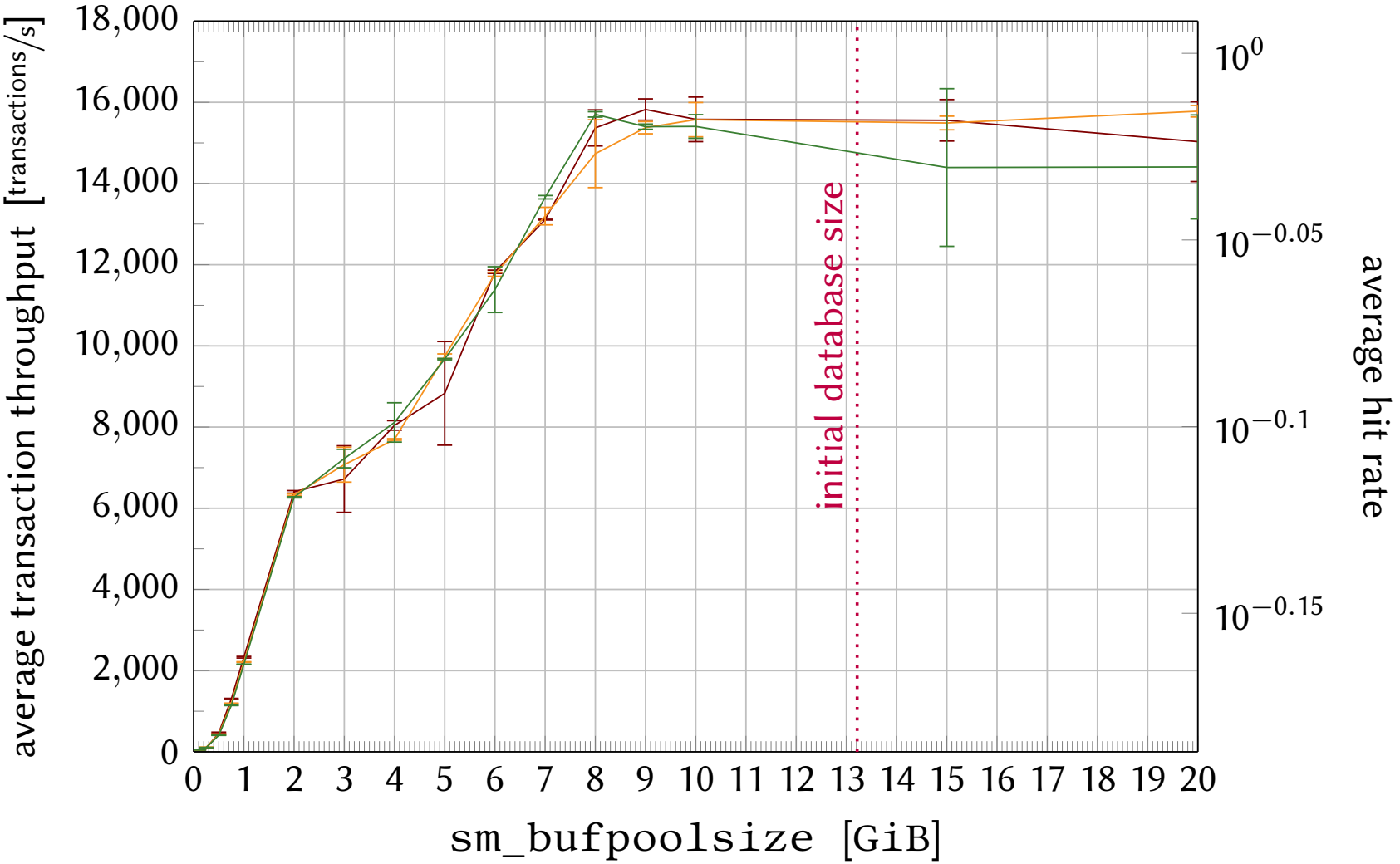

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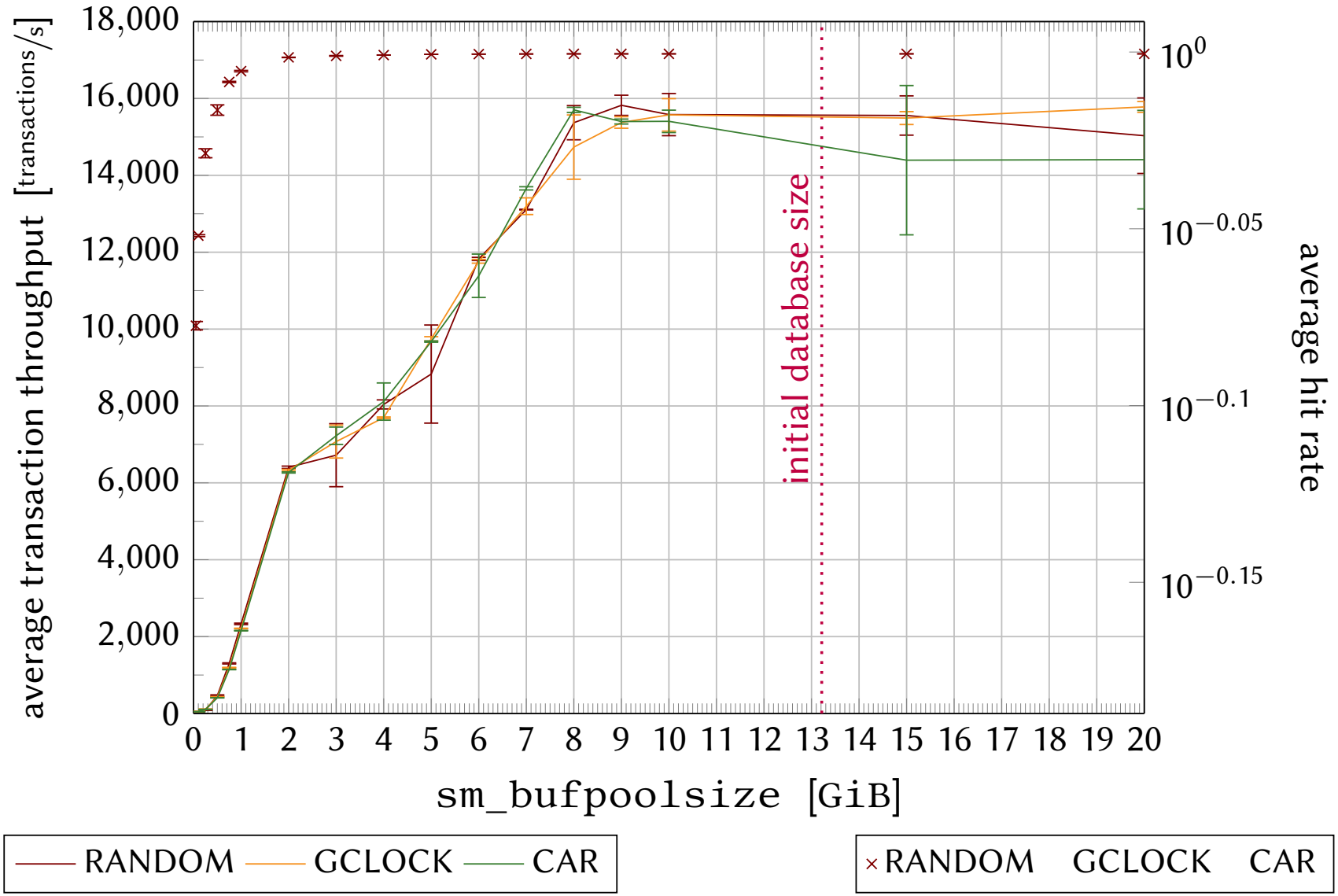

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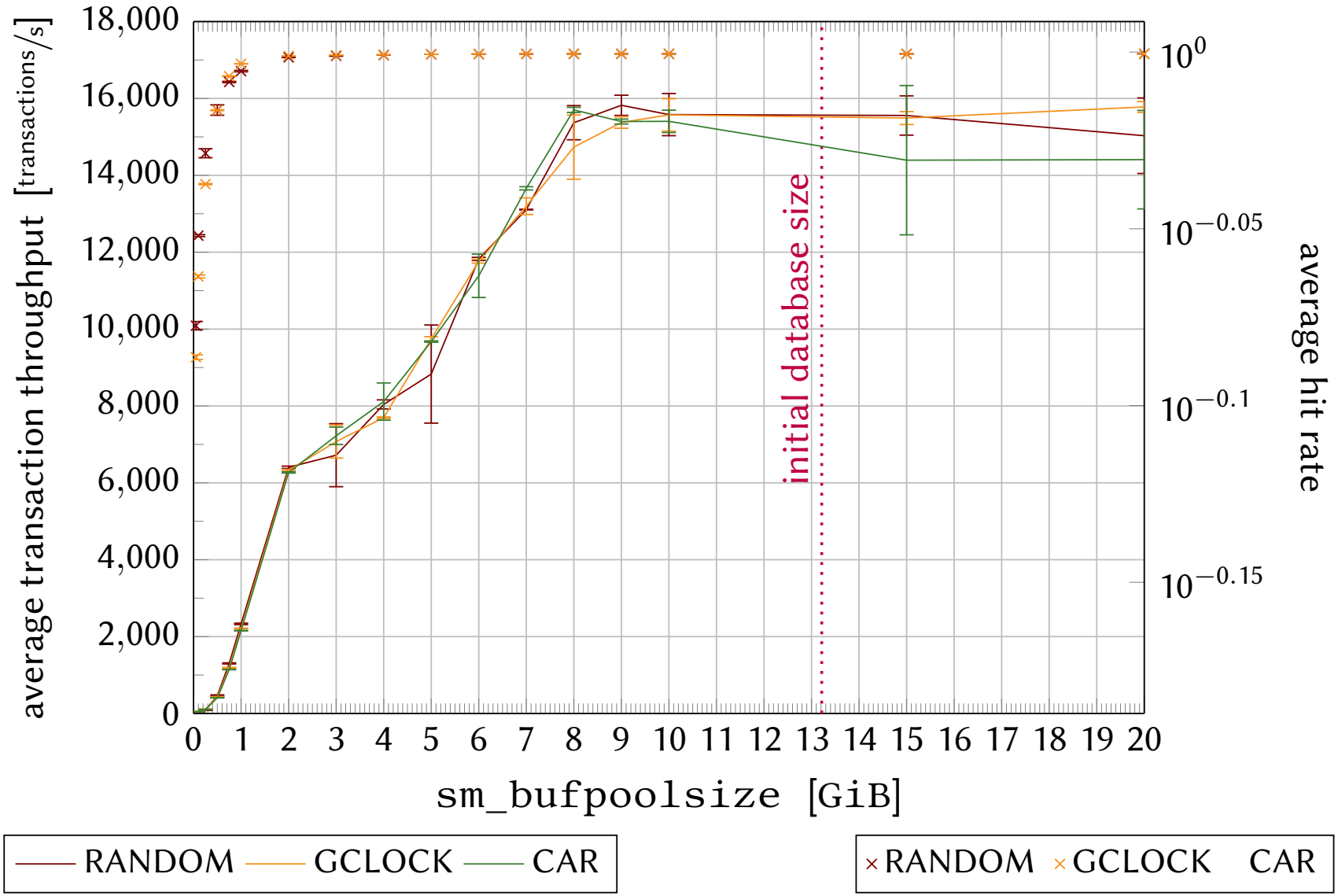

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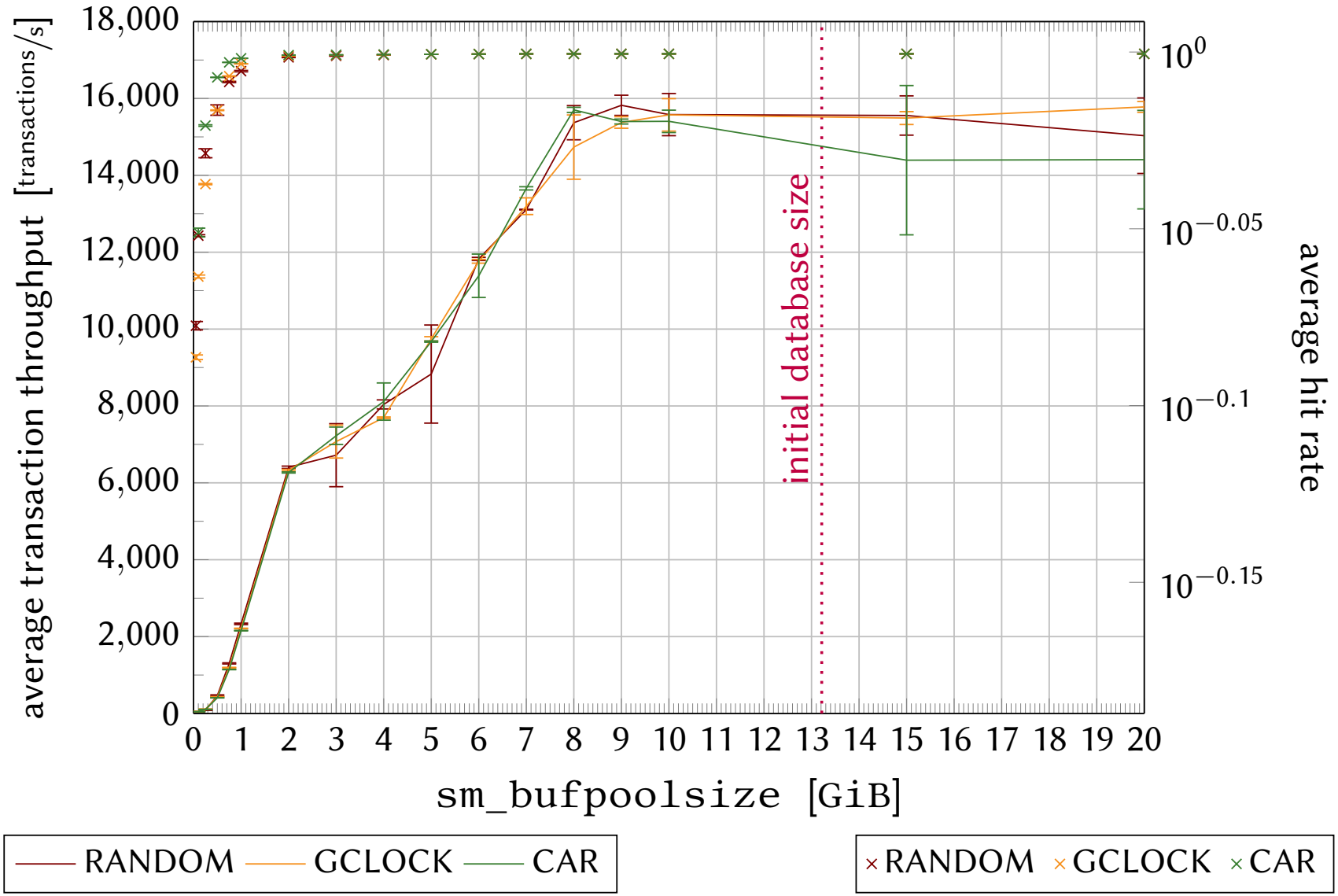
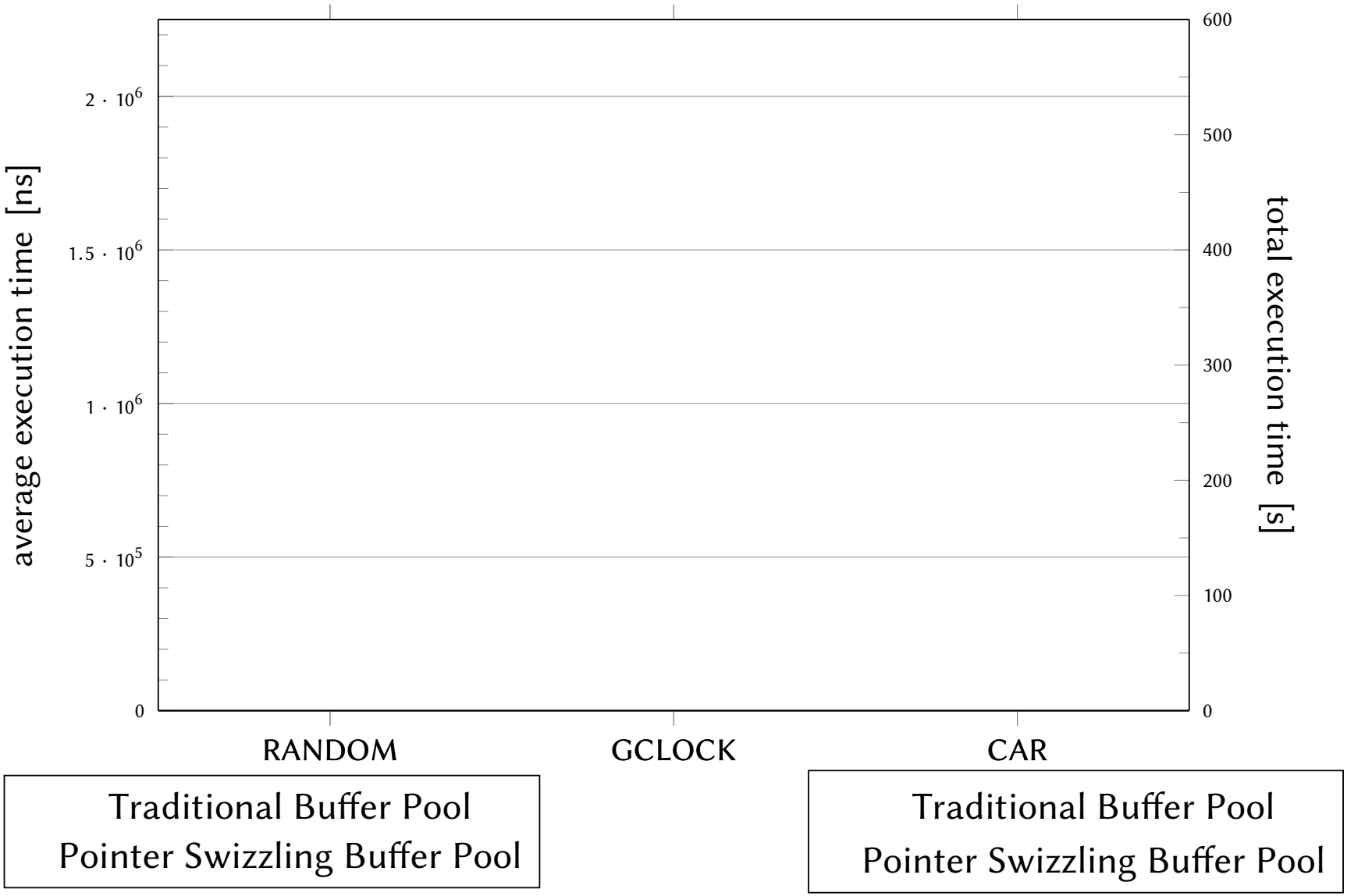


Operation Performance



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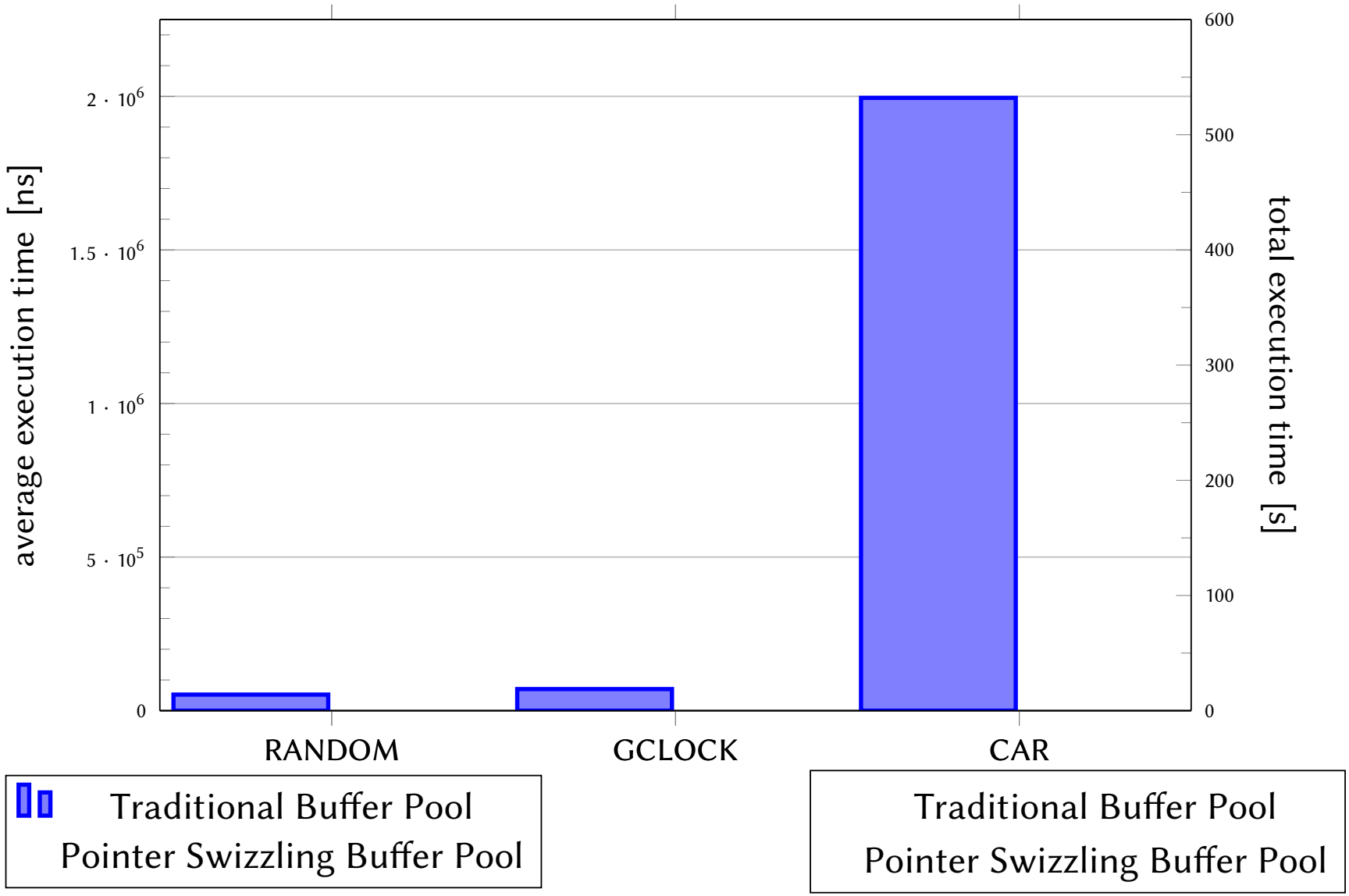

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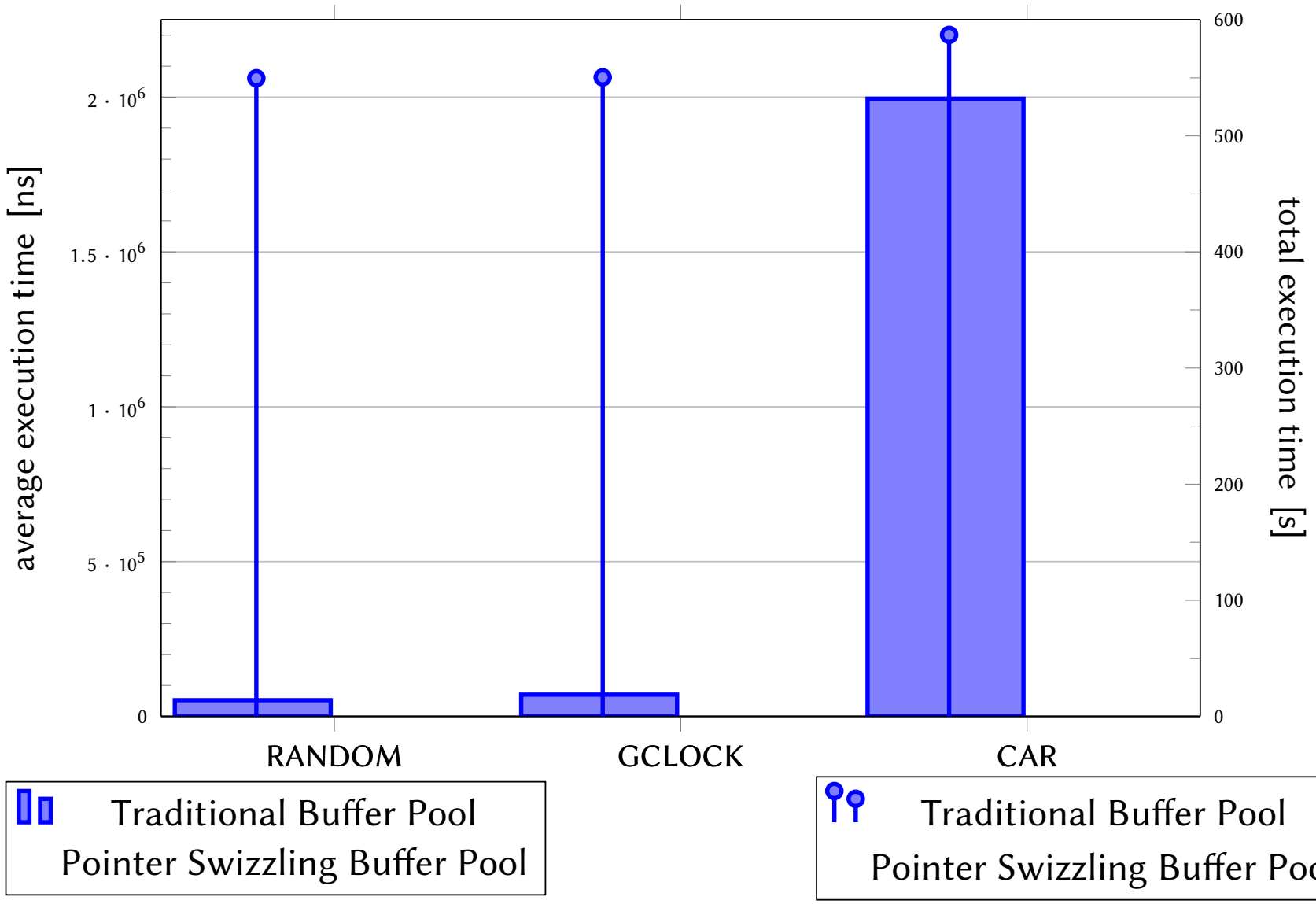

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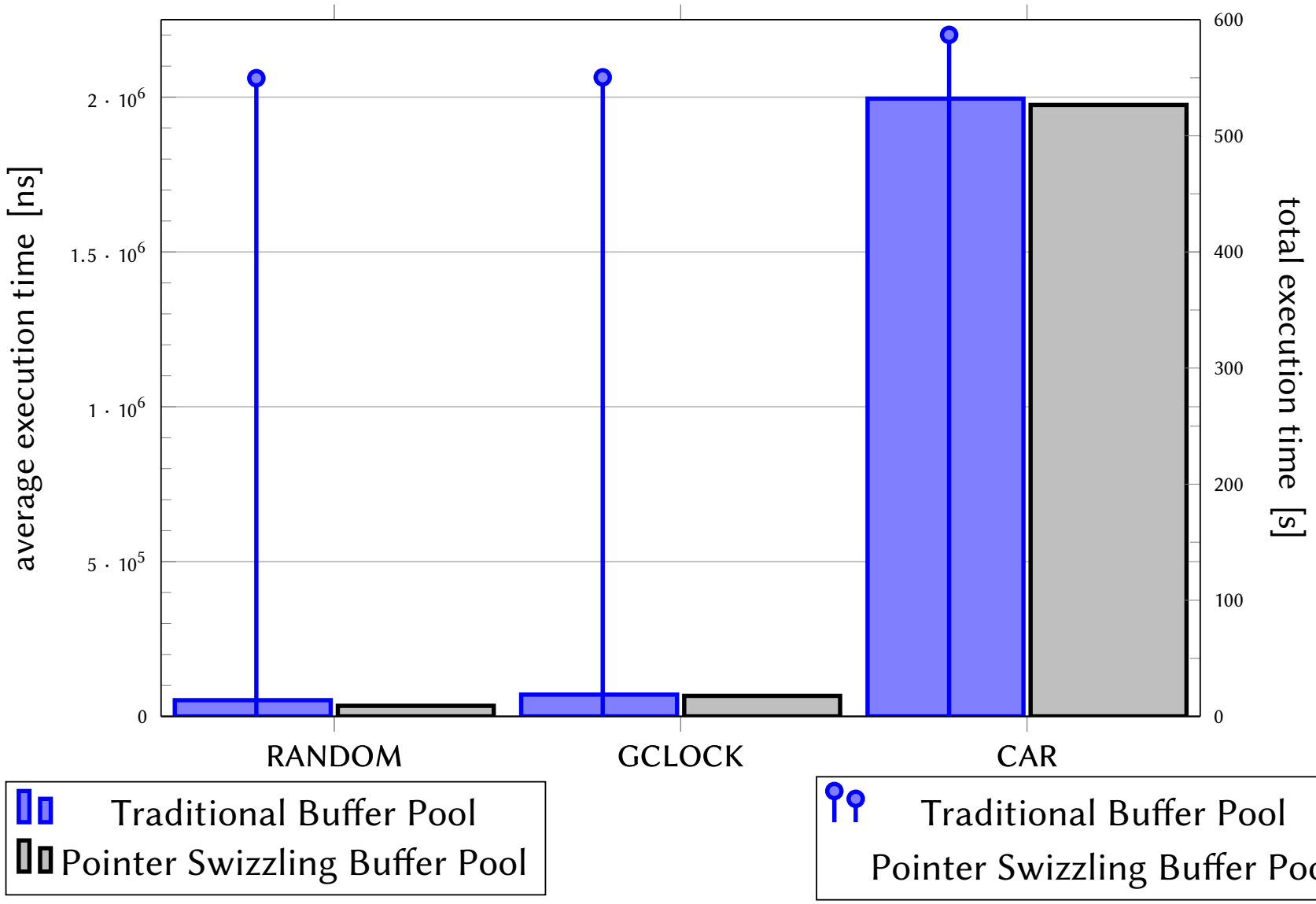

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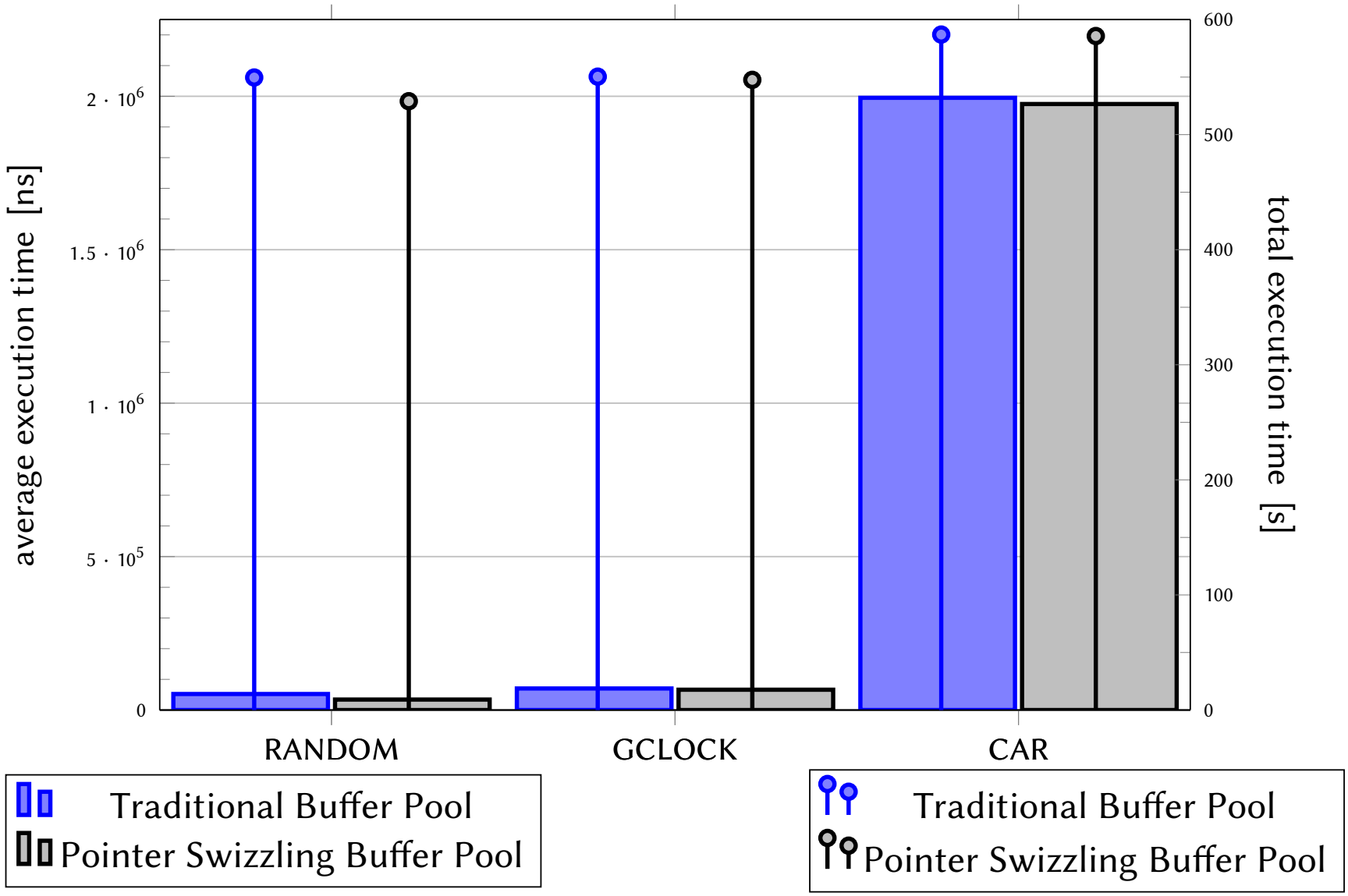

Subsection 4

Conclusion

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Performance

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- Major differences in hit rate are only for buffer pool sizes of $\leq \frac{1}{10}$ of the database size
- The computational effort spent to do CAR eviction is 27–58 times higher
- The overall performance of CAR isn't better than the one of RANDOM or GCLOCK

References I


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