IBM Research

Increasing Buffer-Locality for Multiple Index Based Scans through Intelligent Placement and Index Scan Speed Control

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Goal

Improve query performance (throughput+latency)
for
ad-hoc index scan-heavy multi-query workloads
(e.g., DSS workloads)
with minimal architecture dependency/impact

Example DSS Queries

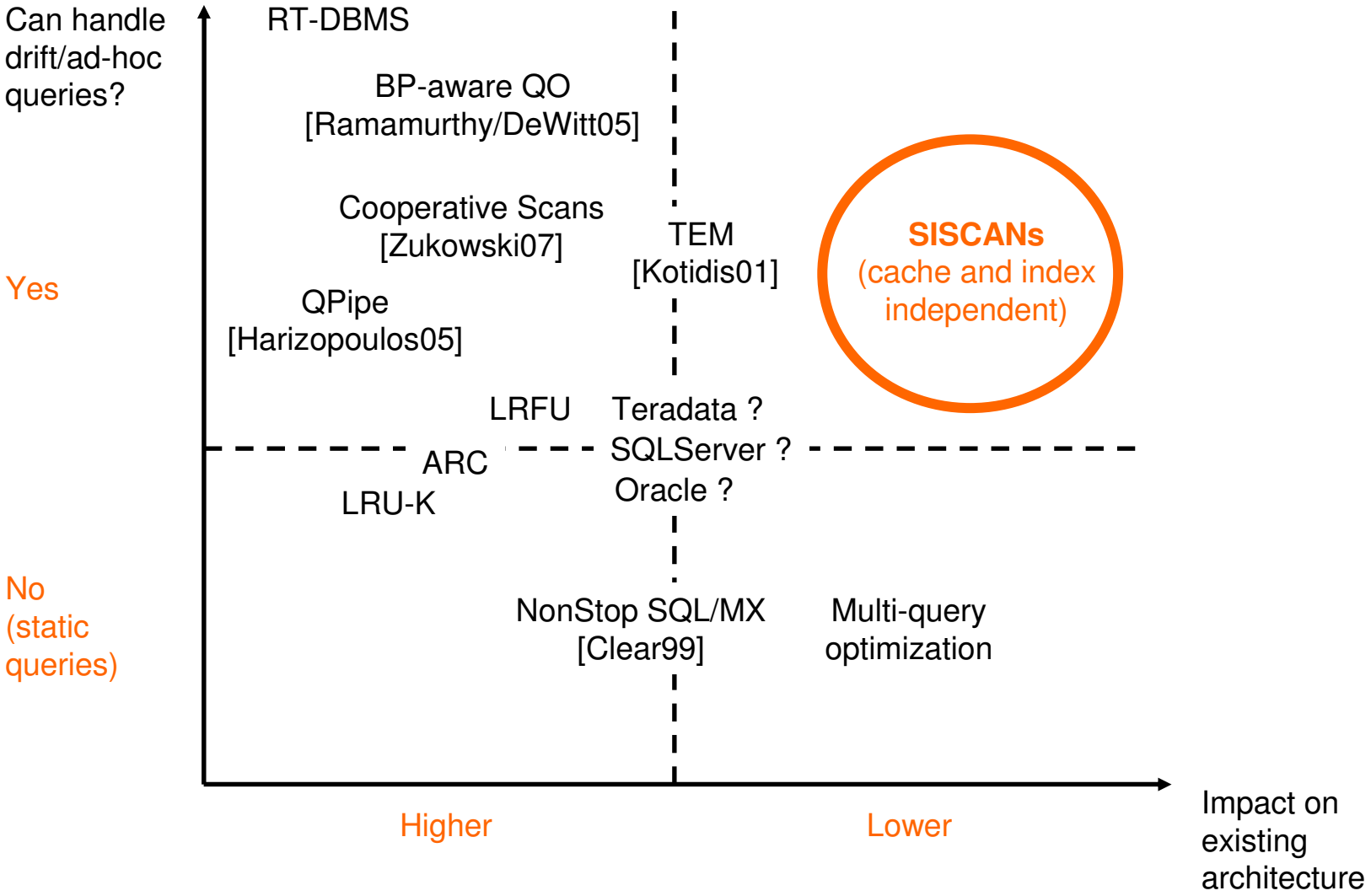
- select sum(l_extendedprice*l_discount) as revenue
  from lineitem
  where l_shipdate >= ’01/01/2006’ and
  l_shipdate < ’01/01/2006' + interval '1' year
  and l_quantity > 10;

- select sum(l_extendedprice*l_discount) as revenue,
  avg(l_extendedprice*l_discount) as avgSale
  from lineitem
  where l_shipdate >= ’10/01/2006’ and
  l_shipdate < ’10/01/2006’ + interval ‘3' month
  and l_quantity > 30;

Challenges in Multi-Query DSS Workloads

- DSS workloads include scanning of large amounts of data (e.g., aggregate calculation)
- Cannot optimize ahead of time (many ad-hoc queries, unknown start times)
- Trend: even more I/O bound queries (disk seek/access times not keeping up with capacity growth/CPU speed)
- Sub-optimal cache reuse (current RDBMS treat queries (mostly) in isolation)

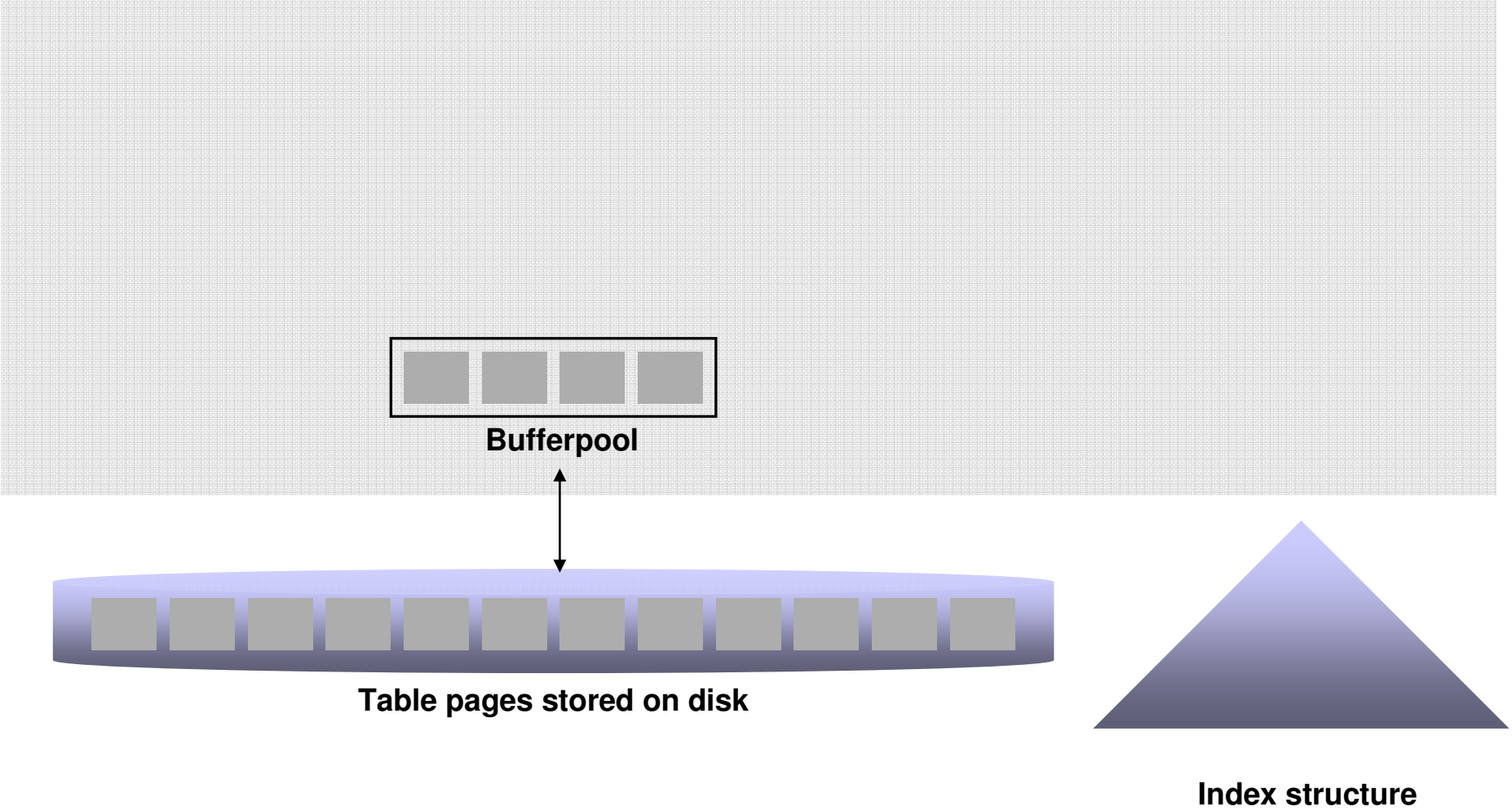
Known Solutions (not to scale)



Outline

- **Current Index Scan Architecture**
- **SISCAN – "Circular" Index Scan**
  - **Placement**
  - **Speed Control**
- **Implementation Issues**
  - **Index-independent Relative SISCAN Location**
  - **"Bufferpool-independent" SISCAN-aware Caching**
- **Experimental Results**
- **Conclusions**

Current Index Scan Architecture



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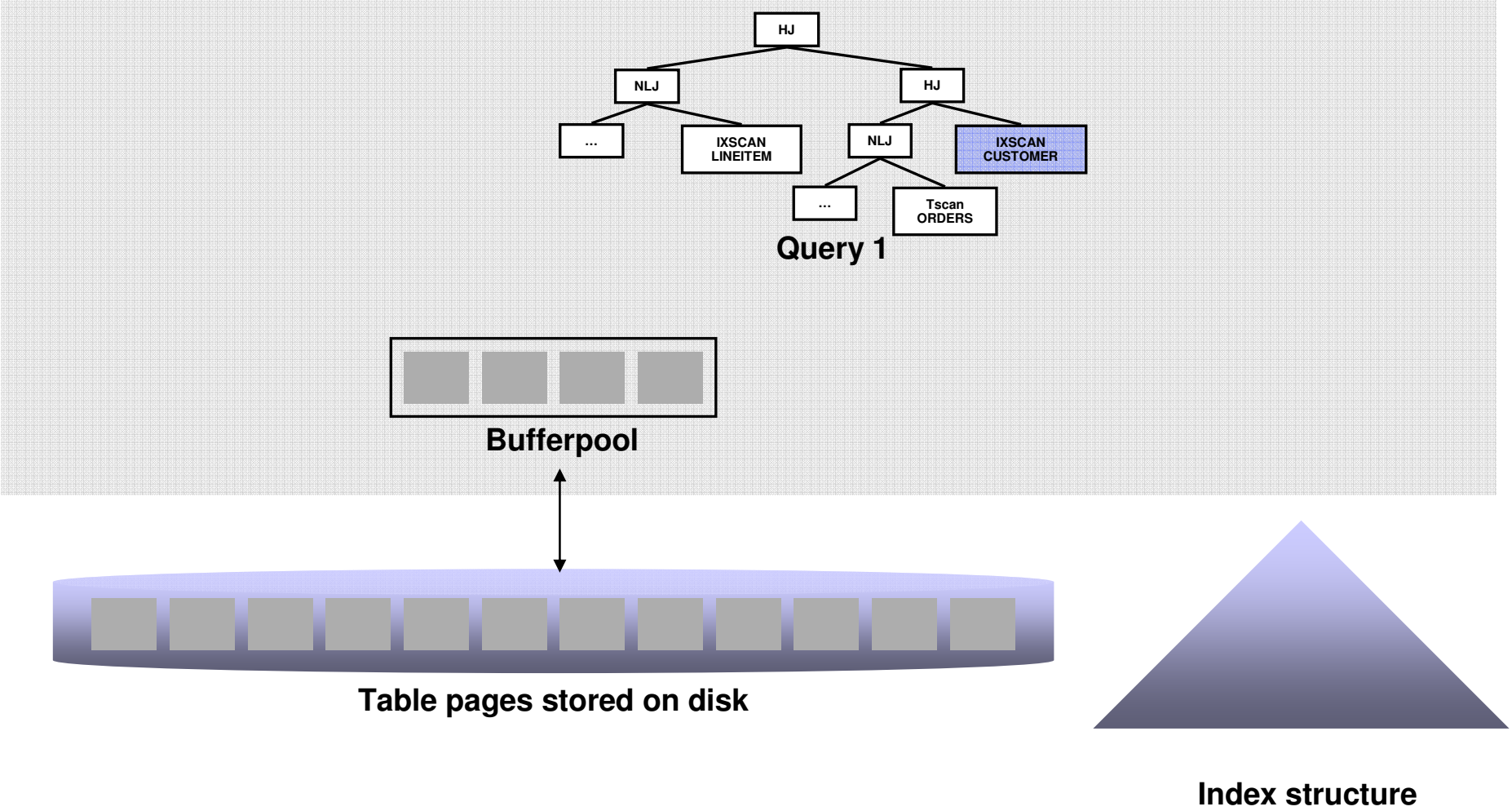

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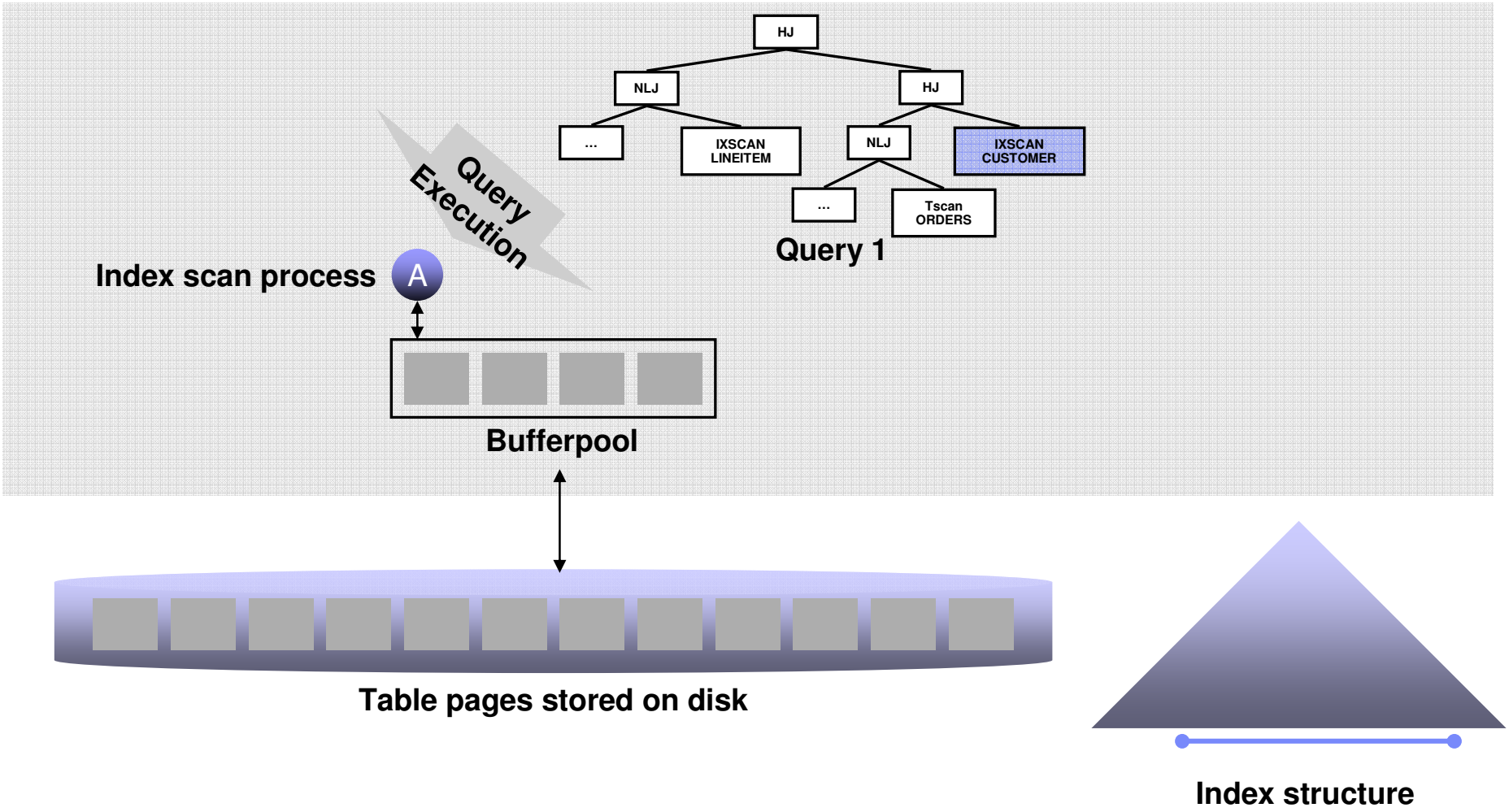

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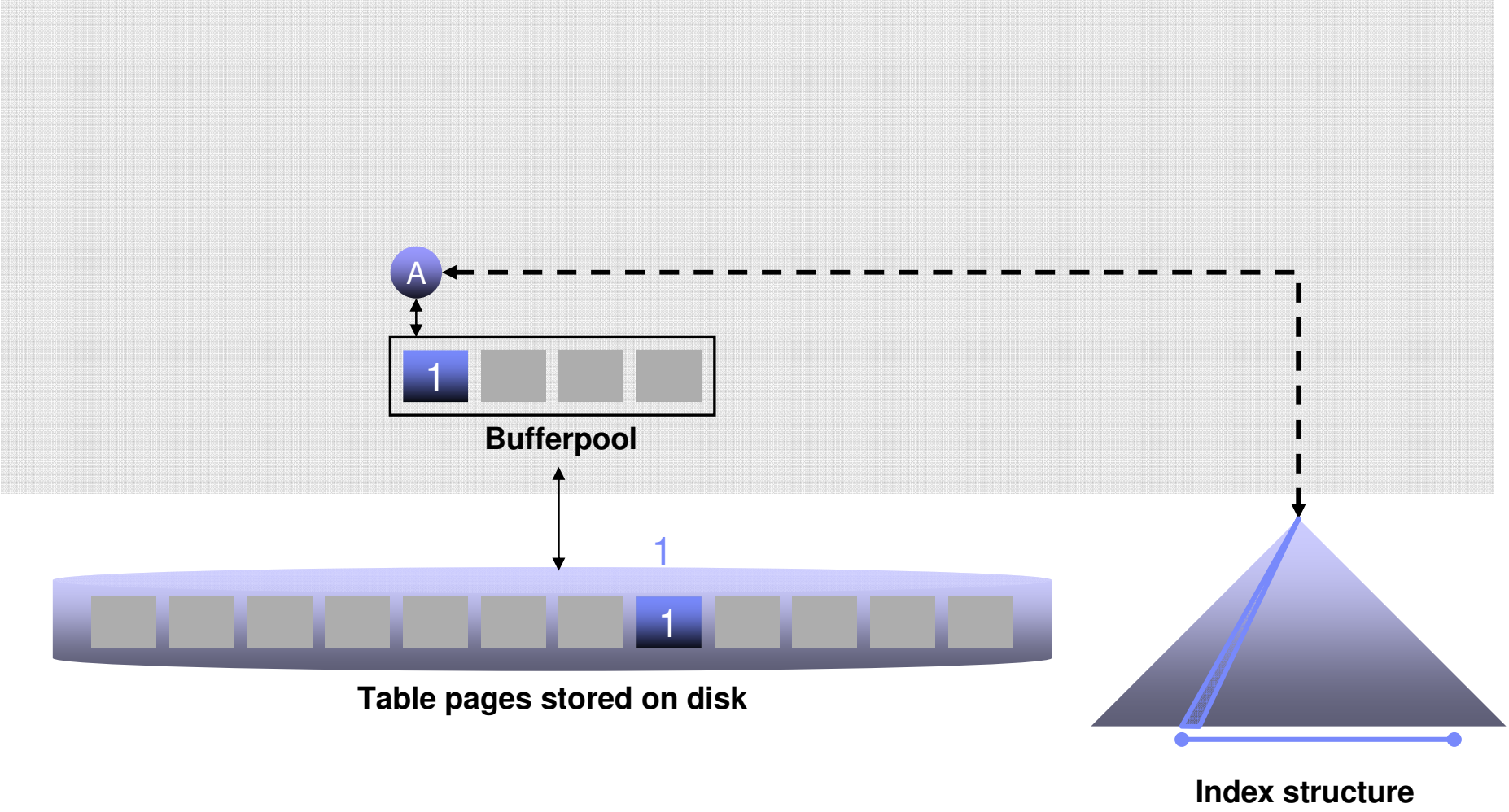

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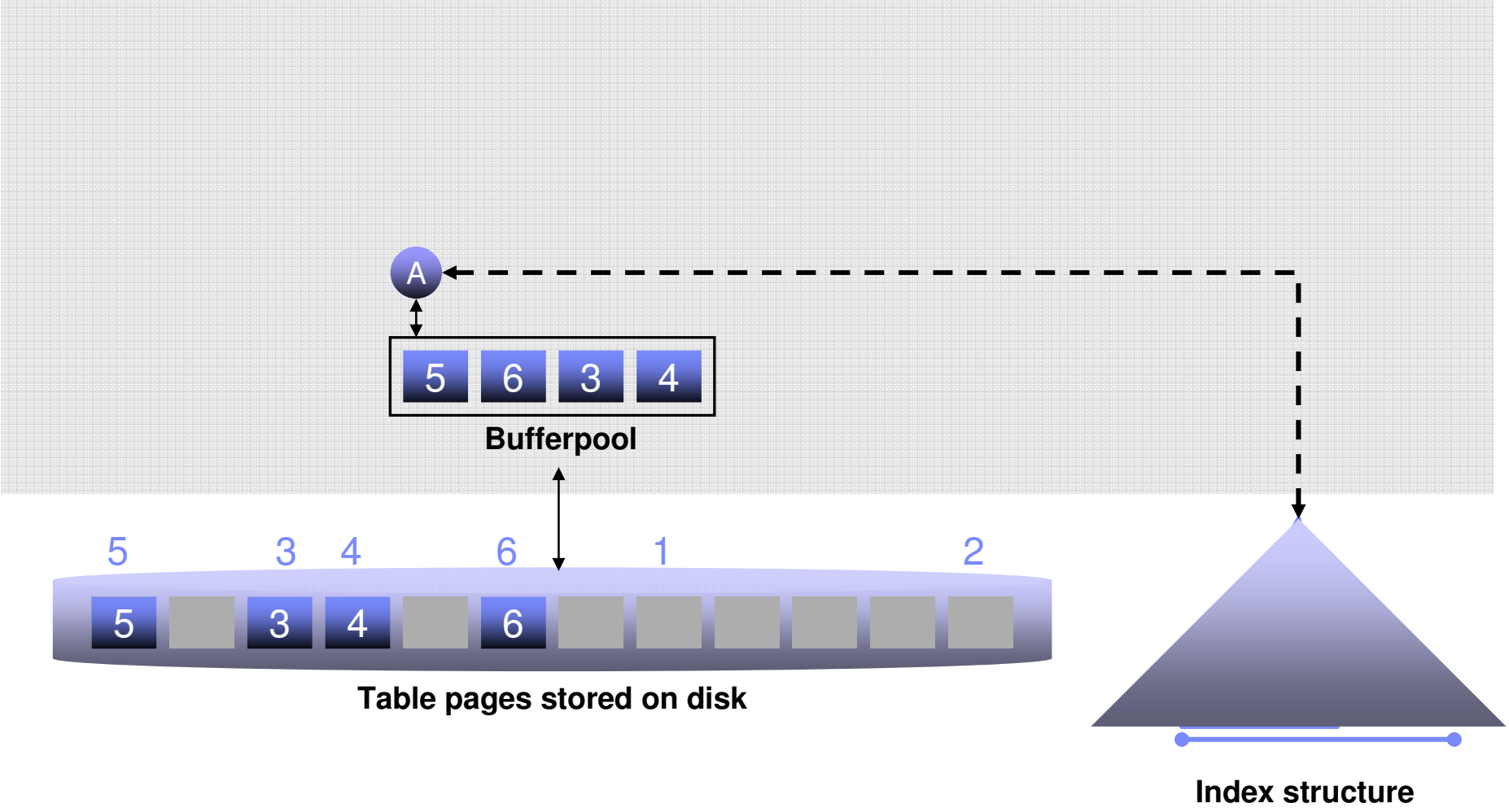

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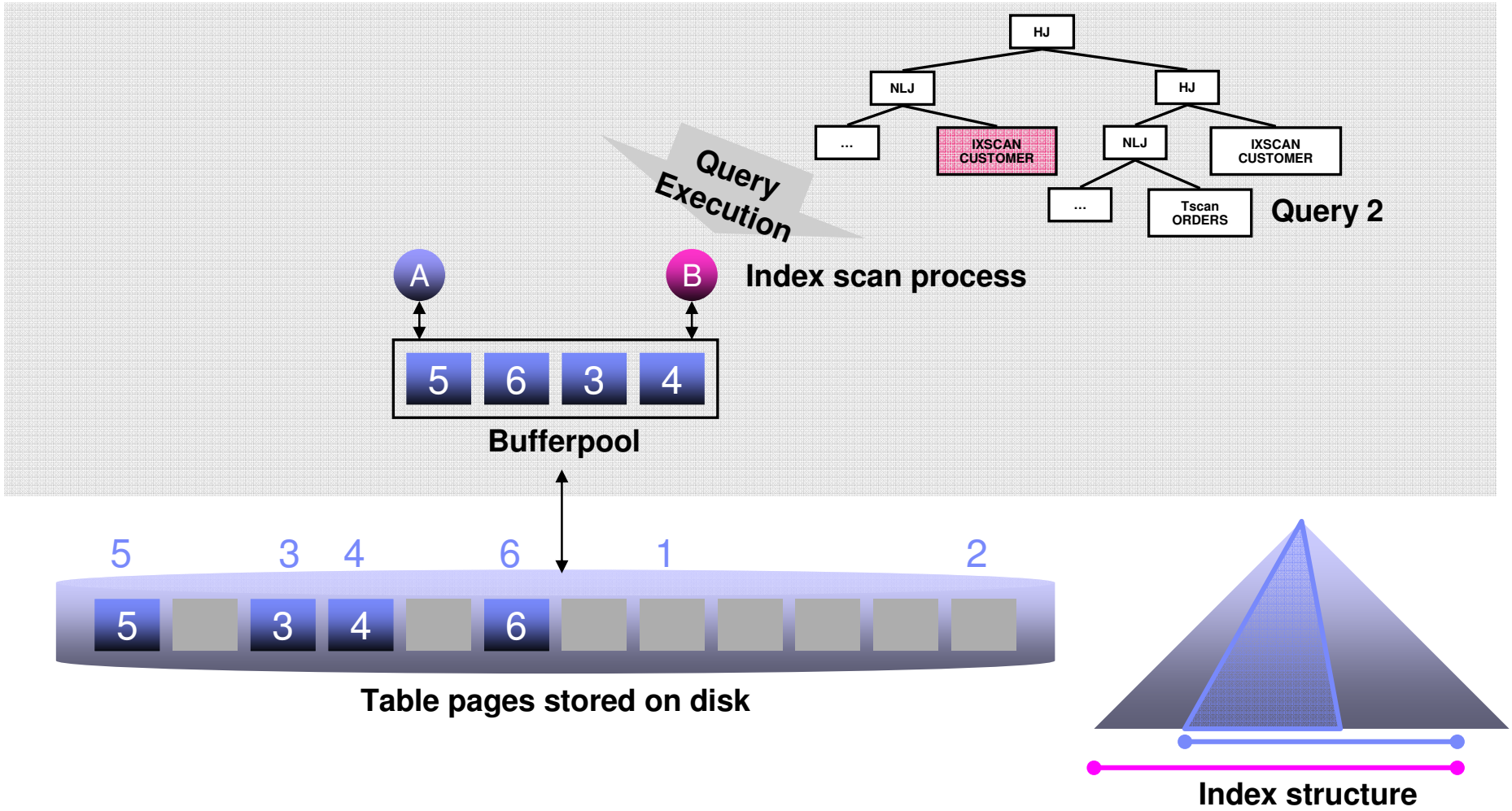

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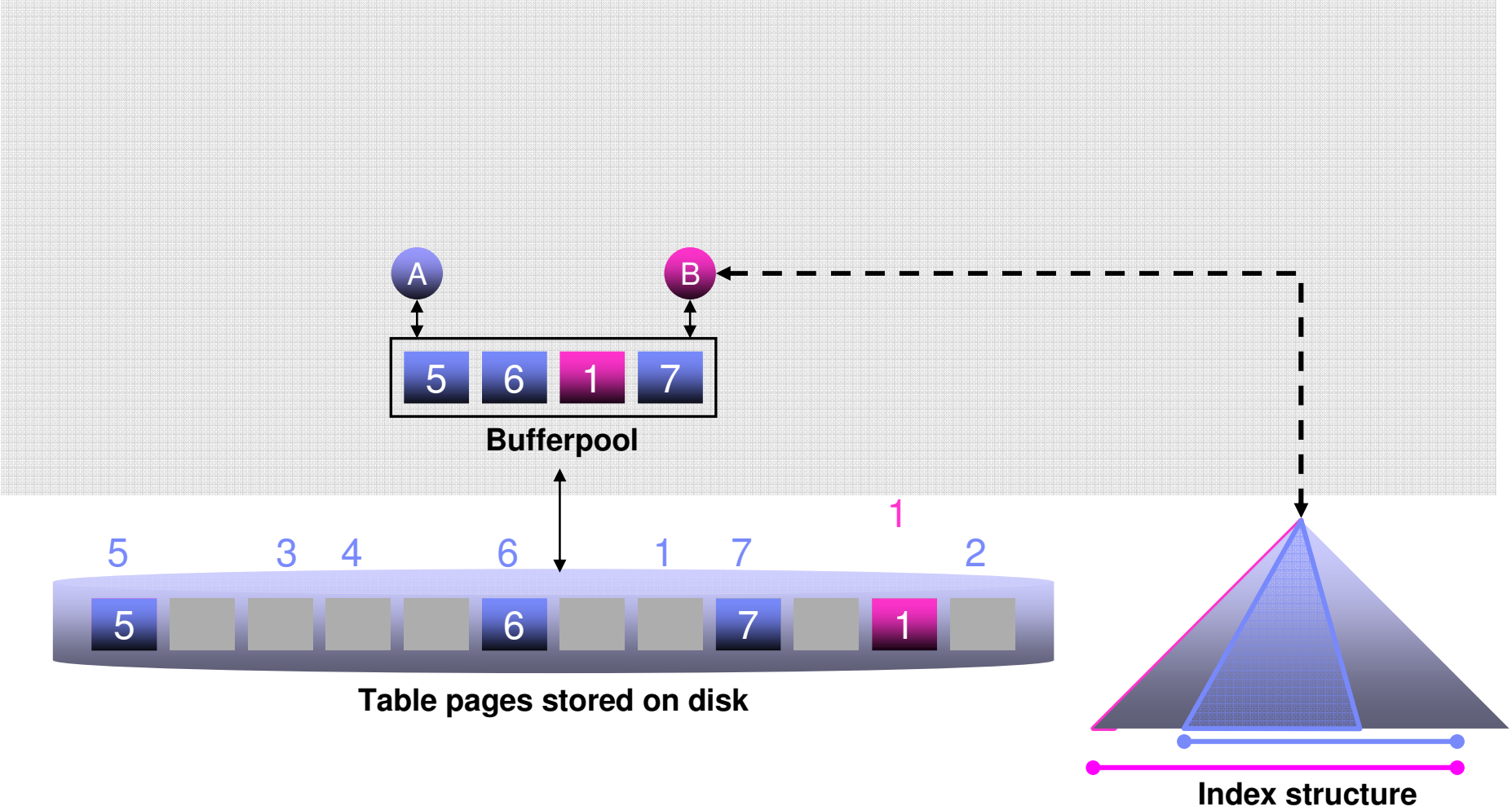

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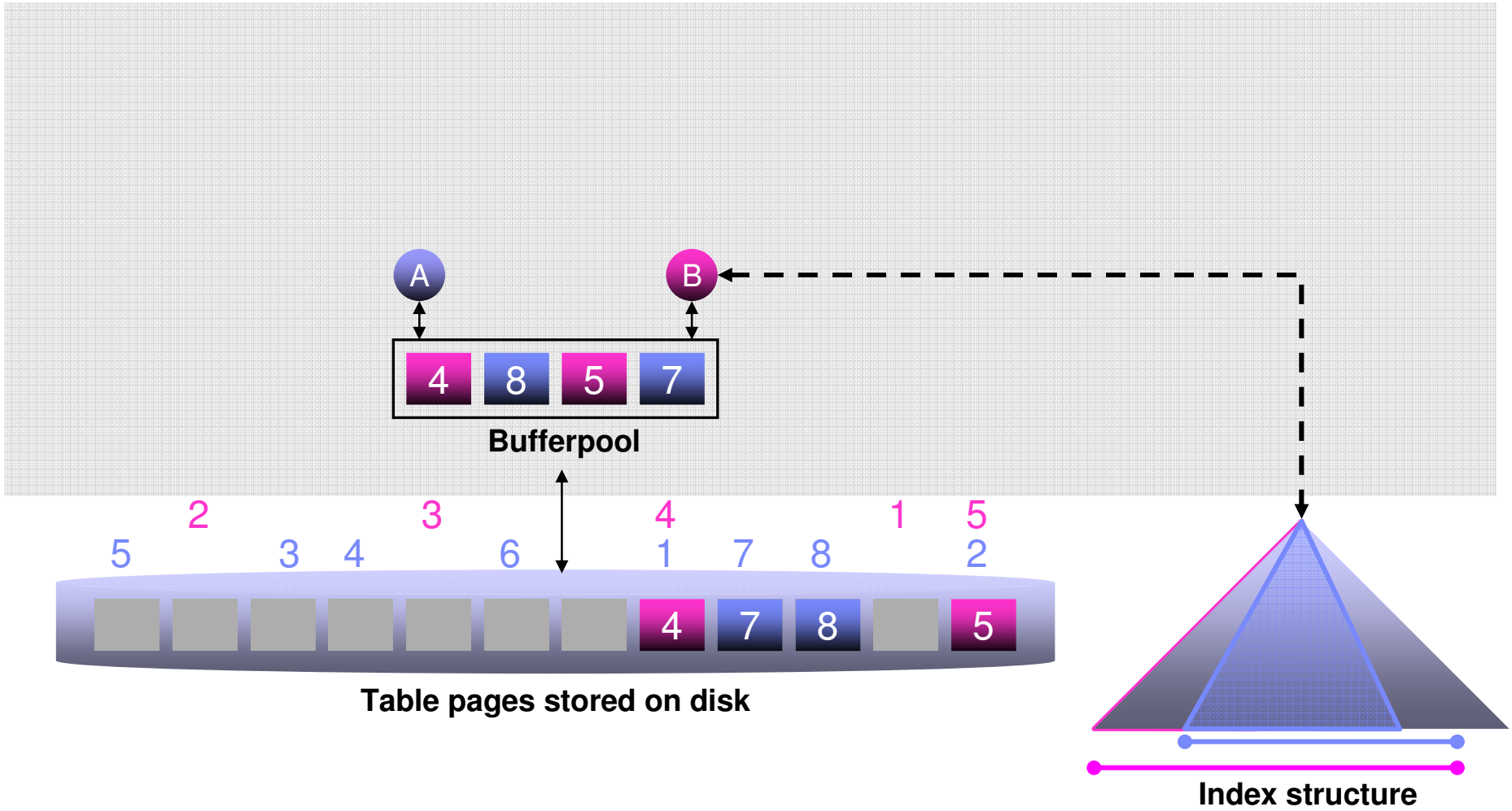

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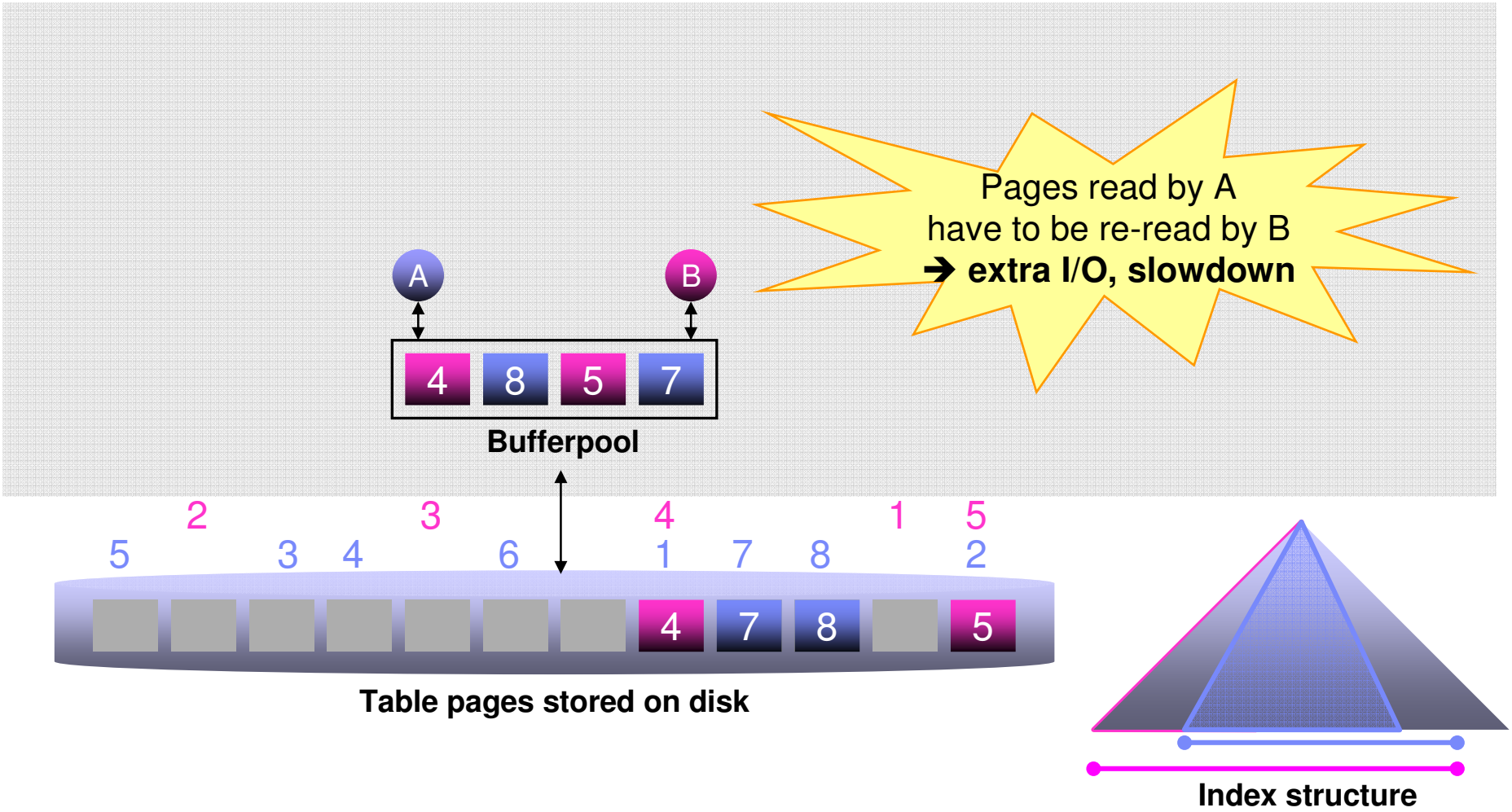

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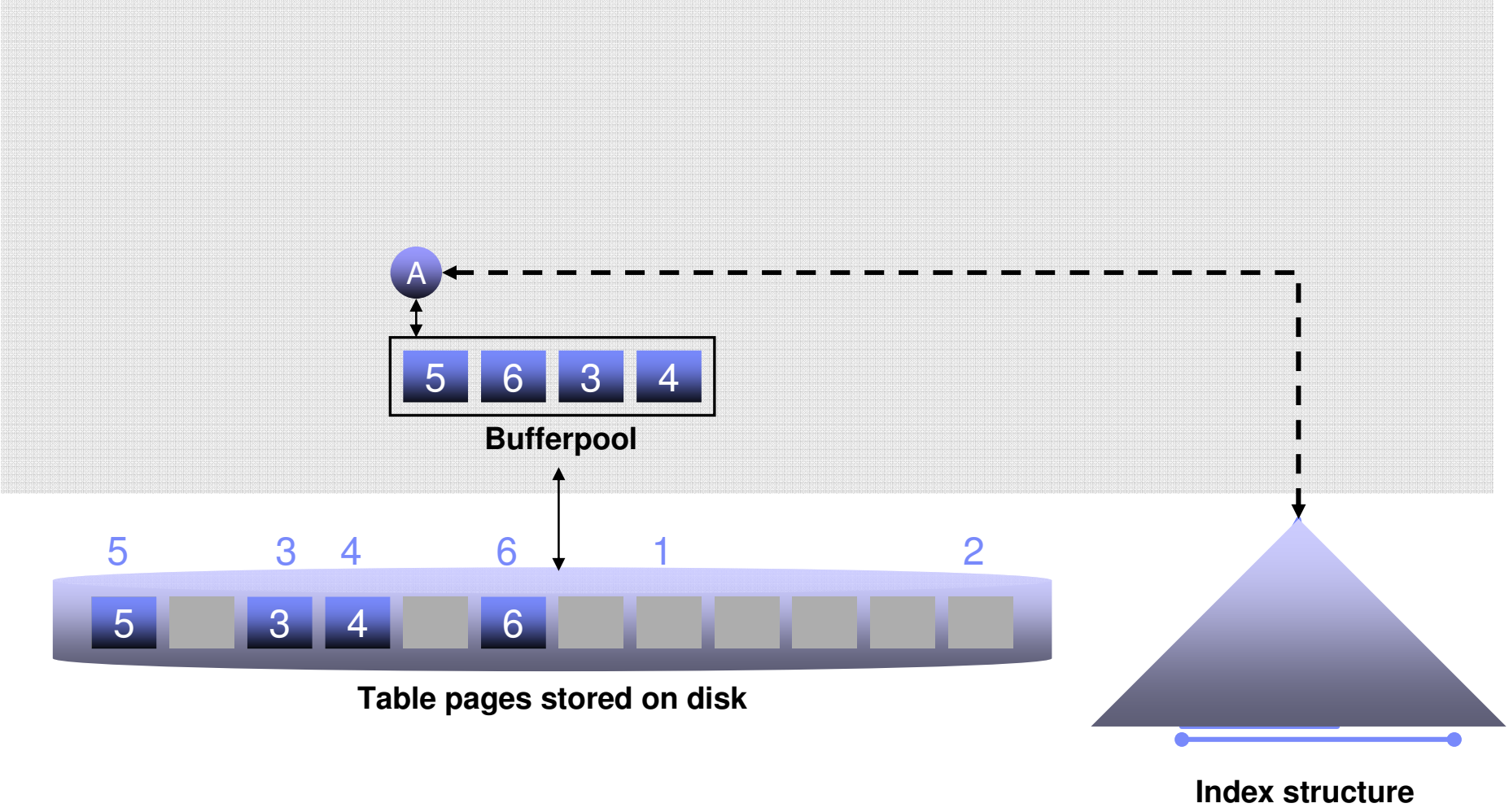

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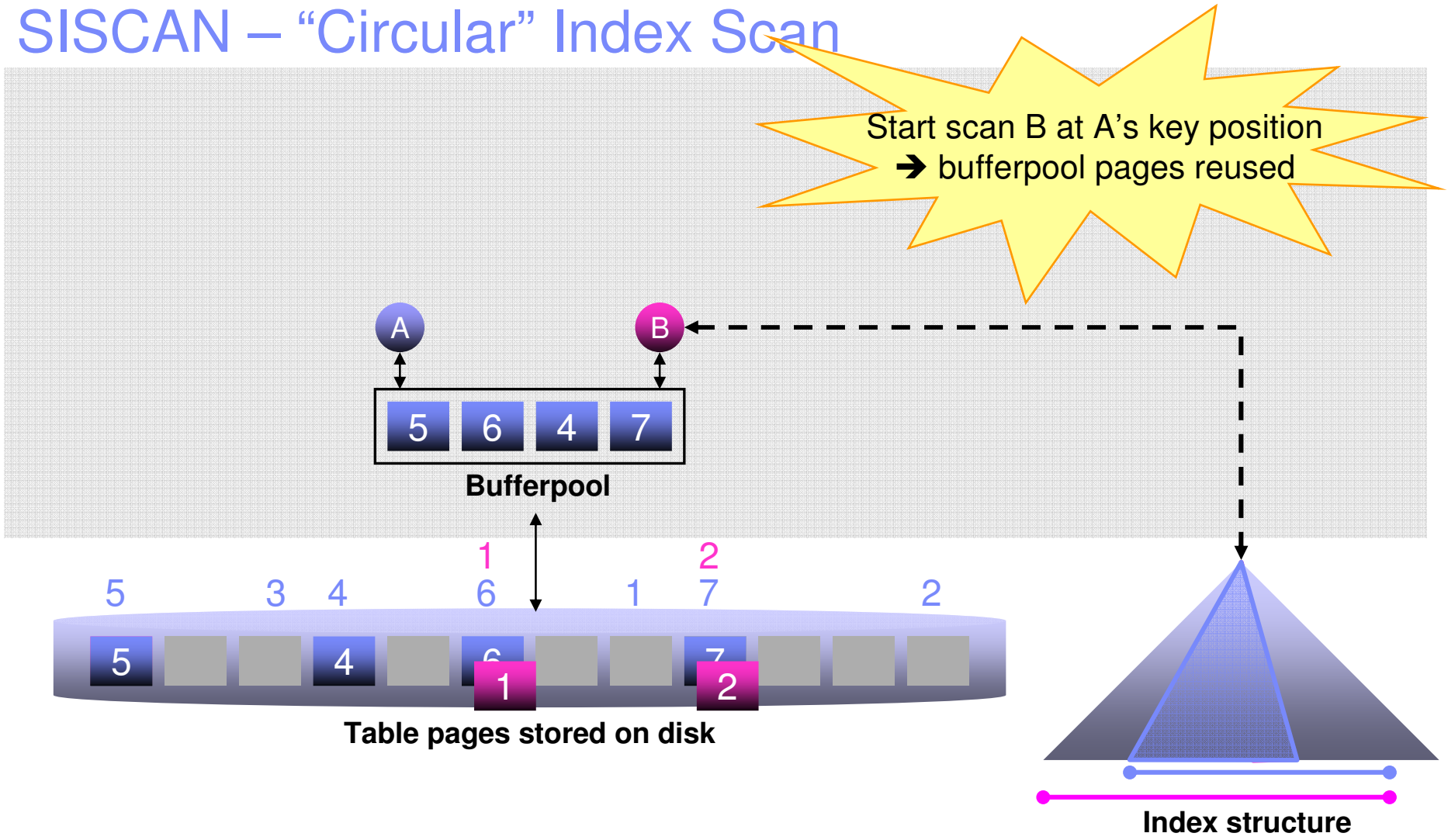

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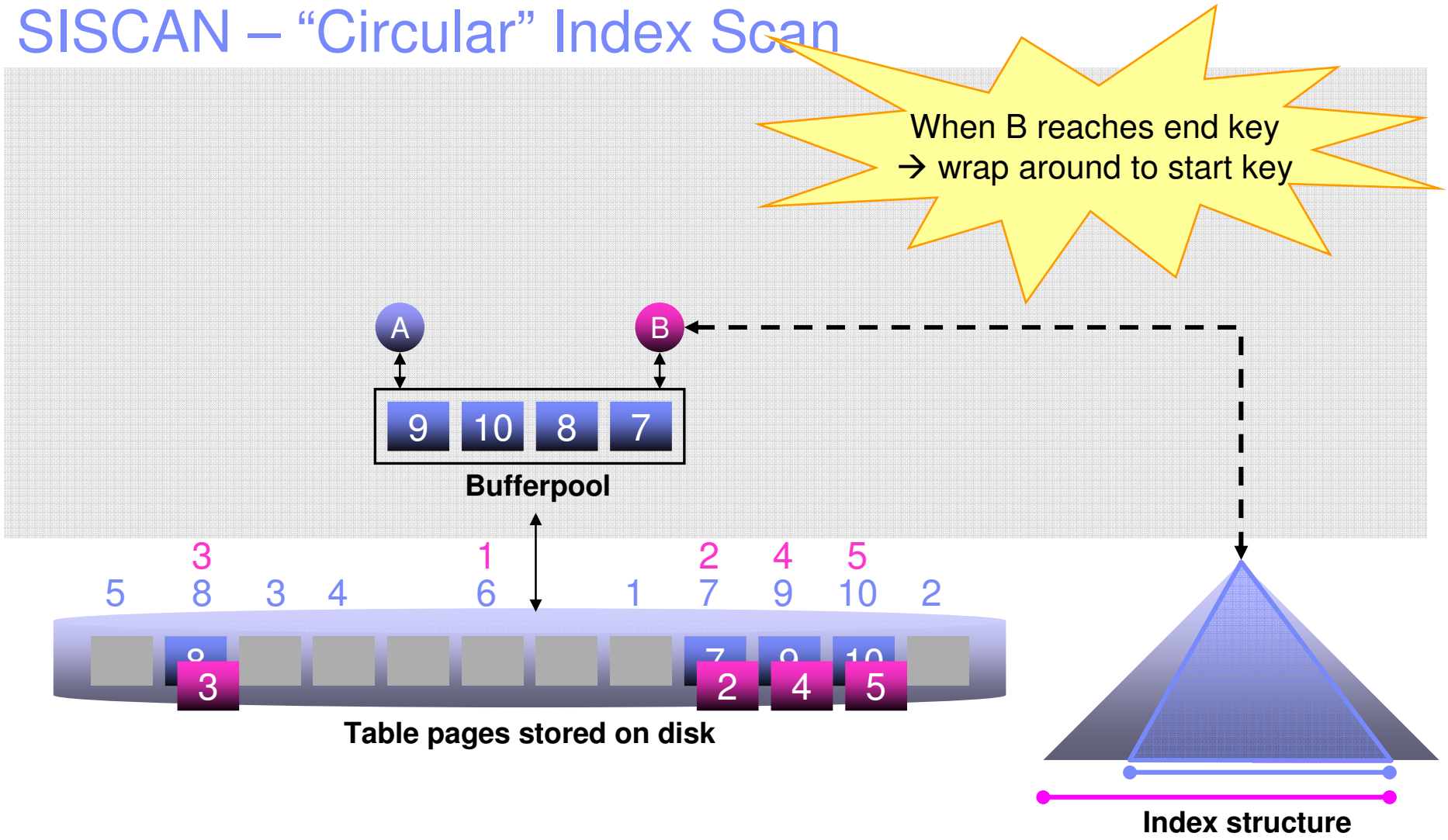

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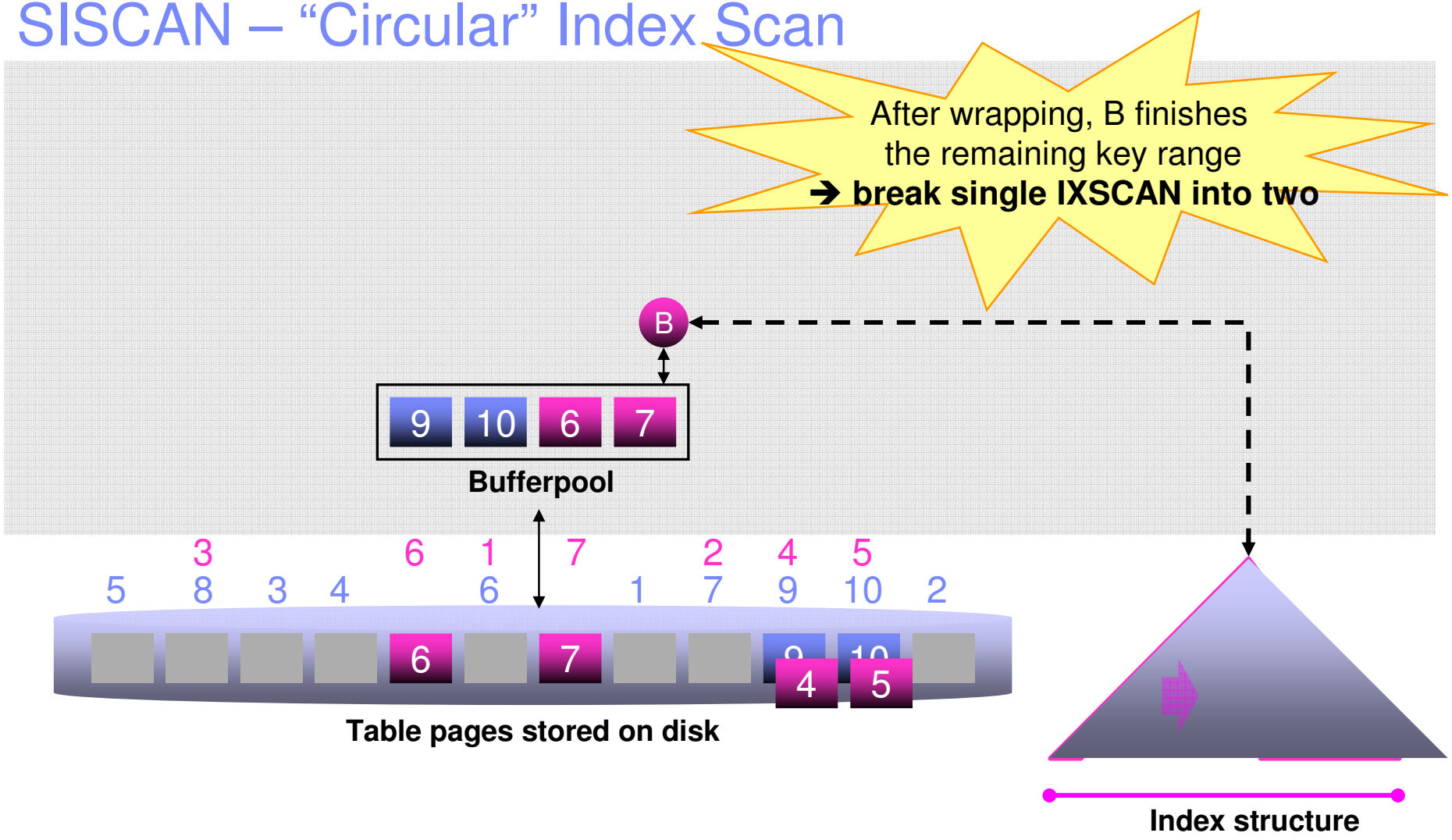
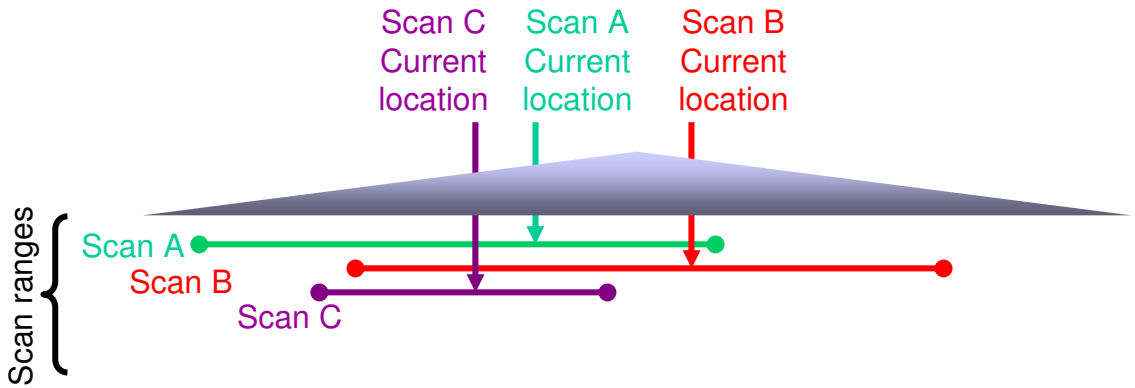


Placement: Where to Start with Multiple Active SISCANs?



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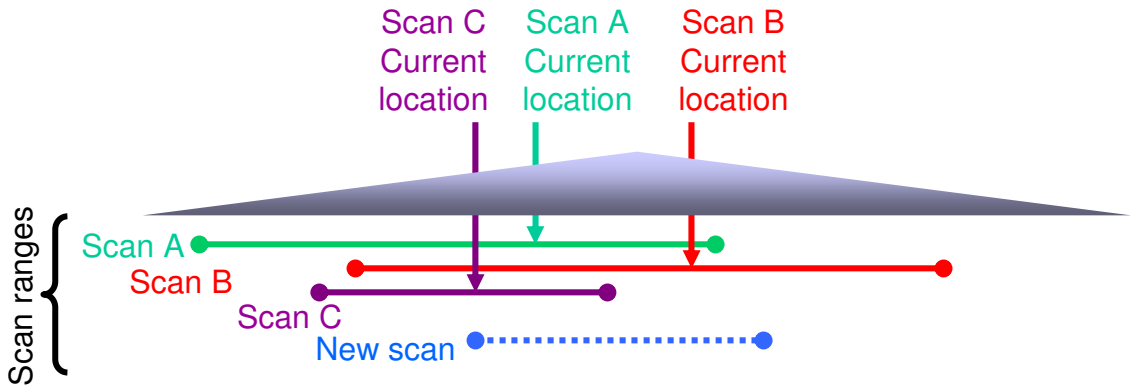
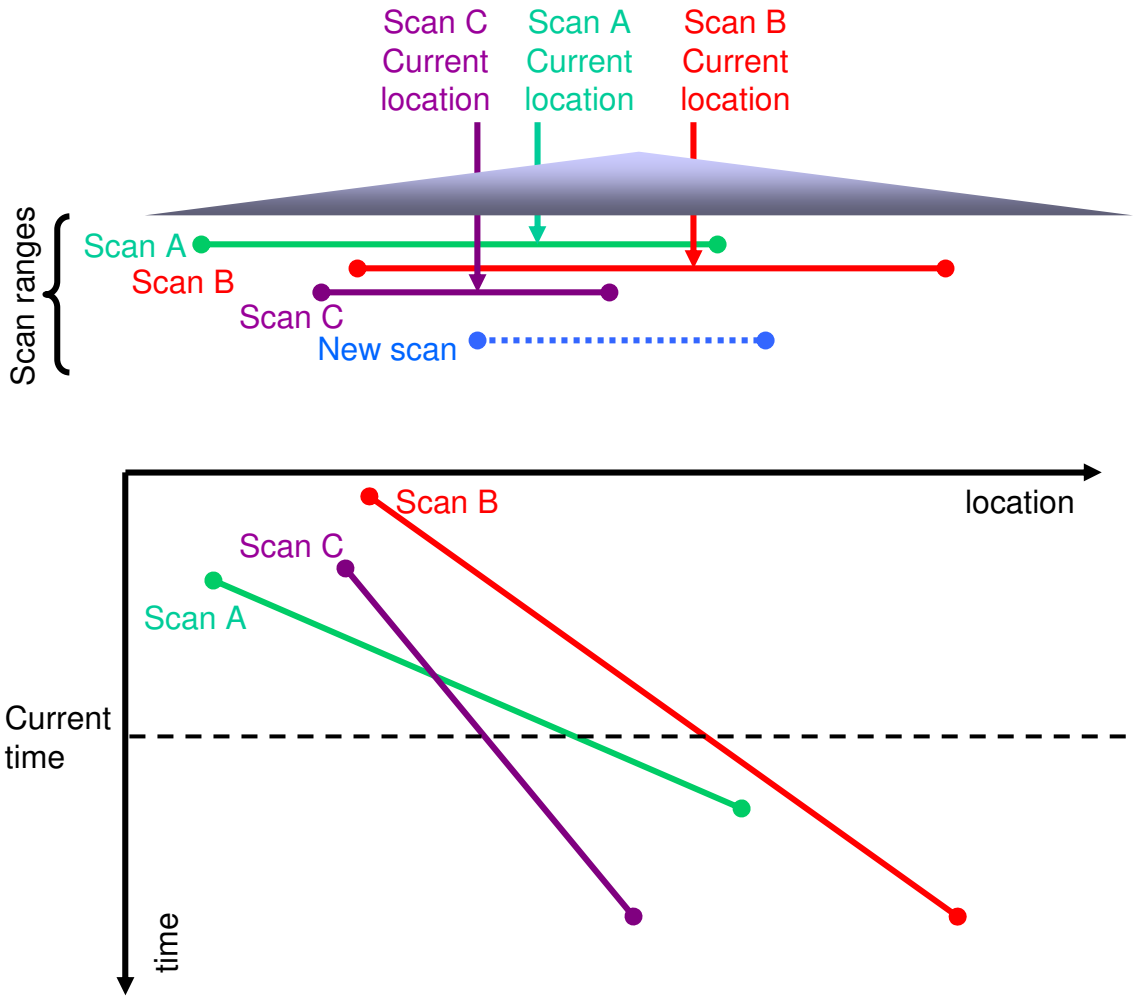


Where to start new scan?
→ need more information

Placement: Where to Start with Multiple Active SISCANs?



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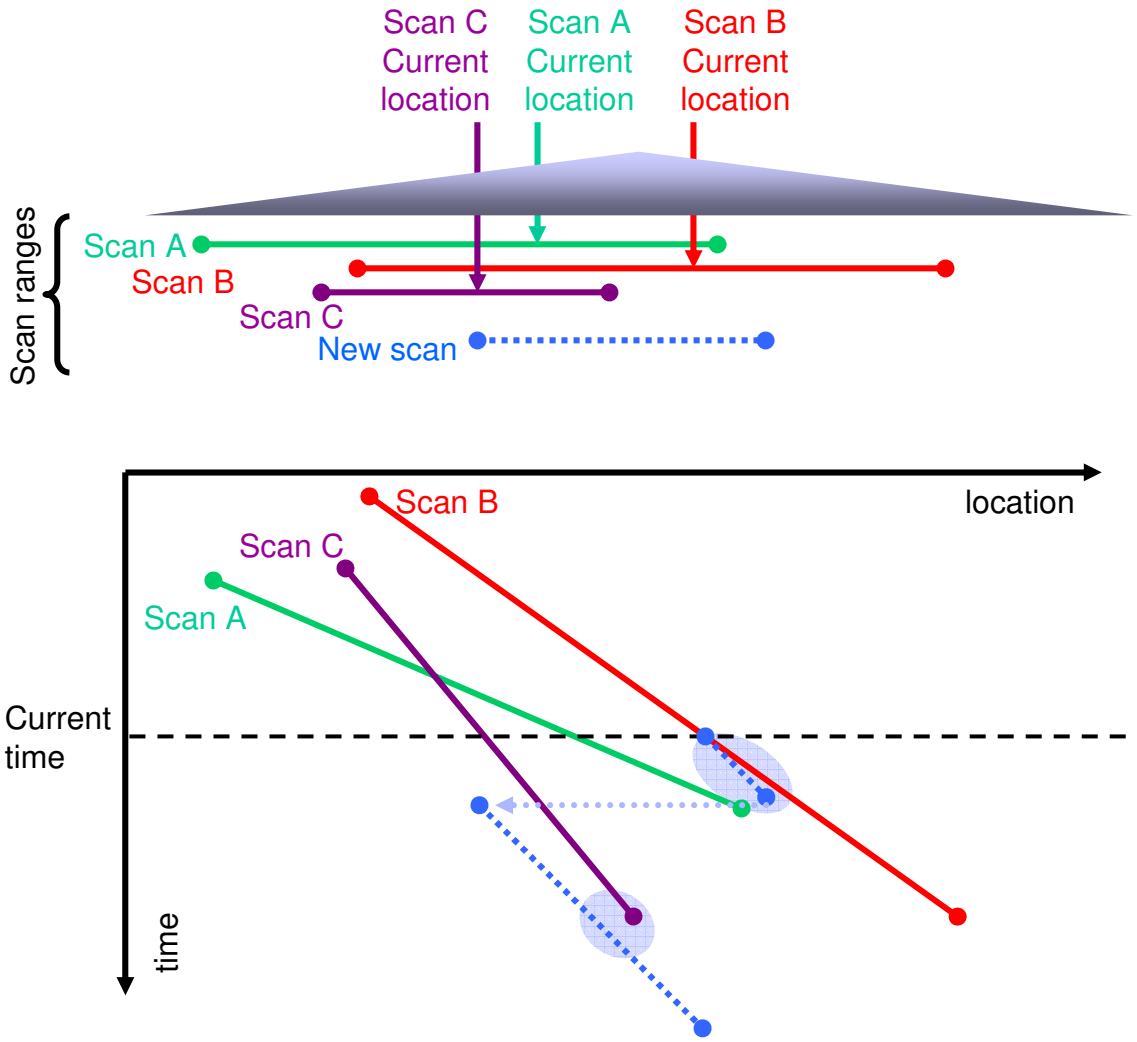
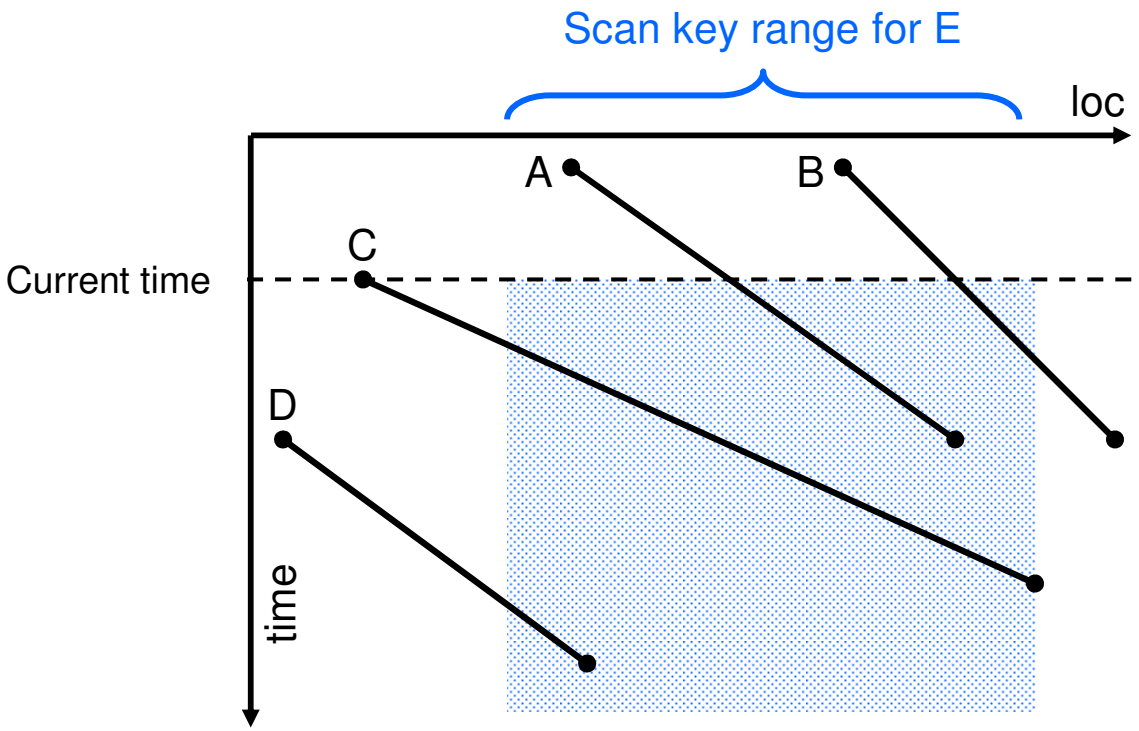


Estimating Sharing Potential



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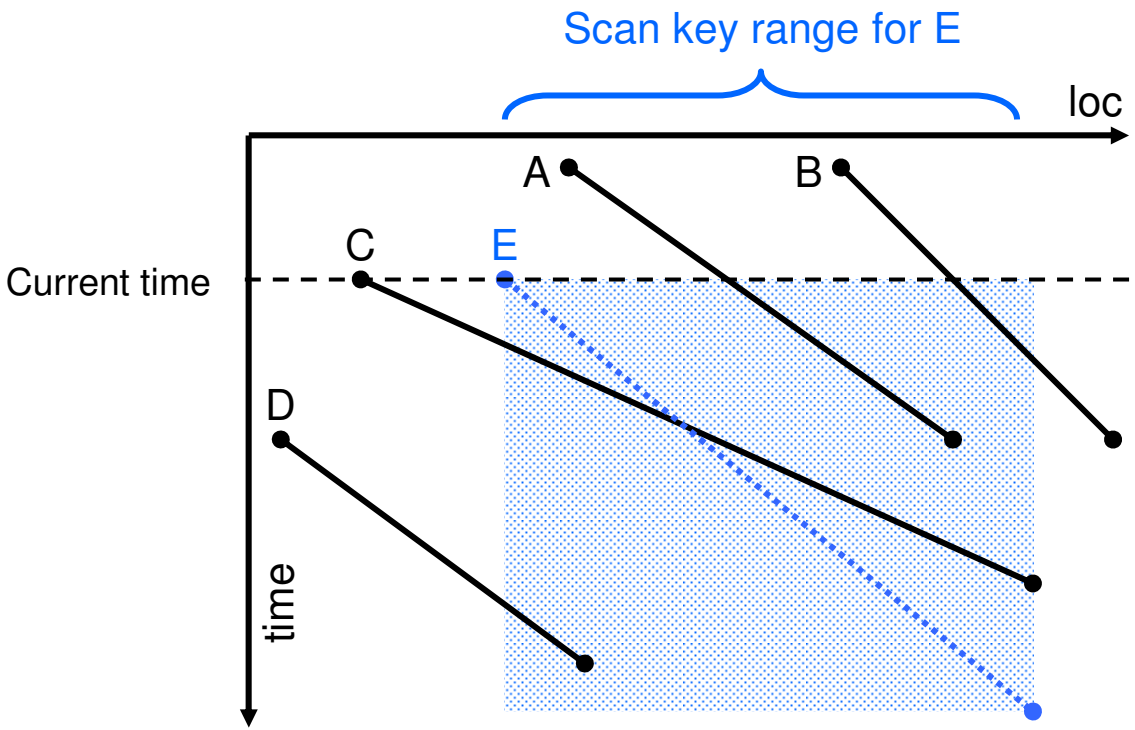

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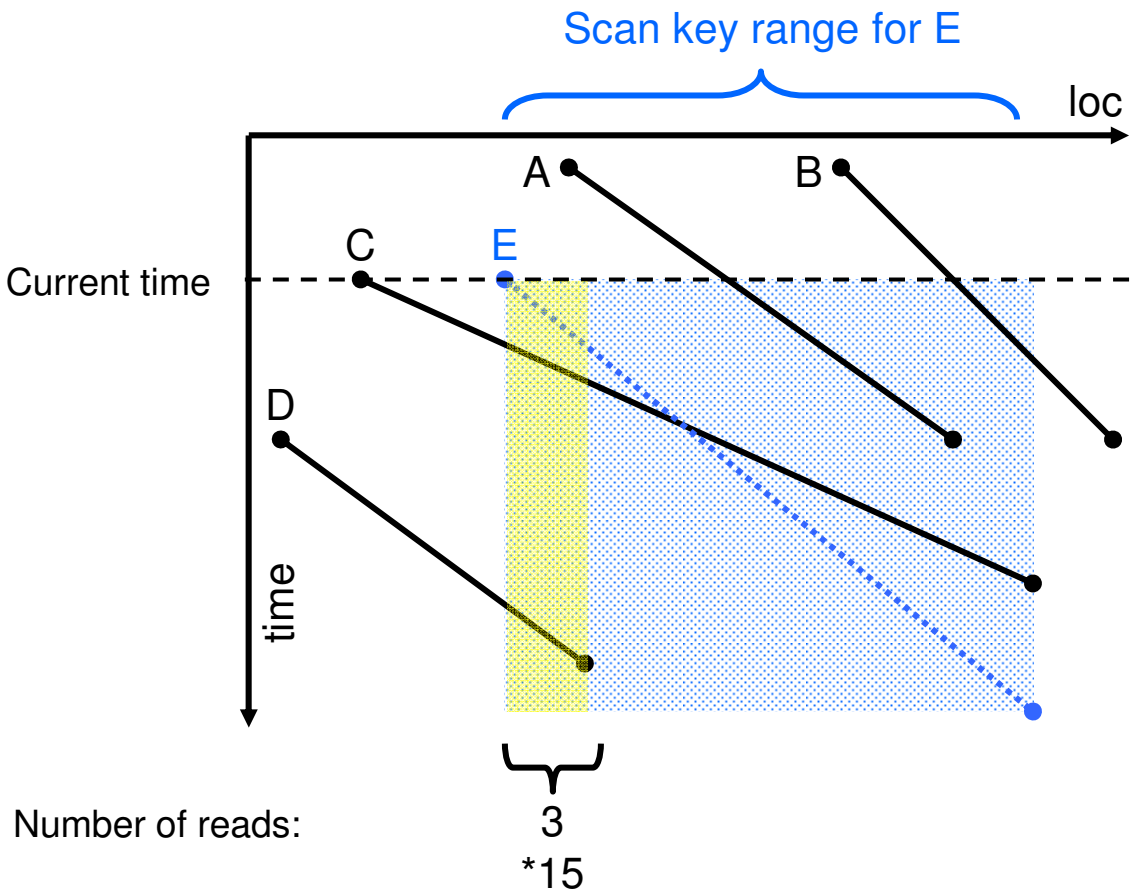

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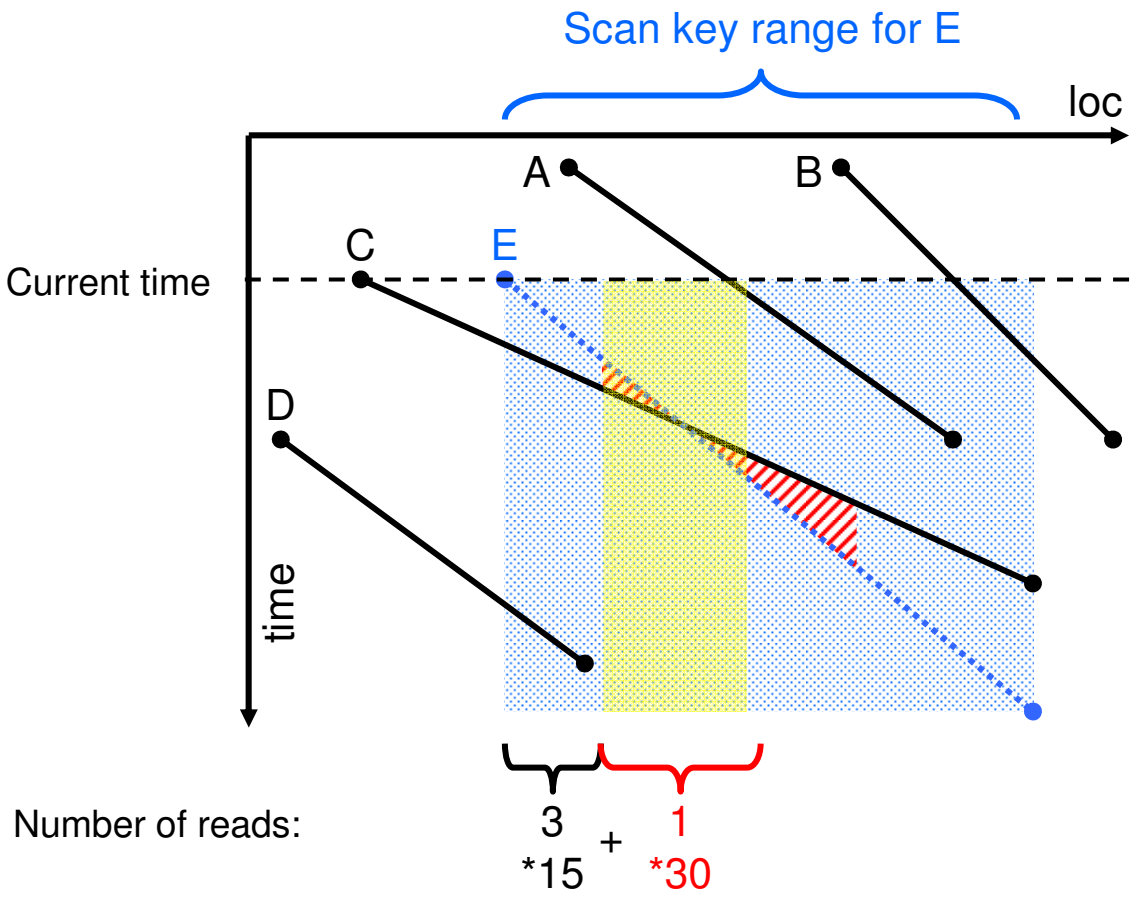

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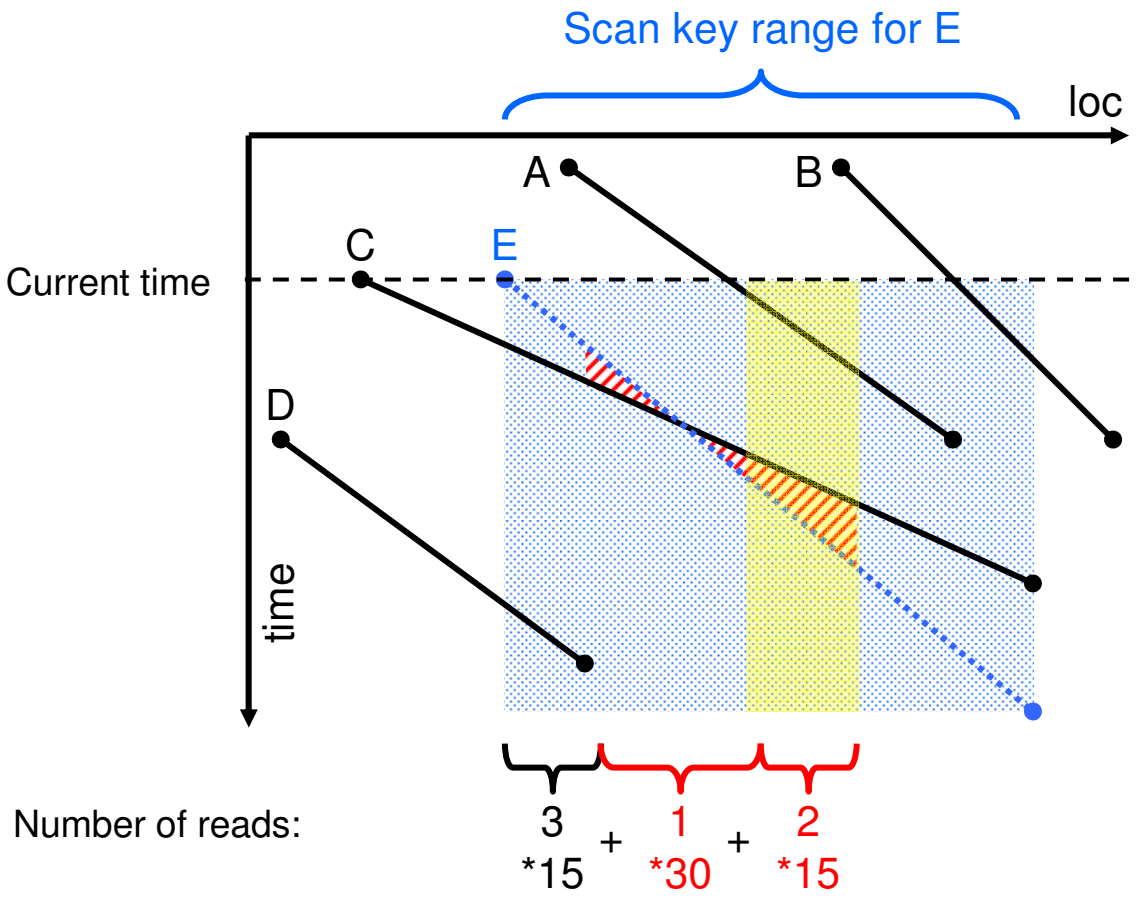

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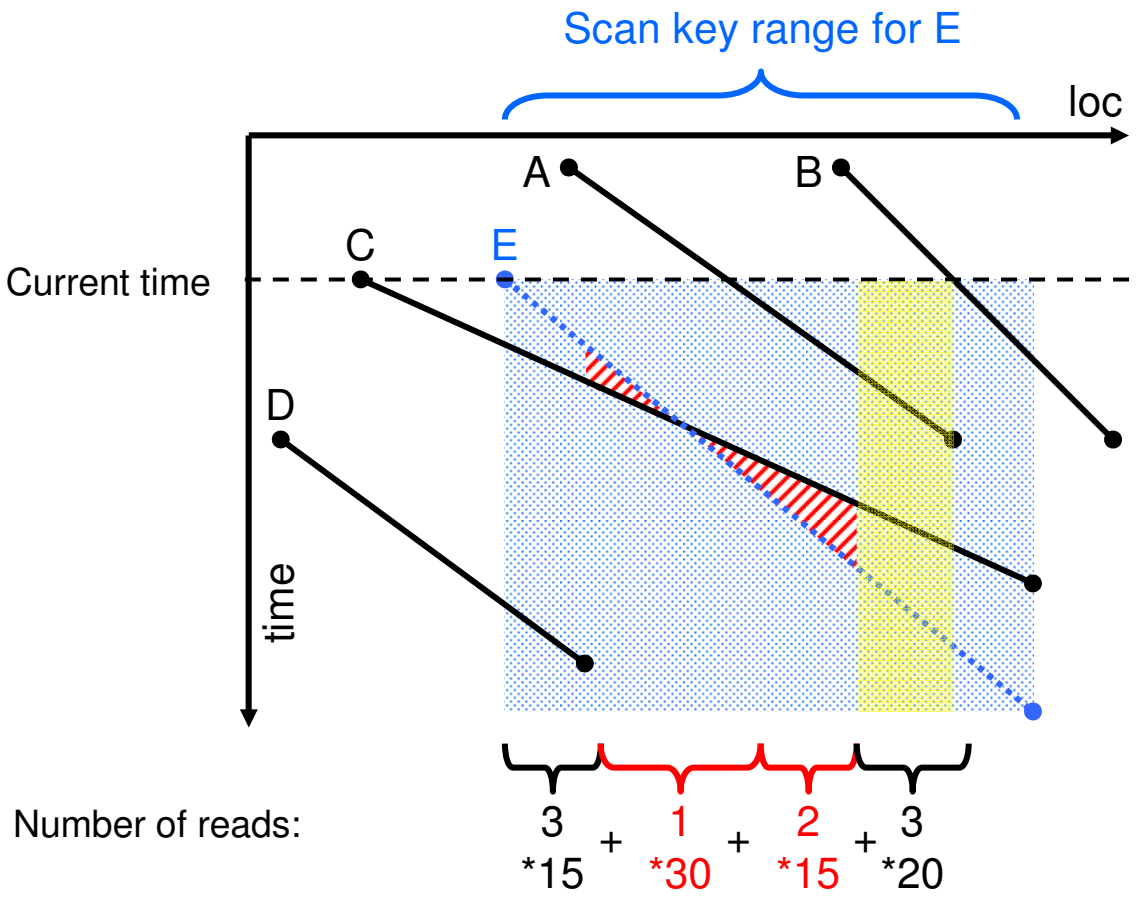

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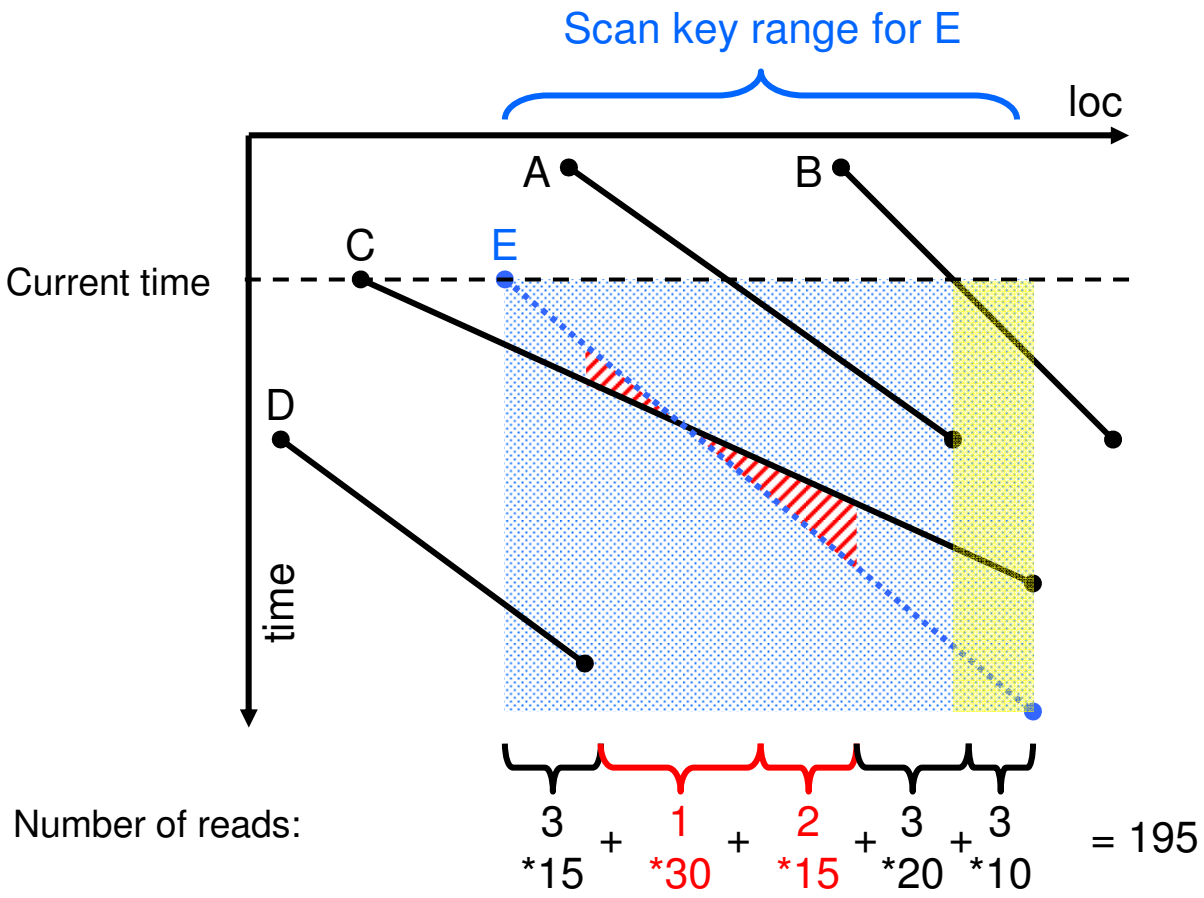

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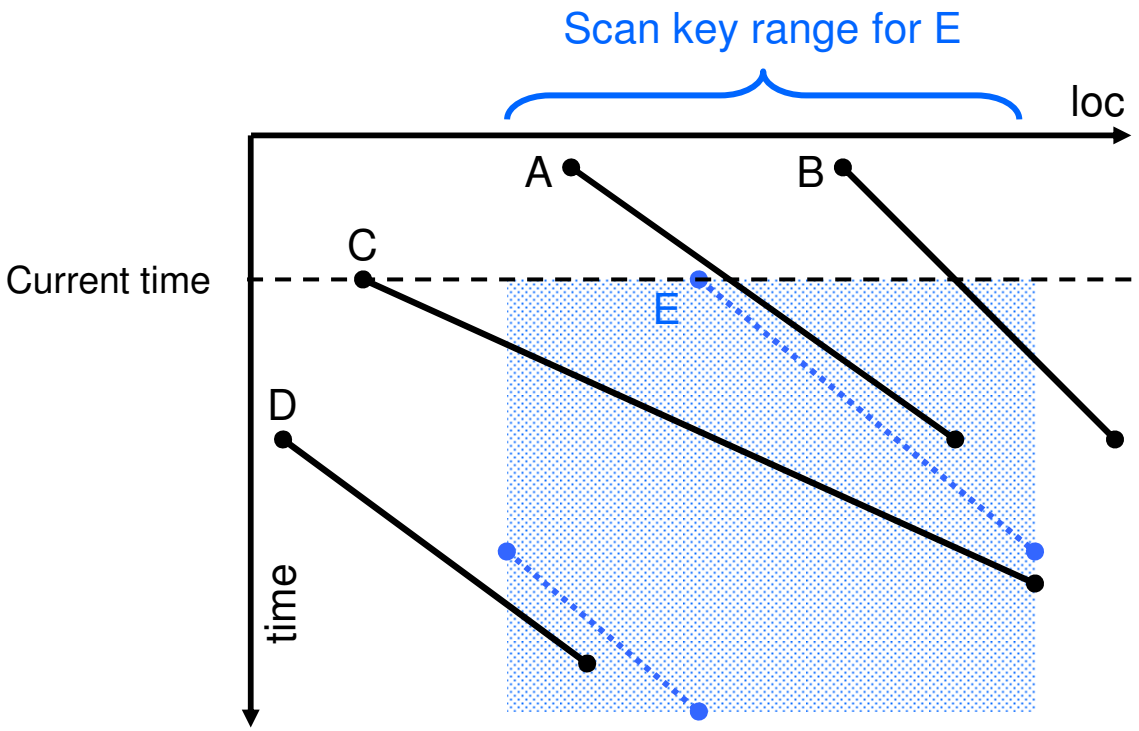

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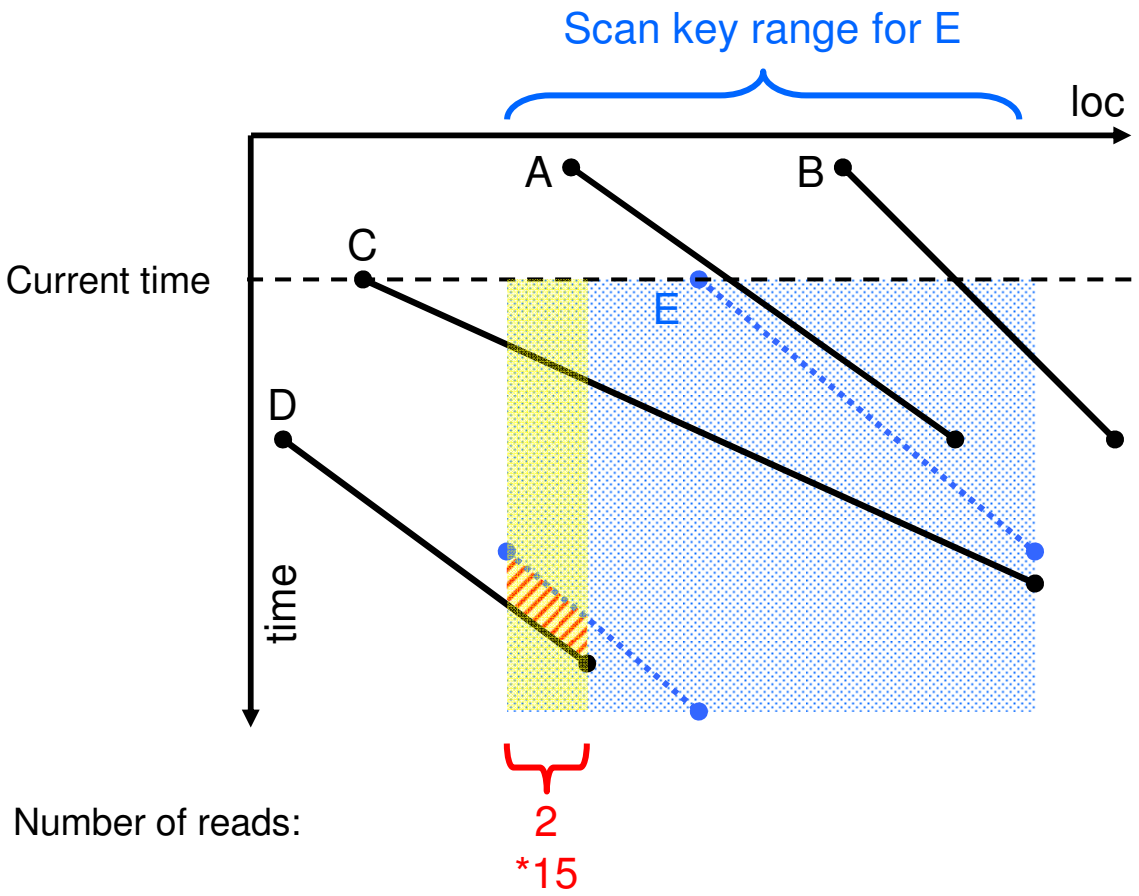

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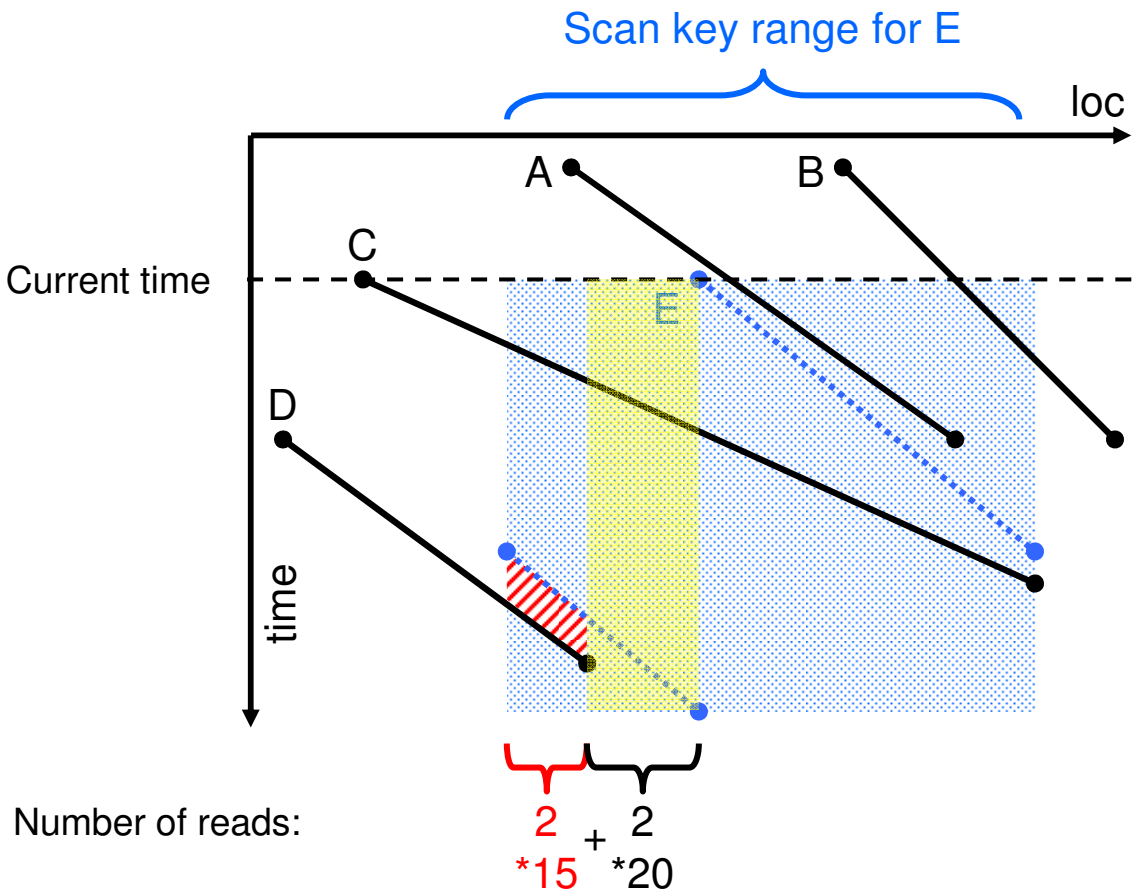

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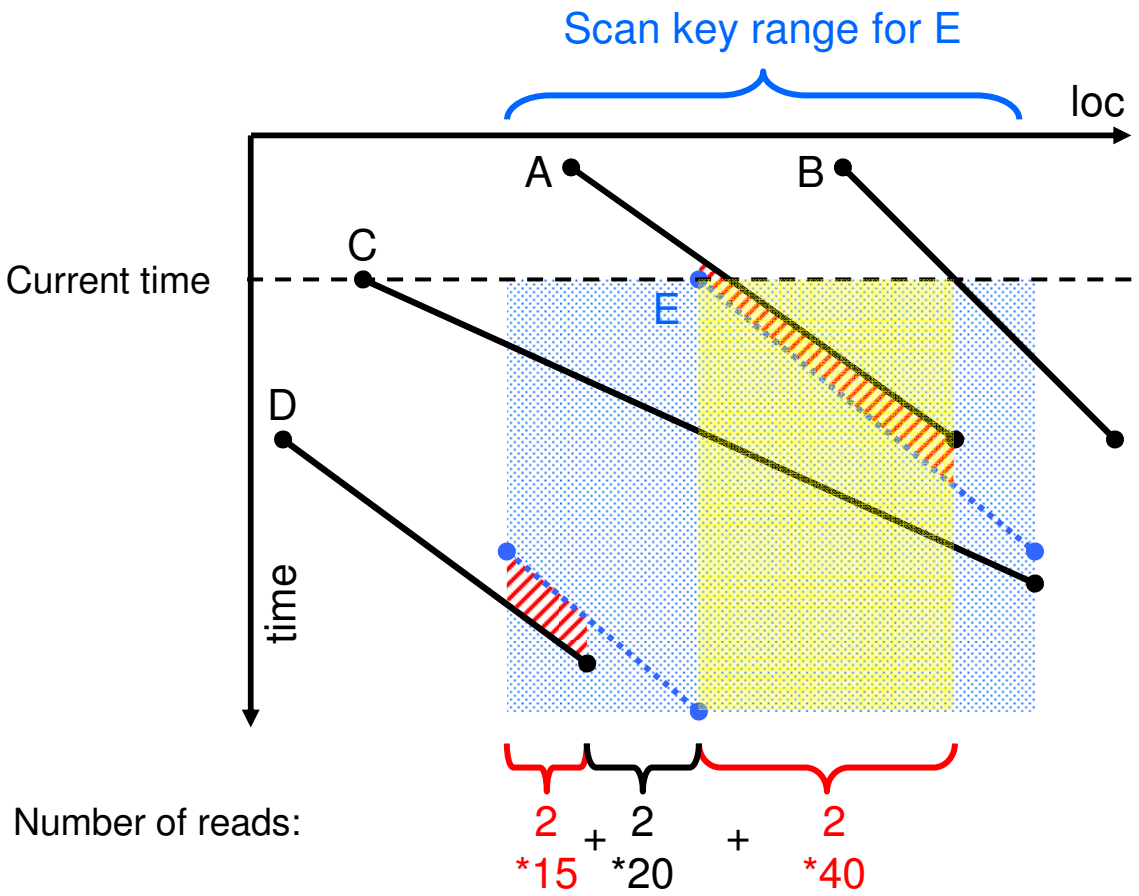

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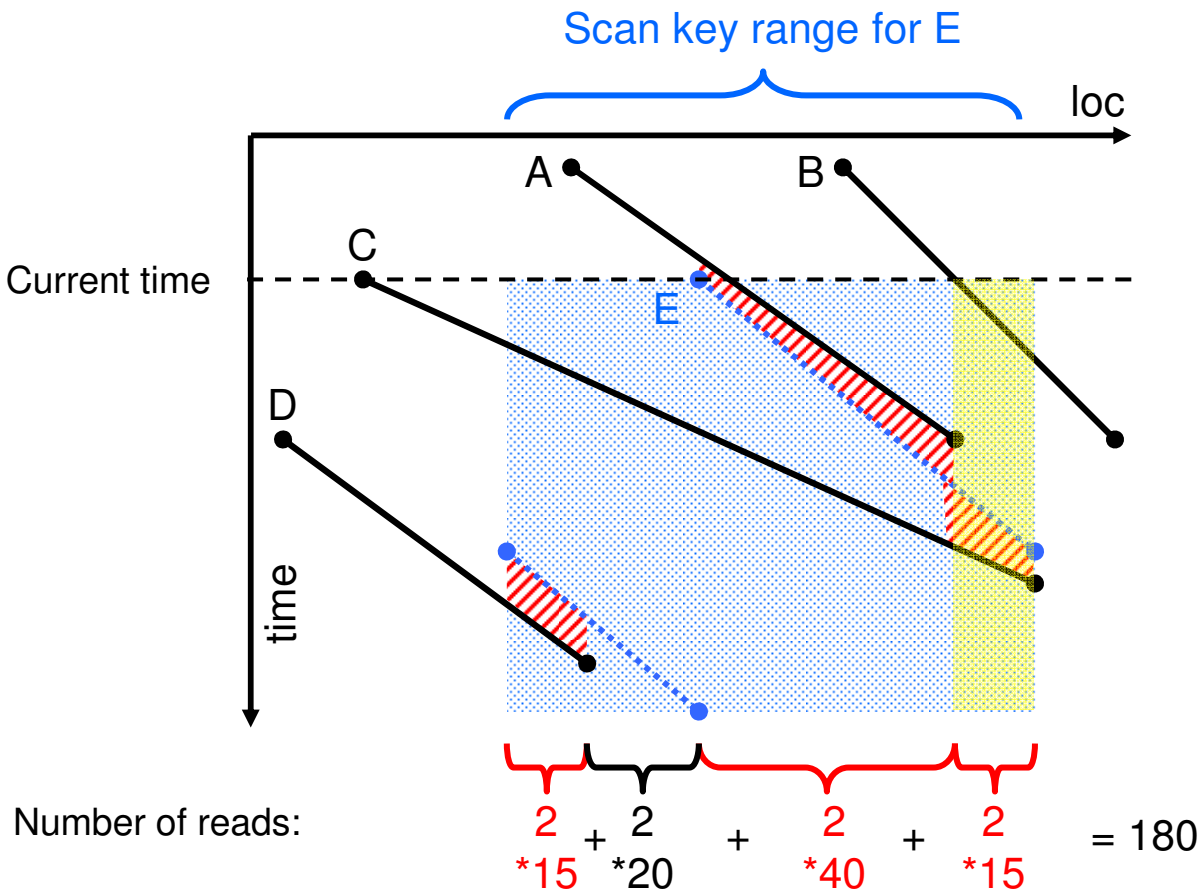

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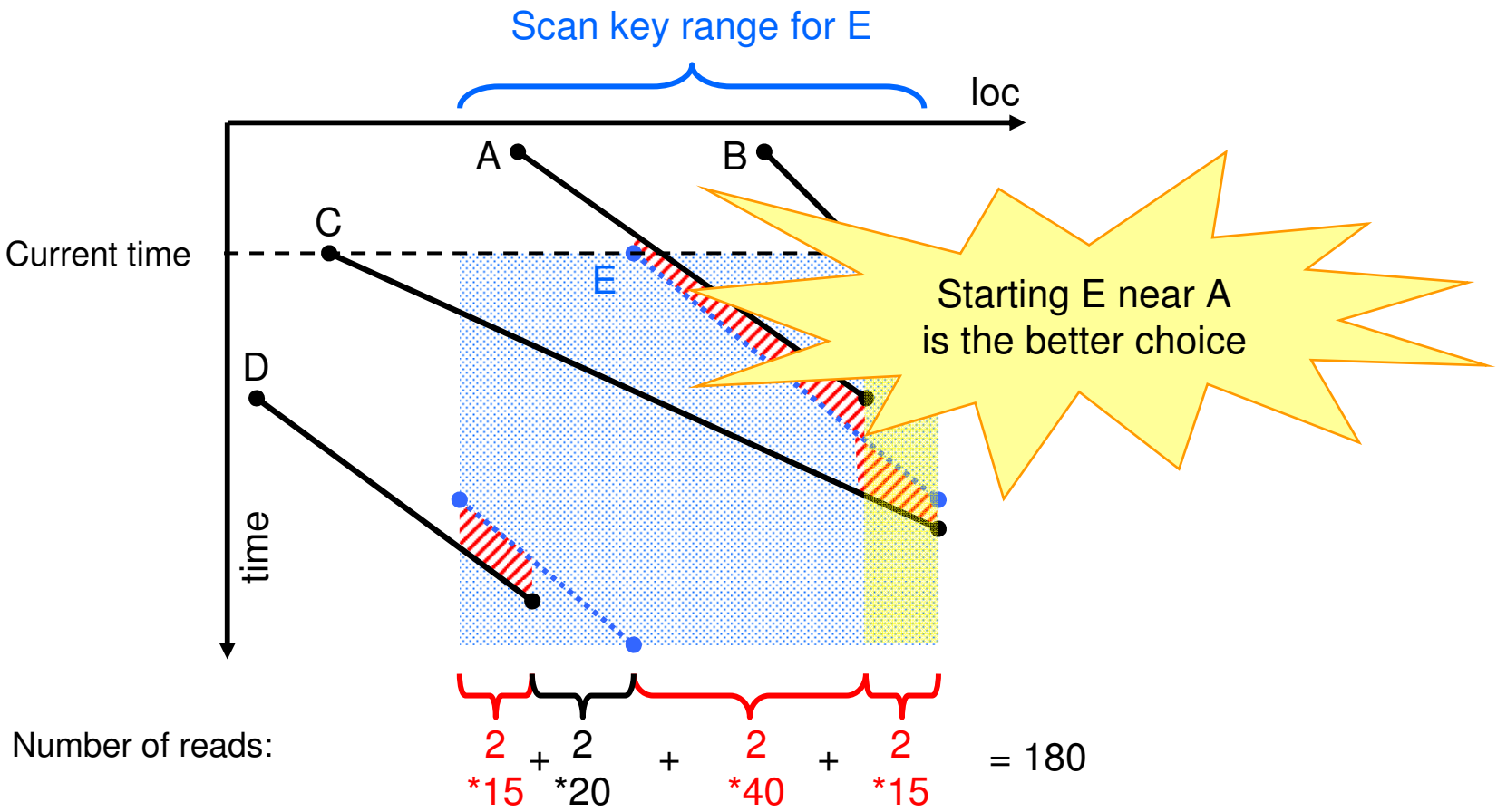
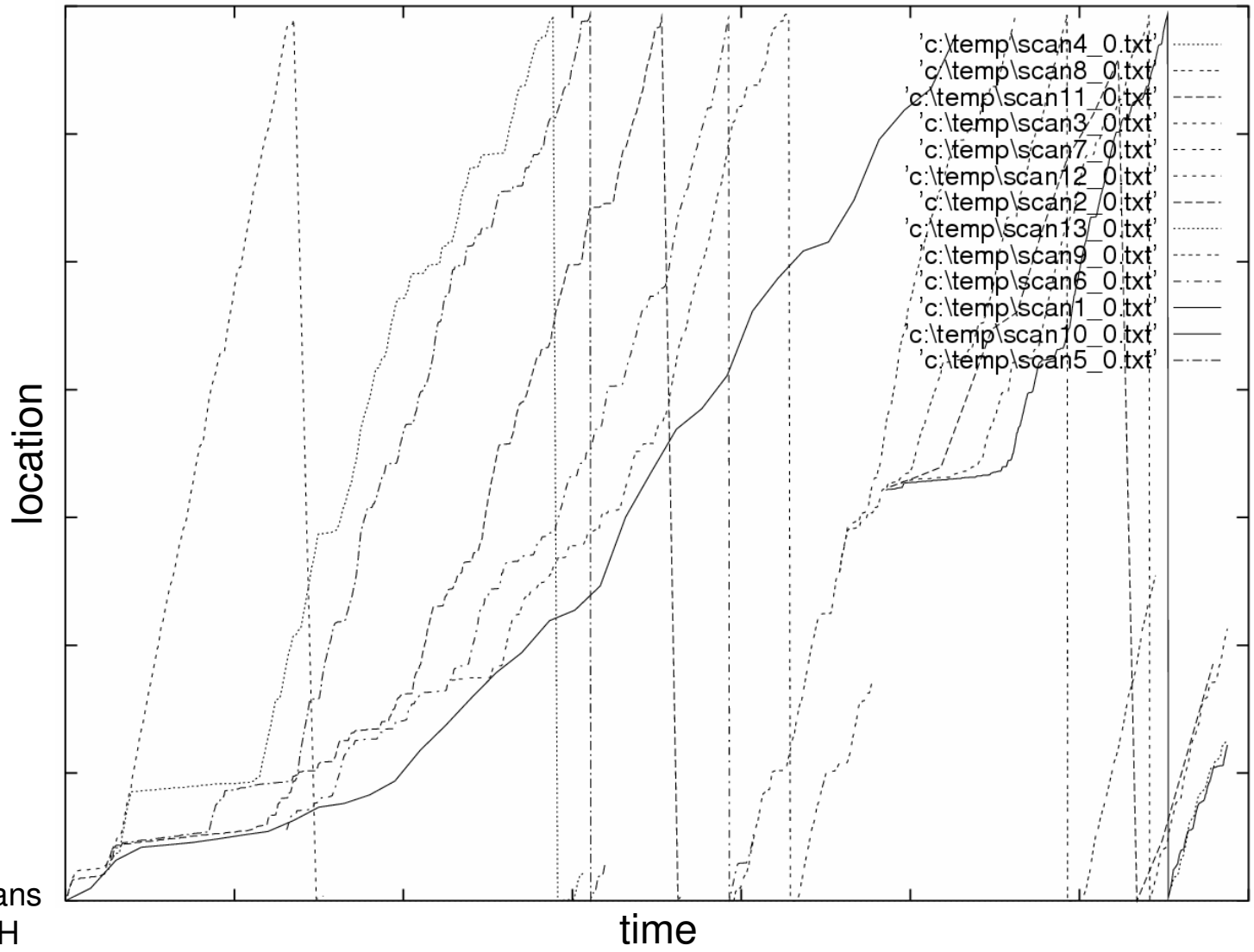
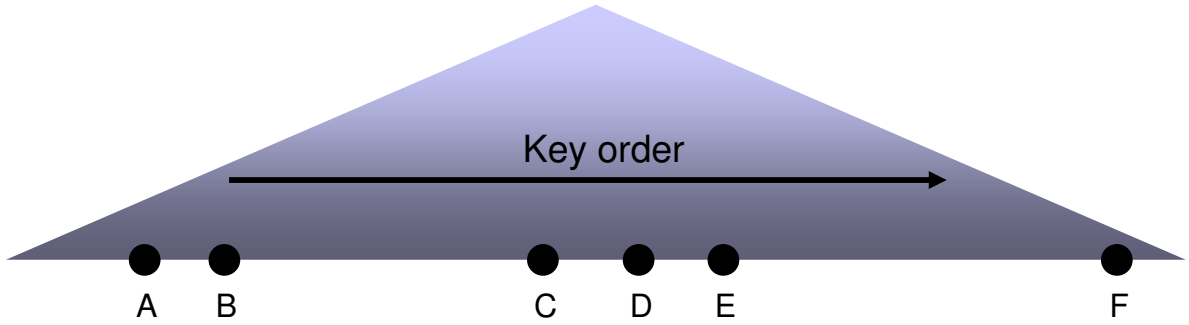


Problem solved? No, scans “drift” apart!



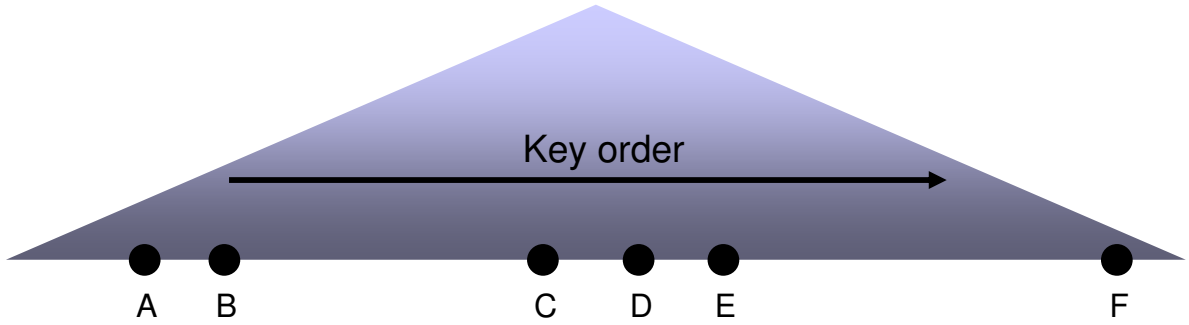
LINEITEM scans during TPC-H

Problem with Drift



Initial reader of pages in key order

Problem with Drift



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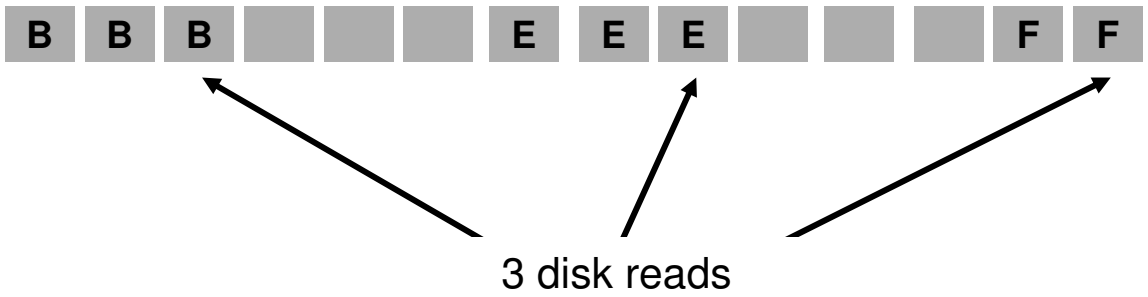

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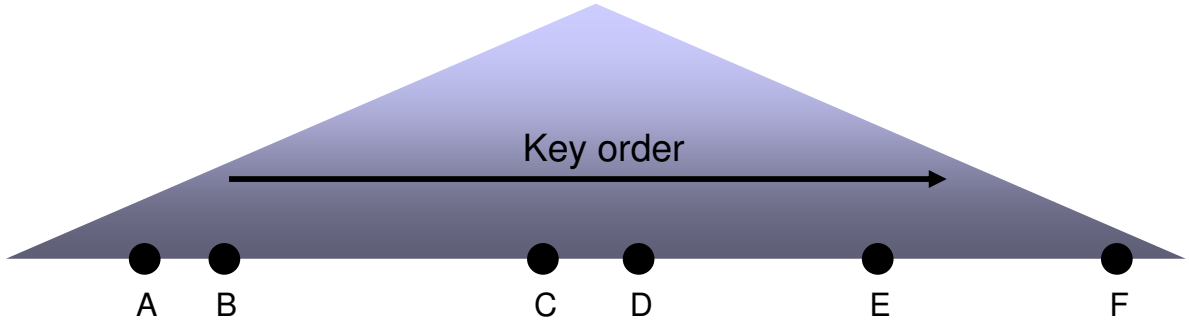
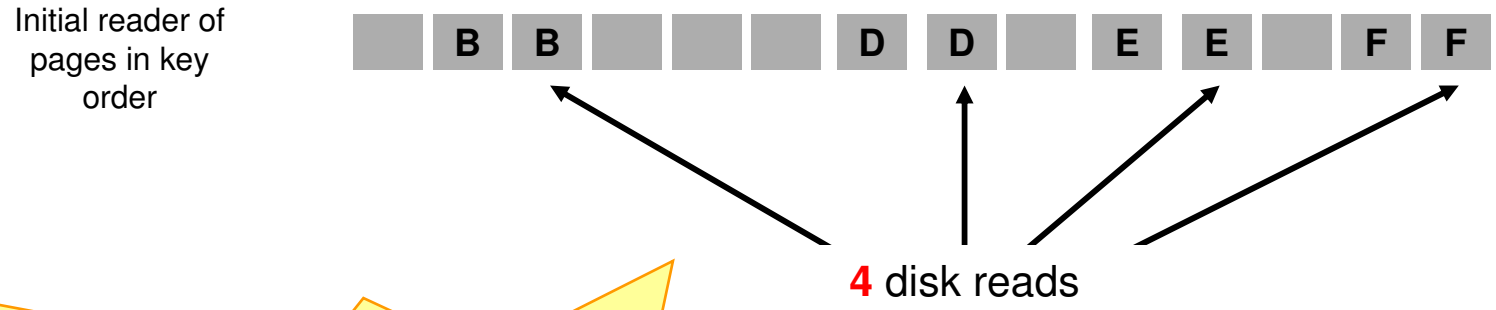
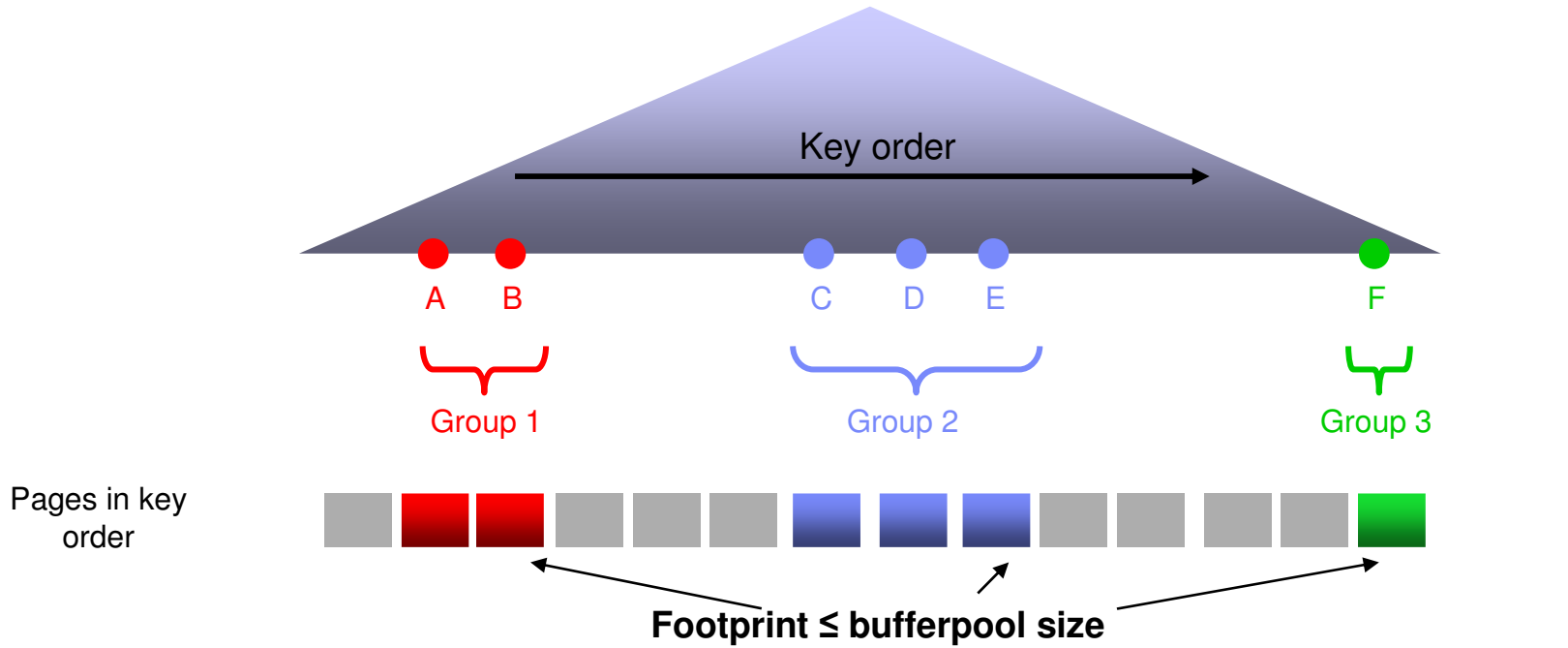




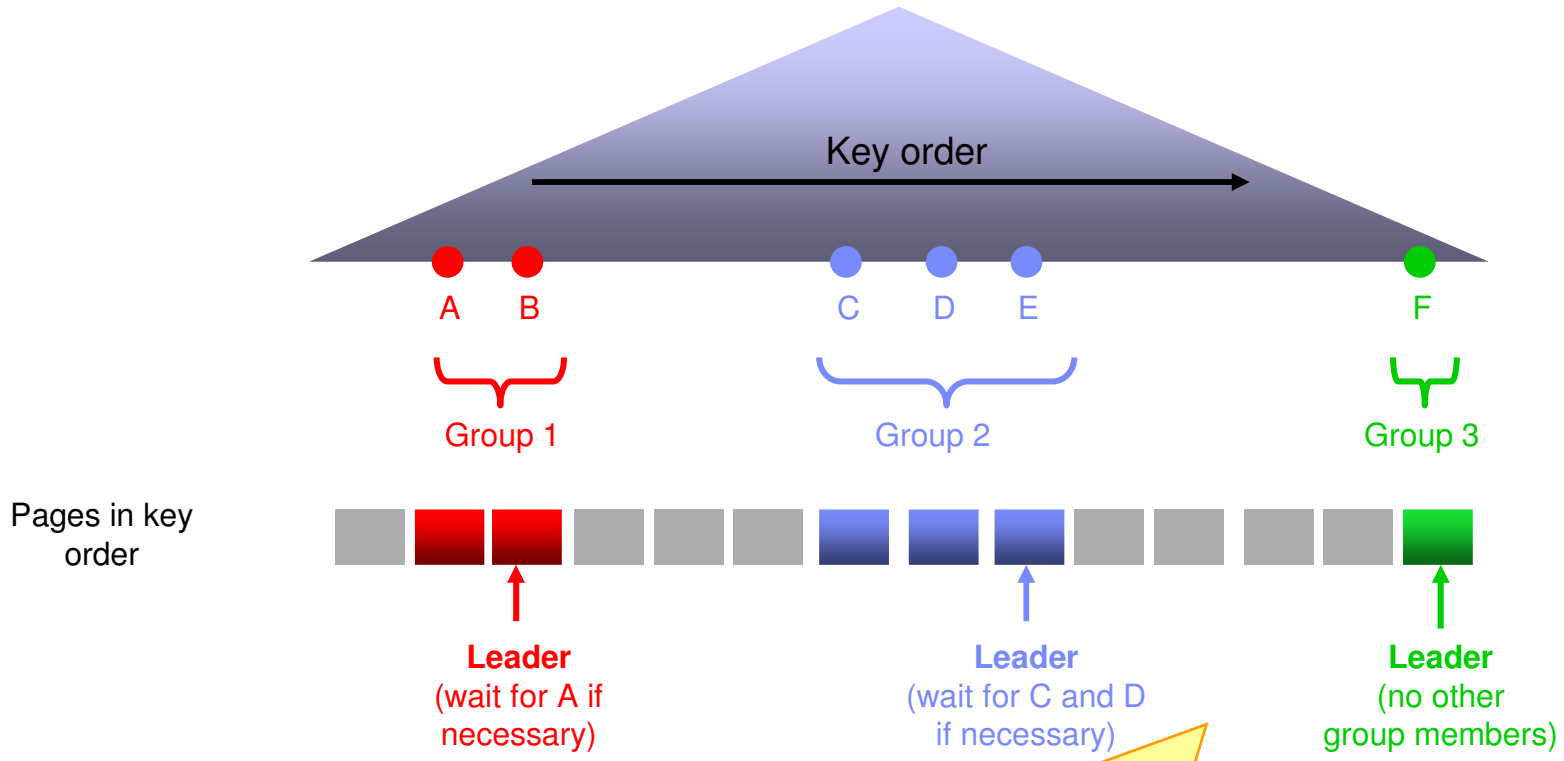
Drift leads to extra disk reads;
How to tolerate some drift without being too rigorous?

SISCAN Speed Control



Greedy algorithm:
group nearby SISCANs until
sum of group footprint exceeds bufferpool size

SISCAN Speed Control



Delay leader until group size ≤ bufferpool size / #groups
Upper bound on wait time per SISCAN;
Details similar to throttling for table scan sharing
[Lang et al., ICDE '07]

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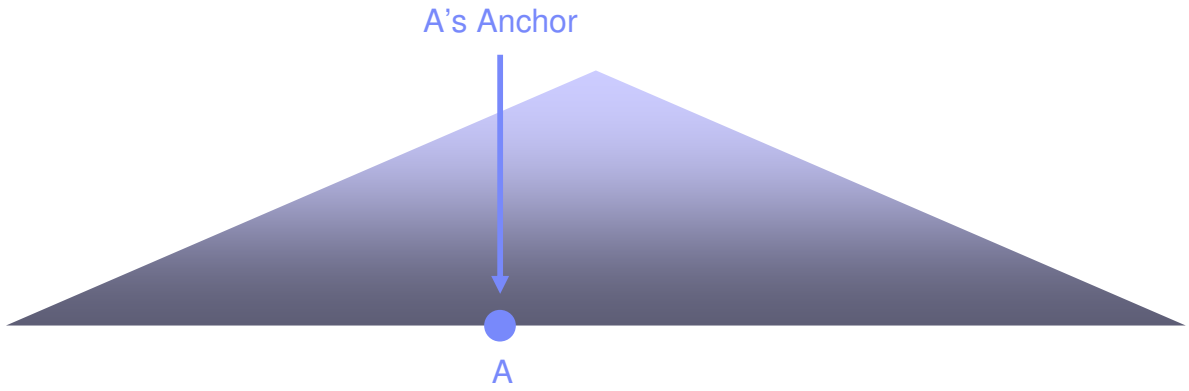
Index-Independent Relative SISCAN Locations

- Problem:
  hard to determine relative IXSCAN locations (while leaving the index a "black box")
- Example (key, page):
  ('Alice', 12), ('Bob', 38), ('Bob', 91), ('Carol', 2)
- What are the relative locations of these scans?
- How far apart are they?

Index-Independent Relative SISCAN Locations



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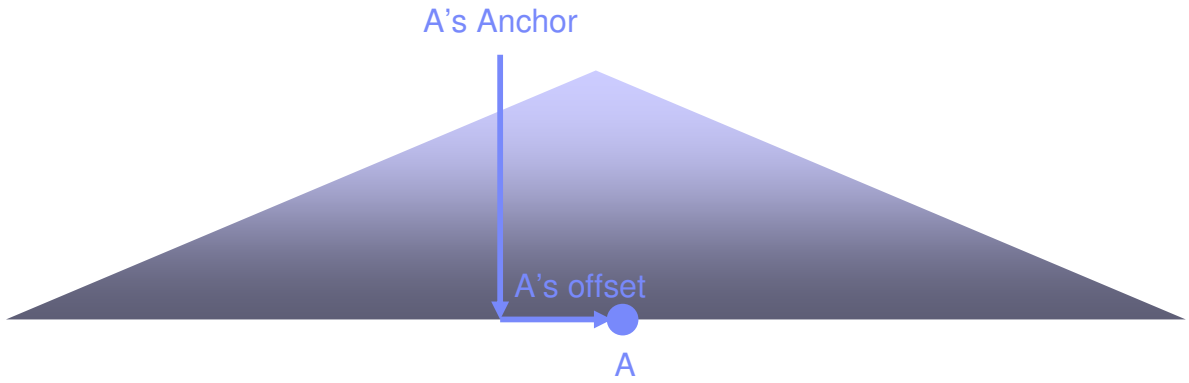

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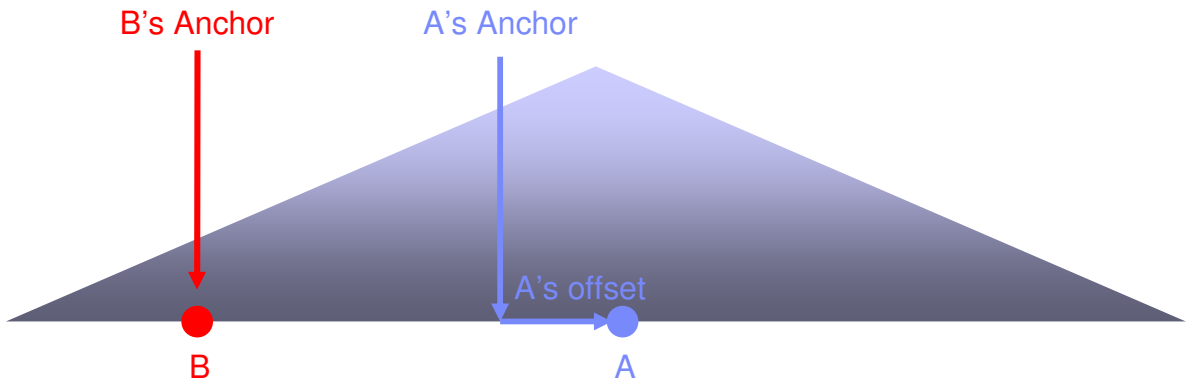

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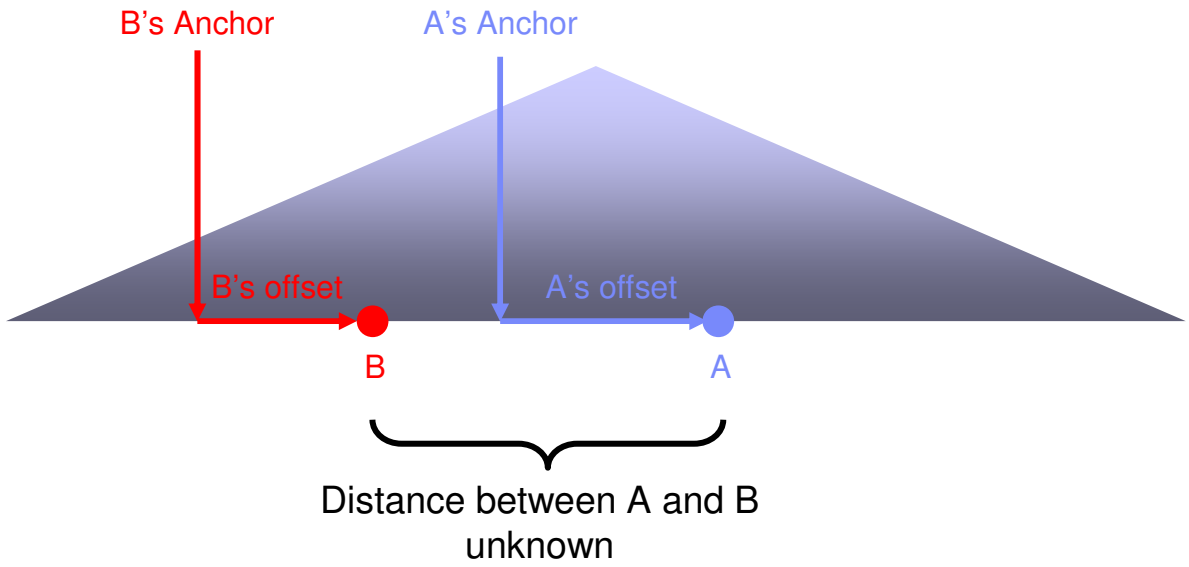

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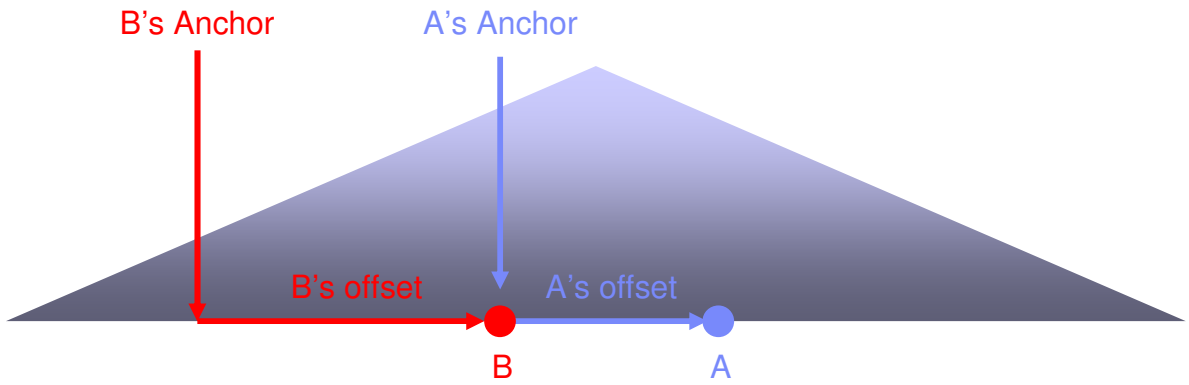

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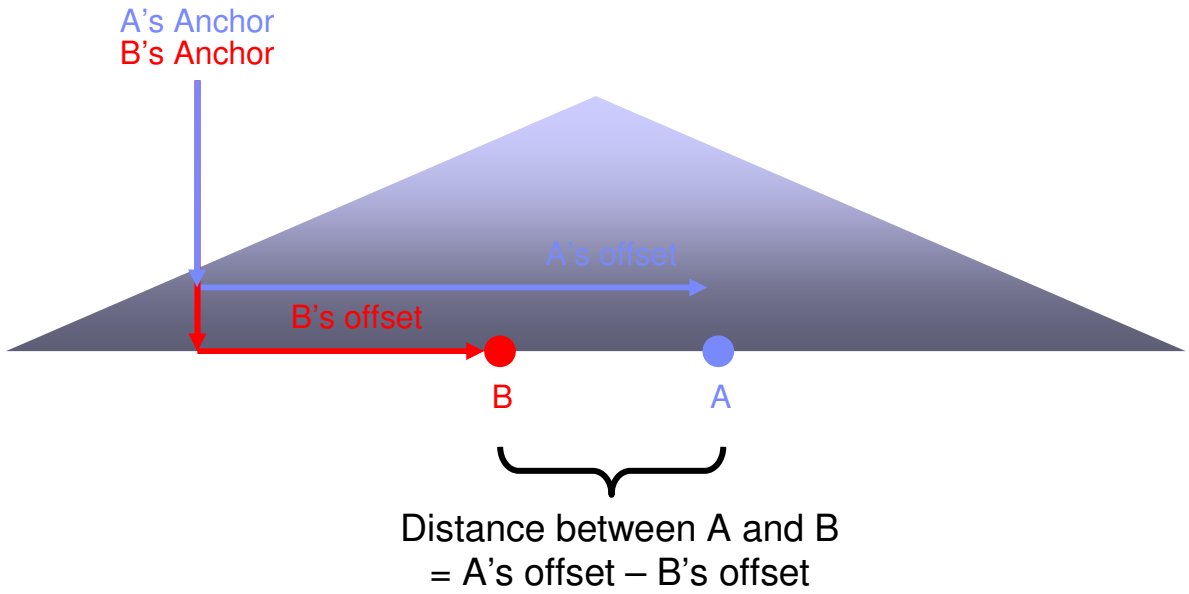

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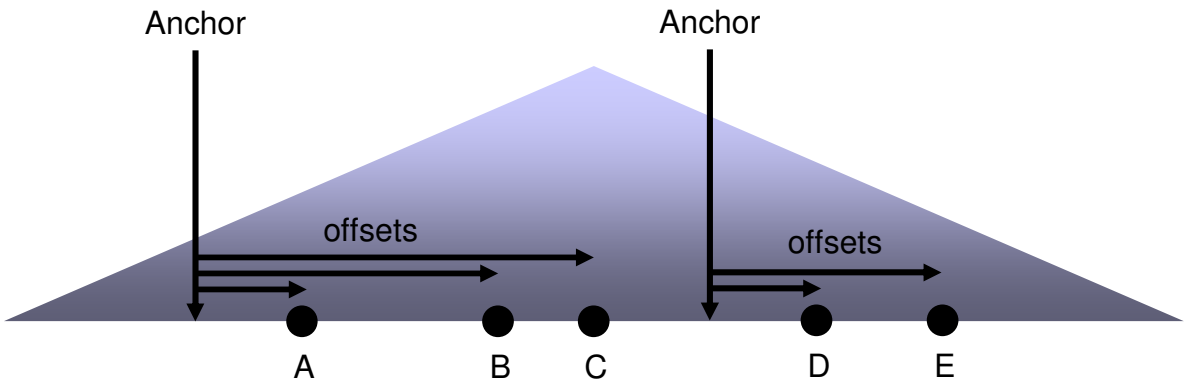
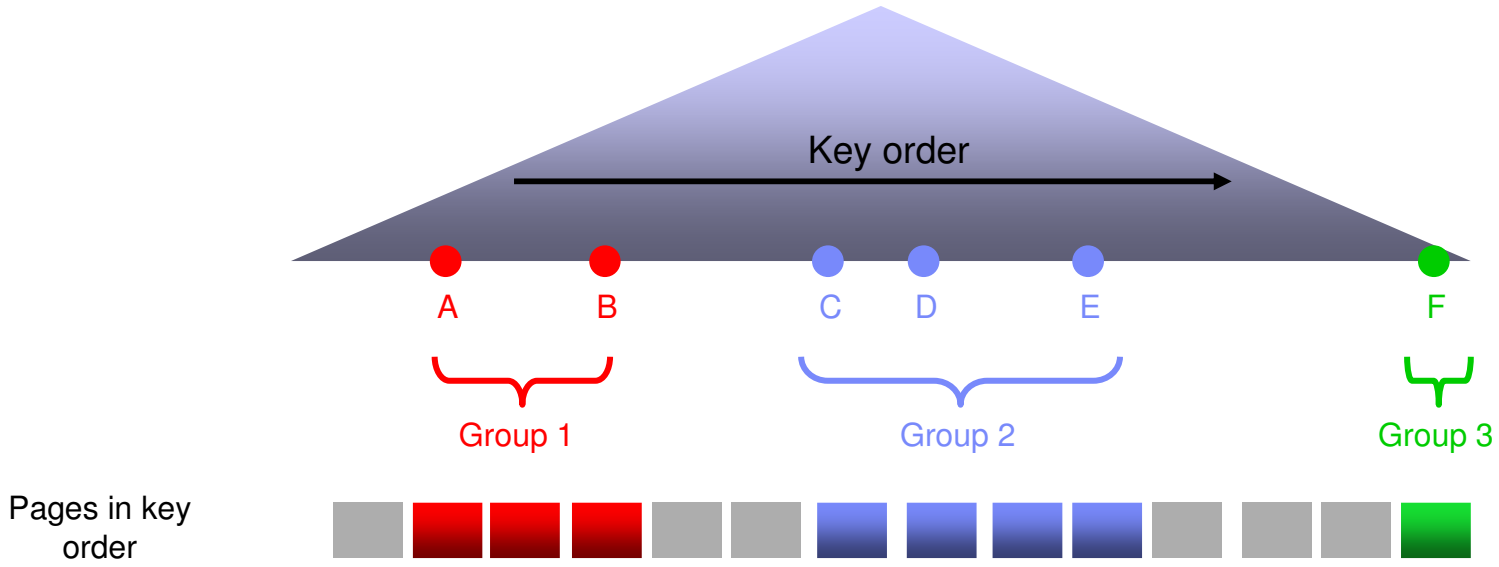


Partial ordering between SISCANs without details of the index structure

“Bufferpool-independent” SISCAN-aware Caching



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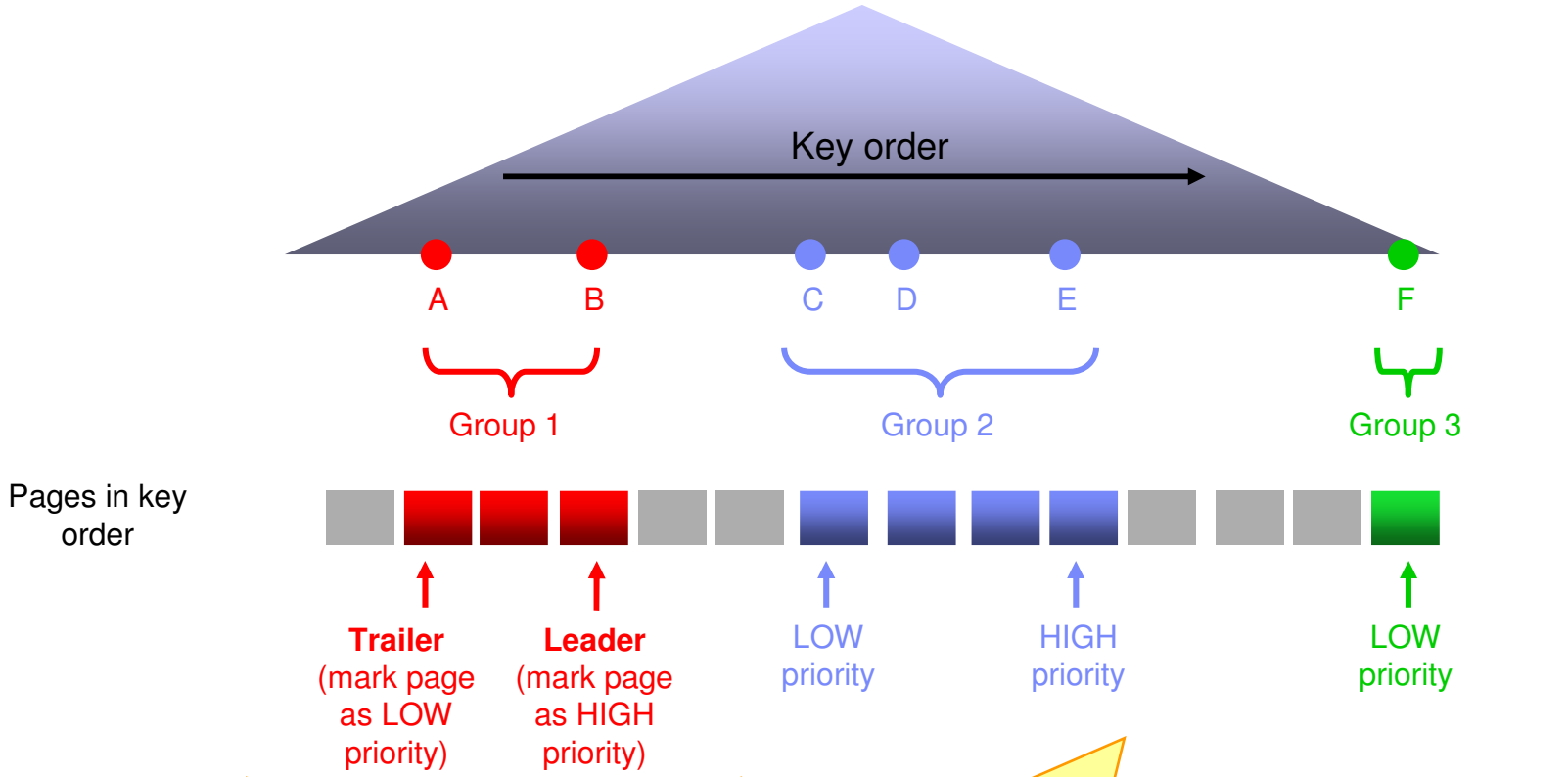
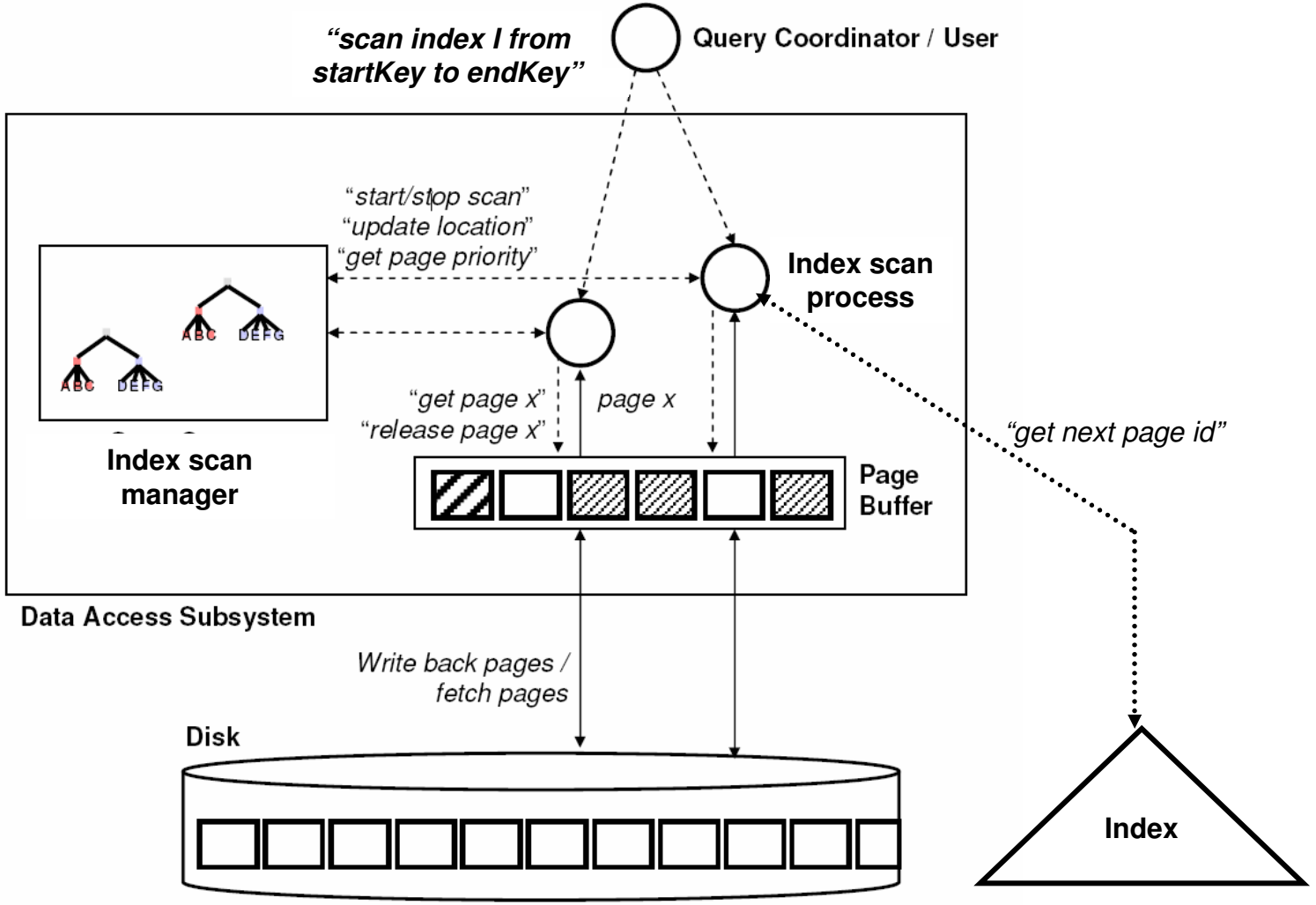


Don't need to change caching algorithm; need only LOW/HIGH priority hints; Details similar to [Lang et al., ICDE '07]

Architectural Changes



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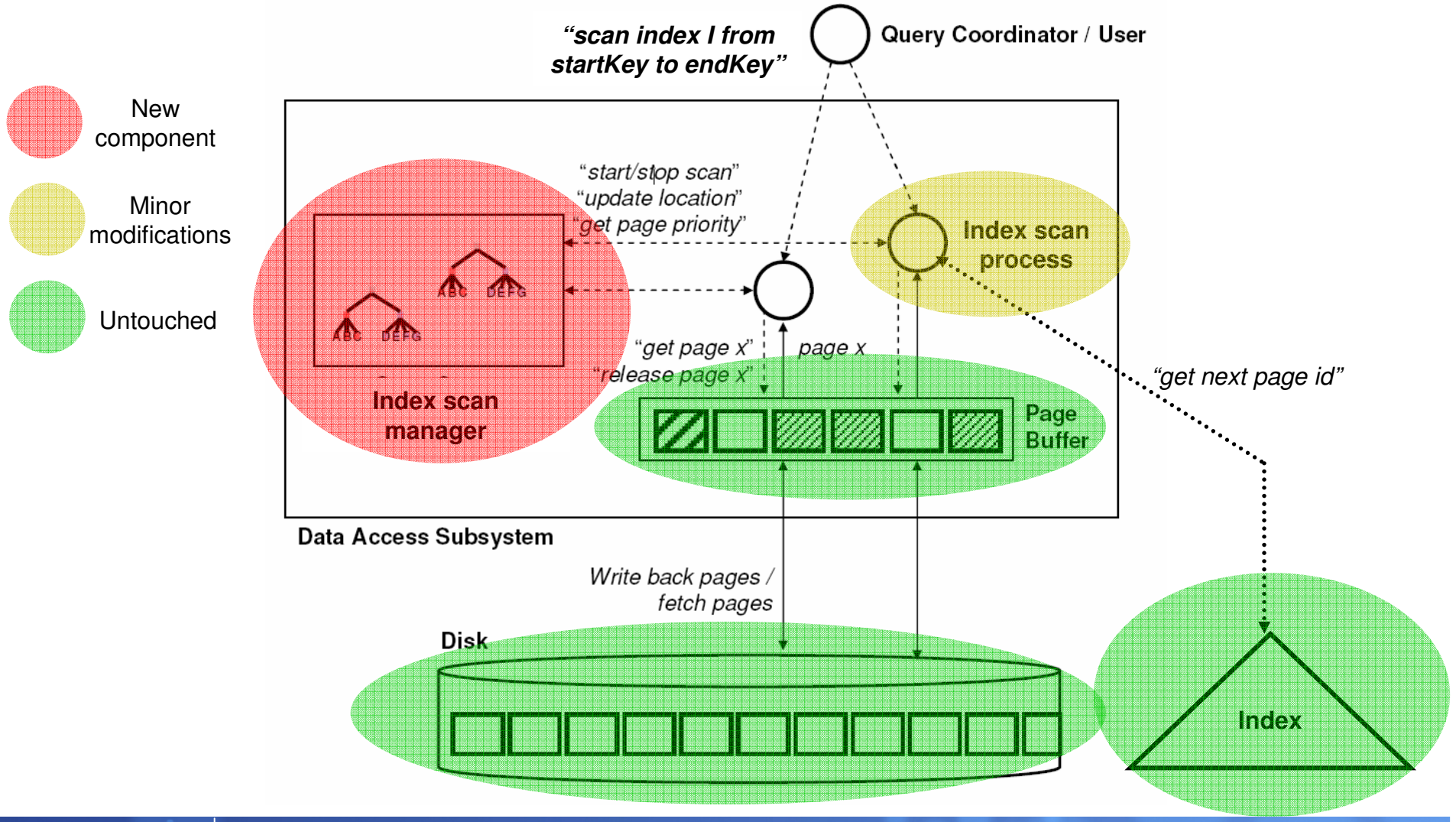

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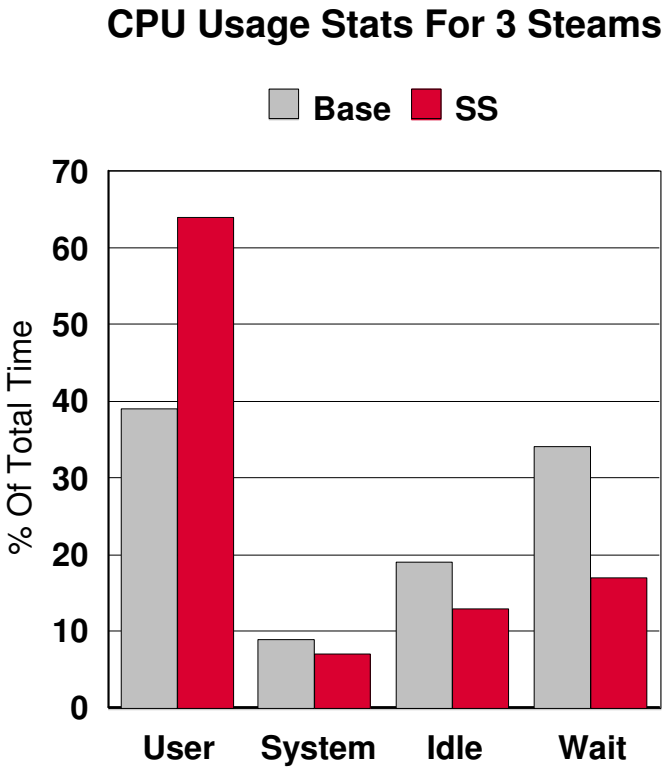
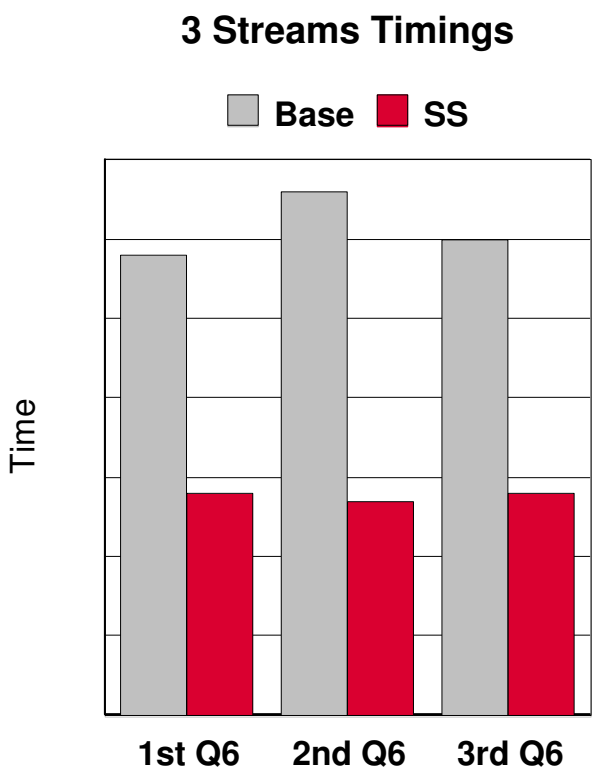
Experimental Results Setup

- Platforms:
  1. HP Integrity rx5670 (4 Itanium2 proc/1GHz, HP-UX, 15GB, FAStT)
  2. 8-node p660 cluster (4 PowerPC/600MHz, AIX, 8GB, 16 SSA disks)
- 100GB TPC-H database
- Bufferpool size ≈5% of DB size
- Standard MDC indexes / no hand-tuning

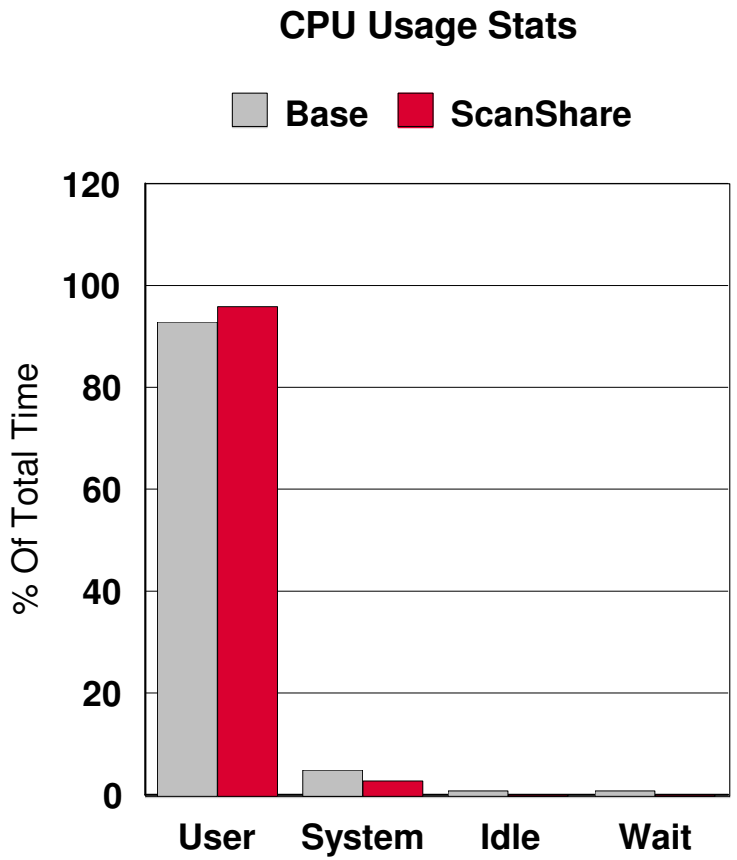
Staggered Q6 (I/O intensive)

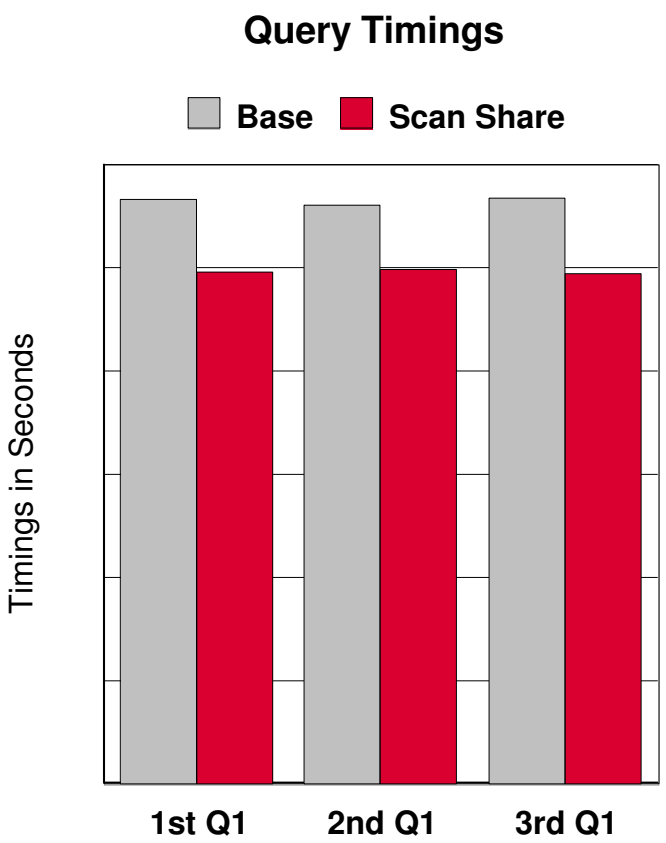




I/O wait reduced by 50%;
More than 50% gain in response time

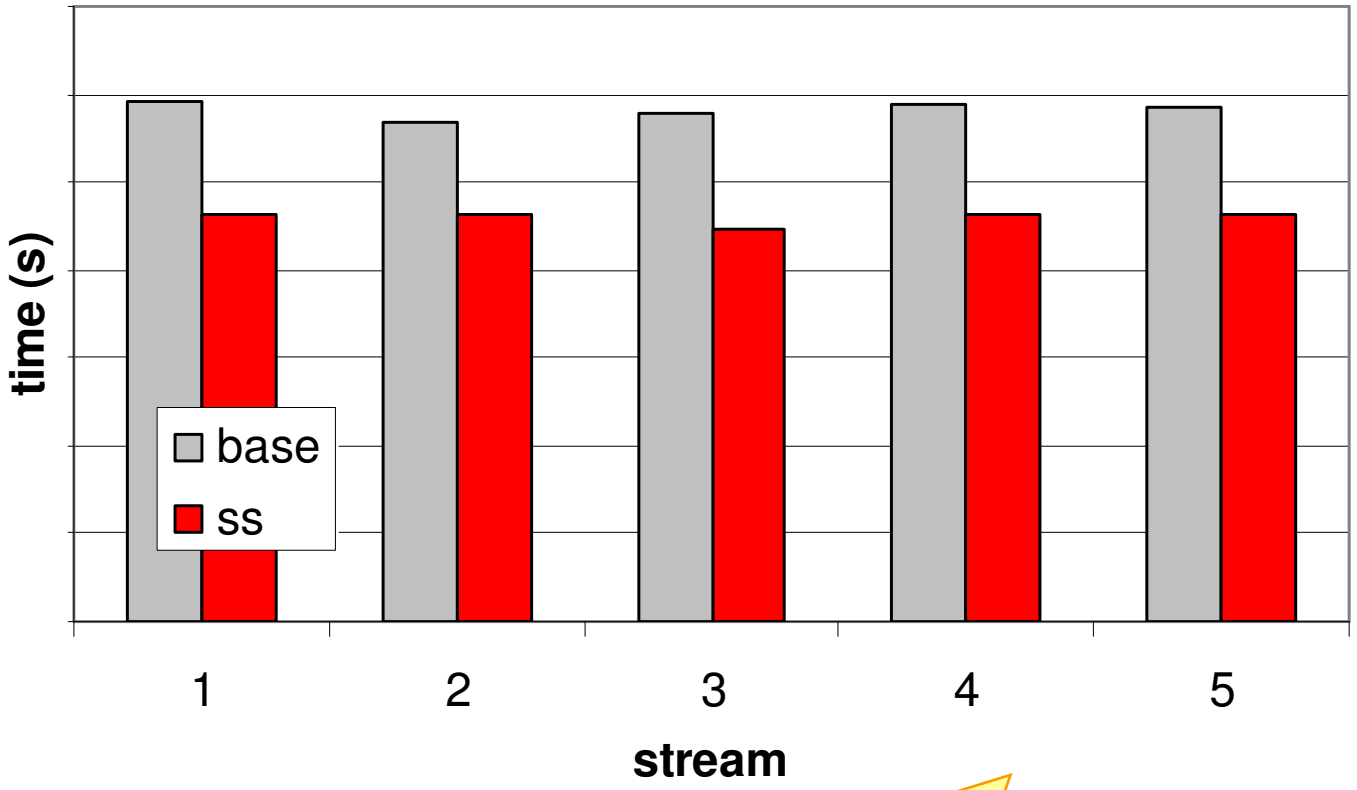
Staggered Q1 (CPU intensive)





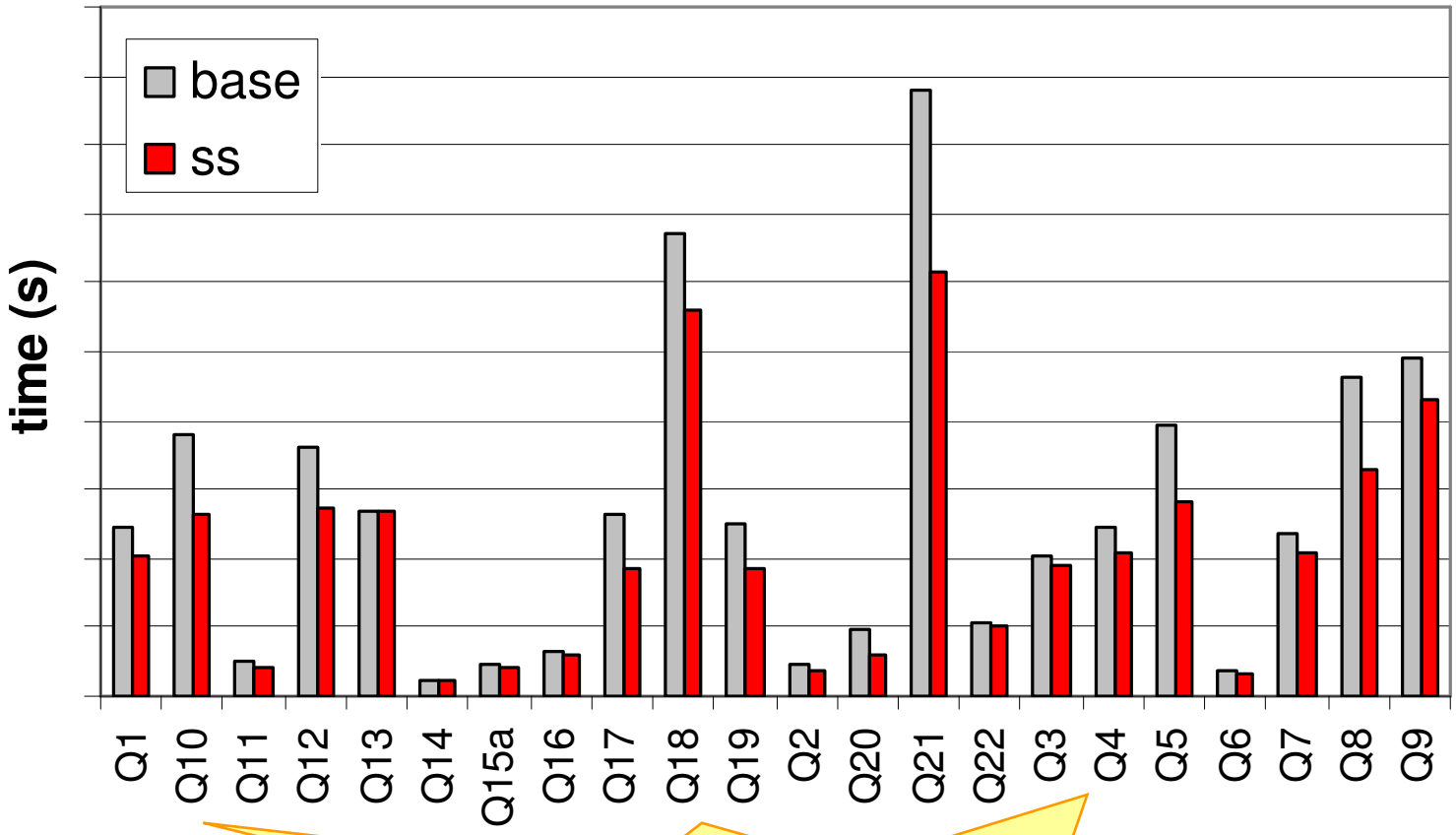
Noticeable reduction in response time even for CPU bound queries

TPC-H Throughput: Per-stream Gains



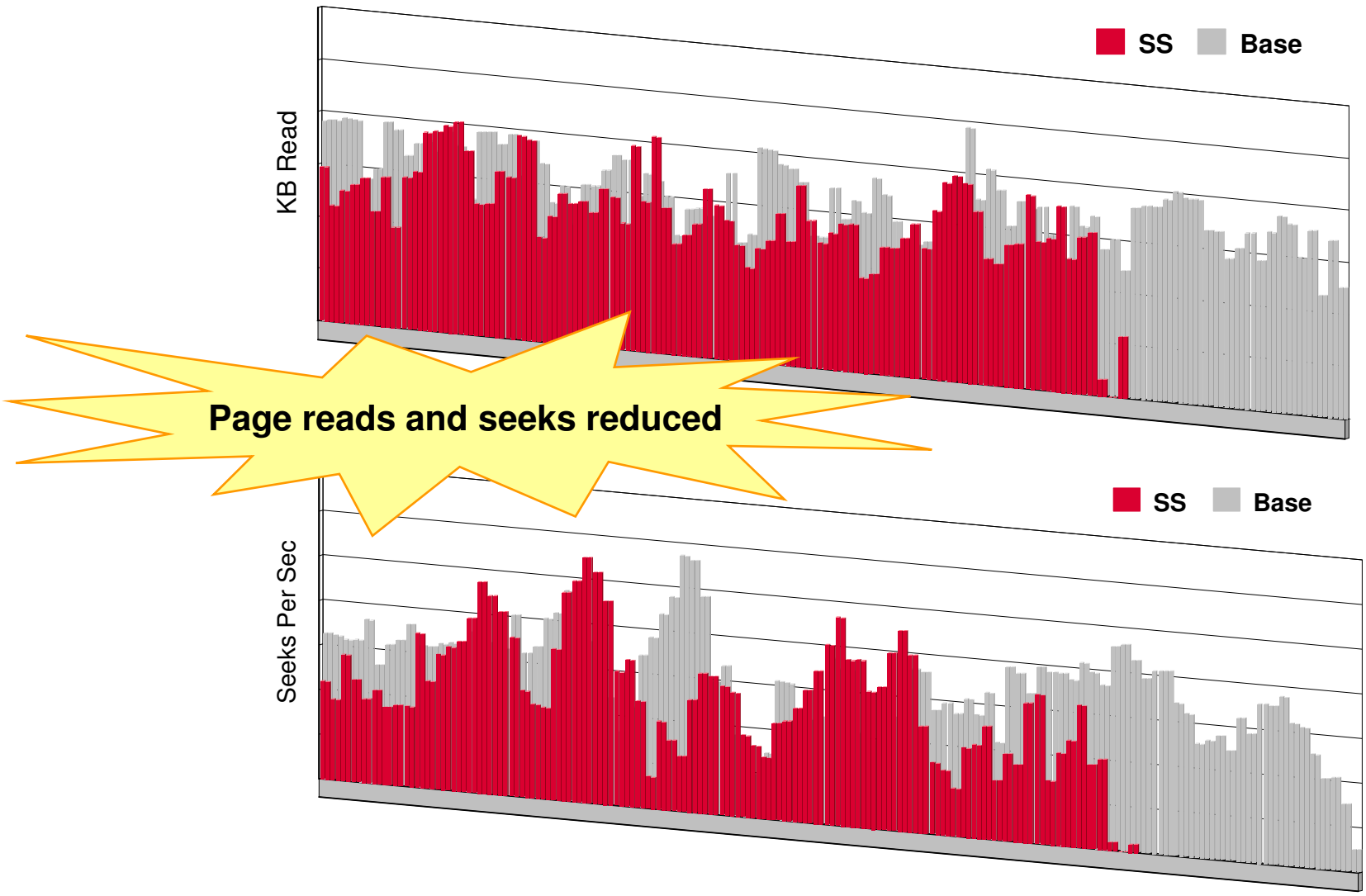
20% reduction in response time for all streams

TPC-H Throughput: Per-Query Gains



No deterioration for any query

TPC-H Throughput: Disk Behavior



Conclusions

- Mechanism for better cache reuse and reduced I/O to increase throughput and reduce latency for ad-hoc index scan-heavy multi-query workloads
- Inter-SISCAN cache locality improved via:
  - Starting new SISCANs near similar (speed/key range) running scans
  - Speed control of SISCANs to reduce drift
  - SISCAN-based priority hints to bufferpool manager
- Fulfills requirements:
  - Can handle dynamic “heterogeneous” workloads
  - Easy integration in architecture

Thank you!

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