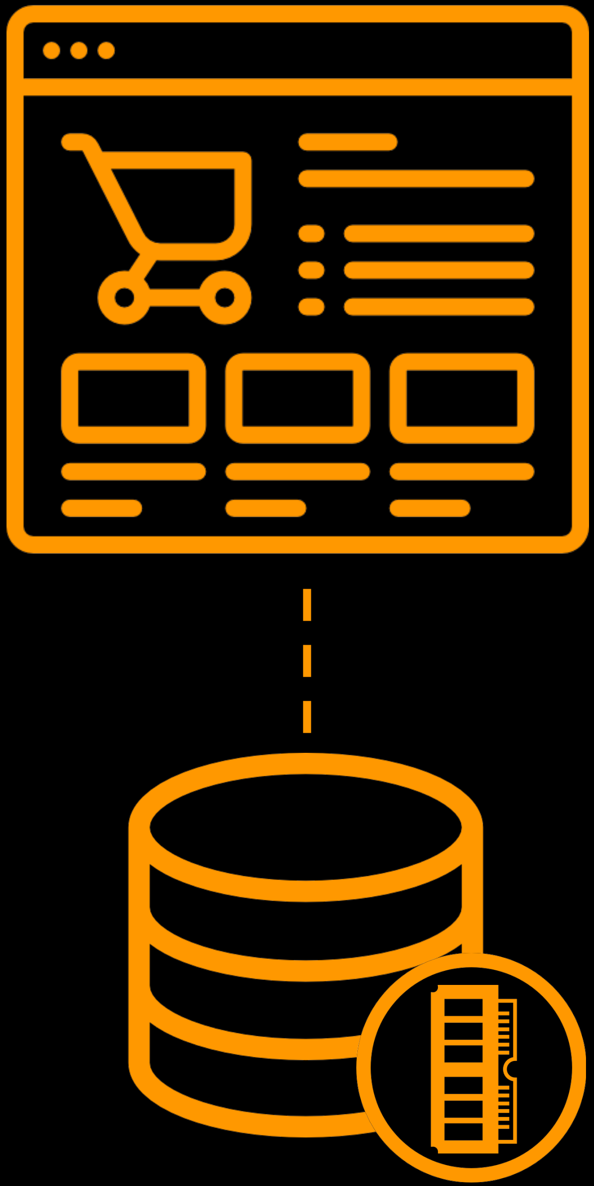
Reducing the Storage Overhead of Main-Memory OLTP Databases with Hybrid Indexes

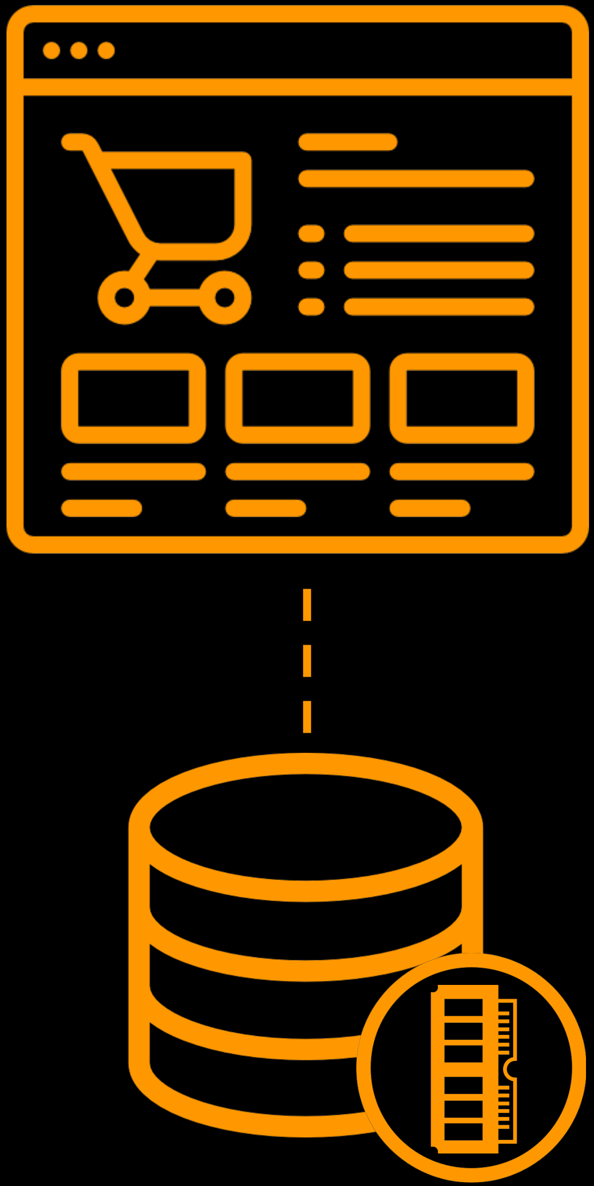
Huanchen Zhang

Co-authors:
David G. Andersen
Andrew Pavlo
Michael Kaminsky
Lin Ma
Rui Shen

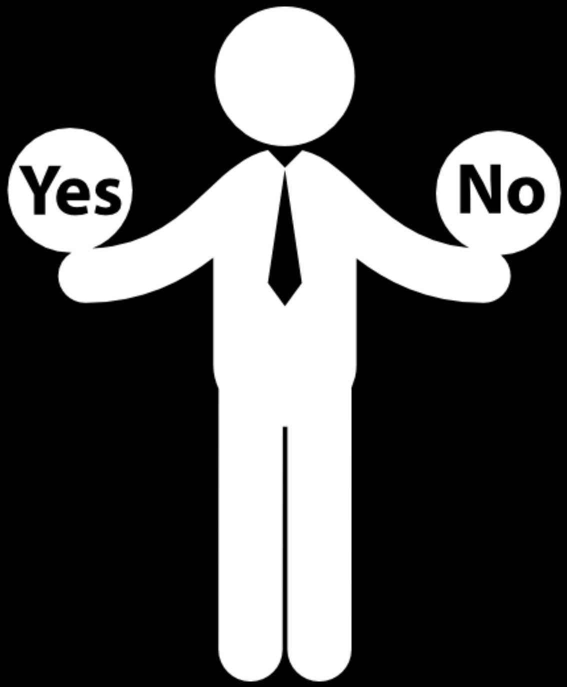

You are running out of memory



⚠ You are running out of memory

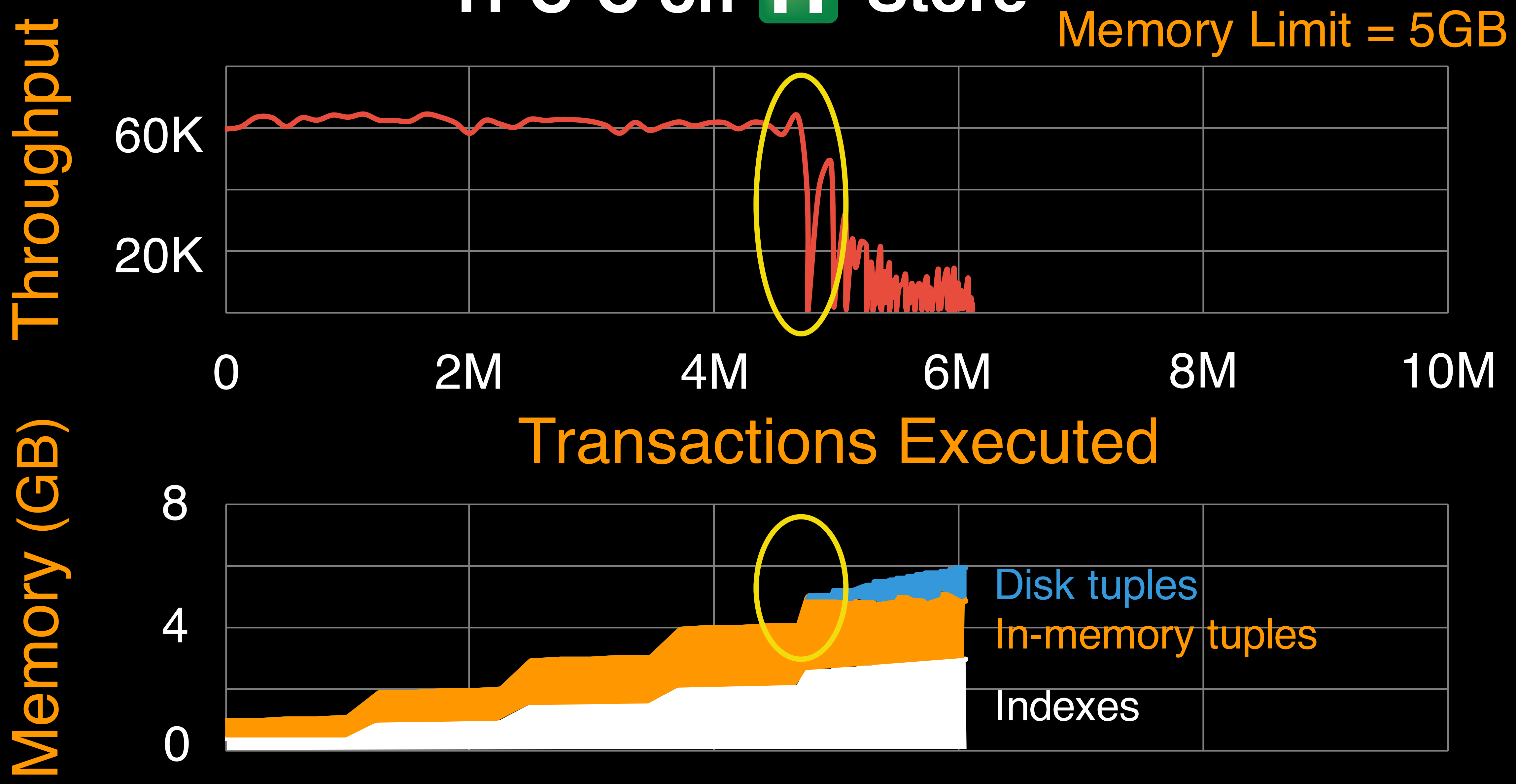


Buy more ?



You are running out of memory

TPC-C on H-Store




I GOT STUCK
SO I WENT TO SLEEP
zipmeme

The better way:

Use memory more efficiently

Indexes are LARGE

Benchmark	% space for index		Hybrid Index
TPC-C	58%	→	34%
Voter	55%	→	41%
Articles	34%	→	18%

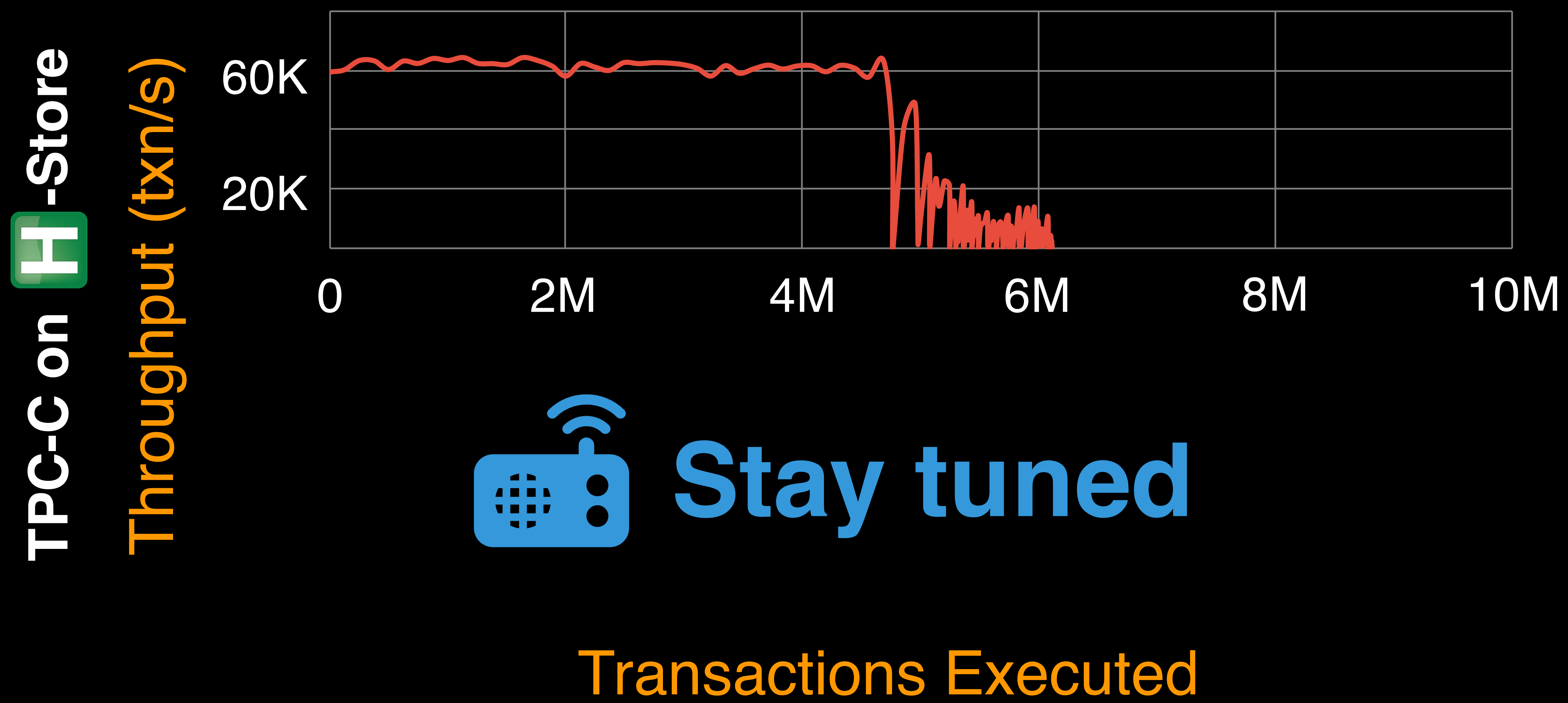
Our Contributions

1. The hybrid index architecture
2. The Dual-Stage Transformation
3. Applied to 4 index structures
   - B+tree
   - Skip List
   - Masstree
   - Adaptive Radix Tree (ART)

Performance ≈

Space 30 – 70% ⬇

Did we solve this problem?



Stay tuned

How do hybrid indexes achieve **memory savings** ?

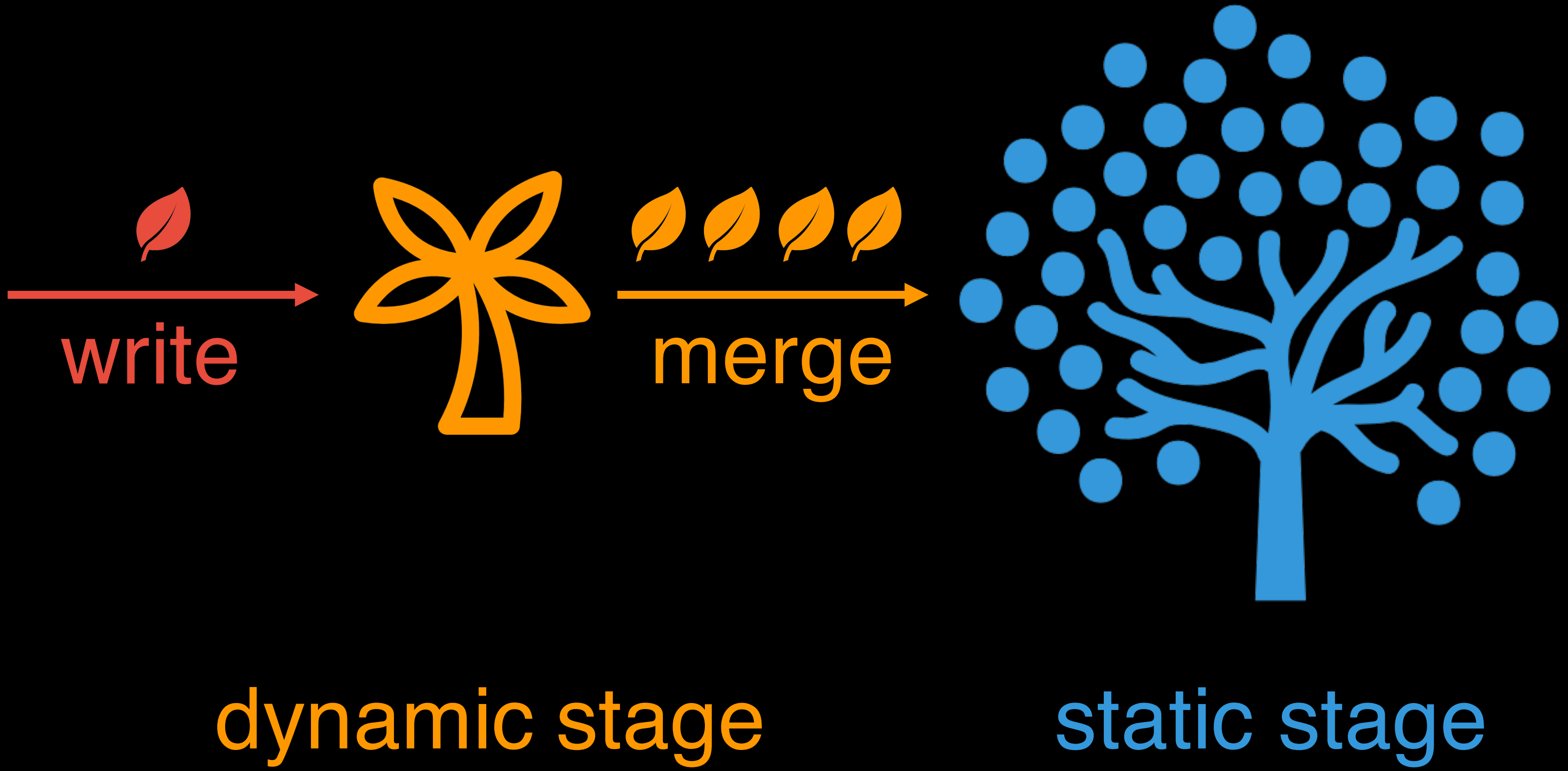
Static

Hybrid Index: a dual-stage architecture

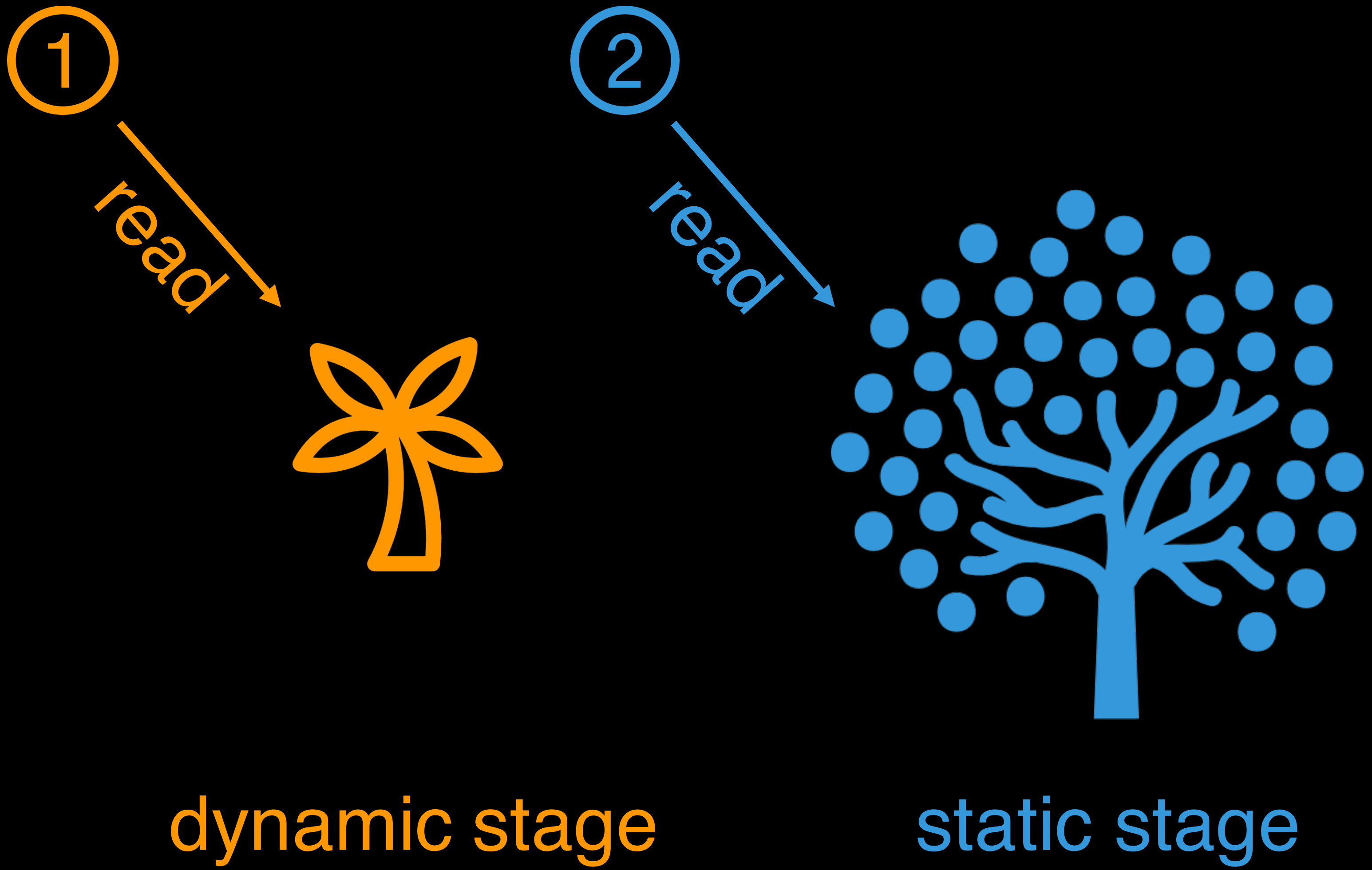
dynamic stage

static stage

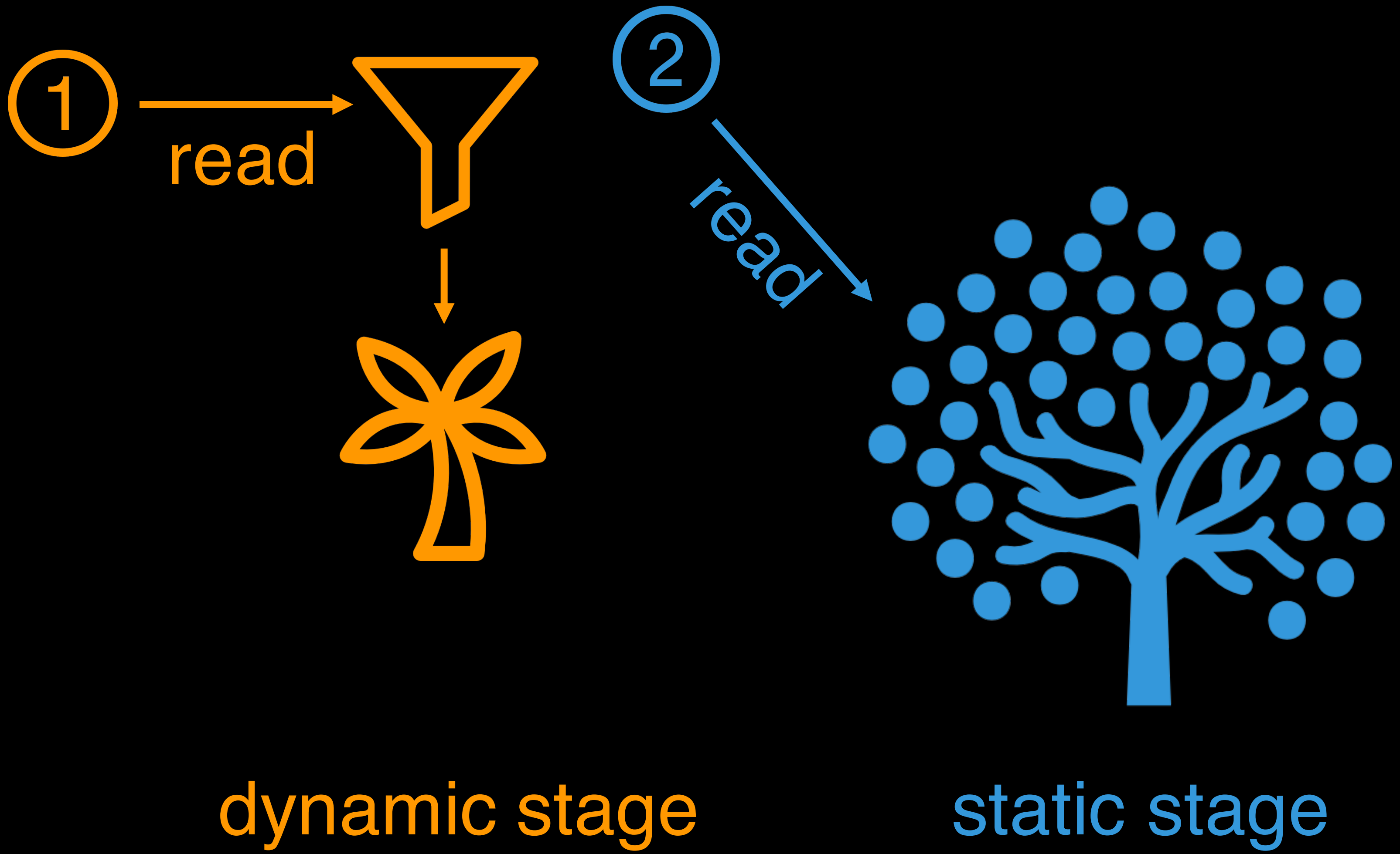
Inserts are batched in the dynamic stage

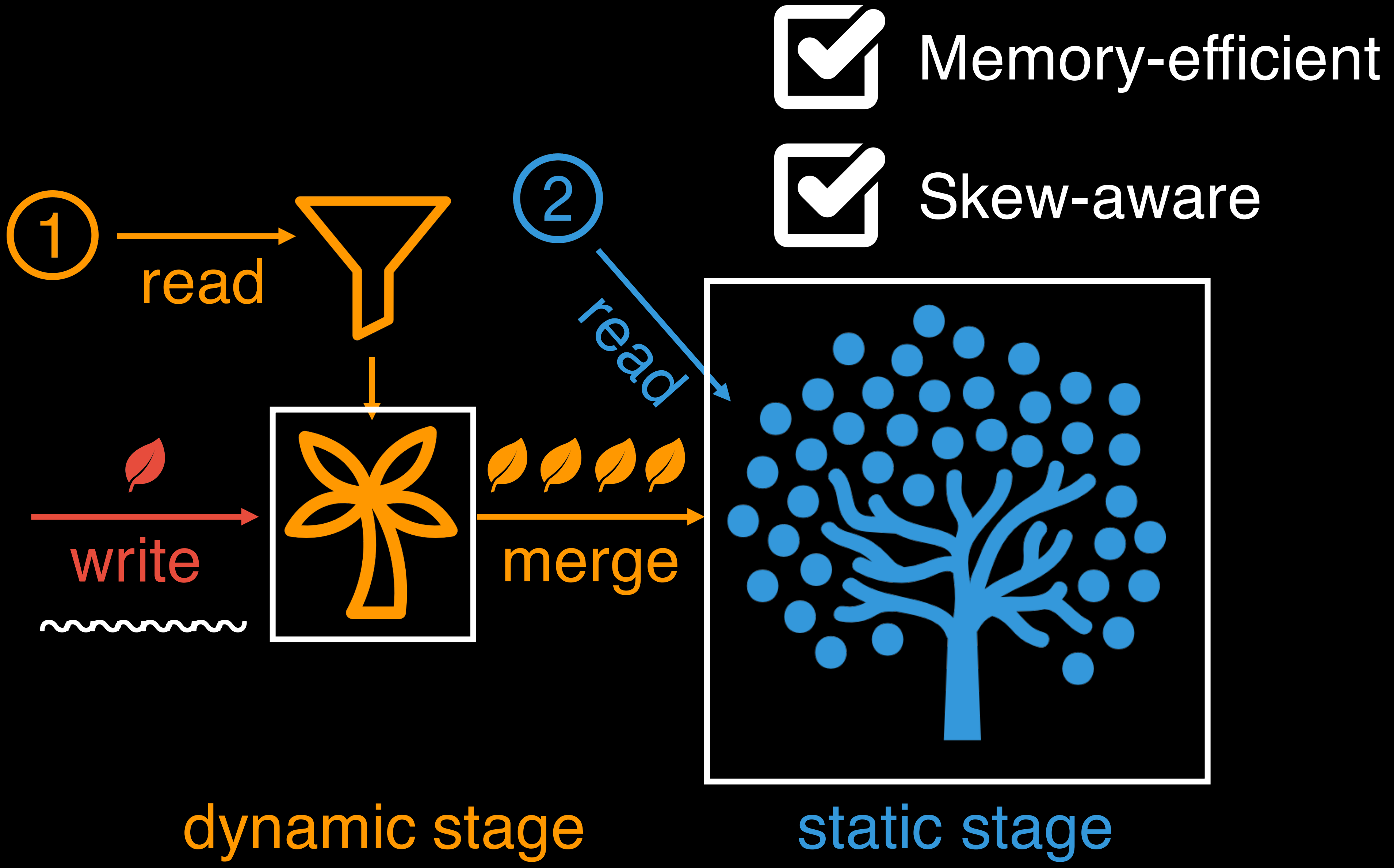


Reads search the stages in order

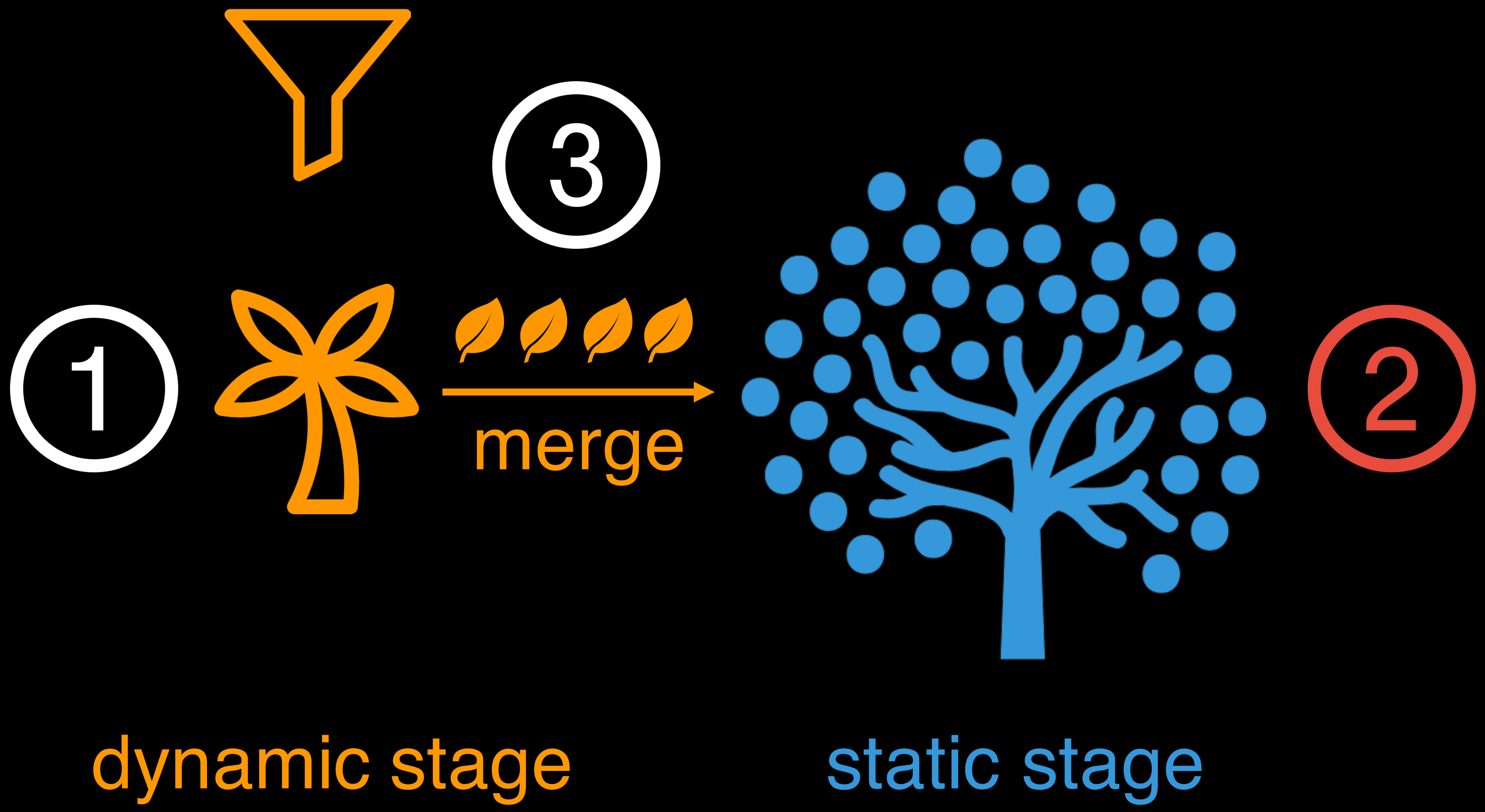


A Bloom filter improves read performance




Memory-efficient
Skew-aware
1
read
2
read
write
merge
dynamic stage
static stage

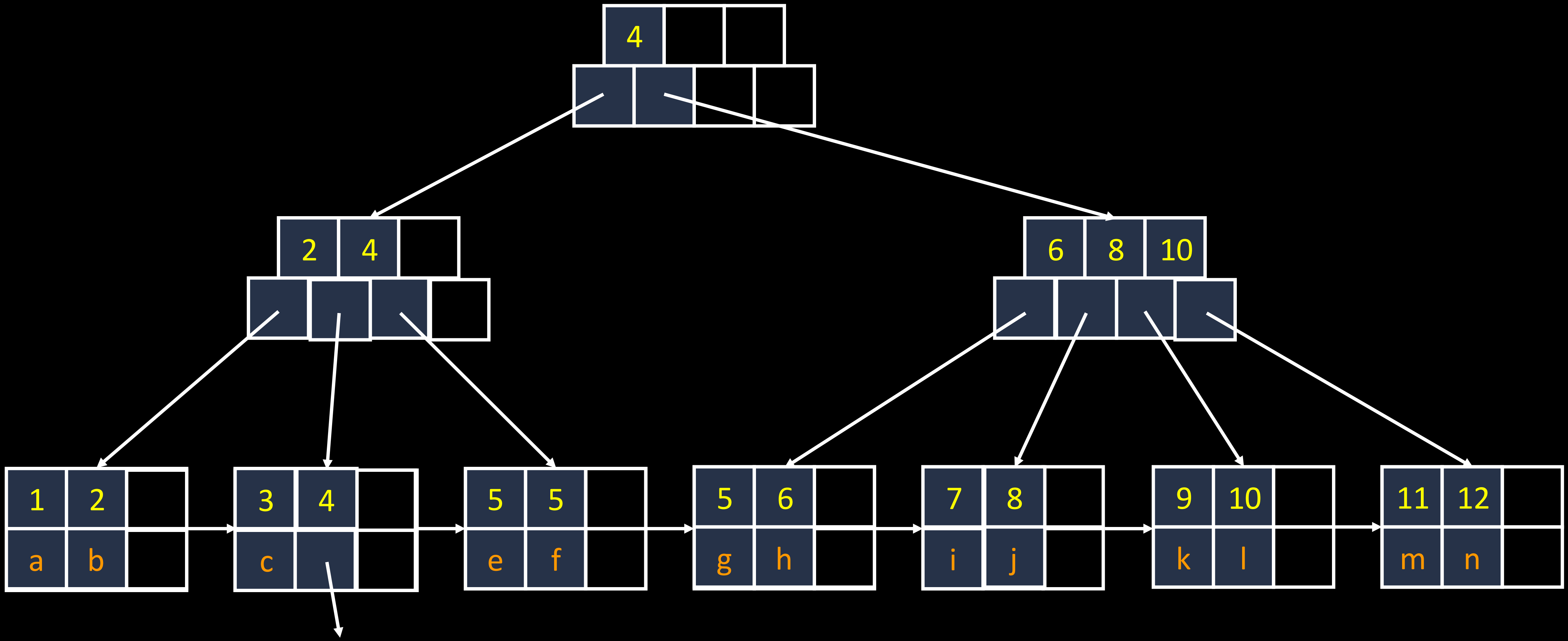
The Dual-Stage Transformation



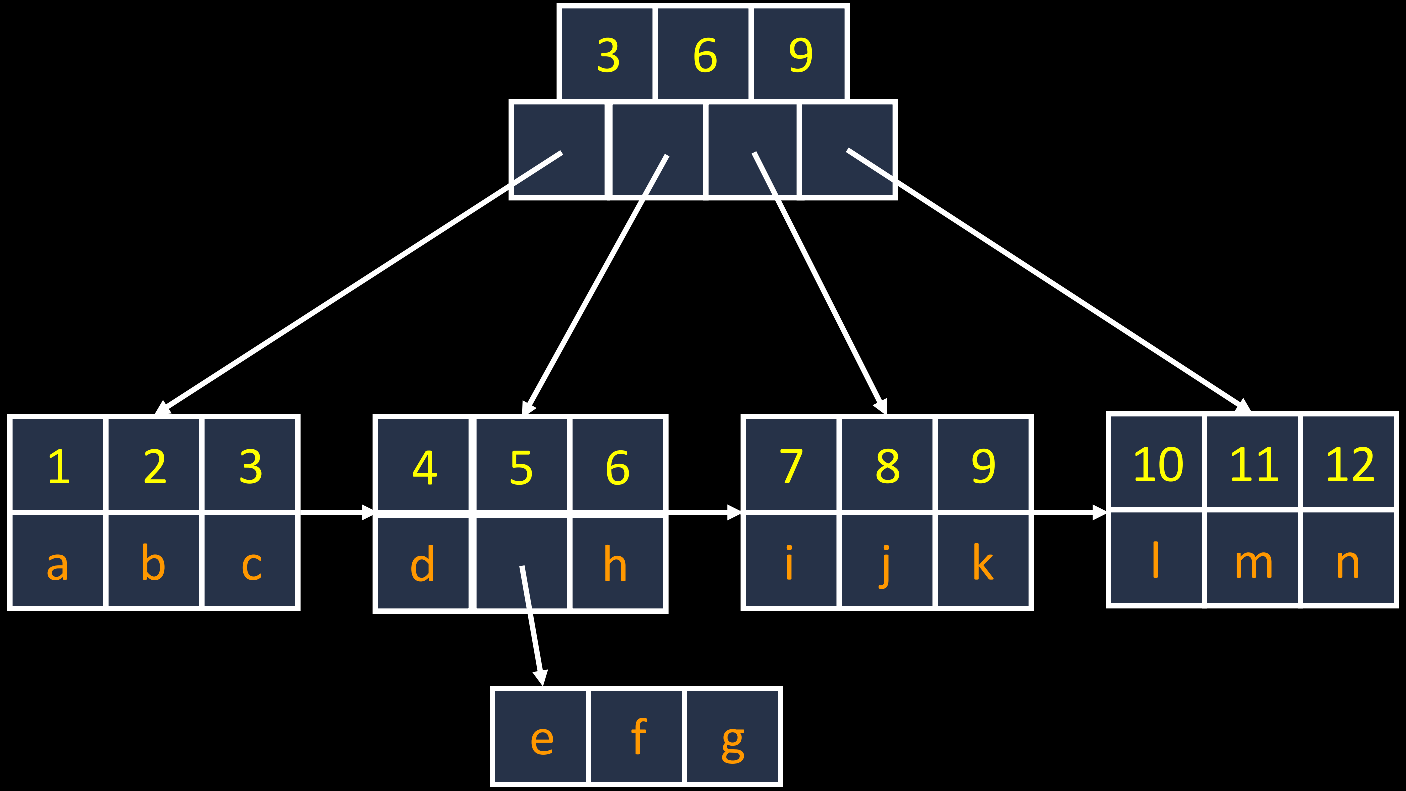
The Dynamic-to-Static Rules

- Compaction
- Reduction
- Compression

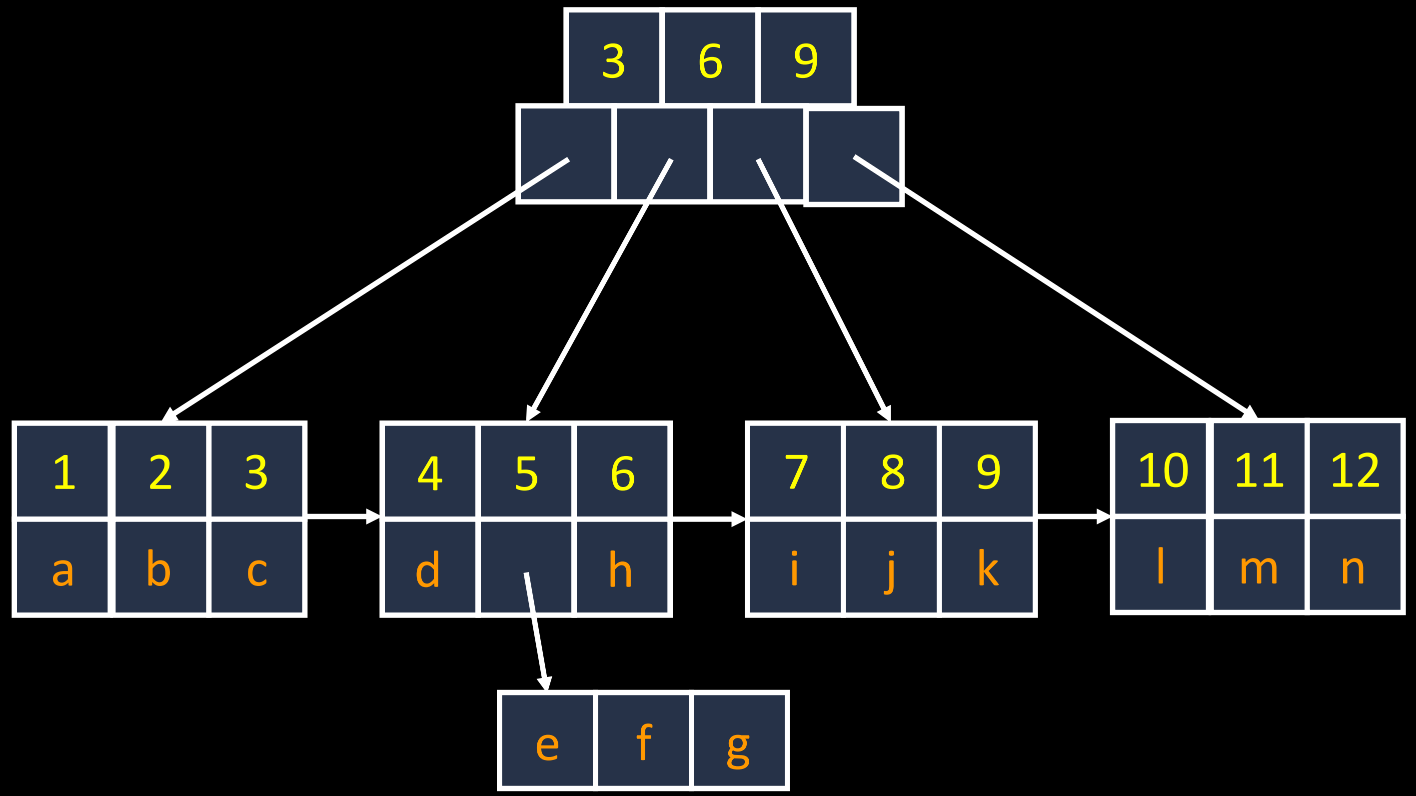
Compaction: minimize # of memory blocks



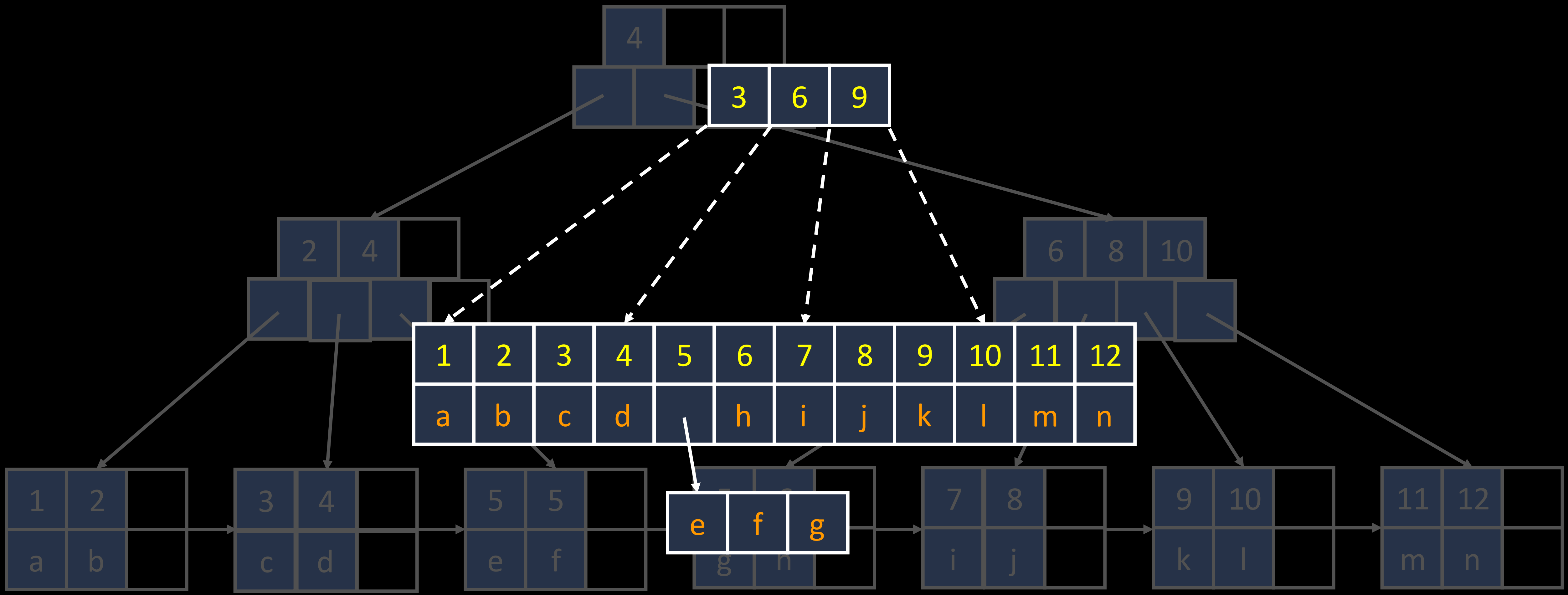
Compaction: minimize # of memory blocks



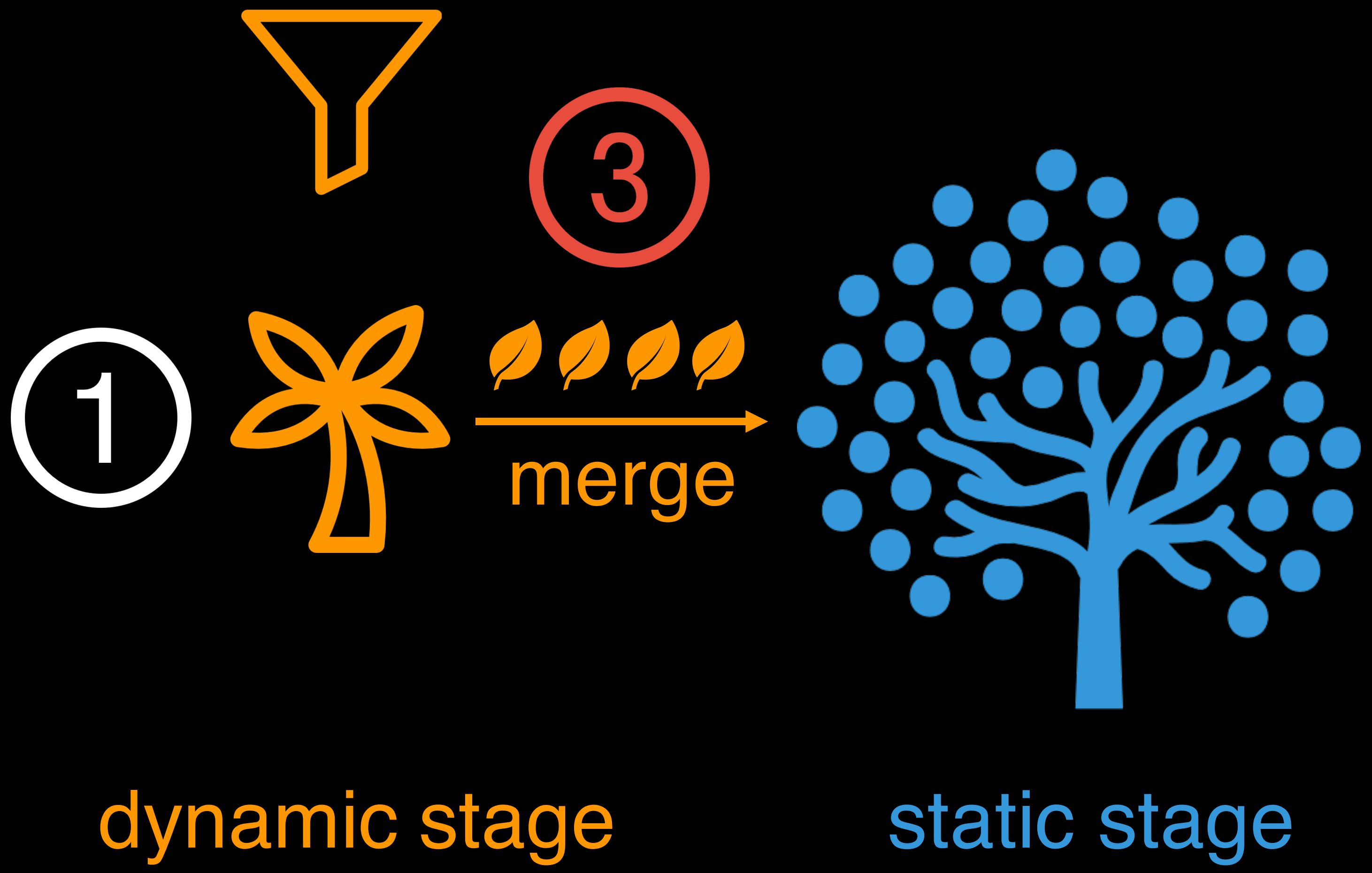
Reduction: minimize structural overhead



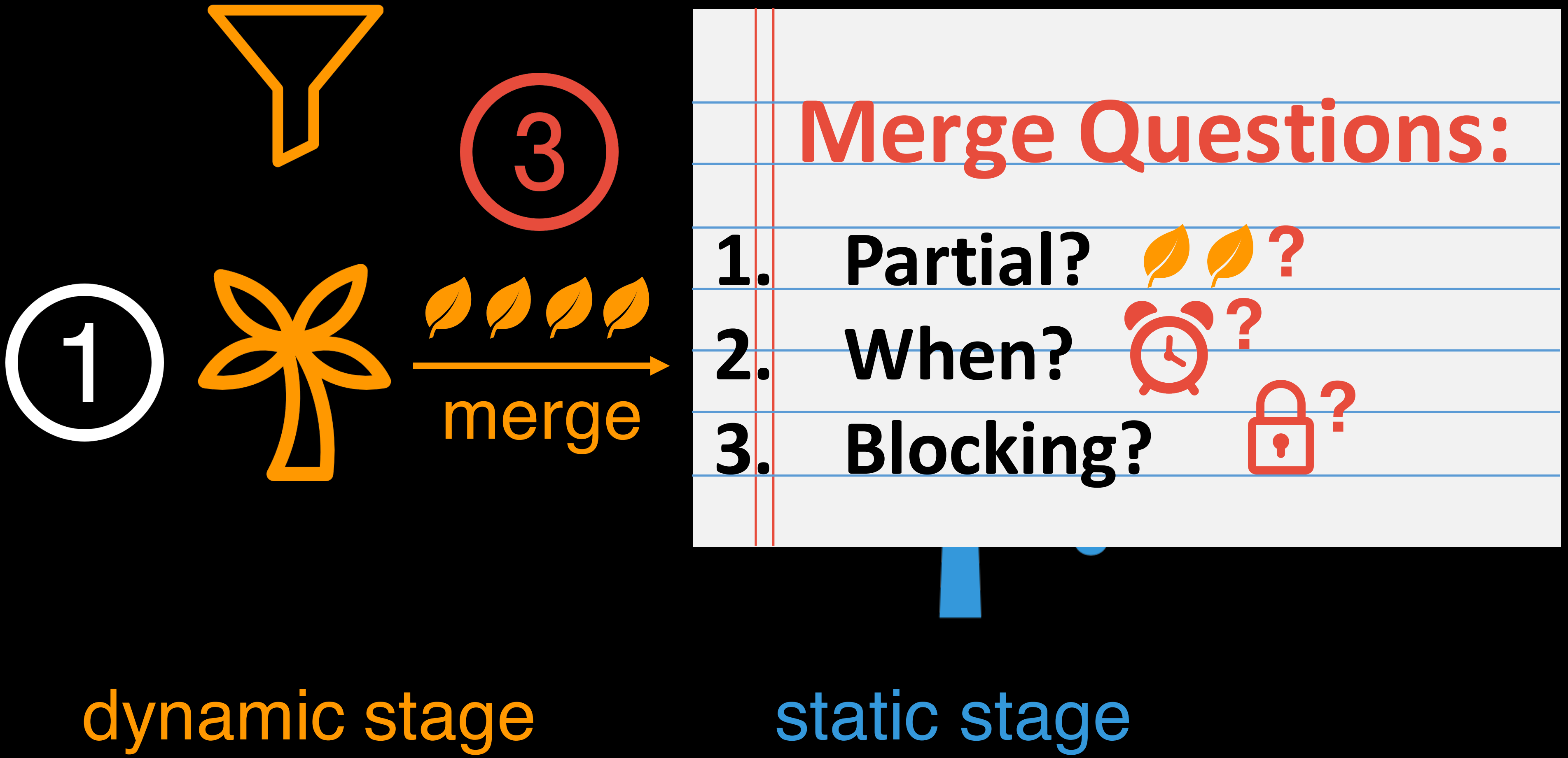
Reduction: minimize structural overhead



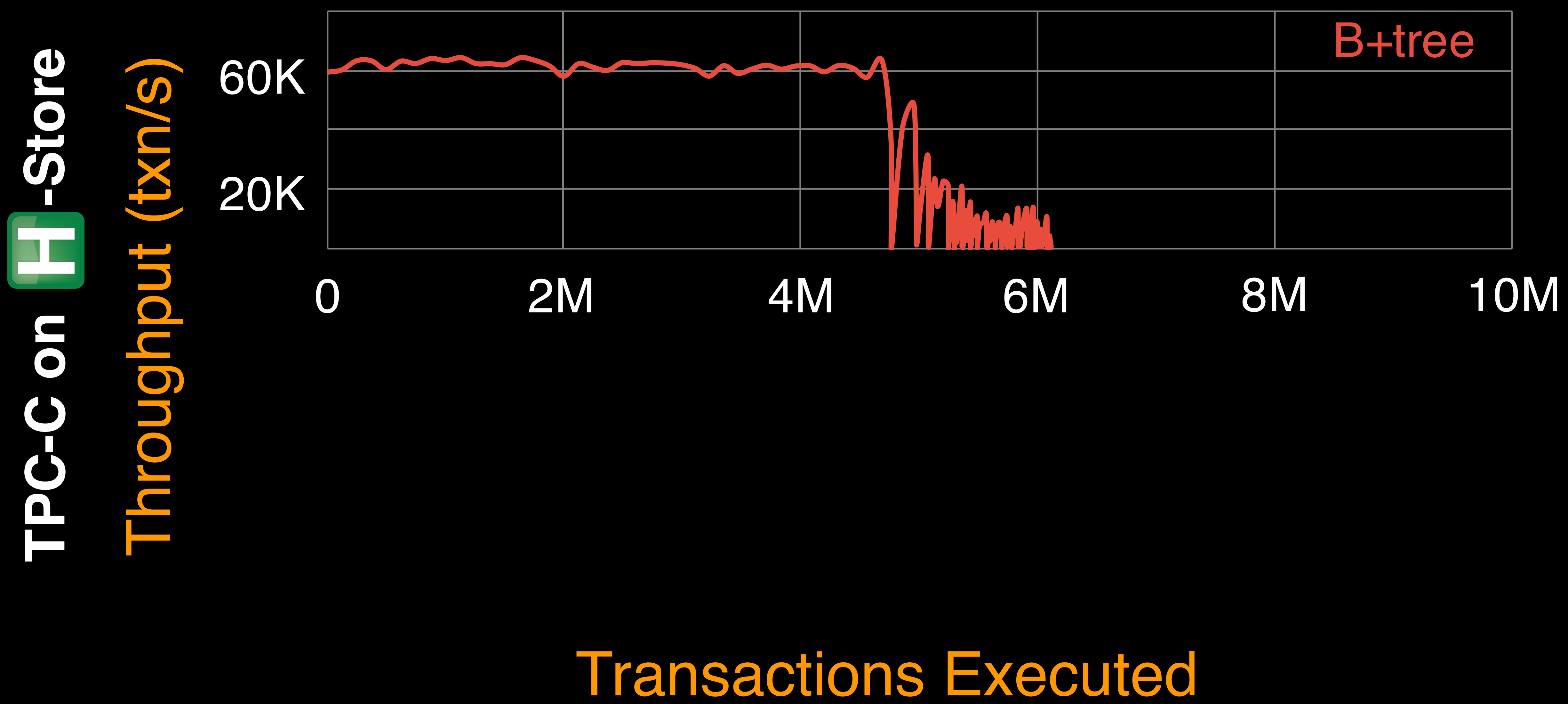
The Dual-Stage Transformation



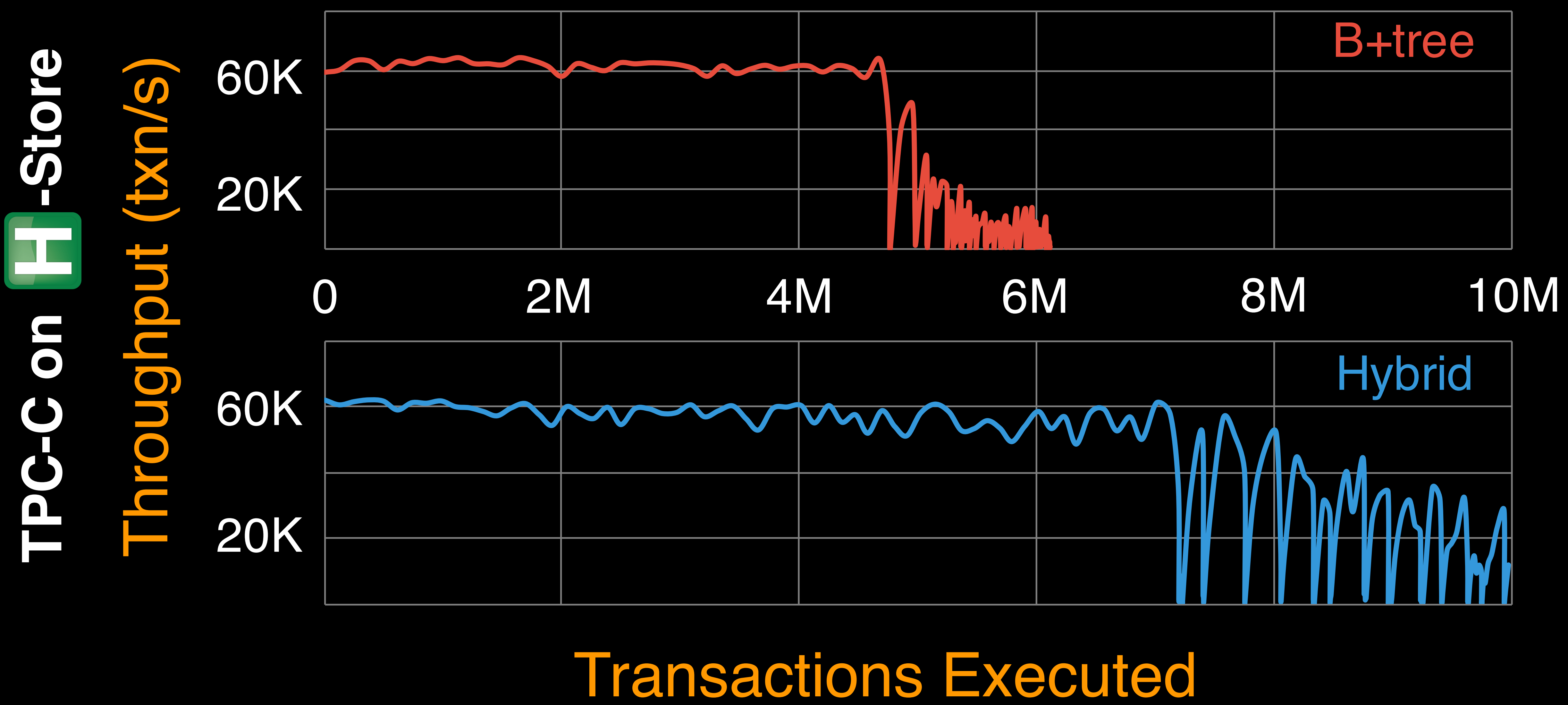
The Dual-Stage Transformation

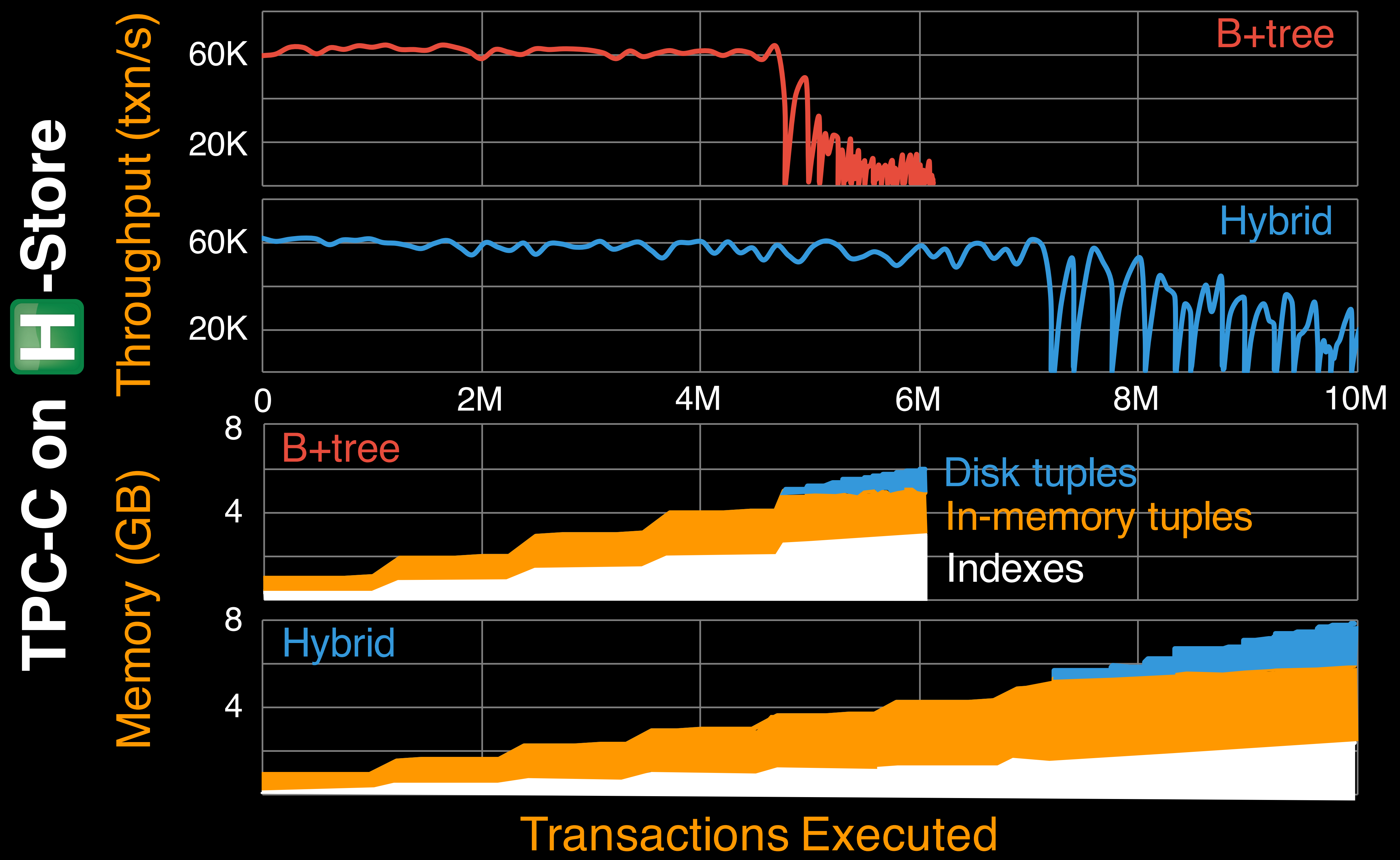


Did we solve this problem?



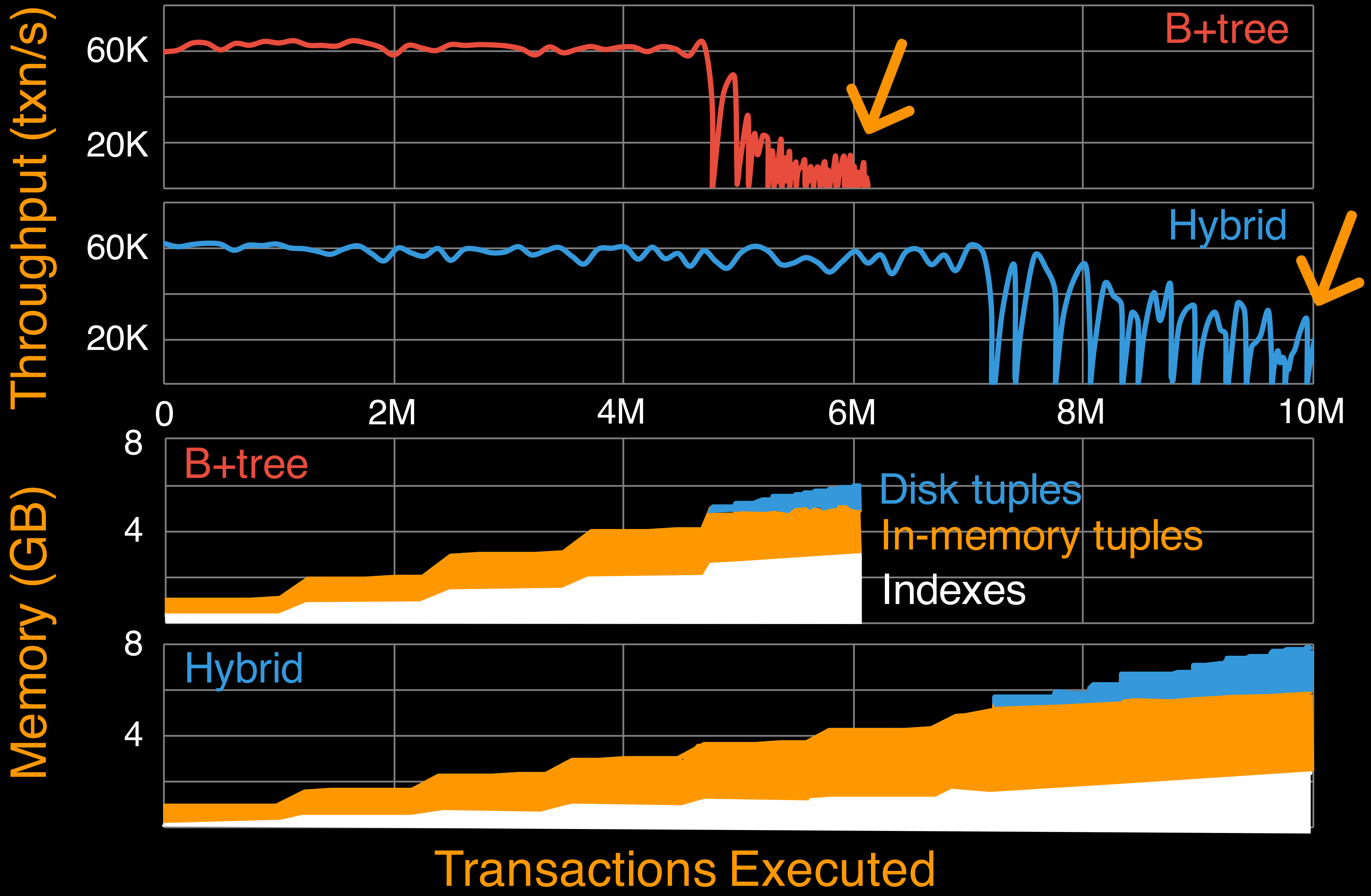
Yes, we improved the DBMS's capacity!

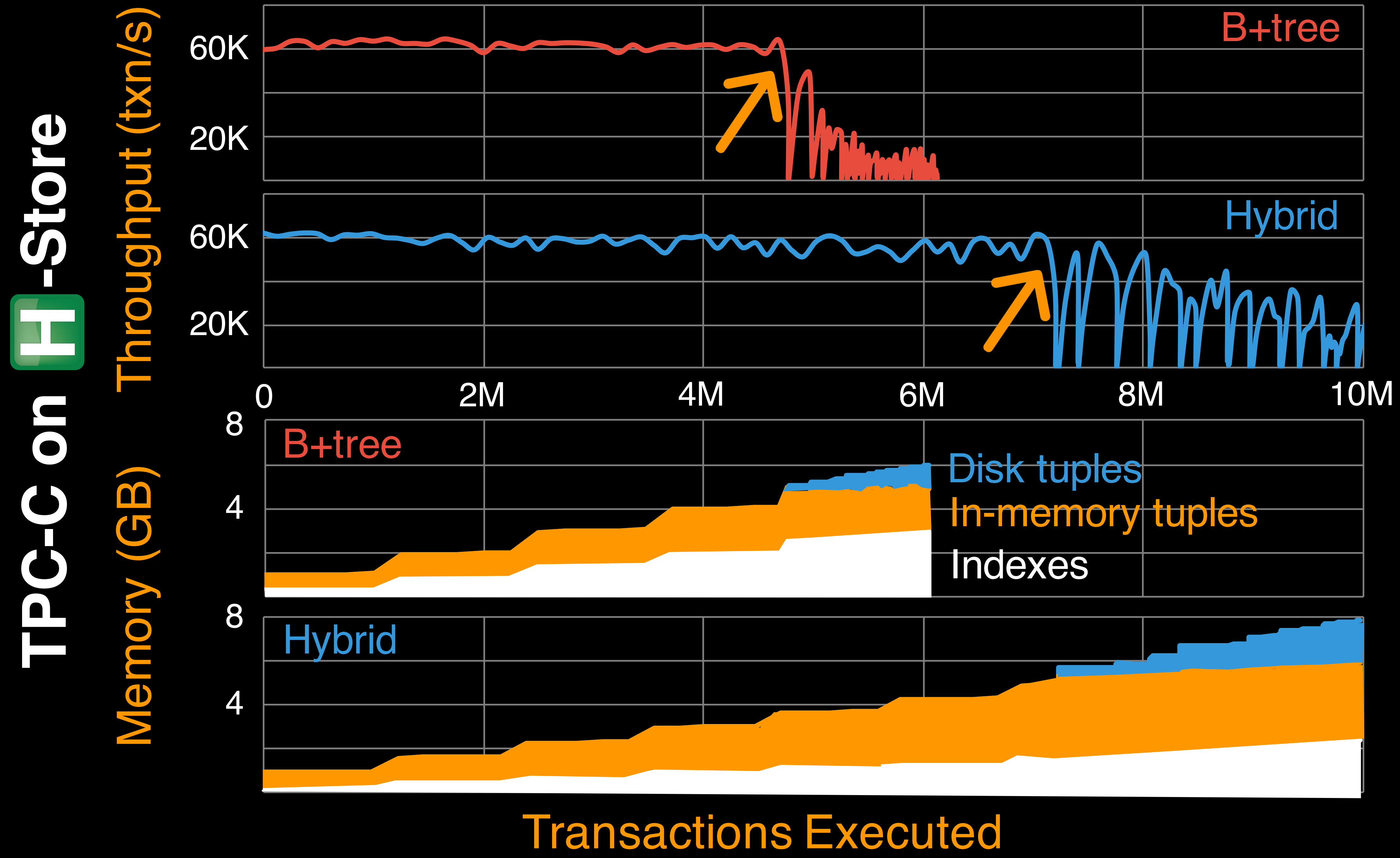




TPC-C on H-Store
Throughput (txn/s)
Memory (GB)
B+tree
Hybrid
60K
20K
0
2M
4M
6M
8M
10M
8
4
Disk tuples
In-memory tuples
Indexes
Transactions Executed

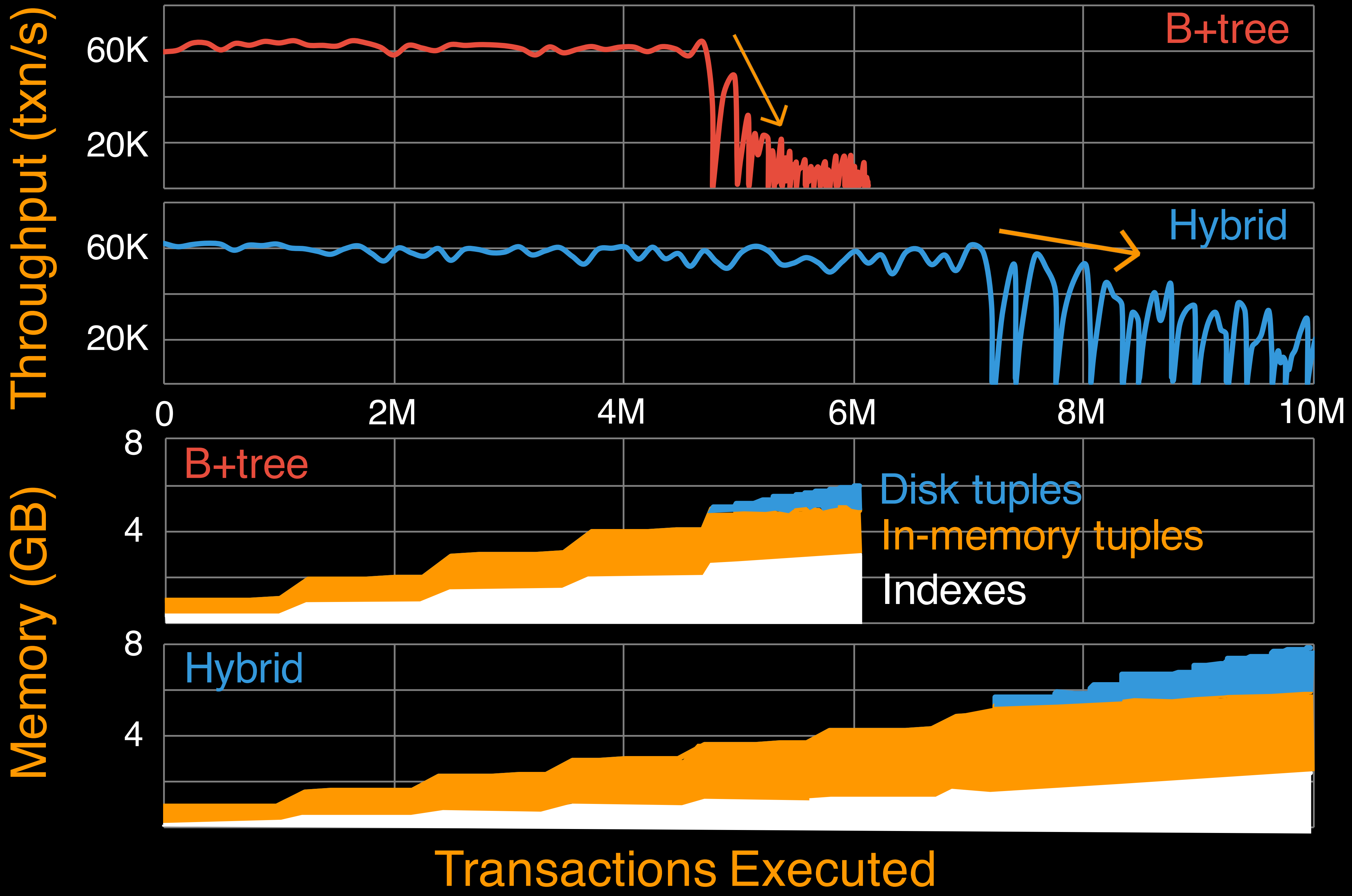
TPC-C on H-Store

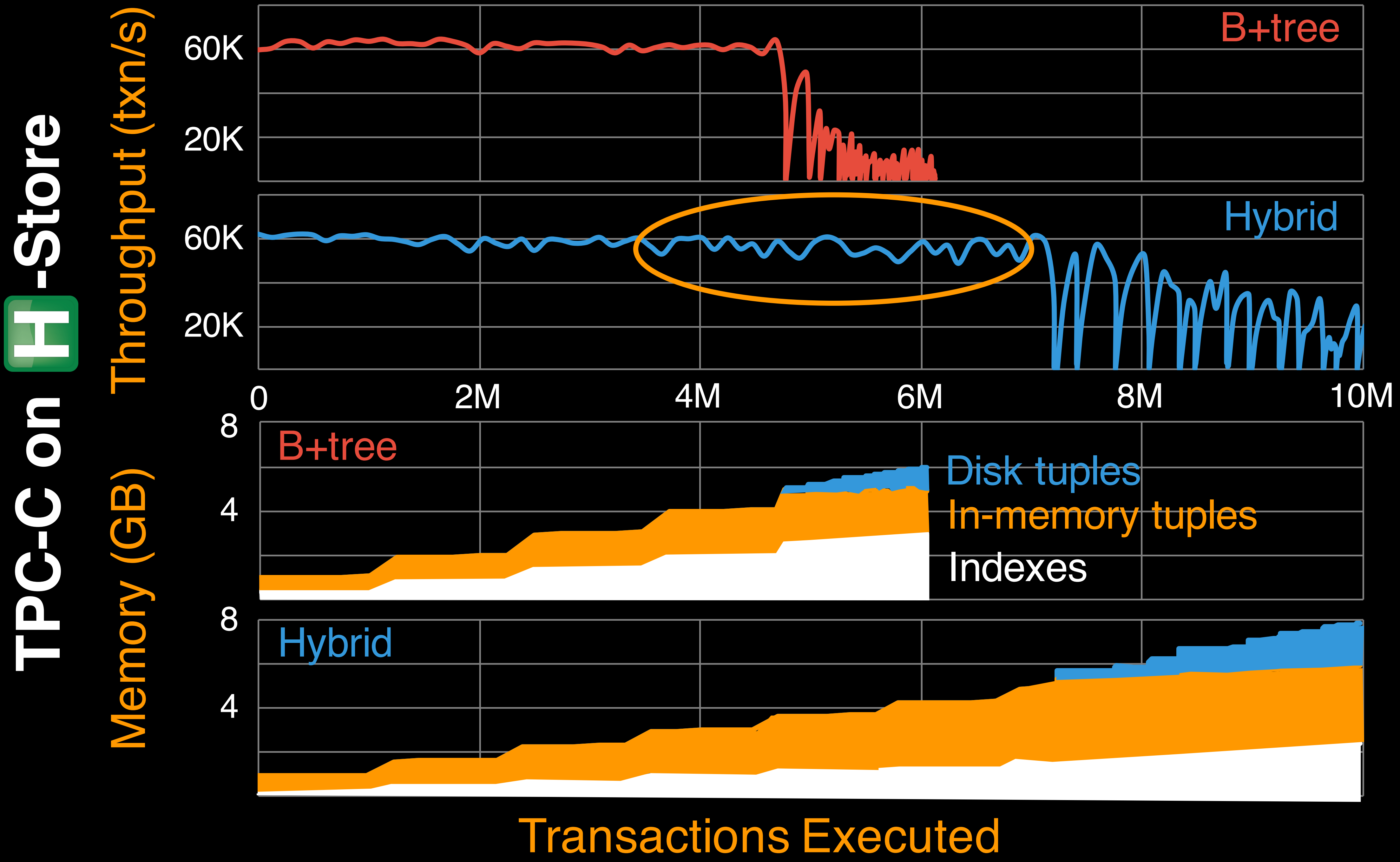




TPC-C on H-Store
Throughput (txn/s)
60K
20K
B+tree
Hybrid
0
2M
4M
6M
8M
10M
Memory (GB)
8
4
Disk tuples
In-memory tuples
Indexes
Transactions Executed

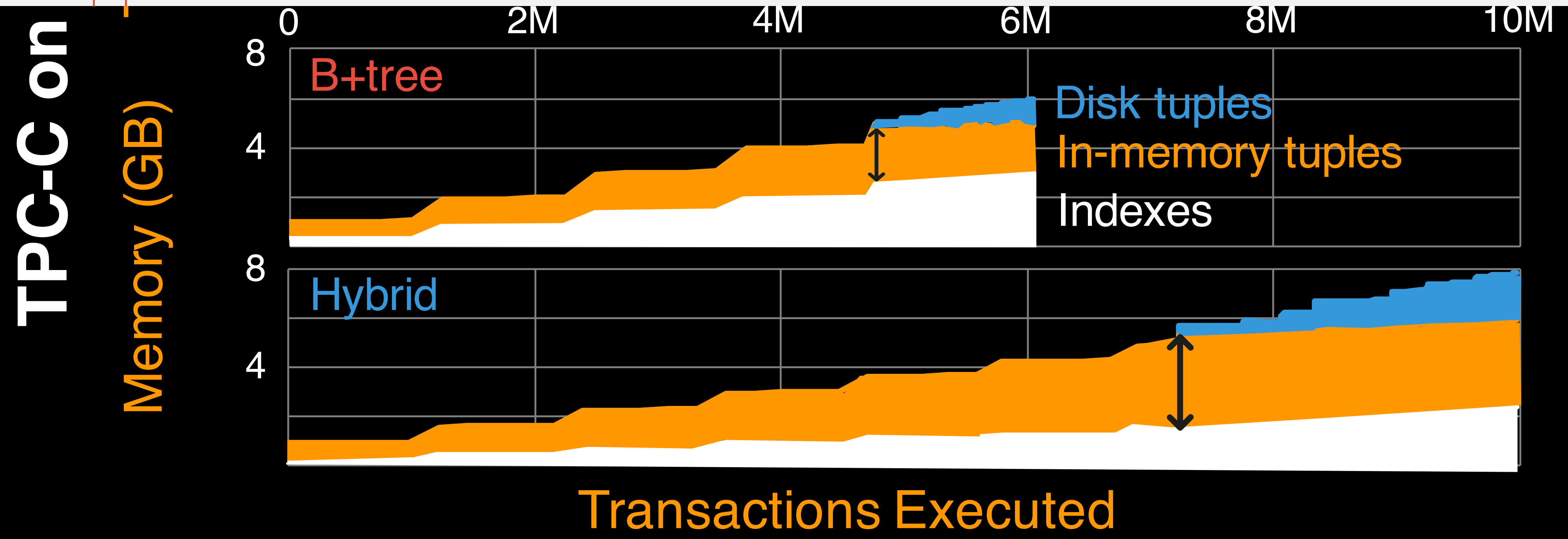
TPC-C on H-Store




TPC-C on H-Store
Throughput (txn/s)
60K
20K
B+tree
Hybrid
0
2M
4M
6M
8M
10M
Memory (GB)
8
4
Disk tuples
In-memory tuples
Indexes
Transactions Executed

Take Away:

Memory saved by indexes → Larger working set in memory → Higher throughput



This is just the **BEGINNING**

Conclusions

1. The hybrid index architecture **GENERAL**
2. The Dual-Stage Transformation **PRACTICAL**
3. Applied to 4 index structures **USEFUL**
   - B+tree
   - Skip List
   - Masstree
   - Adaptive Radix Tree (ART)

Toll-Free Hotline:

1-844-88-CMUDB