Pragh: Locality-preserving Graph Traversal with Split Live Migration

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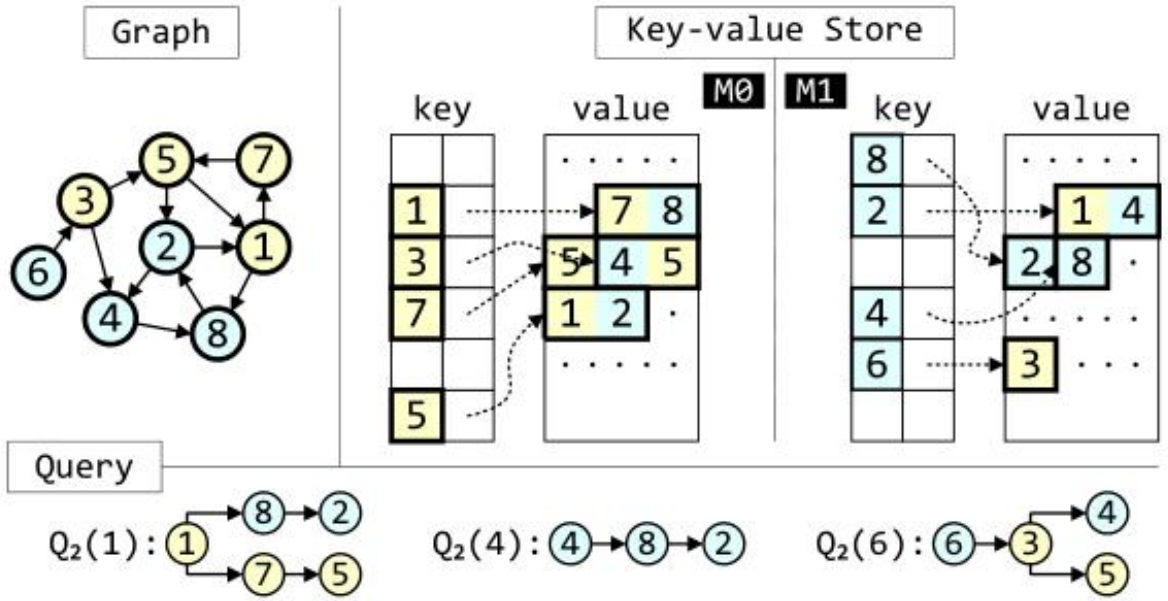
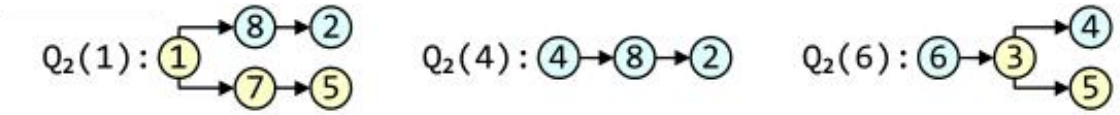
Background

➢**Graph Store and Traversal Workload**



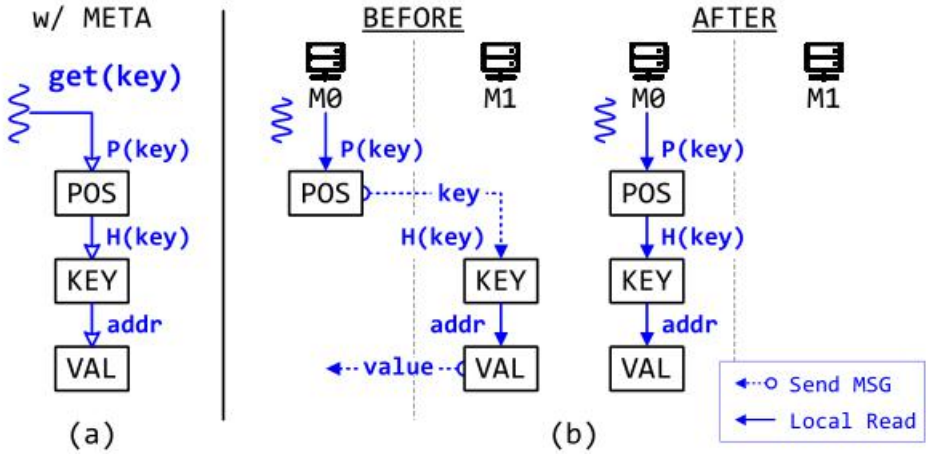
Motivation

- **Poor Locality and Partitioning**
  - For distributed in-memory stores



  - Locality-aware graph partitioning algorithms

- **Live migration**
  - Meta-data (POS)
  - Shard-based: Group the data into shards

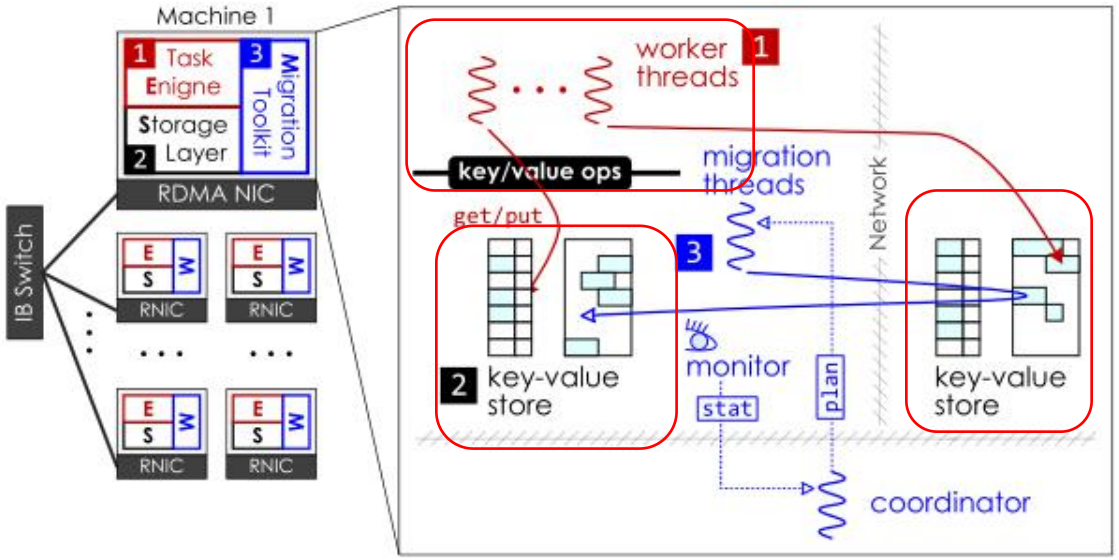


Overview

- **Design**
  - Pragh
  - Split live migration
    - Basic Split Migration *
    - Location cache
    - Lightweight Monitoring
    - Check-and-forward
- **Evaluation**
  - Migration Benefits & Speed & Migration Plan
- **Conclusion**

Architecture

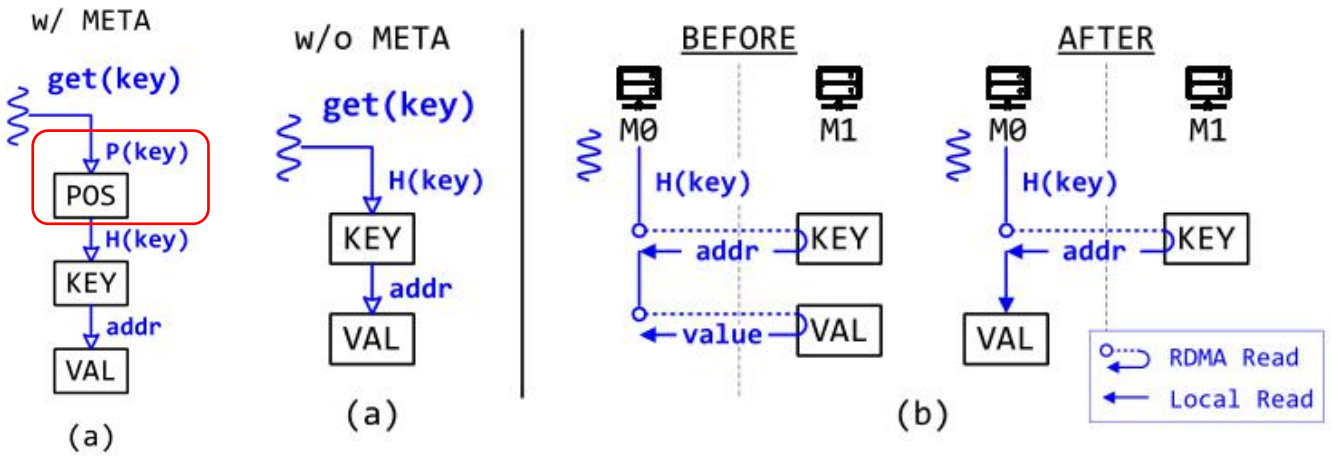
- **Pragh**



- Task engine : Worker thread(GET & PUT)
- Storage layer : RDMA-enabled key-value store
- Migration toolkit : Monitor & Coordinator & Migration threads

Design

➢ Basic Split Migration *



No need for metadata

➢Key is stationary (50% remote)

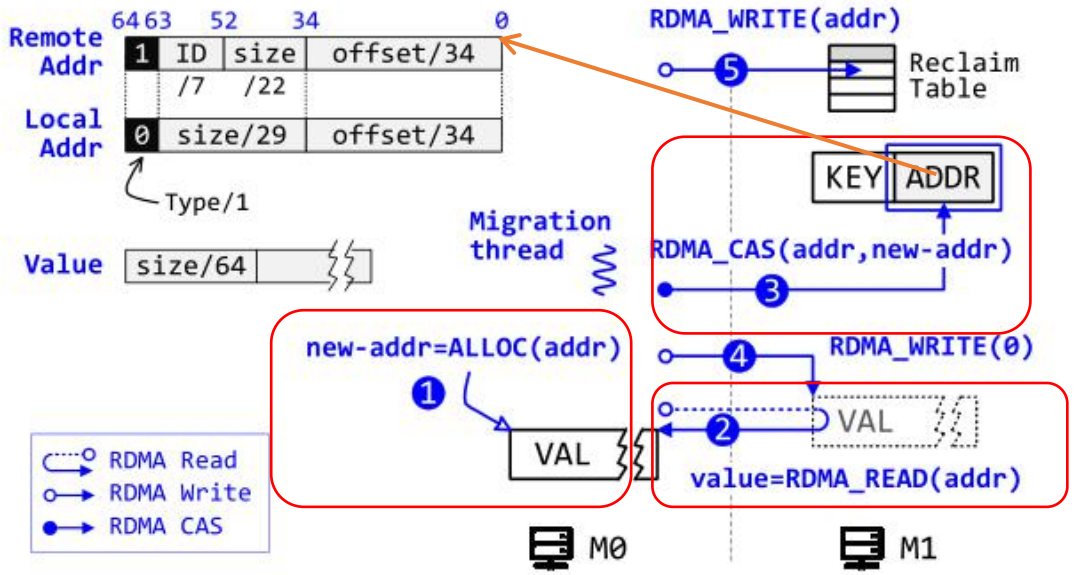
➢Only move the value to target machine

➢RDMA(Remote Direct Memory Access)

- READ & WRITE & CAS
- READ / WRITE to retrieve/update
- Compare-and-swap

Design

➢ Basic Split Migration



➢Address layout

➢Unilateral migration protocol

❶ Allocate memory space in local

❷ RDMA READ: retrieve the value

❸ RDMA CAS: original (local)→new (remote)

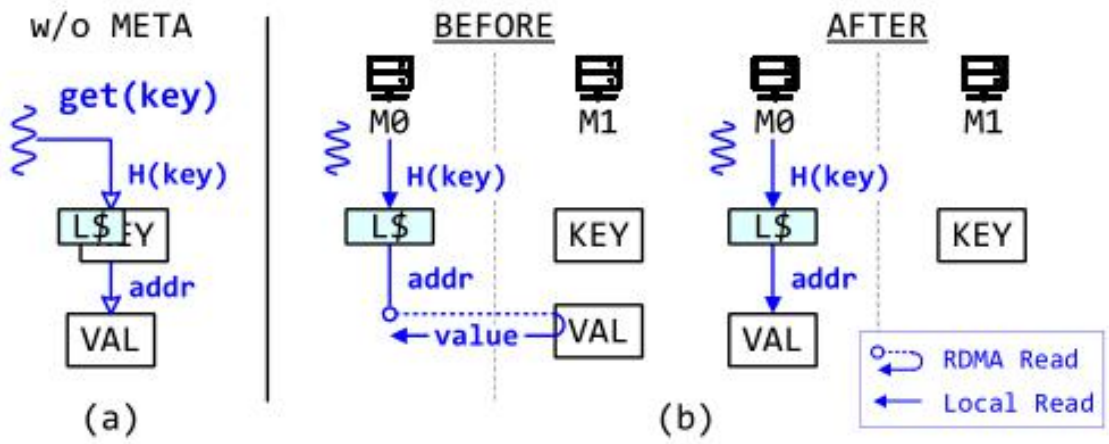
➢Invalidation and reclaim

❹ Invalidate the original memory→0

❺ Reclaim the memory of migrated

Design

- **Location cache**

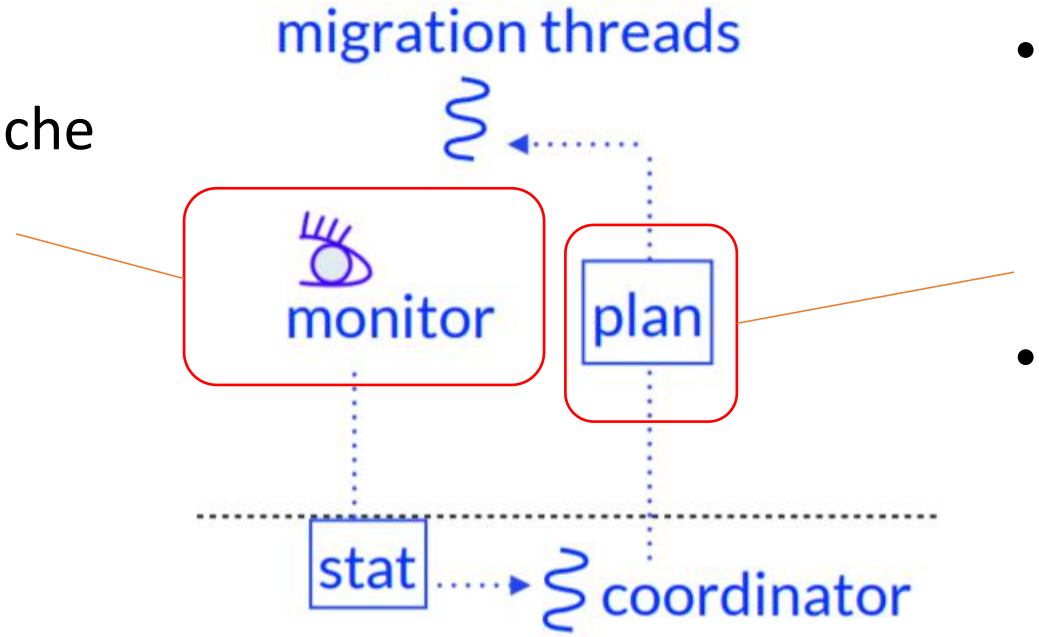


- (L$) stores the address of key-value pair
- Fully-localized

Design

➢Lightweight Monitoring

- Remote access
  Reuse location cache
- Local access
  Separate table

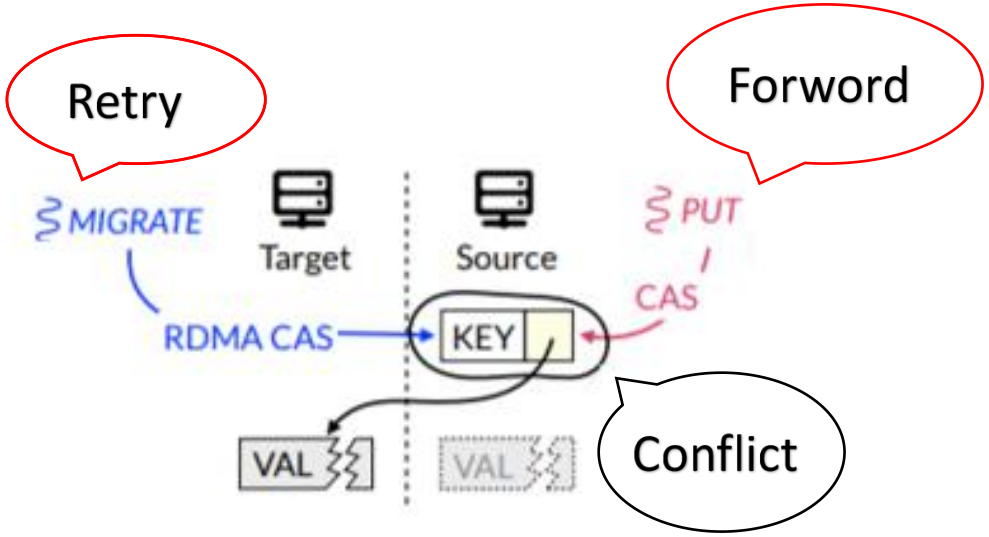


- Eager migration
  Eagerly approving &
  Second migration
- Deferred migration
  Track the local accesses
  using a separate table

Design

➢ **Full-fledged Split**

- Check-and-forward
- Detect conflicts in keys

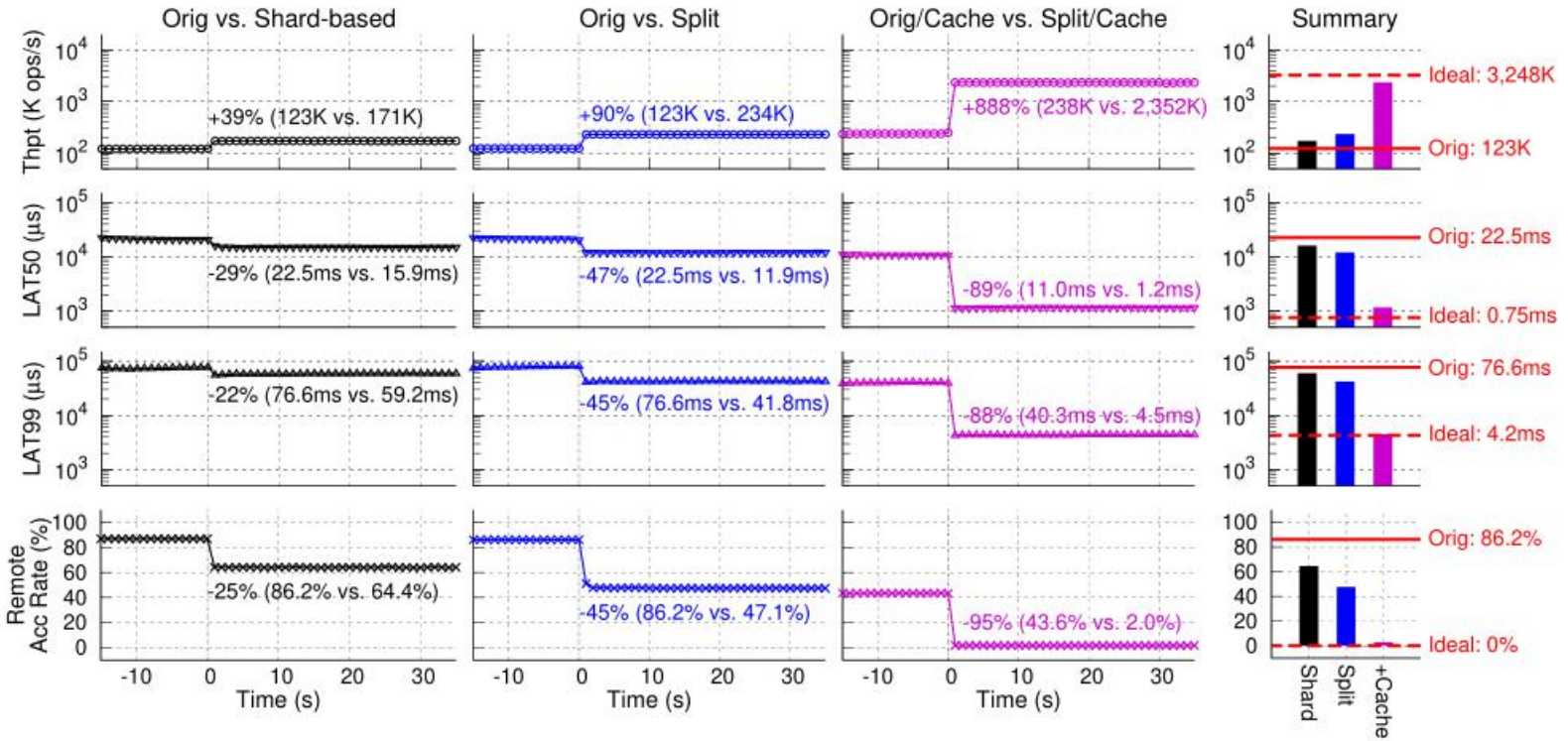


Evaluation

- **Traversal benchmark.**
  - Default dataset: graph with 2^26 vertices and 2^30 edges & rack-scale cluster with 8 nodes
  - 95% two-hop queries (Get) & 5% edge updates/inserts (Put)

Evaluation

➢Migration Benefits

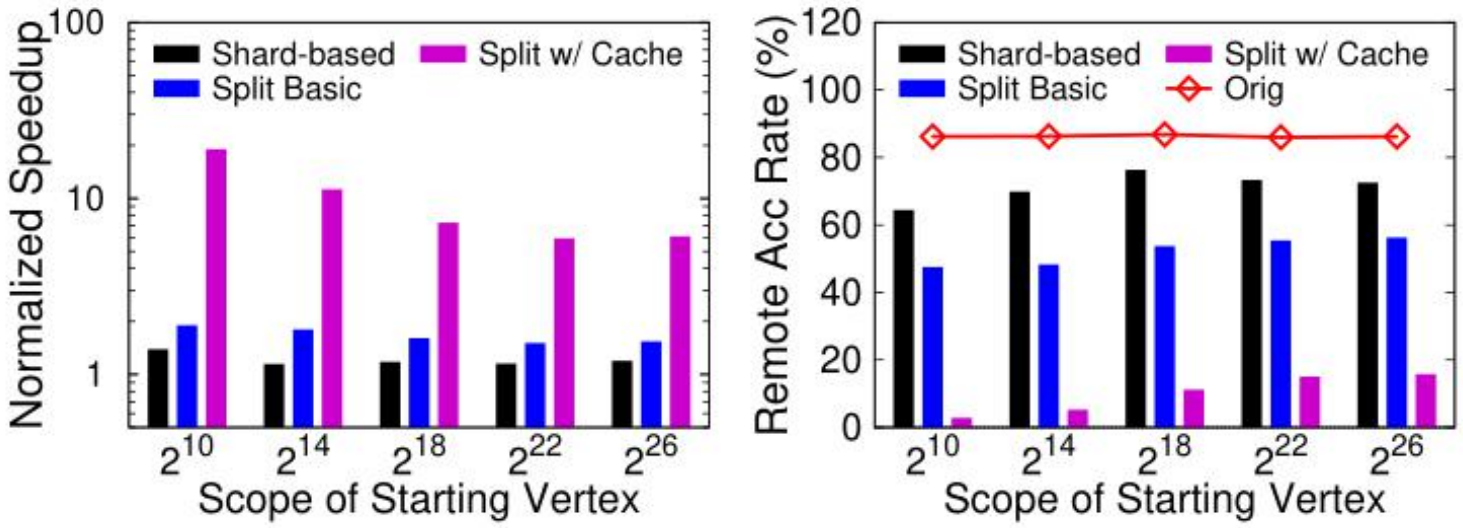


- ➢ Orig
- ➢ Ideal
- ➢ Shred-Based
- ➢ Split and Split/Cache

Pragh can almost double the throughput and reduce the latency by half

Evaluation

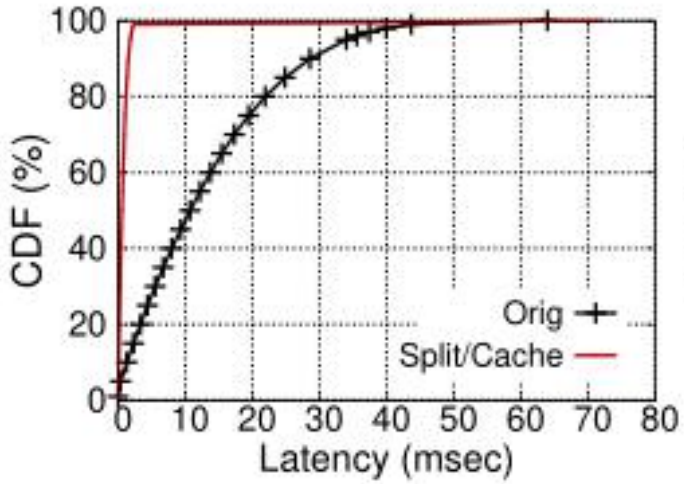
➢Migration Benefits

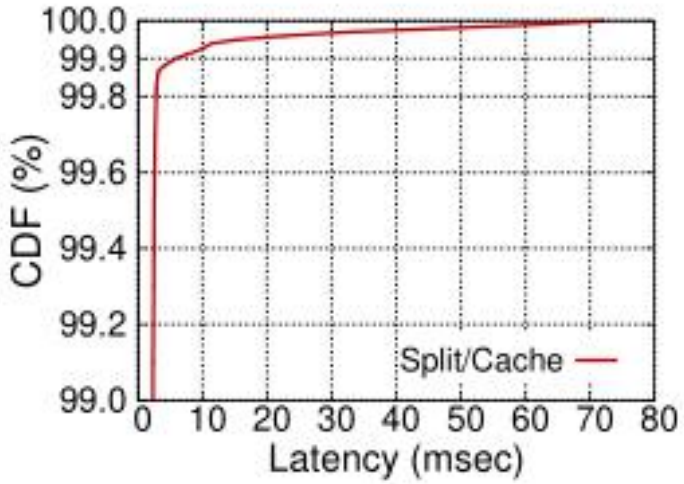


- The speedup decreases & the remote accesses increase with the increase of scope

Evaluation

➢Migration Benefits



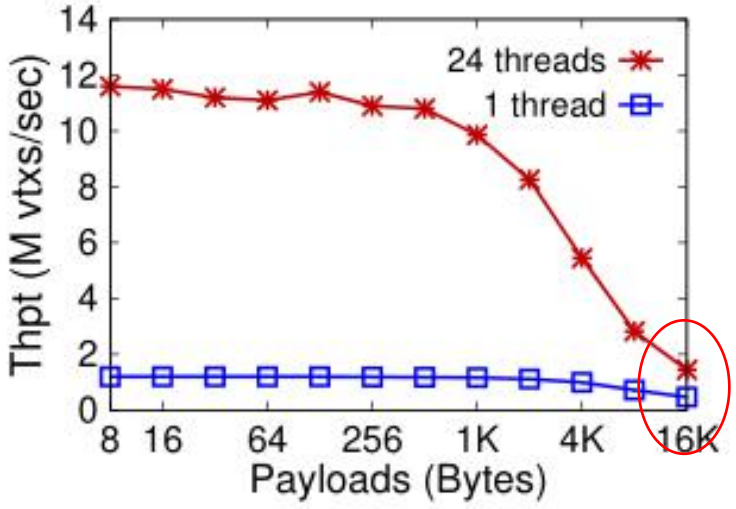


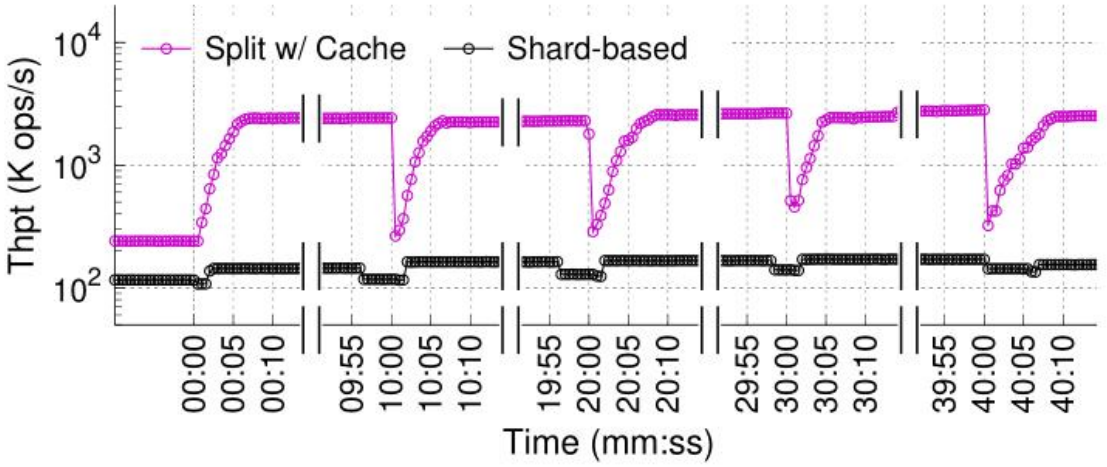
- 50% two-hop queries (Get) & 50% edge updates/inserts (Put)

- After migration, the latency of 99.9% Put operations decreases significantly, 0.11% Put operations→forwarded

Evaluation

➢Migration Speed

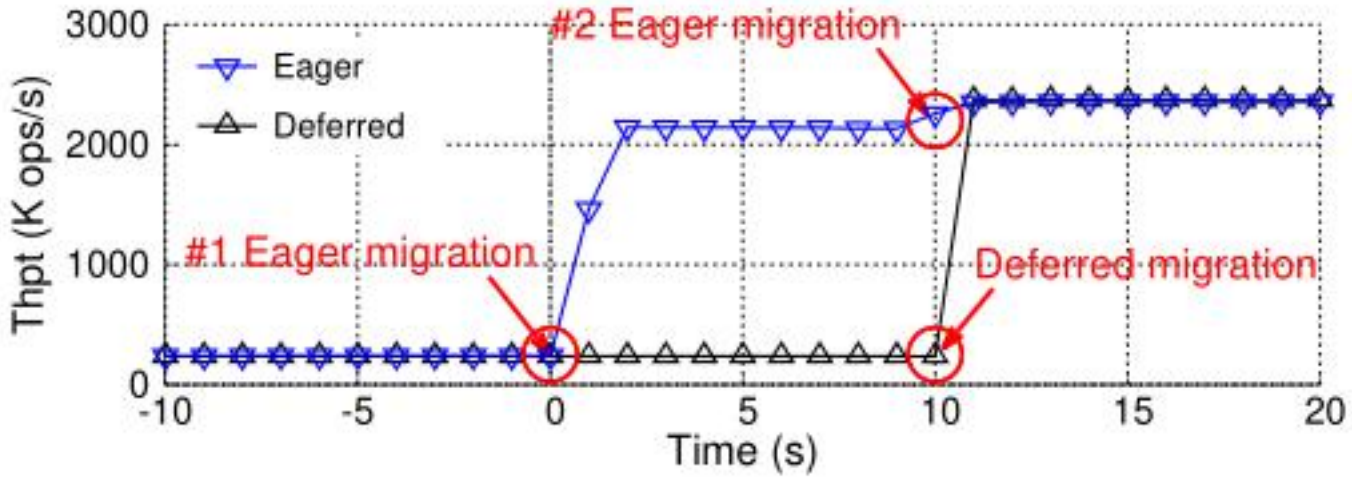




- With the increasing size of payloads, Thpt decreases ,a single thread is enough for 4KB
- The performance notably drops every time the workloads change

Evaluation

➢ **Eager Migration vs Deferred Migration**



- Eager : 0-starts directly, 10-second migration happens
- Deferred : 10-do the migration with an optimal plan

Conclusion

- **Pragh**
  - An efficient locality-preserving live migration
  - Split live migration:
    - Fine-grained migration & no nedd for metadata
    - Location cache
    - Lightweight Monitoring
- **Evaluation**
  - Migration Benefits & Speed & Migration Plan

Append

➢Hardware configuration

- Each node has two 12core Intel Xeon E5-2650 v4 processors and 128GB DRAM.Each node is equipped with two ConnectX-4 MCX455A, 100Gbps InfiniBand NIC via PCIe 3.0 x16 connected to a Mellanox SB7890 100Gbps IB Switch, and an Intel X540 10GbE NIC connected to a Force10 S4810P 10GbE Switch.

➢Wukong