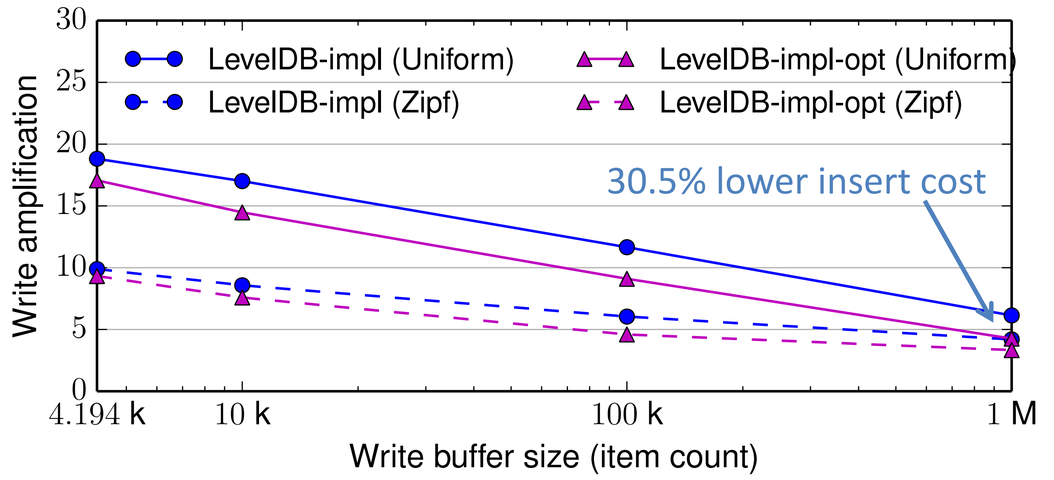
Towards Accurate and Fast Evaluation of Multi-Stage Log-Structured Designs

Hyeontaek Lim (CMU), David G. Andersen (CMU), Michael Kaminsky (Intel Labs)

Multi-Stage Log-Structured Design Evaluation

- Multiple stages of append-only logs to segregate fresh and old data
- Many system designs!
  - LevelDB, RocksDB, BigTable, HBase, Cassandra, …
- Developers need tools for accurate and fast evaluation
  - Which design is best for this workload?
  - How should the systems' parameters be set?
  - How sensitive is that choice to changes in workloads?

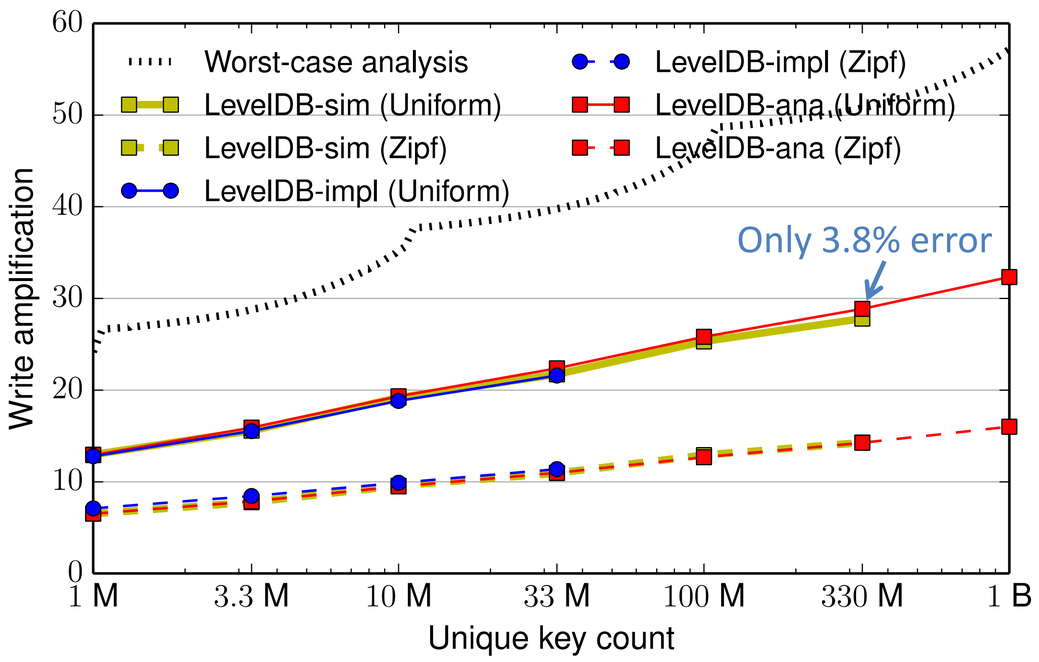


- LevelDB-impl: Default level sizes (10X increase at each level)
- LevelDB-impl-opt: Optimized level sizes

Problems of Prior Evaluation Methods

- Asymptotic analysis: Not very accurate
  - E.g., O(log N) of insert cost often overestimates real cost
- Experiment: Slow and often hard to generalize
  - E.g., Obtaining "12 k inserts/sec" may take hours to days

Accuracy & Speed of Our Method

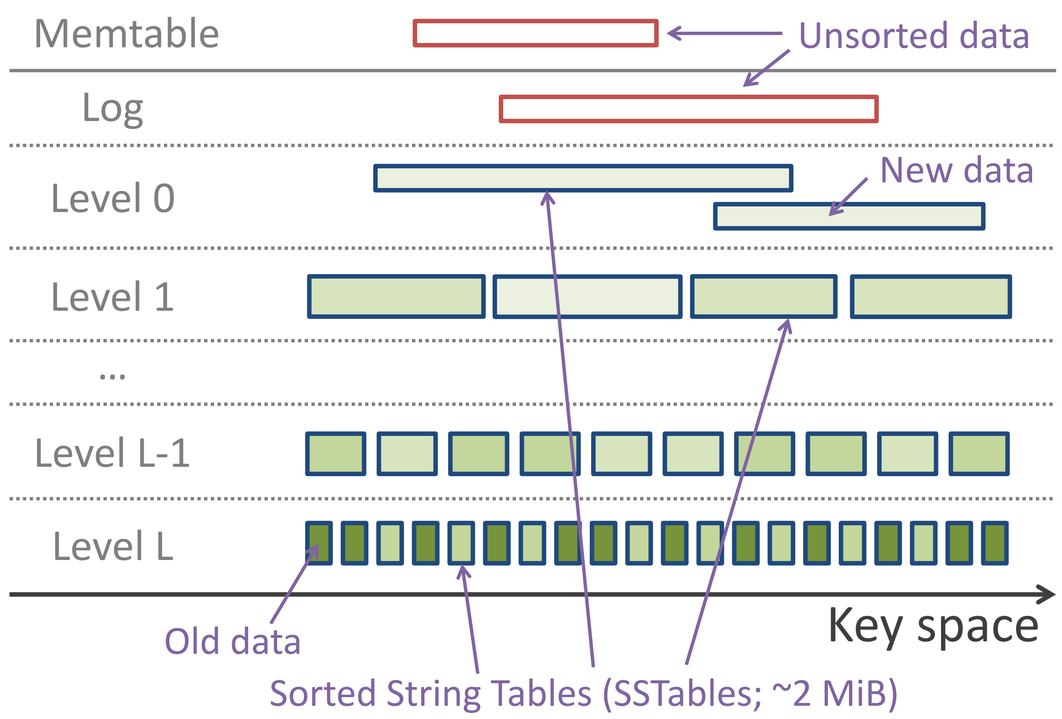


- LevelDB-ana: **Our LevelDB model**
  - 0.01 sec/eval for 100 M unique keys (orders of magnitude faster)
- LevelDB-sim: Our lightweight C++ LevelDB simulator
  - 12 mins/eval for 100 M unique keys
- LevelDB-impl: Full LevelDB implementation
  - 2.9 hours/eval for 10 M unique keys

Solution: New Analytic Primitives

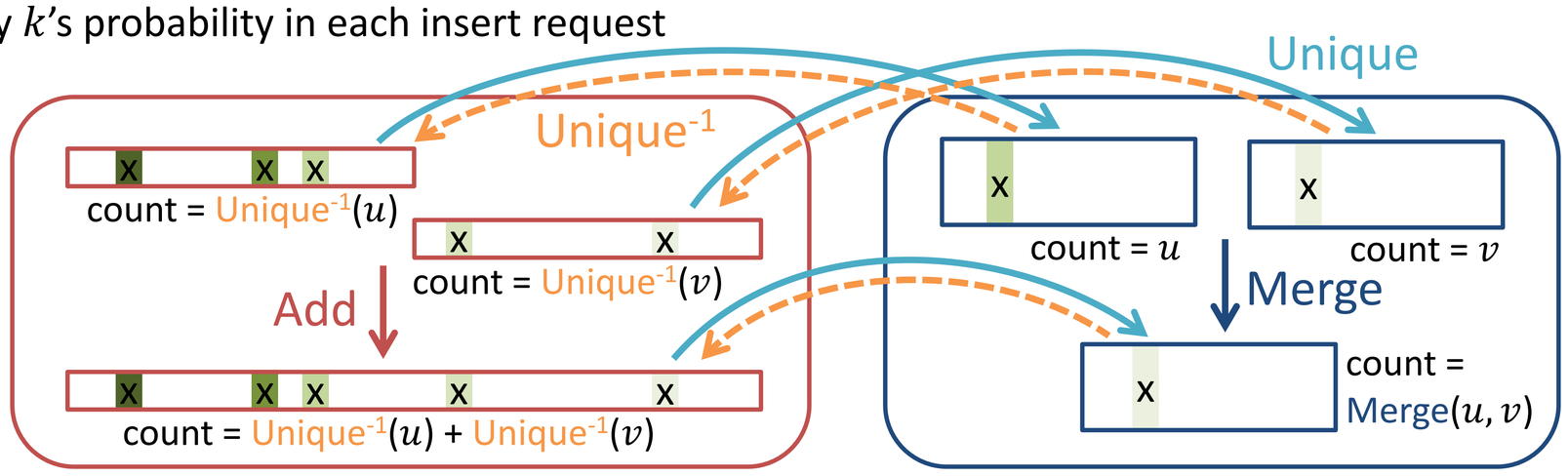
- Unique, Unique^{-1}, Merge
- Convert between **# of requests** and **# of unique keys**
  - Consider redundancy in the workload for high accuracy
- Allow building system models (not shown) to estimate performance metrics
  - How often do table merges occur?
  - How much data do they write?

Example Design: LevelDB



Details of New Analytic Primitives

- Let K be a set of unique keys, $f_X(k)$ be key k's probability in each insert request
- Unique(p): # of unique keys in p inserts
  = $|K| - \sum_{k \in K} \left(1 - f_X(k)\right)^p$
- Unique^{-1}(u): # of inserts for u unique keys
- Merge(u, v): # of unique keys after merging u and v unique keys
  = Unique(Unique^{-1}(u) + Unique^{-1}(v))



Intel Science & Technology Center for Cloud Computing
Carnegie Mellon University
Georgia Tech
intel
PRINCETON UNIVERSITY
UC Berkeley
UNIVERSITY of WASHINGTON