Log-Free Concurrent Data Structures

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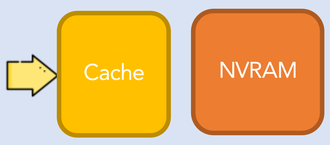
Introduction

- Designing fast data structures for NVRAM: **challenging**



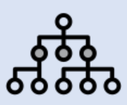
Writes might not reach NVRAM immediately

Crashes may occur at any time

Stores may not reach NVRAM in program order

Need expensive instructions for ordering & persistence

- Previous approaches: transactions & logging



1. Log intention
2. Apply to data structure
3. Log completion

easy to use

high overhead (need to wait for log)

Our objective

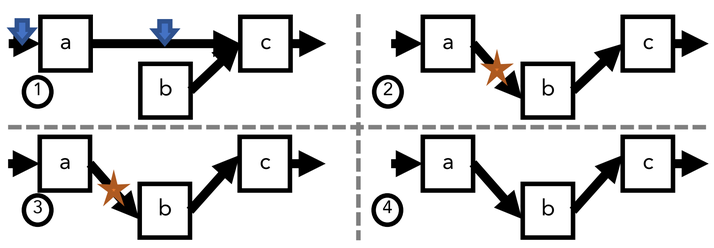
- Design durable concurrent data structures that do not perform any logging in the common case.

Our insights

- Lock-free algorithms are good candidates: they are always in a consistent (recoverable) state.
- Pointer marking can ensure store atomicity w/o logging
- Batching write-backs can improve throughput
- Locality in allocation & deallocation can be exploited to reduce or eliminate logging from memory management

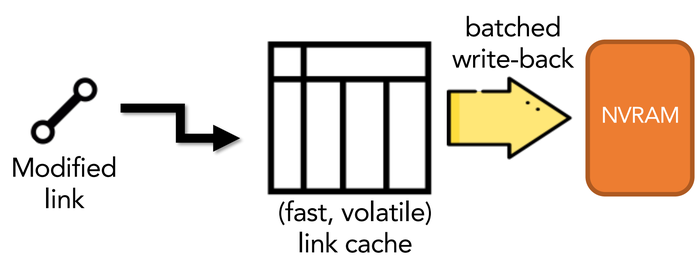
Our Techniques

Link-and-Persist



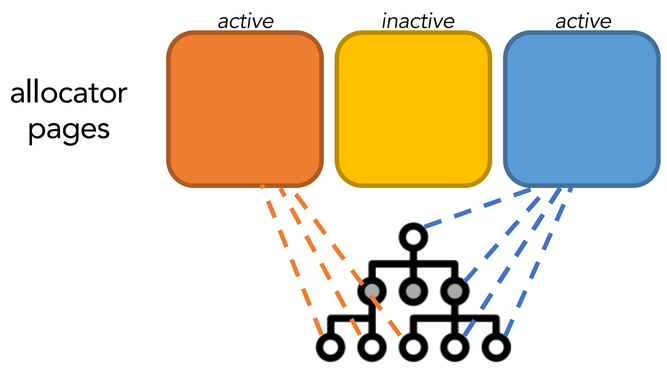
1. Prepare new node & persist dependent links
2. Link new node & add mark (★)
3. Make the new link persistent
4. Remove mark

Link Cache



- Cache modified data structure links and write them to NVRAM in batches → better performance.

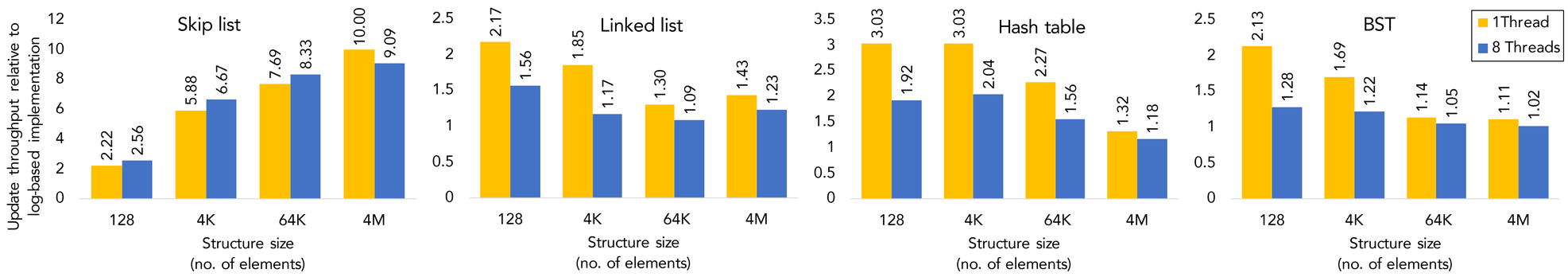
NV-Epochs



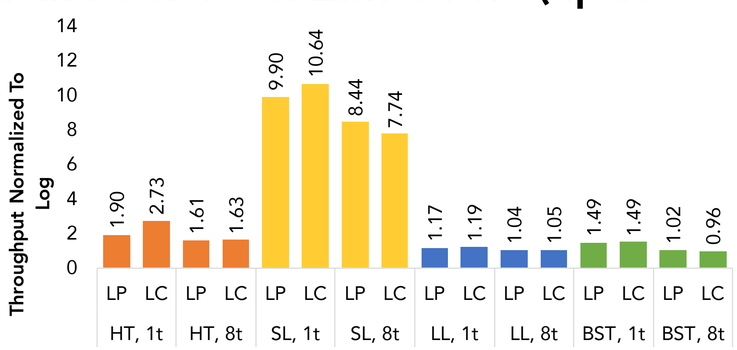
- Instead of logging each allocation/deallocation, keep track of active pages
- When there is locality, no need to log at all

Results

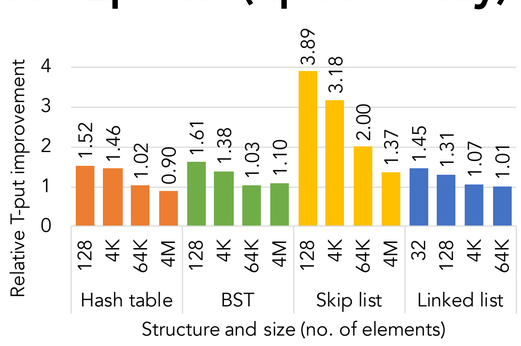
Log-free vs. log-based (update-only)



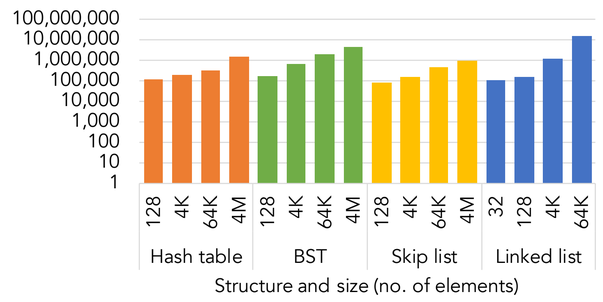
Link-and-Persist & Link Cache (update-only)



NV-Epochs (update-only)



Recovery time (ns)



Find out more in our paper & on our website:

T. David, A. Dragojević, R. Guerraoui, I. Zablotchi. Log-Free Concurrent Data Structures. 2018 USENIX Annual Technical Conference.
https://lpd.epfl.ch/site/nvram

This work has been supported in part by European Research Council Grant 339539 (AOC).

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