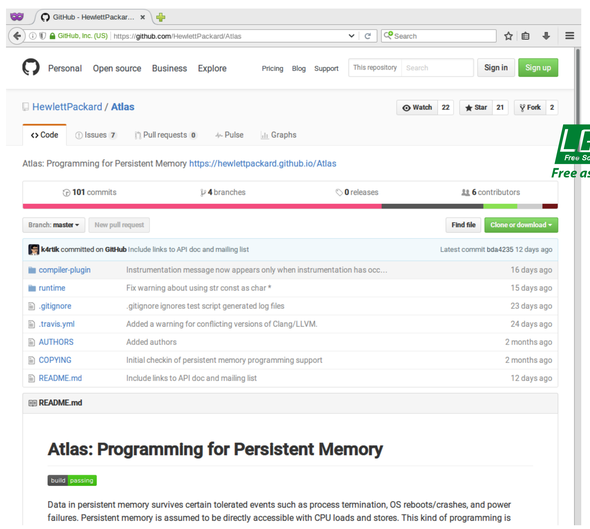
A Concurrent Crash-Resilient Graph Data Structure for Non-Volatile Memory

Problem Statement

- Real-time analysis on large dynamically changing graph datasets is a hard problem
- Current practice is to prepare read-only snapshots for analysis.
- Problems with current practice:
  - Taking snapshots can take considerable time, which slows down analysts
  - Global lock on the graph store conflicts with updates, that need to be throttled
  - Recording and replaying large input streams infeasible
  - No support for crash resilience

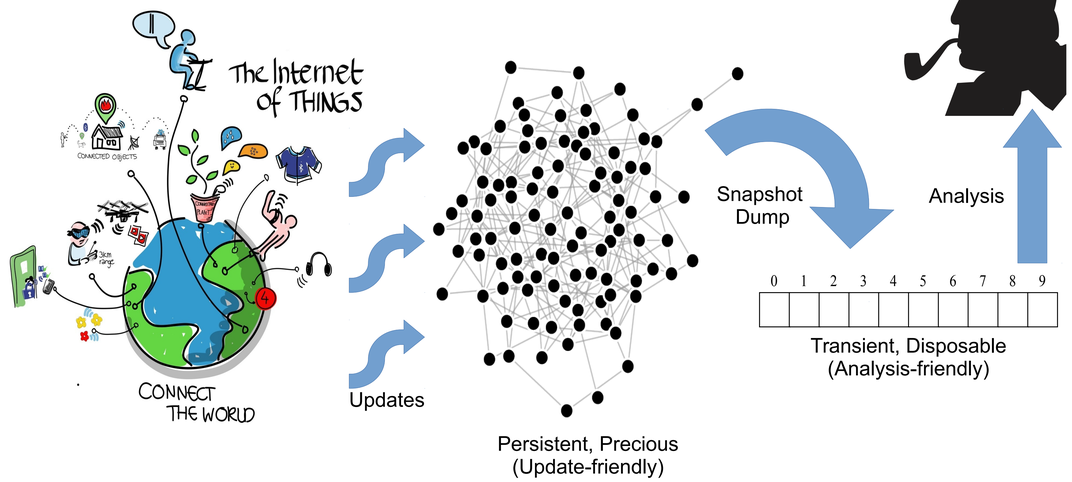
Atlas

- Programming model for durability guarantees on persistent memory
  - Persistency API
    - `nvm_{alloc,free}()`
    - `NVM_{Create,Delete,Find}Region()`
  - Consistency API
    - `NVM_{BEGIN,END}_DURABLE()`
  - Runtime automatically identifies critical sections as Failure-Atomic SEctions (*FASEs*), provides all or nothing guarantee
- *Transforms lock-based multi-threaded code to crash resilient code*
- Open Source: https://github.com/HewlettPackard/Atlas

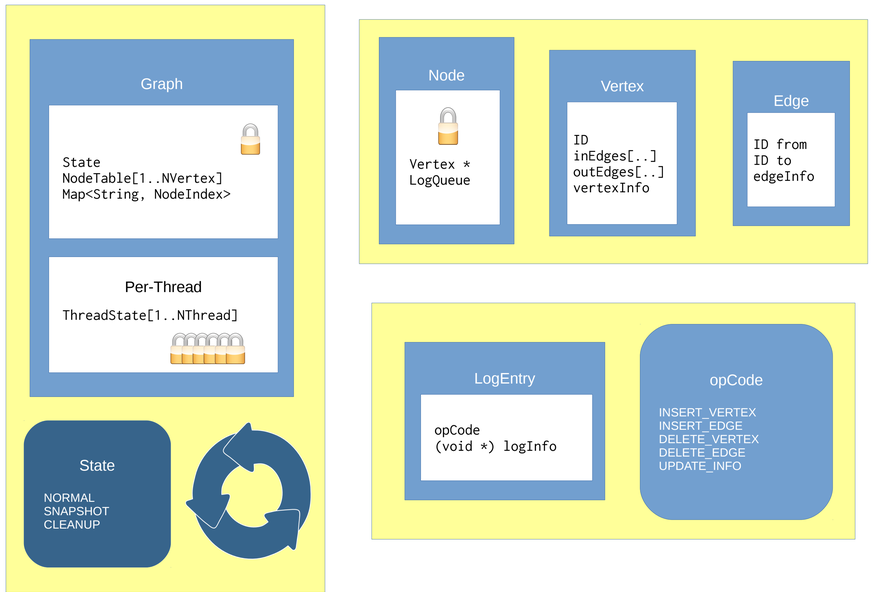


LGPL Free Software Free as in Freedom

The Big Picture



Data Structure Design



Our Approach

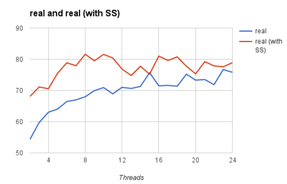
- Taking read-only snapshots dumps is a sensible approach but can be made faster
- Keep primary graph in persistent memory:
  - Allows efficient updates
  - Provide crash resilience with Atlas runtime for precious data, ie, recover to consistent state in case of failure
- Take periodic time-and-space efficient snapshot dumps in transient memory for analysis – Compressed Sparse Row (CSR) format
- *Challenge*: Obtaining efficient and consistent snapshot dumps concurrently without throttling updates to the persistent graph store

Preliminary Results



Time for V=1M, E=~7.6M inserts

Same with periodic snapshots (1 per second)



Comparison of wall clock time for just inputs vs inputs with periodic snapshots

Hardware and Software Configuration:
Intel(R) Xeon(R) CPU X5650 @ 2.67GHz
6 core, 2 hyper-threads per core
Ubuntu 16.04.1
Linux kernel 4.4

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