ArangoDB

The Computer Science behind a Modern Distributed Database

Chicago / February 20, 2018

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Overview

Topics

- Resilience and Consensus
- Sorting
- Log-structured Merge Trees
- Hybrid Logical Clocks
- Distributed ACID Transactions

Bottom line: You need CompSci to implement a modern data store

Resilience and Consensus

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(And we have not even talked about malicious attacks and enemy action.)

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But most importantly: **DO NOT TRY TO INVENT YOUR OWN!**

Raft in a slide

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- Very **smart logic** to ensure a **unique leader** and **automatic recovery from failure**.
- It is all **a lot of fun** to get right, but it is **proven to work**.
- One puts a **key/value store** on top, the log contains the **changes**.

Demo

`http://raft.github.io/raftscope/index.html`

(by Diego Ongaro)

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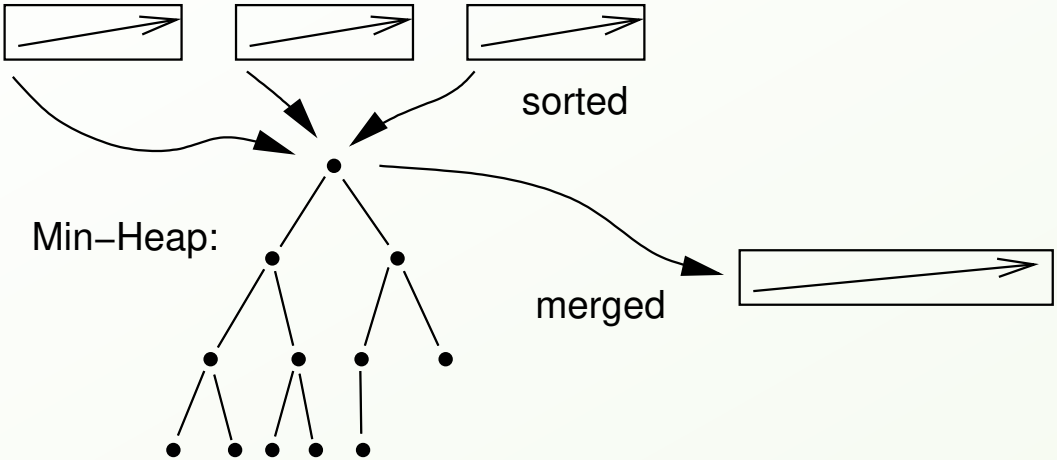
Since 1983 and the Apple IIe,

- compute power in one core has increased by about $\times$**20000**
- and now we have 32 cores in some CPUs
- a single memory access only by about $\times$**40**
- this means **computation** has outpaced **memory access** by $\times$16000!

Idea for a parallel sorting algorithm: Merge Sort



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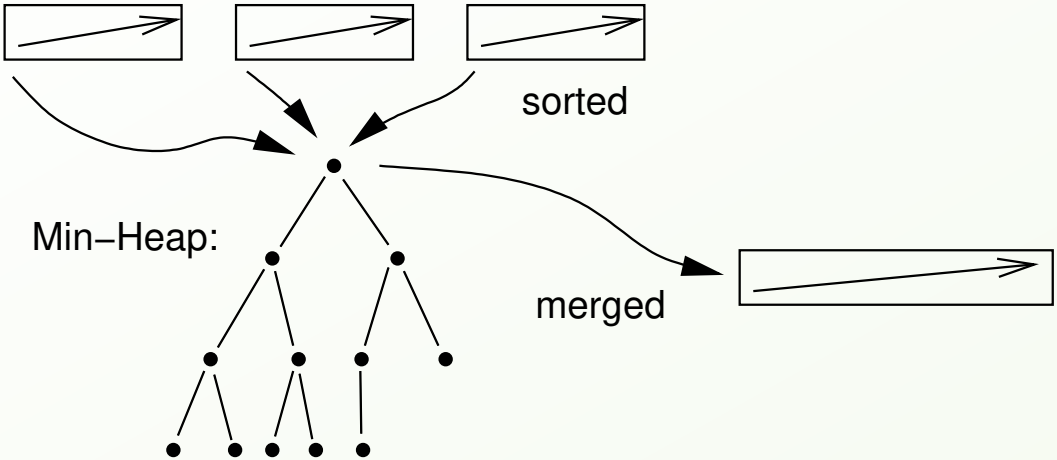

Nearly all comparisons hit the L2 cache!

Log structured merge trees (LSM-trees)

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People rightfully expect from a data store, that it

- can hold **more data than the available RAM**,
- works well **with SSDs and spinning rust**,
- **allows fast bulk inserts** into large data sets, and
- **provides fast reads** in a hot set that fits into RAM.

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Traditional B-tree based structures **often fail to deliver** with the last 2.

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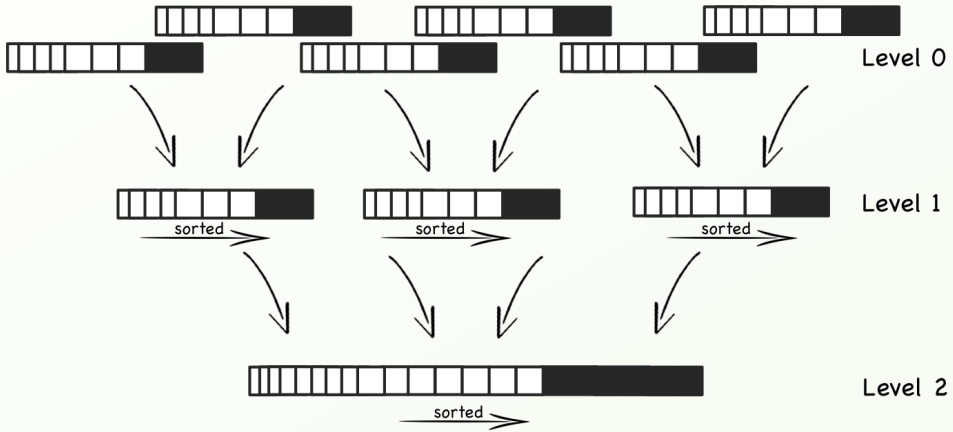

Compaction continues creating fewer, larger and larger files

(Source: `http://www.benstopford.com/2015/02/14/log-structured-merge-trees/`, Author: Ben Stopford, License: Creative Commons)

Log structured merge trees (LSM-trees)

LSM-trees — summary

- writes **first go into memtables**,
- all files are **sorted** and **immutable**,
- **compaction** happens in the background,
- efficient **merge sort** can be used,
- all writes use **sequential I/O**,
- **Bloom filters** or **Cuckoo filters** for fast negatives,
- $\Longrightarrow$ **good write throughput** and **reasonable read performance**,
- used in ArangoDB, BigTable, Cassandra, FaunaDB, HBase, InfluxDB, LevelDB, MarkLogic, MongoDB, MySQL, RocksDB, SQLite4, WiredTiger, etc.

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Why would this help?

- establish **"happened after"** relationship between events,
- e.g. for **conflict resolution**, **log sorting**, **detecting network delays**,
- **time to live** could be implemented easily.

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$$\textbf{causality} \iff \textbf{a message is sent}$$

Send a time stamp **with every message**. The HLC always returns a value

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Causality is preserved, time can **"catch up"** with logical time eventually.

`http://muratbuffalo.blogspot.com.es/2014/07/hybrid-logical-clocks.html`

Distributed ACID Transactions

Atomic — either happens **in its entirety** or **not at all**

Consistent — reading **sees a consistent state**, writing **preserves consistency**

Isolated — concurrent transactions **do not see each other**

Durable — committed writes are **preserved after shutdown and crashes**

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(All relatively doable when transactions happen one after another!)

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We have to take **replication**, **resilience** and **failover** into account.

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Distributed databases without ACID transactions:
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$\Longrightarrow$ **Very few distributed engines promise ACID, because this is hard!**

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  - be **resilient** in case of fail-over **(fault-tolerance)**.
- **Transaction visibility** needs to be implemented (MVCC), so comparing time stamps play a crucial role.

Thank you!

Further questions?

- Follow us on twitter: `@arangodb`
- Join our slack: `slack.arangodb.com`
- Download and documentation: `https://arangodb.com`
- Issues and source (Star us!):
  `https://github.com/arangodb/arangodb`
- Info and slides:
  `https://arangodb.com/speakers/daniel-larkin-york`

Links

http://the-paper-trail.org/blog/consensus-protocols-paxos

https://raft.github.io

https://en.wikipedia.org/wiki/Merge_sort

http://www.benstopford.com/2015/02/14/log-structured-merge-trees/

http://muratbuffalo.blogspot.com.es/2014/07/hybrid-logical-clocks.html

https://research.google.com/archive/spanner.html

https://www.cockroachlabs.com/docs/cockroachdb-architecture.html

https://www.arangodb.com

http://mesos.apache.org