NoSQL and ACID

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FOUNDATIONDB

NoSQL’s Motivation

Make it easy to build and deploy applications.

- ✓ Ease of scaling and operation
- ✓ Fault tolerance
- ✓ Many data models
- ✓ Good price/performance
- X **ACID transactions**

What if we had ACID?

Only good for financial applications?

Big performance hit?

Sacrifice availability?

Nope… When NoSQL has ACID, it opens up a very different path.

The case for ACID in NoSQL

Bugs don’t appear under concurrency

- ACID means *isolation*.
- Reason *locally* rather than *globally*.
  - If every transaction maintains an invariant, then multiple clients running any combination of concurrent transactions also maintain that invariant.
- The impact of each client is *isolated.*

Isolation means strong abstractions

- Example interface:
  - **storeUser**(name, SSN)
  - **getName**(SSN)
  - **getSSN**(name)
- Invariant: **N == getName(getSSN(N))**
  - Always works with single client.
  - Without ACID: Fails with concurrent clients.
  - With ACID: Works with concurrent clients.

Remove/decouple data models

- A NoSQL database with ACID can provide **polyglot** data models and APIs.
  - *Key-value, graph, column-oriented, document, relational, publish-subscribe, spatial, blobs, ORMs, analytics, etc…*
- Without requiring separate physical databases. **This is a huge ops win.**

Limited ACID

- Compare-and-set
- Partial ACID

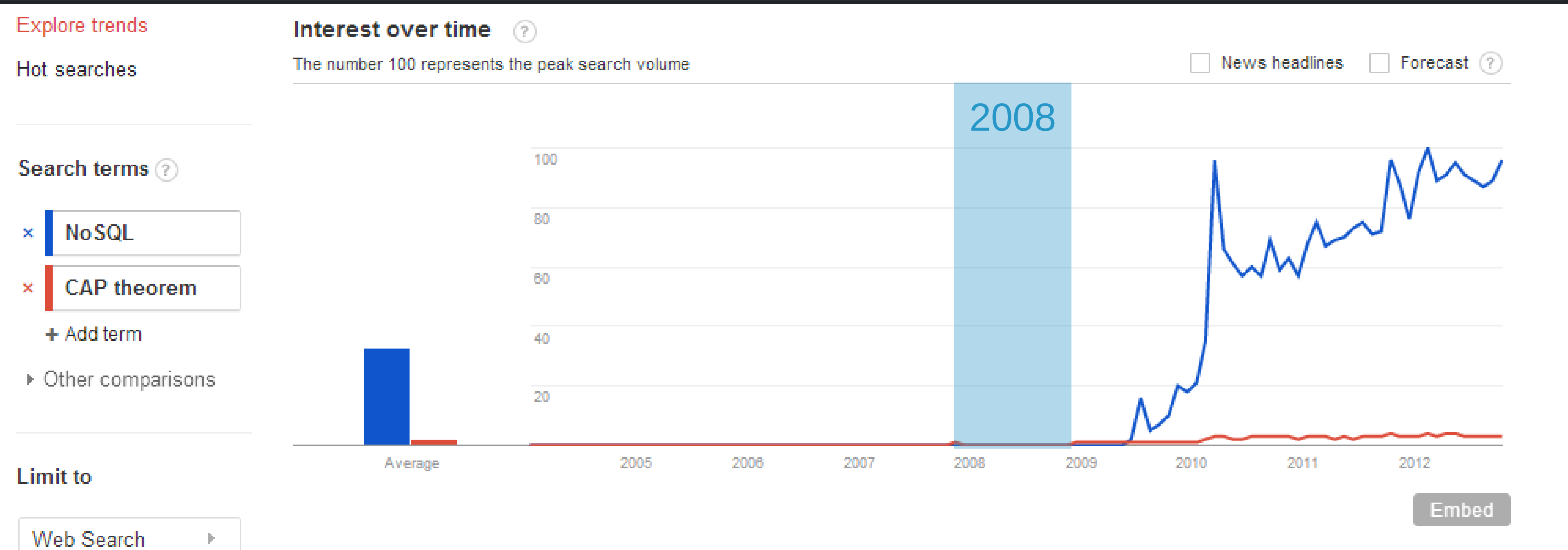
Useful, but don’t enable strong abstractions or correct-by-default code

So, why don't we have ACID?

- History.
- It’s hard.

History

Historical Perspective: 2008



In 2008, NoSQL doesn't really exist yet.

The CAP_{2008} theorem

“Pick **2 out of 3**”

- Eric Brewer

The CAP$_{2008}$ theorem

"**Data inconsistency** in large-scale reliable distributed systems **has to be tolerated** … [for performance and to handle faults]"

- **Werner Vogles (CTO Amazon.com)**

CAP_{2008} Conclusions?

- Scaling requires distributed design
- Distributed requires high availability
- Availability requires no C

So, if we want scalability we have to give up C, a cornerstone of ACID, right?

Thinking about CAP_{2008}

CAP availability != High availability

Fast forward to CAP_{2013}

“Why **’2 out of 3’ is misleading**”

“CAP prohibits… **perfect availability**”

- Eric Brewer

Fast forward to CAP_{2013}

"Achieving strict consistency can come at a **cost** in update or read **latency**, and may result in lower **throughput**…"

- Werner Vogles (Amazon CTO)

Fast forward to CAP_{2013}

"…it is better to have application programmers deal with performance problems due to overuse of transactions as bottlenecks arise, rather than always coding around the lack of transactions."

- Google (Spanner)

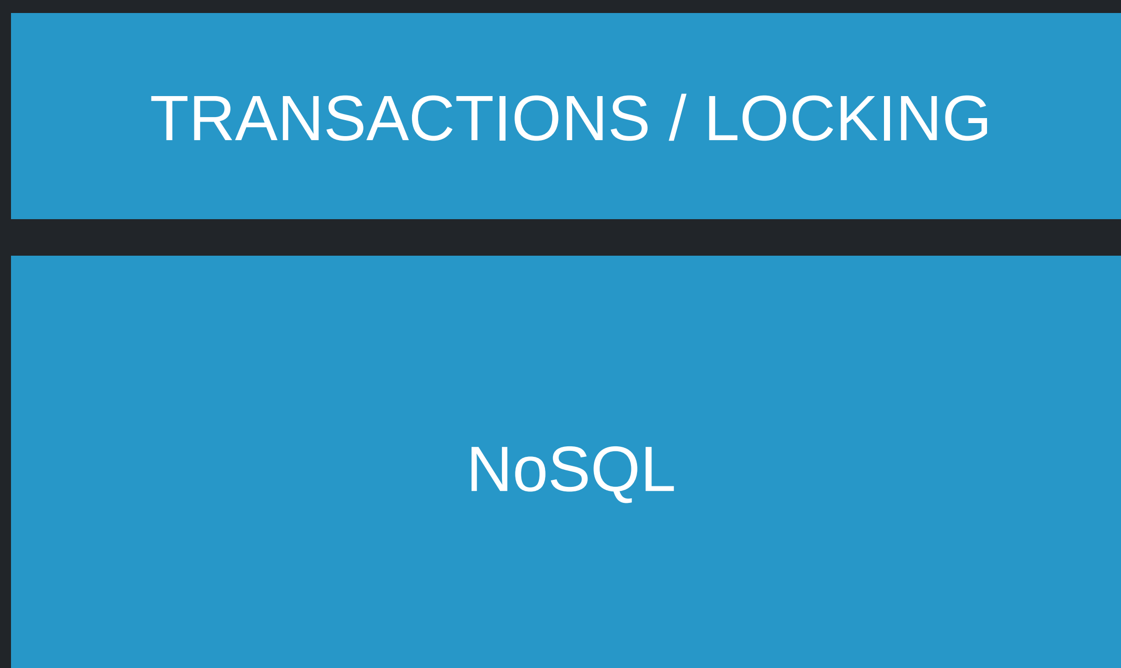
ACID is Hard

The ACID NoSQL plan

- Maintain both **scalability** and **fault tolerance**
- Leverage CAP_{2013} and deliver a CP system with true **global ACID transactions**
- Enable abstractions and **many data models**
- Deliver high per-node **performance**

Bolt-on approach

Bolt transactions on top of a database without transactions.



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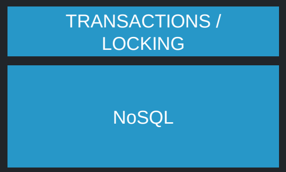
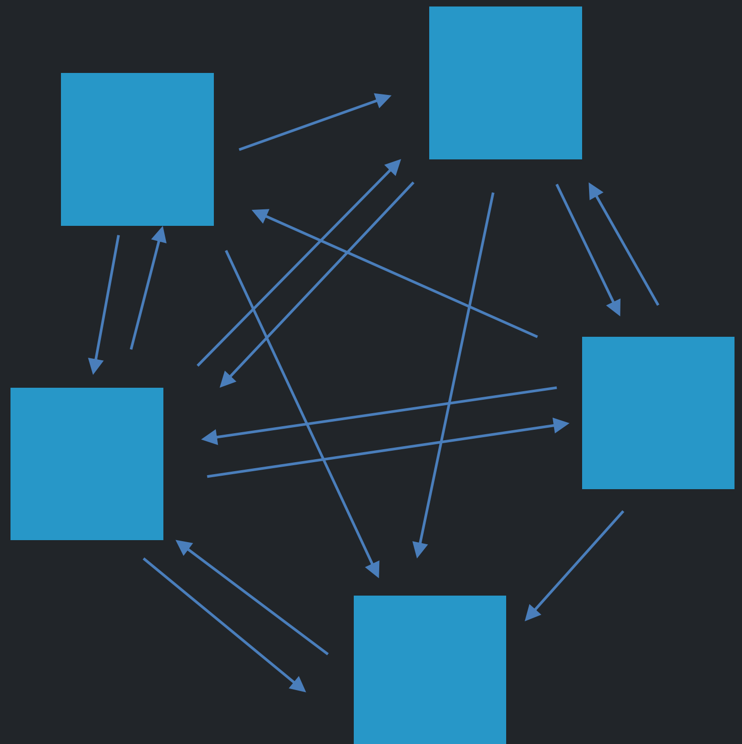


- **Upside**: Elegance.
- **Downsides**:
  - Nerd trap
  - Performance. "…integrating multiple layers has its advantages: integrating concurrency control with replication reduces the cost of commit wait in Spanner, for example" -Google

Transactional building block approach

Use non-scalable transactional DBs as components of a cluster.



Transactional building block approach

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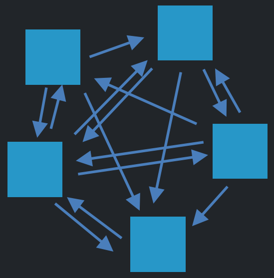
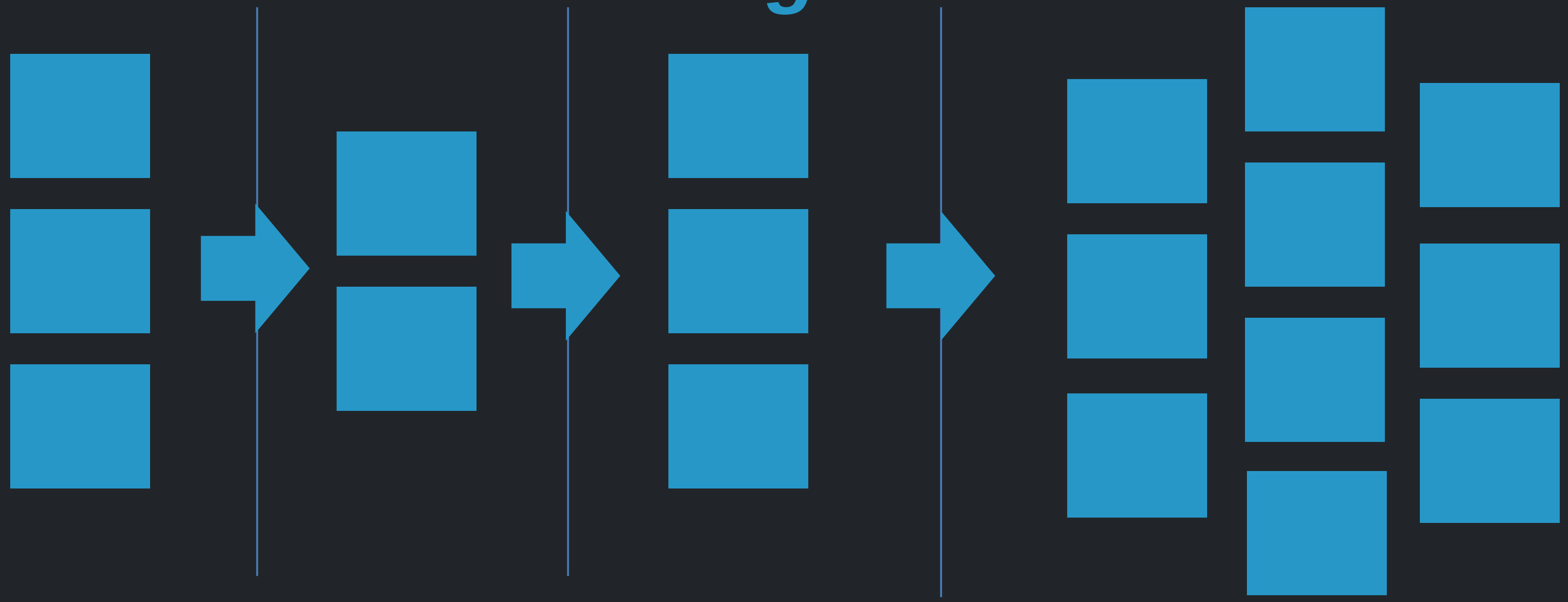


- **Upside**: Local transactions are fast
- **Downside**: Distributed transactions across machines are hard to make fast, and are messy (timeouts required)

Decomposition approach

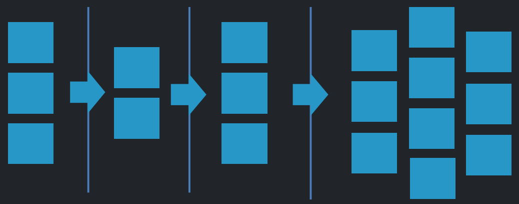
Decompose the processing pipeline of a traditional ACID DB into *individual stages*.



Decomposition approach

Decompose the processing pipeline of a traditional ACID DB into *individual stages*.

- Stages:
  - Accept client transactions
  - Apply concurrency control
  - Write to transaction logs
  - Update persistent data representation



- **Upside**: Performance
- **Downside**: “Ugly” and complex architecture needs to solve tough problems for each stage

Challenges with ACID

Split brain challenge

- Any consistent database need a fault-tolerance source of “ground truth”
- Must prevent database from splitting into two independent parts

Solution :

- Using thoughtfully chosen Paxos nodes can yield high availability, even for drastic failure scenarios
- Paxos is not required for each transaction

Latency challenge

- Durability costs latency
- Causal consistency costs latency

Solution:

- Bundling ops reduces overhead
- ACID costs only needed for ACID guarantees

Correctness challenge

- MaybeDB:
  - Set(key, value) – Might set key to value
  - Get(key) – Get a value that key was set to

Solution:

- The much stronger ACID contract requires vastly more powerful tools for testing

NoSQL + ACID!

ACID results

Jepsen test results

```
2000 total
2000 acknowledged
2000 survivors
All 2000 writes succeeded. :-D
```

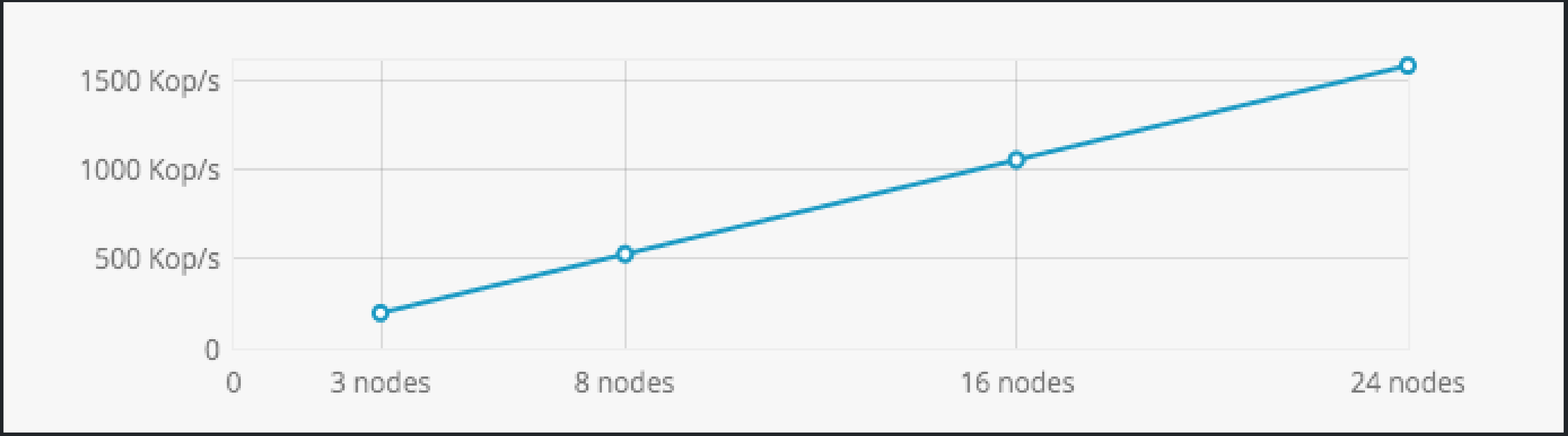
0% data lost!

Performance results

- A 24-machine FoundationDB cluster processing 100% cross-node transactions **saturates its SSDs at 890,000 op/s**

Scalability results

Performance of different cluster sizes



A vision for NoSQL

- The next generation should **maintain**
  - Scalability and fault tolerance
  - High performance
- While **adding**
  - ACID transactions
  - Data model flexibility

Thank you

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