Eiger:

Stronger Semantics for Low Latency Geo-Replicated Storage

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Michael Kaminsky (Intel Labs)

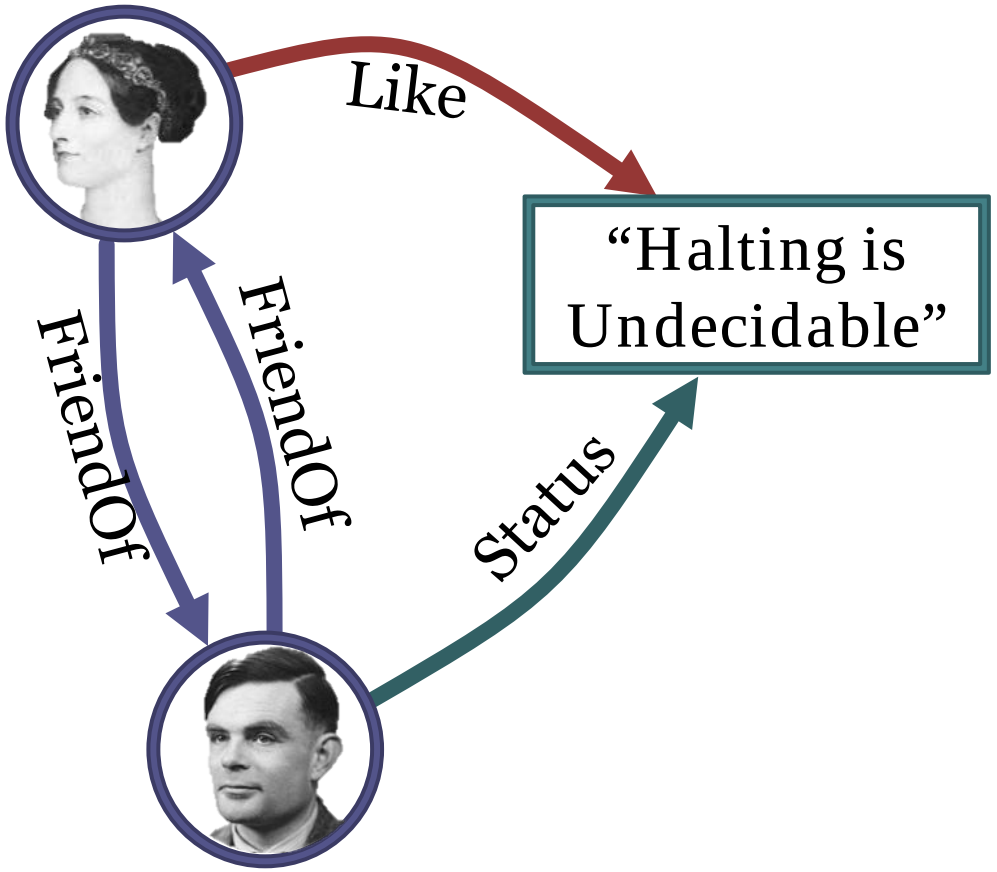
David G. Andersen (CMU)

http://www.istc-cc.cmu.edu/

Geo-Replicated Storage

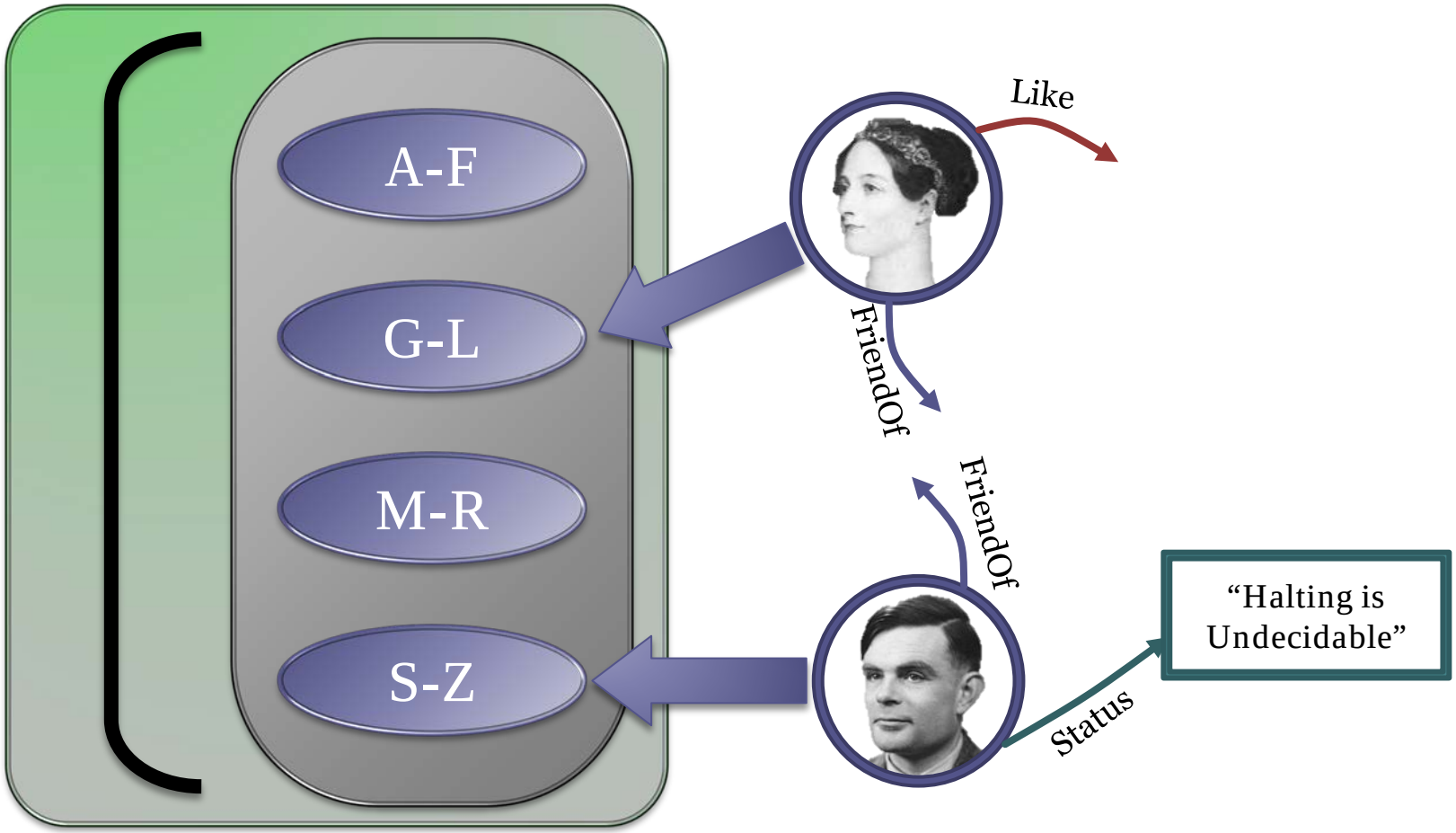
is the backend of massive websites

amazon



Storage Dimensions

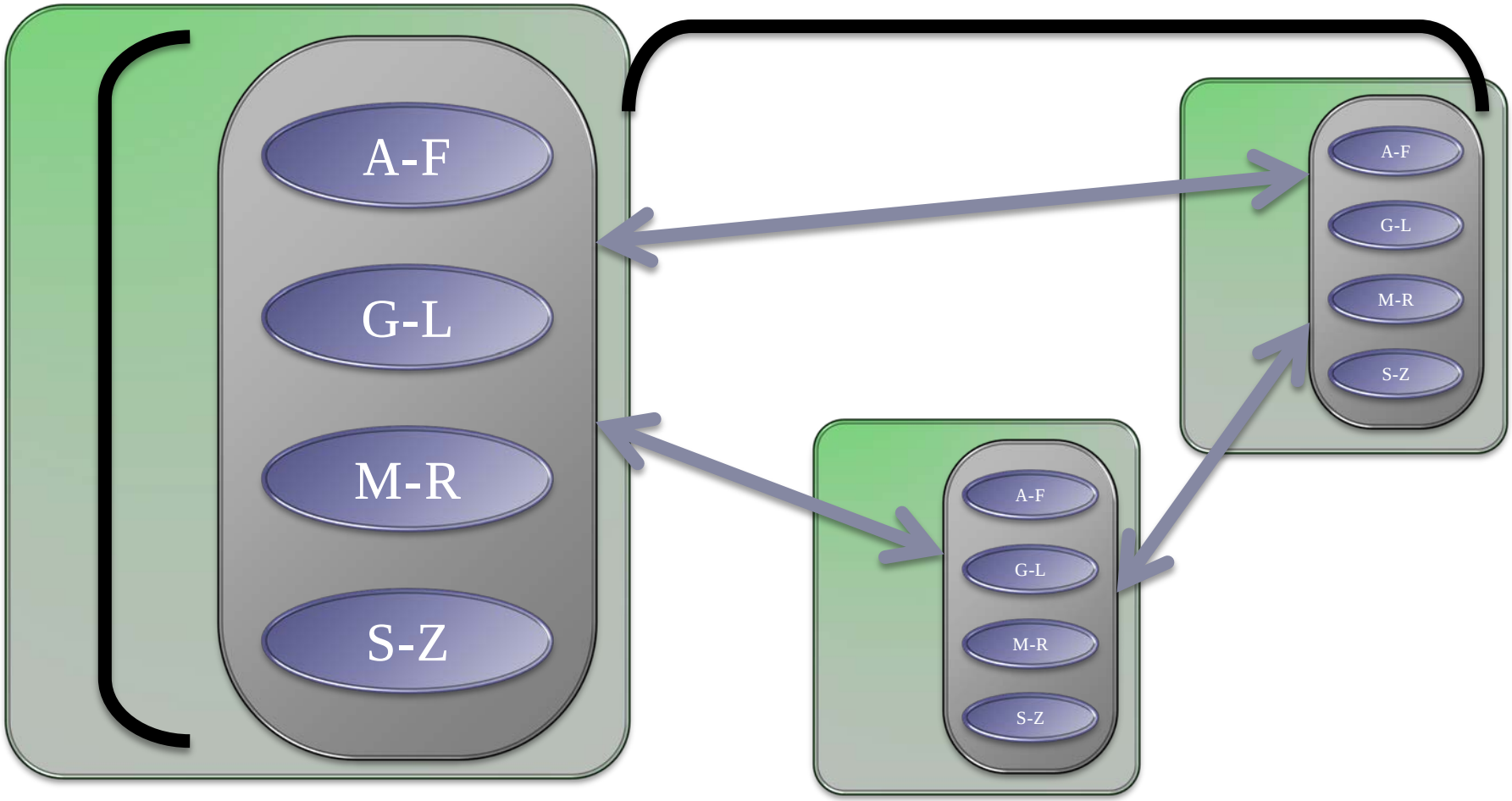
Shard Data Across
Many Nodes



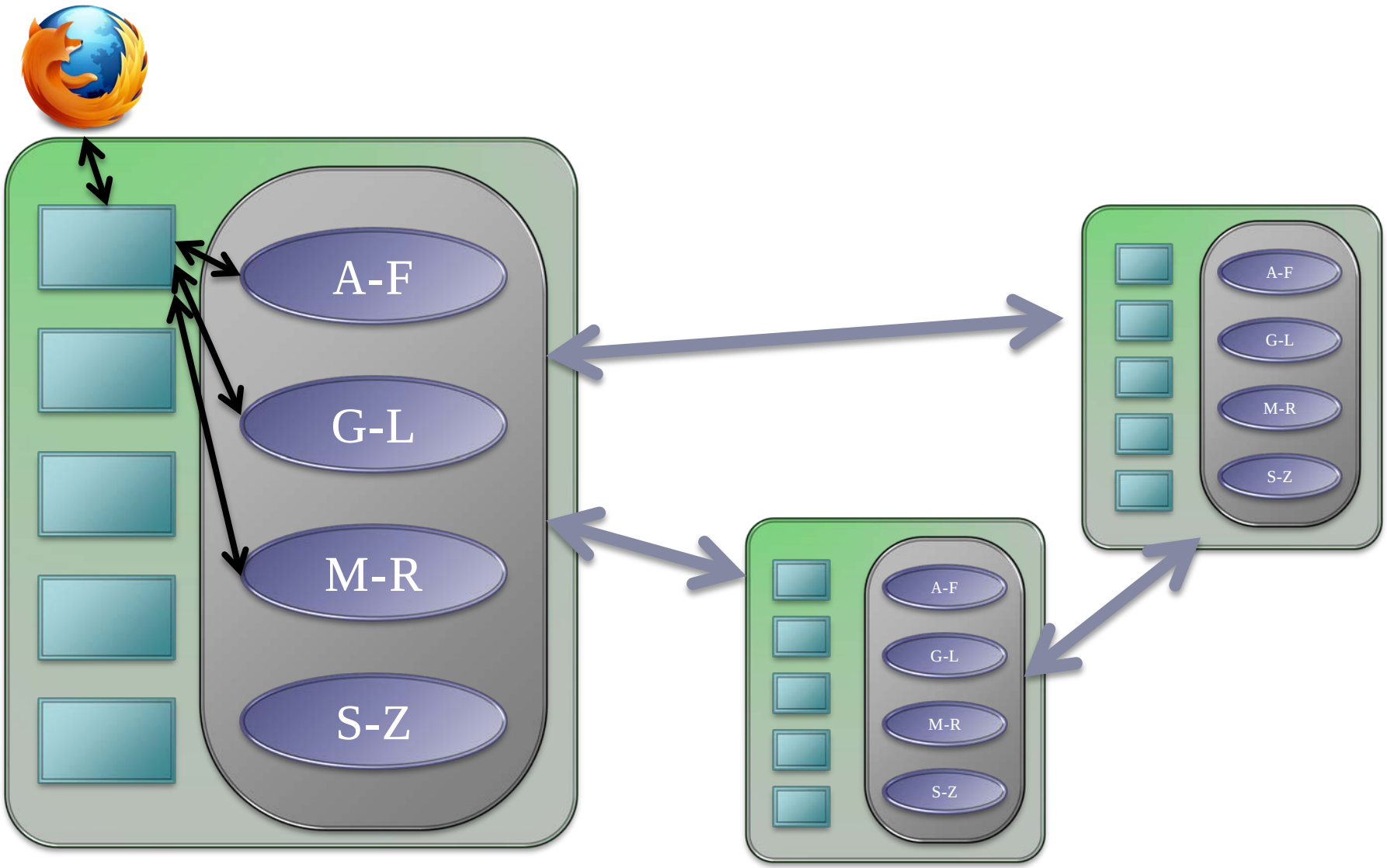
Storage Dimensions

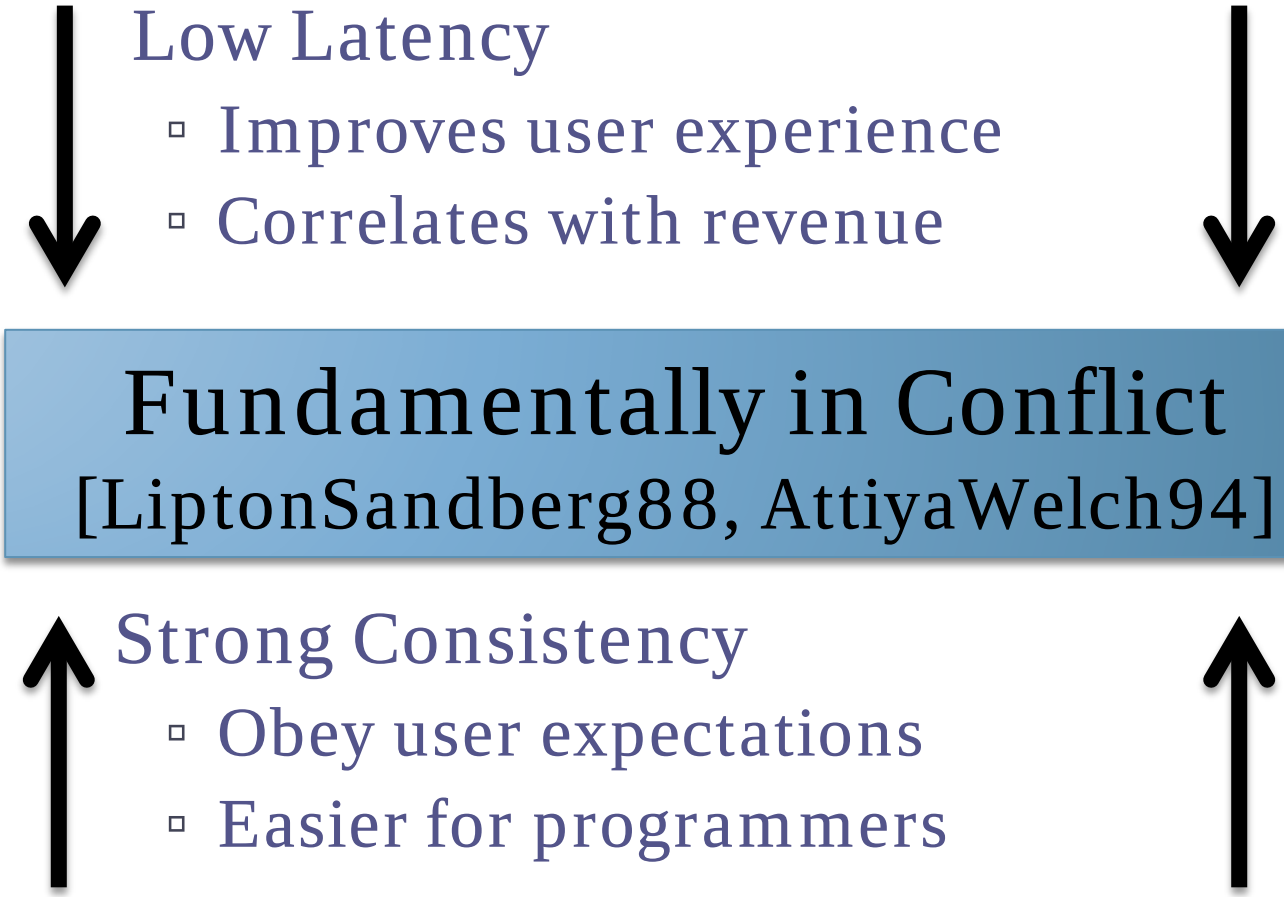
Shard Data Across
Many Nodes

Data Geo-Replicated In
Multiple Datacenters

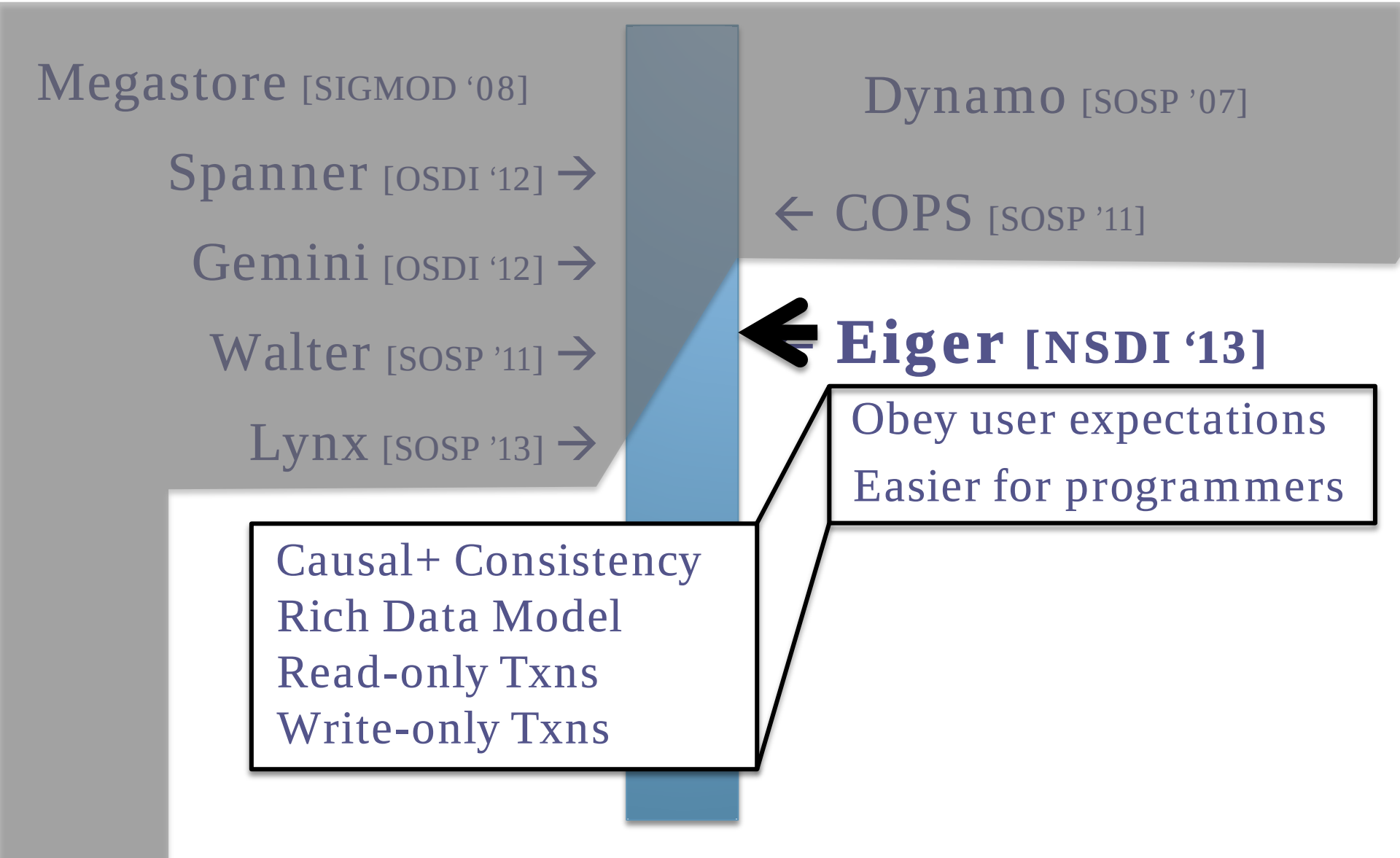


Sharded, Geo-Replicated Storage

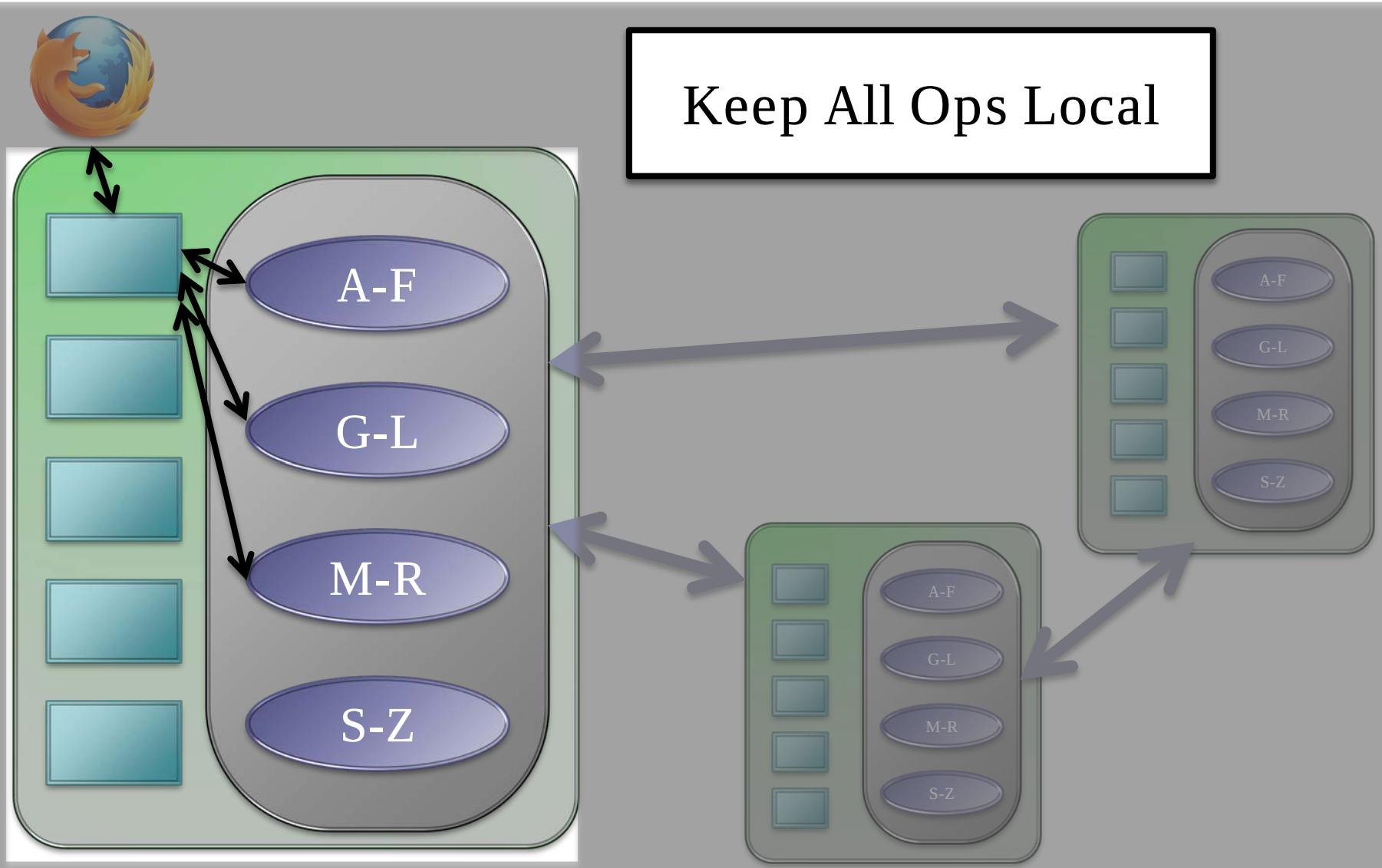



Low Latency
Improves user experience
Correlates with revenue
Fundamentally in Conflict
[LiptonSandberg88, AttiyaWelch94]
Strong Consistency
Obey user expectations
Easier for programmers

Strong Consistency or Low Latency



Eiger Ensures Low Latency

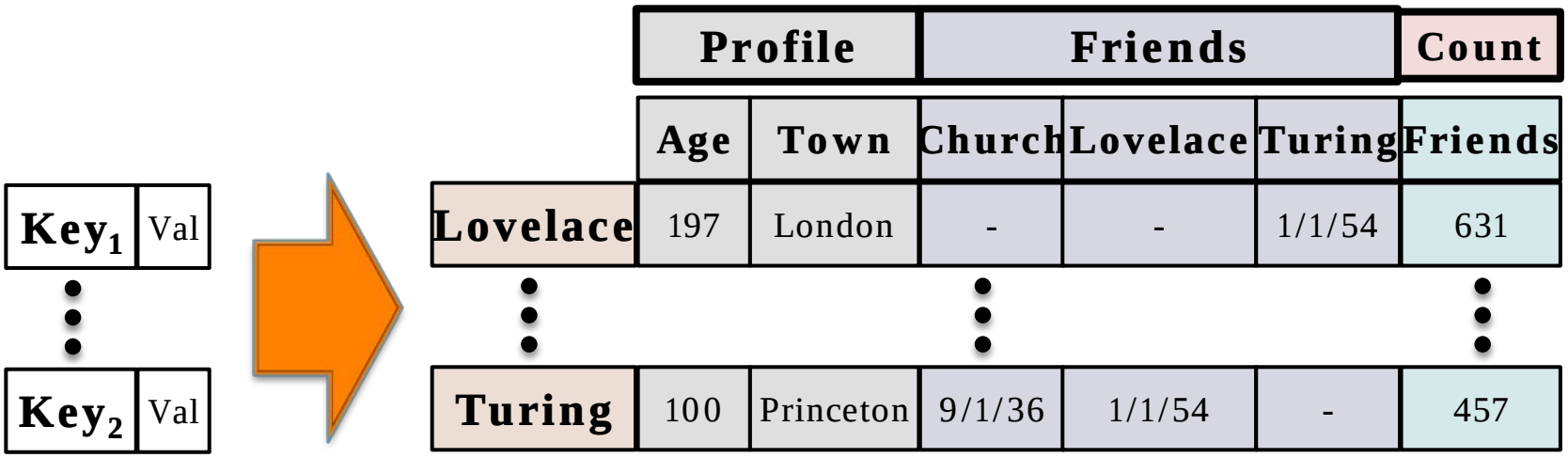


Causal+ Consistency Across DCs

- If *A* happens before *B*
  - Everyone sees *A* before *B*
- Obeys user expectations

- Simplifies programming

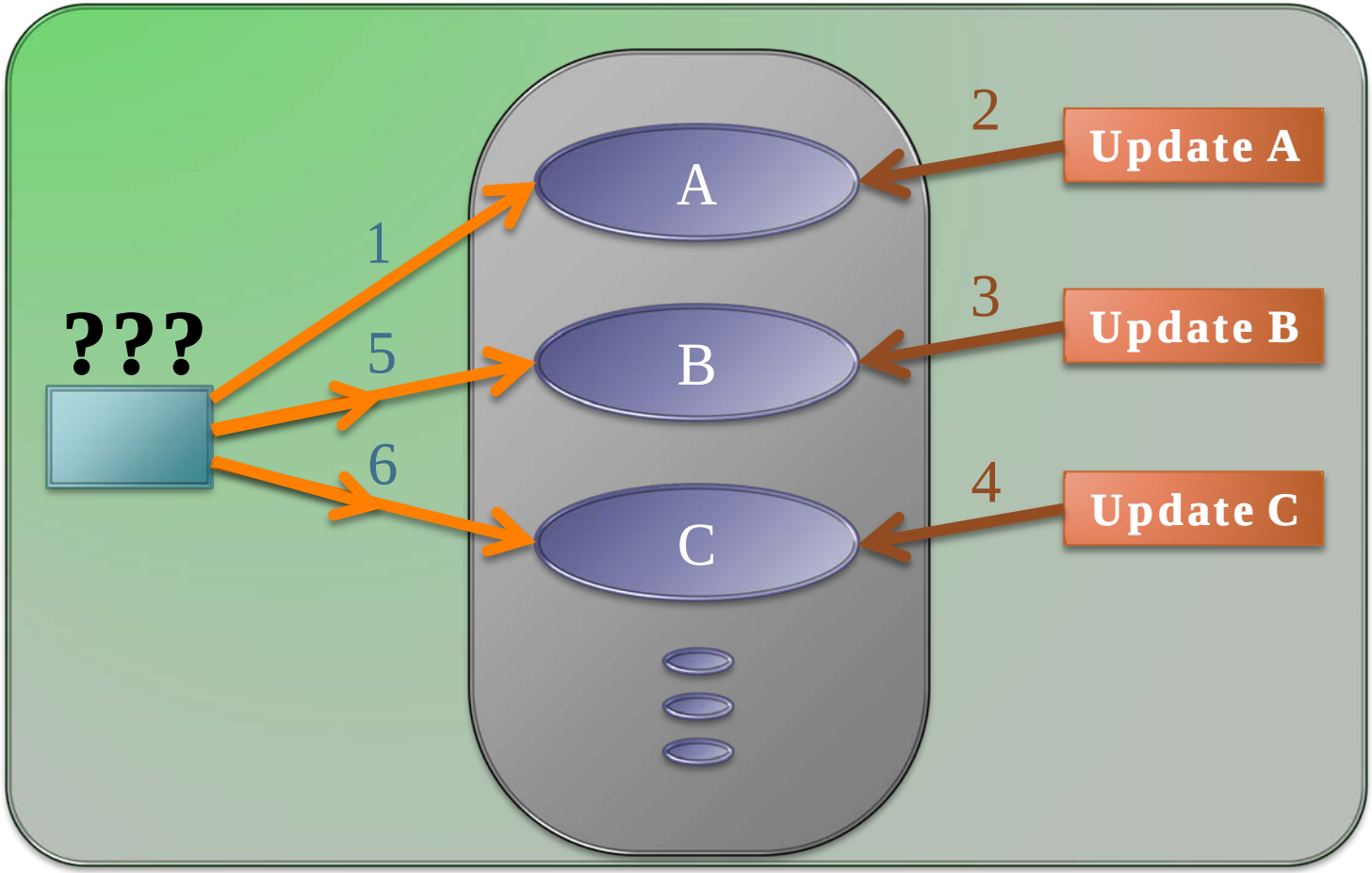
Causal For Column Families



- Operations update/read many columns
- Range query columns concurrent w/ deletes
- Counter columns
- See paper for details

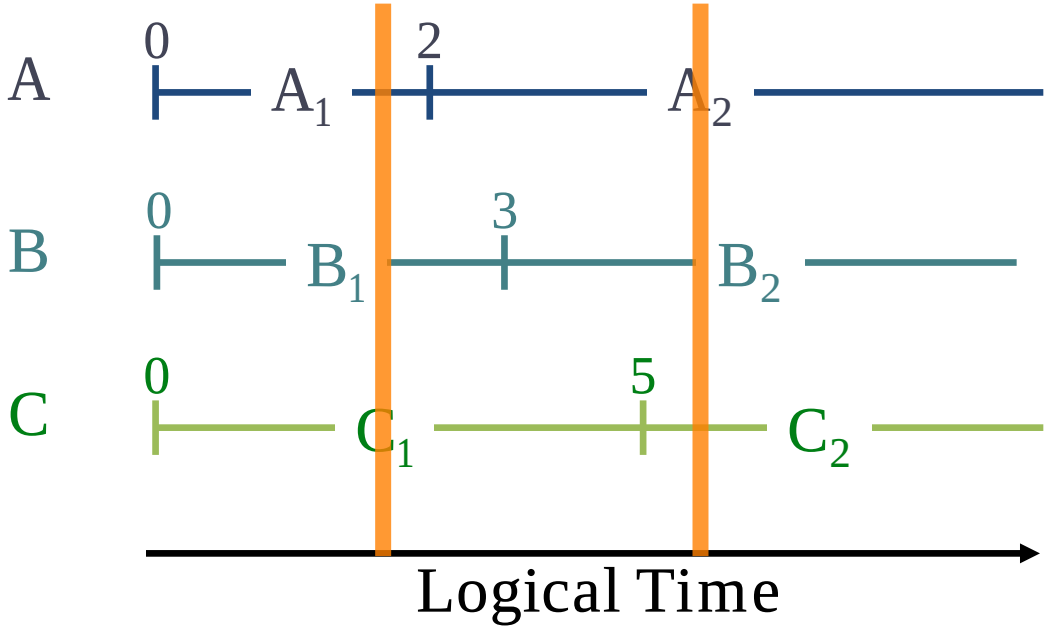
Viewing Data Consistently Is Hard

Asynchronous requests + distributed data = ?????



Read-Only Transactions

- Logical time gives a global view of data store
  - Clocks on all nodes, carried with all messages
- Insight: Store is consistent at all logical times

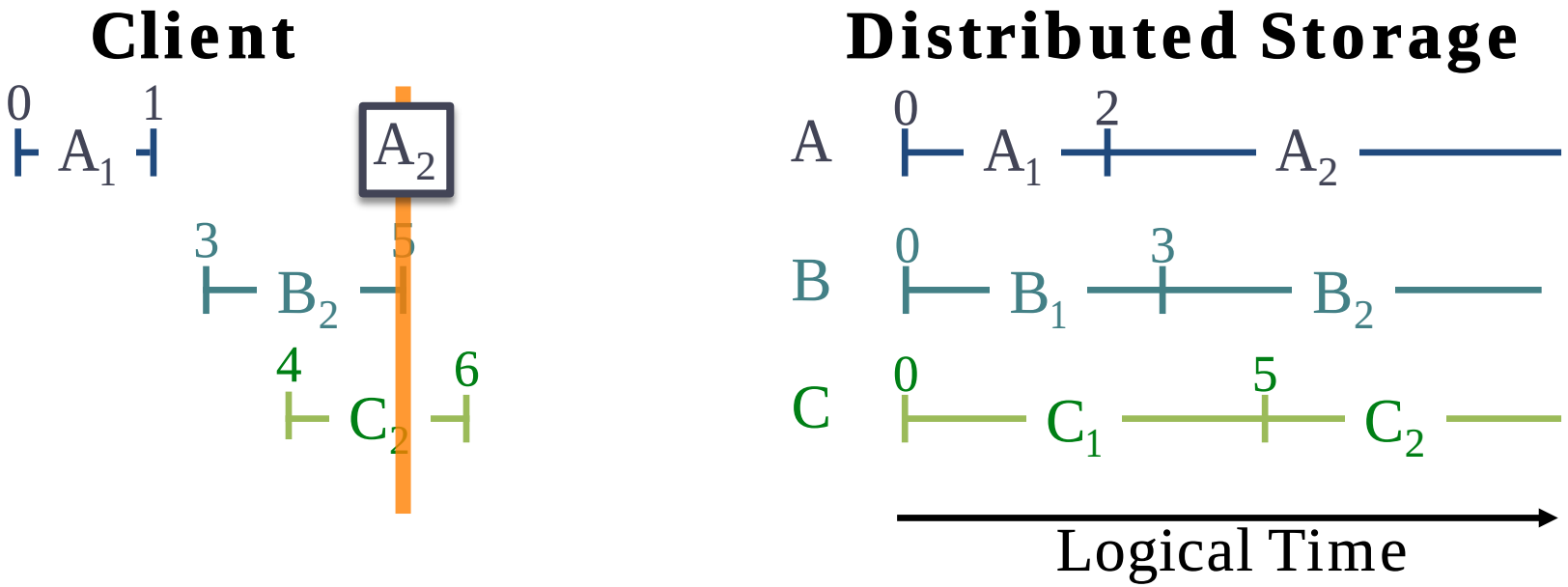


Read-Only Transactions

- Extract consistent up-to-date view of data
  - Across many servers
- Challenges
  - Scalability
    - Decentralized algorithm
  - Guaranteed low latency
    - At most 2 parallel rounds of local reads
    - No locks, no blocking
  - High performance
    - Normal case: 1 round of reads

Read-Only Transactions

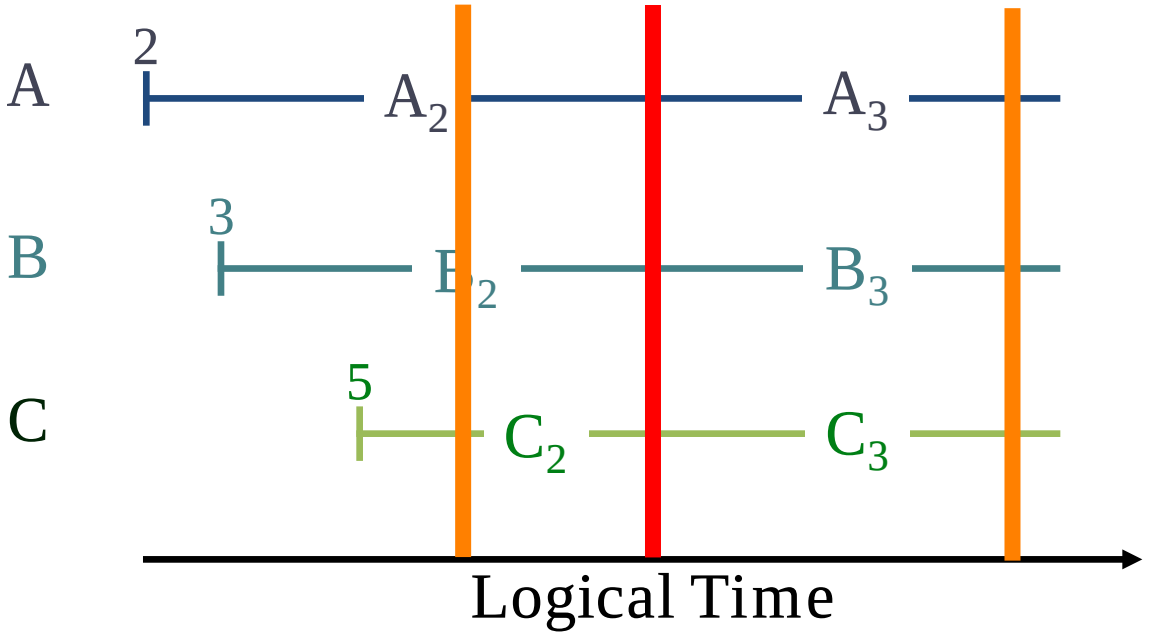
- Round 1: Optimistic parallel reads
- Calculate *effective time*
- Round 2: Parallel read_at_times



Transaction Intuition

- Read-only transactions
  - Read from a single logical time
- Write-only transactions
  - Appear at a single logical time

Bonus:
Works for Linearizability



Eiger Provides

√ Low latency

√ Rich data model

√ Causal+ consistency

√ Read-only transactions

√ Write-only transactions

But what does all this cost?

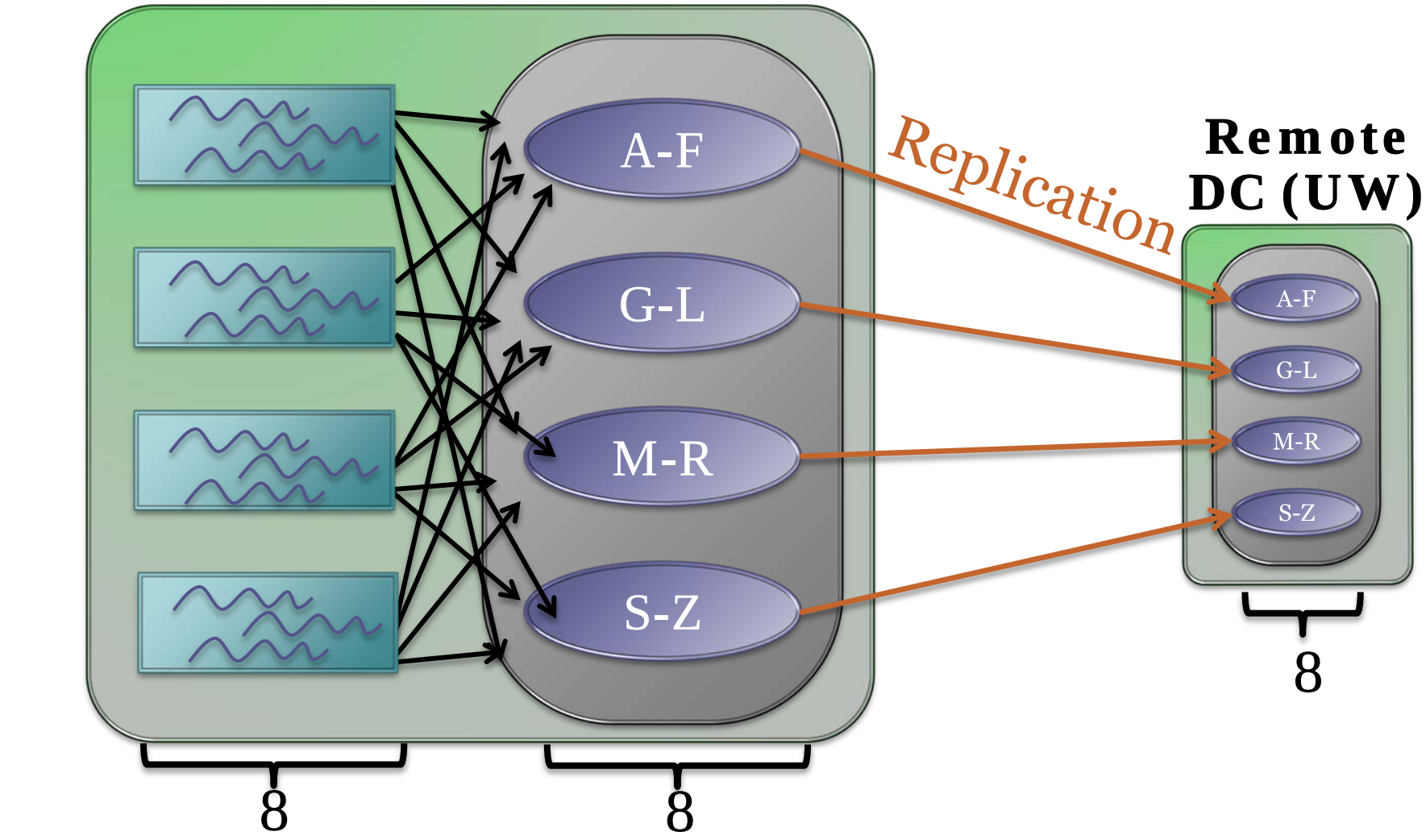
Does it scale?

Eiger Implementation

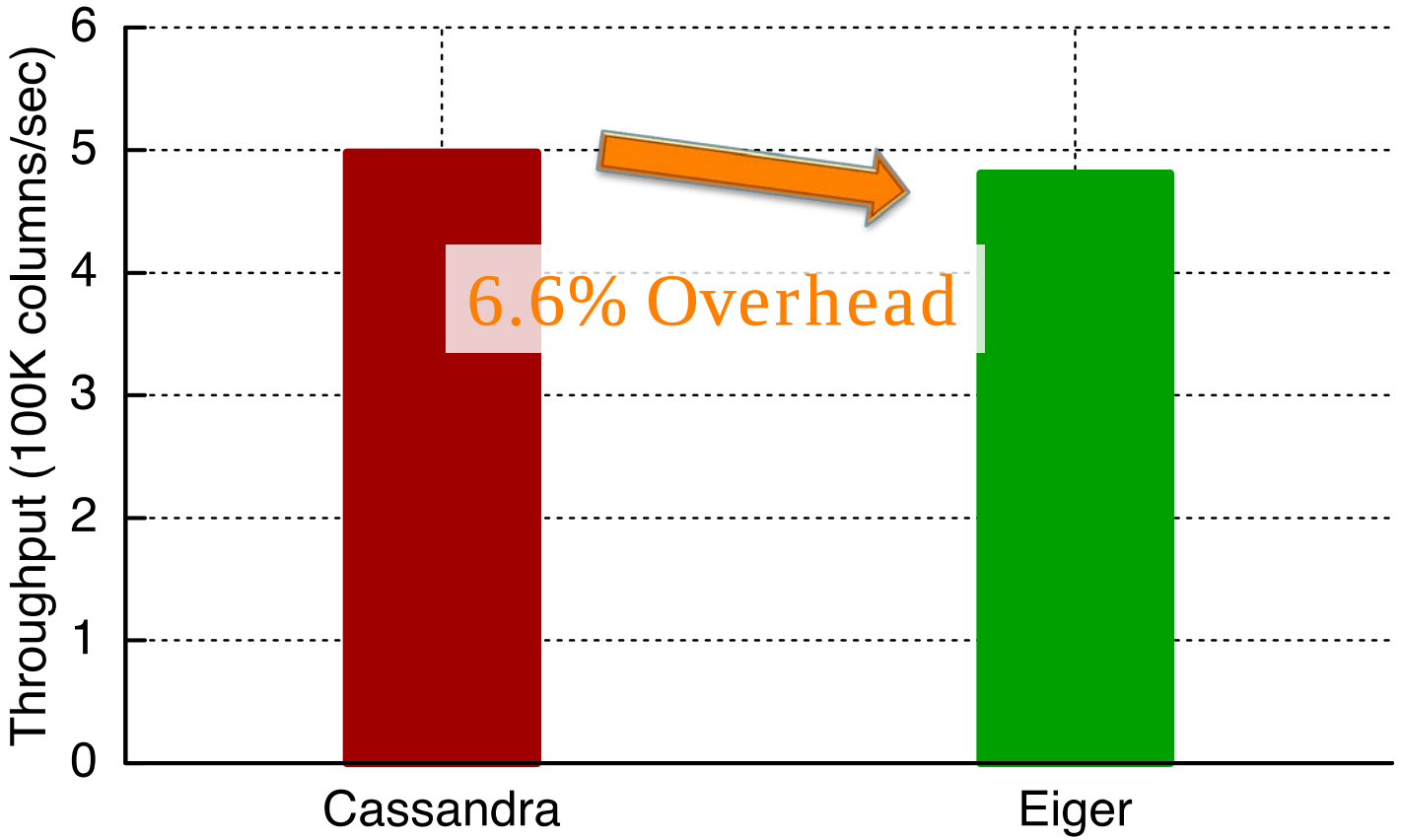
- Fork of open-source Cassandra
- +5K lines of Java to Cassandra's 75K
- Code Available:
  - https://github.com/wlloyd/eiger

Evaluation

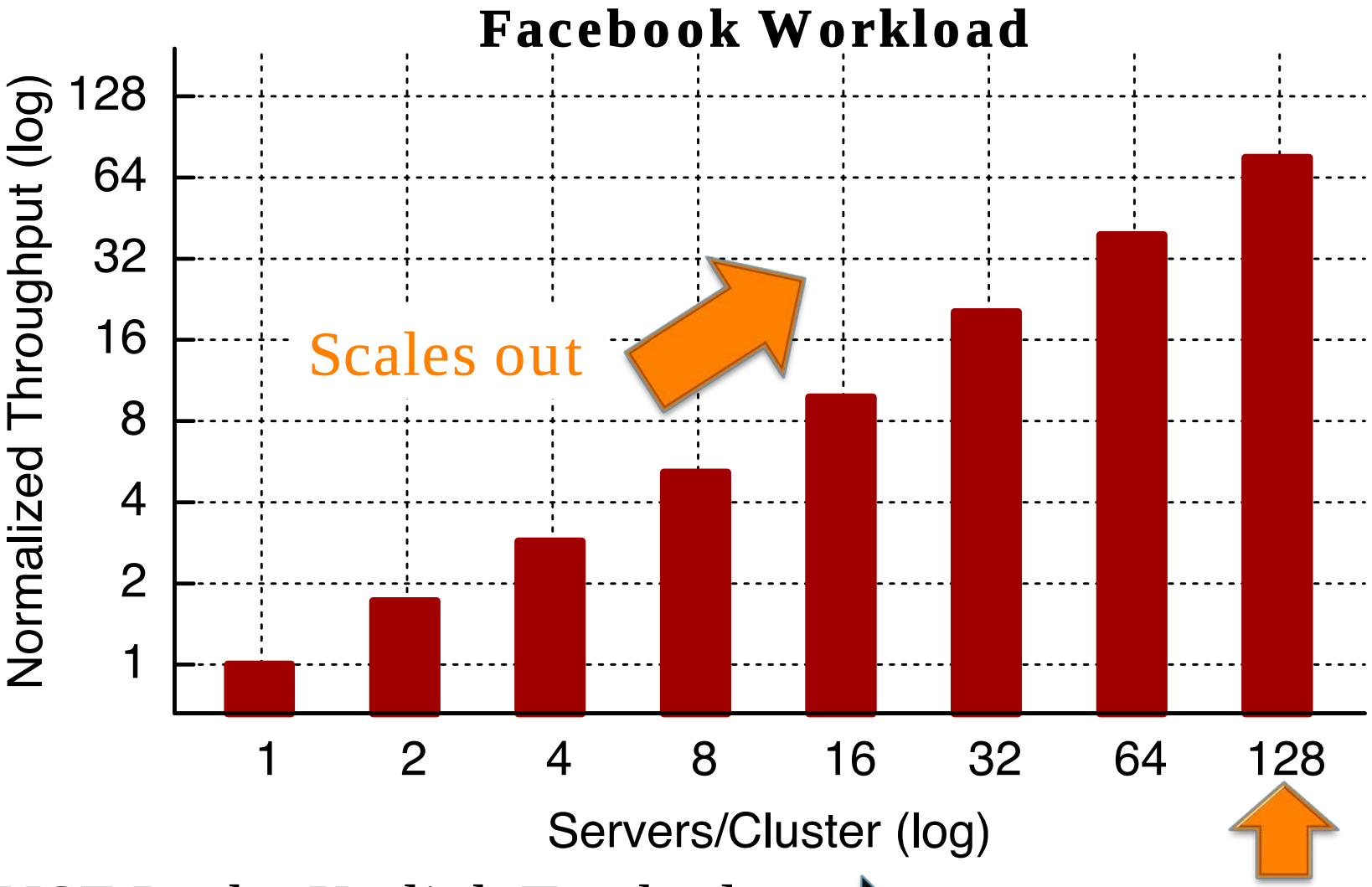
- Cost of stronger consistency & semantics
  - Vs. eventually-consistent Cassandra
  - Overhead for real (Facebook) workload
  - Overhead for state-space of workloads
- Scalability


Local Datacenter (Stanford)
A-F
G-L
M-R
S-Z
Replication
Remote DC (UW)
A-F
G-L
M-R
S-Z
8
8
8

Facebook Workload Results



Eiger Scales



NSF Probe Kodiak Testbed → 384 Machines!

Improving Low-Latency Storage

	COPS	→ Eiger
Data model	Key-Value	→ Column-Family
Read-only Txns	Causal stores	→ All stores
Write-only Txns	None	→ Yes
Performance	Good	→ Great
DC Failure	Throughput degradation	→ Resilient

I'm headed to USC

- Please ask your great students to apply for PhD

- Ramesh Govindan
  - Cloud-enabled mobile computing
- Ethan Katz-Basset
  - Internet measurement, routing, perf, reliability
- Minlan Yu
  - Datacenter networking, software defined networking
- Wyatt Lloyd
  - Distributed systems

Eiger

- Low-latency geo-replicated storage
  - Causal+ for column families
  - Read-only transactions
  - Write-only transactions

- Demonstrated in working system
  - Competitive with eventual
  - Scales to large clusters
  - https://github.com/wlloyd/eiger