Google™

Spanner

Google's Distributed Database

Sebastian Kanthak

Google Spans Entire Planet With GPS-Powered Database

BY CADE METZ 09.19.12 6:30 AM

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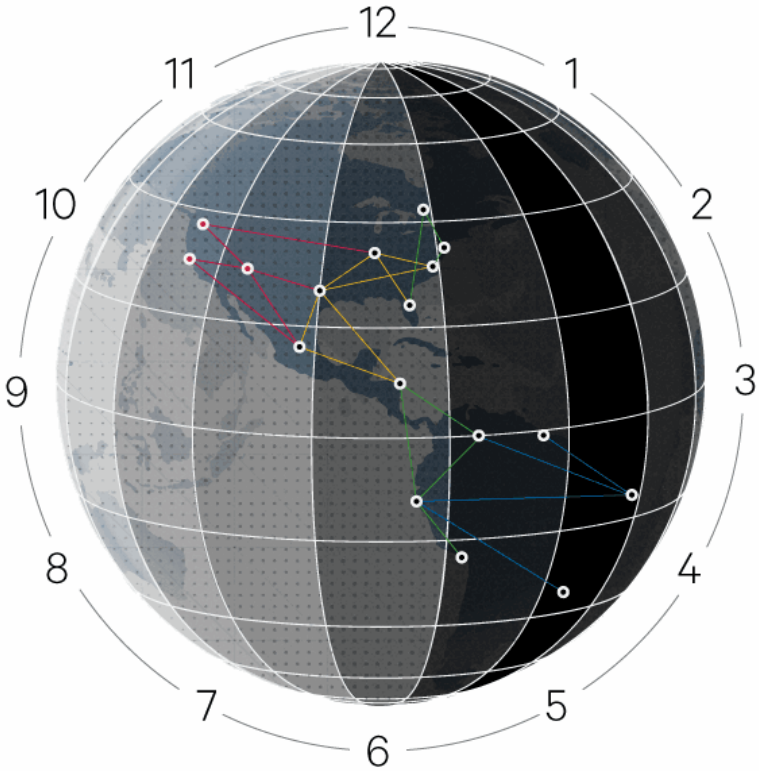

Three years ago, a top Google engineer named Vijay Gill was asked what he would do if someone gave him a magic wand.

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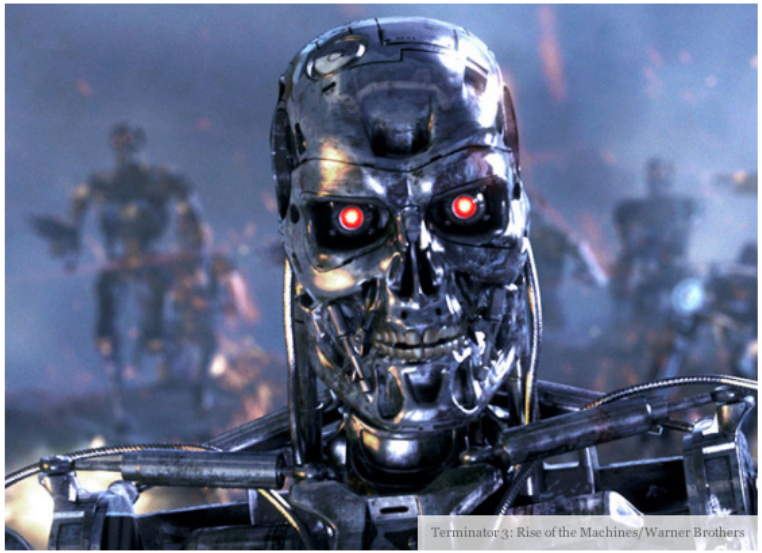


Terminator 3: Rise of the Machines/Warner Brothers

November 26, 2012 4:01 PM
Sean Ludwig

Google's Spanner is a single database that runs across hundreds of data centers throughout the world. It's so smart that it rapidly shifts

Motivation

Heritage: BigTable, Megastore

Spanner Features:

- Familiar row/column data model
- Synchronous Replication
- Transactions across rows

System Overview

Logical Data Layout

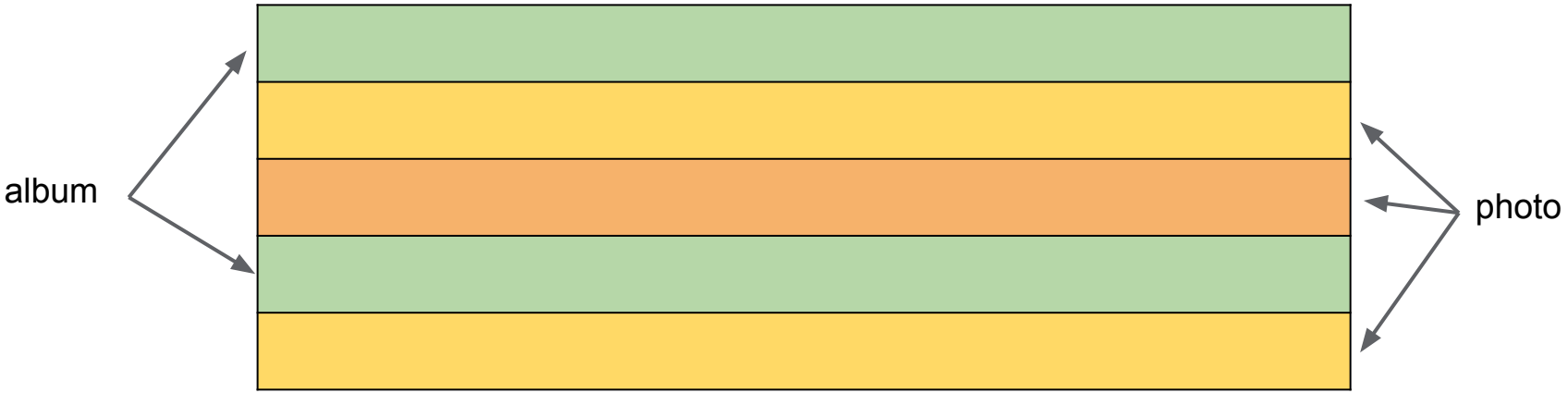
Albums

user_id	album_id	name
1	1	Maui
1	2	St. Louis

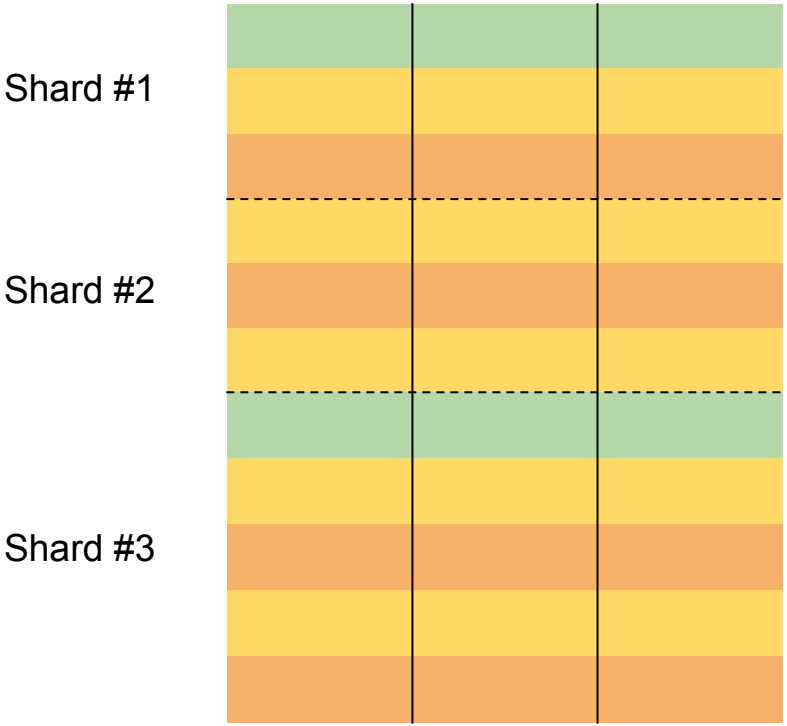
Photos

user_id	album_id	photo_id	title
1	1	2	Beach
1	1	5	Snorkeling
1	2	3	Gateway Arch

Physical Data Layout: Interleaved Tables



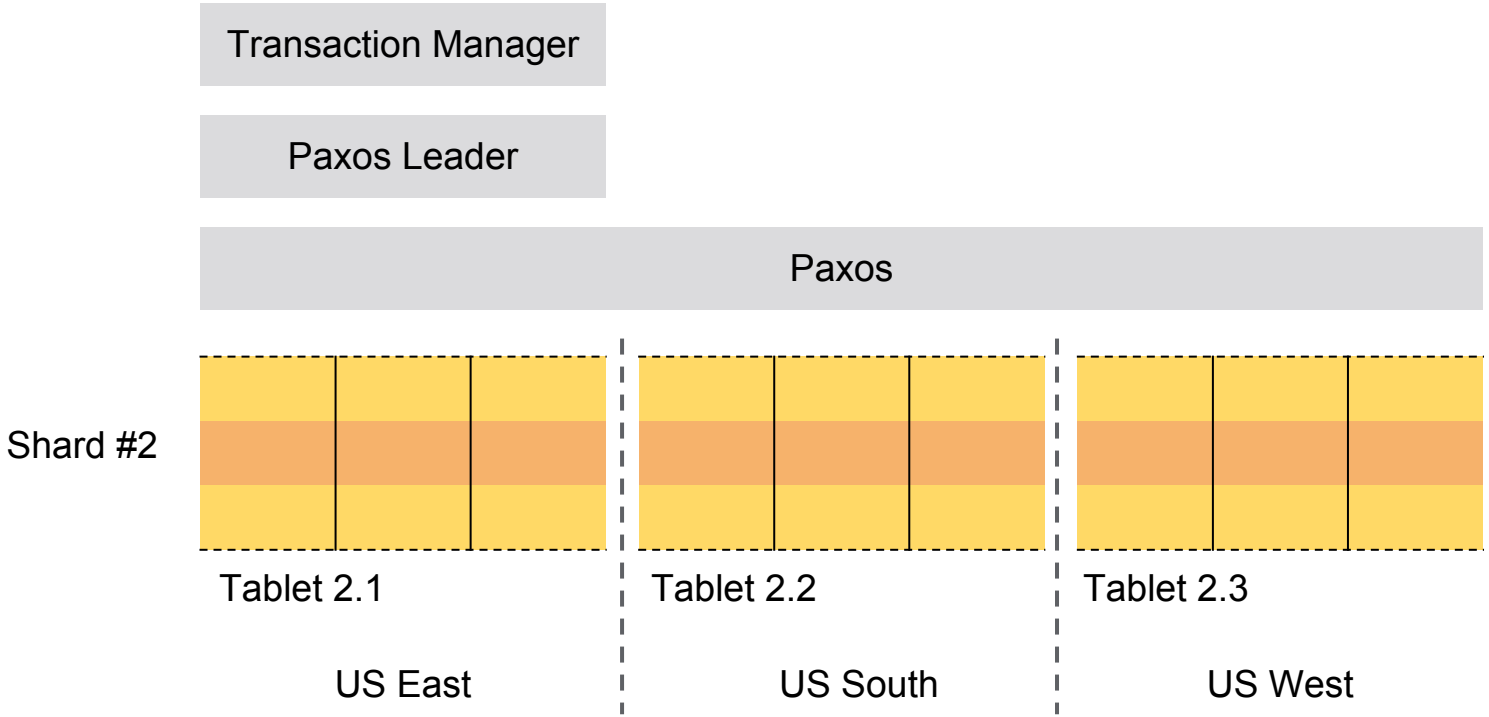
Sharding



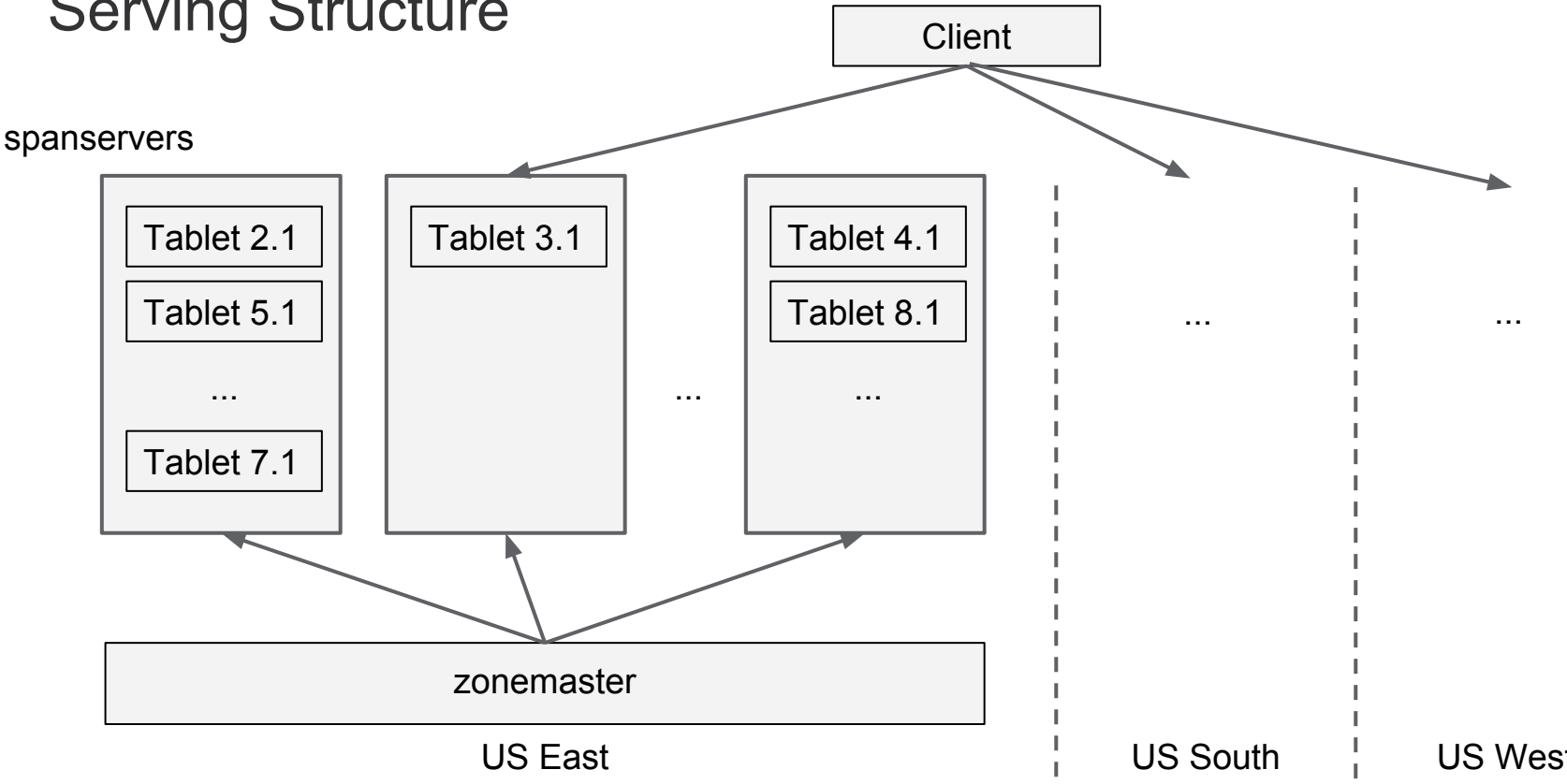
But still support:

- Transactions across shards
- Consistent snapshot reads (range scans) across shards

Replication



Serving Structure

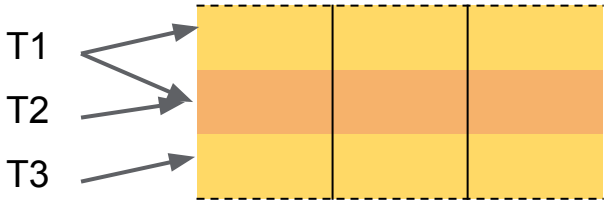


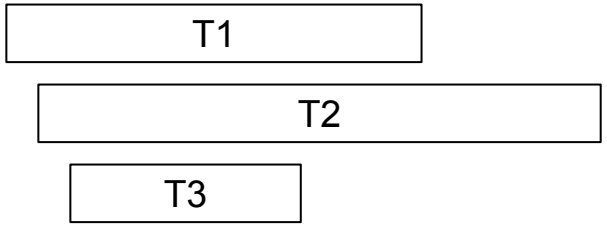
Transactions & Concurrency

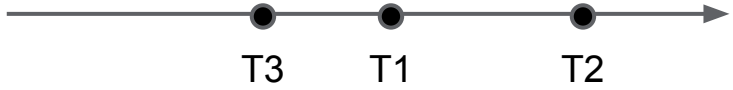
Strict Two-Phase Locking

Life of a transaction:

1. Acquire locks
2. Execute reads
3. Pick commit timestamp
4. Replicate writes (through paxos)
5. Ack commit
6. Apply writes
7. Release locks

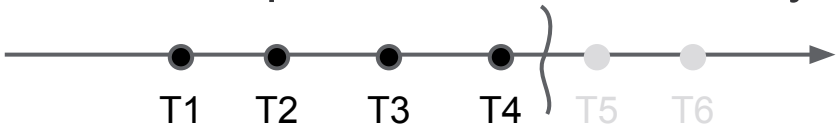






Snapshot Reads

Choose a prefix of commit history



Properties of snapshots:

- immutable
- consistent

Can be used for:

- long-running batch operations (e.g. map reduce)
- stale reads (e.g. 10s old)
- strong (current) reads: lock-free, don’t block writers

Picking commit timestamps

Attempt #1: Assign from local (monotonic) clock

1. Acquire locks
2. Execute reads
3. **Pick commit timestamp = now()**
4. Replicate writes (through paxos)
5. Ack commit
6. Apply writes
7. Release locks

Example: Ad System

Campaigns

campgain_id	keyword	bid
4	strange loop	$2.00

On US server

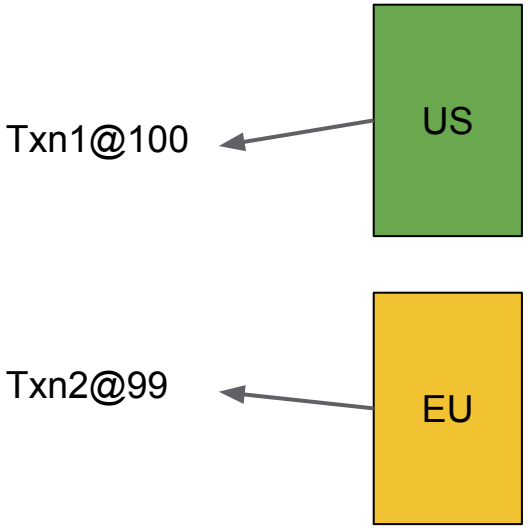
On EU server

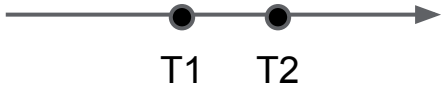
Impressions

region	time	campaign_id	cost
US	2013/09/20-07...	4	$1.50
US			
...			
EU	2013/09/20-06...	4	$0.50
EU			

Example: What goes wrong

- Txn 1 creates a new ad on US server
- Ad serving system notified
- Ad server in Europe
- User clicks on ad
- Txn 2 logs click on EU server





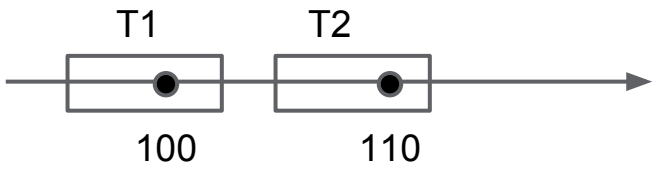
Invariant: Any snapshot that contains txn 2 should also contain txn 1.

External Consistency

Definition:

If T1 commits before T2 starts, T1 should be serialized before T2. In other words, T2's commit timestamp should be greater than T1's commit timestamp.

Note: Applies even if T1 and T2 don't conflict.



TrueTime

Idea: There is a global “true” time t

TT.now() = [earliest, latest] ∋ t.

- TT.now().earliest definitely in the past
- TT.now().latest definitely in the future

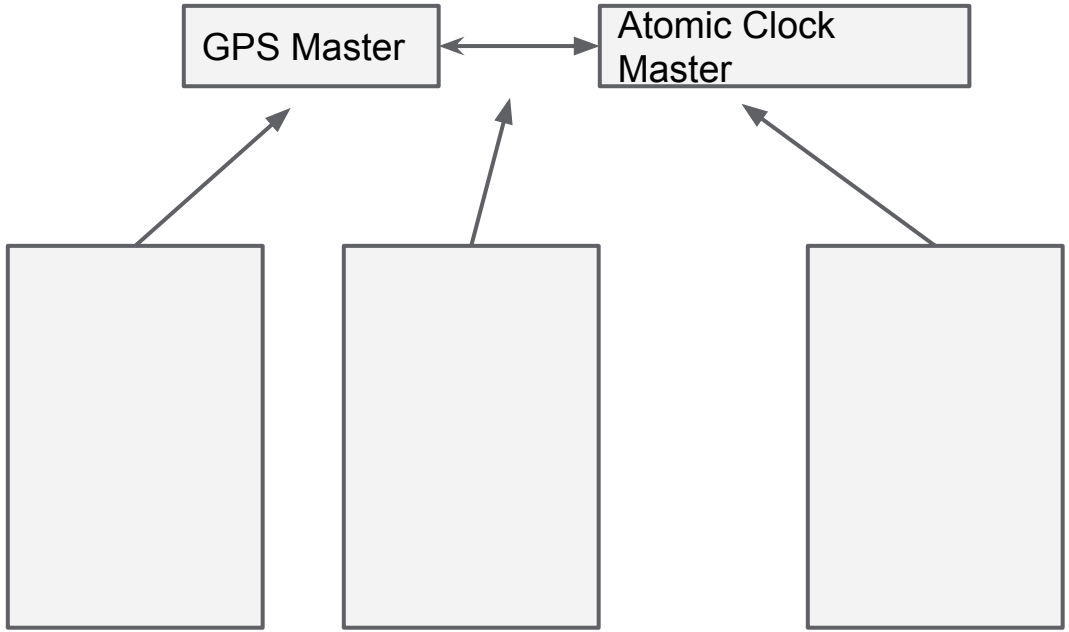
Timestamp assignment: TrueTime

Transaction protocol becomes:

1. Acquire locks
2. Execute reads
3. **Pick commit timestamp T = TT.now().latest**
4. Replicate writes (through paxos)
5. **Wait until TT.now().earliest > T**
6. Ack transaction commit
7. Apply write
8. Release locks

Strong reads: T = TT.now().latest

True Time: Architecture



spanservers

periodic poll: [earliest, latest]

In-between polls, uncertainty radius grows based on worst-case clock drift (200 usec / sec)

Conclusions

Don’t sacrifice semantics

Move complexity lower in the stack

Make clock uncertainty explicit: Known unknowns are better than unknown unknowns

Thank you!

Questions?

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