PingCAP

Building the next generation Cloud Native Database

Benefits and what problems does it solve?

Introduction

Sunny Bains
Architect, PingCAP

- Working on database internals since 2001.
- Was MySQL/InnoDB team lead at Oracle.
- @sunbains (Twitter/X)

Agenda

- Brief history
- Current Architecture
- Serverless Architecture

Trusted by Global Innovation Leaders

3,000 + global adopters use TiDB in production

- *Top Banks in China/Global*

中国建设银行 China Construction Bank · 中国银行 BANK OF CHINA · WeBank · PING AN Finance · Technology · SCB ไทยพาณิชย์ · UnionPay 银联 · hzbank BANK OF HANGZHOU

- ***Top Fintech in the World***

PayPay · Square · PLAID · Razorpay · ZaloPay

- *Global Top Lighthouses*

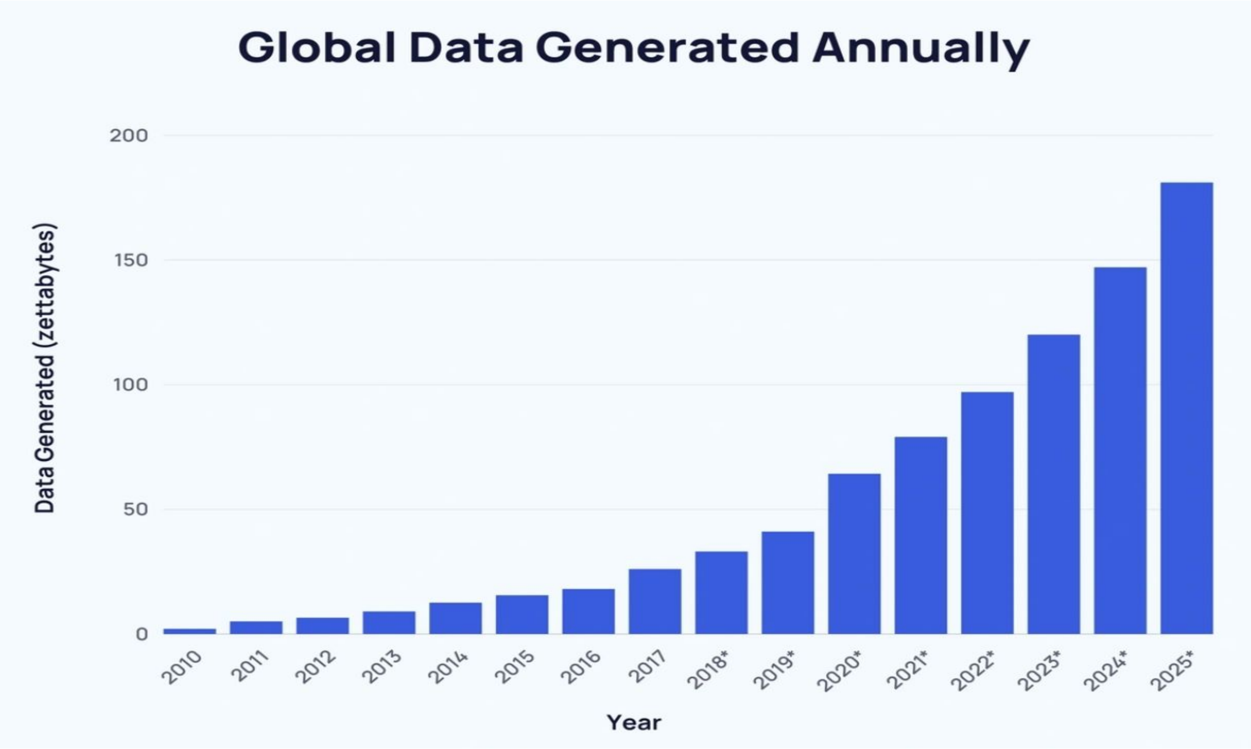
databricks · airbnb · LinkedIn · Pinterest · 拼多多 拼着买 · 才便宜

- ***E-commerce & Logistics Lighthouses***

Shopee · Flipkart · Yum! · Bolt · ZTO Express · J&T EXPRESS · DELHIVERY · ninjavan

And 4 *out of top 5 Cryptocurrency Exchanges*

Data generation trend

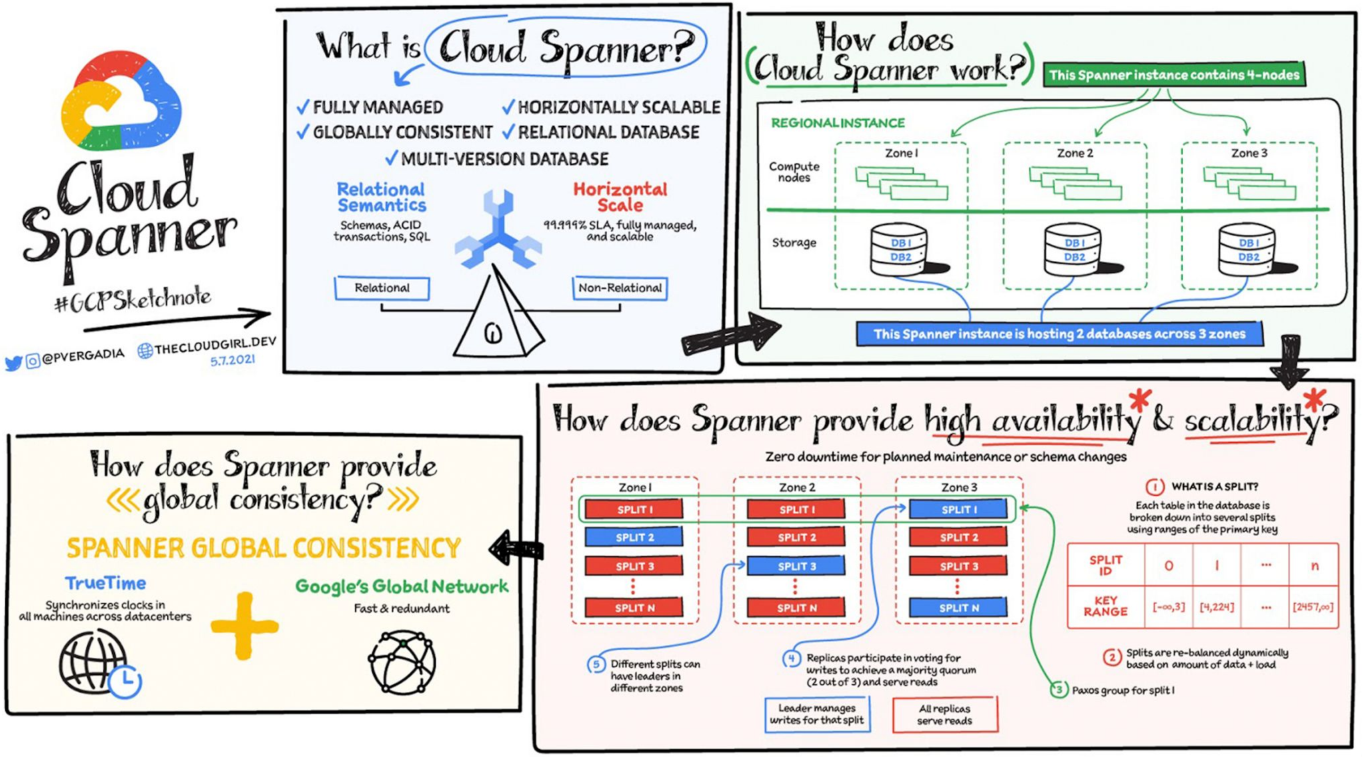


A little bit of history [2014]

"It was the best of times, it was the worst of times …"

- Rapid business and data growth
- Hundreds of TB
- Reshard / Rebalance (at midnight)
- Keep strong consistency when a MySQL node went down
- Explicit sharding (and resharding) was required to scale

We found Spanner (Paper)


Cloud Spanner
#GCPSketchnote
@PVERGADIA
THECLOUDGIRL.DEV
5.7.2021
What is Cloud Spanner?
✓ FULLY MANAGED
✓ HORIZONTALLY SCALABLE
✓ GLOBALLY CONSISTENT
✓ RELATIONAL DATABASE
✓ MULTI-VERSION DATABASE
Relational Semantics
Schemas, ACID transactions, SQL
Horizontal Scale
99.999% SLA, fully managed, and scalable
Relational
Non-Relational
How does Cloud Spanner work?
This Spanner instance contains 4-nodes
REGIONAL INSTANCE
Compute nodes
Storage
Zone 1
Zone 2
Zone 3
DB 1
DB2
This Spanner instance is hosting 2 databases across 3 zones
How does Spanner provide high availability* & scalability*?
Zero downtime for planned maintenance or schema changes
Zone 1
Zone 2
Zone 3
SPLIT 1
SPLIT 2
SPLIT 3
SPLIT N
1 WHAT IS A SPLIT?
Each table in the database is broken down into several splits using ranges of the primary key
SPLIT ID
0
1
...
n
KEY RANGE
[-∞,3]
[4,224]
...
[2457,∞]
2 Splits are re-balanced dynamically based on amount of data + load
3 Paxos group for split 1
4 Replicas participate in voting for writes to achieve a majority quorum (2 out of 3) and serve reads
5 Different splits can have leaders in different zones
Leader manages writes for that split
All replicas serve reads
How does Spanner provide «global consistency?»
SPANNER GLOBAL CONSISTENCY
TrueTime
Synchronizes clocks in all machines across datacenters
Google's Global Network
Fast & redundant

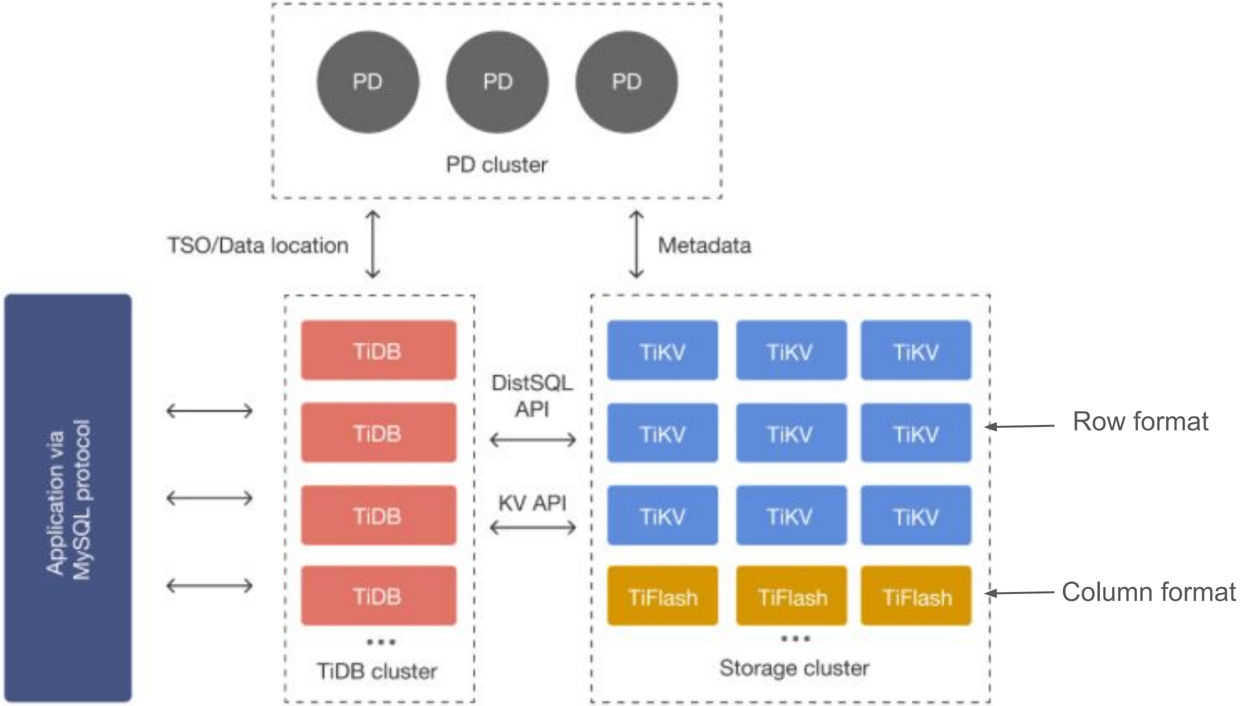
But…

- Proprietary, **not open-source**
- Special hardware is required (TrueTime)
  - We wanted to run it on commodity hardware
- Specialized and proprietary APIs, not standard SQL and wired protocol

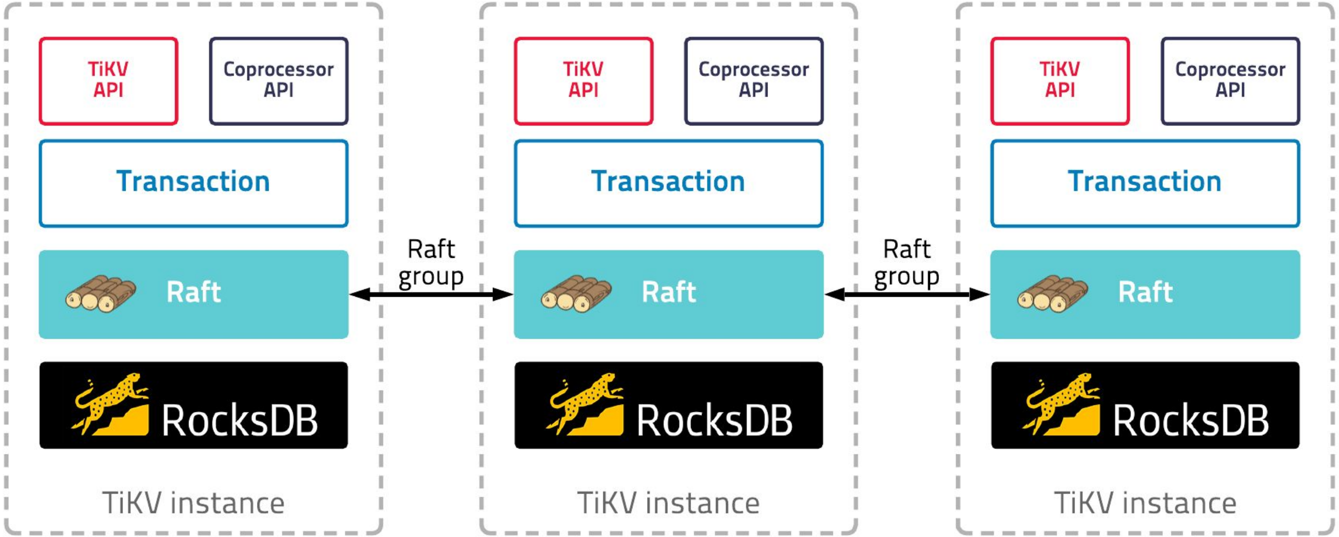
TiDB Design Philosophy

- **Shared-nothing architecture**
  - Developers should not be concerned with shard details
  - Developers should have the flexibility to control data placement
- **Standard SQL**
  - Execution engine should determine the details of distributed execution
- **Distributed Transactions**
  - Strong transactional consistency guarantees out of the box
  - Flexible read consistency policies should be provided
- **Built-in Highly Available**
  - Not at the cost of **strong consistency**

TiDB: Reference Architecture

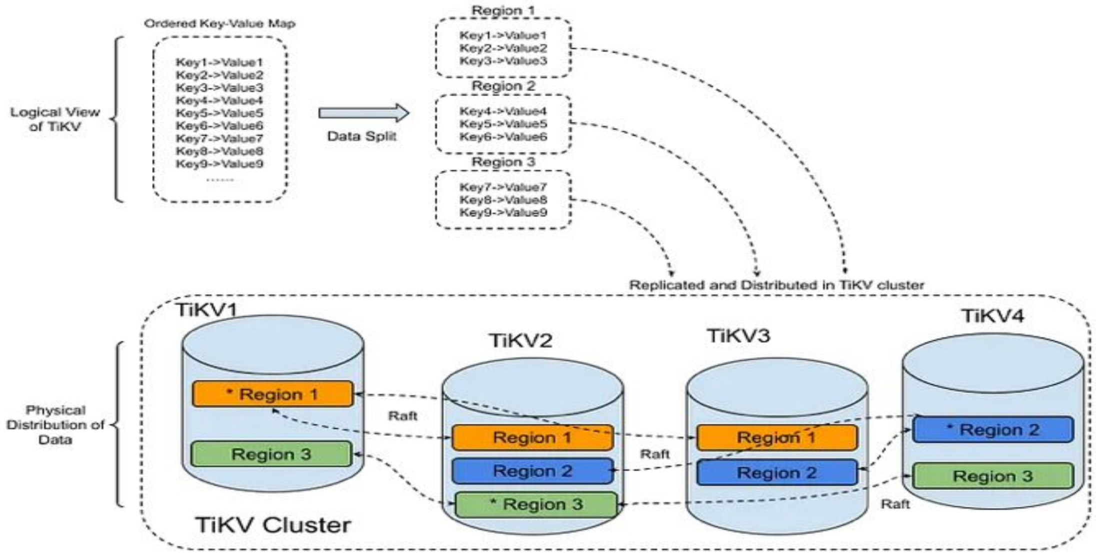


TiKV: Distributed KV Storage [Built in Rust]



TiKV - Data Storage Example

Example to illustrate how TiKV partitions and manages the data



TiDB Region

A **Region** is TiKV's **logical** scale unit

- Operations such as load balance, scale-out, scale-in are all based on **region**
- **Regions** are replicated using the Raft consensus protocol
  - A replicated **region** is called a Raft group
  - **Regions** are spread across the nodes in the cluster
  - A single storage node contains many **Regions**
  - **Regions** are stored on RocksDB, there is one instance of RocksDB per storage node.
  - Rows in a **Region** are ordered

Distributed Transactions in TiDB

- TiDB supports Read-Committed and Snapshot Isolation levels
  - The Snapshot Isolation is mapped to MySQL/InnoDB's Repeatable Read
- TiDB uses an optimized version of the Percolator algorithm for distributed transactions
- A transaction requires a start time stamp and a commit timestamp
  - PD is responsible for handing out these timestamps
  - These timestamps are used in TiDB's MVCC implementation
- Async commit in TiDB
  - The SQL nodes are the Txn Coordinators (TC)
  - The TiKV nodes are the participants
  - Works well when the transaction write set is small and Phase II time dominates
- Supports 1PC Commit Optimization
  - If transaction only updates a non-index column of a record
  - Or, Inserts a record without a secondary index,
  - Only involves a single Region

Challenges Yet To Be Fully Addressed

- How to improve stability at scale?
  - Copying data, LSM compaction may slow down your workloads
  - Provisioning can take time
- How to take scalability to the next level?
  - Exploding data volume, customers asking for 200PB clusters
  - Multiple applications share a single cluster for greater efficiency and lower costs
- How to make it easier and more cost effective for users?
  - Maintenance burden of a distributed system, trade-offs become “knobs”
  - Scale down when the workload reduces

Leverage the Cloud Infrastructure

- Allow a developer to start small and scale to any size
- Better and more varied capabilities e.g., disaggregated storage, use S3
- Elasticity and resilience
- Hide the complexity of a distributed system
- Integrate the database with the capabilities of cloud
- The only cost of a quiescent instance should be storage

Leverage Cloud Storage

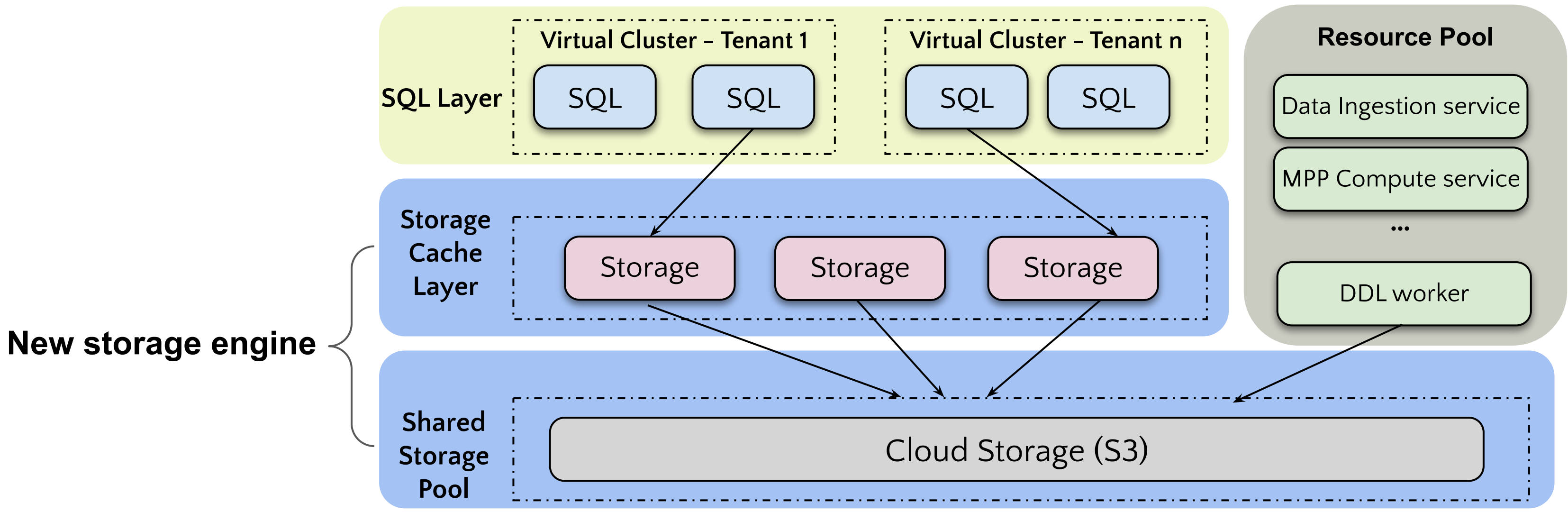
Storage Option	Storage Cost	Storage Limit	Durability	Latency	Request Cost
Object Storage (e.g., S3)	**Low**	**Unlimited**	**High**	High	High
Block Storage (e.g., EBS)	High	Limited	Low	**Low**	**None**

Best of both worlds

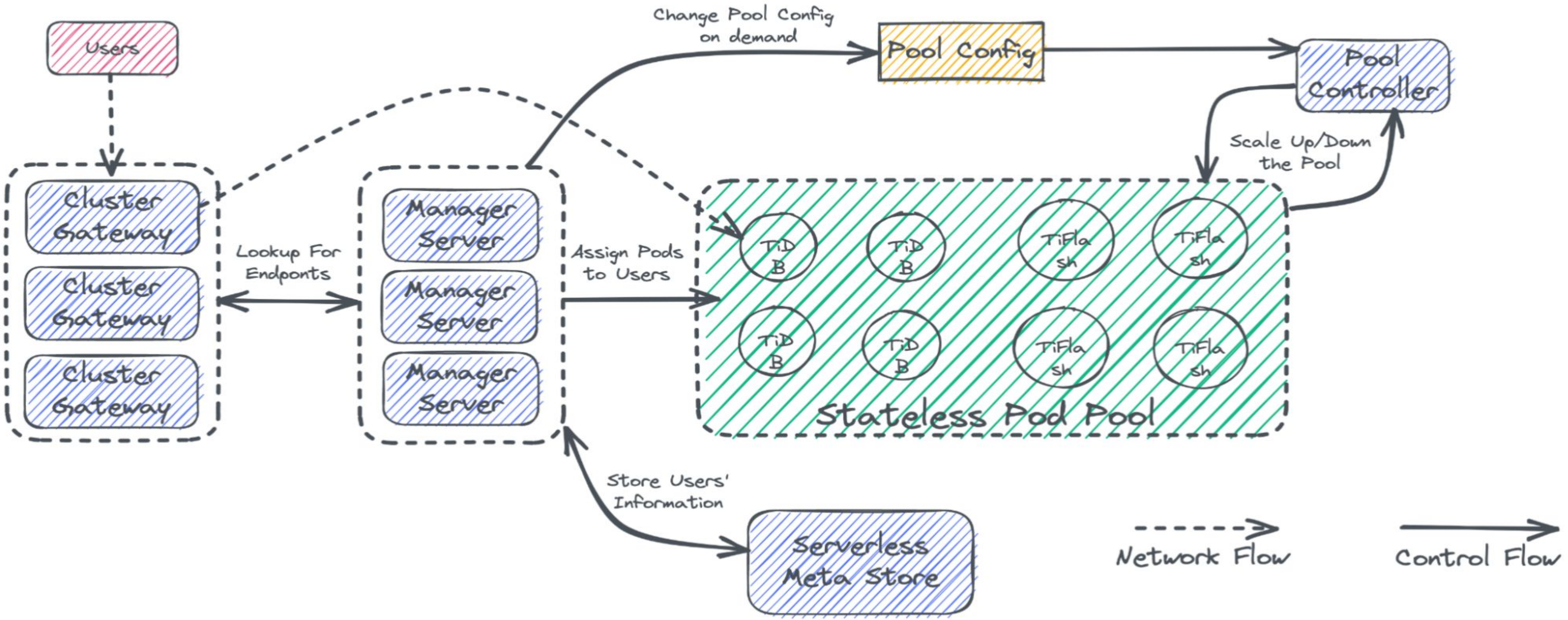
TiDB Serverless Architecture

- Multi-tenant architecture
- Disaggregated storage (new LSM storage engine, replaces RocksDB)
  - Local disk or memory as write through cache
  - Cold data on S3
  - Data shared by row & column store
- Shared resource pool [spot instances]
  - For background tasks
  - Heavy compute load
- Remove LSM WAL, Raft log serves as the only log

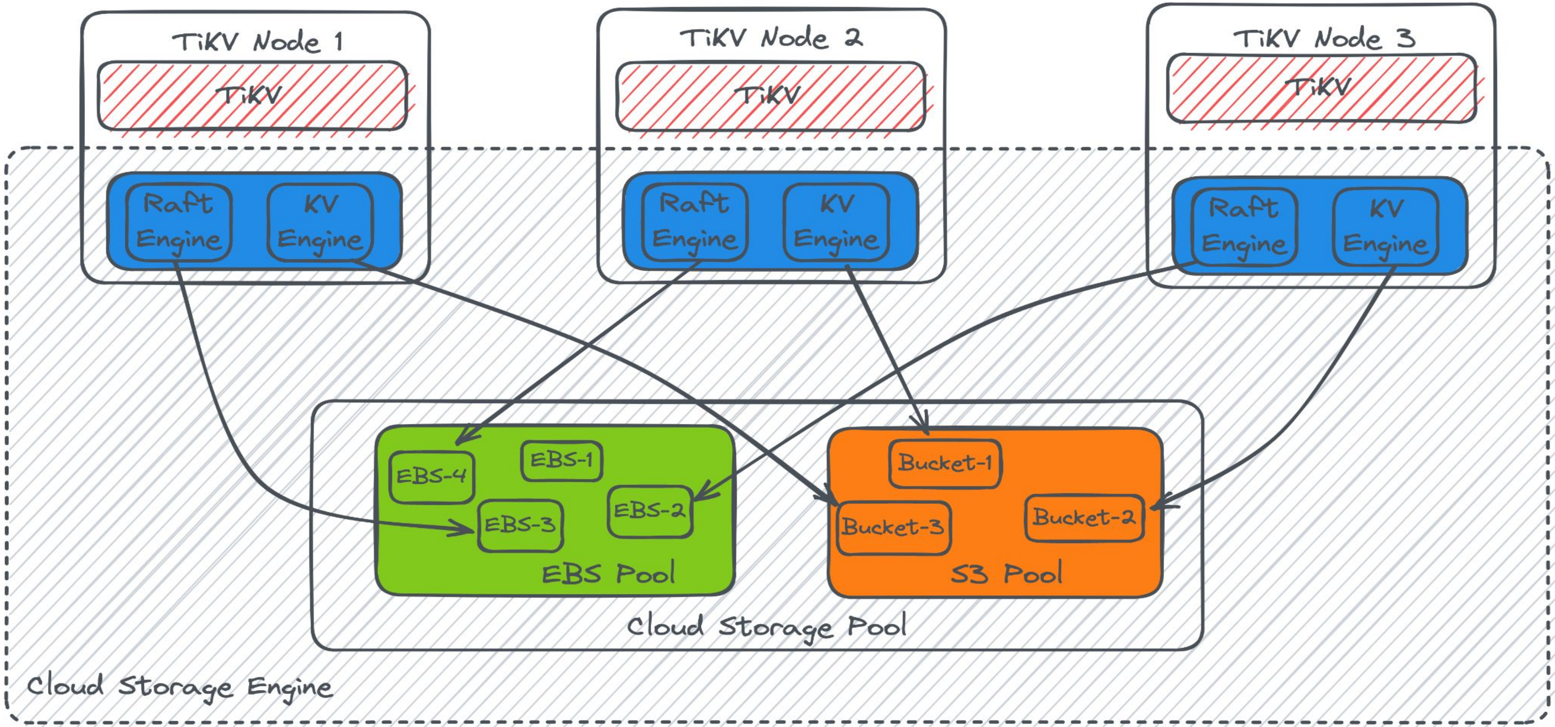
TiDB Serverless Architecture



Cloud Storage Engine Architecture

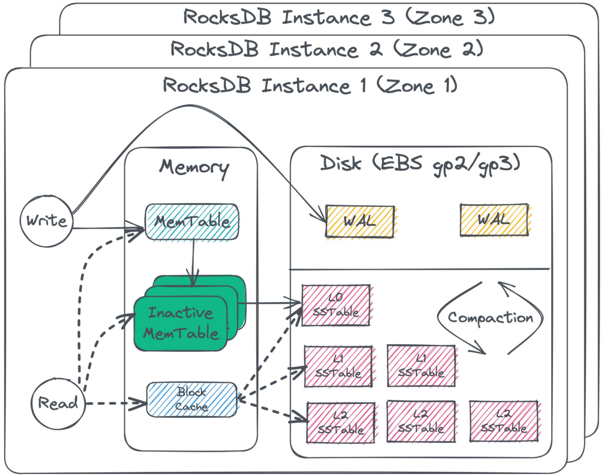


Cloud Storage Engine Architecture

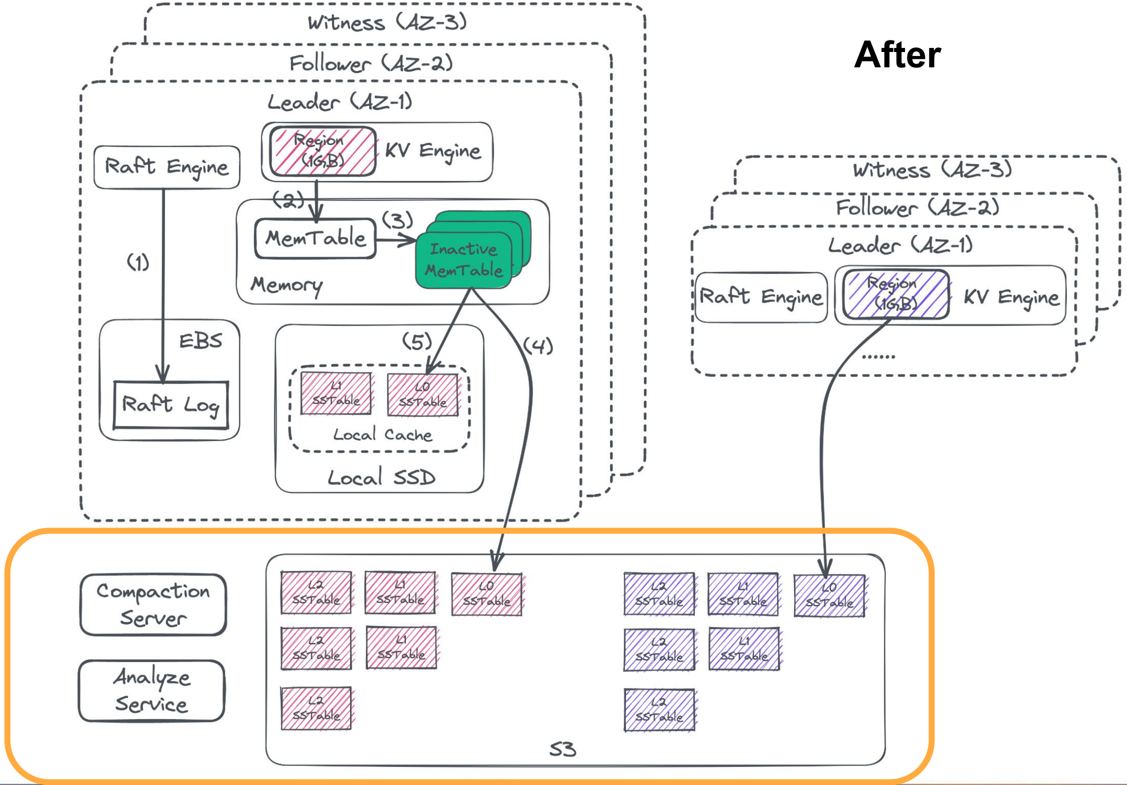


The New Cloud-Based Storage Engine

Before



After



Remote Storage and Services

THANK YOU.