Dynamic Multi-Raft

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SPEAKER INTRODUCE

黄东旭 CTO & Cofounder, PingCAP

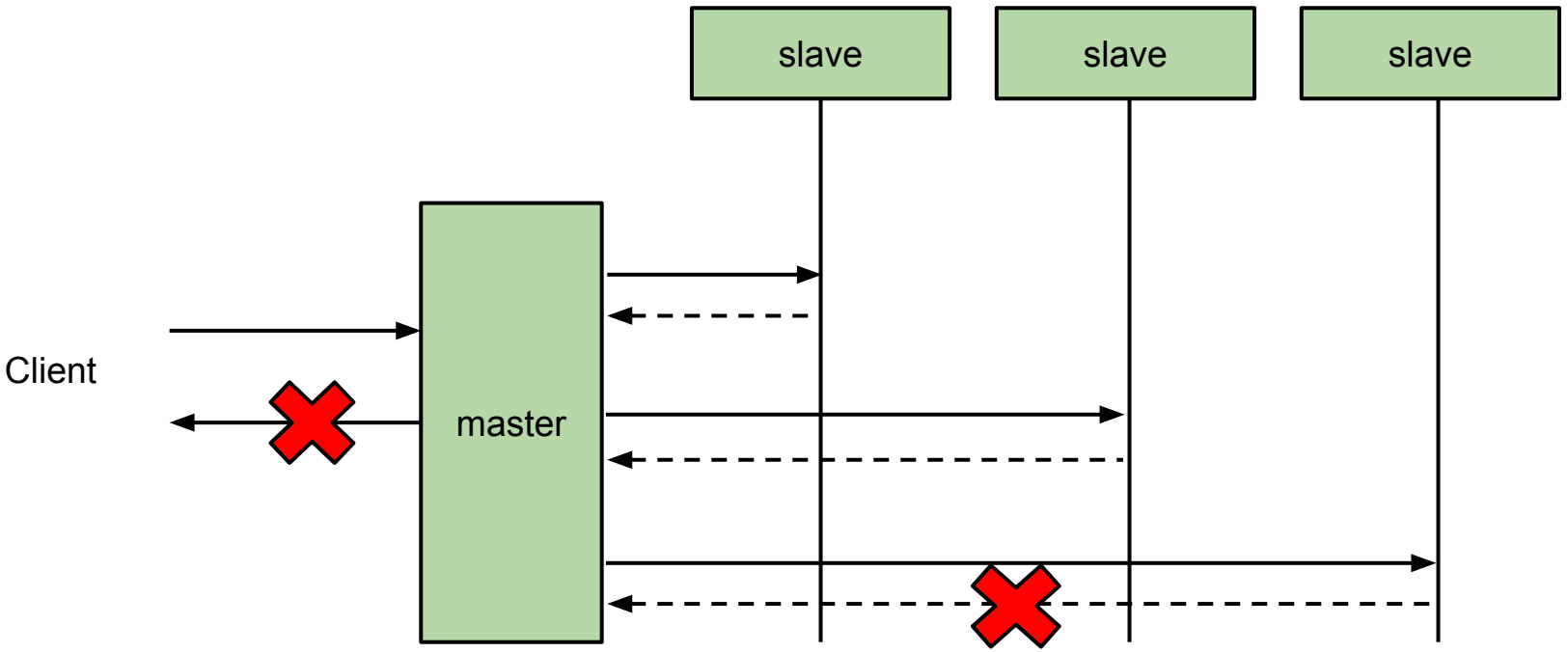
- MSRA / Netease / WandouLabs / PingCAP
- Hacker / Infrastructure software engineer
- Distributed system / Database / PL / …
- Codis / TiDB / TiKV
- Golang / Rust / Python

Consensus

is the only problem in distributed system...

Modern HA

- Master-slave is not an option, why?



MySQL MHA + Semi-Sync?

MySQL

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Bug #80395	**semi-sync: incorrect crash recovery handling**		
Submitted:	16 Feb 2016 12:54	Modified:	16 Feb 2016 18:17
Reporter:	Matt Lord	Email Updates:	Subscribe
Status:	Need Doc Info	Impact on me:	None Affects Me
Category:	MySQL Server: Replication	Severity:	S2 (Serious)
Version:	5.7.11	OS:	Any
Assigned to:	David Moss		

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[16 Feb 2016 12:54] Matt Lord

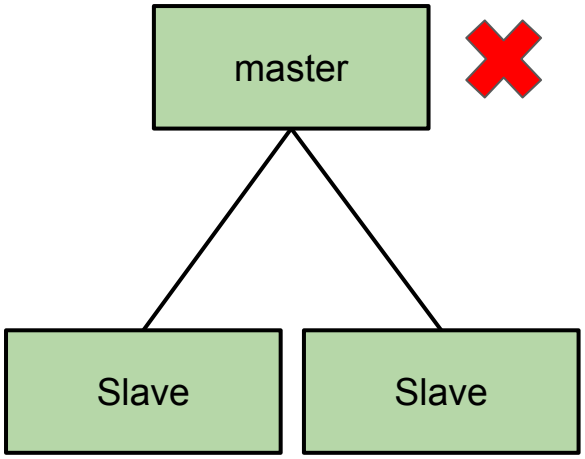
Description:

When mysqld is killed while an open semi-sync replication transaction is waiting for the master timeout, that prepared *but uncommitted* transaction is NOT property rolled back when the master performs its subsequent automated crash recovery.

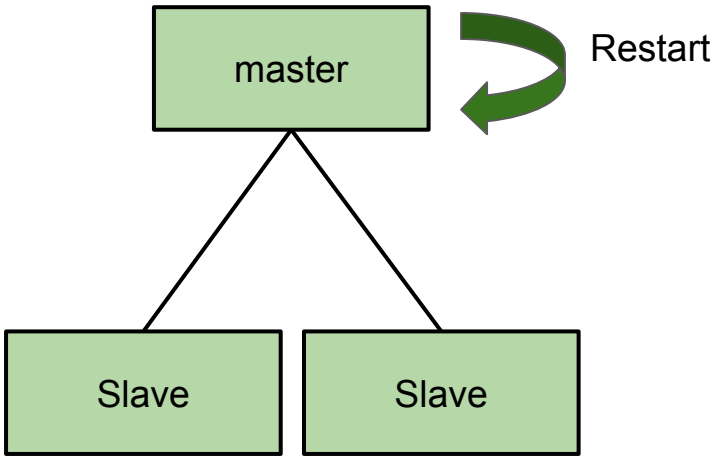
This was verified on OL 7.2 x86_64, using MySQL 5.7.11-community.

How to repeat:

(1) Insert A, but master crash when doing semi-sync

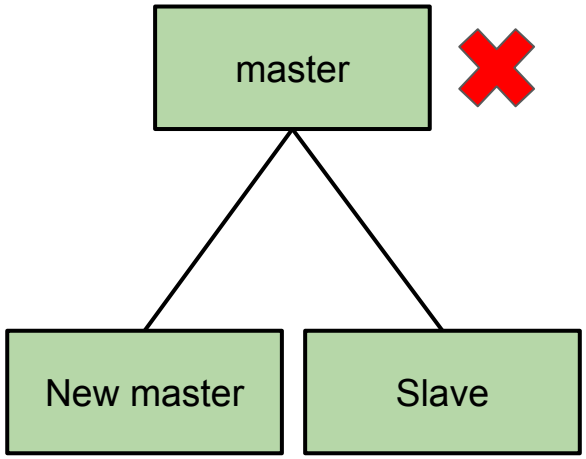


(2) Read A, OK; But degrade to async-replication



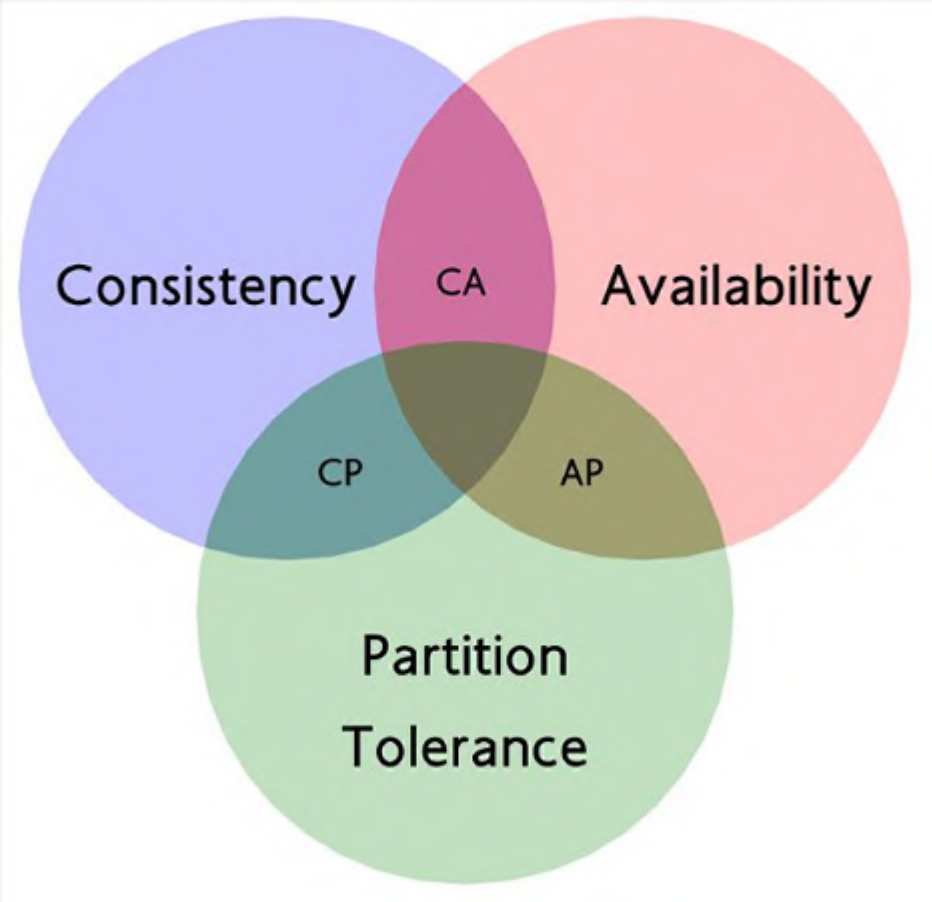
(3) Master crash again...then new master is elected

Read A, fail, oops...

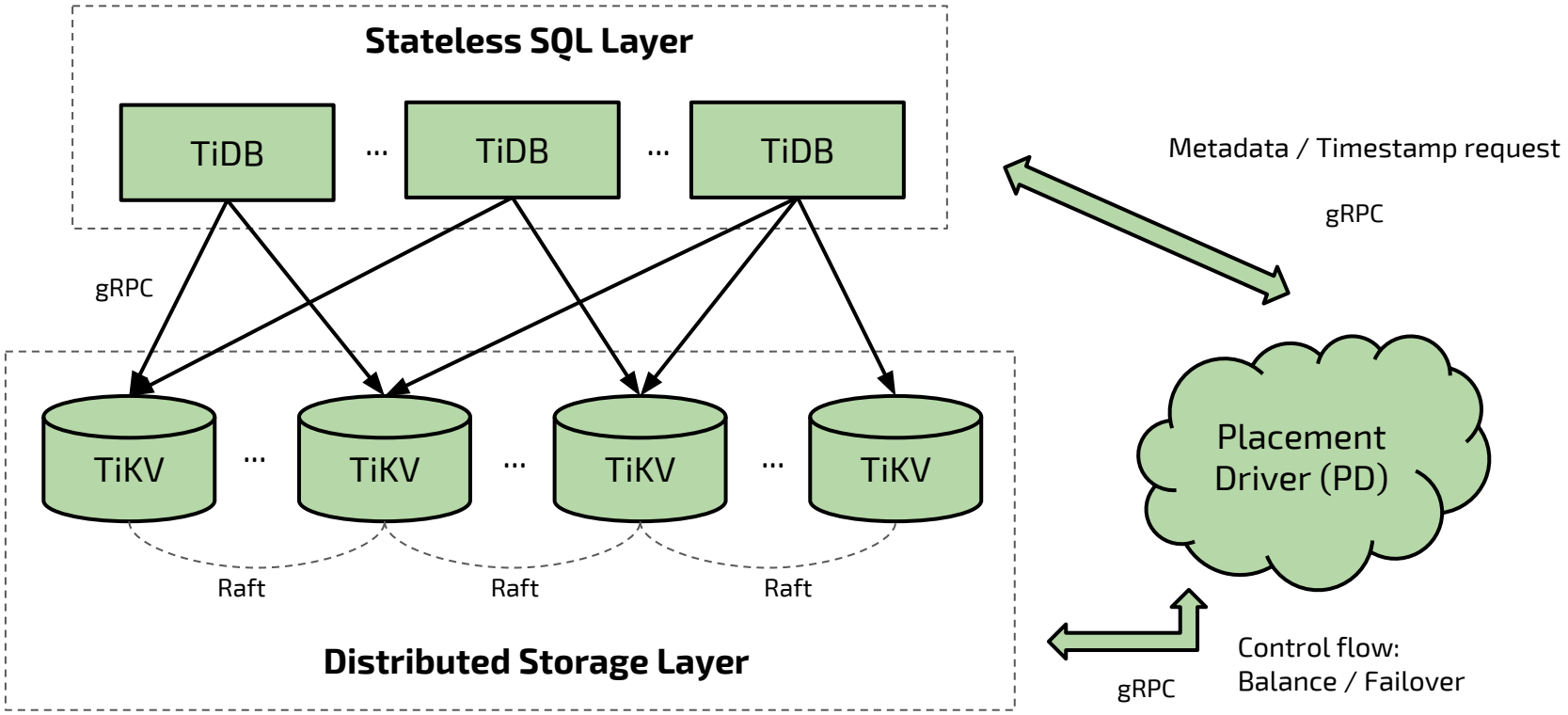


TiDB Project (Requirement)

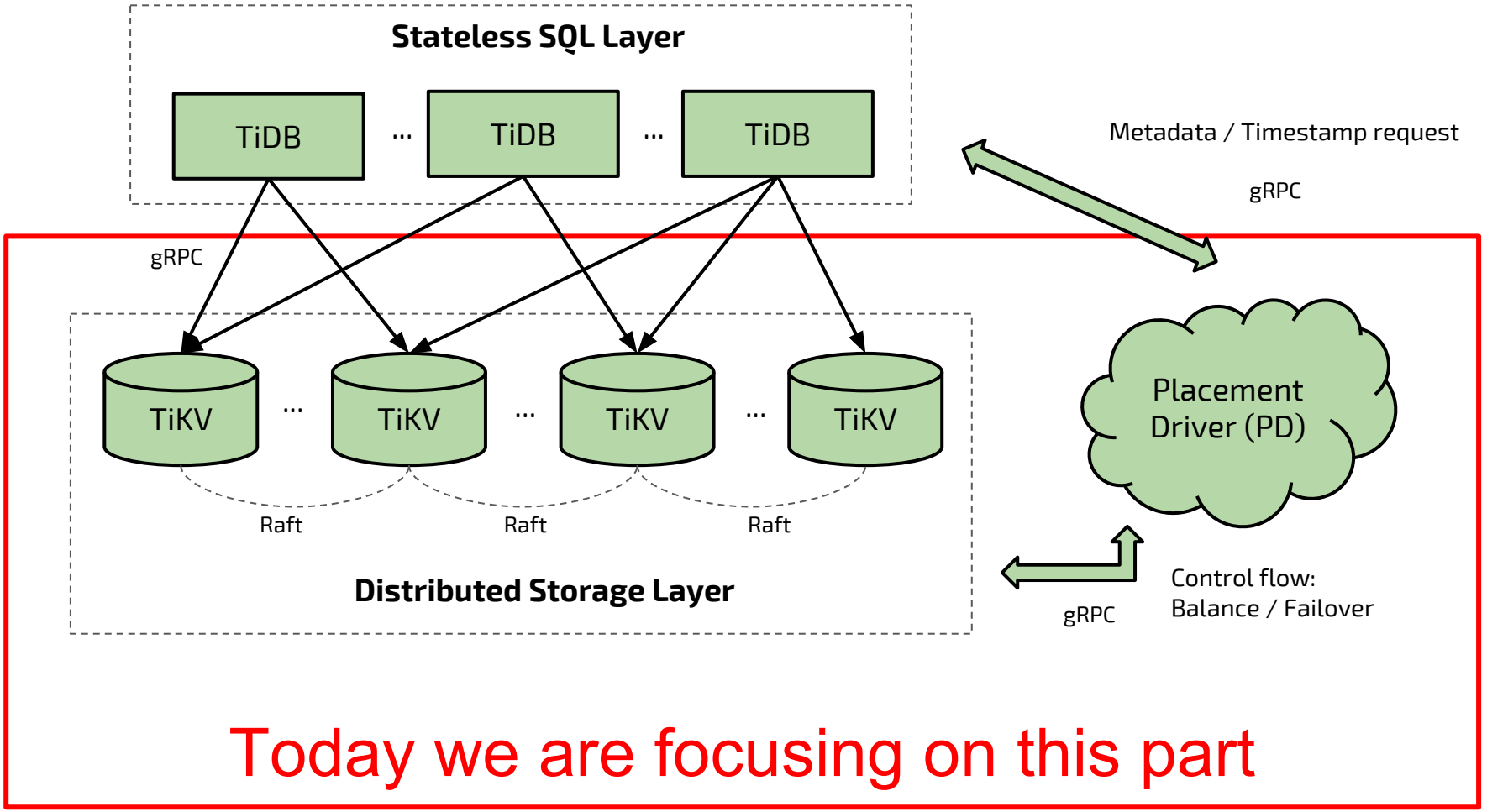
- Strong consistency
- Scalability
- High availability



TiDB Project Overview



TiDB Project Overview



Replicated State Machines

- All servers execute same commands in same order
- System makes progress as long as any majority of servers up
- Agreement on shared state (single system image)
- Recovers from server failures autonomously
  - Minority of servers fail: no problem
  - Majority fail: lose availability, retain strong consistency
- IMHO, there are only two RSM implementations:
  - Multi-Paxos / Raft

The problem in Paxos (Multi Paxos)

“The dirty little secret of the NSDI community is that at most five people really, truly understand every part of Paxos;-).”

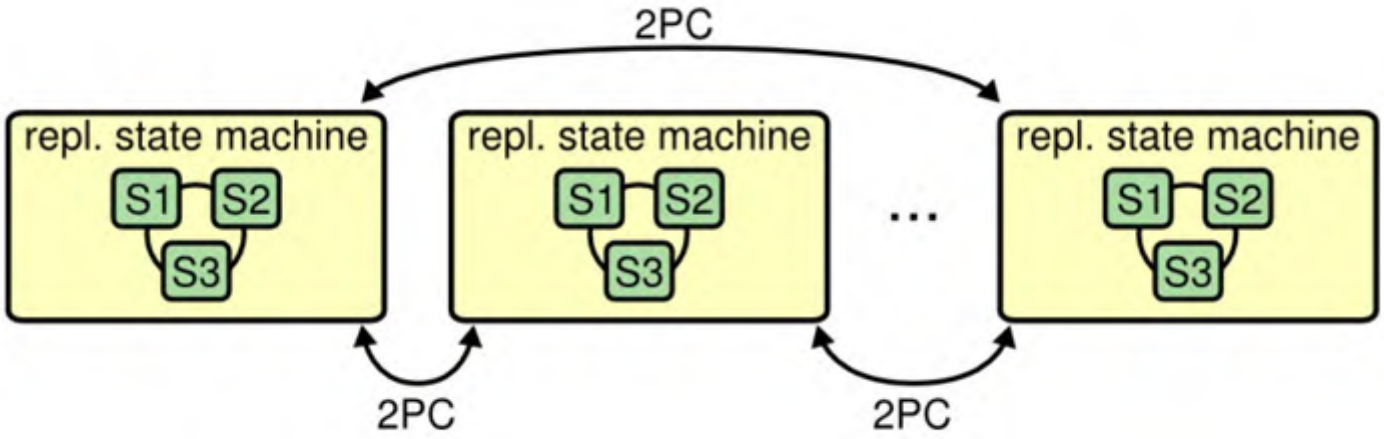
—NSDI reviewer

Raft saves the day

- **Leader election**
  - Select one of the servers to act as cluster leader
  - Detect crashes, choose new leader
- **Log replication**
  - Leader takes commands from clients, appends to its log
  - Leader replicates its log to other servers (overwriting inconsistencies)
- **Safety**
  - Only a server with an up-to-date log can become leader

Use Raft in database

- Single RSM is **NOT** gonna work.
- You need 2PC to retain strong consistency across different RSMs.

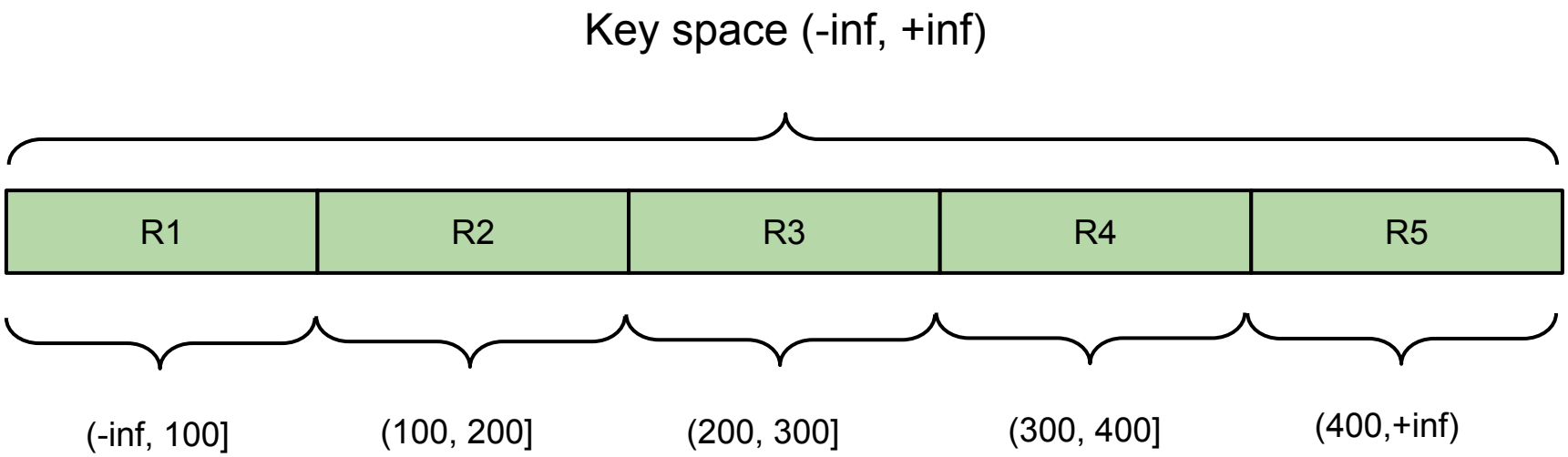


Raft in database

- How to shard?
- How to split / merge dynamically?
- How to balance the workload?
- How to improve the throughput?

Sharding Raft in TiKV

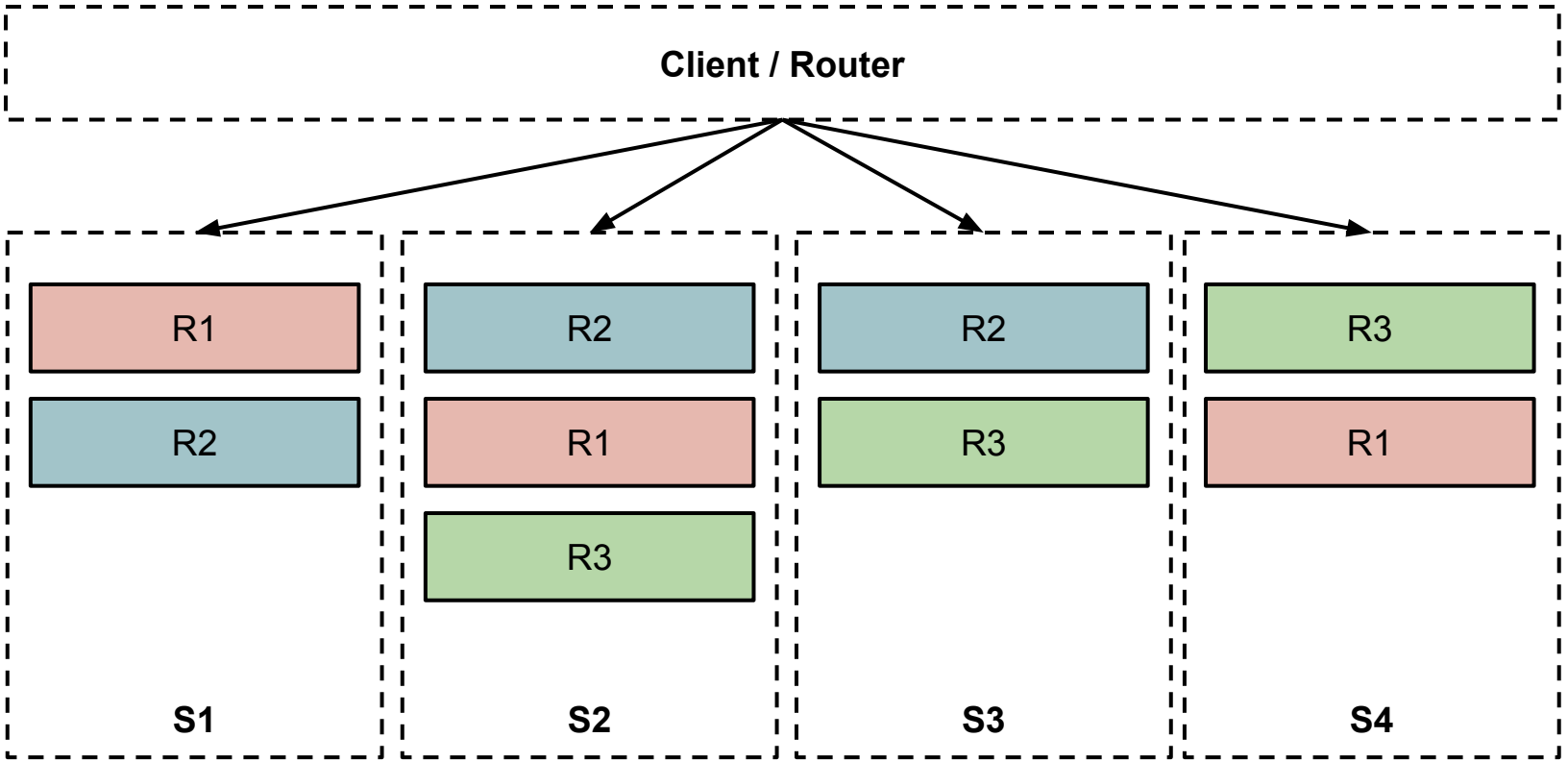
- Split key space into **Regions (normally in byte-order) logically**
- Each region is a raft group
  - Default size: 96 ~ 128 MB
  - Why?



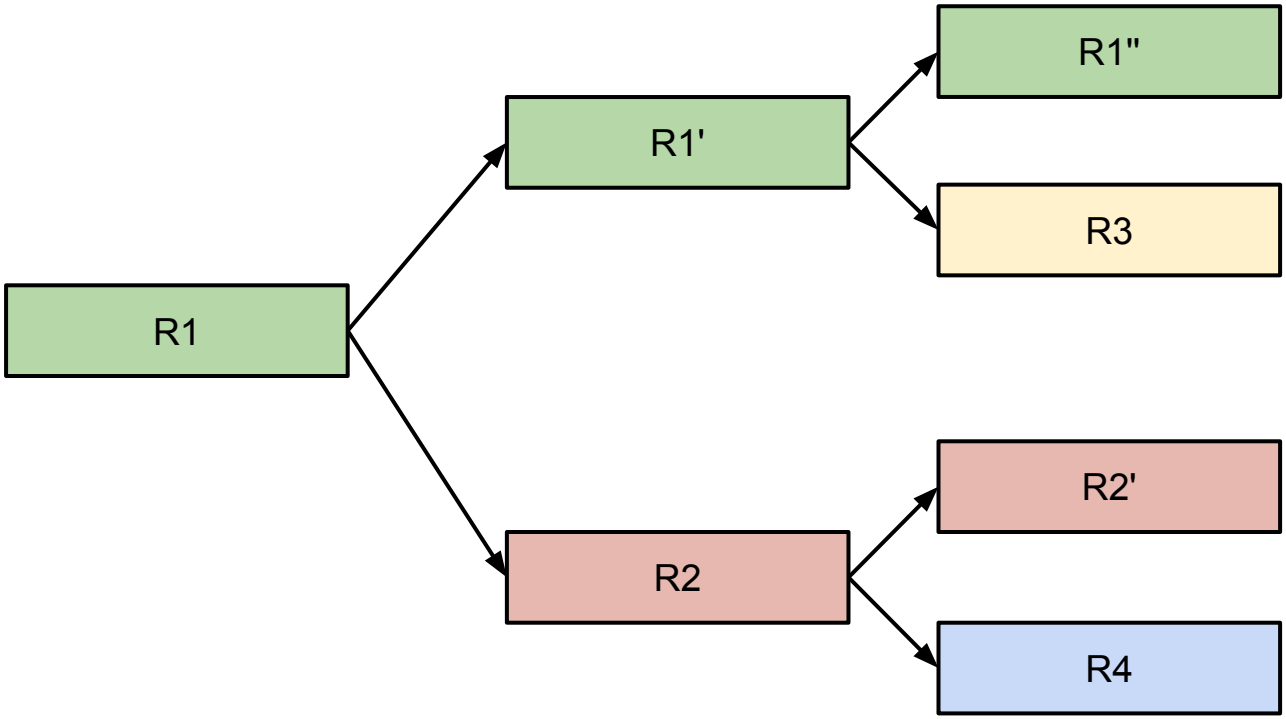
Meta data storage

- We stores region meta in an in-memory B-Tree (in PD)
  - Sorted by the start key of region
  - We can find the right region which contains specific key in O(log N)
- PD is not '***the source of truth***', data server is. Why?
  - Split is always happening
  - The metadata stored in PD may be out-of-date
  - Retry is important

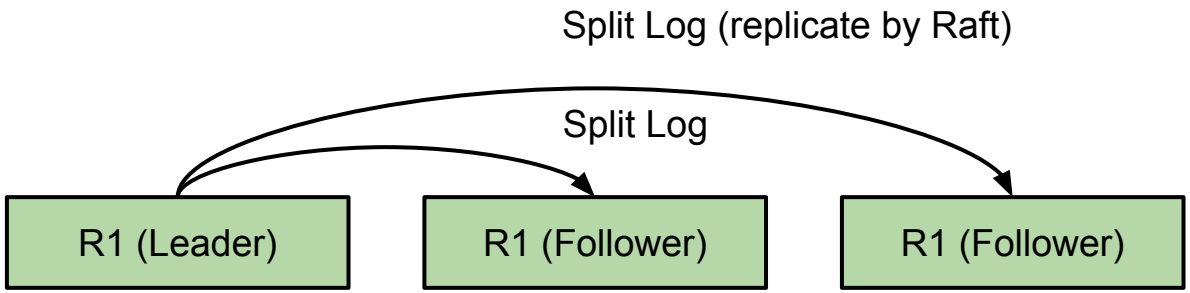
Sharding Raft in TiKV



Sharding Raft in TiKV



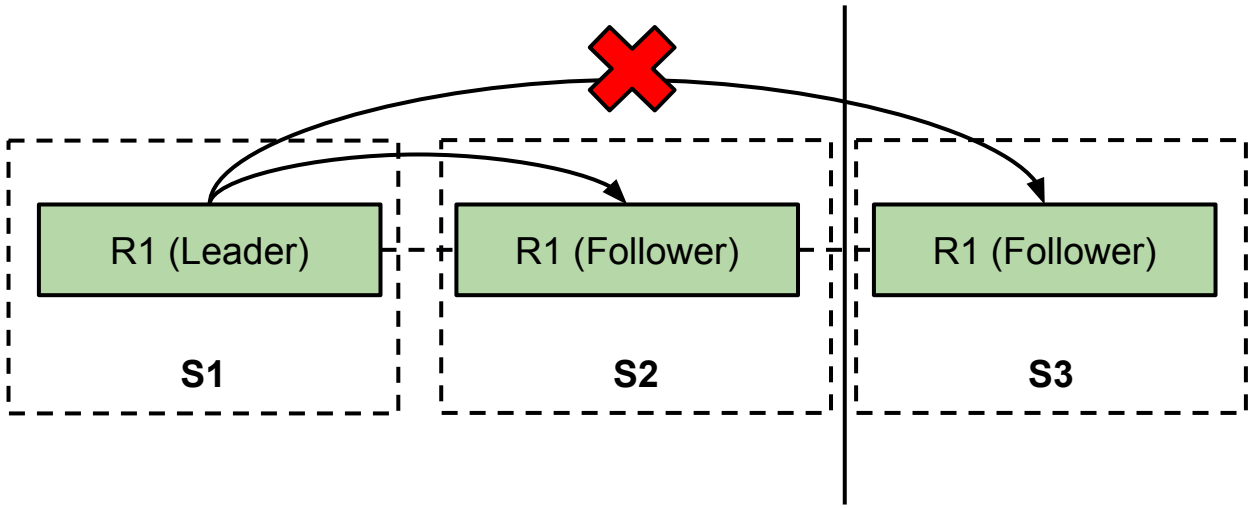
Dynamic split / merge



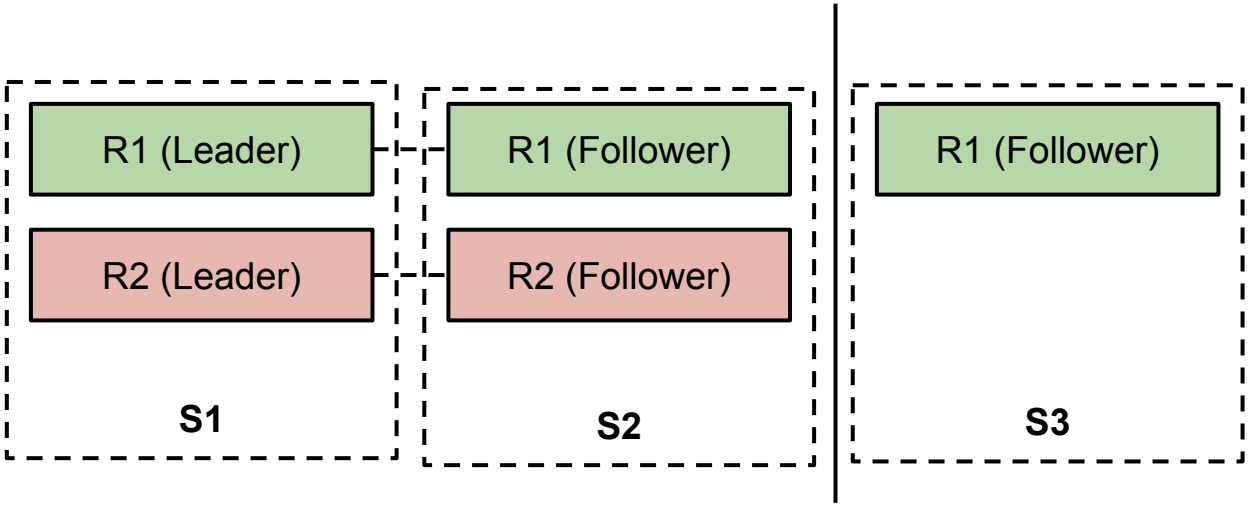
Simple...Huh?

An abnormal situation...

(1)

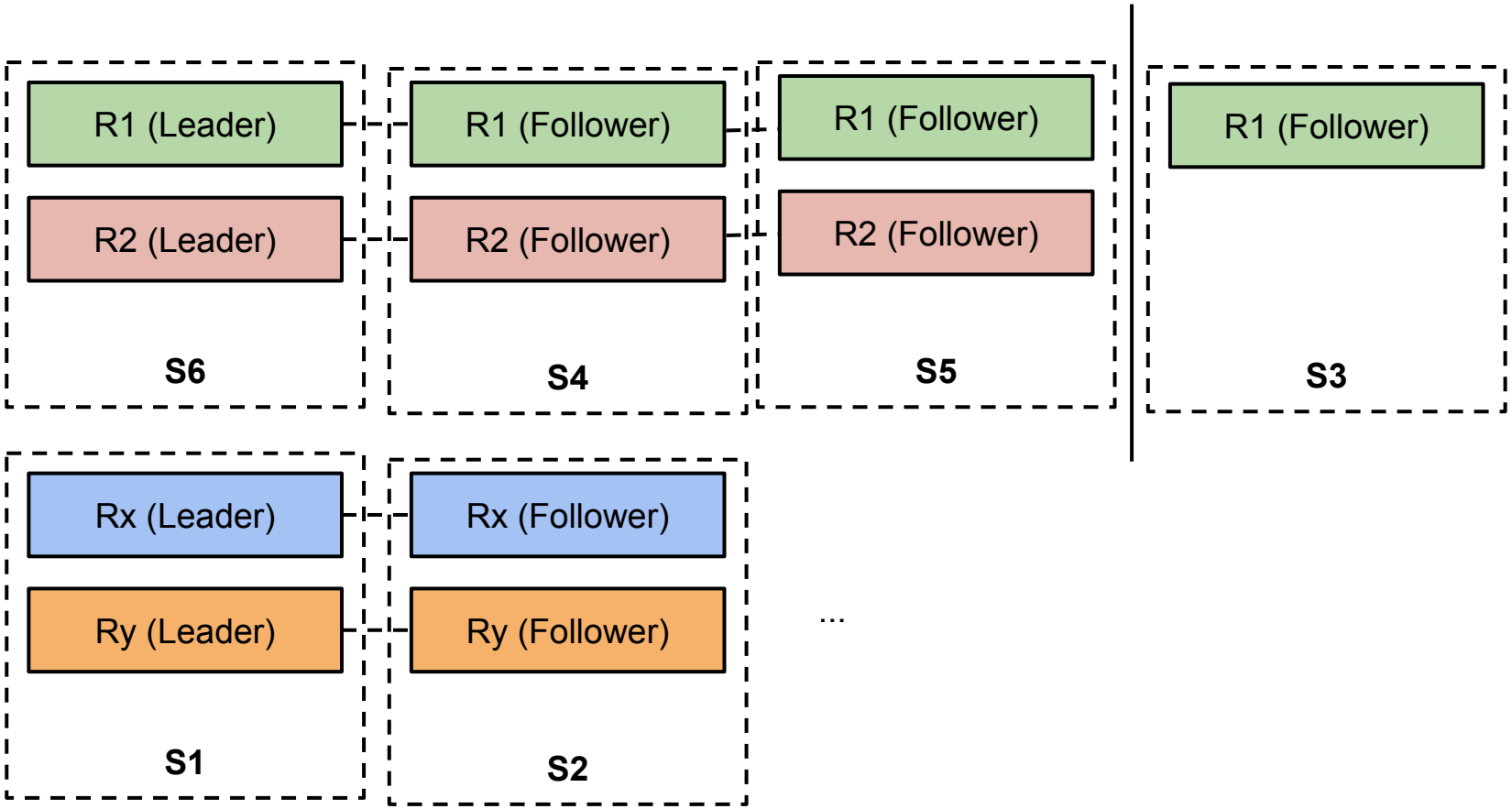


(2)



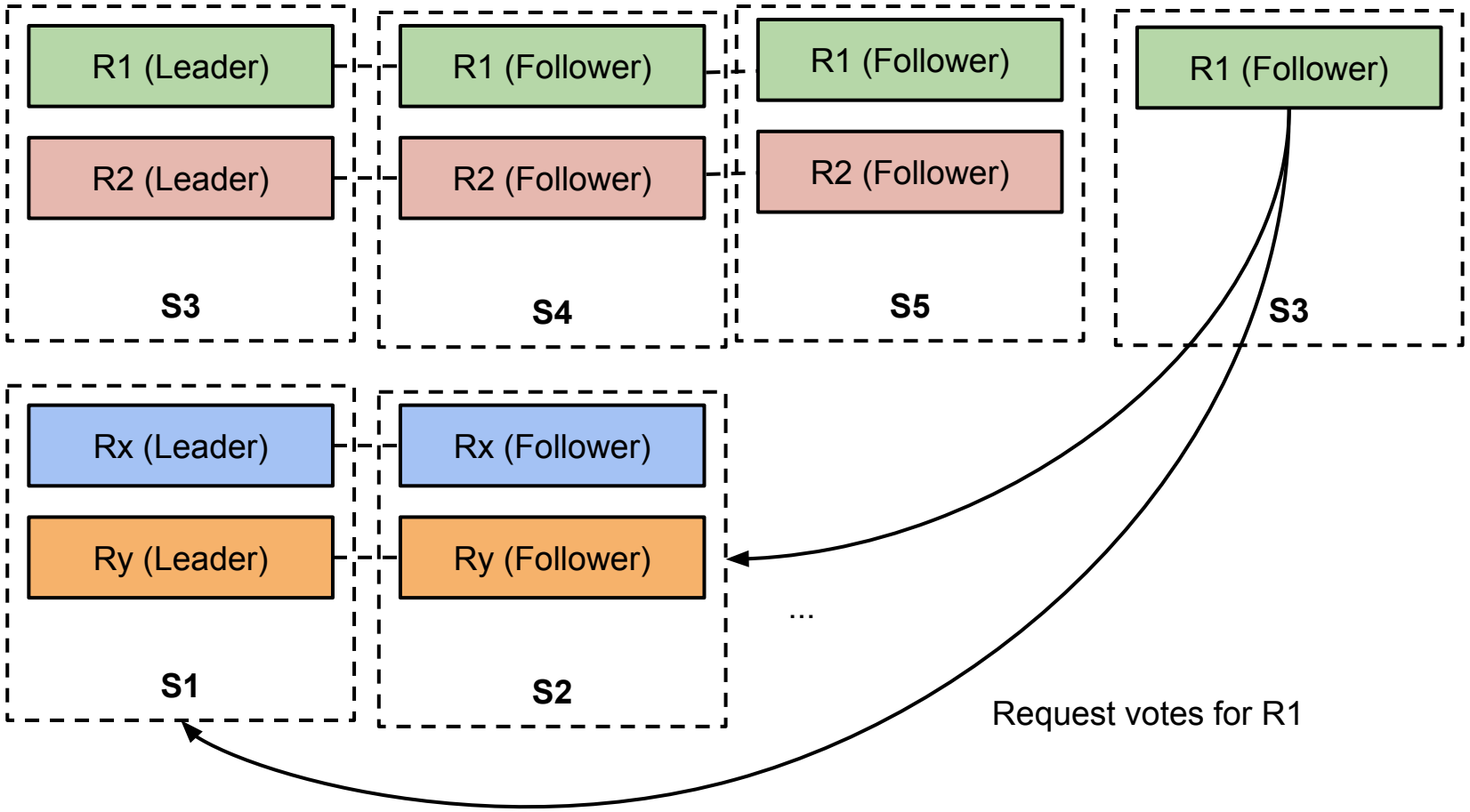
An abnormal situation...

(3) After N rounds of split or membership changes...

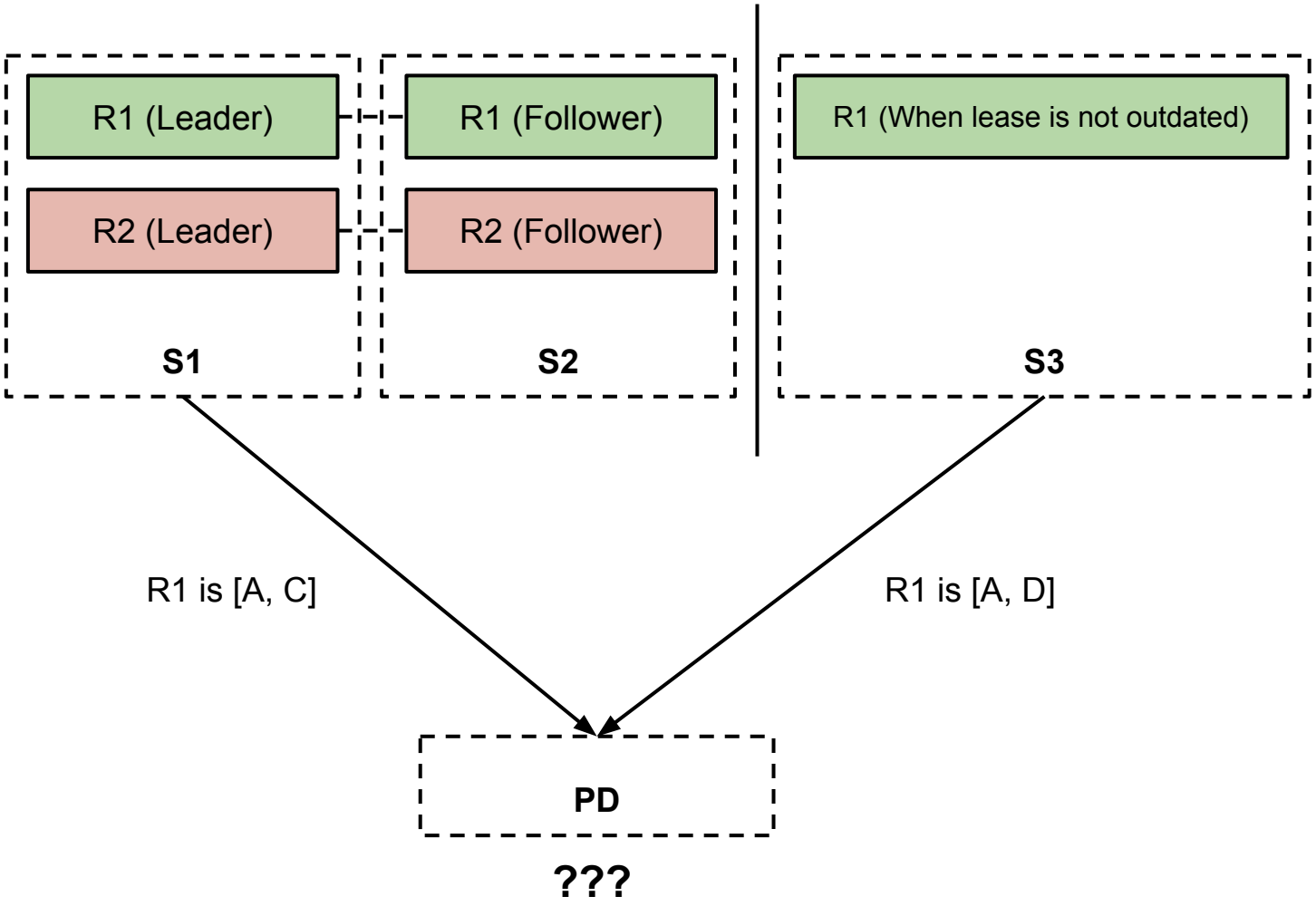


An abnormal situation...

(4)



Another abnormal situation

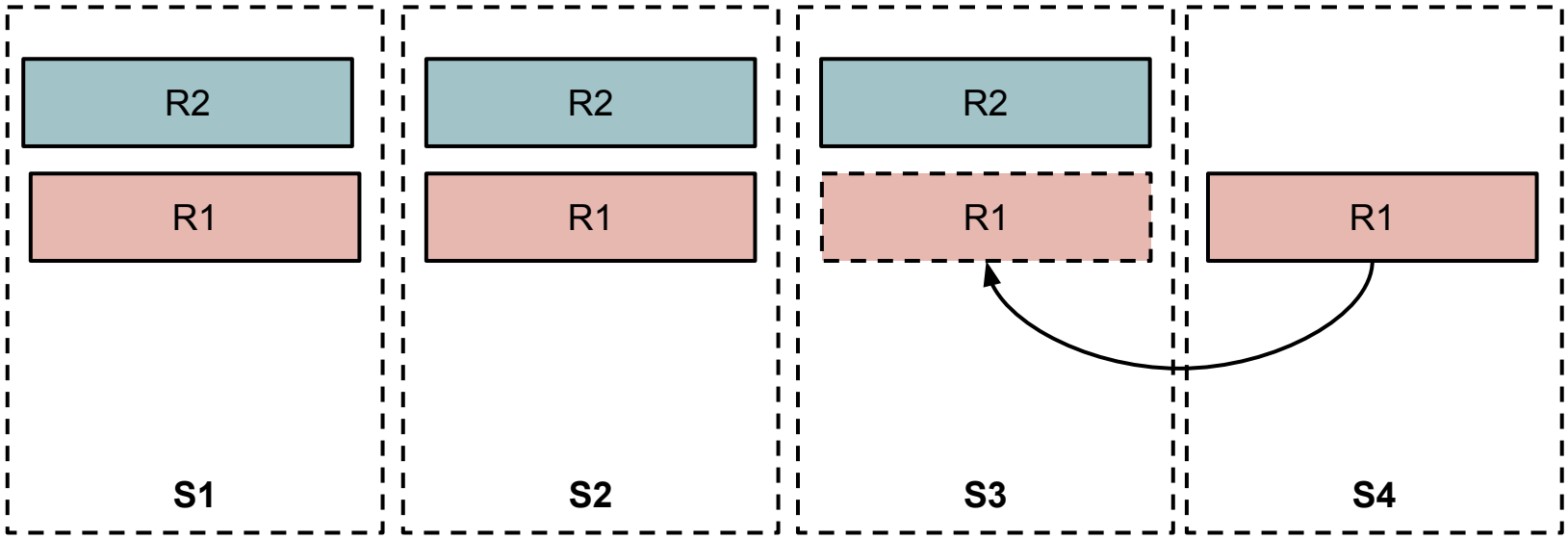


Introduce Region Epoch

- Epoch(Region X) := {ConfVer, SplitVer}
- Every configuration change in Region X will increase the ConfVer
- Every split occurs in Region X will increase the SplitVer
- Let’s say Epoch(R1) >= Epoch(R2), if and only if:
  - ConfVer(R1) >= ConfVer(R2) and SplitVer(R1) >= SplitVer(R2)
- Larger epoch always win

What about merge?

- Make sure all replica for these two regions are in same nodes
- And no more rebalance for these two regions

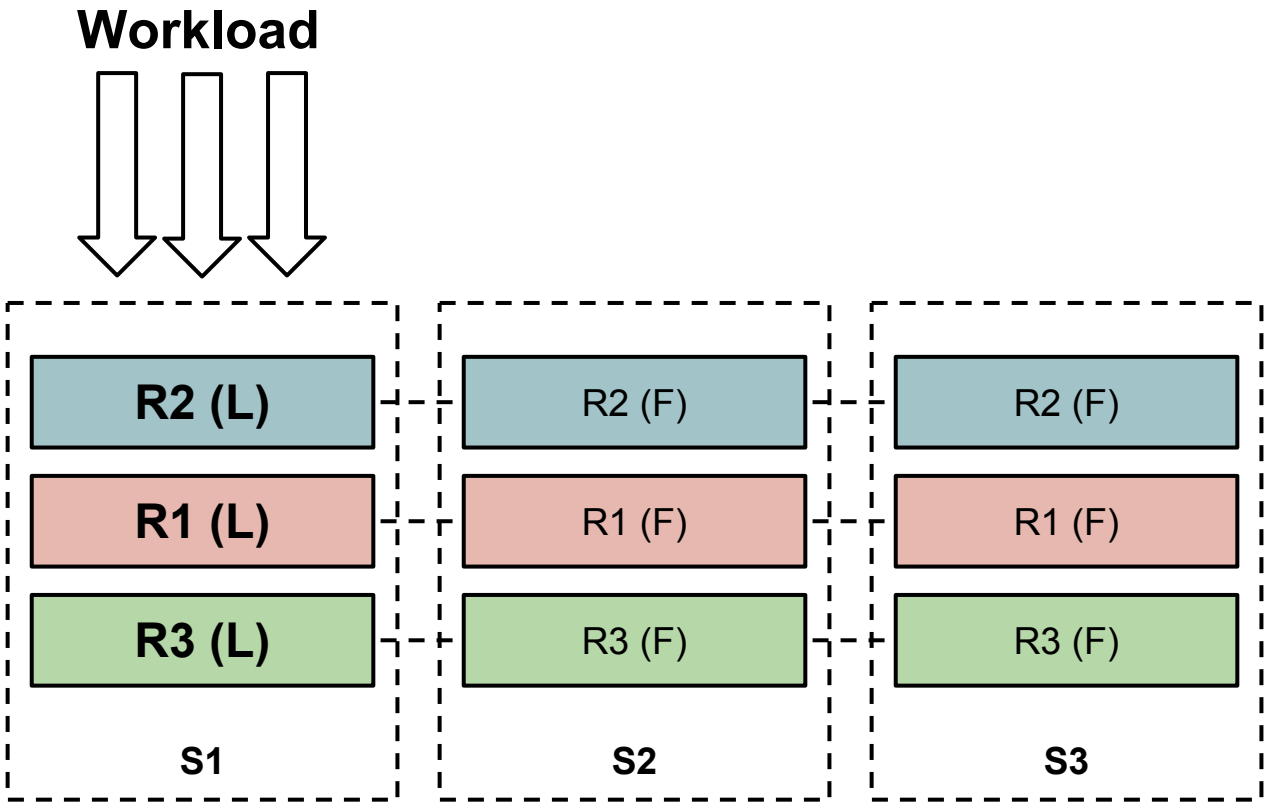


Storage

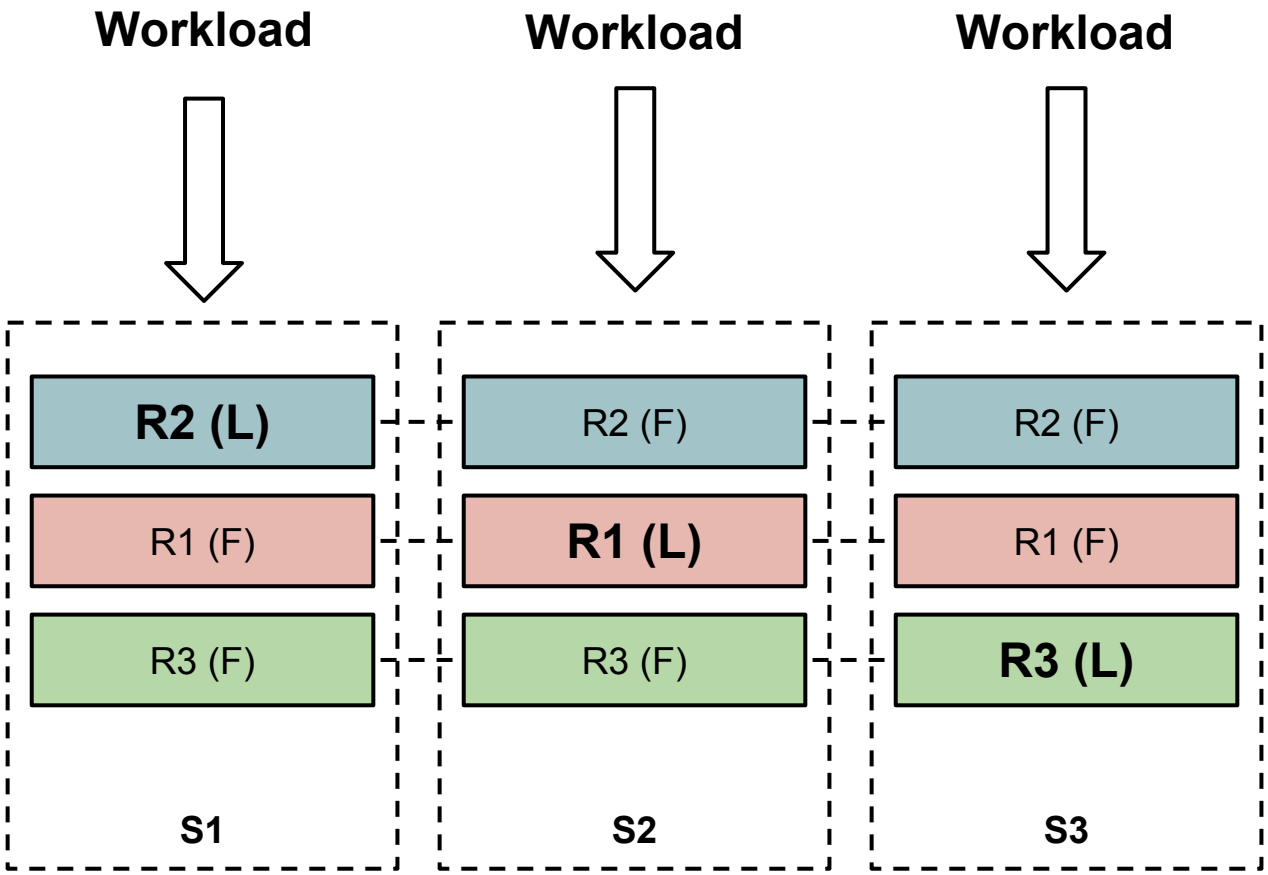
- RSM storage
  - All regions in the same physical node share one RocksDB instance
- Log storage
  - Journal-like storage
  - Share with region storage

Leadership transfer

- For fast rebalance, since Raft is a randomized algorithm, there is a certain probability that one node has too many leaders.

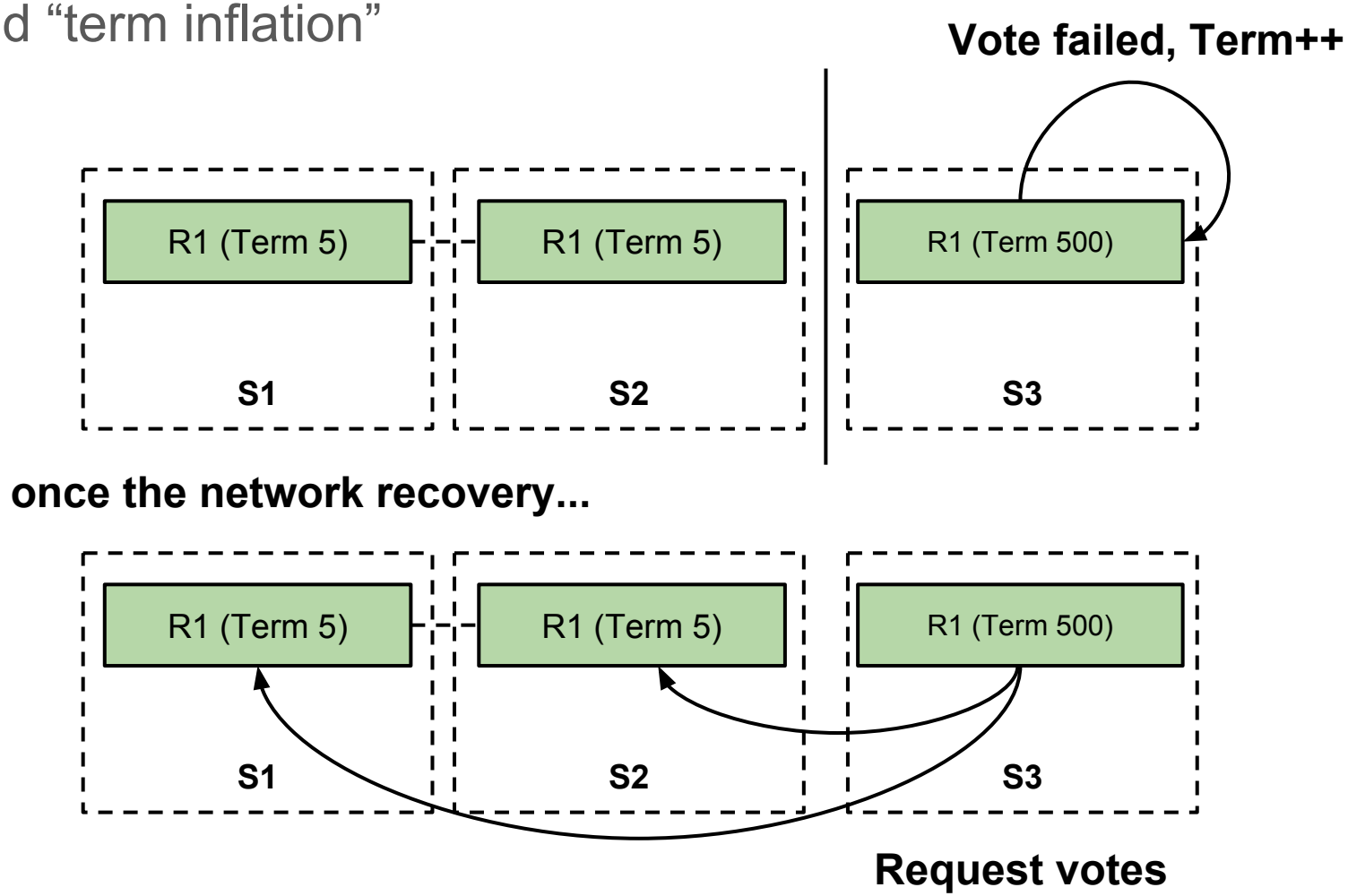


Leadership transfer

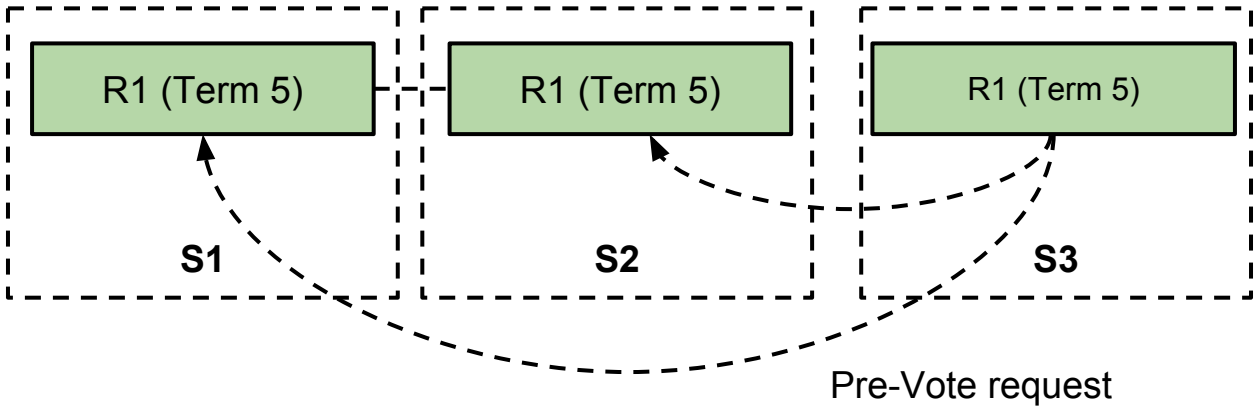


Pre-vote algorithm

- Avoid “term inflation”



Pre-vote algorithm



S3 sends Pre-vote request to S1 and S2 to make sure S3's log is up-to-date, when S3 receives responses from a majority of the cluster, S3 will increase its term and start a normal election

How to test

- Testing in distributed system is really hard
- Test-Driven Development
- Test cases from community
  - Lots of tests in MySQL drivers/connectors
  - Lots of ORMs
  - Lots of applications (Record---replay)
- Fault injection
  - Hardware: disk error, network card, cpu, clock
  - Software: file system, network and protocol
- Simulate everything：Network
- Distribute testing
  - Jepsen
  - Namazu

Benchmark

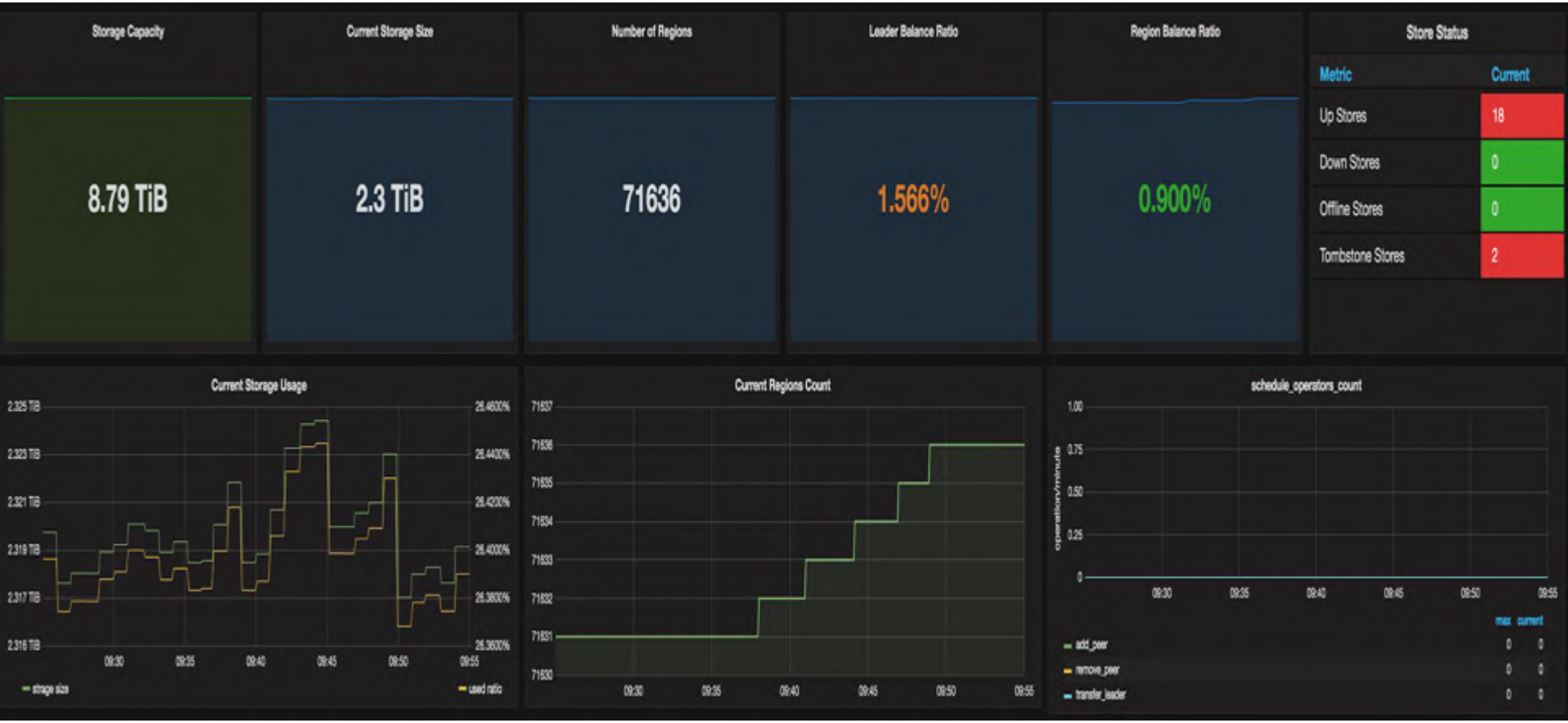
- 46 Physical nodes
- 460 TiKV instances (1 tikv instance for 1 HDD)
- TiKV Raw API Put (Raft)

Put(key, value)
key size: 21 bytes
value size: random (1~100 bytes)

Benchmark


rawkv QPS
put-qps
request-qps
99% rawkv command
put
memory usage
99.99% KV retry duration
pdRPC
regionMiss
pd_client_cmd_total
Region Error
+ ADD ROW

Benchmark


Storage Capacity
8.79 TiB
Current Storage Size
2.3 TiB
Number of Regions
71636
Leader Balance Ratio
1.566%
Region Balance Ratio
0.900%
Store Status
Metric
Current
Up Stores
18
Down Stores
0
Offline Stores
0
Tombstone Stores
2
Current Storage Usage
2.325 TiB
2.323 TiB
2.321 TiB
2.319 TiB
2.317 TiB
2.316 TiB
26.4600%
26.4400%
26.4200%
26.4000%
26.3800%
26.3600%
09:30
09:35
09:40
09:45
09:50
09:55
storage size
used ratio
Current Regions Count
71837
71836
71835
71834
71833
71832
71831
71830
09:30
09:35
09:40
09:45
09:50
09:55
schedule_operators_count
operation/v/minute
1.00
0.75
0.50
0.25
0
09:30
09:35
09:40
09:45
09:50
09:55
max
current
add_peer
0
0
remove_peer
0
0
transfer_leader
0
0

THANKS!

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