arm TREASURE DATA

Dive into PlazmaDB Performance Characteristics And Future Challenges

2018/10/16 TD tech talk

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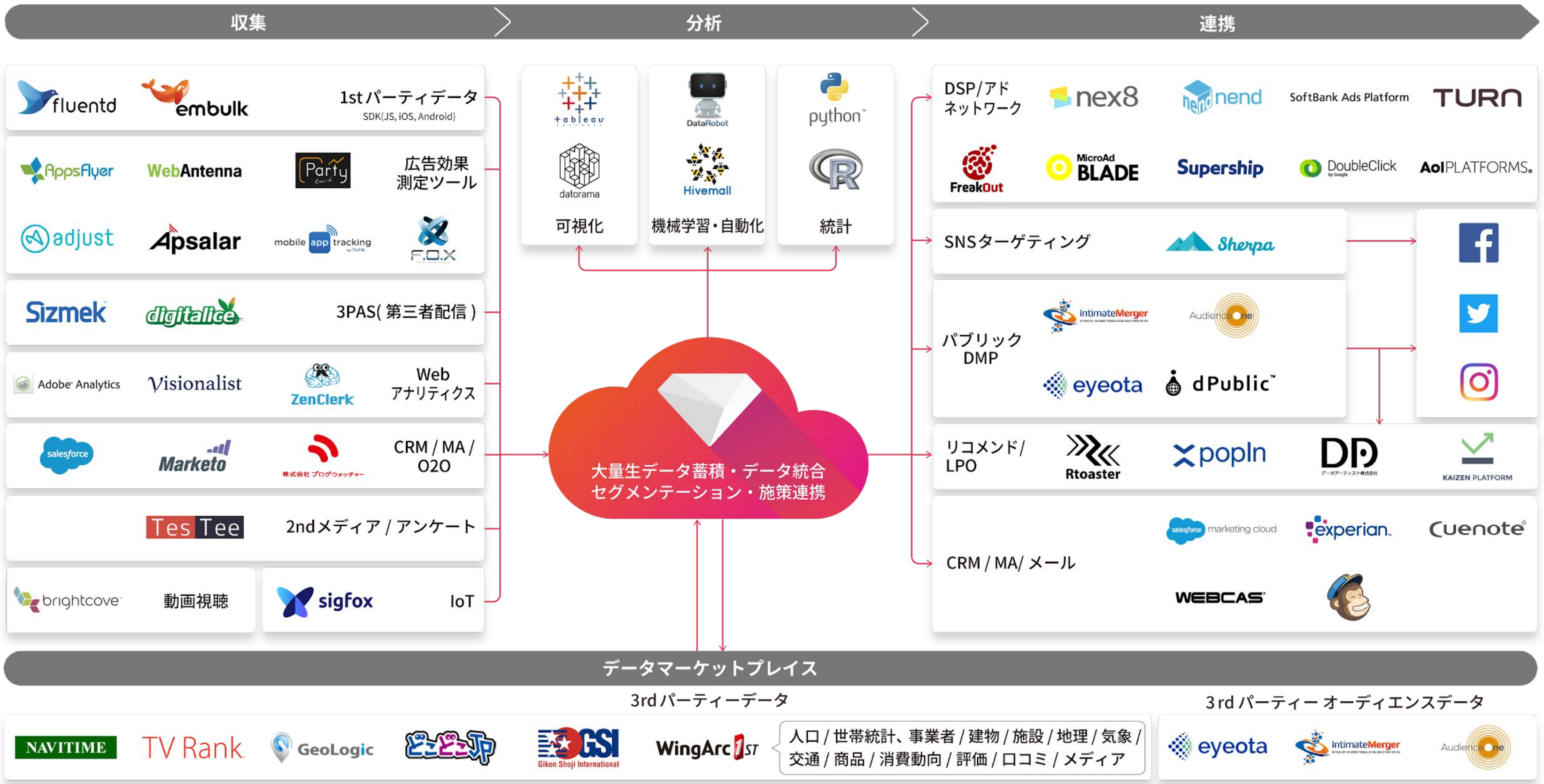
Who am I?

Keisuke Suzuki

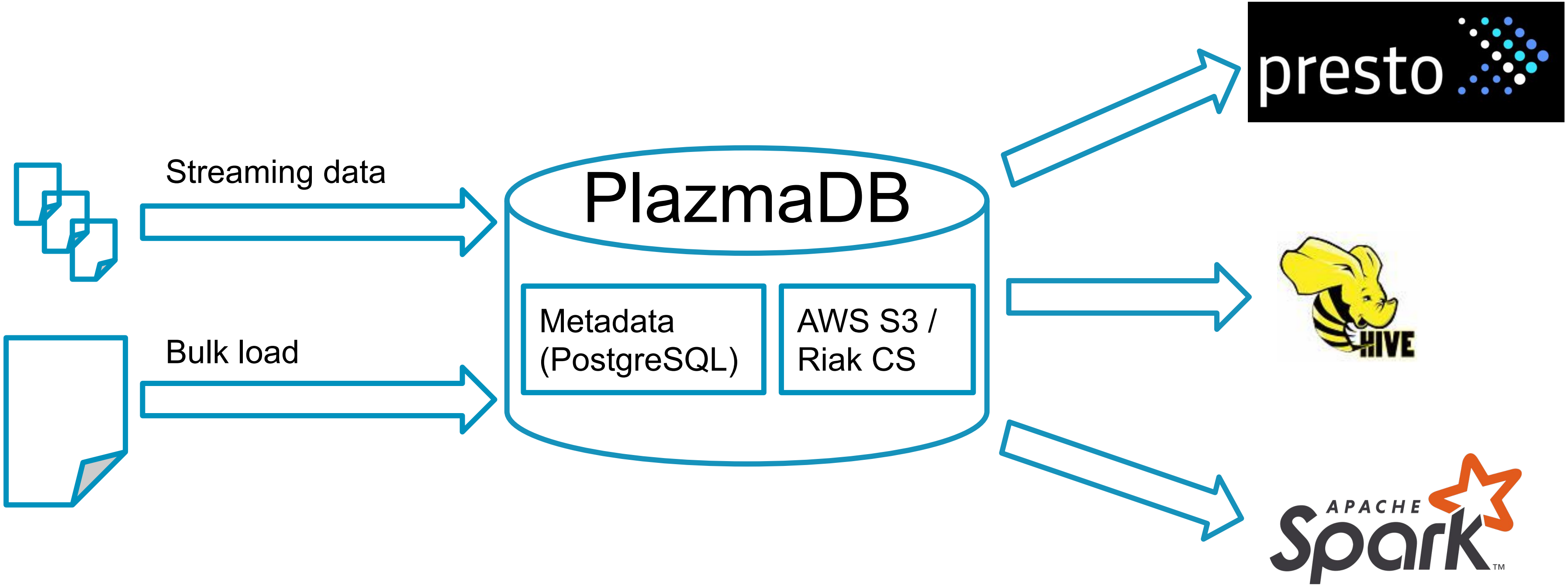
- Backend Engineer @ Treasure Data KK
  - PlazmaDB: distributed storage
  - Datatank: data mart
- DB / Distributed system / Performance optimization
- Twitter: @yajilobee

Treasure Data & PlazmaDB

Arm Treasure Data eCDP



PlazmaDB


Streaming data
Bulk load
PlazmaDB
Metadata (PostgreSQL)
AWS S3 / Riak CS
presto
HIVE
APACHE Spark

Daily Workload & Storage Size

Import

500 Billion Records / day
~ 5.8 Million Records / sec

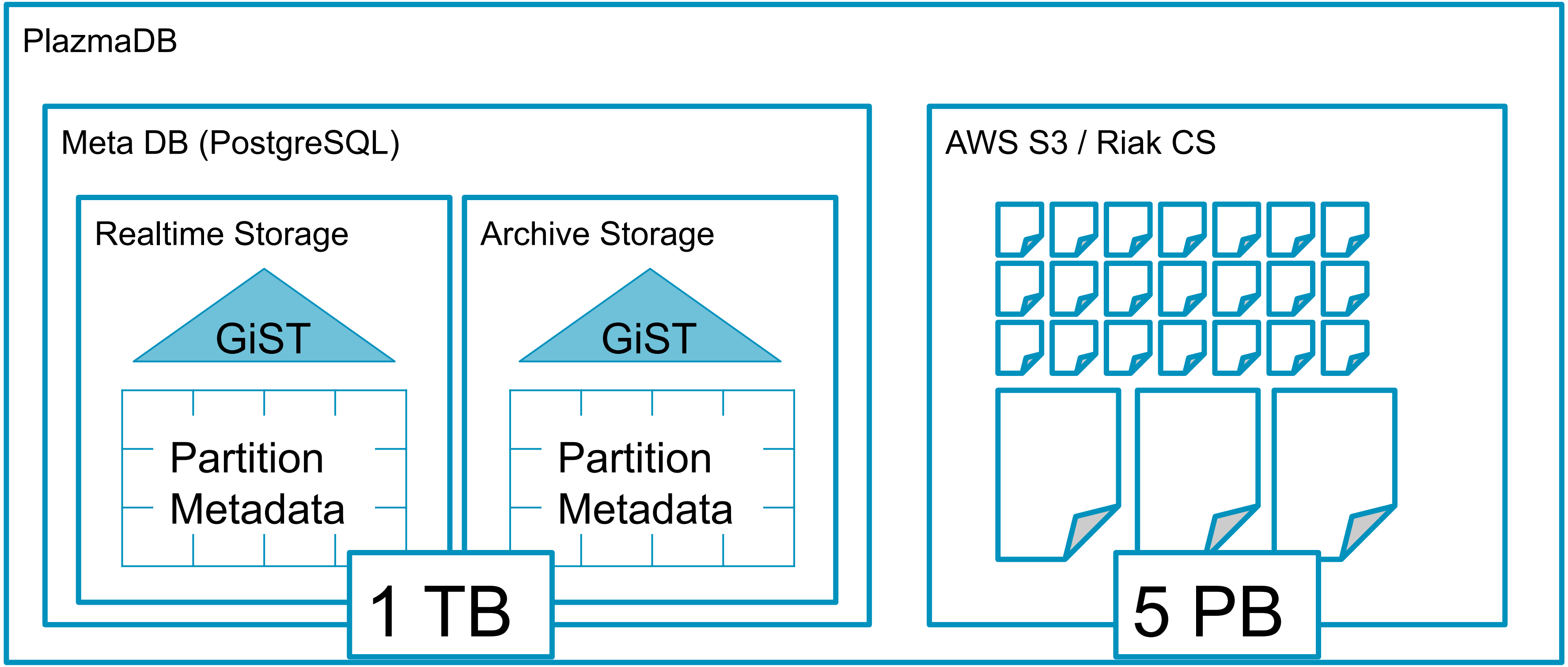
Query

600,000 Queries / day
15 Trillion Records / day

Storage size

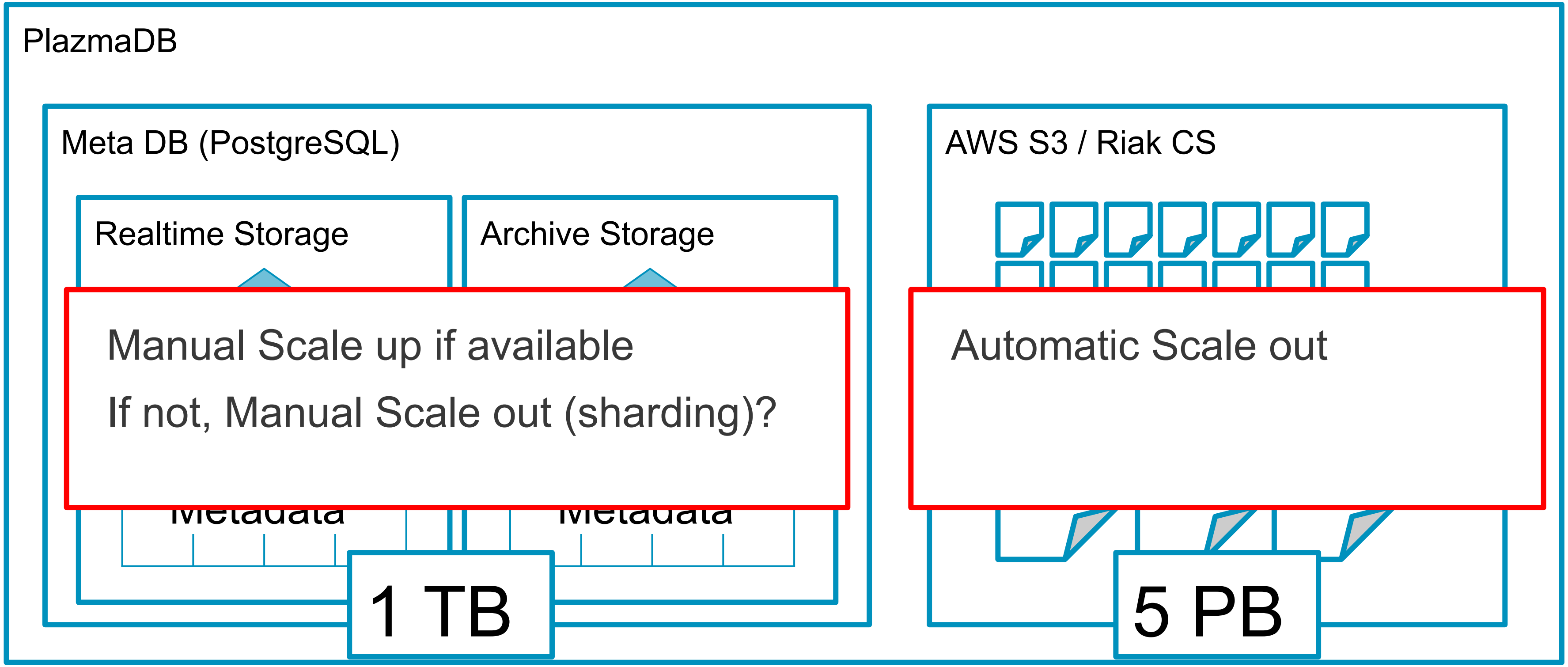
5 PB (+5~10 TB / day)
55 Trillion Records

Data Volume

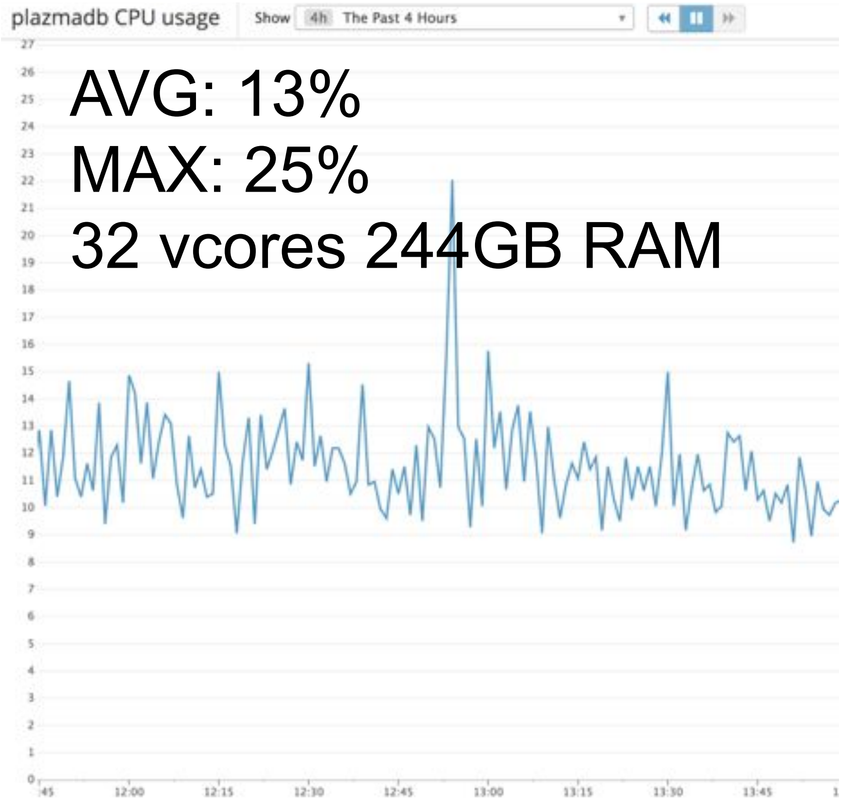


PlazmaDB
Meta DB (PostgreSQL)
Realtime Storage
GiST
Partition
Metadata
Archive Storage
GiST
Partition
Metadata
1 TB
AWS S3 / Riak CS
5 PB

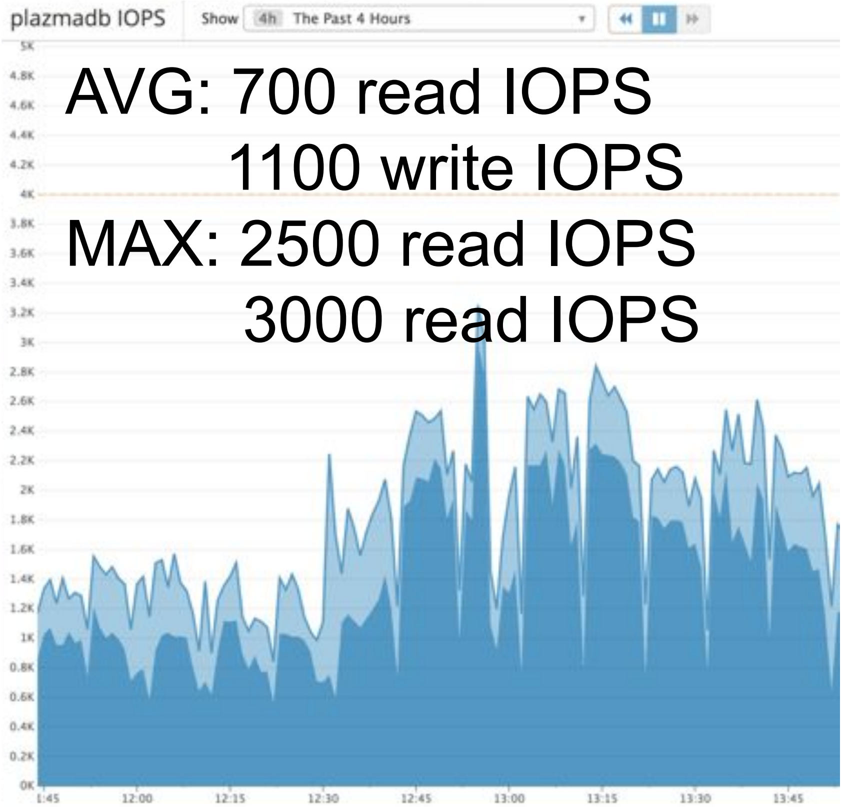
Scaling Strategy



Current MetaDB CPU / IO utilization



AVG: 13%
MAX: 25%
32 vcores 244GB RAM



AVG: 700 read IOPS
1100 write IOPS
MAX: 2500 read IOPS
3000 read IOPS

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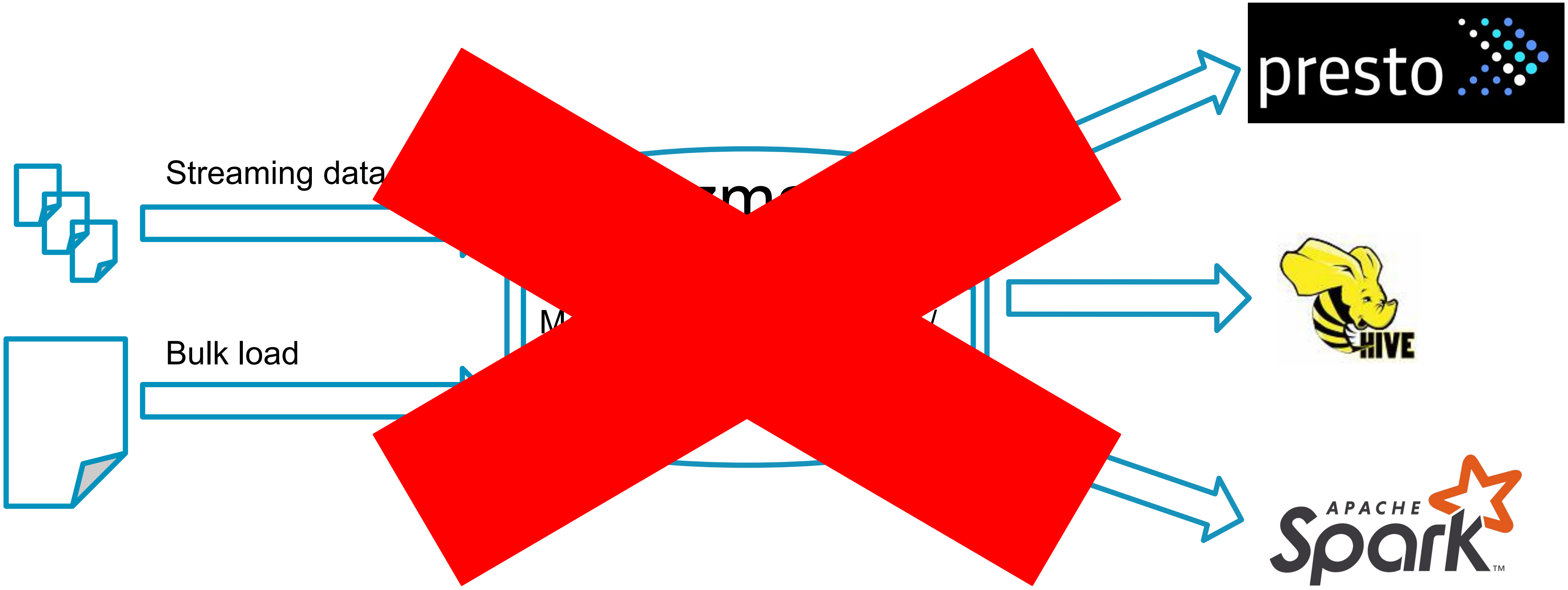
Q: What is MetaDB capacity?

A: Nobody knew

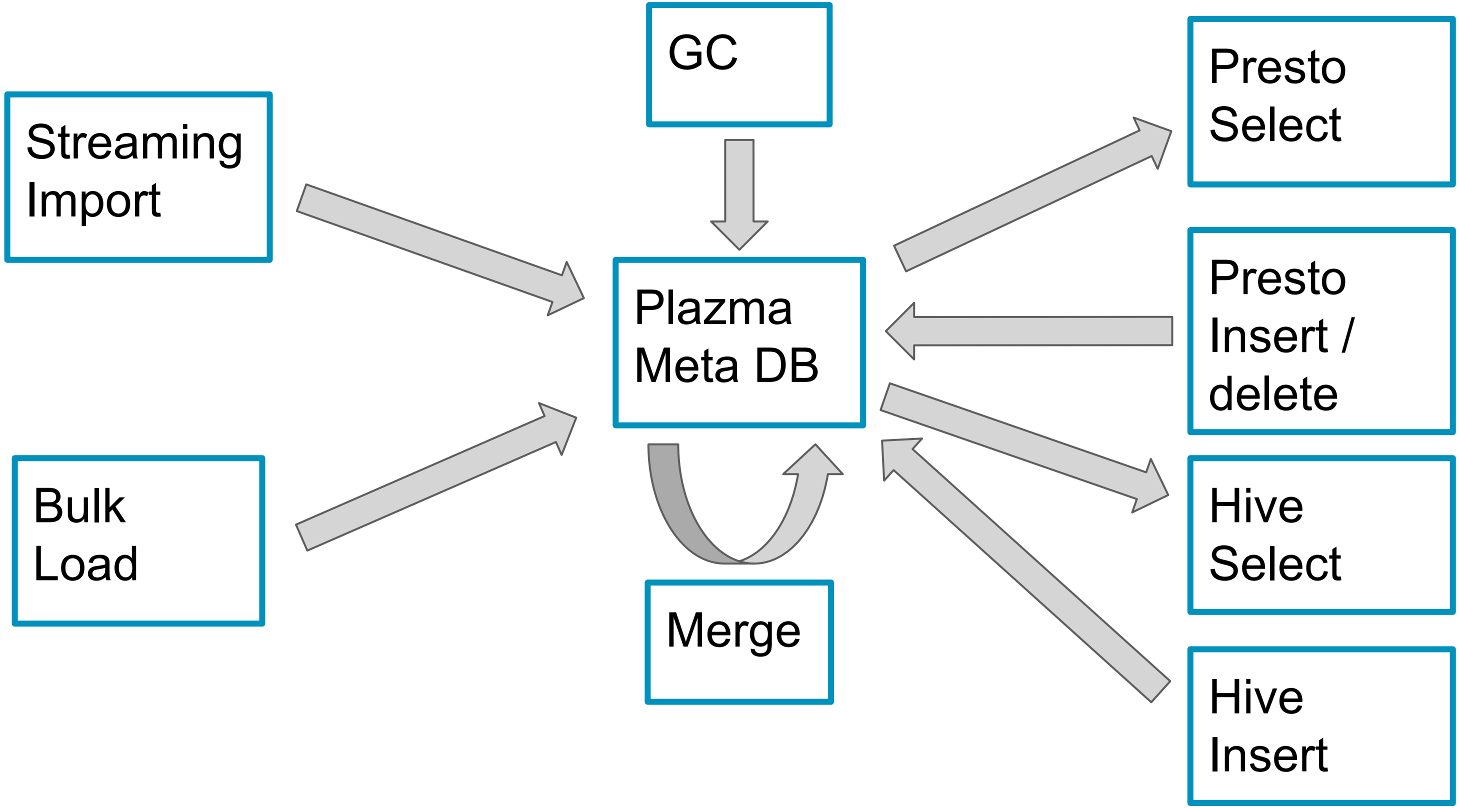
If PlazmaDB is down..



If PlazmaDB down..

Benchmarking Plazma MetaDB

Workload of MetaDB



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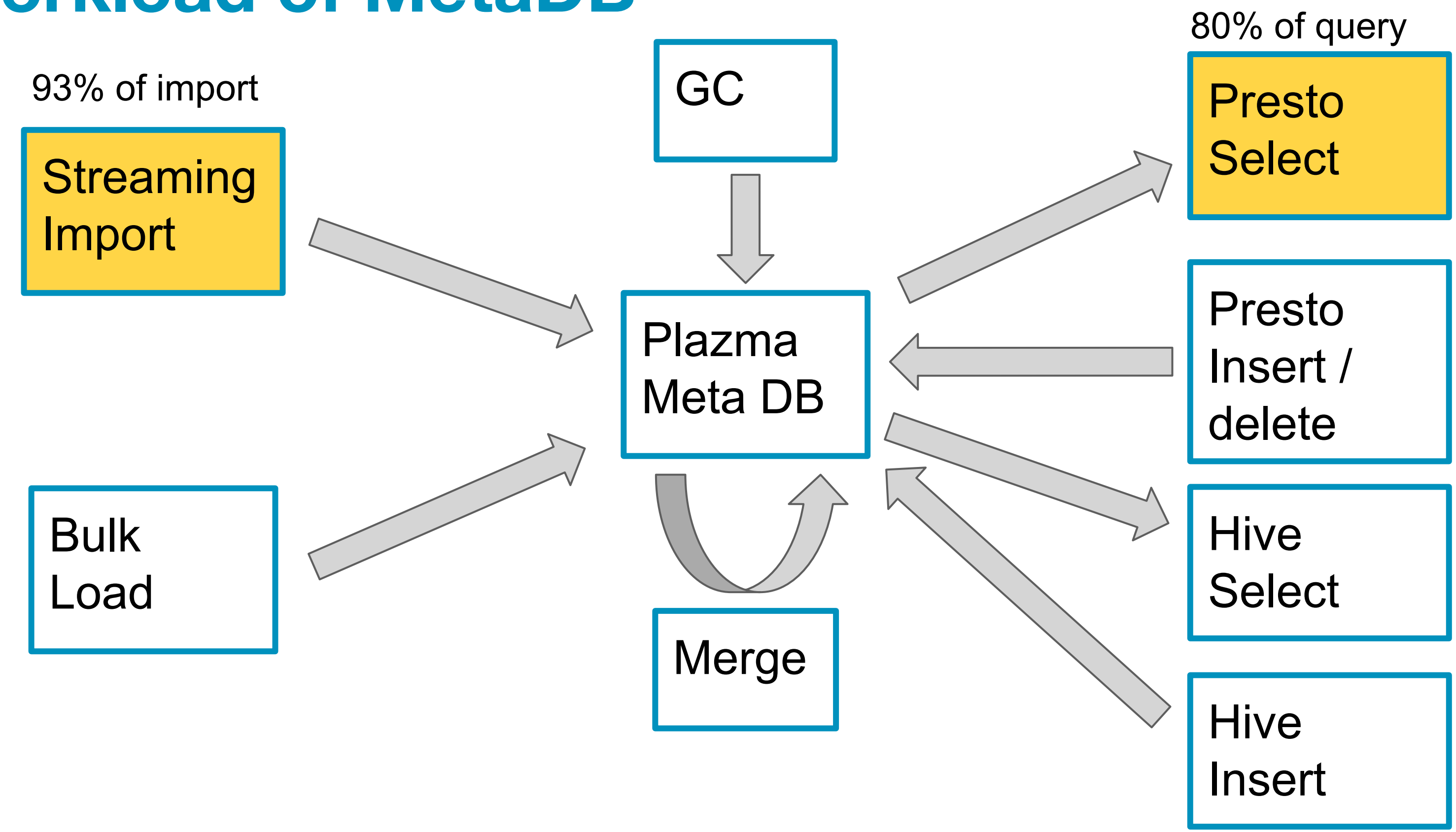
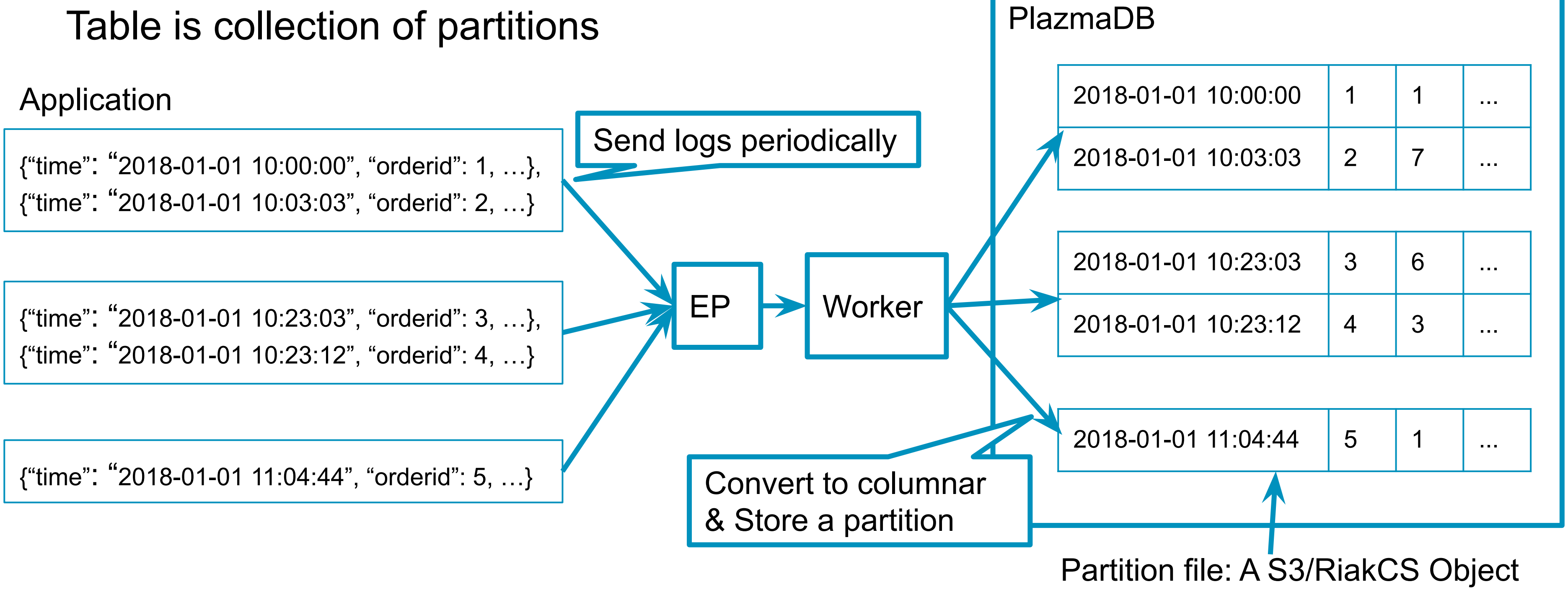
Workload of MetaDB



PlazmaDB Streaming Import



PlazmaDB Metadata

PlazmaDB is Multi tenant

data_set_id: ID combination of User, Database, Table

Meta DB (PostgreSQL)

data_set_id	path	...
1		
1		
1		
2		

AWS S3 / RiakCS

Data set 1

2018-01-01 10:00:00	1	1	...
2018-01-01 10:03:03	2	7	...

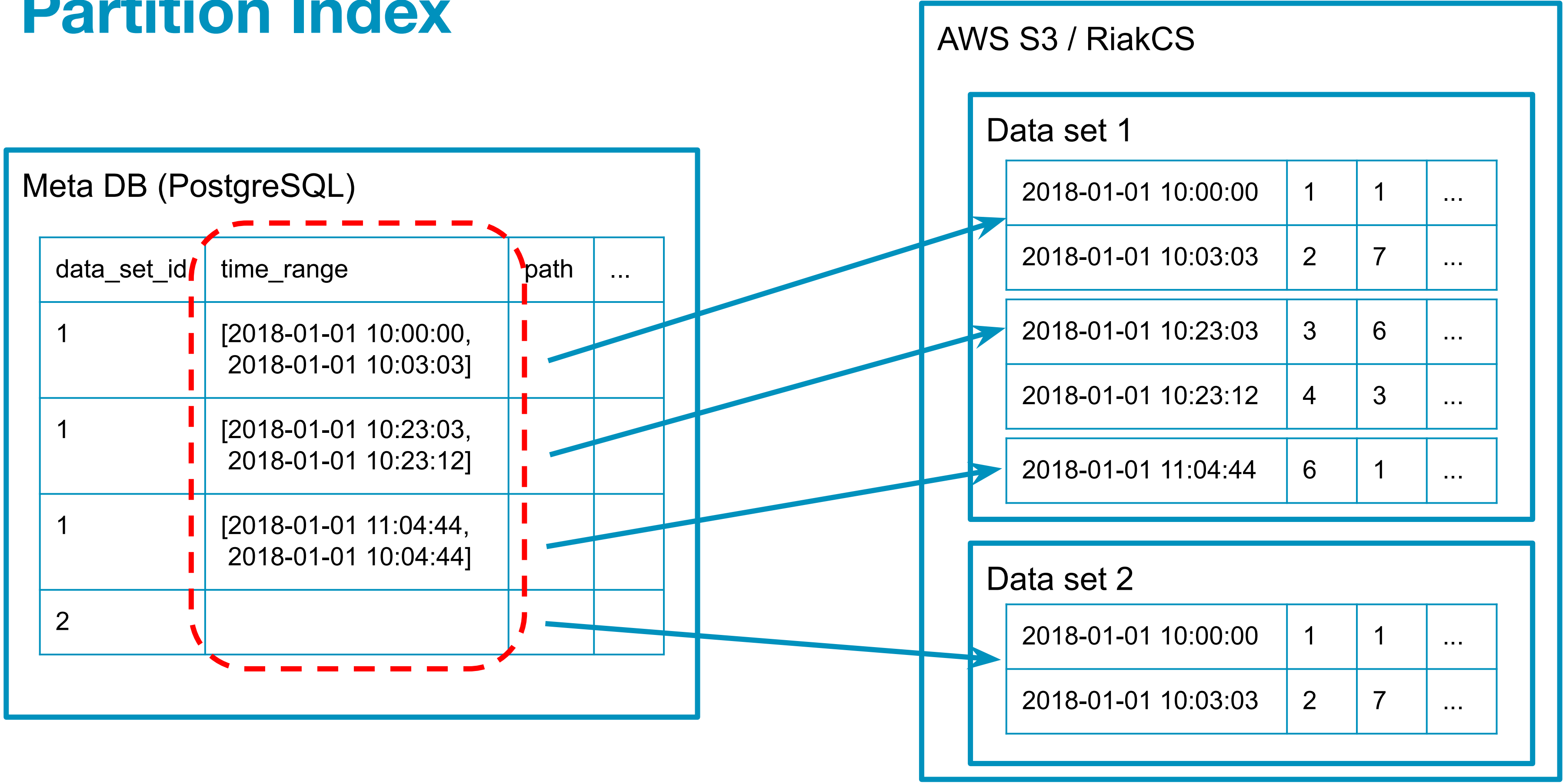
2018-01-01 10:23:03	3	6	...
2018-01-01 10:23:12	4	3	...

2018-01-01 11:04:44	5	1	...

Data set 2

2018-01-01 10:00:00	1	1	...
2018-01-01 10:03:03	2	7	...

Partition Index



Partition Lookup on Analytical Query Processing

Meta DB (PostgreSQL)

data_set_id	time_range	path	...
1	[2018-01-01 10:00:00, 2018-01-01 10:03:03]		
1	[2018-01-01 10:23:03, 2018-01-01 10:23:12]		
1	[2018-01-01 11:04:44, 2018-01-01 10:04:44]		
2			

```
SELECT
  region,
  SUM(price)
FROM
  orders  -- assume this is data set 1
WHERE TD_TIME_RANGE(time,
'2018-01-01 10:00', '2018-01-01 11:00')
GROUP BY
  region
```

Real World Application is Complicated..

Many Performance Related Factors

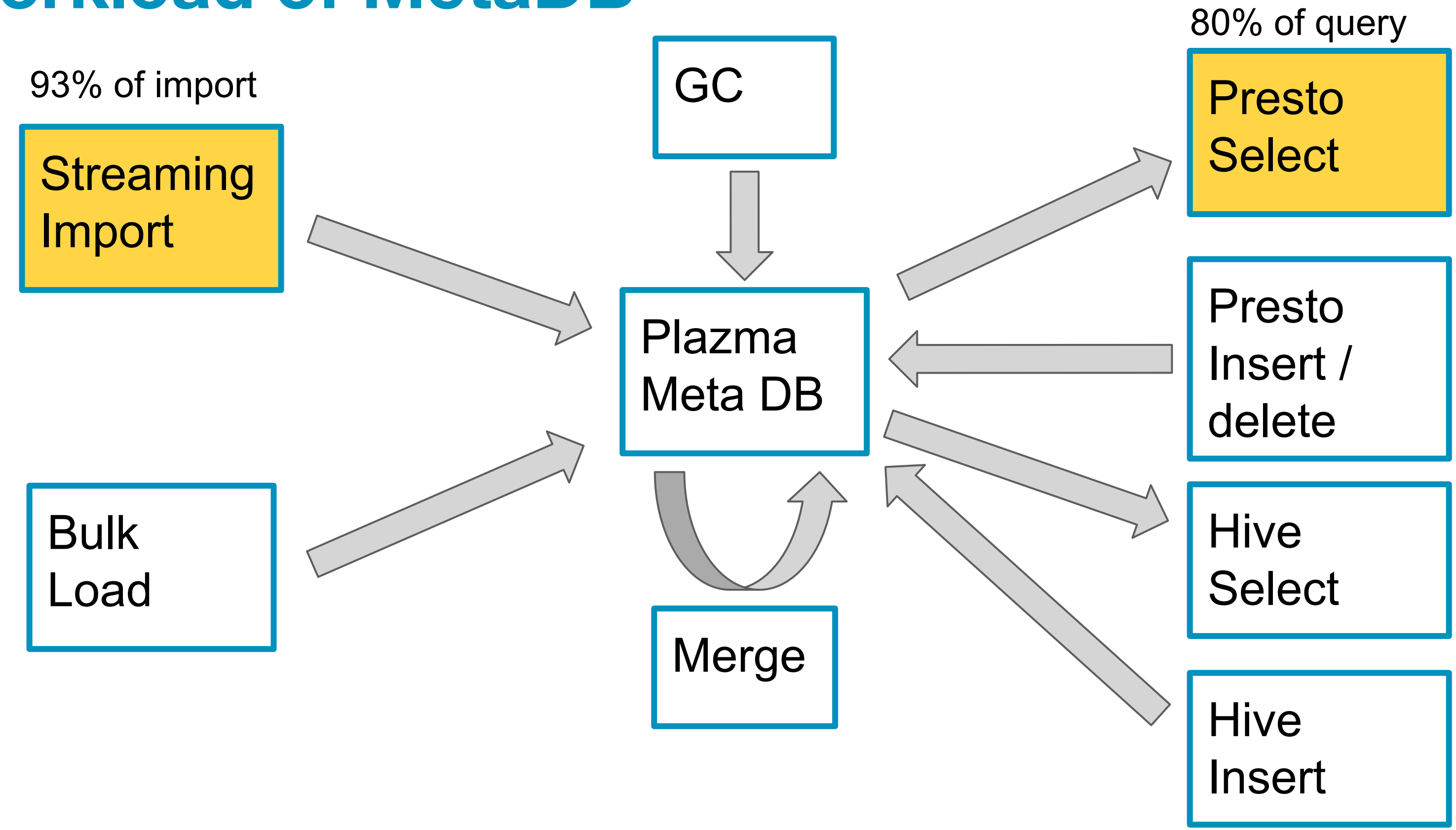
- Type of Workload
- Users' behaviour
  - # of data sets (tables)
  - # of import data
  - # of analytical query request
  - Data skew
- Metadata Storage size
- Server Size (CPU cores, RAM, Storage, Network)
- etc..

Goal of Benchmarking

Define the end of Benchmark task

- Capacity Planning
- Regression Test
- Compare Performance
- Parameter Tuning
- etc..

Workload of MetaDB



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Benchmarking Streaming Import

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Model of Streaming Import Workload

data_set_id	path	...
3		

Insert a partition metadata

Meta DB (PostgreSQL)

data_set_id	path	...
1		
2		
3		
2		

Performance related factors

Concurrency	(1, 2, 4, 8, 16, 32, 64, 128, 256)
Size of tuple	random based on normal distribution (185 byte on average)

Benchmarking Environment

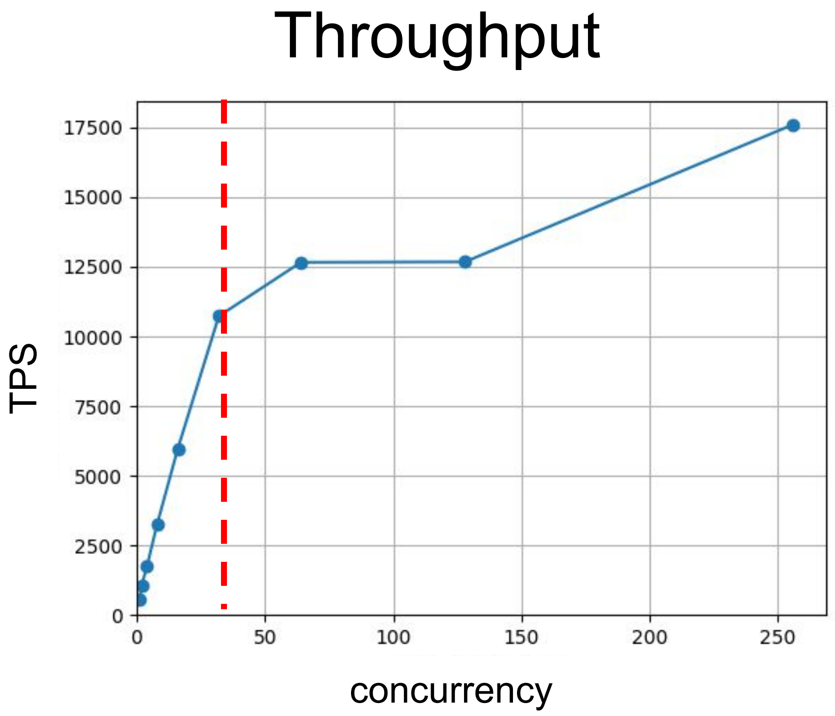
- AWS RDS PostgreSQL

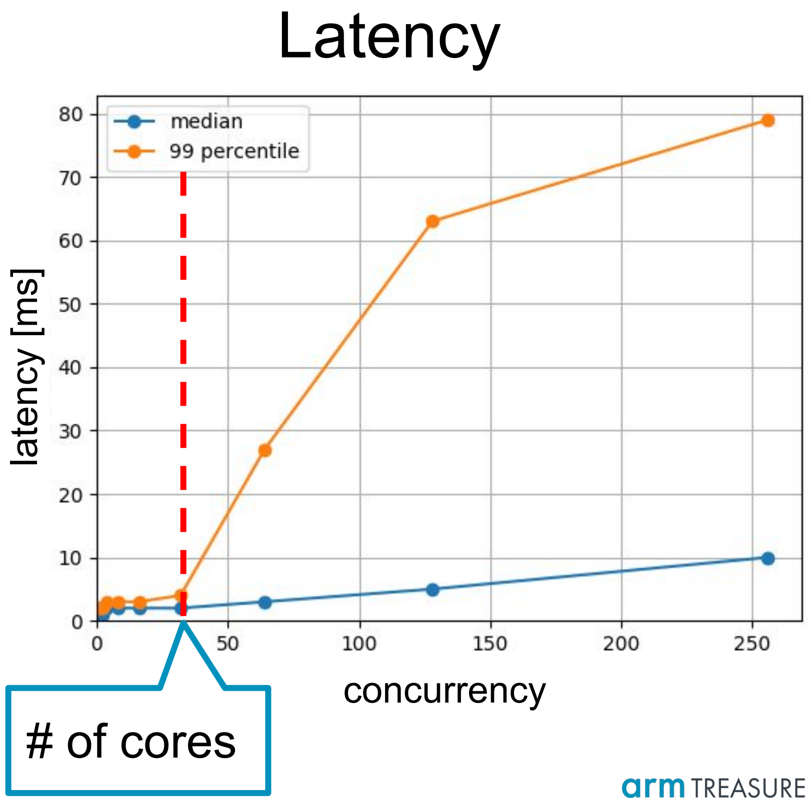
Instance type	db.r3.x8large (32 vcores, 244GB RAM)
Provisioned IOPS	4k
PostgreSQL version	9.4.17

- PostgreSQL parameters

shared_buffers	160GB (~ 60% of RAM)
checkpoint_segments	1500 (24GB)

Scalability of Streaming Import Workload





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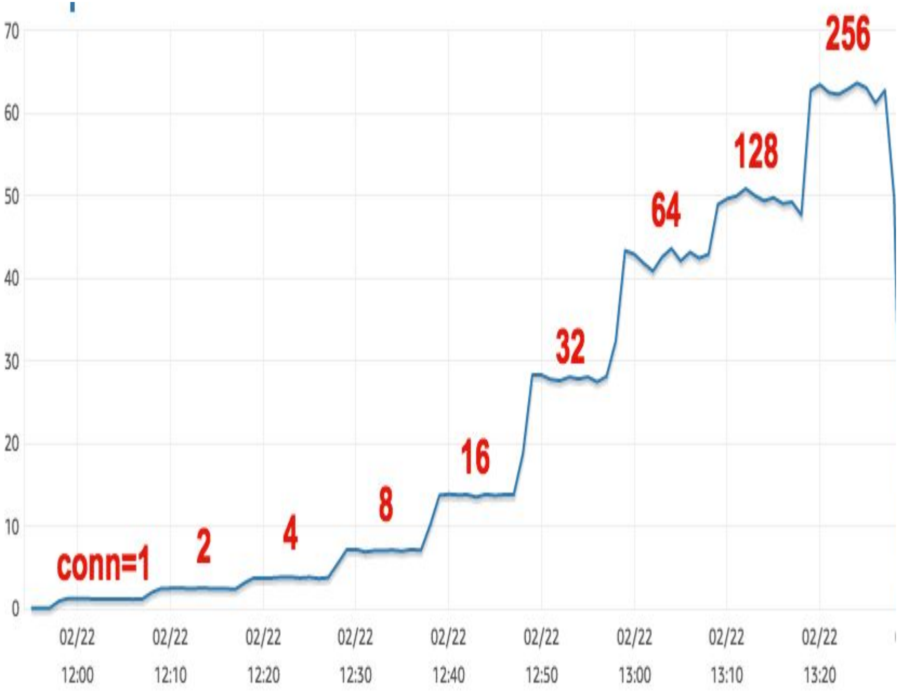
Resource Consumption

CPU utilization

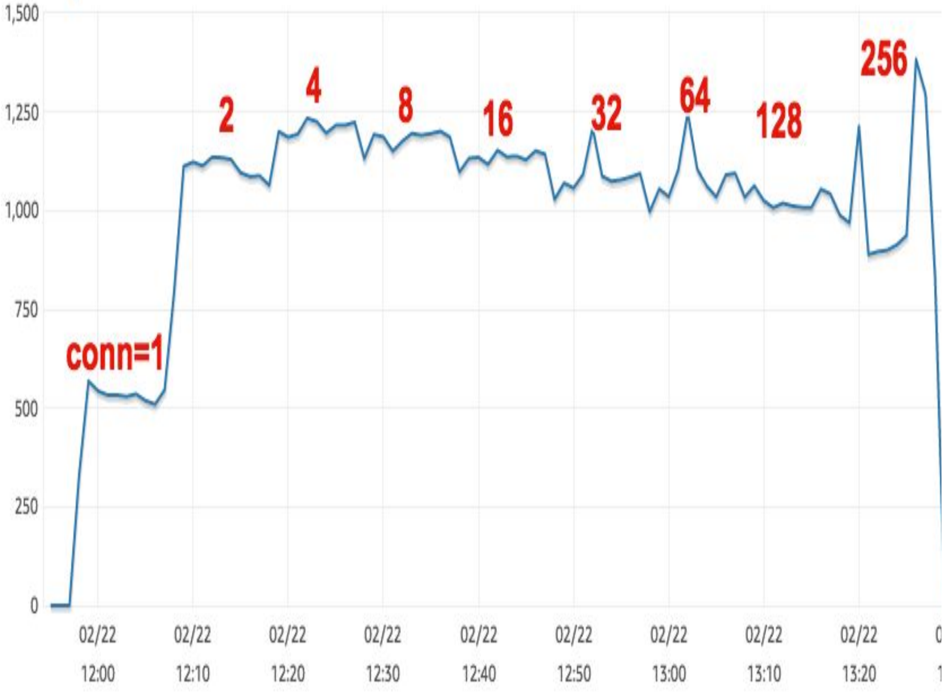


Write IO throughput

Write IO

Write IO throughput

Write IOPS



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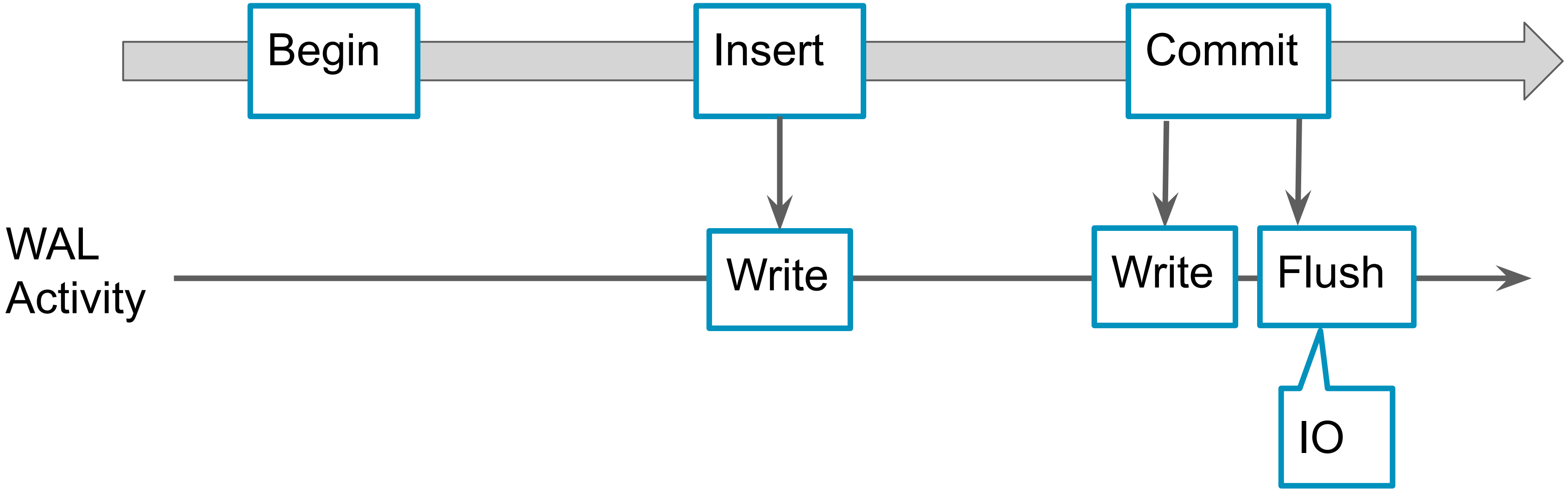
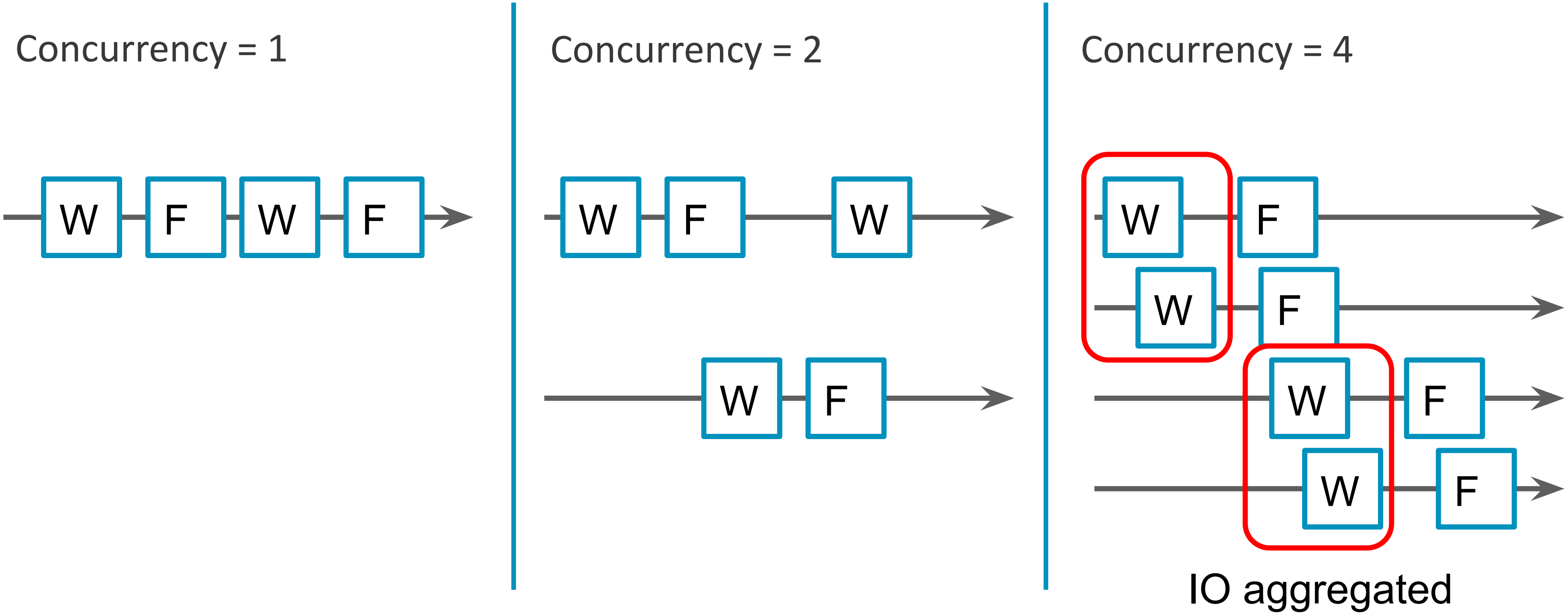
When Write IO issued?

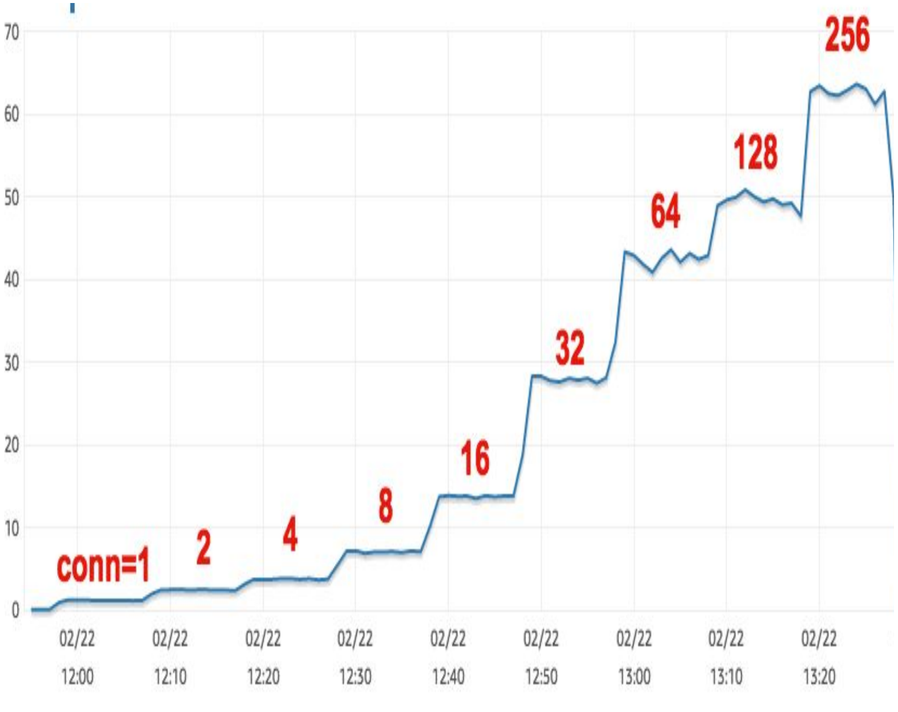


Concurrency and Write IO

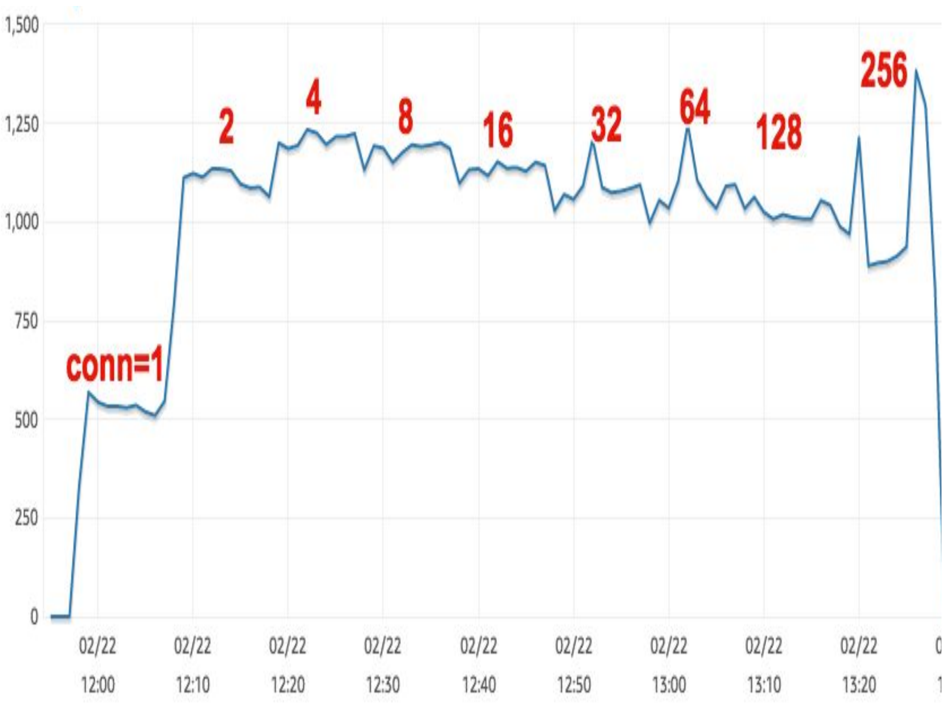


Bottleneck

CPU utilization



Write IOPS



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Summary of Streaming Import Workload

- CPU bottleneck
  - Scale almost linearly when concurrency is less than # of cores
  - Throughput can increase after that, but tail latency increases as well
  - Write IOPS doesn’t increase as increasing concurrency because of IO aggregation

Benchmarking Presto Select

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Model of Presto Select Workload

Meta DB (PostgreSQL)

data_set_id	time_range	path	...
1	[18-01-01 10:00, … 11:00]	a	
2	[18-01-01 10:00, … 11:00]	b	
1	[18-01-01 11:00, … 12:00]	c	
3	[18-01-01 13:00, … 14:00]	d	
2	[18-01-01 13:30, … 14:00]	e	
1	[18-01-01 16:00, … 17:00]	f	
...			
1	[18-01-02 03:00, … 04:00]	m	

data_set_id=1 and
time_range &&
[18-01-01 00:00, 18-01-02 00:00]

path
a
c
f

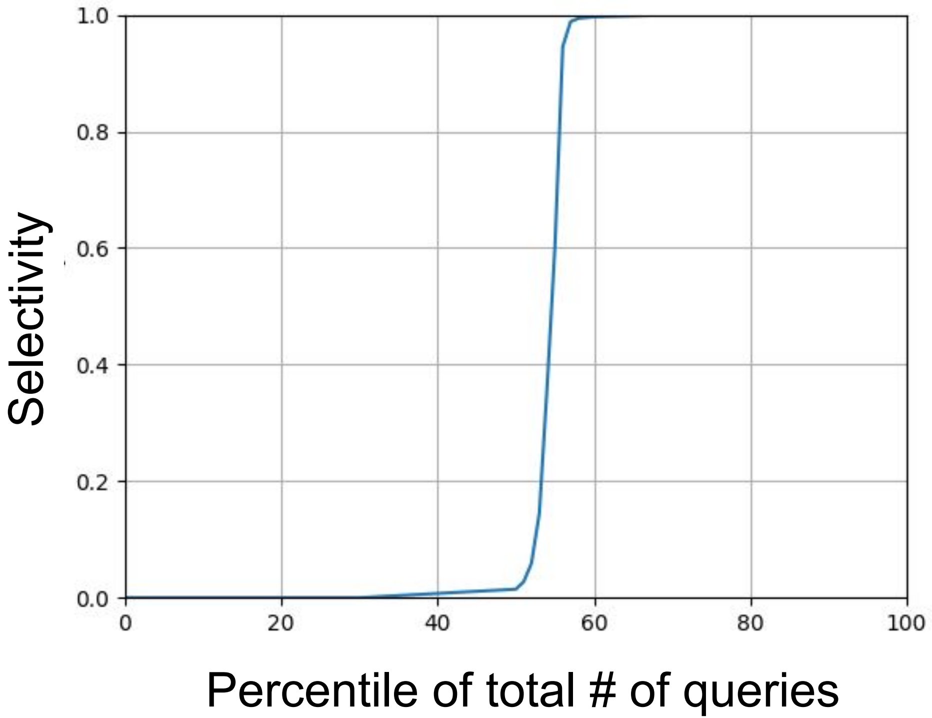
Index scan for data_set_id and time_range

Performance related factors

Concurrency	(16, 32, 64, 128, 256)
Metadata size	600GB (Dummy data based on actual trend)
# of data sets	30k
Time range to scan (selectivity)	(next slide)
Distribution of data set access frequency	(next slide)

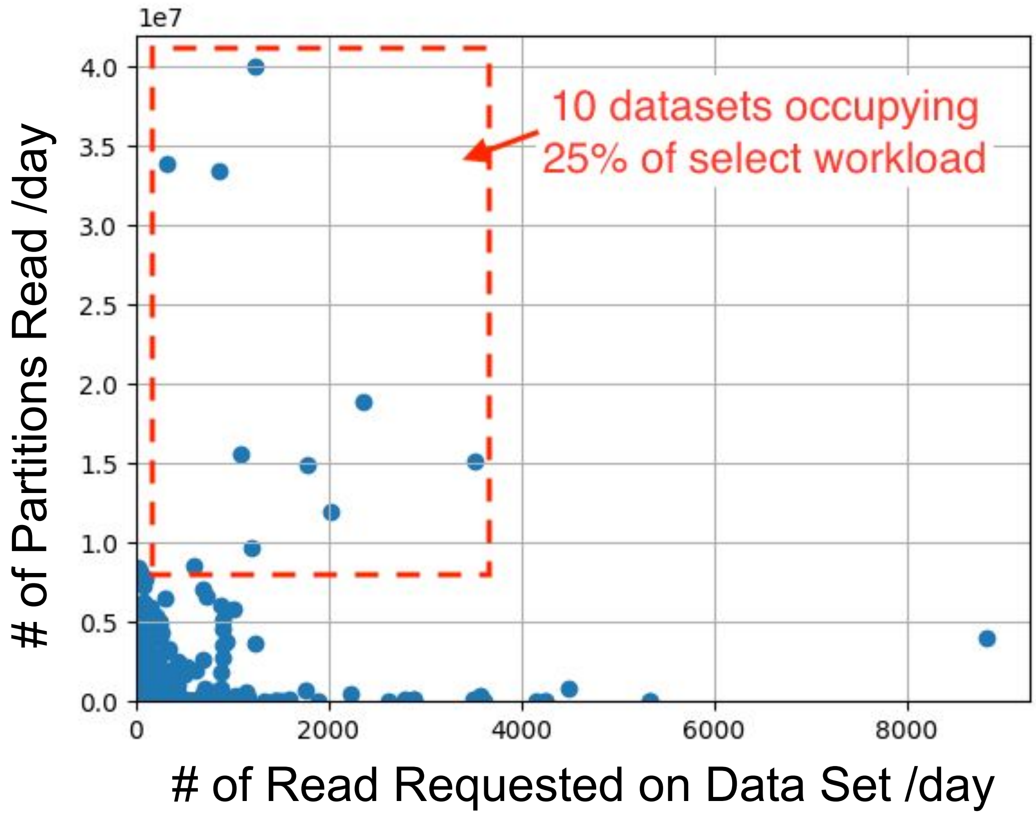
Selectivity

- Random sampling from actual selectivity distribution
  e.g.)
  - 40% queries: sl = 1
  - 5% queries: sl = [0.01, 0.5]
  - 5% queries: sl = [0.5, 0.99]

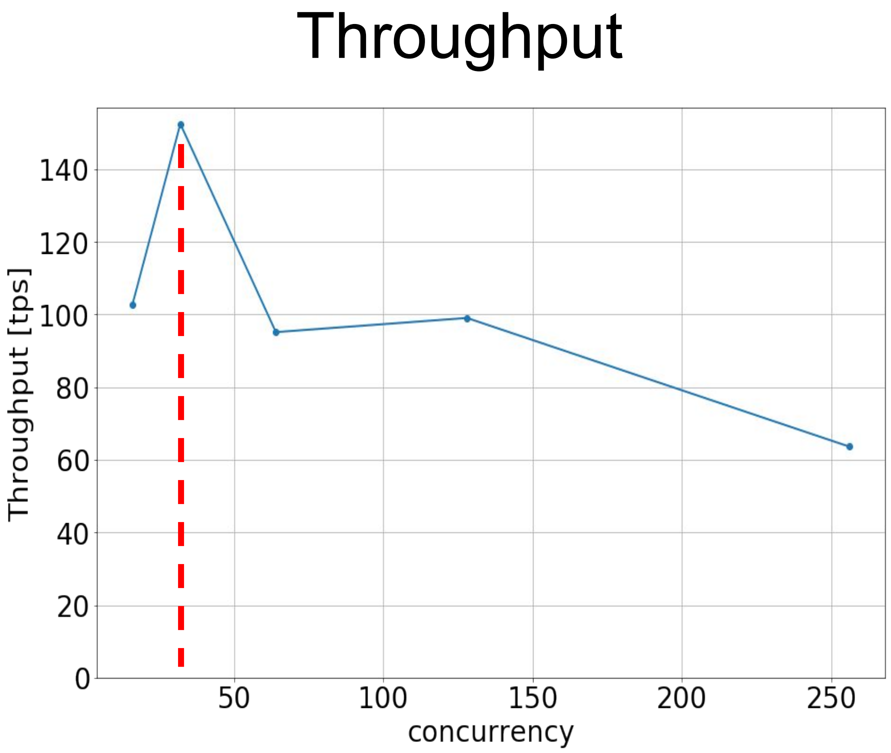


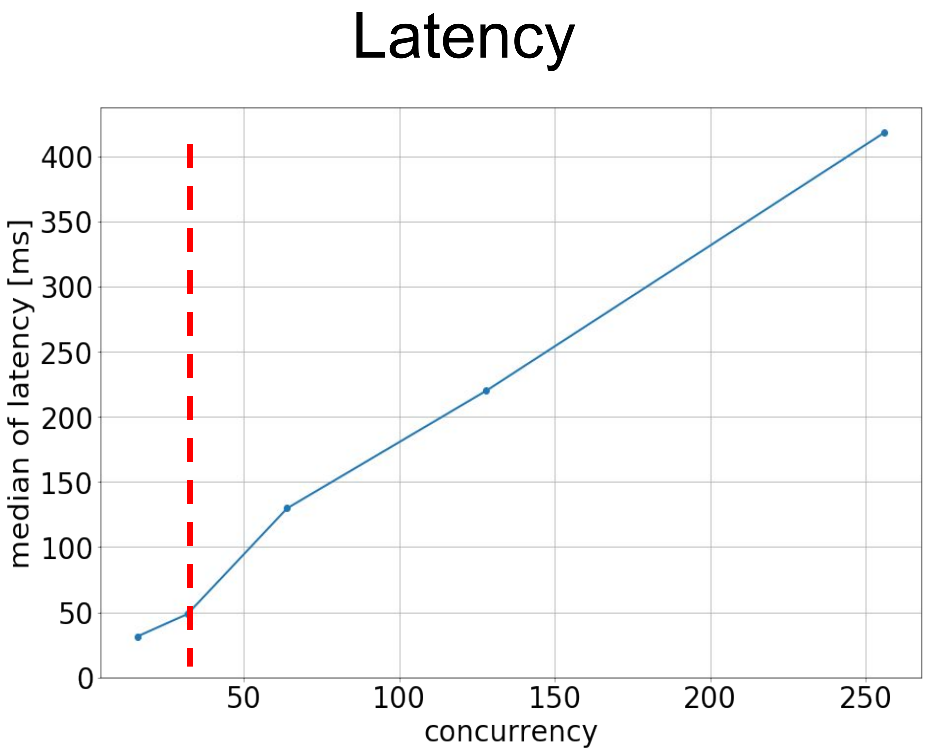
Distribution of Data Set Access Frequency

- Metadata size = 600GB
- Shared Buffer size = 160GB
- But, Hot Data size is smaller than Shared Buffer e.g.)
  - 85% of workload comes from 1% data sets
  - 95% of workload comes from 5% data sets



Scalability of Presto Select Workload





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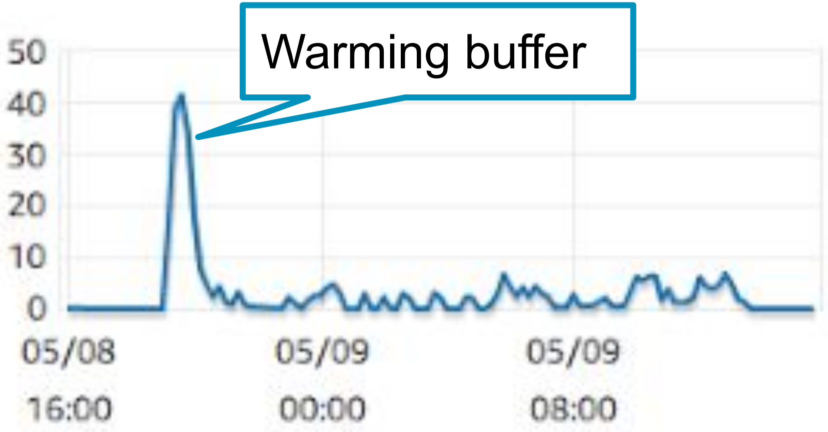
Resource Consumption (Concurrency=128)

CPU utilization [%]

Read IO throughput [MB/s]



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Summary of Presto Select Workload

- CPU bottleneck
  - Scale almost linearly when concurrency is less than # of cores
  - Throughput decreases when concurrency is higher than # of cores
  - Hot data is small enough to fit into DB shared buffer

Benchmarking Mixed Workload

Mixing Streaming Import & Presto Select

data_set_id	...
3	

Insert

Meta DB (PostgreSQL)

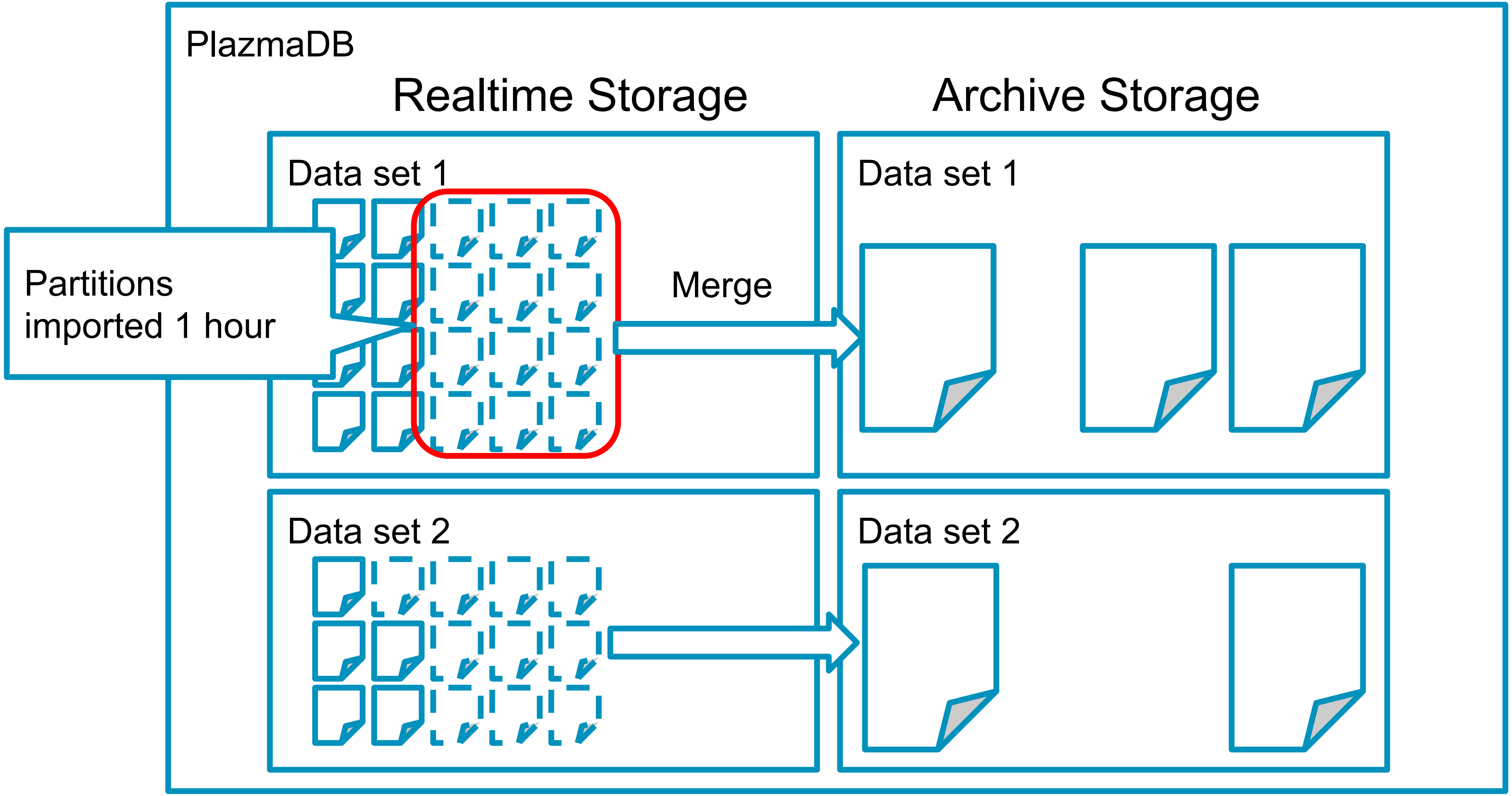
data_set_id	time_range	path	...
1	[18-01-01 10:00, … 11:00]	a	
2	[18-01-01 10:00, … 11:00]	b	
1	[18-01-01 11:00, … 12:00]	c	
3	[18-01-01 13:00, … 14:00]	d	
2	[18-01-01 13:30, … 14:00]	e	
1	[18-01-01 16:00, … 17:00]	f	
...			

Select

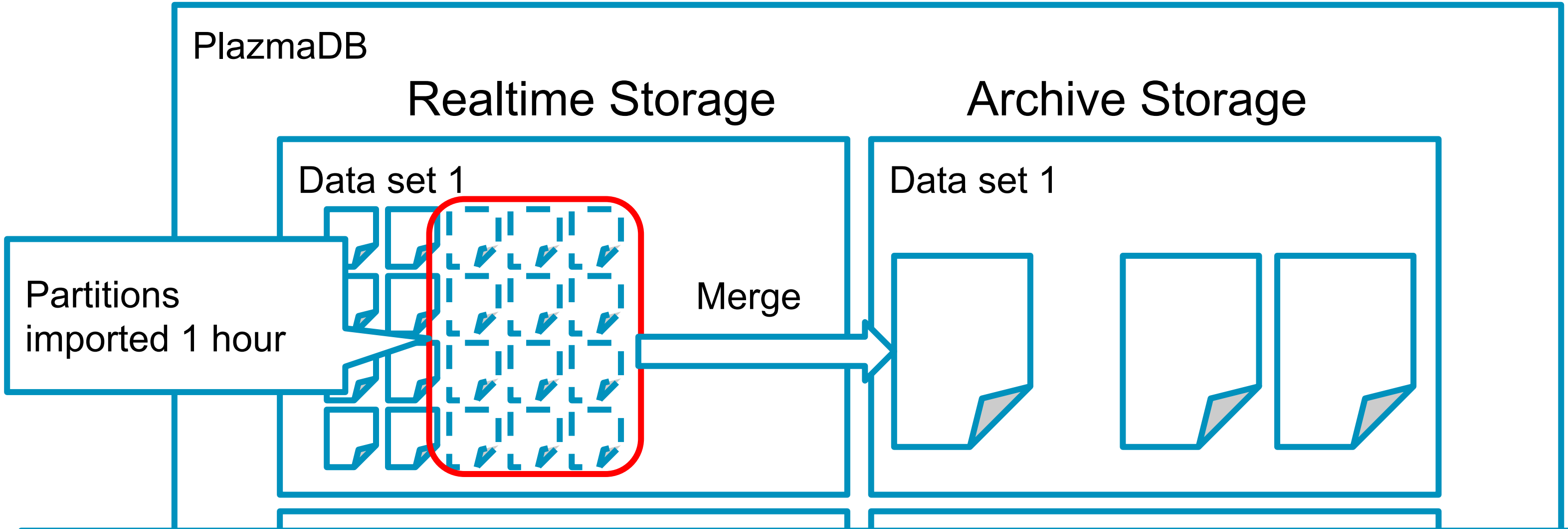
path
a
c
f

Insert : Select = 200 : 1

Realtime Storage & Archive Storage



Realtime Storage & Archive Storage



- Reduced to 1/20 - 1/100 partitions
- Merge can be delayed 5 - 7 hours

-> Metadata will be compressed but accumulate during delay

What is expectation?

- E.g. when concurrency = 64, what throughput will be?
  - Both Streaming Import and Presto Select were CPU bottleneck
- Ref: Single Workload Throughput
  - Streaming Import = 12500 tps
  - Presto Select = 95 tps
- Expectation
  - Streaming Import ~ 6000 tps ?
  - Presto Select ~ 45 tps ?

Result of mixed workload

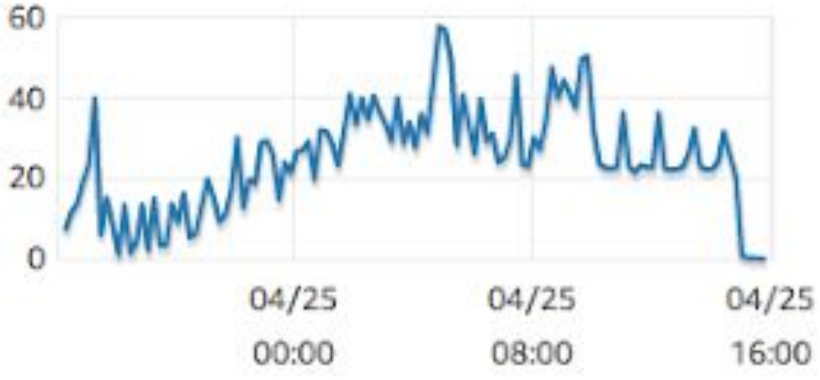
- Throughput when Concurrency = 64

	Streaming Import [tps]	Presto Select [tps]
mix concurrency=64	5547	27.6
Ref: single	12500	95

Resource Consumption

CPU utilization [%]

Read IO throughput [MB/s]



Bottleneck is changed to Disk IO

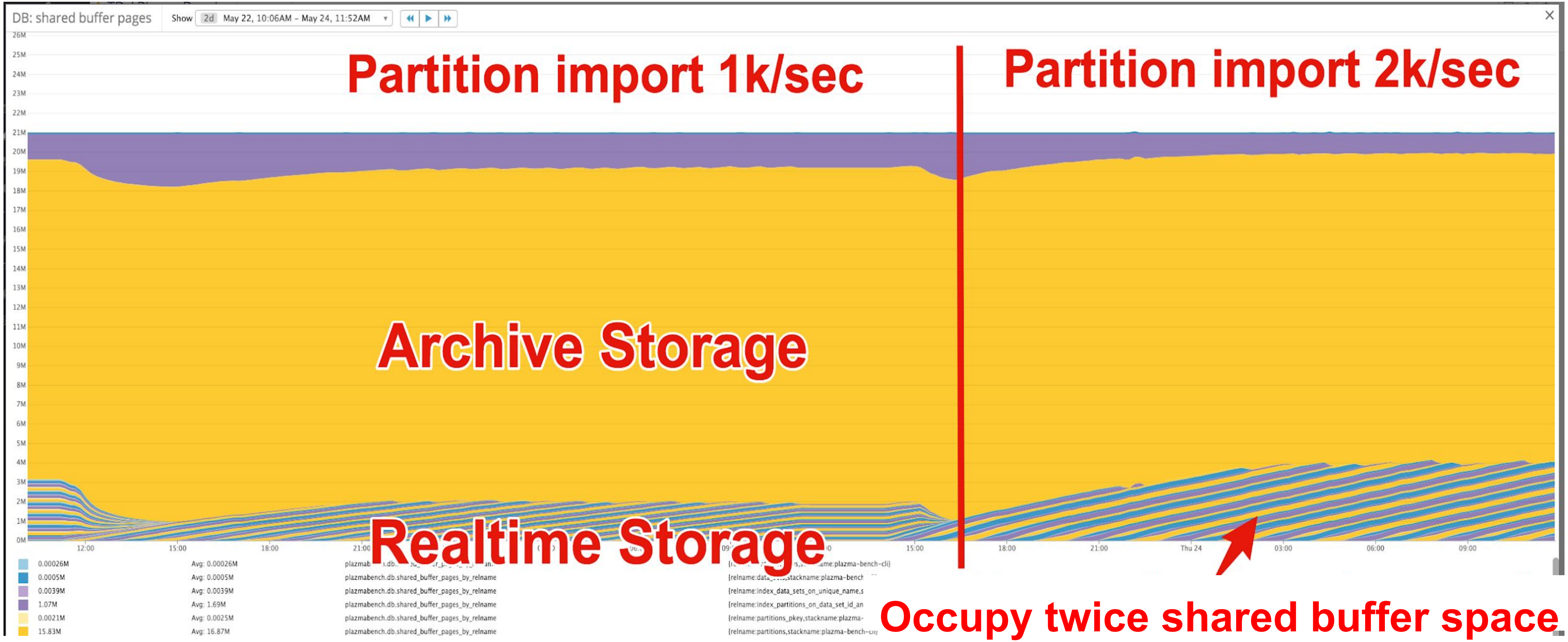
Increase PIOPS

	PIOPS	Streaming Import [tps]	Presto Select [tps]
mix concurrency=64	4k	5488	27.4
mix concurrency=64	20k	7179	35.9
Ref: single	4k	12500	95

Cache (DB Shared Buffer) Hit Ratio

	PIOPS	Streaming Import [tps]	Presto Select [tps]	RT storage size	Cache Hit Ratio
mix con=64	4k	5488	27.4	57GB	93%
mix con=64	20k	7179	35.9	75GB	89.5%
Ref: single	4k	12500	95		

Impact of Streaming Import increase



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Impact of Cache Miss

- Avg # of selected rows per a Presto Select = 8000
- A postgres page mostly includes only 1 row for a data set
  - A page (8kB) has 20 - 30 rows, but different data sets' data are stored together
- # of pages to scan per a Presto Select = 8000 / 1 = 8000
- # of pages to scan per second = 8000 * TPS
  - E.g. TPS=35 -> 8000 * 35 = 280k pages/sec
    -> 1% cache miss causes 2800 IOPS

Another factor: Auto Vacuum

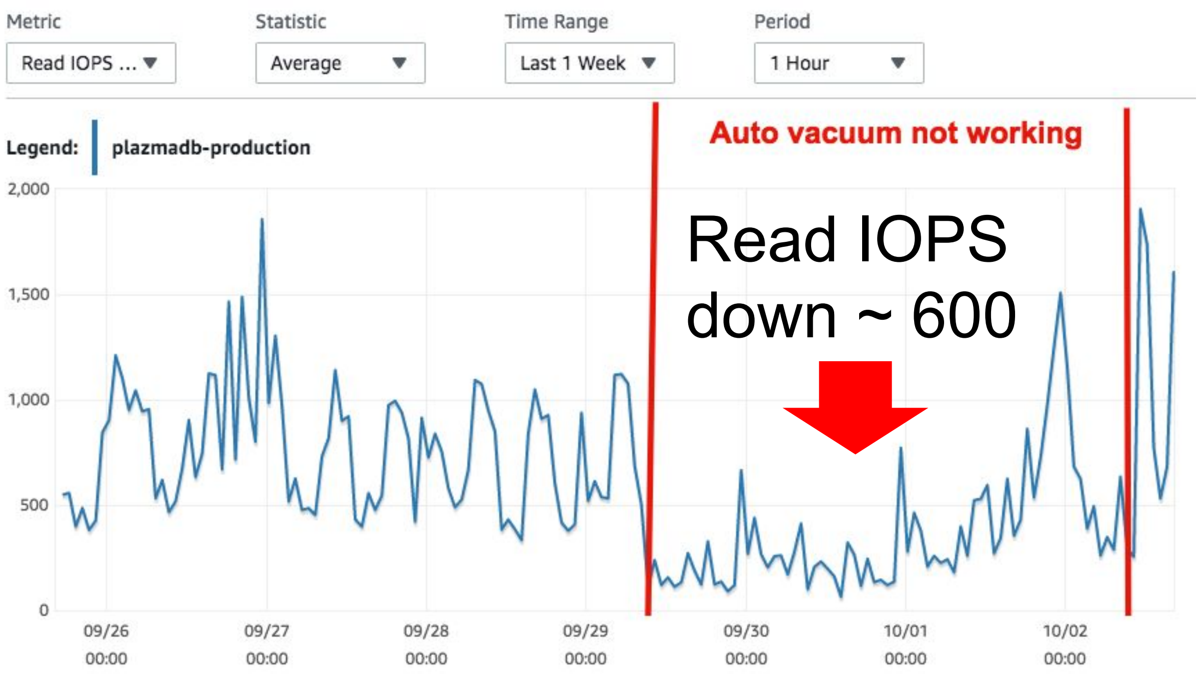
- Vacuum read cold data
  - Especially Vacuum Freeze does force full scan (before postgres 9.6)
- IO related Vacuum parameters

autovacuum_vacuum_cost_limit	400
autovacuum_vacuum_cost_delay	10ms
vacuum_cost_page_miss	10
vacuum_cost_page_dirty	20

- Max read IOPS = (max IO per vacuum) * (vacuum invoked per sec)
  = (400/10) * (1000/10) = 4000

Vacuum is tax of PostgreSQL

Someday auto vacuum stopped accidentally ..



To reduce IO

- Improve cache hit ratio
  - More RAM -> scale up / sharding
  - Improve locality
    -> Partitioning by data set ID: include more relevant rows in a (postgres) page
- Vacuum
  - Avoid full scan of vacuum freeze by using postgres 9.6 or newer

Summary

- IO seems to be a bottleneck
  - Cache miss increases IO dramatically
  - When throughput was increased, we need to pay more tax (vacuum)

- Now we understand what is likely to be a bottleneck
  - Better prioritization of action items
  - Predictable PlazmaDB performance
    Don’t need to worry about spike and increasing demand :)

Thank You!
Danke!
Merci!
谢谢!
Gracias!
Kiitos!

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