Yandex

Yandex Cloud

Caveats of replication in HA clusters and CDC systems

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Yandex and PostgreSQL

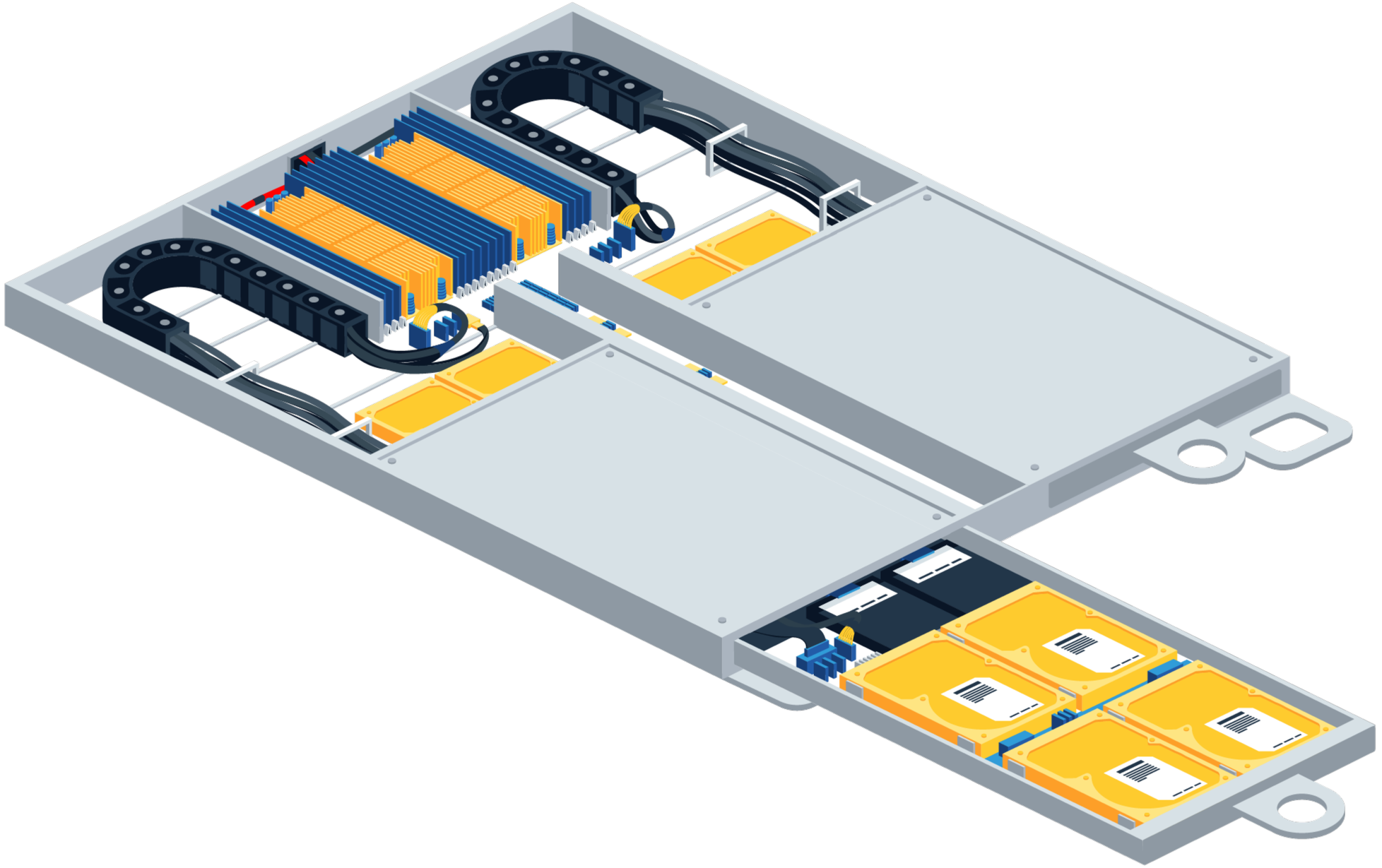
Yandex.Cloud

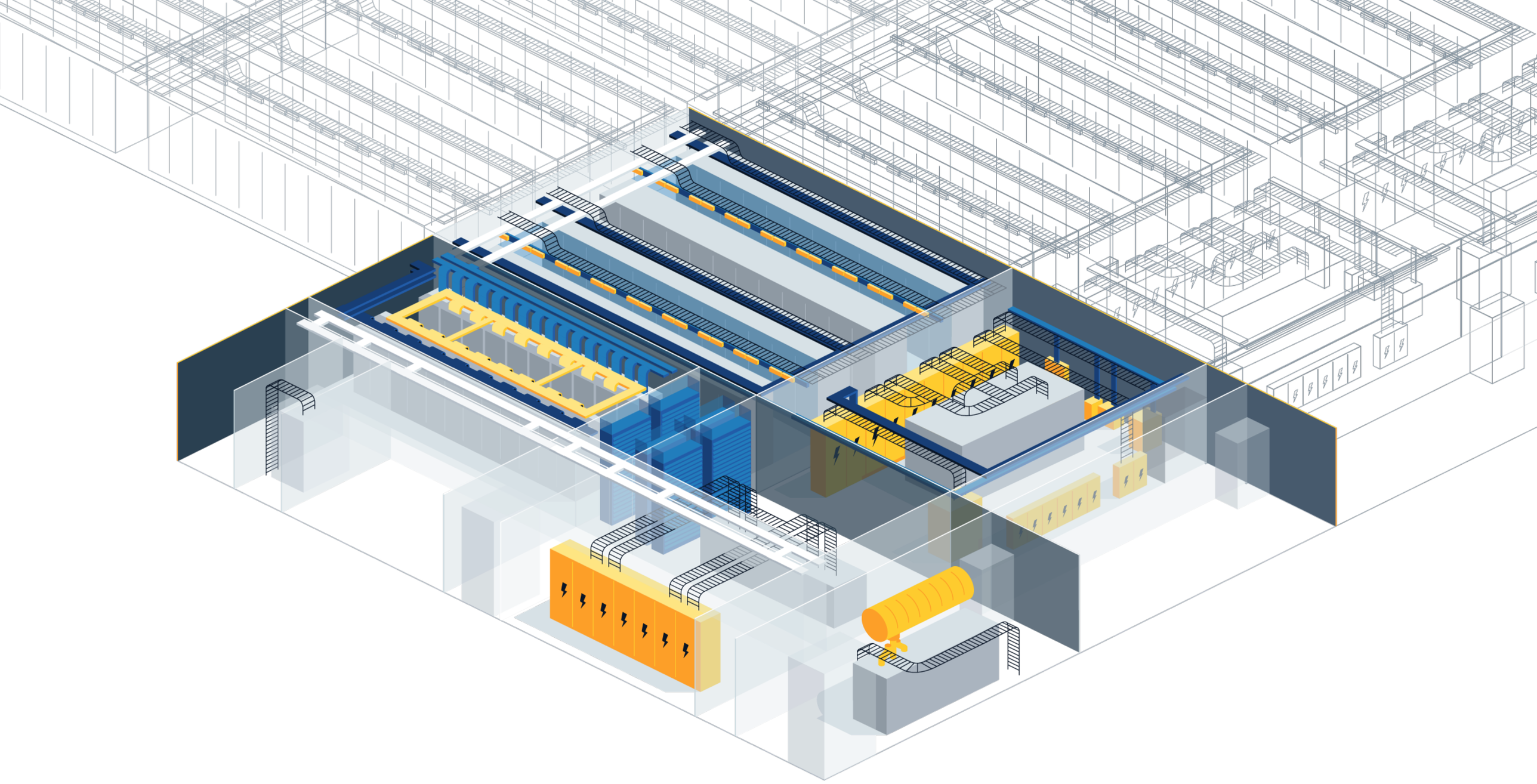
- 2+ petabytes of Postgres
- ~3+ million requests per second

And many other services like Yandex.Mail, Yandex.Taxi, Yandex.Maps, weather forecast, carsharing, food delivery etc.

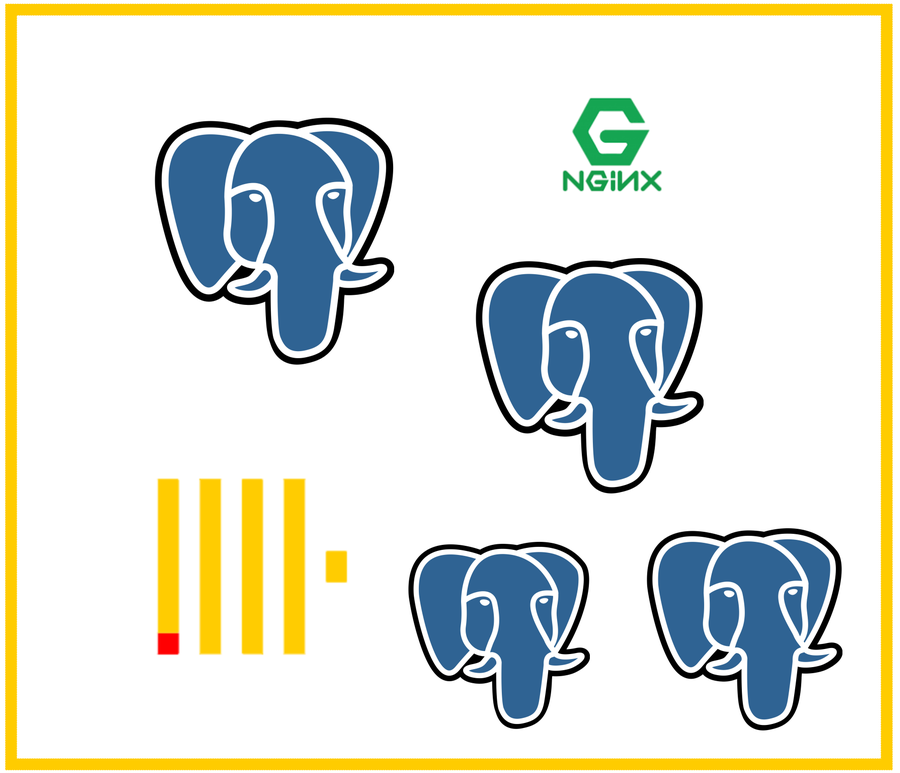
Essential expectations

- 0.9999 read availability
- 0.9995 write availability
- Scalable multi-AZ deployments
- Most up-to date copy of operational data in analytical system

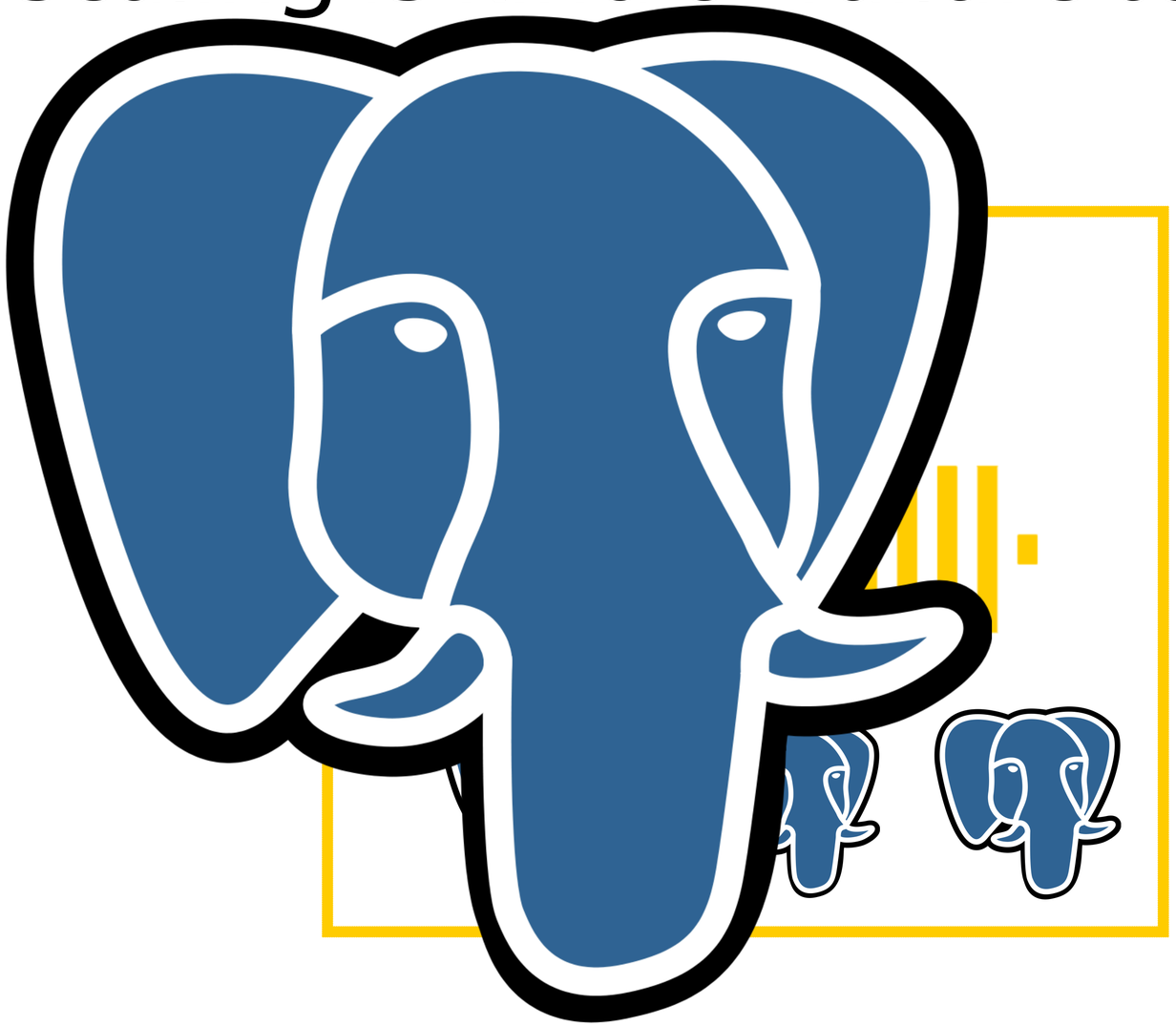




Virtualization utilize resources efficiently



Vertical scaling is kind of failure too



Redundancy

Network block storage

NBS is a kind of redundancy

> But databases are working better on local drives
> This will not be discussed in this talk

Incrementally rebuilding copy of the DB

- WAL archive
- Streaming replication

WAL archive

- Primary node calls archive_command for every segment (typically 16Mb)
  - Synchronous interface, but wal-g and pg_backrest try to solve it
- Standby nodes recover segments calling restore_command

WAL archive

Primary node calls archive_command for every segment (typically 16Mb)

- Synchronous interface, but wal-g and pg_backrest try to solve it

Standby nodes recover segments calling restore_command

- It’s preferred to have archive even if you use streaming replication

Streaming replication

walsender\walreciever processes work in pair sending WAL with granularity up to one WAL record

- Standby startup process can shuttle between archive and replication

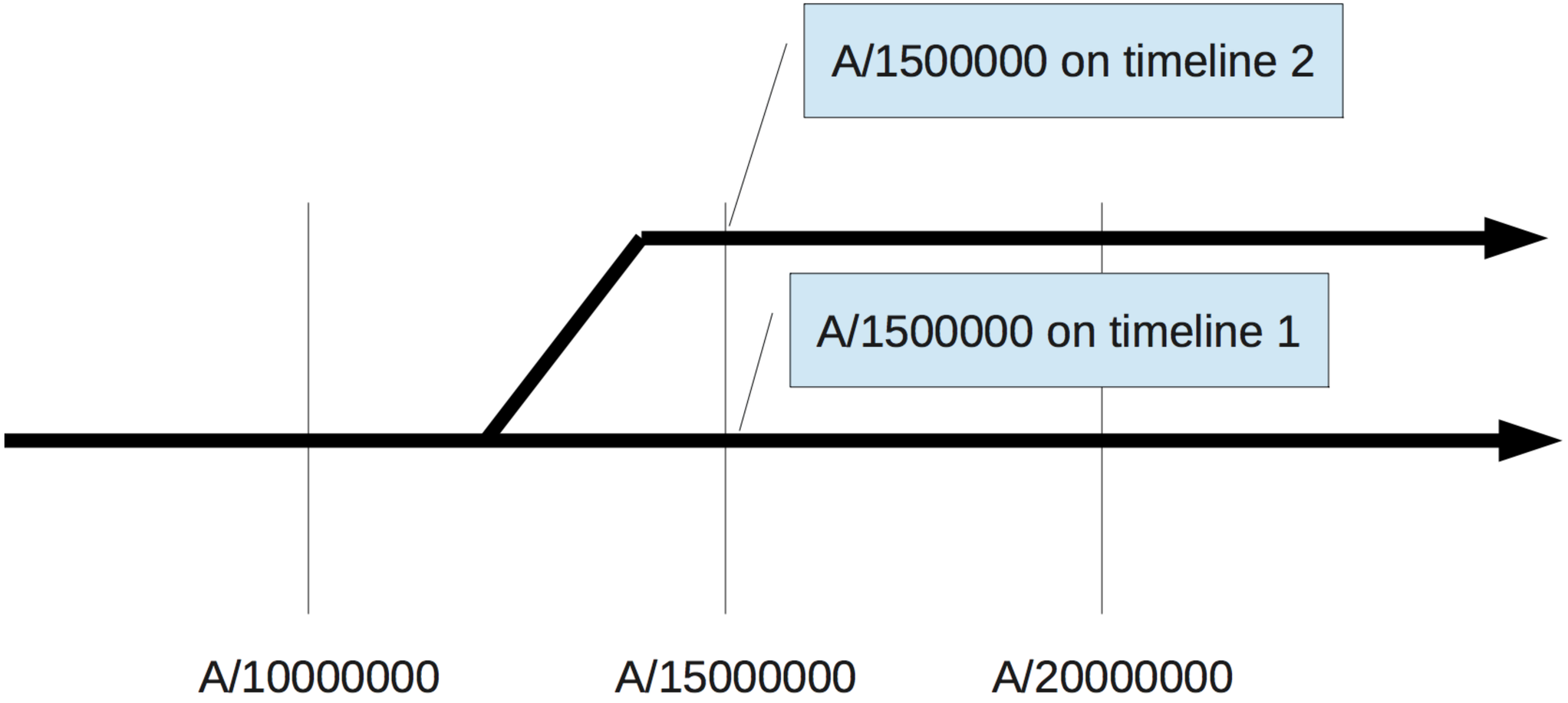
Cascade is possible

- Replication slots have information what was sended and appied by replication target

Synchronous streaming replication

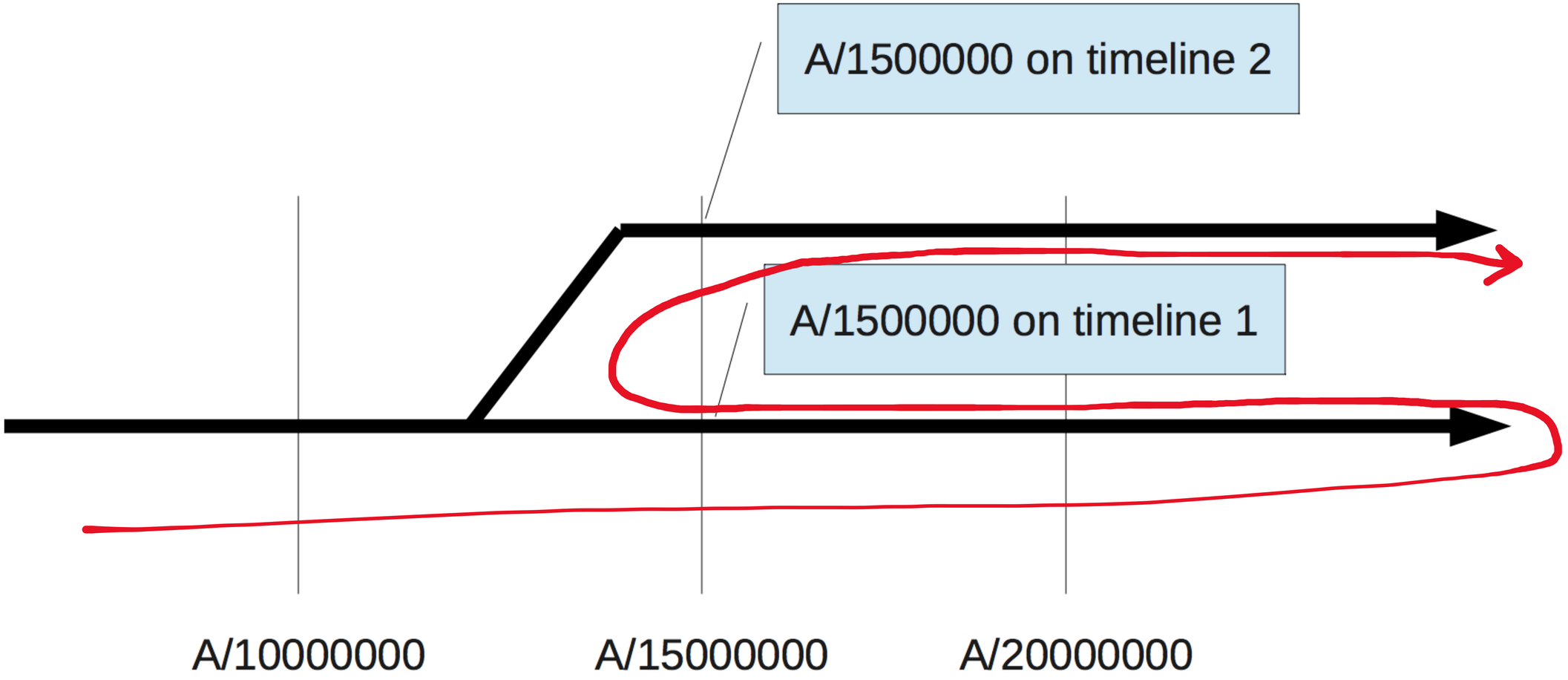
- Do not acknowledge commit to client until replica has all data wrt current transaction

PostgreSQL TimelineId

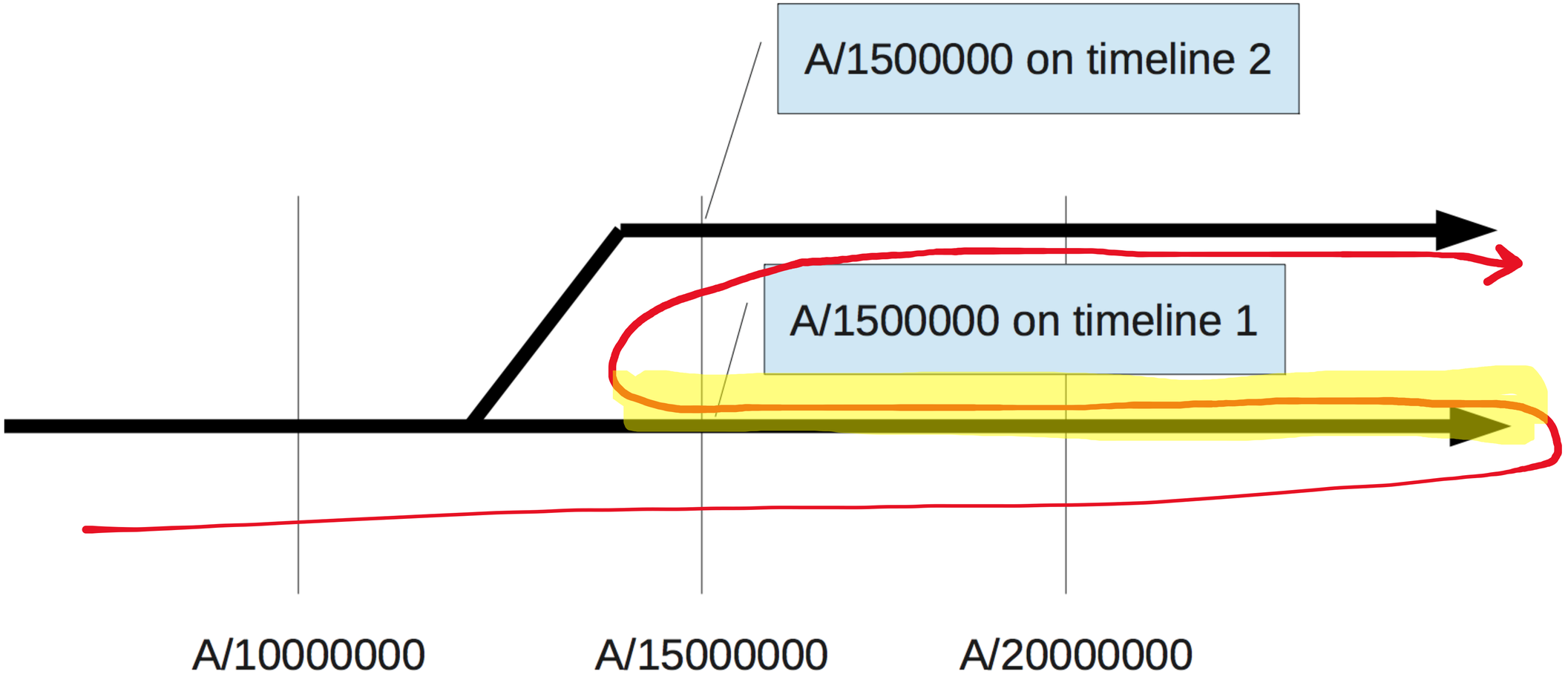


wiki.postgresql.org/images/e/e5/FOSDEM2013-Timelines.pdf

pg_rewind


A/1500000 on timeline 2
A/1500000 on timeline 1
A/10000000
A/15000000
A/20000000

pg_rewind

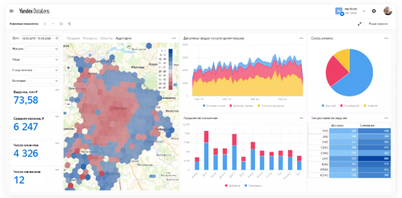

A/1500000 on timeline 2
A/1500000 on timeline 1
A/10000000
A/15000000
A/20000000

Logical replication

Good for replicating:

- only parts of a database
- to other systems (e.g. OLAP)
- Between different versions

Cluster in the cloud



OLAP\MR

RW Queries

Logical replication

WAL

Network
Object
Storage

Backup

Async replication

Sync replication

RO Queries

How to find primary node?

```
psql "host=<host 1 FQDN>,<host 2 FQDN>,<host 3 FQDN> \
      port=6432 \
      sslmode=verify-full \
      dbname=<DB name> \
      user= \
      target_session_attrs=read-write"
```

https://cloud.yandex.com/docs/managed-postgresql/operations/connect

How to find primary node?

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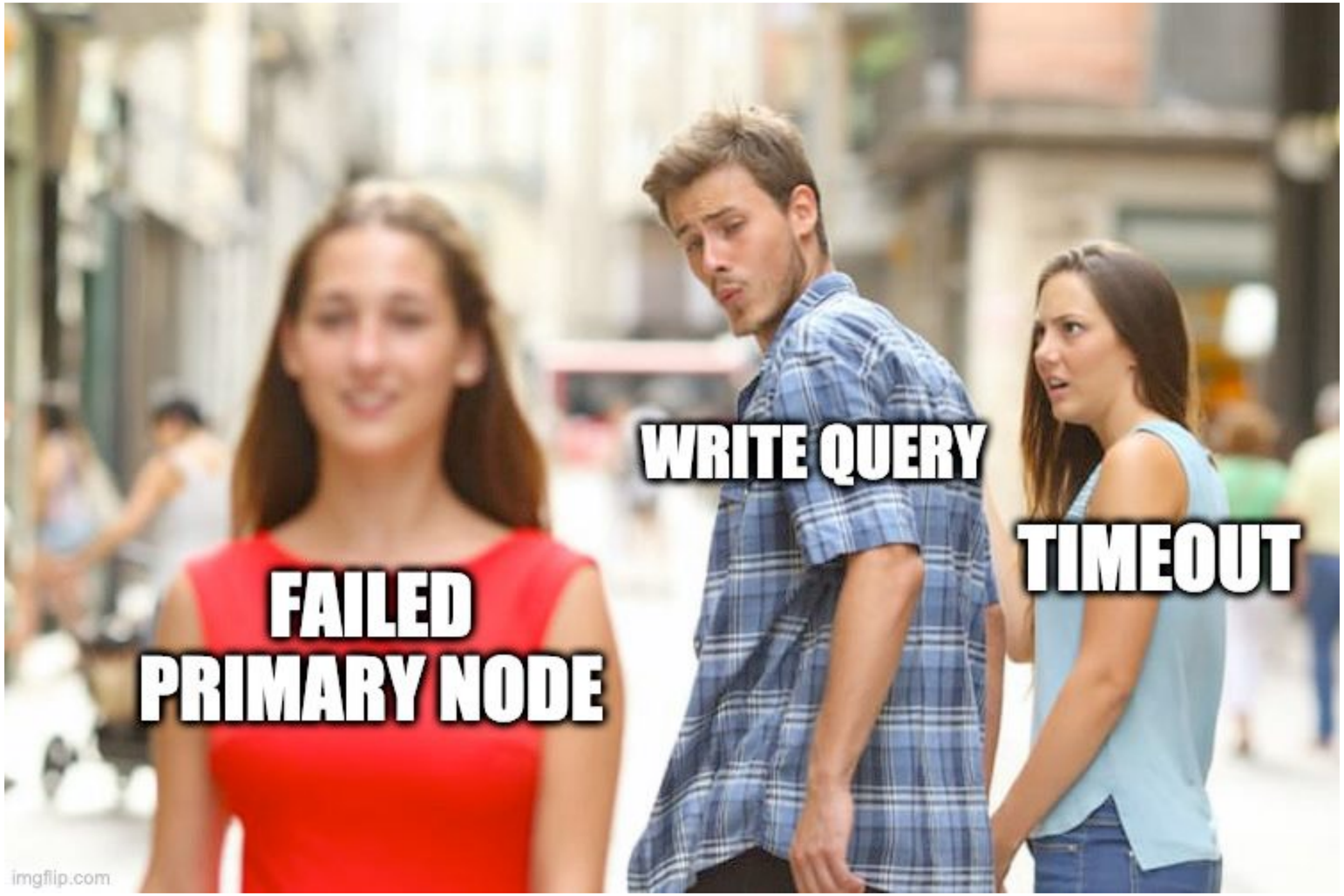
```

https://cloud.yandex.com/docs/managed-postgresql/operations/connect

But how do you know the node had failed?



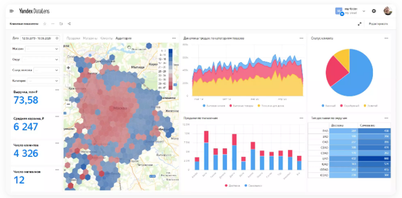
Make sure network timeouts work

- tcp_user_timeout

Libpq have some infinite timeouts relying on keepalives

- keepalives_count, keepalives_interval, keepalives_idle

Maybe automate promotion?



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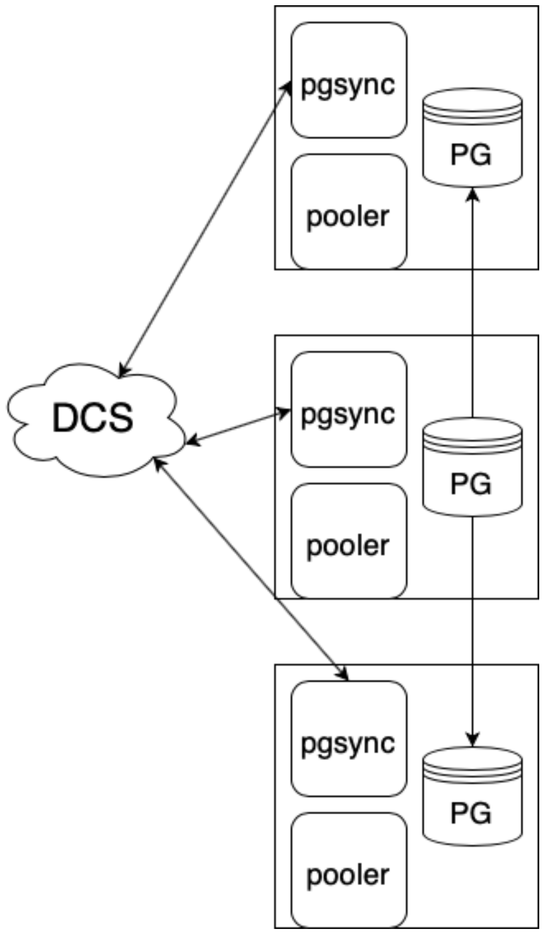
HA orchestration

- Patroni
- Stolon
- Repmgr

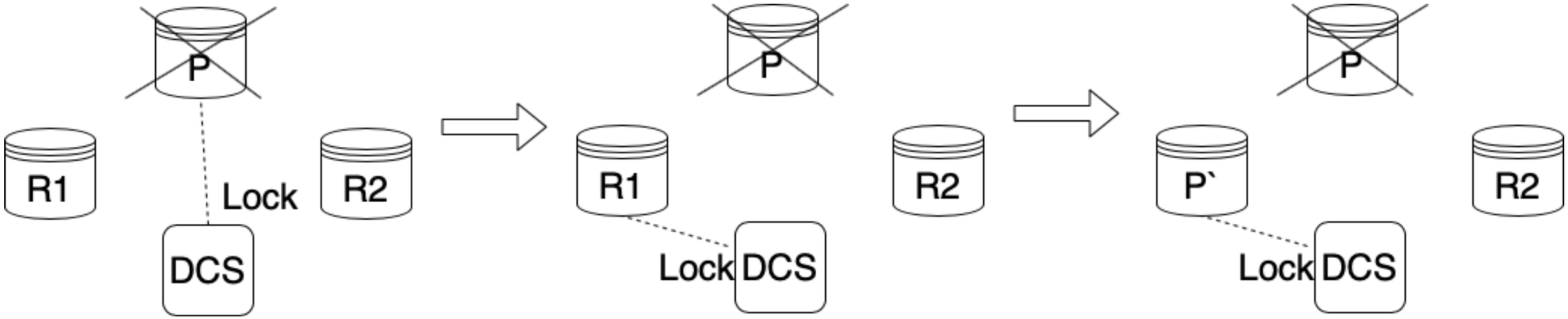
Yet another HA solution

Bird’s-eye view on pgsync

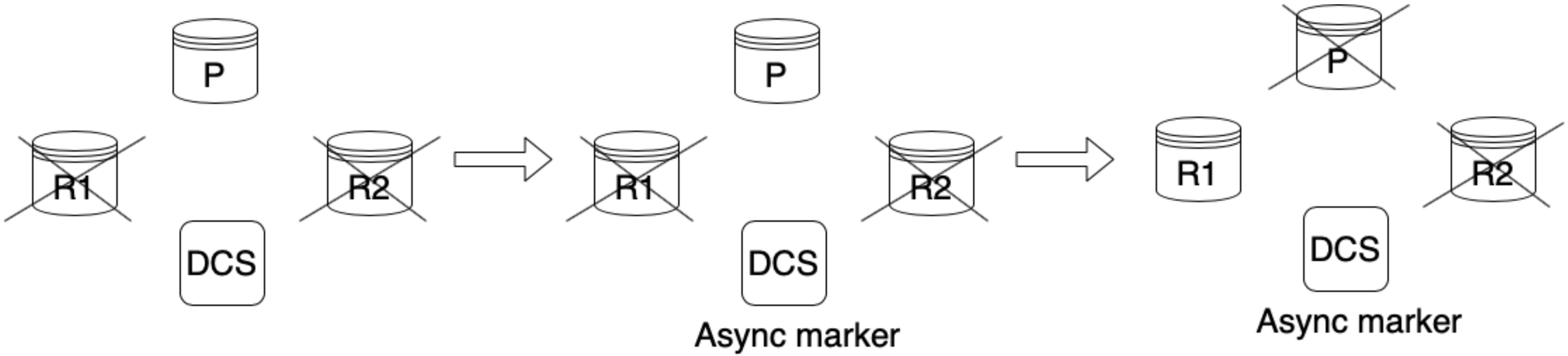
- Shared DCS (2-3k pg clusters per 1 DCS cluster)
- Agent on VM with PostgreSQL
- Pooler for fencing



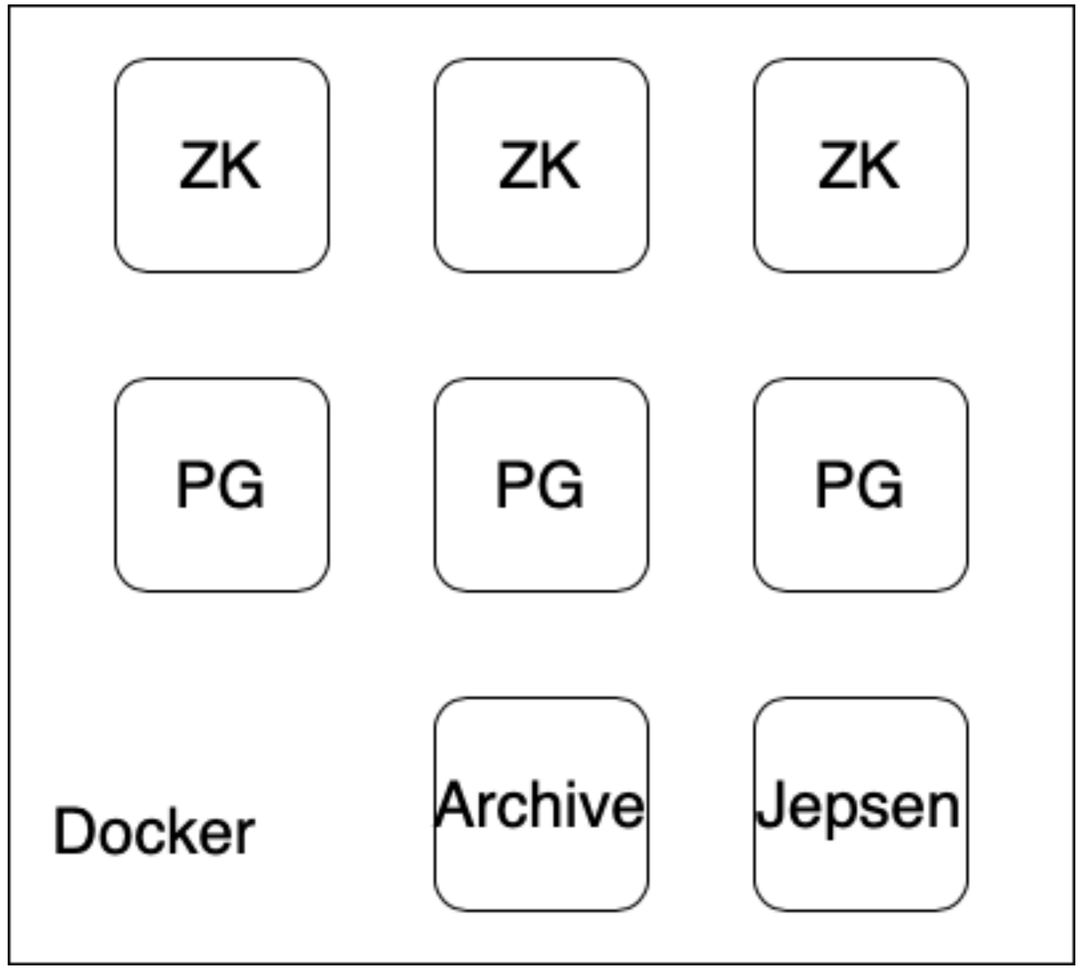
Primary failure



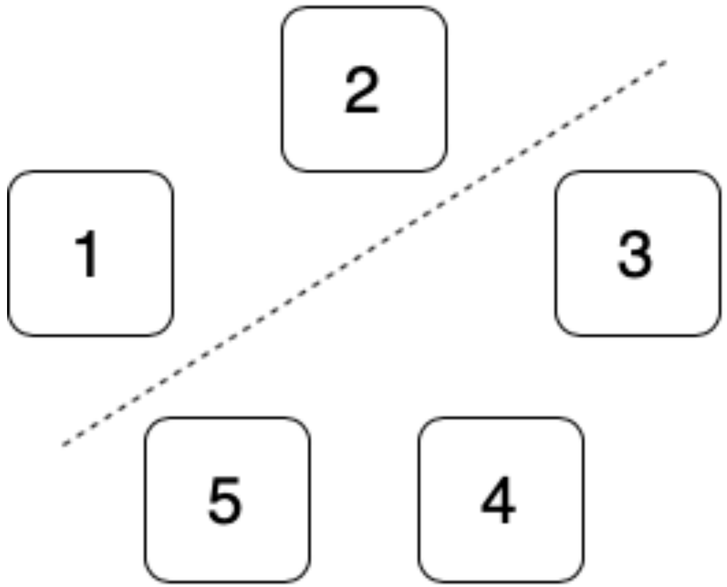
No failover?



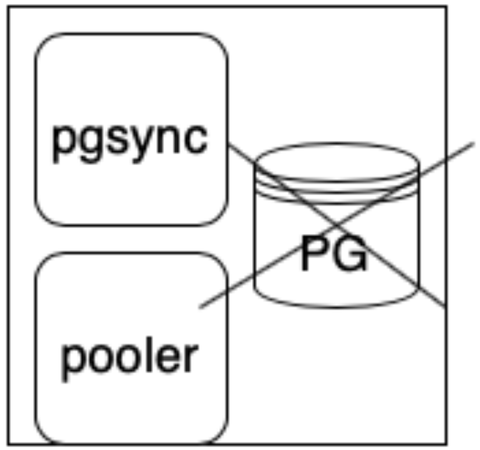
“Distributed fuzzing”



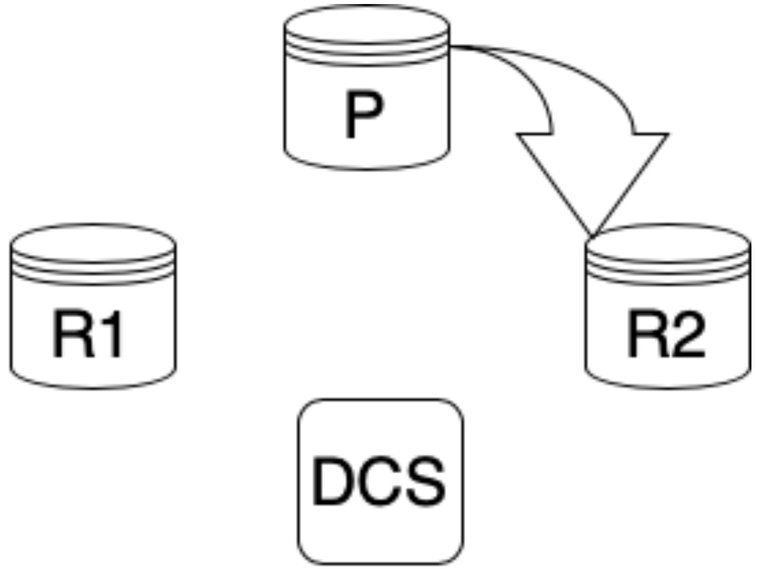
Nemesis



Partition



OOM



Switchover

Test workload

- CREATE TABLE test (value bigint PRIMARY KEY);

try

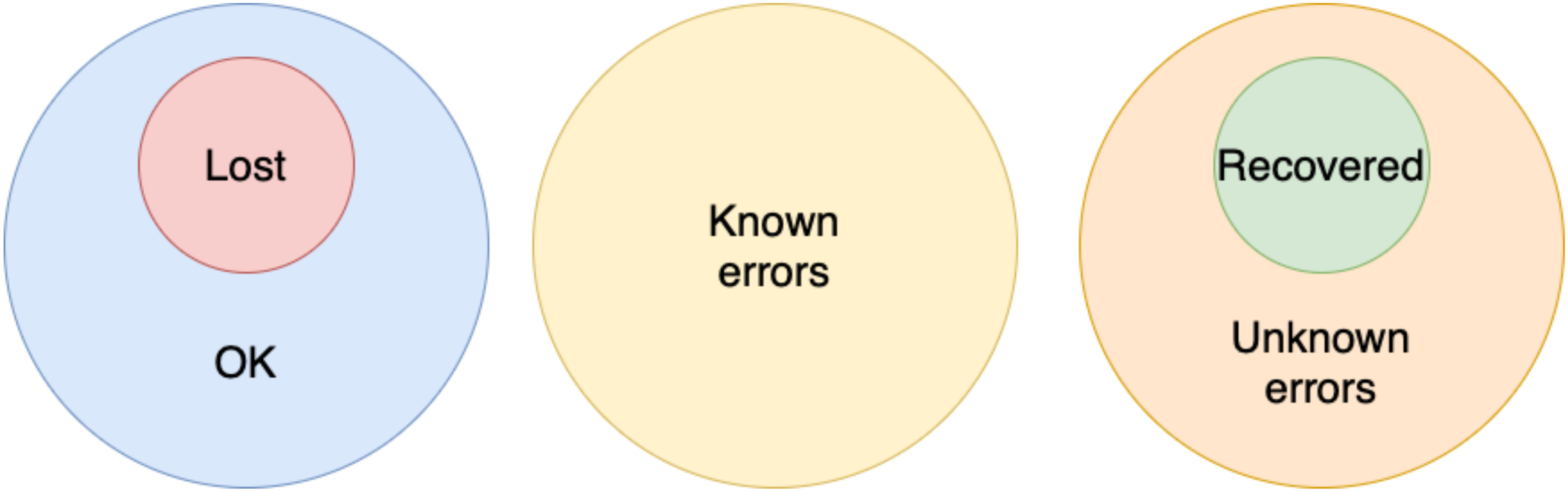
    execute “INSERT INTO test VALUES (:counter);”

    remember “ok”

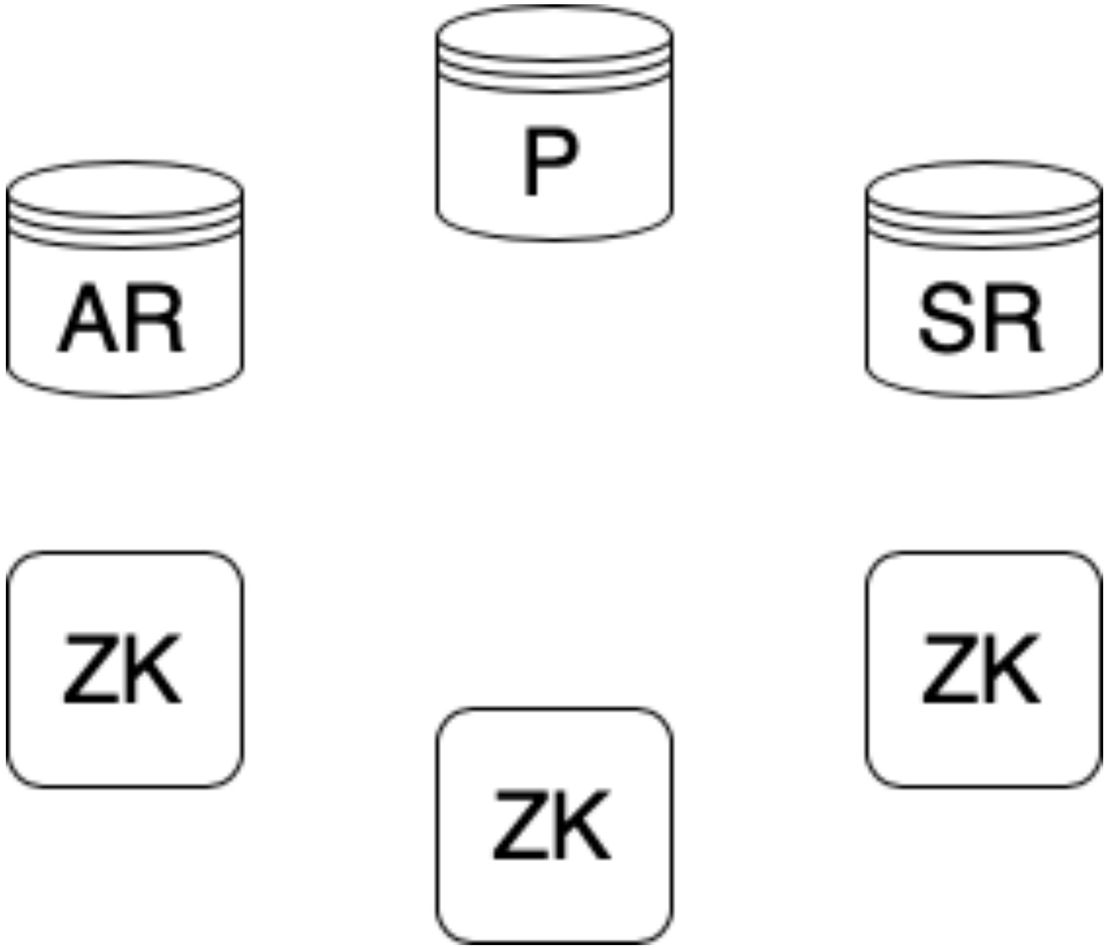
catch Throwable

    remember “error”

Result sets



Why '*' is not always the best value for synchronous_standby_names



Primary/replica loops

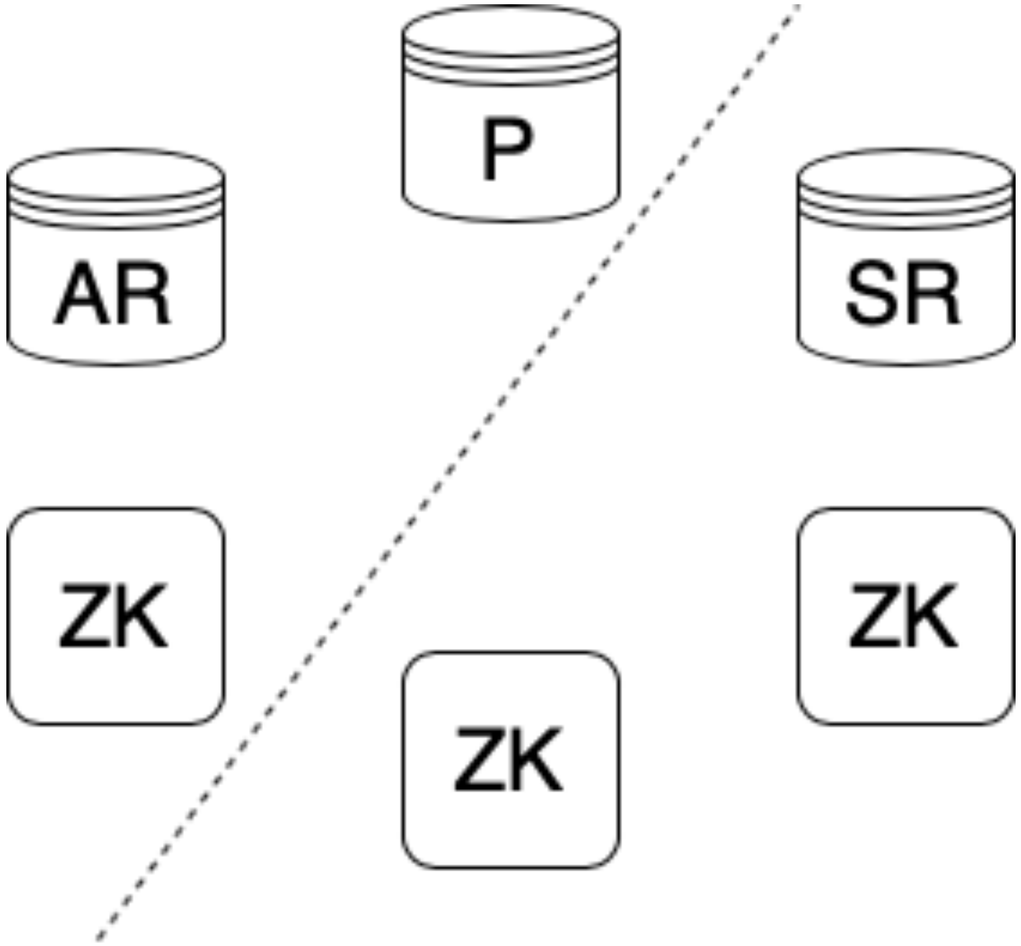
- Primary

```
if has_leader_lock():
    replicas_state = execute(“SELECT * FROM pg_stat_replication”)
    save(replicas_state)
```

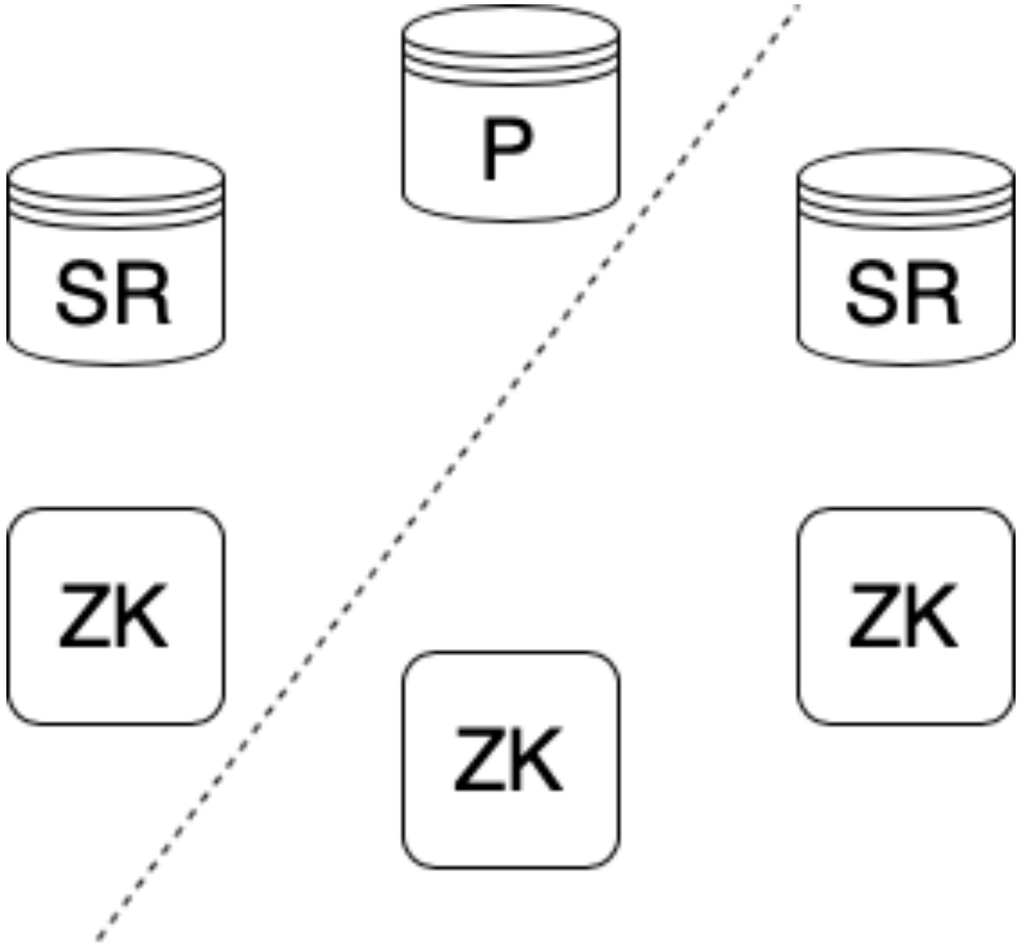
- Replica

```
if not leader_lock_holder():
    saved_state = get_replicas_state()
    if saved_state.get(my_application_name)[‘sync_state’] == ‘sync’:
        take_lock_and_promote()
```

Partition



Partition



Fixed replica loop

```
try_take_sync_lock()

if not leader_lock_holder():

    saved_state = get_replicas_state()

    if saved_state.get(my_application_name)['sync_state'] == 'sync':

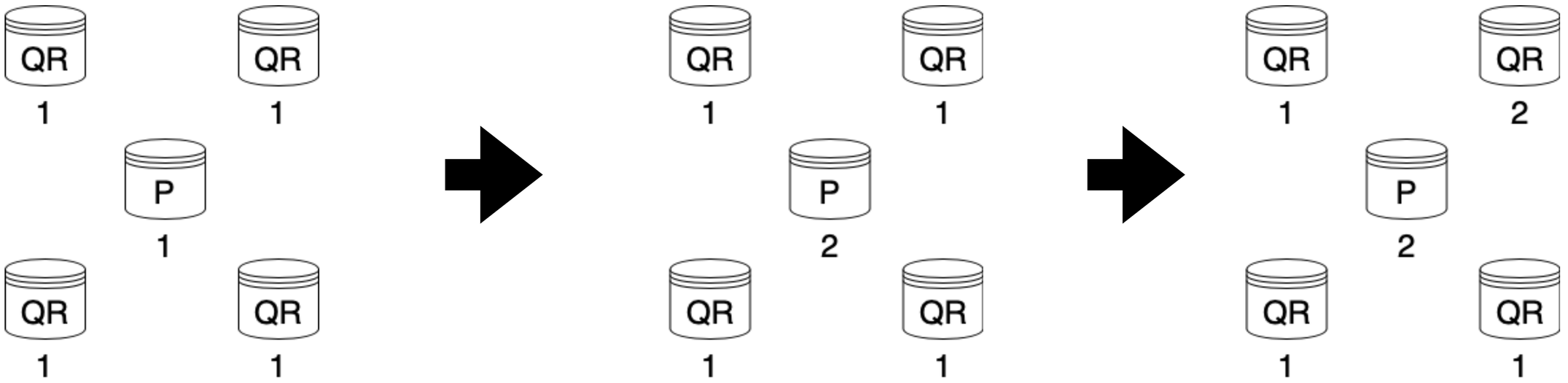
       if has_sync_lock():

          take_lock_and_promote()
```

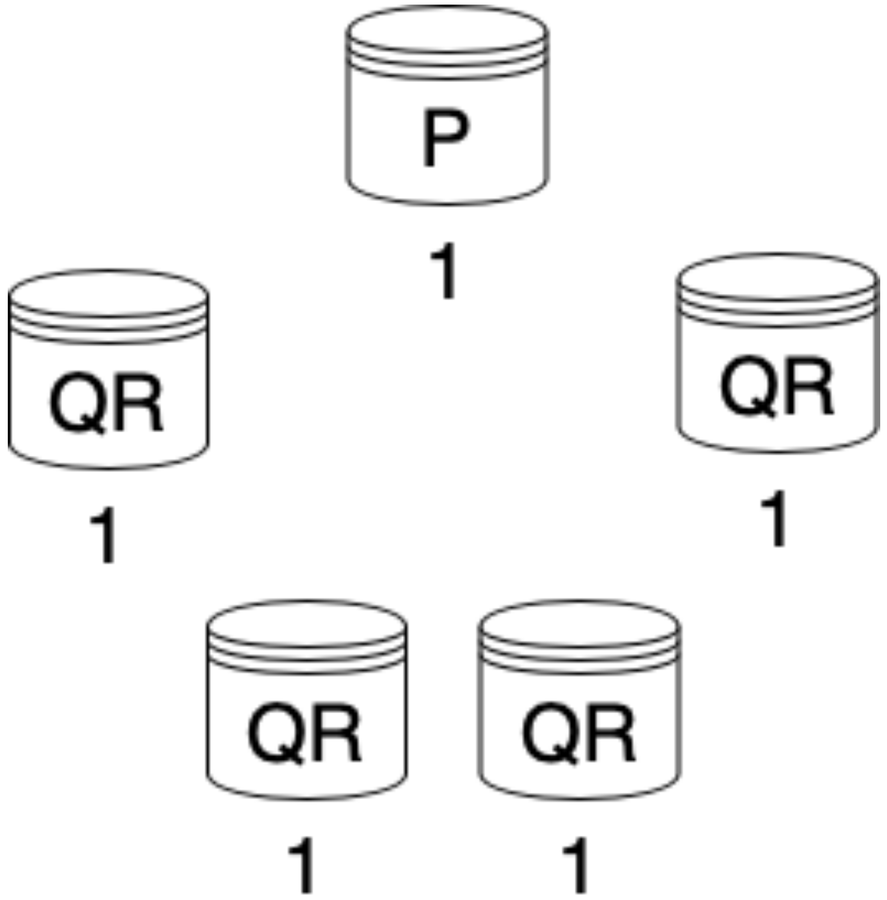
Fixed primary loop

```
if has_leader_lock():
    sync_holder = get_sync_lock_holder()
    fix_standby_names(sync_holder)
    replicas_state = execute(“SELECT * FROM pg_stat_replication”)
    save(replicas_state)
```

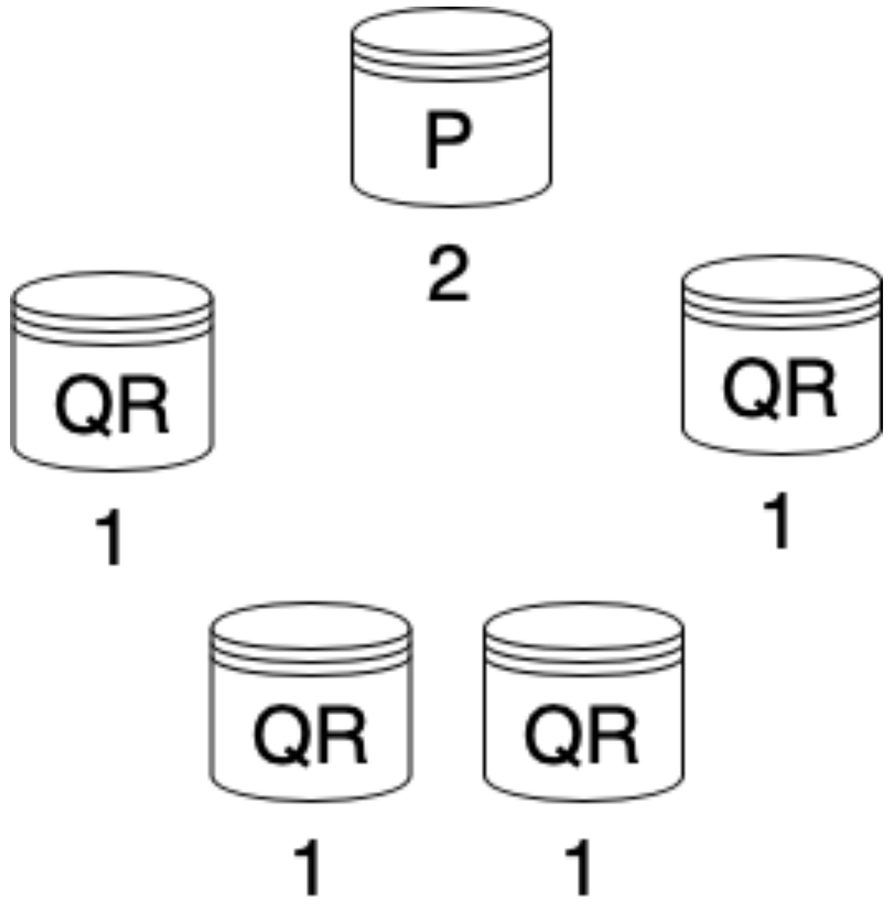
Quorum replication overview



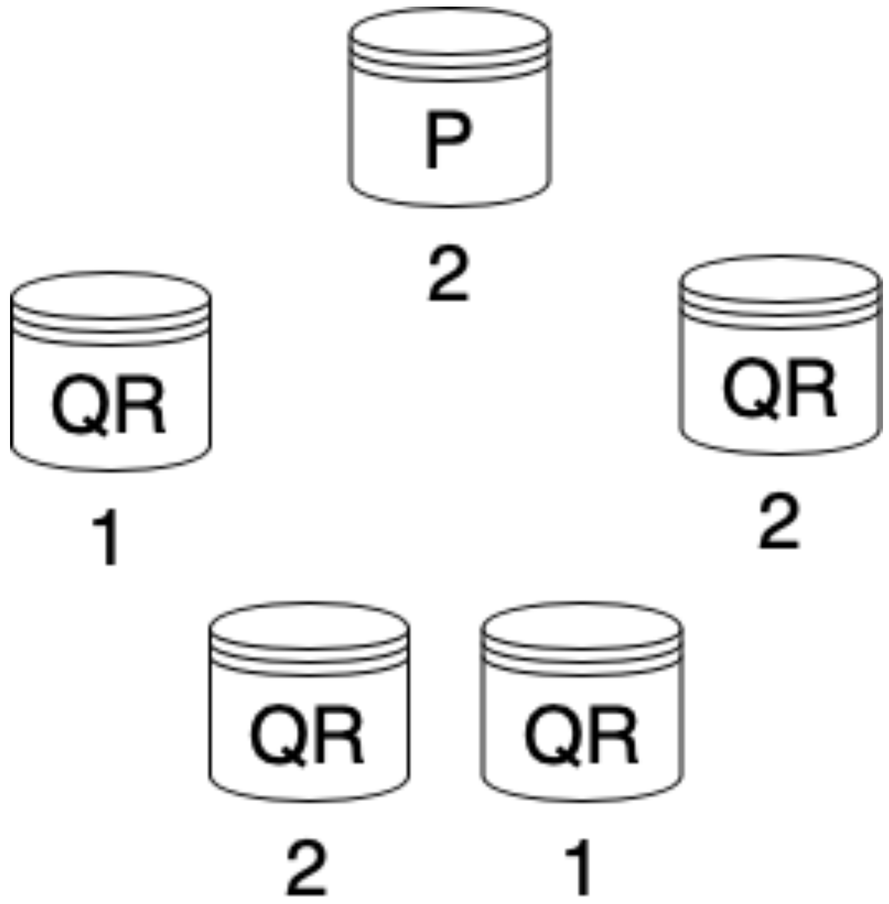
Quorum replication failover



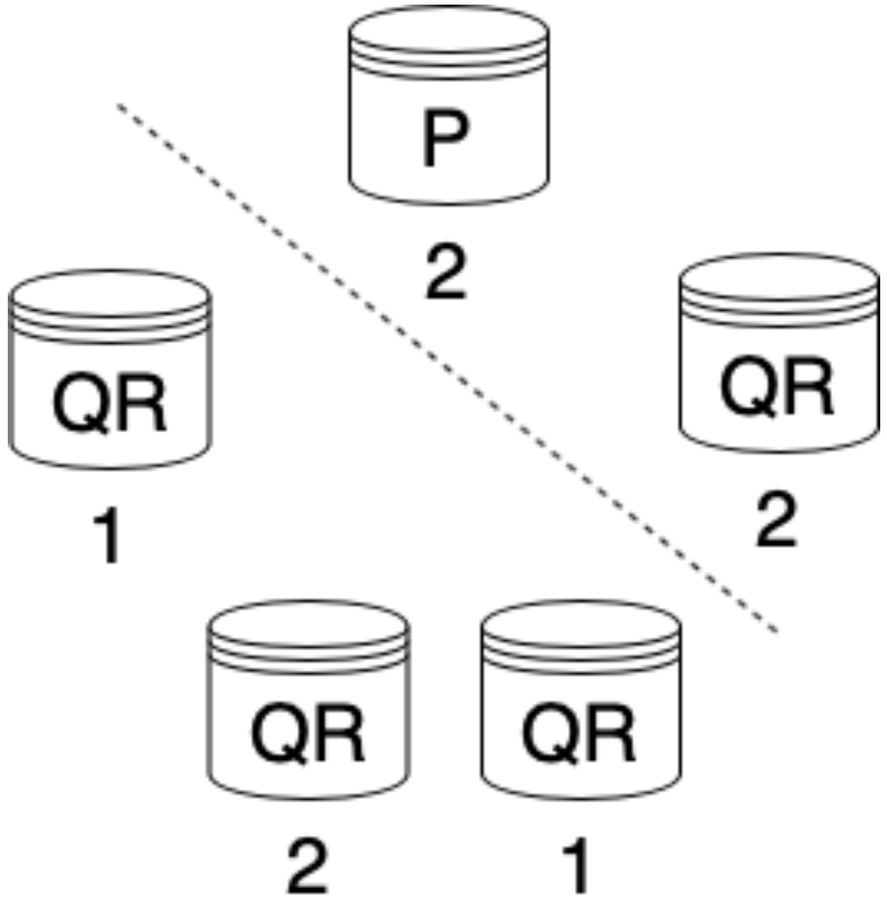
Quorum replication failover



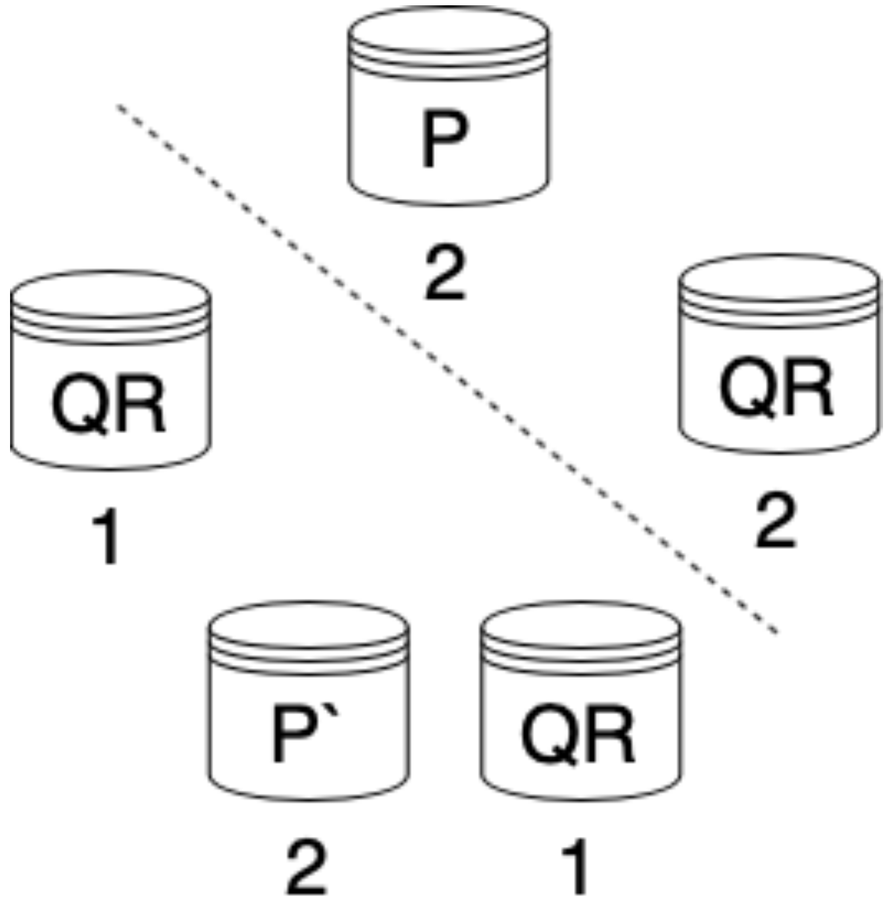
Quorum replication failover



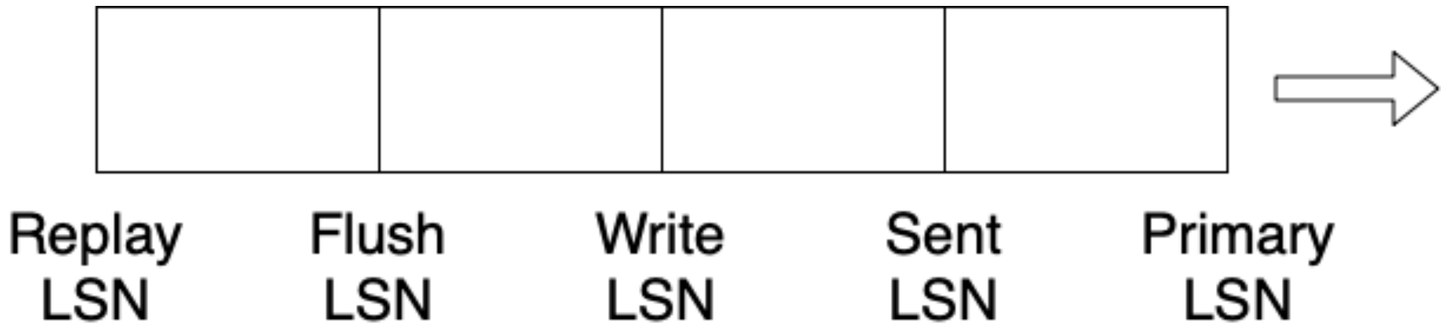
Quorum replication failover



Quorum replication failover



So many LSNs



Unforeseen consequences

- SELECT pg_last_wal_receive_lsn() -> 0/403F482
- SELECT pg_last_wal_replay_lsn() -> 0/403F482

—— Restart PostgreSQL ——

- SELECT pg_last_wal_receive_lsn() -> 0/4000000
- SELECT pg_last_wal_replay_lsn() -> 0/403F482

Just read the WAL

```
start = get_replay_lsn()  # GetXLogReplayRecPtr

state['lsn'] = start

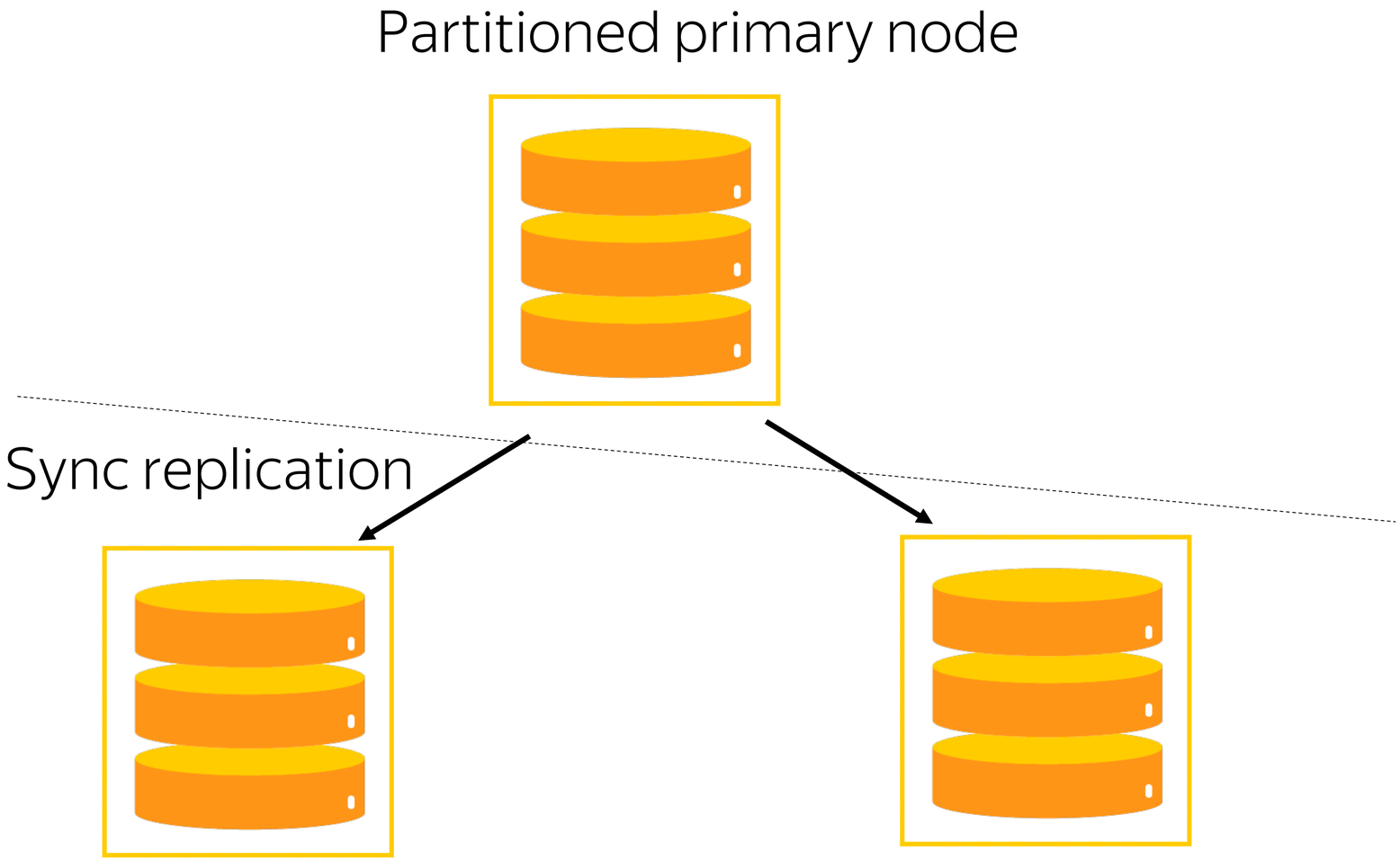
while read_wal(state):  # XLogReadRecord

    pass

return state['lsn']
```

Canceling running query

Synchronous commit guarantees



Transaction pseudocode

Lock data
Modify data locally
Wait for

- WAL flush locally
- WAL shipment remotely

Unlock data for observer

Replicas can be inconsistent

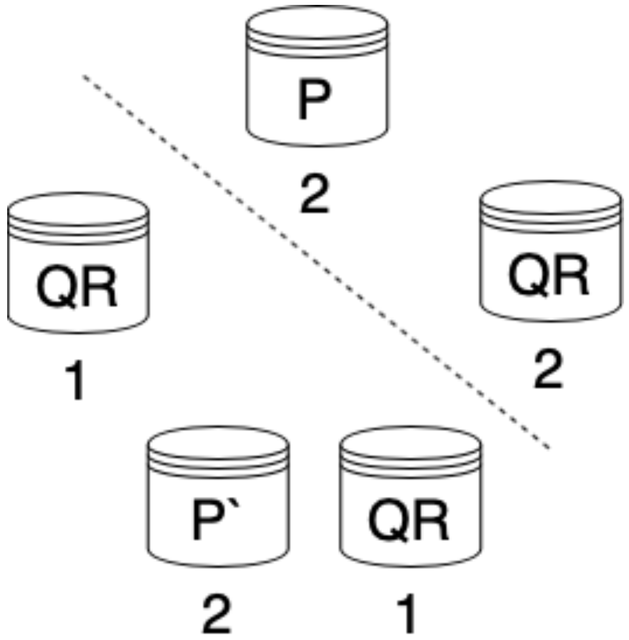
Lock data
Modify data locally
Wait for

- WAL flush locally
- WAL shipment remotely

Client read data on Standby that is not observed on Primary

Unlock data for observer

Replicas can be inconsistent



Lock data
Modify data locally
Wait for

- WAL flush locally
- WAL shipment remotely

Client read data on Standby that is not observed on Primary
Even on failed part of quorum
Unlock data for observer

Acknowledge not replicated data

Primary is partitioned
Lock data
Modify data locally
Wait for

- WAL flush locally
- WAL shipment remotely (hangs dur to network partition or standby promotion)
- Client cancels query, but it’s committed locally

Unlock data for observer
User issues INSERT ON CONFLICT DO NOTHING
No WAL is written => commit is acknoledged

Disable cancellation of executed locally query

- ALTER SYSTEM SET synchronous_commit_cancelation to off;

https://commitfest.postgresql.org/31/2402/

Only partial solution

- Primary restart still makes not-replicated data visible

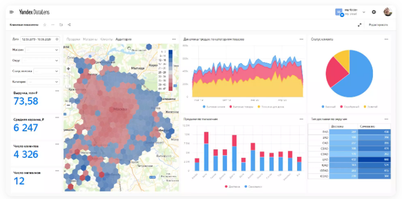
Some additional information

The topic was discussed at PGCon unconference 2020

https://wiki.postgresql.org/wiki/PgCon_2020_Developer_Unconference/Edge_cases_of_synchronous_replication_in_HA_solutions

Changed data capture

So you want to stream logically?



OLAP\MR

RW Queries

Logical replication

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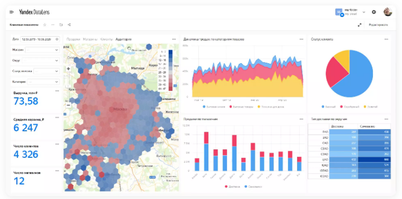
Async replication

Sync replication

RO Queries

Be ready to failover. Logically.



OLAP\MR

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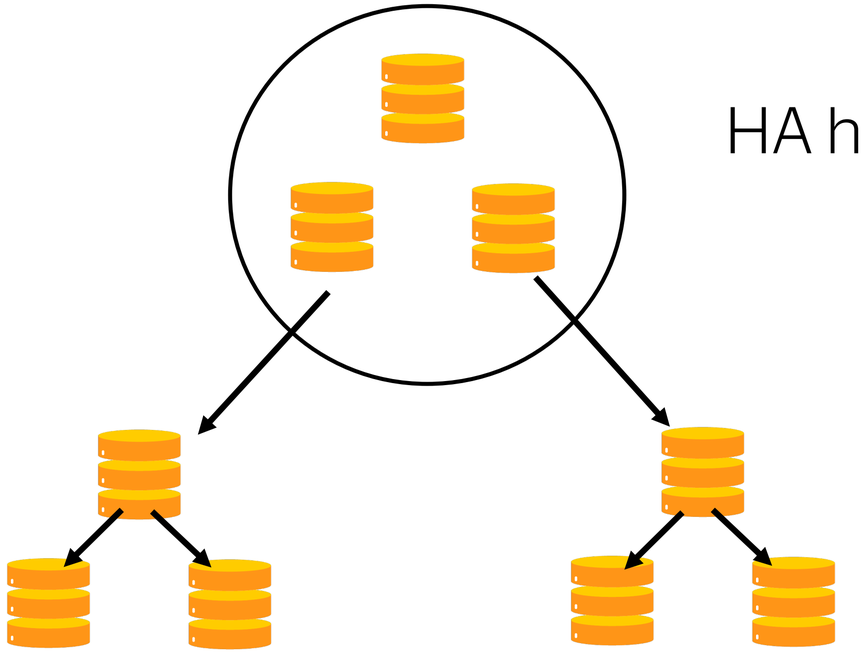
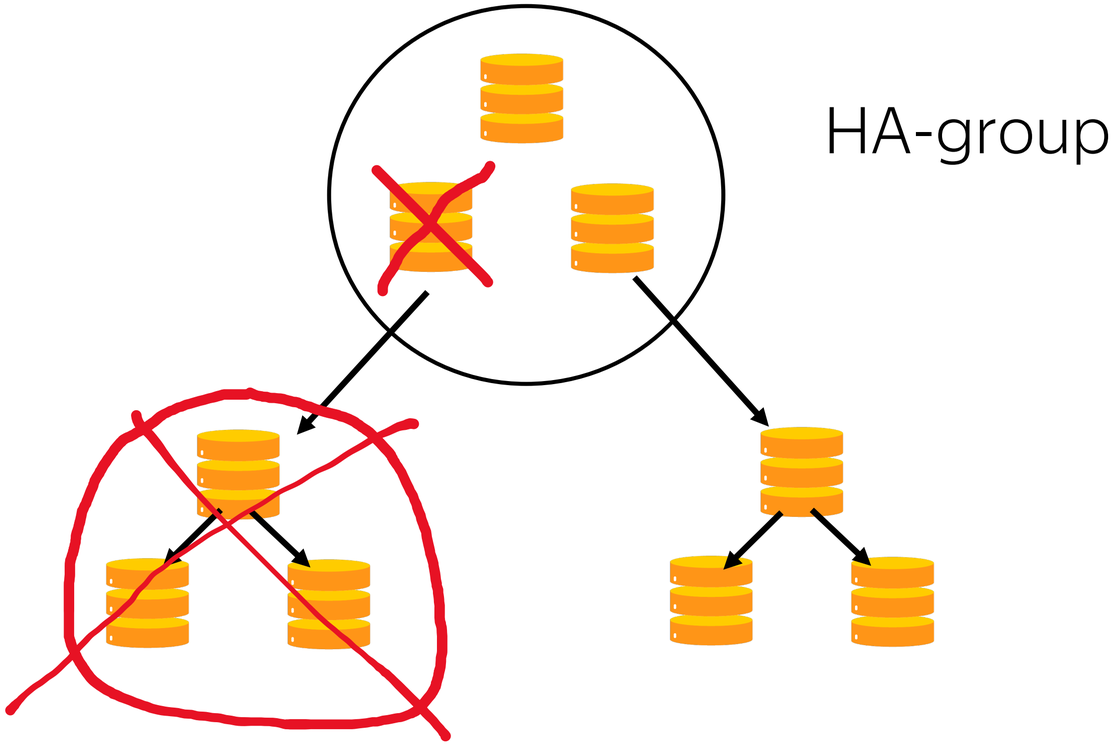
RO Queries

Non-HA standbys

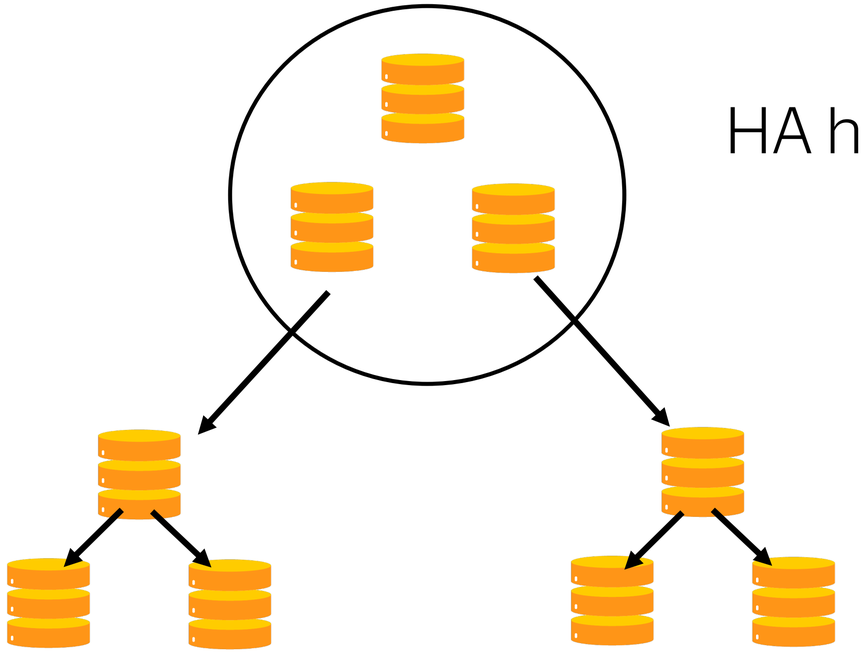


HA host greoup

Rebuilding topology



Non-HA standbys



- Useless for CDC before logical decoding is allowed on Standby

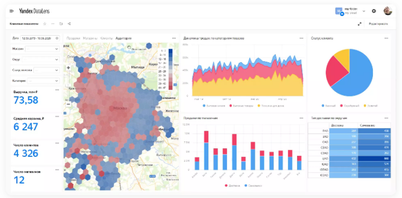
Slots are necessary

Logical streaming start from slot’s restart position

But you can only create slot on latest WAL insert pointer

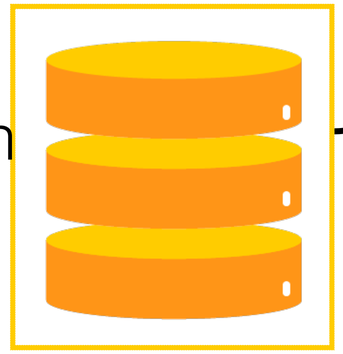
No chances to have LSN on failed primary == LSN of created slot

Maybe logical archive?



OLAP\MR

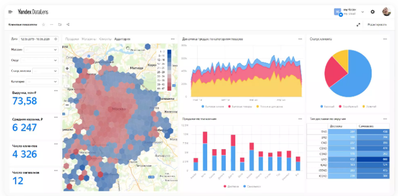
Logical replication



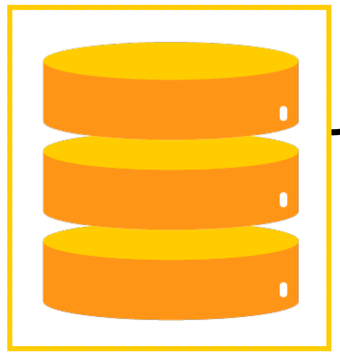
WAL

Network
Object
Storage

Maybe logical decoding in WAL-G?



OLAP\MR



WAL

Network
Object
Storage

WAL-G already parses WAL to make backups and replay faster

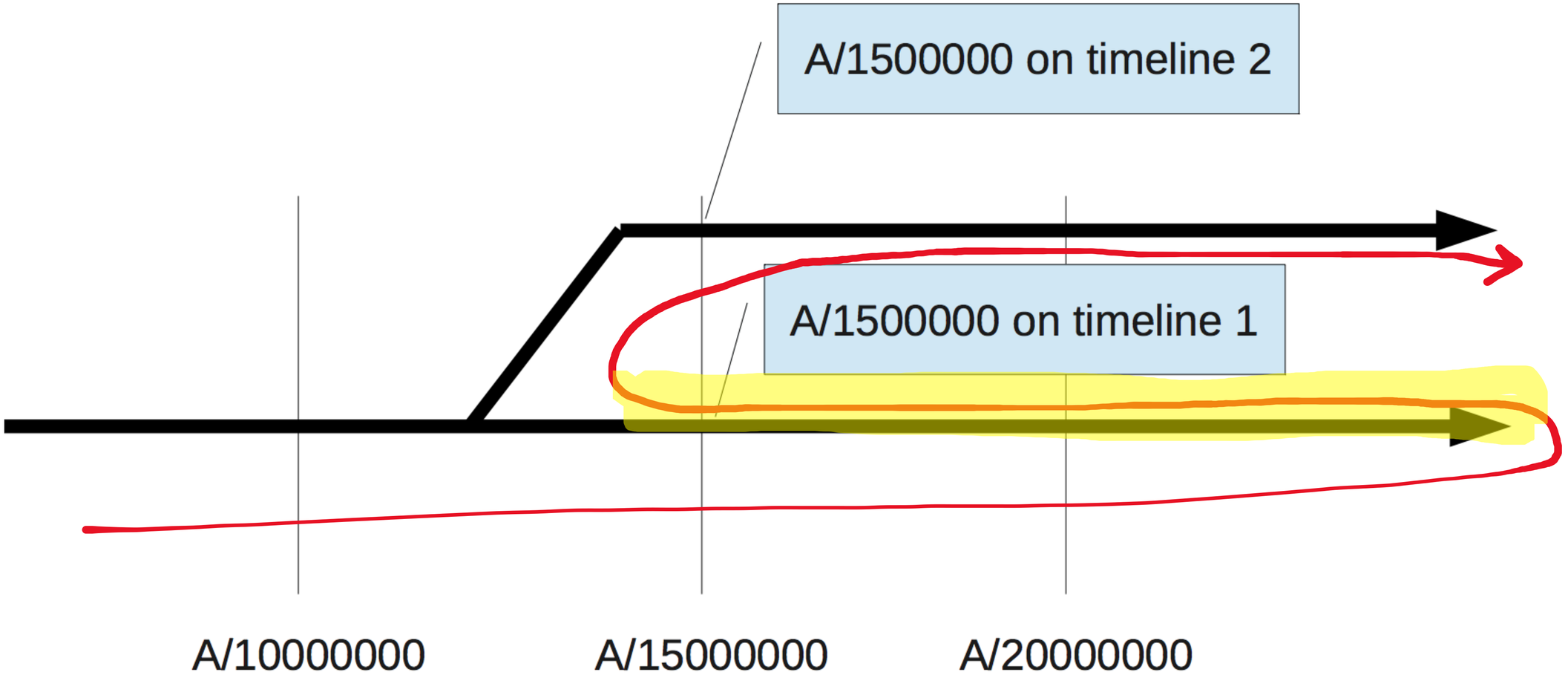
Synchronous standby names

Logical streaming can be ahead of

- Synchronous standby
- Quorum

Maybe add post_synchronous_standby_names?

Maybe logical pg_rewind?

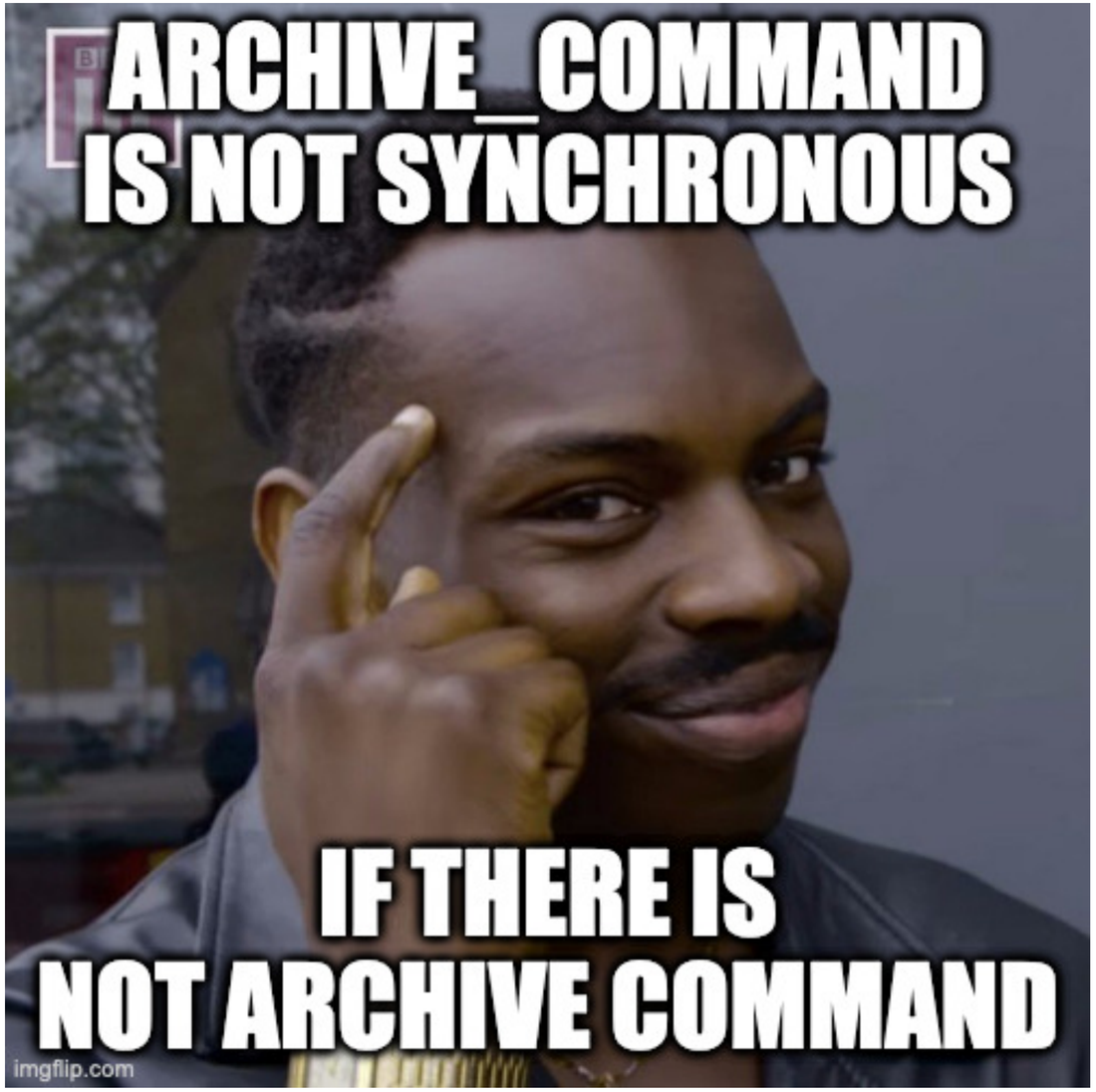


So we have to hack the PostgreSQL

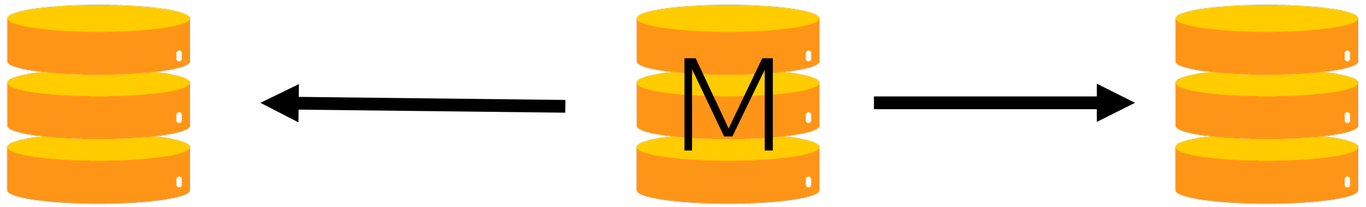
Currently we just implemented an extension to create slot in the past

- We accept the risk of catalog vacuum after promotion
- Anyway we need to stream data from PG 10,11,12,13,14 where things won't change much
- But we are working to make it better

Some word about MySQL


ARCHIVE_COMMAND
IS NOT SYNCHRONOUS
IF THERE IS
NOT ARCHIVE COMMAND
imgflip.com

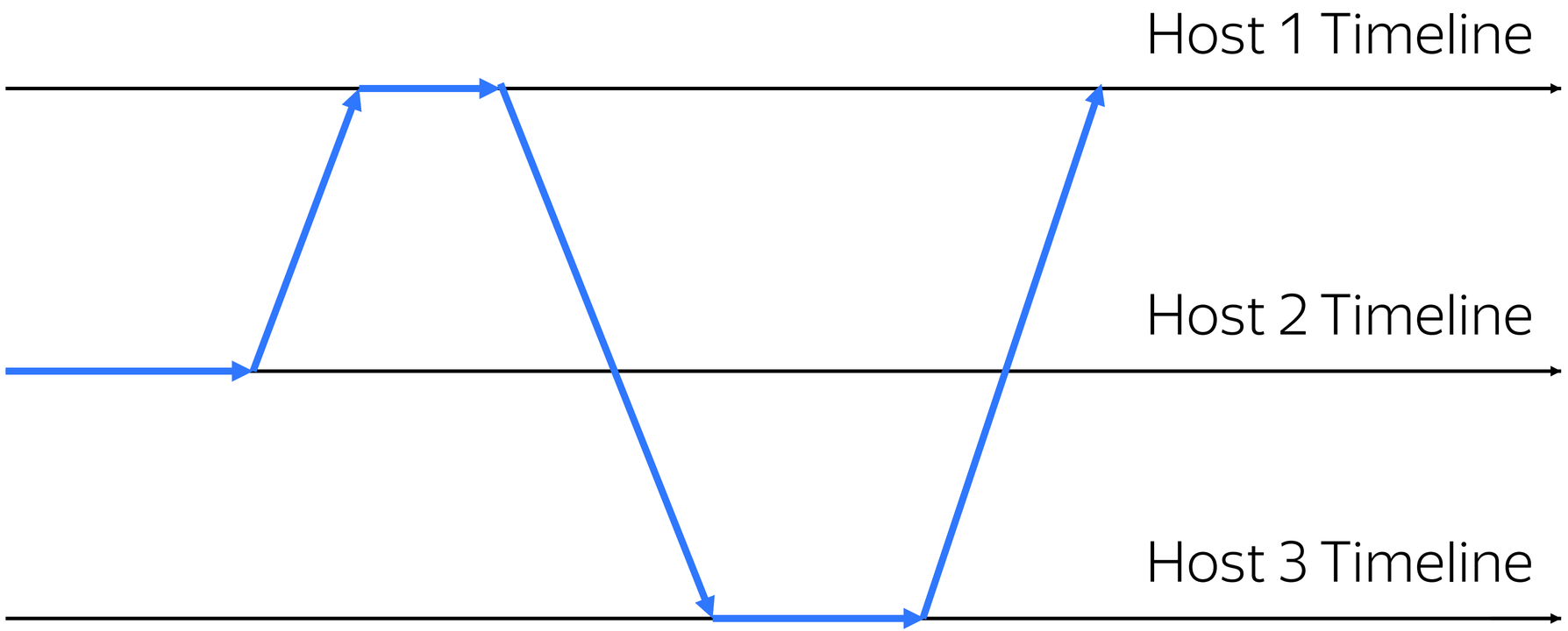
No timelines: separate binlogs on each host



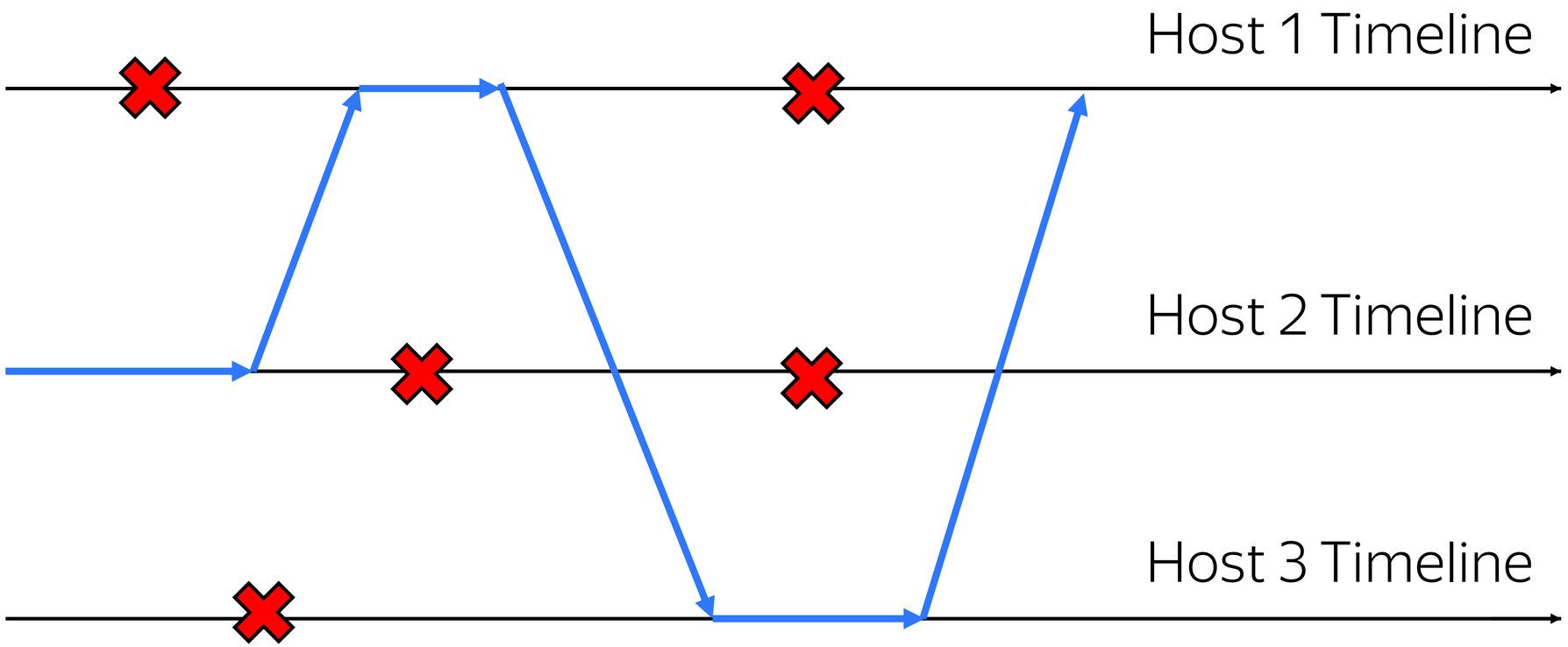

```
mysql> show binary logs;
+------------------------------------------------------------+
| Log_name                                                   |
+------------------------------------------------------------+
| mysql-bin-log-sas-[illegible]-db-yandex-net.000256 |
| mysql-bin-log-sas-[illegible]-db-yandex-net.000257 |
| mysql-bin-log-sas-[illegible]-db-yandex-net.000258 |
```

```
mysql> show binary logs;
+------------------------------------------------------------+
| Log_name                                                   |
+------------------------------------------------------------+
| mysql-bin-log-iva-[illegible]-db-yandex-net.000249 |
| mysql-bin-log-iva-[illegible]-db-yandex-net.000250 |
| mysql-bin-log-iva-[illegible]-db-yandex-net.000251 |
```

Switchover/Failover



Nonlinear history == difficult PITR



MySQL logical replication

Some really nice concepts

- GTID sets are beautiful
- Automatic repositioning if fantastic

Tools

Disable cancellation of executed locally query

- ALTER SYSTEM SET synchronous_commit_cancelation to off;

https://commitfest.postgresql.org/31/2402/

lwaldump

Usage on primary: CREATE EXTENSION lwaldump;
Usage on standby: SELECT lwaldump();

https://github.com/g0djan/lwaldump

Create logical slot in the past

- SELECT pg_create_logical_replication_slot_lsn(name, .., restart_lsn);

https://github.com/x4m/pg_tm_aux

HArd to get it right

but not impossible

HArd to get it right

but not impossible

and corner cases are not that frequent actually

Waiting for questions ☺

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