HOW2025
PostgreSQL & IvorySQL
Eco Conference

What is Patroni, *really*?

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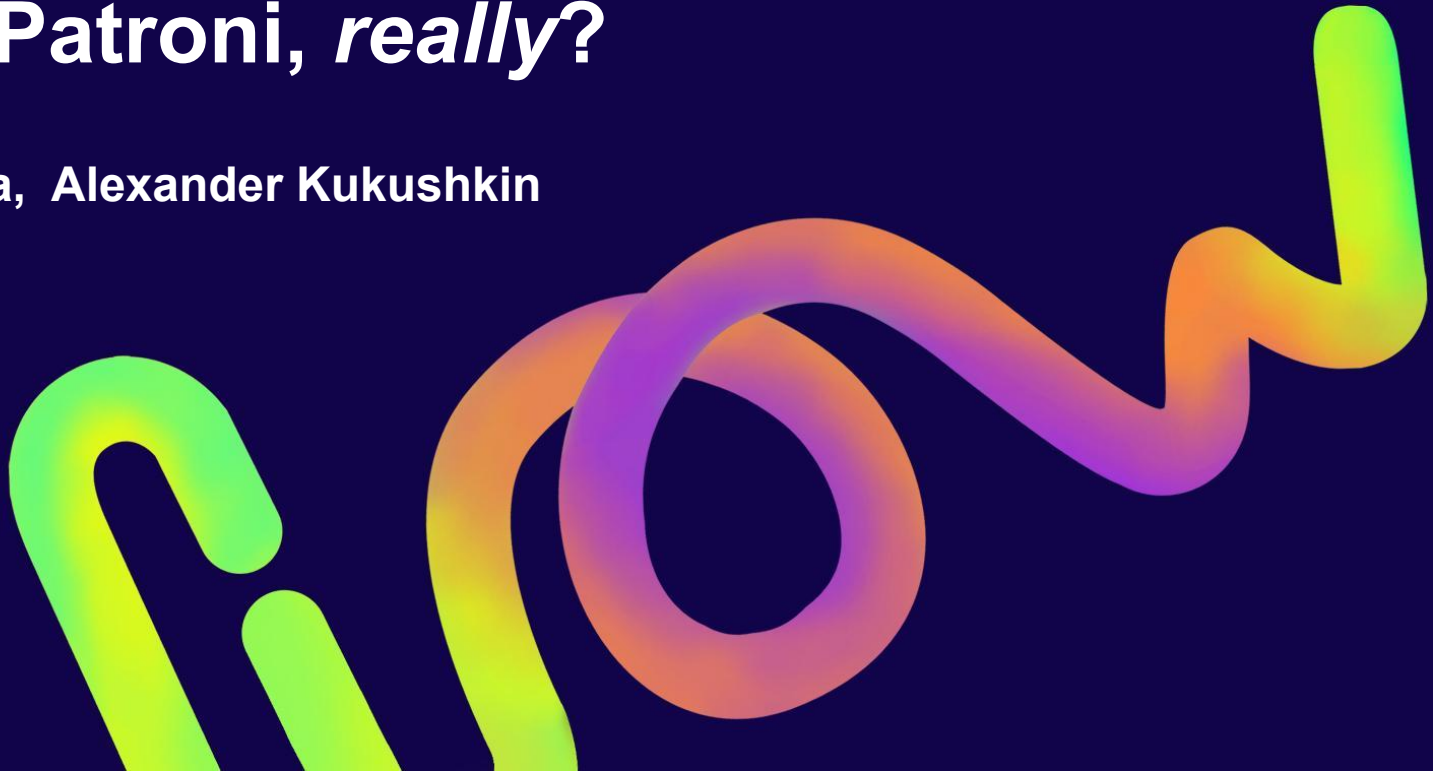
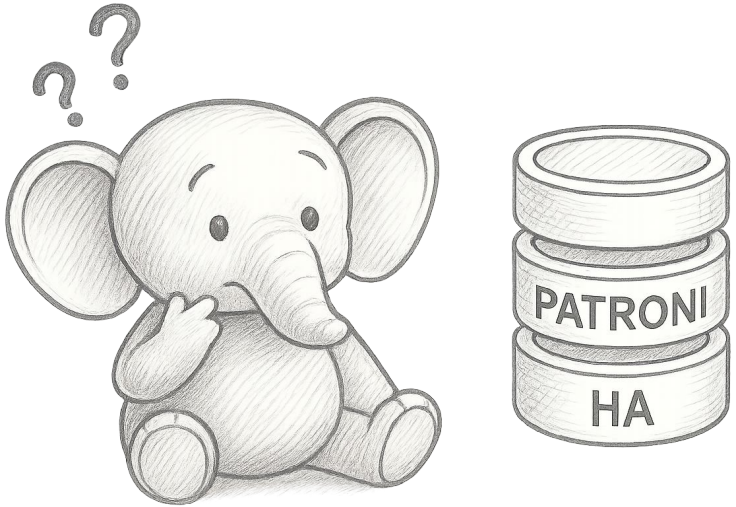
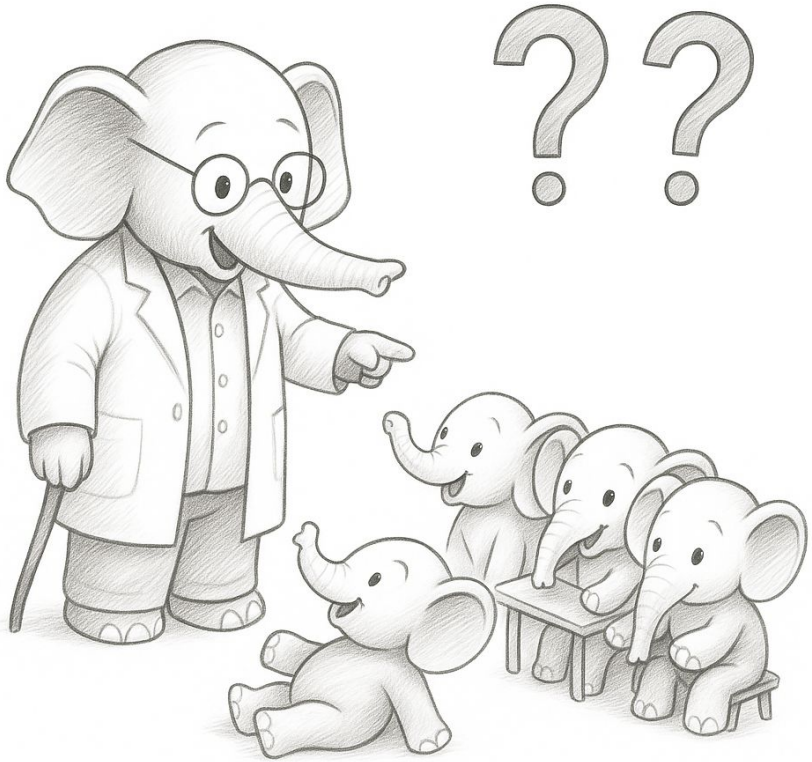


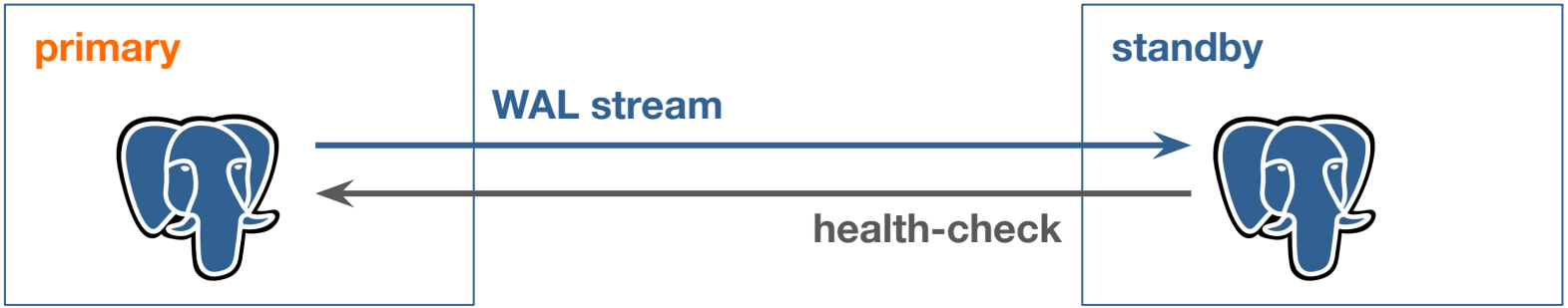
- What is it, really?
- Automatic failover done wrong
- Patroni overview
  - how it works?
  - notable features



What is it, really?

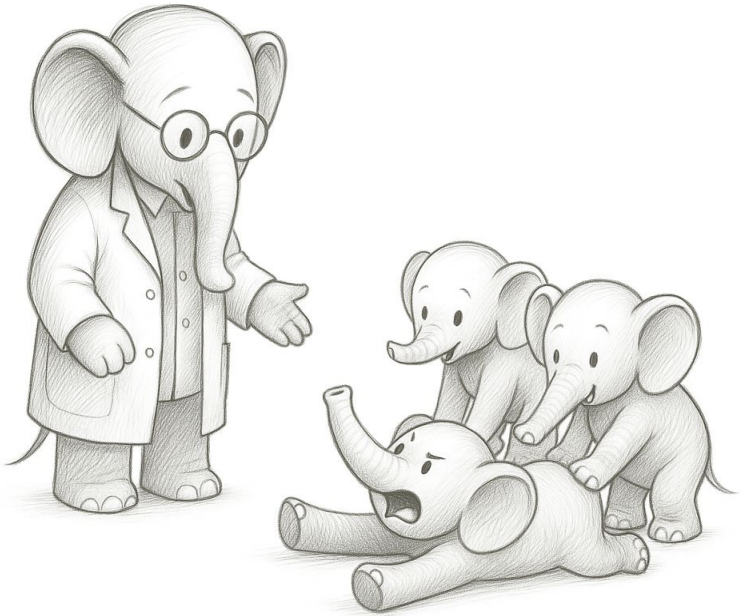


Running two nodes only

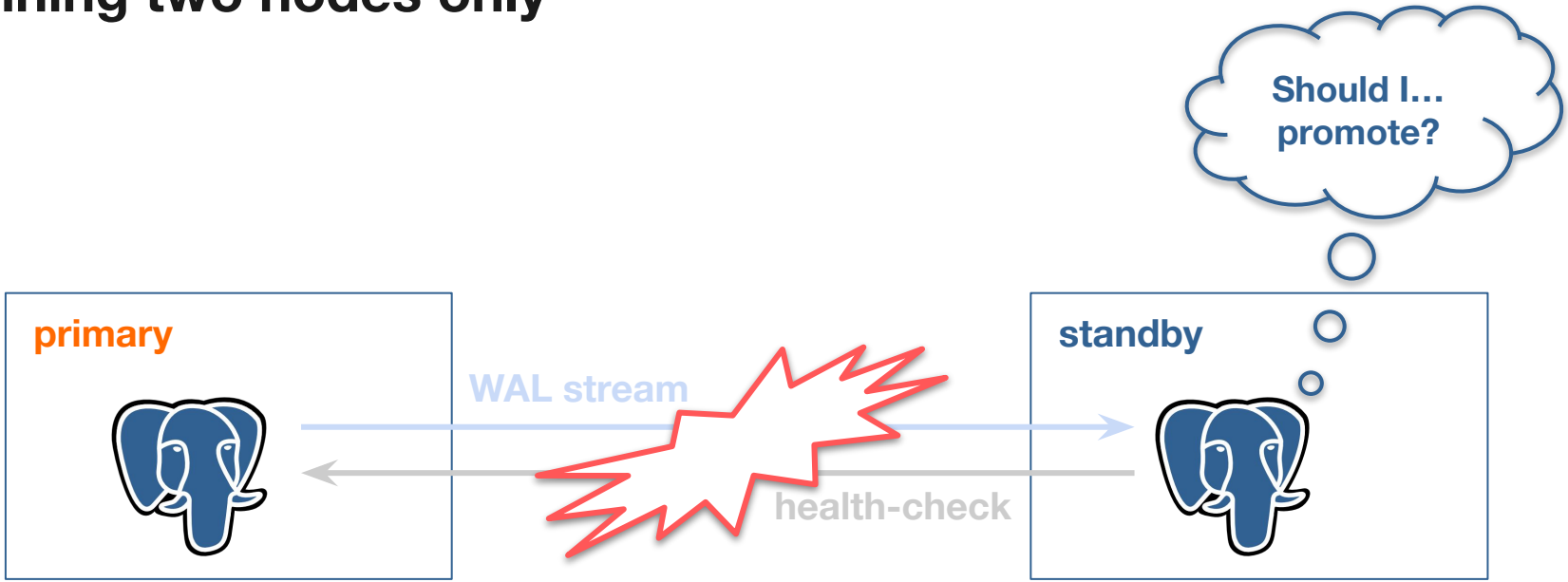


- Originated from Governor project by Compose, in 2015
- Main functions:
  - Automatic failover
  - Cluster creation and initial setup
  - Cluster management
  - ~ Monitoring

Automatic failover done wrong

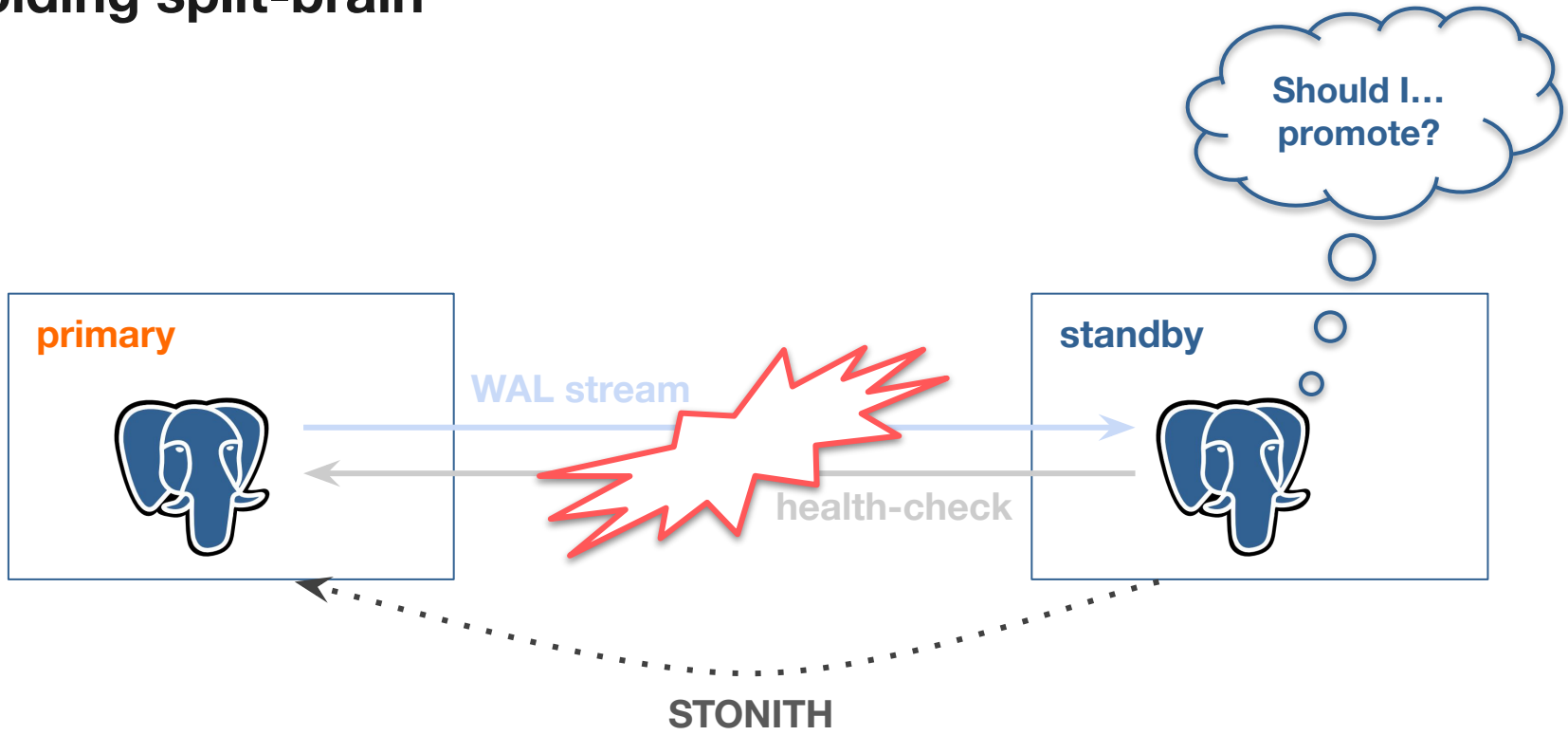


Running two nodes only



Running two nodes only

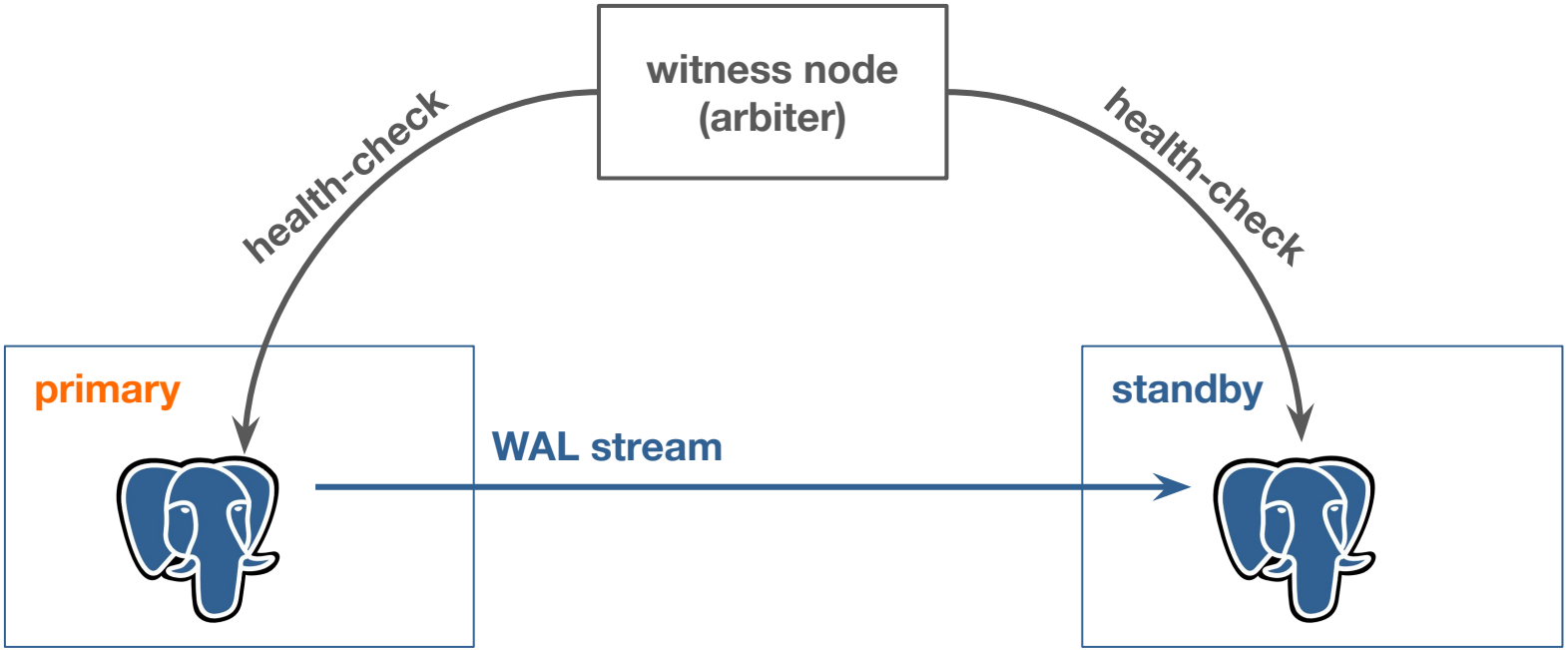
Avoiding split-brain



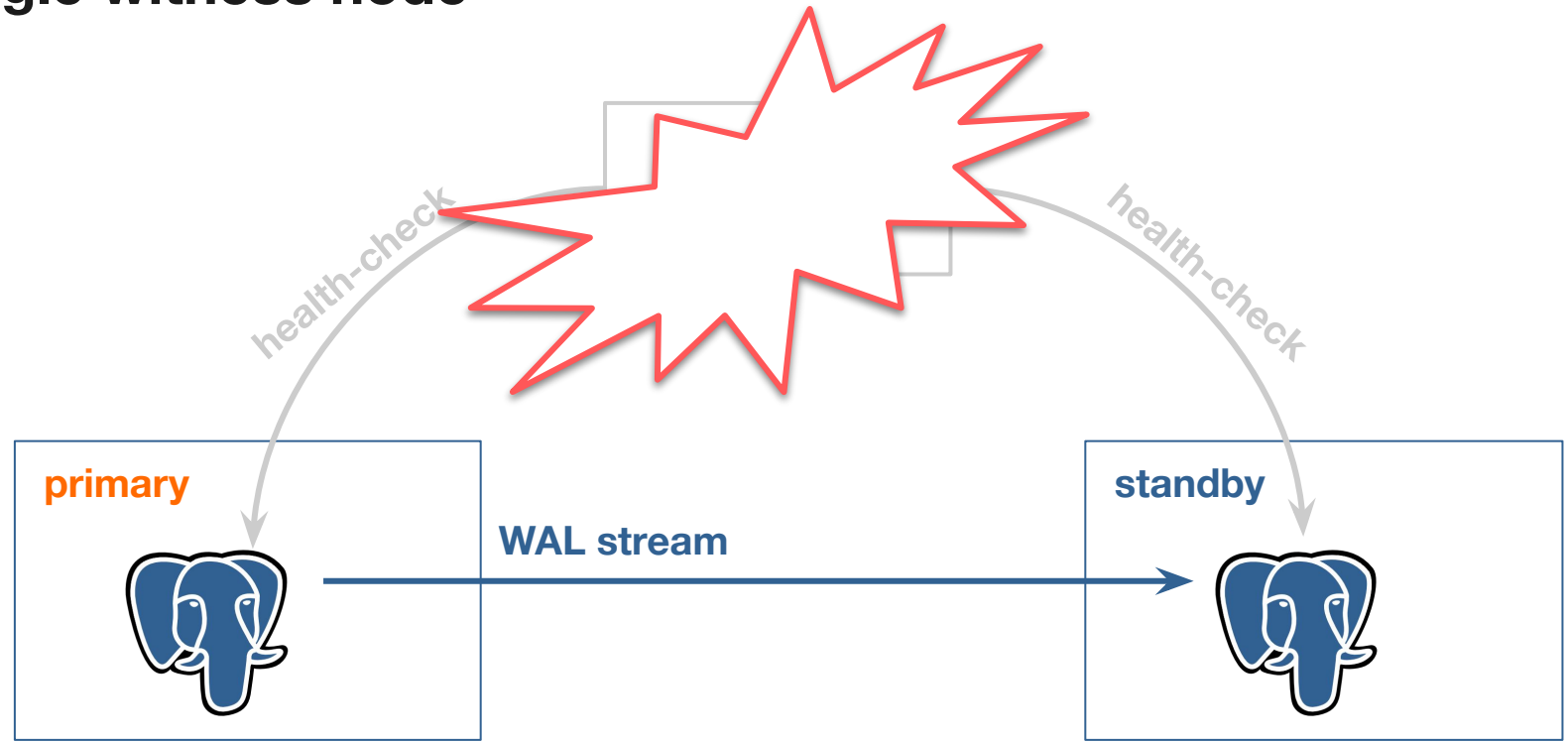
Avoiding split-brain

- STONITH (shoot the other node in the head)
- Must use a secondary network
- Almost impossible to get it right

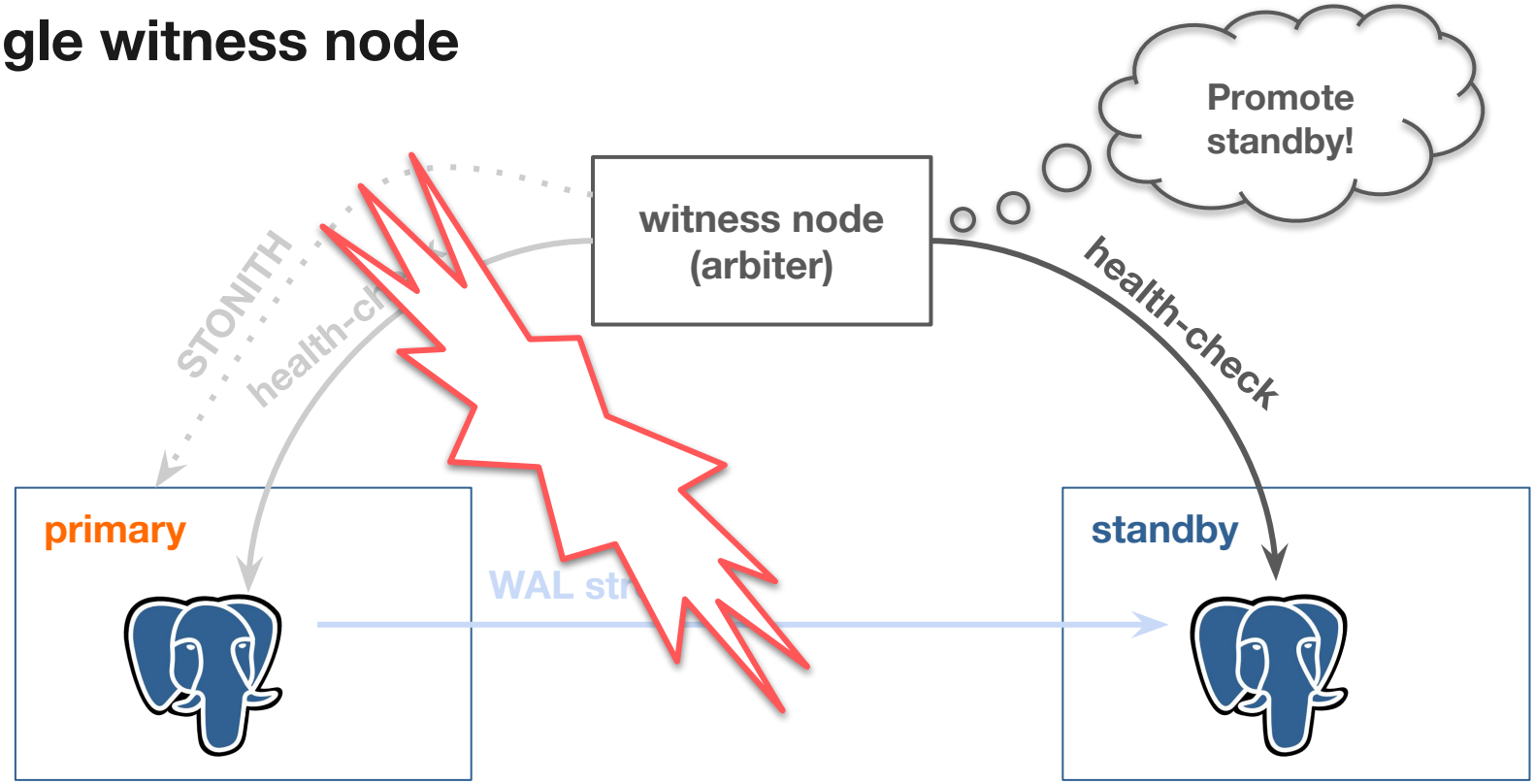
Single witness node



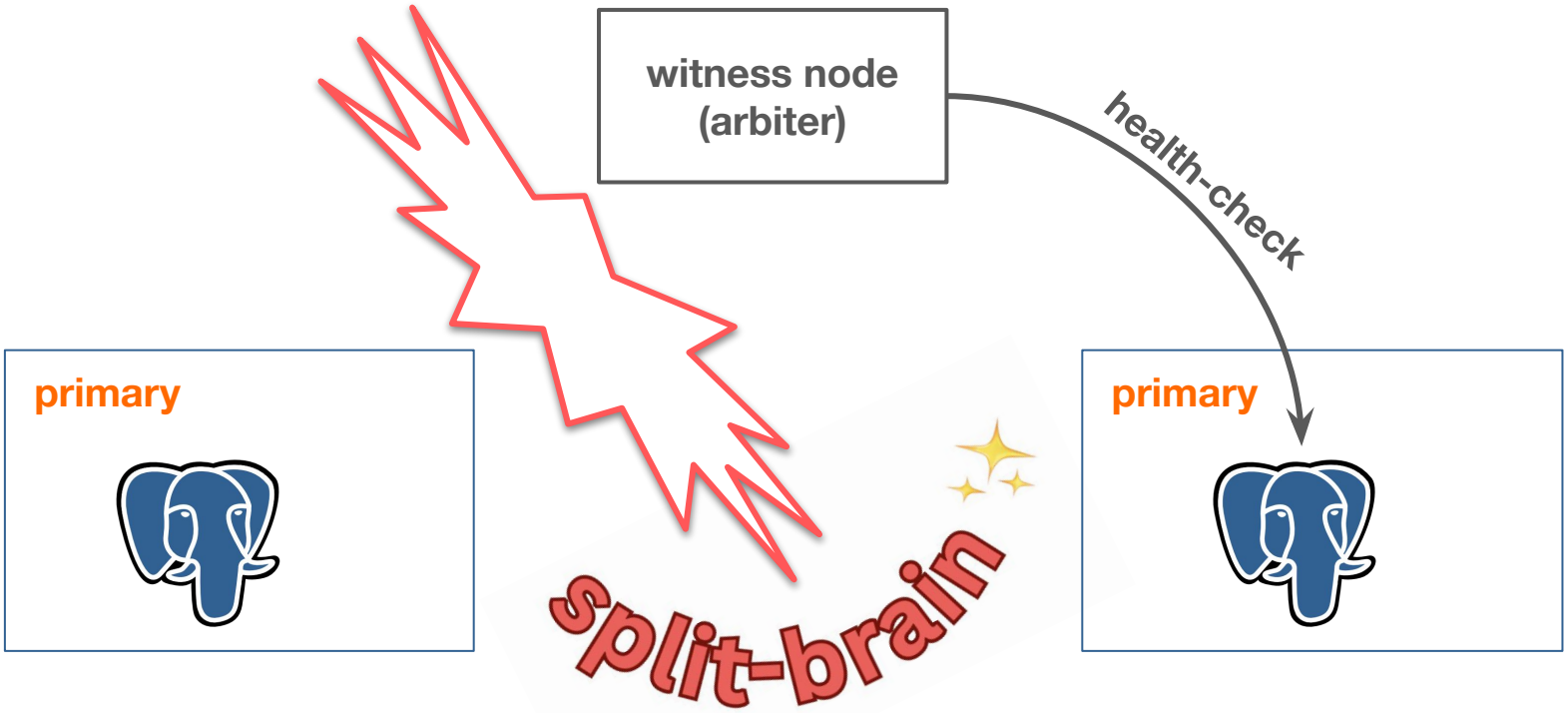
Single witness node



Single witness node



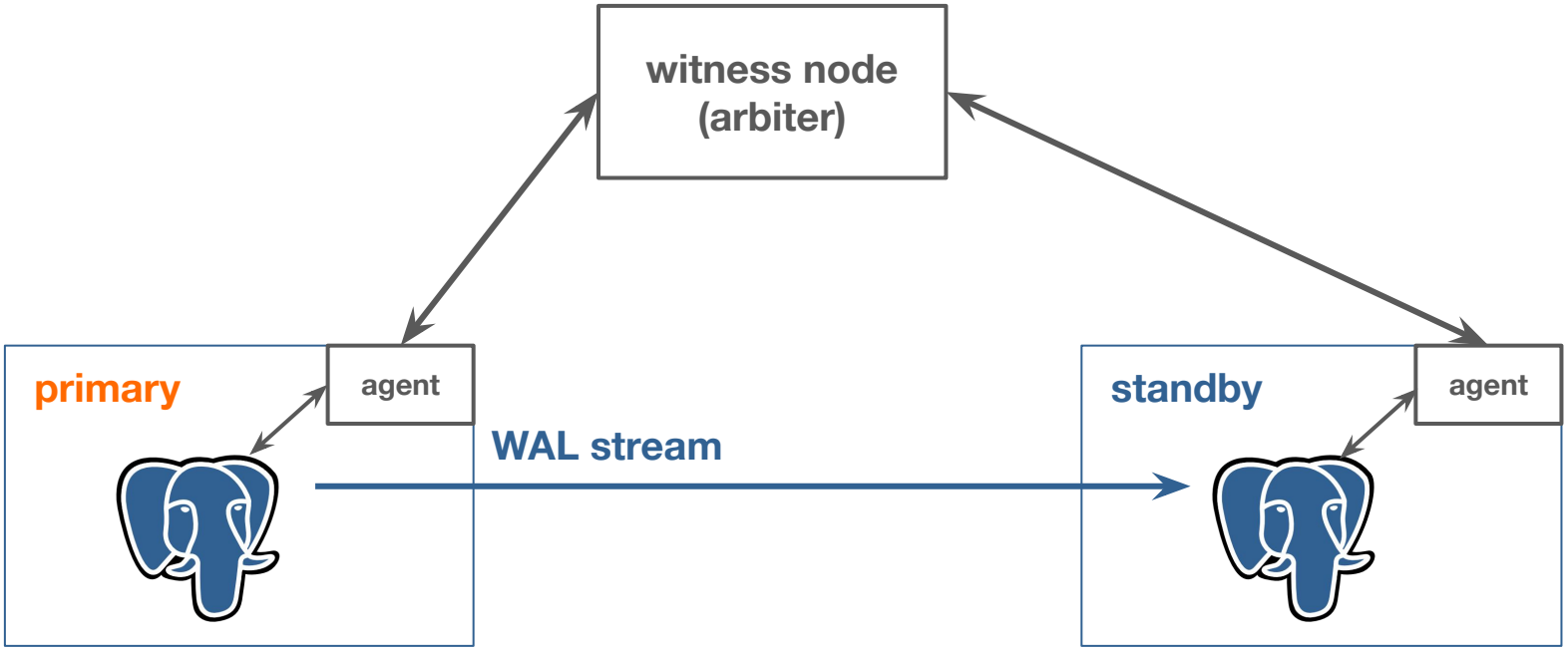
Single witness node



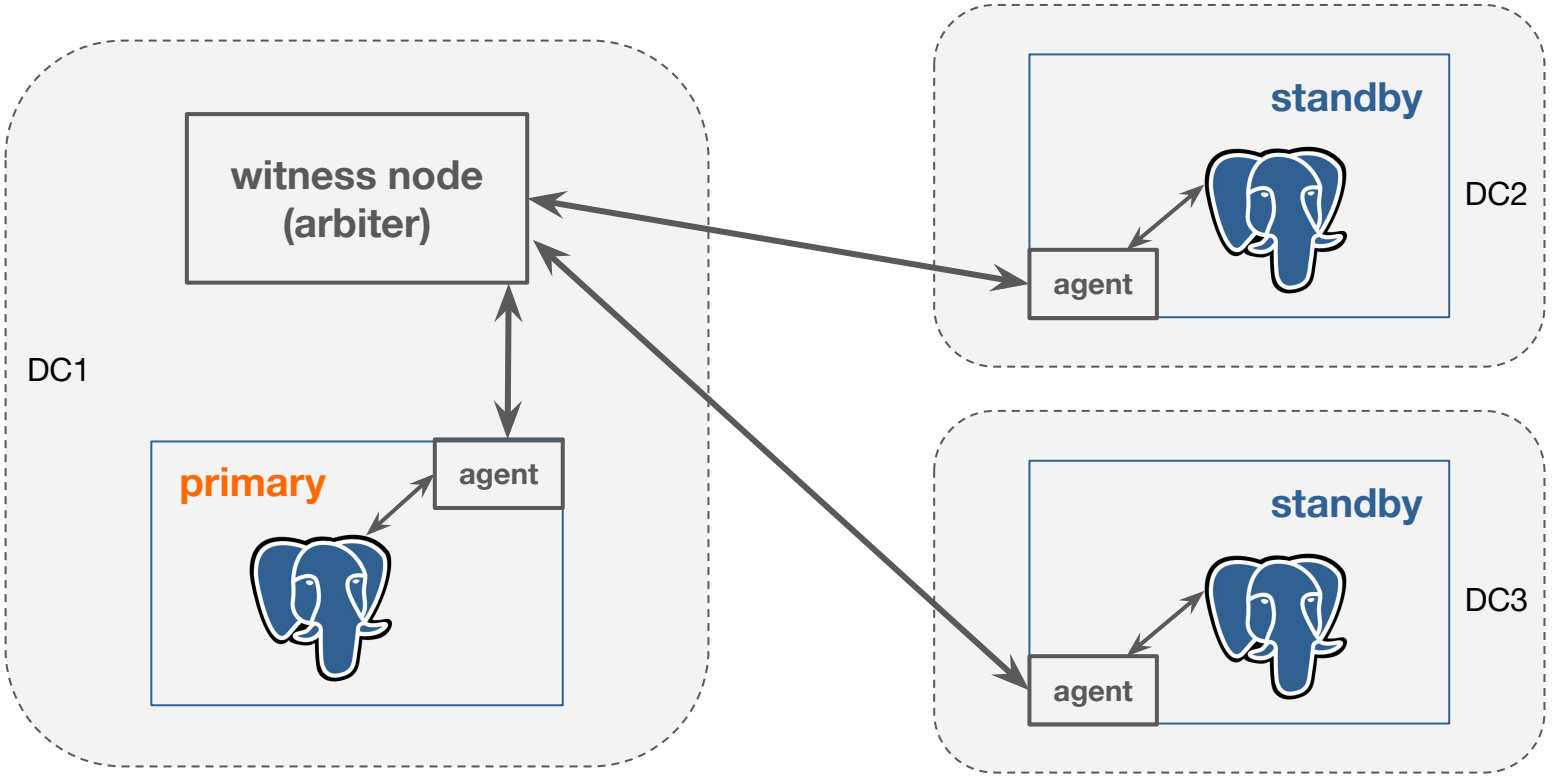
Things to consider

- Think about network partition
- Prevent split-brain → fencing
  - STONITH
    - Shut down
    - Kill old connections, re-configure proxy
  - Self-fencing (locally)
- Watchdog

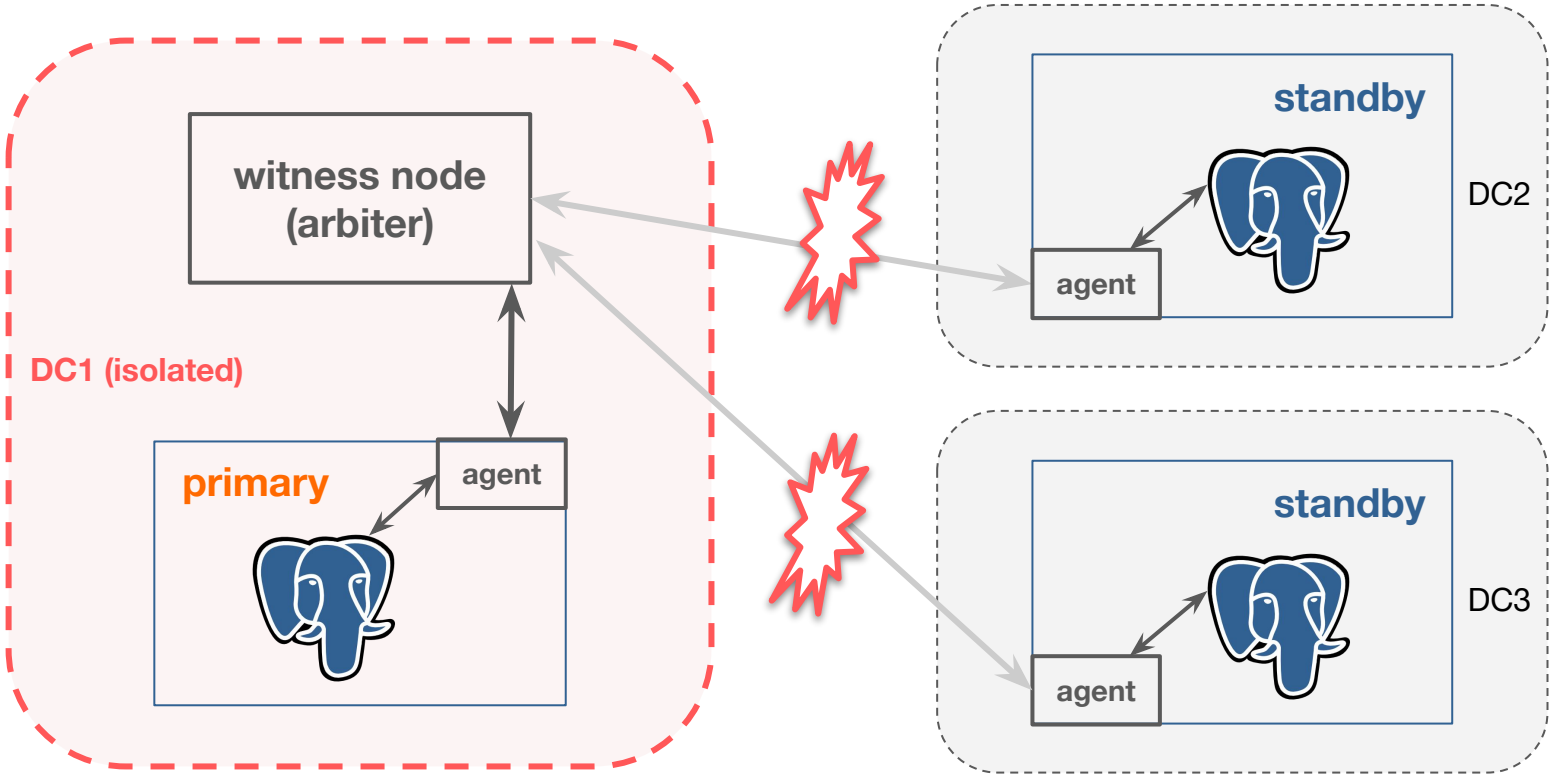
Local agents



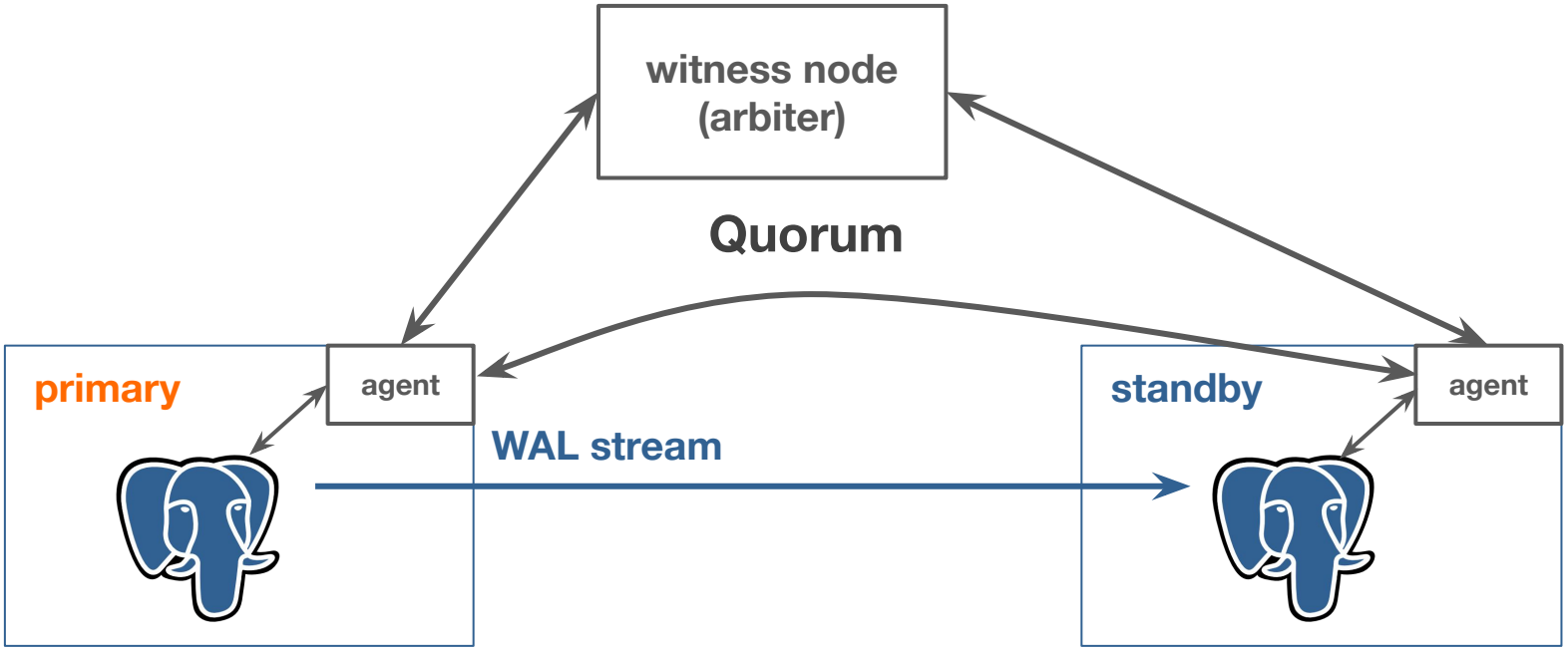
Local agents



Local agents



But how to do it right?



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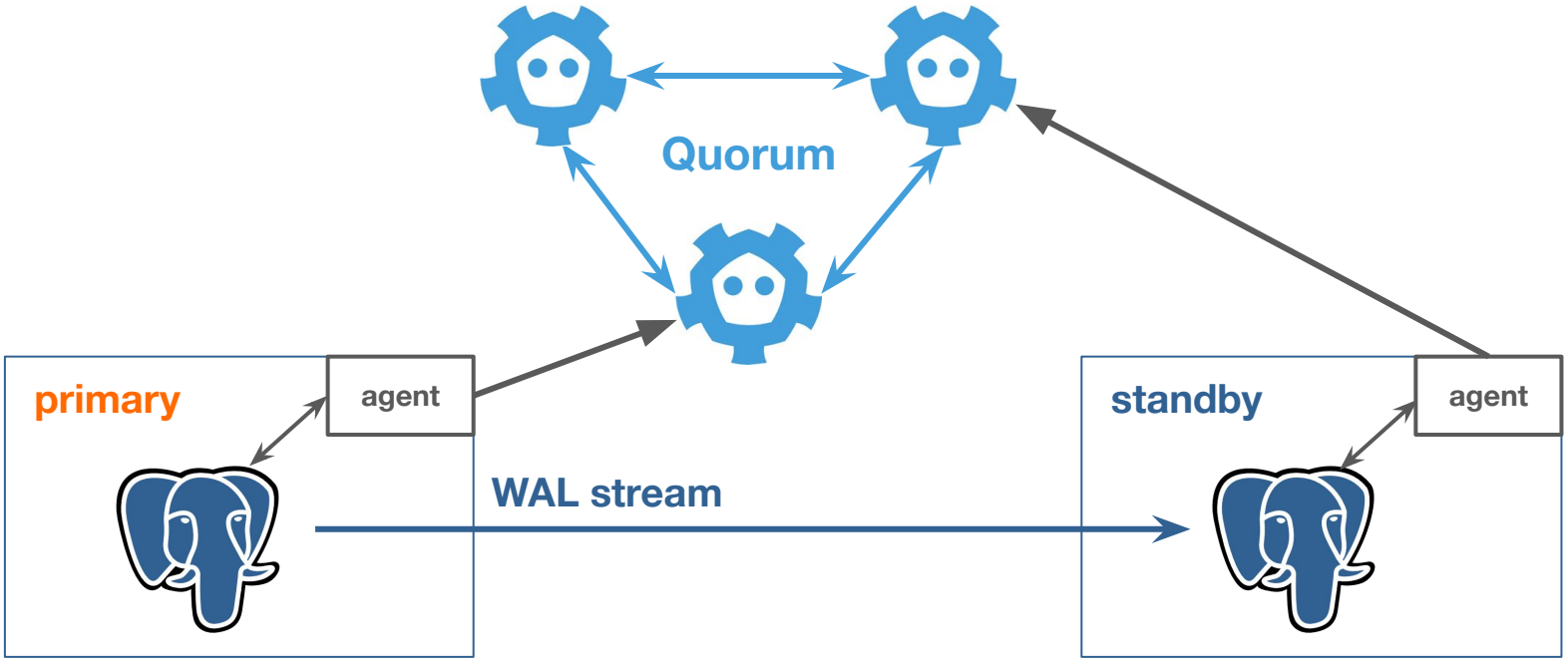

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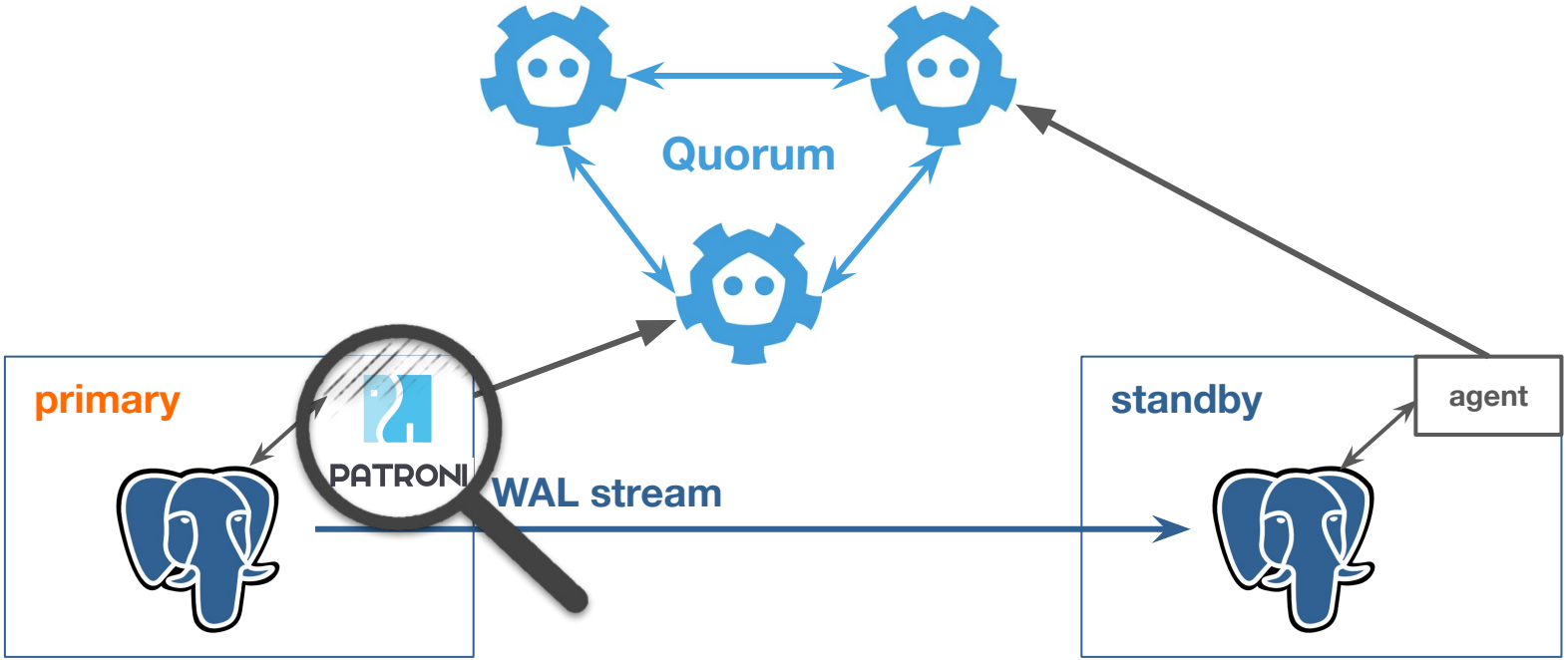
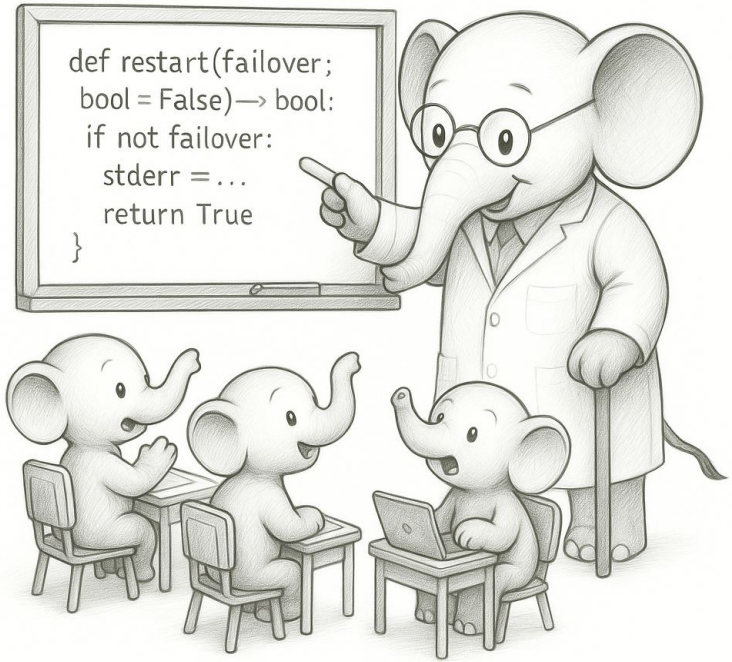


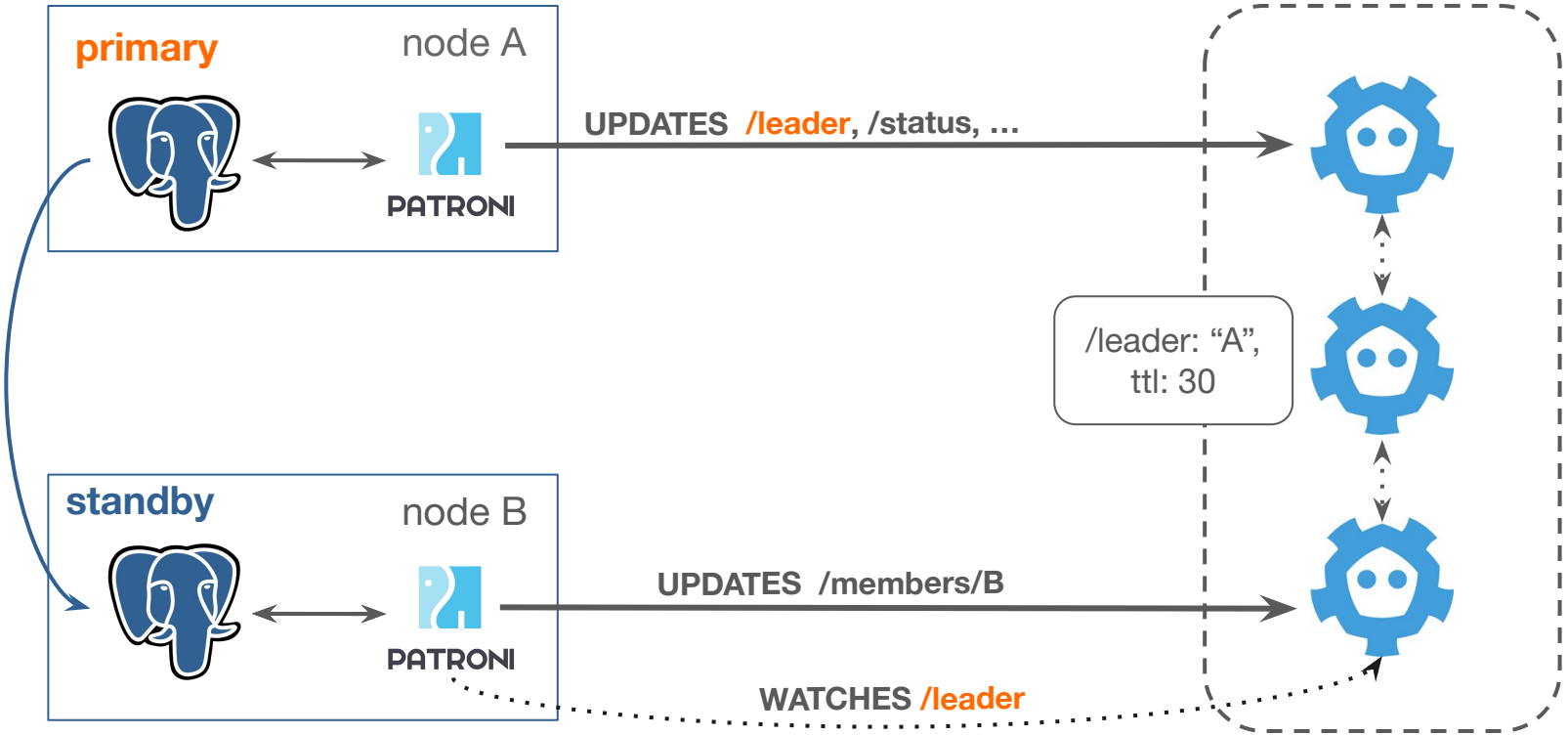
Patroni: how it works?



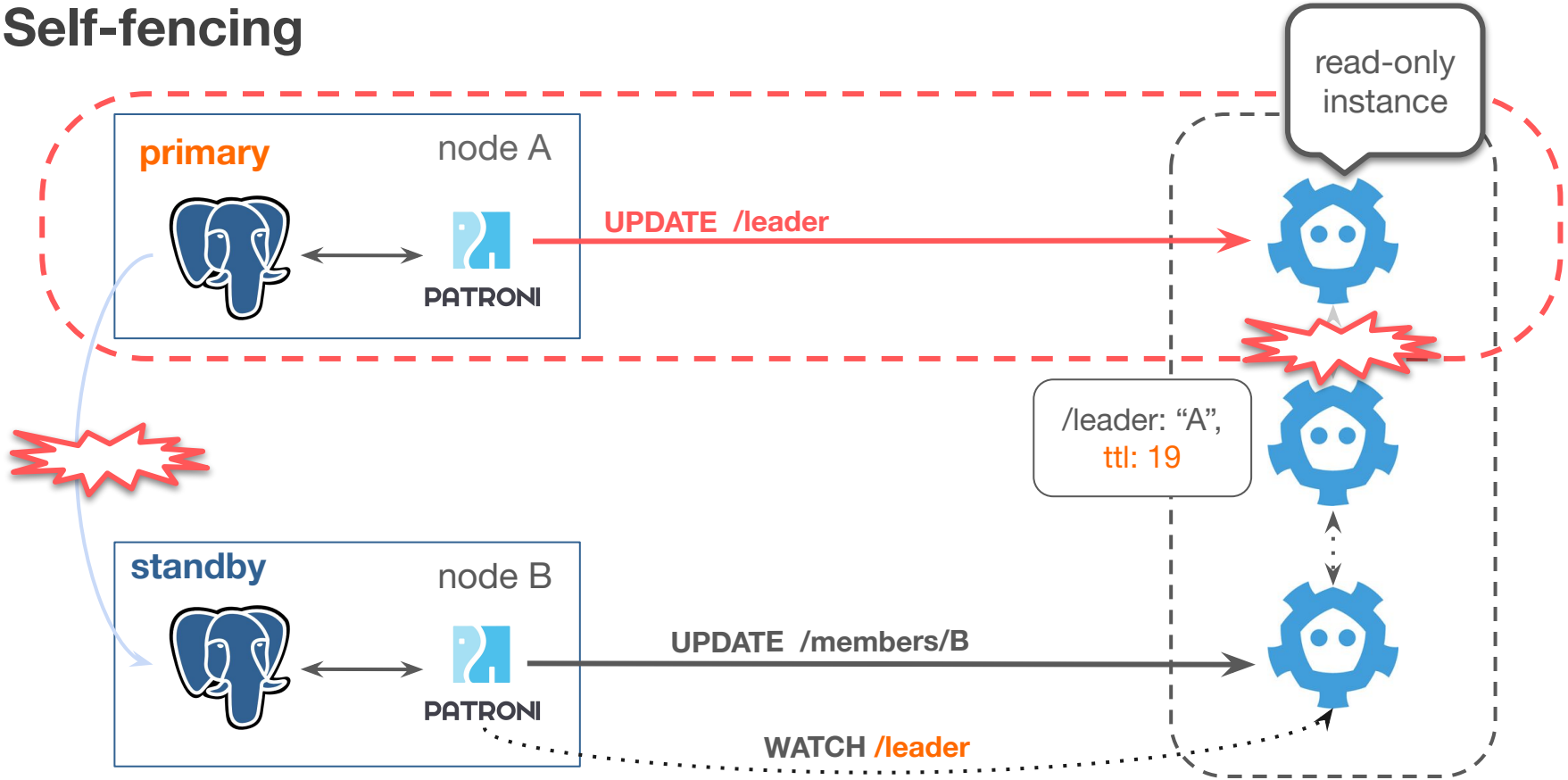
General idea

- State stored in Distributed Configuration Store (**DCS**)
  - Etcd, ZooKeeper, Consul, Kubernetes control-plane
- **Built-in distributed consensus** (RAFT, Zab)
- Key-value store
- **Atomic CAS** (compare-and-swap) **operations**
- **Lease/Session/TTL** to expire data
  - */leader, /members/**
- **Watches** for keys

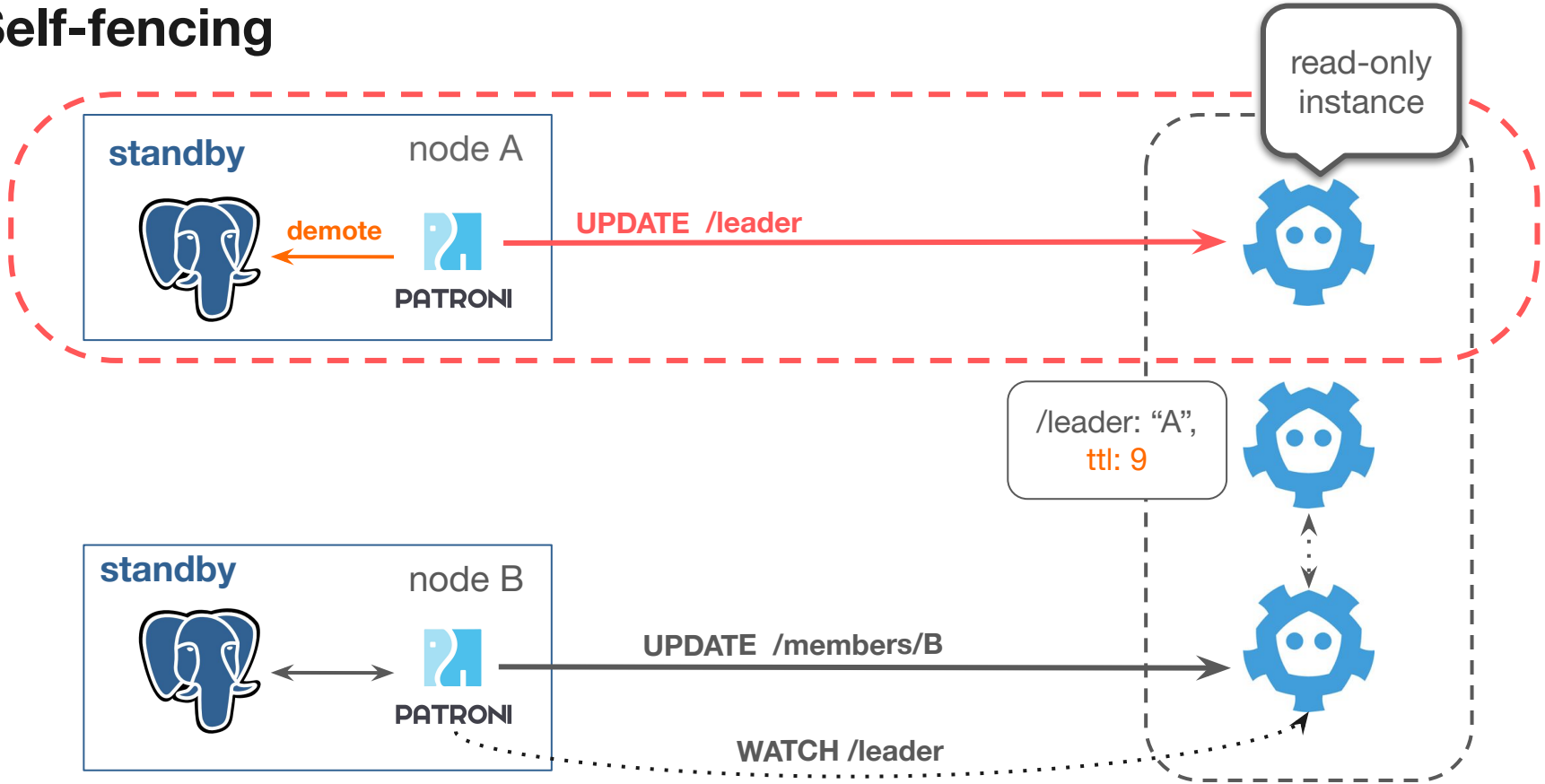
Patroni overview



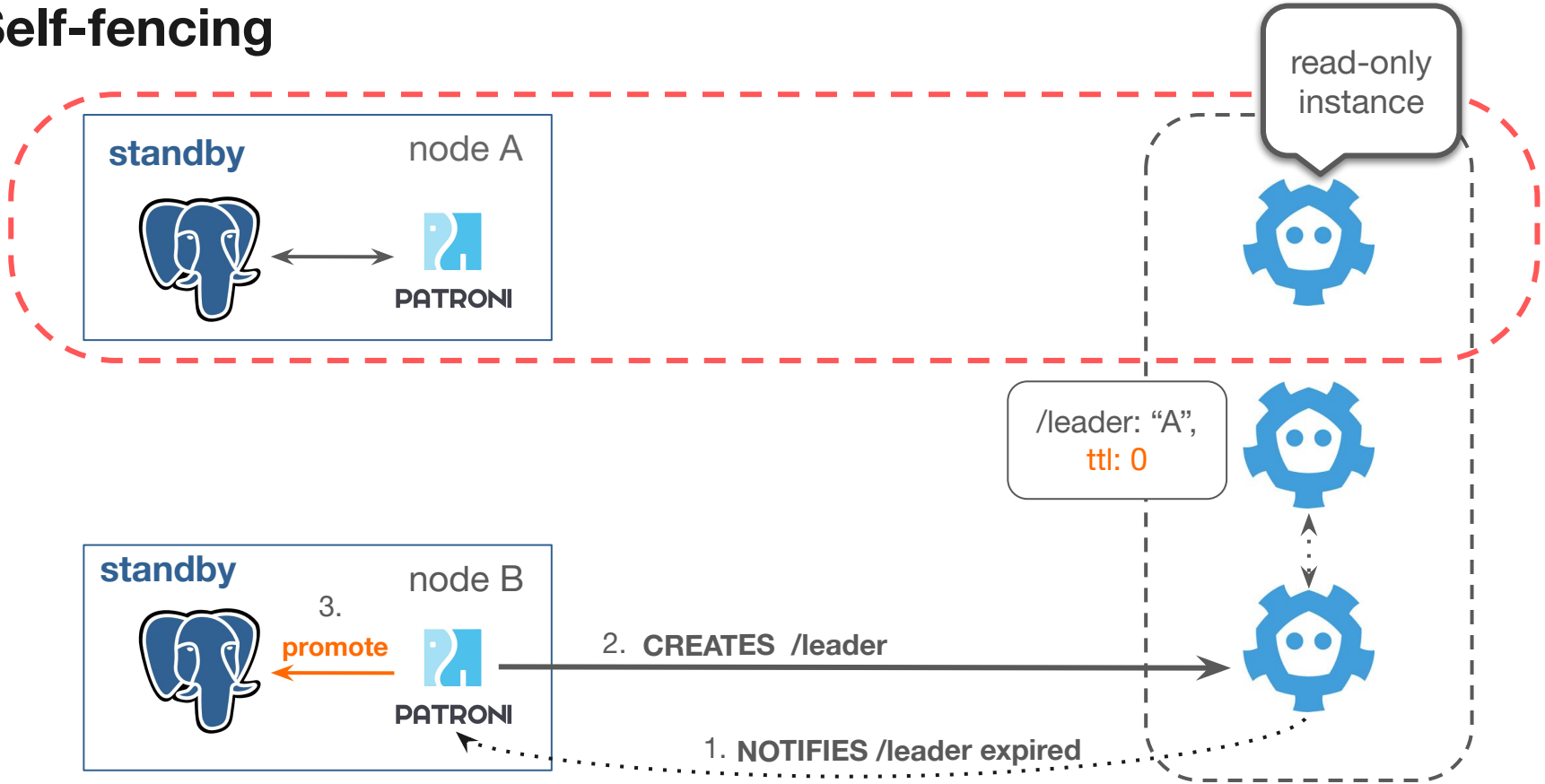
Self-fencing



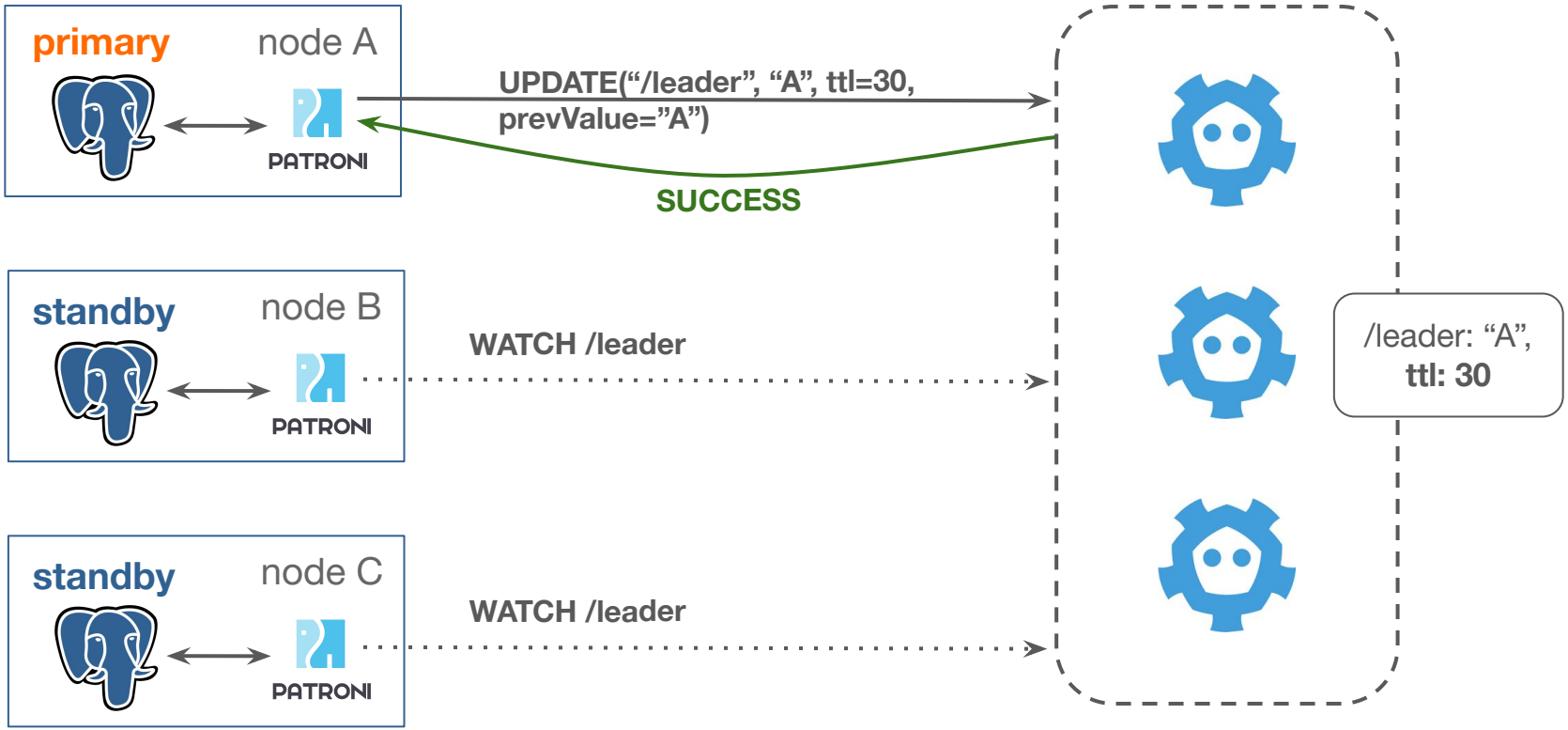
Self-fencing



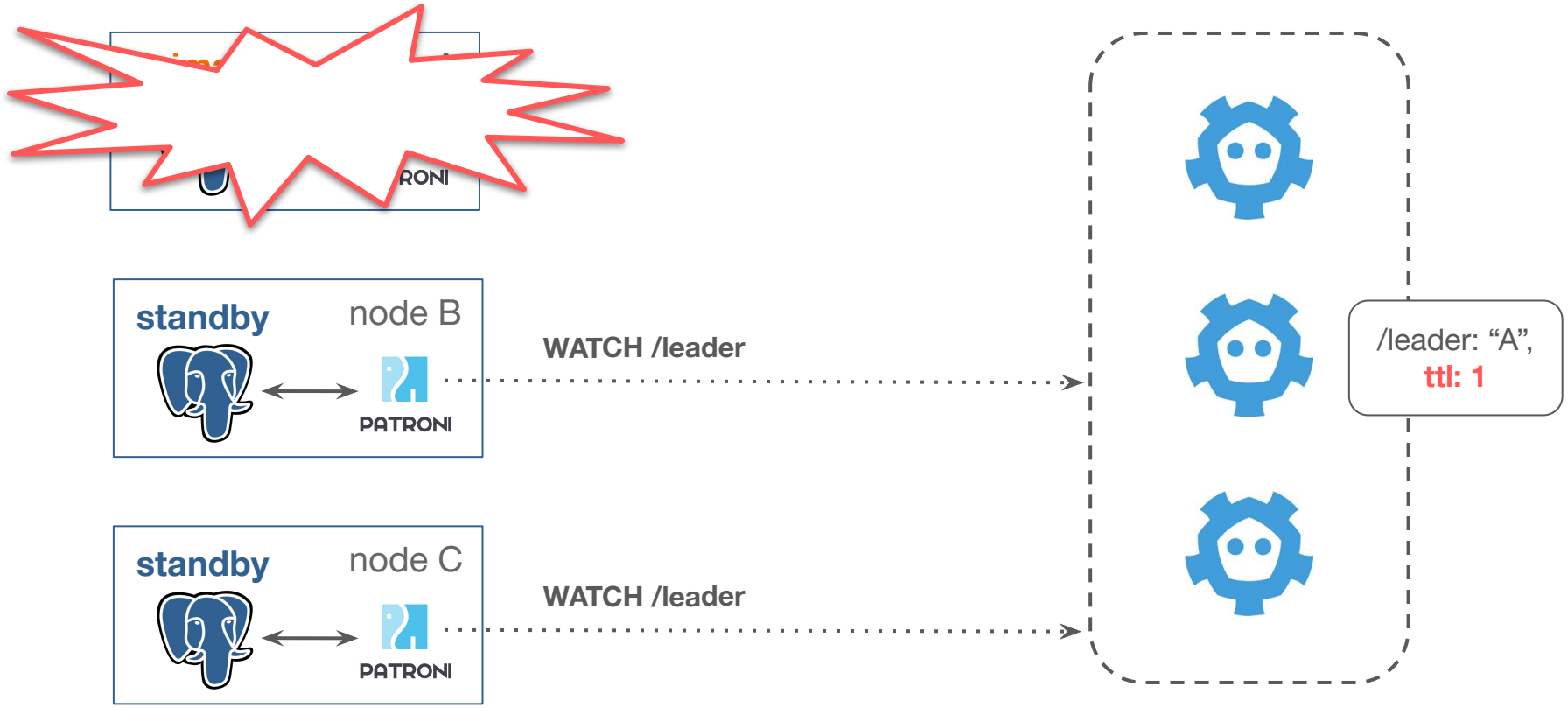
Self-fencing



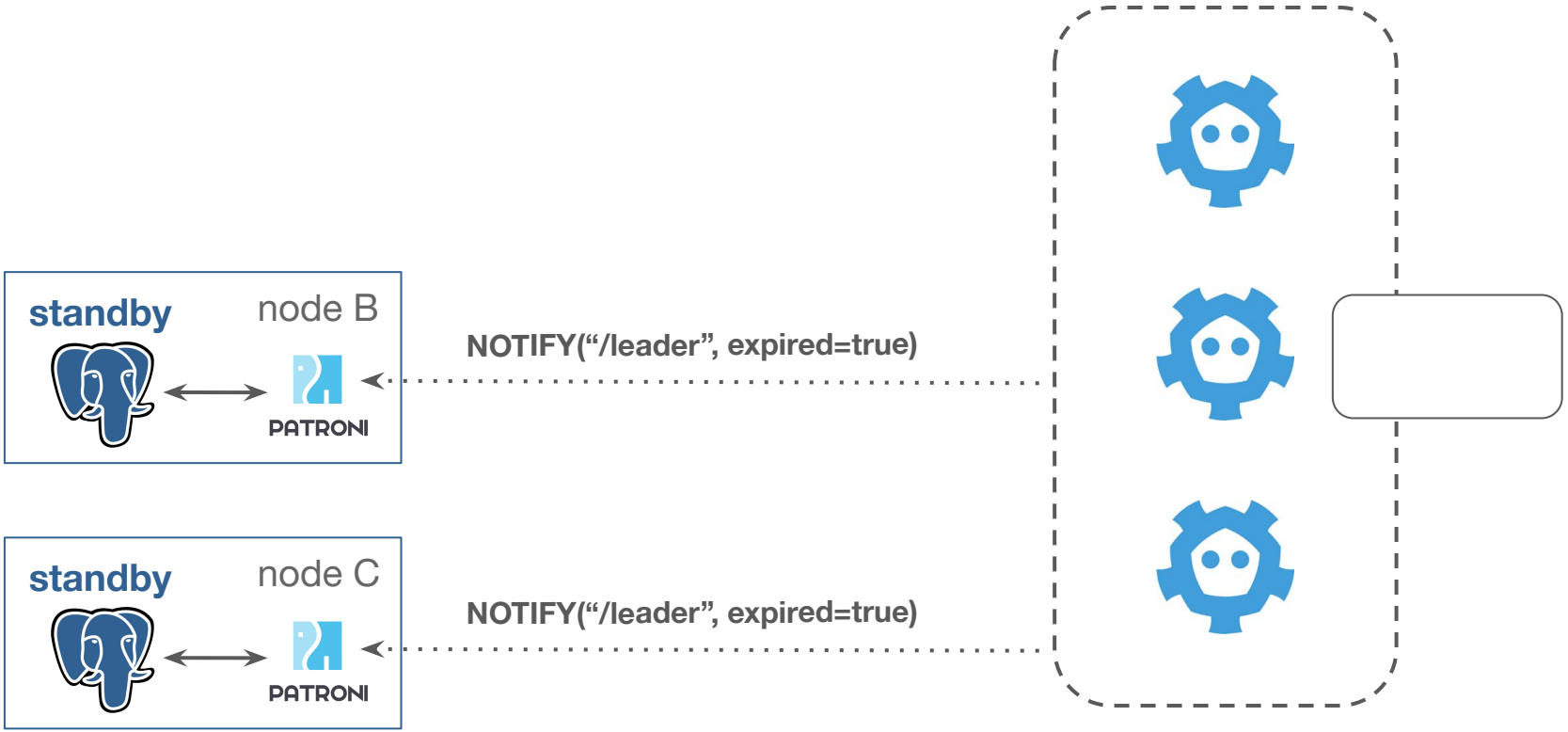
Leader race


primary
node A
PATRONI
UPDATE("/leader", "A", ttl=30, prevValue="A")
SUCCESS
standby
node B
PATRONI
WATCH /leader
standby
node C
PATRONI
WATCH /leader
/leader: "A",
ttl: 30

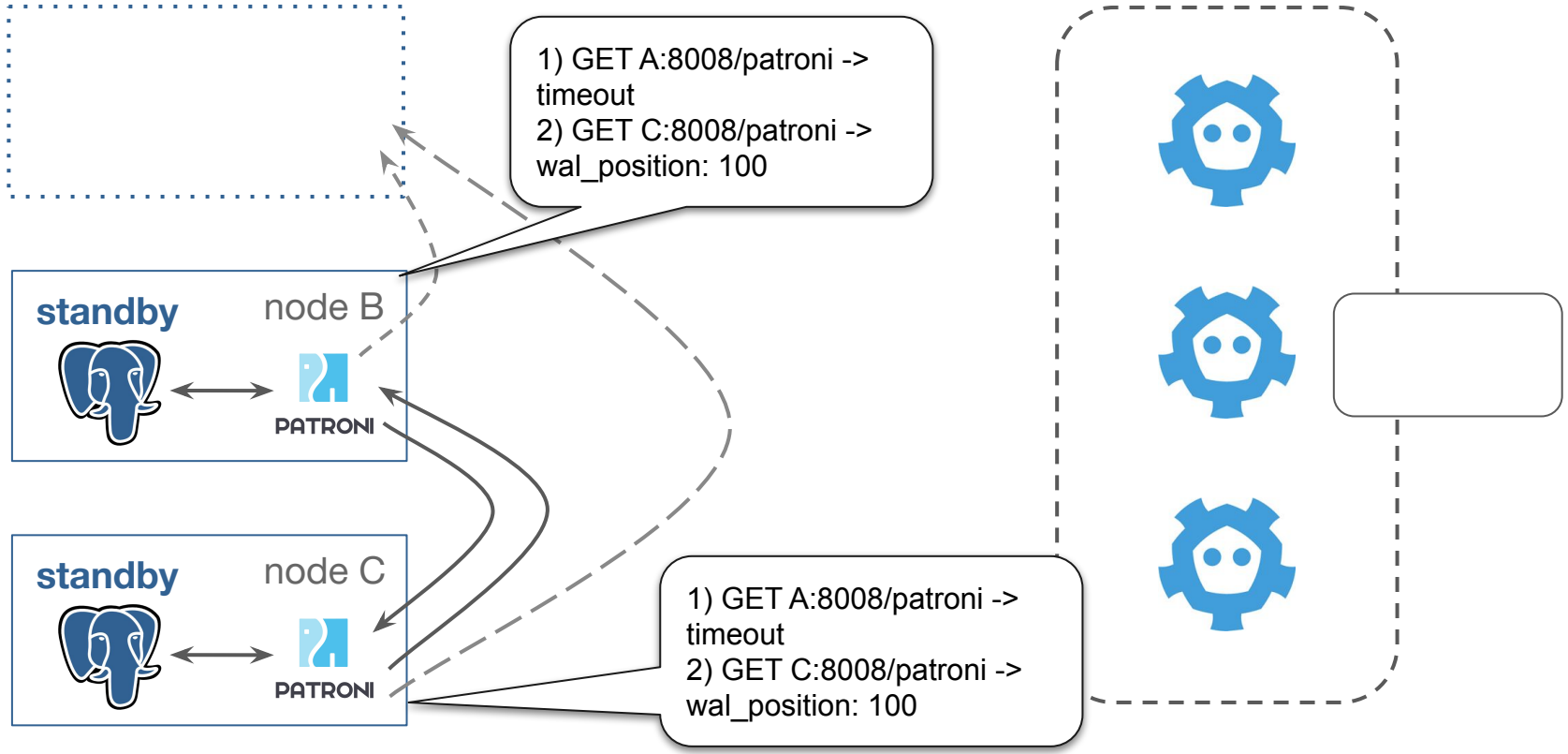
Leader race


standby
node B
PATRONI
WATCH /leader
/leader: “A”,
ttl: 1
standby
node C
PATRONI
WATCH /leader

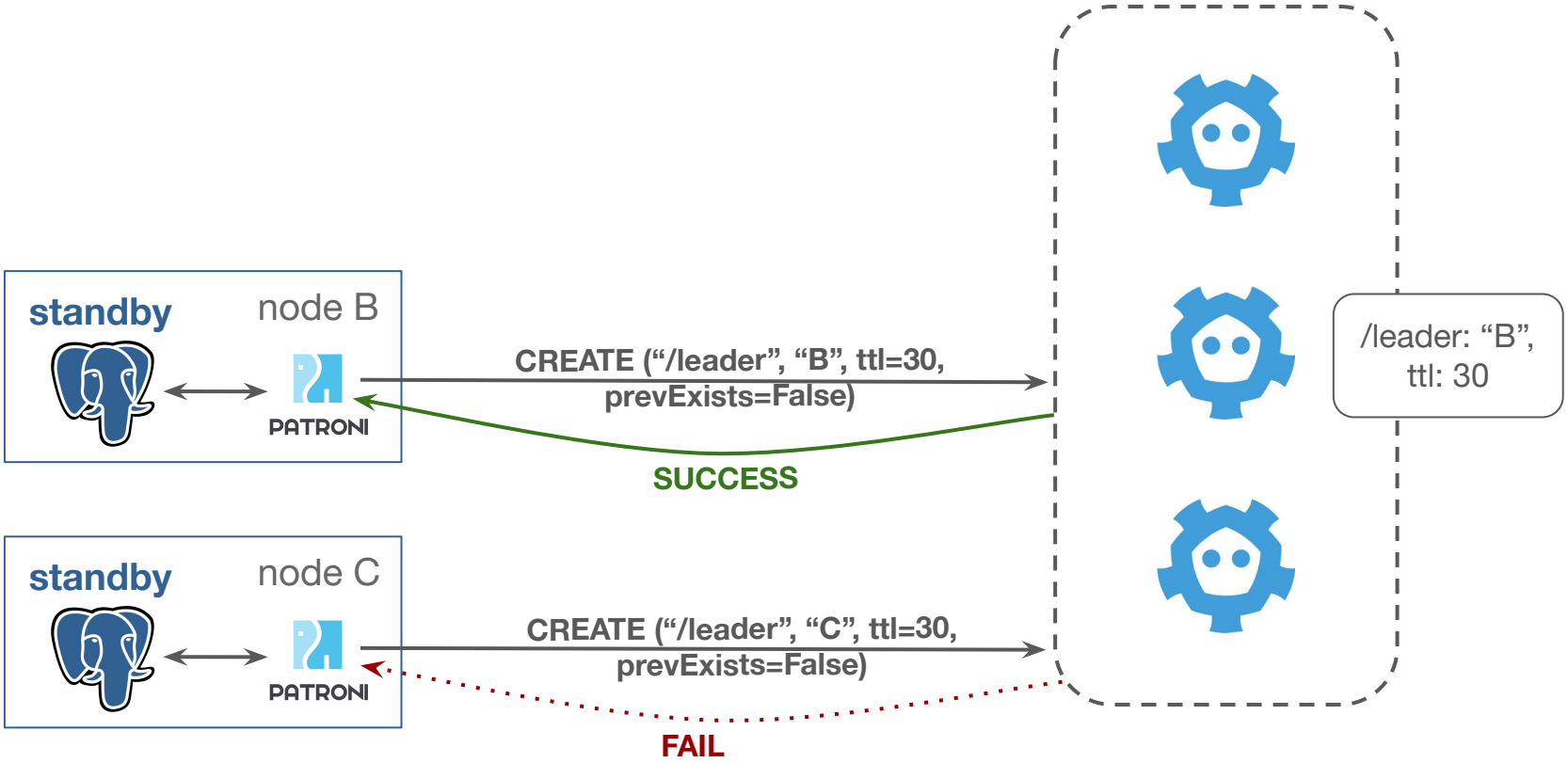
Leader race


standby
node B
PATRONI
NOTIFY(“/leader”, expired=true)
standby
node C
PATRONI
NOTIFY(“/leader”, expired=true)

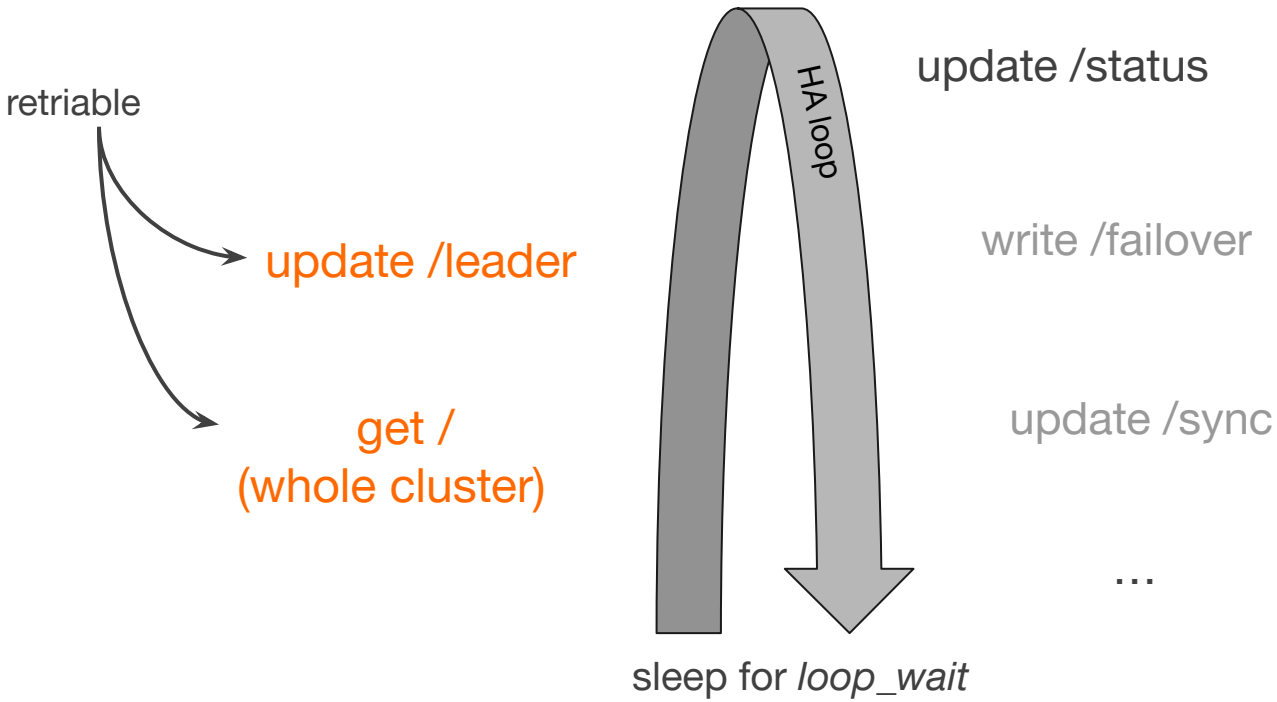
Leader race


1) GET A:8008/patroni ->
timeout
2) GET C:8008/patroni ->
wal_position: 100
standby
node B
PATRONI
standby
node C
PATRONI
1) GET A:8008/patroni ->
timeout
2) GET C:8008/patroni ->
wal_position: 100

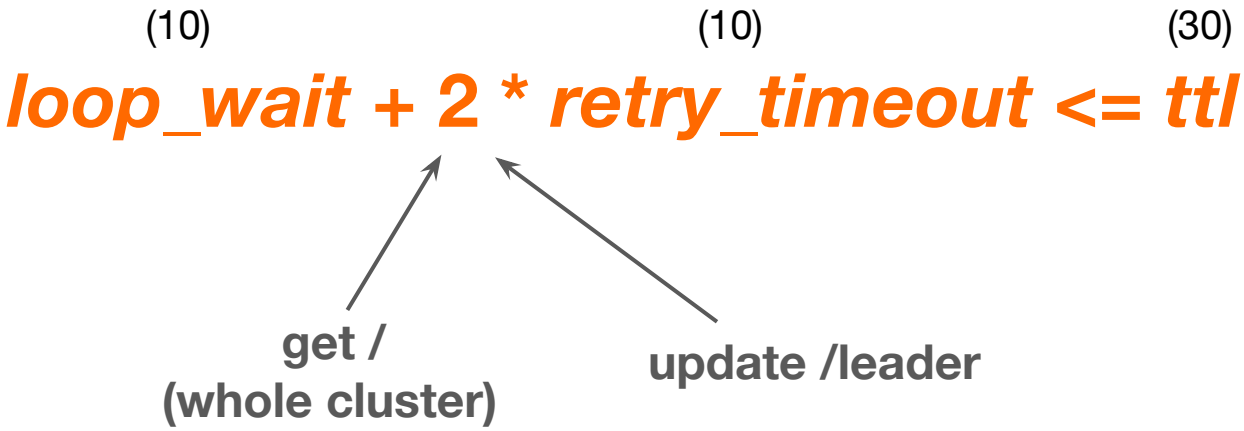
Leader race


standby
node B
PATRONI
CREATE (“/leader”, “B”, ttl=30, prevExists=False)
SUCCESS
/leader: “B”, ttl: 30
standby
node C
PATRONI
CREATE (“/leader”, “C”, ttl=30, prevExists=False)
FAIL

Communication with DCS – leader



ttl, loop_wait, retry_timeout



Data stored in DCS

```
$ etcdctl get --keys-only --prefix /service/demo

/service/demo/config                  /* global (dynamic) configuration */
/service/demo/initialize              /* cluster identifier */
/service/demo/leader                  /* who is the primary? */
/service/demo/members/patroni1
/service/demo/members/patroni2        /* discovery */
/service/demo/members/patroni3
/service/demo/status
/service/demo/history                 /* failover history */
/service/demo/failover                /* manual failover/switchover */
/service/demo/sync                    /* synchronous mode */
```

Data stored in DCS


```
$ patronictl list
+ Cluster: demo (7497665970948870167) --------+----+-----------+
| Member   | Host        | Role    | State     | TL | Lag in MB |
+----------+-------------+---------+-----------+----+-----------+
| patroni1 | 172.18.0.2  | Leader  | running   |  1 |           |
| patroni2 | 172.18.0.7  | Replica | streaming |  1 |         0 |
| patroni3 | 172.18.0.3  | Replica | streaming |  1 |         0 |
+----------+-------------+---------+-----------+----+-----------+
```

Data stored in DCS

```
$ etcdctl get --print-value-only --prefix /service/demo/leader

patroni1
```

```
$ etcdctl get --print-value-only --prefix /service/demo/initialize

7497665970948870167
```

Data stored in DCS

```
$ etcdctl get --keys-only --prefix /service/demo/members/patroni2

{
  "conn_url": "postgres://172.18.0.7:5432/postgres",
  "api_url": "http://172.18.0.7:8008/patroni",
  "state": "running",
  "role": "replica",
  "version": "4.0.5",
  "xlog_location": 67425896,  /* max(receive_lsn or 0, replay_lsn or 0) */
  "replication_state": "streaming",
  "timeline": 1
}
```

Data stored in DCS

```
$ etcdctl get --print-value-only --prefix /service/demo/status
{
  "optime": 67425896, /* pg_current_wal_flush_lsn() */
  "slots": {
    "patroni2": 67425896,
    "patroni3": 67425896,         /* members slots */
    "patroni1": 67425896,
    “my_logical_slot: 67425700    /* permanent slots */
  },
  "retain_slots": [
    "patroni1",
    "patroni2",             /* member_slots_ttl */
    "patroni3"
  ]
}
```

Data stored in DCS

```
$ etcdctl get --print-value-only --prefix /service/demo/config
{
  "loop_wait": 10,
  "ttl": 30,
  "retry_timeout": 10,
  "maximum_lag_on_failover": 1048576,
  "postgresql": {
    "parameters": {
      "max_connections": 100
    },                                        /* applied to all members (global) */
    "use_pg_rewind": true
  },
  "synchronous_mode": "quorum"
}
```

pg_controldata hack

- *max_connections*
  max_worker_processes
  max_wal_senders
  max_prepared_transactions
  max_locks_per_transaction

  PG restriction: value on primary ≤ value on standbys

- Patroni only allows it to be set globally

pg_controldata hack

- New cluster from a backup/standby cluster, *max_connections = 80*

- ```
  $ pg_controldata $PGDATA
  ...
  max_connections setting:              100
  ...
  ```

- start fails

  ```
  WARNING:  hot standby is not possible because of
  insufficient parameter settings
  DETAIL:  max_connections = 80 is a lower setting than on
  the primary server, where its value was 100.
  ```
  ```

pg_controldata hack

- => start Postgres with the value from pg_crontroldata (100) and inform users:

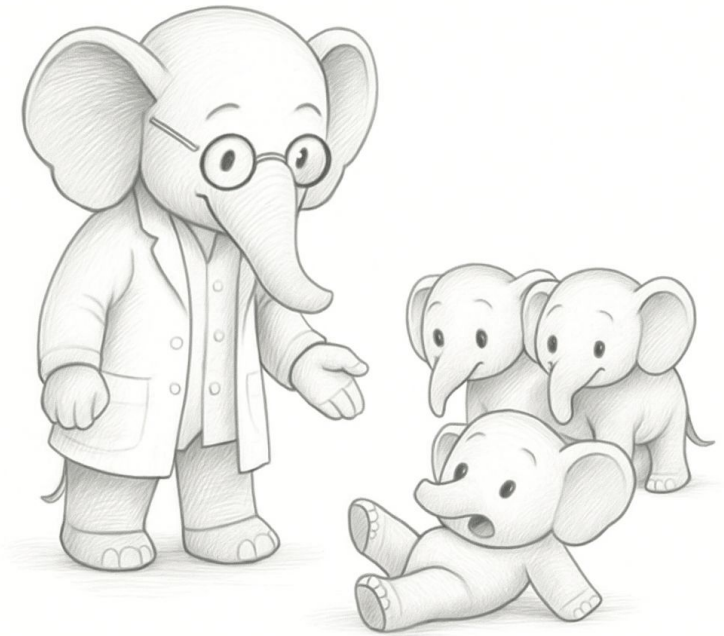
```
INFO: max_connections value in pg_controldata: 100, in the global configuration:
80. pg_controldata value will be used. Setting 'Pending restart' flag
```

- $ patronictl list

```
+ Cluster: my-standby (7387342692208361967) -+--------------------+----+-----------+-----------------+--------------------------+
| Member       | Host       | Role           | State              | TL | Lag in MB | Pending restart | Pending restart reason   |
+--------------+------------+----------------+--------------------+----+-----------+-----------------+--------------------------+
| my-standby-0 | 10.2.26.68 | Standby Leader | in archive recovery | 46 |           | *               | max_connections: 300->100 |
+--------------+------------+----------------+--------------------+----+-----------+-----------------+--------------------------+
```

```
+-----------------+---------------------------+
| Pending restart | Pending restart reason    |
+-----------------+---------------------------+
| *               | max_connections: 300->100 |
+-----------------+---------------------------+
```

What else?



Notable features

- **Standby cluster** – running cascading replication to a remote datacenter (region) [docs]
- **Synchronous mode** – manage "*synchronous_standby_names*" to enable synchronous replication whenever there are healthy standbys available [docs]
- **Quorum-based failover** – reduce latencies, compensating higher latency of replicating to one synchronous standby by other standbys [docs]
- **DCS failsafe mode** – survive temporary DCS outages without primary demotion [docs] [slides]
- **Citus support** [docs] [article]

More links

- Patroni – Postgres.FM podcast
- Patroni tutorial (A bit outdated but still good)
- Step-by-step Patroni cooking guide talk slides

- Official documentation (Read the docs! No, seriously…)
- Changelog (new features and bugfixes)
- Patroni channel in the PostgreSQL Slack

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Thank you!