Patroni: PostgreSQL High Availability made easy

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About us

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Zalando

- ~ 3 bn EUR revenue
- ~ 160 m visits/month
- 65% visits from mobile devices
- > 170 databases
- > 1300 tech employees
- We are hiring!

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Radical agility and autonomous teams

Organizations which design systems ... are constrained to produce designs which are copies of the communication structures of these organizations

Conway's Law

Cloud databases

- Rapid deployments
- Commodity hardware (cattle vs pets)
- Standard configuration and automatic tuning

Existing automatic failover solutions

- Promote a replica when the master is not responding
  - Split brain/potentially many masters
- Use one monitor node to make decisions
  - Monitor node is a single point of failure
  - Former master needs to be killed (STONITH)
- Use multiple monitor nodes
  - Distributed consistency problem

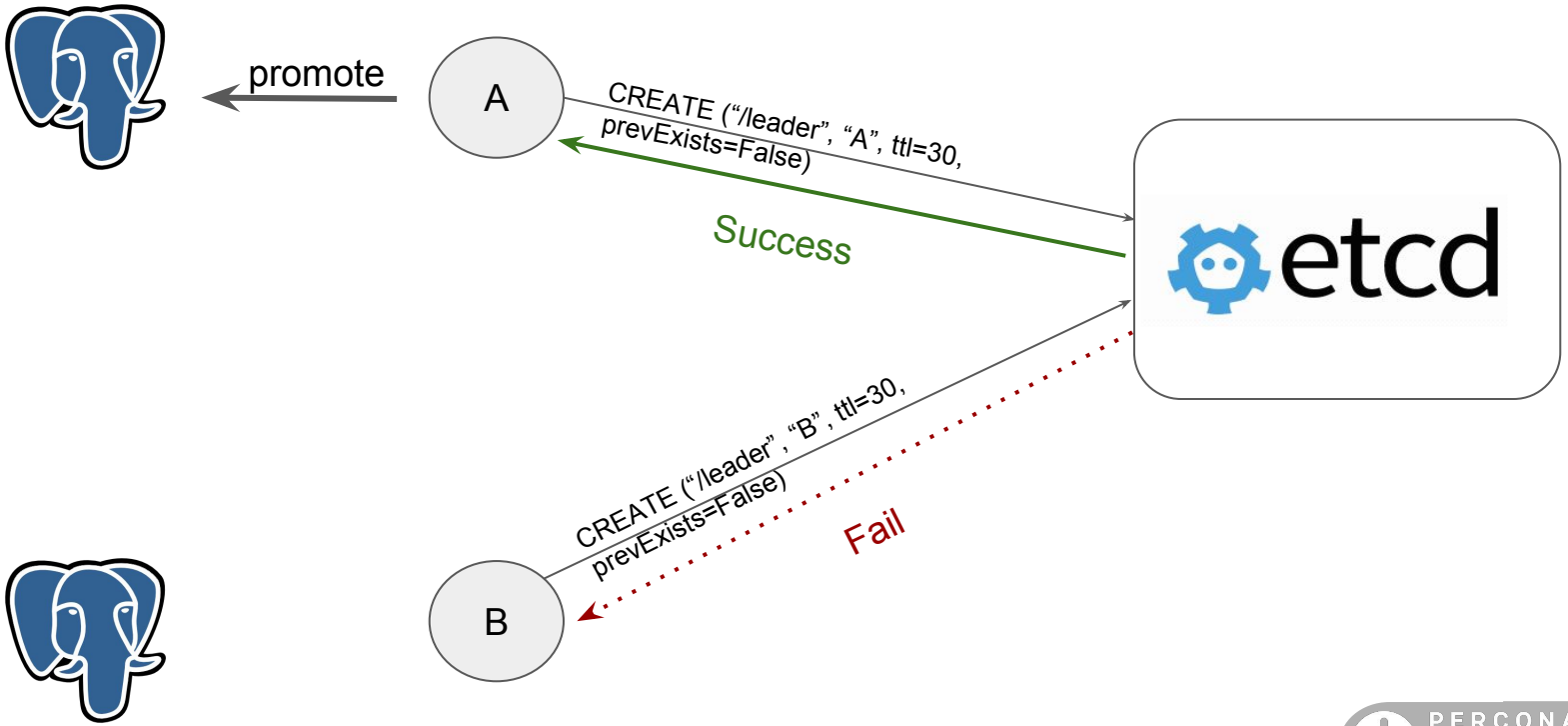
Distributed consistency problem

https://www.flickr.com/photos/kevandotorg

Patroni approach: use DCS

- Distributed configuration system (DCS): Etcd, Zookeeper or Consul
- Built-in distributed consensus (RAFT, Zab)
- Session/TTL to expire data (i.e. master key)
- Key-value storage for cluster information
- Atomic operations (CAS)
- Watches for important keys

Leader race


promote
A
CREATE ("/leader", "A", ttl=30, prevExists=False)
Success
etcd
CREATE ("/leader", "B", ttl=30, prevExists=False)
Fail
B

- /service/cluster/
  - config
  - initialize
  - members/
    - dbnode1
    - dbnode2
  - leader
  - optime/
    - leader
  - failover

Keys that never expire

- initialize
  - "key": "/service/testcluster/initialize",

    "value": "6303731710761975832",
- leader/optime
  - "key": "/service/testcluster/optime/leader",

    "value": "67393608",
- config
  - "key": "/service/testcluster/config",

    "value": "{\"postgresql\":{\"parameters\":{\"synchronous_standby_names\":\"*\"}}}",

Keys with TTL

- leader
  - "key": "/service/testcluster/leader",

    "value": "dbnode2",

    "ttl": 22
- members
  - "key": "/service/testcluster/members/dbnode2",

    “value": "{\"role\":\"master\",\"state\":\"running\",

    \"conn_url\":\"postgres://172.17.0.3:5432/postgres\",

    \"api_url\":\"http://172.17.0.3:8008/patroni\",\"xlog_location\":67393608}",

    "ttl": 22

Bootstrapping of a new cluster

- Initialization race
- initdb by a winner of an initialization race
- Waiting for the leader key by the rest of the nodes
- Bootstrapping of non-leader nodes (pg_basebackup)

Event loop of a running cluster (master)

- Update the leader key or demote if update failed
- Write the leader/optime (xlog position)
- Update the member key
- Add/delete replication slots for other members

Event loop of a running cluster (replica)

- Update the member key
- Check that the cluster has a leader
  - Check recovery.conf points to the correct leader
  - Join the leader race if a leader is not present
- Add/delete replication slots for cascading replicas

Leader race

- Check whether the member is the healthiest
  - Evaluate its xlog position against all other members
- Try to acquire the leader lock
- Promote itself to become a master after acquiring the lock

LIVE DEMO

Patroni features

- Manual and Scheduled Failover
- Attach the old master with pg_rewind
- Customizable replica creation methods
- Dynamic configuration
- Pause (maintenance) mode
- patronictl

Dynamic configuration

- Ensure identical configuration of the following parameters on all members:
  - ttl, loop_wait, retry_timeout, maximum_lag_on_failover
  - wal_level, hot_standby
  - max_connections, max_prepared_transactions, max_locks_per_transaction, max_worker_processes, track_commit_timestamp, wal_log_hints
  - wal_keep_segments, max_replication_slots
- Change Patroni/PostgreSQL configuration dynamically
- Inform the user that PostgreSQL needs to be restarted (pending_restart flag)
- Store parameters in DCS and apply to all members

Building HA PostgreSQL based on Patroni

- Client traffic routing
  - patroni callbacks
  - conf.d + haproxy, pgbouncer
- Backup and recovery
  - WAL-E, barman
- Monitoring
  - Nagios, zabbix, zmon

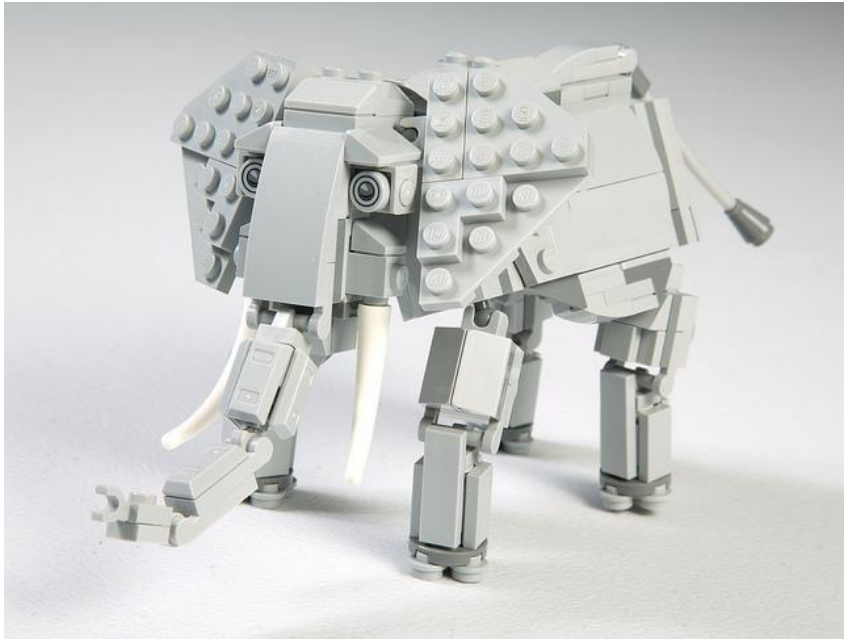
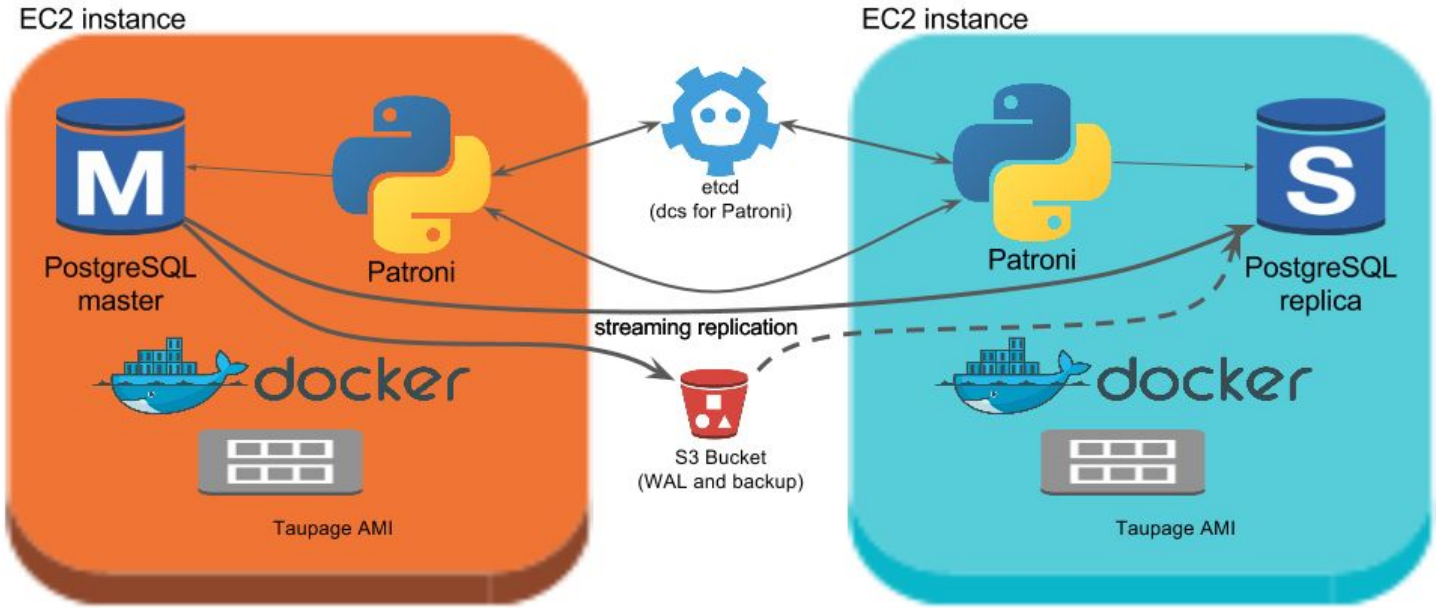
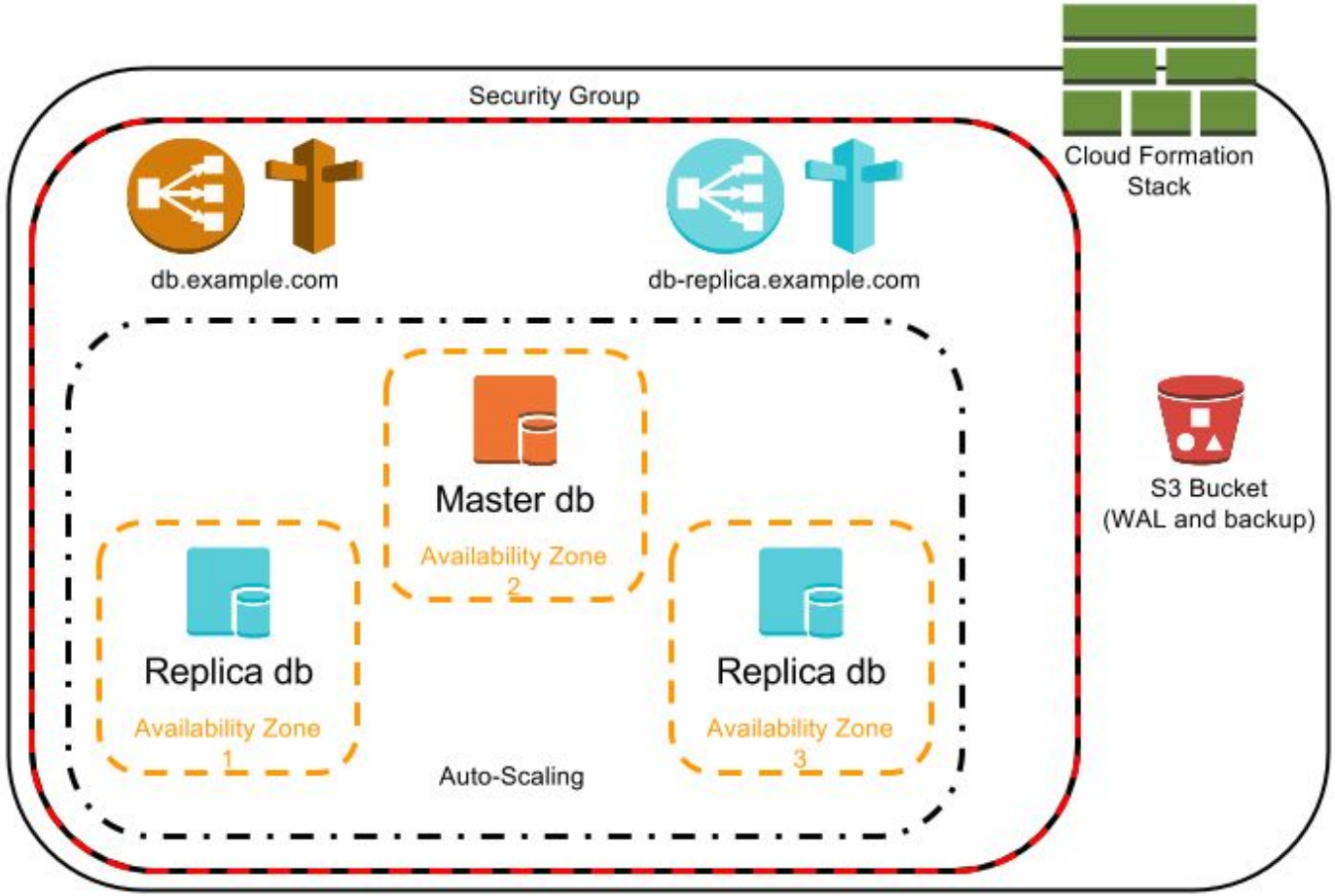


Image by flickr user https://www.flickr.com/photos/brickset/

Spilo: Patroni + Docker + WAL-E + AWS/K8S




Security Group
Cloud Formation Stack
db.example.com
db-replica.example.com
Master db
Availability Zone 2
S3 Bucket (WAL and backup)
Replica db
Availability Zone 1
Replica db
Availability Zone 3
Auto-Scaling

When should the master demote itself?

- Chances of data loss vs write availability
- Avoiding too many master switches (retry_timeout, loop_wait, ttl)
- 2 x retry_timeout + loop_wait < ttl
- Zookeeper and Consul session duration quirks

Choosing a new master

- Reliability/performance of the host or connection
  - nofailover tag
- XLOG position
  - highest xlog position = the best candidate
  - xlog > leader/optime - maximum_lag_on_failover
    - maximum_lag_on_failover > size of WAL segment (16MB) for disaster recovery

Attaching the old master back as a replica

- Diverged timelines after the former master crash
- pg_rewind
  - use_pg_rewind
  - remove_data_directory_on_rewind_failure

Thank you!

https://github.com/zalando/patroni

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Useful links

- Spilo: https://github.com/zalando/spilo
- Confd: http://www.confd.io
- Etcd: https://github.com/coreos/etcd
- RAFT: http://thesecretlivesofdata.com/raft/

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