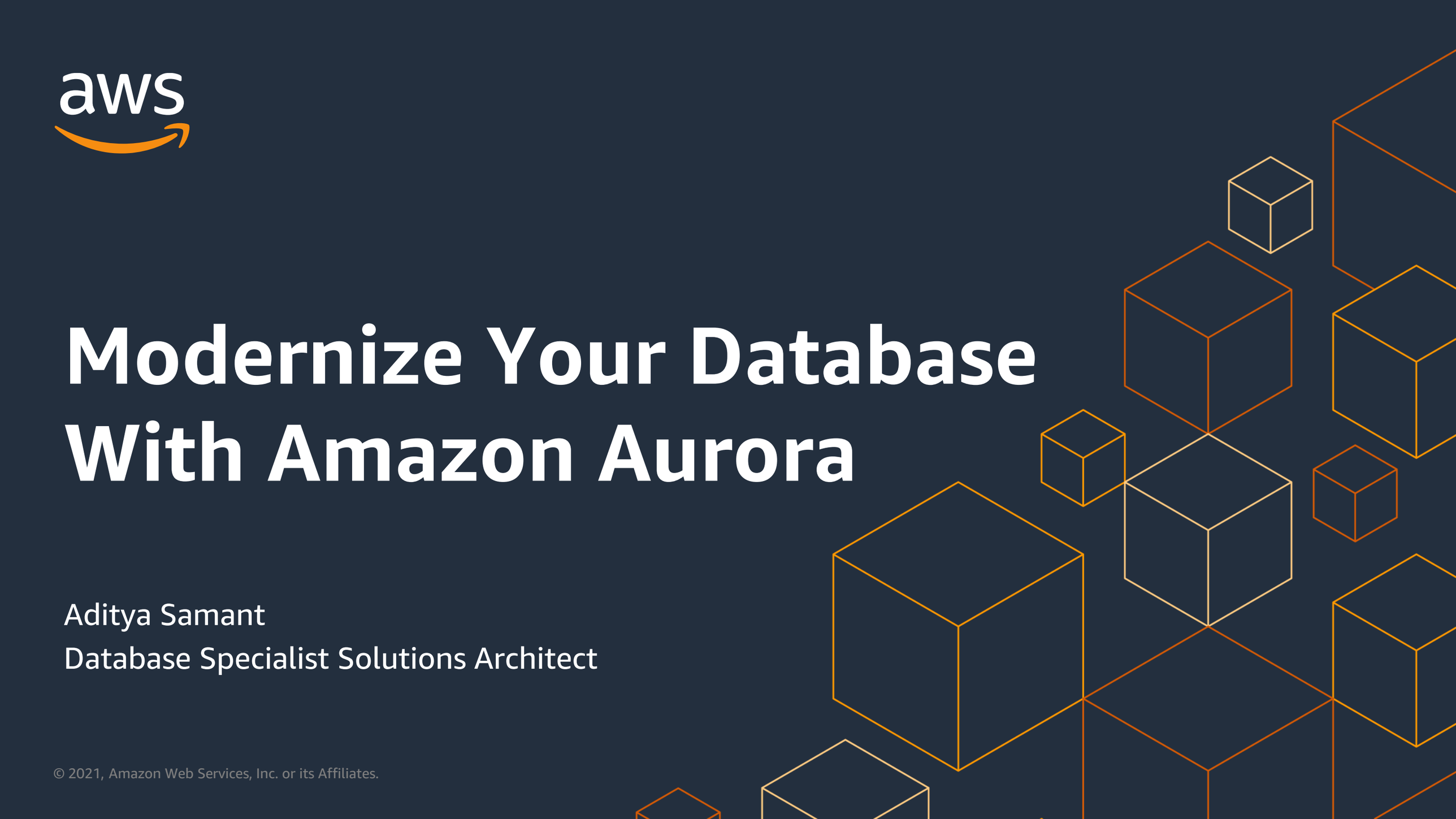


Modernize Your Database With Amazon Aurora

Aditya Samant
Database Specialist Solutions Architect

Agenda

- What is Amazon Aurora?
- Distributed Storage fundamentals
- Aurora Key Innovations
- Monitoring performance
- Minimizing Disruptions
- What’s new?
- What’s coming?
- Summary

aws

A cost-effective, enterprise database…

Amazon Aurora - enterprise database
at open source price, delivered as a managed service

Speed and **availability** of high-end commercial databases

Simplicity and **cost-effectiveness** of open source databases

Drop-in **compatibility** with MySQL and PostgreSQL

Simple **pay as you go** pricing

aws

Re-imagining databases for the cloud…

1. Scale-out, distributed, design
2. Service-oriented architecture using AWS services
3. Fully managed service, automating administrative tasks

aws

Aurora Customer Adoption

Fastest growing service in AWS history

Aurora is used by ¾ of the top 100 AWS customers

aws

Amazon Aurora Fundamentals

Storage System and Cluster Architecture

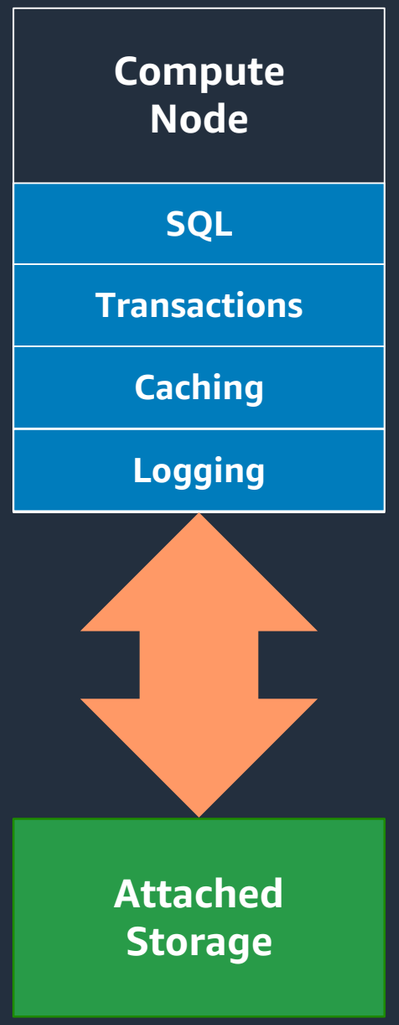
aws

Traditional Database Architecture

Databases are all about I/O…

Design principles over the last 40+ years:

- **Increase** I/O bandwidth
- **Decrease** number of I/Os consumed



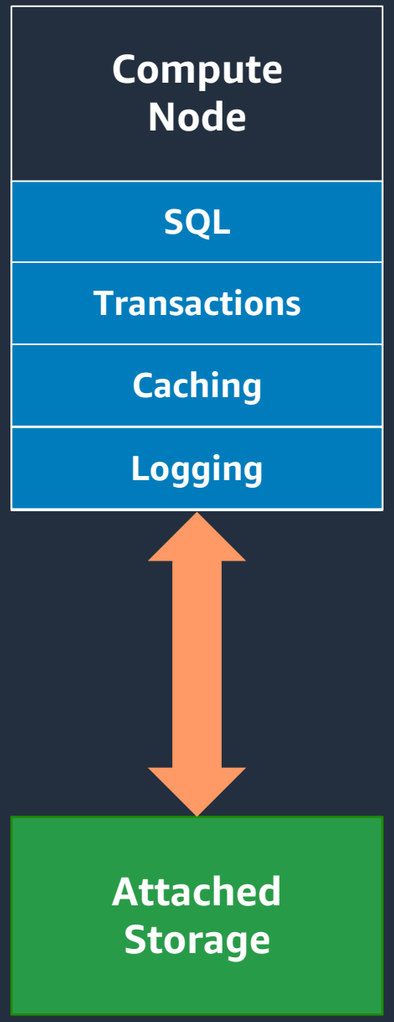
aws

Traditional Database Architecture… in the Cloud

Compute and storage have different lifetimes

- Instances fail and may be replaced
- Instances are shut down
- Instances are scaled up/down
- Instances are added to cluster to scale out

Compute and storage are best **decoupled** for scalability, availability and durability



aws

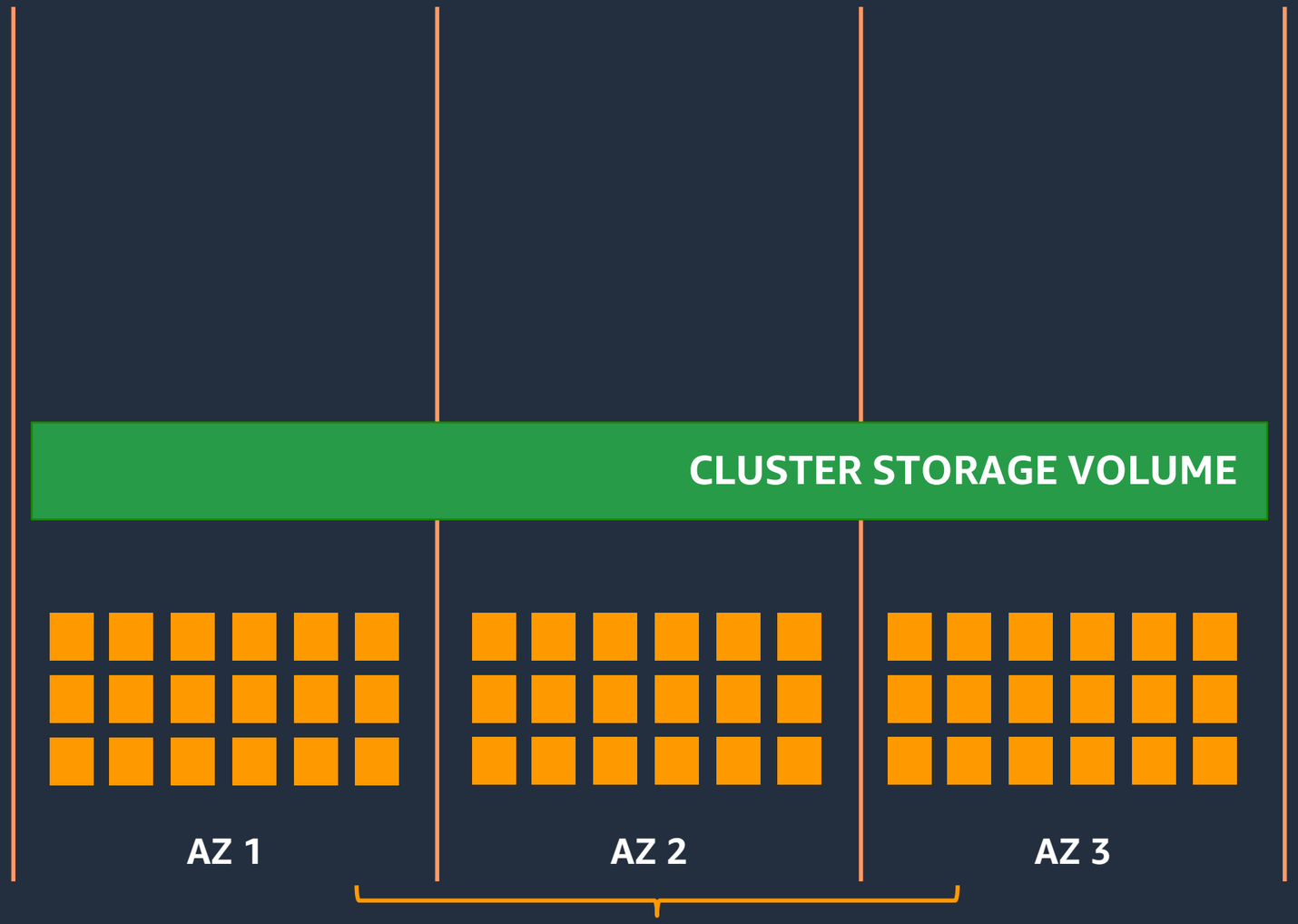
Scale-out, distributed, multi-tenant storage architecture

Purpose-built log-structured distributed storage

Storage volume is striped across hundreds of storage nodes

Storage nodes with locally attached SSDs

Continuous backup to Amazon S3.



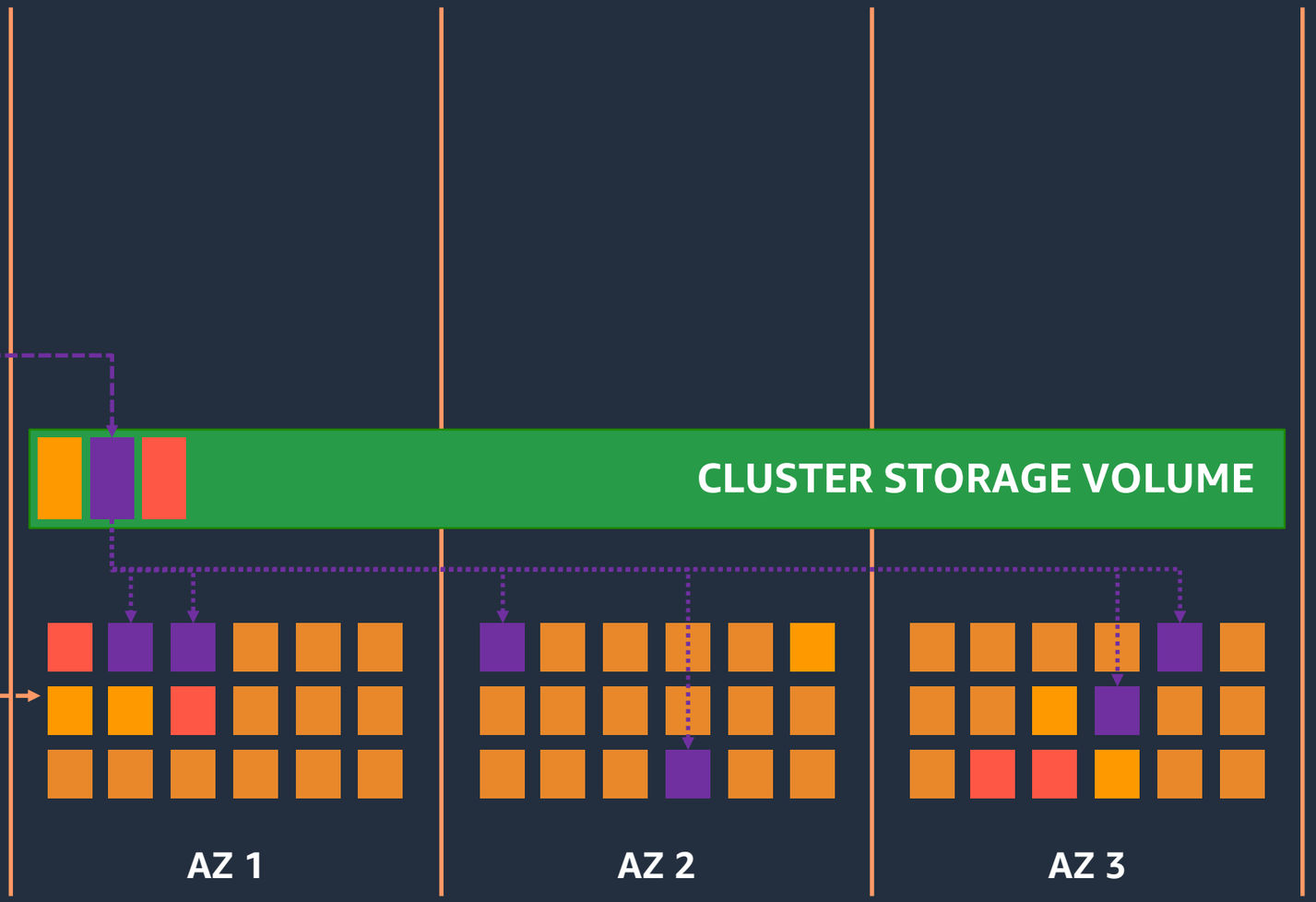
Scale-out, distributed, multi-tenant storage architecture

Six copies of data, two in each Availability Zone to protect against AZ+1 failure modes

Storage volume segmented in 10 GB **protection groups (PG)**

Each PG contains six 10 GB **segments**, copies of the same data on different storage nodes, two in each AZ.

Storage volume grows automatically by adding PGs, up to 128 TB



aws

High durability storage system, tolerant of AZ+1 failures

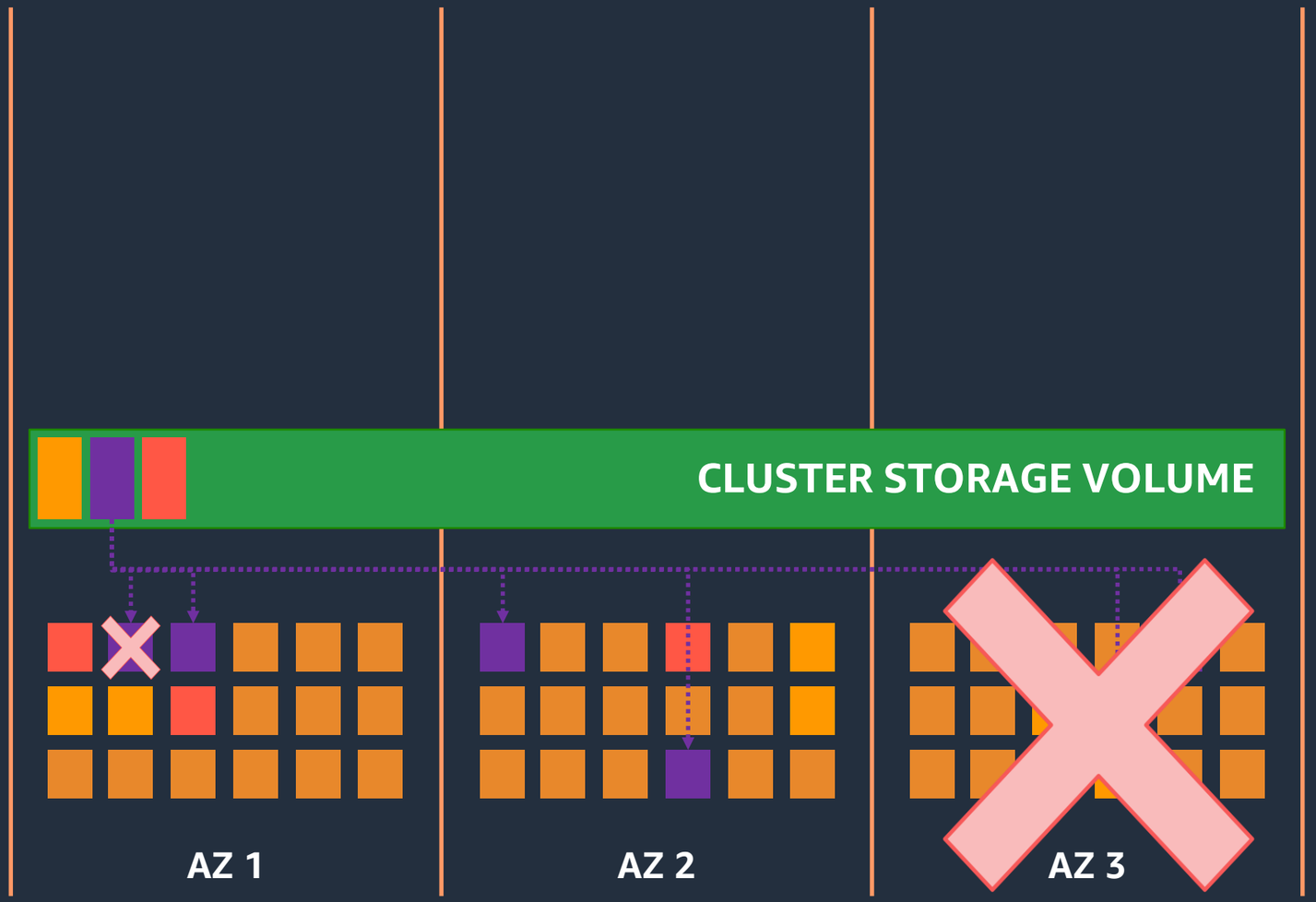
Using quorum model for writes and reads:

- 4 out of 6 for writes
- 3 out of 6 for reads (recovery)

Maintains write capability if an AZ fails, maintains read capability if AZ + 1 storage node fails.

Self-healing architecture rebalances hot storage nodes, rebuilds segments from failed hardware

Peer to peer “gossip protocol” is used for repairs



aws

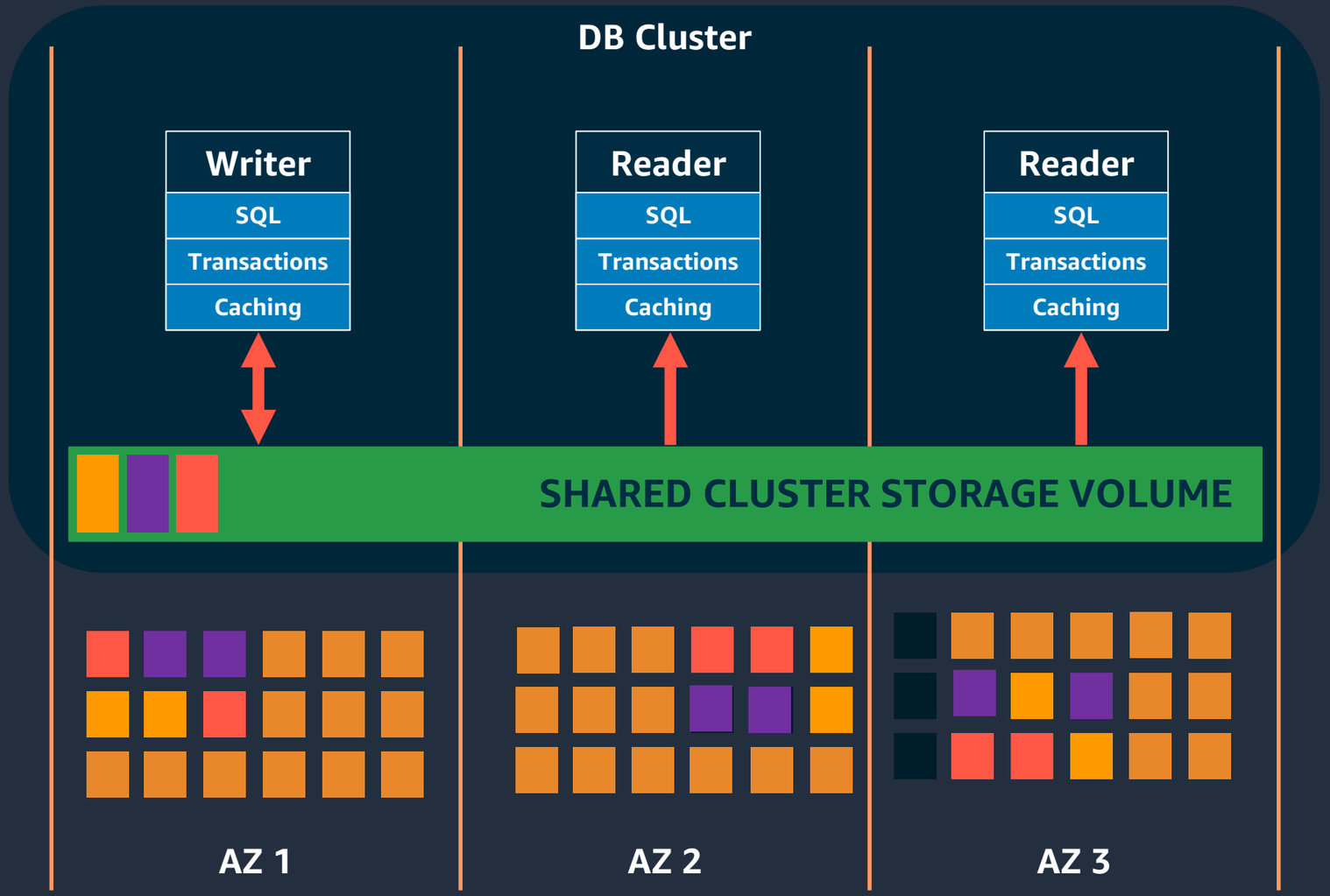
Amazon Aurora cluster topology

Up to 16 DB instances/nodes in a **regional** cluster, spanning multiple AZs

One (first) is always the writer node.

Storage volume shared with readers. Readers open volume in read only mode (MySQL: **innodb_read_only = 1** PostgreSQL: **transaction_read_only=on**).

Low reader lag < ~20ms



aws

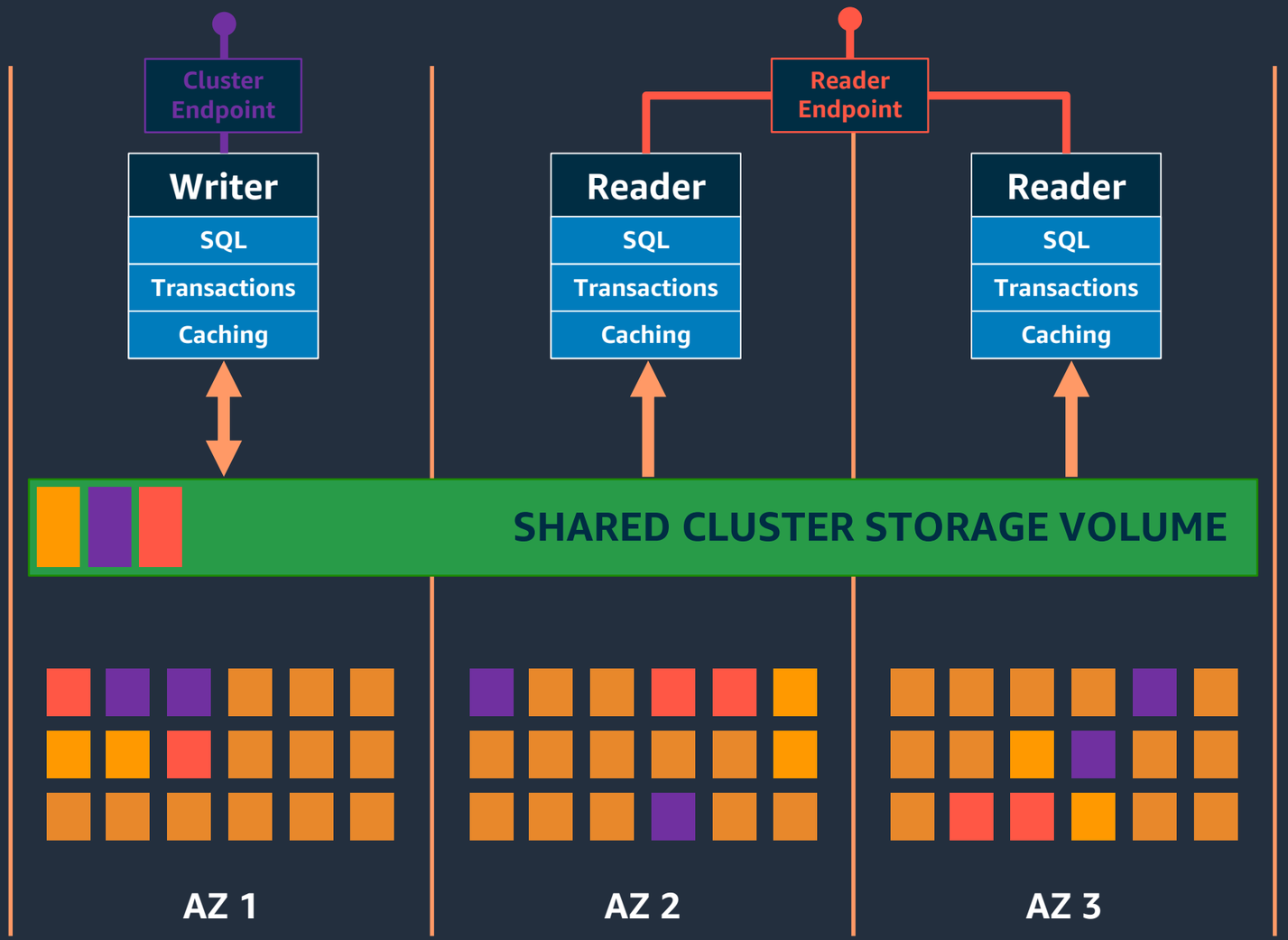
Accessing your Aurora databases

Managed DB service, no OS or filesystem level access

Connect to writer using **Cluster (DNS) Endpoint** – always points to writer!

Round robin load balancing for reads using **Reader (DNS) Endpoint** (excludes writer except on single node clusters)

Custom (DNS) Endpoints, read replica auto scaling supported as well



aws

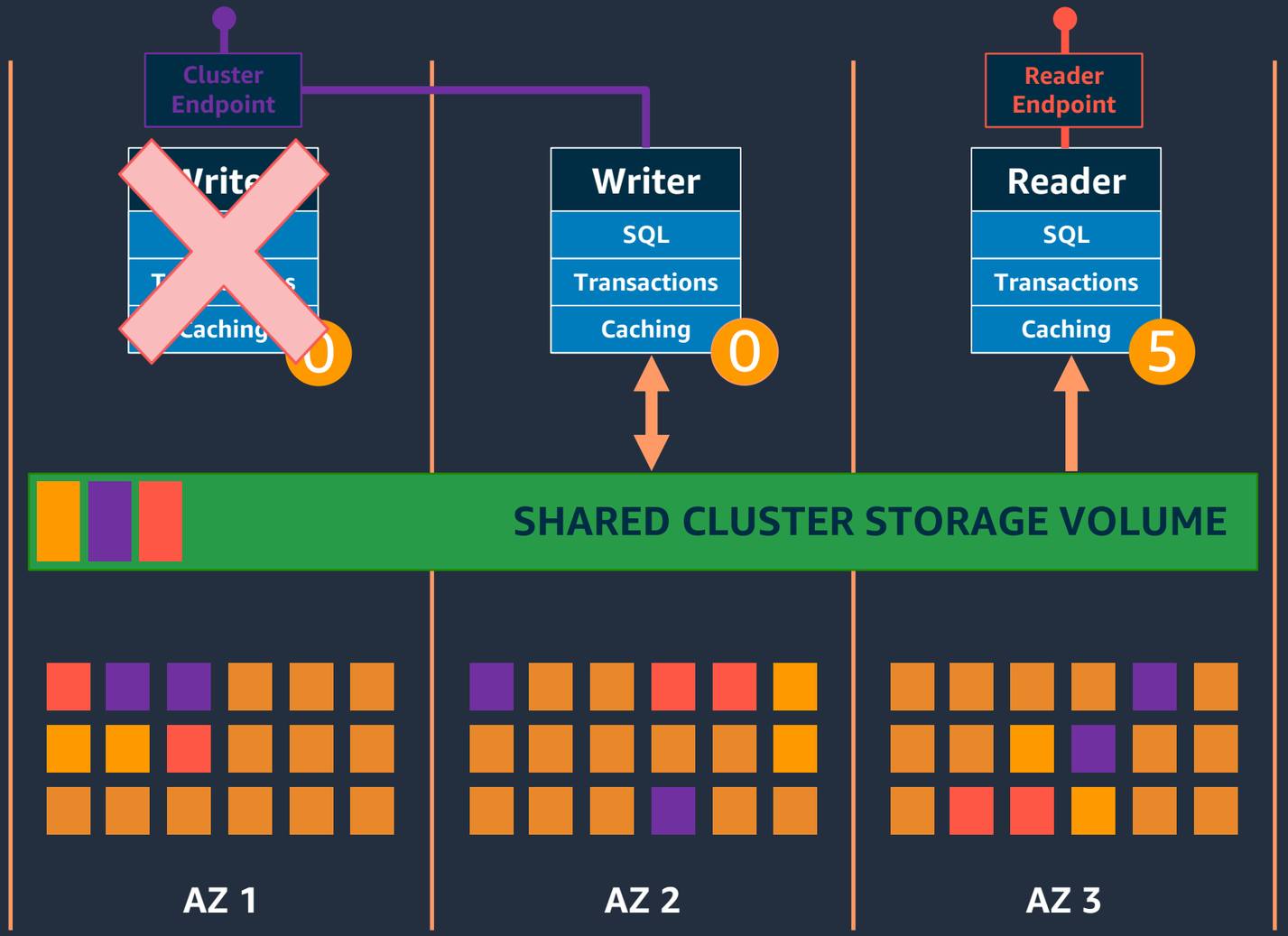
Tolerating compute failures

Any reader node can be promoted to writer/master

Failover tier determines preference on failover reader candidates. Lower values more preferred.

Failed instances/nodes will be replaced after failover and come online as readers.

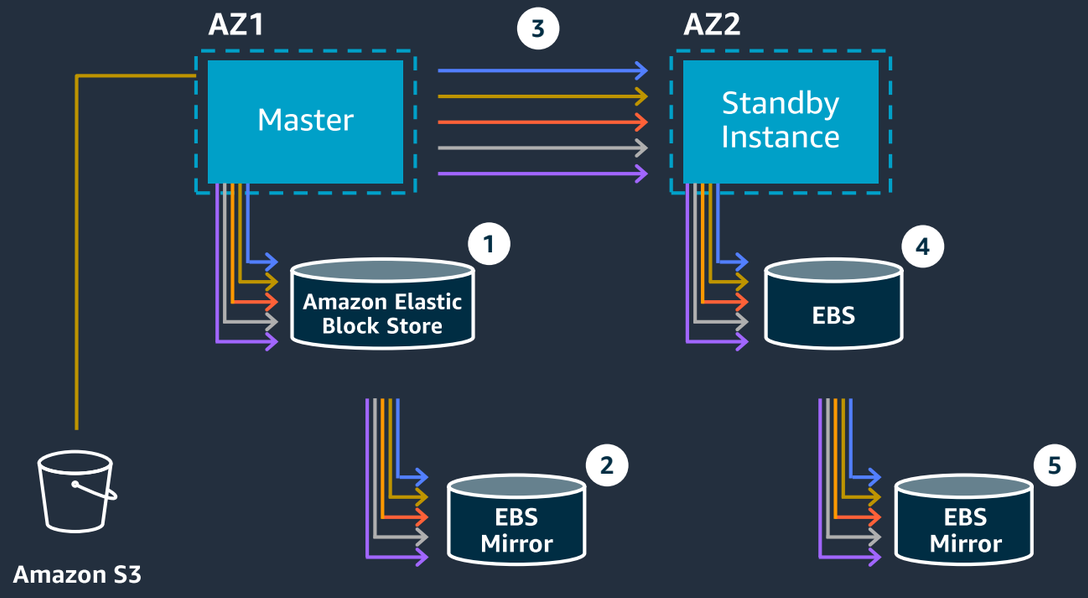
Readers reboot on writer failover.



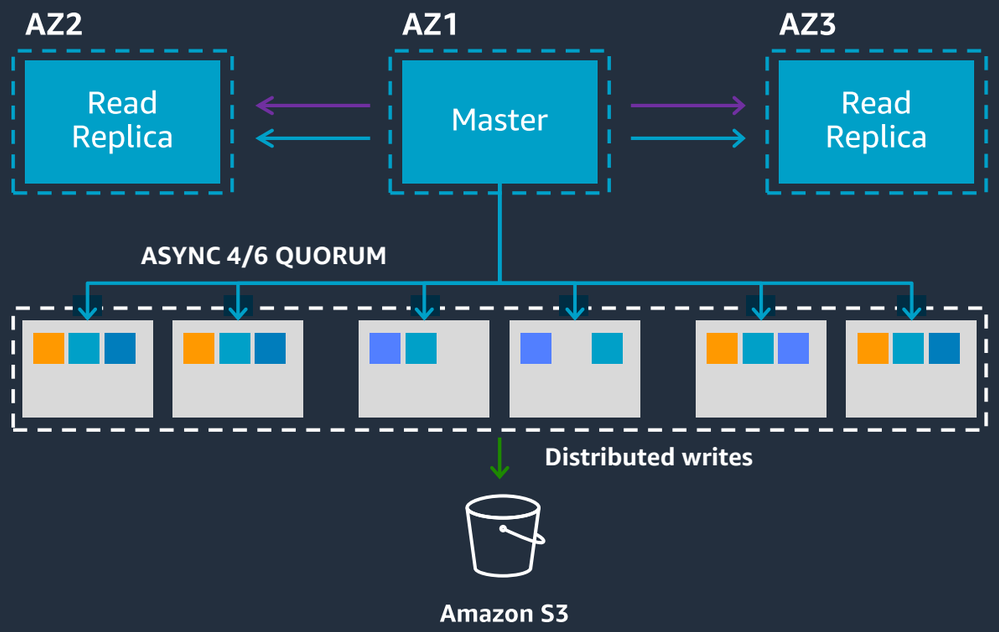
aws

Aurora I/O profile compared (MySQL)

Amazon RDS MySQL Multi-AZ



Amazon Aurora MySQL



MySQL I/O profile for 30 min Sysbench run

- 780K transactions
- Average 7.4 I/Os per transaction

Aurora IO profile for 30 min Sysbench run

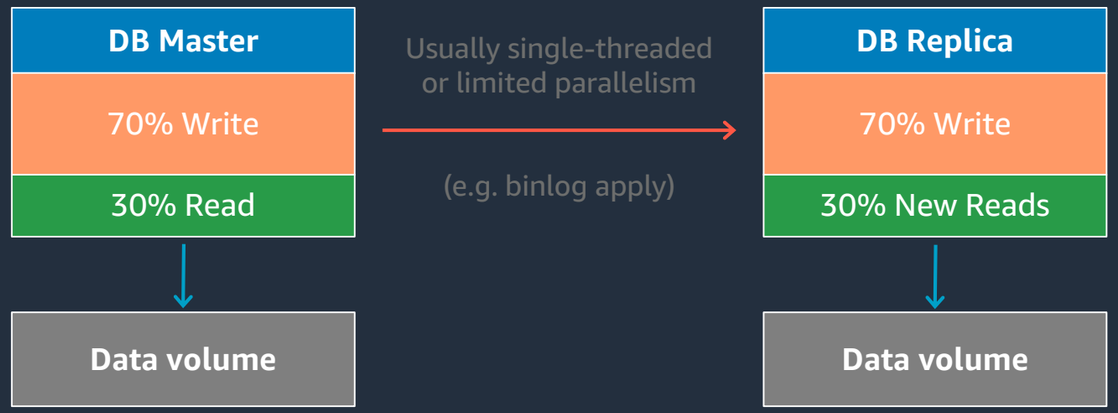
- 27,378K transactions – **35x more**
- 0.95 I/Os per transaction (6x amplification) – **7.7x less**

Log Binlog Data Double-write .frm files

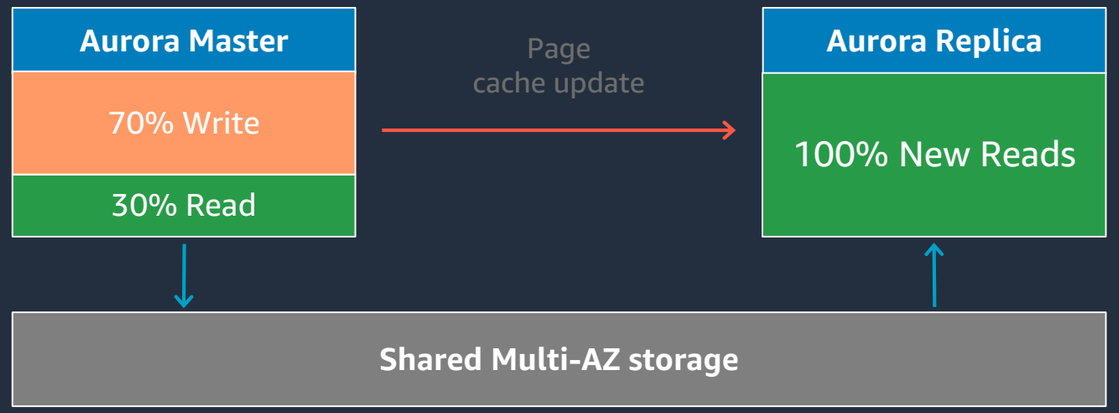
aws

Aurora read replicas are dedicated to reads

Traditional read scaling



Amazon Aurora read scaling



Logical using binary log, or WAL

Same write workload on replica

Independent storage

Physical using page change vectors (redo log)

No writes on replica

Shared storage

Shared: Common MVCC state, efficient for OLTP reads
Independent: safe for ad-hoc, long running or risky queries

aws

Aurora architectural improvements

Do less work:

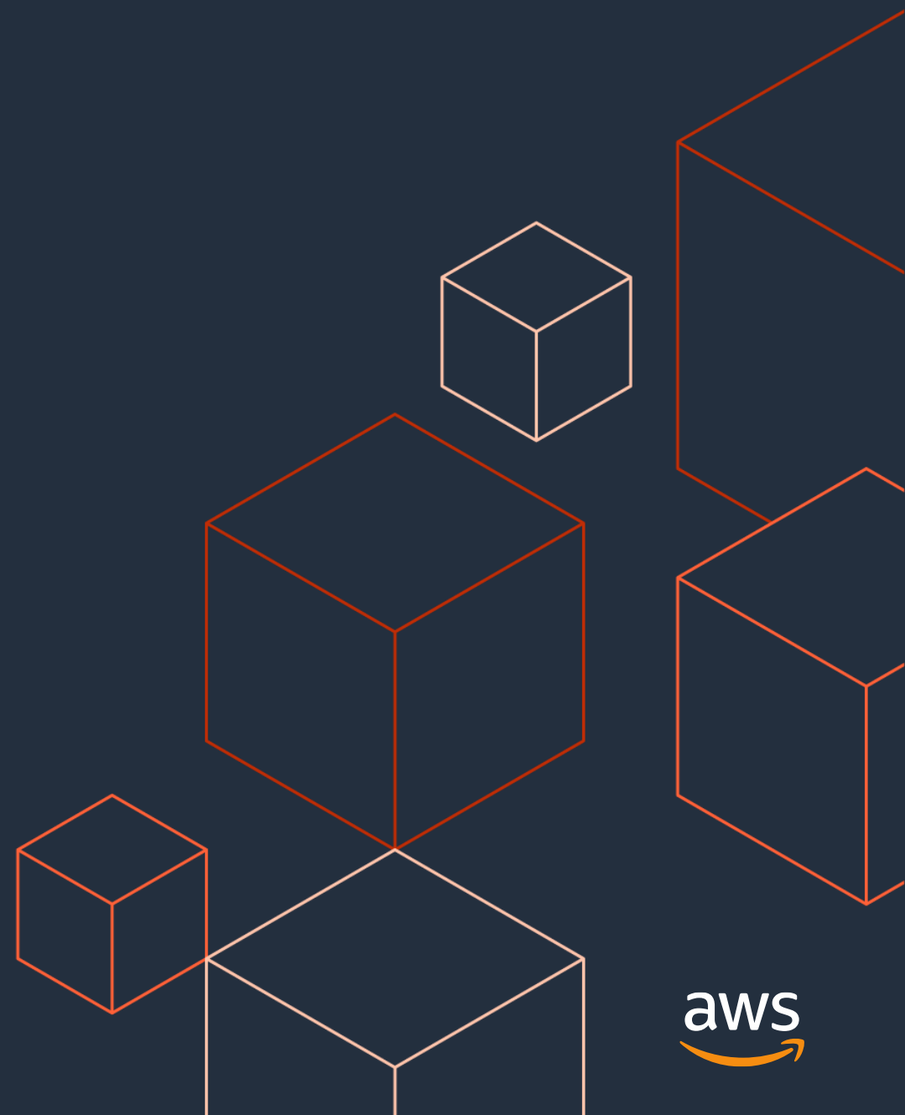
- Do fewer I/Os
- Minimize network packets
- Cache prior results
- Offload the database engine

Be more efficient:

- Process asynchronously
- Reduce latency path
- Use lock-free data structures
- Batch operations together

aws

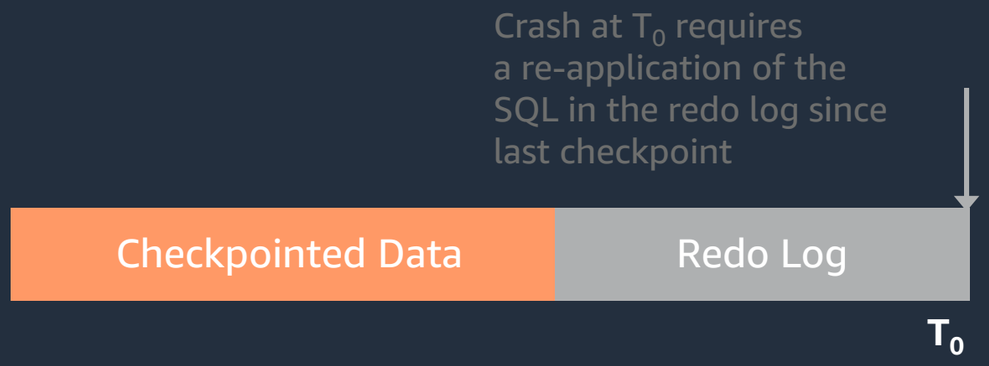
Amazon Aurora Key Innovations



Near-instant crash recovery

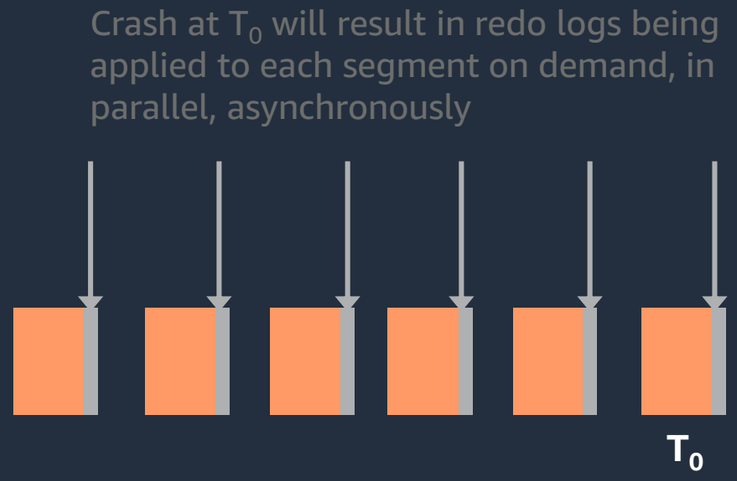
Traditional database

- Have to replay logs since the last checkpoint
- Typically 5 minutes between checkpoints
- Single-threaded in MySQL; requires a large number of disk accesses



Amazon Aurora

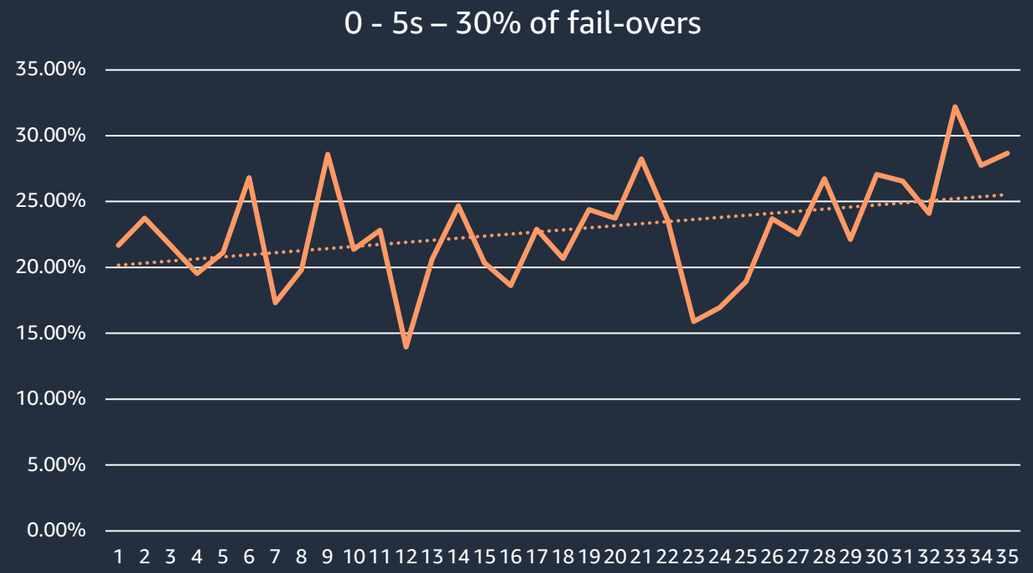
- Underlying storage replays redo records on demand as part of a disk read
- Parallel, distributed, asynchronous
- No replay for startup

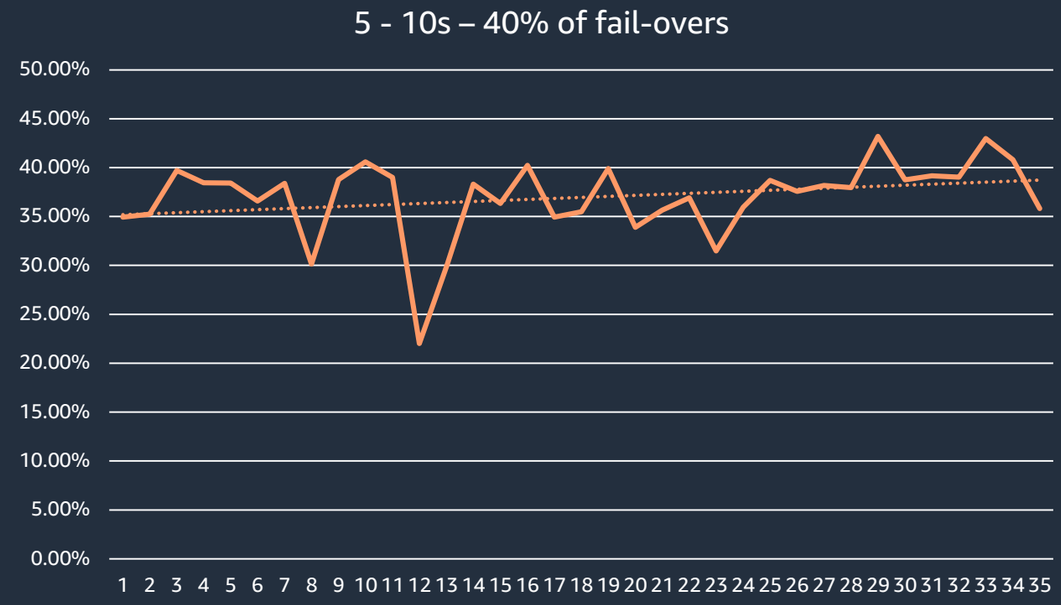


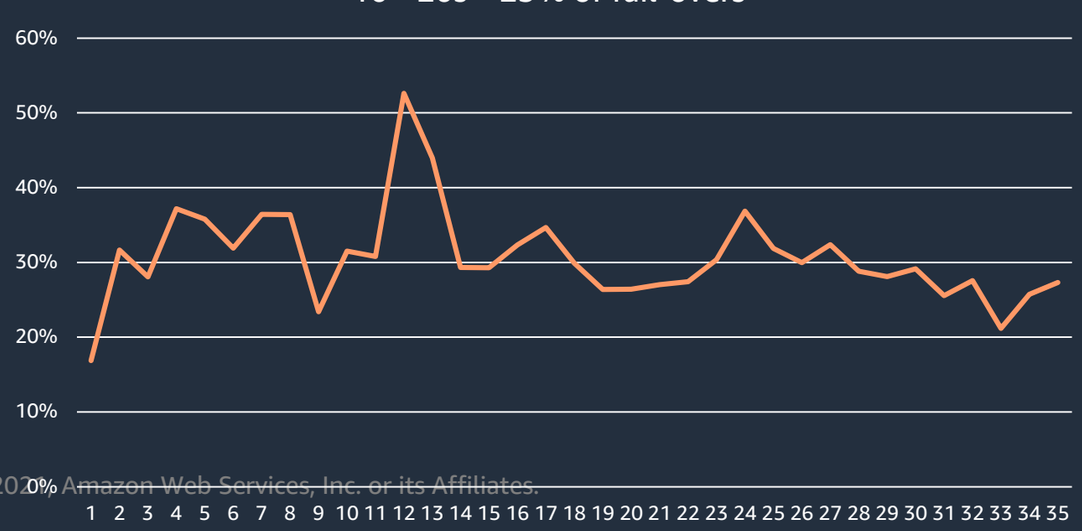
MySQL Note: Binlogs (master), undo logs, catalog, FTS indexes, XA still require crash recovery

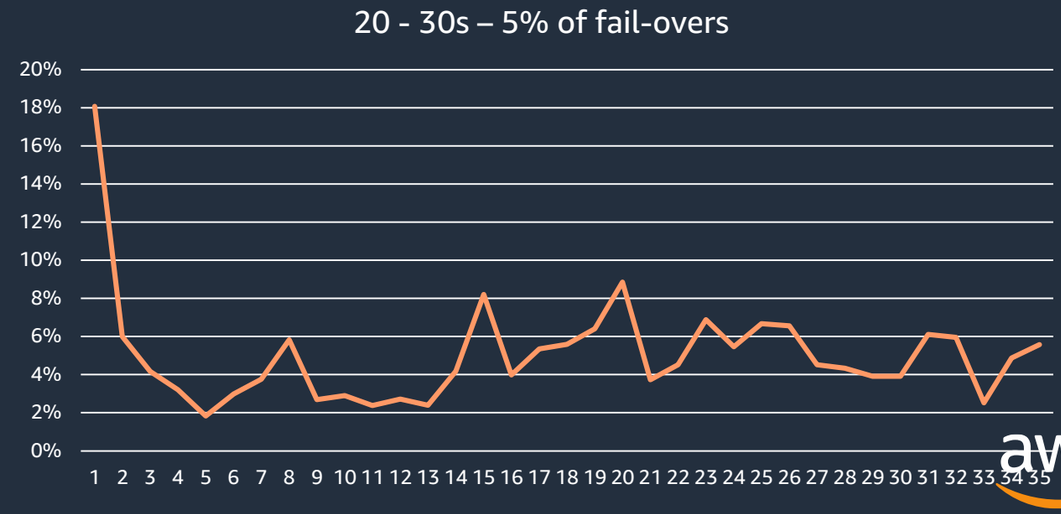
http://blog.symedia.pl/2016/03/crash-recovery-mysql-aurora.html

When the database fails – recovery is fast <30 seconds









Cluster Cache Management (CCM)

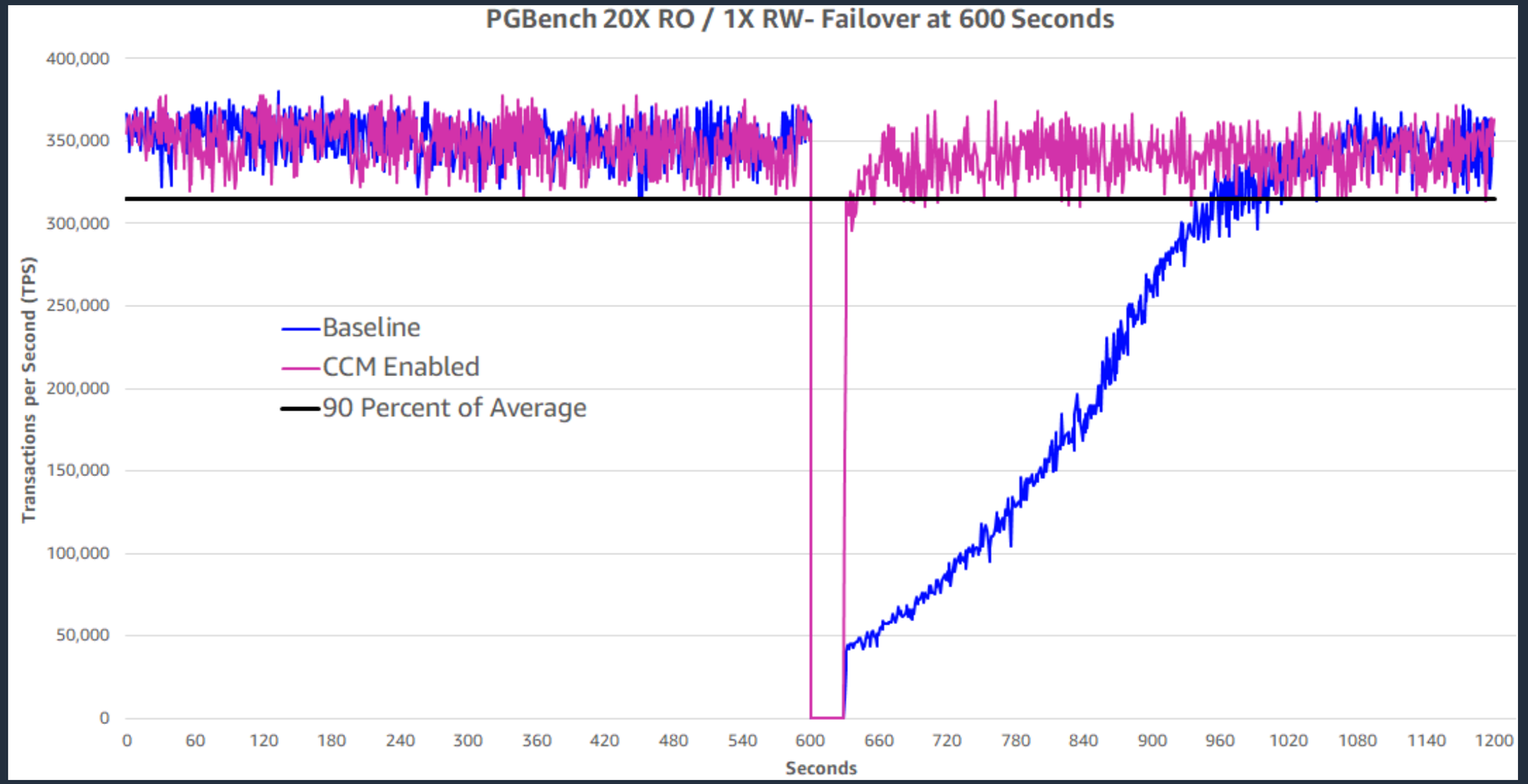
PostgreSQL Only

- Improves the customer experience with regards to the performance of the new writer node after failover.
- Lowest failover tier reader will send the set of buffers that are currently cached to the writer node as a bloom filter (avoid duplicate sends).
- On receipt writer node compares the blocks cached in the buffer cache and sends frequently used buffers to that reader node .
- If a failover occurs, the designated reader (now promoted to new writer) uses values in its warm cache immediately.

aws

CCM in practice

PostgreSQL Only



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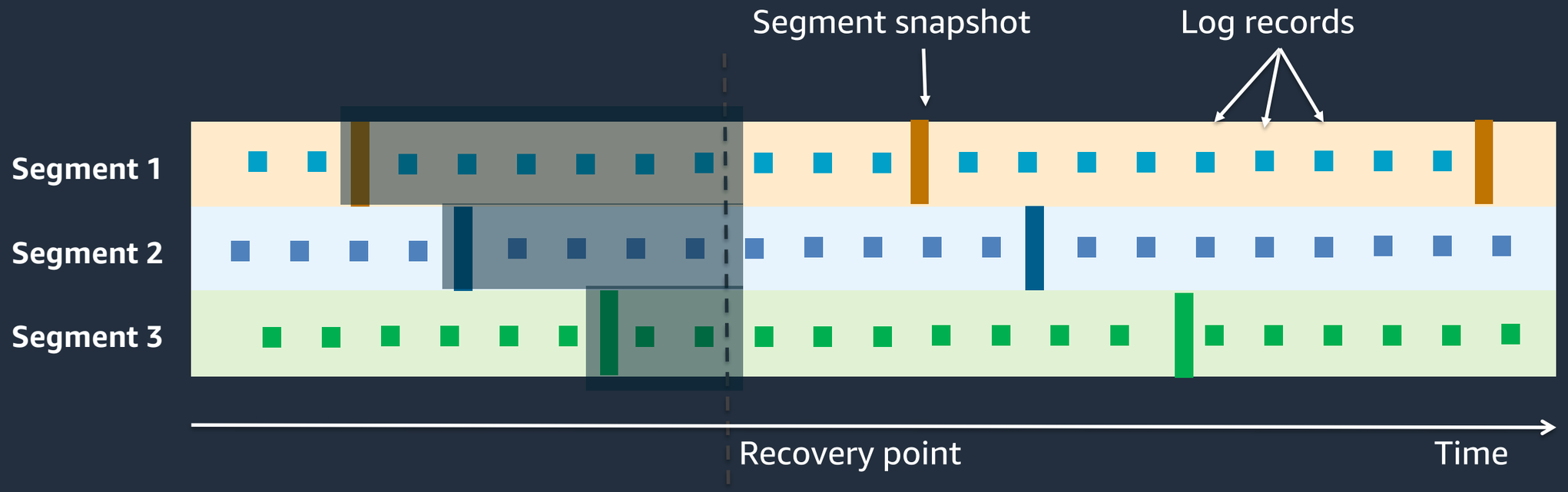
Continuous backup with point-in-time restore

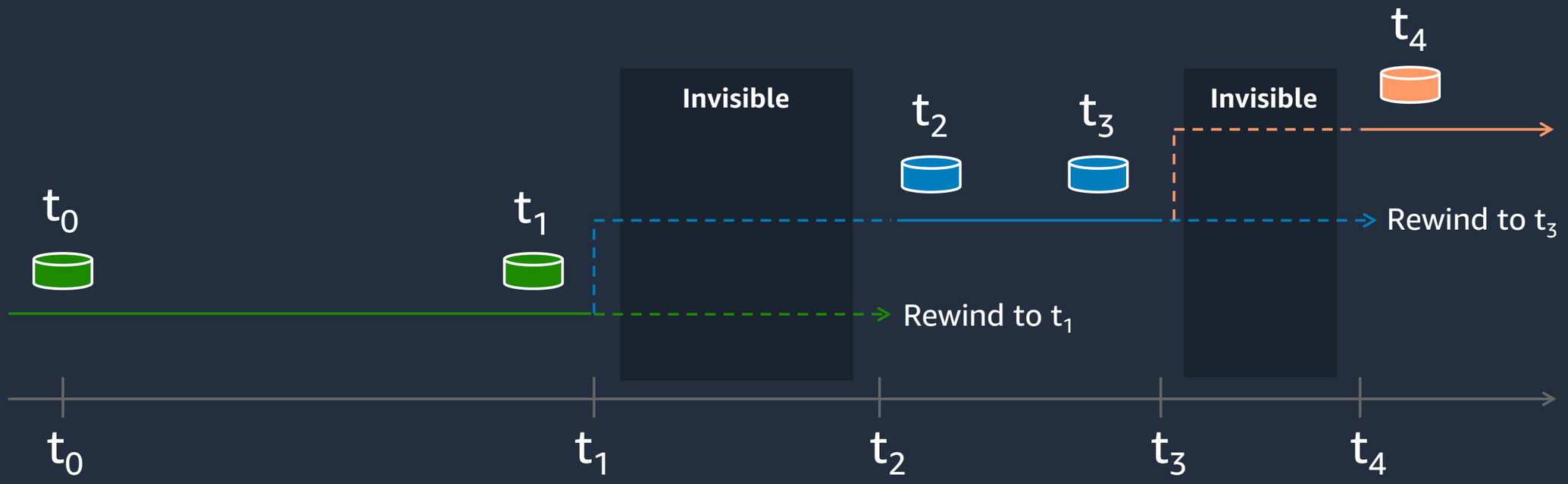


- Backup is performed without performance or availability impact by storage nodes
- Periodic snapshot of each segment is taken in parallel, and stored in S3
- Logs records streamed to Amazon S3 continuously
- At restore, appropriate segment snapshots and log records are retrieved by storage nodes
- At restore, log records are applied to segment snapshots in parallel and asynchronously

aws

Aurora Backtrack

MySQL Only



Backtrack brings the database to a point in time without requiring restore from backups

Recover from an unintentional DML or DDL operation

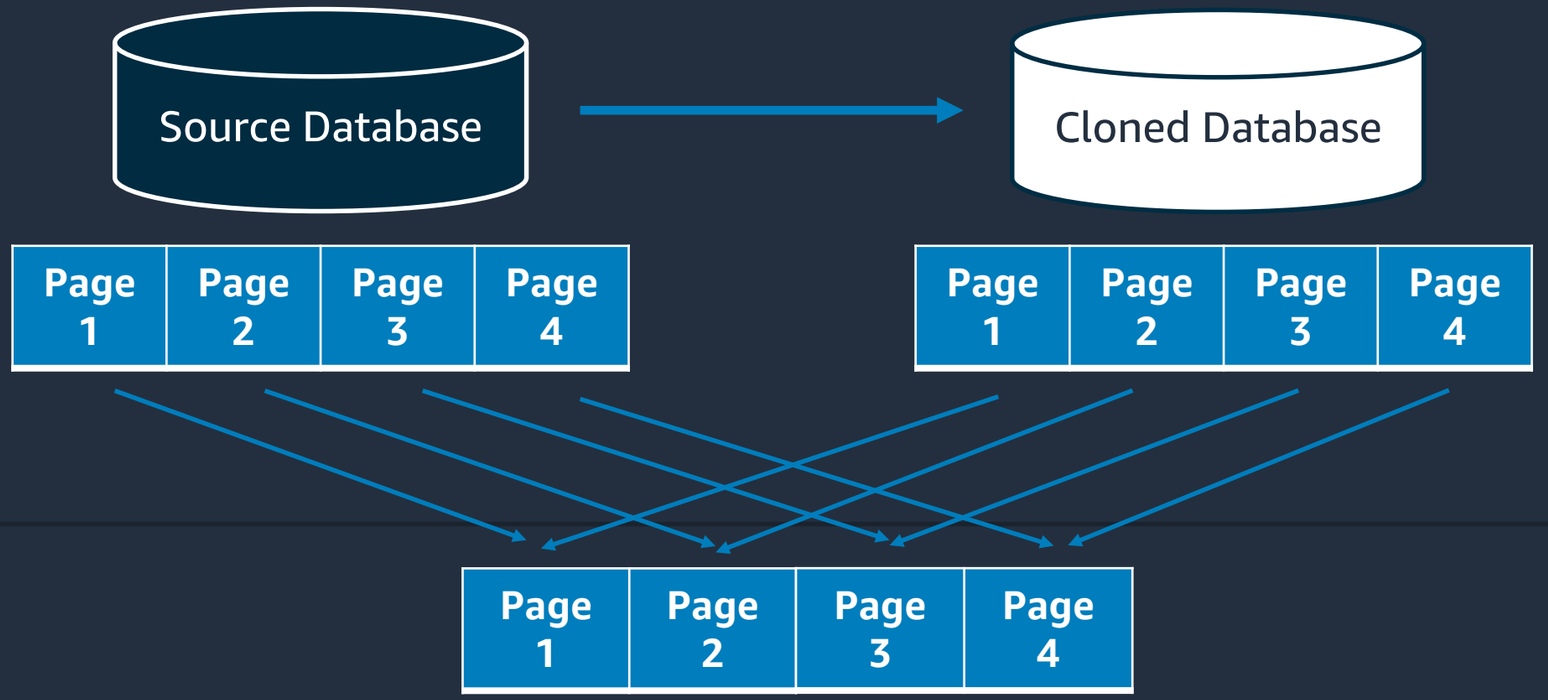
Backtrack is not destructive; you can backtrack multiple times to find the right point in time

Also useful for QA (rewind your DB between test runs)

aws

Fast database cloning

Create a copy of a DB cluster (storage volume) without duplicate storage cost
Creation is fast – we don't physically copy data

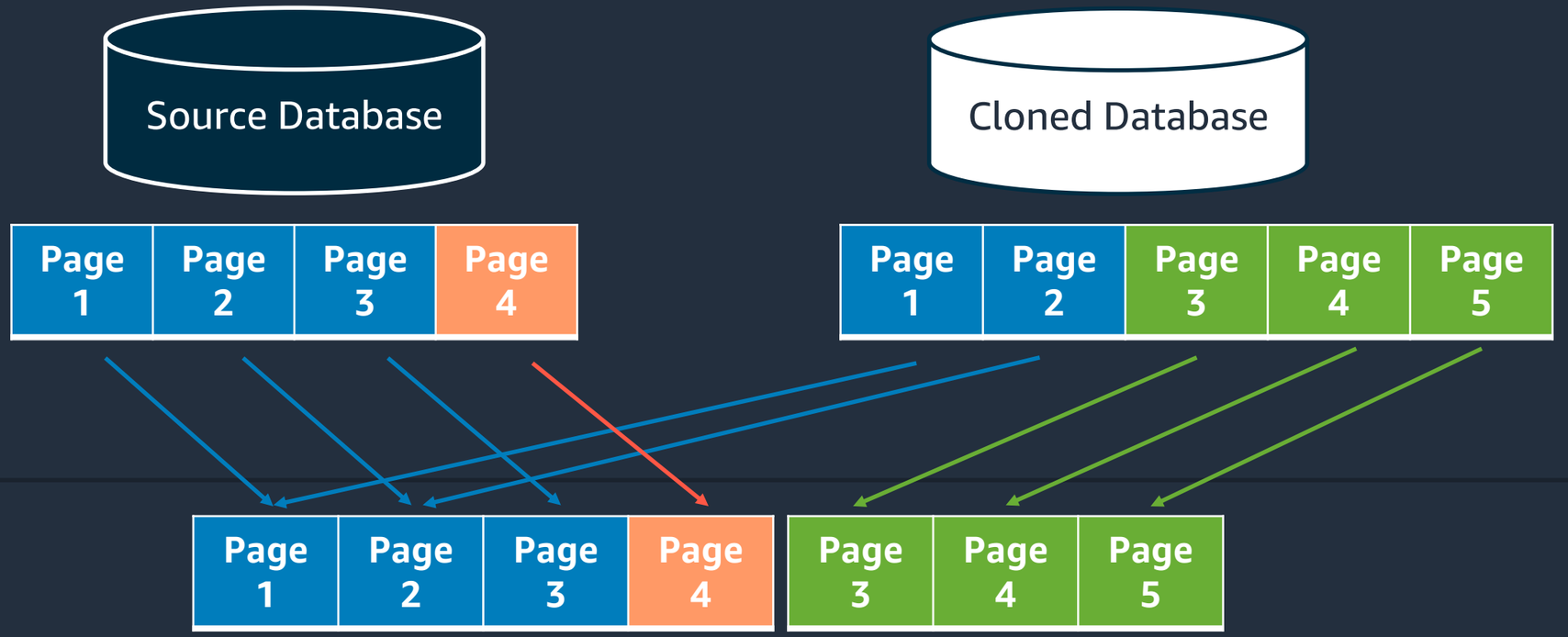


State: Created a clone, made no storage changes
Both databases reference **same** pages on the shared distributed storage system

aws

Fast database cloning (continued)

Isolation: Activity on the clone doesn’t impact performance of the source (and vice-versa)

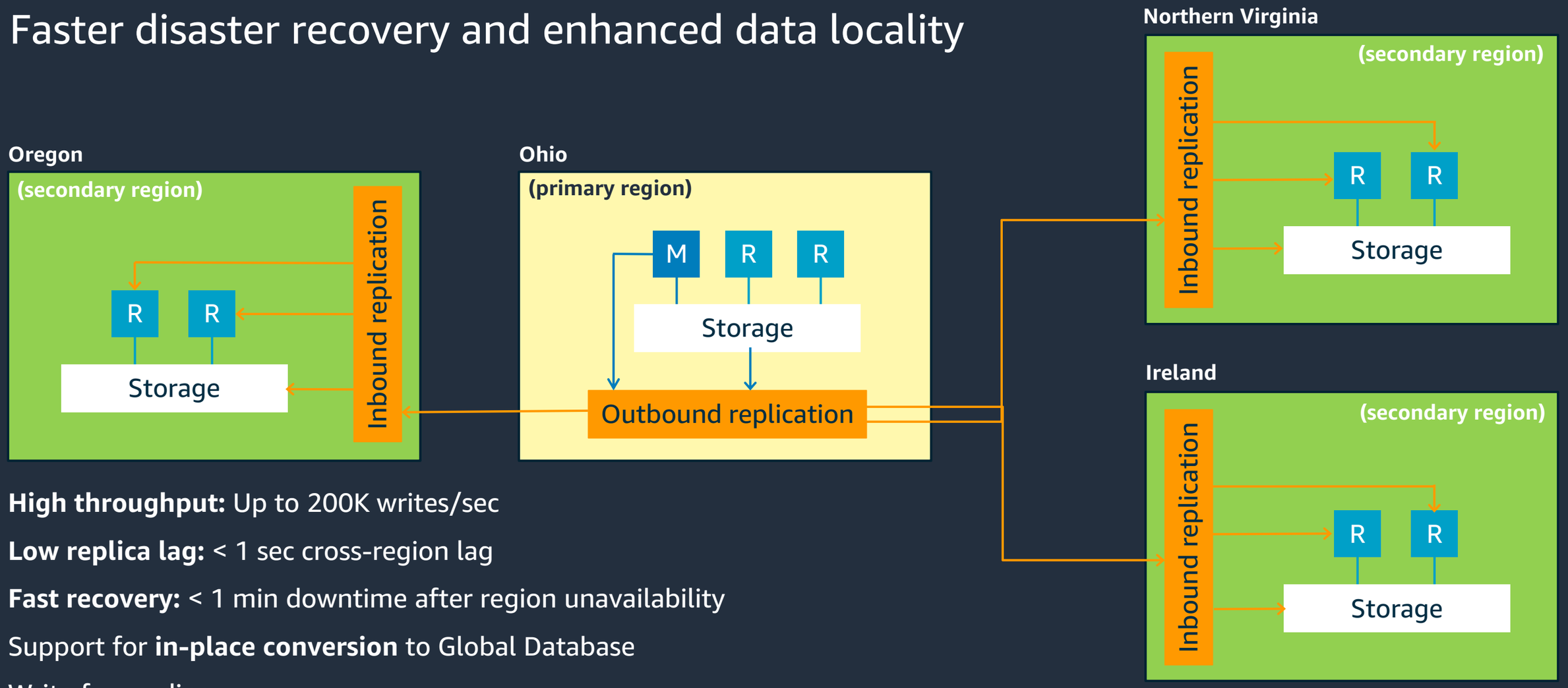


State: Created a clone, made storage changes on both source & clone
Both databases reference **common** pages on the shared distributed storage system

aws

Aurora Global Database

Faster disaster recovery and enhanced data locality



High throughput: Up to 200K writes/sec

Low replica lag: < 1 sec cross-region lag

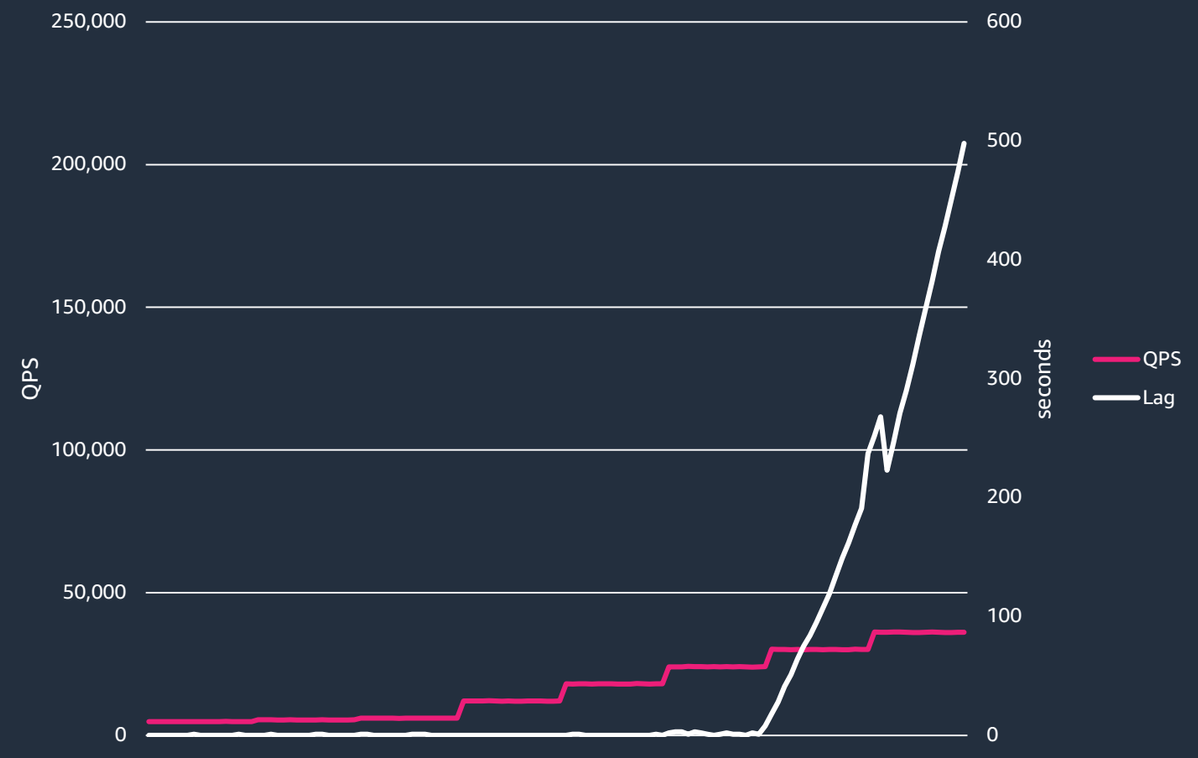
Fast recovery: < 1 min downtime after region unavailability

Support for **in-place conversion** to Global Database

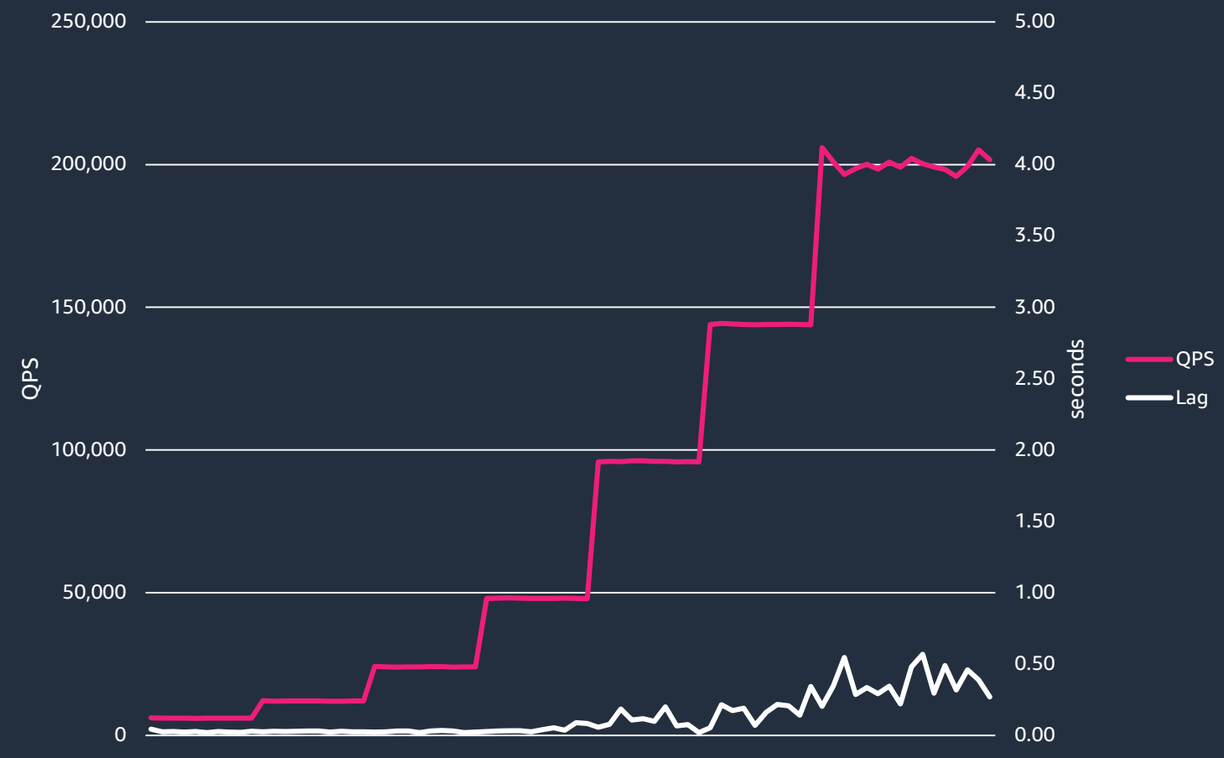
Write forwarding

aws

Performance: logical vs. physical replication



Logical replication
MySQL Binary logs (MTS)



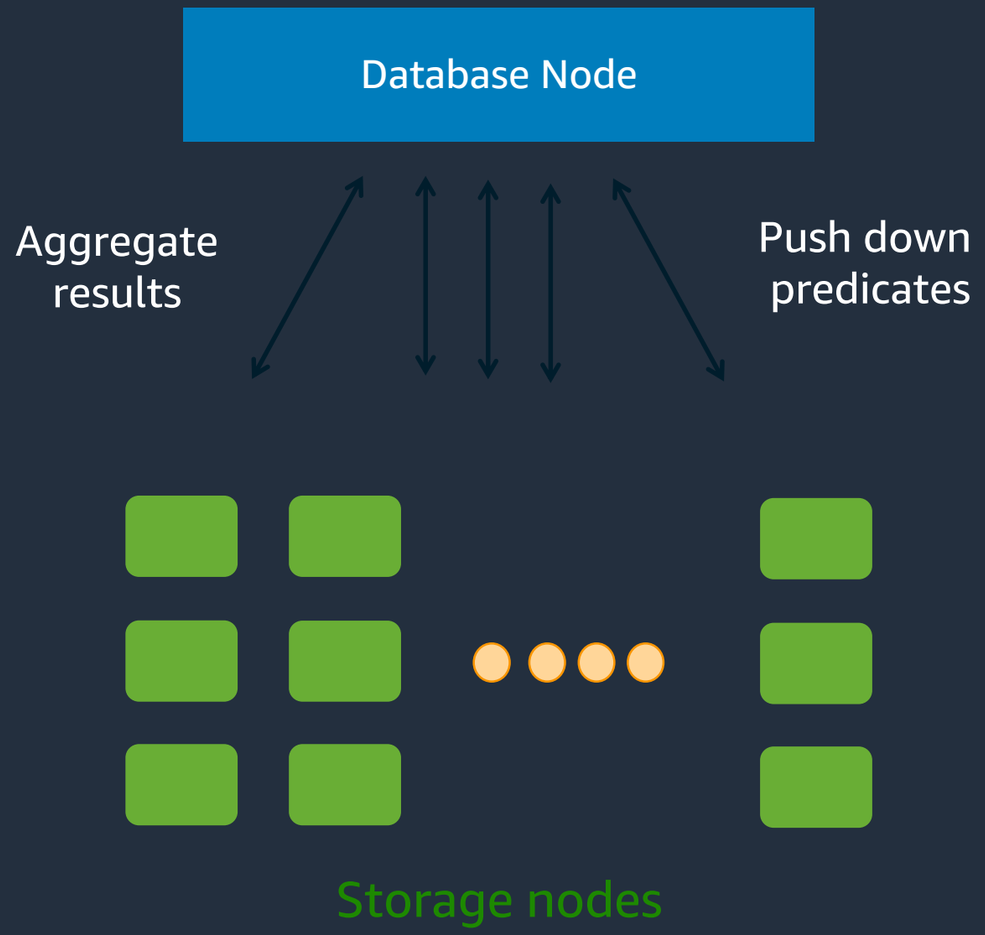
Physical replication
Global Database

SysBench OLTP (write-only) stepped every 600 seconds on R4.16xlarge

aws

Parallel query processing

MySQL Only



Aurora storage has thousands of CPUs

- Opportunity to push down and parallelize query processing
- Moving processing close to data reduces network traffic and latency

However, there are significant challenges

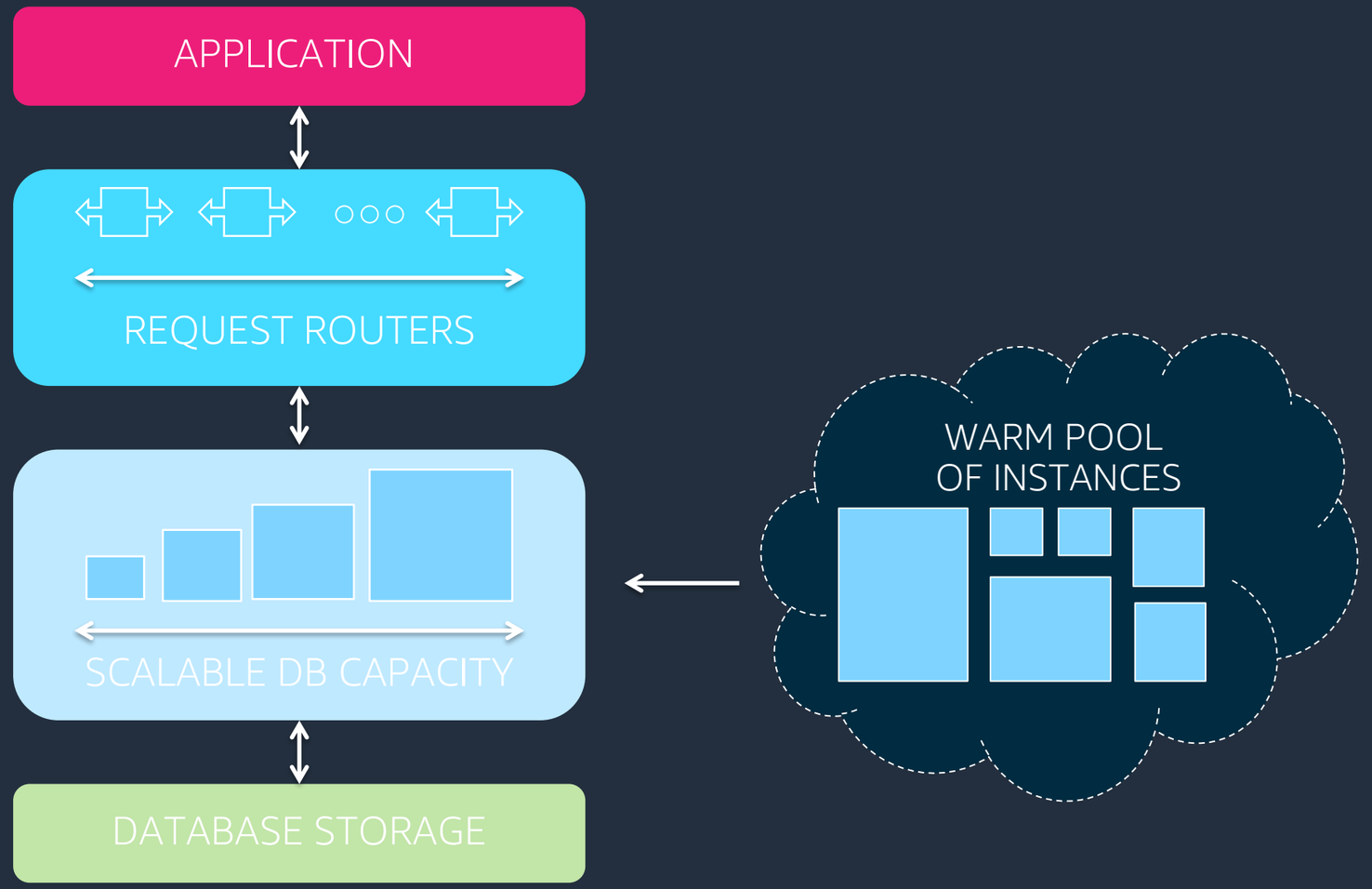
- Data is not range partitioned – require full scans
- Data may be in-flight
- Read views may not allow viewing most recent data
- Not all functions can be pushed down

https://aws.amazon.com/blogs/aws/new-parallel-query-for-amazon-aurora/

aws

Aurora Serverless v1
Warm pool architecture

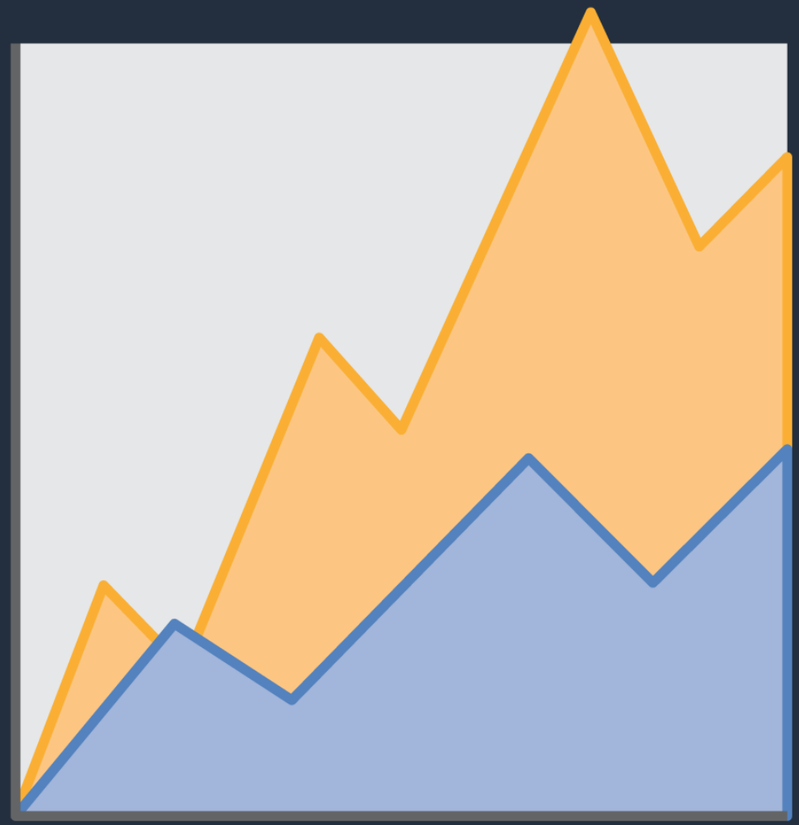
- Starts up on demand, shuts down when not in use
- Scales up/down automatically
- No application impact when scaling
- Pay per second, 1 minute minimum



aws

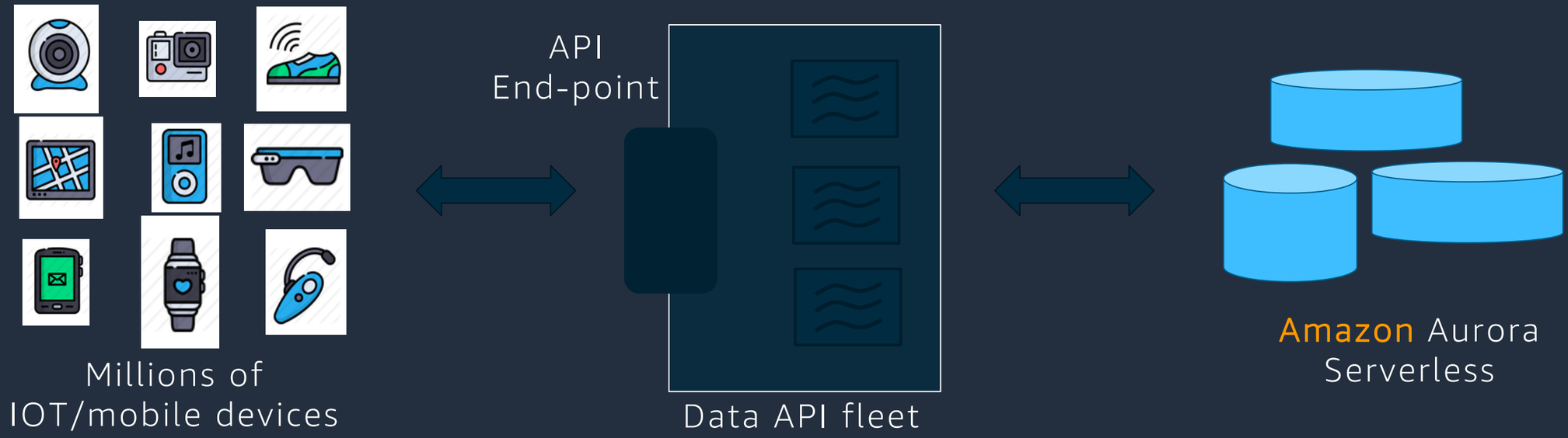
Aurora Serverless
Use cases

- Infrequently used applications (e.g., low-volume blog site)
- Applications with variable load—peaks of activity that are hard to predict (e.g., news site)
- Development or test databases not needed on nights or weekends
- Consolidated fleets of multi-tenant SaaS applications



aws

Amazon RDS Data API for serverless applications



Access through simple web interface

- Public endpoint addressable from anywhere
- No client configuration required
- No persistent connections required

Ideal for Serverless applications (Lambda)

Ideal for light-weight applications (IOT)

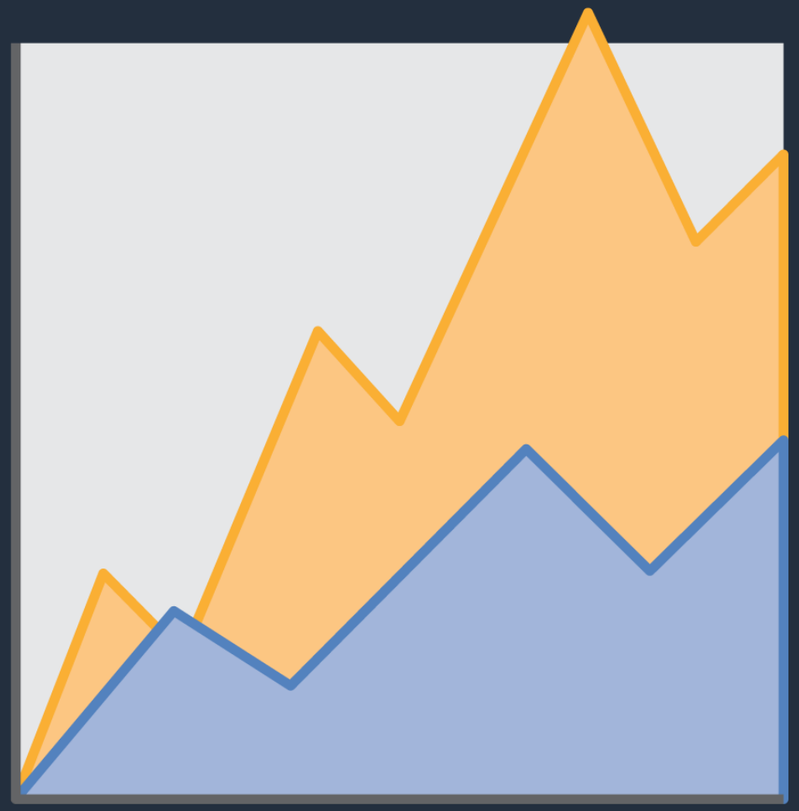
https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/data-api.html

aws

Monitoring Performance

aws

Performance Insights



Why Database Tuning?

RDS is all about managed databases

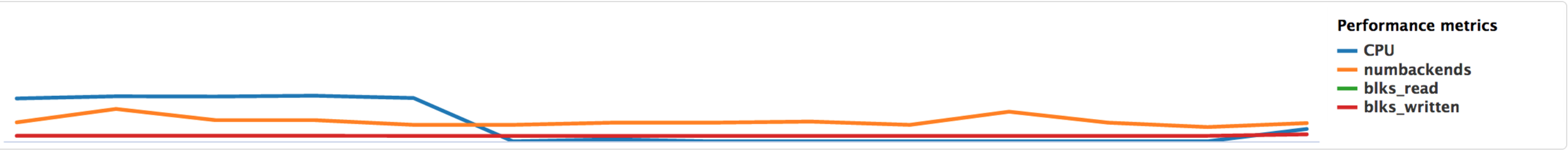
Customers also want performance managed:

❑ Want easy tool for optimizing cloud database workloads
❑ May not have deep tuning expertise

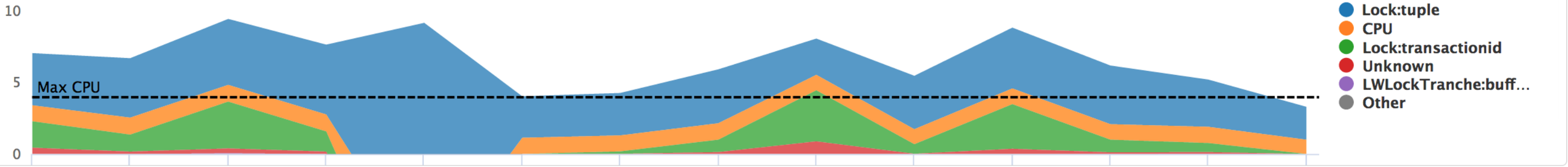
→ Want a single pane of glass to achieve this

aws

Last 5 minutes



DB load by: **Waits** SQL Hosts Users



Waits | **SQL** | Hosts | Users

Search SQL Queries

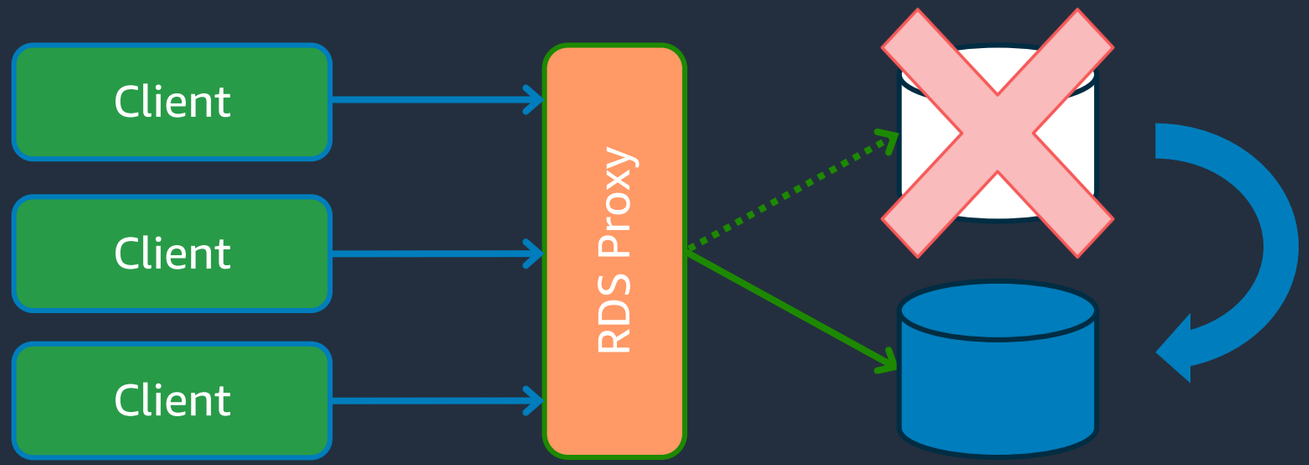
SQL Digest	DB Load	SQL
4e15b546005d9489980349e399cc1d24		UPDATE pgbench_tellers SET tbalance = tbalance + ? WHERE tid = ?;
9037de313c04df497488ab3670c2466b		UPDATE pgbench_branches SET bbalance = bbalance + ? WHERE bid = ?;
f64d0eecd0bac50e4d71b98c500599af		ROLLBACK TO SAVEPOINT JDBC_SAVEPOINT_1
a30112fac30fcf95bebbdc07e3e38573		select foo();
dc20ac1a0efa57e29ebf7f3df136c600		SELECT * FROM LOGIN("username_in" := $1,"password_in" := $2)
3e20d081813ac00ef7ecd3f778eaefa5		SELECT abalance FROM pgbench_accounts WHERE aid = ?;

Minimizing Disruptions

aws

Minimize Failover Disruption with RDS Proxy

- Stabilizes and reduces connections against backend DB
- Multiplexes client requests at transaction boundaries
- Idle application connections are preserved by the proxy
- New requests will be queued up by the proxy during the failover
- Faster failure recovery, bypassing DNS (up to 66% faster)

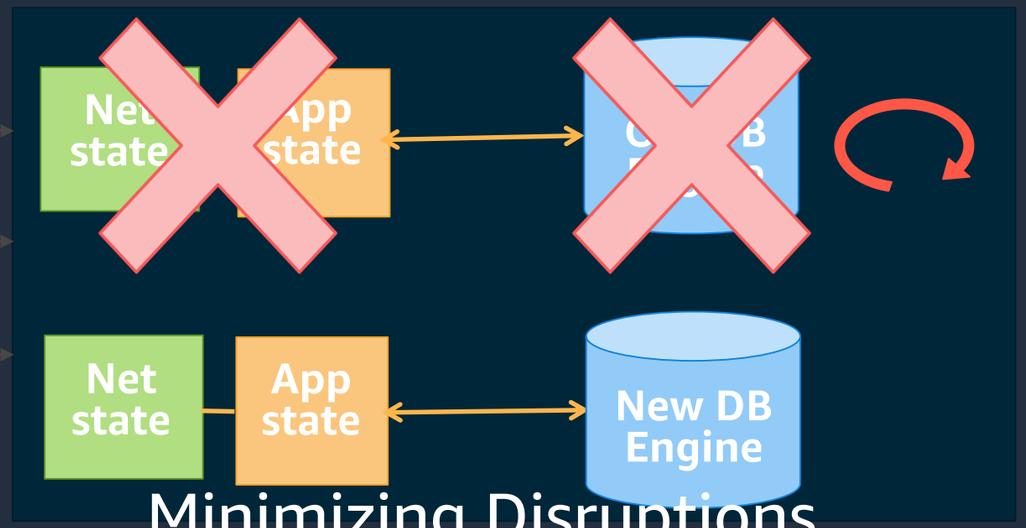


aws

Zero Downtime Patching (ZDP)

Before ZDP

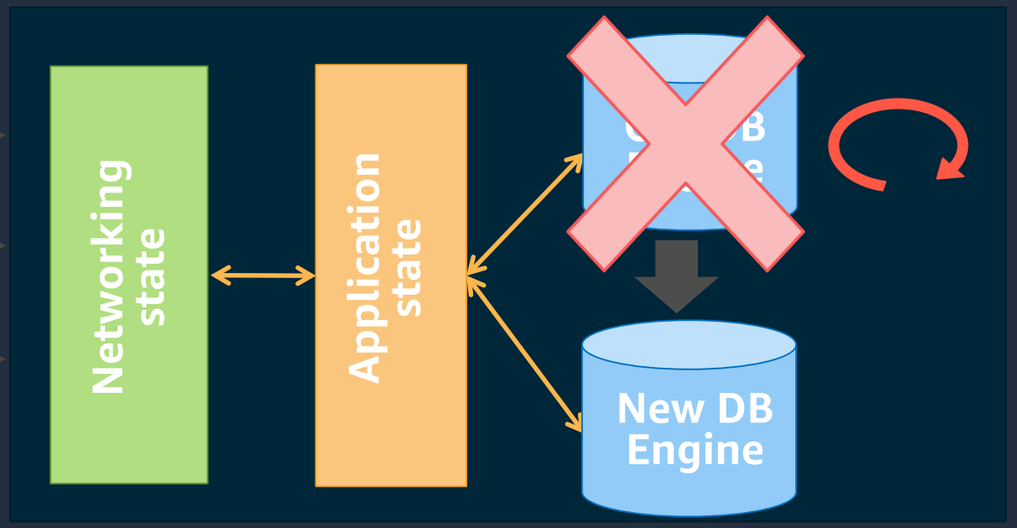
User sessions terminate during patching



Storage Service

With ZDP

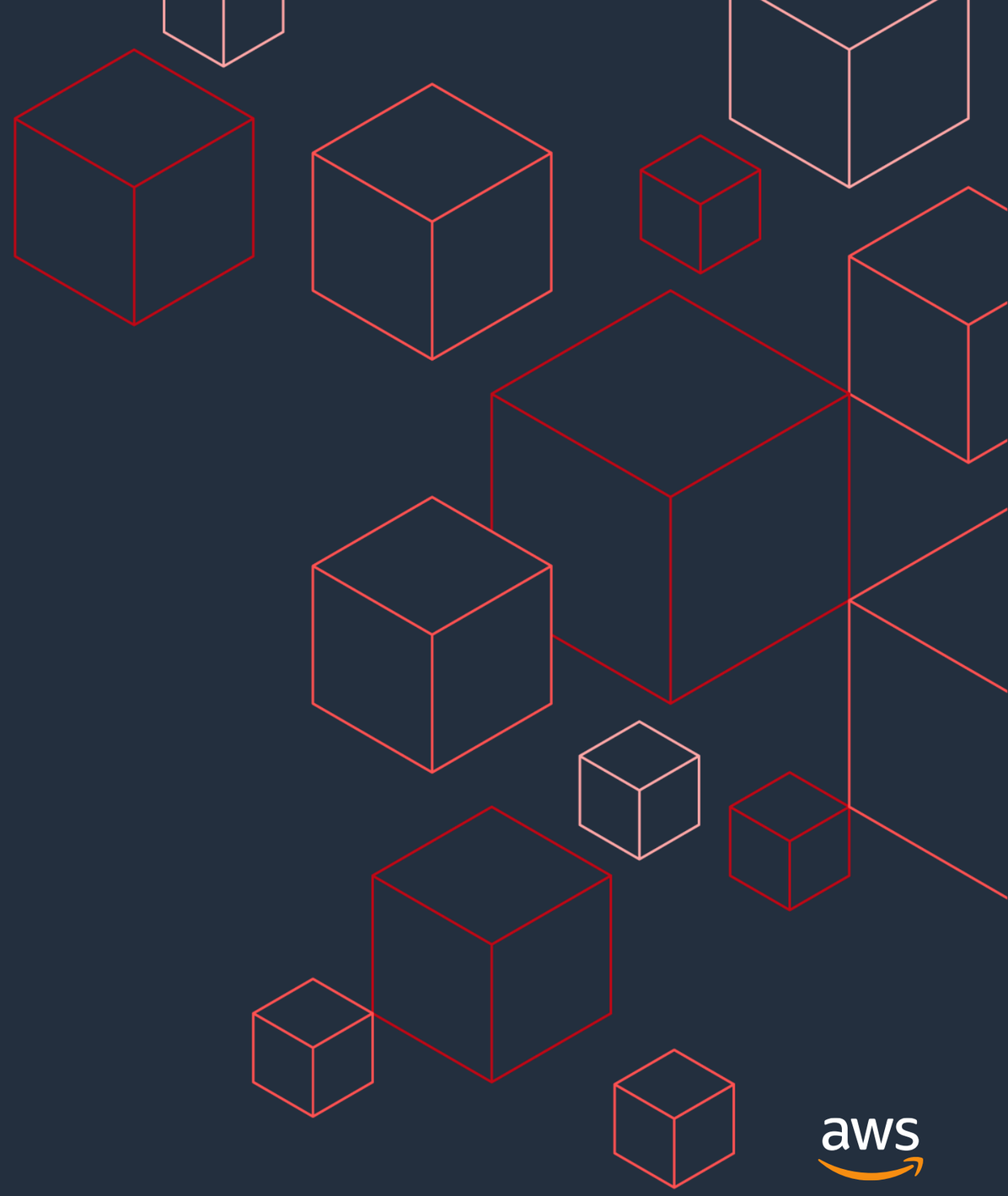
User sessions remain active through patching



Storage Service

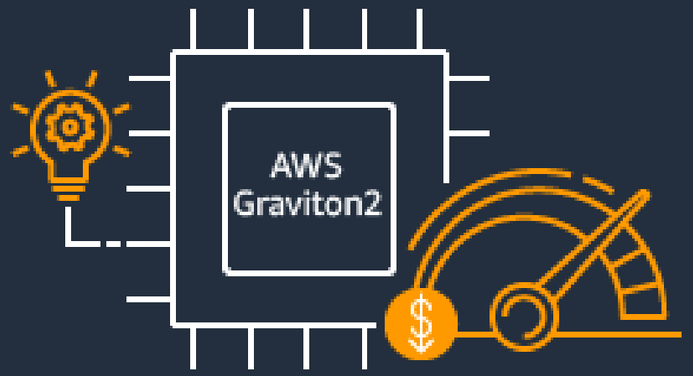
aws

What’s New?



AWS Graviton2 powered Aurora

Aurora Graviton instances



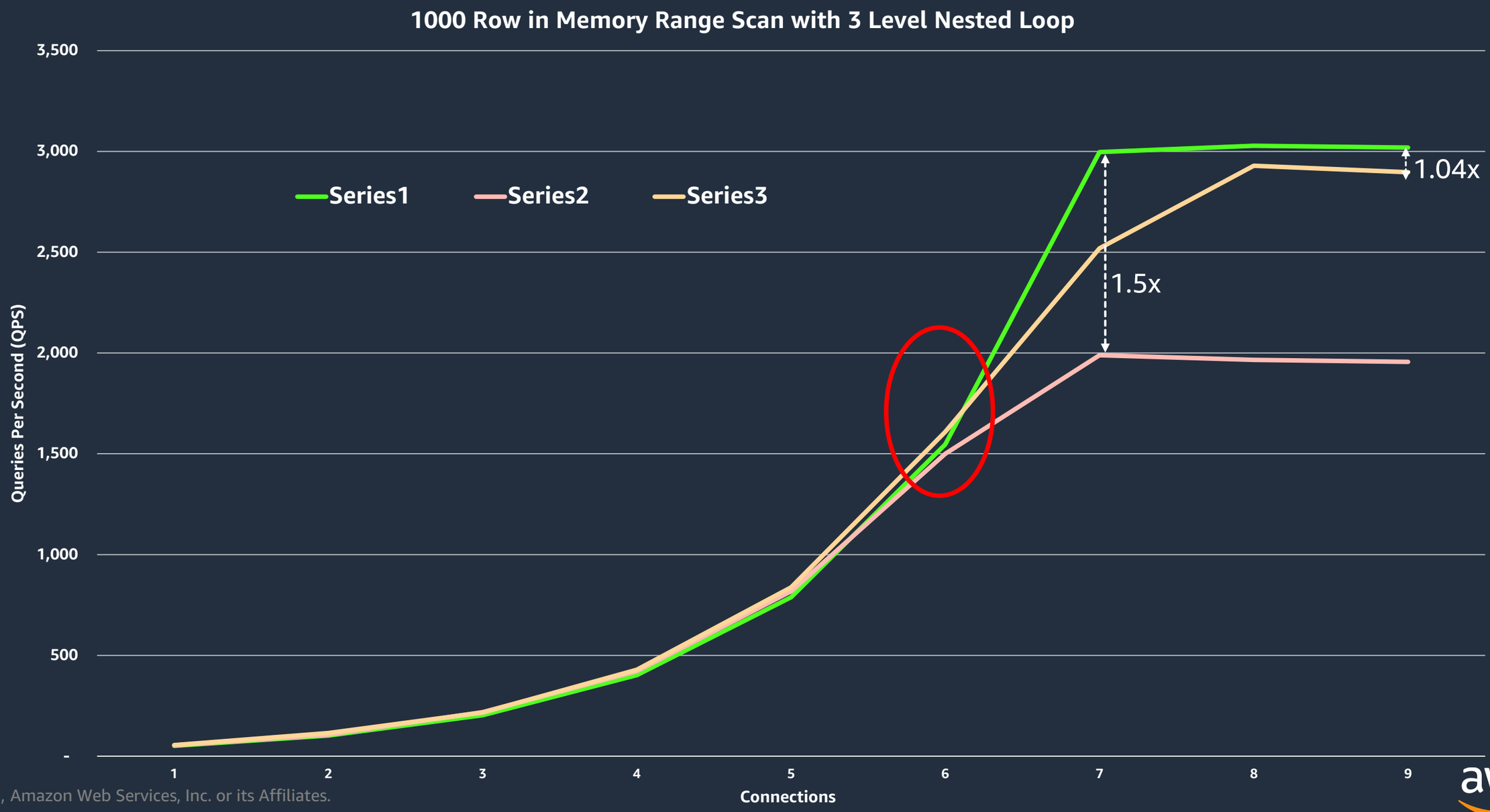
AWS Graviton2

Powerful and efficient,
modern applications

- Custom designed by AWS utilizing Arm Neoverse N1 cores
- Graviton2, fully compatible with all existing Aurora features - No porting needed
- Up to 35% better performance

aws

Graviton2



Aurora Global Database: Managed Planned Failover

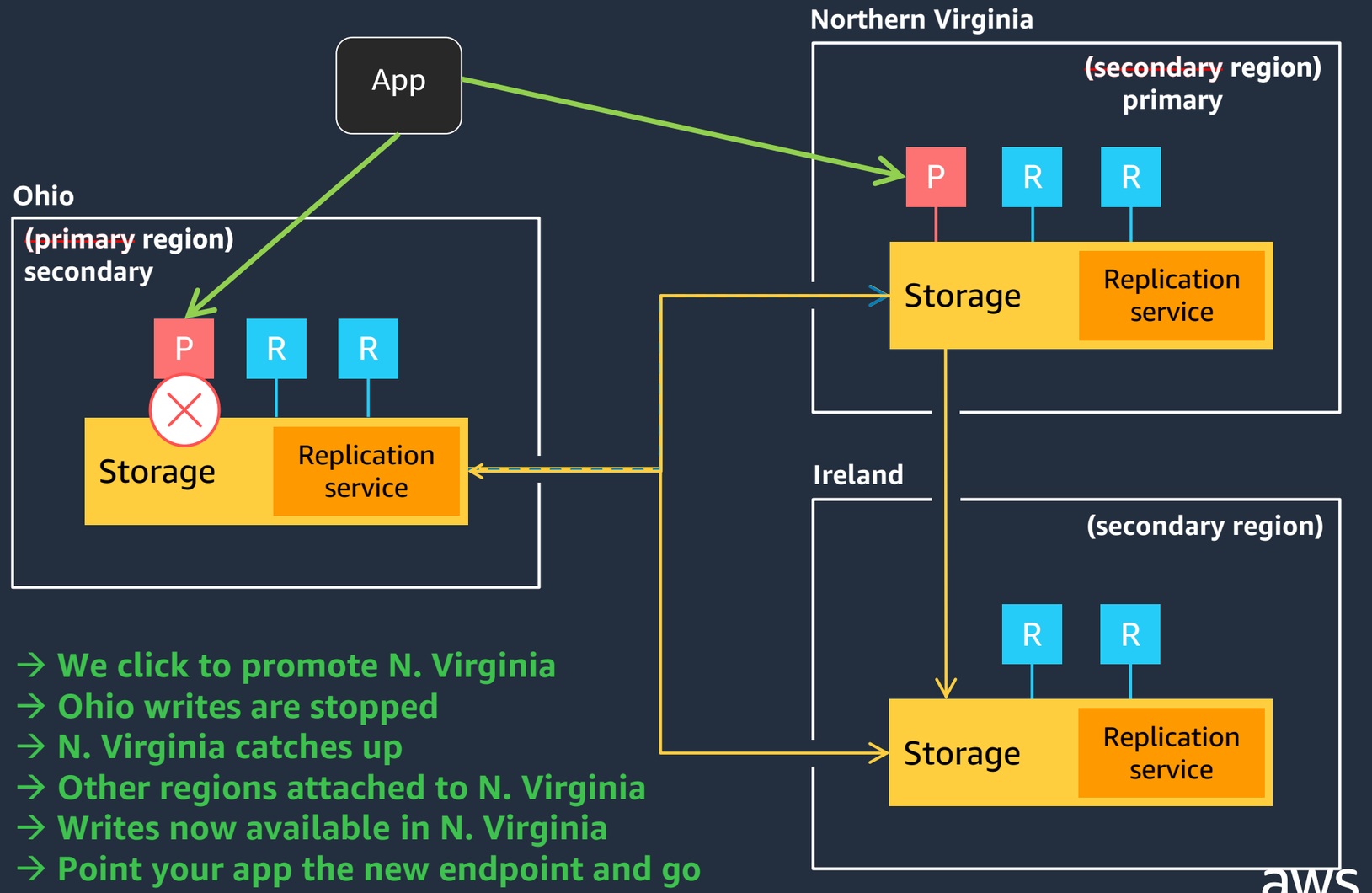
Automated way to promote secondary region to primary

For testing DR setup or relocating primary region

Fully maintains the topology

RPO=0; writes are stopped until new primary catches up

In this example we'll promote N. Virginia to primary



→ We click to promote N. Virginia
→ Ohio writes are stopped
→ N. Virginia catches up
→ Other regions attached to N. Virginia
→ Writes now available in N. Virginia
→ Point your app the new endpoint and go

What’s New?

- Graviton2 instance types – R6g
- Amazon Aurora now supports PostgreSQL 12
- In place upgrades support (MySQL 5.6 -> 5.7 and PostgreSQL 11 -> 12)
- Aurora Global Database Managed Planned Failover

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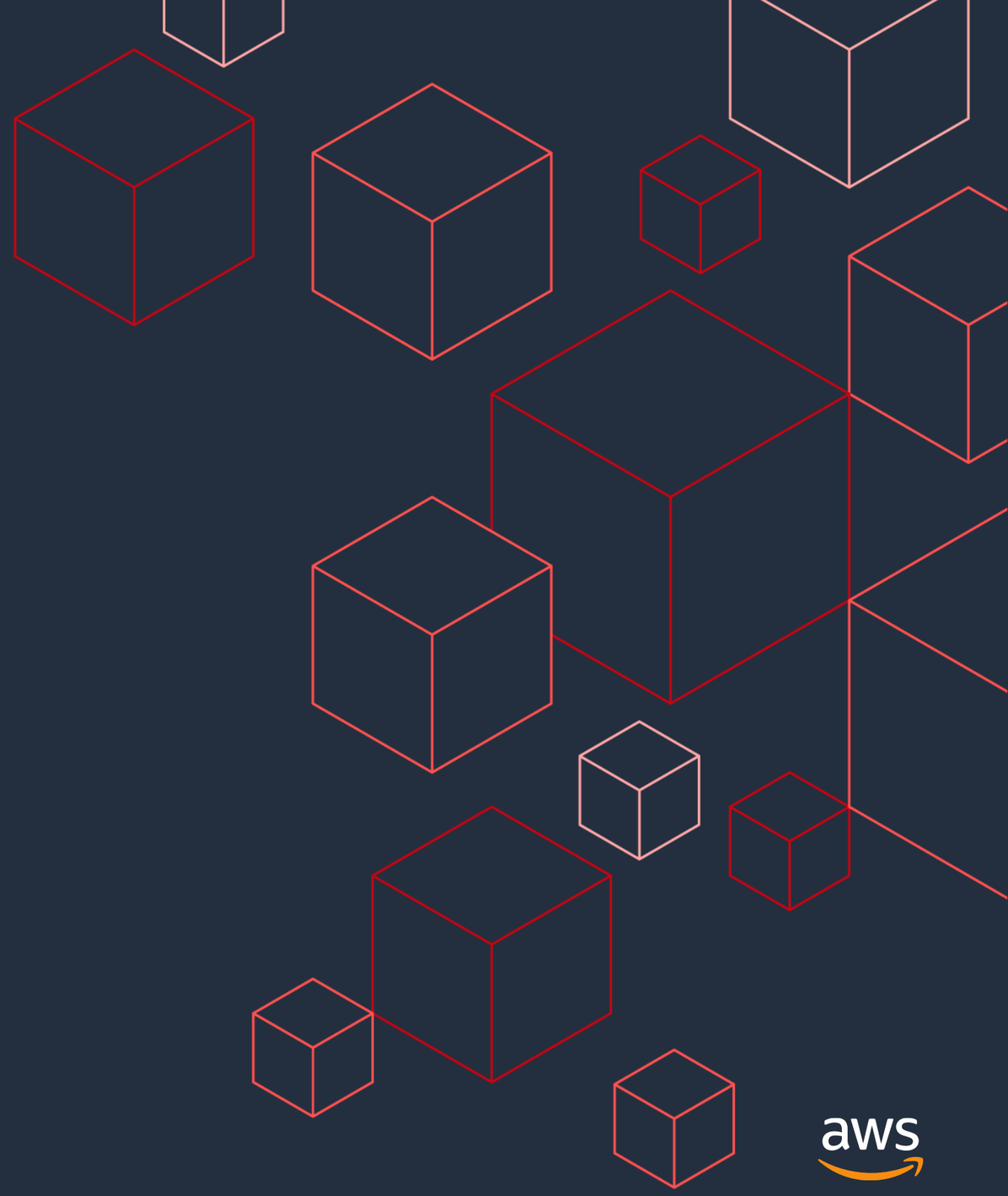
What’s Coming?



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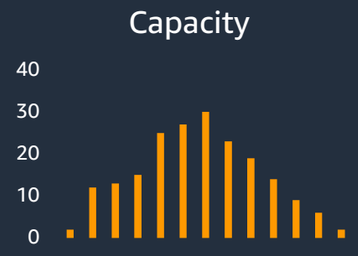
Introducing Amazon Aurora Serverless v2 (preview)

An auto-scaling configuration for Amazon Aurora that now supports even the most demanding applications and database workloads

Scale instantly, from hundreds to hundreds-of-thousands of transactions, in a fraction of a second



Scale in fine-grained increments to provide just the right amount of database capacity

Full breadth of Aurora capabilities including Multi-AZ, Global Database

Up to 90% cost savings when compared to provisioning for peak load

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What’s Coming?

- Aurora Serverless V2
- Babelfish for Aurora PostgreSQL
- MySQL JDBC driver

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Summary

- Amazon Aurora takes advantage of the cloud native features.
- Amazon Aurora uses a purpose built, log structured storage.
- Amazon Aurora has built in features like Automated backups, Multi-AZ, Global DB, and more that make it highly resilient to failures.
- Features like Backtrack, fast recovery, fast cloning makes it easy to recover from failures.
- Recovery from failure can be further managed by using RDS Proxy.
- New features like serverless V2 will improve scaling and performance.

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