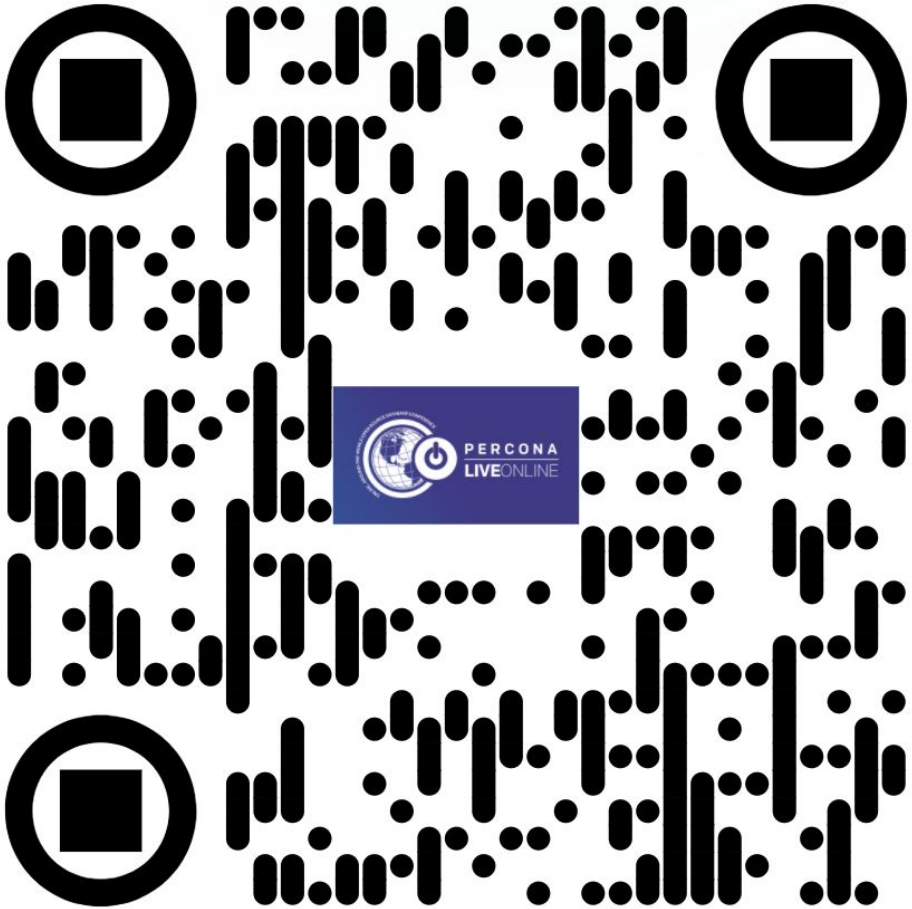
Understanding AWS RDS Aurora Capabilities

Percona Live Online
May 2021

Ronald Bradford - http://ronaldbradford.com



Slides - https://j.mp/RDSAuroraPL21

Overview

- What is Aurora?
  - Features & Capabilities
- Why consider Aurora?
- The various Aurora HA Setups
- Upsizing / Failover Example
- Aurora specific internals for MySQL architects & admins
- Other Aurora Features and Functionality

About Myself

- 20+ years MySQL experience in architecture and operations
- 15 years conference speaking
- Published author of 4 MySQL books

- Lead Data Architect/Engineer at Lifion by ADP

http://ronaldbradford.com

What is AWS RDS Aurora?

- Amazon Web Services (AWS)
- Relational Database Service (RDS)
  - MySQL/MariaDB/Postgresql/Oracle/SQL Server
- Aurora
  - MySQL and Postgres wire-compatible database built specifically for the AWS cloud

https://aws.amazon.com/rds/aurora

Aurora Features & Capabilities

- AWS managed RDBMS option
- Distributed cloud native architecture
- MySQL/Postgresql wire compatible
- A different transactional storage engine
- A different replication approach (read-free replicas)
- HA/Clustering/failover built-in by default

Aurora Features & Capabilities (2)

- Single writer/multiple readers
  - can support multi-master
- Decoupled compute/storage infrastructure
- Highly durable/redundant storage via quorum
- Log based architecture
- Improved recovery capabilities
- Fast DDL

Aurora Improved Availability, Backup & Recovery

- Fast recovery capabilities (log append design)
- Database cloning
- Snapshot restore
- Backtrack
- Zero Downtime Patching (ZDP)

https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/AuroraMySQL.Managing.Backtrack.html

https://aws.amazon.com/about-aws/whats-new/2019/11/amazon-aurora-mysql-5-7-now-supports-zero-downtime-patching/

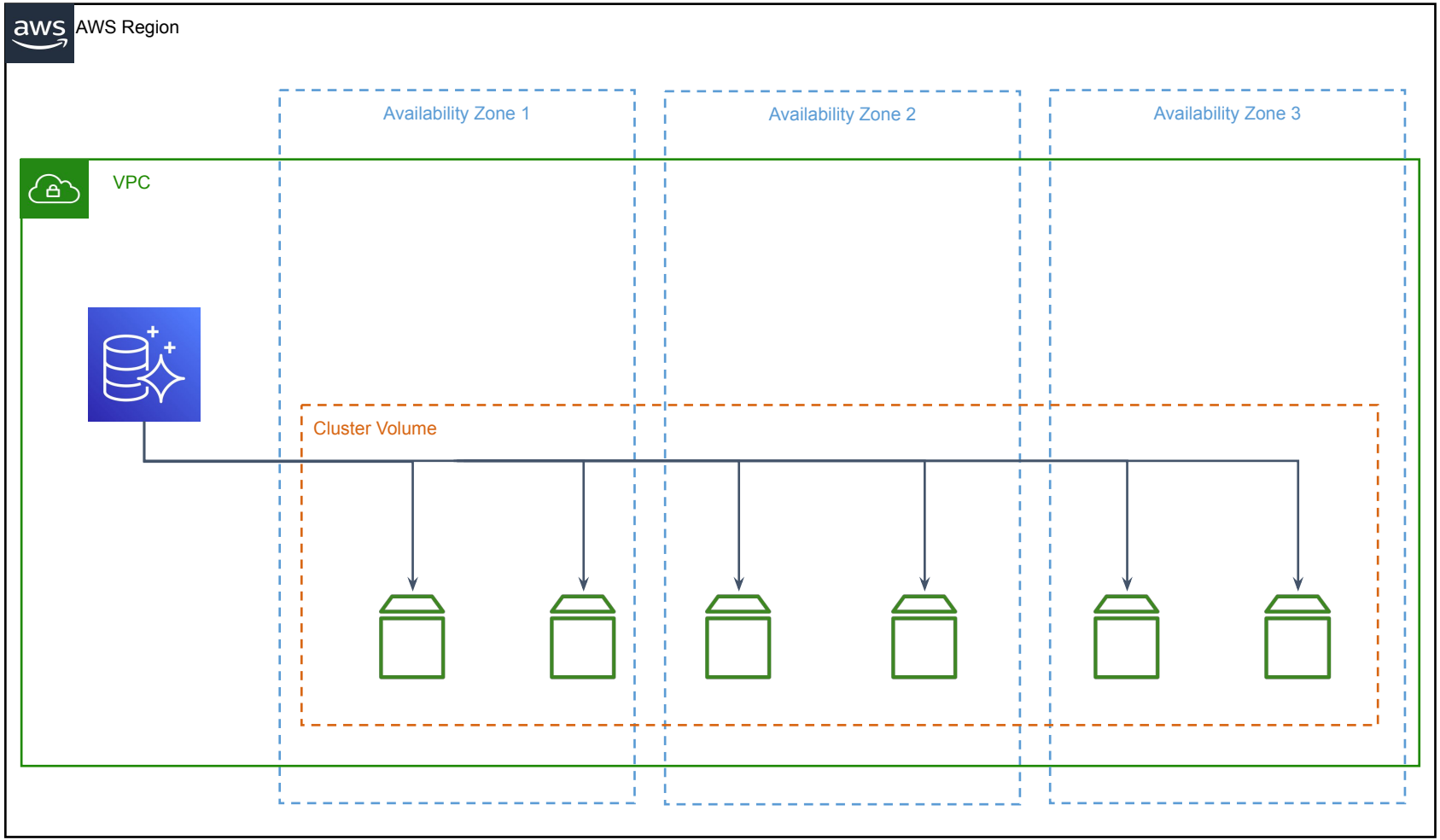
Aurora Cluster Architecture Features

A cluster has:

- Data in 3 Availability Zones (AZ)
- 2 copies per AZ
- 4 of 6 need for Quorum
- Route 53 Cluster & Instance Endpoints
  - Writer, Reader, Custom (Cluster), Instance
- Automatic Instance failover
- Replica Autoscaling

... (Diagram)

Cluster

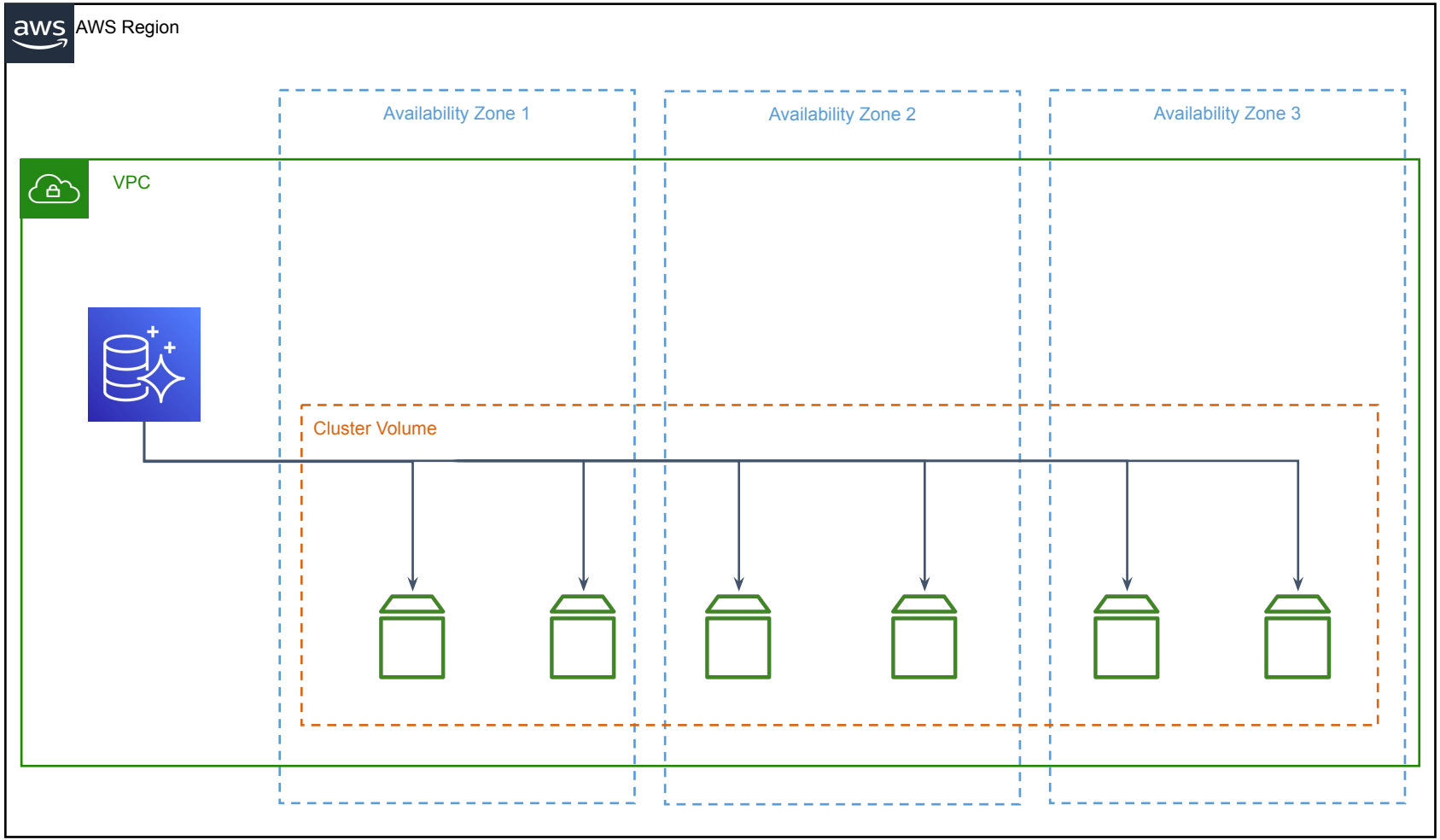

AWS Region
Availability Zone 1
Availability Zone 2
Availability Zone 3
VPC
Cluster Volume

Aurora Cluster - Single Instance

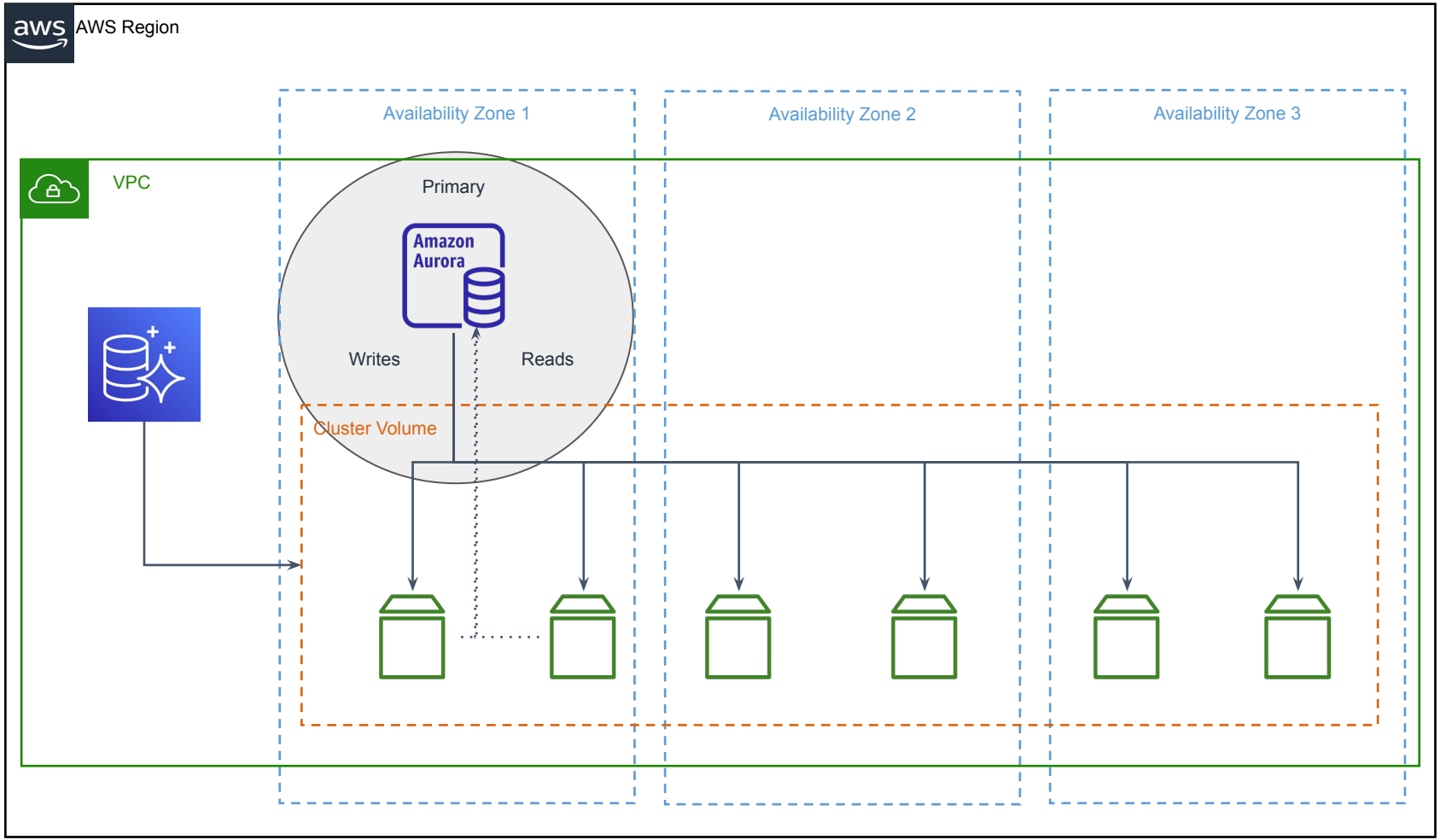
- Cluster
  - Storage in 3 AZs
  - Writer endpoint
  - Reader endpoint
- Single instance
  - In 1 AZ
  - Endpoint
  - Easily add additional instances

... (Diagram)

Cluster


AWS Region
Availability Zone 1
Availability Zone 2
Availability Zone 3
VPC
Cluster Volume

Cluster with Single Instance

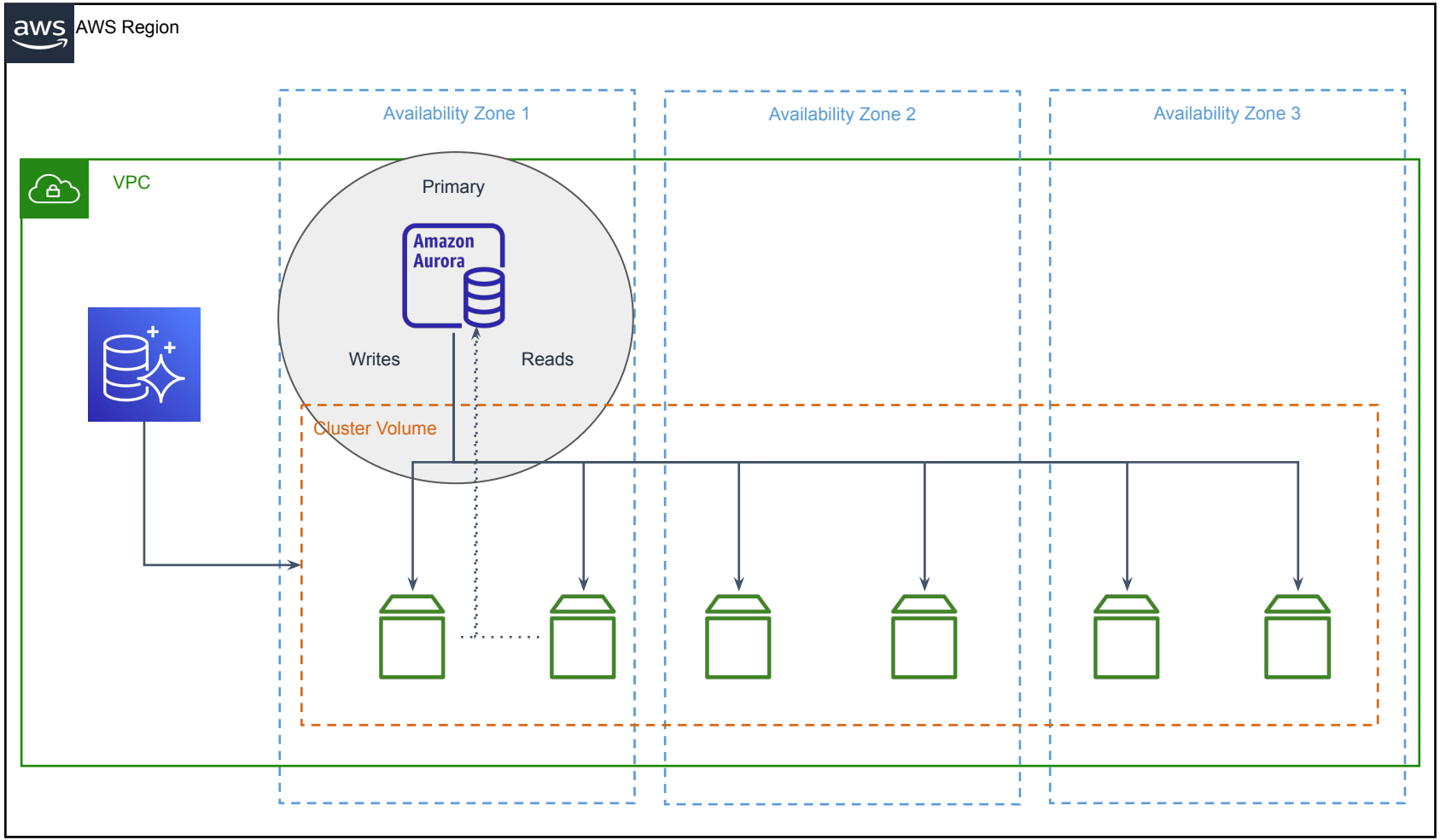


Aurora Cluster - Multiple Instances

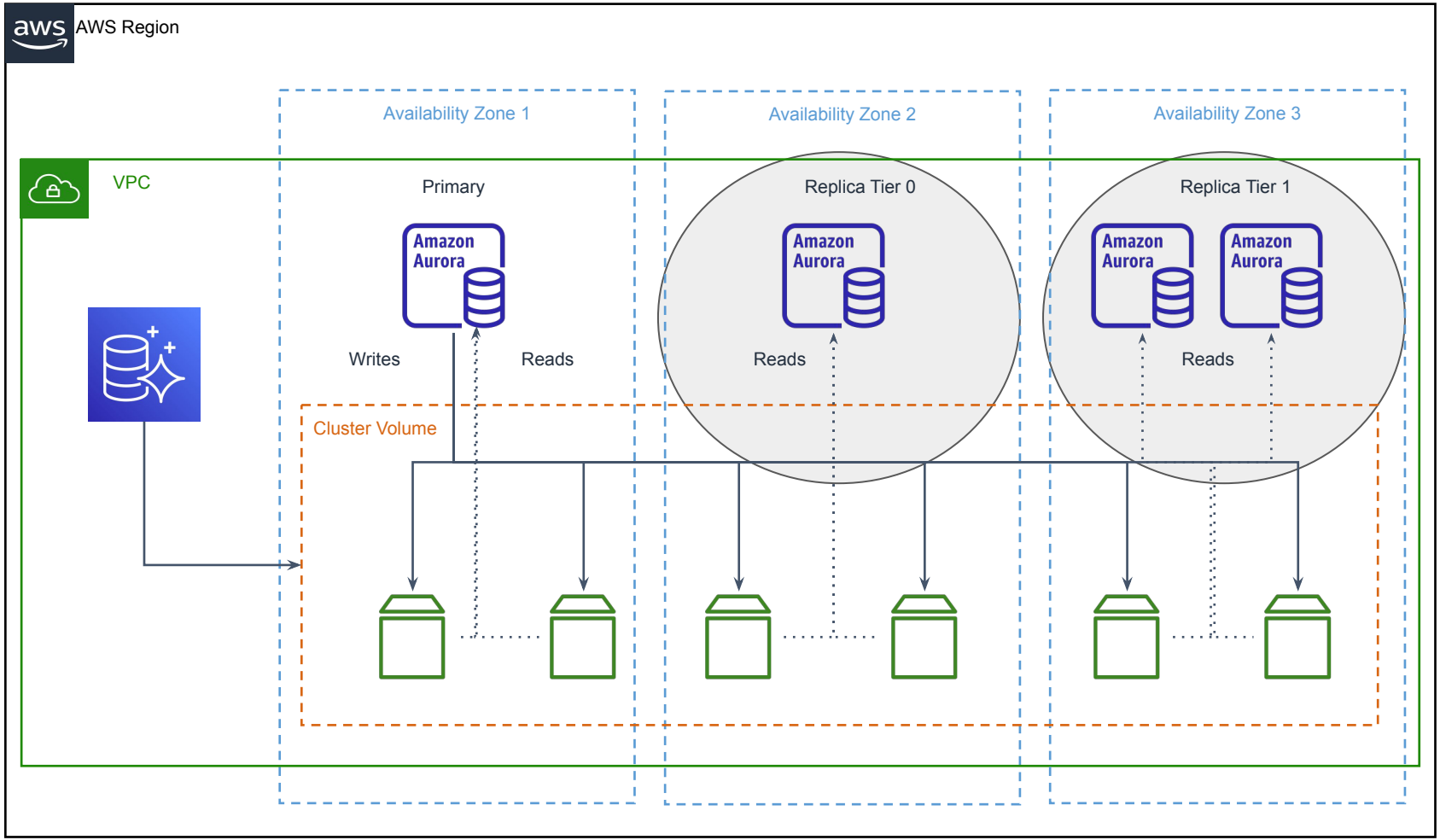
- Cluster
- Writer endpoint
  - Primary
- Reader endpoint
  - Load balanced across non primary instance(s)
- Multiple instance(s)
  - AZs of choice
- Promotion Tiers

... (Diagram)

Cluster with Single Instance



Cluster with Multiple Instances



Aurora Cluster - Multi-Master

- DB Instances are read & write
  - `--engine-mode multimaster`

Limitations

- Snapshots / ZDP / Load Balancing / Backtrack / Performance Insights
- Binary Logging
- Certain Datatypes
- Foreign Key CASCADE
- no fast DDL

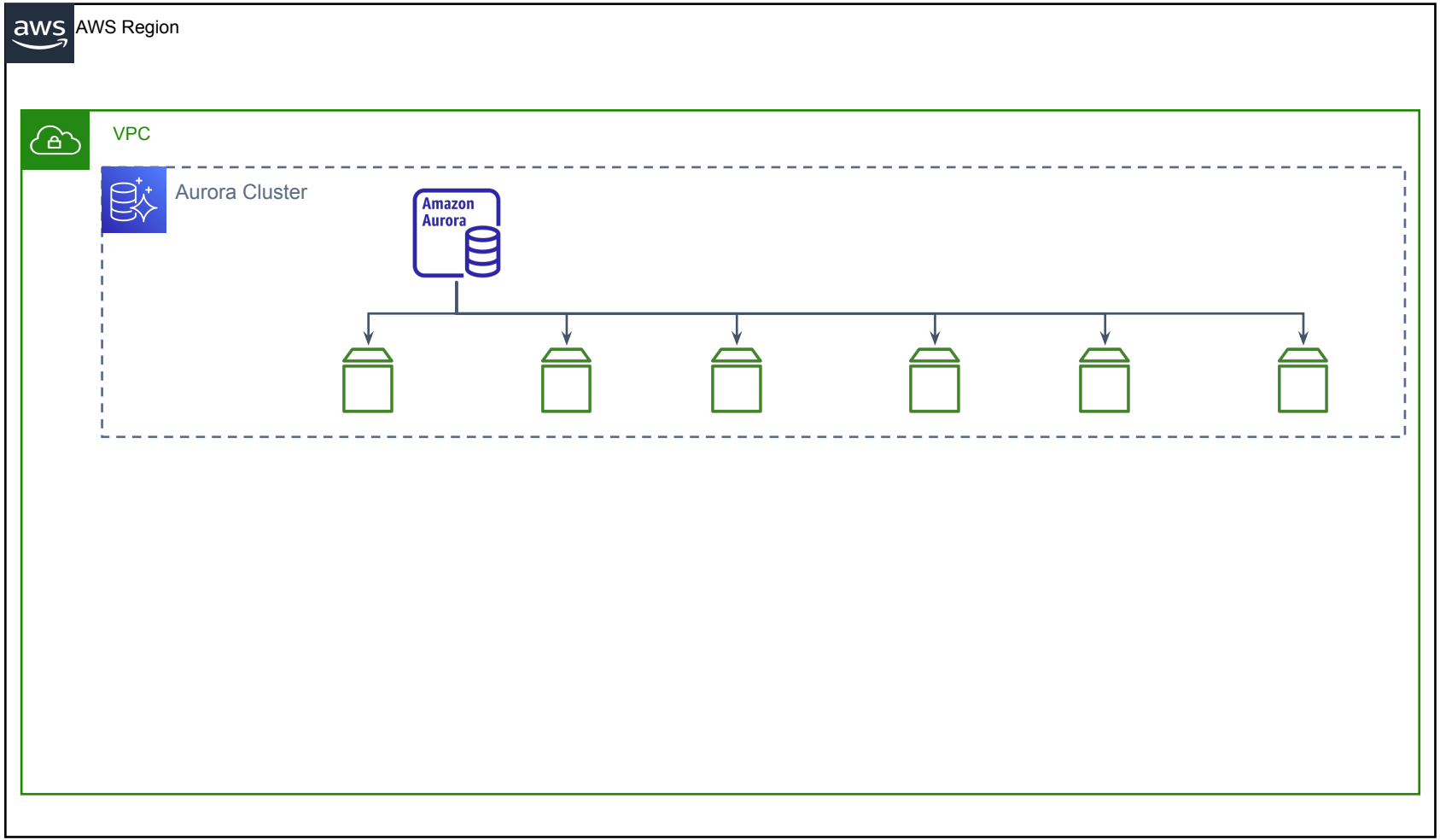
https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/aurora-multi-master.html

Multiple Aurora Clusters (1)

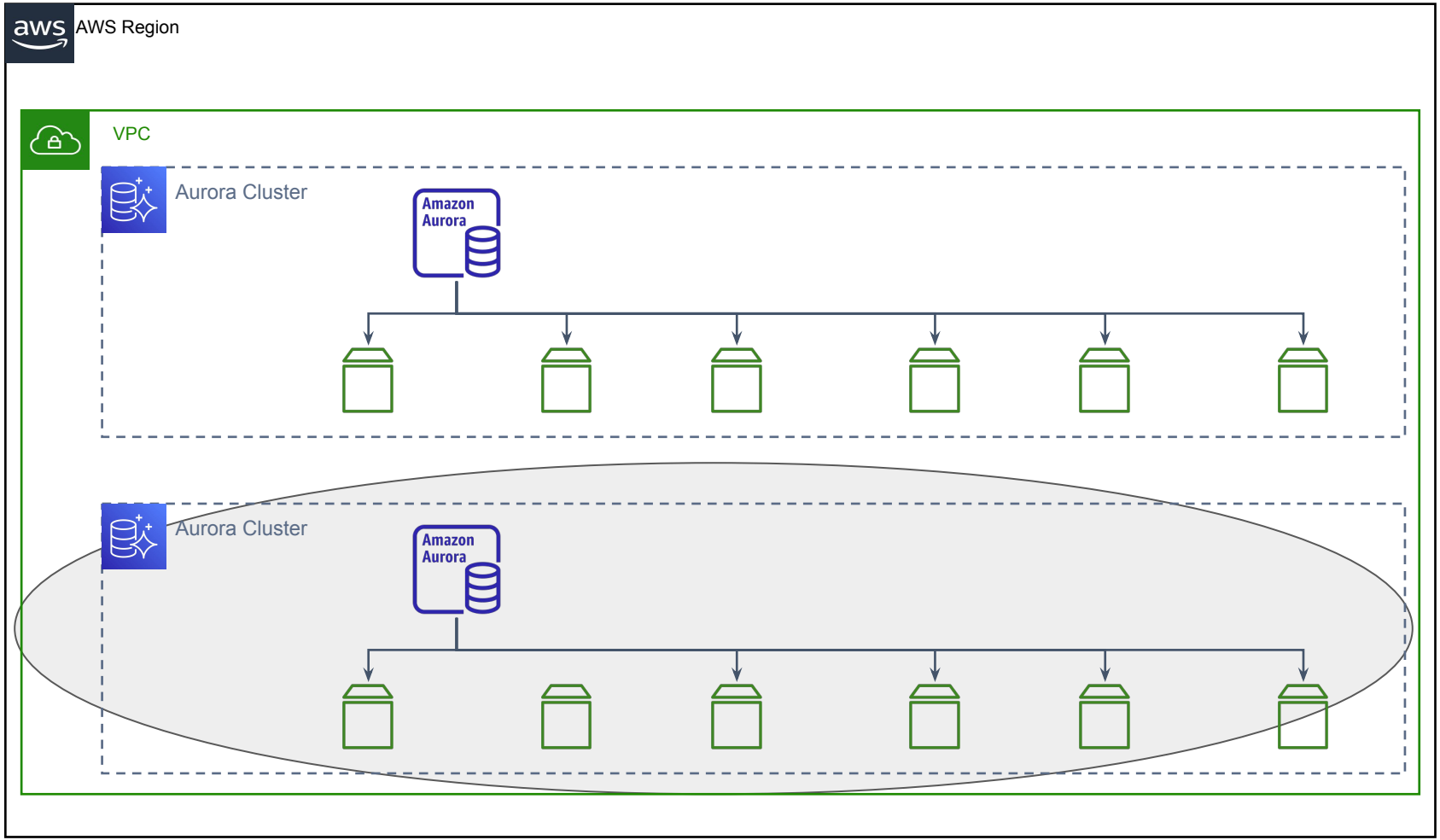
- Same region option
- Uses MySQL binary log replication
  - Needs to be enabled
  - GTID not support > 5.7
- Blue/Green deployments
- Shorter downtime upgrades

https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/AuroraMySQL.Replication.MySQL.html

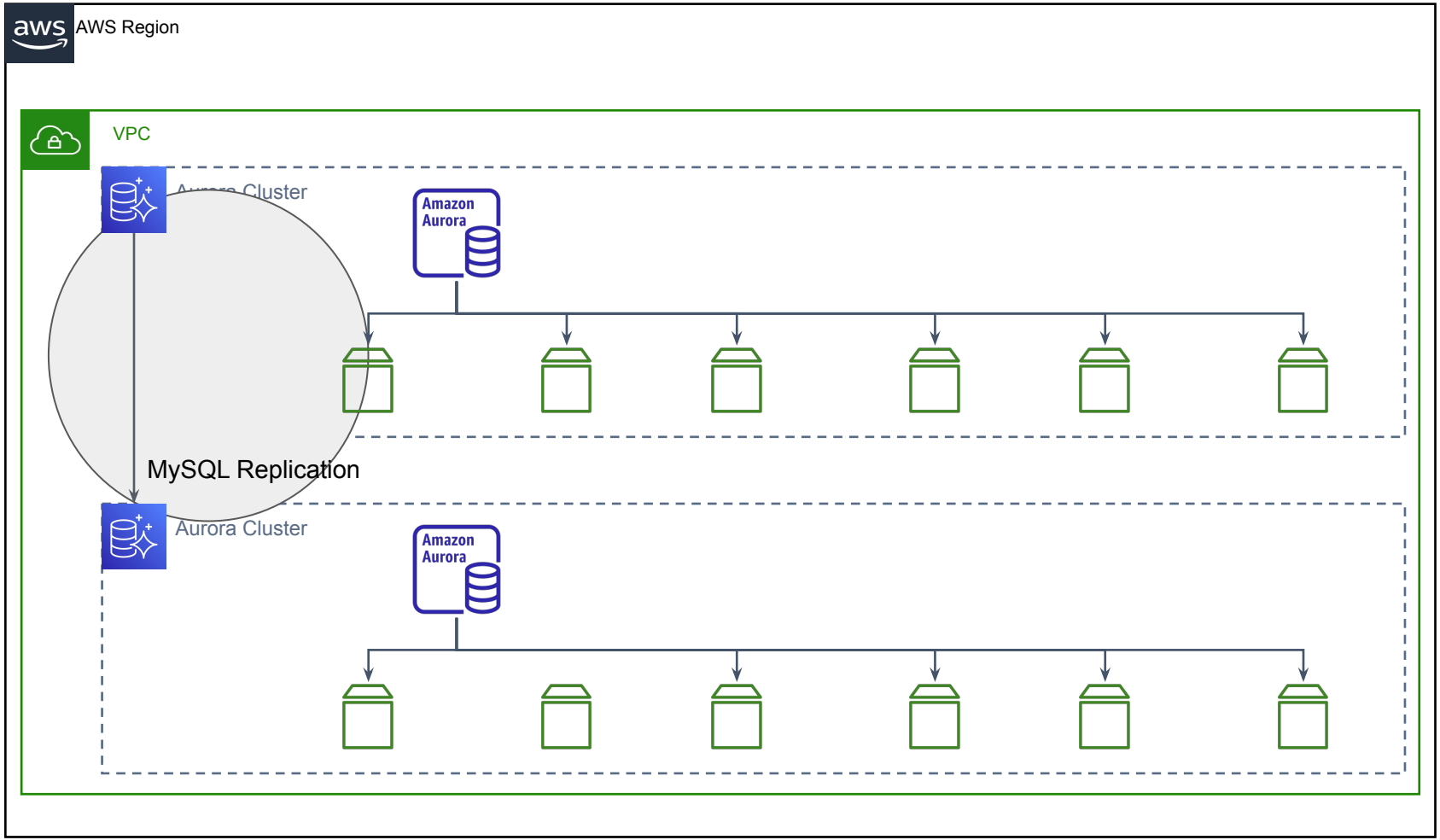
Cluster with Single Instance



Two separate clusters



Two separate clusters with binlog replication



Multiple Aurora Clusters Considerations

Source

```
mysql> CALL mysql.rds_show_configuration;
mysql> CALL mysql.rds_set_configuration('binlog retention hours', 144);
mysql> CREATE USER 'repl_user'@'<domain_name>' IDENTIFIED BY '<password>';
mysql> GRANT REPLICATION CLIENT, REPLICATION SLAVE ON *.* TO 'repl_user'@'<domain_name>';
mysql> GRANT USAGE ON *.* TO 'repl_user'@'<domain_name>' REQUIRE SSL;
```

Target

```
# Get position from snapshot restore
$ aws rds describe-events

mysql> CALL mysql.rds_set_external_master (
                                    host_name, host_port, replication_user_nam  e,replication_user_password,
                                    mysql_binary_log_file_name, mysql_binary_log_file_location,
ssl_encryptio n);
mysql> CALL mysql.rds_start_replication;
mysql> SHOW SLAVE STATUS;
```

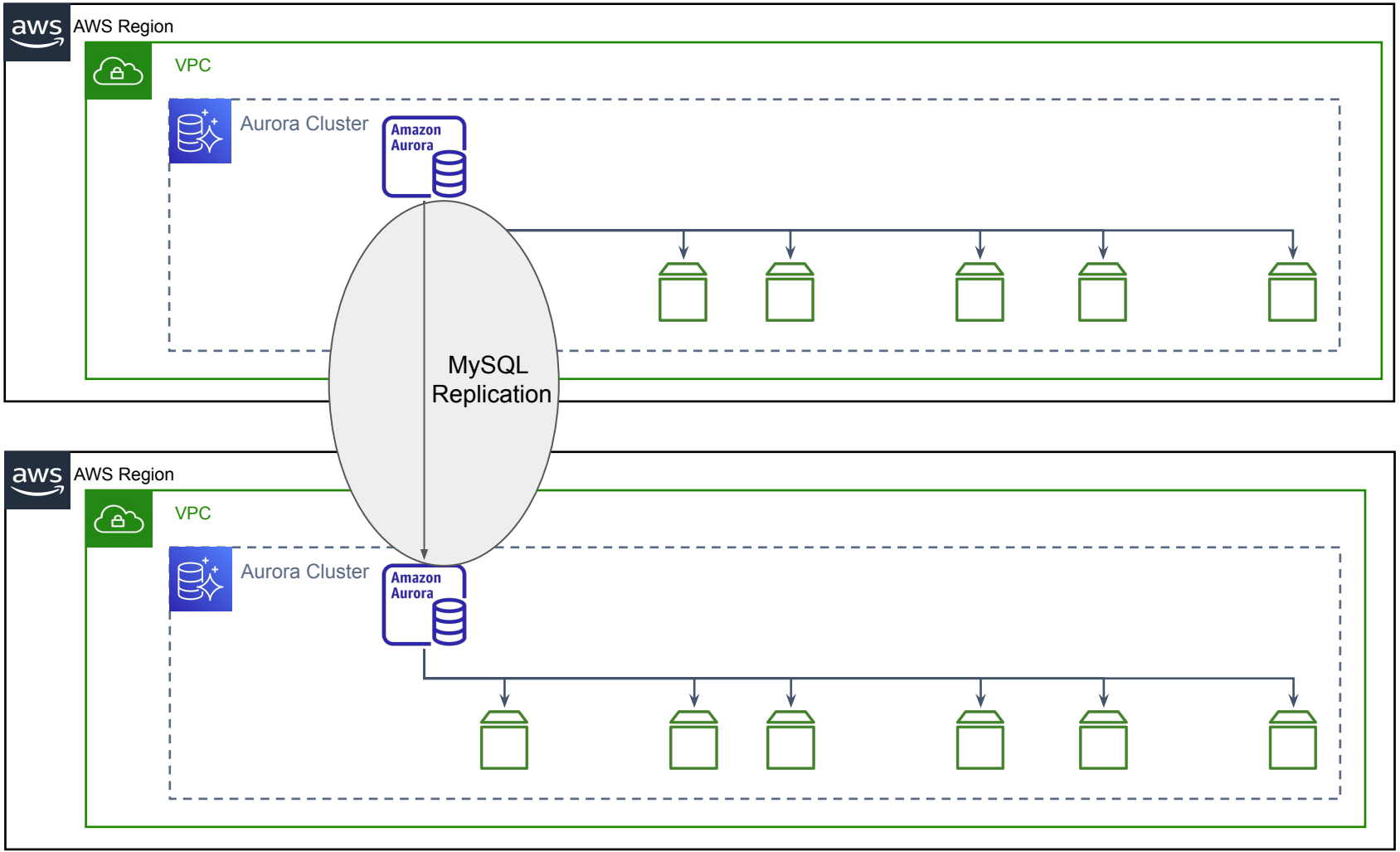
aws rds describe-events

```
# Get position from snapshot restore
$ aws rds describe-events

{
    "Events": [
        {
            "EventCategories": [],
            "SourceType": "db-instance",
            "SourceArn": "arn:aws:rds:us-west-2:123456789012:db:sample-restored-instance",
            "Date": "2016-10-28T19:43:46.862Z",
            "Message": "Binlog position from crash recovery is mysql-bin-changelog.000003 4278",
            "SourceIdentifier": "sample-restored-instance"
        }
    ]
}
```

Multiple Aurora Clusters (2)

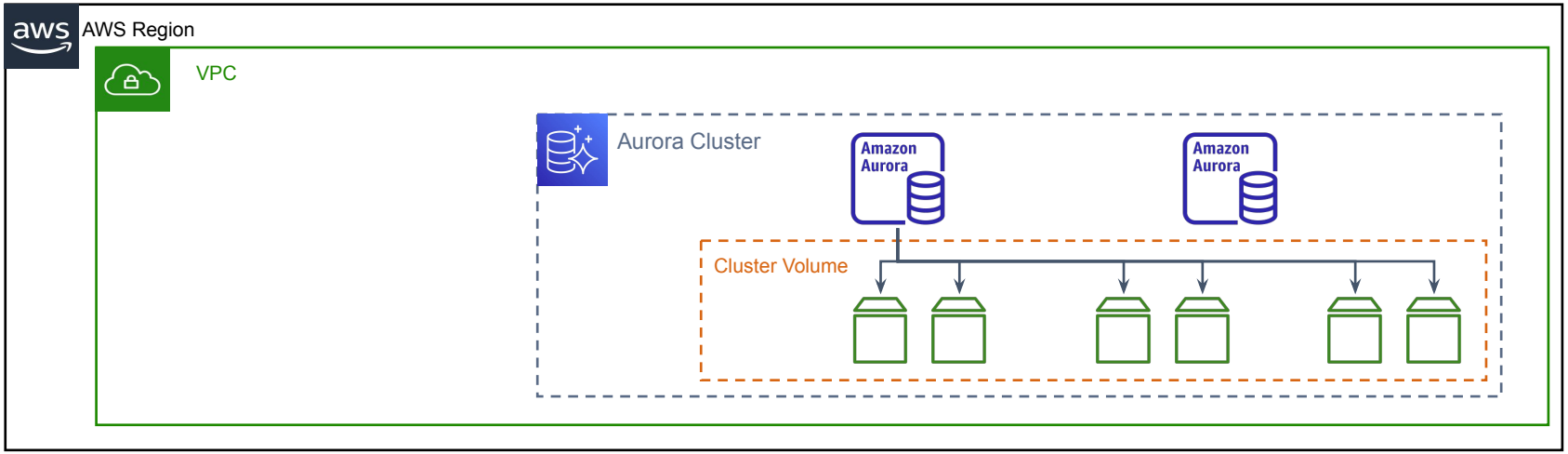
- Cross-region read replica
  - Support local read latency
- Improved DR
  - Failover not failback
- Region migration path
- Requires binary log replication
- Incurs cross-region transfer costs $$$

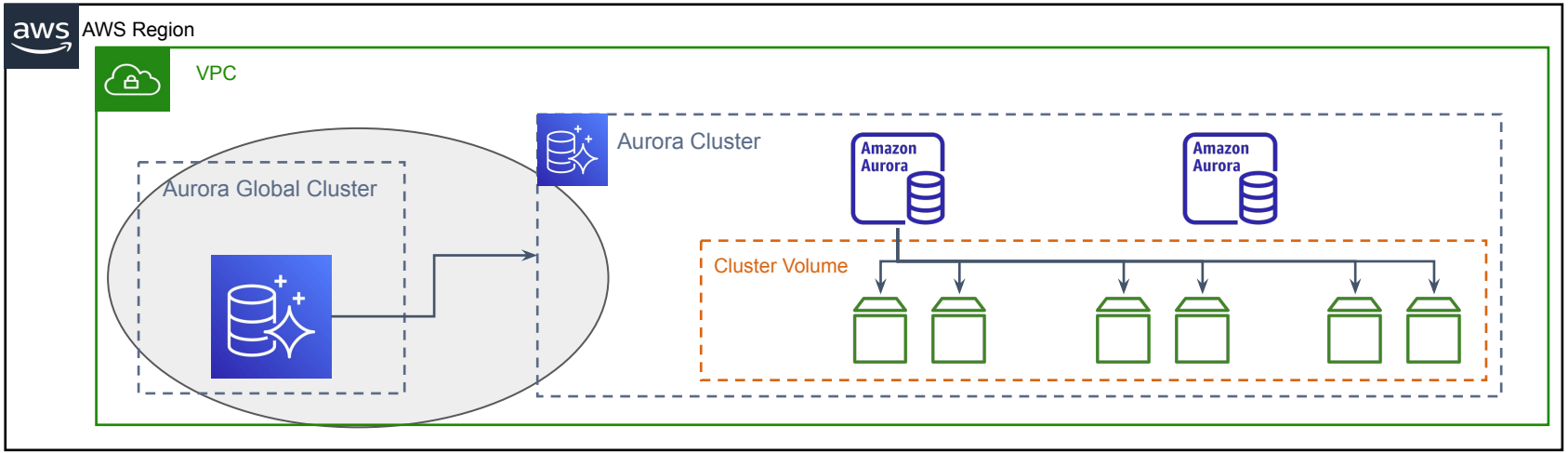
https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/AuroraMySQL.Replication.CrossRegion.html

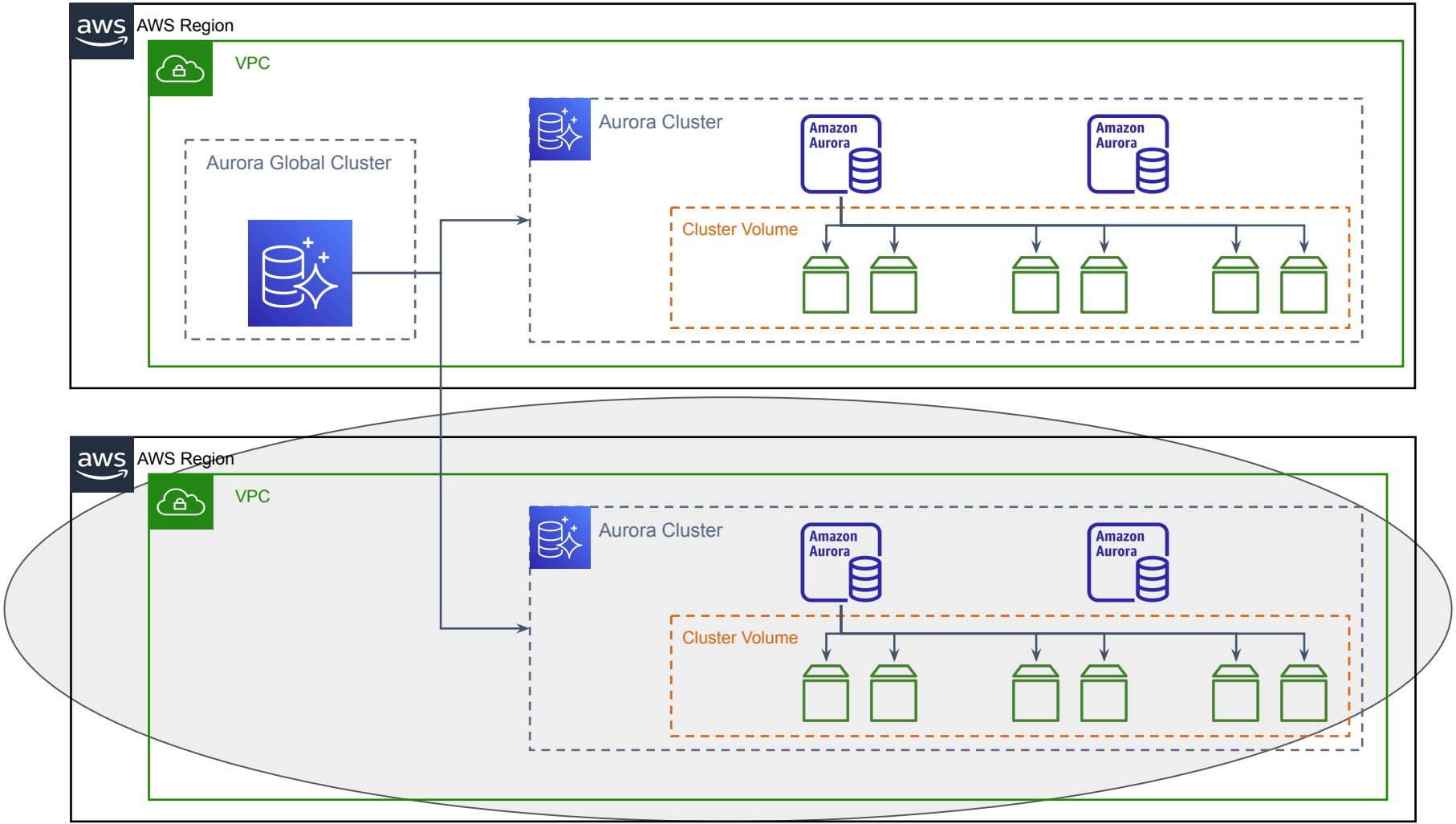

AWS Region
VPC
Aurora Cluster
Amazon Aurora
MySQL Replication
AWS Region
VPC
Aurora Cluster
Amazon Aurora

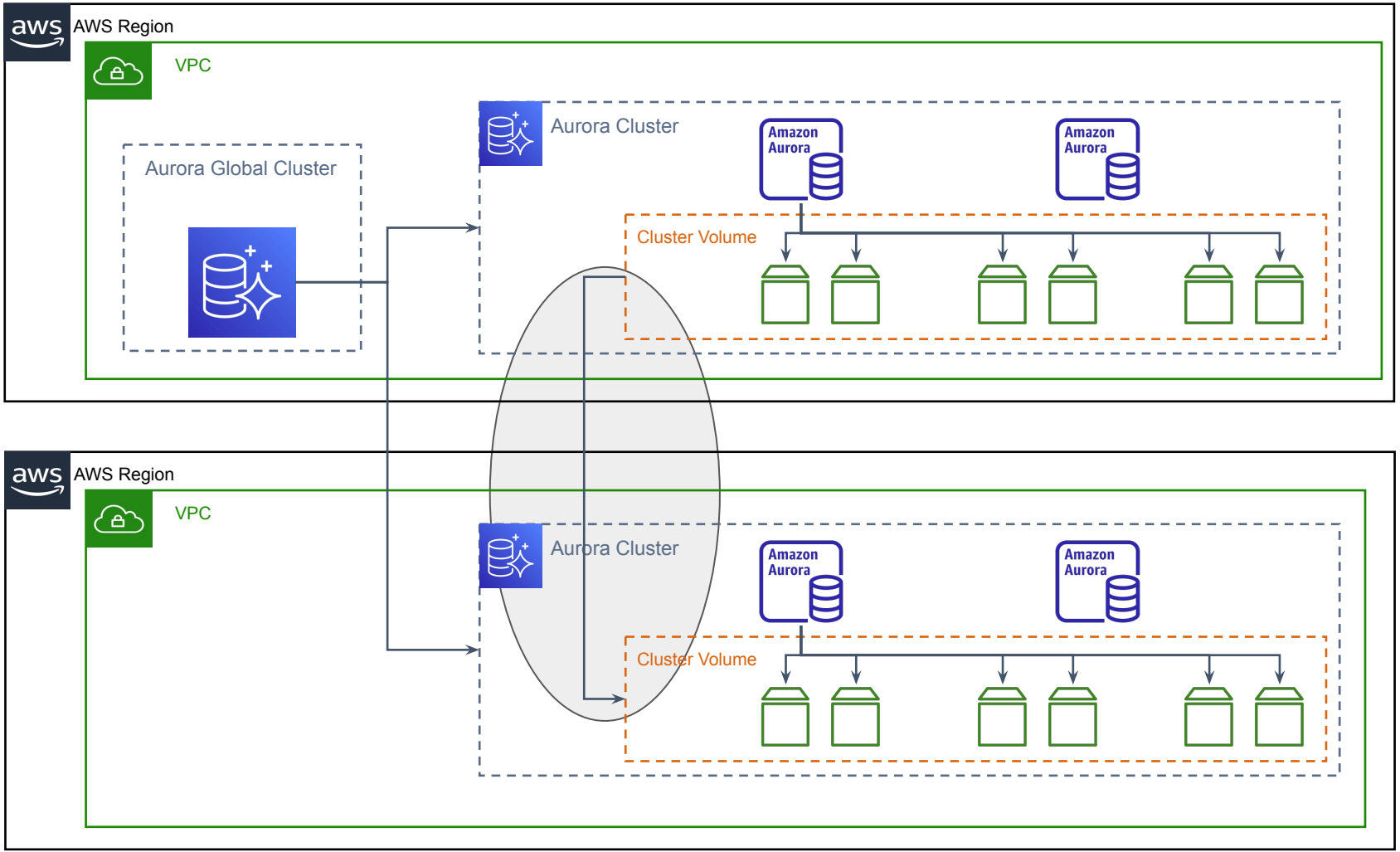
Aurora Global Cluster

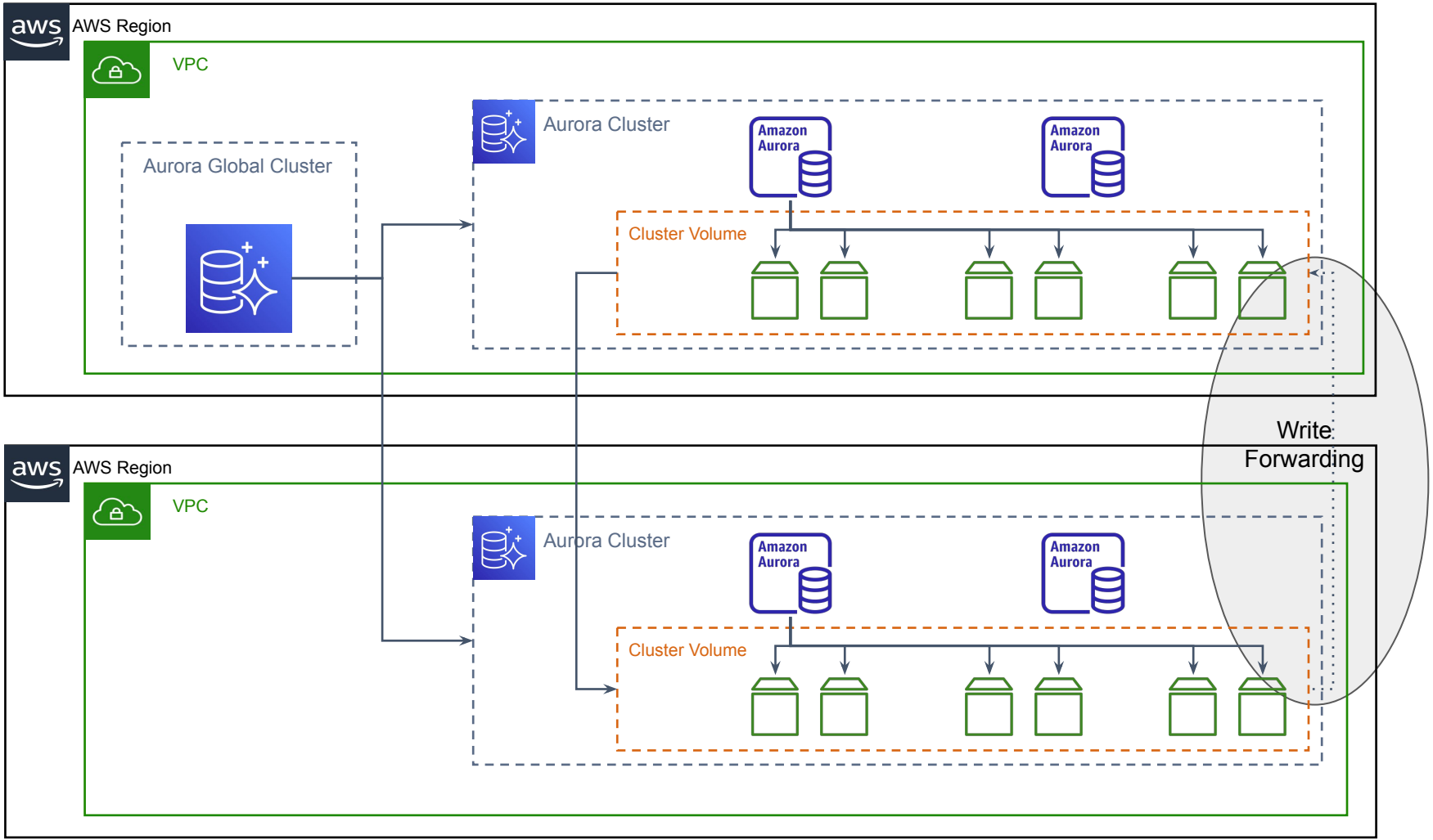
- One primary region
  - Up to 5 read-only secondary regions
- Uses Aurora storage for replication
  - Lag < 1 second
- RPO = 0
- Blocks writes before failover
- Read-only cluster supports write-forwarding capabilities


AWS Region
VPC
Aurora Cluster
Amazon Aurora
Amazon Aurora
Cluster Volume


AWS Region
VPC
Aurora Cluster
Aurora Global Cluster
Amazon Aurora
Amazon Aurora
Cluster Volume


AWS Region
VPC
Aurora Cluster
Amazon Aurora
Amazon Aurora
Aurora Global Cluster
Cluster Volume
AWS Region
VPC
Aurora Cluster
Amazon Aurora
Amazon Aurora
Cluster Volume


AWS Region
VPC
Aurora Cluster
Aurora Global Cluster
Amazon Aurora
Amazon Aurora
Cluster Volume
AWS Region
VPC
Aurora Cluster
Amazon Aurora
Amazon Aurora
Cluster Volume


AWS Region
VPC
Aurora Cluster
Aurora Global Cluster
Amazon Aurora
Amazon Aurora
Cluster Volume
Write Forwarding
AWS Region
VPC
Aurora Cluster
Amazon Aurora
Amazon Aurora
Cluster Volume

Maintenance Situations

Aurora Upgrades

- In-place upgrades (e.g. 2.09.1 to 2.09.2)
  - Whole process 5-10 minutes
  - DNS loss 10-20 seconds
  - ZDP (yet to see this work)
- Minor version (e.g. 2.07.3 to 2.09.2)
  - Very similar to in-place
- Major version (e.g. 2.09.2 to ?.?)
  - Yet to attempt

https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/AuroraMySQL.Updates.MajorVersionUpgrade.html

Aurora Upsizing / Failover

- Instances can be different instance types
  - Read Endpoint moves to Writer during upsize
- Controlled failover
  - Writer endpoint moves to new promoted instance
  - What was writer becomes a reader
- DNS connectivity loss 10-20 seconds

Aurora Upsizing / Failover Commands

```
CLUSTER ID="demo"
INSTANCE ID="${CLUSTER ID}-0"
aws rds describe-db-instances --db-instance-identifier ${INSTANCE_ID} | jq -r '.DBInstances[] | [.DBInstanceIdentifier,
.DBInstanceClass, .DBInstanceStatus]'
[  "demo-0",  "db.r5.large",  "available" ]

aws rds modify-db-instance --db-instance-identifier ${INSTANCE_ID} --db-instance-class db.r5.4xlarge --apply-immediately

aws rds describe-db-instances --db-instance-identifier ${INSTANCE_ID} | jq -r '.DBInstances[] | [.DBInstanceIdentifier,
.DBInstanceClass, .DBInstanceStatus]'
[  "demo-0", "db.r5.large", "modifying" ]

aws rds wait db-instance-available --db-instance-identifier ${INSTANCE ID}
aws rds describe-db-instances --db-instance-identifier ${INSTANCE_ID} | jq -r '.DBInstances[] | [.DBInstanceIdentifier,
.DBInstanceClass, .DBInstanceStatus]'
[  "demo-0",  "db.r5.4xlarge",  "available" ]

# Failover
aws rds describe-db-clusters --db-cluster-identifier ${CLUSTER_ID} | jq '.DBClusters[].DBClusterMembers'

aws rds failover-db-cluster --db-cluster-identifier ${CLUSTER_ID}

aws rds describe-db-clusters --db-cluster-identifier ${CLUSTER_ID} | jq '.DBClusters[].DBClusterMembers'
```

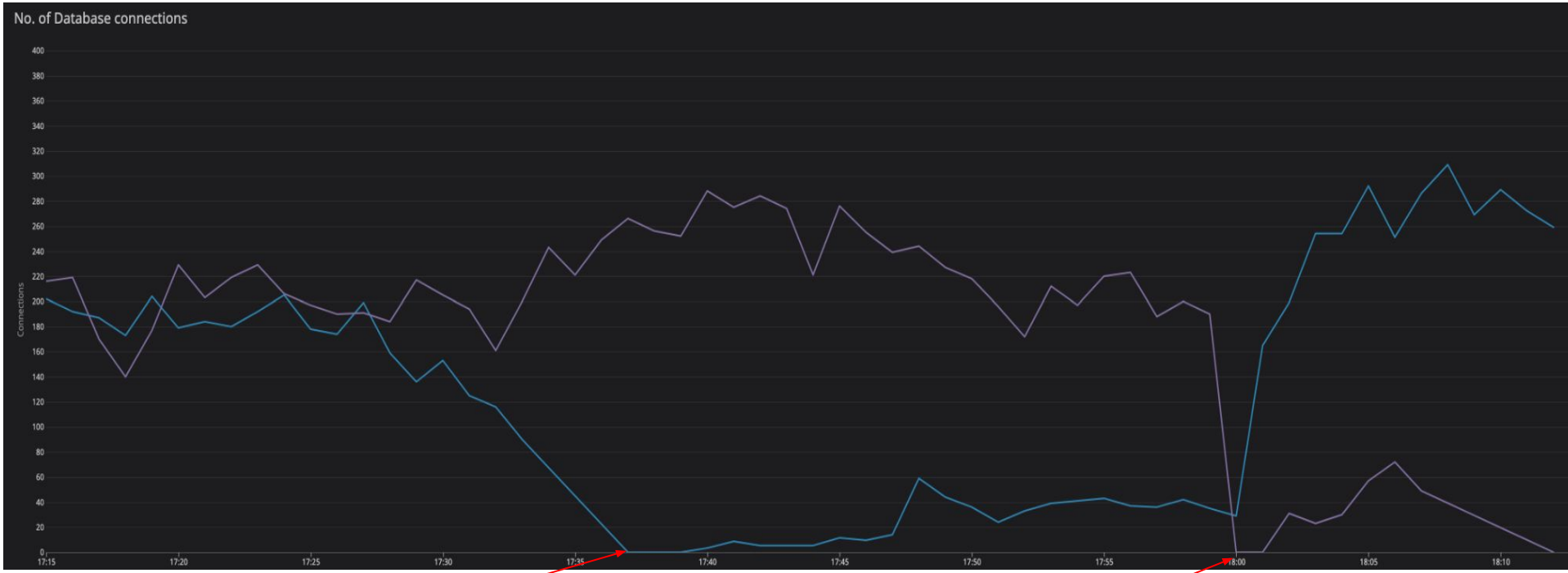
Aurora Upsizing / Failover Monitoring

```
# Endpoints
CLUSTER ID="demo"
INSTANCE ID="${CLUSTER ID}-0"
aws rds describe-db-clusters --db-cluster-identifier ${CLUSTER_ID} | jq '.DBClusters[].DBClusterMembers'


# Cluster Status
while : ; do date ; aws rds describe-db-instances --db-instance-identifier ${INSTANCE_ID} | jq -r '.DBInstances[] |
[.DBInstanceIdentifier, .DBInstanceClass, .DBInstanceStatus]'; sleep 5; done

# Instance endpoint availability (goes down during upsize)
MYSQL HOST=$(aws rds describe-db-instances  --db-instance-identifier ${INSTANCE_ID} | jq -r '.DBInstances[0].Endpoint.Address');
echo $MYSQL_HOST

while : ; do [ -n "${MYSQL PASSWD}" ] && date; time mysql -h ${MYSQL HOST} -u${MYSQL USER} -p${MYSQL PASSWD} -An --connect-timeout=1
-e "SELECT NOW(),@@aurora_server_id, variable_value from information_schema.global_status where variable_name='uptime'"; sleep 1;
done


# Cluster reader endpoint (fails over for new connections)
MYSQL HOST=$(aws rds describe-db-clusters --db-cluster-identifier ${CLUSTER_ID} | jq -r '.DBClusters[0].ReaderEndpoint'); echo
$MYSQL_HOST

while : ; do [ -n "${MYSQL PASSWD}" ] && date; time mysql -h ${MYSQL HOST} -u${MYSQL USER} -p${MYSQL PASSWD} -An --connect-timeout=1
-e "SELECT NOW(),@@aurora_server_id, variable_value from information_schema.global_status where variable_name='uptime'"; sleep 1;
done
```

Aurora Upsizing / Failover Timing Example

status=available	17:30:01 EDT 2021	18:05:12 EDT 2021
status=modifying	17:30:02 EDT 2021	18:05:19 EDT 2021
Reads flip to writer endpoint	17:32:48 UTC 2021	18:07:10 EDT 2021
Lose reader access	17:33:13 EDT 2021	18:07:42 EDT 2021
Accessible reader instance	17:37:33 EDT 2021 Uptime 19s	18:12:42 EDT 2021 Uptime 18s
status=configuring-enhanced-monitoring	17:39:28 EDT 2021	18:13:36 EDT 2021
status=modifying	17:40:35 EDT 2021	18:14:46 EDT 2021
status=storage-optimization	17:41:40 EDT 2021	N/A
status=available	17:53:53 EDT 2021	18:16:15 EDT 2021

Aurora Upsizing / Failover Graphs (CPU example)



First upsize

Second upsize

Other Topics (for another time)

Additional RDS/Aurora Capabilities

- IAM Authentication for users
- Aurora Query Cache
- Aurora Parallel Query — https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/aurora-mysql-parallel-query.html
- Aurora Monitoring — https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/MonitoringAurora.html
- DMS source & target
  - Replicate to/from RDS to RDS/Redshift/Kinesis etc
- Database Activity Streams
  - CDC to Kinesis — https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/DBActivityStreams.html
- Aurora specific tuning (binlog)
- RDS Proxy — https://aws.amazon.com/rds/proxy/
- Autoscaling (ASG) read replicas — https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/Aurora.Integrating.AutoScaling.html
- ...

Aurora Serverless

- For development & integration non 24x7 environments
- Cost versus performance benefits
- V1
- V2 (preview)

https://aws.amazon.com/rds/aurora/serverless/
https://docs.aws.amazon.com/AmazonRDS/latest/AuroraUserGuide/aurora-serverless-2.how-it-works.html

Chaos Aurora

```
SHOW VOLUME STATUS;

ALTER SYSTEM CRASH [ INSTANCE | DISPATCHER | NODE ];

ALTER SYSTEM SIMULATE percentage_of_failure PERCENT READ REPLICA FAILURE

    [ TO ALL | TO "replica name" ]

    FOR INTERVAL quantity { YEAR | QUARTER | MONTH | WEEK | DAY | HOUR | MINUTE | SECOND };

ALTER SYSTEM SIMULATE percentage_of_failure PERCENT DISK FAILURE

    [ IN DISK index | NODE index ]

    FOR INTERVAL quantity { YEAR | QUARTER | MONTH | WEEK | DAY | HOUR | MINUTE | SECOND };

ALTER SYSTEM SIMULATE percentage_of_failure PERCENT DISK CONGESTION

    BETWEEN minimum AND maximum MILLISECONDS

    [ IN DISK index | NODE index ]

    FOR INTERVAL quantity { YEAR | QUARTER | MONTH | WEEK | DAY | HOUR | MINUTE | SECOND };
```

Aurora under the hood

Quorums

https://aws.amazon.com/blogs/database/amazon-aurora-under-the-hood-quorum-and-correlated-failure/

https://aws.amazon.com/blogs/database/amazon-aurora-under-the-hood-quorum-reads-and-mutating-state/

https://aws.amazon.com/blogs/database/amazon-aurora-under-the-hood-reducing-costs-using-quorum-sets/

https://aws.amazon.com/blogs/database/amazon-aurora-under-the-hood-quorum-membership/

Conclusion

Conclusion

- Managed services helps less resourced teams
- Monitoring cost is important
- Review performance between native/ec2/rds/aurora MySQL installations
- With managed services, some existing actions are limited/restricted
- HA infrastructure/ failover / upgrades are built-in capabilities

Slides:
http://ronaldbradford.com/blog/understanding-aws-rds-aurora-capabilities-2021-05-13/

Thank You

https://perconalive.com

Aurora Metadata (5.7)

RDS/Aurora Metadata

- Variables (35)
- Status (101)
- INFORMATION_SCHEMA tables/views (18)
- mysql tables (19)
- MySQL Procedures (31)
- MySQL Privileges (5)
- Other

RDS/Aurora Metadata Variables

```
+-------------------------------------------+-------------------------------+
| Variable name                             | Value                         |
+-------------------------------------------+-------------------------------+
| aurora backtrace compare metrics file     | backtrace compare metrics.txt |
| aurora backtrace dedupe string_filename   | backtrace dedupe strings.txt  |
| aurora backtrace file name                | mysqld-backtrace.txt          |
| aurora binlog reserved event bytes        | 1024                          |
| aurora binlog use large read buffer       | ON                            |
| aurora das persistence threads            | 4                             |
| aurora disable hash join                  | ON                            |
| aurora disable sync tmz                   | OFF                           |
| aurora enable repl bin log filtering      | ON                            |
| aurora enable replica log compression     | ON                            |
| aurora enable staggered_replica_restart   | OFF                           |
| aurora enable zdr                         | OFF                           |
| aurora fwd master idle timeout            | 60                            |
| aurora fwd master max connections_pct     | 10                            |
| aurora globaldb rpo in seconds            | 4294967295                    |
| aurora globaldb rpo wait_timeout          | 60                            |
| aurora is 57 supported                    | OFF                           |
| aurora is mm supported                    | OFF                           |
| aurora lab mode                           | OFF                           |
| aurora load from s3 role                  |                               |
| aurora max alter table log entries        | 1000                          |
| aurora_max_connections_limit              | 16000                         |
...
| aurora oom response                       |
| aurora parallel query                     | OFF
| aurora performance_schema_sql_info_max_size | 4096
| aurora pq force                           | OFF
| aurora read replica read committed        | OFF
| aurora replica read consistency           |
| aurora select into s3 encryption_default | OFF
| aurora select into_s3_role                |
| aurora server id                          | demo-0
| aurora table open cache                   | 0
| aurora use key_prefetch                   | ON
| aurora version                            | 2.09.2
| aurora zdr timeout on replica fall behind   | 60
+-------------------------------------------+-------------
35 rows in set (0.00 sec)
```

RDS/Aurora Metadata Status

```
MySQL [(none)]> SHOW GLOBAL STATUS LIKE 'aurora%';
+-----------------------------------------------------------------+---------------------+
| Variable_name                                                   | Value               |
+-----------------------------------------------------------------+---------------------+
| AuroraDb_commits                                                | 2713838             |
| AuroraDb_commit_latency                                         | 14240360666         |
| AuroraDb_ddl_stmt_duration                                      | 6813933496          |
| AuroraDb_select_stmt_duration                                   | 447117597784        |
| AuroraDb_insert_stmt_duration                                   | 149184545636        |
| AuroraDb_update_stmt_duration                                   | 1160788797          |
| AuroraDb_delete_stmt_duration                                   | 2157752888          |
| AuroraDb_lockmgr_bitmaps0_in_use                                | 0                   |
| AuroraDb_lockmgr_bitmaps1_in_use                                | 0                   |
| AuroraDb_lockmgr_bitmaps_mem_used                               | 6506512             |
| AuroraDb_thread_deadlocks                                       | 0                   |
| Aurora_available_alter_table_log_entries                        | 0                   |
| Aurora_dict_sys_mem_size                                        | 132210210           |
| Aurora_fast_insert_cache_hits                                   | 0                   |
| Aurora_fast_insert_cache_misses                                 | 9                   |
| Aurora_fwd_master_dml_stmt_count                                | 0                   |
| Aurora_fwd_master_dml_stmt_duration                             | 0                   |
| Aurora_fwd_master_errors_rpc_timeout                            | 0                   |
| Aurora_fwd_master_errors_session_limit                          | 0                   |
| Aurora_fwd_master_errors_session_timeout                        | 0                   |
| Aurora_fwd_master_open_sessions                                 | 0                   |
| Aurora_fwd_master_select_stmt_count                             | 0                   |
| Aurora_fwd_master_select_stmt_duration                          | 0                   |
| Aurora_highest_commit_lsn                                       | 15610               |
| Aurora_last_allocated_lsn_for_replication                       | 156                 |
| Aurora_lockmgr_memory_used                                      | 841                 |
| Aurora_missing_history_on_replica_incidents                     | 0                   |
| Aurora_oom_response                                             |                     |
| Aurora_pq_max_concurrent_requests                               | 4                   |
| Aurora_pq_request_attempted                                     | 0                   |
...
| Aurora_pq_request_with_bloom_filter                             | 0                   |
| Aurora_pq_request_with_lob                                      | 0                   |
| Aurora_pq_stmt_attempted                                        | 0                   |
| Aurora_pq_stmt_attempted_hash_join                              | 0                   |
| Aurora_repl_bytes_received                                      | 0                   |
| Aurora_reserved_mem_exceeded_incidents                          | 0                   |
| Aurora_tmz_version                                              | 0                   |
| Aurora_total_op_memory                                          | 0                   |
| Aurora_total_op_temp_space                                      | 0                   |
| Aurora_used_alter_table_log_entries                             | 0                   |
| Aurora_volume_bytes_left_total                                  | 139                 |
+-----------------------------------------------------------------+---------------------+
101 rows in set (0.00 sec)
```

RDS/Aurora I_S tables

```
MySQL [information_schema]> SELECT table_name, table_type FROM information_schema.tables WHERE table_name LIKE 'RDS%' OR table_name
LIKE 'aurora%';
+----------------------------------------+-------------+
| table_name                             | table_type  |
+----------------------------------------+-------------+
| RDS_METRICS_META                       | SYSTEM VIEW |
| RDS_METRICS_GAUGE                      | SYSTEM VIEW |
| RDS_METRICS_COUNTER                  | SYSTEM VIEW |
| RDS_BUFFER_STAT_AT_STARTUP             | SYSTEM VIEW |
| RDS_PROCESSLIST                        | SYSTEM VIEW |
| RDS_CONTROL_PERFORMANCE_INSIGHTS_STATUS | SYSTEM VIEW |
| AURORA_FORWARDING_PROCESSLIST          | SYSTEM VIEW |
| aurora_s3_load_history                 | BASE TABLE  |
| rds_configuration                      | BASE TABLE  |
| rds_global_status_history              | BASE TABLE  |
| rds_global_status_history_old          | BASE TABLE  |
| rds_history                          | BASE TABLE  |
| rds_replication_status                 | BASE TABLE  |
| rds_sysinfo                            | BASE TABLE  |
| rds_events_threads_waits_current       | BASE TABLE  |
| rds_events_threads_waits_lock_current  | BASE TABLE  |
| rds_processlist                        | BASE TABLE  |
| Rds_Cluster_Info                       | BASE TABLE  |
+----------------------------------------+-------------+
18 rows in set (0.11 sec)
```

RDS/Aurora mysql tables

```
# mysql 5.7  31 rows
# aurora 5.7 50 rows
MySQL [mysql]> show tables;
+------------------------------+
| Tables_in_mysql              |
+------------------------------+
...
| aurora_s3_load_history       |
| bin_log_md_table             |
| bin_log_table                |
| ddl_log_md_table             |
| ddl_log_table                |
| general_log_backup           |
| metadata_md_table            |
| metadata_table               |
| rds_configuration              |
| rds_global_status_history    |
| rds_global_status_history_old |
| rds_history                  |
| rds_replication_status       |
| rds_sysinfo                  |
| ro_replica_status            |
| slow_log_backup              |
+------------------------------+
50 rows in set (0.00 sec)
```

RDS/Aurora Procedures

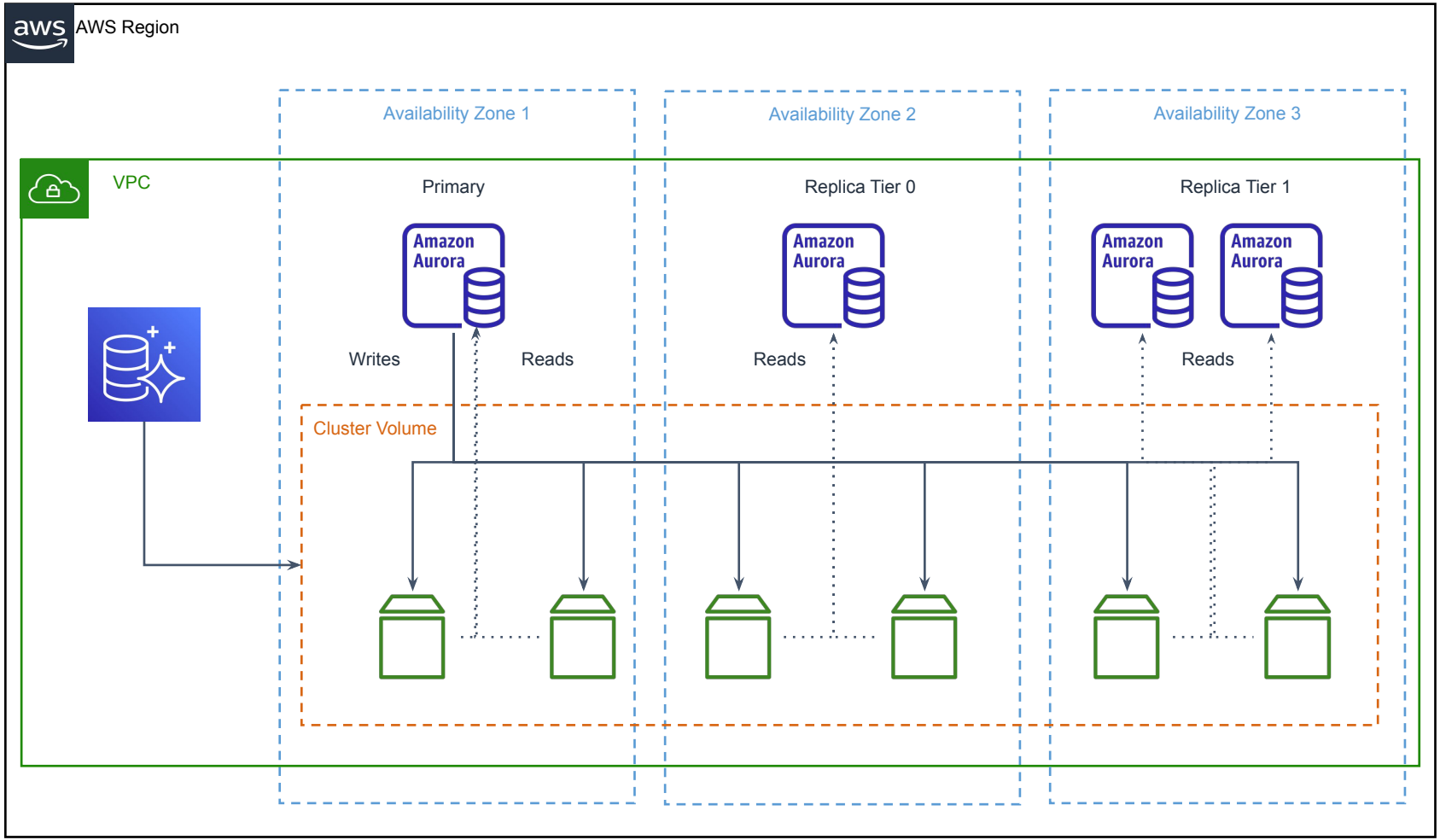
```
MySQL [information_schema]> SELECT name FROM mysql.proc WHERE name like 'rds%';
+-------------------------------------------+
| name                                      |
+-------------------------------------------+
| rds_collect_global_status_history         |
| rds_disable_gsh_collector                 |
| rds_disable_gsh_rotation                  |
| rds_enable_gsh_collector                  |
| rds_enable_gsh_rotation                   |
| rds_external_master                       |
| rds_import_binlog_ssl_material            |
| rds_innodb_buffer_pool_dump_now           |
| rds_innodb_buffer_pool_load_abort         |
| rds_innodb_buffer_pool_load_now           |
| rds_kill                                  |
| rds_kill_query                            |
| rds_next_master_log                       |
| rds_remove_binlog_ssl_material            |
| rds_reset_external_master                 |
| rds_rotate_general_log                    |
| rds_rotate_global_status_history          |
| rds_rotate_slow_log                       |
| rds_set_configuration                     |
| rds_set_external_master                   |
| rds_set_external_master_with_auto_position |
| rds_set_fk_checks_off                     |
| rds_set_fk_checks_on                      |
| rds_set_gsh_collector                     |
| rds_set_gsh_rotation                      |
| rds_set_master_auto_position              |
| rds_show_configuration                    |
| rds_skip_repl_error                       |
| rds_skip_transaction_with_gtid            |
| rds_start_replication                     |
| rds_stop_replication                      |
+-------------------------------------------+
31 rows in set (0.00 sec)
```

https://docs.aws.amazon.com/AmazonRDS/latest/UserGuide/Appendix.MySQL.SQLRef.html

RDS/Aurora Privileges

```
MySQL [information_schema]> SHOW PRIVILEGES;
+-------------------------+---------------------------------------+-------------------------------------------------------------------------
-----+
| Privilege                   | Context                             | Comment
       |
+-------------------------+---------------------------------------+-------------------------------------------------------------------------
-----+
...
| Load from S3                | AWS S3 Access                       | To load files from AWS S3
       |
| Select into S3              | AWS S3 Access                       | To query data from table(s) and store the result into file(s) on
AWS S3 |
| Invoke Lambda               | AWS Lambda Access                   |  To invoke Lambda from within the database
       |
...
+-------------------------+---------------------------------------+-------------------------------------------------------------------------
-----+

INVOKE SAGEMAKER
INVOKE COMPREHEND
```

RDS/Aurora Other


AWS Region
Availability Zone 1
Availability Zone 2
Availability Zone 3
VPC
Primary
Replica Tier 0
Replica Tier 1
Amazon Aurora
Amazon Aurora
Amazon Aurora
Amazon Aurora
Writes
Reads
Reads
Reads
Cluster Volume