AWS re:Invent

ANT418

Deep dive and best practices for Amazon Redshift

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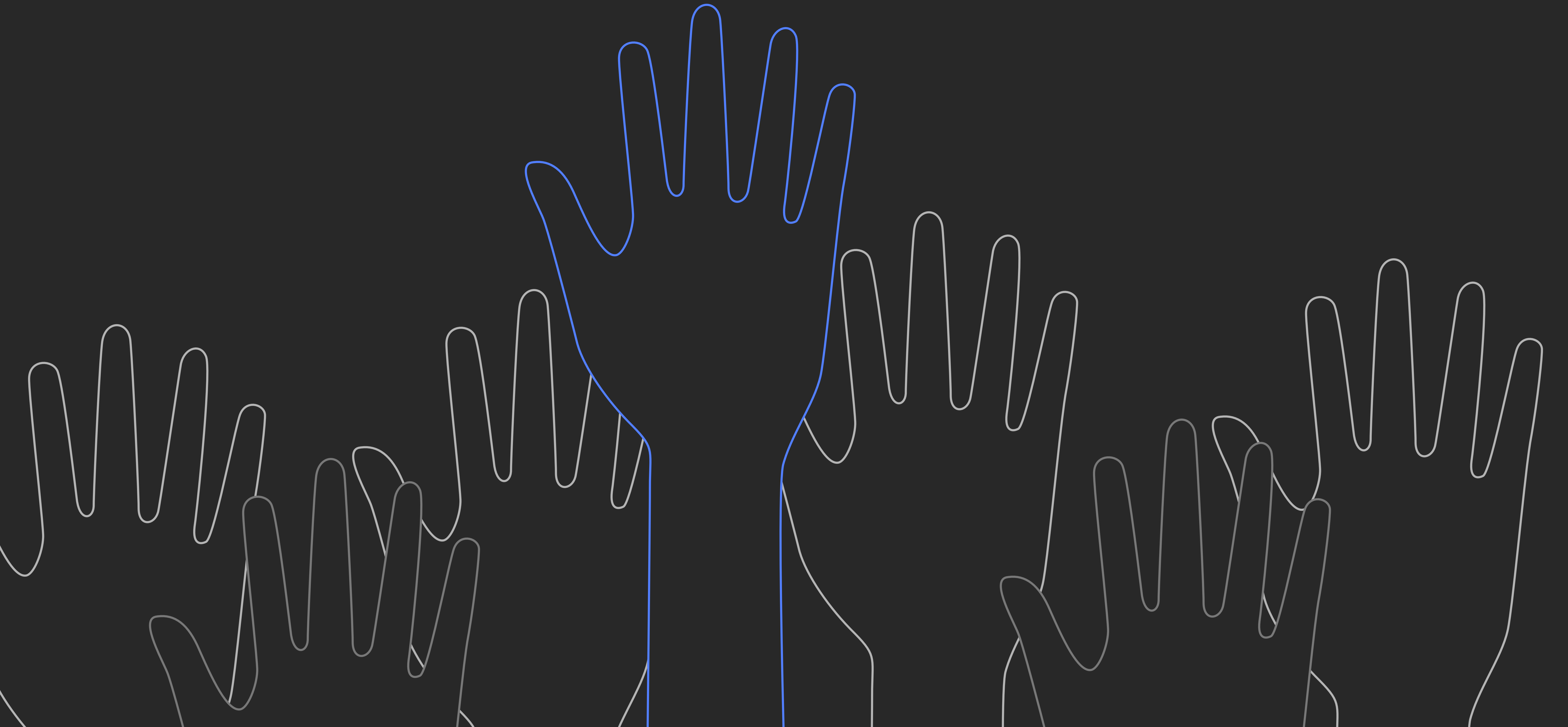
AWS re:Invent

aws

Are you an Amazon Redshift user?

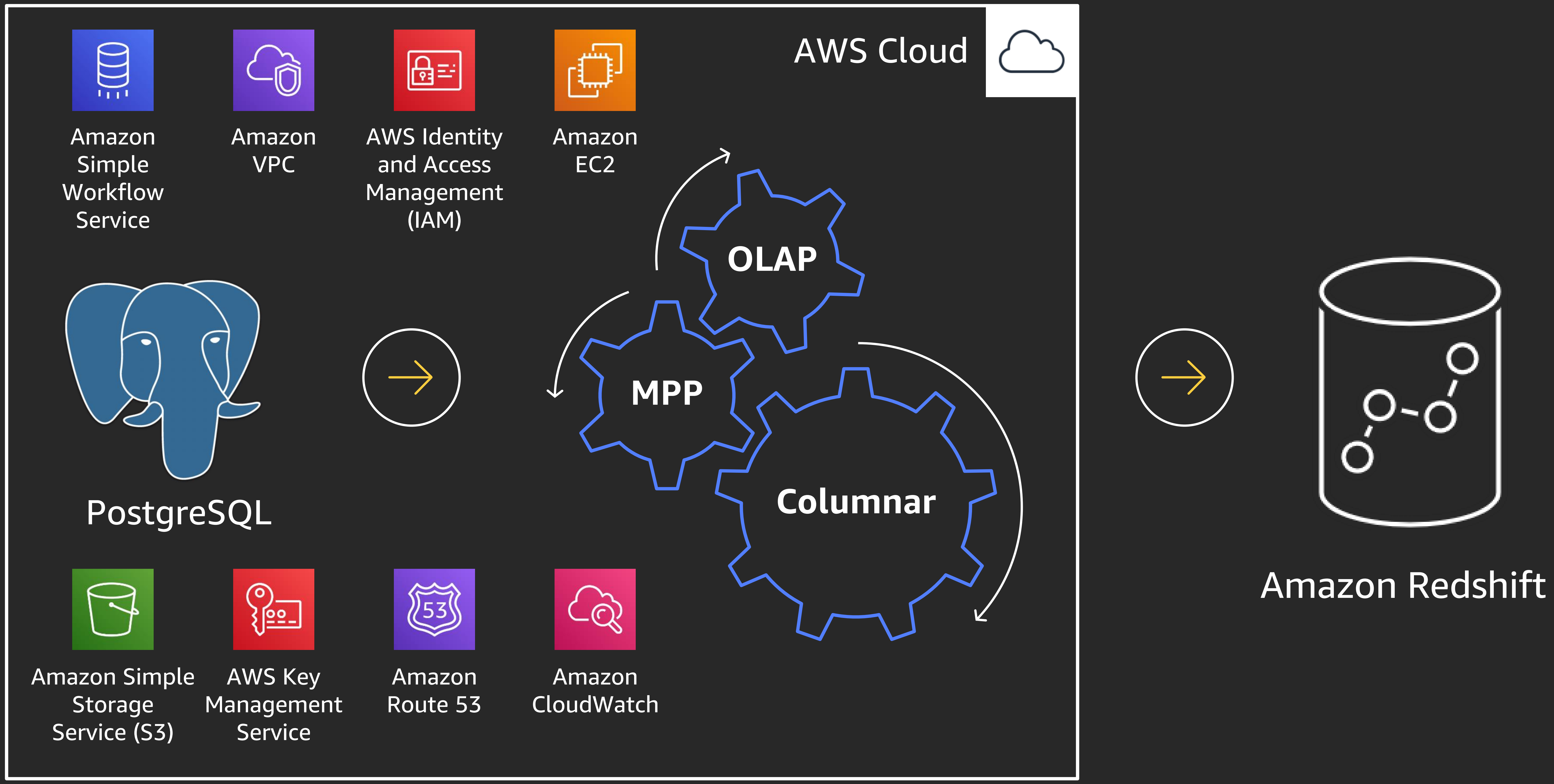


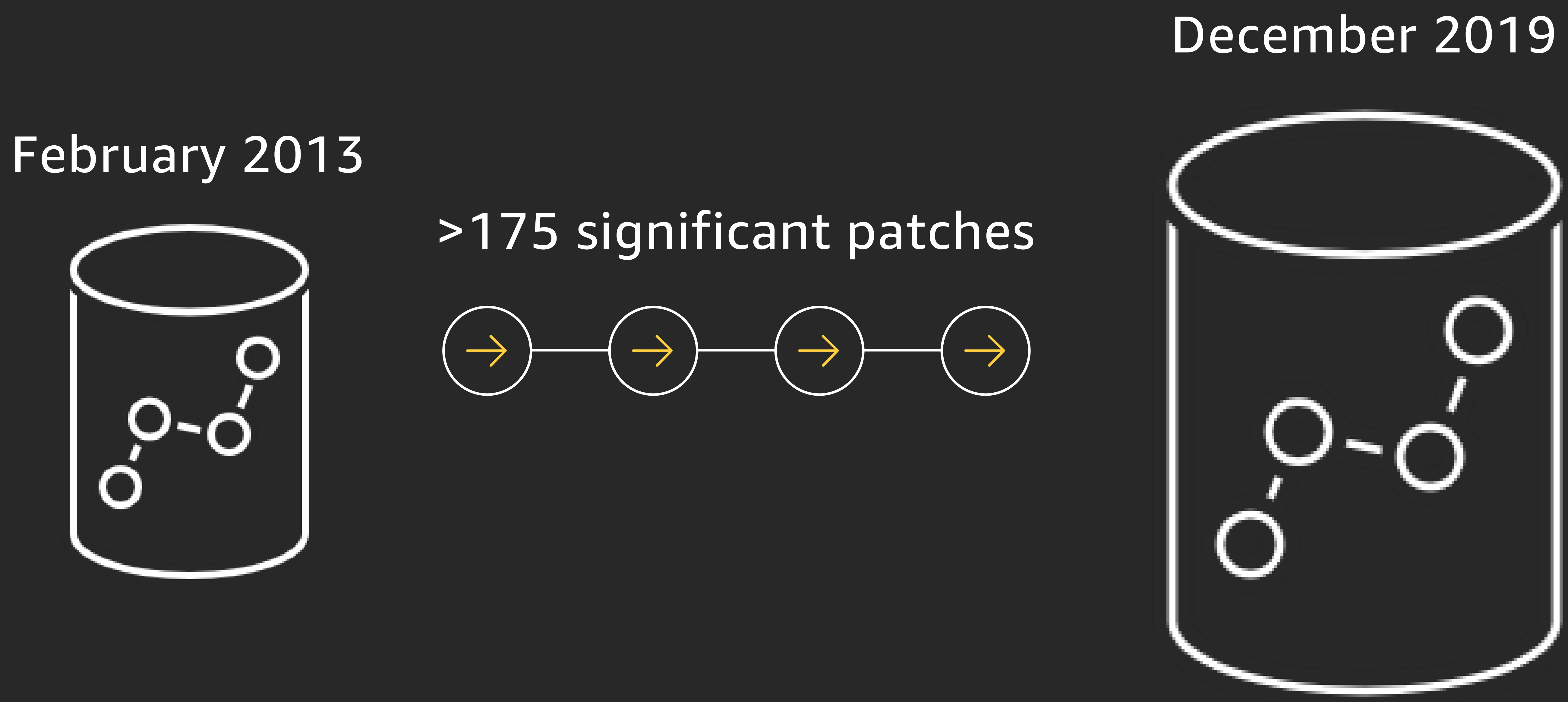
Agenda

- Architecture and concepts
- Data storage, ingestion, and ELT
- Workload management and query monitoring rules
- Cluster sizing and resizing
- Amazon Redshift Advisor
- Additional resources
- Open Q&A

Architecture and concepts

AWS re:Invent


AWS Cloud
Amazon Simple Workflow Service
Amazon VPC
AWS Identity and Access Management (IAM)
Amazon EC2
PostgreSQL
OLAP
MPP
Columnar
Amazon Simple Storage Service (S3)
AWS Key Management Service
Amazon Route 53
Amazon CloudWatch
Amazon Redshift


February 2013
>175 significant patches
December 2019

Amazon Redshift has been innovating quickly

Robust result set caching

Large # of tables support ~20000

Copy command support for ORC, Parquet

IAM role chaining

Elastic resize

Groups

Amazon Redshift Spectrum: Date formats, scalar json and ION file formats support, region expansion, predicate filtering

Auto analyze

Health and performance monitoring w/Amazon CloudWatch

Automatic table distribution style

Amazon CloudWatch support for WLM queues

Performance enhancements: Hash join, vacuum, window functions, resize ops, aggregations, console, union all, efficient compile code cache

Unload to CSV

Auto WLM

~25 Query Monitoring Rules (QMR) support

AQUA

Concurrency Scaling

200+

new features and enhancements in the past 18 months

DC1 migration to DC2

Resiliency of ROLLBACK processing

Manage multi-part query in AWS console

Auto analyze for incremental changes on table

Spectrum Request Accelerator

Apply new distribution key

Redshift Spectrum: Row group filtering in Parquet and ORC, nested data support, enhanced VPC routing, multiple partitions

Faster Classic resize with optimized data transfer protocol

Performance: Bloom filters in joins, complex queries that create internal table, communication layer

Amazon Redshift Spectrum: Concurrency scaling

AWS Lake Formation integration

Auto-Vacuum sort, Auto-Analyze, and Auto Table Sort

Auto WLM with query priorities

Snapshot scheduler

Stored procedures

Performance: Join pushdowns to subquery, mixed workloads temporary tables, rank functions, null handling in join, single row insert

Advisor recommendations for distribution keys

AZ64 compression encoding

Console redesign

Spatial processing

Column level access control with AWS Lake Formation

RA3

Performance of inter-region snapshot transfers

Federated query

Materialized views

Manual pause and resume

Amazon Redshift architecture

Massively parallel, shared nothing columnar architecture

Leader node

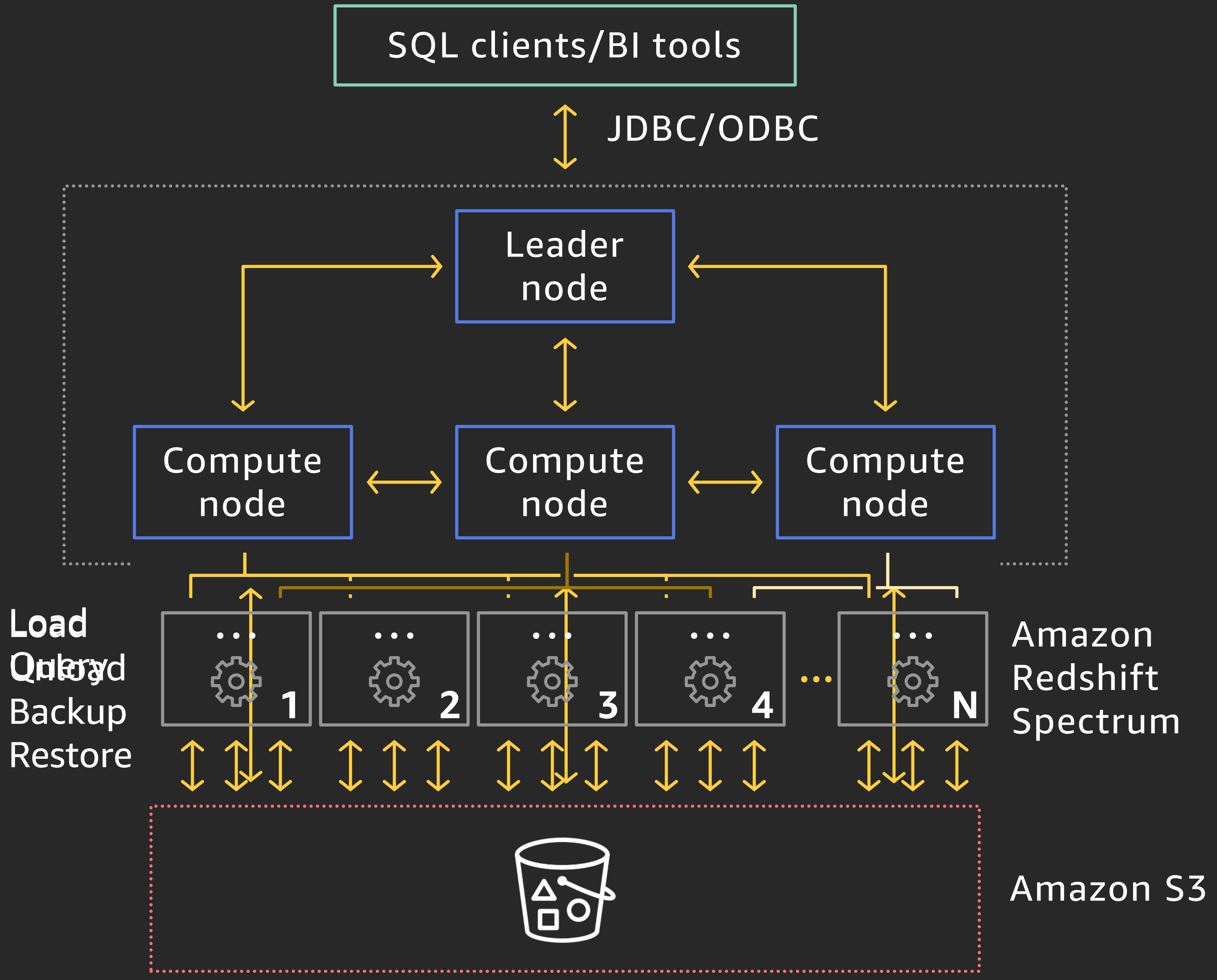
- SQL endpoint
- Stores metadata
- Coordinates parallel SQL processing

Compute nodes

- Local, columnar storage
- Executes queries in parallel
- Load, unload, backup, restore

Amazon Redshift Spectrum nodes

- Execute queries directly against Amazon Simple Storage Service (Amazon S3)



Amazon Redshift evolving architecture

Massively parallel, shared nothing columnar architecture

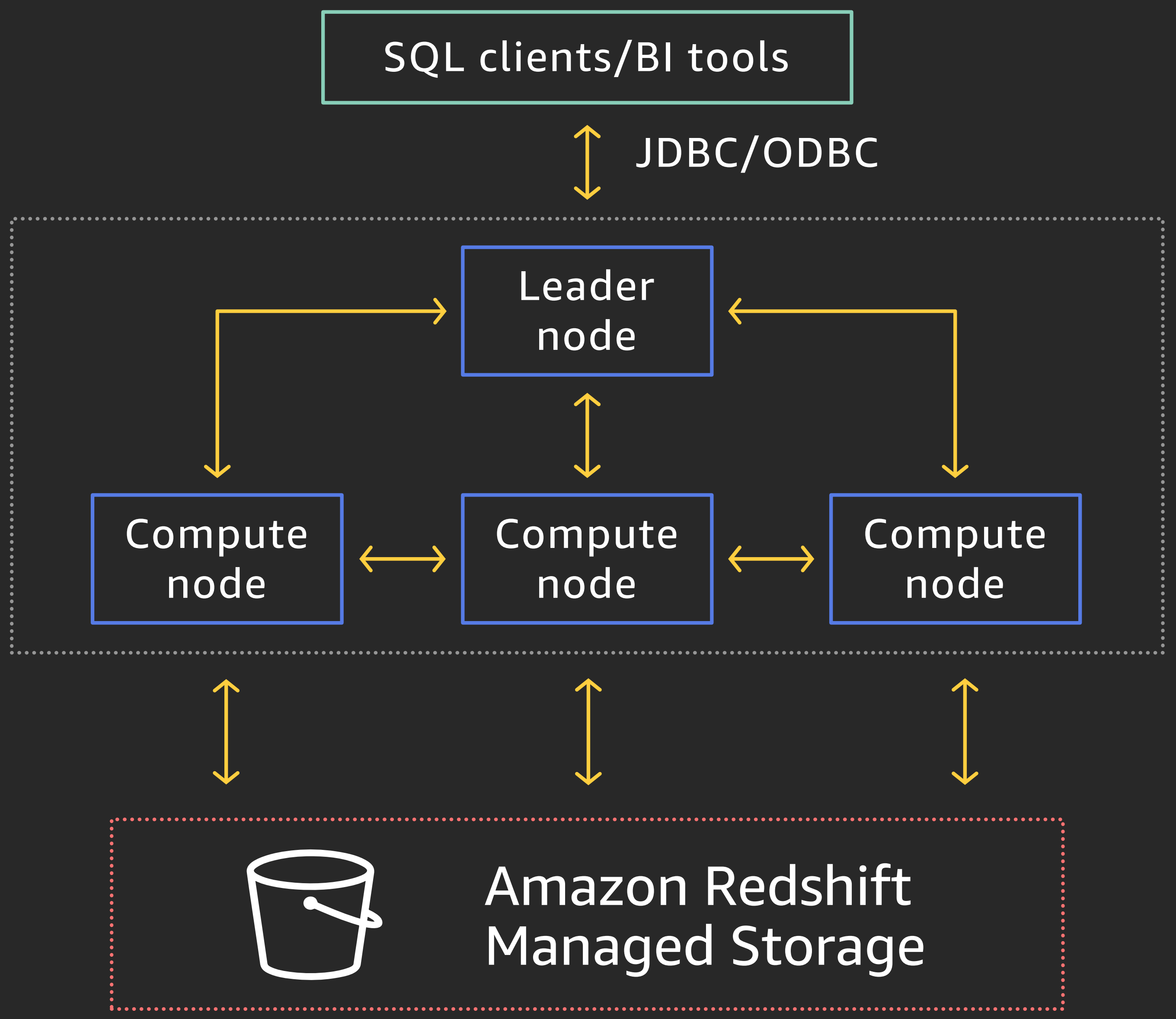
Leader node

Compute nodes

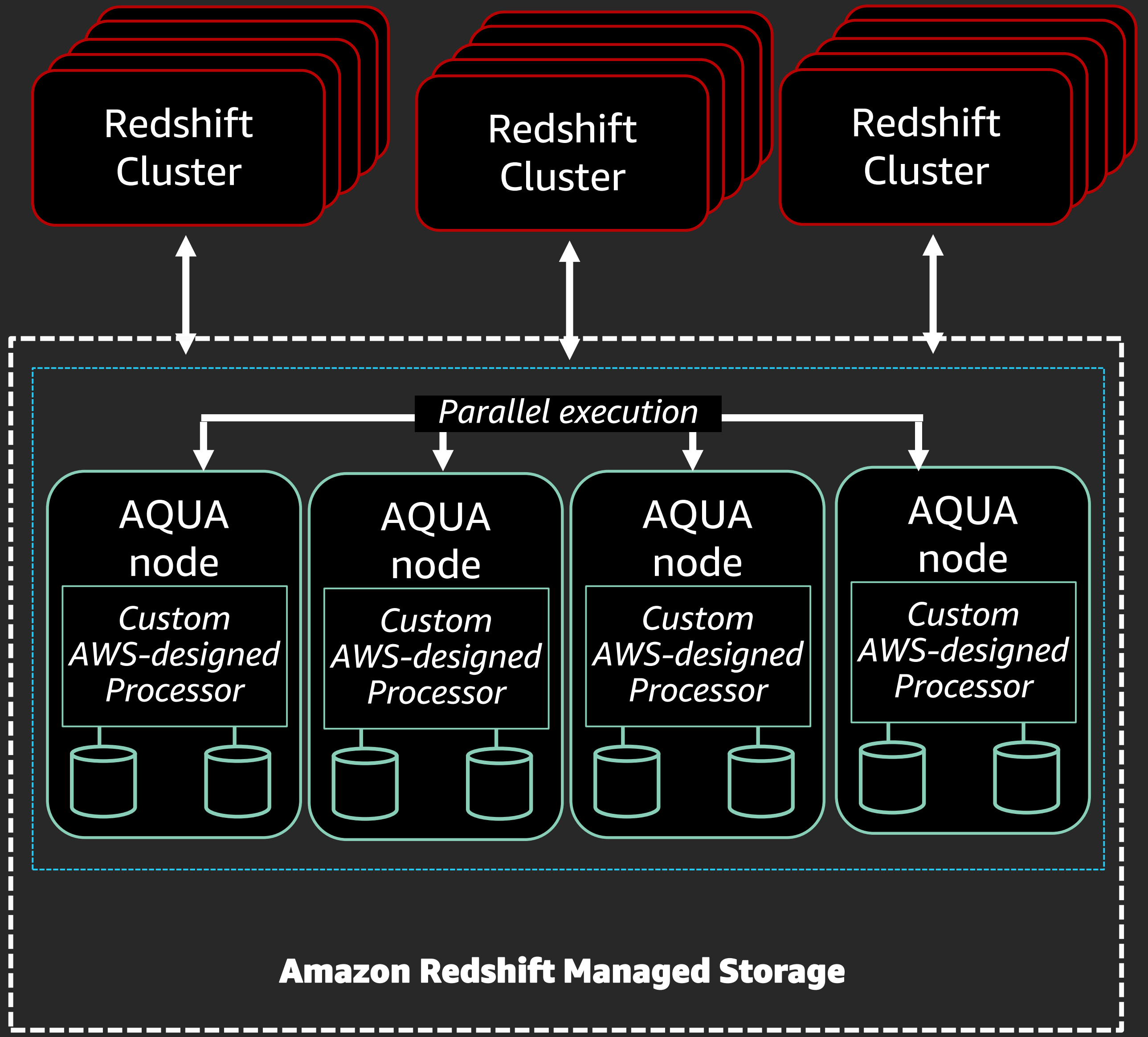
Amazon Redshift Spectrum nodes

Amazon Redshift Managed Storage

- Pay separately for storage and compute
- Large high-speed SSD backed cache
- Automatic scaling (up to 64 TB/instance)
- Supports up to 8.2 PB of cluster storage



AQUA (Advanced Query Accelerator) for Amazon Redshift



New distributed & hardware-accelerated processing layer

With AQUA, Amazon Redshift is up to **10x faster** than any other cloud data warehouse, no extra cost

AQUA Nodes with custom AWS-designed analytics processors to make operations (compression, encryption, filtering, and aggregations) faster than traditional CPUs

Available in Preview with RA3. No code changes required

Terminology and concepts: Node types

Amazon Redshift analytics—RA3 (new)

Amazon Redshift Managed Storage (RMS)—Solid-state disks + Amazon S3

Dense compute—DC2

Solid-state disks

Dense storage—DS2

Magnetic disks

Instance type	Disk type	Size	Memory	CPUs	Slices
RA3 4xlarge (coming soon)	RMS	Scales to 16 TB	96 GB	12	4
RA3 16xlarge (new)	RMS	Scales to 64 TB	384 GB	48	16
DC2 large	SSD	160 GB	16 GB	2	2
DC2 8xlarge	SSD	2.56 TB	244 GB	32	16
DS2 xlarge	Magnetic	2 TB	32 GB	4	2
DS2 8xlarge	Magnetic	16 TB	244 GB	36	16

Terminology and concepts: Columnar

Amazon Redshift uses a columnar architecture for storing data on disk

Goal: reduce I/O for analytics queries

Physically store data on disk by column rather than row

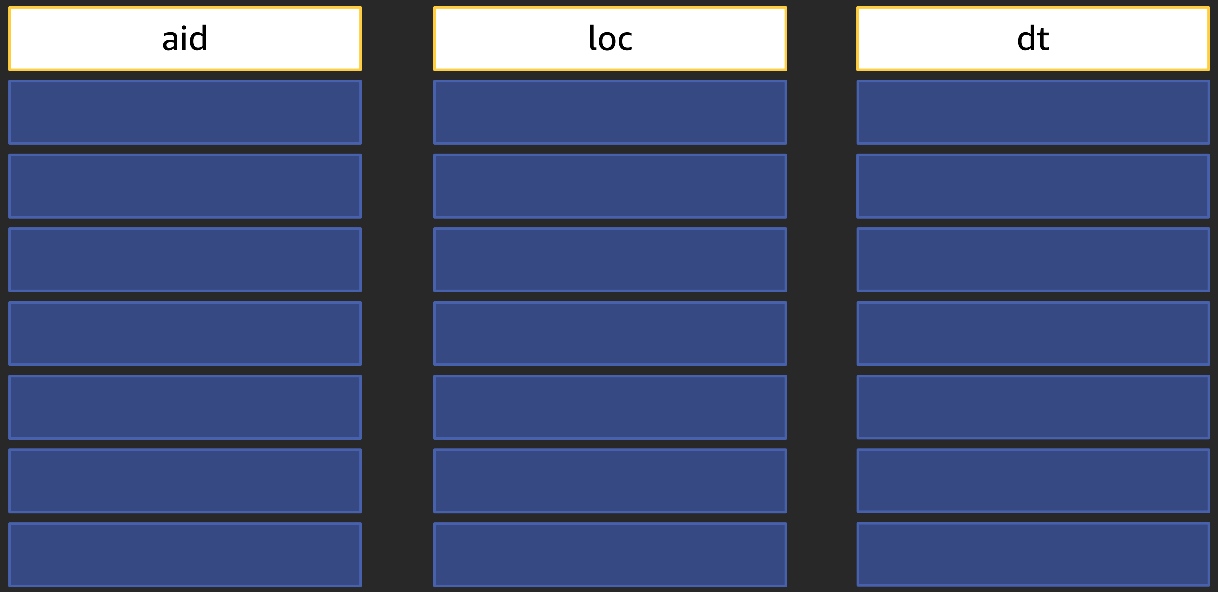
Only read the column data that is required

Columnar architecture: Example

```
CREATE TABLE deep_dive (
     aid  INT         --audience_id
    ,loc  CHAR(3)     --location
    ,dt   DATE        --date
);
```

aid	loc	dt
1	SFO	2017-10-20
2	JFK	2017-10-20
3	SFO	2017-04-01
4	JFK	2017-05-14

```
SELECT min(dt) FROM deep_dive;
```



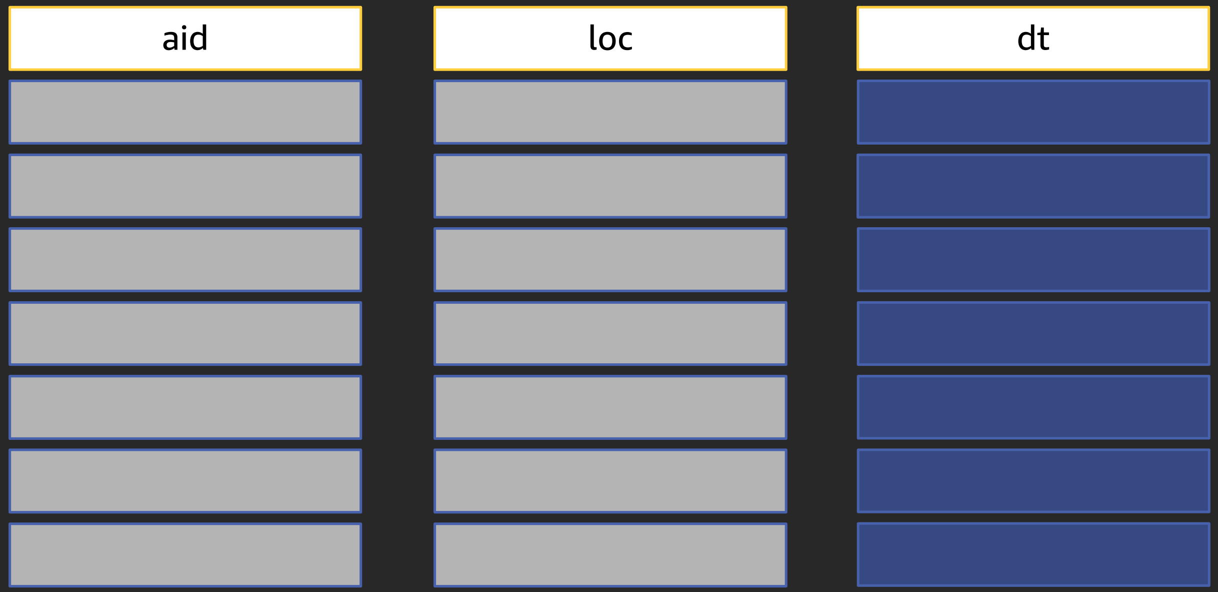
Row-based storage

- Need to read everything
- Unnecessary I/O

Columnar architecture: Example

```
CREATE TABLE deep_dive (
     aid  INT         --audience_id
    ,loc  CHAR(3)     --location
    ,dt   DATE        --date
);
```

aid	loc	dt
1	SFO	2017-10-20
2	JFK	2017-10-20
3	SFO	2017-04-01
4	JFK	2017-05-14




```
SELECT min(dt) FROM deep_dive;
```

Column-based storage

- Only scan blocks for relevant column

Terminology and concepts: Compression

Goals

Allow more data to be stored within an Amazon Redshift cluster

Improve query performance by decreasing I/O

Impact

Allows two to four times more data to be stored within the cluster

---

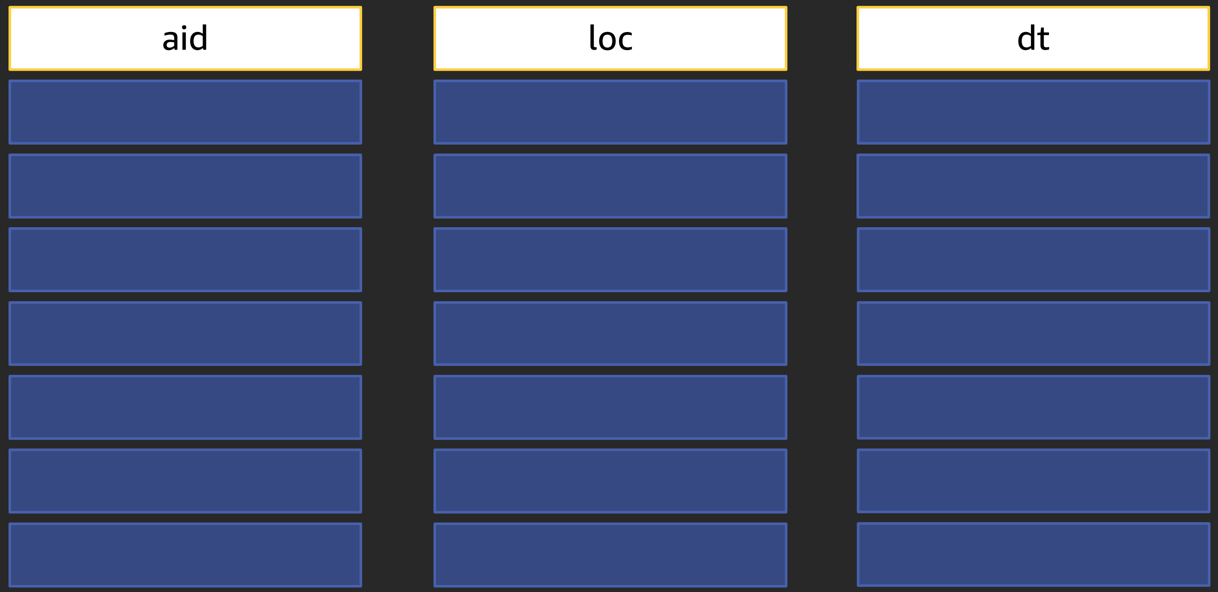
By default, COPY automatically analyzes and compresses data on first load into an empty table

ANALYZE COMPRESSION is a built-in command that will find the optimal compression for each column on an existing table

Compression: Example

```
CREATE TABLE deep_dive (
     aid  INT          --audience_id
    ,loc  CHAR(3)      --location
    ,dt   DATE         --date
);
```

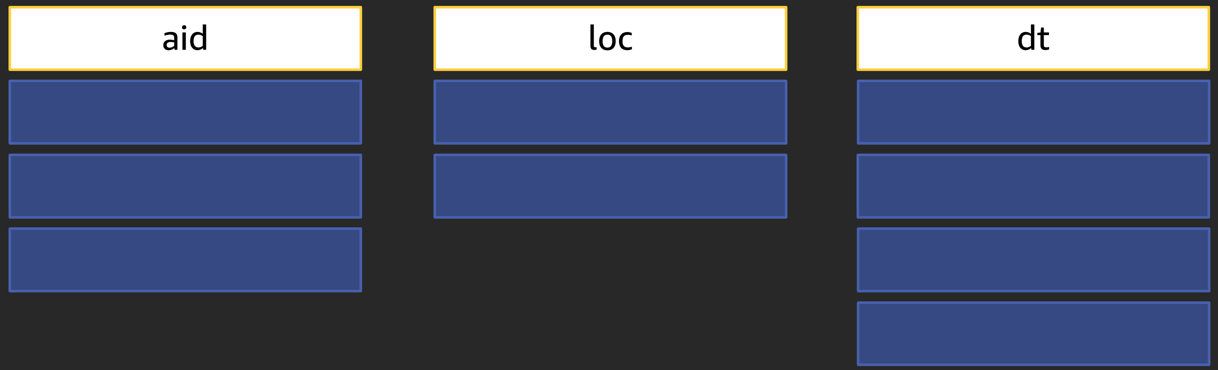
aid	loc	dt
1	SFO	2017-10-20
2	JFK	2017-10-20
3	SFO	2017-04-01
4	JFK	2017-05-14



Add 1 of 13 different encodings to each column

Compression: Example

```
CREATE TABLE deep_dive (
     aid  INT        ENCODE AZ64
    ,loc  CHAR(3)    ENCODE BYTEDICT
    ,dt   DATE       ENCODE RUNLENGTH
);
```



aid	loc	dt
1	SFO	2017-10-20
2	JFK	2017-10-20
3	SFO	2017-04-01
4	JFK	2017-05-14

More efficient compression is due to storing the same data type in the columnar architecture

Columns grow and shrink independently

Reduces storage requirements

Reduces I/O

New Amazon Redshift encoding type: AZ64

AZ64 is Amazon's proprietary compression encoding algorithm designed to achieve a high compression ratio and improved query processing

Goals:

Increase compression ratio, reducing the required footprint

Increase query performance by decreasing both encoding/decoding times

Result:

	AZ64 storage savings	AZ64 performance speed ups
RAW	60–70% less storage	25–30% faster
LZO	35% less storage	40% faster
ZSTD	Comparable footprint	70% faster

30TB Cloud DW benchmark is based on TPC-DS (v2.10) with no query modifications done

Best practices: Compression

Apply compression to all tables

- In most cases, use AZ64 for INT, SMALLINT, BIGINT, TIMESTAMP, TIMESTAMPTZ, DATE, NUMERIC
- In most cases, use LZO/ZSTD for VARCHAR and CHAR

Use ANALYZE COMPRESSION command to find optimal compression

- RAW (no compression) for sparse columns and small tables

Changing column encoding requires a table rebuild

- https://github.com/awslabs/amazon-redshift utils/tree/master/src/ColumnEncodingUtility

Verifying columns are compressed:

```
SELECT "column", type, encoding FROM pg_table_def
WHERE tablename = 'deep_dive';

 column |     type     | encoding
--------+--------------+----------
 aid    | integer      | az64
 loc    | character(3) | bytedict
 dt     | date         | runlength
```

Terminology and concepts: Blocks

Column data is persisted to 1 MB immutable blocks

Blocks are individually encoded with 1 of 13 encodings

A full block can contain millions of values

Terminology and concepts: Zone maps

Goal

Eliminates unnecessary I/O

In-memory block metadata

- Contains per-block min and max values
- All blocks automatically have zone maps
- Effectively prunes blocks that cannot contain data for a given query

Terminology and concepts: Data sorting

Goal

Make queries run faster by increasing the effectiveness of zone maps and reducing I/O

Impact

Enables range-restricted scans to prune blocks by leveraging zone maps

---

Achieved with the table property SORTKEY defined on one or more columns

Optimal sort key is dependent on:

- Query patterns
- Business requirements
- Data profile

Sort key: Example

```
CREATE TABLE deep_dive (
     aid   INT        --audience_id
    ,loc   CHAR(3)    --location
    ,dt    DATE       --date
) SORTKEY (dt, loc);
```

Add a sort key to one or more columns to physically sort the data on disk

deep_dive		
aid	loc	dt
1	SFO	2017-10-20
2	JFK	2017-10-20
3	SFO	2017-04-01
4	JFK	2017-05-14

deep_dive (sorted)		
aid	loc	dt
3	SFO	2017-04-01
4	JFK	2017-05-14
2	JFK	2017-10-20
1	SFO	2017-10-20

Zone maps and sorting: Example

```
SELECT count(*) FROM deep_dive WHERE dt = '06-09-2017';
```

Unsorted table

MIN: 01-JUNE-2017	MAX: 20-JUNE-2017
MIN: 08-JUNE-2017	MAX: 30-JUNE-2017
MIN: 12-JUNE-2017	MAX: 20-JUNE-2017
MIN: 02-JUNE-2017	MAX: 25-JUNE-2017

Sorted by date

MIN: 01-JUNE-2017	MAX: 06-JUNE-2017
MIN: 07-JUNE-2017	MAX: 12-JUNE-2017
MIN: 13-JUNE-2017	MAX: 21-JUNE-2017
MIN: 21-JUNE-2017	MAX: 30-JUNE-2017

Best practices: Sort keys

Place the sort key on columns that are frequently filtered on placing the lowest cardinality columns first

- On most fact tables, the first sort key column should be a temporal column
- Columns added to a sort key after a high-cardinality column are not effective

With an established workload, use the following scripts to help find sort key suggestions:

- https://github.com/awslabs/amazon-redshift-utils/blob/master/src/AdminScripts/filter_used.sql
- https://github.com/awslabs/amazon-redshift-utils/blob/master/src/AdminScripts/predicate_columns.sql

Design considerations:

- Sort keys are less beneficial on small tables
- Define four or less sort key columns—more will result in marginal gains and increased ingestion overhead

Terminology and concepts: Materialize columns

Goal: Make queries run faster by leveraging zonemaps on the fact tables

Frequently filtered and unchanging dimension values should be materialized within fact tables

- Time dimension tables do not allow for range restricted scans on fact tables
- Materializing temporal values in fact table can give significant performance gains

Example:

```
SELECT COUNT(*) FROM fact_dd JOIN dim_dd USING (timeid) WHERE dim_dd.ts >= '2018-11-29';
SELECT COUNT(*) FROM fact_dd WHERE fact_dd.timestamp >= '2018-11-29’;        -- Faster
```

Often calculated values should be materialized within fact tables

Example:

```
SELECT COUNT(*) FROM dd WHERE EXTRACT(EPOCH FROM ts) BETWEEN 1541120959 AND 1543520959;
SELECT COUNT(*) FROM dd WHERE sorted_epoch BETWEEN 1541120959 AND 1543520959; -- Faster
```

Terminology and concepts: Slices

A *slice* can be thought of like a virtual compute node

Unit of data partitioning

Parallel query processing

Facts about slices

Each compute node is initialized with either 2 or 16 slices

Table rows are distributed to slices

A slice processes only its own data

Data distribution

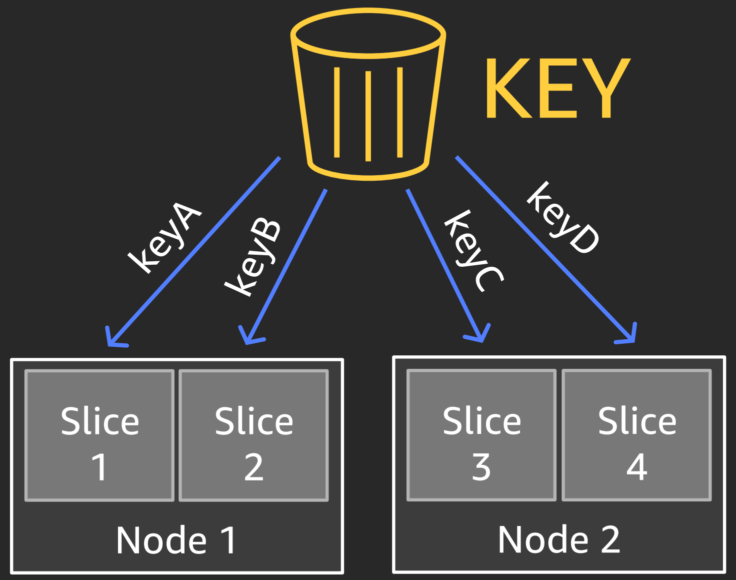
Distribution style is a table property which dictates how that table's data is distributed throughout the cluster

KEY: Value is hashed, same value goes to same location (slice)

ALL: Full table data goes to the first slice of every node

EVEN: Round robin

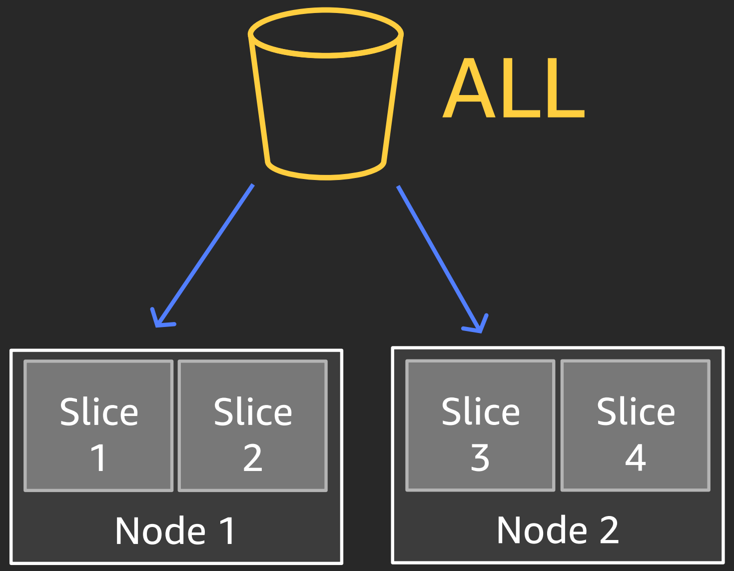
AUTO: Combines EVEN and ALL

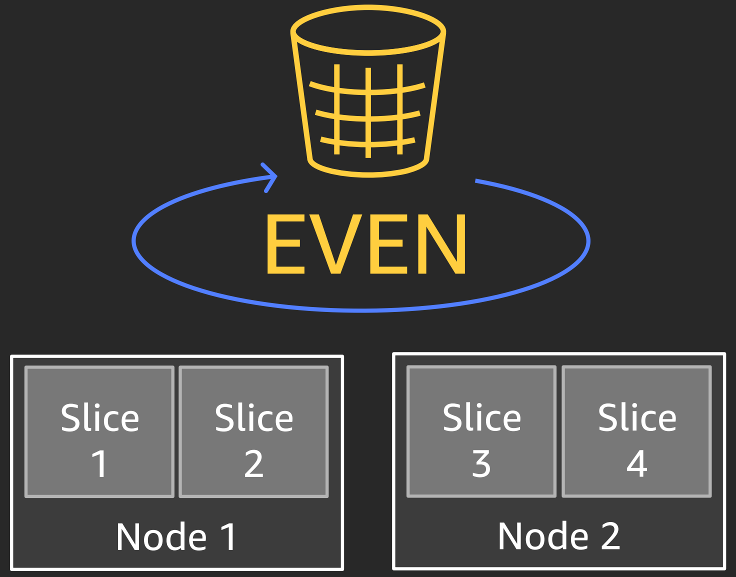


Goals

Distribute data evenly for parallel processing

Minimize data movement during query processing





Data distribution: Example

```
CREATE TABLE deep_dive (
    aid    INT         --audience_id
    ,loc   CHAR(3)     --location
    ,dt    DATE        --date
) (EVEN|KEY|ALL|AUTO);
```

Table: deep_dive					
User columns			System columns		
aid	loc	dt	ins	del	row

Data distribution: EVEN Example

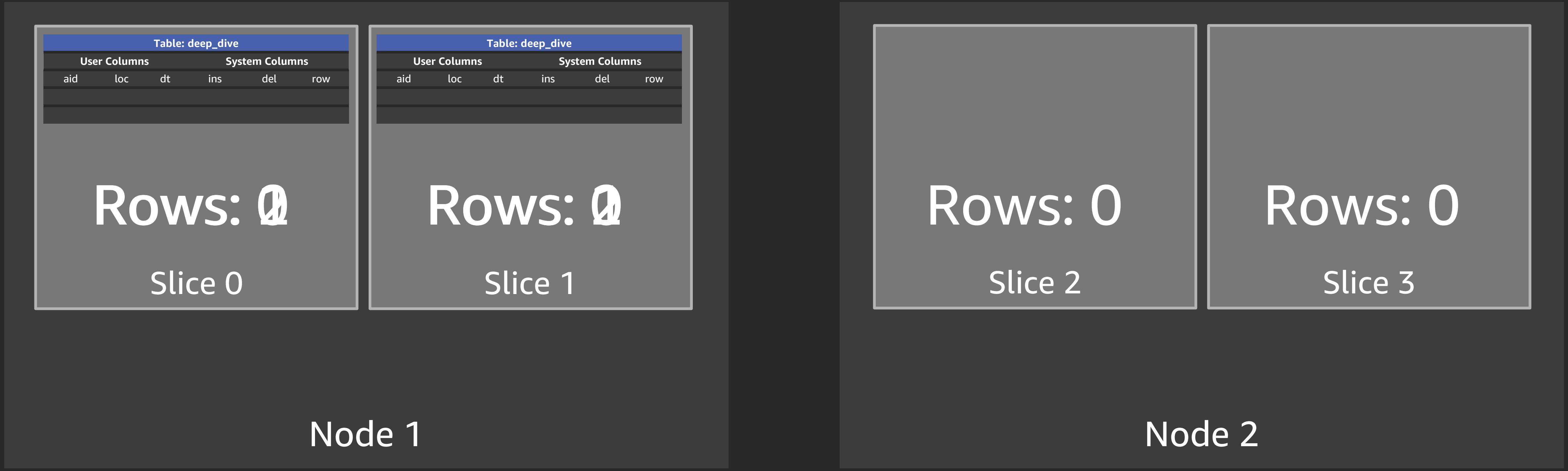
```
CREATE TABLE deep_dive (
    aid    INT          --audience_id
    ,loc   CHAR(3)      --location
    ,dt    DATE         --date
) DISTSTYLE EVEN;
```

```
INSERT INTO deep_dive VALUES
(1, 'SFO', '2016-09-01'),
(2, 'JFK', '2016-09-14'),
(3, 'SFO', '2017-04-01'),
(4, 'JFK', '2017-05-14');
```

Data distribution: KEY Example #1

```
CREATE TABLE deep_dive (
    aid   INT         --audience_id
    ,loc  CHAR(3)     --location
    ,dt   DATE        --date
) DISTSTYLE KEY DISTKEY (loc);
```

```
INSERT INTO deep_dive VALUES
(1, 'SFO', '2016-09-01'),
(2, 'JFK', '2016-09-14'),
(3, 'SFO', '2017-04-01'),
(4, 'JFK', '2017-05-14');
```



Data distribution: KEY Example #2

```
CREATE TABLE deep_dive (
    aid   INT        --audience_id
    ,loc  CHAR(3)    --location
    ,dt   DATE       --date
) DISTSTYLE KEY DISTKEY (aid);
```

```
INSERT INTO deep_dive VALUES
(1, 'SFO', '2016-09-01'),
(2, 'JFK', '2016-09-14'),
(3, 'SFO', '2017-04-01'),
(4, 'JFK', '2017-05-14');
```

Data distribution: ALL Example

```
CREATE TABLE deep_dive (
    aid    INT          --audience_id
    ,loc   CHAR(3)      --location
    ,dt    DATE         --date
) DISTSTYLE ALL;
```

```
INSERT INTO deep_dive VALUES
(1, 'SFO', '2016-09-01'),
(2, 'JFK', '2016-09-14'),
(3, 'SFO', '2017-04-01'),
(4, 'JFK', '2017-05-14');
```

Summary: Data distribution

DISTSTYLE KEY

Goals

- Optimize **JOIN** performance between large tables by distributing on columns used in the **ON** clause
- Optimize **INSERT INTO SELECT** performance
- Optimize **GROUP BY** performance

The column that is being distributed on should have a high cardinality and not cause row skew:

```
SELECT diststyle, skew_rows
FROM svv_table_info WHERE "table" = 'deep_dive';
 diststyle | skew_rows
-----------+-----------
 KEY(aid)  |      1.07
```

← Ratio between the slice with the most and least number of rows

DISTSTYLE ALL

Goals

- Optimize **JOIN** performance with dimension tables
- Reduces disk usage on small tables

Small and medium size dimension tables (<3M rows)

DISTSTYLE EVEN

If neither **KEY** or **ALL** apply

DISTSTYLE AUTO

Default distribution—combines DISTSTYLE **ALL** and **EVEN**

Best practices: Table design summary

Add compression to columns

Use AZ64 where possible, ZSTD/LZO for most (VAR)CHAR columns

Add sort keys on the columns that are frequently filtered on

Materialize often filtered columns from dimension tables into fact tables

Materialize often calculated values into tables

Co-locate large tables using DISTSTYLE KEY if the columns do not cause skew

Avoid distribution keys on temporal columns

Keep data types as wide as necessary (but no longer than necessary)

VARCHAR, CHAR, and NUMERIC

Data storage, ingestion, and ELT

Terminology and concepts: Redundancy

Amazon Redshift DC/DS instances utilize locally attached storage devices
Amazon Redshift RA3 instances utilize Amazon Redshift Managed Storage

Global **commit** ensures all permanent tables have blocks written to multiple locations to ensure data redundancy

Asynchronously back up blocks to Amazon S3—in all cases, snapshots are transitionally consistent

Snapshot generated every 5 GB of changed data or eight hours

User can create on-demand manual snapshots

To disable backups at the table level: `CREATE TABLE example(id int) BACKUP NO;`

Temporary tables

Blocks are not mirrored to the remote partition—two-times faster write performance

Do not trigger a full commit or backups

Terminology and concepts: Transactions

Amazon Redshift is a fully transactional, ACID-compliant data warehouse

Isolation level is serializable

Two-phase commits (local and global commit phases)

Cluster commit statistics

https://github.com/awslabs/amazon-redshift-utils/blob/master/src/AdminScripts/commit_stats.sql

Design consideration

Because of the expense of commit overhead, limit commits by explicitly creating transactions

Data ingestion: COPY statement

Ingestion throughput

Each slice's query processors can load one file at a time:

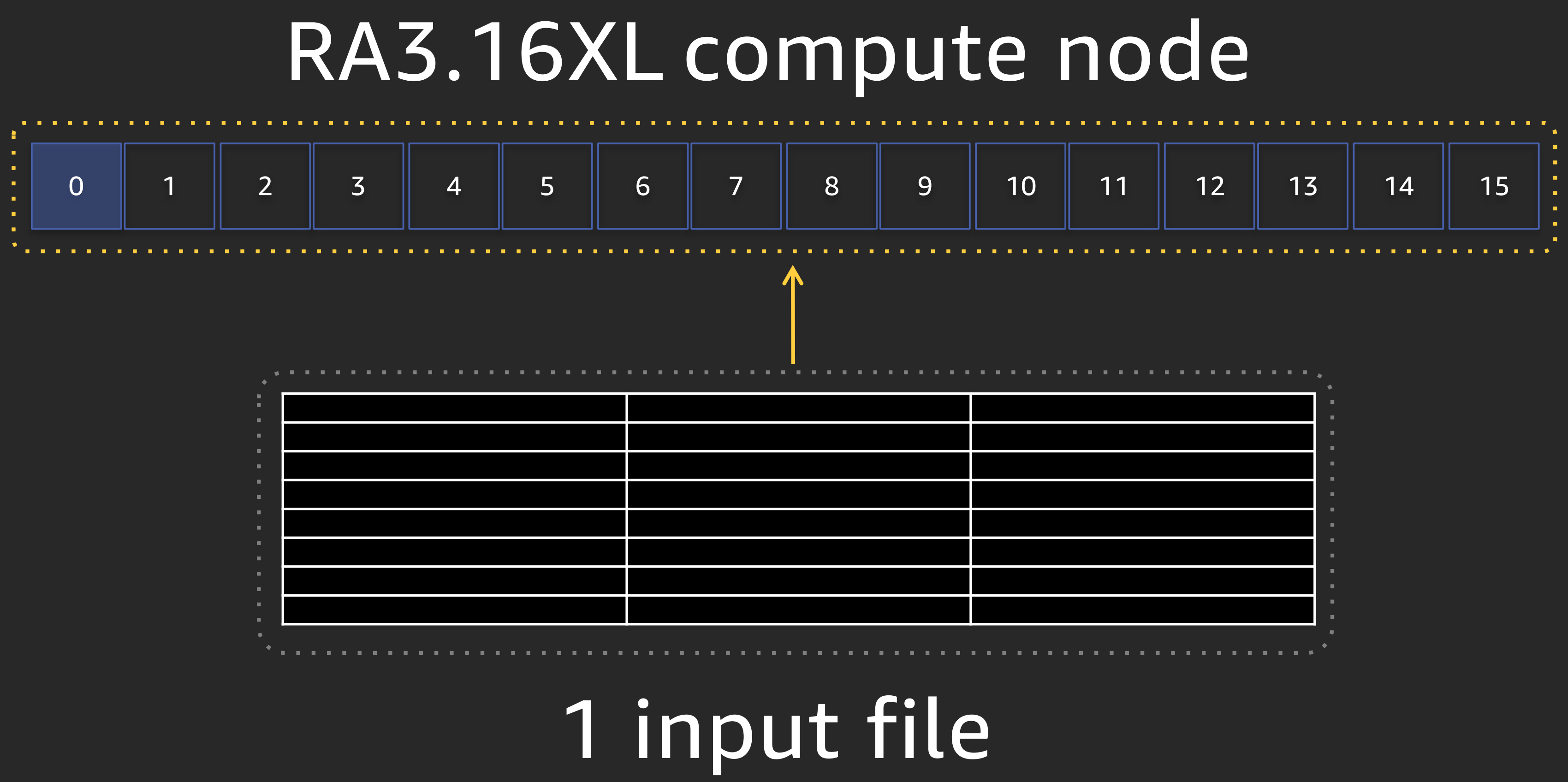
Streaming decompression

Parse

Distribute

Write

Realizing only partial node usage as 6.25% of slices are active

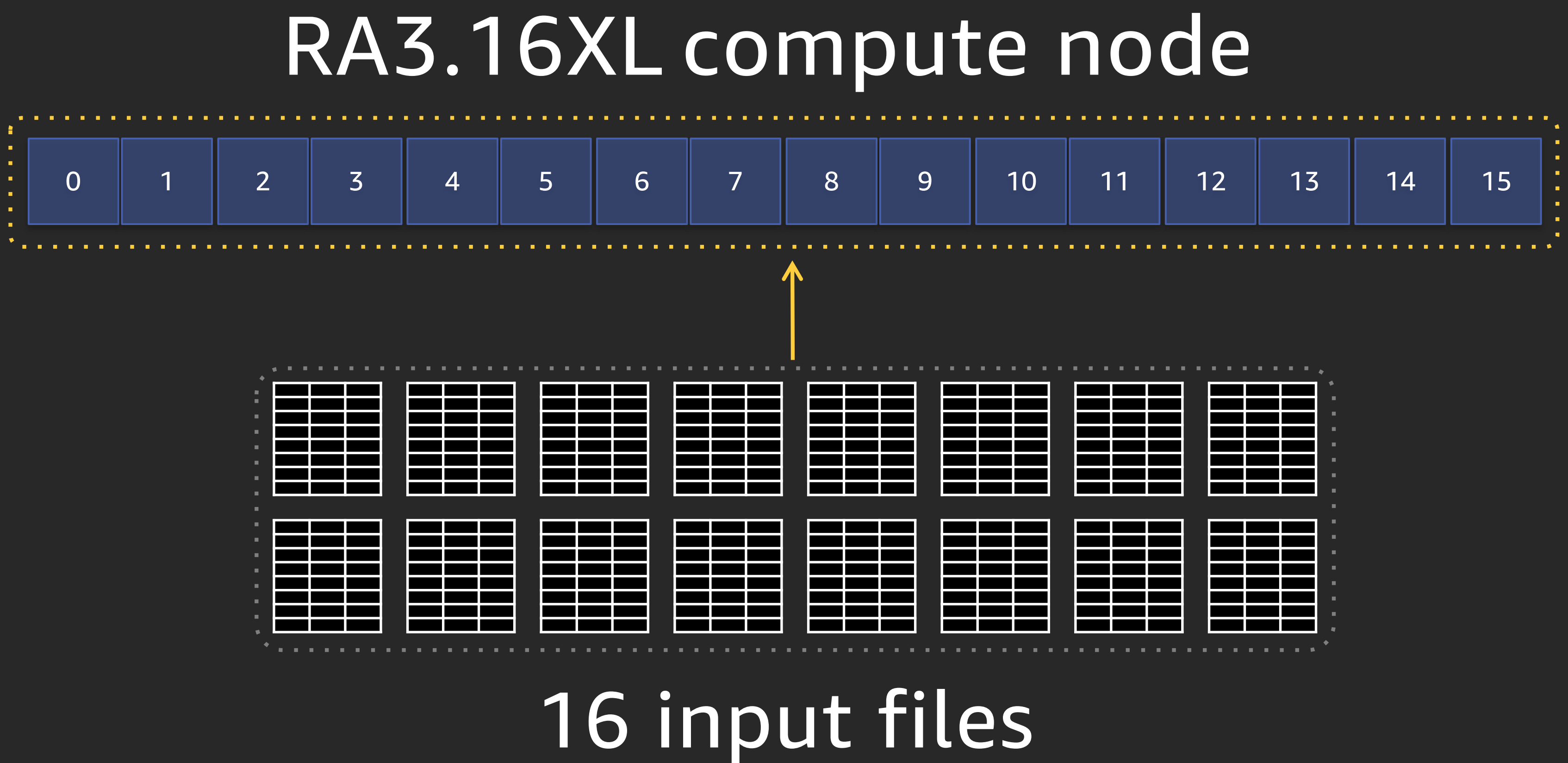


Data ingestion: COPY statement

Number of input files should be a multiple of the number of slices

Splitting the single file into 16 input files, all slices are working to maximize ingestion performance

COPY continues to scale linearly as you add nodes



Recommendation is to use delimited files—1 MB to 1 GB after gzip compression

Best practices: COPY ingestion

Delimited files are recommended

Pick a simple delimiter '|' or ',' or tabs

Pick a simple NULL character (\N)

Use double quotes and an escape character (' \ ') for varchars

UTF-8 varchar columns take four bytes per char

Split files into a number that is a multiple of the total number of slices in the Amazon Redshift cluster

```
SELECT count(slice) from stv_slices;
```

Files sizes should be 1 MB to 1 GB after gzip compression

Data ingestion: Amazon Redshift Spectrum

Use INSERT INTO SELECT from external Amazon S3 tables

Aggregate incoming data

Select subset of columns and/or rows

Manipulate incoming column data with SQL

Load data in alternative file formats: Amazon ION, Grok, RCFile, and Sequence

Best practices

Save cluster resources for querying and reporting rather than on ELT

Filtering/aggregating incoming data can improve performance over COPY

Design considerations

Repeated reads against Amazon S3 are not transactional

$5/TB of (compressed) data scanned

Design considerations: Data ingestion

Designed for large writes

Batch processing system, optimized for processing massive amounts of data

1 MB size plus immutable blocks means that we clone blocks on write so as not to introduce fragmentation

Small write (~1–10 rows) has similar cost to a larger write (~100K rows)

UPDATE and DELETE

Immutable blocks means that we only logically delete rows on UPDATE or DELETE

(AUTO) VACUUM to remove ghost rows from table

Data ingestion: Deduplication/UPSERT

Table: deep_dive		
aid	loc	dt
1	SFO	**2017-10-20**
2	JFK	**2017-10-20**
3	SFO	2017-04-01
4	JFK	2017-05-14
5	SJC	**2017-10-10**
6	SEA	**2017-11-29**

s3://bucket/dd.csv		
aid	loc	dt
1	SFO	2017-10-20
2	JFK	2017-10-20
5	SJC	2017-10-10
6	SEA	2017-11-29

Data ingestion: Deduplication/UPSERT

Steps:

1. Load CSV data into a staging table
2. Delete duplicate data from the production table
3. Insert (or append) data from the staging into the production table

Data ingestion: Deduplication/UPSERT

```
BEGIN;
CREATE TEMP TABLE staging(LIKE deep_dive);
COPY staging FROM 's3://bucket/dd.csv'
:'creds' COMPUPDATE OFF;
DELETE FROM deep_dive d
USING staging s WHERE d.aid = s.aid;
INSERT INTO deep_dive SELECT * FROM staging;
DROP TABLE staging;
COMMIT;
```

Best practices: ELT

Wrap workflow/statements in an explicit transaction

Consider using DROP TABLE or TRUNCATE instead of DELETE

Staging tables:

Use temporary table or permanent table with the “BACKUP NO” option

If possible, use DISTSTYLE KEY on both the staging table and production table to speed up the INSERT INTO SELECT statement

With COPY, turn off automatic compression—COMPUPDATE OFF

Copy compression settings from the production table (using LIKE keyword) or manually apply compression to CREATE TABLE DDL (from ANALYZE COMPRESSION output)

For copying a large number of rows (> hundreds of millions), consider using ALTER TABLE APPEND instead of INSERT INTO SELECT

(AUTO) VACUUM

The VACUUM process runs either manually or automatically in the background

Goals

VACUUM will remove rows that are marked as deleted

VACUUM will globally sort tables

- For tables with a sort key, ingestion operations will locally sort new data and write it into the unsorted region

Best practices

- VACUUM should be run only as necessary
- For the majority of workloads, AUTO VACUUM DELETE will reclaim space and AUTO TABLE SORT will sort the needed portions of the table
- In cases where you know your workload—VACUUM can be run manually
- Use VACUUM BOOST at off peak times (blocks deletes), which is as quick as “Deep Copy”

(AUTO) ANALYZE

The ANALYZE process collects table statistics for optimal query planning

In the vast majority of cases, AUTO ANALYZE automatically handles statistics gathering

Best practices

- ANALYZE can be run periodically after ingestion on just the columns that WHERE predicates are filtered on

Utility to manually run VACUUM and ANALYZE on all the tables in the cluster:
https://github.com/awslabs/amazon-redshift-utils/tree/master/src/AnalyzeVacuumUtility

Workload management and query monitoring rules

Workload management (WLM)

Allows for the separation of different query workloads

Goals

Prioritize important queries

Throttle/abort less important queries

Control concurrent number of executing queries

Divide cluster memory

Set query timeouts to abort long running queries

Terminology and concepts: WLM attributes

Queues

Assigned a percentage of cluster memory

SQL queries execute in queue based on

User group: which groups the user belongs to

Query group session level variable

Query slots (or Concurrency):

Division of memory within a WLM queue, correlated with the number of simultaneous running queries

WLM_QUERY_SLOT_COUNT is a session level variable

Useful to increase for memory intensive operations
(example: large COPY, VACUUM, large INSERT INTO SELECT)

Terminology and concepts: WLM attributes

Short query acceleration (SQA)

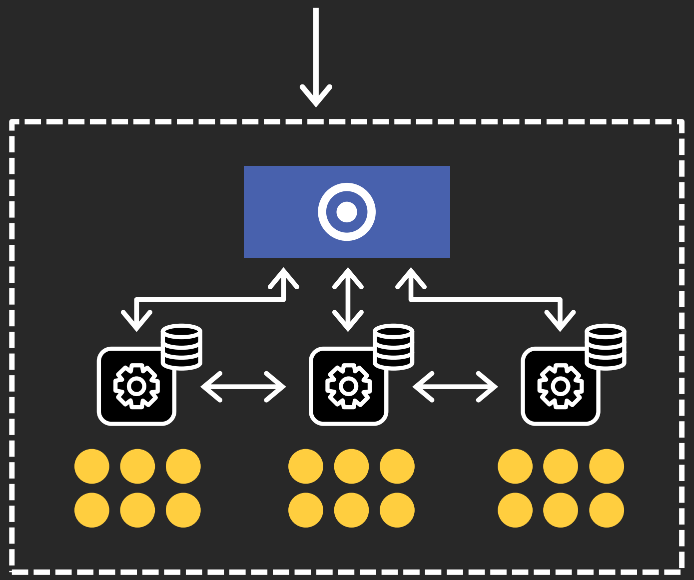
Automatically detect short running queries and run them within the short query queue if queuing occurs

Concurrency scaling

When queues are full, queries are routed to transient Amazon Redshift clusters

Concurrency scaling

Amazon Redshift automatically adds transient clusters, in seconds, to serve sudden spike in concurrent requests with consistently fast performance



For every 24 hours that your main cluster is in use, you accrue a one-hour credit for Concurrency Scaling. This means that Concurrency Scaling is free for >97% of customers.

How it works:

1. All queries go to the leader node, user only sees less wait for queries
2. When queries in designated WLM queue begin queuing, Amazon Redshift automatically routes them to the new clusters, enabling Concurrency Scaling automatically
3. Amazon Redshift automatically spins up a new cluster, processes waiting queries, and automatically shuts down the Concurrency Scaling cluster

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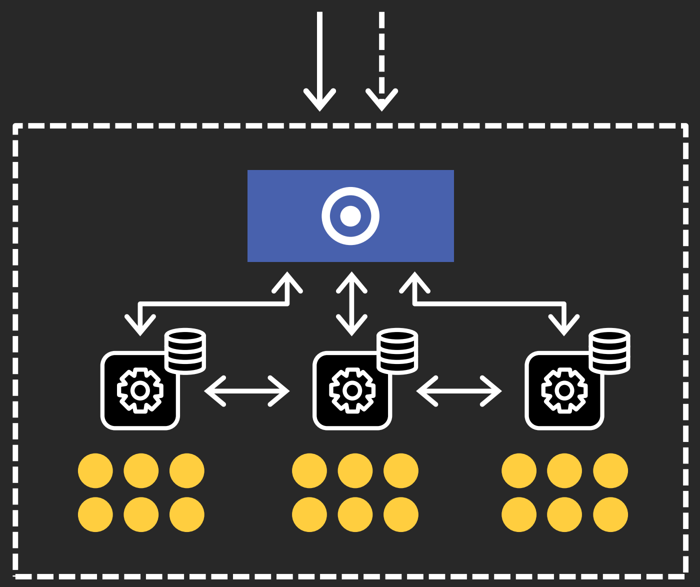

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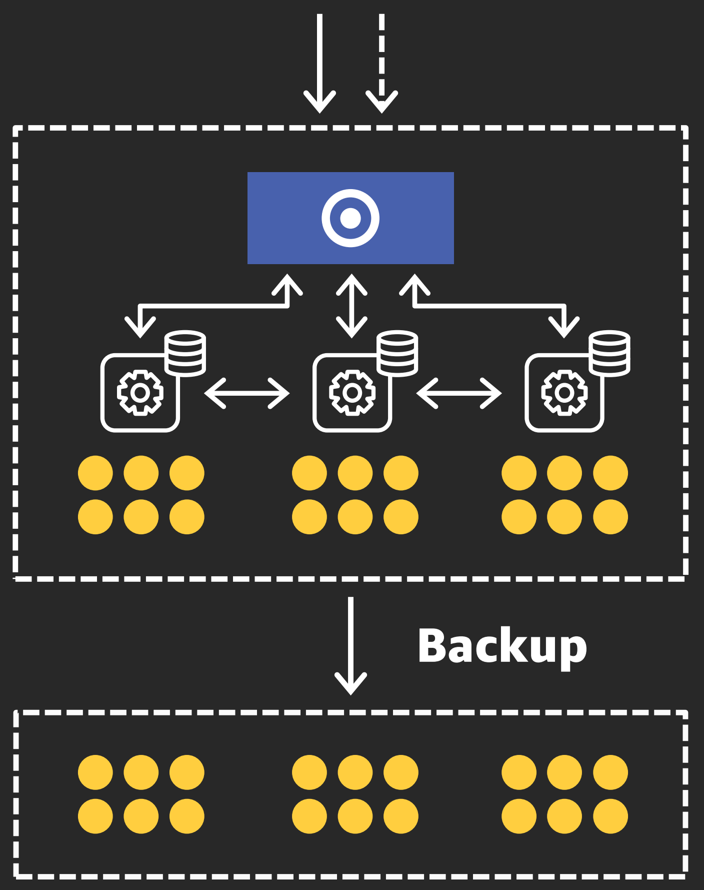

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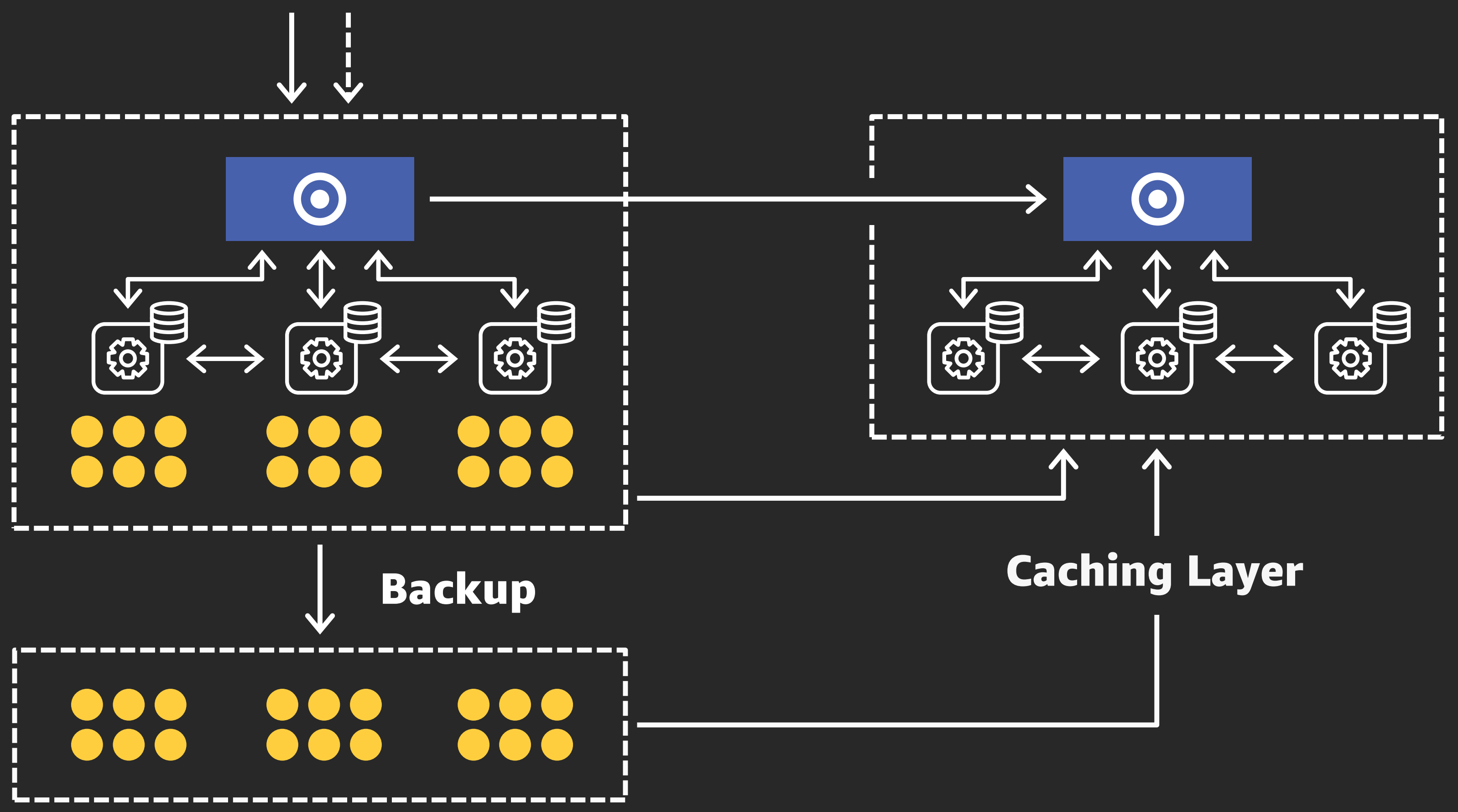

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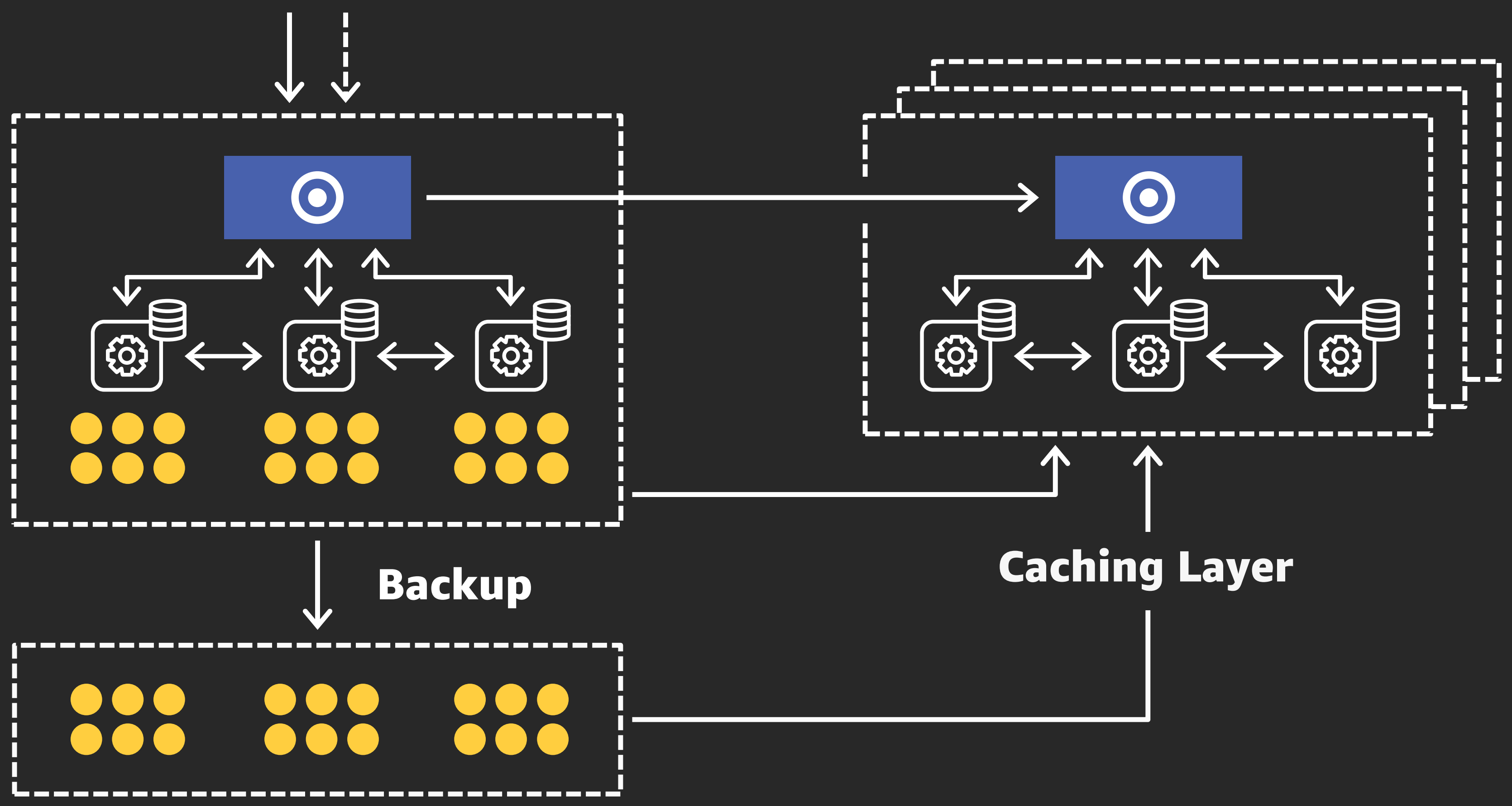

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Workload management: Example

Use case:

Light ingestion/ELT on a continuous cadence of 10 minutes

Peak reporting workload during business hours (7 am–7 pm)

Heavy ingestion/ELT nightly (11 pm–3 am)

User types:

Business reporting and dashboards

Analysts and data science teams

Database administrators

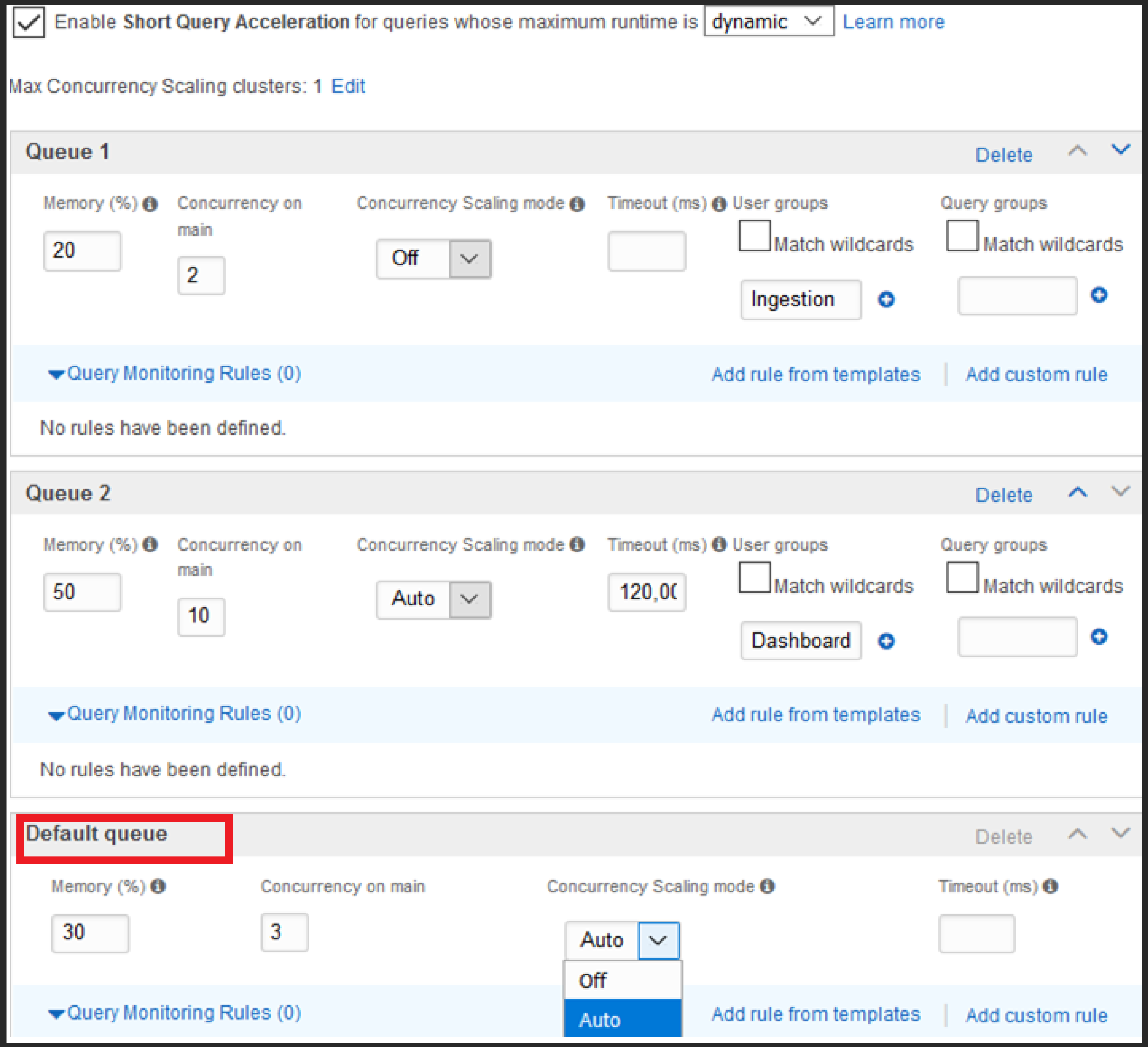
Workload management: Example manual WLM

- Enable: Short Query Acceleration
- Hidden superuser queue can be used by admins, manually switched into:

```
SET query_group TO
'superuser'
```

- The superuser queue has a single slot, the equivalent of 5–7% memory allocation, and no timeout

Create a queue for each workload type:



Terminology and concept: Dynamic WLM

Manual WLM dynamic attributes

- Percent of memory
- Concurrency/queue slots
- Concurrency scaling
- Query timeout
- Enable short query acceleration

Changes to dynamic properties does not require a restart, it’s a simple API call

Dynamic Workload Management Utility

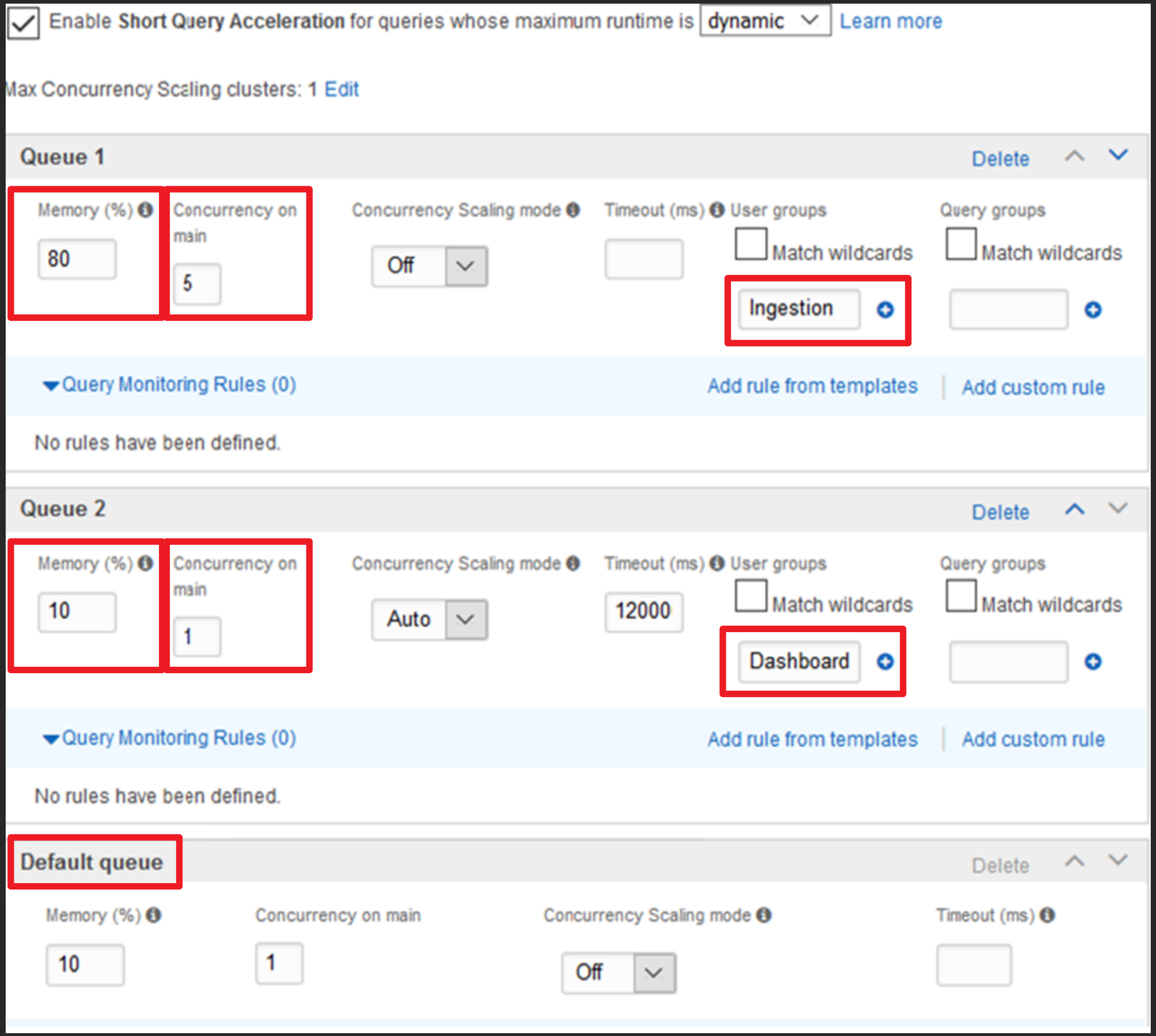
https://github.com/awslabs/amazon-redshift-utils/tree/master/src/WorkloadManagementScheduler

WLM: Example (11 pm–3 am)

Enable: Short Query Acceleration

Increase memory and concurrency for ingestion queue

Decrease memory and concurrency for dashboard and default queues



Automatic workload management (Auto WLM)

Allows for prioritization of different query workload

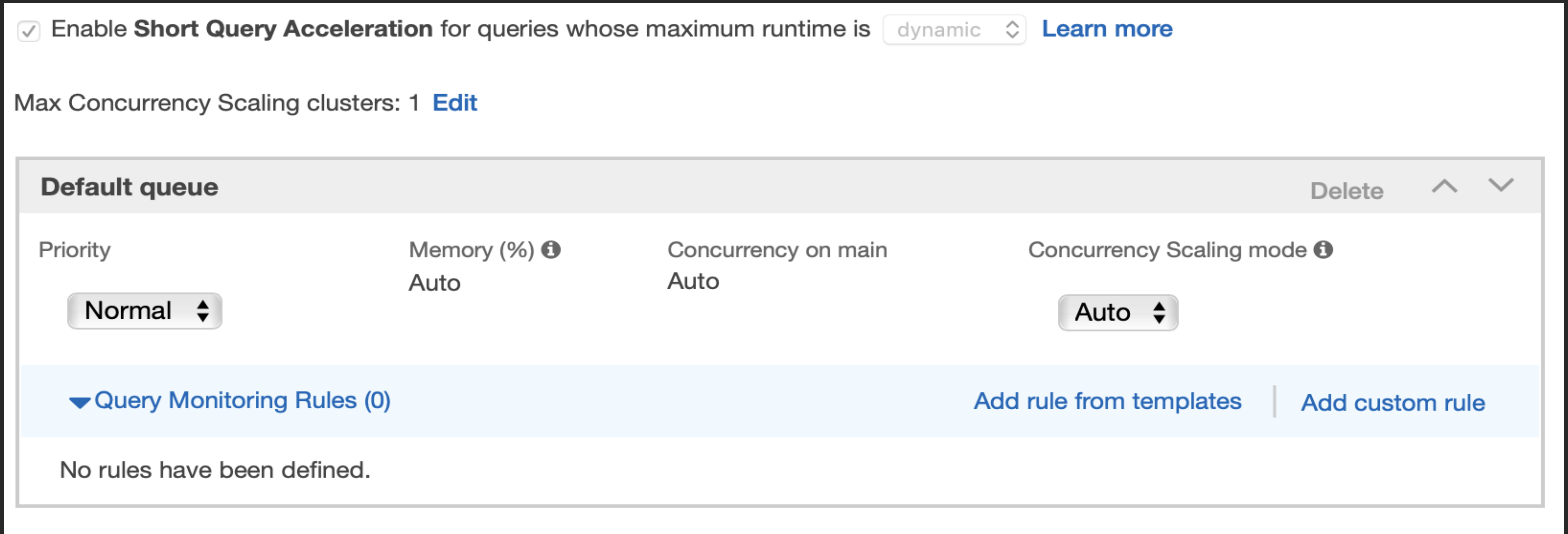
Goals

- Simplify WLM

Automatically controls concurrent number of executing queries

Automatically divides cluster memory

Auto WLM: Example



Automatically manages memory allocation and concurrency of queries

Query monitoring rules (QMR)

Extension of workload management (WLM)

Allow the automatic handling of runaway (poorly written) queries

Rules applied to a WLM queue allow queries to be:

- LOGGED
- ABORTED
- HOPPED

Goals

- Protect against wasteful use of the cluster
- Log resource-intensive queries

Query monitoring rules (QMR)

Metrics with operators and values (e.g., return_row_count > 10000000) create a predicate

Multiple predicates can be AND-ed together to create a rule

Multiple rules can be defined for a queue in WLM. These rules are OR-ed together

```
If  { rule } then [action]
   { rule : metric operator value } e.g.: rows_scanned > 1000000
        Metric:  cpu_time, query_blocks_read, rows scanned, query execution time, cpu &
        io skew per slice, join_row_count, etc.
        Operator:  <, >, ==
        Value:  integer
   [action]: hop, log, abort
```

Best practices: WLM and QMR

Use Auto WLM—if you aren't sure how to set up WLM or your workload is highly unpredictable, or you are using the old default WLM

Use manual WLM—if you understand your workload patterns or require throttling certain types of queries depending on the time of day

Keep the number of WLM queues to a minimum, typically just three queues to avoid having unused queues

https://github.com/awslabs/amazon-redshift-utils/blob/master/src/AdminScripts/wlm_apex_hourly.sql

Use WLM to limit ingestion/ELT concurrency to two to three

To maximize query throughput, use WLM to throttle the number of concurrent queries to 15 or less

Use QMR rather than WLM to set query timeouts

Use QMR to log long-running queries

Save the superuser queue for administration tasks and canceling queries

Cluster sizing and resizing

AWS re:Invent

Sizing Amazon Redshift cluster for production

Estimate the uncompressed size of the incoming data

Assume 3x compression (actual can be >4x)

Target 30–40% free space (resize to add/remove storage as needed)
Disk utilization should be at least 15% and less than 80%

Based on performance requirements, pick SSD or HDD
If required, additional nodes can be added for increased performance

Example: 20 TB of uncompressed data ≈ 6.67 TB compressed
Depending on performance requirements, recommendation:
2-6xRA3.4xlarge or 4xDC2.8xlarge or 5xDS2.xlarge ≈10TB of capacity

Resizing Amazon Redshift

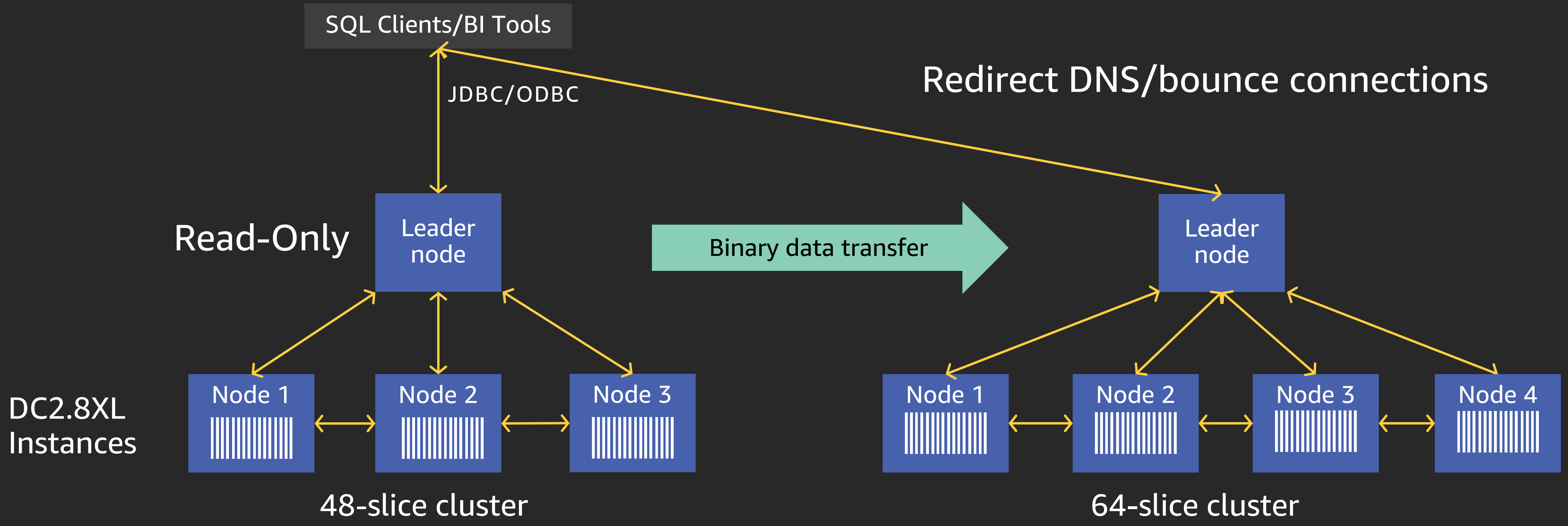
Classic resize

- Data is transferred from old cluster to new cluster (within hours)
- Change node types

Elastic resize

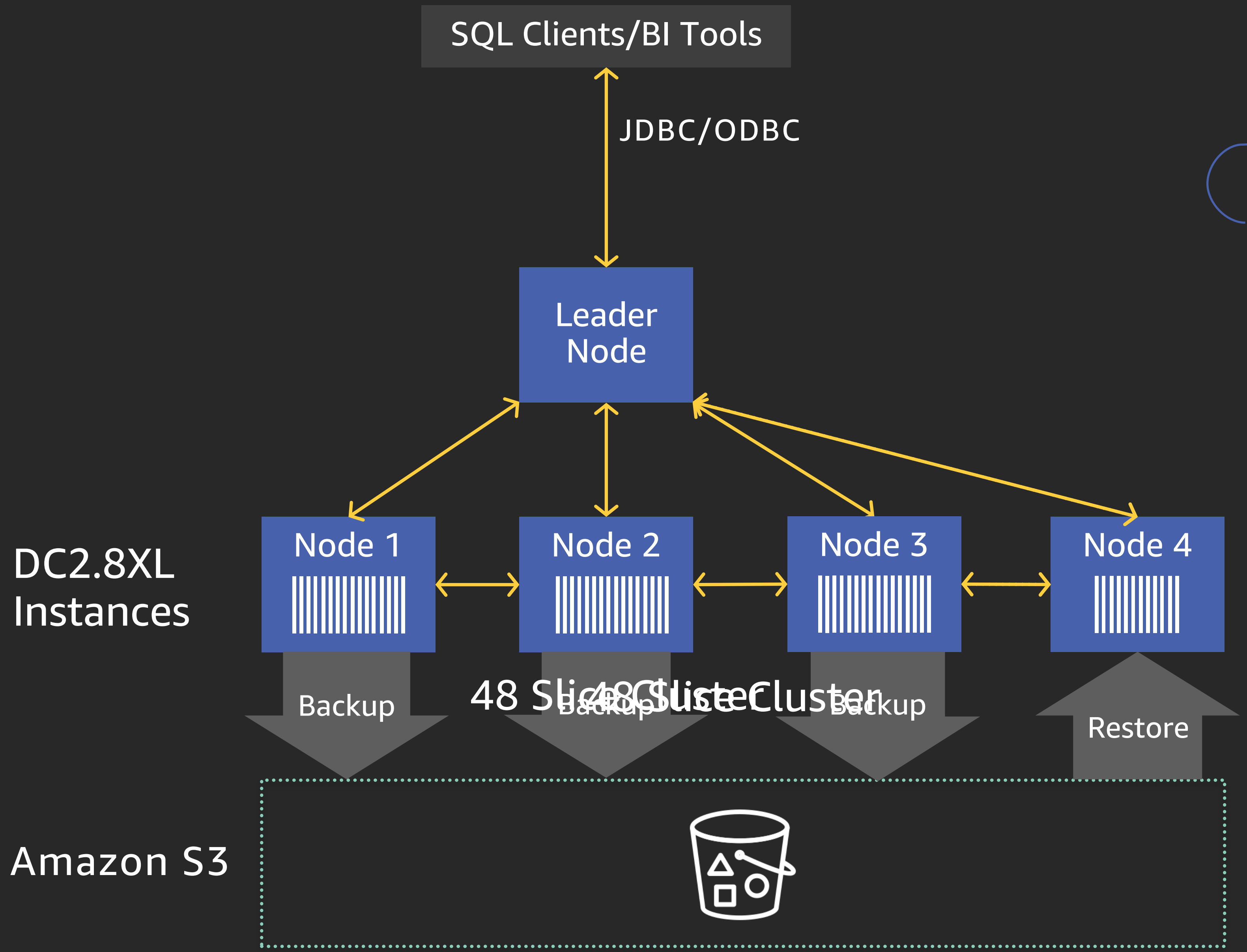
- Nodes are added/removed to/from existing cluster (within minutes)

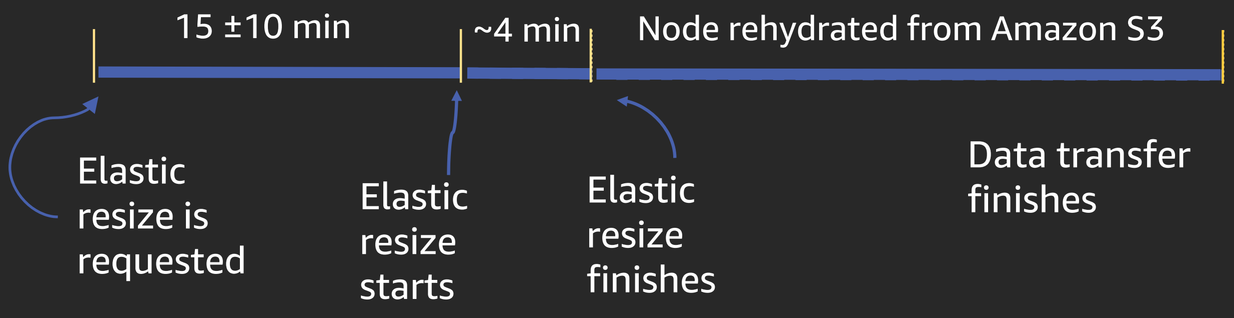
Classic resize



- Source cluster is placed into read-only mode during resize
- All data is copied and redistributed on the target cluster
- Allows for changing node types

Elastic resize





- At start of elastic resize, we take an automatic snapshot to Amazon S3 and provision the new node(s)
- Slices are redistributed/data transferred in the background
- In-flight queries/connections are put on hold
- Hot blocks are restored first
- Cluster is fully available for reads and writes
- Some queries within transactions maybe rollback

Elastic resize node increments

Instance type	Allowed increments	Max change from original size	Example: valid sizes for 4-node cluster
RA3 4xlarge DC2 large DS2 xlarge	2x or ½ original cluster size only	Double, ½ size	2, 4, 8
RA3 16xlarge DC2 8xlarge DS2 8xlarge	Can allow ± single node increments so long as slices remain balanced	Double, ½ size	2, 3, 4, 5, 6, 7, 8

When to use elastic vs. classic resize

	Elastic resize	Classic resize
Scale up and down for workload spikes	✓	
Incrementally add/remove storage	✓	
Change cluster instance type (SSD ⟷ HDD)		✓
If elastic resize is not an option because of sizing limits		✓
Limited availability during resize	<5 minutes (parked connections)	1–24 hours (read-only)

Best practices: Cluster sizing

Use at least two computes nodes (multi-node cluster) in production for data mirroring

- Leader node is given for no additional cost

Maintain at least 20% free space or three times the size of the largest table

- Scratch space for usage, rewriting tables
- Free space is required for vacuum to re-sort table
- Temporary tables used for intermediate query results

The maximum number of available Amazon Redshift Spectrum nodes is a function of the number of slices in the Amazon Redshift cluster

If you’re using DS2 instances, migrate to RA3

If you’re using DC1 instances, upgrade to the DC2 instance type

- Same price as DC1, significantly faster
- Reserved Instances can be migrated without additional cost in the AWS Console

Amazon Redshift Advisor

AWS re:Invent

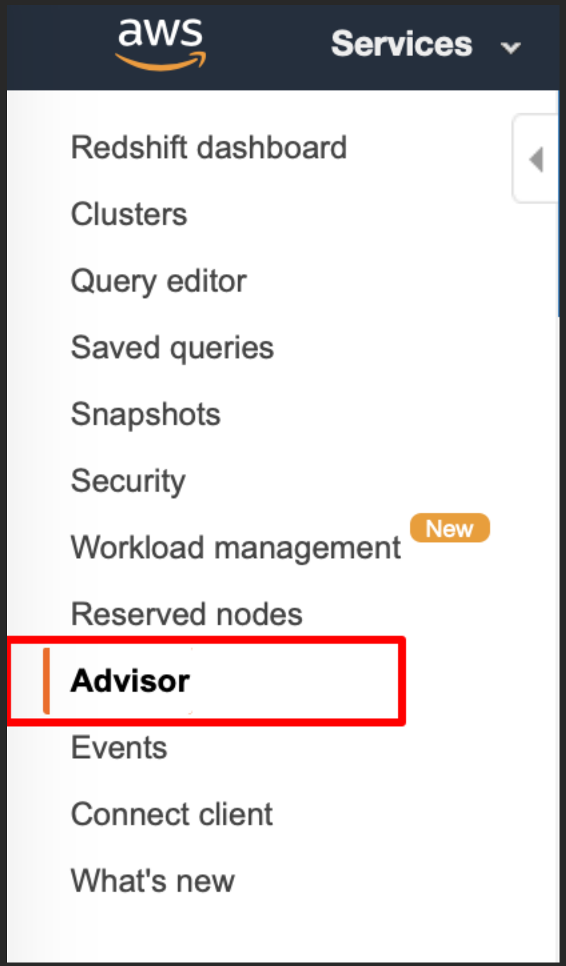
Amazon Redshift Advisor

Amazon Redshift Advisor available in Amazon Redshift Console

Runs daily scanning operational metadata

Observes with the lens of best practices

Provides tailored high-impact recommendations to optimize your Amazon Redshift cluster for performance and cost savings



Amazon Redshift Advisor: Recommendations

Recommendations include

- Skip compression analysis during COPY
- Split Amazon S3 objects loaded by COPY
- Compress Amazon S3 file objects loaded by COPY
- Compress table data
- Reallocate Workload Management (WLM) memory
- Cost savings
- Enable short query acceleration
- Alter distribution keys on tables

Improve Query Performance with Distribution Keys Refreshed 65 hours ago
Checks for appropriate distribution keys on tables.

Significantly improve query performance by using `ALTER TABLE` to redistribute the tables identified in this recommendation.

Amazon Redshift distributes table rows throughout the cluster according to the table distribution style. Tables with `KEY` distribution require a column as the distribution key (`DISTKEY`). The distribution of table rows are based on the `DISTKEY` column values.

An appropriate `DISTKEY` places a similar number of rows on each node and is frequently referenced in join conditions. An optimized join occurs when tables are joined on their `DISTKEY` columns, accelerating query performance.

Observation
An analysis of the cluster's workload between 2019-10-13 and 2019-12-02 (50 days), identified tables that will significantly benefit from a `KEY` distribution style.

Recommendation
Use the following blocks of SQL statements to redistribute tables with the recommended `DISTKEY` column. In order to realize a significant performance benefit, all SQL statements within a recommendation group must be implemented.

```
-- First redistribution group
-- Database: "dev"
ALTER TABLE /*dkru-e554b525-a39c-4973-b17d-5d479ccff796-g0-0*/ [redacted] ALTER DISTSTYLE KEY D
```

Additional resources

AWS Labs on GitHub: Amazon Redshift

https://github.com/awslabs/amazon-redshift-utils

https://github.com/awslabs/amazon-redshift-monitoring

https://github.com/awslabs/amazon-redshift-udfs

Admin scripts

Collection of utilities for running diagnostics on your cluster

Admin views

Collection of utilities for managing your cluster, generating schema DDL, and so on

Analyze Vacuum utility

Utility that can be scheduled to vacuum and analyze the tables within your Amazon Redshift cluster

Column Encoding utility

Utility that will apply optimal column encoding to an established schema with data already loaded

AWS big data blog: Amazon Redshift

Amazon Redshift Engineering's Advanced Table Design Playbook

https://aws.amazon.com/blogs/big-data/amazon-redshift-engineerings-advanced-table-design-playbook-preamble-prerequisites-and-prioritization/
—Zach Christopherson

Top 10 Performance Tuning Techniques for Amazon Redshift

https://aws.amazon.com/blogs/big-data/top-10-performance-tuning-techniques-for-amazon-redshift/
—Ian Meyers and Zach Christopherson

Twelve Best Practices for Amazon Redshift Spectrum

https://aws.amazon.com/blogs/big-data/10-best-practices-for-amazon-redshift-spectrum/
—Po Hong and Peter Dalton

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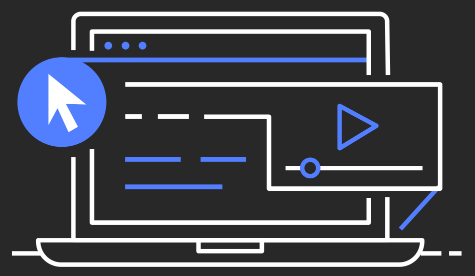

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