ORACLE OPEN WORLD

Oracle Sharding

Geo-distributed, Linearly Scalable, Multi-model, Cloud-native Database

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Oct 23rd, 2018

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Presented with

EPSILON

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Program Agenda

1 Oracle Sharding Overview

2 Customer Case Study – Epsilon

3 Sharding 19c Features

4 Sharding Use Cases

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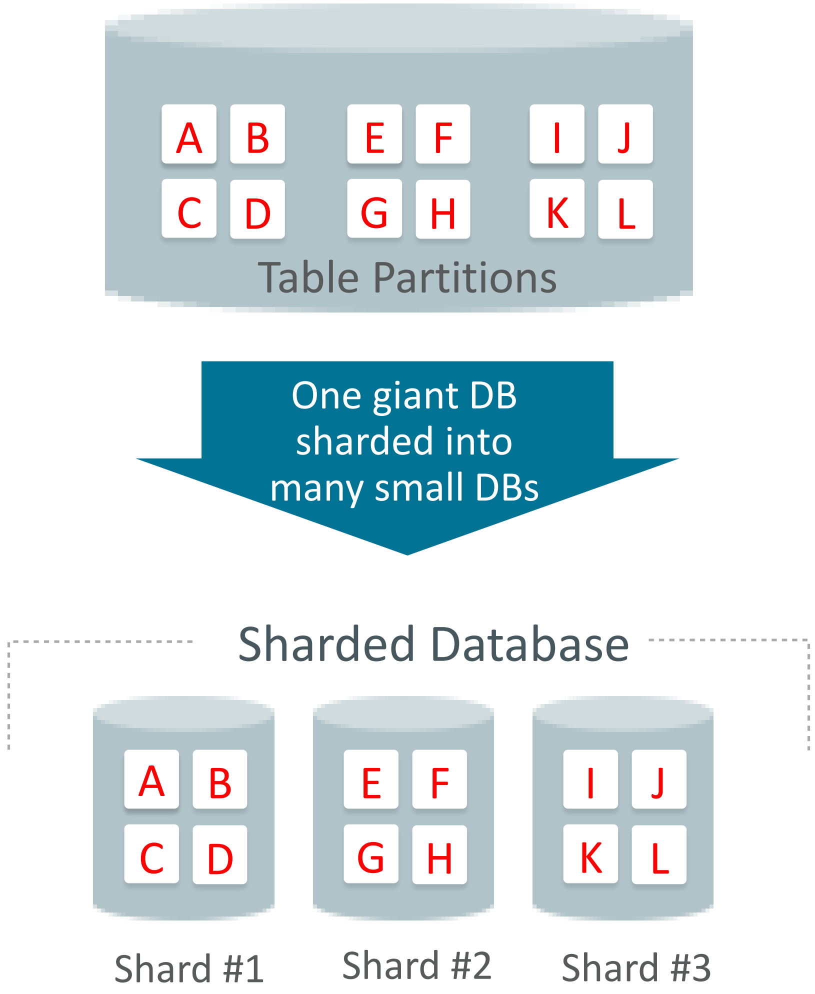
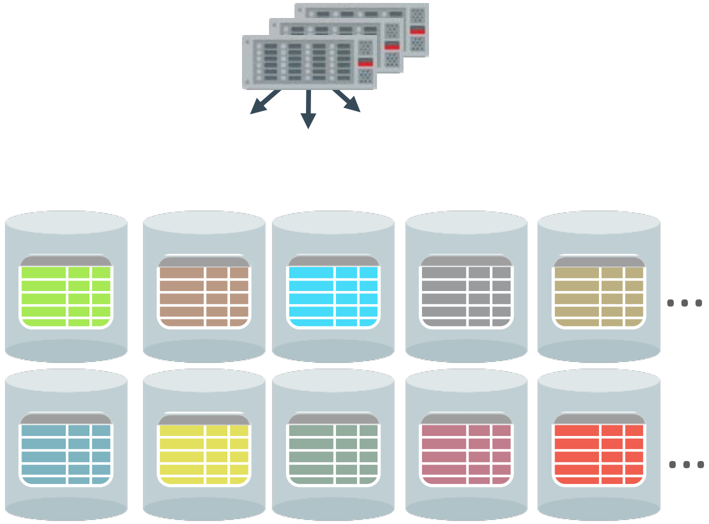
Oracle Sharding | Concepts

- Horizontal partitioning of data across up to 1000 independent Oracle Databases (shards)
- Shared-nothing hardware architecture
  - Each shard runs on a separate server
  - No shared storage
  - No clusterware
- Data is partitioned using a sharding key (i.e. account_id)



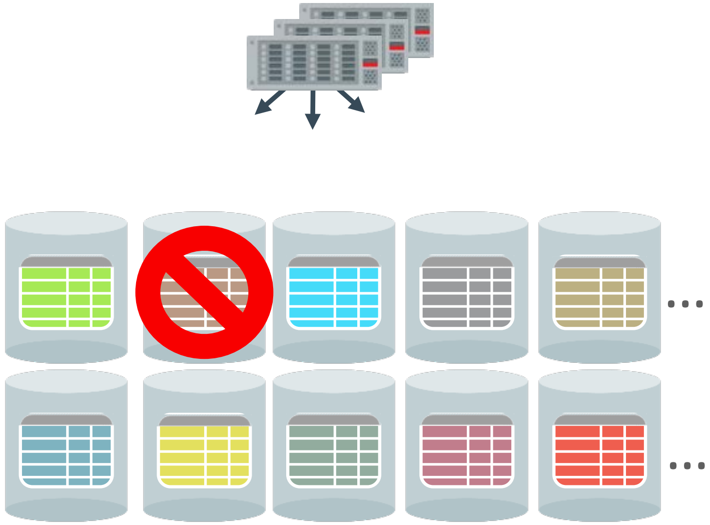
Oracle Sharding | Benefits

Linear Scalability



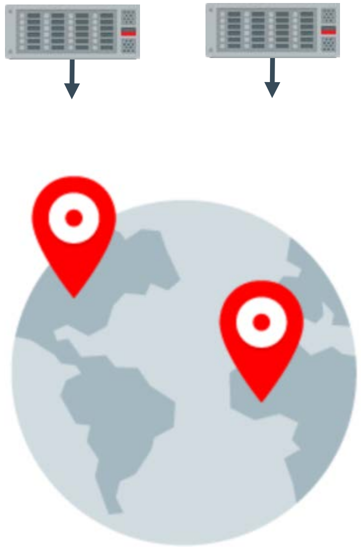
Add shards online to scale database size and throughput. Online split and rebalance.

Ultra Availability



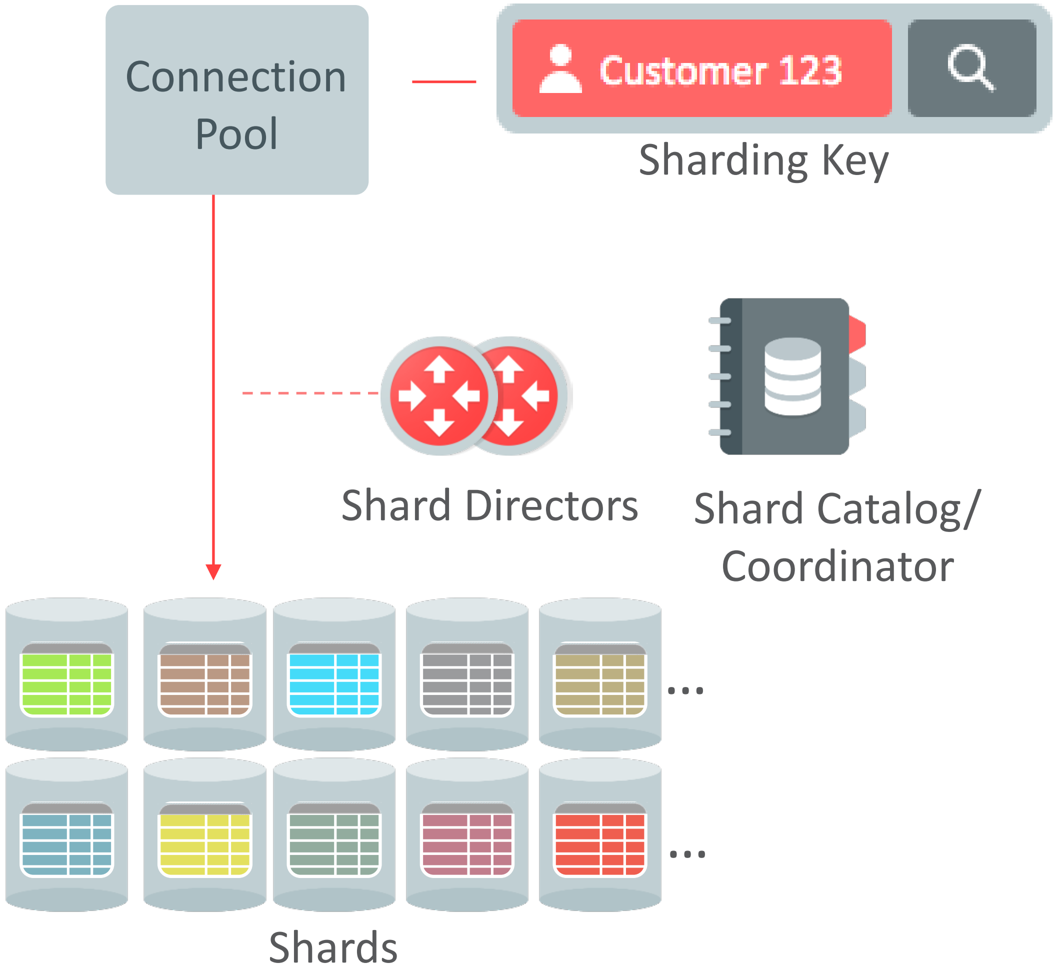
Shared-nothing hardware architecture. Fault of one shard has no impact on others.

Geographic Distribution



User defined data placement for performance, availability, DR or to meet regulatory requirements.

Oracle Sharding | Architecture & Key Features



- Automated deployment of up to 1000 shards with replication (Active Data Guard and Oracle GoldenGate)
- Sharding methods
  - System-managed, User-defined and Composite
- Centralized schema maintenance
  - Native SQL for sharded and duplicated tables
  - Relational, JSON, LOBs and Spatial support
- Direct routing and Proxy routing
- Online scale-out w/ auto-resharding or scale-in
- Mid-tier Sharding
  - Scale mid-tiers along with shards
- RAC Sharding
  - Gives a RAC DB, the performance and scalability of Oracle Sharding with minimal application changes

Oracle Sharding | Sharded and Duplicated Tables

Database Tables

Customers

Customer	Name
123	Mary
456	John
999	Peter

Orders

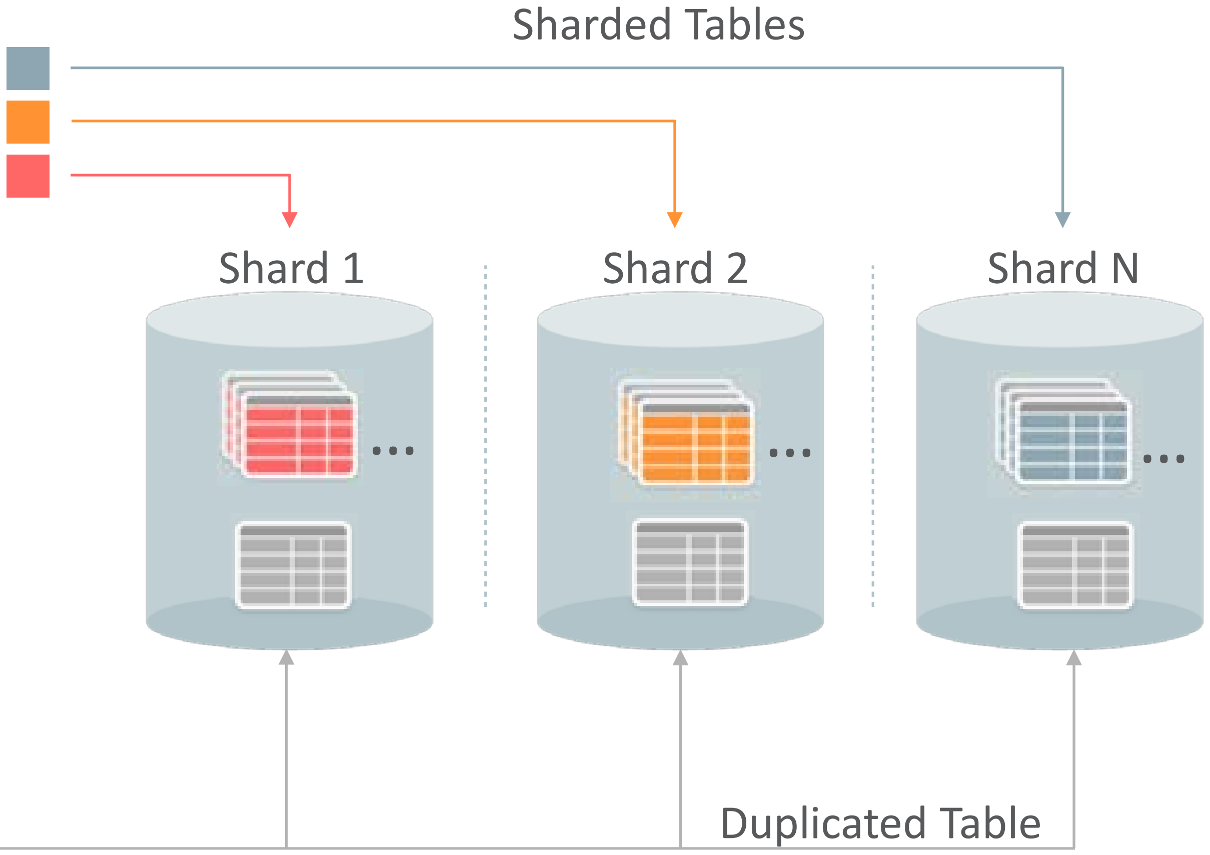
Order	Customer
4001	123
4002	456
4003	999
4004	456
4005	456

Line Items

Customer	Order	Line
123	4001	40011
999	4003	40012
123	4001	40013
456	4004	40014
999	4003	40015
999	4003	40016

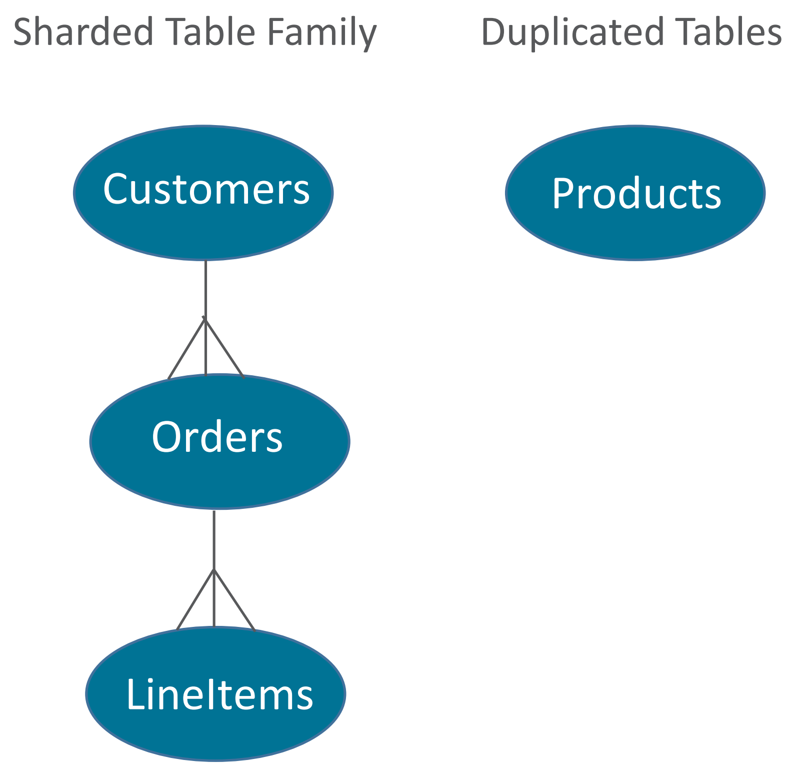
Products

SKU	Product
100	Coil
101	Piston
102	Belt



Oracle Sharding | Data Modeling Considerations

- To reap sharding benefits, schema must be designed to maximize number of single-shard requests
- Sharding-amenable schema consists of:
  - Sharded Table Family:
    - Consists of a single root table and hierarchy of child and grandchild tables
    - Set of tables equi-partitioned by the sharding key
      - Related data is always stored and moved together
      - Joins & integrity constraint checks are done within a shard
    - Sharding method and key are based on App requirements
    - Sharding key must be the leading column of a primary key
  - Duplicated Tables:
    - Non-sharded tables are replicated to all shards
    - Usually contain common reference data
    - Can be read or updated on each shard

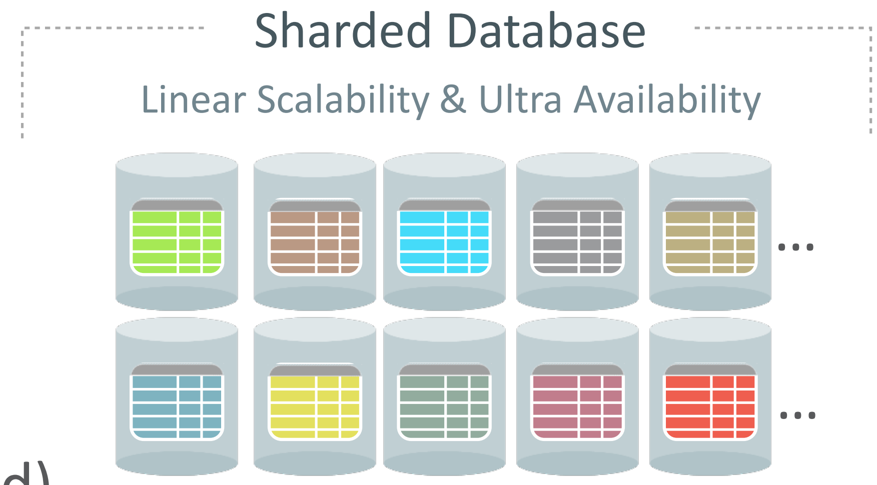


- ➢ Customer profile applications sharded by customer_profile_id

Sharding Method | System-managed

Linear Scalability & Ultra Availability

- Partition data across shards by CONSISTENT HASH
  - Ranges of hash values of sharding keys are assigned to shards
- Data is sharded / re-sharded automatically
- Data is evenly distributed across shards
- All shards are managed and replicated as unit
- Many relatively small equally sized chunks (120 per shard)



+ Automatic balanced data distribution

- User has no control on location of data

System-managed Sharded Table Family | Example

```
CREATE TABLESPACE SET  tbs1 ;
CREATE TABLESPACE products_tsp;

CREATE SHARDED TABLE Customers
( CustId    VARCHAR2(60) NOT NULL,
  FirstName VARCHAR2(60),
  LastName  VARCHAR2(60),
  …
  CONSTRAINT pk_customers
    PRIMARY KEY(CustId)
)
PARTITION BY CONSISTENT HASH (CustId)
PARTITIONS AUTO
TABLESPACE SET tbs1 ;
```

```
CREATE SHARDED TABLE Orders (
  CustId    VARCHAR2(60),
  OrderId   INTEGER,
  OrderDate TIMESTAMP,
  …
  CONSTRAINT pk_orders
    PRIMARY KEY (CustId, OrderId),
  CONSTRAINT fk_orders_parent
    FOREIGN KEY (CustId) REFERENCES
Customers(CustId)
)
PARTITION BY REFERENCE (fk_orders_parent) ;
```

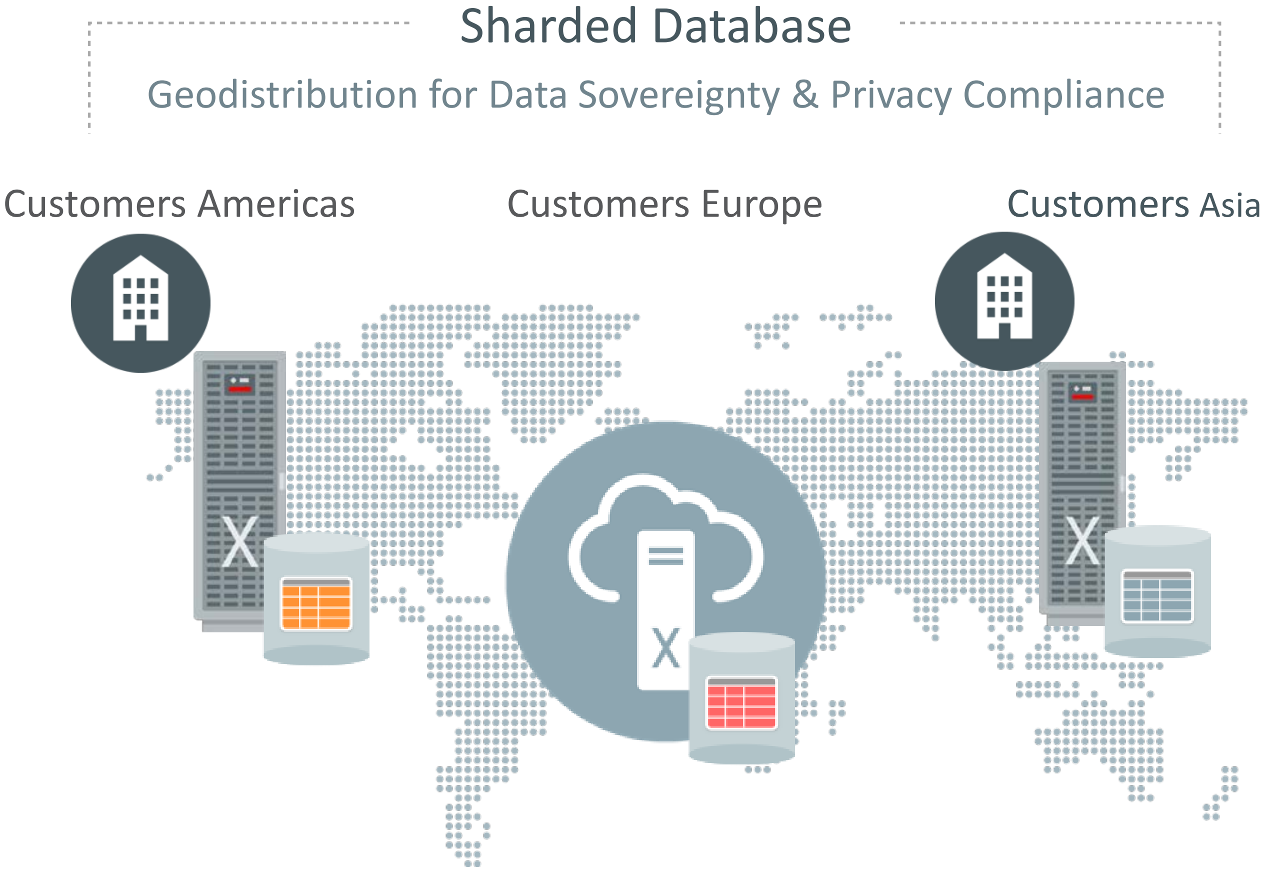
```
CREATE DUPLICATED TABLE Products (
ProductId INTEGER PRIMARY KEY,
Name      VARCHAR2(128),
LastPrice NUMBER(19,4),
…
)
TABLESPACE products_tsp ;
```

- ➢ Fast, direct access from within each region
- ➢ Multi-shard queries access data from all regions

Sharding Method | User-defined

Explicit mapping of data to shards for better control, compliance & performance

- Partition data across shards by RANGE or LIST
  - Ranges or lists of sharding key values are assigned to shards *by the user*
- User-controlled data distribution provides:
  - + Regulatory compliance
    - Data remains in country of origin
  - + Hybrid cloud and cloud bursting
    - Some shards on premises; other shards in the cloud
  - + Control of data availability for planned maintenance
  - + Ability to customize hardware resources and HA configuration for subsets of data
  - + More efficient range queries
  - - User needs to maintain balanced data distribution



- ➢ Allocate separate set of shards for different geographies
- ➢ Billing system sharded by geography, then by customer_id

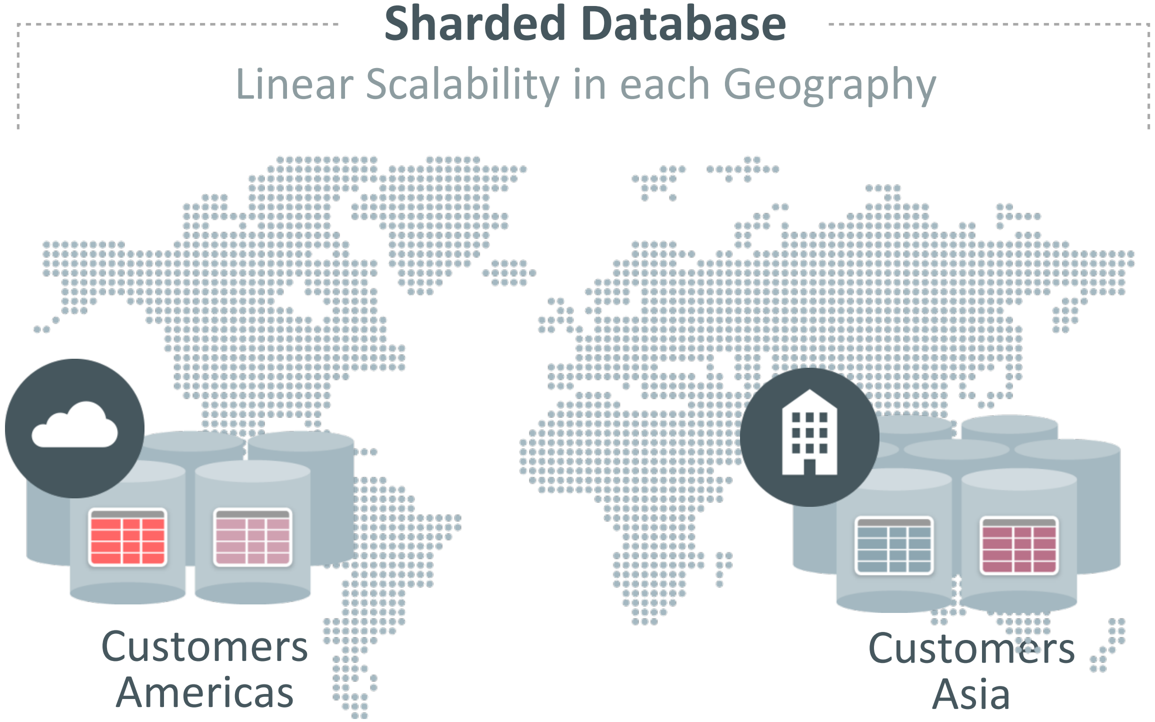
Sharding Method | Composite

Geographic Distribution, Linear Scalability and Ultra Availability

- Provides two-levels of sharding
- The sharded database is divided into N sets of shards called *shardspaces*
  - Data is partitioned across shardspaces by LIST or RANGE on *super-sharding key* (e.g. geography)
  - Within each shardspace, data is partitioned across shards by CONSISTENT HASH using *sharding key* (e.g. customer id)

+ For geo-distribution or hybrid clouds with linear scalability

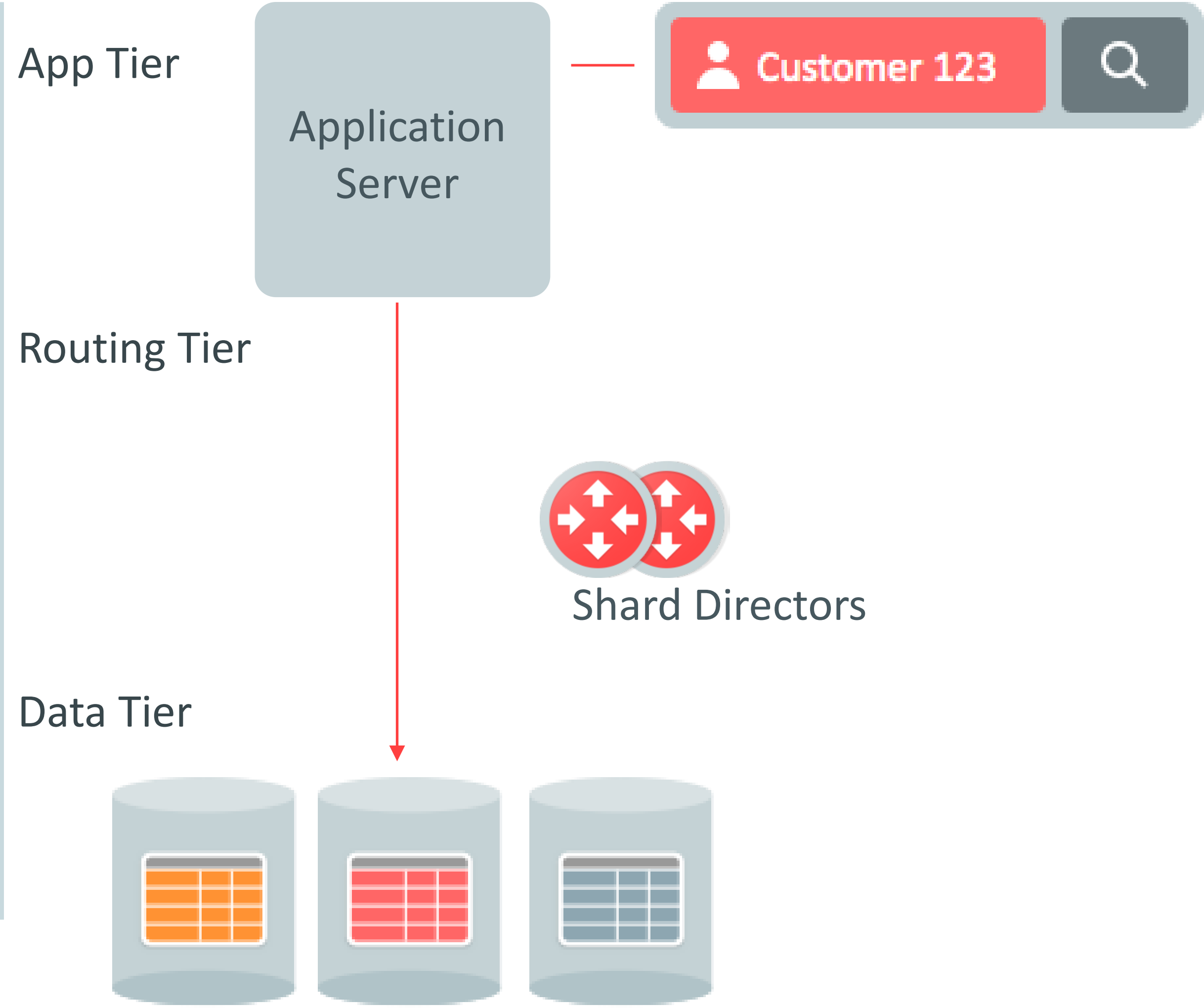
- Requires two sharding keys: super_sharding_key and sharding_key



Oracle Sharding | Direct Routing with Sharding Key

Fast Path for Sharding Key based access

- Connection pool maintains the shard topology cache
  - Upon first connection to a shard
    - Connection pool retrieves all sharding key ranges in the shard
    - Connection pool caches the key range mappings
- DB request for a key that is in any of the cached key ranges goes directly to the shard (i.e., bypasses shard director)



Oracle Sharding | Direct Routing with Sharding Key

Oracle Universal Connection Pooling

- Must use direct routing for linear scalability & fault isolation
  - Requires building and passing the sharding key as part of connection check-out from the pool
  - All data required for a transaction is contained within a single shard
- Example: Using UCP Sharding APIs:

```
OracleShardingKey keyMaryEmail =
                  pds.createShardingKeyBuilder()
                     .subkey("mary.smith@xyz.com", OracleType.VARCHAR2)
                      .build();
Connection connection =
                  pds.createConnectionBuilder()
                      .shardingKey(keyMaryEmail)
                      .build();
```

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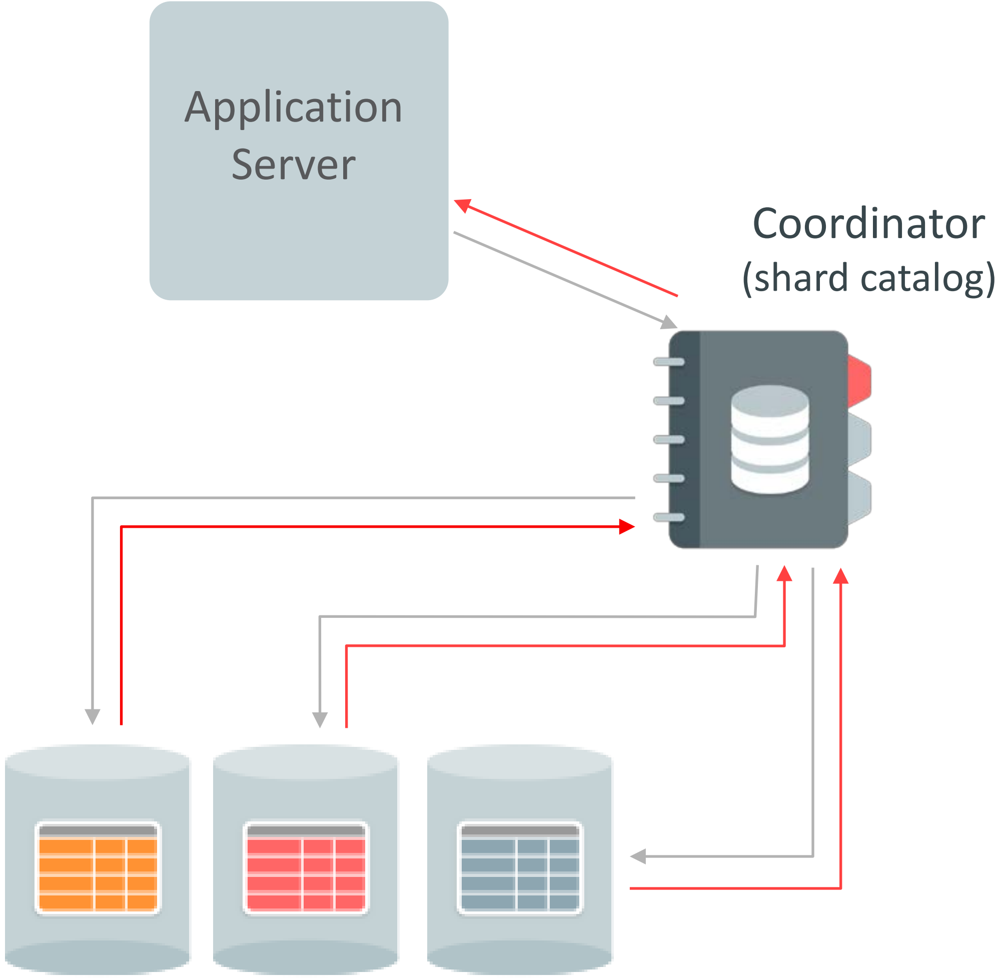
Oracle Sharding | Proxy Routing for Multi-shard Queries

For Workloads that cannot pass sharding key during connection check-out

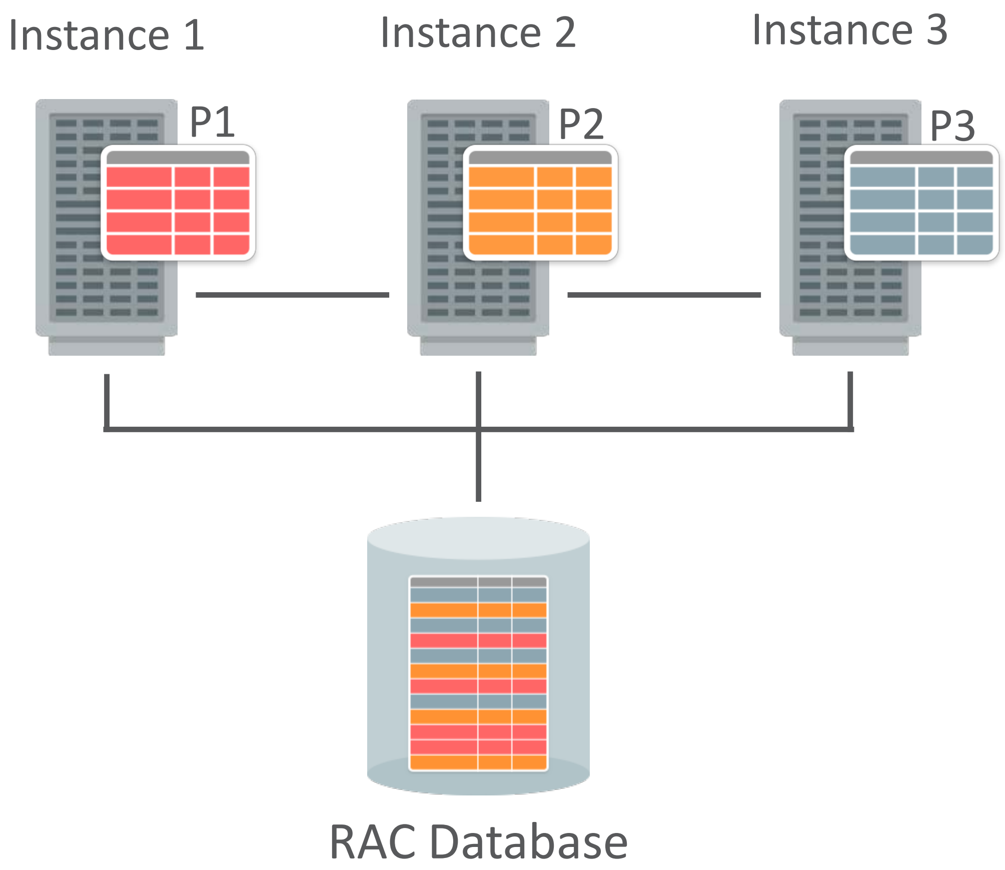
- Applications connect to Query coordinator/Shard Catalog
  - E.g. `SELECT GEO, CLASS, COUNT(*) FROM CUSTOMERS GROUP BY GEO, ROLLUP(CLASS);`
- Coordinator rewrites the query to do most processing on the shards
- Supports shard pruning and scatter-gather
- Final aggregation performed on the coordinator



RAC Sharding | For Partition-amenable Applications

Virtual sharding of a non-sharded RAC database

- Affinitizes table partitions to RAC instances
  - Affinity gives better cache utilization and reduced block pings across instances
- Takes advantage of direct routing API of Sharding
  - Requests that specify sharding key are routed to the instance that logically holds the corresponding partition
  - Requests that don't specify sharding key still work transparently
- Add sharding key to improve performance of OLTP operations; no changes to the database schema
  - `alter system enable affinity <TableName>;`
- Benefits
  - Gives RAC the performance and scalability of a Sharded Database with minimal application changes



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Epsilon – Oracle Sharding Use Case in Public Cloud

Gairik Chakraborty

Senior Director, Database Administration, Epsilon

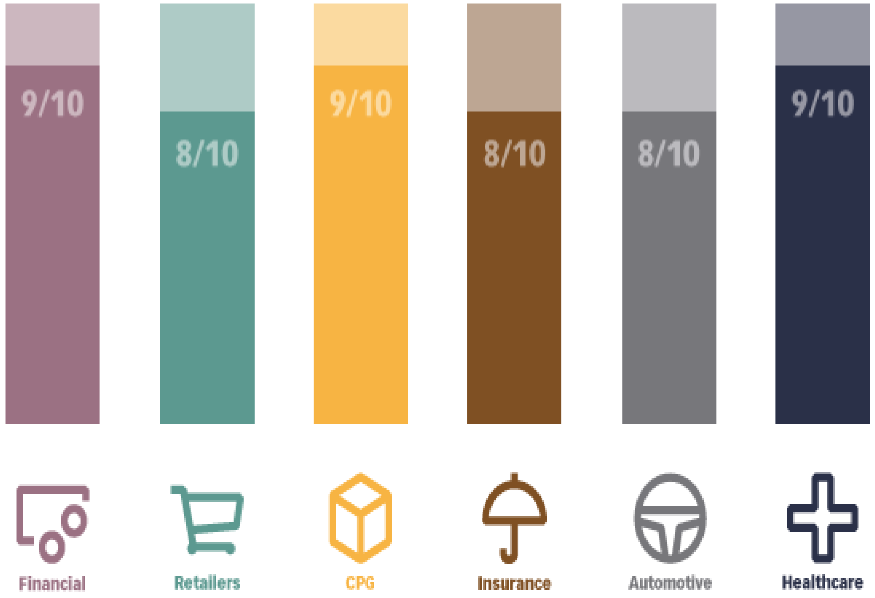
Agenda

- Snapshot of Epsilon
- Oracle Sharding Use Case in Public Cloud

EPSILON

Epsilon at a Glance

- Epsilon is all-encompassing global marketing company, we are global leader in turning data-driven marketing into personalized customer experience and lasting relationships
- More than 9000 associates and 70 offices worldwide
- Largest permission-based e-mailer in the world, delivering over 75 billion emails annually
- World's leading source of data with information covering over 1.5B individual records and 278M devices
- More than 2,000 global clients, including 26 of the Fortune 100
  - 9 out of 10 Top Banks
  - 8 out of 10 Top Retailers
  - 9 out of Top 10 Pharmaceutical Companies



Leader

Email marketing vendor

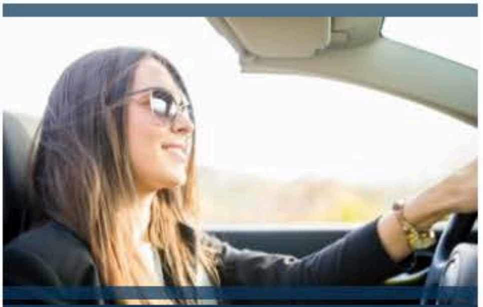
Leader

Database marketing service provider

Leader

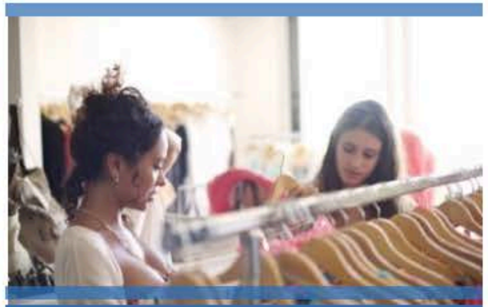
Loyalty program service provider

We deliver personalized connections, build loyalty and drive business for brands around the world



Data

Know each of your customers on a meaningful level with Agility Audience, our premier solution offering unrivaled customer information, data resources and tools.



Loyalty

Create a one-of-a-kind loyalty program and grow long-lasting customer relationships with Agility Loyalty® and our full suite of loyalty capabilities and services.

Digital Messaging

Orchestrate personalized conversations taking your marketing where it needs to go with Agility Harmony®, the first platform built to be omnichannel from the ground up.

Media Reach

Optimize your media mix with the customer data, marketing technology and channels expertise that Epsilon and Conversant provide. We deliver personalized content that gets results.

Multichannel

Consolidate your approach to insights-driven multichannel marketing. Agility Unite combines unmatched consumer insights and machine learning to tailor every interaction to an individual's wants and needs across any channel.

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Oracle Sharding Use Case in Public Cloud

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High Level OLTP Application Business Requirements

- Loyalty real time marketing solution with extreme availability, performance and scalability requirement
- Deployment should support any public cloud as well as on premises if needed – product offering is cloud first
- Platform supports real time POS integration with average call time from 200-500ms average and each API call can have multiple (20–100) SQLs internally
- Scale out solution which can grow flexibly based on workload demand
- Scalable, reliable and highly available infrastructure along with industry standard security and auditing

Why we like Oracle Sharding

- Loyalty marketing solution includes processing of high volume of complex financial transaction which requires strong multi version concurrency control, data protection, security, etc.
  - NoSQL solutions are not very good fit for those use cases
- Application is using many complex joins and a solution needs to support the existing code with minimal change
- Use all other existing oracle feature like data consistency, security, availability, robust performance optimizer, backup and recovery which are key for business critical application deployment and are already part of Oracle Sharding framework
- Using Oracle Sharding, OLTP database can scale up and scale out and we expect to use lesser number of shards based on workload demand

Consideration before using Oracle Sharding

- Application data model needs to change to support sharding
- Identify transaction tables which can be sharded, reference table needs to be duplicated
- Select appropriate sharding key and sharding method
- Non default global database service created using GSDCTL needs to be used for connection
- Data access for OLTP should use sharding key as much as possible to avoid cross shard operation which is expensive in terms of execution time
- Application need to use driver which has sharding support in built . Example includes Oracle JDBC, OCI, ODP.NET (unmanaged driver), Oracle UCP, etc.
- Shard catalog setup is protected with active data guard with maximum availability protection and fast start failover enabled

OLTP System Deployment Architecture at Public Cloud

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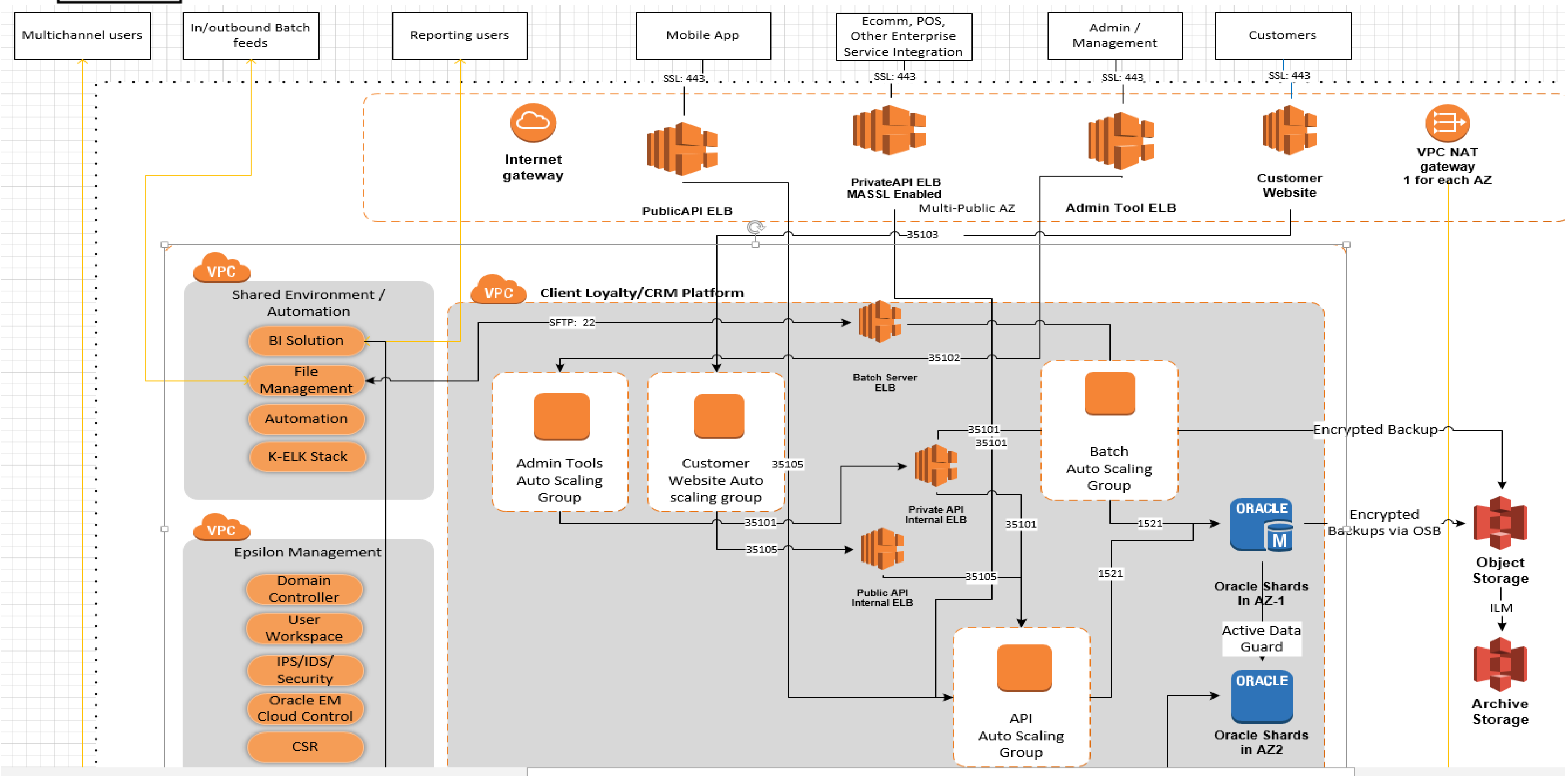
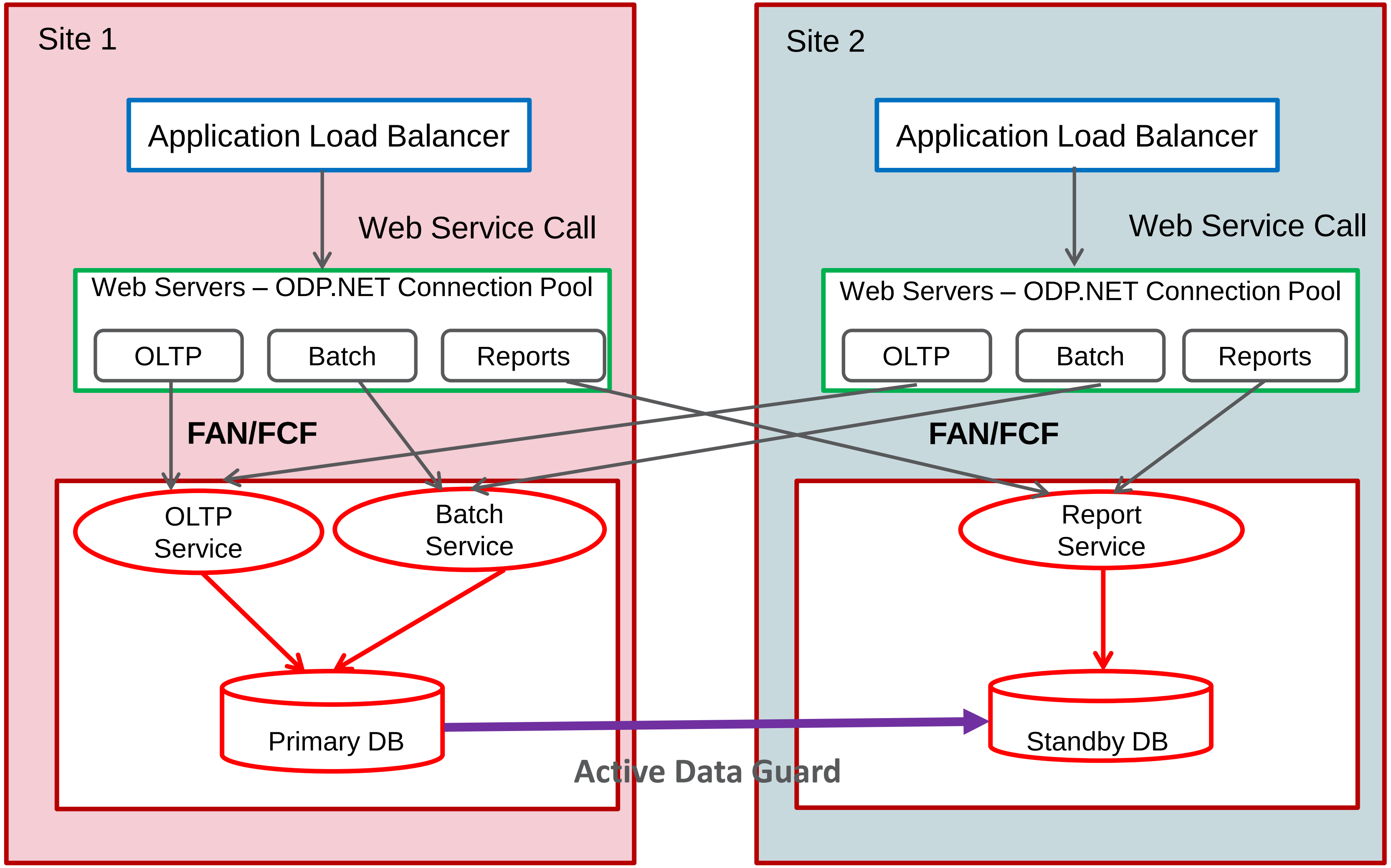
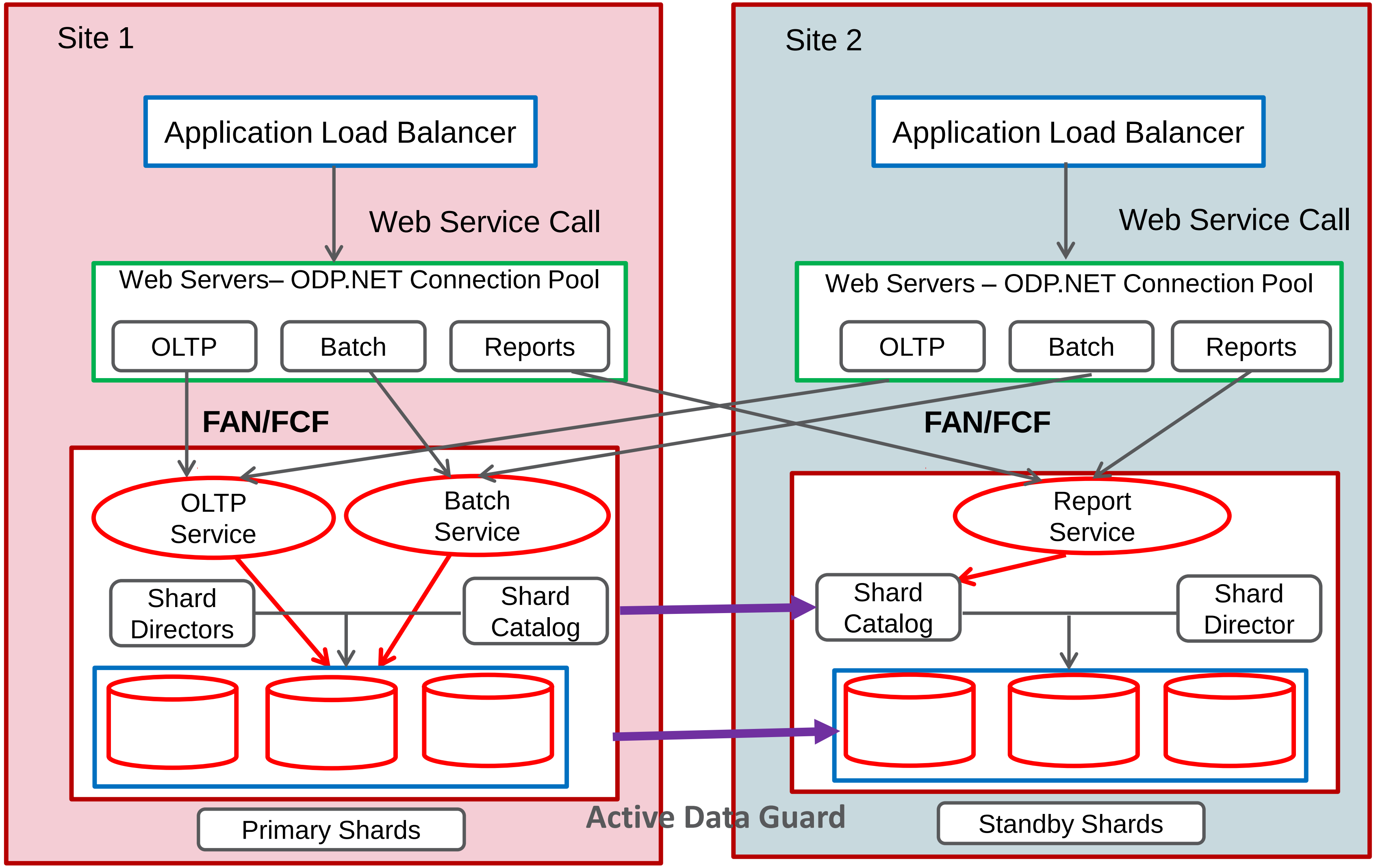


Application Service Placement : Current State



Application Service Placement : Target State with Sharding



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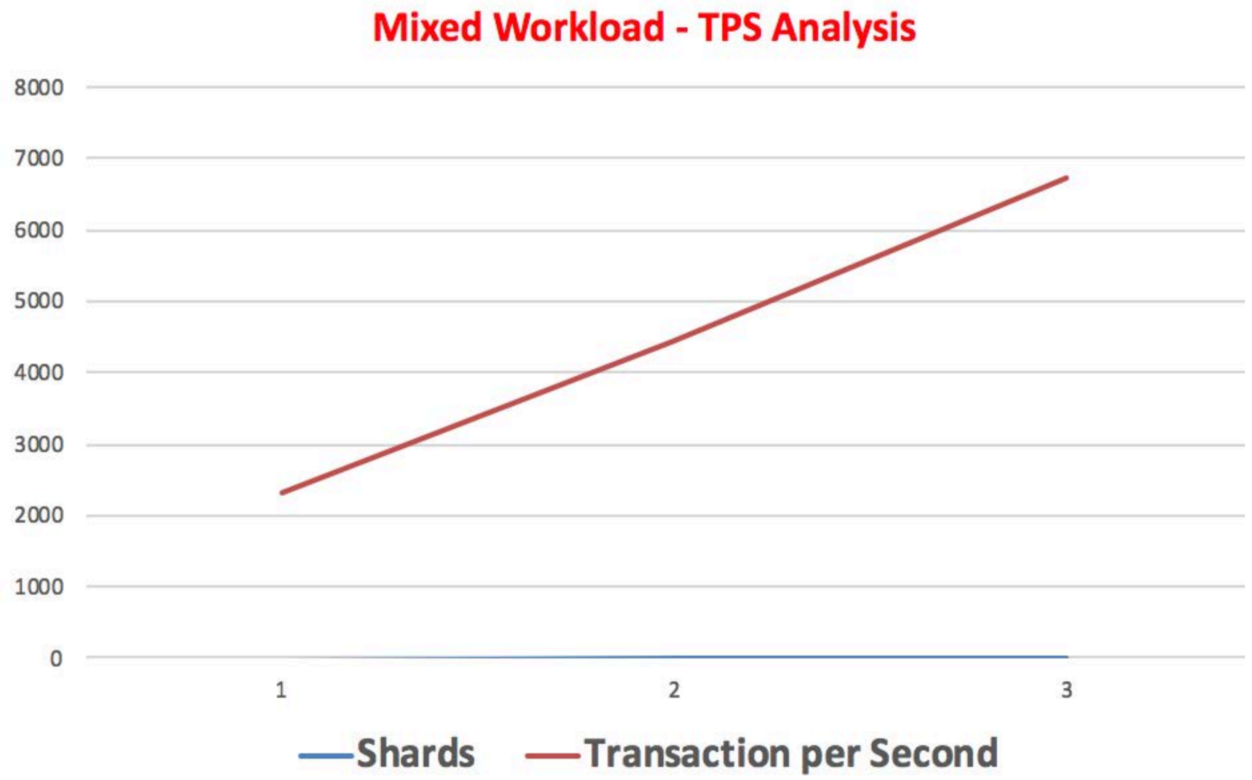
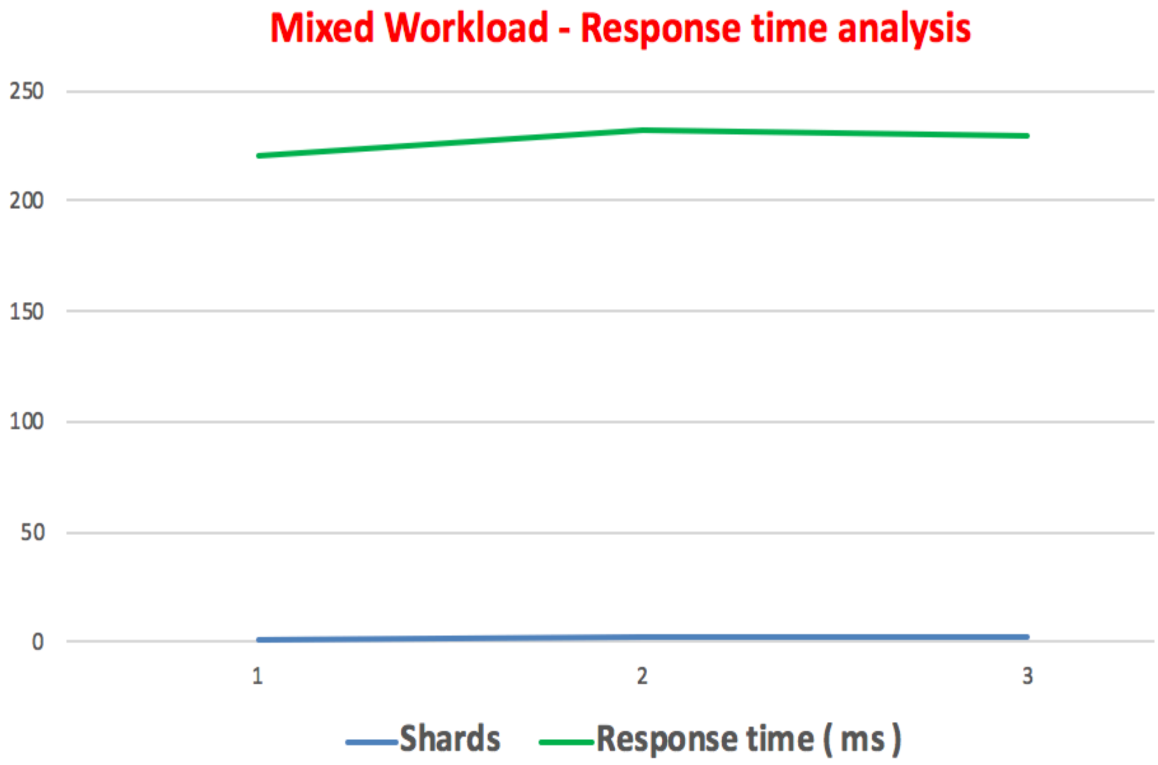
POC Result – Horizontal Scalability





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Best Practices

- Global service used for ODP.NET needs to have –*notification* set to TRUE using GDSCTL while configuring service for FAN
- Client side TNS should point to multiple shard directors for high availability instead of shard nodes.
- Backups should not run during chunk movement (either during re-shard operation or manual chunk movement) as that will not have correct data layout.
- During recovery, validate or recover shard option may be needed to sync it with shard catalog

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Future Plans

- Collaborate with oracle engineering team to convert Epsilon loyalty solution to be sharding capable, configure application for zero downtime using features like application continuity during shard failure or re-shard operation, etc.

- Plan to deploy Oracle sharding for many customers as next generation ***true horizontally scalable multiple cloud global solution across any region*** as part of Epsilon's global loyalty platform deployment plan

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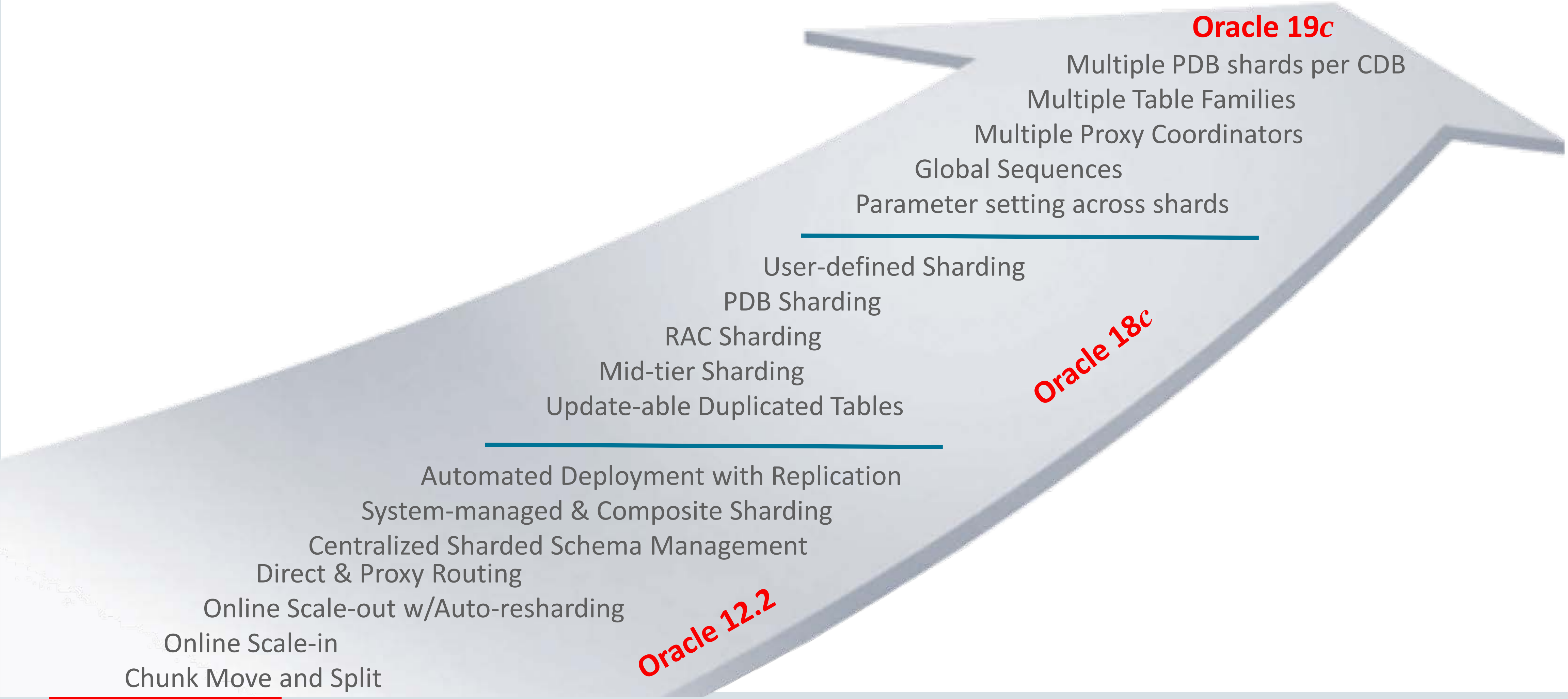
Oracle Sharding Evolution



Oracle 19*c*

Multiple PDB shards per CDB

Multiple Table Families

Multiple Proxy Coordinators

Global Sequences

Parameter setting across shards

User-defined Sharding

PDB Sharding

RAC Sharding

Mid-tier Sharding

Update-able Duplicated Tables

Oracle 18*c*

Automated Deployment with Replication

System-managed & Composite Sharding

Centralized Sharded Schema Management

Direct & Proxy Routing

Online Scale-out w/Auto-resharding

Online Scale-in

Chunk Move and Split

Oracle 12.2

NEW IN 19c

Oracle Sharding | 19c Features

- Support multiple PDB-shards in the same CDB
  - Allows consolidation of sharded databases (SDBs)
- Enables shard catalog's ADG standbys to act as multi-shard query coordinators
  - Improves HA & scalability of proxy routing for reporting and analytical workloads
- Multiple Table Families
  - Allows an SDB to support multiple table families, each of which can be sharded with a different sharding key
- Support for fast data load
  - Data is split and loaded directly to shards in parallel

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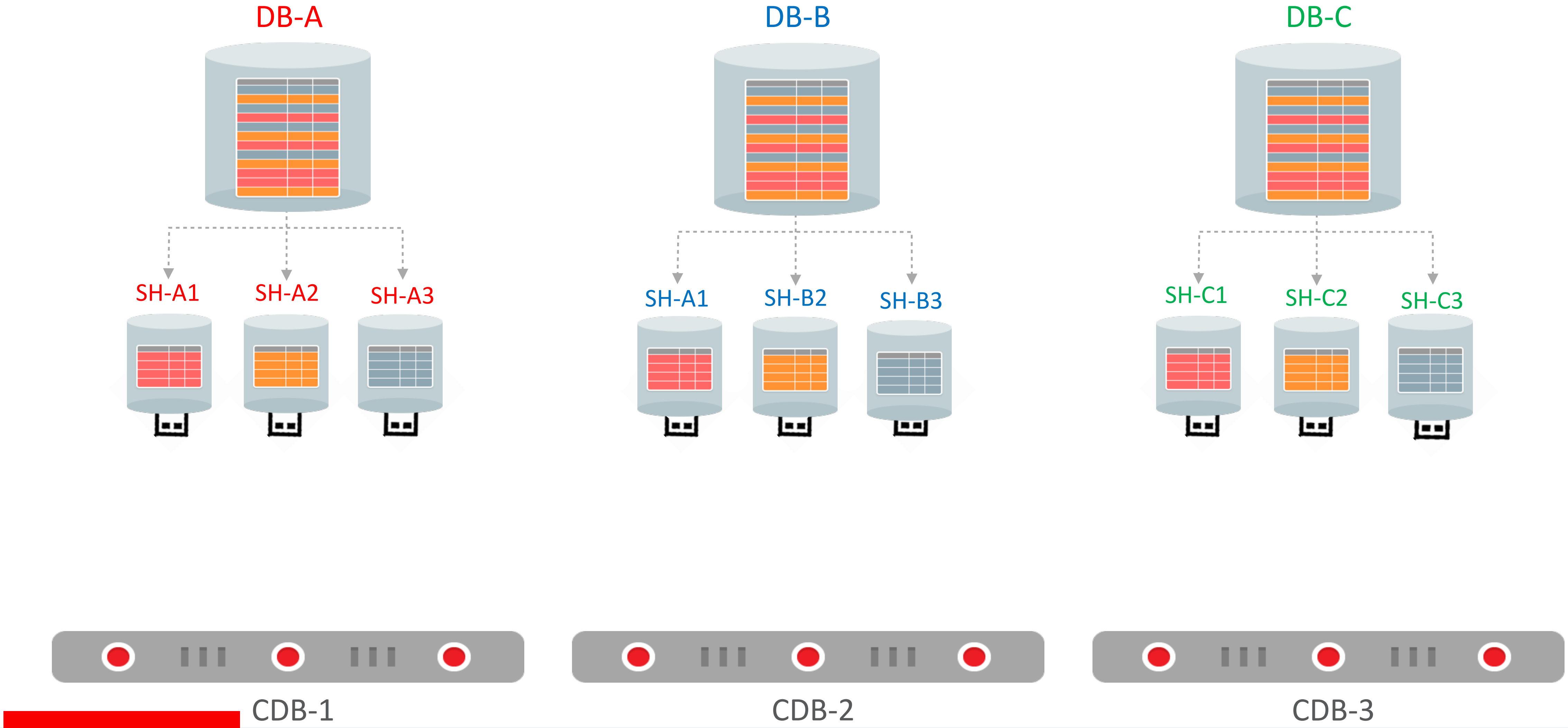
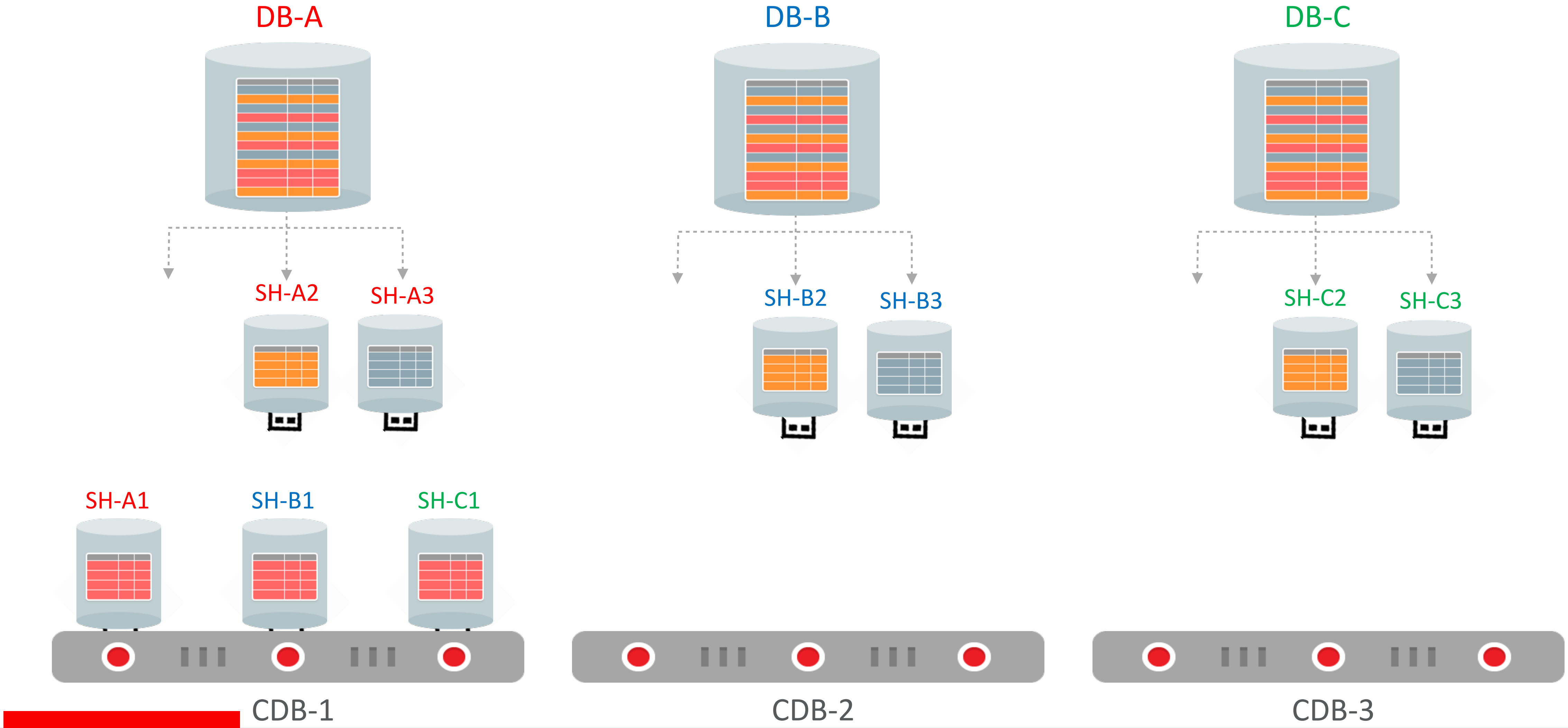
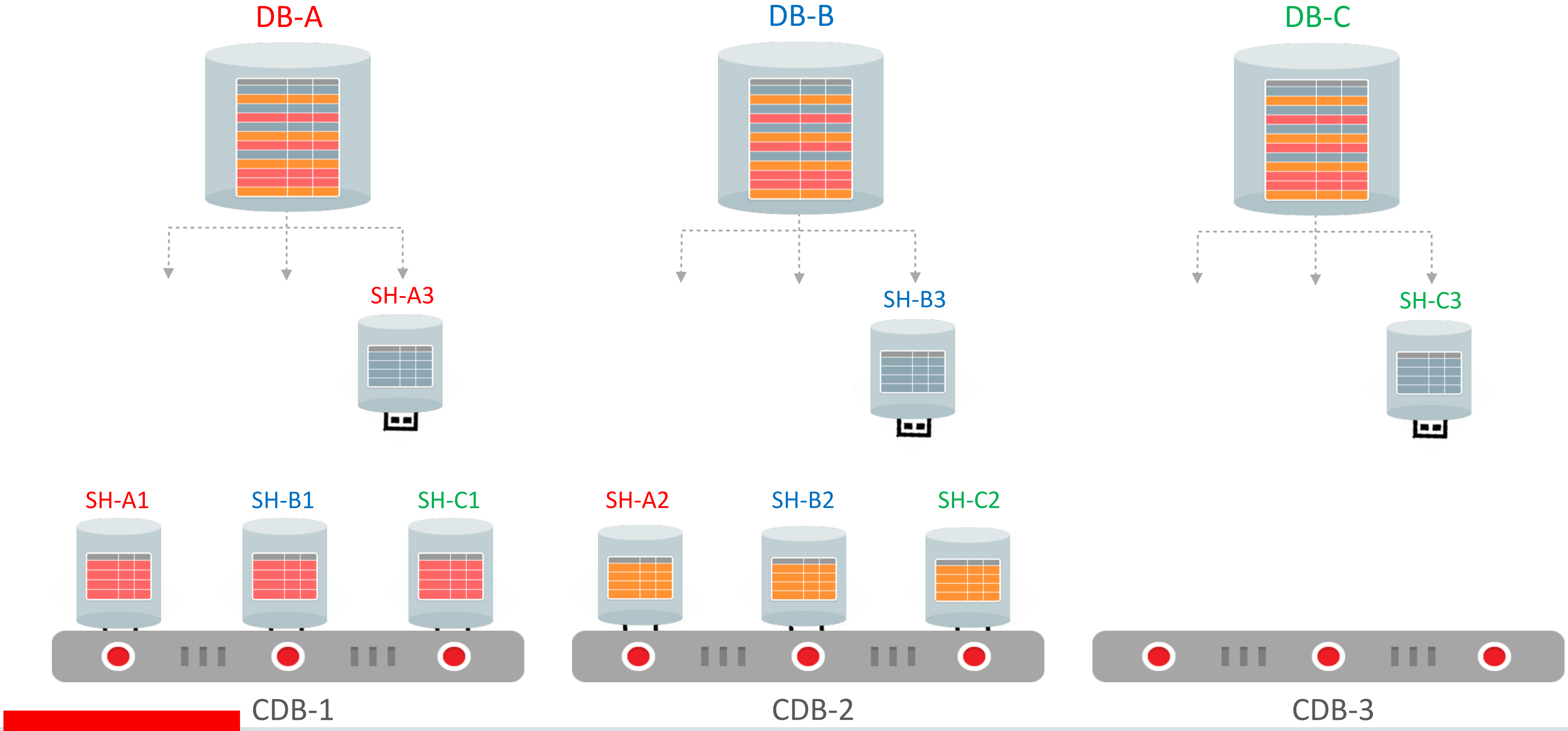
Consolidation of Sharded Databases



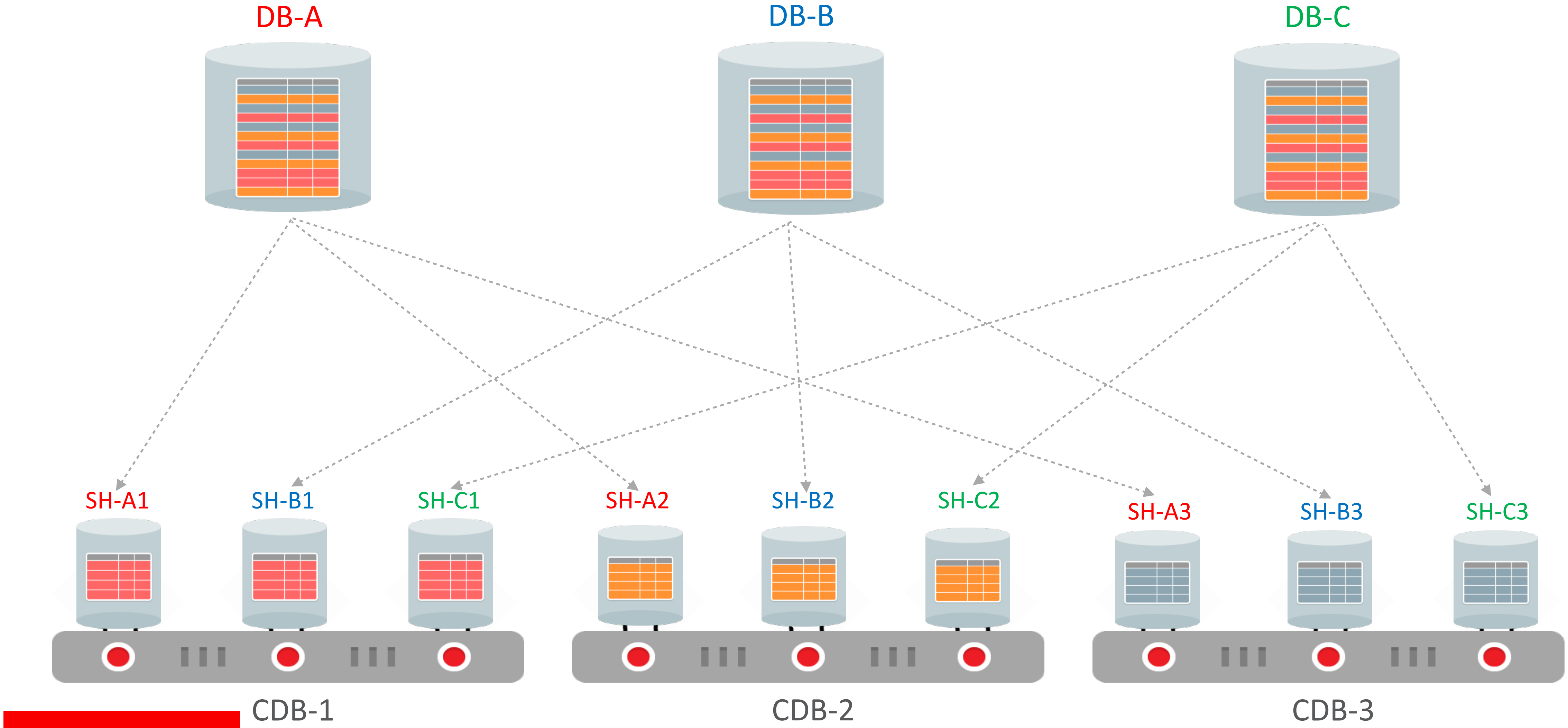
Consolidation of Sharded Databases



Consolidation of Sharded Databases



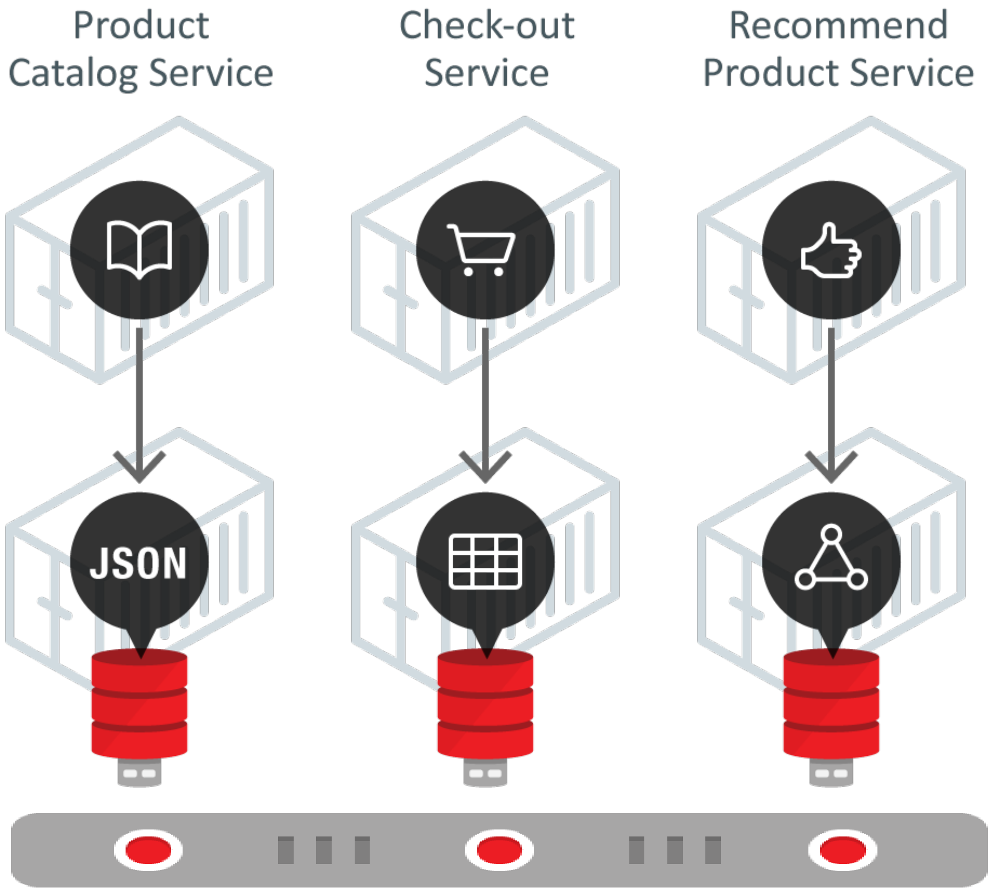
Consolidation of Sharded Databases



Multitenant Database for Microservices

Reduce the cost and complexity of data management for new apps

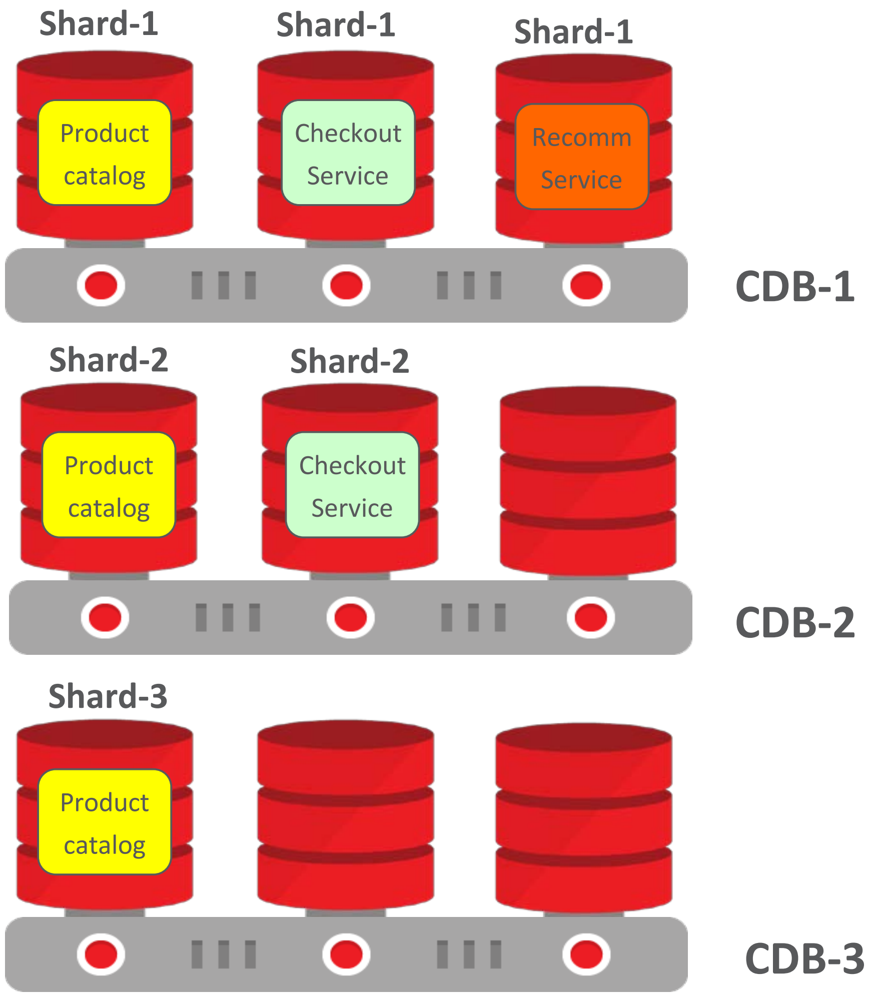
- Microservices use PDBs
  - Each microservice allocates its own dataset (can be a PDB, Schema, or a subset)
  - Each microservice has private data model
- Multitenant database containers deliver
  - Manage many databases as one
  - Secure separation of data
  - Easy sharing and querying of data across PDBs
- Database views isolate what each microservice sees



PDB Sharding for Microservices

Scalability, fault isolation and geo-distribution

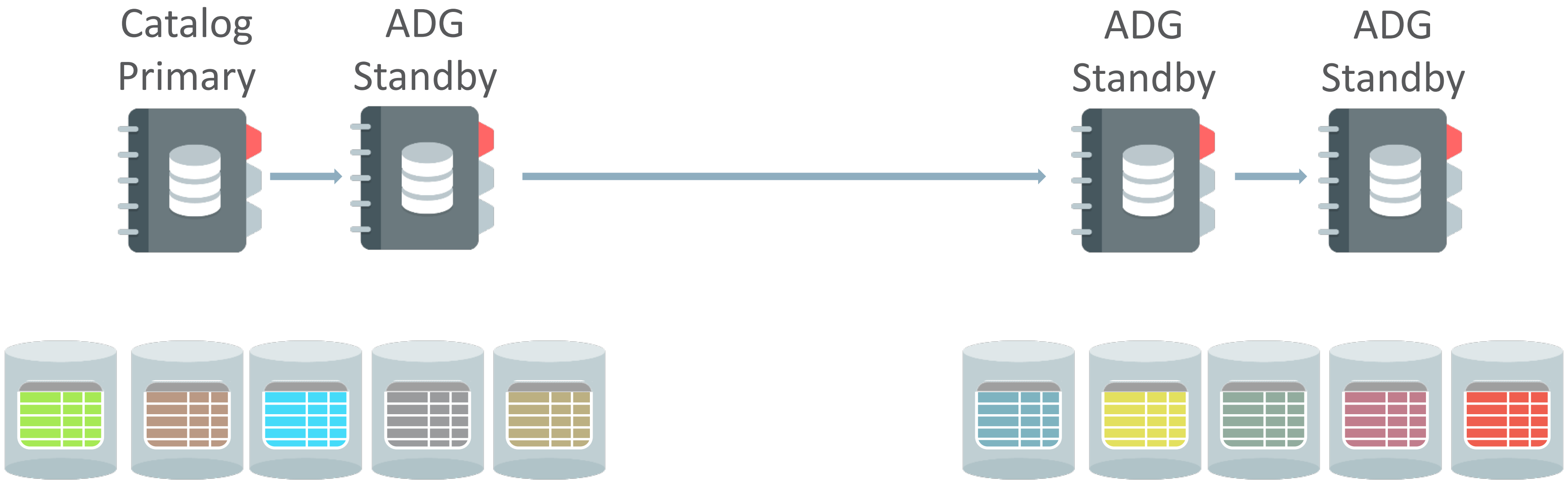
- Multitenant simplifies manageability
- 19c PDB Sharding feature adds benefits of sharding to multitenant
  - Each PDB can be sharded individually across multiple CDBs
- One of the main reasons for using microservices is the ability to scale each service individually
  - Allows to save a lot of resources comparing to scaling a monolithic application.
- PDB Sharding also provides fault isolation and geo-distribution for microservices



NEW IN 19c

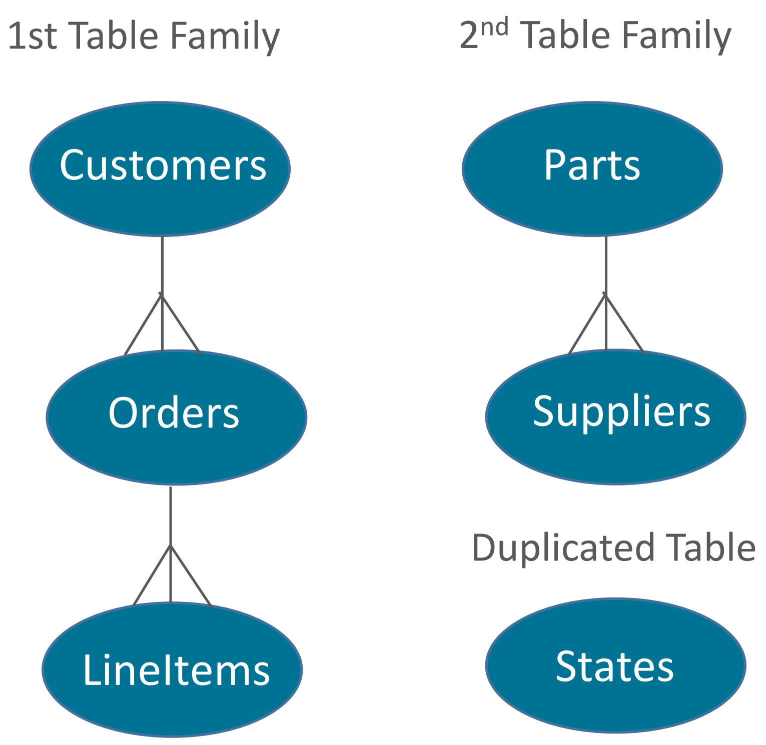
Multiple Query Coordinators

- Enables shard catalog's Active Data Guard standbys to act as multi-shard query coordinators
  - Improves scalability of proxy routing for reporting and analytical workloads
  - Coordinators can be placed in different availability domains and geo regions



Multiple Table Families

- Allows you to make a trade-off:
  - Reduces amount of duplicated data
  - May increase time for executing joins
- Supported for system-managed sharding (by consistent hash)
  - All table families share the same set of chunks
- For direct routing to shards, clients need to provide table family ID (name of the root table) in addition to the sharding key value



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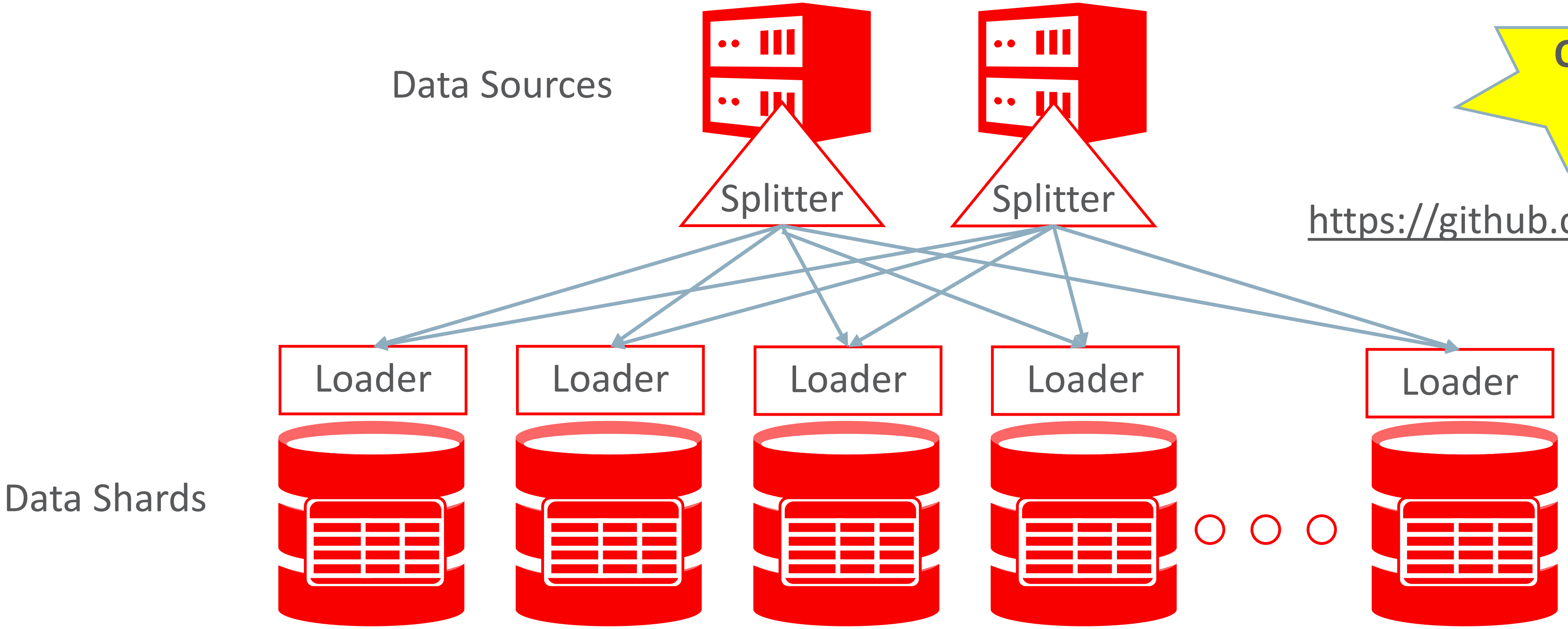
High Speed Data Load

- Utilized fully parallel direct-to-shard data loader
- Sharded architecture scales the CPU, flash, and network interfaces
- Can add shards as needed to accommodate higher ingest rates
- Architecture applies to IIoT, IoT and edge compute scenarios

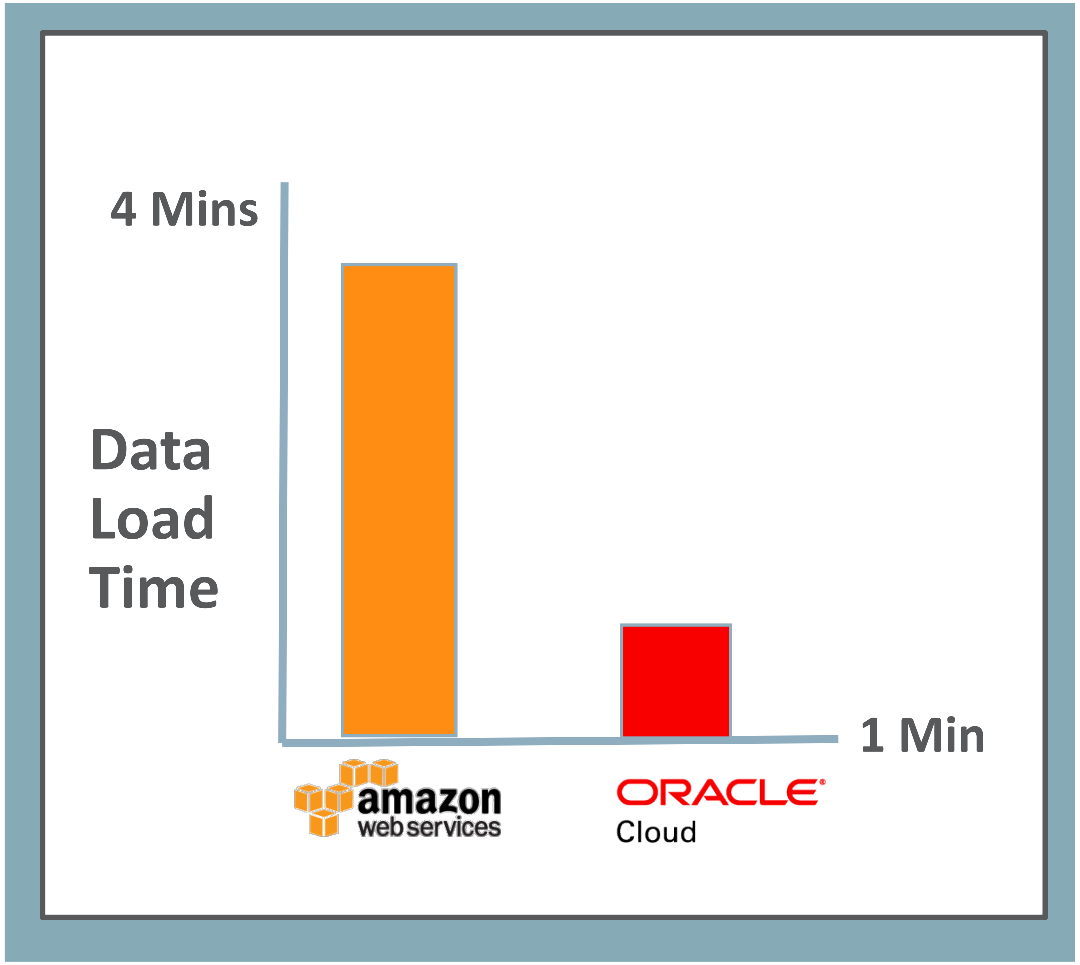


Open Source GitHub

https://github.com/oracle/db-sharding

Evaluation Results

- Need to load 30m rows every 5 min
- Loading from S3 to Redshift
  - 3 to 4 minutes
- Loading from Oracle Object Storage to Shards
  - 500k rows / second
  - Full load in 1 minute
  - 4 minutes of headroom for queries



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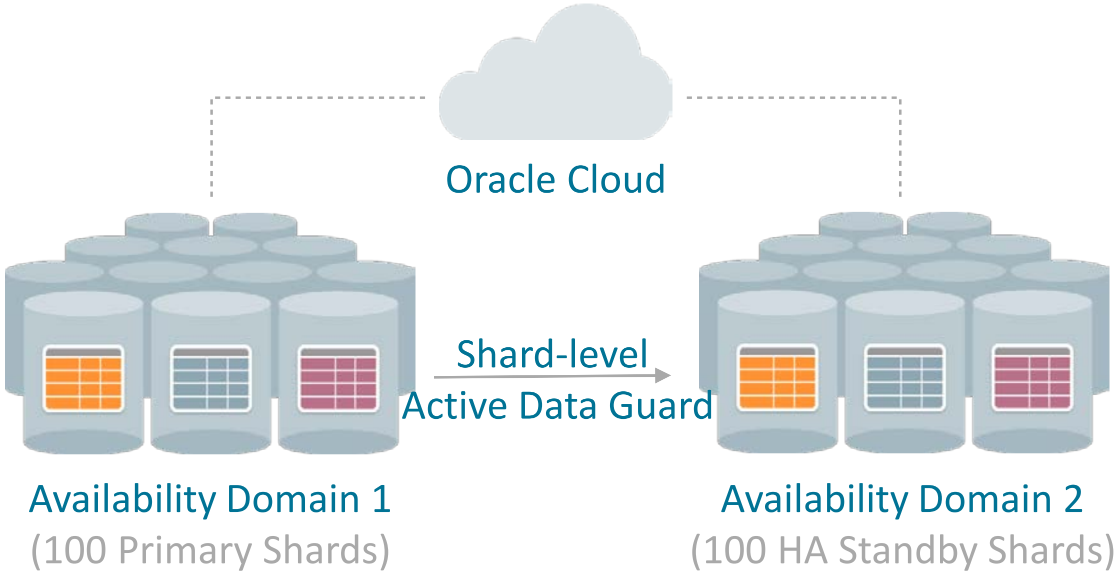
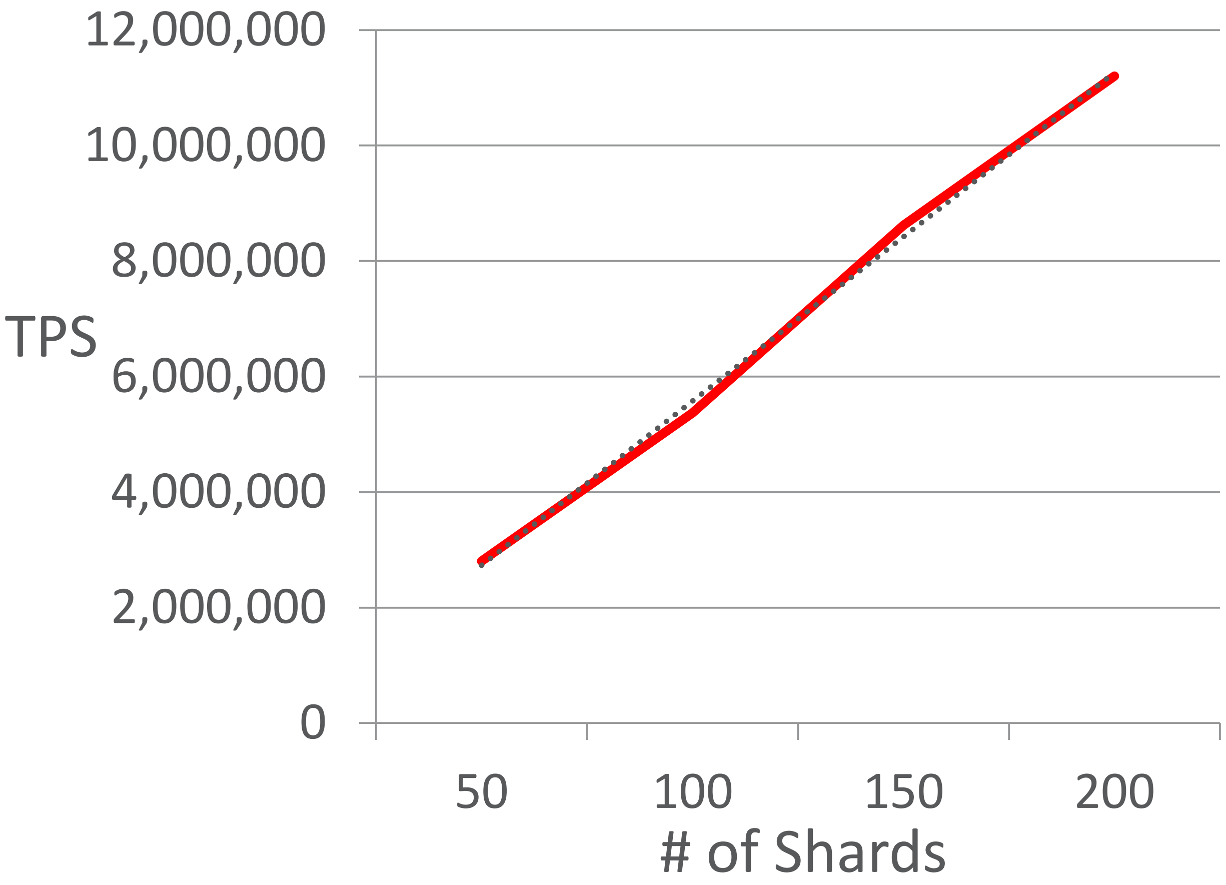
Use Case #1 | Scalability w/ Oracle Sharded Database

Order Entry application sharded by customer_id needs massive linear scalability

System-managed SDB

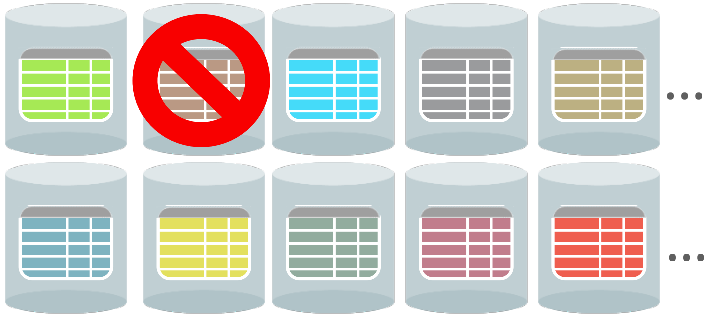


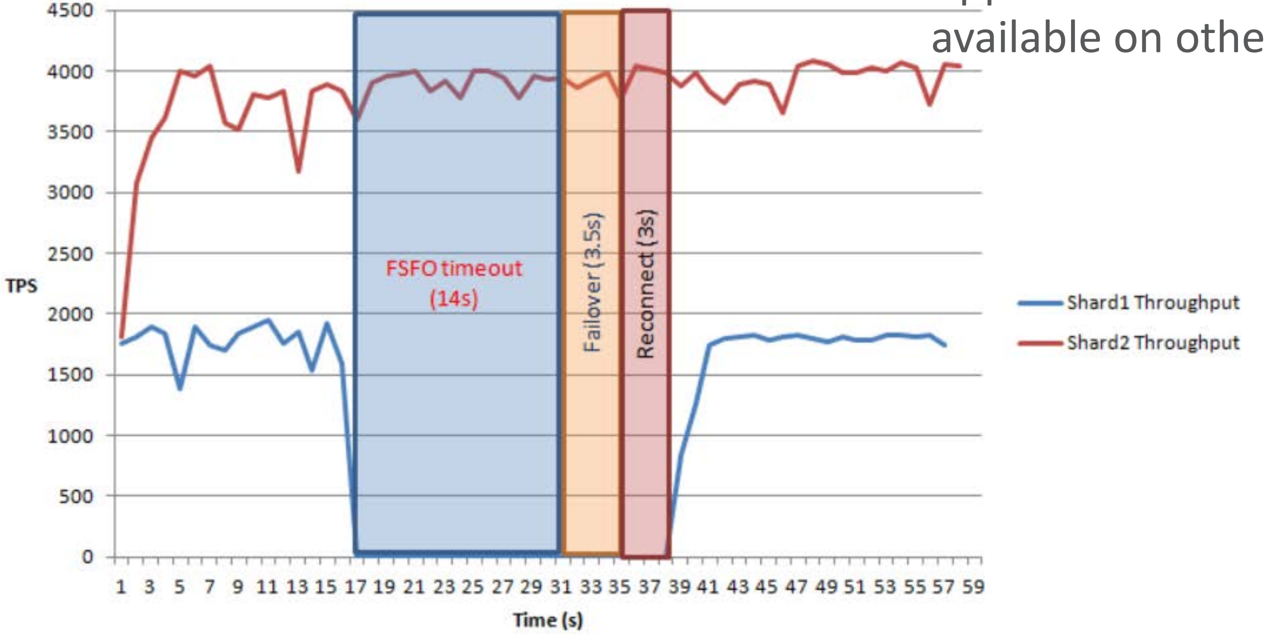


Use Case #2 | Ultra Availability w/ Oracle Sharded Database

Airline Ticketing requires - failure of a database to not take down an entire service

User-defined SDB
Sharded over Airline_id



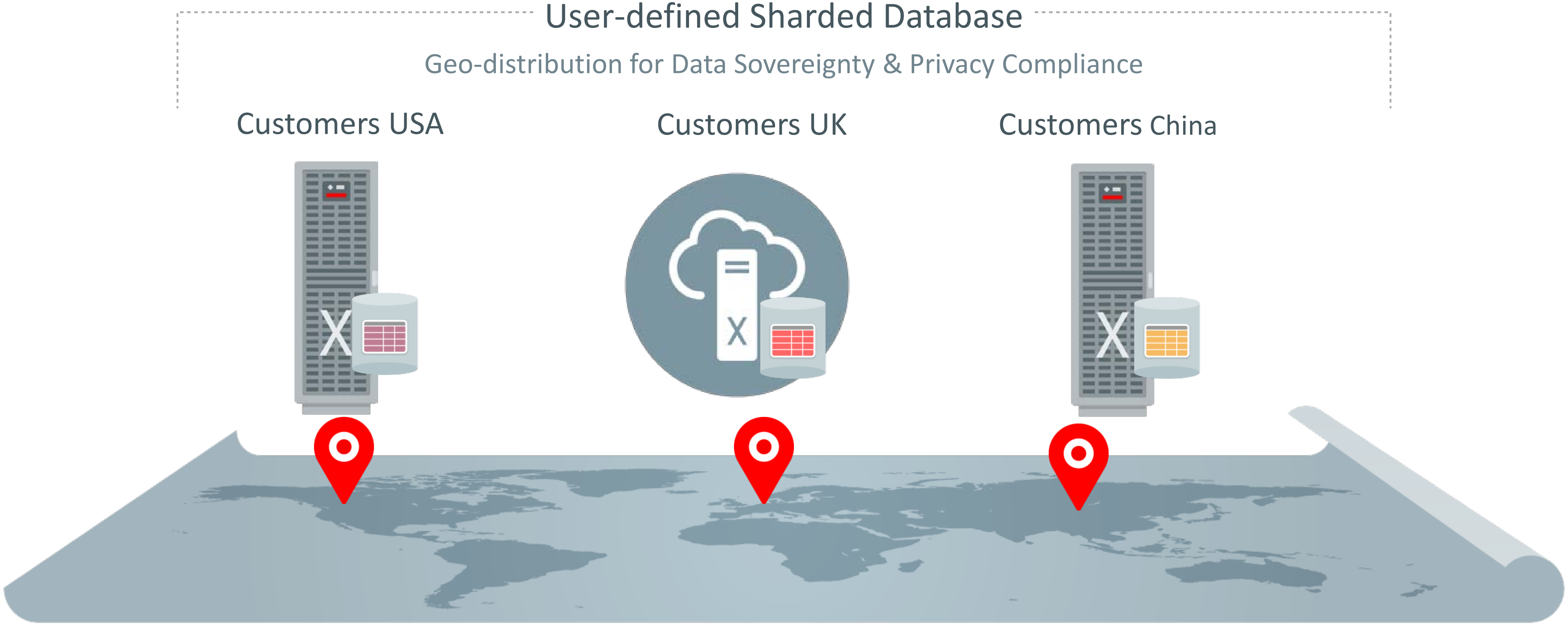


Application remains available on other shards

Shard Outage or Slowdown has Zero Impact on Other Shards

Use Case #3 | Oracle Sharded Database for Data Sovereignty

Global Financial Customer wants to place data in specific geographies for privacy compliance



User-defined Sharded Database

Geo-distribution for Data Sovereignty & Privacy Compliance

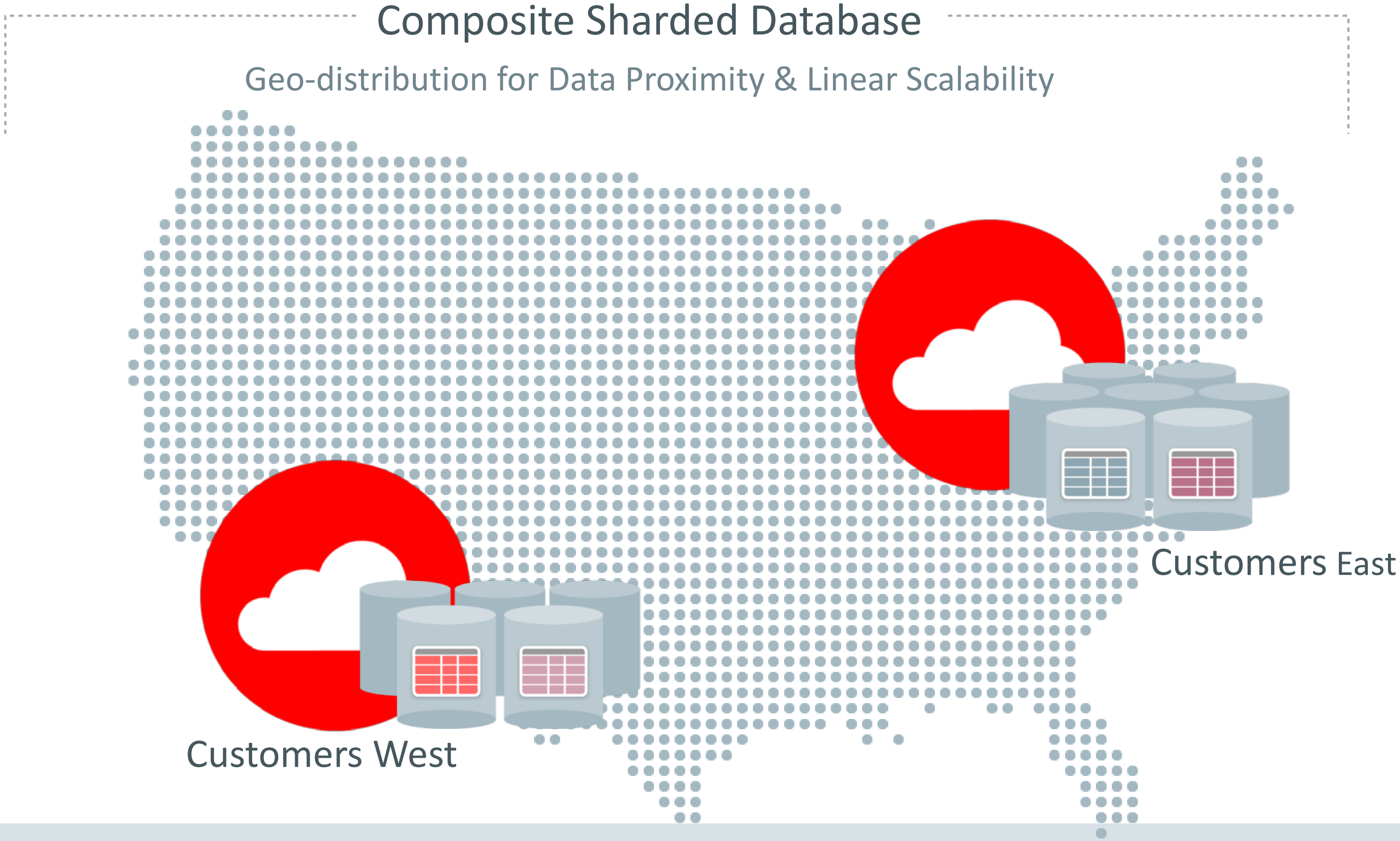
Customers USA

Customers UK

Customers China

Use Case #4 | Oracle Sharded Database for Data Proximity

Billing System Sharded by Geo and then by Account_id - With Composite Sharding

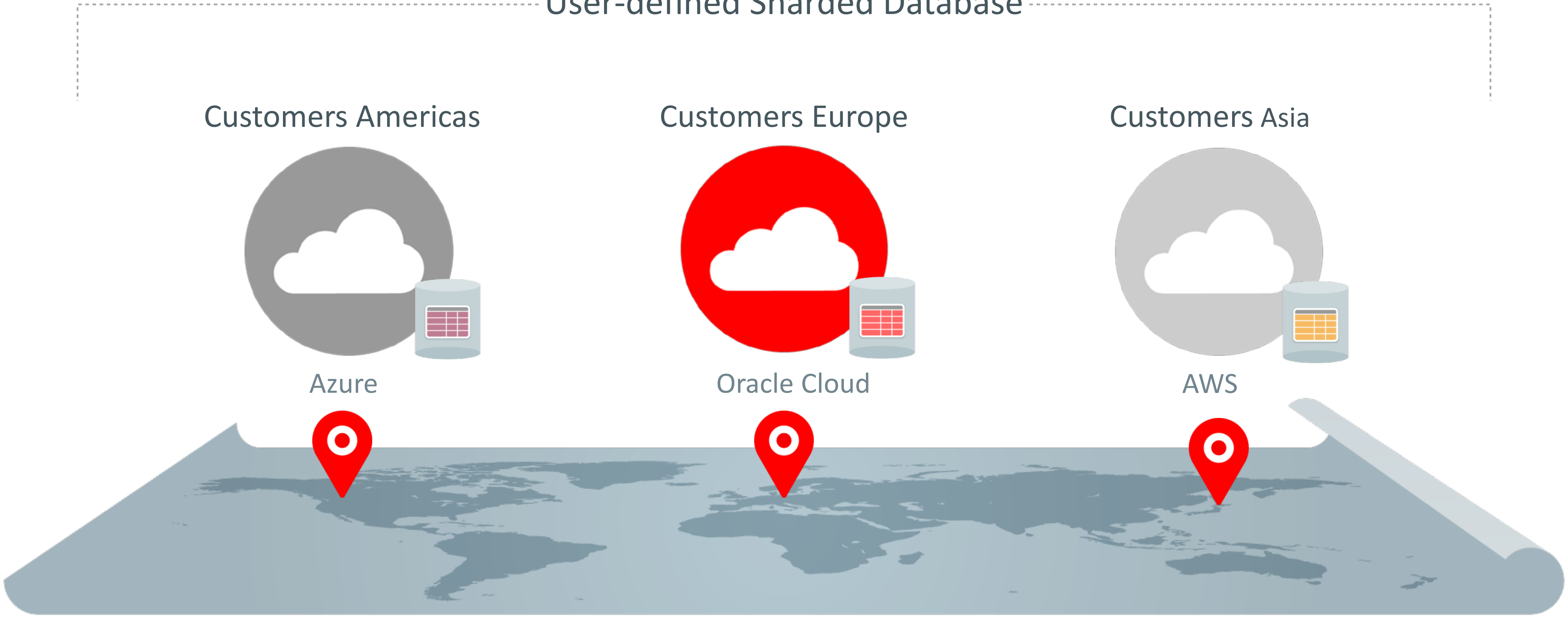


Composite Sharded Database
Geo-distribution for Data Proximity & Linear Scalability
Customers East
Customers West

Use Case #5 | Multi-cloud Deployment w/ Oracle Sharding

Cloud-based SaaS Provider needs to support cloud workload portability with no lock-in

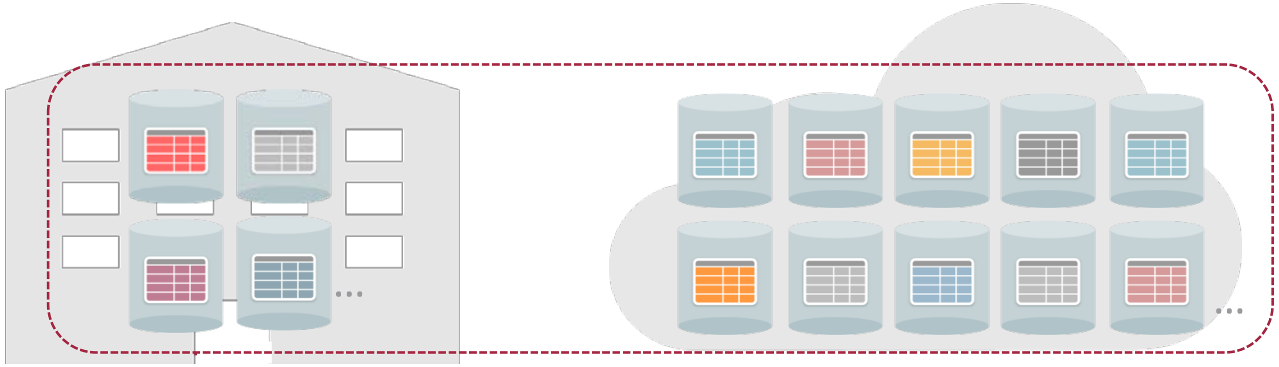
User-defined Sharded Database



Case #6 | Cloud Bursting with Oracle Sharded Database

Online Retailer needs to elastically scale for seasonal demand & new product launch

Sharded Database
Over a Hybrid-cloud



Scale-in

- Scale capacity for holiday shopping – transactions, customers and data
- Scale capacity for new customers from new product launches or services

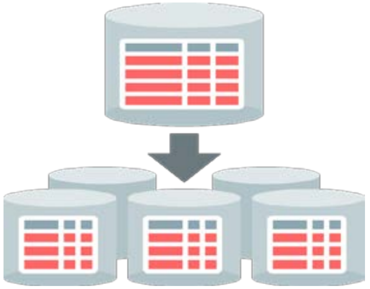
Oracle Sharding = Best of NoSQL + Best of Oracle

- Oracle Sharding Key features
  - Automatic data distribution across a set of commodity servers (using consistent hash)
  - Built-in and customizable replication (Active Data Guard and GoldenGate)
  - Data Sovereignty, Linear scalability, Ultra-availability
  - Plus: Composite and user-defined sharding, duplicated tables, centralized management, …
- With the strength of Oracle RDBMS Engine
  - Familiar and powerful relational data model and query language, including full native support for modern datatypes like JSON, Spatial …
  - Transactions, recovery, in-memory …
  - Industrial-strength and scalable storage engine
  - Data security and access controls
  - Familiar to current staff, and supported by Oracle

Summary | 3 Takeaways

- Complete platform for sharding an Oracle database
- Licensing
  - Oracle Cloud: Extreme Performance
  - On-premises: Enterprise Edition + (either Active Data Guard or GoldenGate or RAC)
- Ideal for applications whose dominant access pattern is via a sharding key and that require:
  - Linear scalability for workload, data size and network throughput
  - Data sovereignty
  - Ultra availability

Oracle Sharding | Sessions and Demos in OOW 2018



Monday, Oct 22nd

- **9 AM** | High Availability and Sharding Deep Dive with Next-Gen Oracle Database [TRN4032] | **Moscone West-3007**
- **3.45 PM** | Industrial-strength Microservice Architectures with Next-Gen Oracle Database [TRN5515] | **Moscone West-3003**

Tuesday, Oct 23rd

- **12:30 PM** | Oracle Sharding: Geo-Distributed, Scalable, Multimodel Cloud-Native DBMS [PRO4037] | **Moscone West-3007**
- **3.45 PM** | Data and Application Modeling in the Brave New World of Oracle Sharding [BUS1845] | **Moscone West-3007**

Thursday, Oct 24th

- **11 AM** | Oracle Maximum Availability Architecture: Best Practices for Oracle Database 18c [TIP4028] | **Moscone West-3006**
- **1 PM** | Using Oracle Sharding on Oracle Cloud Infrastructure [CAS5896] | **Moscone West-160**

Demos

Sharding Demo Booth - 1615

- **High Availability, Moscone South Exhibition Hall**

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https://www.oracle.com/goto/sharding

Related Sessions in Moscone West – Room 3007

Monday, Oct 22nd	Tuesday, Oct 23rd	Wednesday, Oct 24th	Thursday, Oct 25th
9:00am – 9:45am High Availability and Sharding Deep Dive with Next-Generation Oracle Database [TRN4032]			**9:00am – 9:45am** Oracle Maximum Availability Architecture: Best Practices for the Cloud [PRO4035]
10:30am – 11:15am Oracle Active Data Guard: Best Practices and New Features Deep Dive [PRO4030]			
	11:15am – 12:00pm Oracle Real Application Clusters 18c Internals [TRN4022]	**11:15am – 12:00pm** Transparent High Availability for Your Applications [TRN4040]	**11:00 – 11:45** Oracle Maximum Availability Architecture: Best Practices for Oracle Database 18c [TIP4028]
	12:30pm – 1:15pm Oracle Sharding: Geo-Distributed, Scalable, Multimodel Cloud-Native DBMS [PRO4037]		**12:00pm – 12:45pm** Oracle GoldenGate: Best Practices for Deploying the Microservices Architecture [TIP4020]
	1:45pm – 2:30pm No Outages: Maintenance Operations Without Impact [TIP4039]		**1:00pm – 1:45pm** Oracle GoldenGate Active-Active Replication Best Practices [TIP4021]
3:45pm – 4:30pm Oracle Real Application Clusters Roadmap for New Features [PRM4023]		**3:45pm – 4:30pm** Wells Fargo Streamlined Patching and Deployment with RHP Framework Automation [CAS1628]	
4:45pm – 5:30pm Oracle Automatic Storage Management: Best Practices [PRO4036]	**4:45pm – 5:30pm** Oracle GoldenGate: Automating Failover Using Grid Infrastructure with Microservices [TRN4019]		
5:45pm – 6:30pm Oracle RMAN: Latest-Generation Features for On-Premises and the Cloud [TRN4219]	**5:45pm – 6:30pm** Rapid Home Provisioning: Managing Gold Images for Easy Patching and Upgrading [PRO4038]		

Oracle Sharding | Resources

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