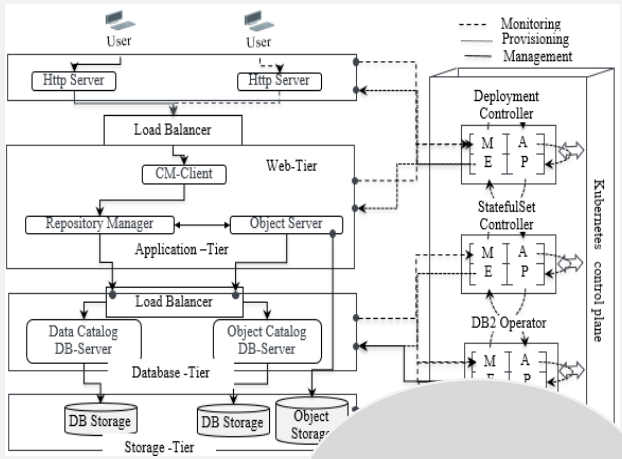
Universität Stuttgart
Institute for Parallel and Distributed Systems
Department: Applications of Parallel and Distributed Systems

# Orchestrating Information Governance workloads as stateful services using the Kubernetes Operator Framework




Dipl.-Phys. Cataldo Mega

17th Symposium and Summer School On Service-Oriented Computing (SummerSoC) June 25th - July 1st, 2023

# Agenda

- Introduction
- Problem Statement – What is the pain …
  - How to reduce the Information Governance as a cost burden
- Kubernetes Operator Framework
  - Automating Container Orchestration
- Orchestrating stateful IG workloads with Kubernetes
- IBM DB2 Operator Prototype
- Evaluation, Verification Tests & Results
- Conclusion

# Introduction

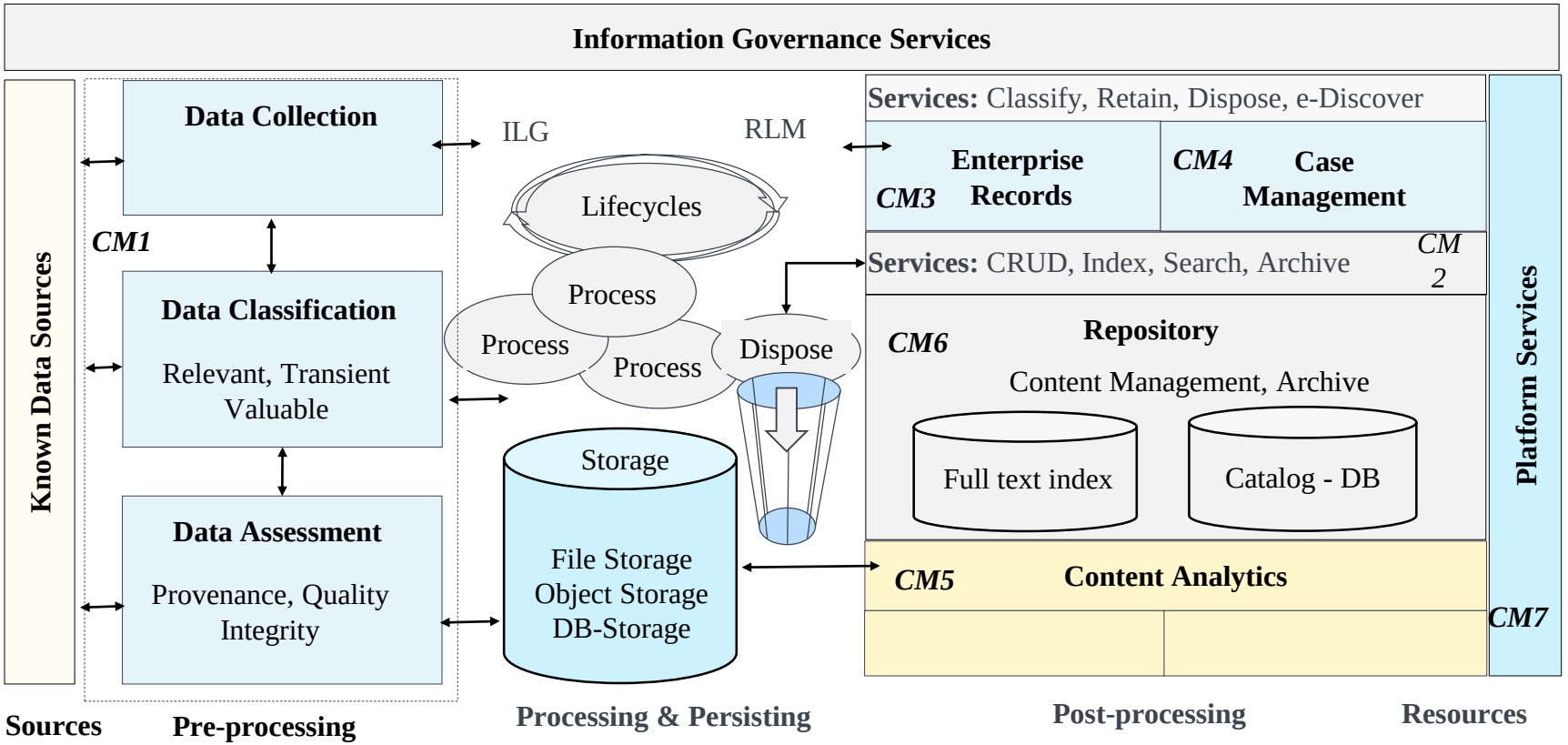
- Information governance **(IG) mandates** that companies **preserve business control information** for a specific time, based on **corporate and regulatory compliance.**
- Consequences are:
  - IG requirements complement business requirements and are an additional cost factor
  - By definition IG solutions are complex and stateful – as we will see.

➢ This initiated the **“run into the Cloud”** among these customers

- **Cloud Solutions aim** at the following **Goals**:
  - Pay-as-you-go payment model (no investment capital, no maintenance costs )
  - Built-in **Scalability, H**igh **A**vailability **(HA)** and **D**isaster **R**ecovery **(DR)**
  - **Cost Effectiveness** through exploitation of **M**assive **M**ulti-tenancy, IT-**Elasticity** and **Process Automation**
- **But process automation comes at a cost**
  - ✓ **Transfer** of **Operator Knowledge & Experience** from **Humans to Infrastructure**
  - ✓ **Automating Container Orchestration** using the **Operator Pattern**

# IG Solution Blueprint

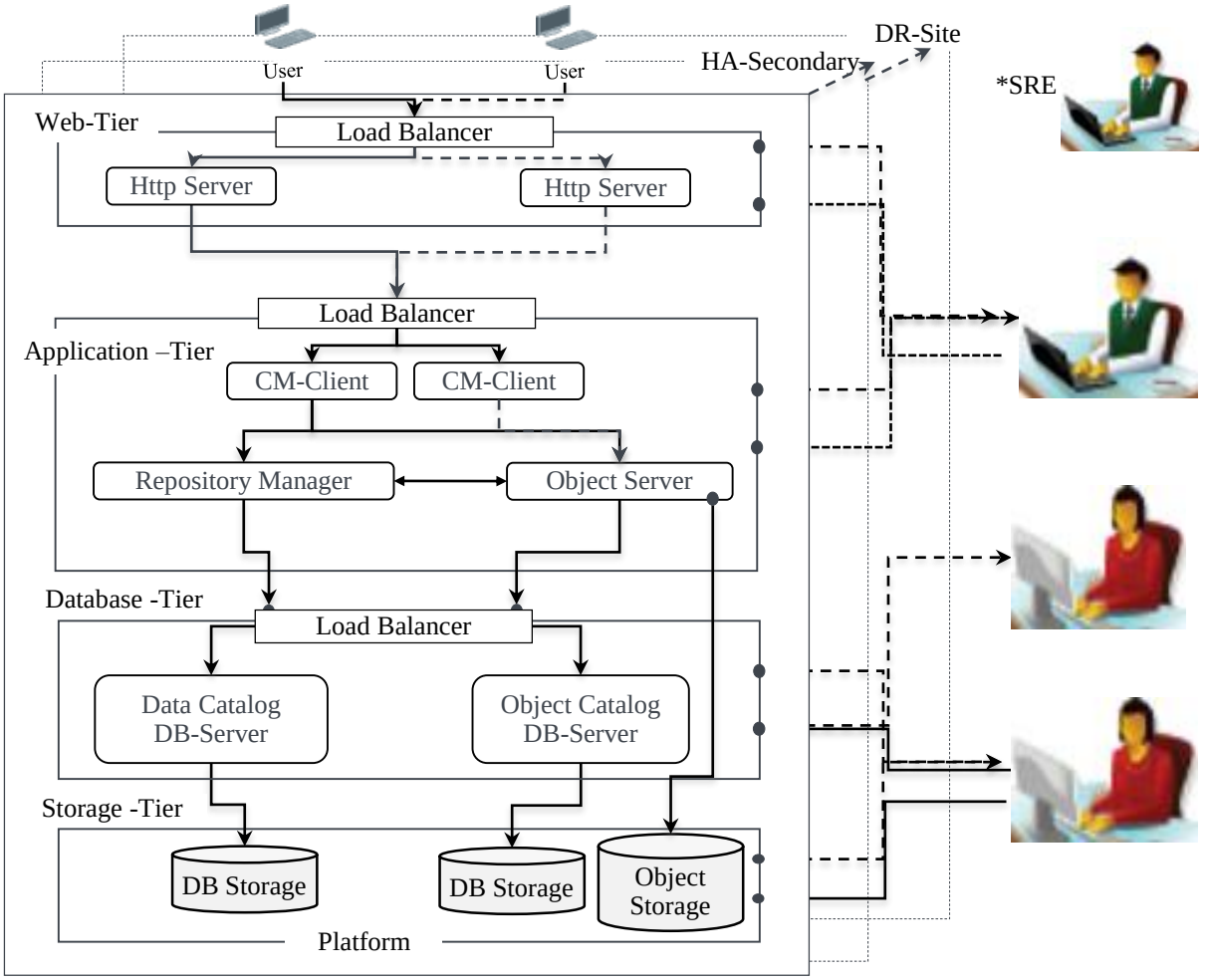
## IG component model outline




CM1: Data Services: Collection, Classification, Assessment and Ingest.
CM2: Content Services: Access, Index, Search, Retrieval, Security, Management.
CM3: Records Services: Classification, Retention, Disposition, Compliance.
CM4: Case Management Services: e-Discovery, Legal Data Requests, Holds.
CM5: Content Analytics: Classification, Statistics, Reporting.
CM6: Repository services: Information Retrieval, Catalog, Archive.
CM7: Platform Services: Compute, Storage, and Network.

# IG Solution Deployment model

## Employing scalability, HA and DR capabilities the bare metal way




- **Clusters for each tier**
- **Tier specific cluster management**
- **Tier specific application lifecycle logic**
- **Site Reliability Engineering**

*Site Reliability Engineering (SRE)

[1] ** SLA: Service Level agreement

# Kubernetes Background

- Automating Container Orchestration started around 2015 at **Google** with Kubernetes a container orchestrator given to the **Cloud Native Computing Foundation** (CNCF) and eco-system.
- Kubernetes would originally automate the lifecycle of a stateless application
  - by simply replacing failing app-instances with an identical replica.
  - would not work for stateful applications which were left out of the cloud platform.
- The Operator pattern emerged at **CoreOS then acquired by Red Hat**
  - Problem: automating orchestrations of increasingly complex applications on K8s clusters, including managing Kubernetes itself.
  - Operator work continued at **Red Hat** 2018 Red hat released the open source Operator Framework and SDK.
  - By design an Operator extends K8s to automate the management of the lifecycle of stateful applications providing means to distribute, monitor, maintain, recover, and upgrade the deployed applications through K8s APIs.

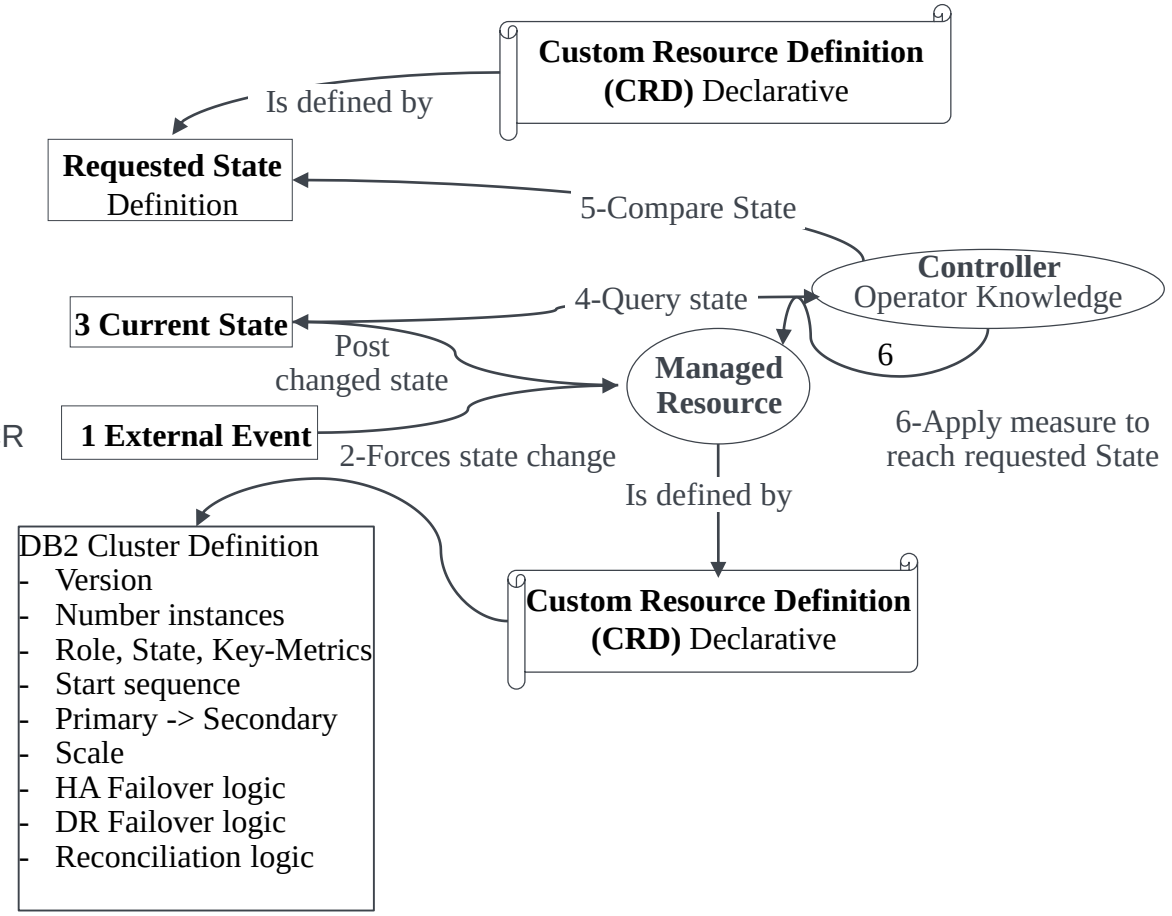
# Kubernetes Operator Pattern

## Custom Resource Definition (CRD) & Custom Resource (CR)

### Kubernetes Operator Foundations Entities

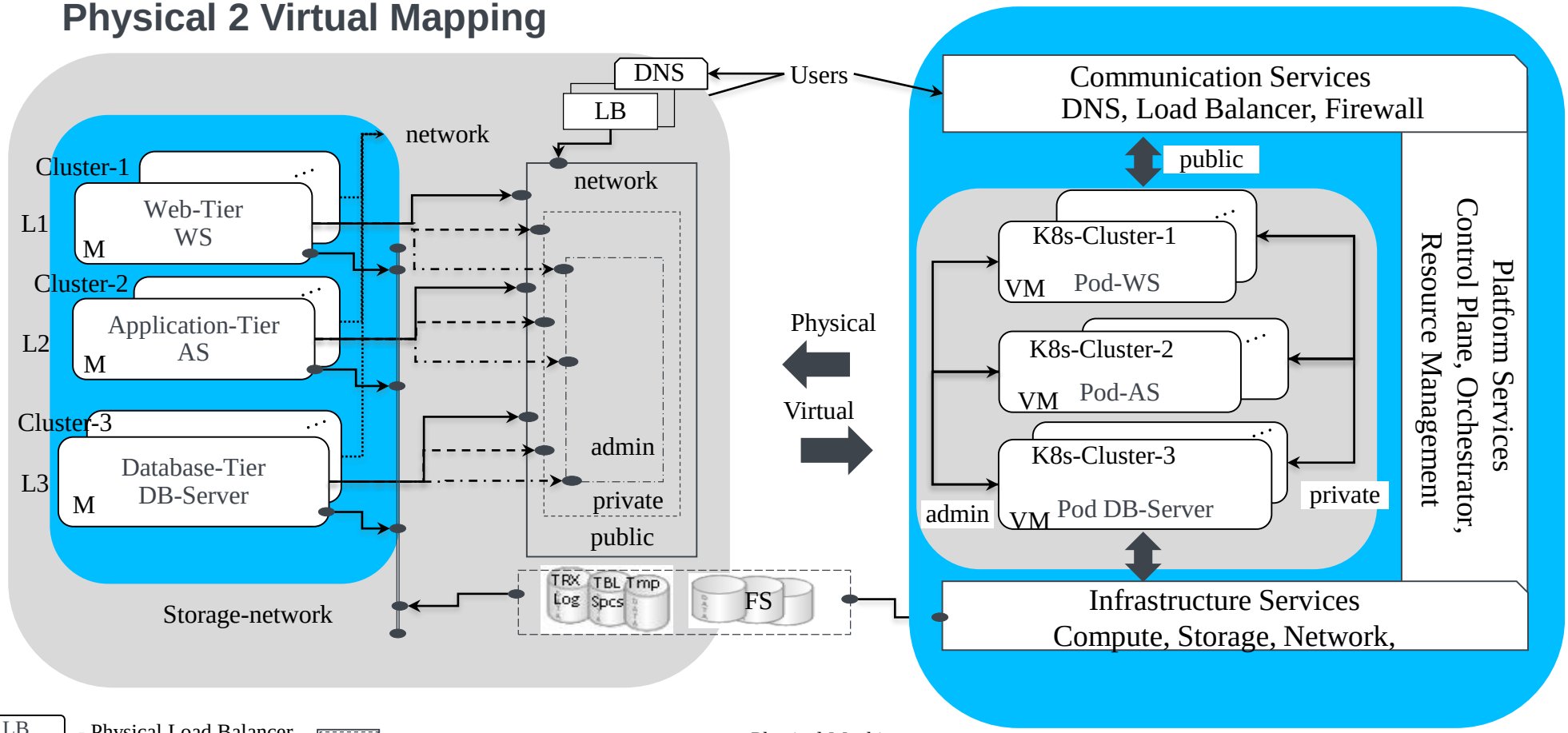
- Kubernetes Operator
  - **Custom Resource (CR) … managed resource.**
    - Extend Kubernetes API with additional types
  - **Custom Resource Definition (CRD)**
    - Define a schema of configuring CR
  - **Controller**
    - Compare the desired state with the current state
    - Apply changes to Kubernetes objects that make up CR

### Kubernetes Operator Pattern Outline



# IG Solution

## Physical 2 Virtual Mapping



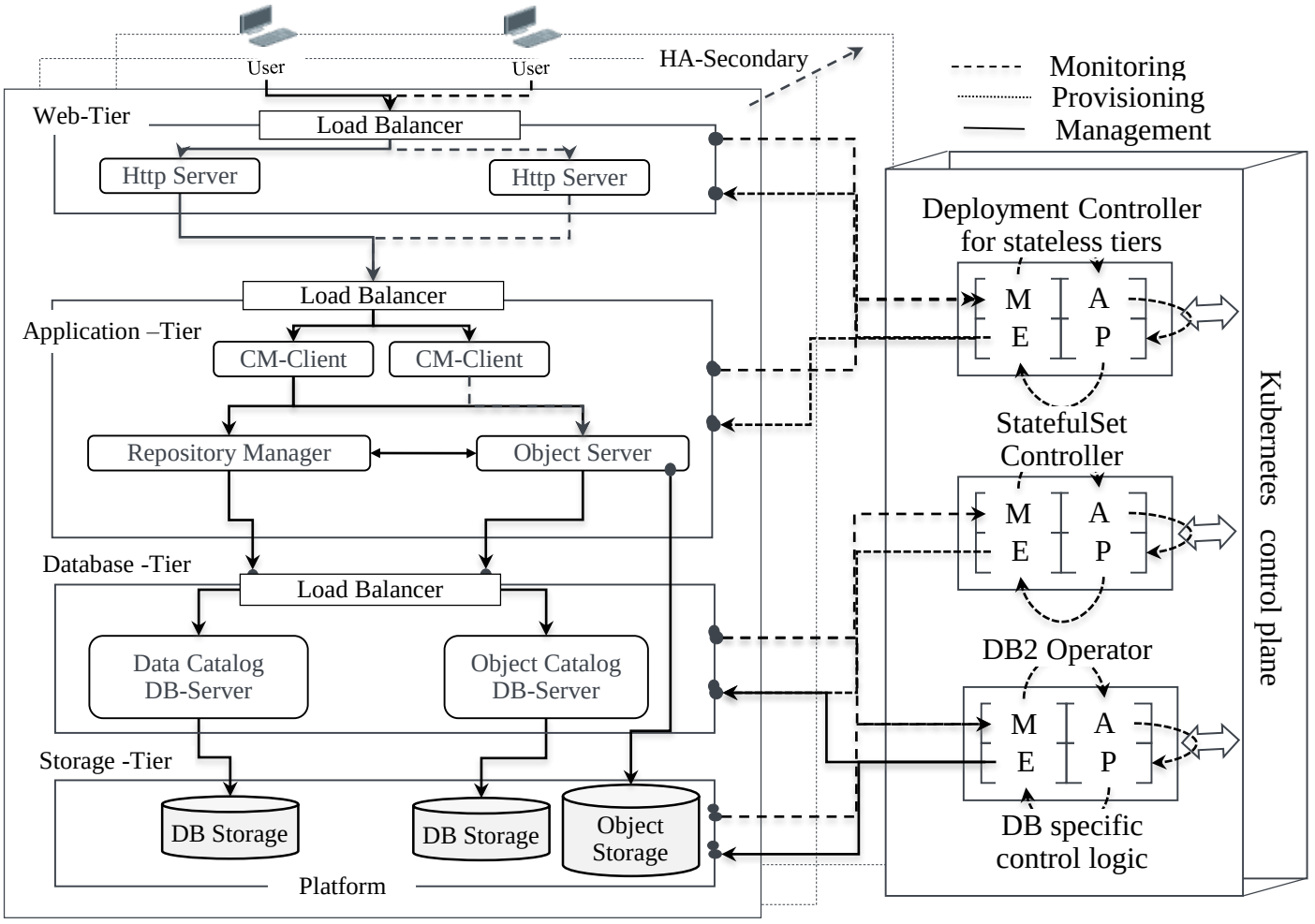

LB - Physical Load Balancer
WS - Bare Metal Web-Server
AS - Bare Metal App-Server
DB-Server - Bare Metal DB-Server
- Physical Storage-Server

- Physical Network Segments
- Communication Links
DNS - Domain name Service

M - Physical Machine
L - Topology Layer/Tier
FS - Filesystem Access
Https - Network Access

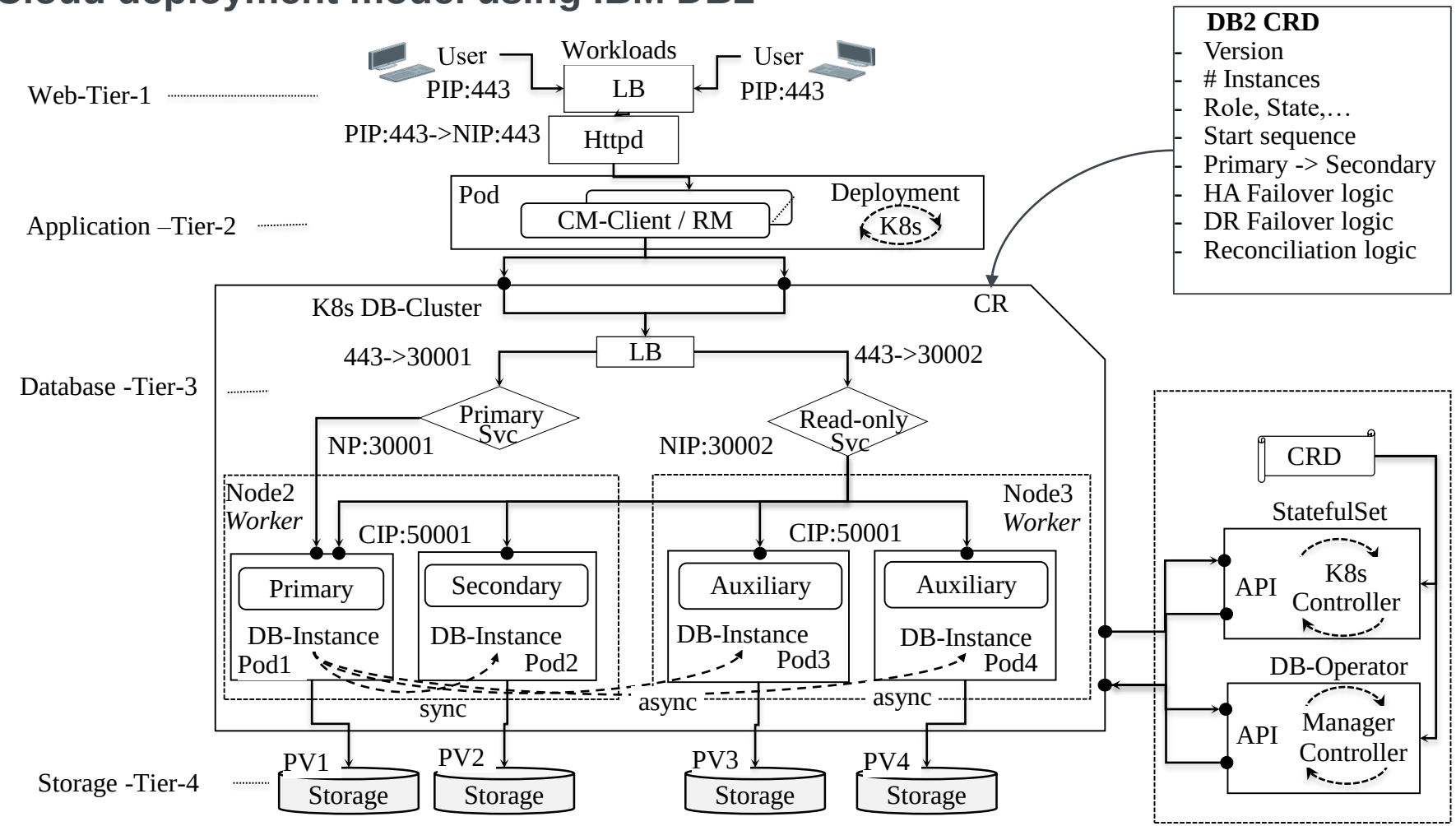
# IG Solution Deployment Model

## Employing scalability, HA and DR capabilities the Kubernetes way



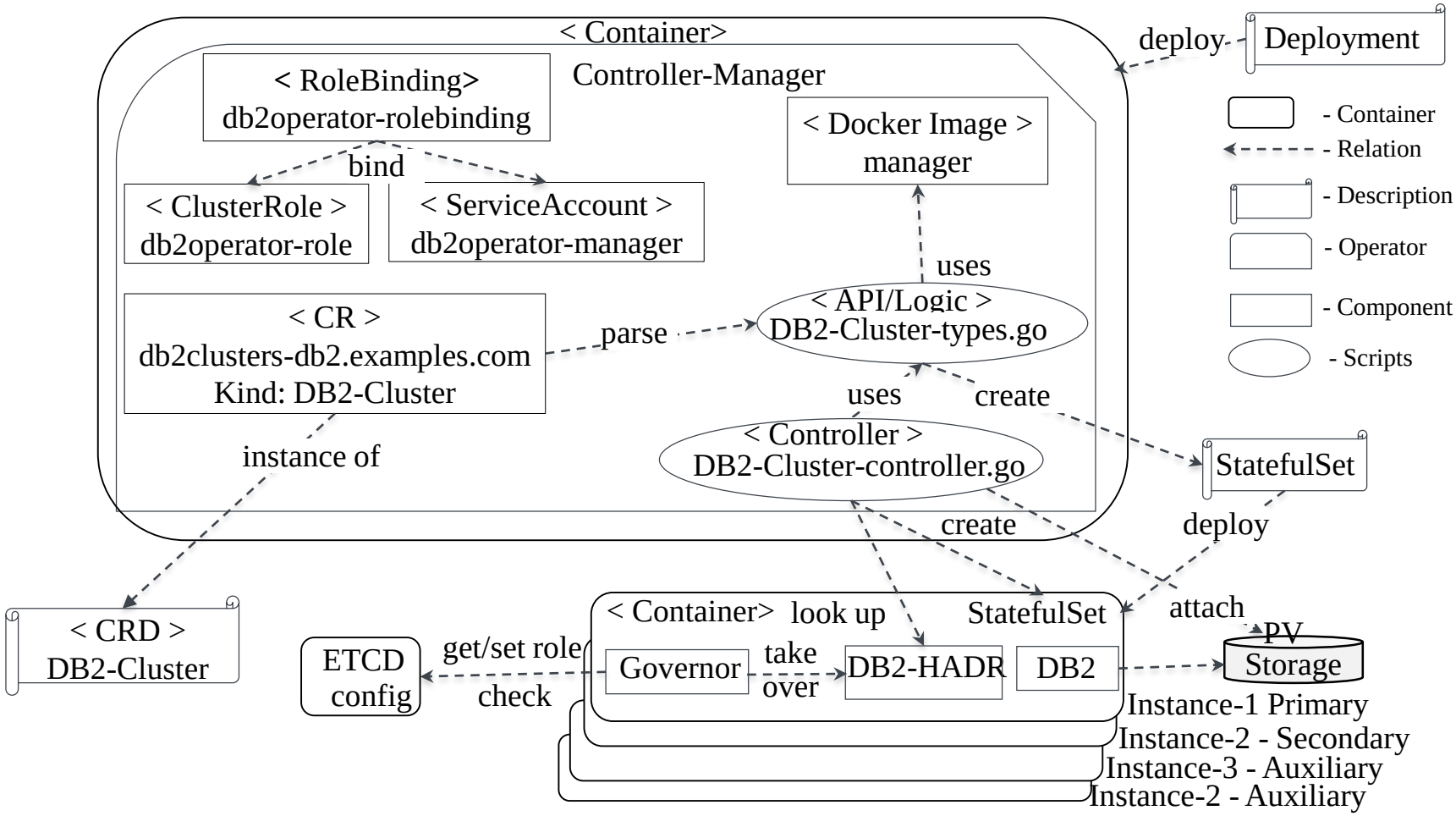
# IG Solution

## Cloud deployment model using IBM DB2



# Kubernetes DB2 Operator Outline

## Component Model



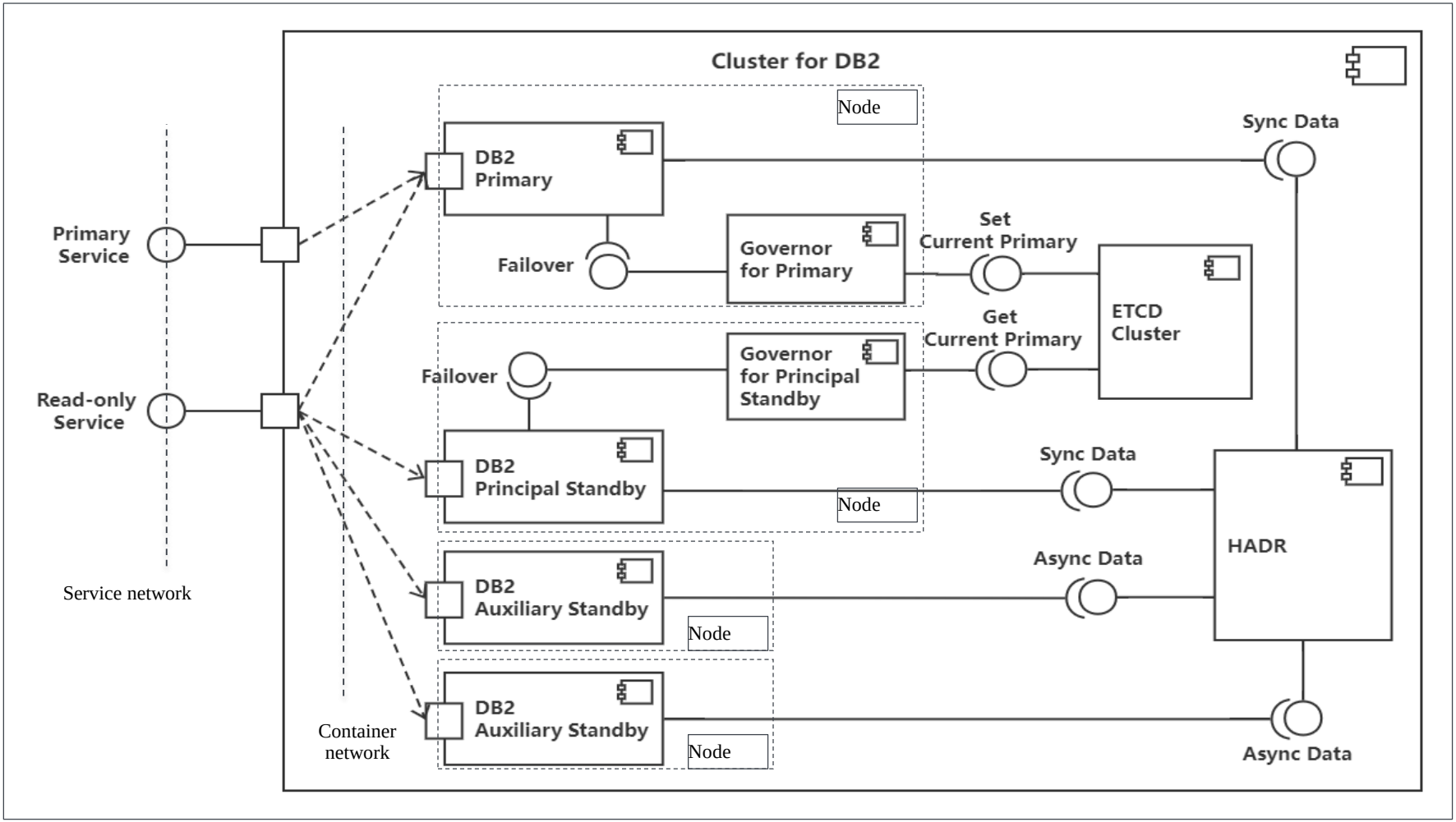
# Test Scenarios
## DB2 Cluster Prototype

- High Availability (HA)
- Read Scalability
- Disaster Recovery (DR)

- Note: Test results show indicative figures only.

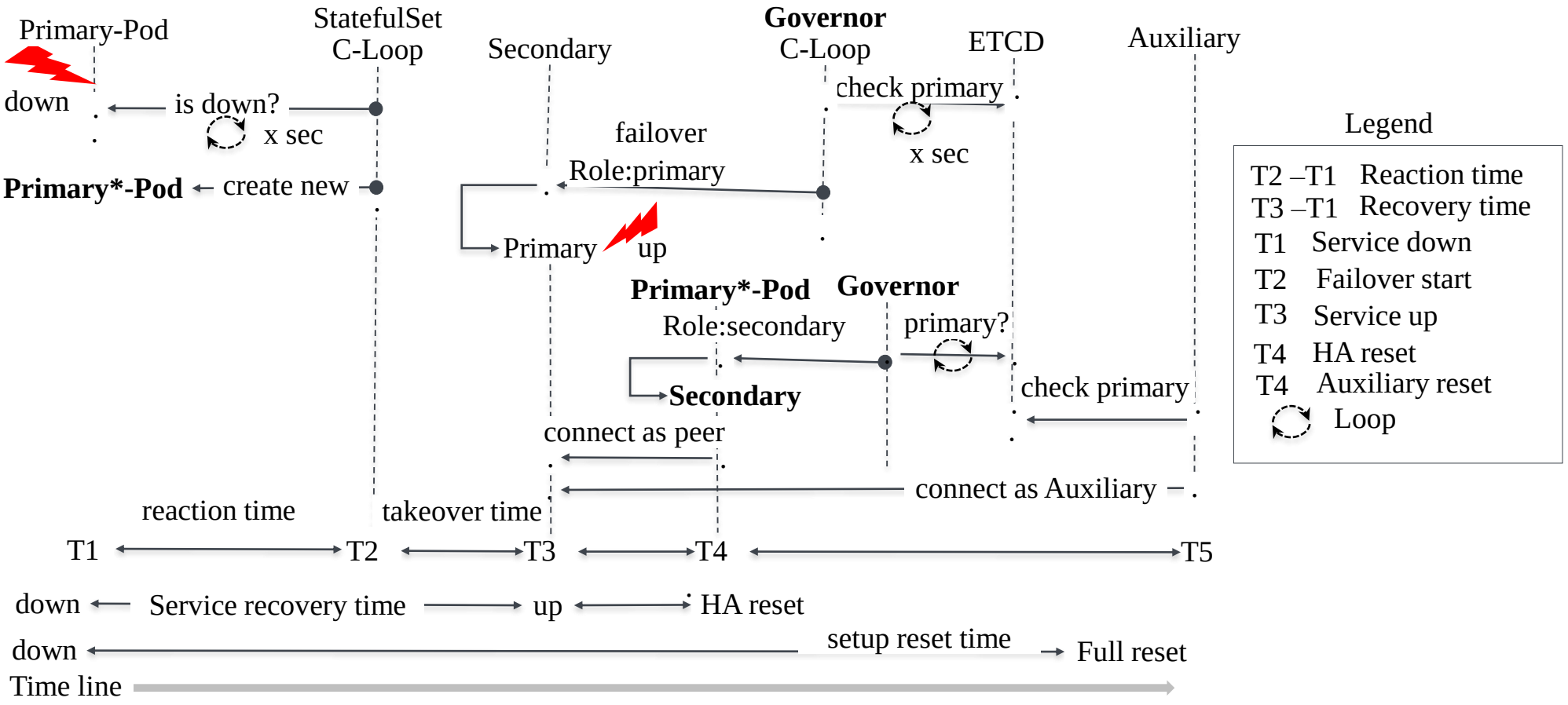
# IBM DB2 Instance Cluster

## Cloud component model



# Test Scenarios:

## High Availability (HA)*



# Test Scenarios

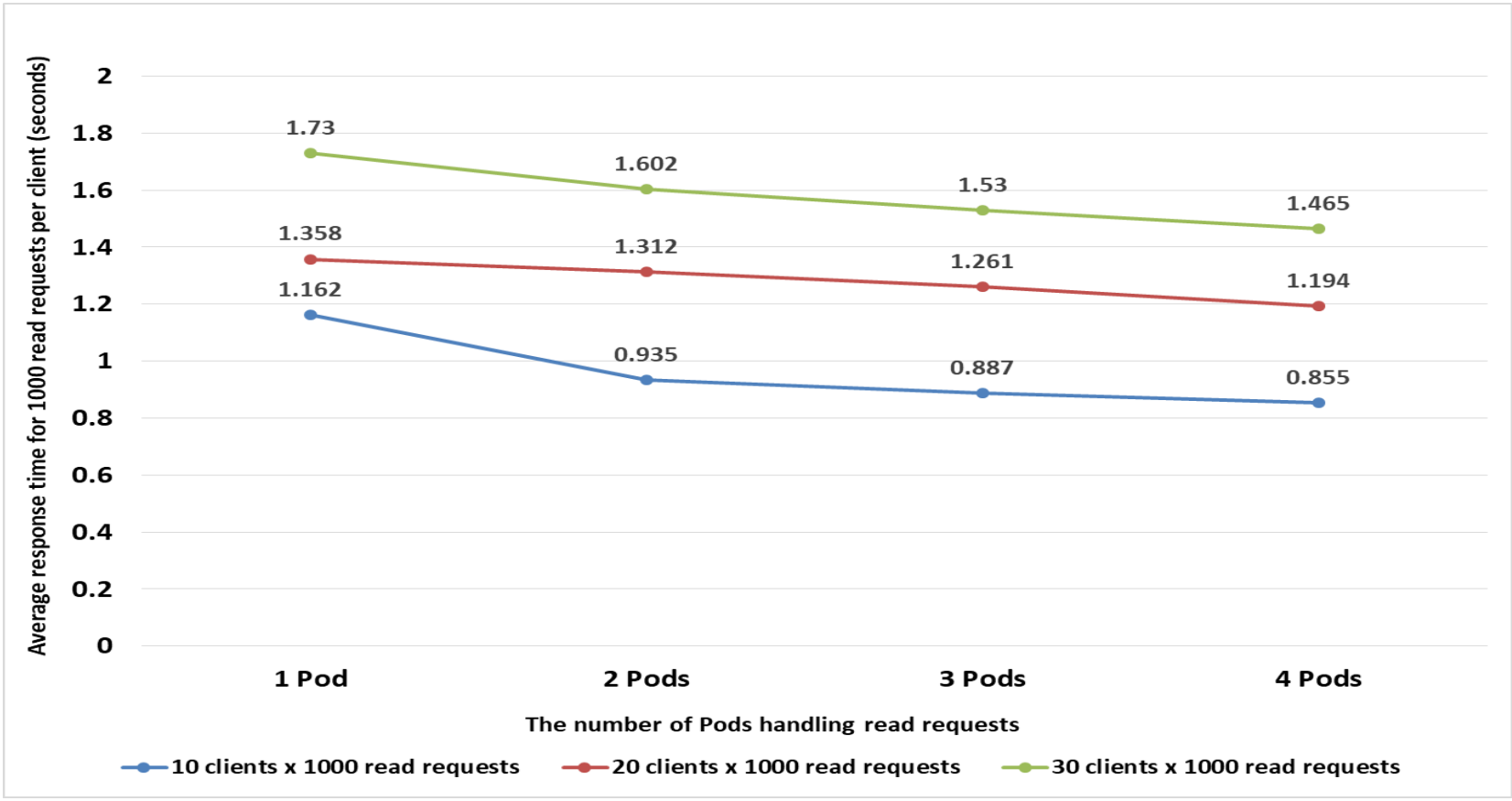
## High Availability (HA)*

| (Unit: seconds) | Reaction Time | Failover Time | Service Outage Time |
|---|---|---|---|
| **1** | 2.859 | 3.621 | 6.425 |
| **2** | 1.995 | 4.322 | 6.839 |
| **3** | 2.403 | 9.655 | 18.180 |
| **4** | 2.066 | 5.856 | 13.793 |
| **5** | 2.022 | 36.309 | 41.639 |
| **6** | 2.051 | 9.632 | 14.555 |
| **7** | 1.720 | 4.839 | 9.570 |
| **8** | 2.058 | 29.886 | 32.728 |
| **9** | 2.624 | 9.679 | 18.111 |
| **10** | 2.059 | 33.286 | 34.581 |
| **Average** | **2.186** | **14.709** | **19.642** |


*Note: Test results show indicative figures only.

# Test Scenarios

## Read-only Workload Scalability*

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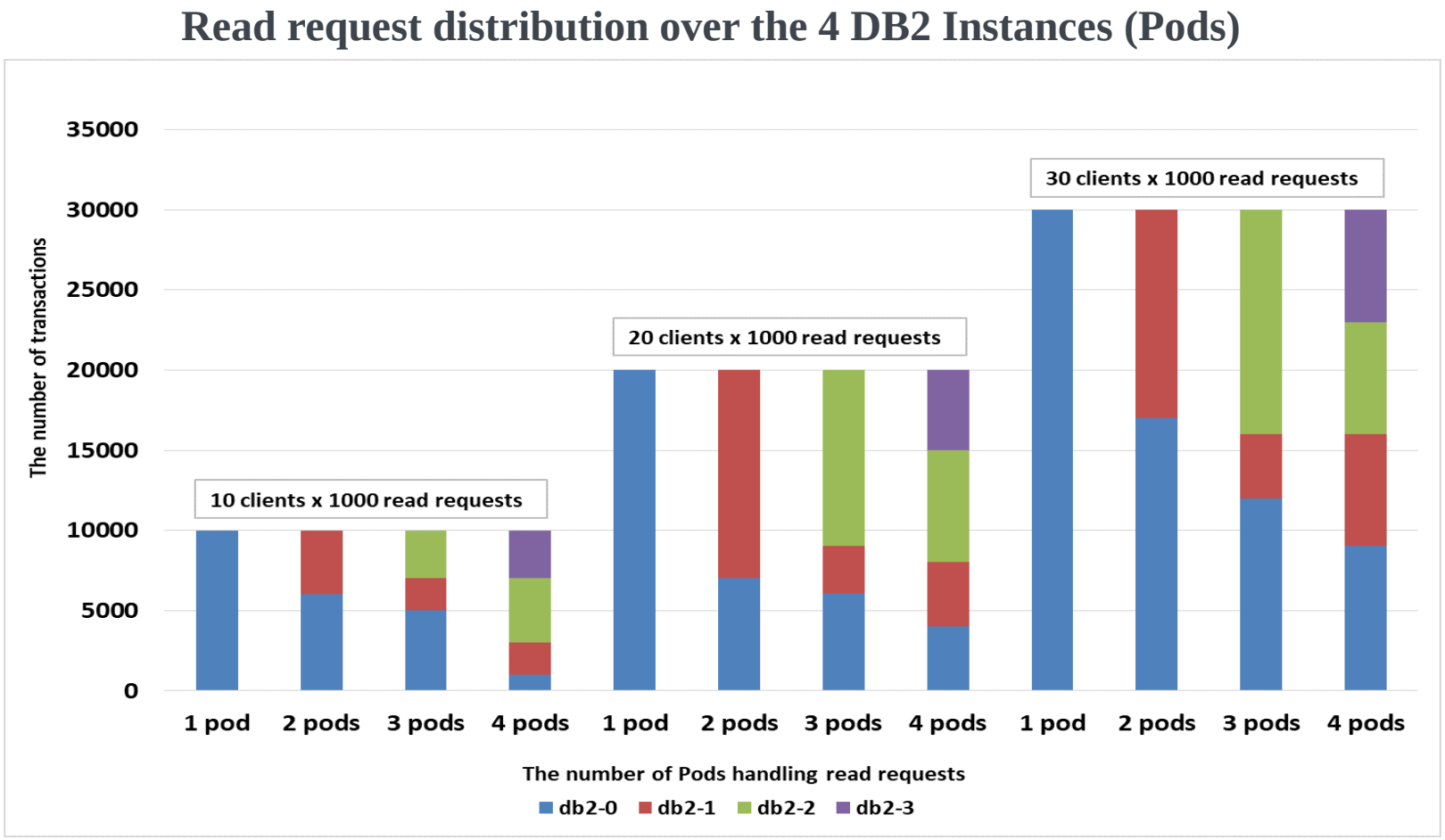
# Test Scenarios

## Read-only Workload Scalability*




*Note: Test results show indicative figures only.

# Summary & Conclusions

- ✓ Kubernetes provides an efficient cluster control mechanism that allows dynamic topology changes based on workload demand for stateless applications.
- ✓ Stateful services Kubernetes requires substantial domain/application specific knowledge to be integrated through the K8s operator framework.
- ✓ Eat your own cooking does not apply leave it to the pro's.
- ✓ Migrating legacy solutions into the cloud requires to replace traditional component with new cloud native substitutes where possible. I.e. Traditional RDMBS vs. cloud native RDBMS or equivalent DAAS service.

# Thank you !

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