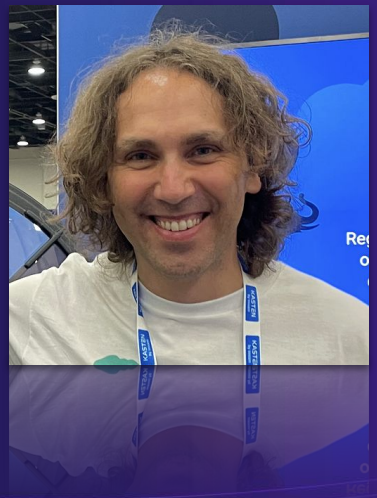
Kubernetes & Data

Gabriele Bartolini
VP Cloud Native at EDB

May 2023

About me



- VP/CTO of Cloud Native at EDB
  - Previously at 2ndQuadrant
- PostgreSQL user since ~2000
  - Community member since 2006
  - Co-founder of PostgreSQL Europe
- DevOps evangelist
- Open source contributor
  - Barman (2011)
  - CloudNativePG (2022)

Follow me: **@_GBartolini_**

EDB

Kelsey Hightower
@kelseyhightower

EDB

Kelsey Hightower ✓
@kelseyhightower

You can run databases on Kubernetes because it's fundamentally the same as running a database on a VM. The biggest challenge is understanding that rubbing Kubernetes on Postgres won't turn it into Cloud SQL. 🧵

Traduci il Tweet

Soham Dasgupta @thesobercoder · 10 feb

@kelseyhightower Bust a myth for us please - running any sort of database on a Kubernetes instance is bad idea. I've heard this enough times to actually start believing it. #kubernetes #mythbuster

Mostra questa discussione

5:21 PM · 10 feb 2023 · **318.944** visualizzazioni

A majority (83%) attribute over 10% of their revenue to running data on Kubernetes

One-third of organizations saw their productivity increase twofold.

EDB

Timeline and team involvement

- **2014**, June: Google open sources Kubernetes
- **2015**, July: Version 1.0 is released
- **2015**, July: Google and Linux Foundation start the CNCF
- **2016**, November: The **operator pattern** is introduced in a blog post
- **2018**, August: The Community takes the lead
- **2019**, April: Version 1.14 introduces **Local Persistent Volumes**
- **2019**, August: my team starts the Kubernetes initiative
- **2020**, June: we publish this blog about benchmarking local PVs on bare metal
- **2020**, June: Data on Kubernetes Community founded
- **2021**, February: EDB Cloud Native Postgres (CNP) 1.0 released
- **2022**, May: EDB donates CNP and open sources it under CloudNativePG

EDB

*"The **same** as running a **database** on a **VM**"*

EDB

*I would add: "... provided **you ...**"*

- Know PostgreSQL
- Know Kubernetes
- Have a good **operator** like CloudNativePG

You = You organization, made up of one or more multidisciplinary teams

EDB

#1 - The right architecture for Kubernetes

Kubernetes architectural concepts

- A Kubernetes Cluster (**k-cluster**)
- Availability zones (**AZ**)- also known as failure zones or data centers
  - Connected by redundant, low-latency, private network connectivity
  - At least 3 per k-cluster
- Kubernetes control plane to be distributed across the AZ
- Kubernetes worker nodes in each AZ running applications (workloads)
- Normally:
  - **1 k-cluster = 1 region with 3+ AZ**

EDB

1 k-cluster = 1 region with 3+ AZ

- Taken for granted if you know Kubernetes
- All major public cloud providers offering managed K8s services have 3+ AZ
- What about on-premise deployments?
  - You need to plan in advance
  - Stay away from the “2 data center in a region” setup typical of “Lift-and-Shift” exercises
    - Often results in 2 separate Kubernetes clusters
      - Severely impacts the benefits of Kubernetes, particularly self-healing
      - Shifts maintenance and procedural complexity up to the application level

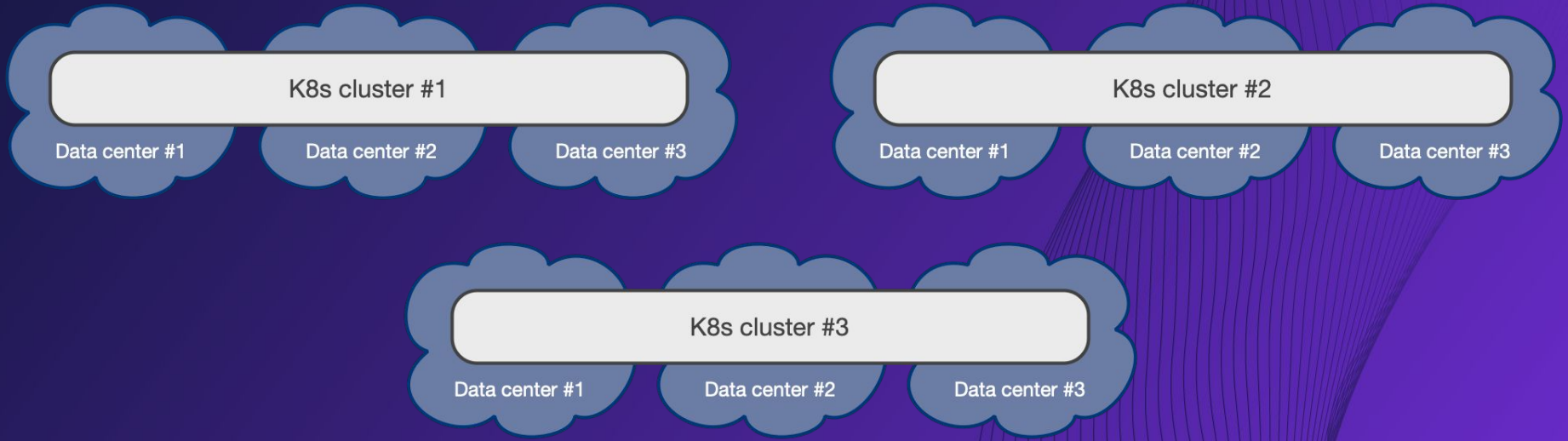
EDB

No!

EDB

Yes!

Yes! Yes! Yes!



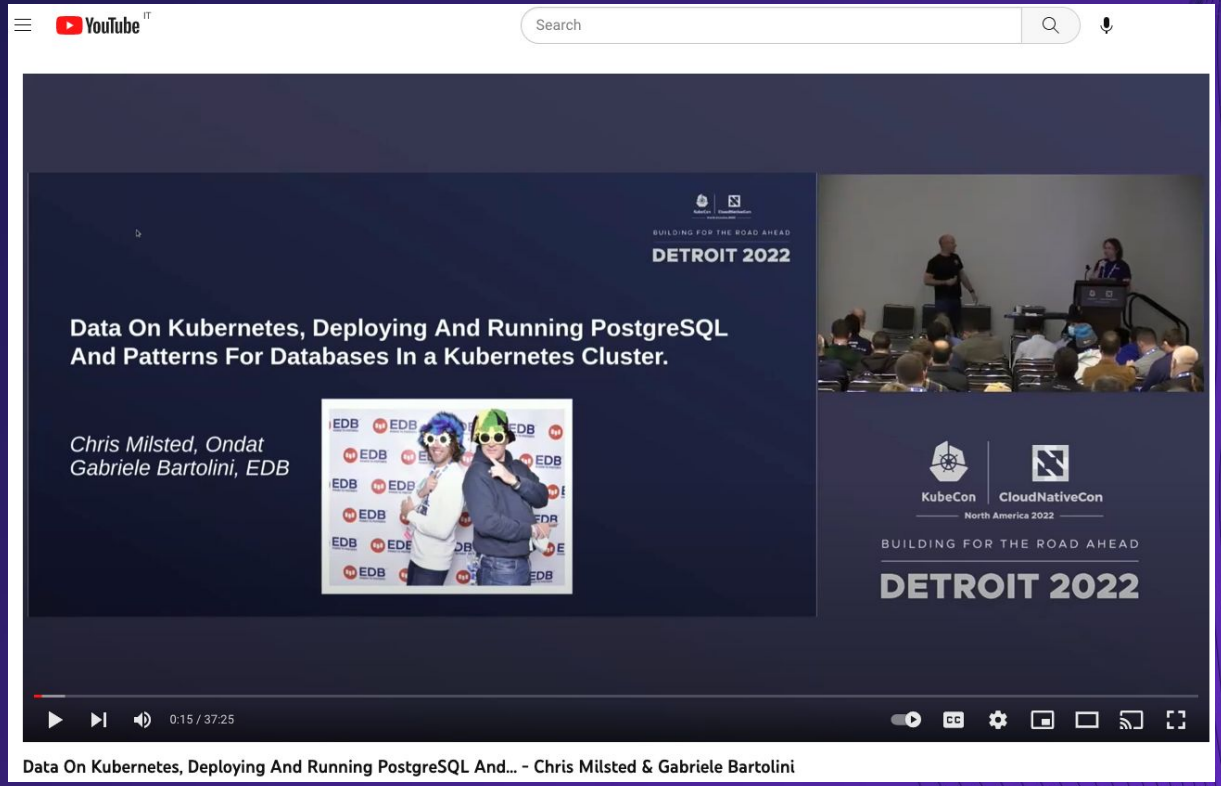
#2 - Synchronizing the state

Synchronizing the state of a Postgres database

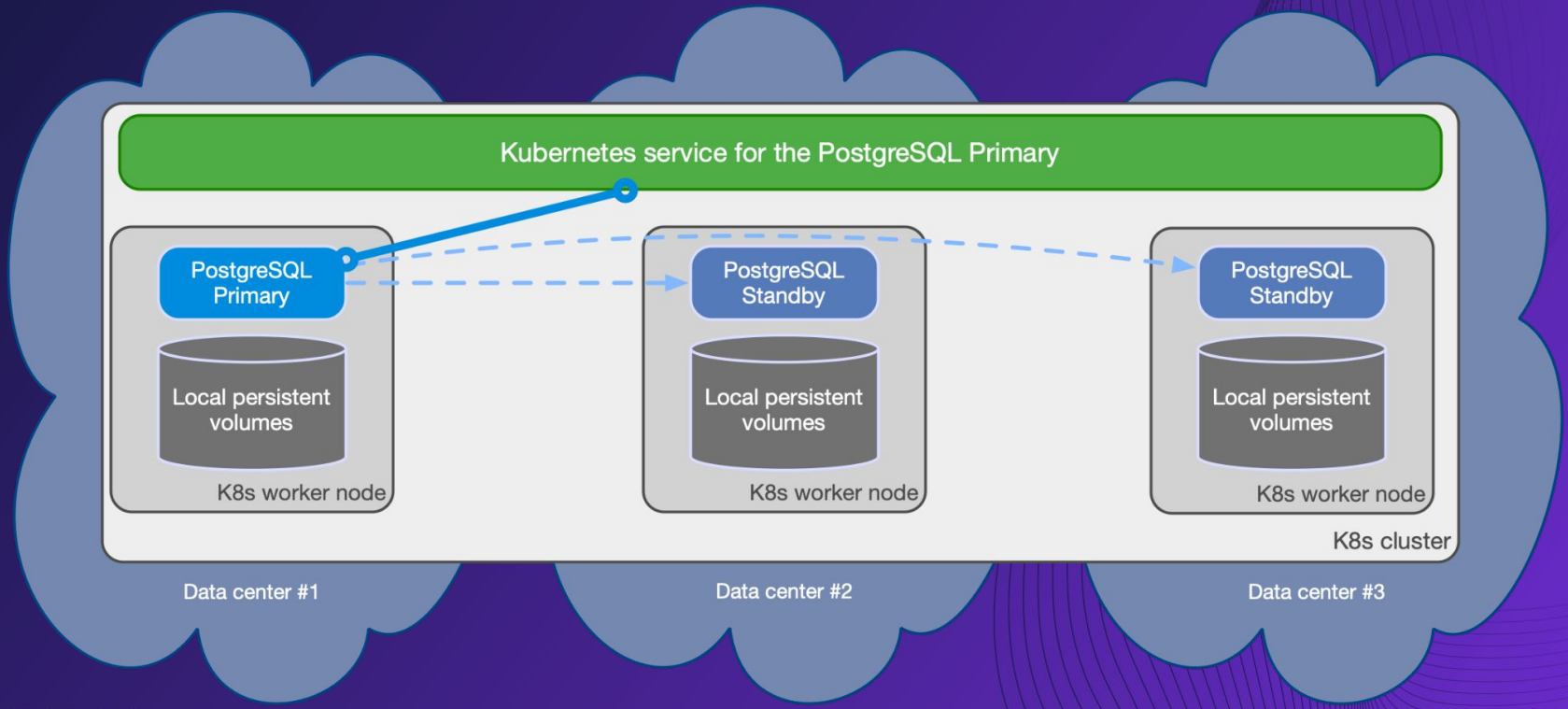
- Being a DBMS, PostgreSQL is a **stateful workload** in Kubernetes
- Stateless workloads achieve HA and DR mainly through traffic redirection
- Stateful workloads require the state to be replicated in multiple locations:
  - **Storage-level** replication
  - **Application-level** replication (in our case, application = Postgres)
- Postgres has a very robust and powerful native replication system
  - We've built it
  - Founded on the Write Ahead Log
  - Read-only standby servers
  - Supports also synchronous replication controlled at the transaction level
- **We recommend application-level** over storage-level replication for Postgres

EDB

KubeCon NA 2022 - talk with Chris Milsted (Ondat)



Yes!



#3 - The right storage for you

Storage management

- Storage is the most critical component for a database
- Direct support for Persistent Volume Claims (PVC)
  - We deliberately do not use Statefulsets
- The PVC storing the PGDATA is central to CloudNativePG
  - Our motto is: “PGDATA is worth a 1000 pods”
- Storage agnostic
- Freedom of choice
  - Local storage
  - Network storage
- Automated generation of PVC
  - Support for PVC templates
  - Storage classes

Main components

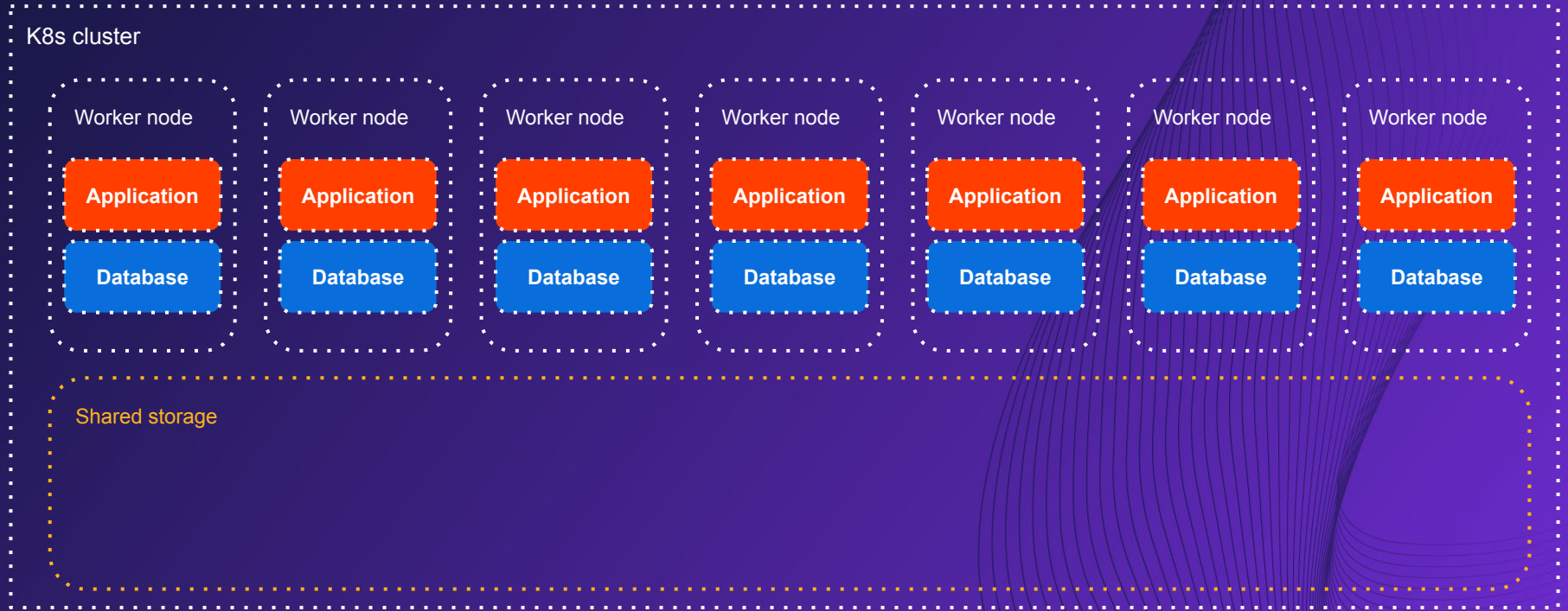
- Kubernetes cluster
- Availability zone
- Application pod
- Postgres pod
- Kubernetes worker node
- Network storage
- Local storage
  - i.e. dedicated and local to the worker node

EDB

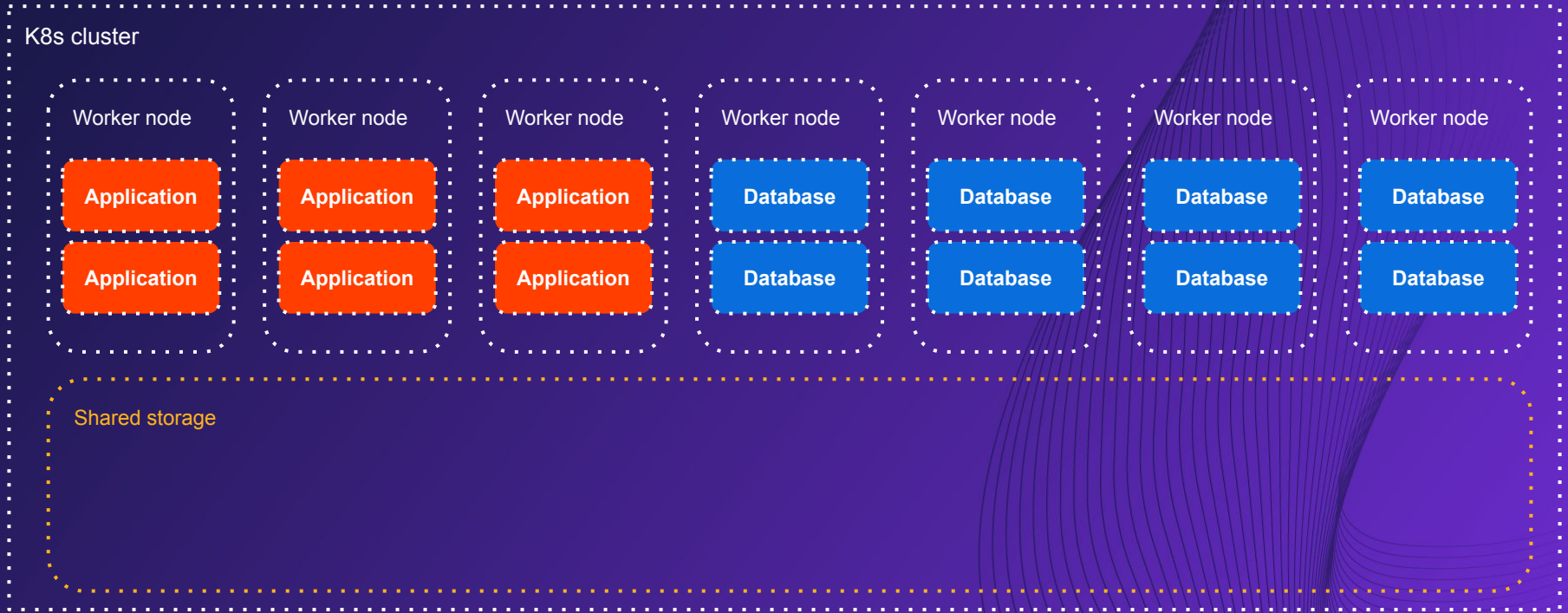
Scheduling Postgres instances with CloudNativePG

- Entirely declarative!
- Affinity section in the `Cluster` specification
  - pod affinity/anti-affinity
  - node selectors
  - tolerations against taints placed on nodes

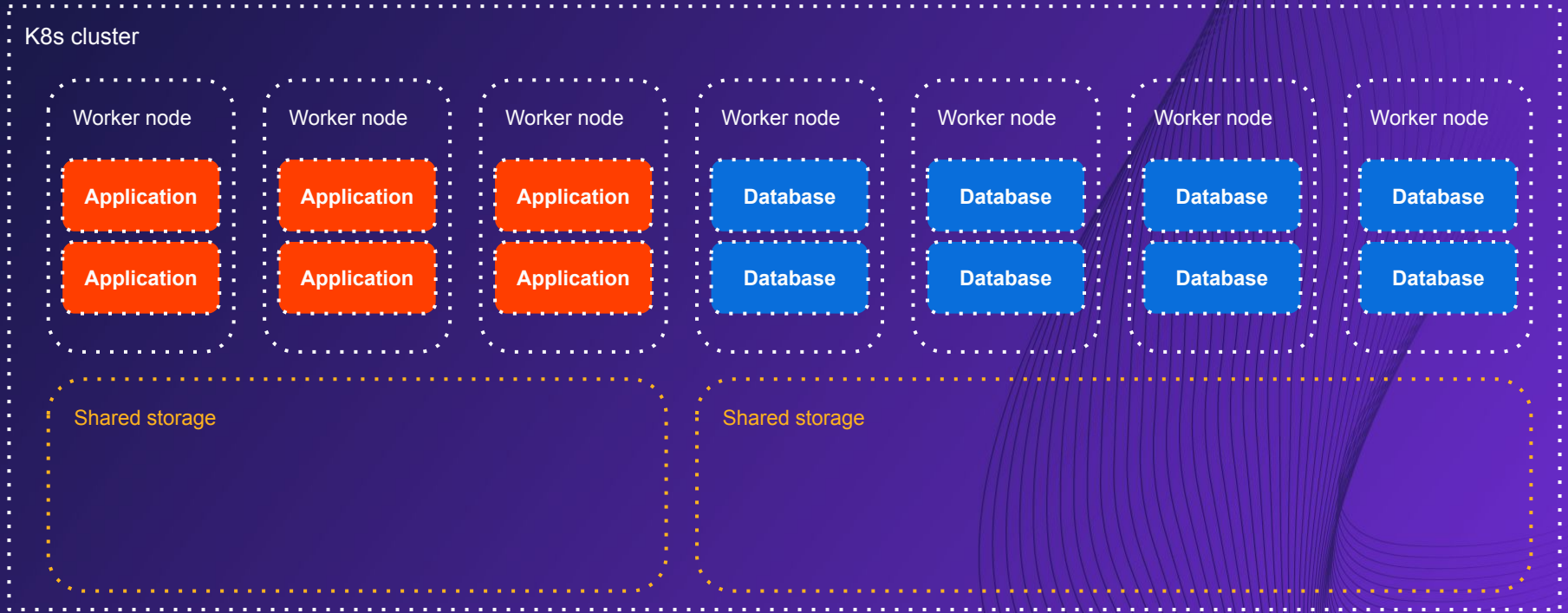
Shared workloads, shared storage #1



Shared workloads, shared storage #2

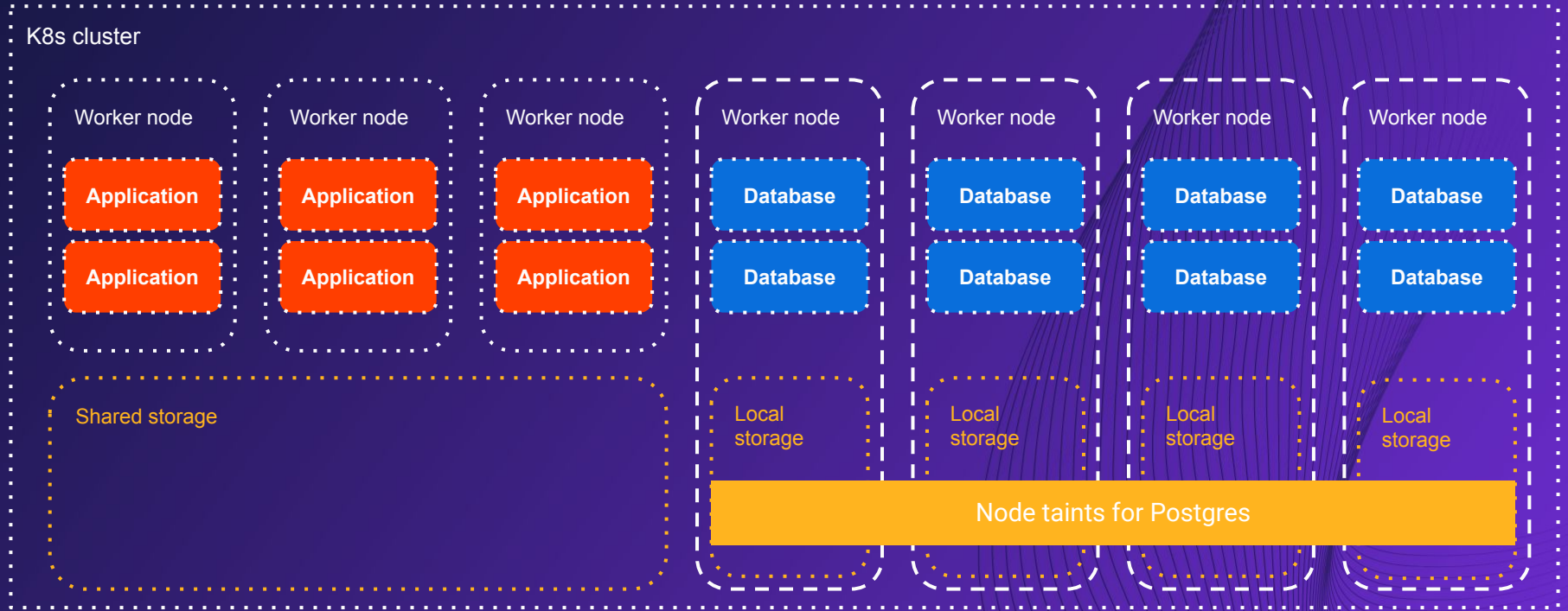


Shared workloads, shared storage #3



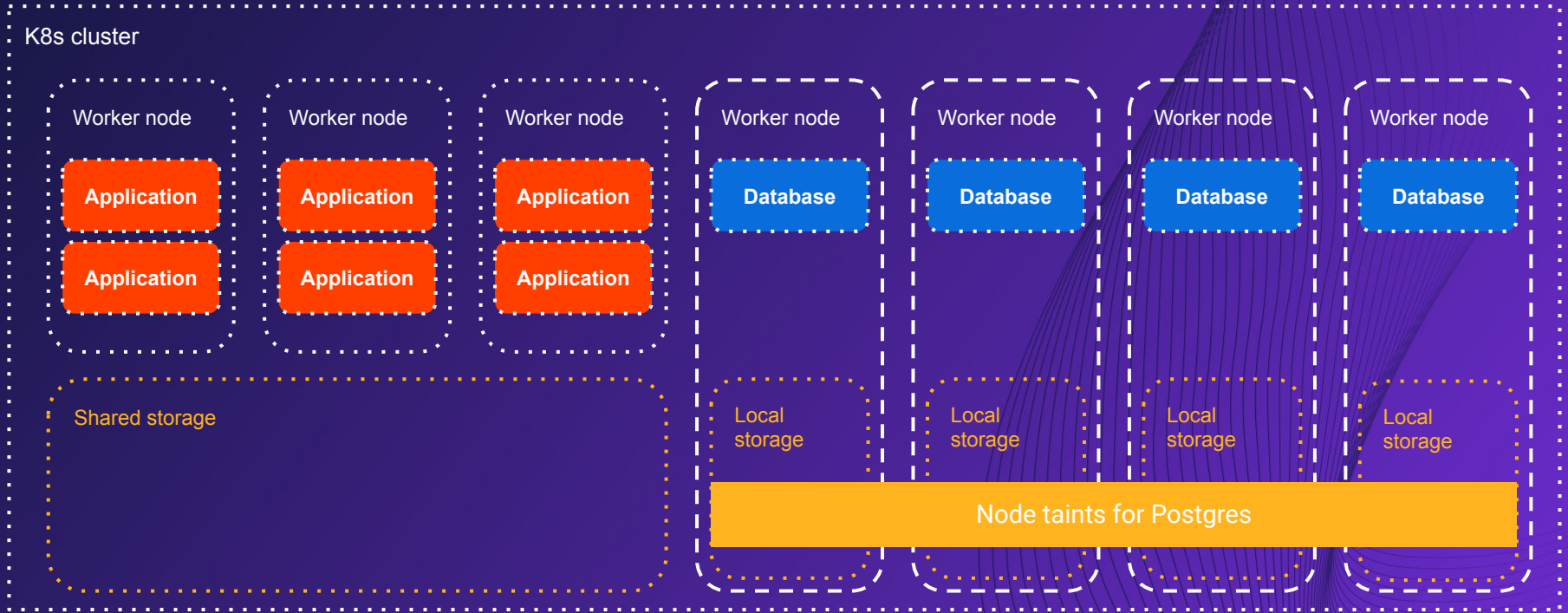
Shared workloads, local storage

Good value for money!

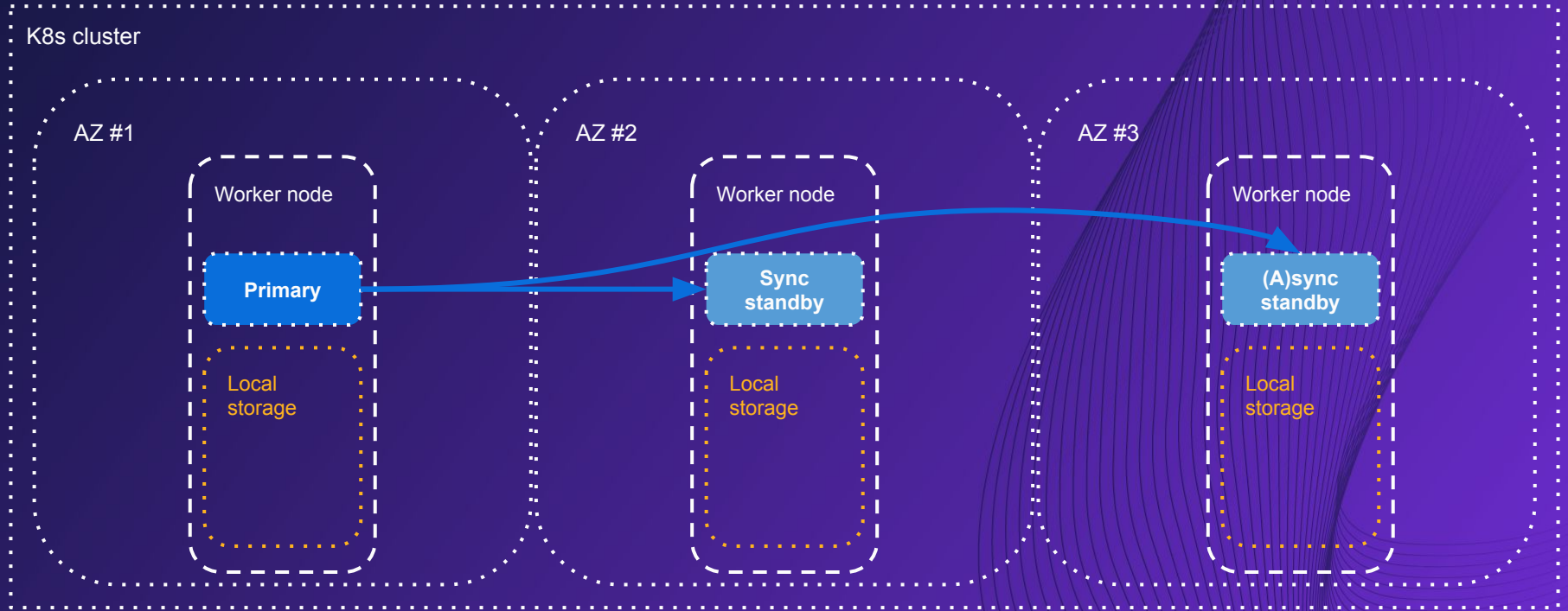


Dedicated workloads, local storage

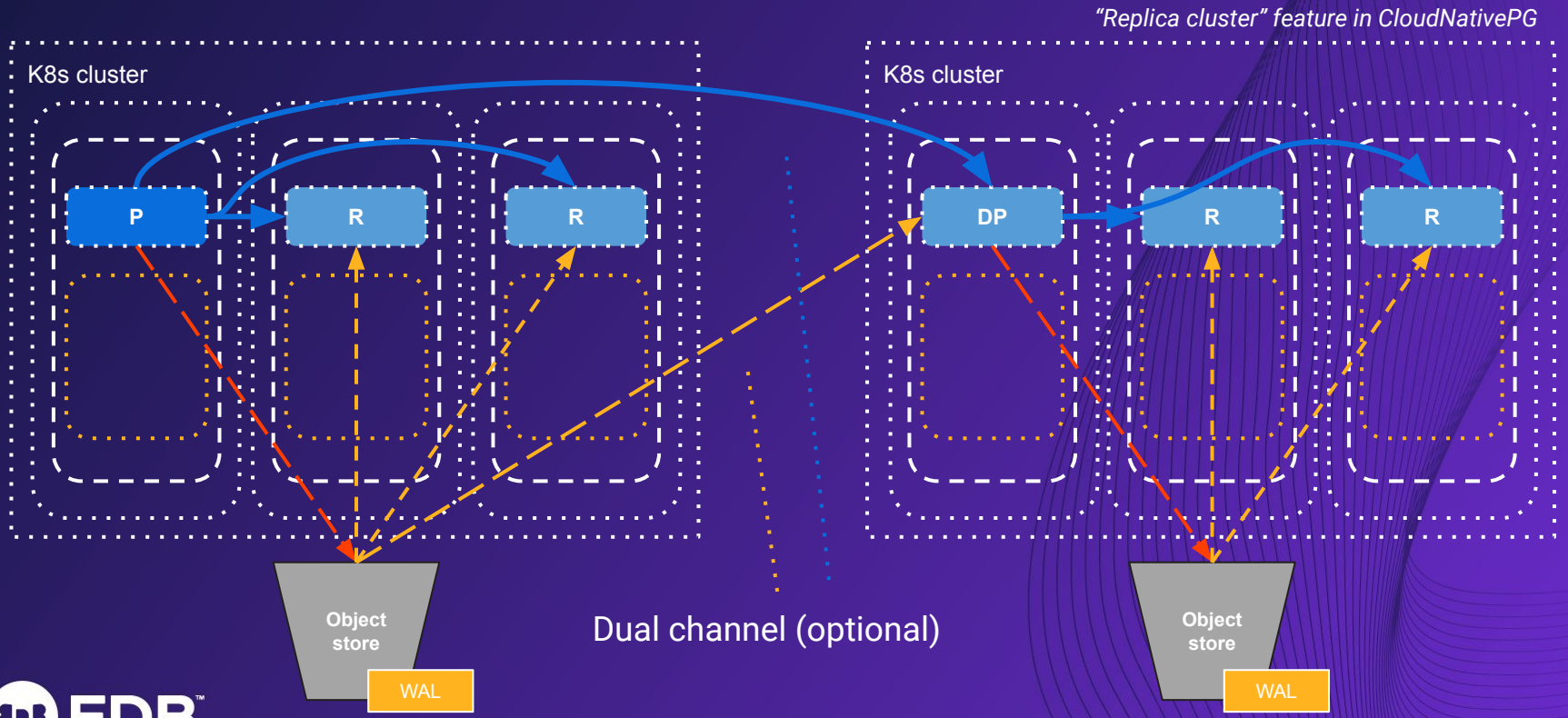
Best Postgres results!



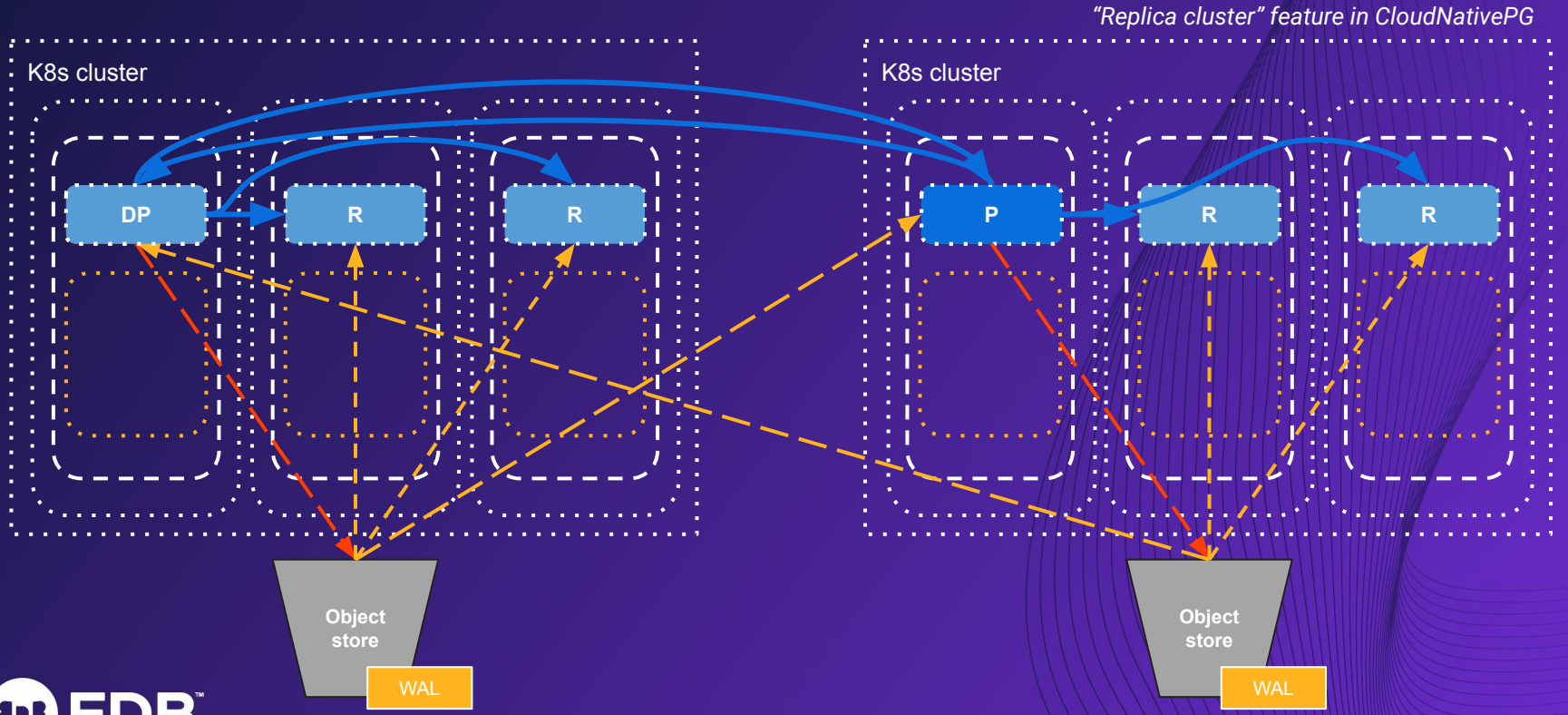
Shared nothing architecture



Shared nothing architecture (hybrid/multi)

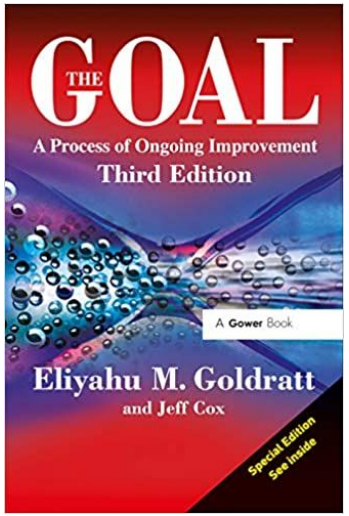


Shared nothing architecture (hybrid/multi)



#4 - The “Goal”

(“Your goal”)



Identify your business continuity goals

- Recovery Point Objective (RPO)
  - Time it takes for you to safely store each WAL file in separate locations
- Recovery Time Objective (RTO)
  - Time it takes for you to promote a standby as primary after a failure
    - Single k-cluster (region)
    - To a different k-cluster (region)
  - Time it takes for you to issue a PITR operation from a backup
- Identify your SPOFs!
- Practice! Measure! Improve!

EDB

RPO with CloudNativePG

- Recovery Point Objective (RPO)
  - WAL files are archived to object stores at least every 5 minutes, depending on the workload
  - RPO <= 5 minutes
- Recovery Time Objective (RTO)
  - Same k-cluster:
    - Automated failover
    - Recommended setup: 3 instances with 1 sync standby
    - Instantaneous detection by Kubernetes
      - (we had to introduce delayed failover configuration)
    - RTO = time taken by a standby to exit recovery and become primary
      - Normally between 5 seconds and a minute
      - Depends on the workload and lag of a standby
  - Different k-cluster:
    - Use replica clusters with WAL shipping and/or streaming
    - Current: manual detection and triggering of the promotion

RPO with CloudNativePG

- HA replicas:
  - Asynchronous replicas: RPO ~ 0
  - Synchronous replicas RPO = 0
- Local object store:
  - WAL files are archived to object stores at least every 5 minutes
    - Depending on the workload
  - RPO <= 5 minutes
- Global object store:
  - (Stored in another region)
  - Local object store RPO + relay of WAL file to another region
  - RPO <= 10 minutes

EDB

RTO with CloudNativePG

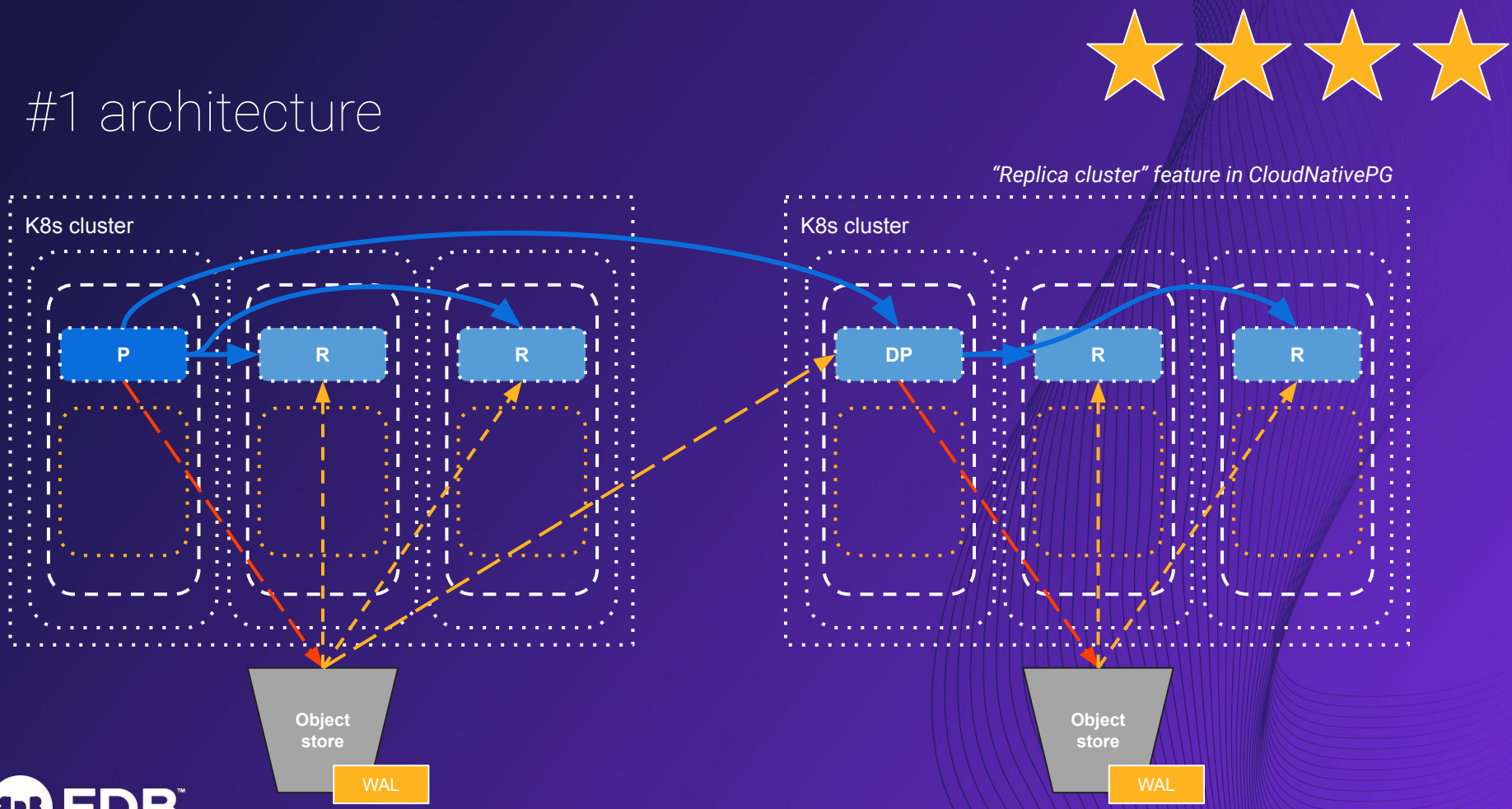
- Same k-cluster:
  - Automated failover
  - Recommended setup: 3 instances with 1 sync standby
  - Instantaneous detection by Kubernetes
    - (we had to introduce delayed failover configuration)
  - RTO = time taken by a standby to exit recovery and become primary
    - Normally between 5 seconds and a minute
    - Depends on the workload and lag of a standby
- Different k-cluster:
  - Use replica clusters with WAL shipping and/or streaming
  - Current: manual detection and triggering of the promotion
- PITR varies on the database size and the amount of WAL to replay

Key takeaways

1. Take advantage of 3+ AZ K-Clusters
2. Rely on PostgreSQL Primary/Standby clusters - like you did on VMs
3. Choose your storage carefully - like you did on VMs
4. Plan your infrastructure around your goals
    - RPO
    - RTO
    - Benchmarks
5. Shared nothing architecture, if you can
    - Otherwise, at least separate PostgreSQL workloads from the rest of your cluster
6. Application and database must be in the same K-Cluster
    - Applications are automatically rerouted to the primary via the updated service

EDB

#1 architecture



Shared workloads, local storage