PASS SQLSATURDAY LISBOA

From Docker to Big Data Clusters

A new era for SQL Server ....

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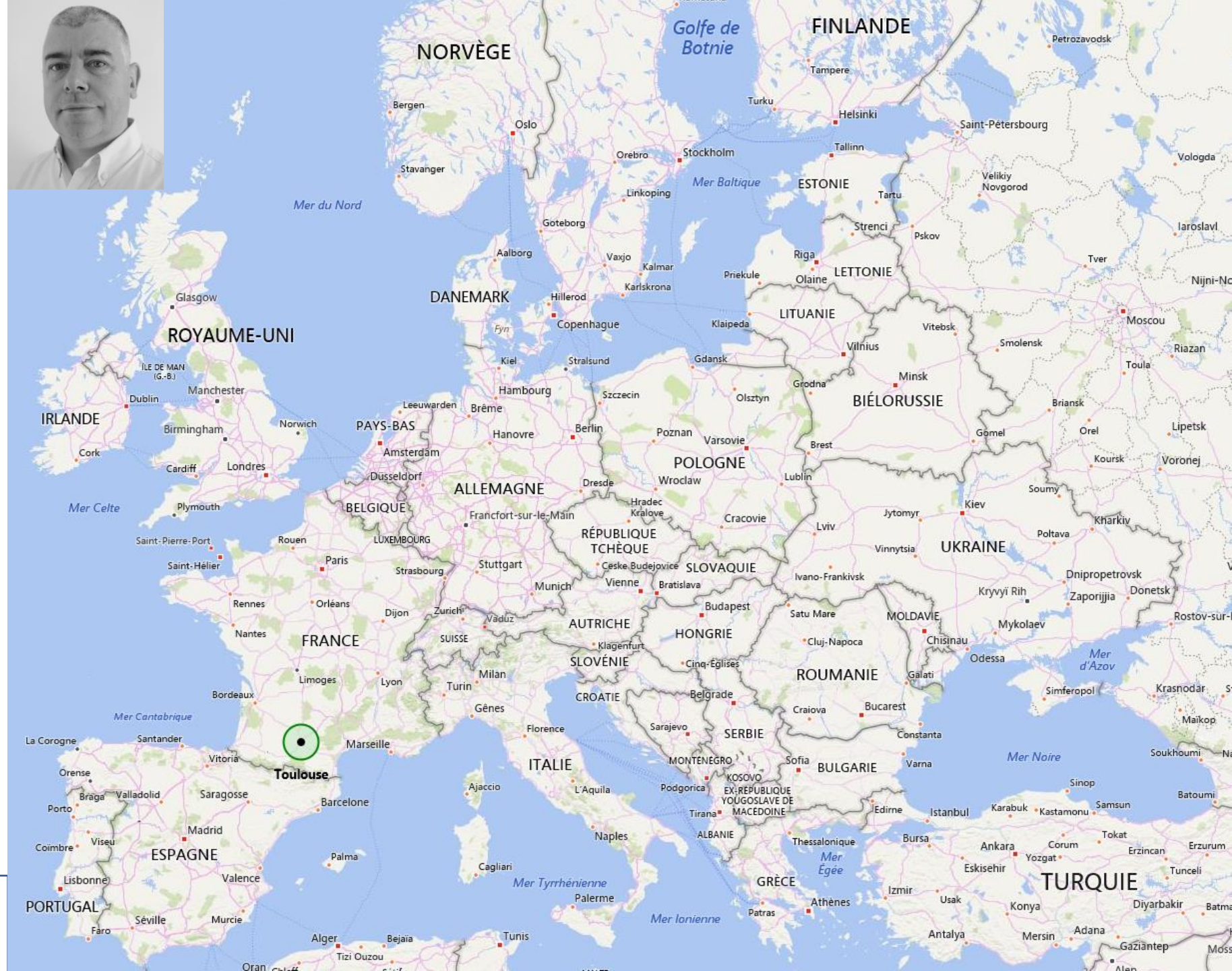

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A bit of history

- 10 years ago, we were wondering …
  - Should I virtualize SQL Server ?
  - What about performance issues ?
  - Which hypervisor ?
- Nowadays
  - Almost all SQL Server instances are virtualized OnPrem
  - And we have good performance
    - Even with Tier-1 workloads …

A bit of history

- 2016 : SQL Server 2017 on Linux announcement

Announcing SQL Server on Linux

Mar 7, 2016 | Scott Guthrie - Executive Vice President, Cloud and Enterprise Group, Microsoft

Extending SQL Server to Also Now Run on Linux

Today I'm excited to announce our plans to bring SQL Server to Linux as well. This will enable SQL Server to deliver a consistent data platform across Windows Server and Linux, as well as on-premises and cloud. We are bringing the core relational database capabilities to preview today, and are targeting availability in mid-2017.

SQL Server on Linux will provide customers with even more flexibility in their data solution. One with mission-critical performance, industry-leading TCO, best-in-class security, and hybrid cloud innovations – like Stretch Database which lets customers access their data on-premises and in the cloud whenever they want at low cost – all built in.

SQL Server on Linux

Remember, SQL Server was derived from Sybase (Unix) back in 1988

- A requirement from customers and ISVs
- New OS
  - An achievement ?
  - … or a new the chapter for SQL Server …

TPC-H data warehousing top results by TPC-H configuration (size)

Company	System	Performance Price/QphH	Database Operating System
Hewlett Packard Enterprise	HPE Proliant DL380 Gen10	1,244,450 QphH@3000GB 0.38 USD	Microsoft SQL Server 2017 Enterprise Edition SUSE Linux Enterprise Server 15
Hewlett Packard Enterprise	HPE Proliant DL380 Gen9	717,101 QphH@1000GB 0.61 USD	Microsoft SQL Server 2017 Enterprise Edition Red Hat Enterprise Linux Server 7.3
CISCO	Cisco UCS C460 M4 Server	1,115,298 QphH@10000GB 0.87 USD	Microsoft SQL Server 2016 Enterprise Edition Microsoft Windows Server 2016 Standard Edition

ubuntu

redhat

SUSE

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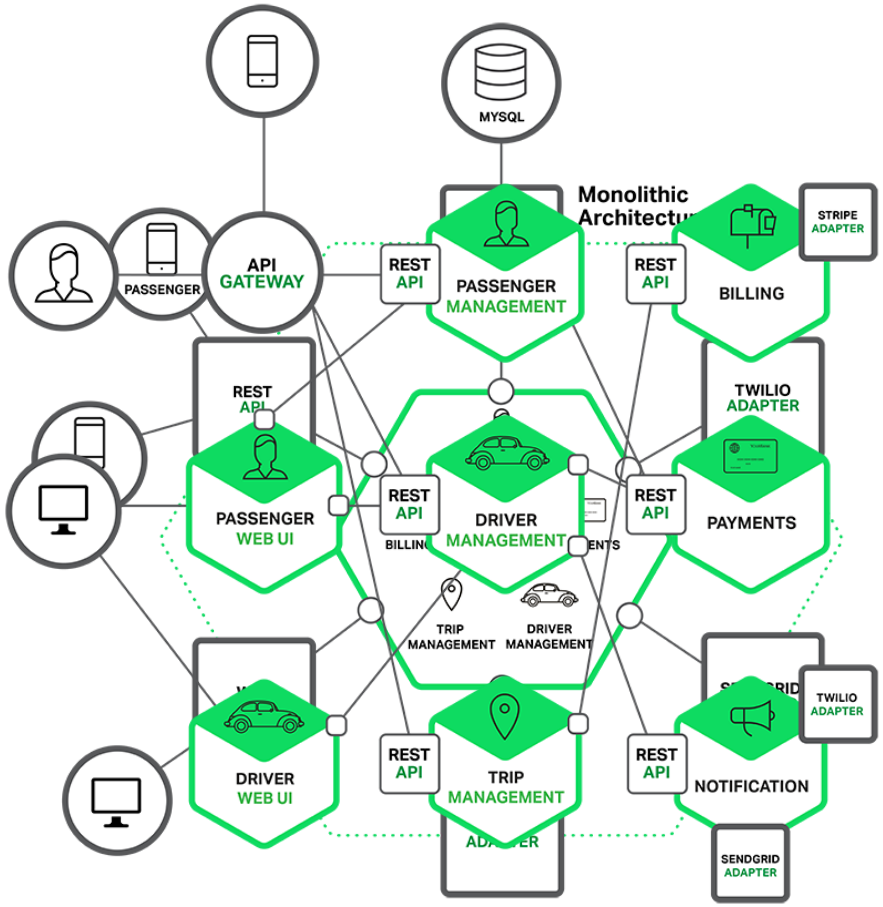
Installing SQL Server on linux

- Quite straightforward
  - For basic installation

```
# ubuntu
wget -qO- https://packages.microsoft.com/keys/microsoft.asc | sudo apt-key add -
sudo add-apt-repository "$(wget -qO- https://packages.microsoft.com/config/ubuntu/16.04/mssql-server-2017.list)"
sudo apt-get update
sudo apt-get install -y mssql-server
sudo /opt/mssql/bin/mssql-conf setup

# RedHat
sudo curl -o /etc/yum.repos.d/mssql-server.repo https://packages.microsoft.com/config/rhel/7/mssql-server-2017.repo
sudo yum install -y mssql-server
sudo /opt/mssql/bin/mssql-conf setup


# Suse
sudo zypper addrepo -fc https://packages.microsoft.com/config/sles/12/mssql-server-2017.repo
sudo zypper --gpg-auto-import-keys refresh
sudo zypper install -y mssql-server
sudo /opt/mssql/bin/mssql-conf setup
```

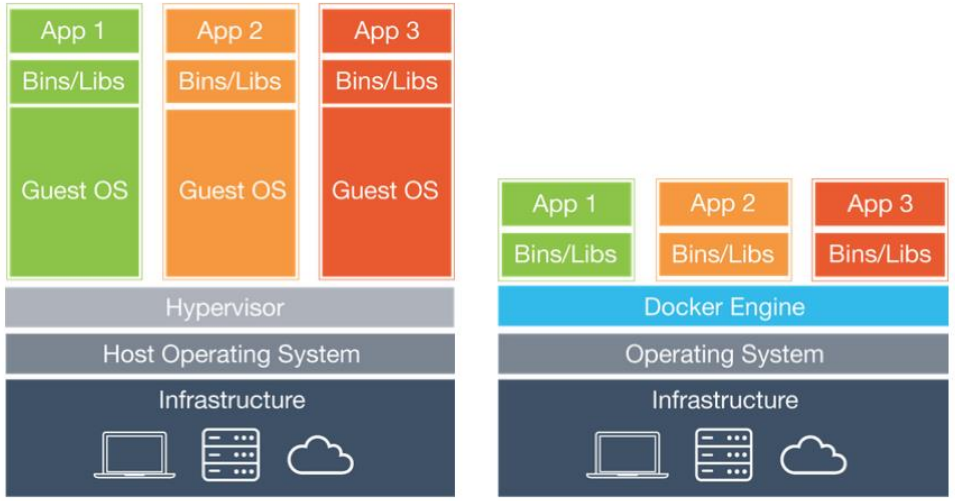
Micro services design pattern

- Yesterday : monolithic applications
  - Hard to maintain / evolve
- Today : micro services
  - New way to develop applications
  - Lightweight pieces of SW evolving independently
  - 1, 10s or 100s of containers composed as a single application
- It seems to become a standard
  - From an infrastructure prospective
  - From a DevOps “philosophy”



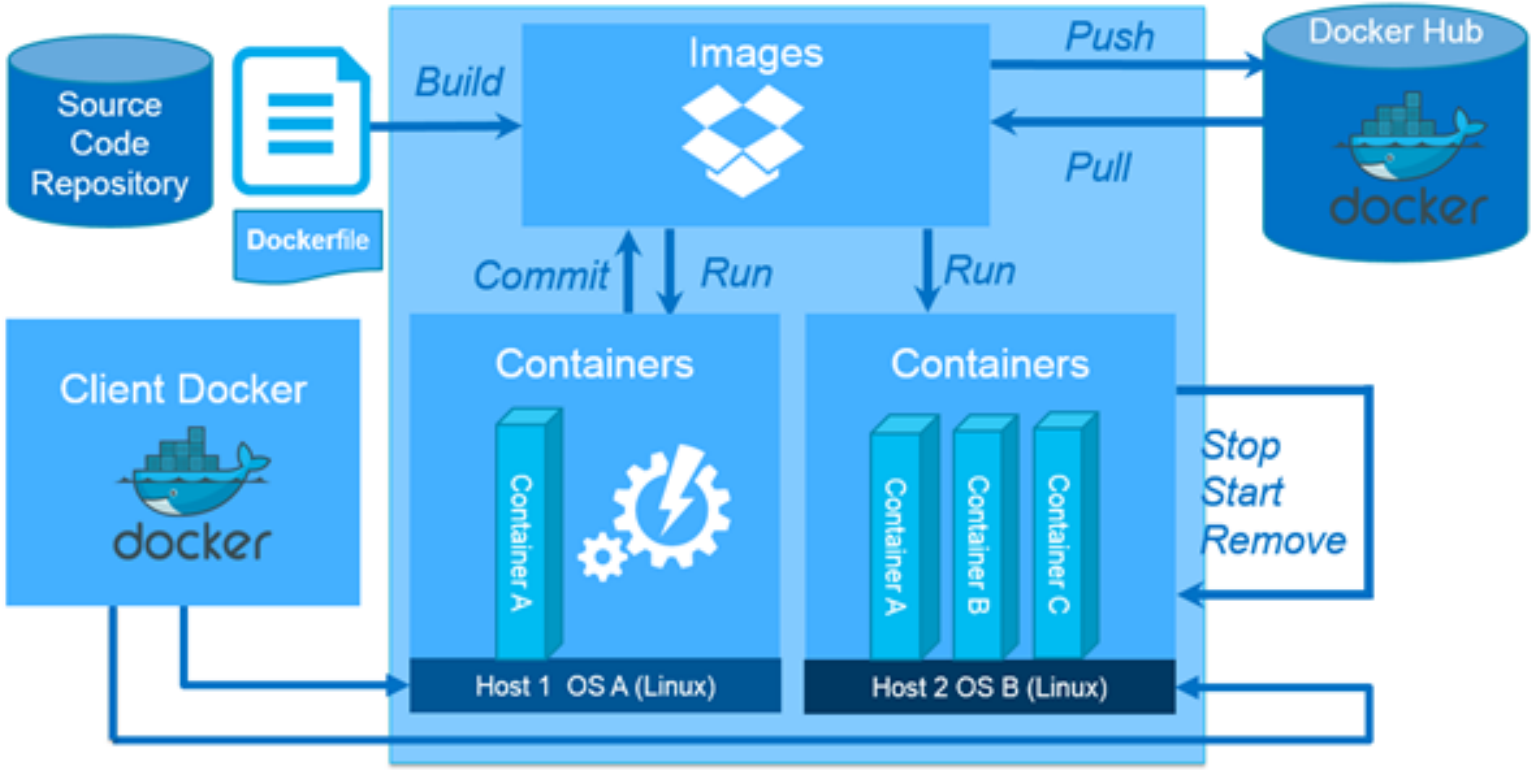
Containerization : virtualization v2.0

- Small system footprint
  - Lightweight -> better efficiency on host servers
- Single image
  - Multiple deployments (dev / test / prod)
  - Avoid : “it works on my computer” !
- Will always run the same
  - Regardless of where it is deployed



docker

- Multi OS
  - Windows, Linux, Mac
- Docker engine
  - Containers execution
- Docker client
  - Command line utility
- Terminology
  - Image
  - Container
  - Repository



Docker – The command line utility

Command	Description
Docker search	Find an image on a repository
Docker pull	Download an image from the repository
Docker build	Create an image from a Dockerfile
Docker create	Create a container
Docker start	Start a container
Docker run	All-in-one command to pull, create and start a container
Docker stop	Stop a container
Docker rm	Remove the container – but not the image (Docker RMI)

Running my first container


```
# Survival kit : Docker commands
docker

## Display Docker version and info
docker version
docker info

## Docker images CLI commands
docker image --help
docker image ls  # <=>  docker images

## Docker container CLI commands
docker container --help
docker container ls       #  <=>  docker ps
docker container ls --all #  <=>  docker ps -a

# Running my first container
docker run hello-world
```

But … Wait ….

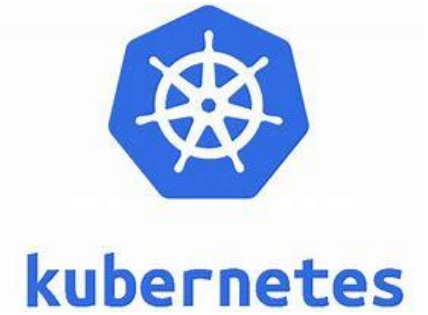
- We can run SQL Server on Linux
- So, why not running it in a container ?


```
# Run (Pull+Create+Start) the container in detach mode
docker run  --detach \                                  # Run (Pull+Create+Start) the container in detach mode
            --name sqldocker \                          # Container name
            --hostname sqldocker \                      # OS name
            --env 'MSSQL_PID=developer' \               # Edition : developer is the default value
            --env 'SA_PASSWORD=Password1!' \            # Password for SA account
            --env 'ACCEPT_EULA=Y' \                     # You still need to acknowledge licence terms
            --volume /mssql:/var/opt/mssql/data \       # Redirect storage to persist data
            --publish 1433:1433 \                       # TCP endpoint to connect the container
            mcr.microsoft.com/mssql/server:2019-latest  # Image used to build and start the container
```

Now … What’s next ?

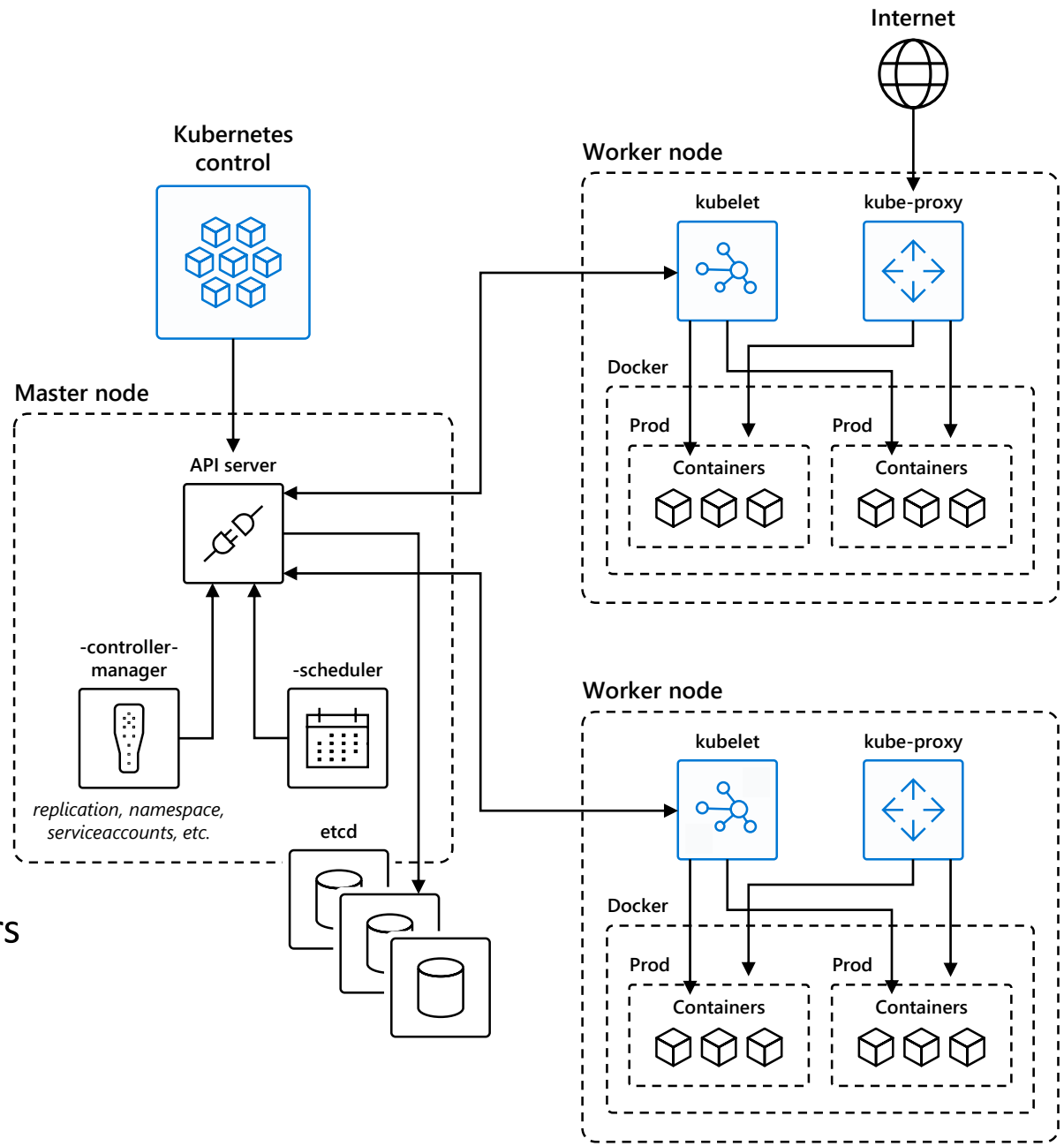
- We need some orchestration for containers
  - Ensure container is healthy --> restart container
  - Ensure host is healthy --> Restart on a different host
  - Provide network access to the containers
  - Provide persistent storage across all nodes
  - Manage container resources (CPU, RAM ...)
- And we wish a similar deployment experience
  - OnPrem
  - Public Cloud
- And some scaling functions

Sounds familiar … Hey, that’s a cluster !



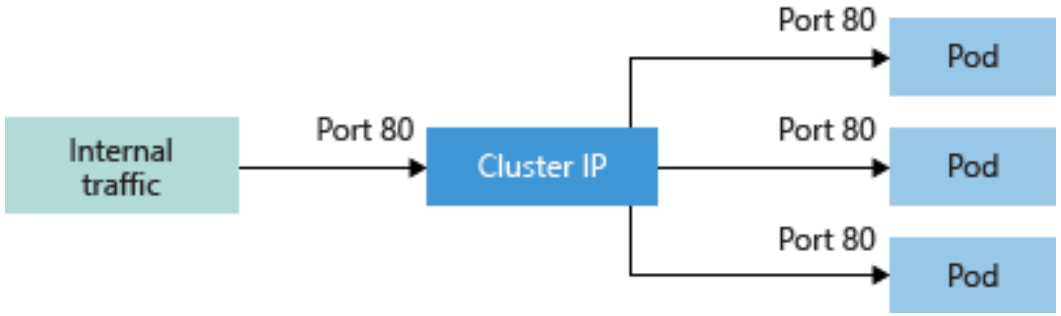
Kubernetes for DBAs

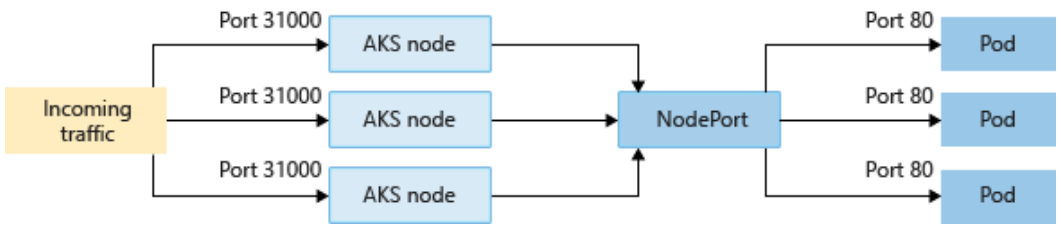
- Also known as K8s
- Terminology
  - Container
  - Pod
    - Smallest management unit
    - 1..N containers
    - Unique @IP across the cluster
  - Master node
    - Responsible for pod scheduling
  - Worker node
    - Node of the K8s Cluster
    - Kubelet : responsible for running containers
    - Kube-proxy : manage network traffic
- Desired State Configuration

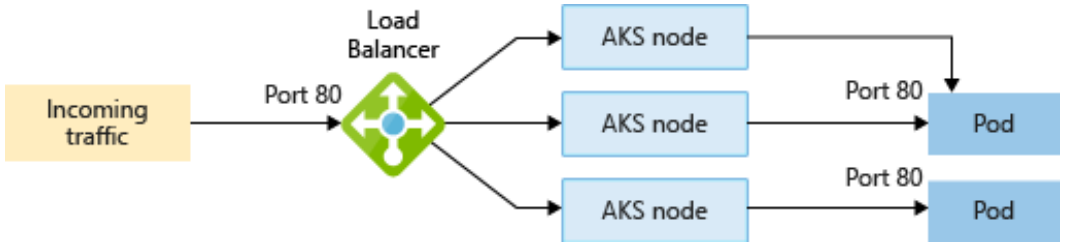


Connecting to applications

- Connections goes through kube-proxy
  - Routing and NATing to the Pod
  - No matter the worker node
- Services
  - Exposes applications
  - Logical abstraction of one or more Pods
- Different types of service
  - ClusterIP
  - Node Port
  - Load Balancer







Kubectl : the command line utility

Command	Description
kubectl create|apply -f ./somefile.yaml	Resource creation
kubectl delete -f ./somefile.yaml	Resource deletion
kubectl run nginx –image=nginx	Run a single instance from Nginx image
Kubectl get pods	List Pods
kubectl get service(s)	List Services
kubectl get deployment(s)	List Deployments
kubectl get node(s)	List Nodes of the cluster
kubectl logs <pod-name>	Display container / pod logs
kubectl exec -it <pod-name> — bash	Run a command inside a container

A bit of history (again)

- 10 years ago, we were wondering …
  - Should I virtualize SQL Server ?
- 10 years ago, Microsoft was introducing Azure

Microsoft Cloud Services Vision Becomes Reality With Launch of Windows Azure Platform

November 17, 2009 |

LOS ANGELES — Nov. 17, 2009 — Microsoft Corp. today announced the availability of the Windows Azure platform at the Microsoft Professional Developers Conference (PDC). In his opening keynote address, Ray Ozzie, chief software architect at Microsoft, described Windows Azure and SQL Azure as core elements of the company's cloud services strategy. The company also announced a set of new Windows Azure features, Windows Server capabilities, and marketplace offerings that will make it easier for developers to build profitable businesses from their Microsoft-based solutions.

Containers services on Azure

- ACI : Azure Container Instance
  - Easiest way to spin up a container, without managing Kubernetes / Servers / …
  - Charged for each GB and vCPU second your container group consumes

```
# create a resource group
az group create --name sqlserver-aci --location westeurope

# and create a container inside ACI
az container create --resource-group sqlserver-aci  \
                    --name mssqlaci \
                    --image mcr.microsoft.com/mssql/server:2019-latest \
                    --ip-address public --ports 1433 \
                    --environment-variables ACCEPT_EULA=Y MSSQL_SA_PASSWORD=P@ssw0rd1! \
                    --dns-name-label conseilit-sqlserver-aci \
                    --cpu 4 --memory 16

# and finally connect to the SQL Server instance
/opt/mssql-tools/bin/sqlcmd -S conseilit-sqlserver-aci.westeurope.azurecontainer.io \
                            -U SA -P 'P@ssw0rd1!' -Q "SELECT name from sys.databases;"
```

Containers services on Azure

- AKS : Azure Kubernetes Service
  - Fully managed K8s cluster
  - Everything is configured for you
    - Storage
    - Network
    - K8s configuration (master, worker nodes)
- But you have to create the cluster
- You have to maintain the cluster
- Charged for the virtual machines and the associated storage and networking resources consumed

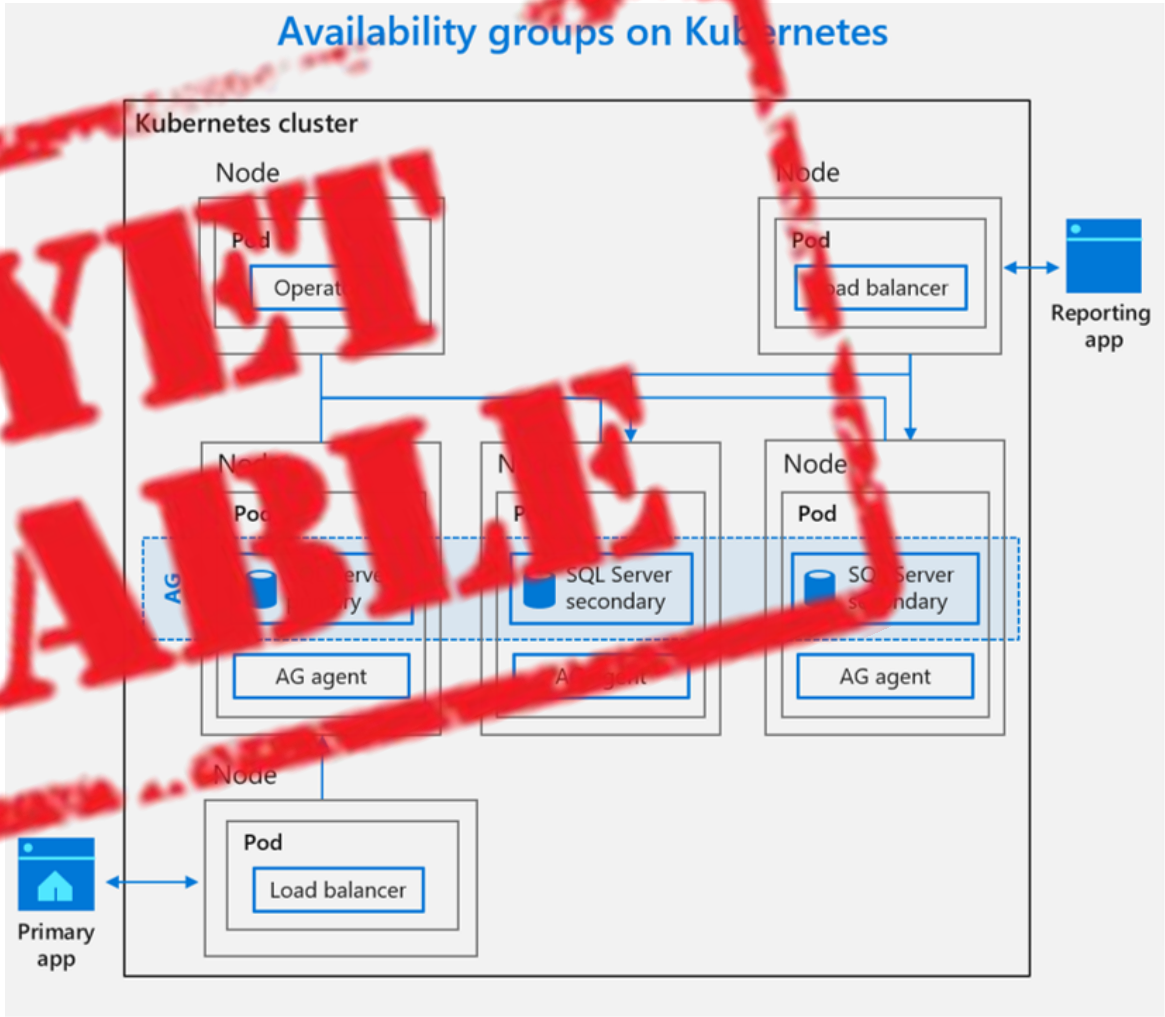
```
# Create a resource group
az group create --name k8s-group --location francecentral

# List currently supproted Kubernetes version
az aks get-versions --location francecentral --output table

# Create the cluster
az aks create --name k8s-cluster \
--resource-group k8s-group \
--generate-ssh-keys \
--node-vm-size Standard_B8ms \
--node-count 3 \
--kubernetes-version 1.14.7

# Get Nodes and Pods
kubectl get nodes -o wide
kubectl get pods -o wide --all-namespaces
```

Deploying SQL Server on AKS


```
# Create a dedicated Namespace
kubectl create namespace mssql-standalone
kubectl get namespaces

# Create a secret to be used by SQL Server deployment
kubectl create secret generic mssql --from-literal=SA_PASSWORD="MyC0m9l&xP@ssw0rd"  --namespace mssql-standalone

# Deply a SQL Server Pod with a single YAML file containing
#   - Storage Class
#   - Persistent Volume Claim
#   - Deployment
#   - Service
cat sqlserver-standalone/sqlserver-standalone.yaml
kubectl apply -f sqlserver-standalone/sqlserver-standalone.yaml --namespace mssql-standalone

# Get some information during deployment
kubectl get events --namespace=mssql-standalone

kubectl get deployment --namespace mssql-standalone
kubectl get pods --namespace mssql-standalone
kubectl get services --namespace mssql-standalone

# Connect to SQL server instance
/opt/mssql-tools/bin/sqlcmd -S 20.40.142.17,1433 -U SA -P 'MyC0m9l&xP@ssw0rd' -Q "SELECT @@servername,@@version;"
```

SQL Server HA inside K8s

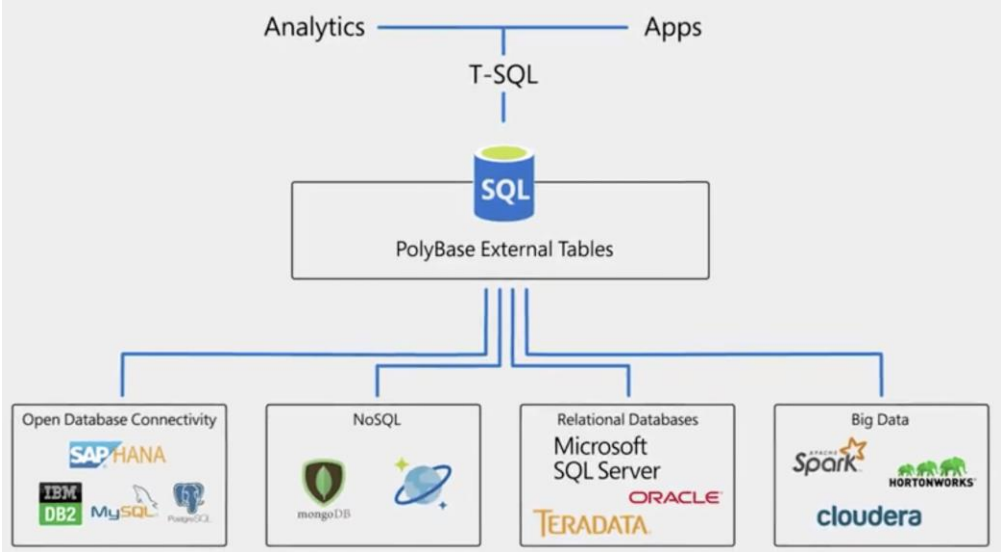
- *mssql-operator*
  - Implements the Kubernetes operator for SQL Server and Availability Groups.
- *mssql-server-k8s-health-agent*
  - Implements the logic to determine the health of a SQL Server Instance
- *mssql-ha-supervisor*
  - Implements the AG health detection and management logic, including the leader election logic to determine the Primary replica for the availability group. The leader election functionality is based on a fork of the Kubernetes client leader election.
- *mssql-server-k8s-init-sql*
  - Implements the logic for deployment and initialization of a desired state configuration to a SQL Server instance.



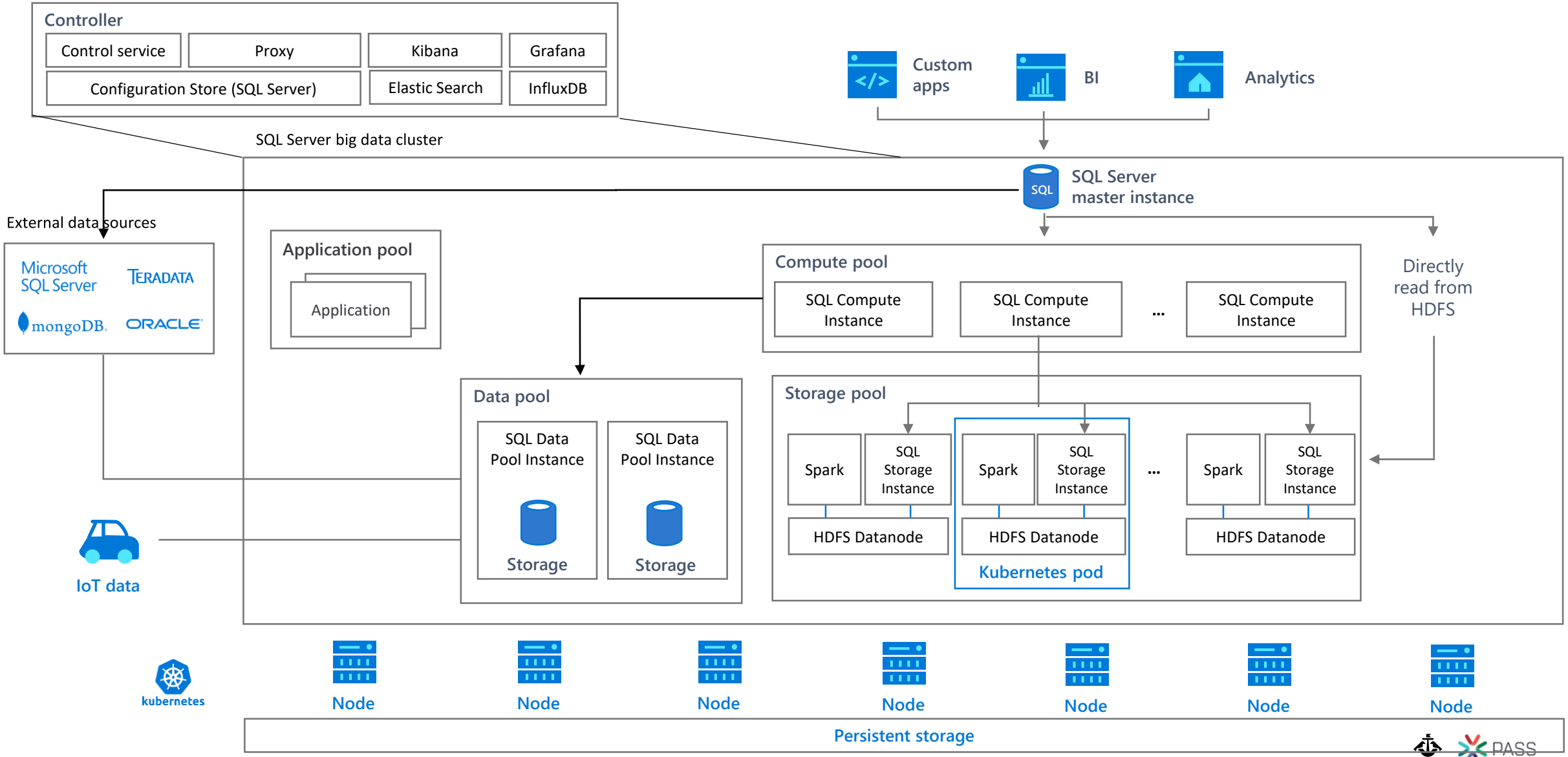
NOT YET AVAILABLE

But … Wait ….

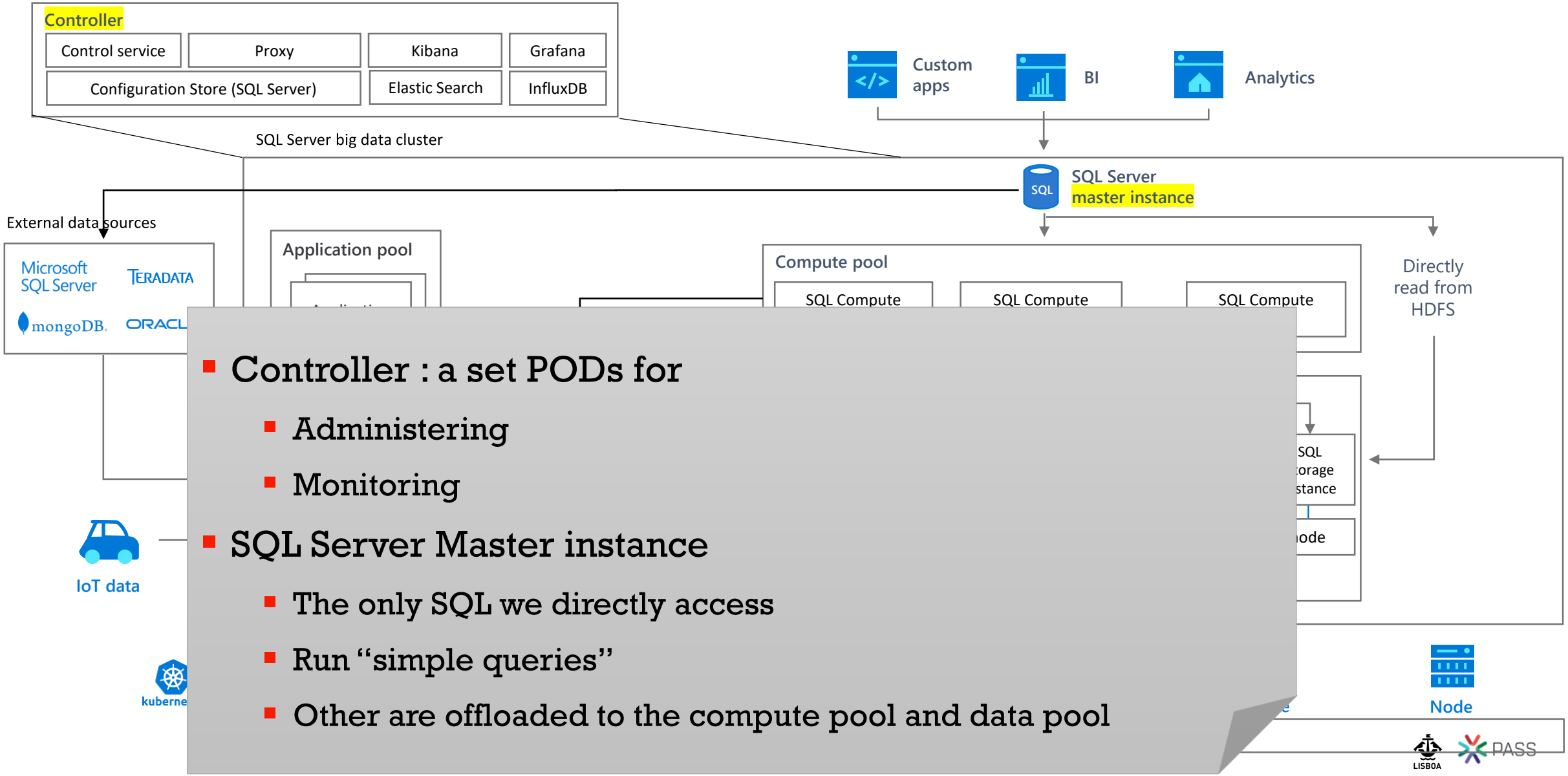
- Nowadays SQL Server is more than a SGBD
  - SQL Server offers Data Virtualization with Polybase
- K8s can run almost all kind of applications
- K8s can run SQL Server
  - ~~with AlwaysOn Availability Groups~~
- Pods can host multiple containers
- Hummmm ….
- Let’s add some « Big Data» containers
  - With Spark engine
  - And some kind of HDFS storage



That's SQL Server 2019 Big Data Cluster



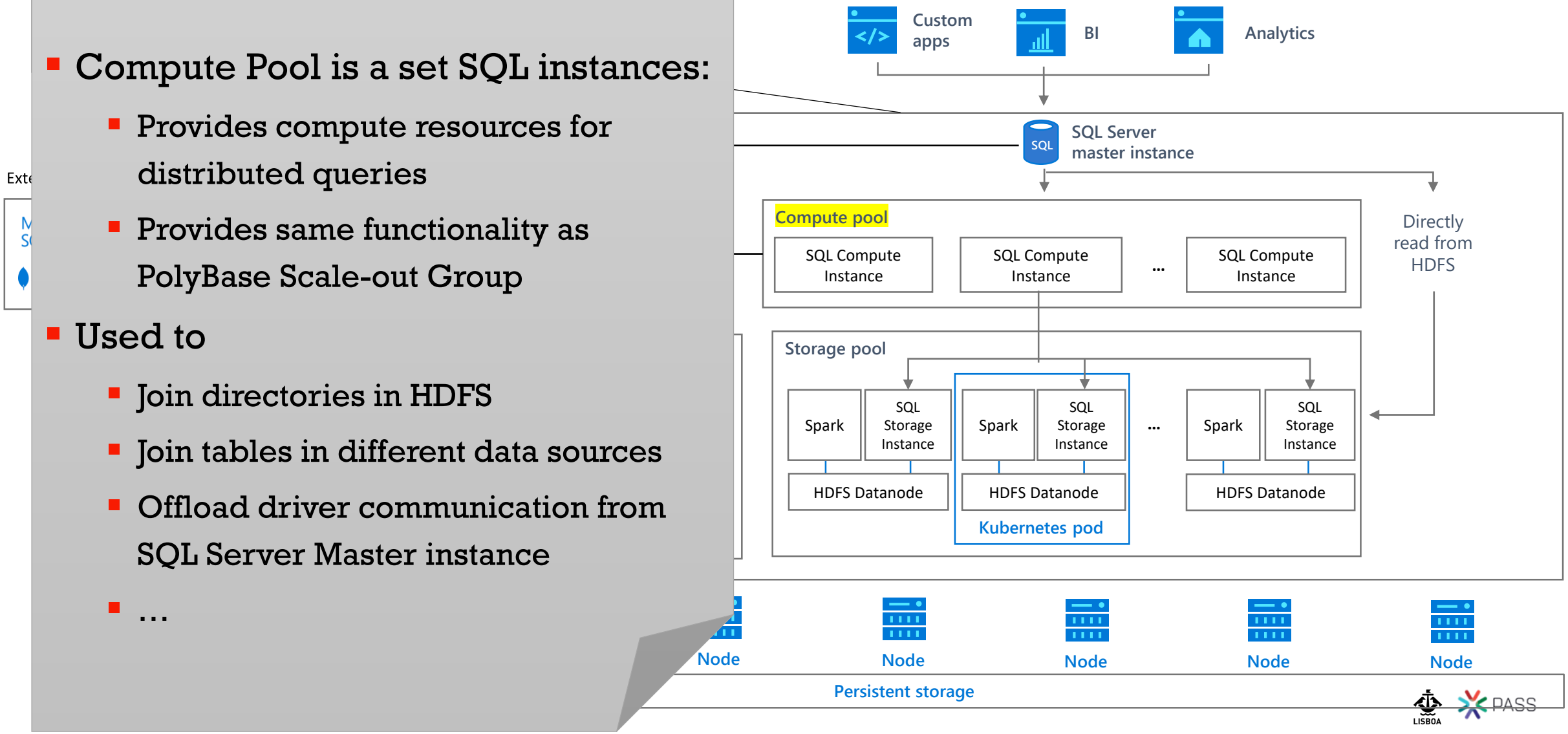
Control plane



- Controller : a set PODs for
  - Administering
  - Monitoring
- SQL Server Master instance
  - The only SQL we directly access
  - Run “simple queries”
  - Other are offloaded to the compute pool and data pool

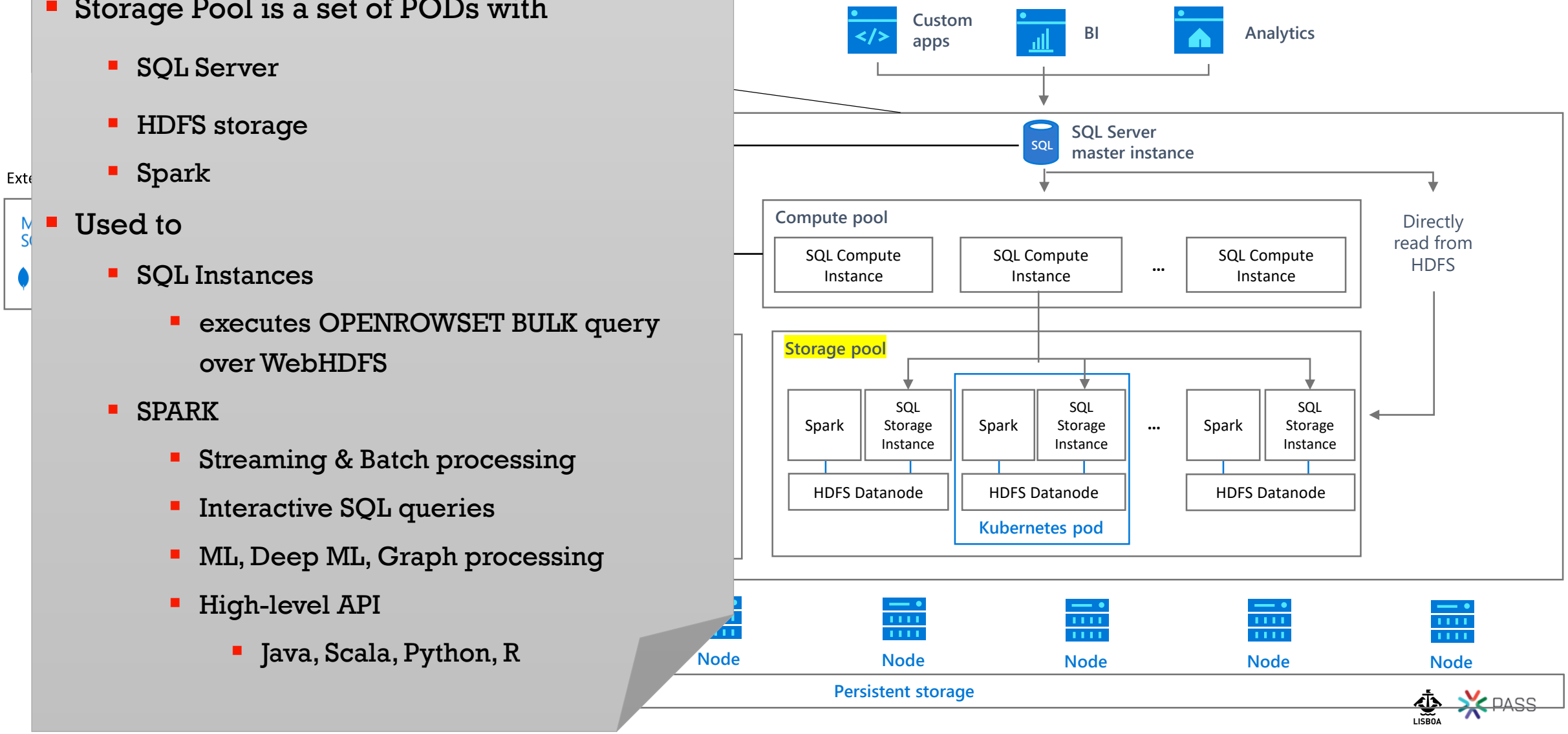
Compute plane

- Compute Pool is a set SQL instances:
  - Provides compute resources for distributed queries
  - Provides same functionality as PolyBase Scale-out Group
- Used to
  - Join directories in HDFS
  - Join tables in different data sources
  - Offload driver communication from SQL Server Master instance
  - …

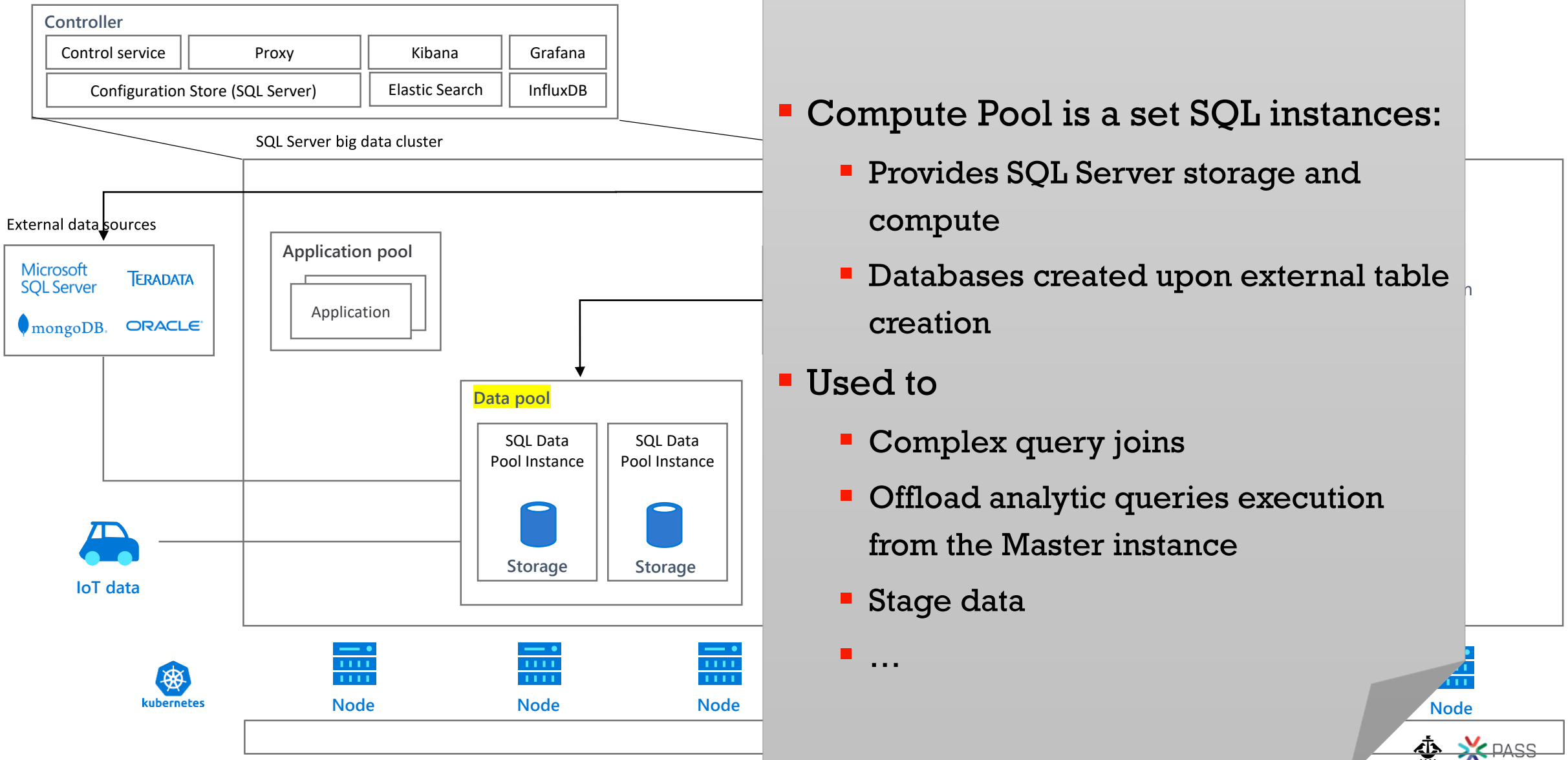


Data plane : Storage pool

- Storage Pool is a set of PODs with
  - SQL Server
  - HDFS storage
  - Spark
- Used to
  - SQL Instances
    - executes OPENROWSET BULK query over WebHDFS
  - SPARK
    - Streaming & Batch processing
    - Interactive SQL queries
    - ML, Deep ML, Graph processing
    - High-level API
      - Java, Scala, Python, R



Data plane : Data pool



- Compute Pool is a set SQL instances:
  - Provides SQL Server storage and compute
  - Databases created upon external table creation
- Used to
  - Complex query joins
  - Offload analytic queries execution from the Master instance
  - Stage data
  - …

Let’s play with SQL Server 2019 BDC

[7]

```
USE DemoDB;
GO
SELECT TOP 10 * FROM [dbo].[WxLog]
```

Commands completed successfully.

(10 rows affected)

Total execution time: 00:00:13.527

	Date	Time	Baro	QNH	Gust Speed	Gust
1	11/05/2013	13:25	1024.00	1024.00	16.92	270
2	11/05/2013	13:26	1024.00	1024.00	16.92	248
3	11/05/2013	13:27	1024.00	1024.00	16.20	248
4	11/05/2013	13:28	1024.00	1024.00	16.92	293
5	11/05/2013	13:29	1024.00	1024.00	9.36	248
6	11/05/2013	13:30	1024.00	1024.00	14.04	293
7	11/05/2013	13:31	1024.00	1024.00	9.72	293
8	11/05/2013	13:32	1024.00	1024.00	12.60	293
9	11/05/2013	13:33	1024.00	1024.00	12.24	293
10	11/05/2013	13:34	1024.00	1024.00	12.60	270

[3]

```
# Read the CSV file(s) into a spark dataframe and print schema
results = spark.read \
    .option("inferSchema", "true") \
    .csv('/csvfiles/temperature-last-year_poolhouse.csv') \
    .toDF("DateTime","Humidity","Temperature","Temperature_range (low)","Temperature_range (high)")
results.printSchema()
```

Starting Spark application

ID	YARN Application ID	Kind	State	Spark UI	Driver log	Current session?
5	application_1573997616589_0001	pyspark	idle	Link	Link	✓

SparkSession available as 'spark'.

```
root
 |-- DateTime: string (nullable = true)
 |-- Humidity: string (nullable = true)
 |-- Temperature: string (nullable = true)
 |-- Temperature_range (low): string (nullable = true)
 |-- Temperature_range (high): string (nullable = true)
```

[11]

```
results.show(5)
```

```
+-------------------+--------+-----------+----------------------+-----------------------+
|           DateTime|Humidity|Temperature|Temperature_range (low)|Temperature_range (high)|
+-------------------+--------+-----------+----------------------+-----------------------+
|           DateTime|Humidity|Temperature|   Temperature_range...|    Temperature_range...|
|2018-05-14 00:00:00|      80|      10.06|                   8.8|                   11.2|
|2018-05-15 00:00:00|      88|      11.83|                  10.5|                   13.6|
|2018-05-16 00:00:00|      83|      13.47|                  11.7|                   16.6|
|2018-05-17 00:00:00|      84|      14.69|                  12.9|                   18.1|
+-------------------+--------+-----------+----------------------+-----------------------+
only showing top 5 rows
```

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[12]

```
results.filter("Humidity > 70").show()
```

DateTime	Humidity	Temperature	Temperature_range (low)	Temperature_range (high)
2018-05-14 00:00:00	80	10.06	8.8	11.2
2018-05-15 00:00:00	88	11.83	10.5	13.6
2018-05-16 00:00:00	83	13.47	11.7	16.6
2018-05-17 00:00:00	84	14.69		
2018-05-18 00:00:00	82	15.91		
2018-05-19 00:00:00	76	17.69		
2018-05-28 00:00:00	82	18.27		
2018-05-29 00:00:00	82	19		
2018-05-30 00:00:00	84	18.23		
2018-05-31 00:00:00	79	18.97		
2018-06-03 00:00:00	73	20.36		
2018-06-04 00:00:00	73	20.77		
2018-06-05 00:00:00	79	19.86		
2018-06-06 00:00:00	80	18.21		
2018-06-07 00:00:00	73	19.86		
2018-06-10 00:00:00	76	21.46		
2018-06-11 00:00:00	79	19.29		
2018-06-12 00:00:00	76	18.69		
2018-06-15 00:00:00	71	19.54		
2018-06-18 00:00:00	72	19.03		

only showing top 20 rows

[13]

```
results.filter("Humidity > 70").filter("Temperature > 15").show()
```

DateTime	Humidity	Temperature	Temperature_range (low)	Temperature_range (high)
2018-05-19 00:00:00	76	17.69	13.9	21.6
2018-05-28 00:00:00	82	18.27	16.4	19.8
2018-05-29 00:00:00	82	19	16.4	22.2
2018-05-30 00:00:00	84	18.23	16.2	20.6
2018-05-31 00:00:00	79	18.97	15.7	23.4
2018-06-03 00:00:00	73	20.36	15.9	25.2
2018-06-04 00:00:00	73	20.77	15.5	26
2018-06-05 00:00:00	79	19.86	16.8	25.7
2018-06-06 00:00:00	80	18.21	15.5	22.3
2018-06-07 00:00:00	73	19.86	16	24.7
2018-06-10 00:00:00	76	21.46	18.7	25
2018-06-11 00:00:00	79	19.29	16.8	23.6
2018-06-12 00:00:00	76	18.69	14.1	32.9
2018-06-15 00:00:00	71	19.54	16.3	23.8
2018-06-18 00:00:00	72	19.03	14.7	23.5
2018-09-06 00:00:00	73	20.93	19.4	23.8
2018-10-09 00:00:00	82	16.55	13.7	20.7
2018-10-10 00:00:00	77	18.77	16.4	22.6
2018-10-11 00:00:00	74	19	14.2	23.5
2018-10-12 00:00:00	74	20.63	16.5	25.2

only showing top 20 rows

We can switch a TSQL like syntax to query the dataframe

```
[18]  1 results.select("temperature","Humidity").show(10)
```

```
+-----------+--------+
|temperature|Humidity|
+-----------+--------+
|Temperature|Humidity|
|      10.06|      80|
|      11.83|      88|
|      13.47|      83|
|      14.69|      84|
|      15.91|      82|
|      17.69|      76|
|      19.07|      67|
|      19.26|      65|
|      19.31|      69|
+-----------+--------+
only showing top 10 rows
```

We can also use some real TSQL statements.

Let's creae a kind of view ands make some queries

```
[20]  1 results.createOrReplaceTempView("meteo")
```

```
[21]  1 spark.sql("SELECT * from meteo").show(10)
```

```
+-------------------+--------+-----------+----------------------+------------------------+
|           DateTime|Humidity|Temperature|Temperature_range (low)|Temperature_range (high)|
+-------------------+--------+-----------+----------------------+------------------------+
|           DateTime|Humidity|Temperature|   Temperature_range...|    Temperature_range...|
|2018-05-14 00:00:00|      80|      10.06|                   8.8|                    11.2|
|2018-05-15 00:00:00|      88|      11.83|                  10.5|                    13.6|
|2018-05-16 00:00:00|      83|      13.47|                  11.7|                    16.6|
|2018-05-17 00:00:00|      84|      14.69|                  12.9|                    18.1|
|2018-05-18 00:00:00|      82|      15.91|                  11.1|                    20.8|
|2018-05-19 00:00:00|      76|      17.69|                  13.9|                    21.6|
```

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[23]

```
spark.sql("SELECT MIN(Temperature),MAX(Temperature),AVG(Temperature) from meteo").show()
```

```
+----------------+----------------+--------------------------------+
|min(Temperature)|max(Temperature)|avg(CAST(Temperature AS DOUBLE))|
+----------------+----------------+--------------------------------+
|           -0.09|     Temperature|              15.283779680952737|
+----------------+----------------+--------------------------------+
```

[24]

```
spark.sql("SELECT DateTime,Temperature,LEAD(Temperature) OVER (order by DateTime) as NextValue,avg(Temperat
```

```
+--------------------+-----------+---------+------------------+
|            DateTime|Temperature|NextValue|           avgTemp|
+--------------------+-----------+---------+------------------+
|2018-05-14 00:00:00|      10.06|    11.83|15.283779680952737|
|2018-05-15 00:00:00|      11.83|    13.47|15.283779680952737|
|2018-05-16 00:00:00|      13.47|    14.69|15.283779680952737|
|2018-05-17 00:00:00|      14.69|    15.91|15.283779680952737|
|2018-05-18 00:00:00|      15.91|    17.69|15.283779680952737|
|2018-05-19 00:00:00|      17.69|    19.07|15.283779680952737|
|2018-05-20 00:00:00|      19.07|    19.26|15.283779680952737|
|2018-05-21 00:00:00|      19.26|    19.31|15.283779680952737|
|2018-05-22 00:00:00|      19.31|    20.69|15.283779680952737|
|2018-05-23 00:00:00|      20.69|    21.14|15.283779680952737|
|2018-05-24 00:00:00|      21.14|    20.15|15.283779680952737|
|2018-05-25 00:00:00|      20.15|    21.54|15.283779680952737|
|2018-05-26 00:00:00|      21.54|    21.87|15.283779680952737|
|2018-05-27 00:00:00|      21.87|    18.27|15.283779680952737|
|2018-05-28 00:00:00|      18.27|       19|15.283779680952737|
|2018-05-29 00:00:00|         19|    18.23|15.283779680952737|
|2018-05-30 00:00:00|      18.23|    18.97|15.283779680952737|
|2018-05-31 00:00:00|      18.97|    22.18|15.283779680952737|
|2018-06-01 00:00:00|      22.18|    21.65|15.283779680952737|
|2018-06-02 00:00:00|      21.65|    20.36|15.283779680952737|
+--------------------+-----------+---------+------------------+
only showing top 20 rows
```

We can also work on multiple files in the same folder

```
allfiles = spark.read \
    .option("inferSchema", "true") \
    .csv('/csvfiles/*.csv') \
    .toDF("DateTime","Humidity","Temperature","Temperature_range (low)","Temperature_range (high)")
allfiles.count()
```

```
2844
```

[26]

```
allfiles.select("temperature","Humidity").summary().show()
```

```
+-------+--------------------+------------------+
|summary|         temperature|          Humidity|
+-------+--------------------+------------------+
|  count|                2844|              2844|
|   mean|   21.64290264575081| 43.94069418930773|
| stddev|   8.124551245802312|18.989245280131374|
|    min|               -0.09|             10.01|
|    25%|                17.8|             26.58|
|    50%|               22.04|              46.0|
|    75%|               24.14|              57.0|
|    max|Temperature_range...|       Temperature|
+-------+--------------------+------------------+
```

It is also possible to use the JOIN operator between dataframes

[27]

```
salledebain = spark.read \
    .option("inferSchema", "true") \
    .csv('/csvfiles/temperature-last-year_salledebain.csv') \
    .toDF("DateTime","Humidity","Temperature","Temperature_range (low)","Temperature_range (high)")

salon = spark.read \
    .option("inferSchema", "true") \
    .csv('/csvfiles/temperature-last-year_salon.csv') \
    .toDF("DateTime","Humidity","Temperature","Temperature_range (low)","Temperature_range (high)")

salledebain.select("DateTime","temperature","Humidity").join(salon.select("DateTime","temperature","Humidity"),"DateTime").show(10)

```

```
+-------------------+-----------+--------+-----------+--------+
|           DateTime|temperature|Humidity|temperature|Humidity|
+-------------------+-----------+--------+-----------+--------+
|           DateTime|Temperature|Humidity|Temperature|Humidity|
|2018-05-14 00:00:00|      21.32|      57|      19.75|      52|
|2018-05-15 00:00:00|      21.27|      58|      19.67|      55|
|2018-05-16 00:00:00|      21.15|      61|      20.42|      55|
|2018-05-17 00:00:00|      21.14|      64|      21.16|      58|
|2018-05-18 00:00:00|      21.63|      67|      21.81|      58|
|2018-05-19 00:00:00|      21.83|      68|      22.17|      59|
|2018-05-20 00:00:00|      21.78|      64|       22.8|      57|
|2018-05-21 00:00:00|       22.1|      63|      23.09|      55|
|2018-05-22 00:00:00|      22.55|      68|      23.22|      57|
+-------------------+-----------+--------+-----------+--------+
only showing top 10 rows
```

Conclusion

- SQL Server is constantly evolving
  - New features / capabilities
  - Even new architecture …
- DBAs must constantly acquire new skills
  - Containers and orchestration
  - Cloud (Azure, AWS, GCP)
- SQL Server is entering a new era
  - Multi platform
  - Containerization is the next step of virtualization
  - Working with “Big Data” and Relational Databases is easiest than ever

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