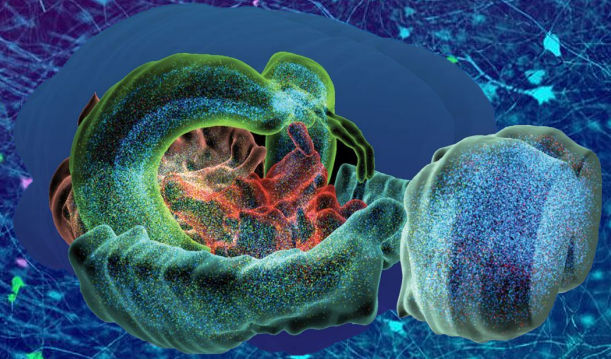
EPFL Blue Brain Project



Kubernetes from Scratch for Neuroscientific Research

Carolina Lindqvist & Daniel Fernández

KubeCon | CloudNativeCon
Europe 2023

Agenda

- About us
- Target audience
- How did our interest in Kubernetes start
- Prototyping Kubernetes
- Blue Brain Project infrastructure overview
- Cluster running and maintenance
- Kubernetes use cases within the Blue Brain Project
- The process of migrating to Kubernetes
- A Kubernetes user’s point of view

About us

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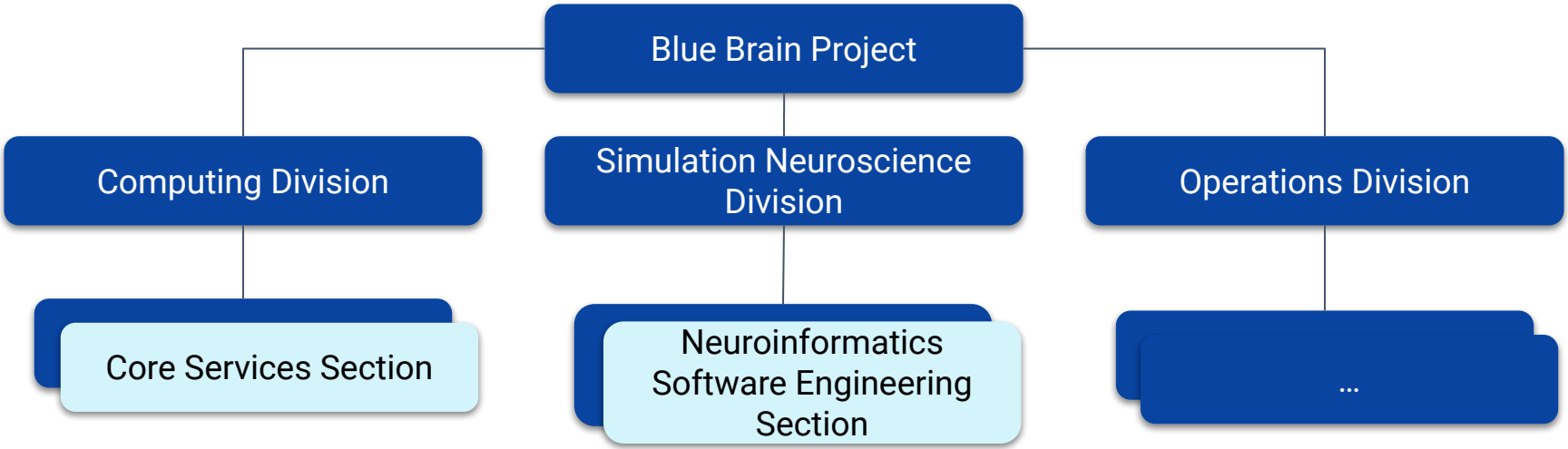
About the Blue Brain Project

- Goal: Digitally reconstructing and simulating a mouse brain
- Pioneering simulation neuroscience
- Better understanding of the human brain with potential applications in health and disease research



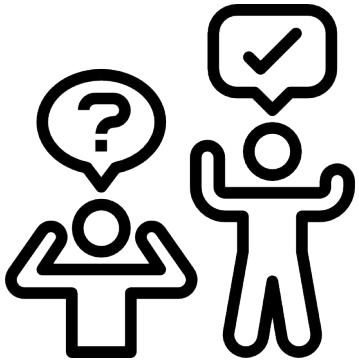
Content

- Ideas for how to approach an on-premise cluster setup
- The ideas can also be applied to a cloud environment
- Where to start

Useful prerequisites

- Basic knowledge about Kubernetes architecture
- Basic knowledge about some resource types
- Knowledge of Helm and Helm chart is a plus

How did our interest in Kubernetes start



OPENSHIFT

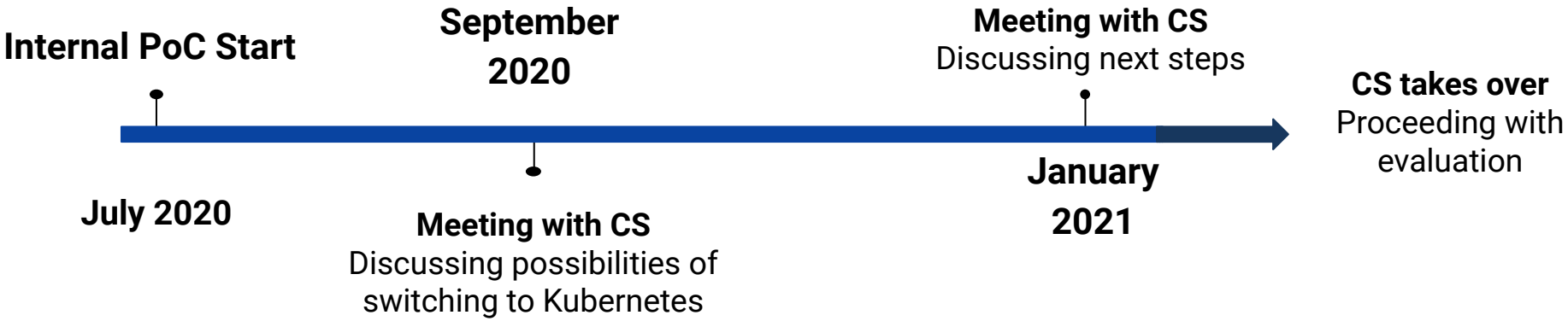
NGINX
Part of F5

kubernetes

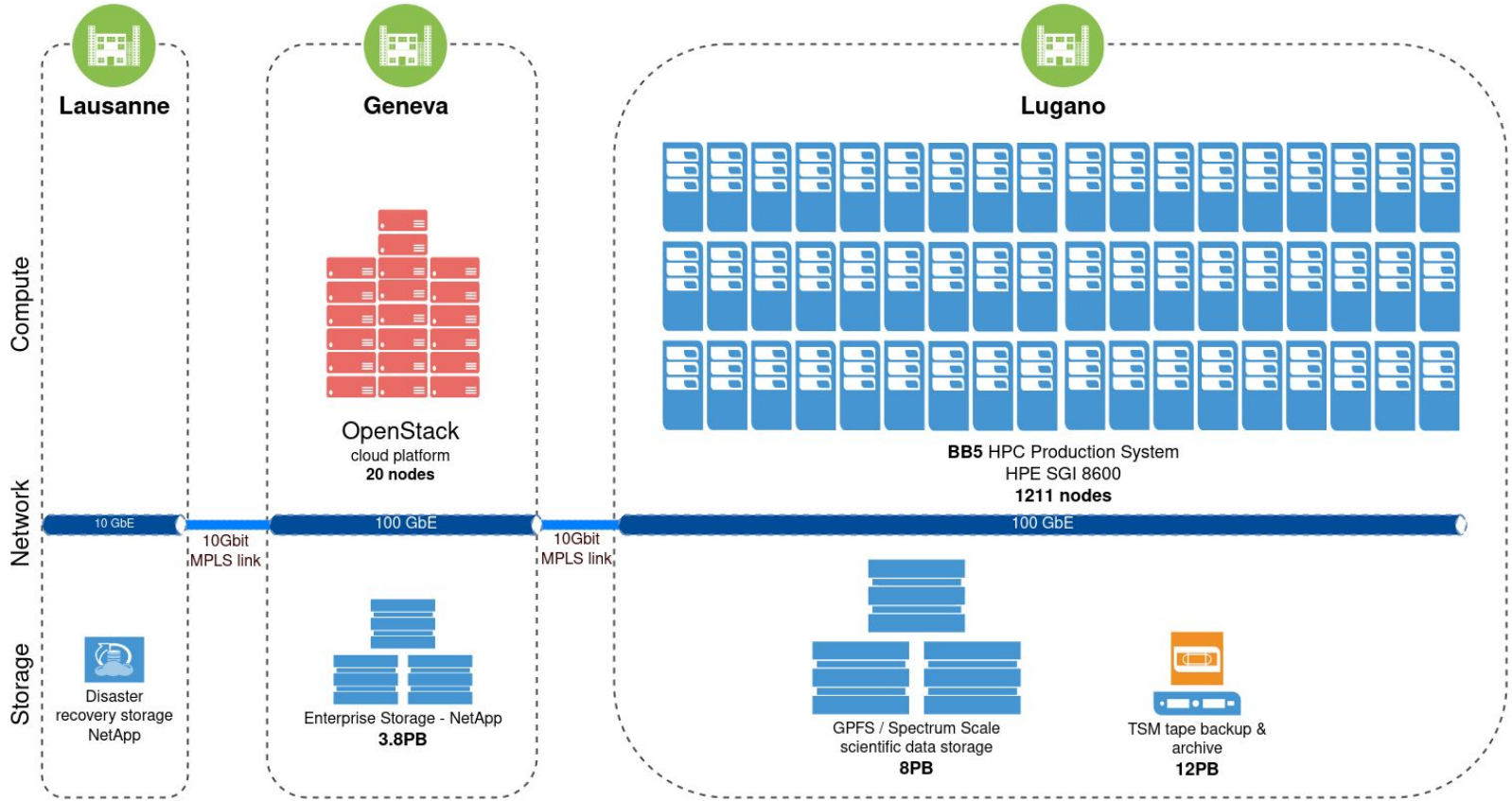
HELM

Prototyping

- How to deploy Kubernetes on Openstack
- Creating an Ubuntu-based Kubernetes cluster for internal testing
- Documenting the installation and deployment process
- Presenting the test results to Daniel's team and discussing the next steps



About Blue Brain Project Infrastructure



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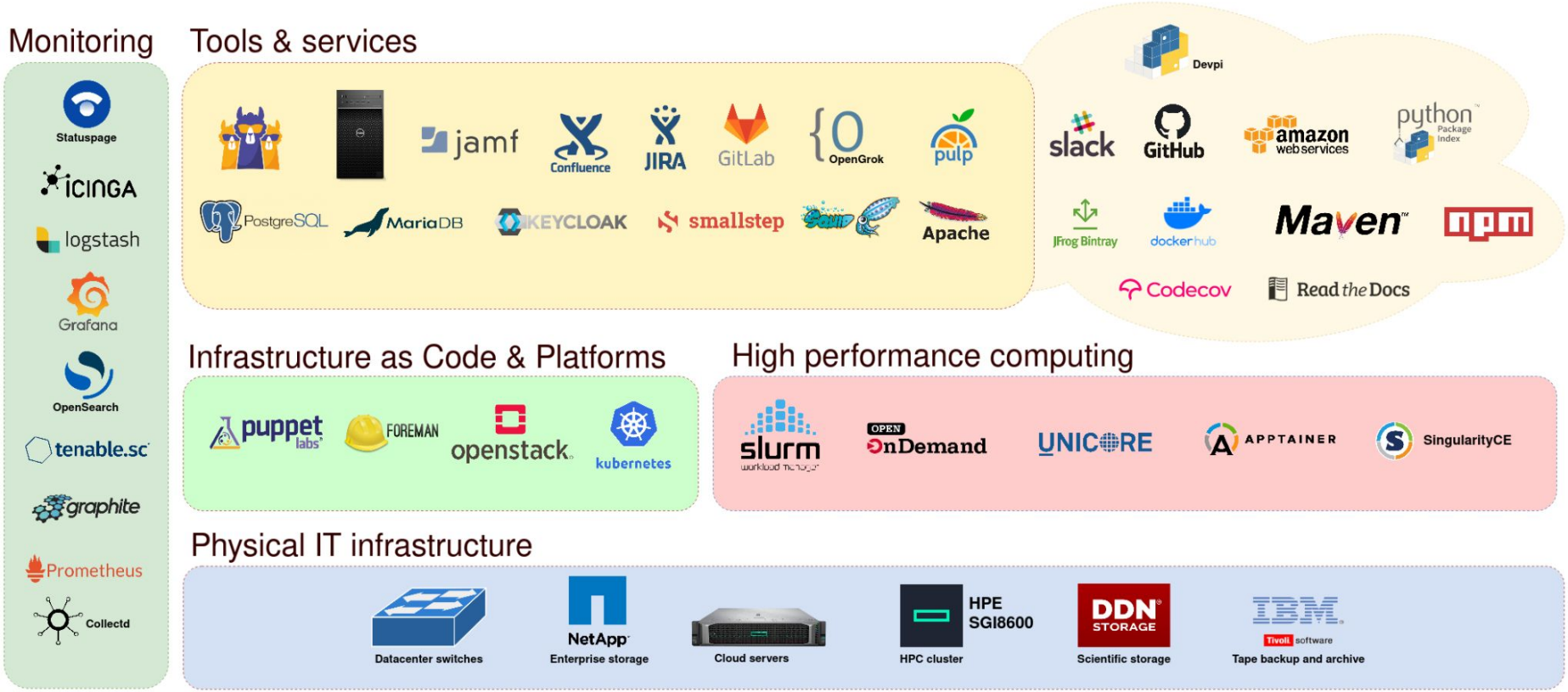
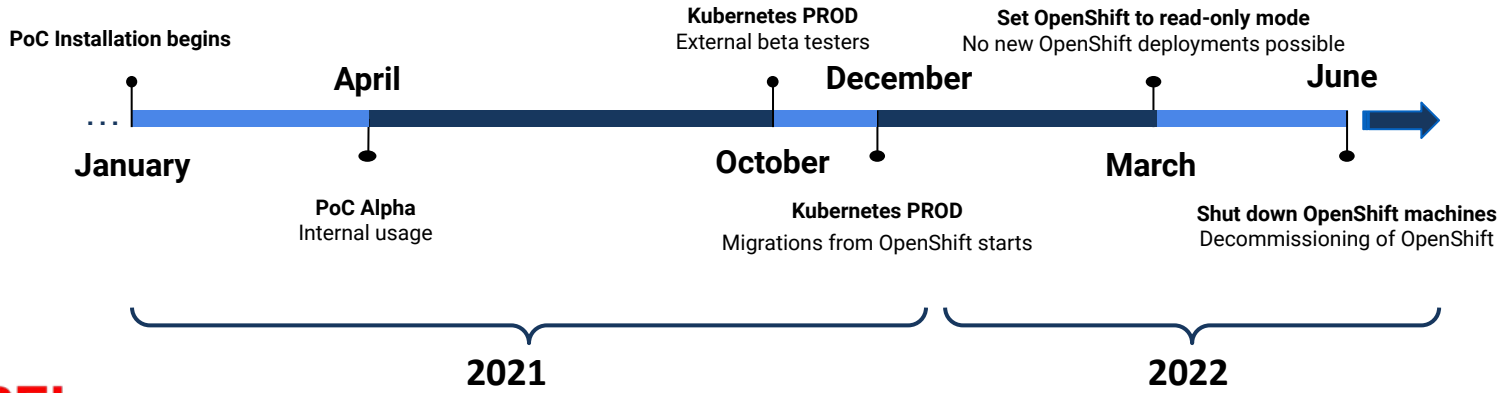


Pre-Kubernetes (2021)

- OpenShift Origin 3.11 (Based on Kubernetes 1.11)
  - Released in Oct 11, 2018
- People who worked on its deployment had left the team
- Deployment was relying on an Ansible playbook
- Day-to-day operations were tedious and cumbersome:
  - Adding new worker nodes
  - Changing the quota of a project
- Lack of support for new features which users were requesting:
  - Helm
  - GitOps
  - Ingress

Proof Of Concept - Kubernetes (2021)

- Kubernetes 1.20 (containerd/runc)
- On OpenStack VMs
- RHEL operating system
  - SElinux enabled and set to enforcing :)
- Installation and initial cluster configuration: Puppet
- GitOps to automate the configuration of the clusters



Features

Kubernetes 1.21

Calico

Ingress Nginx controller

Kyverno

GitLab Registry

Flux

mozilla/sops

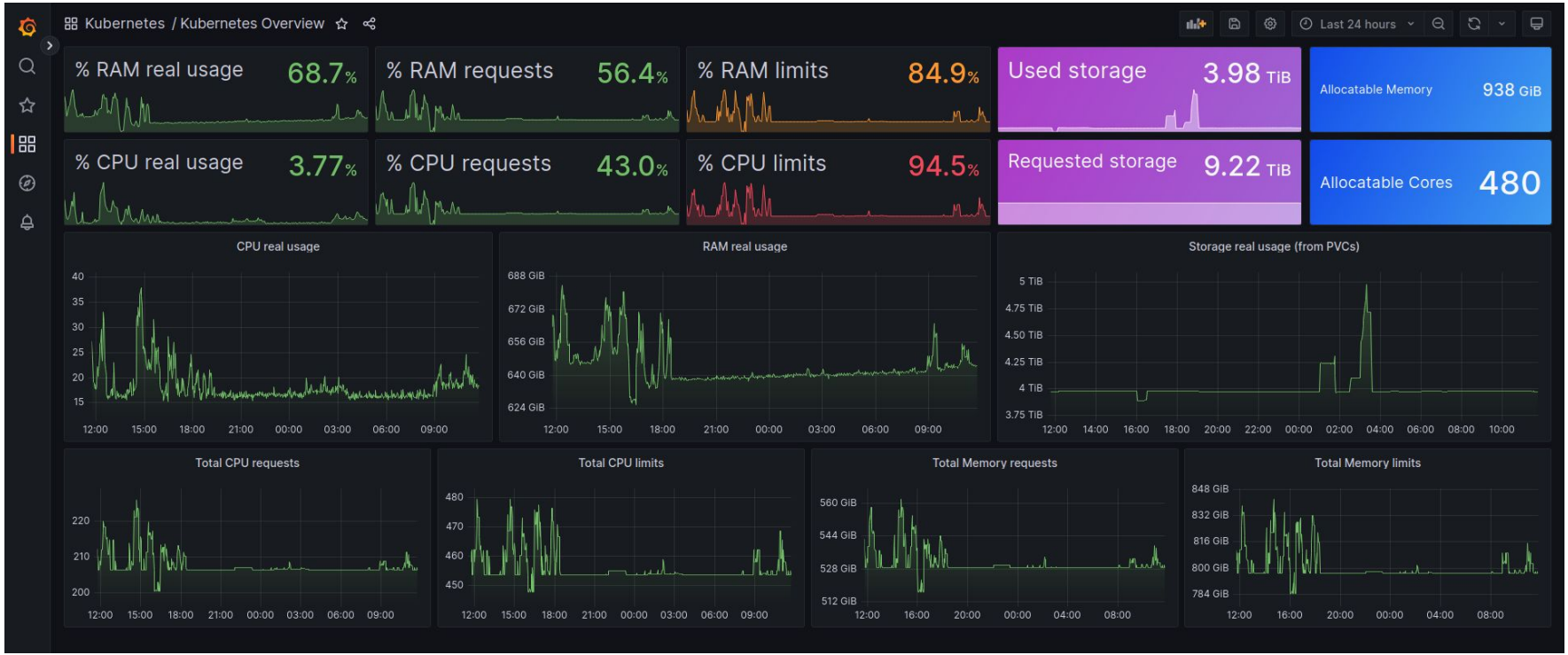
Migration from OpenShift

- We audited everything running on OpenShift and contacted those in charge
- Majority of users managed their migrations themselves
  - In most cases: `oc get <resource> -o yaml` and then re-apply those yaml on Kubernetes
- No way to automatically migrate OpenShift volumes to Kubernetes
  - The data migration process depended upon the app, but usually it was a matter of:
    - `oc cp / kubectl cp`
- Migration from OpenShift Container registry to GitLab Registry:
  - Push image to new registry

Cluster deployment

- 100% on-premises
- Kubernetes on OpenStack
- RHEL8 (started with RHEL7)
- Current version: 1.25
  - 5 upgrades in ~2 years
- 2 clusters: **PROD** and **DEV**
  - 3 control plane nodes + ‘N’ worker nodes
  - PROD & DEV have the same configuration (enforced by Flux)
    - DEV: fewer and smaller worker nodes
  - We test every change / upgrades first on DEV

Kubernetes usage overview



Multitenancy

- Heavily based on: flux2-multi-tenancy although we ended up doing our own thing
- Each team has its own namespace
  - Defined ResourceQuotas
  - RoleBinding references an LDAP group
    - Each member has admin access within the namespace
    - User groups are passed in the OIDC token
  - Pods within a namespace are by default isolated (NetworkPolicy)
    - Ingress and egress traffic blocked unless specified otherwise
  - Optional Flux integration

Installation

- Installation with puppetlabs-kubernetes:
  - caveats: etcd/Kubernetes certificates are generated before installation
    - They are tied to node's IPs/hostnames

```
$ docker run --rm -v /tmp/k8s/production:/mnt
  -e OS=redhat
  -e VERSION=1.22.2 -e CONTAINER_RUNTIME=cri_containerd
  -e CNI_PROVIDER=calico-tigera -e CNI_PROVIDER_VERSION=3.20.1
  -e ETCD_INITIAL_CLUSTER="<node1>:<node1_ip>,<node2>:<node2_ip>,<node3>:<node3_ip>"
  -e ETCD_IP="%{::ipaddress}"
  -e KUBE_API_ADVERTISE_ADDRESS="<cluster_ip>"
  puppet/kubetool:7.0.0

$ ls -l /tmp/k8s/production
total 52K
-rw-r--r-- 1 root root 9.1K Oct  4  2021 node1.yaml
-rw-r--r-- 1 root root 9.1K Oct  4  2021 node2.yaml
-rw-r--r-- 1 root root 9.1K Oct  4  2021 node3.yaml
-rw-r--r-- 1 root root  15K Oct  4  2021 Redhat.yaml
```

Installation: Redhat.yaml


```
kubernetes::kubernetes_version: 1.22.2
kubernetes::container_runtime: cri_containerd
kubernetes::cni_network_provider: https://docs.projectcalico.org/archive/3.20.1/manifests/calico.yaml
kubernetes::cni_pod_cidr: 192.168.0.0/16
kubernetes::cni_provider: calico-tigera
kubernetes::etcd_initial_cluster:
<node1>=https://<node1_ip>:2380,<node2>=https://<node2_ip>:2380,<node3>=https://<node3_ip>:2380
kubernetes::etcd_peers:
 - <node1_ip>
 - <node2_ip>
 - <node3_ip>
kubernetes::etcd_ip: "%{::ipaddress}"
kubernetes::kube_api_advertise_address: <cluster_ip>
kubernetes::token: bf1bce.d0ef29da7bfc92658
kubernetes::etcd_ca_crt: |
  -----BEGIN CERTIFICATE-----
  MIIC7jCCAdagAwIBAgIUTWX6UV38XofpTGFKBtdCrM36d9IwDQYJKoZIhvcNAQEL
  [...]
kubernetes::kubernetes_ca_crt: |
  -----BEGIN CERTIFICATE-----
  MIIC+jCCAeKgAwIBAgIUBbK3L5d9H/mNwZ+rNgJ68z1qGM8wDQYJKoZIhvcNAQEL
  [...]
```

Installation

- Ensure the certificates are created on the nodes
- Bootstrap an initial etcd cluster
- Install Kubernetes via Kubeadm (init/join)
- Install and configure CNI Calico-Tigera

- Flux bootstrapping and initial configuration
- Enable OIDC auth by adding the corresponding flags in API server

- Kyverno + ClusterPolicy
- cert-manager
- Trident (CSI maintained by NetApp)
- Kubernetes dashboard
- ingress-nginx
- gitlab-runners
- …

Cluster running and maintenance

- Quota changes managed with Flux
- Adding extra worker nodes
  - Create new VM, put VM in the correct hostgroup, and run Puppet
- Cluster upgrades
  - In-place
  - Puppet and some helper scripts
    - Update Hiera variable with new Kubernetes version
    - Push changes and run Puppet
      - `kubeadm kubectl kubelet` packages will be upgraded
  - Control plane nodes
    - `kubeadm upgrade apply --certificate-renewal=false v1.25.8`
  - Worker nodes
    - drain, run Puppet, uncordon

Core Services migration to Kubernetes and future

- Applications:
  - GitLab Runners
  - Dummy applications to verify cluster status
  - Slack bots
  - OpenSearch
  - Various Prometheus exporters
    - Pgpool
    - Foreman
    - Blackbox
- Future plans:
  - Cluster Autoscaler
  - Service Mesh with Linkerd

Overall experience

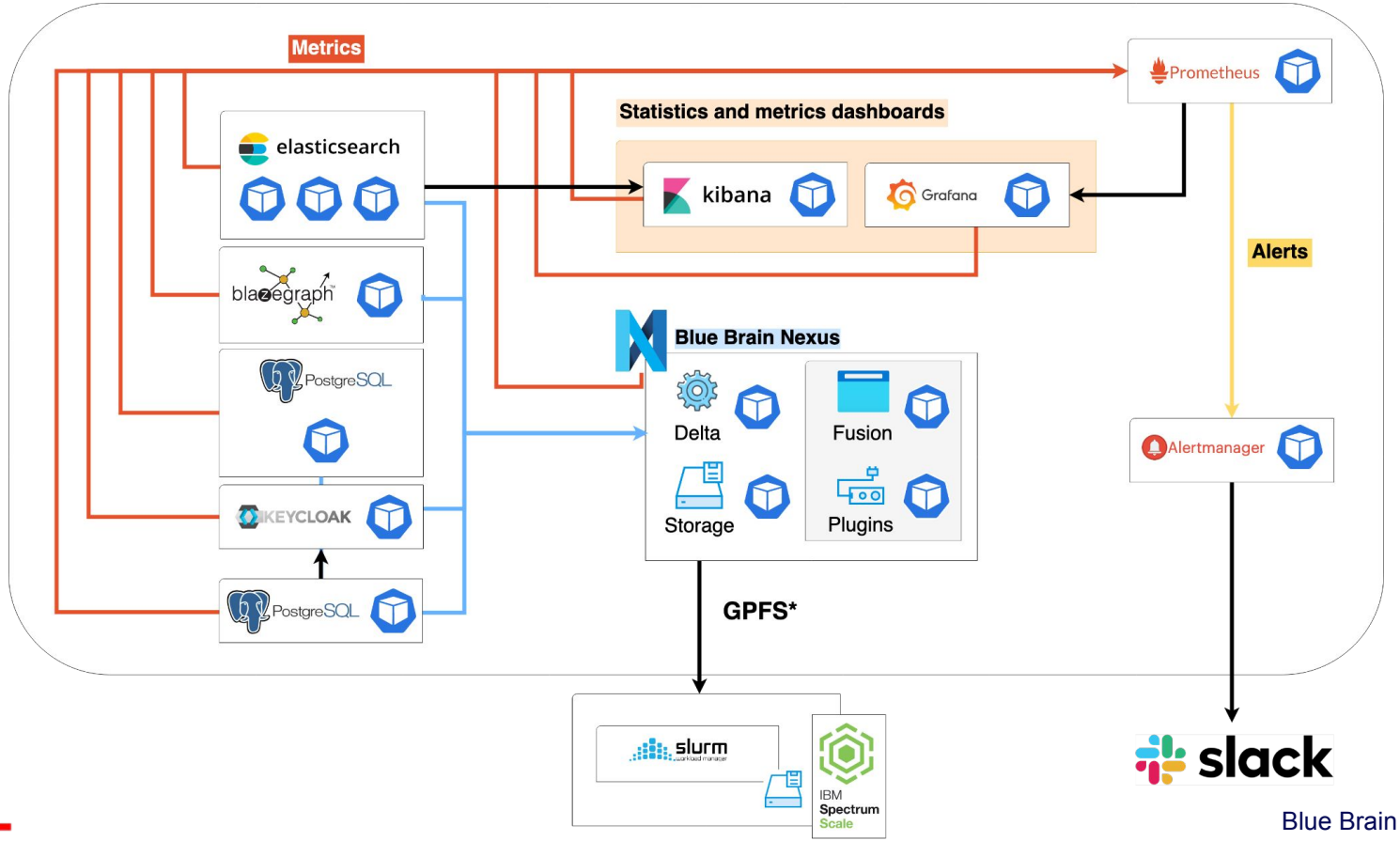
- We are very happy with Kubernetes
- Huge YAMLs and Flux core concepts can be intimidating at first
- People were using OpenShift web UI - we thought they would miss it
  - End users interact with the cluster via: kubectl CLI, Lens, k9s, Kubernetes dashboard
- For end-users we wrote easy to follow how-to guides:
  - Connect to cluster (via kubelogin)
  - Use the Kubernetes dashboard
  - Change pod network policies to allow ingress/egress traffic
  - Expose applications via ingress
  - Quick start with Flux

Example: Blue Brain Nexus

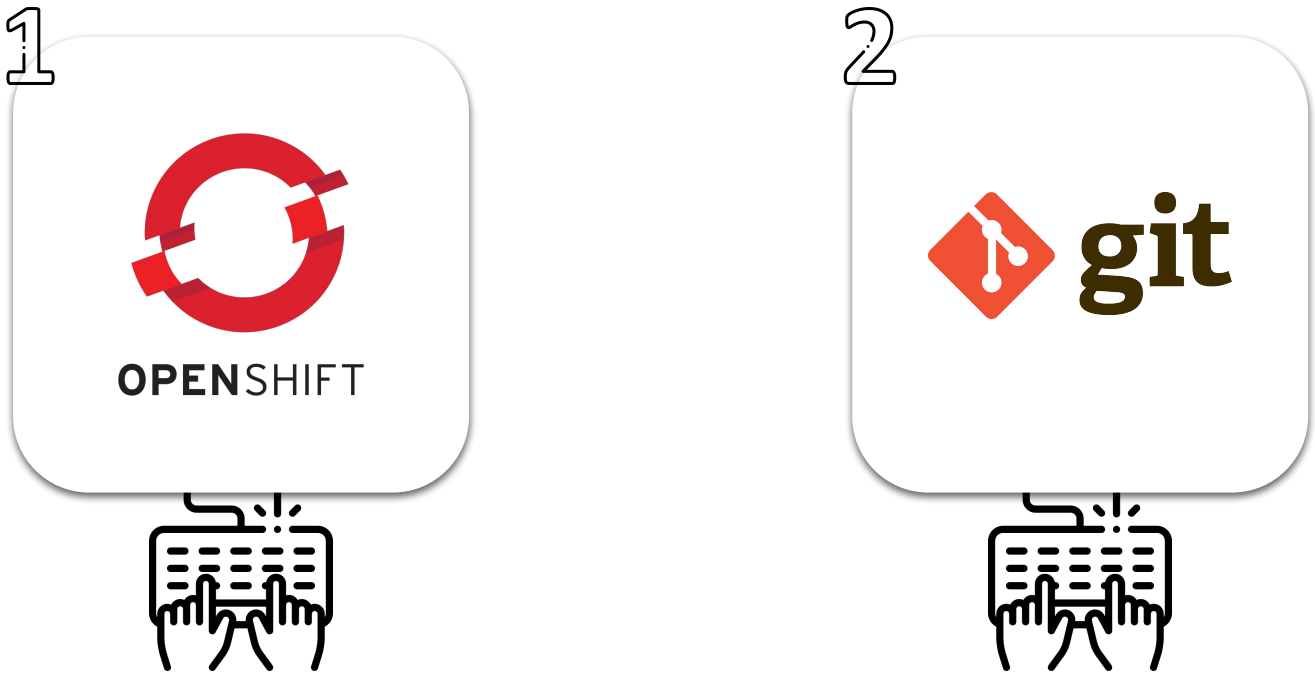
- Main data management platform at BBP to organise all neuroscience data
- Backend for knowledge graph management
- Web interface to provide user-friendly access
- Fully deployed in Kubernetes

https://bluebrainnexus.io/

Blue Brain Nexus infrastructure



Changing the infrastructure (before)



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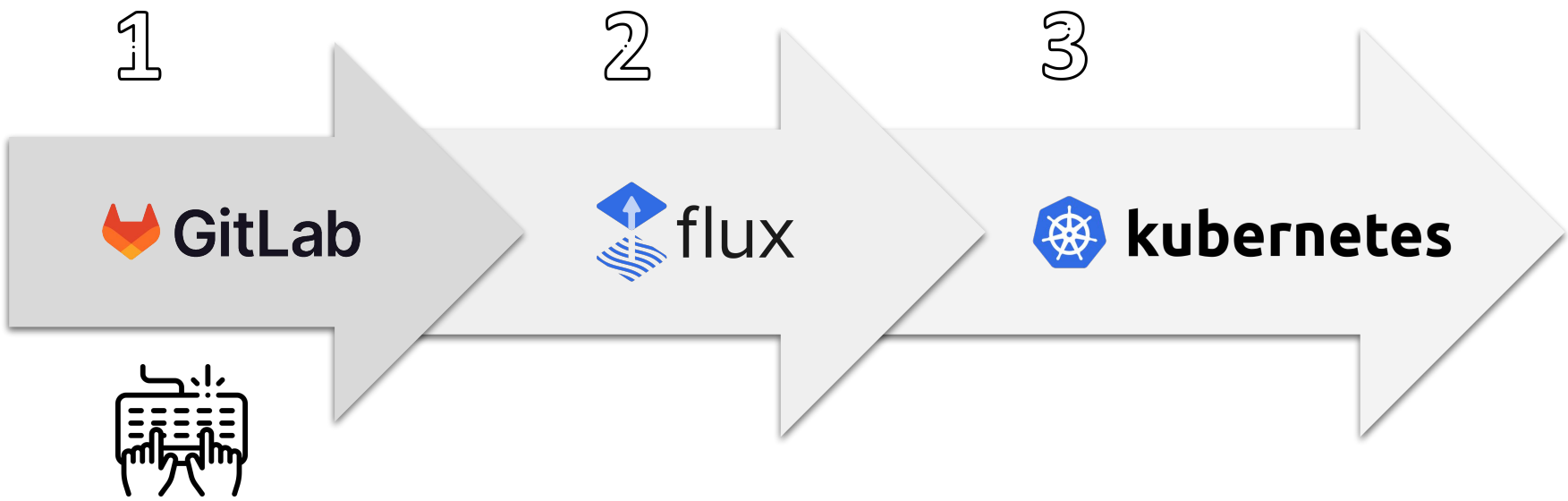


New use cases possible with Kubernetes

Git as source of truth

flux

Automation for infrastructure

HELM

Helm charts

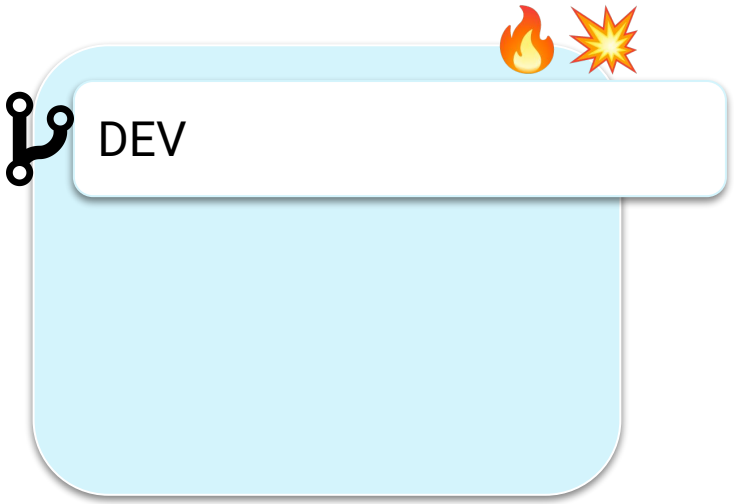
Flexible ingress configuration

mozilla/**sops**

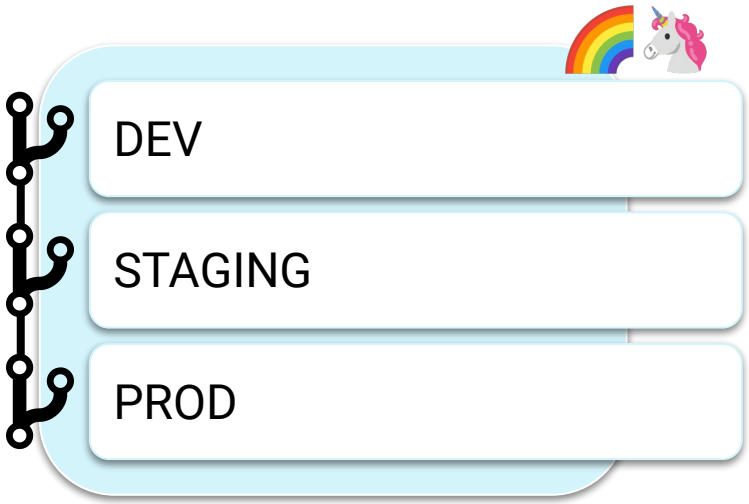
Encrypted secrets stored in Git

Daily operations

Kubernetes dev cluster



Kubernetes production cluster



Example: Porting an application to Kubernetes

Decide how to deploy your application, some alternatives are:

- Find a Helm chart
- Create a Helm chart
- Create the necessary Kubernetes manifests (Deployment, StatefulSet, Service, Ingress…)

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Configure and test the Helm chart or Kubernetes manifests

- Deploy them in your dev cluster or dev environment
- Keep resolving any errors that may appear when deploying a Helm chart or manifest
- Ensure that the storage and network configuration works, add test data if needed

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3

Apply your working configuration to other environments

- Storing your manifests and charts in git makes it easier
- Generate new secrets for the new instances of your applications
- Using Helm charts and Flux makes it easy to scale your application to new environments

The migration process for a user

Learn about Kubernetes

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Plan, test and execute data migration

- Back up your applications
- Migrate existing data to the new environments – this may require downtime
- Keep a backup of old data in case it's needed

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4

Switch to the new environments

- Verify that the new deployment is working with the migrated data
- Notify users in case of downtime
- Route traffic to the new deployment

Caveats throughout the process

- A lot of time spent on prototyping and testing
- A Kubernetes version has ~1 year of support
- Make sure to consider and test existing use cases – talk to users
- Allocate time to train your team(s)
- Ensure that it is easy to roll back changes if needed – use GitOps
- Network policies, RBAC and Ingress configurations may need adjustment
- Beware of internal networks running behind a proxy – $HTTP_PROXY
- Helm chart quality varies a lot
- Set up monitoring, alerts and dashboards to keep an eye on the applications

Summary

- Start prototyping as early as possible
- Set up a collaboration between the users and operations teams
- Evaluate decisions against the needs of your team or organization
  - Kubernetes clusters vs. namespaces
  - Which CNI (Container Network Interface)?
  - What permissions do users have in the cluster?
  - …
- Use standard alternatives unless you have a reason not to
- Ask for help in the Kubernetes and CNCF Slack instances
- Benefit from the automation possibilities that the Kubernetes ecosystem offers
- Become a Kubernaut and present what you did at KubeCon + CloudNativeCon!

EPFL

Blue Brain Project

The EPFL Blue Brain Project is recruiting – several positions available

For more information and how to apply, visit
go.epfl.ch/bluebrain-careers