Integrating Kubernetes into OpenStack using Cluster API

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Swiss Cloud Native Bern Meetup

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Speaker

- Niklaus Hofer
- stepping stone AG
  - Local cloud Provider
    - IaaS
    - PaaS
    - CaaS
    - SaaS
    - ...

Overview

- OpenStack
- Deploying Kubernetes
- Cluster API
- OpenStack + Cluster API
- Improvements and contributions
- Operations
- Usage

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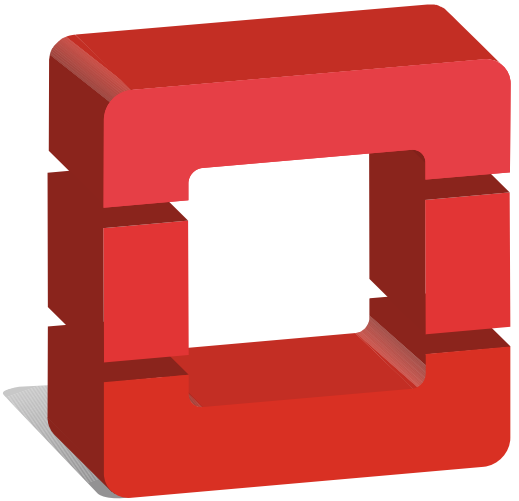

openstack

OpenStack history

- Cloud software
- First released in 2010 by NASA and Rackspace
- OpenStack Foundation since 2012
  - Renamed to Open Infrastructure Foundation in 2020

OpenStack deployments

- Private cloud
  - NASA
  - CERN
  - Volkswagen AG
- Public cloud
  - Rackspace
  - OVH
  - Open Telekom Cloud
  - stepping stone AG

- Over 55 million cores world wide
  - As of October 2025

OpenStack features

- Identity
- Virtual Machines (VMs)
- Software Defined Networking
- Block storage (volumes)
- Object storage (S3)
- WebUI and API
- Extensible
  - Load Balancer
  - Container orchestration
  - ...

OpenStack architecture

Control plane

- Microservices
  - Separate projects
  - They all have funny names
- Communication via HTTP APIs and RabbitMQ
- MariaDB / MySQL backend

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Deploying Kubernetes

kubernetes

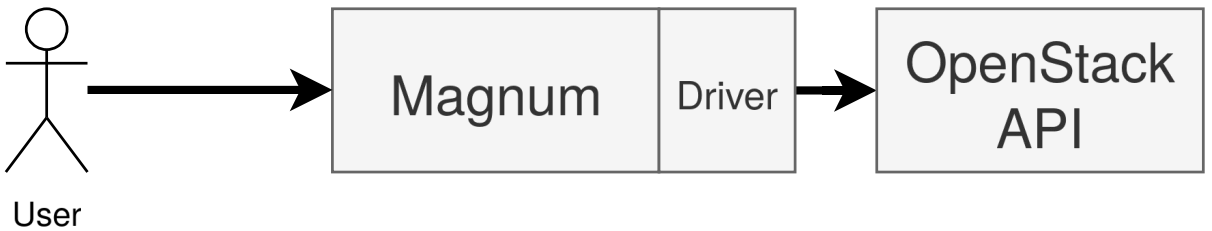
Requirements

- Automated
- API
  - Integrates wit the OpenStack APIs
- Self service
- Billable
- High quality
  - Reliable and stable
  - Modern, standardized clusters
  - Additional features (rolling updates, auto scaling, ...)

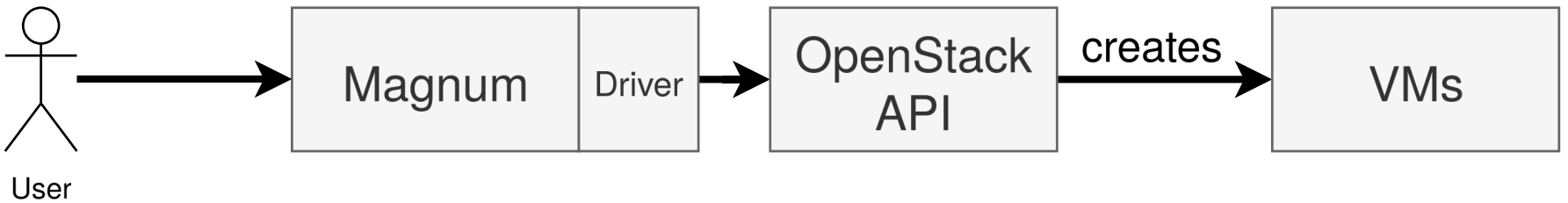
Magnum

- OpenStack component
- Development started in late 2014
- First release in OpenStack Kilo (April 2015)
- Deploys and manages container orchestration engines
  - Kubernetes
  - Mesos (EoL)
  - Docker Swarm (EoL)

Magnum workflow



Magnum workflow



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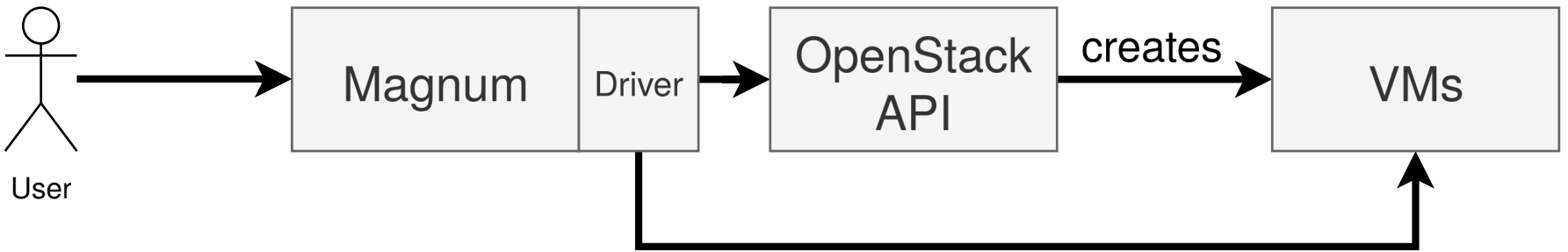

Magnum Heat driver (1/2)

Uses

- OpenStack Heat
  - Not well maintained
- Hyperkube
  - Deprecated and no longer good practice
- Bash scripts inside the VMs
  - Brittle and difficult to debug

Works about as well as it sounds...

Magnum Heat driver (2/2)

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- A product of it’s time
- Viscious cycle
  - Does not work well
  - --> Not much used
  - --> Not well maintained
  - --> Slow progress
  - --> Continues to not work well
  - --> …

Requirements?

- ☑ Automated
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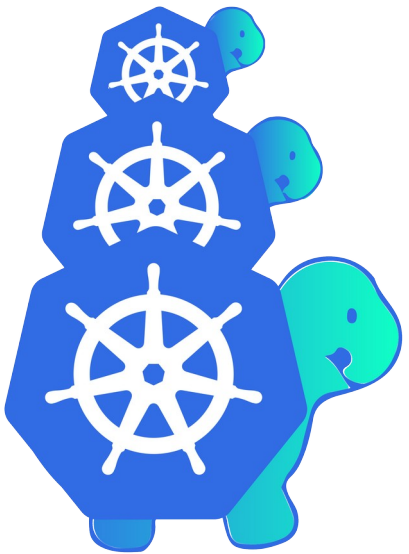
Cluster API



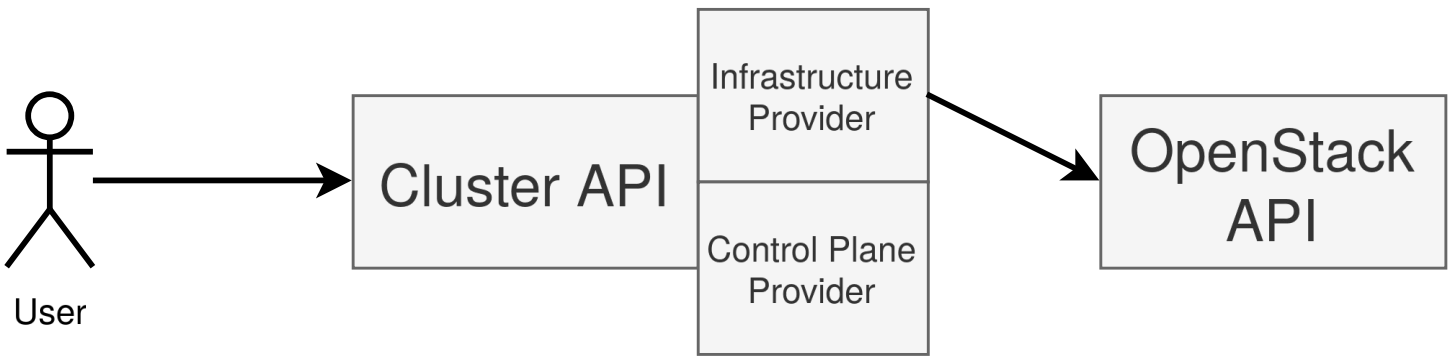
Cluster API

- Standard way to manage Kubernetes Clusters
  - provisioning
  - upgrading
  - operating
- A native Kubernetes project
- Runs inside Kubernetes (self hosted)
- Uses «infrastructure providers» to abstract the target infrastructure

Cluster API features

- Reliable, standardized way to manage clusters
- Deploy
- Upgrade
  - Underlying OS
  - Kubernetes Version
- Auto scaling
- Immutable infrastructure. You never upgrade a VM nor the software within one. Instead it alwasys replaces it with one built for a new image.
- CAPI API can manage it’s own cluster

Cluster API workflow



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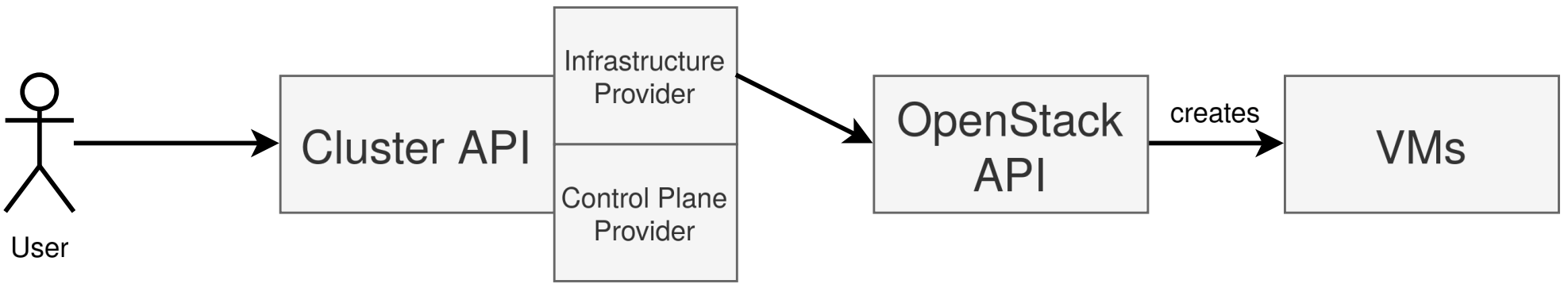

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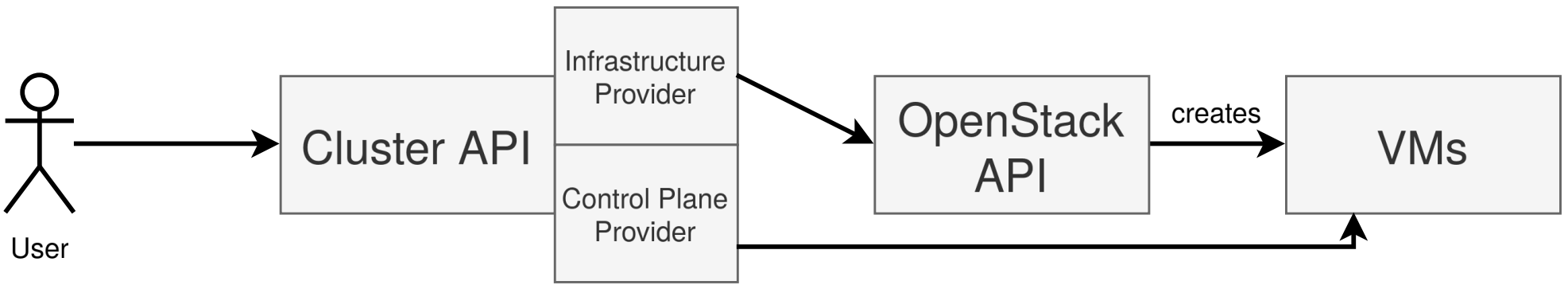

Cluster API direct use

We can use Cluster API natively, however, by doing so, we lose all the integration with OpenStack:

- Foreign API
- User management not integrated
- Cluster API credentials must be managed by the user

Requirements?

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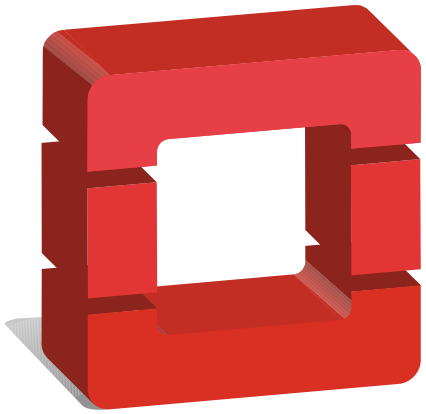
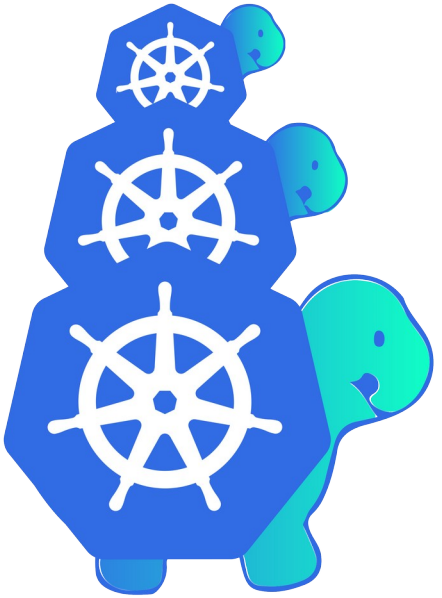
OpenStack + Cluster API

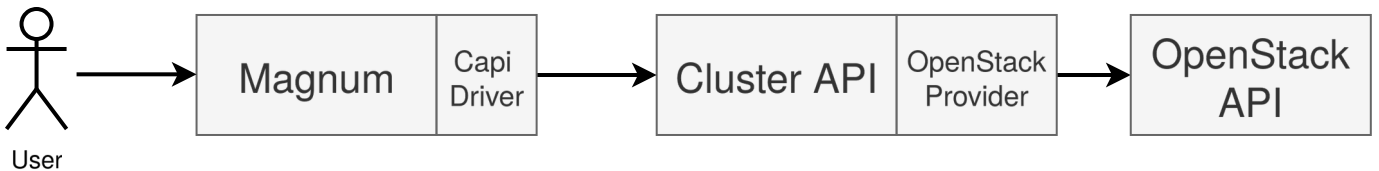


openstack



Basic idea

- Magnum uses pluggable «drivers»
- Write a Magnum driver that is using Cluster API



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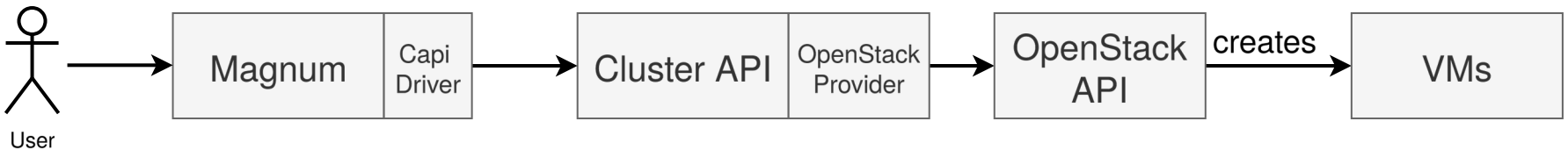

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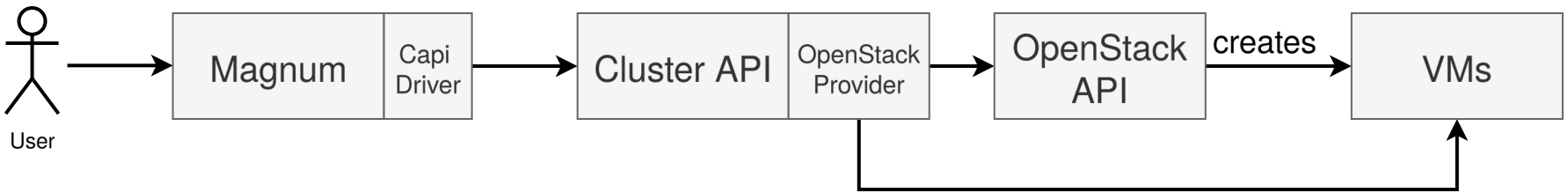


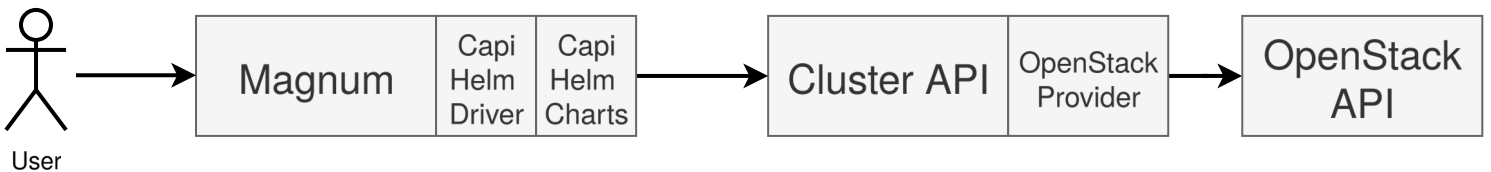
Implementations (1/2)

- Magnum CAPI Helm Driver
  - By StackHPC
- Cluster API driver for Magnum
  - By Vexxhost
- Developed simultaneously
  - Presented together at OpenInfra Summit Vancouver, 2023
  - «Magnum Episode IV - A new Hope»

Implementations (2/2)

- Magnum CAPI Helm Driver
  - By StackHPC
  - Upstreamed in 2024
  - OpenStack 2024.2 «Dalmatian»
- Cluster API driver for Magnum
  - By Vexxhost
  - Still being developed and used by Vexxhost
- Magnum Heat
  - Deprecated as of OpenStack 2025.1 «Epoxy»

Magnum CAPI Helm Driver



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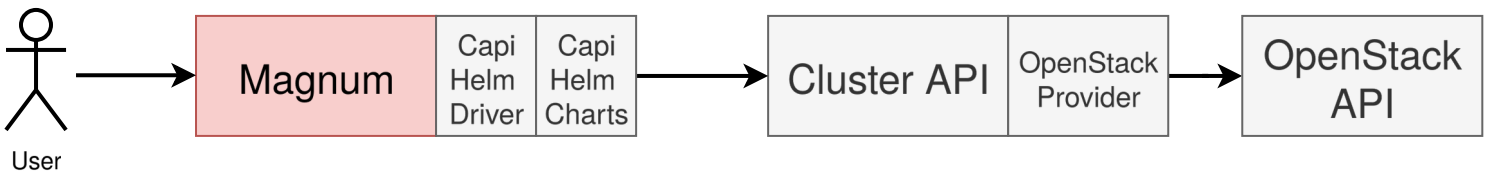

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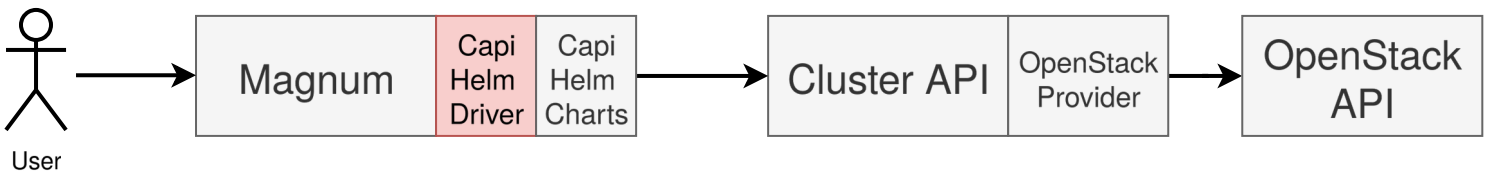

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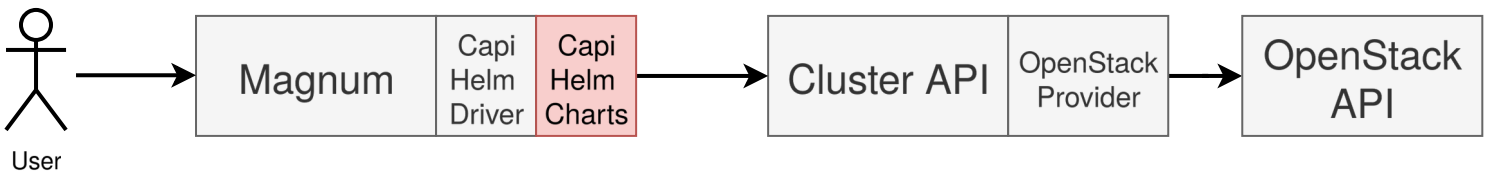

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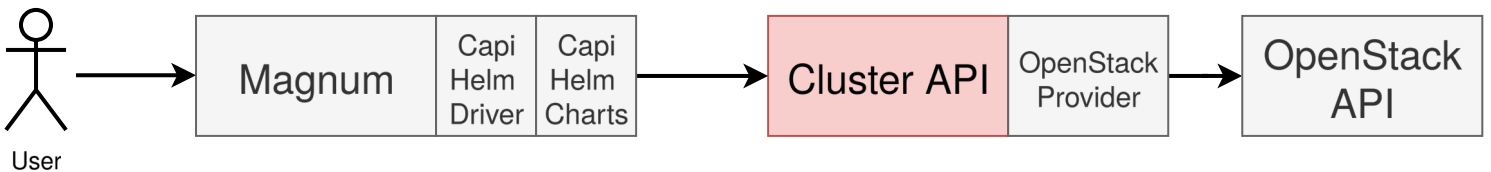

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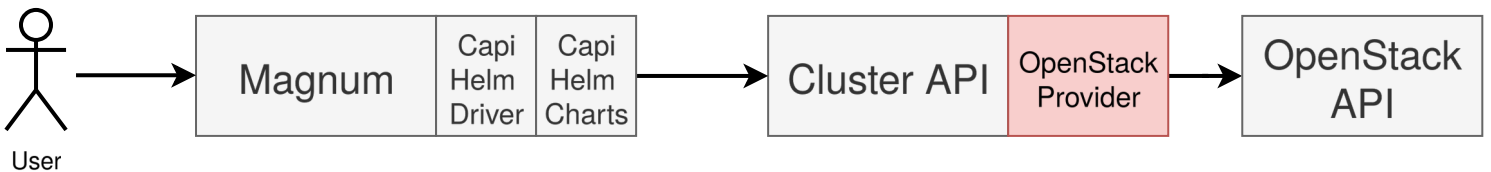

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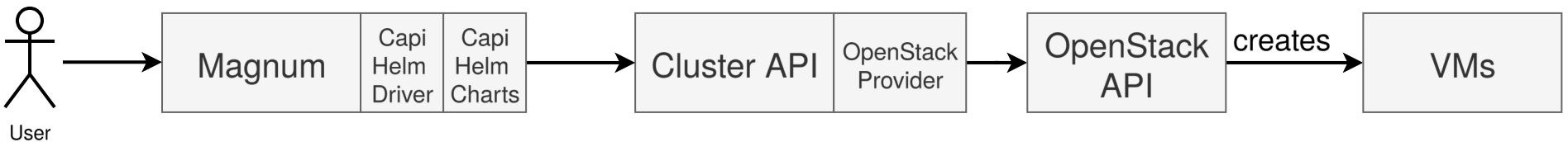

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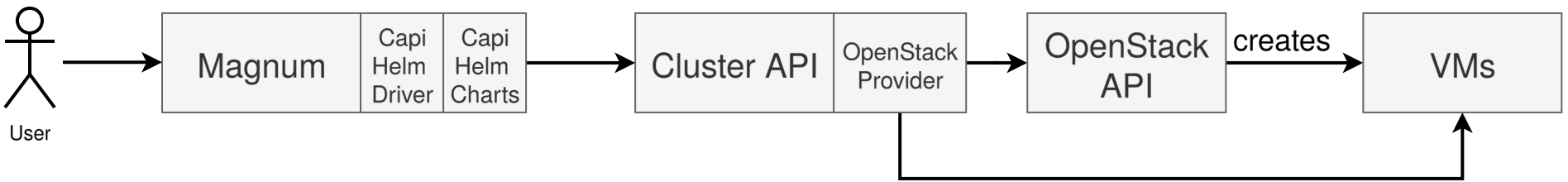

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Improvements and contributions

Open Source

- We have found a number of bugs
- Customers have requested improvements
- We work closely with StackHPC
  - They develop fixes and implement new features
  - We pay for development
  - Good citizens: All changes are upstreamed

UTF-8 support

- Cluster API OpenStack provider was unable to handle non-ASCII characters in OpenStack Region names.
  - Even spaces broke it
- Our regions:
  - Düdingen
  - Düdingen Test
- The Chinese are happy about this fix, too!

Nodegroup deletion

- Creating additional node groups worked fine
- Deleting them, not so much!

Nodegroup race condition

- Creating multiple Nodegroups in short order could lead to race conditions.
- OpenTofu would almost always run into this.

WIP: Propagation of annotations

- It was not possible to pass custom annotations to Nodegroups.
- We have a work-around for that in our cloud.
- A more in-depth solution is currently being upstreamed.

WIP: Scale down to zero

- Currently, Nodegroups cannot be scaled all the way down to zero nodes.

Operations

Moving target

- There are many components involved.
- They need to stay in sync.
- Need to keep up-to-date
  - Bug fixes
  - New features
  - New versions of Kubernetes

Kubernetes Versions

- New Kubernetes Releases some times require changes
- Waiting for the next OpenStack release is not always an option
  - Especially since we tend to skip every other release

Automated testing

- Automated testing using Rally
- Easily test the impact of changes
- Nightly tests

Usage

Cluster templates

- Magnum uses Cluster templates
  - We maintain appropriate templates for our customers

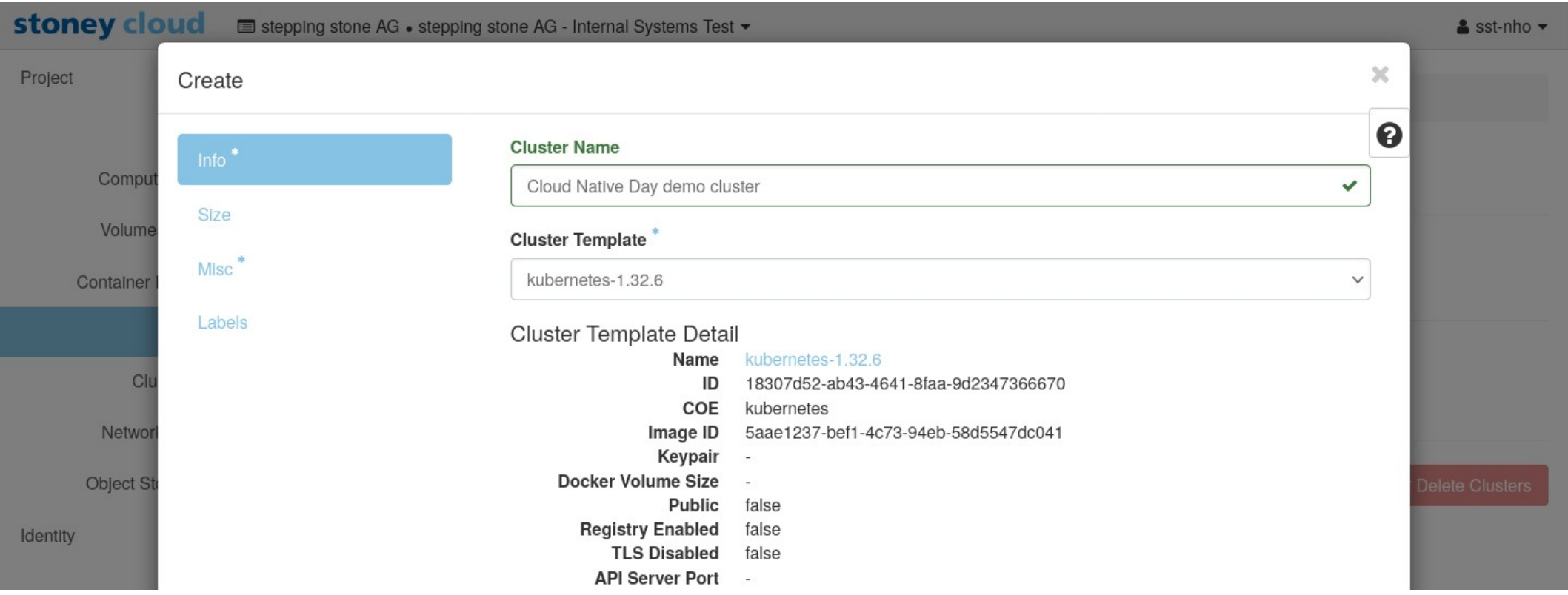
```
> openstack coe cluster template create "my_template" \
  --public \
  --coe kubernetes \
  --image "<IMAGE>" \
  --external-network public \
  --master-flavor 'Standard Düdingen c002m0004' \
  --flavor 'Standard Düdingen c002m0004' \
  --network-driver cilium \
  --master-lb-enabled
```

Cluster creation

- Creating clusters is easy and fast
  - ~7 minutes

```
> openstack coe cluster create "my_cluster" \
  --cluster-template "<CLUSTER_TEMPLATE>" \
  --master-count 3 \
  --node-count 7
```

WebUI


stoney cloud
stepping stone AG • stepping stone AG - Internal Systems Test
sst-nho
Project
Create
Info *
Size
Misc *
Labels
Cluster Name
Cloud Native Day demo cluster
Cluster Template *
kubernetes-1.32.6
Cluster Template Detail
Name kubernetes-1.32.6
ID 18307d52-ab43-4641-8faa-9d2347366670
COE kubernetes
Image ID 5aae1237-bef1-4c73-94eb-58d5547dc041
Keypair -
Docker Volume Size -
Public false
Registry Enabled false
TLS Disabled false
API Server Port -
Delete Clusters
Identity

Conclusion

- Magnum + CAPI
- Modern Kubernetes Clusters in OpenStack

Fragen?

Links

- https://www.stepping-stone.ch/
- https://www.stoney-backup.com/
- https://www.stoney-cloud.com/
- https://www.stoney-mail.com/
- https://www.stoney-meet.com/
- https://www.stoney-office.com/
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