RBMS User Guides

Version 25.1.1.1, 18 June 2025

Table of Contents

1. RBMS Overview

RtBrick's Management System (RBMS) provides network level workflows such as image lifecycle management, network upgrades, event and log Management. RBMS actions are available through REST APIs making them easy to integrate into existing Operations Support Systems (OSS) systems. RBMS provides a single point of interaction for operations staff – from provisioning and management to monitoring and debugging.

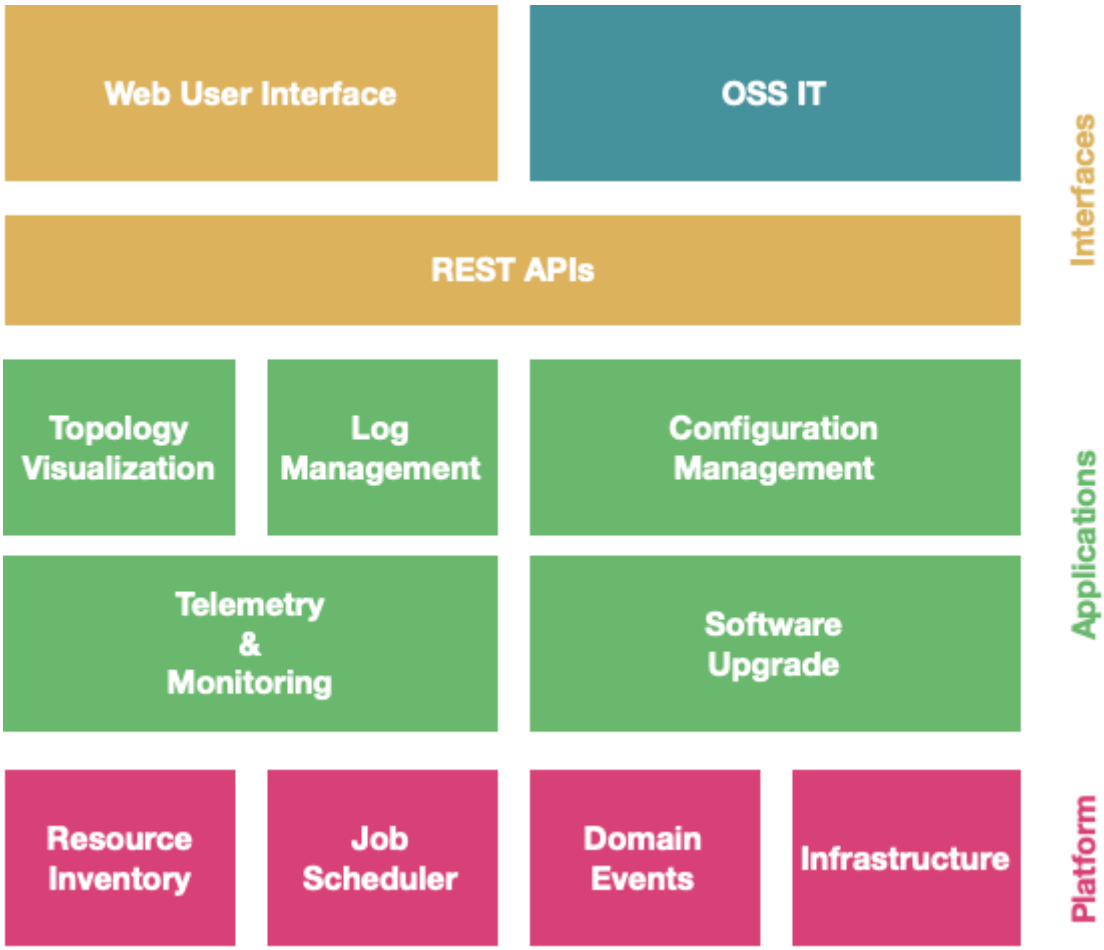
The RBMS user interface provides the following capabilities:

- **Image**: Manage software images
- **Inventory**: Manage network elements
- **Metrics**: Manage the metrics sampled from network devices
- **Jobs**: Review the currently active or scheduled jobs
- **Logs**: View logs messages from the switches
- **Administration**: Manage users, roles, and access tokens.

1.1. System Architecture

RBMS follows a *service-oriented architecture* and defines three categories of services:

1. Platform Services
2. Applications
3. Connectors



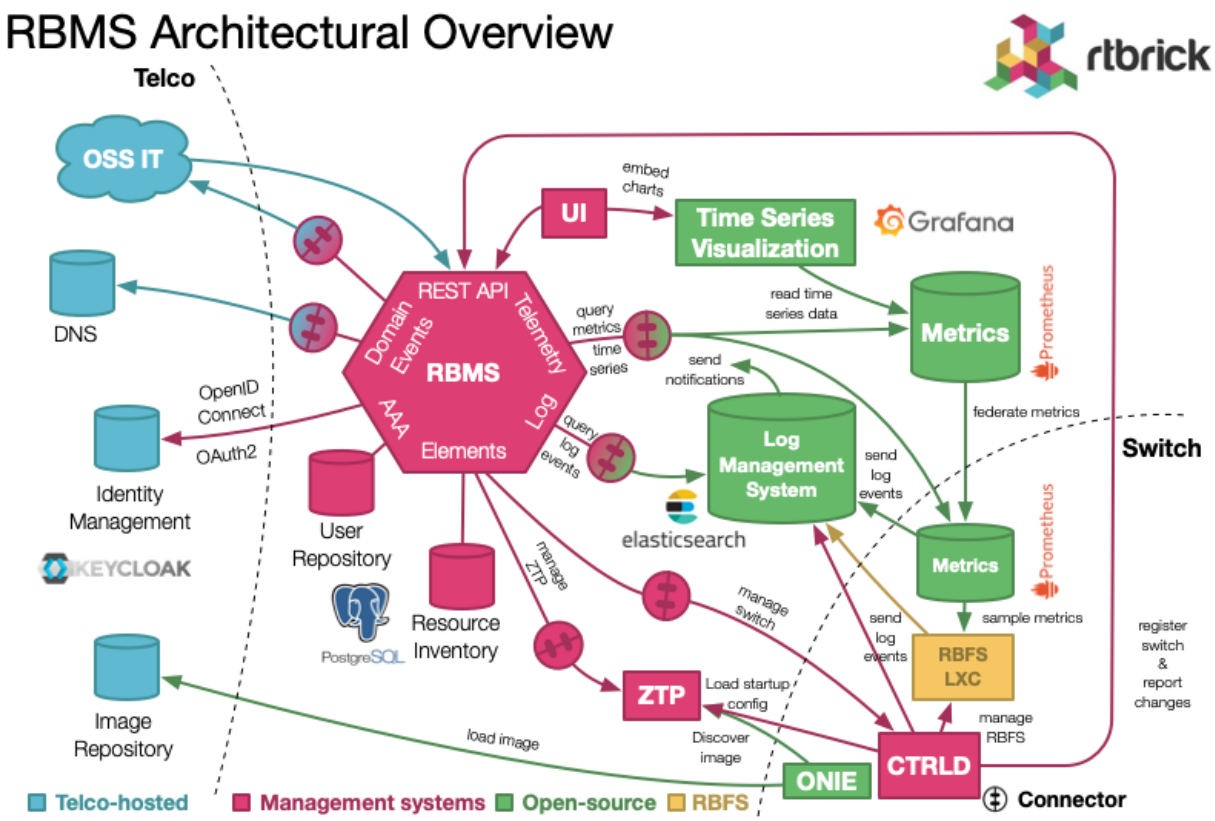
Platform Services provide the foundation for all network management functions available in RBMS. The platform services include the resource inventory, job scheduler, authentication and authorization and event subscription.

Applications provide a specific network management function. Applications use the platform services and also services provided by other applications to implement network management functions. For example, the topology application visualizes the link-state graph of a fabric.

Connectors interface RBMS with open-source solutions like log management systems or time series databases.

All services provide a REST API to interface with the service. The RBMS User Interface uses these REST APIs. Consequently, all UI actions can be automated through REST API calls. Services can contribute views to the RBMS UI to make the provided service functions accessible from the RBMS UI.

The figure below shows a real-world RBMS deployment.



OSS-IT and RBMS UI manage the switches installed in the network. This includes to inspect the state of a switch but also to manage the switch configurations or to install a new software image.

OSS-IT can also subscribe for *domain events*. A domain event reports when a switch inventory record has changed.

RBMS maintains the switch configurations and publishes the switch startup configuration on the ZTP service. This configuration also includes the software image to be installed on the switch.

ONIE, the open network install environment reads the installer image information from the ZTP service and installs RBFS. Next CTRLD reads the startup configuration from the ZTP service.

RBFS reports log messages to Graylog, an open-source enterprise log management. Graylog uses elasticsearch to store log messages. RBMS is connected to elasticsearch to query the logs and display them in RBMS.

Prometheus, an open-source monitoring system with built-in timeseries database, runs on the switch to sample metrics and to monitor metrics for alert conditions. A centralized Prometheus federates the metrics from the switches. RBMS is

connected to this Prometheus instance to show the metric values in the RBMS user interfaces.

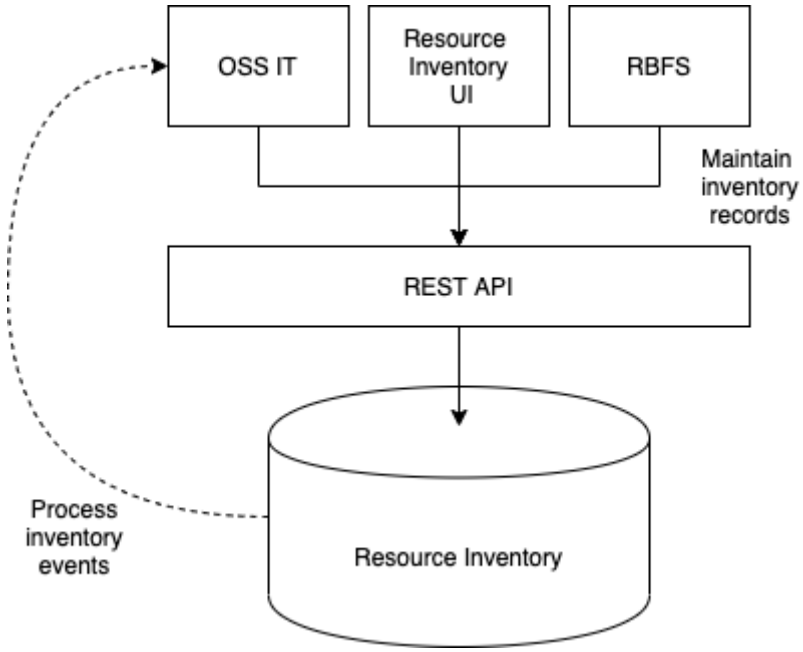
Grafana, an open-source visualization platform, provides dashboards to visualized the time series data. The RBMS UI provides quick-access to the dashboards and embedds dashboard panels in RBMS views.

Authentication and authorization is either delegated to an OpenID/Connect and OAuth2-compatible authorization service or done by the built-in user repository shipped with RBMS.

2. Managing Inventory

2.1. Introduction

The resource inventory stores information about the elements installed in the network. The resource inventory provides a REST API to maintain the resource inventory records. In addition, the resource inventory contributes views to the RBMS UI. The resource inventory UI only uses the REST API to maintain the resource inventory records. Typcially three consumers of the resource REST API exists as illustrated below:

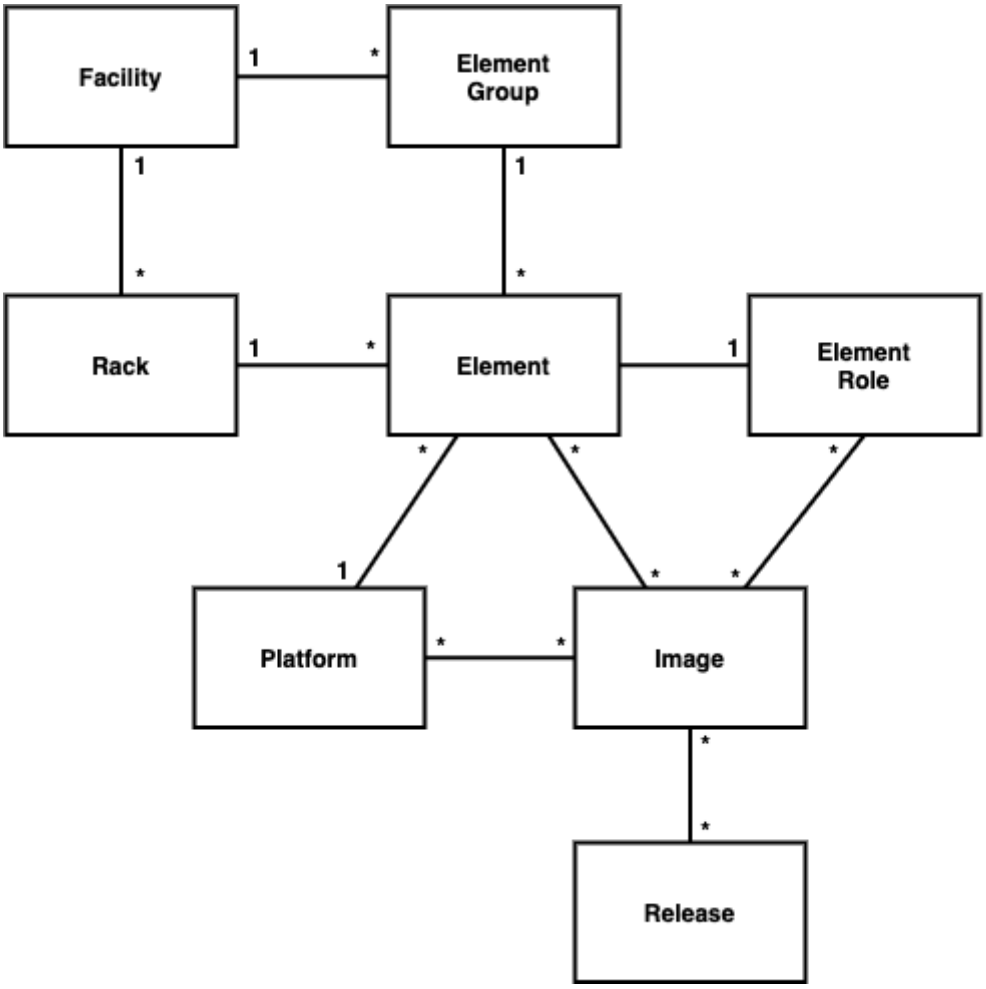


1. RBFS uses the resource inventory API to register itself in RBMS. RBFS reports the running services, physical interfaces, discovered neighbors, logical interfaces, hardware module information, information about the installed software image and the current configuration, including configuration changes, to RBMS.
2. The RBMS UI uses the resource inventory API to enable an operator to view and manage resource inventory records.
3. The OSS IT, or any other customer IT system can use the REST API to manage resource inventory records. It is also feasible to subscribe for events to get notified when a resource inventory record changes.

2.2. Data model

The resource inventory data is also the basis for the network management applications provided by RBMS. The data model is generalized allowing you to define additional roles to store custom elements, for example,to simplify automation of network management operations by storing the required data in the same database.

The main entities of the resource inventory and their relationships are shown below:



2.2.1. Element, element role and platform

The element forms the cornerstone of the resource inventory. Every element has a certain role, like a spine or a leaf switch of a fabric for example. The element role describes the function of an element in the network.

The resource inventory stores the following information per element:

- General settings including the element role, element name, an optional element alias, the operational and administrative state, the serial number, the hardware platform, an optional asset ID and management interfaces like SSH or REST API access.
- List of physical interfaces and their operational state
- List of logical interfaces and their operational state
- Information about the installed software image
- Installed services including their current state
- Element hardware modules
- Element configurations including a configuration history
- Environments containing custom data used to generate the element configuration.

The platform provides information about the hardware platform vendor, model and chipset. This information is needed to discover the software images that can be installed on this element.

The element has one of the following administrative states:

Administrative State	**Description**
NEW	A new element that has not yet been installed or enabled in the network.
ACTIVE	An element that has been installed in the network and is supposed to be up and running.
RETIRED	An element that is about to being removed from the network.

The following operational states exist:

Operational State	**Description**
DOWN	The element is down.
UP	The element is up.

Operational State	Description
DETACHED	RBMS did not receive heartbeats from the element and declares it as detached from RBMS.
MAINTENANCE	The element is currently in maintenance.

2.2.2. Image

The image provides information about the images being eligible for deployment. RBMS supports prupose-build image that can be installed on certain element roles and platforms only. RBMS includes a image lifecycle management with the following states:

State	Description
NEW	A new image that is not yet eligible for deployment.
CANDIDATE	A candidate image to become the next release. The image is eligible for deployment but not installed by default.
RELEASE	The image that get installed by default.
SUPERSEDED	A former release image that has been replaced by another release image.
REVOKED	An image that has been revoked and must not be installed any more. A revoked image retains in the intenvory for the sake of documentation.

2.2.3. Element Group

Each element belongs to an element group. Elements of the same element group form a logical unit inside the network. For example, a pod of an access network is modelled as element group.

2.2.4. Facility and racks

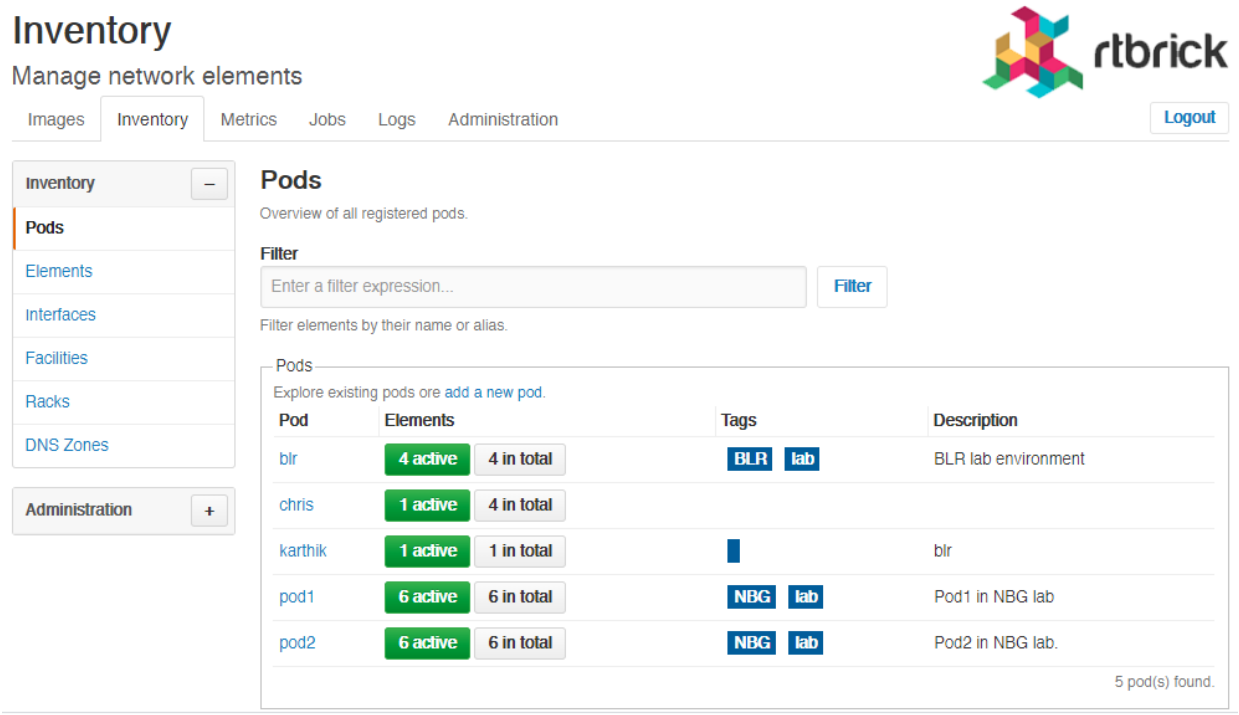
The facility describes a network facility including it's physical location. Moreover the racks installed at a facility can be specified. This also includes the locations of elements in a rack.

2.3. Managing Pods

2.3.1. Filtering Pod list by Pod name

To filter Pod list by Pod name

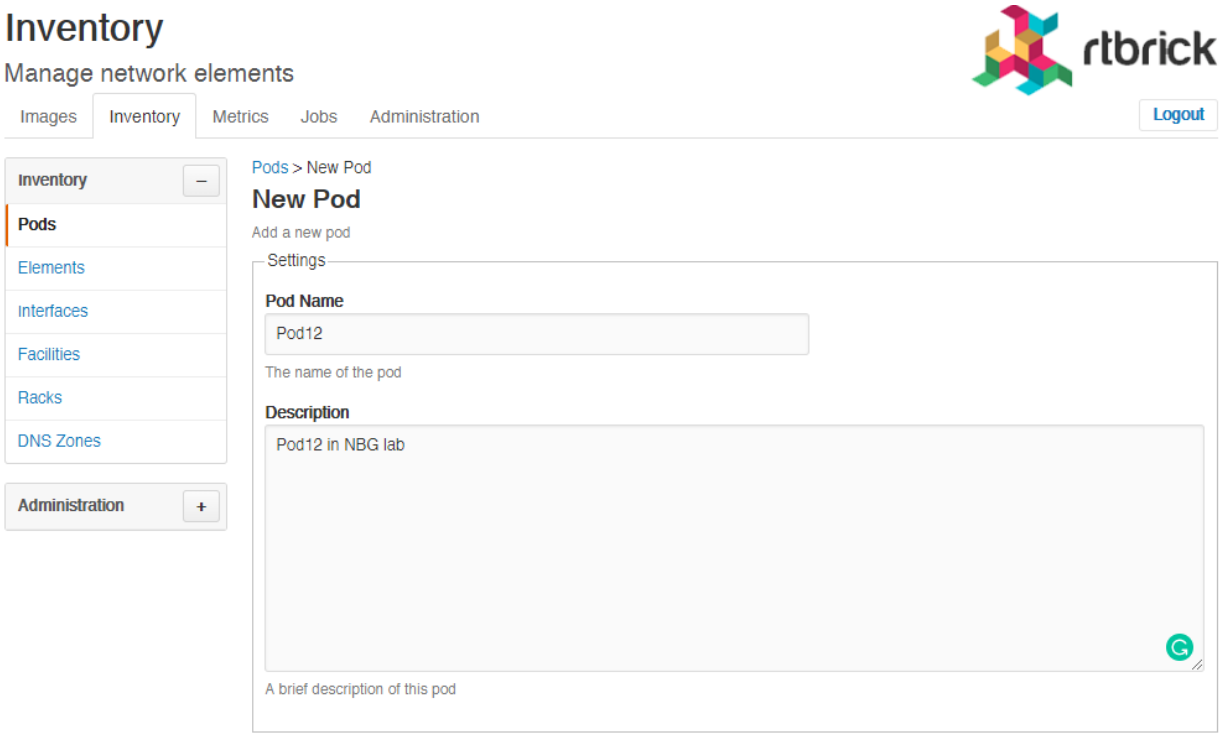
1. Click the **Inventory** tab. The Pods page appears by default.
2. In the **Filter** text box, specify the filter criteria and then click **Filter**. The Pods that match the filter criteria appear.



2.3.2. Creating Pods

To create a Pod

1. Click the **Inventory** tab. The list of Pods appears by default.
2. In the **Pods** page, click the **Add pod**.

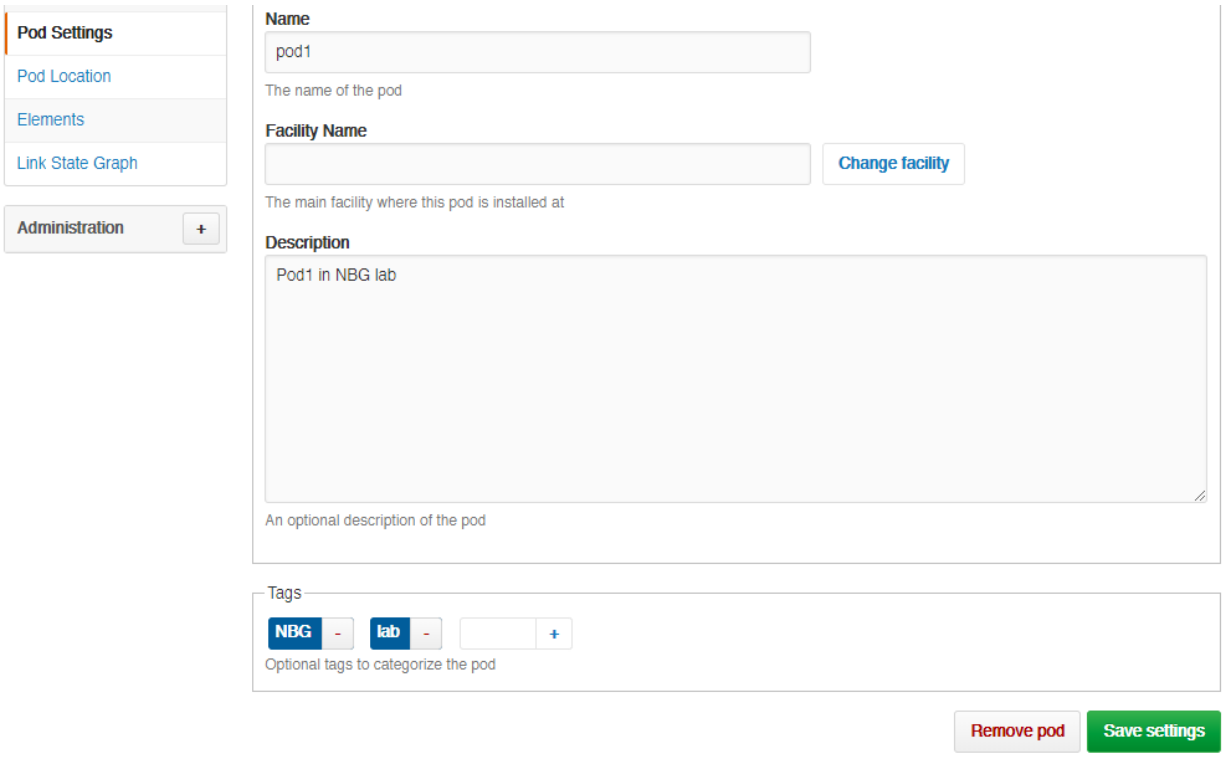


3. In the **Pod Name** field, specify the name of the Pod.
4. In the **Description** field, specify a brief description for the Pod.
5. In the **Tags** field (optional), specify the tags that can be used to categorise the Pod.
6. Click **Add Pod**.

2.3.3. Modifying Pod settings

To modify the Pod settings

1. Click the **Inventory** tab. The list of Pods appear by default.
2. In the **Pods** group box, click the Pod that you want to modify. The **Pod Settings** page appears.

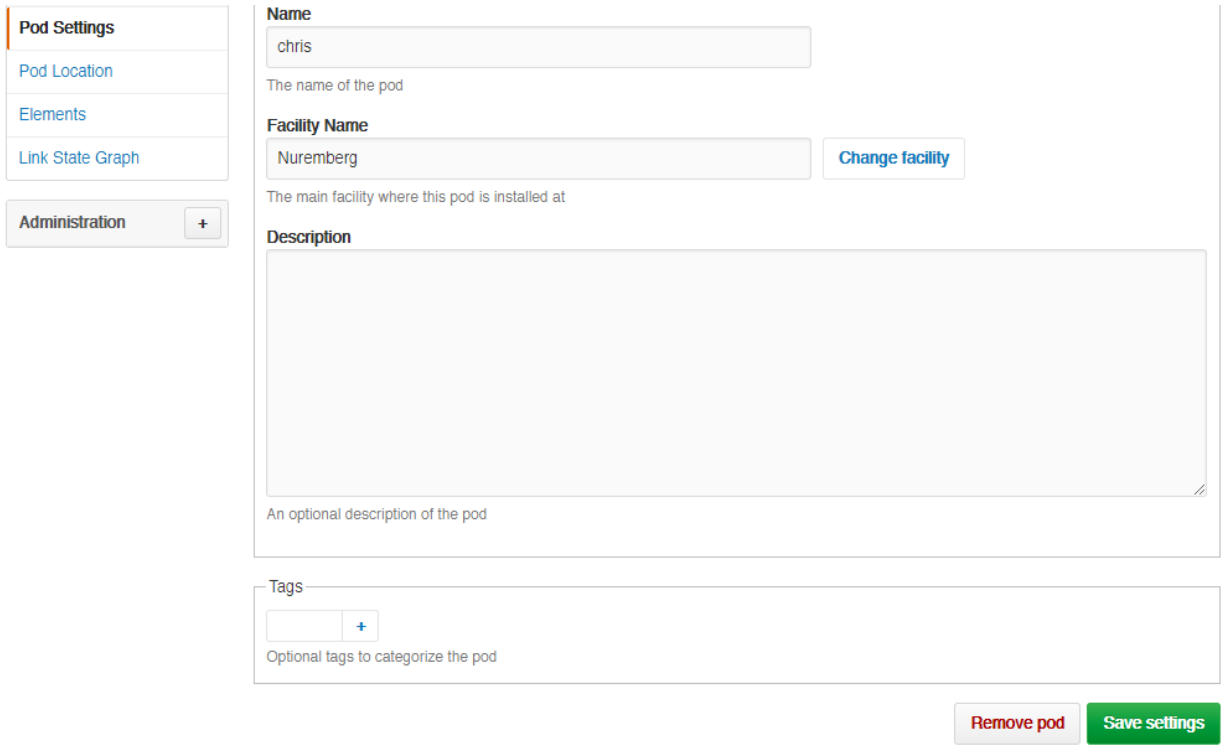


3. Make the necessary updates and click **Save settings**.

2.3.4. Removing Pods

To remove a Pod

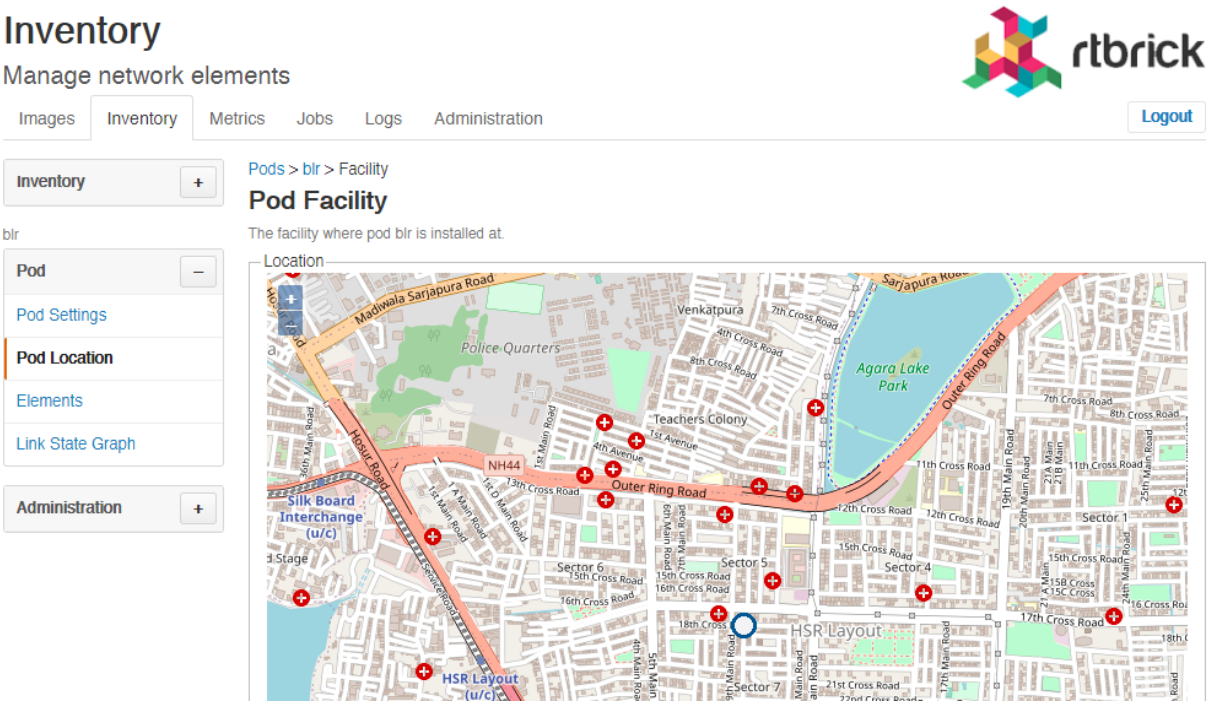
1. Click the **Inventory** tab. The list of Pods appear.
2. In the **Pods** group box, click the Pod that you want to remove. The **Pod Settings** page appears.



2.3.5. Viewing Pod location

To view the facility where a Pod is installed

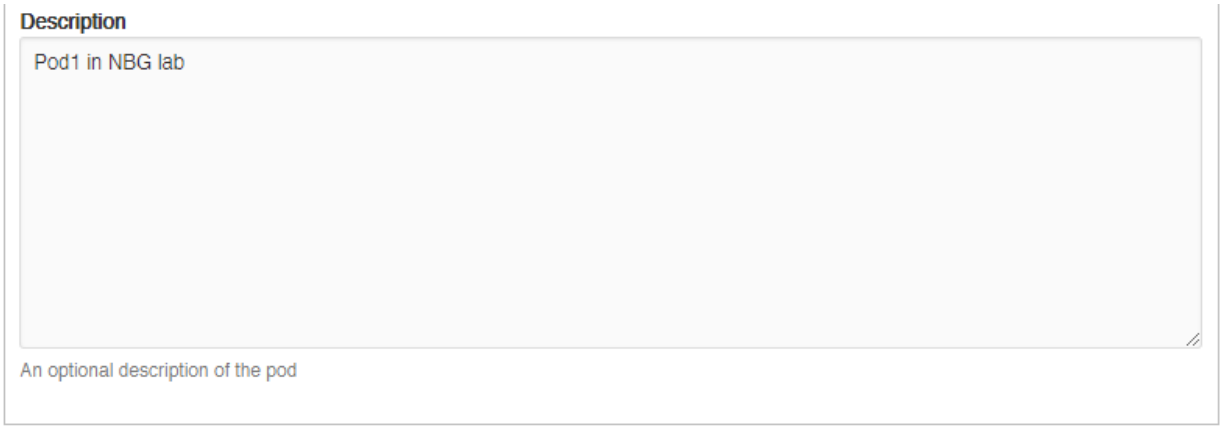
1. Click the **Inventory** tab. The list of Pods appear.
2. In the **Pods** group box, click the Pod whose facility you want to view.
3. Click **Pod location** in the left navigation pane. The **Pod Facility** page appears.



2.3.6. Describing Pod racks

To describe the Pod racks

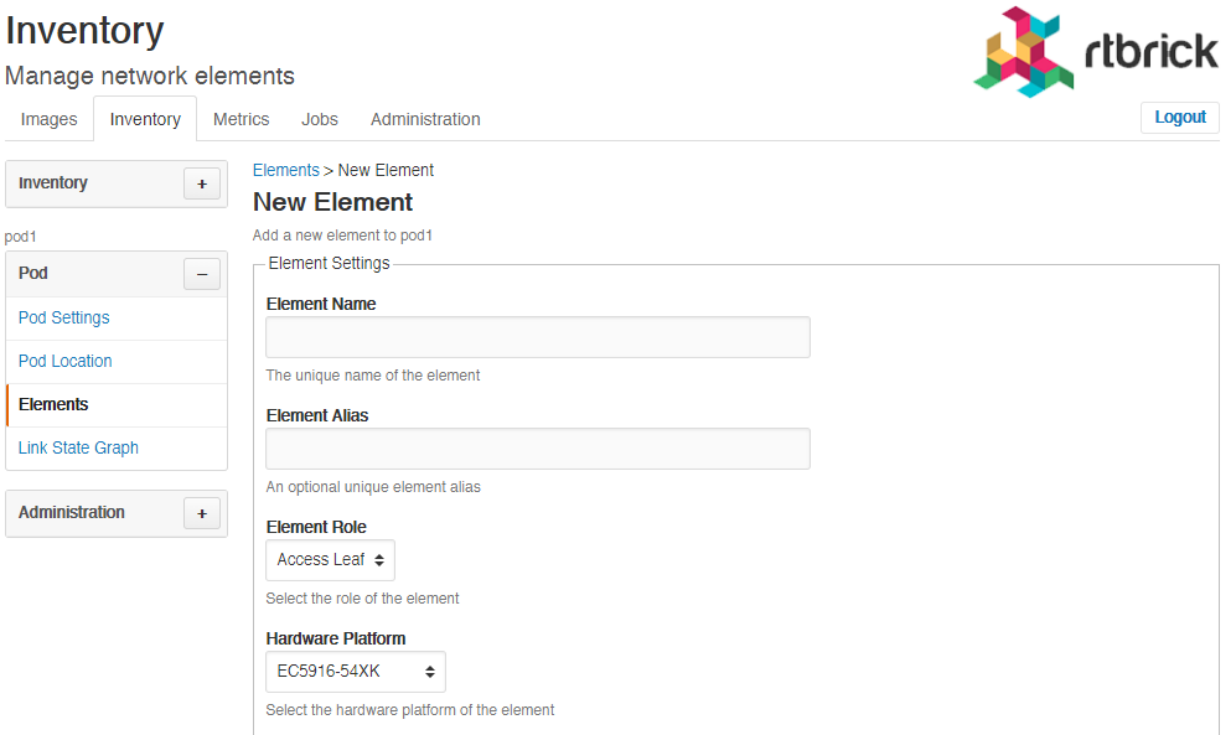
1. Click the **Inventory** tab. The list of Pods appear.
2. In the **Pods** group box, click the Pod that you want to modify. The **Pod Settings** page appears.
3. Specify the description for Pod rack.



2.3.7. Adding element to Pod

To add element to Pod

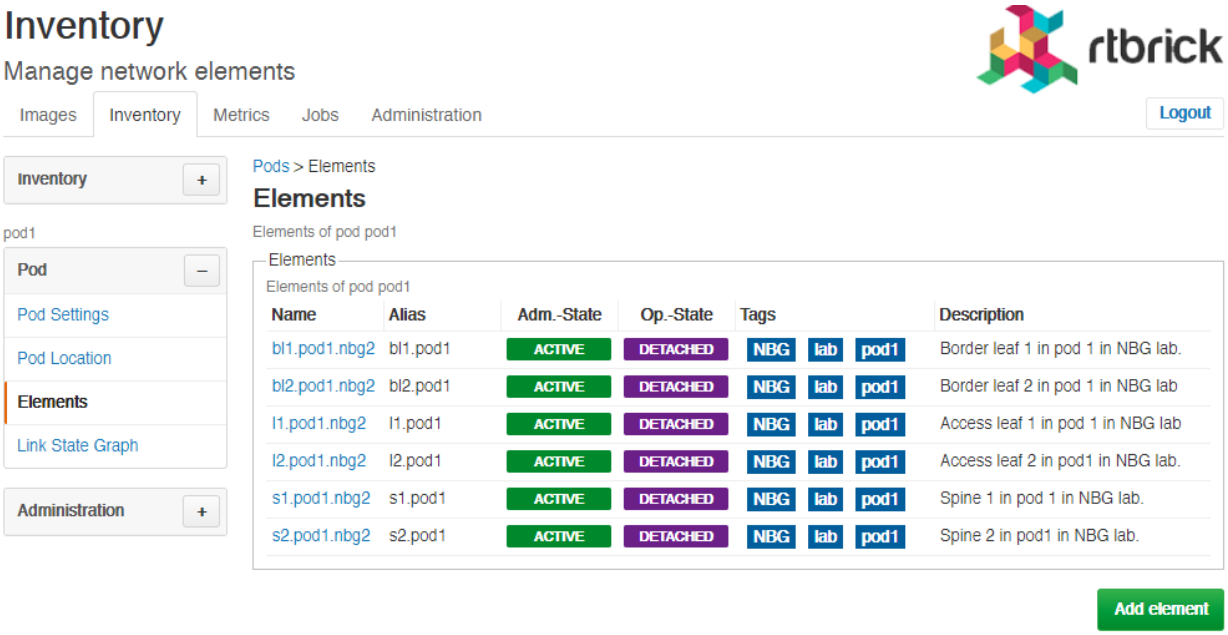
1. Click the **Inventory** tab. The list of Pods appear.
2. In the **Pods** group box, click the Pod that you want to modify. The **Pod Settings** page appears.
3. Click **Elements** from the left navigation pane. The **Elements** page appears.
4. Click **Add element**.



2.3.8. Listing elements of a Pod

To view the list of element in Pod

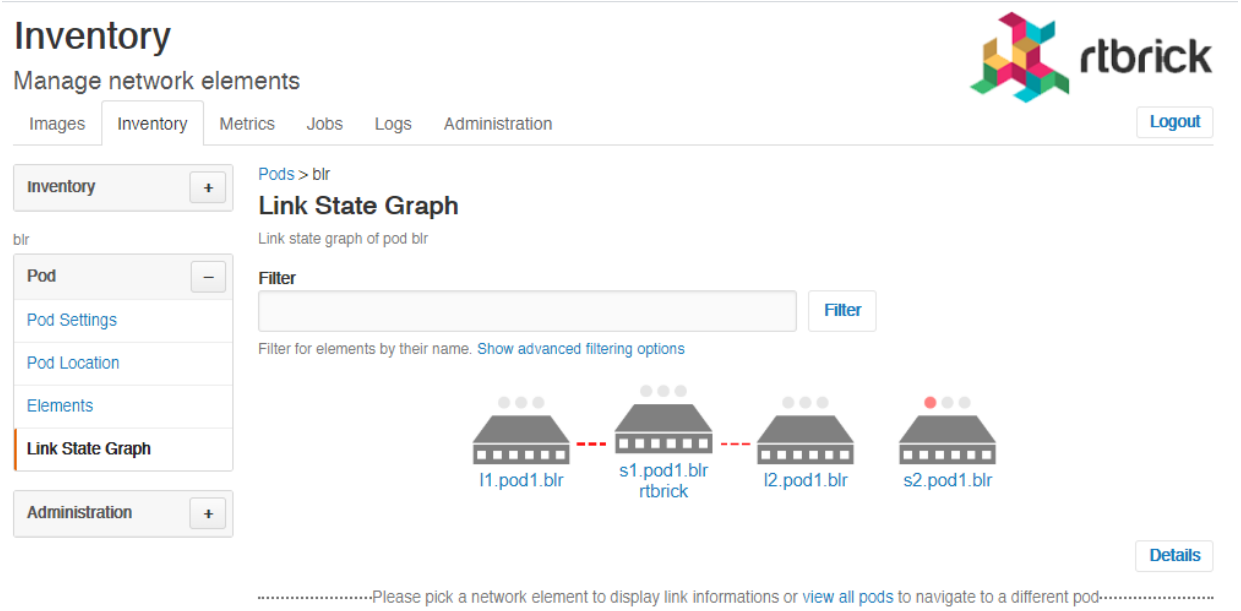
1. Click the **Inventory** tab. The list of Pods appear.
2. In the **Pods** group box, click the Pod that you want to modify. The **Pod Settings** page appears.
3. Click **Elements** from the left navigation pane. The **Elements** page appears and the list of elements in the selected Pod appear.



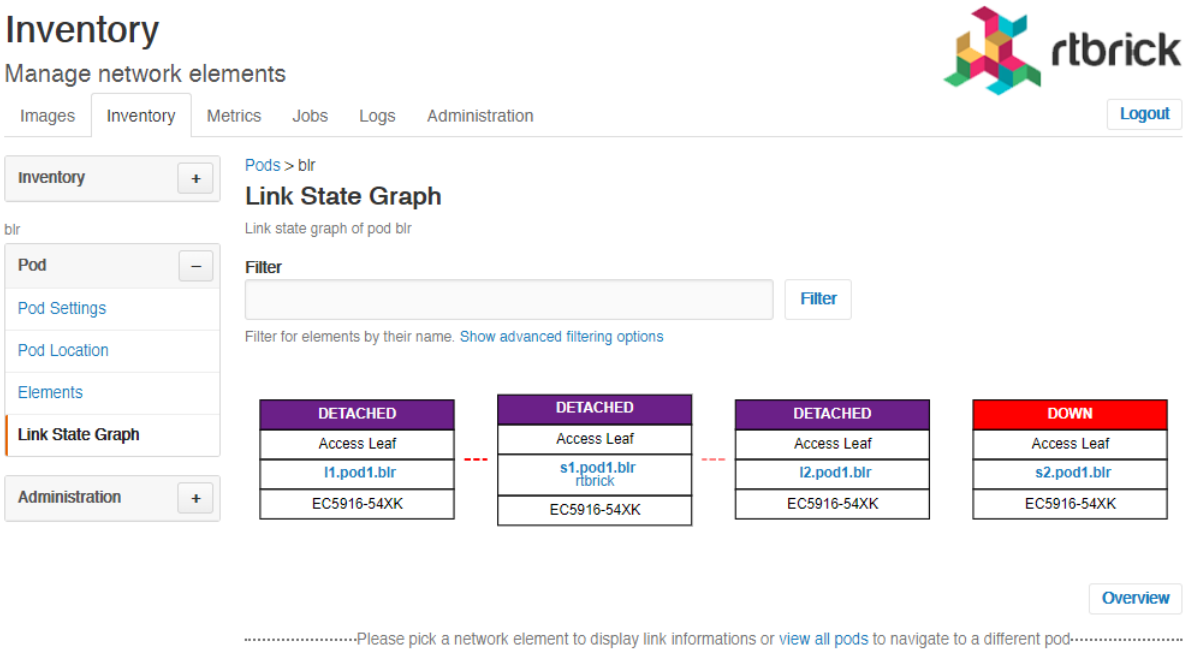
2.3.9. Viewing Link State Graph

To view the link state graph of Pod

1. Click the **Inventory** tab. The list of Pods appear.
2. In the **Pods** group box, click the Pod that you want to view. The **Pod Settings** page appears.
3. Click **Link State Graph** in the left navigation pane. The **Link State Graph** page appears.



4. On the **Link State Graph** page, select a network element to display link information.
5. Click **Details** to view the detailed information of network elements.



2.3.10. Viewing Pod Topology

The topology view provides the following functionalities:

- Visualizes the Pod link-state graph
- Visualizes connected Pods
- Provides quick access to most relevant information

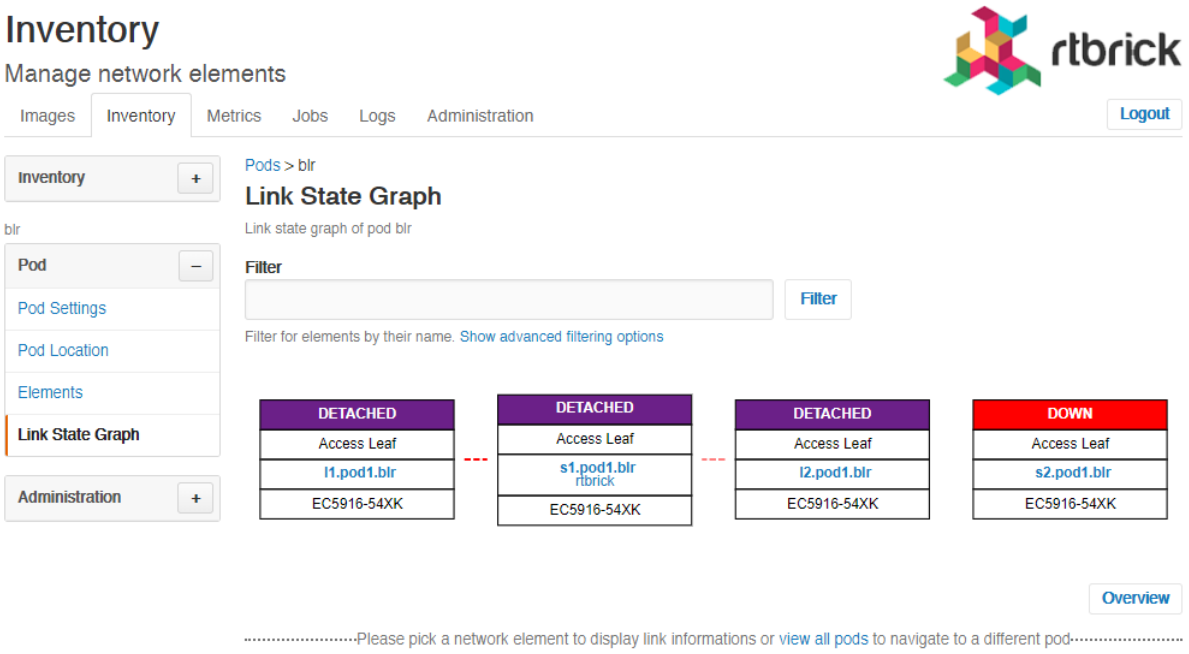
    Alerts

    Events

    Established links

To view the Pod topology

1. Click the **Inventory** tab. The list of Pods appear.
2. In the **Pods** group box, click the Pod that you want to view. The **Pod Settings** page appears.
3. Click **Link State Graph** in the left navigation pane. The **Link State Graph** page appears.
4. Click the **view all pods** link that is displayed along the bottom of the page. The **Topology** page appears.

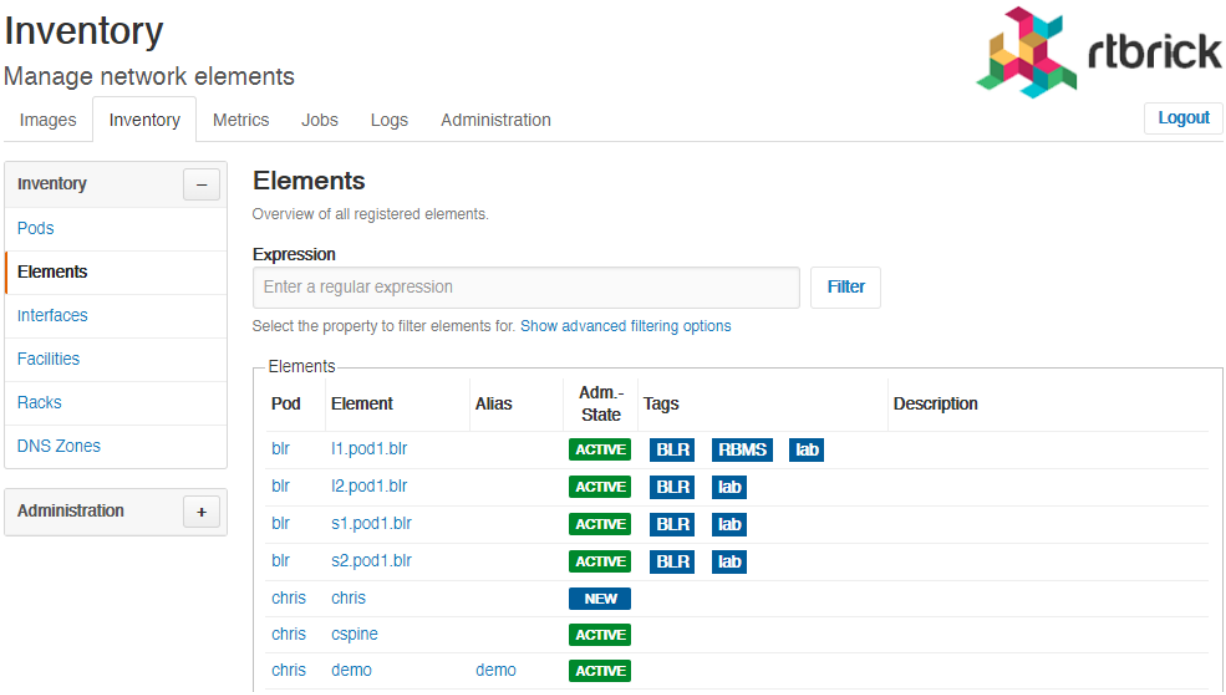


The **Topology** page displays the overview of the Pod topology in a graphical interface along with a table that shows the list of Pods deployed in the network.

2.4. Managing Elements

To view the list of all registered elements

1. Click the **Inventory** tab, and then click **Elements** in the left navigation pane. The list of registered elements appear.



2.4.1. Assigning roles to elements

1. Click the **Inventory** tab, and then click **Elements** in the left navigation pane. The list of registered elements appear.
2. Click the name of the element that you want view.
3. In the **Element Role** box, select the role you want to use. The following roles are available:

   Access Leaf- Access leaf fabric switch

   Border Leaf - Border leaf fabric switch

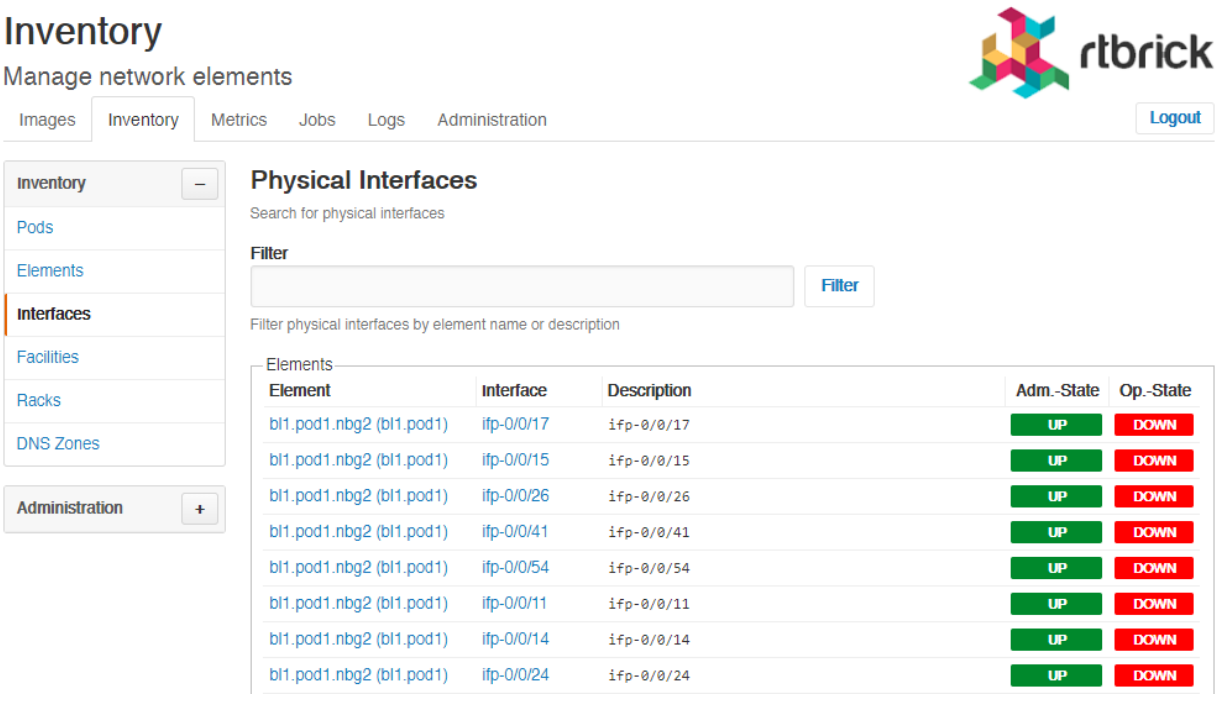
   Spine - Spine fabric switch

2.5. Viewing Physical Interfaces

The physical interface summary shows the information of a physical interface and its logical interfaces. The view might be augmented with telemetry data (for example, current interface utilization, log messages).

To view the list of physical interfaces

1. Click the **Inventory** tab.
2. In the left navigation pane, click **Interfaces**. The **Physical Interfaces** page appears.

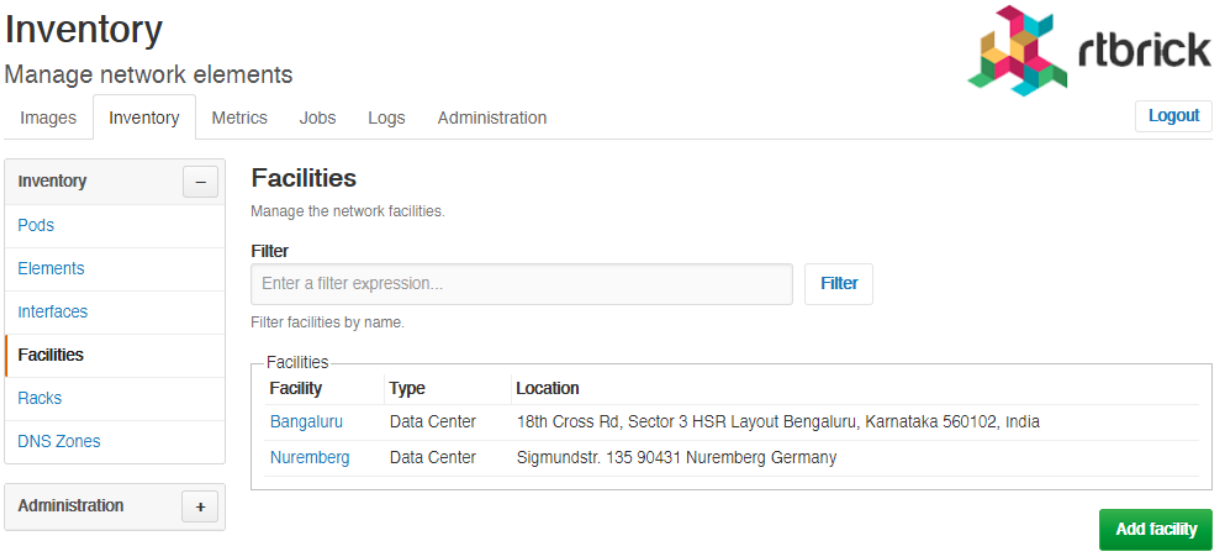


2.6. Managing Facilities

2.7. Viewing list of facilities

To view the list of facilities

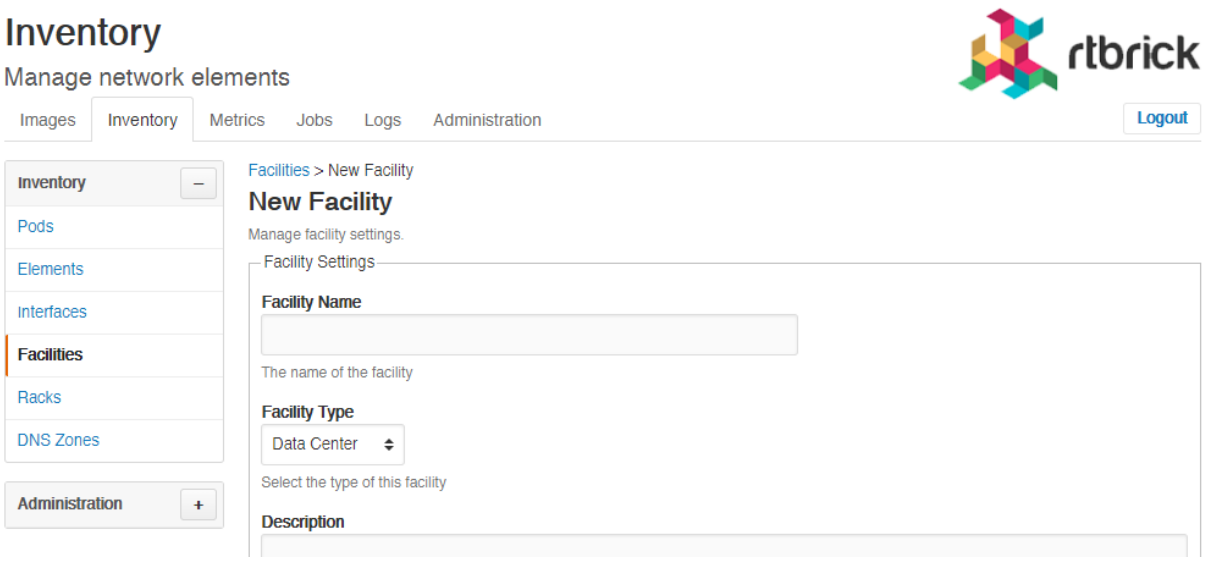
1. Click the **Inventory** tab.
2. In the left navigation pane, click **Facilities**. The list of available facilities appear.



2.7.1. Creating a Facility

To create a facility

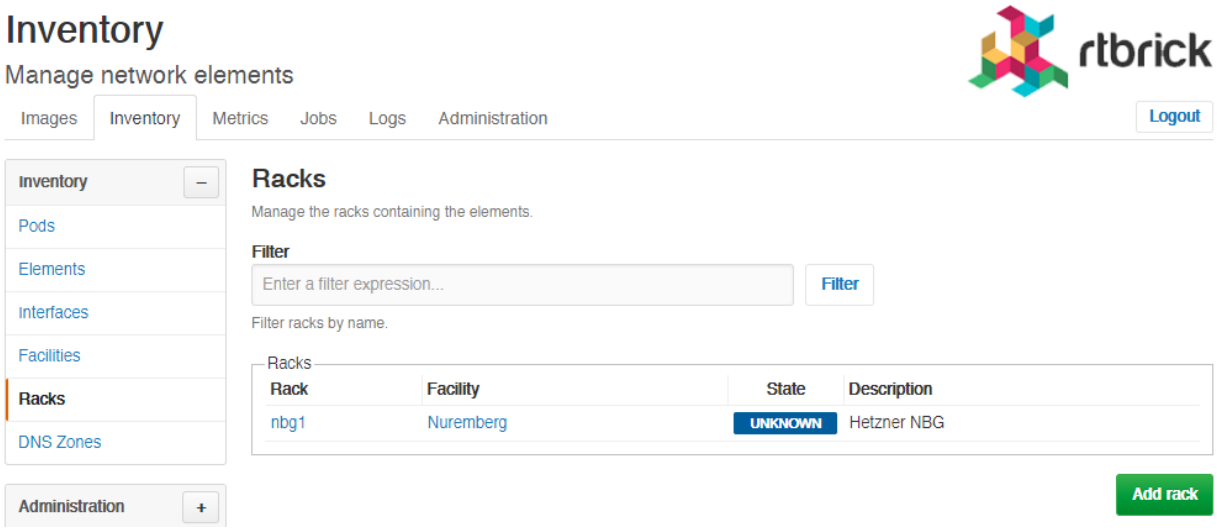
1. Click the **Inventory** tab.
2. In the left navigation pane, click **Facilities**. The list of available facilities appear.
3. Click **Add facility**.
4. Specify the facility settings such as facility name, type, and description.
5. Click **Add facility**.



2.8. Managing Racks

To view the list of racks

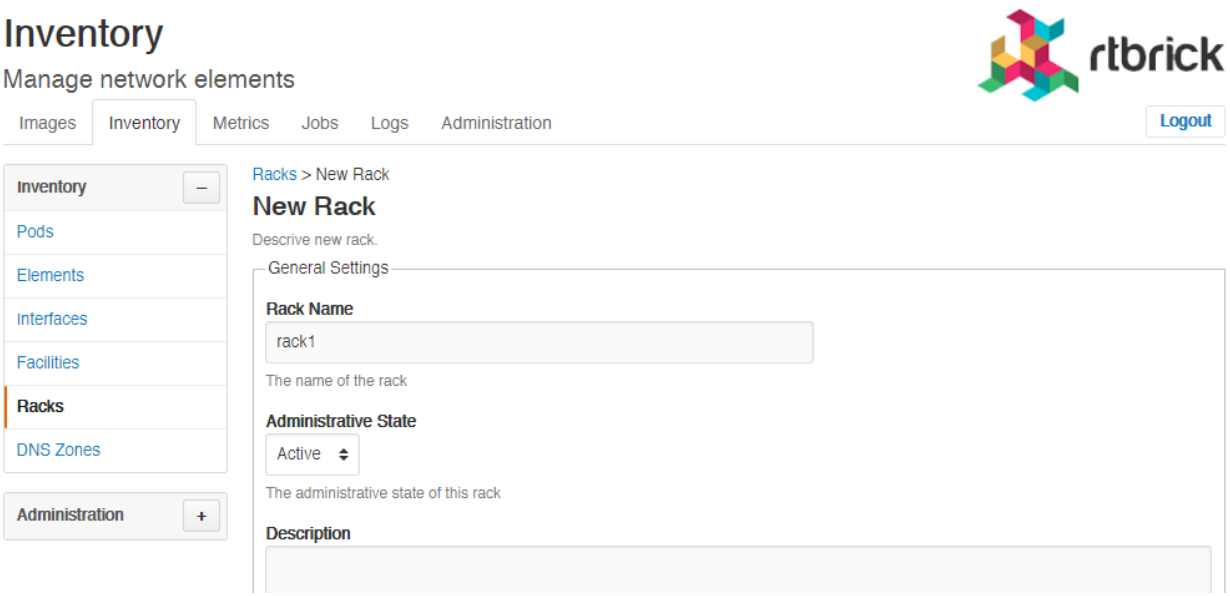
1. Click the **Inventory** tab.
2. In the left navigation pane, click **Racks**. The list of available racks appear.



2.8.1. Creating a Rack

To create a rack

1. Click the **Inventory** tab.
2. In the left navigation pane, click **Racks**. The list of available racks appear.
3. Click **Add rack**.



4. Specify the rack settings such as rack name, administration state, description, rack dimensions, and other additional information.
5. Click **Add rack**.

2.9. Managing DNS Zones

To view the list of DNS zones

1. Click the **Inventory** tab.
2. In the left navigation pane, click **DNS Zones**. The list of available DNS Zones appear.

2.9.1. Creating a DNS Zone

To create a DNS zone

1. Click the **Inventory** tab.
2. In the left navigation pane, click **DNS Zones**. The list of available DNS zones appear.
3. Click **Add DNZ Zone**.
4. Specify the rack settings such as canonical DNS zone name and description.
5. Click **Add zone**.

2.10. Inventory Administration

To configure the inventory administration settings in the **Inventory** page, click the plus sign (+) next to **Administration**.

2.10.1. Managing element platforms

To list down the known hardware platforms

1. Click the **Inventory** tab.
2. click the plus sign (+) next to **Administration**.
3. Click **Platforms**. The list of hardware platforms appear.

Creating element platforms

To create a hardware platform

1. Click the **Inventory** tab.
2. click the plus sign (+) next to **Administration**.
3. Click **Platforms**. The list of hardware platforms appear.
4. Click **Add platform**.
5. Specify the settings and dimensions of the hardware platform.
6. Click **Save platform**.

Removing element platforms

To remove an element platform

1. Click the **Inventory** tab.
2. Click the plus sign (+) next to **Administration**, and then click **Platforms**. The list of hardware platforms appear.
3. Click the name of the element platform that you want delete. The **Platform Settings** page displays the settings of the element platform.
4. Click **Remove**.

2.10.2. Managing Element Roles

To list down the existing element roles

1. Click the **Inventory** tab.
2. click the plus sign (+) next to **Administration**.
3. Click **Roles**. The list of existing element roles appear.

Creating Element Roles

To create an element role

1. Click the **Inventory** tab.
2. click the plus sign (+) next to **Administration**. The list of existing element roles appear.
3. Click **Roles**. The list of existing element roles appear.
4. Click **Add role**
5. Specify the role settings.
6. Click **Save role**.

Removing Element Roles

To remove an element role

1. Click the **Inventory** tab.
2. click the plus sign (+) next to **Administration**. The list of existing element roles appear.
3. Click **Roles**. The list of existing element roles appear.
4. Click the name of the element role that you want delete. The next page displays the settings of the element role.
5. Click **Remove role**.

2.10.3. Managing Templates

To list down the existing templates

1. Click the **Inventory** tab.
2. click the plus sign (+) next to **Administration**.
3. Click **Templates**. The list of existing element templates appear.

Creating Templates

To create a template

1. Click the **Inventory** tab.
2. click the plus sign (+) next to **Administration**. The list of existing element templates appear.
3. Click **Add templates**
4. Specify the template settings such as template name and description.
5. Click **Save template**.

Removing Templates

To remove a template

1. Click the **Inventory** tab.
2. click the plus sign (+) next to **Administration**. The list of existing element templates appear.
3. Click **Templates**. The list of existing element templates appear.
4. Click the name of the template that you want delete. The next page displays the settings of the template.
5. Click **Remove template**.

3. Managing Software Images

RBMS manages a list of software images that are currently installed on the switches in the network or eligible for being installed. The image lifecycle encompasses the following states:

- **NEW**, a new image that has been uploaded to RBMS but is not yet eligible for deployment. Typcially the integrity of a new image needs to be verified before it becomes eligible for deployment.
- **CANDIDATE**, a candidate image is eligible for deployment. It is a candidate to become the new release image if it passes all tests in the network.
- **RELEASE**, the release image gets installed by default.
- **SUPERSEDED**, a superseded image is a former release image which has been replaced by a newer release.
- **REVOKED**, a revoked image must not be installed on switches in the network.

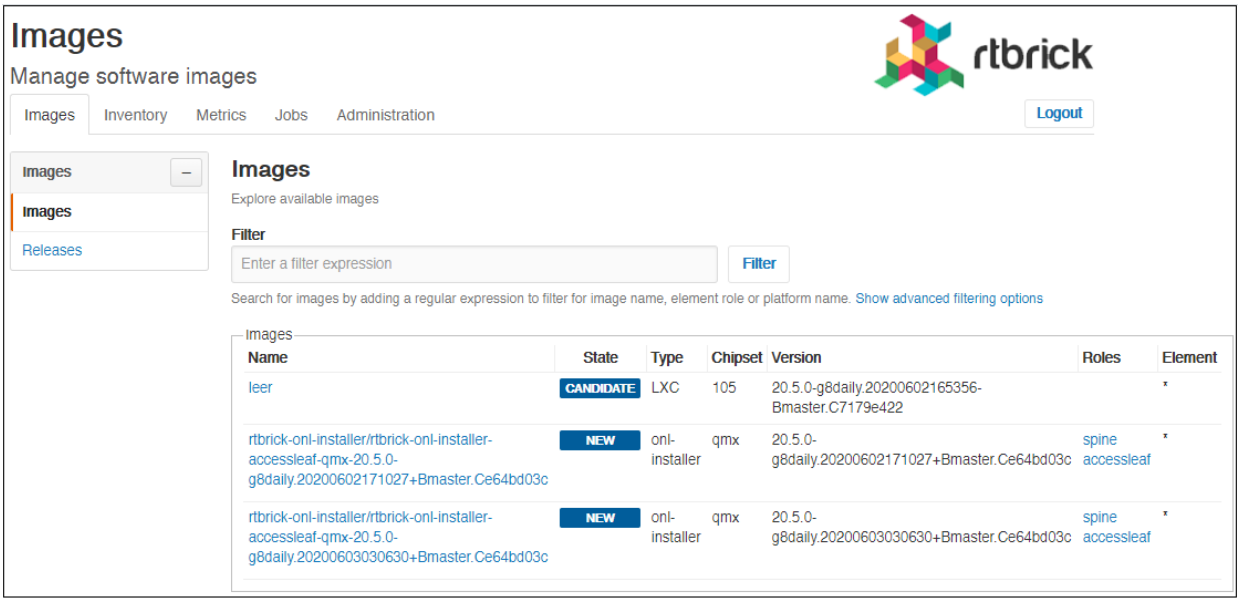
Superseded and revoked images are kept in the resource inventory for the sake of documentation and to track on how many switches superseded or revoked images are installed.

The rtb-image tool provides an option to register new image in RBMS. The new image can be installed on a switch via Zero-Touch Provisioning (ZTP).

3.1. Viewing all registered images

To view all registered images

- Click the **Images** tab. The **Images** page appears, showing the list of registered images.



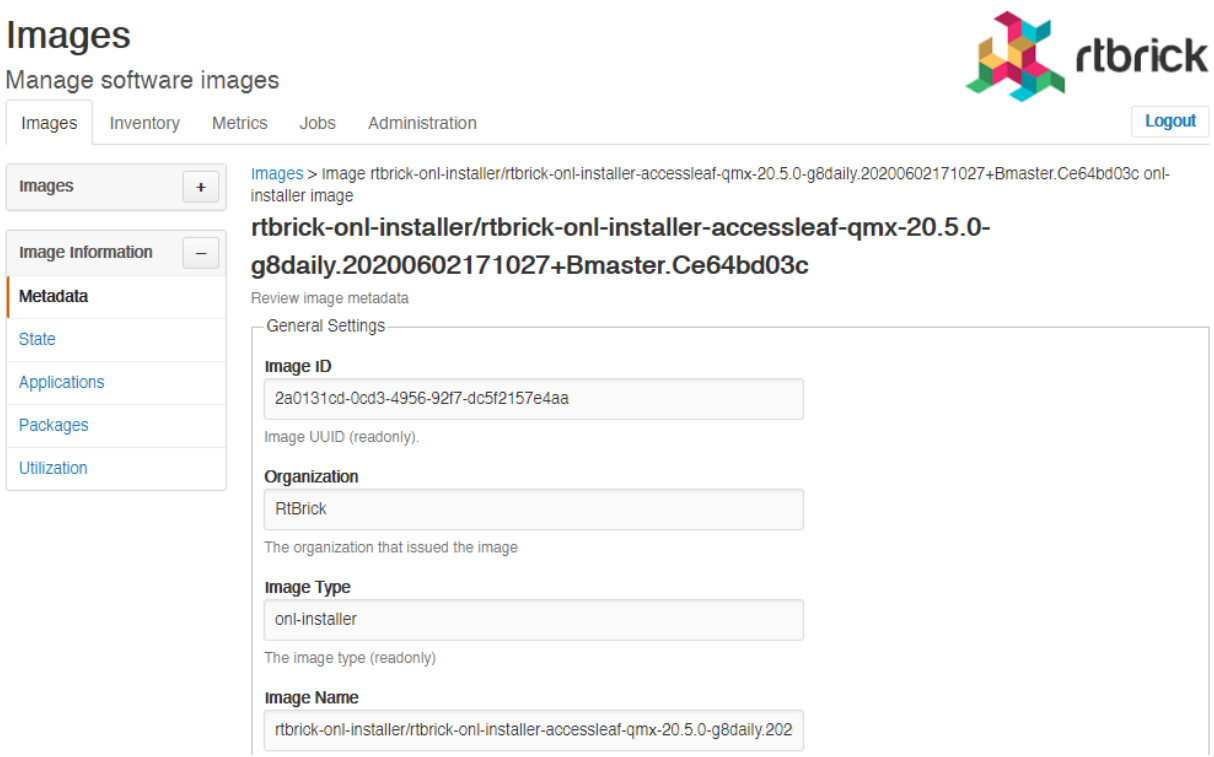
The **Images** page displays the following fields:

Field	Description
Name	Name of the software image
State	Indicates the image state such as New, Candidate, Release, Suspended, Revoked. For more information, see the Image Lifecycle Management section.
Type	Type of the software image such as LXC or ONL
Chipset	Specifies the supported hardware name
Version	Version of the software image
Roles	The image is deployed on the specified element roles.
Element	Name of the registered element

3.1.1. Viewing image details

To view the details of an image

1. Click the **Images** tab. The list of registered images appear.
2. In the **Images** group box, click the name of the image that you want to view. The image details page appears.



This page displays the following fields:

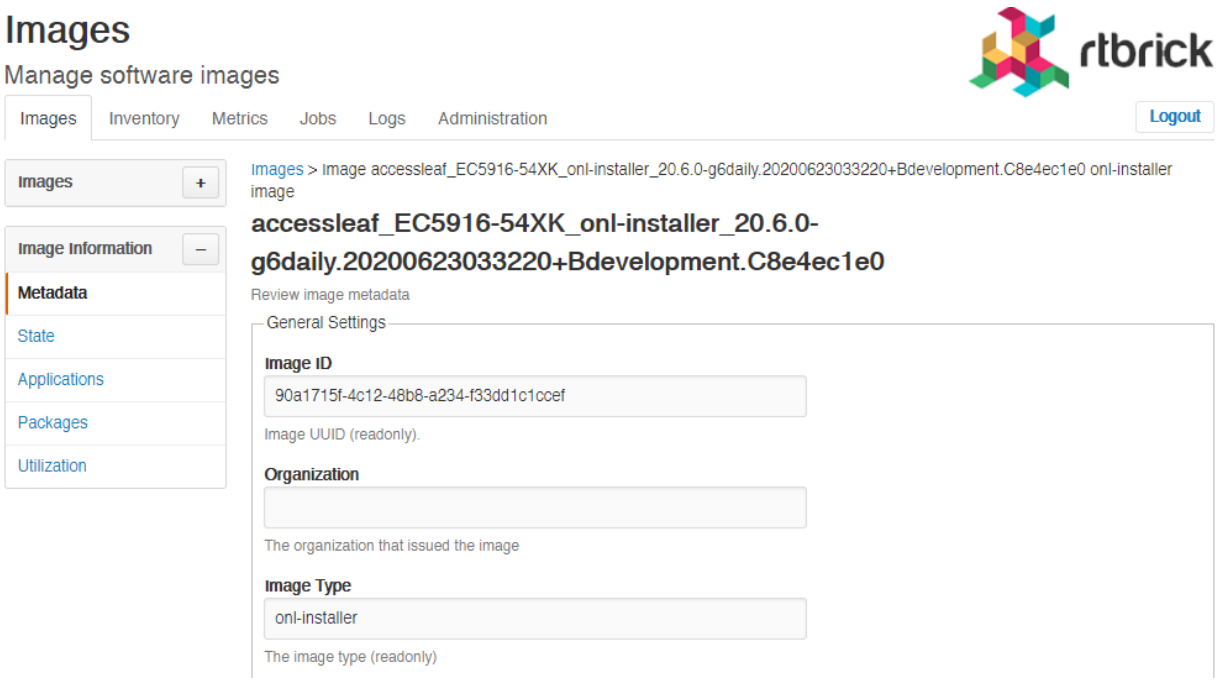
Field	Description
Image ID	Image UUID (read-only)
Organization	The organization that issued the image
Image Type	The image type (read-only)
Image Name	The unique image name
Image Version	Image version (read-only)
Category	Optional image category
Description	Optional description of the image
Platform Chipset	The chipset this image is build for (read-only)
Element Roles	This image can be deployed on the selected element roles
Supported Platforms	The list of platforms on which the image can be installed

3.1.2. Updating image metadata

To update the metadata of an image

1. Click the **Images** tab. The list of registered images appear.

2. In the **Images** group box, click the name of the image whose metadata you want to update. The image details page appears.
3. On the left navigation pane, click **Metadata**.

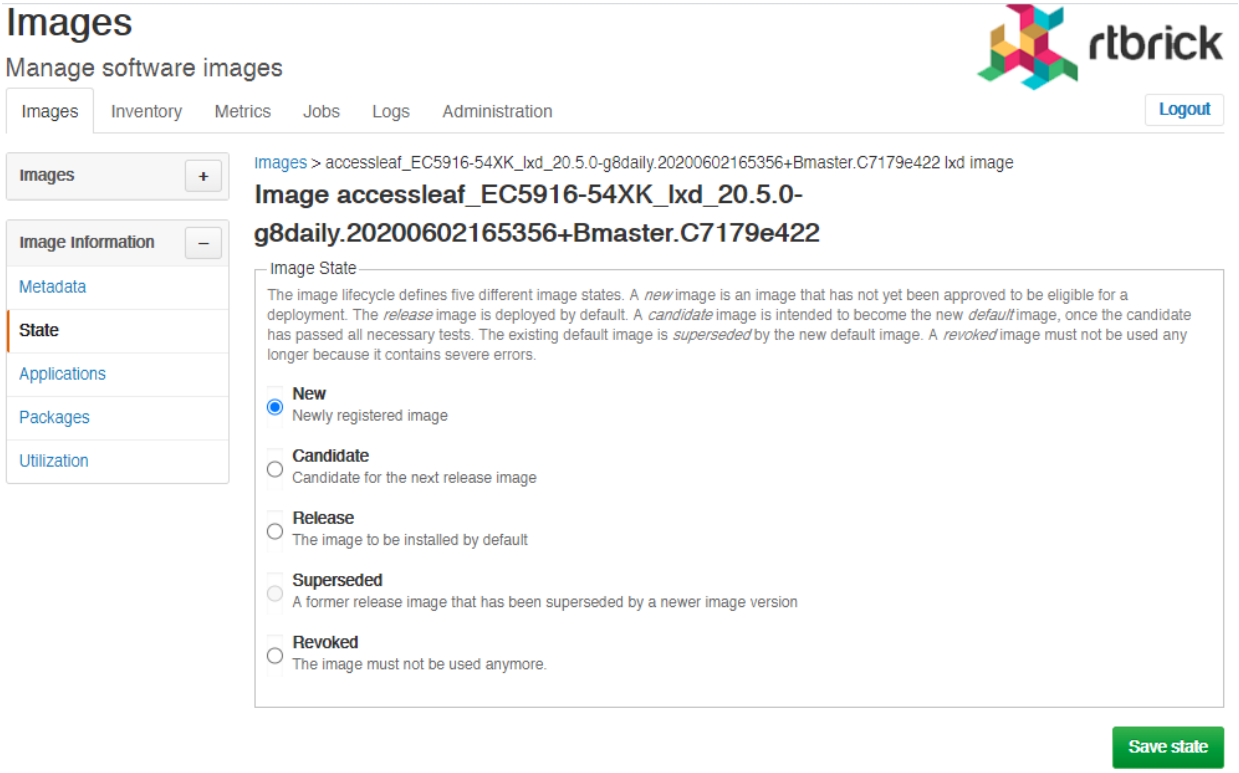


4. Update image metadata such as image ID, type, name, and version.
5. Click **Save settings**.

3.2. Image Lifecycle Management

The image lifecycle defines five different image states. A new image is an image that has not yet been approved to be eligible for a deployment. The release image is deployed by default. A candidate image is intended to become the new default image, once the candidate has passed all necessary tests. The existing default image is superseded by the new default image. A revoked image must not be used any longer because it contains severe errors.

1. Click the **Images** tab. The list of registered images appear.
2. Click the name of the image that you want to view.
3. Click **State** in the left navigation pane.
4. From the following list of states, select the state that you want to apply.



- **New**: Newly registered image
- **Candidate**: Candidate for the next release image
- **Release**: The image to be installed by default
- **Superseded**: A former release image that has been superseded by a newer image version
- **Revoked**: The image must not be used anymore.

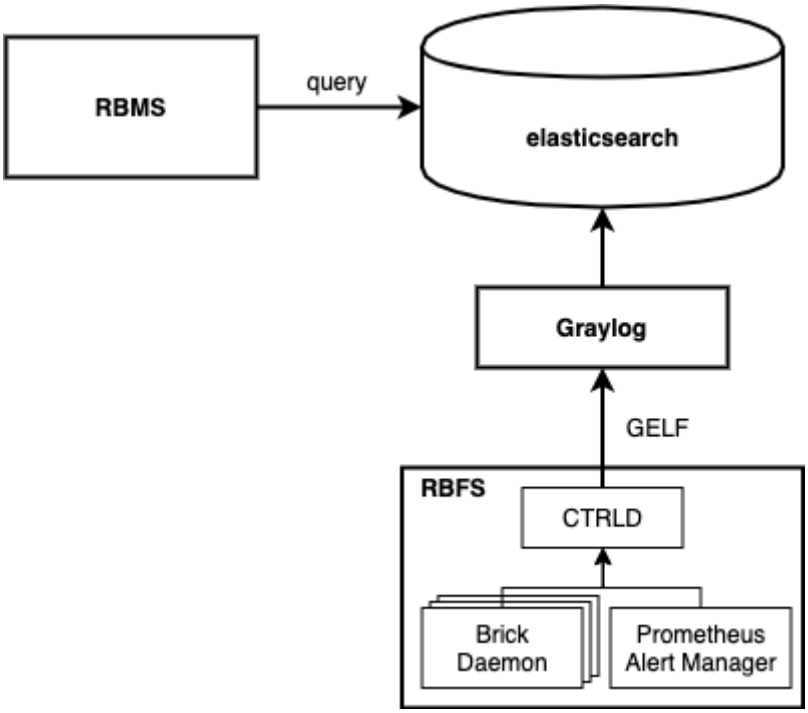
5. Click **Save state**.

4. Managing Logs

4.1. Introduction

In order to understand the RBMS log viewer it is key to understand the RBFS logging concept. RBFS stores log information in Brick Data Store (BDS) tables. The BDS is an in-memory database developed by RtBrick and optimized for the networking domain. The BDS log tables contain only the raw data of a log event. Exporters pass the raw data to a template string to create a human friendly log message.

By default RBFS exports log messages in GELF format. The Graylog Extended Logging Format (GELF) is a JSON representation of the Syslog protocol, with the option to add custom fields.



The CTRLD forms the egress node for all GELF messages. CTRLD receives log messages from brick daemons, augments the GELF message with the element name, element role, serial number and pod name and forwards it to the configured GELF endpoint. In addition, CTRLD receives all notification of the Prometheus Alert Manager running on the switch and translates them to GELF messages. Last but not least, CTRLD generates GELF messages to log events.

All messages are send to a configured GELF endpoint. The GELF endpoint stores the data in a central log database. The GELF message is already a structured

message. Thus the endpoint does not have to create a log message into a structured record.

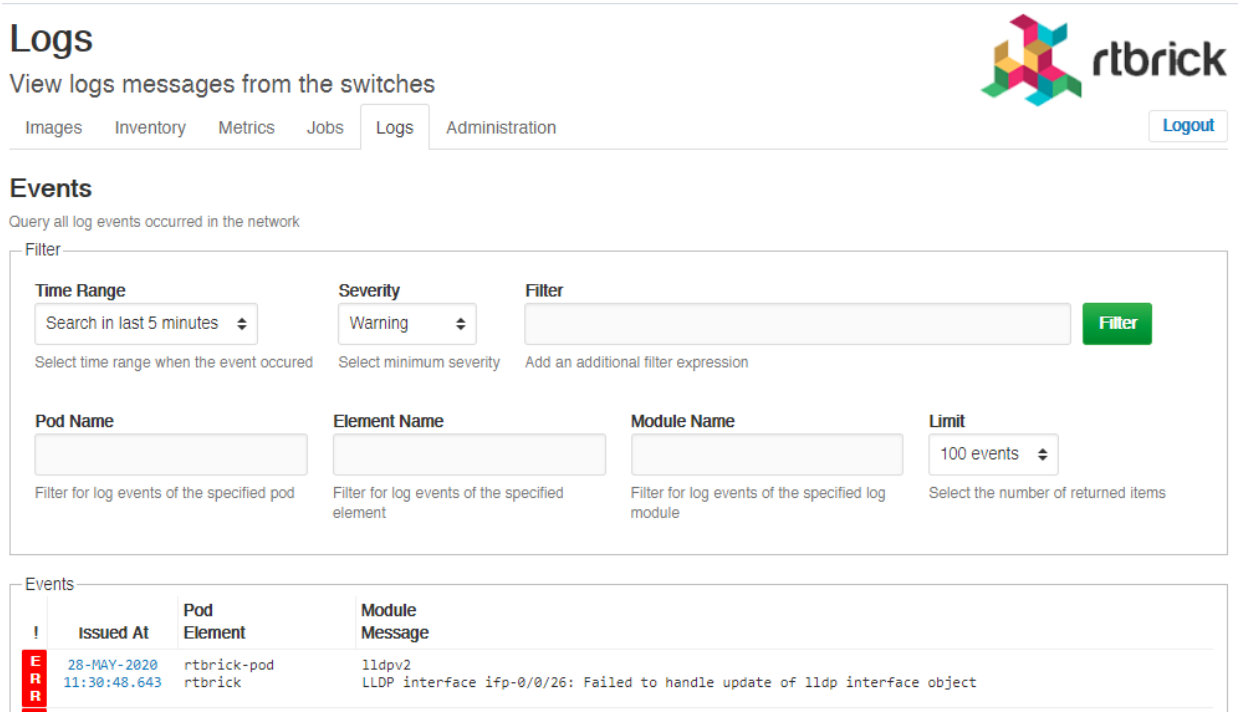
RBMS queries log events from the log management system to provide quick access to log messages. In addition, RBMS links all log messages to the inventory records to quickly inspect the state of an element.

4.2. Viewing log events

The log viewer reads log records from the Elasticsearch database. The query is formed from the resource inventory data and can be amended by the operator to fine-tune the result set. You can inspect the details of a log message in the RBMS UI.

To view the list of logs

1. Click the **Logs** tab. The list of all log events occurred in the network within the last five minutes having at least *WARNING* severity appears.

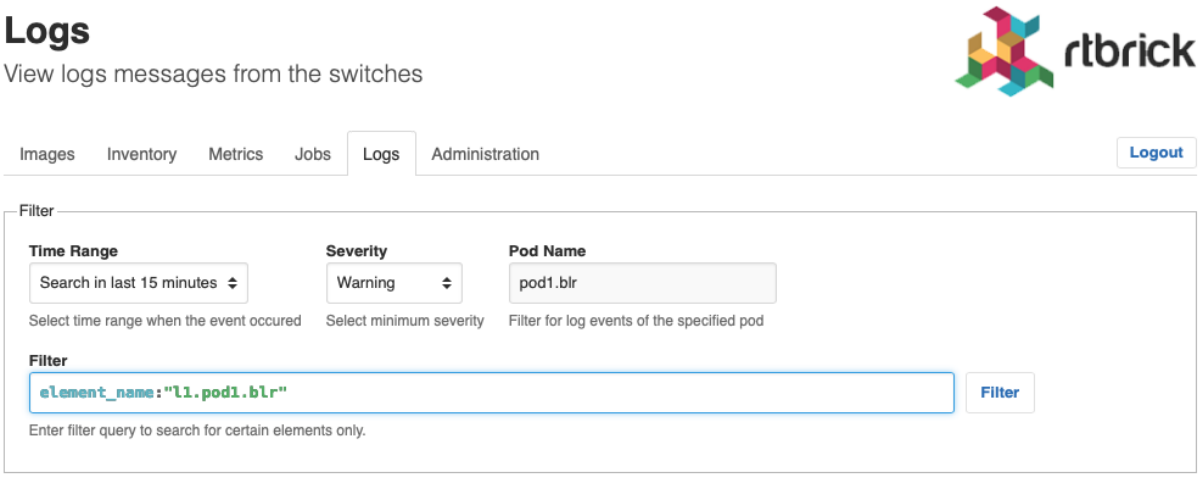


2. Click the timestamp of the event that you want to view.

4.3. Filtering log events

To filter the list of logs

1. Click the **Logs** tab. The list of all log events occurred in the network appear.



2. Specify the filter criteria to filter the log events.

5. Metric Management

5.1. Overview

In order to understand metric processing in RBMS it is key to understand how metrics are sampled on RBFS.

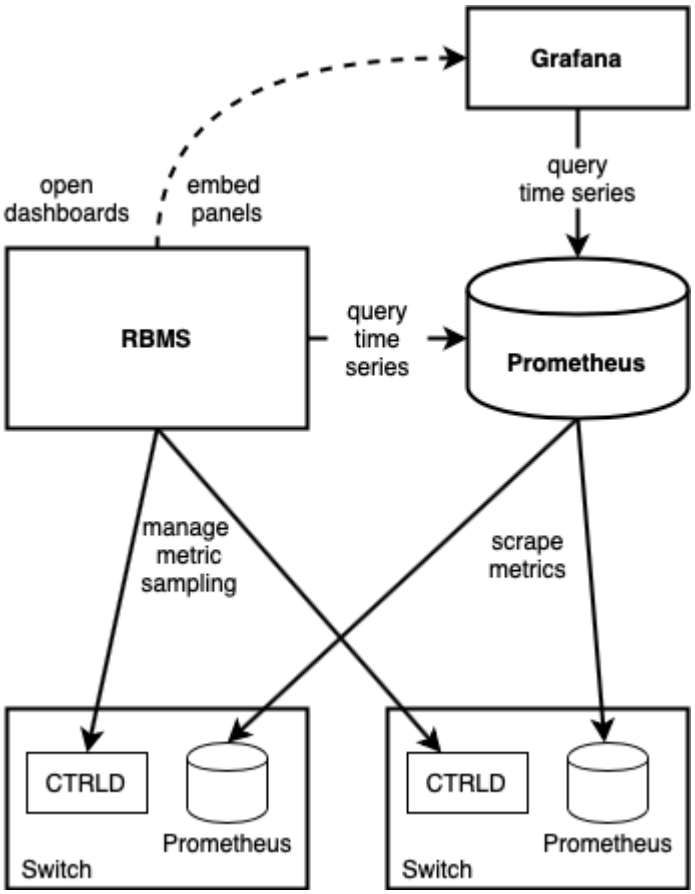
RBFS runs Prometheus, an open-source monitoring tool with built-in time series database, to sample metrics from the Brick Data Store (BDS). The BDS is an in-memory database developed by RtBrick and optimized for networking use cases. All configuration and state information is stored in BDS. BDS can be configured to expose certain BDS attributes as metrics in the Prometheus Exposition Format. Prometheus periodically samples the exposed values to create a time series over them. The Prometheus Query Language allows querying the time series data and to apply transformations and statistical computations.

Prometheus includes an alert manager to scan time series for alert conditions and to create a notification whenever an alert condition is satisfied. Since Prometheus runs on the switch the alert conditions are also evaluated on the switch.

All metrics and alerts that shall be enabled permanently by default are configured in the running configuration of the switch. CTRLD allows enabling and disabling metrics on-demand.

The main goal of RBMS is to provide quick access to metrics and time series visualization. RBMS runs a Prometheus instance to federate metrics from the Prometheus instances on the switches. Grafana, an open-source visualization platform, is used to visualize time series data.

The figure below summarizes how RBMS interfaces with Grafana and Prometheus.



The RBMS UI provides quick access to Grafana dashboards and embedds dashboard panels in the RBMS UI. In addition, RBMS queries Prometheus based on the configured metrics and the inventory data to provide quick access to the current metric values.

The Metrics Sampling and Monitoring Tutorial provides more details about the concepts outlined in this section.

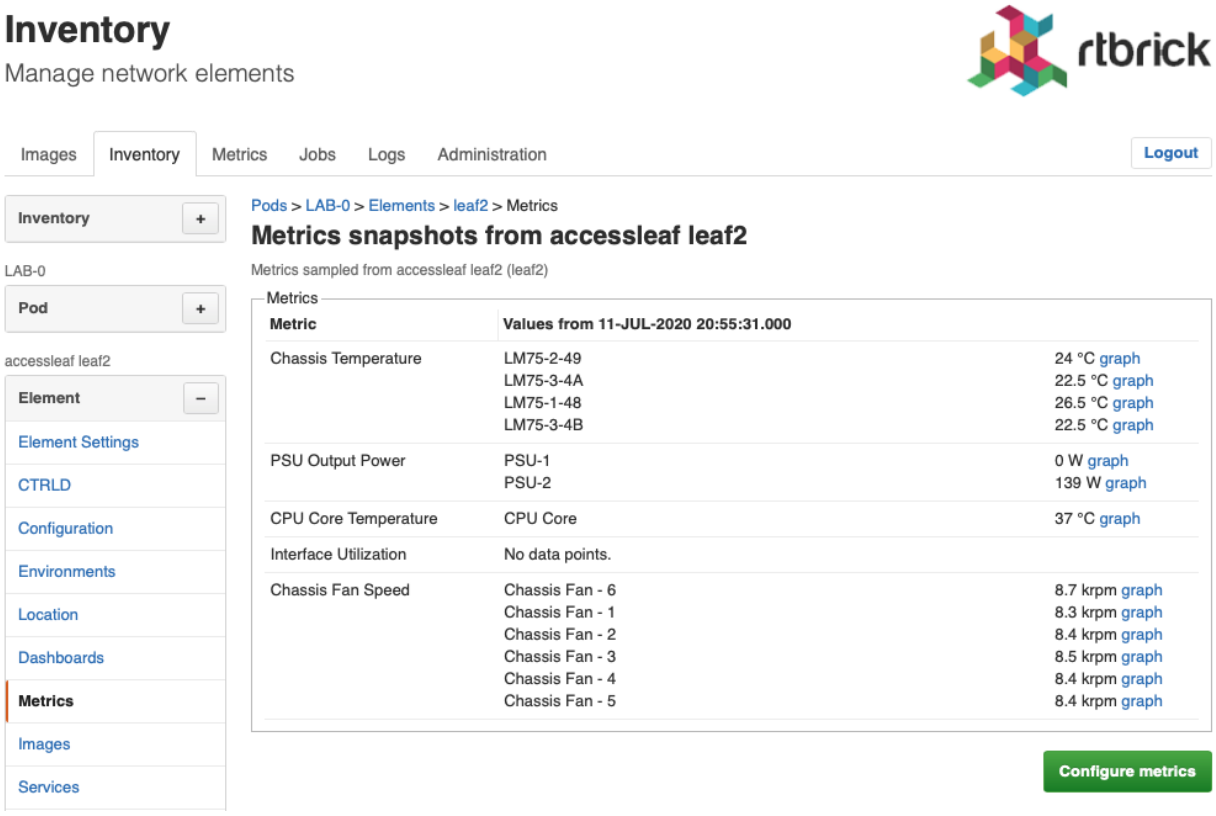
5.2. Working with metrics

5.2.1. Viewing metrics

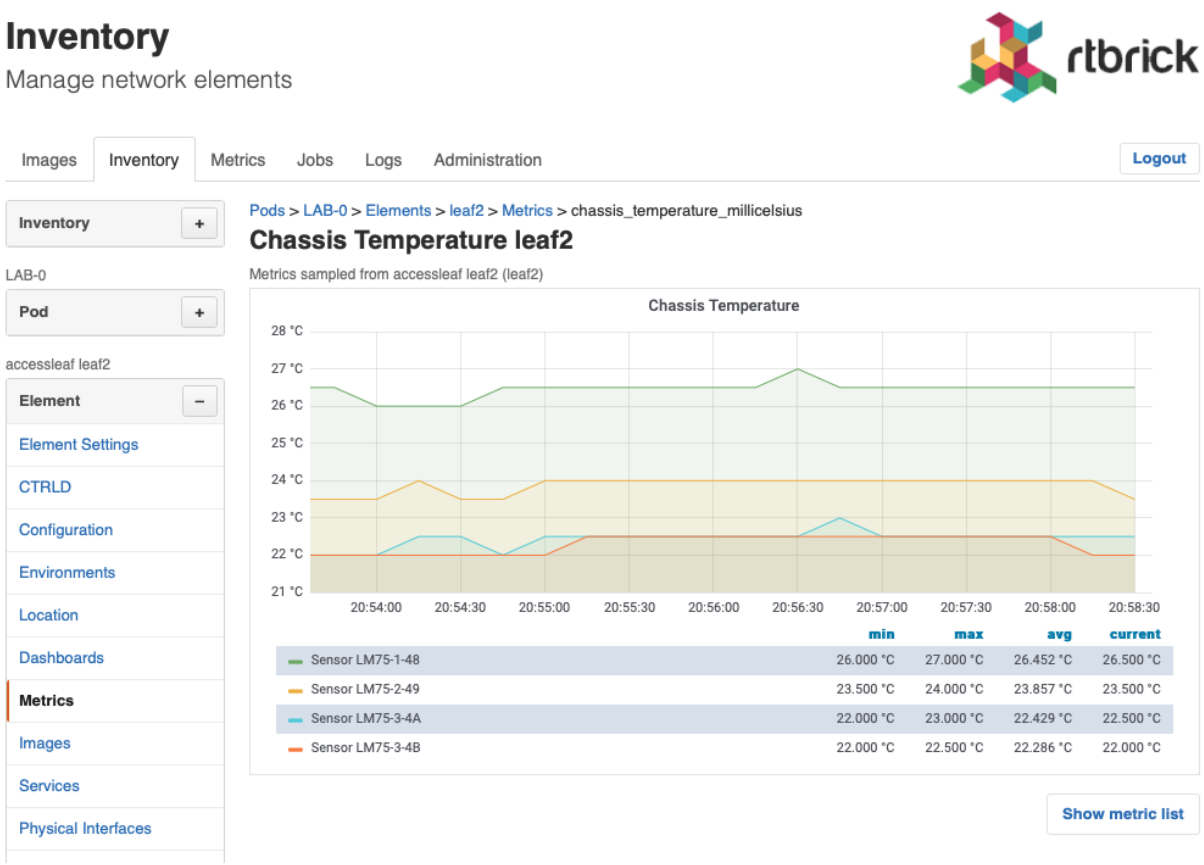
To view the metrics of an element

1. Click the **Inventory** tab. The list of pods appears.
2. In the pods group box, click on the elements link for pod that contains the element you want to view the metrics for. The list of elements appears.
3. In the elements group box, click on the element you want to view the metrics for.

4. Click **Metrics** in the left navigation pane. The list of metrics and their current values appears.



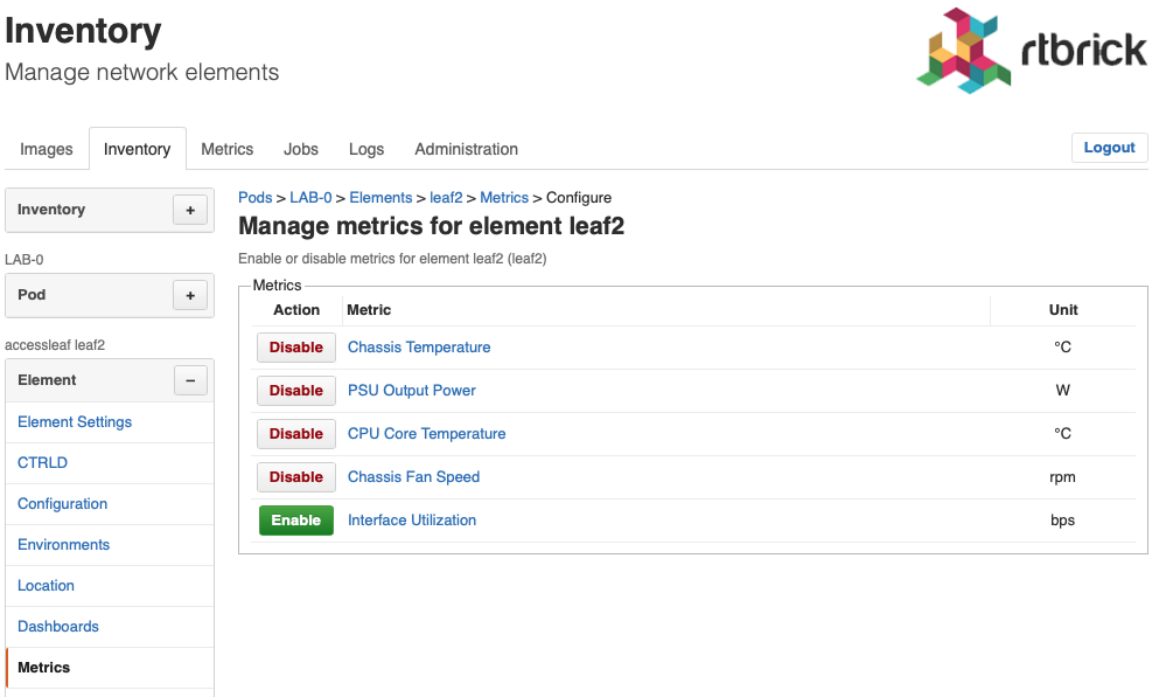
5. Click on **graph** to view the time series of a metric.



5.2.2. Enabling a metric

To enable a metric, go to the metric list view

1. Click **Configure metrics**. A list of available metrics appears.

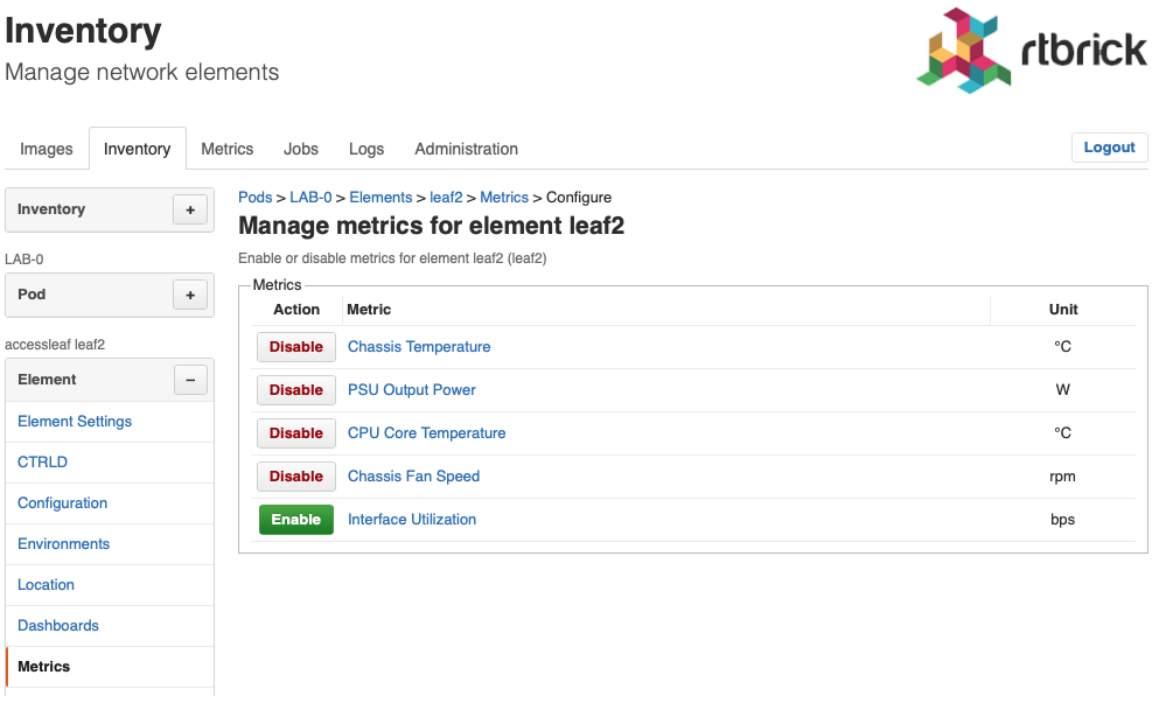


2. Click **Enable** for all metrics you want to enable.

5.2.3. Disabling a metric

To disable a metric, go to the metric list view

1. Click **Configure metrics**. A list of available metrics appears.

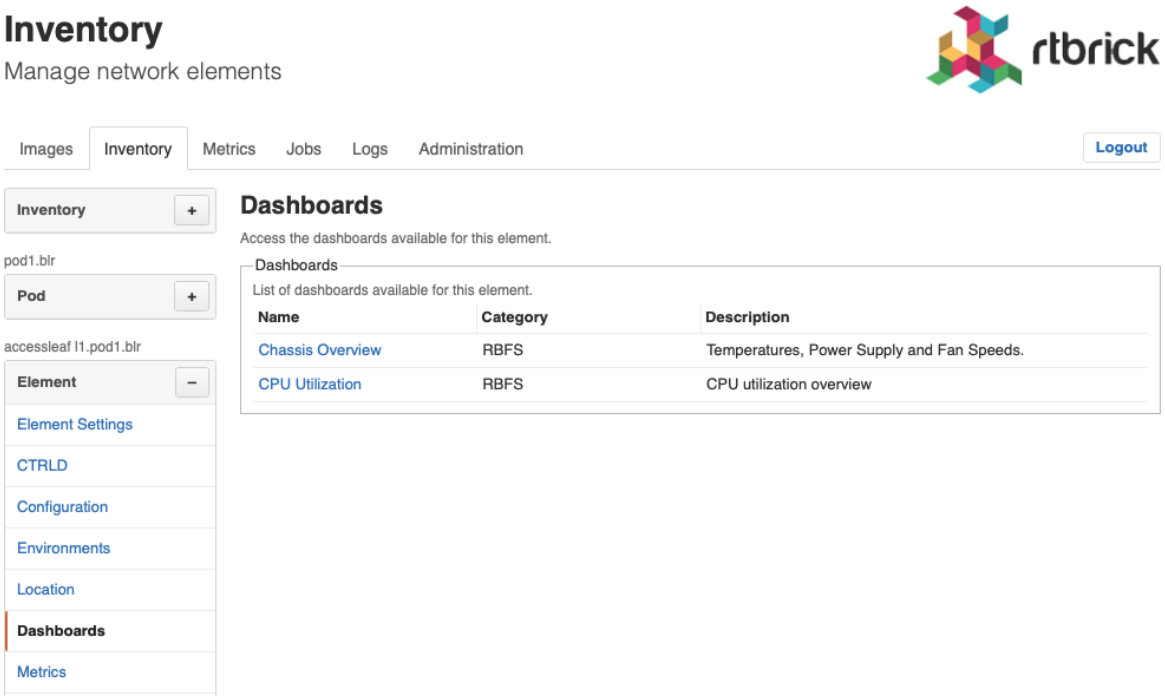


2. Click **Disable** for all metricy you want to disable.

5.2.4. Viewing element dashboards

To open a dashboards of an element

1. Click the **Inventory** tab. The list of pods appears.
2. Click on **Elements** in the left navigation pane to show the list of known elements.
3. Click on the element for which you want to access a dashboard. Use the filter to search for a particular element.
4. Click on **Dashboards**. The list of available dashboards appears.



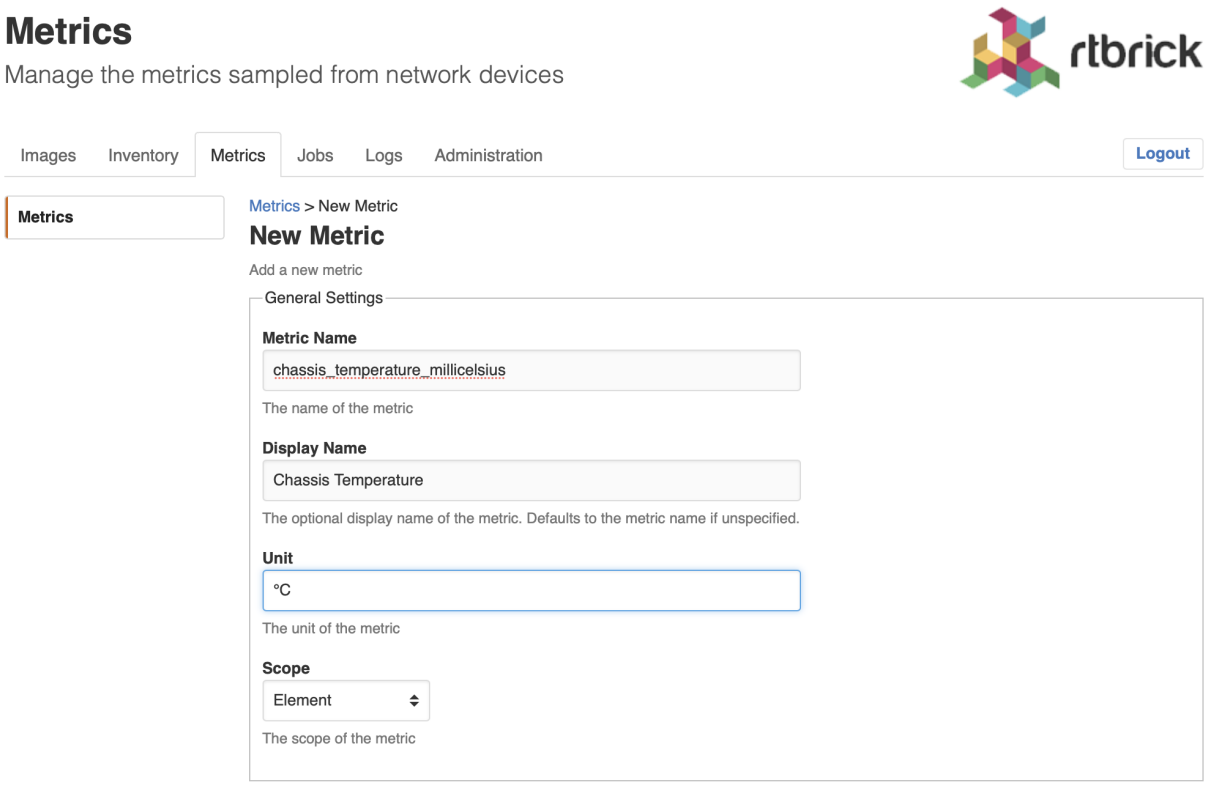
5. Click on the **Dashboard** you would like to view. RBMS opens the dashboard in Grafana.

5.3. Managing metrics

5.3.1. Adding a new metric

To add a metric

1. Click the **Metrics** tab. The list of metrics appears in the **Metrics** page.
2. In the **Metrics** page, click the **Add metric** button. The **New Metric** page appears.



3. In the **Metric Name** field, assign a unique metric name.

> The metric name should be in lower case. The name suffix should contain the metric unit. The name prefix should be used to group metrics. Use the _ as delimiter. For example *psu_powerout_milliwatts* or *psu_voltageout_millivolts*

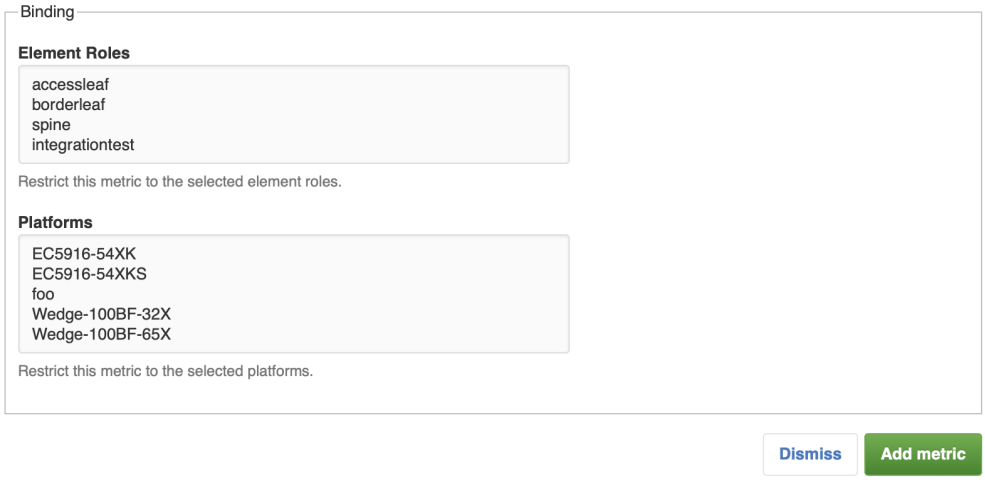
4. In the **Display Name** field, assign a descriptive metric name.
5. In the **Unit** field, specify the metric unit (e.g. °C, W, bps)
6. In the **Scope** field, select the scope of the metric.

The following metric scopes exist:

Metric Scope	Description
Element	The metric exists for the element (e.g. chassis temperature)
Physical Interface	The metric exists per physical interface (e.g. interface utilization)
Service	The metric exists per service or daemon (e.g. CPU and memory utilization of a daemon)

Logical Interface	The metric exists per logical interface.

7. Optionally restrict the metric to certain element roles and platforms.



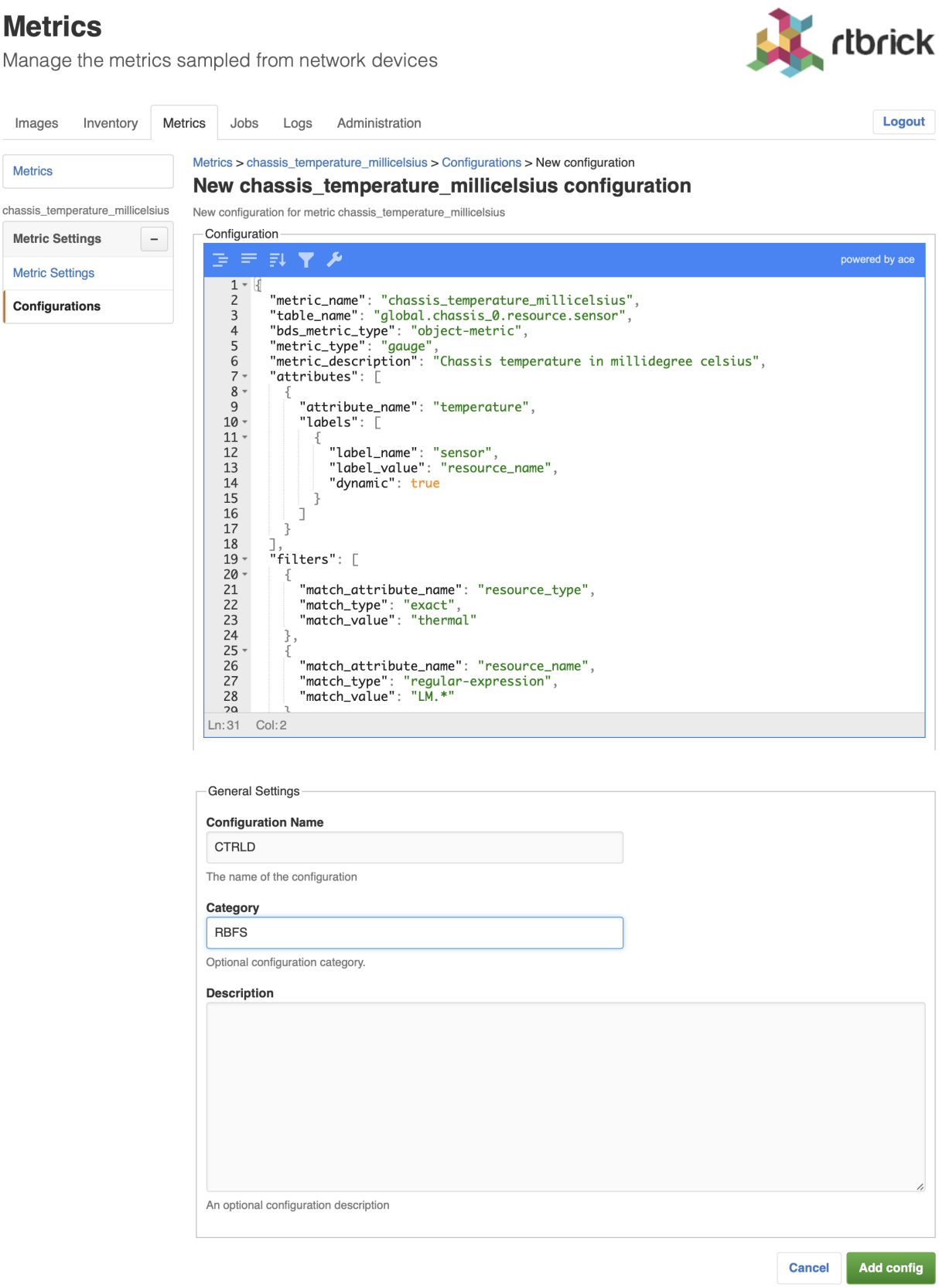
8. Click **Add metric**.

Adding the CTRLD configuration

The *CTRLD* configuration contains the JSON message to enable the metric via CTRLD.

To add the CTRLD configuration

1. Click **Configurations** in the left navigation pane. The list of configurations appears.
2. Click **Add config**. The New Configuration view appears.
3. Add the CTRLD JSON object to the JSON editor.



The Metrics sampling and monitoring tutorial provides more information about how to use CTRLD API to manage metrics.

4. In the **Configuration Name** field, enter **CTRLD**.

5. In the **Category** field, enter **RBFS**.
6. In the **Description** field, enter an optional description for the configuration.
7. Click **Add config** to add the new configuration.

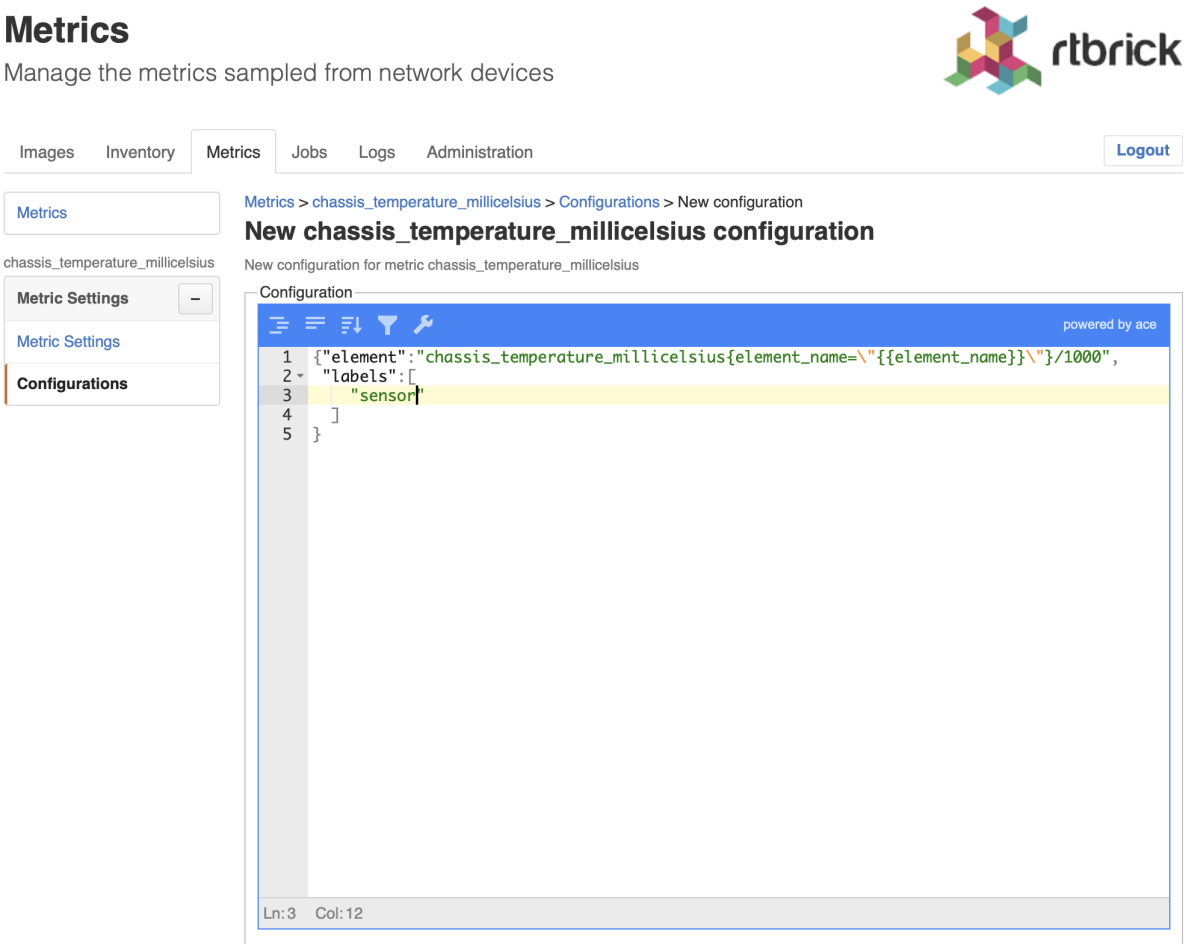
The value of the metric_name attribute in the CTRLD JSON object must be equal to the metric name in RBMS to avoid trouble.

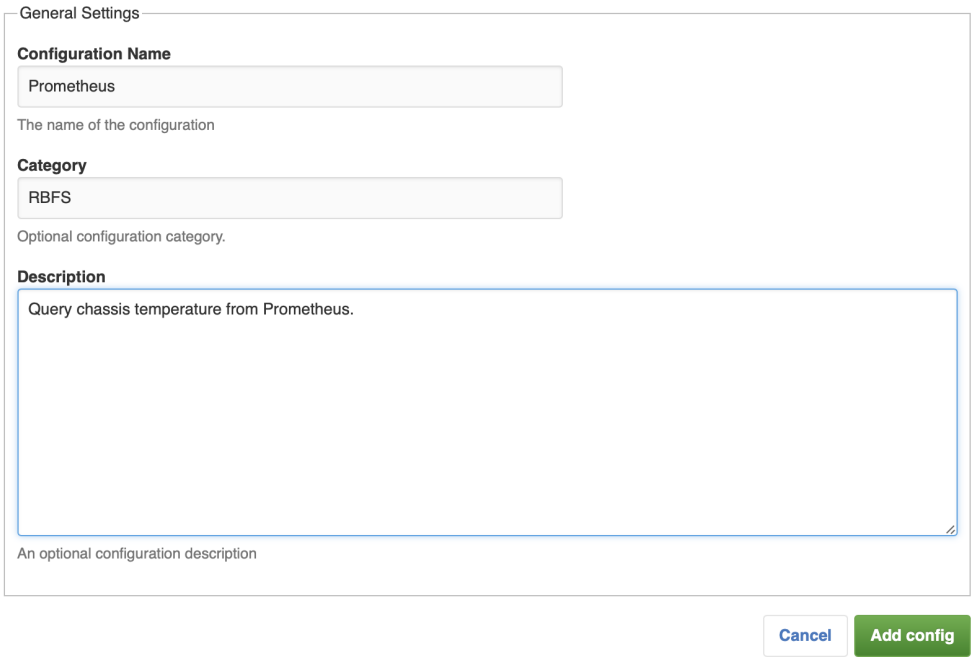
Adding the Prometheus configuration

The *Prometheus* configuration provides the Prometheus queries to fetch the metrics from Prometheus.

To add the Prometheus configuration.

1. Click **Configurations** in the left navigation pane. The list of configurations appears.
2. Click **Add config**. The New Configuration view appears.





3. Add the Prometheus JSON object to the JSON editor.

The Prometheus JSON object contains the following properties:

Attribute	Description
element	The Prometheus query to fetch the metric values for an element. RBMS replaces {{element_name}} with the name of the selected element.
ifp	The Prometheus query to fetch the metric values for a physical interface. RBMS replaces {{element_name}} with the name of the selected element and {{ifp_name}} with the name of the selected physical interface.
ifl	The Prometheus query to fetch the metric values for a logical interface. RBMS replaces {{element_name}} with the name of the selected element and {{ifl_name}} with the name of the selected physical interface.

service	The Prometheus query to fetch the metric values for a physical interfaces. RBMS replaces {{element_name}} with the name of the selected element and {{service_name}} with the name of the selected physical interface.
labels	String array with the names of the labels that shall be displayed in the metrics list.

4. In the **Configuration Name** field, enter **Prometheus**.
5. In the **Category** field, enter **RBFS**.
6. In the **Description** field, enter an optional description for the configuration.
7. Click **Add configuration** to add the new configuration.

5.3.2. Removing a metric

To remove a metric from RBMS

1. Click on the **Metrics** tab. The list of metrics appears.
2. Click on the metric you want to remove.
3. Click on **Remove metric**. A confirmation dialog appears.
4. Click on **Confirm** to remove the metric. Check the **force** option to remove the metric including the metric configurations.

5.4. Managing dashboards

5.4.1. Registering Dashboards

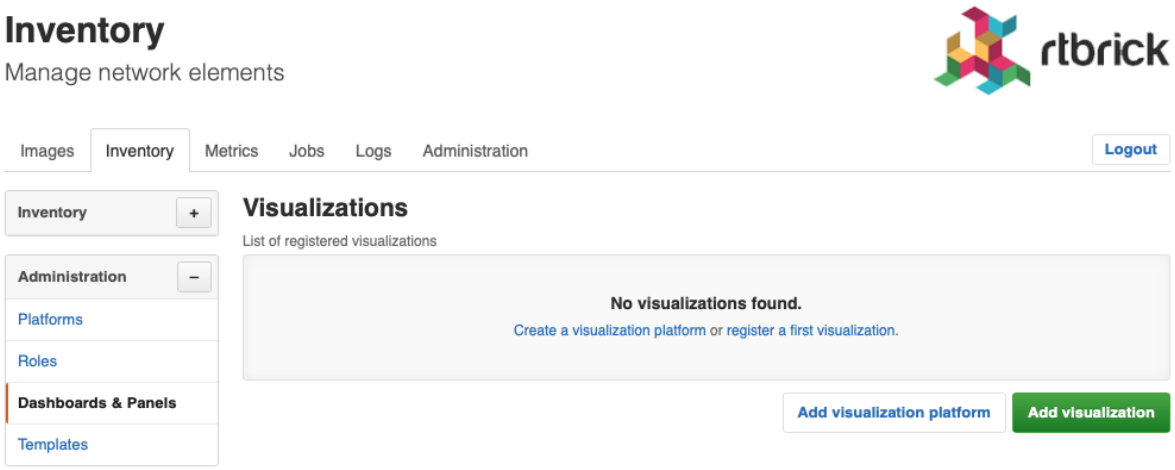
Configuring the visualization platform

RBMS needs to know the visualization platform hosting the dashboard that shall be accessible from RBMS.

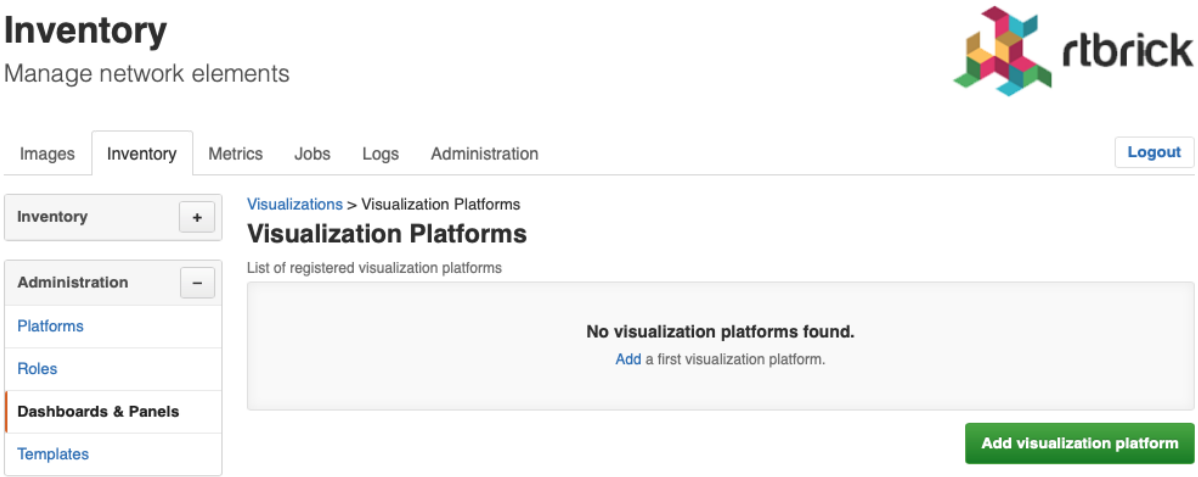
To register a visualization platform

1. Click the **Inventory** tab.

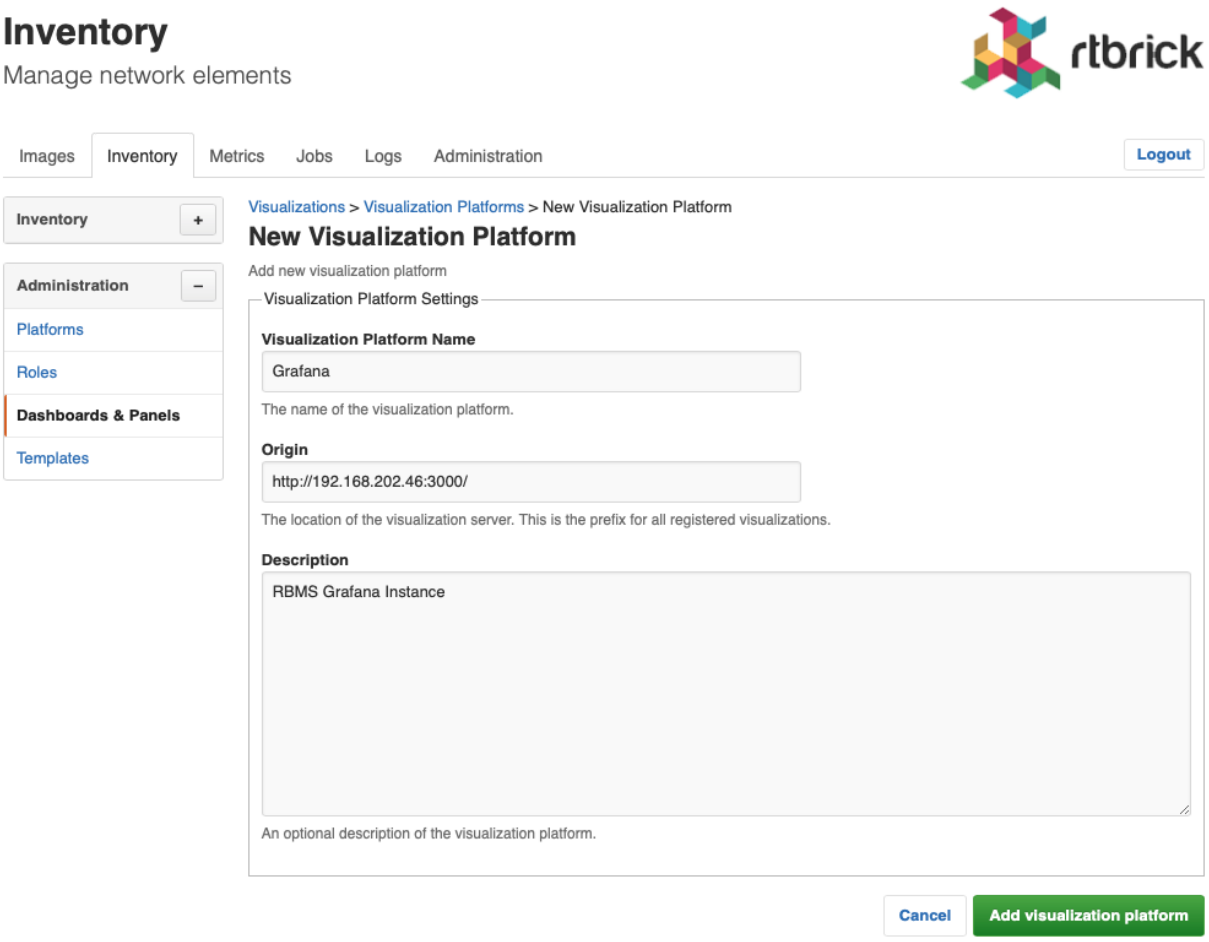
2. Click on **+** to expand the **Administration** menu.
3. Click on **Dashboard & Panels** in the navigation pane. The list of registered dashboards and panels appears.



4. Click on **Add visualization platform**. The list of known visualization platforms appears.



5. Click on **Add visualization platform** to add a new visualization platform. The New visualization platform appears.



In the **Name** field, provide a unique visualization platform name. In the **Origin** field, provide the origin of the visualization. In the **Description** field, provide an optional description of the visualization platform.

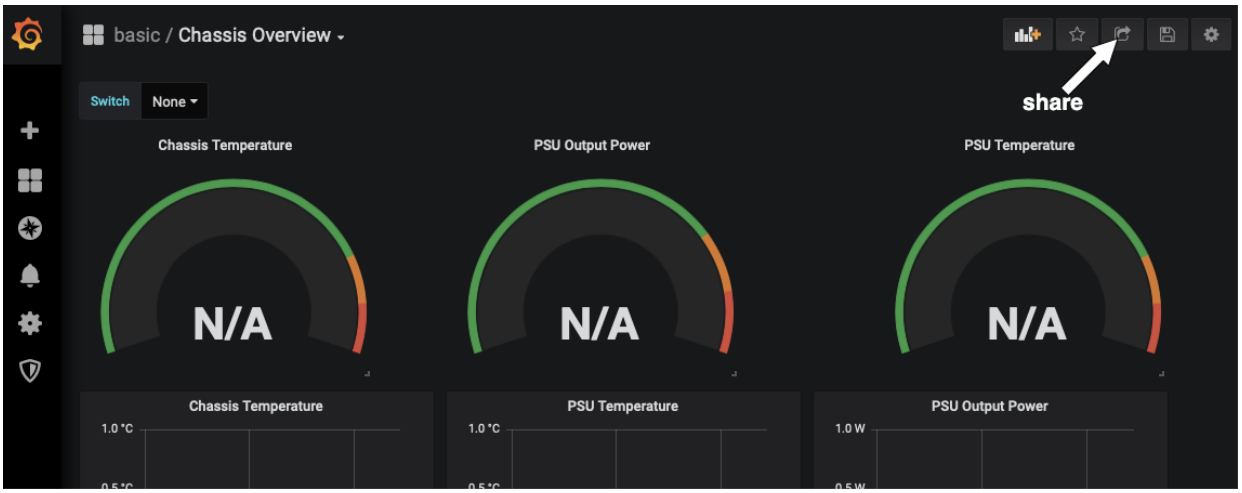
Click **Add visualization platform** to add the visualization platform.

Registering a dashboard

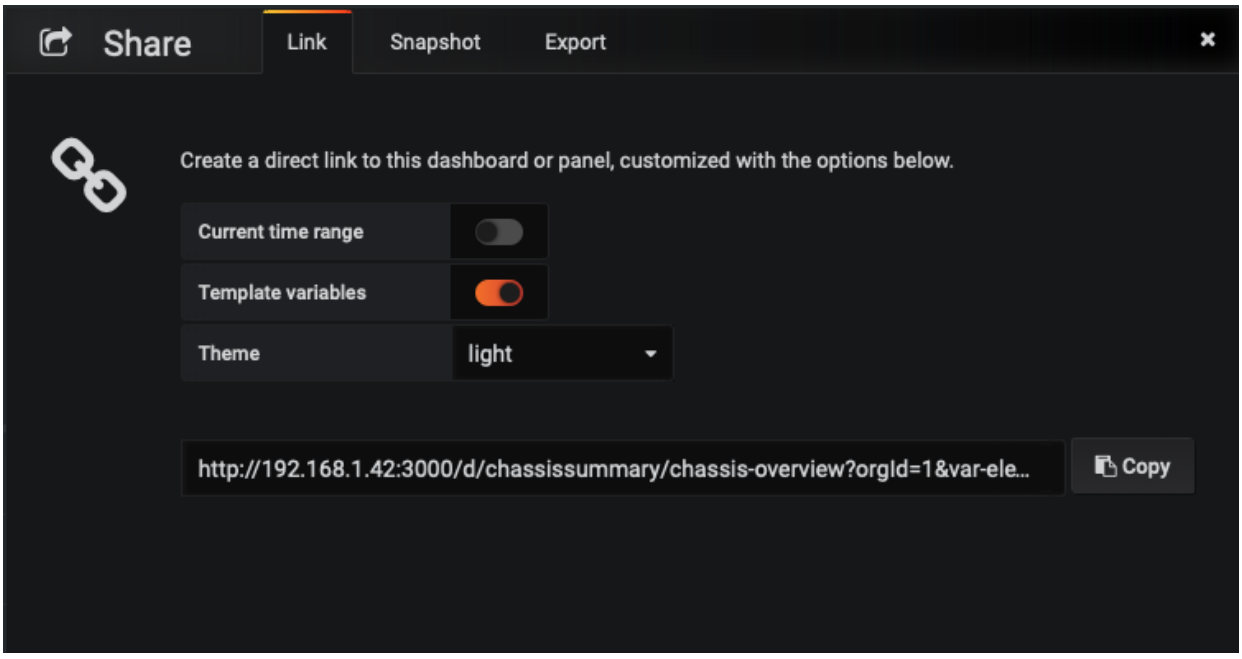
The dashboard must accept an element query parameter specifying the element for which the metrics shall be displayed.

To add a Grafana dashboard to RBMS

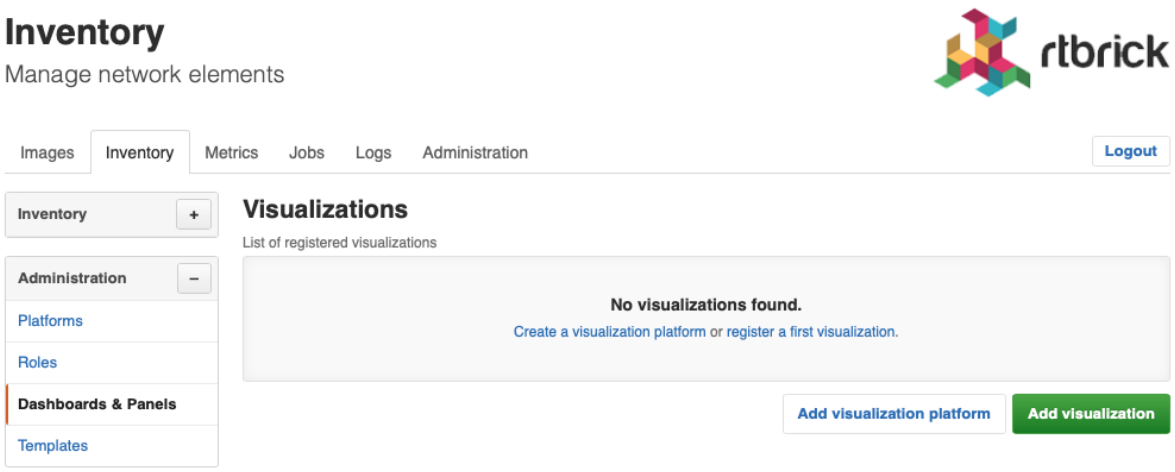
1. Open the dasbhoard in Grafana.
2. Click the **Share** Icon.



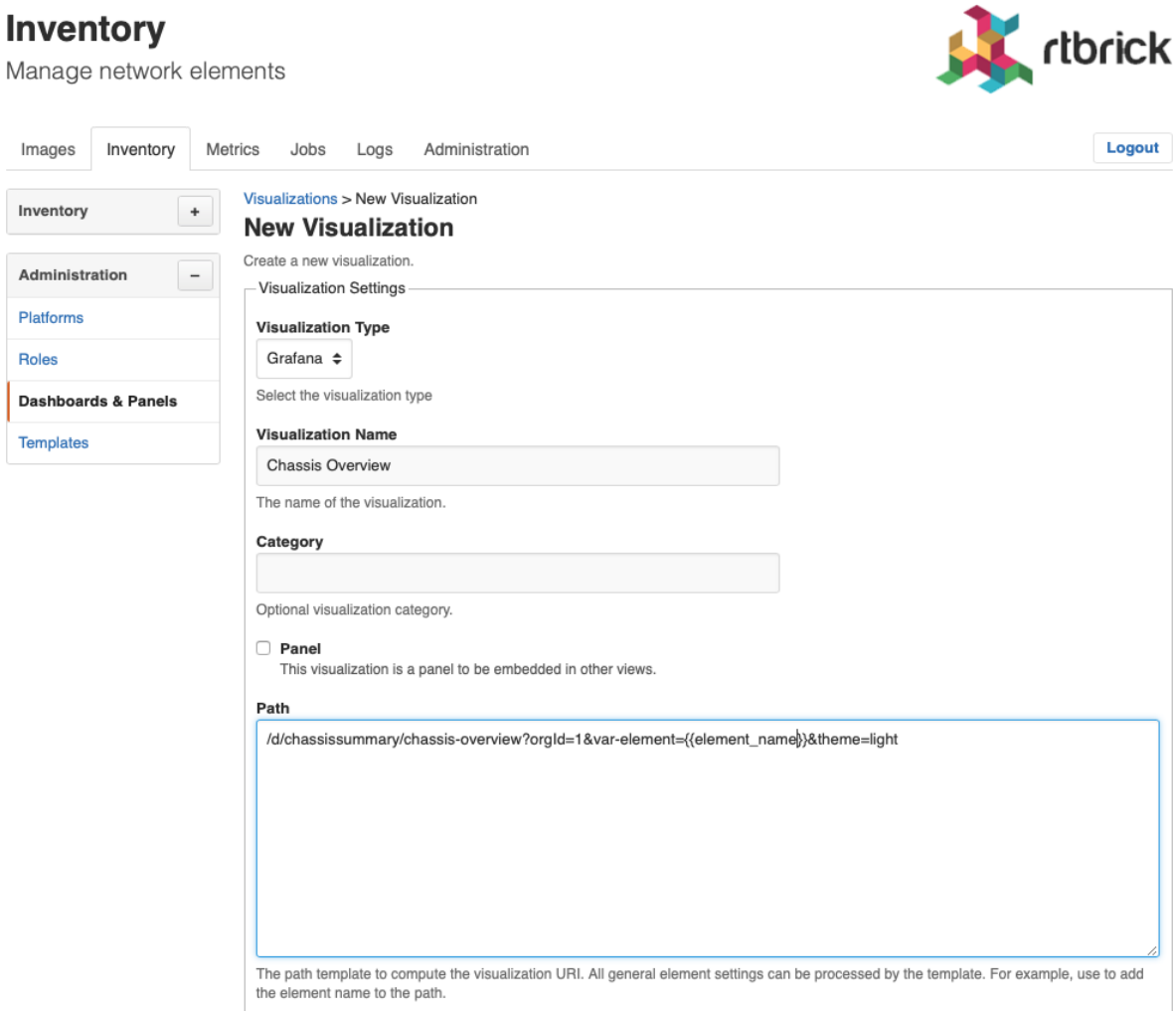
3. Uncheck the **Current time** option.
4. Select the *light* **theme**.
5. Click on **Copy** to copy the displayed link.



6. Proceed to RBMS.
7. Click on the **Inventory** tab.
8. Click on **+** to expand the **Administration** menu.
9. Click on **Dashboard & Panels** in the left navigation pane. The list of registered dashboard and panels appears.

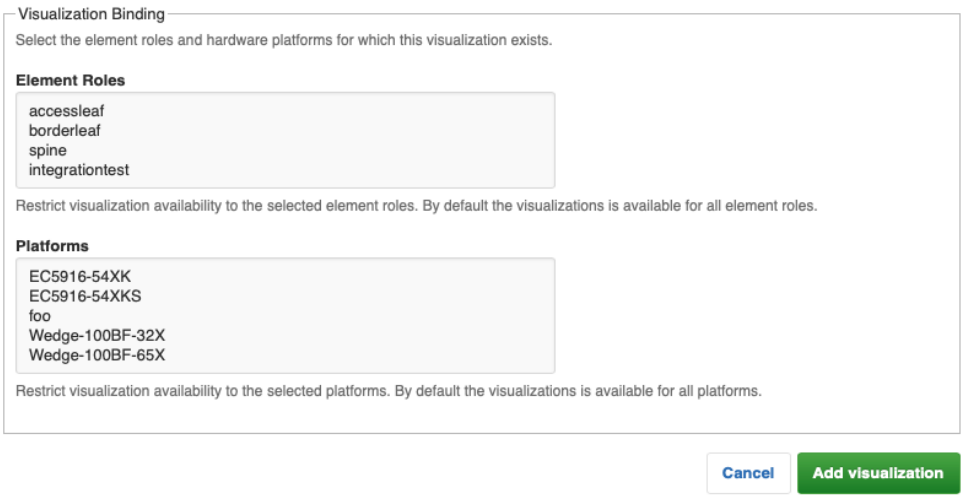


10. Click **Add visualization**. The New Visualization page appears.



11. From the **Visulization Platform** select box, select the Grafana instance that hosts the dashboard.
12. In the **Visualization Name** field, specify a unique descriptive name. The name is displayed in the dashboard list of an element.

13. In the **Description** field, add an optional dashboard description. The description is displayed in the element dashboard list.
14. Paste the link into the **URL** field. Assign {{element_name}} as value for the element variable declared in the dashboard. RBMS replaces {{element_name}} with the name of the currently displayed element.
15. Optionally restrict the dashboards to certain element roles or platforms.



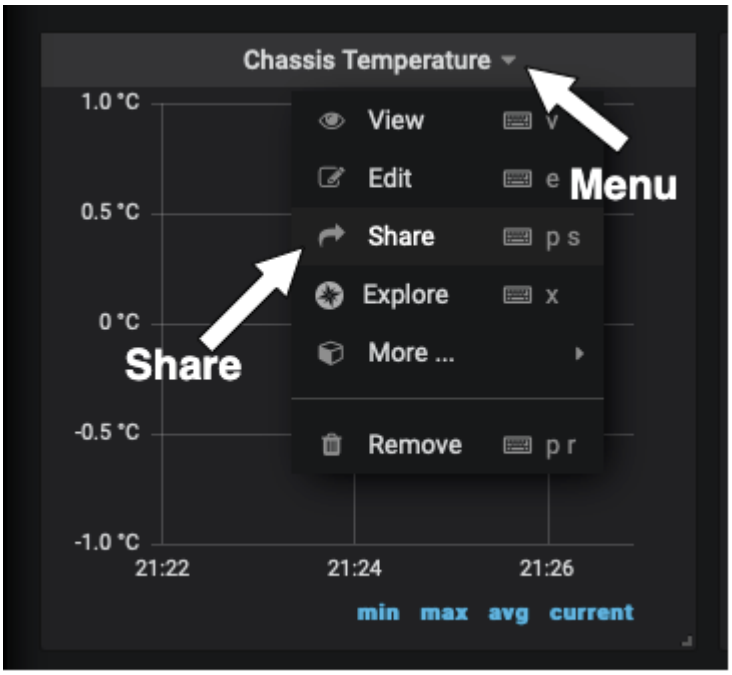
16. Click **Add visualization** to add the dashboard.

Registering a panel for a configured metric

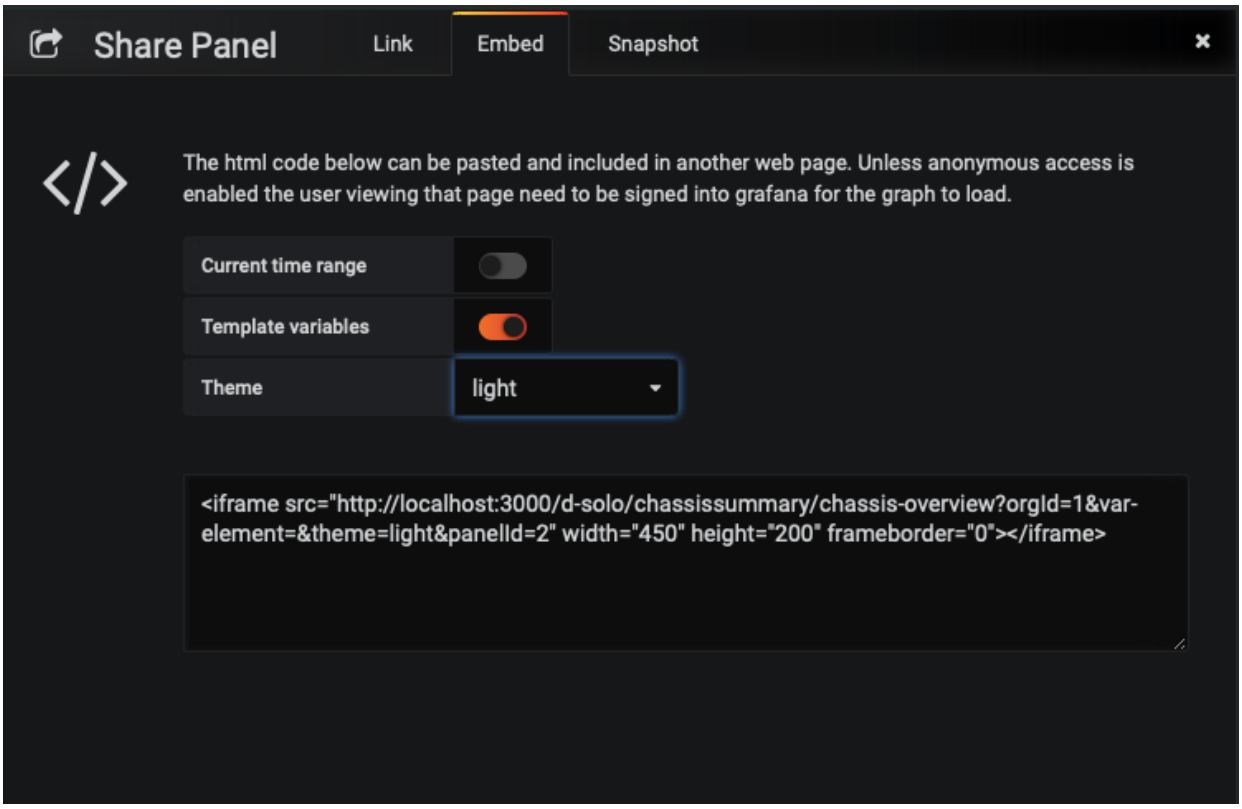
The panel must accept URL query parameters specifying the element for which the metric shall be displayed.

To add a Grafana panel to RBMS

1. Open the dasbhoard in Grafana.
2. Open the context menu for the panel you want to embedd in RBMS.
3. Click the **Share** menu.

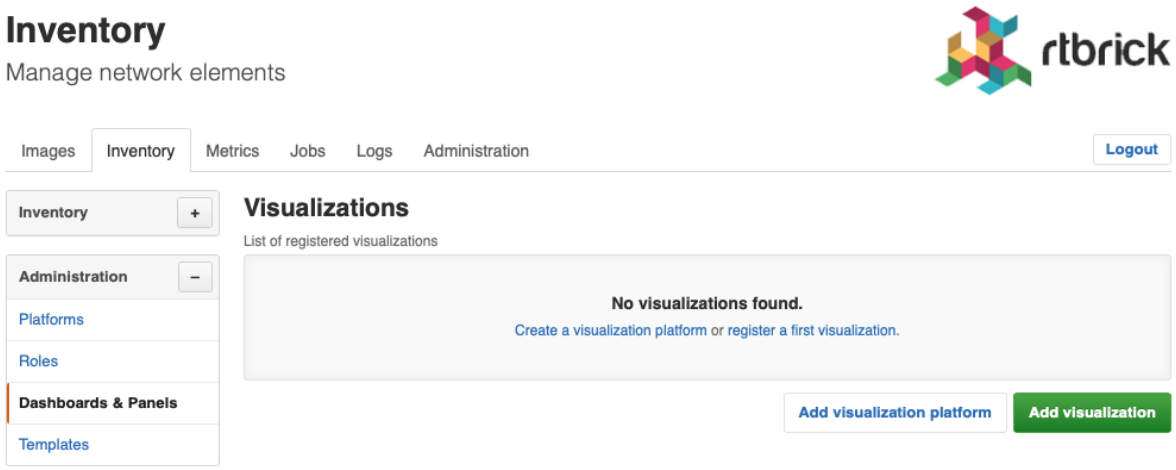


4. Uncheck the **Current time** option.
5. Select the *light* **theme**.
6. Click on **Copy** to copy the displayed link.

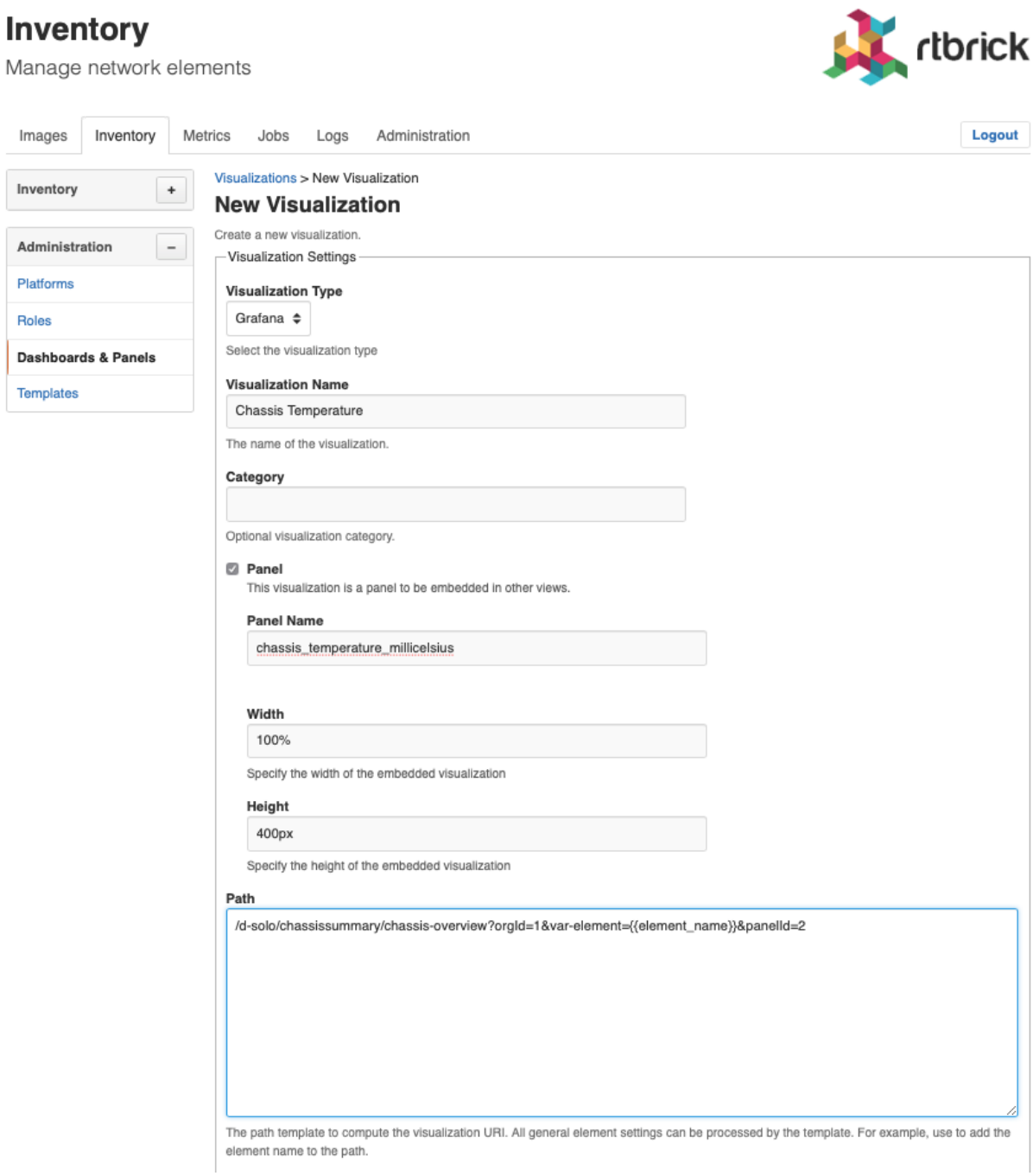


7. Proceed to RBMS.
8. Click on the **Inventory** tab.

9. Click on **+** to expand the **Administration** menu.
10. Click on **Dashboard & Panels** in the left navigation pane. The list of registered dashboard and panels appears.

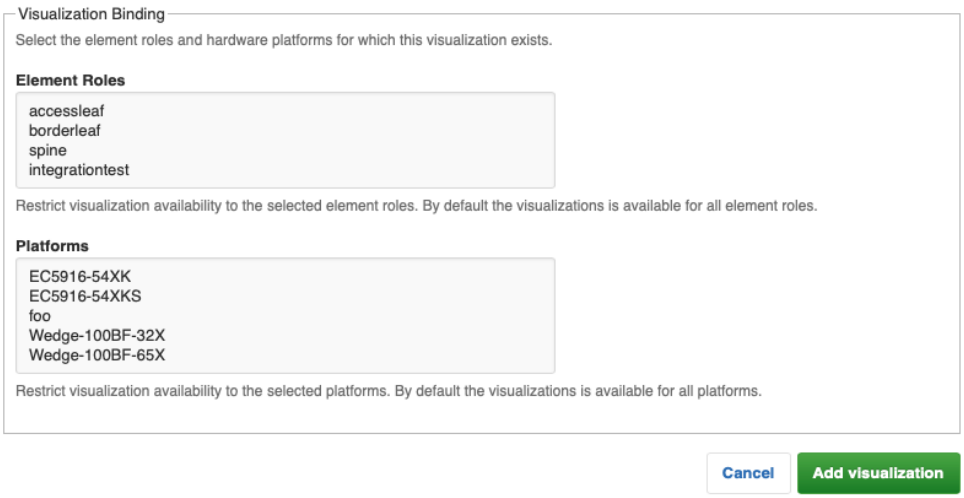


11. Click **Add visualization**. The New Visualization page appears.



12. From the **Visulization Platform** select box, select the Grafana instance that hosts the dashboard.
13. In the **Visualization Name** field, specify a unique descriptive name.
14. Check the **Panel** checkbox.
15. In the **Panel Name** field, add the name of the metric displayed in the panel.
16. In the **Width** field, add the width of the panel as absolute value (px or em) or in percent.
17. In the **Height** field, add the height of the panel as absolute value (px or em) or in percent.

18. In the **Description** field, add an optional dashboard description. The description is displayed in the element dashboard list.
19. Paste the link into the **URL** field. Assign {{element_name}} as value for the element variable declared in the dashboard. RBMS replaces {{element_name}} with the name of the currently displayed element.
20. Optionally restrict the panel to certain element roles or platforms.



21. Click **Add visualization** to add the panel.

5.4.2. Support for other visualization platforms

RBMS supports all visualization platforms accepting the element for which data shall be displayed as URL query parameter.

6. Metric Sampling and Monitoring

6.1. Metric sampling Overview

Metric sampling is configured through the CTRLD/RESTCONFD API. The sampled data is stored in Prometheus, an open source monitoring tool with a built-in time series database (TSDB), and can be queried from the switch using PromQL, the Prometheus Query Language. The CTRLD API also supports programming alert conditions in Prometheus Alert Manager.

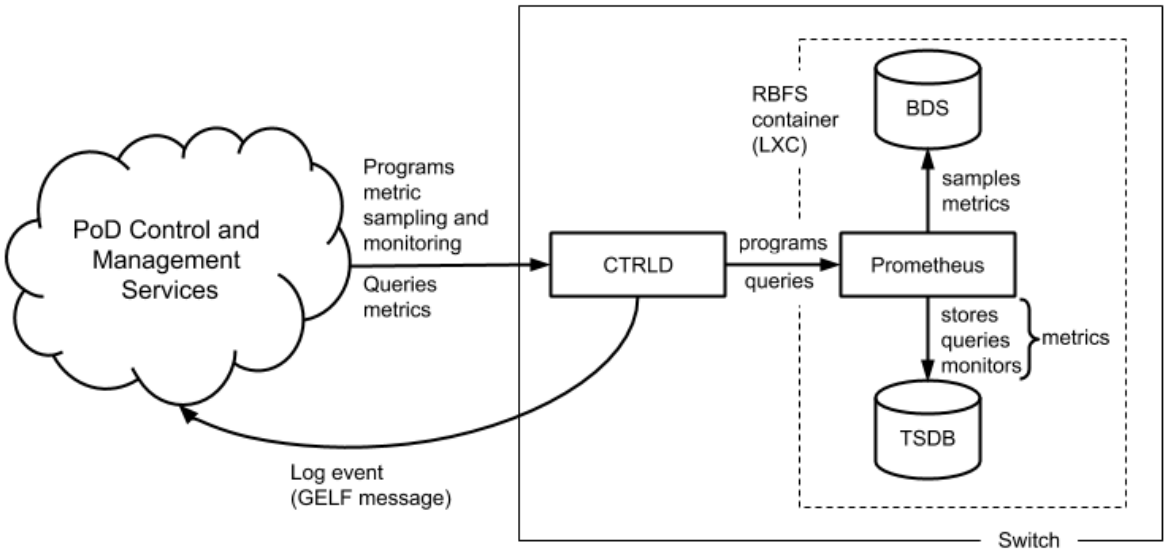


Figure 1. Metric sampling and monitoring overview.

Brick daemons feeding data into BDS are not depicted to keep the drawing simple.

6.1.1. BDS as Single Point of Truth

The Brick Data Store (BDS) is an object-oriented in-memory database that stores the switch configuration and operational state. BDS objects are typed objects, which means that every object and object attribute is of a certain type. BDS objects are described in schemas and organized in tables. One or more indexes per table exists to query objects. BDS supports sampling values from

- BDS object attributes and from
- BDS table indexes.

Every *numeric* BDS object attribute can be periodically sampled to create a time

series of the attribute value. In addition, BDS provides built-in converters for some attribute types that can be converted to numeric values. The bandwidth type is a good example. The bandwidth is stored as a string and consists of a numeric value and a data rate unit, for example, 100.000 Gbps. The built-in converter translates the bandwidth to a numeric value in bits per seconds.

BDS indexes are sampled if the number of objects in a table is of interest. This tutorial includes examples for object- and index-based metrics.

6.1.2. Metric Types

There exist two types of metrics:

- gauge
- counters

A gauge metric values are within a certain range and can basically be visualized as is or after applying a simple linear transformation. The value of a gauge metric can increase and decrease. A temperature value is an example for a metric of type gauge.

Counters increase until they are reset manually or by a restart (or by an overflow which is very unlikely to happen because of the length of the data word to store the counter value). The interesting aspect when working with counters is the delta of the count value between two samples, i.e. the derivation of the counter value over time. The derivation of the counter value is still an absolute value that needs to be put into perspective to the available resources to compute the resource utilization in percent. The CPU tick counters are examples for counter metrics.

6.1.3. Metric Labels

Metric labels separate metric instances from each other. Metric labels have either a static value or is read from a BDS object attribute.

The byte counters, for example, exist for each physical interface. The *ifp_name* label assigns the sampled counter values to the physical interface and is read from the *interface_name* attribute.

6.1.4. Sampling Rate and Retention Period

The sampling rate is 5 seconds and the retention period is five days. The configuration is built-in to the image and cannot be changed through the CTRLD API.

6.1.5. Metric Monitoring

Metric monitoring relies on the *Prometheus Alert Manager*. The alert manager notifies CTRLD about all satisfied alert conditions. CTRLD translates the notification and forwards the message to the configured log management system. CTRLD exposes an API for programming alert conditions and in turn programs the Prometheus Alert Manager based on the specified alert rules.

6.2. Temperature Monitoring

The first example in this tutorial samples and monitors temperature values to outline how to work with gauge metrics. Open the RBFS CLI and run show sensor temperature` to list all available temperature sensors.

Listing 1 - CLI output of temperature values.

```
supervisor@rtbrick>BNG: op> show sensor temperature
Name                      Temperature          Status
CPU Core                      49°C             PRESENT
LM75-1-48                     34°C             PRESENT
LM75-2-49                     33°C             PRESENT
LM75-3-4A                     29°C             PRESENT
LM75-3-4B                     31°C             PRESENT
PSU-1 Thermal Sensor 1        28°C             PRESENT
```

This switch has four chassis temperature sensors (LM75), a CPU temperature sensor (CPU Core) and a power supply unit (PSU) temperature sensor (PSU-1 Thermal Sensor 1). A switch typically has two independent power supply units. The second PSU of this switch was not attached in the lab environment.

The temperature is read from the temperature attribute of the *sensor_object* stored in the *global.chassis_0.resource.sensor* BDS table. The sensor object also includes a type (*resource_type* attribute) and a name (*resource_name* attribute). The unit of the temperature is millidegree celsius. An excerpt of the sensor schema definition is listed below:

Listing 2 - Excerpt from BDS sensor object schema definition.

```
      {
        "codepoint": 2,
        "name": "resource_name",
        "type": "string",
        "description": "Name of the resource"
      },
...
      {
        "codepoint": 4,
        "name": "resource_type",
        "type": "string",
        "description": "resource type"
      },
    ...
      {
        "codepoint": 33,
        "name": "temperature",
        "type": "uint32",
        "description": "temperature in millidegree celsius"
      }
```

Contact RtBrick professional services if you need help in finding the BDS table and attribute names.

6.2.1. Sampling Temperature Sensors

Based on the available sensors it makes sense to create three temperature metrics:

- *chassis_temperature_millicelsius* to sample the chassis temperature
- *cpu_temperature_millicelsius* to sample the CPU temperature and
- *psu_temperature_millicelsius* to sample the PSU temperature.

The CTRLD/RESTCONFD API exposes the `/api/v1/rbfs/elements/{{element}}/services/restconfd/proxy/restconf/data/rtbrick-config:time-series/metric={metric_name} endpoint. A HTTP PUT request to this endpoint configures a metric by either creating a new metric or replacing an existing metric with the specified {*metric_name*}. {*element*} contains the name of the element assigned in the element configuration file and defaults to the container name if no element name was specified. The default container name is rtbrick.

All metrics need to be labeled with the sensor name. In addition, a filter is needed to sample only the sensors for the respective type of temperature. The listings

below show the JSON objects to sample the chassis temperature as an example:

Listing 3 - JSON object to configure chassis temperature sampling.

```
{
    "rtbrick-config:metric": [
        {
            "name": "chassis_temperature_millicelsius",
            "table-name": "global.chassis_0.resource.sensor",
            "bds-type": "object-metric",
            "prometheus-type": "gauge",
            "description": "Chassis temperature in millidegree celsius",
            "filter": [
                {
                    "match-attribute-name": "resource_name",
                    "match-attribute-value": "LM.*",
                    "match-type": "regular-expression"
                },
                {
                    "match-attribute-name": "resource_type",
                    "match-attribute-value": "thermal",
                    "match-type": "exact"
                }
            ],
            "attribute": [
                {
                    "attribute-name": "temperature",
                    "label": [
                        {
                            "label-key": "sensor",
                            "label-value": "resource_name",
                            "label-type": "dynamic"
                        }
                    ]
                }
            ]
        }
    ]
}
```

The temperature metric is of type gauge (metric_type) and sample from a BDS object (bds_metric_type). The temperature value shall be sampled, which is of numeric type (uint32, see the schema definition above). The filter section makes sure that only thermal sensors are sampled and also filters for the LM sensors that measure the chassis temperature.

6.2.2. Querying the Chassis Temperature

The following PromQL query returns the chassis temperature in degree Celsius from the Prometheus running on the switch.

```
chassis_temperature_millicelsius / 1000
```

The next query converts the chassis_temperature from degree Celsius to Fahrenheit:

```
(chassis_stemperature_millicelsius / 1000) * 9 / 5 + 32
```

Both expressions are examples for simple linear transformations of a gauge metric. The queries can be used in Grafana to visualize the chassis temperature time series. The screenshot below shows a chassis temperature panel of a Grafana dashboard:

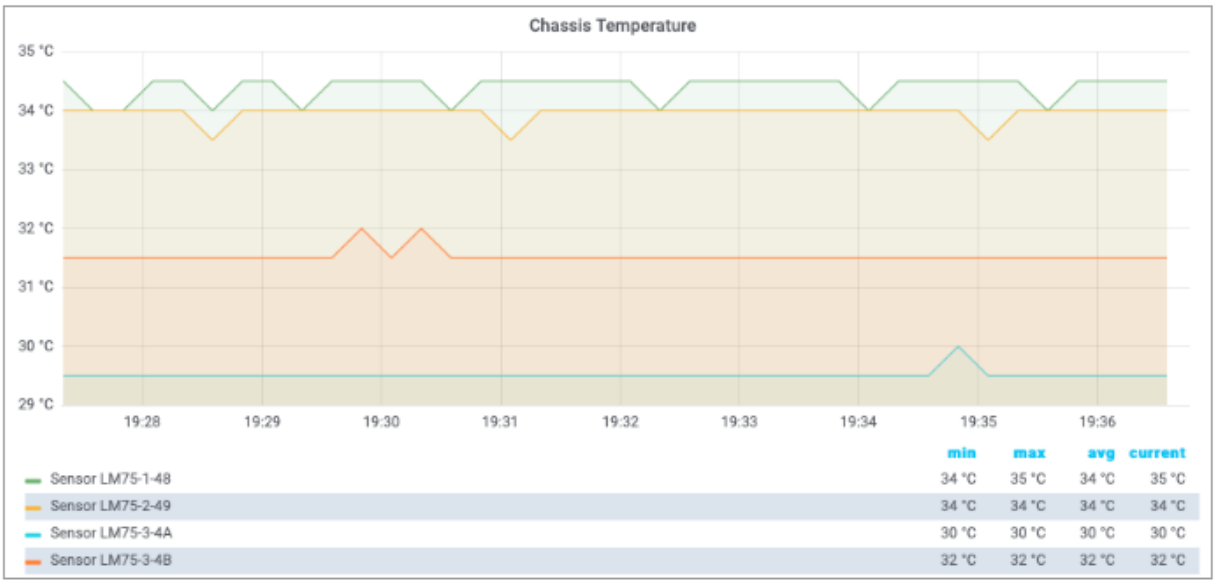


Figure 2. Chassis temperature Grafana panel.

The Grafana dashboard settings for the metrics used in this tutorial can be requested from RtBrick professional services.

6.2.3. Monitoring Temperature Values

A high temperature can damage the device or shorten its lifetime. Therefore it makes sense to monitor the temperature to get notified about critical temperature values. The alert condition is defined by the acceptable duration of exceeding a specified temperature value, for example, the average chassis temperature is not allowed to exceed 40°C over the last five minutes.

The temperature threshold and evaluation period are example values. The actual values must be taken from the hardware platform documentation or requested from the vendor.

The listing below shows the complete chassis temperature alert rule.

Listing 4 - Chassis temperature alert rule.

```
{
    "rtbrick-config:alert": [
        {
            "name": "ChassisTemperatureAlert",
            "group": "health",
            "interval": "1m",
            "expr": "avg_over_time(chassis_temperature_millidegrees[1m]) / 1000 >
40",
            "for": "5m",
            "level": "1",
            "summary": "The chassis temperature exceeded 40°C.",
            "description": "The {{$labels.element_name}} average chassis
temperature over the past 5 minutes exceeded 40°C."
        }
    ]
}
```

The alert rule evaluates every single minute (interval) whether the average temperature in the past minute exceeded 40 degrees (expr) and raises an alert if the expression is satisfied for 5 minutes (for), that is, 5 times in a row. The summary field contains a short description of the problem whereas the optional description field contains a more detailed message. The summary is mapped to the *short_message* GELF field and the description is mapped to the *full_message* GELF field. The severity is set to Alert (level). The level attribute values are taken from the GELF format which in turn took it from the Syslog protocol. The table below lists all supported levels:

GELF message severity levels

Level	**Description as in RFC 5424**	
	Name	**Comment**
0	Emergency	System is unusable
1	Alert	Action must be taken immediately
2	Critical	Critical conditions
3	Error	Error conditions
4	Warning	Warning conditions
5	Notice	Normal but significant condition
6	Informational	Informational messages
7	Debug	Debug-level messages

Every alert rule has a unique name (alert_rule_name). The PUT operation replaces

an existing alert rule with the same name. Every alert rule is assigned to exactly one alert group (alert_group). All alert rules in the same alert group with the same interval setting are evaluated at the same time.

The for attribute is optional. A similar alert rule can be implemented by omitting the for attribute and computing the average temperature over the past five minutes:

Listing 5 - Alternative chassis temperature alert rule.

```
{
    "rtbrick-config:alert": [
        {
            "name": "ChassisTemperatureAlert",
            "group": "health",
            "interval": "1m",
            "expr": "avg_over_time(chassis_temperature_millidegrees[5m]) / 1000 >
40",
            "level": "1",
            "summary": "The chassis temperature exceeded 40°C.",
            "description": "The {{$labels.element_name}} average chassis
temperature over the past 5 minutes exceeded 40°C."
        }
    ]
}
```

There is a subtle difference between both rules. Consider the following temperature values:

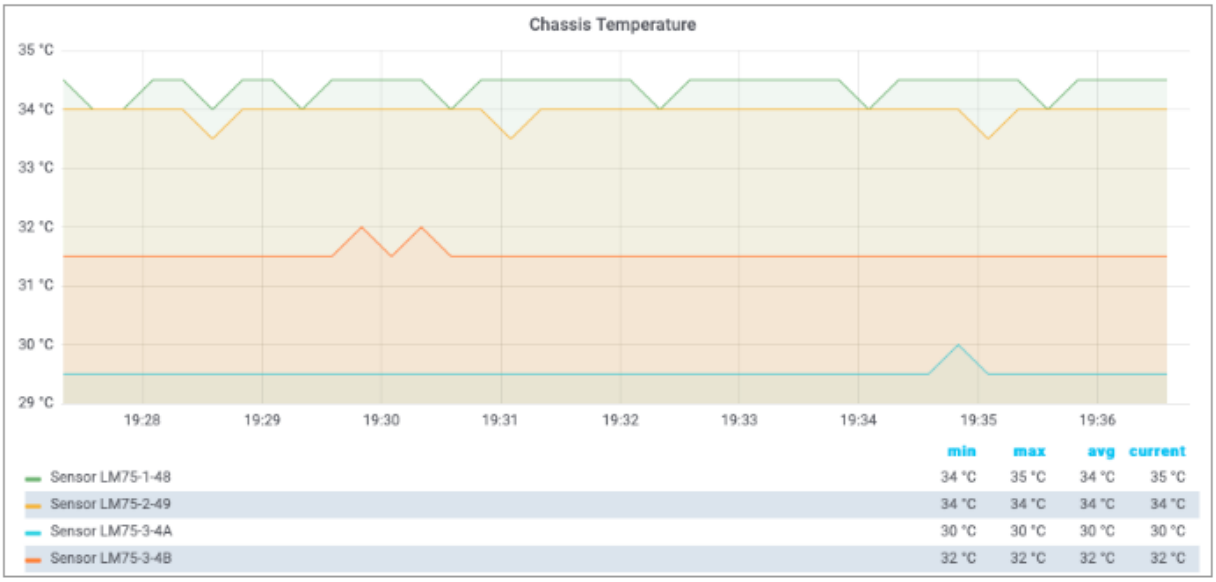


Figure 3. Chassis temperature values.

The first rule does not fire because the threshold is only exceeded for three times, whereas the second rule fires because the average over the past five minutes

exceeds 40°C. In fact, the second rule fires an alert albeit the temperature exceeds the alert threshold for 4 minutes only. How about using the min rather than the avg function, i.e. the temperature must exceed the threshold for five minutes? In this case, the rule wouldn't fire an alert if the chassis temperature is wobbling around the threshold.

The first rule aims to mitigate both effects:

- The first rule fires an alert if the chassis temperature is wobbling around the threshold but on average exceeds the threshold five times in a row.
- The first rule does not fire an alert in case of a chassis temperature spike as depicted in Figure 3, because a spike does not satisfy the rule five times in a row.

6.3. CPU Utilization

The second example measures the CPU utilization to outline how to work with counter metrics. Open the RBFS CLI and run show cpu usage to display the current CPU utilization.

Listing 6 - CPU core utilization CLI command.

```
supervisor@rtbrick>BNG: op> show cpu usage
Name          Total       User     System       Nice   I/O Wait       Idle        IRQ   Soft IRQ
cpu            4%         2%         2%         0%       0%         95%         0%        0%
cpu0           1%         0%         1%         0%       0%         99%         0%        0%
cpu1           16%        12%        4%         0%       0%         83%         0%        0%
cpu2           3%         2%         0%         0%       0%         96%         0%        0%
cpu3           10%        1%         9%         0%       0%         89%         0%        0%
cpu4           2%         1%         1%         0%       0%         97%         0%        0%
cpu5           4%         0%         4%         0%       0%         96%         0%        0%
cpu6           3%         3%         0%         0%       0%         97%         0%        0%
cpu7           0%         0%         0%         0%       0%         100%        0%        0%
```

The CPU provides a set of counters to measure the CPU utilization in jiffies /3/. A jiffy is the duration of a software clock tick, which is platform-dependent. By that, a jiffy is neither a constant period of time nor very meaningful to a human, which is why the counter values need to be put into perspective.

First, it is important to measure the total CPU utilization to see how busy the switch is. Secondly, if the CPU utilization is considerably high, it is interesting to find out which processes cause the high CPU utilization. Both aspects are addressed in this tutorial.

The time spend in user and kernel space needs to be divided by the total amount

of available processing time to compute the total CPU utilization:

total_cpu_utilization = (total_cpu_user_jiffy + total_cpu_sys_jiffy) / (total_cpu_total_jiffy)

where

- total_cpu_user_jiffy is the total amount of time spent in user mode in a sampling interval,
- total_cpu_sys_jiffy is the total amount of time spent in kernel mode in a sampling interval and
- total_cpu_total_jiffy is the total amount of computing time available in a sampling interval.

The cpu_total_utilization value is dimensionless. The value range is between 0 and 1. It can be converted into percentage by being multiplied by 100%.

total_cpu_utilization_percentage = total_cpu_utilization * 100%

The process total load ratio expresses the ratio a process load to the total load:

proc_total_load_ratio = (proc_cpu_user_jiffy + proc_cpu_sys_jiffy) / (total_cpu_user_jiffy + total_cpu_sys_jiffy)

where

- proc_cpu_user_jiffy is the process time spent in user mode in a sampling interval and
- cpu_sys_proc_jiffy is the process time spent in user mode in a sampling interval

The process_total_load_ratio value is dimensionless. The value range is between 0 and 1. It can be converted into percentage by being multiplied by 100%.

proc_total_load_ratio_percentage = proc_total_load_ratio * 100%

6.3.1. Sampling CPU Counters

The CPU counters are located in two different tables. The total CPU utilization can be sampled from the user_cpu_tick, sys_cpu_tick and total_cpu_tick attributes in the global.chassis_0.resource.cpu_usage table. This table contains the total

counters but also counters per supported hardware thread (virtual core).

The JSON objects below enables CPU counter sampling for the three mentioned counters:

Listing 7 - JSON object to enable total CPU utilization counter sampling.

```
{
  "rtbrick-config:metric": {
    "name": "total_cpu_total_jiffy",
    "table-name": "global.chassis_0.resource.cpu_usage",
    "bds-type": "object-metric",
    "prometheus-type": "counter",
    "description": "Total CPU utilization in jiffies",
    "attribute": [
      {
        "attribute-name": "total_cpu_tick",
        "label": [
          {
            "label-key": "cpu",
            "label-value": "cpu_id",
            "label-type": "dynamic"
          }
        ]
      }
    ]
  }
}
```

Listing 8 - JSON object to enable total user mode CPU utilization counter sampling.

```
{
  "rtbrick-config:metric": {
    "name": "total_cpu_user_jiffy",
    "table-name": "global.chassis_0.resource.cpu_usage",
    "bds-type": "object-metric",
    "prometheus-type": "counter",
    "description": "Total user CPU utilization.",
    "attribute": [
      {
        "attribute-name": "user_cpu_tick",
        "label": [
          {
            "label-key": "cpu",
            "label-value": "cpu_id",
            "label-type": "dynamic"
          }
        ]
      }
    ]
  }
}
```

Listing 9 - JSON object to enable total kernel CPU utilization counter sampling.

```
{
```

```
    "rtbrick-config:metric": {
        "name": "total_cpu_sys_jiffy",
        "table-name": "global.chassis_0.resource.cpu_usage",
        "bds-type": "object-metric",
        "prometheus-type": "counter",
        "description": "Total kernel CPU utilization in jiffies",
        "attribute": [
            {
                "attribute-name": "sys_cpu_tick",
                "label": [
                    {
                        "label-key": "cpu",
                        "label-value": "cpu_id",
                        "label-type": "dynamic"
                    }
                ]
            }
        ]
    }
}
```

6.3.2. Computing Total CPU Utilization From Counter Samples

The Prometheus Query Language /2/ provides functions to work with counters and also allows to put time series into perspective.

Some PromQL functions should be used for gauge metrics only others only for counter metrics.

The PromQL queries below computes the total user, kernel and user + kernel CPU utilization:

```
rate(total_cpu_user_jiffy{cpu="cpu"}[60s])
/ rate(total_cpu_total_jiffy{cpu="cpu"}[60s])

rate(total_cpu_sys_jiffy{cpu="cpu"}[60s])
/ rate(total_cpu_total_jiffy{cpu="cpu"}[60s])

( rate(total_cpu_user_jiffy{cpu="cpu"}[60s])
  + rate(total_cpu_sys_jiffy{cpu="cpu"}[60s]) )
/ rate(total_cpu_total_jiffy{cpu="cpu"}[60s])
```

The rate function computes the delta between two sampled count values. The rate function is optimized for counters and can detect counter resets by being aware that a counter value always increases unless a reset has taken place. The rate function handles counter resets properly. The cpu label filters for the total count values for all virtual cores.

The PromQL query below computes the virtual core utilization:

```
( rate(total_cpu_user_jiffy{cpu!="cpu"}[60s])
  + rate(total_cpu_sys_jiffy{cpu!="cpu"}[60s]))
/ rate(total_cpu_total_jiffy{cpu!="cpu"}[60s])
```

The cpu label identifies the virtual core. The BDS contains count values for each virtual core but also the total count over all virtual cores. The first dashboard queried the total count by filtering for cpu="cpu", whereas the second dashboards fetched the per virtual core counters by filtering for cpu!="cpu", i.e. by excluding the total count over all virtual cores from the result set.

The screenshots below show Grafana dashboard panels to display the computed total CPU utilizations and the utilization of the virtual cores.

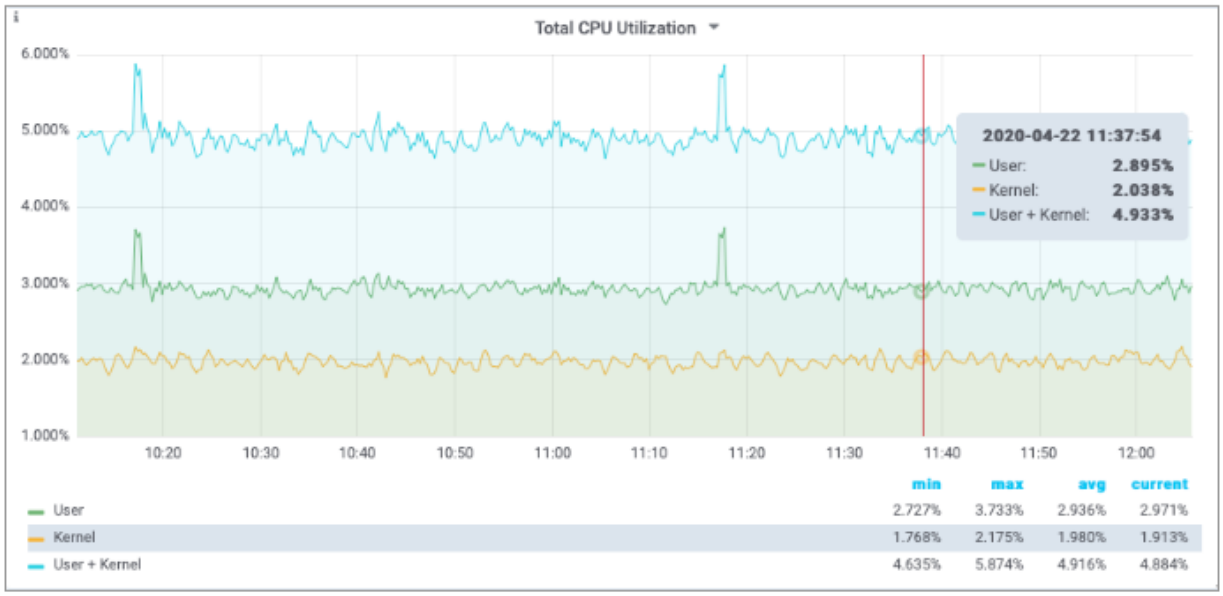


Figure 4. Total CPU utilization Grafana panel.

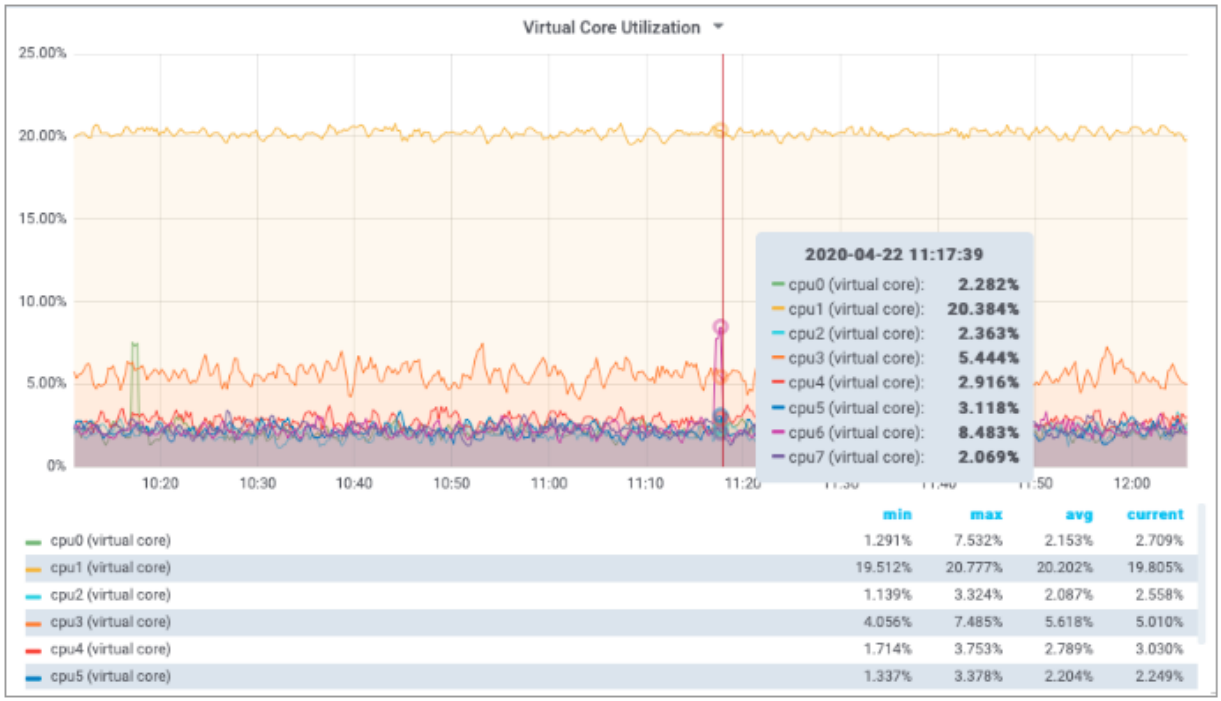


Figure 5. Virtual core utilization Grafana panel.

6.3.3. Sampling Process CPU Counters

The next step is to compute the per process CPU utilization. This requires to sample the process utilization counters of each process and put them into perspective of the total CPU counters.

The process CPU usage can be read from the cpu_user and cpu_sys attributes in the *global.chassis_0.resource.proc_usage* table. The process name can be read from the *process_name* attribute. The listings below configure user mode and kernel mode CPU utilization sampling per process:

Listing 10 - JSON object to enable process kernel mode CPU utilization sampling.

```
{
    "rtbrick-config:metric": {
        "name": "proc_cpu_sys_jiffy",
        "table-name": "global.chassis_0.resource.proc_usage",
        "bds-type": "object-metric",
        "prometheus-type": "counter",
        "description": "Process kernel mode CPU utilization in jiffies",
        "attribute": [
            {
                "attribute-name": "cpu_sys",
                "label": [
                    {
                        "label-key": "process",
                        "label-value": "process_name",
                        "label-type": "dynamic"
                    }
```

```
                ]
            }
        ]
    }
}
```

Listing 11 - JSON object to enable process user mode CPU utilization sampling.

```
{
    "rtbrick-config:metric": {
        "name": "proc_cpu_user_jiffy",
        "table-name": "global.chassis_0.resource.proc_usage",
        "bds-type": "object-metric",
        "prometheus-type": "counter",
        "description": "Process user mode CPU utilization in jiffies",
        "attribute": [
            {
                "attribute-name": "cpu_user",
                "label": [
                    {
                        "label-key": "process",
                        "label-value": "process_name",
                        "label-type": "dynamic"
                    }
                ]
            }
        ]
    }
}
```

6.3.4. Computing Process CPU Utilization From Counter Samples

The PromQL query puts the CPU counters of each process into perspective of the total CPU utilization.

```
( rate(proc_cpu_sys_jiffy[60s]) + rate(proc_cpu_user_jiffy[60s]) )
/ scalar(rate(total_cpu_total_jiffy{cpu="cpu"}[60s]))
```

The scalar function converts the one-dimensional total_cpu_total vector to a scalar to put the CPU process utilization into perspective.

Prometheus differentiates between vectors and scalars. Algebraic operations between two vectors, like the addition of the proc_cpu_sys and the proc_cpu_user vectors above, require that both vectors have the same labels. Otherwise no data points are returned by Prometheus, because a built-in filter excludes all items with different labels from the computation.

The screenshot below shows a Grafana panel to display the total CPU utilization of each brick daemon.

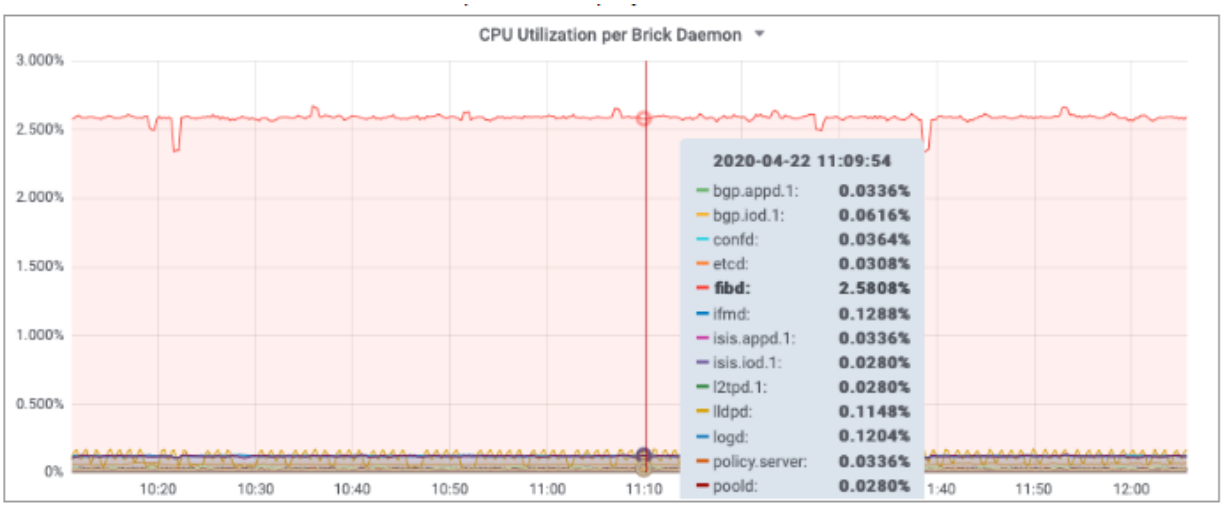


Figure 6. Brick daemon CPU utilization.

6.4. PPPoE Session Count

Sampling the number of PPPoE sessions is an example for a metric from a dedicated index table. The subscriber daemon maintains statistics of subscriber sessions grouped by access interface, access type and session lifecycle state. The show subscriber count command lists the session summary statistics

Listing 12 - Subscriber session count statistics

```
supervisor@BNG>rbms-tst00.vm.nbg.rtbrick.net: cfg> show subscriber count
                     Total        Setup        Established  Terminating  Standby
Summary              1000         22           978          0            0
  PPPoE              1000         22           978          0            0
  L2TP               0            0            0            0            0
  IPoE               0            0            0            0            0
  L2BSA              0            0            0            0            0
  Test               0            0            0            0            0
hostif-0/0/1         1000         22           978          0            0
  PPPoE              1000         22           978          0            0
  L2TP               0            0            0            0            0
  IPoE               0            0            0            0            0
  L2BSA              0            0            0            0            0
  Test               0            0            0            0            0
```

The Listing below configures a metric to sample the PPPoE counters from the subscriber session statistic.

Listing 13 - JSON object to enable PPPoE session count sampling

```
{
    "rtbrick-config:metric": {
```

```
        "name": "pppoe_session_count",
        "table-name": "local.access.subscriber.count",
        "bds-type": "object-metric",
        "prometheus-type": "gauge",
        "description": "PPPoE sessions",
        "attribute": [
            {
            "attribute-name": "pppoe_setup",
            "label": [
                {
                "label-key": "ifp_name",
                "label-value": "ifp_name",
                "label-type": "dynamic"
                },
                {
                "label-key": "access_type",
                "label-value": "pppoe",
                "label-type": "static"
                },
                {
                "label-key": "state",
                "label-value": "setup",
                "label-type": "static"
                }
            ]
            },
            {
            "attribute-name": "pppoe_established",
            "label": [
                {
                "label-key": "ifp_name",
                "label-value": "ifp_name",
                "label-type": "dynamic"
                },
                {
                "label-key": "access_type",
                "label-value": "pppoe",
                "label-type": "static"
                },
                {
                "label-key": "state",
                "label-value": "established",
                "label-type": "static"
                }
            ]
            },
            {
            "attribute-name": "pppoe_terminating",
            "label": [
                {
                "label-key": "ifp_name",
                "label-value": "ifp_name",
                "label-type": "dynamic"
                },
                {
                "label-key": "access_type",
                "label-value": "pppoe",
                "label-type": "static"
                },
                {
                "label-key": "state",
```

```
                "label-value": "terminating",
                "label-type": "static"
                }
            ]
            }
        ]
    }
}
```

The PPPoE session count can increase and decrease. Therefore the metric type must be gauge rather than counter.

Each count is labelled with the access type, the session state and the access interface name. This allows aggregation over all time-series to compute the total counts per interface and also for the entire switch in Prometheus.

Run show datastore subscriberd table local.access.subscriber.count to display the statistics raw data. The local.access.subscriber.count table contains one object for each interface. Each object contains an attribute for each combination of access type and lifecycle state.

Listing 14 - Subscriber session raw data.

```
show datastore subscriberd.1 table local.access.subscriber.count
Object: 0, Sequence 1, Last update: Fri Jan 12 09:48:35 GMT +0000 2024
  Attribute                               Type                           Length
Value
  ifp_name (1)                            string (9)                         13
hostif-0/0/1
  interval (2)                            interval (26)                       4
3000
  pppoe_setup (3)                         uint32 (4)                          4
22
  pppoe_established (4)                   uint32 (4)                          4
978
  pppoe_terminating (5)                   uint32 (4)                          4
0
  pppoe_standby (6)                       uint32 (4)                          4
0
  l2tp_setup (7)                          uint32 (4)                          4
0
  l2tp_established (8)                    uint32 (4)                          4
0
  l2tp_terminating (9)                    uint32 (4)                          4
0
  l2tp_standby (10)                       uint32 (4)                          4
0
  ipoe_setup (11)                         uint32 (4)                          4
0
  ipoe_established (12)                   uint32 (4)                          4
0
  ipoe_terminating (13)                   uint32 (4)                          4
0
  ipoe_standby (14)                       uint32 (4)                          4
```

```
0
  l2bsa_setup (15)                        uint32 (4)                      4
0
  l2bsa_established (16)                  uint32 (4)                      4
0
  l2bsa_terminating (17)                  uint32 (4)                      4
0
  l2bsa_standby (18)                      uint32 (4)                      4
0
  test_setup (19)                         uint32 (4)                      4
0
  test_established (20)                   uint32 (4)                      4
0
  test_terminating (21)                   uint32 (4)                      4
0
  test_standby (22)                       uint32 (4)                      4
0
```

6.5. Count of Received IPv4 Unicast Prefixes

Sampling the number of received unicast prefixes is an example for an index based metric. The IPv4 unicast prefixes are stored in the *instance*.default.ribd.1.fib-local.ipv4.labeled-unicast table, which exists per routing instance with *instance* being the instance name. The prefix count can be read by sampling the active-entry-count attribute of the primary index. The listing below shows the JSON object to sample the active PPPoE sessions:

Listing 15 - JSON object to enable PPPoE session count sampling

```
{
    "rtbrick-config:metric": {
        "name": "default_ipv4_unicast_prefix_count",
        "table-name": "default.ribd.1.fib-local.ipv4.unicast",
        "bds-type": "index-metric",
        "index-name": "primary",
        "prometheus-type": "gauge",
        "description": "IPv4 unicast prefixes default instance",
        "attribute": [
            {
                "attribute-name": "active-entry-count"
            }
        ]
    }
}
```

The prefix count can increase and decrease. Therefore the metric type must be gauge rather than counter.

Run show datastore ribd schema table table-name default.ribd.1.fib-local.ipv4.unicast to inspect the definition of the default.ribd.1.fib-local.ipv4.unicast table.

Listing 16 - Excerpt of the table definition CLI output

```
$ show datastore fibd schema table-name default.ribd.1.fib-local.ipv4.labeled-
unicast
{
  "table": {
    "type": "rib_fiblocal_v4_table",
    "object": "rib_entry",
    "table_objects": {
      "shared_object": "generic_table_attributes",
      "app_objects": [
        "generic_table_attributes"
      ]
    },
    "index": [
      {
        "name": "primary",
        "type": "radix",
        "immutable": true,
        "key": [
          "prefix4"
        ]
      },
 ...
```

The primary index uses the IPv4 prefix (prefix4) as key and contains an object per prefix. Counting the objects therefore represents the stored prefixes.

6.6. Metric Management

A HTTP GET request to the /api/v1/rbfs/elements/{{element}}/services/restconfd/proxy/restconf/data/rtbrick-config:time-series/metric=/name CTRLD/RESTCONFD API endpoint lists all metrics configured on the switch. A HTTP GET request to `/api/v1/rbfs/elements/{{element}}/services/restconfd/proxy/restconf/data/rtbrick-config:time-series/metric={metric_name} returns the complete metric settings. {element} is the assigned element name and {metric_name} contains the name of the requested metric.

Metric sampling is stopped by sending a HTTP DELETE request to the /api/v1/rbfs/elements/{{element}}/services/restconfd/proxy/restconf/data/rtbrick-config:time-series/metric={metric_name} RESTCONFD API endpoint to remove the metric settings from the switch configuration. More information can be found in the CTRLD/RESTCONFD API /1/.

6.7. Grafana Dashboards

Grafana can visualize time series data from Prometheus /5/. Grafana can query the Prometheus instance on RBFS by using CTRLD as proxy:

```
http://<SWITCH_MGMT_IP>:19091/api/v1/rbfs/elements/rtbrick/services/PROMETHEUS/pro
xy/
```

The downside of this approach is that a Prometheus datasource needs to be created in Grafana for every switch. In addition, all dashboards must be created per switch too, because a dashboard panel can operate on a single datasource only. Fortunately, Prometheus can federate data from other Prometheus instances /6/. By that, all sampled metrics get accessible through a single Prometheus instance. In combination with Grafana dashboard variables, a dashboard can be configured to access all existing switches.

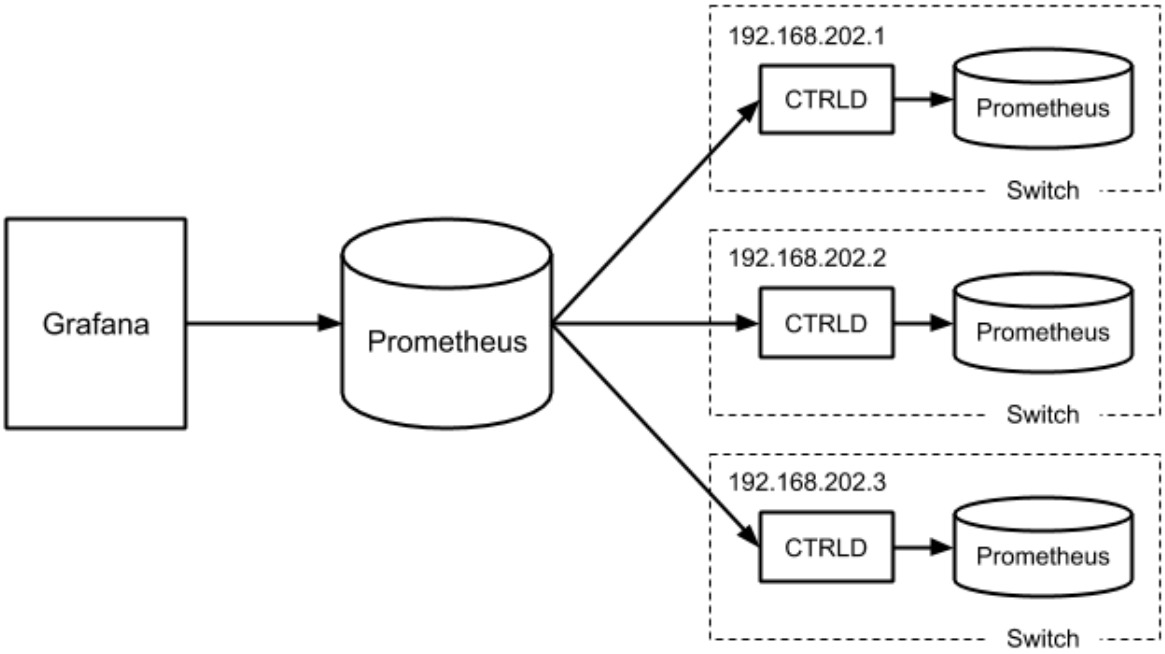


Figure 7. Prometheus federation.

The federating Prometheus instance can assign new label names. This allows to assign a unique element_name label value, if the element name is not specified on the switches and defaults to rtbrick. The listing below shows an excerpt of the Prometheus configuration to federate data from other Prometheus instances.

Listing 17 - Excerpt of a Prometheus federation configuration

```
scrape_configs:
```

```
- job_name: federate
  params:
    match[]':
    - '{job="bds"}'
  static_configs:
  - targets: ["192.168.202.1:19091"]
    labels:
      element_name: "l1.pod2"
      __metrics_path__:
"/api/v1/rbfs/elements/rtbrick/services/PROMETHEUS/proxy/federate"
  - targets: ["192.168.202.2:19091"]
    labels:
      element_name: "s1.pod2"
      __metrics_path__:
"/api/v1/rbfs/elements/rtbrick/services/PROMETHEUS/proxy/federate"
  - targets: ["192.168.202.3:19091"]
    labels:
      element_name: "bl1.pod2"
      __metrics_path__:
"/api/v1/rbfs/elements/rtbrick/services/PROMETHEUS/proxy/federate"
```

The remaining step is to create a single datasource in Grafana to query the federated time series data.

6.8. Summary

This tutorial outlines how to configure metric sampling and monitoring in RBFS. Providing a full introduction to Grafana, Prometheus and the Prometheus Query Language would go beyond the scope of this tutorial. However, we mentioned some pitfalls and key aspects for working with PromQL and Grafana and recommend looking up more information in the Grafana and Prometheus documentations.

A postman collection to work with RBFS metrics and Grafana dashboards, including the dashboards this tutorial refers to, can be requested from RtBrick.

6.9. References

/1/	/resources/techdocs/25.1.1.1/ctrld/01_switch_mgmt_api.html[Switch Management API Overview]
/2/	Querying Prometheus https://prometheus.io/docs/prometheus/latest/querying/basics/
/3/	Overview of time and timers http://man7.org/linux/man-pages/man7/time.7.html

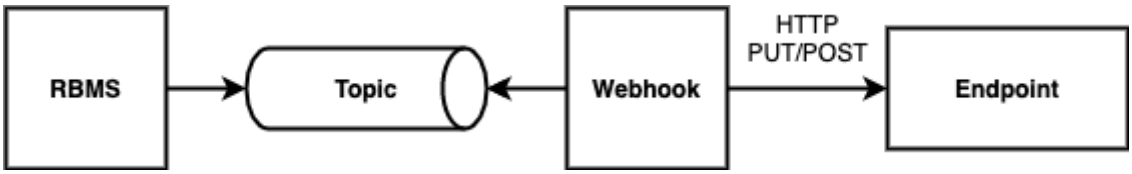
/4/	GELF - Graylog Extended Logging Format https://docs.graylog.org/en/3.2/pages/gelf.html
/5/	Grafana Documentation https://grafana.com/docs/grafana/latest/
/6/	Prometheus Federation https://prometheus.io/docs/prometheus/latest/federation/

7. Administering RBMS

7.1. Administration

7.1.1. Managing Webhooks

A webhooks is a registered HTTP endpoint that forwards notifications from RBMS to an external endpoint.



RBMS stores a *domain event* if a status in RBMS has changed. An event is only created when the transaction was comitted. An event is not fired when the transaction rolls back.

The events are grouped in different topics:

- **element**, the element topic contains all element-related messages
- **image**, the image topic contains all image-related messages

An event has a descriptive name that describes what state change is being reported. All events have a unique ID to identify different instances of the same event unambiguously.

For example, the *ElementRenamedEvent* informs about an element being renamed. The event is stored in the element topic.

A webhook subscribes a topic and calls the configured endpoint for all events that match the specified name filter. By default, the message send to the endpoint contains the JSON representation of the domain event. An optional template allows rewriting the event message.

The authentication can be done via HTTP Basic Authorization or bearer token. RBMS stores the provided credentials AES-protected in the database.

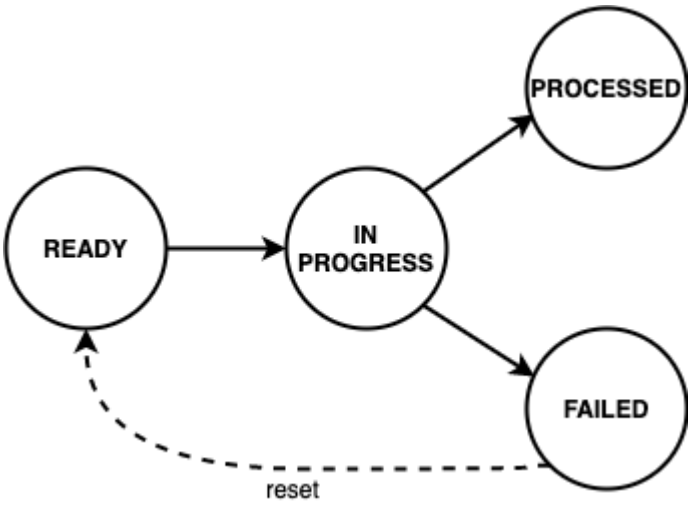
The AES secret and initialization vector (IV) can be specified in the master.secret and master.iv environment variables.

Unauthenticated endpoint calls are also supported.

A webhook invocation is considered *successful* if a HTTP success family status code is returned. For all other status codes the invocation is considered as failed.

A webhook can retry all failed messages. In addition, a webhook can be reset to a certain message to process this message and all subsequent messages again.

The complete message processing lifecycle is shown below:



New domain event messages are *READY* for being processed. The state changes to *IN PROGRESS* when the processing has begun and eventually to *PROCESSED* if the endpoint processed the message successfully and to *FAILED* otherwise respectively.

A webhook can be disabled to temporarily suspend the event processing. All events that occured while the webhook was disabled are processed when the webhook gets enabled again unless the event got dropped because the topic buffering capacity was exceeded.

Viewing Webhooks

To view the list of webhooks

1. Click the **Administration** tab.
2. Click **Webhooks** in the left navigation pane. The list of all webhooks appear.
3. Click the name of the webhook that you want to view.

Adding Webhooks

To add a webhook

1. Click the **Administration** tab.
2. Click **Webhooks** in the left navigation pane. The list of all webhooks appear.
3. Click **Add webhook**
4. Specify the general, subscription and authentication information about the webhook.
5. Click **Save webhook**.

Disabling a Webhook

To disable a webhook

1. Click the **Administration** tab.
2. Click **Webhooks** in the left navigation pane. The list of all webhooks appear.
3. Select the webhook to be disabled.
4. Click **Disable webhook**.

Enabling a Webhook

To enable a webhook

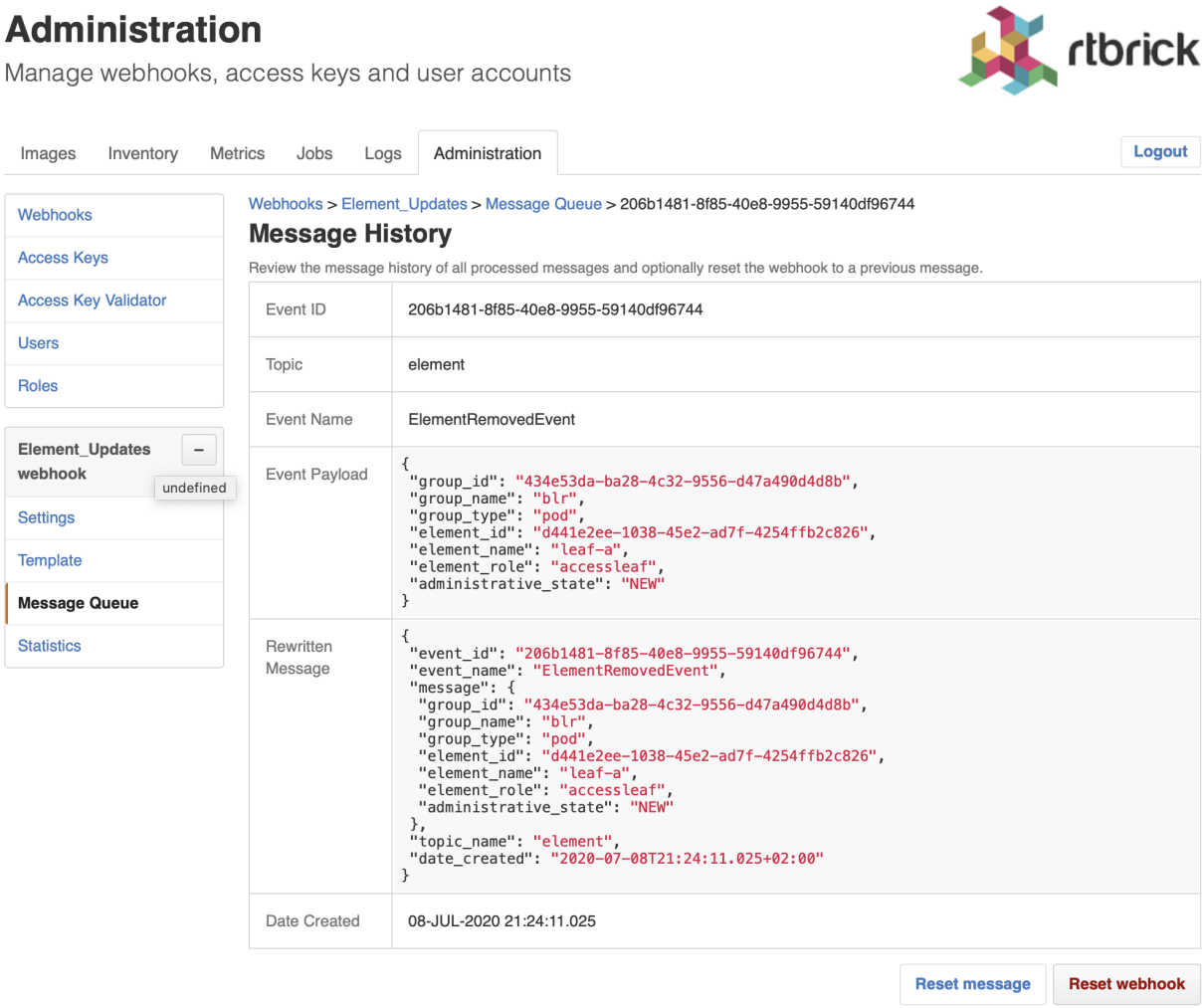
1. Click the **Administration** tab.
2. Click **Webhooks** in the left navigation pane. The list of all webhooks appear.
3. Select the webhook to be enabled.
4. Click **Enable webhook**.

Reset a Webhook

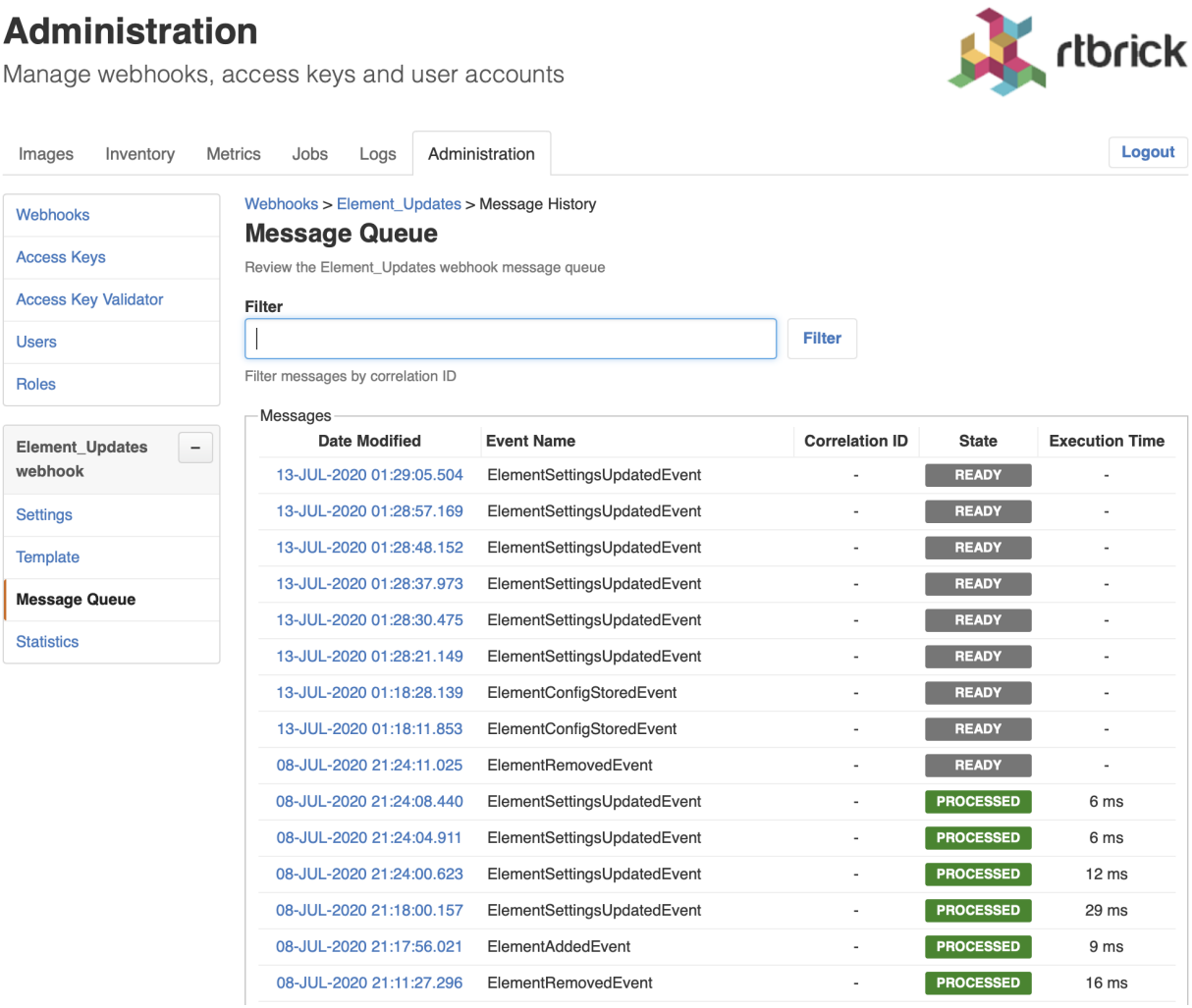
To reset a webhook

1. Click the **Administration** tab.
2. Click **Webhooks** in the left navigation pane. The list of all webhooks appear.
3. Select the webhook to be reset.

4. Click **Message Queue** in the left navigation pane. The list of the last 100 processed messages appear.
5. Enter the event ID in the **Filter** field and click **Filter**.
6. Open the displayed message.



7. Click **Reset webhook** to process the message and all subsequent messages again. The message queue view appears.

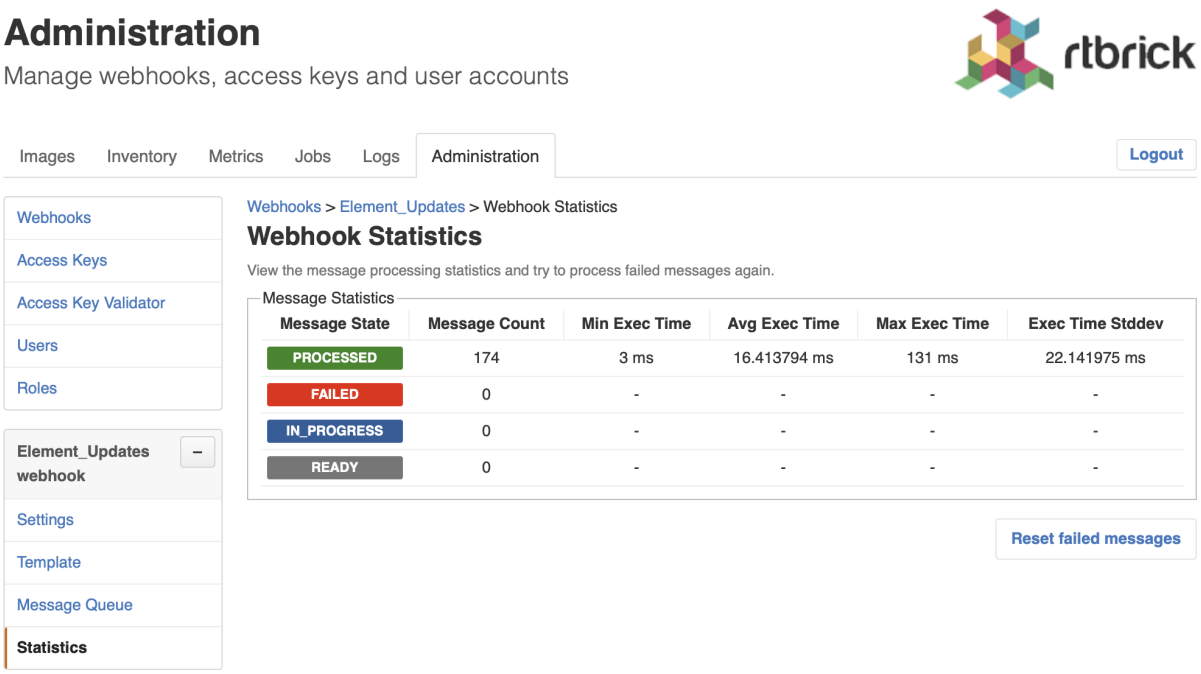


Viewing Webhook Statistics

The webhook statistics provides information about processing times and the message count grouped by the processing state.

To view the webhook statistics

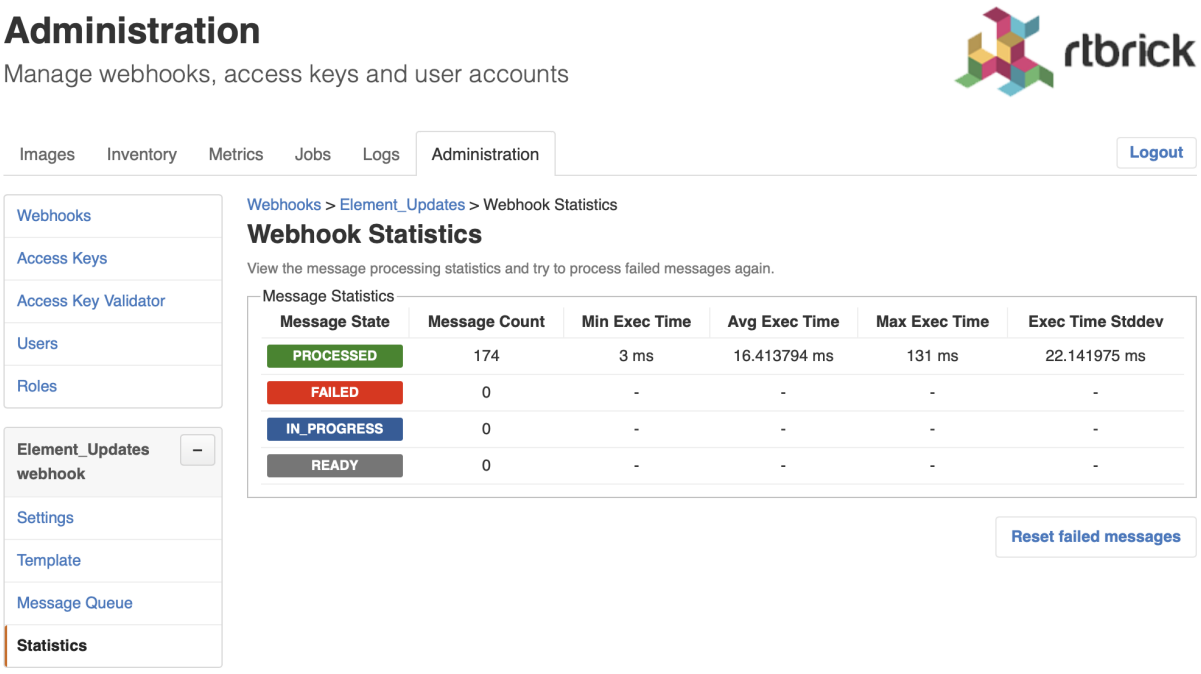
1. Click the **Administration** tab.
2. Click **Webhooks** in the left navigation pane. The list of all webhooks appear.
3. Select the webhook for which to retry the failed invocations.
4. Click **Statistics** in the left navigation pane. The webhook statistics appear.



Retrying Failed Webhook Invocations

To retry failed webhook invocations

1. Click the **Administration** tab.
2. Click **Webhooks** in the left navigation pane. The list of all webhooks appear.
3. Select the webhook for which to retry the failed invocations.
4. Click **Statistics** in the left navigation pane. The message statistics appear.



1. Click **Reset failed messages** to reset all failed messages to ready state.

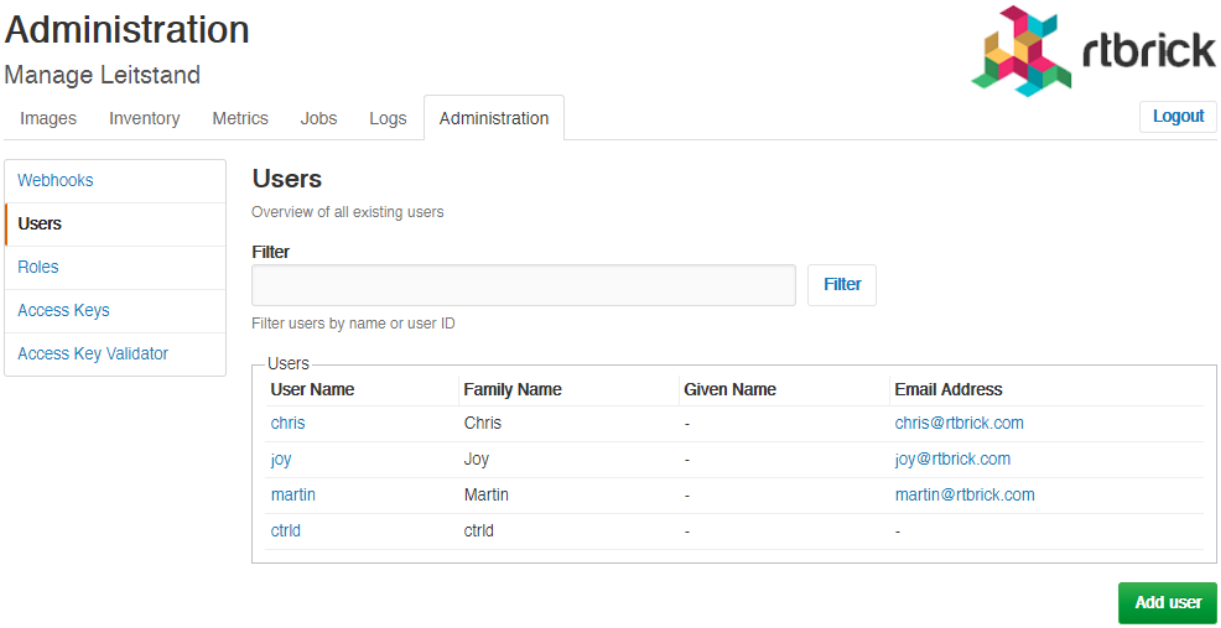
7.1.2. Managing Users

This section outlines how to manage users in the RBMS built-in user repository. If RBMS is connected to an authorization service the users are configured in the authorization service.

Viewing all existing users

To view all existing users

1. Click the **Administration** tab.
2. Click **Users** in the left navigation pane. The list of all existing users appear.



3. Click the name of the user whose details you want to view.

Adding users

You can add a new users to the user repository.

To add a user

1. Click the **Administration** tab.
2. Click **Users** in the left navigation pane. The list of all existing users appear.
3. On the **Users** page, click **Add user**.

4. Specify user details such as username, password, and access token.
5. Click **Add user**.

Removing users

To remove a user

1. Click the **Administration** tab.
2. Click **Users** in the left navigation pane. The list of all existing users appear.
3. Click the name of the user whom you want to remove.
4. On the **User Settings** page, click **Remove user**.

Resetting Password

To reset a user password

1. Click the **Administration** tab.
2. Click **Users** in the left navigation pane. The list of all existing users appear.
3. Click the name of the user whom you want to remove.
4. On the **User Settings** page, click **Reset password**. The **Reset Password** page appears.
5. Enter the new password.
6. Re-type the new password in order to detect accidental typos.
7. Click **Reset Password**.

7.1.3. Managing Roles

This section outlines how to manage roles in the RBMS built-in user repository. If RBMS is connected to an authorization service the roles are be configured in the authorization service. See Scopes for more information about the existing acccess scopes.

Viewing list of roles

To view the list of roles

1. Click the **Administration** tab.
2. Click **Roles** in the left navigation pane. The list of all existing users appear. image::admin_roles.png[]
2. Click the role that you want to view or modify.

7.1.4. Creating Roles

To create a role

1. Click the **Administration** tab.
2. Click **Roles** in the left navigation pane. The list of all existing users appear.
3. On the **Roles** page, click **Add role**.
4. Specify the details of the new role such as role name, Accessible Resource Scopes, and description.
5. Click **Add role**.

Removing roles

To remove a role

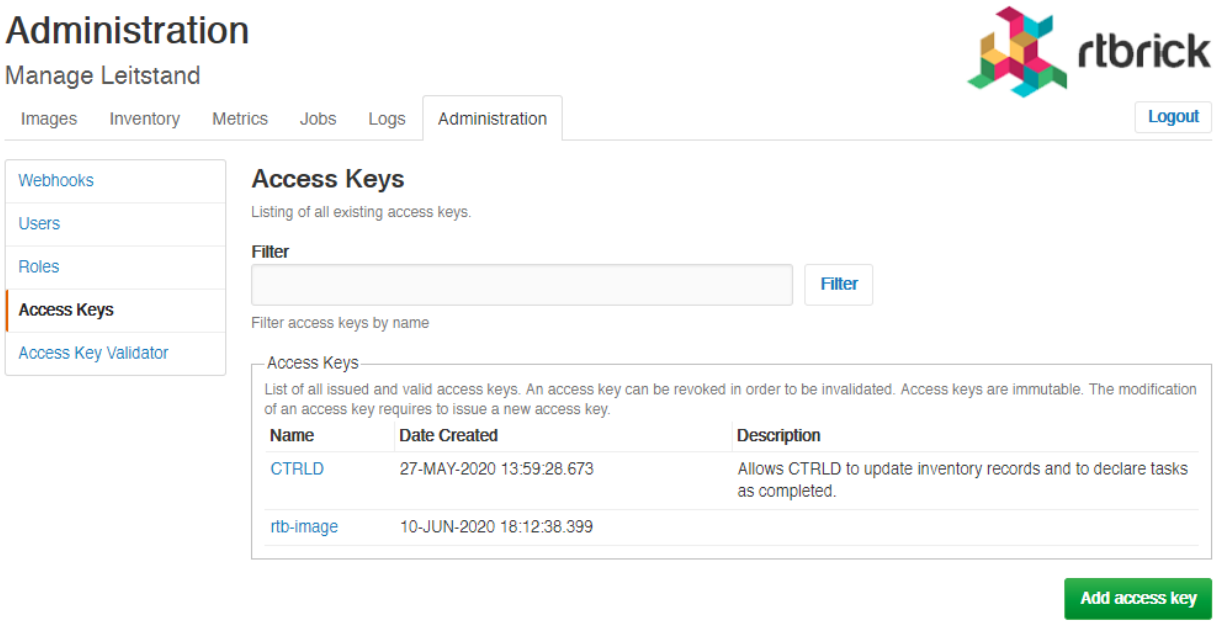
1. Click the **Administration** tab.
2. Click **Roles** in the left navigation pane. The list of all existing roles appear.
3. Click the role that you want to remove.
4. On the **Role** <rolename> page, click **Remove role**.

7.1.5. Managing Access Keys

Viewing list of access keys

To view the list of all existing access keys

1. Click the **Administration** tab.
2. Click **Access Keys** in the left navigation pane. The list of all existing access keys appear.

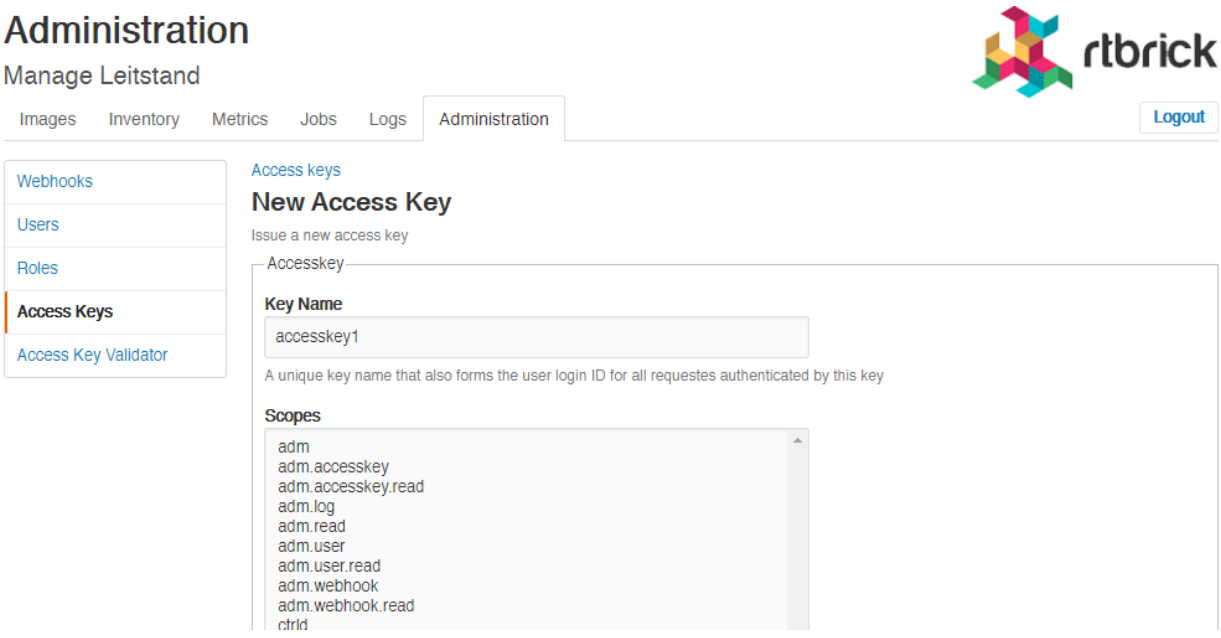


3. Click the name of the access key that you want to view or modify.

7.1.6. Creating Access Keys

To create an access key

1. Click the **Administration** tab.
2. Click **Access Keys** in the left navigation pane. The list of all existing access keys appear.
3. On the **Access Keys** page, click **Add access key**.



4. Specify the details of the new access key such as key name, scopes, and

description.

5. Click **Create access key**.

Revoking an access key

To revoke an access key

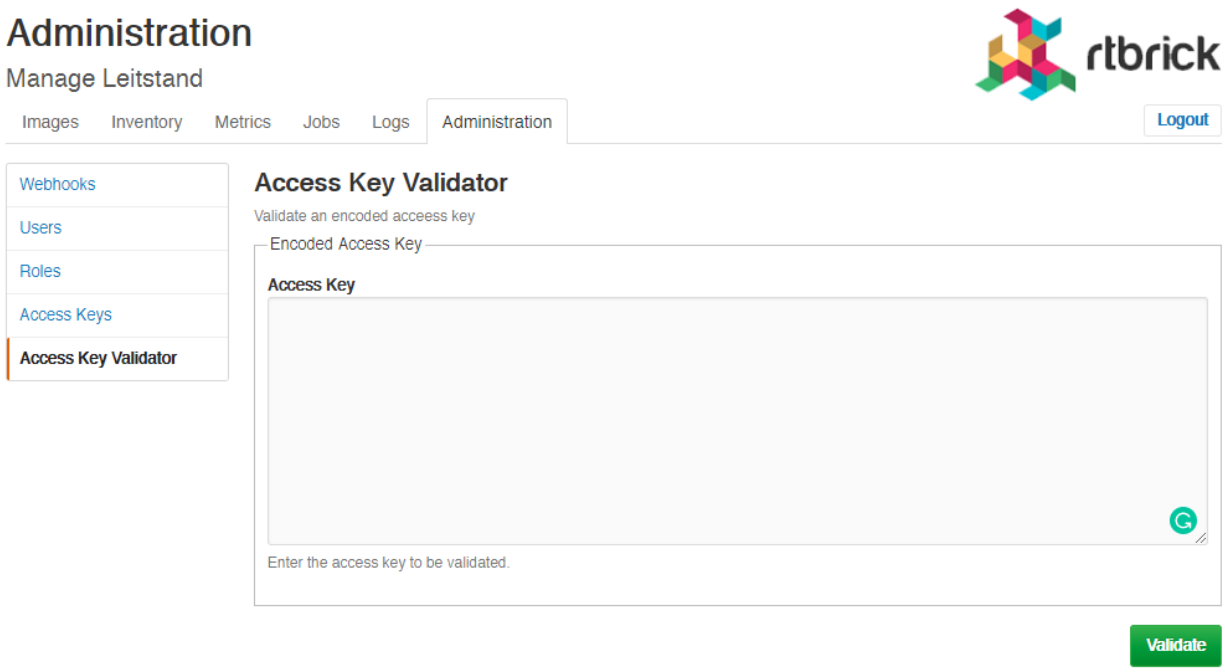
1. Click the **Administration** tab.
2. Click **Access Key** in the left navigation pane. The list of all existing access keys appear.
3. Click the access key that you want to revoke.
4. On the <access key name> **accesskey** page, click **Revoke access key**.

Validating an access key

The validating access key feature enables you to validate an encoded access key.

To validate an access key

1. Click the **Administration** tab.
2. Click **Access Key Validator** in the left navigation pane.



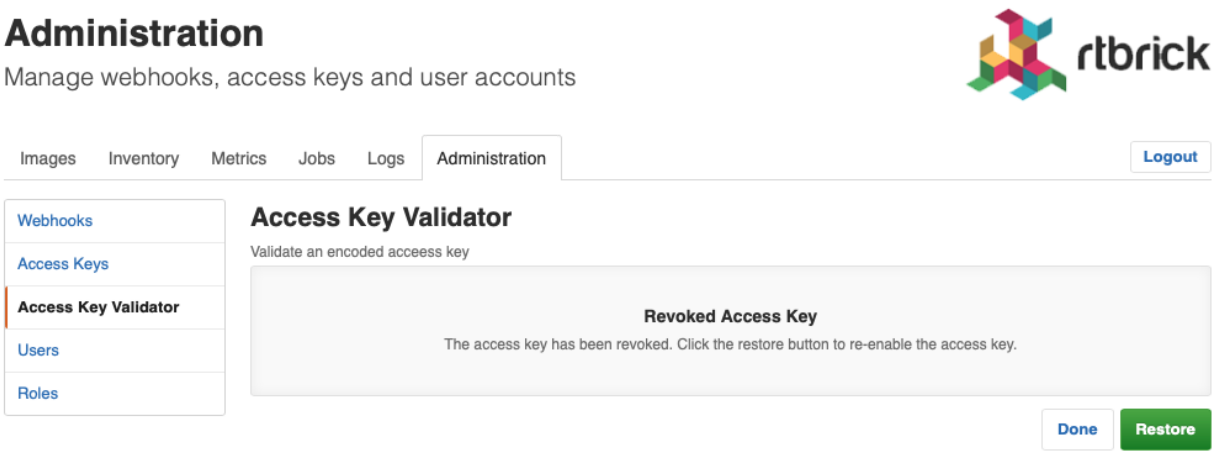
3. In the **Access Key** text box, enter the access key to be validated.

4. Click **Validate**.

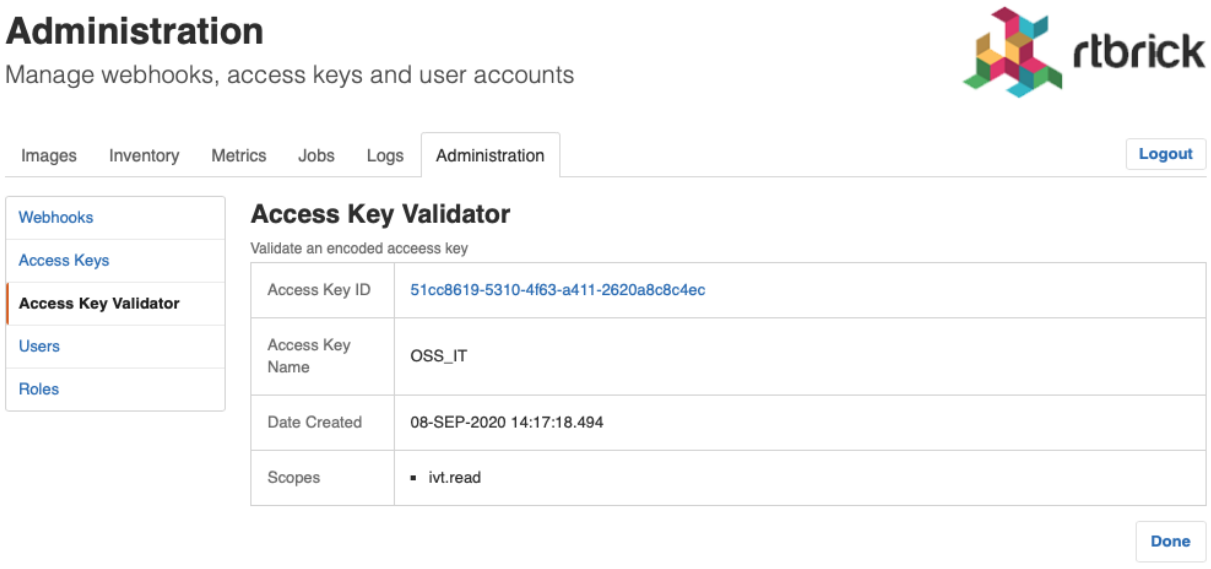
Restoring an revoked access key

To restore an accidentally revoked access key

1. Click the **Administration** tab.
2. Click the **Access Key Validator** in the left navigation pane.
3. Paste the access key to be restored in the text area.
4. Click **Validate**.



5. Clicke **Restore** to restore the revoked access key.



7.1.7. Scopes

Access to RBMS is granted through an access token. The access token is either issued by an OAuth2 compliant authorization service or by RBMS itself, depending on whether RBMS delegates to an authorization service or the RBMS built-in user repository is used.

The access token conveys the list of *scopes* the user is allowed to access. The table below lists all existing scopes:

Scope	Description
adm	Full access to the RBMS administration API and UI.
adm.read	Readonly access to the RBMS administration API and UI.
adm.accesskey	Full access to the RBMS access key administration API and UI.
adm.accesskey.read	Readonly access to the RBMS access key administration API and UI.
adm.user	Full access to the RBMS user management API and UI.
adm.user.read	Readonly access to te RBMS user management API and UI.
adm.webhook	Full access to the RBMS webhook management API and UI.
adm.webhook.read	Readonly access to the RBMS webhook management API and UI.
ctrld	Full access to all CTRLD actions that can be triggered from RBMS.
ctrld.reinstall	Permission to trigger CTRLD to run ZTP sequence for an software image upgrade again.
ctrld.settings	Permissions to update the CTRLD settings on the switch via RBMS.
ivt	Full access to the resource inventory.

ivt.read	Readonly access to the resource inventory.
ivt.element	Manage elements in the resource inventory.
ivt.element.settings	Manage element settings in the resource inventory.
ivt.element.config	Manage element configuration in the resource inventory.
ivt.element.dns	Manage element DNS records in the resource inventory.
ivt.element.module	Manage element hardware module information in the resource inventory.
ivt.group	Manage element grouos in the resource inventory.
ivt.group.settings	Manage element group settings in the resource inventory.
ivt.image	Manage software images in the resource inventory.
ivt.rack	Manage racks in the resource inventory.
job	Full access to the RBMS job API and UI.
job.read	Readonly access to the RBMS job API and UI
job.task	Manage job tasks via RBMS Job API or UI.
tmy	Full access to the RBMS metric API and UI.
tmy.read	Readonly access to the RBMS metric API and UI.
tmy.metrics	Full access to manage RBMS metrics.
tmy.metrics.read	Readonly access to metrics.

Scopes are *cumulative* by convention. For example, the ivt.elment scope includes the ivt.element.settings scope.

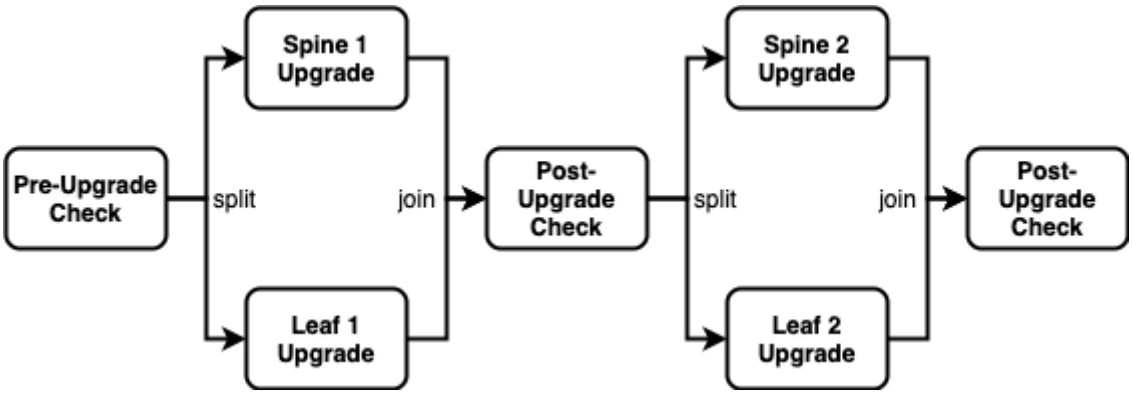
For UI access always grant the read scope in combination with a specific write scope to avoid trouble. For example, grant ivt.element.settings in combination with ivt.read. Otherwise a user might not be able to navigate to the view to apply the changes.

7.2. Managing Jobs

RBMS includes a job scheduler used by the network management applications to run management jobs. A job is a set of tasks that are executed in a specified order.

The task execution flow is defined by the application creating the job. Tasks can be executed sequentially or in parallel. Parallel execution flows can be joined to continue with a single flow. Technically speaking a job is described as *state engine*. Each task represents a node in the the state engine. The transition between tasks form the execution flow.

The figure below shows a simplified execution flow for a fabric upgrade.



The *Pre-Upgrade Check* task runs all checks to test whether the fabric can be upgraded. If the fabric passes all checks the execution flow is splitted to run the *Spine 1 Upgrade* and *Spine 2 Upgrade* in parallel. The *Post-Upgrade Check* waits for both upgrades to be completed before it runs the checks to test whether the upgrade was successful. If both switche upgrades were successful the job upgrades the two remaining switches in parallel. Finally another *Post-Uograde Check* is executed to check whether the upgrade was successful.

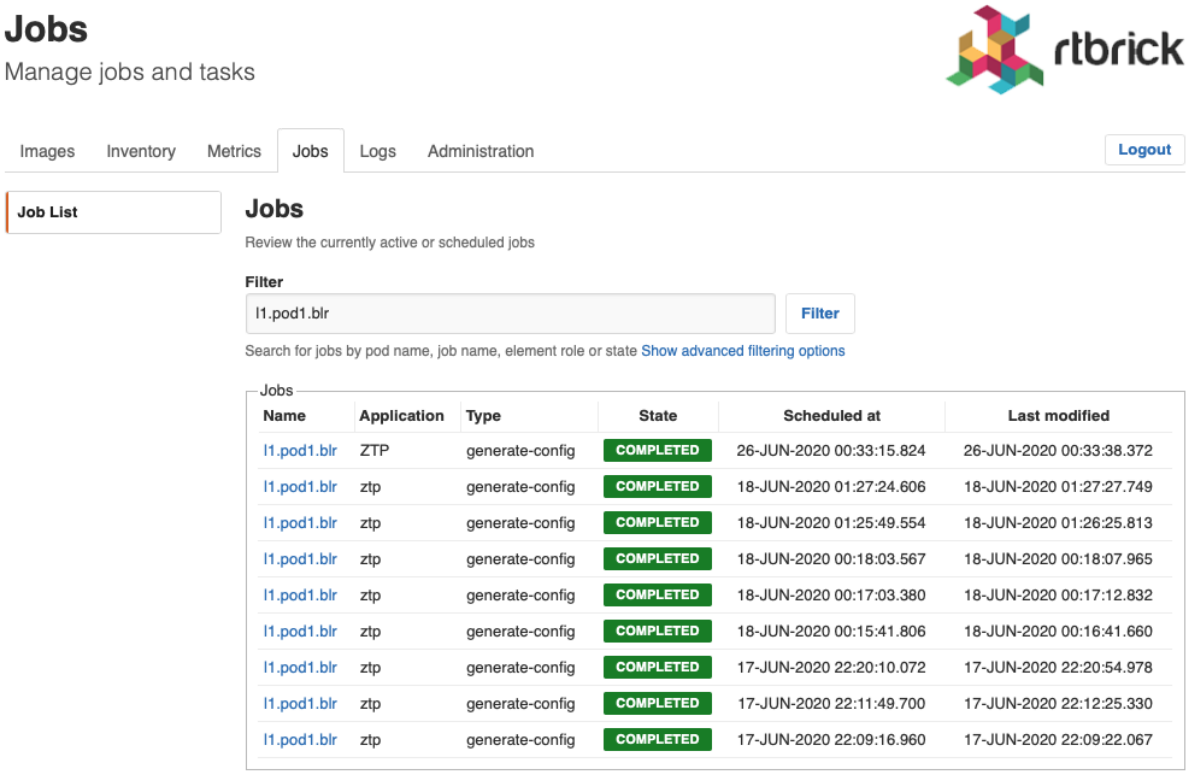
An application can program a job task to wait for an explicit confirmation. For example, an operator might want to inspect the state of a switch when a new image has been installed the very first time in the network. The upgrade application can program the *first* post-upgrade check to wait for confirmation before proceeding with the next upgrade.

The job module is a generic job viewer to inspect the state and progress of scheduled jobs. It also allows to confirm that a job can continue.

7.2.1. Viewing job list

To view the list of jobs

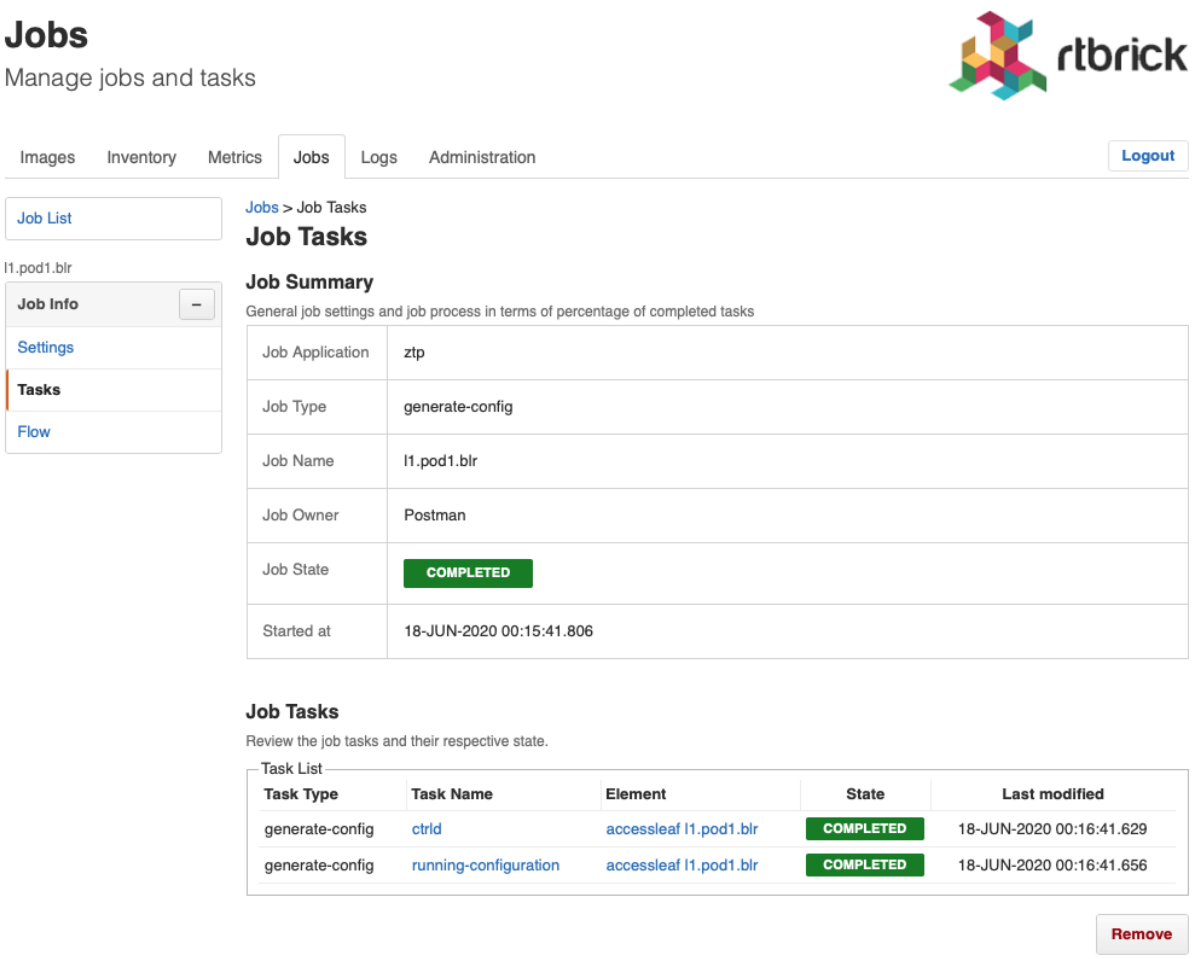
1. Click the **Jobs** tab. The list of currently active or scheduled jobs appear.
2. Optinally filter the job list by job name. The job name can be specied as prefix, full name of regular expression.



7.2.2. Viewing job task list

To view the list of job tasks

1. Click the **Jobs** tab. The list of currently active or scheduled jobs appear.
2. Click the name of the job that you want to view. The **Job Tasks** page appears.

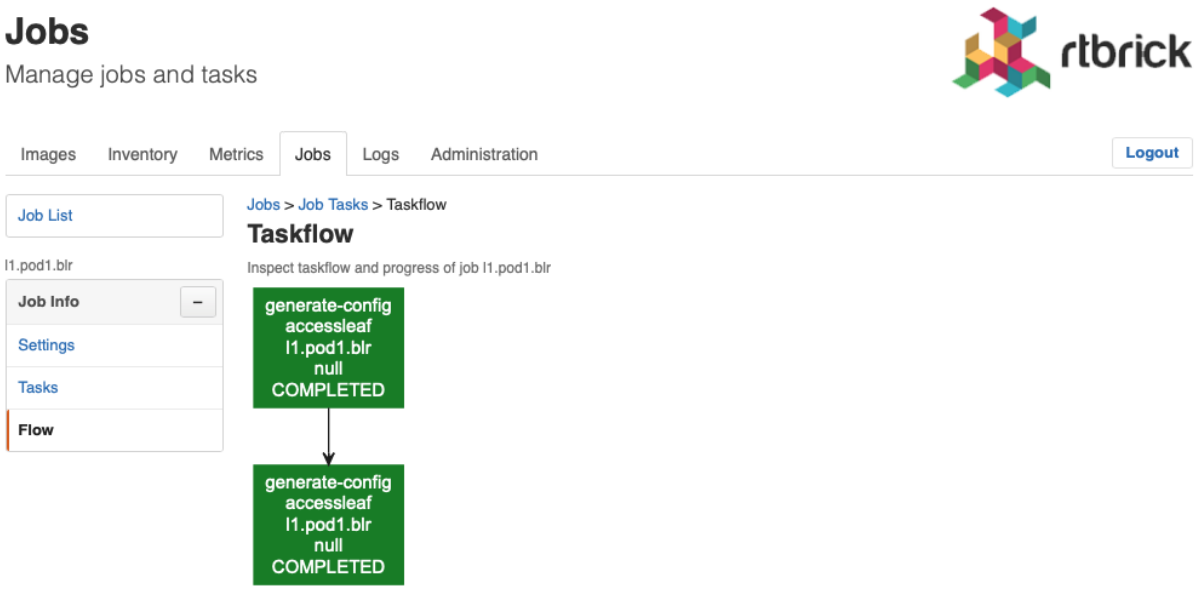


7.2.3. Viewing task flow

The task flow enables you to inspect taskflow and progress of the selected task.

To view the list of task flow

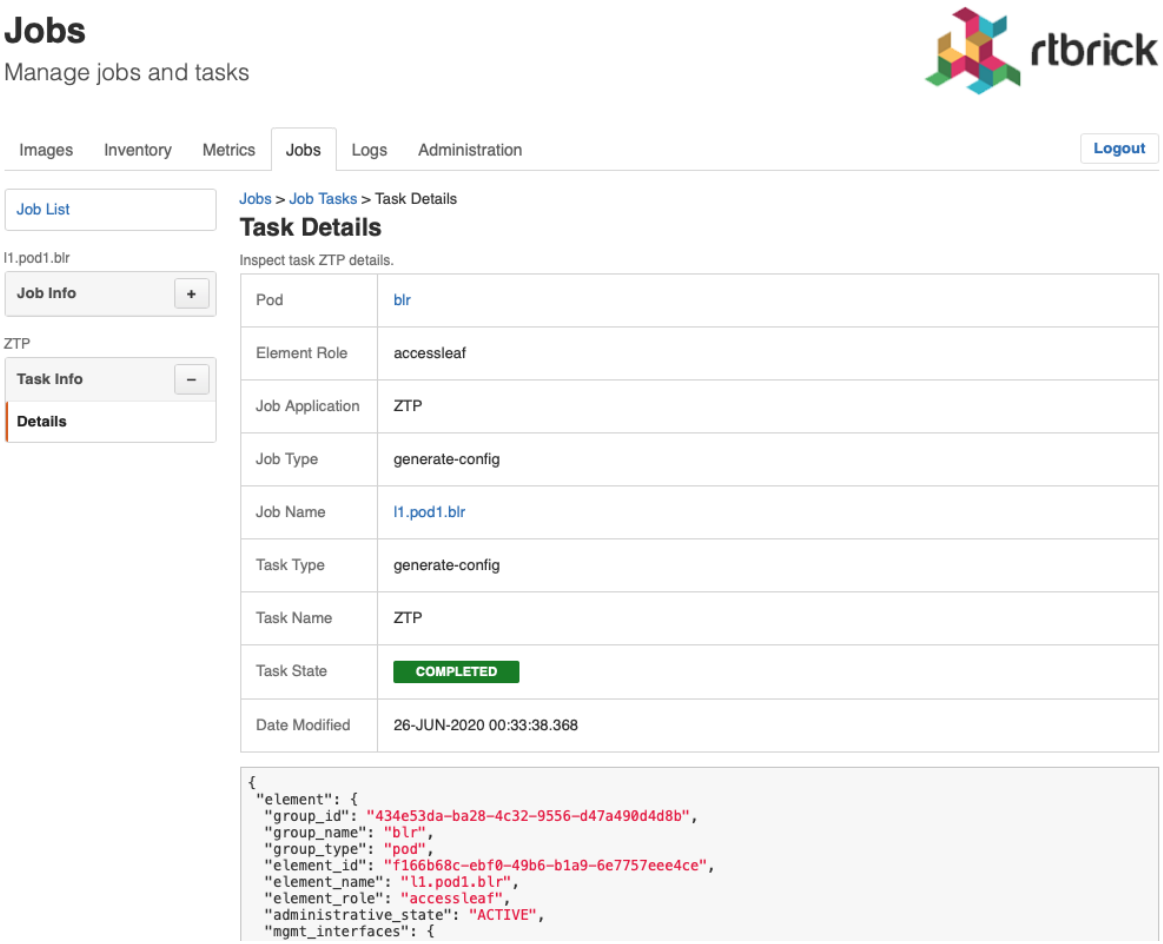
1. Click the **Jobs** tab. The list of currently active or scheduled jobs appear.
2. Click the name of the job that you want to view.
3. Click **Flow** in the left navigation pane. The **Taskflow** page appears.



7.2.4. Viewing task details

To view the task details

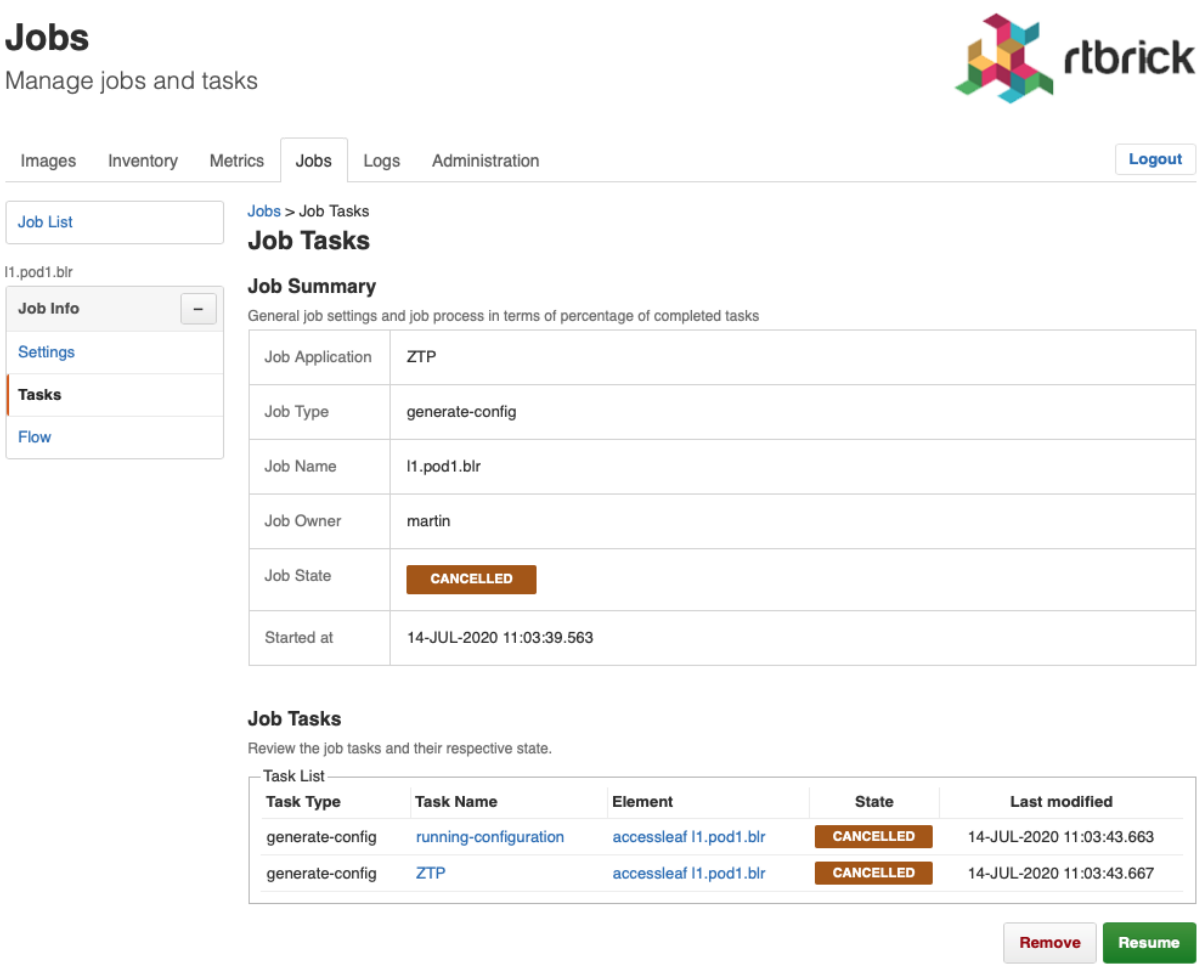
1. Click the **Jobs** tab. The list of currently active or scheduled jobs appear.
2. Click the name of the job that you want to view. The **Job Tasks** page appears.
3. Click the name of the task that you want to view. The **Job Task** page appears.



7.2.5. Canceling a Job

To cancel a job

1. Click the **Jobs** tab. The list of currently active or scheduled jobs appear.
2. Click the name of the job that you want to view.
3. Click **Tasks** in the left navigation pane. The **Job Tasks** page appears.
4. Click **Cancel job**. The job state changes to cancelled.



7.2.6. Removing a Job

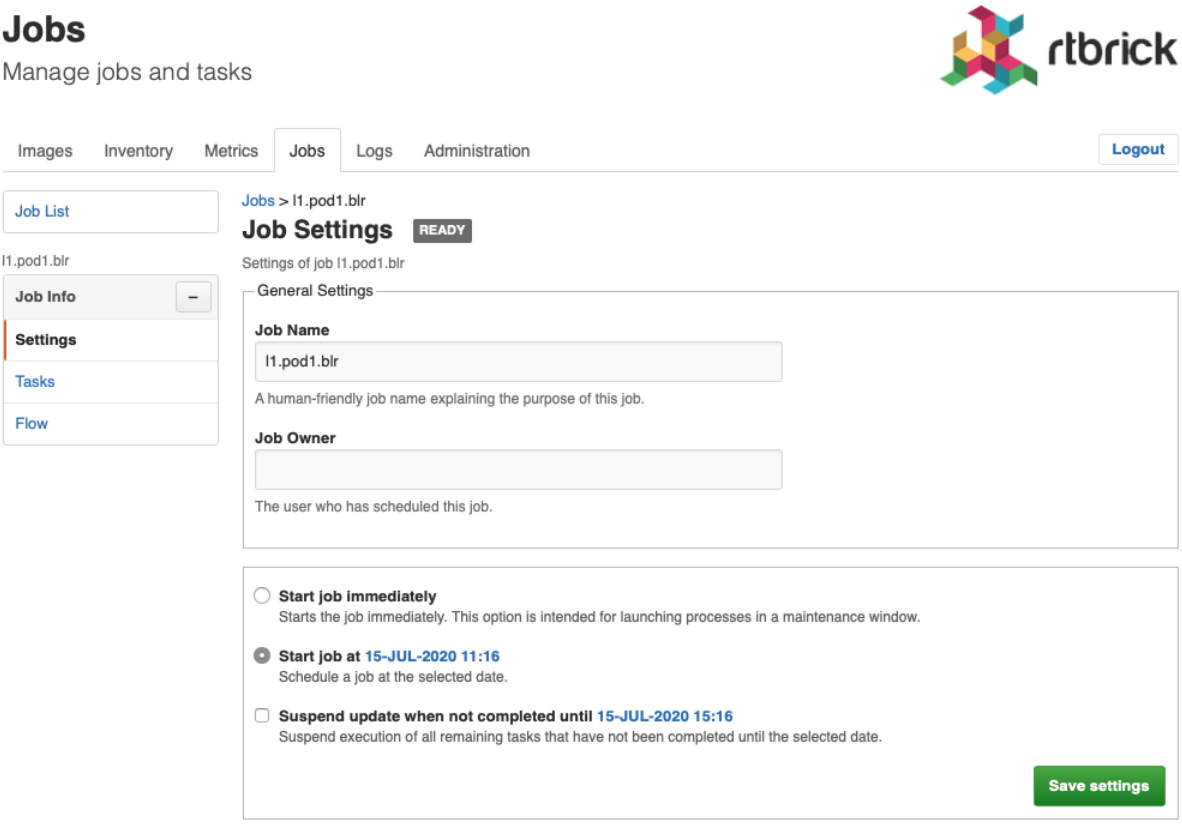
To remove a completed, cancelled or failed job

1. Click the **Jobs** tab. The list of currently active or scheduled jobs appear.
2. Click the name of the job that you want to view.
3. Click **Tasks** in the left navigation pane. The **Job Tasks** page appears.
4. Click **Remove**. A confirmation dialog is displayed.
5. Click **Confirm** to remove the job.

7.2.7. Configuring Job Settings

To configure the job settings

1. Click the **Jobs** tab. The list of currently active or scheduled jobs appear.
2. Click the name of the job that you want to configure.



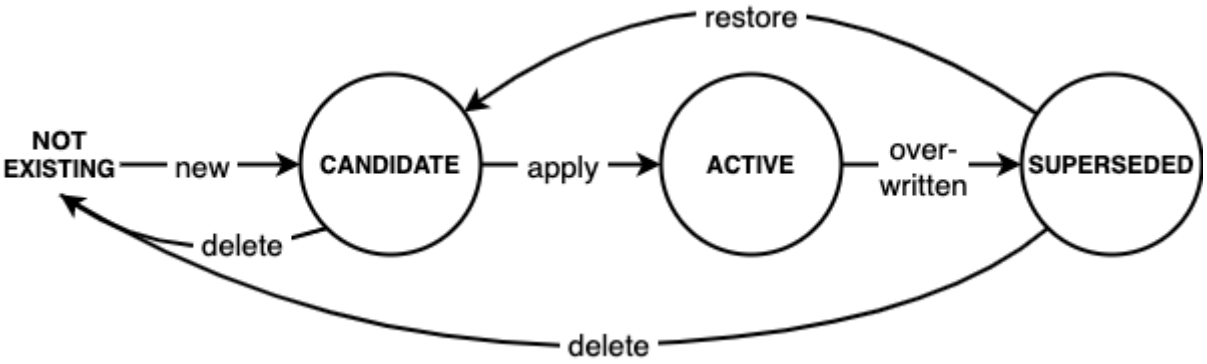
3. Make necessary configurations for the job.
4. Click **Save settings**.

8. RBMS Configuration Store

The RBMS resource inventory includes a configuration store to maintain switch configurations. The configuration store can store an arbitrary number of configurations per switch and provides a history of up to 50 revisions for each configuration.

RBFS stores the active configuration in RBMS after every configuration change.

The figure below shows the configuration lifecycle.



A new configuration is considered a *candidate* configuration. A candidate configuration turns into the *active* configuration when being applied to the switch. The previously activate configuration is marked as *superseded* at the same time. A superseded configuration can be restored by creating a new candidate configuration from it and applying the candidate configuration again. Candidate and superseded configurations can be removed from the configuration store. The active configuration cannot be deleted.

RBMS provides means to create or upload new configurations and apply them to the switch. In addition, RBMS UI allows inspecting configuration changes in the configuration history.

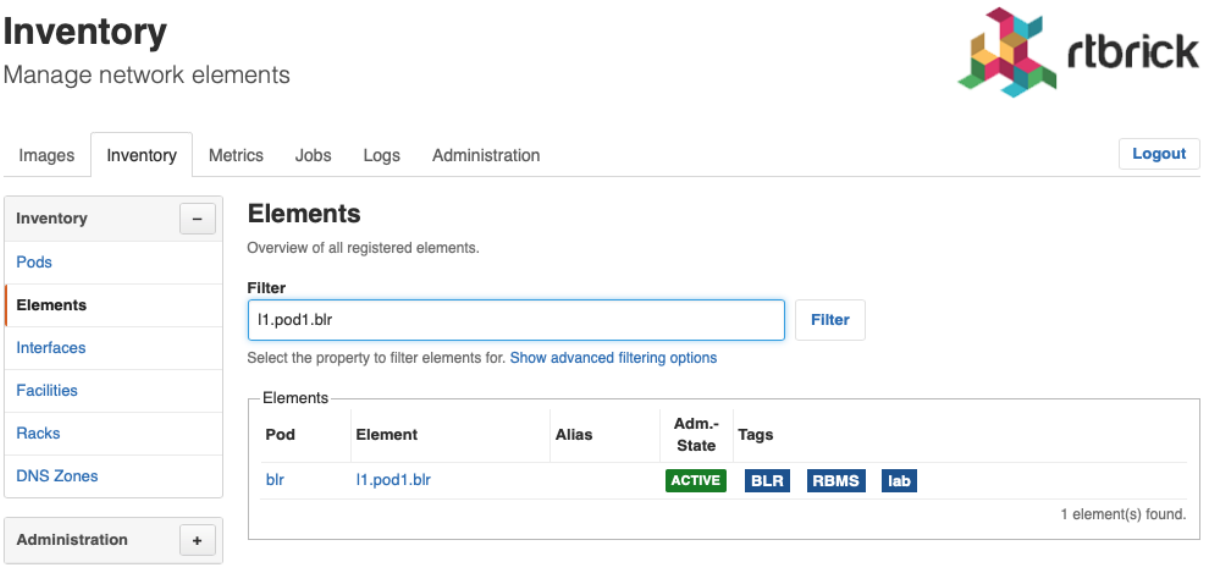
8.1. Creating a new candidate configuration

8.1.1. Uploading a candidate configuration

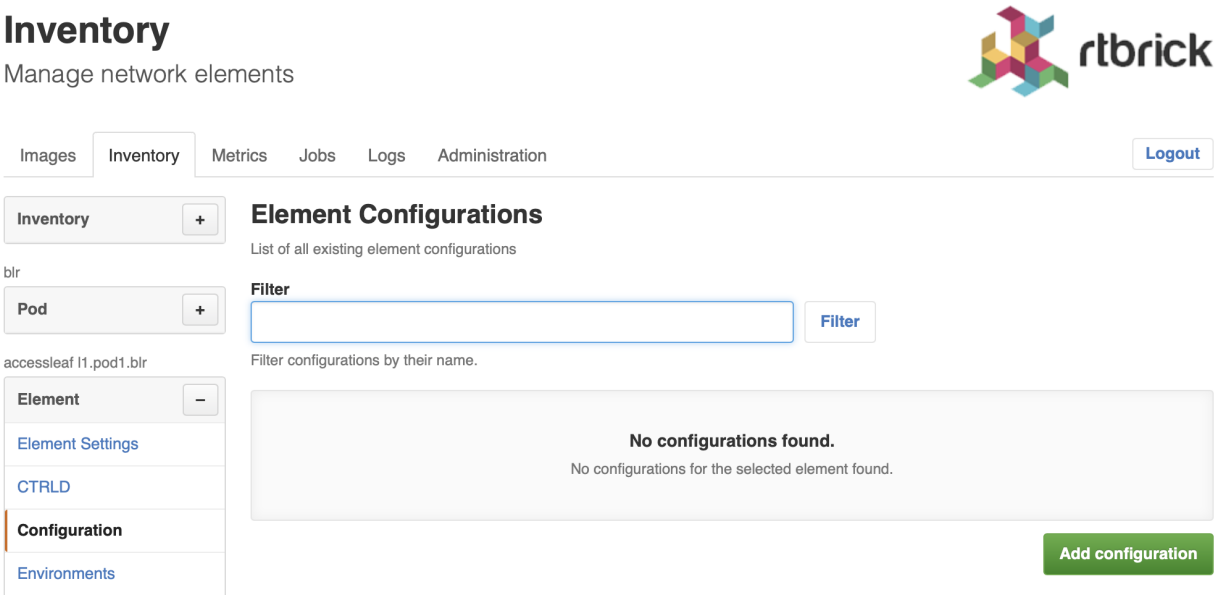
The simplest way to add a new candidate configuration is to upload a new configuration to the configuration store.

To upload a new candidate configuration

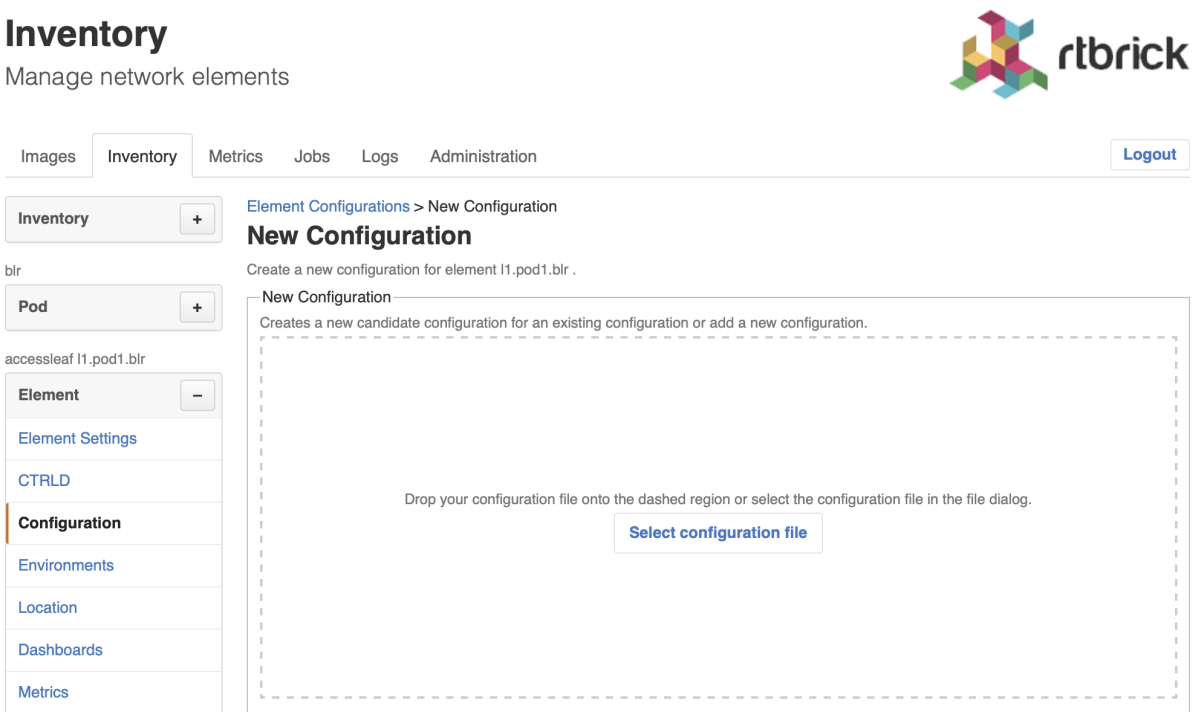
1. Click the **Inventory** tab.
2. Click **Elements** in the left navigation pane. The element list appears.



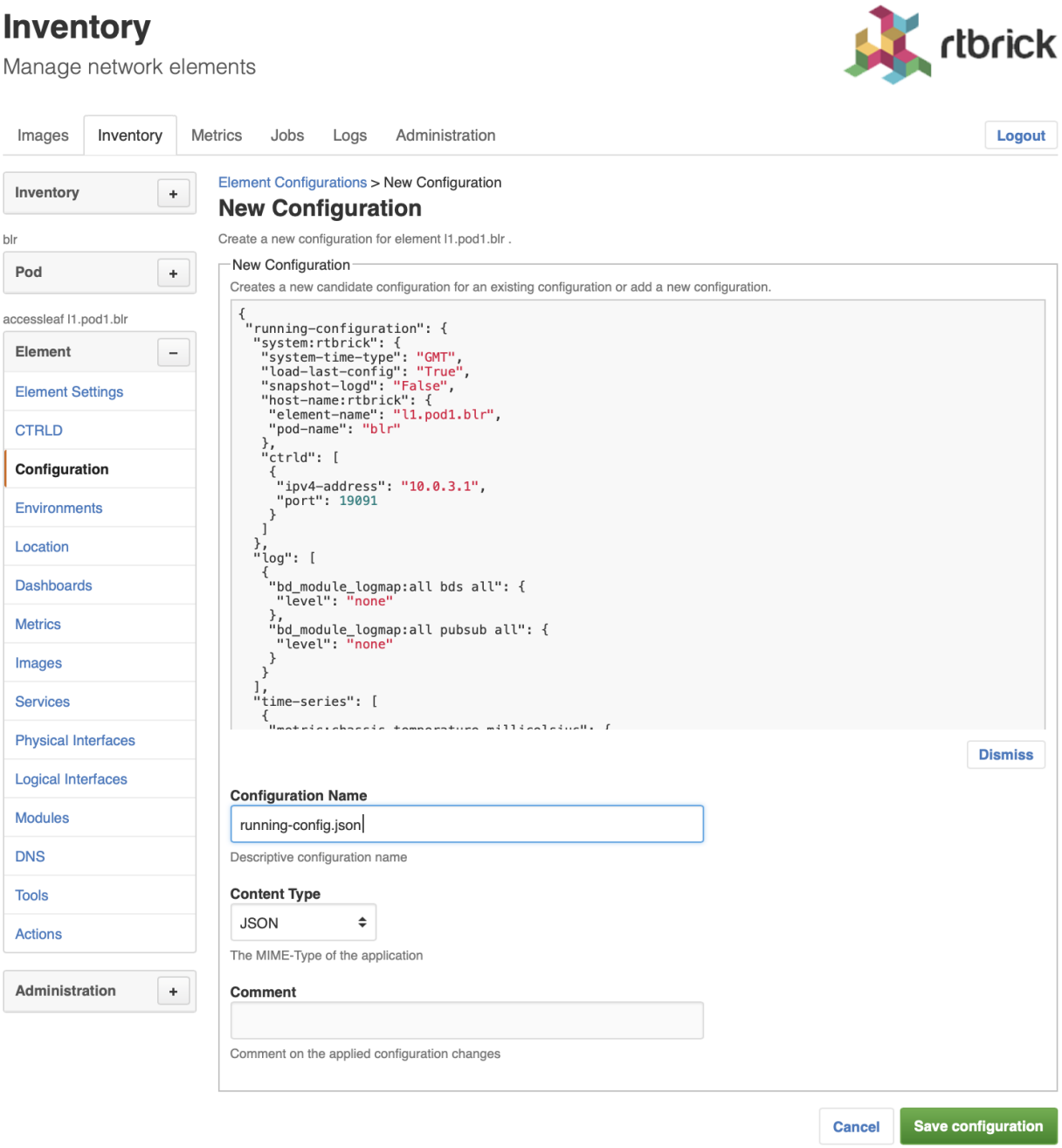
3. Click the element name for which you want to upload a new configuration.
4. Click **Configuration** in the left navigation pane. The configurations list appears.



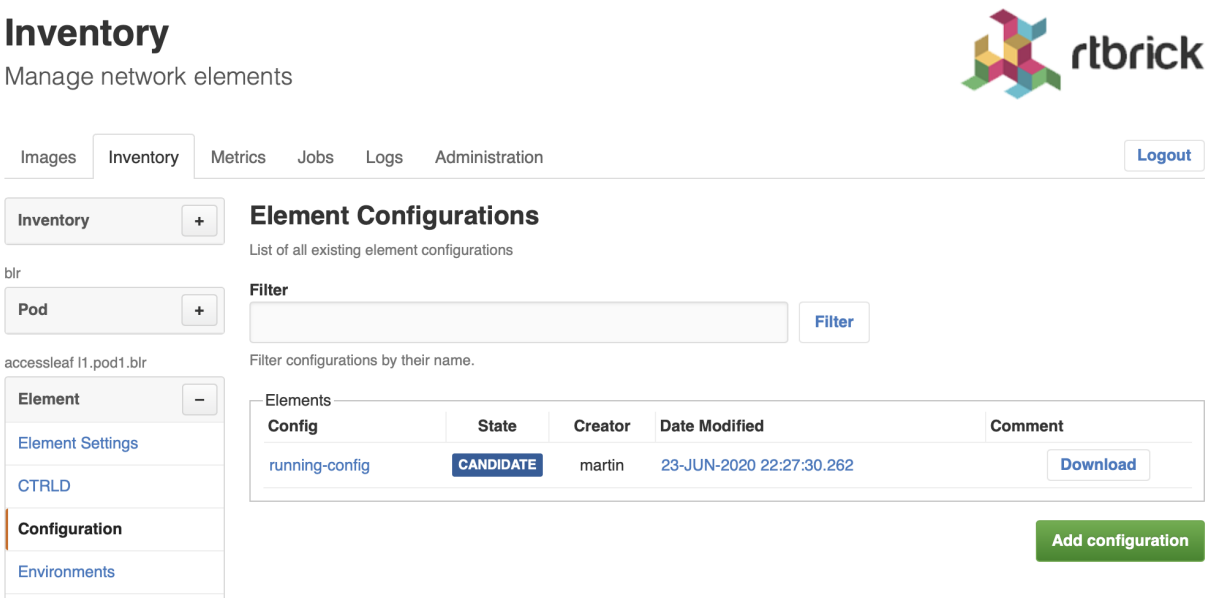
5. Click **Add configuration**. The New Configuration page appears.



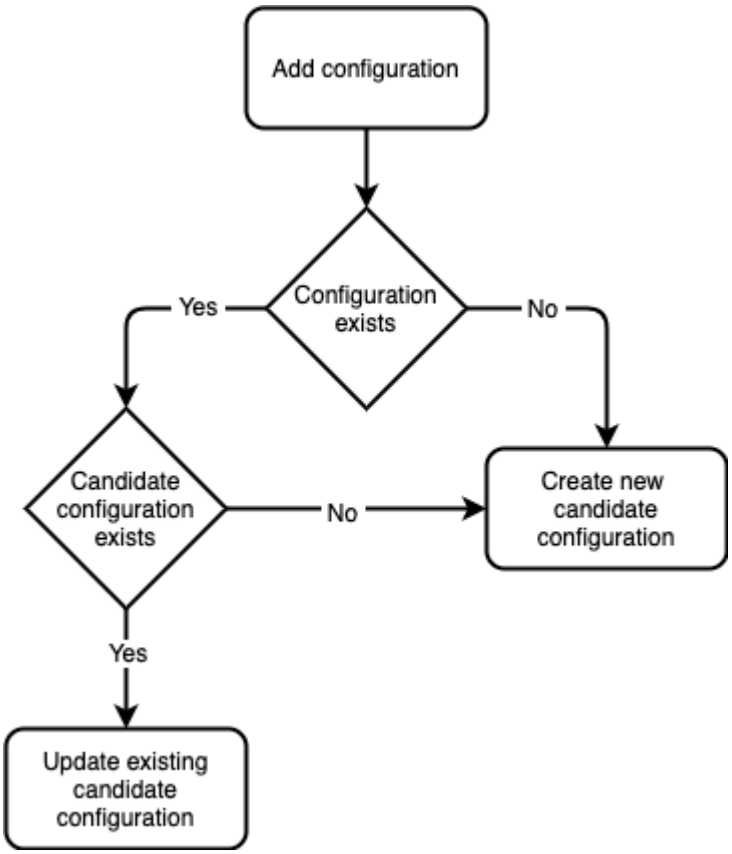
6. Drop a configuration file onto the dashed area or click **Select configuration file** to open the file dialog to select a file.
7. Review the configuration in the preview.



8. In **Configuration Name**, enter the switch configuration name. By default the configuration name is taken from the file name.
9. Check whether the selected **Content Type** is correct.
10. Optionally comment the configuration.
11. Click **Save configuration** to add the candidate configuration.



RBMS either creates a new candidate configuration or updates an existing candidate configuration if a candidate configuration for the specified configuration name exists. The complete flow is illustrated below:



8.1.2. Generating a candidate configuration

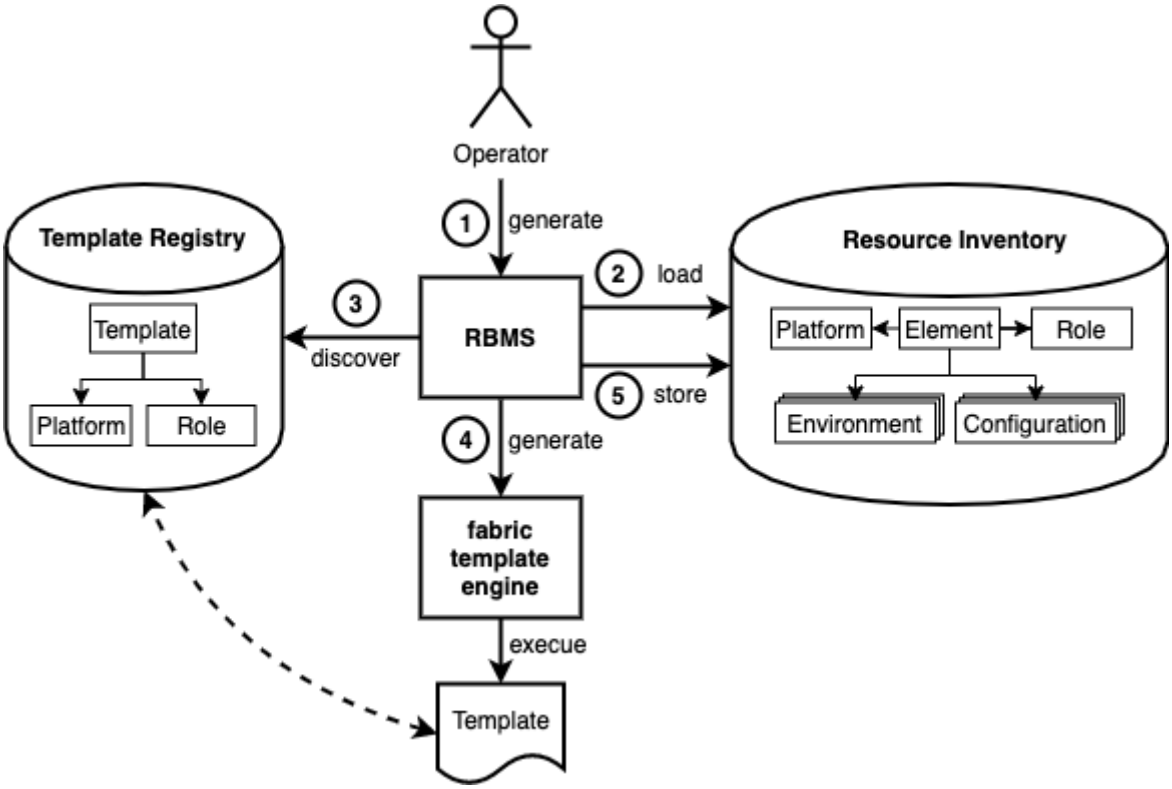
RBMS includes a template engine to generate switch configurations. The configuration templates are designed based on your conventions for building a

fabric and then added to the template engine. The templates need to be registered in RBMS to make them eligible for execution. RBMS passes the following information to the template engine:

- the general element settings
- the software image to be installed on the switch and
- all registered environments

RBMS can store an arbitrary set of *environments* per element. An environment is a JSON object containing parameters processed in the template. The structure and number of environments is defined by the template author.

The figure below shows the configuration generation flow:



1. The operator triggers the switch configuration generation in RBMS.
2. RBMS loads the element settings, environments and image information from the resource inventory.
3. RBMS discovers the templates eligible for the selected switch.
4. RBMS invokes the template engine for each discovered template.
5. RBMS stores the generated configuration as candidate configuration in the configuration store.

Template registration

The template registration maintains the list of templates available in the template engine.

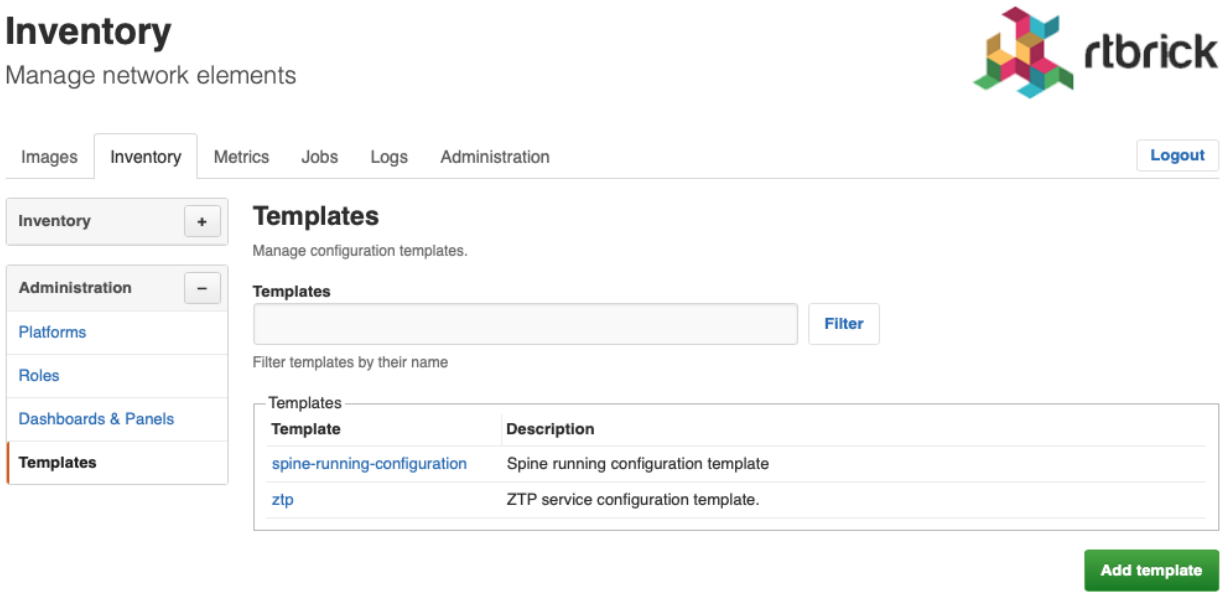
Say you have three different templates:

- ztp.gojson generates the ZTP configuration snippet for a switch.
- leaf-running-configuration.gojson generates the running-configuration of a leaf switch.
- spine-running-configuraton.gojson generates the running-configuration of a spine switch.

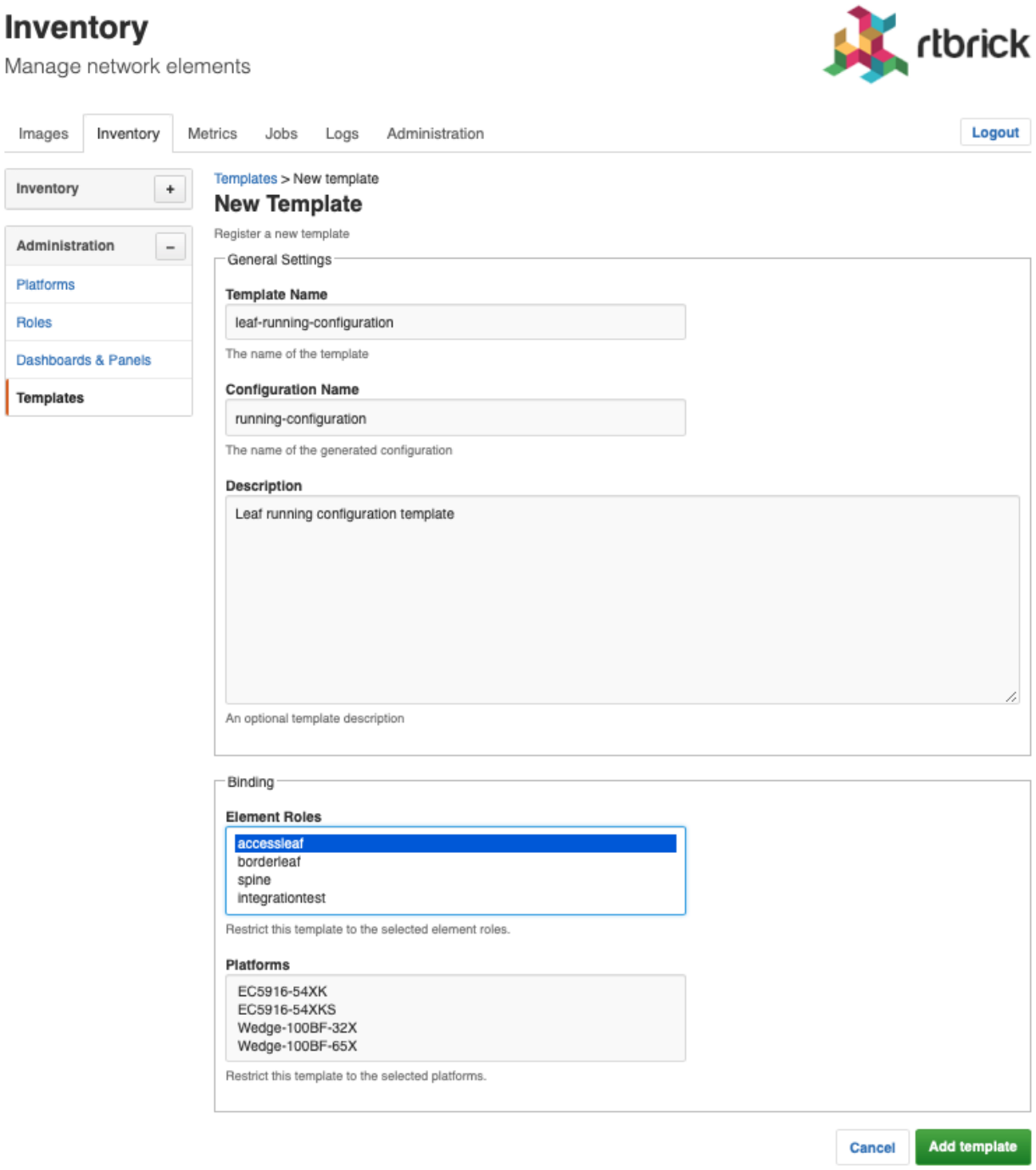
All templates need to be registered in RBMS to get executed when the switch configuration is genereated.

To register a new template

1. Click the **Inventory** tab.
2. Click **+** to expand the **Administration** menu.
3. Click **Templates** in the left navigatio pane. The template list appears. ZTP and spine templates are already registered.



4. Click **Add template** to register the leaf template.

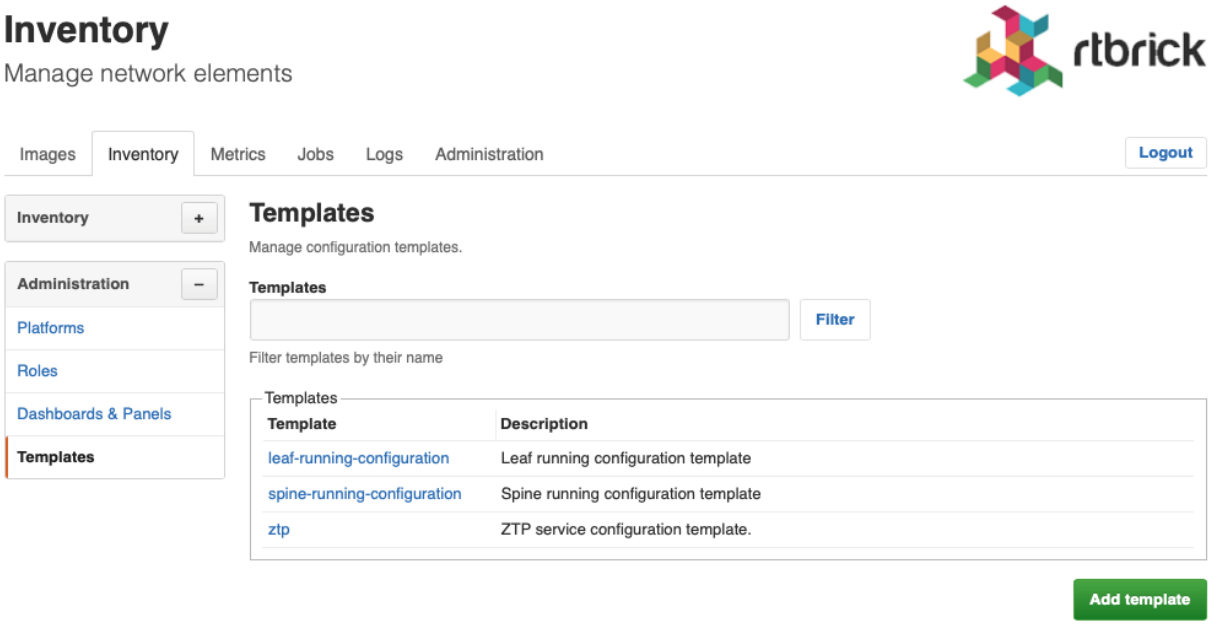


5. In **Template Name**, enter *leaf-running-configuration*.

> The template name in RBMS matches the template folder name in the template engine. See the template engine guide for more details.

6. In **Configuration Name**, enter *running-configuration* since the template generates the *running-configuration* for a switch.
7. In **Element Roles**, select *accessleaf* to bind the template to accessleaf switches.

8. In **Description**, optionally describe the template and the generated configuration.
9. Click **Save template**. The template list appears. The new template is listed.

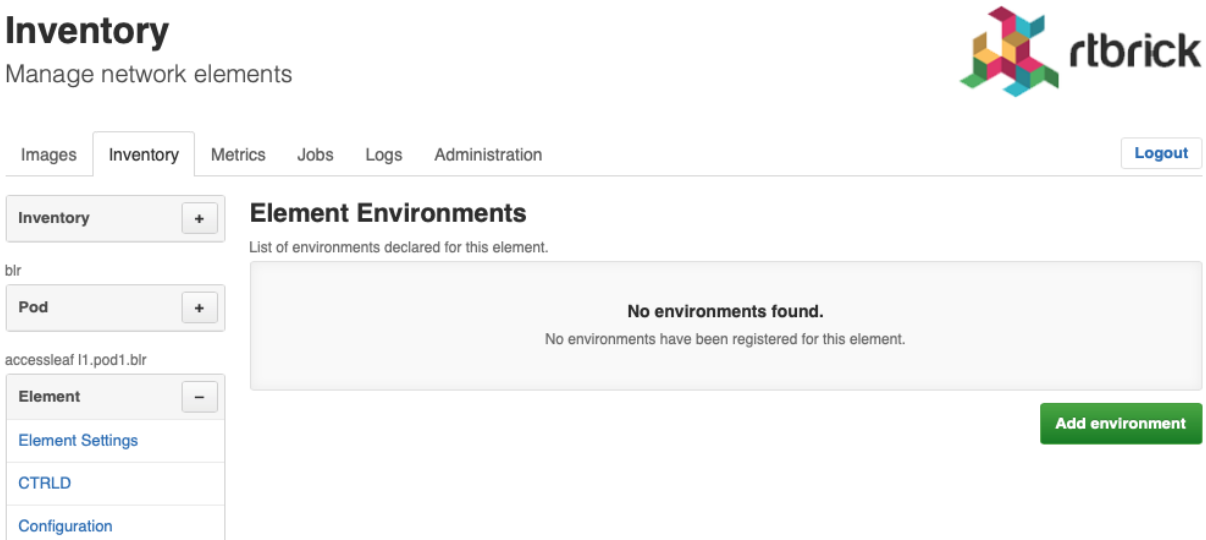


Environment management

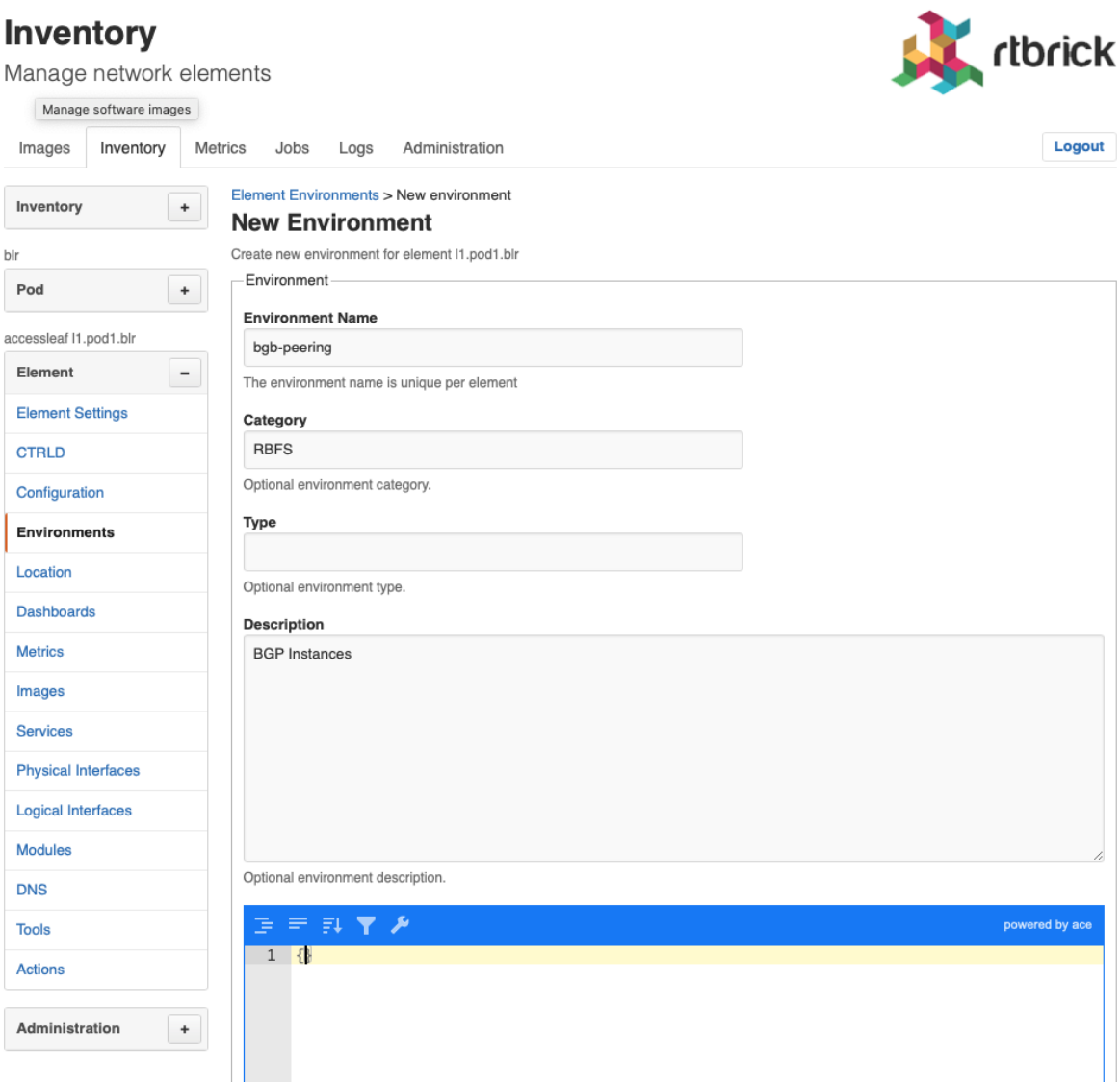
Adding a new environment

To add a new environment

1. Click **Environments** in the left navigation pane. The list of environment appears.



2. Click **Add environment**. The New Environment view appears.



3. In **Environment Name** enter the name of this environment.
4. In **Category** enter *RBFS*.

   Only RBFS environments are processed by the template engine.

5. In **Type** enter an optional type or schema information of the environment.
6. In **Description** enter an optional environment description.
7. Enter the environment variables in the displayed JSON editor or click **Upload new environment** to upload a JSON file.
8. Click **Add environment** to add a new environment.

Editing an environment

To update an existing environment

1. Click **Environments** in the left navigation pane. The list of environment appears.
2. Click the name of the environment you want to edit.
3. Apply the modifications to the environment.
4. Click **Save environment** to save the environment.

Removing an environment

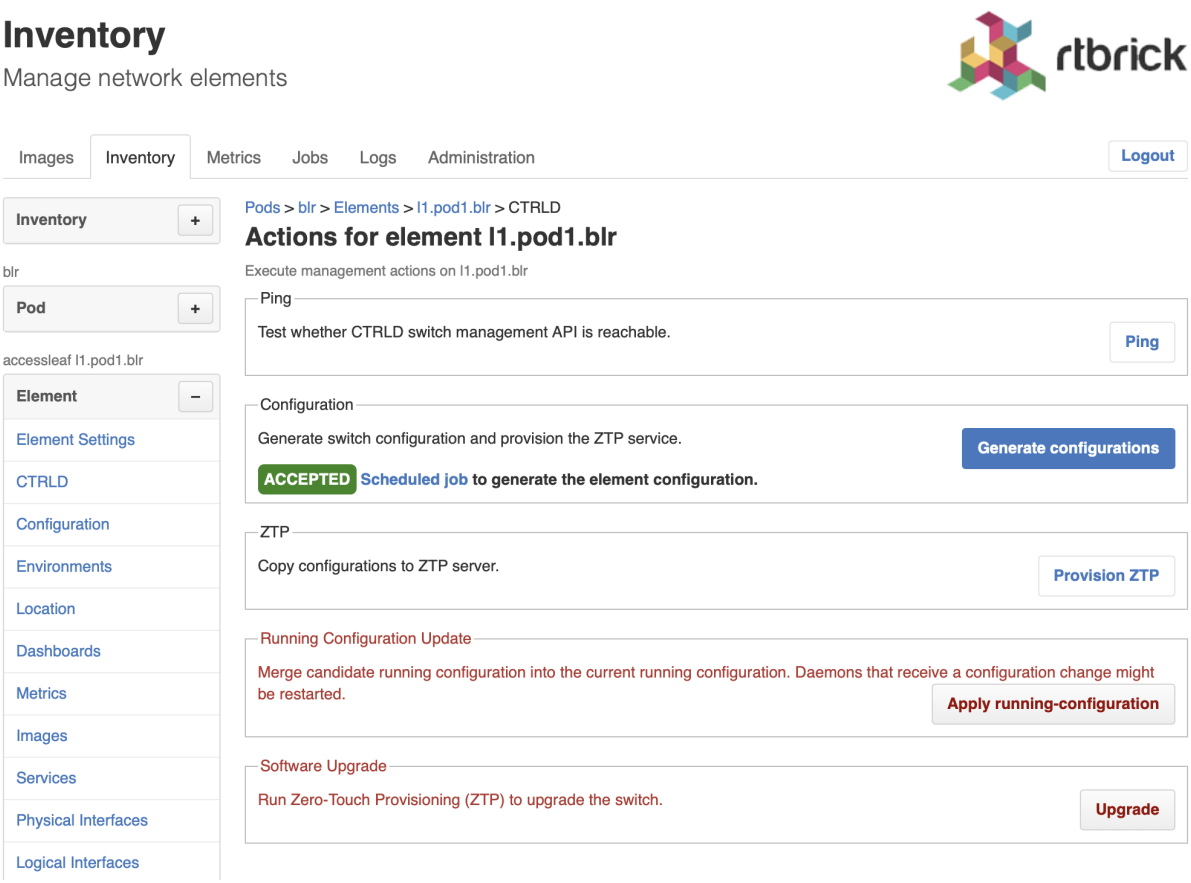
To remove an environment

1. Click **Environments** in the left navigation pane. The list of environment appears.
2. Click the name of the environment you want to remove.
3. Click **Remove environment**. A confirmation dialog is displayed.
4. Click **Confirm** to remove the environment.

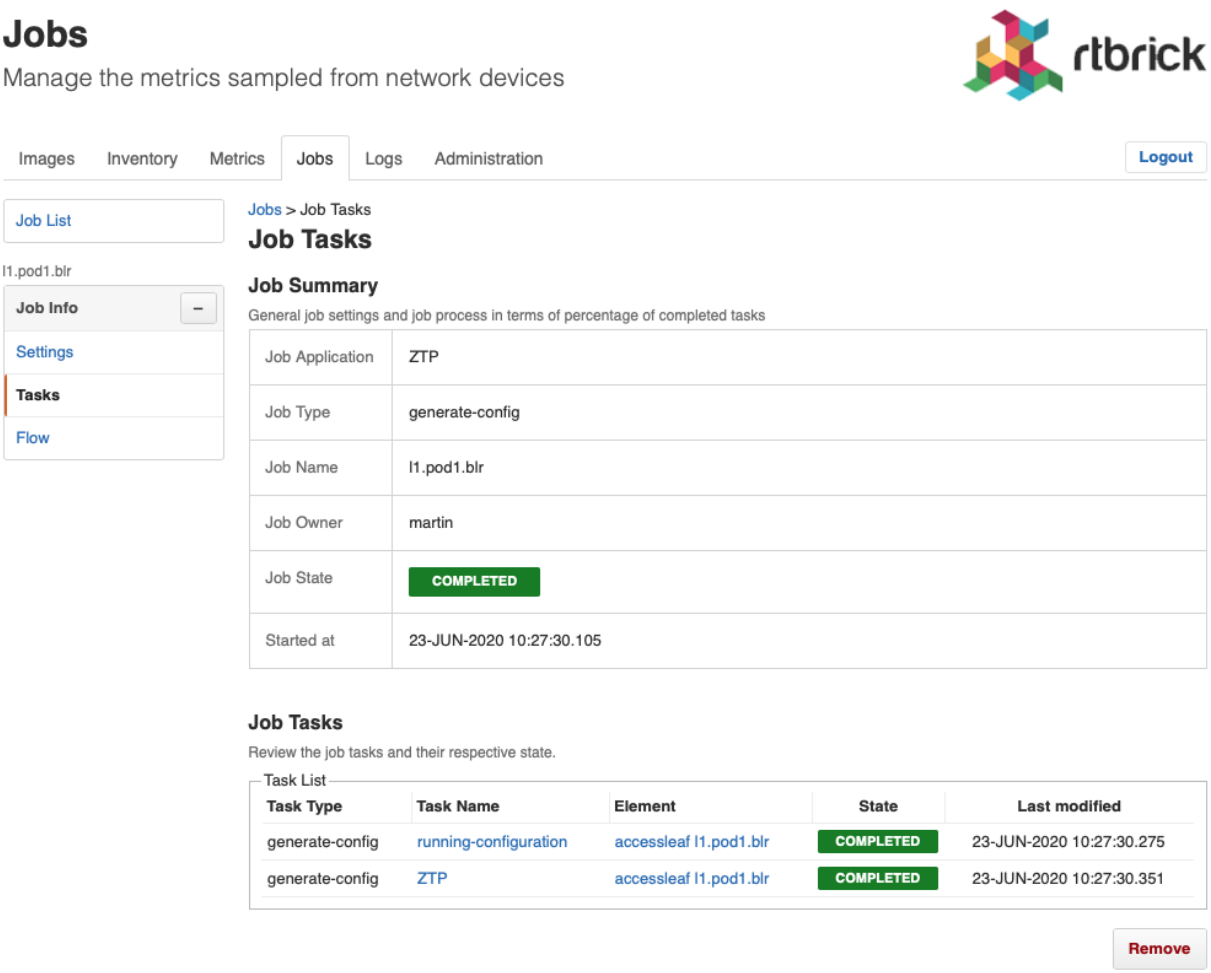
Configuration generation

To generate a configuration

1. Click **Actions** in the left navigation pane.



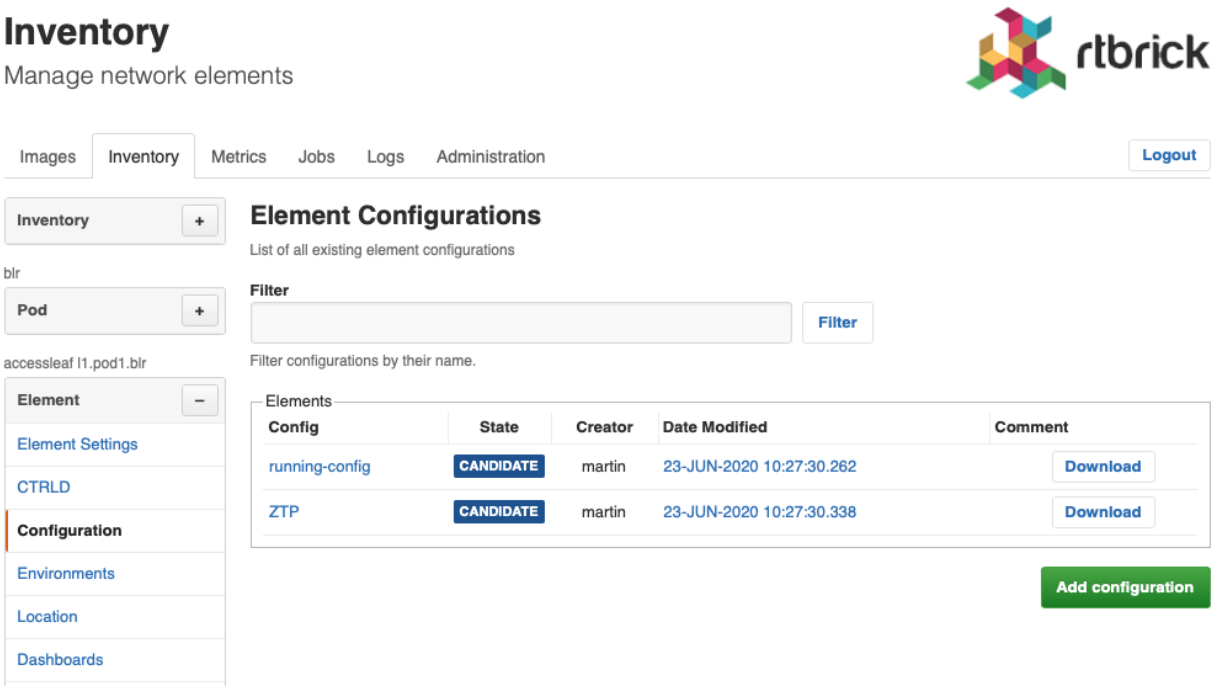
2. Click **Generate configurations**. RBMS schedules a configuration generation job. The job contains a task for each configuration and invokes the template engine to create the configuration.



The generated configurations are stored as new candidate configurations.

To review the generated configuration

1. Click **Configuration** in the left navigation pane. The configuration list shows new candidate configurations.

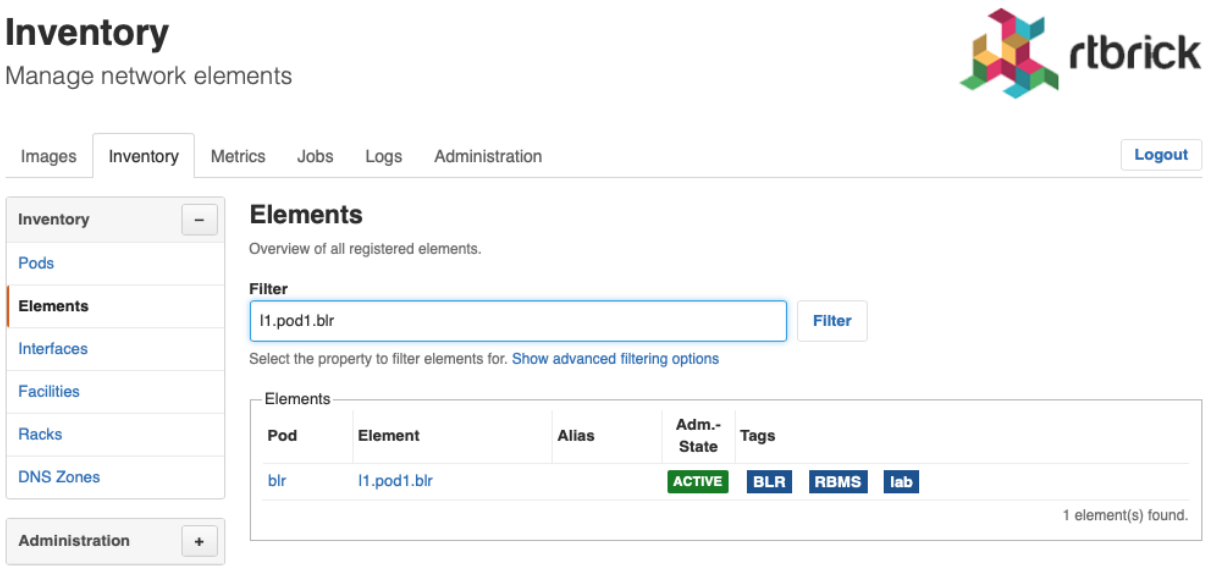


2. Click the timestamp of the generated configuration to show the configuration content. Click the configuration name to display the configuration history.

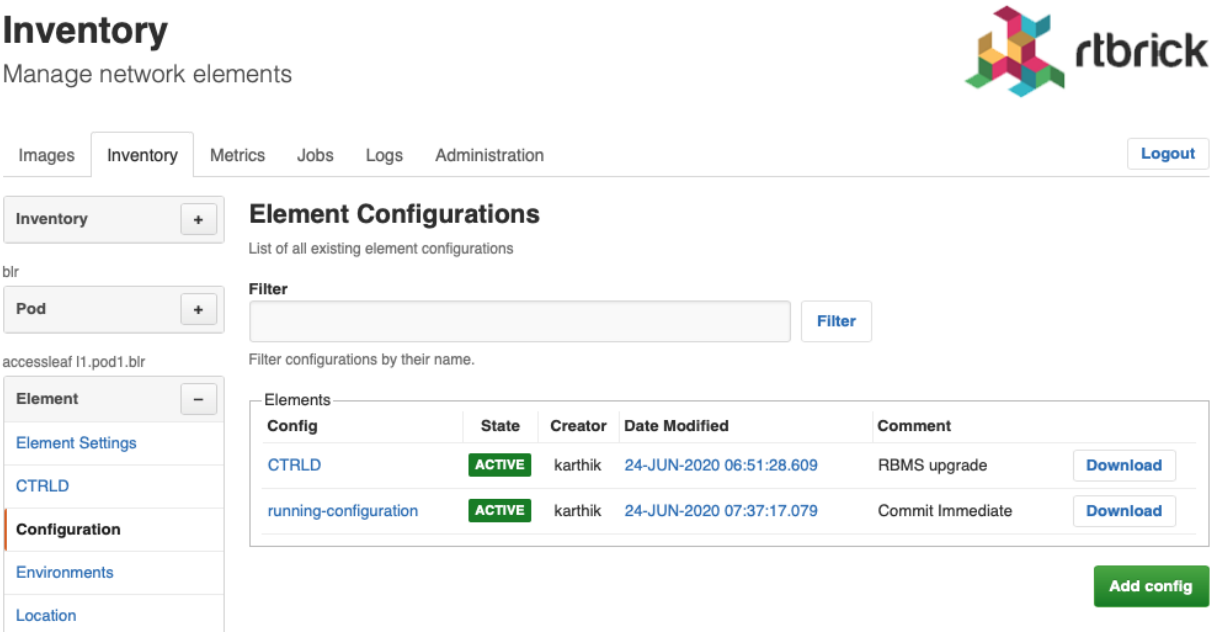
8.2. Review configuration history

To review configuration changes in the configuration history

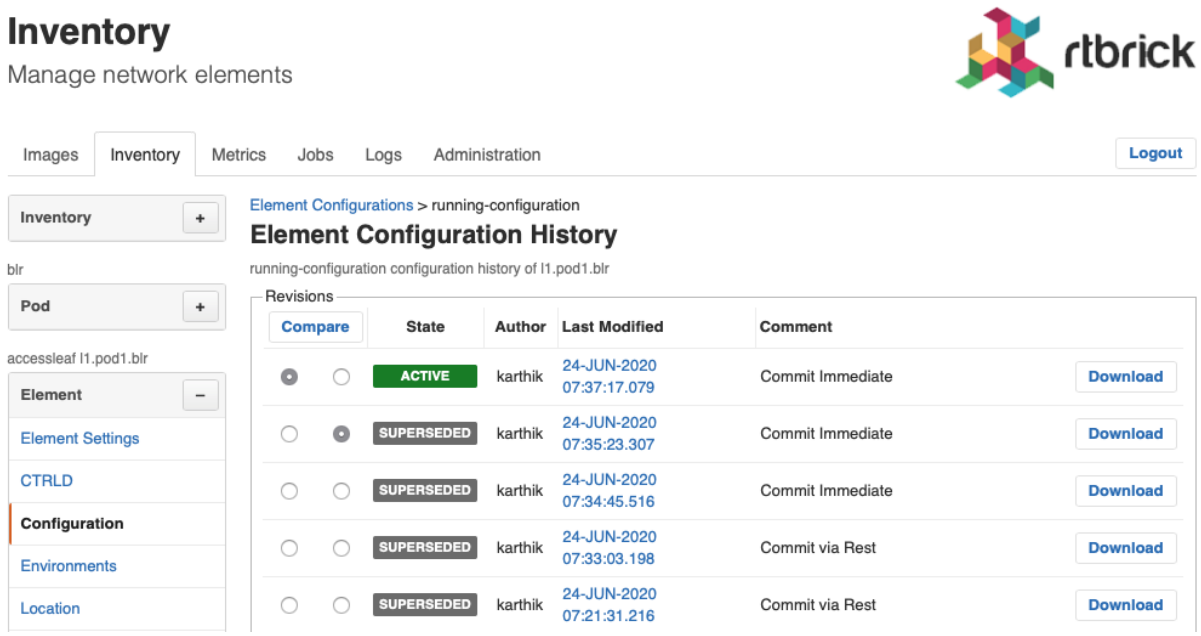
1. Click the **Inventory** tab. The list of pods appears.
2. Click **Element** in the left navigation pane. The element list appears.
3. In **Filter** enter the name of the switch and click **Filter**. The list of matching elements appears.



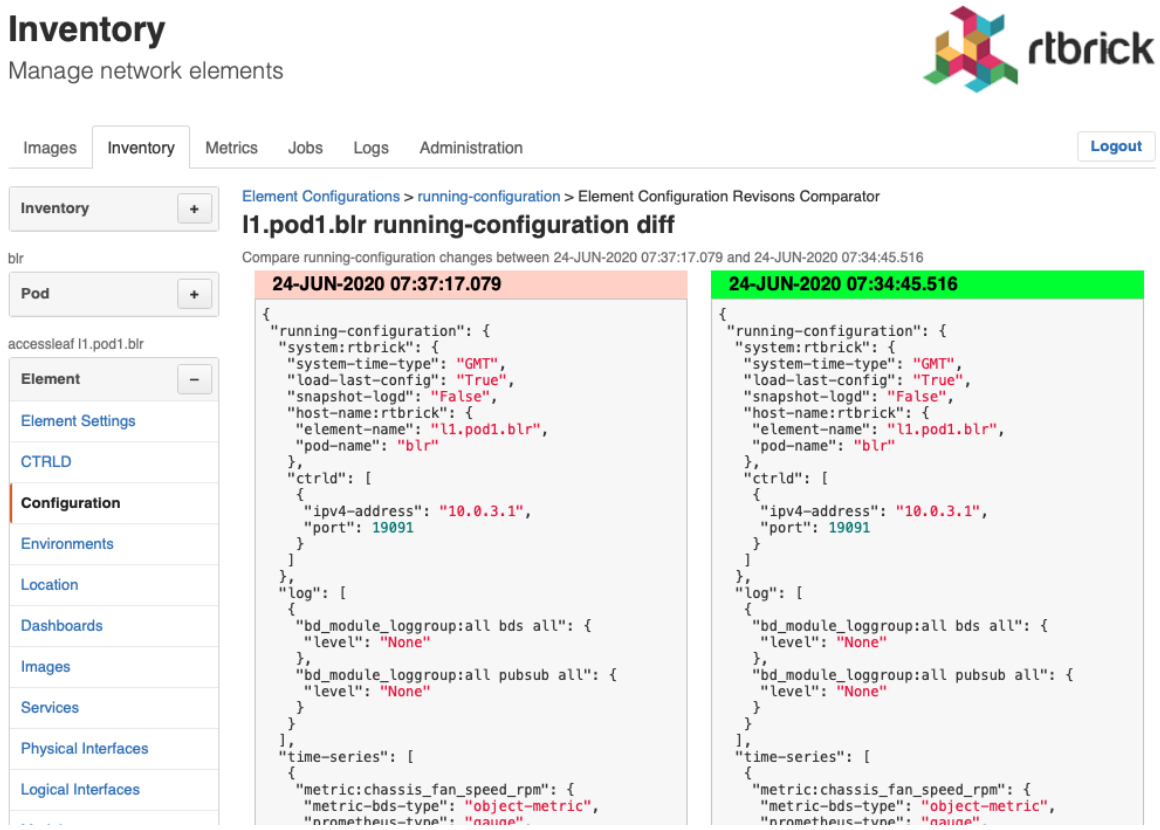
4. Click the element name for which you want to inspect configuration changes. The element settings appears.
5. Click **Configurations**. The list of configurations appears.



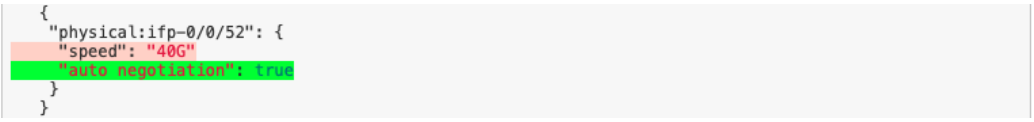
6. Click the configuration name. The configuration history appears.



7. Select the two configurations you want to compare and click the **Compare** button. The diff viewer appears.



The diff viewer shows both configurations and the diff if you scroll down.



9. RBMS Template Engine

The RBMS Template Engine is an execution engine for templates. A folder in the filesystem serves as template storage for the engine. The content of the folder follows a convention.

9.1. Template Folder structure

Template folder structure

```
templates
 |-- includes
 |   |-- <include-template>.gojson
 |-- <template name>
     |-- config.yaml
     |-- <include-template>.gojson
     |-- <main-template>.gojson
```

The template engine uses one templates folder where all the templates are stored. Each template resides in his own folder, the folder name is the template name. The config.yaml file inside a template folder indicates that this folder is a template. In this file also other configurations for the template engine can be made.

The template folder contains one main-template and can contain multiple `include-templates. The include-templates can be included into the main template.

Folders that don't contain a config.yaml are not treated as templates. This folders can be used as containers for other include-template files.

9.2. Template config

This section describes the config.yaml file. Image this folder structure for the next examples.

Simple example folder structure

```
templates
|-- includes
|   |-- global_include.gojson
|-- sample
    |-- config.yaml
    |-- local_include.gojson
    |-- main.gojson
```

Here there is a main-template which includes the local_include-template and the global_include-template. The config.yaml is used by the template engine to parse the right files, so that the include-directives work.

templates/sample/config.yaml

```
engine: golang
main_template: "main.gojson"
main_pattern: "*.gojson"
include_pattern: "includes/*.gojson"
post_processors:
  - removeTrailingCommas
  - prettyJSON
```

config.yaml attributes

Attribute	Default	Description
engine	golang	selects the template engine, at the moment only golang is supported
main_template	none	points to the entrypoint of the rendering process, this template is used as the top most, it hast to be included in the main pattern.
main_pattern	none	describes which files the engine should parse from the template folder.
include_pattern	none	describes which files the engine should additionally parse relative to the templates folder.
post_processors	none	allows to specify post processors that are used in that order on top of the generated output.

Post processors

Attribute	Description
removeTrailingCommas	removes in json files the commas which are not valid, this makes the template much easier
removeEmptyLines	removes empty lines
prettyJSON	Pretty converts the input json into a more human readable format where each element is on it's own line with clear indentation

Attribute	Description
uglyJSON	Ugly removes insignificant space characters from the input json byte slice and returns the compacted result.

9.3. GO Lang Template Engine

The default engine is the golang template engine. This gives some links to more detailed information.

The GO Lange template engine is based on:

- GoLang test template
  The golang text template engine. This allows evaluating arguments, execute actions and include other templates.
- sprig functions
  Beside of the default functions golang already provides, the sprig function library is added to the engine.

9.4. Example

This section shows a simple example, that covers a lot of functionality of the templates.

The example uses the following folder structure. Each file will be described in more detail.

Full example folder structure

```
templates
|-- includes
|   |-- global_include.gojson
|-- sample
    |-- config.yaml
    |-- example_variables.json
    |-- local_include.gojson
    |-- main.gojson
```

The template is called sample, because there is a config.yaml in the folder sample.

templates/sample/config.yaml

```
engine: golang
main_template: "main.gojson"
main_pattern: "*.gojson"
```

```
include_pattern: "includes/*.gojson"
post_processors:
  - removeTrailingCommas
  - prettyJSON
```

The config.yaml file states that the main_template is called main.gojson, so thats the entrypoint for the generation.

The main_pattern defines this files templates/sample/*.gojson should be parsed into the template engine, so also the main_pattern is included.

The include_patterns defines this files templates/includes/*.gojson should be parsed into the template engine.

The post_processors are used to remove the trailing commas and make the JSON output more readable.

Let's expect the following example variables structure.

templates/sample/example_variables.json

```
{
  "description": "sample",
  "interfaces": [
    {
      "name": "ifp_0/0/1",
      "ipv4": "127.0.0.1",
      "x": 5,
      "y": 3
    },    {
      "name": "ifp_0/0/2",
      "ipv4": "127.0.0.2",
      "x": 4,
      "y": 4
    }
  ]
}
```

The this variables can be used to fill a template.

templates/sample/main.gojson

```
{{define "t1"}}
    "hostname": "static",
{{end}}
{
    {{template "t1"}}
    "description": "{{.description}}",
    "interfaces": {
        {{template "local_include.gojson" .interfaces}}
    },
    "list": {{template "global_include.gojson" .}}
```

```
}
```

This templates starts with a definition of a new template t1 that will be used in this template.

This template t1 is included immediately after {.

Then the description is added, the selection from the variable is done via the .description.

For the interfaces we use the local template local_include.gojson, the variables that are forwarded to the template are the .interfaces so only the array of the original variable set.

To render the list we include the global_include.gojson template and forward the original variable set.

templates/sample/local_include.gojson

```
{{range .}}
"{{.name}}": {
    "ip": "{{.ipv4}}",
    "1000/x*y": {{div 10000 (mul .x .y) }},
},
{{end}}
```

The local_include.gojson iterates over the interfaces list and prints the name and ip-address of the interface.

Also a simple computation is done by using the sprig functions div and mul.

templates/includes/global_include.gojson

```
[
{{range .interfaces}}"{{.name}}",{{end}}
]
```

The global_include.gojson iterates over the interfaces list and prints in an array.

This json template does not create a valid json. The commas are not set correct. The document is not well formatted. Therefore it is easier to create the templates. To create a syntactically correct and well formatted document we use post processors. The syntax is corrected by removeTrailingCommas` post processor. The format is corrected by the prettyJSON post processor.

The next source block shows the expected outcome when applying the variables from above to the template.

templates/sample/example_result.json

```
{
  "description": "sample",
  "hostname": "static",
  "interfaces": {
    "ifp_0/0/1": {
      "1000/x*y": 666,
      "ip": "127.0.0.1"
    },
    "ifp_0/0/2": {
      "1000/x*y": 625,
      "ip": "127.0.0.2"
    }
  },
  "list": [
    "ifp_0/0/1",
    "ifp_0/0/2"
  ]
}
```

9.5. TestKit

In order to do a fast template prototyping we developed a test kit. The test kit allows to execute a template with a given variable set and validate the outcome against an expected result.

To execute we have to specify:

- templatePath: Template main folder (default ".")
- template: Template name
- format: File format [txt, json, json5] (default "txt")

So for example if we execute template-engine-test -template sample -test example -format json inside the templates folder, this command will execute the sample template with the content of the example_variables.json file as input variables. After execution the outcome is stored in the example_got.json file, and validated against the example_result.json file. The format not only specifies the file endings, it also specifies how the validation is done. So for example the json format does not care about ordering of whitespace differences.

10. Auto-DNS Provisioning

10.1. DNS Introduction

The Domain Name Service (DNS) assigns names to IP addresses of network resources such as hosts, routers, or services. Names are easier to memorize than IP addresses, especially when intuitive naming conventions have been established. Moreover, hostnames form the common name (CN) of a certificate and are needed to issue valid certificates in order to enable Transport Layer Security (TLS).

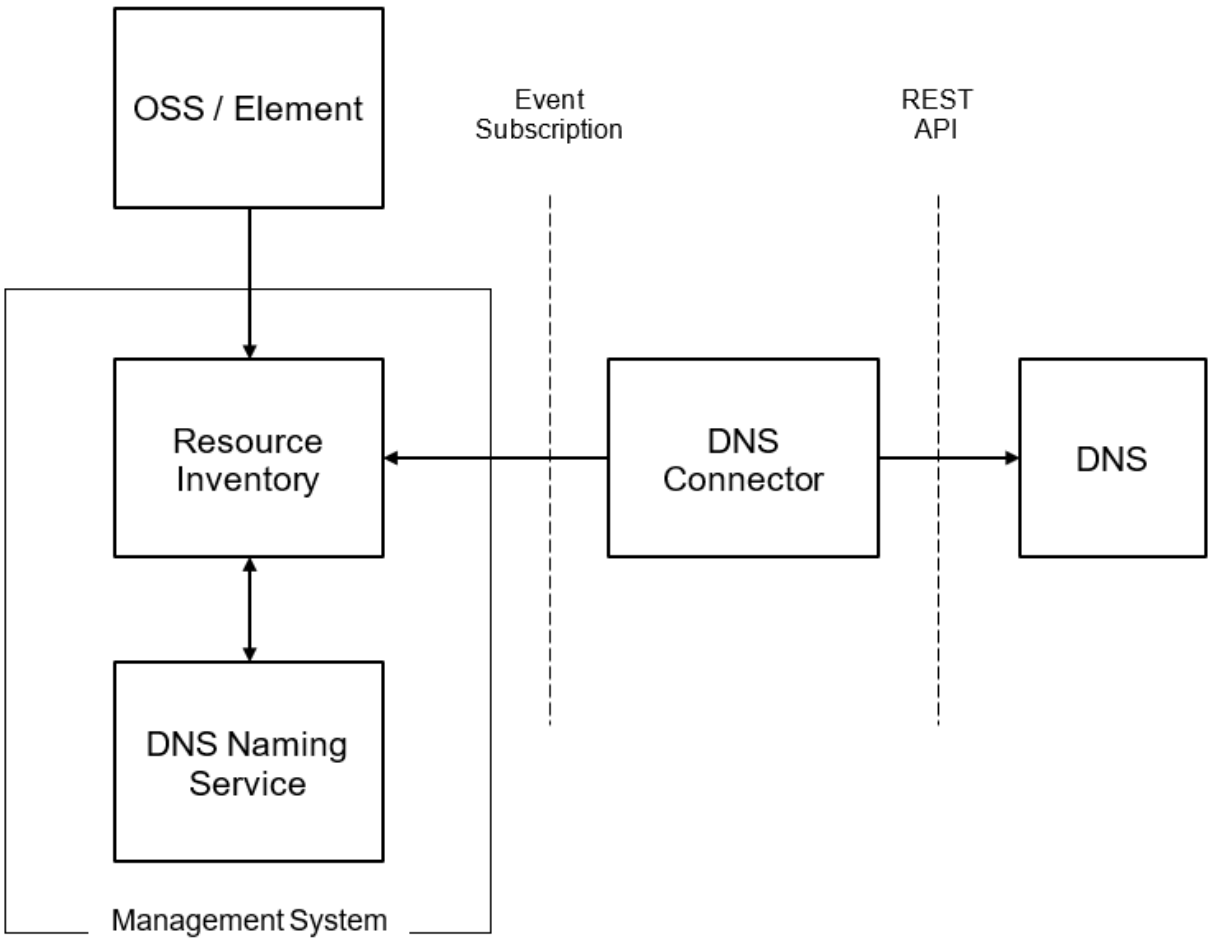
The management system keeps track of what elements exist in the network. Consequently, the management system shall be connected to the DNS such that DNS records are updated automatically whenever needed. This document discusses how to connect the management system to a DNS infrastructure.

10.1.1. Supported Platforms

Not all features are necessarily supported on each hardware platform. Refer to the *Platform Guide* for the features and the sub-features that are or are not supported by each platform.

10.2. DNS Overview

Figure 1 gives an overview of the network management system. The resource inventory forms a cornerstone of the network management system and maintains inventory records for all elements installed in the network. Operation support systems (OSS) or the element itself feed the resource inventory with data. The resource inventory issues a domain event whenever the state of an inventory record has changed.



The DNS Naming Service subscribes all domain events that have an effect on the DNS name of an element and updates the DNS name accordingly. The DNS connector subscribes domain events related to DNS name changes and invokes the REST-API of the DNS infrastructure to update the DNS records. The focus of this document is the contract between the DNS Connector and the management system.

10.2.1. Terms and Definitions

Element

An element represents either a physical or a virtual resource in the network. For example, the switches forming the fabric are physical resources whereas a virtual machine on a compute node is a virtual resource. DNS records are created for elements, but not necessarily every element requires a DNS record.

Element Role

The element role describes the function of an element in the network. Leaf switch,

Spine switch and OLT are examples of element roles.

PoD

The Point of Distribution aggregates all subscribers of a geographic region and connects them to the core network.

Resource Inventory

The resource inventory stores all elements, including their role, configuration, resources, capabilities, operational and administrative state. It also allows to group elements.

The resource inventory is fed by planning processes, which add planned elements to the inventory, and all active elements, which register themselves in the resource inventory and report configuration or operational state changes to the resource inventory.

Domain Event

A domain event describes a change that has taken place in the resource inventory. The domain event contains the information of what has changed as well as the identifiers needed to read additional information from the resource inventory.

Operation Support System (OSS)

The Operation Support System supports to control, monitor, manage and plan the network.

Management System

The management system allows the execution of management functions on the elements forming the network and inspects the configuration and operational state of an element.

DNS Naming Service

The DNS naming service assigns DNS names to all elements in the resource inventory that are supposed to have a DNS name.

Resource Record and Resource Record Set

A resource record is the basic DNS configuration entity. The resource record set contains all resource records related to the same DNS name.

DNS Connector

The DNS connector creates resource record sets from all assigned DNS names.

10.3. DNS Record Management

10.3.1. DNS Naming Convention

A sophisticated DNS naming convention leads to intuitive and concise names and supports the use of wildcard certificates, which in turn simplifies certificate management.

The prerequisite to creating a DNS naming convention is to decide which element roles and services require a DNS name.

Forward DNS Lookup

This section summarizes DNS aspects of common element management patterns briefly, without discussing the advantages and disadvantages of each management pattern in general. A sustainable DNS provisioning solution must support all common management patterns.

Out-of-Band Management

Out-of-Band management establishes a dedicated management network to manage the network elements. Each element is connected via the management interface to this network. The management system also needs to be connected to the management network to access the network elements.

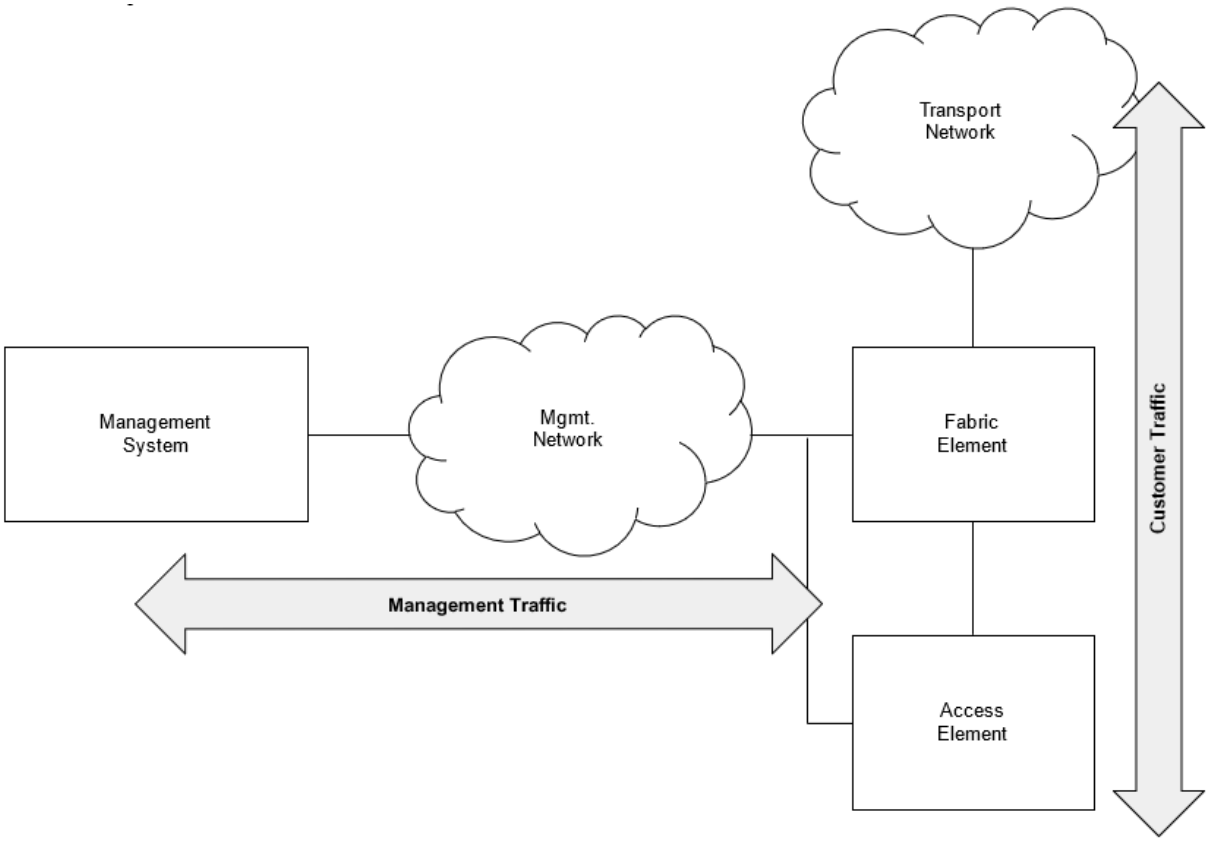


Figure 8. Schematic illustration of the out-of-band management pattern

The DNS lookup resolves the IP address of the management interface.

In-Band Management

In-band management leverages the transport network, which conveys the customer traffic, and also for network management.

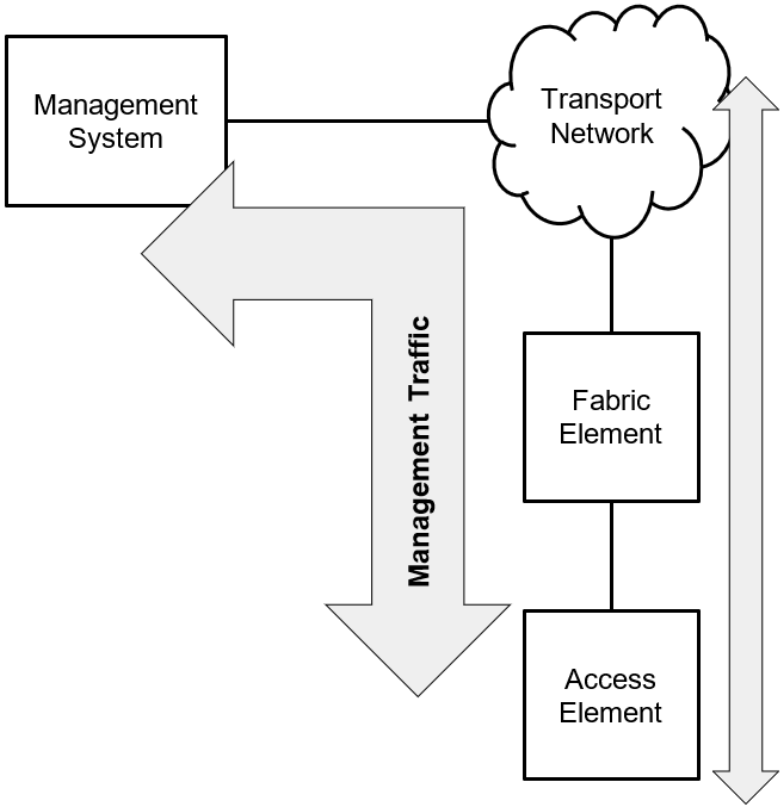


Figure 9. Schematic illustration of the in-band management pattern

The DNS lookup resolves the transport layer loopback IP address for all elements connected with more than one interface to the transport network. For elements with a single connection to the transport network, the IP address assigned to this interface is resolved.

API Gateway

An API gateway forms a single entry point to access multiple elements. The management system interfaces with the API gateway and the API gateway forwards the API call to the appropriate element. The API gateway is either accessed in-band or out-of-band.

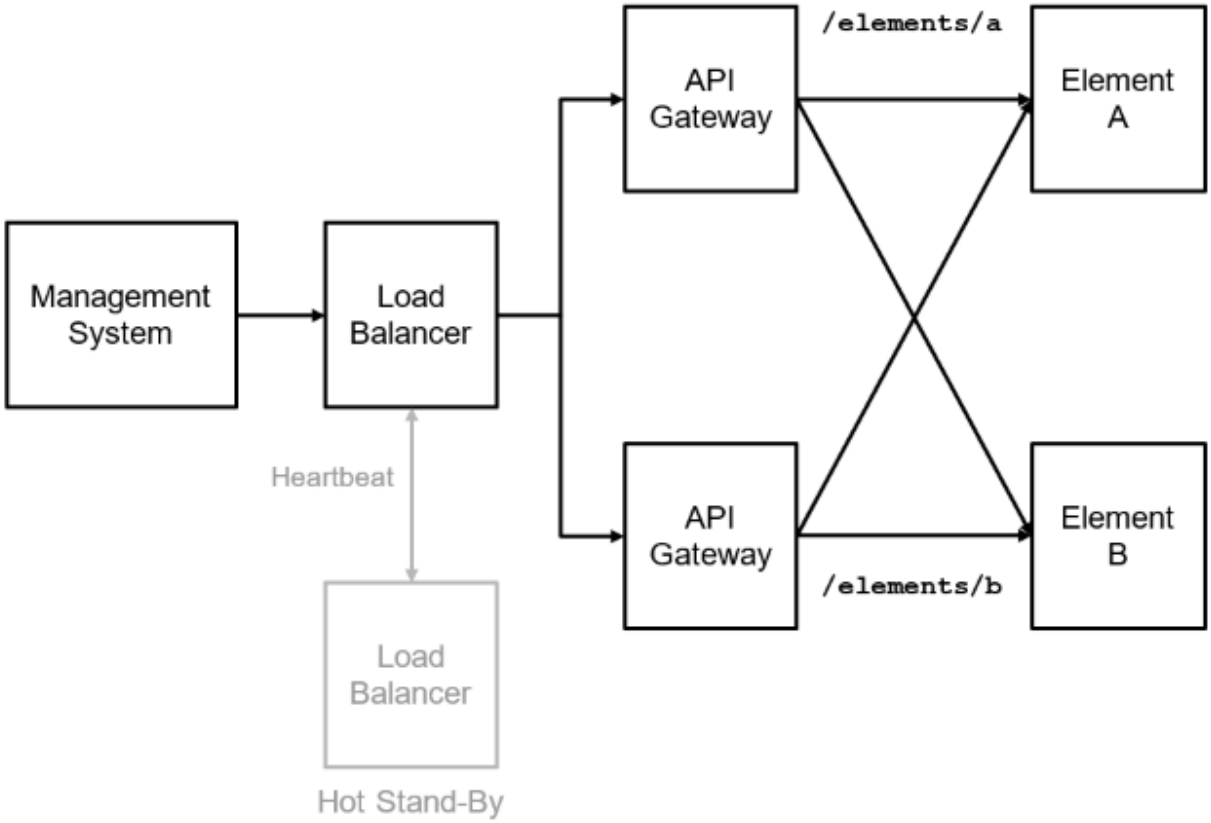


Figure 10. Schematic illustration of the API gateway pattern

The API gateway addresses non-functional requirements such as TLS termination, authentication and authorization.

Many instances of an API gateway are typically started at the same time to avoid creating a single point of failure. All instances are accessible through the same IP address, the cluster IP address. Consequently, the API Gateway DNS name resolves the cluster IP address. Additional DNS records per gateway instance are required to access a gateway instance for troubleshooting.

The management system needs to know the REST API endpoint URL for every element. The REST API invocation is the same for all management patterns outlined before. A management process reads the REST API endpoint from the element record in the resource inventory to invoke the API. Looking at the API gateway pattern, an element does not have to have a DNS name despite providing a REST API endpoint.

Reverse DNS Lookup

A reverse DNS lookup discovers the hostname for a given IP address. Reverse DNS lookups are handy for troubleshooting as they translate an IP address to a human-

friendly name. Consequently, a hostname needs to be assigned to the transport layer loopback IP address or the IP address of the interface connected to the transport network respectively.

DNS Naming Service

The DNS naming service implements the DNS naming convention and assigns a DNS name to all elements that are supposed to have a DNS name.

DNS Naming Service is beyond the scope of this document as it depends on the DNS Naming Convention.

The resource inventory will be enhanced to store zero, one or more DNS records per element as illustrated below. The DNS Naming Service maintains the DNS records per element.

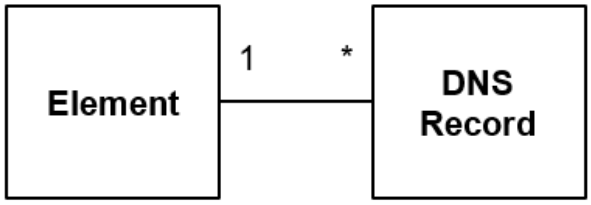


Figure 11. Relation between element and DNS record

A DNS record basically consists of:

- DNS name
- IPv4/v6 address
- status flag indicating whether the DNS record is enabled
- creation date and last modification date and
- an optional expiry date (defaults to never expire)

The resource inventory fires a domain event when a DNS record set has been added, modified or removed (**DnsRecordSetModifiedEvent**).

The following information is conveyed with a DNS record domain event:

- **event_id** - the event ID in UUIDv4 format.
- **event_name** - the event name (DnsRecordSetModifiedEvent).
- **group_id** - the element group ID in UUIDv4 format

- **group_type** - the element group type (set to pod)
- **group_name** - the element group name
- **element_id** - the ID, in UUIDv4 format, of the element whose DNS name has been modified
- **element_name** - the name of the element whose DNS name has been modified
- **element_alias** - an optional alias of the element whose DNS name has been modified. This property is omitted if no alias has been set.
- **element_role** - the role of the element whose DNS name has been modified
- **group_id** - the ID of the group the element is a member of
- **group_name** - the name of the group the element is a member of
- **group_type** - the type of the group the element is a member of, which is always set to pod
- **dns_recordset** - the DNS record set

  dns_zone_id - the DNS zone ID in UUIDv4 format of the DNS zone in the resource inventory.

  dns_zone_name - the canonical DNS zone name

  dns_name - the canonical DNS name that shall be stored in the DNS

  dns_ttl - the optional time-to-live for the DNS record (in seconds).

  dns_withdrawn_name - the DNS name that shall be removed from the DNS

  dns_type - the DNS record type (e.g. A, AAAA, CNAME)

  dns_record - the array of DNS records

    dns_value - the DNS record value (e.g. IPv4 address, IPv6 address, alias)

    dns_setptr - a flag indicating whether to create a PTR record

    disabled - a flag indicating whether this record is disabled

In addition, the resource inventory fires an event if a DNS zone was added (**DnsZoneCreatedEvent**) or removed (**DnsZoneRemovedEvent**). A DNS zone event merely contains the zone ID and canonical DNS zone name:

- **event_id** - the event ID in UUIDv4 format.

- **event_name** - the event name (DnsZoneCreatedEvent or DnsZoneRemovedEvent).
- **dns_zone** - the DNS zone that was subject to the reported change

  dns_zone_id - the DNS zone ID in UUIDv4 format of the DNS zone in the resource inventory.

  dns_zone_name - the canonical DNS zone name

DNS Connector

The DNS Connector subscribes to the DNS domain events outlined before using providing a REST API endpoint that accepts **HTTP POST** requests with the domain event as a requesting entity. The DNS connector creates and removes DNS zones according to the DNS zone events and translates the DNS record set domain event to resource record sets using the following semantics:

- Store a resource record set in the DNS if the **dns_name** property is present. The **dns_name** property value becomes the resource record set name. The resource record set contains up to two resource records: a type A record for the IPv4 address and another type AAAA record for the IPv6 address. The connector derives the time-to-live (TTL) of the resource record set from the expiry date. The TTL is omitted if no expiry date has been specified.
- Remove a resource record set from the DNS if the **dns_withdrawn_name** property is present. The **dns_withdrawn_name** property contains the name of the resource record set to be removed.

The DNS Connector uses the REST API provided by PowerDNS, an open-source DNS server, to maintain the DNS records. PowerDNS can either be configured as a DNS server or merely acts as a gateway and forwards all DNS changes to the actual DNS service.

Figure 6 illustrates the DNS records provisioning flow.

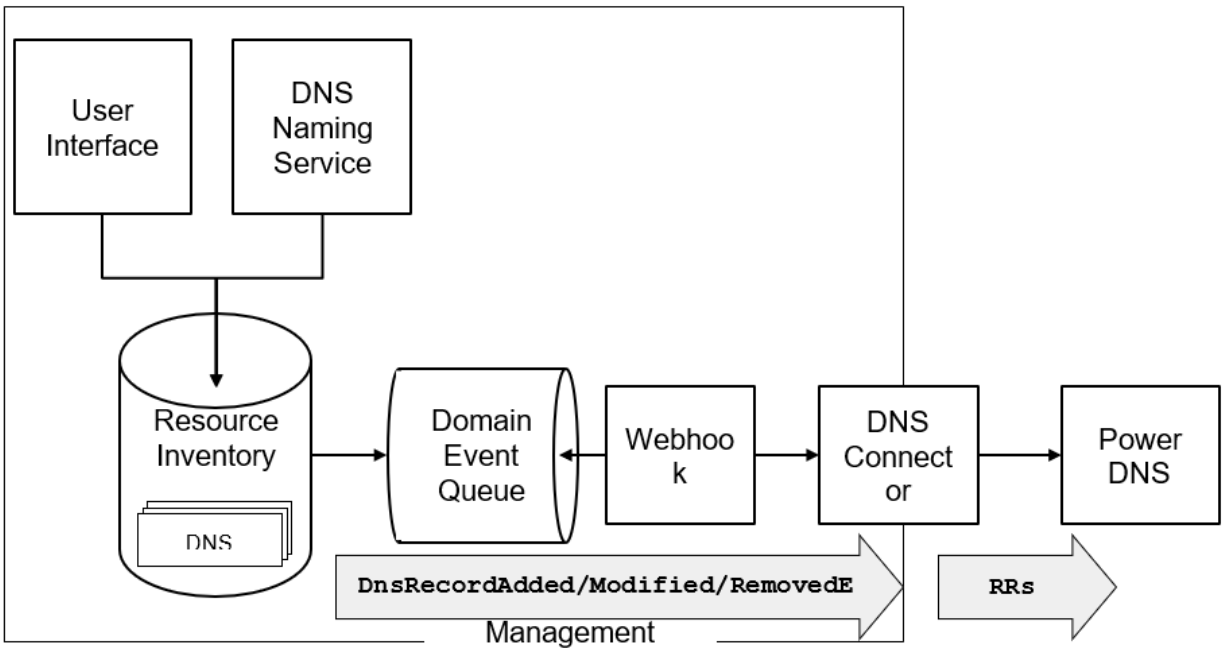


Figure 12. DNS Resource Record Set provisioning flow

The DNS records are stored in the resource inventory and maintained by the DNS Naming Service application or manually through the user interface. All DNS record changes fire an event, which is stored in the Domain Event Queue. The domain even queue is a persistent and transactional queue, which means that domain events are stored for successfully committed transactions only. A webhook, which is a configurable service, forwards all DNS events to the DNS connector, which in turn maintains the resource records sets (RRs) in PowerDNS.

10.3.2. Sample Fabric DNS Naming Convention

This section introduces a sample fabric DNS naming convention. The DNS name tree is depicted below.

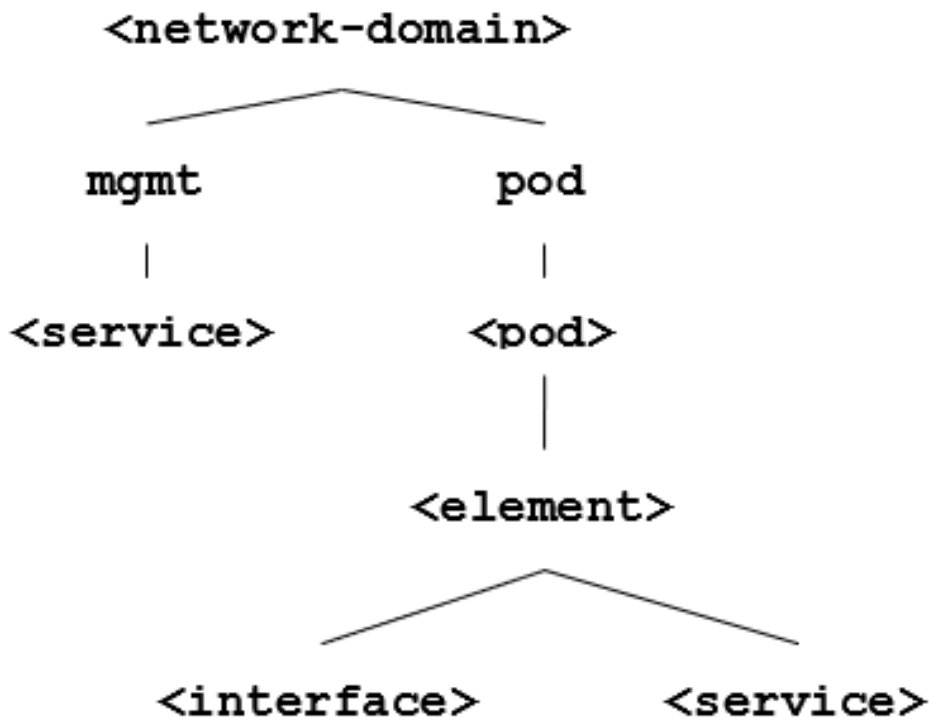


Figure 13. Sample DNS naming convention

The <*network-domain*> is the base domain name for the entire network (e.g. lab.rtbrick.net for the RtBrick lab environment). The next level of the DNS tree differentiates between central management services (mgmt) and pods (pod). Every management service has a designated DNS name. Every element in a pod has a designated DNS name too. Moreover, certain interfaces (for example, the management interface) or services deployed on an element might also get a DNS name assigned.

The network diagram below illustrates a lab topology that consists of two pod fabrics, Bangalore and Nuremberg, each formed by four switches and managed by a fabric daemon as well as a central management system. The central management system consists of three services: the control center to manage the network, the log management system to query log messages and process alerts, and the telemetry management system to process and visualize metrics. Each switch has a unique router ID, which is equal to the transport layer loopback IP address, a management interface and runs the control daemon (ctrld) to manage the switch.

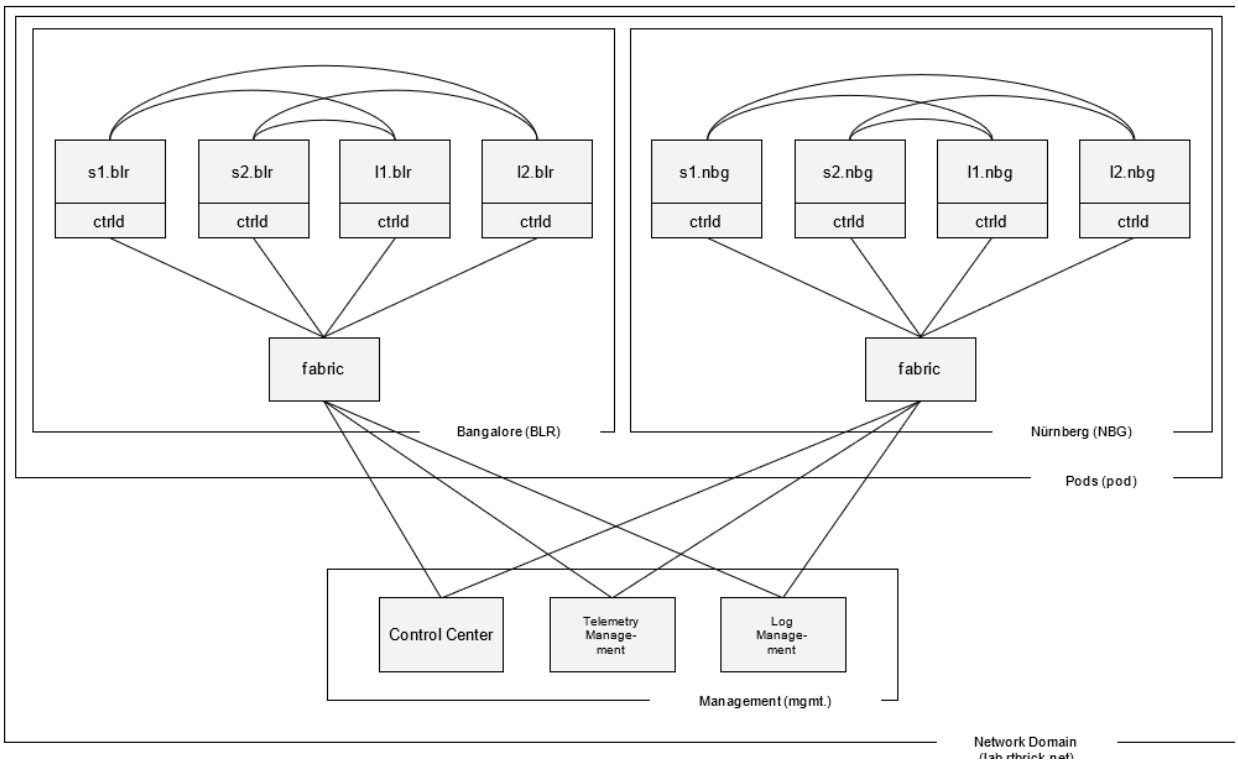


Figure 14. Sample network topology

The table below lists samples DNS names of elements and services in the sample network topology:

Sample DNS names

DNS Name	Description
lab.rtbrick.net	Network domain forming the top-level domain for all elements in the network
mgmt.lab.rtbrick.net	Subdomain for all management services in the network.
leitstand.lab.rtbrick.net	Control center service name.
log.lab.rtbrick.net	Log management service name.
telemetry.lab.rtbrick.net	Telemetry management service name.
pod.lab.rtbrick.net	Subdomain for all pods and their respective elements.
blr.pod.lab.rtbrick.net	Subdomain for all elements and services in pod Bangalore (BLR)
nbg.pod.lab.rtbrick.net	Subdomain for all elements and services in pod Nürnberg (NBG).

DNS Name	Description
fabric.blr.pod.lab.rtbrick.net	Name of fabric in pod Bangalore (BLR)
l1.blr.pod.lab.rtbrick.net	Name of leaf 1 in pod Bangalore (BLR). This name resolves to the transport layer loopback IP address.
me0.1.blr.pod.lab.rtbrick.net	Name of the management interface of leaf 1 in pod Bangalore (BLR). This name resolves to the IP address assigned to the management interface.
ctrld.l1.blr.pod.lab.rtbrick.net	An alias to access the control daemon of leaf 1 in pod Bangalore. In the case of in-band management, the name is an alias of leaf1.blr.pod.lab.rtbrick.net whereas for out-of-band management the name is an alias for the management me0.leaf1.blr.pod.lab.rtbrick.net
All remaining leaf and spine switches have similar names. Below is another example for spine 2 located in pod Nürrnberg (nbg)	
s2.nbg.pod.lab.rtbrick.net	Name of spine 2 in pod Nürnberg (NBG). This name resolves to the transport layer loopback IP address.
me0.s2.nbg.pod.lab.rtbrick.net	Name of the management interface of spine 2 in pod Nürnberg (NBG). This name resolves to the IP address assigned to the management interface.
ctrld.s2.nbg.pod.lab.rtbrick.net	An alias to access the control daemon of spine 2 in pod Bangalore. In the case of in-band management, the name is an alias of spine2.nbg.pod.lab.rtbrick.net whereas for out-of-band management the name is an alias for the management me0.spine2.nbg.pod.lab.rtbrick.net

The Domain Naming Service subscribes the following domain events in order to maintain the DNS names according to this naming scheme:

Domain Events subscribed by DNS Naming Service in order to maintain DNS records

Domain Event	Action
ElementAddedEvent	Create DNS records for the added element.
ElementRenamedEvent	Update the DNS records for the renamed element.
ElementMovedEvent	Update the DNS records for the moved element, i.e. the element is now in a different pod.
ElementRetiredEvent / ElementRemovedEvent	Remove the DNS records of a retired or removed element. An element must be in the retired state before it can be removed from the inventory. A retired element is inactive and kept in the repository for documentation purposes only. It depends on whether the DNS record shall be part of the documentation, and whether the records are removed when an element is retired or gets removed from the inventory.
ElementIflAddedEvent	Update the DNS record of an element if the management interface or transport layer loopback interface was added
ElementIflModifiedEvent	Update the DNS record of an element if the management interface or transport layer loopback interface IP address has changed
ElementIflRemovedEvent	Update the DNS record of an element if the management interface or transport layer loopback interface was removed
PodRenamedEvent	Update the DNS records for all elements in the pod.

Registered Address	Support	Sales
40268, Dolerita Avenue Fremont CA 94539		
+1-650-351-2251		+91 80 4850 5445
http://www.rtbrick.com	support@rtbrick.com	sales@rtbrick.com