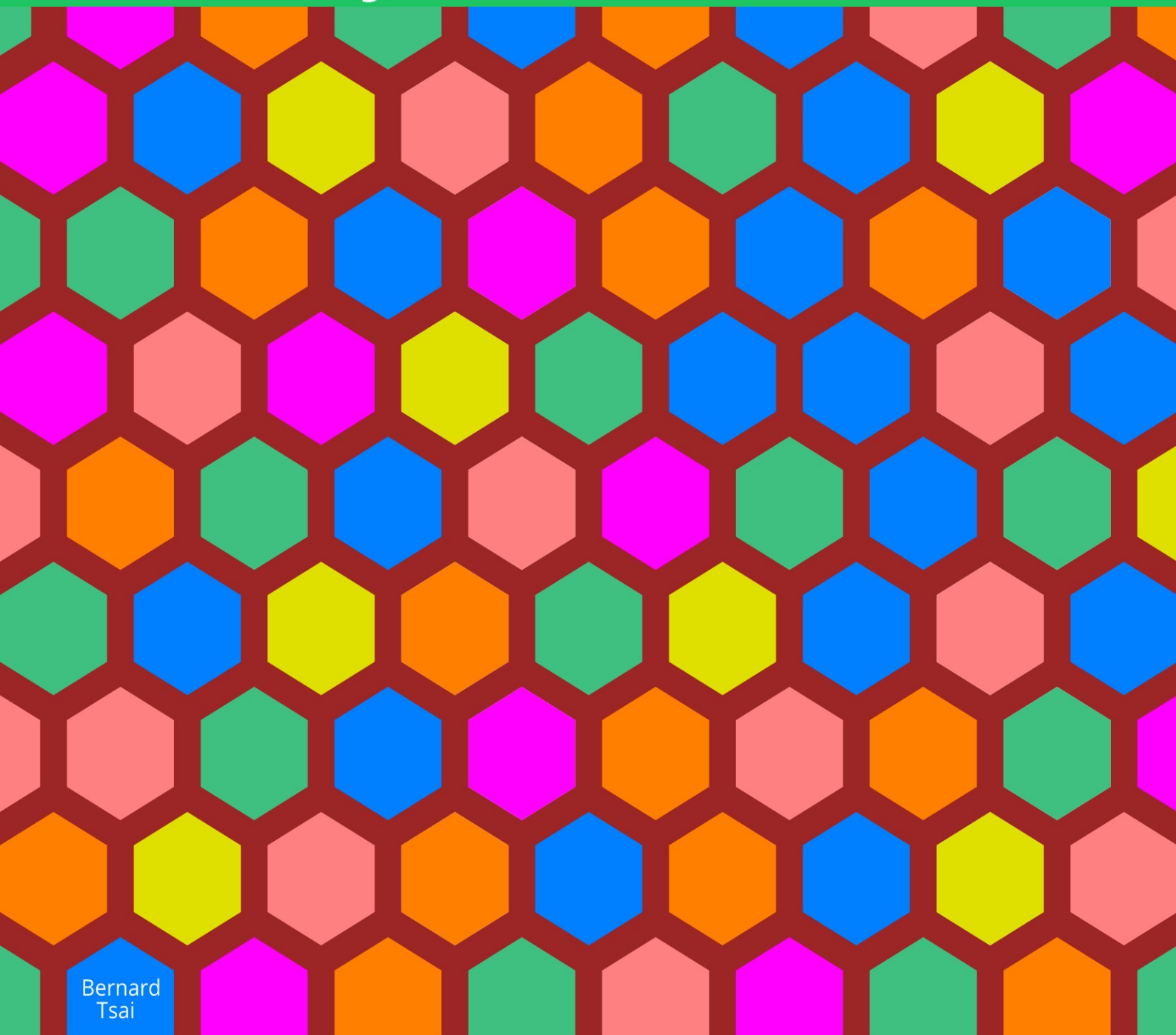
Orchestration

Lifecycle Automation



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Foreword

There is a proliferation of new technologies which have the potential to provide exciting new types of services to the customers. This leads to a continuous evolution of the technological landscape which needs to be managed consistently so that the users of these services on the one hand benefit from the new features but at the same time can rely on the service quality.

This is an example of the stability/flexibility dilemma and there are many traditional ways of how to address this, e.g.

- don't change anything,
- build different isolated solutions,
- introduce change advisory boards,
- etc.

In the age of automation where recurring tasks can be executed much faster a specific set of guidelines will allow to solve this dilemma in a more efficient way.

This book will describe such an approach and is intended for a technical audience which would not only want to learn about the main ideas but is interested in applying these concepts to their domain of interest.

Merci!

I thank my family and friends for making me feel being in the right place at the right time.

Wiesbaden, January 1st, 2019

Introduction

How can we constantly change and optimise customer services which require the well-aligned interaction of various technologies and at the same time maintain overall service quality according to the customers needs?

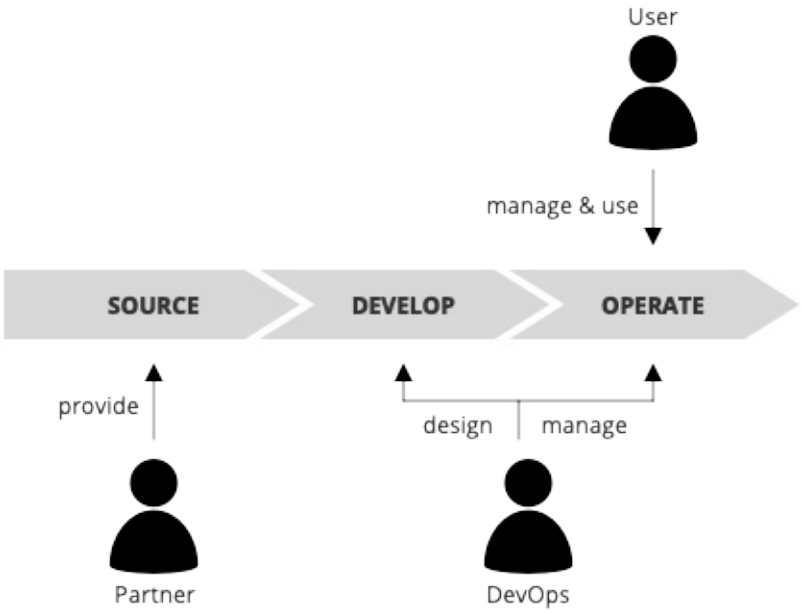
Context

Typical solutions nowadays consist of a multitude of different solution elements which need to interact consistently in order to provide the desired services. These services are typically provided to the users as managed services in the sense that the user need not be concerned of how to assemble and maintain the various solution elements. This task can be handled by a DevOps team which has partnered with a set of vendors providing the solution components from which the solution architecture with its elements can be derived.

It is not a trivial task for the DevOps team and this book will list a couple of the issues they will encounter when attempting to provide high quality services in a constantly evolving context.

The main expertise which a DevOps team needs to acquire is the capability of managing the solution according to the varying demand of it's users and the handling the required changes related to the lifecycle of its solution elements.

The value chain for a solution shown in the following diagram depicts how vendors of solution components and the DevOps team need to work together in order to provide a managed service to the users.



In the sourcing phase the vendors provide the components for the customer solutions. These serve as building blocks for the architecture which the DevOps teams design for their users in the development phase. The architecture is then instantiated in the operations phase and continuously updated in order to support the lifecycle of the managed service.

Motivation

Customer services nowadays make use of a vast amount of different technologies. Ensuring service quality for the customers therefore needs to align the various corresponding management concepts in such a way that a customer requirement is broken down into a sequence of changes on the appropriate technological components.

Technological evolution and the rapid increase of automation capabilities has lead in the previous years to a plethora of heterogenous management concepts which require rather immense integration efforts due to the complexity of the possible interaction patterns.

Taking into account that technological change is part of the game a core dilemma as stated above becomes obvious.

There is no golden bullet solution for solving this dilemma in the context of highly automated technology based services. Each approach has its advantages and disadvantages.

There are two traditional approaches of how to tackle this dilemma and an alternative concept which will be introduced in this book.

Approach A: Don't touch a running system

This approach is favoured by many Telco operators who need to guarantee a service quality of 99,999% service availability and often reduce the introduction of new technical features to an absolute minimum.

Approach B: Throw away

Why try to ensure compatibility with old hardware? Simply throw away the old technology and make use of the advantages of the new one. This has been the motto for the introduction of many storage technologies ranging from magnetic tapes, hard drives, solid state disks and cloud storage facilities. Each of the technological options addressed different qualities and found their own market leaving the consumer with the task to tackle the actual migration.

Approach C: Choreography of Managed Components and Services

This book presents a third approach of how to bridge the requirements related to change and in parallel maintaining a well defined service quality based on a choreography of managed components and services.

The disadvantage being that the various management and automation concepts need to adhere to a common way of interacting with one another. The benefits of this approach allow for the continuous integration of ever changing technological services in a seamless manner thereby focussing on the need of the customers in a consistent way.

Challenges

These are the main abilities which need to be taken into consideration when addressing the dilemma:

Hyper Convergence

The ability to consistently manage a diverse variety of technologies and align possibly different functional and non-functional requirements.

Lifecycle Automation

The ability to manage the full lifecycle of all technological components and services in an automated manner.

Closed Loop Control

The ability to continuously evaluate the lifecycle state and configurations of components and services and triggering policies as needed in order to fulfill the customer requirements.

Model-Driven Automation

The ability to manage automation procedures with the help of models which define the desired outcome instead of having to provide custom code which describes for each type of requirement how to apply the needed changes.

Dependency Management

The ability to consistent handle the dependencies between different components and services when applying changes.

Fault Tolerance

The ability to recover from unforeseen errors and reestablish a comprehensive lifecycle management for all components and services.

Reconciliation

The ability to recover from manual interventions and reestablish a comprehensive lifecycle management for all components and services.

Concurrency

The ability to consistently handle multiple concurrent customer requests and changes in a well-defined manner.

Scalability

The ability to seamlessly scale with the number of managed component, services as well with the number of changes regardless of the location of the managed elements.

Continuous Integration/Continuous Deployment

The ability to continuously roll-out or roll-back versions of components and services in a well-defined manner.

Near Real Time

The ability to manage changes in a close to real time timescale.

High Availability

The ability to provide highly available services even when applying changes.

Concepts

Composable solution architectures simplify lifecycle automation.

The basic idea behind the orchestration approach presented in this book is not to create an extremely powerful system capable of handling even the most exotic cases but rather identify a set of best practices which would reshape the overall complexity in such a way that the various management tools can work efficiently together based on what they can do best.

These best practices/core concepts allow for a choreography of managed components and serve as the foundation for the design of composable solution architectures:

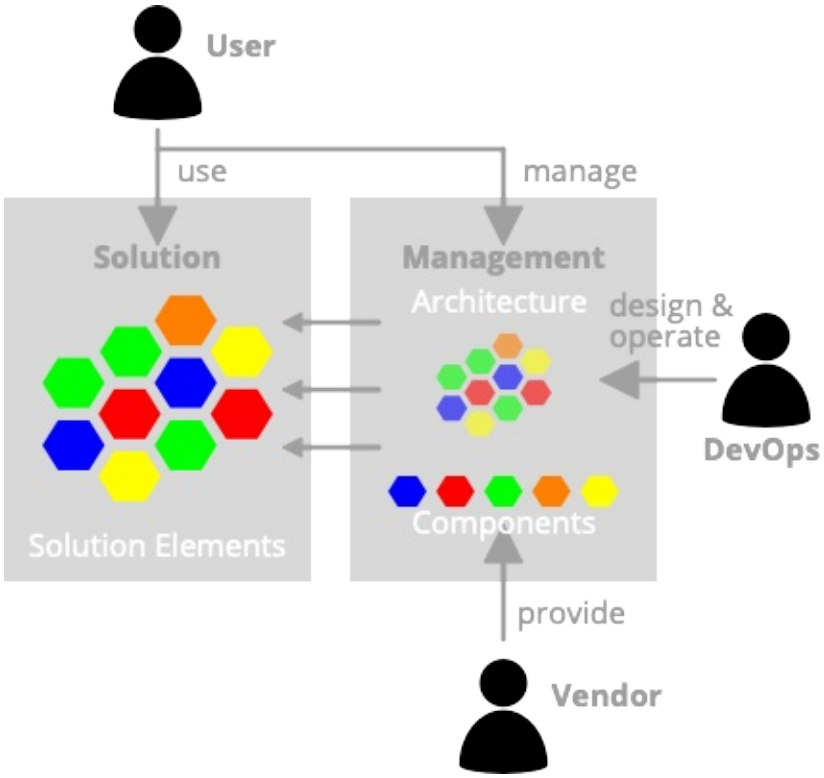
- Prerequisites: assumptions and prerequisites
- Decomposition: divide and conquer
- Components: everything is a component
- Services: purpose of components
- Versions: evolution of services
- Cluster: no single points of failure
- Lifecycle Model: initial, inactive, active, failure
- Dependencies: interaction patterns
- Closed-Loop: converging towards target states
- Configuration: customization of components

These concepts are detailed in the corresponding subchapters and together simplify the design of the orchestration algorithm.

Prerequisites and Assumptions

The capabilities of the technological components of a solution are provided to the users as a managed service.

The solution approach is based on following assumptions and prerequisites which define the context in which the approach presented in this book could be applied.

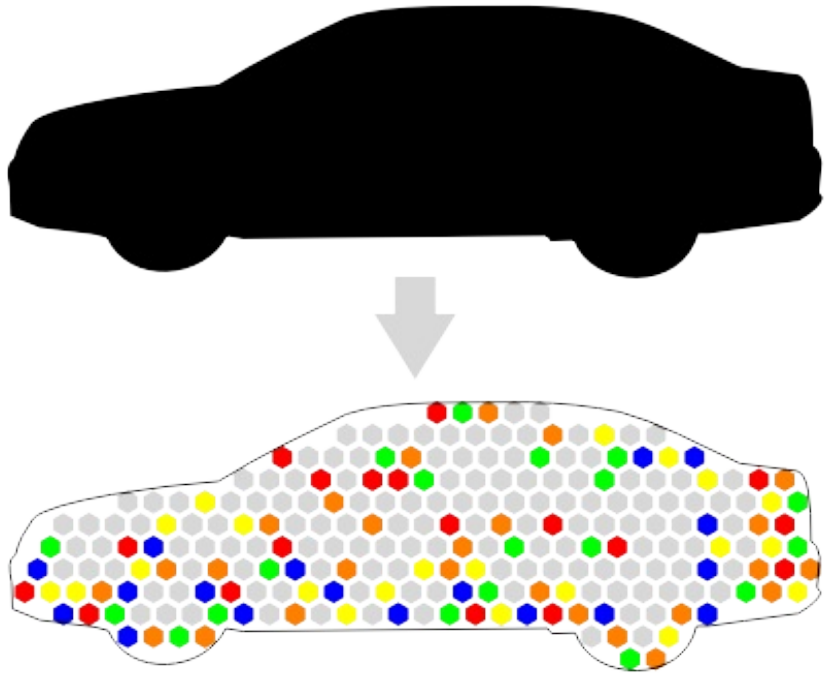


- Users consume services and require a certain quality of service.
- Services are provided by a set of technological components.
- Automation APIs can fully control the lifecycle of components.
- Administration has access to all available automation APIs.
- Self-Service allow users to access a subset of the automation APIs.

Decomposition

Divide and conquer

User services make use of the functionality provided by a solution consisting of a set of interacting technological elements. The overall architecture of such a solution can therefore can be regarded as a composition of solution elements.



Following aspects indicate how to decompose the overall architecture into its various elements:

- an element of the solution can be exchanged independently from the rest of the solution
- an element of the solution provides a specific functionality for other elements or users
- an element of the solution may have its individual lifecycle state

The result of the decomposition is map of individual technological elements identifiable by unique identifiers within the administrative realm.

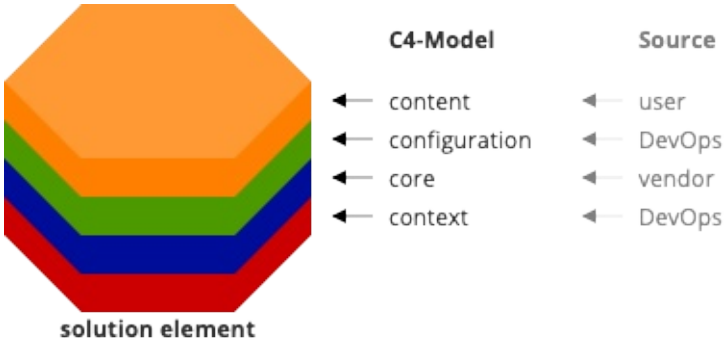
Components

Everything is a component.

The concept assumes that the technological elements obtained by the decomposition of a solution share a set of common attributes, behaviours and relationships although they may each be of very different nature. Therefore all technological elements are regarded to be components or to be more precise instances of a component. These component instances may be of specific type and may form clusters to ensure service availability.

Structure (C4-Model)

The C4-Model structures components into four fundamental aspects which may evolve independently from one another and are possibly managed by different roles.



1. Context: each component requires a dedicated environment to support the way it can evolve along its lifecycle and provide its services.
2. Core: each component consists of a core structure which is capable of providing the required functionality. of the component.
3. Configuration: each component may need to be configured, so that it fits into its context and provides its service according to the generic requirements of its service consumers.
4. Content: each component may have to make use of content information based on the usage of the service (in contrast to the configuration information).

The context is managed by the DevOps teams responsible for the corresponding components. The core structure is provided by the developers of the component itself. The configuration is defined by the DevOps team responsible for the component and the content is generated in the course of the interaction of the component with the service consumers.

Attributes

Instances of a component share following common attributes:

- Name: a unique identifier for the instance within the administrative realm
- Type: an indicator specifying which type of component the instance has
- Version: an indicator following the rules as specified by Semantic Versioning, describing which version of the component type the instance relates to.
- State: lifecycle state of the instance.
- Endpoint: service interface via with the service functionality can be accessed.

- Configuration: the configuration information controllers require to configure a component instance.

Behaviour

Each component instance will provide a type specific service. The common behaviour which all instances of components expose in addition to that is related to the transitions defined in the common lifecycle model and a status operation which allows to determine which lifecycle state a component instance has:

- Status: queries the current state of a component instance
- Create: provision a component instance as defined in a descriptor
- Start: activate a component instance
- Stop: deactivate a component instance
- Configure: configure an inactive component instance
- Reconfigure: configure an active component instance
- Destroy: remove an inactive instance
- Reset: remove a component instance after it has failed

Relationships

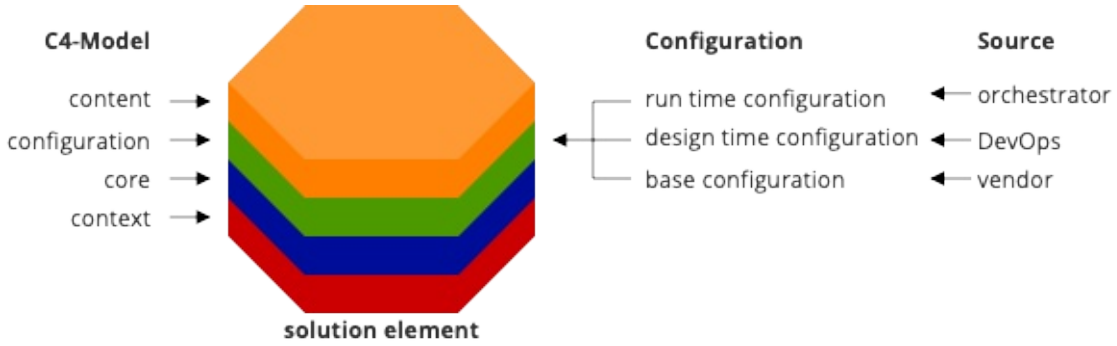
There are three main types of core relationships defining how component instances need to interact amongst one another:

- Runtime-Context: defining which component environment a component requires in order to be instantiated
- Service-Context: a service relationship defining which components need to provide services to a component so that it is able to provide its own service
- Cluster-Context: the component instances providing similar functionality need to coordinate their Lifecycle transitions in order to ensure overall service availability from a cluster perspective

Configuration

Configuration customises a component to the environment and general requirements of its service consumers.

The configuration of a component typically depends on the type of the component and possibly even on the version and therefore can not be handled in a generic manner but needs to be executed by the corresponding specialised controller.



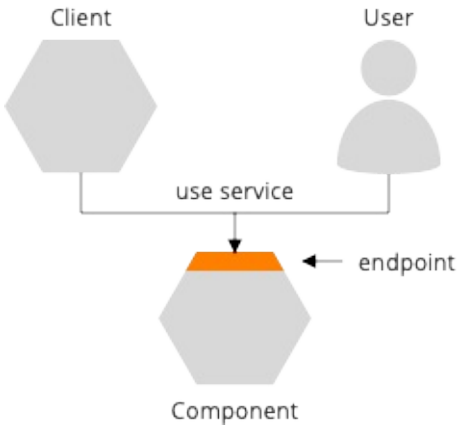
Nevertheless it is possible to distinguish between following aspects of the required configuration information:

- Base Configuration: the data which is provided by the vendor of a component to parametrise its generic service behaviour.
- Design Time Configuration: the data which is related to the architecture of the solution and is developed by the DevOps team to customise the component in such a way that it can be integrated into its runtime context and service context.
- Run Time Configuration: the configuration data which is determined during the run time by the orchestrator (e.g. the endpoints of services).

Services

Services are the purpose of a component.

Instances of components as technological elements provide a type specific functionality to other components and/or users (service consumers). This functionality is the actual purpose of a component and is called its "service".



Which kind of functionality is provided is determined by the type and version of the component following the rules for Semantic Versioning.

The interactions between components is governed by the services and the graph of service relationships between different components will be named "service-network". It is essential for the service quality from a user perspective that the service network is always kept in a consistent state (i.e. no failing service interactions).

Endpoint

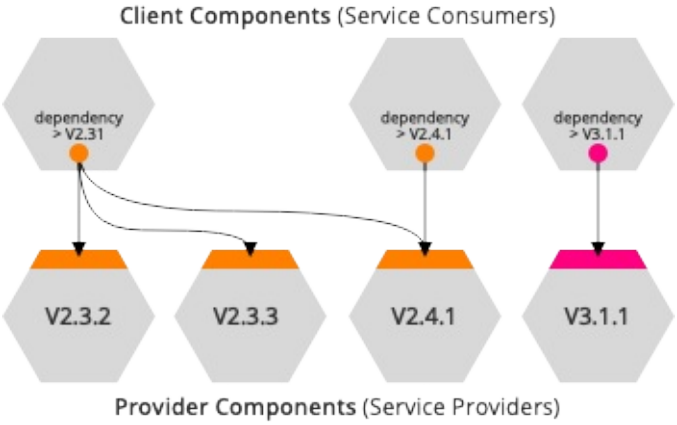
An Endpoint describes how a service provided by a component can be accessed. The service consumers need to able to interpret this information in order to access the service of the service providing component.

Endpoints may change over time and the distribution of any changes to the endpoint information needs to be well organised in order to ensure a consistent service network.

Versions

Versions mark how components change their purpose over time.

Over time components will have to change the functionality they provide to their service consumers (other components or users). These changes need to be accounted for and are captured by tagging each specification with a version tag as defined by the rules for Semantic Versioning.



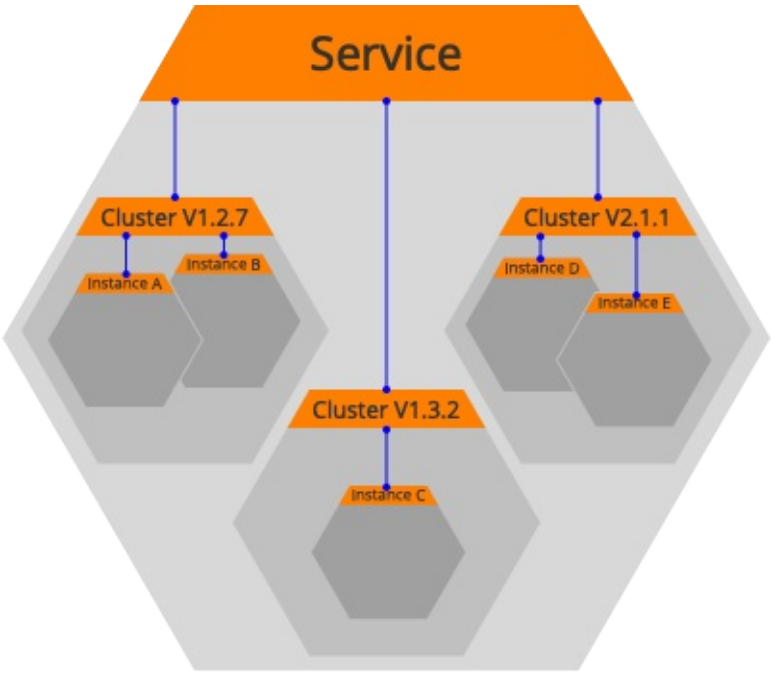
The rules state that given a version number MAJOR.MINOR.PATCH, one needs to increment the:

1. MAJOR version when an incompatible change is made,
2. MINOR version when functionality is added in a backwards-compatible manner, and
3. PATCH version when backwards-compatible bug fixes are applied.

Cluster

Clusters prevent single points of failure for services.

Several component instances of a specific type can group together to form a cluster. These clusters follow the same lifecycle model as the individual components instances.



The service endpoints of component instances are exposed by a component cluster in a stable manner ensuring that changes in the lifecycle state of individual component instances do NOT change the service endpoint of the whole cluster.

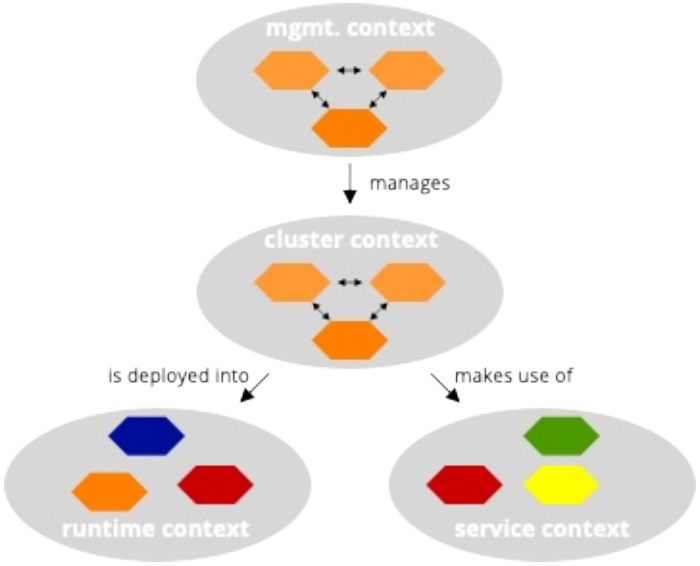
This allows service consumers to access a service independent of the availability of a single component instance. Service consumers should therefore only bind to the service endpoints of a component cluster and not to the endpoints of individual component instances.

The only times a service endpoint of a component cluster changes is when it transitions to or from the active state.

Dependencies

Components interact along well defined interaction patterns

There are three main types of relationships between components or instances of components. These define the rules of how these elements need to interact with one another and the main reason for requiring an orchestrator to synchronise the activities of the controllers as type specific management components.



- Runtime Context: runtime environment for components
- Service Context: client-service relationships between components
- Cluster Context: interactions within a component cluster

Runtime Context

Often components require a specific environment in which they will need to be provisioned. This is the runtime environment of a component.

Relating this constraint to the lifecycle model of components immediately implies that components can not be created if the components which are providing their runtime environment are not in the active state.

Vice versa if a runtime environment leaves the active state it is necessary to inform the dependent components that they will have to be destroyed as well in the course of this process.

Service Context

Often components require a set of services from other components in order to be capable of providing their own service. These backend components are the service environment of these components.

Relating this constraint to the lifecycle model of components immediately implies that components can not be activated if the components which are providing their service environment are not in the active state.

Vice versa if a component of a service environment leaves the active state it is necessary to inform the dependent components that they will have to be deactivated as well in the course of this process.

Cluster Context

Several component instances of a specific type can group together to form a cluster.

The service endpoints of component cluster are exposed by a component cluster in a stable manner ensuring that changes in the lifecycle state of individual component instances do NOT change the service endpoint of the whole cluster.

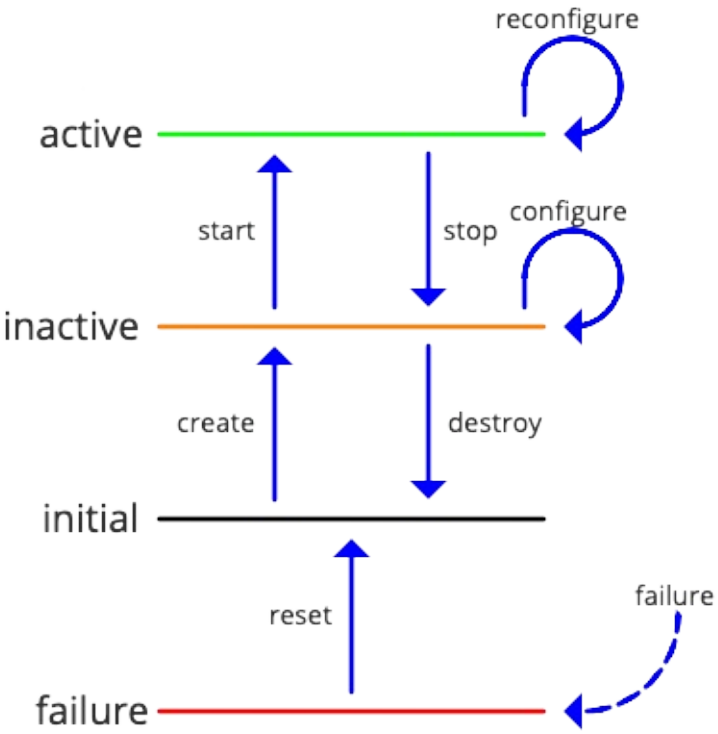
Relating this constraint to the lifecycle model of component instances immediately implies that component instances can not be activated or deactivated without informing their siblings by triggering a corresponding reconfigure transition.

Lifecycle

All components and component clusters follow the exactly same lifecycle model.

Each component regardless of type or version and every component cluster is governed by a generic lifecycle model which defines in which states these entities may be and which transitions are allowed between these aforementioned states.

These states and transitions are depicted in the following diagram:



The lifecycle of the components and clusters runs through following states:

- Initial State:

  In the initial state the definition of the component has been stored in a repository or catalogue system which maintains the descriptor along with all corresponding software artefacts to bring this component to life with the help of an orchestrator and the type specific controllers.

  Create transition

  The orchestrator may be triggered to create the component and initiate the creation procedure for an instance of the component.

  It will have to ensure that the components runtime context is already available and active so that this transition can be conducted.

  If the transition is successful within a certain time period the component is regarded to be inactive.

In the case the component cannot be installed due to time-outs or other errors even after a limited set of repetitions the component is regarded to be in the failure state.

- Inactive State:

  In the inactive state the component already resides in its runtime context although it might not be configured and activated to provide services to its consumers

  The orchestrator may also be triggered to either configure, start or destroy the component instance.

  Configure Transition

  The orchestrator may now be triggered to configure the component instannce and initiate the configuration procedure. It will have to ensure that all of the components service dependencies at least have already been configured so that the corresponding endpoint information is available and that this transition can be conducted with the help of this information.

  If the transition is successful within a certain time period the component instance is still regarded to be inactive.

  In the case the component instance cannot be configured due to time-outs or other errors even after a limited set of repetitions the component is regarded to be in the failure state.

  Start Transition

  In the case of the start trigger the orchestrator initiates the starting procedure which will after successful termination change the state of the component instance to active.

  In the case the component instance cannot be started due to time-outs or other errors even after a limited set of repetitions the component is regarded to be in the failure state.

  Destroy Transition

  If the trigger was destroy the orchestrator destroys the component instance. This will change the state if the component instance to initial again.

  In the case the component instance cannot be destroyed due to time-outs or other errors even after a limited set of repetitions the component is regarded to be in the failure state.

- Active State:

  In the active state the component instance has been deployed into its runtime context, has obtained all the information it requires to access the services of all the components it depends upon and now actively exposes its services to the service consumers.

  The orchestrator may now be triggered to either stop or reconfigure the component instance.

  Stop Transition

  In the case of the stop trigger the orchestrator notifies the service consumers that the component instance will cease to provide its services and initiate the stopping procedure which will after successful termination change the state of the component instance to inactive.

  In the case the component instance cannot be stopped due to time-outs or other errors even after a limited set of repetitions the component is regarded to be in the failure state.

  Reconfigure Transition

  If the trigger was update the orchestrator will reapply the new configuration to the component in the course of the updating procedure which will after successful termination again lead the component to the active state. During the updating of the component will still maintain the availability of its services.

Depending on the nature of the component this behaviour might or might not be supported. This behaviour is required for clusters which need to provide a 24x7 service, whereas components which serve as a part of a cluster should either be created anew with the correct configuration and then integrated into the cluster or first be stopped and taken out of the cluster, then reconfigured and after that started and taken into the cluster again.

In both cases, if the transition is not successful due to time-outs or other errors even after a limited set of repetitions the component is regarded to be in the failure state.

- Failure State:

  There may be several reasons for a component instance to have reached the failure state in which the status of the component instance is undetermined and therefore regarded to be unusable.

  Reset Transition

  As soon as the orchestrator has identified that a component has reached this state it needs to inform all of its service consumers and then initiate a reset procedure which should free any bound resources and as a result transfer the component into the initial state again.

Closed Loop Automation

Control loop to converge the current state towards the desired target state.

A set of actors are involved in the closed loop automation procedure described in this subchapter.

Actors

DevOps

It is assumed that the administration of the solution providing customer services is handled by a DevOps team which understands the design of the solution and can trigger required administrative changes.

This team will also serve as escalation path if the automation procedures are not able to handle configuration requests even after reiterating the request a limited amount of times.

Controllers

In reality it will be impossible to implement a single automation engine capable of handling all lifecycle transitions for every component type. Therefore it is assumed that a set of type specific controllers will be available which can transition component instances along the transition paths defined in the lifecycle model.

These controllers will receive intent based requests which specify the desired lifecycle state for a component instance. These requests need to to handled in an fault-tolerant idempotent way so that issues which may have occurred during the execution could as a first option be addressed by restating the request.

Orchestrator

Controllers specialise on the managing the lifecycle of component instances of a specific type. Since the components need to interact it is necessary to have an automation element which aligns the automation procedures between the various controllers, i.e. the orchestrator.

Catalog and Repository System

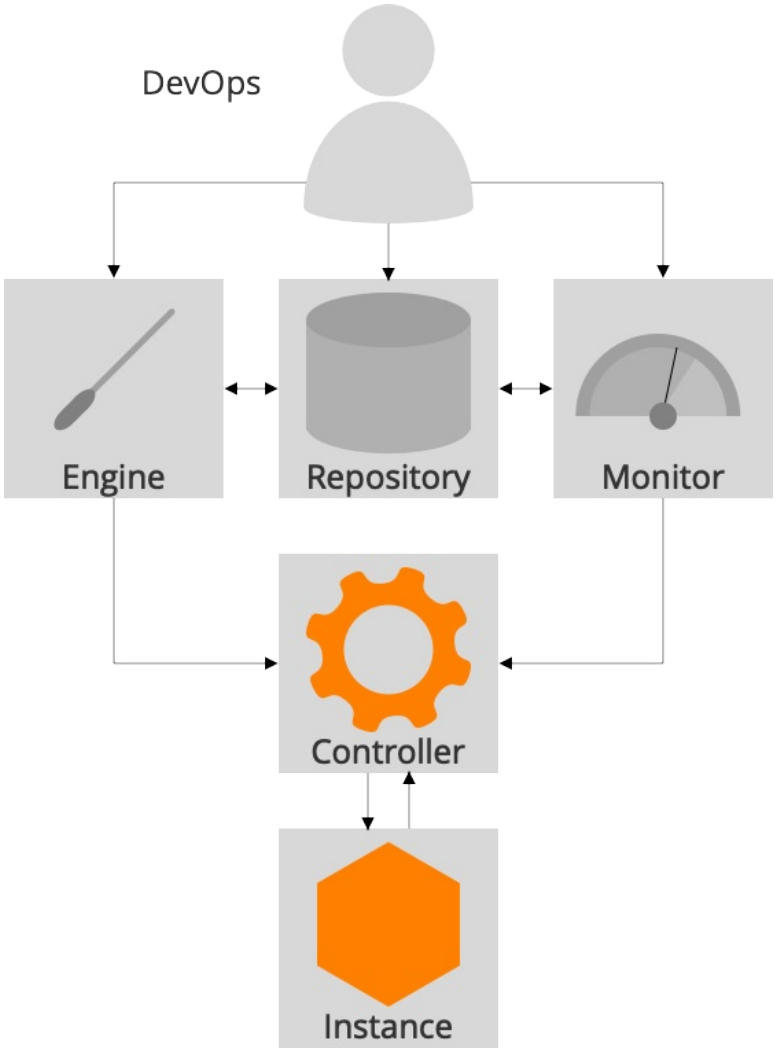
The solution designers describe the structure of the solution with the help of a set of descriptors. These also specify which software artefacts are required by the controllers in the course of the closed loop automation.

The descriptors are stored in the catalog system and the artefacts need to be uploaded to the repository system.

Monitoring

The monitoring system continuously captures the status of the defined component instances by querying the corresponding controllers and forwarding this information to the orchestrator.

Closed Loop



Model based closed loop automation makes use of following process steps in order to implement an intent based solution management approach.

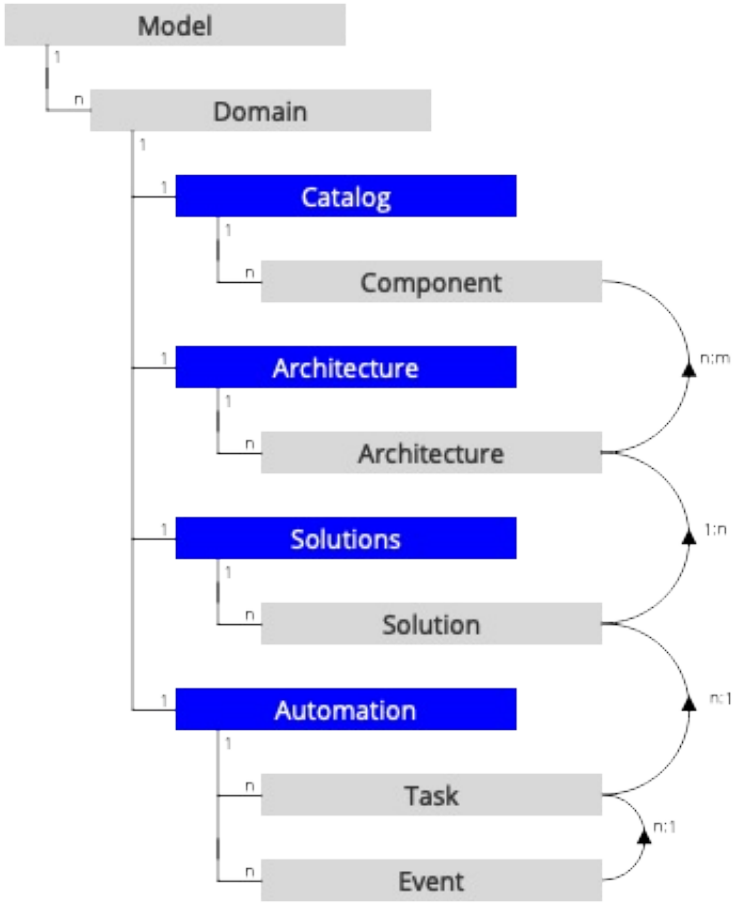
1. Service Design: DevOps onboards a service descriptor along with all of its corresponding artefacts into a catalog/repository system. It is assumed for simplicity reasons that the validity of the service description has been ensured by test procedures before the onboarding takes place.
2. Service Provisioning: DevOps triggers the provisioning of a service by detailing parameters for the component instances and passing this way the intent, i.e. desired target state of the solution to the orchestrator.
3. Delta Calculation: The orchestrator compares the desired target state with the current state, i.e. the current information it has of the solution. The differences for each component instance are identified and passed as delta list containing information about which component instances need to be created, reconfigured or destroyed.
4. Sequencing: The orchestrator triggers all required lifecycle state changes in parallel for each component instance of the delta list. The orchestrator calculates the prerequisites for each transition based on the relationship information captured in the descriptor and triggers the corresponding required transitions. This may lead to additional ripple effects as further prerequisites may have to be met.
5. Transitions: The transition requests are forwarded from the orchestrator to the corresponding type specific controllers which then transition the component instance along the path of the lifecycle model. During this operation the orchestrator informs the monitoring system as well, that the specific component instance has a new desired target state and should be monitored accordingly.
6. Monitoring: The monitoring system continuously retrieves state information of each component instance by querying their controllers and forwards this information to the orchestrator so that it can update its status information of the instance specific current state and trigger a new delta calculation.

This automation approach constantly compares the current state with a desired target state and will eventually converge the solution in a fault tolerant way to the state specified by the intent of the DevOps team.

Model

Intent based automation requires a well structured information model.

The following diagram provides an overview of the information model:



The information model or Model is divided into administration realms or domains. This allows for sharding the information model into substructures which can be managed independently from one another if needed.

Model

The model entity is the central entry point to the information required by the closed-loop automation procedures. It is subdivided into a set of subdomains which can be administrated independently from one another.

Attribute	Type	Description
Schema	string	schema of the model
Name	string	name of the model
Domains	map to Domains	map of names to domains

Domain

A domain is an administrative realm which can be managed independently from other domains and may serve as a context for sharding the model.

Attribute	Type	Description
Name	string	name of the model
Catalog	map to Components	map of names to components
Architectures	map to Architectures	map of names to architectures
Solutions	map to Solutions	map of names to solutions
Tasks	map to Tasks	map of uuids to tasks
Events	map to Events	map of uuids to events

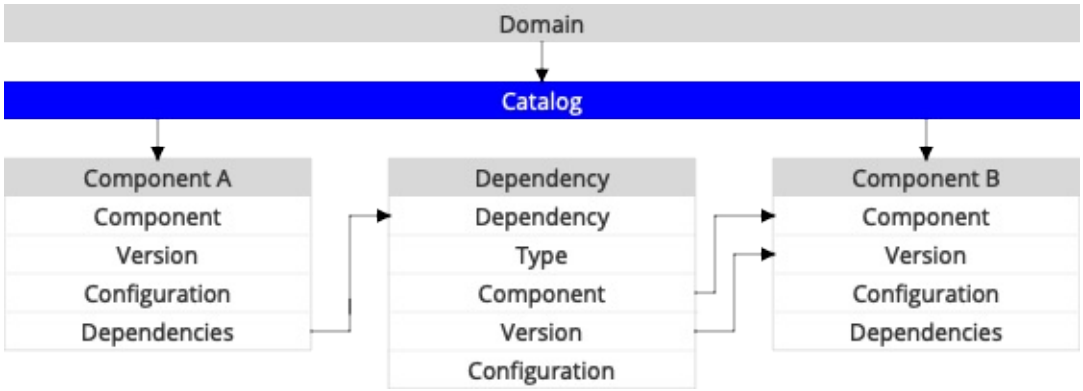
A domain holds four types of information:

- Catalog: the catalog holds the templates for all components including their version information, their dependencies amongst one another and a basic generic configuration. The catalog can therefore be regarded as a repository of building blocks for the elements of a solution.
- Architectures: The architectures are designed to depict what a solution should look like and in this way resemble the desired target state of a solution. They describe the structure of the solutions by listing the required solution elements (which are of a specific component type), their element specific configurations including which element will need to fulfill the dependencies as defined in the component templates. Each solution architecture maintains version information since they will need to evolve over time.
- Solutions: the actual runtime information (current state) of a solution and its elements is registered here to allow for closed loop automation. It includes information related to the runtime configuration, the status and the service endpoints of the elements.
- Automation: For a closed-loop automation it is also necessary to maintain information regarding which tasks need to be conducted to align the current state with the desired target state and react to events which are triggered by the execution of tasks.

The schema file in swagger: swagger-model.yaml

Domain-Catalog

The catalog is a subset of the information model of a domain which holds templates (components and their dependencies) for solution elements along with their basic configuration.



Component

A component is a versioned template for a solution element. It describes its basic configuration with the help of a structured object and a set of named dependencies to other components

Attribute	Type	Description
Component	string	name of the component
Version	string	version of the component
Configuration	object	basic configuration object
Dependencies	map to dependencies	map of names to dependencies

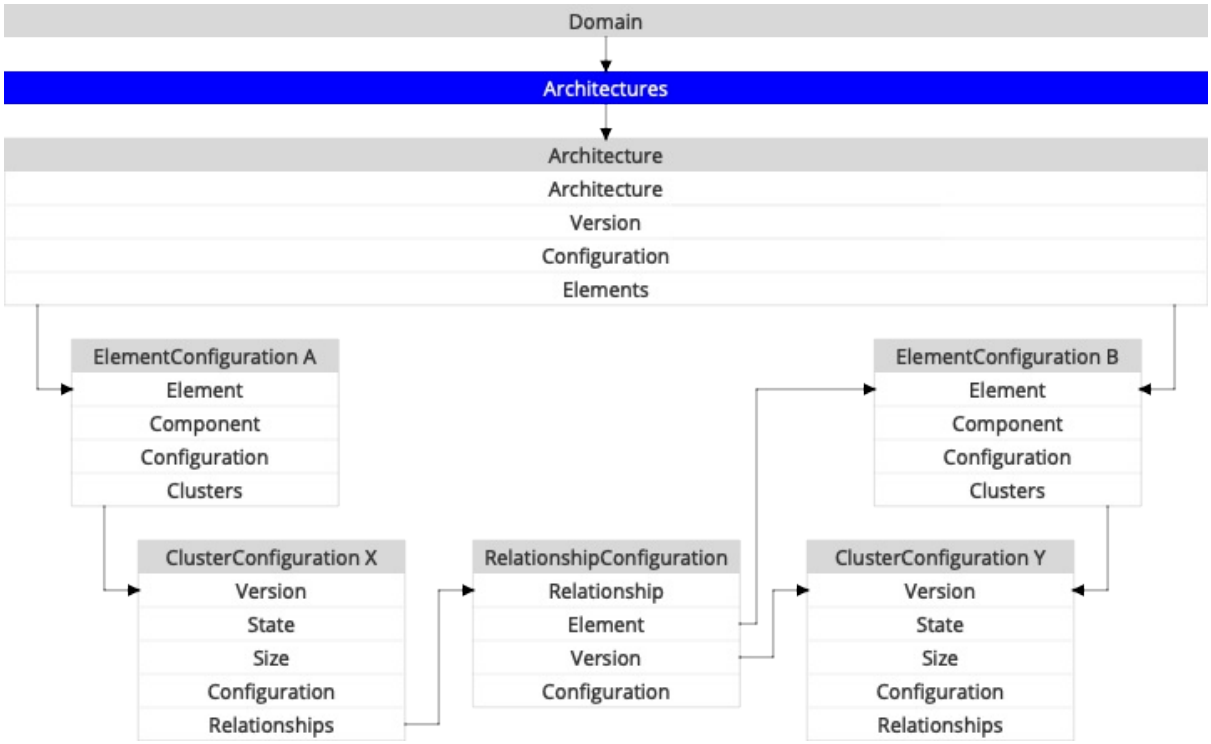
Dependency

A dependency describes how the containing component relates to other components. It can either be a "context" dependency which defines that the referenced component needs to be "active" before the component can be created, or it may be a "service" dependency which states that the referenced component needs to be "active" before the component can be started. The configuration attribute is a structured object with the basic configuration for the establishing the component relationship described in the dependency.

Attribute	Type	Description
Dependency	string	name of the dependency
Type	string	type of dependency ("context"/"service")
Component	name of the component	name of the referenced component
Version	version of the component	version of the referenced component
Configuration	object	basic configuration object of the dependency

Domain-Architectures

Architectures are a subset of the information model of a domain describing the desired structure and configuration of a solution with the help of a list configurations for solution elements and their relationships amongst one another.



The configurations are "design-time" configurations. Since they can only describe the configuration parameters which are known at the time the solution is being designed.

Architecture

An architecture is a versioned description of the desired configuration of a solution. The name of the architecture matches the name of the solution. It holds a general structured configuration object (with general parameters) and a set of configurations for solution elements which can be identified by their names.

Attribute	Type	Description
Architecture	string	name of the architecture
Version	string	version of the architecture
Configuration	object	architecture configuration object
Elements	map to ElementConfigurations	map of names to configurations

ElementConfiguration

An ElementConfiguration describes the configuration of a solution element based on a component type. A solution element may need to comprise several versions of a component (Clusters) which may require their own specific configurations.

Attribute	Type	Description
Element	string	name of the solution element
Component	string	name of the component
Configuration	object	element configuration object
Clusters	map to ClusterConfigurations	map of names to configurations

ClusterConfiguration

A ClusterConfiguration describes the configuration for a cluster within a solution element for a specific version of a component type. A cluster has a certain size and should be in a certain state of the lifecycle. Due to its dependencies to other solution elements it will also have to describe this information it its relationships attribute.

Attribute	Type	Description
Version	string	version of the component
State	string	desired lifecycle state
Size	positive integer	desired cluster size
Configuration	object	cluster configuration object
Relationships	map to RelationshipConfigurations	map of names to configurations

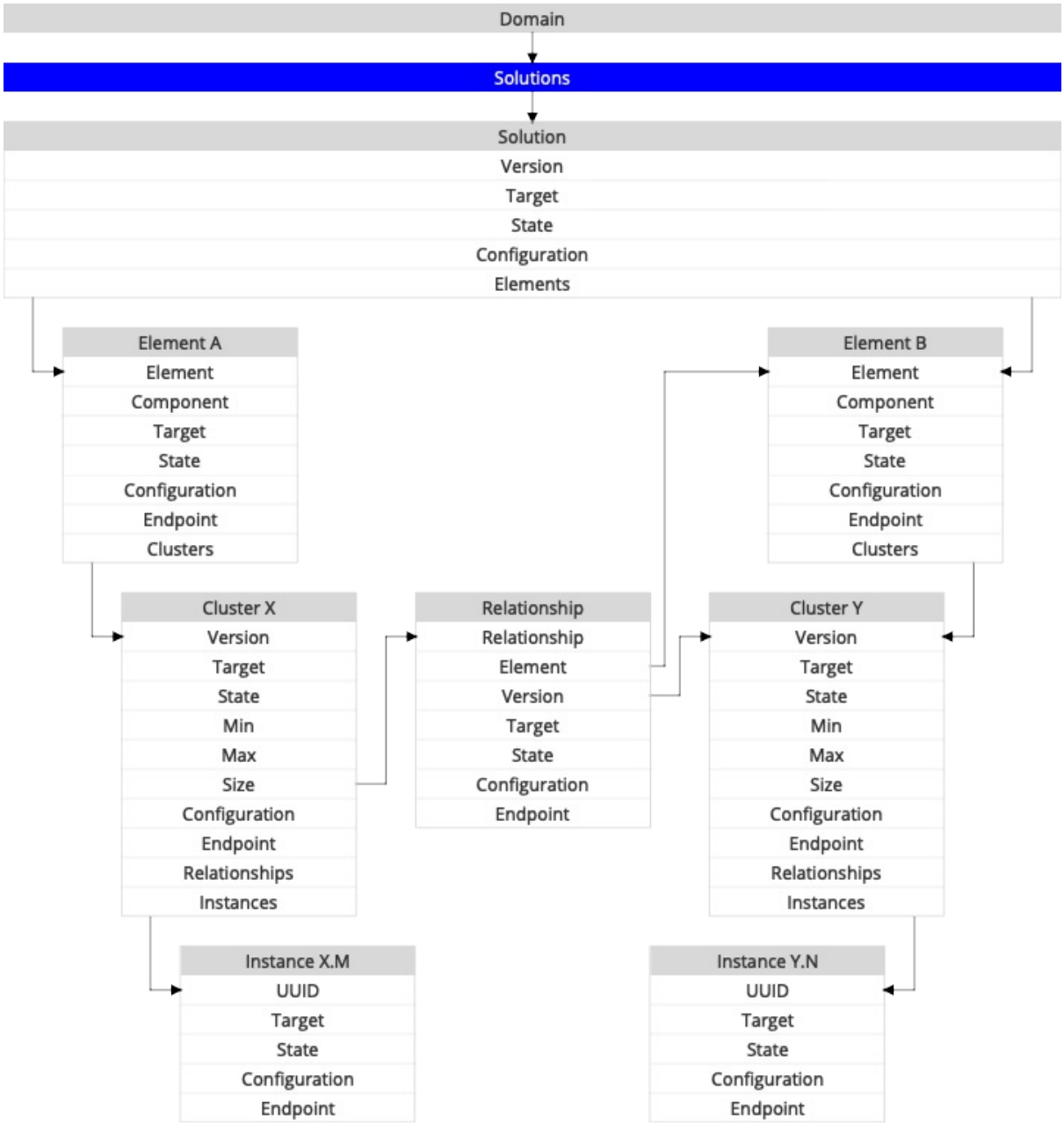
RelationshipConfiguration

A RelationshipConfiguration describes the configuration for a relationship between clusters of related solution elements.

Attribute	Type	Description
Relationship	string	name of the dependency
Element	string	name of the referenced element
Version	string	version of the referenced element
Configuration	object	relationship configuration object

Domain-Solutions

Solutions are a subset of the information model of a domain describing the current structure and configuration of a solution with the help of a list actual configurations for solution elements and their relationships amongst one another.



The configurations are "run-time" configurations. Since they also describe those configuration parameters which can only be known at the time the solution is being provisioned.

Solution

A solution entity describes the current configuration and state of a solution. Its name matches the name of the architecture describing its design.

It holds a general structured configuration object (with general parameters) and a set of configurations for solution elements which can be identified by their names.

Attribute	Type	Description
Solution	string	name of the solution
Version	string	version of the solution
Target	string	target state of the solution
State	string	state of the solution
Configuration	object	runtime configuration object
Elements	map to Elements	map of names to elements

Element

An Element describes the runtime configuration of a solution element based on a component type. A solution element may need to comprise several versions of a component (Clusters) which may require their own specific configurations.

Attribute	Type	Description
Element	string	name of the solution element
Component	string	name of the component
Target	string	target state of the element
State	string	state of the element
Configuration	object	runtime configuration object
Endpoint	object	service endpoint
Clusters	map to Cluster	map of names to clusters

Cluster

A Cluster describes the runtime configuration for a cluster within a solution element for a specific version of a component type. A cluster has a certain size and should be in a certain state of the lifecycle. Due to its dependencies to other solution elements it will also have to describe this information it its relationships attribute.

Attribute	Type	Description
Version	string	version of the component
Target	string	target state of the cluster
State	string	state of the cluster
Min	positive integer	minimum cluster size
Max	positive integer	maximum cluster size
Size	positive integer	desired cluster size
Configuration	object	runtime configuration object
Endpoint	object	service endpoint

Relationships	map to Relationships	map of names to relationships
Instances	map to Instances	map of names to instances

Relationship

A Relationship describes the runtime configuration for a dependency between clusters of related solution elements.

Attribute	Type	Description
Relationship	string	name of the dependency
Element	string	name of the referenced element
Version	string	version of the referenced element
Target	string	target state of the relationship
State	string	state of the relationship
Configuration	object	runtime configuration object
Endpoint	object	endpoint of the referenced element

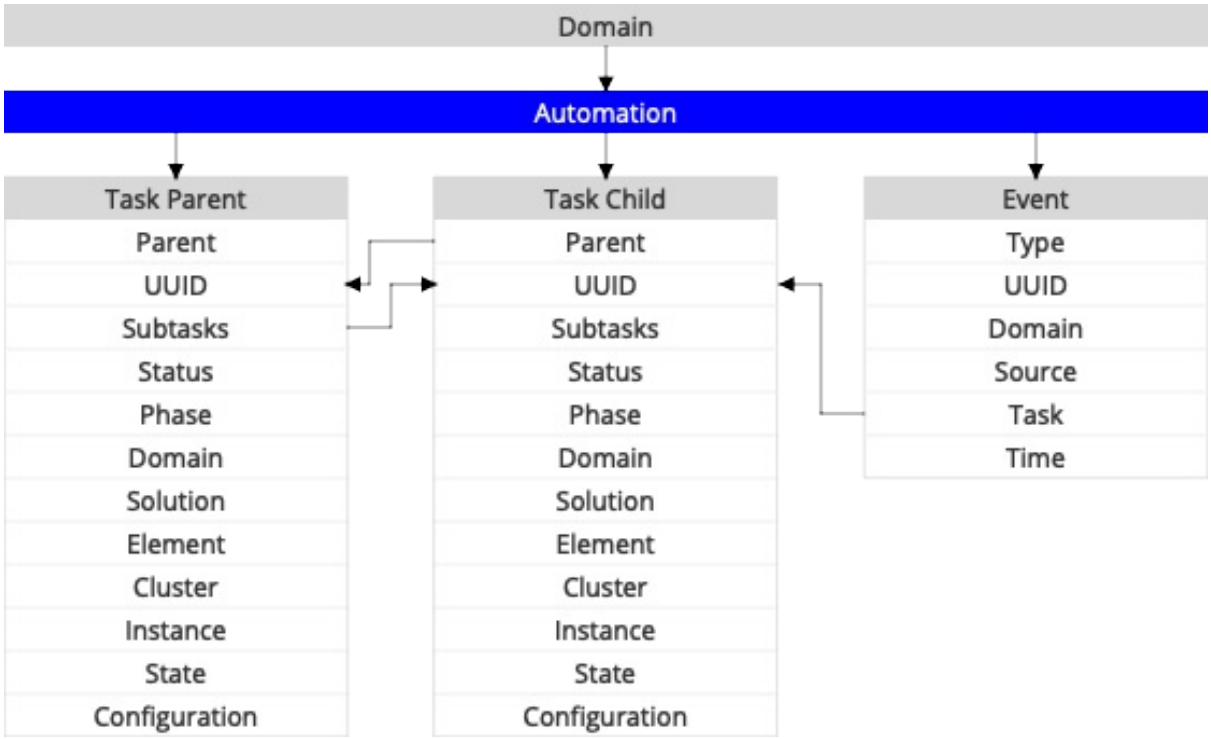
Instance

An Instance describes an instance of a cluster of a solution element. This comprises it's state, runtime configuration and service endpoint.

Attribute	Type	Description
UUID	string	unique identifier of the instance
Target	string	target state of the instance
State	string	state of the instance
Configuration	object	runtime configuration object
Endpoint	object	service endpoint

Domain-Automation

Tasks and events form the automation subset of the information model of a domain describing the current structure and configuration of a solution.



Task

A task describes an activity to manipulate the solution.

Attribute	Type	Description
Type	string	type of the task
UUID	string	unique identifier for the task
Parent	string	identifier of the parent task
Subtasks	array of UUIDs	array of UUIDs of subtasks
Status	string	status of the task
Phase	string	execution phase of the task
Domain	string	name of the domain
Solution	string	name of the solution
Element	string	name of the element
Cluster	string	name of the cluster
Instance	string	name of the instance
State	string	desired lifecycle state

Configuration	object	runtime configuration object

Event

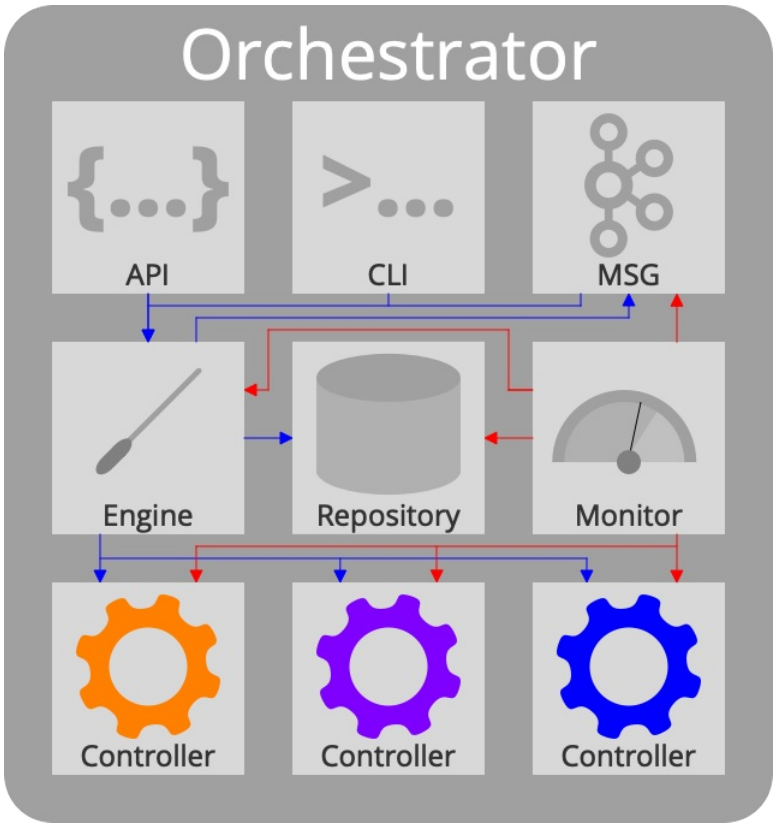
An event notifies about the occurrence of a task related event.

Attribute	Type	Description
Type	string	type of event
UUID	string	unique identifier for the event
Domain	string	name of the domain
Source	string	identifier of the source task
Task	string	identifier of the task
Time	string	time since 1.1.1970 in nsecs

Orchestrator

A plug and play architecture to manage the lifecycle of various types of solution elements in a consistent manner in order to provide a managed customer service.

The diagram below shows the high-level architecture of the orchestration engine capable of flexibly coordinating the lifecycles of interdependent solution elements.



The architecture consists of three layers. The northbound interfaces allow for the interaction with the DevOps team and external systems and provide:

- API: an application programming interface via REST
- CLI: a command line interface for the operators
- MSG: a message bus interface for sending and receiving events

The core modules of the orchestrator facilitate the closed loop automation of the lifecycle of solution elements and consist of:

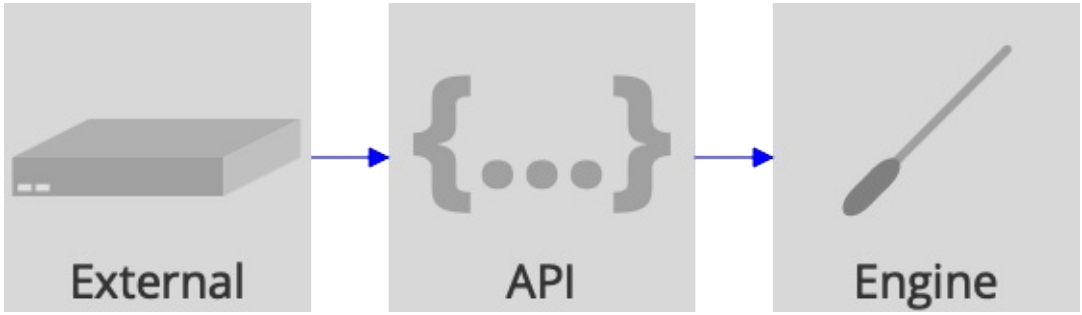
- Engine: the orchestration engine,
- Repository: the data store and
- Monitor: the monitoring system.

The southbound controllers represent specific code fragments capable of managing the lifecycle of solution elements of a specific type according to the common lifecycle model.

Application Programming Interface

The orchestrator API exposes all required capabilities for the lifecycle automation of solutions covering the sourcing, design and operations phase to external systems via REST interface.

The application programming interface is exposed to external systems and serves as a gateway to expose the capabilities of the orchestration engine.



The API provides interfaces to

- support the administration,
- manage templates in a catalog,
- manage architectures and configurations and
- manage the lifecycle of solutions.

Administration

The API will need to support following administrative use cases to facilitate the management of independent domains by a DevOps team:

- ResetModel: reset model in the repository to initial state
- StoreModel: create model from yaml data and store it into the repository
- RetrieveModel: retrieve model from the repository as yaml data
- ListDomains: list all the available domains
- StoreDomain: create a new domain from yaml data and store it in the repository
- RetrieveDomain: retrieve domain from the repository as yaml data
- RemoveDomain: remove domain from the repository

Catalog Management

Catalog management is conducted in the context of a specific domain. The API will need to support the following use cases for the sourcing phase to support the management of templates for components.

- ListComponents: list all the available components in a domain
- ListComponentVersions: list all the available versions of a component in a domain
- StoreComponent: create a new component from yaml data and store it in the repository
- RetrieveComponent: retrieve component from the repository as yaml data
- RemoveComponent: remove component from the repository

Component templates are regarded to be immutable. Therefore no update operations are provided for components.

It is regarded to be an error if:

- an unknown domain is referenced,
- a component references unknown components,
- an attempt is made to redefine a component or
- an unknown component is referenced when intending to show or delete a component.

Architecture Management

Architecture Management is also conducted in the context of a specific domain. The API will need to support the following use cases for the design phase to support the management of solution architectures.

- ListArchitectures: list all the available architectures in a domain
- ListArchitectureVersions: list all the available versions of an architecture in a domain
- StoreArchitecture: create a new architecture from yaml data and store it in the repository
- RetrieveArchitecture: retrieve architecture from the repository as yaml data
- RemoveArchitecture: remove architecture from the repository

Architectures are regarded to be immutable. Therefore no update operations are provided for architectures.

It is regarded to be an error if:

- an unknown domain is referenced,
- an architecture definition is inconsistent,
- an attempt is made to redefine an architecture or
- an unknown architecture is referenced when intending to show or delete an architecture.

Solution Management

Solution Management is also conducted in the context of a specific domain. The API will need to support the following use cases for the operations phase to support the management of solutions.

- ListSolutions: list all the available solutions in a domain
- StoreSolution: create a new solution from yaml data and store it in the repository
- RetrieveSolution: retrieve solution from the repository as yaml data
- RemoveSolution: remove solution from the repository
- ModifySolution: create a new solution or update an existing solution based on the information provided in an architecture blueprint
- ListElements: list all the available elements in a solution
- RetrieveElement: retrieve element from the repository as yaml data
- ModifyElement: update an existing element based on the information provided in a configuration object
- ListClusters: list all the available clusters of an element
- RetrieveCluster: retrieve cluster from the repository as yaml data
- ModifyCluster: update an existing cluster based on the information provided in a configuration object
- ListInstances: list all the available instances of a cluster
- RetrieveInstance: retrieve instance from the repository as yaml data
- ModifyInstance: update an existing instance based on the information provided in a configuration object

It is regarded to be an error if:

- an unknown domain is referenced,
- an unknown architecture blueprint is referenced,
- an unknown solution is referenced when intending to retrieve or update a solution,

- an unknown element is referenced when intending to retrieve or update an element,
- an unknown cluster is referenced when intending to retrieve or update a cluster or
- an unknown instance is referenced when intending to retrieve or update an instance.

Automation

Automation is also conducted in the context of a specific domain. The API will need to provide visibility and operational control over all the tasks being executed in order to manage the lifecycle of a solution.

- ListTasks: list all toplevel tasks in a domain (optionally matching a certain request ID)
- RetrieveTask: retrieve task from the repository as yaml data
- TerminateTask: stop a task in a domain
- ListEvents: list all events related to a task in a domain
- RetrieveEvent: retrieve event from the repository as yaml data

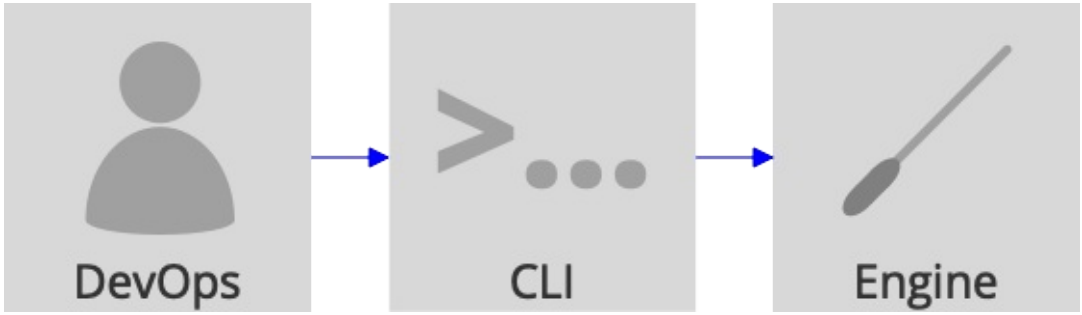
It is regarded to be an error if:

- an unknown domain is referenced,
- an unknown reference ID is used,
- an unknown task is referenced when intending to retrieve or terminate a task or list the corresponding events or
- an unknown event is referenced when intending to retrieve an event.

Command Line Interface

The orchestrator CLI exposes all required capabilities for the lifecycle automation of solutions covering the sourcing, design and operations phase to the DevOps team with console access.

The command line interface is exposed to the DevOps team and serves as a gateway to expose the capabilities of the orchestration engine.



The CLI provides commands to

- support the administration,
- manage templates in a catalog,
- manage architectures and configurations and
- manage the lifecycle of solutions.

Administration

The API will need to support following administrative use cases to facilitate the management of independent domains by a DevOps team:

- ResetModel: reset model in the repository to initial state
- StoreModel: create model from yaml data and store it into the repository
- RetrieveModel: retrieve model from the repository as yaml data
- ListDomains: list all the available domains
- StoreDomain: create a new domain from yaml data and store it in the repository
- RetrieveDomain: retrieve domain from the repository as yaml data
- RemoveDomain: remove domain from the repository

Catalog Management

Catalog management is conducted in the context of a specific domain. The API will need to support the following use cases for the sourcing phase to support the management of templates for components.

- ListComponents: list all the available components in a domain
- ListComponentVersions: list all the available versions of a component in a domain
- StoreComponent: create a new component from yaml data and store it in the repository
- RetrieveComponent: retrieve component from the repository as yaml data
- RemoveComponent: remove component from the repository

Component templates are regarded to be immutable. Therefore no update operations are provided for components.

It is regarded to be an error if:

- an unknown domain is referenced,
- a component references unknown components,
- an attempt is made to redefine a component or
- an unknown component is referenced when intending to show or delete a component.

Architecture Management

Architecture Management is also conducted in the context of a specific domain. The API will need to support the following use cases for the design phase to support the management of solution architectures.

- ListArchitectures: list all the available architectures in a domain
- ListArchitectureVersions: list all the available versions of an architecture in a domain
- StoreArchitecture: create a new architecture from yaml data and store it in the repository
- RetrieveArchitecture: retrieve architecture from the repository as yaml data
- RemoveArchitecture: remove architecture from the repository

Architectures are regarded to be immutable. Therefore no update operations are provided for architectures.

It is regarded to be an error if:

- an unknown domain is referenced,
- an architecture definition is inconsistent,
- an attempt is made to redefine an architecture or
- an unknown architecture is referenced when intending to show or delete an architecture.

Solution Management

Solution Management is also conducted in the context of a specific domain. The API will need to support the following use cases for the operations phase to support the management of solutions.

- ListSolutions: list all the available solutions in a domain
- StoreSolution: create a new solution from yaml data and store it in the repository
- RetrieveSolution: retrieve solution from the repository as yaml data
- RemoveSolution: remove solution from the repository
- ModifySolution: create a new solution or update an existing solution based on the information provided in an architecture blueprint
- ListElements: list all the available elements in a solution
- RetrieveElement: retrieve element from the repository as yaml data
- ModifyElement: update an existing element based on the information provided in a configuration object
- ListClusters: list all the available clusters of an element
- RetrieveCluster: retrieve cluster from the repository as yaml data
- ModifyCluster: update an existing cluster based on the information provided in a configuration object
- ListInstances: list all the available instances of a cluster
- RetrieveInstance: retrieve instance from the repository as yaml data
- ModifyInstance: update an existing instance based on the information provided in a configuration object

It is regarded to be an error if:

- an unknown domain is referenced,
- an unknown architecture blueprint is referenced,
- an unknown solution is referenced when intending to retrieve or update a solution,

- an unknown element is referenced when intending to retrieve or update an element,
- an unknown cluster is referenced when intending to retrieve or update a cluster or
- an unknown instance is referenced when intending to retrieve or update an instance.

Automation

Automation is also conducted in the context of a specific domain. The API will need to provide visibility and operational control over all the tasks being executed in order to manage the lifecycle of a solution.

- ListTasks: list all toplevel tasks in a domain (optionally matching a certain request ID)
- RetrieveTask: retrieve task from the repository as yaml data
- TerminateTask: stop a task in a domain
- ListEvents: list all events related to a task in a domain
- RetrieveEvent: retrieve event from the repository as yaml data

It is regarded to be an error if:

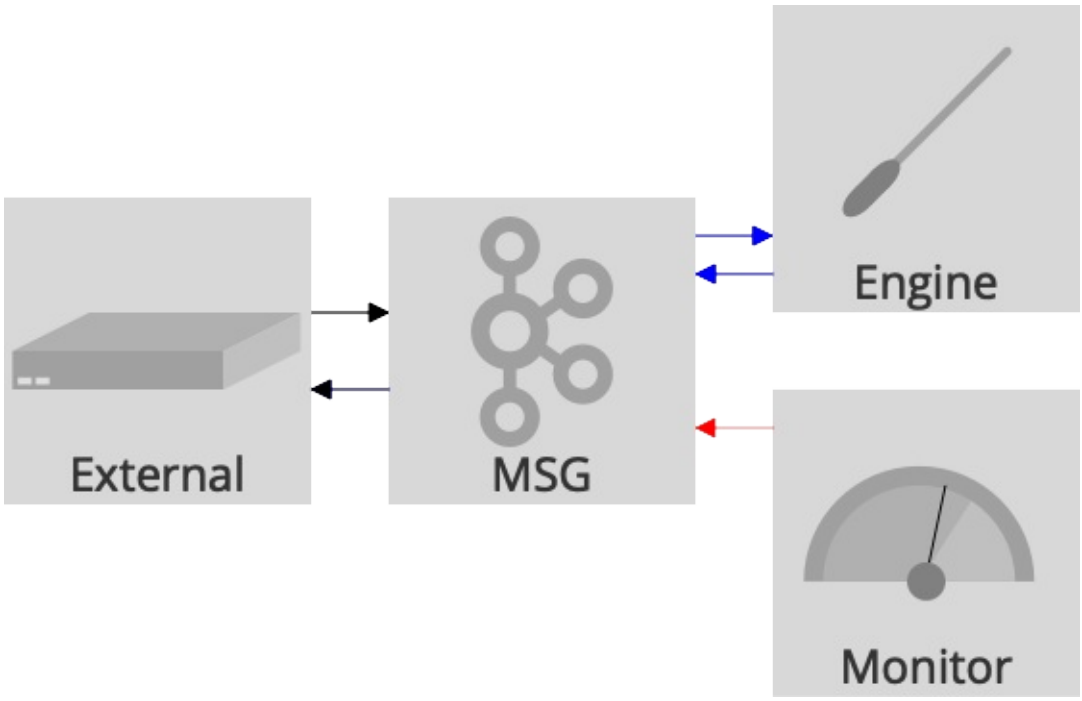
- an unknown domain is referenced,
- an unknown reference ID is used,
- an unknown task is referenced when intending to retrieve or terminate a task or list the corresponding events or
- an unknown event is referenced when intending to retrieve an event.

Message Bus

The orchestrator notifies about events related to tasks and the status of the solution.

The message bus interface is exposed to external systems and serves as a gateway to expose:

- task related notification events and
- status information of the the solution.



Events

The orchestrator can be handed a unique topic identifier "TOPIC1" in the course of the startup process. This is the topic to which it will publish its events to a Kafka broker.

Each event is related to a task and will notify wether:

- Execution: the execution of a task has been triggered
- Termination: the termination of a task has been triggered
- Timeout: a task has run into a time-out
- Failure: a task has failed
- Success: a task has completed successfully
- Terminated: a task has been terminated

The type of tasks to which an event may relate are:

- Architecture: tasks related to the instantiation or update of a solution based on an architecture blueprint
- Element: tasks related to the instantiation, modification or deletion of an element
- Cluster: tasks related to the instantiation, modification or deletion of a cluster
- Instance: tasks related to the instantiation, modification or deletion of an instance
- Parallel: a task representing a group of tasks which can be executed in parallel

- Instance: a task representing a group of tasks which need to be executed sequentially

The event information captures following attributes of the event and the corresponding task:

Attribute	Type	Description
Request	string	request identifier
Type	string	type of event
UUID	string	unique identifier for the event
Source	string	identifier of the source task
Time	string	time since 1.1.1970 in nsecs
Task	string	unique identifier for the task
TaskType	string	type of the task
Parent	string	identifier of the parent task
Subtasks	array of UUIDs	array of UUIDs of subtasks
Status	string	status of the task
Phase	string	execution phase of the task
Domain	string	name of the domain
Solution	string	name of the solution
Element	string	name of the element
Cluster	string	name of the cluster
Instance	string	name of the instance
State	string	desired lifecycle state
Configuration	object	runtime configuration object

Status

The orchestrator can be handed a second unique topic identifier "TOPIC2" in the course of the startup process. This is the topic to which it will publish its status information to a Kafka broker.

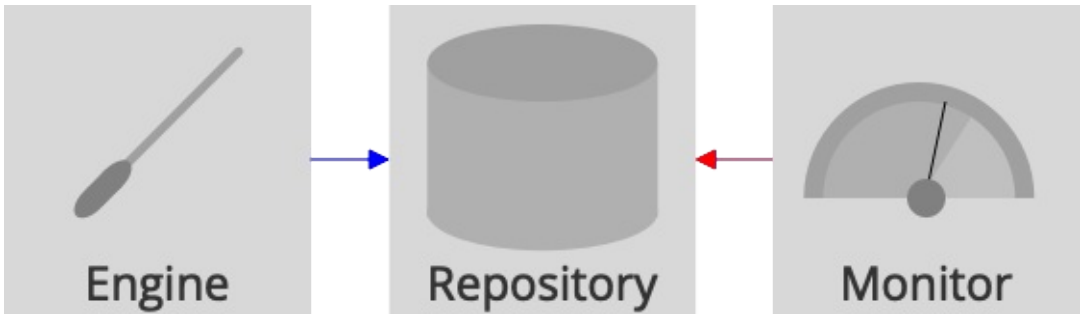
The status information captures following attributes of the state of a solution, element, cluster or instance within a domain.

Attribute	Type	Description
Time	string	time since 1.1.1970 in nsecs
Domain	string	name of the domain
Solution	string	name of the solution
Element	string	name of the element
Cluster	string	name of the cluster
Instance	string	name of the instance
State	string	current lifecycle state

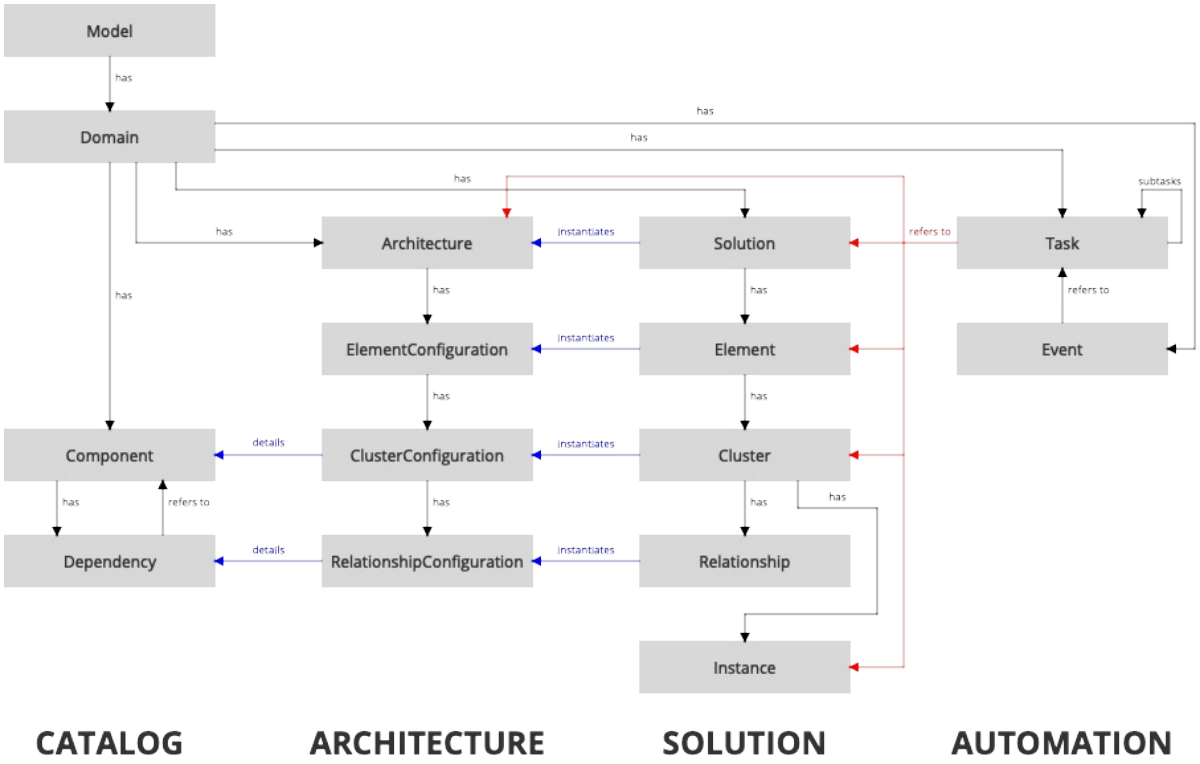
Repository

The repository maintains the entities defined in the information model supporting the sourcing, design and operations phase of a solution.

The repository interacts with the orchestrator engine and monitor system to support the automation of the lifecycle management of solutions.



The following diagram provides an overview of the model maintained in the repository.



The model follows the structure defined in the information Model and is clearly subdivided into domains which allow for differentiating administrative realms.

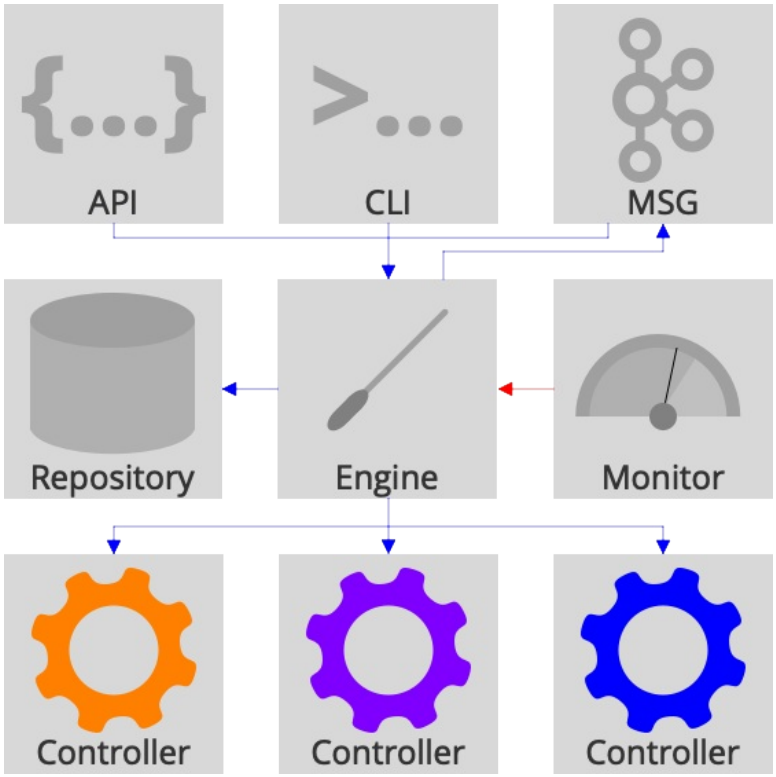
In addition it differentiates between sections for information obtained in the sourcing phase (Catalog), the design/development phase (Architecture) and the operations phase (Solution).

The information related to the automation of the lifecycle of the solution elements is persisted in the Automation section.

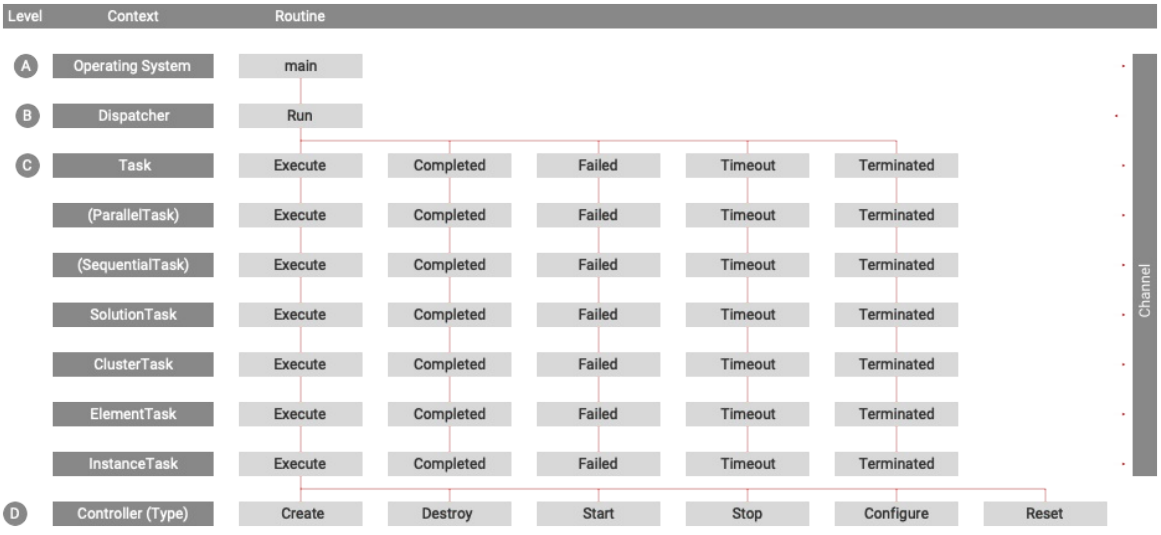
Engine

The orchestrator engine is responsible for coordinating the lifecycle management activities of the various component specific controllers.

The engine is a core module of the orchestrator. It exchanges commands and information via the northbound interfaces, receives reconciliation requests from the monitoring system, parametrises its procedures with the help of descriptors maintained in the repository and orchestrates the lifecycle management procedures of the southbound controllers.



The following diagram provides an overview of the algorithm of the orchestration engine:



The algorithm splits up into several distinct layers:

Layer A: Main Routine

The main routine:

- registers all controllers,
- starts the internal communication channel,
- starts the timeout monitoring system,
- starts the monitoring system,
- starts the task dispatcher and finally
- initiates all external interfaces (application programming interface, command line interface and message bus interface).

The interfaces collect the requests coming in from DevOps or external systems and publish these requests to the internal channel.

Layer B: Task Dispatcher

The task dispatcher listens to requests published to the internal channel these requests are evaluated in order to identify what kind of task needs to be executed. The task dispatcher then spawns an appropriate subprocess and waits for the next request.

Layer C: Task Execution

The task to be executed depends on type of the task context and the state of the task. The context of a task can be:

- Architecture: the instantiation/update of a solution based on architectural blueprint,
- Cluster: the resizing, status update or reconfiguration of a cluster,
- Instance: the status update or reconfiguration of an instance.

The task states are related to the influencing events:

- Execution: indicates that a task should be executed/reexecuted
- Completed: indicates that a task has completed successfully and that all finalising activities need to be conducted
- Failed: indicates that a task has failed and that all required cleanup activities need to be conducted
- Timeout: indicates that a task has run into a timeout and that all required recovery or cleanup activities need to be conducted
- Terminate: indicates that a task needs to be terminated

The component type specific controllers are invoked synchronously when executing tasks in the context of instances.

The task may trigger subtasks depending on the information provided in the catalog and architecture section of the model by issuing corresponding requests.

Layer D: Controller

Controllers are capable of transitioning instances of a specific component type along the paths defined in the common lifecycle model.

This includes the capabilities to:

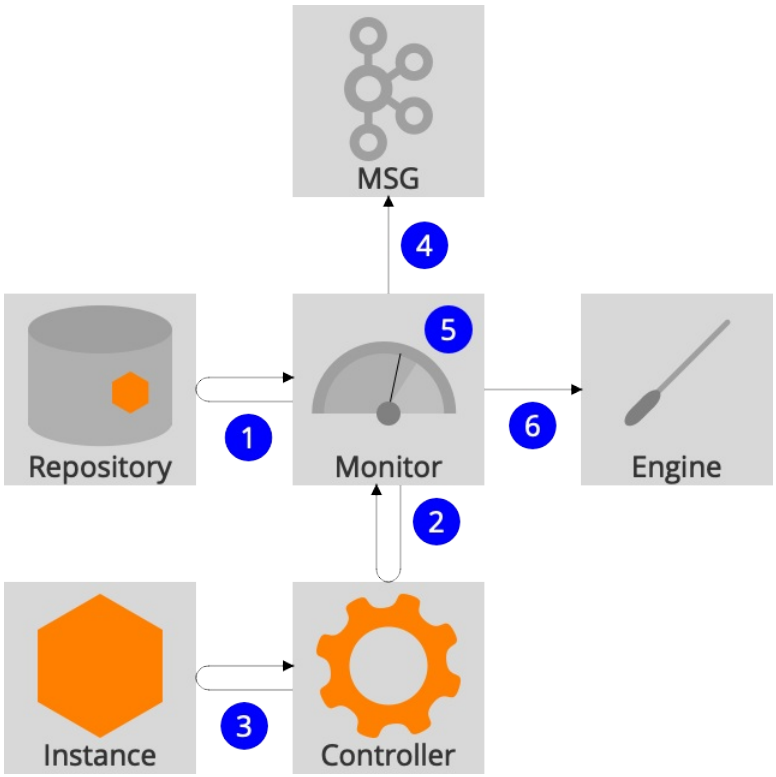
- Create: create an instance,
- Destroy: destroy an instance,
- Start: start an instance,
- Stop: stop an instance,
- Configure: configure or reconfigure an instance and

- Reset: cleanup an instance.

Monitor

The monitoring system continuously compares the current state of instances with the desired target state and if needed triggers compensating measures.

The following diagram depicts the basic functionality provided by the monitoring system.



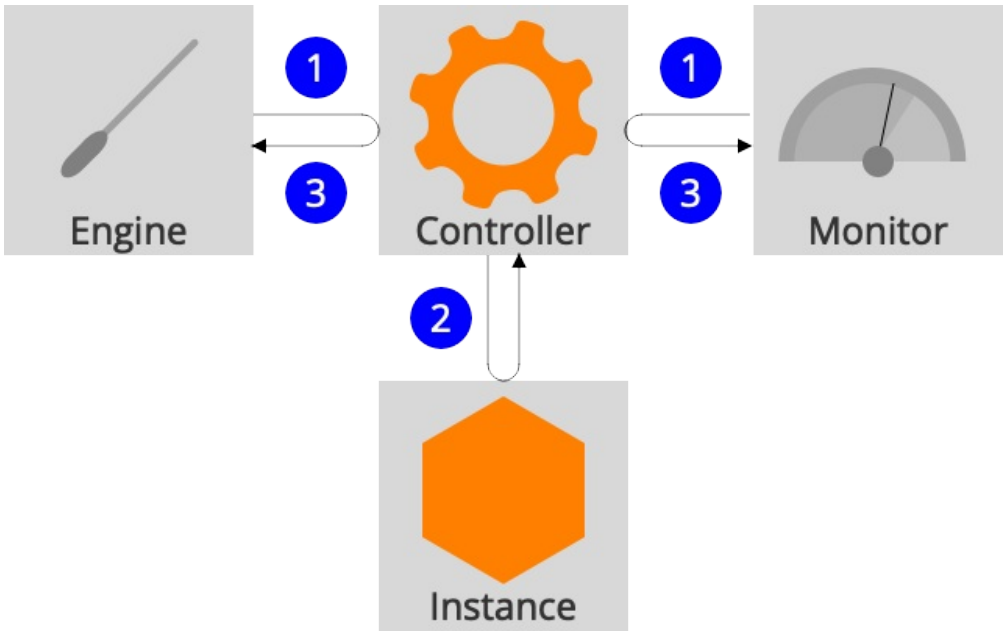
The monitoring system will conduct in regular intervals the following steps:

1. acquire from the model database all the instances of solution elements which need to be monitored
2. trigger the corresponding controllers to obtain the status of an instance of the solution elements
3. the controllers evaluate the status of the instances of solution elements
4. the monitoring system notifies external systems via message bus about the status of an instance of the solution elements
5. the monitoring system checks if the desired state matches the current state
6. the monitoring triggers if required a compensating measure to align the current state of an instance of a solution element with the desired state

Controller

A controller is a component type specific management component capable of applying the changes to component instances according to the standardised component lifecycle model and providing information about the status of these instances.

The diagram shows how the orchestrator engine and the monitor system interact with the controller:



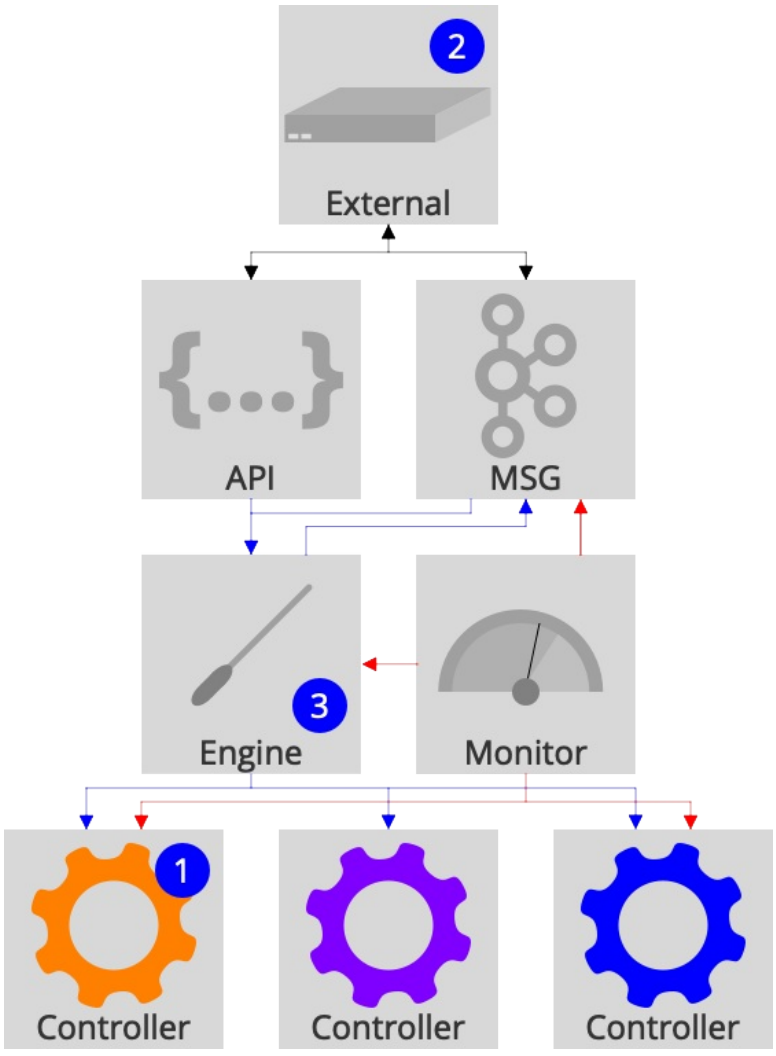
1. The controller can either receive lifecycle management instructions from the orchestration engine or be triggered by the monitoring system to determine the status of instances of solution elements.
2. The controller then executes these requests and
3. delivers the results to the requesting module of the orchestrator.

The interface specification of the controller is listed in the appendix Controller API.

Extensions

Enhancing closed loop automation in a well defined way with custom code.

Managing the lifecycle of a complex solution may have to include sophisticated procedures which can not be covered by a closed-loop automation framework in a generic manner.



Therefore an extension mechanism is required to include these procedures in a well defined way. Following options could be made available:

1. Controller: writing a custom controller for a specific component type is the most obvious way to include custom code into the orchestration framework
2. Hook: custom code could subscribe to monitoring information published by the monitoring system via the message bus interface and trigger actions which could include interactions with the orchestrator via its API. The same applies to the task related events issued by the orchestrator engine via the message bus interface.
3. Component Specific Task Handlers: the orchestrator code could invoke component specific task handlers which would overwrite the generic handlers defined in the core orchestration engine.

SOLAR System

Simple Orchestration of the Lifecycle Automation of Resources - a reference implementation

SOLAR-System is a reference implementation of the concepts presented in the previous chapters. It is deliberately intended to be kept as simple as possible and in its current state is not intended to serve for production purposes.

It has been implemented in GO and the source code together with sample data can be found on https://github.com/BernardTsai/solar.

This chapter serves as a quickstart introduction to the SOLAR system covering which prerequisites will need to be met, the installation procedure, and how to configure and make use of the reference implementation.

Further information can found in the appendix and on the project website.

Prerequisites

SOLAR basically only requires:

- access to a BASH environment with internet access,
- a tool e.g. wget to retrieve files from the internet,
- tar - a tool to handle archived information and
- a golang runtime environment. Instructions of how to install GO onto the preferred operating system can be found on the golang website: Getting Started.

Installation

The installation of SOLAR is described here for a Linux environment with a BASH command line interface (but could be applied with only slight modifications to other operating systems) and requires following steps:

1. Create a root directory and change into this directory.

```
> mkdir <SOLAR>    # create the working directory
> cd <SOLAR>       # change into the working directory
```

2. Retrieve the solar src files from SOLAR GitHub repository:

```
> wget https://github.com/BernardTsai/solar/archive/master.zip
```

3. Unpack the archive (omitting the top-level folder):

```
> tar xvf master.zip --strip 1
```

4. Source the setup script:

```
> source setup.sh
```

   The script will create the proper go environment for SOLAR by creating the required directories, downloading the required dependencies and installing the SOLAR binaries.

Configuration

The configuration file of solar has the name "solar-conf.yaml". It has following structure:

```
MSG:
  Events: events
  Status: status
```

It currently lists the topics which the message bus interface should use in order to publish task event and status related information.

The solar binary looks for the configuration file in the current working directory and will reflect the information it finds there in the course of its initialisation.

Usage

Simply invoke the solar binary on the command line and the application will respond with a command prompt waiting for input:

```
> solar
SOLAR Version 1.0.0
>>>
```

The available commands are demonstrated in the following chapter Demo and listed in the appendix Orchestrator CLI

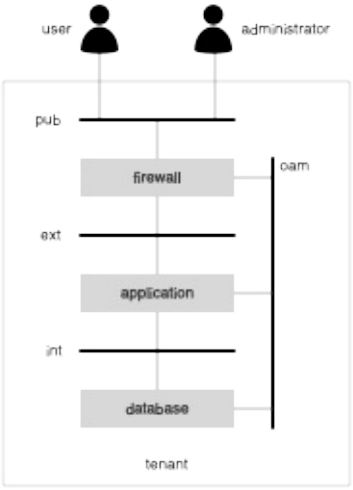
Solar will terminate after it has received the "exit" command and return control to BASH:

```
>>> exit
>
```

Demo

SOLAR provides a reference implementation of the concepts presented in this document. As such it does not manage actual resources and solution elements but rather simulates the administration procedures in order to serve as a proof-of-concept.

An example will help to demonstrate the capabilities of the orchestrated lifecycle management approach of SOLAR. In this example a simple application server hosted together with a database backend in a tenant is providing it's service via a firewall to users in the internet as shown in the diagram below.



The solution makes use of four networks for establishing communication amongst the applications, the users and administrators according to following considerations:

- users can access the application services from the internet (pub) via the firewall
- administrators can manage the firewall, the application server and the database from the internet (pub) via the firewall
- the firewall forwards external user requests via the machine-to-machine network (ext)
- the firewall forwards external administrative requests via the operation, administration and maintenance network (oam)
- the application server persists its information to the database via the machine-to-machine network (int)

All applications need to be hosted on their corresponding servers which belong together with the networks listed above to a tenant context.

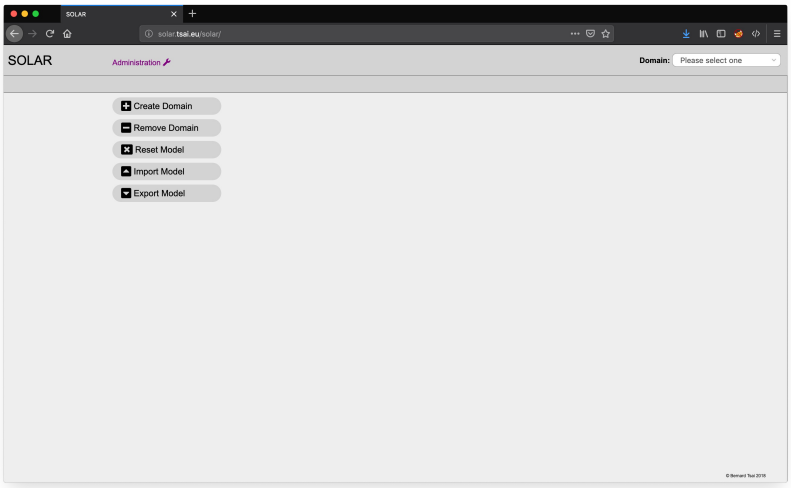
The following sections explain how to make use of the SOLAR system in order to handle the tasks listed below:

- Administration: i.e. how to setup and manage domains representing independent administrative realms with their corresponding catalog, architectures and solutions.
- Catalog Management: describing how to define and manage components which will serve as the building blocks for a solution
- Architecture Design: covers the steps in order to define a blueprint for solutions which can then later be deployed automatically
- Solution Management: explains how to obtain an overview of the status of a solution and conduct simple operational tasks such as scaling clusters or changing the lifecycle state of individual instances of solution elements.
- Automation Control: allows to visualise and manage the flow of activities related to automated change procedures.

Administration

SOLAR makes use of a central repository holding a model which is split up into several independent administrative domains.

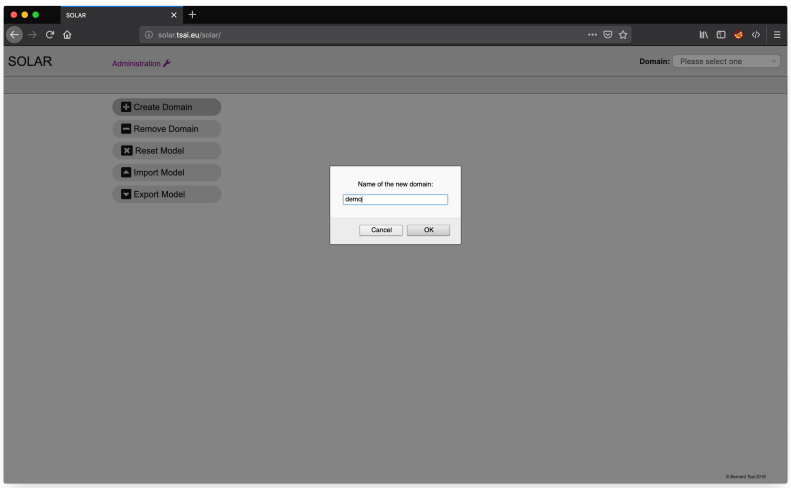
The first step is therefore to create a domain for the example solution by opening the web interface of SOLAR (URL: http://localhost/solar/index.html).



The administration view of SOLAR will appear offering the possibility to conduct the following five administrative tasks:

1. Create Domain: allows to define a new administrative domain with an independent catalog and set of architecture blueprints and solutions,
2. Remove Domain: provides the possibility to completely remove a domain from the repository,
3. Reset Model: removes all domains from the repository,
4. Import Model: imports a repository by uploading the contents of a local file and
5. Export Model: exports a repository by downloading the contents of the repository into a file.

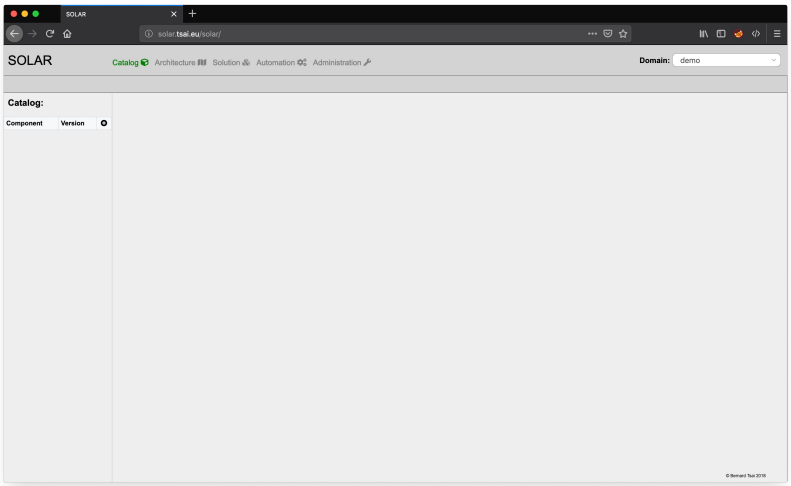
Clicking on "Create Domain" will prompt the user to enter the name of a new domain. For this example enter "demo" and press "OK".



A new domain with the name "demo" will be created and SOLAR will present the catalog view of the domain. A different domain can be selected at any time by picking one of the domains offered in the selection at top right of the navigation bar at the top of the screen.

Catalog Management

The catalog view allows to define the components which may serve as the building blocks for solutions. It can be selected by clicking on the catalog icon in the navigation bar at the top of the screen. Initially the catalog is empty.



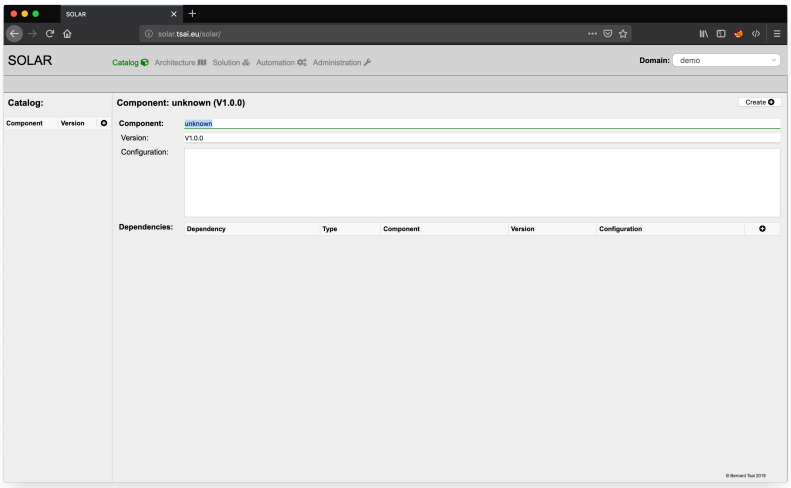
This example requires four types of components:

1. a tenant representing a virtual datacenter containing servers and networks
2. a network representing a communication domain via which servers and/or external communication partners can communicate with one another
3. a server which will host applications and which is connected to networks
4. an application representing software processes which are deployed to servers and may depend on the services exposed by other hosts.

The components will be listed on the left side of the window whereas details of a component will be presented on the right side of the screen.

Creating a new component

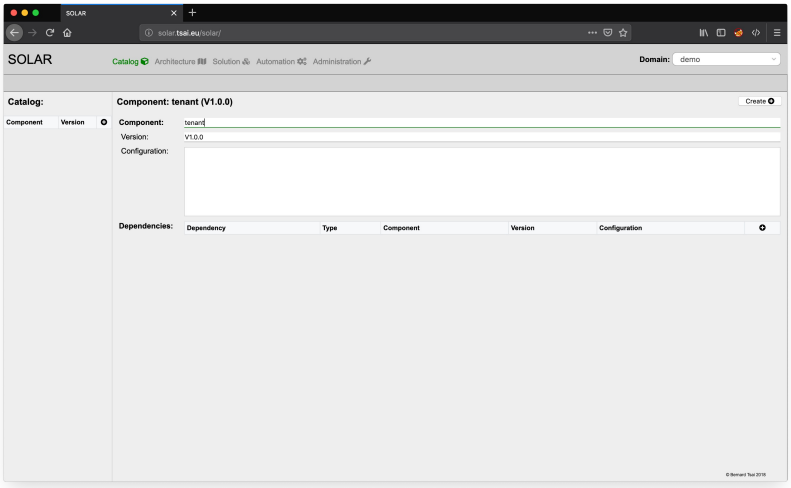
Pressing the "+" button on the left side will open the detail view for a new component. Initially the attributes of the new component are set to default values and need to be redefined.



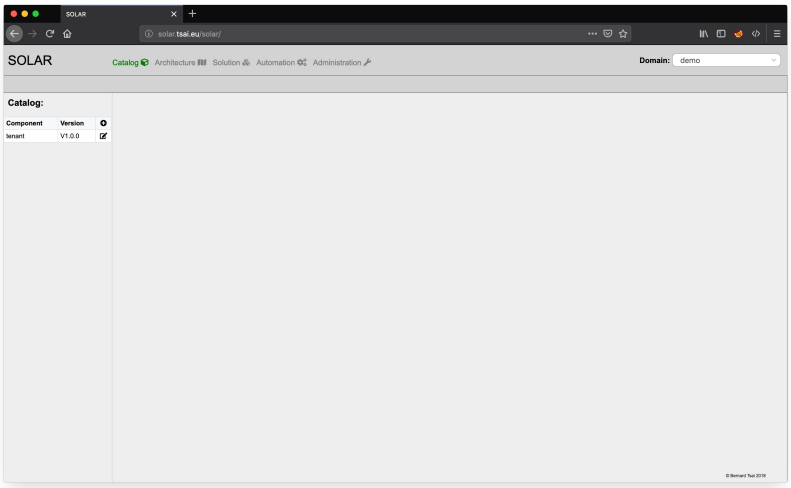
The main attributes for a component are:

- the name of the component (this corresponds to the type of a solution instance),
- the version represented by a string starting with a 'V' and followed by a version number which complies with the rules for semantic versioning (e.g. V1.10.3) and
- a base configuration, which can be a component specific configuration string.

The screenshot below displays the information of a "tenant" component:



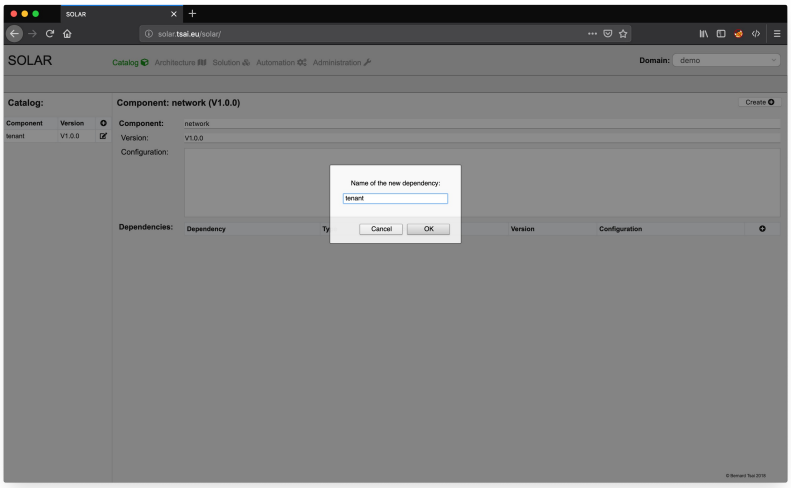
The component is added to the catalog by pressing the "Create" button on the top right of the details view.



The components which have been stored in the catalog appear on the left side of the screen.

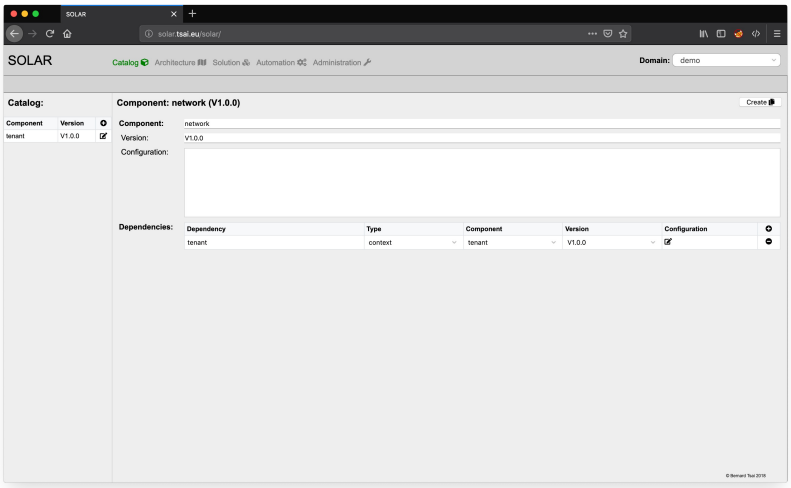
A "network" component can be defined in the similar way. It is assumed that a "network" has a runtime context dependency to a "tenant", i.e. it can only be created within the context of a tenant.

A new dependency is added by clicking on the "+" icon on the right of the dependencies list which is initially empty. A prompt will appear asking for the name of the dependency.



Each dependency is described by:

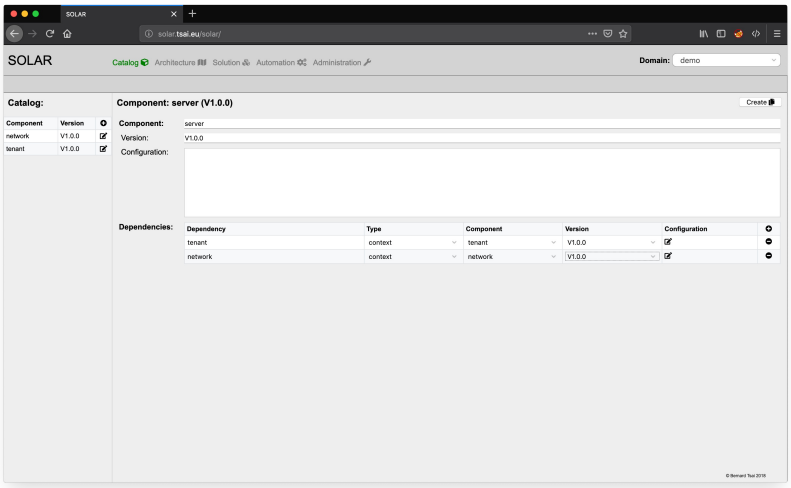
- the type of dependency (runtime context or service context),
- the component type which can fulfil the dependency,
- the required version of the component type and
- an optional dependency specific base configuration.



Dependencies which are not needed can be removed by pressing the "-" icon to the left of each dependency.

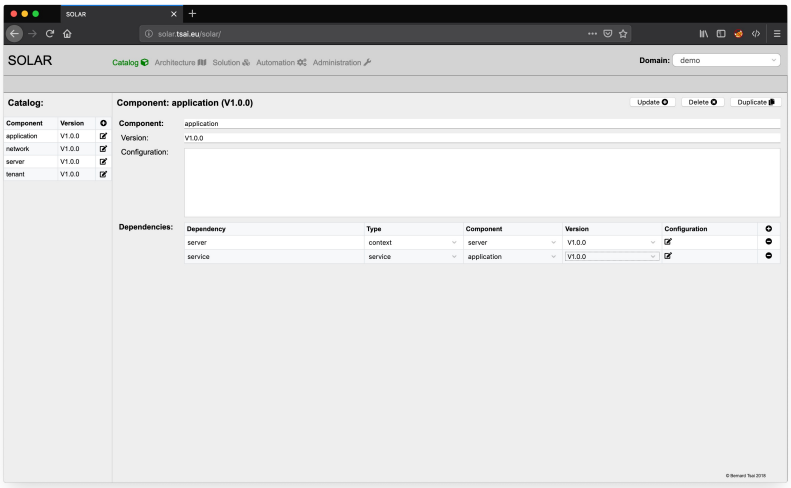
It is important to note that changes to the repository will only be made if the "Create" button is pressed.

The following screenshots display the definition for the "server" component. The assumption is that "servers" require a "tenant" and "networks" as their runtime context.



Updating a component

"Applications" require "servers" as their runtime context and other "applications" as their service context. Since the "application" component has a self-referential service dependency to itself it is necessary to first create the component without this dependency and then later update the component by adding the missing dependency. This can be achieved by pressing the icon to the left of a component in the list, which will open the details view for the component again.



The changes made will only be synchronised with the repository after pressing the "Update" button on the top right of the details view. It is recommended to not change a component definition after having referred to it in the context of dependencies or architecture blueprints.

Duplicating a component

In some cases it might be helpful to make a copy of an existing component definition without having to reenter all the information, e.g. when creating a new version of a component definition. The detail view of a component offers a "Duplicate" button for this purpose, which when pressed copies the definitions of the component and updates the minor number of the version indicator. The "Update" button will allow to then persist any required modifications.

Deleting a component

The "Delete" button of the component detail view allows to remove the component definition from the repository in the case this definition is not required any longer.

At this point all required components have been defined and can now be used for designing an architecture which will serve as a solution blueprint.

Architecture Design

It is necessary to first model the blueprint of a solution in order to later automate the lifecycle management of its elements.

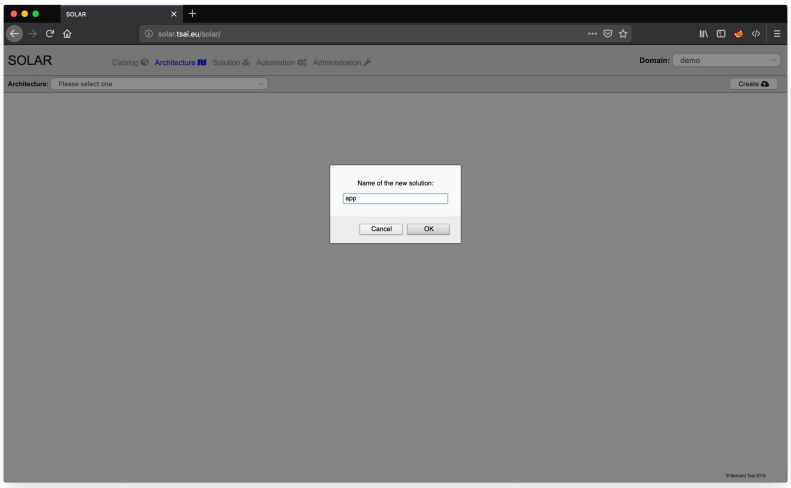
The catalog contains all the components serving as the potential building blocks of such a solution. A target architecture for a solution is designed by one by one adding components as solution elements to a solution and configuring them according to the environment specific considerations.

A solution element resembles a functional element of a specific component type providing a service which may evolve over time. A solution element may therefore consist of clusters - each representing a specific version of the component and holding a group of component instances of the same version.

Creating an architecture for a new solution

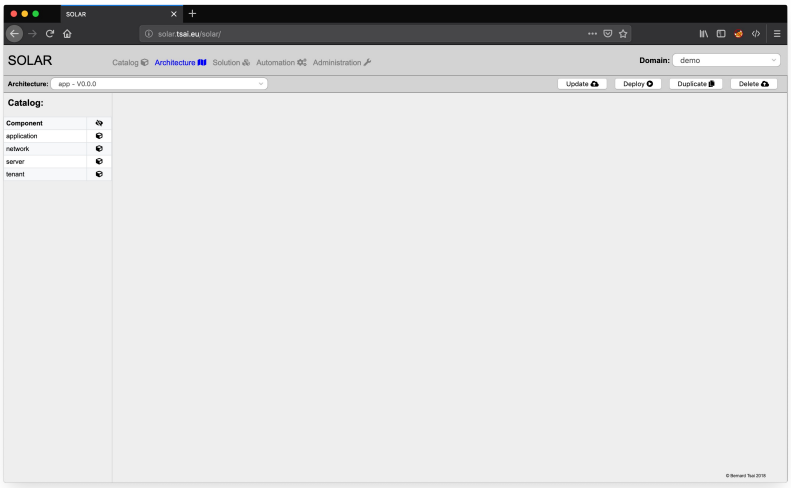
The first step is to create a new solution by changing to the architecture view of SOLAR. This can be achieved by clicking on the "Architecture" icon on the top of the window.

Then press the "Create" button on the top right of the window to define the name of the solution for which an architectural blueprint should be designed.



A prompt will appear asking for the name of the new solution. For this example enter "app" and press "OK".

The initial version of the architecture will be "V0.0.0" and not hold any elements as shown in the screenshot below.



The architecture view of SOLAR will show the catalog components to the left and the architecture design on the right side. At the top right a set of buttons allow to update, deploy, duplicate and delete architectures as described later in this section.

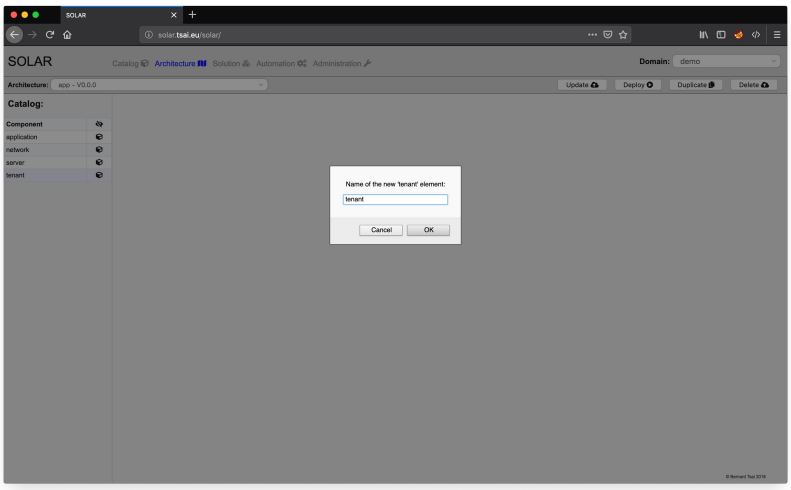
The naming convention implies that the name of the architecture and the name of the solution need to be the same. It probably will become necessary to design several versions of the solution architecture to support the evolution of the solution and therefore each architecture will have a specific version tag following the naming conventions for versions (represented by a string starting with a 'V' and followed by a version number which complies with the rules for semantic versioning, e.g. V1.10.3)

In order to continue working on an existing architecture simply select an architecture from the options presented in the select box at the top left of the window.

Adding an architecture element

Solution elements can be added to the architecture by clicking on the "+" icon located right to the required component.

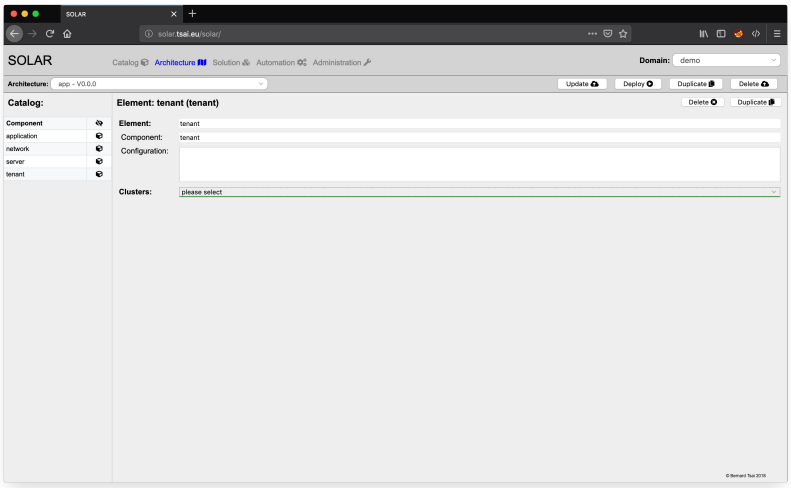
In order to create a "tenant" solution element click on "+" icon next to the tenant component. A prompt will appear asking which name the name tenant element should have.



After entering "Tenant" and pressing OK a new element with the specified name and of selected component type is added to the architecture.

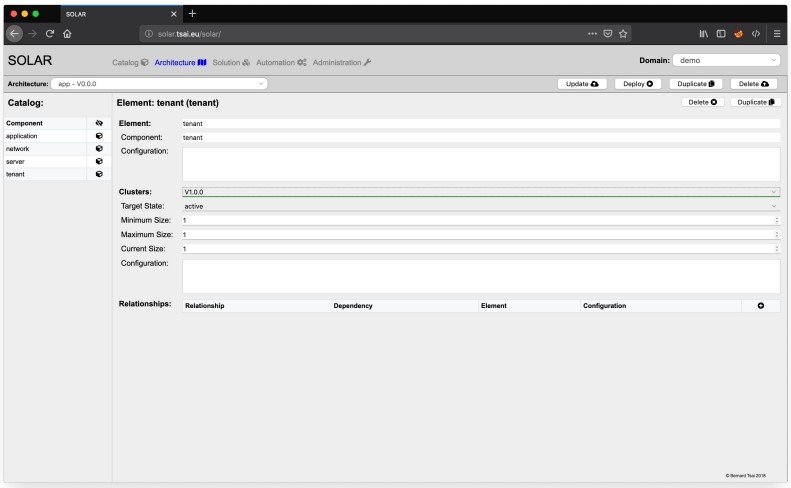
Editing an architecture element

After having selected which component to add and assigning a name to the element a dialog for entering configuration information is presented:



The name of the element and the component type of the element can not be changed anymore. The configuration field allows to enter information which relates to all versions of the solution element.

A solution element may need to support several version and therefore specific configurations for each version need to be taken into account. A dropdown box next to the "Clusters" label allows to select a version and then enter the corresponding cluster configuration information.

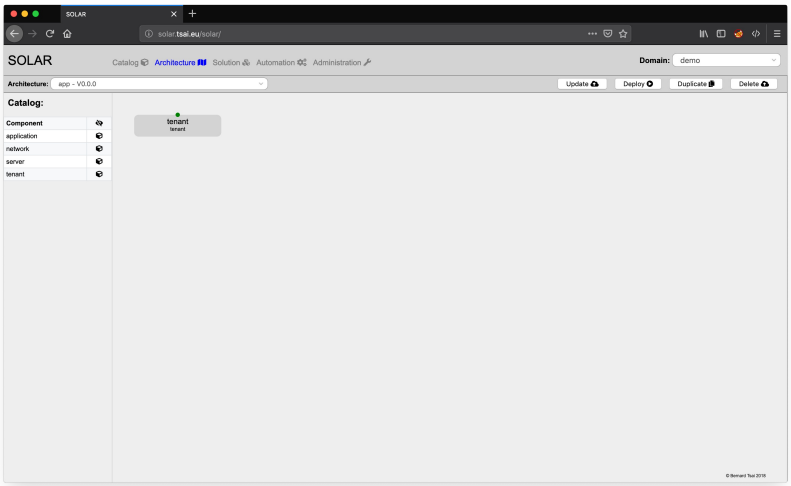


The main cluster specific configuration information relates to following attributes:

- the target state which describes which lifecycle state the instances of the cluster should have,
- the minimum size which states how many instances the cluster should at least have,
- the maximum size which states how many instances the cluster should at most have,
- the current size which states how many instances of the cluster should have the desired target state and

- the configuration which holds any cluster and component type specific configuration information for the element.

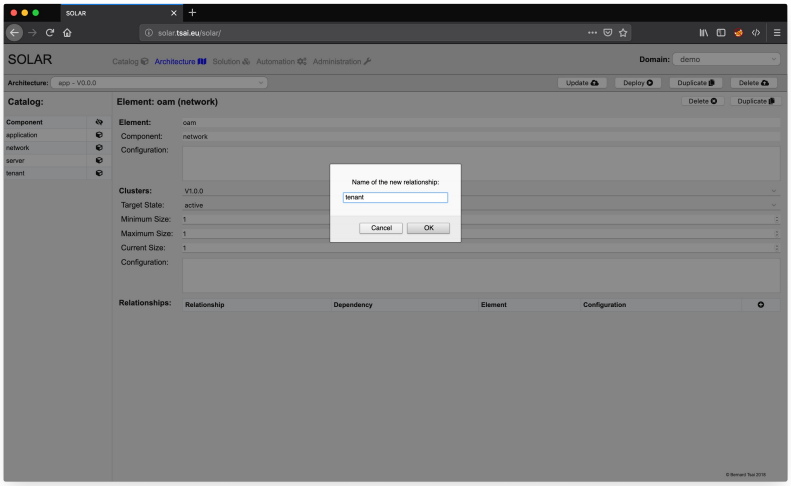
The "Tenant" solution element will not require any additional information and by clicking on "close" icon next to the "Component" headline of the catalog an overview of the currently presented architecture will be shown:



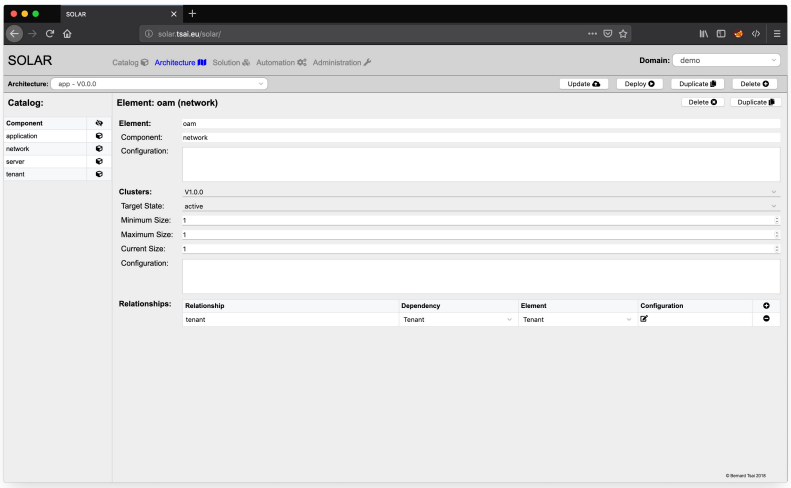
It depicts a single box referring to the new solution element "Tenant" of component type "tenant". The green dot on the top indicates that it exposes one cluster service interface which should be active.

The relationship details are of relevance when defining the "OAM" network element. After adding a "network" element with the name "OAM" to the architecture and selecting the cluster "V1.0.0" add a new relationship to the cluster by pressing "+" icon located at the far right to the "Relationships" label.

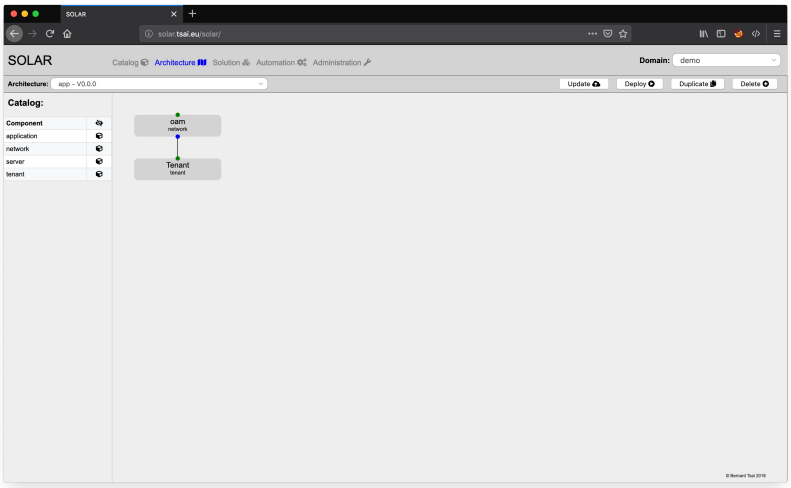
A prompt appears asking for the name of the new relationship:



Entering "tenant" and pressing OK will add a line to the relationships table. Specifying that "Dependency" should relate to the "Tenant" dependency of a "network" component and referring to the "Tenant" element of the solution by selecting it from the drop-down box and optionally entering configuration information for the relationship is what is needed to specify the relationship in detail:



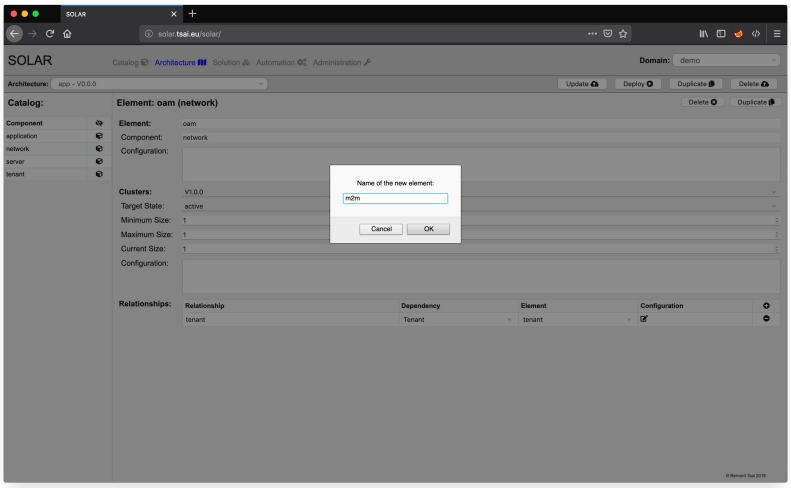
Changing back to the overview by pressing the "close" button next to the "Component" label of the catalog shows how the two components relate to one another:



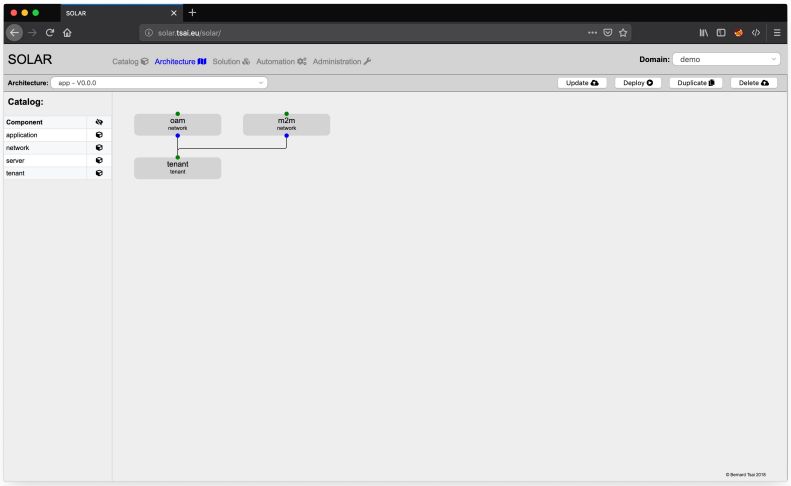
The solid line between the "oam" element and the "tenant" element indicates that there is runtime context dependency between these two entities.

Duplicating an architecture element

Elements can be duplicated in order to simplify the process of creating similar elements. After clicking on the "oam" element in the overview the dialog appears allowing to edit the element information. This dialog also exposes at the top right a button to duplicate this element. When clicking on the button a prompt appears asking for the name of the element:



After entering "m2m" and pressing "OK" the dialog for editing the new "m2m" element appears in which all of the attributes of the "oam" element have been copied apart from the name. Switching back to the overview displays how the new element fits into the architectural overview.

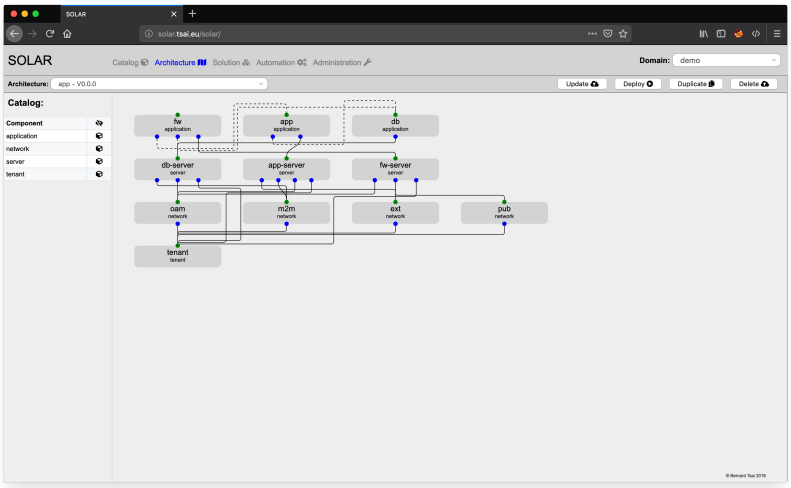


Deleting an architecture element

Removing an element from the architecture is achieved is by selecting an element from the overview and pressing on the "Delete" button located at the top right of the dialog.

Updating an architecture

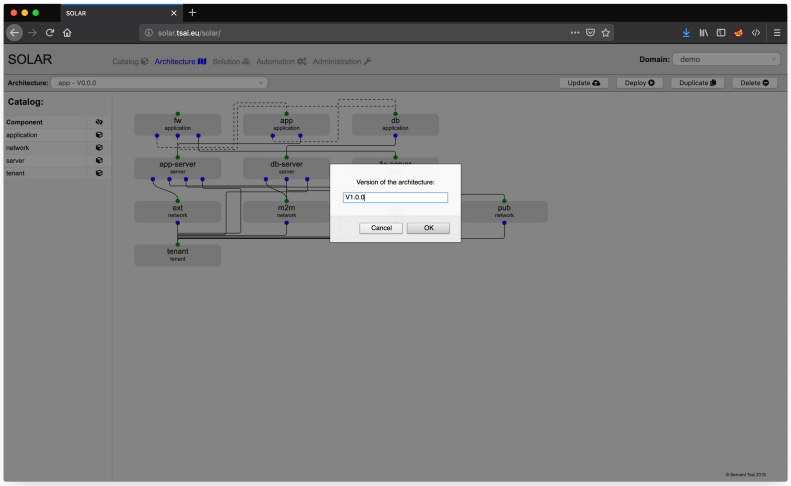
It is essential to upload the architecture definition to the repository after having added and configured all the required elements:



This is achieved by pressing the "Update" button at the top right of the window (architectures should not be updated as soon as they have been deployed in order to avoid inconsistencies).

Duplicating an architecture

The architecture of a solution needs to evolve. SOLAR therefore offers the possibility to make a copy of the architecture and assigning it a new version tag by pressing the "Duplicate" button located at the top right of the window.



A prompt will appear asking for the version identifier and the architecture overview will present the newly created copy of the architecture.

Deleting an architecture

Architectures which are not needed any longer can be easily removed by first selecting the appropriate architecture and then pressing the "Delete" button at the top right of the window.

Deploying an architecture

An architecture defines the target picture of a solution. This may differ from the current state a solution may have. SOLAR offers the possibilities to automatically derive the required transactions in order to converge the current state to the target state defined by an architecture.

For this purpose it is necessary to first select the desired version of the architecture and then press the "Deploy" button located at the top right of the window.

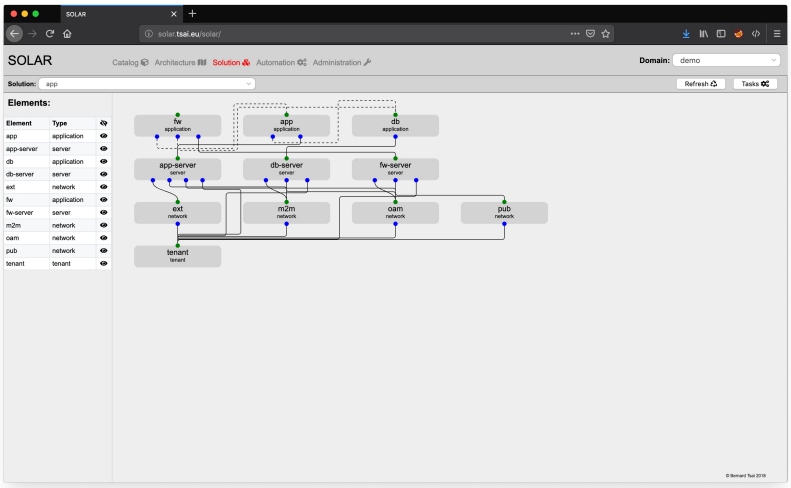
This triggers the closed-loop deployment process. The view will switch to the solution view which will be explained in the following section.

Solution Management

Managing a solution requires obtaining an overview of the current state of a solution and all of its solution elements. The solution management view can be selected by clicking on the "Solution" button at the top of the window.

Selecting a Solution

There may be several solutions within a domain. To select a specific solution pick a solution from the drop-down box located at the top left of the window.



The overview displays on the left side the elements of the solution as a table. The right side displays the architecture in a graphical representation which displays a box for each element. The labels within each box state the name of the element and to which type of component the solution element belongs. The circles at the top of each box relate to the status of each cluster of the solution element:

- grey: initial state
- yellow: inactive state
- green: active state
- red: failure state

The circles at the bottom relate to the various relationships the solution elements may have to other solution elements. These relationships are depicted as solid or dashed lines. Solid lines relate to runtime context dependencies whereas service context dependencies are shown as dashed lines.

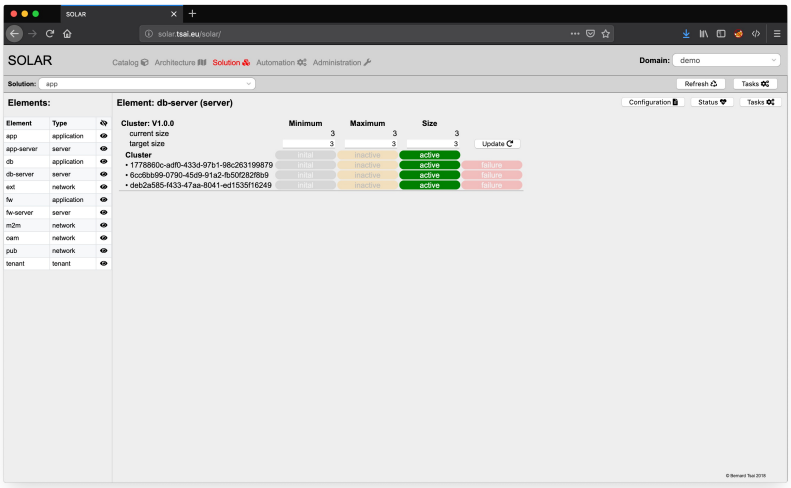
The view can be refreshed by pressing the "Refresh" button at the top right of the window.

View the Tasks Related to a Solution

Tasks may be associated with the creation, modification or deletion of a solution. An overview of all the tasks related to the specific solution are is obtained by pressing the "Tasks" button at the top right of the window.

Display the Status of a Solution Element

In order to display the status of a single solution element either press on the icon right to element listed on the left side of the window or click on one of the solution elements:

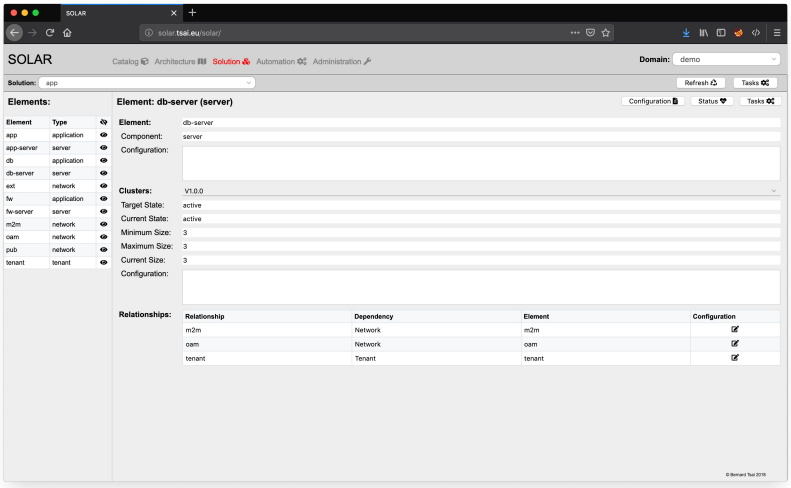


The status of the solution element display the current sizing of the clusters and the status of each cluster instance.

Pressing the "Close" button on the top right of the element list closes the detail view and changes the view back to the solution overview.

Display the Configuration of a Solution Element

The current configuration of a solution element is displayed after pressing the "Configuration" button at the top right of the dialog.



By pressing the "Status" button the view is changed back to the status view of the solution element.

View the Tasks Related to a Solution Element

Tasks may be associated with the scaling of cluster and the lifecycle management of instances of solution elements. An overview of all the tasks related to the specific solution are is obtained by pressing the "Tasks" button at the top right of the dialog.

Administrate the Lifecycle of a Solution Element

The desired target state of a instances of a cluster or of single instances of a cluster may be adjusted by clicking on the corresponding buttons. The task may take some time and therefore it is recommended to click on the refresh button to verify that the changes have been applied as desired.

Some changes may not be applicable since they would violate scaling rules (e.g. deactivating an instance of cluster where all cluster instances need to be active)

Scale a Solution Element

The status view allows to adjust the scaling of a cluster by modifying the target size parameters of the cluster and pressing the corresponding update button. The task may take some time and therefore it is recommended to click on the refresh button to verify that the changes have been applied as desired.

Automation Control

The closed-loop algorithm initiates a vast set of tasks in order to converge the current state of the solution towards a desired target state. These tasks may relate to:

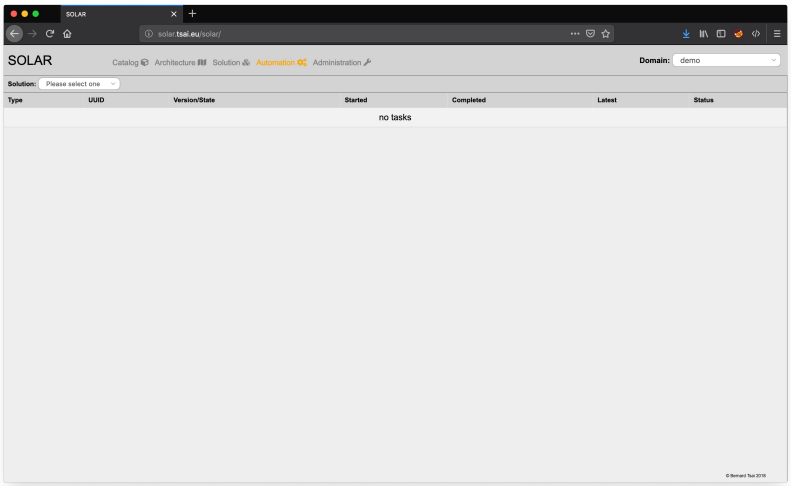
- the solution level or
- the element level or
- the cluster level or
- the instance level

of the solution. Tasks may trigger a hierarchy of required subtasks and are executed until either:

- the task terminates successfully or
- the task fails or
- the task runs into a timeout or
- the task has been terminated by DevOps intervention.

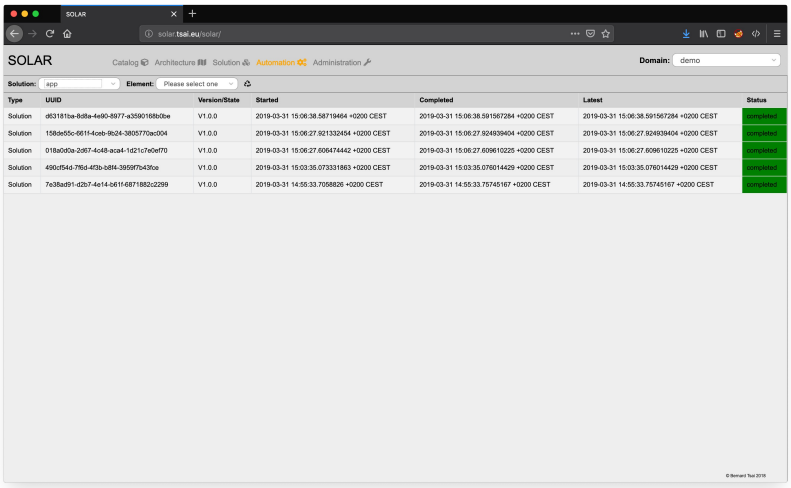
Events relate to these situations tasks and may trigger subsequent tasks.

The automation control view of SOLAR can be selected by clicking on the "Automation" button at the top of the window.



Filtering Automation Tasks

The automation control view allows to identify the relevant tasks by successively drilling down to the level of entities for which the relevant tasks should be listed:



This is achieved by selecting the specific solution, solution element, cluster and instance with the help of drop-down fields located at the top of the window.

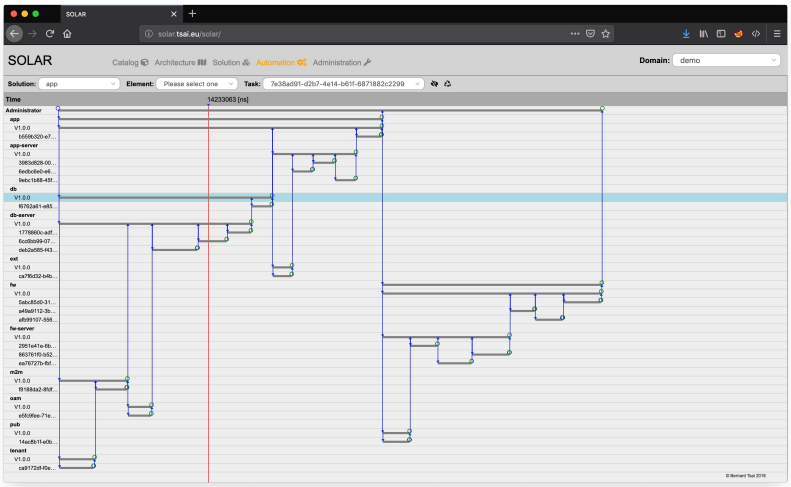
The list of tasks are presented in chronological order with the latest initiated tasks listed first exposing:

- the type of the task,
- the UUID of the task,
- the desired architecture version or instance state,
- the time the task was started
- the time the time has been completed
- the last known event related to the task and
- the status of the task .

The list can be refreshed by pressing on the "Refresh" button.

Displaying an Automation Task

Clicking on a task item in the task list displays the task flow with the help of a graphical representation:



The graph displays the affected entities (elements/clusters and instances) as horizontal swimlanes containing the related tasks. The events exchanged between the tasks a depicted as vertical lines originating from the source task and directed to the task which is to be informed about the event. A red vertical cursor allows to determine the time at which a certain event has occurred.

Clicking on a swimlane opens the solution view and focuses on the corresponding solution element.

The view can be refreshed by pressing on the "Refresh" button and closed by clicking on the "Close" button next to it.

Appendix

- Orchestrator Application Programming Interface
- Orchestrator Command Line Interface
- Orchestrator Message Bus Interface
- Controller Application Programming Interface

Orchestrator API

Orchestrator

Version: 0.0.1

Orchestrator API (mailto:bernard@tsai.eu)

Schemes: http

Summary

Tag: orchestration

Orchestration

Operation	Description

Tag: default

Operation	Description
POST /	Store model
GET /	Retrieve model
DELETE /	Reset model
GET /domain	List domains
POST /domain/{d}	Store domain
GET /domain/{d}	Retrieve domain
DELETE /domain/{d}	Remove domain
GET /domain/{d}/catalog	List components
GET /domain/{d}/catalog/{c}	List versions of a component template
POST /domain/{d}/catalog/{c}/version/{v}	Create component
GET /domain/{d}/catalog/{c}/version/{v}	Retrieve component
DELETE /domain/{d}/catalog/{c}/version/{v}	Remove component
GET /domain/{d}/architecture	List architectures
GET /domain/{d}/architecture/{a}	List architecture versions

POST /domain/{d}/architecture/{a}/version/{v}	Store architecture
GET /domain/{d}/architecture/{a}/version/{v}	Retrieve architecture
DELETE /domain/{d}/architecture/{a}/version/{v}	Remove architecture
GET /domain/{d}/solution	List solutions
POST /domain/{d}/solution/{s}	Store solution
GET /domain/{d}/solution/{s}	Retrieve solution
DELETE /domain/{d}/solution/{s}	Remove solution
PUT /domain/{d}/solution/{s}/version/{v}	Modify solution
GET /domain/{d}/solution/{s}/element	List elements
GET /domain/{d}/solution/{s}/element/{e}	Retrieve element
PUT /domain/{d}/solution/{s}/element/{e}	Modify element
GET /domain/{d}/solution/{s}/element/{e}/cluster	List clusters
GET /domain/{d}/solution/{s}/element/{e}/cluster/{c}	Retrieve cluster
PUT /domain/{d}/solution/{s}/element/{e}/cluster/{c}	Modify cluster
GET /domain/{d}/solution/{s}/element/{e}/cluster/{c}/instance	List instances
GET /domain/{d}/solution/{s}/element/{e}/cluster/{c}/instance/{e}	Retrieve instance
PUT /domain/{d}/solution/{s}/element/{e}/cluster/{c}/instance/{e}	Modify instance
GET /domain/{d}/task	List tasks
GET /domain/{d}/task/{t}	Retrieve task
PUT /domain/{d}/task/{t}	Terminate task
GET /domain/{d}/event	List events
GET /domain/{d}/event/{e}	Retrieve event

Paths

Reset model

DELETE /

reset model in the repository to initial state

200 OK
success

Retrieve model

GET /

retrieve model from the repository as yaml data

application/x-yaml

200 OK
model data as yaml

Model

Store model

POST /

create model from yaml data and store it into the repository

application/x-yaml

model data as yaml

Model

200 OK
Success

List domains

GET /domain

Retrieves list of domain names

application/x-yaml

200 OK
domain names as yaml

Names

Remove domain

DELETE /domain/{d}

remove domain from the repository

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	

application/x-yaml

200 OK
Success

404 Not Found
domain not found

Retrieve domain

GET /domain/{d}

retrieve domain from the repository as yaml data

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	

application/x-yaml

200 OK
domain data as yaml

Domain

404 Not Found
domain not found

Store domain

POST /domain/{d}

create a new domain from yaml data and store it in the repository

application/x-yaml

domain data as yaml

Domain

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	

200 OK
Success

List architectures

GET /domain/{d}/architecture

list all the available architectures in a domain

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	

application/x-yaml

200 OK
architecture names as yaml

Names

List architecture versions

GET /domain/{d}/architecture/{a}

list all the available versions of an architecture in a domain

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
a	architecture name	path	string	

application/x-yaml

200 OK
version names as yaml

Names

Remove architecture

DELETE /domain/{d}/architecture/{a}/version/{v}

remove architecture from the repository

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
a	architecture name	path	string	
v	version of architecture	path	string	

200 OK
success

Retrieve architecture

GET /domain/{d}/architecture/{a}/version/{v}

retrieve architecture from the repository as yaml data

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
a	architecture name	path	string	
v	version of architecture	path	string	

application/x-yaml

200 OK
architecture data as yaml

Architecture

Store architecture

POST /domain/{d}/architecture/{a}/version/{v}

create a new architecture from yaml data and store it in the repository

application/x-yaml

architecture data as yaml

Architecture

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
a	architecture name	path	string	
v	version of architecture	path	string	

200 OK
Success

List components

GET /domain/{d}/catalog

list all the available components in a domain

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	

application/x-yaml

200 OK
component names as yaml

Names

List versions of a component template

GET /domain/{d}/catalog/{c}

list all the available versions of a component in a domain

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
c	component name	path	string	

application/x-yaml

200 OK
version names as yaml

Names

Remove component

DELETE /domain/{d}/catalog/{c}/version/{v}

remove component from the repository

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
c	component name	path	string	
v	version of component	path	string	

200 OK
success

Retrieve component

GET /domain/{d}/catalog/{c}/version/{v}

retrieve component from the repository as yaml data

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
c	component name	path	string	
v	version of component	path	string	

application/x-yaml

200 OK
component data as yaml

Component

Create component

POST /domain/{d}/catalog/{c}/version/{v}

create a new component from yaml data and store it in the repository

application/x-yaml

component data as yaml

Component

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
c	component name	path	string	
v	version of component	path	string	

200 OK
Success

List events

GET /domain/{d}/event

list all events related to a task in a domain

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
t	task name	query	string	

application/x-yaml

200 OK
event names as yaml

Names

Retrieve event

GET /domain/{d}/event/{e}

retrieve event from the repository as yaml data

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
e	event name	path	string	

application/x-yaml

200 OK
event data as yaml

Event

List solutions

GET /domain/{d}/solution

list all the available solutions in a domain

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	

application/x-yaml

200 OK
solution names as yaml

Names

Remove solution

DELETE /domain/{d}/solution/{s}

remove solution from the repository

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	

200 OK
success

Retrieve solution

GET /domain/{d}/solution/{s}

retrieve solution from the repository as yaml data

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	

application/x-yaml

200 OK
solution data as yaml

Solution

Store solution

POST /domain/{d}/solution/{s}

create a new solution from yaml data and store it in the repository

application/x-yaml

solution data as yaml

Solution

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	

200 OK
Success

List elements

GET /domain/{d}/solution/{s}/element

list all the available elements in a solution

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	

application/x-yaml

200 OK

element names as yaml

Names

Retrieve element

GET /domain/{d}/solution/{s}/element/{e}

retrieve element from the repository as yaml data

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	
e	element name	path	string	

application/x-yaml

200 OK

element data as yaml

Element

Modify element

PUT /domain/{d}/solution/{s}/element/{e}

update an existing element based on the information provided in a configuration object

application/x-yaml

configuration data as yaml

Configuration

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	
e	element name	path	string	

200 OK
Success

List clusters

GET /domain/{d}/solution/{s}/element/{e}/cluster

list all the available clusters in an element

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	
e	element name	path	string	

application/x-yaml

200 OK
cluster names as yaml

Names

Retrieve cluster

GET /domain/{d}/solution/{s}/element/{e}/cluster/{c}

retrieve cluster from the repository as yaml data

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	
e	element name	path	string	
c	cluster name	path	string	

application/x-yaml

200 OK
cluster data as yaml

Cluster

Modify cluster

PUT /domain/{d}/solution/{s}/element/{e}/cluster/{c}

update an existing cluster based on the information provided in a configuration object

application/x-yaml

configuration data as yaml

Configuration

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	
e	element name	path	string	
c	cluster name	path	string	

200 OK

Success

List instances

GET /domain/{d}/solution/{s}/element/{e}/cluster/{c}/instance

list all the available instances in a cluster

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	
e	element name	path	string	
c	cluster name	path	string	

application/x-yaml

200 OK

instance names as yaml

Names

Retrieve instance

GET /domain/{d}/solution/{s}/element/{e}/cluster/{c}/instance/{e}

retrieve instance from the repository as yaml data

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	
e	element name	path	string	
c	cluster name	path	string	
i	instance name	path	string	

application/x-yaml

200 OK
instance data as yaml

Instance

Modify instance

PUT /domain/{d}/solution/{s}/element/{e}/cluster/{c}/instance/{e}

update an existing instance based on the information provided in a configuration object

application/x-yaml

configuration data as yaml

Configuration

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	
e	element name	path	string	
c	cluster name	path	string	
i	instance name	path	string	

200 OK
Success

Modify solution

PUT /domain/{d}/solution/{s}/version/{v}

create a new solution or update an existing solution based on the information provided in an architecture blueprint

application/x-yaml

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
s	solution name	path	string	
v	version of the solution	path	string	

200 OK
Success

List tasks

GET /domain/{d}/task

list all toplevel tasks in a domain (optionally matching a certain request ID)

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
r	request name	query	string	

application/x-yaml

200 OK
task names as yaml

Names

Retrieve task

GET /domain/{d}/task/{t}

retrieve task from the repository as yaml data

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
t	task name	path	string	

application/x-yaml

200 OK
task data as yaml

Task

Terminate task

PUT /domain/{d}/task/{t}

stop a task in a domain

Name	Description	Type	Data Type	Annotation
d	domain name	path	string	
t	task name	path	string	

200 OK
Success

Schema definitions

Architecture: object

An configuration for a version of a solution

Name: string

Name of the solution architecture

Version: string
Version of the solution architecture

Configuration: Configuration

Elements: object
Map of component names to configurations for solution elements

ElementConfiguration

Cluster: object

A cluster of instances of an element

Version: string
Version of the instance

Configuration: Configuration

Endpoint: Endpoint

Relationships: object
Map of dependency names to dependencies

Relationship

Instances: object
Map of uuids to cluster element instances

Instance

ClusterConfiguration: object

A configuration for a cluster of solution elements

Version: string
Version of a component template

State: string
Desired state of the version of a solution element

Size: integer , { $x \in \mathbb{Z} \mid x \geq 0$ }
Desired size of the version of a solution element

Configuration: Configuration

Dependencies: object
Map of dependency names to dependency configurations

RelationshipConfiguration

Component: object

A template for a version of a component

Component: string
Name of the component

Version: string
Version of the component

Configuration: Configuration

Dependencies: object
Map of names to dependencies of a component version

Dependency

Configuration: object

Configuration information as structured object

object

Dependency: object

A template for a component dependency

Name: string
Name of the dependency

Type: string , x ∈ { context , service }
Type of dependency (context/service)

Component: string
Name of the referenced component

Version: string
Version of the referenced component

Configuration: Configuration

Domain: object

An adminsitrative realm within a model

Name: string
Name of the domain

Catalog: object
Map of names to templates for elements

Component

Architectures: object
Map of names to architecture blueprints

Architecture

Solutions: object
Map of names to components

Solution

Task: object
Map of uuids to tasks

Task

Event: object
Map of uuids to events

Event

Element: object

An element of a solution

Name: string
Name of the element

Component: string
Name of the component

Configuration: Configuration

Endpoint: Endpoint

Clusters: object
Map of version names to clusters

Cluster

ElementConfiguration: object

A configuration for a solution element

Name: string
Name of the solution element

Component: string
Name of the component template

Configuration: Configuration

Versions: object
Map of version names to configurations for versions of solution elements

ClusterConfiguration

Endpoint: object

Endpoint information as structured object

object

Event: object

An event related to a task

Domain: string
Name of the domain

UUID: string
Univesal unique identifier of the event

Task: string
Univesal unique identifier of the task

Type: string , x ∈ { execution , completion , failure , timeout }
Type of the event

Source: string
Univesal unique identifier of the issuing task or ''

Time: string
time since 1.1.1970 in nsecs

Instance: object

An instance of an element

UUID: string
Unique universal identifier of the instance

State: string
State of the instance

Configuration: Configuration

Endpoint: Endpoint

Model: object

The information model for the orchestration of lifecycles

Schema: string
Schema of the model

Name: string
Name of the model

Domains: object
Map of names to domains

Domain

Names: string[]

List of names

string

Relationship: object

An instance of an element

Name: string
Name of the dependency

Configuration: Configuration

Endpoint: Endpoint

RelationshipConfiguration: object

A configuration for a dependency of a version of a solution element

Name: string
Name of the dependency

Configuration: Configuration

Solution: object

A solution consisting of elements

Name: string
Name of the solution

Configuration: Configuration

Elements: object
Map of element names to elements

Element

Task: object

An adminsitrative realm within a model

Type: string
Type of the task

Domain: string
Name of the Domain

Solution: string
Name of the Solution

Element: string
Name of the element

Cluster: string
Cluster (version) of the element

Instance: string
Univesal unique identifier of the instance

State: string
Desired state for the entity

UUID: string
Univesal unique identifier of the task

Parent: string
Univesal unique identifier of the parent task

Status: string , x ∈ { execution , completion , failure , timeout }
Execution status of the task

Phase: string
Execution phase of the task

Subtasks: string[]
Unique universal identifiers of the subtasks

string

Command Line Interface Version: 0.0.1

Documentation of the command line interface of the orchestrator.

Load Model

Create model from yaml data and store it into the repository.

Usage:

```
>>> model load <filename>
```

Parameters:

- filename: name of a file with yaml data

Save Model

Retrieve model from the repository as yaml data and save it into a file.

Usage:

```
>>> model save <filename>
```

Parameters:

- filename: name of a file

Reset Model

Reset model in the repository to its initial state.

Usage:

```
>>> model reset
```

List Domains

Retrieves list of domain names

Usage:

```
> ListDomains
```

Response:

Names: domain names as yaml

Store domain.

create a new domain from yaml data and store it in the repository

Usage:

```
> StoreDomain -d [domain name] -domain [domain data as yaml]
```

Parameters:

-d [domain name] (required)

-domain [domain data as yaml] (required)

Response:

Retrieve domain.

retrieve domain from the repository as yaml data

Usage:

```
> RetrieveDomain -d [domain name]
```

Parameters:

-d [domain name] (required)

Response:

Domain: domain data as yaml

Remove domain.

remove domain from the repository

Usage:

```
> RemoveDomain -d [domain name]
```

Parameters:

-d [domain name] (required)

Response:

List components.

list all the available components in a domain

Usage:

```
> ListComponents -d [domain name]
```

Parameters:

-d [domain name] (required)

Response:

Names: component names as yaml

List versions of a component template.

list all the available versions of a component in a domain

Usage:

```
> ListComponentVersions -d [domain name] -c [component name]
```

Parameters:

-d [domain name] (required)

-c [component name] (required)

Response:

Names: version names as yaml

Create component.

create a new component from yaml data and store it in the repository

Usage:

```
> CreateComponent -d [domain name] -c [component name] -v [version of component] -component [component data as yaml]
```

Parameters:

-d [domain name] (required)

-c [component name] (required)

-v [version of component] (required)

-component [component data as yaml] (required)

Response:

Retrieve component.

retrieve component from the repository as yaml data

Usage:

```
> RetrieveComponent -d [domain name] -c [component name] -v [version of component]
```

Parameters:

-d [domain name] (required)

-c [component name] (required)

-v [version of component] (required)

Response:

Component: component data as yaml

Remove component.

remove component from the repository

Usage:

```
> RemoveComponent -d [domain name] -c [component name] -v [version of component]
```

Parameters:

-d [domain name] (required)

-c [component name] (required)

-v [version of component] (required)

Response:

List architectures.

list all the available architectures in a domain

Usage:

```
> ListArchitectures -d [domain name]
```

Parameters:

-d [domain name] (required)

Response:

Names: architecture names as yaml

List architecture versions.

list all the available versions of an architecture in a domain

Usage:

```
> ListArchitectureVersions -d [domain name] -a [architecture name]
```

Parameters:

-d [domain name] (required)

-a [architecture name] (required)

Response:

Names: version names as yaml

Store architecture.

create a new architecture from yaml data and store it in the repository

Usage:

```
> StoreArchitecture -d [domain name] -a [architecture name] -v [version of architecture] -architecture [architecture data as yaml]
```

Parameters:

-d [domain name] (required)

-a [architecture name] (required)

-v [version of architecture] (required)

-architecture [architecture data as yaml] (required)

Response:

Retrieve architecture.

retrieve architecture from the repository as yaml data

Usage:

```
> RetrieveArchitecture -d [domain name] -a [architecture name] -v [version of architecture]
```

Parameters:

-d [domain name] (required)

-a [architecture name] (required)

-v [version of architecture] (required)

Response:

Architecture: architecture data as yaml

Remove architecture.

remove architecture from the repository

Usage:

```
> RemoveArchitecture -d [domain name] -a [architecture name] -v [version of architecture]
```

Parameters:

-d [domain name] (required)

-a [architecture name] (required)

-v [version of architecture] (required)

Response:

List solutions.

list all the available solutions in a domain

Usage:

```
> ListSolutions -d [domain name]
```

Parameters:

-d [domain name] (required)

Response:

Names: solution names as yaml

Store solution.

create a new solution from yaml data and store it in the repository

Usage:

```
> StoreSolution -d [domain name] -s [solution name] -solution [solution data as yaml]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

-solution [solution data as yaml] (required)

Response:

Retrieve solution.

retrieve solution from the repository as yaml data

Usage:

```
> RetrieveSolution -d [domain name] -s [solution name]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

Response:

Solution: solution data as yaml

Remove solution.

remove solution from the repository

Usage:

```
> RemoveSolution -d [domain name] -s [solution name]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

Response:

Modify solution.

create a new solution or update an existing solution based on the information provided in an architecture blueprint

Usage:

```
> ModifySolution -d [domain name] -s [solution name] -v [version of the solution]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

-v [version of the solution] (required)

Response:

List elements.

list all the available elements in a solution

Usage:

```
> ListElements -d [domain name] -s [solution name]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

Response:

Names: element names as yaml

Retrieve element.

retrieve element from the repository as yaml data

Usage:

```
> RetrieveElement -d [domain name] -s [solution name] -e [element name]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

-e [element name] (required)

Response:

Element: element data as yaml

Modify element.

update an existing element based on the information provided in a configuration object

Usage:

```
> ModifyElement -d [domain name] -s [solution name] -e [element name] -configuration [configuration data as yaml]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

-e [element name] (required)

-configuration [configuration data as yaml] (required)

Response:

List clusters.

list all the available clusters in an element

Usage:

```
> ListClusters -d [domain name] -s [solution name] -e [element name]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

-e [element name] (required)

Response:

Names: cluster names as yaml

Retrieve cluster.

retrieve cluster from the repository as yaml data

Usage:

```
> RetrieveCluster -d [domain name] -s [solution name] -e [element name] -c [cluster name]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

-e [element name] (required)

-c [cluster name] (required)

Response:

Cluster: cluster data as yaml

Modify cluster.

update an existing cluster based on the information provided in a configuration object

Usage:

```
> ModifyCluster -d [domain name] -s [solution name] -e [element name] -c [cluster name] -configuration [configuration data
 as yaml]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

-e [element name] (required)

-c [cluster name] (required)

-configuration [configuration data as yaml] (required)

Response:

List instances.

list all the available instances in a cluster

Usage:

```
> ListInstances -d [domain name] -s [solution name] -e [element name] -c [cluster name]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

-e [element name] (required)

-c [cluster name] (required)

Response:

Names: instance names as yaml

Retrieve instance.

retrieve instance from the repository as yaml data

Usage:

```
> RetrieveInstance -d [domain name] -s [solution name] -e [element name] -c [cluster name] -i [instance name]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

-e [element name] (required)

-c [cluster name] (required)

-i [instance name] (required)

Response:

Instance: instance data as yaml

Modify instance.

update an existing instance based on the information provided in a configuration object

Usage:

```
> ModifyInstance -d [domain name] -s [solution name] -e [element name] -c [cluster name] -i [instance name] -configuration
 [configuration data as yaml]
```

Parameters:

-d [domain name] (required)

-s [solution name] (required)

-e [element name] (required)

-c [cluster name] (required)

-i [instance name] (required)

-configuration [configuration data as yaml] (required)

Response:

List tasks.

list all toplevel tasks in a domain (optionally matching a certain request ID)

Usage:

```
> ListTasks -d [domain name] -r [request name]
```

Parameters:

-d [domain name] (required)

-r [request name] (optional)

Response:

Names: task names as yaml

Retrieve task.

retrieve task from the repository as yaml data

Usage:

```
> RetrieveTask -d [domain name] -t [task name]
```

Parameters:

-d [domain name] (required)

-t [task name] (required)

Response:

Task: task data as yaml

Terminate task.

stop a task in a domain

Usage:

```
> TerminateTask -d [domain name] -t [task name]
```

Parameters:

-d [domain name] (required)

-t [task name] (required)

Response:

List events.

list all events related to a task in a domain

Usage:

```
> ListEvents -d [domain name] -t [task name]
```

Parameters:

-d [domain name] (required)

-t [task name] (required)

Response:

Names: event names as yaml

Retrieve event.

retrieve event from the repository as yaml data

Usage:

```
> RetrieveEvent -d [domain name] -e [event name]
```

Parameters:

-d [domain name] (required)

-e [event name] (required)

Response:

Event: event data as yaml

Message Bus Interface

The message bus interface is exposed to external systems and serves as a gateway to expose:

- task related notification events and
- status information of the the solution.

Events

The orchestrator can be handed a unique topic identifier "TOPIC1" in the course of the startup process. This is the topic to which it will publish its events to a Kafka broker.

Each event is related to a task and will notify wether:

- Execution: the execution of a task has been triggered
- Termination: the termination of a task has been triggered
- Timeout: a task has run into a time-out
- Failure: a task has failed
- Success: a task has completed successfully
- Terminated: a task has been terminated

The type of tasks to which an event may relate are:

- Architecture: tasks related to the instantiation or update of a solution based on an architecture blueprint
- Element: tasks related to the instantiation, modification or deletion of an element
- Cluster: tasks related to the instantiation, modification or deletion of a cluster
- Instance: tasks related to the instantiation, modification or deletion of an instance
- Parallel: a task representing a group of tasks which can be executed in parallel
- Instance: a task representing a group of tasks which need to be executed sequentially

The event information captures following attributes of the event and the corresponding task:

Attribute	Type	Description
Request	string	request identifier
Type	string	type of event
UUID	string	unique identifier for the event
Source	string	identifier of the source task
Time	string	time since 1.1.1970 in nsecs
Task	string	unique identifier for the task
TaskType	string	type of the task
Parent	string	identifier of the parent task
Subtasks	array of UUIDs	array of UUIDs of subtasks
Status	string	status of the task
Phase	string	execution phase of the task
Domain	string	name of the domain
Solution	string	name of the solution
Element	string	name of the element

Cluster	string	name of the cluster
Instance	string	name of the instance
State	string	desired lifecycle state
Configuration	object	runtime configuration object

Status

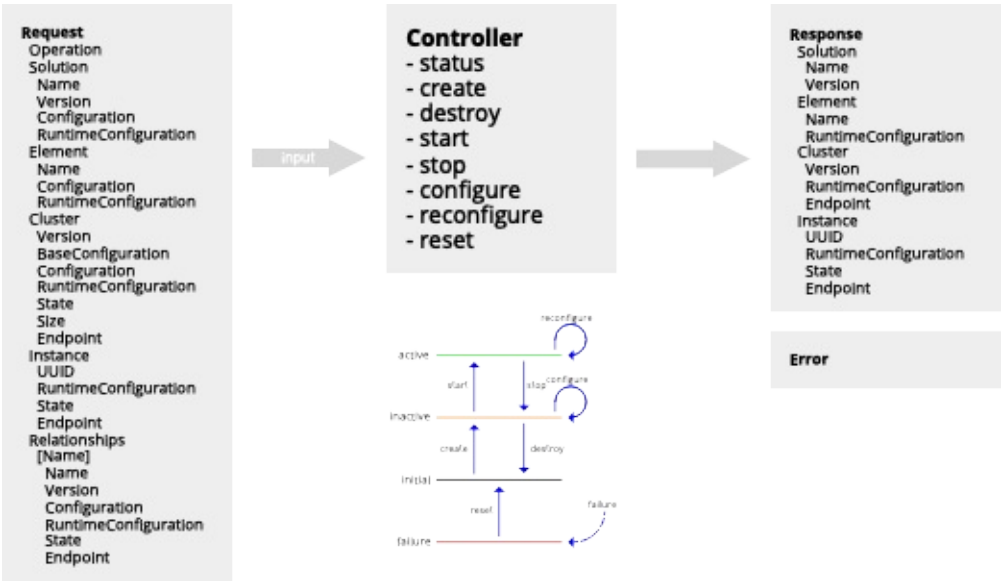
The orchestrator can be handed a second unique topic identifier "TOPIC2" in the course of the startup process. This is the topic to which it will publish its status information to a Kafka broker.

The status information captures following attributes of the state of a solution, element, cluster or instance within a domain.

Attribute	Type	Description
Time	string	time since 1.1.1970 in nsecs
Domain	string	name of the domain
Solution	string	name of the solution
Element	string	name of the element
Cluster	string	name of the cluster
Instance	string	name of the instance
State	string	current lifecycle state

Controller API

The methods which a controller needs to expose are described in the following sections. They aim to support the standard lifecycle management concept for instances and allow for monitoring their state as well.



Methods

Create

Creates a new instance of a cluster of an element of a solution.

```
response, error = create(request)
```

The variables are:

Variable	Type	Description
request	Request	Request as issued by the orchestrator
response	Response	Response returned by the controller
error	Error	Error object if an error has occurred

Destroy

Destroys an existing instance of a cluster of an element of a solution.

```
response, error = destroy(request)
```

The variables are:

Variable	Type	Description

request	Request	Request as issued by the orchestrator
response	Response	Response returned by the controller
error	Error	Error object if an error has occurred

Start

Activates an instance of a cluster of an element of a solution.

```
response, error = start(request)
```

The variables are:

Variable	Type	Description
request	Request	Request as issued by the orchestrator
response	Response	Response returned by the controller
error	Error	Error object if an error has occurred

Stop

Deactivates an instance of a cluster of an element of a solution.

```
response, error = stop(request)
```

The variables are:

Variable	Type	Description
request	Request	Request as issued by the orchestrator
response	Response	Response returned by the controller
error	Error	Error object if an error has occurred

Configure

Configures a deactivated instance of a cluster of an element of a solution.

```
response, error = configure(request)
```

The variables are:

Variable	Type	Description
request	Request	Request as issued by the orchestrator
response	Response	Response returned by the controller
error	Error	Error object if an error has occurred

Reconfigure

Reconfigures an active instance of a cluster of an element of a solution.

```
response, error = reconfigure(request)
```

The variables are:

Variable	Type	Description
request	Request	Request as issued by the orchestrator
response	Response	Response returned by the controller
error	Error	Error object if an error has occurred

Reset

Resets an instance of a cluster of an element of a solution.

```
response, error = reset(request)
```

The variables are:

Variable	Type	Description
request	Request	Request as issued by the orchestrator
response	Response	Response returned by the controller
error	Error	Error object if an error has occurred

Status

Determines the status of an instance of a cluster of an element of a solution.

```
response, error = status(request)
```

The variables are:

Variable	Type	Description
request	Request	Request as issued by the orchestrator
response	Response	Response returned by the controller
error	Error	Error object if an error has occurred

Objects

Request

A request object is passed as a serialised yaml object.

▼ Schema Definition:

```yaml
Request:
  type: "object"
  description: |
    The request object as passed by the orchestration engine to the controller
    when requesting a lifecycle operation on a specific instance.
  properties:
    Operation:
      type: string
      description: "The requested lifecycle operation."
      enum: ["create", "destroy","start","stop","configure","reconfigure","reset","status"]
    Solution:
      type: object
      description: "Solution"
      properties:
        Name:
          type: string
          description: "Name of the solution"
        Version:
          type: string
          description: "Version of the solution"
        Configuration:
          type: object
          description: "Configuration of the solution"
          additionalProperties: true
        RuntimeConfiguration:
          type: object
          description: "Runtime configuration of the solution"
          additionalProperties: true
    Element:
      type: object
      description: "Element of the solution"
      properties:
        Name:
          type: string
          description: "Name of the element"
        Configuration:
          type: object
          description: "Configuration of the element"
          additionalProperties: true
        RuntimeConfiguration:
          type: object
          description: "Runtime configuration of the element"
          additionalProperties: true
    Cluster:
      type: object
      description: "Cluster of the element of the solution"
      properties:
        Version:
          type: string
          description: "Version of the element"
        BaseConfiguration:
          type: object
          description: "Base configuration of the cluster"
          additionalProperties: true
        Configuration:
          type: object
          description: "Configuration of the cluster"
          additionalProperties: true
        RuntimeConfiguration:
          type: object
          description: "Runtime configuration of the cluster"
          additionalProperties: true
```

```
        Endpoint:
          type: object
          description: "Endpoint information of the cluster"
          additionalProperties: true
    Instance:
      type: object
      description: "Instance of a cluster of the element of the solution"
      properties:
        UUID:
          type: string
          description: "Universal unique identifier of the instance"
        RuntimeConfiguration:
          type: object
          description: "Runtime configuration of the instance"
          additionalProperties: true
        Endpoint:
          type: object
          description: "Endpoint information of the instance"
          additionalProperties: true
    Relationships:
      type: object
      description: "Instance of a cluster of the element of the solution"
      additionalProperties:
        $ref:
          type: object
          description: "Relationship"
          properties:
            Name:
              type: string
              description: "Name of the relationship"
            Configuration:
              type: object
              description: "Configuration of the relationship"
              additionalProperties: true
            RuntimeConfiguration:
              type: object
              description: "Runtime configuration of the relationship"
              additionalProperties: true
            Endpoint:
              type: object
              description: "Endpoint information of the relationship"
              additionalProperties: true
```

Response

A response object is passed back as a serialised yaml object as a result from a lifecycle operation:

▼ Schema Definition:

```
Response:
  type: "object"
  description: |
    A response object is passed back as a serialised yaml object as a result from a lifecycle operation.
  properties:
    Solution:
      type: object
      description: "Solution"
      properties:
        Name:
          type: string
          description: "Name of the solution"
        Version:
          type: string
          description: "Version of the solution"
        Configuration:
          type: object
          description: "Configuration of the solution"
```

```
        additionalProperties: true
      RuntimeConfiguration:
        type: object
        description: "Runtime configuration of the solution"
        additionalProperties: true
  Element:
    type: object
    description: "Element of the solution"
    properties:
      Name:
        type: string
        description: "Name of the element"
      Configuration:
        type: object
        description: "Configuration of the element"
        additionalProperties: true
      RuntimeConfiguration:
        type: object
        description: "Runtime configuration of the element"
        additionalProperties: true
  Cluster:
    type: object
    description: "Cluster of the element of the solution"
    properties:
      Version:
        type: string
        description: "Version of the element"
      BaseConfiguration:
        type: object
        description: "Base configuration of the cluster"
        additionalProperties: true
      Configuration:
        type: object
        description: "Configuration of the cluster"
        additionalProperties: true
      RuntimeConfiguration:
        type: object
        description: "Runtime configuration of the cluster"
        additionalProperties: true
      Endpoint:
        type: object
        description: "Endpoint information of the cluster"
        additionalProperties: true
  Instance:
    type: object
    description: "Instance of a cluster of the element of the solution"
    properties:
      UUID:
        type: string
        description: "Universal unique identifier of the instance"
      RuntimeConfiguration:
        type: object
        description: "Runtime configuration of the instance"
        additionalProperties: true
      Endpoint:
        type: object
        description: "Endpoint information of the instance"
        additionalProperties: true
  Relationships:
    type: object
    description: "Instance of a cluster of the element of the solution"
    additionalProperties:
      $ref:
        type: object
        description: "Relationship"
        properties:
          Name:
            type: string
            description: "Name of the relationship"
```

```
            Configuration:
              type: object
              description: "Configuration of the relationship"
              additionalProperties: true
            RuntimeConfiguration:
              type: object
              description: "Runtime configuration of the relationship"
              additionalProperties: true
            Endpoint:
              type: object
              description: "Endpoint information of the relationship"
              additionalProperties: true
```

Error

An error object indicating possible issues is passed as a serialised yaml object according to following schema definition:

▼ Schema Definition:

```
Error:
  type: "object"
  description: |
    An error indicating the issues which occurred in the context of a lifecycle operation.
  properties:
    additionalProperties: true
```

Glossary

Architecture

An architecture is a versioned description of the desired configuration of a solution.

Catalog

The catalog is a subset of the information model of a domain which holds templates (components and their dependencies) for solution elements along with their basic configuration.

Cluster

A Cluster describes the runtime configuration for a cluster within a solution element for a specific version of a component type.

Component

A component is a versioned template for a solution element. It describes its basic configuration with the help of a structured object and a set of named dependencies to other components

Configuration

A configuration describes how to setup a Solution, Element, Cluster, Relationship or Instance. A basic configuration is provided by the defintion of a Component in the catalog. Architectures capture design time configurations in the entities: ElementConfiguration, ClusterConfiguration and RelationshipConfiguration. The actual run-time configuration is held in the entities themselves.

Controller

A component type specific management component capable of applying the changes to component instances according to the standardised component life cycle model.

Orchestrator

An automation tool which coordinates the versions, configurations and lifecycle states of a set of interdependent components so that a desired target version, configuration and lifecycle state of these components is achieved.

Depedency

A dependency describes how the containing component relates to other components. It can either be a "context" dependency which defines that the referenced component needs to be "active" before the component can be created, or it may be a "service" dependency which states that the referenced component needs to be "active" before the

component can be started.

Domain

A domain is an administrative realm which can be managed independently from other domains

Element

An Element describes the runtime configuration of a solution element based on a component type. A solution element may need to comprise several clusters which resemble versions of a component.

Endpoint

An Endpoint describes how a service provided by a component can be accessed.

Engine

The orchestrator engine is responsible for coordinating the lifecycle management activities of the various component specific controllers.

Event

An event notifies about the occurrence of a task related event.

Extensions

Extensions enhance the functionality of the orchestrator by augmenting it with custom code.

Hook

A hook subscribes to lifecycle events and status information coming from the message bus interface and triggers custom code.

Instance

An Instance describes an instance of a cluster of a solution element.

Lifecycle Model

A lifecycle model can be represented as a directed graph of states and transitions describing how an instance of a component may evolve in the course of its existence.

Model

The information required for the closed-loop automation procedures for managing the lifecycle of solutions.

Monitor

The monitoring system is a module of the orchtestrator and continuously compares the current state of instances with the desired target state and if needed triggers compensating measures.

Relationship

A Relationship describes the runtime configuration for a dependency between clusters of related solution elements.

Repository

The repository is a module of the orchestrator and holds the information required for the closed-loop automation procedures.

Solution

A solution entity describes the current configuration and state of a solution which may consist of a number of elements.

State

The lifecycle state of an entity of a solution. The current lifecycle state of an entity might differ from the desired target state.

Task

A task describes an activity to manipulate a solution or parts of a solution.

Version

Versions mark how entities change their purpose over time.