# Apache Syncope - Reference Guide

Version 4.0.0-SNAPSHOT

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*This document is under active development and discussion!*

If you find errors or omissions in this document, please don't hesitate to submit an issue or open a pull request with a fix. We also encourage you to ask questions and discuss any aspects of the project on the mailing lists or IRC. New contributors are always welcome!

# Preface

This guide covers Apache Syncope services for:

- identity management, provisioning and compliance;
- access management, single sign-on, authentication and authorization;
- API gateway, secure proxy, service mesh, request routing.

# Chapter 1. Introduction

**Apache Syncope** is an Open Source system for managing digital identities in enterprise environments, implemented in Java EE technology and released under the Apache 2.0 license.

Often, *Identity Management* and *Access Management* are jointly referred, mainly because their two management worlds likely coexist in the same project or in the same environment.

The two topics are however completely different: each one has its own context, its own rules, its own best practices.

On the other hand, some products provide unorthodox implementations so it is indeed possible to do the same thing with both of them.

**Identity Management**

Tools and practices to keep identity data consistent and synchronized across repositories, data formats and models.

**Access Management**

Systems, protocols and technologies supporting user authentication (how Users are let accessing a given system) and authorization (which capabilities each user owns on a given system).

From the definitions above, Identity Management and Access Management can be seen as complementary: very often, the data synchronized by the former are then used by the latter to provide its features - e.g. authentication and authorization.

## 1.1. Identity Technologies

Identity and Access Management (IAM) is not implemented by a single technology; it is instead a composition of heterogeneous technologies - differing by maturity, scope, applicability and feature coverage - which require some 'glue' to fit together.

As with other application domains, it can be observed that tools that appeared earlier tend to partially overlap with more recent, targeted products.

### 1.1.1. Identity Stores

*Identity Stores* are the places where identity-related information is stored.

An Identity Store can be shared among several systems: as a result, there is a single place where account data is managed by administrators, and the same password can be used for the same user for accessing different applications.

Various Identity Store types are available:

- Flat files (XML, CSV, …)

- LDAP
- Relational databases (MySQL, Oracle, Microsoft SQL Server, PostgreSQL, …)
- Platform-specific (Microsoft Active Directory, FreeIPA, PowerShell, …)
- Web services (REST, SOAP, …)
- Cloud providers
- …and much more.

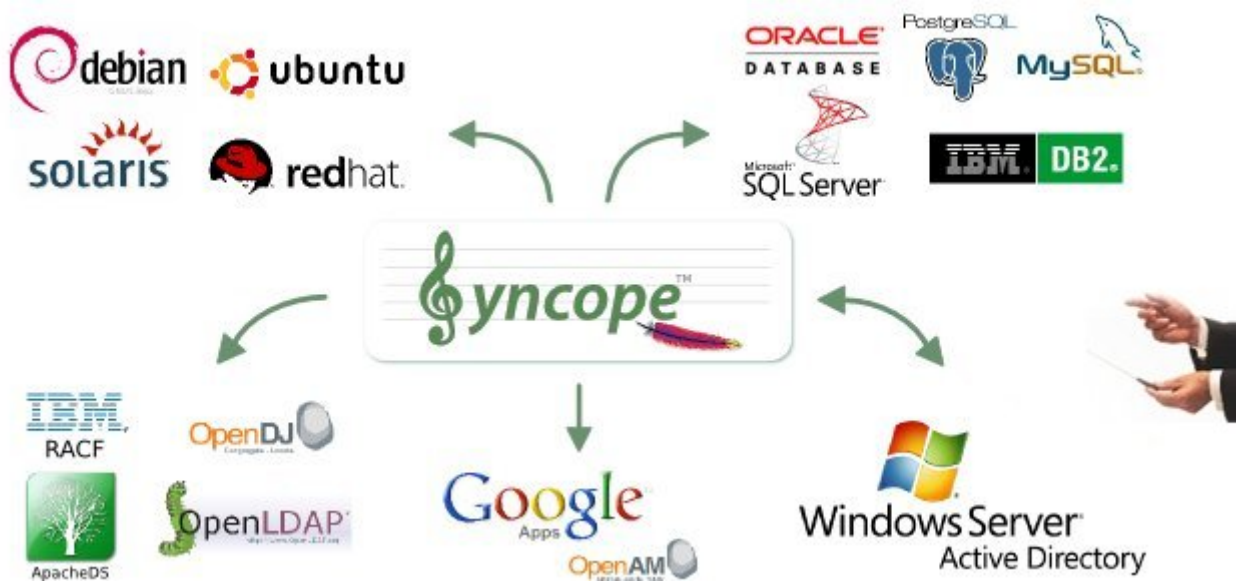



*Figure 1. Apache Syncope and the external world*

### ConnId

Apache Syncope relies on ConnId for communication with Identity Stores; ConnId is designed to separate the implementation of an application from the dependencies of the system that the application is attempting to connect to.

ConnId is the continuation of The Identity Connectors Framework (Sun ICF), a project that used to be part of market leader Sun IdM and has since been released by Sun Microsystems as an Open Source project. This makes the connectors layer particularly reliable because most connectors have already been implemented in the framework and widely tested.

The new ConnId project, featuring contributors from several companies, provides all that is required nowadays for a modern Open Source project, including an Apache Maven driven build, artifacts and mailing lists. Additional connectors – such as for SOAP, CSV, PowerShell and Active Directory – are also provided.

*Aren't Identity Stores enough?*

One might suppose that a single Identity Store can solve all the identity needs inside an organization, but there are a few drawbacks with this approach:

1. Heterogeneity of systems
2. Lack of a single source of information (HR for corporate id, Groupware for

mail address, ...)

3. Often applications require a local user database
4. Inconsistent policies across the infrastructure
5. Lack of workflow management
6. Hidden infrastructure management cost, growing with the size of the organization

### 1.1.2. Identity Managers

The main role of *Identity Managers* is to keep Identity Stores synchronized as much as possible.

Some other characteristics and features provided:

- Adapt to Identity Store data and application models
- Do not require changes in Identity Stores or applications
- Build virtual unified view of identity data distributed across several Identity Stores
- Allow to define and enforce security policies
- Permit workflow definition, with transitions subject to approval
- Focused on application back-end

In brief, Identity Managers take heterogeneous Identity Stores (and business requirements) as input and build up high-level identity data management throughout what is called the **Identity Lifecycle**.

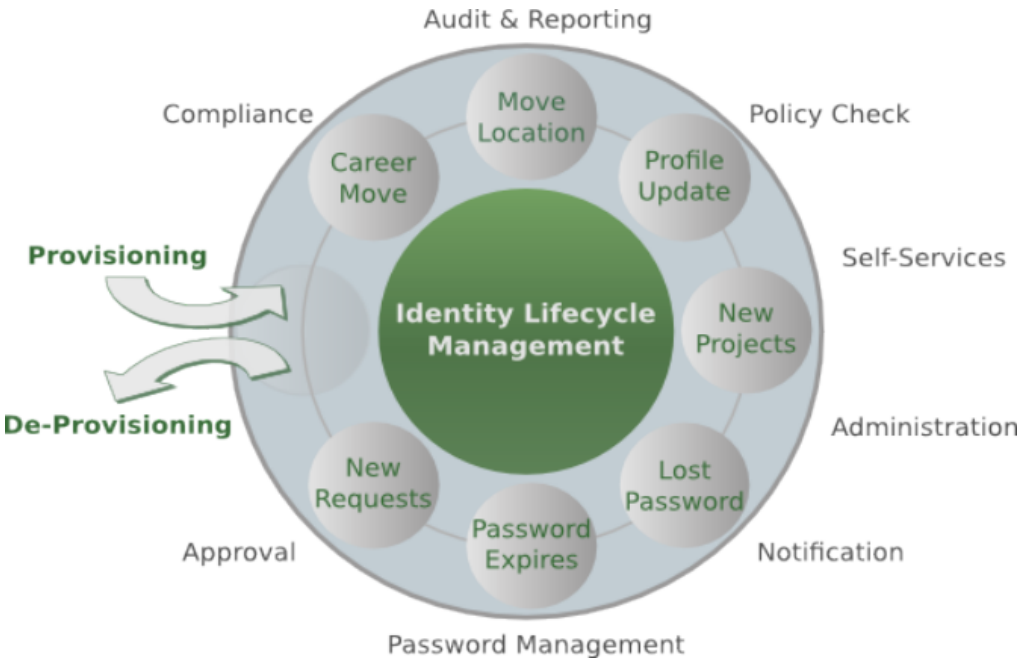



*Figure 2. Identity Lifecycle*

Applications can typically integrate with Identity Managers by:

- exposing some sort of provisioning API (often via REST or SOAP) being invoked by Identity Managers - also called *native integration*;

- having their identity repository externally managed by Identity Managers - also called *legacy integration*.

### 1.1.3. Access Managers

*Access Managers* focus on the application front-end, enforcing application access via authentication (how users are let access a given system) and authorization (which capabilities each user owns on a given system).

Several practices and standards can be implemented by Access Managers:

- Single Sign-On
- Multi-Factor Authentication
- OAuth
- SAML
- OpenID Connect

Applications can typically integrate with Access Managers by:

- implementing at least one of the most diffuse protocols as OpenID Connect or SAML - also called *native integration*;
- being protected by a security-enabled HTTP reverse proxy, which will in turn interact with Access Managers - also called *legacy integration*.

### 1.1.4. The Complete Picture

The picture below shows a typical scenario where an organization's infrastructure is helped by identity technologies in providing secure and trusted application access to end-Users, while keeping different levels of data and processes under control for business owners, help-desk operators and system administrators.

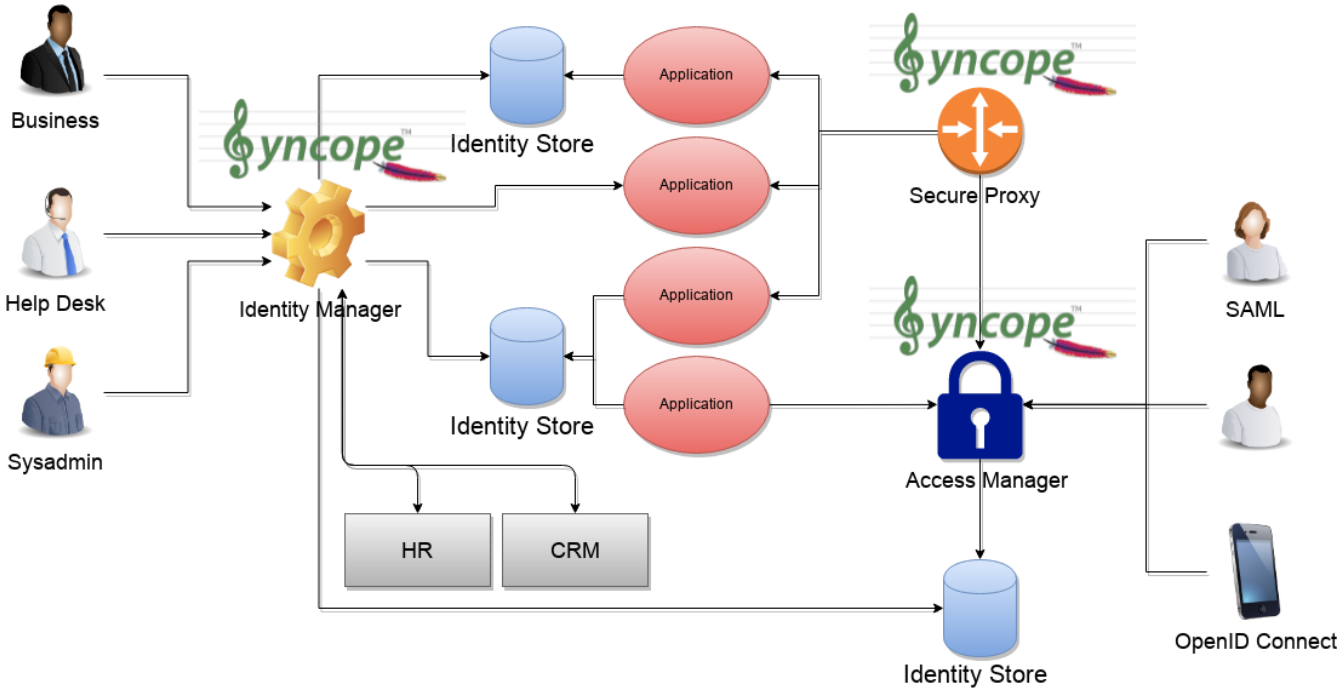



*Figure 3. Identity Technologies - The Complete Picture*

# Chapter 2. Architecture

Apache Syncope is made of several components, which are logically summarized in the picture below.

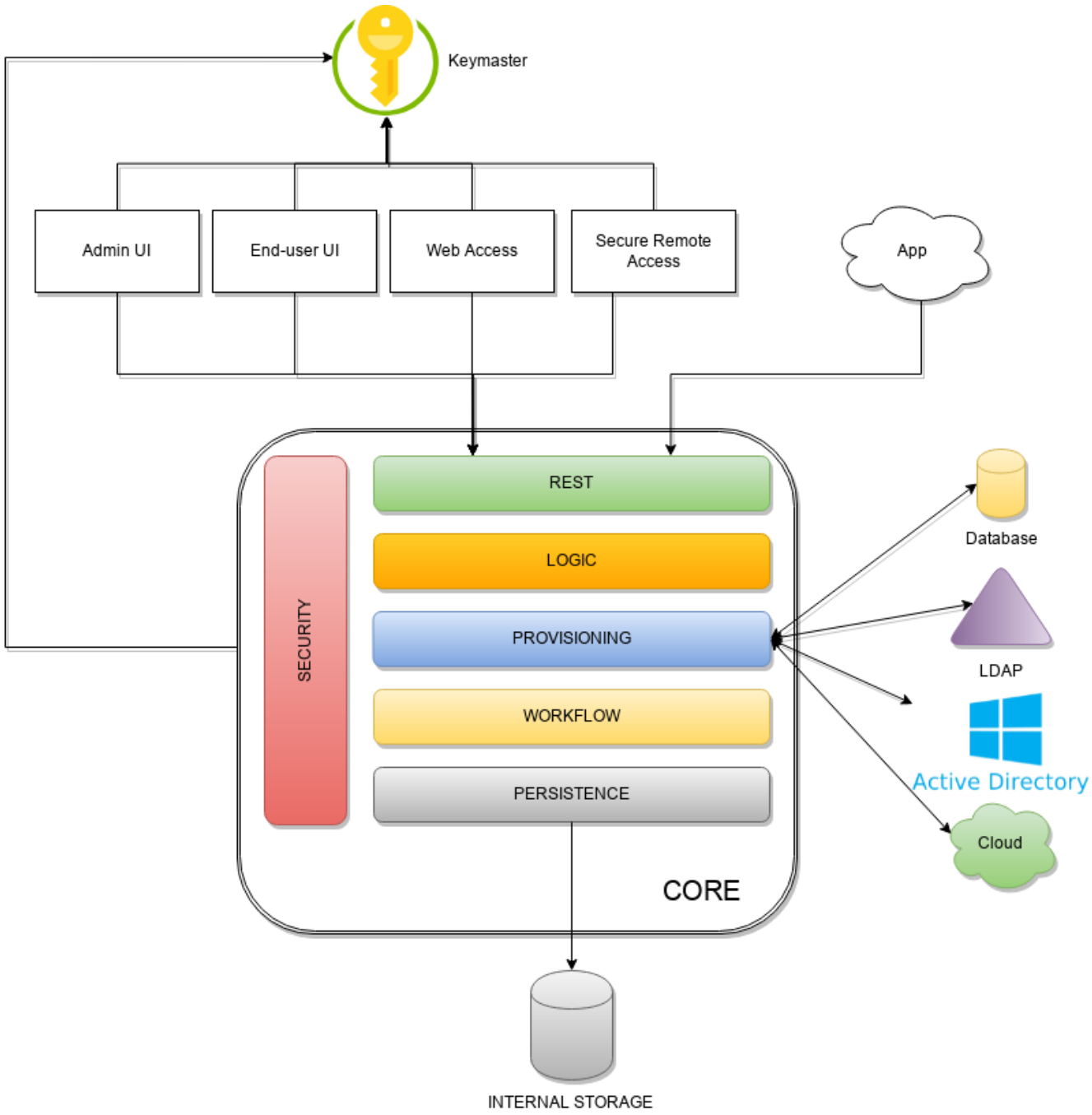



*Figure 4. Architecture*

## 2.1. Keymaster

The ***Keymaster*** allows for dynamic service discovery so that other components are able to find each other.
On startup, all other component instances will register themselves into Keymaster so that their references can be found later, for intra-component communication.

In addition, the Keymaster is also used as key / value store for configuration parameters and as a

directory for defined domains.

Two different implementations are provided, following the actual needs:

1. as an additional set of RESTful services exposed by the Core, for traditional deployments (also known as *Self Keymaster*);
2. as a separate container / pod based on Apache Zookeeper, for microservice-oriented deployments.

## 2.2. Core

The ***Core*** is the component providing IdM services and acting as central repository for other components' configuration.

The Core is internally further structured into several layers, each one taking care of specific aspects of the identity management services.

### 2.2.1. REST

The primary way to consume Core services is the RESTful interface, which enables full access to all the features provided. This interface enables third-party applications, written in any programming language, to consume IdM services.

The rich pre-defined set of endpoints can be extended by adding new ones, which might be needed on a given Apache Syncope deployment to complement the native features with domain-specific operations.

At a technical level, the RESTful interface is a fully-compliant JAX-RS 2.1 implementation based on Apache CXF, natively dealing either with JSON, YAML and XML payloads.

More details are available in the dedicated usage section.

### 2.2.2. Logic

Right below the external interface level, the overall business logic is responsible for orchestrating the other layers, by implementing the operations that can be triggered via REST services. It is also responsible for controlling some additional features (notifications, reports and auditing).

### 2.2.3. Provisioning

The Provisioning layer is involved with managing the internal (via workflow) and external (via specific connectors) representation of Users, Groups and Any Objects.

One of the most important features provided is the mapping definition: internal data (Users, for example) representation is correlated with information available on the available Identity Stores.
Such definitions constitute the pillars of inbound (pull) and outbound (propagation / push) provisioning.

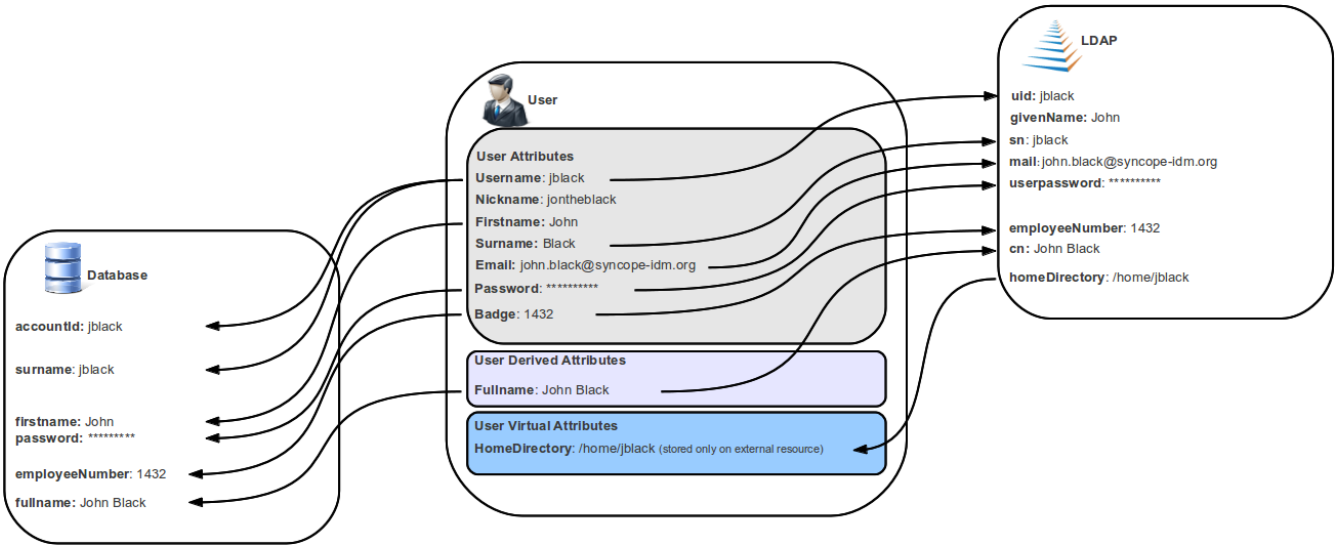



*Figure 5. Internal / External Mapping*

The default implementation can be sometimes tailored to meet the requirements of a specific deployment, as it is the crucial decision point for defining and enforcing the consistency and transformations between internal and external data.

### 2.2.4. Workflow

The Workflow layer is responsible for managing the internal lifecycle of Users, Groups and Any Objects.

Besides the default engine, another engine is available based on Flowable, the reference open source BPMN 2.0 implementation. It enables advanced features such as approval management and new statuses definitions; a web-based GUI editor, the Flowable Modeler, is also available.

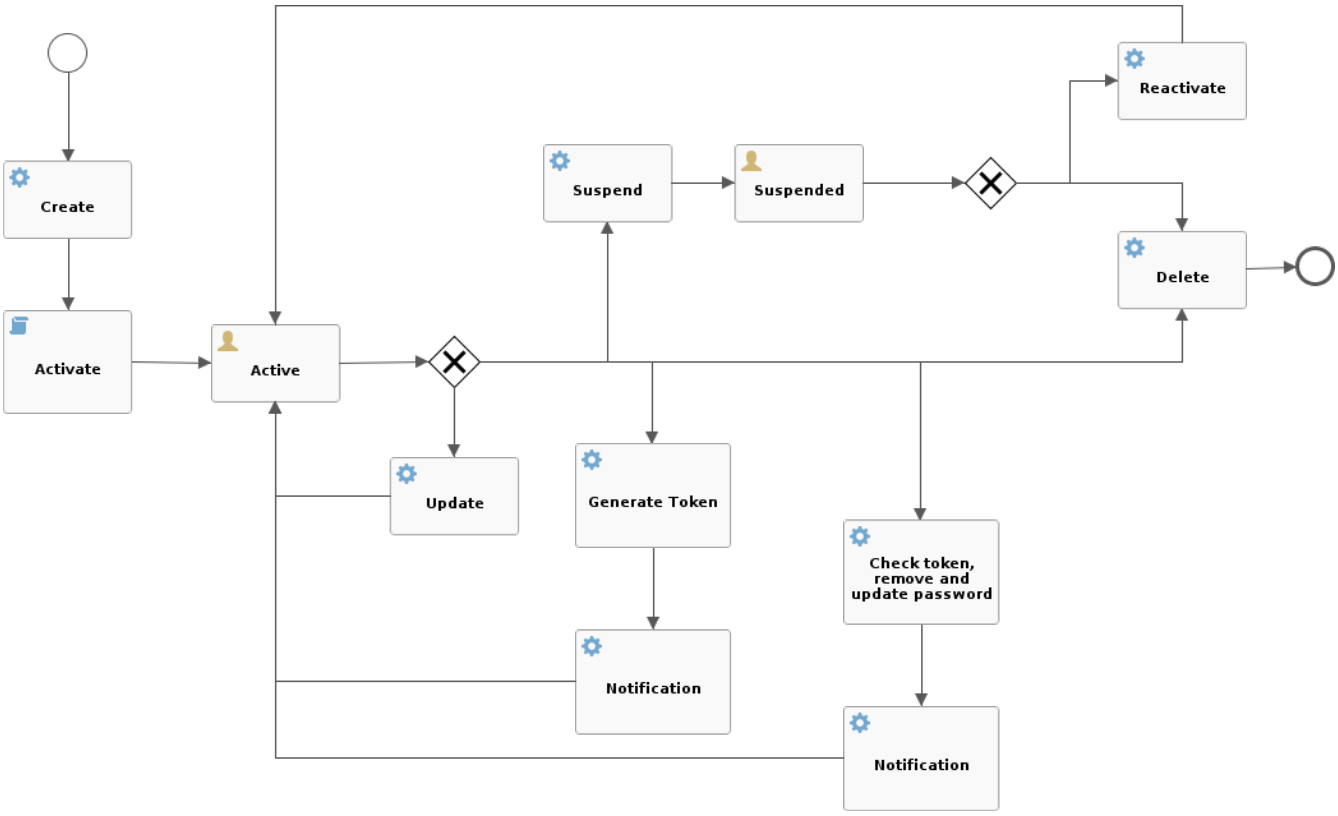



*Figure 6. Default Flowable user workflow*

Besides Flowable, new workflow engines - possibly integrating with third-party tools as Camunda or jBPM, can be written and plugged into specific deployments.

### 2.2.5. Persistence

All data (users, groups, attributes, resources, ...) is internally managed at a high level using a standard JPA 2.2 approach based on Apache OpenJPA. The data is persisted into an underlying database, referred to as ***Internal Storage***. Consistency is ensured via the comprehensive transaction management provided by the Spring Framework.

Globally, this offers the ability to easily scale up to a million entities and at the same time allows great portability with no code changes: MySQL, MariaDB, PostgreSQL, Oracle and MS SQL Server are fully supported deployment options.

Domains allow to manage data belonging to different tenants into separate database instances.

### 2.2.6. Security

Rather than being a separate layer, Security features are triggered throughout incoming request processing.

A fine-grained set of entitlements is defined which can be granted to administrators, thus enabling the implementation of delegated administration scenarios.

## 2.3. Web Access

The ***Web Access*** component is based on Apereo CAS.

In addition to all the configuration options and features from Apereo CAS, the Web Access is integrated with Keymaster, Core and Admin UI to offer centralized configuration and management.

## 2.4. Secure Remote Access

The ***Secure Remote Access*** component is built on Spring Cloud Gateway.

In addition to all the configuration options and features from Spring Cloud Gateway, the Secure Remote Access is integrated with Keymaster, Core and Admin UI to offer centralized configuration and management.

The Secure Remote Access allows to protect legacy applications by integrating with the Web Access or other third-party Access Managers implementing standard protocols as OpenID Connect or SAML.

## 2.5. Admin UI

The ***Admin UI*** is the web-based console for configuring and administering running deployments, with full support for delegated administration.

The communication between Admin UI and Core is exclusively REST-based.

More details are available in the dedicated usage section.

## 2.6. End-user UI

The ***End-user UI*** is the web-based application for self-registration, self-service and password reset.

The communication between End-user UI and Core is exclusively REST-based.

More details are available in the dedicated usage section.

## 2.7. Third Party Applications

Third-party applications are provided full access to IdM services by leveraging the REST interface, either via the Java Client Library (the basis of Admin UI and End-user UI) or plain HTTP calls.

# Chapter 3. Concepts

## 3.1. Users, Groups and Any Objects

Users, Groups and Any Objects are definitely the key entities to manage: as explained above in fact, the whole identity management concept is literally about managing identity data.

The following identities are supported:

- **Users** represent the virtual identities build up of account information fragmented across the associated external resources
- **Groups** have the dual purpose of representing entities on external resources supporting this concept (say LDAP or Active Directory) and putting together Users or Any Objects for implementing group-based provisioning, e.g. to dynamically associate Users or Any Objects to external resources
- **Any Objects** actually cover very different entities that can be modeled: printers, services, sensors, ...

For each of the identities above, Apache Syncope is capable of maintaining:

1. `name` (`username`, for Users) - string value uniquely identifying a specific user, group or any object instance;
2. `password` (Users only) - hashed or encrypted value, depending on the selected `password.cipher.algorithm` - see below for details - which can be used for authentication;
3. set of attributes, with each attribute being a `(key,values)` pair where
   - `key` is a string label (e.g. `surname`);
   - `values` is a (possibly singleton) collection of data (e.g. `[Doe]` but also `[john.doe@syncope.apache.org, jdoe@gmail.com]`) ; the type of values that can be assigned to each attribute is defined via the schema matching the `key` value (e.g. *plain*, *derived* and *virtual*);
4. associations with external resources, for provisioning.

*Which schemas can be populated for a given user / group / any object?*

Each user / group / any object will be able to hold values for all schemas:

1. defined in the Any Type classes associated to their Any Type;
2. defined in the Any Type classes configured as ***auxiliary*** for the specific instance.

Moreover, Users and Any Objects can be part of Groups, or associated to other any objects.

*Memberships and Relationships*

When an user or an any object is assigned to a group, a ***membership*** is defined; the (static) members of a group benefit from type extensions.

When an user or an any object is associated to another any object, a ***relationship*** is defined, of one of available relationship types.

*Static and Dynamic Memberships*

Users and Any Objects are *statically* assigned to Groups when memberships are explicitly set.

With group definition, however, a condition can be expressed so that all matching Users and Any Objects are *dynamic* members of the group.
Dynamic memberships have some limitations: for example, type extensions do not apply; group-based provisioning is still effective.

*Security Questions*

The password reset process can be strengthened by requesting users to provide their configured answer to a given security question, chosen among the ones defined.

# 3.2. Type Management

In order to manage which attributes can be owned by Users, Groups and any object, and which values can be provided, Apache Syncope defines a simple yet powerful type management system, vaguely inspired by the LDAP/X.500 information model.

## 3.2.1. Schema

A schema instance describes the values that attributes with that schema will hold; it can be defined plain, derived or virtual.

It is possible to define i18n labels for each schema, with purpose of improving presentation with Admin and End-user UIs.

**Plain**

Values for attributes with such schema types are provided during user, group or any object create / update.

When defining a plain schema, the following information must be provided:

- Type
  - `String`
  - `Long` - allows to specify a *conversion pattern* to / from string, according to DecimalFormat
  - `Double` - allows to specify a *conversion pattern* to / from string, according to DecimalFormat
  - `Boolean`
  - `Date` - allows to specify a *conversion pattern* to / from string, according to DateFormat
  - `Enum`

        - enumeration values (mandatory)
        - enumeration labels (optional, values will be used alternatively)
    - `Encrypted`
        - secret key (stored or referenced as Spring property)
        - cipher algorithm
        - whether transparent encryption is to be enabled, e.g. attribute values are stored as encrypted but available as cleartext on-demand (requires AES ciphering)
    - `Binary` - it is required to provide the declared mime type
- Validator class - (optional) Java class validating the value(s) provided for attributes, see EmailAddressValidator for reference
- Mandatory condition - JEXL expression indicating whether values for this schema must be necessarily provided or not; compared to simple boolean value, such condition allows to express complex statements like 'be mandatory only if this other attribute value is above 14', and so on
- Unique constraint - make sure that no duplicate value(s) for this schema are found
- Multivalue flag - whether single or multiple values are supported
- Read-only flag - whether value(s) for this schema are modifiable only via internal code (say workflow tasks) or can be instead provided during ordinary provisioning

**Derived**

Sometimes it is useful to obtain values as arbitrary combinations of other attributes' values: for example, with `firstname` and `surname` plain schemas, it is natural to think that `fullname` could be somehow defined as the concatenation of `firstname` 's and `surname` 's values, separated by a blank space.

Derived schemas are always read-only and require a JEXL expression to be specified that references plain schema types.
For the sample above, it would be

```
firstname + ' ' + surname
```

With derived attributes, values are not stored into the internal storage but calculated on request, by evaluating the related JEXL expression

**Virtual**

Virtual attributes are somehow linked from Identity Stores rather than stored internally.

The typical use case is when attribute values can change in the Identity Store without notice, and it is required to always have access to the most recent values that are available.

It can also be said that virtual schemas are for attributes whose ownership is not that of Syncope but of an Identity Store; the external resources for such Identity Stores are said to be the *linking*

*resources*.

As best practice, only attributes for which Apache Syncope retains ownership should be modeled as plain attributes; attributes for which Apache Syncope does not retain ownership should be modeled as virtual instead.

When defining a virtual schema, the following information must be provided:

- External resource - linking resource
- External attribute - attribute to be linked on the external resource
- Any Type - reference any type on the external resource
- Read-only flag - whether the external attribute value(s) for this schema can only be read, or whether they can be written to as well

### 3.2.2. AnyTypeClass

Any type classes are aggregations of plain, derived and virtual schemas, provided with unique identifiers.

Classes can be assigned to any types and are also available as auxiliary (hence to be specified on a given user / group / any object instance) and for type extensions.

### 3.2.3. AnyType

Any types represent the type of identities that Apache Syncope is able to manage; besides the predefined `USER` and `GROUP`, more types can be created to model workstations, printers, folders, sensors, services, ...

For all Any Types that are defined, a set of classes can be selected so that instances of a given Any Type will be enabled to populate attributes for schemas in those classes.

*Example 1. Any types and attributes allowed for Users, Groups and Any Objects*

Assuming that the following schemas are available:

1. plain: `firstname`, `surname`, `email`
2. derived: `fullname`
3. virtual: `enrollment`

and that the following Any Type classes are defined:

1. `minimal` - containing `firstname`, `surname` and `fullname`
2. `member` - containing `email` and `enrollment`

and that the `USER` Any Type has only `minimal` assigned, then the following Users are valid (details are simplified to increase readability):

```
{
  "key": "74cd8ece-715a-44a4-a736-e17b46c4e7e6",
  "type": "USER",
  "realm": "/",
  "username": "verdi",
  "plainAttrs": [
    {
      "schema": "surname",
      "values": [
        "Verdi"
      ]
    },
    {
      "schema": "firstname",
      "values": [
        "Giuseppe"
      ]
    }
  ],
  "derAttrs": [
    {
      "schema": "fullname",
      "values": [
        "Giuseppe Verdi"
      ]
    }
  ]
}

{
  "key": "1417acbe-cbf6-4277-9372-e75e04f97000",
  "type": "USER",
  "realm": "/",
  "username": "rossini",
  "auxClasses": [ "member" ],
  "plainAttrs": [
    {
      "schema": "surname",
      "values": [
        "Rossini"
      ]
    },
    {
      "schema": "firstname",
      "values": [
        "Gioacchino"
      ]
    },
    {
      "schema": "email",
```

```
      "values": [
        "gioacchino.rossini@syncope.apache.org"
      ]
    }
  ],
  "derAttrs": [
    {
      "schema": "fullname",
      "values": [
        "Gioacchino Rossini"
      ]
    }
  ],
  "virAttrs": [
    {
      "schema": "enrollment",
      "values": [
        "154322"
      ]
    }
  ]
}
```

### 3.2.4. RelationshipType

Relationships allow the creation of a link between a user and an any object, or between two Any Objects; relationship types define the available link types.

*Example 2. Relationship between Any Objects (printers)*

The following any object of type `PRINTER` contains a relationship of type `neighbourhood` with another `PRINTER` (details are simplified to increase readability):

```
{
  "key": "fc6dbc3a-6c07-4965-8781-921e7401a4a5",
  "type": "PRINTER",
  "realm": "/",
  "name": "HP LJ 1300n",
  "auxClasses": [],
  "plainAttrs": [
    {
      "schema": "model",
      "values": [
        "Canon MFC8030"
      ]
    },
    {
      "schema": "location",
      "values": [
```

```
        "1st floor"
      ]
    }
  ],
  "relationships": [
    {
      "type": "neighbourhood",
      "rightType": "PRINTER",
      "rightKey": "8559d14d-58c2-46eb-a2d4-a7d35161e8f8"
    }
  ]
}
```

### 3.2.5. Type Extensions

When a user (or an any object) is part of a group, a *membership* is defined.

It is sometimes useful to define attributes which are bound to a particular membership: if, for example, the `University A` and `University B` Groups are available, a student might have different e-mail addresses for each university. How can this be modeled?

Type extensions define a set of classes associated to a group, that can be automatically assigned to a given user (or any object) when becoming a member of such group.

*Example 3. Membership with type extension*

With reference to the sample above (details are simplified to increase readability):

```
{
  "key": "c9b2dec2-00a7-4855-97c0-d854842b4b24",
  "type": "USER",
  "realm": "/",
  "username": "bellini",
  "memberships": [
    {
      "type": "Membership",
      "rightType": "GROUP",
      "rightKey": "bf825fe1-7320-4a54-bd64-143b5c18ab97",
      "groupName": "University A",
      "plainAttrs": [
        {
          "schema": "email",
          "values": [
            "bellini@university_a.net"
          ]
        }
      ]
    },
    {
```

```
      "type": "Membership",
      "rightType": "GROUP",
      "rightKey": "bf825fe1-7320-4a54-bd64-143b5c18ab96",
      "groupName": "University B",
      "plainAttrs": [
        {
          "schema": "email",
          "values": [
            "bellini@university_b.net"
          ]
        }
      ]
    }
  ]
}
```

# 3.3. External Resources

**Connector Bundles**

The components able to connect to Identity Stores; not specifically bound to Apache Syncope, as they are part of the ConnId project.

**Connector Instances**

Instances of connector bundles, obtained by assigning values to the defined configuration properties. For instance, there is only a single `DatabaseTable` (the bundle) that can be instantiated several times, for example if there is a need to connect to different databases.

**External Resources**

Meant to encapsulate all information about how Apache Syncope will use connector instances for provisioning. For each entity supported by the related connector bundle (user, group, printer, services, ...), mapping information can be specified.

## 3.3.1. Connector Bundles

Several Connector Bundles come included with Apache Syncope:

- Active Directory
- Azure
- CSV Directory
- Database
- Google Apps
- LDAP
- Scripted REST

- ServiceNow
- SCIM
- SOAP

More Connector Bundles can be installed, if needed.

### 3.3.2. Connector Instance details

When defining a connector instance, the following information must be provided:

- administration realm - the Realm under which administrators need to own entitlements in order to be allowed to manage this connector and all related external resources
- connector bundle - one of the several already available, or some to be made from scratch, in order to fulfill specific requirements
- pooling information
- configuration - depending on the selected bundle, these are properties with configuration values: for example, with LDAP this means host, port, bind DN, object classes while with DBMS it would be JDBC URL, table name, etc.
- capabilities - define what operations are allowed on this connector: during provisioning, if a certain operation is invoked but the corresponding capability is not set on the related connector instance, no actual action is performed on the underlying connector; the capabilities are:
  - `AUTHENTICATE` - consent to pass-through authentication
  - `CREATE` - create objects on the underlying connector
  - `UPDATE` - update objects on the underlying connector
  - `DELETE` - delete objects on the underlying connector
  - `SEARCH` - search / read objects from the underlying connector; used during pull with `FULL RECONCILIATION` or `FILTERED RECONCILIATION` mode
  - `SYNC` - synchronize objects from the underlying connector; used during pull with `INCREMENTAL` mode

*Configuration and capability override*

Capabilities and individual configuration properties can be set for *override*: in this case, all the external resources using the given connector instance will have the chance to override some configuration values, or the capabilities set.

This can be useful when the same connector instance is shared among different resources, with little difference in the required configuration or capabilities.

### 3.3.3. External Resource details

Given a selected connector instance, the following information is required to define an external resource:

- priority - integer value, in use by the default propagation task executor

- propagation actions - which actions shall be executed during propagation
- trace levels - control how much tracing (including logs and execution details) shall be carried over during propagation, pull and push
- configuration - see above
- capabilities - see above
- account policy - which account policy to enforce on Users, Groups and Any Objects assigned to this external resource
- password policy - which password policy to enforce on Users, Groups and Any Objects assigned to this external resource
- pull policy - which pull policy to apply during pull on this external resource
- push policy - which push policy to apply during push on this external resource

### 3.3.4. Mapping

The mapping between internal and external data is of crucial importance when configuring an external resource. Such information, in fact, plays a key role for provisioning.

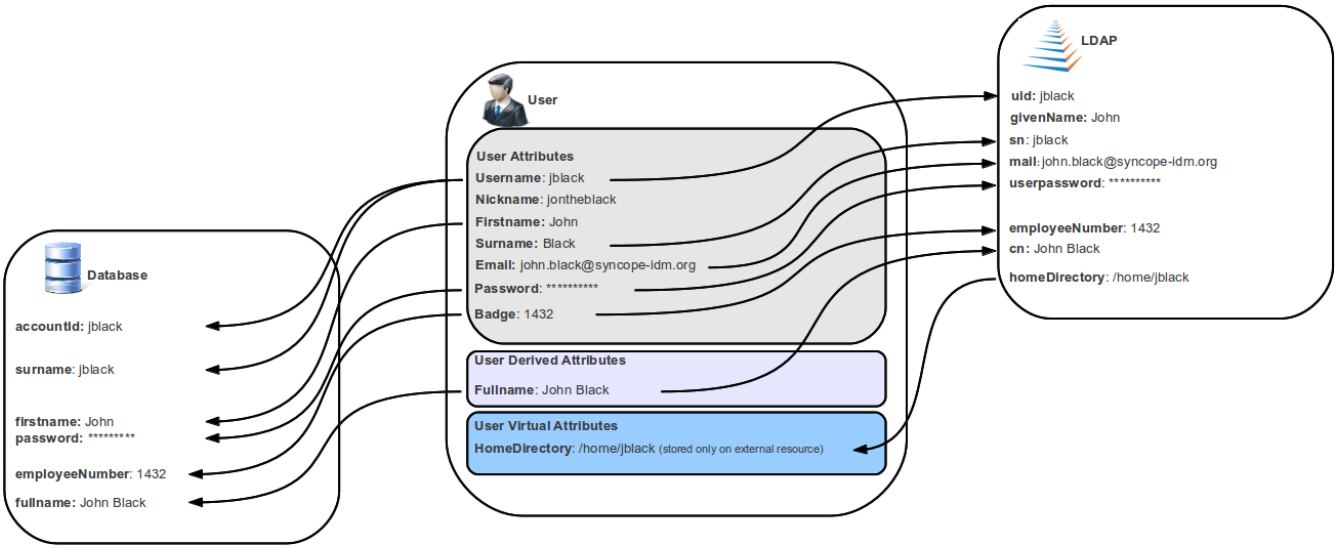



*Figure 7. Sample mapping*

For each of the any types supported by the underlying connector, a different mapping is provided.

A mapping is essentially a collection of *mapping items* describing the correspondence between an user / group / any object attribute and its counterpart on the Identity Store represented by the current external resource. Each item specifies:

- internal attribute - the schema acting as the source or destination of provisioning operations; it must be specified by an expression matching one of the following models:
  - `schema` - resolves to the attribute for the given `schema`, owned by the mapped entity (user, group, any object)
  - `groups[groupName].schema` - resolves to the attribute for the given `schema`, owned by the group with name `groupName`, if a membership for the mapped entity exists
  - `users[userName].schema` - resolves to the attribute for the given `schema`, owned by the user

with name `userName`, if a relationship with the mapped entity exists

- `anyObjects[anyObjectName].schema` - resolves to the attribute for the given `schema`, owned by the any object with name `anyObjectName`, if a relationship with the mapped entity exists
- `relationships[relationshipType][relationshipAnyType].schema` - resolves to the attribute for the given `schema`, owned by the any object of type `relationshipAnyType`, if a relationship of type `relationshipType` with the mapped entity exists
- `memberships[groupName].schema` - resolves to the attribute for the given `schema`, owned by the membership for group `groupName` of the mapped entity (user, any object), if such a membership exists
- `privileges[applicationKey]` - resolves to the list of privileges related to the given application, owned by the mapped entity (which can only be user, in this case)

- external attribute - the name of the attribute on the Identity Store
- transformers - JEXL expression or Java class implementing ItemTransformer ; the purpose is to transform values before they are sent to or received from the underlying connector
- mandatory condition - JEXL expression indicating whether values for this mapping item must be necessarily available or not; compared to a simple boolean value, such condition allows complex statements to be expressed such as 'be mandatory only if this other attribute value is above 14', and so on
- remote key flag - should this item be considered as the key value on the Identity Store, if no pull or push correlation rules are applicable?
- password flag (Users only) - should this item be treated as the password value?
- purpose - should this item be considered for propagation / push, pull, both or none?

Besides the items documented above, some more data needs to be specified for a complete mapping:

- which object class shall be used during communication with the Identity Store; predefined are `__ACCOUNT__` for Users and `__GROUP__` for Groups
- whether matches between user / group / any object's attribute values and their counterparts on the Identity Store should be performed in a case-sensitive fashion or not
- which schema shall be used to hold values for identifiers generated upon create by the Identity Store - required by some cloud providers not accepting provided values as unique references
- the model for generating the DN (distinguished name) values - only required by some connector bundles as LDAP and Active Directory

*Example 4. Mapping items*

The following mapping item binds the mandatory internal `name` schema with the external attribute `cn` for both propagation / push and pull.

```
{
  "key": "a2bf43c8-74cb-4250-92cf-fb8889409ac1",
  "intAttrName": "name",
```

```
  "extAttrName": "cn",
  "connObjectKey": true,
  "password": false,
  "mandatoryCondition": "true",
  "purpose": "BOTH"
}
```

The following mapping item binds the optional internal `aLong` schema for the membership of the `additional` group with the external attribute `age` for propagation / push only; in addition, it specifies a JEXL expression which appends `.0` to the selected `aLong` value before sending it out to the underlying connector.

```
{
  "key": "9dde8bd5-f158-499e-9d81-3d7fcf9ea1e8",
  "intAttrName": "memberships[additional].aLong",
  "extAttrName": "age",
  "connObjectKey": false,
  "password": false,
  "mandatoryCondition": "false",
  "purpose": "PROPAGATION",
  "propagationJEXLTransformer": "value + '.0'"
}
```

*Object link and Realms hierarchy*

When Object link is applicable - typically with LDAP or Active Directory, as said - the need may arise to map the Realms hierarchy into nested structures, as Organizational Units.

In such cases, the following JEXL expressions can be set for Object link (assuming `o=isp` is the root suffix), for example, which leverage the `syncope:fullPath2Dn()` custom JEXL function:

- Realms: `syncope:fullPath2Dn(fullPath, 'ou') + ',o=isp'`
- Users: `'uid=' + name + syncope:fullPath2Dn(realm, 'ou', ',') + ',o=isp'`
- Groups: `'cn=' + name + syncope:fullPath2Dn(realm, 'ou', ',') + ',o=isp'`

### 3.3.5. Linked Accounts

Sometimes the information provided by the mapping is not enough to define a one-to-one correspondence between Users / Groups / Any Objects and objects on External Resources.

There can be many reasons for this situation, including existence of so-called *service accounts* (typical with LDAP or Active Directory), or simply the uncomfortable reality that system integrators keep encountering when legacy systems are to be enrolled into a brand new IAM system.

Users can have, on a given External Resource with `USER` mapping defined:

1. zero or one *mapped account*
   if the External Resource is assigned either directly or via Group membership.
2. zero or more *linked accounts*
   as internal representation of objects on the External Resource, defined in terms of username, password and / or plain attribute values override, with reference to the owning User.

Linked Accounts are propagated alongside with owning User - following the existing push correation rule if available - and pulled according to the given pull correation rule, if present.

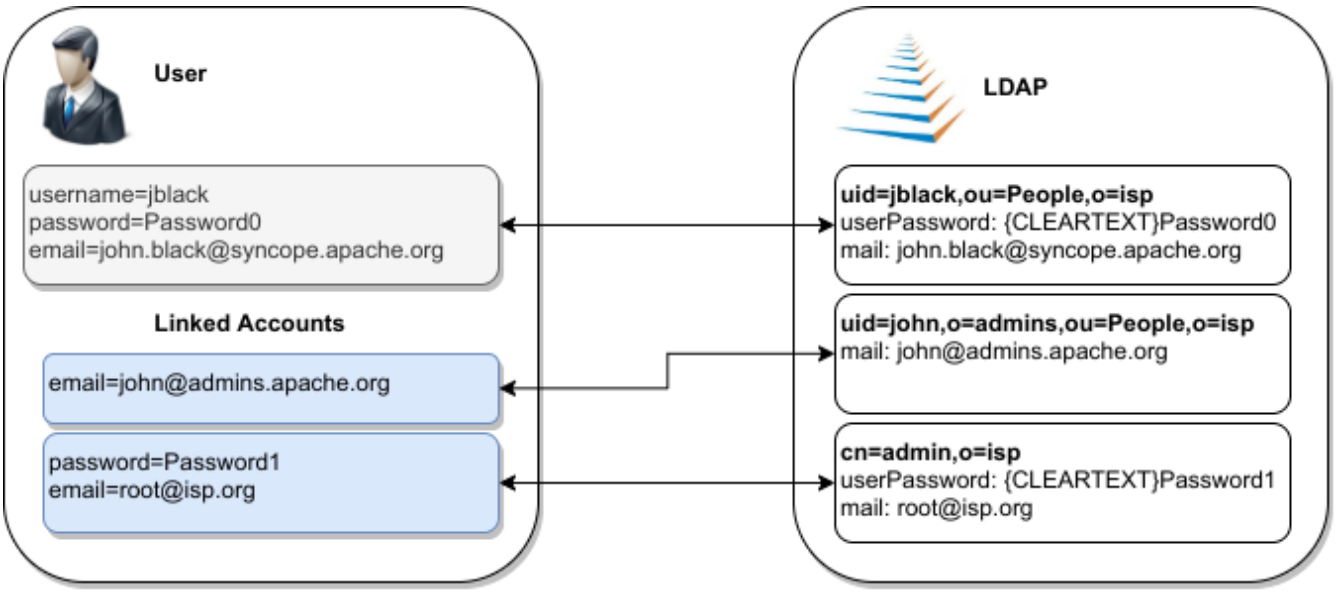



*Figure 8. Linked Accounts*

## 3.4. Realms

Realms define a hierarchical security domain tree, primarily meant for containing Users, Groups and Any Objects.

Each realm:

1. has a unique name and a parent realm - except for the pre-defined *root realm*, which is named `/`;
2. is either a leaf or root of a sub-tree of realms;
3. is uniquely identified by the path from the root realm, e.g. `/a/b/c` identifies the sub-realm `c` in the sub-tree rooted at `b`, having in turn `a` as parent realm, directly under the root realm;
4. optionally refers to account and password policies: such policies are enforced on all Users, Groups and Any Objects in the given realm and sub-realms, unless some sub-realms define their own policies.

If Users, Groups and Any Objects are members of a realm then they are also members of the parent realm: as a result, the root realm contains everything, and other realms can be seen as containers that split up the total number of entities into smaller pools.

This partition allows fine-grained control over policy enforcement and, alongside with entitlements and roles, helps to implement delegated administration.

**Dynamic Realms**

Realms provide a means to model static containment hierarchies.
This might not be the ideal fit for situations where the set of Users, Groups and Any Objects to administer cannot be statically defined by containment.

Dynamic Realms can be used to identify Users, Groups and Any Objects according to some attributes' value, resource assignment, group membership or any other condition available, with purpose of granting delegated administration rights.

*Logic Templates*

As with pull it is also possible to add templates to a realm.

The values specified in the template are applied to entities belonging to that realm, hence this can be used as a mechanism for setting default values for attributes or external resources on entities.

Logic Templates apply to all operations passing through the logic layer, e.g. triggered by REST requests.

### 3.4.1. Realm Provisioning

Provisioning can be enabled for realms: mapping information can be provided so that realms are considered during propagation, pull and push execution.

A typical use case for realm provisioning is to model an organization-like structure on Identity Stores, as with LDAP and Active Directory.

### 3.4.2. LogicActions

When Users, Groups or Any Objects get created, updated or deleted in a realm, custom logic can be invoked by associating the given Realm with one or more implementations of the LogicActions interface.

LogicActions apply to all operations passing through the logic layer, e.g. triggered by REST requests.

## 3.5. Entitlements

Entitlements are basically strings describing the right to perform an operation on Syncope.

The components in the logic layer are annotated with Spring Security to implement declarative security; in the following code snippet taken from RealmLogic , the `hasRole` expression is used together with one of the standard entitlements to restrict access only to Users owning the `REALM_SEARCH` entitlement.

```
@PreAuthorize("hasRole('" + IdRepoEntitlement.REALM_SEARCH + "')")
public List<RealmTO> list(final String fullPath) {
```

Entitlements are granted via roles to Users, scoped under certain realms, thus allowing delegated administration.

The set of available entitlements is statically defined - even though extensions have the ability to enlarge the initial list : this is because entitlements are the pillars of the internal security model and are not meant for external usage.

If you need to model the rights that Users own on external applications, look at privileges, instead.

## 3.6. Privileges

Privileges model the rights that Users own on external applications.

Privileges are granted via roles to Users.

The typical use case for privileges is to use Syncope as registry for available applications and privileges that users can own on those; once done this, external tools can query Syncope about the privileges owned by given users.

## 3.7. Roles

Roles map a set of entitlements to a set of realms and / or dynamic realms.

In addition, Roles can be used to assign privileges to Users.

*Static and Dynamic Memberships*

Users are *statically* assigned to roles when assignments are explicitly set.

However, a condition can be expressed in the role definition so that all matching Users are *dynamic* members of the role.

### 3.7.1. Delegated Administration

The idea is that any user U assigned to a role R, which provides entitlements $E_1$...$E_n$ for realms $Re_1$...$Re_m$, can exercise $E_i$ on entities (Users, Groups, Any Objects of given types - depending on $E_i$ - or Connector Instances and External Resources) under any $Re_j$ or related sub-realms.

Moreover, any user U assigned to a role R, which provides entitlements $E_1$...$E_n$ for dynamic realms $DR_1$..$DR_n$, can exercise $E_i$ on entities (Users, Groups, Any Objects of given types, depending on $E_i$) matching the conditions defined for any $DR_k$.

*Dynamic Realms limitations*

Users to whom administration rights were granted via Dynamic Realms can only **update** Users, Groups and Any Objects, not create nor delete.
Moreover, the only accepted changes on a given entity are the ones that do not change any Dynamic Realm's matching condition for such entity.

*Example 5. Authorization*

Let's suppose that we want to implement the following scenario:

> Administrator A can create Users under realm $R_5$ but not under realm $R_7$, administrator B can update users under realm $R_6$ and $R_8$, administrator C can update Groups under realm $R_8$.

As by default, Apache Syncope will have defined the following entitlements, among others:

- `USER_CREATE`
- `USER_UPDATE`
- `GROUP_UPDATE`

Hence, here is how entitlements should be assigned (via roles) to administrators in order to implement the scenario above:

- Administrator A: `USER_CREATE` on $R_5$
- Administrator B: `USER_UPDATE` on $R_6$ and $R_8$
- Administrator C: `GROUP_UPDATE` on $R_8$

*Delegated Administration via Admin Console*

When administering via REST, the entitlements to be granted to delegated administrators are straightforward: `USER_CREATE` for certain Realms will allow to create users under such Realms.

When using the Admin Console, instead, more entitlements are generally required: this because the underlying implementation takes care of simplifying the UX as much as possible.
For example, the following entitlements are normally required to be granted for user administration, besides the actual `USER_CREATE`, `USER_UPDATE` and `USER_DELETE`:

1. `USER_SEARCH`
2. `ANYTYPECLASS_READ`
3. `ANYTYPE_LIST`
4. `ANYTYPECLASS_LIST`
5. `RELATIONSHIPTYPE_LIST`
6. `USER_READ`

7. `ANYTYPE_READ`
8. `REALM_SEARCH`
9. `GROUP_SEARCH`

**Group Ownership**

Groups can designate a User or another Group as *owner*.

The practical consequence of this setting is that Users owning a Group (either because they are directly set as owners or members of the owning Group) is that they are entitled to

- perform all operations (create, update, delete, …) on the owned Group
- perform all operations (create, update, delete, …) on all User and Any Object members of the owner Group, with exception of removing members from the Group itself

regardless of the Realm.

The actual Entitlements are assigned through the predefined `GROUP_OWNER` Role:

1. `USER_SEARCH`
2. `USER_READ`
3. `USER_CREATE`
4. `USER_UPDATE`
5. `USER_DELETE`
6. `ANYTYPECLASS_READ`
7. `ANYTYPE_LIST`
8. `ANYTYPECLASS_LIST`
9. `RELATIONSHIPTYPE_LIST`
10. `ANYTYPE_READ`
11. `REALM_SEARCH`
12. `GROUP_SEARCH`
13. `GROUP_READ`
14. `GROUP_UPDATE`
15. `GROUP_DELETE`

The `GROUP_OWNER` Role can be updated to adjust the set of assigned Entitlements.

### 3.7.2. Delegation

With Delegation, any user can delegate other users to perform operations on their behalf.

In order to set up a Delegation, the following information shall be provided:

- delegating User (mandatory) - administrators granted with `DELEGATION_CREATE` Entitlement can create Delegations for all defined Users; otherwise, the only accepted value is the User itself;
- delegated User (mandatory) - any User defined, distinct from delegating;
- start (mandatory) - initial timestamp from which the Delegation is considered effective;
- end (optional) - final timestamp after which the Delegation is not considered effective: when not provided, Delegation will remain valid unless deleted;
- roles (optional) - set of Roles granted by delegating to delegated User: only Roles owned by delegating can be granted, when not provided all owned Roles are considered as part of the Delegation.

Audit events generated when operating under Delegation will report both delegating and delegated users.

# 3.8. Provisioning

As described above, provisioning is actually *the* core feature provided by Apache Syncope.

Essentially, it can be seen as the process of keeping the identity data synchronized between Syncope and related external resources, according to the specifications provided by the mapping. It does this by performing create, update and delete operations onto the internal storage or external resources via connectors.

## 3.8.1. Overview

The picture below contains an expanded view of the core architecture, with particular reference to the components involved in the provisioning process.

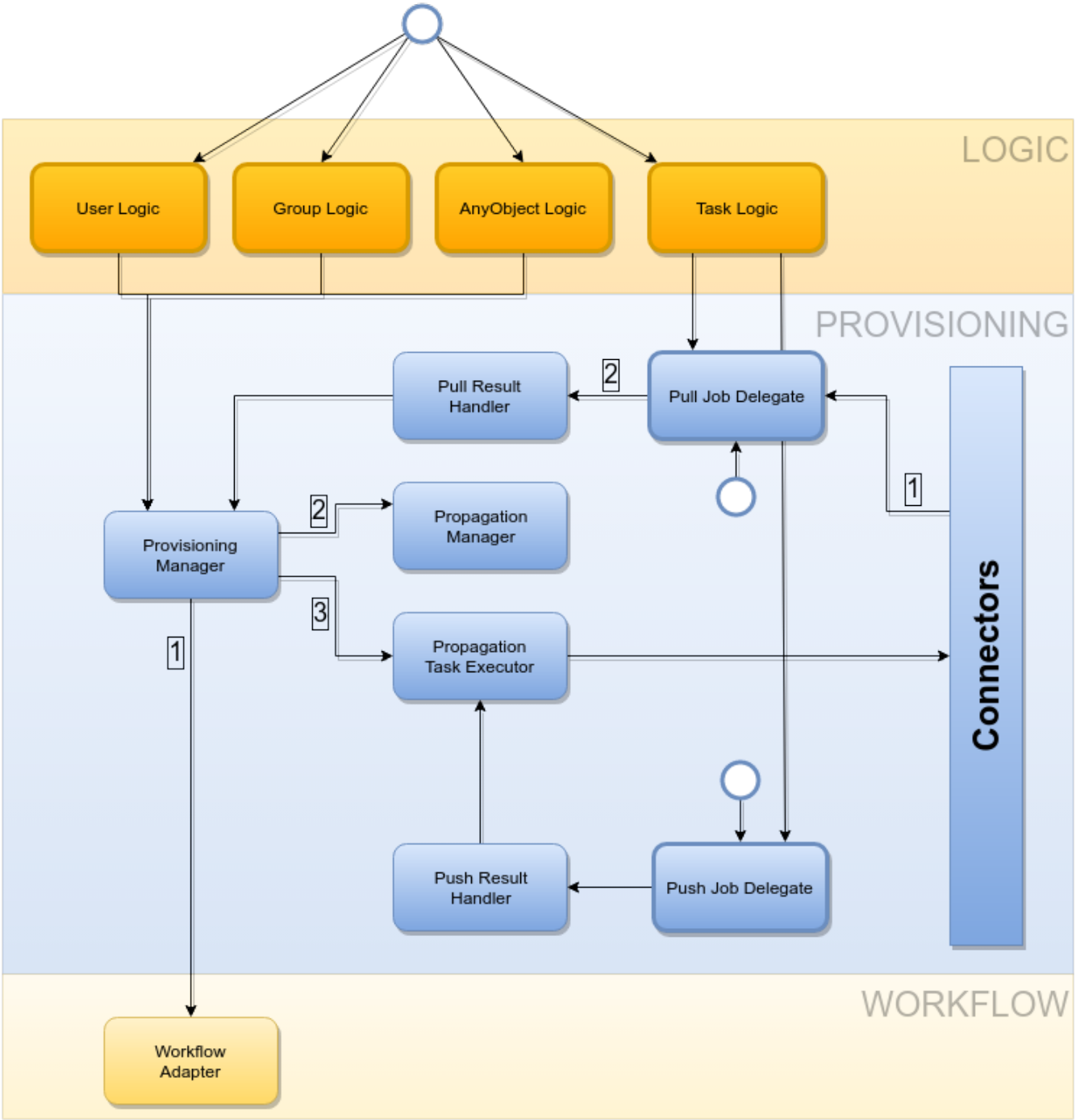



*Figure 9. Provisioning flow*

The provisioning operations can be initiated in several different ways:

- by creating, updating or deleting Users, Groups or Any Objects via REST (thus involving the underlying logic layer)
- by requesting execution of pull or push tasks via REST
- by triggering periodic pull or push task executions

*Provisioning Managers*

The provisioning operations are defined by the provisioning manager interfaces:

- UserProvisioningManager
- GroupProvisioningManager

- AnyObjectProvisioningManager

Default implementations are available:

- DefaultUserProvisioningManager
- DefaultGroupProvisioningManager
- DefaultAnyObjectProvisioningManager

### 3.8.2. Propagation

Whenever a change is performed via REST on Users, Groups or Any Objects:

1. a set of propagation tasks is generated, one for each associated external resource;
2. the generated propagation tasks are executed, e.g. the corresponding operations (create, update or delete) are sent out, via connectors, to the configured Identity Stores; the tasks can be saved for later re-execution.

*Which external resources?*

Depending on the entity being created / updated / deleted, different external resources are taken into account by the propagation process:

- **Group**: only the external resources directly assigned
- **User**: the external resources directly assigned plus the ones assigned to Groups configured for the User
- **Any Object**: the external resources directly assigned plus the ones assigned to Groups configured for the Any Object

*Adequate capabilities to Connectors and External Resources*

Ensure to provide an adequate set of capabilities to underlying Connectors and External Resources for the actual operations to perform, otherwise the Propagation Tasks will report `NOT_ATTEMPTED` as execution status.

*Propagate password values*

Password values are kept in the internal storage according to the `password.cipher.algorithm` configuration parameter, whose value is `SHA1` by default. `SHA1` is a hash algorithm: this means that, once stored, the cleartext value cannot be reverted any more.

During propagation, Syncope fetches all data of the given User, then prepares the attributes to propagate, according to the provided mapping; password has a special treatment:

- if cleartext value is available (this cannot happen during Push), it is sent to the External Resource
- if `password.cipher.algorithm` is `AES` (the only supported reversible algorithm),

then the ciphered password value is made cleartext again, and sent to the External Resource

- if the `GenerateRandomPasswordPropagationActions` is enabled, a random password value is generated according to the defined password policy and sent to the External Resource
- otherwise, a `null` value is sent to the External Resource

Password values are always sent to External Resources wrapped as ConnId GuardedString objects.

By default, the propagation process is controlled by the PriorityPropagationTaskExecutor, which implements the following logic:

- sort the tasks according to the related resource's *priority*, then execute sequentially
- tasks for resources with no priority are executed afterwards, concurrently
- the execution of a given set of tasks is halted (and global failure is reported) whenever the first sequential task fails
- status and eventual error message (in case of no resource priority) can be saved for reporting, in the case where the related external resource was configured with adequate tracing
- minimize the set of operations to be actually performed onto the Identity Store by attempting to read the external object corresponding to the internal entity and comparing with the modifications provided

*Create or update?*

The minimization performed by `PriorityPropagationTaskExecutor` might lead to behaviors which look at first unexpected, but sound perfectly understandable once explained; in particular:

- a `CREATE` propagation task might result in an effective `UPDATE` sent to the Connector
  if preliminary read returns an external object matching the same remote key of the object requested to be created
- an `UPDATE` propagation task might result in an effective `CREATE` sent to the Connector
  if preliminary read does not find any external object matching the remote key of the objected requested to be updated

Different implementations of the PropagationTaskExecutor interface can be provided, in case the required behavior does not fit into the provided implementation.

#### PropagationActions

The propagation process can be decorated with custom logic to be invoked around task execution, by associating external resources to one or more implementations of the PropagationActions interface.

Some examples are included by default, see table below.

| | |
|---|---|
| AzurePropagationActions | Required for setup of an External Resource based on the ConnId Azure connector bundle. |
| DBPasswordPropagationActions | If no password value was already provided in the propagation task, sends out the internal password hash value to DBMS; the cipher algorithm associated with the password must match the value of `Password cipher algorithm` for the ConnId DatabaseTable connector bundle. |
| GenerateRandomPasswordPropagationActions | If no password value was already provided in the propagation task, random password value is generated according to the defined password policy and sent to the External Resource. |
| GoogleAppsPropagationActions | Required for setup of an External Resource based on the ConnId GoogleApps connector bundle. |
| LDAPMembershipPropagationActions | If a User is associated with a Group in Syncope, keep the corresponding User as a member of the corresponding Group in LDAP or AD. |
| LDAPPasswordPropagationActions | If no password value was already provided in the propagation task, sends out the internal password hash value to LDAP; the cipher algorithm associated with the password must match the value of `passwordHashAlgorithm` for the LDAP connector bundle. |

### 3.8.3. Pull

Pull is the mechanism used to acquire identity data from Identity Stores; for each external resource, one or more pull tasks can be defined, run and scheduled for period execution.

Pull task execution involves querying the external resource for all mapped any types, sorted according to the order defined by a custom implementation of ProvisionSorter or its default implementation DefaultProvisionSorter .

Each entity is then processed in an isolated transaction; a retrieved entity can be:

1. *matching* if a corresponding internal entity was found, according to the mapping of - or the pull policy set for, if present - the enclosing external resource;
2. *unmatching* otherwise.

Once this has been assessed, entities are processed according to the matching / unmatching rules specified for the pull task: by default, unmatching entities get created internally, and matching entities are updated.

**Matching Rules**

- `IGNORE`: do not perform any action;
- `UPDATE`: update matching entity;

- `DEPROVISION`: delete external entity;
- `UNLINK`: remove association with external resource, without performing any (de-)provisioning operation;
- `LINK`: associate with external resource, without performing any (de-)provisioning operation;
- `UNASSIGN`: unlink and delete.

### Unmatching Rules

- `IGNORE`: do not perform any action;
- `UNLINK`: do not perform any action;
- `ASSIGN`: create internally, assign the external resource;
- `PROVISION`: create internally, do not assign the external resource.

*Pull Mode*

The Identity Store can be queried in different ways, depending on the *pull mode* that is specified:

**FULL RECONCILIATION**

The complete list of entities available is processed.

**FILTERED RECONCILIATION**

The subset matching the filter (provided by the selected implementation of ReconFilterBuilder) of all available entities is processed.

**INCREMENTAL**

Only the actual modifications performed since the last pull task execution are considered. This mode requires the underlying connector bundle to implement the ConnId `SYNC` operation - only some of the available bundles match this condition.
**This is the only mode which allows pulling delete events**, which may end up causing the removal of internal entities.

*Pull Templates*

With every pull task it is possible to add a template for each defined any type.

As the values specified in the template are applied to pulled entities, this can be used as mechanism for setting default values for attributes or external resources on entities.

A typical use case is, when pulling Users from the external resource `R`, to automatically assign `R` so that every further modification in Apache Syncope to

> such Users will be propagated back to R.

**PullActions**

The pull process can be decorated with custom logic to be invoked around task execution, by associating pull tasks to one or more implementations of the PullActions interface.

Some examples are included by default, see the table below.

| | |
|---|---|
| ADMembershipPullActions | If a User is associated with a Group in AD, keep the corresponding User as a member of the corresponding Group in Syncope. |
| LDAPMembershipPullActions | If a User is associated with a Group in LDAP, keep the corresponding User as a member of the corresponding Group in Syncope. |
| LDAPPasswordPullActions | Import hashed password values from LDAP; the cipher algorithm associated with the password must match the value of `passwordHashAlgorithm` for the LDAP connector bundle. |
| DBPasswordPullActions | Import hashed password values from DBMS; the cipher algorithm associated with the password must match the value of `Password cipher algorithm` for the DatabaseTable connector bundle. |

**Remediation**

Errors during pull might arise for various reasons: values might not be provided for all mandatory attributes or fail the configured validation, delete User as consequence of an incremental change's processing might be blocked because such User is configured as Group owner, and so on.

When Remediation is enabled for a certain Pull Task, execution errors are reported to administrators, which are given the chance to examine and possibly fix, or just discard.

### 3.8.4. Push

With push, the matching set of internal entities can be sent to Identity Stores - mainly for (re)initialization purposes; for each external resource, one or more push tasks can be defined, run and scheduled for period execution.

Push task execution involves querying the internal storage for all mapped any types, sorted according to the order defined by a custom implementation of ProvisionSorter or its default implementation DefaultProvisionSorter .

Each entity is then processed in an isolated transaction; an internal entity can be:

1. *matching* if a corresponding remote entity was found, according to the push policy set for the enclosing external resource;
2. *unmatching* otherwise.

Once this has been assessed, entities are processed according to the matching / unmatching rules specified for the push task: by default, unmatching entities are pushed to Identity Stores, and matching entities are updated.

**Matching Rules**

- `IGNORE`: do not perform any action;
- `UPDATE`: update matching entity;
- `DEPROVISION`: delete internal entity;
- `UNLINK`: remove association with external resource, without performing any (de-)provisioning operation;
- `LINK`: associate with external resource, without performing any (de-)provisioning operation;
- `UNASSIGN`: unlink and delete.

**Unmatching Rules**

- `IGNORE`: do not perform any action;
- `UNLINK`: remove association with external resource, without performing any (de-)provisioning operation;
- `ASSIGN`: create externally, assign the external resource;
- `PROVISION`: create externally, do not assign the external resource.

**PushActions**

The push process can be decorated with custom logic to be invoked around task execution, by associating push tasks to one or more implementations of the PushActions interface.

### 3.8.5. Password Reset

When users lost their password, a feature is available to help gaining back access to Apache Syncope: password reset.

The process can be outlined as follows:

1. user asks for password reset, typically via end-user
2. user is asked to provide an answer to the security question that was selected during self-registration or self-update
3. if the expected answer is provided, a unique token with time-constrained validity is internally generated and an e-mail is sent to the configured address for the user with a link - again, typically to the end-user - containing such token value
4. user clicks on the received link and provides new password value, typically via end-user

5. user receives confirmation via e-mail

The outlined procedure requires a working e-mail configuration.

In particular:

- the first e-mail is generated from the `requestPasswordReset` notification template: hence, the token-based access link to the end-user is managed there;
- the second e-mail is generated from the `confirmPasswordReset` notification template.

The process above requires the availability of security questions that users can pick up and provide answers for.

The usage of security questions can be however disabled by setting the `passwordReset.securityQuestion` value - see below for details.

Once provided via Enduser Application, the answers to security questions are **never** reported, neither via REST or Admin UI to administrators, nor to end-users via Enduser Application.

This to avoid any information disclosure which can potentially lead attackers to reset other users' passwords.

In addition to the password reset feature, administrators can set a flag on a given user so that he / she is forced to update their password value at next login.

## 3.9. Policies

Policies control different aspects. They can be used to fine-tune and adapt the overall mechanisms to the particularities of the specific domain in which a given Apache Syncope deployment is running.

*Policy Composition*

When defining policies and associating them with different realms and resources, it is common to observe that several policies of the same type have to be enforced on the same user, group or any object.

In such cases, Apache Syncope transparently composes all of the candidate policies and obtains a single applicable policy which contains all the conditions of the composing policies; this process, however, is not guaranteed to be successful, as different policies of the same type might provide conflicting clauses.

### 3.9.1. Account

Account policies allow the imposition of constraints on username values, and are involved in the authentication process.

When set for realm R, an account policy is enforced on all Users of R and sub-realms.

When set for resource R, an account policy is enforced on all Users that have R assigned.

When defining an account policy, the following information must be provided:

- max authentication attempts - how many times Users are allowed to fail authentication before getting suspended
- propagate suspension - when suspended as a consequence of too many authentication failures, should Users also be suspended on associated resources or not?
- pass-through resources - which external resources are involved with pass-through authentication
- rules - set of account rules to evaluate with the current policy

### Account Rules

Account rules define constraints to apply to username values.

Some implementations are provided out-of-the-box, custom ones can be provided on given deployment.

As `JAVA` implementation, writing custom account rules means:

1. providing configuration parameters in an implementation of AccountRuleConf
2. enforcing in an implementation of AccountRule annotated via @AccountRuleConfClass referring to the configuration class.

As `GROOVY` implementation, writing custom account rules means implementing AccountRule

#### Default Account Rule

The default account rule (enforced by DefaultAccountRule and configurable via DefaultAccountRuleConf ) contains the following controls:

- maximum length - the maximum length to allow; `0` means no limit set;
- minimum length - the minimum length to allow; `0` means no limit set;
- pattern - Java regular expression pattern to match; `NULL` means no match is attempted;
- all uppercase - are lowercase characters allowed?
- all lowercase - are uppercase characters allowed?
- words not permitted - list of words that cannot be present, even as a substring;
- schemas not permitted - list of schemas whose values cannot be present, even as a substring;
- prefixes not permitted - list of strings that cannot be present as a prefix;

- suffixes not permitted - list of strings that cannot be present as a suffix.

Before being able to configure the default account rule as mentioned above, you will need to first create a `JAVA` `ACCOUNT_RULE` implementation for the `org.apache.syncope.common.lib.policy.DefaultAccountRuleConf` class.

**Pass-through Authentication**

During user authentication, if the resulting applicable account policy defines pass-through resources, the provided credentials are verified first against the internal storage, then against each configured external resource (provided that the underlying connector instance has the `AUTHENTICATE` capability set): the first check that succeeds will successfully authenticate the user.

This feature allows, for example, to reuse credentials contained in Identity Stores (without extracting them), instead of storing password values in the internal storage. It also facilitates implementing authentication chains.

### 3.9.2. Password

Password policies allow the imposition of constraints on password values.

When set for realm R, a password policy is enforced on all Users of R and sub-realms.

When set for resource R, a password policy is enforced on all Users that have R assigned.

When defining a password policy, the following information must be provided:

- allow null password - whether a password is mandatory for Users or not
- history length - how many values shall be considered in the history
- rules - set of password rules to evaluate with the current policy

**Password Rules**

Password rules define constraints to apply to password values.

Some implementations are provided out-of-the-box, custom ones can be provided on given deployment.

As `JAVA` implementation, writing custom password rules means:

1. providing configuration parameters in an implementation of PasswordRuleConf
2. enforcing in an implementation of PasswordRule annotated via @PasswordRuleConfClass referring to the configuration class.

As `GROOVY` implementation, writing custom account rules means implementing

PasswordRule

#### Default Password Rule

The default password rule (enforced by DefaultPasswordRule and configurable via DefaultPasswordRuleConf ) is based on Passay and contains the following controls:

- maximum length - the maximum length to allow (`0` means no limit set);
- minimum length - the minimum length to allow (`0` means no limit set);
- alphabetical - the number of alphabetical characters required;
- uppercase - the number of uppercase characters required;
- lowercase - the number of lowercase characters required;
- digit - the number of digits required;
- special - the number of special characters required;
- special chars - the set of special characters allowed;
- illegal chars - the set of characters not allowed;
- repeat same - the size of the longest sequence of repeating characters allowed;
- username allowed - whether a username value can be used;
- words not permitted - list of words that cannot be present, even as a substring;
- schemas not permitted - list of schemas whose values cannot be present, even as a substring;

The default password rule can be extended to cover specific needs, relying on the whole set of features provided by Passay.

Before being able to configure the default password rule as mentioned above, you will need to first create a `JAVA PASSWORD_RULE` implementation for the `org.apache.syncope.common.lib.policy.DefaultPasswordRuleConf` class.

#### "Have I Been Pwned?" Password Rule

This password rule (enforced by HaveIBeenPwnedPasswordRule and configurable via HaveIBeenPwnedPasswordRuleConf ) checks the provided password values against the popular "Have I Been Pwned?" service.

Before being able to configure the "Have I Been Pwned?" password rule as mentioned above, you will need to first create a `JAVA PASSWORD_RULE` implementation for the `org.apache.syncope.common.lib.policy.HaveIBeenPwnedPasswordRuleConf` class.

### 3.9.3. Access

Access policies provide fine-grained control over the access rules to apply to client applications.

The following access policy configurations are available by default:

| | |
|---|---|
| DefaultAccessPolicyConf | It describes whether the client application is allowed to use WA, allowed to participate in single sign-on authentication, etc; additionally, it may be configured to require a certain set of principal attributes that must exist before access can be granted. |
| HttpRequestAccessPolicyConf | Make access decisions based on HTTP request properties as client IP address and user-agent. |
| RemoteEndpointAccessPolicyConf | Delegate access decisions to a remote endpoint by receiving the authenticated principal as url parameter of a `GET` request; the response code that the endpoint returns is then compared against the policy setting and if a match is found, access is granted. |
| TimeBasedAccessPolicyConf | Access is only allowed within the configured timeframe. |

Access Policy instances are dynamically translated into CAS Service Access Strategy.

### 3.9.4. Attribute Release

Attribute Release policies decide how attributes are selected and provided to a given client application in the final WA response.
Additionally, each instance has the ability to apply an optional filter to weed out their attributes based on their values.

Attribute Release Policy instances are dynamically translated into CAS Attribute Release Policy.

### 3.9.5. Authentication

WA presents a number of strategies for handling authentication security policies, based on the defined authentication modules.
Authentication Policies in general control the following:

1. Should the authentication chain be stopped after a certain kind of authentication failure?
2. Given multiple authentication handlers in a chain, what constitutes a successful authentication event?

Authentication Policies are typically activated after:

1. An authentication failure has occurred.
2. The authentication chain has finished execution.

Typical use cases of authentication policies may include:

1. Enforce a specific authentication module's successful execution, for the entire authentication event to be considered successful.
2. Ensure a specific class of failure is not evident in the authentication chain's execution log.

3. Ensure that all authentication modules in the chain are executed successfully, for the entire authentication event to be considered successful.

Authentication Policy instances are dynamically translated into CAS Authentication Policy.

### 3.9.6. Propagation

Propagation policies are evaluated during the execution of propagation tasks and are meant to tweak the propagation process by setting the pre-fetch option or letting Syncope to retry the configured operations in case of failures.

When defining a propagation policy, the following information must be provided:

- fetch around provisioning - the default behavior is to attempt to read upfront the object being propagated (to ensure it exists or not, depending on the actual operation scheduled to perform) and to read it again afterwards (to check the effective results); this can be disabled
- update delta - in case of update, all object attributes are propagated by default; when enabled, only the changed attributes will be instead propagated
- max number of attempts
- back-off strategy
  - `FIXED` - pauses for a fixed period of time before continuing
  - `EXPONENTIAL` - increases the back off period for each retry attempt in a given set up to a limit
  - `RANDOM` - chooses a random multiple of the interval that would come from a simple deterministic exponential

### 3.9.7. Pull

Pull policies are evaluated during the execution of pull tasks and are meant to:

1. help match existing Users, Groups and Any Objects during pull, thus generating update events (rather than create)
2. determine which action shall be taken in case such match is not unique (e.g. what to do if the same external account can be mapped to two distinct Users in Apache Syncope?)

When set for resource R, a pull policy is enforced on all Users, Groups and Any Objects pulled from R.

When defining a pull policy, the following information must be provided:

- conflict resolution action
  - `IGNORE` - do nothing
  - `FIRSTMATCH` - pull first matching object only
  - `LASTMATCH` - pull last matching object only

    - `ALL` - pull all matching objects
- rules - set of correlation rules to evaluate with the current policy; for each defined any type, a different rule is required

**Pull Correlation Rules**

Pull correlation rules define how to match objects received from External Resources with existing Users (including Linked Accounts), Groups or Any Objects.

The default implementation attempts to match entities on the basis of the values of the provided plain attributes, according to the available mapping.

Custom pull correlation rules can be provided by implementing the PullCorrelationRule interface.

### 3.9.8. Push

Push policies are evaluated during the execution of push tasks.

When set for resource R, a push policy is enforced on all Users, Groups and Any Objects pushed to R.

**Push Correlation Rules**

Push correlation rules define how to match Users (including Linked Accounts), Groups or Any Objects with objects existing on External Resources.

The default implementation attempts to match entities on the basis of the values of the provided plain attributes, according to the available mapping.

Custom push correlation rules can be provided by implementing the PushCorrelationRule interface.

### 3.9.9. Ticket Expiration

Ticket Expiration policies control the duration of various types of WA sessions.

Ticket Expiration Policy instances are dynamically translated into their CAS equivalent.

## 3.10. Workflow

Workflow manages the internal identity lifecycle by defining statuses and transitions that every user, group or any object in Apache Syncope will traverse. A workflow instance is started once identities get created, and shut down when they are removed.

Workflow is triggered during the provisioning process as the first step in creating, updating or

deleting identities into the internal storage.

*Workflow Adapters*

The workflow features are defined by the workflow adapter interfaces:

- UserWorkflowAdapter
- GroupWorkflowAdapter
- AnyObjectWorkflowAdapter

Default implementations are available:

- DefaultUserWorkflowAdapter
- DefaultGroupWorkflowAdapter
- DefaultAnyObjectWorkflowAdapter

Custom adapters can be provided by implementing the related interfaces, also as bridges towards third-party tools as Camunda or jBPM.

*Which workflow adapter for users?*

1. Do you need approval management? Flowable
2. If approval management is not needed, do you want to customize the internal user processing, or attach custom logic to it? Provide a Java class with your customizations, extending DefaultUserWorkflowAdapter
3. No approval nor customizations needed? Stick with DefaultUserWorkflowAdapter

### 3.10.1. Flowable User Workflow Adapter

An advanced adapter is provided for Users, based on Flowable, one of reference open source BPMN 2.0 implementations.

The FlowableUserWorkflowAdapter is bootstrapped from userWorkflow.bpmn20.xml and presents several advantages and more features, if compared to the default user adapter:

1. Besides mandatory statuses, which are modeled as BPMN `userTask` instances, more can be freely added at runtime, provided that adequate transitions and conditions are also inserted; more details about available BPMN constructs are available in the Flowable User Guide.
   Additional statuses and transitions allow the internal processes of Apache Syncope to better adapt to suit organizational flows.
2. Custom logic can be injected into the workflow process by providing BPMN `serviceTask` instances.
3. Flowable forms are used for implementing approval.
4. The Flowable Modeler is available with the admin console, thus allowing web-based graphical modeling of the workflow definition.

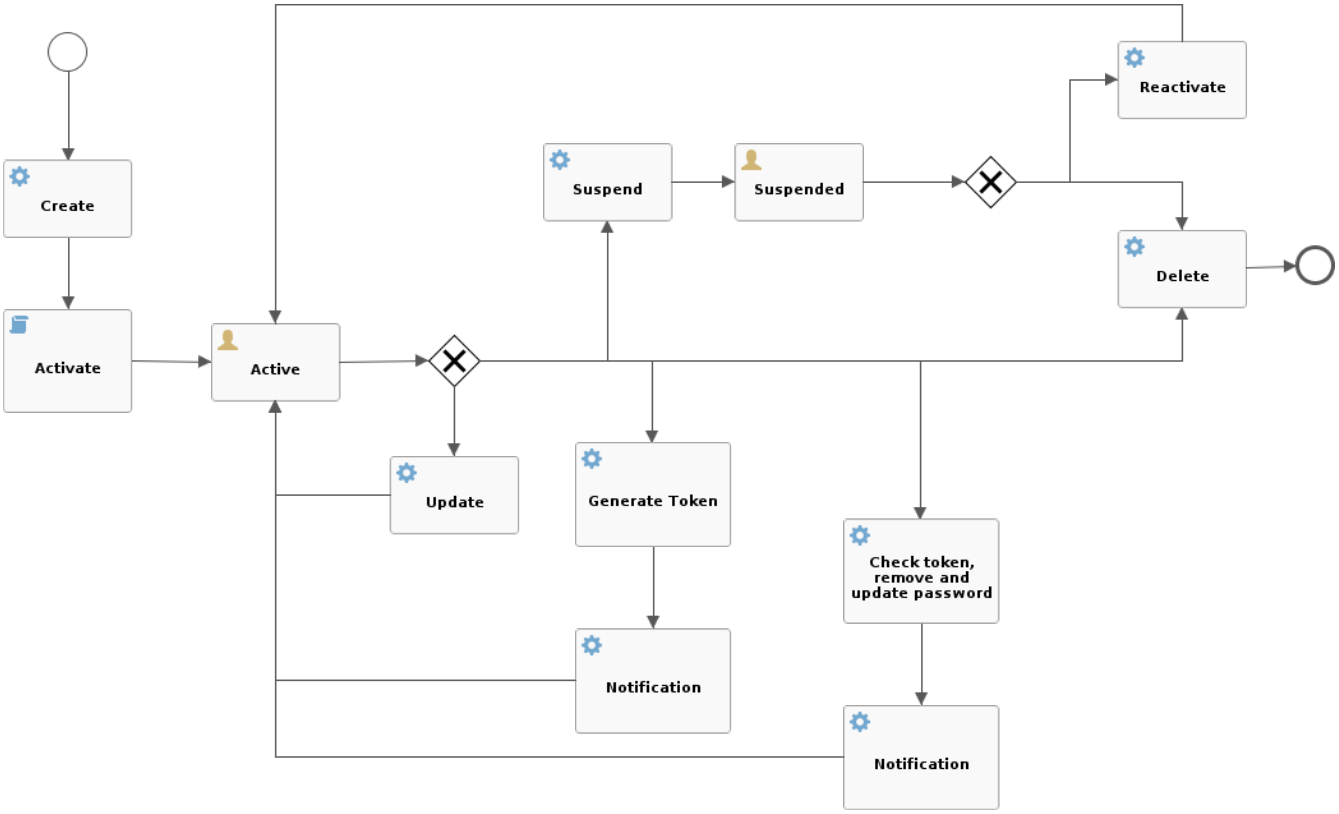



*Figure 10. Default Flowable user workflow*

### Approval

Every transition in the Flowable user workflow definition can be subjected to approval.

The underlying idea is that some kind of self-modifications (group memberships, external resource assignments, ...) might not be allowed to 'plain' Users, as there could be conditions which require management approval. Managers could also be asked to complete the information provided before the requested operation is finished.

In order to define an approval form, a dedicated BPMN `userTask` needs to be defined, following the rules established for Flowable forms.

*What is required for administrators to manage approval?*

The following conditions must be met, for an User `U` to act as administrator for approval:

1. `U` must own the following entitlements, for all the required realms:
    a. `USER_REQUEST_FORM_CLAIM`
    b. `USER_REQUEST_FORM_LIST`
    c. `USER_REQUEST_FORM_SUBMIT`
    d. `USER_READ`
2. The BPMN `userTask` must either indicate `U` among `candidateUsers` or at least one of the groups assigned to `U` among `candidateGroups`, as required by Flowable's task assignment rules

> The special super-user `admin` is entitled to manage all approvals, even those not specifying any `candidateUsers` or `candidateGroups`.

*Example 6. Approving self-registration*

The snippet below shows how to define an approval form in XML; the same operation can be performed via the Flowable Modeler.

```
<userTask id="createApproval" name="Create approval"
          flowable:candidateGroups="managingDirector"
          flowable:formKey="createApproval"> ①
  <extensionElements>
    <flowable:formProperty id="username" name="Username" type="string"
                           expression="${userTO.username}" writable="false"/> ②
    <flowable:formProperty id="approve" name="Approve?" type="boolean"
                           variable="approve" required="true"/> ③
    <flowable:formProperty id="rejectReason" name="Reason for rejecting"
type="string"
                           variable="rejectReason"/>
  </extensionElements>
</userTask>
```

① `formKey` and `id` must be unique across the workflow definition, `name` is displayed by the admin console; `candidateGroups` and `candidateUsers` might be defined, even both, to indicate which Groups or Users should be managing these approvals; if none are specified, only `admin` is entitled to manage such approval

② `expression` will be evaluated against the current requesting `user` (as workflow variable) and related properties; read-only form input can be defined by setting `writable="false"`

③ exporting approval inputs into workflow variables is possible via the `variable` attribute; required form input can be defined by setting `required="true"`

Once the form is defined, any modification subject to that approval will be manageable via the admin console, according to the following flow (the actual operations on the admin console for the sample above are reported below):

1. administrator A sees the new approval notifications
2. administrator A claims the approval and is then allowed to manage it
3. administrator A reviews the updated user, with ongoing modification applied (no actual modification performed yet)
4. administrator A can approve or reject such modification

#### Request Management

Request management is a key-feature of Identity Governance and allows to define and manage, in a structured way, whatever process intended to update identity attributes, memberships and relationships.

Request examples are "assign mobile phone", "grant groups on AD" or "consent access to application".

Users can initiate whichever request among the ones defined; once initiated, such requests will follow their own path, which might also include one or more approval steps.

*Example 7. Assigning printer to user*

The BPMN process below shows how to define an user request in XML; the same operation can be performed via the Flowable Modeler.

In this user request definition:

1. user selects one of printers defined in the system, for self-assignment
2. administrator approves user's selection
3. a relationship between user and printer is established

```
<process id="assignPrinterRequest" name="Assign printer" isExecutable="true">
  <startEvent id="startevent1" name="Start"/>
  <endEvent id="endevent1" name="End"/>
  <sequenceFlow id="flow1" sourceRef="startevent1" targetRef="selectPrinter"/>
  <userTask id="selectPrinter" name="Select printer"
flowable:formKey="selectPrinter"
            flowable:assignee="${wfExecutor}"> ①
    <extensionElements>
      <flowable:formProperty id="printer" name="Printer"
                             variable="printer" type="dropdown" required="true">
②
        <flowable:value id="dropdownValueProvider" name="printersValueProvider"/>
      </flowable:formProperty>
      <flowable:formProperty id="printMode" name="Preferred print mode?"
type="enum">
        <flowable:value id="bw" name="Black / White"/>
        <flowable:value id="color" name="Color"/>
      </flowable:formProperty>
    </extensionElements>
  </userTask>
  <userTask id="approvePrinter" name="Approve printer"
flowable:formKey="approvePrinter"> ③
    <extensionElements>
      <flowable:formProperty id="username" name="Username" type="string"
                             expression="${userTO.username}" writable="false"/>
      <flowable:formProperty id="printer" name="Selected printer" type="string"
                             expression="${printer}" writable="false"/>
      <flowable:formProperty id="approve" name="Approve?" type="boolean"
                             variable="approve" required="true"/>
    </extensionElements>
  </userTask>
  <sequenceFlow id="sid-D7047714-8E57-46B8-B6D4-4844DE330329"
                sourceRef="selectPrinter" targetRef="approvePrinter"/>
```

```
  <serviceTask id="createARelationship" name="Create ARelationship"
               flowable:delegateExpression="${createARelationship}"/> ④
  <sequenceFlow id="sid-33880AE7-35C6-4A39-8E5B-12D8BA53F042"
                sourceRef="approvePrinter" targetRef="createARelationship"/>
  <sequenceFlow id="sid-831E1896-EDF9-4F7D-AA42-E86CC1F8C5D3"
                sourceRef="createARelationship" targetRef="endevent1"/>
</process>
```

① the first form defined is self-assigned to the user which has started this request

② the `dropdown` type is a Syncope extension of the form property types supported by Flowable and allows to inject a list of elements via the `dropdownValueProvider` value (with name `printersValueProvider` in this sample), which must be a Spring bean implementing the DropdownValueProvider interface

③ the second form is a traditional approval form, as seen above

④ this is a FlowableServiceTask implementation which takes care of establishing the relationship

## 3.11. Notifications

Apache Syncope can be instructed to send out notification e-mails when certain events occur.

Every notification generates one or more notification tasks, holding the actual e-mails to be sent. The tasks are ordinarily scheduled for execution according to the value provided for `notificationjob.cronExpression` - see below for details - and can be saved for later re-execution.

When defining a notification, the following information must be provided:

- notification template - template for e-mail generation
- sender - e-mail address appearing in the `From` field of the generated e-mail(s)
- subject - text used as e-mail subject
- recipient e-mail attribute - which user attribute shall be considered as e-mail address for delivery (as users might in principle have different e-mail attributes)
- recipient(s) - the actual e-mail recipient(s) which can be specified either as:
  - list of static e-mail addresses
  - matching condition to be applied to available users
  - Java class implementing the RecipientsProvider interface
- notification event(s) - event(s) triggering the enclosing notification
- about - the condition matching Users, Groups or Any Objects which are evaluated for the specified events; for users, the matching entities can be also considered as additional recipients
- trace level - control how much tracing (including logs and execution details) shall be carried over during execution of the generated notification tasks

### 3.11.1. Notification Events

Notification (and Audit) events are essentially a means of identifying the invocation of specific methods within the Core, in line with *join points* in the Aspect Oriented Programming (AOP).

An event is identified by the following five coordinates:

1. type - which can be one of
   - `LOGIC`
   - `TASK`
   - `PROPAGATION`
   - `PULL`
   - `PUSH`
   - `CUSTOM`
2. category - the possible values depend on the selected type: for `LOGIC` the Logic components available, for `TASK` the various Scheduled Tasks configured, for `PROPAGATION`, `PULL` and `PUSH` the defined Any Types
3. subcategory - completes category with external resource name, when selecting `PROPAGATION`, `PULL` or `PUSH`
4. event type - the final identification of the event; depends on the other coordinates
5. success or failure - whether the current event shall be considered in case of success or failure

The admin console provides tooling to assist with the specification of valid events.

An event is uniquely identified by a string of the following form:

```
[type]:[category]:[subcategory]:[event type]:[SUCCESS|FAILURE]
```

Some samples:

- `[PUSH]:[GROUP]:[resource-db-scripted]:[matchingrule_deprovision]:[SUCCESS]` successful Group push to the external resource `resource-db-scripted`, when deprovisioning matching entities
- `[LOGIC]:[RealmLogic]:[]:[create]:[FAILURE]` unsuccessful Realm creation
- `[CUSTOM]:[]:[]:[unexpected identification]:[SUCCESS]` successful execution of the event identified by the `unexpected identification` string

Custom events can be used to trigger notifications from non-predefined joint points, as BPMN `userTask` instances within the Flowable User Workflow Adapter, PropagationActions, PushActions, PullActions or other custom code.

### 3.11.2. Notification Templates

A notification template is defined as a pair of JEXL expressions, to be used respectively for plaintext and HTML e-mails, and is available for selection in the notification specification.

Notification templates can be easily managed via the admin console.

The full power of JEXL expressions - see reference and some examples - is available.
For example, the `user` variable, an instance of UserTO with actual value matching the *about* condition as introduced above, can be used.

*Example 8. Plaintext notification template*

```
Hi ${user.getPlainAttr("firstname").get().values[0]}
${user.getPlainAttr("surname").get().values[0]},
  welcome to Syncope!

Your username is ${user.username}.
Your email address is ${user.getPlainAttr("email").get().values[0]}.

Best regards.
```

*Example 9. HTML notification template*

```
<html>
  <body>
    <h3>Hi ${user.getPlainAttr("firstname").get().values[0]}
${user.getPlainAttr("surname").get().values[0]},
      welcome to Syncope!</h3>
    <p>Your username is ${user.username}.<br/>
    Your email address is ${user.getPlainAttr("email").get().values[0]}.</p>
    <p>Best regards.</p>
  </body>
</html>
```

## 3.12. Commands

A Command is defined via an Implementation of type `COMMAND`, providing a Java or Groovy class for the Command, interface, designed to optionally take parameters.

The typical use case is to encapsulate, in a single logical unit, the equivalent of two or more REST calls.

Once defined, Commands can be executed via dedicated REST endpoints, or via Console UI.

## 3.13. Tasks

Tasks control the effective operations that are ongoing in the Core.

Whilst tasks define what and how to perform, they are supposed to be run by some entity (depending on the actual task type, see below for details); their execution result can be saved for later examination.

### 3.13.1. Propagation

A propagation task encapsulates all the information that is required - according to the defined mapping - to create, update or delete a given User, Group or Any Object, to / from a certain Identity Store:

- operation - `CREATE`, `UPDATE` or `DELETE`
- connObjectKey - value for ConnId unique identifier on the Identity Store
- oldConnObjectKey - the former unique identifier on the Identity Store: bears value only during updates involving the unique identifier
- attributes - set of ConnId attributes built upon internal identity data and configured mapping
- resource - related external resource
- objectClass - ConnId object class
- entity - reference to the internal identity: User, Group or Any Object

Propagation tasks are automatically generated via the configured PropagationManager, executed (by default) via the PriorityPropagationTaskExecutor during the propagation process, and are permanently saved - for later re-execution or for examining the execution details - depending on the trace levels set on the related external resource.

Automatic retry in case of failure can be configured by mean of a propagation policy, for the related external resource.

### 3.13.2. Pull

Pull tasks are required to define and trigger the pull process from Identity Stores.

When defining a pull task, the following information must be provided:

- related external resource
- chosen pull mode
- destination Realm - where entities selected for creation are going to be placed
- whether creation, update or deletion on internal storage are allowed or not
- whether remediation is enabled
- whether to synchronize the status information from the related identity store

- selected matching and unmatching rules
- optional pull action(s)
- entity templates
- scheduling information:
  - when to start
  - cron expression

Pull tasks are executed, either upon request or due to a schedule, via the PullJobDelegate during the pull process, and are permanently saved - for later re-execution or for examining the execution details - depending on the trace level set on the related external resource.

*DryRun*

It is possible to simulate the execution of a pull (or push) task without performing any actual modification by selecting the *DryRun* option. The execution results will be still available for examination.

*Concurrent Pull Task Executions*

By default, pull tasks are set to accept and sequentially process the objects received from the configured External Resource; it is also possible to configure a pull task to work on several objects at once in order to speed up the overall execution time.

### 3.13.3. Push

Push tasks are required to define and trigger the push process to Identity Stores.

When defining a push task, the following information must be provided:

- related external resource
- source Realm - where entities to push will be read from
- filter information for selecting which internal entities will be pushed onto the identity store
- whether creation, update or deletion on the identity store are allowed or not
- whether to synchronize the status information with internal storage
- selected matching and unmatching rules
- optional push action(s)
- scheduling information:
  - when to start
  - cron expression

Push tasks are executed, either upon request or due to a schedule, via the PushJobDelegate during the push process, and are permanently saved - for later re-execution or for examining the execution details - depending on the trace level

set on the related external resource.

*Concurrent Push Task Executions*

By default, push tasks are set to sequentially send items to the configured External Resource; it is also possible to configure a push task to work on several objects at once in order to speed up the overall execution time.

### 3.13.4. Notification

A notification task encapsulates all the information that is required to send out a notification e-mail, according to the specification provided in a given notification:

- entity - reference to the internal identity - User, Group or Any Object - the notification task refers to
- sender e-mail address
- e-mail subject
- effective e-mail recipient(s)
- e-mail body as plaintext and / or HTML

Notification tasks are automatically generated via the NotificationManager, executed via the NotificationJob and are permanently saved - for later re-execution or for examining the execution details - depending on the trace level set on the related notification.

### 3.13.5. Macros

Macro tasks are meant to group one or more Commands into a given execution sequence, alongside with arguments required to run.

When defining a macro task, the following information must be provided:

- commands to run, with their args
- Realm for delegated administration to restrict the set of users entitled to list, update or execute the given macro task
- scheduling information:
  - when to start
  - cron expression

### 3.13.6. Scheduled

Scheduled tasks allow for the injection of custom logic into the Core in the area of execution and scheduling.

When defining a scheduled task, the following information must be provided:

- job delegate class: Java class extending AbstractSchedTaskJobDelegate providing the custom logic to execute
- scheduling information:
  - when to start
  - cron expression

Scheduled tasks are ideal for implementing periodic checks or clean-up operations, possibly in coordination with other components; some examples:

- move users from "pending delete" to "deleted" status 15 days after they reached the "pending delete" status (requires interaction with Flowable User Workflow Adapter)
- send out notification e-mails to users whose password is about to expire on an Identity Store
- disable all users not logging into the system for the past 6 months

## 3.14. Reports

Reports are a powerful tool to extract, filter and format relevant information from a running Apache Syncope deployment, for a wide range of purposes: from business to DevOps.

When defining a report, the following information must be provided:

- mime type and file extension: the type of content that the report is expected to generate
- job delegate class: Java class extending AbstractReportJobDelegate providing the custom logic to extract information from Syncope and generate output according to the configured mime type
- scheduling information:
  - when to start
  - cron expression

## 3.15. Audit

The audit feature allows to capture events occurring within the Core and to store relevant information about them.
By default, events are written as entries into the `AuditEvent` table of the internal storage.
Audit events can also be processed differently, for example when using the Elasticsearch extension.

Once events are reported, they can be used as input for external tools.

### 3.15.1. Audit Events

The information provided for notification events is also valid for audit events, including examples - except for the admin console tooling, which is naturally distinct.

### 3.15.2. Audit Event Processors

In addition to default processing, events are also available for custom handling via Audit Event Processors. This allows to write implementations to route audit events to files, queues, sockets, syslog, etc.

Custom implementations must implement the AuditEventProcessor interface.

## 3.16. Routes

Routes represents the main configuration to instruct SRA to respond to HTTP requests.

Every route is defined by providing the following information:

1. name - unique reference to the current route
2. target - base URI to proxy requests for
3. error URI - where to redirect in case of errors
4. type - `PUBLIC` or `PROTECTED`: the latter requires authentication against the configured Access Manager
5. logout - whether to proceed with logout against the configured Access Manager
6. post-logout URI - where to redirect after logging out
7. CSRF - whether protection against Cross-Site Request Forgery shall be applied to incoming requests
8. order - value to sort routes for evaluation
9. predicates - composed condition, supporting logic operators as `AND`, `OR` and `NOT`, to specify if incoming requests shall match the owning route
10. filters - ordered list of elements allowing to perform modification of the incoming request and / or outgoing response

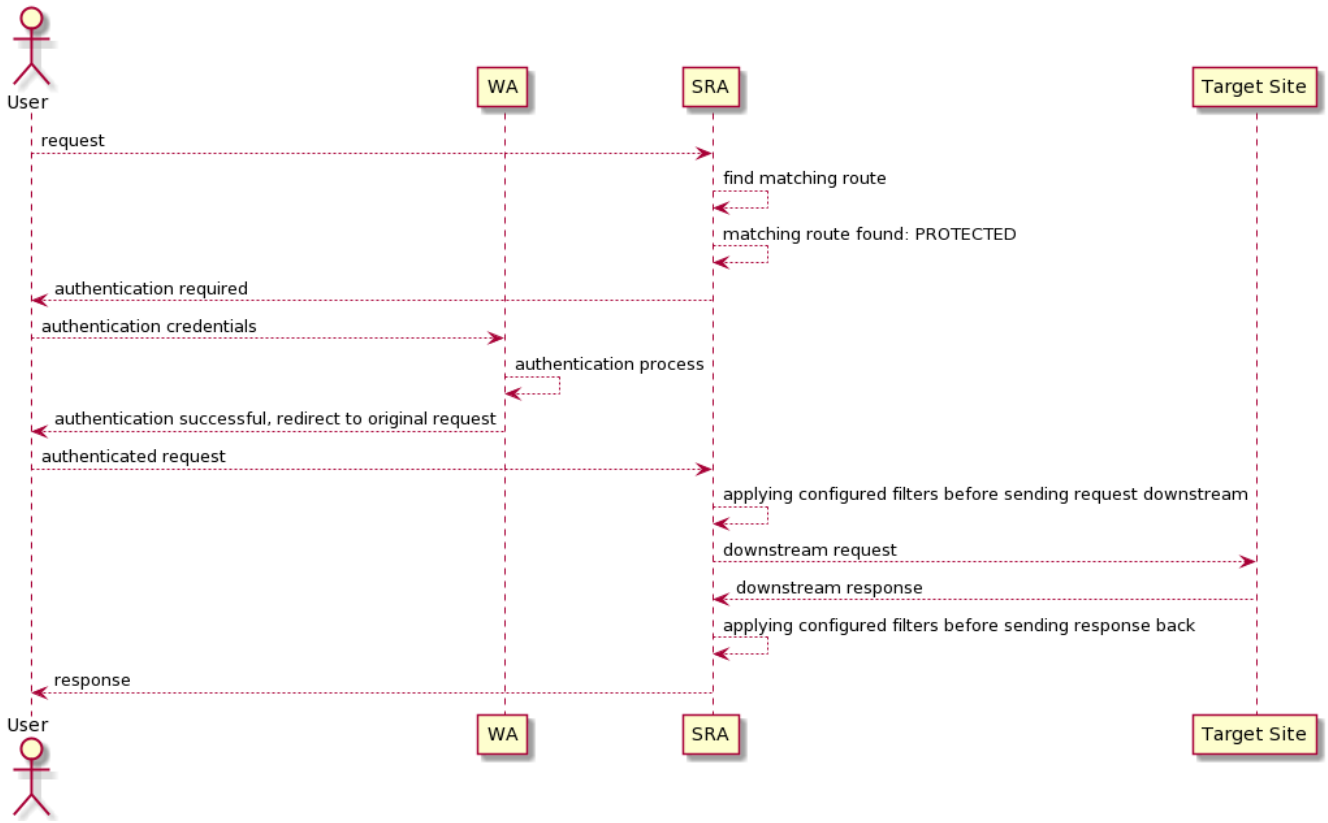



*Figure 11. SRA request processing*

When an HTTP request is received, SRA evaluates all the configured *predicates*, sorted by their owning *route*'s *order*, to determine the first matching route among the ones defined.

If the matching route has *type* `PROTECTED`, the configured Access Manager is involved to authorize the request; while WA works out-of-the-box, others can be configured, provided that they implement standard protocols as OpenID Connect or SAML.

The incoming request is then pre-processed by matching route's *filters* and sent to the configured *target*.
The received response, after being post-processed by matching route's *filters*, is finally returned to the initial caller.

### 3.16.1. Predicates

Inside Route definition, each predicate will be referring to some Spring Cloud Gateway's Predicate factory:

- `AFTER` matches requests that happen after the specified datetime;
- `BEFORE` matches requests that happen before the specified datetime;
- `BETWEEN` matches requests that happen after first datetime and before second datetime;
- `COOKIE` matches cookies that have the given name and whose values match the regular expression;
- `HEADER` matches with a header that has the given name whose value matches the regular expression;
- `HOST` matches the `Host` header;

- `METHOD` matches the provided HTTP method(s);
- `PATH` matches the request path;
- `QUERY` matches the query string;
- `REMOTE_ADDR` matches the caller IP address;
- `WEIGHT` matches according to the weights provided per group of target URIs;
- `CUSTOM` matches according to a provided class extending CustomRoutePredicateFactory.

### 3.16.2. Filters

Inside Route definition, each filter will be referring to some Spring Cloud Gateway's Filter factory:

- `ADD_REQUEST_HEADER` adds a header to the downstream request's headers;
- `ADD_REQUEST_PARAMETER` adds a parameter too the downstream request's query string;
- `ADD_RESPONSE_HEADER` adds a header to the downstream response's headers;
- `CLIENT_CERTS_TO_REQUEST_HEADER` takes SSL certificates associated with the request to downstream request's headers;
- `DEDUPE_RESPONSE_HEADER` removes duplicate values of response headers;
- `FALLBACK_HEADERS` after an execution exception occurs, the request is forwarded to a fallback endpoint; the headers with the exception type, message and (if available) root cause exception type and message are added to that request;
- `LINK_REWRITE` rewrites HTTP links in the response body before it is sent back to the client;
- `MAP_REQUEST_HEADER` creates a new named header with the value extracted out of an existing named header from the incoming request;
- `PREFIX_PATH` will prefix a part to the path of the incoming request;
- `PRESERVE_HOST_HEADER` sets a request attribute that the routing filter inspects to determine if the original host header should be sent, rather than the host header determined by the HTTP client;
- `PRINCIPAL_TO_REQUEST_HEADER` takes authenticated principal to downstream request's headers;
- `QUERY_PARAM_TO_REQUEST_HEADER` takes incoming query params to downstream request's headers;
- `REDIRECT_TO` will send a HTTP status `30x` with a `Location` header to perform a redirect;
- `REMOVE_REQUEST_HEADER` removes a header to the downstream request's headers;
- `REMOVE_RESPONSE_HEADER` removes a header to the downstream response's headers;
- `REQUEST_HEADER_TO_REQUEST_URI` changes the request URI by a request header;
- `REQUEST_RATE_LIMITER` determines if the current request is allowed to proceed: if it is not, a HTTP status `429` is returned;
- `RETRY` attempts to connect to downstream request's target for the given number of retries before giving up;
- `REWRITE_PATH` uses regular expressions to rewrite the request path;
- `REWRITE_LOCATION` modifies the value of the `Location` response header;

- `REWRITE_RESPONSE_HEADER` modifies the value of response header;
- `SECURE_HEADERS` adds a number of recommended security headers to the response;
- `SAVE_SESSION` forces to save the current HTTP session before forwarding the call downstream;
- `SET_PATH` manipulates the request path;
- `SET_REQUEST_HEADER` replaces a header to the downstream request's headers;
- `SET_RESPONSE_HEADER` replaces a header to the downstream response's headers;
- `SET_STATUS` sets HTTP status to return to caller;
- `SET_REQUEST_SIZE` restricts a request from reaching the downstream service;
- `SET_REQUEST_HOST` sets host header to the downstream request's headers;
- `STRIP_PREFIX` removes parts from the path of the incoming request;
- `CUSTOM` will manipulate downstream request or response according to a provided class extending CustomGatewayFilterFactory.

## 3.17. Authentication Modules

Authentication Modules allow to specify how WA shall check the provided credentials against specific technology or repository, in the context of a certain Authentication Policy.

Several authentication modules are provided:

- Principal Authentication:
  - Database
  - JAAS
  - LDAP
  - OpenID Connect
  - OAuth2
  - Syncope
  - X509
  - SAML
  - Apple Signin
  - Azure Active Directory
  - Google OpenID
  - Keycloak
- MFA:
  - Duo Security
  - Google Authenticator

Custom authentication modules can be provided by implementing the

AuthModuleConf interface and extending appropriately the WAPropertySourceLocator class.

Authentication Modules are dynamically translated into CAS Authentication Handlers.

## 3.18. Attribute Repositories

Attribute Repositories allow to enrich the profile of an user authenticated by WA, in the context of a certain Attribute Release Policy.

Some attribute repositories are provided:

- Database
- LDAP
- Stub
- Syncope

Custom authentication modules can be provided by implementing the AttrRepoConf interface and extending appropriately the WAPropertySourceLocator class.

Attribute Repositories are dynamically translated into CAS Attribute Resolution configuration.

## 3.19. Client Applications

Client Applications represent web applications (including SRA) allowed to integrate with WA.

Depending on the communication protocol, the following client applications are supported:

- OpenID Connect Relying Party
- SAML 2.0 Service Provider
- CAS Service

When defining a client application, the following parameters shall be specified:

1. id - unique number identifier of the current client application
2. realm - used to inherit policies
3. name - regular expression to match requests
4. description - optional textual description
5. username attribute provider, mapping to CAS Attribute-based Principal Id
6. authentication policy

7. access policy
8. attribute release policy
9. ticket expiration policy
10. additional properties
11. logout type, mapping to the equivalent CAS setting

More parameters are required to be specified depending on the actual client application type.

Client Applications are dynamically translated into CAS Services.

## 3.20. Domains

Domains are built to facilitate multitenancy.

Domains allow the physical separation of all data managed by Apache Syncope, by storing the data for different domains into different database instances. Therefore, Apache Syncope can facilitate Users, Groups, Any Objects, External Resources, Policies, Tasks, etc. from different domains (e.g. tenants) in a single Core instance.

By default, a single `Master` domain is defined, which also bears the configuration for additional domains.

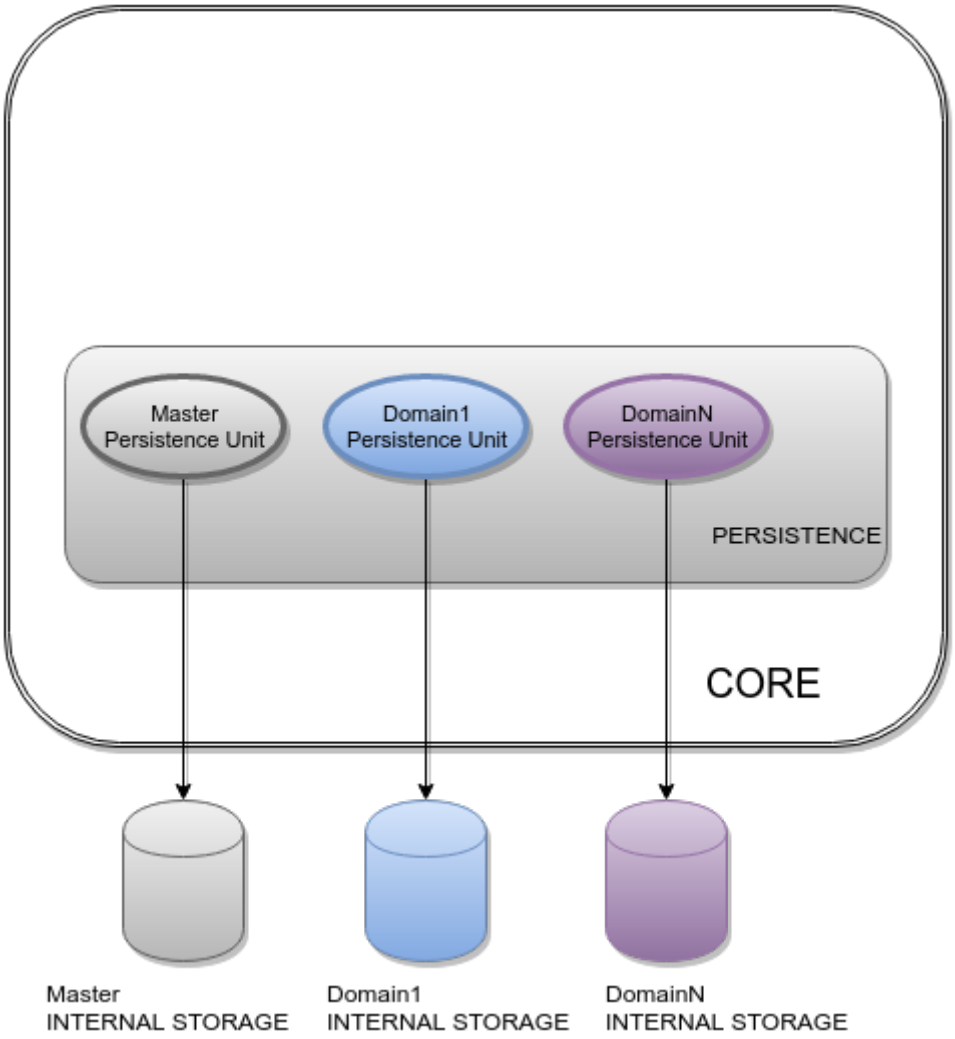



*Figure 12. Domains*

Each domain's persistence unit can be configured to work with one of the supported DBMSes: `Master` can be on MySQL, `Domain1` on PostgreSQL, `DomainN` on Oracle and so on.

## 3.21. Implementations

It is possible to provide implementations suitable for customization as:

1. Java classes
2. Apache Groovy classes

While the former shows some advantages about execution performance, the latter is extremely useful as it allows for runtime updates, freeing from the hassle to redeploy when something needs to be changed.

*With great power comes great responsibility*

Customizing and extending the Core behavior by uploading a Groovy class via REST adds further flexibility to the platform, allows to speed up the development cycle and can be used as Swiss army knife for maintenance and administration.

Please beware that granting the permission to manage Implementations to non-admin users can result in security threat, as there is virtually no limitation in what the Groovy code has access to.

## 3.22. Extensions

The *vanilla* Apache Syncope deployment can be optional enriched with useful features via an Extension, instead of bloating every single deployment with unneeded libraries and configurations.

With reference to architecture, an extension might add a REST endpoint, manage the persistence of additional entities, extend the security mechanisms, tweak the provisioning layer, add features to the Admin UI or the End-user UI, or even bring all such things together.

Extensions are available from different sources:

1. as Maven artifacts published from the Apache Syncope codebase, part of the official releases - this is the case of the ones detailed below;
2. as Maven artifacts published by third parties;
3. as part of a given deployment source code, as explained in the following.

### 3.22.1. SAML 2.0 Service Provider for UI

This extension can be leveraged to provide SAML 2.0-based Single Sign-On access to the Admin UI, the End-user UI or any other Java application dealing with the Core.

Once installed, one or more Identity Providers can be imported from their metadata. For each Identity Provider, it is to configure which one of the attributes - returned as part of the assertion containing the attribute statements - is going to be used by Syncope to match the internal users.

*Extension Sources*

The source code of this extension is available from the Apache Syncope source tree .

This extension adds features to all components and layers that are available, and can be taken as reference when creating new extensions.

### 3.22.2. OpenID Connect Client for UI

This extension can be leveraged to provide OpenID Connect-based Single Sign-On access to the Admin UI, the End-user UI or any other Java application dealing with the Core.

Once installed, one or more OpenID Providers can be created either from the discovery document if it is supported or from inserting manually the required attributes, in any case the `client_id` and the `client_secret` from the OAuth 2.0 credential and the issuer are required. After configuring the OpenID provider, the Authorization Code Flow is going to be implemented in order to reach the user information to be used by Syncope to match the internal users.

*Extension Sources*

The source code of this extension is available from the Apache Syncope source tree .

This extension adds features to all components and layers that are available, and can be taken as reference when creating new extensions.

### 3.22.3. Elasticsearch

This extension provides an alternate internal search engine for Users, Groups and Any Objects ,Realms and Audit Events, requiring an external Elasticsearch cluster.

This extension supports Elasticsearch server versions starting from 8.x.

As search operations are central for different aspects of the provisioning process, the global performance is expected to improve when using this extension.

*Extension Sources*

The source code of this extension is available from the Apache Syncope source tree .

### 3.22.4. OpenSearch

This extension provides an alternate internal search engine for Users, Groups and Any Objects ,Realms and Audit Events, requiring an external OpenSearch cluster.

As search operations are central for different aspects of the provisioning process, the global performance is expected to improve when using this extension.

*Extension Sources*

The source code of this extension is available from the Apache Syncope source tree .

### 3.22.5. SCIM

SCIM (System for Cross-domain Identity Management) 2.0 is the open API for managing identities, published under the IETF:

1. Definitions, Overview, Concepts, and Requirements
2. Core Schema
3. Protocol

This extension enables an additional `/scim` REST endpoint, implementing the communication according to the SCIM 2.0 standard, in order to provision User, Enterprise User and Group SCIM entities to Apache Syncope.

*Extension Sources*

The source code of this extension is available from the Apache Syncope source tree
.

# Chapter 4. Usage

Before proceeding, please ensure that you have access to a running Apache Syncope deployment. You can take a look at the Apache Syncope Getting Started Guide to check system requirements and to choose among the various options for obtaining Apache Syncope.

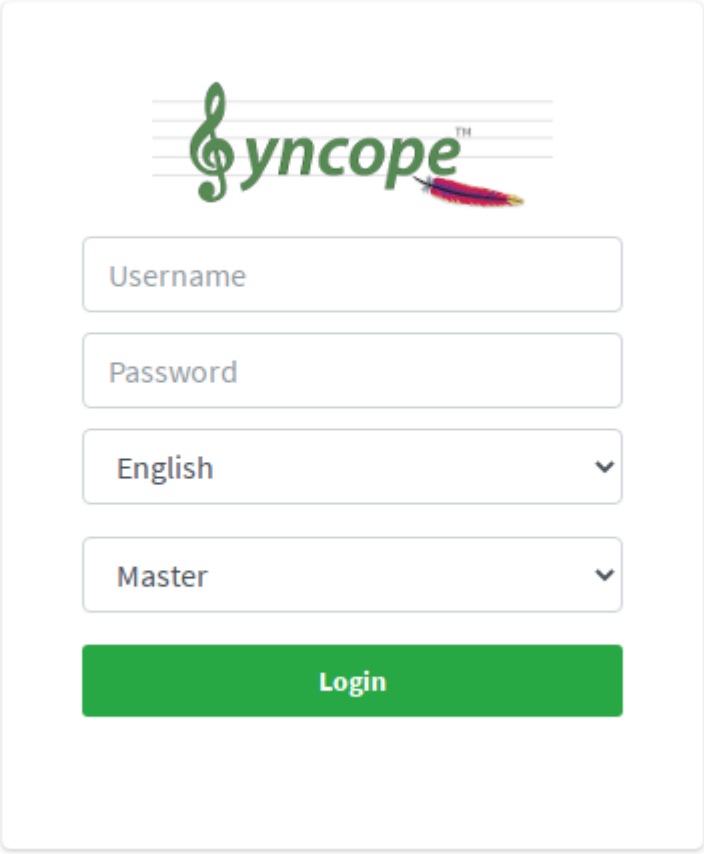
## 4.1. Admin Console

Once the deployment is ready, the admin console can be accessed at:

```
protocol://host:port/syncope-console/
```

where `protocol`, `host` and `port` reflect your deployment.

You should be greeted by the following web page.




You can use the default admin credentials to login.

### 4.1.1. Accessibility

The Admin UI is accessible to the visually impaired.

Two icons are present in the main login page and in the menu on the right:

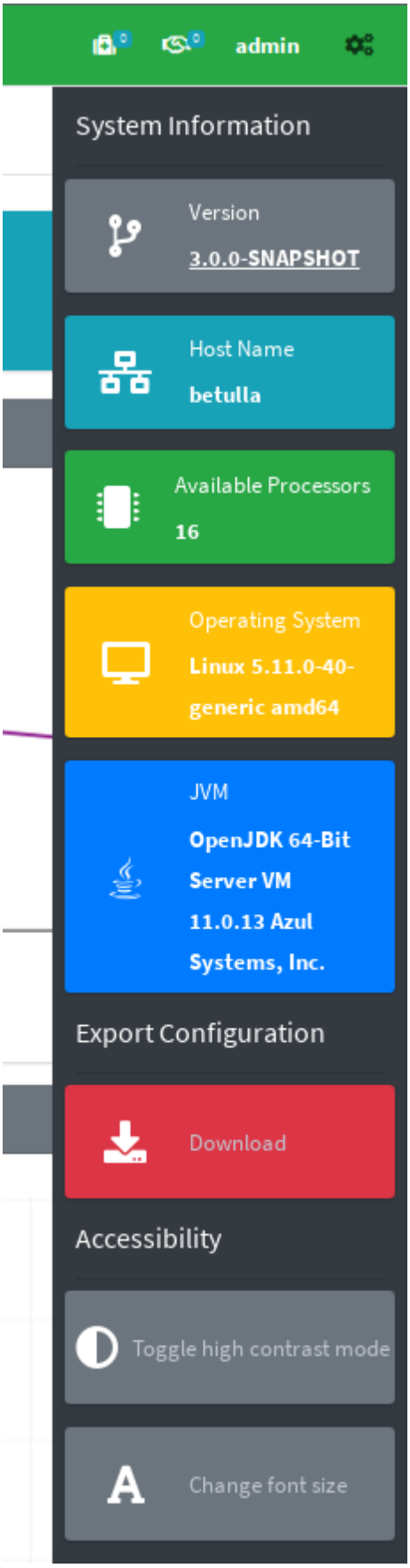



*Figure 13. Admin Console accessibility buttons*

By clicking the top right corner icon it is possible to toggle the "High contrast mode". In this mode, the website colors are switched to a higher contrast color schema.

The H accesskey shortcut can be used to easily toggle "High contrast mode" by using the keyboard.

E.g.

| Shortcut | Purpose |
|---|---|
| Alt + Shift + H | Toggle "High contrast mode" on Firefox and Chrome browsers on Linux |

By clicking the second icon A it is possible to toggle the "Increased font mode". In this mode, the website font size is increased.

The F accesskey shortcut can be used to easily toggle "Increased font mode" by using the keyboard.

E.g.

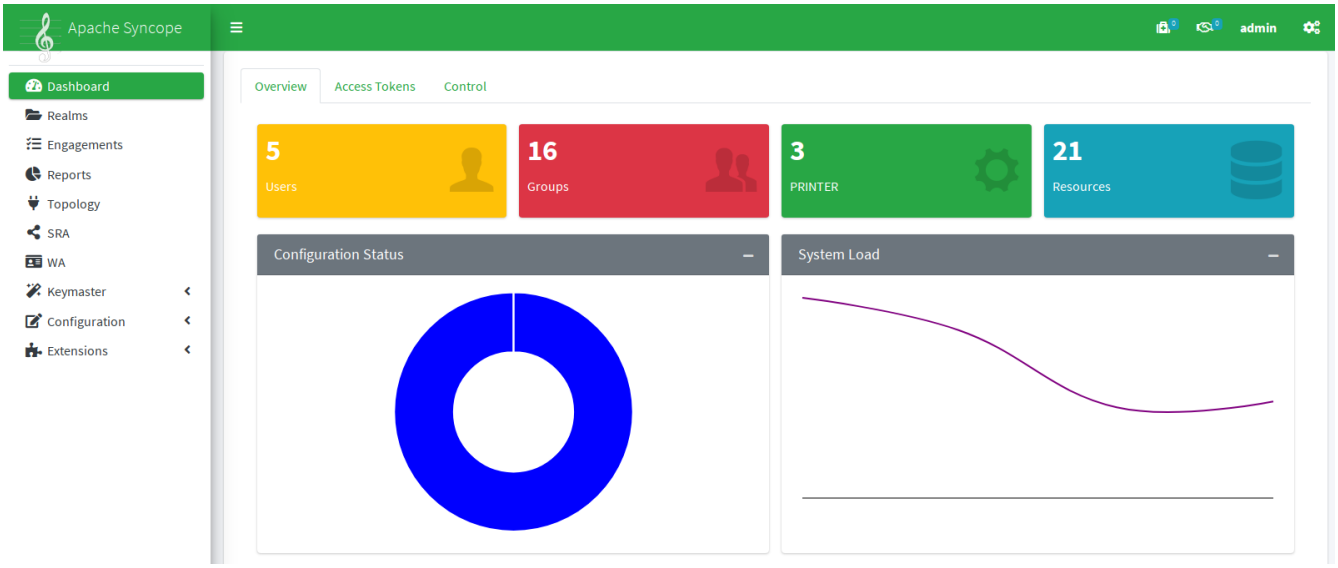
| Shortcut | Purpose |
|---|---|
| Alt + Shift + F | Toggle "Increased font mode" on Firefox and Chrome browsers on Linux |

To reset to the default mode, it is enough to click again on the specific icon.

### 4.1.2. Pages

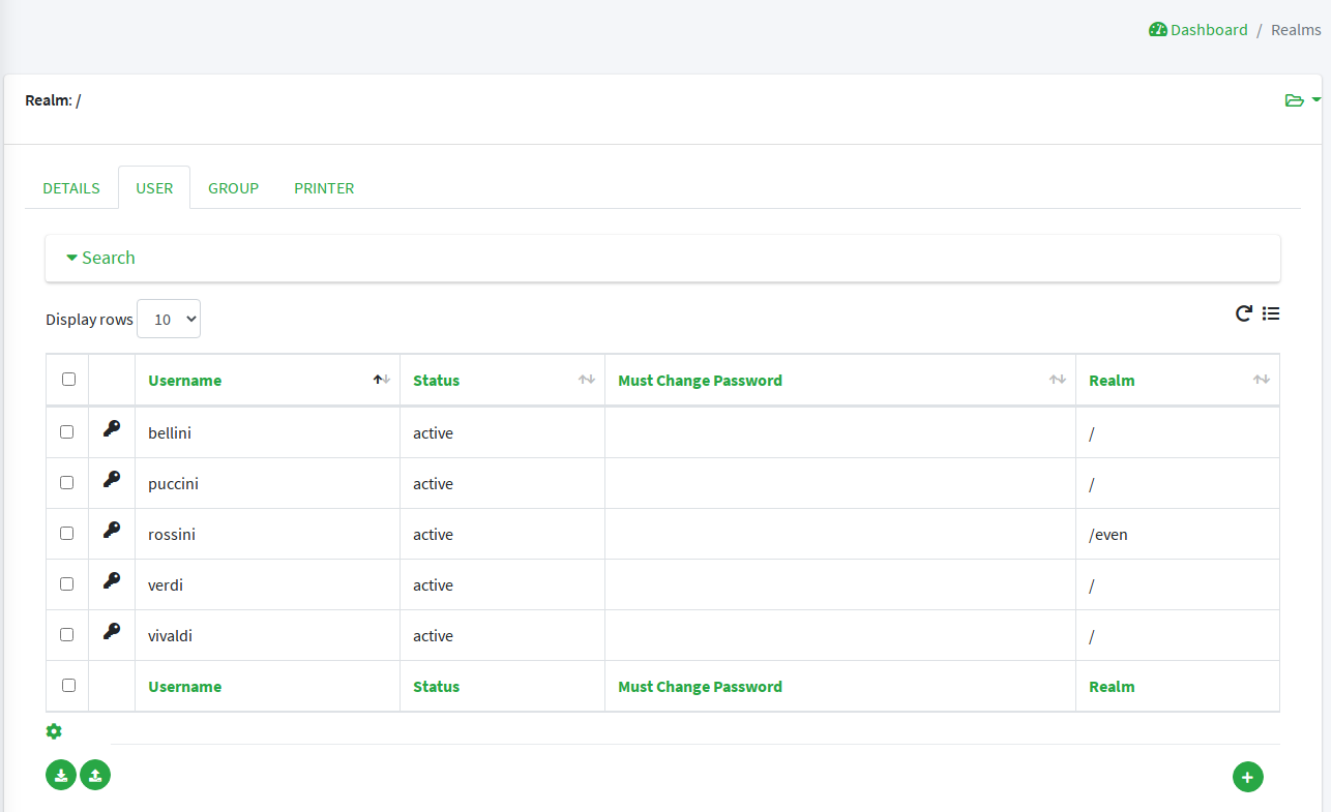
#### Dashboard

The dashboard provides an overall view of the current state of the Apache Syncope deployment. It consists of various widgets and tabs that show the different metrics and details of each component that is available.



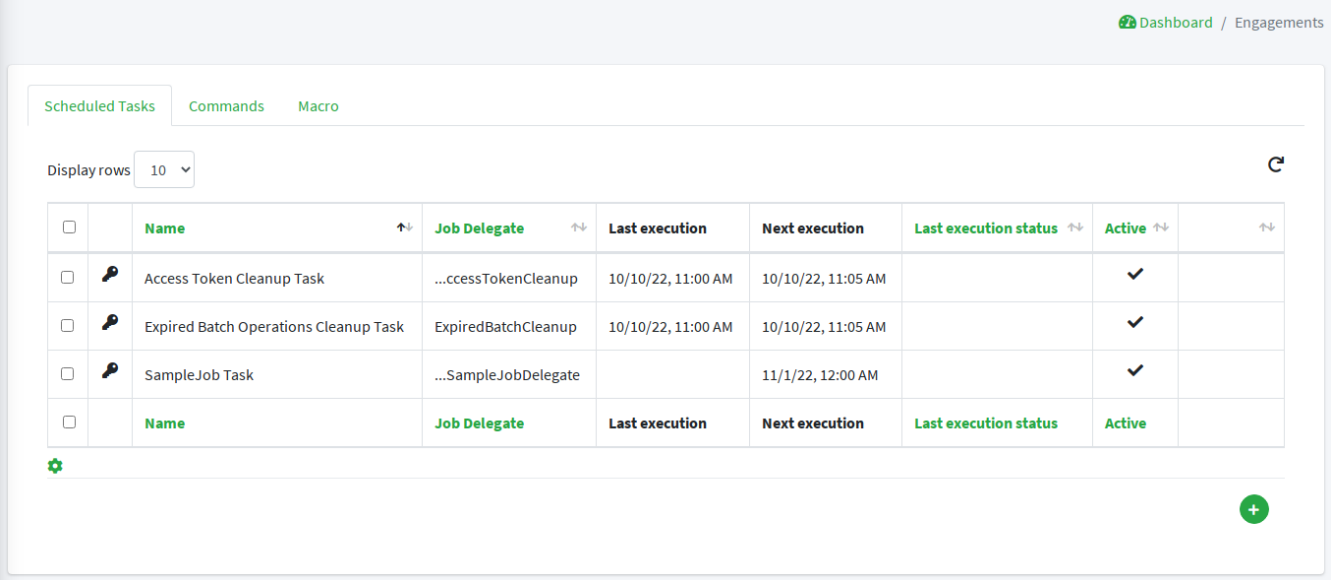
### Realms

The realms page provides the designated administrators with the power to manage Realms as well as Users, Groups and Any Objects, for all any types that are defined.



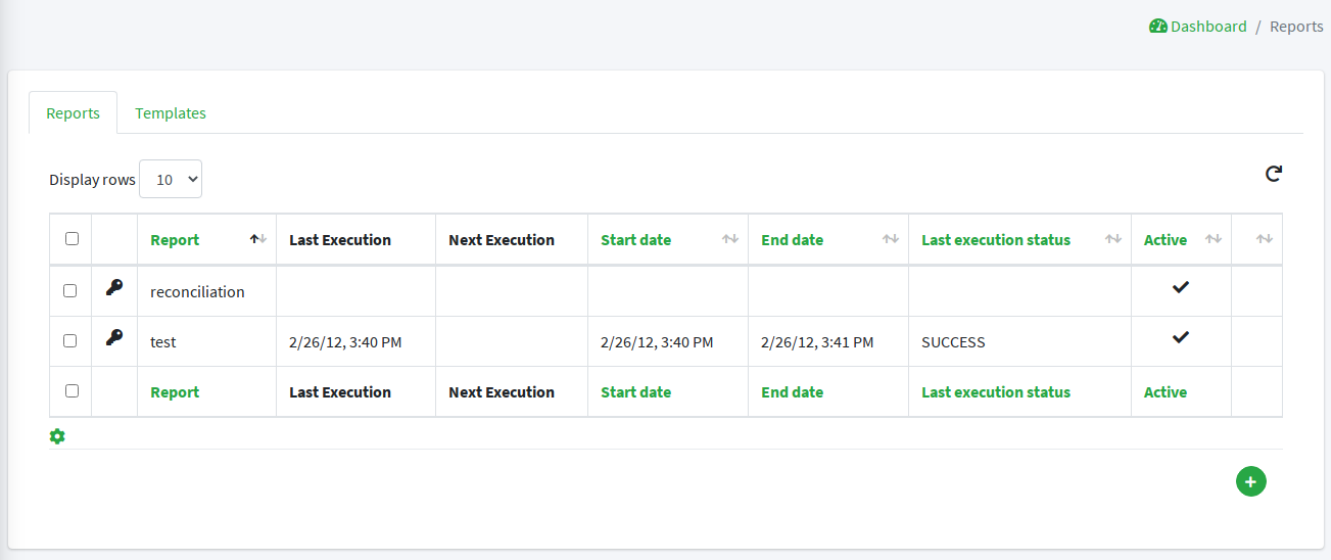

### Engagements

From the engagements page it is possible to administer scheduled tasks, commands and macros.



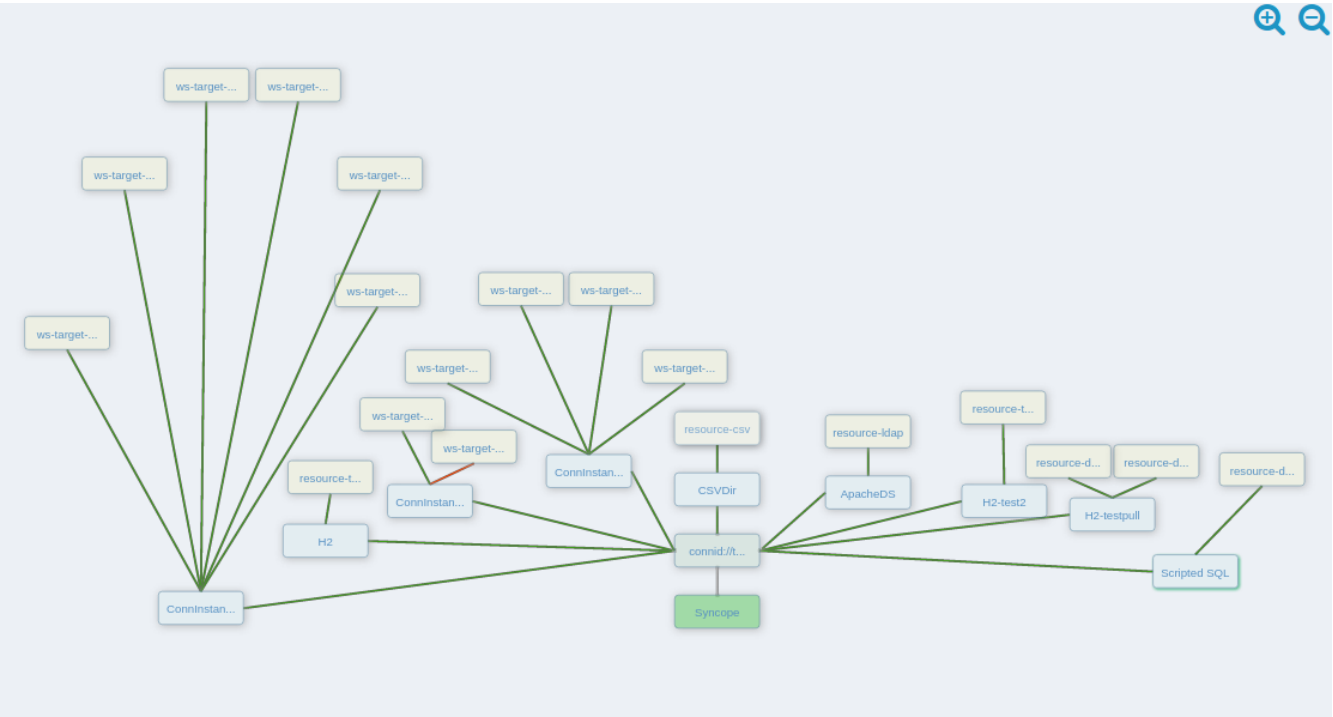

### Reports

The reports page presents the designated administrators with the list of reports configured on the given deployment.



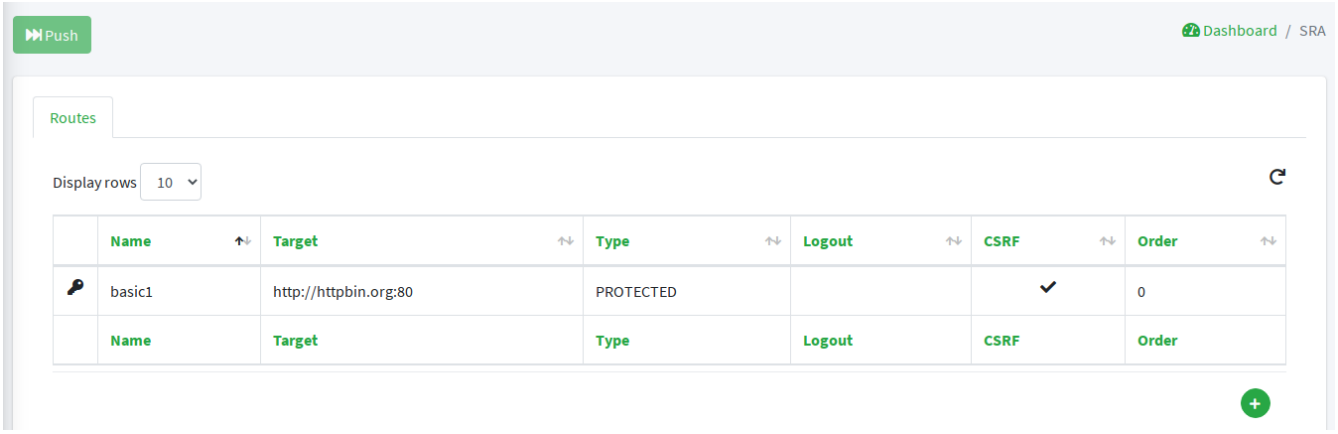

## Topology

The topology page provides a mapped view of the connectors and external resources that are available and configured in the given deployment.
Different actions are available when clicking on the various nodes.



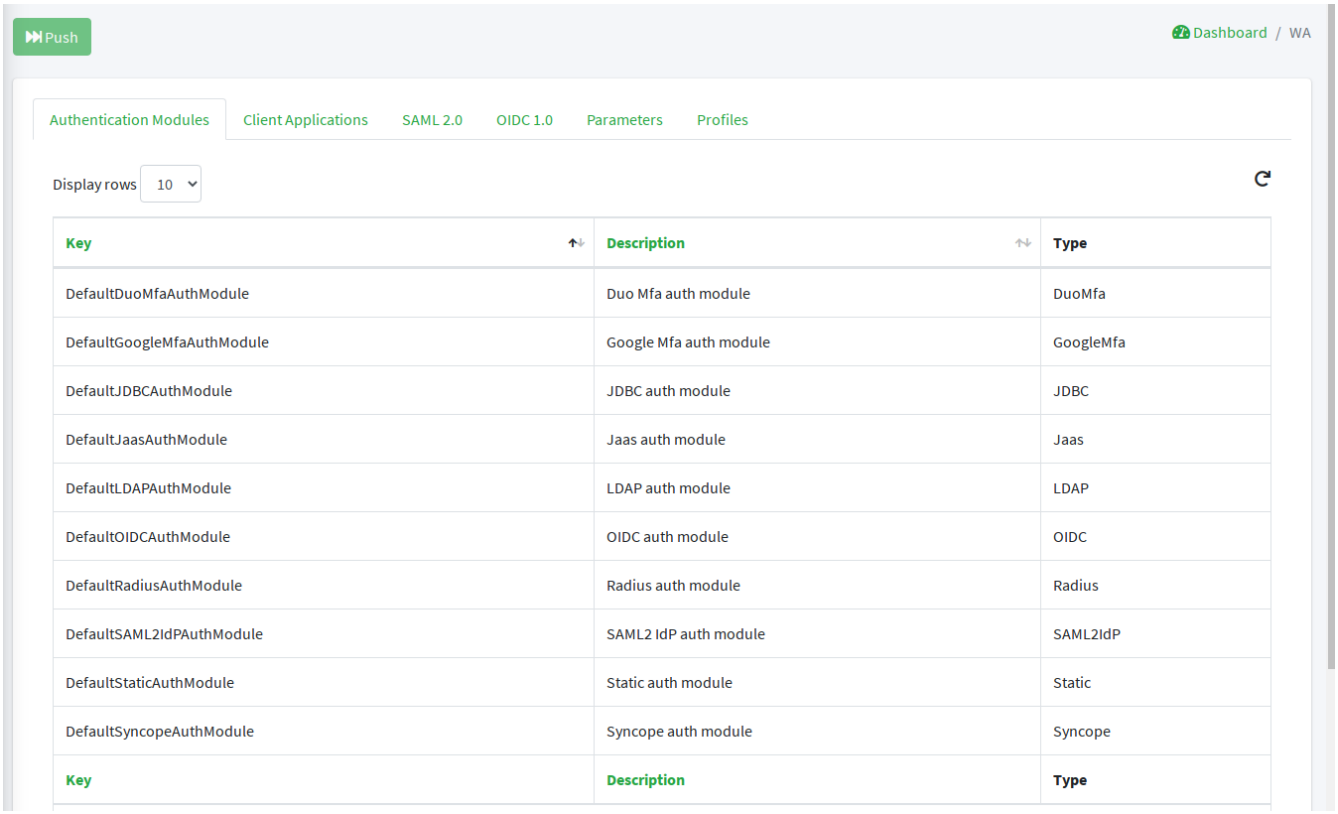

## SRA

From the SRA page it is possible to manage the routes served and to immediately deploy the updated configuration.




### WA

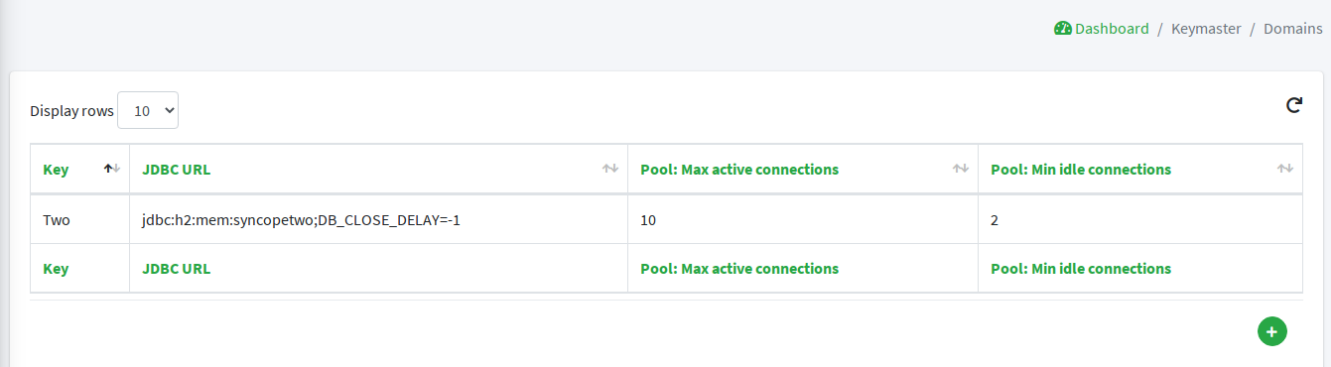
The WA page allows to manage authentication modules, client applications and other access management features, and to immediately deploy the updated configuration.




### Keymaster

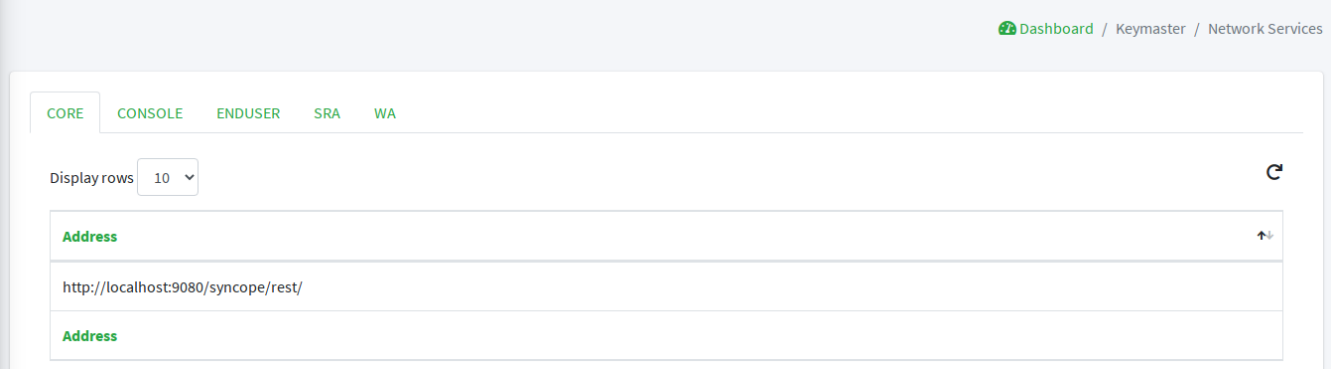
#### Domains

Allows for domain management.



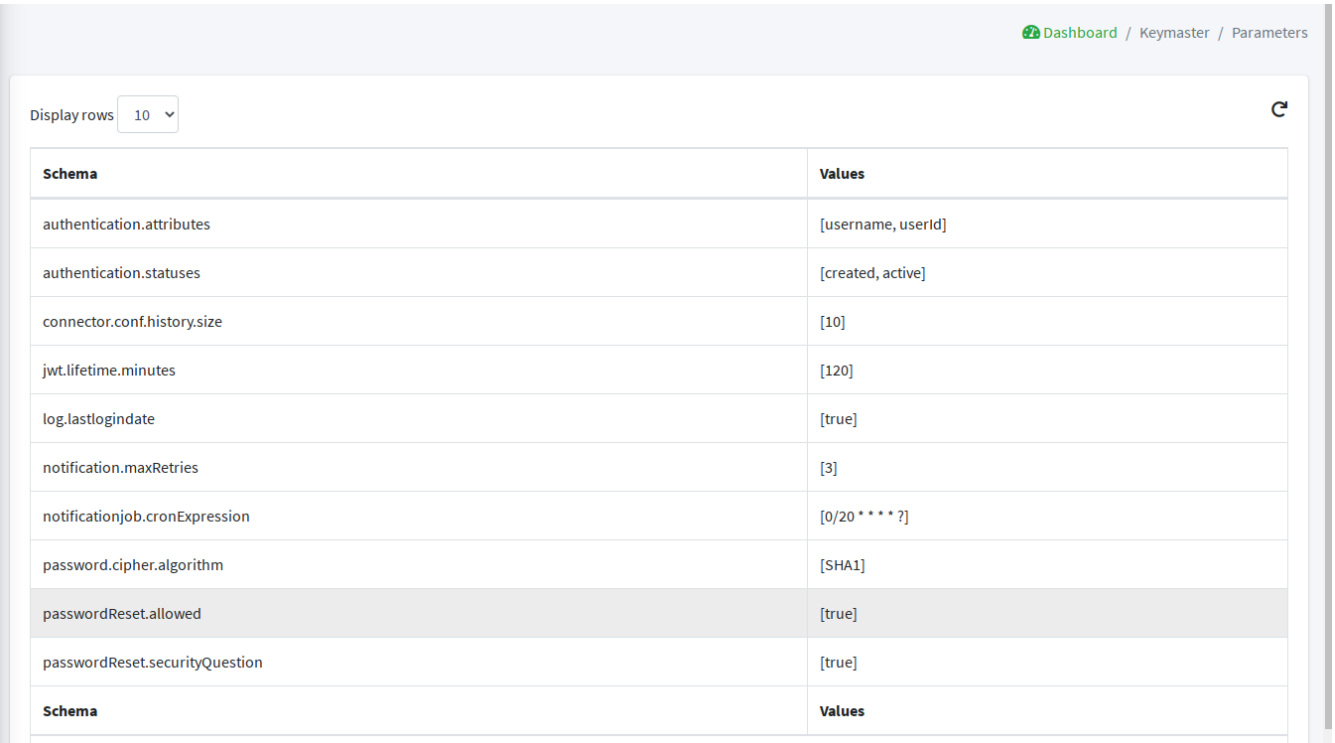

### Network Services

Displays the components as registered in the configured keymaster instance.




### Parameters

Presents the administrators with the list of defined configuration parameters used in the given deployment such as `token.expireTime` and `password.cipher.algorithm`. These can be edited to further customize the deployment.
New parameters can also be added, for use with custom code.



### Configuration

The configuration pages allow the designated administrators to customize the given deployment to fit the needs of the organization.

#### Audit

Controls the configuration of the auditing features.

#### Implementations

Allows the administrators to manage implementations.

#### Logs

The logging levels available can be dynamically adjusted; for example, the admin can set it to display only the errors of `io.swagger`, in which case the warning and information logs will not be reported.

#### Notifications

Gives access to the notification management.
This page also allows the administrators to create and edit notification templates.

#### Policies

Allows the administrators to manage all available type of policies.

#### Security

Displays and provides editing functionality for the security aspects, including roles, delegations and security questions.

#### Types

Entry point for type management.

### Extensions

The extensions configured for the given deployment are dynamically reported in the navigation menu: each extension generally produces one or more pages and makes one or more widgets available in the dashboard.

### Approval

The images below refer to the self-registration approval sample and to the typical approval flow as explained above.

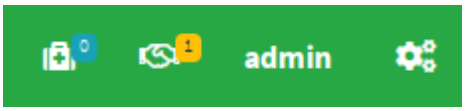



*Figure 14. Approval notification*

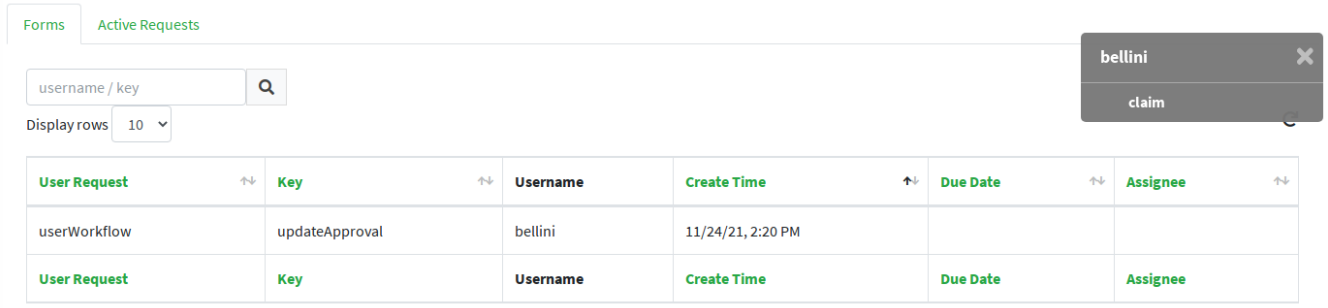



*Figure 15. Claiming an approval*

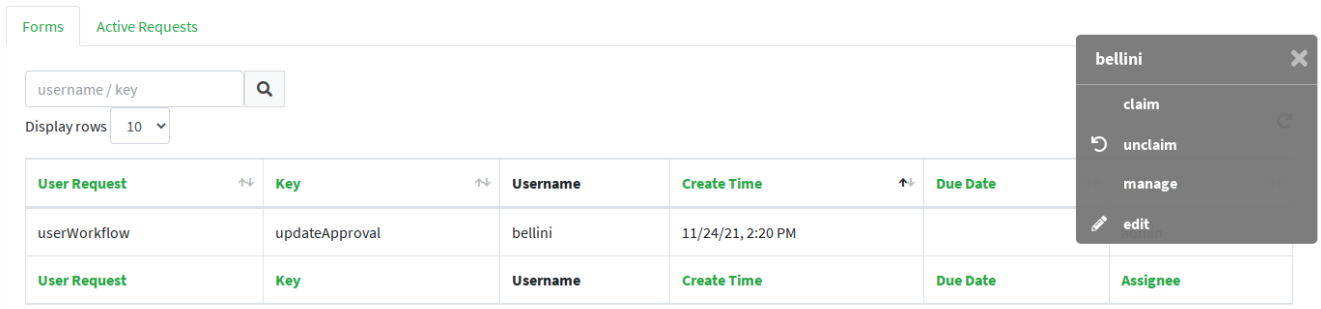



*Figure 16. Managing an approval*


*Figure 17. Approval form*

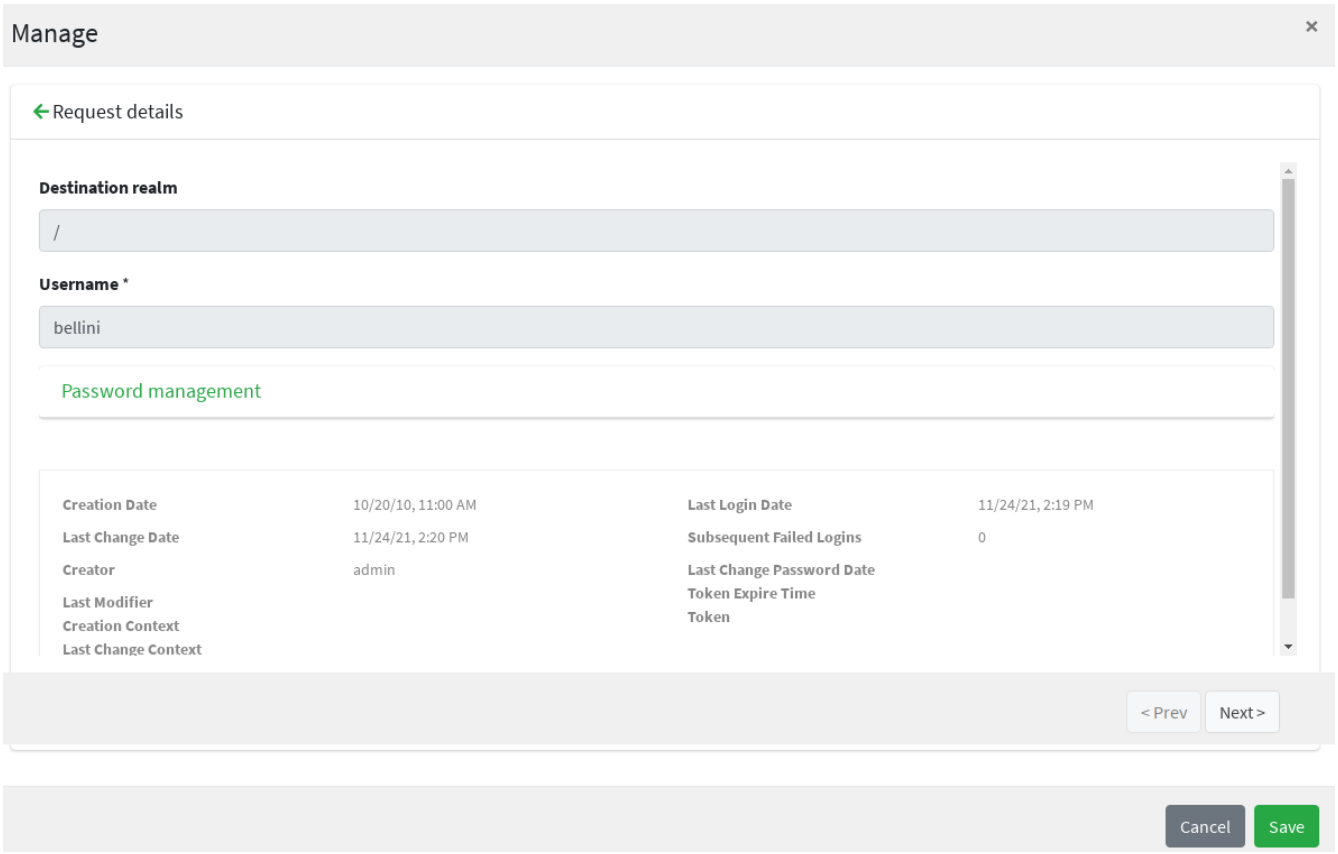



*Figure 18. Reviewing modifications*

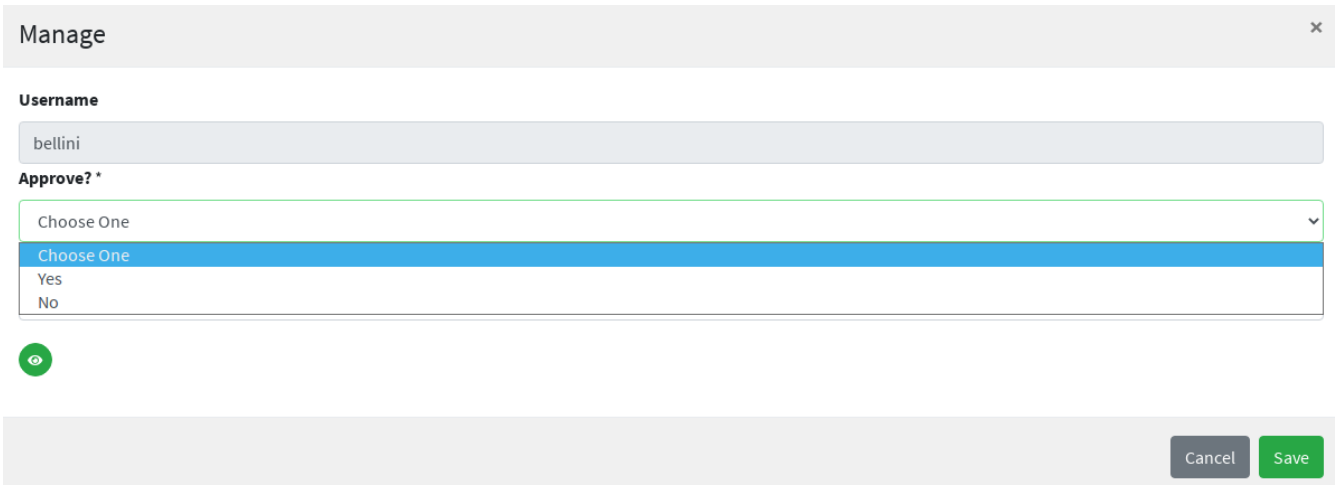



*Figure 19. Approving modifications*

### User Requests

User requests are managed exactly in the same way how approvals are managed: check the typical request management flow as explained above.

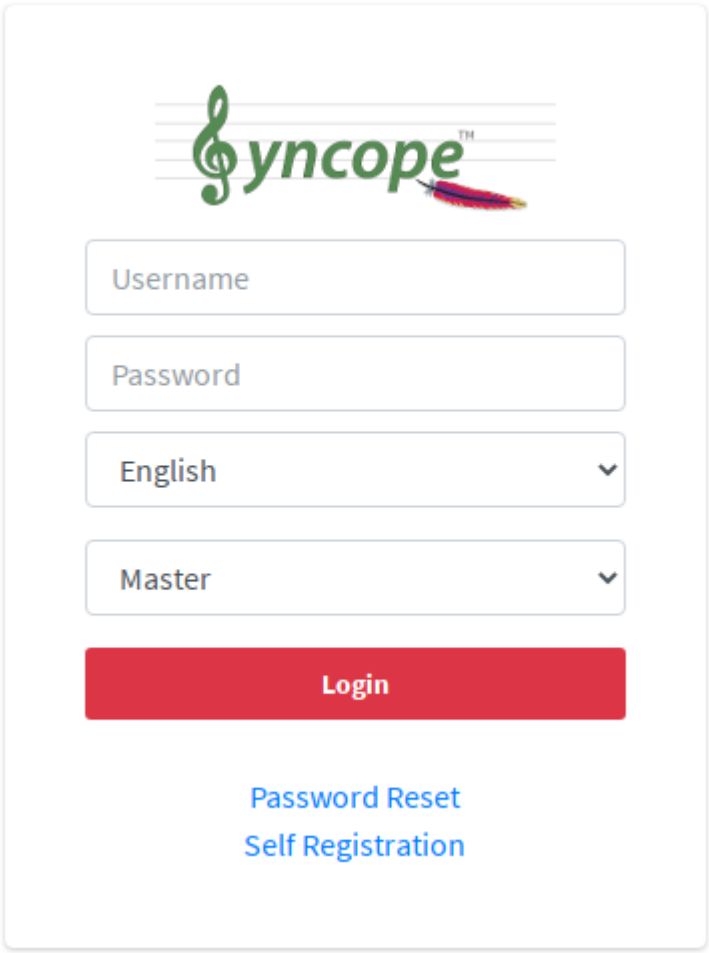
## 4.2. Enduser Application

Once the deployment is ready, the enduser application can be accessed at:

```
protocol://host:port/syncope-enduser/
```

where `protocol`, `host` and `port` reflect your deployment.

The scope of the enduser application is primarily to provide a dedicated web-based entry-point for self-registration, self-service and password reset.




### 4.2.1. Accessibility

The End-user UI is accessible to the visually impaired.

Two icons are present in the main page, in the right corner:

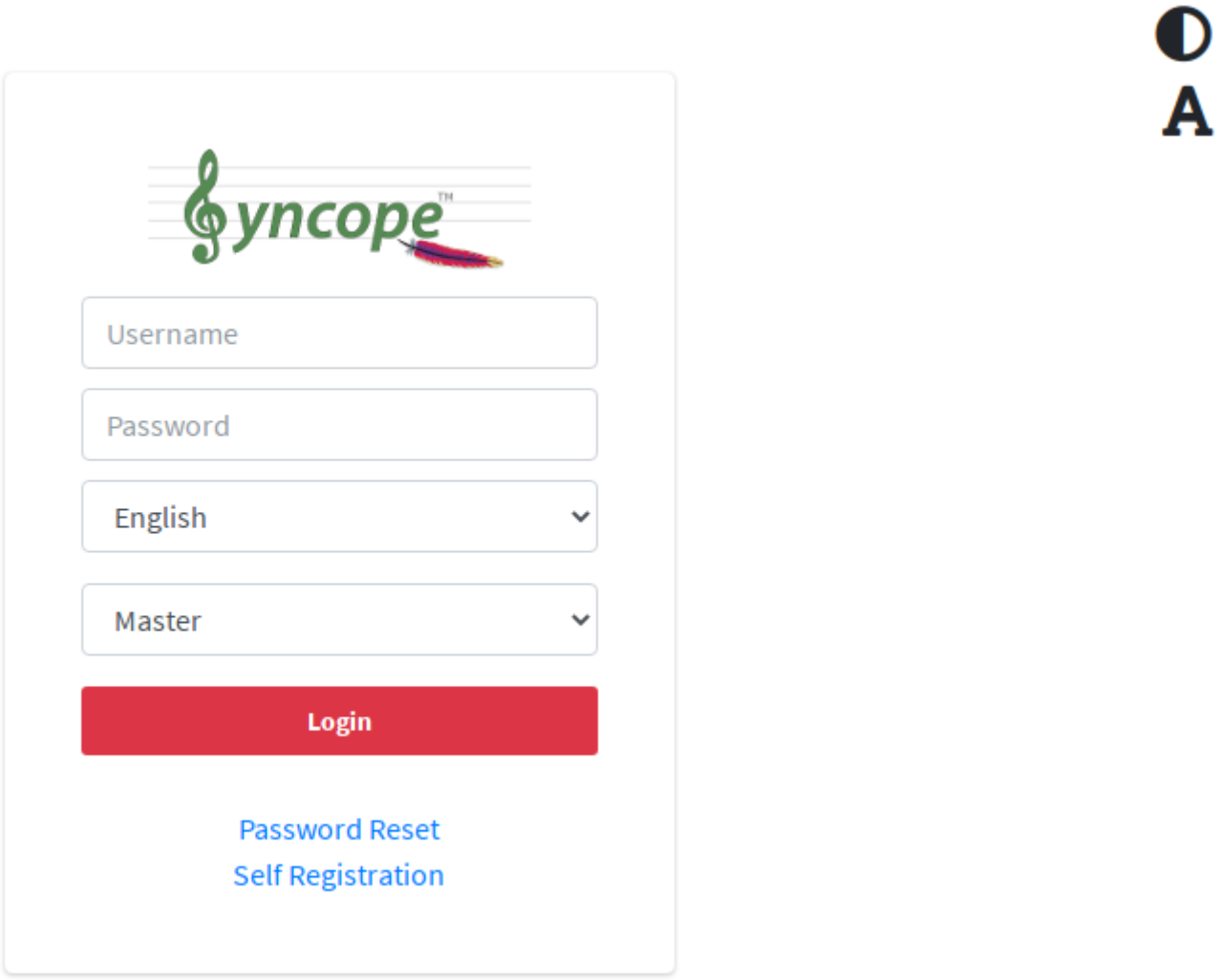



*Figure 20. Enduser accessibility icons*

By clicking the top right corner icon it is possible to toggle the "High contrast mode". In this mode, the website colors are switched to a higher contrast color schema.

The `H` accesskey shortcut can be used to easily toggle "High contrast mode" by using the keyboard.

E.g.

| Shortcut | Purpose |
|---|---|
| `Alt` + `Shift` + `H` | Toggle "High contrast mode" on Firefox and Chrome browsers on Linux |

By clicking the second icon it is possible to toggle the "Increased font mode". In this mode, the website font size is increased.

The `F` accesskey shortcut can be used to easily toggle "Increased font mode" by using the keyboard.

E.g.

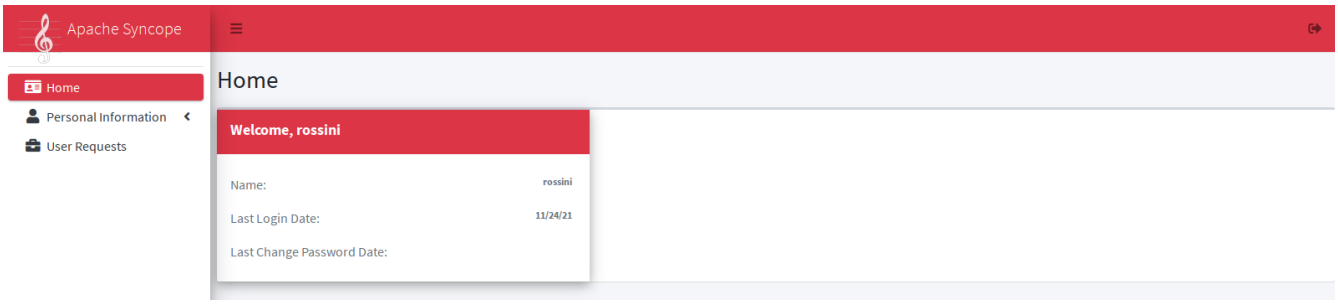
| Shortcut | Purpose |
| --- | --- |
| `Alt` + `Shift` + `F` | Toggle "Increased font mode" on Firefox and Chrome browsers on Linux |

To reset to the default mode, it is enough to click again on the specific icon.

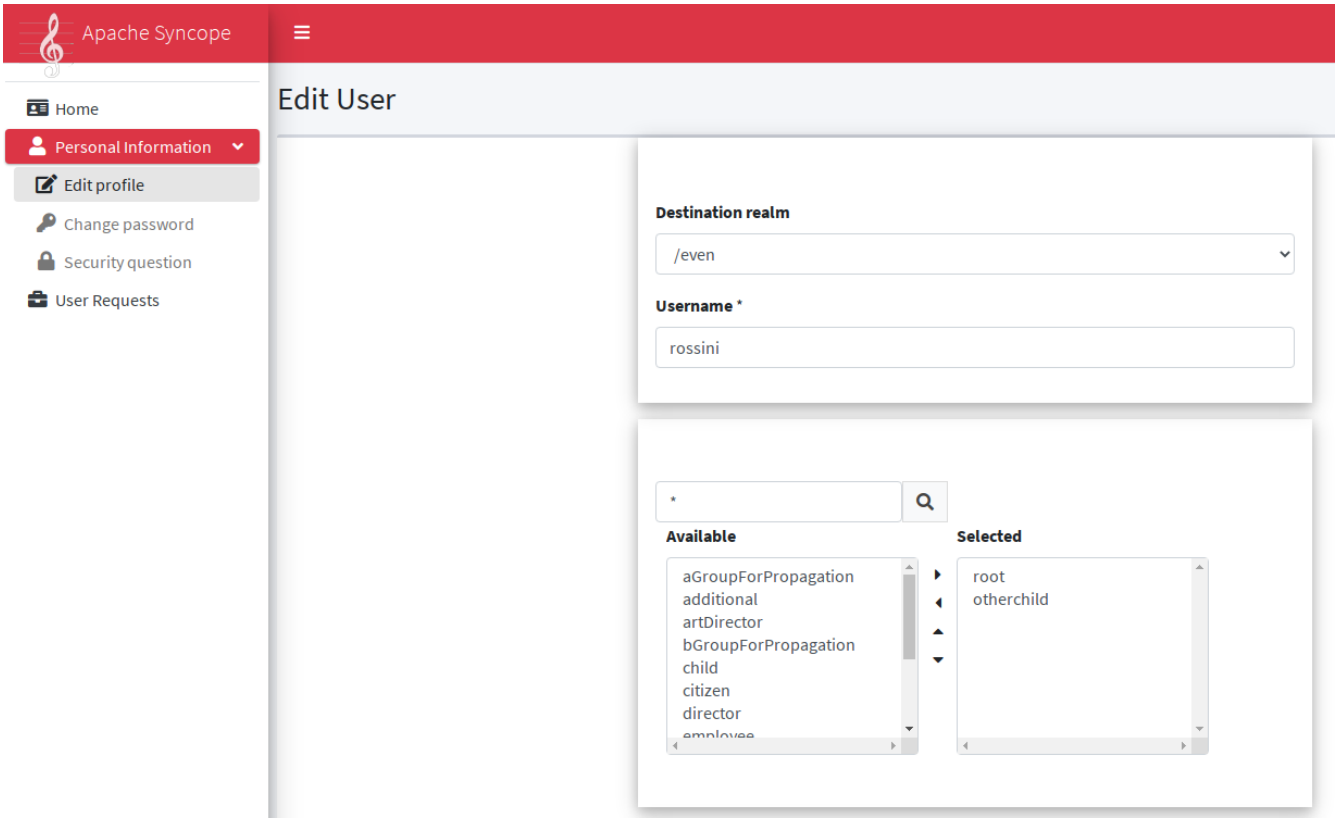
## 4.2.2. Pages

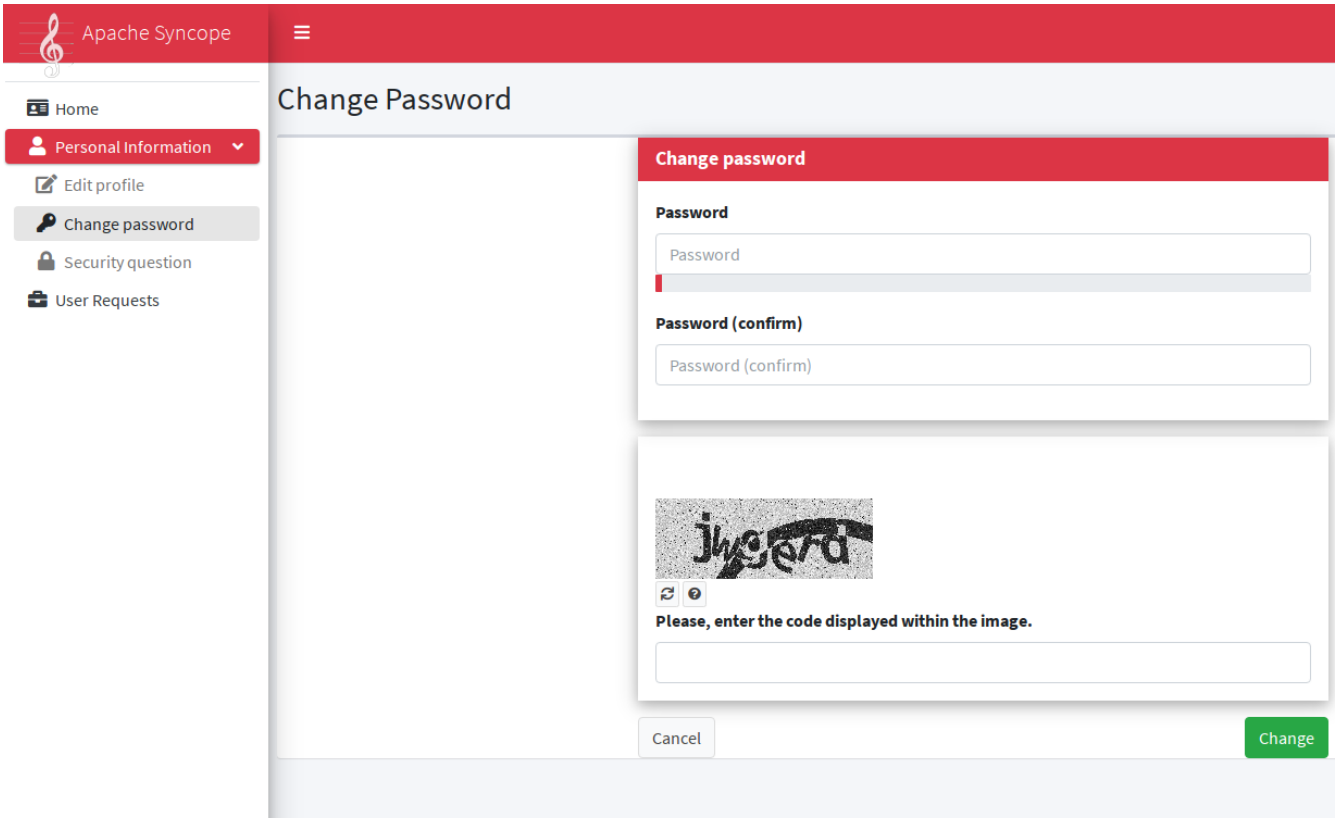
### Home

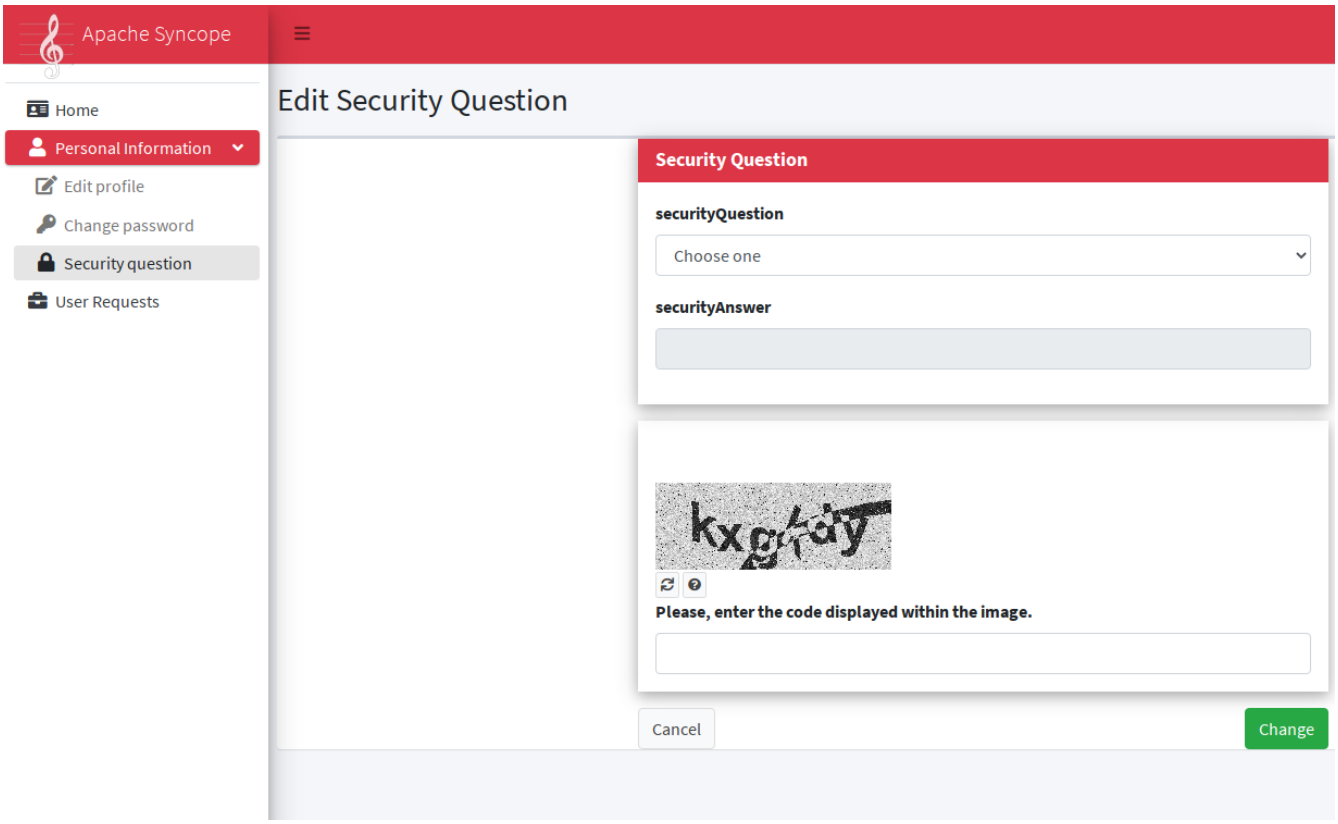
The Home page provides a welcome page for logged-in users.




### Personal Information






### User Requests

The images below refer to the printer assignment sample and to the typical request management flow as explained above.

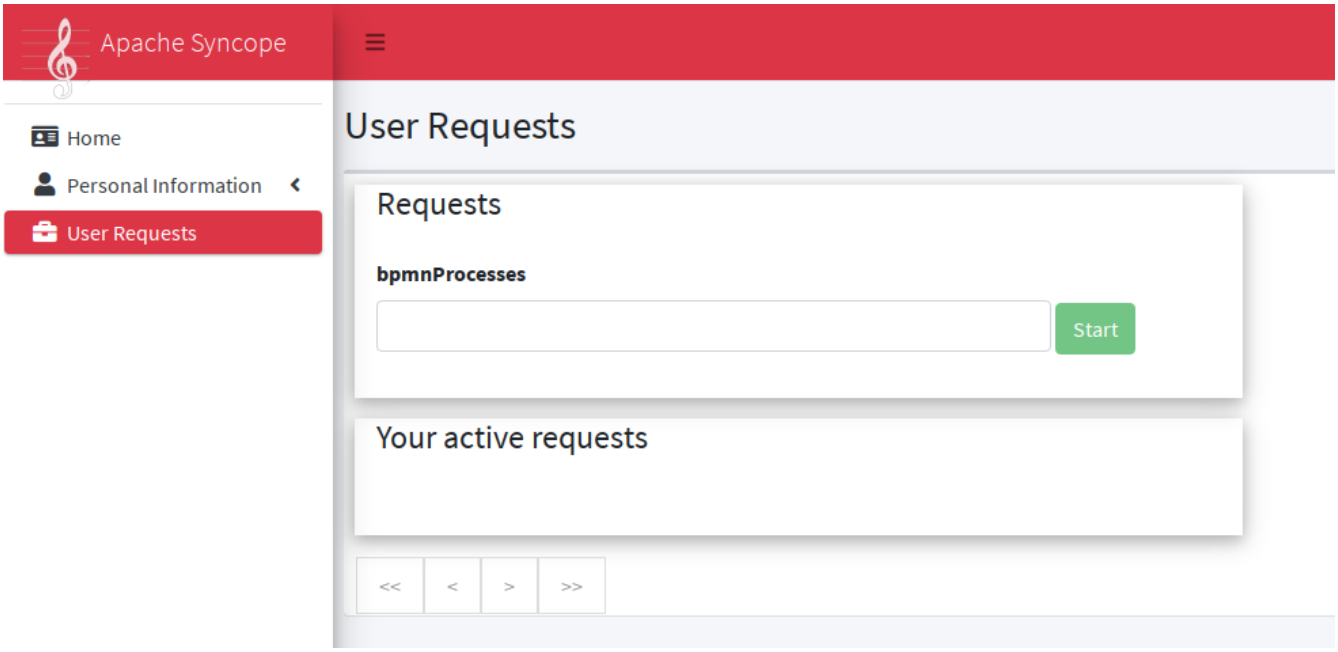



*Figure 21. Initial situation: no active requests*

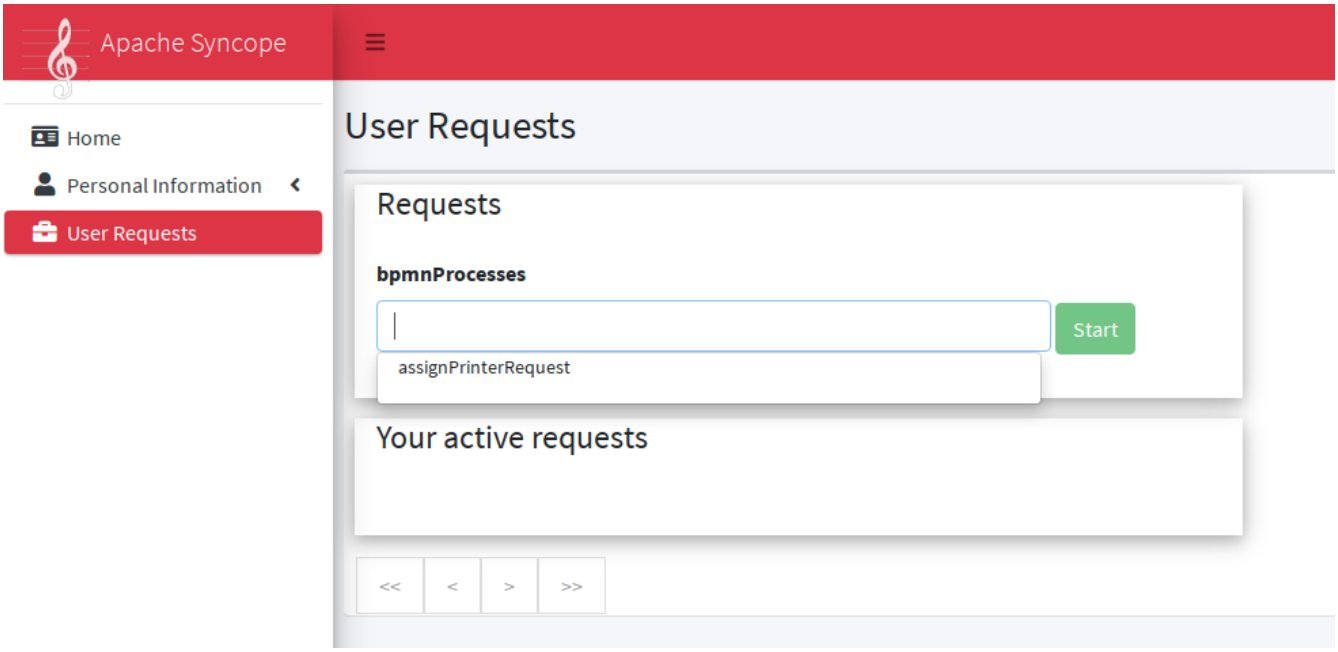



*Figure 22. Starting new request*

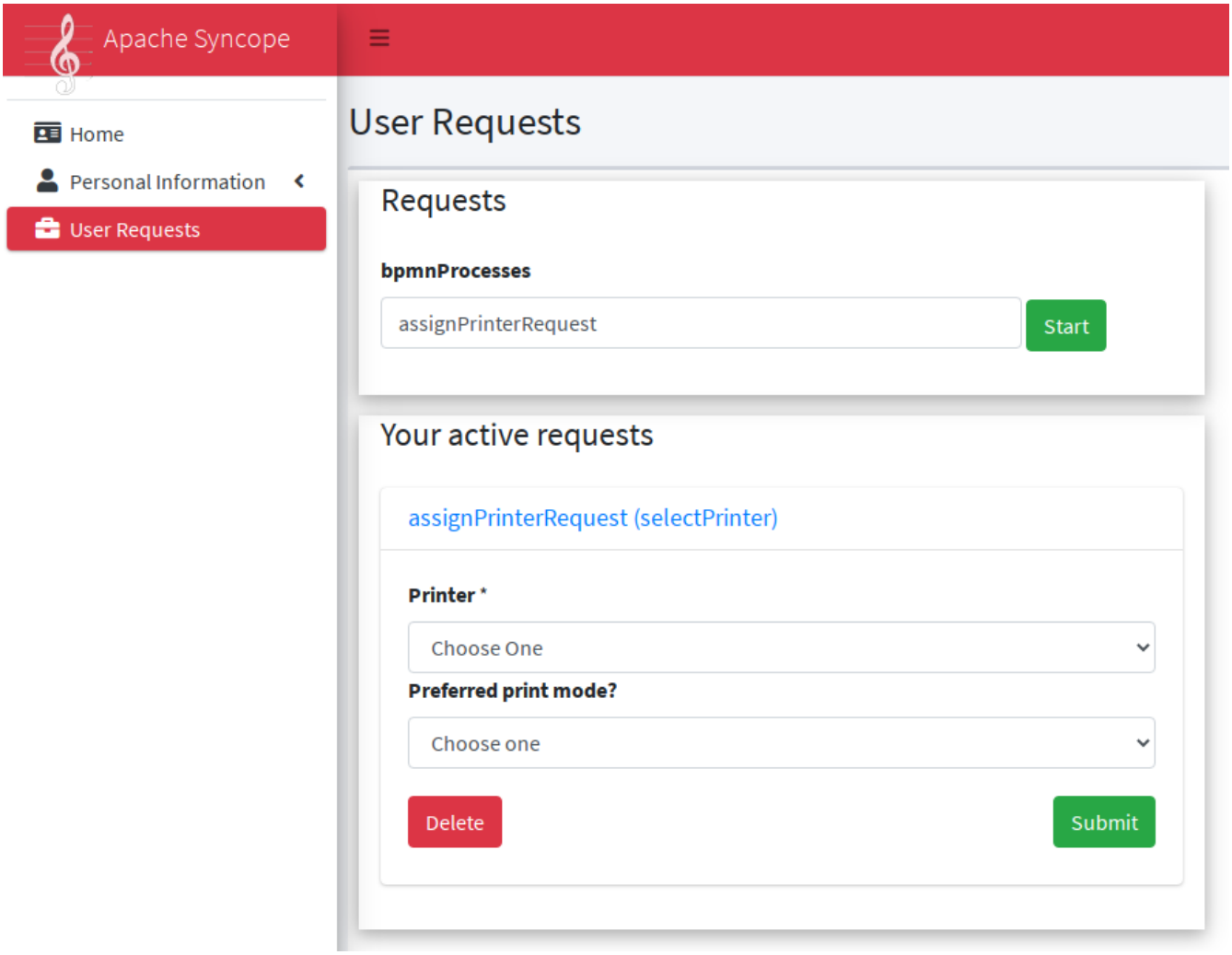



*Figure 23. Filling request form*

After submit, the request is ready to be managed by the configured administrators.

### Password Reset

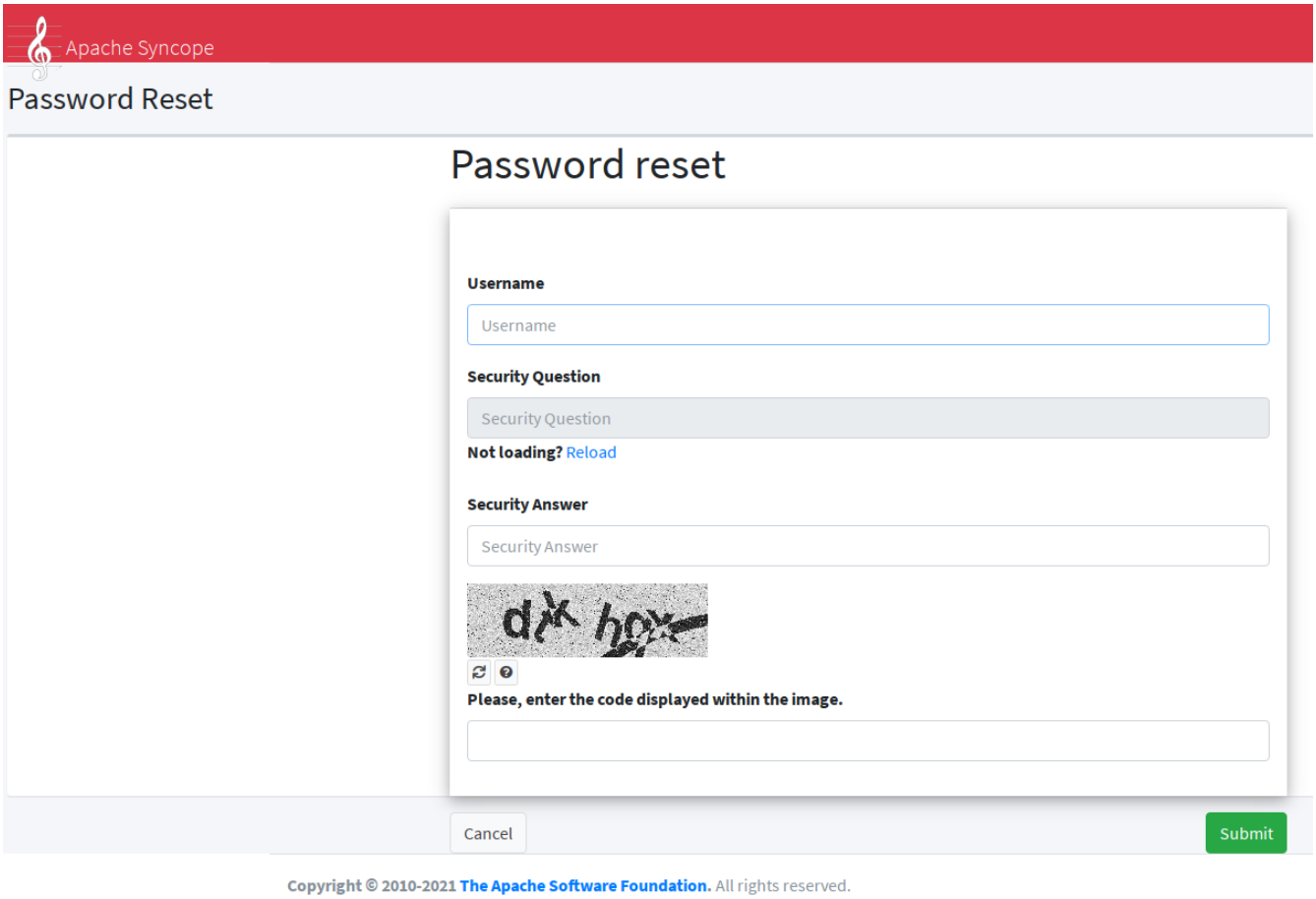



*Figure 24. Password reset*

## 4.3. Core

All the features provided by the Core are available as RESTful services.

The base URL for invoking such services is normally set as

```
protocol://host:port/syncope/rest/
```

where `protocol`, `host` and `port` reflect your deployment.

*REST Reference*

A complete REST reference generated from OpenAPI specification 3.0 is published as well as made available with each deployment at

```
protocol://host:port/syncope/rest/openapi.json
```

where `protocol`, `host` and `port` reflect your deployment.

REST APIs are available to visualize and interact via Swagger UI at

```
protocol://host:port/syncope/
```

### 4.3.1. REST Authentication and Authorization

The Core authentication and authorization is based on Spring Security.

As an initial step, authentication is required to obtain, in the `X-Syncope-Token` HTTP header, the unique signed JSON Web Token to include in all subsequent requests.

By providing the token received in the initial exchange, the requester can be identified and checked for authorization, based on owned entitlements.

Users can examine their own entitlements looking at the `X-Syncope-Entitlements` header value, and their own privileges looking at the `X-Syncope-Privileges` header value.

The relevant security configuration lies in securityContext.xml; while normally not needed, this configuration can be anyway customized via the override behavior.

HTTP Basic Authentication is set for use by default.

#### JWTSSOProvider

Besides validating and accepting the JSON Web Tokens generated during the authentication process as sketched above, Apache Syncope can be enabled to cope with tokens generated by third parties, by providing implementations of the JWTSSOProvider interface.

**Authorization Summary**

The set of RESTful services provided by Apache Syncope can be divided as:

1. endpoints accessible without any sort of authentication (e.g. truly anonymous), for self-registration and password reset;
2. endpoints disclosing information about the given Syncope deployment (available schema, configured extensions, Groups, ...), requiring some sort of shared authentication defined by the `anonymousKey` value in the `security.properties` file - for more information, read about Spring Security's Anonymous Authentication;
3. endpoints for self-service (self-update, password change, ...), requiring user authentication and no entitlements;
4. endpoints for administrative operations, requiring user authentication with authorization granted by the related entitlements, handed over to users via roles.

### 4.3.2. REST Headers

Apache Syncope supports a number of HTTP headers as detailed below, in addition to the common HTTP headers such as `Accept`, `Content-Type`, etc.

It is possible to deal with the headers below when using the Client Library via the

> `SyncopeClient` class methods.

#### X-Syncope-Token

`X-Syncope-Token` is returned on response to successful authentication, and contains the unique signed JSON Web Token identifying the authenticated user.

The value returned for the `X-Syncope-Token` header must be included in all subsequent requests, in order for the requester to be checked for authorization, as part of the standard Bearer `Authorization` header.

*Example 10. Obtaining JWT with curl*

```
curl -I -u admin:password -X POST
http://localhost:9080/syncope/rest/accessTokens/login
```

returns

```
HTTP/1.1 204
X-Syncope-Token: eyJ0e..
```

which can then be used to make a call to the REST API

```
curl -I -H "Authorization: Bearer eyJ0e.."
http://localhost:9080/syncope/rest/users/self
```

The token duration can be configured via the `jwt.lifetime.minutes` property - see below for details.

#### X-Syncope-Domain

`X-Syncope-Domain` can be optionally set for requests (when not set, `Master` is assumed) to select the target domain.
The value for this header is provided in all responses.

#### X-Syncope-Key and Location

When creating an entity (User, Group, Schema, External Resource, ...) these two headers are populated respectively with the entity key (which may be auto-generated) and the absolute URI identifying the new REST resource.

#### X-Application-Error-Code and X-Application-Error-Info

If the requested operation is in error, `X-Application-Error-Code` will contain the error code (mostly from ClientExceptionType) and `X-Application-Error-Info` might be optionally populated with more details, if available.

#### X-Syncope-Delegated-By

When requesting an operation under Delegation, this header must be provided to indicate the delegating User, either by their username or key.

#### X-Syncope-Null-Priority-Async

When set to `true`, this request header instructs the propagation process not to wait for completion when communicating with External Resources with no priority set.

#### Prefer and Preference-Applied

Some REST endpoints allow the clients to request certain behavior; this is done via the `Prefer` header.

When `Prefer` is specified in the request, the response will feature the `Preference-Applied` header, with value set to the effective preference applied.

##### return-content / return-no-content

REST endpoints for creating, updating or deleting Users, Groups or Any Objects return the entity in the response payload by default.
If this is not required, the `Prefer` request header can be set to `return-no-content` (`return-content` will instead keep the default behavior).

Use `Prefer: return-no-content` in scenarios where it is important to avoid unnecessary data in the response payload.

##### respond-async

The Batch endpoint can be requested for asynchronous processing.

#### ETag, If-Match and If-None-Match

For each response containing Users, Groups or Any Objects, the ETag header is generated, which contains the latest modification date.

This value can be passed, during subsequent requests to modify the same entity, via the `If-Match` or `If-None-Match` headers.
When the provided `If-Match` value does not match the latest modification date of the entity, an error is reported and the requested operation is not performed.

The combined usage of `ETag` and `If-Match` can be enforced to implement optimistic concurrency control over Users, Groups and Any Objects operations.

#### X-Syncope-Entitlements

When invoking the REST endpoint `/users/self` in `GET`, the `X-Syncope-Entitlements` response header will list all the entitlements owned by the requesting user.

#### X-Syncope-Delegations

When invoking the REST endpoint `/users/self` in `GET`, the `X-Syncope-Delegations` response header will list all delegating users for each Delegation for which the requesting user is delegated.

#### X-Syncope-Privileges

When invoking the REST endpoint `/users/self` in `GET`, the `X-Syncope-Privileges` response header will list all the privileges owned by the requesting user.

### 4.3.3. Batch

Batch requests allow grouping multiple operations into a single HTTP request payload.
A batch request is represented as a Multipart MIME v1.0 message, a standard format allowing the representation of multiple parts, each of which may have a different content type (currently JSON, YAML or XML), within a single request.

Batch requests are handled by the `/batch` REST endpoint: via HTTP `POST` method to submit requests, via HTTP `GET` method to fetch responses asynchronously.

The specification and implementation of batch processing in Apache Syncope is inspired by the standards defined by OData 4.0

#### Batch requests

The batch request must contain a `Content-Type` header specifying a content type of `multipart/mixed` and a boundary specification as defined in RFC2046.

The body of a batch request is made up of a series of individual requests, each represented as a distinct MIME part (i.e. separated by the boundary defined in the `Content-Type` header).

Core will process the requests within a batch request sequentially.

An individual request must include a `Content-Type` header with value `application/http` and a `Content-Transfer-Encoding` header with value `binary`.

*Example 11. Sample batch request*

```
--batch_61bfef8d-0a00-41aa-b775-7b6efff37652 ①
Content-Type: application/http
Content-Transfer-Encoding: binary
^M ②
POST /users HTTP/1.1 ③
Accept: application/json
Content-Length: 1157
Content-Type: application/json
^M
{"@class":"org.apache.syncope.common.lib.to.UserTO","key":null,"type":"USER","real
m":"/"}
--batch_61bfef8d-0a00-41aa-b775-7b6efff37652
```

```
Content-Type: application/http
Content-Transfer-Encoding: binary
^M
POST /groups HTTP/1.1 ④
Accept: application/xml
Content-Length: 628
Content-Type: application/xml
^M
<?xml version="1.0" encoding="UTF-8" standalone="yes"?><syncope30:group
xmlns:syncope30="https://syncope.apache.org/3.0">
</syncope30:group>
--batch_61bfef8d-0a00-41aa-b775-7b6efff37652
Content-Type: application/http
Content-Transfer-Encoding: binary
^M
PATCH /users/24eb15aebatch@syncope.apache.org HTTP/1.1 ⑤
Accept: application/json
Content-Length: 362
Content-Type: application/json
Prefer: return-no-content
^M
{"@class":"org.apache.syncope.common.lib.request.UserUR","key":"24eb15aebatch@sync
ope.apache.org"}
--batch_61bfef8d-0a00-41aa-b775-7b6efff37652
Content-Type: application/http
Content-Transfer-Encoding: binary
^M
DELETE /groups/287ede7c-98eb-44e8-979d-8777fa077e12 HTTP/1.1 ⑥
--batch_61bfef8d-0a00-41aa-b775-7b6efff37652--
```

① message boundary

② represents CR LF

③ user create, with JSON payload (shortened)

④ group create, with XML payload (shortened)

⑤ user update, with JSON payload (shortened)

⑥ group delete

**Batch responses**

Requests within a batch are evaluated according to the same semantics used when the request appears outside the context of a batch.

The order of individual requests in a batch request is significant.

If the set of request headers of a batch request are valid (the `Content-Type` is set to `multipart/mixed`, etc.) Core will return a `200 OK` HTTP response code to indicate that the request was accepted for processing, and the related execution results.

If Core receives a batch request with an invalid set of headers it will return a `400 Bad Request` code and perform no further processing of the request.

A response to a batch request must contain a `Content-Type` header with value `multipart/mixed`.

Structurally, a batch response body must match one-to-one with the corresponding batch request body, such that the same multipart MIME message structure defined for requests is used for responses

*Example 12. Sample batch response*

```
--batch_61bfef8d-0a00-41aa-b775-7b6efff37652 ①
Content-Type: application/http
Content-Transfer-Encoding: binary
^M ②
HTTP/1.1 201 Created ③
Content-Type: application/json
Date: Thu, 09 Aug 2018 09:55:46 GMT
ETag: "1533808545975"
Location: http://localhost:9080/syncope/rest/users/d399ba84-12e3-43d0-99ba-
8412e303d083
X-Syncope-Domain: Master
X-Syncope-Key: d399ba84-12e3-43d0-99ba-8412e303d083
^M
{"entity":{"@class":"org.apache.syncope.common.lib.to.UserTO"}
--batch_61bfef8d-0a00-41aa-b775-7b6efff37652
Content-Type: application/http
Content-Transfer-Encoding: binary
^M
HTTP/1.1 201 Created ④
Content-Type: application/xml
Date: Thu, 09 Aug 2018 09:55:46 GMT
ETag: "1533808546342"
Location: http://localhost:9080/syncope/rest/groups/843b2fc3-b8a8-4a8b-bb2f-
c3b8a87a8b2e
X-Syncope-Domain: Master
X-Syncope-Key: 843b2fc3-b8a8-4a8b-bb2f-c3b8a87a8b2e
^M
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<syncope30:provisioningResult
xmlns:syncope30="https://syncope.apache.org/3.0"></syncope30:provisioningResult>
--batch_61bfef8d-0a00-41aa-b775-7b6efff37652
Content-Type: application/http
Content-Transfer-Encoding: binary
^M
HTTP/1.1 204 No Content ⑤
Content-Length: 0
Date: Thu, 09 Aug 2018 09:55:47 GMT
Preference-Applied: return-no-content
X-Syncope-Domain: Master
```

```
^M
--batch_61bfef8d-0a00-41aa-b775-7b6efff37652
Content-Type: application/http
Content-Transfer-Encoding: binary
^M
HTTP/1.1 200 OK ⑥
Content-Type: application/json
Date: Thu, 09 Aug 2018 09:55:47 GMT
X-Syncope-Domain: Master
^M
{"entity":{"@class":"org.apache.syncope.common.lib.to.GroupTO"}
--batch_61bfef8d-0a00-41aa-b775-7b6efff37652--
```

① message boundary (same as request)

② represents CR LF

③ user create response, with JSON payload (shortened)

④ group create respose, with XML payload (shortened)

⑤ user update, no content as `Prefer: return-no-content` was specified

⑥ group delete response, with JSON payload (shortened)

**Asynchronous Batch Processing**

Batch requests may be executed asynchronously by including the `respond-async` preference in the `Prefer` header.

Core will return an empty response, with status `202 Accepted`.

Clients can poll the `/batch` endpoint in `GET` by passing the same boundary used for request: if `202 Accepted` is returned, then the request is still under processing; otherwise, `200 OK` will be returned, along with the full batch response.
Once retrieved, the batch response is not available any more from the `/batch` endpoint.

### 4.3.4. Search

It is possible to search for Users, Groups and Any Objects matching a set of given conditions expressed through FIQL.

The Feed Item Query Language (FIQL, pronounced “fickle”) is a simple but flexible, URI-friendly syntax for expressing filters across the entries in a syndicated feed.

The FIQL queries can be passed (among other parameters) to the search endpoints available, e.g.

- `GET /users?fiql=query`
- `GET /groups?fiql=query`
- `GET /anyObjects?fiql=query`
- `GET /resources/{resource}/{anytype}?fiql=query`

where:

- `query` is an URL-encoded string representation of the given FIQL query, as in the following examples;
- `resource` is one of defined external resources;
- `anytype` is one of defined any types.

*Example 13. Simple attribute match*

```
username==rossini
```

*Example 14. Wildcard attribute match*

```
username==*ini
```

*Example 15. Case-insensitive attribute match*

```
username=~rOsSiNi
```

*Example 16. Case-insensitive wildcard attribute match*

```
username=~*iNi
```

*Example 17. Null attribute match*

```
loginDate==$null
```

*Example 18. Date attribute comparison*

```
lastLoginDate=ge=2016-03-02 15:21:22
```

*Example 19. Auxiliary Any Type class assignment*

```
$auxClasses==csv
```

*Example 20. Resource assignment match*

```
$resources==resource-ldap
```

*Example 21. Group membership match (only for Users and Any Objects)*

```
$groups==root
```

*Example 22. Wildcard group membership match (only for Users and Any Objects)*

```
$groups==*child
```

*Example 23. Role membership match (only for Users)*

```
$roles==Other
```

*Example 24. Relationship type match (only for Users and Any Objects)*

```
$relationshipTypes==neighborhood
```

*Example 25. Relationship match (only for Users and Any Objects)*

```
$relationships==Canon MF 8030c
```

*Example 26. Type match (only for Any Objects)*

```
$type==PRINTER
```

*Example 27. Complex match (featuring logical AND and OR)*

```
username=~*iNi;(loginDate==$null,$roles==Other)
```

#### Sorting Search Results

Search results can be requested for sorting by passing the optional `orderBy` query parameter to the search endpoints available, e.g.

- `GET /users?fiql=query&orderBy=sort`
- `GET /groups?fiql=query&orderBy=sort`
- `GET /anyObjects?fiql=query&orderBy=sort`
- `GET /resources/{resource}/{anytype}?orderBy=sort`

where `sort` is an URL-encoded string representation of the sort request, as in the following examples.

*Example 28. Single attribute sort, default direction (`ASC`)*

```
username
```

*Example 29. Single attribute sort, with direction*

```
username DESC
```

*Example 30. Multiple attribute sort, with directions*

```
email DESC, username ASC
```

## 4.4. Client Library

The Java client library simplifies the interaction with the Core by hiding the underlying HTTP communication details and providing native methods and payload objects.

The library is available as a Maven artifact:

```
<dependency>
  <groupId>org.apache.syncope.client.idrepo</groupId>
  <artifactId>syncope-client-idrepo-lib</artifactId>
  <version>4.0.0-SNAPSHOT</version>
</dependency>
```

Do not forget to add the following repository to your `pom.xml`:

```
<repository>
```

```
  <id>ASF</id>

<url>https://repository.apache.org/content/repositories/snapshots/</url
>
  <snapshots>
    <enabled>true</enabled>
  </snapshots>
</repository>
```

#### Initialization

First you need to build an instance of `SyncopeClientFactoryBean` by providing the deployment base URL, as follows:

```
SyncopeClientFactoryBean clientFactory = new SyncopeClientFactoryBean().
              setAddress("http://localhost:9080/syncope/rest/");
```

You might also select a specific domain - other than `Master`, choose to exchange XML payloads - rather than JSON (default), to select HTTP compression or to set the TLS client configuration (more options in the Javadoc):

```
TLSClientParameters tlsClientParameters = ...;
SyncopeClientFactoryBean clientFactory = new SyncopeClientFactoryBean().
              setAddress("http://localhost:9080/syncope/rest/").
              setDomain("Two").
              setContentType(SyncopeClientFactoryBean.ContentType.XML).
              setUseCompression(true).
              setTlsClientParameters(tlsClientParameters);
```

At this point an instance of `SyncopeClient` can be obtained by passing the login credentials via:

```
SyncopeClient client = clientFactory.create("admin", "password");
```

Or you can combine into a single statement as:

```
SyncopeClient client = new SyncopeClientFactoryBean().
              setAddress("http://localhost:9080/syncope/rest/").
              create("admin", "password");
```

#### Examples

Select one of the RESTful services and invoke one of the available methods:

```
LoggerService loggerService = client.getService(LoggerService.class);
```

```
LoggerTO loggerTO = loggerService.read(LoggerType.LOG,
"org.apache.syncope.core.connid");
loggerTO.setLevel(LoggerLevel.DEBUG);

loggerService.update(LoggerType.LOG, loggerTO);
```

Advanced REST features are also available from `SyncopeClient` instances: check the javadoc for more information.

*Example 31. Search for Users, Groups or Any Objects*

All search operations return paged result handlers which can be exploited both for getting the actual results and for extrapolating pagination coordinates.

```
UserService userService = client.getService(UserService.class);

int count = userService.search(new
AnyQuery.Builder().page(0).size(0).build()).getTotalCount(); ①

PagedResult<UserTO> matchingUsers = userService.search(
    new AnyQuery.Builder().realm(SyncopeConstants.ROOT_REALM).
    fiql(SyncopeClient.getUserSearchConditionBuilder().is("username").
    equalTo("ros*ini").query()).build()); ②

PagedResult<UserTO> matchingUsers = userService.search(
    new AnyQuery.Builder().realm(SyncopeConstants.ROOT_REALM).

fiql(SyncopeClient.getUserSearchConditionBuilder().isNull("loginDate").query()).
    build()); ③

PagedResult<UserTO> matchingUsers = userService.search(
    new AnyQuery.Builder().realm(SyncopeConstants.ROOT_REALM).
    fiql(SyncopeClient.getUserSearchConditionBuilder().inRoles("Other").query()).
    build()); ④

AnyObjectService anyObjectService = client.getService(AnyObjectService.class);

PagedResult<AnyObjectTO> matchingAnyObjects = anyObjectService.search(
    new AnyQuery.Builder().realm(SyncopeConstants.ROOT_REALM).
    fiql(SyncopeClient.getAnyObjectSearchConditionBuilder("PRINTER").query()).
    build()); ⑤

GroupService groupService = client.getService(GroupService.class);

PagedResult<GroupTO> matchingGroups = groupService.search(
    new AnyQuery.Builder().realm("/even/two").page(3).size(150).
    fiql(SyncopeClient.getGroupSearchConditionBuilder().
        is("name").equalTo("palo*").query()).
```

```
    build()); ⑥
```

① get the total number of users available in the given deployment (and domain)

② get users in the root realm with username matching the provided wildcard expression

③ get users in the root realm with no values for `loginDate`, i.e. that have never authenticated to the given deployment

④ get users in the root realm with role `Other` assigned

⑤ get all any objects in the root realm with type `PRINTER`

⑥ get all groups having name starting with prefix 'palo' - third page of the result, where each page contains 150 items

*Example 32. Delete several users at once*

```
BatchRequest batchRequest = client.batch(); ①

UserService batchUserService = batchRequest.getService(UserService.class);

final int pageSize = 100;
final int count = userService.search(
        new AnyQuery.Builder().page(0).size(0).build()).getTotalCount(); ②
for (int page = 1; page <= (count / pageSize) + 1; page++) {
    for (UserTO user : userService.search(
            new AnyQuery.Builder().page(page).size(pageSize).build()).getResult())
{  ③

        batchUserService.delete(user.getKey()); ④
    }
}

BatchResponse batchResponse = batchRequest.commit();  ⑤
List<BatchResponseItem> batchResponseItems = batchResponse.getItems(); ⑥
```

① begin the batch request

② get the total number of users available in the given deployment (and domain)

③ loop through all users available, using paginated search

④ add each user's deletion to the batch request

⑤ send the batch request for processing

⑥ examine the batch results

*Example 33. Self-read own profile information*

```
Triple<Map<String, Set<String>>, List<String>, UserTO> self = client.self();
UserTO userTO = self.getRight(); ①
```

```
Map<String, Set<String>> realm2entitlements = self.getLeft(); ②
List<String> delegations = self.getMiddle(); ③
```

① UserTO of the requesting user

② for each realm, the owned entitlements

③ delegations assigned to the requesting user

*Example 34. Change user status*

```
String key = ...; ①
StatusR statusR = new StatusR();
statusR.setKey(key);
statusR.setType(StatusRType.SUSPEND); ②
UserTO userTO = userService.status(statusR).
  readEntity(new GenericType<ProvisioningResult<UserTO>>() {
  }).getEntity(); ③
```

① assume the key of the user to be suspended is known in advance

② `ACTIVATE`, `SUSPEND`, `REACTIVATE` values are accepted, and honoured depending on the actual status of the user being updated

③ request for user update and read back the updated entity

## 4.5. Customization

Only Maven projects can be customized: if using Standalone, none of the customizations discussed below can be applied.

Apache Syncope is designed to be as flexible as possible, to best suit the various environments in which it can be deployed. Besides other aspects, this means that every feature and component can be extended or replaced.

Once the project has been created from the provided Maven archetype, the generated source tree is available for either adding new features or replacing existing components.

In general, the Embedded Mode (see the Apache Syncope Getting Started Guide for details) allows developers to work comfortably from a single workstation, with no need of additional setup; it is effectively implemented as the `all` Maven profile, where the available optional components and extensions are enabled.
When deploying the generated artifacts as Standalone or into an external JavaEE Container however, the required components and extensions need to be explicitly selected and enabled, as shown in the following text.

The artifacts are generated by running the Maven command (with reference to the suggested directory layout):

```
$ mvn clean verify
$ cp core/target/classes/*properties /opt/syncope/conf
$ cp console/target/classes/*properties /opt/syncope/conf
$ cp enduser/target/classes/*properties /opt/syncope/conf
$ cp enduser/target/classes/*json /opt/syncope/conf
$ cp wa/target/classes/*properties /opt/syncope/conf
$ cp sra/target/classes/*properties /opt/syncope/conf
```

After downloading all of the dependencies that are needed, three following artifacts will be produced:

1. `core/target/syncope.war`
2. `console/target/syncope-console.war`
3. `enduser/target/syncope-enduser.war`
4. `wa/target/syncope-wa.war`
5. `sra/target/syncope-sra.jar`

If no failures are encountered, your basic Apache Syncope project is now ready to be deployed.

Do not forget to define the following system properties:

- `-Dsyncope.conf.dir=/opt/syncope/conf`
  (required by Core and WA)
- `-Dsyncope.connid.location=file:/opt/syncope/bundles`
  (required by Core)
- `-Dsyncope.log.dir=/opt/syncope/log`
  (required by all components)

*JPDA Debug in Embedded Mode*

The Java™ Platform Debugger Architecture (JPDA) is a collection of APIs aimed to help with debugging Java code.

Enhancing the `embedded` profile of the `fit` module to enable the JPDA socket is quite straightforward: just add the `<profile>` below to `fit/pom.xml`:

```
<profile>
  <id>debug</id>

  <build>
    <plugins>
      <plugin>
        <groupId>org.codehaus.cargo</groupId>
        <artifactId>cargo-maven3-plugin</artifactId>
        <inherited>true</inherited>
        <configuration>
          <configuration>
```

```
            <properties>
              <cargo.jvmargs>
                -Xdebug

-Xrunjdwp:transport=dt_socket,address=8000,server=y,suspend=n
                -Dspring.profiles.active=embedded
                -Xmx1024m -Xms512m
              </cargo.jvmargs>
            </properties>
          </configuration>
        </configuration>
      </plugin>
    </plugins>
  </build>
</profile>
```

Now, from the `fit` subdirectory, execute:

```
$ mvn -P embedded,debug
```

At this point your favourite IDE can be attached to the port `8000`.

### 4.5.1. General considerations

#### Override behavior

As a rule of thumb, any file of the local project will take precedence over a file with the same name in the same package directory of the standard Apache Syncope release.

For example, if you place

```
core/src/main/java/org/apache/syncope/core/spring/security/UsernamePasswordAuthenticat
ionProvider.java
```

in the local project, this file will be picked up instead of UsernamePasswordAuthenticationProvider.

The same happens with resources as images or HTML files; if you place

```
console/src/main/resources/org/apache/syncope/client/console/pages/BasePage.html
```

in the local project, this file will be picked up instead of BasePage.html.

#### Extending configuration

Apache Syncope components are built on Spring Boot, hence designing and extending Syncope configuration very much comes down to their guide, some aspects of which are briefly highlighted

here.

To design your own configuration class, take inspiration from the following sample:

```
package org.apache.syncope.custom.config;

@Configuration("SomethingConfiguration") ①
@EnableConfigurationProperties(LogicProperties.class)
public class SomethingConfiguration {

    @Autowired
    private LogicProperties logicProperties;

    @Autowired
    @Qualifier("someOtherBeanId")
    private SomeBean someOtherBeanId;

    @RefreshScope ②
    @Bean
    public MyBean myBean() {
        return new MyBean();
    }
}
```

① `@Configuration` classes can be assigned an order with `@Order(1984)` which would place them in an ordered queue waiting to be loaded in that sequence; to be more explicit, `@Configuration` classes can also be loaded exactly before/after another `@Configuration` component with `@AutoConfigureBefore` or `@AutoConfigureAfter` annotations.

② The `@Bean` definitions can also be tagged with `@RefreshScope` to become auto-reloadable when the enclosing Syncope componet context is refreshed as a result of an external property change.

In order to register your own configuration class, create a file named

```
<component>/src/main/resources/META-
INF/spring/org.springframework.boot.autoconfigure.AutoConfiguration.imports
```

with content

```
org.apache.syncope.custom.config.SomethingConfiguration
```

What if you needed to override the definition of a Syncope-provided bean and replace it entirely with your own?
Most component/bean definitions are registered with some form of `@Conditional` tag that indicates to the bootstrapping process to ignore their creation, if a bean definition with the same id is already defined. This means you can create your own configuration class, register it and the design a `@Bean` definition only to have the context utilize yours rather than what ships with Syncope by default.

*Bean Names*

To correctly define a conditional Bean, you generally need to make sure your own bean definition is created using the same name or identifier as its original equivalent. It is impractical and certainly overwheling to document all runtime bean definitions and their identifiers. So, you will need to study the Syncope codebase to find the correct onfiguration classes and bean defnitions to note their name.

**Deployment directories**

Apache Syncope needs three base directories to be defined:

- bundles - where the connector bundles are stored;
- log - where all the system logs are written;
- conf - where configuration files are located.

The `bundles` directory should only contain connector bundle JAR files.
The presence of any other file might cause the unavailability of any connector bundle in Apache Syncope.

For reference, the suggested directory layout can be created as follows:

```
$ mkdir /opt/syncope
$ mkdir /opt/syncope/bundles
$ mkdir /opt/syncope/log
$ mkdir /opt/syncope/conf
```

The `conf` directory must be configured for deployment, following Spring Boot's Externalized Configuration settings; with above reference:

- Standalone: `--spring.config.additional-location=/opt/syncope/conf/`
- JavaEE Container: `-Dspring.config.additional-location=/opt/syncope/conf/`

### 4.5.2. Core

When providing custom Java classes implementing the defined interfaces or extending the existing implementations, their package **must** be rooted under `org.apache.syncope.core`, otherwise they will not be available at runtime.

Besides replacing existing classes as explained above, new implementations can be provided - in the source tree under `core/src/main/java` when Java or via REST services if Groovy - for the following components:

- propagation, push, pull and logic actions
- push / pull correlation rules

- reconciliation filter builders
- commands
- macros
- scheduled tasks
- reports
- account and password rules for policies
- plain schema validators
- mapping item transformers
- workflow adapters
- provisioning managers
- notification recipient providers
- JWT SSO providers
- audit event processors

#### Customize OpenJPA settings

Apache OpenJPA is at the core of the persistence layer; its configuration can be tweaked under several aspects - including caching for example, to best suit the various environments.

The main configuration classes are:

- PersistenceContext
- MasterDomain
- DomainConfFactory

The `@Bean` declarations from these classes can be customized as explained above.

#### Enable the Flowable User Workflow Adapter

Add the following dependency to `core/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.flowable</groupId>
  <artifactId>syncope-ext-flowable-rest-cxf</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

#### Enable the SAML 2.0 Service Provider for UI extension

Add the following dependencies to `core/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.saml2sp4ui</groupId>
```

```
  <artifactId>syncope-ext-saml2sp4ui-rest-cxf</artifactId>
  <version>${syncope.version}</version>
</dependency>
<dependency>
  <groupId>org.apache.syncope.ext.saml2sp4ui</groupId>
  <artifactId>syncope-ext-saml2sp4ui-persistence-jpa</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

Setup a keystore and place it under the configuration directory, then take the properties from `core/src/test/resources/core-all.properties` into your configuration and review accordingly.

#### Enable the OpenID Connect Client for UI extension

Add the following dependencies to `core/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.oidcc4ui</groupId>
  <artifactId>syncope-ext-oidcc4ui-rest-cxf</artifactId>
  <version>${syncope.version}</version>
</dependency>
<dependency>
  <groupId>org.apache.syncope.ext.oidcc4ui</groupId>
  <artifactId>syncope-ext-oidcc4ui-persistence-jpa</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

#### Enable the Elasticsearch extension

Add the following dependencies to `core/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.elasticsearch</groupId>
  <artifactId>syncope-ext-elasticsearch-provisioning-java</artifactId>
  <version>${syncope.version}</version>
</dependency>
<dependency>
  <groupId>org.apache.syncope.ext.elasticsearch</groupId>
  <artifactId>syncope-ext-elasticsearch-persistence</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

Create

```
elasticsearch.hosts[0]=http://localhost:9200
elasticsearch.indexMaxResultWindow=10000
elasticsearch.numberOfShards=1
```

```
elasticsearch.numberOfReplicas=1
```

as `core/src/main/resources/core-elasticsearch.properties`.

Do not forget to include `elasticsearch` as Spring Boot profile for the Core application.

If needed, customize the `@Bean` declarations from ElasticsearchClientContext as explained above.

It is also required to initialize the Elasticsearch indexes: add a new Java implementation for `TASKJOB_DELEGATE` and use `org.apache.syncope.core.provisioning.java.job.ElasticsearchReindex` as class.
Then, create a new scheduled task, select the implementation just created as job delegate and execute it.

The `org.apache.syncope.core.provisioning.java.job.ElasticsearchReindex` task created above is not meant for scheduled execution; rather, it can be run every time you want to blank and re-create the Elasticsearch indexes starting from Syncope's internal storage.

**Enable the OpenSearch extension**

Add the following dependencies to `core/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.opensearch</groupId>
  <artifactId>syncope-ext-opensearch-provisioning-java</artifactId>
  <version>${syncope.version}</version>
</dependency>
<dependency>
  <groupId>org.apache.syncope.ext.opensearch</groupId>
  <artifactId>syncope-ext-opensearch-persistence</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

Create

```
opensearch.hosts[0]=http://localhost:9200
opensearch.indexMaxResultWindow=10000
opensearch.numberOfShards=1
opensearch.numberOfReplicas=1
```

as `core/src/main/resources/core-opensearch.properties`.

Do not forget to include `opensearch` as Spring Boot profile for the Core application.

If needed, customize the `@Bean` declarations from OpenSearchClientContext as explained above.

It is also required to initialize the OpenSearch indexes: add a new Java implementation for

`TASKJOB_DELEGATE` and use `org.apache.syncope.core.provisioning.java.job.OpenSearchReindex` as class.
Then, create a new scheduled task, select the implementation just created as job delegate and execute it.

The `org.apache.syncope.core.provisioning.java.job.OpenSearchReindex` task created above is not meant for scheduled execution; rather, it can be run every time you want to blank and re-create the OpenSearch indexes starting from Syncope's internal storage.

**Enable the SCIM extension**

Add the following dependencies to `core/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.scimv2</groupId>
  <artifactId>syncope-ext-scimv2-rest-cxf</artifactId>
  <version>${syncope.version}</version>
</dependency>
<dependency>
  <groupId>org.apache.syncope.ext.scimv2</groupId>
  <artifactId>syncope-ext-scimv2-scim-rest-cxf</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

**New REST endpoints**

Adding a new REST endpoint involves several operations:

1. create - in an extension's `rest-api` module or under `common` otherwise - a Java interface with package `org.apache.syncope.common.rest.api.service` and proper JAX-RS annotations; check BpmnProcessService for reference;
2. if needed, define supporting payload objects - in an extension's `common-lib` module or under `common` otherwise; check BpmnProcess for reference;
3. implement - in an extension's `rest-cxf` module or under `core` otherwise - the interface defined above in a Java class with package `org.apache.syncope.core.rest.cxf.service`; check BpmnProcessServiceImpl for reference.

By following such conventions, the new REST endpoint will be automatically picked up alongside the default services.

### 4.5.3. Console

When providing custom Java classes implementing the defined interfaces or extending the existing implementations, their package **must** be rooted under `org.apache.syncope.client.console`, otherwise they will not be available at runtime.

#### Enable the Flowable User Workflow Adapter

Add the following dependency to `console/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.flowable</groupId>
  <artifactId>syncope-ext-flowable-client-console</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

#### Enable the SAML 2.0 Service Provider for UI extension

Add the following dependencies to `console/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.saml2sp4ui</groupId>
  <artifactId>syncope-ext-saml2sp4ui-client-console</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

#### Enable the OpenID Connect Client for UI extension

Add the following dependencies to `console/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.oidcc4ui</groupId>
  <artifactId>syncope-ext-oidcc4ui-client-console</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

#### Enable the SCIM extension

Add the following dependencies to `console/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.scimv2</groupId>
  <artifactId>syncope-ext-scimv2-client-console</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

### 4.5.4. Enduser

When providing custom Java classes implementing the defined interfaces or extending the existing implementations, their package **must** be rooted under `org.apache.syncope.client.enduser`, otherwise they will not be available at

runtime.

#### Enable the Flowable User Workflow Adapter

Add the following dependency to `enduser/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.flowable</groupId>
  <artifactId>syncope-ext-flowable-client-enduser</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

#### Enable the SAML 2.0 Service Provider for UI extension

Add the following dependencies to `enduser/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.saml2sp4ui</groupId>
  <artifactId>syncope-ext-saml2sp4ui-client-enduser</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

#### Enable the OpenID Connect Client for UI extension

Add the following dependencies to `enduser/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.ext.oidcc4ui</groupId>
  <artifactId>syncope-ext-oidcc4ui-client-enduser</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

#### Form customization

The Enduser Application allows to customize the form in order to:

- hide / show attributes
- set attributes read-only for users
- provide default value(s)

Under the `enduser/src/main/resources` directory, the `customFormLayout.json` file is available, allowing to configure form customization.

### 4.5.5. WA

When providing custom Java classes implementing the defined interfaces or

extending the existing implementations, their package **must** be rooted under `org.apache.syncope.wa`, otherwise they will not be available at runtime.

### 4.5.6. SRA

When providing custom Java classes implementing the defined interfaces or extending the existing implementations, their package **must** be rooted under `org.apache.syncope.sra`, otherwise they will not be available at runtime.

### 4.5.7. Extensions

Extensions can be part of a local project, to encapsulate special features which are specific to a given deployment.

For example, the CHOReVOLUTION IdM - based on Apache Syncope - provides an extension for managing via the Core and visualizing via the Admin UI the running choreography instances.

## 4.6. Actuator Endpoints

Spring Boot's actuator endpoints let you monitor and interact with Syncope components.

Each individual endpoint can be enabled / disabled and exposed over HTTP (pre-defined, under the `/actuator` subcontext) or JMX.

Besides a number of built-in endpoints, more are made available for each component, as reported below.

The pre-defined `health` and `info` endpoints are extended by each Syncope component, to add sensible data for the given component.

The pre-defined `health` endpoint is typically used for liveness and readiness probes, even with Kubernetes.

### 4.6.1. Core

| | |
|---|---|
| `entityCache` | Allows to work with JPA cache statistics<br>• `GET` - shows JPA cache statistics<br>• `POST {ENABLE,DISABLE,RESET}` - performs the requested operation onto JPA cache<br>• `DELETE` - clears JPA cache's current content |

### 4.6.2. WA

| | |
|---|---|
| `ssoSessions` | More details |

| | |
|---|---|
| `registeredServices` | More details |
| `authenticationHandlers` | More details |
| `authenticationPolicies` | More details |
| `resolveAttributes` | More details |

### 4.6.3. SRA

| | |
|---|---|
| `sraSessions` | • `GET` - lists the current sessions<br>• `GET {id}` - reads the session with given `id`<br>• `DELETE {id}` - removes the session with given `id` |
| `gateway` | More details |

# Chapter 5. Configuration

**Where are the configuration files?**

Depending on which Apache Syncope distribution you are running, the configuration files mentioned in the following text might reside in different locations.

**Standalone**

Assuming that `$CATALINA_HOME` is the Apache Tomcat base directory created when the distribution archive was unzipped, the configuration files are located under

- `$CATALINA_HOME/webapps/syncope/WEB-INF/classes/`
- `$CATALINA_HOME/webapps/syncope-console/WEB-INF/classes/`
- `$CATALINA_HOME/webapps/syncope-enduser/WEB-INF/classes/`
- `$CATALINA_HOME/webapps/syncope-wa/WEB-INF/classes/`

**Maven project**

Assuming that `$CONF_DIRECTORY` is the directory passed among deployment directories at build time and that `$SOURCE` is the path where the Maven project was generated, the configuration files will be first searched in `$CONF_DIRECTORY`, then under the selected deployment's application classpath, according to the content of

- `$SOURCE/core/target/classes/`
- `$SOURCE/console/target/classes/`
- `$SOURCE/enduser/target/classes/`
- `$SOURCE/wa/target/classes/`
- `$SOURCE/sra/target/classes/`

## 5.1. Deployment

Apache Syncope components are built on Spring Boot, hence components can be generally deployed either as standalone applications or into one of the supported Java EE containers.

The only exception is Secure Remote Access that, being based on Spring Cloud Gateway - which in turn is built on Spring WebFlux and Project Reactor, is only available as standalone application.

For all components, please ensure to reference the proper Keymaster instance by including the following properties:

```
keymaster.address=<KEYMASTER_ADDRESS>
keymaster.username=${anonymousUser}
```

```
keymaster.password=${anonymousKey}
```

where <KEYMASTER_ADDRESS> can be either:

- protocol://host:port/syncope/rest/keymaster pointing to the Core instance, in case of *Self Keymaster*;
- host:port (typically host:2181) in case Apache Zookeeper is used.

### 5.1.1. Standalone

Projects generated from Maven archetype feature a dedicated standalone profile, which will re-package all applications as standalone fat JAR or WAR files.

Spring Boot applications can also be installed as system services.

*Example 35. Run Core application as standalone under GNU / Linux*

Assuming that the JDBC driver JAR file for the configured DBMS is available under /opt/syncope/lib, the Core application can be built and run as follows:

```
$ mvn -P standalone clean verify
$ cp core/target/syncope.war /opt/syncope/lib
$ cp core/target/classes/*properties /opt/syncope/conf

$ export LOADER_PATH=/opt/syncope/conf,/opt/syncope/lib,BOOT-INF/classes/WEB-
INF/classes
$ java -Dsyncope.conf.dir=/opt/syncope/conf \
  -Dsyncope.connid.location=file:/opt/syncope/bundles \
  -Dsyncope.log.dir=/opt/syncope/log \
  -jar /opt/syncope/lib/syncope.war
```

Further options can be passed to last command, according to Spring Boot documentation; for example:

- --spring.config.additional-location=/path
  to customize the location of the configuration files
- --server.port=8080
  to change the default HTTP port

### 5.1.2. JavaEE Container

Deployment into the Java EE containers listed below might require Maven project changes or tweaking some configuration settings.

### Database Connection Pool

The internal storage is the central place where all data of a given Core deployment are located.

After choosing the appropriate DBMS, it is of fundamental importance to provide an adequate configuration for the related database connection pool.

The database connection pool can be:

1. Application-managed (default); based on HikariCP, the related parameters can be tuned in the related domain configuration file, e.g. `domains/Master.properties`, for the Master domain.
2. JavaEE Container-managed, via the JNDI resource matching the name specified for a given domain, e.g. `java:comp/env/jdbc/syncopeMasterDataSource` for the `Master` domain.
   Each JavaEE Container provides its own way to accomplish this task:
   - Apache Tomcat 10
   - Payara Server 6
   - Wildfly 32

## 5.1.3. Apache Tomcat 10

On GNU / Linux - Mac OS X, create `$CATALINA_HOME/bin/setenv.sh` with similar content (keep everything on a single line):

```
JAVA_OPTS="-Djava.awt.headless=true -Dfile.encoding=UTF-8 -server \
-Dsyncope.conf.dir=/opt/syncope/conf \
-Dsyncope.connid.location=file:/opt/syncope/bundles \
-Dsyncope.log.dir=/opt/syncope/log \
-Xms1536m -Xmx1536m -XX:NewSize=256m -XX:MaxNewSize=256m -XX:+DisableExplicitGC \
-Djava.security.egd=file:/dev/./urandom"
```

On MS Windows, create `%CATALINA_HOME%\bin\setenv.bat` with similar content (keep everything on a single line):

```
set JAVA_OPTS=-Djava.awt.headless=true -Dfile.encoding=UTF-8 -server \
-Dsyncope.conf.dir=C:\opt\syncope\conf \
-Dsyncope.connid.location=file:/C:\opt\syncope\bundles \
-Dsyncope.log.dir=C:\opt\syncope\log \
-Xms1536m -Xmx1536m -XX:NewSize=256m -XX:MaxNewSize=256m -XX:+DisableExplicitGC
```

## 5.1.4. Payara Server 6

Add

```
    <dependency>
      <groupId>org.glassfish</groupId>
      <artifactId>jakarta.faces</artifactId>
      <version>${jakarta.faces.version}</version>
    </dependency>
```

to `core/pom.xml`, `console/pom.xml`, `enduser/pom.xml` and `wa/pom.xml`,

then replace

```
    <dependency>
      <groupId>org.apache.syncope.core</groupId>
      <artifactId>syncope-core-persistence-jpa</artifactId>
    </dependency>
```

with

```
    <dependency>
      <groupId>org.apache.syncope.core</groupId>
      <artifactId>syncope-core-persistence-jpa</artifactId>
    </dependency>
```

in `core/pom.xml`.

When using a datasource for internal storage, be sure to add

```
<resource-ref>
  <res-ref-name>jdbc/syncopeMasterDataSource</res-ref-name>
  <jndi-name>jdbc/syncopeMasterDataSource</jndi-name>
</resource-ref>
```

right after `</context-root>` in `core/src/main/webapp/WEB-INF/glassfish-web.xml`, assuming that your Payara Server instance provides a datasource named `jdbc/syncopeMasterDataSource`.

Do not forget to include the following system properties:

- `-Dsyncope.conf.dir=/opt/syncope/conf`
  (required by Core and WA)
- `-Dsyncope.connid.location=file:/opt/syncope/bundles`
  (required by Core)
- `-Dsyncope.log.dir=/opt/syncope/log`
  (required by all components)

For better performance under GNU / Linux, do not forget to include the system

property:

```
-Djava.security.egd=file:/dev/./urandom
```

### 5.1.5. Wildfly 32

Add

```
    <dependency>
      <groupId>jakarta.xml.ws</groupId>
      <artifactId>jakarta.xml.ws-api</artifactId>
    </dependency>
    <dependency>
      <groupId>org.apache.cxf</groupId>
      <artifactId>cxf-core</artifactId>
      <version>${cxf.version}</version>
    </dependency>
    <dependency>
      <groupId>org.apache.cxf</groupId>
      <artifactId>cxf-rt-transports-http</artifactId>
      <version>${cxf.version}</version>
    </dependency>
    <dependency>
      <groupId>org.apache.cxf</groupId>
      <artifactId>cxf-rt-ws-policy</artifactId>
      <version>${cxf.version}</version>
    </dependency>
    <dependency>
      <groupId>org.apache.cxf</groupId>
      <artifactId>cxf-rt-wsdl</artifactId>
      <version>${cxf.version}</version>
    </dependency>
```

as additional dependencies in `core/pom.xml`, `console/pom.xml`, `enduser/pom.xml` and `wa/pom.xml`,

then replace

```
    <dependency>
      <groupId>org.apache.syncope.core</groupId>
      <artifactId>syncope-core-starter</artifactId>
    </dependency>
```

with

```
    <dependency>
      <groupId>org.apache.syncope.core</groupId>
```

```
      <artifactId>syncope-core-starter</artifactId>
      <exclusions>
        <exclusion>
          <groupId>org.apache.tomcat.embed</groupId>
          <artifactId>tomcat-embed-el</artifactId>
        </exclusion>
      </exclusions>
    </dependency>
```

in `core/pom.xml`.

Finally, create

```
persistence.metaDataFactory=jpa(URLs=\
vfs:/content/${project.build.finalName}.war/WEB-INF/lib/syncope-core-persistence-jpa-
${syncope.version}.jar; \
vfs:/content/${project.build.finalName}.war/WEB-INF/lib/syncope-core-self-keymaster-
starter-${syncope.version}.jar, \
Resources=##orm##)

javadocPaths=/WEB-INF/lib/syncope-common-idrepo-rest-api-${syncope.version}-
javadoc.jar,\
/WEB-INF/lib/syncope-common-idm-rest-api-${syncope.version}-javadoc.jar,\
/WEB-INF/lib/syncope-common-am-rest-api-${syncope.version}-javadoc.jar
```

as `core/src/main/resources/core-wildfy.properties`.

Do not forget to include `widlfly` as Spring Boot profile for the Core application.

Do not forget to include the following system properties:

- `-Dsyncope.conf.dir=/opt/syncope/conf`
  (required by Core and WA)
- `-Dsyncope.connid.location=file:/opt/syncope/bundles`
  (required by Core)
- `-Dsyncope.log.dir=/opt/syncope/log`
  (required by all components)

For better performance under GNU / Linux, do not forget to include the system property:

```
-Djava.security.egd=file:/dev/./urandom
```

## 5.2. DBMS

### 5.2.1. PostgreSQL

Apache Syncope 4.0.0-SNAPSHOT is verified with PostgreSQL server >= 16 and JDBC driver >= 42.7.3.

Create

```
persistence.domain[0].key=Master
persistence.domain[0].jdbcDriver=org.postgresql.Driver
persistence.domain[0].jdbcURL=jdbc:postgresql://localhost:5432/syncope?stringtype=unsp
ecified
persistence.domain[0].dbUsername=syncope
persistence.domain[0].dbPassword=syncope
persistence.domain[0].databasePlatform=org.apache.openjpa.jdbc.sql.PostgresDictionary
persistence.domain[0].poolMaxActive=20
persistence.domain[0].poolMinIdle=5
```

as `core/src/main/resources/core-postgres.properties`.

Do not forget to include `postgres` as Spring Boot profile for the Core application.

This assumes that you have a PostgreSQL instance running on localhost, listening on its default port 5432 with a database `syncope` fully accessible by user `syncope` with password `syncope`.

### 5.2.2. PostgreSQL (JSONB)

With the configurations reported below, Apache Syncope will leverage the JSONB column type for attribute storage.

Apache Syncope 4.0.0-SNAPSHOT is verified with PostgreSQL server >= 16 and JDBC driver >= 42.7.3.

Add the following dependency to `core/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.core</groupId>
  <artifactId>syncope-core-persistence-jpa-json</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

Create

```
persistence.indexesXML=classpath:pgjsonb/indexes.xml
persistence.viewsXML=classpath:pgjsonb/views.xml

persistence.domain[0].key=Master
persistence.domain[0].jdbcDriver=org.postgresql.Driver
persistence.domain[0].jdbcURL=jdbc:postgresql://${DB_CONTAINER_IP}:5432/syncope?string
type=unspecified
persistence.domain[0].dbUsername=syncope
persistence.domain[0].dbPassword=syncope
persistence.domain[0].databasePlatform=org.apache.openjpa.jdbc.sql.PostgresDictionary
persistence.domain[0].orm=META-INF/spring-orm-pgjsonb.xml
persistence.domain[0].poolMaxActive=20
persistence.domain[0].poolMinIdle=5
```

as `core/src/main/resources/core-pgjsonb.properties`.

Do not forget to include `pgjsonb` as Spring Boot profile for the Core application.

This assumes that you have a PostgreSQL instance running on localhost, listening on its default port 5432 with a database `syncope` fully accessible by user `syncope` with password `syncope`.

### 5.2.3. MySQL

Apache Syncope 4.0.0-SNAPSHOT is verified with MySQL server >= 8.0 and JDBC driver >= 8.4.0.

Create

```
persistence.domain[0].key=Master
persistence.domain[0].jdbcDriver=com.mysql.cj.jdbc.Driver
persistence.domain[0].jdbcURL=jdbc:mysql://localhost:3306/syncope?useSSL=false&allowPu
blicKeyRetrieval=true&characterEncoding=UTF-8
persistence.domain[0].dbUsername=syncope
persistence.domain[0].dbPassword=syncope
persistence.domain[0].databasePlatform=org.apache.openjpa.jdbc.sql.MySQLDictionary(blo
bTypeName=LONGBLOB,dateFractionDigits=3,useSetStringForClobs=true)
persistence.domain[0].poolMaxActive=20
persistence.domain[0].poolMinIdle=5
```

as `core/src/main/resources/core-mysql.properties`.

Do not forget to include `mysql` as Spring Boot profile for the Core application.

It is important to set the collation to `utf8_general_ci` after creation of `syncope` database.

This assumes that you have a MySQL instance running on localhost, listening on its default port 3306 with a database `syncope` fully accessible by user `syncope` with password `syncope`.

### 5.2.4. MySQL (JSON)

With the configurations reported below, Apache Syncope will leverage the JSON_TABLE function.

Apache Syncope 4.0.0-SNAPSHOT is verified with MySQL server >= 8.0 and JDBC driver >= 8.4.0.

Add the following dependency to `core/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.core</groupId>
  <artifactId>syncope-core-persistence-jpa-json</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

Create

```
persistence.indexesXML=classpath:myjson/indexes.xml
persistence.viewsXML=classpath:myjson/views.xml

persistence.domain[0].key=Master
persistence.domain[0].jdbcDriver=com.mysql.cj.jdbc.Driver
persistence.domain[0].jdbcURL=jdbc:mysql://localhost:3306/syncope?useSSL=false&allowPu
blicKeyRetrieval=true&characterEncoding=UTF-8
persistence.domain[0].dbUsername=syncope
persistence.domain[0].dbPassword=syncope
persistence.domain[0].databasePlatform=org.apache.openjpa.jdbc.sql.MySQLDictionary(blo
bTypeName=LONGBLOB,dateFractionDigits=3,useSetStringForClobs=true)
persistence.domain[0].orm=META-INF/spring-orm-myjson.xml
persistence.domain[0].poolMaxActive=20
persistence.domain[0].poolMinIdle=5
```

as `core/src/main/resources/core-myjson.properties`.

Do not forget to include `myjson` as Spring Boot profile for the Core application.

This assumes that the InnoDB engine is enabled in your MySQL instance.

It is important to set the collation to `utf8_general_ci` after creation of `syncope` database.

This assumes that you have a MySQL instance running on localhost, listening on its default port 3306 with a database `syncope` fully accessible by user `syncope` with password `syncope`.

### 5.2.5. MariaDB

Apache Syncope 4.0.0-SNAPSHOT is verified with MariaDB server >= 11 and JDBC driver >= 3.3.3.

Create

```
persistence.domain[0].key=Master
persistence.domain[0].jdbcDriver=org.mariadb.jdbc.Driver
persistence.domain[0].jdbcURL=jdbc:mariadb://localhost:3306/syncope?characterEncoding=
UTF-8
persistence.domain[0].dbUsername=syncope
persistence.domain[0].dbPassword=syncope
persistence.domain[0].databasePlatform=org.apache.openjpa.jdbc.sql.MariaDBDictionary(b
lobTypeName=LONGBLOB,dateFractionDigits=3,useSetStringForClobs=true)
persistence.domain[0].poolMaxActive=20
persistence.domain[0].poolMinIdle=5
```

as `core/src/main/resources/core-mariadb.properties`.

Do not forget to include `mariadb` as Spring Boot profile for the Core application.

It is important to set the collation to `utf8_general_ci` after creation of `syncope` database.

It is necessary to use `utf8mb4_unicode_ci` instead of `utf8mb4_general_ci` if case-sensitive queries are required. In this case, set

```
init_connect = "SET NAMES utf8mb4 COLLATE utf8mb4_unicode_ci"
```

under either the `[mysqld]` section or the `[mariadb]` section of your option file.

This assumes that you have a MariaDB instance running on localhost, listening on its default port 3306 with a database `syncope` fully accessible by user `syncope` with password `syncope`.

### 5.2.6. Oracle Database

Apache Syncope 4.0.0-SNAPSHOT is verified with Oracle database >= 19c and JDBC driver >= ojdbc11 23.4.0.24.05.

Create

```
persistence.domain[0].key=Master
persistence.domain[0].jdbcDriver=oracle.jdbc.OracleDriver
persistence.domain[0].jdbcURL=jdbc:oracle:thin:@localhost:1521:XE
persistence.domain[0].schema=SYNCOPE
persistence.domain[0].dbUsername=syncope
persistence.domain[0].dbPassword=syncope
persistence.domain[0].databasePlatform=org.apache.openjpa.jdbc.sql.OracleDictionary
persistence.domain[0].orm=META-INF/spring-orm-oracle.xml
persistence.domain[0].poolMaxActive=20
persistence.domain[0].poolMinIdle=5

persistence.indexesXML=classpath:oracle_indexes.xml
```

as `core/src/main/resources/core-oracle.properties`.

Do not forget to include `oracle` as Spring Boot profile for the Core application.

This assumes that you have an Oracle instance running on localhost, listening on its default port 1521 with a database `syncope` under tablespace `SYNCOPE`, fully accessible by user `syncope` with password `syncope`.

### 5.2.7. Oracle Database (JSON)

With the configurations reported below, Apache Syncope will leverage the JSON features.

Apache Syncope 4.0.0-SNAPSHOT is verified with Oracle database >= 19c and JDBC driver >= ojdbc11 23.4.0.24.05.

Add the following dependency to `core/pom.xml`:

```
<dependency>
  <groupId>org.apache.syncope.core</groupId>
  <artifactId>syncope-core-persistence-jpa-json</artifactId>
  <version>${syncope.version}</version>
</dependency>
```

Create

```
persistence.indexesXML=classpath:ojson/indexes.xml
persistence.viewsXML=classpath:ojson/views.xml

persistence.domain[0].key=Master
persistence.domain[0].jdbcDriver=oracle.jdbc.OracleDriver
```

```
persistence.domain[0].jdbcURL=jdbc:postgresql://${DB_CONTAINER_IP}:5432/syncope?string
type=unspecified
persistence.domain[0].schema=SYNCOPE
persistence.domain[0].dbUsername=syncope
persistence.domain[0].dbPassword=syncope
persistence.domain[0].databasePlatform=org.apache.openjpa.jdbc.sql.OracleDictionary
persistence.domain[0].orm=META-INF/spring-orm-ojson.xml
persistence.domain[0].poolMaxActive=20
persistence.domain[0].poolMinIdle=5
```

as `core/src/main/resources/core-ojson.properties`.

Do not forget to include `ojson` as Spring Boot profile for the Core application.

This assumes that you have an Oracle instance running on localhost, listening on its default port 1521 with a database `syncope` under tablespace `SYNCOPE`, fully accessible by user `syncope` with password `syncope`.

### 5.2.8. MS SQL Server

Apache Syncope 4.0.0-SNAPSHOT is verified with MS SQL server >= 2017 and JDBC driver >= 12.6.1.jre1111.

Create

```
persistence.domain[0].key=Master
persistence.domain[0].jdbcDriver=com.microsoft.sqlserver.jdbc.SQLServerDriver
persistence.domain[0].jdbcURL=jdbc:sqlserver://localhost:1433;databaseName=syncope
persistence.domain[0].schema=dbo
persistence.domain[0].dbUsername=syncope
persistence.domain[0].dbPassword=Syncope123
persistence.domain[0].databasePlatform=org.apache.openjpa.jdbc.sql.SQLServerDictionary
persistence.domain[0].orm=META-INF/spring-orm-sqlserver.xml
persistence.domain[0].poolMaxActive=20
persistence.domain[0].poolMinIdle=5

persistence.viewsXML=classpath:sqlserver_views.xml
```

as `core/src/main/resources/core-sqlserver.properties`.

Do not forget to include `sqlserver` as Spring Boot profile for the Core application.

This assumes that you have a MS SQL Server instance running on localhost, listening on its default port 1433 with a database `syncope` fully accessible by user `syncope` with password `syncope`.

## 5.3. High-Availability

**OpenJPA**

When deploying multiple Syncope Core instances with a single database or database cluster, it is of fundamental importance that the contained OpenJPA instances are correctly configured for remote event notification.
Such configuration, in fact, allows the OpenJPA data cache to remain synchronized when deployed in multiple JVMs, thus enforcing data consistency across all Syncope Core instances.

The default configuration in `core.properties` is

```
persistence.remoteCommitProvider=sjvm
```

which is suited for single JVM installations; with multiple instances, more options like as TCP or JMS are available; see the OpenJPA documentation for reference.

The OpenJPA documentation's XML snippets refer to a different configuration style; for example, when used in `core.properties`, this:

```
<property name="openjpa.RemoteCommitProvider"
value="tcp(Addresses=10.0.1.10;10.0.1.11,TransmitPersistedObjectIds=tru
e)"/>
```

becomes:

```
persistence.remoteCommitProvider=tcp(Addresses=10.0.1.10;10.0.1.11,Tran
smitPersistedObjectIds=true)
```

## 5.4. Domains Management

Besides the pre-defined `Master` domain, other Domains are bootstrapped during Core startup from three files in the configuration directory; assuming that the domain name is `Two`, such files are:

- `domains/TwoSecurity.json` - admin credentials;
- `domains/TwoKeymasterConfParams.json` - for Keymaster initialization;
- `domains/TwoContent.xml` - for content initialization.

Starting from Syncope 3.0 it is also possible to create, update and delete Domains at runtime by managing the related configuration on the configured Keymaster instance.

## 5.5. ConnId locations

Core can be configured to use either local or remote connector bundles:

- **local** connector bundles are located somewhere in the same filesystem where Apache Syncope is deployed;
- **remote** connector bundles are provided via Java or .NET connector server.

While local connector bundles feature an easy setup, remote connector bundles allow enhanced deployment scenarios and are particularly useful when it is needed to deal with architectural security constraints or when a connector bundle requires to run on a specific platform OS (say MS Windows) while Apache Syncope is deployed on another platform OS (say GNU/Linux).

The `core.properties` file holds the configuration for defining which ConnId locations (either local or remote) will be considered.

The format is quite straightforward:

```
provisioning.connIdLocation=location1,\
location2,\
...
locationN
```

where each location is the string representation of an URI of the form `file:/path/to/directory/` for local locations, `connid://key@host:port` for remote non-SSL connector servers or finally `connids://key@host:port[?trustAllcerts=true]` for remote SSL connector servers, with optional flag to disable certificate check.

*Example 36. Single local location*

```
provisioning.connIdLocation=file:/opt/syncope/bundles/
```

*Example 37. Single remote location*

```
provisioning.connIdLocation=connid://sampleKey@windows2008:4554
```

*Example 38. Multiple locations*

```
provisioning.connIdLocation=file:/opt/syncope/bundles/,\
file:/var/tmp/bundles/,\
connid://sampleKey@windows2008:4554,\
connids://anotherKey@windows2008:4559,\
connids://aThirdKey@linuxbox:9001?trustAllCerts=true
```

# 5.6. Install connector bundles

Connector bundles are made available as JAR files and can be configured, for a given deployment:

- for Maven project, in local sources;
- for all distributions, at run-time.

## 5.6.1. Local sources

#### Different version of predefined connector bundle

First of all, verify which connector bundles are predefined in your project by looking at your project's parent POM.

As you can see, there are several Maven properties on the form `connid.*.version`, controlling the related connector bundle's version.

If you want your own project to use a different version of a given connector bundle, all you need to do is to override the related property in your own project's root pom.xml.

Hence, supposing that you would like to use `net.tirasa.connid.bundles.db` version `3.0.0-SNAPSHOT` rather than the one with version shipped with Apache Syncope, add the following property to your own project's root `pom.xml`:

```
<properties>
   ...
   <connid.db.version>3.0.0-SNAPSHOT</connid.db.version>
</properties>
```

#### Non-predefined connector bundle

If the needed connector bundle is not in the predefined set as shown above, you will need to add a new property into your own project's root `pom.xml`:

```
<properties>
   ...
   <my.new.connector.version>1.0.0</my.new.connector.version>
</properties>
```

then change the `maven-dependency-plugin` configuration both in `core/pom.xml` and `console/pom.xml` from

```
<plugin>
  <groupId>org.apache.maven.plugins</groupId>
  <artifactId>maven-dependency-plugin</artifactId>
  <inherited>true</inherited>
  <executions>
```

```
    <execution>
      <id>set-bundles</id>
      <phase>process-test-resources</phase>
      <goals>
        <goal>copy</goal>
      </goals>
    </execution>
  </executions>
</plugin>
```

to

```
<plugin>
  <groupId>org.apache.maven.plugins</groupId>
  <artifactId>maven-dependency-plugin</artifactId>
  <inherited>true</inherited>
  <configuration>
    <artifactItems>
      <artifactItem>
        <groupId>my.new.connector.groupId</groupId>
        <artifactId>my.new.connector.artifactId</artifactId>
        <version>${my.new.connector.version}</version>
        <classifier>bundle</classifier>
      </artifactItem>
    </artifactItems>
  </configuration>
  <executions>
    <execution>
      <id>set-bundles</id>
      <phase>process-test-resources</phase>
      <goals>
        <goal>copy</goal>
      </goals>
    </execution>
  </executions>
</plugin>
```

### 5.6.2. Run-time

Connector bundles can be added or replaced at run-time by performing the following steps:

1. Download the required connector bundle JAR file;
2. Copy the downloaded JAR file into one of configured ConnId locations, typically the `bundles` directory where the other connector bundles are already available.

## 5.7. E-mail Configuration

The `core.properties` file holds the configuration options to enable the effective delivery of

notification e-mails:

- `spring.mail.host` - the mail server host, typically an SMTP host;
- `spring.mail.port` - the mail server port;
- `spring.mail.username` - (optional) the username for the account at the mail host;
- `spring.mail.password` - (optional) the password for the account at the mail host;
- `spring.mail.properties.mail.smtp.auth` - when `true`, the configured `username` and `password` are sent to SMTP server;
- `spring.mail.properties.mail.smtp.starttls.enable` - when `true`, enable the use of the `STARTTLS` command to switch the connection to a TLS-protected connection before issuing any login commands;

All the JavaMail™ properties are available for usage with prefix `spring.mail.properties.`.

*Example 39. Basic configuration, no authentication*

```
spring.mail.host=your.local.smtp.server
spring.mail.port=25
spring.mail.username=
spring.mail.password=
spring.mail.properties.mail.smtp.auth=false
spring.mail.properties.mail.smtp.starttls.enable=false
```

*Example 40. STARTTLS configuration, with authentication*

```
spring.mail.host=smtp.gmail.com
spring.mail.port=587
spring.mail.username=your_username@gmail.com
spring.mail.password=your_password
spring.mail.properties.mail.smtp.auth=true
spring.mail.properties.mail.smtp.starttls.enable=true
```

In order to make the changes to `core.properties` effective, the deployment needs to be restarted.

Be sure to provide a sensible value for the `notificationjob.cronExpression` configuration parameter, otherwise the notification tasks will not be triggered; see below for details.

## 5.8. Control JWT signature

As explained above, the REST authentication process generates, in case of success, a unique signed

JWT (JSON Web Token).
Such JWT values are signed by Apache Syncope according to the JWS (JSON Web Signature) specification.

### 5.8.1. Hash-based Message Authentication Code

This is the default configuration, where Core and clients posses a shared secret, configured under `core.properties` as the `jwsKey` property value.

*Example 41. Default JWS configuration*

```
security.jwsAlgorithm=HS512 ①
security.jwsKey=ZW7pRixehFuNUtnY5Se47IemgMryTzazPPJ9CGX5LTCmsOJpOgHAQEuPQeV9A28f
②
```

① Valid values are `HS256`, `HS384` and `HS512`

② Any alphanumeric value satisfying the length requirement can be used

### 5.8.2. RSA Public-Key Cryptography

This configuration requires to specify a key pair: the former key value, said *private*, must be kept secret for internal Core usage while the latter key value, said *public*, is to be shared with clients.

The commands below will generate the required key pair via OpenSSL and format their values for usage with `core.properties`:

```
$ openssl genrsa -out private_key.pem 2048
$ openssl pkcs8 -topk8 -in private_key.pem -inform pem -out jws.privateKey -outform
pem -nocrypt
$ openssl rsa -pubout -in private_key.pem -out jws.publicKey
$ echo `sed '1d;$d' jws.privateKey | awk '{printf "%s", $0}'`:`sed '1d;$d'
jws.publicKey | awk '{printf "%s", $0}'`
```

*Example 42. JWS configuration with RSA PKCS#1*

```
security.jwsAlgorithm=RS512 ①
security.jwsKey=MIIEvgIBADANBgkqhkiG9w0BAQEFAASCBKgwggSkAgEAAoIBAQCdXTaAPRoIAvWjm5
MskNtcGakkME4HEhZ8oQ2J8XNU29ZT7Qq5TP769/O8OH5Pb56mPULswYSocycrAARPzjAKpxr+YN7w2/zo
5MsBRZsASgpCxnCeYLCWtJzmzY/YYlAHdsu3jj/4wuAcYozR1xE5e2gEj0BQ6Xz7NELhceEZpbXIeKSDol
LdCKrVZ1vdD0q/HdjY2qeBACqeG8yYXsj2MiAMJY6df80ZCqpHkcD9mhfzqUo5EcWCD7XzcOJQRNUKkBEO
bemq//tt5NHFbWnBeGeTJBcyXV7Uqqbjnd6hwBBS1d6usAagGQ4RWDHPBMk02BdEFyrZjgJXM1C1iU/9Ag
MBAAECggEBAJpbnaNKzCcBqCuU5ld3vARqk1QRIeijoHUdkWc29TdO8LygLr22vgI1h9qf255V0dwlCWmt
JVAKrGfse05A5TT912egY+8FCt7z1gFoYnN1LP11I3DnTTB299UZ3DiXrwKzT368xRlhJm4RaSpIePfWii
C215LGhTbve48iongBXzkpzFYe1SCV1FmNl5Px6FE3C9GcTrFpe+rqVcIVrTLZ95+JDF4/YLgTRccW8V/Y
O+4OtqUo+vt8tckDGhrHrfwgTo53kxDQttecB4AryDg1eUe8vPMx1+yJz8VFwx0yaUa5fqEYlxPehRQiVJ
i0+YMosRqKtcm1mLxoGcwSyo0CgYEAynhB/FM9DnARwg/PsE/AuXVpXlxPU5F+shpYX2sF3rItTD4EWFr/
```

```
glo26LT/MLw2ckNkLT11yAWdR8hAzVZ48Ly3Ur8Fi88iInLPEixunBIsPcR3dI2UoI9dswnTM+H/Z83yQ1
6VWGjtE3437LWSXBHEw/am9W9pArEunt3TQz8CgYEAxvgS7BAokIqASi0zBpmyogRVHGs0eC3mMWLG+t5V
XJ5M1z1pV9dOuInnI29wJqBscefueOPcT6mNJngW/kHlcGGOxij+hRUnAdVltTod4CJ3Q/IyM6h/FzunEe
umZyZ1BW3G5KTcpegcBquUW6impyJbnUvKV4p9rpLTEBooKcMCgYEAhB1skUWPdbhTHhpLH3UrANlIZDY/
3Pv3fCgMulaPgf0p6bIeC7l1OI29fqN8UUS/Elg/KfYMwPRI6OoWvuZKDGxYAzp6V/xU/b2EuQsdMeH51G
Q6vmcUMKDcN1OV6SjzC70q9CLnuMTezfVycJcaZdGCX4y27ThBgWw0S53bmOkCgYAdCHfiYF068irUKBJJ
BUZuo8kzk2UdoDz1ud8lHipAkIzP35MukSlYfi7vGcS4rjIE0P4YP8+XBDungGCCi2UKaAHoYnT5QGPnvZ
bQwgE4Am96x62RoiWhYz/2uncWmCL9Ps6F8JSN1Pe59XF5int+6eGKa1PEQF4kiiIoOFjh9wKBgG6XXGl8
4fBaOaTsCPu+oQcAAp1GzweSy4l1Y1L71YvbxU1bs5338vgiH5OeUA4d5w0Ei9d/bSw0PWV4aACWWGGclL
hzv8ia6bEWqt0TskUiUJVzgTXWp3ojpsP/QE36Ty+uWWqckBXv6dnEXEgrLqzbA6qTAohSSFjV4FAjxBxa
:MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEAnV02gD0aCAL1o5uTLJDbXBmpJDBOBxIWfKENi
fFzVNvWU+0KuUz++vfzvDh+T2+epj1C7MGEqHMnKwAET84wCqca/mDe8Nv86OTLAUWbAEoKQsZwnmCwlrS
c5s2P2GJQB3bLt44/+MLgHGKM0dcROXtoBI9AUOl8+zRC4XHhGaW1yHikg6JS3Qiq1Wdb3Q9Kvx3Y2Nqng
QAqnhvMmF7I9jIgDCWOnX/NGQqqR5HA/ZoX86lKORHFgg+183DiUETVCpARDm3pqv/7beTRxW1pwXhnkyQ
XMl1e1Kqm453eocAQUtXerrAGoBkOEVgxzwTJNNgXRBcq2Y4CVzNQtYlP/QIDAQAB ②
```

① Valid values are `RS256`, `RS384` and `RS512`

② Value is obtained by the commands above; the public key value is the string after the `:` sign, e.g.

```
QB3bLt44/+MLgHGKM0dcROXtoBI9AUOl8+zRC4XHhGaW1yHikg6JS3Qiq1Wdb3Q9Kvx3Y2NqngQAqnhvMm
F7I9jIgDCWOnX/NGQqqR5HA/ZoX86lKORHFgg+183DiUETVCpARDm3pqv/7beTRxW1pwXhnkyQXMl1e1Kq
m453eocAQUtXerrAGoBkOEVgxzwTJNNgXRBcq2Y4CVzNQtYlP/QIDAQAB
```

Longer RSA keys offer stronger protection against cracking. The JWS specification suggests at least 2048 bits. Please consider that higher CPU usage is involved with longer keys.

## 5.9. Configuration Parameters

Most run-time configuration options are available as parameters and can be tuned via the admin console:

- `password.cipher.algorithm` - which cipher algorithm shall be used for encrypting password values; supported algorithms include `SHA-1`, `SHA-256`, `SHA-512`, `AES`, `S-MD5`, `S-SHA-1`, `S-SHA-256`, `S-SHA-512` and `BCRYPT`; salting options are available in the `core.properties` file;

The value of the `security.secretKey` property in the `core.properties` file is used for AES-based encryption / decryption. Besides password values, this is also used whenever reversible encryption is needed, throughout the whole system.
When the `secretKey` value has length less than 16, it is right-padded by random characters during startup, to reach such mininum value.
It is **strongly** recommended to provide a value long at least 16 characters, in order to avoid unexpected behaviors at runtime, expecially with high-availability.

- `jwt.lifetime.minutes` - validity of JSON Web Token values used for authentication (in minutes);
- `notificationjob.cronExpression` - cron expression describing how frequently the pending notification tasks are processed: empty means disabled;

Restarting the deployment is required when changing value for this parameter.

- `notification.maxRetries` - how many times the delivery of a given notification should be attempted before giving up;

Restarting the deployment is required when changing value for this parameter.

- `token.length` - the length of the random tokens that can be generated as part of various workflow processes, including password reset;
- `token.expireTime` - the time after which the generated random tokens expire;
- `selfRegistration.allowed` - whether self-registration (typically via the enduser application) is allowed;
- `passwordReset.allowed` - whether the password reset feature (typically via the enduser application) is allowed;
- `passwordReset.securityQuestion` - whether the password reset feature involves security questions;
- `authentication.attributes` - the list of attributes whose values can be passed as login name for authentication, defaults to `username`; please note that the related plain schemas must impose the unique constraint, for this mechanism to work properly;
- `authentication.statuses` - the list of workflow statuses for which users are allowed to authenticate;

Suspended Users are anyway not allowed to authenticate.

- `log.lastlogindate` - whether the system updates the `lastLoginDate` field of users upon authentication;
- `return.password.value` - whether the hashed password value and the hashed security answer (if any) value shall be
- `connector.test.timeout` - timeout (in seconds) to check connector connection in Admin Console; `0` to skip any check;

This parameter is useful to avoid waiting for the default connector timeout, by setting a shorter value; or to completely disable connector connection testing.

- `resource.test.timeout` - timeout (in seconds) to check resource connection in Admin Console; `0` to skip any check;

This parameter is useful to avoid waiting for the default resource timeout, by setting a shorter value; or to completely disable resource connection testing.

Besides this default set, new configuration parameters can be defined to support custom code.

# Chapter 6. HOWTO

## 6.1. Set admin credentials

The procedure below affects only the `Master` domain; for other domains check above.

The credentials are defined in the `core.properties` file; text encoding must be set to UTF-8:

- `security.adminUser` - administrator username (default `admin`)
- `security.adminPassword` - administrator password (default `password`)'s hashed value
- `security.adminPasswordAlgorithm` - algorithm to be used for hash evaluation (default `SSHA256`, also supported are `SHA1`, `SHA256`, `SHA512`, `SMD5`, `SSHA1`, `SSHA512` and `BCRYPT`)

*Example 43. Generate SHA1 password value on GNU / Linux*

The `sha1sum` command-line tool of GNU Core Utilities can be used as follows:

```
echo -n "new_password" | sha1sum
```

Please beware that any shell special character must be properly escaped for the command above to produce the expected hashed value.

*Example 44. Generate SSHA256 password value on GNU / Linux*

```
$ python3 pySSHA/ssha.py -p password -enc sha256 -s 666ac543 \
 | sed 's/{.*}//' | xargs echo -n | base64 -d | xxd -p | tr -d $'\n' | xargs echo
```

Several tools involved here:

- pySSHA-slapd
- xargs
- echo
- base64
- xxd
- tr

The command above will:

1. generate a `SHA256` hash for input value `password` with suffixed salt `666ac543` (4 bytes in hex format), via `ssha.py`
2. remove the `{SSHA256}` prefix from the generated value and newline, via `sed` and `xargs`

3. since the generated value is Base64-encoded while Syncope requires Hexadecimal format, perform the required conversion via `base64`, `xxd` and `tr`
4. append newline to ease copy / paste, via `xargs` and `echo`

## 6.2. Internal storage export - import

Almost every configurable aspect of a given deployment is contained in the internal storage: schemas, connectors, resources, mapping, roles, groups, tasks and other parameters.

During the implementation phase of an Apache Syncope-based project, it might be useful to move such configuration back and forth from one Apache Syncope instance to another (say developer's laptop and production server).
One option is clearly to act at a low level by empowering DBMS' dump & restore capabilities, but what if the developer is running MySQL (or even in-memory H2) while the sysadmin features Oracle?

*Wipe existing content*

When not running in-memory H2, the internal storage's data must be wiped before starting Apache Syncope, otherwise the provided content will be just ignored.

Check `core-persistence.log` for message

```
Empty database found, loading default content
```

If the internal storage is not empty, instead, you will get

```
Data found in the database, leaving untouched
```

All references in the following are set to `MasterContent.xml`; when other domains are defined, the content file is renamed accordingly. For example, `TwoContent.xml` if domain name is `Two`.

*MySQL and lower case table names*

On some platforms (namely, Mac OS X) MySQL is configured by default to be case insensitive: in such cases, you might want to edit the `/etc/my.cnf` file and add the following line in the `[mysqld]` section:

```
lower_case_table_names=1
```

### 6.2.1. Export

This task can be accomplished either via the admin console or by barely invoking the REST layer through curl, for example:

```
curl -X GET -u admin:password -o MasterContent.xml \
  http://localhost:9080/syncope/rest/configurations/stream?tableThreshold=100
```

where `tableThreshold` indicates the maximum number of rows to take for each table of internal storage.

### 6.2.2. Import

Basically, all you need to do is to replace the local `MasterContent.xml` with the one exported as explained above; this file is located at:

- `$TOMCAT_HOME/webapps/syncope/WEB-INF/classes/domains/MasterContent.xml` for Standalone
- `core/src/test/resources/domains/MasterContent.xml` for Maven projects in embedded mode
- `core/src/main/resources/domains/MasterContent.xml` for Maven projects

## 6.3. Keystore

A Java Keystore is a container for authorization certificates or public key certificates, and is often used by Java-based applications for encryption, authentication, and serving over HTTPS. Its entries are protected by a keystore password. A keystore entry is identified by an alias, and it consists of keys and certificates that form a trust chain.

A keystore is currently required by the SAML 2.0 Service Provider for UI extension in order to sign and / or encrypt the generated SAML 2.0 requests.

While a sample keystore is provided, it is **strongly** recommended to setup a production keystore; in the following, a reference procedure for this is reported.

The procedure below is not meant to cover all possible options and scenarios for generating a keystore, nor to provide complete coverage of the `keytool` command.

**Create new keystore**

```
keytool -genkey \
  -keyalg RSA \
  -keysize 2048 \
  -alias saml2sp4ui \
  -dname "CN=SAML2SP,OU=Apache Syncope, O=The ASF, L=Wilmington, ST=Delaware, C=US" \
  -keypass akyepass \
  -storepass astorepass \
  -storetype JKS \
```

```
  -keystore saml2sp4ui.jks
```

This command will create a keystore file with name `saml2sp4ui.jks` in the execution directory, containing a new 2048-bit RSA key pair, under the specified alias (`saml2sp4ui`); password values for `keypass` and `storepass` are also set.

#### Create new CSR

```
keytool -certreq \
  -alias saml2sp4ui \
  -keyalg RSA \
  -file certreq.pem \
  -keypass akyepass \
  -storepass astorepass \
  -storetype JKS \
  -keystore saml2sp4ui.jks
```

This command will create a CSR file with name `certreq.pem` in the execution directory, within the keystore generated above.
The generated CSR file can be sent to a Certificate Authority (CA) to request the issuance of a CA-signed certificate.

#### Have the CSR signed by a Certificate Authority (CA)

This step cannot be automated, and is definitely out of the scope of the this document.

Before proceeding, it is fundamental to have ready the root / intermediate CA certificate(s) and the signed certificate.

#### Import the certificates into the keystore

```
keytool -import \
  -alias root \
  -file cacert.pem \
  -keypass akyepass \
  -storepass astorepass \
  -storetype JKS \
  -keystore saml2sp4ui.jks
```

This command will import the root / intermediate CA certificate(s) from the `cacert.pem` file into the keystore generated above.

```
keytool -import \
  -alias saml2sp4ui \
  -file cert.pem \
  -keypass akyepass \
  -storepass astorepass \
```

```
  -storetype JKS \
  -keystore saml2sp4ui.jks
```

This command will import the signed certificate from the `cert.pem` file into the keystore generated above.

**Finalize**

The keystore file `saml2sp4ui.jks` can now be placed in the configuration directory; the relevant part of the `core.properties` file should be:

```
saml2.sp4ui.keystore=file://${syncope.conf.dir}/saml2sp4ui.jks
saml2.sp4ui.keystore.type=jks
saml2.sp4ui.keystore.storepass=astorepass
saml2.sp4ui.keystore.keypass=akyepass
```

## 6.4. Upgrade from 2.1

The distance between earlier releases and Syncope 3.0 Maggiore is relevant under different aspects: architecture, technology, project organization and naturally internal data representation.

For this reason there is no practical way to migrate an old project to Syncope 3.0.

It is possible, however, to setup a new Syncope 3.0 project, replicate configurations and finally migrate the existing data. Here is the outlined approach:

1. create a new Maven project based on Syncope 3.0
2. update code customization and extensions made from your previous Syncope project to the new classes and interfaces provided by Syncope 3.0
3. with both projects up and running:
    a. download relevant configurations - especially connectors and resources - via REST from your previous Syncope project
    b. upload via REST to the new Syncope 3.0 project
    c. configure a new REST resource in the new Syncope 3.0 project to pull users, groups and any objects from your previous Syncope project