



Governance of openEHR based local repository compliant with openEHR Clinical Knowledge Manager

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Abstract

Objectives: The aim of the study is to implement a suitable way of having the different openEHR local repositories updated and compliant with the openEHR CKM (Clinical Knowledge Manager).

Methods: A comparison was made between archetypes stored in a local repository of an ongoing project and the current version of the same archetypes in the openEHR CKM. A script for comparison of both repositories based on Angular 2/Typescript was made using REST API calls from ADL Designer and GitHub API.

Results: Creation of documentation about how to deal with the versioning of archetypes on new and ongoing projects, together with a script that runs on local repositories connected to ADLDesigner to search new archetype versions from CKM.

Conclusion: Contribution with an added value to the governance of openEHR resources by keeping them updated in a way that can facilitate and save time for the local repository management team, when searching new versions of openEHR CKM.

Keywords: (MeSH) Electronic Health Records, Medical Informatics, Health Information Exchange, (Non MeSH) OpenEHR, Version Control.

Introduction

- A lot of new applications were developed and have improved the way physicians interact with electronic health records, but the underlying information model of how the patient data should be recorded and stored was left to be implemented exclusively by developers.
- To address this issue, some standards emerged over the years, and from those, the most promising is openEHR [1], which has its own open governance library of archetypes and templates called Clinical Knowledge Manager (CKM) [2].

Introduction – openEHR

- **Free open-source standard** which provides specifications of how to store, share and retrieve health data with the main idea of separating this data from applications implementation logic as an agnostic approach [5].
- OpenEHR is divided in two-level modeling:
 - **Reference Model (RM)** that gives the software specification
 - **Archetype Model (AM)**, where the archetypes and templates are presented.

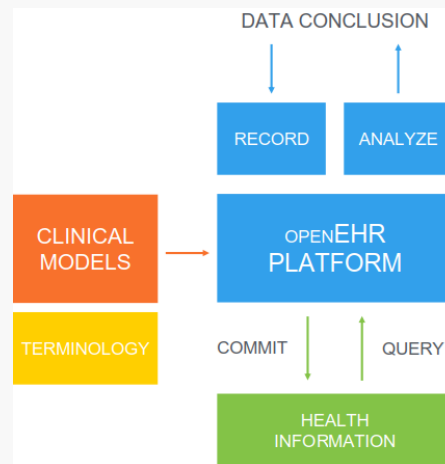


Fig. 1 - OpenEHR workflow

Introduction – openEHR AM

- An archetype is the key feature of the separation between information models and domain models, that defines how to capture clinical data [8].
- Its composed by a set of data elements and other data types with formal definition of knowledge domain for a healthcare information system and can be shared and reusable in different situations, so it is not necessary to create new archetypes for different templates.
- These resources have a Lego™ model approach, giving an elementary concept base to create structures - the templates.



Fig. 2 – Basic concepts (Lego™ blocks) can be reused to create structures – openEHR basis

Introduction – openEHR CKM

- Main web tool that makes the management of clinical models' resources [9,10,11].
- Created in April 2009 product from Ocean Health System (ex-Ocean Informatics).
- Under the management of the openEHR community.
- **Free registration** for individuals from all around the world, focused on giving added value to the repository on a **voluntary basis** [12].
- All non-technical healthcare area professions are also encouraged to contribute, it is not a requirement to be a physician to redound.
- Is possible to:
 - purpose new artifacts (archetypes and templates),
 - suggest corrections and participate in discussions,
 - translate archetypes to other languages,
 - watch and adopt archetypes.
 - All the changes to an archetype are subjected to a consensual decision from all reviewers before being published.
- Website: <https://www.openehr.org/ckm/>

Introduction (2)

- Each company or institution working with openEHR archetypes and templates, cannot use it directly for each individual project, since implementation specifications requires, very often, a fine-grained level of detail, very localized, which is not part of the internationally agreed upon common concepts.
- System implementers need to have a working version of all artefacts used, so they need to have their own local repository with a file system or a control version system (CVS) to manage them. **These local repositories are usually created at the start of a project by downloading copies of the available archetypes from openEHR CKM at a certain point in time and usually these are not kept updated.**
- Over the years, the main CKM (also known as International openEHR CKM) had new updated versions for the different archetypes, having a very well-structured management of the archetype's lifecycles, with the new version being approved after a community consensus [3]. **This implies that knowledge in the openEHR CKM stays always updated, but that does not necessarily happen on the local repositories.**

Introduction (3)

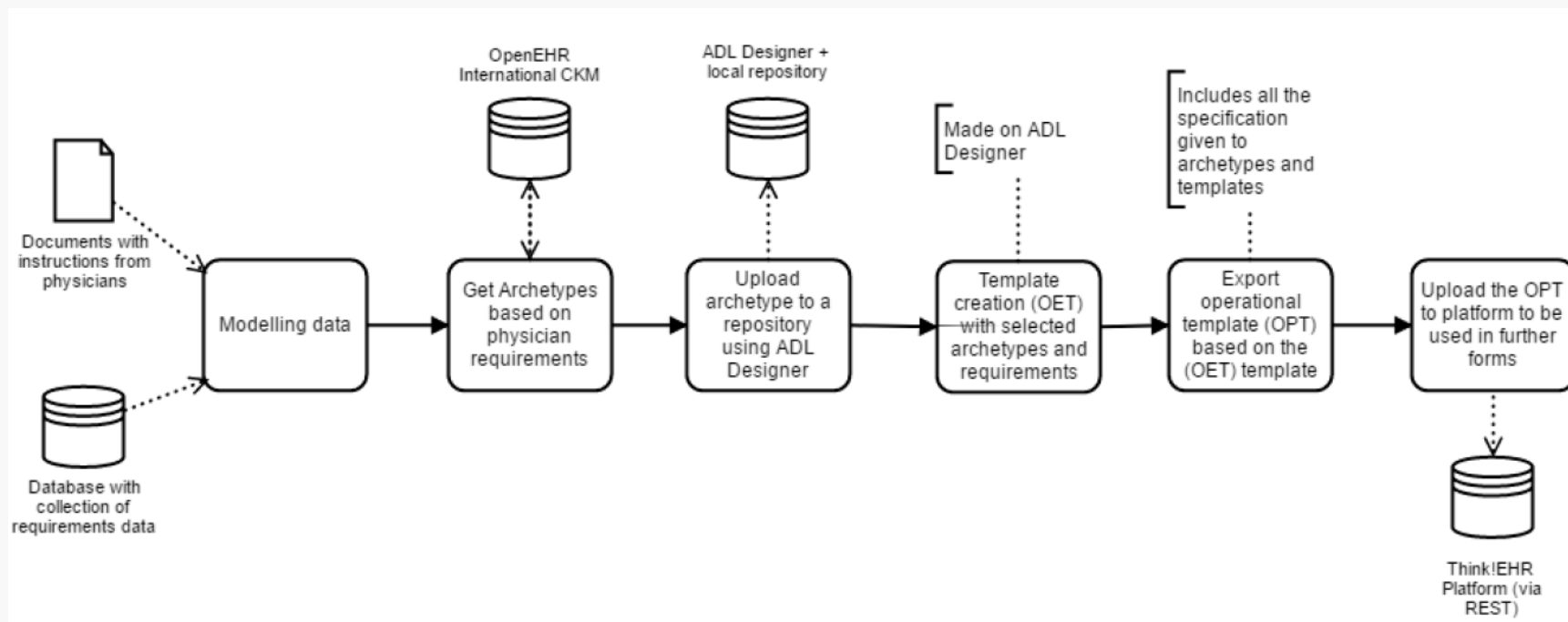


Fig. 1 - Archetype to template workflow using ADL Designer (Marand d.o.o)

Methods

The aim of the study is to find and implement a suitable way of having the different openEHR local repositories updated and compliant with the international openEHR CKM. In order to achieve it, the following studies were made:

1. Learn how the openEHR CKM works, history, features, functionalities and how the verification of new versions of artifacts is made;
2. Study state of art methodologies used for managing software and document lifecycles;
3. Review of the openEHR specifications for Reference Model (RM) and Archetype Model (AM), related with archetype identification and versioning;
4. Creation of documentation about how to deal with archetype versioning on a local repository and a script to compare the artifacts content in both repositories and verify new updates for each archetype from openEHR CKM;
5. Development and implementation of the proposed methodology and verification of results.

The junction of all the information gathered from these studies allowed to create a methodology and script with rules for versioning comparison.

Identifying parameters of new versions of archetypes (1)

- OpenEHR has dedicated a section that specifies the versioning of archetypes and templates, called the Archetype Object Model (AOM)[14]
 - Contains many classes like ARCHETYPE, ARCHETYPE_HRID and AUTHORED_ARCHETYPE with version parameters [15,16].
 - An archetype has two ways of being identified:
 - human readable identification (HRID);
 - machine-readable identification.
-
- ```

classDiagram
 class ARCHETYPE {
 +parent_archetype_id : String [0..1]
 +is_differential : Boolean [1]
 +concept_code() : String [1]
 +physical_paths() : String [1..*]
 +logical_paths(lang : String [1]) : String [1..*]
 +specialisation_depth() : Integer [1]
 +is_specialised() : Boolean [1]
 }
 class ARCHETYPE_HRID {
 +namespace : String [0..1]
 +rm_publisher : String [1]
 +rm_package : String [1]
 +rm_class : String [1]
 +concept_id : String [1]
 +release_version : String [1]
 +version_status : VERSION_STATUS [1]
 +build_count : String [1]
 +semantic_id() : String
 +physical_id() : String
 +version_id() : String
 +major_version() : String
 +minor_version() : String
 +patch_version() : String
 }
 class AUTHORED_ARCHETYPE {
 +adl_version : String [0..1]
 +build_uid : UUID [1]
 +rm_release : String [1]
 +is_generated : Boolean [1]
 +other_meta_data : hash<String, String>
 }
 ARCHETYPE <|-- AUTHORED_ARCHETYPE
 ARCHETYPE "1" -- "*" ARCHETYPE_HRID : +archetype_id
 ARCHETYPE_HRID "1" -- "*" ARCHETYPE : +definition
 ARCHETYPE_HRID "1" -- "*" STATEMENT : +rules

```

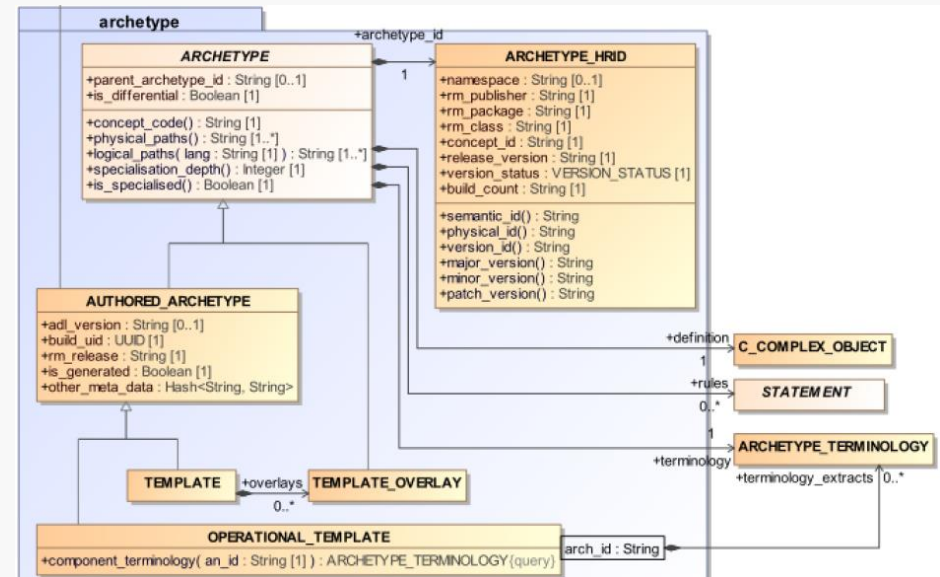


Fig. 2 - am.aom2.archetype Package (from openEHR Archetype specification)

# Identifying parameters of new versions of archetypes (2)

- Human readable identification (HRID) contains:

- *Semantic\_id*:

(namespace::rm\_publisher-model\_name-rm\_class.concept\_id.v.major\_version.minor\_version.patch\_version-version\_status.build\_count)

- org.openehr::openEHR-EHR-OBSERVATION.blood\_pressure.v1.0.5-alpha
    - org.openehr::openEHR-EHR-OBSERVATION.blood\_pressure.v1.0.5-rc.17

- *Physical\_id*:

(namespace::rm\_publisher-model\_name rm\_class.concept\_id.v.major\_version.minor\_version.patch\_version)

- org.openehr::openEHR-EHR-OBSERVATION.blood\_pressure.v1.0.5

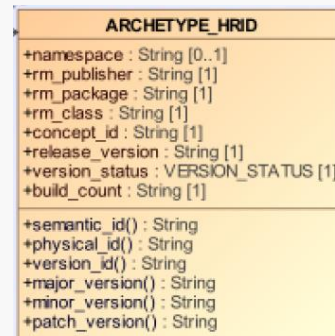


Fig. 3 - ARCHETYPE\_HRID class

# Identifying parameters of new versions of archetypes (3)

- In **machine readable**, these parameters are present on “uid”, “MD5-CAM”, “build\_uid” and “revision”:

```
archetype(adl_version=1.4;uid=b1506a87-9bf2-4978-9eed-6ceecb0c2be9)
 openEHR-EHR-OBSERVATION.blood_pressure.v1

lifecycle_state = <"published">
other_details = <
 ["MD5-CAM-1.0.1"] = <"7341F7E8A07ACE883A5F541BA79F2B95">
 ["build_uid"] = <"68040aab-98da-4b3c-a93c-c91df19b05f8">
 ["revision"] = <"1.1.1">
>
```

Fig. 4 - Blood Pressure ADL excerpt

# Identifying parameters of new versions of archetypes (4)

- **“uid”** is the unique identification number for each archetype.
  - “blood pressure” uid=“b1506a87-9bf2-4978-9eed-6ceecb0c2be9”, even if the version of the archetype changed. The format is made by an universal unique identifier (UUID), an identifier that is unique across both space and time.
- **“archetype\_id”**: which contains the information about the archetype name including the major version.
  - “openEHR-EHR-OBSERVATION.blood\_pressure.v1”
- **“lifecycle\_state”** which gives the stage of different life cycles associated to the archetype development
  - (e.g. “published”)
- **“MD5-CAM-1.0.1”** is a hash that is calculated by the actual values inside of the archetype, which means that every new version with changes will have a different hash code.
- **“build\_uid”** - Every time the archetype gets a new change or version and is uploaded or committed to some repository, it will get a new “build\_id”, which is unique for every build. The format is also made by an UUID.
- **“revision”**: (e.g. “1.1.1”), based on the semantic versioning from semVer [17].

# Analysis of archetype content from local repository and comparison with openEHR CKM repository (1)

- This analysis consisted on a direct comparison between the **major version (V.x)**, **versioning parameters** and the **content of archetypes** inside of this local repository in GitLab, with the archetypes from the international openEHR CKM hosted on GitHub.
  - The local repository had 41 archetypes.
  - The primary search was made by archetype name (archetype\_id) on both repositories.

Table 1 - Summary of archetype comparison analysis from the provided CKM repository with GitHub mirror of openEHR international CKM (June 2018) (n=41)

| Archetype Status | Total (n=41) |         |
|------------------|--------------|---------|
|                  | n            | (%)     |
| Outdated         | 12           | (29,27) |
| Internal         | 16           | (39,02) |
| Not found        | 3            | (7,32)  |
| Compliant        | 10           | (24,39) |

# Analysis of archetype content from local repository and comparison with openEHR CKM repository (2)

- For each one of the archetypes was given a status to define the conformity with openEHR CKM:
  - **"Outdated"**: different versioning parameters (Major Version, revision, archetype UID, MD5-CAM) and content inside of the archetype in both repositories;
  - **"Internal"**: case of creation of new archetypes that needs to meet certain clinical needs and are not present on the international openEHR CKM or when they are specialized to meet some local or national requirement;
  - **"Not found"**, if the archetype in the local repository was totally changed by another one on the international openEHR CKM, but with similar content, or even if this archetype does not exist anymore on the international openEHR CKM - case of archetype specializations that lost connection with the parent archetype;
  - **"Compliant"**, when the archetype has the same versioning parameters (Major Version, revision, archetype UID, MD5-CAM) and content are similar in both repositories, which means that has the latest version from the international CKM;

# Analysis of archetype content from local repository and comparison with openEHR CKM repository (3)

- **Conclusion:**

- It was expected to have some outdated archetypes during the analysis, since it is a normal behavior in the developing information systems - with time, changes are made, features added and bugs can be found.
- Although it is a repository with a high percentage of internal archetypes due to local or national requirements, which are not present in the international CKM, a lot of archetypes are outdated too.
- Some of them were downloaded to the local repository in November 2016 and since that date, **there was no verification of new versions of archetypes from the international CKM.** This can result in **errors that can still exist in the local repository, that most probably were fixed on the international CKM,** or even additional content that would enrich the local archetypes.
- Having a repository with these characteristics is not the aim of openEHR ideals, where less than ¼ of the artifacts are compliant with the international CKM. To manually verify same archetypes on both repositories, side by side and check all the content and versioning parameters **took around nine hours to complete.**



# Current outcomes from openEHR artifacts usage

## The good:

1. Aim of openEHR was to provide public archetypes, after being agreed by the international online community, in a single international repository (openEHR CKM) that could be used in several EHR systems around the globe.
2. It is also possible to add regional or local archetypes that would still be compatible with the previous ones inserted in the international CKM (using CKM incubator feature) and making the information shareable with everybody.

## The Bad:

1. Each project that makes use of archetypes have their own repository. Some of them are using the international CKM and being compliant with it, others are not.
2. Other projects have initially downloaded the archetypes from international CKM, but made a few changes to comply to specification requirements and then saved on local repositories like GitHub, GitLab, SubVersion or Preforce.

**This results in a jumble of archetypes variations from the international base of these archetypes, which was not the aim from openEHR.**

# Script definition

- The script only works with a GIT repository connected to ADL Designer, a tool for archetype and template modelling: <https://ehrscape.marand.si/designerv2/> and it is free to use.
- The repository can be either online or local, such as:
  - GitHub,
  - GitLab,
  - Bitbucket,
  - Dropbox,
  - Google Drive,
  - OneDrive ,
  - Local GIT folder in a single computer.
- Currently the script makes comparison between *archetype\_id*.

# Script definition

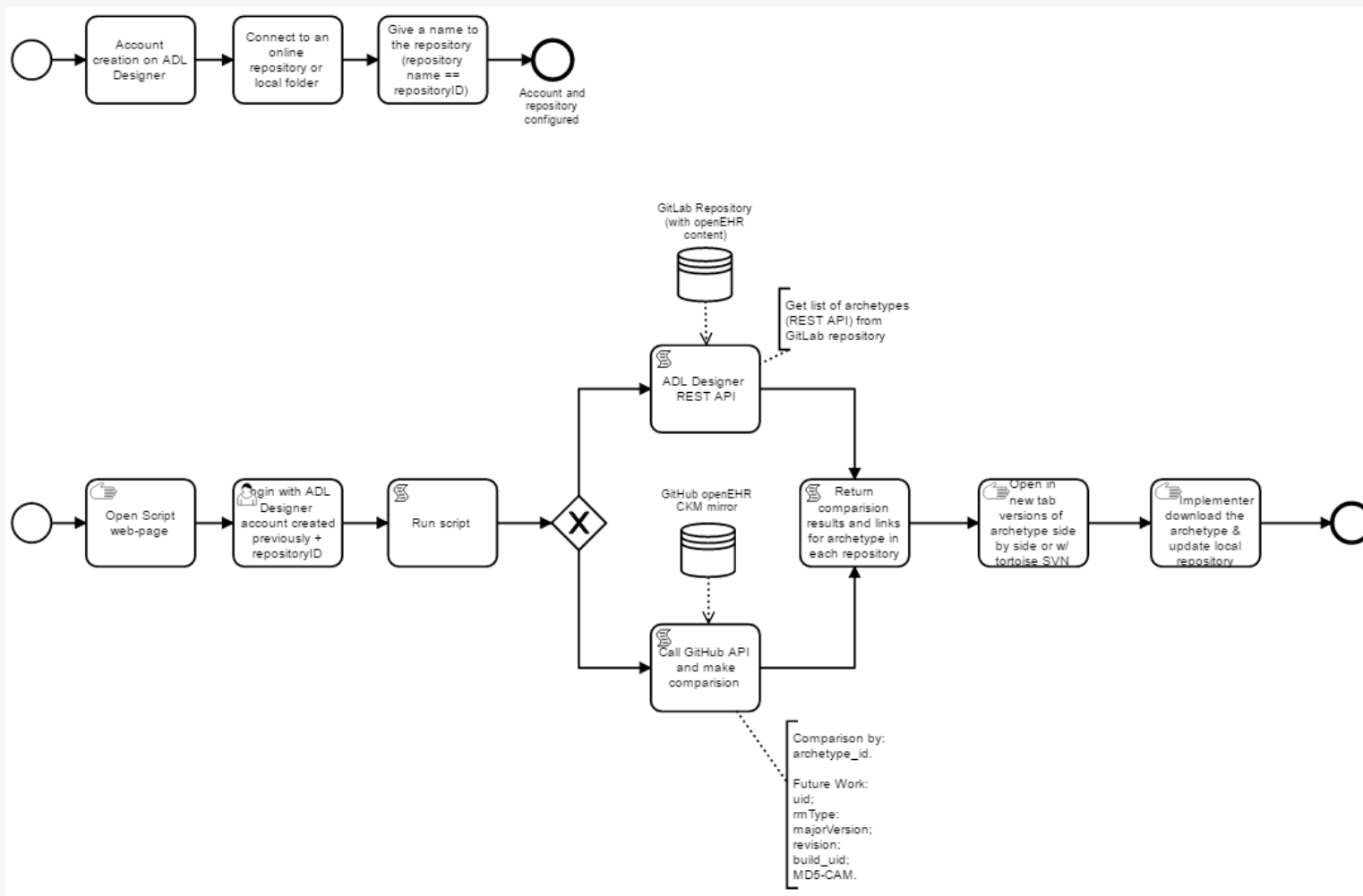


Fig. 5 – Script Process

# Results (1)

Script available at <https://mim-script-openehr.stackblitz.io/>

Functionalities and features:

- Get Archetypes list from local repository;
- Comparison from local repository and compliance with the openEHR CKM mirror at Github;
- Get Templates list from local repository;

Archetypes comparison from both repositories (local repository VS OpenEHR CKM GitHub)

Total archetypes: 42  
 Compliant archetypes: 13  
 Outdated archetypes/internal archetypes: 29  
 Specialized archetypes: 5

Search resource...

| # | Archetype Name                                                                                                          | UID                                  | Result                                                                   | URL OpenEHR CKM GitHub Mirror | URL Internal/local repository                                                                                                                                                                                                       | Compare Archetypes               |
|---|-------------------------------------------------------------------------------------------------------------------------|--------------------------------------|--------------------------------------------------------------------------|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| 1 | openEHR-EHR-SECTION.adhoc.v1<br>Specialized archetype from: Not specialized                                             | a8223b9-7d24-4d45-8db4-376963d8bc    | Compliant archetype with CKM                                             | Compliant with openEHR CKM    | <a href="https://github.com/and47/Think8RegistryV1ckm/tree/master/openEHR-EHR-SECTION.adhoc.v1.ad">https://github.com/and47/Think8RegistryV1ckm/tree/master/openEHR-EHR-SECTION.adhoc.v1.ad</a>                                     | <a href="#">Click to compare</a> |
| 2 | openEHR-EHR-EVALUATION.absence.v1<br>Specialized archetype from: Not specialized                                        | d58da80-7bf7-4eba-a68-d923ef309e26   | Compliant archetype with CKM                                             | Compliant with openEHR CKM    | <a href="https://github.com/and47/Think8RegistryV1ckm/tree/master/openEHR-EHR-EVALUATION.absence.v1.ad">https://github.com/and47/Think8RegistryV1ckm/tree/master/openEHR-EHR-EVALUATION.absence.v1.ad</a>                           | <a href="#">Click to compare</a> |
| 3 | openEHR-EHR-CLUSTER.nyha_heart_failure-slow.v1<br>Specialized archetype from: openEHR-EHR-CLUSTER.nyha_heart_failure.v1 | 69453c5f-b814-40d9-98a4-a3a1a1164077 | Attention Required! Outdated Major Version on CKM or Internal archetype. | Internal Archetype            | <a href="https://github.com/and47/Think8RegistryV1ckm/tree/master/openEHR-EHR-CLUSTER.nyha_heart_failure-slow.v1.ad">https://github.com/and47/Think8RegistryV1ckm/tree/master/openEHR-EHR-CLUSTER.nyha_heart_failure-slow.v1.ad</a> | <a href="#">Click to compare</a> |
| 4 | openEHR-EHR-CLUSTER.malignancy_details.v0<br>Specialized archetype from: Not specialized                                | 5a5c4d28-8076-38f6-6709-cc304a146af  | Attention Required! Outdated Major Version on CKM or Internal archetype. | Internal Archetype            | <a href="https://github.com/and47/Think8RegistryV1ckm/tree/master/openEHR-EHR-CLUSTER.malignancy_details.v0.ad">https://github.com/and47/Think8RegistryV1ckm/tree/master/openEHR-EHR-CLUSTER.malignancy_details.v0.ad</a>           | <a href="#">Click to compare</a> |

Fig. 5 – Script Web Page, comparison module

## Results (2)

When comparing the manual study made from the local repository to the openEHR CKM on GitHub to the developed script:

Table 2 - Comparison of the local repository analysis results retrieved by the manual analysis and the developed script.

|                                        | Manual Analysis | Developed Script                                                         |
|----------------------------------------|-----------------|--------------------------------------------------------------------------|
| <b>Total archetypes</b>                | 41              | 41                                                                       |
| <b>Compliant archetypes</b>            | 16              | 14                                                                       |
| <b>Not found archetypes</b>            | 3               | N.A.                                                                     |
| <b>Outdated archetypes</b>             | 6               | 6                                                                        |
| <b>Internal archetypes</b>             | 16              | 21                                                                       |
| <b>Outdated or Internal archetypes</b> | N.A.            | 27 (6 outdated, 21 internal, which are presented together in the script) |

# Results discussion

1. The major differences from both analysis are presented in the number of compliant archetypes and internal archetypes. Due to the mirror errors from the openEHR CKM to the GitHub account during the committing process:
  - openEHR-EHR-CLUSTER.healthcare\_provider\_parent,
  - openEHR-EHR-CLUSTER.address\_isa,have not been mirrored, and these causes a mislead to the script by recognizing them as internal archetypes.
2. Other case that turns into misleading information, but in this case in the number of internal archetypes, are the archetypes whose archetype\_id have been renamed and cannot be found anymore on the openEHR CKM. These cases are:
  - openEHR-EHR-OBSERVATION.indirect\_oximetry to openEHR-EHR-OBSERVATION.pulse\_oximetry;
  - openEHR-EHR-CLUSTER.timing\_repetition to openEHR-EHR-CLUSTER.timing\_nondaily.

# Conclusion (1)

- The usage of repositories is in constant growth and it can become troublesome to manage all information inside of them.
- When a knowledge repository based on openEHR artefacts for a project is being created, archetypes are simply downloaded from the openEHR CKM and saved in the local repository of the on-going project. When new versions for the same archetypes are uploaded to the openEHR CKM, they usually are not updated on the local repository.
- Normally a local archetype will be updated only when a bug, error or new requirement is found during the usage of the software that contains that archetype and a check for new version is made manually on the openEHR CKM.
- Manually checking versions on openEHR CKM can be really time consuming and are usually avoided.

# Conclusion (2)

Herewith this documentation and the script is expected to give:

- A quick and reliable archetype verification between the local repositories and the openEHR CKM;
- Make it compliant and updated with the main source;
- Facilitate the managing work of the local clinical knowledge repository owner.

The script:

- First version;
- Developed as a proof of concept (POC) using the archetype HRID to help managing the search in the REST API calls: (rm\_publisher-model\_name-rm\_class.concept\_id.v.major);
- This version only checks if the archetype on the local repository has a major version (e.g. v0 to v1) in the openEHR CKM mirror on Github;
- Returns the uniform resource locator (URL) links from the different repositories allowing to make a side by side comparison of both versions.



# Future Work

1. Add the archetype parsing functionality in order to get fully internal versioning differences:

- MD5-CAM;
- *build\_uid*;
- *Revision*;
- Archetype content;

from both repositories, since archetypes can also have smaller changes during a period of time that cannot be checked by using only the *archetype\_id*.

2. Add “diff” comparison of archetypes from both repositories, similar to services like <https://www.diffchecker.com/>

# Acknowledges

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