Open Virtual Mobility

O3-A1.1: Definite set of VM Skill definitions

to be used in preparation for

(O3-A1.2: Competency directory requirements (backend and frontend)

- Final draft -

Outcome 3 Activity A1.1 Competency Directory and Matching Tool	
Document submission and review information	
Declared due date of deliverable	30.03.2018
Reviewed due date of deliverable	30.03.2018
Actual submission date	16.05.2018
Organisation name of lead contractor	Beuth University of Applied Sciences, Berlin
Revision	1.2
Author and reviewer information	
Name of the author	Johannes Konert
Affiliation of the author	Beuth University of Applied Sciences, Berlin
Name of the reviewer	Diana Andone
Affiliation of the reviewer	UNIVERSITATEA POLITEHNICA TIMISOARA

The creation of these resources has been (partially) funded by the ERASMUS+ grant program of the European Union under grant no. **2017-1-DE01-KA203-003494***. Neither the European Commission nor the project's national funding agency DAAD are responsible for the content or liable for any losses or damage resulting of the use of these resources.*

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Imprint: This publication is O3-A1.1 of the Open Virtual Mobility Erasmus+ strategic partnership founded by the European Commission 2017 - 2020 under **2017-1-DE01-KA203-003494,** URL: https://www.openvirtualmobility.eu/

This paper is to discuss the definite set of VM skill definitions to be implemented by a competency repository software produced as part of Outcome O3 "Competency Directory and Matching Tool " and aims at defining the technical possibilities and restrictions to setup a competency directory. Originally the definite set of skills was expected to be definable, but the project team realized the dependency on output O1 results, why the decision was rescheduled. Still, the means of the competency directory are discussed here.

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Suggested citation

Konert, J. (2018) O3-A1.1: Definite set of VM Skill definitions Open Virtual Mobility Erasmus+ (2017-2020). Berlin, Germany. Retrieved from https://www.openvirtualmobility.eu/topics/outputs

Corresponding author

Johannes Konert
Beuth University of Applied Sciences
Luxemburger Straße 10, 13353 Berlin, Germany
johannes.konert[at]beuth-hochschule[dot]de

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Executive summary

Definition of competencies in a structured machine-readable and human-readable way helps in connecting systems. Semantic data formats define a specific vocabulary to express competencies without ambiguities and allow to cross-reference competencies within one competency framework as well as across different frameworks. To address one such defined competency a unique address (IRI) is provided by digital competency directories. These IRIs can then be used to reference one or more competencies from competency-related applications, e.g. Open Badges. To find existing competency definitions a directory provides search interfaces (web-frontend or API).
After providing an overview over the existing solutions to express competencies in a semantic way, the technical solutions are discussed. Finally, the specific needs for the provision of a competency directory for open virtual mobility skills are discussed. A survey is developed and presented to collect answers from the experts of project-involved partner organizations. The answers are meant to clarify the prioritization of the needed functionality of the competency directory and the needed data attributes of competencies.

What are the objectives of this paper?

- Semantic technology: formats and systems to be used
- Competency frameworks: heterogeneity, multi-language and cross-referencing
- Data collection to prioritize needs in the open virtual mobility project
- Preparation for specification of the competency directory functional requirements and technical environment

Who is this paper for?

- Technicians interested in a.) using semantic competency definitions or b.) setting up an own competency directory.
- Pedagogues and didacticians interested in the technical infrastructure behind semantic competency definitions.
- Researchers interested in discussion and presentation of currently existing challenges in the field of semantic competency frameworks.

What topics are addressed in this paper?

competency frameworks, competency definition, data formats, attributes and vocabulary, cross-referencing, semantic web, linked data, InLOC, ESCO, CASS, OBN, prioritization of requirements, online survey

Contributors

- Johannes Konert, Beuth University of Applied Sciences, Germany
- Marica Franchi, Cineca Consortio Interuniversitario, Italy

Acknowledgements

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1. Aims and Scope

The Semantic Competency Directory will provide an overview and (graph-based) search possibility open to all interested parties to find and browse existing definitions of virtual mobility skills. Originally the aim was to collect these skills (automatically) from existing suitable competency frameworks (such as EQF, DIGICOMP, ESCO). During the joint work for Output 1 it became clear that the project consortium will define its own competency framework for virtual mobility skills as no coherent definition set exists covering the virtual mobility skills. This work is still in progress.
Consequently, the document at hand cannot present a finalized set of competencies but can provide and define boundary conditions such definitions must fulfill. Likewise, the metadata to be expected from the semantic entries is discussed and the possibilities of cross-referencing.

It is expected that most existing competency frameworks-including competencies relevant for VM Skills- will *not* have the proper metadata and semantic cross-referencing (an overview is given in Hall et al.,2014). Thus, one major effort of the project and innovative output is the enrichment of such
VM skill definitions, addition of missing skill definitions and cross-referencing (relating) them in order to describe dependencies of skills and levels. Still, the project cannot produce all versions in all languages of the partner organizations.
Major use of the competency directory is then made by the Bestr Badge issuing platform which is referencing the competency definitions by unique URLs in the alignment field of the Open Badge standard.
Furthermore, learning resources and e-tests (assessments) of the VM Learning Hub can reference these competencies as to be delivered by the learning resource and tests (and probably as well define which of these competencies are prerequisites).

2. Background and rationale (State of the Art)

Competency Frameworks and Standardized Competencies

Traditionally, each organizational unit and industry defines its own competencies and organizes them in a competency framework. Thus, for education and business sectors several specific competency frameworks evolved and equality (or at least similarities) between some of them (but far from all) have been defined. Compare e.g. EQF[1], eCompetencies[2], ECVET[3], CGMA[4], UK CCCF[5], DCF[6], SUNY GLQF[7], ESCO[8],Tuning Reference Points[9], DigiComp[10] to name a few.

[1] https://ec.europa.eu/ploteus/en/compare
[2] http://www.esc.edu/suny-real/global-learning-qualifications-framework/

While there are activities to define one global competency framework where all possible competencies of all educational sectors and businesses can be defined (see discussion of Taxonomies Working Group, 2015), it can be concluded that in the near future no such solution will exist. Main reasons are the dynamic change and evolvement of competency definitions, as they depend on culture, work domain and like labor market expectations the corresponding competency definitions change. Thus, the strategy is to allow definition of well-maintained, but manifold competency frameworks and cross-reference between them for better compatibility. This means that a competency C1 defined in framework F1 defines a graph-like edge (reference) to another competency C2 in framework F2. The reference is labeled, e.g. as *is the same as* or *is required by*. By such means, humans and machines alike can follow these references to conclude connections between fields of expertise (qualifications) expressed as competency sets of individuals. To allow better connectivity among existing frameworks another proposal is to cross-reference to one central major framework definition in a star-structure. Such a central definition of competencies is hard to achieve, but currently ESCO is a promising candidate for Europe.

Resolving ambiguity by semantic metadata

The major problem for less ambiguity in competency definition is the dependency to the vocabulary used. The problem increases when definitions are translated to several other languages. Partly, the ambiguity can be addressed by machine-learning algorithms, which calculate similarity based on statistical models and language analysis. Still the missing explicit semantic linkage sets limits to these approaches' precision.

Ever since the world wide web existed, mankind worked hard to define machine readable linked structures that are still manageable (and readable) by human beings (cf. Tim Berners-Lee talk about the next web and linked data Berners-Lee, 2009). Standards like Standard Generalized Markup Language (SGML), the subset eXtensible Markup Language (XML), Resource Description Framework (RDF) and its derivative for web usage RDFa (The RDF Web Apps Working Group at W3C, 2018), Web Ontology Language (OWL) and recently JavaScript Object Notation Linked Data (W3C JSON-LD Working Group, 2018) to name a few. The general problem is to find a balance between being too generic (and thus the concepts expressed by semantic annotation are too simple to be of use) and too specific (then the solution is not usable in manifold application fields).

[3] http://www.ecvet-team.eu
[4] http://www.cgma.org/Resources/Tools/Pages/cgma-competency-framework.aspx
[5] https://www.gov.uk/government/publications/civil-service-competency-framework
[6] https://ec.europa.eu/jrc/en/digcomp/digital-competence-framework
[7] http://www.esc.edu/suny-real/global-learning-qualifications-framework/
[8] https://ec.europa.eu/esco/portal/home
[9] http://www.unideusto.org/tuningeu/
[10] https://ec.europa.eu/jrc/en/digcomp/governance

Data Format

While competency frameworks still exist in purely human-readable format as a table in downloadable PDF, formats of the semantic web can be used to express the metadata (attributes) of a competency and its cross-references. The recent movement towards *linked data (LD)* with a distributed design (using the formats RDF or JSON-LD) is based on unique resource identifiers (IRI[11]). IRIs allow explicit unambiguous reference to a concept or instance defined in a different context (domain). As such it is easy to cross-reference meaning. Linked data is decentralized and in each namespace new concepts can be defined. Thus, it is easy to create a vocabulary and a valid schema for one's own scope. Still, with IRIs it is possible to reference concepts (and data) outside the own scope, e.g. by using standardized LD attributes like isSimilarTo (Hepp, 2018) or educationalAlignment (schema.org, 2018) as defined by the Learning Resource Metadata Initiative (LRMI) (Dublin Core Metadata Initiative, 2018).

Concerning the most popular formats, RDFa is for augmentation of HTML by semantic means, while JSON-LD is the suitable format for (computer) systems exchange and interoperability for linked data. This format is to favour currently, especially since Open Badges are committed to JSON-LD support since version 1.1 (Otto & Gylling, 2017). Still, RDFa and JSON-LD can be converted into each other.

Data structures to express semantic meaning of competency frameworks

Beside the format, a discussion is necessary about the *vocabulary* used within the competency specification expressed in such a format. The vocabulary is the set of noun terms and relations used to express the competency definitions and their structure. Competency frameworks need to be written in a machine-readable format (e.g. JSON-LD) and expressed in a standardized, machine-understandable vocabulary (and data structure).

The problem of ambiguities in terms, keywords, tags and their relation is addressed by the SKOS Simple Knowledge Organization System (W3C, 2012), a RDF standard of the W3C Semantic Web Working Group (W3C, 2009). SKOS allows the standardized semantic linkage of terms, e.g. in thesauri or folksonomies. Thus, it is primarily a standardized data model for expressing these cross-references and knowledge terms. Its applicability to the competency alignment problem is of limited value as it does not explicitly distinguish evidences (LO) and their links to competencies.

InLOC

In the project *InLOC ELM 2.0: Integrating Learning Outcomes and Competences* (European Commitee for Standardization, 2013), from the ICT Standardisation Work Programme of the European Commission's DG Enterprise and Industry (European Commission, 2018), the problem of semantic metadata for learning outcomes and competencies was addressed. With Integrating

[11] Formerly only based on ASCII characters (URI), extended by international characters (IRI)

Learning outcomes and competencies (InLOC) the project committee released a European standard which is able to express all existing CFs in a semantic and machine readable form. They provide suggestions on representations in XML, RDF and more recently in JSON-LD. InLOC provides several examples on how to apply InLOC to CFs. One example is the EU CF eCompetence Framework 2.0 for occupations in ICT , which contains five responsibility areas (PLAN; BUILD; RUN; ENABLE; MANAGE), each with several dimensions. One dimension (3) defines the competency levels while another (4) defines the knowledge and skill examples for a specific competency. The example can be found in (InLOC working group of European Commission, 2016)

While InLoc has its strength in the semantic definition with more specific constructs than a pure RDF triple, it lacks an implementation.

ESCO

Recently, the European Skills Competencies and Occupations Frameworks (ESCO) offers a machine-readable download in RDFa or CSV[12]. The aim of ESCO is provision of semantic information that allows computational comparability of qualification certificates (like diplomas, work experience, recommendation letters and certifications, and Open Badges) with job requirements to match offers and demands. It would be of much benefit for the interoperability of educational, occupational, and voluntary work systems in Europe. ESCO is an ambiguous project whose key advantages are:

1. Its definition of a vocabulary to express competencies, skills, occupations, and their relation among each other
2. Its expression of thousands of existing occupations (jobs) in several sectors as well as competencies that are job specific and uniform 21st century skills
3. Its translation into manifold languages of Europe (even though the first set is primarily available in English only).

Like InLOC, ESCO allows the expression of semantic relations among competencies within ESCO, but as well to reference similarities to competency frameworks other than ESCO (European Commission, 2013). As this is a core aspect to allow a decentralized, inter-linked web of competency framework definitions that reference each other, InLOC and ESCO remain as candidates for vocabulary. It remains an open question, whether these two are of same flexibility and can be transformed into each other easily. ESCO comes with an implementation and existing competency definitions. Still, it seems to be not suitable to use ESCO CF alone for the open VM project, as Output 1 aims for defining a new Virtual Mobility CF. Consequently, the ESCO vocabulary can still be used to express the new VM CF.

[12] https://ec.europa.eu/esco/portal/download/ , since March 2017 competencies are accessible as RDFa or CSV. Additionally, an API is offered to access ESCO as linked-data (see https://ec.europa.eu/esco/portal/escopedia/ESCO_API)

OBN Competency Directory

For the Open Badge Network Europe Erasmus+ project (2015-2017) an implementation of a competency directory using semantic technology was realized (Konert, Buchem, Lewis, Hamilton, & Riches, 2017). The competency directory aimed for providing unique URLs and a simple web-interface for searching competency definitions in order to use the found unique URLs in Open Badge definitions. During the course of the project first an implementation for InLOC vocabulary (using RDFa and JSON-LD format) was provided, then after ESCO release, a re-implementation was done for importing the ESCO competency definitions. In the end, prototypical implementations are available for InLOC and ESCO vocabulary[13].

CASS

Finally, in 2016 the Competency and Skills System (CASS) started to work on an Open Source implementation[14] of a directory to host competency frameworks, identities (of learners) and assertions (competency profiles) while supporting several CFs in parallel (Robson, 2017). During 2017 the project improved its applicability by providing several example implementations for client systems (e.g. JAVA, C#, JavaScript)[15] and application plugins (e.g. Moodle, xAPI)[16] to connect applications to the directory. While CASS defines another data model vocabulary to express and store CFs (CASS Project, 2018b), the project aims at being compatible to existing formats and vocabularies by using the concept of converters and adapters (CASS Project, 2018a). For example, an import of ESCO defined competencies and skills was already done. CASS supports JSON-LD as format to express competency frameworks, relations, identities and assertions in import and export.

3. Methodology

Requirement analysis

In contrast to the project proposal the needed skill definitions cannot simply be collected from existing competency frameworks, as they are freshly defined and created in Output 1. To continue work on O3, the focus is shifted to the question "*Which (functional) requirements need a skill to fulfill when accessed via the competency directory*"?

To answer this question in a scientific way, two methods are used. First, the state of the art of competency framework management with modern web technologies from a technical point of view is collected from scientific databases, conferences, former European projects and by discovery from the internet resources and personal contacts in the field. The found results are presented and

[13] https://github.com/openbadgenetwork/

[14] https://github.com/cassproject/

[15] http://devs.cassproject.org/index.html?doc=1oPEFo7M5RHv9kB8DoVwCFBEcsctiYMpU-QDVcOyXIz8

[16] http://devs.cassproject.org/index.html?doc=1DZlrMrPd8Me2BsYHB0vUovtocWUMaj_VvKQD2_Ibb70

discussed. Afterwards they are evaluated regarding the required functionality and in alignment of the Open Virtual Mobility project goals. All these steps are done and presented in the current document.
Second, to define these requirements for comparison a semi-structured data collection from expert interviews (maybe as online questionnaire) with the partner organizations' experts is planned. Aligned to grounded theory, the answers to questions are transformed into requirements (MUST and NICE-TO-HAVE), non-requirements (NOT CONSIDERED) and non-functional requirements (SOFT). The questions for the interviews are derived from the project proposal and work plan (see *section 3 First results*).

Implementation

The list of requirements is then analyzed for its practicability. Probably not all desired functionality can be implemented during the project due to the resource limitations. In that case, the output leader will provide a prioritized list to the project partners to agree on. This will be altered at maximum two times after online meeting discussions to come to a final list.
For the final list, the output leader will decide the most suitable technological approach based on the state of the art research and estimated effort. The proposed set of technology, necessary implementations and data processing/collection will be discussed with the quality reviewer of the output before implementation.
Implementation itself will be conducted as an agile, iterative process using the prioritized list of requirements. For version control GIT on github.com will be used.
A test server will be setup for partners to test and integrate their components using the competency directory.

4. Intermediate results

For the competencies to exist in the directory

No specific work needs to be done by output leader 3 currently, as a new competency framework will be defined by Output 1, which needs to be added into the technical solution of O3 then.

Required functionality of the competency directory

Based on the project partner meetings, technical meetings and project proposal text the following questions are derived for interviewing the partner organizations:

1. Please rate the following functionality of the **competency directory backend (API)** importance for your own work in the open VM project. [-1 I disagree to have that in the project, 0 not needed, 1 optional but useful, 2 needed uncritical, 3 definitely needed]
   - identity management (login, credentials)
   - role management (for limited editing, reading of competencies)

- competency management (adding, editing, deleting of VM competencies)
- multiple competency framework support
- multi-language support for competency definitions (same competency in x languages)
- assertion management (sets of competencies per user)
- import of complete other competency frameworks from different sources
- other: [name here what you would need]

2. Please rate the following functionality of the **competency directory frontend (web-interface)** importance for your own work in the open VM project. [-1 I disagree to have that in the project, 0 not needed, 1 optional but useful, 2 needed uncritical, 3 definitely needed]
   - list of all competencies
   - direct editing of competencies (add, edit, remove)
   - reference editing (this competency is similar/contains/prerequisite of another)
   - mobile interface support (small displays)
   - multi-language support (other interfaces than English)
   - search by keyword
   - search by framework
   - search by country of origin (of the framework)
   - search by existing language translation
   - direct access by ID
   - browsing by exploring search results (this implies to show links to connected other competencies in the frontend)
   - translation support (web frontend for language editing of competencies)
   - other: [name here what you would need]
3. What elements (attributes) does **~one~ competency need to support in the output format** for your work in the open VM project [-1 I disagree to have that in the project, 0 not needed, 1 optional but useful, 2 needed uncritical, 3 definitely needed]
   - description
   - levels (as advancements in ~same~ competency)
   - cross-referencing of competencies (similarity, includes, ..) within the VM competency framework
   - cross-referencing of competencies (similarity, includes, ..) with other frameworks
   - evidence definitions for a competency (how it has been proven by an individual)
   - criteria definitions for a competency (what measurable aspects exactly have to be fullfilled to have that competency)
   - other: [name here what you need]
4. Please rate the following **interoperability aspects** importance for your own work in the open VM project. [-1 I disagree to have that in the project, 0 not needed, 1 optional but useful, 2 needed uncritical, 3 definitely needed]
   - synchronization/copy of the competency frameworks into Moodle (from the CD to Moodle)
   - Service Level Agreement (SLA) as accessibility of a high level (95%)
   - low latency on response to requests (<200ms)
   - encrypted communication via HTTPS
   - unique URL to individual competency
   - REST-Level 2 conform HTTP-API
   - SOAP WebService conform HTTP-API
   - JSON-LD format for input/output
   - RDFa format for input/output
   - read/write to an xAPI
   - other: [name here what you need]

5. Describe in short words what of your work will use the directory (technical components and/or humans)?
6. Describe in short words what data and how often it will access (or send)?
7. Something else to mention?

5. Discussion

Anticipating the results from the interviews about needed functionality, the state of the art reveals that CASS is the best option as it is the most robust implementation that already comes with unique URLs per competency, REST-API, encryption, multi-language support, client-side prototypical implementations (for Moodle and xAPI) and support for one (or many) competency framework definition. Additionally, a usable frontend for editing frameworks seems to exist (rudimentary). Compared to a development of an own (smaller) prototype of a competency directory, building on CASS contains the risk of high effort to comprehend the code base for adaptation and extension. CASS comes with components for identity management and assertions which are expected to not be needed for open VM Learning Hub. This will be clear after the experts commented.

6. Conclusions

This document contains results from literature and scientific review about current state of the art for semantic competency definitions and providing appropriate programming interfaces (APIs) for web services to fetch the semantic definitions of competencies from a server. Afterwards the expert survey questions where presented to collect the needs from within the open virtual mobility project outputs in order to provide a suitable competency directory. This survey is planned to be conducted until summer 2018. Results will be analyzed and presented in following document O3-A1.2 with the definite requirements for the competency directory. Until then the results from O1 will be available concerning the newly created competency framework for open virtual mobility skills. It is expected that the resulting new Virtual Mobility Competency Directory will not contain more than 6-8 competencies in about 2-3 levels and several cross-references. Thus, the needed resources to add it to the competency directory in a machine readable, semantic format can be estimated as few days.

Much more complexity and work is needed for the setup, configuration and implementation of the technical infrastructure itself. Estimations are impossible at this stage of the project, but it is already clear that most likely not all requirements of partners can be fulfilled.

7. References

References to tools and software are as footnotes directly in text.

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Attachments

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