/DH.arc Vocabularies: Making semantic artefacts more visible and accessible using SKOS

Laurent Fintoni[1]
[1] Dipartimento di Filologia Classica e Italianistica, Università di Bologna, Italia – laurent.fintoni2@unibo.it

ABSTRACT (ENGLISH)
This paper presents /DH.arc Vocabularies, a repository for semantic artefacts built using Skosmos and intended to make non-conventional research products such as ontologies and controlled vocabularies created by the Digital Humanities Advanced Research Centre at the University of Bologna more visible and accessible. The paper defines semantic artefacts, their importance, and the need to increase their FAIR-ness before reviewing related work and available technology and giving an overview of the repository, including why Skosmos was chosen, how it was implemented, and the publishing process which includes transforming ontologies written in OWL into SKOS in order to enable their browsing via the interface, a novel approach to existing uses of Skosmos in the fields of cultural heritage and Digital Humanities.
Keywords: Knowledge Organization Systems; Skosmos; Semantic Web; Ontologies; RDF

ABSTRACT (ITALIANO)
/DH.arc Vocabularies: rendere gli artefatti semantici più visibili e accessibili utilizzando SKOS. Questo articolo presenta /DH.arc Vocabularies, un repository per artefatti semantici creato utilizzando Skosmos e destinato a rendere più visibili e accessibili prodotti di ricerca non convenzionali come ontologie e vocabolari controllati creati da Digital Humanities Advanced Research Centre, Università di Bologna. L'articolo definisce gli artefatti semantici, la loro importanza e la necessità di aumentare la loro FAIR-ness prima di esaminare il lavoro correlato e la tecnologia disponibile e fornire una panoramica del repository, incluso il motivo per cui è stato scelto Skosmos, come è stato implementato e il processo di pubblicazione che include la trasformazione di ontologie scritte in OWL in SKOS per consentire la loro navigazione tramite l'interfaccia, un nuovo approccio agli usi esistenti di Skosmos nei campi del patrimonio culturale e delle discipline umanistiche digitali.
Parole chiave: Sistemi di organizzazione della conoscenza; Skosmos; web semantico; ontologie; RDF

1. INTRODUCTION
Over the past two decades the importance of Knowledge Organization Systems (KOS) within the humanities has grown, starting with the interoperability promised and enabled by Semantic Web standards in the 2000s and continuing with the emergence of FAIR Data Principles (Wilkinson et al., 2016) and the prevalence of data-intensive research in the 2010s, which requires data to be defined in a way that is understandable by both computers and humans. At the same time, these technological and research advancements have pushed against the limits of the term KOS. Defined by Hodge as any type of scheme "for organizing information and promoting knowledge management," (Hodge, 2000) KOS have come to cover a variety of digital objects, with the DCMI/NKOS Task Group listing 14 types[1] such as gazetteer, taxonomy, thesaurus, ontology, and controlled vocabulary, all of which enable interoperability at the semantic level by "providing a formal conceptualization of the data that can be shared, reused, and aligned" (d'Aquin & Noy, 2012). More recently, the term semantic artefact has emerged as an alternative (Jonquet et al., 2023), broadening the scope to a "machine-actionable formalization (represented using appropriate formats and serializations, including RDF and non-RDF standards) of a conceptualization, enabling sharing and reuse by humans and machines" (Corcho et al., 2024). This offers a more up-to-date definition that expands the types of objects covered, adding for example standards and metadata schemas to the list, and aligns with both private and public sector practices as well as the goals of international research efforts such as the European Union's Horizon 2020 program (Le Franc et al., 2020).
Regardless of how they are labelled, these research products hold a special importance in that they are both key to achieving FAIR-ness in the data being produced and are themselves research objects that should be FAIR (Cox et al., 2021). However, the latter is often less considered than the former (Poveda-Villalón et al., 2020). This is apparent in the Italian context, which interests us and where semantic artefacts hold a place of importance within humanities, and especially Digital Humanities (DH), research. Despite this importance they can often be difficult to share, find, and (re)use. These issues arise in part

[1] https://nkos.dublincore.org/nkos-type.html

due to the specificities of professional recognition and evaluation within the Italian academic system which prioritizes the processes (theoretical and practical) through which the object was produced rather than the object itself (Fintoni, 2024; Tammaro, 2014). A direct example of this is the lack of representation for semantic artefacts at the metadata level within IRIS institutional repositories where Italian academic research products are expected to be stored and where they are often assimilated into a generic dataset typology. A subtler example is the prioritization of research products that are easier to understand within the Italian academic system, such as digital editions, over semantic artefacts like ontologies.
For the past two decades, efforts to make semantic artefacts more visible and reusable have largely focused on the use of organizational systems that can facilitate their spread and which have been identified as an important component of Semantic Web infrastructure (Baclawski & Schneider, 2009). Due to the increasing number of these semantic artefacts and their usage, within the humanities and other fields such as the life sciences, there is an argument that such organizational systems should be mandatory (Jonquet et al., 2023).
In this paper, we present /DH.arc Vocabularies, a new repository developed to improve the visibility and FAIR-ness of the semantic artefacts produced by the Digital Humanities Advanced Research Centre (/DH.arc) at the University of Bologna and built using the open-source Simple Knowledge Organization System (SKOS) browser Skosmos[2]. Following a review of related work on the subject and available technology, we detail why Skosmos was chosen, how it was implemented, and the publishing process which includes transforming ontologies written in the Web Ontology Language (OWL) into SKOS in order to enable their browsing via the Skosmos interface, which, to our knowledge, offers a novel approach to existing uses of Skosmos in the fields of cultural heritage and DH.

2. RELATED WORK

Existing research into the distribution and accessibility of semantic artefacts has focused primarily on the aforementioned organizational systems, starting with a definition of ontology libraries in 2001 which already underlined the importance of re-usability (Ding & Fensel, 2001). By the end of the 2000s, the concept of ontology repository was introduced to expand these libraries beyond the mere description and listing of items and include other features, by then more common in web-based systems, such as searching, browsing, and querying of content via Application Programming Interfaces (API) (Hartmann et al., 2009). Two reviews of ontology libraries by d'Aquin & Noy (2011) and Naskar & Dutta (2016) built upon this previous work highlighting different categories of libraries such as directories, registries, application platforms, and repositories, with d'Aquin & Noy noting that as libraries all provide means for discovery and access to ontologies "they all serve as ontology repositories" (d'Aquin & Noy, 2011). More recently, Corcho et al. called for the need to adopt an inclusive definition of where semantic artefacts are stored, settling on the term "catalogue of semantic artefacts" for their maturity model, which they define as "a dedicated web-based system that fosters the availability, discoverability and long-term preservation and maintenance of semantic artefacts" (Corcho et al., 2024). We have chosen to refer to /DH.arc Vocabularies as a repository, in line with the features first outlined by d'Aquin & Noy, though semantic artefact catalogue would also be applicable.
As noted by Jansen, the biomedical and wider life sciences domains of research have done much to contribute to ontology development and this is reflected in the common usage of repositories for semantic artefacts in those domains such as OBO Foundry[3] and the NCBO BioPortal[4] (Jansen, 2009). Outside of the life sciences, notable efforts to make semantic artefacts accessible and usable come primarily from public administration and memory institutions such the ARDC Research Vocabularies Australia[5], the National Library of Finland's finto.fi[6], the RDA Registry[7], and the EU's EU-Vocabularies[8]. Looking more specifically at the DH, the Austrian Centre for Digital Humanities and Cultural Heritage's (ACDH-CH) Vocabs[9] is a

[2] https://skosmos.org/

[3] https://obofoundry.org/

[4] https://bioportal.bioontology.org/

[5] https://vocabs.ardc.edu.au/

[6] https://finto.fi/

[7] https://www.rdaregistry.info/

[8] https://op.europa.eu/en/web/eu-vocabularies/

[9] https://vocabs.dariah.eu/en/

repository that offers a single access point for vocabularies related to the Digital Research Infrastructure for the Arts and Humanities (DARIAH), including the latest version of the TaDiRAH taxonomy, popular in the DH. Linked Open Vocabularies[10] is another popular source of semantic artefacts for DH projects. Of the 26 catalogues that Corcho et al. assessed in their research, among the most recent available, nine can be considered to cover semantic artefacts related in part to the humanities, with a particular focus on cultural heritage.

3. SEMANTIC ARTEFACT REPOSITORY TECHNOLOGY

In terms of the technology that powers these repositories, a useful reference is the Software for controlled vocabularies wiki page[11] maintained by the Basic Register of Thesauri, Ontologies & Classifications (BARTOC) (Voß, 2016). Currently, the wiki lists upwards of 35 software and despite the title many of these can be used to edit, view, analyze, and make available most types of semantic artefacts with a particular focus on ontologies and controlled vocabularies. Among these, notable and relevant to our work are solutions that include both services for and services that use semantic artefacts, a key shift from the functionality of early ontology libraries: OntoPortal[12] (developed in Ruby and based on the NCBO BioPortal technology) and OLS[13] (developed in JavaScript and Java and deployed by the EBI Ontology Lookup Service), both used primarily in the life sciences; Skosmos (based on the SKOS data model and developed in PHP[14]), used by finto.fi and ACDH-CH's Vocabs; VocBench and ShowVoc[15] (developed in JavaScript and Java and managed by the Publications Office of the EU), used for the EU-Vocabularies service; TemaTres[16] (developed in PHP), used primarily in the Spanish-speaking world; and Semantic MediaWiki[17] (an extension of the software that powers Wikipedia developed in PHP) used by the semantic web portal Ontology Design Patterns[18].

4. /DH.ARC VOCABULARIES OVERVIEW

The original driver for the creation of the repository was the need to make the controlled vocabularies created by the KNOT project[19] available, thus completing the checklist from Cox et al. to ensure their FAIR-ness (Fintoni, 2024). This led us to consider Skosmos for a number of reasons: (i) it is intended for controlled vocabularies and based on SKOS, which was used to create the KNOT vocabularies, and enables the underlying RDF serializations to be served using HTTP content negotiation when URIs are accessed, thus simplifying the Linked Data publishing infrastructure needed; (ii) it is an open-source solution, which makes potential customizations easier at the cost of requiring more technical skills, and it has a clear separation between code and data with a simple configuration and importing system given the expected technical knowledge of DH practitioners; (iii) it offers multilingual user interfaces and a clean and intuitive presentation layer; (iv) it is already in use within a DH context for ACDH-CH's Vocabs, giving us a use case whose code could be referenced; (v) it offers a REST API for read-only access; (vi) and it is still being developed and supported by the team at the National Library of Finland, for whom the finto.fi service, built on Skosmos, serves as a central hub for shared authority files of all national memory institutions in the country (Suominen et al., 2015). The primary drawbacks of using Skosmos were the lack of an integrated editor, the lack of support for using different triple stores than the one recommended by the developers, and its inability to handle non-SKOS formatted files. We were eventually able to find some solutions to these last two points, which are detailed below.

---

[10] https://lov.linkeddata.es/dataset/lov/

[11] https://github.com/gbv/bartoc.org/wiki/Software-for-controlled-vocabularies

[12] https://ontoportal.org/

[13] https://github.com/EBISPOT/ols4

[14] While Skosmos is referred to as a browser and publishing tool for vocabularies in its documentation, the project from which it emerged, ONKI, was an ontology repository used for the Finnish Linked Open Ontology Cloud KOKO and several international vocabularies (Suominen et al., 2015).

[15] https://vocbench.uniroma2.it/

[16] https://vocabularyserver.com/web/

[17] https://www.semantic-mediawiki.org/wiki/Semantic_MediaWiki

[18] http://ontologydesignpatterns.org/wiki/Main_Page

[19] https://icdp-digital-library.github.io/KNOT/

Skosmos's architecture is relatively simple with a SPARQL endpoint acting as the backend data store and the front-end interface rendered using the Twig templating engine for PHP with additional functionality, such as browsing of vocabulary contents, provided by client-side JavaScript code. Due to the limitations of SPARQL 1.1. for text-based queries, the developers recommend using Apache Jena Fuseki with the jena-text index as the endpoint to handle larger vocabulary needs alongside Varnish as an HTTP proxy cache to improve performance. This approach allows for fast updates to the underlying data and fast page generation, alongside ensuring data is always up to date (Suominen et al., 2015). While it is possible to run Skosmos with a different triple store as backend, which would have been our preferred method due to previous issues with Apache Jena Fuseki within the existing /DH.arc infrastructure, there is no supporting documentation to do so requiring a larger technical investment that was not possible. As such we opted to implement Skosmos using Docker, which mimics the baseline installation[20]. Currently, /DH.arc Vocabularies uses Skosmos 2.18.1[21] which is the last stable release before the current 3.0 version that is still in development. Our production workflow involves a GitHub repository hosting a copy of 2.18.1, which can be run on personal computers using the desktop Docker app to act as a development environment for testing and implementing new functionalities and styles or semantic artefacts[22]. The repository is in turn connected to the /DH.arc web infrastructure where it is used as the production version of the application. Both the development and production versions use Docker Compose, as the dockerized version of Skosmos involves three containers: one for Fuseki, one for Varnish, and one for the application itself. Docker Compose commands are used to push changes from development to live. Though the developers do not recommend using Docker for production we have so far found it to be appropriate for our needs, as our semantic artefacts are relatively small in terms of the number of triples contained and it allows us to bypass internal technical difficulties with Apache Jena Fuseki while having a manageable production workflow that can be easily documented and handed over if need be.

All semantic artefacts made available via Skosmos need to be formatted using SKOS, though there is also support for non-SKOS properties and classes defined using RDF (discussed in more detail in Section 5). The publishing process we follow is similar to that suggested by the developers (Suominen et al., 2015), starting with a pre-process of the files using the Skosify Python library[23] to clean and validate them. This is then followed by a manual check and the addition of any necessary triples or information (for example Italian and English text strings, as these are the two languages used by the repository). Files are then imported into the triple store using cURL commands as per the existing Docker documentation. The last step is the addition of the semantic artefact to the Skosmos configuration file (which uses the Turtle syntax), where it is represented as a dataset and additional options can be set such as supported languages, display options, and download links. A last round of checking is then conducted via the front-end to ensure no information is missing or that there are no display issues. Wherever possible, source files for the semantic artefacts in /DH.arc Vocabularies are hosted in the same GitHub repository as the application. Any update to the files requires the cURL commands to simply be rerun for changes to be reflected in the front-end. Changes to the config file (needed if the URI of the source file changes) or any development changes require the Docker container to be relaunched via Compose commands.

On the front-end, all instances of *skos:Concept* are given their own page, with SKOS mapping relationships shown in a separate section, while instances of *skos:ConceptScheme* act as the de facto 'homepage' of the semantic artefact providing information about the artefact itself. In addition to the standard information one would expect to find at the concept scheme level (agents, creation dates, title, description, publisher etc.) we have chosen to add two additional properties for now: *foaf:homepage* to indicate the homepage of the project which created the artefact, and *dcat:downloadURL* to indicate where a non-SKOS version of the file may be found if it exists. The latter is particularly relevant when dealing with ontologies originally created in OWL as we will see in Section 5. Following early tests of this Skosmos implementation using controlled vocabularies from the KNOT and National Edition of Aldo Moro's Works projects we decided to try and widen its usage to include all semantic artefacts created by /DH.arc, including ontologies. Currently, /DH.arc Vocabularies is intended to host only semantic artefacts created by /DH.arc members and associated research projects and which are already formatted in SKOS or can be.

[20] https://github.com/NatLibFi/Skosmos/tree/main/dockerfiles

[21] https://github.com/NatLibFi/Skosmos/releases/tag/v2.18.1

[22] https://github.com/laurentfintoni/dharc-skosmos

[23] https://github.com/NatLibFi/Skosify

5. ADDING OWL ONTOLOGIES TO SKOSMOS

In the Semantic Web, OWL is intended to be used for the representation of formal ontologies while the SKOS data model was designed to port KOS such as thesauri or taxonomies without formal semantics (Belk et al., 2015). While the W3C indicates that SKOS may be used with OWL[24], as the data model itself is an OWL ontology, existing research into the usage of both languages together is rather limited with early work on moving from KOS to OWL (Hepp & de Bruijn, 2007)[25] and, more relevant to our interests, some explorations of the combination of both published shortly before and after the release of SKOS: usage patterns to help identify modeling errors and infer additional information (Belk et al., 2015), and use cases for combining both (Jupp et al., 2008).

While the majority of existing Skosmos implementations are dedicated to making only controlled vocabularies and similar KOS available[26], finto.fi does make explicit reference to ontologies in its front-end and documentation. As such, we investigated how these SKOS representations of ontologies differed from controlled vocabularies by looking at the General Finnish Ontology YSO[27], one of the central ontologies in finto.fi. This ontology consists mainly of concepts represented as instances of *owl:Class* that are subclasses of *skos:Concept*, alongside a handful of OWL object and data type properties used to indicate labelling types and deprecated concepts. This approach is well suited to SKOS as the concepts in the YSO are traditional KOS elements that don't require the inclusion of more formal semantics as might be found in an OWL formatted ontology where, for example, object properties could be used to describe binary relationships between individuals or a class might make use of restrictions. However, the ontologies created by /DH.arc are all written in OWL and it is the formal semantics the language makes possible and the ontological commitment in a domain these ontologies express (Bruseker et al., 2017) that should be made evident to the end user for their publication and browsing to be useful (beyond making them FAIR).

To solve this issue, we took inspiration from a 2008 W3C document[28] (which predates the 2009 SKOS recommendation and is connected to Jupp et al.) that indicates four patterns for working with SKOS and OWL including going from more (OWL) to less (SKOS) formal by either overlaying the two languages or transforming one into the other. We tested both approaches and settled on overlaying, whereby triples are merged, as this allowed us to make our ontologies viewable in the Skosmos browser (which requires SKOS classes and properties in order to display the underlying RDF triples) while ensuring that the formal semantics they offer are still understandable to both humans and machines. As noted by the aforementioned W3C document, this approach implies two key points: the resulting ontologies are necessarily OWL Full and *skos:Concept* and *owl:Class* cannot be disjoint. In effect, this approach lets us provide taxonomy- or thesaurus-like representations of OWL ontologies, which Jupp et al. noted as a sensible option for specific applications like navigation systems (Jupp et al., 2008).

Our overlaying approach for OWL ontologies is as follows: (i) the ontology is given the *skos:ConceptScheme* class, in addition to *owl:Ontology*, as well as the *skos:hasTopConcept* property (which points to all classes in the ontology as these are now also instances of concepts as explained next), and where needed or appropriate generic information properties are added such as *dc:license*, *foaf:homepage,* and *dcat:downloadURL* as noted in Section 4; (ii) each class and property in the original ontology is given the additional *skos:Concept* class and the *skos:prefLabel* (a duplicate of *rdfs:label*) and *skos:inScheme* properties to correctly reflect the structure of the ontology as a concept scheme as well as correctly enable front-end browsing; (iii) definitions of OWL specific properties, such as *rdfs:domain* and *rdfs:range,* are also added in order for them to be displayed in the front-end; (iv) lastly the *rdfs:subClassOf* property is kept (and defined so as to be displayed) and used in place of SKOS semantic relation properties (*skos:broader* and *skos:narrower*) so as to not confuse any potential subclass structure within the ontology with a more rigid, hierarchical KOS structure.

Figure 1 offers a simplified example of this approach in practice, using the Turtle syntax to show how the F Entry ontology and one of its classes were converted during the development phase of /DH.arc

[24] https://www.w3.org/TR/skos-reference/

[25] https://www.heppnetz.de/projects/skos2owl/

[26] This includes the ACDCH's Vocabs as well as the CNRS' Lottere, the UNESCO thesaurus, and the ELSST's social sciences thesaurus, links to which can all be found at https://skosmos.org/

[27] https://finto.fi/yso/en/

[28] https://www.w3.org/2006/07/SWD/SKOS/skos-and-owl/master.html

Vocabularies[29]. Please note the description property has been removed to keep the example concise.

fentry: a owl:Ontology, skos:ConceptScheme ;
dc:title "F Entry (Scheda F) Ontology"@en, "Ontologia Scheda F"@it;
skos:prefLabel "F Entry (Scheda F) Ontology"@en, "Ontologia Scheda F"@it;
dc:creator "Marilena Daquino", "Silvio Peroni" ;
owl:imports skos:, fabio:, hico:, cito:, pro:, scoro: ;
dct:language "English"@en, "Italiano"@it ;
dct:created "2016" ;
dct:issued "2016-12-15"^^xsd:date ;
owl:versionInfo "1.0" ;
skos:hasTopConcept fentry:photograph, fentry:FEntry, fentry:shot ;
foaf:homepage <https://essepuntato.it/fentry/current/fentry.html> ;
dcat:downloadURL <https://svn.code.sf.net/p/dwellonit/code/FEO/feo.owl> .

fentry:FEntry a owl:Class, skos:Concept ;
skos:inScheme fentry: ;
skos:topConceptOf fentry: ;
rdfs:label "F Entry"@en, "Scheda F"@it ;
skos:prefLabel "F Entry"@en, "Scheda F"@it ;
rdfs:comment "It is a document containing metadata about a photograph and about the concrete object portrayed by the photograph."@en, "È un documento contenente metadati su una fotografia e sull'oggetto concreto rappresentato dalla fotografia."@it ;
rdfs:subClassOf fabio:EntityMetadata .

Figure 1. Simplified example of an OWL ontology and one of its classes overlaid with SKOS for inclusion in the /DH.arc Vocabularies repository

6. FUTURE WORK

The development and release of the /DH.arc Vocabularies semantic artefact repository offers an example of how existing software solutions can be adapted to the needs of smaller DH centers and institutions to enhance the FAIR-ness of their semantic artefacts by using existing infrastructure, staff, and technical skill levels to help make these research products more visible and reusable, a challenge that the humanities must contend with as the importance of these artefacts continues to increase. While the overlaying of OWL and SKOS we have detailed works well for simple OWL ontologies, such as the ones we have currently included in the repository, the approach nonetheless has limits for ontologies with more intricate formal semantics that simply cannot be reproduced in SKOS (such as restrictions).
The next phases of work for the repository include further exploration of how to handle more intricate OWL ontologies (for example by using SKOS notation properties to indicate semantics to an end user), evaluation of the Docker instance for continued production use, the addition of documentation for how to access the API, and the implementation of a documented internal workflow for conversion and publication of future ontologies and other semantic artefacts to ensure their timely addition to the repository and its continued use.

REFERENCES

Baclawski, K. (2009). The Open Ontology Repository initiative: Requirements and research challenges. *CEUR Workshop Proceedings*. https://ceur-ws.org/Vol-514/paper6.pdf

Belk, S., Wohlgenannt, G., & Polleres, A. (2015). Exploring and exploiting(?) the awkward connections between SKOS and OWL. International Workshop on the Semantic Web. http://ceur-ws.org/Vol-1486/paper_96.pdf

[29] The fully converted ontology and all others can be found at https://github.com/laurentfintoni/dharc-skosmos/tree/main/vocab_files

Bruseker, G., Carboni, N., & Guillem, A. (2017). Cultural heritage data management: The role of formal ontology and CIDOC CRM. In *Heritage and Archaeology in the DigitalAge* (pp. 93–131). Springer International Publishing.

Corcho, O., Ekaputra, F. J., Heibi, I., Jonquet, C., Micsik, A., Peroni, S., & Storti, E. (2024). A maturity model for catalogues of semantic artefacts. *Scientific Data, 11*(1), 479. https://doi.org/10.1038/s41597-024-03185-4

Cox, S. J. D., Gonzalez-Beltran, A. N., Magagna, B., & Marinescu, M.-C. (2021). Ten simple rules for making a vocabulary FAIR. *PLoS Computational Biology*, 17(6), e1009041. https://doi.org/10.1371/journal.pcbi.1009041

Ding, Y., & Fensel, D. (2001). Ontology Library Systems: The key to successful Ontology Reuse. International Conference on Semantic Web & Web Services, 93–112. https://files.ifi.uzh.ch/ddis/iswc_archive/iswc/ih/SWWS-2001/program/full/paper58a.pdf

d'Aquin, M., & Noy, N. F. (2012). Where to publish and find ontologies? A survey of ontology libraries. *Web Semantics*, 11, 96–111. https://doi.org/10.1016/j.websem.2011.08.005

Fintoni, L. A. (2024). Rethinking Scholarly Digital Objects as Cultural Heritage: The KNOT Project. In A. Di Silvestro & D. Spampinato (Eds.), Me.Te. Digitali. Mediterraneo in rete tra testi e contesti, Proceedings del XIII Convegno Annuale AIUCD2024 (pp. 582–587).

Hartmann, J., Palma, R., & Gómez-Pérez, A. (2009). Ontology Repositories. In *Handbook on Ontologies* (pp. 551–571). Springer Berlin Heidelberg.

Hepp, M., & de Bruijn, J. (2007). GenTax: A generic methodology for deriving OWL and RDF-S ontologies from hierarchical classifications, thesauri, and inconsistent taxonomies. In *Lecture Notes in Computer Science* (pp. 129–144). Springer Berlin Heidelberg.

Hodge, G. M., & Digital Library Federation. (2000). *Systems of knowledge organization for digital libraries: Beyond traditional authority files*. Washington, DC : Digital Library Federation, Council on Library and Information Resources.

Jansen, L. (2019). Ontologies for the Digital Humanities: Learning from the life sciences? *Joint Ontology Workshops*. https://ceur-ws.org/Vol-2518/paper-WODHSA5.pdf

Jonquet, C., Graybeal, J., Bouazzouni, S., Dorf, M., Fiore, N., Kechagioglou, X., Redmond, T., Rosati, I., Skrenchuk, A., Vendetti, J. L., Musen, M., & members of the OntoPortal Alliance. (2023). Ontology repositories and semantic artefact catalogues with the OntoPortal technology. In *The Semantic Web – ISWC 2023* (pp. 38–58). Springer Nature Switzerland.

Jupp, S., Bechhofer, S., & Stevens, R. (2008). *SKOS with OWL: Don't be Full-ish!* https://ceur-ws.org/Vol-432/owled2008eu_submission_22.pdf

Le Franc, Y., Parland-von Essen, J., Bonino, L., Lehväslaiho, H., Coen, G., & Staiger, C. (2020). *D2.2 FAIR Semantics: First recommendations*. Zenodo. https://doi.org/10.5281/ZENODO.3707984

Naskar, D., & Dutta, B. (2016). *Ontology libraries: A study from an ontofier and an ontologist perspectives*. http://docs.ndltd.org/collection/etd2016/etd16-hal-01398427-2.pdf

Poveda-Villalón, M., Espinoza-Arias, P., Garijo, D., & Corcho, O. (2020). Coming to terms with FAIR ontologies. In *Lecture Notes in Computer Science* (pp. 255–270). Springer International Publishing.

Suominen, O., Ylikotila, H., Pessala, S., Lappalainen, M., & Frosterus, M. (2015). *Publishing SKOS vocabularies with Skosmos*. https://skosmos.org/publishing-skos-vocabularies-with-skosmos.pdf

Tammaro, A. M. (2014). Evaluation of digital humanities: An interdisciplinary approach. In *Communications in Computer and Information Science* (pp. 136–146). Springer Berlin Heidelberg.

Voß, J. (2016). *Open Source web applications for Knowledge Organization Systems*. Zenodo. https://doi.org/10.5281/zenodo.61262

Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J. J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J.-W., da Silva Santos, L. B., Bourne, P. E., Bouwman, J., Brookes, A. J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo, C. T., Finkers, R., … Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data*, 3, 160018. https://doi.org/10.1038/sdata.2016.18