

# One ontology to bind them all: The META-SHARE OWL ontology for the interoperability of linguistic datasets on the Web

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## 1 Introduction [JPM, JG]

The study of language and the development of natural language processing applications requires the access to language resources. Lexicographers and terminologists require access to lexical resources and language corpora, corpus linguistics require access to language corpora and developers of natural language processing applications require annotated corpora to train models for part-of-speech tagging, named entity recognition (NER), parsing, etc. Recently, several digital repositories that index metadata for language resources (LRs) have emerged, supporting the discovery and reuse of LRs. One of the most remarkable of such initiatives is META-SHARE [14] ([www.meta-share.eu](http://www.meta-share.eu)), an open, integrated, secure and interoperable exchange infrastructure where LRs are documented, uploaded, stored, catalogued and announced, downloaded, exchanged and discussed, aiming to support reuse of LRs. Towards this end, META-SHARE has developed a rich metadata schema that allows to describe aspects of LRs accounting for their whole lifecycle from their production to their usage. The schema has been implemented as an XML Schema Definition (XSD). Descriptions of specific LRs are available as XML documents.

Yet, META-SHARE is not the only metadata repository for language resources and other repositories include [4, CLARIN] as well as the [7, LRE-Map]. The metadata schemes of these different repositories vary with respect to their coverage and the set of specific metadata captured. All these repositories are complementary and index different language resources. Currently, it is not possible to query all these repositories in an integrated and uniform fashion.

In this paper we contribute to the interoperability of all these repositories by developing an ontology in the Web Ontology Language (OWL) [?] that allows to represent the metadata schemes of these repositories uniformly, thus achieving an important first crucial step to establish interoperability between these repositories. The proposed ontology is based on the ontology developed by Villegas et al. [17] for the UPF’s META-SHARE node, covering part of the original schema, however extending this initial effort to the whole schema and all LRs and incorporating the consensus reached in the context of the W3C Linked Data for Language Technologies (LD4LT) Community Group<sup>5</sup>.

As a proof of concept of this ontology, we describe how we have mapped metadata records from the above mentioned three repositories (META-SHARE, CLARIN, LRE-Map) into this ontology. Further, we describe *LingHub*<sup>6</sup>, a portal that indexes and provides access to all these metadata records from the mentioned repositories.

Our approach has several advantages. Firstly, the use of Semantic Web techniques (i.e., OWL, RDF) allows us to interlink different LR metadata among themselves and with other external resources on the Web of Data, and enables standardized means of representing and accessing the data (e.g., via SPARQL) thus not relying on domain-specific data formats or proprietary APIs. Secondly, we hope that the use of this ontology will enable the representation of metadata in a manner that allows existing resources to adopt a common core vocabulary, while still being able to represent specific extensions to their existing model and we evaluate this hypothesis by reference to the CLARIN and LRE-Map data models.

The remainder of this paper is structured as follows: In section 2 we will describe the related work in the fields of LR metadata and metadata harmonization. The development of the META-SHARE ontology is described in section ?? as well as its conversion to RDF and how the ontology was used for other data sources in that resource. Finally, in section ?? we consider the broader impact of this ontology as a tool for computational linguists and as a method to realize an architecture of (linked) data-aware services.

## 2 Related Work

The task of finding common vocabularies for linguistics is of wide interest and several general ontologies for linguistics have been proposed. The General Ontology for Linguistic Description [9, GOLD] was proposed as a common model for linguistic data, but its relatively limited scope and low coherence has not lead to wide-spread adoption. An alternative approach that has been proposed is to use ontologies to create coherence among the resources, in particular either by using ontologies to align different linguistic schemas [8] or by means of agreed identifiers [13]. For the particular case of linguistic metadata there have been a number of attempts to define basic metadata for linguistic resources,

<sup>5</sup> <https://www.w3.org/community/ld4lt>

<sup>6</sup> <http://linghub.org/>

most notable the Open Language Archive Community [2, OLAC] which built on the Dublin Core metadata. A similar initiative, that provided more structured metadata was the ISLE Metadata Initiative [5, IMDI]. The CLARIN project has played an important role in collecting information about metadata and in particular proposed a common system by which metadata from disparate sources could be aggregated. This system, called the Component Metadata Infrastructure [6], involved the bringing together and sharing of individual data “profiles”, which are already in use for different resource types by different user communities (e.g. for literary texts, for corpora as used by social scientists, for video corpora as used by linguists etc.), by means of customized XSD schemes. Data profiles are themselves created on the basis of “components”, which are description building blocks consisting of semantically close elements. As we observe in section 2.6, this has in practice merely resulted in each contributing institute using its own scheme, with very little commonality between different institutes. To improve this situation it was recently proposed that the conversion of these CMDI schemas to RDF would enable better interoperability [16], however it is not clear if this project has been realized.<sup>7</sup>

### 3 The META-SHARE OWL Ontology

#### 3.1 Original MS XSD schema[PL]

The design of the META-SHARE schema [11] has been designed not only as an aid for LRs’ search and retrieval processes but also as a means to fostering their production, use and re-use by bringing together knowledge about LRs and related objects and processes. Thus, the schema purports to encode information about the whole lifecycle of the LR from production to usage stages: for instance, information about funding is of interest to policy makers, about creation tools and processes can serve as a model for other LR producers, about the use of LRs in various projects and research papers for specific applications shows their usefulness and can be recommended to prospective LR consumers working on the same area. The central entity of the META-SHARE schema is the LR *per se*, which encompasses both **data sets** (e.g., textual, audio and multimodal/multimedia corpora, lexical data, ontologies, terminologies, computational grammars, language models) and **technologies (tools/services)** used for their processing. It should also be stressed here that the term “LR” in META-SHARE is intended for whole sets of text/audio/video files (corpora), sets of lexical entries (lexical/conceptual resources), integrated tools/services and so on, rather than individual items (e.g. single texts, such as journal articles, poems in corpora or noun entries in lexica). In addition to the central entity, other entities are also documented in the schema; these are reference documents related to the LR (papers, reports, manuals etc.), persons/organizations involved in its creation and use (creators, distributors etc.), related projects and activities

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<sup>7</sup> JPM: I emailed Menzo Windhouwer about this and may change this statement based on his response, if any

(funding projects, activities of usage etc.), accompanying licenses, etc. Thus, the schema recognizes the following distinct “satellite entities”:

- the actor, further distinguished into person and organization,
- the project,
- the document, and
- the licence.

These are described only when the case arises, i.e. when they are linked to a specific LR. For their description, other schemas and guidelines that have been devised specifically for them (e.g. BibTex for bibliographical references) have been taken into account. The META-SHARE schema proposes a set of elements to encode specific descriptive features of each of these entities and relations holding between them, taking as a starting point the LR. Following the CMDI approach, these elements are grouped together into “components”, which act as placeholders for well defined categories of information: for instance, the communication component of a person or organisation includes elements on email, postal address, telephone, URL etc., while the identification component of a LR brings together elements required to identify it, such as the LR’s full and short names, identifiers, a short description of its contents etc. One of the advantages of this mechanism is that it allows for a better structuring of the information, which is crucial for a complex schema like META-SHARE. The core of the schema is the resourceInfo component (Figure 1– **JPM where is this??**), which subsumes components that combine together to provide the full description of a resource and its lifecycle. For each LR there are:

- Identification Info: Giving the name and other identifiers for the resource.
- Distribution Info: Describing the location of the resource.
- Contact Person
- Metadata Info: Self description of the metadata.
- Version Info
- Validation Info: Indicating the evaluation of the resource.
- Usage Info: Giving the intended and actual usage of the resource.
- Resource Documentation Info: Giving documentation of the resource.
- Resource Creation Info: Describing the provenance of the resource. **JMC: this should probably be mapped to PROV-O**
- Relation Info: Giving related resources.
- Type-specific components that cater for the encoding of information relevant to text, audio, video and image parts of corpora, text, audio, video and image parts of lexical/conceptual resources, including information related to contents, formatting, classification

The META-SHARE schema has been implemented as an XSD (available at **GITHUB**). An integrated environment supports the description of LRs, either from scratch or through uploading of XML files adhering to the META-SHARE metadata schema, as well as browsing, searching and viewing of the LRs.

### 3.2 Purpose of the ontology [MV,JG,JPM]

We argue that the Web of Data is a natural scenario for exposing LRs metadata in order to allow their automated discovery, share and reuse by humans or software agents. To that end, we have chosen an OWL based representation for the META-SHARE ontology. OWL allows for a higher expressive level than the original XML representation as well as the application of semantic reasoning techniques (i.e., to infer new knowledge that were not initially declared). Also, the XML-based representation proves inefficient when relating metadata resources. In fact, the use of RDF for representing the annotation of the underlying LRs metadata enable direct mechanisms for establishing links between metadata of different LRs and between metadata of LRs and other external sources. The resulting data is lighter, better suited for exploitation and eases further extensions and links with external resources such as DBpedia. Finally, the use of Semantic Web techniques enable also standardized means of accessing the data (e.g., via SPARQL) thus not relying on domain-specific data formats or proprietary APIs.

### 3.3 Formal modelling and mapping issues [MV, JPM, PL]

The META-SHARE metadata model is formalised in a XSD schema that ‘transcodes’ a component-based model as suggested by CLARIN [6]. Essentially, the component-based approach revolves around two central concepts: *elements* and *components*. *Elements* are used to encode specific descriptive features of the resources and are linked to conceptually similar existing elements in the Dublin Core and/or the ISOcat registry. *Components* are complex elements and can be seen as bundle of semantically coherent *elements*. In the META-SHARE XSD schema, *elements* are formalized as simple elements whereas *components* are formalized as complex-type elements. When mapping the XSD schema to RDF, *elements* can be naturally understood as properties (e.g. name, gender, etc.). *Components* (i.e. complex-type elements), however, deserve a careful analysis. General mapping rules from XSD to RDF establish that a local element with complex type translates into an object property and a Class. An insight analysis of the META-SHARE schema showed that the straightforward application of such a principle may derive into unnecessary verbose graphs. META-SHARE distinguishes between two kinds of *components*, namely:

- ‘special status components’: these are used for the representation of three satellite entities (persons, organizations and documents), which can be reused throughout the model with different roles: validators, annotators, resource documentation, validation reports etc. These are implemented as components(personInfo, organizationInfo, documentInfo) which can be used for elements denoting the roles: validator, annotator, contactPerson, validation-Report etc. Moreover, some of these elements are implemented as a choice between two components: annotator can be implented as either a personInfo or an organizationInfo; documentation is used to bring together the choice

between a structured `documentInfo` component (intended to be filled in like a bibliographic record) and a simple element `'documentUnstructured'` (allowing for typing in links to or titles of simple readme files) Marta, are these choices the complex elements or linked components? what about `contactPerson` which is implemented directly as a `personInfo`?

- ‘normal components’, which simply group together semantically coherent information (e.g. `metadataInfo`, `validationInfo` etc.).

In the XSD schema, ‘special status components’ are formalised as complex types and the different roles they perform in the model are encoded as complex elements. Thus, for example, the `peronInfo` type is reused in the schema by a number of complex elements performing different roles (i.e. `contactPerson`) When applying the conversion rules, the ‘special status components’ have a double mapping: types become Classes and complex elements become object properties which correctly captures the semantics behind. For ‘normal components’ things are more complex. They are also formalised as both complex elements with complex types. In this case, however, the complex type involved is only tied to a unique element. According to the general conversion rules, ‘normal components’, will produce an object property and the corresponding Class which, in most cases, may be unnecessary.

Following [17], we identified potentially removable nodes before the actual RDFication process. The criteria applied take into account the tree structure of the nodes, their cardinality and the XPath axes. Thus, embedded complex elements with `cardinalityMax=1` are identified as potentially removable, provided they do not contain text nor attributes. This allows for a simplification of the model, for example in the chain `resourceInfo/identificationInfo/resourceName`, the `identificationInfo` property is not needed. Note that such a simplification rule can be applied provided this does not derive in sibling conflicts: promoted nodes may cause naming conflicts in their new axe. Thus, a careful checking is needed in order to avoid possible clashes. Interestingly enough, the removal of the superfluous wrapping elements has also led to a change of philosophy to the schema and a need for re-structuring in order to ensure that properties are attached to the most appropriate node, as exemplified and discussed in Section 2.5

Beyond this, we made the following extensions to our mapping strategy:

- We decided to rename some of the elements when falling into one of the following categories: (a) removed the Info suffix from the wrapping elements: e.g. `validationInfo` becomes simply `validation` PL: check tomorrow all classes and make a list as promised (b) changed the names of elements that created confusion, as already noted by the META-SHARE group and/or the ld4lt group; thus, ‘resource’ was renamed ‘languageResource’, ‘restrictionsOfUse’ became ‘conditionsOfUse’, etc. (c) PL: I lost some text and I can’t remember what I had here; tomorrow... (d) shortened some names such as `ConformanceToBestStandardsAndPractices` JPM: Perhaps we introduce sameAs links to handle this; PL: I think we decided against d; pls confirm

- Developed novel classes based on existing values, e.g., `Corpus`  $\equiv \exists \text{resourceType.corpus}$   
**PL: IMPORTANT: discuss what we do with `resourceComponentType`, `corpusMediaType`, `corpusTextInfo` etc.; what remains and what is removed; tomorrow...**
- Removing unnecessary properties such as `versionInfo`. PL: I think this is the same as `identificationInfo`; if yes, removed
- Generalized elements such as `notAvailableThroughMetashare` to `availableThroughOtherDistributor`
- Simplified some complex structures, such as `membershipInfo` PL: come back to this tomorrow
- Grouping similar elements under novel superclasses, e.g., `DiscourseAnnotation`, `genre` PL: one of the advantages of the RDF approach; say a bit more
- Extending existing classes with new values and including new properties (see section 2.5)

### 3.4 Interface with DCAT and other vocabularies [JPM]

The META-SHARE model can be considered broadly similar to DCAT in that there are classes that are nearly an exact match to ones in DCAT for three out of four cases. DCAT's *dataset* corresponds nearly exactly to the *resource info* tag and similarly, *distributions* are similar to *distribution info* classes and *catalog record* is similar to *metadata info*. The fourth main class, *catalog* covers a level not modelled by META-SHARE. DCAT uses Dublin Core properties for many parts of the metadata, and often these properties are in fact deeply nested into the description. For example, language is found in several places deeply nested under six tags<sup>8</sup>. In META-SHARE this allows different media types in the resource to have different languages ,e.g., the dialogues and the scripts of a video may be in English, but the subtitles can be in French and German (two translations). We still include this fine-grained metadata but also add the property at the resource level to indicate if any part of the resource is in the stated language. Similarly, it also the case that some Dublin Core properties are not directly specified in the META-SHARE model, but can be inferred from related properties, e.g., Dublin Core's 'contributor' follows from people indicated as 'annotators', 'evaluators', 'recorders' or 'validators'. Similarly, several DCAT specific-properties, such as 'download URL', are nearly exactly equivalent to those in Metashare but occur in places that do not fit the domain and range of the properties. In this particular case, it was a simple fix to move the property to the enclosing `DistributionInfo` class. Inevitably, several properties from DCAT did not have equivalences in META-SHARE, notably 'keyword'.

### 3.5 Licensing module [VRD, PL]

One of the most important achievements of META-SHARE has been the formulation of a clear, consise and easy-to-use licensing model to specify the rights

<sup>8</sup> `resourceInfo` > `resourceComponentType` > `corpus*` > `corpusMediaType` > `corpusVideoInfo` > `languageInfo`

information of the LRs. Licensed LRs can be shared and re-used with legal guarantees complying with the statement of the META-SHARE Charter<sup>9</sup>: “*LRs should be shared and further re-used with the minimum possible transaction costs and efforts and under clear and easy to understand rules*”. This is of high importance since the production of LRs of good quality and quantity, as required for the research and development of Language Technology, is cost-consuming and only their sharing and re-use can render them cost-effective.

LR are sometimes offered under a well-known license (e.g. Creative Commons, CC), and sometimes under the specific terms and conditions declared by the rightsholder; they are sometimes open<sup>10</sup> and sometimes offered under more limiting conditions. In order to limit fuzziness in the terms and conditions of use of LRs, a range of recommended standard licenses are provided in the META-SHARE model licensing scheme organised on the following axes: open licences are the preferred option (CC licences for data resources and Free Open Source Software for tools and services), followed by a set of model (standard) licences built in response to LR providers’ requests (META-SHARE Commons and NoRedistribution licences); previous custom and proprietary licences are the last resort only for legacy resources that cannot be licensed otherwise.

The mechanism for implementing this set of recommendations has been the metadata module on licensing, which is an essential ingredient of the schema. The elements describing rights of use and distribution details are included in the obligatory component `distributionInfo` and its embedded `licenceInfo`, i.e. all LRs documented in META-SHARE include obligatorily a description on their conditions of use in a standardised format. The schema contains specific elements for:

- the distribution and use conditions, namely:
  1. ‘availability’ (simply to say that an LR is available with or without restrictions or under negotiation),
  2. ‘licence’, which takes a value from a list of the recommended standard licences and additional values for proprietary and non-standard (legacy) licences
  3. elements describing in a abbreviated human-oriented way terms and conditions of use (mainly ‘restrictionsOfUse’ which comprises a list of the most frequent terms associated with LRs, eg. `noDerivatives`, `nonCommercialUse`, `attribution` etc.; and ‘userNature’ which is used for the user restriction axis, i.e. `academic` vs. `commercial`)
  4. elements for the more detailed information required by specific conditions of use, i.e. ‘fee’ for LRs offered with a monetary compensation, ‘`attributionText`’ for those requiring attribution, and the component ‘member-

<sup>9</sup> [http://http://www.meta-net.eu/meta-share/METASHARE\\_Charter.pdf](http://http://www.meta-net.eu/meta-share/METASHARE_Charter.pdf)

<sup>10</sup> We consider *open licenses* to be those that include not only the right to read the relevant content but also to allow transformative uses, dissemination and distribution of such resources and their derivatives, according to the needs and policies of LR owners and users.



- ‘shipInfo’ which is used for LRs offered with different prices for members of specific groups
- rights holders (‘iprHolder’, ‘distributionRightsHolder’ and ‘licensor’)
- the medium and url (if available over the internet) from which the LR is distributed (‘distributionAccessMedium’, ‘downloadLocation’, ‘executionLocation’)
- the dates that an LR will be made (or stop to be) available (‘availabilityEndDate’ and ‘availabilityStartDate’).

Optionality and cardinality are specified for each element/component. Thus, ‘licence’ is obligatory for all available LRs and the component ‘licenceInfo’ can be repeated to cater for LRs that are offered with dual licensing, e.g. for commercial purposes with a fee and for research for free; in fact, the ‘licenceInfo’ groups together elements that may differ when licensed under different licences, e.g. a form of the LR accessible via a web interface with limited results for free for research and a downloadable form offered for commercial purposes with a fee.

In the conversion of META-SHARE from XSD to OWL/RDF, the simplification rule described in Section 2.2 **VRD: I think you mean 3.3...** does not suffice: the license attributes the *distribution* rather than the *resource* and dual (or multiple) licensing is permitted.

**Short introduction on the ODRL vocabulary. [VRD]** The terms and conditions of use can be declared by using URIs pointing to well-known licenses or to the specific text with the specific terms of the publishing institution. However, this practice would not favour automated processing and the rights information thus referred would not be queryable. In order to overcome this, a fine-grain representation of licenses, where the specific rights and conditions are given in RDF, was considered. Some languages already exist for this purpose, and among them, ODRL 2.1 was chosen and extended. ODRL (Open Digital Rights Language) is a policy and rights expression language specified by the W3C ODRL Community Group<sup>11</sup> which defines a model for representing permissions, prohibitions and duties, as well as a core vocabulary. The abstract model can be serialized as JSON, XML or RDF, the latter option being supported by the ODRL 2.1 Ontology<sup>12</sup>. The most common licenses (for software, data or general works) have been already expressed in ODRL in the RDF License dataset[?], however new vocabulary was needed to represent some of the specificities of the language resources domain.

The specification of the RDF resources to describe licenses was based on a list of requirements<sup>13</sup> and led to changes, some of them structural, with respect to the previous versions. These changes included the selection of classes and properties were taken from other existing vocabularies (specifically from ODRL, Dublin Core, Creative Commons REL and SKOS) as well as the definition of new ones.

**JPM: I would remove/reduce the text after this point**

<sup>11</sup> <https://www.w3.org/community/odrl/>

<sup>12</sup> <http://www.w3.org/ns/odrl/2/>

<sup>13</sup> <https://www.w3.org/community/ld4lt/wiki/Metasharevocabularyforlicenses>

The main decision we took as regards the licensing module, was the re-structuring of the elements as stemming from the removal of the notion of the wrapping elements. Thus, instead of using the components as a way of grouping together information, we decided to replace them with classes that can be used to better represent the licensing ecosystem of LRs, and to re-structure the elements in order to attach them as properties to the appropriate nodes. As a result, we recognize the following three entities/classes, each associated with different properties as appropriate:

- LanguageResource, which is the intellectual property *work*, can be attributed the *iprHolder*, *distributionRightsHolder*;
- Distribution, taken from the DCAT vocabulary where it “*represents an accessible form of a dataset as for example a downloadable file, an RSS feed or a web service that provides the data*”; this is the entity to which properties for describing licencing, forms and other details of distribution must be attached;
- License, with the specific information that can help us generalize over terms and conditions and enriched with concepts from the ODRL ontology.

PL, VR: we need a figure here. How much space do we have?

In order to ease the task of writing RDF expressions to represent licenses, a number of recommended licenses has been already published<sup>14</sup>. Further, as some of these licenses have to be written by Semantic Web laymen, the new concept of *license templates* has been proposed. A license template is an RDF document with common terms and conditions ready to be complemented by other information that changes more frequently. Thus, some of the variable elements are detached and more easy editable.

### 3.6 Harmonizing other resources with META-SHARE [JPM]

The LingHub portal indexes metadata from a wide-range of sources. While a basic level of interoperability can be established by used standard vocabularies such as DCAT and Dublin Core, this can only be done by sacrificing completeness and ignoring all metadata particular to language resources. For this reason, we rely the META-SHARE model to represent and harmonize the metadata relating specifically to the domain of linguistics and language resources. As a proof-of-concept, we show how the META-SHARE ontology supports the harmonization of CLARIN data. The CLARIN repository describes its resources using a small common set of metadata and a larger description defined by the Component Metadata Infrastructure [6, CMDI]. These metadata schemes are extremely diverse as shown in table 1. We will focus on the top five of these types, where we have also developed mappings using the LIXR model. Two of these schemes are only Dublin Core properties and so do not have specific language resource metadata. The most frequent ‘Song’ tag focusses on a database of musical

<sup>14</sup> Penny: which is the last location?

recordings, and many of these properties (e.g., ‘number of stanzas’) did not correspond to any properties, however the META-SHARE Ontology could be used to describe the language and technical format information (i.e., ‘audio encoding’). The `Session` tag is in fact the IMDI metadata [5] and as such corresponds loosely with META-SHARE but highlighted areas where the META-SHARE ontology does not provide sufficient properties, for example in describing the participants in a media recording. The MODS metadata scheme [?] was similar in that the META-SHARE ontology provided some properties but was often insufficient in the details that were recorded. This highlights the advantage of taking an open world, ontological approach as opposed to a fixed schema, in that we can easily introduce new properties while still reusing the META-SHARE properties where they were available. **I doubt I will manage it but I will try to include the number of MS props used - JPM**

Component Root Tag	Institutes	Frequency
Song	1 (MI)	155,403
Session	1 (MPI)	128,673
OLAC-DcmiTerms	39	95,370
mods	1 (Utrecht)	64,632
DcmiTerms	2 (BeG,HI)	46,160
SongScan	1 (MI)	28,448
media-session-profile	1 (Munich)	22,405
SourceScan	1 (MI)	21,256
Source	1 (MI)	16,519
teiHeader	2 (BBAW, Copenhagen)	15,998

**Table 1.** The top 10 most frequent component types in CLARIN and the institutes that use them. Abbreviations: MI=Meertens Institute (KNAW), MPI=Max Planck Insitute (Nijmegen), BeG=Netherlands Institute for Sound and Vision, HI=Huygens Institute (KNAW), BBAW=Berlin-Brandenburg Academy of Sciences

## 4 Applications

### 4.1 IULA LOD Catalogue [MV]

The IULA-UPF CLARIN Competence Centre<sup>15</sup> aims to promote and support the use of technology and text analysis tools in the Humanities and Social Sciences research. The centre includes a Catalogue<sup>16</sup> with information on language resources and technology. The Catalogue is based on the initial LOD version of the META-SHARE model as described in [17] and the original data come

<sup>15</sup> <http://www.clarin-es-lab.org/index-en.html>

<sup>16</sup> <http://lod.iula.upf.edu/>

from the UPF META-SHARE node<sup>17</sup>. The source XML records were converted into RDF and augmented with service descriptions (not included in the UPF META-SHARE node) and relevant documentation (appropriate articles, documentation, sample data and results, illustrative experiments, examples from outstanding projects, illustrative use cases, etc) to encourage potential users to embrace digital tools. Finally, the data was enriched with internal and external links. The eventual linked data allowed maximizing the information contained in the original repository and developing data mashup techniques that get relevant data from the DBpedia and the DBLP<sup>18</sup>. The Catalogue demonstrates the benefits of the LOD framework and how this can be easily used as the basis for a web browser application that maximizes information and helps users to navigate throughout the dataset in a comprehensive way.

## 4.2 LingHub [JPM]

## 5 Conclusion [PC, JPM]

This work represents only a first starting point for the harmonization of language resources by providing a standard ontology that can be used in the description of metadata of linguistic resources. The LingHub portal we have presented here is proof-of-concept for the level of harmonization that the use of a common ontology provides, as metadata originating from different repositories can be uniformly queried in LingHub in an integrated fashion. We adhere to an open architecture in which not only LingHub but other discovery services aggregate and index data could potentially be developed.

The work described here is only a first step to harmonization in that there are still a number of challenges ahead of us to be addressed:

- **Data availability:** The next step would be to make sure that not only metadata, but the actual data is available on the Web in open web standards such as RDF so that data can be automatically crawled and analyzed.
- **Data integration and querying:** Linguistic data published on the Web should ideally follow the same format (e.g. RDF) so that it can be easily integrated and data can be queried across datasets. This presupposes the agreement on best practices for data publication and formats. The Natural Language Processing Interchange Format (NIF)[12] is an obvious candidate for that.
- **Service harmonization and discovery:** Harmonization should be extended to the description of NLP services so that NLP services can be discovered across providers and repositories. The mechanisms for description of the functionality of NLP services should be extremely light-weight.
- **Service composition and execution on the cloud:** Input and output formats for services should be standardized and homogenized so that services can be easily composed to realize more complex workflows, without

<sup>17</sup> <http://metashare.upf.edu>

<sup>18</sup> <http://dblp.uni-trier.de/db/index.html>

relying on too much parametrization. Workflows of services should be easily executable ‘*on the cloud*’. In order to scale, services should support parallelization and streaming and support non-centralized processing. Service execution and composition should not require special libraries, grids or other proprietary infrastructures or protocols, but rely only on open web standards and protocols such as the hypertext transfer protocol (HTTP) and content negotiation, ideally being RESTful to keep APIs simple and stateless.

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