

Transforming TEI Manuscript Descriptions into RDF Graphs

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INTRODUCTION

This paper reports on the transformation of the Bodleian Library’s online medieval manuscripts catalogue, based on the Text Encoding Initiative (TEI) Guidelines, into RDF graphs using the CIDOC-CRM and FRBR₀₀ ontologies which enable integration of datasets. The catalogue uses the “Manuscript Description” section of the TEI Guidelines to encode entries which were originally published in printed form, but also incorporates amendments and additions from unpublished documents prepared in the Bodleian Library. The transformation of this catalogue has required the development of processes to extract the relevant elements from the TEI XML documents, assemble these extracts into a new XML file, and match the various elements and attributes to CIDOC-CRM and FRBR₀₀ entities and properties which can be expressed as RDF triples and incorporated into graph databases.

As a result of this work, information from the manuscripts catalogue has been ingested into Linked Data graph databases developed by two Oxford projects: (a) OXLOD, a pilot project on Linked Data in Oxford which brought together data from a range of Oxford’s cultural institutions, and (b) Mapping Manuscript Migrations, an international project designed to track the ownership and provenance of medieval manuscripts using data from several databases related to manuscript history (Burrows, Hyvönen, Ransom and Wijsman, 2018). The specific aims of these two projects are somewhat different, and their technical infrastructure also differs: OXLOD used the ResearchSpace software developed by the British Museum and Metaphacts (Oldman and Tanase 2018), while Mapping Manuscript Migrations uses Fuseki SPARQL servers combined with a customized environment built with React and NodeJS (Hyvönen et al. 2019). But the projects share a common methodology which relies on mapping to RDF and Linked Data to integrate heterogeneous datasets relating to cultural heritage objects.

STATE of the ART

The Manuscript Description section of the TEI Guidelines has become the de-facto schema for structuring detailed descriptions of manuscripts.¹ Institutions using TEI descriptions include the University of Pennsylvania (for its OPenn and Bibliophilly services) and Manuscriptorium, the digital manuscript library managed by the National Library of the Czech Republic. The Bodleian Library chose TEI for its online manuscript catalogues, launched in 2017.² As well as the catalogue of medieval manuscripts in Oxford libraries, they include Fihrist, a cooperative catalogue of manuscripts from the Islamic world, and seven other specialized Oxford catalogues.

The TEI Guidelines are designed to be flexible and hospitable to different approaches to encoding and markup. In the case of the Manuscript Description section, this means that there are various ways of encoding the same basic information, with no definitive agreed standards. The Bodleian Library has recently made available draft encoding guidelines for manuscript descriptions, aimed at promoting consistency of encoding across different catalogues.³ Developed in association with Cambridge University Library and the British Library, the guidelines for medieval manuscripts draw on earlier work by Patrick Granholm and Eva Nyström for the Swedish manuscript catalogue manuscripta.se.

¹ Some examples are listed at: https://wiki.tei-c.org/index.php/TEI_manuscript_catalogues

² <http://medieval.bodleian.ox.ac.uk>

³ <https://bodleian.github.io/consolidated-tei-schema/msdesc.html>

In parallel, there has been growing interest in developing Linked Data approaches to the aggregation of manuscript data. Europeana, which includes records and images for more than 305,000 manuscripts, has established workflows for mapping manuscript records in a variety of formats to its Europeana Data Model (EDM), represented in RDF. The limitations of the EDM for manuscript metadata have been addressed by the Digitised Manuscripts to Europeana (DM2E) project, which developed a specialization of the EDM to extend its properties and classes for use with manuscript records (Dröge, Iwanova and Henniecke 2014).

Another important aggregator of manuscript data is Biblissima, which brings together descriptions from about forty mainly French manuscript catalogues. For its initial prototype, Biblissima combined data from the Mandragore and Initiale databases into an RDF-based framework, using an ontology modelled on CIDOC-CRM and FRBR_{oo} (Frunzeanu, Robineau and MacDonald, 2016). The full Biblissima service, however, is based on XML pivot tables instead, and includes mappings from the TEI. It uses Linked Data techniques to align data through external identifiers from services like data.bnf.fr, GeoNames, and VIAF, and also makes available an RDF version which can be queried through a SPARQL end-point (Robineau 2019).

The relationship between TEI manuscript descriptions and the world of Linked Data, RDF, and ontologies has only been given relatively limited attention. In 2007, Øyvind Eide and Christian-Emil Ore produced a draft mapping from TEI to CIDOC-CRM, covering a selection of “events, time appellations, actors and actor appellations” drawn from several areas of the TEI Guidelines, but not including the ‘Manuscript Description’ section. The same two authors (Ore and Eide 2009) subsequently produced a set of recommendations for TEI extensions and adjustments aimed at making “the ontological information in a TEI document compliant with the other cultural heritage models” including CIDOC-CRM. They noted that Manuscript Description was one of the TEI sections where ontologically oriented elements are defined. Eide’s more general reflections on linking the TEI with external ontologies can be found in Eide 2014/15. More recently, Ciotti and Tomasi (2016/17) and Ciotti (2018) have presented a model aimed at “furnishing the TEI with a semantics based on a formal ontology”. Crompton and Schwartz (2018) have proposed the “the development of XSLT-backed tools to convert and connect otherwise incommensurable [TEI] data sets”.

To our knowledge, the only previous work on transforming TEI-encoded manuscript descriptions into RDF has been carried out by the Medieval Electronic Scholarly Alliance (MESA), which is one of the nodes of the Advanced Research Consortium (ARC). The ARC RDF schema is designed for encoding descriptions of digital resources made available through the Collex interface, and consists of a number of Dublin Core elements supplemented by a few Collex-specific elements.⁴ Several TEI-based manuscript catalogues have been mapped for the MESA-Collex search interface, and one example of a transformation of a TEI manuscript description from the Walters Art Museum has been published.⁵ For the most part, the TEI elements involved are limited to title, language, and date, while the TEI <provenance> element has simply been mapped to <dc:provenance> without any encoding or mapping of persons, places, or events within a provenance statement.

METHODOLOGIES

At the Bodleian Library a customized TEI schema is used. Written in the TEI’s ODD schema language, it is available in RELAX NG, XSD and DTD versions, and is used in eight different manuscript catalogues managed by the Bodleian. Separate authority files for persons, organisations, places and works are maintained and linked to the medieval manuscript descriptions. The raw TEI-XML files are stored in a public GitHub repository, where they are grouped by manuscript collection.⁶ Publicly accessible and searchable versions of the files are made available through a Web site built with technologies including XSLT, xQuery, Solr and Blacklight.

TEI manuscript data can be complex, often describing manuscripts divided into several parts, each with its own history and containing works-within-works (e.g., a collection of poetry and individual poems). Information about the history and provenance of the manuscripts (the focus of the Mapping Manuscript Migrations project) has been encoded in different ways, such as a single XML element describing the entire history of the manuscript, or multiple <provenance> elements which each recount one event. Dates are encoded with date tags or attributes on the provenance element.

⁴ http://wiki.collex.org/index.php/Submitting_RDF

⁵ http://wiki.collex.org/index.php/RDF_samples#MESA:_Walters_Art_Gallery

⁶ <https://github.com/bodleian/medieval-mss>

The first step in our workflow is to identify those parts of the TEI schema which will be needed to answer the research questions of the Mapping Manuscript Migrations project. An xQuery script is used to extract these parts and copy them into a simplified XML document. It also creates URIs for each included entity. This simplified XML output is then mapped to classes and properties of the CIDOC-CRM and FRBR_{oo} ontologies using the 3M mapping tool (Oldman, Theodoridou and Samaritakis, 2010). The table below summarizes the mappings for the TEI <provenance> element.

TEI element	Field in simplified XML	Ontology mapping in 3M
provenance	provenance	crm:E5_Event
	provenance/@xml:id	URIorUUID
	provenance/text	crm:P3_has_note > Literal
	provenance/date	crm:P4_has_time-span > crm:E52_Time-Span
	provenance/org	crm:P11_had_participant > crm:E74_Group
	provenance/org[@role='formerOwner']	crm:P51_has_former_or_current_owner > crm:E74_Group
	provenance/person	crm:P11_had_participant > crm:E21_Person and frbr:F10_Person
	provenance/ person[@role='formerOwner']	crm:P51_has_former_or_current_owner > crm:E21_Person and frbr:F10_Person
	provenance/place	crm:P7_took_place_at > crm:E53_Place and frbr:F9_Place

Table 1: Mappings for the TEI <provenance> element

The Bodleian's XML authority files are handled as separate datasets following the same method. Manuscript instances are then integrated with the authority records via corresponding URIs. These have been manually reconciled with URIs in external authorities such as the Virtual International Authority File (VIAF), GeoNames, the Getty Thesaurus of Geographical Names (TGN), Gemeinsame Normdatei (GND), and WikiData.

The constraints of the OXLOD and Mapping Manuscript Migrations projects have made it necessary to work with the existing TEI documents produced by the Bodleian Library. Within the project timeframes, it was simply not feasible to re-encode the files or to enhance the existing encoding manually. Nevertheless, some bulk updating was done to add generic provenance statements to multiple files, especially where the existing <provenance> elements for a specific named collection did not include an entry for the Bodleian's acquisition of the manuscripts from the named collector. These updates were done at the University of Pennsylvania Library by forking the relevant TEI documents from GitHub, writing a Ruby script to add standard <provenance> and <change> statements to each file, and returning the files to the Bodleian. The TEI documents for 22 out of 71 Bodleian manuscript collections have been enhanced in this way.

DISCUSSION

While the TEI manuscript descriptions may appear to be highly structured, there are important elements within them which are not. The focus of the Mapping Manuscript Migrations project is on the history and provenance sections of the descriptions, which record the evidence for the production and ownership of manuscripts over the many centuries of their existence. To meet the requirements of this project, we needed to extract as much of this evidence as possible in a suitably structured form.

The TEI <provenance> elements, in particular, hold most of the information needed. But these elements are often presented as a free-text narrative with marked-up entities for those persons, organisations, dates and places mentioned in the narrative. They often also hold transcriptions of annotations and inscriptions on the manuscript itself.

This reflects the traditional approach to printed manuscript catalogues, where this kind of information is given primarily in narrative form. The TEI Guidelines, at least initially, were designed to encode digital versions of these printed catalogues. A

typical example of the Bodleian Library's treatment of <provenance> encoding – for manuscript Lat. th. (Latin theology) d. 29 – looks like this:

```
<provenance>Titles (13th–15th cent.) 'Consuetudines Lanfranci et excerpta de
poenitentiale. Item Seneca ad lucillum', and press-mark 'E 25' (fol.
iii)</provenance>
<provenance>
    <persName role="fmo" key="person_1259"><!-- not found. His
tomb mentioned in VCH. -->
        William Brent of Willington, Warwick
    </persName>, given to <persName role="fmo"
key="person_61575100">
        Sir William
        Dugdale
    </persName>, 'i Oct.1675' (fol.iii verso)</provenance>
<provenance>Thorpe catalogue, 1831, no. 4108</provenance>
<provenance>W. Shaw Mason (fol.iii verso)</provenance>
<provenance>4th Duke of
        Newcastle, Sotheby's 6 Dec.1937, lot 955</provenance>
<provenance>
    <persName role="fmo" key="person_40764209">
        André de Coppet
    </persName>, his sale at Sotheby's 6 Dec. 1954,
    lot 34, bought by Quaritch for £95.</provenance>
<provenance>Given
    by <persName role="fmo" key="person_111104108">
        Arthur. A. Houghton
    </persName>.</provenance>
```

Figure 1. TEI <provenance> encoding for Bodleian Library Lat. th. d. 29

There are seven provenance statements here, most of which include an encoded personal name, usually that of a former owner. None of the dates have been encoded, however; nor have any of the booksellers' names.

As well as the <provenance> statements, we also made use of the <origin> encoding within the <history> element. This is more rigorously encoded, as the example for the same manuscript demonstrates:

```
<origin
>
    <origDate calendar="Gregorian" notAfter="1200"
notBefore="1150">12th century, second half</origDate>
    <origPlace>
        <country key="place_7002445">English</country>
    </origPlace>
</origin>
```

Figure 2. TEI <origin> encoding for Bodleian Library Lat. th. d. 29

Here the date of production – usually given as an approximate verbal range – has been converted to Gregorian dates in a notAfter / notBefore pattern. The place of origin, whether a country or a more specific location, has been linked to the value in the Bodleian Library’s authority file for places, which normally has an associated TGN identifier.

Our aim was to extract the salient information about history and provenance automatically from the narrative of transfers of ownership. By using a combination of role attributes relating to ownership (where available) and the encoded entities within the provenance statements, we were able to construct event-related statements linking the manuscript and the actors in its history. We limited our model to generic relationships of provenance activities (primarily ownership, acquisition, and production) to ensure the accuracy of the resulting RDF statements, rather than attempting to infer more specific relationships from narrative statements which lacked the necessary markup.

The rest of the required information for Mapping Manuscript Migrations is related to bibliographical descriptions of the manuscripts, which were also the focus of the OXLOD project. Titles of works, and their authors, have been consistently encoded in the TEI documents and linked to the relevant authority file entry, making them relatively straightforward to extract and match to FRBR_{oo} entities and relationships. The other key piece of data from each TEI document is the manuscript shelfmark, which serves as an identifier in the absence of any international standard for manuscript identifiers (Figure 3).

```
<msIdentifie
r>

                                <country>United Kingdom</country>
                                <region type="county">Oxfordshire</region>
                                <settlement>Oxford</settlement>
                                <institution>University of
Oxford</institution>
                                <repository>Bodleian Library</repository>
                                <idno type="shelfmark">MS. Lat. th. d.
29</idno>
                                <altIdentifier type="internal">
                                <idno type="SCN">Not in SC (late
accession)</idno>
                                </altIdentifier>
                                </msIdentifier>
```

Figure 3. <msIdentifier> encoding for Bodleian Library Lat. th. d. 29

The TEI treatment of shelfmarks is highly structured and relatively straightforward to extract and transform into RDF triples. It should be noted that, although the mapping process produced a unique URI for each manuscript, this cannot yet be linked automatically to entries for the same manuscript in other datasets. The Mapping Manuscript Migrations project is experimenting with manual and semi-automated linking of manuscripts across datasets, while an International Standard Manuscript Identifier (ISMI) for Linked Data purposes is in development (Cassin 2018). The Bodleian Library is investigating the possible use of ARK identifiers for its manuscripts (Burns et al. 2019).

RESULTS

The TEI schema, the xQuery script and the simplified XML output are all available from the Bodleian Library’s GitHub repository, together with the 3M mapping file and the RDF representations. The Mapping Manuscript Migrations interface to query the RDF records is in development and is expected to be publicly available towards the end of 2019. The OXLOD pilot project has not yet been made available for external access.

Our workflow output was initially evaluated through a series of SPARQL queries run against the OXLOD pilot data. These queries focused on identifying relevant manuscripts through origin, provenance and acquisition events, filtered by location and time period. Additional contextual information was supplied through federated queries on the Getty Thesaurus of Geographic Names (TGN) and on WikiData. Examples of these queries can be seen in Velios, 2018.

A second evaluation is currently in progress for the Mapping Manuscript Migrations project. This involves running SPARQL queries against the aggregated RDF data from the Bodleian Library and two other datasets (the Schoenberg Database of Manuscripts and the Bibale database), using a set of research questions identified by researchers connected with the project. These queries have been able to produce results which match those obtained directly from the Bodleian site using a combination of keyword searches and browsing by persons and places. The RDF queries connected with places of production and ownership have been able to take advantage of the geographical hierarchies embedded in the Getty TGN, even though these are not explicitly present in the relevant Bodleian authority file. A query like “Find all manuscripts produced in Lombardy in the 15th century” will return manuscripts originating specifically from places like Milan, Brescia and Pavia, for instance. This is not possible using a single query in the native interface to the Bodleian catalogue, since each place has to be searched separately.

On the other hand, the RDF queries have identified some issues with interpreting the dates used in manuscript descriptions, which are often expressed in very approximate terms. A date range like “xv – xvi centuries” would be encoded as follows:

```
<origDate calendar="Gregorian" notAfter="1500" notBefore="1400">
```

But should this manuscript be counted among those produced in 15th-century Lombardy or not? The answer is a matter for the manuscript researcher rather than the TEI encoder, however, and should be defined in the SPARQL query independently of the TEI encoding.

The work done to transform the Bodleian TEI documents for these two projects has demonstrated that it is possible to extract encoded manuscript data in a form which can be expressed as RDF, loaded to a graph database, incorporated into a Linked Data environment, and retrieved using SPARQL queries. But the nature of some of the TEI markup – and especially the lack of encoding for various components of the narrative <provenance> statements – means that the RDF representation cannot include all the relevant information from the catalogue records. In the Bodleian catalogue itself, the keyword search function can still find occurrences of (for example) a bookseller’s name, even though this has not been encoded. Replicating this functionality in the RDF environment would mean either re-encoding the TEI files in a more thorough and structured way or developing additional scripts to parse, extract, and transform provenance information which is currently presented in unencoded narrative statements within a <provenance> element.

FUTURE WORK

An important output from the Mapping Manuscript Migrations project will be a set of recommendations for re-thinking the structure and encoding of the TEI <provenance> element to enable its more effective reuse in graph applications. These recommendations will draw on the concepts previously outlined by Ore and Eide (2009), but will also take into account the parallel work currently being done in the art museum and gallery community on documenting and reusing provenance information. This includes improving the structure of provenance records in museum databases (Bergen-Fulton, Newbury, and Snyder 2015), as well as transforming museum databases to Linked Data and RDF graphs based on CIDOC-CRM (Knoblock et al. 2017). The Linked Art Data Model, which is in the process of development, will have a specific section devoted to the provenance of art works, based on CIDOC-CRM as the core ontology.⁷

Our aim is to ensure that the project’s recommendations relating to the TEI <provenance> element can be framed within the existing TEI Guidelines, and can be incorporated into the Bodleian Library’s customization and encoding guidelines for medieval manuscripts. These improvements are not just a matter of improving the specifics of TEI encoding. They will also require a significant re-thinking of the way in which manuscript provenance information is recorded and structured within catalogue records.

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⁷ <https://linked.art/model/provenance/>

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