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# Case-oriented Semantic Enrichment of Bibliographic Entities

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**Abstract.** The semantic enrichment of cultural heritage data is a crucial step for memory institutions to provide enhanced search services and to reduce the costs for managing resources. Yet, using information systems based on semantic web technologies implies to migrate and enrich the legacy data according to the dedicated semantic models. In the library community such task can be very complex when handling large catalogs of records stored using old and flat models. This paper focuses on the challenges related to metadata migration process and semantic enrichment of bibliographic data. We present the contributions and lessons learned from the FRBRization study and we provide preliminary discussions and ongoing work about the enrichment of FRBRized entities.

**Keywords:** semantic enrichment, metadata migration, FRBRization, FRBR, record interpretation, metric, model, tool

## 1 Introduction

The emergence of Semantic Web technologies makes people who seek cultural heritage data expecting more efficient and simplified ways to get information [6]. With catalogs of cultural data growing more and more, memory institutions have to improve their information systems and reinvent their practices [27, 16]. This thesis focuses on a major challenge for cultural institutions: *how to improve the search and enrichment of information while reducing the cataloguing efforts?*

In the digital library community, the widely used data models like the Machine-Readable Cataloging formats (MARC) have shown their limitations for reusing and enriching the semantics of data [15]. Such models, based on a flat structure and coded metadata, have been derived for years leading nowadays to many of different cataloguing practices making it more and more difficult to reuse the data. Some major national libraries promote the adoption of new semantic models with new cataloguing rules such as principles from the Function Requirements for Bibliographic Records (FRBR) [26], and more recently, the Library Reference

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Model (LRM) [21]. Those recommendations enhance the representation of bibliographic data and its enrichment leveraging on an entity-relationship formalism and vocabularies with more explicit semantics [5].

However, only few libraries already use FRBR-based systems, mainly because the transformation of the legacy data to the new model is still a very challenging task[1]. When migrating thousand of records, the process must be done semi-automatically using dedicated rules. In the context of MARC-based catalogs, the FRBRization (i.e., the metadata migration from MARC to FRBR) may imply hundreds of migration rules due to the deep differences between the flat model of data in input and the graph-based structure of FRBR. The migration process can be even more complex due to inconsistencies in data, duplicate resources or even bad cataloguing practices. Thus, the FRBRization requires time to analyze a catalog, to write the migration rules and to validate the results of the process.

Even if the obstacles to the Semantic Web adoption are known, the evolution of digital catalogs remains a necessary step for librarians to move forward [30]. Thus, they must be accompanied with relevant tools to facilitate and automate as much as possible their migration process [19, 11]. This paper presents our contributions and perspectives related to the semantic enrichment of bibliographic data. First, we detail improvements for the FRBRization process in terms of effectiveness, for instance by enhancing the interpretation of records in input, and in terms of efficiency, by using a semi-automated tool with automatically assigned rules. Secondly, we introduce our benchmark for the FRBRization in which we provide different metrics, dedicated datasets and evaluation results done on recent FRBRization solutions. Finally, we present initial works done for the enrichment of FRBRized entities using external repositories.

The remainder of the paper is organized as follows: Section 2 presents motivating challenges and summarizes the state of the art, Section 3 describes the contributions on the migration process. Section 4 provides an open discussion about preliminary results. Section 5 concludes the paper with future directions.

## 2 Motivating challenges

The Semantic Web principles promote the use of graph-based model (e.g., RDF) to represent information and to facilitate its linkage and enrichment. In the context of cultural heritage data, many digital catalogs are still based on flat models (e.g., MARC format) and remain isolated from other sources (e.g., national repositories). Hence, the main challenges for the evolution of bibliographic catalogs are both related to the migration of legacy records towards new graph-based models and to the enrichment of the migrated entities with other sources. This section presents important challenges from both tasks which should be considered for a successful Semantic Web adoption.

**Selecting a migration tool.** Metadata migration is a process which aims at offering a more expressive way to represent information by transforming the model of a data collection into another while preserving the completeness and the nature of the data [28]. In the library community, the FRBRization is a well-

known migration process since it is a privileged way to adopt the new standards for representing bibliographic data [18, 14]. The process consists in interpreting bibliographic records to extract the relevant FRBR entities and relationships to generate a FRBR-based graph. Yet, after decades of discussions and contributions on this subject (see these recent surveys about FRBRization [29, 8]), it is still complicated to select the relevant FRBRization tool for a given catalog and to configure it properly.

**Tuning of the migration.** When FRBRization is done automatically or semi-automatically, a tuning task is necessary to write the set of rules which should be applied on input records for extracting the FRBR entities (e.g., a migration rule can specify that the presence of a title in a record should trigger the creation of a Manifestation entity from FRBR). Yet, the writing task of rules becomes much more complex when dealing with records based on former bibliographic models. For instance the MARC format is based on a flat structure of fields (i.e., key-value pairs) where each field does not necessarily contain atomic values, requiring sometimes to filter the relevant data during the migration. Moreover, some fields may be used regardless of the MARC specification forcing the creation of dedicated (and not reusable) rules. Those aspects, related to cataloguing practices or potential errors, make it impossible for a generic FRBRization tool to deal with all different catalogs. Thus, the challenge of the tuning step is to better anticipate the specificities of an input catalog to ease the writing task of all migration rules.

**Building the migration model.** Another challenging aspect of the FRBRization relates the models and systems used to build the migration rules. Existing FRBRization solutions have proposed migration models (e.g., with XSL files), which generally consist in mappings between MARC fields and FRBR entities. The X3ML solution [17] proposes, for instance, a framework to build rich mappings between different models used for cultural heritage. Nevertheless, entity-centric mappings are sometimes not sufficient to express the rich knowledge that a bibliographic record may contain. The latter may include complex patterns not only representing the description of a work but also its context and its place in larger bibliographic families [20]. For instance, a single work in a MARC catalog can appear in different records to express different realizations (translations, adaptations), different embodiments (digital, paperback), and several links to related works. Hence, while the migration rules of FRBRization should deal with catalogs specificities, it must also ease the handling of complex bibliographic patterns to generate richer FRBR output [1].

**Evaluating the migration.** The evaluation of the FRBRization is also a crucial challenge. Although the specificity of each catalog requires a manual validation of the migration results, it remains necessary to be able to evaluate any tools with criteria representing real-world cases. The TelPlus project [14] provided quantitative statistics of extraction and aggregation and also results of a survey about the search service. Some performance results were also available from the eXtensible Catalog experiments [3]. However, few metrics have been designed to evaluate the quality results of the migration. Furthermore, the

datasets used in most attempts of FRBRization have not been published making it impossible to reproduce the experiments. To tackle this lack of data, FRBR-ML [24] proposed to evaluate the FRBRization by transforming back FRBR into MARC. Considering that some complex FRBR patterns can be implicitly expressed in MARC, we advocate that the domain still needs relevant metrics and datasets to ease the detection of weaknesses in the different tools.

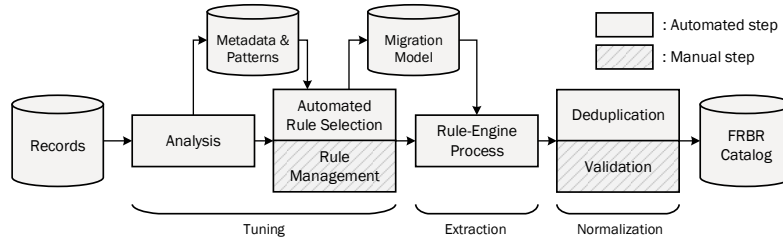
**Entity Linking challenge.** The next phase, after the metadata migration of records, involves an enrichment step which aims at bringing new information to the migrated entities [13]. In the context of cultural heritage data, important challenges relate the linking task of entities with data from external repositories (e.g., Linked Open Data) [12, 10] and the deduplication task to detect and merge equivalent entities [4]. Major initiatives like Europeanana [22] have recently raised important challenges and issues in the linking domain like dealing with multiple languages or managing all various forms of cultural items. Furthermore, other branches of research try to perform the enrichment task with larger datasets and multiple repositories, sometimes different than Linked Open Data to generate richer information [23]. Unfortunately, many enrichment experiments limit their action into making links between entities while institutions expect real solutions for aggregating relevant data into their existing entities. In the context of MARC data, the FRBR model is close to the triple-based standards of Semantic Web making it easier to map the FRBR semantics with other repositories [25].

**Data matching and merging.** The fusion of extracted data is a well known challenge in the enrichment task. It implies to have the correspondences between different entities extracted from different sources. Yet, while major sources from LOD already provide *sameAs* links between them, getting correspondences between isolated repositories may require an extra Ontology Matching process [2]. This becomes even more important for the new approaches using unstructured sources (e.g., Websites, Blogs) to get more fresh information. Considering that bibliographic families become increasingly rich and complex, the fusion process is very crucial. However, thanks to the emergence of more semantic models, the domain offers new possibilities to improve quality by leveraging on the semantics and graph structures [9].

### 3 Contributions on Metadata Migration Issues

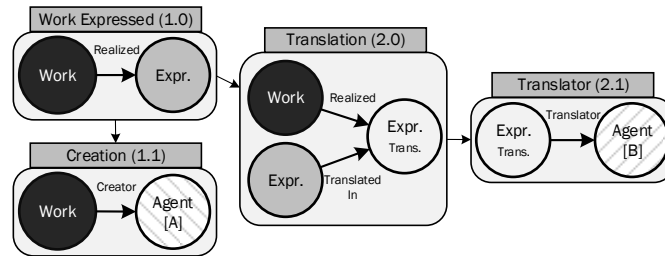
The main vision of this paper is to consider the migration and enrichment steps using a case-oriented approach rather than common entity-centric ways. A case means a real-world combination of data that is important in the application domain and that can be clearly formulated using a pattern. In the context of digital libraries, many bibliographic patterns (e.g., adaptation in motion picture, aggregation of poems, addition of appendix) are important for user search and should be considered in the enrichment task. Hence, this thesis aims at showing the benefits of such approach for the migration and enrichment. So far, we bring contributions to the FRBRization process since most of existing tools use entity-centric mapping rules to perform the migration. We follow the double objectives

of improving the quality of the migration while making the process easier to tune. The figure 1 shows the workflow of the FRBRization from our approach.



**Fig. 1.** Workflow of the FRBRization

This workflow is divided in three tasks (in the bottom of the Figure 1) which represent the main steps of the process. The *Tuning* task aims at writing the migration rules, the *Extraction* step consists in applying all rules on each record to generate FRBR entities and relationships and the *Normalization* task aims at cleaning and merging the extracted entities to build a final FRBR catalog. The workflow is based on a specific knowledge about Metadata and Patterns that should be interpreted from the records and on a migration model that should be used in the extraction step. Both are represented with cylinder at the top of the Figure 1. The remainder of this Section presents details and specific recommendations for the FRBRization process.



**Fig. 2.** Conceptual representation of the Case-Oriented Model with the bibliographic pattern of Translation in example

**Migration Model.** The model used to represent the migration rules is the cornerstone of the process. Since hundreds of rules may be necessary to handle a bibliographic catalog, they must be enough expressive to represent any complex pattern while being readable to be shared and easily refined. Our case-oriented approach brings a new abstraction layer to the rules by designing a graph a cases. Each case represents a bibliographic pattern to be handled by including

a set of conditions and a set of actions to realize if conditions are valid. The Figure 2 shows a conceptual view of the translation pattern in an case-oriented way. Here are the characteristics of such model:

- **The model is an oriented graph.** It means that a node of the graph is a distinct case and an edge represents a relationship between cases. Each record to be migrated will follow the path of cases starting by root cases. Since each case can have its own conditions to be satisfied (e.g., presence of variant language to activate the case *Translation (2.0)*), a record may skip a whole branch of cases if the first case is not validated. For instance in Figure 2, if the case *Work Expressed (1.0)* is validated, then both cases *Creation (1.1)* and *Translation (2.0)* will be evaluated.
- **Each case can be built independently.** To improve readability, some distinct cases may involve a same entity to design a complete pattern. An example in Figure 2 shows the same Work (black circle) reused in three different cases, *1.0*, *1.1* and *2.0*. Yet, to prevent any deduplication error, the rule engine will only deal with one unique entity during the migration.
- **Cases can be specialization of other cases.** When a case is linked to another case, it means that the latter is a specialization of the first case. In such way, the specialization case inherits from the conditions and actions of the previous case. For instance, the case *Translator (2.1)* which deals with the translator Person entity will be evaluated only if the case *Translation (2.0)* is validated.

**Automated detection of record’s characteristics.** While enhancing the representation of migration rule with cases may help handling more complex patterns and prevent lacks, creating all those cases can still be a long and tedious task to perform. Yet, the efforts should be reduced both by automating the discovery of patterns from records and by reusing common cases. Since the cases are a clear representation of real-world pattern from input data, practical functions can be written to detect those patterns in records. As an example, a MARC record with different languages, variant titles or translator relator code should lead to the activation of the Translation case in the migration model. Thus, many cases can be automatically activated from the interpretation of records. Such analysis can also be used to detect the cataloguing practices and ease to the writing of dedicated migration functions.

**Evaluation of the Migration.** FRBRization will be a necessary step for many libraries in the future making it important for them to choose a migration strategy and the relevant tool. Yet, the actual differences between library challenges and the state of existing FRBRization tool raise a need for evaluating them. Hence, the pre-FRBRization metrics must be completed with post-FRBRization metrics to evaluate the results of the migration. By leveraging on our study on bibliographic patterns and catalog inconsistencies we provide both datasets and metrics to perform a complete Benchmark of a FRBRization solution. BIB-R [7], the Benchmark for the Interpretation of Bibliographic Records presents the evaluation results of three recent FRBRization tools.

## 4 Preliminary results and lessons learned

In this Section we present the results obtained so far via our FRBRization prototype named CoM3T (for Case-oriented MARC Metadata Migration Tool). This tool implements our case-oriented approach presented in the previous Section.

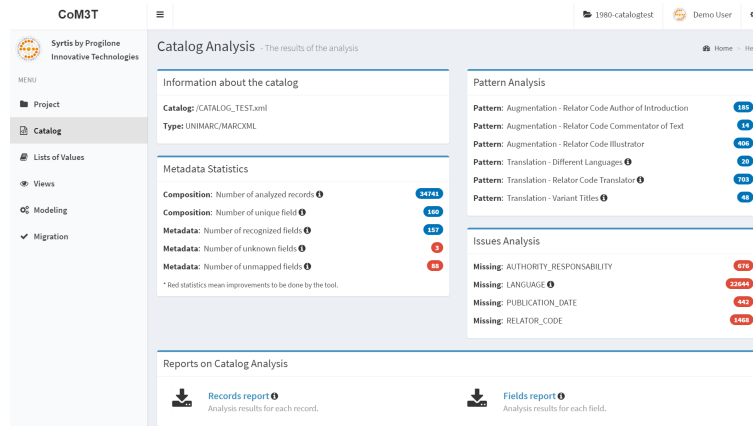


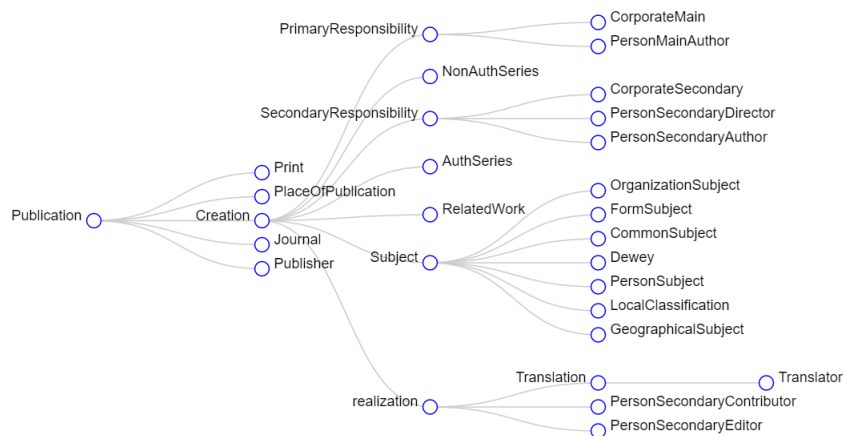
Fig. 3. Screenshot of the catalog analysis view in CoM3T

The tuning task is handled by an automated process which analyzes the input catalog of MARC/XML records. This analysis is based on the pre-FRBRization metrics to extract all the specific interpretations that should be handled by rules. It also provides statistics on the catalog, details on the bibliographic pattern detected and detailed reports for each distinct Metadata used in the records. The figure 3 shows a web interface provided by our tool to ease the access to the analysis results. The results of the pre-analysis are also used to automatically instantiate the case-oriented model and store it in a graph database. Here another web interface allows the management of each cases. The Figure 4 shows a sample overview of all cases. By clicking on a case, the user can see the details of its conditions and actions. Finally, by pressing a launch button, each record of the catalog to be migrated will be processed with this model (from the left to the right in the example of the Figure 4).

The tool has been experienced on two real world catalogs of MARC records, 100.000 records from a public library and 300.000 records from a university hospital library. Each of catalog statistics of analysis were first generated, then the records were FRBRized using our tool and finally, the results were loaded in an Integrated Library System, based on the FRBR model, to ease the navigation in generated entities. Those experiments helped us to make observations on the benefit of our approach:

- The pre-analysis results are a reliable source of decision to build specific rules or to clean part of the catalog before FRBRization. It helps for communicating on the FRBRization model and to reduce lacks of errors.





**Fig. 4.** Overview of a case-oriented migration model like it can be showed in our FRBRization tool CoM3T

- The automated activation of cases from pre-analysis results allows us to provide a FRBRization tool where the migration step can be launched without human intervention. Hence, with an automated deduplication phase, the whole FRBRization can be done fully automatically. This is crucial when dealing with periodic flows of records.
- The case-oriented model, implemented in a web application, allows to draw overviews of the FRBRization rules. Once again it eases the communication with actors of the migration.
- The processing time for applying the complete migration model on each record (even on large catalogs) is negligible using recent Java parallel processing features. The deduplication remains the most time consuming task.

These results also showed us the limits and improvements to be done with such approach. Although the case-oriented model can be managed easily, some specific needs of the migration could not be handled by this approach. For instance, creating links between FRBR entities generated from different catalogs may imply an additional process, done independently of the extraction step. Improvements are also expected for the deduplication phase in which the quality of the matching task is hardly dependant on the completeness of input data and also from the way the migration model extracts such data. Hence, the fully automation of the deduplication can sometimes be impossible since it always requires specific adjustments. The web application for managing the FRBRization should be evaluated in terms of usability to involve more non-IT specialists in the configuration of the process. Finally, the major expected contribution relates to the enrichment of FRBRized data with external repositories. Since many challenges related to semantic enrichment are well-known by the community, the case-oriented approach should be an interesting way to bring qualitative improvements in the context of bibliographic entities. The knowledge of patterns representing complex relationship between entities should refine the way the external sources are requested and should ease the fusion of extracted information.

## 5 Future directions

This paper presents contributions for the metadata migration of bibliographic entities. We present a new case-oriented approach which was applied on the FRBRization process. We also promote a novel vision for the interpretation of bibliographic records which allowed us to provide a benchmark of FRBRization solutions with dedicated metrics, open datasets and experiments results. However, the migration of legacy records is just the beginning of the road for the semantic enrichment of bibliographic data. The benefits of models like FRBR should lead to new processes for creating rich relationships between entities to improve the search and navigation of users in cultural heritage collections.

In the next steps of our research we plan to extend or approach to the extraction of new information from external repositories to complete or discover bibliographic patterns. The main idea is to improve the generation of queries and the selection and normalization of results by leveraging on the acquired knowledge of bibliographic cases from FRBRization. Our future work includes a theoretical formulation of our case-oriented approach and new experiments of knowledge extraction from different databases to enrich FRBRized data.

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