A Step towards Semantic Digital Library in the Arabic Region

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ABSTRACT: *The use of semantic web technologies is very limited in Arab libraries, even with the existence of important historical and literary documents, and the great digitization movement now, the documents are still trapped within the databases of the separated libraries and are not visible to search engines. The research aims to Study the applications of semantic web technologies in catalogs of digital, hybrid libraries and catalogs of public libraries, exploring the main ontologies and conceptual Data models used in the field, and the possibilities of reusing them with Arab libraries, or the need to build new ontologies, studying the necessary steps, tools, and best practices, define the difficulties and challenges facing the Arabic semantic library and searching for possible technical solutions, our experiments target the heterogeneous databases of small, medium or large libraries, considering that some Arabic library catalogs are not following a standard Data Model, to contribute to the research and development of integrating bibliographic data of Arab libraries and moving towards the Semantic web and Linked Open Data.*

Subject Categories and Descriptors: [H.3.7 Digital Libraries] Standards [H.3.3 Information Search and Retrieval

General Terms: Digital Libraries, Semantic Web, Arabic Digital Libraries, RDF

Keywords: Semantic web, RDB to RDF, Cataloging, library Database, BIBFRAME

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1. Introduction

Library management systems are huge and complex systems that include many functions such as membership management, billing, loan operations, catalogue management, etc., there are a lot of open source Integrated Library Systems that can be customized to serve our choices towards Linked Open Data, some of the well-known examples are Koha, Dspace, and Fedora[1]*, recent researches in the field of libraries deal with many concepts such as NLP*[2]*, NER/NEE*[3] *cross-lingual ontology enrichment techniques, Semantic search, Recommendation systems, Ontology-based automatic text classification.. etc., but cataloging remains the heart and foundation of Library work, and traditional databases with*

[1]https://fedora.lyrasis.org/

[2]Natural Language processing

[3]Named entity Recognition/Named Entity Extraction

traditional search based on Considering names as literal strings are insufficient now, catalogs of most of the libraries in the Arabic region are still a part of the Deep Web, so the need for Semantic Web technologies in libraries has become urgent, In addition, The sources of information between libraries are similar, and efforts are repeated in preparing the same sources of information, which leads to duplication of effort and loss of time [1], Because of the different methods of modeling data, the library community has developed many standards to unify the methods to deal with physical and digital containers, such as (AACR2[4], RDA[5], MARC[6], FRBR[7], BIBFRAME, etc.), and all new standards and data models adopt the principles of Linked Data.

2. Background Study

2.1. The Semantic Web

Means sharing data and facts rather than sharing the text of a page. It was first given by Sir Tim Berners-Lee in 2001. And it helps build a technology stack to support a 'web of data' rather than a 'web of documents'[2], the basic data model in the semantic web is the Resource Description Framework (RDF) and SPARQL is the W3C recommendation query language for RDF graphs.

2.2. Semantic Digital Libraries

According to the IFLA/UNESCO Manifesto for Digital Libraries [3], "a digital library is an online collection of digital objects, of assured quality, that are created or collected and managed according to internationally accepted principles for collection development and made accessible in a coherent and sustainable manner, supported by services necessary to allow users to retrieve and exploit the resources", and being 'semantic' means that all data stored in the library is available in RDF for querying and processing by other applications[4]. In fact, this definition is too idealistic and our current goal is to have library catalogs at least stored in RDF format with unified URIs for Names and main concepts, with consideration to the relationships between different intellectual works such as reprint, translation, review, criticism, and the relations between other main catalog entities like persons, organizations, events, etc.

2.3. Bibliography

A word consisting of two syllables, 'biblion', means book, and 'graphía', means writing, the simplest definition of the word is a description of books, Bibliography includes the name of the author, the title of the information container, the edition, the publication data, the number of pages, and the type of the information container (a book, a document, a map, etc.).

2.4. Ontology is defined by Gruber [5] as" an explicit specification of conceptualization" it provides a shared understanding for shared concepts between different data sources or applications. Librarians state three main types of ontologies used with semantic libraries [6], [7]:

• Bibliographic ontologies

They describe metadata standards, such as Bibliographic ontology BIBO and MarcOnt, according to [8] Main LOD vocabularies used by libraries to publish bibliographic information are: BIBFRAME, BIBO, FRBRoo, Dublin Core, EDM, FRBR, LRM, RDA, and Schema.org.

• Subject ontologies

They are useful as knowledge sources that define the meaning of most domain concepts, their hierarchy, properties, and relationships, for instance, OntoMath [9]is related to the development of specialized ontologies in the field of mathematics, while we find in [7] a sample of creating domain ontologies for Bulgarian folk songs, organized in a digital library called DjDL, LCSH[8] also is a famous example.

• Community-aware Ontologies

are oriented to the description of the different types of users, their requirements, and interactions, and the most well-known ontology here is foaf.

2.5. BIBFRAME2.0[9]

Is a bibliographic data model, published by the Library of Congress on 2012, and considered as the future of libraries [10]and the successor of MARC[10] which has been the dominant library data model for the last five decades, BIBFRAME is an ontological data model for bibliographic description, based on the principles of linked data and semantic web technologies; it supports the interoperability between libraries Network that requires a high degree of data analysis and relationships between them; and improves the quality of the information retrieval process across the web environment, the higher levels of abstraction of the bibliographic data representation model according to BIBFRAME 2.0 are shown in Fig.1 as: Work class and is used to express the same intellectual work that the indexed information source includes, Instance class is used to express the embodiment or the material of the intellectual work, Item or indexed item (for example, The Merchant of Venice is an intellectual work, and the novel or film represents it is Instance, while the copy owned by the library is the Item).

[4]Anglo-American Cataloguing Rules

[5]Resource Description and Access

[6]Machine-Readable Cataloging

[7]Functional Requirements for Bibliographic Records

[8]Library of Congress Subject Headings

[9]https://www.loc.gov/bibframe/docs/bibframe2-model.html

[10]Machine Readable Catalogue

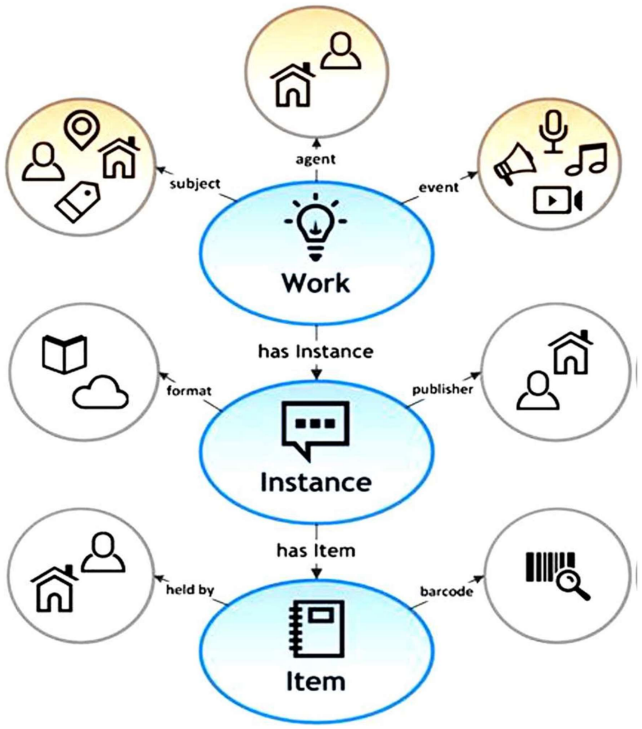

Figure 1. BIBFRAME2 higher level of abstraction

2.6. Mapping Databases to Ontology

Integrating heterogeneous databases is a challenge for organizations and researchers[11] and in the field of libraries the solution to this problem was _for a long time_ using the Union Catalog [1] where a group of libraries can translate their records into a shared format _which was MARC in most cases_ so they can communicate with each other, which is similar to ETL (Extract, transform, load) the idea is still the same, but we use ontology as a shared understanding between databases of different libraries, so mapping between databases and ontology generate RDF triples that can be queried by SPARQL, Two ways of data access and integration are usually used: the first is materialization: where data are transformed taking into account the mappings and the ontologies(for example, data are converted into RDF and loaded into a triple store, so that it can be natively queried using SPARQL) just like the usual ETL(Extract, Transform, Load), and the second way is virtualization: where the transformation is done on the queries using the mapping rules and ontologies, which can then be evaluated on the original data sources.[12].

W3C recommended using Direct mapping where each table maps to a class, each row maps to an instance, and each column maps to a data type property, this way is quick and easy but causes a lot of redundancy, the other recommendation is using R2RML[11] or RML and now there is some easier languages like YARRRML [13], in addition to a diversity of converters to RDF or Mapping tools like Openrefine, Ontop plugin+ Protégé, Morph family (Morph-CSV, Morph-RDB, Mapeathor..)[12], D2RQ[14], RDB2RDF plugin for Eclipse.

3. Related Works

The research required a review of the most important data models and ontologies in the field, discovering tools and techniques, and understanding the potentials and challenges in Arab libraries to reach the semantic Library.

Many researchers have discussed the importance of the Semantic Web and its benefits related to digital libraries in a theoretical way without going into the implementation mechanisms and practical application (i.e. review of literature, surveys) such[10], [15]–[19], while others were more focused on Bibliographic ontologies [1], [14], [20]–[26], most of the recent researches in this field study Mapping between one Data Model with another, in particular, MARC to BIBFRAME [26]–[28], or between EDM and BIBFRAME [23], [29], [30], these studies focus on the transition from standard data models to BIBFRAME, while the current research aims to work on small, medium, or even large libraries that use some old databases that do not adopt any known standard, depending on mapping mechanisms between databases and ontology to obtain the knowledge graph [12]. many Artificial Intelligence researches studied the document automatic classification based on measuring the similarity [31], and some Arabic researchers combine natural language processing of the Arabic language with automatic classification and automatic ontology building [32], [33] which is more

[11] https://www.w3.org/TR/r2rml/

Paper	Pub Date	Standard Data Models/ reused ontologies	Methodology/ main Programing tools	Main Ontology type (Library perspective)
[15]	2011		Principles and guidelines	
[1]	2013	FRBR, MARC	Java + jena library, Protégé	bibliographic
[33]	2014		Java + jena library, Protégé	subject
[29]	2014	EDM, BIBFRAME	Mapping ontologies	Bibliographic, subject
[37]	2014	AGROVOC, CAB Thesaurus, ASFA Thesaurus		
[7]	2015		ASP.NET MVC5, Protégé	subject
[26]	2015	Dublin Core, BIBFRAME	Open refine +RDF extension, Apache Jena	Bibliographic
[10]	2016	BIBFRAME, MARC		Bibliographic
[20]	2017	OAI-PMH VIVO, BIBO, FOAF, SKOS, geonames, Dublin Core, Vitro, and Marc 21.	ABCD, Moodle and DSpace VIVO software, PHP, MySQL	Bibliographic
[27]	2017	BIBFRAME, RDA, Schema.org, CIDOC CRM.	LD4P Labs	Bibliographic
[38]	2017	BIBFRAME, EDM, FRBR, FRBRoo	Review of literature	Bibliographic
[39]	2017	FaBiO, CiTO, BiRO, C4O DoCO, PRO, PSO, PWO	PHP-script, VBA macro	Bibliographic
[17]	2017		Review of literature	
[40]	2018		Interviews	
[14]	2018	FABIO, SWRC, Dublin Core	D2RQ Pubby linked data interface Grails framework	Bibliographic, community-aware ontology
[41]	2019	OAI-PMH	R2RML, Jena Fuseki triplestore,, ElasticSearch server, Pubby tool	Bibliographic
[18]	2018		Review of literature	
[36]	2019	MARC		
[21]	2019	CIDOC CRM, FRBR, BIBO, HiCO, CiTO, AAT, FaBiO,Biro, BCO		Bibliographic
[19]	2019		Review of literature	Bibliographic
[30]	2020	BIBFRAME2.0, RDA	Python, XSLT, Protégé, Virtuoso RDF server	Bibliographic
[42]	2020	(LRM[12]) + aspects of (FRBRoo), DOing REusable MUSic (DOREMUS)	Protégé SPARQL	subject
[22]	2020	EDM, LIDO	Europeana portal, eCHO Framework, JAVA	bibliographic
[11]	2020		Jena API, Protégé	
[32]	2020		GATE, Arabic WordNet (AWN), Protégé	subject

[28]	2020	MARC, Schema.org, BIBFRAME	HTRC's suite of tools, (VIAF[13]) through its API, LoC's subject heading API	bibliographic
[24]	2020	SHACL[14]		bibliographic
[43]	2020		Similarity measures, Jena Subject (domain ontology)	
[31]	2021		Document Classification	
[12]	2021		Mapping Languages, Morph_RDB, Ontop.	
[44]	2022		OpenRefine	bibliographic

Table 1. A Sample of the Related Works with the Main Reused Data Models and Methodologies.

useful in the side of subject ontologies rather than bibliographic ontologies where we are depending on some strong, well-defined ontologies that built by the experts of the field, and many Arabic researchers assure the urgent need for developing Arabic Ontologies to be exploited in the Arabic SW applications [34]. one of the serious attempts in the Arab region to assure the importance of directing libraries toward LOD is the conference titled "The Standard Model "BIBFRAME" for Resources Description and Access in Web Environment" [35] (proceedings only available in Arabic language), the work on [36] discussed interoperability of data and mapping between 'Winisis' system and Koha system in the library of Damascus university, but to the best of our knowledge, there is no Arabic research that tried to exploit BIBFRAME ontology to achieve the semantic interoperability between libraries,(i.e. Theory has not been put into practice). Most Arabic researches were written from the point of view of library specialists and focused on conceptual aspects such as [10], and did not go into the practical steps of the transition to linked data, except for some rare cases like [1], [32], [33] where the authors built their own ontologies without exploiting the benefits of reusing standard data models. Table1 shows a sample of the reviewed papers to view the most popular Data Models and tools in the field.

4.Prototype Implementation

We presume having multiple heterogenous library databases, and their data will go through the steps as shown in figure 2.

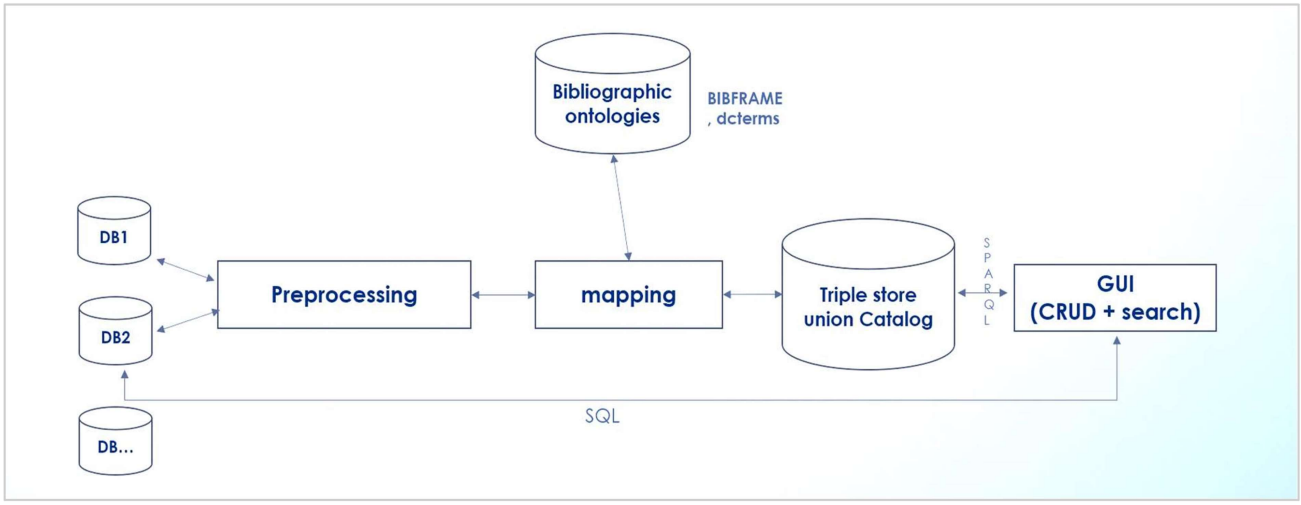

Figure 2. Main steps of implementation

[12]IFLA Library Reference Model
[13]Virtual International Authority File
[14]Shapes Constraint Language

The first step is the necessary preprocessing of data sets, dealing with messy data in the world of libraries is very important, [22] described the efforts to deal with multiple Date formats in a dataset, we used OpenRefine [25], [26], which provided the ability to cluster similar names and correct mistakes semi-automatically, then applied reconciliation for author names, Titles, publishers, etc., so we obtained the URIs of these entities according to Wikidata and VIAF, to enrich our local datasets with LOD, using Natural Language Processing here could be very useful, for example to eliminate some words that are usually used as titles for author like('الشاعر','الإمام','العلّامة','الرحالة')

In this stage we couldn't find unified automated Authority files in Arabic, no automated Arabic subject heading lists, no automated Arabic thesauri for libraries, and when trying to use the available English subject heading such as LCSH, librarians in local libraries assured that they are difficult to use and not suitable for Arabic subjects, which means there is a great need to develop new Arabic domain ontology for libraries.

The second step is mapping between our datasets and the ontology to generate RDF triples, we used Protégé+ Ontop plugin which provides the ability to reuse mappings and to generate a virtual graph[13], as for the ontology we reused a subset of BIBFRAME2.0 classes and properties in addition to a subset of DCMI Metadata Terms, our prototype application 'experimental system' is a client-server application built on the .NET Framework 4.8 and ASP.NET MVC5, the tool used for its implementation is Microsoft Visual Studio Enterprise 2017, with an additional package of Open Source .Net Library (dotnetRdf) that provide a powerful and easy-to-use API for working with RDF [42].

In the application we used the triple store as a union catalog so we could query about books of the other libraries using SPARQL and we can import the retrieved results and modify them then save them in our local database, which saves a lot of time for the librarians as shown in figure 5.

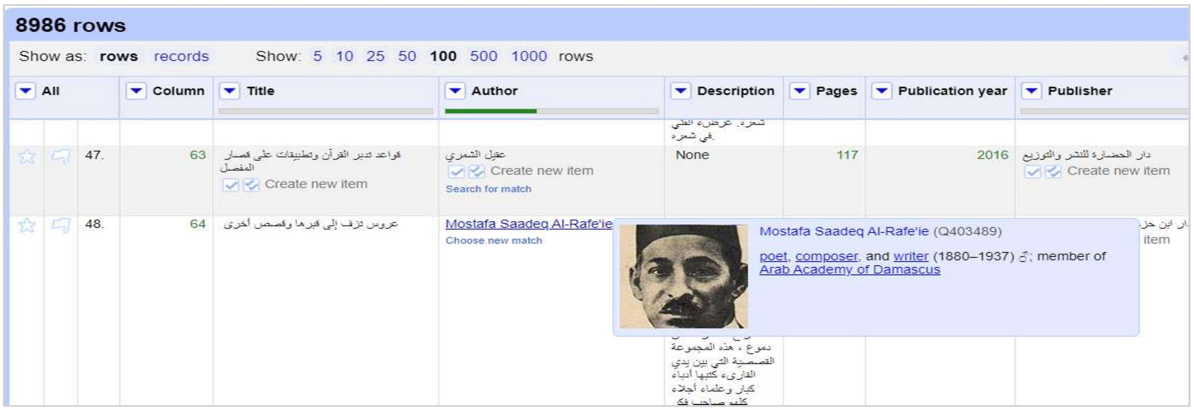

Figure 3. Using Openrefine reconciliation service for authors names with Wikidata service

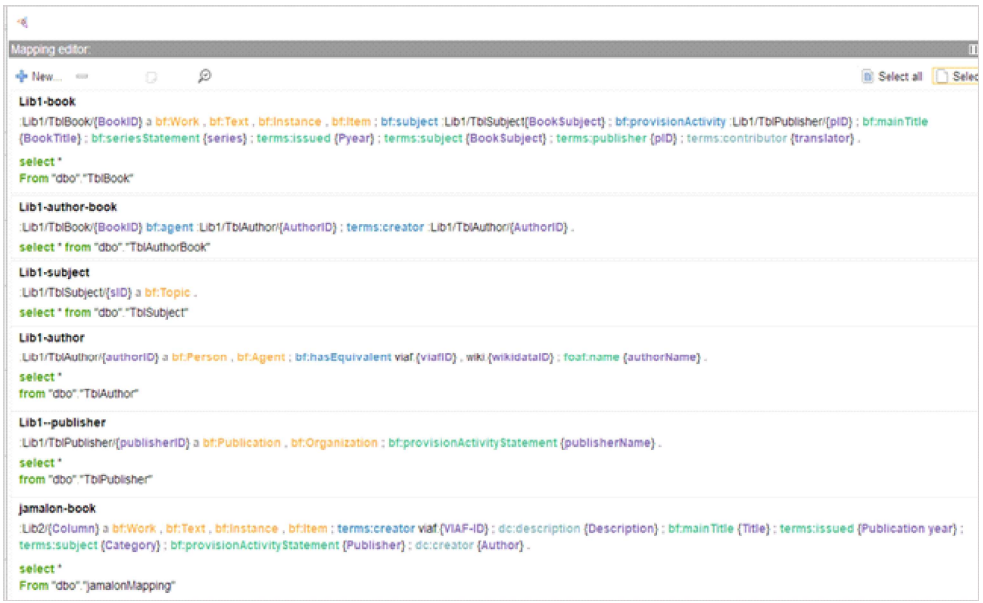

Figure 4. Using Ontop Mapping Editor, sample of the mapping rules to create RDF Triples

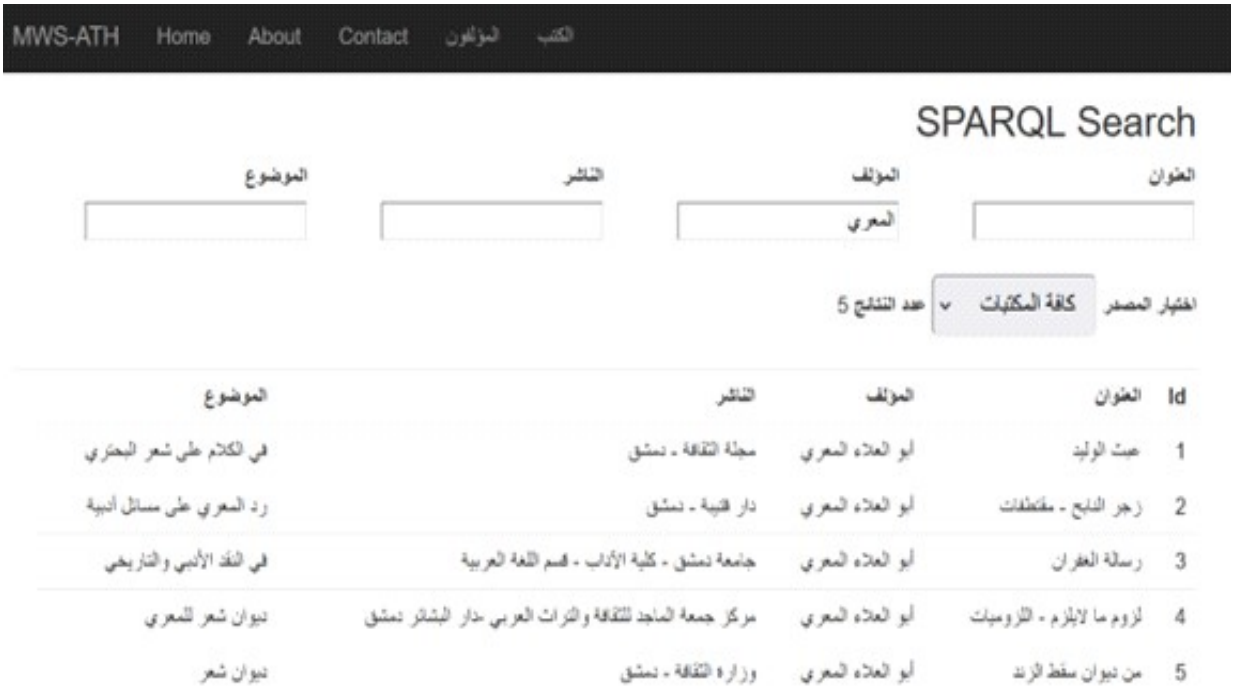

Figure 5. Getting the books written by"المعري" from all the connected libraries

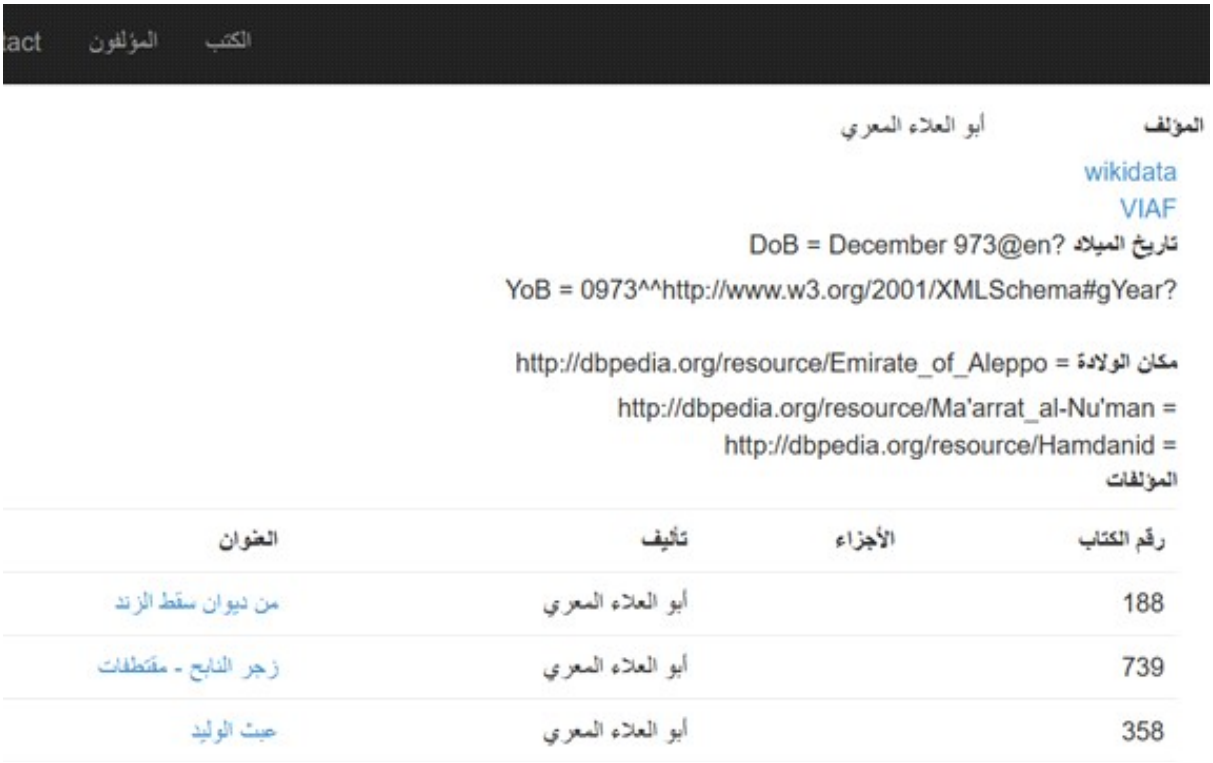

Figure 6. LOD enrichment, new details about the author "المعري",birth place ,birth date..

And we enriched our local library with linked open data, by connecting to remote SPARQL endpoints and getting some useful details like birthdate, birthplace and the links to the author's wikidata page or the author's VIAF page, as in Figure 6, and we need to mention that we did not fix the formatting intentionally to show the Sparql results from the remote endpoint, not from the local database.

5. Testing and Evaluation

we experimented using two Datasets, First Dataset is a relational database built using MS SQL Server2019, it contains a collection of Arabic or translated into Arabic books and represents a sample of the database in the Arabic Cultural Center in Damascus, Second Dataset is a sample of 'Jamalon' bookstore database, available as MS Excel datasheet, Dataset A =1136 records, Dataset J =8986 records, Table2 shows that there is low availability of the names of Arabic authors on Wikidata and VIAF, the best result comes from VIAF, we can explain the very low rates of availability on ORCID because of the nature of the data sets that contain old and traditional books in the majority, and Arabic letters are not usually used on ORCID which affected the retrieval of the IDs, results of reconciliation can vary in case of using other samples but still very low.

Through the testing process, we have noticed the following:

• The ability to use BIBFRAME2.0 classes and properties without the need to translate into Arabic, because the mapping step is executed by the data analyst and the GUI is already in Arabic so dealing with it can be at the application level and not in direct contact with the user, which can be acceptable in concerns of bibliographic ontology.

• Using the predefined classes, object properties and data properties has some difficulties because of the tables in the relational databases did not match with the classes. so we highly recommend considering the architecture of BIBFRAME when planning to develop new databases, and it can be very acceptable to use DCMI Metadata Terms, with the small and medium local Arabic libraries, as a start point.

• Mapping to BIBFRAME2.0 classes and properties was executed in our prototype at the ITEM level to achieve migrating old data while adding new WORK or INSTANCE is available for new entries one by one.

• We have taken into consideration the limited resources of some Arabic countries like Syria, Yemen, and Sudan, so open-source tools are mostly used here.

• The focus in the Arab library world so far is on MARC and the difficulty of accepting the change easily, which is not limited to the Arab world. Most of international libraries still use MARC while trying to convert to BIBFRAME including the library of Congress, due to the difficulties of conversion of large blocks of data[28]

Service	Author Name	Title	subject	publisher
Wikidata	40%	5%	15%	14%
ORCID	1%	-	-	-
VIAF	61%	6%	0%	10%

(a)

Service	Author Name	Title	subject	publisher
Wikidata	42%	10%	27%	2%
ORCID	0%	-	-	-
VIAF	65%	1%	1%	0%

(b)

Table 2. Availability of Arabic metadata as linked open data, (a) represents the first sample with 1136 record, (b) represents the second sample with 8986 records

6. Conclusion and Future Work

Reusing standard Bibliographic Ontologies to achieve interoperability and data integration between Arabic libraries is applicable with good results, while there is a clear weakness in the availability of Subject Ontologies in Arabic and the difficulty of using Subject Ontology of other languages, the availability of open source tools to enrich our libraries with LOD can be of great help, our future work includes developing Arabic library subject ontologies and more focusing on natural language processing techniques.

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