

Interactive displays for the next generation of entity-centric bibliographic models

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Abstract. The model of bibliographic entities defined in the IFLA Functional Requirements for Bibliographic Records (FRBR) represents a major transition from the digital card catalog to databases containing a rich structure of entities and relationships with well-defined semantics. However, the question of how to best search and present this entity-centric bibliographic data remains a challenge. In this paper we present a system for entity-centric search and a user study on how the displays of the FRBR entities compare in their ability to support different user tasks.

Keywords: Search, user interface, user study, library reference model

1 Introduction

Libraries worldwide are in the process of adopting the next generation of bibliographic information models to meet the expectations of modern end users, support new ways of search and exploration as well as increase the long-term value of the data. The E-R model of bibliographic entities defined in the IFLA Functional Requirements for Bibliographic Records (FRBR) [1] – soon to be superseded by IFLA Library Reference Model (IFLA LRM) [22] – represents a major transition from the record-oriented digital card catalog to entity-centric catalogs with rich and semantically well-defined structures of entities and relationships. The core entities introduced in FRBR; *work*, *expression*, *manifestation* and *item*, have slowly made their way into the common understanding of the bibliographic universe and are now aligned with current cataloguing practice (Resource Description and Access – RDA)[12]. Additional interesting new developments include BIBFRAME [16], a project exploring new formats for bibliographic data, and FRBRoo [18], which is the result of the harmonisation of FRBR with CIDOC CRM [17]. However, the modernization of library catalogs worldwide has been surprisingly slow and the question of how to best display FRBR or other entity-centric data in search results remains a challenge [4, 14].

Entity-centric bibliographic data, describing intellectual and artistic products as entities at different levels of abstraction, inherently complicates the process of indexing, querying and presenting results compared to the traditional digital card catalog, which is displaying a list of publications (manifestations) as the result of all queries. A list of manifestations is not appropriate for all contexts;

users might be focused on the work level or on the expression level. They might wish to get a very specific answer or they might want to explore and learn about the opus of a particular person or about various adaptations of a particular work. As a consequence, the one-size-fits-all approach does not work.

To address this challenge, we have implemented the BIBSURF search system [19] to research design issues and conduct systematic studies of bibliographic search in entity-centric catalogs. In this paper, we give a presentation of the displays implemented in BIBSURF, which offers three different views of the graph structure: focusing on works, expressions and manifestations respectively. A user study was conducted to measure how the different displays compare in their ability to support different user tasks. The contribution of this research includes a novel bibliographic search system, a new methodological approach to evaluation of entity-centric bibliographic search and display, and insight into the effects of different display strategies for the FRBR model.

2 Background

Improved search experience was early recognized as the key contribution of FRBR [2] and this has been the main motivation for research and experimental prototypes applying the model [8, 11, 3, 6, 20]. Unfortunately most systems developed so far are based on existing data, automatically transformed from MARC records into a FRBR-based representation [15]. Due to missing and inconsistent information, frbrization is incomplete, resulting in simple pragmatic systems, focusing only on works and manifestations (such as OCLC Fiction Finder or data.bnf.fr). Even locating works throughout multiple records in current catalogs is a major challenge as addressed by Carlyle [7]. The actual effect of the FRBR model on the user experience, or the fundamental design issues that need to be addressed are thus hard to study in these implementations. The need for more user studies was recognized by Salaba and Zhang [14], who performed (1) user evaluation of three FRBR-based catalogs, (2) user participatory design of a prototype FRBR-based catalog, and (3) user evaluation of the resulting catalog.

The lack of research of how to adapt the display of FRBR-based information to different contexts is the main motivation for the research presented in this paper. Our previous work on display of FRBR-based information resulted in the development of the FRBRVis prototype and extensive user testing [21, 20]. There the focus was on supporting browsing and exploration and choosing the best visualization technique. The results show that the visualized displays in general rated better compared to the baseline traditional faceted display in all elements of usability, i.e. efficiency, effectiveness and user experience. The limitation of that study was that it did not include searching and was focused on graphical visualizations. What is presented here is a logical continuation and has a focus on the search experience and result lists presented using UI features that are commonly found in search interfaces.

3 Design

FRBR is often presented as a model with a hierarchical structure, but is in reality a network consisting of typed nodes for the bibliographic entities and typed links for bibliographic relationships. Each bibliographic entity is described using attributes – which in a graph-context can be defined as typed node values. The main challenge when implementing searching and displaying results for such data is a) how to index and query the data so that a user can retrieve information relevant to a query, and b) how to display what is found in order to enable the user to understand and explore the results.

The BIBSURF system utilizes an indexing strategy based on dividing the graph into *indexing units* that loosely correspond to dynamically created metadata records which can be indexed using a text search engine. Works, expressions, manifestations, and even agents represent different perspectives of the same graph and are possible main (or root) entities for such dynamic metadata records (see figure 1). Each created metadata record needs to include the attribute values from the the main entity as well as the attribute values from related entities that are needed to support querying and retrieval. A dynamic metadata record for a specific work will e.g. include the attributes of the work such as title and type of work, as well as the attributes of all related agents such as names. A search using specific keywords will then return all units for which these keywords appear in any of the attribute values. Determining the boundaries of an indexing unit is a question of tuning for precision and recall in the context of an application. Expanding the graph will add more terms to the indexing unit with increased recall but possibly reduced precision because of more irrelevant terms.

A search performed on the index will find the set of units matching the query and return the identifier of the main entity of the index unit, which then can be used to construct *display units* for the result listing. Each display unit is essentially a subgraph selected for a presentation of the main entity. The choice of entities to include in the integrated display unit will impact the understanding and contextualization. Determining the boundaries of each display unit is based on principles of strong and weak links comparable to what is explored in [13]. Some relationships represent strong connections and indicate entities that should naturally be integrated in the same display unit. Other relationships are weaker and better represented as links to other display units in the user interface. A self-contained display unit of an expression e.g. needs to integrate information about the work as well as agents associated with the expression and the work, and combine it with a presentation of all manifestations that embodies this expression.

Distinguishing between indexing units and display units for the concepts of interest to end-users in the search and exploration process, and the notion of entities that are integrated in a display unit vs. entities that are interlinked, forms a framework that is reusable across models. Our focus in the current setup of the interface has been on the work, expression and manifestation entities as defined in the initial FRBR model.

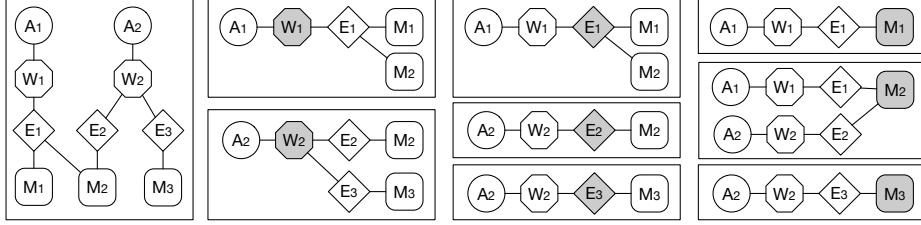


Fig. 1. Transforming a bibliographic graph into indexing units. The source graph to the left followed by the subsets used in the indexing of works, expressions and manifestation, with the main (root) entity in each unit highlighted.

4 Implementation

The BIBSURF system is designed as a generic keyword-based bibliographic search web interface where a user can enter terms or a phrase in a single field, and retrieve a ranked listing of units found. The main elements of the user interface is the search box and the result display. A filtering feature is added to enable users to refine the listing based on names or categorical values in the result set. Additional elements in the search interface are oriented towards the researchers, such as an option to choose between display views, select a ranking mechanism, and examine the underlying data. The user interface is developed using the component-based React framework and the React Bootstrap UI-widget library to create an interactive and responsive front-end.

On the backend side, the system uses the eXistdb³ open source native XML database utilizing xquery to produce the search results. The eXist database has built-in support for full text indexing using the Lucene search engine. Search is based on an intermediary index of RDF-fragments for each of the index unit types, mainly because dynamic support for this would add an expensive processing overhead. The technology is chosen to enable rapid development and easy management, but the same solution can in theory be based on a triple store with flexible support for full text indexing of RDF such as described in [9].

Our test collections have been created by enhancing and transforming existing MARC 21 records into rich and well-structured FRBR data coded in RDF using the RDA vocabularies⁴. Records have been retrieved from different library catalogs using Z39.50, and have been manually enhanced to make the inherent structure more explicit, based on the techniques identified in [10]; e.g. by adding missing uniform title and relator codes, or coding information in note fields or responsibility statements using explicit fields. Afterwards, the data has been transformed using a rule-based FRBRization process [5]. Collections used in the experiments presented in this paper include crime fiction novels and short stories and other works related in different ways, and a collection of publications of Don Quixote in various languages and editions.

³ <http://exist-db.org/exist/apps/homepage/index.html>

⁴ <http://www.rdaregistry.info>

To enable comparative evaluation of alternative indexing and display units, we have separate search and result views for works, expressions and manifestations units. The views have the same visual "look and feel", but are different to account for the nature and structure of the units and required interactive support. See figure 2 for examples of result presentations.

In the **work display** each unit consists of a header with the title and type of the work and agents associated with the work. A tabbed display is used to present subordinate groups of expressions of the same type and language, with a listing of manifestations grouped according to agents associated with those expression in each tab window. An additional tab for related works is included next to the expression tabs. A "show more" feature for each manifestation allows the user to explore the table of contents. Each content item is a header describing the expression and work and their associated agents.

For the **expression display** each display unit consists of a header with the title, the work and expression type, as well as all related agents. We are using the same tab display to create a presentation consistent with the work display, and include the same related works tab. In this view, the manifestations are listed directly under each expression, and the same "show more" feature for table of contents is included.

The **manifestation display** is based on display units that are visually comparable to those for work and expression, but does not include a tabbed display. The header is based on the publication title and statement of responsibility. As for other displays, we have included an expandable "show more" feature for the table of contents, which is where the user will find details about all embodied expressions and works.

A query performed using a specific view will search the corresponding index, and present the corresponding display units. Due to different decomposition of the bibliographic graph into indexing units as illustrated in figure 1, the returned result list may differ in what is returned and how it is presented in the display. The different display units reflect a different "starting point" and reflects a particular way of viewing, interpreting and interacting with the bibliographic graph. Another difference will be the replication of information across units. In the manifestation view, the same expressions and work descriptions may appear in the contents listings of many manifestation. In the work view, replication of manifestation listing will occur for manifestations that embodies multiple expressions and works. The displays also represent different choices in implicit and explicit description of entities. In the work display, we explicit describe the work and list and describe expressions individually. In the expression display, we describe each expression and work as one unit.

5 User study methodology

An exploratory user testing of the three displays was conducted in March 2017 with 15 volunteer students from the Faculty of Arts at University of Ljubljana. The study design was set up as a between-subjects experiment, where each par-

Murder in Mesopotamia / Clegg, Tom (director) ; Suchet, David (actor) [TV adaptation]

Moving image (English) Related works

Murder on the Orient Express / Martin, Philip Martin, Philip (director) ; Suchet, David (actor) [TV adaptation]

Moving image (English) Related works

Murder on the Orient Express / Christie, Agatha (author) [Novel]

Spoken word (English) Text (English) Text (Esperanto) Text (French) Text (Latvian) Text (Russian) Related works

Suchet, David (narrator)

- Murder on the Orient Express : a Hercule Poirot mystery / Agatha Christie.** [electronic - audio book]
[Auburn, Calif.]: Audio Partners Pub, [2006].
show more >>
- Murder on the Orient Express / Agatha Christie.** [CD - audio book]
Auburn, CA: [Chivers Audiobooks], p2001. 6 discs (1 container)
show more >>

Barker, Peter (narrator)

- Murder on the Orient Express / Agatha Christie.** [DVD - audio book]
Toronto: CNIB, 2010. 1 disc (7 hrs., 56 min.) ; 12 cm.
show more >>

(a) Work display

Poirot and Me / Suchet, David (author) [Autobiography - English - text]

Editions

- Poirot and me / David Suchet and Geoffrey Wansell.** [print - book]
[Large print edition]. 345 pages (large print) ; 24 cm
show more >>
- Poirot and Me / David Suchet.** [electronic - book]
1 online resource (320 pages)
show more >>

Murder in Mesopotamia / Clegg, Tom (director) ; Suchet, David (actor) [TV adaptation - English - moving image]

Editions Related works

- Murder in Mesopotamia / producer, Brian Eastman ; director, Tom Clegg.** [DVD - video]
New York: A&E Home Video, c2001. Full screen ed. 1 videodisc (ca. 100 min.)
show more >>
- Murder in Mesopotamia / producer, Brian Eastman ; director, Tom Clegg.** [VHS - video]
New York: A&E Home Video, c2001. 1 videocassette (ca. 100 min.)
show more >>

Murder on the Orient Express / Christie, Agatha (author) ; Suchet, David (narrator) [Novel - English - spoken word]

Editions Related works

(b) Expression display

- Murder in Mesopotamia / producer, Brian Eastman ; director, Tom Clegg.** [VHS - video]
New York: A&E Home Video, c2001. 1 videocassette (ca. 100 min.)
show more >>
- Murder in Mesopotamia / producer, Brian Eastman ; director, Tom Clegg.** [DVD - video]
New York: A&E Home Video, c2001. Full screen ed. 1 videodisc (ca. 100 min.)
show more >>
- Murder on the Orient Express / Agatha Christie.** [CD - audio book]
Auburn, CA: [Chivers Audiobooks], p2001. 6 discs (1 container)
show more >>
- Murder on the Orient Express : a Hercule Poirot mystery / Agatha Christie.** [electronic - audio book]
[Auburn, Calif.]: Audio Partners Pub, [2006].
show more >>
- The merchant of Venice / William Shakespeare ; edited by Gàmini and Fenella Salgàdo ; with a personal essay by David Suchet.** [print - book]
Harlow: Longman, 1986. xvii,276p. : ; 19cm.
show less <<
- Contents:
 - The merchant of Venice / Shakespeare, William Shakespeare, William (author) [Play - text - English]
 - [Essay to The merchant of Venice] / Suchet, David (author) [Essay - text - English]
- Agatha Christie's Poirot : the movie collection / produced by Karen Thrussell.** [CD - video]
Silver Spring, MD: Acorn Media, [2010]. Widescreen ed. 3 videodiscs (ca. 275 min.) (3 containers) (boxed)
show more >>

(c) Manifestation display

Fig. 2. Selection from the different displays

ticipant was randomly assigned to work with one of the three displays. This means that 5 participants solved the tasks using manifestation view, 5 participants using the expression view and 5 with the help of work-oriented view. All participants were given 5 tasks which were recorded and analysed using Tobii Studio and eye tracking equipment. The results in this paper focus on the measured aspects of participants' interaction with the system, such as a) the time needed to complete the task, b) successful completion of the task and c) the user understanding of the results. By looking at those measures, our aim was to analyse how manifestation, expression and work view compare in terms of:

- their ability to support different user tasks,
- users' understanding of what is displayed,
- what users learn about the entity they are interested in, and
- users' effort needed to identify and make sense of specific information?

As the aim of this experiment was to test only the displays, the participants were only presented with the scenario for each task and a list of results that were retrieved for the predefined search. Although the interface and the bibliographic data were predominantly in English language, all students who participated in the study had a high level of English comprehension and were not distracted by the foreign language. The results in this paper do not include eye tracking data or participants' perceptions of the task difficulty.

For each scenario, researchers assigned the following measures to evaluate how well the display supported users in discovering the correct answer and to assess participant's understanding of the displayed entities for the given scenario:

Success score noted whether the participant found the correct answer where
5 = complete success, 3 = partial success and 1 = no success

Description score reflected the quality of participant's description regarding the retrieved set of results: 5 = complete description, 4 = one element of description missing, 3 = two elements missing; 2 = three elements missing; 1 = no relevant description

Time needed to complete the task (the overall mean task time for each scenario was afterwards calculated only for those tasks with success score 5 or 3).

To give context and explain the content of each result listing, we have implemented a simple notation to show the core W-E-M chains with numbers indicating how many of each entity type that is found in a result set (as shown in table 2). The rightmost E is for expressions in the contents listing and the corresponding work count is redundant due to the 1:1 relationship from an expression to its parent work.

6 Results

Our main research question is focused on the usefulness of each of the displays. The collected data can provide an insight and give some conclusions for the FRBR entity displays. Table 1 shows the final results of our test with end users

Scenario 1: "Chekhov Murder"

A professor asked you to read an English translation of a short story by Anton Pavlovich Chekhov that was translated into English under the title Murder. You have made a query "Chekhov Murder" in the library catalog and retrieved a list of results.

Task: Explain what is presented in the list of results. Is this short story available in the library collection?

Objective: In the data set, Chekhov's short story Murder appears only in manifestations that embody multiple expressions of different works - collections of short stories. Additionally, the title "Murder" represents an expression title (work title is in Russian) and differs from the manifestation titles that represent a collection of stories (for example "Peasants and other stories"). The user needs to find among the results of a search resources that embody a manifestation of the expression sought. In the work display, the manifestations are grouped under a work title in Russian, which can make it difficult for the user to recognize what the search result represents.

Scenario 2: "Don Quixote Charles Jarvis"

You would like to read an English edition of Don Quixote that was translated by Jarvis. You have made a search "Don Quixote Charles Jarvis" and got a list of results.

Task: How many different editions can you choose from and how do the editions differ based on their content?

Objective: The user needs to identify manifestations embodying a particular expression (Jarvis' translation of Don Quixote) and compare how these manifestations differ. In the expression and manifestation display, the list of results provides the user with an exact match to the query, while the work display shows the user also all other translations and versions.

Scenario 3 Query "Murder on Orient Express Agatha Christie"

You are interested a mystery story Murder on the Orient Express by Agatha Christie. You have made a search...

Task: Explain what you got as the result of this search. What are the different versions you can choose from?

Objective: The query retrieves texts and narrated versions in English as well as some translations in different languages and TV adaptations of the novel Murder on the Orient Express. The user explores expressions and manifestations associated with the work and follows the derivation relationships between the progenitor work and other works adapted from it. In the expression display, information about the different versions is clearly visible as it is not obscured by numerous editions as in manifestation display or hidden in a single result which is the case in work display.

Scenario 4 Query "Agatha Christie"

You are interested in the works by Agatha Christie and would like to see the selection of her works in your library. You have made a search and got a list of results.

Task: How many different novels by Agatha Christie are available in the library?

Objective: The data set includes works about Agatha Christie, works by Agatha Christie and some adaptations of her works. Some of her novels appear only in manifestations that embody multiple expressions (collections of stories). The user needs to explore the entities associated with Agatha Christie and identify the novels written by Agatha Christie. In case of manifestation display, some of the novels can only be identified using the full content display, while other novels appear in numerous publications.

Scenario 5 Query "David Suchet"

You have recently seen a play starring David Suchet. You liked his performance and would like to discover what other works connected to David Suchet are available in your library.

Task: Explore the list and explain the results you got. Now write down what you have learned about Suchet and his repertoire.

Objective: In the data set, David Suchet appears in different roles (author, narrator, actor) and is often linked to the expression and not the work level. The user explores the works and expressions associated with the given agent and the roles played by that agent in their creation or realization. The expression display therefore gives the most comprehensive information about the roles and different endeavours.

for individual scenarios. As our main research question was focused on the usefulness of the three displays for different user tasks, the results were not analysed from the viewpoint of overall score per display, but individually for each scenario.

For scenario 1, the success score was highest for the manifestation display, while the descriptions of the retrieved results were most comprehensive using the expression display. The low score for the work display and higher scores for manifestation and expression display reflect the use case scenario where the main emphasis was to identify manifestations that embody expressions of the work in a particular language.

Scenario 2 also asked the user to identify manifestations that embody a specific expression. As shown in figure 1, this scenario is also well reflected in the high success and description scores that were the same for the manifestation and expression display. In the work view, some participants had difficulty locating the sought information as it was displayed among other expressions of the work.

Scenario 3 required the user to focus on the different versions of a chosen work and the results indicate that the expression view was the most appropriate for this task.

In contrast to all other use cases, the scores for scenario 4, where the user was primarily interested in the works of an author, reveal a high advantage of the work display, particularly in comparison to the manifestation display. In manifestation view, participants not only spent more time to identify individual works, but also made more errors, viewing some expressions (translations) and manifestations (collections) as new works written by Agatha Christie. A smaller difference in the scores appeared in scenario 5, but again the results from the user test, where the highest scores were achieved using expression view, coincide well with the scenario.

In some scenarios (for example scenario 4 and 2) low or high scores also correlate with the mean time needed to complete the task, but not in others (scenario 3). Overall however, it seems that participants needed more time using the expression display, which might be connected to the fact that such display is quite novel to the users (in contrast to manifestation display), but at the same time gives a longer list of results than the work display.

7 Conclusions and future work

The results of our preliminary user testing with the three displays indicate that each type of display is useful for some scenarios, but not all of them. The work-oriented view, which has already been adopted in some FRBR-inspired catalogs, supported users well in exploring and learning about a repertoire of a selected agent, but made it somewhat more difficult for participants to identify specific manifestations or expressions they were looking for. The expression view was successful in cases where participants needed publications in a chosen language, while the manifestation view remained quite consistent, but did not really excel the other two views in any of the scenarios at least in terms of success and understanding of the presented bibliographic entities. In our future analysis, we

	Display type	Success score (max sum = 25)	Description score (max sum = 25)	Mean time (successful tasks)
Scenario 1	Manifestation (N=5)	19	14	72
	Expression (N=5)	15	16	110
	Work (N=5)	13	8	90
Scenario 2	Manifestation (N=5)	25	20	84
	Expression (N=5)	25	20	70
	Work (N=5)	19	14	127
Scenario 3	Manifestation (N=5)	15	17	97
	Expression (N=5)	19	19	150
	Work (N=5)	15	14	76
Scenario 4	Manifestation (N=5)	7	11	154
	Expression (N=5)	17	17	135
	Work (N=5)	23	21	67
Scenario 5	Manifestation (N=5)	17	15	190
	Expression (N=5)	23	22	205
	Work (N=5)	17	17	210

Table 1. A comparison of scores by display type for each scenario.

Query	Work display	Expression display	Manifestation display
Scenario 1	W1-E4-M4-E39	E4-M4-E39	M4-E39
Scenario 2	W1-E21-M32-E58	E1-M5-E9	M5-E9
Scenario 3	W3-E9-M22-E31	E9-M22-E31	M22-E31
Scenario 4	W21-E30-M57-E117	E30-M57-E117	M46-E61
Scenario 5	W8-E14-M29-E43	E8-M11-E18	M9-E12

Table 2. Complexity chains for each scenario result set.

will have to compare this usability data with user perception data, which might be more influenced by the familiar interactions and displays in current catalogs. While the presented test suggests that FRBR catalogs and digital libraries might need to adapt the results display to the user's query, more studies will be needed to confirm this hypothesis, further testing of the users' perception of different displays as well as analyzing how to automatically understand what the user is looking for in order to offer an optimal view.

Our experience in using the search prototype in this study also proves that research should be done using realistic search prototypes that can exploit the rich structure of the data and test collections which reflect how information is intended to be represented if it was originally created according to FRBR. In our research we have so far only focused on the basic FRBR-models, but the system can be adapted to related models such as BIBFRAME [16] which can be seen as a simplification of the initial FRBR model, or FRBRoo [18] which can be characterized as an elaborated and extended version of FRBR. Comparative studies on how these models perform within the setting of the same search user interface and use cases would be a valuable contribution to determine which model or features best fit the needs of end users.

Ranking of results is another topic we have identified as future work. Default ranking based on term frequency is rather unpredictable when indexing fragments due to the different number of entities that may be included. Currently we deploy a ranking solution that simply weights forewords, illustrations etc. lower than others, and we also support a ranking solution that includes a count of entities. Ranking strategies based on the structure of the nodes or based on the distance between the nodes that include the search terms, are other strategies worth exploring further.

By creating data that fully exploit FRBR, we have also come across challenges that have not been revealed in systems that utilize simpler FRBR data (the kind of data that is produced by transforming MARC records). Cataloguing all content as distinct expressions and works, including illustrations and forewords, tends to introduce noise in the result displays for users not primarily interested in this content. Different strategies for dealing with this could be default low ranking or default hiding of specific types of entities, leaving it to the user to decide when to put them in front. Another challenge is the representation of works that have parts, manifestation that have parts, or aggregates (e.g. collections of short murder stories by different authors or text augmented by illustrations). This is a topic that has been discussed in theory, but real world experiments are needed to establish best practice representation and determine which entities are needed to offer specific functionality – or not needed – to include and manage in the database.

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