Journal of Documentation

Presenting bibliographic families: Designing an FRBR-based prototype using information visualization

Tanja Merčun Maja Žumer Trond Aalberg

Received 6 January 2015
Revised 21 October 2015
Accepted 26 November 2015

Presenting bibliographic families

Designing an FRBR-based prototype using information visualization

Tanja Merčun
Department of Library and Information Science and Book Studies, University of Ljubljana, Ljubljana, Slovenia
Maja Žumer
Faculty of Arts, Department of Library and Information Science and Book Studies, University of Ljubljana, Ljubljana, Slovenia, and
Trond Aalberg
Department of Computer and Information Science, Norwegian University of Science and Technology, Trondheim, Norway

Abstract

Purpose – Despite the importance of bibliographic information systems for discovering and exploring library resources, some of the core functionality that should be provided to support users in their information seeking process is still missing. Investigating these issues, the purpose of this paper is to design a solution that would fulfil the missing objectives.

Design/methodology/approach – Building on the concepts of a work family, functional requirements for bibliographic records (FRBR) and information visualization, the paper proposes a model and user interface design that could support a more efficient and user-friendly presentation and navigation in bibliographic information systems.

Findings – The proposed design brings together all versions of a work, related works, and other works by and about the author and shows how the model was implemented into a FrbrVis prototype system using hierarchical visualization layout.

Research limitations/implications – Although issues related to discovery and exploration apply to various material types, the research first focused on works of fiction and was also limited by the selected sample of records.

Practical implications – The model for presenting and interacting with FRBR-based data can serve as a good starting point for future developments and implementations.

Originality/value – With FRBR concepts being gradually integrated into cataloguing rules, formats, and various bibliographic services, one of the important questions that has not really been investigated and studied is how the new type of data would be presented to users in a way that would exploit the true potential of the changes.

Keywords User interfaces, Library catalogues, Model, FRBR, Bibliographic systems, Bibliographic data, Information visualization

Paper type Research paper

Introduction

Online bibliographic information systems have brought users the possibility to search and explore library collections anywhere and anytime, but they have also been repeatedly characterized as difficult to use, frustrating, inefficient, and missing the required functionality. Losing the position of primary information providers due to their inadequate services in the changing information environment (Coyle and Hillmann, 2007), information systems such as library catalogues would need to better

This research was supported in part by the ARRS projects P5-0361 and J5-6827.

Journal of Documentation
Vol. 72 No. 3, 2016
pp. 490-526

0022-0418
DOI 10.1108/JD-01-2015-0001

support users in their information seeking process and bring out the richness and value of bibliographic data in order to regain their value. While the summons for better bibliographic information systems have been made in literature throughout the last three decades (Hildreth, 1985, 1989; Borgman, 1986, 1996; Bates, 1986, 2003, etc.), changes have been slow and have actually come to a hold in the 1990s. In the last few years, competing services on the web and demanding web-savvy users have forced the library community to reconsider its services, which has led to some noticeable modernizations in the way bibliographic information systems provide search, presentation, and navigation. Despite the changes, however, current linear displays of records still do not fulfil all the objectives and do not have the adequate structure for representing as well as making navigable the "multidimensional complexity of the bibliographic universe" (Bianchini, 2010). Approaching a turning point, some believe that catalogues will need to "change or perish" as the current state will only remove them further from readers and collections (Bianchini and Guerrini, 2015).

Our research therefore sought an alternative design to current bibliographic information systems that would not only improve the presentation of and navigation within bibliographic records, but also structure displays in a way that would facilitate user tasks and understanding of the data. Exploring possible approaches to address the identified issues, the following concepts have been chosen as the building blocks of our work:

(1) Functional requirements for bibliographic records (FRBR): published by the International Federation of Library Associations (IFLA Study Group on the Functional Requirements for Bibliographic Records, 1998), FRBR is a conceptual model of the bibliographic universe that was developed to improve the cataloguing process as well as online library catalogues (Carlyle, 2006). It holds the potential for creating more efficient and user-friendly bibliographic information systems by bringing together all editions of a work that exist in a collection as well as by creating relationships between various entities, such as related works or editions. While some attempts have been made on implementing the model (overviews in Yee, 2005; Zhang and Salaba, 2009; Pisanski and Žumer, 2007), the experiments so far have used only a fraction of FRBR potential. This means that even FRBR-inspired catalogues have not provided a suitable structure to identify or navigate the majority of relationships that exist between bibliographic resources. Our research used the entity-relationship model proposed by FRBR to restructure existing bibliographic data. It also looked at how the converted data could be best presented in a user interface to create an informative overview and support semantic exploration.

(2) Work family: based on FRBR and other literature on organizing and presenting bibliographic data (Fattahi, 1996, 2010; Ercegovac, 2006; Carlyle, 1997a), the concept of a work family was set as the main element of our research. We have therefore not looked at the complete user interface design, but only at how the entities and relationships within a work family could be brought together in a single display, collocating different editions and versions of the work, showing related work, and providing a broader exploration of works by or about an author.

(3) Information visualization: traditional linear lists of records do not provide the necessary structure that would naturally support meaningful clustering or exploration of relationships (Carlyle, 1997a). To overcome these limitations and

provide a frame that would better suit the proposed model of a work family presentation, a dynamic graphical display was chosen. As there are various information visualization techniques available, each having its pros and cons, four alternative visualization techniques have been selected in order to test which of them would be most appropriate for our model.

Combining the three concepts, the first objective of our research sought to propose an interface design for presenting FRBR-based bibliographic data using work family grouping and hierarchical visualization. While the proposed design was later also implemented and tested with users, this paper reports on the first segment of the research that looked into information architecture and investigated possible display options. Deriving from the objectives of bibliographic information systems, the introductory part analyses past and current literature to identify their unfulfilled potential and possible solutions. The second part of the paper is dedicated to FRBR and various questions related to its implementation, while the third part describes the design of a prototype system FrbrVis[1]. It explains the underlying ideas behind the prototype system and shows an example of how work families could be presented and interacted with using information visualization.

Theoretical background

Problematic presentation and navigation of results

Online library catalogues as well as other bibliographic information systems have often been characterized as frustrating, unintuitive, time consuming, and difficult to use and find relevant information. Literature on the topic (e.g. Borgman, 1996; Bates, 2003; Novotny, 2004; Yu and Young, 2004; UC Bibliographic Services Task Force, 2005) describes these problems and looks for reasons behind them. While not the sole factor, display and navigation seem to be among the biggest problems in search systems today.

Carlyle (1999) emphasizes that poorly designed displays contribute to search failure and, in one of her works (Carlyle, 1997b), concludes: "[…] the disorganization of current online catalogue displays may cause users to abandon their searches, leaving the catalogue frustrated and confused. Even experienced catalogue users may be thwarted in their searches for particular authors and works by the lack of organization that exemplifies current online catalogue displays". She suggests that online catalogue displays are inadequate for searches where many items are retrieved and proposes the use of summary displays that would classify or cluster search results and thus enhance users' ability to identify items of interest. She also points out that "displays that do not demonstrate relationships among related items retrieved may leave users, at best, disgruntled over the amount of time necessary to find what they are looking for and, at worst, oblivious to the fact that the library actually holds the very item or items they seek" (Carlyle, 1996). Already in 1997 she concludes that changes are long overdue and summons the library community to provide relationship-based displays that could be created using various approaches such as graphical, hierarchical tree-structures (Carlyle, 1997a).

Also Ercegovac (2006) emphasizes the importance of utilizing bibliographic relationships and clustering, claiming that the quality of today's search systems depends on their ability to link entities using bibliographic relationships. Partitioning results in smaller units and displaying them in meaningful clusters would be beneficial not only for presenting bibliographic data but also for enhanced information processing by the users. She, too, points at the issue of long lists of records and argues

that in current library catalogues, valuable information is buried behind user interfaces. On the topic of presenting records in library catalogues, also Mimno *et al.* (2005) discuss catalogue's inability to find and collocate all versions of a distinct intellectual work that exist in a collection and the inability to take into account known variations in titles and personal names. On the same topic Yee (2005) writes that the user should be able to tell if there is an illustrated edition, if there are edited versions, what translations of the work exist, if any of the editions are available electronically, what types of versions are available, etc. and notes that these are all features that are badly supported in library catalogues. Going even a step further, Chandel and Prasad (2013) suggest that today's users expect not only the documents on their interest area, but also other related resources that may interested them more than their primary search. Adding links among similar resources and concepts would not only satisfy users' need for full navigation capabilities, but also their need of knowledge and serendipitous discovery (Bianchini and Guerrini, 2015).

The critiques on the shortcomings of library information systems to efficiently collocate records and present relationships are not new by far, but they have not really been in the forefront, probably also because our existing cataloguing practice, rules and formats did not provide a good base for implementing these ideas. As Carlyle (1997a) observed, a "widespread implementation of relationship-based displays would require an expansion of the scope of the cataloguing rules". However, many of the presented ideas have been somewhat indirectly expressed in the primary objectives of a library catalogue which formed the basis for cataloguing rules; they have just not been fully put into practice.

The library catalogue and its objectives

During the last two centuries, the library catalogue has transitioned from book to card and finally to online computer format. Each transformation has brought new possibilities and improved some of the former shortcomings, but at the same time some of the useful characteristics were lost in translation. From Cutter and Panizzi to Lubetzky and Verona, we can follow the development of catalogue's objectives that have served as the basis in the formation of cataloguing rules. In his *Rules for a Dictionary Catalog* from Cutter (1876) listed the objectives that had a powerful influence on the structure and purpose of catalogues:

(1) to enable a person to find a book of which either the author, the title, or the subject is known;

(2) to show what the library has: by a given author, on a given subject, or in a given kind of literature; and

(3) to assist in the choice of a book as to its edition (bibliographically) or as to its character (literary or topical).

These objectives that have been later reworded also by Verona (1959) and Lubetzky (1960) were finally adopted by the International Conference on Cataloguing Principles in Paris (1961) in a slightly different formulation, which said that the catalogue should be an efficient instrument for asserting:

- whether the library contains a particular book specified by its author and title, or if the author is not named in the book, its title alone, or if author and title are inappropriate or insufficient for identification, a suitable substitute for the title; and

- which works by a particular author and which editions of a particular work are in the library.

While the first objective of the catalogue is directed at helping users find known-items, the second one emphasizes the exploratory function that is only partly supported in current online catalogues which Yee (2005) describes as finding lists that carry out the first objective, but fail to display works of an author and editions of a work in full. According to some broader interpretations of the second objective, this not only includes editions of a work and works by an author, but also works related to the author or a given work.

Fulfilling the second objective

To better meet the second objective, several authors have stressed the importance of establishing the concept of work and showing relationships between works, both of which would enable catalogues to more efficiently present author and work records to the user. Carlyle (1997a), for example, argues that "the use of relationship-based organization of records in catalogue displays has the potential to increase a user's understanding of the nature of the items retrieved in an author or work search and to shorten long displays". Fattahi (2010) goes even further and promotes a more knowledge-oriented library catalogue where the value lays in "its ability to help the user not only find relevant information but also provide him/her with knowledge about the bibliographic universe (a network of works, related works, and works about a work)". Moreover, he argues that it should "represent an integrated picture of bibliographic families (entities and their relationships)" understandable to the user, all of which the current linear structure of library catalogues lacks. Similarly Ercegovac (2006) writes that the catalogue or any other bibliographic information system should build upon bibliographic families as the created clusters would be helpful to users in their decision-making process. Smiraglia (2007) further discusses how implementing a bibliographic family – a group of works that share a common intellectual content and form various types of derivative relationship to the originating work called "the progenitor" such as successors, predecessors, extractions, translations, adaptations, performances, amplifications, etc. – would help accomplish the goals of the catalogue.

As a possible solution to these ideas Fattahi (1996) describes how the catalogue as well as the bibliographic record could be restructured in order to facilitate turning information into knowledge. He believes that introducing a superwork record, a meta-record that would integrate all records presenting instances of a work as well as works about the work, would generate a better understanding of bibliographic families by presenting the size of the bibliographic family, types of entities that are related to the work, as well as types of relationships that exist between works. Similar ideas can be traced also in the works of Allyson Carlyle, who published a number of papers researching the organization and arrangement of records that would provide better displays in library catalogues, focusing particularly on works of fiction.

The work of Allyson Carlyle

In her "organized display scheme", Carlyle (1997a) introduced a summary work and author display (see Table I), an approach that would give users a precise indication of the nature of retrieved items and the relationships among them by taking into account

Work display for text original	Author display
Editions	Single works
Books	Collected works
Recordings	Selections from author's works
Large print, braille	Spurious and doubtful works
Illustrated editions, edition with commentary	Works about the author
Published with other works	Item probably related to the author
Revisions, updated editions, etc.	Items that may or may not be related to the author
Translations	
Parts, selections, extracts	
Adaptations and related works	
Abridgements, simplified versions, summaries, etc.	
Sequels, supplements	
Videos, motion pictures	
Musical versions	
Pictures and other graphic versions	
Computer versions, CDs	
Indexes, concordances	
Miscellaneous	
Works about	
Items probably related to the work	
Items that may or may not be related to the work	
Other works by the author of the work	

Table I.
Carlyle's organized display scheme

the types of relationship as well as the distance of an item from the original. It would also provide for peripheral and unlinked items that are typically also retrieved in a keyword environment ("probably related to", "may or may not be related to"). The categories used would appear when and if needed for a particular work or an author.

Carlyle (1996) also proposed a superwork hierarchical tree structure summary display for A Christmas Carol, composed of three main categories:

(1) editions of A Christmas Carol (English language editions, editions in other languages, audio editions, etc.);

(2) works related to A Christmas Carol (textual adaptations, musical adaptations, audiovisual adaptations, etc.); and

(3) works about A Christmas Carol (criticism, etc.).

In her concluding remarks she stresses that cataloguing rules should become a code governing not just catalogue records, but also the construction of catalogues – their arrangement and display – if they were truly to support collocation of related author and work records in online catalogues. She also notes that one of the most critical areas for future research is an investigation into how collocation affects the catalogue use: in order to do that, most problematic cases should be identified and experimental systems that provide perfectly collocated record displays should be developed. However, in order to create such collocations and relationship-based displays "two major obstacles must be overcome first: the inadequate identification of relationships in existing cataloguing records and the limitations of current cataloguing practice and the MARC format" (Carlyle, 1997a). FRBR (IFLA Study Group on the Functional Requirements for Bibliographic Records, 1998), presented

the first formal step within the library community towards identifying all the needed elements and re-structuring bibliographic data in a way that would enable better collocation and navigation of records.

FRBR

Building on existing theories of works, bibliographic families and relationships, FRBR extended these ideas into a functional concept suitable for implementation in library catalogues (Bennett *et al.*, 2003). Being a conceptual, entity-relationship model developed with the primary purpose of improving bibliographic records, the process of cataloguing as well as online library catalogues (Carlyle, 2006), FRBR describes how our bibliographic databases could be structured and what functions they should fulfil (Gonzales, 2005). Due to its theoretical nature, FRBR does not prescribe how its implementation should look like and acts more as a reference for building a bibliographic environment that would best reflect and answer to users' needs. The model was developed around four user tasks performed by users in their interaction with bibliographic information systems: find entities that correspond to the user's stated search criteria; identify an entity; select an entity that is appropriate to the user needs; acquire and obtain access to the entity described. Later on, experts started adding a fifth task: navigate a bibliographic database to find works related to given work by generalization, association, and aggregation and to find attributes related by equivalence, association, and hierarchy (Svenonius, 2007). This task will now be included as explore also in the revised and harmonized version of the FRBR model.

The core of FRBR is constituted of four entity types of Group 1, their attributes and relationships among them. Each entity represents a different level of abstraction of an intellectual or artistic product: work as the most abstract entity refers to intellectual creations at the conceptual level, expression presents an intellectual or artistic realization of a *work*, manifestation is a physical embodiment of one or more expressions and is equivalent to the concept of publication, while item is a single exemplar of a manifestation and is equivalent to a copy. An example of practical demonstration would be:

> The novel Da Vinci Code is an intellectual creation by Dan Brown – a *work*, which has been expressed by the author in English language – an original *expression*, but has been later translated also into Spanish by Juan José Estrella – a new *expression* and this translation has been adapted into an audio version read by Raúl Amundaray – another new *expression*. Spanish translation by Estrella published in 2003 by Umbriel presents a *manifestation* of that expression and was reprinted in 2004 and 2005, which means there are two more *manifestations* of the same expression. Our local library holds one copy of the 2004 edition and three copies – *items* of the 2005 edition. Furthermore, several new *works* have been created based on the novel: a movie directed by Ron Howard, a sequel novel titled The lost symbol, as well as several other texts.

This excerpt from the Da Vinci Code work family shows a work realized through multiple expressions, at least one of these expressions being embodied in not just one but in multiple manifestations. This is a very typical example of a tree-like structure that FRBR is usually associated with, where one work has one or more expressions, which in turn have one or more manifestations. However, the structure is not necessarily always a top-down hierarchy, but can also take other forms (e.g. when a manifestation embodies more expressions of different or of the same work), thus creating various possible complexities (Figure 1, see also Merčun *et al.*, 2012). The network can become even more diverse when adding horizontal links among primary entities such as related works

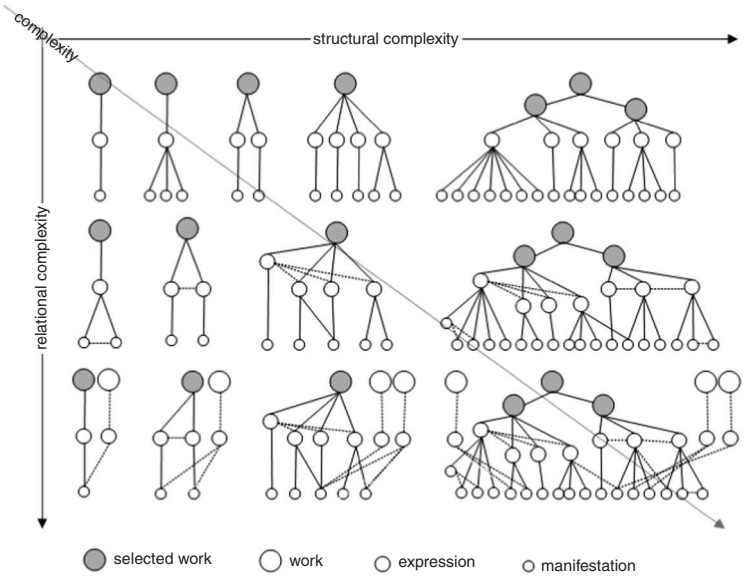


Figure 1.
Dimensions of possible complexities within work families

(successor, adaptation, transformation, etc.), related expressions (translation, abridgement, revision, etc.), and related manifestations (reproduction, etc.) or between primary entities and associated entities of responsibility (author, translator, etc.).

FRBR and its potentials for bibliographic information systems

The potential of FRBR lies not only in improving the quality of records, but also in providing users with a better browsing and searching experience (Babeu, 2008) required to fulfil the second objective of library catalogues. Rose (2012, p. 130) described the advantages of a frbrised catalogue by saying: "Instead of today's bewildering list of disparate manifestations of various expressions ordered only by some obscure 'relevancy' algorithm, the catalog searcher would receive a results list in which manifestations are collocated by work".

An investigation of literature shows that one of the major benefits could be a more efficient and advanced user interface that would enable new ways of finding, exploring, and discovering relevant content (Aalberg *et al.*, 2011), presenting users with opportunities they did not imagine, but have, once seen, recognized them as relevant (Riva, 2007). Showing explicit relationships between entities could enhance the navigational capability, enable grouping of related entities as well as communicate how entities are collocated (Ercegovac, 2006), while a separate identification of works should diminish redundancy and "lead to increasingly sophisticated retrieval of *works*" (Smiraglia, 2007). The model presents a good solution particularly for large work families where an FRBR-based organization could solve the problem of "unorganized bulky results" by creating shorter lists, thus improving the intelligibility and browsability of results (Arastoopoor *et al.*, 2011; O'Neill, 2002; Carlyle, 2006). Also recent user studies conducted by Pisanski and Žumer (2010a, b, 2012) give a long awaited confirmation that FRBR in itself is intuitive and thus presents a viable option for new bibliographic information systems.

Being a conceptual, theoretical model, FRBR implementations can vary, but the tasks that need to be supported, the underlying motives, and potential outcomes stay

the same. FRBR records relationships between resources and helps to bring together all versions of a distinct intellectual work that exist in a collection, all expressions of a work and all manifestations of an expression. By collocating and displaying bibliographic families in smaller and meaningful clusters, the structural foundation of FRBR should make the display more understandable and organized, helping users to navigate search results, identify relationships, and easily access all works and expressions derived from and centring around a specific intellectual creation. However, the benefits of FRBR are greater for large works and for certain types of resources, for example collections of fictional works, music collections, serial collections, and other works that have been published in a variety of ways or published in different editions, by different publishers and on different mediums (Teixeira, 2010).

Frbrisation and its problems

A transition towards FRBR-based library catalogues will not only require new infrastructure for creating FRBR-born data, but also the conversion of existing bibliographic records – a so called frbrisation. While we have seen the development of some algorithms that attempted to automatically frbrise legacy data (mainly from MARC formats), the process of transforming existing records into FRBR-based ones is still problematic. Zhang and Salaba (2009) point out some key implementation questions: how to identify FRBR entities from existing bibliographic records, how to draw precise boundaries among the four FRBR entities, how to establish relationships among FRBR entities, and how to display FRBR entities, relationships, and attributes. There are no "one-size-fits-all" solutions as the rules have to be adapted to the specific cataloguing practice used by the library in question (which is sometimes even changing in time) and it is also difficult to provide a comprehensive mapping from MARC to FRBR due to fundamental differences in their structural architecture (Aalberg and Žumer, 2013).

Furthermore, cataloguing standards and practice have resulted in a varying quality of records, which has in turn caused that a certain percentage of entities cannot be correctly identified (useful examples to demonstrate that are given in Carlyle *et al.*, 2008). Examining reports on frbrisation attempts (e.g. O'Neill, 2007; Hickey *et al.*, 2002; Aalberg, 2002; Babeu, 2008; McGrath and Bisko, 2008; Aalberg *et al.*, 2011), we can see similar problems generally deriving from two main classes of errors as distinguished by Mönch and Aalberg (2003): first, inconsistency – identical information might be represented differently in different records, and second, incompleteness – information that is required to identify an entity or a relationship defined in the FRBR model is not present in the record. Issues with frbrisation have limited not only the application of FRBR ideas in existing research, but also the exploration into how the full potential of the new framework could be employed to create richer services and user interface design. In order to design a more comprehensive functionality for displaying future FRBR-born data, our research therefore not only dealt with a typical transformation of existing MARC records (as in Hegna and Murtomaa, 2002; Aalberg, 2002, 2006; Riva, 2004), but went a step further by manually editing and enriching records to gain as complete frbrisation results as possible.

Presenting FRBR in a user interface

According to Dickey (2008), the "admitted weakness" of the FRBR model is that it still remains basically a theory with only a few working systems. Despite some progress, this holds true even today and, as Rose (2012, p. 131) observed, it seems that the "philosophical and logical frameworks for realizing a FRBR-ized interface are many

years away". So far, most of the work concerning the transition to FRBR has been focused on establishing new cataloguing rules, finding ways to transform existing bibliographic records, and creating formats that would work better also with FRBR-based data. Dealing with the infrastructure, researchers, and libraries have, however, forgotten to consider how this new data should be presented to the users (Arastoopoor *et al.*, 2011), especially since, as a conceptual model, FRBR is open to various interpretations and implementations (Zhang and Salaba, 2012).

Our review of literature found little discussion or systematic exploration on the choice of features, presentation techniques, or elements needed for displaying FRBR in user interfaces. This issue was raised already in 2006, when Carlyle observed that "little to no user research has been published investigating the usefulness of catalogue displays organized around the FRBR four-entity model". She further wrote that user research on what kind of displays were most effective and which attributes most facilitated the use of catalogue were highly desirable and needed to guide the decision-making process of the new set of cataloguing rules as well as the design of online catalogue display that incorporate FRBR.

Arastoopoor *et al.* (2011) were some of the handful of researchers who questioned the presentation of FRBR entities and sought answers also through user research. In a user study they explored whether it was sufficient to group all different instantiations into four clusters and present them as such. They found that the general view of the family was aligned with the model, but participants also liked to categorize a bibliographic family into more specific categories, combining similar instantiations of different expressions and manifestations. Another study was performed by Zhang and Salaba (2012), who found that overall, 84 per cent of the participants could easily navigate the hierarchical presentation of work, expression, and manifestation. They also collected some valuable insights, such as users' preference for expression grouping by language first and then by content type and their need for visual cues, hyperlinks, clear labelling, and clearly aligned groups.

FRBR implementations and FRBR-inspired displays

Due to the lack of guidance as well as user research, FRBR implementations have so far been largely exploratory in nature in terms of user interface display, system features, and the way they applied the FRBR model (Zhang and Salaba, 2012). With the new cataloguing rules being adopted in a growing number of countries, the implementation of the model is, however, slowly becoming a reality. While the limited number of FRBR-inspired catalogues developed so far show improvements over traditional catalogues, previous reviews as well as our own examination presented in the following part show that the majority has not applied the complete model or fulfilled the full potential of FRBR. In 2005, Yee looked at the implementations that have been available at that time (OCLC FictionFinder, FRBR Display Tool, RedLightGreen, VTLS Virtua) and concluded that the projects appear to have been designed without complete awareness of the degree to which our existing records could be used to frbrise catalogues. A comparison of two FRBR-based implementations (FictionFinder and LibraryLabs) has also been done by Pisanski and Žumer (2007), who found that neither of the prototypes implemented FRBR as it was conceived by the IFLA Study Group and that while prototypes clearly show improvements over traditional OPACs, many enhancements associated with FRBR are yet to be realised. A third and probably most extensive overview was made by Zhang and Salaba (2009), who studied the use of FRBR in full-scale systems (WorldCat and UCLA Film and Television Archive OPAC) as well as prototypes or experimental systems (FictionFinder, LibraryLabs, RedLightGreen, Kent State University FRBR project). In the last few years, some of

the examined systems have disappeared, others have been redesigned and new FRBR-based systems have been created. To examine the current state of the art, the following part introduces some of the main FRBR-inspired systems currently available online and describes them from the viewpoint of their display of FRBR entities.

Recent FRBR-based user interfaces

In Finland, libraries developed a unique web service Kirjasampo.fi for exploring and discovering fiction that was either created by Finnish authors or was published in Finnish language (see Hypén, 2014). Building on enriched databases they have created over the years to help them answer the variety of patrons' questions on fiction, they set out to develop a novel system based on the semantic web and FRBR that would be available to the public. While the service goes well beyond a typical library catalogue by offering numerous browsing possibilities and news related to literature, the bibliographic data is presented in form of "abstract work" displays, "publication or physical work" displays and "author" displays. The "abstract work" (FRBR work) contains a rich set of annotated work-related attributes (type, genre, themes, main characters, time/place, language of the original work as well as information about related works, work adaptations and awards), followed by a summary text and a list of publications (manifestations) (Figure 2). Selecting any of the publications shows a new display with more information on a particular manifestation, while clicking on an author's name leads the user to the author page with more biographical information and a list of the author's works. Kirjasampo.fi gives a good example of the potential richness of work-based and author-based displays and even leads users through the new type of record (green boxes on the figure). The implementation, however, only partly follows FRBR as it excludes expressions as separate entities and, despite its modern design and browsing possibilities, offers somewhat limited overviews.

Recent developments that combine semantic web principles and FRBR-based data come also from national libraries of Spain (datos.bne.es) and France (data.bnf.fr). Besides work and author pages, both interfaces include also topic displays and integrate a powerful dynamic suggestions feature in the general search box that is based on authority control. Especially well designed in the Spanish version, suggested entities with a label representing their type (authors, work, subject, resource) are offered as the user types the query (Santos *et al.*, 2015). Making a selection, the user is directed to the entity page that collects all the connected data in one place. In case of the author page, the user first gets a summary based on the resources in the library – Figure 3 (left), for example, tells that in the National library of Spain, Cervantes is the author of 149 works, the subject of 116 works, and plays some kind of a role in 158 works, all of which are listed down the page. Similarly the work page gives a summary of available editions (grouped by language) as well as works about the work. In contrast to the Spanish version, the French implementation distinguishes editions of a work by media type and not by language and presents a more elaborate author page that groups works by the person's role and shows also various adaptations based on the author's works (Figure 4). Compared to other implementations, the two services provided by national libraries designed a promising searching approach and included some interesting overview features not only for search results, but also for the author and work display. But as in many other attempts, the expression entity is not really included and the displays clearly show problems in the frbrization (Cervantes, for example, never wrote the huge number of works that are attributed to him). Le Bœuf (2015) describes the French application as semi-frbrised and reveals that expression representation is included in future plans.

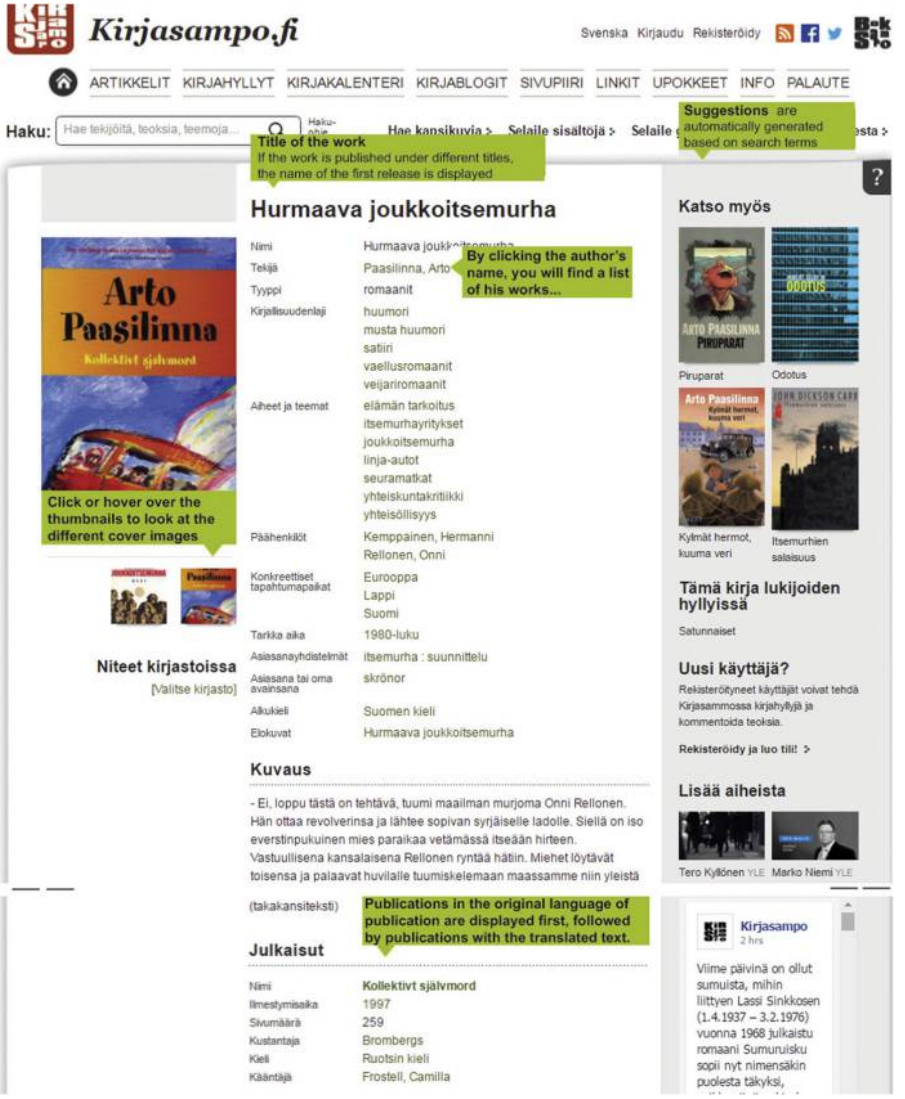


Figure 2.
Work page in Kirjasampo.fi, the Finnish library web service

Another experiment with dedicated work displays comes from OCLC and is also dedicated to fiction. While the so called FictionFinder tool has been around for some time, it has been recently remodelled after some years of inactivity. Also here, the general attributes of the work (summary, genre, subject) are presented first, followed by a list of manifestations and a reference to other works by the author. The summary display (Figure 5) tells the user how many editions there are and in how many languages, but there is a lack of expression entity or any kind of structure that would guide the user through what may be a very long list of manifestations. Furthermore, the list seems to include also some related works (adaptations for children, etc.), but at the same time many editions belonging to the same work are often identified as new works due to automatic frbrisation issues.

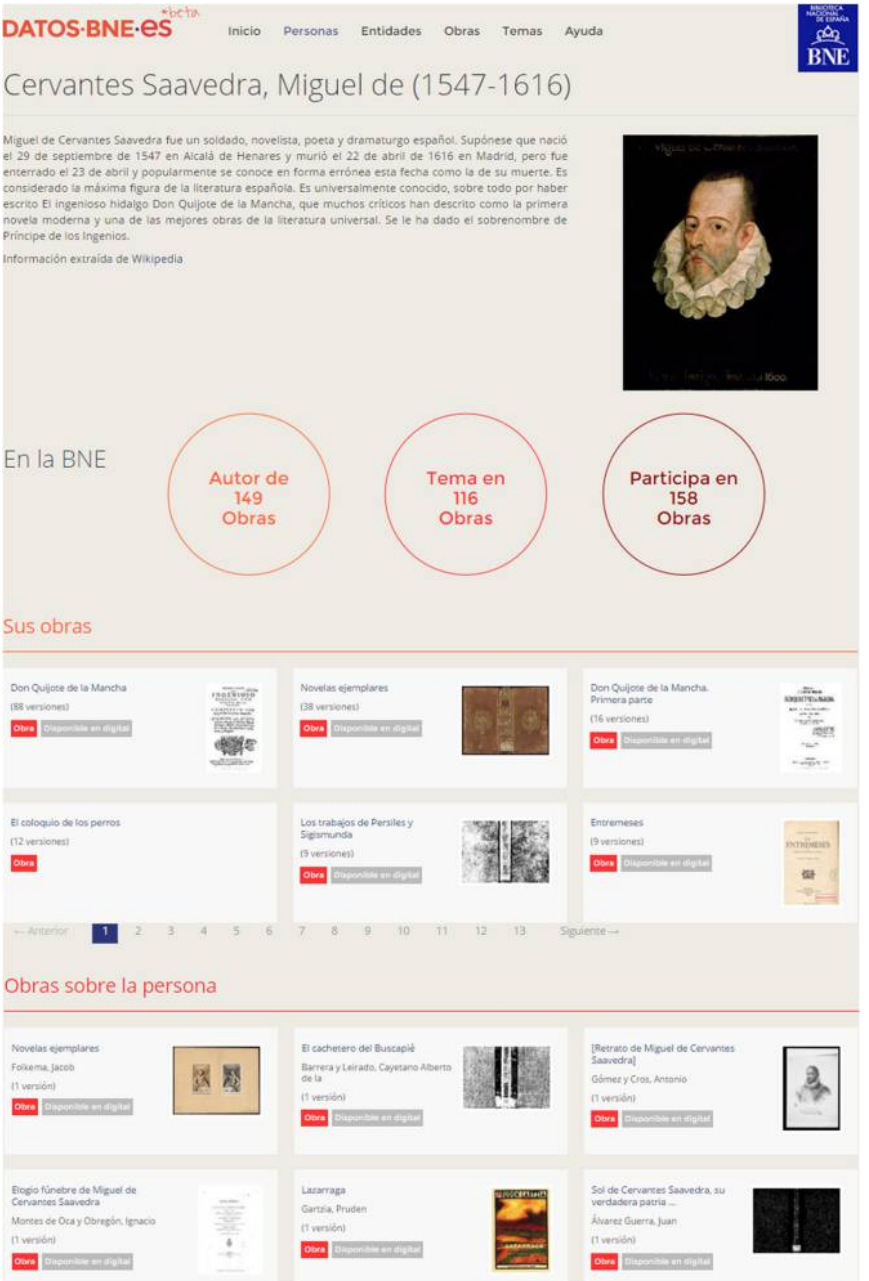


Figure 3.
Author page in the Spanish system datos.bne.es

Moving away from applications for fiction, music represents another area where FRBR was recognized for its potential. In 2011, Scherzo, a large-scale FRBR-based music discovery system was developed at Indiana University. In the user interface, works are featured separately in the results list, followed by a list of manifestation

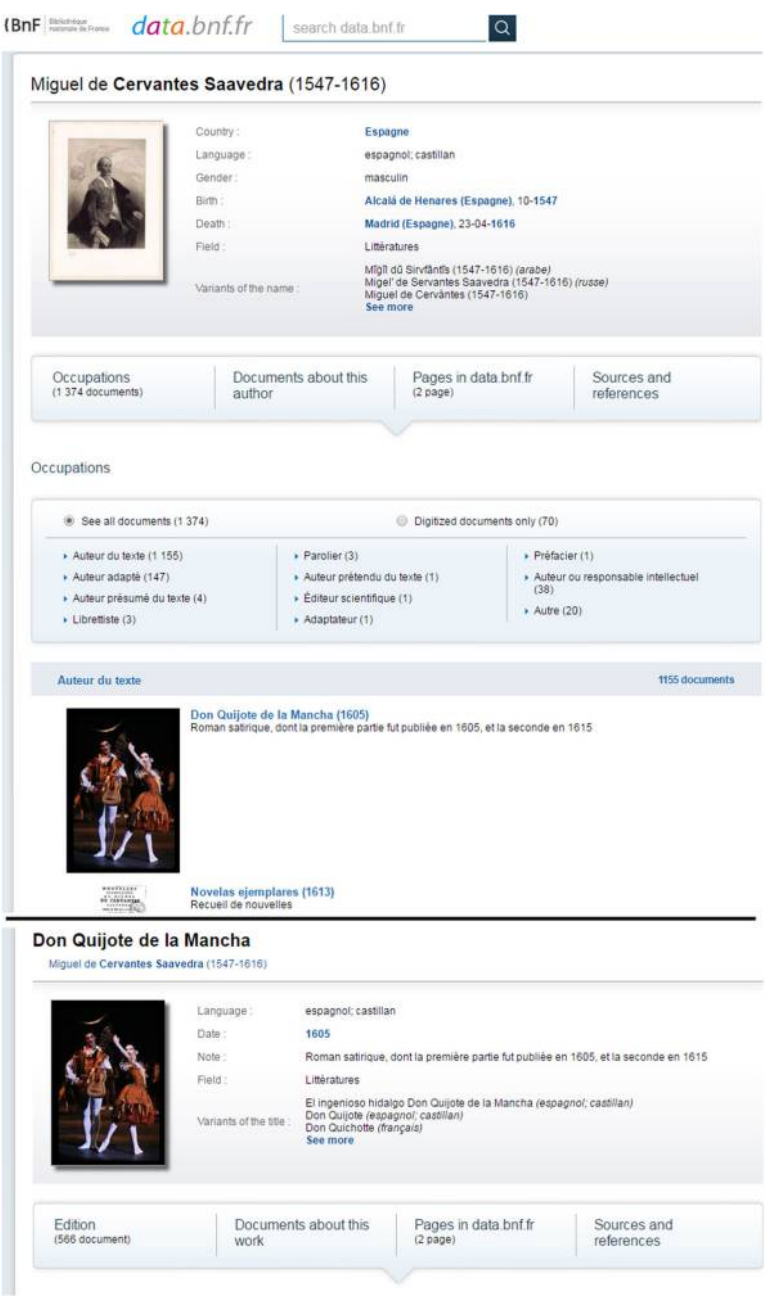


Figure 4.
Author page (top) and work page (bottom) in the French system data.bnf.fr

records containing both scores and recordings. The system does not introduce work and author pages neither does it present the expression entity to group manifestations despite having it in the frbrised data. It does, however, use the expression level data in the faceted navigation and enables advanced searching by different roles, such as composer,

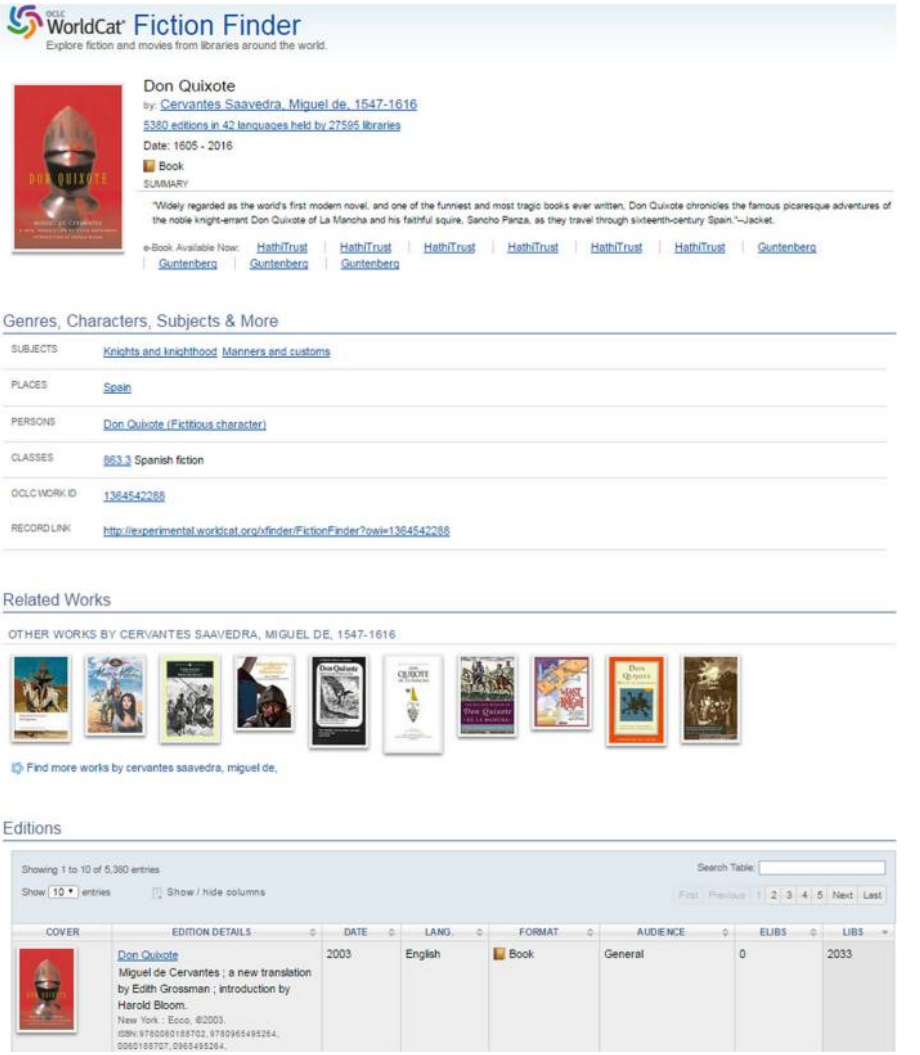


Figure 5.
Work page display in OCLC's experimental service Fiction Finder

Note: A screenshot of OCLC FictionFinder (April 1, 2016)
Source: ©2016 OCLC Online Computer Library Center, Inc. Used with permission

performer, conductor, or editor. Usability evaluation (Hardesty *et al.*, 2012) indicated that the possibility of searching by different roles and navigating the results via facets was valuable, but the highlighted list of works was confusing to the users as they did not intuitively understand the difference between the two displays.

Judging from the examined systems, the most comprehensive FRBR implementation can be found in AustLit – the Australian Literature Gateway that builds on collaborative efforts of librarians and scholars and presents an authoritative database about Australian literature and storytelling. As the data are edited and authored by experts, frbrisation is more precise, and the bibliographic entities richer with attributes,

relationships, and other information. The new interface was launched in May 2013 and while many of the functionalities were present also in the previous version (see Ayres, 2005), the design now includes improved ranking of search results, rich advanced search possibilities, and faceted navigation for filtering and sorting the results. As in some of the other presented implementations, AustLit provides a dedicated page for each work and each agent, but they are more comprehensive and offer also expression level categorization that tells the user how many versions of the work are available and how many publications each version has (Figure 6). One of the more advanced features following the FRBR idea is also that each individual creation, for example a poem, is

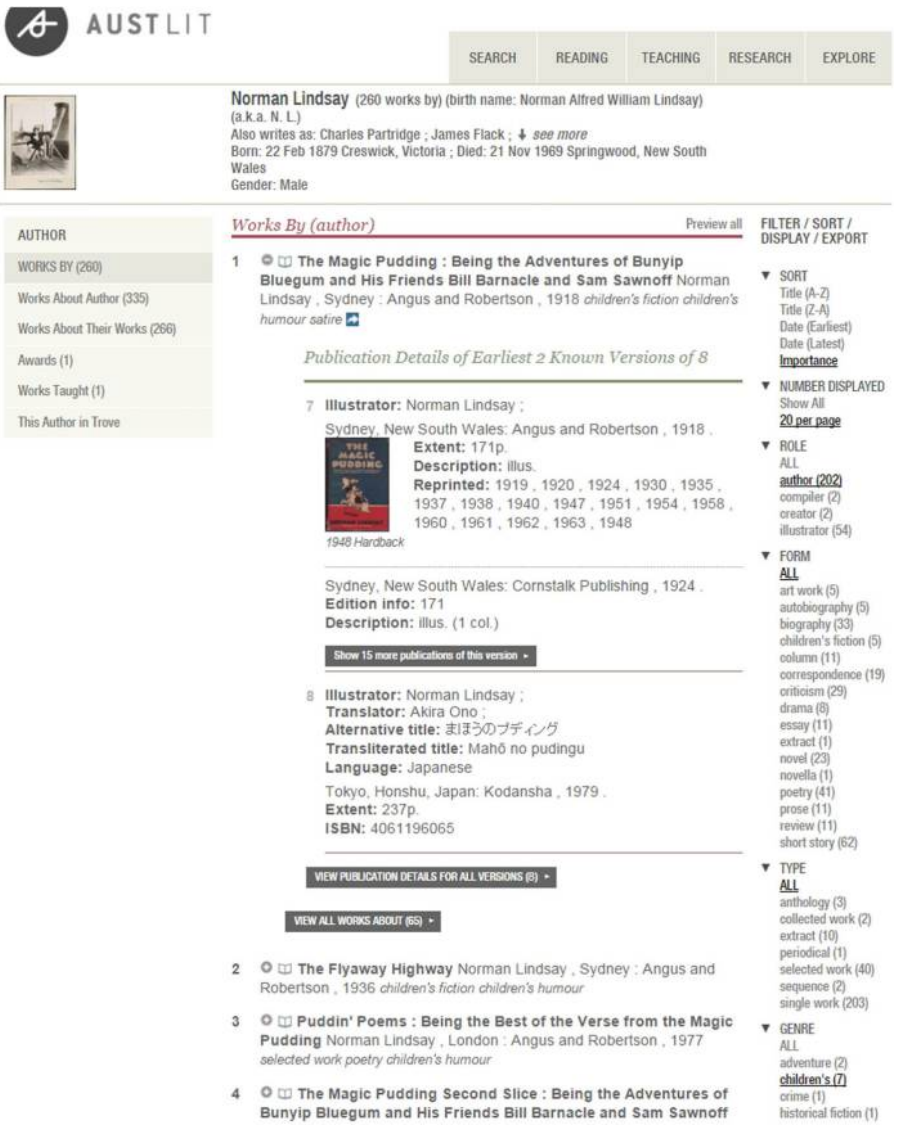


Figure 6.
Author page in AustLit with work preview

treated as a single work, which means that the user can instantly see in what publications it appeared in and can trace what has been written about that poem (Figure 7). Information about related works present another significant part of data in AustLit: on a work page (Figure 8), for example, users can explore works about the work and related works, while the author page (Figure 6) enable them to see works by and about the person as well as what has been written about their work. In the author page, displaying all works can result in very long lists, but the filter/sort feature presents a valuable tool not only for managing the results (e.g. sorting by importance, date of creation), but also for acquiring knowledge about the authors' endeavours. Faceted navigation serves well also for managing and understanding search results, but it has not been applied to manifestations display where it might also be useful when the list is long. According to the information on the AustLit webpage, the developers are, however, planning to improve data manipulation and add visualization functions.

Summing up the presented FRBR implementations and experiments, we can see that except in the AustLit project, expression entity is still only partially included in

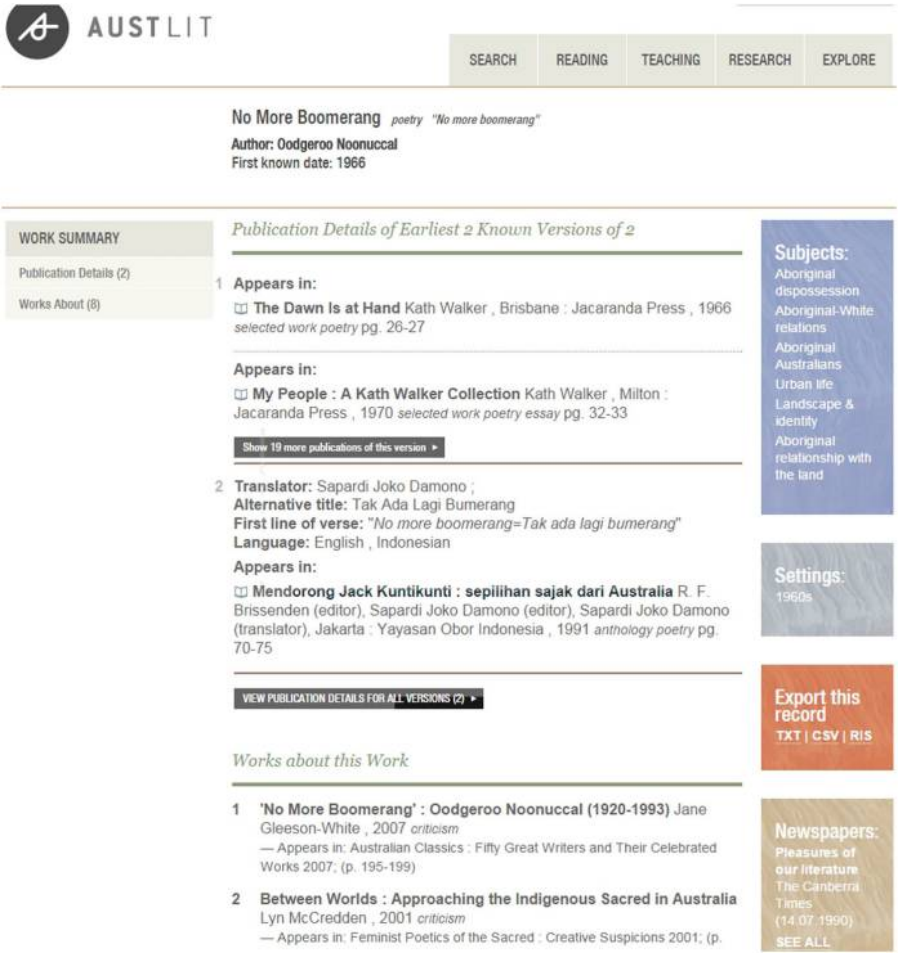


Figure 7.
AustLit work page for a poem that appeares in different publications

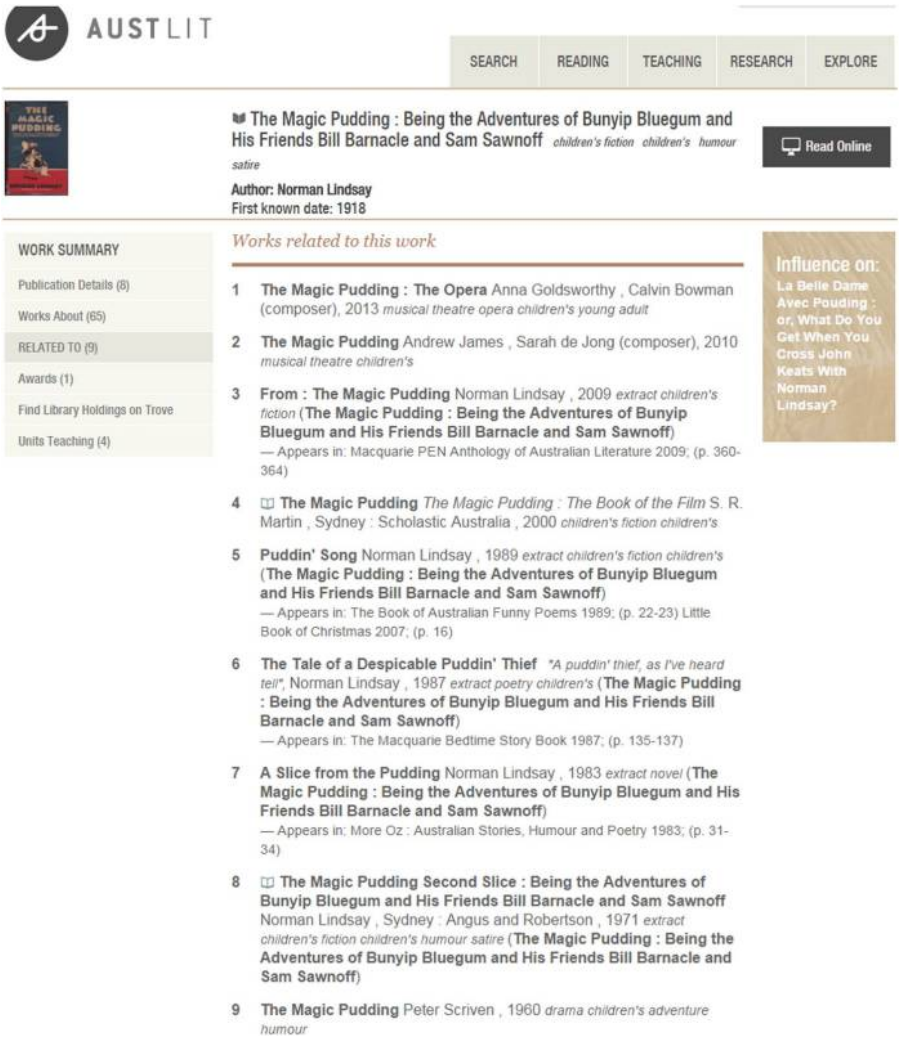


Figure 8.
AustLit work page section listing related works

displays, mostly in form of expression level attributes and contributors that serve as filtering options within faceted navigation. Faceted navigation itself seems to have become a popular option in FRBR-based systems and while there are definite benefits, it would be interesting to test whether users get the same understanding of the work family through facets as they do through hierarchical groupings or some other kind of more explicitly stated relationships. Compared to the first generations of FRBR implementations, there are now also more examples where work and author pages have taken up the central role, presenting not only different editions of a work or author's works, but also some related works and even some general information brought to the page using linked data. The presented relationships such as "related works" are often still very general, requiring users to make judgements based on other data, but it is promising to see that some implementations have already made a distinction between agent's different creative roles (e.g. author, translator, editor, etc.).

Designing for exploration and insight

Exploratory information seeking can be defined as a class of search activities that move beyond fact or known-item retrieval towards fostering learning and investigation (White *et al.*, 2006, 2007). As such, it also represents an important objective for bibliographic information systems that need to fulfil a broad spectrum of user needs. To support the interactive and dynamic exploratory process between the user, the system, and the information sources, experts (e.g. Marchionini, 2006; Kules, 2006; White *et al.*, 2007; Shneiderman, 2008) promote the implementation of two key elements: meaningful organization and navigation on one hand and graphical overviews or visualizations of collections and search results on the other. While FRBR provides the structure needed for better organization and navigation of bibliographic data, information visualization holds interesting potential to not only display this data but also to support interactive browsing, analysis, and understanding of the FRBR-based information space.

Information visualization

With the complex sets of bibliographic entities and relationships that emerge within and among work families, simple lists of records or even work sets used until now are not really able to accommodate all emerging semantic structures. Communicating and presenting data, information, and knowledge through a graphic display, information visualization has therefore a better capacity not only for mapping different structures and categories, but also for supporting perception, understanding and discovery in large data sets (Purchase *et al.*, 2008; André *et al.*, 2009).

With various possible techniques to display data, the challenge, however, lies in first, choosing the one that will be most appropriate for our data and will best serve the aims of our information system and user tasks and second, using the elements of visualization in a way that will create meaning of geometric and structural patterns and convey this meaning to users in a clear, useful, and informative manner (Chen, 2010). Two layout techniques that bare the most potential for presenting bibliographic data seem to be trees and networks. Trees are used to present hierarchical parent-child data structures and can be divided into two main representation schemes: node-link representations and space-filling representations (Plaisant *et al.*, 2002). Node-link representations are most familiar to users and better at showing the depth of the tree, but fail to scale to large data sets (Zhao *et al.*, 2005) and can be quite inefficient in their use of screen space (Plaisant *et al.*, 2002). As a response, space-filling representations have been developed to make more efficient use of the display area and can be characterized by their compactness (Shi *et al.*, 2005). When data relationships exceed the hierarchical structure or cannot be captured using hierarchical structures, a network structure, where items are linked to a number of other items, can be used. Although powerful and flexible to represent complex structures, networks are associated with their own set of problems, such as positioning of nodes, managing links so they convey actual information, handling the scale of graphs with large number of nodes, and interacting with and navigating through large networks of information (Polanco and Zartl, 2002).

In FRBR-based bibliographic data we encounter two types of structures that should be reflected in the presentation of data to users: hierarchical/tree and network. Displaying these structures directly mapped on information visualization would require the use of a network technique which shows the user all relationships among individual entities and supports also horizontal links (e.g. work-to-work). While that would allow users to freely explore and move from one entity to another, such

presentation has its shortcomings: it would not provide quick overviews of the data, reduce the complexity of large data sets or make it easy to compare different resources. The display itself could become too dense with nodes and links to even identify individual entities and would not make use of the valuable hierarchical relationships that present an important segment in FRBR. As the main goal of our research was to create a prototype that would really make use of the structures provided in FRBR-based data and would, at the same time, provide users with an intuitive and simple user interface, a decision was made to proceed using only hierarchical information visualization techniques which have been mentioned as viable options also by other researchers (Carlyle, 1997a; Dickey, 2008; Arastoopoor *et al.*, 2011). Doing so meant losing some of the potential for visually showing horizontal structures within data but has, at the same time, enabled a much better collocation function, not only for grouping manifestations of the same expression or expressions of the same work, but also for employing other relationships and attributes to convey relevant information about entities in the work family.

Interestingly, information visualization has already been applied to user interfaces in the context of FRBR, not for end-users but for cataloguers. Within AustLit, a graphical editor was developed for examining, creating, and editing resource maps where cataloguers can, for example, add entities and create links between them simply by dragging arcs or explore relationships using "explore view" (see Gerber and Hunter, 2010). Another application can be found in RIMMF (Eustis, 2013), a cataloguing training tool developed to help cataloguers and educators transition to the new, FRBR-based cataloguing process. Contrary to the AustLit which was designed to show and create a network of relationships, the RIMMF uses a tree structure to group attributes and relationships under individual entities.

FrbrVis prototype design

Objectives

The objective of the FrbrVis prototype was to create a user interface that would:

(1) bring together different versions and editions of a work;

(2) create relationships within a broader concept of a work family; and

(3) provide the information and the navigational infrastructure for creating a good overview of what is available as well as for distinguishing between individual entities and relationships, thus supporting the find, identify, select as well as explore user tasks.

While the first of the three requirements has already been more or less successfully implemented in most FRBR experiments, the second requirement was only partially employed in a handful of systems due to the lack of supporting bibliographic data, cataloguing rules, and infrastructure. The third task, however, goes beyond data processing and aims at bringing the benefits of FRBR-based data to the end-user by creating a positive user experience that would derive from an intuitive and efficient presentation and navigation of FRBR entities and relationships.

Scope

The final design should work equally well for small and large data sets and should be easy to use also for novice and occasional users. However, the diversity in bibliographic data and user requirements tells us that a single design would not necessarily be useful for all types of

resources (music, fiction, scholarly publications, etc.) or for all purposes. Different end-users might have different requirements and a system designed for a public library would most likely have to fulfil different user needs compared to a system designed for an academic library. The same can be said for different types of resources and for each resource type an independent study would be needed to examine current cataloguing practices, the most important relationships and attributes, user requirements, and possible presentations of the data. That being an immense task, the scope of this study was limited to fiction (which is, next to music, most often talked about in connection to FRBR potential) as it would be used in a typical public library setting.

The prototype was also limited in its functionality, offering only presentation and exploration within four selected work family examples, without the possibility to search or follow links to other works or agents, as the main goals at this early stage of the development was first of all to create a basic implementation that would be tested for user acceptance of the proposed work family presentation and interaction concepts and would serve for identification of the most appropriate design for further development.

Implementation model

Relationships between entities in the FRBR conceptual model create hierarchical as well as network structures. Even in FRBR Group 1, which is most commonly described as a hierarchical data structure, the relationships go well beyond that as one manifestation can include more expressions of the same or different works. Displaying the variety of structures directly mapped to information visualization would require the use of a network technique, but the complex network structure is not best suited to efficiently navigate large data sets or to provide a general overview of what is available. An alternative approach to network is the use of hierarchical display which limits the possibility to map horizontal relationships but gives the opportunity to make large data sets more usable for interactive exploration and retrieval through the use of aggregated categories. In literature (Kules, 2006; Jiang and Koshman, 2008; Marchionini, 2006; Kules and Shneiderman, 2008), a clustering approach is also recommended to create a better user experience, support exploration, and overcome issues associated with large information spaces such as the bibliographic universe. As Smith *et al.* (2006) noted: when data items are aggregated into a small number of categories at each level, the user can rapidly find a single item out of many, just by iteratively choosing from among the categorized choices. Examples of filing rules for card catalogues as well as some later research suggested display schemes based on the work family concept.

To design a prototype that would make the most of FRBR-based data also by providing a user-friendly and intuitive interface, a hierarchical structure was selected over a network. While gaining a much better collocation function, choosing a hierarchical display also meant that some of the potential for visually presenting horizontal structures within data was lost. To (at least partially) overcome this limitation, a separate hierarchical structure was made for each of the three types of relationships within a work family record:

- versions for displaying expressions and manifestations of the work;
- related works to show works related to the work in question; and
- works by/about an author to present the user other works by the author and works about that author.

Data mapping

Mapping FRBR-based data to an implementation model upon which the user interface would be built, FRBR entities were additionally clustered by their attributes and relationship types. Doing so allowed us to retain the FRBR concepts but at the same time utilize the potentials of a hierarchical structure. The same approach has been suggested by Arastoopoor *et al.* (2011) where user testing results indicated that FRBR displays should move beyond the simple transfer of work-expression-manifestation categories and "employ an in-depth hierarchical structure based on specifications of the bibliographic family".

Figure 9 illustrates how the FRBR model was mapped to the visual presentation structure for each of the three displays. For versions of the work, three additional category levels were introduced, based on expression attributes: first the user could choose between languages, within a language between content types and then between different versions (the same scenario has been suggested also by Zhang and Salaba, 2012). To get an overview and to explore various related works, works were collocated first by relationship type and then by form of work. Although the relationships suggested in FRBR-based cataloguing rules are more specific, a combination of more general relationships with the form of work proved more useful for our hierarchically structured interactive display. The same has been done for works about and by the author, where collocation was based on the main work-person relationships and the form of work. In both cases, works belonging to a category were displayed on a separate list and not in the visualization itself, as the first prototype showed that first, in some cases, despite grouping on several levels, there were still too many works to be mapped into visualization and second, in case of related works, the titles are often the same, so a lot of information would be needed in the visualization itself to distinguish between different works.

Prototype development

For the prototype to fulfill all the requirements, the development process was two twofold: on one hand it meant managing bibliographic data and frbrisation of that data to support the required functionality and, on the other hand, it involved designing a user interface that would enable exploration of and interaction with the frbrised data. While each of the two aspects could also present a standalone research, building a prototype demanded an iterative approach that moved between data processing and user interface implementation.

Bibliographic data

To test the suitability and usability of the developed model and prototype design, bibliographic records presenting work families of different sizes and levels of complexity were needed. Four work families were selected (Little Women, Millennium Trilogy, Don Quixote, and Sapramiška), for each of them a number of records were handpicked to ensure a variety in the number and range of entities, relationships, and attributes.

Mercury Z39.50 client was used to download a total of 270 MARC21 records from various catalogues and save them to MARCXML format. To capture the potential and richness of the FRBR conceptual model and to create as complete FRBR-based work family structures as possible in the process of frbrisation, records needed to be manually enriched and corrected as current MARC records do not provide all the

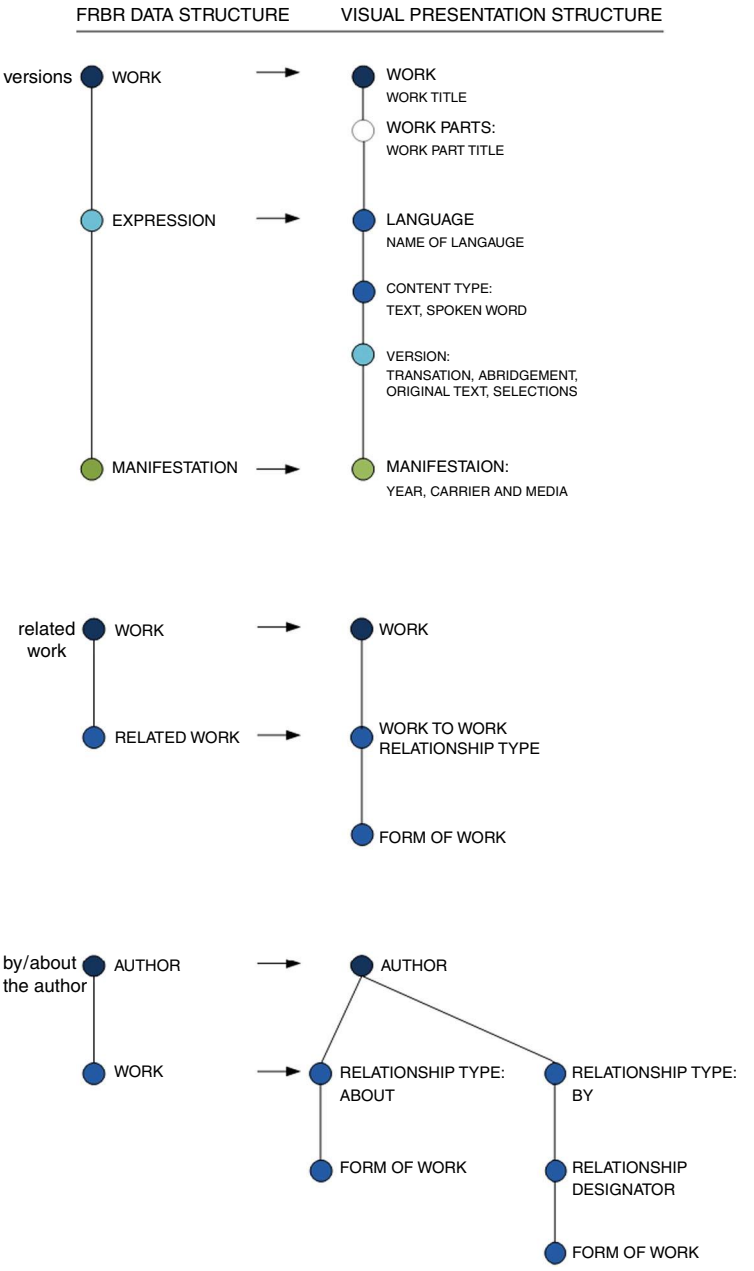


Figure 9.
Mapping FRBR-based bibliographic data to hierarchical structures

needed relationships or consistent identification of entities to achieve that (a more detailed report on frbrisation issues is described in Aalberg *et al.*, 2011). Conversion from MARC to FRBR-based records was made using the FRBR tool (Aalberg, 2006) with rules adapted to the new frbrisation approach. To inspect whether the entities were correctly identified and all relationships established, a graph was generated for

each work family example, mapping all the entities and relationships from the created FRBRXML record. Several iterations were needed before the data and conversion rules enabled successful frbrisation.

Information visualization application

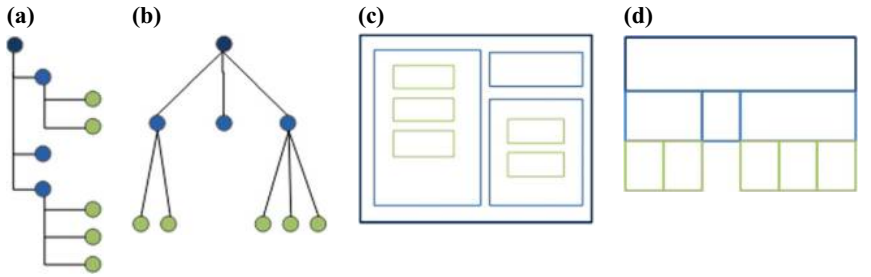
A prototype system FrbrVis was designed to test our implementation model for presenting and interacting with bibliographic data using FRBR and hierarchical information visualization. However, as any single tree visualization technique presents some aspects of data well while obscuring others (Teoh, 2007), four visual designs were created using the same organizational structure and underlying data but different hierarchical layout technique. The four common hierarchical representations identified by Zhao *et al.* (2005) were used to test which hierarchical visualization would prove best for presenting and interacting with the FRBR-based data (Figure 10). For each representation, one of the possible 2D layouts was selected and implemented (see Figure 11).

Visualizations were based on the D3.js library graphical layouts which were then adapted to our data, the desired structures, and envisioned dynamic behaviour. Using layouts provided by the library, there were some limitations in our visual designs as the final implementation depended on possible manipulations as well as on our own ability to make the adjustments and implement the desired interactions and displays. Certain shortcomings also derived from the fact that the same design principles (such as CSS formatting) applied to all four designs.

FrbrVis prototype

In FrbrVis prototype, each work family record includes three displays (different versions of the work, related works, and works by or about the author) that could be switched between using tab navigation. As demonstrated in Figures 12-14, each of the three tabs is divided into two parts: visual navigation on the left and results display on the right.

Using a hierarchical structure and aggregated categories, the visual navigation feature gives an overview of what is available in the collection, enables navigation between entities and the choice of category level that best corresponds to user's information needs. An interactive visualization allows a user to explore the hierarchy by clicking on different nodes; he can, however, also select any category and examine records belonging to that category in the right results display (in the "versions" display,



Notes: (a) Indented outline; (b) node-link graph; (c) nested containment; (d) alignment and adjacency. (a) and (b) belong to a node-link tree representation, while (c) and (d) present space-filling tree representations

Figure 10.
Common hierarchical representations

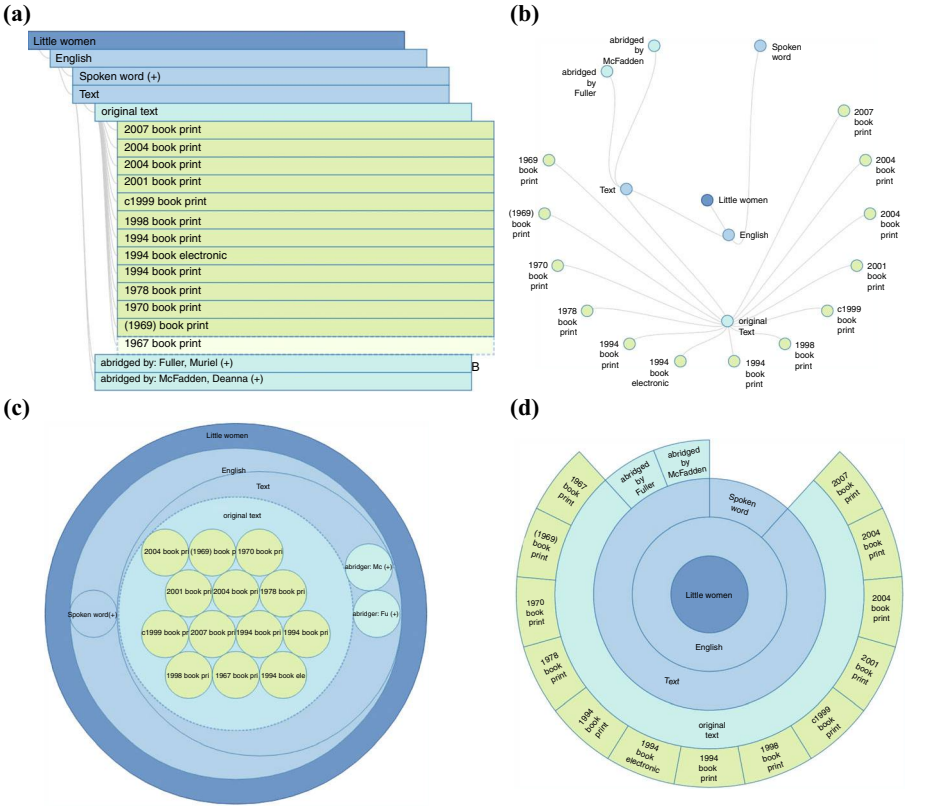


Figure 11.
Data for versions of the work mapped to the four hierarchical layouts selected for implementation

Notes: (a) Indented hierarchical tree; (b) radial tree; (c) circular treemap (Circlepack); (d) Sunburst

the right side lists manifestations, while the "related works" and "works by/about the author" tab show a list of works).

A blue to green colour scheme sequence was used for all four visual designs: main node (work/author) – dark blue, aggregating categories – lighter blue, expression – pale blue, and manifestation – light green.

Examples of interaction

Figure 15 demonstrates an example of the dynamic nature of visual navigation for versions display.

Discussion

The study encompassed three areas of research: bibliographic information systems, bibliographic data, and information visualization. As we have seen in the literature review, the concept of bibliographic families that bring together different versions of a work, its related works and works written by and about the author has been repeatedly suggested by researchers and domain experts as an essential step towards improving library catalogues. FRBR formalised this idea in the late 1990s, but being a theoretical model, it only provided high-level guidelines and not an

Figure 12.
Final FrbrVis prototype design: "versions" display in Sunburst layout

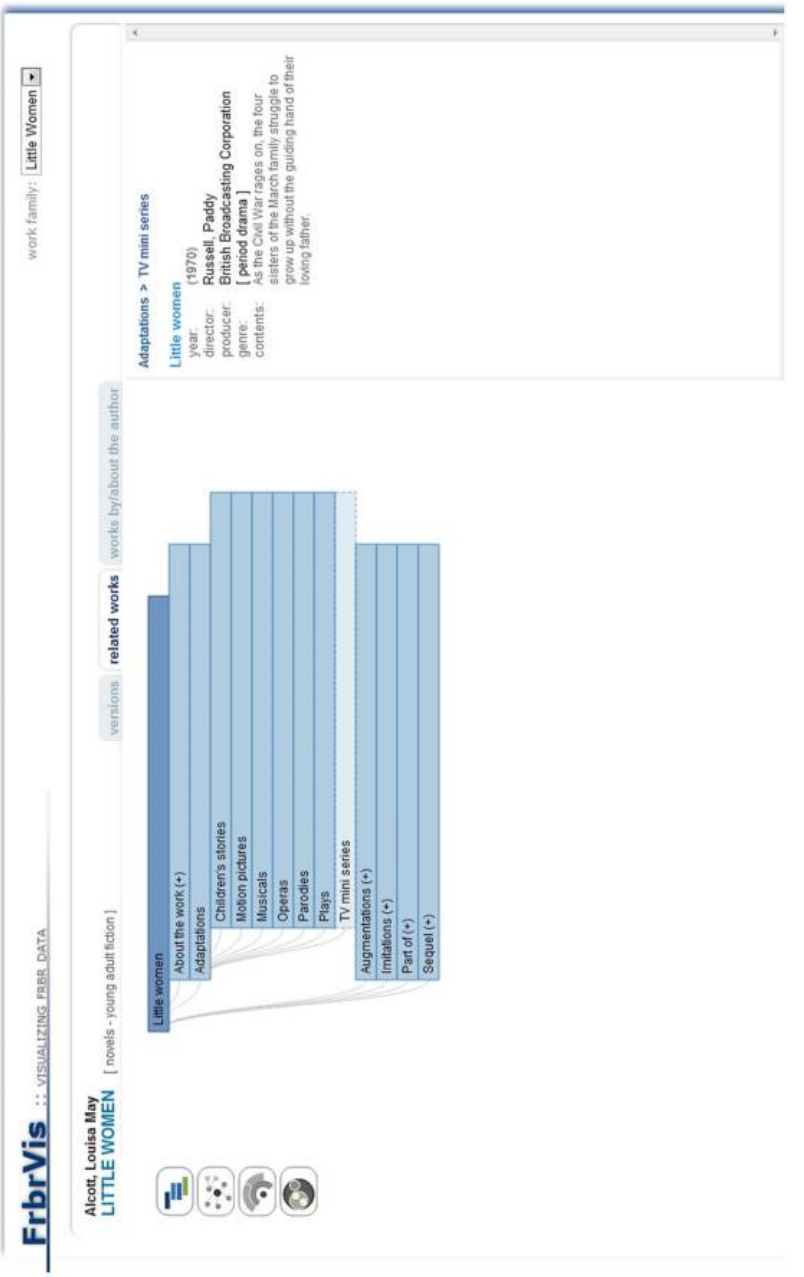
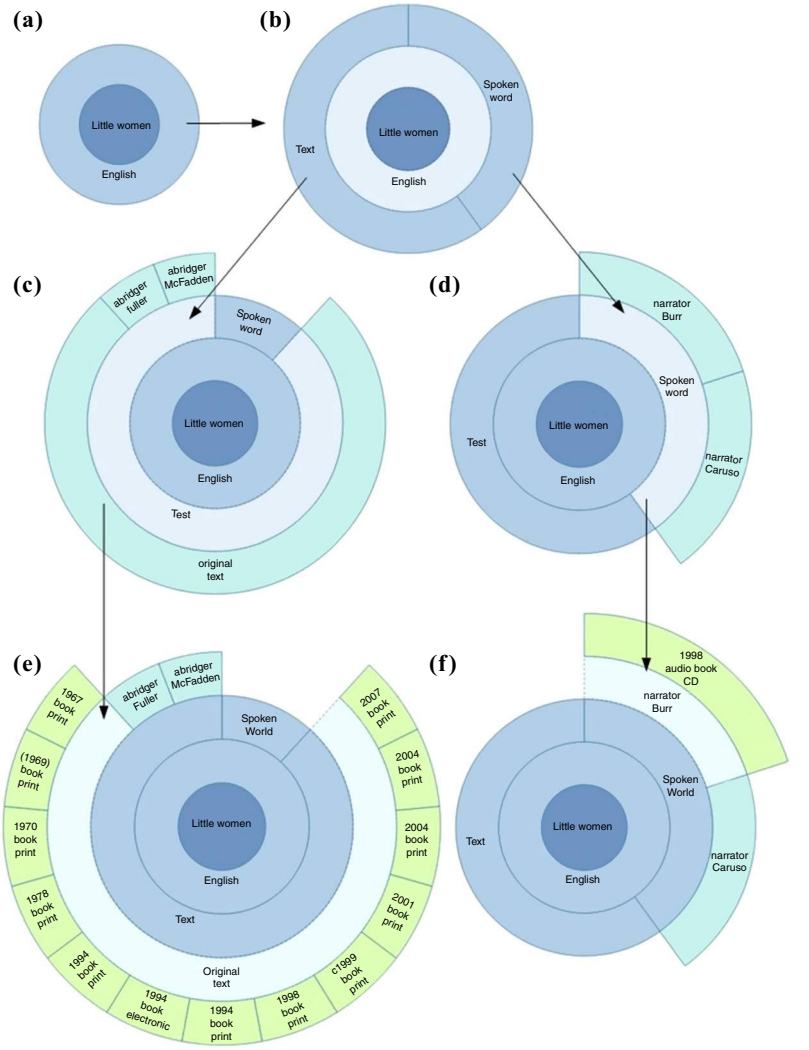


Figure 13.
Final FrbrVis prototype design: "related works" display in Indented tree layout

Figure 14.
Final FrbrVis prototype design: "by/about the author" display in Circular treemap layout



Notes: (a) The default display shows the main node and language level. Since our collection only has English versions of Little Women, there is only one category on this level that the user can choose to explore in more detail; (b) by clicking on the "English" node, two new categories open up, telling the user that items are available in form of text as well as in form of spoken word; (c) deciding for text option, a new level is opened up, giving the user an option of original texts and two different abridgements; (d) if the user decides on the audiobook, clicking on that category would open up two versions with different narrators; (e) choosing the original versions, a list of manifestations arranged by date is presented to the user; (f) visualization shows there is only one available manifestation for the chosen version

Figure 15.
Example of interaction for "versions" display in Sunburst design

instant solution to all the problems, as some have expected. In fact, it presented only the beginning of what has turned out to be a difficult and slow process of transformation. Experiments with implementing FRBR model to current bibliographic data have soon shown that transforming legacy records created over the last two centuries would not be trivial, not only because of the different cataloguing practices that have transpired over the years, errors, and inconsistencies in the data, but also due to the missing or machine uninterpretable information. Examining the characteristics of existing bibliographic records, experimenting with frbrisation of legacy data, further developing the FRBR model, and developing new cataloguing rules have therefore been the main focus of FRBR related research in the past 15 years. For a few years it seemed that the amount of work needed to even consider implementing FRBR-based records in library catalogues is too overwhelming and the slow progress made the initial enthusiasm of the larger community ware of, relinquishing the quest for improving bibliographic data and leaving implementation of FRBR in the hands of a rather small group of experts and supporters. While legacy data still presents a problem that will need to be solved, the new rules have been an important step towards establishing FRBR and defining it as the framework for future developments in the area. The undeniable potential of FRBR for providing the needed changes in our bibliographic records and consequently in bibliographic information systems, the recent confirmation of FRBR as the concept on which future bibliographic data will be built upon, as well as the problems faced by FRBR implementation attempts gave us good motivation for choosing FRBR as the basis for our research.

Most of the experiments so far created work-based clusters collocating manifestations of works (sometimes offering filtering by expression level attributes such as language) without looking at other possibilities in terms of categorization or user interaction. We have seen only a few exceptions that moved beyond the classical work-expression-manifestation display and took advantage of the attributes and relationships. It seems interesting that their approach did not have a quicker impact on other implementation experiments in terms of going beyond work-expression-manifestation representation and providing access and navigation through a broader bibliographic family, but the most recent developments by libraries in Spain, France, and Finland seems to be finally heading in that direction. The lack of work on this area could be attributed to the amount of effort such a project requires on the one hand and to the absence of adequate support within cataloguing rules as well as the MARC format to provide the basic guidelines and structure on the other. This overview of the areas that have not been adequately supported or even discussed in terms of designing FRBR-inspired bibliographic information systems explains the guiding motivation for the second stage of our research.

After analysing and defining the strategy (objectives of the system that would serve user's needs), scope (functional and content requirements), and structure (information architecture and interaction design), the next stage was dedicated to mapping all these features on an interface design. Already in the early stages, when it became obvious that traditional lists of results (even if combined with faceted navigation) are not able to support the rich relationship structure that exists within the bibliographic universe, a decision was made to test information visualization as a possible technique that would provide a better overview of the data and enable interactive exploration of entities and relationships within a bibliographic family. Although the final selection of a hierarchical structure presented a compromise, an implementation of three views

and four different layouts demonstrated the feasibility of such presentation for bibliographic family exploration.

There are, nevertheless, still certain aspects of such displays that evoke a number of questions for future research, for example: does visualization make sense for simple works with only one expression and one manifestation? What is the threshold of complexity where a visual display becomes actually useful? What happens when there are just too many categories and entities to be clearly presented? Should the hierarchy levels be dynamic so that new categories would be created if needed or some levels would disappear if they do not convey any important information? How would it be possible to create simple interfaces that allow users to visually explore not only top-down, but also bottom-up and horizontal relationships between entities? Should users be able to choose the order of categories in the hierarchy so they would not necessarily be obliged to first select language and then content (which would be particularly useful in the case of different resource types, for example music resources)? Would it be possible to combine the visualization with a faceted navigation so that users could immediately filter out the entities or properties they are not interested in? But what is clear is that libraries will need to embrace the upcoming changes and take full advantage of the possibilities they bring as they will otherwise not be able to become part of the future semantic web environment.

Conclusion

In order to carry out a research that encompasses everything from analysis and design to implementation and evaluation (the latter is not presented in this paper), it was necessary to limit the scope of our work in this first development cycle. It was also not the purpose of this study to develop a fully functional system, but only to search for and test approaches that would help in the creation of better bibliographic information systems in the future. Further development and research will no doubt be needed to test the usefulness of the proposed system for all bibliographic families and for real information seeking process. The current scope of the prototype will also need to be broadened by investigating how to transfer this concept to the search results list (so far we have looked only at the presentation of a work family result), by testing the prototype with a larger number of work families, and by looking for more automatic processing solutions that would reduce the amount of manual work needed within the frbrisation process. Besides optimizing our concept for works of fiction, there are also other resource types that will need to be studied in the future in order to determine which categorizations and interaction approaches would be most appropriate based on user needs and the characteristics related to those resources.

Nevertheless, FrbrVis prototype presents one of the first implementations that went beyond the classical work-expression-manifestation display and also exposed relationships within a broader work family context. Although it is not a ready-to-implement model and is limited in scope, it presents a step towards building an idea of how future bibliographic information systems should work and what objectives they should support. FrbrVis also demonstrates how the second objective of the catalogue could be fulfilled and a work family presented within information systems such as library catalogues or national bibliographies using the FRBR model. We hope this visual prototype attempt encourages more research on how to create, present, and implement FRBR-inspired information systems. After all, surfacing the

richness hidden in bibliographic data and developing more functional systems is necessary if libraries wish to create services that will not only bring users back to the library, but also establish library information systems as valuable information resources, ensuring that the rich library collections are better utilized and that the high-quality bibliographic data are used to provide services other information providers do not.

Note

1. FrbrVis prototype can, at this time, be viewed online at: http://dijon.idi.ntnu.no/exist/rest/db/frbrvis/index.html. This is not the exact version that was presented in the paper as the site serves as an active testing system for our research and therefore changes over time.

References

Aalberg, T. (2002), "Navigating in bibliographic catalogues", in Agosti, M. and Thanos, C. (Eds), *Proceedings of the 6th European Conference on Research and Advanced Technology for Digital Libraries ECDL 2002, LNCS*, Vol. 2458, Springer Verlag, Heidelberg, pp. 238-250.

Aalberg, T. (2006), "A process and tool for the conversion of MARC records to a normalized FRBR implementation", in Sugimoto, S., Hunter, J., Rauber, A. and Morishima, A. (Eds), *Proceedings of the 9th International Conference on Asian Digital Libraries: Achievements, Challenges and Opportunities ICADL 2006, LNCS*, Vol. 4312, Springer Verlag, Heidelberg, pp. 283-292.

Aalberg, T. and Žumer, M. (2013), "The value of MARC data, or, challenges of frbrisation", *Journal of Documentation*, Vol. 69 No. 6, pp. 851-872.

Aalberg, T., Merčun, T. and Žumer, M. (2011), "Coding FRBR-Structured Bibliographic Information in MARC", in Xing, C., Crestani, F. and Rauber, A. (Eds), *Proceedings of the 13th International Conference on Asia-Pacific Digital Libraries: for Cultural Heritage, Knowledge Dissemination, and Future Creation ICADL 2011, LNCS*, Vol. 7001, Springer Verlag, Heidelberg, pp. 128-137.

André, P., Schraefel, M.C., Teevan, J. and Dumais, S.T. (2009), "Discovery is never by chance: designing for (un)serendipity", *C&C '09: Proceedings of the Seventh ACM Conference on Creativity and Cognition*, ACM, New York, NY, pp. 305-314.

Arastoopoor, S., Fattahi, R. and Perirokh, M. (2011), "Developing user-centered displays for literary works in digital libraries: integrating bibliographic families, FRBR and users", paper presented at 2nd International Conference of Asian Special Libraries ICoASL, Tokyo, 10-12 February, pp. 83-91.

Ayres, M.L. (2005), "Case studies in implementing functional requirements for bibliographic records [FRBR]: AustLit and MusicAustralia", *The Australian Library Journal*, Vol. 54 No. 1, pp. 43-54.

Babeu, A. (2008), "Building a 'FRBR-inspired' catalog: the Perseus digital library experience", available at: www.perseus.tufts.edu/~ababeu/PerseusFRBRExperiment.pdf (accessed 30 May 2014).

Bates, M.J. (1986), "Subject access in online catalogs: a design model", *Journal of the American Society for Information Systems*, Vol. 37 No. 6, pp. 357-376.

Bates, M.J. (2003), "Task force recommendation 2.3 research and design review: improving user access to library catalog and portal information", final report, Department of Information Studies, University of California, Los Angeles, CA, available at: www.loc.gov/catdir/bibcontrol/2.3BatesReport6-03.doc.pdf (accessed 15 March 2014).

Bennett, R., Lavoie, B. and O'Neill, E.T. (2003), "The concept of a work in WorldCat: an application of FRBR", *Library Collections, Acquisitions & Technical Services*, Vol. 27 No. 1, pp. 45-59.

Bianchini, C. (2010), "FRBR before FRBR = FRBR prima di FRBR", *JLIS.it*, Vol. 1 No. 1, pp. 11-39.

Bianchini, C. and Guerrini, M. (2015), "A turning point for catalogs: Ranganathan's possible point of view", *Cataloging & Classification Quarterly*, Vol. 53 Nos 3-4, pp. 341-351.

Borgman, C.L. (1986), "Why are online catalogs hard to use? Lessons learned from information-retrieval studies", *Journal of the American Society for Information Science*, Vol. 37 No. 6, pp. 387-400.

Borgman, C.L. (1996), "Why are online catalogs still hard to use?", *Journal of the American Society for the Information Science*, Vol. 47 No. 7, pp. 493-503.

Carlyle, A. (1996), "Ordering author and work records: an evaluation of collocation in online catalog displays", *Journal of the American Society for Information Science*, Vol. 47 No. 7, pp. 538-554.

Carlyle, A. (1997a), "Fulfilling the second objective in the online catalog: schemes for organizing author and work records into usable displays", *Library Resources and Technical Services*, Vol. 41 No. 2, pp. 79-100.

Carlyle, A. (1997b), "The role of classification in the creation of author and work displays in online catalogs", *Knowledge Organization for Information Retrieval, Proceedings of the Sixth International Study Conference on Classification Research, International Federation for Information and Documentation, The Hague*, pp. 90-96.

Carlyle, A. (1999), "User categorization of works: toward improved organization of online catalogue displays", *Journal of Documentation*, Vol. 55 No. 2, pp. 184-208.

Carlyle, A. (2006), "Understanding FRBR as a conceptual model", *Library Resources and Technical Services*, Vol. 50 No. 4, pp. 264-273.

Carlyle, A., Ranger, S. and Summerlin, J. (2008), "Making the pieces fit: little women, works, and the pursuit of quality", *Cataloging and Classification Quarterly*, Vol. 46 No. 1, pp. 35-64.

Chandel, A.S. and Prasad, R.V. (2013), "Journey of catalogue from Panizzi's principles to resource description and access", *DESIDOC Journal of Library & Information Technology*, Vol. 33 No. 4, pp. 314-322.

Chen, C. (2010), "Information visualization", *WIREs Comp Stat*, Vol. 2 No. 3, pp. 387-403.

Coyle, K. and Hillmann, D. (2007), "Resource description and access (RDA): cataloging rules for the 20th century", *D-Lib Magazine*, Vol. 13 No. 12, available at: www.dlib.org/dlib/january07/coyle/01coyle.html (accessed 1 January 2015).

Cutter, C.A. (1876), *Rules for a Dictionary Catalog*, Government Printing Office, Washington, DC.

Dickey, T.J. (2008), "Frbrization of a library catalog: better collocation of records, leading to enhanced search, retrieval, and display", *Information Technology and Libraries*, Vol. 27 No. 1, pp. 23-31.

Ercegovac, Z. (2006), "Multiple-version resources in digital libraries: towards user-centered displays", *Journal of the American Society for Information Science and Technology*, Vol. 57 No. 8, pp. 1023-1032.

Eustis, J.M. (2013), "Tech services on the web: the *MARC* of quality's RIMMF: www.marcof quality.com/rimmf/doku.php", *Technical Services Quarterly*, Vol. 30 No. 3, pp. 342-343.

Fattahi, R. (1996), "Super records: an approach toward the description of works appearing in various manifestation", *Library Review*, Vol. 45 No. 4, pp. 19-29.

Fattahi, R. (2010), "From information to knowledge: superworks and the challenges in the organization and representation of the bibliographic universe (Dall'informazione alla conoscenza: le super-opere e le sfide dell'organizzazione e rappresentazione dell'universo bibliografico)", Lectio magistralis in Biblioteconomia, Università degli Studi di Firenze, Casalini Libri, Firenze.

Gerber, A. and Hunter, J. (2010), "Authoring, editing and visualizing compound objects for literary scholarship", *Journal of Digital Information*, Vol. 11 No. 1, pp. 1-13.

Gonzales, L. (2005), "What is FRBR?", *Library Journal*, Vol. 130 No. 7, pp. 12-14.

Hardesty, J.L., Harris, S., Coogan, A. and Notess, M. (2012), "Scherzo usability test report: testing a FRBR search interface for music", Indiana University, Bloomington, available at www.dlib.indiana.edu/projects/vfrbr/projectDoc/usability/usabilityTest/ScherzoUTestReport.pdf (accessed 1 January 2015).

Hegna, K. and Murtomaa, E. (2002), "Data mining MARC to find: FRBR?", project report, available at http://folk.uio.no/knuthe/dok/frbr/datamining.pdf (accessed 20 December 2014).

Hickey, T.B., O'Neill, E.T. and Toves, J. (2002), "Experiments with the IFLA functional requirements for bibliographic records (FRBR)", *D-Lib Magazine*, Vol. 8 No. 9, available at: www.dlib.org/dlib/september02/hickey/09hickey.html (accessed 1 January 2015).

Hildreth, C.R. (1985), "Online public access catalogs", *Annual Review of Information Science and Technology*, Vol. 20 No. 1, pp. 233-285.

Hildreth, C.R. (1989), "Extending the access and reference service capabilities of the online public access catalog", in Smith, L.C. (Ed.), *Questions and Answers: Strategies for Using the Electronic Reference Collection*, Clinic on Library Applications of Data Processing, Graduate School of Library and Information Science, Urbana, IL, pp. 14-33.

Hypén, K. (2014), "Kirjasampo: rethinking metadata", *Cataloging & Classification Quarterly*, Vol. 52 No. 2, pp. 23-39.

IFLA Study Group on the Functional Requirements for Bibliographic Records (1998), *Functional Requirements for Bibliographic Records: Final Report*, Vol 19, UBCIM Publications-NewSeries, K.G. Saur, Munich.

International Conference on Cataloguing Principles (1961/1971), "Statement of principles", International Conference on Cataloguing Principles, Paris.

Jiang, T. and Koshman, S. (2008), "Exploratory search in different information architectures", *Bulletin of the American Society for Information Science and Technology*, Vol. 34 No. 6, pp. 11-13.

Kules, B. and Shneiderman, B. (2008), "Users can change their web search tactics: design guidelines for categorized overviews", *Information Processing and Management*, Vol. 44 No. 1, pp. 463-484.

Kules, W.B. (2006), "Supporting exploratory web search with meaningful and stable categories overviews", dissertation, University of Maryland, College Park, MD, available at: http://hcil2.cs.umd.edu/trs/2006-14/2006-14.pdf (accessed 15 November 2014).

Le Bœuf, P. (2015), "Customized OPACs on the semantic web", in Cervone, H.F. and Svensson, L.G. (Eds), *Linked Data and User Interaction: The Road Ahead*, 162, IFLA Publications, De Gruyter Saur, Berlin, Boston, MA, pp. 31-47.

Lubetzky, S. (1960), *Code of Cataloging Rules: Author and Title Entry*, An unfinished draft, American Library Association, Chicago, IL.

McGrath, K. and Bisko, L. (2008), "Identifying FRBR work-level data in MARC bibliographic records for manifestations of moving images", *The Code4Lib Journal*, Vol. 1 No. 5, available at: http://journal.code4lib.org/articles/775 (accessed 1 January 2015).

Marchionini, G. (2006), "Exploratory search: from finding to understanding", *Communications of the ACM*, Vol. 49 No. 4, pp. 41-46.

Merčun, T., Žumer, M. and Aalberg, T. (2012), "Presenting and exploring the complexity of bibliographic relationships", in Chen, H. and Chowdhury, G. (Eds), *The Outreach of Digital Libraries: A Globalized Resource Network, LNCS*, Vol. 7634, Springer Verlag, Heidelberg, pp. 63-66.

Mimno, D., Crane, G. and Jones, A. (2005), "Hierarchical catalog records", *D-Lib Magazine*, Vol. 11 No. 10, available at: www.dlib.org/dlib/october05/crane/10crane.html (accessed 1 January 2015).

Mönch, C. and Aalberg, T. (2003), "Automatic conversion from MARC to FRBR", in Koch, T. and Sølvberg, I.T. (Eds), *Proceedings of the 7th European Conference on Research and Advanced Technology for Digital Libraries ECDL 2003, LNCS*, Vol. 2769, Springer Verlag, Heidelberg, pp. 405-411.

Novotny, E. (2004), "I don't think I click: a protocol analysis study of use of a library online catalog in the internet age", *College and Research Libraries*, Vol. 65 No. 6, pp. 525-563.

O'Neill, E.T. (2002), "FRBR (Functional requirements for Bibliographic records): application of the entity-relationship model to Humphry Clinker", *Library Resources and Technical*, Vol. 46 No. 4, pp. 150-159.

O'Neill, E.T. (2007), "The impact of research on the development of FRBR", in Tylor, A.G. (Ed.), *Understanding FRBR: What it is and How it will Affect Our Retrieval Tools*, Libraries Unlimited, Westport, CT, pp. 59-72.

Pisanski, J. and Žumer, M. (2007), "Functional requirements for bibliographic records: an investigation of two prototypes", *Program*, Vol. 41 No. 4, pp. 400-417.

Pisanski, J. and Žumer, M. (2010a), "Mental models of the bibliographic universe. Part 1: mental models of descriptions", *Journal of Documentation*, Vol. 66 No. 5, pp. 643-667.

Pisanski, J. and Žumer, M. (2010b), "Mental models of the bibliographic universe. Part 2: comparison task and conclusions", *Journal of Documentation*, Vol. 66 No. 5, pp. 668-680.

Pisanski, J. and Žumer, M. (2012), "User verification of the FRBR conceptual model", *Journal of Documentation*, Vol. 68 No. 4, pp. 582-592.

Plaisant, C., Grosjean, J. and Bederson, B. (2002), "SpaceTree: supporting exploration in large node link tree, design evolution and empirical evaluation", *InfoVis'02: Proceedings of the IEEE Symposium on Information Visualization, IEEE Computer Society, Washington, DC*, pp. 57-64.

Polanco, X. and Zartl, A. (2002), "Information visualization. State of the art, Deliverable 1.4", EICSTSES Project, available at: www.eicstes.org/EICSTES_PDF/Deliverables/Information%20Visualization.pdf (accessed 20 April 2014).

Purchase, H.C., Andrienko, N., Jankun-Kelly, T.J. and Ward, M. (2008), "Theoretical foundations of information visualization", in Kerren, A., Stasko, J.T., Fekete, J. and North, C. (Eds), *Information Visualization: Human-Centered Issues and Perspectives, LNCS*, Vol. 4950, Springer-Verlag, Heidelberg, pp. 46-64.

UC Bibliographic Services Task Force (2005), "Rethinking how we provide bibliographic services for the University of California", final report, The University of California libraries, CA, available at: http://libraries.universityofcalifornia.edu/sopag/BSTF/Final.pdf (accessed 20 December 2014).

Riva, P. (2004), "Mapping MARC21 linking entry fields to FRBR and Tillett's taxonomy of bibliographic relationships", *Library Resources & Technical Services*, Vol. 48 No. 2, pp. 130-143.

Riva, P. (2007), "Introducing the functional requirements for bibliographic records and related IFLA developments", *Bulletin of the American Society for Information Science and Technology*, Vol. 33 No. 6, pp. 7-11.

Rose, M.Z. (2012), "The ship has sailed and we aren't on it: how catalogers could support user tasks and why we won't", *Journal of Library Metadata*, Vol. 12 Nos 2-3, pp. 127-139.

Santos, R., Manchado, A. and Vila-Suero, D. (2015), "Datos. bne. es: a LOD service and a FRBR-modelled access into the library collections", paper presented at IFLA WLIC 2015, Cape Town, 15-21 August, available at: http://library.ifla.org/1085/ (accessed 10 October 2015).

Shi, K., Irani, P. and Li, B. (2005), "An evaluation of content browsing techniques for hierarchical space-filling visualizations", *InfoVis '05: Proceedings of the 2005 IEEE Symposium on Information Visualization, IEEE Computer Society*, *Washington, DC*, pp. 81-88.

Shneiderman, B. (2008), "Research agenda: visual overviews for exploratory search", Information Seeking Support Systems Workshop: an International Workshop Sponsored by the National Science Fundation, available at: www.ils.unc.edu/ISSS/ISSS_final_report.pdf#page=96 (accessed 20 December 2014).

Smiraglia, R.P. (2007), "Bibliographic families and superworks", *Understanding FRBR: What it is and How it Will Affect our Retrieval Tools*, Libraries Unlimited, Westport, CT, pp. 73-86.

Smith, G., Czerwinski, M., Meyers, B., Robbins, D., Robertson, G. and Tan, D.S. (2006), "FacetMap: a scalable search and browse visualization", *IEEE Transactions on Visualization and Computer Graphics*, Vol. 12 No. 5, pp. 797-801.

Svenonius, E. (2007), *The Intellectual Foundation of Information Organization*, MIT Press, Cambridge.

Teixeira, M.T. (2010), "Contributions to FRBRization. The library catalogue in a new digital environment: how FRBR can help produce better displays in OPACs", master thesis, Instituto Universitário de Lisboa, ISCTE, Lisbon.

Teoh, S.T. (2007), "A study on multiple views for tree visualization", *Electronic Imaging 2007, International Society for Optics and Photonics*, pp. 64950B.

Verona, E. (1959), "Literary unit versus bibliographical unit", *Libri*, Vol. 9 No. 2, pp. 79-104.

White, R.W., Kules, B., Drucker, S.M. and Schraefel, M.C. (2006), "Supporting exploratory search", *Communications of the ACM*, Vol. 49 No. 4, pp. 37-39.

White, R.W., Hearst, M., Drucker, S.M., Schraefel, M.C. and Marchionini, G. (2007), "Exploratory search and HCI: designing and evaluating interfaces to support exploratory search interaction", in Begole, B., Payne, S., Churchill, E., Amat, R., Gilmore, D. and Rosson, M.B. (Eds), *CHI '07 Extended Abstracts on Human Factors in Computing Systems*, ACM, New York, NY, pp. 2877-2880.

Yee, M.M. (2005), "FRBRization: a method for turning online public finding lists into online public catalogs", *Information Technology and Libraries*, Vol. 24 No. 3, pp. 77-95.

Yu, H. and Young, M. (2004), "The impact of web search engines on subject searching in OPAC", *Information Technology and Libraries*, Vol. 23 No. 4, pp. 168-180.

Zhang, Y. and Salaba, A. (2009), *Implementing FRBR in Libraries: Key Issues and Future Directions*, Neal-Schuman, New York, NY.

Zhang, Y. and Salaba, A. (2012), "What do users tell us about FRBR-based catalogs?", *Cataloging & Classification Quarterly*, Vol. 50 Nos 5-7, pp. 705-723.

Zhao, S., McGuffin, M.J. and Chignell, M.H. (2005), "Elastic hierarchies: combining treemaps and node-links diagrams", *INFOVIS '05: Proceedings of the Proceedings of the 2005 IEEE Symposium on Information Visualization, IEEE Computer Society*, *Washington, DC*, pp. 57-64.

About the authors

Dr Tanja Merčun is an Assistant Professor of Library and Information Science at the University of Ljubljana (Slovenia). Her main research interests are end-user interfaces, bibliographic information systems, user experience evaluation, and information visualization. She is a Member of IFLA FRBR Review Group and JLIS.it editorial board. Dr Tanja Merčun is the corresponding author and can be contacted at: tanja.mercun@ff.uni-lj.si

Dr Maja Žumer is a Professor of Library and Information Science at the University of Ljubljana (Slovenia). Her research interests include design and evaluation of information retrieval systems, end-user interfaces, usability, and conceptual modelling. She has been involved in IFLA working groups and several EU projects. She was a Member of IFLA FRBR Review Group and Co-chair of FRSAD. She is currently Chair of IFLA Classification and Indexing Standing Committee.

Dr Trond Aalberg is an Associate Professor at the Department of Computer and Information Science, Data and Information Management Group. His main field of research is methods and techniques to make content available, searchable, and accessible in the context of user needs. The focus of current research is semantic description of contents using metadata and ontologies, search services that utilize metadata and ontologies to facilitate explorative search strategies, reuse of metadata in the broader context of the semantic web, crowdsourcing and collaborative creation of metadata and ontologies.