A metadata practice of the IFLA FRBR model
A case study for the National Palace Museum in Taipei

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Abstract *In 1998, the Functional Requirements for Bibliographic Records (FRBR) model which is composed of four entities (work, expression, manifestation and item) and their associative relationships (primary, responsibility and subject), was proposed by the International Federation of Library Associations and Institutions (IFLA). The FRBR model can be deployed as a logical framework for proceeding metadata analysis and developing metadata format. This paper presents a case study of the National Palace Museum (NPM) in Taipei to examine the feasibility of the FRBR model. Based on the examination of case study at the NPM, the FRBR model is proven to be a useful and fundamental framework for metadata analysis and implementation. Findings show that the FRBR model is helpful in identifying proper metadata elements organization and their distribution over the FRBR entities. The model is more suitable for media-centric and association-rich contents. However, in order to refine the FRBR model as a common framework for metadata, it would also require supportive mechanisms for management responsibility relationships for the workflow consideration and refine the distinction between work and expression entity.*

Introduction

Cataloguing has been used traditionally as a means to describe collections in library and museum communities. As the world moves into a new era of digital libraries, metadata analysis, with its inherent dynamic and diverse features, becomes a new technique for dealing with networked resources, which often lack structure. In order to clarify the process of metadata analysis, conceptual models such as the Functional Requirements for Bibliographic Records (FRBR) model developed by the IFLA Study Group on the Functional Requirements for Bibliographic Records (1998) (hereafter IFLA Study Group), which has been applied to descriptive and rights-management metadata, can be used to help develop metadata framework.

The National Palace Museum (NPM) in Taipei has the biggest collection of Chinese artifacts in the world. Most of its collection is inherited from the imperial court of Ch'ing Dynasty. There are over 10,000 pieces of Chinese

painting and calligraphy alone in its collection, which includes many rare Sung (AD 960) and Ming (AD 1368) artworks. Since Chinese painting and calligraphy often appear together and are created by similar means, they are often regarded as sister arts. When combined with poetry and the seal, the work is complete in form and spirit to create one of the enduring features of Chinese painting. Because of this unique feature, Chinese artwork differs greatly from its western counterpart both in content and presentation. On the other hand, two different strands exist at the NPM for metadata requirements. From the researchers' point of view, the description and annotation of intellectual content for artwork are their major efforts, but they are careless of physical medium and avoid to entering metadata for the same artwork across diverse formats. Managers, such as registration, publication departments and information center, are care about the management responsibility for various formats of the same artwork.

In general, the FRBR model is mostly used to develop metadata for traditional and electronic publications in libraries, but is seldom applied to other communities (such as museums) in a broad view. In this paper, we use case study as a research methodology to examine the feasibility of the FRBR model for the metadata framework on Chinese painting and calligraphy at the NPM, and explore what generic benefits can be applied to metadata deployments in museums, as well as enhance the FRBR model to be a common metadata framework in digital library domain.

Practices of the FRBR model

The FRBR model was proposed by IFLA in 1998, and inspired much discussion especially in the digital library domain. Applying this model correctly to digital library systems and services requires much consideration. This section will review the FRBR model and then discuss the application of FRBR model to six selected cases.

The FRBR model

The FRBR model is the research result of the IFLA Study Group on the FRBR using entity-relationship (ER) modeling to build up a conceptual model for bibliographic records. The model was approved by the Standing Committee of the IFLA Section on Cataloguing in 1997. There are four entities in the model, including "work", "expression", "manifestation", and "item". There are also three relationships, namely, primary, responsibility and subject relationships associated with the four entities. WORK and EXPRESSION are defined to reflect intellectual or artistic content; manifestation and item are defined to reflect physical form. In the case of subject relationship, the FRBR model represents a set of entities of which each may serve as the subject of a work and may include concept, object, event, and place.

Day (1998) has conducted a research on the comparison of Dublin core, FRBR model, and common information system in terms of data modeling.

Furthermore, he offered a comparative table of FRBR entity with proposed attributes and Dublin core elements. He also emphasized six types of relations from the FRBR model including created by, embodied in, exemplified by, has a subject, realized by, and realized through relationships.

The FRBR model has been defined by four entities associated with three kinds of relationships (primary, responsibility, and subject relationship), however, the issue of how to implement them as a real IT system is not given. In 1995, Heaney developed three models based on an object-oriented (OO) approach for cataloging, and these models are "text", "publication", and "copy". According to Heaney's conceptual definitions, the text model is strings of sentences, the publication model of reformatting and republication covers attributes of publication, and publication is a particular text object that can be embedded in a publication. As for the copy model, Heaney further explains that every copy has its own characteristics, and it embodies all of the characteristics inherited from the publication model, which in turn embodied those inherited from the text model. In the copy model, Heaney exemplifies that functions such as loan, reservation and sending for binding can be operated in the copy model (Heaney, 1995, pp. 140-2). The FRBR model is more general than Heaney's OO models since the inheritance is not required in the four entities of FRBR model. One may find that the work and expression entities are identical to the text model, manifestation is identical to the publication model, and item is identical to the copy model, if explicit inheritance is required in the FRBR model.

With the understanding of Heaney's approach, one may use the FRBR model as a conceptual framework for developing a metadata system. First, these entities and relationships can be considered as a basic structure for record representation. Second, entities and their metadata elements can be used as a basis for system development in light of database schema, indexing key, record structure, access point, and so forth. Third, the manifestation entity is helpful to record the transfer of intellectual property rights. Fourth, the item entity is useful for operation considerations, such as circulation, collection management, transfer of ownership of physical format, etc.

Selected case studies
It becomes popular to adopt the FRBR model as a foundation framework for proceeding metadata analysis and developing metadata format. Six selected cases are chosen to review the state-of-the-art status of the FRBR model practices in metadata development. Three cases focus on library practices, and the others focus on film and digital intellectual property. These cases are MARC21 in Library of Congress, OCLC's experiment, a case of data mining, the European Chronicles On-line (ECHO) Project in European Union IST Programme, the Interoperability of Data in E-Commerce Systems (INDECS) Project in Info 2000 Programme, and the "digital rights management architectures" which was raised by Iannela at IPR Systems in Australia.

MARC 21 bibliographic and holdings formats. The Network Development and MARC Standards Office is responsible for development of the MARC 21 formats. In order to respond to user requests in a digital era, the FRBR model is selected for analyzing MARC 21 Format for Bibliographic Data and the MARC 21 Format for Holdings Data. According to the analytical report that T. Delsey conducted for the Network Development and MARC Standards Office in 2002, several revisions to the FRBR model are summarized as below (Delsey, 2002, pp. 10-15):

- On a basis of MARC 21 content, Delsey offered additional attributes for work, expression, manifestation, and item entities.
- In this report, Delsey suggested that eight entities related to work should be added into the FRBR model, and they are task, project, program, work unit, contract, grant, program, and curriculum.
- Next, three entities related to item are also suggested in the following: action, authority, and position.
- Furthermore, Delsey also created a "record metadata" entity, which includes attributes and relationships associated with record, segment, field, and data element.

OCLC's experiment. In the late of 2001, OCLC (Hickey *et al.*, 2002) initiated a series of experiments on the FRBR model, in order to explore the implications of the FRBR model and practical difficulties in system implementation. OCLC selected 1,000 bibliographic records from WorldCat database as an examination on the FRBR model; several focal points deserve recognition:

- The FRBR model, which is full of relationships between entities, is useful for de-duplication task of bibliographic records.
- One may also find that the system prototype that OCLC designed for this experiment is clearly clarified as a real example of how to achieve "finding, identity, obtain, and access" functions.
- On the other hand, this report also shows that cost is very high for cataloguing tasks based on the FRBR model.

Data mining. In Europe, librarians are also dedicated to applying the FRBR model to bibliographic systems and cataloguing codes, and several papers have discussed this issue in ELAG Annual Meeting since 2000. One of the most interesting papers was presented by Murtomaa. Although the focus of Murtomaa's work was the extraction of FRBR information from existing MARC records, Murtomaa also employed the FRBR model as a basis to analyze the relationships of bibliographic records based on MARC records in the Finnish and Norwegian national bibliographies, and BIBSYS. In terms of data mining, Murtomaa (2002) offered two suggestions to cataloguing as follows:

· The meaning of the authority data and of the language codes should be stressed. With help of authority files we can give our customers the possibility to navigate in the bibliographic universe. With help of language codes we can identify the manifestation as translation.

· The role of the functions became more and more important. The function statement in the main or added entry field would be very helpful. The search systems and the design of hit lists could make good use of the function statements. In addition our users could benefit from the function statement in their bibliographical navigation. The functions should not be optional.

The ECHO Project. The ECHO Project aims at developing a long-term reusable software infrastructure and new metadata models for films in order to support the development of interoperable audiovisual digital libraries. The project is funded by the European Community within the Fifth Framework Program which was launched in 2000 and its completion is expected by 2002 (Savino, 2000). Because the present definition of metadata elements does not describe film information well, the ECHO Metadata Model has been developed, therefore, to better describe film information and to automate the metadata analysis.

The ECHO metadata modelling report, generated in 2000, was composed of two key parts: ECHO metadata model and ECHO metadata fields. Four entities of the FRBR model in the ECHO Project are interpreted into work ↔ av-document, expression ↔ version: video/audio/transcript, manifestation ↔ media, and item ↔ storage (Amato *et al.*, 2000, p. 15). The report explains some points, such as:

· ECHO metadata model is built on the FRBR model with the corresponding av-document, version, media, and storage entities to support digital films archives.

· The construction of ECHO metadata fields are based on the media-centric approach for audiovisual resources metadata both in traditional and digital format.

The INDECS Project. The INDECS Project was established at the end of 1998 with support from the European Commission, which stands for Interoperability of Data in E-Commerce Systems. It is recognized from the outset that metadata would be generated in diverse ways and by diverse players in the value chain (Framework Ltd., 2000). The initial goal of the INDECS Project focuses on intellectual property rights and the Project uses the FRBR model as a logical foundation and framework for metadata development and implementation. Some revisions are proposed, subsequently, to achieve the INDECS Project's requirements as below (Bearman *et al.*, 1999):

- Instead of a clear division of manifestation and item, the INDECS Project integrates these two entities into one in order to meet the requirements of intellectual property rights.
- The INDECS Project also emphasizes the equal importance of information resource, agents and actions, time, and place in order to formulate the INDECS model.

Digital rights management (DRM) architectures. According to results of the INDECS Project, Iannella extends "DRM architecture" into two components: functional architecture and information architecture. In light of the information architecture, the FRBR model is used as a framework to define the content and expression models as well as their statements in order (Iannella, 2001):

- The IFLA FRBR model allows content to be identified at the work, expression, manifestation, and item layers. In each of these layers, different rights and rights holders may need to be supported.
- Another aspect that may affect rights is when content is made of many parts. Some of these parts may have different rights associated with them that need to be recognized in the aggregated content.

One may draw a few conclusions based on the above studies:

(1) The usage pattern of the FRBR model can be generalized into four types. The first one is to adopt a metadata standard to examine the FRBR model and offer feedback advices, such as MARC 21 case. Second, the FRBR model is used to develop system in order to examine the feasibility, such as OCLC's experiment. Third, the FRBR model is employed as a data-mining framework to analyze the relationship of bibliographic records for advising cataloguing, such as a case conducted by Murtomaa. Finally, the FRBR model is deployed as a base to design a metadata standard for specific purpose, such as audiovisual digital materials and intellectual property rights, and case includes the ECHO Project, the INDECS Project and the DRM architecture offered by Iannella.

(2) However, it is useful to adopt the FRBR model as a basic model of metadata framework for different purposes and clarify relationship among diverse entities, such as person, event, time, space, and thing attributes.

(3) The focus of the FRBR model is on still functionality of material (i.e. thing) for bibliographic records. Gill (2000) in the Research Libraries Group also finds the similar result. It uses an integrated approach of surrogate-based and ER modeling to define relationships associated with entities to re-examine and enrich functions of library catalog. Then, other typical attributes such as person, event, time-span, and place name become supportive entities; therefore, they are not parallel to thing attribute in this model.

A case study and result: Chinese painting and calligraphy at the NPM

The NPM in Taipei owns a lot of Chinese paintings and calligraphies from the Ancient China Emperors. Before 1999, the NPM had developed a system for managing these collections. Since 1999, the NPM devoted effort toward the Digital Museum Project in Taiwan and adopted a DC-based standard as a metadata format for Chinese collections, namely Metadata Interchange for Chinese Information (MICI). With the initiated preparation of the National Digital Archives Program in Taiwan in 2002, the Metadata Architecture and Application Team (MAAT) at the Computing Centre of Academia Sinica was invited to design metadata for two projects at the NPM. One is for "Chinese painting and calligraphy", and the other is "Chinese antiques". These artworks are owned and researched by the NPM, and however focus of metadata requirements for this project should be emphasized on researching and management simultaneously. More importantly, the workflow of content management system (CMS) for the same object accessed by various departments is also highlighted. The practice of FRBR model on Chinese painting and calligraphy will be selected as a case study to examine what beneficial deployments of this model can be generally used for metadata applications in digital library, such as museums. This case study includes examinations of entities and primary relationships, entities and responsibility relationships, and entities and subject relationships that have been defined in the FRBR model.

Entities and primary relationships

The FRBR model is composed of four layers (work, expression, manifestation, and item) in order to represent the different aspects of user interests in the products of intellectual or artistic endeavour (IFLA Study Group, 1998, p. 12). First, we adopt the FRBR as a framework to illustrate the relationship between various objects for different layers. Based on the FRBR model, two types of objects at the NPM are required to draw a clear line: original artwork, and counterpart duplication of slides, photos, and digital images. Up to date, the CDWA, developed by the J. Paul Getty Trust and the College Art Association, is selected as a metadata format for this project. Next, metadata elements of CDWA are allocated into layers (as shown in Figure 1). Entirely, patterns of primary relationship are proven to attain the same results for the FRBR model by the IFLA Study Group: is realized through, is embodied in, and is exemplified by.

Besides relationships between diverse formats of an artwork, a seamless relation also exists among artworks. Therefore, a single object identity in the FRBR model is expanded into multiple identities in order to delineate the rich relationship between related objects. This clear delineation of relationship is useful as a reference to a metadata record's separation and object linkages. In
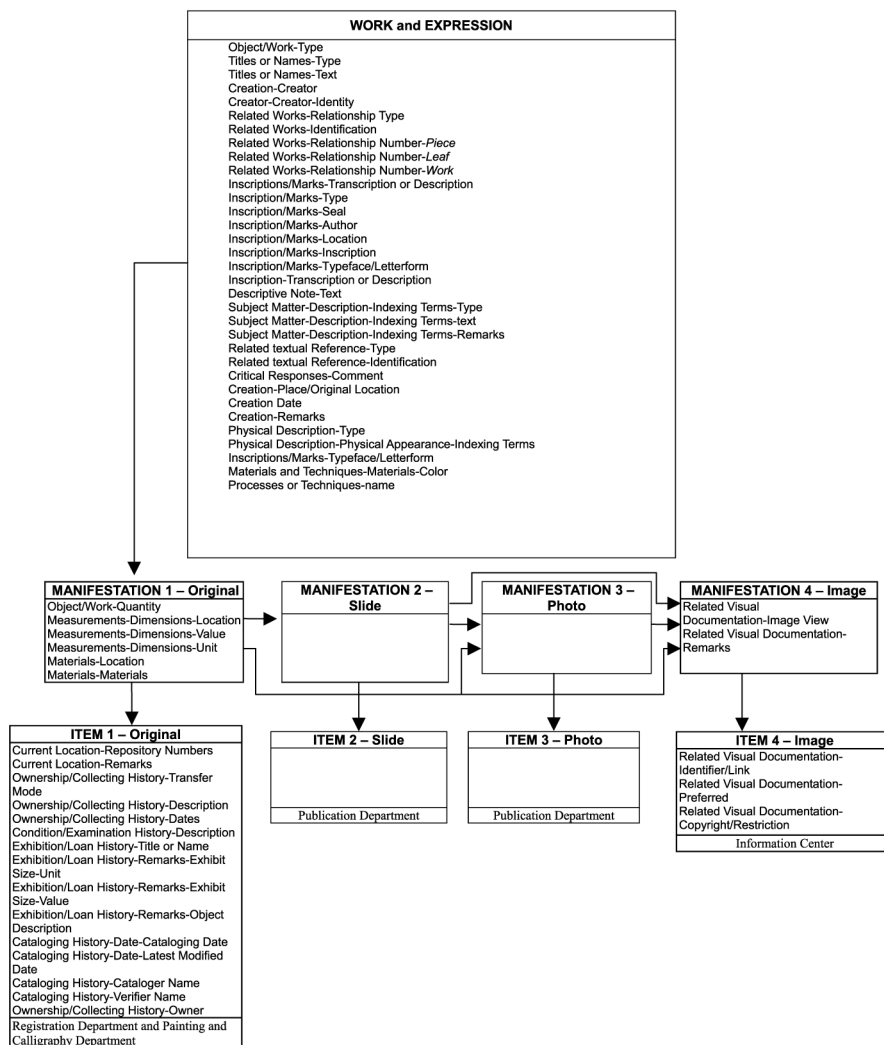
WORK and EXPRESSION

Object/Work-Type
Titles or Names-Type
Titles or Names-Text
Creation-Creator
Creator-Creator-Identity
Related Works-Relationship Type
Related Works-Identification
Related Works-Relationship Number-*Piece*
Related Works-Relationship Number-*Leaf*
Related Works-Relationship Number-*Work*
Inscriptions/Marks-Transcription or Description
Inscription/Marks-Type
Inscription/Marks-Seal
Inscription/Marks-Author
Inscription/Marks-Location
Inscription/Marks-Inscription
Inscription/Marks-Typeface/Letterform
Inscription-Transcription or Description
Descriptive Note-Text
Subject Matter-Description-Indexing Terms-Type
Subject Matter-Description-Indexing Terms-text
Subject Matter-Description-Indexing Terms-Remarks
Related textual Reference-Type
Related textual Reference-Identification
Critical Responses-Comment
Creation-Place/Original Location
Creation Date
Creation-Remarks
Physical Description-Type
Physical Description-Physical Appearance-Indexing Terms
Inscriptions/Marks-Typeface/Letterform
Materials and Techniques-Materials-Color
Processes or Techniques-name

MANIFESTATION 1 – Original
Object/Work-Quantity
Measurements-Dimensions-Location
Measurements-Dimensions-Value
Measurements-Dimensions-Unit
Materials-Location
Materials-Materials

MANIFESTATION 2 – Slide

MANIFESTATION 3 – Photo

MANIFESTATION 4 – Image
Related Visual Documentation-Image View
Related Visual Documentation-Remarks

ITEM 1 – Original
Current Location-Repository Numbers
Current Location-Remarks
Ownership/Collecting History-Transfer Mode
Ownership/Collecting History-Description
Ownership/Collecting History-Dates
Condition/Examination History-Description
Exhibition/Loan History-Title or Name
Exhibition/Loan History-Remarks-Exhibit Size-Unit
Exhibition/Loan History-Remarks-Exhibit Size-Value
Exhibition/Loan History-Remarks-Object Description
Cataloging History-Date-Cataloging Date
Cataloging History-Date-Latest Modified Date
Cataloging History-Cataloger Name
Cataloging History-Verifier Name
Ownership/Collecting History-Owner

Registration Department and Painting and Calligraphy Department

ITEM 2 – Slide

Publication Department

ITEM 3 – Photo

Publication Department

ITEM 4 – Image
Related Visual Documentation-Identifier/Link
Related Visual Documentation-Preferred
Related Visual Documentation-Copyright/Restriction

Information Center

Figure 1.
A FRBR-based metadata
format (CDWA) for the
NPM

light of the IFLA results, relationship between entities can be generalized into two types: vertical and horizontal. The vertical relationship is used to describe the relation between different entities at various levels, namely, "work to expression to manifestation to item". On the other hand, the horizontal one is deployed to indicate the relation for same identity at the same layer, that is, "work-to-work", "expression-to-expression", "manifestation-to-manifestation", and "item-to-item". According to verification of Chinese painting and calligraphy at the NPM, one interesting finding is that all relationships both of horizontal and vertical are partially employed at different entities as follows:

(1) *Horizontal relationship*:
  - Work: successor (i.e. related series), supplement (i.e. appendix), and whole/part (i.e. series).
  - Expression: successor, supplement, and whole/part.
  - Manifestation: whole/part and reproduction (i.e. image).
  - Item: reconfiguration, reproduction, and whole/part.

(2) *Vertical relationship*: summarization (expression-to-work) and reproduction (manifestation-to-item).

Entities and responsibility relationships

The responsibility relationships in the FRBR model are depicted by the relationship between two groups of entities: "work, expression, manifestation, and item", and "person and corporate body". Actually, the responsibility aims to clarify the role's function to work, expression, manifestation, and item. Therefore, four types of responsibility are defined by the IFLA Study Group in order: is created by, is realized by, is produced by, and is owned by. In the NPM case, more than three responsibility relationships are deployed, but one is not revealed so obviously: is produced by. Therefore, the "is produced by" relationship is treated as the default value for duplicate counterparts at the NPM. Although the "is realized by" relationship exists in the NPM case, there is no corresponsive metadata element, and is thus merged into "is created by". Consequently, only three metadata elements for responsibility relationship are needed: creator (both for is created by, and is realized by), owner (is owned by), and producer (is produced by).

Entities and subject relationships

In the FRBR model, the IFLA has defined a work with "has as subject" relationship between work, expression, manifestation, item, person, corporate body, concept, object, event and place, in order to indicate the subject attribute among various entities. In the NPM case, several distinctive compromises are made to reflect the project requirements in accordance to the IFLA's suggestions (IFLA Study Group, 1998, pp. 4-5), and are listed as follows (as shown in Figure 2):

  - The concept, person and place subject relationships are separated into three independent authority files: concept, person and place names. As for the place names, geo-spatial information system is integrated to achieve the function for geo-spatial representation.
  - Time is not included in the FRBR model, but there is a strong request for temporal metadata elements and authority file in arts. Therefore, a temporal metadata authority file for Chinese arts is under development in response to this requirement.
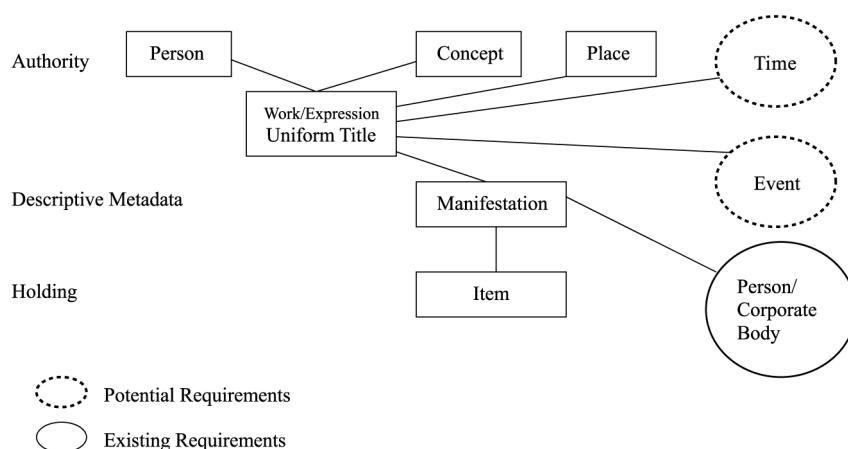
Figure 2.
FRBR applications for
the NPM

Findings

Based on our analysis of the NPM case study, we have produced several findings regarding the feasibility of the FRBR model in projects similar to the NPM projects. Our findings indicate that the FRBR model is very useful for such projects as a conceptual model to clarify metadata elements and their relationships. These findings concern both metadata analysis and system implementation.

Adoption of the FRBR model as the primary conceptual model

Our case is somewhat different from the MARC21 study in that we adopt the FRBR model to support use of CDWA metadata elements rather than to examine the CDWA standard. Based on our analysis of the relationships between groups of entities, as shown in Figure 1, we find that applying the FRBR model to our case (the NPM) results in a distribution of metadata elements that focuses on intellectual content. This distribution shows that work and expression are two focal entities of the metadata requirements and proves to be especially suited for projects dealing with the research of Chinese painting and calligraphy, because the emphasis on work and expression in the distribution mirrors a similar emphasis in the research itself. If, on the other hand, metadata elements lacked such an emphasis on the work and expression entities, the model would not be as suitable as it is in our case, and additional metadata requirements would be needed to re-analyze and re-organize metadata elements. Thus, we find that the FRBR model is very useful, in our case, as a foundation for analysis and needs identification of metadata elements.

We also find that an important relationship defined in the FRBR model – reproduction for manifestation-to-manifestation – is well represented using the FRBR model. In at least one project at the NPM, several metadata elements such as image type, image description, and resolution (as shown in Figure 1)

are lost during transfers from one manifestation to another. During a transformation of manifestation, those elements that stemmed from slide, photo, and digital images are combined into a single manifestation entity, rather than multiple entities, for each original artwork. This integration of information into a single entity, especially with respect to the digitization of various types of data, provides great assistance in clarifying the diversity of both metadata elements and associative relationships resulting from a transformation of manifestation. Thus, we find the FRBR model to be a very useful tool toward meeting this end.

Functionality of metadata elements for workflow
The basic functionality defined in the FRBR model comprises four functions: find, identify, select, and obtain. These functions are theoretically defined with a variety of instructive exemplars based on bibliographic record unit (IFLA Study Group, 1998, pp. 100-11). Furthermore, these instructive exemplars, which include explanations, are also useful to clarify the function of each metadata element. The four functions are considered basic functions for system implementation and for users.

Regarding practice for metadata analysis and system implementation, the FRBR model is beneficial for analyzing the metadata elements and their relationships at four entities. From an examination of the NPM case study, we also find that the management responsibility relationships for workflow between entities are insufficient for system implementation. An original artwork at the NPM has three types of duplicate counterparts: slide, photo, and digital image. Each collection of duplicate counterparts is managed and owned by different departments. A clear, sequential flow for these duplicate counterparts and departments is needed to refine context for relationships in the FRBR model.

At the NPM, an original artwork might undergo various transactions. Upon acquisition, each original artwork must be registered at the registration department before it can be available for use. once registered, an artwork can be checked out for various purposes ranging from research, annotation, photo creation, slide creation, digitization, and exhibition. The artwork can be checked out by various departments including the painting and calligraphy department, the publication department, the information centre, and the education and exhibition department. These various transactions require different types of metadata to accurately record and describe the status of the transactions. For the most part, the FRBR model provides an adequate framework for such metadata. However, in order to achieve reuse of metadata at the manifestation and item entities for both original and duplicate artworks, we employ the concept of a content management system (CMS) to develop a workflow model for metadata for the NPM. This workflow is composed of three major components: collection,

management, and publication (see Figure 3). The first component, collection, consists of metadata requirements governing acquisition and registration of artworks, so that various transactions involving original artworks, including assessment and transfer of custody, can be well described. The second component, management, consists of metadata requirements governing inventory-related transactions such as check-out, check-in, examination, and so forth. Also covered in the second component are metadata requirements governing long-term preservation of original artwork and equivalent digital materials. The third component, publication, consists of metadata requirements governing access control and usage restrictions, which are needed to regulate the delivery of publications and digital materials to the public. An example of this is the annotation of artworks for the public exhibition. In addition to these basic components, which primarily include metadata elements at the item entity, the CMS also incorporates a set of rights, which includes metadata elements at the manifestation entity. These rights pertain to the relations between original artworks and their duplicate counterparts such as photos, slides, and digital images; the set of rights also covers the description of copyright details for duplication of artworks. Furthermore, the set of rights includes metadata elements at the item entity that will help facilitate e-commerce activities. In total, the CMS incorporates eight functional metadata sets as a workflow model for metadata, and these sets are acquisition, registration,
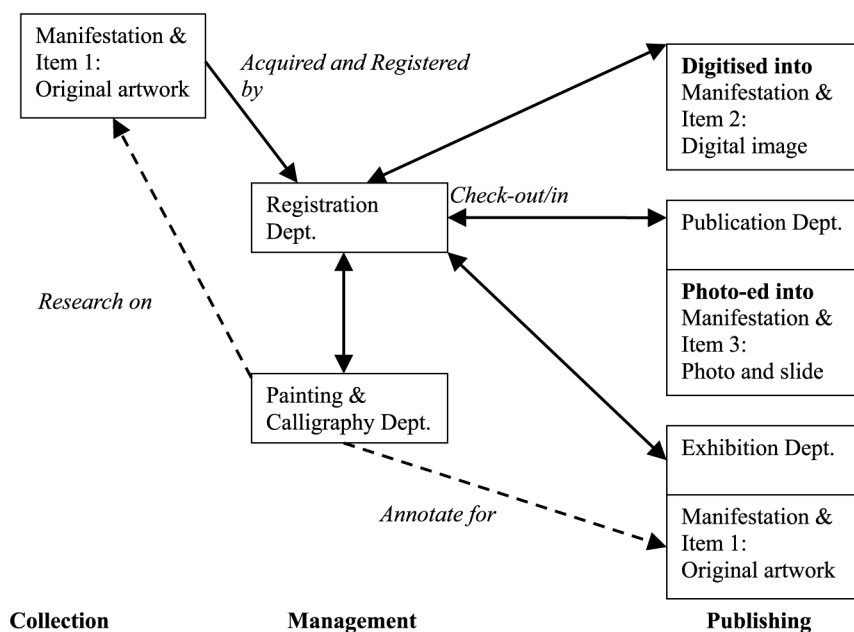

Figure 3.
A workflow of functionality metadata sets for the NPM

inventory, preservation, rights, access control, usage restrictions, and exhibition. Consequently, one may find that the resulting functional metadata sets reflect another strand of element requirements, namely that for management at the NPM.

A media-centric and association-rich approach

The original aim of the FRBR model is to develop a logical framework for bibliographic records; nevertheless, such bibliographic records are designed to cover a variety of materials including textual, music, cartographic, audio-visual, graphic, and three-dimensional materials. They can cover the full range of physical media (paper, film, magnetic tape, optical storage media, etc.) described in a bibliographic record, can cover all formats (books, sheets, discs, cassettes, cartridges, etc.), and can reflect all modes of recording information (analogue, acoustic, electric, digital, optical, etc.) (IFLA Study Group, 1998, pp. 7-8). The FRBR model adopts a "surrogate or aboutness" approach that Burnet *et al.* proposed to analyze a range of entities and relationships for bibliographic records (Burnett *et al.*, 1999, pp. 1209-13). Its purpose is to re-examine the appropriateness of the cataloguing theory and practice. The model could be extended to cover the additional information that is normally recorded in authority records (IFLA Study Group, 1998, pp. 7-8).

Although the FRBR model brings the new concept of entities and their relationships, it is still, essentially, a media-centric and association-rich approach. After considering the NPM case study, one may also find that the FRBR model could extend its focus into person, time, space, concept and event, as well as their relationships at the same level. In effect, inheritance is an unspecified characteristic in the FRBR model, so a reciprocal connection of metadata elements between entities would be achieved seamlessly if ad-hoc inheritance were introduced. It could be convenient and cost-effective for end users in terms of data creation and record representation since metadata elements needn't be repeated, thanks to the feature of inheritance. Otherwise, it may become a challenging task for system architecture, indexing, linkage, and so on.

A minor problem during the analysis process arises when distinguishing between the work and expression entities for artworks. Specifically, while it is easy for publications to ensure the distinction between the work and expression entities, this distinction is not possible in some cases that we have encountered. This is because the work and expression entities are considered a single entity for some cases, particularly for artworks. Hence, we will find lots of metadata elements in the NPM case that are lumped together into one work and expression entity, as shown in Figure 1. These elements include collector's seal, transcription, inscription, color, techniques, and so forth.

Related issues

Besides the findings detailed above, the NPM case study brings up two issues that deserve exploring, though they are not covered in the FRBR model. These issues will fundamentally impact any digital project, especially with regard to metadata.

A tension between a generic and a comprehensive approach to metadata formats

At the present, a principle adopted by the NPM case is to employ the DC and another one domain-specific standard (i.e. CDWA) at the same time for the purpose of standardization and crosswalk. In essence, the DC elements set is very simple and popularly accepted; furthermore, it is also a highly conceptual metadata set which serves as a common crosswalk ground for mapping and federated meta-search across a diversity of disciplinary domains. On the other hand, one may also find that the DC is too ambiguous for most of research-oriented digital library projects. However, a principle of simultaneously adopting both the DC and another specific comprehensive metadata standard is deployed. This principle of adopting parallel standards at the same time can bring two obvious benefits in order:

(1) a common interface with a federated meta-search engine across various metadata standards and systems can be developed for a wider range of digital projects; and

(2) a precise crosswalk between different metadata formats, including MICI, can also be achieved.

Information granularity

How to distinguish and construct a bibliographic record unit is an ordinary issue for any cataloguing professional. Each library always defines its own best practice and principles to solve this issue and attain quality consistency, but neither a generic principle nor best practice is suitable for all libraries around the world. Although four entities are clearly defined based on an ER modeling approach, how to distinguish from various works remains a problem and is without any substantial suggestions or practices in the FRBR model. In the NPM case study, the same issue also becomes a problematic issue for metadata design. Two practical cases are often raised: one is that several painting artworks can be put at the same piece; the other is that a painting artwork may appear at more than two pieces. To date two types are categorized for Chinese painting and calligraphy at the NPM: one is oriented to physical object, and another is focused on content-based theme. In terms of metadata record and system, the state-of-the-art principle of content-based theme approach to "information granularity" in the NPM case is adopted. Further, one relationship linkage both for content-based theme and physical object is also constructed to represent the diverse associations. However, a common principle regarding a unit of information granularity still deserves

exploring with a broad range of case studies and practices; this issue will heavily impact metadata interoperability matters including mapping and searching.

Conclusion

In terms of the NPM case study, one may find that the FRBR model is useful as a fundamental framework for metadata analysis and implementation. The FRBR model is proven to be suitable for both media-centric and association-rich contents. However, this model requires other supportive mechanisms, such as management responsibility relationships and related functional metadata element sets for workflow consideration, to refine the FRBR model as a common framework for metadata. Furthermore, how to use other theoretical models (such as ICOM/CIDOC conceptual model) to refine the distinction between work and expression entities for artworks clearly will also impact the FRBR model to become a logically common framework for other communities, such as museums. At the same time, the principle of adopting parallel metadata standards is beneficial to solve a tension between a generic and a comprehensive approach to metadata formats; it also acts as a grounded mechanism for a precise crosswalk and as a cross-domain across a variety of metadata formats. Eventually, the issue of information granularity will deserve finding an appropriate and workable generic principle.

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