Metadata Development for Palm Leaf Manuscripts in Thailand

Lampang Manmart
Khon Kaen University,
Thailand
lamman@kku.ac.th

Nisachol Chamnongsri
Suranaree University of
Technology, Thailand
nisachol@sut.ac.th

Vilas Wuwongse
Asian Institute of
Technology, Thailand
vilasw@ait.ac.th

Shigeo Sugimoto
University of Tsukuba,
Japan
sugimoto@slis.tsukuba.ac.jp

Abstract

The main objective of this research is, to develop metadata scheme for the management of digitized PLMs to increase efficiency in the search, access, management and use. The research framework was based on Functional Requirements for Bibliographic Records (FRBR) model developed by International Federation of Library Associations and Institutions (IFLA), while the metadata development process was developed on the concept of Metadata Life Cycle Model (MLM). Thus, there were three main parts in this study: (1) analysis of the user needs and expectations with respect to the manuscripts, of the requirements for managing collections of palm leaf manuscripts, and of physical structure and content of palm leaf manuscripts; (2) development of a metadata schema based on the results of these analyses; and (3) implementation and evaluation of the final metadata schema. The prototype of PLM management system was developed to implement the PLMM to test and evaluate the usefulness of PLMM for access to PLM original copies and their content and for managing PLM digital collection. The finding suggests that the perception of the PLMM usefulness is relatively significant with users' experience with the PLM. Finally, the PLM metadata schema (PLMM) was developed for palm leaf manuscripts consisted of 76 properties (34 core elements and 42 element refinements) to describe all versions and formats of the PLM. It can support both user tasks in searching for the PLMs and the collection management tasks. PLMM can dominantly express and describe the special characteristics and content of Thai Palm Leaf Manuscripts.

Keywords: metadata; metadata development; Palm Leaf manuscripts; digital collection

1. Research Background

The palm leaf manuscripts (PLMs) are one of the archaic recordings that had been important to the Thai people, particularly Isan people (the people who live in the northeastern part of Thailand) who have used it as their life manual that sets out their responsibilities as well as the community structure. These manuscripts contain recordings of beliefs, politics and economy (Thalang, 2001). They are referred to when one goes through each stage in life: birth, marriage, house-warming, illness and death as well as when seasonal rituals such as pre or post- harvest ceremonies approach. Thai people believe that these manuscripts are holy and have to be kept on religious ground (Samutkhup & Kittiarsa, 2003). The palm leaf manuscripts are also recognized as the primary sources and key to the knowledge in various fields that have been passed on from our ancestors. The wisdoms found in these manuscripts are considered valuable to the development of the country, and are part of the nation's as well as the world's history. Therefore, UNESCO (2008) considers palm leaf manuscripts as a literary heritage recording the world's history that should be digitally preserved for public access to the knowledge recorded.

Besides, the researcher and expert such as anthropologists, folklorists, linguists and literature experts are interested in the reading of these PLMs in search of knowledge, world views, beliefs, and their way of life recorded in them. This is done through the research, collection, categorization, records keeping, exchange, analysis and preservation of PLMS as historical evidence (Samutkhup & Kittiarsa, 2003).

However, the study of PLMs is still limited because PLMs are not systematically collected and managed. Public access to PLMs is limited, because some of the manuscripts being lost or damaged even after listings have already been made. Besides, there is a lack of experts who can read and translate palm leaf manuscripts that are sometimes fragile and prone to damages. Access to PLMs are difficult and limited among some disciplines with experts who are able to understand archaic scripts while the knowledge contained in the PLMs covers various topics such as history, culture, and many other useful fields such as therapeutic massage, herbal treatment, herbal products, food and drinks, handicraft, and local fabric. With recognition of the benefits and the importance of the contents of PLMs, academics have tried to find the way to access and bring out this knowledge without destroying the original copy through the management via information technology. The technique most popularly used at present is the digitization of the original copy. This allows users to access any part of the manuscript while allowing collection managers to make changes and publish the work on the computer network or through various forms of recording media to serve users' background and different objectives. Digitization of the PLMs original copies allows us to preserve the knowledge recorded in the manuscripts even after the original copies themselves have deteriorated. It also prevents future damages to the copies from frequent use. Currently, PLM preservation projects in Thailand have attempted to digitize the PLMs in their collections to make it easier for users to access and use them and for project staff to translate and preserve the original PLMs. For example, the National Library has set up a one year project to digitize their PLMs; the Lanna PLMs preservation project at Chiang Mai University digitized their PLM collection in microfilm format; and the Northeastern Thai PLM preservation project has digitized significant PLMs (e.g., PLMs recording traditional medicine and Isan classical folktales) in order to subsequently translate them (Chamnongsri, 2009).

In order for the digitized document to be effectively accessed, retrieved, and used, a metadata which is a structured data used to describe another set of resource data needs to be created. For digitized document which is made up of many elements that may consist of various types of files and should be kept in different servers, metadata is the tool used to describe the features of these documents and also to facilitate the finding, access, and retrieval of the digitized document. The design of metadata scheme requires a clear set of attributes and values to enable both human and computers to process and use the metadata. The main aim of this study was to develop metadata for the management of digitized PLMs in order to increase efficiency of search, access, management and use regarding the special characteristics, contents and user community of palm leaf manuscripts. Consequently, the developed metadata is expected to serve as a standard information structure to be used in the management of Thai digitized archaic documents. This will also make possible the linking of Thai cultural heritage and wisdom with that of other countries via the internet, as a part of world memory project where the wisdom and culture of people in different places and times are recorded.

2. The Characteristics of Thai Palm Leaf Manuscripts

Palm leave manuscripts are one of the archaic documents employed in the recording of vast knowledge and wisdom of the people of the ancient times for the following generations to study and consult with in their daily practices. The manuscripts were made from palm trees' leaves that had passed several preparation steps before becoming yellow-white dry leaves with the right size for inscription. The inscription was made on both sides of the leaves (with connecting pages inscribed in a way that is convenient to read). Each page of PLMs contains 4-5 lines. For the binding of the manuscripts, holes were punched into these leaves to allow the fastening by cotton ropes (SaiSanong). The collective noun for each manuscript is "fascicle". Each fascicle contains

24 leaves (48 pages) and may contain one or more stories while one story may need more than one fascicle to tell (Veeraprajak & Dhasugond, 1994a, 1994b; Wirat Unnatwaranggul, 1984). Palm leaf Manuscripts vary in size. A standard palm leaf manuscript is generally 5-6 cm. in width and 50-60 cm. in length with 48 pages (24 leaves written on both sides). PLMs can be as short as 15 cm. or as long as 80 cm. and can vary in the number of pages (i.e., leaves). Thai people used the different sizes in different ways: the longer PLM was used as a textbook to record Buddhist stories and doctrine, while the shorter one was used as a notebook to record local wisdom related to daily life (Thalang 2001). The languages in which PLMs were written are either local or undergoing shift (Pali, Isan, and Khmer), and the manuscripts were written in three archaic orthographies (Tham-Isan, Thai Noi, and Khmer) requiring expert translation (Northeastern Thai Palm Leaf Manuscript Preservation Project MSU (MSU, 2004). Since the length of a PLM is determined by it physical dimensions rather than its content, a single manuscript may record many stories or a single story may require more than one manuscript. Finally, a PLM may have pictures in addition to text.

The only access point to the bound manuscript is its title; but this presents a problem for the user who is not already familiar with both the content of a specific PLM and the archaic language in which it was written. Furthermore, access to individual stories is difficult when many stories were recorded in one bound manuscript or when a particular story has different titles in different PLMs. However, because users generally access manuscripts using title or subject, the title (or story) is obviously the most important access point to the knowledge contained in PLMs. To preserve the knowledge recorded in palm leaf manuscripts and make it accessible to modern users, preservation projects transcribe a PLM in modern Thai alphabet and language and then reproduce the transcription in a variety of formats. The original PLM, its transcriptions and its translations are reproduced in the form of microfilms, photocopies, digital images, PDF files, and text files. Because of the complicated physical and linguistic characteristics of PLMs, the creation of a digital collection of these manuscripts must address complex issues of description, representation, organization, and use of the knowledge in PLMs. A hierarchical relationship model such as FRBR can help to develop a conceptual framework for metadata that can support access to one work in its various versions and formats; maintain the link between creators or owners; and help to manage the relationship between an original manuscript and the stories it contain (see the palm leaf Manuscript in Figure 1).

FIG. 1. Palm leaf Manuscript

3. The research conceptual Framework

In determining the conceptual framework for this research, Chen et al.'s Metadata Life Cycle Model (MLM) was adopted for metadata developing process, while IFLA's FRBR Model, the concept of application profiles, and DCMI Metadata Terms were employed in the design and development of the metadata schema.

The International Federation of Library Associations and Institutions (IFLA) proposed the Functional Requirements for Bibliographic Records (FRBR) model in 1998. It is a conceptual model that defines a structured framework and the relationships between metadata records by

focusing on the kinds of resources that a data record describes. In order to solve the problem of searching for intellectual works in a digital library where one work may have variation in titles, versions and/or formats, FRBR uses a hierarchical structure that establishes relationships between four levels of representation: a work, its expression(s), an expression's manifestation(s), and the individual item(s). This approach ensures that the user will be able to select the most appropriate version or format of the desired work (IFLA, 1998). The hierarchical model of FRBR was inspired by the entity relationship model for relational databases and by the concept of inheritance, which ensures that the properties (or data elements) described at superordinate levels of representation are inherited by all the subordinate levels nested under them (Coyle, 2005). FRBR lays the foundation for hierarchical catalog records by recognizing the difference between a particular work, several expressions of work, various formats in which an expression exists, and the particular item (Mimno, Crane, & Jones, 2005)

The FRBR model uses an entity analysis technique to identify entities and relationships.

Analysis begins by isolating key entities to be represented. The attributes associated with each entity are then identified with the emphasis on attributes important in formulating bibliographic searches, interpreting responses to those searches, and navigating the universe of entities described in bibliographic records (IFLA, 1998).

This research involved an innovative development that applies the conceptual framework of the system development life cycle. However, because the development of metadata had to take into account the characteristics of documents as well as users, MLM was adapted. Chen, Chen, Sum, & Lin (2003) proposed the steps in metadata development in four groups according to their similar features which are Metadata requirements analysis, metadata requirements specification, metadata development and metadata service provision. These concepts were applied to define the framework of the study into three steps:

1. Metadata requirement analysis - the study issues were composed of analysis of the physical features and content of PLMs in investigating its user's behavior and expectation needs, and exploring the current situation of the document collection management as well as analyzing some existing metadata schemas.

2. Development of a metadata schema -this step consists of identification of each type of document metadata requirements and design and development of metadata elements. The design and development of metadata elements were based on the analysis of metadata elements and extraction, and metadata vocabulary development. The two important activities were conducted by using the Functional Requirement for Bibliographic Record (FRBR) model (IFLA, 1998).

3. Implementation and evaluation of the final metadata schema. The metadata schema was evaluated to determine its ability to support main tasks of the document storage and retrieval systems in describing documents for search and access, displaying ancient document in digital form, and monitoring access to and preservation of digitized documents (see the diagram of research conceptual framework in Figure 2).
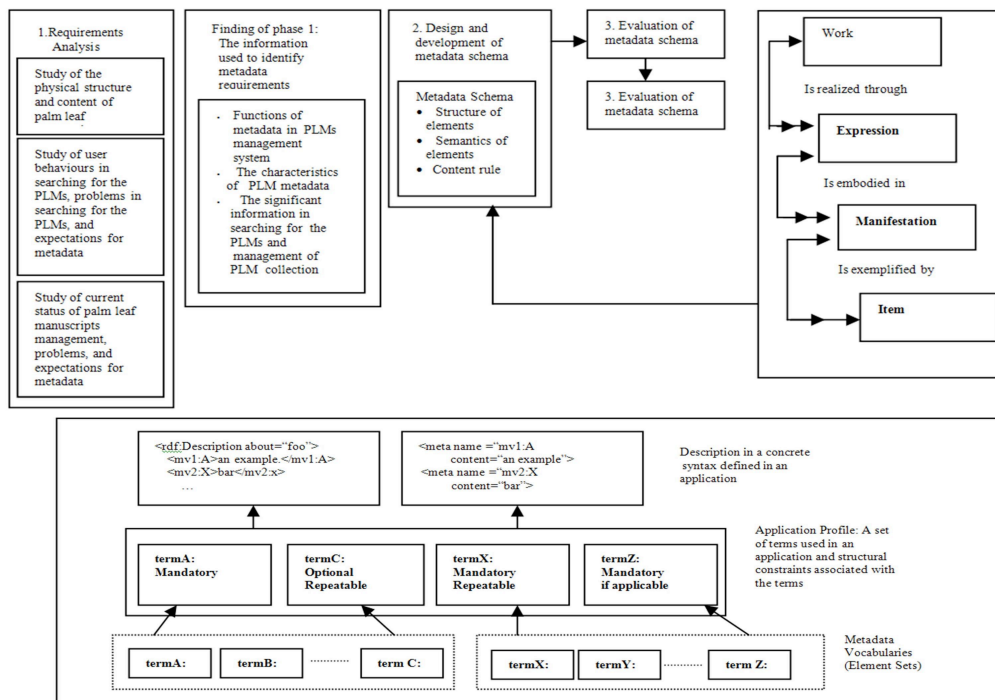
FIG. 2. The Research Framework

4. Research Methodology

The study employed R&D and qualitative research approaches as the basis for the development of metadata. In-depth interview, participatory observation, document analysis, and testing techniques were frequently performed in data collection. Research locations included the National Library of Thailand Headquarter in Bangkok, The National Library King Rama IX, NakornRatchasima and the Palm Leaf Manuscripts preservation projects of Mahasarakham University and Chiang Mai University. The research process was separated into three stages according to the research framework. 1) research for basic facts for metadata requirement - this stage consists of three studies; the users' behaviors in searching and using PLMs analysis, the analysis of physical structure and content in PLM, and the study of the current state of PLM management; 2) the development of PLM metadata schema; and 3) Metadata evaluation.

Document analysis was carried out to analyze the physical structure and types of content in the palm leaf manuscripts. In-depth interviews were conducted with two groups of users to determine their needs and expectations; and the project managers and staff to identify data requirements for managing collections. The Functional Requirement for Bibliographic Record (FRBR) conceptual model was used to define the metadata entities, its attributes, and the relationships between entities and attributes that can be used to support information search. In addition, certain functionalities of the FRBR model were adopted in the design of the metadata model for palm leaf manuscript collections. Then the mapping of the PLM metadata elements with metadata schemas in similar communities and domains was done. The Resource Description Framework (RDF/XML and RDFS) was used to define the metadata schema in order to allow the reuse of the elements defined in the palm leaf manuscript metadata schema. The last step was the evaluation of the developed metadata for the management of PLMs by community's users. The process of metadata research and development is summarized in Figure 3.
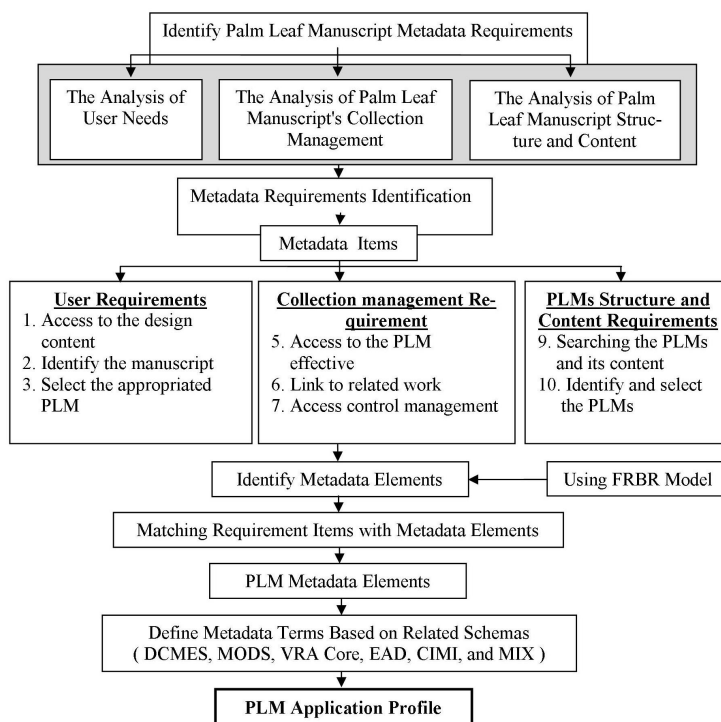
FIG. 3. The Design Framework of Developing PLM Metadata Schema

5. Results of the Study

5.1 The Metadata Requirements Analysis

The study of users' behaviors in access to the PLMs and their expectations for metadata revealed that the searching pattern for the PLMs employed by participants consists of four steps; (1) clarifying what the information or content they want and identifying its concepts, (2) relating the concepts to the PLMs' titles because it is a single access point in existing retrieval tools, (3) searching for the needed PLMs to know that they are still available and where they are stored, and (4) selecting the suitable PLMs by checking the physical condition and the completeness of the PLMs, the length of the story, the age of the PLM, script, and language. In addition, the users who cannot read the ancient script and language like to search for the translation versions by using the original titles. "Title" is the main access point that users normally use when they are searching for the PLMs. In accessing the desired contents and the physical PLMs, users required reasonable access points (Title, Keywords, Subject, Place of found, Script, Language, etc.). They expect the PLMs metadata to help them access the PLMs' contents, link them to the related contents (e.g. similar titles, similar subjects), and the multiple versions and formats of the same PLMs.

PLMs Collection Management, the main objectives of all preservation projects are: to preserve both the physical PLMs and its contents. Their works have been focused on collection, registration, and preservation of the PLMs in their located regions. The research found that the two groups of PLMs were treated differently in terms of keeping and accessing. The PLMs that are held by PLMs preservation projects, especially at the National Library's headquarter are kept in a good condition where the humidity, heat and light are controlled. The PLMs in the national library are organized and the guideline for collection management is valuable. Furthermore, the rights control management is very strict because they treat the PLMs as national property. On the contrary, the value of PLMs kept in the original locations such as temples and households is not recognized by government agencies. These PLMs are not kept in a good condition. There is no management that makes it difficult to access.

The analysis of PLMs characteristics revealed that the specific characteristics which are important to model metadata framework includes: (1) a PLM can include single title recorded in a single fascicle or separated into a number of fascicles (2) a PLM can include more than one chapter/sub-title and each chapter/ sub-title can consist of more than one fascicle (3) a PLM can include more than one content subject (4) a PLM (single title) can be expressed in different literary styles and it can also be inscribed in various scripts and languages. These unique characteristics need a specific schema to describe. This also conforms to previous studies which argue that for the development of metadata schema, each document needs specific metadata depending on its physical structure, content, and user needs (Haynes, 2004; Liu, 2007; NISO, 2004; Zeng & Qin, 2008).

The results from these studies were integrated, compared and the essential point of characteristics of PLM, users' needs and the collection management drawn to construct the conceptual model for extracting the significant attributes of metadata element set. The developed metadata again was compared with the elements of existing metadata schemas for finding the common specified attributes of PLM metadata. The significant attributes and their definitions are listed in the Table 1.

TABLE 1: The significant attributes and their definitions

Information	Definition
1. PLMs' Title/ Stories' Title	The name of the PLM or the name of the story recorded in the PLM. It might be the name of the PLM when title represents the whole fascicles.
2.Keyword	The topic or concept of the content express as natural language—the words appear in the document, and the words users' familiar with.
3. Subject/ Subject Heading	The controlled vocabulary express content topic, bring all similar concepts together, includes classification scheme
4. Where the PLM was found	The place where the original PLM was found (province, district, sub-district)
5. Script	The alphabet used to inscribed the PLMs (ThamIsan, Thai Noi, Khom Thai, Modern Thai alphabet, Roman alphabet)
6. Language	The language used to express the stories or content recorded in the PLMs (Thai Isan, Pali, Pali-Thai Isan, ancient Thai, modern Thai, and English)
7. Physical Characteristics	The appearance of the PLM - Dimension (width x length) - Number of Pages - Number of Fascicles - Physical Condition (pages and fascicles which damaged and lost) - Edition (PLMs' edge decoration styles, such as paint with vermilion, gold, natural and etc.)
8. Literary Style	The manner the inscribers express the story (out standing, fine, ordinary).
9. Form of PLM	The reproduction formats of the PLM (microfilm, digital image, rich text, PDF, paperback)
10. Storage Place	The places where the PLMs are holding (temple, library, PLM preservation project). Include their address
11. Use Restriction	The restrictions on use of and access to each format of PLM include the original PLM
12. Access Methods	The technical information about how to use and *obtain the PLM in each form* (borrow, access, display, play, download)
13. Uniform Title	The formal name or the well known name of the PLM/story recorded in the PLM.
14. Time Period/ Date of inscription	The date when the inscription was finished, normally record in the first page of the fascicle.
15. Holding Location	The geographic location where the storage place located in (province, district, sub-district).
16. Copyright Statement	Information about rights held in and over the resource
17. Owner	Institute or person who own the PLMs (personal name and corporate body)
18. Negotiation Terms	
19. Date of Registration	A date the PLM was input to the system
20. Date of Preservation	A date the PLM was preserved
21. Preservation Methods/ Preservation Actions Taken	The methods taken to preserve the PLM (Migration or emulation methods and policies)

Information	Definition
22. Technical Information	The technical information related to the creation of the digital PLMs (e.g. Image resolution, File format, Compression methods, Capture devices, Encoding software, Encryption methods and etc.
23. Producer	Person or institution who responsible for reproducing the PLMs

5.2 The PLM metadata schema

The PLM metadata schema (PLMM) developed for palm leaf manuscripts consist of 76 properties (34 core elements and 42 element refinements) to describe all versions and formats available in the PLMs collection, and to support users' tasks in searching for the PLMs and the collection management tasks. There are 25 elements based on DCMI Metadata Term: four elements based on Metadata Object Description Schema (MODS), two elements based on Computer Interchange of Museum Information (CIMI), four elements based on NISO Metadata for Images in XML (MIX 2.0), two elements based on Visual Resource Association (VRA) Core 4.0, and there are 39 PLM newly defined elements. These 76 elements can be separated by the function supporting as follows:

1. There are 11 elements describing the content of the PLM to support the decision making of users (Title, Uniform title, Alternative title, Related content, Subject, Summary, Place found, Date, Date of inscription, Date of translation, and Literary style). Information in this group will confirm that the retrieved PLM is the right PLM. According to the finding of this study, users will start their search by clarifying the concept of content, then relate the concept to the PLM titles which might contain the desired content. The information in this group can satisfy the user requirements: more elements describing the content of the PLM. When compared to the existing metadata standards, DC and MODS also provide five of the elements in this group. The other useful information that does not exist in other schema is "related content" which presents other titles with similar or related contents that are specific characteristics of the PLMs. This element will give users all the related content in the collection. This is very helpful particularly for the novices to search for all related contents.

2. There are 15 descriptive elements describing the physical characteristics of the original PLM (Script, Language, Original language, Translation language, Dimension, Lines per page, Object quality, Number of pages, Number of fascicles, Holding fascicles, Lost fascicles, Physical condition, Cover board, Wrapper, and Edge style). Most of their elements in this group are the newly defined element to describe the specific physical characteristics of the PLM that cannot be applied from the existing metadata standard because the definition of their elements are defined following the PLMs characteristics.

3. There are 11 elements describing the related works of a single PLM, presenting all versions and formats of the original PLM (Related works, Is version of, Has version, Is format of, Has format, Is part of, Has part, Is copy of, Has copy, Version, and Format). Moreover, it presents the whole and a part of the PLM and all sub-stories or sub-contents in the PLM. By adding the IDimages, it can be linked to the PLM digital images that contain the sub-stories or sub-content. The existing standards that have similar elements are DC, MODS, and VRA Core. However, inVRA Core the element "imageOf" and "imageIs" are designed for digital images only, but the PLM could have more than one format. The MODS elements "ortherVersion" and "otherFormat" could not show the superordinate and subordinate of the objects, whereas DC does. However, the definition needs to be redefined and the example in the context of the PLMs needs to be given. For example, "Is part of" means the resource is a physical or logical part of the reference source e.g. other fascicles in the same PLM, other stories in the same fascicle. In addition, the PLMM has defined two new elements "Has copy", and "Is a copy of" to present the relationship between each item of each manifestation.

4. There are 10 administrative elements supporting the use and access functions (Storage place, Storage place name, Storage place address, Physical location, Status, Use restriction, History of use, Preservation history, Date of last preservation, and Provenance). Elements in this group enable users to know where they can get the PLMs they want and which preservation project or library they should visit. This information supports decision-making in finding the PLMs that are suitable to their situation. When compared to other standards, DC, MODS, VRA Core are quite similar. These three schemas use "Location" to present a spatial region or named place but do not separate the address of the place which has different values and purposes. Some institute might want to display the address, while some might not. On the other hand, EAD separates this information into two elements under the element "StoragePlace" which is different from the meaning of the storage place in palm leaf manuscript concept where users can use and borrow the available PLMs like library material but under instruction. Besides, the PLMs they hold do not belong to other institutes. Thus, the concept of EAD "StoragePlace" is not accommodated in the PLM context. Other similar elements that can be applied from another standard is "Use restriction" which is similar to MODS "use and restriction", and qualified DC "accessRights". However, this research employed DC terms because it is widely used in digital library projects. Another element based on DC is provenance, whereas Status, Use history, Preservation history, and Date of last Preservation are newly defined.

5. There are 14 elements presenting the technical information regarding the creation or reproduction of the other versions and formats (Production information, File format, Folder size, Resolution, Color space, Technique, Capture device, Capture software, Reduction ratio, File size, Polarity, Number of images, Number of Frame and Date of production). Because information in this group is a technical term, most are based on the various international standards. However, there are newly defined elements including Production information, Reduction ratio, Polarity, and Folder size.

6. There are 9 elements presenting the identifiers pointing to each version, format, a part, and a whole of the PLM (Identifier, Registration ID, Call number, Image ID, images ID, text ID, Microfilm ID, Fascicle number and Frame number). The core element "Identifier" is based on DCMES while the other elements are newly defined to make reference to the formats of PLM in PLM collection.

7. There are 6 administrative elements presenting the information regarding the person or organization responsible for the creation, production, and rights holding of the PLM in each version and format (Creator, Inscriber, Patron, Translator, Producer, and Owner). Information in this group responds to the copyrights of each version and format of the PLM. However, two of them: inscriber and patron are newly defined elements used in PLM and ancient document context to identify the difference of the PLM by the status of inscriber and patron or the period of time when they were living.

6. Conclusion and Discussions

The research findings have confirmed the previous research results that the development of metadata to support user requirement and access to information resource, each document needs specific metadata depending on its physical structure, content, and user needs (Haynes, 2004; Liu, 2007; NISO, 2004; Zeng & Qin, 2008). Additionally, there is no single metadata schema that can meet every requirement of digital PLM collection, or the collection of digital ancient documents that are complex by nature (document structure and content), although there are several current standards with the scope and purpose similar to the PLMM including DCMES, MODS, VRA Core, EAD, CIMI, and MIX 2.0. However, after mapping the PLMM definition and requirements to these similar standards, it was found that the requirement is similar to the finding of previous research (IFLA cataloging section, 2009). Under the concept of application profile (mixing and

matching existing recognized schemas), the PLM metadata vocabulary will be reused in other ancient document digitization projects. The PLMM shows the special features and differentiate them from the other schemas.

The Palm Leaf Manuscript Metadata as an ancient document has its own value. Hence, palm leaf manuscript is considered the cultural heritage that represents the wisdom of the nation in multi dimensions: local content which is rooted in local circumstances such as the experiences and problem-solving skills of Thai ancestors, local alphabets and languages, arts and culture, and the history of the nation. In order to represent these unique characteristics, the PLMM needs to define new elements and values to describe the PLMs. The dominant features of PLM metadata schema include 21 elements defined to present the unique characteristics of palm leaf manuscript that is different from other type of documents and cannot be found from the existing metadata standards. They include; fifteen elements describing the physical characteristics of the original PLM (Script, Language, Original language, Translation language, Dimension, Lines per page, Object quality, Number of pages, Number of fascicles, Fascicle number, Holding fascicles, Lost fascicles, Physical condition, Cover board, Wrapper, and Edge style). The four elements define the content (Related content, Place of found, Literary style, and Date of inscription), and the two relationships (Has copy, and Is a copy of).

Although the PLMM is basically designed for the PLMs, it can be implemented to describe other types of ancient documents with similar characters, users, and purposes. The PLMM relationship elements are very important in PLM context, because they are complicated in both physical and content structure. A PLM may consist of many fascicles, and each sub-story or sub-content can be recorded in different fascicles, whereas in some cases the content could be recorded continuously in a set of fascicles (one fascicle normally includes 25-30 leaves). In this case some parts of the content may be recorded in other fascicles. This makes access to individual story difficult. The PLMM relationship elements are applied from the set of relationship in qualifying DC (http://dublincore.org) to express the relationships among related PLM versions and formats, and the whole and a part of the PLM. There are six relationships based on DC qualifiers (Is format of, Has format, Is part of, Has part, Is version of, Has version), and two newly defined relationships (Has copy, and Is a copy of) displaying the relationships between copies of each format. The PLMM content elements, in general, the existing metadata standards such as MARC, AACR2, and Dublin Core intend to describe and provide access to physical objects rather than their content, whereas accessing the content is what users want most. The PLMM was developed based on this finding; therefore it proposes 10 elements to describe the content of the PLM. These elements are Title, Uniform title, Alternative title, Related content, Subject, Summary, Place of found, Date of inscription, Date of translation, and Literary style. Furthermore, this research found that the elements "Has part" and "Is part of" which are generally used to link a whole and a part of the physical objects or documents can present and link the sub contents recorded in the PLM to the main content or title, or link the individual content to the PLM it belongs to.

According to the implementation and evaluation of the PLMM in digital PLM management system, the PLMM content elements can enhance the content discovery of complicated documents rather than access to physical documents only. The result of user's evaluation after the implementation of the PLMM with digital PLM management system, most of them appreciated this set of metadata elements and their relationships that are very helpful in leading users to the desired version and format. It satisfactorily meets the user requirements in searching for the PLMs and managing the PLMs collection. These results show that the set of qualified DC relationships can apply to the digital collection of ancient documents. However, when it has been implemented in real practice of digital collections, it was found that the schema has too many elements and complicated explanation, making it is not easy for use in general. Therefore, the PLMM needs to be further studied, verified, and simplified as a standard to be used in general worldwide.

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