How Descriptive Metadata Changes in the UNT Libraries' Collections: A Case Study

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Abstract

This paper reports results of an exploratory quantitative analysis of metadata versioning in a large-scale digital library hosted by University of North Texas. The study begins to bridge the gap in the information science research literature to address metadata change over time. The authors analyzed the entire population of 691,495 unique item-level metadata records in the digital library, with metadata records supplied from multiple institutions and by a number of metadata creators with varying levels of skills. We found that a high proportion of metadata records undergo changes, and that a substantial number of these changes result in increased completeness (the degree to which metadata records include at least one instance of each element required in the Dublin Core-based UNTL metadata scheme). Another observation of this study is that the access status of a high proportion of metadata records changes from hidden to public; at the same time the reverse process also occurs, when previously visible to the public metadata records become hidden for further editing and sometimes remain hidden. This study also reveals that while most changes -- presumably made to improve the quality of metadata records -- increase the record length, surprisingly, some changes decrease record length. Further investigation is needed into reasons for unexpected findings as well as into more granular dimensions of metadata change at the level of individual records, metadata elements, and data values. This paper suggests some research questions for future studies of metadata change in digital libraries that capture metadata versioning information.

Keywords: metadata quality; distributed digital libraries; metadata change; measurement; quality assessment; best practices

1. Introduction and Background

Maintaining usable digital libraries requires high-quality metadata; one related piece involves looking at how metadata records change to determine how frequently records are edited, and, ultimately, if they have been improved. These measurements can factor into various kinds of evaluations including aspects of quality, such as "completeness," one commonly-accepted quality criterion (Moen, Stewart, & McClure, 1998; Park & Tosaka, 2010; Zavalina, 2011, etc.). Metadata completeness is evaluated as an extent to which objects are described using all applicable metadata elements to their full access capacity (Park, 2009). Of the three major metadata quality criteria (completeness, accuracy, and consistency), accuracy is the most subjective and therefore difficult to measure, while the consistency and especially completeness criteria lend themselves to variety of analyses including computational.

Stvilia and colleagues (Stvilia et al., 2004; Stvilia & Gasser, 2008) concluded that metadata changes made to improve metadata quality should be quantified and justified based on changes of value and cost of metadata to assist metadata specialists in optimizing quality assurance processes and to provide justification for spent resources. However, the analysis of literature demonstrates little research into metadata change in information science literature.

To the end of our knowledge, none of the published metadata quality studies measured metadata change. One exception is a small-scale component examining metadata change in the broader study of collection-level metadata quality in the IMLS DCC aggregation. As part of this study, researchers conducted longitudinal analysis of the modifications that had been made by digital collection developers housed at various cultural heritage institutions throughout the United States to collection-level metadata records created by hosting institutions' staff in the IMLS DCC (Zavalina, Palmer, Jackson, & Han, 2008) and found that the data values associated with the Dublin Core Collections Application Profile's Subject, Audience, Size, Spatial Coverage and Temporal Coverage metadata elements are modified the most frequently.

A number of information science studies relied on Wikipedia's so called "revision metadata" that documents who made a particular revision to the Wikipedia article and when, as well as "rollbacks" -- the process of restoring a database or program to a previously defined state -- to detect vandalism (e.g., West, Kannan, & Lee 2010; Alfonseca, Garrido, Delort, & Peñas, 2013). Similarly, Yan and McLane (2012) discussed metadata management process for "revision metadata," including the edits, history, and tracking, made to spatial data and GIS (Geographic Information System) map figures. While using administrative metadata that documents revisions as a tool to answer other research questions, none of these studies focused on the changes made to metadata per se as opposed to information objects (e.g., Wikipedia articles) themselves.

Outside of the information science field in general and the metadata quality area in particular, one can see discussion of change in relation to texts, strings, files, etc., however, a review of the literature identified a gap in information science research in relation to analysis of metadata change. In particular, no studies to date have attempted to measure metadata change in digital libraries. The authors of this paper believe that metadata change can and should be viewed as one of the indicators of metadata quality and therefore should be examined as a step toward improving the quality of metadata in digital libraries. To begin bridging this gap, the study reported in this paper sought to answer the following research question: What is the amount of change in metadata?

The authors of this paper selected as the target for their research the centralized digital library hosted by the University of North Texas Libraries, consisting of multiple collections with varying subject scope, material types, etc. The UNT digital collections include the UNT Digital Library (containing items owned by UNT and the output of the University's research, creative, and scholarly activities), The Portal to Texas History (containing historical materials owned by more than 200 partner institutions across the state of Texas), and the Gateway to Oklahoma History (containing primarily newspapers and photographs through partnership with the Oklahoma Historical Society). The collections incorporate different types of materials including photographs, theses and dissertations, newspapers, artwork, performances, musical scores, journals, government documents, rare books and manuscripts, and posters. All items in the UNT digital collections are described using a locally-modified Dublin Core metadata schema. The digital library's infrastructure has been established according to open-source components and standards, protocols, and formats. At the time of data collection (April 18, 2014), this large-scale digital library held 691,495 unique item-level metadata records, written by a number of metadata creators with varying levels of metadata creation skills.

These records reside in the digital library infrastructure operated by the UNT Libraries that is a purpose-built system for managing and providing long-term access to digital resources. Aubrey, the system used for this management, was put into production during June of 2009. The UNT Libraries placed the metadata editing component into service in September 2009; as part of

metadata management, this component versions metadata records each time they change in the system. This provides a unique collection of rich data for analysis into metadata changes.

2. Methods

According to Ochoa and Duval (2009), most of the metadata quality studies involve manual content analysis on statistically-significant samples of metadata records. Collection-level metadata records that describe entire collections of information objects as a whole, as opposed to individual objects, can still often be examined manually due to the reasonable numbers of metadata records in each sample. However, with the rapid growth of digital libraries and repositories that aggregate hundreds of thousands and often millions of items and their respective item-level metadata records, the evaluation of much more numerous item-level metadata will need to rely -- at least in part -- on computational approaches.

The study reported in this paper adopted the semi-automated quantitative research approach to analyze the entire population of metadata records in the target centralized digital library with the purpose to answer the following research question: What is the amount of change in metadata? The following broad indicators of metadata change were selected:

- frequency distribution of the number of editing events per record (i.e., how many records were edited only once and how many were edited 2, 3, or more times),
- frequency distribution of the number of editors per record,
- frequency distribution of the record length change in the process of editing,
- frequency distribution of change in record completeness (in terms of the number of metadata elements, including required elements, used), and
- frequency distribution of change in the record status (i.e., availability for the user) through the process of editing.

To measure these indicators, metadata records from the UNT Digital Library, The Portal to Texas History, and the Gateway to Oklahoma History were extracted (Phillips, 2014). The authors wrote a Python script to extract and aggregate statistics about each metadata record version into a tab-delimited format that presents a less complex view of the data (see the Appendix for the full list of data collected for each record). The dataset extraction script processed each of the 1,193,813 record instances in the Aubrey system and calculated the number of instances (presented in the dataset as an integer) for each of the elements in the UNTL metadata scheme (UNT Libraries, 2014). Additionally, the script extracted important creation information for each metadata record including the timestamp for when it was created and last updated, the metadata creator and the last metadata modifier, whether the record is hidden to the public or unhidden, and the number of seconds that elapsed between the metadata record creation date and the metadata record edit date.

There are three fields in the dataset which may need additional description: the completeness metric, the record_length, and the record_content_length. The completeness metric calculates how "complete" a metadata record is in terms of the UNTL metadata scheme. This metric is calculated by examining the record and the existence of values for the seven fields required in our database: title, description, language, resource type, format, collection, institution, and subject. The existence or nonexistence of these values are used in a calculation that results in a number between 0 and 1, where 0 indicates a severely incomplete record with none of the required elements present, and 1 represents a complete record that has at least one instance of each of the seven elements that are required in the UNTL metadata scheme. The record_length measurement is the total number of bytes that the metadata record occupies on disk, and the record_content_length is the number of bytes of the record excluding metadata elements -- field names, qualifiers, attributes, and attribute values -- which results in the total length of data values in these metadata elements. By removing the text of metadata elements, administrative changes to

the record status -- such as hiding and unhiding the record -- are not included, so a better sense of the records full size can be seen.

3. Findings

In the dataset used for this study there are a total of 1,193,813 record instances of edited or unedited metadata record versions (see Table 1). These record instances represent 691,495 unique objects in the UNT digital collections; in the following analyses, this number is used as the "total" number of unique records in the system. The data presented in Table 1 demonstrates the steady growth in both the total number of metadata records in the system and the number of metadata records edited each year, with the highest proportion of metadata records (24.5%) added or edited in 2013.

TABLE 1: Valid edited and unedited record instances by year*.

Year	New Record Instances	Percent of Dataset
2004	928	0.1%
2005	43,425	3.6%
2006	33,899	2.8%
2007	31,053	2.6%
2008	25,138	2.1%
2009	88,580	7.4%
2010	179,498	15.0%
2011	188,810	15.8%
2012	248,439	20.8%
2013	292,342	24.5%
2014	61,695	5.2%

*Note: 6 records in the dataset are missing a metadata creation date.

As of April 2014, there were 502,675 instances of edited record versions. These versions represent 271,754 unique metadata records that have undergone changes since September 2009, when we started versioning metadata (see Table 2), or 39.3% of all metadata records in the system. Additionally, the data indicates that 9,830 records were edited one or more times before the migration to the Aubrey system and have not been edited since. That means that a total of 42.5% of all item-level metadata records in the centralized digital library operated by the UNT Libraries have been edited at least once. However, the records last edited before September 2009 are excluded from the edit analysis since only one -- the most current -- version of each record was retained prior to migration.

TABLE 2: Valid instances of edited records (versions) by year, September 2009-April 2014.

Year of Last Edit	Record Instances	Percentage of Edited Record Instances
2009	20,314	4.0%
2010	39,817	7.9%
2011	105,465	21.0%
2012	124,041	24.7%
2013	188,652	37.5%
2014	24,386	4.9%

The data presented in Table 2 demonstrates the steady growth in the number of metadata records edited each year, with the sharp spike (from 7.9% to 21%) in 2011 and the highest proportion of metadata records (37.5%) edited in 2013.

To get a better sense of the scope of editing frequency across the collections, we analyzed the number of edits per record and the number of editors per record. Of the edited records, nearly all (99%) have been edited five or fewer times (see Table 3), although some outlying records have been edited more than 50 times. Additionally, the majority of edited records (93.6%) have only been changed by one or two different editors (see Table 4).

For the following data analyses, edit events are compared across the entire collection of unique metadata records (n=691,495), or across the unique metadata records that have been edited at least once since September 2009 (n=271,754).

TABLE 3: Number of edits per record (n=691,495).

Number of Edits	Number of Records	Percentage of Edits	Cumulative Percentage of Edits
0	419,741	60.7%	60.7%
1	152,900	22.1%	82.8%
2	66,236	9.6%	92.4%
3	27,983	4.0%	96.4%
4	12,004	1.7%	98.1%
5	4,944	0.7%	98.8%
6	2,925	0.4%	99.2%
7	1,963	0.3%	99.5%
8	950	0.1%	99.6%
9	664	0.1%	99.7%
10	373	0.1%	99.8%
11-20	772	0.1%	99.9%
21-50	33	0.0%	100.0%
51+	7	0.0%	100.0%

TABLE 4: Number of metadata editors per record (n=271,754).

Number of Editors	Number of Records	Percentage of Records
1	197,358	72.6%
2	57,068	21.0%
3	15,397	5.7%
4	1,731	1.0%
5	180	0.1%
6	75	0.0%
7	3	0.0%
8	0	0.0%
9	0	0.0%
10	1	0.0%

In order to understand how records change over time, the authors investigated how the size of a metadata record changes during its life using the record_content_length field. The instance of this value from the first stored record (either newly created or migrated from the previous system) was compared to the most recent version in the dataset. This resulting number was categorized as an increase, a decrease, or no change in the size of the record over its life. Records that have not yet been edited have "no change." Across the entire collection, more than sixty-six percent of the records have not changed in length (see Table 5); however, among the subset of records that have been edited, more than half increased in size (see Table 6).

TABLE 5: Change in size of metadata records September 2009-April 2014 (n=691,495).

Change Category	Number of Records	Percentage of All Records
No Size Change (0)	459,350	66.4%
Size Increase (+)	146,046	21.1%
Size Decrease (-)	86,099	12.5%

TABLE 6: Change in size of edited metadata records September 2009-April 2014 (n=271,754).

Change Category	Number of Records	Percentage of Edited Records
No Size Change (0)	39,610	14.6%
Size Increase (+)	146,046	53.7%
Size Decrease (-)	86,099	31.7%

The authors took a similar approach to determine the change in completeness among records across time as they did for calculating the record content length over time (using the automatically-calculated metric that measures the presence of all required fields in a metadata record). The earliest value of completeness from the record samples was compared with the most recently edited values to determine whether the completeness increased, decreased, or stayed the same. A large majority of the whole collection -- nearly 96% -- had no change in completeness (see Table 7); and, even among the subset of edited records, roughly 90% had no change in completeness (see Table 8). Overall, completeness generally stayed the same or increased, although thirteen records decreased in completeness, likely due to a mistake or misunderstanding when editing.

TABLE 7: Change in completeness of metadata records September 2009-April 2014 (n=691,495).

Change Category	Number of Records	Percentage of All Records
No Completeness Change (0)	662,508	95.8%
Completeness Increase (+)	28,974	4.2%
Completeness Decrease (-)	13	0.0%

TABLE 8: Change in completeness of edited metadata records September 2009-April 2014 (n=271,754).

Change Category	Number of Records	Percentage of Edited Records
No Completeness Change (0)	242,767	89.3%
Completeness Increase (+)	28,974	10.7%
Completeness Decrease (-)	13	0.0%

Aside from general size and completeness of records, one aspect of particular interest in this analysis relates to the accessibility of records to the public. In UNTL metadata, records contain a field that controls whether or not a record is hidden; if the value is "true," the record cannot be viewed in any way without administrative access to the item. For items that have a hidden value of "false," the metadata record is visible to the public and searchable. This value only governs the metadata record and does not affect the accessibility of the item (i.e., items that have restricted usage or embargoes can still have a hidden value of "false").

First, to see how this value changes over time, the authors compiled statistics for the number of records for which the record access status value has changed -- either hidden to visible, or visible to hidden. More than eighty percent of unique metadata records in the system have not changed in access status (see Table 9), while a lesser majority (65%) of the edited records remained unchanged (see Table 10).

TABLE 9: Change in access status of metadata records September 2009-April 2014 (n=691,495).

Change Category	Number of Records	Percentage of All Records
Access Status Changed	94,516	13.7%
Access Status Unchanged	596,979	86.3%

TABLE 10: Change in access status of edited metadata records September 2009-April 2014 (n=271,754).

Change Category	Number of Records	Percentage of Edited Records
Access Status Changed	94,516	34.8%
Access Status Unchanged	177,238	65.2%

In general, looking at how record access status has changed is important since it affects accessibility and usage, however, we particularly want to highlight records that have moved from a visible status to a hidden status. This event represents a situation in which a digital object that was available to the public -- and may have been viewed, cited, or linked -- is no longer available. Tables 11 and 12 present a more detailed analysis of this kind of metadata change, breaking down the number of records that had a value of "false" (visible) that changed to "true" (hidden) at any point in their edit history. For comparison, Tables 11 and 12 also contain statistics for records that did not change access status, but an additional column gives the current status of each set of records, providing detail as to how many records are unchanged but visible, versus unchanged but hidden.

Overall, more than ninety percent of the all metadata records currently have a hidden value of "false," making them publicly accessible (see Table 11). More than 60% of the records that have been edited have started as visible and not changed, while another 33% have been changed in access status from hidden to visible during the course of editing (see Table 12).

TABLE 11: Current (April 2014) access status and status changes across all records (n=691,495).

Change Category	Changed from Visible to Hidden	Final Hidden Value	Number of Records	Percentage of All Records
Access Status Changed	No	False (Visible)	90,295	13.1%
Access Status Changed	Yes	False (Visible)	1,899	0.3%
Access Status Changed	Yes	True (Hidden)	2,322	0.3%
Access Status Unchanged	No	False (Visible)	553,262	80.0%
Access Status Unchanged	No	True (Hidden)	43,717	6.3%

TABLE 12: Current (April 2014) access status and status changes across edited records (n=271,754).

Change Category	Changed from Visible to Hidden	Final Hidden Value	Number of Records	Percentage of Edited Records
Access Status Changed	No	False (Visible)	90,295	33.2%
Access Status Changed	Yes	False (Visible)	1,899	0.7%
Access Status Changed	Yes	True (Hidden)	2,322	0.9%
Access Status Unchanged	No	False (Visible)	167,478	61.6%
Access Status Unchanged	No	True (Hidden)	9,760	3.6%

The rows that have particular significance in Tables 11 and 12 show statistics for the records that have changed in status from visible to hidden at some point in their history. Forty-five percent of those 4,221 records have ultimately been edited in some way and then made visible again. However, the other fifty-five percent (2,322 records) have remained hidden and may need additional review.

4. Discussion and Conclusions

As a preliminary step, the data in this paper outlines information to answer some general questions about the function of change or editing metadata records across a body of digital items. This study revealed that a high proportion of metadata records in the UNT digital collections (almost 40%) have been edited at least once in the period between September 2009 and April 2014 to change record content and/or access status. In addition, our data provides evidence that the purposive metadata change activity -- expressed in the sheer number and proportion of edited records -- has steadily and substantially grown over time. These findings support the assumption that metadata is a constantly-evolving resource.

Several other points particularly stood out as part of this analysis. First, a considerable number (nearly 11%) of edited records improved in quality based solely on the "completeness" metric. Although this does not give a holistic view of the final metadata quality of those records (in particular, with regards to accuracy, consistency or record completeness beyond the mere presence of at least one instance of each required metadata element), in general, metadata editors are adding required information when it is missing, improving the overall value of the metadata.

Next, regarding change in length, a larger than expected number of edited records (31.7%) decreased in size as a result of changes, suggesting the removal of information. However, since the record_content_length indicator represents the total number of characters in the record, even minor changes could have accounted for a net decrease in record length, such as the removal of an extra space, the correction of typographical errors with extra letters/characters, or the replacement of longer placeholder values with shorter actual values as editors completed partial records. Additionally, qualifiers and terms from controlled vocabularies contribute to the length, so changing those values could decrease the number of characters. Based on this understanding, a decrease in record length does not necessarily equate to a loss of information, or a decrease in the quality or accuracy of a particular record.

Finally, as noted in the previous section, a number of metadata records (2,322) were hidden at the time of data collection, even though they had been visible at some point in their edit history. Although it is a small subset within the whole system -- only .3% of the total records -- any links to those records have been broken. Since the general goal is to provide as much access as possible and maintain permanent links to items and their respective metadata records in the UNT digital collections, those records should be reviewed to see if changes would allow them to become accessible once again, and to gain details about the circumstances to try and limit or avoid similar situations in the future.

4.1. Further Study

The research reported in this paper is a case study that sought to explore quantitative dimensions of metadata change and its general effects within a large digital collection. It helps identify some areas for future exploration that will be addressed by further, more in-depth, mixed-methods studies. These future studies will need to examine both quantitative and qualitative characteristics of metadata change in various digital repositories to answer these and other research questions:

- What is the frequency of change? What is the distribution of the lengths of time between initial record creation and its first modification; between the first and subsequent modifications?
- How does the number of instances of key metadata elements (such as title, creator, description, subject, etc.) change in the process of editing?
- Which common metadata change categories can be identified? What is the relative frequency of occurrence of these metadata change categories?
- Which elements in metadata records are changed the most often?
    - How do they change?

- How do these changes affect the overall quality – completeness, consistency, and accuracy – of metadata records?

To answer these and other more specific research questions, future studies will need to involve in-depth manual comparative analysis of versions for a manageable sample of metadata records. The role of the current exploratory study is to serve as the first stepping stone and to spur interest among metadata practitioners in conducting research into metadata change.

With major digital content management tools (e.g., Fedora, Islandora, and Hydra) now incorporating metadata versioning, more and more digital repositories will be able to capture versions of their metadata records and explore the change in their metadata over time. Further work by other institutions in this same area could allow for important comparative research. Without similar data, there is no way to evaluate whether the findings in this study are consistent across most digital libraries, or to determine the significance of any situations in which the experience at UNT differs from other digital libraries. Results of measuring metadata change will also help to determine the overall metadata quality, compare metadata quality across different collections of items, and will inform metadata management decisions such as setting priorities in metadata quality.

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Appendix

Alphabetical list of information captured in the dataset for all versions of metadata records in the UNT.

Field	Example	Description
sample_id	ark:/67531/metacrs10000_2009-12-20T02:07:08	Unique identifier for a sample record version.
ark	ark:/67531/metacrs10000	Unique record identifier.
citation	0	Number of citation element entries.
collection	1	Number of collection element entries.
completeness	0.983050847458	Completeness metric.
contributor	0	Number of contributor element entries.
coverage	1	Number of coverage element entries.
creator	4	Number of creator element entries.
date	0	Number of date element entries.
degree	0	Number of degree element entries.
description	2	Number of description element entries.
format	1	Number of format element entries.
hidden	False	Record hidden status (true/false).
identifier	2	Number of identifier element entries.
institution	1	Number of institution element entries.
language	1	Number of language element entries.
meta	11	Number of meta element entries.
metadata_creation_date	2007-06-12, 16:50:25	Date and time record was created.
metadata_creator	mphillips	Username for the record creator.
metadata_edit_date	2008-02-18, 15:22:21	Date and time record was last edited.
metadata_editor	govdocs	Username of the last metadata editor.
note	0	Number of note element entries.
primarySource	0	Number of primary source element entries.
publisher	1	Number of publisher element entries.
record_content_length	1775	Record length in bytes, excluding "meta" fields.
record_length	2445	Size of the metadata record in bytes.
relation	0	Number of relation element entries.
resourceType	1	Number of resource type element entries.
rights	1	Number of rights element entries.
source	0	Number of source element entries.
subject	12	Number of subject element entries.
time_since_creation	2168116	Time in seconds from record creation to last edit.
title	1	Number of title element entries.