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Original order in the digital world

Jinfang Niu*

Jinfang Niu is an Assistant Professor at the School of Information, University of South Florida. She received her PhD from the University of Michigan, Ann Arbor. Prior to that, she worked as a librarian at the Tsinghua University Library for three years. Her current research focuses on electronic records and digital curation.

This article expands the concept of original order and presents two systematic views of the order of electronic records. In one view, abstract conceptual order can be used as guidance for the physical arrangement of records storage media and intellectual arrangement of records through a software interface. In the second view, organising electronic records entails managing the relationship between electronic records and the paper records in the same collection, between electronic records and their metadata, among different electronic records, as well as managing the relationships among the different copies, different versions and different captures of the same electronic records.

Keywords: archives management; electronic records; original order

Introduction

Respecting the original order of records is a fundamental principle in archives management. In classical archival theory, original order means '[t]he organization and sequence of records established by the creator of the records'.[1] In the past several decades, there have been various discussions concerning the complexities and limitations of the concept and the principle of respecting original order.[2] Some writers argue that the original order 'is to be respected when it is usable'.[3] In this line of thought, archivists do not have to respect a chaotic original order; instead they should rearrange the records into a proper order.[4] In some scenarios, the imperfect or even chaotic original order is retained, not because it is 'respectable', but because it is too expensive to fix the order.[5] Sometimes the order as received by archivists is not original, because the records have been reorganised by other custodians before they enter the current archival institution.[6] This inherited order may be retained even though it is not original, because it is meaningful, facilitates access, and it is too expensive to rearrange the records. Together, these valuable contributions have transformed the principle of original order from simply respecting and retaining the original order of records to a statement that better captures the complexities in archival arrangement: respect and retain the order of records as received when appropriate, otherwise, impose a meaningful order that facilitates access when it is affordable to do so.

The principle of original order was developed for traditional records that were mostly paper based. With the ever-growing quantity of digital records, it is important to study whether and how the concept and principle of original order still applies in the

*Email: Jinfang@usf.edu

digital world. However, although there are many discussions about whether and how traditional archival management theories in general apply to electronic records,[7] only a few authors have mentioned specifically how the concept and principle of original order evolved in the digital world, and this usually only briefly. David Bearman pointed out that the original order of electronic records in an automated record keeping system is the relations among records and the relations between records and the actions they document.[8] He argued that the way that electronic records are organised on storage devices does not reveal these relationships, thus we need to create metadata about information systems and business processes to document the relationships.[9] Heather MacNeil argued that the principle of original order remains applicable for electronic records because 'preserving original order has always meant preserving the records' documentary relations'. In contrast to Bearman's argument that the organisation of electronic records on storage devices does not reflect the original order of electronic records, MacNeil pointed out the documentary relationships of electronic records are represented by the record directories.[10] In an appendix to the 2002 version of the Open Archival Information System (OAIS) reference model, the Electronic and Special Media Records Services Division of the US National Archives and Records Administration stated: 'For electronic records, "original order" is expressed in the logical structure of files and databases and in the indexing which the producer used.'[11] Since there is no further explanation of this statement, it is not very clear whether this statement is consistent with the arguments of other authors. Jane Zhang interviewed archivists regarding their practices in dealing with electronic records and identified three distinctive orders of electronic records: the file directory system, the file classification system and the metadata schema, which allows electronic records to be organised in multiple orders without generating multiple copies.[12]

These existing opinions and arguments, although insightful, do not provide a systematic or comprehensive view of original order in the digital world. To assist archivists and students in the archives management field to understand the concept and principle of original order in the digital world, this paper will go a step further based on these existing contributions, by presenting a framework that examines the various kinds of order that exist for electronic records, and a discussion of how the framework relates to the arguments presented above about the original order of electronic records.

A framework for the order of electronic records

When archivists talk about original order in traditional archival management, they usually mean the physical order in which the storage media (paper and other analogue media) are arranged, because it is this physical order that they actually deal with in their archival processing practices. In fact the order of records, especially that of electronic records, is much more than the physical order of storage media. This framework presents two different views of the order of electronic records.

In the first, or vertical, view, three kinds of order are identified for electronic records: abstract conceptual order, order on the user interface of application software, and order in storage. The abstract conceptual order can be used as guidance for organising electronic records through the user interface of application software. In this case, the order displayed on a software interface represents the conceptual order whereas the underlying order in storage, which is automatically generated by application software, may or may not be consistent with the conceptual order among electronic records. The abstract conceptual order can also be used as guidance for manually organising records

storage media. The order of electronic records in storage has several layers. The top layer is the physical order of storage media. The second layer is the folder structure within each storage medium, which is visible through the operating system of a computer. The third layer is the internal structure of individual container computer files. The bottom layer is the physical order of bits inscribed on the digital storage media. This first view looks at the order of electronic records vertically. See Figure 1.

The second, or horizontal, view looks at the order of electronic records horizontally. In this view, there is the order between the paper and electronic components of the same collection, the order between electronic records and their metadata, the order among different electronic records, as well as the order among the multiple versions and multiple copies, or, in the case of dynamic records, among the multiple captures of the same electronic records.

The framework presented in this paper applies to the order of electronic records in both records management and archives management settings, and thus it avoids using the term 'original order'. In the digital world, it is possible to create such an integrated framework for the orders of electronic records, because both archivists and records producers need to take on the responsibility of preserving electronic records owing to the short life span of digital storage media and rapid technology obsolescence. For the same reason, this framework does not make a distinction between records managers and archivists in the preservation of electronic records. Instead, it uses the term 'preserver' to include both parties. The following sections illustrate the details of each kind of order in the framework.

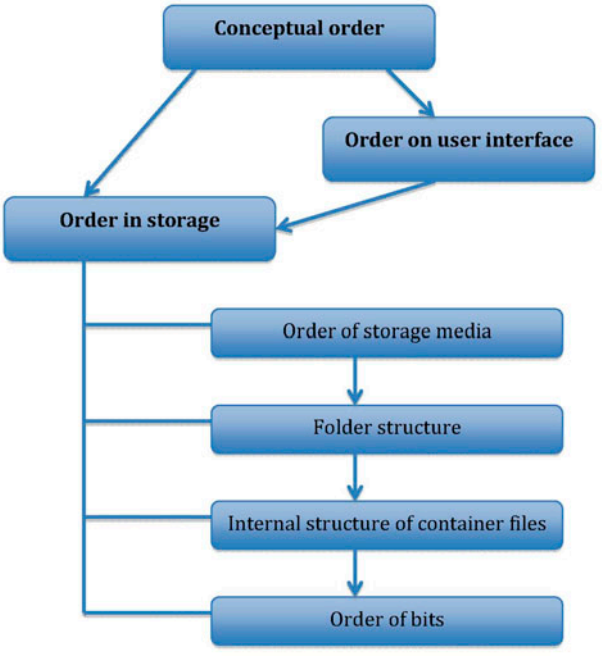

Figure 1. Vertical view of the order of electronic records.

Vertical view

Conceptual order

Records are produced during the business and activities of organisations and individuals. The records creation context, including the organisational structure, functions, activities and work processes of the records producer, dictates the conceptual relationships among records. It is these conceptual relationships that determine how a record collection should be hierarchically divided into series and sub-categories and how record units on the same levels should be arranged sequentially, that is, the sequential order among records, among series and so on. Conceptual relationships are independent of records media. They always exist whether or not they are manifested through the visible arrangement of records. In an organisation with an established records management program, the abstract conceptual relationships are often manifested through a records classification scheme, which serves as concrete guidance for the arrangement of records. Many records producers, especially individual donors, do not have formal record control. Their electronic records tend to be disorganised. As stated in the AIMS report: 'files may have been saved on whatever floppy disk was at hand, or disks may have been filled sequentially until full. In other cases, files may have been merged from other media carriers onto a new one without their original contextual arrangement.'[13] In this case, the conceptual order among the records may exist only in the brain of the records creator and is not made explicit through a records classification scheme or the arrangement of the electronic records.

Order in storage

Physical order of storage media

The conceptual order among records can be used as guidance for the arrangement of digital storage media, that is, the physical order in which the CDs, DVDs, file servers, tapes and even computers are arranged on shelves and in a storage area. Owing to their large storage capacity, one piece of digital storage media may contain a series or even a whole archival collection, rather than an individual record, therefore arranging electronic storage media often entails managing the relationships among collections or series, rather than the relationships among individual records.

When copying digital content from multiple digital storage media to one target storage medium, the original order can be respected by creating a folder structure that mimics the physical arrangement of the storage media.[14] This means copying all records originally in one storage medium into one directory within the target storage medium. This respects the physical order of the original storage media. Another approach to copying respects the functional order. Two folders from different computers may be copied to one directory in the target storage medium because they belong to the same series. For example, a record producer used computer 1 for producing professional and personal papers during the time period 1995–2000, and then used computer 2 for producing professional and personal papers during the time period 2001–06; when copying and transferring records, if the physical original order were to be respected, all records in computer 1 would be copied to one directory in the target storage medium, and all records in computer 2 would be copied to another directory in the target storage medium. If the functional original order were to be respected, the professional papers from the two computers would be copied into one directory, whereas personal papers from the two computers would be copied into another directory.

Folder structure

Within a particular digital storage medium, the folder structure shows the order in which electronic records are organised. Folder structure here includes the hierarchical structure of folders and subfolders, and the sequential order among folders and computer files. Folder structures are visible through the operating system of a computer or through some specialised file viewers, such as the software tool AccessData Forensic ToolKit (FTK). As mentioned earlier, there were debates regarding whether the directory (folder) structure reflects the relations among electronic records. The answer depends on whether the conceptual relationships among records were used as guidance for constructing the folder structure. An organisation with an established records management program may carefully construct the folder structure based on its records classification scheme, which manifests the conceptual order among records. For example, a folder is created for each records collection. Within each folder for a record collection, a subfolder is created for each series. Likewise, within each series subfolder, a lower level folder is created for each subseries, and so on. In contrast, the folder structure of a disorganised collection may be arbitrarily constructed and does not reflect the conceptual order among electronic records. In this case, preservers may reorganise digital records into a folder structure that is more consistent with the conceptual order.

In cases where the records collection contains compound electronic records that are composed of multiple computer files, some lower levels in the folder structure may be automatically created and managed by software, rather than constructed manually by records producers or preservers based on the conceptual order among records. For example, when a website record is harvested by a crawler, the multiple components of the website are automatically organised and stored onto the hard drive. The textual content of each webpage is saved into an HTML file. In addition, one folder is created for each webpage to store the images and style sheets. Another folder is created to store the Java scripts that support the structure and navigation of the website. This software-generated folder structure represents the internal order among the components of one electronic record rather than the conceptual order among different electronic records.

This internal order of an electronic record has an analogy in the paper world. A paper record, such as a letter, may contain one single page or multiple pages. One difference between the internal order of an electronic record and that of a paper record is that multiple electronic records may share the same component file. For example, a font library is shared by many word-processing records and a style sheet is shared by many XML documents. Another distinction is that some components of electronic records do not contain content; instead, they define the behaviour or the content layout in the presentation of electronic records. The codes that define font size, colour, paragraphs and page breaks of an electronic record, for instance, may be stored as a separate component file. A database is often used to produce digital equivalents of printed records, such as purchase orders and reports. In that case, there are often record templates that are stored as external files. These templates specify the structure and form of the records to be produced. Content elements are extracted from the database and then assembled following the structure specified by templates to produce records.[15] Unlike paper records, the internal relationships among multiple components of an electronic record are often managed automatically by software. Different software may render the same components and relationships slightly differently in the presentation of the electronic records. For example, the same email may be presented differently when viewed using different email client applications.[16]

Another cause of the inconsistency between conceptual order among records and the folder structure is preservation requirements. In traditional archives arrangement, the physical order of records is often not a perfect representation of the conceptual relationships among the records, because records that belong together conceptually are often separated for proper storage or preservation. For example, traditional photos and audiovisual records are stored separately from paper records that belong to the same series because they require different storage environments; maps, for instance, are stored separately owing to their large sizes. In the digital world, electronic records may be assigned to storage media and storage locations 'appropriate to their physical composition, technical characteristics, extent, and condition',[17] rather than assigned solely on the basis of conceptual relationships. In some cases, even the different components of an electronic record may be stored separately for preservation purposes. For example, email messages are often stored separately from their attachments because different types of electronic records require different preservation approaches. 'Separating the attachments from the e-mails makes it possible to use the most suitable archiving solution for each type of electronic record.'[18] When records that belong together conceptually are separated physically, they need to be conceptually integrated and described together in archival finding aids, so that users can see the conceptual relationships among the records.

Various approaches have been used to preserve the original folder structure during records transfer. At Emory University's Manuscript, Archives, and Rare Book Library, bit-by-bit forensic images are created for the whole hard drive of a computer, then an emulator is used to emulate the operating system of the computer, so that users can view the folder structure and files in their original context.[19] When a forensic image is not allowed owing to donor restrictions or other concerns, logical images can also preserve the folder structure of a computer, except unallocated spaces and deleted files. The UK Paradigm project suggests packaging files in existing directory structures using lossless compression formats, such as a .TAR or .ZIP file.[20] In addition to the selected folders, sometimes the parent folder structure needs to be captured to preserve the context and original order of electronic records. The Belgian DAVID project used two methods to record the folder structure.[21] One method automatically created XML dossier lists, which recorded the hierarchical structures of folders and subfolders through the nesting of XML elements. A second method replicated the folder structure from the root down to the level of the selected folder. In the latter method, the selected folder was copied or moved with the selected parent folder names. The Paradigm project also recommended several methods to produce a record of the original directory structure, including taking snapshots, using commands in the Windows, Linux and Unix operating systems to save the directory tree in a text file[22] or using more specialised tools such as DirPrinting and Karen's Directory Printer.[23]

For paper records, the original order may be lost when archivists rearrange disorganised records into a proper order because archivists usually do not duplicate paper records for arrangement purposes. In the digital world, the ease of duplication makes it affordable to maintain both the original and rearranged folder structure. A forensic or logical image preserves the original order. Meanwhile, an additional copy of the records can be reorganised into a meaningful folder structure. An imagined design specification for an arrangement and description tool proposed in the AIMS report requires both structures to be visible to the processing archivists: 'the original ingested accessions could be represented in a pane on the left side of the window, and the intellectual arrangement could be represented in a pane on the right side of the window'.[24] Compared with paper records, the power of computing offers more flexibility in the folder

structure of electronic records. The sequential orders among the folders and computer files can be automatically generated by computers based on the attributes (metadata) of folders and files, such as name, creation date, size and file format. Usually the order based on file or folder names is the default order. Proper naming of these computer files and folders will allow them to be sorted in a certain order. For example, if we want records to be arranged by default in alphabetical order, we can name the records based on their subjects or functions. Otherwise, if we want records to be sorted primarily in chronological order, we should name records based on their date of creation or the data range covered by the record unit.

The fact that metadata attributes of folders and files affect the order of electronic records makes it important to preserve the integrity of these metadata attributes when transferring and copying records. When files are copied across different operating systems and file systems, certain metadata attributes may be modified and thus disturb the original order. For example, Unix/Linux and Windows have different file-naming conventions. When copying files between these two systems, un-allowed characters may be deleted during the transfer.[25] Similarly, when harvested webpages are stored in a local file system, owing to the differences between the naming conventions of the file system and a URL some characters in the URL may be lost. Since the relationships among records and their components are sometimes recorded in file names, URLs or other identifiers, the loss of some characters may result in the loss of some relationship information. Also, creation dates are handled differently in Macintosh and Windows operating systems. A copy made in Windows takes on the date of the copy operation, not the creation date of the original from which it was made.[26] This may affect the chronological order of electronic records.

Internal structure of container files

One individual computer file may encapsulate a large number of electronic records. For example, an exported email file contains all email messages in an email account that includes multiple email boxes, a Web ARChive file container aggregates a large number of web records together, a database file contains many data tables, and a forensic image file created for a hard drive includes all the folders and files in the hard drive. The content of some container files can be opened by specialised software and then rearranged by preservers. For instance, once an email container file is opened with the right software, preservers can rearrange the email messages into a different folder structure. The software tool AccessData FTK Imager can be used to preview and reorganise the contents of forensic images.

For preservation purposes, sometimes the original internal structure of some container files needs to be altered. For example, proprietary databases are often converted into XML files for preservation. The DeepArc tool allows database managers to build a mapping relationship between the data model of the database and an XML schema. Based on this mapping relationship, content in the database is automatically converted into XML databases, which are suitable for long-term preservation.[27] In this process, conceptual relationships are preserved through the mapping. The Swiss Federal Archives developed the SIARD software program, which can convert proprietary databases into a file archive in a non-proprietary SIARD format. The SIARD archive retains not only the content and the metadata, but more importantly all the relations among tables.[28]

Order of bits

Computer folders and files are stored as digital bits inscribed onto digital storage media. The order of bits is determined by operating systems and file systems, software applications and the storage media, often based on availability of storage space. This order is invisible to human beings without special devices, independent of the conceptual order of electronic records, and does not contribute to the understanding of archival collections. When electronic records are copied between different file systems, converted into different file formats or migrated into different storage media, the physical order of bits is often altered. In fact, according to Kirschenbaum and colleagues, every time a file is opened and modified, the physical storage location of the bits in the file will change.[29] But this change of the order of bits is usually not a concern as long as the conceptual order and intellectual content of electronic records are preserved. In cases where the integrity of bits is a major concern, some projects use digital forensic tools to conduct bit-for-bit imaging for the entire disk, or some specific folders or files, and thus preserve the original order of electronic records to the greatest extent.[30]

Order displayed on software interface

Original order was originally a concept for the physical arrangement of records. In the digital world, the power of computing causes the distinction between order in storage and order displayed to humans on a software interface. For example, an archivist creates a tree structure to organise all the records in a collection through a software interface. Yet at the backend, the storage of the records may be dispersed in several different servers located in different places. Earlier in this paper, folder structure was listed as a layer of order in storage because it can be used to organise electronic records in a storage medium. On the other hand, compared with the physical order of bits, folder structure can also be considered as a kind of order displayed on the graphic user interface by the computer operating system. Although the folders and computer files can be automatically sorted into multiple orders on the user interface, the underlying physical order of bits does not change with these different orders of display. When records are managed and organised through the interface of a records or archives management system, the folder structure for storing the records may be automatically generated in the backend, not visible, or even not of concern to records producers or preservers, as long as the order displayed on the software interface is consistent with the conceptual order. In this scenario, compared with the order displayed on the software interface, the folder structure is a kind of order in storage. Web records can be automatically organised by a web crawler into a folder structure in storage, but when displayed in a web browser, the order is represented through the website structure and hyperlinks.

Sometimes only preserving the folder structure is not enough to preserve the original order because even though the order in storage is preserved, the order on the user interface may not be preserved appropriately. For example, in web archiving, the hyperlink structure among webpages is part of the original order and thus needs to be preserved, so that users can navigate the archived pages in a similar manner to browsing the original pages. To preserve the hyperlink structure, the absolute links that point to a web URL need to be redirected to the archived webpages. According to Masanes,[31] this redirection is achieved through two methods. First, in a web-based archive, the original URLs and links are preserved, and the link redirection or transformation happens on the fly when users access those links. Second, in a web archive that is stored in a local file system, the absolute links are modified into relative links.

Horizontal view

The above description illustrates the order of electronic records vertically from the arrangement of storage media to the order of bits in computer files. The unique features of electronic records also spawned horizontal order issues that often do not exist in the paper world. Today, archivists increasingly receive hybrid records collections that include both paper and digital records. The relationships between the paper and digital components of the same collection need to be managed. Although paper and digital components of the same hybrid records collection may be stored separately owing to their distinct storage and access requirements, their classification and organisation should be consistent. For example, in processing the records of the famous writer Salman Rushdie, Emory University Library staff assigned each digital record to a corresponding series that mirrored the series they used in the paper material: correspondence, writings, subject files, photographs and so on.[32] Consistent classification and organisation is the basis of an integrated finding aid and seamless access for paper and digital records. Archivists may also need to decide whether to retain or remove the duplicates between paper and digital records in the same collection.

As mentioned earlier, preservers often create forensic or logical images of original digital storage media received from records producers, and generate an additional copy of the digital records in order to reorganise the records into a more meaningful order. If the original file format of the digital records is not suitable for long-term preservation, preservers also need to migrate the records to a preservation format. For example, a Word document is converted to PDF or a proprietary database is converted into XML for preservation purposes. For disaster recovery purposes, preservers may need to store several copies of the preservation masters, in different locations. Each of the preservation master copies may have different versions. Many archival repositories keep the original version of electronic records after migrating them into a newer file format in case future technologies allow for better migration. When the preservation format is not suitable for online access, as in the case of TIFF images, preservers also need to create access copies of digital records. For records that are dynamically changing, such as databases and websites, preservers often take multiple snapshots for preservation. Emory University Library keeps at least five copies for its digital records: the original records which remained untouched except to recover and duplicate the initial data set; two copies in the dark archive, one stored onsite and another stored off-site; a grey archive copy that staff work with and a white archive copy that is available to researchers.[33] Managing and arranging the relationships among the multiple copies, multiple versions and multiple snapshots of electronic records is a unique issue for electronic records that did not exist in the paper world. One approach to maintaining these relationships is through the use of file names or identifiers. For example, use '12345_pm' for a preservation master and use '12345_as' for the access source copy of that preservation master.[34]

Preservers also need to manage the relationships between metadata and digital records. Metadata may be stored separately from digital records. For example, the case study reported by the Emory University Library[35] used a database and a spreadsheet to manage metadata and stored digital records in external folders. Metadata may also be packaged together with digital objects. For example, an Archival Information Package defined in the OAIS model binds content and metadata together, and a Metadata Encoding and Transmission Standard document can be used to create such packages. The user guide of the software tool UC3Merritt, created by the California Digital

Library, recommends data depositors to create a container file (.ZIP or .TAR) that includes all object component files as well as the metadata files and submit the container file to a digital repository, which will preserve metadata records together with the digital objects.[36]

As mentioned earlier, some scholars argued that metadata and indexes are kinds of order for electronic records. While this author does agree that some metadata information is used to sort electronic records directly, in many cases, metadata and indexes are used to sort metadata records instead of electronic records themselves. Two kinds of metadata are relevant for the order of electronic records. The first kind is the descriptive metadata created by preservers that describe the overall hierarchical structure and each level of record collections, such as the collection level, series level and record level. Another kind of metadata are the attributes of folders and files, some of which are automatically generated by computers, such as the creation date, size and file format; others can be assigned or modified by people, such as file names.

These two kinds of metadata are often managed separately through a two-part system, where the first kind is managed by a records or archives management system and the second kind is stored together with associated electronic records in a records repository. The first kind of metadata enables users to search the records or archives management system. When a user types in the query, a list of search results (metadata records) is returned. This list of search results can be sorted based on the metadata elements, such as title and date, into multiple orders, which are the order of metadata records instead of the order of electronic records themselves. Following the link from the metadata record to the electronic record in the records repository, users might be able to see the files and folders in the records repository. The multiple orders in which the metadata records are sorted on the search interface of the records or archives management system do not affect the order in which the electronic records are stored in the records repository. In the records repository, the metadata attributes of files and folders can be used to automatically sort electronic records into multiple orders.

In a records or archives management system, metadata can be searched owing to the indexes automatically generated based on metadata. These indexes are like the cross-referencing index cards used in a manual records management context. In a paper records management environment, paper records are arranged in paper folders, drawers and cabinets in a particular order. In addition, records managers generate several indexes to provide additional access points. For example, the paper records are arranged based on classification codes. Then two sets of index cards are created: one is sorted based on dates, and another set sorted on the basis of the records' titles. These two sets of index cards sort the cards (metadata records) instead of the records themselves. Similarly, in the digital world, computer-generated indexes do not sort the electronic records themselves; instead they sort the metadata descriptions of electronic records in additional orders and provide additional access points. These indexes do not affect the order in which electronic records are stored in the records repository, but they do affect the order in which the metadata records are searched and presented on a user interface.

Conclusion

The framework presented in this paper provides a systematic and comprehensive view of the order of digital records. It has theoretical and practical implications for the arrangement of digital records. Theoretically, it adapts the principle of original order, which is fundamental in archives management, to the digital world. Practically, it

advocates that the arrangement of digital records is much less about maintaining the physical order of storage media, and instead is more about maintaining the conceptual relationships among electronic records because the physical order of digital records often needs to be altered for storage and preservation purposes. It also reminds archivists that the arrangement of digital records is much more than keeping or reorganising the original order, because new kinds of order issues have occurred for digital records such as the co-existence of multiple orders, the arrangement of multiple copies and the multiple versions of digital records.

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