On the Preservation of Evolving Digital Content – The Continuum Approach and Relevant Metadata Models

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Abstract. We consider the preservation of digital objects in continually evolving ecosystems, for which traditional lifecycle approaches are less appropriate. Motivated by the Records Continuum theory, we define an approach that combines active life with preservation and is non-custodial, which we refer to as the continuum approach. Preserving objects and their associated environment introduces high level of complexity. We therefore describe a model-driven approach, termed the Continuum approach, in which models rather than the digital objects themselves can be analysed. In such setting, the use of appropriate metadata is very important, we therefore outline the PERICLES Linked Resource Model, an upper ontology for modelling digital ecosystems, and compare and contrast it to the Australian Government Recordkeeping Metadata Standard, developed within the record keeping community.

Keywords: Preservation · Dependency management · Ontology · LRM · Evolving content · Continuum approach

1 Introduction

In this paper, we consider the preservation of digital objects comprising a number of interdependent digital entities. Such objects are assumed to exist within a continually changing environment, which may result in them becoming unusable over time. Traditional approaches to digital preservation (e.g. OAIS [1]) are based on lifecycle models where digital objects are submitted to an archive or repository at the end of their active life. The objects are then maintained as far as possible in a reusable form, aiming to preserve both the content and state. We present two examples from media and science which illustrate when separation of preservation from active life is not feasible or desirable, and where it is required to preserve digital objects within their existing environment. We term this a continuum approach, motivated by the Record Continuum theory in the related field of record keeping [2].

In order to maintain the reusability of complex digital objects and their associated environment, it is necessary to consider risks that can occur due to changes in the environment and to determine and perform mitigating actions. In previous

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approaches, experiments are performed on representations of the digital ecosystem itself such as a sandbox. However when considering complex interdependent ecosystems, in which change can propagate across multiple entities, this approach becomes impractical. We therefore adopt a model-driven approach, where the models provide an abstract representation of essential features of the ecosystem, which can then be analysed and manipulated independently of the ecosystem itself. In such an approach, the use and organization of appropriate metadata to represent relevant information is crucial.

We introduce the PERICLES Linked Resource Model (LRM) as an abstract tool for modelling digital ecosystems. PERICLES is a four-year Integrated Project (2013-2017) funded by the European Union under its Seventh Framework Programme (ICT Call 9), which aims to address the challenge of ensuring that digital content remains accessible in an environment that is subject to continual change. We then compare and contrast the LRM with the Australian Government Recordkeeping Metadata Standard Version 2.0 [3] (AGRkMS), which has been developed based on the Records Continuum approach by the record keeping community, particularly in relation to describing digital ecosystems.

The paper is organised as follows. In section two we describe our model-driven continuum approach to preservation, and compare this to traditional lifecycle approaches. In section three we introduce, compare, and contrast the two metadata models that can be used to support this model-driven approach to preservation, namely the LRM and AGRkMS models. We present the conclusions in section four.

2 Continuum Versus Lifecycle Approaches to Digital Preservation

2.1 Lifecycle Models

Lifecycle models are a point of reference for many approaches to digital preservation. They provide a framework for describing a sequence of actions or phases such as creation, productive use, modification and disposal for the management of digital objects throughout their existence. These models suggest a linear sequence of distinct phases and activities which in practice might be non-linear or even chaotic. Lifecycle models provide an idealised abstraction of reality, and might typically be used in higher-level organisational planning and for detecting gaps in procedures. This approach has provided a basis for much research and practice in digital preservation.

The DCC lifecycle model [4] is one of the most well-known preservation-related lifecycle models. It provides a graphical, high-level overview of the stages required for successful curation and preservation of data from initial conceptualisation or receipt through the iterative curation cycle.

The UK Data Archive describes a research data lifecycle [5]. It comprises six sequential activities and, unlike the DCC model, it is more focused on the data user's perspective. Overviews of lifecycle models for research data are provided by Ball [6] and the CEOS Working Group on Data Life Cycle Models and Concepts [7].

So-called lifecycle approaches typically envisage a clear distinction between active life and end-of-active life. The Open Archival Information System (OAIS) [1] is a commonly adopted reference model for an archive, consisting of an organisation of people and systems that has accepted the responsibility to preserve information and make it available for a designated community. The focus of OAIS is therefore on "long term", being also concerned with the impacts of changing technologies, including support for new media and data formats, but also changing user communities.

The PLANETS project developed a functional model [8] and an associated test bed that demonstrate how certain types of external change can be managed within the setting of an OAIS compliant archive. The basic principle is to monitor and detect external change, to conduct experiments on a representative sample of the entities within a sandbox to determine the impact of potential mitigating actions (e.g. migration or emulation), and to implement the proposed actions. Such actions should preserve a pre-defined set of properties considered important by user communities in characterising the content (often termed significant properties [9]). A major focus in PLANETS and in related projects was on document formats. This overall approach has been extended by many other projects such as SCAPE[1]and CASPAR[2]. We will refer to the principle of adapting content in a changing environment to enable future reuse as "dynamic" preservation.

2.2 Continuum Approaches

Continuum approaches combine two main aspects. Firstly, there is no distinction made between active life and end-of-active life; that is, preservation is fully integrated into the active life of the digital objects. A second aspect is that preservation is non-custodial, that is we do not aim to remove entities from their environment, both physical and organisational and place them in the custody of a third party.

Continuum approaches have been proposed in the related field of record keeping. A record is defined as something that represents proof of existence[3]. Records can either be created or received by an organisation in pursuance of or compliance with legal obligations, or in the transaction of business [10]. An essential aspect is that the content and structure of a record are fixed, but the surrounding context can change over time. Thus a record is "always in a state of becoming" [2]. This is in marked contrast to archival theory, which aims to preserve not only content but also state.

The Records Continuum (RC) was originally proposed by Upward in 1996 [11]. Despite this, it is only relatively recently that attempts have been made at practical implementation of these ideas. This has occurred primarily at institutions in Australia. The Australian Government Recordkeeping Metadata Standard Version 2.0 [3] (AGRkMS) adopts a number of RC concepts. The corresponding metadata model represents "information about records and the contexts in which they are captured and used". This is a static representation that cannot adapt to changing context.

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1 http://www.scape-project.eu/

2 http://cordis.europa.eu/project/rcn/92920_en.html

3 http://en.wikipedia.org/wiki/Records_management

2.3 Example: Software -Based Art

In this sub-section, we provide a concrete example to illustrate the applicability of the continuum approach from the PERICLES Media case study, provided by Tate. Software-based art (SBA) includes self-contained or networked systems, where the functionality depends on external data or services. Works can be written in different programming languages with different configurations of hardware and proprietary and open source software.

SBAs are often based on emerging computing technology, with which artists explore the potential for creating new and innovative works. Due to the rapid pace of technological advances, the hardware and software platforms on which these works are constructed rapidly become obsolete, which poses a major challenge for longer term preservation. The artist's intent is often a major factor in determining the conservation strategy for SBAs. In some cases, artists will specify for instance a specific type of display technology for viewing the artwork, such as a CRT device. In other cases, the artist provides no specification of their intent, and in such cases it is left to the discretion of the conservator to determine the most appropriate form of display.

There is often a requirement to display artworks in different exhibitions, which have varying physical and technical constraints. For instance some artworks make use of an internet connection to display live data from the internet. However, it may be desirable in some cases to operate an artwork from locally cached data. This would require modification to the underlying software. Unlike traditional artworks, there is not one definitive physical object to preserve. SBAs can exist in multiple versions, with varying claims of authenticity. Indeed without appropriate provenance information or information about the artist intent, it is often difficult to determine which versions can be considered as the most faithful representation.

To summarise, when considering SBAs, there is no clear final state of the data. Indeed the works are in a state of continuous evolution as changing technology requires updates to be made to deal with technological obsolescence, both to allow continuing access (e.g. by scholars) as well as display at public exhibitions. If these works are viewed as sufficiently valuable to be retained for long timeframes, and resources allow, then they will need to be updated indefinitely. Despite the need for preserving and conserving a large number of digital artefacts, it is not clear that a repository or archive in the traditional sense is the most appropriate solution. An organisation such as a gallery or a museum is involved both in acquiring and conserving artworks, whilst at the same time supporting their active use.

3 Metadata Models for the Continuum Approach

3.1 PERICLES Linked Resource Model

The Linked Resource Model (LRM) is an upper level ontology designed to provide a principled way to modelling evolving ecosystems, focusing on aspects related to the changes taking place. At its core the LRM defines the ecosystem by means of participating entities and dependencies between them. A set of other properties and specialised entity types are also provided but they are all conditioned on what is allowed/required by the *change management* policy. The main concepts of the LRM are illustrated in Fig. 1 (the prefix `pk` refers to the LRM namespace) and discussed below.

Resource. Represents any physical, digital, conceptual, or other kind of entity and in general comprises all things in the universe of discourse of the LRM Model[4]. A resource can be *Abstract* (c.f. `AbstractResource` in Fig. 1), representing the abstract part of a resource, for instance the idea or concept of an artwork, or *Concrete* (c.f. `ConcreteResource` in Fig. 1), representing the part of an entity that has a physical extension and can therefore be accessed at a specific location (a corresponding attribute called location is used to specify spatial information; for instance for a `DigitalResource`, which represents objects with a digital extension, this information can be the URL required to retrieve and download the corresponding bit stream). The above two concepts can be used together to describe a resource; for example, both the very idea of an artwork, as referred by papers talking about the artist's intention behind the created object, and the corresponding video stream that one can load and play in order to manifest and perceive the artwork. To achieve that, the abstract and concrete resources can be related through a specific `realizedAs` predicate, which in the above example could be used to express that the video file is a concrete realization of the abstract art piece.

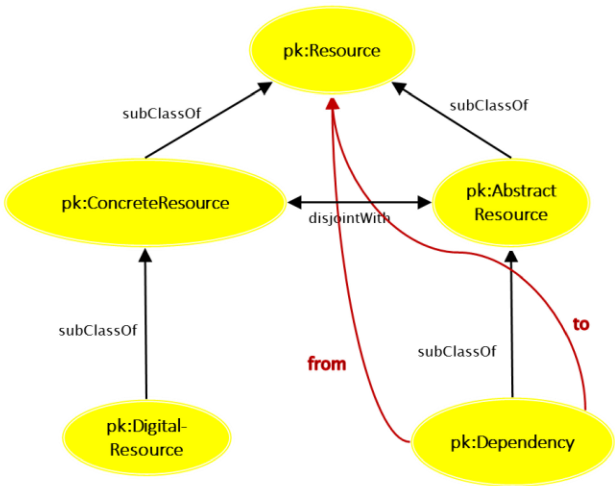

Fig. 1. Part of the core LRM ontology.

Dependency. The core concept of the static LRM is that of *dependency*. An LRM `Dependency` describes the context under which change to one or more entities has an impact on other entities of the ecosystem. The description of a dependency minimally includes the intent or purpose related to the corresponding usage of the involved

[4] This definition is close to CIDOC CRM's Entity [12] – we are also exploring other possible mappings [13].

entities. The topology of a dependency is potentially higher than a binary relation, as it can relate several dependees to several dependent resources. From a functional perspective, we expect that dedicated policies/rules will further refine the context (e.g. conditions, time constraints, impact) under which change is to be interpreted for a given type of dependency.

To enable recording the intent of a dependency, we can relate in the LRM the Dependency entity with an entity that describes the intent formally or informally via a property that we name “intention”, as illustrated in Fig. 2. In Fig. 2 the “from” and “to” properties indicate the directionality of the dependency.

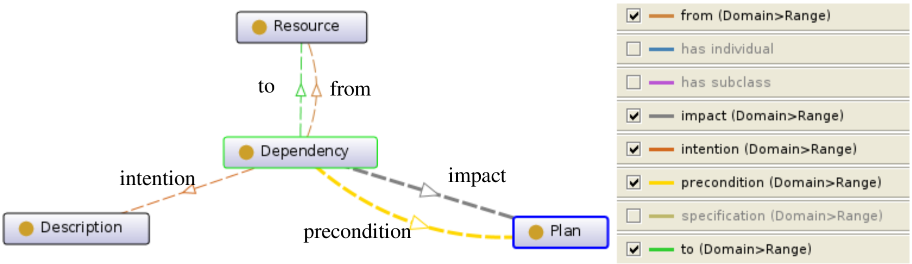

Fig. 2. A view of the Dependency concept in LRM

Plan. The condition(s) and impact(s) of a change operation are connected to the `Dependency` concept in LRM via `precondition` and `impact` properties as illustrated in Fig. 2. These connect a `Dependency` to a `Plan`, which represents a set of actions or steps to be executed by someone/something (either human or software). The Plan can be used, thus, as a means of giving operational semantics to dependencies. Plans can describe how preconditions and impacts are checked and implemented (this could be for example defined via a formal rule-based language, such as SWRL [14]. The temporally coordinated execution of plans can be modelled via activities.

Activity. The `Activity` class has a start and/or end time, or a duration. An `Event` class is used to situate events in terms of activities. An activity is something that occurs over a period of time and, via events, acts upon or influences entities. Finally, a resource that performs an activity, i.e. is the “bearer” of change in the ecosystem, either human or man-made (e.g. software), is represented by a class called `Agent`.

3.2 Australian Government Recordkeeping Metadata Standard

The AGRkMS is designed to provide the necessary metadata that will help ensuring that records remain accessible and usable over time. The AGRkMS standard defines five different entity types, Record (e.g. electronic documents), Agent (e.g. people), Business (e.g. the functions and activities of what an organisation does), Mandate (e.g. policies), and Relationship (e.g. information about the relationship between a record and an agent) [15]. Definitions and detailed description of all entity types can be found in [3], [15].

3.3 On the Relation of the AGRkMS to the PERICLES LRM

As mentioned in the previous paragraphs, the AGRkMS focuses on the accessibility and utility of records over time, while the LRM aims at modelling how changes to the ecosystem, and their impact, can be captured. The above difference is also reflected in the models themselves: while the AGRkMS meta-model introduces a number of constructs for recording provenance, current and past relationships among specific types of entities, and a number of metadata to describe security, authentication, and licensing related aspects, the LRM concentrates on notions that can help in characterising change. Naturally, therefore, the LRM does not define in great detail the metadata required for domain-specific purposes but rather focuses on the main concepts and structures that allow change to be recorded and acted upon, including operational notions.

Another important aspect of the LRM stems from the nature of the relation that it has to the notion of policy (which seems to correspond in some aspects to the notion of Mandate in AGRkMS). A policy governs at all times the dynamic aspects related to changes (e.g. conditions required for a change to happen and/or impact of changes). As a consequence, the properties of the LRM are dependent on the policy being applied, and therefore most of the defined concepts are related to what the policy expects. The LRM therefore at its core is only assuming the ecosystem is described by means of entities and dependencies between these. A set of other properties and specialised entity types are also provided but they are all conditioned on what is allowed/required by the policy.

Entities and Implementation Approaches. The AGRkMS supports two different approaches to instantiating its core entities (c.f. 3.2).

- Single-entity implementation: Only records are modelled as entities (typed using the Record class), while the rest are modelled as properties of a record.
- Multiple-entity implementation: More than one of the core types is modelled as an entity. For example specific instances can use two entities (Record and Agent), three entities (e.g. Record, Agent, and Relationship), or all five entities.

As mentioned in [15] a multiple-entity implementation is recommended. That is because, among other reasons, a single-entity approach implies significant simplification of metadata for all other entities except for Record and has limited ability to record and trace changes to the rest of the entities (more detailed comparison between the two approaches can be found in [15]).

On the other hand, the LRM is mainly centered to the notion of dependency and domain-specific entity types can be represented by domain-specific LRM instantiations that specialise the core entities presented in section 3.1. For instance, the physical extension of a record can be represented as an instance of the ConcreteResource class (or DigitalResource class if the record is in digital form) in the LRM, while the AGkRMS Agent concept can be mapped to the LRM Agent class enabling explicit representation of the activities that the agent carries out. When compared to the two implementations of the AGRkMS standard, an approach implementing the LRM is closer to the multiple-entity implementation. Single-entity implementations are not supported, as change is modelled in term of the relations between different entities.

On the Notions of Relationship and Dependency. In AGRkMS a Relationship is defined as an entity that "provides the means of linking records to their business context, not only at creation, but also with continued use and management of the records over time" [15].

The Relationship entity, we believe, is therefore extremely useful as it links two or more entities together in time and context. The following example extracted from [15, pp. 52-53] illustrates how this can be done (Fig. 3).

"Consider a digital record item — a document containing a set of diagrams — that has been created using the Microsoft Visio 2000 drawing application. The organisation is about to implement a new corporate drawing package to replace MS Visio 2000. The work group who created the set of diagrams wants to be able to continue accessing (but not editing) the diagrams created using MS Visio 2000. Therefore, the work group has decided to convert these diagrams to JPEG format. Example 15 shows the metadata required to describe this conversion using the Relationship entity: the Agent entity A (a 'Person' — someone from the work group) 'Converts' (Relationship — entity B) the Record entity C (an 'Item' — the Microsoft Visio 2000 drawing) to the new format." [15, pp. 52-53].

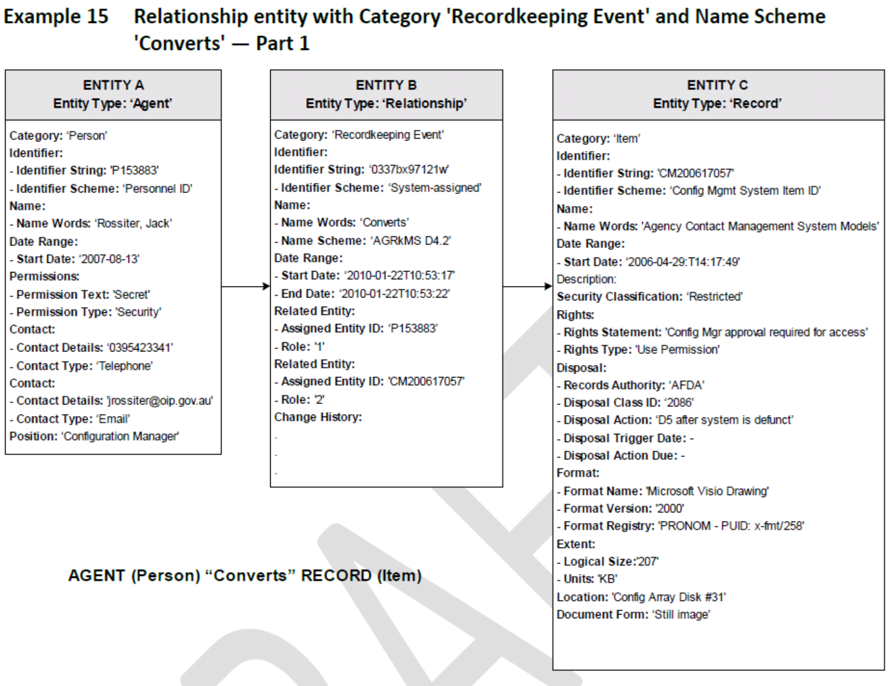

Fig. 3. Example from the Records Continuum meta-model documentation

The Relationship entity, as presented above, shares a number of similarities to the notion of Dependency as defined by the LRM model (c.f. 3.1). Take for instance the same example described above but with the assumption that MS Visio is not about to be replaced by another tool but that a corresponding policy defines that MS Visio drawings should be periodically backed up as JPEG objects by the specific work group. The Relationship entity contains a number of important metadata already describing each Conversion in terms of its temporal information and the entities it involves along with their roles in the relationship (i.e. Person making the conversion and object being converted). The same information can be expressed also by LRM dependencies. The main difference is that the LRM dependency is strictly connected to the intention underlying a specific change.

In the case described here the intent may be described as "The work group who created the set of diagrams wants to be able to access (but not edit) the diagrams created using MS Visio 2000. Therefore, the work group has decided to convert these diagrams to JPEG format" and it implies the following.

- There is an explicit dependency between the MS Visio and the JPEG objects. More specifically, the JPEG objects are depending on the MS Visio ones. This means that if an MS Visio object MS1 is converted to a JPEG object JPEG1 and the MS1 is edited before the transfer to the new drawing package then JPEG1 should either be updated accordingly or another JPEG object JPEG2 should be generated and JPEG1 optionally deleted (the description is not explicit enough here to decide which of the two actions should be performed). This dependency would be especially useful in a scenario where MS Visio keeps on being used for some time in parallel to the JPEG entities being used as back up.
- The dependency between MS1 and JPEG1 is unidirectional. Actually JPEG objects are not allowed to be edited and if they are, no change to the corresponding MS Visio objects should apply.
- The dependency applies to the specific work group, which means that if a Person from another work group modifies one of the MS Visio objects, no specific conversion action has to be taken (the action should be defined by the corresponding Policy). This is partly captured by the Permissions, Rights, and Security Classification related properties of the Agent and Record entities.

Operational Aspects. The AGRkMS metamodel via the Relationship concept, in addition to information we saw above, allows information about who or what carried out the change (viewed as an "event" in AGRkMS), but also who or what authorised it, the effects it had, and any resulting actions.

The LRM model aims in addition to such descriptive information to also provide concepts that will allow to record operational information such as what are the conditions under which a change is triggered and what is the possible impact of this change on other entities. Let us take once more the example above: we need to be able to express the fact that a transformation to the JPEG is possible only if the corresponding MS Visio object exists (which corresponds to an existential constraint) and if the Human that triggers the Conversion has the required Permissions to do that (e.g. belongs to the specific workgroup). The impact of the Conversion (generating a new JPEG object) could also be conditioned on the existence of a corresponding JPEG object containing an older version of the MS Visio object. The actions to be undertaken in that case, would be decided based on the policy governing the specific operation. Assuming that only the most recent JPEG object must be archived, the old one must be deleted and replaced by the new one (conversely deciding to keep the old JPEG object as well may imply having to archive the old version of the corresponding old MS Visio object as well).

As explained in section 3.1 the condition(s) and impact(s) of a change operation are connected to the Dependency concept in LRM via "precondition" and "impact" properties (Fig. 2) and can be used to give operational semantics to dependencies.

Events. The Relationship entity in the AGRkMS meta-model describes events that take place and/or provenance relationships. According to [15], recordkeeping event relationships can also be scheduled for the future, providing a way of triggering these events automatically something that is delegated to the specific infrastructure of the organization/company adopting the AGRkMS meta-model.

Events in LRM have a different status. They are the concepts that allow the LRM to record and plan how stimuli received from the external world and/or from the system itself should be interpreted. Events in the LRM are like instantaneous messages that trigger a change to the system. Events can trigger activities. An activity is something that occurs over a period of time and, via events, acts upon or influences entities. Using this model, the LRM makes a fine-grained separation of the entities involved in the triggering of a change. For example, being able to record external events that led to a change in regulations and consequently to the policies governing the set of entities.

4 Conclusions

We have defined a continuum approach to preservation that integrates preservation processes into the active life of content to deal with digital objects within continually evolving environments. We have also provided examples where this approach is more appropriate than traditional lifecycle approaches. Dealing with the environment on which digital objects are dependent introduces additional complexity. Following a model-driven approach, we have defined an ontology termed the Linked Resource Model to model evolving ecosystems that aim to deal with this issue by providing an abstract representation.

Continuum approaches have been proposed in the parallel field of record keeping. The AGRkMS meta-model provides a static representation of ecosystems, but we conclude that it is not sufficient for modelling evolving ecosystems, the primary purpose of the LRM. Indeed the models are complementary in several important aspects.

The AGRkMS meta-model describes in detail a large set of metadata that can be useful for the LRM. (For now we have identified the notions of Roles, Identifier Schemes and Security and Permissions-related properties as candidates for integration). When designing the LRM we decided to delegate the definition of domain-specific properties and metadata to domain-specific instantiations/specialisations. The RC meta-model can be used to enrich the LRM ontology in that vain.

The LRM treats in detail the notions related to change and its propagation. We believe that the LRM could extend relevant aspects of the RC meta-model related to how change is not only recorded but also acted upon. The LRM concepts related to operational aspects of change could be of interest for the AGRkMS meta-model.

The study presented in this paper is based on a limited number of examples. We plan to further validate our conclusions in the context of PERICLES, based on use cases of real-world complexity, and explore other aspects related to the LRM, such as how much overhead is required for the continuum approach and the LRM model to be implemented. We believe though that the benefits of a principled approach to metadata modelling, as proposed by the LRM model, could lead to a number of useful functionalities, at least in the setting considered here, such as risk analysis, certified information integrity (via provenance recording), and impact-based recommendations.

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References

1. CCSDS - Consultative Committee for Space Data Systems: Reference Model for an Open Archival Information System (OAIS), Recommended Practice, CCSDS 650.0-M-2 (Magenta Book) (2) (2012)
2. McKemmish, S.: Placing records continuum theory and practice. Archival Science **1**(4), 333–359 (2001)
3. National Archives of Australia: Australian Government Recordkeeping Metadata Standard Version 2.0 (2008). http://www.naa.gov.au/Images/AGRkMS_tcm16-47131.pdf (accessed on May 28, 2015)
4. Higgins, S.: The DCC Curation Lifecycle Model. International Journal of Digital Curation **3**(1), 134–40 (2008). http://ijdc.net/index.php/ijdc/article/view/69 (accessed on May 28, 2015)
5. UK Data Archive. Research Data Lifecycle. http://www.data-archive.ac.uk/create-manage/life-cycle (accessed on May 28, 2015)
6. Ball, A.: Review of Data Management Lifecycle Models (version 1.0). REDm-MED Project Document redm1rep120110ab10. Bath, UK: University of Bath (2012). http://opus.bath.ac.uk/28587/1/redm1rep120110ab10.pdf (accessed on May 28, 2015)
7. Committee on Earth Observation Satellites Working Group on Information systems and Services (WGISS): Data Life Cycle Models and Concepts CEOS 1.2 (2012). http://ceos.org/document_management/Working_Groups/WGISS/Interest_Groups/Data_Stewardship/White_Papers/WGISS_DSIG_Data-Lifecycle-Models-And-Concepts-v13-1_Apr2012.docx (accessed on May 28, 2015)
8. Sierman, B., Wheatley, P.: PLANETS. D3-4 Report on the Planets Functional Model (2009). http://www.planets-project.eu/docs/reports/Planets_PP7-D3-4_ReportOnThePlanetsFunctionalModel.pdf (accessed on May 28, 2015)
9. Wilson, A.: Significant Properties Report (2007). http://www.significantproperties.org.uk/wp22_significant_properties.pdf (accessed on May 28, 2015)
10. ARMA International: Glossary of Records and Information Management Terms, 4th edn. ARMA International. ISBN: 978-1-933654-15-4

11. Upward, F.: Structuring the records continuum (Series of two parts) Part 1: post custodial principles and properties. Archives and Manuscripts **24**(2), 268–285 (1996). http://www.infotech.monash.edu.au/research/groups/rcrg/publications/recordscontinuum-fupp1.html (accessed on May 28, 2015)
12. Doerr, M.: The CIDOC CRM, an ontological approach to schema heterogeneity. In: Semantic Interoperability and Integration, vol. 4391 (2005)
13. Vion-Dury, J.-Y., Lagos, N., Kontopoulos, E., Riga, M., Mitzias, P., Meditskos, G., Waddington, S., Laurenson, P., Kompatsiaris, Y.: Designing for inconsistency – the dependency-based PERICLES approach. In: Proceedings of SW4CH Workshop in Advances in Intelligent Systems and Computing (to appear, 2015)
14. Horrocks, I., Patel-Schneider, P.F., Boley, H., Tabet, S., Grosof, B., Dean, M.: SWRL: A Semantic Web Rule Language Combining OWL and RuleML. W3C Member Submission (2004). http://www.w3.org/Submission/SWRL/ (accessed on May 28, 2015)
15. National Archives of Australia: Australian Government Recordkeeping Metadata Standard Version 2.0 Implementation Guidelines: Exposure Draft (2010). http://www.naa.gov.au/Images/AGRkMS-guidelines_tcm16-47133.pdf (accessed on May 28, 2015)

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