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Diachronic and Synchronic Indexing: Modeling Conceptual Change in Indexing Languages

Abstract: This paper outlines a model of conceptual change in indexing languages. Findings from this modeling effort point to three ways meaning and relationships are established and then change in an indexing language. These ways: structural, terminological, and textual point to ways indexing language metadata can aid in managing conceptual change in indexing languages.

Résumé : Cette communication esquisse un modèle du changement conceptuel des langages d'indexation. Les résultats de cette tentative de modélisation convergent vers une triple dimension. Les relations sont établies, puis modifiées dans un langage d'indexation. Ces dimensions, structurelle, terminologique et textuelle, indiquent de quelle manière les langages de métadonnées peuvent contribuer à la gestion du changement conceptuel des langages d'indexation.

1. Introduction

Indexing languages represent concepts in a domain. However domains evolve, and thereby change their terminology and conceptual structures. Indexing languages in turn adapt to this change in terminology and conceptual structure. In the print world, this has required at least two types of adaptation: annotation and revision. Indexers have traditionally made *annotations* to represent this change, and editors have traditionally made *revisions* to indexing languages. Indexers applying in-house policy changes through annotation make notes in schedules on which term to use and what they mean locally. An example of this is the Vancouver Public Library working from three annotated versions of the Dewey Decimal Classification scheme (DDC). On the other hand, editors of indexing languages adapt through revision. Once revision is complete, they issue a new edition of the indexing language. The process then continues with indexers adopting the new edition, and possibly making annotations to their indexing practice. DDC, as a work, started in 1876. It has been revised and annotated since that time; it is now in its 22nd edition.

If the purposes of an indexing language are to identify concepts and collocate all documents that deal with those concepts, then any adaptation, as defined above, affects these purposes. Thus, if we shift a classification number we shift shelf-arrangement. If we shift terminology we shift display, thereby confounding collocation. The problem is compounded when we think of completely digital systems existing through more than a hundred years of change. How can we pull together documents on biological notions of eugenics, if the concept is no longer represented in an indexing language? How could we do this in 200 years' time? In order to accommodate this long-term need we must model change in indexing languages in order to design and implement systems that accommodate this kind of adaptation. We need a model of diachronic indexing.

In order to understand diachronic indexing we must model revisions to indexing languages. What kinds of changes have occurred? How can we account for them in order to make these changes machine-readable? In order to answer these questions and

build a model that will allow us to better predict these changes and make them explicitly machine-readable, we need to look at how revision is carried out and recorded through successive editions of indexing languages.

2. Research Design

Starting from and using the concept of revision, I examine a single indexing language, DDC, as an exemplar. I investigate changes to concepts by (1) examining structures for the management of concepts in indexing languages and by (2) examining change of a sample concept through a long history of an indexing language. This analytical and empirical analysis is supplemented by literature discussing indexing language revision. The result is a model of diachronic indexing – illustrating how concepts in indexing languages change over time through adaptation (annotation and revision), and how indexing language metadata should accommodate such change.

2.1. Definitions

Indexing languages are controlled vocabularies or classification systems and the rules for their application (ANSI/NISO, 1993; 2005; ISO 5127/1, 1983). An editor makes *revisions* of an indexing language based on, among other things, notes in records for concepts (which are represented through terms or classes). Both annotation and revision are *adaptations* to the indexing language. Three things change in the indexing language: the concept, a term or class (depending on if it is a controlled vocabulary or a classification system), or any attribute of the concept. Attributes of concepts are recorded in *concept descriptions*.

2.3. Epistemic Stance

This research comes from a neo-pragmatic stance (Rorty, 1982; 1999), which claims that the objects of study are part of a textual conception of knowledge that offer themselves to a textual interpretation. It is an anti-essentialist approach to knowledge organization.

3. Diachrony and Synchrony in Indexing

A diachronic indexing model, a model of indexing over time, can only be described in relation to a synchronic model of indexing, where we understand the indexing process at one point in time. That is, in order to establish the apparatus of change, we must establish assumptions in stasis. Such a view of indexing can be constructed from a composite narrative of concept descriptions, which comprise: concept records (Soergel, 1974; ANSI/NISO 2005), classification formats (Library of Congress, 2005; UDCC, 2003), knowledge organization transfer encodings (Miles and Brickley, 2005).

3.1. Synchronic Indexing and Concept Descriptions

Indexing requires that the indexer understand the concept that is appropriate to use. Meaning of a concept is constrained by scope notes, definitions, and/or relationships to other concepts. These definitions and relationships are attributes of a concept, and are formalized in concept descriptions. There are three types of concept description considered here: the concept record, classification format, and transfer encoding. The concept record is a tool used in constructing indexing languages, and presents the concept, its relationship to other concepts, a definition, and other administrative information relevant to managing the concept in a particular indexing language (see Figure 1). Classification formats and transfer encodings are similar. They are all statements, at one point in time, of the nature of a concept in an indexing language. For

example the concept record used in building a thesaurus would identify the preferred term, its relationship to other terms in the thesaurus, scope notes, and administrative data including source of term and who proposed it. Classification formats identify similar information: classification number, how it is constructed from schedules, scope notes, and administrative information (Figures 2 and 3). Transfer encodings capture similar information (Figure 4). These descriptions define the concept and its relationship to other concepts in the indexing language – at one point in time – hence they are synchronic.

01. Hierarchical Level	01. When terms are later sorted into hierarchies, based on BT and NT descriptors, each term will fall at a particular hierarchical level.
02. Type: DS, OP, NP, EL, CH	02. These codes indicate the current status of the main term in field 10: DS=descriptor (authorized term); OP=other preferred term (but not adopted as an authorized descriptor); NP=non-preferred term; EL=eliminate term; CH=change term information.
03. Subject Field	03. In order to find different terms indicating the same, or essentially the same concept, terms must be sorted conceptually. The subject field is the first large category for conceptual sorting. For faceted thesauri, these first level categories will be the main facets.
05. Notation	05. Later, when cards are sorted into final conceptual order, a notation can be assigned to maintain this order.
10. MT	10. This is the main term for this card. All the information on the card will relate to this term.
12. Standard Abbreviation	12. A standard abbreviation for a term is often helpful to indexers, who can use it to save time. Later, before an index is prepared for users, most abbreviations would be expanded to the full standard form. (Abbreviations can be the standard form when they are better known, as with acronyms such as "radar" and "Unesco.")
20. Variant Spellings	20. Variant spellings go here (as well as variant abbreviations).
30. Synonymous Terms (ST), including Equivalent Terms (ET)	30. Synonymous and equivalent terms go here.
40. Classification 42. Category (CA)	40./42. This field can be used for finer categorization within the broad subject field, noted in field 03.
44. Broader Terms (BT)	44. Broader terms go here.
45. Narrower Terms	45. Narrower terms go here.
46. Related Terms	46. Related terms go here.
50. Translations	50. If the thesaurus is to be multilingual, than the equivalent terms in others languages go here.
60. Definition, Scope Note	60. A definition of the term, if needed, or a scope note explaining the usage of the term in the indexing language, goes here.
65. Sources/Authorities	65. Here is recorded the source of the term, or the authority for the definition/scope note.
70. Unspecified Relation (UN)	70. Any terms whose relationship to the main term has not yet been determined can go here.
81. Editor/Date	81. The name or initials of the thesaurus editor, plus the date, go here.

Figure 1. Concept Record as depicted by Anderson and Perez-Carballo (2005 p. 316-7).

Tag	Scope	Definition/Narrative
008	Fixed-Length Data Elements	Fourteen character positions (00-13) that contain positionally-defined data elements that provide coded information about the record as a whole or about special aspects of the 1XX classification number or explanatory index term field. Each character position must contain either a defined code or a fill character (|).
084	Classification Scheme and Edition	Information that identifies the classification scheme used to formulate the number caption in field 153 (Classification Number).
153	Classification Number	Classification numbers that are constructed according to the classification scheme that is identified in field 084 (Classification Scheme and Edition). This field may contain a single classification number (008/07, Type of number, code a) or a span of classification numbers (008/07, code b or c) from a schedule (008/06, Kind of record, code a) or from a table (008/06, code b) and its associated caption (subfield $j) and caption hierarchy (subfields $h and $k). The subject context of the classification number is indicated by the preceding hierarchy captions contained in repeatable subfields $h and $k. (Field 153 must contain at least one subfield $a and one subfield $j.)
154	General Explanatory Index Term	A general explanatory term from the index to the classification scheme that is identified in field 084 (Classification Scheme and Edition). Field 154 is appropriate only in an index term record (008/06, Kind of record, code c) that is created because the index term cannot be accommodated in a 70X-75X Index Term field in a schedule or table record (008/06, code a or b) that contains a classification number in field 153 (Classification Number). This occurs when the index term is not associated with one classification number or span. Field 753 (Index Term-Uncontrolled) is always used in a record containing field 154 to direct the user to different locations within the classification scheme for classifying the topic.
253	Complex See Reference	Complex see references contain explanatory text and classification numbers referred to when the relationship that exists between classification numbers cannot be adequately conveyed using simple cross references. In the MARC 21 classification format, only one Complex See Reference field is currently defined. The explanatory text and the Classification number referred to that are required when a see reference relationship exists between classification numbers that cannot be adequately conveyed by one or more simple cross references generated from a 453 or 553 tracing field.
453	Invalid Number Tracing	A tracing for a cross reference from an invalid classification number.
553	Valid Tracing Number	A tracing for a cross reference from one valid classification number to another valid classification number. If the classification number in the tracing is valid for some topics but invalid for others, this field is used, and the topics that refer to another number are specified in subfield $t (Topic).
680	Scope Note	Information about the classification number or number span in field 153 (Classification Number) that describes its scope in the scheme identified in field 084 (Classification Schedule and Edition).
683	Application Instruction Note	Instructions for applying tables, subarrangements, or additions to classification numbers.
684	Auxiliary Instruction Note	Information from, or reference to, a section of a classifier's manual or other documentation. An auxiliary instruction note provides advice for classifying in difficult areas, and describes policies and practices that may accompany a classification schedule.
685	History Note	Information about the history of the use and meaning of a classification number that is contained either in a 153 classification number field or in a 453/553 tracing field with subfield $w/3, Control subfield, code a.
753	Index Term – Uncontrolled	Uncontrolled subject access terms that provide subject access to a classification number or span in field 153 (Classification number) or an index term in field 154 (General Explanatory Index Term).
761	Add or Divide-like Instructions	Information necessary to construct a classification number by adding numbers from other parts of a schedule or from a table or by basing it on numbers defined in other part of a schedule (dividing it the way numbers in other parts of the schedule are divided).
765	Synthesized Number Components	Information about how a synthesized number or a portion of a synthesized number was built. It traces the different components of a synthesized number, showing the different portions of the number and where the add instructions are given. If a number was built using two or more instructions, a separate field 765 is given for each instruction. The information in this field is primarily intended to serve as a tracing of how classification numbers are synthesized to assist classifiers. It facilitates computer manipulation of synthesized numbers, both for validation that the numbers have been synthesized correctly and for index-building, to allow searching every use of a specific number.

Figure 2. Select sample of Fields from the MARC 21 Classification Format

FIELD 001 - UDC Number
FIELD 002 - Table
FIELD 003 - Type of special auxiliary
FIELD 004 - Combination type
FIELD 010 - Parallel derivation
FIELD 011 - Instruction for parallel division
FIELD 012 - Special auxiliary supplied by parallel division
FIELD 013 - Special auxiliary supplied by annotation
FIELD 100 - Description
FIELD 105 - Verbal examples
FIELD 110 - Scope note
FIELD 111 - Application note
FIELD 115 - Examples of combination
FIELD 120 - Examples of parallel division
FIELD 125 - References
[900s Administration]
[FIELDS 901, 903, 904 – Introduction]
FIELD 901 – Date of Introduction
FIELD 903 – Source
FIELD 904 – Comments
[FIELDS 911, 912, 913, 914 – Cancellation]
FIELD 911 – Date of cancellation
FIELD 912 – Replacing UDC notation (if any)
FIELD 913 – Source of cancellation
FIELD 914 – Comments
[FIELDS 921-5 – Revision]
FIELD 921 – Date of last revision
FIELD 922 – Field(s) revised.
FIELD 923 – Source
FIELD 924 – Comments
FIELD 925 History
FIELD 951 - Index only UDC notations
FIELD 952 - Use special characters
FIELD 955 - Editorial annotations
FIELD 957 - Administrative notes
FIELD 958 - For next Expansion & Correction

Figure 3. Fields used in the UDC Master Reference File (UDCC, 2003).

```
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:skos="http://www.w3.org/2004/02/skos/core#">

    <skos:Concept rdf:about="http://www.ukat.org.uk/thesaurus/concept/1750">
       <skos:prefLabel>Economic cooperation</skos:prefLabel>
       <skos:altLabel>Economic co-operation</skos:altLabel>
       <skos:scopeNote>Includes cooperative measures in banking, trade, industry etc.,
         between and among countries.</skos:scopeNote>
       <skos:broader rdf:resource="http://www.ukat.org.uk/thesaurus/concept/4382"/>
       <skos:narrower rdf:resource="http://www.ukat.org.uk/thesaurus/concept/2108"/>
       <skos:narrower rdf:resource="http://www.ukat.org.uk/thesaurus/concept/9505"/>
       <skos:narrower rdf:resource="http://www.ukat.org.uk/thesaurus/concept/15053"/>
       <skos:narrower rdf:resource="http://www.ukat.org.uk/thesaurus/concept/18987"/>
       <skos:related rdf:resource="http://www.ukat.org.uk/thesaurus/concept/3250"/>
       <skos:inScheme rdf:resource="http://www.ukat.org.uk/thesaurus"/>
    </skos:Concept>
</rdf:RDF>
```

Figure 4. Transfer encoding of a concept (economic cooperation) using SKOS (Miles, 2005).

There are similarities and differences that obtain between these types of concept descriptions. Some are used to create indexing languages, like concept records. Others, like the classification formats, are intended to be used for decision-making in indexing. As a result, the latter contain more information on how to apply the representation of concepts (in this case, classification numbers). They do not focus on the creation and management of concepts in an indexing language (like the concept records). Thus, they differ in intent.

The similarities are useful for understanding both synchronic and diachronic indexing. Each of these types of descriptions can be used in managing revision. For example, the UDC Master Reference File (Figure 3) provides space for the editor of UDC to make comments about what should change in the next revision. Similarly, MARC21 Classification Format and UNIMARC Classification Format provide history notes and other references that are used to situate the current application in a historical context (e.g., Figure 2). Finally, SKOS Core, as an encoding guideline, captures information on

revision as well in history notes, and using other metadata standards, such as the Web Ontology Language, known as OWL (Herman and Hendler, 2006), offers some insight into the revision process of a given indexing language (Miles and Brickley, 2005; see Figure 4).

If we were to conflate these structures, and focus on attributes that affect revision, we have a composite structure that looks like Figure 5.

Indexing Language			**Revisions**	
	Name of Indexing Language			History
	Hierarchical Level			Invalid Concept
Concept				Date Canceled
	Number/Term			Replaced By
	Alternatives/Synonyms			Source Citing Cancellation
	Type of Number/Term			Comments on Cancellation
Scope				Date Revised
	Scope Note			Attributes of Concept Revised
	Definition			Source Citing Revision
	Description			Comments on Revision
	Application Note			Editorial Comments
	Instruction Note			Administrative Notes
	Examples			Notes for Next Revision
			Discourse	
Relationships				Source/Authority
	Broader Concepts		**Authorship**	
	Narrower Concepts			Editor/Date
	Related Concepts			
	Unspecified Relation			
	See Reference			

Figure 5. Composite Concept Description – highlighting attributes useful for revision

I have organized attributes according to type. In this figure we see the constellation of attributes considered important to understanding a concept at one point in time – but also through time. These 31 attributes are the attributes that, in theory, change with each revision of an indexing language. We can see these seven types as hypotheses for change. Is complete change manifest through scope change? Through a change in source or authority for a concept and its relationships? Through changes in broader or narrower terms? Design literature (Soergel, 1974) tells us yes, these are major categories of change. What does a case study of indexing language revision tell us?

3.2. Diachronic Indexing Observed

Diachronic indexing can be seen through artifacts, primarily the revisions of indexing languages over time. For example the Dewey Decimal Classification (DDC) has been in existence since 1876 and has survived many changes, some of them quite significant. The interesting result of such a long history and such significant change lies in the meaning of the class number in the DDC. For example, one can browse the online pathfinder for materials at the State Library of Indiana, and find materials classed in 575.6, among other classification numbers, that are all part of the discourse of early twentieth century eugenics (King, 2001). Yet 575.6 is a biological science class. However, one could not index materials on eugenics in DDC in the discipline of science anymore. The current edition of the DDC only offers social sciences and one health class (dealing with a new meaning for the term eugenics). Further, the current schedules have 575.6 to mean *reproductive organs of flowers*. We can examine the DDC, sampling at different points in its development, to get a sense of how the change to eugenics occurs. Table 1 presents a sample of editions and how they represent eugenics.

Eugenics			**100**	**300**	**500**	**600**
Year	***Edition and relative index entry***					
1911	**7th**				575.6	
1942	**14th rev. enl.**					
		Eugenic method crimol.		364.3018		
		crime prevention		364.42		
		evolution			575.1	
		hygiene				613.94
		mental psychology	136.3			
1958	**16th**					613.94
		Eugenic practices crime prevention		364.42		
		Hygiene				613.94
				[301.323 officially killed]	[575.1 officially killed]	
2003	**22nd**			363.92		
		crime prevention		363.4		
		ethics	176			
		health				613.94
		social services		363.92		
		sterilization services		363.97		

Table 1. Sample of Dewey Decimal Classification Schedules' representation of eugenics

In this Table we see eugenics contextualized in disciplines, and refined with additional words. We can speculate on the many reasons why eugenics has changed over the years. DDC does provide us with some general reasons for change (OCLC, 2006). We can interpret, in this case, that different aspects of eugenics have surfaced over the years, the term has been used in different ways in the literature (and DDC wants to reflect that change both in scholarship and in viewpoint), and the editors want to reduce bias. To reflect these differences, the entry for eugenics in the relative index points to many different places in schedules – and in some cases, no longer points to places it once did.

We can see two types of change here: structural and terminological. The structure of DDC has changed, and with it classification numbers have changed. Also, the term *eugenics* is sometimes haloed with other terms, and sometimes not. This, coupled with the placement in a particular discipline, changes the meaning indexers can ascribe (with justification) to the concept – making it a kind of terminological change. We can visualize this change in a different way, highlighting the terminological changes over time. See Table 2.

1911	1942	1958	2003
	Eugenics-Mental Psychology		
			Eugenics-Ethics
		[Eliminated]	
			Eugenics-Crime Prevention
			Eugenics (Social Science) & Eugenics-Social Services
			Eugenics-Sterilization
	Eugenics-Eugenic Method Criminology		
	Eugenics-Crime Prevention	Eugenics-Eugenic Practices Crime Prevention	
	Eugenics-Evolution		
Eugenics (Biology)		[Eliminated]	
	Eugenics-Hygiene	Eugenics- Hygiene	Eugenics-Health

Table 2. Terms used to identify and contextualize *eugenics* in four editions of DDC, including when classification numbers were eliminated.

4. Findings

4.1. Assumptions of Synchronic Indexing Based on Concept Descriptions

There are a number of assumptions about synchronic indexing we can derive from looking at concept descriptions. Looking at the seven types of attributes that reflect meaning and change we see that concepts have a past. Concepts have many relationships, and some of them are complex. Further, we can say that concepts are situated in an intertextual universe bounded by links within an indexing language, an editing and concept management environment, and a discourse beyond the indexing language. We can consider these contextual links, administrative links, and discursive links.

4.2. Change in Indexing Languages

Diachronically we can see indexing shift meaning. The shift is of three types: structural, terminological, and textual. We can these types of change manifest in Tables 1 and 2, and in the eugenics pathfinder (King, 2001). The terminological change is evidenced clearly in Table 2 we see how eugenics is first understood as a biological endeavor, and then it shifts to be a concern of psychology, ethics, social science, and eventually public health. Because classification schemes like DDC do not control this terminiology it affects revision and synchronic indexing (which in turn affects textual change see below).

Structure is also changed in successive revisions of the DDC, and with it relationships change. This affects the extension and intension of the concept of eugenics in the scheme, simply because of its relationships with other concepts.

Finally, textual change can be observed by looking at the collection of texts at the 575.6 class mark in a collection. We see from this, that eugenics is not the concept used to describe all of those texts (King, 2001).

4.3. Model of Diachronic Indexing

The model presented below is a theoretical model (Mäki, 2001), which is a set of assumption about diachronic indexing, and specifically to its internal structure and mechanisms: what forms change. Fundamentally, this model states, that descriptively, diachronic indexing is the successive erasure of links in deference to synchronic indexing enterprise. Prescriptively, diachronic indexing must transform itself into a succession of explicit contextual, administrative, and discursive links, without which the validity of indexing languages as tools for persistent access can be questioned. The descriptive model favours indexers. The prescriptive privileges users and the value of an indexing language.

The assumption of the prescriptive model is that indexing languages are built to identify and collocate concepts. They do this by establishing a set of concepts and relationships between concepts. Revisions to an indexing language must strengthen this purpose, yet in through successive revisions, it is not always clear what terms or classes mean, and what relationships obtain between concepts. Tracking changes, through links, made to concepts and relationships in schemes enables an indexing language to carry out its mission no matter how much it changes. Erasure of any sort dulls the system's long-term pragmatic lustre.

4.4. Apparatus of Concept Change

Wittgenstein asked, is the chessboard really one thing or 64 things (Rorty, 1999 p. 58)? The same can be asked of the concept, especially when it changes. As we can see from

our investigation of concept descriptions, a concept's meaning, that must be understood by an indexer for her to do her job. It is constrained by various types of attributes: which edition of an indexing language it comes from, what its alternative names are, various relationships. It is also interpreted in light of extant documents indexed. We see this from Sauperl's work (1999). What we are left with, as far as a model for understanding diachronic indexing, then, is a an intertextual model – one that links the indexing language to the names of the concept (term or class number), links the concept with other concepts, and links the concept with its past. This model, when described based on our case study demonstrates an erasure of intertextual links. Prescriptively this model would record those links.

Thus we can see the machine-readable model of diachronic indexing as a succession of concept descriptions linked together. This can be visualized, as in Figure 6 below, by displaying multiple stylized representations of Figure 5.

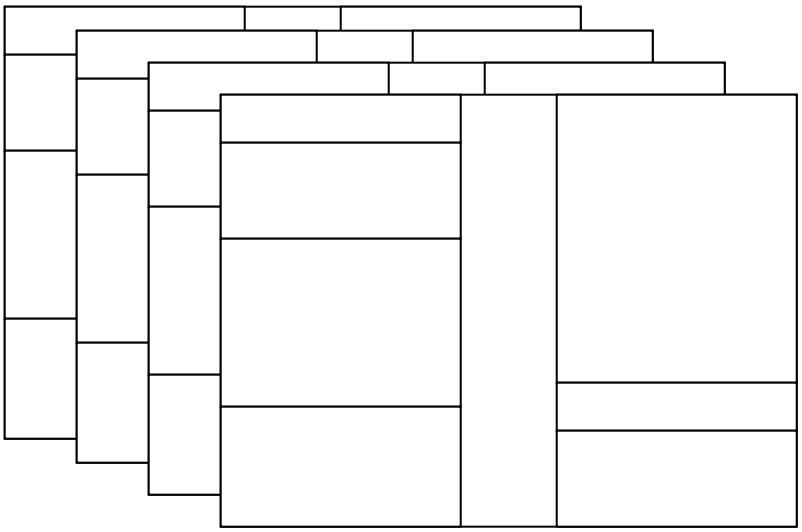

Figure 6. Successive concept descriptions as the model of diachronic indexing

The areas represented by these rectangles will then fill with links to sources, texts, and relationships. Making the phenomenon of change in indexing languages citable, and bound to each concept.

5. Conclusions

The major finding drawn from this modeling work is that revision can be characterized as one of three types: structural, terminological, or textual. Structural adaptation affects hierarchy and other syndetic structure. Terminological adaptation affects word choice and form. Textual adaptation affects the definitions and scope notes linked to terms and structure. It also affects literary warrant considerations. These types of adaptations in indexing languages affect indexing diachronically and synchronically. This is because these adaptations constrain interpretation in complex and temporally layered ways, that to the synchronic models thus far constructed, seem invisible.

These changes are recorded with three types of links: contextual (marking relationships), administrative (noting editorial decisions), and discursive (citing sources, authorities, and

texts beyond the indexing language). All of these exist in deference to the domain represented by the indexing language.

The practical outcome of this finding is information retrieval needs to make available and actionable structural, terminological, and textual links between different adaptations. This would require designing systems that could manage the many complex links. The NSDL Metadata Registry is an example of this kind of work (Registry, 2006). The theoretical outcome is: (1) indexing is not an act of periodic erasure, rather (2) it is, as an act of control, an implicitly intertextual regime, and must become more explicit, in order to constrain meaning of concepts in indexing languages, when placed against the complexity of a living and constantly changing panoply of discourses.

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