Change Tracking in Knowledge Organization Systems with skos-history

Joachim Neubert & Osma Suominen
ZBW – Leibniz Information Centre for Economics, Kiel/Hamburg & The National Library of Finland, Helsinki

DCMI/ASIST/AIMS Webinar Series:
Generic Tools and Methods for SKOS-based Concept Schemes
16.3.2016
Agenda

- User questions and requirements
- Getting a grip on changes:
  - Overview
  - Creating a version store
  - Generic queries
  - Dataset-specific adaption of queries
- skos-history in use
  - Application at the National Library of Finland
  - Application for STW Thesaurus for Economics
- Outlook: Future work and the skos-history project
What users want to know …

… when we publish a new KOS version:

- What's new?
- What has changed?
Use cases for extended change information

- Human indexers wanting to learn about new and deprecated concepts
- Human indexers (and supporting applications) re-indexing large sets of documents
- People maintaining mappings to other vocabularies, and applications supporting them
- People maintaining a derived subset of a KOS
- Vocabulary-based automatic or semi-automatic indexing applications
- Search applications utilizing the KOS
Agenda

- User questions and requirements
- Getting a grip on changes:
  - **Overview**
  - Creating a version store
  - Generic queries
  - Dataset-specific adaption of queries
- skos-history in use
  - Application at the National Library of Finland
  - Application for STW Thesaurus for Economics
- Outlook: Future work and the skos-history project
Overview: getting a grip on changes

Provided that we have no access to the KOS maintenance system where the changes take place originally, or can’t extend it to report this changes comprehensively.

Dataset versioning + skos-history approach

=> should work on every SKOS vocabulary
Scope of vocabulary versioning

- Versioning the concept scheme, not each individual concept
- URIs for the concepts remain stable over the different versions
- Distinct versions of a vocabulary, or at least timestamped dumps, must be available
- Support for a continuous flow of changes, e.g., the LoC Subject Headings, or the concepts of the GND, is currently not provided
Three basic steps to an actionable skos-history

Start with one SKOS file per version.

1) Create the deltas - insertions and deletions - between every two version files.
   (Via a raw diff of sorted ntriples files, or via SPARQL MINUS in a triple store. This gives you thousands and thousands of differences - added or deleted triples -, even excluding bnodes.)

2) Load the version files and the insertions and deletions into a triple store as named graphs.

3) Add metadata about the versions and the deltas in a separate „version history graph“.

https://github.com/jneubert/skos-history/blob/master/bin/load_versions.sh
Agenda

• User questions and requirements
• Getting a grip on changes:
  • Overview
  • Creating a version store
  • Generic queries
  • Dataset-specific adaption of queries
• skos-history in use
  • Application at the National Library of Finland
  • Application for STW Thesaurus for Economics
• Outlook: Future work and the skos-history project
Hands on: Create a version store for skos-history

Requirements:

- SPARQL 1.1 compliant service or repository (‘triple store’), accessible in read/write mode
  https://github.com/NatLibFi/Skosmos/wiki/InstallTutorial#install-jena-fuseki
- An environment for executing bash scripts for the data load script
  (any Linux should do, Cygwin may).

Tutorial: https://github.com/jneubert/skos-history/wiki/Tutorial
Code of scripts and queries: also on GitHub
Load a version store: config file for JEL

```
#!/bin/bash

files are loaded from $BASEDIR/VERSIONS/FILENAME
VERSIONS=(20120320 20130621)
BASEDIR=/opt/thes/var/jelv
FILENAME=rdf/jelv.ttl
SCHEMEURI="http://zbw.eu/beta/external_identifiers/jel"

private read/write endpoints
PUT_URI=http://localhost:8080/fuseki/jelv/data
UPDATE_URI=http://localhost:8080/fuseki/jelv/update

public read-only endpoint
QUERY_URI=http://zbw.eu/beta/jelv/sparql/query

"jel.config" 14L, 406C 14,1 All
```

Configuration for Fuseki (https://github.com/jneubert/skos-history/blob/master/bin/jel.config); see also configuration for Sesame (https://github.com/jneubert/skos-history/blob/master/bin/jel.sesame.config)
Load a version store: load_versions.sh script
Load a version store: load_versions.sh script

```
[root@ite-srv11 bin]#
[root@ite-srv11 bin]#
[root@ite-srv11 bin]#
[root@ite-srv11 bin]# ./load_versions.sh -f jel.config

Initializing the version history graph with the current version

Loading version http://zbw.eu/beta/external_identifiers/jel/version/20120320

Loading version http://zbw.eu/beta/external_identifiers/jel/version/20130621

Creating the delta http://zbw.eu/beta/external_identifiers/jel/version/20120320/delta/20130621

[root@ite-srv11 bin]#
[root@ite-srv11 bin]#
```
Version History Graph, discoverable via fix URI, e.g.: http://zbw.eu/stw/version
Version History Graph, published as HTML/RDFa

**STW Thesaurus for Economics**

**Versions**

Prior versions of the STW are provided here for reference (See also the Changes overview).

Published versions have even version numbers. Odd version numbers are reserved for internal purposes.

The current version of STW is 9.0.

**All published versions:**

- 9.0 (2015-06-15)
  - Change Reports: [Text](http://zbw.eu/stw/9.0/changes/1) (in German) | Interactive
  - Change Reports: [Text](http://zbw.eu/stw/8.14/changes/1) (in German) | Interactive
- 8.12 (2013-10-30)
  - Change Reports: [Text](http://zbw.eu/stw/8.12/changes/1) (in German)
- 8.10 (2012-03-21)
  - Change Reports: [Text](http://zbw.eu/stw/8.10/changes/1) (in German)
- 8.08 (2011-06-30)
  - Change Reports: [Text](http://zbw.eu/stw/8.08/changes/1) (in German)
- 8.06 (2010-04-22)
  - Change Reports: [Text](http://zbw.eu/stw/8.06/changes/1) (in German)
- 8.04 (2009-02-16)
  - Change Reports: (first web and linked data version)


http://zbw.eu/stw/version
Vocabularies used for the plumbing

- dc:/dcterms:
  Dublin Core, as usual the base for everything
- void: http://rdfs.org/ns/void#
  Vocabulary of interlinked datasets
- sd: http://www.w3.org/ns/sparql-service-description#
  SPARQL service description
- delta: http://www.w3.org/2004/delta#
  Differences between RDF graphs
- dsv: http://purl.org/iso25964/DataSet/Versioning#
  Version history records (providing version identifier and date) and a pointer to the current version – outside the actual version data
- sh: http://purl.org/skos-history/
  Scheme and concept version deltas
What’s the benefit?

A database of all versions of a KOS and all deltas between versions – which can be queried in parallel!
Agenda

- User questions and requirements
- Getting a grip on changes:
  - Overview
  - Creating a version store
  - **Generic queries**
  - Dataset-specific adaption of queries
- skos-history in use
  - Application at the National Library of Finland
  - Application for STW Thesaurus for Economics
- Outlook: Future work and the skos-history project
SELECT distinct (?concept AS ?addedConcept) (str(?prefLabel) AS ?addedConceptLabel)
WHERE {
  GRAPH ?versionHistoryGraph {
    # parameters
      ( undef undef undef "en" )
    }
    # get the current and the previous version as default versions
    # select the versions to actually use
    BIND(coalesce(?oldVersion, ?previousVersion) AS ?oldVersionSelected)
    # get the delta and via that the relevant graphs
    ?delta a sh:SchemeDelta ;
      sh:deltaFrom/dc:identifier ?oldVersionSelected ;
      sh:deltaTo/dc:identifier ?newVersionSelected ;
      sh:deltaFrom/sh:usingNamedGraph/sd:name ?oldVersionGraph .
    ?insertions a sh:SchemeDeltaInsertions ;
      dctrans:isPartOf ?delta ;
      sh:usingNamedGraph/sd:name ?insertionsGraph .
  }
  # for each inserted concept, a newly inserted prefLabel must exist ...
  GRAPH ?insertionsGraph {
  }
  # ... and the concept must not exist in the old version
  FILTER NOT EXISTS {
    GRAPH ?oldVersionGraph {
      ?concept ?p []
    }
  }
  # restrict output to a certain language
  FILTER ( lang(?prefLabel) = ?language )
}
ORDER BY ?prefLabel

Newly inserted concepts – results

Results of the query:

<table>
<thead>
<tr>
<th></th>
<th>Table</th>
<th>Raw Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>addedConcept</td>
<td>Accountants</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Accounting fraud</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Addiction prevention</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Alternative currency</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Anti-discrimination law</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Asset-market approach of the exchange rate</td>
</tr>
</tbody>
</table>
Reports operating on standard SKOS structures

### SPARQL queries

The queries linked from this page provide examples on how a skos-history version store can be utilized to create useful change reports. The queries can be executed via [an interactive SPARQL GUI](https://github.com/jneubert/skos-history/tree/master/sparql) against an example endpoint with different versions of STW Thesaurus for Economics, prepared as a skos-history version store according to [Versions and Deltas as Named Graphs](https://github.com/jneubert/skos-history/tree/master/sparql).

#### Generic queries for any SKOS vocabulary

<table>
<thead>
<tr>
<th>Query</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>version_overview</td>
<td>Discover the version history graph and all available scheme versions</td>
</tr>
</tbody>
</table>

#### Lists of concepts

<table>
<thead>
<tr>
<th>Query</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>added_concepts</td>
<td>Identify all concepts inserted in the current version</td>
</tr>
<tr>
<td>added_concepts_with_top_concepts</td>
<td>Identify all concepts inserted in the current version with their top concepts</td>
</tr>
<tr>
<td>labels Moved to added concepts</td>
<td>Show the labels which have moved to newly inserted concepts (flag new concepts if subordinated to the old one)</td>
</tr>
<tr>
<td>deprecated_concepts</td>
<td>Identify all concepts deprecated with the current version</td>
</tr>
<tr>
<td>deleted_concepts</td>
<td>Identify all concepts deleted with the current version</td>
</tr>
<tr>
<td>changed_notations</td>
<td>For a classification (in this case the subject categories of STW), show which notation has changed</td>
</tr>
</tbody>
</table>

#### Aggregated information about versions

<table>
<thead>
<tr>
<th>Query</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>count_added_concepts</td>
<td>Count concepts inserted per version</td>
</tr>
</tbody>
</table>
Reports … (continued)

## History of selected concepts

<table>
<thead>
<tr>
<th>Query</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>concept_delta</td>
<td>All version deltas for the concept Personnel selection (insert either example concept ids into the VALUES clause - suggestions in the comment)</td>
</tr>
<tr>
<td>concept_history</td>
<td>Early alternative approach for the history of the concept Personnel selection (changes in prefLabel only)</td>
</tr>
</tbody>
</table>

## Technical background information

<table>
<thead>
<tr>
<th>Query</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>version_graph</td>
<td>Complete version history graph</td>
</tr>
<tr>
<td>service_graph</td>
<td>Complete service description graph (default graph)</td>
</tr>
</tbody>
</table>

### Extension to SKOS-XL

Some of the example queries have been adapted to work against version of thesauri, which uses SKOS-XL. The queries can be directed to the thesaur or agrovoc example endpoints (see below).

## Dataset-specific queries

More often than not, SKOS publications contain information specific to the dataset in question. Dataset-specific queries may exploit and expose this additional information.

- STW Thesaurus for Economics (beta)
- GND subject headings (experiments)

So while the examples will not run with other datasets, they may show how value can be added by exploiting custom data structures, while at the same time making use of a common version history scheme.

### Further (purely experimental) skos-history example endpoints

- TheSoZ - add &query=http://zbw.eu/beta/sparql/thesaurus/query to the URL (version overview)
- YSO - add &endpoint=http://zbw.eu/beta/sparql/ysos/query to the URL (version overview)
## Changed notations

<table>
<thead>
<tr>
<th>old</th>
<th>new</th>
<th>concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.02.02.01</td>
<td>B.02.03</td>
<td><a href="http://zbw.eu/stw/thsys/71044">http://zbw.eu/stw/thsys/71044</a></td>
</tr>
<tr>
<td>B.06.02</td>
<td>B.06.03</td>
<td><a href="http://zbw.eu/stw/thsys/70310">http://zbw.eu/stw/thsys/70310</a></td>
</tr>
<tr>
<td>B.06.03</td>
<td>B.06.02</td>
<td><a href="http://zbw.eu/stw/thsys/70471">http://zbw.eu/stw/thsys/70471</a></td>
</tr>
<tr>
<td>B.11</td>
<td>B.01.07</td>
<td><a href="http://zbw.eu/stw/thsys/179318">http://zbw.eu/stw/thsys/179318</a></td>
</tr>
<tr>
<td>N.04.04.01</td>
<td>N.04.04.05</td>
<td><a href="http://zbw.eu/stw/thsys/73365">http://zbw.eu/stw/thsys/73365</a></td>
</tr>
<tr>
<td>N.04.04.02</td>
<td>N.04.04.06</td>
<td><a href="http://zbw.eu/stw/thsys/73364">http://zbw.eu/stw/thsys/73364</a></td>
</tr>
<tr>
<td>N.04.04.04</td>
<td>N.04.04.02</td>
<td><a href="http://zbw.eu/stw/thsys/73362">http://zbw.eu/stw/thsys/73362</a></td>
</tr>
<tr>
<td>N.05.08</td>
<td>N.05.07</td>
<td><a href="http://zbw.eu/stw/thsys/73333">http://zbw.eu/stw/thsys/73333</a></td>
</tr>
<tr>
<td>N.05.08.01</td>
<td>N.05.07.01</td>
<td><a href="http://zbw.eu/stw/thsys/73332">http://zbw.eu/stw/thsys/73332</a></td>
</tr>
<tr>
<td>N.05.08.02</td>
<td>N.05.07.02</td>
<td><a href="http://zbw.eu/stw/thsys/73331">http://zbw.eu/stw/thsys/73331</a></td>
</tr>
</tbody>
</table>

New concepts, split from old ones

Labels moved to added concepts:

<table>
<thead>
<tr>
<th>oldConcept</th>
<th>movedLabel</th>
<th>newConcept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial professions</td>
<td>Buchhaller</td>
<td>Accountants</td>
</tr>
<tr>
<td>Commercial professions</td>
<td>Accountants</td>
<td>Accountants</td>
</tr>
<tr>
<td>Free-money theory (S. Gesell)</td>
<td>Freigeld</td>
<td>Alternative currency</td>
</tr>
<tr>
<td>Free-money theory (S. Gesell)</td>
<td>Komplementärgeld</td>
<td>Alternative currency</td>
</tr>
<tr>
<td>Free-money theory (S. Gesell)</td>
<td>Regiogeld</td>
<td>Alternative currency</td>
</tr>
<tr>
<td>Free-money theory (S. Gesell)</td>
<td>Regionalgeld</td>
<td>Alternative currency</td>
</tr>
<tr>
<td>Free-money theory (S. Gesell)</td>
<td>Regionalwährung</td>
<td>Alternative currency</td>
</tr>
<tr>
<td>Free-money theory (S. Gesell)</td>
<td>Schwundgeld</td>
<td>Alternative currency</td>
</tr>
<tr>
<td>Labour market discrimination</td>
<td>Affirmative action</td>
<td>Anti-discrimination law</td>
</tr>
</tbody>
</table>

Change history of a concept: “Personnel selection”

```
<http://zbw.eu/stw/descriptor/12571-4/version/8.06/delta/8.08>
  a sh:ConceptDelta ;
  dcterms:isPartOf <http://zbw.eu/stw/version/8.06/delta/8.08> ;
  delta:deletion [] ;
  delta:deletion [] ;
  delta:deletion [] ;
  delta:deletion [ skos:altLabel "Job matching"@en ] ;
  delta:deletion [] ;
  delta:deletion [] ;
  delta:deletion [] .

<http://zbw.eu/stw/descriptor/12571-4/version/8.08/delta/8.08>
  a sh:ConceptDelta ;
  dcterms:isPartOf <http://zbw.eu/stw/version/8.08/delta/8.08> ;
  delta:deletion [] ;
  delta:insertion [ skos:altLabel "Eignungsdagnostik"@de ] ;
  delta:insertion [ skos:altLabel "Bewerberauswahl"@de ] ;
  delta:insertion [] ;
  delta:insertion [ ] .

  a sh:ConceptDelta ;
  delta:deletion [] ;

  a sh:ConceptDelta ;
  delta:insertion [] .

  a sh:ConceptDelta ;
  dcterms:isPartOf <http://zbw.eu/stw/version/8.04/delta/8.06> ;
  delta:deletion [] ;
  delta:insertion [ skos:altLabel "Bewerbungsgespräch"@de ] .

<http://zbw.eu/stw/descriptor/12571-4>
Agenda

- User questions and requirements
- Getting a grip on changes:
  - Overview
  - Creating a version store
  - Generic queries
  - **Dataset-specific adaption of queries**
- skos-history in use
  - Application at the National Library of Finland
  - Application for STW Thesaurus for Economics
- Outlook: Future work and the skos-history project
GND subjects by subject category – query

```sparql
# for each inserted concept, a newly inserted prefLabel must exist ...
GRAPH ?insertionsGraph {
  gndo:gndSubjectCategory ?category
  .
}
# ... and the concept must not exist in the old version
FILTER NOT EXISTS {
  GRAPH ?oldVersionGraph {
    ?concept ?p []
  }
}
GRAPH ?newVersionGraph {
  ?category skos:prefLabel ?catLabel ;
  skos:notation ?notation
  .
}
}
ORDER BY ?category ?prefLabel
```

https://github.com/jneubert/skos-history/blob/master/sparql/swtdskos/added_concepts_by_category.rq
# GND subjects by subject category – results

Showing 1 to 25 of 25 entries (filtered from 736 total entries)

<table>
<thead>
<tr>
<th>notation</th>
<th>category</th>
<th>addedConcept</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Cyberattacke</td>
</tr>
<tr>
<td>2 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Desktop-Computer</td>
</tr>
<tr>
<td>3 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Fortgeschrittene elektronische Unterschrift</td>
</tr>
<tr>
<td>4 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Industrie 4.0</td>
</tr>
<tr>
<td>5 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Machine to Machine</td>
</tr>
<tr>
<td>6 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Mikroservice</td>
</tr>
<tr>
<td>7 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Namensschild</td>
</tr>
<tr>
<td>8 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Online-Community</td>
</tr>
<tr>
<td>9 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Produktionstechnik</td>
</tr>
<tr>
<td>10 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Proxy &lt;Entwurfsmuster&gt;</td>
</tr>
<tr>
<td>11 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Serious game</td>
</tr>
<tr>
<td>12 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Soft Error</td>
</tr>
<tr>
<td>13 30</td>
<td>Informatik, Datenverarbeitung</td>
<td>Text-to-Speech</td>
</tr>
</tbody>
</table>
STW deprecated concepts – query

```
# identify the deprecated concepts
GRAPH ?insertionsGraph {
    ?concept owl:deprecated true
}
# get the replacedBy information
GRAPH ?newVersionGraph {
    # get concepts and restrict to conceptType
    ?concept a ?conceptType .
    OPTIONAL {
        ?concept dcterms:isReplacedBy ?replacedBy .
        ?replacedBy skos:prefLabel ?replacedByPrefLabel .
    }
}
# get categories
```
## STW deprecated concepts – result

<table>
<thead>
<tr>
<th>secondLevelCategory</th>
<th>deprecatedConcept</th>
<th>replacedByConcept</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 G.02 Asia</td>
<td>Greater China</td>
<td>China</td>
</tr>
<tr>
<td>2 N.04 Politics and Political Science</td>
<td>Constituency</td>
<td>Electoral system</td>
</tr>
<tr>
<td>3 N.04 Politics and Political Science</td>
<td>Government system</td>
<td>Political system</td>
</tr>
<tr>
<td>4 N.04 Politics and Political Science</td>
<td>National symbol</td>
<td>State</td>
</tr>
<tr>
<td>5 N.04 Politics and Political Science</td>
<td>Occupation of territory</td>
<td>Military intervention</td>
</tr>
<tr>
<td>6 N.04 Politics and Political Science</td>
<td>Parliamentary allowance</td>
<td>Political finance</td>
</tr>
<tr>
<td>7 N.04 Politics and Political Science</td>
<td>Parliamentary committee</td>
<td>Parliament</td>
</tr>
<tr>
<td>8 N.04 Politics and Political Science</td>
<td>Parliamentary group</td>
<td>Political party</td>
</tr>
<tr>
<td>9 N.04 Politics and Political Science</td>
<td>Party congress</td>
<td>Party politics</td>
</tr>
</tbody>
</table>
Agenda

- User questions and requirements
- Getting a grip on changes:
  - Overview
  - Creating a version store
  - Generic queries
  - Dataset-specific adaption of queries
- skos-history in use
  - Application at the National Library of Finland
  - Application for STW Thesaurus for Economics
- Outlook: Future work and the skos-history project
skos-history at the National Library of Finland

see separate slides at http://tinyurl.com/skos-history-nlf
Agenda

- User questions and requirements
- Getting a grip on changes:
  - Overview
  - Creating a version store
  - Generic queries
  - Dataset-specific adaption of queries
- skos-history in use
  - Application at the National Library of Finland
  - **Application for STW Thesaurus for Economics**
- Outlook: Future work and the skos-history project
STW Thesaurus for Economics

- created in the 1990s
- on the web and available as SKOS since 2009
- bilingual (German/English)
- about 6000 descriptors, 500 subject categories
- overhaul during the last five years (five consecutive versions)
STW change reports (precompiled query results)

STW Thesaurus for Economics

Change details in v 9.0

The interactive change reports were generated from the Linked Data version history of STW.

Descriptors:

- Added
- Deprecated (with replacements)
- Changed preferred labels
- Added labels
- Deleted labels
- Added narrower relationships
- Added broader relationships
- Splits: Labels moved to new descriptors
- Merges: Labels moved from deprecated descriptors

Subject categories:

- Added
- Deprecated (with replacements)
- Changed notations/labels
Visualizing change with aggregated data

Added and deprecated descriptors (by sub-thesaurus)
Version 8.06 to 9.0

- V Economics
- B Business economics
- W Economic sectors
- P Commodities
- N Related subject areas
- G Geographic names
- A General descriptors

- Deprecated descriptors
- Added descriptors

Highcharts.com
Added and deprecated descriptors "B" (by 2nd level category)

Version 8.06 to 9.0

- B.00 Business economics
- B.01 Management and business
- B.02 Corporate finance and capital
- B.03 Accounting
- B.04 Human resource
- B.05 Materials management and
- B.06 Production management
- B.07 Marketing
- B.08 Corporate tax management
- B.09 Business information
- B.10 Operations research

**Deprecated descriptors**

**Added descriptors**
Drill down from chart to change report

### STW Thesaurus for Economics

#### Added descriptors (in v 8.06 - 9.0)

<table>
<thead>
<tr>
<th>secondLevelCategory</th>
<th>addedConcept</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  B.07 Marketing</td>
<td>Brand architecture</td>
</tr>
<tr>
<td>2  B.07 Marketing</td>
<td>Brand extension</td>
</tr>
<tr>
<td>3  B.07 Marketing</td>
<td>Brand loyalty</td>
</tr>
<tr>
<td>4  B.07 Marketing</td>
<td>Brand name</td>
</tr>
<tr>
<td>5  B.07 Marketing</td>
<td>Cause-related marketing</td>
</tr>
<tr>
<td>6  B.07 Marketing</td>
<td>Celebrity endorsement</td>
</tr>
<tr>
<td>7  B.07 Marketing</td>
<td>Competitive analysis</td>
</tr>
</tbody>
</table>
Future work and the skos-history project

- Apply to differing concept schemes
- Distill general properties useful for human-readable change reports as well as machine-actionable data
- Get a grip on clusters of interrelated changes

Please consider joining – particularly if
- you are in charge of a KOS and want to publish its change history
- you are using one or several KOS in an application, or intellectually, and want to trace and re-apply upstream changes
- just feel challenged by the task
Thanks for listening!

Joachim Neubert
ZBW – Leibniz Information Centre for Economics
j.neubert@zbw.eu

Osma Suominen
The National Library of Finland
osma.suominen@helsinki.fi

Project repository: https://github.com/jneubert/skos-history