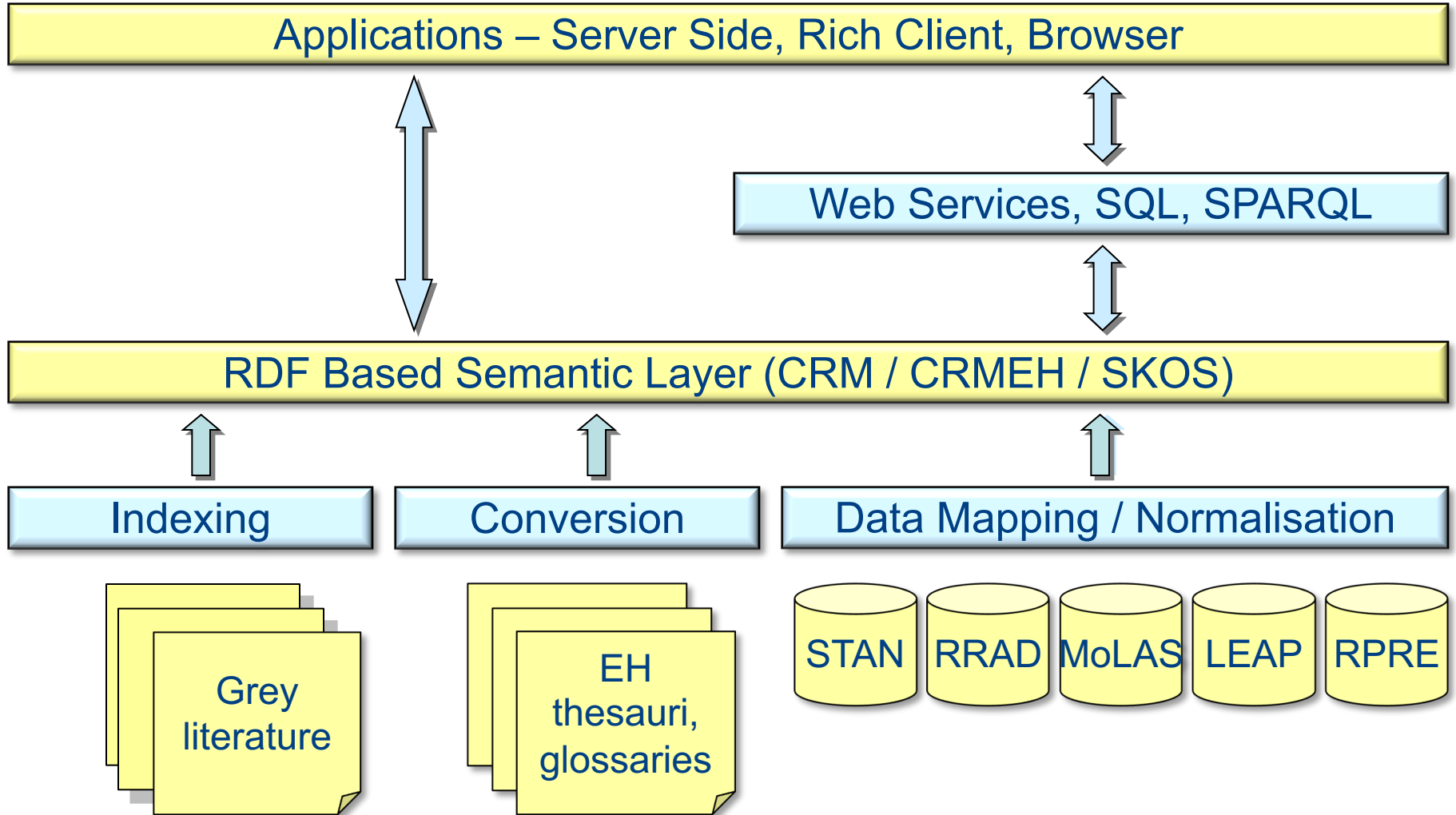


Reflections on KOS based data integration

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STAR Project - General Architecture



Natural Language Processing (NLP)

of archaeological grey literature

Extract key concepts in same semantic representation as for data.

Allows unified searching of different datasets and grey literature
in terms of same underlying CRM-based conceptual structure

Output as RDF triples in Demonstrator and as [XML with greylit](#)

“ditch containing prehistoric pottery dating to the Late Bronze Age”

EHE1002.ContextFindProductionEvent	
prehistoric pottery dating to the Late Bronze Age	
EHE0009.ContextFind	EHE0039.TimeSpanAppellation
pottery [#ehg027.2]	Late Bronze Age [#134734]
EHE1004.ContextFindDepositionEvent	
ditch containing prehistoric pottery	
EHE0007.Context	EHE0009.ContextFind
ditch [#ehg003.20]	pottery [#ehg027.2]

STAR Demonstrator – search for a conceptual pattern

An Internet Archaeology publication on one of the (Silchester Roman) datasets we used in STAR discusses the finding of a *coin* within a *hearth*.

-- does the same thing occur in any of the grey literature reports?

Requires comparison of extracted data with NLP indexing in terms of the ontology.

The screenshot displays the STAR Demonstrator interface, which is divided into several panels. On the left, there is a navigation pane with tabs for 'Groups', 'Contexts', 'Finds', and 'Samples'. Below these tabs is a list of search criteria, including 'Site', 'Context ID', 'Context Type', 'Context Notes', 'Within Group', 'Within Context', 'Contains Context', 'Contains Context Find', 'Contains Context Sample', 'Stratigraphically Above Context', 'Stratigraphically Below Context', and 'Stratigraphically Equal To Context'. A 'Run Query' button is located below the list. The main area is divided into four panels: 'Group Details', 'Context Details', 'Context Sample Details', and 'Context Find Details'. Each panel shows a hierarchical tree diagram and a list of attributes. The 'Group Details' panel shows a tree with a green root node and two orange child nodes. The 'Context Details' panel shows a tree with a green root node, an orange child node, and three colored child nodes (orange, blue, red). The 'Context Sample Details' panel shows a tree with an orange root node and a red child node. The 'Context Find Details' panel shows a tree with an orange root node and a blue child node. Each panel also has a list of attributes, such as 'Site', 'Group ID', 'Location', 'Group Type', 'Context ID', 'Context Type', 'Sample ID', 'Sample Type', 'Sample Notes', 'Find ID', 'Find Type', 'Find Dating', and 'Material'.

STAR Demonstrator – search for a conceptual pattern

Research paper reports finding a *coin in hearth* – exist elsewhere?

Groups Contexts Finds Samples

- Site
- Context ID
- Context Type
- Context Notes
- Within Group
- Within Context
- Contains Context
- Contains Context Find
- Contains Context Sample
- Stratigraphically Above Context
- Stratigraphically Below Context
- Stratigraphically Equal To Context

Run Query

Group Details

Site [not set]
Group ID [not set]
Location [not set]
Group Type

Context Details

Hierarchy Stratigraphy

Site [not set]
Context ID [not set]
Context Type [not set]

Context Sample Details

Site [not set]
Sample ID [not set]
Sample Type [not set]
Sample Notes

Context Find Details

Site [not set]
Find ID [not set]
Find Type [not set]
Find Dating
Material

Stratigraphic query

Groups
Contexts
Finds
Samples

- Within Context
- Contains Context
- Contains Context Find
- Find ID
- Find Type
-
- Find Material
- Find Notes
- Contains Context Sample
- Stratigraphically Above Context
- Stratigraphically Below Context
- Context ID
- Context Type
-
- Context Notes

Run Query

- 6474
- 4589
- 86207
- 8573
- 86197
- 84995
- 84700

Group Details

Site

[not set]

Group ID

[not set]

Location

[not set]

Group Type

[not set]

Context Details

Hierarchy

Stratigraphy

Context Type

Crushed tile and gravel floor

Location

[not set]

Notes

Crushed tile and gravel floor surface preserved under clay (4558). Strat above (4589), (4581). Completely removed in 2003. Plan no: <http://tempuri/star/base#ehe0007.leap.contexts.context.4569>

Context Sample Details

Site

[not set]

Sample ID

[not set]

Context Find Details

Find Type

Coin Illegible

Find Dating

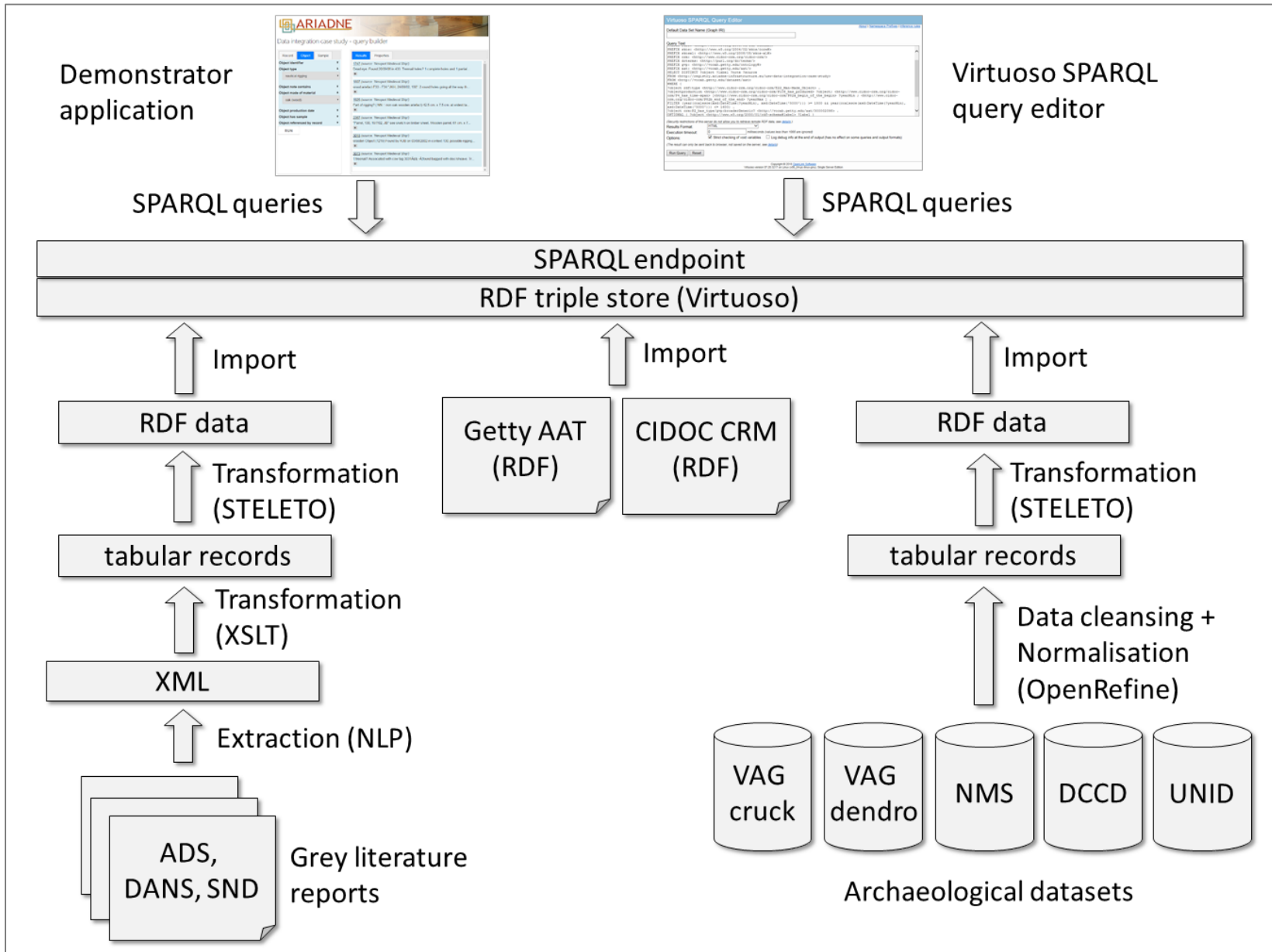
[not set]

Feasibility Study of Research Data Integration

- part of European ARIADNE project

- Extracts of 5 archaeological datasets, output from NLP on extracts from 25 grey literature reports
- broad theme of wooden material, objects and samples dated via dendrochronological analysis
- Multilingual - English, Dutch and Swedish data/reports
- Data integration via CIDOC CRM and Getty AAT
- 1.09 million RDF triples
- 23,594 records
- 37,935 objects
- Demonstration query builder for easier cross-search and browse of integrated datasets
- Concept based query expansion via AAT

General workflow and architecture



STELETO data conversion application

- A simpler, cross-platform version of the (previous project) STELLAR.Console application
- Performs bulk transformation of tabular delimited data via user-defined templates
- Cross platform (tested on Linux and Windows)
- Open source (<https://github.com/cbinding/steleto>)
- Flexible (can produce any textual output format)
- Simple, fast

ARIADNE vocabulary mapping to Getty AAT

- Subject metadata in different languages , so potentially:
 - useful resources missed
 - false results from homographs (eg 'coin' French for corner, 'boot' German for boat and 'monster' Dutch for sample)
- Scalable solution – employ hub architecture
- Getty AAT adopted (available as LOD)
- Interactive (intellectual) mapping tools developed
 - generates SKOS mapping relationships in JSON and other formats
- Mapping guidelines produced
- 6416 concepts (27 vocabularies, 12 partners) mapped

NLP methods

- Rule based Named Entity Recognition (NER) pipelines for English, Dutch, and Swedish text using GATE platform
- Builds on previous English language NLP work on archaeological grey literature
- Supported by a controlled vocabulary based on Getty AAT with mappings to Dutch and Swedish vocabulary
- Intermediate XML output with inline mark-up transformed to same RDF format as for datasets
- Different strategies explored for identifying potentially relevant material (manual, automatic)

Illustrative examples of NLP output

Examples illustrating English, Dutch and Swedish NLP output (before transformation to RDF), with colour coding (objects, materials, dates, samples):

Two timbers dated from the west wing roof produce felling dates in the winter of AD 1735/6 and the spring of AD 1736.

Dendrochronologisch onderzoek door Stichting RING in Amersfoort wijst uit dat de eik waaruit de paal is vervaardigd, is geveld tussen 55 en 69 na Chr.

Prov 1 som var bearbetat virke av ek daterades till fällningsår vinterhalvåret 1536/37.

Data integration case study - query builder

Record	Object	Sample
Record data source		∨
Record identifier		∨
Record note contains		∨
Record refers to material		∧
	Salix (genus)	∨
Record refers to date		∨
Record refers to object		∨
Record refers to sample		∨

RUN

Results	Properties
<u>P:2001114</u> (domain: stichtingring.nl) (source: 'Results from search for 'Stichting RING' on DCCD site')	
Moerasbos Ypenburg	
<u>115610</u> (source: 'Göteborg 218, Nya Lödöse Gångtunnel vid Gamlestadstorget. Arkeologisk förundersökning i Göteborgs kommun')	
Johan Linderholm vid MAL har miljöarkeologiskt bedömt påträffade sediments poten...	
∨	
<u>2141875</u> (source: 'Report on an Archaeological Investigation at Beverley Minster, East Yorkshire')	
One was accompanied by a willow rod and bead, and was covered by a wooden board;...	
∨	
<u>2142009</u> (source: 'Report on an Archaeological Investigation at Beverley Minster, East Yorkshire')	
This burial was accompanied by two objects: a thin willow rod or wand (sf 232), ...	
∨	
<u>2142095</u> (source: 'Report on an Archaeological Investigation at Beverley Minster, East Yorkshire')	
The earliest datable objects comprise an Anglo-Saxon polychrome glass bead sf231...	
∨	

[University of South Wales - Hypermedia Research Group](#), 2016

ARIADNE is funded by the [European Commission's 7th Framework Programme](#)

Query Builder (query on left, results on right): Records referring to material “Salix (genus)” Shows English, Dutch & Swedish results, originating from NLP and database records

Leveraging thesaurus structure

AAT hierarchical structure for concept 300012498 "willow (wood)"

Materials Facet	aat:300264091
- Materials (hierarchy name)	aat:300010357
- - - materials (matter)	aat:300010358
- - - - <materials by origin>	aat:300206573
- - - - - biological material	aat:300265629
- - - - - - plant material	aat:300124117
- - - - - - - <wood and wood products>	aat:300011913
- - - - - - - - wood (plant material)	aat:300011914
- - - - - - - - - <wood by composition or origin>	aat:300011915
- - - - - - - - - - hardwood	aat:300011916
- - - - - - - - - - - willow (wood)	aat:300012498
- - - - - - - - - - - - black willow (wood)	aat:300012500
- - - - - - - - - - - - Japanese willow (wood)	aat:300012502
- - - - - - - - - - - - western black willow (wood)	aat:300012504
- - - - - - - - - - - - white willow (wood)	aat:300012508

AAT Taxonomic structure for concept 300375384 (not a formal Scientific taxonomy)

Agents Facet	aat:300264089
- Living Organisms (hierarchy)	aat:300265673
- - - living Organisms (entities)	aat:300390503
- - - - Eukaryota (domain)	aat:300265677
- - - - - Plantae (kingdom)	aat:300132360
- - - - - - Angiospermae (division)	aat:300265706
- - - - - - - Magnoliopsida (class)	aat:300375593
- - - - - - - - Malpighiales (order)	aat:300374936
- - - - - - - - - Salicaceae (family)	aat:300374937
- - - - - - - - - - salix (genus)	aat:300375384
- - - - - - - - - - - salix lucida (species)	aat:300375387
- - - - - - - - - - - - Salix lucida ssp caudata	aat:300375389

References to wood in datasets (and grey literature) often use material/family/genus/species interchangeably.

For more effective search employ the link between the material (type of wood) and the agent (living organism) in AAT this is a specific GVP RT specialisation and its reciprocal (inverse) relationship. e.g.:

aat:300012498 gvp:2841_derived-made_from aat:300375384 .

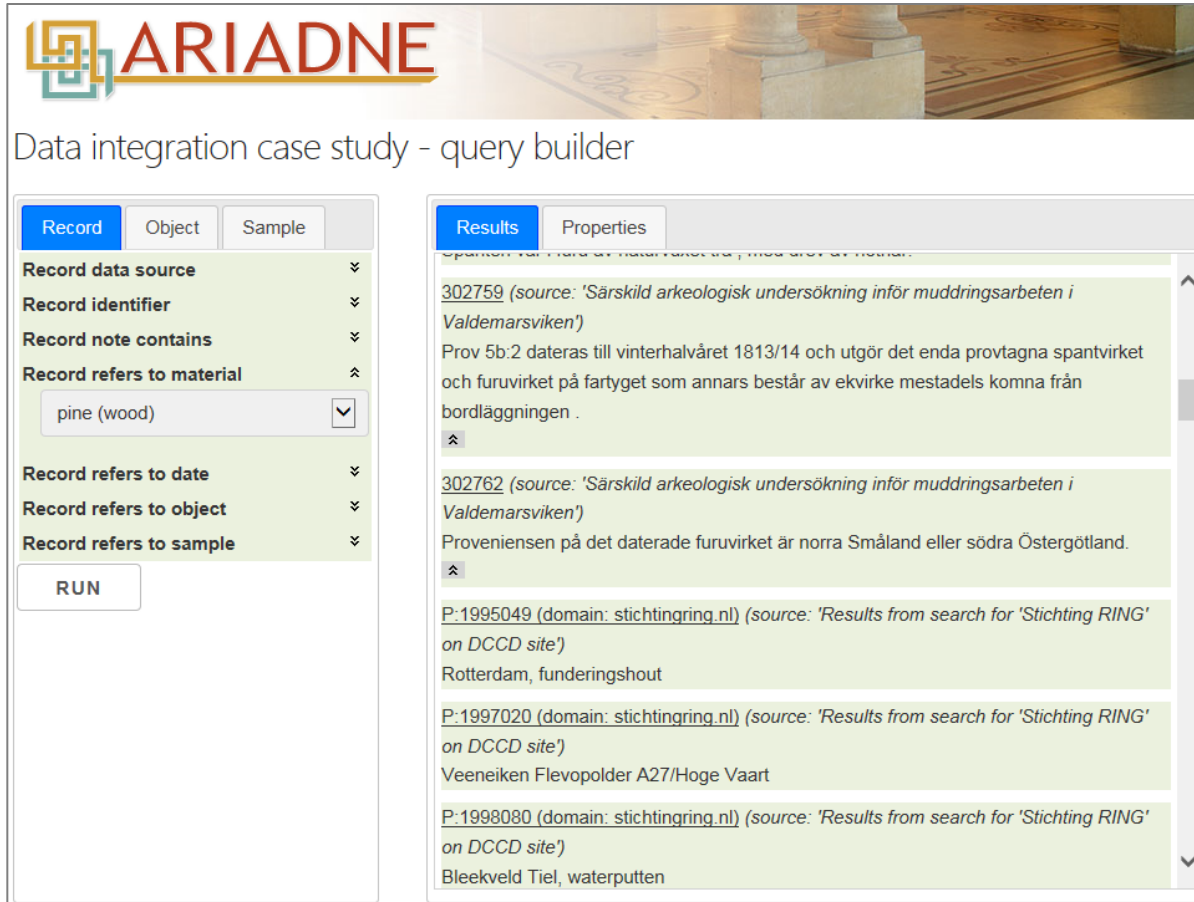
"willow (wood)" derived/made-from "Salix (genus)" .

aat:300375384 gvp:aat2842_source_for aat:300012498 .

"Salix (genus)" source for "willow (wood)" .

A search on e.g. "willow (wood)" can retrieve the Material [aat:300012498], the Agent [aat:300375384] and their respective hierarchical descendant concepts.

Leveraging thesaurus structure



The screenshot displays the ARIADNE interface for a data integration case study. The main title is "ARIADNE" with a logo. Below it, the text "Data integration case study - query builder" is visible. The interface is divided into two main panels: "Record" and "Results".

Record Panel:

- Buttons: Record (selected), Object, Sample
- Record data source: [dropdown]
- Record identifier: [dropdown]
- Record note contains: [dropdown]
- Record refers to material: [dropdown] (selected: pine (wood))
- Record refers to date: [dropdown]
- Record refers to object: [dropdown]
- Record refers to sample: [dropdown]
- RUN button

Results Panel:

- Buttons: Results (selected), Properties
- Search results list:
 - 302759 (source: 'Särskild arkeologisk undersökning inför muddringsarbeten i Valdemarsviken')
Prov 5b:2 dateras till vinterhalvåret 1813/14 och utgör det enda provtagna spantvirket och furuvirket på fartyget som annars består av ekvirke mestadels komna från bordläggningen .
 - 302762 (source: 'Särskild arkeologisk undersökning inför muddringsarbeten i Valdemarsviken')
Proveniensen på det daterade furuvirket är norra Småland eller södra Östergötland.
 - P:1995049 (domain: stichtingring.nl) (source: 'Results from search for 'Stichting RING' on DCCD site')
Rotterdam, funderingshout
 - P:1997020 (domain: stichtingring.nl) (source: 'Results from search for 'Stichting RING' on DCCD site')
Veeneiken Flevopolder A27/Hoge Vaart
 - P:1998080 (domain: stichtingring.nl) (source: 'Results from search for 'Stichting RING' on DCCD site')
Bleekveld Tiel, waterputten

Swedish records referring to aat:300012620 “pine (wood)”, English records referring to aat:300343658 “Pinus (genus)” and Dutch records referring to aat:300343781 “Pinus sylvestris (species)”
- a hierarchical descendant of aat:300343658 “Pinus (genus)”

Design decisions

- KOS-based development efforts involve design choices
- Usually impractical to develop parallel implementations to compare major design alternatives and thus not easy to know the consequences of one design choice over another
- Reflecting on some major design decisions encountered during the two projects, with a view to informing future work ...

Design decisions 1

- How to select datasets, how much to model
How much of the source datasets and reports should be extracted, aligned to KOS and expressed as linked data? Should it be a subset (*USW case studies*) or as much as possible (*which is possibly usual CRM schema based approach*)?
- How to match datasets, reports, research questions
 - *An operational project should budget resources to locate key datasets and reports to address a particular research question (addressing issues of access and permission)*
- Should native schema of the source datasets be maintained in the resulting integration (*in Dutch Ships and Sailors linked data cloud – datasets converted to RDF using own data model and enriched with links to connect to interoperability layer*) or replaced by the new semantic framework (*USW case studies*)?

Design decisions 2

- Appropriate balance of application modeling detail, expressed between ontology and vocabulary side. **How much to handle via the ontology and how much to handle via the thesaurus** (or other vocabulary)? How much detail is it worthwhile to model?
 - *Not go beyond original data semantics ... Depends on use cases*

➔ ISO 25964 Part 2 (ch21)

One of the fundamental purposes of an ontology is reasoning, including generic tasks such as:

- inferring class membership for individuals;
- inferring relationships between classes and properties; and
- checking the consistency of a knowledge base

... Whereas the role of most of the vocabularies described in this part of ISO 25964 is to guide the selection of search/indexing terms, or the browsing of organized document collections, the purpose of ontologies in the context of retrieval is different. Ontologies are not designed for information retrieval by index terms or class notation, but for making assertions about individuals, e.g. about real persons or abstract things such as a process. ...

Design decisions 3

- How to mitigate the possibility of creating **alternative (valid) ontology mapping expressions of the same underlying semantics** from different sources and thus make cross search and interoperability difficult?



- *Mapping pattern based approach (in our case the template based STELLAR/STELETO tools)*
<http://hypermedia.research.southwales.ac.uk/resources/STELLAR-applications/>
- *Similarly see Linked Art project (also using CRM and AAT)*
<https://linked.art>

Design decisions 4

- Both projects required **substantial data cleansing**. How represent the new information, what is the relationship with the source dataset? - *replaced by new semantic framework?*

Examples encountered

- obvious spelling errors, reordering of words
- Additional prefixes or suffixes (e.g. *“red hill (possible)”*, *“trackway (cobbled)”*, *“croft?”*, *“portal dolmen (re-erected)”*)
- attempts at providing additional structure within a single field (e.g. *“pottery;ceramic tile;iron objects;glass”*)
- very specific compound phrases (e.g. *“side wall of pot with lug”*)
- how to represent ‘non-information’ values?
 - unstated NULL values or empty strings
 - *known unknowns* “not known”, “blank”, “null”, “nothing”, “void”, “not specified”, “unspecified”, “uncertain”, “missing”, “empty”.

Design decisions 5

- How to express information extracted via NLP? How much certainty to associate with the derived data, what kinds of elements are represented (archaeological texts often refer to types of object or material rather than named specific individual items)?
- How to express results from search over both data and textual reports, how to express the provenance of the subject metadata extracted and also the method by which it was extracted?
- ➔ Future work identifying passages of particular relevance for NLP information extraction (or sections to avoid).
STAR project focused mainly on report abstracts

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Open Access versions of Hypermedia Research Group's KOS papers are available from <https://bit.ly/2ocaHC6>

Acknowledgments

- Andreas Vlachidis (NLP)

Thank you

ARIADNE is a project funded by the European Commission under the Community's Seventh Framework Programme, contract no. FP7-INFRASTRUCTURES-2012-1-313193.

The views and opinions expressed in this presentation are the sole responsibility of the authors and do not necessarily reflect the views of the European Commission.

