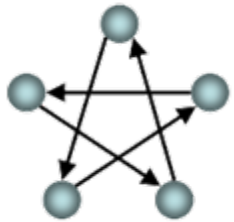
Semantic Annotations in the Archaeological Domain

Andreas Vlachidis, Ceri Binding, Keith May, Douglas Tudhope

STAR

Semantic Technologies for Archaeological Resources



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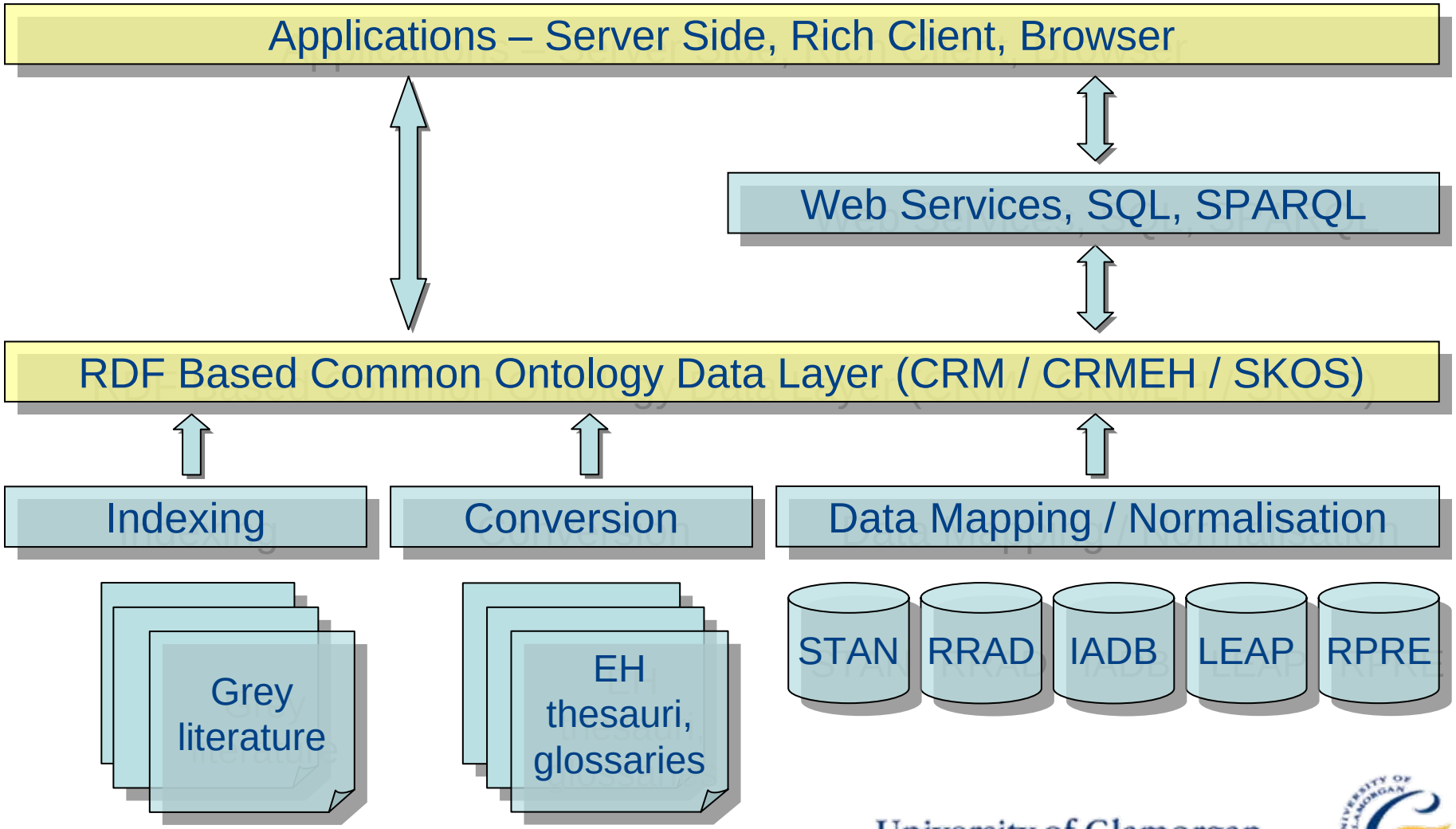
About This Presentation

- **The STAR project**
  - Aims and Objectives
  - Architecture of Semantic Access to Disparate data sets
  - Adapted Conceptual Models and Knowledge Resources
  - Progress to date and available Web services
- **Semantic Annotations Pathway**
  - The aim of the Research
  - OBIE for rich, semantic indexing
  - Domain Specific Requirements
- **Excavating Grey Literature Documents**
  - General Architecture for Text Engineering (GATE)
  - Rule Based Pattern Matching Approaches
  - 'Gold Standard' Pilot Evaluation
- **Adaptation Issues and Conclusions**
  - Ontological Model Verbosity
  - Prototype Query Builder
  - Prototype Indexing Deployment

The STAR Project

- **3 year AHRC funded project**
  - Started January 2007, finish December 2009
- **Collaborators**
  - English Heritage
  - RSLIS, Denmark
- **Aims**
  - To investigate the potential of semantic terminology tools for widening access to digital archaeology resources, including disparate datasets and associated grey literature
  - To demonstrate cross search and browsing at detailed, meaningful level

STAR - General Architecture



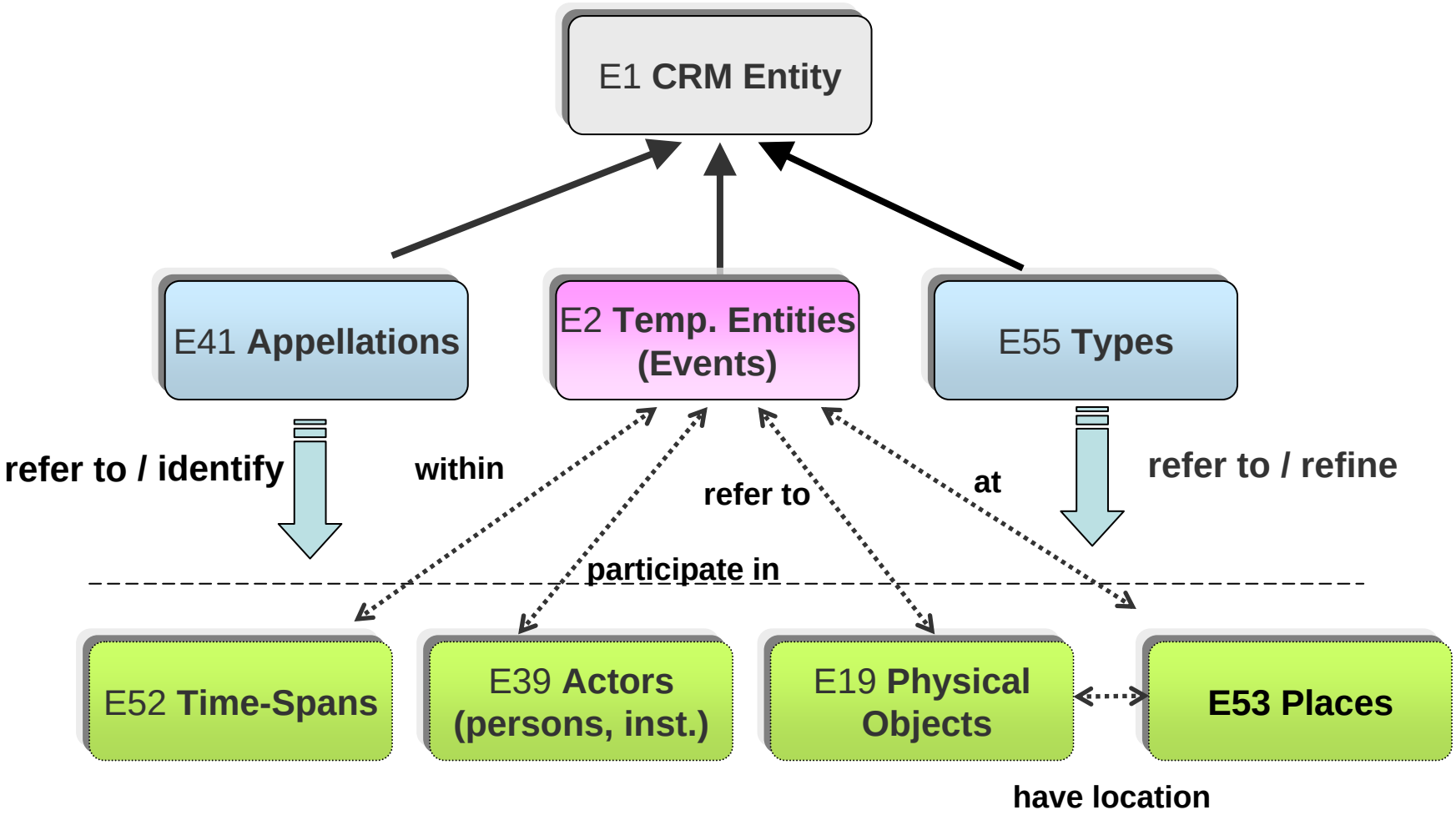
Conceptual Models and Knowledge Resources

- **CRM** [http://cidoc.ics.forth.gr/]
  - CIDOC Conceptual Reference Model
  - International standard ISO 21127:2006
- **CRMEH** [http://hypermedia.research.glam.ac.uk/kos/CRM/]
  - English Heritage Ontological Model
  - Extends CIDOC CRM for archaeological domain
- **SKOS** [http://www.w3.org/2004/02/skos/]
  - Simple Knowledge Organization System
  - RDF representation of thesauri, glossaries, taxonomies, classification schemes etc.

CIDOC Conceptual Reference Model

- *"The **CIDOC CRM** is intended to promote a shared understanding of cultural heritage information by providing a common and extensible semantic framework that any cultural heritage information can be mapped to"* [http://cidoc.ics.forth.gr/]
- About 80 classes and 130 properties for cultural and natural history
- Intellectual guide to create schemata, formats, profiles Extension of CRM with a categorical level, e.g. reoccurring events
- Best practice guide for data integration (mapping) Transportation format for data integration / migration /Internet

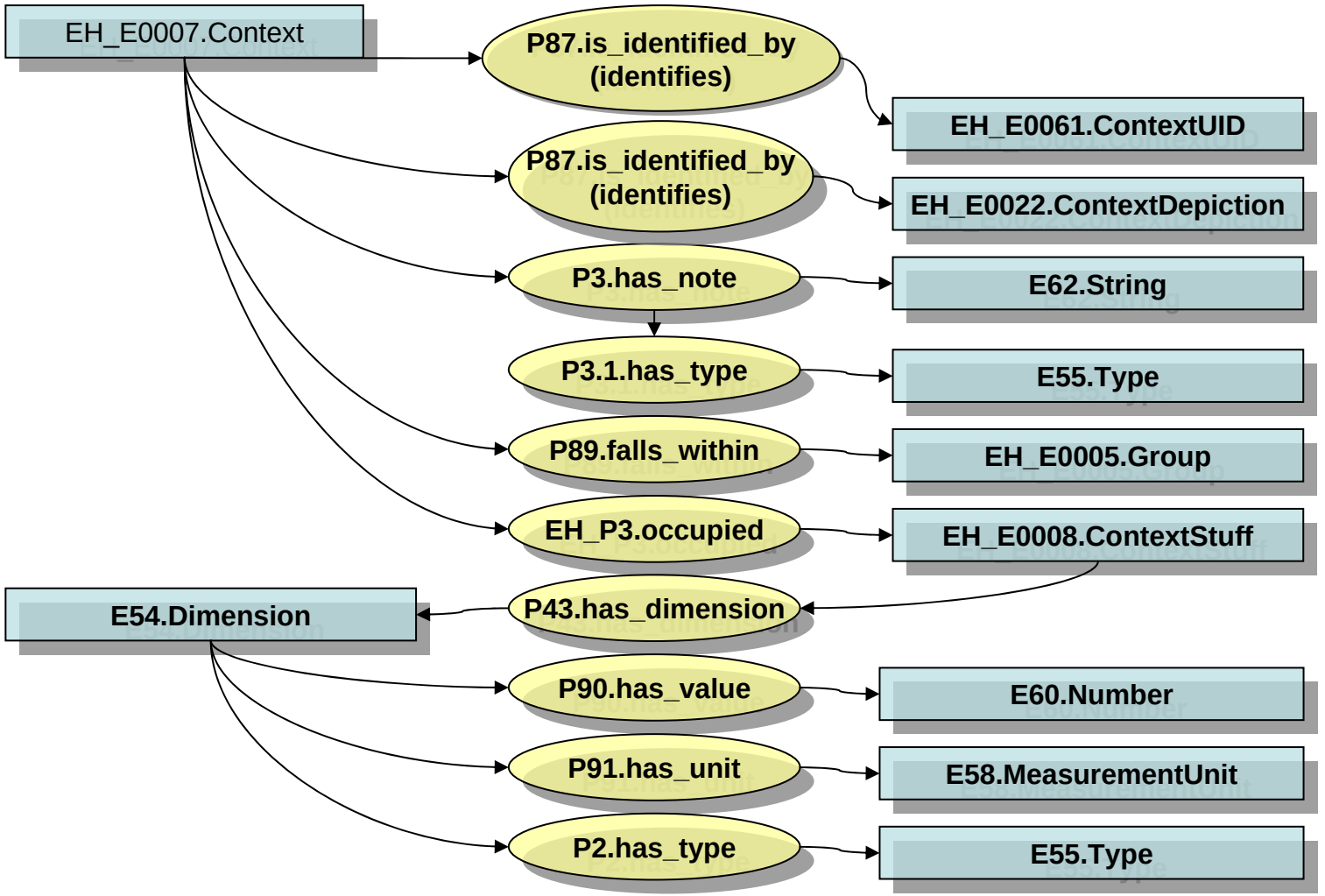
CIDOC Conceptual Reference Model



CRMEH- English Heritage Ontological Model

- Adopting and **extending** CRM for complete picture of on-site and off-site processes.
- **Entities and relationships** relating to Stratigraphic relations and phasing information, finds recording and environmental sampling.
- The extended CRM model CRM-EH, comprises **125** extension sub-classes and **4** extension sub-properties.
- Multiple disconnected **databases** and **legacy data**: CRM as 'semantic glue' to pull the data together

CRMEH A Closer Look



Description, Interpretive comments, Post-ex comments

Length, width, height, diameter etc.

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Simple Knowledge Organisation System

- Standard set for representation
  - Thesauri, Taxonomies, Classification Schemes
- Publication of controlled structured vocabularies
  - Intended for the Semantic Web
  - Built upon standard RDF(S)/XML W3C technologies
- Looser semantics than e.g. OWL

English Heritage Thesauri

- Monument types thesaurus
  - Classification of monument type records
- Evidence thesaurus
  - Archaeological evidence
- MDA object types thesaurus
  - Archaeological objects
- Building materials thesaurus
  - Construction materials
- Archaeological sciences thesaurus
  - Sampling and processing methods and materials
- Timelines thesaurus
  - Periods, and time-based entities

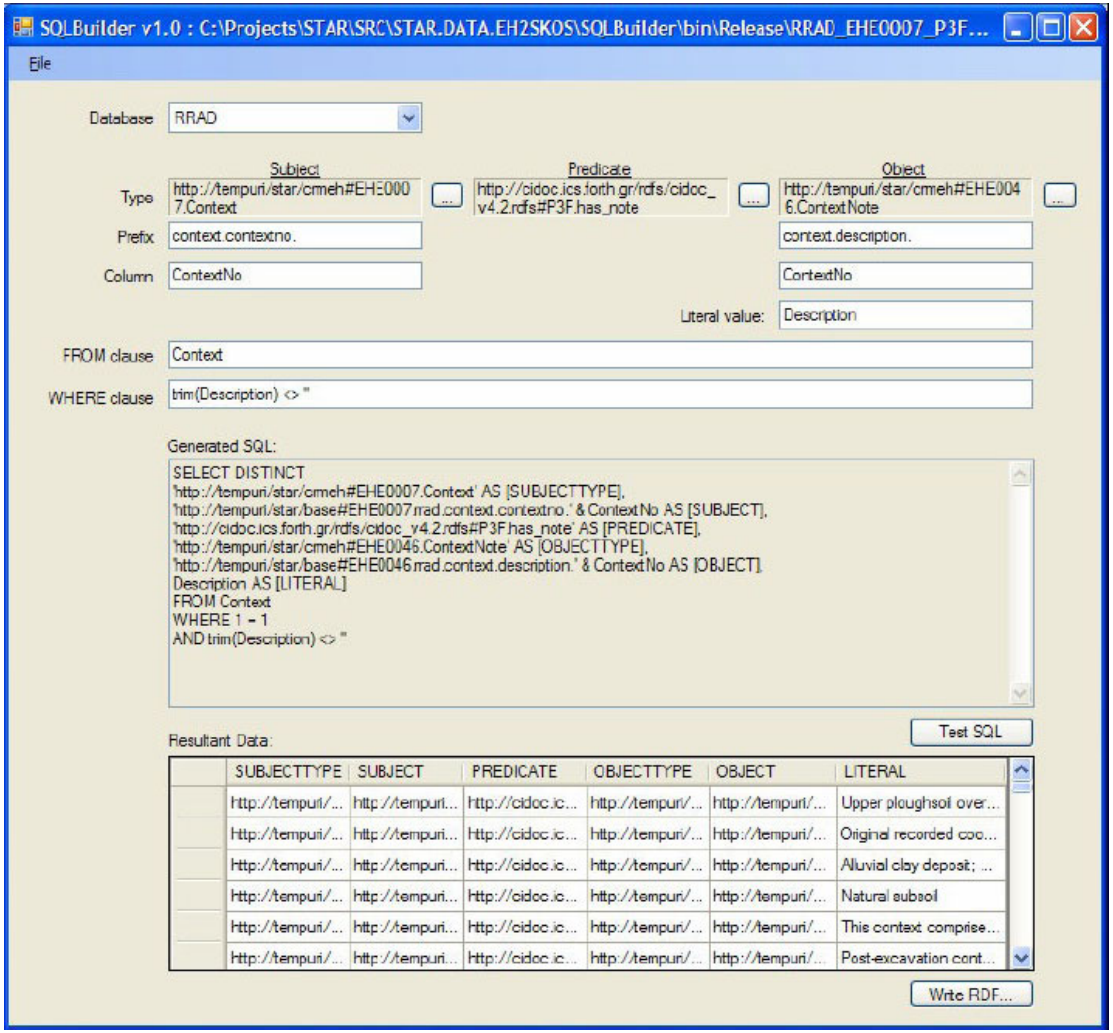
Data Mapping and Extraction

- Extraction of data to RDF triples
  - 5 archaeological datasets
  - Custom data extraction application
- Conversion of controlled terminology
  - 7 thesauri converted to SKOS
  - 27 glossaries created in SKOS
    - Created based on recording manuals
    - MultiTes XSL transformation to SKOS

Applications and Utilities

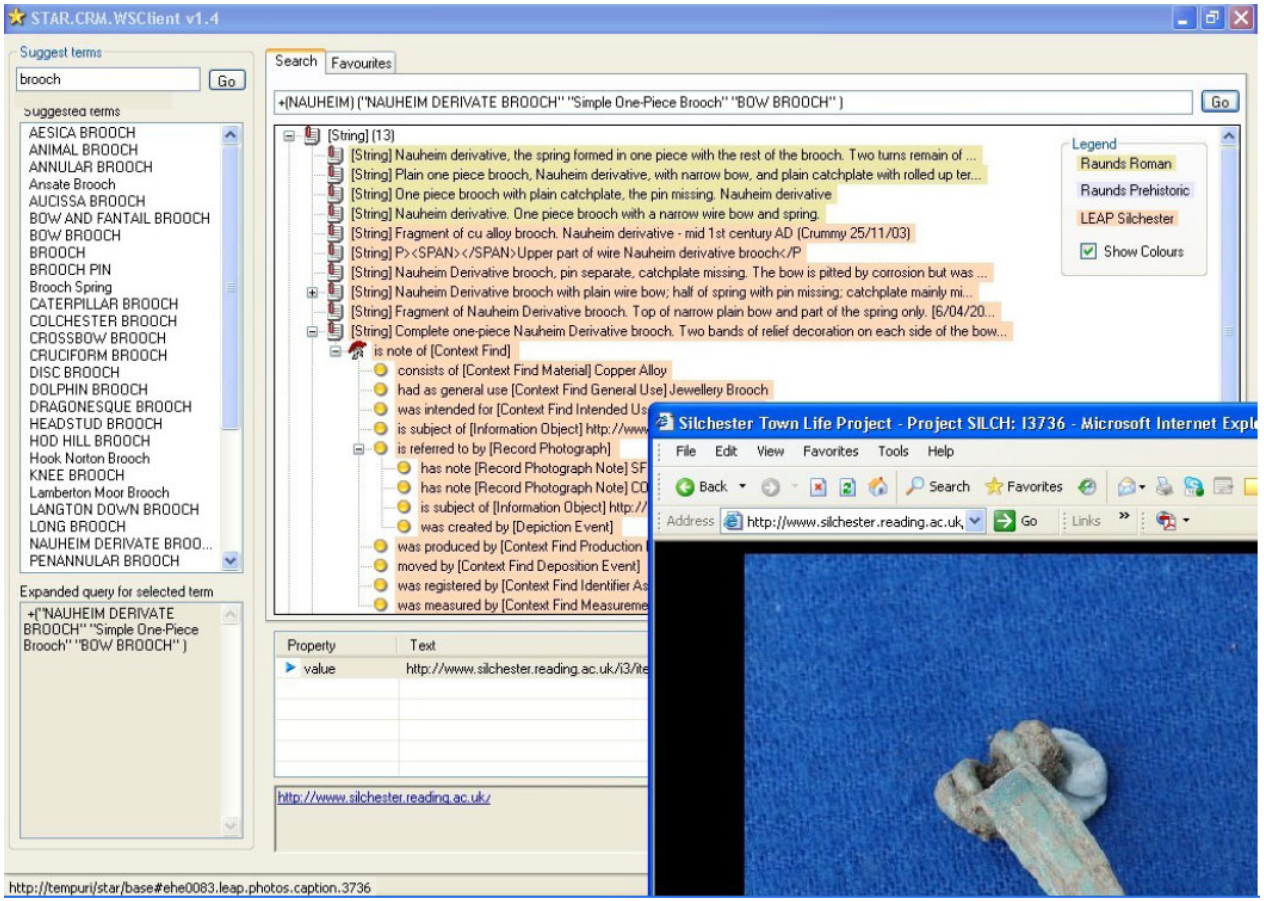
- **Data Mapping and Extraction Utility**
  - Bespoke mapping/extraction utility
  - Extract archaeological data conforming to mapping
  - Semi-automated manner
- **Prototype CRM Browser**
  - Prototype CRM browser
  - Query entry of free-text search terms
  - Option to navigate the results of returned queries.

STAR Data Mapping and Extraction Utility



- Entry boxes corresponding to Entity-Relationship-Entity elements of the CRM-EH statement.
- SQL query building up: SQL query incorporating selectable consistent URIs (CRM, CRM-EH, SKOS, Dublin Core and others).
- Query execution against the selected database
- Tabular data export to RDF format file

Prototype CRM Browser



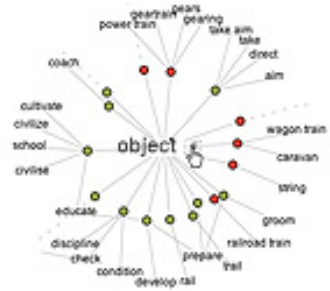
- Test and demonstrate interoperability between datasets.
- Incorporated the SKOS based thesauri browsing interface
- Distinguish between results, colour coding
- Search for “Nauheim Brooch”, Browse results and ‘drill’ deeper
- Link to live data, via returned URL hyperlinks

Semantic Annotations Pathway

- Semantic Annotations
  - specific **metadata generation** and usage schema
  - aimed to automate identification of concepts and their relationships in documents
- Research effort
  - Directed towards the generation of **rich document indices** carrying semantic and interoperable properties for the purposes of semantic interoperability .

Ontology Based Information Extraction

- Ontologies; a mediator technology between concepts and their worded representations
- Advance Information Retrieval
  - Beyond the limitations of words to the level of concepts
- Aid Information Retrieval
  - To make inferences from heterogeneous data sources
- Information Extraction
  - A specific text analysis task aimed to extract specific information snippets from documents
  - Ontologies to drive/inform IE
  - To describe the conceptual arrangements of semantic annotations.



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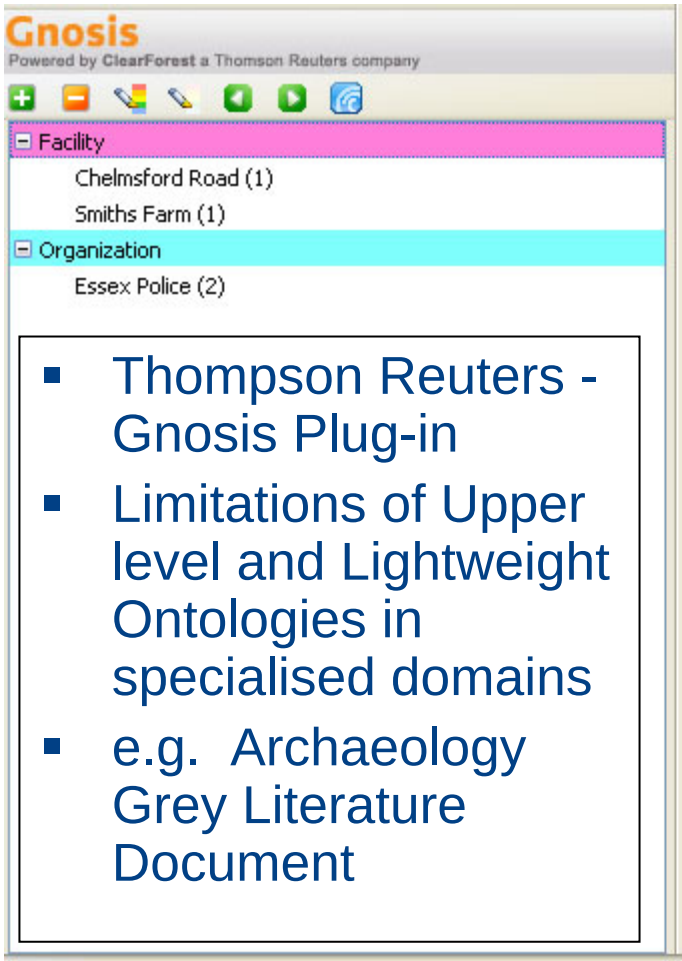
Archaeology Domain & Upper Level Ontologies



- Thompson Reuters - Gnosis Plug-in
- Limitations of Upper level and Lightweight Ontologies in specialised domains
- e.g. Archaeology Grey Literature Document

An archaeological evaluation was carried out by ECC FAU on behalf of Essex Police on the site of a proposed new police station at Smiths Farm, on the southeastern outskirts of Great Dunmow, Essex. The site was formerly rough pasture. The Chelmsford Road, which is thought to be the line of a Roman road, runs immediately to the east of the site. Five 30m x 2m trenches were excavated within the footprint of the proposed building and the area of associated carpark. Only one archaeological feature was revealed, a ditch containing prehistoric pottery dating to the Late Bronze Age or Early Iron Age along with burnt flints and flint flakes. No other archaeological features were identified, although a number of prehistoric pottery sherds and flint flakes were discovered on the surface of the natural geology. Although the results of the evaluation do not suggest intensive landscape use during the Late Bronze/ Early Iron Ages it is clear from this and other nearby investigations that a focus for the low level activity seen may well lie in the general vicinity. The absence of Roman or medieval remains indicates that this site was well outside the settlements of these periods. The low quantity and quality of the remains encountered on the site suggests that there is only a minor archaeological implication for the location of the proposed police

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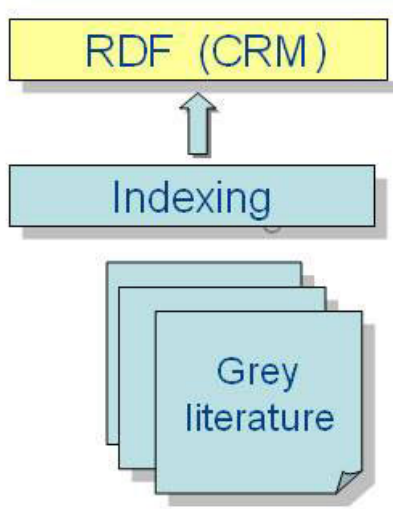
Excavating Grey Literature Documents

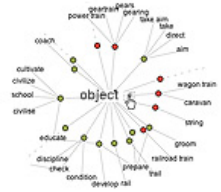
- **Grey Literature**; *source materials that can not be found through the conventional means of publication*
  - Raunds reports
  - Online AccesS to the Index of archaeological excavationS (OASIS)
    [http://ads.ahds.ac.uk/project/oasis/]
  - Library of unpublished fieldwork reports
  - English Heritage listed Buildings System (LBS)
- Semantic Indexing
  - Interoperable technologies W3C standards
    - XML, RDF representation
  - TEI adoption



Information Extraction Framework

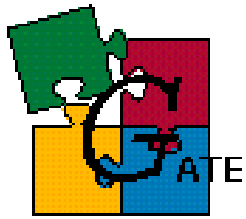
EH Thesaurus
- Object Types
-Archaeological Periods

Ontology
-CIDOC CRM-EH



Java Pattern Engine

JAPE



Gazetteer Lists

General Architecture for Text Engineering

ADS – OASIS
Grey Literature

XML structures to represent semantic properties

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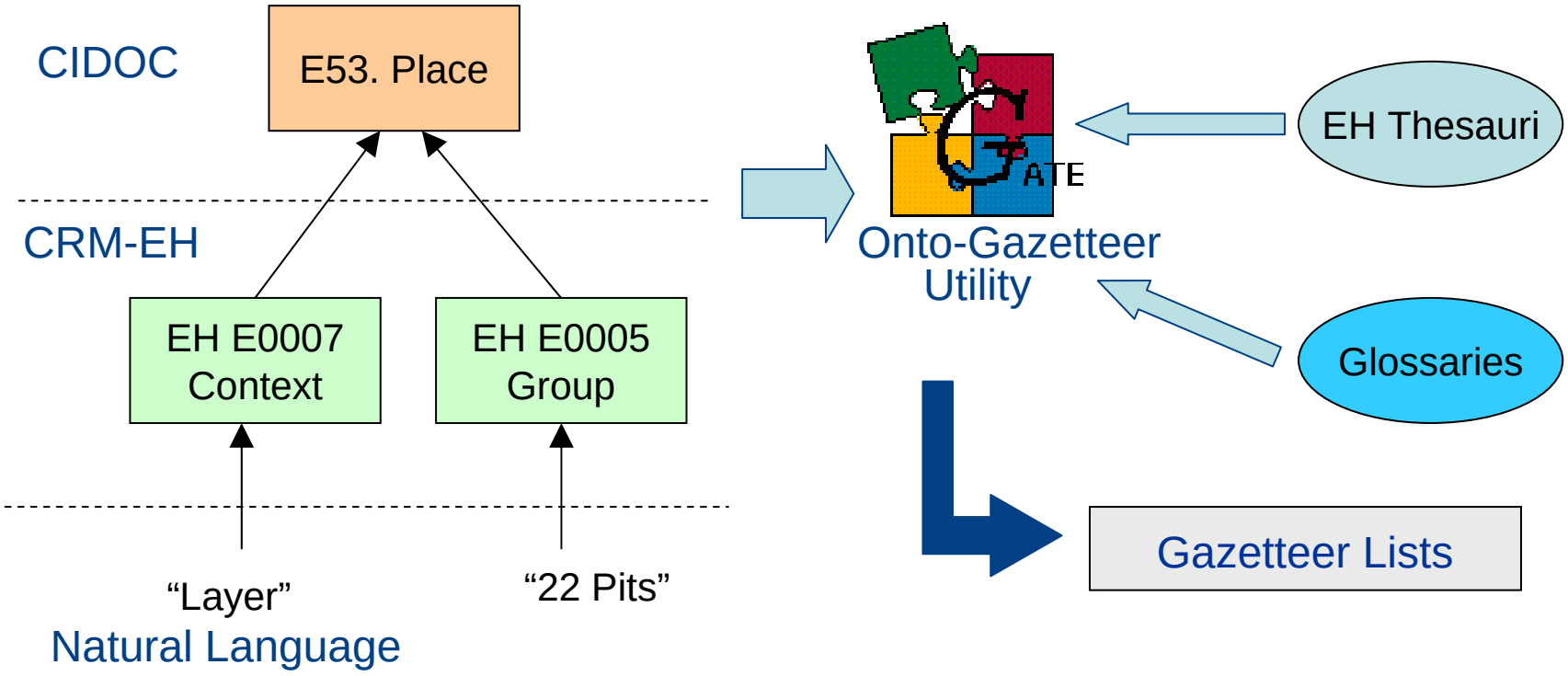
GATE Mapping of Knowledge Resources



Reference to SKOS mapped to the MinorType attribute of list entries

JAPE Pattern Matching Rules

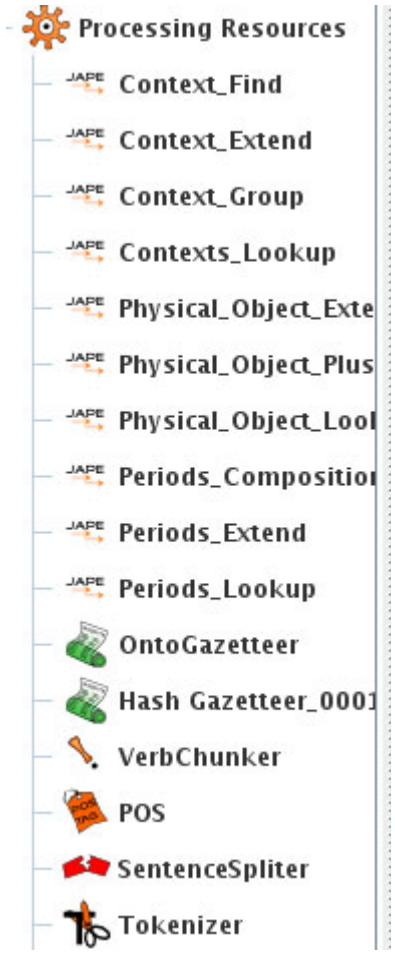
Natural Language – Gazetteer Look-up

"**Ditch** containing **prehistoric pottery** dating to the **Late Bronze Age or Early Iron Age** along with **burnt flints** and **flint flakes**"

Pattern Matching Rules expanded beyond simple gazetteer look-up

<entity><*same*-entity>	E49 E49	***"Late Bronze Age or Early Iron Age"***
<entity><*other*-entity>	E49 E19	**"prehistoric pottery"**
<entity><verb>(<entity> /<structure>)	E53	**"Ditch containing prehistoric pottery"**

A Cascading Extraction Process



- A cascading order of natural language processes over text
- Expanding from simple gazetteer *Look-Up* matching rules to complex JAPE transducers
- Build up from previously defined annotations to express annotation structures (templates) of ontological concepts

Annotation Types exposed in XML

Annotation Types

- Context
- ContextExtend
- ContextFind
- ContextGroup
- ContextPLusTime
- PhysicalObject
- PhysicalObjectExtend
- PhysicalObjectPLusTime
- TimeAppellation
- TimeAppellationComposition
- TimeAppellationExtend

XML Annotation Structures

("Ditch containing prehistoric pottery")

```
<ContextFind>
  <Context>Ditch<Context>
  <VG>containing</VG>
  <PhysicalObjectPLusTime>
    <Time_Appellation>
        prehistoric
    <Time_Appellation>
    <PhysicalObject>
        pottery
    </PhysicalObject>
 </PhysicalObjectPLusTime>
</ContextFind>
```

DOM – XML Applications

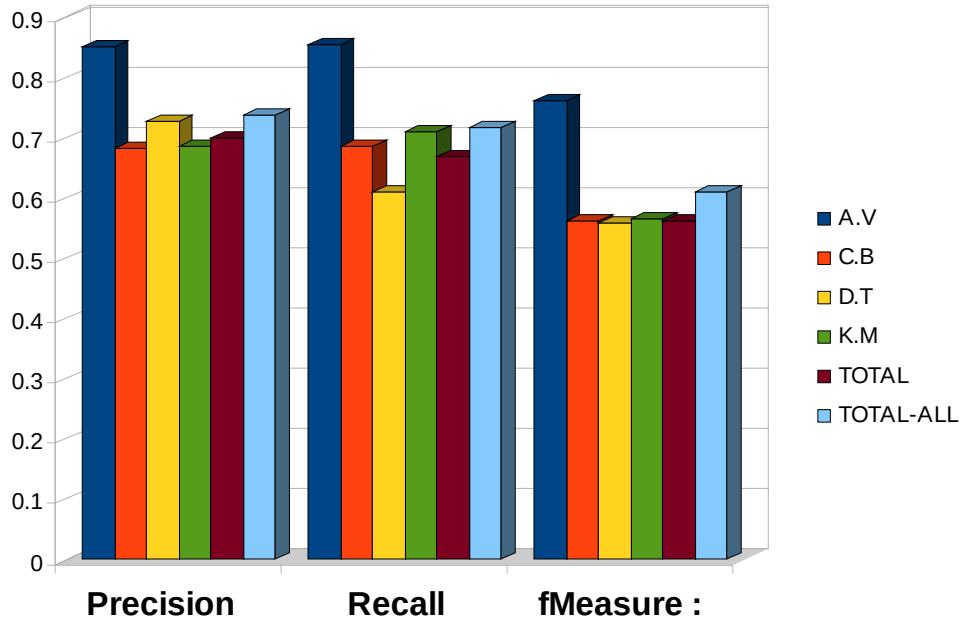
Andronikos*
Uses PHP-MySQL to display semantic indices values in HTML format

Semantic Attributes for Annotation Types

```
<PhysicalObject gateId="8749" SKOS-EH="134718" thesaurus ="EH-Object
   Types" class="EHE0009.ContextFind"
   ontology="http://hypermedia.research.glam.ac.uk/media/files/documents/2
   008-04-01/CIDOC_v4.2_extensions_eh_.rdf"}
```

‘Gold Standard’ PILOT Evaluation

- ‘Gold standard‘; a collective effort of human annotators
- Manual annotation of GS with respect to the Annotation Types (aimed to suggest expansion)
- Pilot study (formative assessment).
- Aimed to benchmark the performance of the extraction mechanism
- **Inter-Annotators** Scores



	AV	CB	DT	KM	TOTAL	TOTAL-ALL
Precision	0.85	0.68	0.72	0.68	0.69	0.73
Recall	0.85	0.68	0.61	0.71	0.66	0.71
fMeasure :	0.76	0.56	0.56	0.56	0.56	0.61

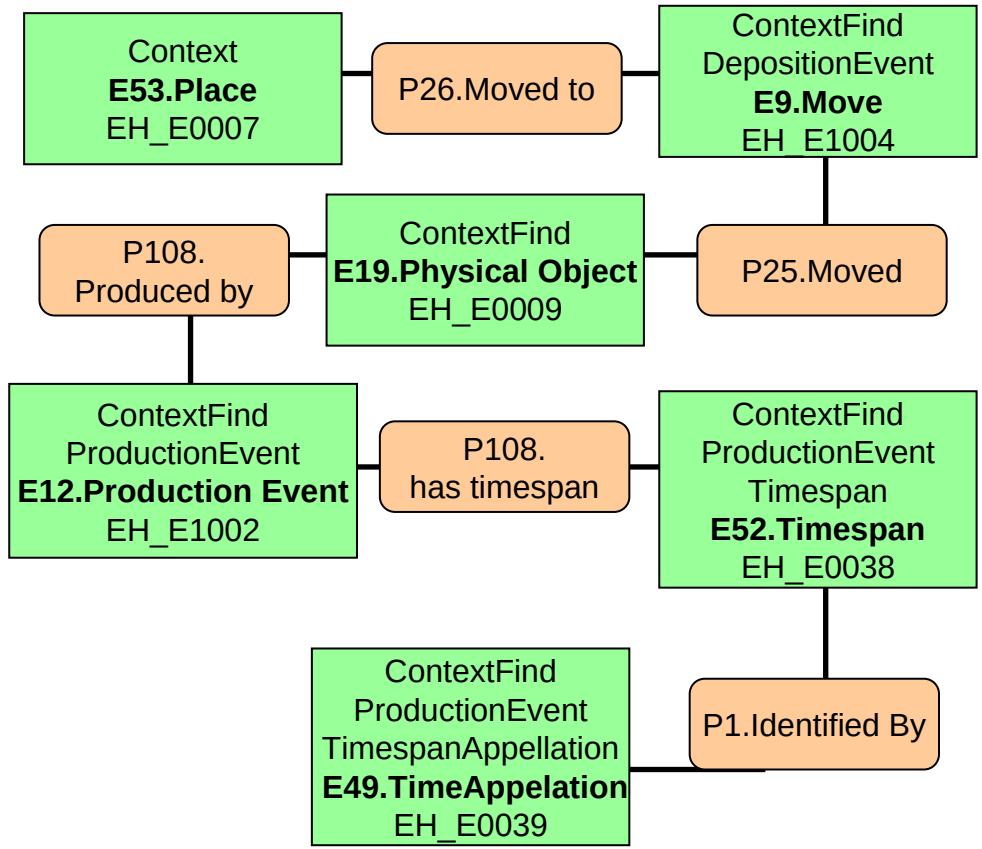
Pilot Evaluation Results - Discussion

- Encouraging Recall and Precision rates over 70% for *Time Appellation* concepts
- The limited amount of glossary terms (*Places)* has influenced the performance
- Agreement for *Place* and *Physical Objects* was not always clear cut (i.e 'burnt tree throws')
- The potential of the method to extract complex phrases associated to two or more ontological entities
- Future work
  - Incorporation of additional Ontological Entities (Material, Samples)
  - Gazetteer enhancement
  - Pattern matching rules expansion
  - Formal evaluation of the Extraction method and overall retrieval performance

Model Adaptation Issues

- CRM-EH is a detailed event driven model. Natural Language can be abstract. Mapping with entities/properties can by-pass model verbosity

```
<ContextFind>
  <Context>Ditch<Context>
  <VG>containing</VG>
 <PhysicalObjectPLusTime>
<Time_Appellation>prehistoric
<Time_Appellation>
    <PhysicalObject>pottery
</ PhysicalObject>
 <PhysicalObjectPLusTime>
<ContextFind>
```



Interoperable Indices Formats

TEI

RDF

Prototype Query Builder

- Inter-relationships of the CRM-EH modeled data.
- Short-cuts for traversing the commonly followed relationships between key entities

- Archaeological *Context* associated key relationships:
  - Find
  - Sample
  - Stratigraphic, Spatial, Temporal
  - Group

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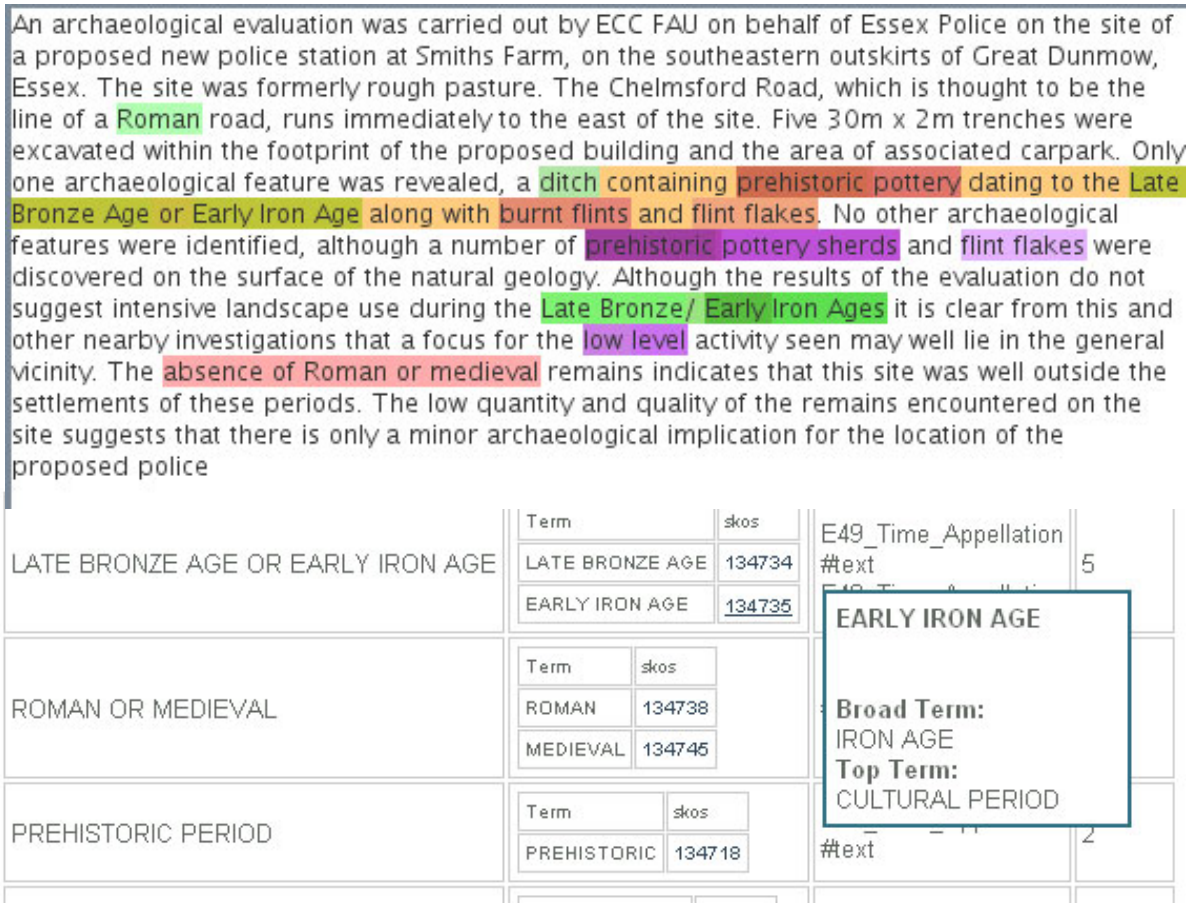
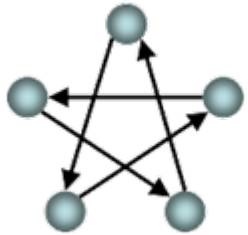
Prototype Indices Deployment



- Andronikos web-portal development
- Utilise semantic annotation XML files
- The server side technology PHP DOM XML
- MySQL database server to store relevant thesauri structures.



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Semantic Technologies for Archaeological Resources

http://hypermedia.research.glam.ac.uk/kos/star/
http://andronikos.kyklos.co.uk

avlachid@glam.ac.uk
cbinding@glam.ac.uk
keith.may@english-heritage.org.uk
dstudhope@glam.ac.uk

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