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Leopold Franzens
Universität Innsbruck



A Coordination Model for Triplespace Computing

Elena Simperl, Reto Krummenacher, and Lyndon JB Nixon

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making semantics **real**.



- 1. *Introduction***
- 2. *Semantic Tuples & Spaces***
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- 4. *Ontologies & Reasoning***
- 5. *Conclusions & Outlook***



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Introduction

Triplespaces provide a communication paradigm for *anonymous* and *asynchronous* information exchange that ensures the *persistency* and *unique identification* of the communicated *semantic, semi-structured* data.





<http://www.tripcom.org>





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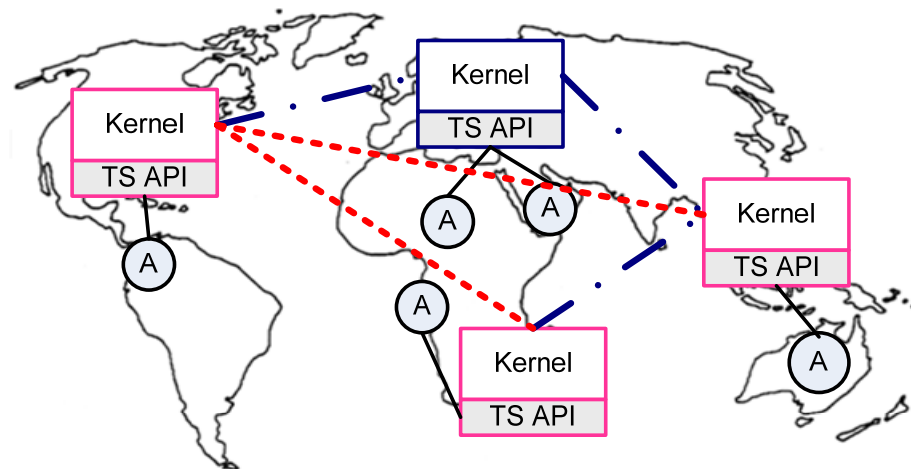
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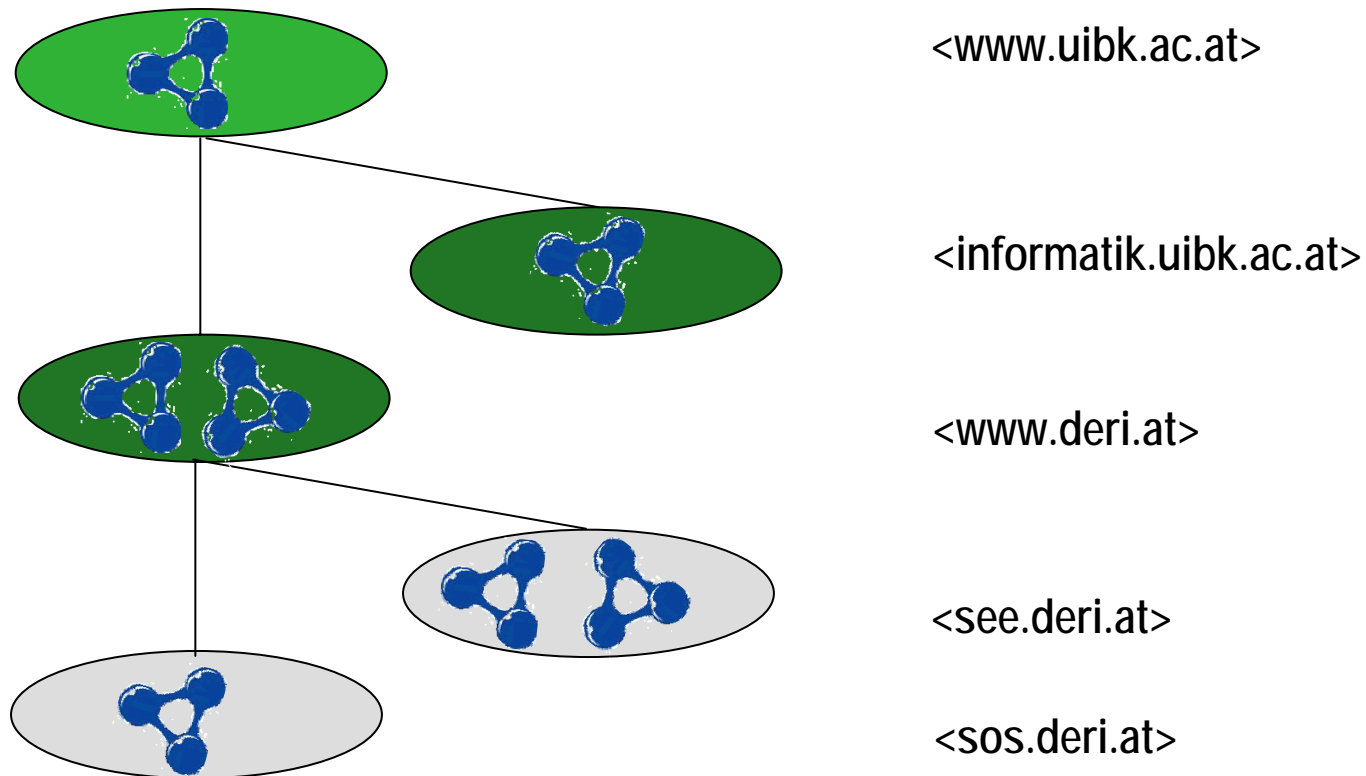
Semantic Triples & Spaces

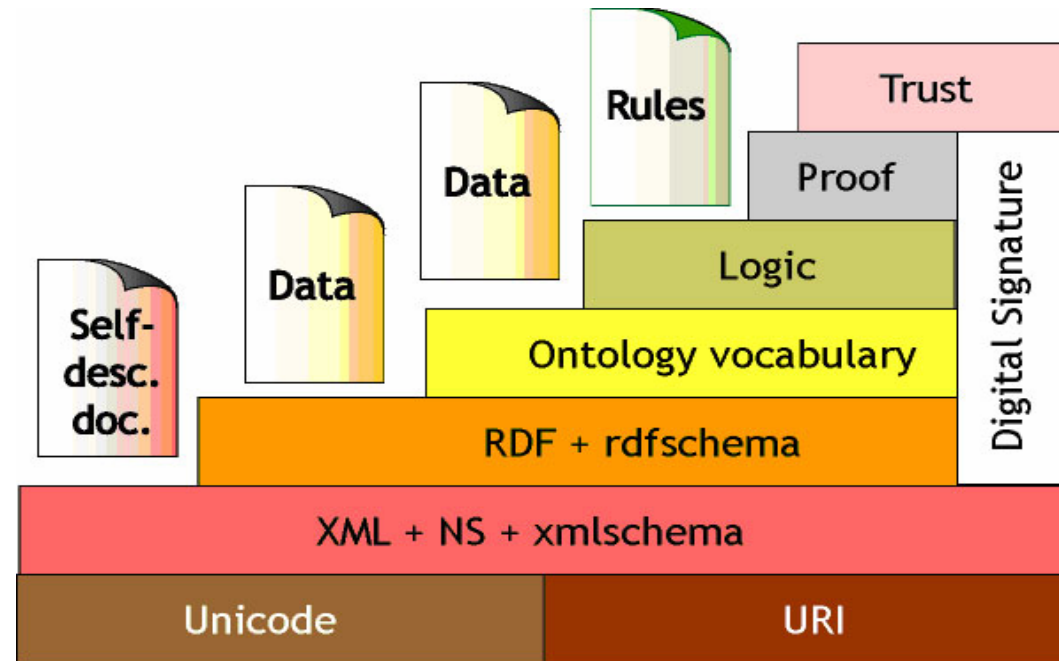
Triple Space: a virtual unit of the shared middleware, a container for triples.

Triple Space URI: the **identifier** of a Triple Space, e.g. `<ts://www.deri.at/tspace/>`



- Tree-structure: natural approach to scalability through direct addressing by URI.



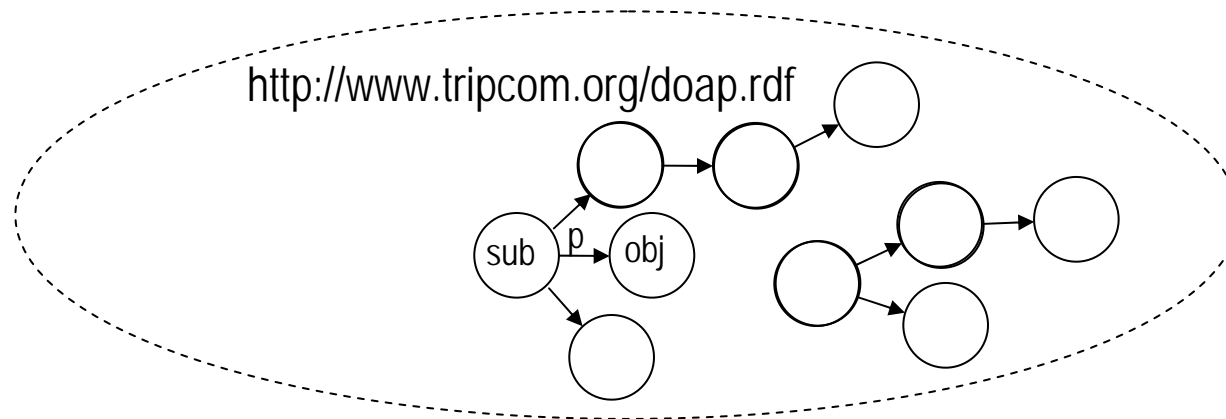


The ***Semantic Web*** is a web of ***data*** that provides a common framework that allows data to be ***shared and reused*** across application, enterprise, and community boundaries.

RDF Triples: Semantic Web data model

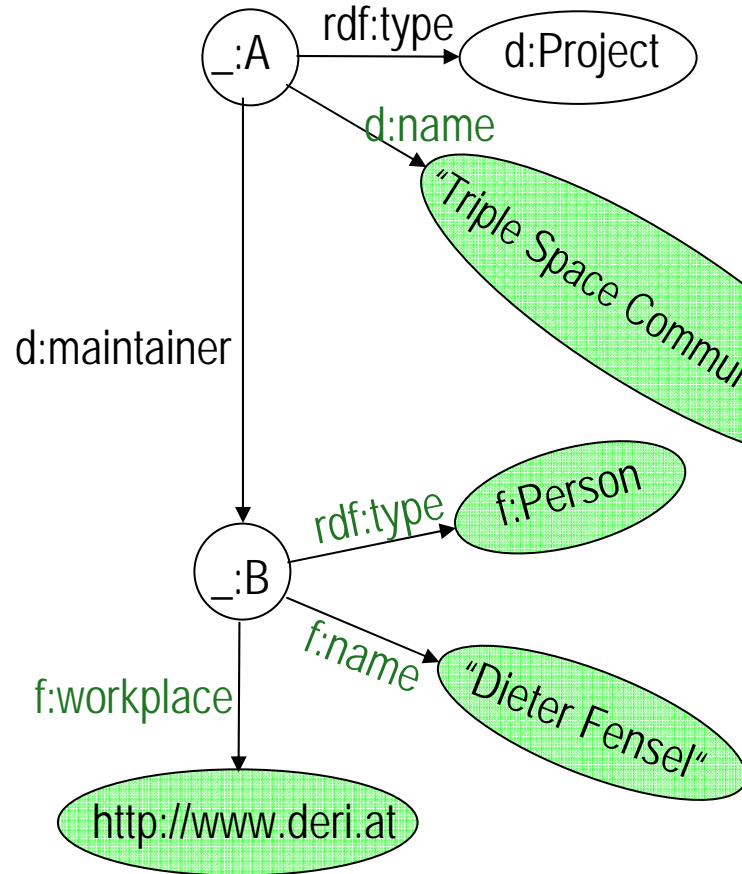
RDF **Graph:** a set of “manually” grouped triples

Named Graph: a pair (URI u , Graph g)





<http://www.tripcom.org/doap.rdf>



```

<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:doap="http://usefulinc.com/ns/doap#"
  xmlns:foaf="http://xmlns.com/foaf/0.1/"
  xml:lang="en">
  <doap:Project>
    <doap:name>Triple Space Communication</doap:name>
    <doap:shortname>TripCom</doap:shortname>
    <doap:homepage rdf:resource="http://www.tripcom.org"/>
    <doap:mailing-list rdf:resource="http://lists.deri.org/mailman/listinfo/tri">
    <doap:created>2006-04-01</doap:created>
    <doap:description>The aim of the TripCom project is to develop Triple Space
    <doap:maintainer>
      <foaf:Person>
        <foaf:name>Alice Carpentier</foaf:name>
        <foaf:workplaceHomepage rdf:resource="http://www.deri.at"/>
        <foaf:title>Administrative Coordinator</foaf:title>
      </foaf:Person>
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    <doap:maintainer>
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        <foaf:title>Project Manager for Freie Universitaet Berlin</foaf:title>
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        <foaf:title>Project Manager for Universitaet Innsbruck</foaf:title>
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      </foaf:Person>
    </doap:maintainer>
    <doap:maintainer>
      <foaf:Person>
        <foaf:name>Frank Leymann</foaf:name>
  
```



- **Reference Mechanism**

Uniquely identify resources for direct addressing on the Web by URI.

- **Separation Mechanism**

Namespaces help to distinguish terms of distributed applications on the Web.

- **Nesting/Linking of Tuples**

RDF tuples/triples are interlinked and form graphs, hence no independence of tuples in the Semantic Web.



Further issue with traditional Linda implementations:

Tuples with the same number of fields and the same field typing cannot be distinguished.

RDF triples have always three fields that are „always/mostly“ of type URI.

```
<reto> foaf:knows <elena> : URI URI URI
```

```
==
```

```
<reto> <isAt> <coordination07> : URI URI URI
```



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Coordination API & Matching



- **Triples and graphs**
 - Multiple triples describe the same piece of information/data
 - Only triples as a whole describe the information sufficiently
- **Identification of resources**
 - Direct addressing of resources, in particular graphs
 - Business orders, Service descriptions,...
- **Semantic matching**
 - Distinguish <URI URI URI>-triples by their meaning
 - Discover information based on the relationship of triples
 - e.g. find the name of a person that <reto> knows?



`out(Graph g, URI space,
URI ng)`

A *graph* contains multiple triples (multi-write); triples are written to a particular space *s*, and might be grouped as a graph with the name *ng*.

Six retrieval operations, three read (`rd`, `rda`, `rdg`) and three take (`in`, `ina`, `ing`) with the same semantics but destructive.

`rda(Template t, URI
space, int timeout)`

Returns a graph containing **one** (a) matching triple and its bounded description.

Generalizes `rda` by returning an undetermined number of matching triples.

`rd(Template t, URI
space, int timeout)`

`rdg(Template t, URI
space, int timeout)`

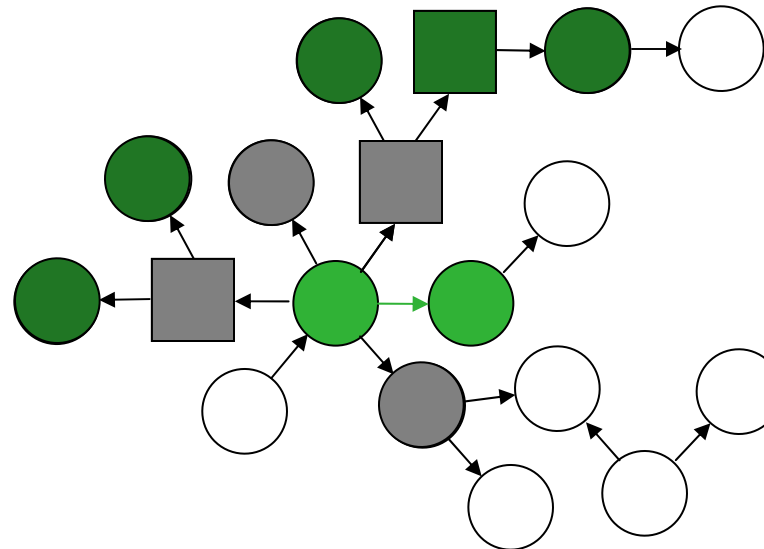
Returns all triples belonging to the same graph that contains the matching triple.



Concise Bounded Description

Given a particular node in an RDF graph, a *concise bounded description* can be identified as follows (in short):

1. Include all statements where the subject of the statement is the starting node;
2. Recursively, for all statements identified, include all statements where the subject of the statement is a blank node and which are not already included.



 blank node



- Publish / Subscribe mechanism
 - subscription for a given template in a given space
 - important for long-term coordination of services and applications
- Creation, destruction of spaces
 - installation of a new space
 - assignement of identifier
 - integration in space hierarchy
 - release of identfier binding and published data



- Matching the structure and meaning of triples, related triples and graphs

- Triple patterns: **<reto> foaf:knows ?o**
- Graph patterns

TEMPLATE	DESCRIPTION
<code>?s a doap:Project; foaf:member ?o.</code>	Matches all triples where the subject is of type doap:Project and where the same subject has triples indicating the members.
<code>?s ?p ?o. ?o a foaf:Person.</code>	Matches all triples where the object is of type foaf:Person.
<code>?s foaf:name ?a; foaf:mbox ?b.</code>	Matches the triples that contain subjects for which the name and a mailbox (foaf:mbox) are indicated.

- RDF queries, e.g. SPARQL (W3C Working Draft, 03/07)
- Rules...



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Ontologies & Reasoning



One of the major advantages of semantics-aware tuplespaces / triplespaces compared to traditional approaches is ontology-driven management

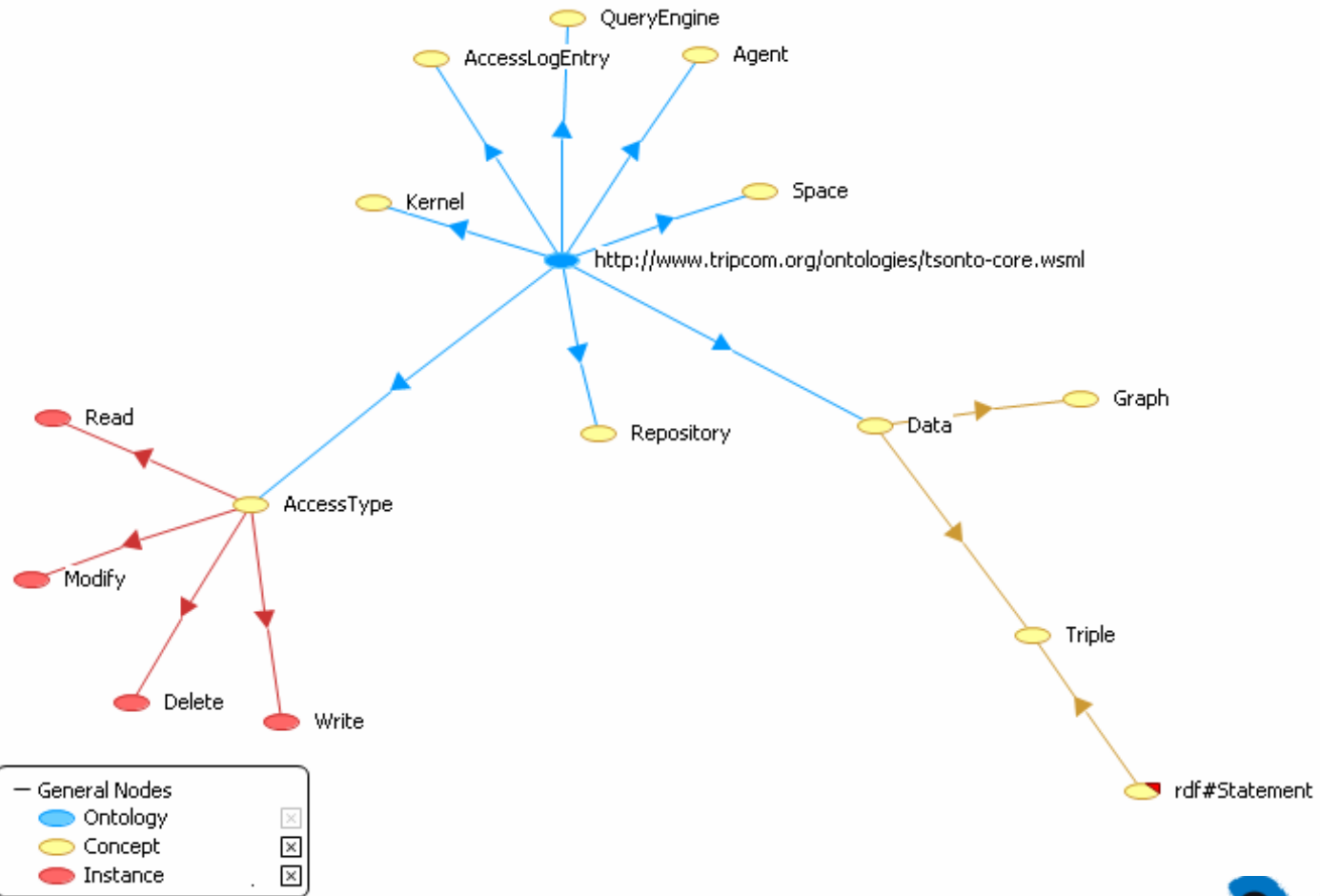
- **Meta information (Data and Self-Representation)**
- **Ontologies: formalisation of meta information**
- **Reasoning about meta information**

...as integrated part of the space installation...

- **(Self-)Adaptation, Reflection: „reasoning about itself“.**



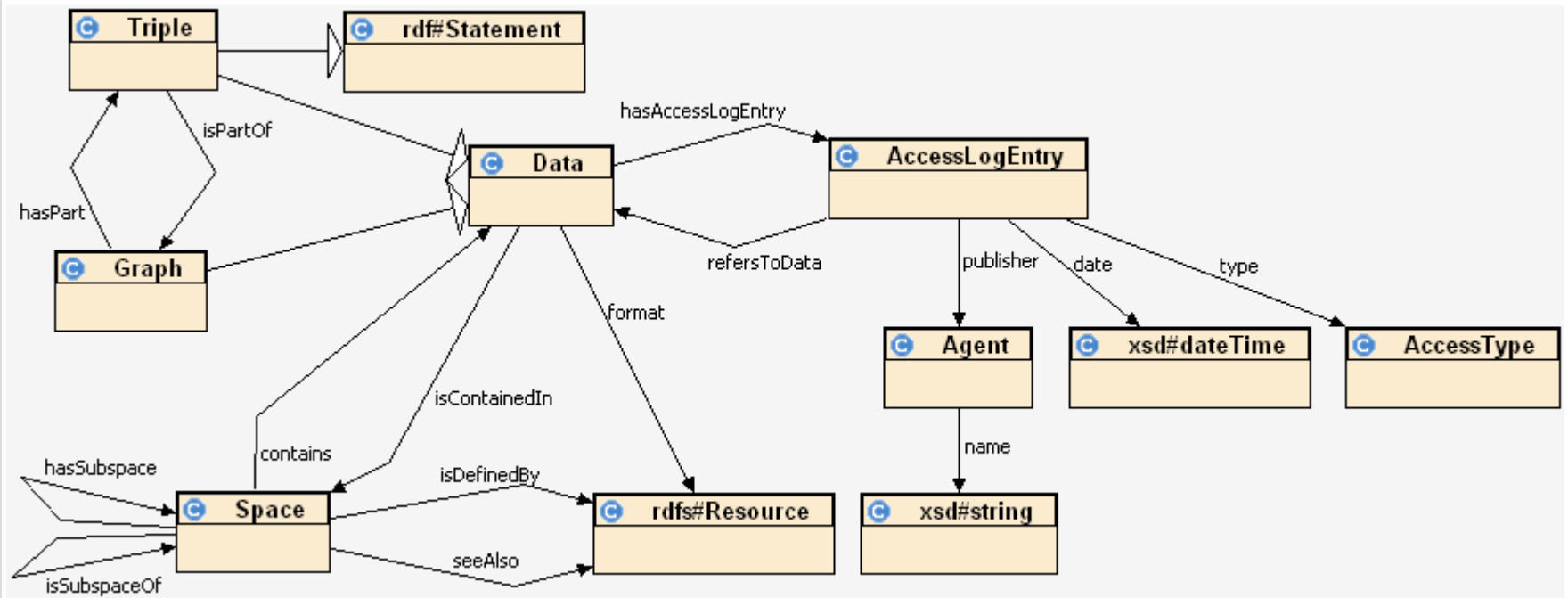
Triplespace Ontology



SEMANTIC EXECUTION ENVIRONMENT



Triplespace Ontology (2)





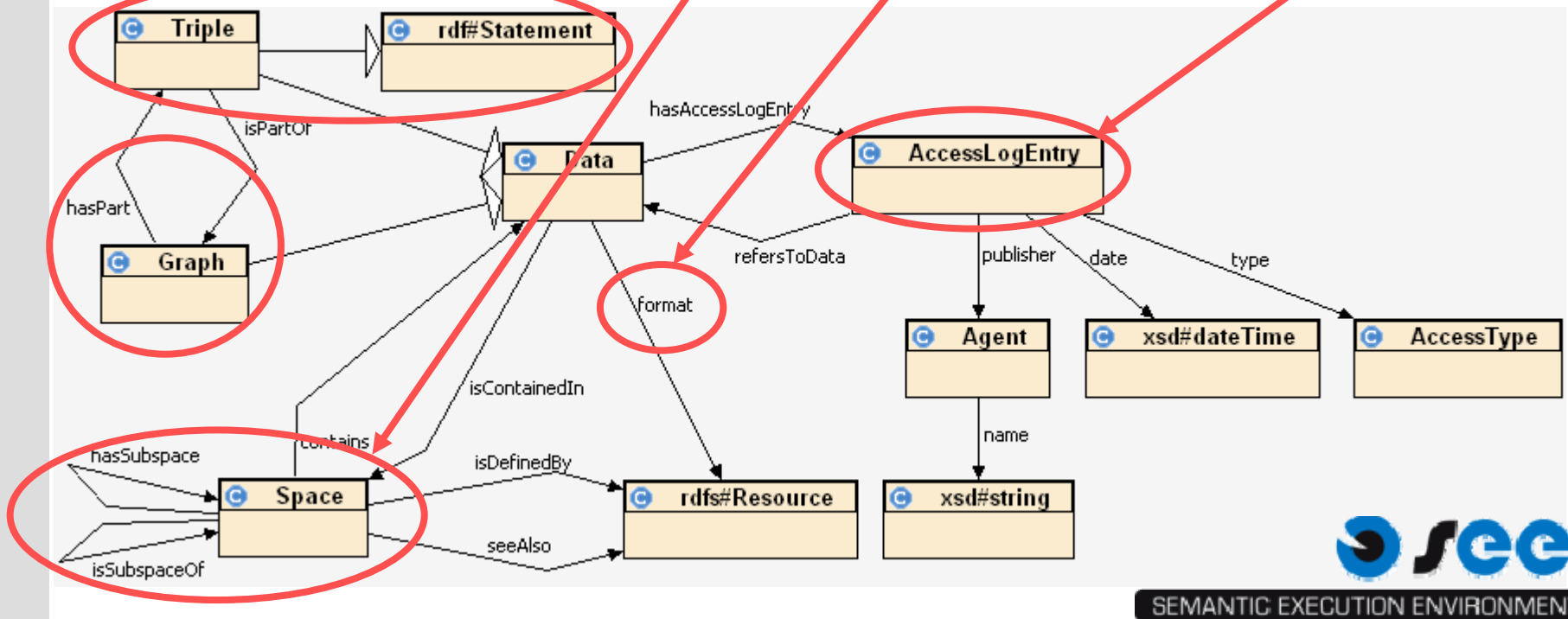
Triplespace Ontology (2)

Triples are RDF statements and part of an RDF graph

Space hierarchy

Language formalisms

Data access logs might be required, e.g. in eHealth





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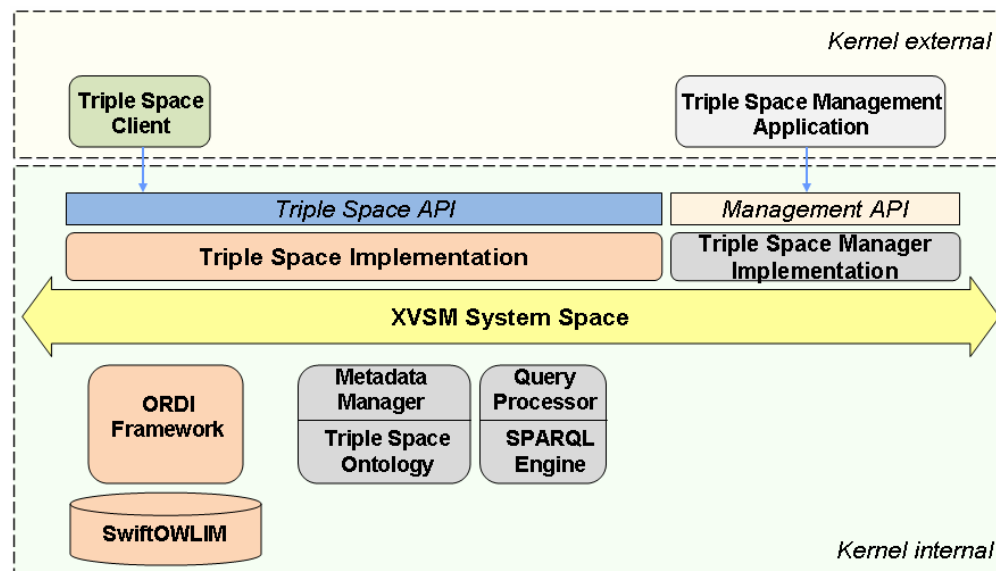


Conclusions & Outlook



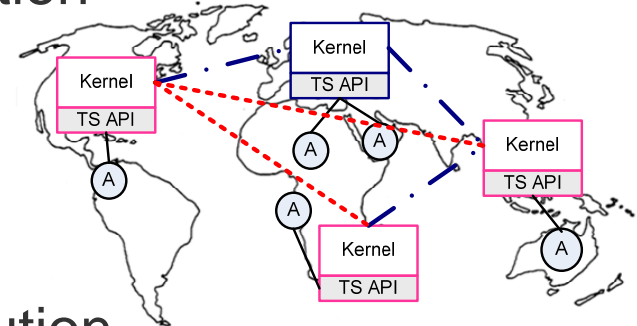
- There is a first prototype available
 - Single node solution
 - Coordination API support
 - Modeling of spaces and graphs
 - Query Engine for triple pattern and SPARQL templates
- Next release
 - Integration of ontology
 - Distribution of space and data
 - Multi-kernel space implementation

- There is a first prototype available
 - Single node solution
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Next Steps: Distribution & Scalability

- Distribution of space functionality
 - Multiple kernels
 - Multiple sites with global distribution
- Distribution of semantic data
 - Partitioning, replication
 - Distributed template/query resolution
- Scalability
 - Global space implementation
 - Internet of Services





- Tuplespace technology for Serviceware (Semantic Web services, Internet of Services)
- Semantic data has new requirements
 - Reference mechanism
 - Linking of triples, clusters as graphs
 - Semantic matching: graph structure and meaning
- Presentation of TripCom approach
 - Tuple and space model with Coordination API
 - Convergence of semantic matching and RDF querying



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Leopold Franzens
Universität Innsbruck



Thank you.

*Reto Krummenacher
Digital Enterprise Research Institute DERI
University of Innsbruck, Austria
reto.krummenacher@deri.at*

www.tripcom.org

