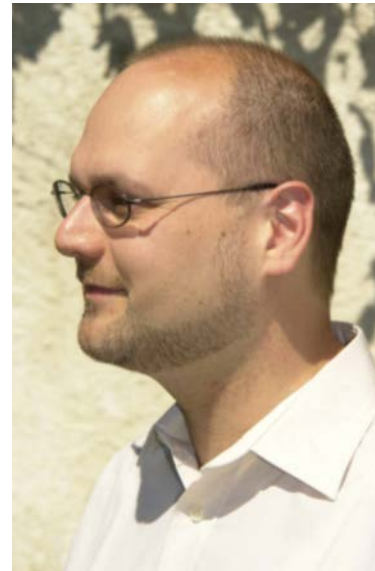


# Ontology Design Patterns for Ocean Science Data Discovery



**Pascal Hitzler**

DaSe Lab for Data Semantics  
Wright State University  
<http://www.pascal-hitzler.de>

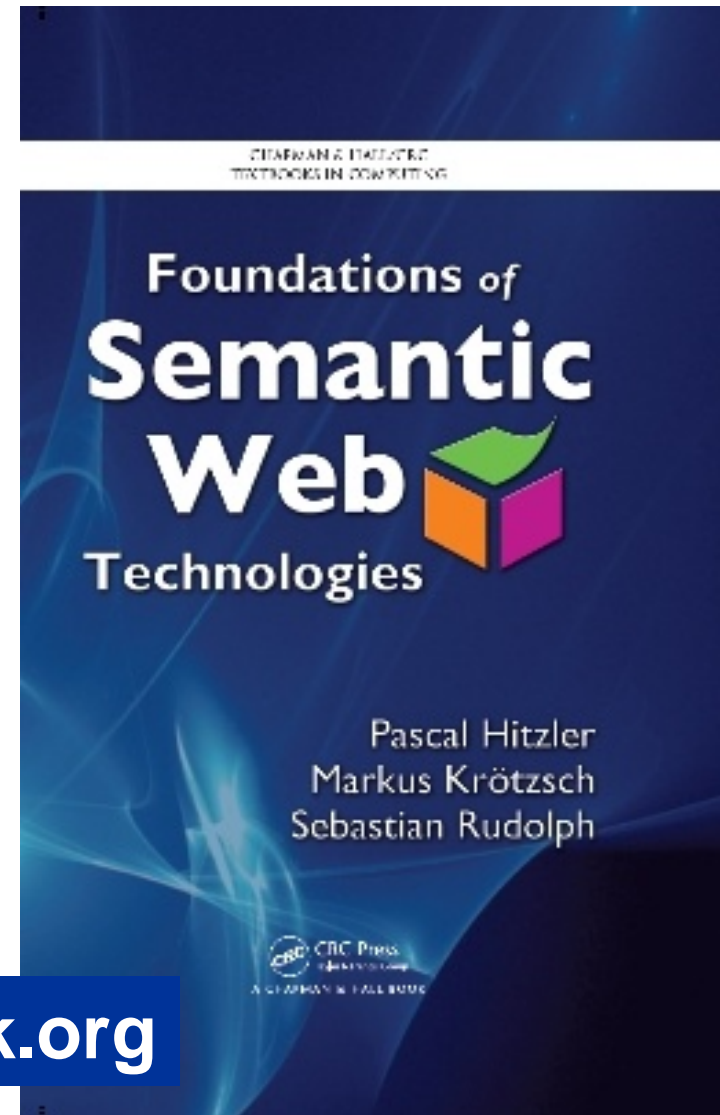
Pascal Hitzler, Markus Krötzsch,  
Sebastian Rudolph

Foundations of Semantic Web  
Technologies

Chapman & Hall/CRC, 2010

**Choice Magazine Outstanding Academic  
Title 2010 (one out of seven in Information  
& Computer Science)**

<http://www.semantic-web-book.org>



Pascal Hitzler, Markus Krötzsch, Sebastian Rudolph

## 语义Web技术基础

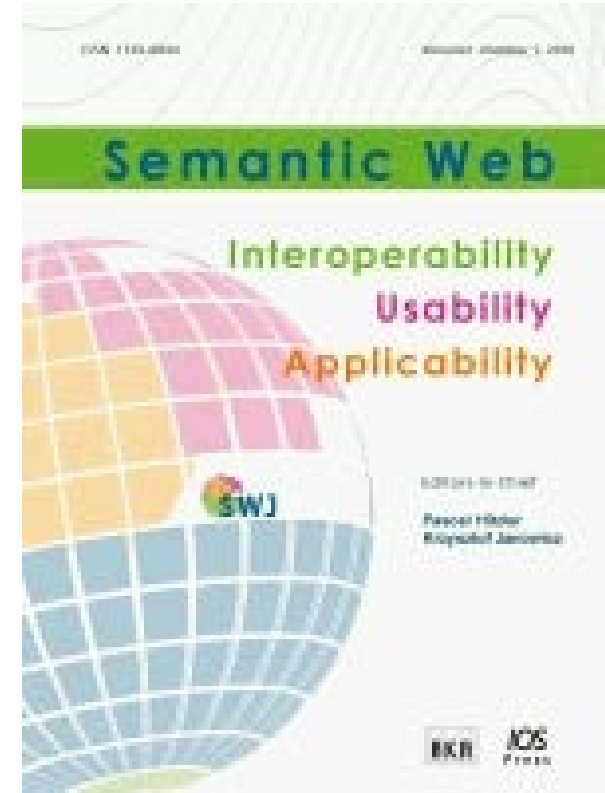
Tsinghua University Press (清华大学出版社), 2013.

Translators:

Yong Yu, Haofeng Wang, Guilin Qi (俞勇, 王昊奋, 漆桂林)

<http://www.semantic-web-book.org>

- **EiCs:** Pascal Hitzler  
Krzysztof Janowicz
- **New journal with significant uptake.**
- **We very much welcome contributions at the “rim” of traditional Semantic Web research – e.g., work which is strongly inspired by a different field.**
- **Non-standard (open & transparent) review process.**
- **<http://www.semantic-web-journal.net/>**



## **EarthCube:**

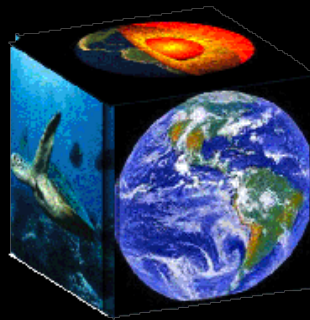
### **Developing a Community-Driven Data and Knowledge Environment for the Geosciences**

**“concepts and approaches to create integrated data management infrastructures across the Geosciences.”**

**“EarthCube aims to create a well-connected and facile environment to share data and knowledge in an open, transparent, and inclusive manner, thus accelerating our ability to understand and predict the Earth system.”**

## EarthCube requires

- information integration
- interoperability
- conceptual modeling
- intelligent search
- data-model intercomparison
- data publishing support



## Semantic Web studies

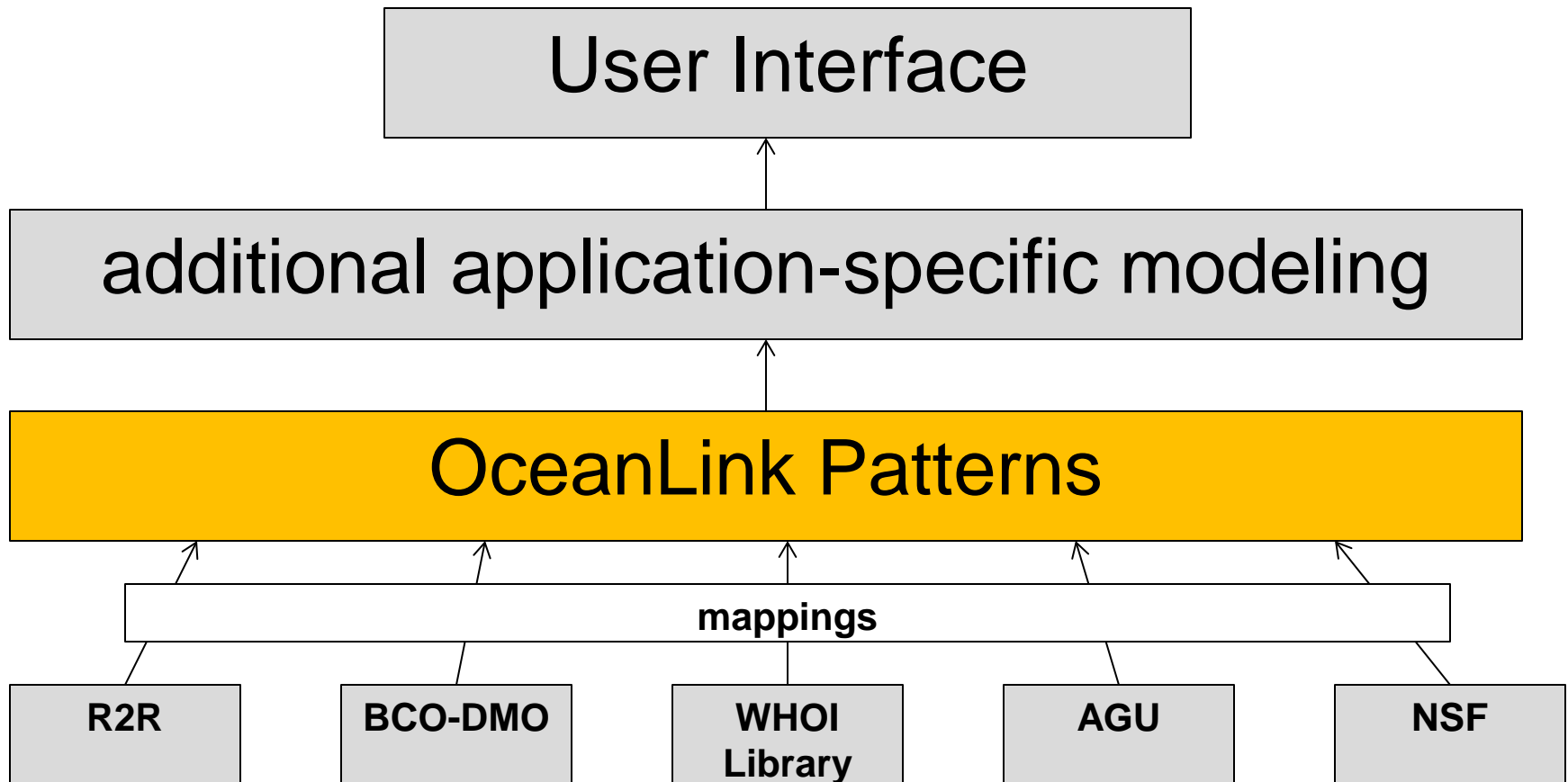
- information integration
- interoperability
- conceptual modeling
- intelligent search
- data-model intercomparison
- data publishing support



## NSF EarthCube project “OceanLink”:

- **Integration of existing ocean science data repositories.**
- **For faceted browsing and semantic search.**
- **To be done in a flexible, extendable, modular way.**
- **With minimal effort for additional data providers to integrate their content.**

National Science Foundation award 1354778 "EAGER: Collaborative Research: EarthCube Building Blocks, Leveraging Semantics and Linked Data for Geoscience Data Sharing and Discovery."





“An ontology design pattern is a reusable successful solution to a recurrent modeling problem.”

So-called *content patterns* usually encode specific abstract notions, such as process, event, agent, etc.

Patterns provide modular, reusable, replaceable, pieces.

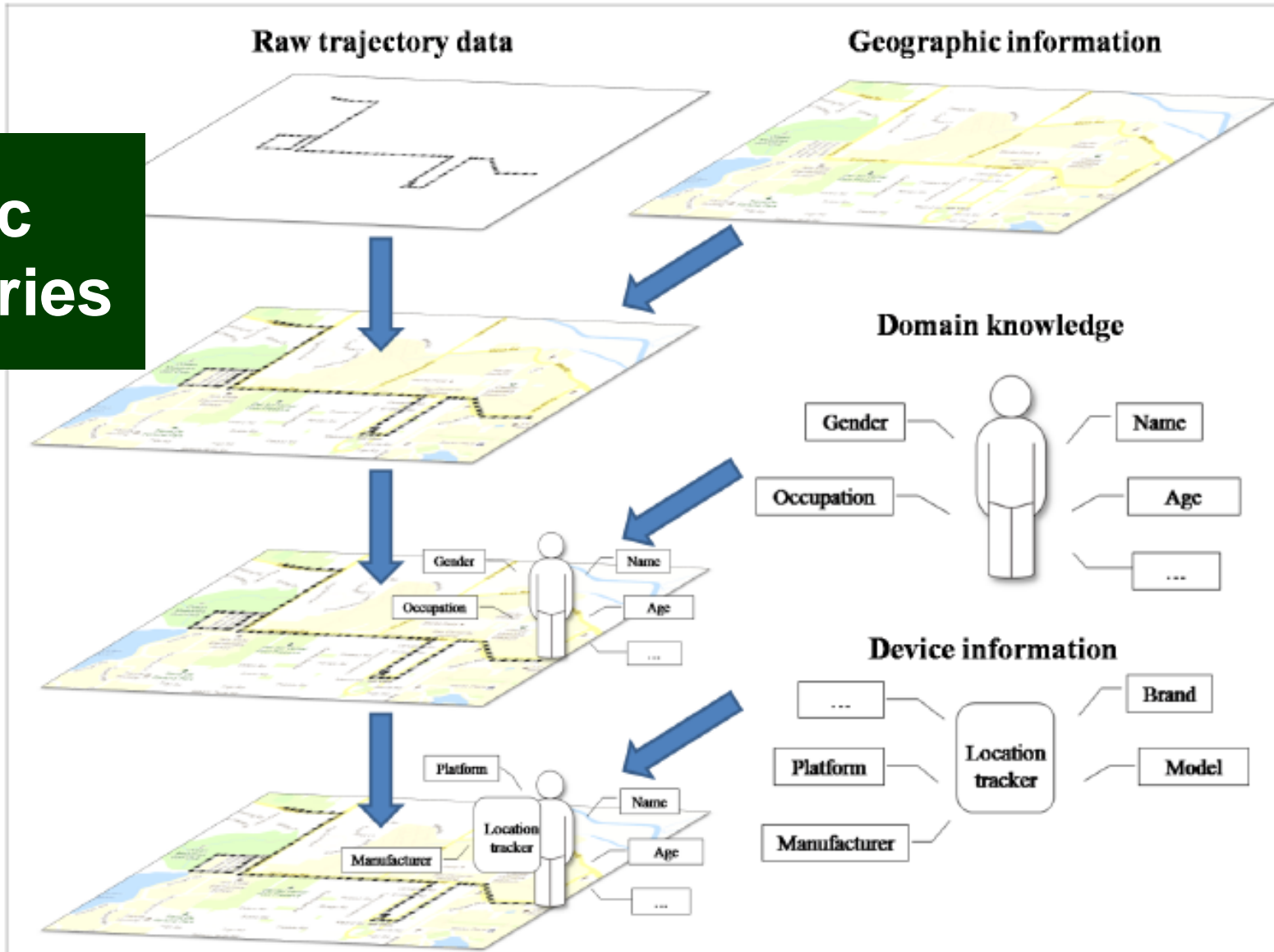
By agreeing on **reuse of generic patterns** (but **leaving the relationships** between the patterns to a specific assembly **for a special purpose**), we can have **reuse while preserving heterogeneity**.

## Some central patterns:

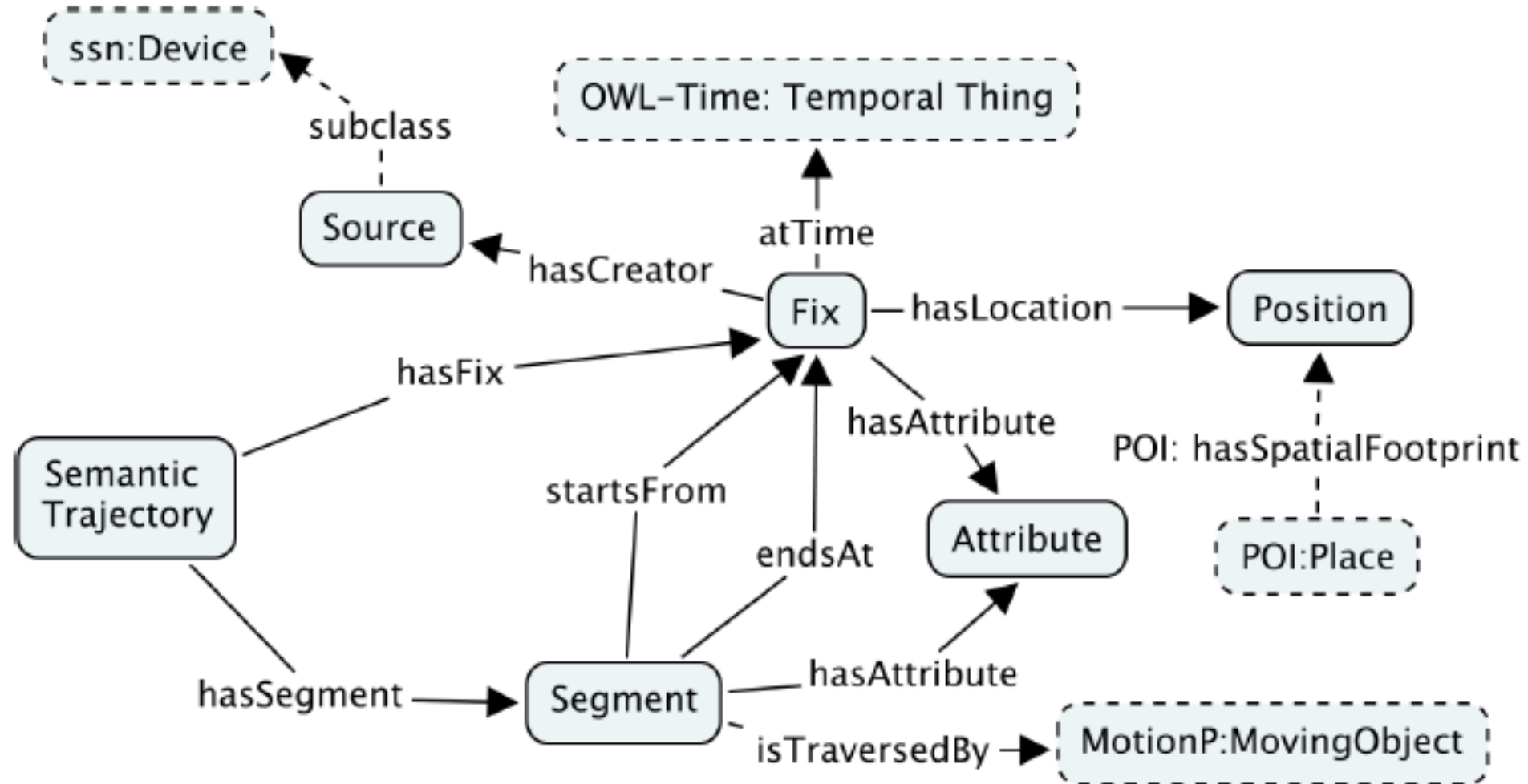
- **Cruise**
- **Trajectory**
- **Person**
- **Organization**
- **Roles of Agents**
- **Repository Object**
- **Data Set**
- **Document**

**We're not starting from zero of course.**

# Semantic Trajectories



[Hu, Janowicz, Carral, Scheider, Kuhn, Berg-Cross, Hitzler, Dean, COSIT2013]



$$\begin{aligned} \textit{Fix} \sqsubseteq & \exists \textit{atTime}.\textit{OWL-Time:Temporal Thing} \sqcap \exists \textit{hasLocation}.\textit{Position} \\ & \sqcap \exists \textit{hasFix}^-.\textit{SemanticTrajectory} \end{aligned} \quad (1)$$

$$\textit{Segment} \sqsubseteq \exists \textit{startsFrom}.\textit{Fix} \sqcap \exists \textit{endsAt}.\textit{Fix} \quad (2)$$

$$\top \sqsubseteq \leq 1 \textit{startsFrom}.\top \quad (3)$$

$$\top \sqsubseteq \leq 1 \textit{endsAt}.\top \quad (4)$$

$$\textit{Segment} \sqsubseteq \exists \textit{hasSegment}^-.\textit{SemanticTrajectory} \quad (5)$$

$$\textit{startsFrom}^- \circ \textit{endsAt} \sqsubseteq \textit{hasNext} \quad (6)$$

$$\textit{hasNext} \sqsubseteq \textit{hasSuccessor} \quad (7)$$

$$\textit{hasSuccessor} \circ \textit{hasSuccessor} \sqsubseteq \textit{hasSuccessor} \quad (8)$$

$$\textit{hasNext}^- \sqsubseteq \textit{hasPrevious} \quad (9)$$

$$\textit{hasSuccessor}^- \sqsubseteq \textit{hasPredecessor} \quad (10)$$

$$Fix \sqcap \neg \exists endsAt.Segment \sqsubseteq StartingFix \quad (11)$$

$$Fix \sqcap \neg \exists startsFrom.Segment \sqsubseteq EndingFix \quad (12)$$

$$Segment \sqcap \exists startsFrom.StartingFix \sqsubseteq StartingSegment \quad (13)$$

$$Segment \sqcap \exists endsAt.EndingFix \sqsubseteq EndingSegment \quad (14)$$

$$SemanticTrajectory \sqsubseteq \exists hasSegment.Segment \quad (15)$$

$$hasSegment \circ startsFrom \sqsubseteq hasFix \quad (16)$$

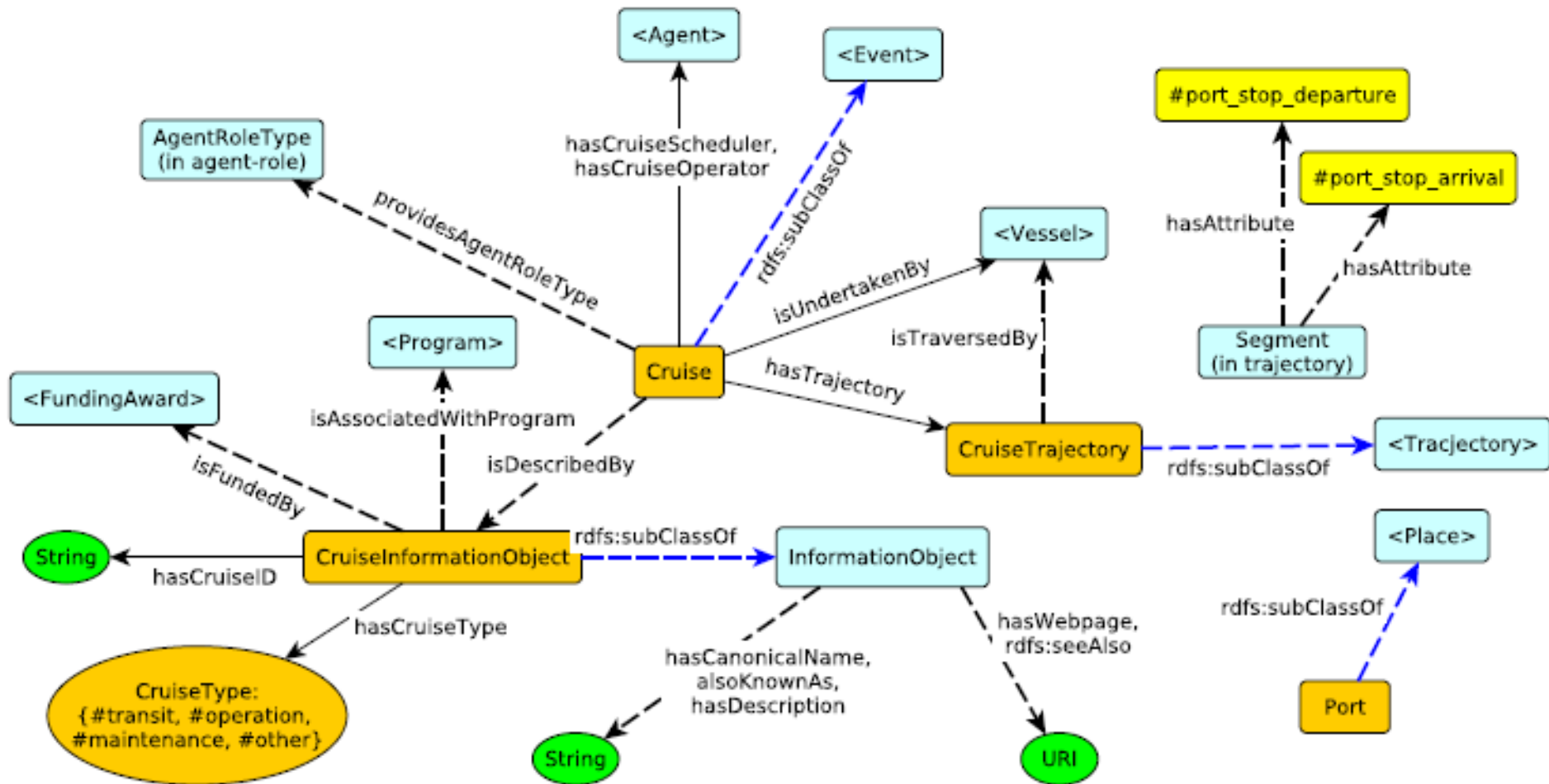
$$hasSegment \circ endsAt \sqsubseteq hasFix \quad (17)$$

$$\exists hasSegment.Segment \sqsubseteq SemanticTrajectory \quad (18)$$

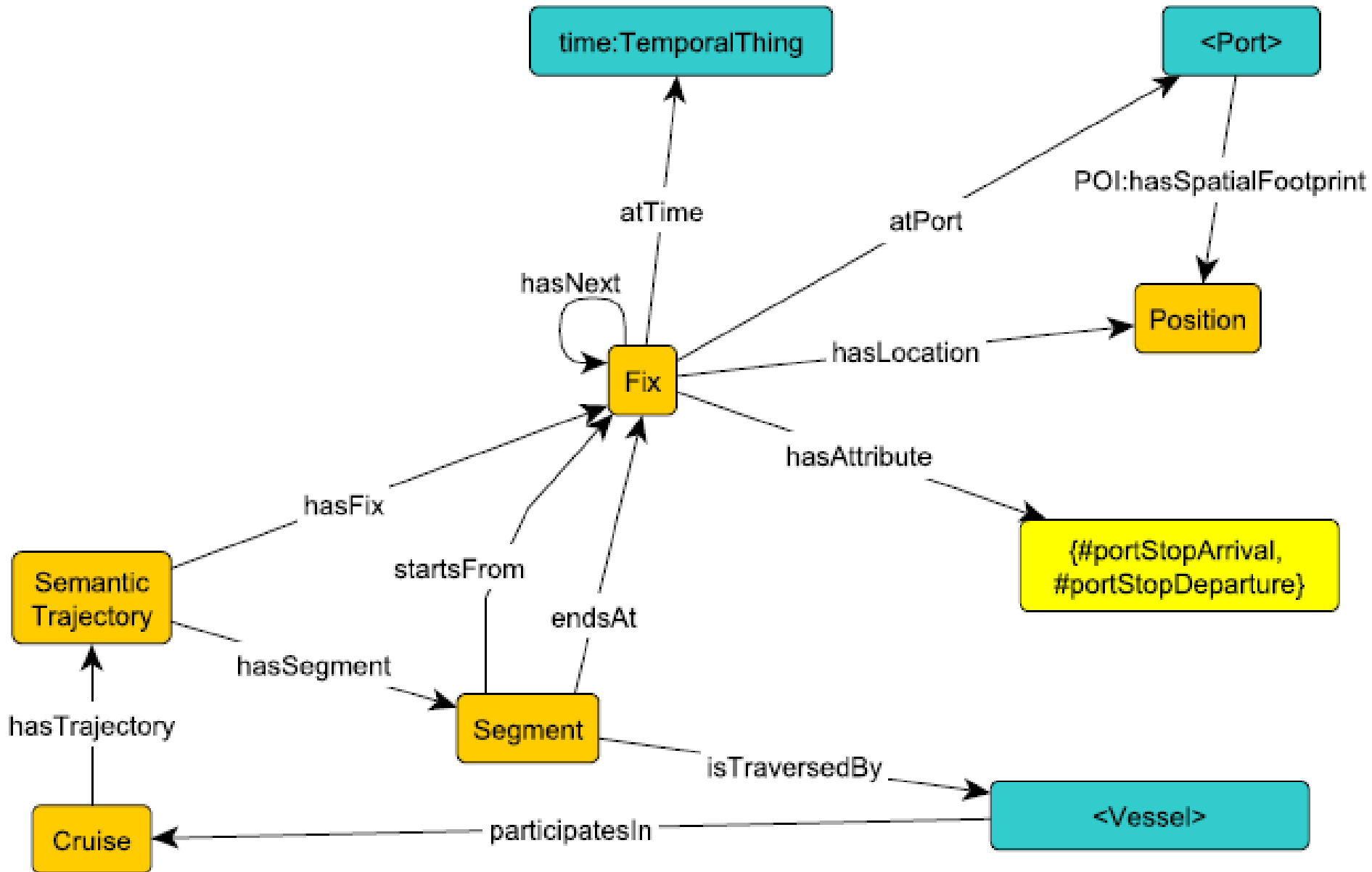
$$\exists hasSegment^- .SemanticTrajectory \sqsubseteq Segment \quad (19)$$

$$\exists hasFix.Segment \sqsubseteq SemanticTrajectory \quad (20)$$

$$\exists hasFix^- .SemanticTrajectory \sqsubseteq Fix \quad (21)$$

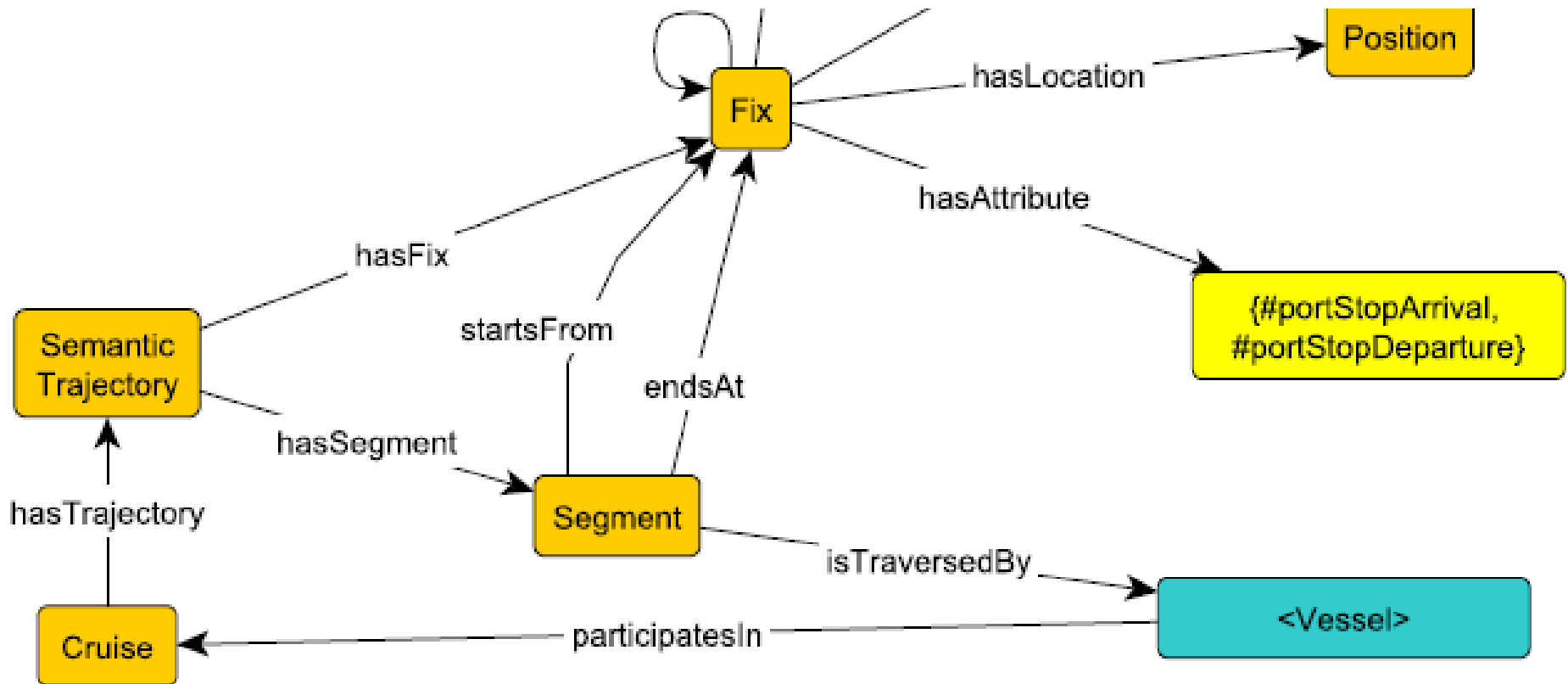


# Cruise trajectory (draft)

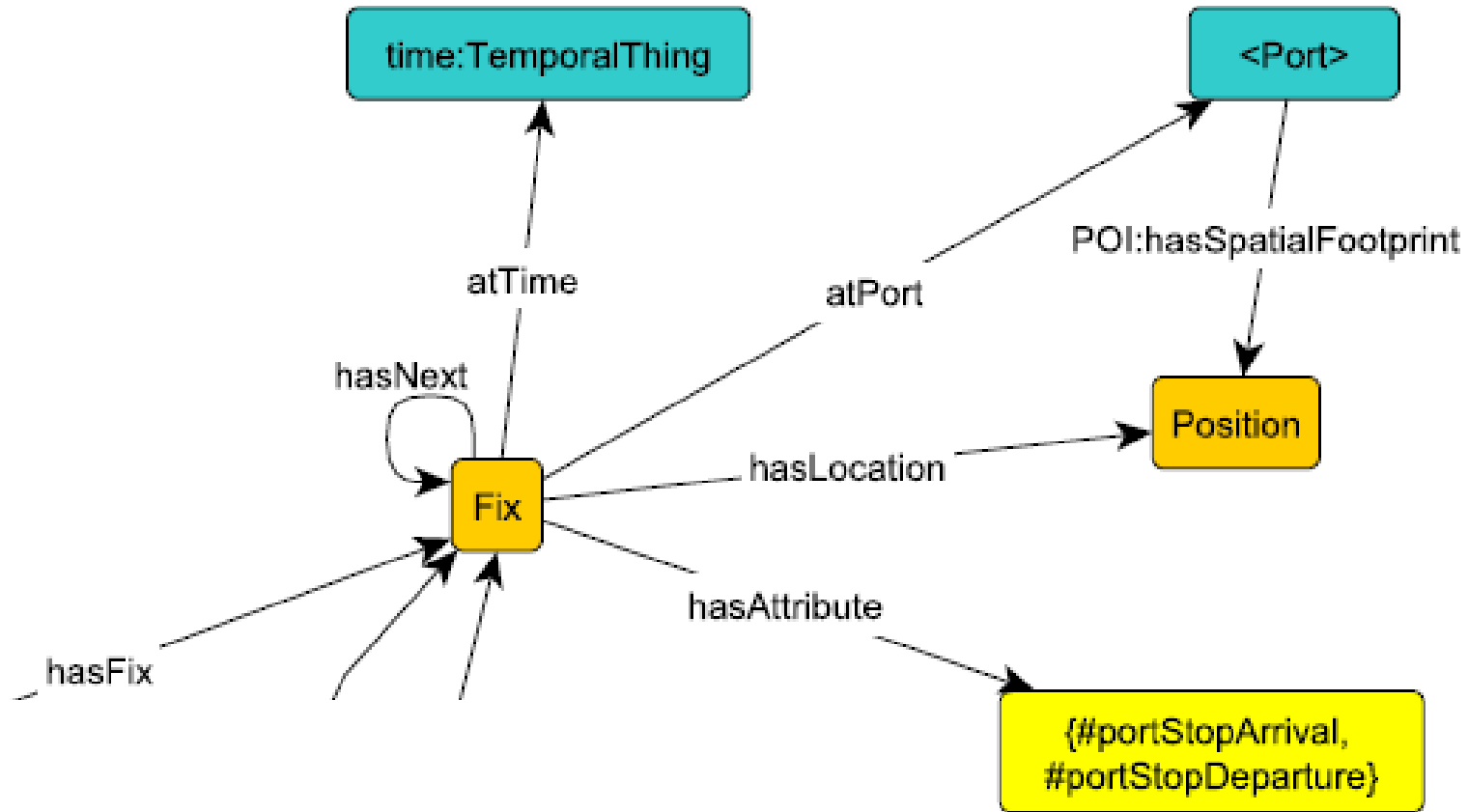




$\text{Cruise}(x) \wedge \text{hasTrajectory}(x, y)$   
 $\wedge \text{hasSegment}(y, z) \wedge \text{isTraversedBy}(z, v)$   
 $\rightarrow \text{participatesIn}(v, z)$



$$\begin{aligned} & \text{Cruise}(x) \wedge \text{hasTrajectory}(x, y) \\ & \quad \wedge \text{hasSegment}(y, z) \wedge \text{isTraversedBy}(z, v) \\ & \quad \rightarrow \text{participatesIn}(v, z) \end{aligned}$$
$$\text{Cruise} \equiv \exists \text{cruise}.\text{Self}$$
$$\text{cruise} \circ \text{hasTrajectory} \circ \text{hasSegment} \circ \text{isTraversedBy}$$
$$\sqsubseteq \text{hasParticipant}$$
$$\text{hasParticipant} \equiv \text{participatesIn}^-$$



$\text{Fix}(x) \wedge \text{hasAttribute}(x, \#portStopArrival)$   
 $\wedge \text{atPort}(x, y) \wedge \text{hasSpatialFootprint}(y, z)$   
 $\wedge \text{hasLocation}(x, w) \rightarrow \text{locatedIn}(w, z)$



$$\begin{aligned} & \text{Fix}(x) \wedge \text{hasAttribute}(x, \#\text{portStopArrival}) \\ & \wedge \text{atPort}(x, y) \wedge \text{hasSpatialFootprint}(y, z) \\ & \wedge \text{hasLocation}(x, w) \rightarrow \text{locatedIn}(w, z) \end{aligned}$$
$$\begin{aligned} \text{Fix} \wedge \exists \text{hasTrajectory}.\{\#\text{portStopArrival}\} & \equiv \exists \text{fixps}.\text{Self} \\ & \text{hasLocation}^- \circ \text{fixps} \circ \text{atPort} \circ \text{hasSpatialFootprint} \\ & \sqsubseteq \text{locatedIn} \end{aligned}$$

**Robert Arko, Columbia University**

**Suzanne Carbotte, Columbia University**

**Cynthia Chandler, Woods Hole Oceanographic Institution**

**Michelle Cheatham, Wright State University**

**Timothy Finin, University of Maryland, Baltimore County**

**Pascal Hitzler, Wright State University**

**Krzysztof Janowicz, University of California, Santa Barbara**

**Adila Krisnadhi, Wright State University**

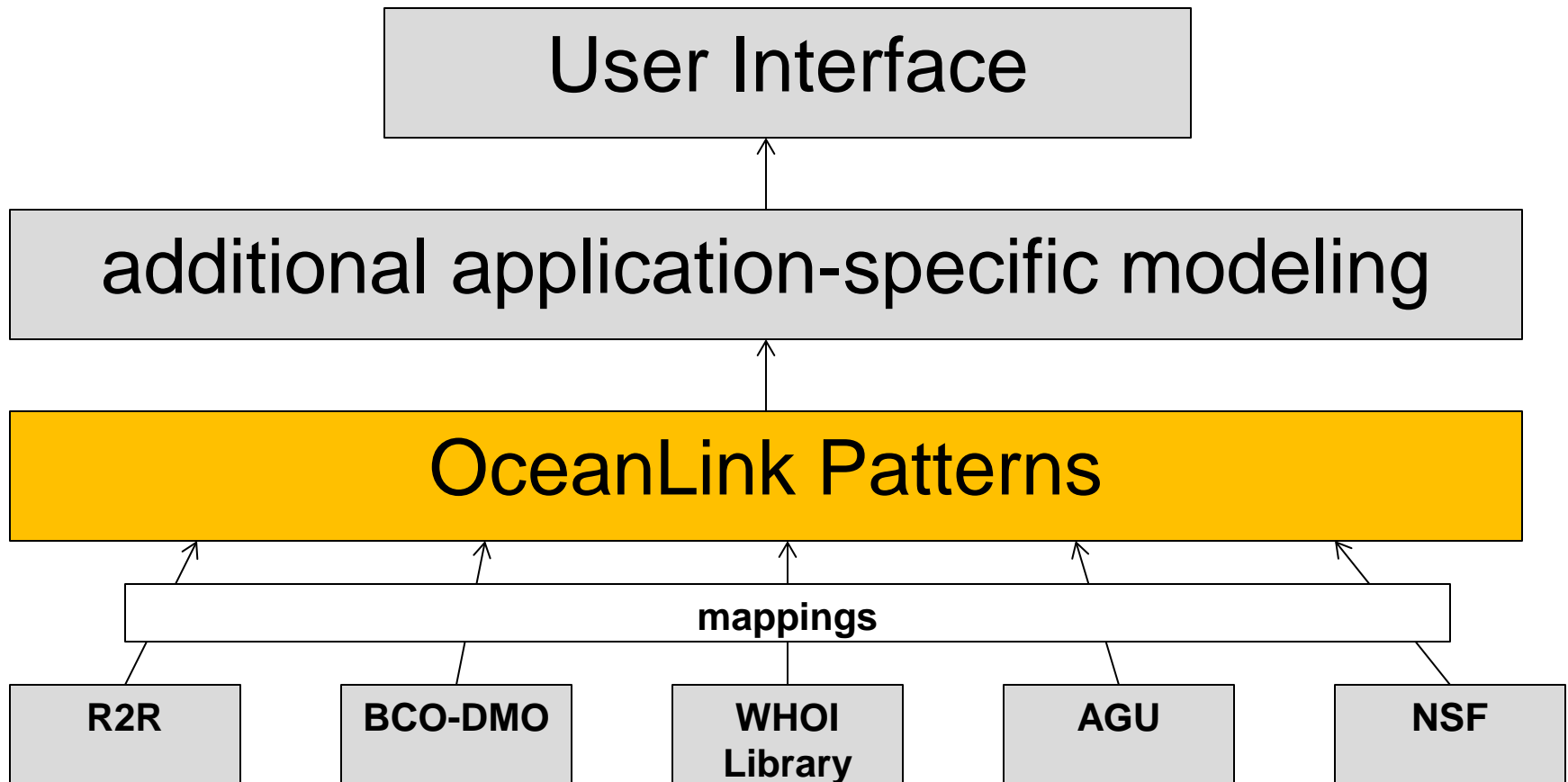
**Thomas Narock, Marymount University**

**Lisa Raymond, Woods Hole Oceanographic Institution**

**Adam Shepherd, Woods Hole Oceanographic Institution**

**Peter Wiebe, Woods Hole Oceanographic Institution**

**The presented work is part of the NSF *OceanLink* project:  
EarthCube Building Blocks, Leveraging Semantics and Linked Data  
for Geoscience Data Sharing and Discovery**

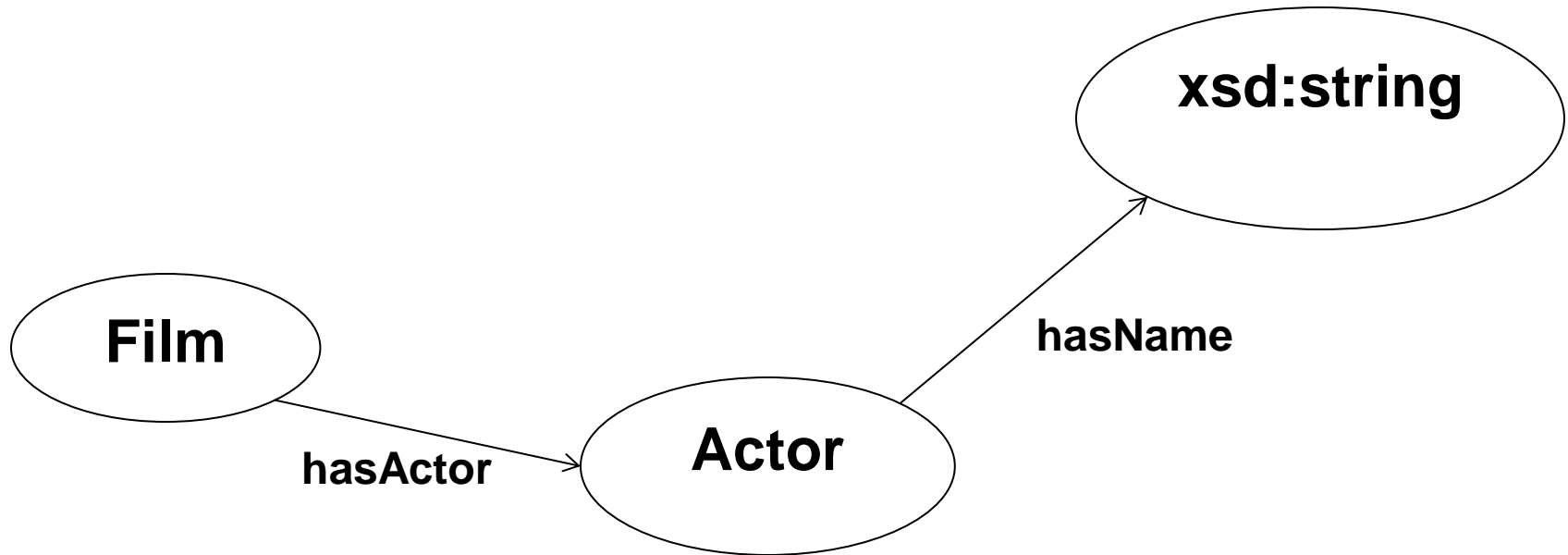


## Namespaces:

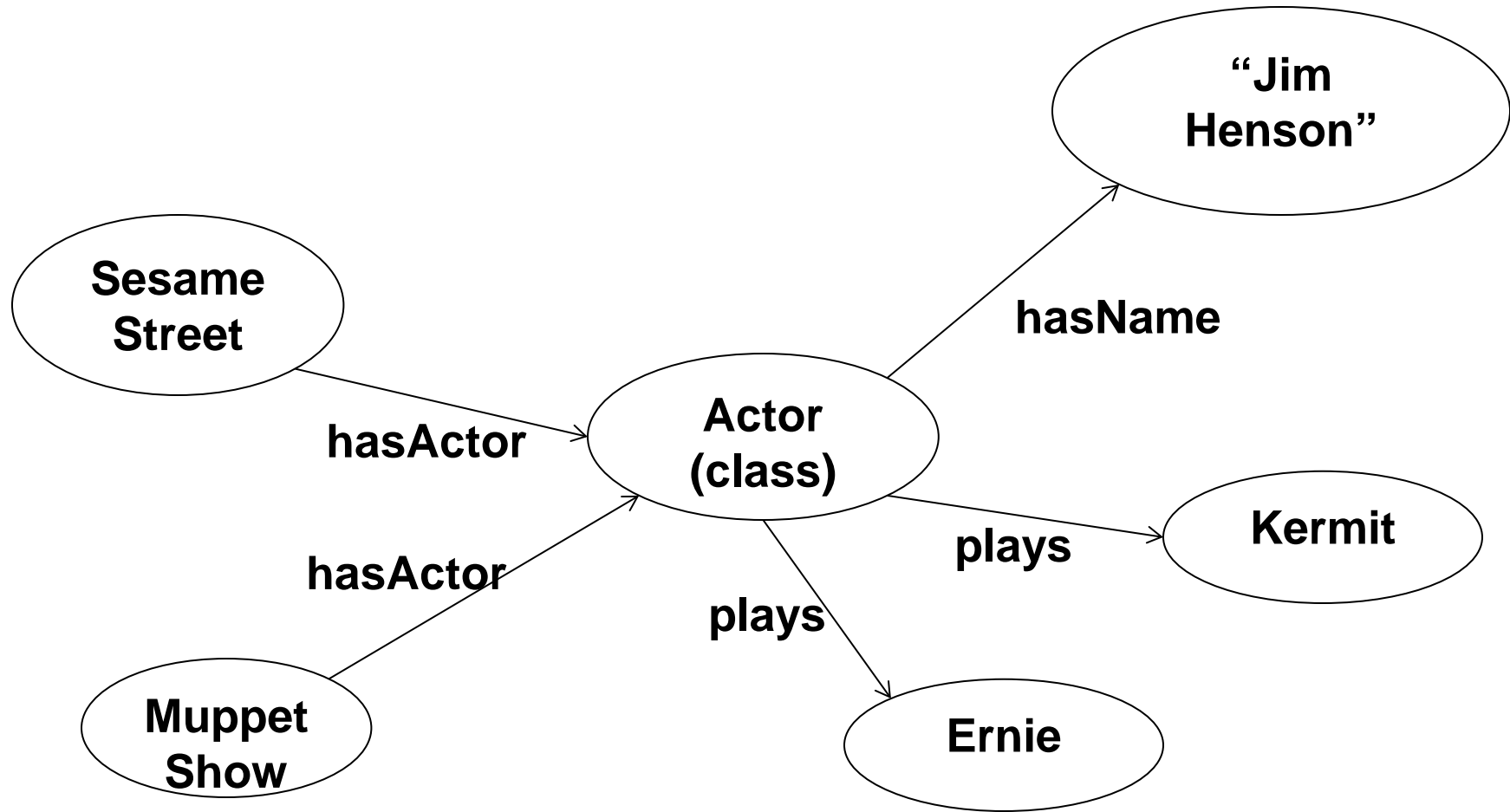
lmdb: <http://data.linkedmdb.org/resource/>  
dc: <http://purl.org/dc/terms/>

## Triples:

```
lmdb:film/463      rdf:type          lmdb:movie/film .
lmdb:film/463      dc:title          "The Lord of the Rings: The Fellowship of the Ring" .
lmdb:film/463      lmdb:movie/director  lmdb:director/8618 .
lmdb:director/8618 lmdb:movie/director_name "Peter Jackson" .
lmdb:director/8618 rdf:type          lmdb:movie/director .
lmdb:film/463      lmdb:movie/actor    lmdb:actor/31526 .
lmdb:actor/31526   rdf:type          movie:actor .
lmdb:actor/31526   lmdb:movie/actor_name "Liv Tyler" .
lmdb:film/464      lmdb:movie/actor    lmdb:actor/31526 .
lmdb:film/464      rdf:type          lmdb:movie/film .
lmdb:film/464      lmdb:movie/director  lmdb:director/8618 .
lmdb:film/463      lmdb:movie/sequel    lmdb:film/464 .
lmdb:film/464      dc:title          "The Lord of the Rings: The Two Towers" .
```







**“Identify congress members, who have voted “No” on pro environmental legislation in the past four years, with high-pollution industry in their congressional districts.”**

**In principle, all the knowledge is there:**

- **GovTrack**
- **GeoNames**
- **DBPedia**
- **US Census**

**But even with LoD we cannot answer this query.**

“Identify **congress members**, who have voted “No” on pro environmental legislation in the past four years, with high-pollution **industry** in their **congressional districts.**”

Some missing puzzle pieces:

- Where is the data?

- **GovTrack**  
**GeoNames**  
**US Census**

requires intimate knowledge of the LoD data sets

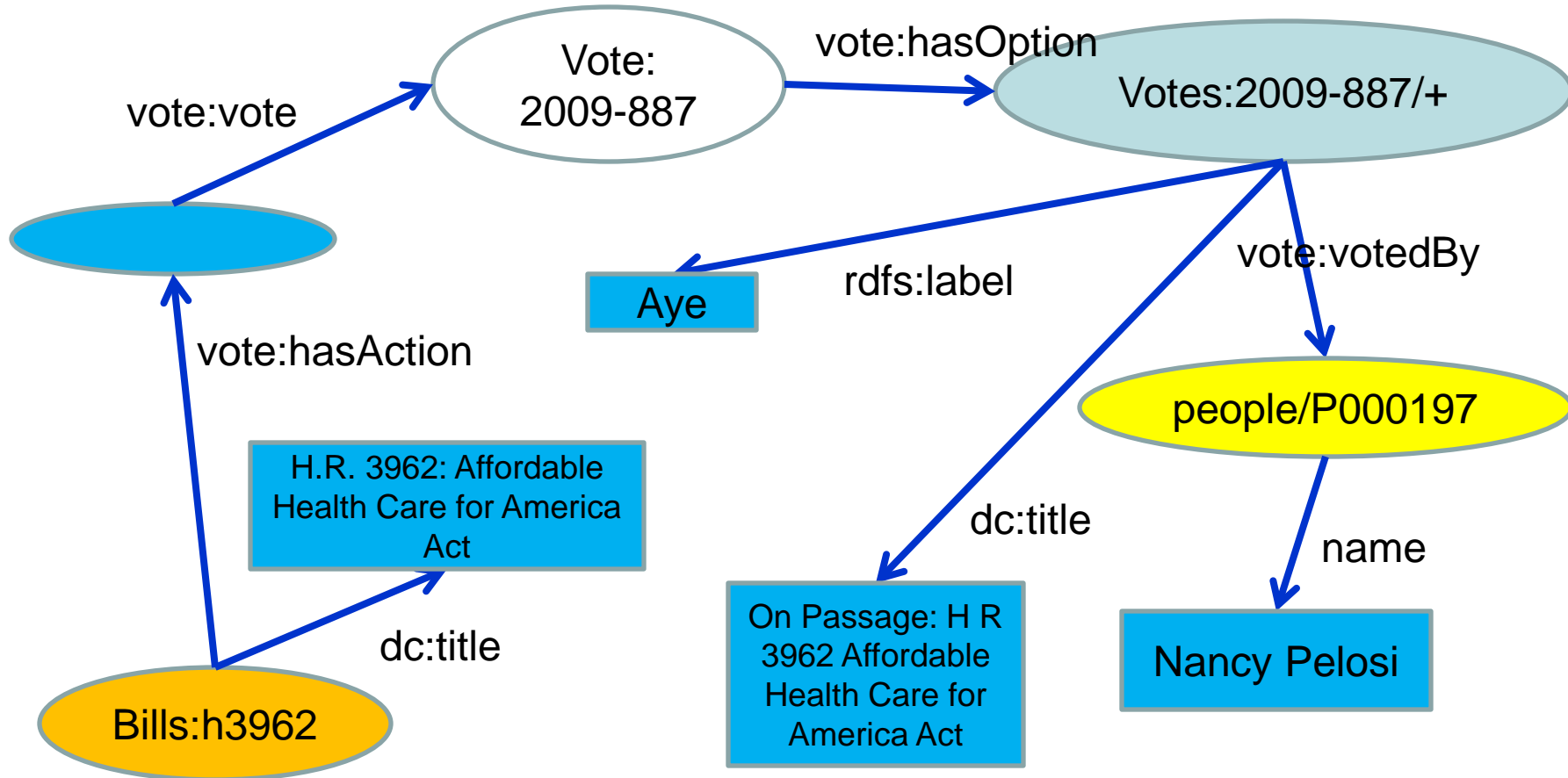
“Identify congress members, who have voted “No” on pro **environmental legislation** in the past four years, with **high-pollution industry** in their congressional districts.”

Some missing puzzle pieces:

- Where is the data?  
(smart federation needed)
- **Missing background (schema) knowledge.**  
(enhancements of the LoD cloud)
- **Crucial info still hidden in texts.**  
(ontology learning from texts)
- **Added reasoning capabilities (e.g., spatial).**  
(new ontology language features)

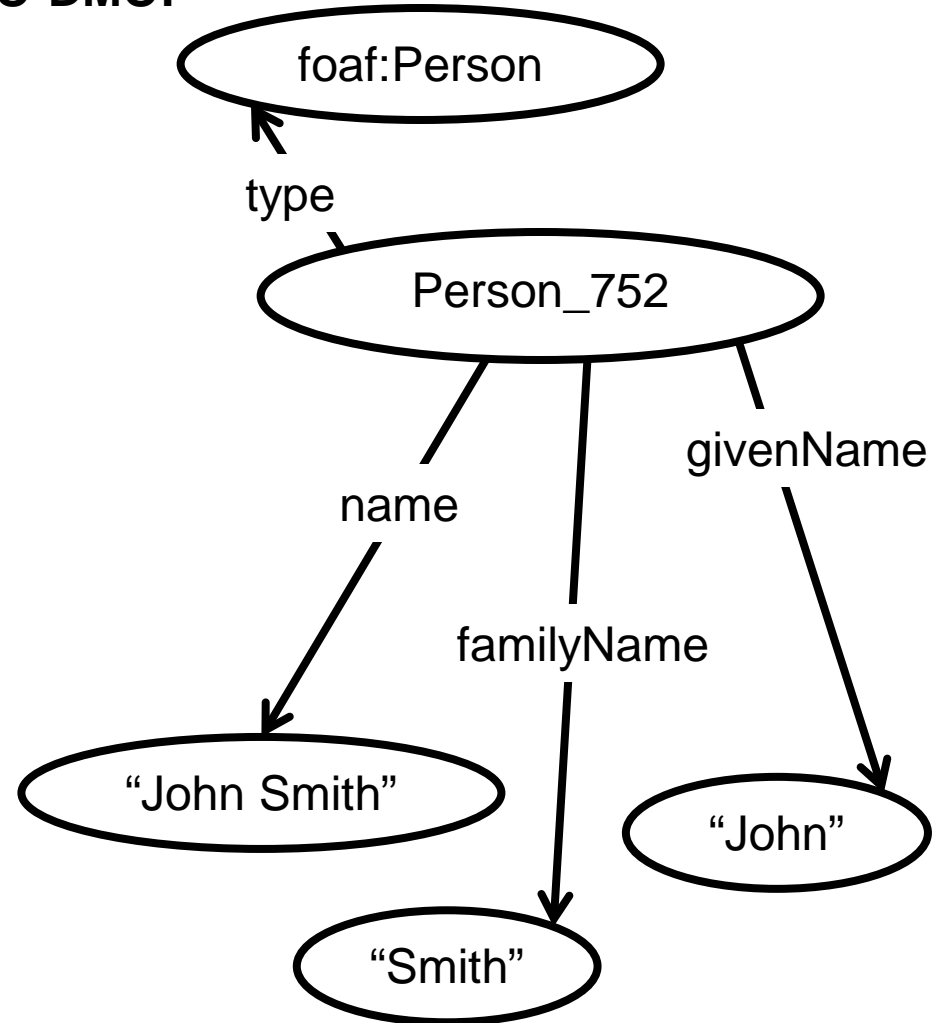
# Linked Data Example

“Nancy Pelosi voted in favor of the Health Care Bill.”

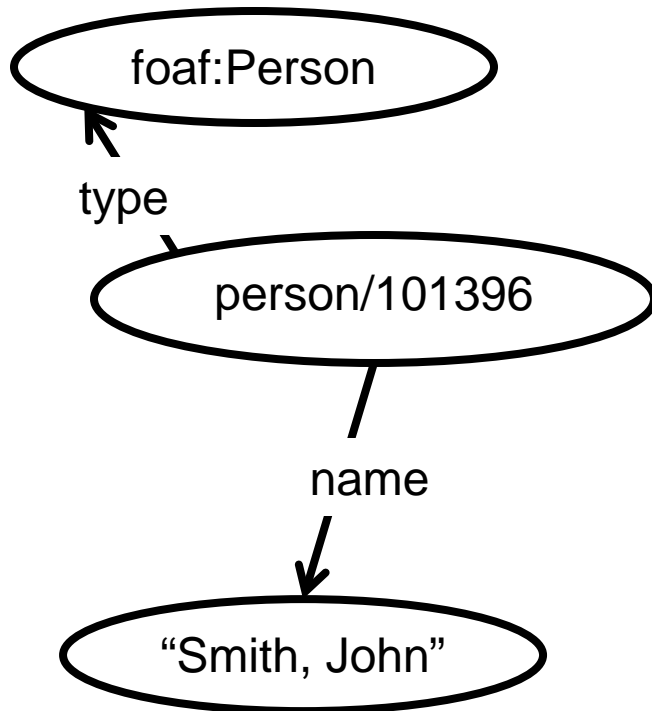


# Automated federation?

BCO-DMO:



R2R:



$a:\text{hasWife} \sqsubseteq a:\text{hasSpouse}$   
 $\text{symmetric}(a:\text{hasSpouse})$   
 $\exists a:\text{hasSpouse}.a:\text{Female} \sqsubseteq a:\text{Male}$   
 $\exists a:\text{hasSpouse}.a:\text{Male} \sqsubseteq a:\text{Female}$   
 $a:\text{hasWife}(a:\text{john}, a:\text{mary})$   
 $b:\text{Male}(a:\text{john})$   
 $b:\text{Female}(a:\text{mary})$   
 $a:\text{Male} \sqcap a:\text{Female} \sqsubseteq \perp$

$\text{symmetric}(b:\text{hasSpouse})$   
 $b:\text{hasSpouse}(b:\text{mike}, b:\text{david})$   
 $b:\text{Male}(b:\text{david})$   
 $b:\text{Male}(b:\text{mike})$   
 $b:\text{Female}(b:\text{anna})$

# Thanks!



Semantic Web - Interoperability, Usability, Applicability *an IOS Press Journal*

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Tracking Number

## Special Call for Ontology Design Pattern descriptions

Submitted by [Pascal Hitzler](#) on 03/20/2014 - 13:25

Semantic Web journal:  
Special Call for  
Ontology Design Pattern descriptions

An ontology design pattern is a reusable solution to a recurring ontology modeling problem. Different kinds of ontology design patterns have been identified, and they are used for different purposes ranging from their use as building blocks and strategies for ontology creation to their utilization for heterogeneity preservation in information integration.

The Semantic Web journal calls for papers containing concise descriptions of an Ontology Design Pattern. Papers are typically expected to include discussions of at least the following aspects.

- A general introduction concerning the rationale of making the pattern.
- A graphical depiction of the pattern accompanied by an explanation, in intuitive terms, of the design choices made.
- A detailed axiomatization, e.g. using OWL, for the relationships between the vocabulary terms used in the patterns.
- A detailed discussion of related patterns or ontology modeling practices and their relationships with the presented pattern.
- A convincing discussion of use cases.
- Examples for existing datasets which can be used with the pattern.

Papers will be evaluated along the following dimensions: Quality of the pattern, usefulness (or potential usefulness) of the pattern, clarity and completeness of the descriptions.

Prospective authors must take notice of the submission guidelines posted at <http://www.semantic-web-journal.net/authors>

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- **Adila Alfa Krisnadhi, Frederick Maier, Pascal Hitzler, OWL and Rules. In: A. Polleres, C. d'Amato, M. Arenas, S. Handschuh, P. Kroner, S. Ossowski, P.F. Patel-Schneider (eds.), Reasoning Web. Semantic Technologies for the Web of Data. 7th International Summer School 2011, Galway, Ireland, August 23-27, 2011, Tutorial Lectures. Lecture Notes in Computer Science Vol. 6848, Springer, Heidelberg, 2011, pp. 382-415.**