Ontology Design Pattern-driven Linked Data Publishing

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This talk is about …

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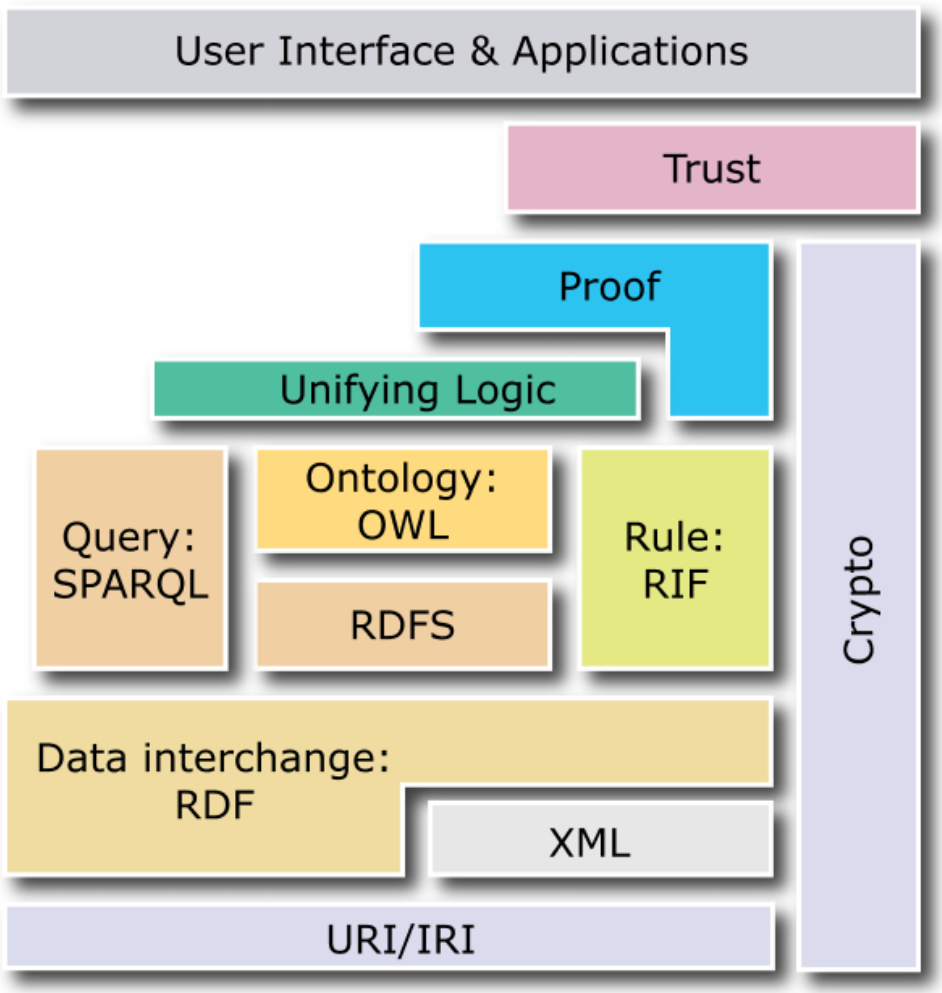
Realizing interoperability without sacrificing (semantic) heterogeneity.

Semantic Technology (again!)

- At least mentioned/introduced in …
  - Botts, Fredericks, Gayanilo, Rueda. "Building Semantic and Syntactic Interoperability Into EnviroSensing Systems" (Tuesday afternoon)
  - Narock. "Ontologies and the Semantic Web - An Introduction for Non-Experts" (Late Wednesday afternoon)

Semantic Web is …



https://www.w3.org/2007/03/layerCake.png

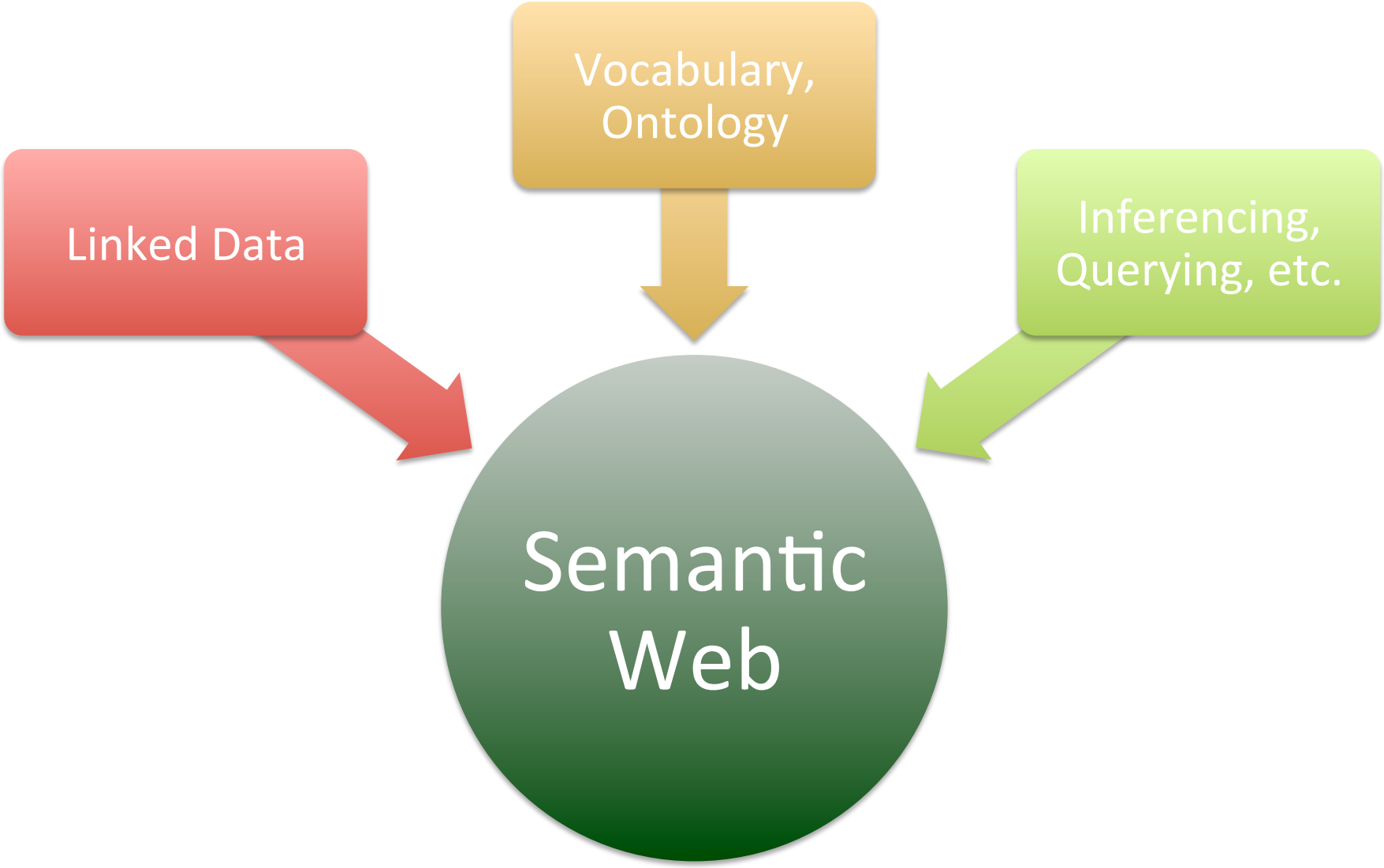
"Often seen, though not all are realized"

W3C Semantic Web Activity (until end of 2013)

W3C Data Activity (2014 onward)

- WG on Data on the Web Best Practices
- WG on RDF Data Shapes
- WG on Spatial Data on the Web (Joint with OGC)
- SIG on Health Care and Life Sciences

Or alternatively …



LINKED DATA PUBLISHING

Linked Data In a Nutshell

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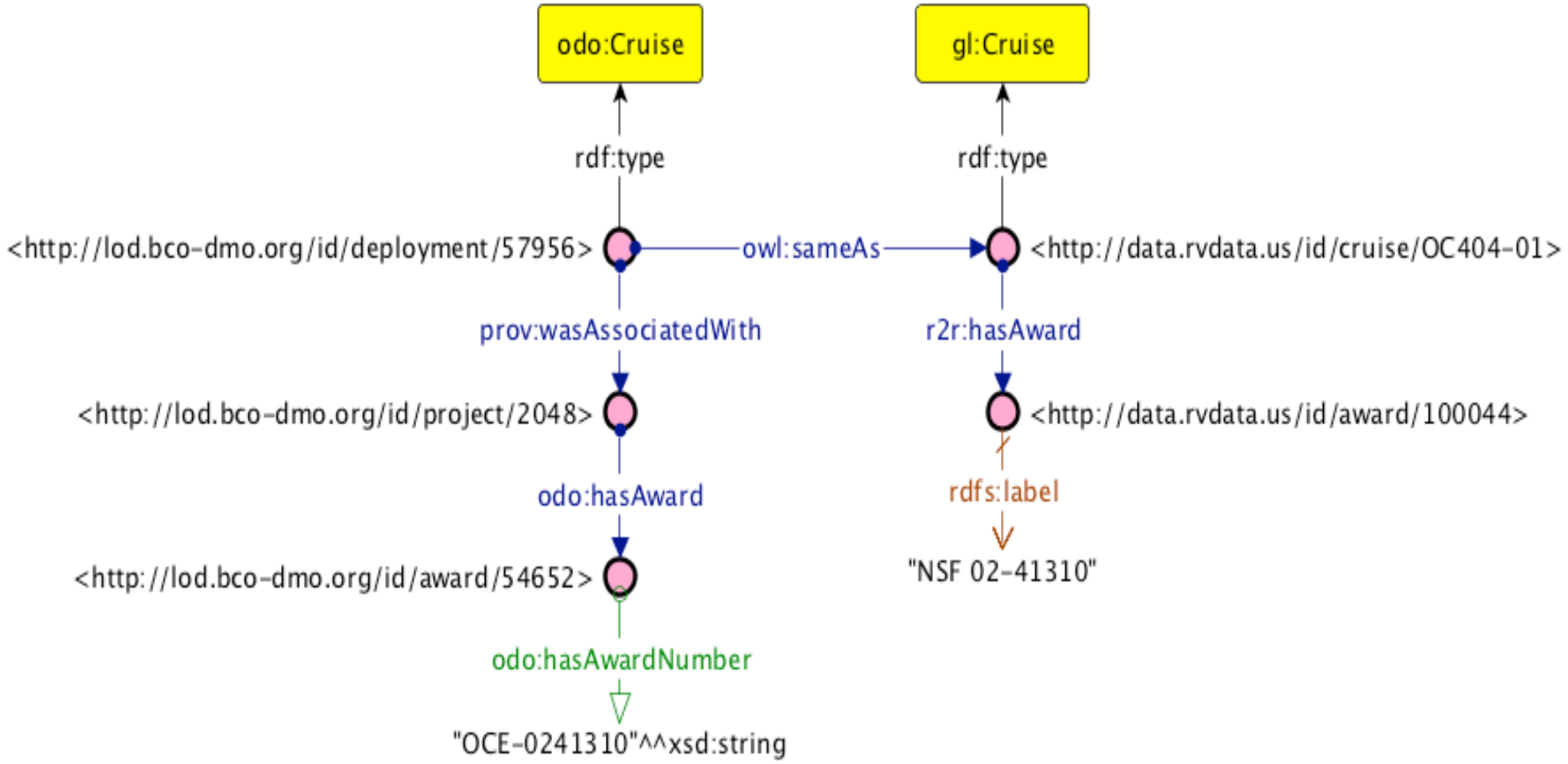
- Use graph data model based on RDF.
- RDF graph is a set of RDF triples.
- RDF triple consists of:
  - Subject: URI, anonymous resource
  - Predicate: URI
  - Object: URI, literal, anonymous resource.
- Serialization format: XML, Turtle, Ntriple, JSON-LD.
- A triple can express a linking between pieces of data.
- Simplicity leads to popularity.
- See also Carlos Rueda's slides on how to triplify tabular/relational data.

Linked Data Graph (of 2 Repos)

rdf: http://www.w3.org/1999/02/22-rdf-syntax-ns#
owl: http://www.w3.org/2002/07/owl#
rdfs: http://www.w3.org/2000/01/rdf-schema#

odo: http://ocean-data.org/schema/
prov: http://www.w3.org/ns/prov#
gl: http://schema.geolink.org/1.0/base/main#
r2r: http://data.rvdata.us/vocab/id/class/



State of Linked Data

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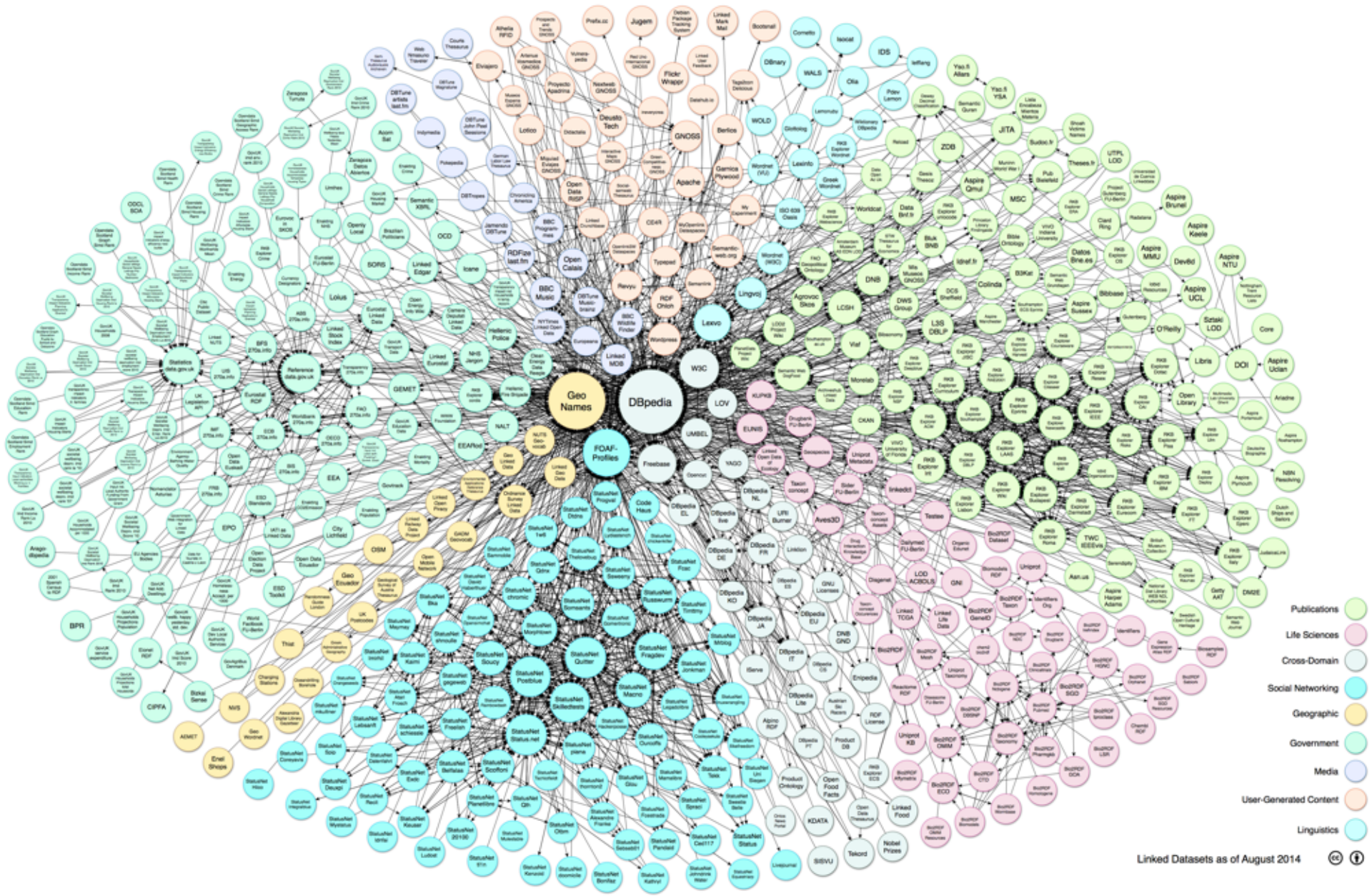


How do you publish (linked) data

- Linked Data Principles:
  - Use Web identifiers: HTTP URI/IRI
  - Ensure that URIs are Web-resolvable so human AND machine can obtain further information about the things URIs represented.
    - Machine-processable description → RDF graph/triples.
  - As much as possible link to data from other parties.
- In practice, you need to decide how to:
  - Prepare vocabulary to describe/link your data
  - Mint URIs for your data and vocabulary
    - Incl. minting resolvable URIs for the vocabulary terms if necessary.
  - Set up infrastructure to serve the data as Linked Data.

Should I mint URI for X?

- Google (2012): "Things, not strings"
- If X is instance data:
  - Do, if X comes from your own local database/source.
  - Don't (i.e., reuse existing one), if X originates from external source you don't maintain.
- If X is a vocabulary term:
  - Do, if there's no known URI for X or you want to assert your own definition for X (because it does not exist, or you dislike the existing one).
    - Unless the current maintainer of definition of X agrees with your (new) definition.
  - Don't, if you like existing defn and it fits your current AND future needs.
- In any case, if you DO decide to mint a new URI for X, you're responsible to maintain it. ➔URIs must be persistent!
- URIs should preferably be opaque ➔machines should not parse or read into URI to infer anything about the referenced resource; infer from the description of the data in the graph (the RDF triples).

Other things to consider …

- Hash URI vs. Slash URI
  - Hash URI, e.g.: http://www.w3.org/ns/prov#wasAssociatedWith
  - Slash URI, e.g.: http://data.rvdata.us/id/award/100044
    - May involve a 303 Redirect
  - see https://www.w3.org/TR/cooluris/ and https://www.w3.org/wiki/HashVsSlash
  - I personally like to use hash URI for vocabulary terms, and slash URI for data instances
- Naming convention for URIs
  - CamelCase-ing?
  - Use of '-' (dash) and/or '_' (underscore), etc.

Ensuring Web-resolvability in a Linked Data way

- Every lookup of a URI should return *something*.
- If a human-readable description is requested:
  - Usually indicated by *content-type* header `text/html`
  - Return HTML page.
- If a machine-readable description is requested:
  - Indicated by *content-type* header: `application/rdf+xml`, `application/json`, `text/turtle`, etc.
  - Return the appropriate serialization format.
- Easing the URI persistence: use permanent redirection through PURL service (see http://www.purlz.org, https://w3id.org/)

VOCABULARY PREPARATION

Vocabulary and Ontology

- Ontology = formalized vocabulary
  - Formally, ontology = set of logical statements (axioms) involving the vocabulary terms.
  - Standardized ontology languages: RDFS, OWL
  - Rule-based language such as RIF and SWRL can also be used, though more rarely.
- Why ontologies are valuable (Janowicz, 2016)?
  - Improve discoverability of your own data (as opposed to simple keyword search)
  - Cornerstone of data publication and managing strategies
  - Improve data reproducibility (through provenance information)
  - Ease cross-repository knowledge exploration (follow-your-nose browsing)
  - Ease the detection of inconsistency in the data.
  - Enable data integration

Misconceptions about Ontology

- Misconception #1: The purpose of ontology is to agree on what the term means.
  - Correction: Its purpose is to make intended meaning explicit.
- Misconception #2: Common upper-level and (large, overarching) domain ontologies could solve the messiness of Linked Data world.
  - Correction: different and conflicting perspectives are natural in the open, so there is no way to force everyone to use the same classes and properties.
- Misconception #3: Ontology constrains the way the vocabulary terms are used.
  - Correction: Ontology employs open-world assumption and inferential semantics,
  - e.g., specifying a (global) domain restriction of a property does not constrain the property usage, instead it adds more inferences.

Where to find ontologies/vocabularies?

- LOV (Linked Open Vocabulary) site - http://lov.okfn.org/
- W3C hosts several prominent ontologies/vocabularies:
  - See http://lov.okfn.org/dataset/lov/agents/W3C
- ESIP repositories:
  - http://cor.esipfed.org/ont#/
  - http://semanticportal.esipfed.org/ontologies
- OBO Foundry - http://www.obofoundry.org/
- ODP Portal - http://ontologydesignpatterns.org/
- ODP Public Catalog - http://www.gong.manchester.ac.uk/odp/html/
- NCBO Bioportal - http://bioportal.bioontology.org/

Reuse or not?

- Choosing appropriate ontologies essentially depends on what you want to do with them.
  - Your use case: discovery? integration? Both? anything else?
  - Does ontology X defines the terms you need? Do you like/ agree with the term definitions? Is X sufficiently extendible
  - If your needs can only be satisfied by multiple ontologies, does using them together lead to potential problems?
- "I have been told to reuse other ontologies"
  => Yes, but don't do it at an early stage! Start first with providing your own definition; then align with existing ontologies later.
  - may lead to confusion (e.g., FOAF, Organization onto, vCard, or Schema.org?) and restrict creativity
  - May lead to endless discussion on terms (not to mention: translations)

Source: Oscar Corcho, 2014

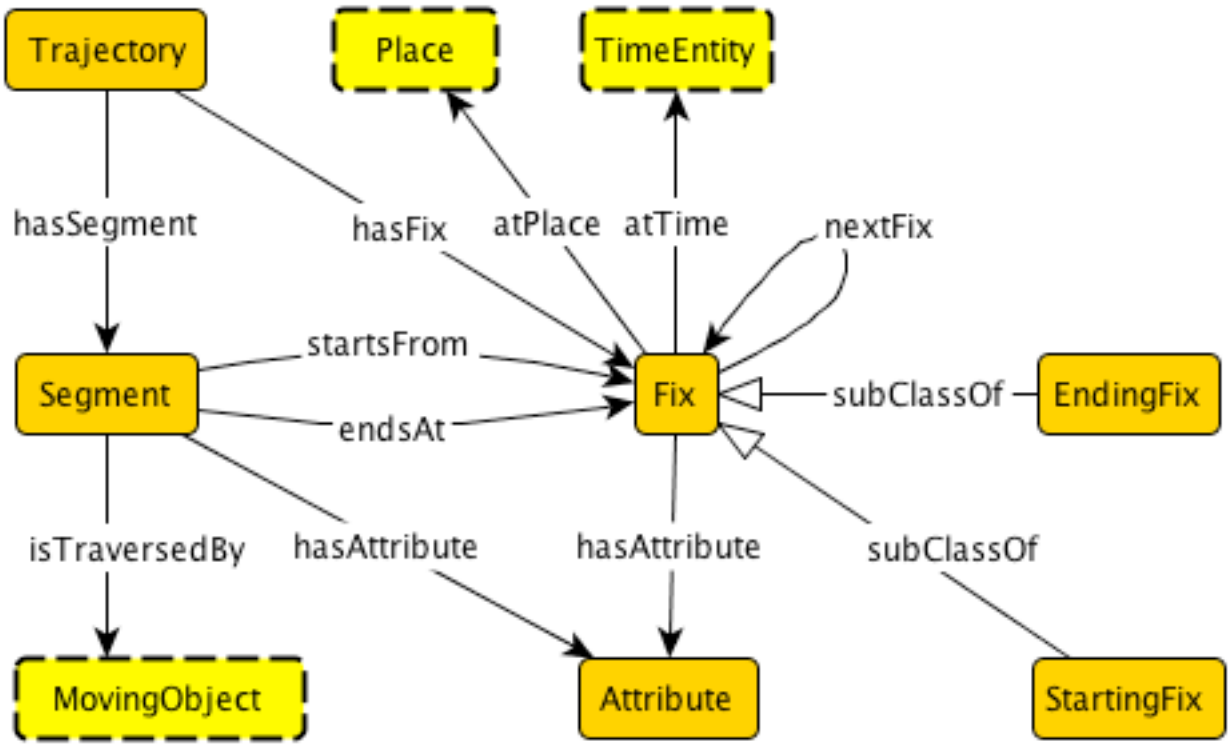
If an ontology needs to be developed ……

- Principle #1: Small >>> Large.
  - Smallness usually implies simplicity
- Principle #2: Modular >>> monolithic.
  - Easier to use as building blocks.
  - Highly extendibile
  - Easily understandable
- Principle #3: Be aware of multiple perspectives. Strike a balance between fostering interoperability vs. allowing semantic heterogeneity.
  - e.g., street is a connection between two places, but also a separation that cuts a habitat into pieces.
- Principle #4: Add human-readable annotations
  - Improve understandability.

Ontology Design Pattern (ODP)

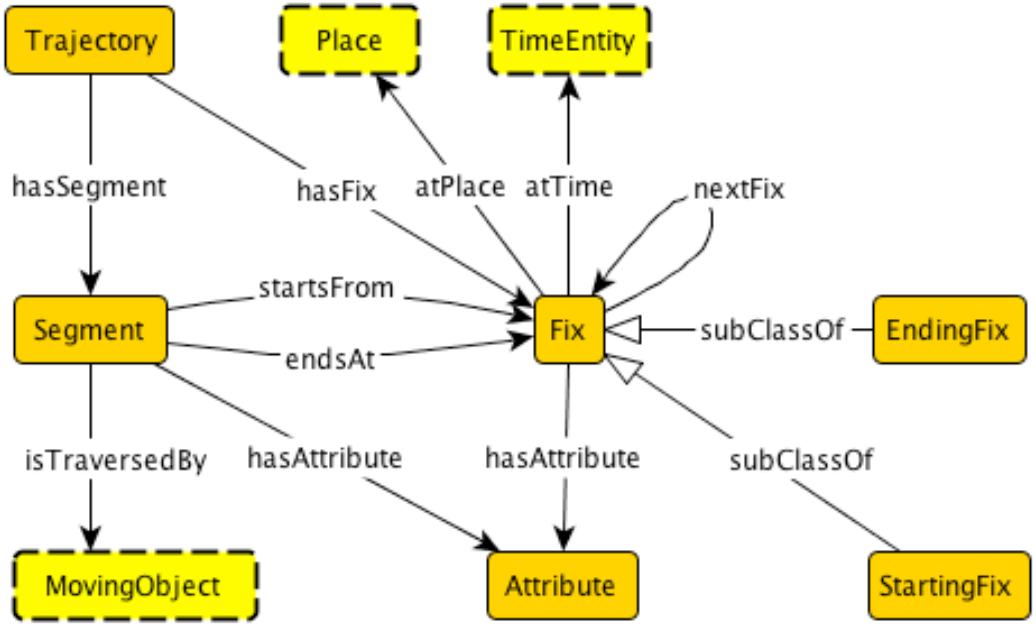
- Is a good candidate w.r.t earlier principles
- ODP: reusable solution of a recurrent modeling problem
- Content ODPs (aka knowledge patterns): ODP corresponding to a core notion in a particular domain.
  - Cover a wide range of domains or application areas.
  - Be extensible to allow additional details; minimal ontology commitments fostering reuse.
  - Be self-contained to a degree where they can be used on their own.
  - Supports multiple granularities.
  - Provide an axiomatization beyond mere surface semantics.
  - Have various hooks to well-known ontologies / patterns.

Example ODP



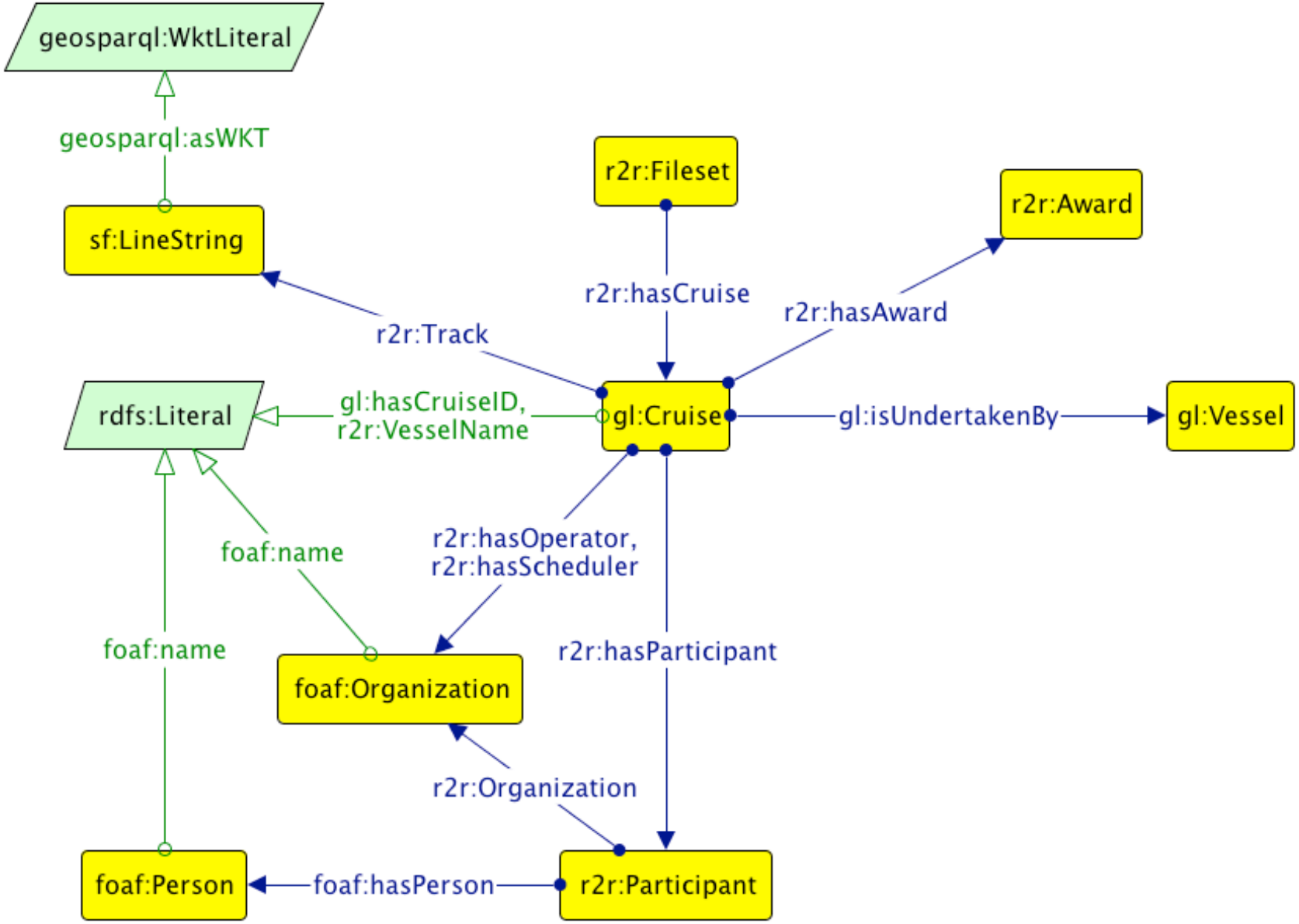
Variant of Semantic trajectory pattern (Hu, et al., 2013). Axiomatization is also important part of the pattern, but not displayed here. Consult the OWL encoding at http://w3id.org/daselab/onto/trajectory

Example ODP (contd.)

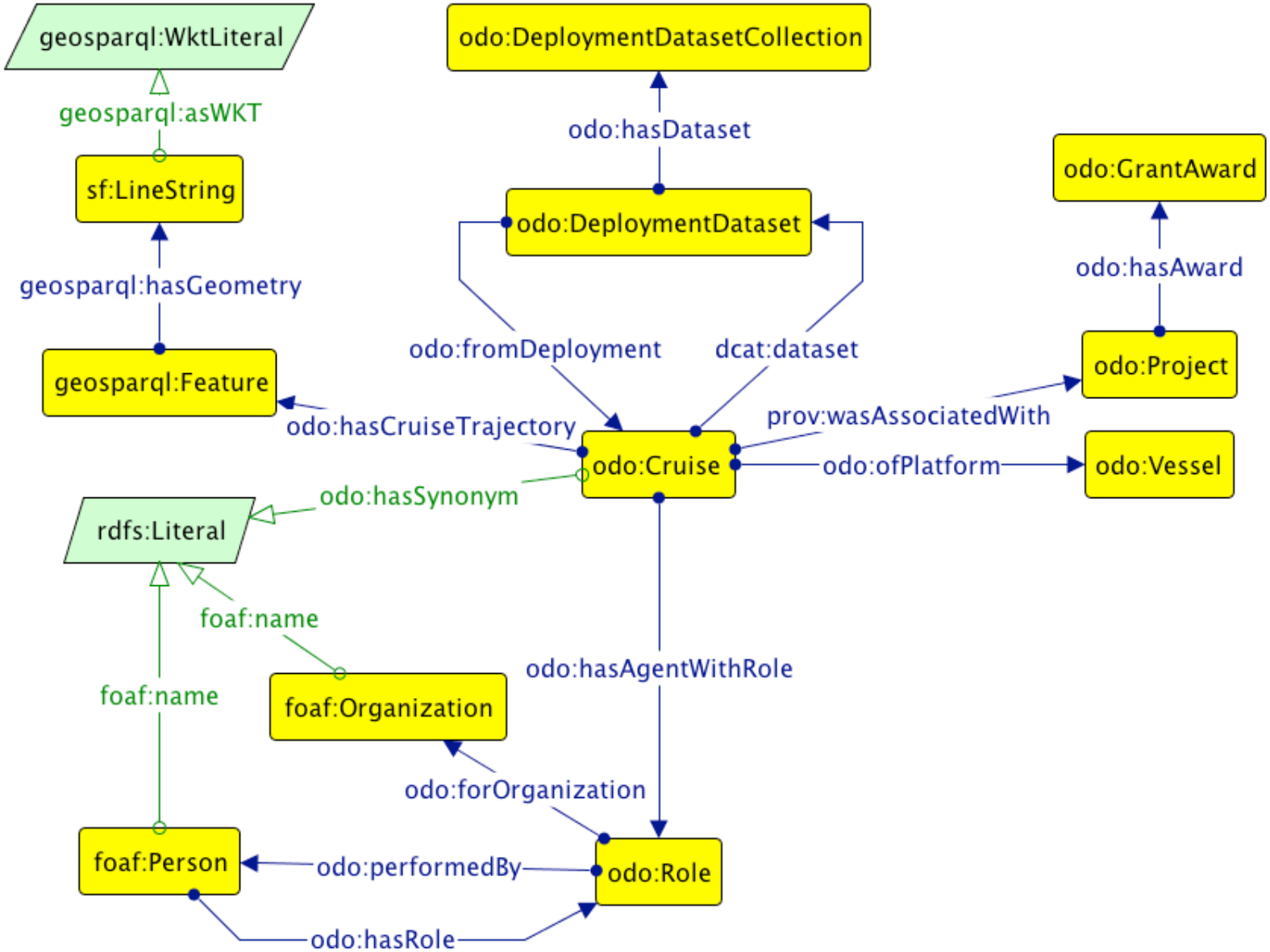


- Data providers A, B, and C, each with their own local ontologies, but use semantic trajectory pattern as a core component.
- A: data about (pedestrian) human mobility captured using smartphones, other mobile devices, and social media.
- B: data about cars, buses, taxis, trucks, and so forth.
- C: sparse GPS-based wildlife tracking data from Californian mountain lions.
- Federated query example: detect spots where wildlife crosses highways or enters human settlements.

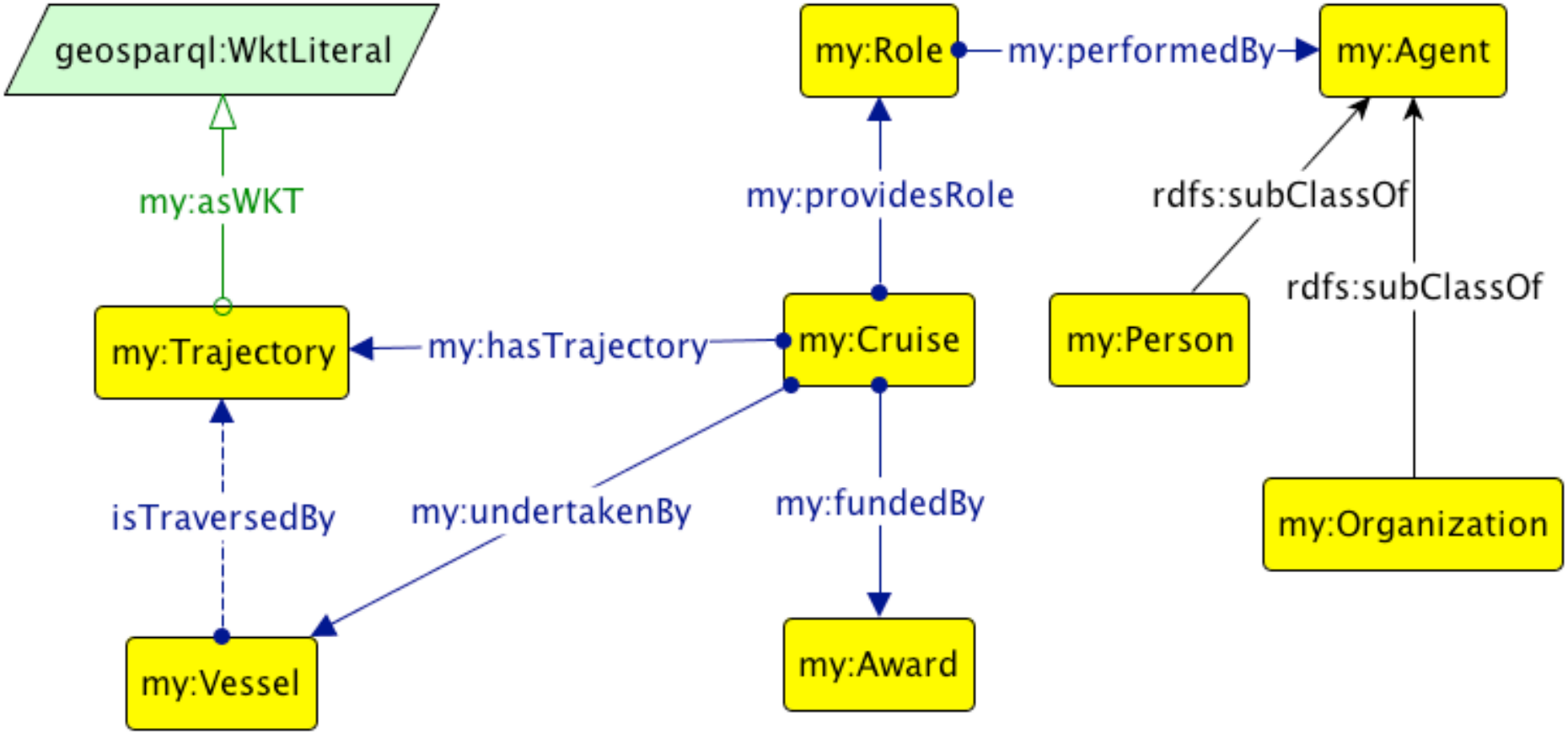
Cruise at R2R



Cruise at BCO-DMO



My not-so-well-designed Cruise pattern



Next steps

- Fill in the logical axiomatization of the pattern.
  - Use ontology editors, e.g., Protégé
- Prepare human-readable HTML documentation.
  - E.g., use LODE, Parrot, etc.
- Make both the pattern and the documentation available online according the pattern URI (may need to set up content negotiation)
- Start populate the pattern with data (virtual or warehousing-style).

PUBLISHING AGAINST THE PATTERNS

Local schemas to pattern mapping

- Mappings can be expressed as rules / SPARQL Construct queries / OWL axioms [live demo running SPARQL queries on the R2R and BCO-DMO SPARQL endpoints]
- R2R:
  - gl:Cruise (x) -> my:Cruise(x)
  - gl:isUndertakenBy(x,y) -> my:isUndertakenBy(x,y)
  - r2r:hasAward(x,y) -> my:fundedBy(x,y)
  - etc.
- BCO-DMO:
  - odo:Cruise(x) -> my:Cruise(x)
  - odo:ofPlatform(x,y) -> my:isUndertakenBy(x,y)
  - odo:Cruise(x), prov:associatedWith(x,y), odo:Project(y), odo:hasAward(y,z), odo:GrantAward(z) -> my:Cruise(x), my:fundedBy(x,z), my:Award(z)
  - etc.

Interoperability through the pattern

- We can make data available according to the pattern.
  - Possible even without physically persistently housing the data.
  - Mapping rules are needed (expressible in SPARQL).
- R2R and BCO-DMO do not have to annotate their data using vocabulary terms in the pattern directly.
- Federated query can also be posed in any of the two repositories' endpoints, assuming the corresponding repository can read the mapping.

Conclusion

- ODPs can act as interoperability bridge, or as a glue, without sacrificing the local heterogeneity from each data source.
- There is no need to force everyone to use the same class and properties, as one can map/align local schemas/data models to the ODPs.
  - Helped by the fact that ODPs are small and modular.
- ODPs open a way to publish Linked Data more cheaply since the costly endeavor of developing overarching upper level and domain ontologies can be avoided.

Data Semantics Lab

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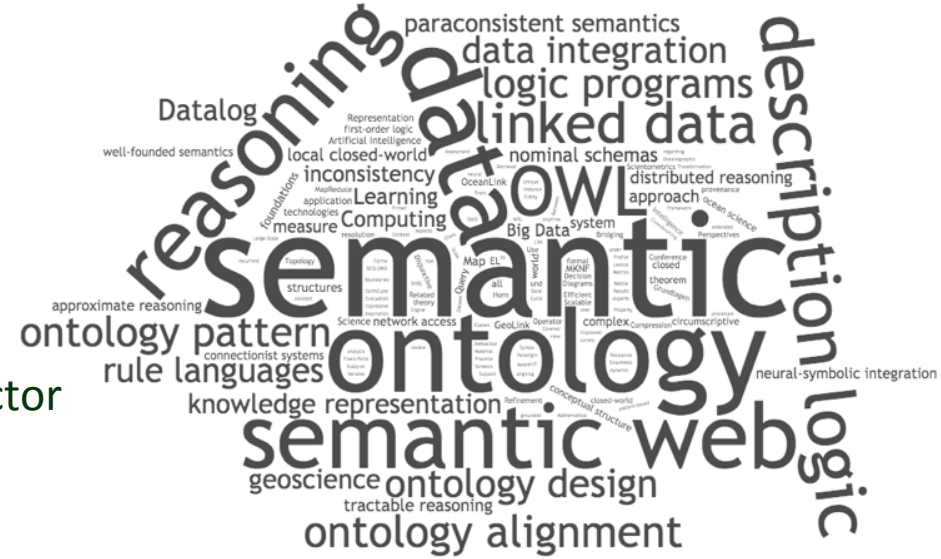

Other Members:

- Postdoc: Adila Krisnadhi
- 8 PhD Students
- A few Master's students and visiting researchers

Web: http://www.daselab.org
Twitter: @DaSeLab
FB: https://www.facebook.com/daselab

References

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