Ontologies in a data-driven world: Finding the middle ground

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The ontology hype

- **Large, well-thought-out ontologies (foundational/domain/etc).**
- **Networked, interlinked ontologies**

- **“You just have to get your formal definitions right, and a lot of the rest will just fall into place.”**

The ontology hype

- "You just have to get your formal definitions right, and a lot of the rest will just fall into place."
  - This does not even work for
    - scientists
    - wanting to share and reuse scientific data
    - through well-kept data repositories
  - So how is this supposed to work for the web at large?

Multiple perspectives

$$\text{a:flowsInto} \sqsubseteq \text{a:IsConnected} \quad (1)$$
$$\text{a:IrrigationCanal} \sqsubseteq \text{a:Canal} \quad (2)$$
$$\exists\text{a:flowsInto.a:AgriculturalField} \sqsubseteq \text{a:IrrigationCanal} \quad (3)$$
$$\text{a:Waterbody} \sqcap \text{a:Land} \sqsubseteq \bot \quad (4)$$
$$\text{a:AgriculturalField} \sqsubseteq \text{a:Land} \quad (5)$$

$$\text{b:flowsInto} \sqsubseteq \text{b:IsConnected} \quad (6)$$
$$\text{b:Canal} \sqsubseteq (\geq 2\ \text{b:IsConnected.b:Waterbody}) \quad (7)$$
$$\text{b:IrrigationCanal} \equiv (=1\ \text{b:isConnected.b:Waterbody}) \sqcap (=1\ \text{b:flowsInto.b:AgriculturalField}) \quad (8)$$

Two ontologies.

Left: transportation domain

Right: agriculture domain

We cannot simply equate a:Canal and b:Canal !

Multiple perspectives

- Try to find a universal definition for
  - Forest
  - Mountain
  - City
  - River

  - Etc.

- The stronger our ontological commitments, the more we loose reusability.

- We need to accept that conceptualizations are often very local, resulting in “micro-ontologies”.

The well-done ontologies

- Where are they used on the web?
- Brittle
- Expensive
- Sometimes unintuitive
- Unwieldy
- Difficult to reuse

- Work in some contexts.
- Work if a lot of central control is imposed.
- Take a lot of manpower.

The linked data counter-hype

- "Ontologies don't work, let's just link data"

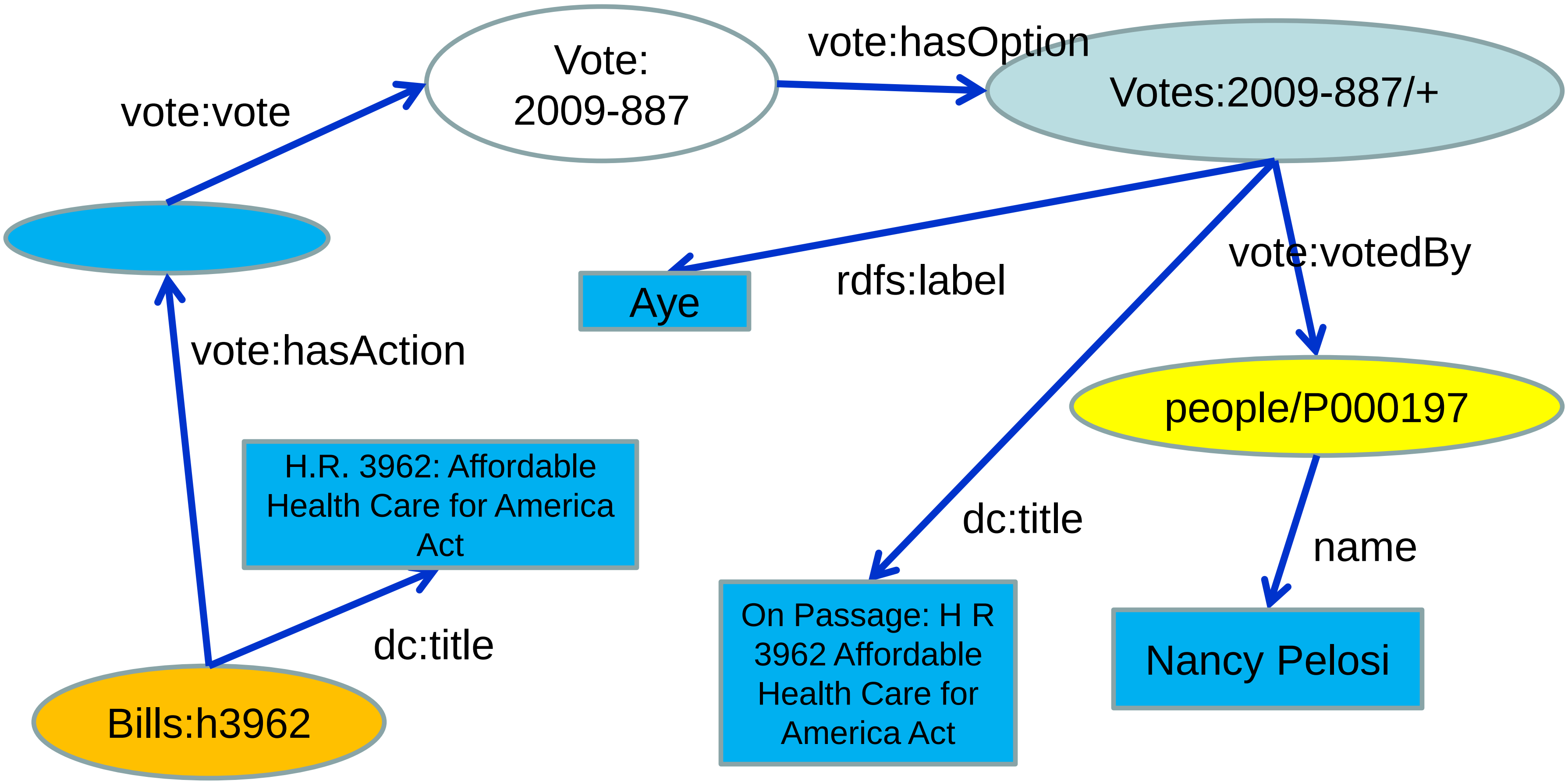
- "Okay, with a little bit of ontologies on top."

- But then we don't even know how to effectively query over multiple linked datasets (without using a lot of manpower to manually integrate them).

- It seems rather obvious that we need to get ontologies into the picture, but how to do it while avoiding the drawbacks of strong ontological commitments?

Linked Data: Variety and Value

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



Ways forward

- Identify, which logical or conceptual depth of modeling is suitable for which purpose.

But even more importantly.

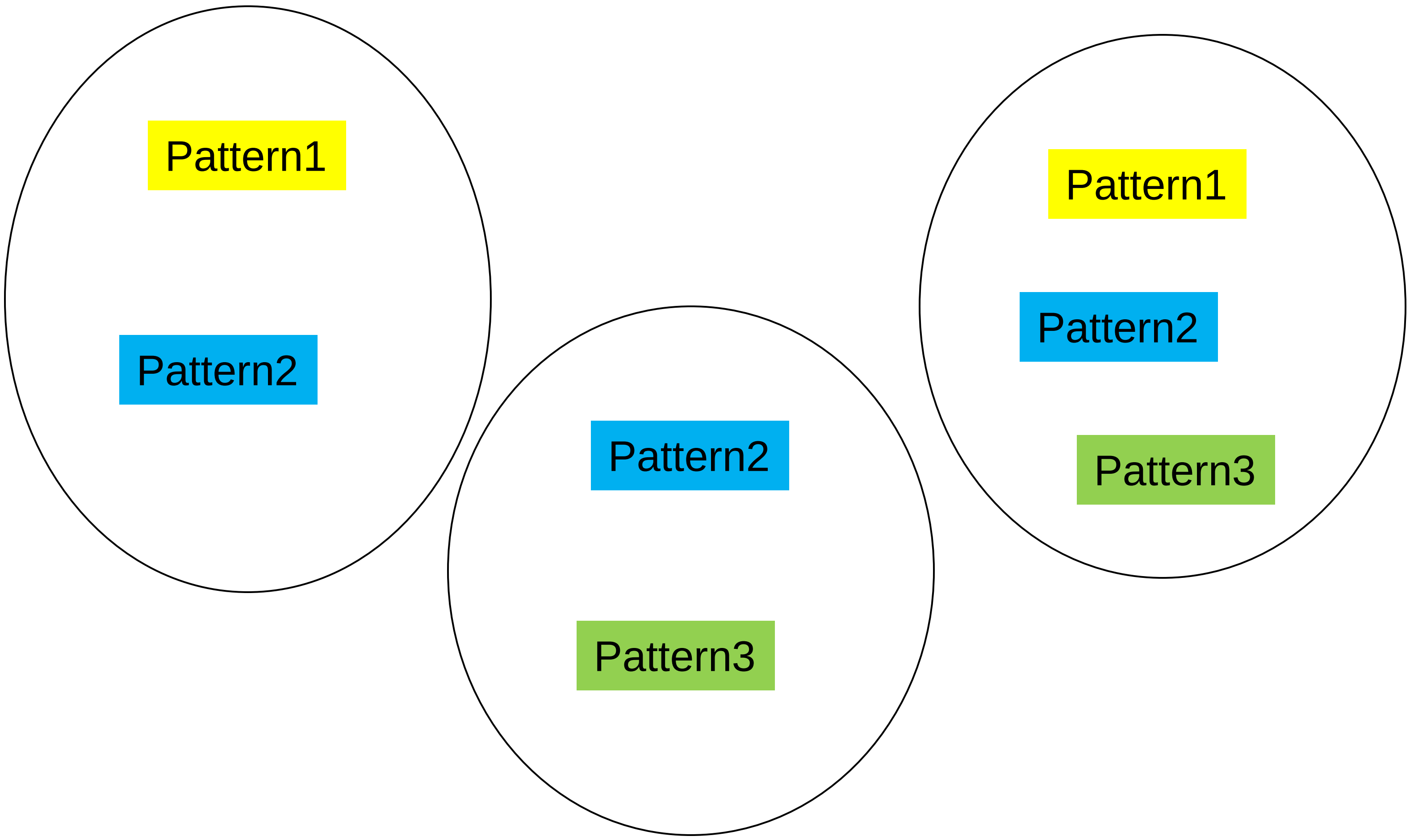
- Establish a flexible conceptual architecture using data and ontological modeling.

Ontology Design Patterns

- **Bottom-up homogenization of data representation.**
- **Avoidance of strong ontological commitments.**
- **Avoidance of standardization of specific modeling details.**
- **Well thought-out patterns can be very strong and versatile, thus serve many needs.**

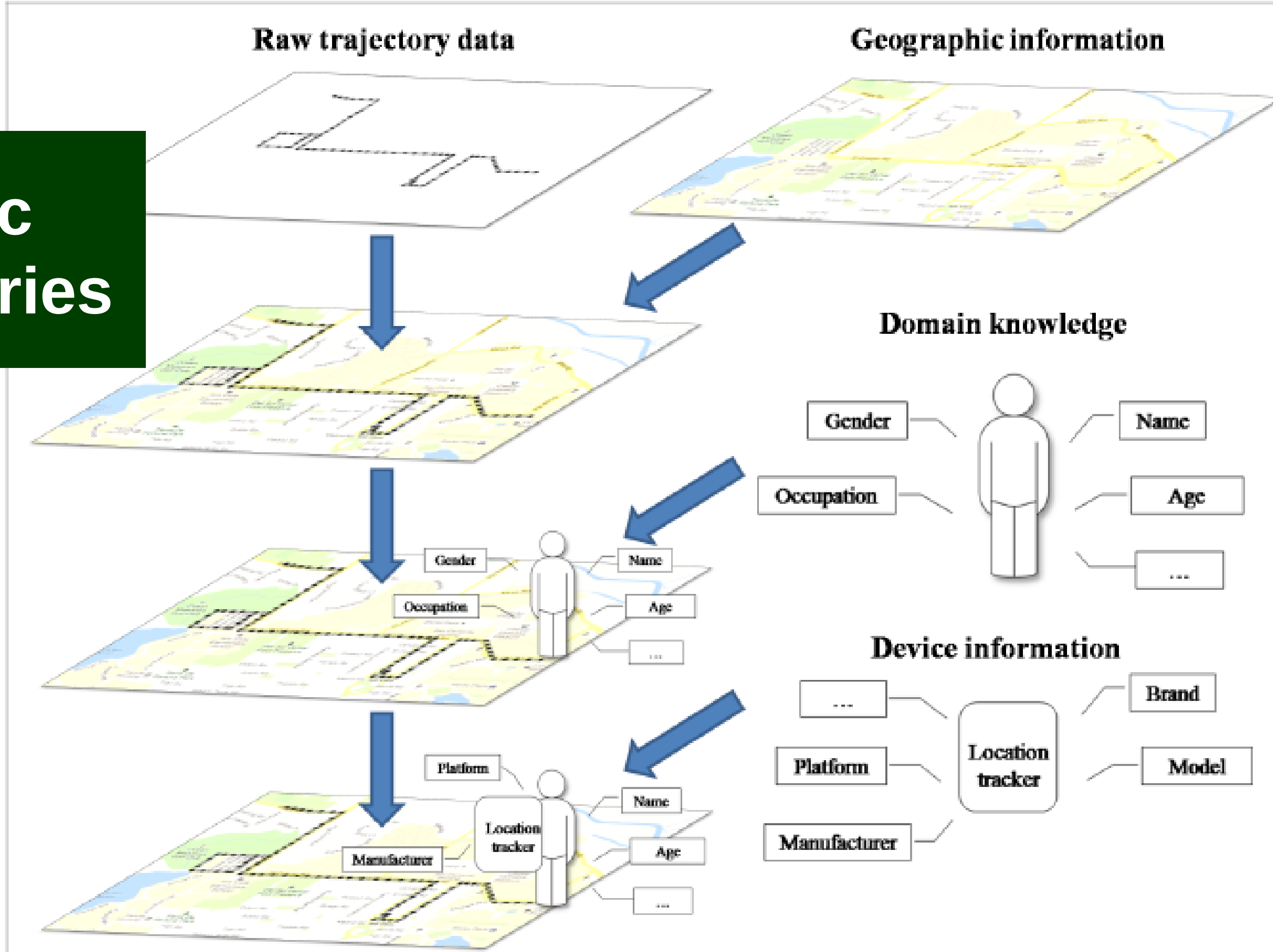
We are currently establishing many geo-patterns in a series of hands-on workshops, the GeoVoCamps, see http://vocamp.org/

Ontology Design Patterns



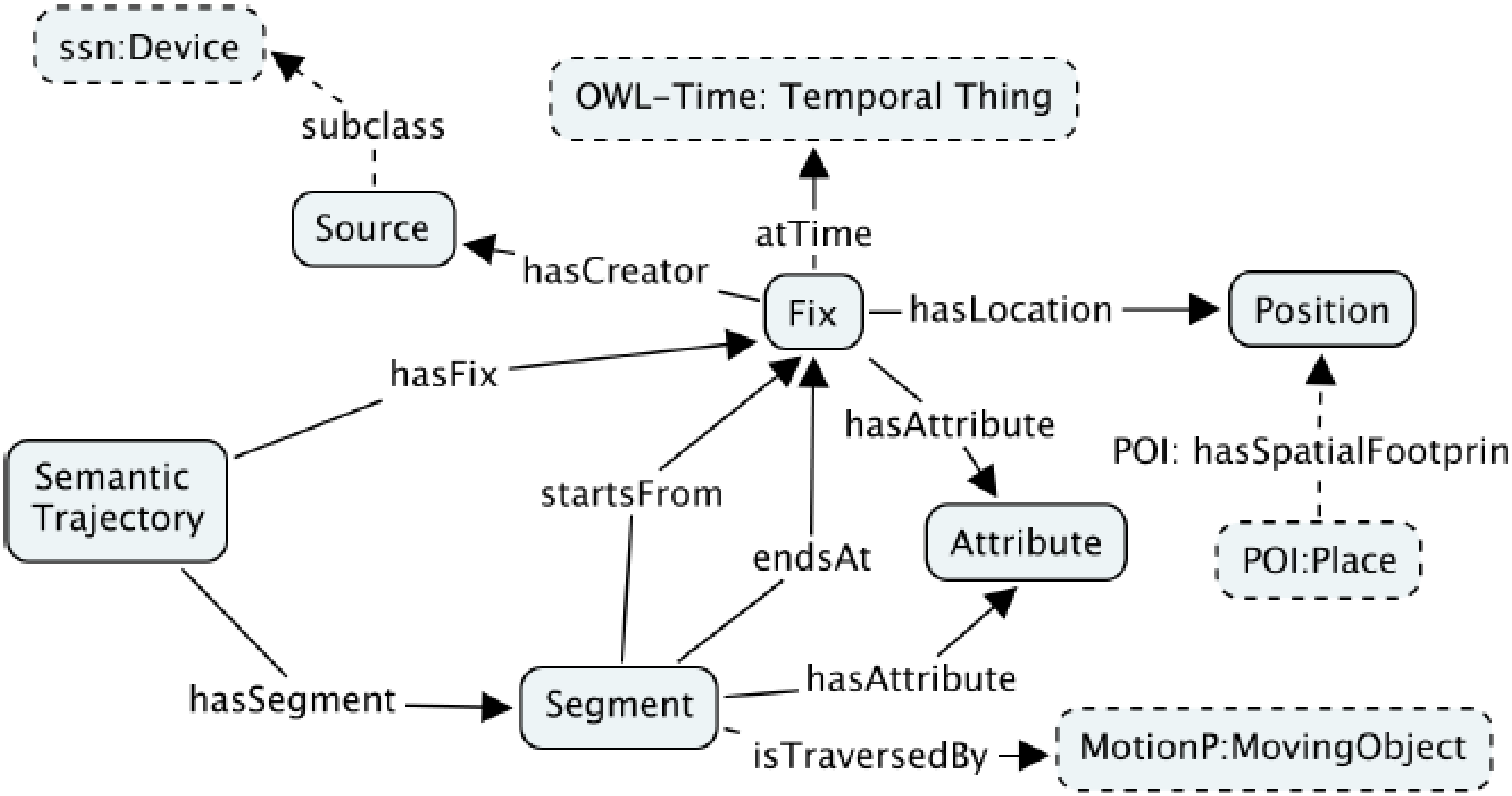
"Horizontal" alignment via patterns

Semantic Trajectories



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

Semantic Trajectories



Semantics in OWL

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

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

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

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

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

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

$$hasNext \sqsubseteq hasSuccessor \quad (7)$$

$$hasSuccessor \circ hasSuccessor \sqsubseteq hasSuccessor \quad (8)$$

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

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

Semantics in OWL

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

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

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

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

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

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

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

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

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

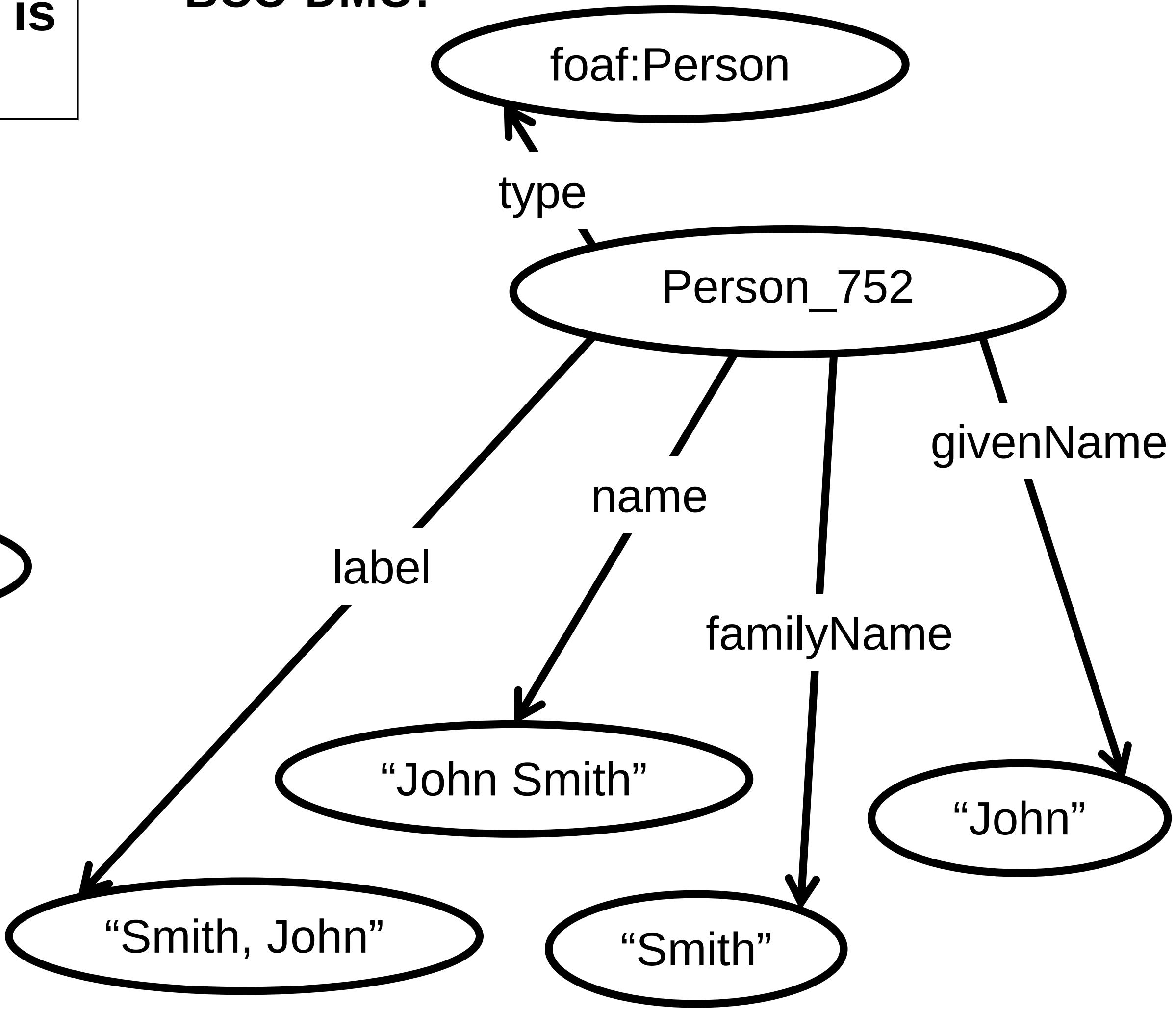
$$\exists hasFix.Segment \sqsubseteq SemanticTrajectory \quad (20)$$

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

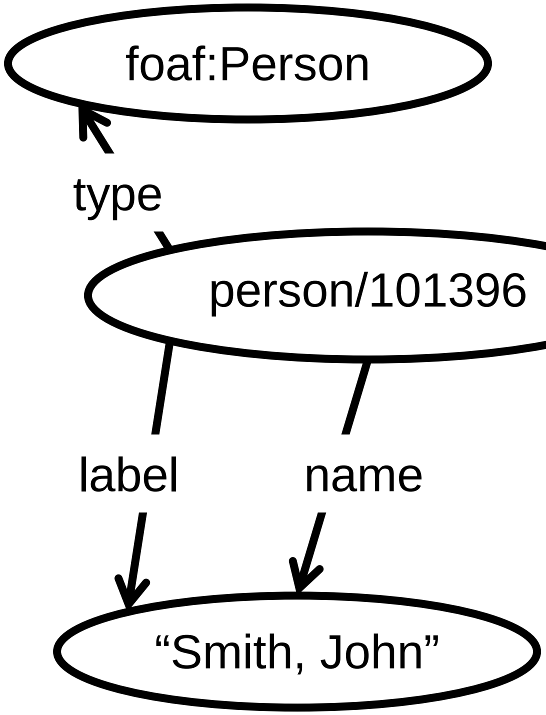
Helpfulness of patterns

Even minimalistic reuse is helpful:

BCO-DMO:



R2R:



Patterns

- Help to focus when modeling (one key notion at a time).
- Good ontology modeling implicitly employs the patterns idea anyway. It's just that you expose the patterns.
- An ontology composed of patterns exposes its internal conceptual structure (as a composition of formal vocabulary pieces).
- Well-designed patterns are widely reusable and adaptable.
- You don't have to buy a whole ontology when you adopt a few patterns from it.
- You can easily modify a pattern without giving up on a lot of similarity to the original pattern (which can be leveraged for data integration).
- You can separate the patterns from specific (application-driven) modifications.
- You can separate the patterns from specific axiomatically defined "views".

Ways forward

- Identify, which logical or conceptual depth of modeling is suitable for which purpose.

But even more importantly.

- Establish a flexible conceptual architecture using data and ontological modeling.
- A principled use of patterns, including
  - the development of a theory of patterns and
  - the provision of a critical amount of central patterns

  may provide a primary path forward.

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