Experiences with Foundational, Domain and Application Ontologies in OWL2

March 16 2021

CC BY 4.0 License

OntoInsights, LLC
andrea@ontoinsights.com

Experiences with Foundational and Domain Ontologies

- Member of program to understand correlation and cause and effect relationships of events from news articles and research documents
- Analyses based on CERDEC's Common Core and TRADOC's Operational Environment ontologies
  - Both derived from BFO
  - Program originally intended to reuse these ontologies with no new ontology development
- After ~6 months, 3 different teams could not determine how to encode ***most*** events and their participants
  - Where teams published triples, they chose different classification entities and design approaches
- Use of the original ontologies was discontinued and a specific event-based ontology was created instead

CC BY 4.0, OntoInsights, LLC

Similar Findings, Published 2019

- https://www.sciencedirect.com/science/article/pii/S157082681830043X
  - "Measuring expert performance at manually classifying domain entities under upper ontology classes"
  - Study "to measure the performance of human experts at manually classifying classes in a general knowledge domain ontology with entities in the Basic Formal Ontology (BFO)"
- Findings
  - "… even for a well understood general knowledge domain such as travel, the results of the manual classification tasks are highly inconsistent"
    - Mean agreement of the participants with the classification decisions of an expert panel was only 51%

CC BY 4.0, OntoInsights, LLC

Event and Linguistic Theory

- Davidson's 1967 paper, "The Logical Form of Action Sentences" and Vendler's 1967 paper, "Verbs and Times"
  - Distinguish states vs events
  - Decompose events to achievements, accomplishments and activities
  - Reify events and states as individuals
- Bach's 1981 paper, "On Time, Tense, and Aspect: An Essay in English Metaphysics"
  - Use of the term, "eventuality" for both events and states
- Fillmore's 1967 paper, "The Case for Case" => Semantic role labeling
- And much more

CC BY 4.0, OntoInsights, LLC

Why Events and Narrative?

- **Humans** are not ideally set up to understand logic; they are ideally set up to understand stories.

  Roger C. Schank, cognitive scientist

- Stories and the real world have in common that human cognition divides them up into events.

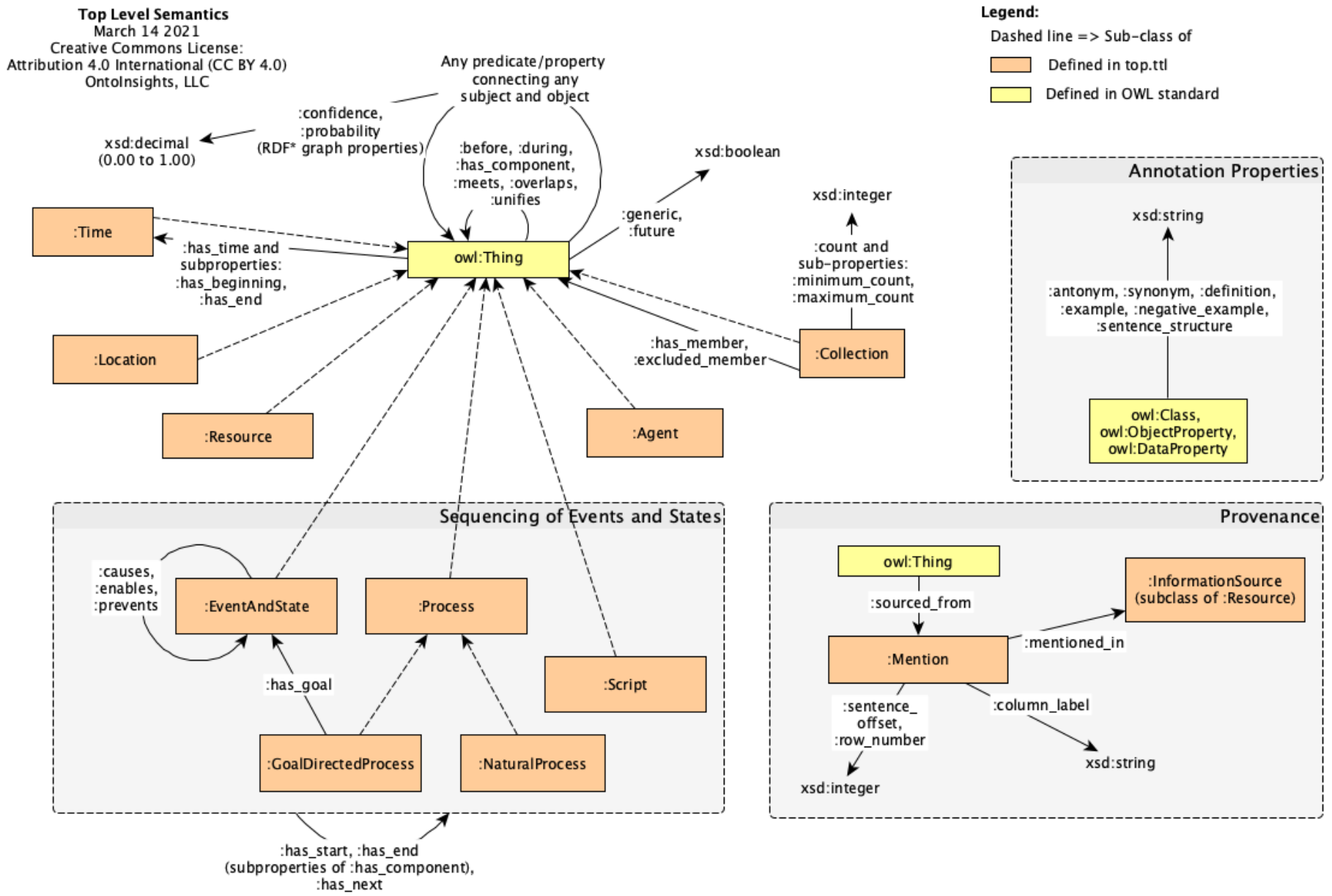
  http://ceur-ws.org/Vol-2160/C3GI_2017_paper_1.pdf

- Producing narratives is not only an ability that is more or less natural, but a specific topology for storing information.

  https://www.sciencedirect.com/science/article/pii/S2212683X16300184

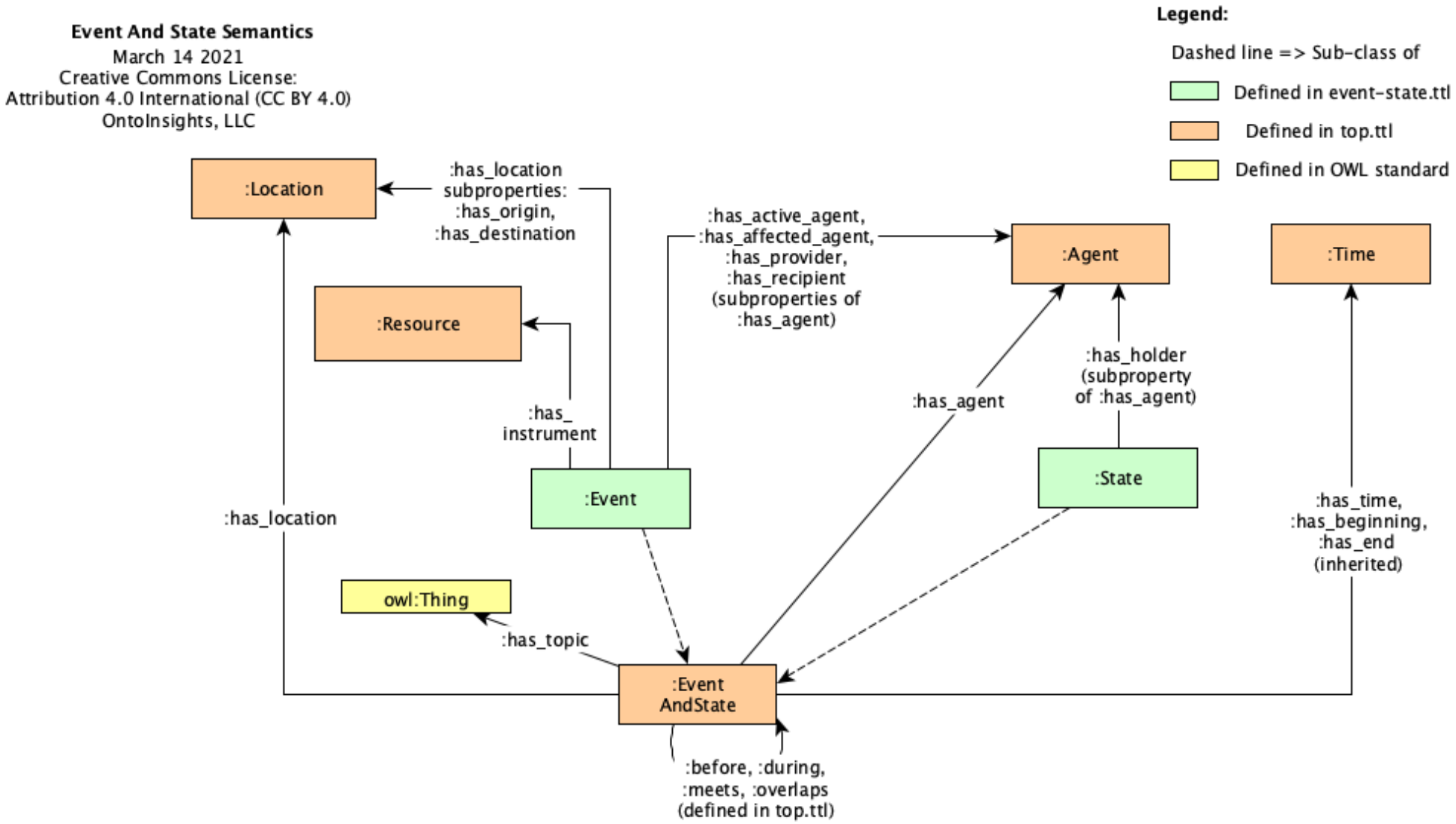
CC BY 4.0, OntoInsights, LLC

‘Top Level’ Ontology - Semantics of Events



CC BY 4.0,
OntoInsights, LLC

Event - State Ontology



CC BY 4.0, OntoInsights, LLC

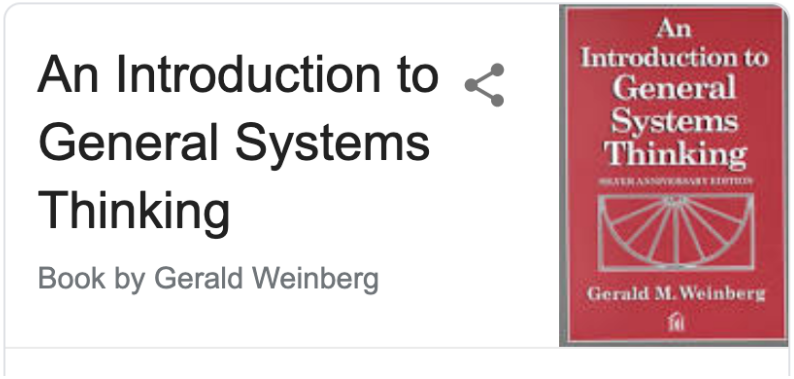
Aspects of Events

- Agents/actors/participants (who and what)
  - Including affected agents/actors
- Location (where)
- Time/sequence (when)
- Happening/occurrence/state (what)
- Tools/instruments/resources used or provided/consumed (what and how)
- Goal/intent (why)
- Causation, precondition and prevention (why)
- Modality+ (planned/possible, attempted/failed, …)
- Other relationships
  - For example, component events

CC BY 4.0, OntoInsights, LLC

Developing an Ontology of Events

- Approaching the problem
  - Start from verbs, not nouns
  - Understand what events, changes, etc. influence the domain
  - For example, a pizza ontology only matters if you are buying/selling or making/eating pizzas
- Using a systems thinking approach to understand the domain
  - What is the domain of interest?
  - What is its purpose?
  - What are its functions?
  - What are its boundaries?
  - What influences the domain?
  - What constitutes its environment?
  - What are its component parts?



CC BY 4.0, OntoInsights, LLC

Ontological Definition and Communication

- Not only OWL2 definition but creation of diagrams and spreadsheets for review

```
¬
:Event a owl:Class ;¬
  rdfs:subClassOf :EventAndState ;¬
  :definition "An occurrence or phenomenon that is typically described by what happened (the Event sub-class), to whom (defined using the
:has_agent property or its sub-properties), when (defined using the :has_time property or its sub-properties) and where (defined using the
:has_location property or its sub-properties)." ;¬
  :synonym "occurrence", "happening", "act", "incident", "phenomenon".¬
¬
:has_agent a owl:ObjectProperty ;¬
  rdfs:domain :EventAndState ;¬
  rdfs:range :Agent ;¬
  :definition "References an Agent who participates in or who experiences an Event or State. Whether the Agent is active in the Event or
experiences/is affected by an Event or State can be distinguished by the sub-properties, :has_active_agent, :has_affected_agent or
:has_holder." .¬
¬
```

	A	B	C	D	E	F	G	H
	Class Name	Label	Is Enum? (TRUE or blank)	Definition	Examples	Synonyms	Direct Super-classes	All Super-classes
3	:Event	Event		An occurrence or phenomenon that is typically described by what happened (the Event sub-class), to whom (defined using the :has_agent property or its sub-properties), when (defined using the :has_time property or its sub-properties) and where (defined using the :has_location property or its sub-properties).		act; happening; incident; occurrence; phenomenon	:EventAndState	:EventAndState

CC BY 4.0
OntoInsights, LLC

Use of Logic and Probabilities in OWL2

- RDFS inference/reasoning
  - Via subclassing hierarchy – for example, querying for all acts of violence
  - Via domain and range definitions – for example, understanding that an instance with a count is a Collection with members
- Validation of consistency with:
  - Identification of inconsistencies and contradictions
  - Possible repair or exclusion of offending triples
- Reasoning with user-defined rules – SWRL
  - Especially to capture relevant common sense
    - ATOMIC, An Atlas of Machine Commonsense for If-Then Reasoning, https://homes.cs.washington.edu/~msap/atomic/
    - ConceptNet, https://conceptnet.io/
- Use of probabilities
  - Via RDF* edge properties

CC BY 4.0, OntoInsights, LLC

Argumentation

- Discovery of evidence for cause and effect
  - Answers range from yes/no to unknown or undecided
- Analyzing events
  - For example, to determine if a competitive or cooperative relationship exists between two individuals
  - What events have been observed regarding these individuals?
  - Do the events support or refute competition? (With the additional benefit of explainability)
- Analyzing narratives
  - What events are discussed in a narrative?
  - Is there consistency in the inclusion of specific events in certain types of narratives?
  - Which event sequences lead to positive vs negative outcomes?
  - What assertions can be made? What weight is given to different supporting vs conflicting events?
    - => Defeasible knowledge

CC BY 4.0, OntoInsights, LLC