# Taxonomies to Ontologies
# How, When and Why to Connect and/or Extend

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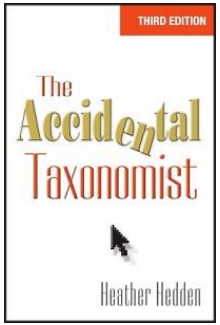
# About Heather Hedden

- Independent taxonomy consultant, Hedden Information Management
- Instructor of online and corporate taxonomy courses and workshops
- Previously a taxonomy consultant in consulting firms, Enterprise Knowledge and PPC. Also, a contract consultant for others.
- Former taxonomy-related roles at Semantic Web Company, Gale/Cengage, Viziant, and First Wind.
- Author of *The Accidental Taxonomist, 3rd ed.* (2022, Information Today, Inc.)

Hedden Information Management

Making information findable



# Outline

- Why combine taxonomies and ontologies
- Definitions and features of taxonomies and ontologies
- Semantic Web standards for taxonomies and ontologies
- Approaches to combining a taxonomy and ontology
- Combining taxonomies and ontologies: examples in tools

# Why Combine Taxonomies and Ontologies?

# Why Combine Taxonomies and Ontologies

## What you can do with a taxonomy

- Search: find content about…. (search string matches taxonomy concepts)
- Topic browse: explore subjects arranged in a hierarchy and then content on the subject
- Faceted (filtering/refining) search: find content meeting a combination of basic criteria
- Tagging: index content consistently so that retrieval is comprehensive and accurate
- Discovery: find other content tagged with same concepts as tagged to found content; explore broader, narrower, and (sometimes) related taxonomy topics
- Content curation: create feeds or alerts based on user profile (personalization) and taxonomy concepts tagged
- Metadata management: for retrieval, identification, comparison, analysis, etc.

# Why Combine Taxonomies and Ontologies

## What you cannot do with a taxonomy alone, but can with an added ontology

- Complex multi-part searches: “chained” queries beyond just “about a subject.” (e.g. contacts in a location, employed by companies, which belong to certain industries)
- Search on data: obtain specific data, and not just content (full documents)
- Search on more specific criteria: searches that vary based on category (class)
- Knowledge graph or semantic layer creation: to connect data and content from different repositories and to search, analyze, and infer across all sources

## What else you can do with an ontology

- Modeling complex interrelationships: to understand operations and systems better (e.g. in product approval or supply chain processes)
- Exploring explicit relationships: between concepts (not just broader, narrower, related)
- Visualization: graph representations of concepts and semantic relationships
- Reasoning and inferencing: based on logic, to gain new knowledge

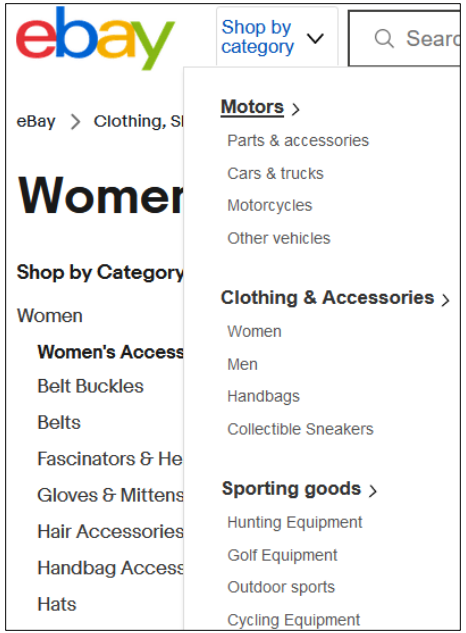
# Why Combine Taxonomies and Ontologies

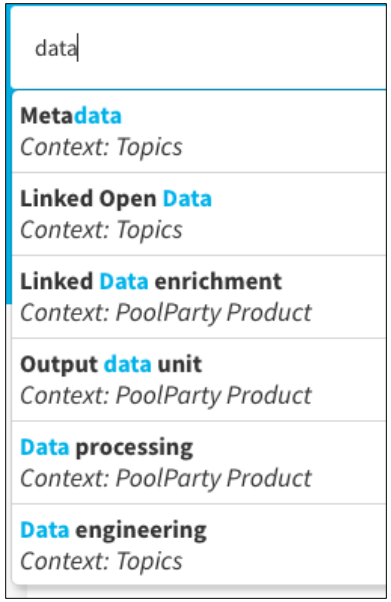
## What you can do with a taxonomy and not with an ontology

- Search with synonyms: utilize alternative labels to match to search strings
- Tag with synonyms: utilize alternative labels to match to text strings
- Support multiple languages: support access to users of different languages and tag content in different language
- Include definitions and scope notes: as standardized types of fields
- Map/link to other taxonomies: enable access to other content tagged with other taxonomies
- Support metadata as filters: aligning concept schemes to metadata properties and facets
- Browse hierarchies in a frontend UI: browsable display of concepts link directly to content, unlike ontology visualizations
- Implement easily in content systems: CMSs, DAM systems, Intranets, websites, etc.

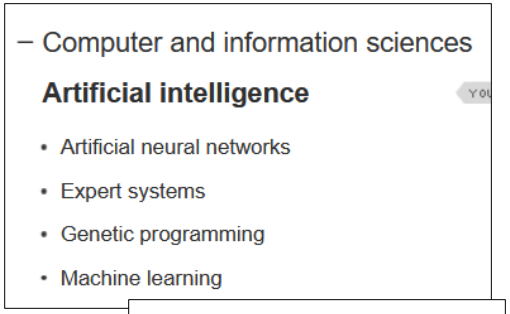
# Definitions and Features of Taxonomies and Ontologies

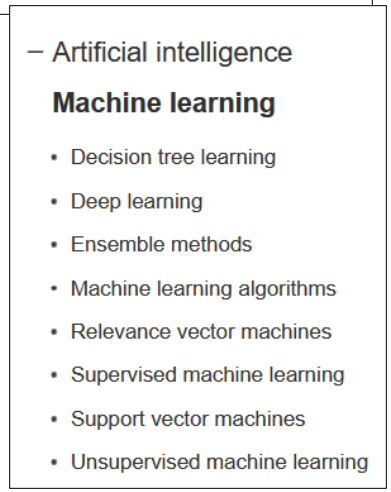
# Introduction to Taxonomies








Taxonomies help people find information

# Introduction to Taxonomies

Taxonomy Type Examples

Hierarchical Taxonomy Example

Leisure and culture
. Arts and entertainment venues
. . Museums and galleries
. Children's activities
. Culture and creativity
. . Architecture
. . Crafts
. . Heritage
. . Literature
. . Music
. . Performing arts
. . Visual arts
. Entertainment and events
. Gambling and lotteries
. Hobbies and interests
. Parks and gardens
. Sports and recreation
. . Team sports
. . . Cricket
. . . Football
. . . Rugby
. . Water sports
. . Winter sports
. Sports and recreation facilities
. Tourism
. . Passports and visas
. Young people's activities

Faceted Taxonomy Example

**Career Level**
- Student
- Entry Level
- Experienced
- Manager
- Director
- Executive

**Function**
- Customer Service & Support
- Delivery
- Engineering
- Finance
- General Management
- Legal & Regulatory Affairs
- Marketing & Advertising

[more]

**Industry**
- Agriculture
- Apparel & Fashion
- Automotive
- Aviation & Aerospace
- Banking
- Biotechnology
- Broadcast Media
- Chemicals

[more]

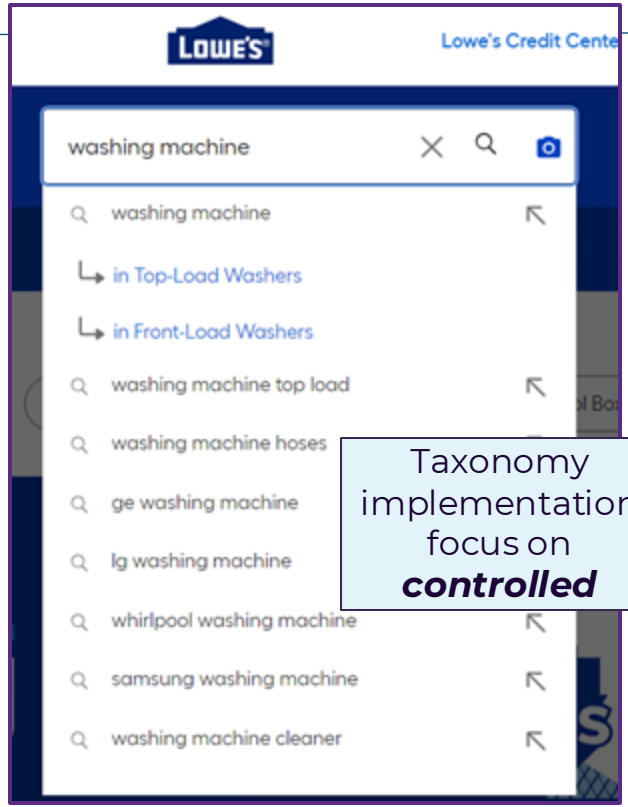
# Taxonomy Features

A taxonomy is:

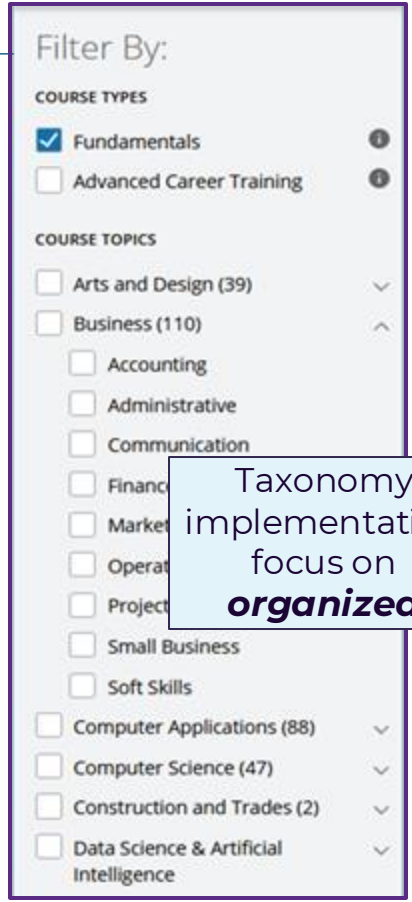
***Controlled*** and ***organized***

1. Controlled:
A kind of controlled vocabulary or knowledge organization system,
based on unambiguous concepts, not just words:
**things, not strings**

2. Organized:
Concepts are arranged in a structure of hierarchies, categories, or facets to organize them.

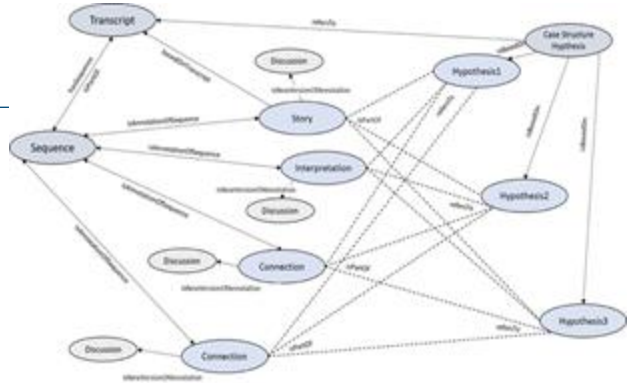



Taxonomy implementation focus on ***controlled***




Taxonomy implementation focus on ***organized***

# Introduction to Ontologies

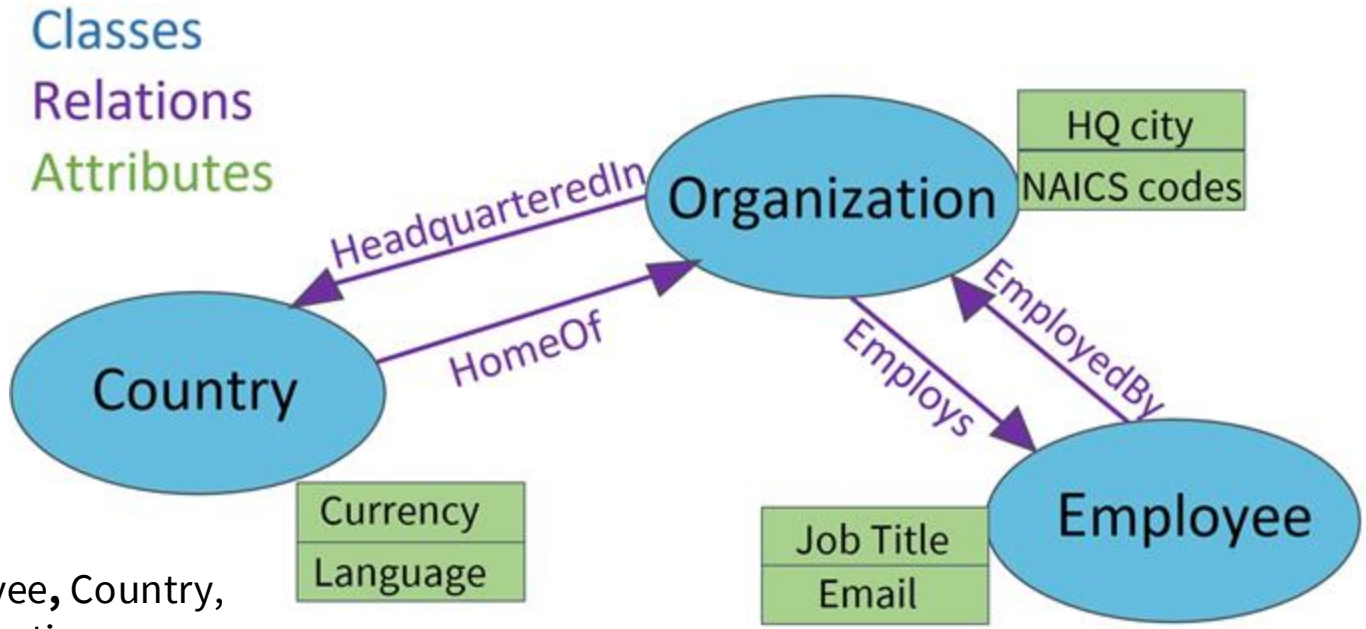



## Definitions of an ontology

- A form of knowledge representation
  - Not just knowledge organization
- A formal naming and definition of the **types**, **properties** and **interrelationships** of entities in a particular domain.
  - Classes, custom attributes, and semantic relationships
- A set of precise descriptive statements about a particular domain.
  - Statements as *subject-predicate-object* are expressed as triples.

- A more abstract layer in describing a knowledge organization system
  - Overlays and connects to a taxonomy or other controlled vocabulary to add semantics

# Ontology Features




**Classes**

Employee, Country, Organization

**Relations:** HeadquarteredIn < > HomeOf
EmployedBy < > Employs

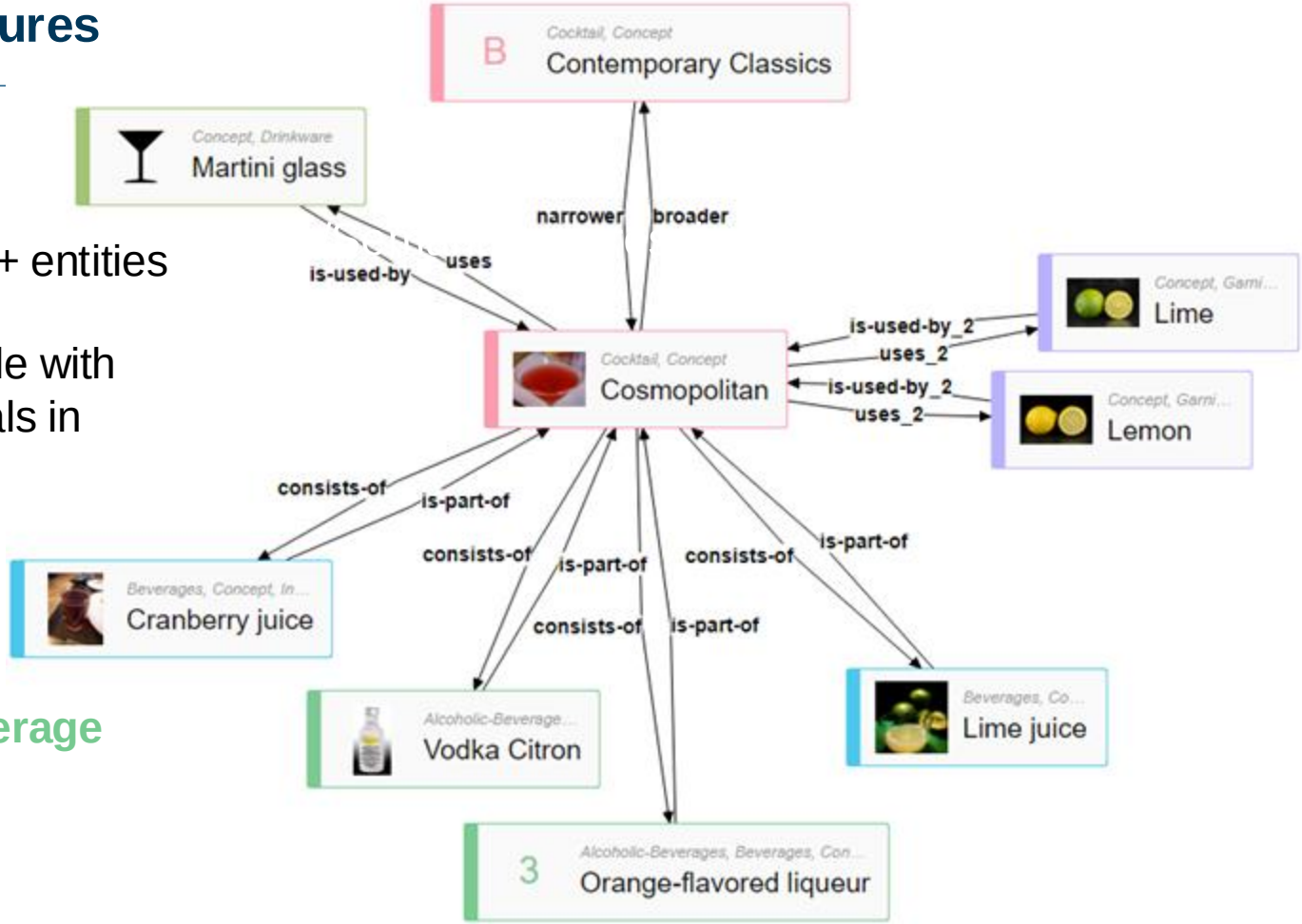
**Attributes:** Email address, Job title, HQ city, NAICS codes, Currency, Language

# Ontology Features

Ontology model + entities

Ontology example with specific individuals in each class:

- Cocktail
- Garnish
- Drinkware
- Beverage
- Alcoholic Beverage



# Definitions of Ontologies


## Ontology definition questions

Is it

- A knowledge model, an abstract layer, a form of knowledge representation, that describes the classes, relationship types, and attribute types in a domain,

or

- A knowledge organization system, that includes both:
  the classes, relationship types, and attribute types *and*
  the specific concepts, entities/individuals, and their specific attributes


Both definitions exist.

*Combining* an ontology and a taxonomy implies the first definition of ontology (a model).

*Extending* a taxonomy into an ontology implies the latter definition of ontology.

# Knowledge Organization System Types


| Term List | Name Authority | Taxonomy | Thesaurus | Ontology |
|---|---|---|---|---|
| Ambiguity control | Ambiguity control<br>Synonym control<br>(Attributes) | Ambiguity control<br>(Synonym control)<br>Hierarchical relationships | Ambiguity control<br>Synonym control<br>Hierarchical relationship<br>Associative relationships | Ambiguity control<br>Model + entities<br>Semantic relationships<br>Classes<br>Attributes |

# Knowledge Organization System Types

*Less* Complexity/Semantic expressiveness *More*

| Ontology (model/layer) | | | |
|---|---|---|---|
| **Term List** | **Name Authority** | **Taxonomy** | **Thesaurus** |
| Ambiguity control | Ambiguity control<br>Synonym control<br>(Attributes) | Ambiguity control<br>(Synonym control)<br>Hierarchical relationships | Ambiguity control<br>Synonym control<br>Hierarchical relationship<br>Associative relationships |

Ontology as a semantic model

# Semantic Web Standards for Taxonomies and Ontologies

# Semantic Web Standards for Taxonomies and Ontologies

**For both ontologies and taxonomies/controlled vocabularies:**

RDF (Resource Description Framework) www.w3.org/TR/rdf11-concepts

- "A standard model for data interchange on the Web"
- Requires the use of URIs and information modelled as subject – predicate – object triples.

**For taxonomies/controlled vocabularies:**

SKOS (Simple Knowledge Organization System) www.w3.org/TR/skos-reference (2009)

- "A common data model for sharing and linking knowledge organization systems via the Web"
- Encoded using XML and RDF for publication and use of vocabularies as linked data

**For ontologies:**

RDFS (RDF-Schema) www.w3.org/2001/sw/wiki/RDFS

- "A general-purpose language for representing simple RDF vocabularies on the Web"
- Goes beyond RDF to designate classes and properties of RDF resources.

OWL (Web Ontology Language) www.w3.org/OWL

- "A Semantic Web language designed to represent rich and complex knowledge about things, groups of things, and relations between things"
- Based on RDF and RDFS; OWL is W3C's attempt to extend RDFS.

# Semantic Web Standards for Taxonomies: SKOS

## SKOS (Simple Knowledge Organization System) elements

| Concept Scheme & Collection | Concepts | Labels & Notation | Documentation | Semantic Relations | Mapping Relations |
|---|---|---|---|---|---|
| ConceptScheme | Concept | prefLabel | scopeNote | broader | exactMatch |
| inScheme | hasTopConcept | altLabel | definition | narrower | closeMatch |
| Collection | topConceptOf | hiddenLabel | example | related | broaderMatch |
| orderedCollection | | notation | changeNote | broaderTransitive | narrowerMatch |
| member | | | editorialNote | narrowerTransitive | relatedMatch |
| memberList | | | historyNote | | |

https://www.w3.org/TR/skos-reference

# Semantic Web Standards for Ontologies: OWL

## OWL-Defined Ontology Components

Entities – subjects (domains) or objects (ranges) of properties, within RDF triples

- Classes (in SKOS: concepts)
  - Named sets of concepts that share characteristics and relations
  - May contain subclasses or individuals (instances of the class)
- Individuals (in SKOS: concepts)
  - Members or instances of a class. Unique named entities.

Properties – predicates about individuals (instances)

- Object properties (in SKOS: relations)
  - Relations between individuals
  - May be directed (single direction), symmetric, or with an inverse (different in each direction)
- Datatype properties
  - Attributes or characteristics of individuals
  - The object of a datatype property is a *value*.

Literals – values of attributes, with just a *lexical form* and a *datatype.*

https://www.w3.org/TR/2012/REC-owl2-primer-20121211/

# Approaches to Combining a Taxonomy and Ontology

# Ontology + Taxonomy Creation Approaches

## Options for creating the semantic model + individual instances type of an ontology:

1. Use a dedicated ontology tool, e.g. Protégé, or hand-coding OWL to build out the detailed taxonomic hierarchy (of classes, subclasses) and individuals within the ontology
2. Use taxonomy/ontology combined tool to create taxonomy and an ontology and link them, with the ontology providing semantic enrichment

# Ontology + Taxonomy Creation Approaches

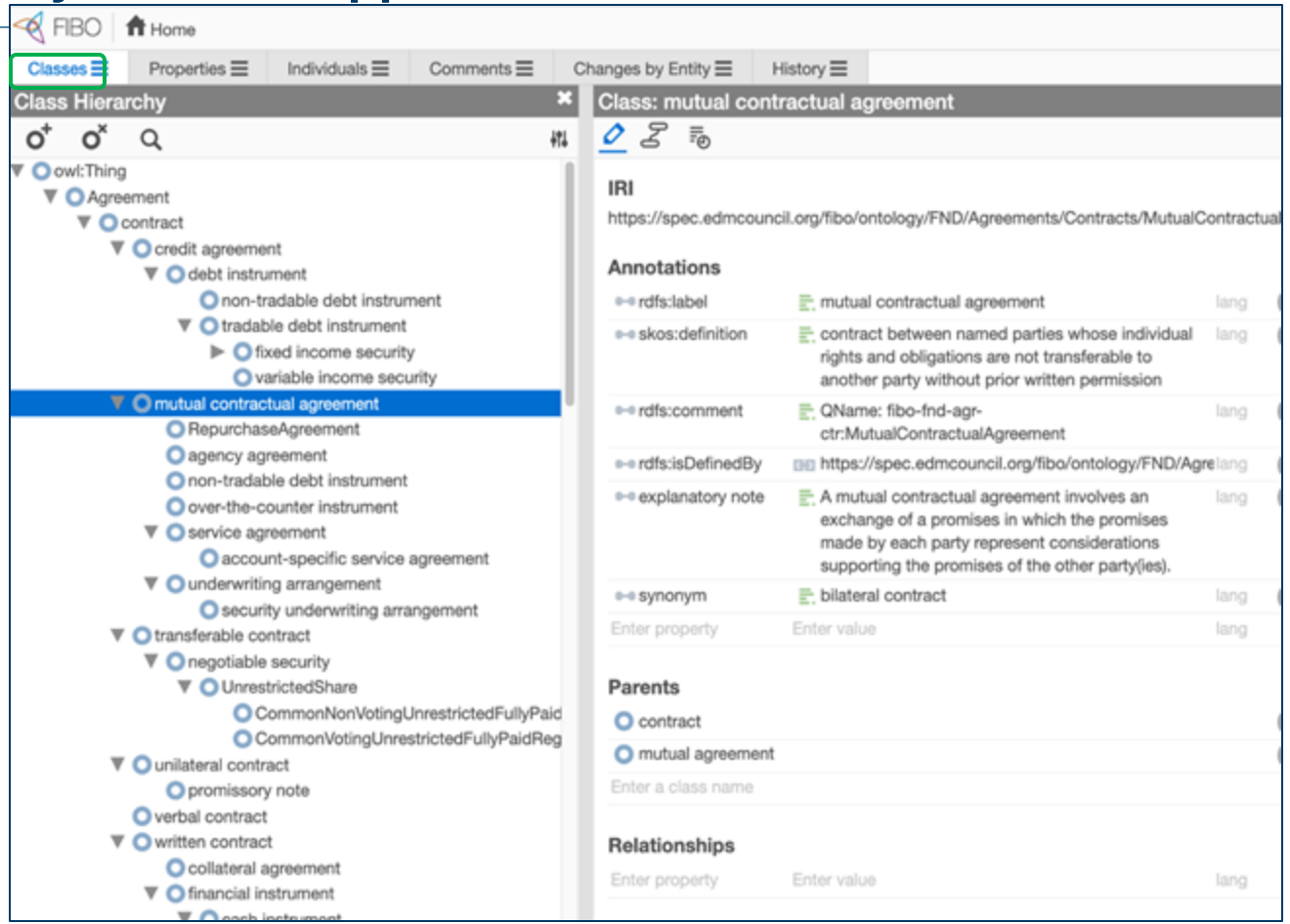
## Method 1:

Using a dedicated ontology tool: Protégé

Example of FIBO Financial Industry Business Ontology

Classes and subclesses in a taxonomy hierarchy

protégé



# Ontology + Taxonomy Creation Approaches

## Method 1 Issues

- Follows ontology standards, but not thesaurus/taxonomy best practices
- Top-down taxonomy building focus; less bottom-up
- Hierarchies focus on subject domain classification; less on supporting users and UX
- Users considers securicies
- Designed by engineers and ontologists, not taxonomists or information architects

*Not* recommended approach to extending a taxonomy into an ontology:

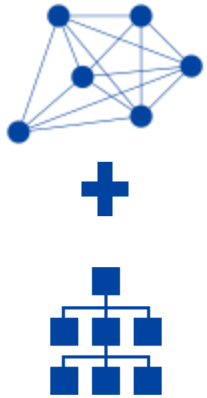
Importing taxonomies into an OWL-based ontology or dedicated ontology tool.

- All taxonomy hierarchies get converted to class-subclass hierarchies.
  - Importing taxonomies into ontologies will incorrectly treat:
    - whole-part taxonomy relations (e.g. geographic) as class-subclass relations
    - generic-instance (named entity) taxonomy relations as class-subclass relations, not class-instance affiliations
- Alternative labels can import, but as “Annotation” properties, and may not function as alternative labels for tagging and search.

# Applying Ontologies to Taxonomies

## Method 2: Extending SKOS taxonomy concepts to be part of an ontology (adding an ontology as a semantic model to a taxonomy)

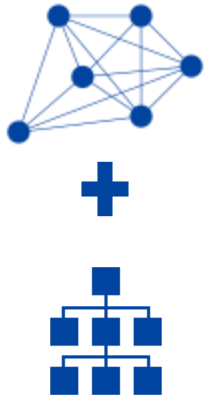
- Starts with existing taxonomies.
- Taxonomies based on SKOS can integrate with RDFS and OWL ontology resources, as all are based on RDF.
- Ontology class labels correspond/match the SKOS concept scheme or concept labels to which they will be applied
  - The ontology “layer” is not an upper hierarchical layer, but an **overlay** to the higher levels of the SKOS taxonomy.
- Combined taxonomy/ontology management software supports integrating them.



# Applying Ontologies to Taxonomies

## Benefits of the method of adding an ontology as a semantic model to a taxonomy

- Brings together *multiple* existing controlled vocabularies, term sets, named entity lists
- Easier to model the ontology
  - Existing taxonomies provide a basis for knowledge modeling.
  - No need to distinguish between sub-classes and individuals.
- Supports expert specialization
  - Taxonomists develop and maintain taxonomies.
  - Ontologists (if needed) develop and maintain the ontology.
- More flexible and adaptable
  - The taxonomy changes more frequently than does the ontology.
  - Taxonomies can easily be added.
- Different purposes served
  - The ontology is for modeling, reasoning, analysis, and data queries
  - The taxonomy is for tagging and information retrieval.
- More practical

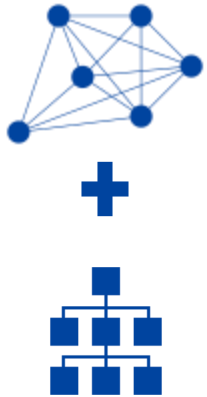


"The main problem SKOS solves is that many of these OWL projects become too involved and the organization loses interest before it ever sees any value. The less formal, concept-oriented SKOS is more practical for 95% of organizations." *Posted on Reddit September 27, 2024 [Best Ontology Development Environment Tool?]*

# Applying Ontologies to Taxonomies

## Tips on how to extend taxonomies to become an ontology

- High level classes in the ontology are based on individual taxonomies, controlled vocabularies, terms lists.
- SKOS concept schemes (and to a lesser extent top concepts) are good candidates for classes.
- The OWL-based ontology “semantic model” should include classes and subclasses only for which there is a use case for distinct properties (attributes and semantic relations).
    - Deeper levels of a “subclass” hierarchy reside in the SKOS taxonomy concepts and their broader/narrower relations.

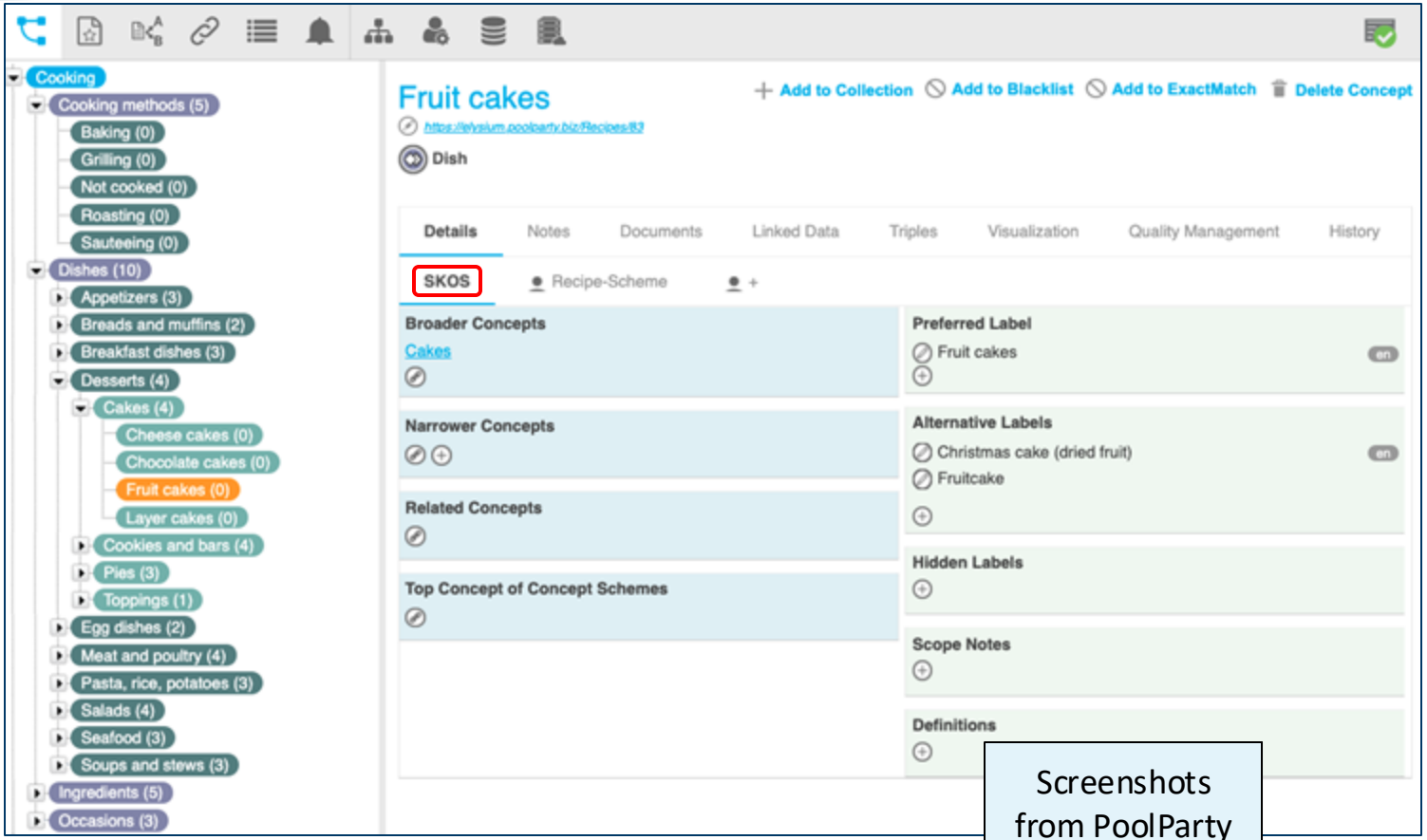


# Combining Taxonomies and Ontologies: Examples in Tools

# Applying Ontologies to Taxonomies

Concepts have both:

SKOS relationships and properties



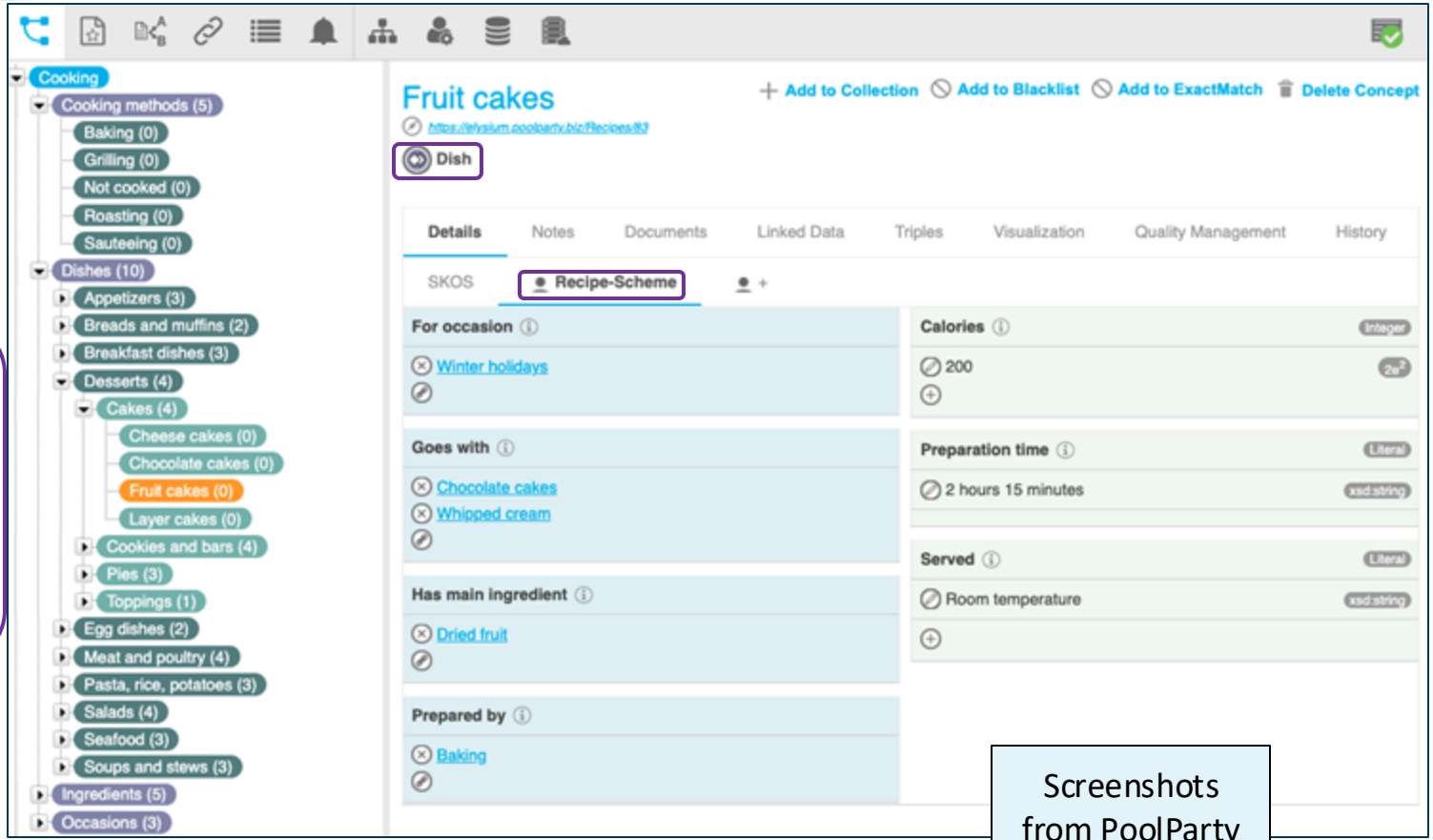

Screenshots from PoolParty

# Applying Ontologies to Taxonomies

Concepts have both:

SKOS relationships and properties *and*

RDFS-based semantic relationships and attributes from an ontology-based custom scheme.

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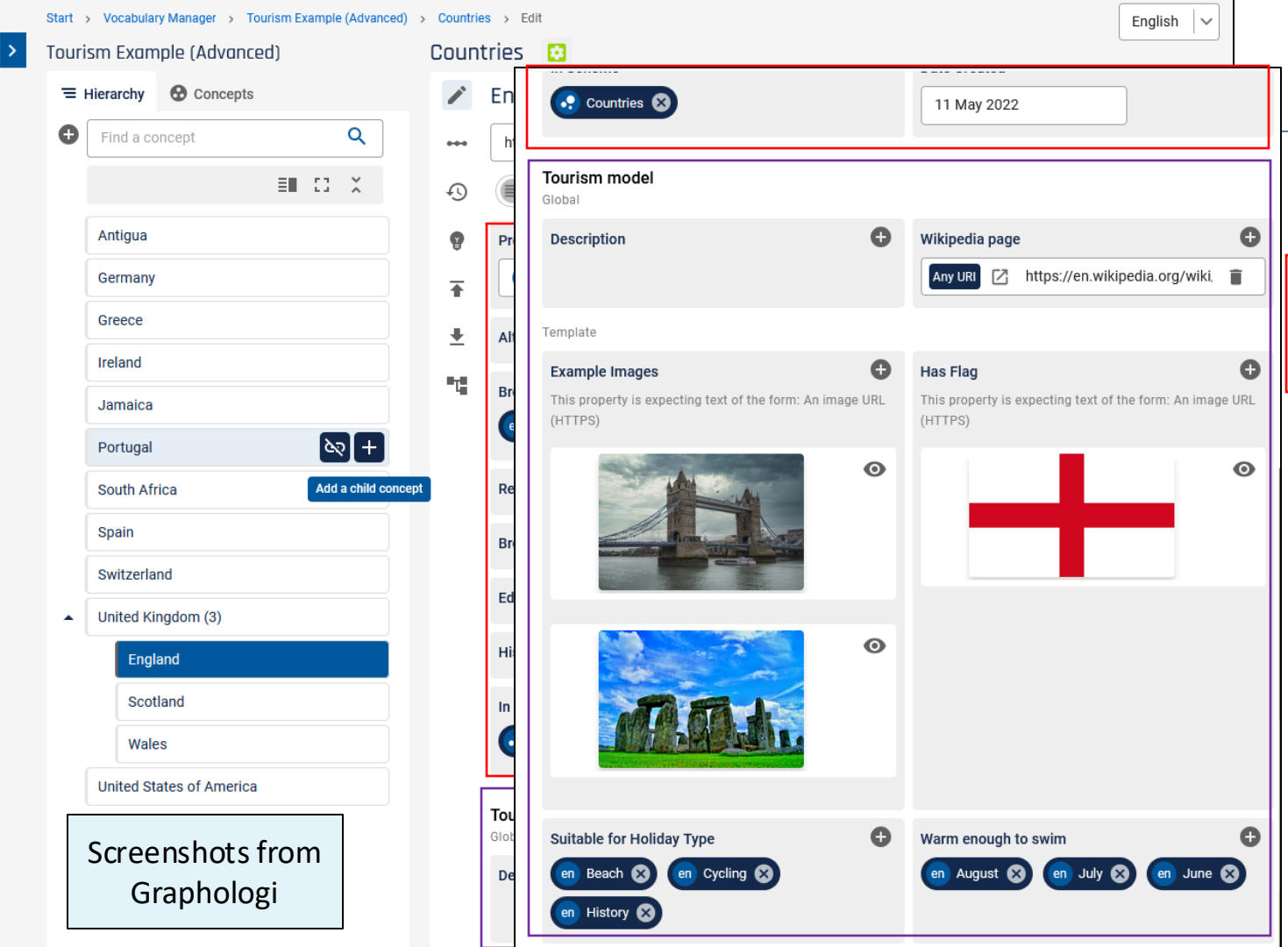


Screenshots from Graphologi

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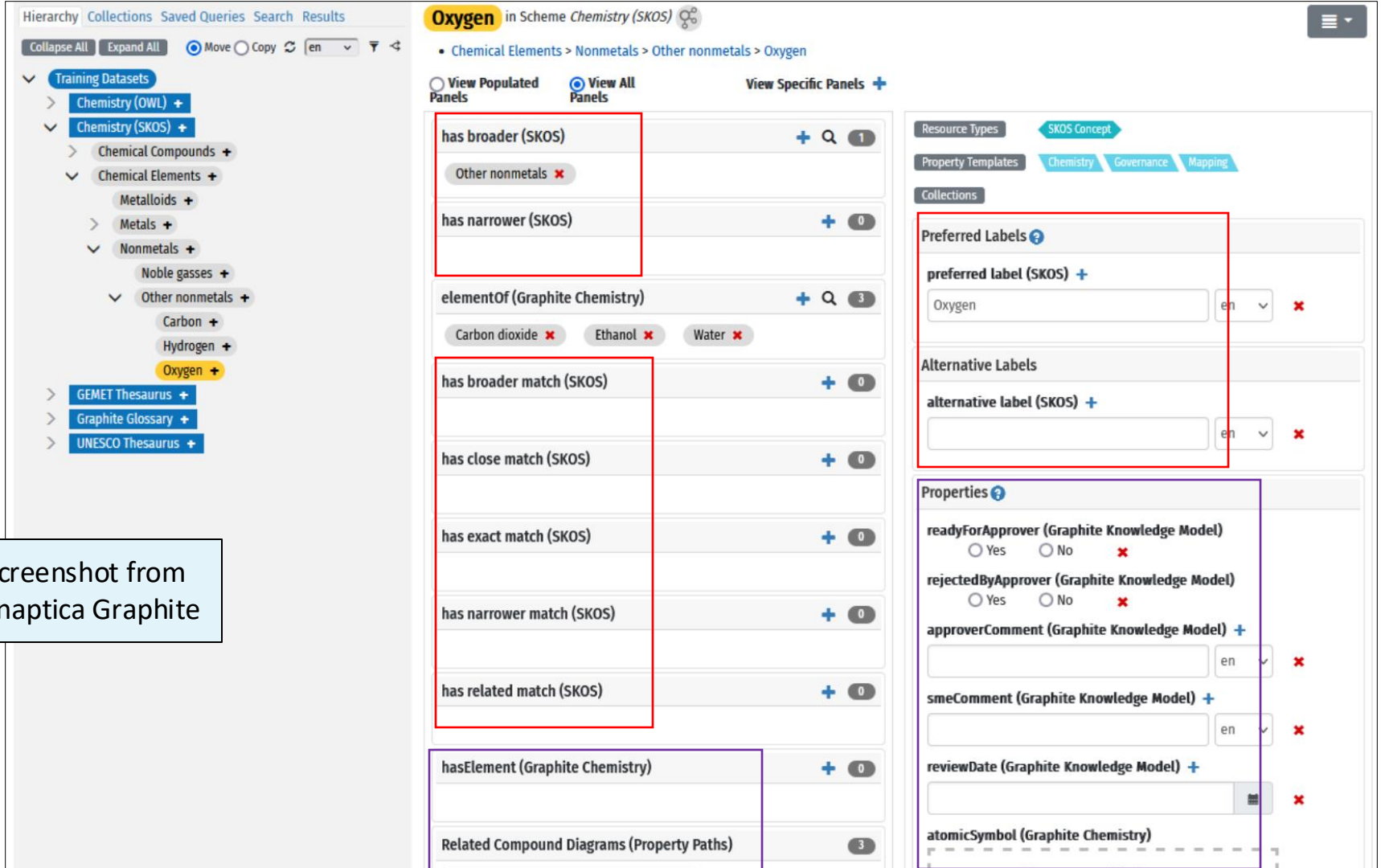
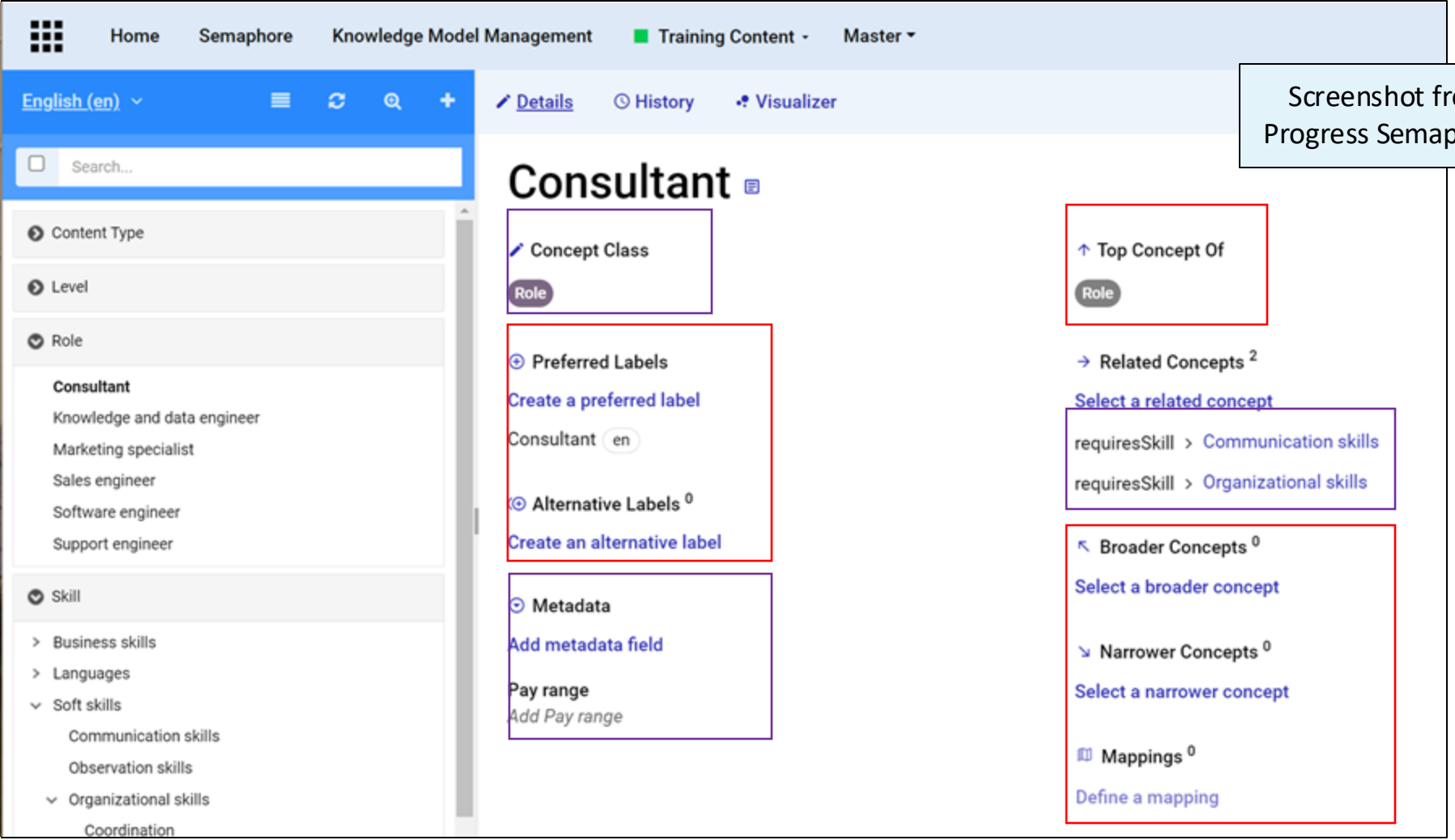



Screenshot from Synaptica Graphite




Screenshot from Progress Semaphore

# Conclusions

**Why** connect taxonomies and ontologies or extend a taxonomy to an ontology?

- Provides more uses than either a taxonomy or ontology alone
- Brings together the strengths of each: semantic and linguistic expressiveness
- Supports knowledge graphs and semantic layers and their benefits
- Makes use of existing taxonomies
- Conforms to both taxonomy and ontology standards for interoperability

**When** to connect taxonomies and ontologies

- When you have identified a business use case
- When you have resources skilled in taxonomies, ontologies, and implementations
- When you have a combined taxonomy/ontology management tool

**How** to connect a taxonomy and ontology

- Use a software tool dedicated to combined taxonomy/ontology management (based on RDF, SKOS, RDFS and OWL)
- Extend existing taxonomies into an ontology, by adding the ontology “layer”; or develop a taxonomy and ontology together

# Resources on Taxonomy / Ontology Combinations

Posts from The Accidental Taxonomist Blog

- "Taxonomies and Ontologies as Semantic Models," August 18, 2024
- "Taxonomies vs. Ontologies," January 31, 2023

Presentations

- "The Role of Taxonomy and Ontology in Semantic Layers" webinar, April 16, 2024
- (*first half hour of 1-hour video recording link*)
  "Taxonomy-Driven Ontology Design" The Knowledge Graph Conference, May 8, 2023.
  (*1.5 hour video recording link*)

Articles by others

- "Combined usage of SKOS and OWL: an experimentation on the Digital Europa Thesaurus," by Nicolas Figay, April 21, 2024
- "Editing schemas, ontologies, and SKOS taxonomies with VocBench," by Bob Ducharme, August 25, 2024

# Upcoming Taxonomy Presentations and Workshops

- "Building Taxonomies to Leverage Content" half-day pre-conference workshop, LavaCon content strategy conference, October 27, Portland, OR
- "The Complete Guide To Sourcing Terms" presentation
  Taxonomy Boot Camp, November 18, Washington, DC
- "Taxonomy Design Best Practice for Knowledge Graphs" 2-hour masterclass, Connected Data London, December 11, London, UK (also online/recorded)
- "Taxonomy Development" pre-conference workshop
  Information Architecture Conference, Philadelphia, April 29, 2025
- Virtual Bite-Sized Taxonomy Boot Camp London (3 sessions/hours each time)
  March 12, June 18, and October 8, 2025

Any time:

- "Controlled Vocabularies and Taxonomies" training course of four 75-minute video recordings, HS Events

# Questions/Contact

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