

Taxonomies to Ontologies

How, When and Why to Connect and/or Extend

Heather Hedden

HS Semantic Data New York

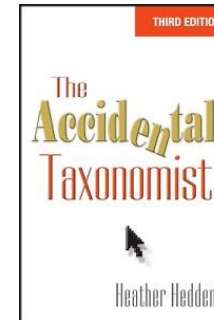
October 23, 2024

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

ebay > Clothing, S

Shop by category

Search

Motors >

- Parts & accessories
- Cars & trucks
- Motorcycles
- Other vehicles

Clothing & Accessories >

- Women
- Men
- Handbags
- Collectible Sneakers

Sporting goods >

- Hunting Equipment
- Golf Equipment
- Outdoor sports
- Cycling Equipment

data

- Metadata**
Context: Topics
- Linked Open Data**
Context: Topics
- Linked Data enrichment**
Context: PoolParty Product
- Output data unit**
Context: PoolParty Product
- Data processing**
Context: PoolParty Product
- Data engineering**
Context: Topics

Topic

- Advanced Content (73)
- Agile, Design Thinking, & Facilitation (60)
- Artificial Intelligence (25)
- Change Management & Communications (23)
- Company (19)
- Content & Brand Strategy (5)
- Enterprise Learning (23)
- Enterprise Search (49)
- Knowledge Graphs & Data Modeling (108)
- Knowledge Management Strategy & Design (243)
- Taxonomy & Ontology Design (113)
- Technology Solutions (98)

Article Type

- Blog (324)
- Podcast (71)
- Presentation (56)
- Case Study (40)
- White Paper (31)

– Computer and information sciences

Artificial intelligence

- Artificial neural networks
- Expert systems
- Genetic programming
- Machine learning

– Artificial intelligence

Machine learning

- Decision tree learning
- Deep learning
- Ensemble methods
- Machine learning algorithms
- Relevance vector machines
- Supervised machine learning
- Support vector machines
- Unsupervised machine learning

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

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]

Faceted Taxonomy Example

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:

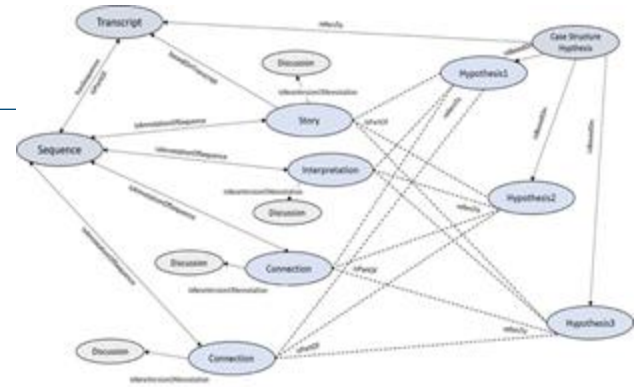
Concepts are arranged in a structure of hierarchies, categories, or facets to organize them.

The screenshot shows the Lowe's website search interface. The search bar contains 'washing machine'. Below the search bar, a dropdown menu lists suggestions: 'washing machine', 'washing machine top load', 'washing machine hoses', 'ge washing machine', 'lg washing machine', 'whirlpool washing machine', 'samsung washing machine', and 'washing machine cleaner'. Two callout boxes are overlaid on the image. The first callout box, pointing to the search suggestions, contains the text: 'Taxonomy implementation focus on **controlled**'. The second callout box, pointing to the filter sidebar, contains the text: 'Taxonomy implementation focus on **organized**'. The filter sidebar is titled 'Filter By:' and includes sections for 'COURSE TYPES' (with 'Fundamentals' selected) and 'COURSE TOPICS' (with various categories like 'Arts and Design (39)', 'Business (110)', etc.).

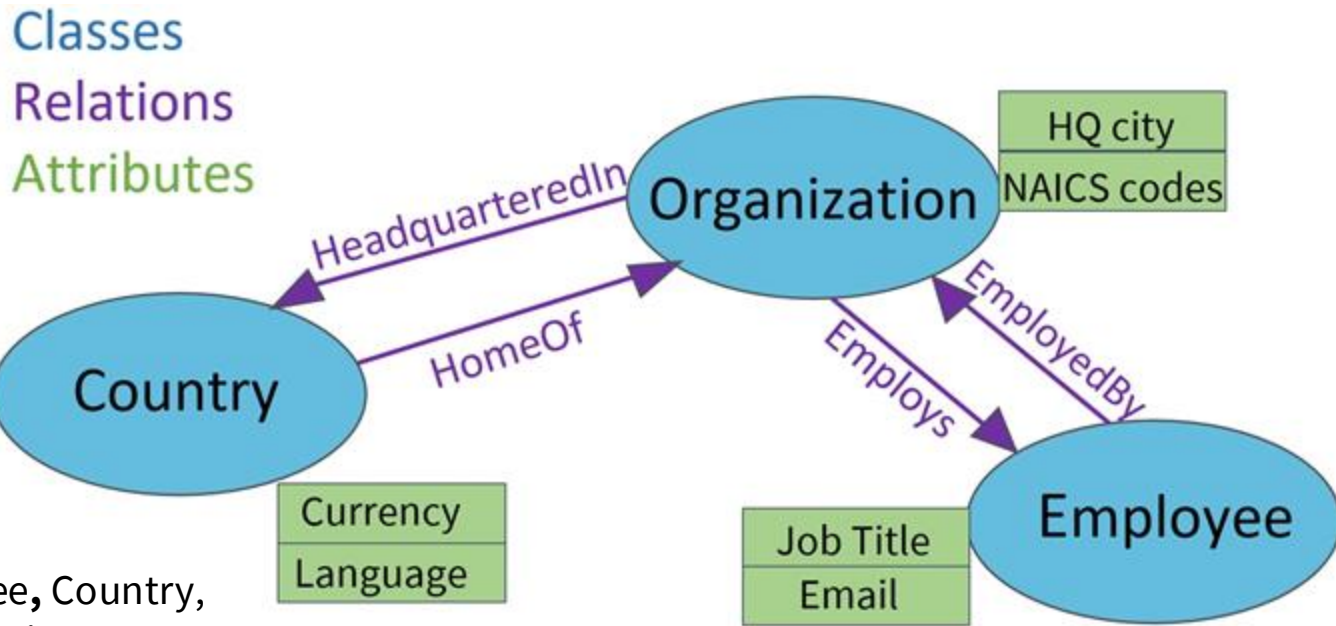
Introduction to Ontologies

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:

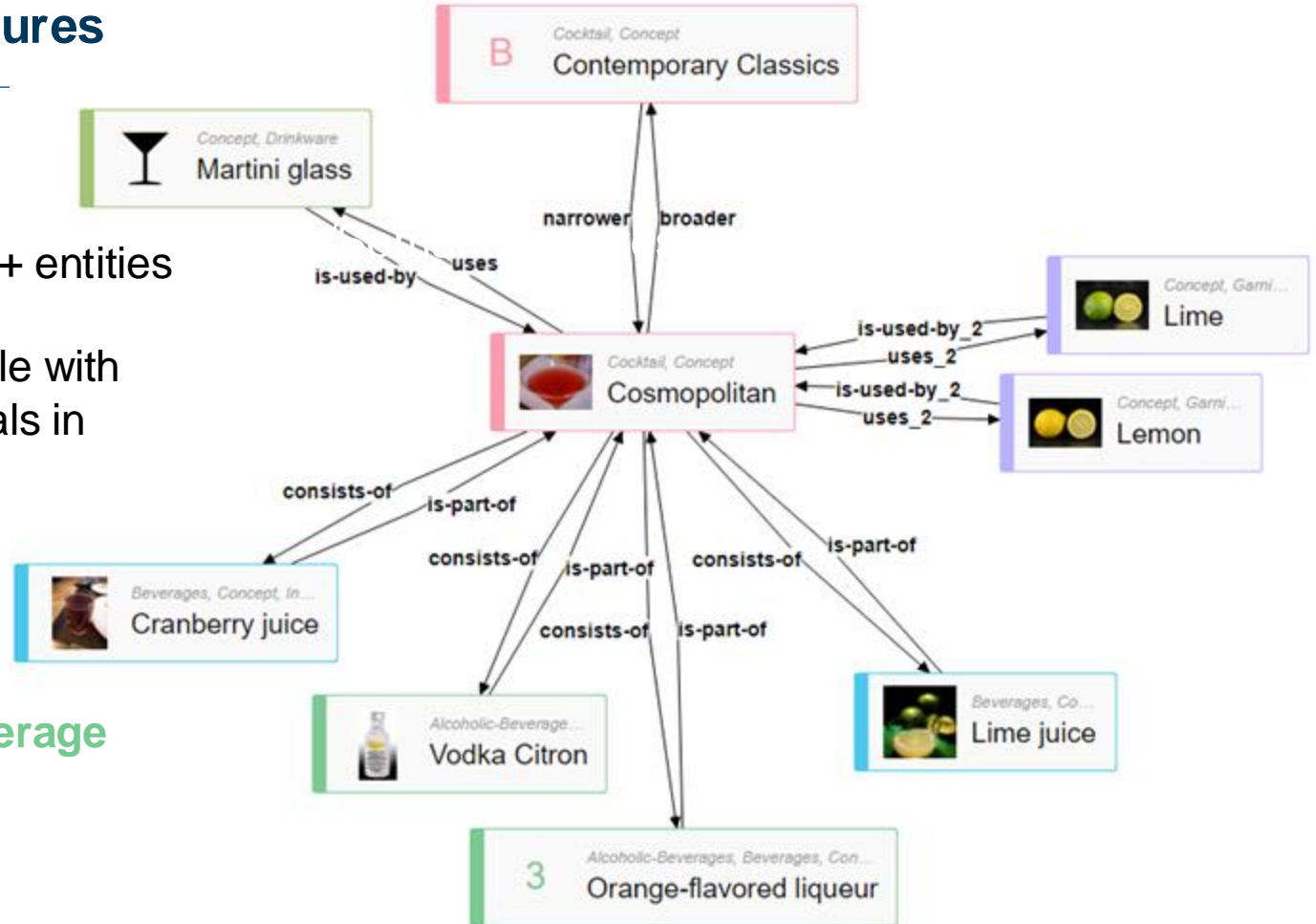
Cocktail

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

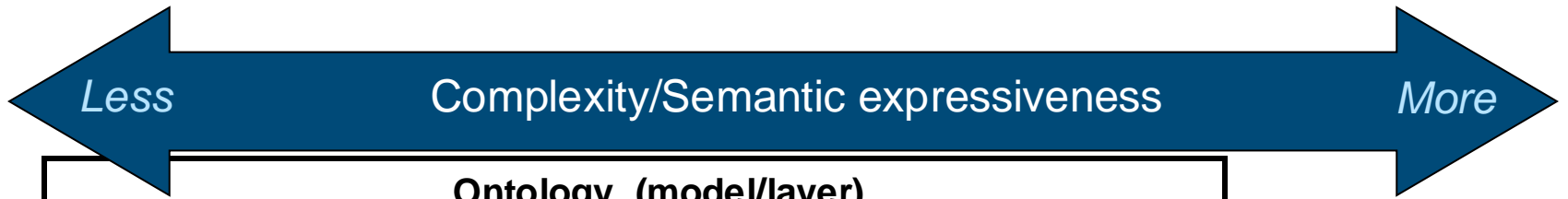


Term List	Name Authority	Taxonomy	Thesaurus	Ontology
Ambiguity control	Ambiguity control Synonym control (Attributes)	Ambiguity control (Synonym control) Hierarchical relationships	Ambiguity control Synonym control Hierarchical relationship Associative relationships	Ambiguity control Semantic relationships Classes Attributes

Model + entities



Knowledge Organization System Types



Ontology (model/layer)			
Term List	Name Authority	Taxonomy	Thesaurus
Ambiguity control	Ambiguity control Synonym control (Attributes)	Ambiguity control (Synonym control) Hierarchical relationships	Ambiguity control Synonym control Hierarchical relationship 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



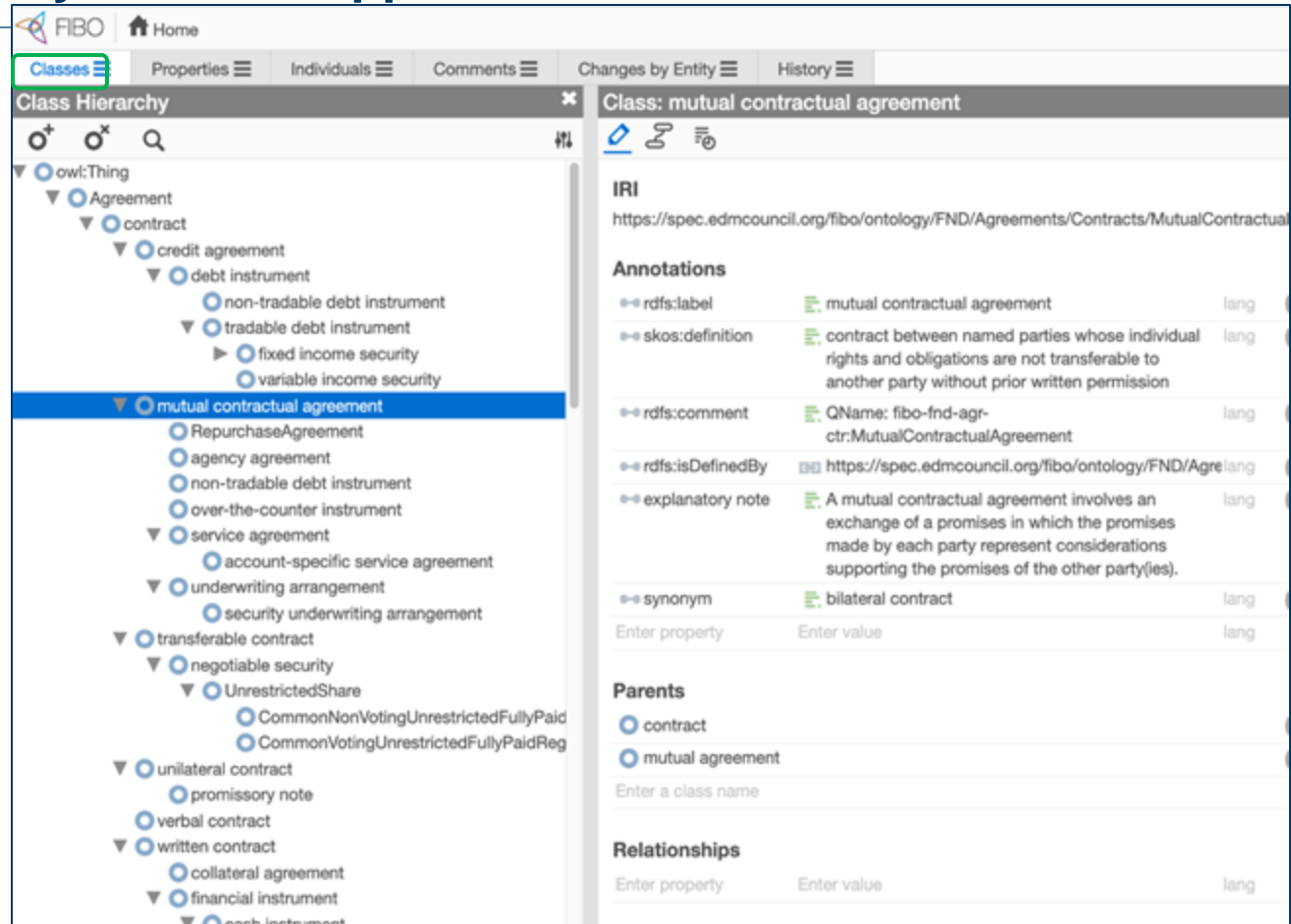
Ontology + Taxonomy Creation Approaches

Method 1:

Using a dedicated ontology tool: Protégé

Example of FIBO
Financial Industry
Business Ontology

Classes and subclasses
in a taxonomy hierarchy



The screenshot displays the FIBO ontology editor interface. The top navigation bar includes "Classes", "Properties", "Individuals", "Comments", "Changes by Entity", and "History". The main area is split into two panes. The left pane, titled "Class Hierarchy", shows a tree structure starting from "owl:Thing", with "Agreement" as a top-level class. Under "Agreement", there is a "contract" class, which has several subclasses including "credit agreement", "debt instrument", "non-tradable debt instrument", "tradable debt instrument", "fixed income security", and "variable income security". The "mutual contractual agreement" class is highlighted in blue. The right pane, titled "Class: mutual contractual agreement", shows the IRI (https://spec.edmouncil.org/fibo/ontology/FND/Agreements/Contracts/MutualContractual...), annotations (including rdfs:label, skos:definition, rdfs:comment, rdfs:isDefinedBy, and explanatory note), parents (contract and mutual agreement), and relationships.

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:

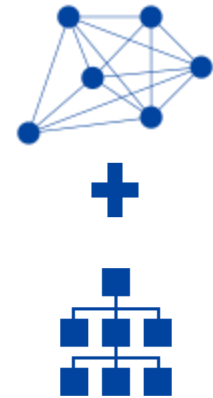
Importing taxonomies into an OWL-based ontology or dedicated ontology tool.

- 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.

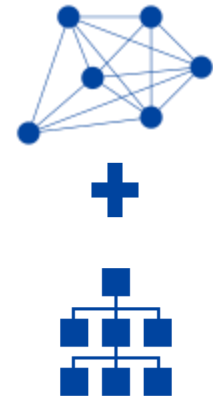


Applying Ontologies to Taxonomies

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

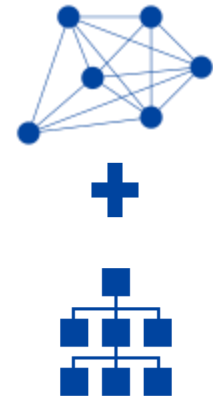
“The main problem SKOS solves is that many of these OWL projects become too involved and the organization loses interest before it ever sees any value. The less formal, concept-oriented SKOS is more practical for 95% of organizations.” *Posted on Reddit September 27, 2024 [Best Ontology Development Environment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

The screenshot displays the PoolParty interface. On the left is a taxonomy tree under the 'Cooking' root. The tree is expanded to show 'Dishes (10)', which includes 'Cakes (4)'. Within 'Cakes', 'Fruit cakes (0)' is highlighted in orange. On the right, the 'Fruit cakes' concept page is shown. The 'SKOS' tab is selected and highlighted with a red box. The page shows various SKOS properties and relationships, including 'Broader Concepts' (Cakes), 'Narrower Concepts', 'Related Concepts', 'Top Concept of Concept Schemes', 'Preferred Label' (Fruit cakes), 'Alternative Labels' (Christmas cake (dried fruit), Fruitcake), 'Hidden Labels', 'Scope Notes', and 'Definitions'. The 'Recipe-Scheme' tab is also visible above the SKOS tab.

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.

Screenshots
from Poolparty

The screenshot displays the PoolParty interface. On the left is a taxonomy tree under 'Cooking', with 'Fruit cakes (0)' highlighted in orange. On the right is the 'Fruit cakes' concept page. A purple box highlights the 'Dish' property, and another purple box highlights the 'Recipe-Scheme' SKOS property. The 'Details' tab shows various properties: 'For occasion' (Winter holidays), 'Calories' (200), 'Goes with' (Chocolate cakes, Whipped cream), 'Preparation time' (2 hours 15 minutes), 'Has main ingredient' (Dried fruit), 'Served' (Room temperature), and 'Prepared by' (Baking).

Screenshots
from PoolParty

Tourism Example (Advanced)

Countries

Hierarchy Concepts

Find a concept

Antigua

Germany

Greece

Ireland

Jamaica

Portugal

South Africa

Spain

Switzerland

United Kingdom (3)

England

Scotland

Wales

United States of America

Add a child concept

En

h

Pr

Al

Br

Re

Br

Ed

Hi

In

Tou

Glob

De

Countries

11 May 2022

Tourism model

Global

Description

Wikipedia page

Any URI <https://en.wikipedia.org/wiki/>

Template

Example Images

This property is expecting text of the form: An image URL (HTTPS)



Has Flag

This property is expecting text of the form: An image URL (HTTPS)



Suitable for Holiday Type

en Beach en Cycling en History

Warm enough to swim

en August en July en June

Concepts have both:

SKOS relationships and properties *and*

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

Screenshots from Graphologi

- Training Datasets
 - Chemistry (OWL) +
 - Chemistry (SKOS) +
 - Chemical Compounds +
 - Chemical Elements +
 - Metalloids +
 - Metals +
 - Nonmetals +
 - Noble gasses +
 - Other nonmetals +
 - Carbon +
 - Hydrogen +
 - Oxygen +
- GEMET Thesaurus +
- Graphite Glossary +
- UNESCO Thesaurus +

View Populated Panels View All Panels View Specific Panels +

has broader (SKOS)	+ Q 1
Other nonmetals x	
has narrower (SKOS)	+ 0
elementOf (Graphite Chemistry)	+ Q 3
Carbon dioxide x Ethanol x Water x	
has broader match (SKOS)	+ 0
has close match (SKOS)	+ 0
has exact match (SKOS)	+ 0
has narrower match (SKOS)	+ 0
has related match (SKOS)	+ 0
hasElement (Graphite Chemistry)	+ 0
Related Compound Diagrams (Property Paths)	3

Resource Types	SKOS Concept
Property Templates	Chemistry Governance Mapping
Collections	
Preferred Labels ?	
preferred label (SKOS) +	Oxygen en x
Alternative Labels	
alternative label (SKOS) +	en x
Properties ?	
readyForApprover (Graphite Knowledge Model)	<input type="radio"/> Yes <input type="radio"/> No x
rejectedByApprover (Graphite Knowledge Model)	<input type="radio"/> Yes <input type="radio"/> No x
approverComment (Graphite Knowledge Model) +	en x
smeComment (Graphite Knowledge Model) +	en x
reviewDate (Graphite Knowledge Model) +	x
atomicSymbol (Graphite Chemistry)	

Screenshot from
Synptica Graphite



English (en) ▾



[Details](#)

[History](#)

[Visualizer](#)

Search...

Content Type

Level

Role

Consultant

Knowledge and data engineer

Marketing specialist

Sales engineer

Software engineer

Support engineer

Skill

Business skills

Languages

Soft skills

Communication skills

Observation skills

Organizational skills

Coordination

Consultant

Concept Class

Role

Preferred Labels

Create a preferred label

Consultant en

Alternative Labels ⁰

Create an alternative label

Metadata

Add metadata field

Pay range

Add Pay range

Top Concept Of

Role

Related Concepts ²

Select a related concept

requiresSkill > Communication skills

requiresSkill > Organizational skills

Broader Concepts ⁰

Select a broader concept

Narrower Concepts ⁰

Select a narrower concept

Mappings ⁰

Define a mapping

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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**Hedden Information
Management**

Making information findable

Hedden, Heather. (2022) *The Accidental Taxonomist, 3rd edition*.
Medford, NJ: Information Today Inc.

www.hedden-information.com/accidental-taxonomist

