

Community-based ontology development, alignment, and evaluation

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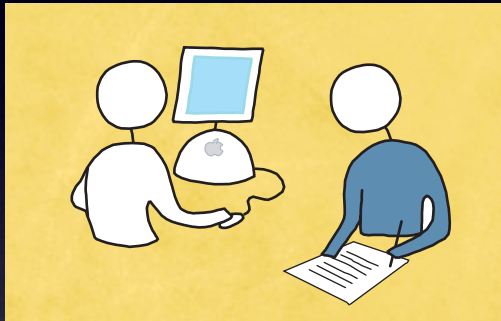
Community-based Ontology ... Everything

**Development
and
Evolution**

**Evaluation
and Reuse**

**Mapping and
Alignment**

How Large Can the “Community” be?



*Can be just a
few
distributed
users*



*Or anyone in
the world*

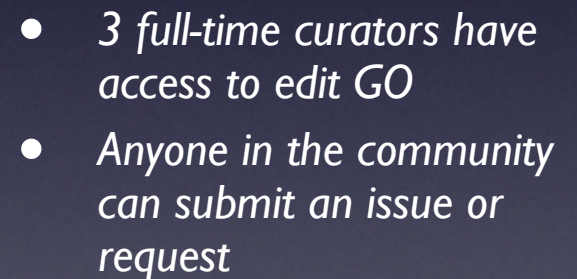
Collaborative Ontology Development

- **Collaborative**
 - Several users contribute to a single developing ontology
 - There are mechanisms to carry out discussions and to reach consensus
- **Ontologies**
 - From simple taxonomies
 - To expressive OWL ontologies

Use Cases in Biomedical Domain

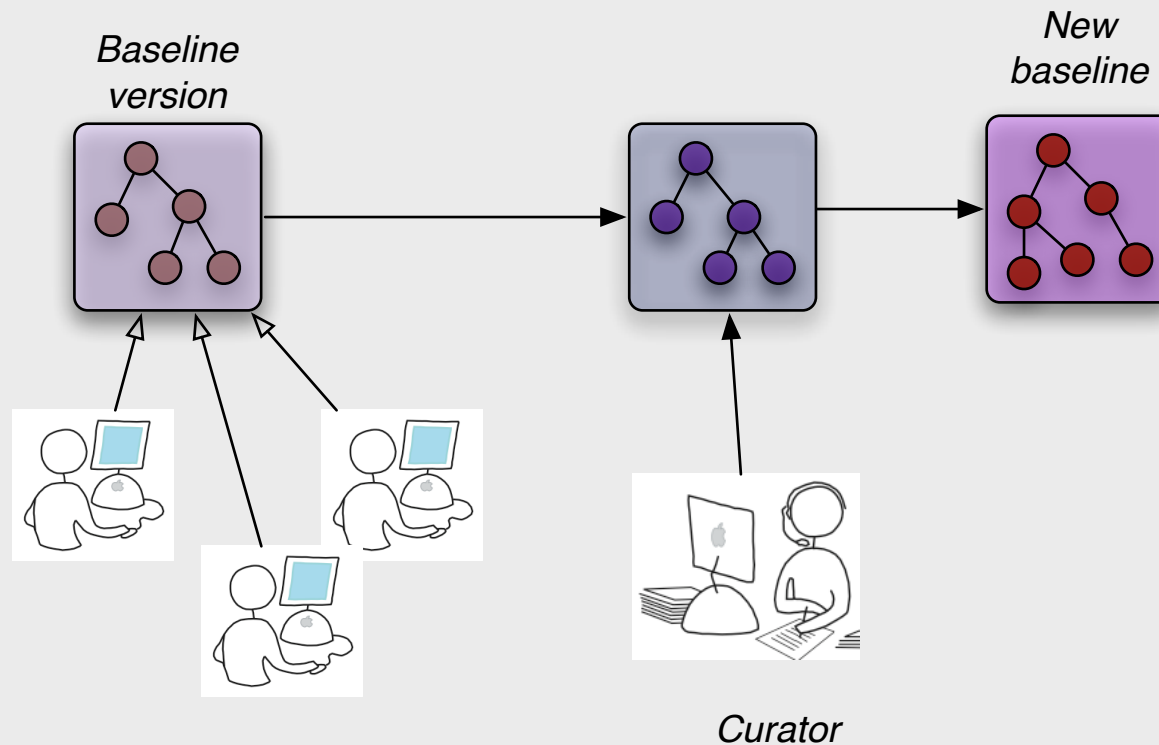
- Gene Ontology (GO)
- NCI Thesaurus
- BiomedGT
- OBI, BIRNLex

Terminology for consistent description of gene products



The NCI Thesaurus

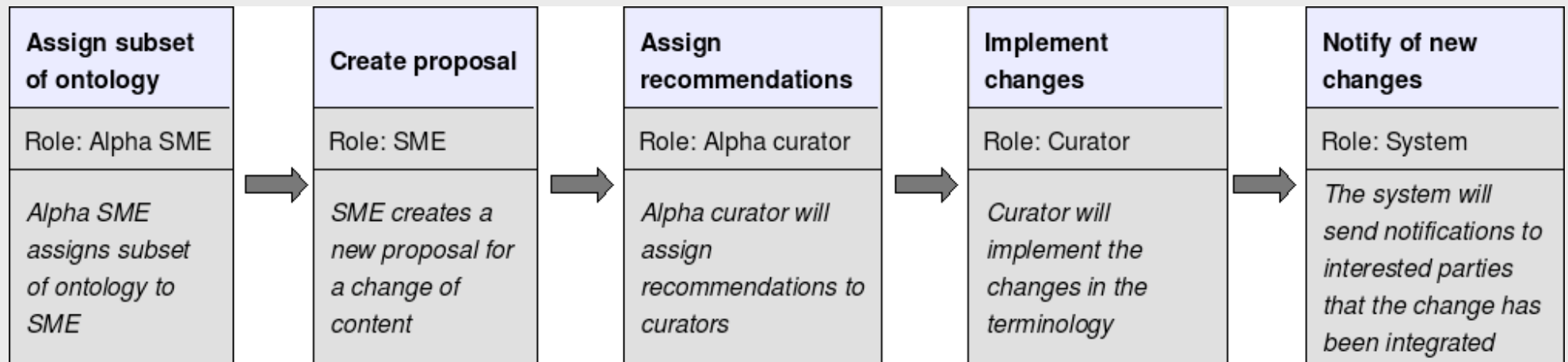
Reference ontology for cancer biology, translational science, and clinical oncology



- ~20 full-time editors making changes
- Changes are not immediately visible
- 1 “lead editor” who approves the changes, and assigns new tasks

BiomedGT

An “open” version of the NCI Thesaurus



- *Several different roles*
- *Capabilities depend on the user's role*
- *Anyone in the community can contribute suggestions; small number of curators*

Other Biomedical Projects

- OBI, BIRNLex, RadLex
 - tightly-knit community of developers (20-30)
 - most actively participate in discussions
 - 1 or 2 editors make changes to the ontology

Dimensions of Collaborative Workflows

- Ontology size
 - *from 100s to 10,000s of concepts*
- Size of the community
 - Contributors (in some form): *from 2-3 to dozens*
 - Editors: *from 1-2 to 20*
- Control mechanisms
 - Variety of roles
 - Gatekeepers, etc.
 - Client-server editing
- Discussion tools
 - mailing lists, message boards
 - face-to-face meetings, telecons
- Synchronization and editing mechanisms
 - CVS, SVN

Tool Requirements

- Tools for **discussion and reaching consensus**
 - annotate components and, maybe, changes
 - have as an integral part of the development process
- **Context** for discussions on modeling decisions
- **Record of changes** and associated discussions and controversies
- **Provenance and trust**
 - support concept histories
 - have ways establish trust and credibility
- **Personalized views** of an ontology
 - based on user's role and tasks
 - based on user's level of expertise
 - based on user's trust network

Tool Requirements (cont'd)

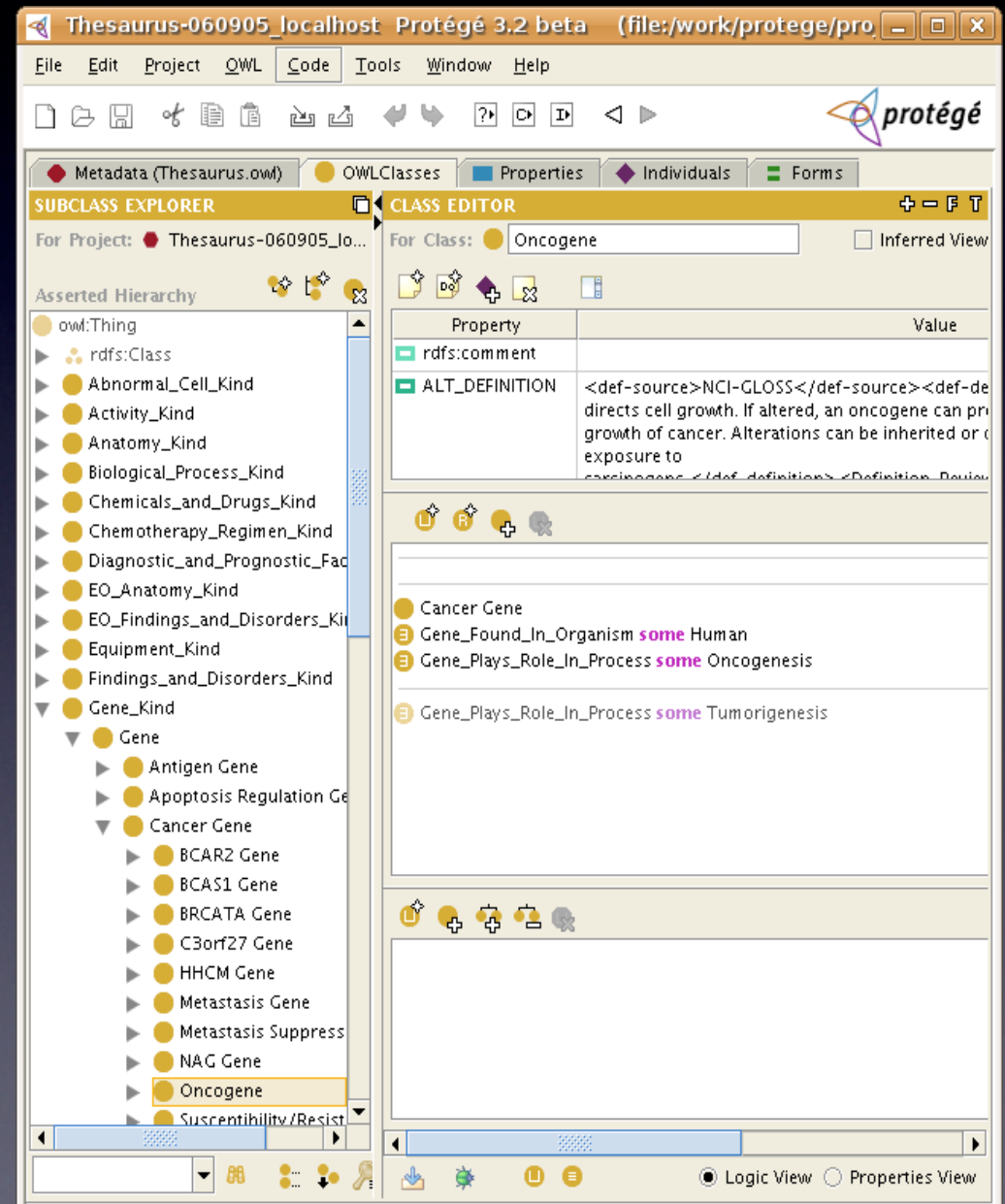
- Support for **personal and shared** spaces
- **Access control**
 - fine-grained control for editing and viewing rights
- **User roles**
- **Flexible workflow support**
 - configurable workflows
 - workflow-execution coupled with ontology development

Bringing Collaboration to Protégé

- Protégé
 - is an open-source ontology editor
 - developed at Stanford, in collaboration with University of Manchester
 - with more than 100,000 registered users
 - has dozens of plugins for
 - visualization
 - inference
 - import and export
 - natural-language processing
 - ... (things we don't know exist)

Collaborative Protégé

- An extension of the Protégé to support collaborative development



Features of Collaborative Protégé

- Support for:
 - annotating ontology components and changes in the ontology
 - discussion threads
 - proposals and voting
 - searching and filtering
 - defining users, groups, policies
- Distributed with Protégé installation

<http://protege.stanford.edu/doc/collab-protege/>

Annotations

- Annotations are **linked to a specific ontology component**:
 - class
 - property
 - individual
 - ontology as a whole
 - ontology change
 - ... others
- There are **different types** of annotations:
 - question
 - comment
 - proposal
- Users may **filter and search** annotations based on different criteria

Collaborative Protégé Interface

The screenshot displays the Protégé software interface for collaborative ontology development. The window title is "Thesaurus Protégé 2.0.3 (C:\projects\nci\0712e\Thesaurus.pprj, OWL / RDF Files)".

Collaborative Panel: A callout points to the "Collaboration" panel on the right, which includes tabs for "Annotations", "Changes", "Discussion Threads", "Search", and "Chat".

Collaborative Tabs: A callout points to the "Annotations" tab within the Collaboration panel.

Annotations: A callout points to the "GO Biological Process" entry in the "Annotations" list, which includes a detailed description and a list of authors.

Annotation details: A callout points to the "Created" field at the bottom right, showing the date and time "02/26/2008 09:46:35 EST".

has annotations: A callout points to the "Gene_Product" class in the "Subclass Explorer" on the left, which is marked with a key icon indicating it has annotations.

Class Editor: The central "CLASS EDITOR" shows the "Gene_Product" class (instance of owl:Class) with the following properties and values:

Property	Value
rdfs:comment	
code	C26548
DEFINITION	<def-source>NCI</def-source><def-definition>A protein or RNA whose structure is represented in and determined by genomic sequences.</def-definition>
DesignNote	In NCI Thesaurus: Includes Proteins, Functional RNAs, Protein Complexes, and Riboprotein Complexes
FULL_SYN	<term-name>Gene Product</term-name><term-group>PT</term-group><term-source>NCI</term-source>
FULL_SYN	<term-name>Genome Encoded Entity</term-name><term-group>SY</term-group><term-source>NCI</term-source>
NCI_META_CUI	CL055397
Preferred_Na...	Gene Product
rdfs:label	Gene Product
Semantic_Type	Classification
Synonym	Gene Product
Synonym	Genome Encoded Entity

The "Subclass Explorer" on the left shows the "Asserted Hierarchy" with "Gene_Product" selected. The "Properties" and "Changes" panels are also visible at the top of the main workspace.

Chat

The screenshot displays the Protégé ontology editor interface. The top menu bar includes File, Edit, Project, OWL, Reasoning, Code, Tools, Window, Change, Collaboration, and Help. The toolbar contains various icons for file operations and editing. The main workspace is divided into several panes:

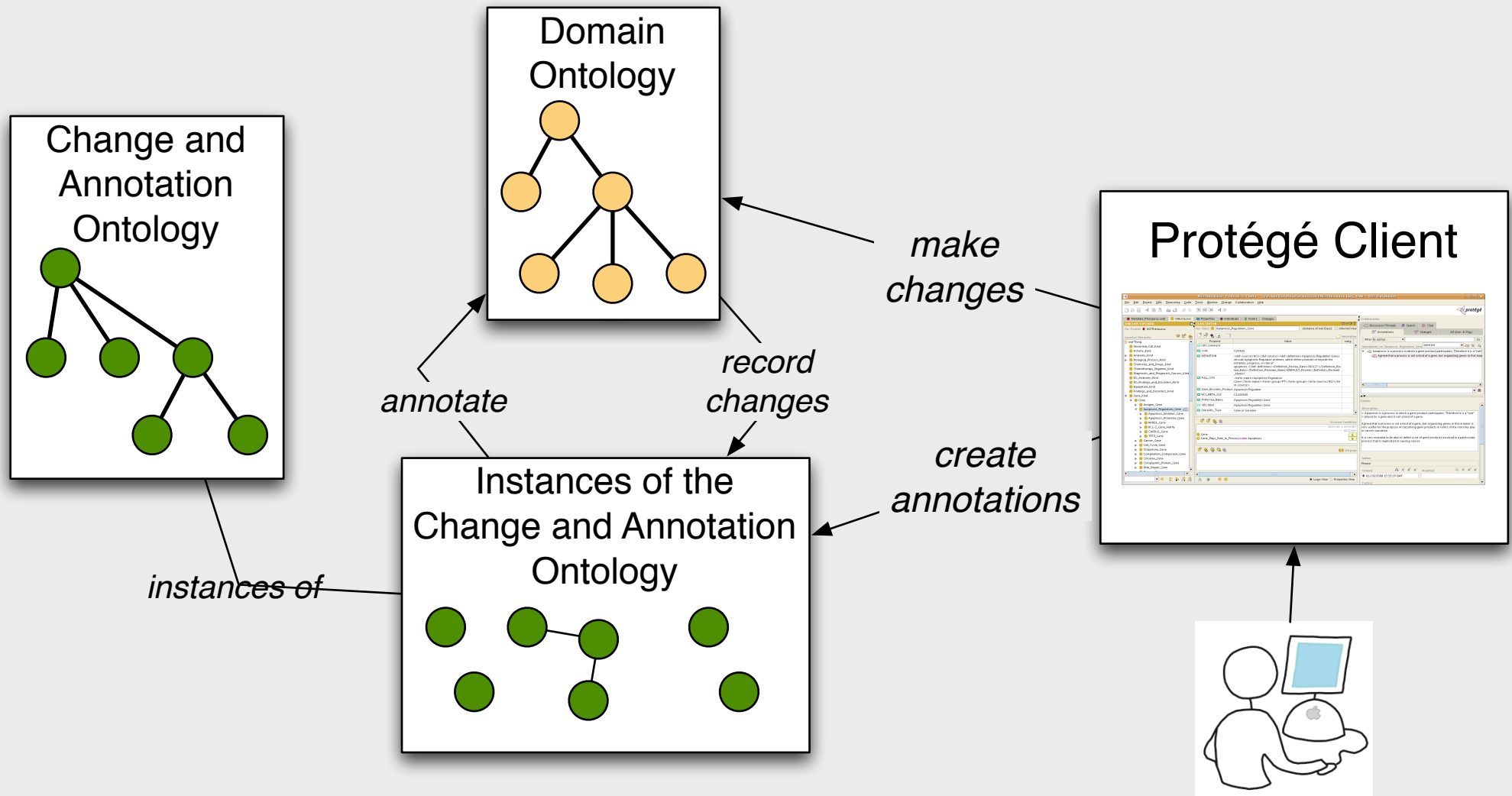
- SUBCLASS EXPLORER:** Shows a hierarchy of classes under 'owl:Thing', including 'Gene_Kind' which is currently selected.
- CLASS EDITOR:** Displays the properties of the selected class 'Gene_Kind'. The properties table is as follows:

Property	Value
rdfs:comment	
code	K6
DEFINITION	<def-source>NCI</def-source><def-label>endogenous functional compound</def-label><def-definition>sequence, capable of being transcribed into a chemically related nucleic acid species with functional significance.</def-definition>
FULL_SYN	<term-name>Gene_Kind</term-name><term-group>PT</term-group><term-source>NCI</term-source>
NCL_META_CUI	CL337151
Preferred_Name	Gene_Kind
rdfs:label	Gene_Kind
Semantic_Type	Conceptual Entity
Synonym	Gene_Kind

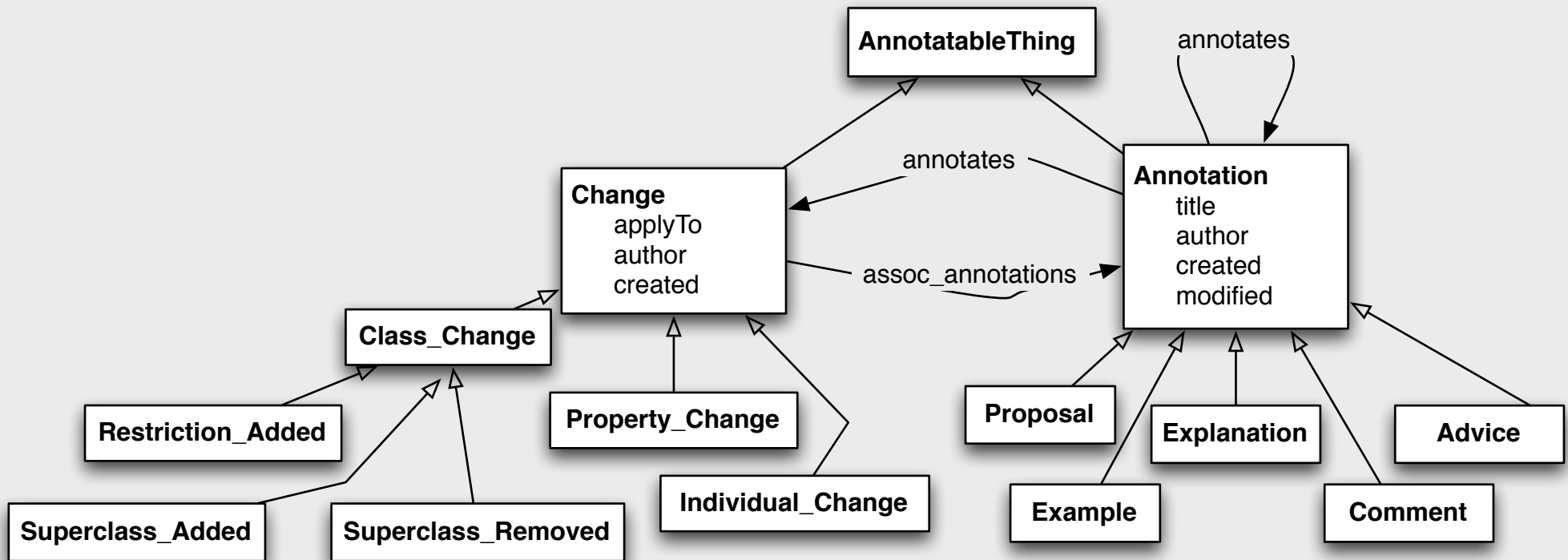
The **Collaboration** pane on the right contains a chat window, which is highlighted with a red circle. The chat window shows a conversation between users 'jbr2007' and 'sbarna'. A speech bubble points to the chat window with the text: "Hyperlinks to the entities in the ontology".

Another speech bubble points to the bottom of the chat window with the text: "Users currently on-line". The bottom of the chat window shows the text "Other users: sbarna".

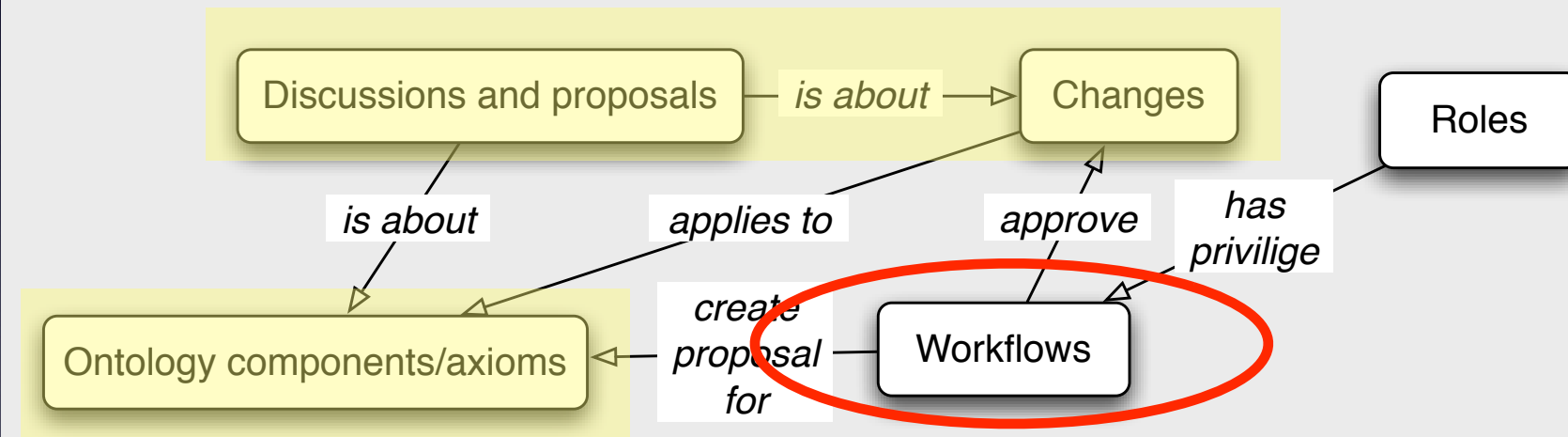
Architecture



Changes and Annotations



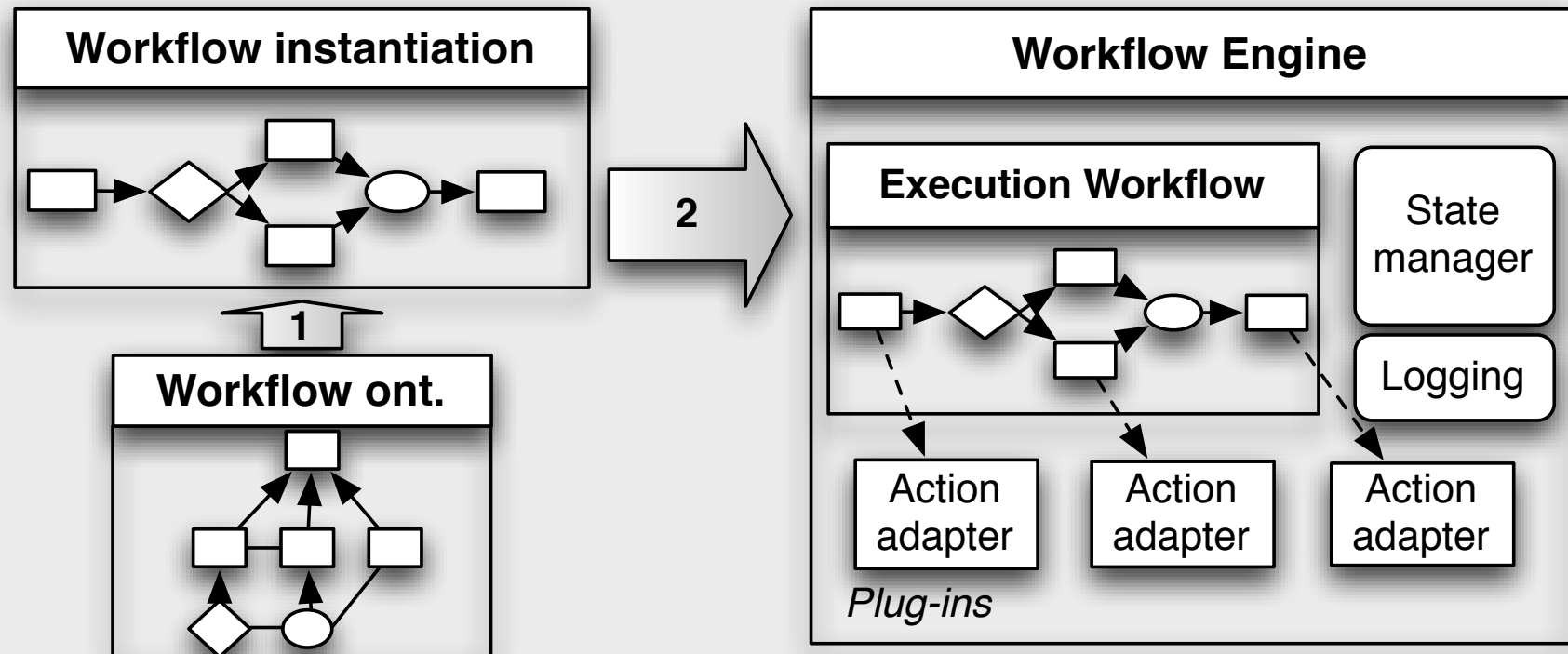
But wait, there is more...



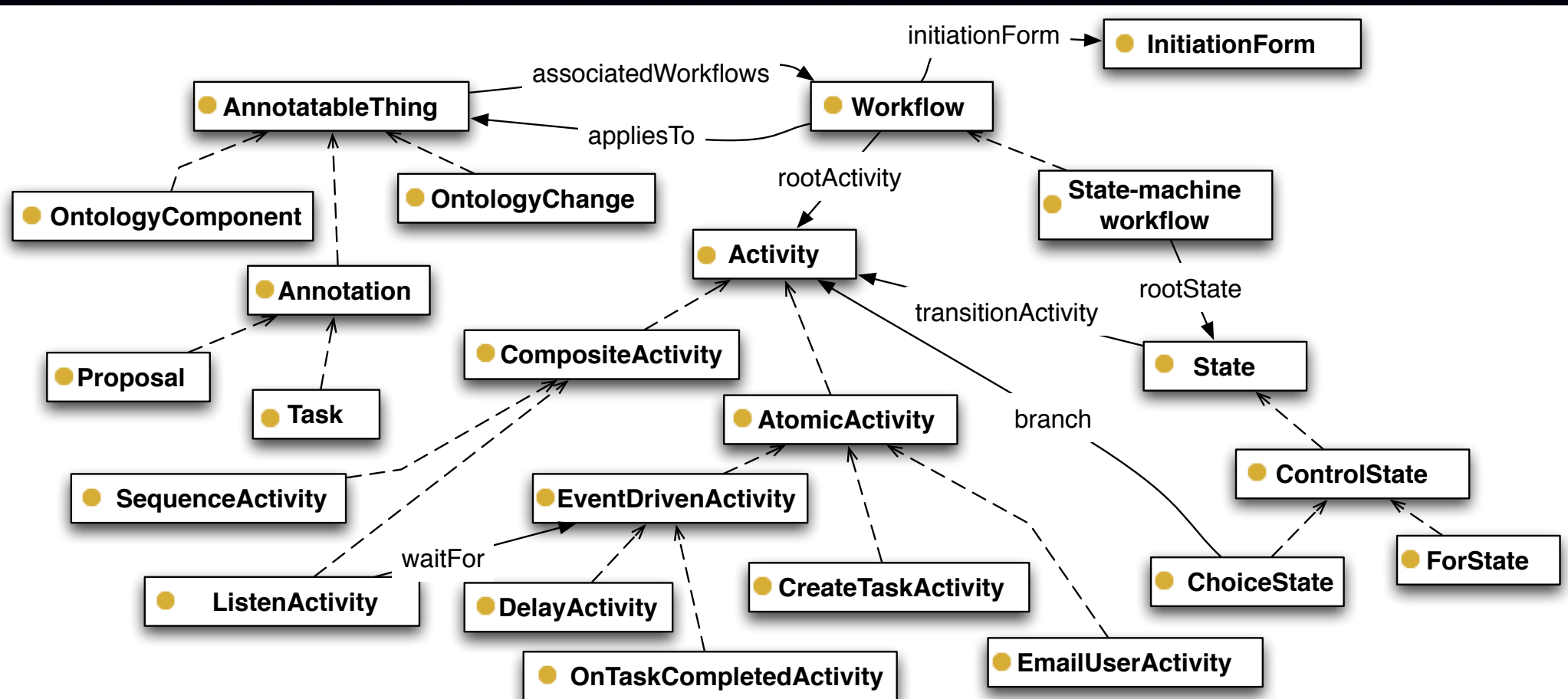
Support For Flexible Workflows

- Goal:
 - automatically generate tools that support custom-tailored workflows
 - cover a wide range of existing workflows

Custom-Tailored Workflows



Workflow Ontology



Community-based Ontology ... Everything

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NCBO BioPortal

- The National Center for Biomedical Ontology (<http://bioontology.org>) is developing **BioPortal**, an open-source repository of ontologies, terminologies, and thesauri of importance in biomedicine.
- An early version of BioPortal is accessible at <http://bioportal.bioontology.org>. An alpha version of the next release is at <http://alpha.bioontology.org/>
- Users can **access** the BioPortal content interactively **via Web browsers** or programmatically **via Web services**.

The BioPortal Ontology Repository

- Open **repository** of ontologies in biomedicine
- Each ontology is described by a set of **metadata**
- Ontologies in different **formats**
 - OWL, RDF(S)
 - OBO
 - Protégé frames
- BioPortal **technology**
 - open-source
 - domain-independent

Home	Browse	Search	Projects	Mappings			
Ontology Name	Format	Version	Author	Date	Related Projects	Reviews	
African Traditional Medicine	OBOF	1.0.1			0 Related Projects	See All 0 Reviews	Explore
Amino Acid	OWL-FULL	1.2			0 Related Projects	See All 0 Reviews	Explore
Amphibian gross anatomy	OBOF	1.7			0 Related Projects	See All 0 Reviews	Explore
Animal natural history and life history	PROTEGE	See Remote Site			0 Related Projects	See All 0 Reviews	Exploring Unavailable
Basic Vertebrate Anatomy	OWL-FULL	1.1			0 Related Projects	See All 0 Reviews	Explore
Biological imaging methods	OBOF	1.1			0 Related Projects	See All 0 Reviews	Explore
Biological process	OBOF	1.204			0 Related Projects	See All 0 Reviews	Explore
Biomedical Resource Ontology	OWL-LITE	1.1			0 Related Projects	See All 0 Reviews	Explore
BIRNLex	OWL-DL	1.3.1			0 Related Projects	See All 0 Reviews	Explore
BRENDA tissue / enzyme source	OBOF	1.295			0 Related Projects	See All 0 Reviews	Explore
C. elegans development	OBOF	1.3			0 Related Projects	See All 0 Reviews	Explore
C. elegans gross anatomy	OBOF	See Remote Site			1 Related Projects	See All 1 Reviews	Exploring Unavailable
C. elegans phenotype	OBOF	See Remote Site			0 Related Projects	See All 0 Reviews	Exploring Unavailable

Ontology Navigation in BioPortal

THE NATIONAL CENTER FOR BIOMEDICAL ONTOLOGY

 **BioPortal**

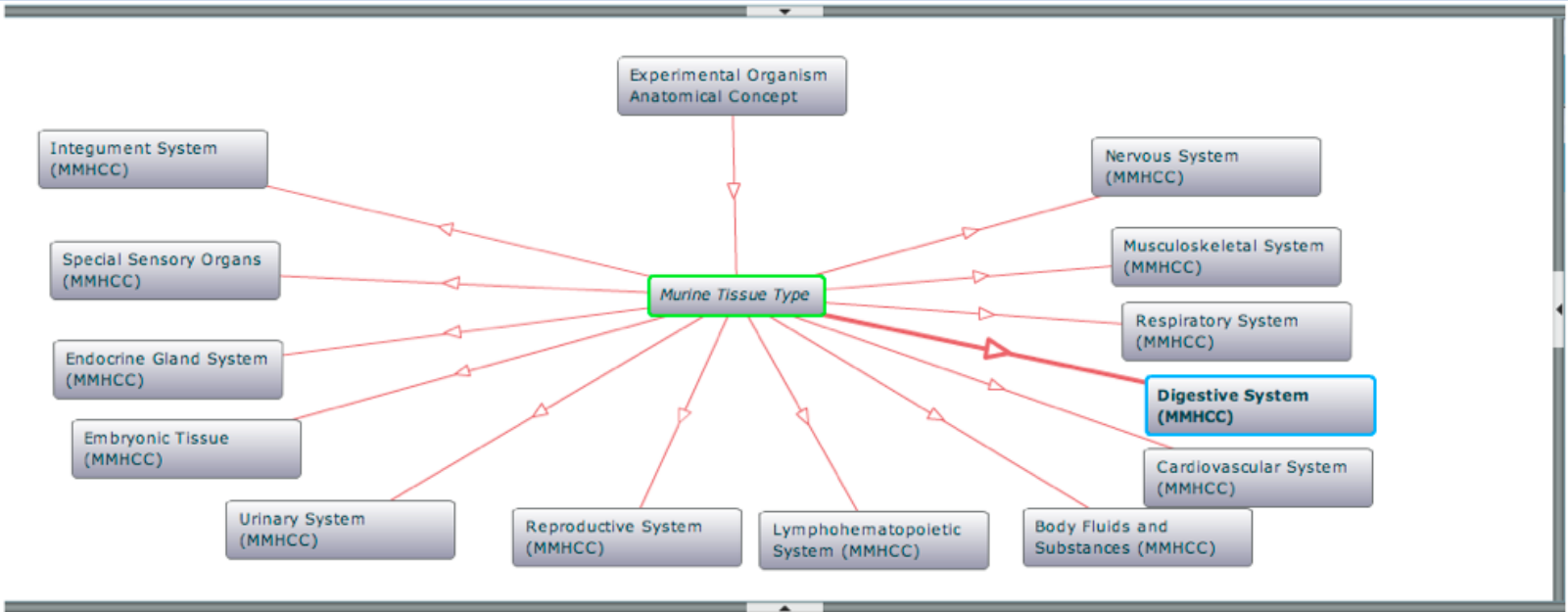
Home Browse Search Projects Mappings **NCI Thesaurus** [Sign In](#) [Register](#)

View Ontology Metadata

- + Abnormal_Cell_Kind
- + Activity_Kind
- + Anatomy_Kind
- + Biological_Process_Kind
- + Chemicals_and_Drugs_Kind
- + Chemotherapy_Regimen_Kin
- + Diagnostic_and_Prognostic
- EO_Anatomy_Kind
 - Experimental Organism A
 - Animal Cap
 - Chloroplast
 - Chorioallantoic Membr
 - + Chromatophore
 - Dorsal Lip
 - Endomesoderm
 - + **Murine Tissue Type**
 - + Rat Anatomy Concept
- + EO_Findings_and_Disorders
- + Equipment_Kind
- + Findings_and_Disorders_Kin

Murine Tissue Type

Visualization Details Marginal Notes Mappings Resources Annotations



```
graph TD; EO[Experimental Organism Anatomical Concept] --> MT[Murine Tissue Type]; MT --> IS[Integument System (MMHCC)]; MT --> SSO[Special Sensory Organs (MMHCC)]; MT --> EGS[Endocrine Gland System (MMHCC)]; MT --> ET[Embryonic Tissue (MMHCC)]; MT --> US[Urinary System (MMHCC)]; MT --> RS[Reproductive System (MMHCC)]; MT --> LHS[Lymphohematopoietic System (MMHCC)]; MT --> BFS[Body Fluids and Substances (MMHCC)]; MT --> CVS[Cardiovascular System (MMHCC)]; MT --> DS[Digestive System (MMHCC)]; MT --> RSP[Respiratory System (MMHCC)]; MT --> MS[Musculoskeletal System (MMHCC)]; MT --> NS[Nervous System (MMHCC)];
```

Major Function: Ontology Assessment



Which ontology is appropriate for my task?

- Sources of information for the answer:
 - Ontology metadata
 - *usually provided by authors*
 - Computable metrics
 - *can be provided by the tools*
 - Community-based evaluation
 - *provided by other users of the ontologies*

Ontology Metadata

- Provides answers to pertinent questions about the content and provenance of the ontology in the library:
 - What is the **domain** covered by an ontology?
 - What are the **key classes and concepts**?
 - **Who** developed the ontology?
 - What is the **policy** for maintenance and distribution?
 - What is the **format** of the ontology (syntax, language, tools used to build it, etc.)

Computable ontology metrics

- Logical consistency checking
 - e.g., use a reasoner to determine if an ontology is consistent
- Structural consistency based on meta-properties
 - e.g., OntoClean
- Rules of thumbs and heuristics
- Statistical information
 - number of classes and properties
 - connectedness, fan-out, etc.
 - cycles

Not all useful metrics are computable

- Many aspects of ontology quality are **subjective**
- The most useful information for the user selecting an ontology:
 - *who used an ontology for a similar task and how well did it work?*

Some Ontology Metrics are Subjective

What is a “good” feature in some setting, can be a “bad” feature in another setting

- *High level of axiomatization:*
 - good if you want to perform reasoning
 - can be bad because of the high computational and cognitive cost if you don't need the axioms
- *Organizing anatomy concepts based primarily on their structure rather than function*
 - can be good if you need to understand which organs a wound goes through
 - not appropriate if you need to understand spread of disease

Community-Based Evaluation



Which ontology from the library is appropriate for my task?

- The only people who know the answer to these question are
 - (maybe) ontology authors
 - other users of the ontology
- Allow users to provide ratings for ontologies

Open-Rating Systems

- Open publishing system
 - anyone can publish content
 - (Semantic) Web is inherently an open publishing system
 - many ontology libraries allow contributions by anyone
- Closed Rating system
 - only a group of “editors” can provide ratings
 - Open directory
 - Yahoo! directory
- Open Rating system
 - anyone can publish reviews and ratings
 - Amazon reviews

1.



Semantic Web for the Working Ontologist: Effective Modeling in RDFS and OWL by Dean Allemang and James Hendler (**Paperback** - May 9, 2008)

Buy new: ~~\$49.95~~ **\$44.96** 26 Used & new from \$40.71

Get it by **Thursday, Jul 3** if you order in the next **58 minutes** and choose one-day shipping.

Eligible for **FREE** Super Saver Shipping.

★★★★★ (3)

Excerpt - page 1: "... CHAPTER What is the **Semantic Web**? 1 This book is about something we call the **Semantic** ..."

Surprise me! See a random page in this book.

Metadata

Ratings

2.



A Semantic Web Primer, 2nd Edition (Cooperative Information Systems) by Grigoris Antoniou and Frank van Harmelen (**Hardcover** - Mar 31, 2008)

Buy new: ~~\$42.00~~ **\$33.60** 36 Used & new from \$27.00

Get it by **Thursday, Jul 3** if you order in the next **58 minutes** and choose one-day shipping.

Eligible for **FREE** Super Saver Shipping.

★★★★★ (1)

3.



Explorer's Guide to the Semantic Web by Thomas B. Passin (**Paperback** - Mar 1, 2004) - **Illustrated**

Buy new: ~~\$39.95~~ **\$26.37** 41 Used & new from \$3.94

Get it by **Thursday, Jul 3** if you order in the next **28 minutes** and choose one-day shipping.

Eligible for **FREE** Super Saver Shipping.

★★★★★ (6)

4.



Social Networks and the Semantic Web (Semantic Web and Beyond) by Peter Mika (**Hardcover** - Sep 18, 2007)

Buy new: ~~\$99.00~~ **\$79.20** 26 Used & new from \$79.17

Get it by **Thursday, Jul 3** if you order in the next **28 minutes** and choose one-day shipping.

Eligible for **FREE** Super Saver Shipping.

★★★★★ (1)

Other Editions: [Kindle Edition](#)

Excerpt - page 6: "... 1 The **Semantic Web** The **Semantic Web** is the application of advanced knowledge technologies ..."

Surprise me! See a random page in this book.

Rating

Review

Rating
the
raters

Most Helpful First | [Newest First](#)

4 of 5 people found the following review helpful:



Could have been great, June 6, 2008

By **C. Schumacher** - [See all my reviews](#)

REAL NAME™

There is a great need for a book like this, and the authors are well-credentialed, but unfortunately, this book is more like an introduction than a craftsman's resource. It reads like a first draft with typos, belabored repetitive text, and some odd examples. There is almost no discussion of internationalization, security, performance, or tricky basic types such as dates, times, or currency. More discussion of SPARQL would have been useful, as well as discussion of what should go in the model vs. what should be queried out. The chapter "Good and Bad Modeling Practices" was a particular let-down. A sharp, thoughtful, deeper book on this topic would really help the field.

Help other customers find the most helpful reviews

Was this review helpful to you?

[Report this](#) | [Permalink](#)

[Comment](#)

4 of 5 people found the following review helpful:



Must read for all who want to get into the semantic web,

June 5, 2008

By **Henry Story "bblfish"** (MPK20) - [See all my reviews](#)

REAL NAME™

Finally a book that explains the key aspects of the Semantic Web in easy to understand language, with well thought out examples and taking a step by step approach to this eminently stackable technology. No RDF/XML in the whole book! This will save all who get started on the semantic web years of work hunting down specs, and will give them the right initial intuitions.

A God send! Buy one for yourself and one for your friends too :-)

Help other customers find the most helpful reviews

Was this review helpful to you?

[Report this](#) | [Permalink](#)

[Comment](#)

Applying Open Ratings to Ontologies

Project Name: RadLex	Institution: RSNA
Description: RadLex is a controlled terminology for radiology.	People:
	Home Page: http://radlex.org

Ontologies Used

RadLex

☆☆☆☆☆ Degree Of Formality

☆☆☆☆☆ Documentation And Support

☆☆☆☆☆ Usability

☆☆☆☆☆ Domain Coverage

☆☆☆☆☆ Correctness

☆☆☆☆☆ Quality Of Content

Home Browse Search Projects Mappings NCI Thesaurus FMA

Sign In Register

View Ontology Metadata

Anatomical entity

- Non-physical anatomical entity
- Physical anatomical entity
 - Immaterial physical anatomical entity
 - Material anatomical entity
- Attribute entity
- Dimensional entity

Physical anatomical entity

Visualization Details Marginal Notes Mappings Resources Annotations

Comment: Wrong superclass in Class/Details ngriff at 01/31/08 17:09

The superclass for this class in the Class detail is wrong.

Reply

Comment: ngriff at 01/31/08 17:10

New Thread

Reviewers Provide

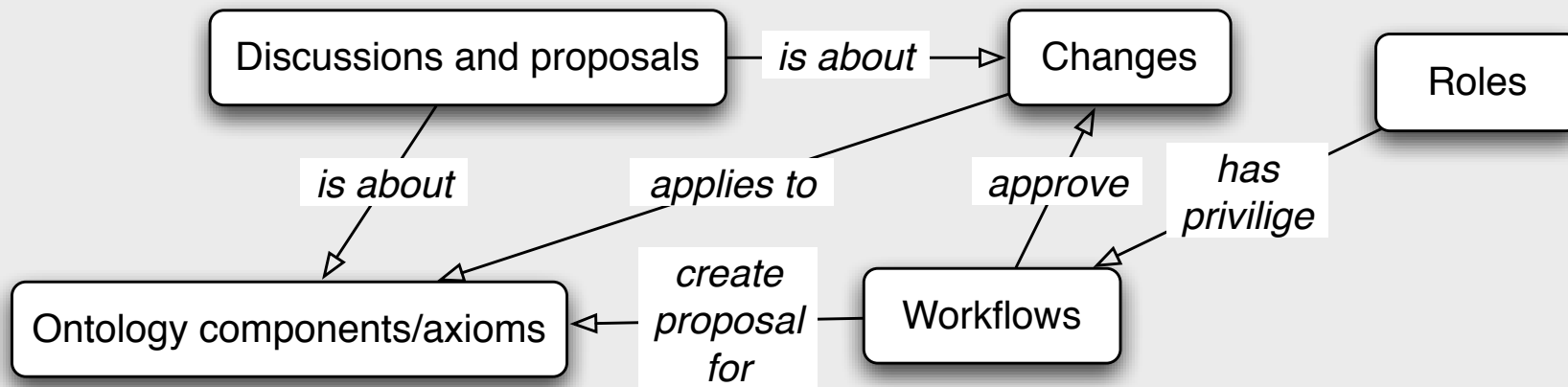
- General review and rating
- **Usage** information
 - Which applications have successfully used the ontology?
 - What problems were encountered?
- **Coverage**
 - Does it cover the domain properly?
 - Are there major gaps?
 - Are some parts developed better than others?
- **Concept-specific comments**
 - Are there problems with specific concepts?
 - What alternative definitions should be used?

Conflicting Sources of Metadata

- Authors and users can contradict one another
 - Quality of documentation?
 - References (e.g., positive and negative analyses of the ontology)
 - ...
- Metadata schema must enable diversity of views on some metadata values

Representing Reviews and Ratings

Looks familiar?



Community-based Ontology ... Everything

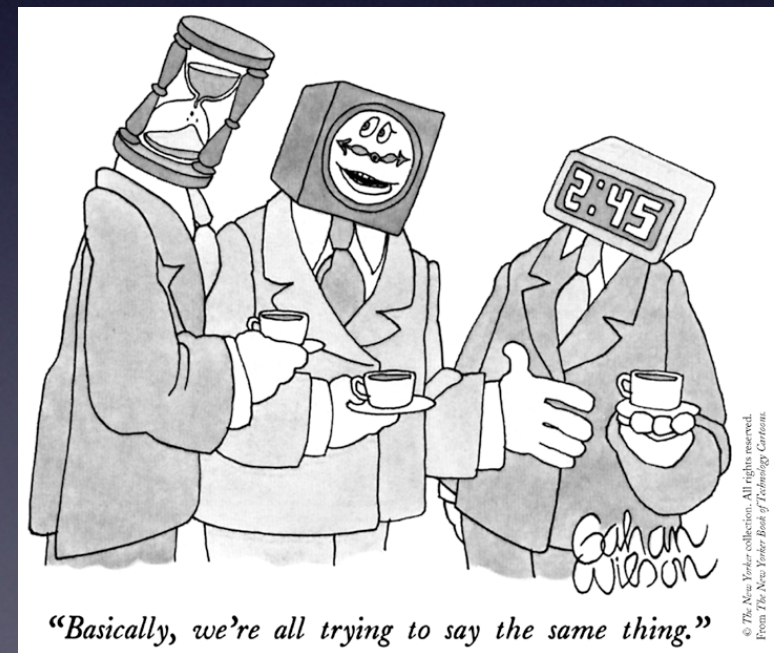
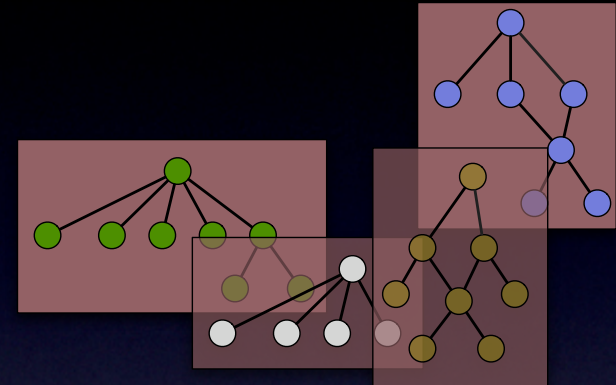
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Multiple and Overlapping Ontologies

- Ontologies, vocabularies, and terminologies will inevitably overlap in coverage
- An ontology library can provide declarative mappings
 - found by the **tools** (efficient, but far from perfect)
 - specified by **users** (low throughput, but better quality)



Mappings in BioPortal

Home Browse Search Projects Mappings **NCI Thesaurus**

Sural Artery

Visualization Details Marginal Notes **Mappings** Resources Annotations

New Point-to-Point Mapping

Mapping To	Source	Mapped By	Mapped On
external sural artery (Mouse adult gross anatomy)	NCICB	TerryHayamizu	04/23/08
sural artery (Mouse adult gross anatomy)	NLM	SongmaoZhang	04/23/08
external sural artery (Mouse adult gross anatomy)	NLM	SongmaoZhang	04/23/08
superficial sural artery (Mouse adult gross anatomy)	NLM	SongmaoZhang	04/23/08

Left sidebar (Artery list): Middle Colic Artery, Perineal Artery, Popliteal Artery, Popliteal Artery Branch, Azygos Articular Artery, Inferior External Articular Artery, Inferior Internal Articular Artery, Superior External Articular Artery, Superior Internal Articular Artery, **Sural Artery**, Posterior Tibial Artery, Posterior Tibial Artery Branch, Pulmonary Artery, Pulmonary Artery Branch, Radial Artery, Retinal Artery, Spiral Artery of the Endometrium, Splenic Trabecular Artery, Straight Artery of the Endometrium

Creating Point-to-Point Mappings

Home Browse Search Projects **Mappings** NCI Thesaurus 

Point-to-Point Mapping from Sural Artery to :

Ontology: 

Search:

RenalAnteriorSegmentalArtery

RenalAnteriorSuperiorSegment

RenalArtery

RenalInferiorSegmentalArtery

RenalInferiorSupraRenalArtery

RenalPosteriorSegmentalArtery

RenalSuperiorSegmentalArtery

RightColicArtery

RightGastricArtery

RightGastroepiploicArtery

RightHepaticArtery

RightInferiorPhrenicArtery

RightPulmonaryArtery

SplenicArtery

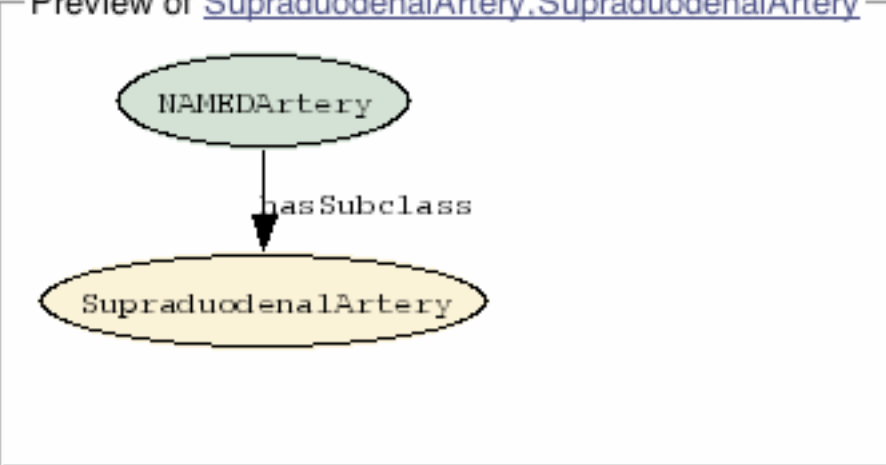
SuperiorMesentericArtery

SuperiorRectalArtery

SupraduodenalArtery

UlnarArtery

Preview of [SupraduodenalArtery.SupraduodenalArtery](#)



```
graph TD; NAMEDArtery([NAMEDArtery]) -- hasSubclass --> SupraduodenalArtery([SupraduodenalArtery]);
```

Analyzing Mappings

Filter User: Any Source: Any Filter Export Current Results To RDF	
« Previous 1 2 3 4 5 6 7 8 9 ... 15 16 Next »	
Concept	Maps To
NCI Thesaurus : Pelvic Bone -->	Mouse adult gross anatomy : pelvis bone (1)
	Mapped By TerryHayamizu
	Mouse adult gross anatomy : hip bone (1)
NCI Thesaurus : Sural Artery -->	Mapped By SongmaoZhang
	Mouse adult gross anatomy : pelvic girdle bone (1)
	Mapped By SongmaoZhang
NCI Thesaurus : Spermatic Vein -->	Mouse adult gross anatomy : external sural artery (2)
	Mapped By TerryHayamizu , SongmaoZhang
	Mouse adult gross anatomy : sural artery (1)
NCI Thesaurus : Spermatic Vein -->	Mapped By SongmaoZhang
	Mouse adult gross anatomy : superficial sural artery (1)
	Mapped By SongmaoZhang
NCI Thesaurus : Spermatic Vein -->	Mouse adult gross anatomy : spermatic vein (2)
	Mapped By TerryHayamizu , SongmaoZhang
	Mouse adult gross anatomy : testicular vein (1)
NCI Thesaurus : Spermatic Vein -->	Mapped By SongmaoZhang
	Mouse adult gross anatomy : internal spermatic vein (1)
	Mapped By SongmaoZhang

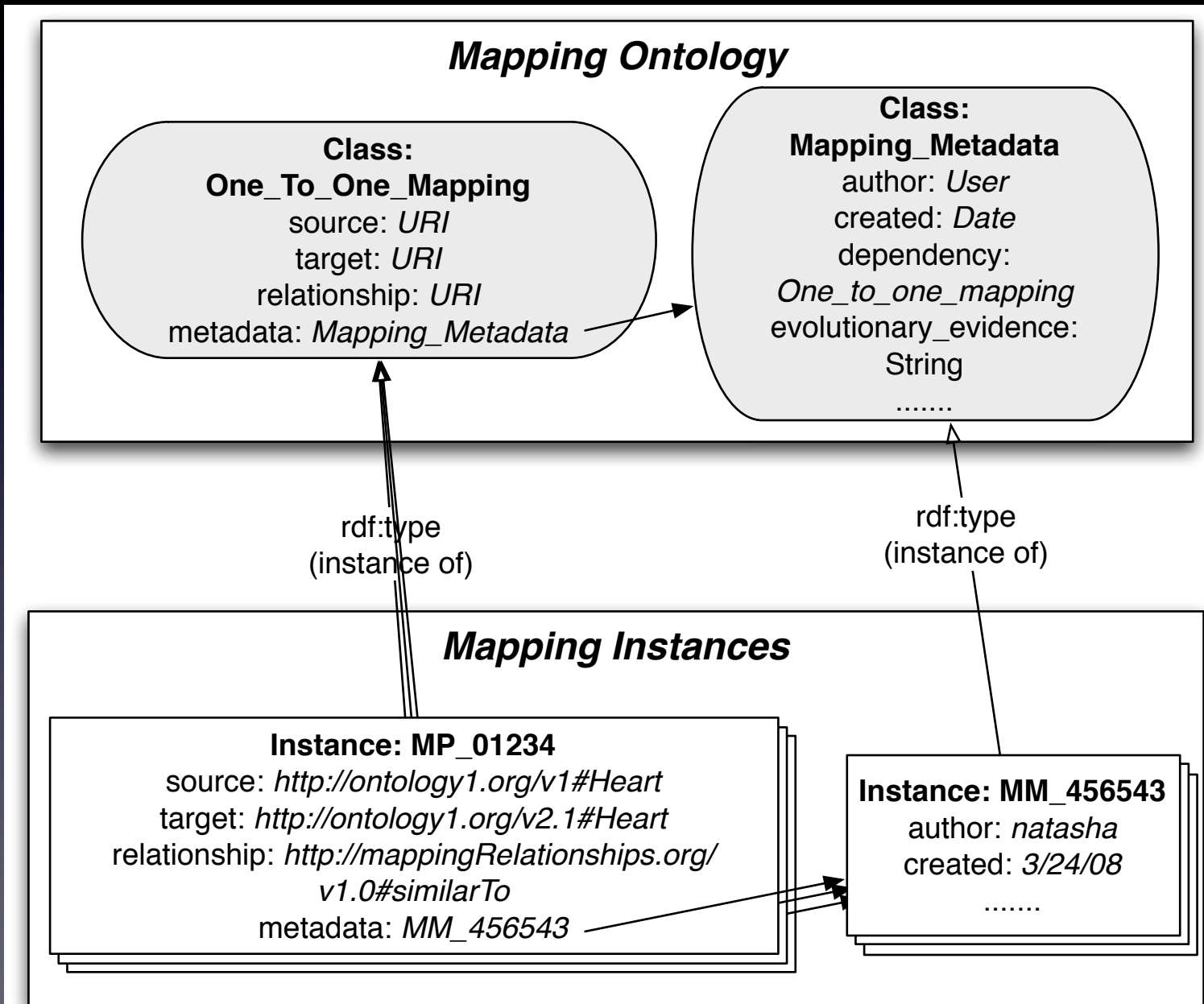
Functionality for Mapping Support

- Enable users to
 - **upload** bulk mappings in a specified format
 - **download** mappings based on a selection criteria
 - **define** point-to-point mappings interactively
 - **comment** on mappings created by others
 - **refine** and **discuss** existing mappings

Mapping Metadata

- yes, metadata again...
- Users require a comprehensive set of metadata to augment mappings
 - mapping relationship
 - provenance (who created the mapping and when)
 - discussion and comments
 - application context
 - mapping dependency
 - algorithm used to create the mapping (configuration, parameters, etc.)
 - external references

Representing mappings



Current Mappings in BP

- More than 30,000 mappings
 - created manually
 - as part of concept definition (OBO xref, UMLS)
 - as a mapping (NCI Mouse-Human anatomy)
 - created automatically
 - Using algorithms such as Prompt

Mappings as the Product of Community Contribution

- Mappings can contradict each other
 - application context may be different
 - trust is the key again
- Users can use the BioPortal framework to reach consensus on the mappings

Use of Mapping Repository

- Source of data for **automatic algorithm**
 - machine learning
 - algorithms that need a priori alignment
- Accessible through **web services**
 - can be used in other applications
- Used for **annotating and browsing** resources through ontology elements
- Use for finding “**important**” ontologies:
 - If everyone maps to NCI Thesaurus, it must be important

Community-based Ontology ... Everything

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and
Evolution

Evaluation
and Reuse

Are we there yet?

Mapping and
Alignment

Research Challenges

- If we build it, will they come?
- How do we encourage users?
 - it is a paradigm shift, in some sense
 - so far, our users are asking for these features
 - collaborative ontology development is hot!
 - community-based mappings and evaluation is still new

One of the key issues: Trust

- Aggregation
- Meta-rankings: rating the raters
- Personalized and filtered views of the system: Web of Trust
- Online version of “word of mouth”
- Topic-specific trust



Collaborative Workflows

- How do we develop a **representation** that is comprehensive enough to capture a wide variety of collaborative workflows?
- How do we make it **simple and usable**?
- What are the **reusable workflow modules**?
Can we have a simple wizard that instantiates a workflow description?

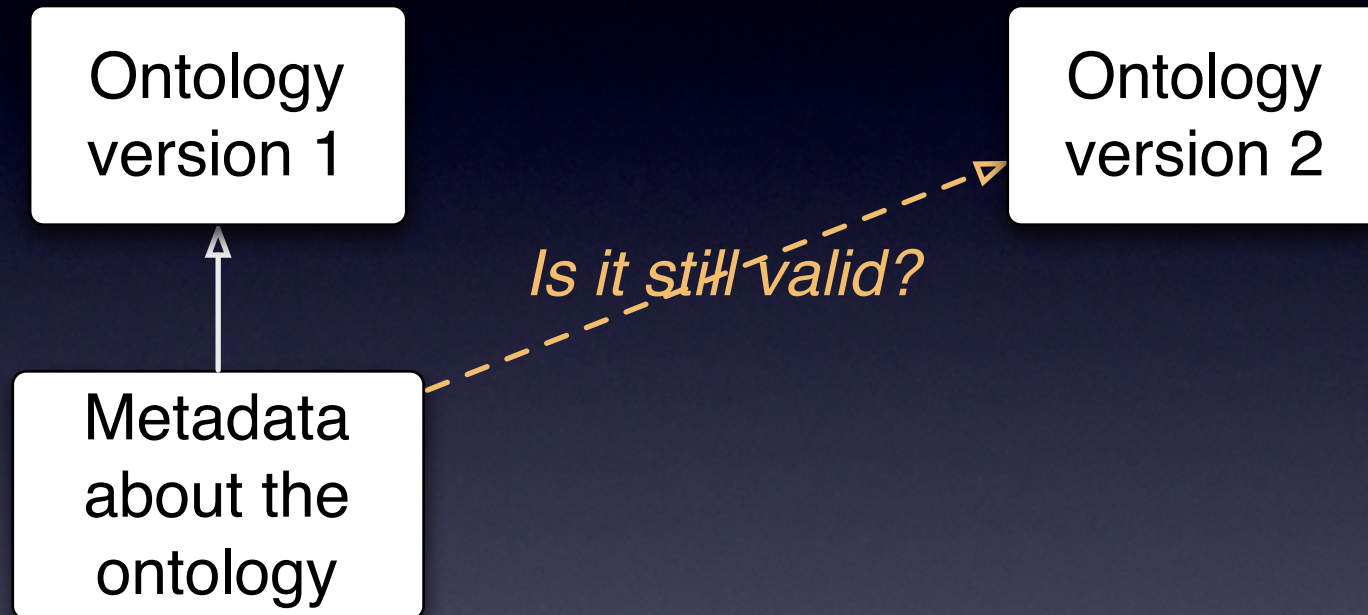
Dynamics of Collaborative Ontology Development

- Properties and dynamics of the **social networks** that form as the result of collaborative ontology editing?
- What are the **different types of users** based on their activity in the editing process (e.g., those who lead the discussions vs those who do most of the editing)?
- What are the **characteristics of the concepts** that are discussed most actively?
- Do tools such as Collaborative Protégé make collaboration **more efficient or hinder** it?

Personalized Views of Ontologies

- How do we **represent and compute** personalized views
 - based on the areas of interest
 - based on the user's web of trust?
- How do you enable **local editing** of ontologies with subsequent integration in the ontology being developed by others?

Maintaining Metadata through Ontology Versioning



Potentially, any part of the *description* can change:
author, language, domain, ...

Mappings can become invalid, too...

Reviews may no longer apply...

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