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INsight to Diverse Information using Graphs and Ontologies

Collaborative MBE across Diverse System Models Including AADL

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Agenda

- Example Open Model-Based Engineering Environment (OpenMBEE)
- Characteristics common to digital models
- INsight to Diverse Information using Graphs and Ontologies (INDIGO)
- Example use cases
- Interoperability features and guidelines

Open Model-Based Engineering Environment

OpenMBEE is an open source collaborative engineering system. It enables engineers to work in the language of their choice and easily share and document their work across other tools.

- NASA initiated
- NumFOCUS foundation open source project
- https://www.openmbee.org
- https://groups.google.com/g/openmbee

See also

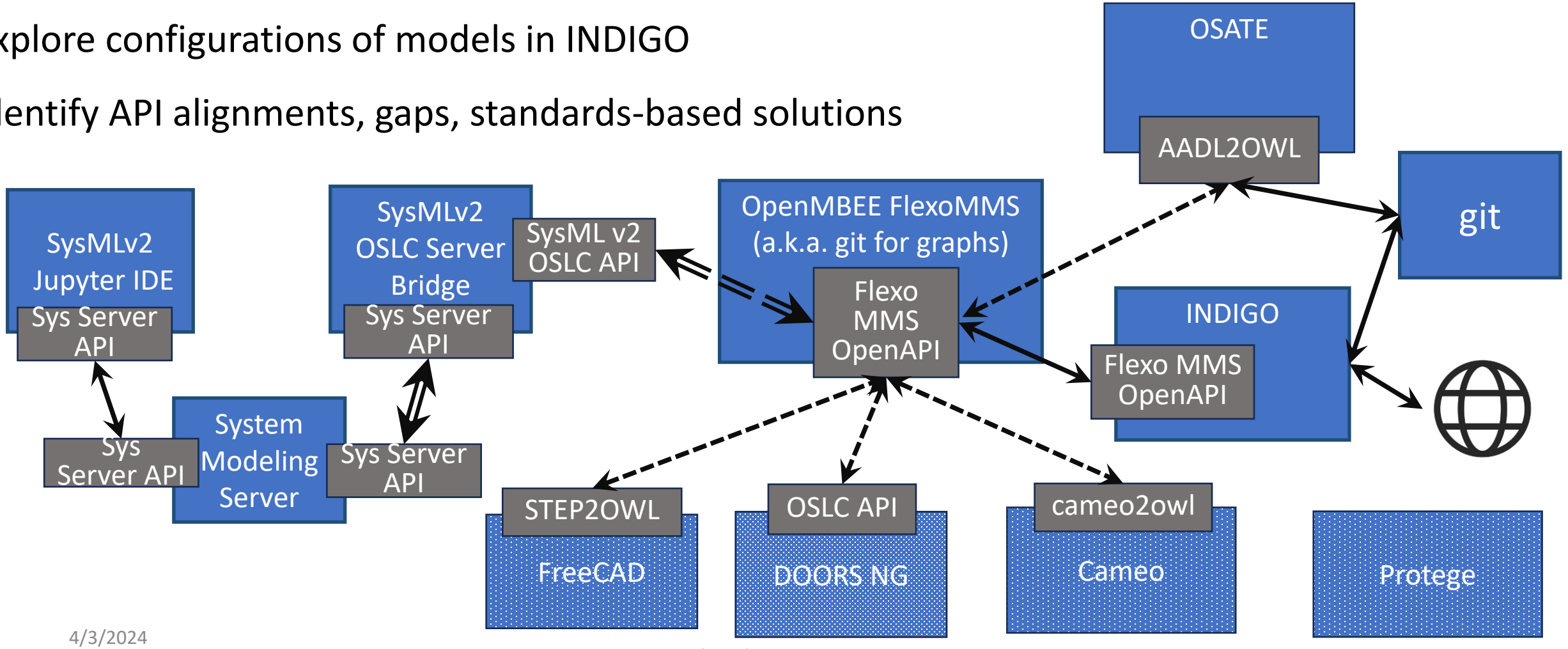
- OSLC https://open-services.net/
- SysML-v2 https://groups.google.com/g/sysmlforum
- Open AADL http://www.openaadl.org/

Example Open MBEE

Move diverse models in and out of a FlexoMMS server

Explore configurations of models in INDIGO

Identify API alignments, gaps, standards-based solutions



Example Modeling Languages & Tools Features

What is a Digital Model?

- Modelica
  - Specification (4 “model” instances): can be translated into a simulation model, other tool usages allowed but not specified
  - In practice: concrete textual syntax, translate to a dynamical systems simulation model
  - Semantics: systems of differential equations
- AADL
  - Specification (211 instances): model describes a system as a hierarchy of components with their interfaces and interconnections
  - In practice: concrete textual syntax, set of package files required to instantiate a system implementation
  - Semantics: state machines, scheduling theory, temporal logics, assume/guarantee, fault trees, Markov chains,…
- SysML-V2
  - Specification (486 instances): represented according to the syntactic requirements (abstract and concrete syntax)
  - In practice: a SysML modeling tool is conformant with either the abstract or concreate syntax and creates, manages, analyzes, visualizes, executes or performs services on SysML models
  - Semantics (KerML): model-theoretic
- Resource Description Framework (RDF)
  - Specification (model=graph): RDF graphs are independent of syntax. Graphs not RDF-isomorphic are distinct graphs.
  - In practice: sets of triples <resourceIRI> <propertyIRI> <resourceIRI or dataValue>, multiple syntaxes, flexible and varied
  - Semantics: referents and entailment regimes, flexible and varied
- Web Ontology Language (OWL)
  - Specification (model=ontology): defined by behavior and structure, multiple standard and common syntaxes, content identified by self-declared ontology and version IRIs
  - In practice: RDF-based syntaxes, syntactic/shape validation, logical consistency validation
  - Semantics: model-theoretic, decidable description logic, entailment regimes

Characteristics of Digital Engineering Models

Digital Model: a body of information that

- Evolves over time
- Can be expressed in one or more multi-media syntaxes
- Has modularization and dependency features
- Copies can be stored in multiple storage systems
- Has a principle of individuation (is distinct from other models)
- Has zero or more formal (math-based) semantics
- Has one or more tools, vendors, user interfaces
- Has information that relates to information in other models
- Often analyzed to provide parameters for other models
- Often overlap with other models

INDIGO

INsight to Diverse Information using Graphs and Ontologies

INDIGO Client

Locate, Query, Understand

Identify sources and manage sets of assets

Develop & understand domain ontologies

Explore, visualize, understand sets of assets

Model Server Access

Flexo MMS
git

RDF Document Access

World Wide Web URL

File Access

Local URL
Local workspace

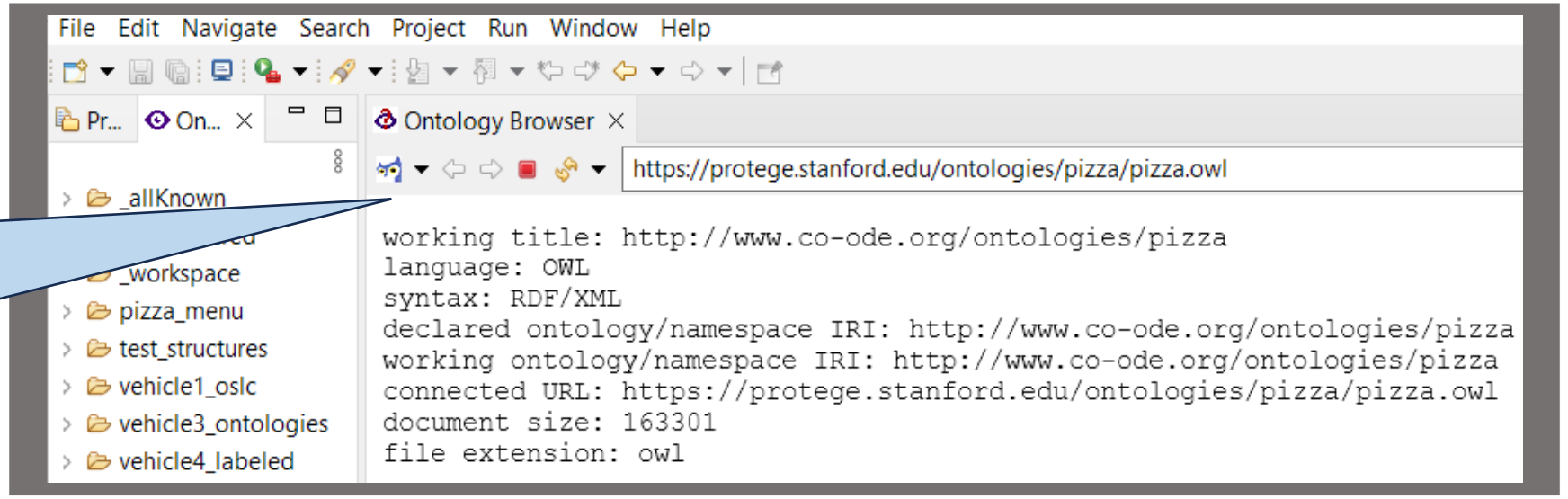
Populate Library of Models and Ontologies

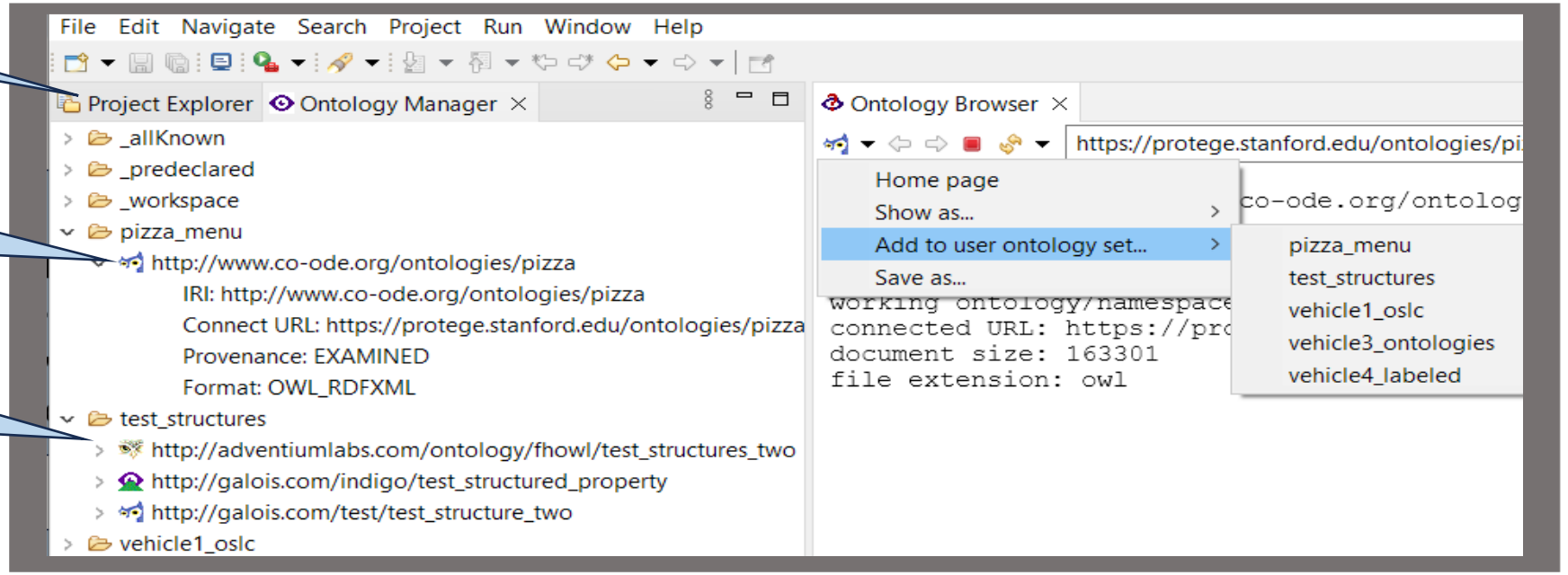
Browser enhanced to recognize RDF languages and access protocols. API allows plugins to recognize added protocols.

Workspace listener recognizes RDF syntaxes.

Descriptor is created with meta-data that enables access to the RDF document.

User collects a library of sets of descriptors.





Explore Set of Models (tree viewer)

FireSat is a SysML satellite mission specification.
CSAH is an AADL cubesat design & analysis architecture.

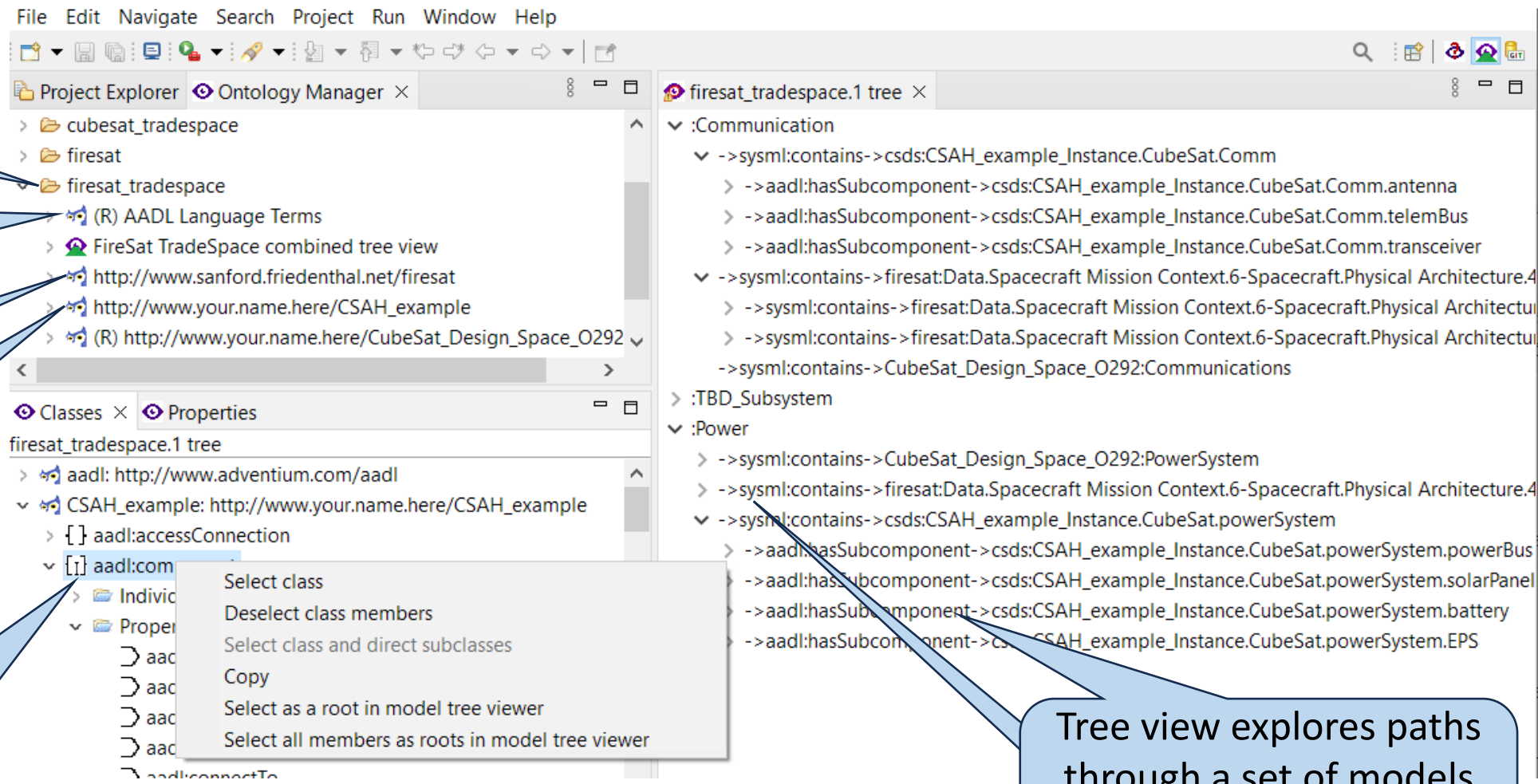
Choice of model viewer can be opened on a set of models.

AADL domain ontology (terms from SAE AS5506)

SysML Model

AADL Model

Users interactively query-with-reasoning by selecting classes, properties, etc.



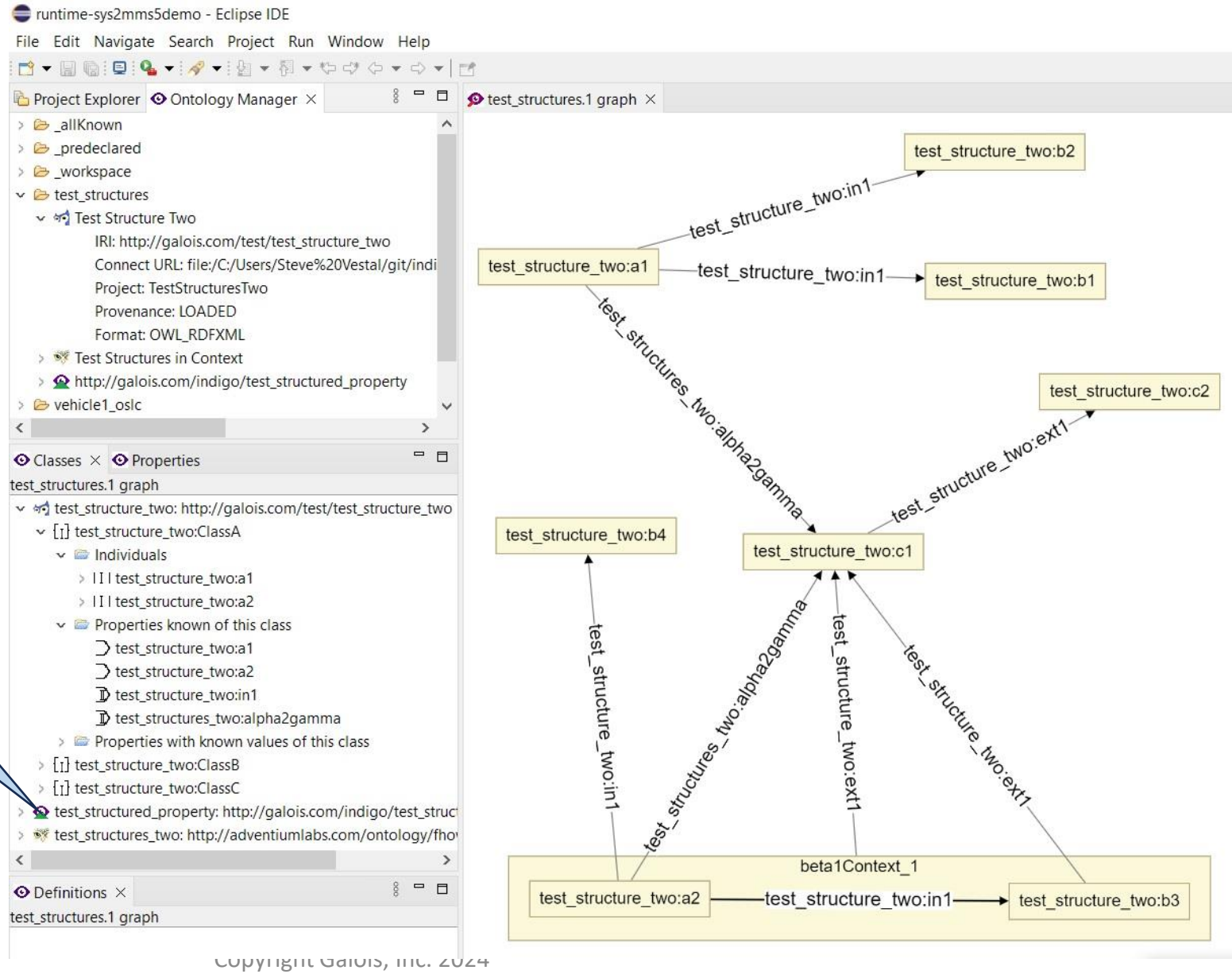
Tree view explores paths through a set of models following user-selected properties, classes, etc.

Explore Set of Models (graph viewer)

Different sets can be opened using different kinds of model viewers at the same time.

User selections can be saved as a viewpoint ontology, a set of rules to reconstruct the view.

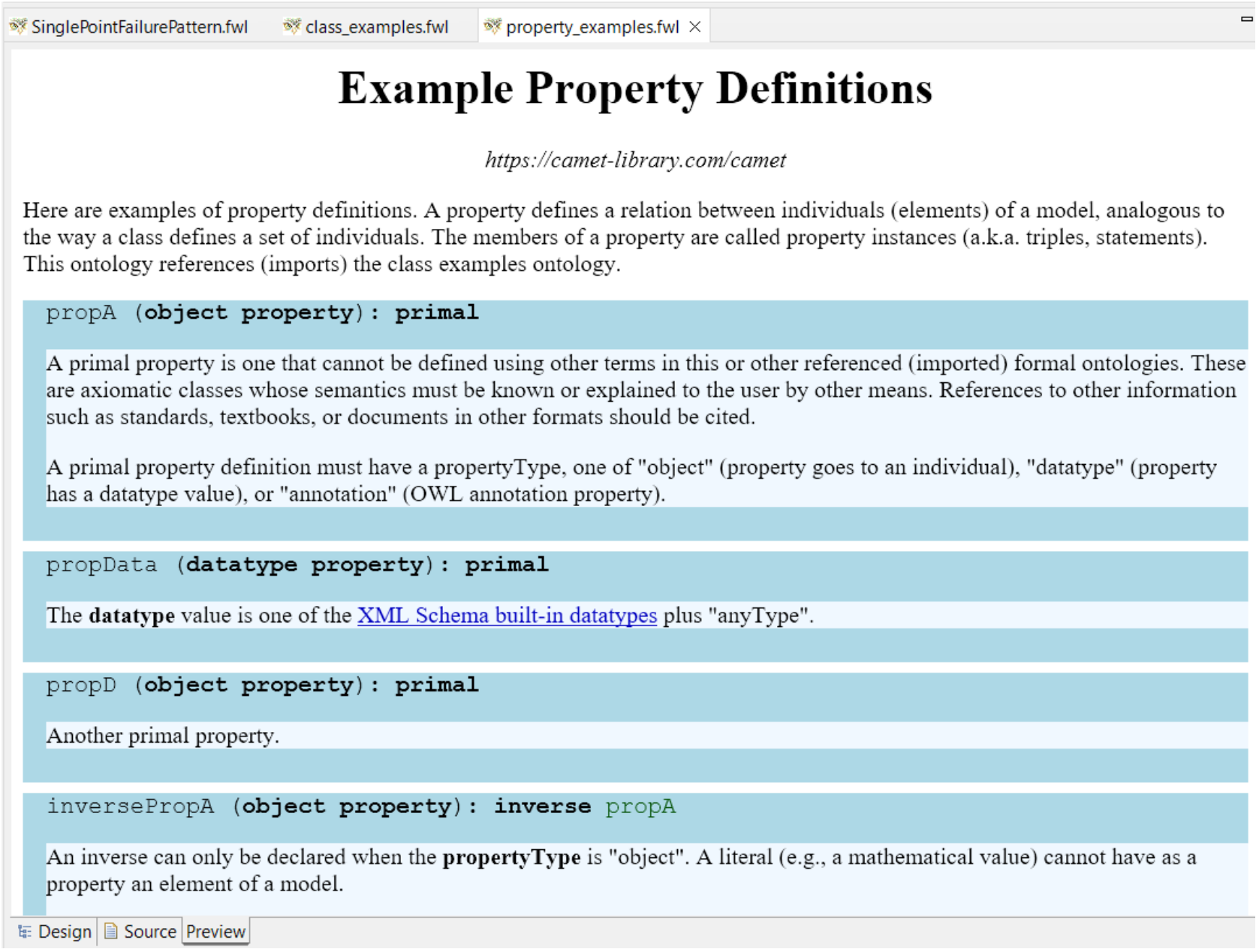
API allows other viewers to be added as plugins.



FHOWL Literate Ontology

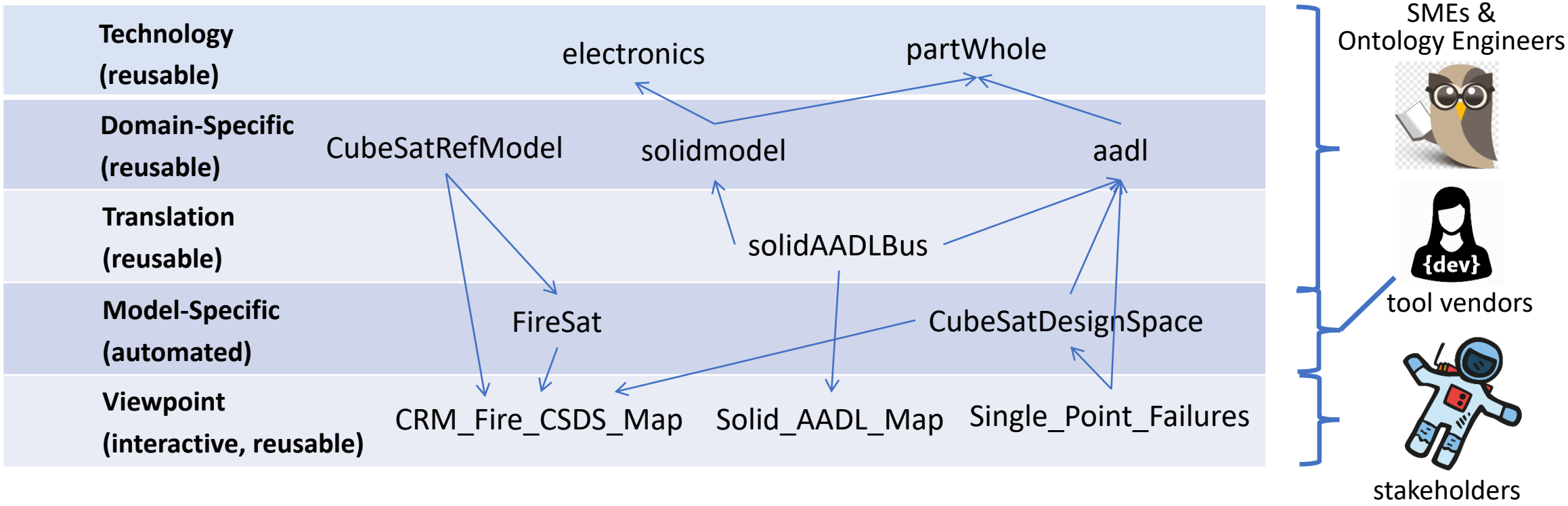
Literate format interleaves formal ontology definitions into an XHTML document.

FHOWL extends OWL with structured classes and properties defined by patterns that recognize subgraphs in a given context.



Ontologies for Multiple Domains and Sources

Domain ontologies are widely used to provide a vocabulary with definitions.
They serve as schemas for RDF graphs that support logic-based reasoning.



Interoperability Features and Guidelines

Resource Description Framework (RDF) exchange formats

- Graph structure vs folders of files of lines of text
- Semantic referents and entailment regimes
- SPARQL standard query language and protocols
- OWL model-theoretic semantics and reasoning tools
- Aligned with other web standards, XML, etc.
- Widely used and supported, e.g., OSLC, WikiData, SNOMED, PubChemRDF

Domain Ontologies

- Vocabulary of terms with definitions relating them
- Formal OWL ontologies
- Multiple types
  - Schemas for languages, e.g., terms from SAE AS5506
  - Translations, e.g., aadl:bus defined for 3D CAD patterns
  - Viewpoints, e.g., selections and rules to generate diagrams

Interoperability Features and Guidelines

Open source conversion frameworks, e.g.,

- Eclipse Lyo (OSLC)
- Ecore2OWL
- ReDeFer (XSD2OWL and XML2RDF)
- STP2OWL

Standards and guidelines

- Ontology/namespace/base IRIs to uniquely identify models
- Version IRIs and properties
- Modeling language domain ontologies
- Standard domain ontologies, e.g., OSLC, QUDT,…