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The OWL API: An Introduction

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OWL

OWL allows us to describe a domain in terms of:

- Individuals
  - Particular objects in our domain
- Classes
  - Collections of objects (usually sharing some common characteristics)
- Properties
  - Binary relationships between individuals.
- Plus a collection of axioms describing how these classes, individuals, properties are related

OWL

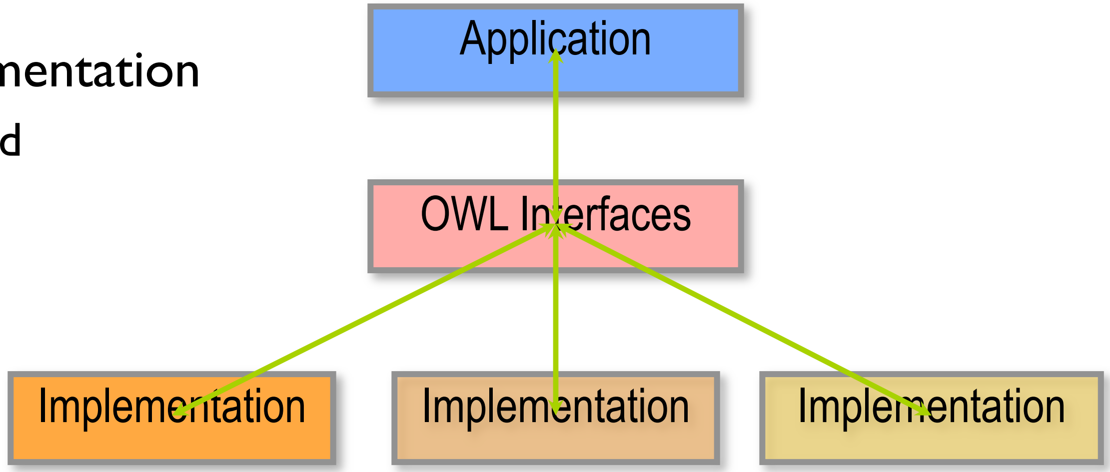
- OWL has a number of operators that allow us to describe the classes and the characteristics that they have
- Boolean operators
  - and, or, not
- Quantification over properties/relationships
  - universal, existential.
- A clear and unambiguous semantics for the operators and composite class expressions

Why build an OWL API?

- The use of a higher level data model can help to
  - insulate us from the vagaries of concrete syntax.
  - make it clear what is happening in terms of functionality.
  - increase the likelyhood of interoperating applications.

Assumptions

- Primarily targeted at OWL-DL
  - This does not mean that we cannot handle OWL-Full ontologies, but a number of design decisions reflect this assumption.
- Java based
  - Interfaces
  - Java reference implementation
    - Main memory based



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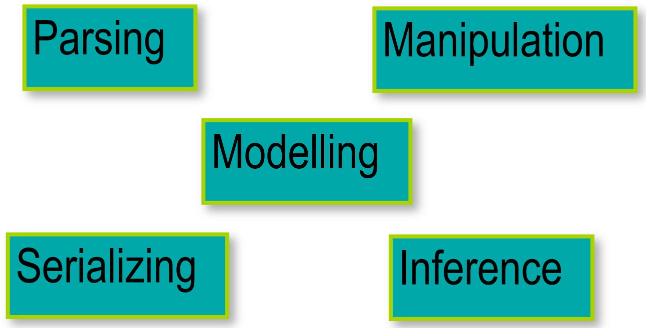
What *is* an "OWL Implementation"?

- Modelling
  - Provide data structures that represent OWL ontologies/ documents.
- Parsing
  - Taking some syntactic presentation, e.g. OWL-RDF and converting it to some [useful] internal data structure.
- Serializing
  - Producing a syntactic presentation, e.g. OWL-XML from a local data structure.
- Manipulation/Change
  - Being able to manipulate the underlying objects.
- Inference
  - Providing a representation that implements/understands the formal semantics of the language.

OWL Structural Specification

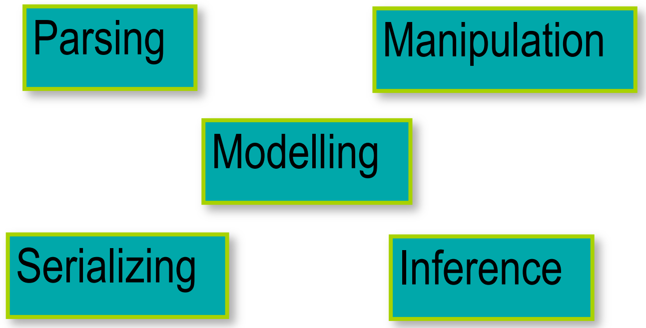
- Provides a definition of the language in terms of the constructs and assertions allowed.
- Semantics are then defined in terms of this abstract syntax.
- Our OWL API data model is based largely on this abstract presentation.
  - Conceptually cleaner.
  - Syntax doesn't get in the way

Considerations



- Clear identification of functionalities and a separation of concerns
- Representation
  - Syntax vs. Data Model
  - Interface vs. Implementation
  - Locality of Information
- Parsing/Serialization
  - Insulation from underlying concrete presentations
  - Insulation from triples

Considerations



- Manipulation/Change
  - Granularity
  - Dependency
  - User Intention
  - Strategies
- Inference
  - Separation of explicit assertions from inferred consequences
  - External reasoning implementations

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Caveats

- Primarily designed to support manipulation of T-Box/ schema level ontologies
  - Large amounts of instance data may cause problems.
- Designed to support OWL (not RDF)
- This isn't industrial production level quality code
  - It's not bad though :-)
- We can't promise to answer all your questions
- We can't promise to fix all your bugs
- But we'll try……

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Where's it used?

- Pellet
  - OWL reasoner
- SWOOP
  - OWL editor
- Protégé 4
  - OWL editor
- ComparaGrid
- CLEF
- OntoTrack
  - OWL Editor
- DIP Reasoner
- BT
  - SNOMED-CT support
- BioPAX
  - Lisp bindings (!!)

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Other, Related Work

- Jena
  - Provides OWL Ontology interfaces, layered on the RDF structures of Jena
- Protégé API
  - Protégé 3 provided OWL API layered on Protégé model
  - Mixture of frames, RDF and OWL
  - Evolution to support a UI
- KAON2
  - Support for OWL
  - Not open source

References

- **Matthew Horridge, Sean Bechhofer**. *The OWL API: A Java API for OWL Ontologies*. Semantic Web Journal 2(1), Special Issue on Semantic Web Tools and Systems, pp. 11-21, 2011

- *Cooking the Semantic Web with the OWL API*, ISWC2003
- *Parsing OWL DL: Trees or Triples?*, WWW2004
- *Patching Syntax in OWL Ontologies*, ISWC 2004
- *The Manchester OWL Syntax*, OWLEd 2006
- *Igniting the OWL 1.1 Touch Paper: The OWL API*, OWLEd 2007
- *The OWL API: A Java API for Working with OWL 2 Ontologies*, OWLEd 2009

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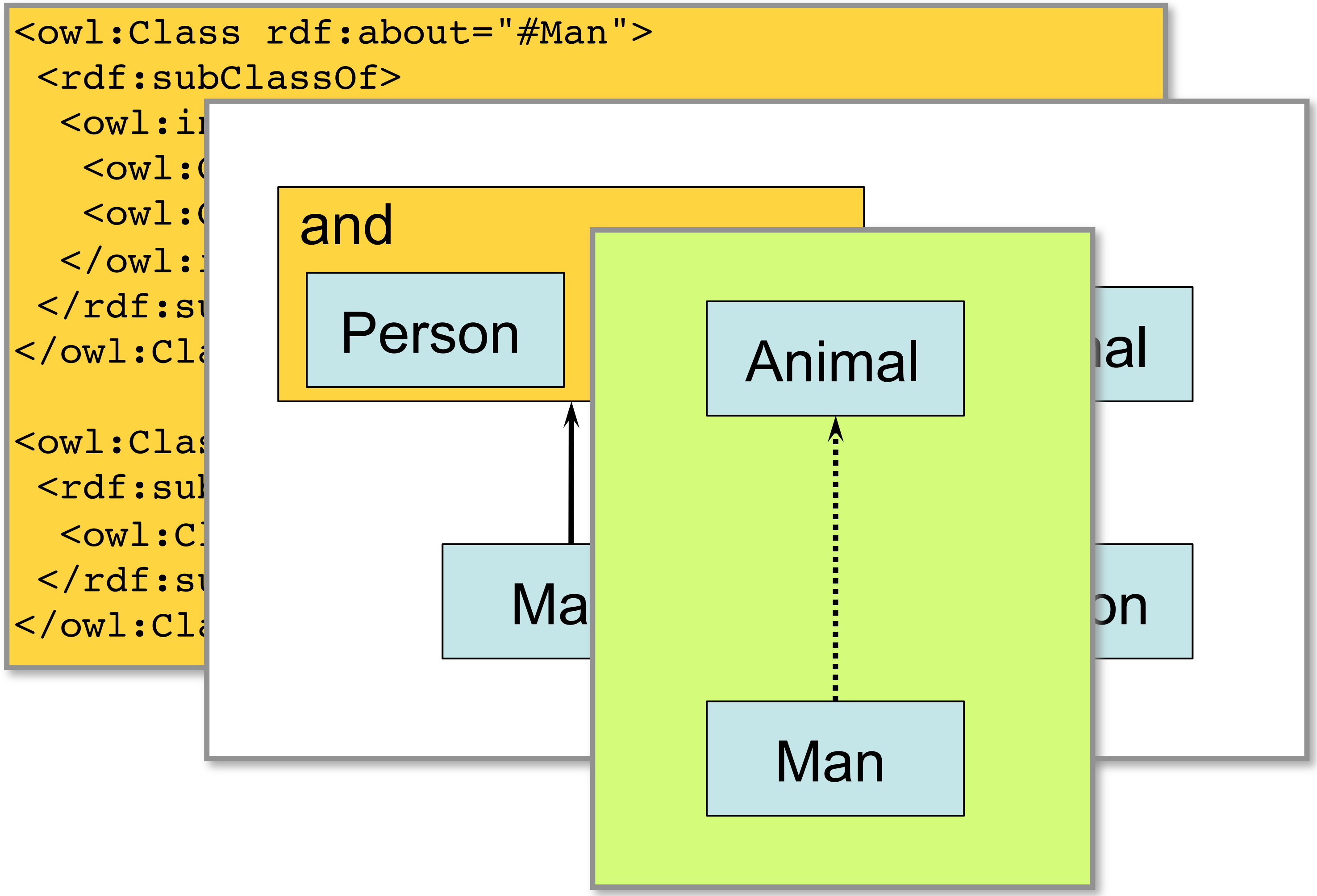
Programming to the OWL API

What is an Ontology?



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OWL API Philosophy

- An Ontology is represented as
  - a collection of axioms
  - that assert information about the classes, properties and individuals
- OWL API provides a uniform view on the ontology
- More or less direct implementation of the OWL 2 specification
- Helpful Resources!

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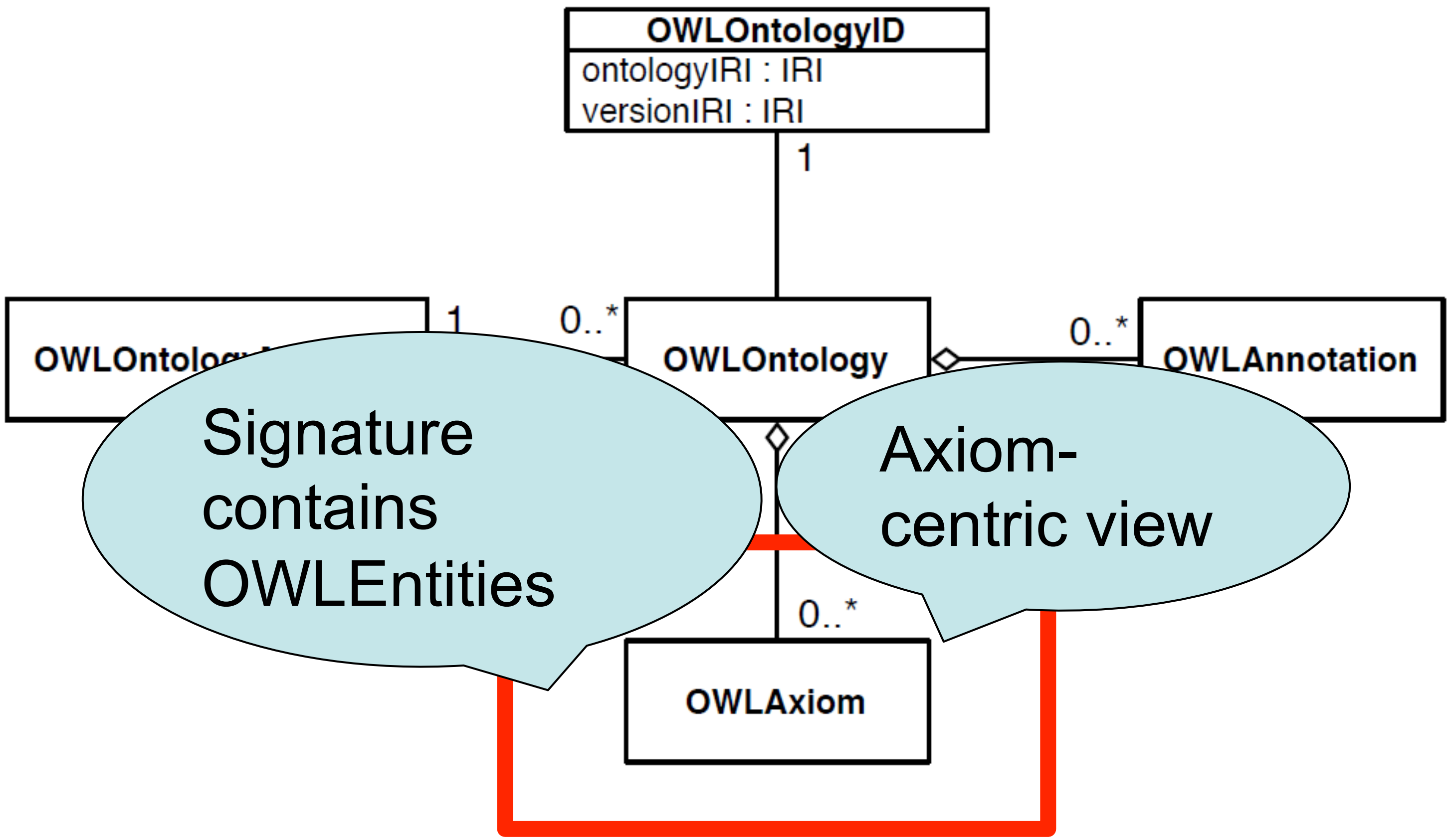
Basic Data Structures

- At its heart, the OWL API provides data structures representing OWL ontologies, like their axioms, classes and relations
- Plus classes to help
  - Create;
  - Manipulate;
  - Parse;
  - Render; and
  - Reason about those structures

Main Building Blocks

- OWLOntology
- OWLOntologyManager
- OWLAxiom
  - SubclassOf
  - EquivalentClasses
  - DisjointClasses
- OWLEntity
  - OWLClass
  - OWLObjectProperty
  - OWLDataProperty
  - OWLIndividual

OWLOntology



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Names and URIs

- Ontologies in OWL are named using URIs
- Entities in OWL are identified using URIs

Ontology: <http://owl.cs.manchester.ac.uk/ontologies/sushi.owl>

Class: <http://owl.cs.manchester.ac.uk/ontologies/sushi.owl#Sushi>

OWLEntity

- OWLEntity is the fundamental building block of the ontology
  - Classes
  - Properties
  - Individuals
  - Datatypes
- Named using URIs

Class: <http://owl.cs.manchester.ac.uk/ontologies/sushi.owl#Sushi>

OWLClass

- Represents an OWL Class.
- The Class itself is a relatively lightweight object
  - A Class doesn't hold information about definitions that may apply to it.
- Axioms relating to the class are held by an OWLOntology object
  - E.g. a superclass axiom must be stated within the context of an OWLOntology
  - Thus alternative characterisations/perspectives can be asserted and represented for the same class.

OWLClass

- Methods are available on OWLClass that give access to the information within a particular ontology

```
java.util.Set<OWLDescription> getDisjointClasses(OWLOntology ontology)
java.util.Set<OWLDescription> getEquivalentClasses(OWLOntology ontology)
```

- But these are simply *convenience* methods.

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OWLProperty

- OWL makes a distinction between
  - Object Properties: those that relate two individuals
    - E.g. hasBrother
  - Data Properties: those that relate an individual to a concrete data value
    - E.g. hasName
- There is a strict separation between the two and two explicit classes representing them
  - OWLObjectProperty
  - OWLDataProperty

OWLProperty

- Properties can have associated domains and ranges
- There is also a property hierarchy
  - Super properties
  - Property equivalences
  - Disjoint Properties (OWL2)
- Assertions about properties are made in the context of an Ontology.
  - E.g functional properties

OWLObjectProperty

- Represents an Object Property that can be used to relate two individuals
- Object properties can have additional characteristics
  - Transitivity
  - Inverses

OWLDataProperty

- Represents an Data Property that can be used to relate an individual to some concrete data value
- Data properties can also have additional characteristics
  - Functional

Project Setup and Task 1

- Lets get our hands dirty.

The structure of axioms

OWLAxiom

- An ontology contains a collection of OWLAxioms
- Each axiom represents some fact that is explicitly asserted in the ontology
- There are a number of different kinds of axiom
  - Annotation Axioms
  - Declaration Axioms
  - Import Axioms
  - Logical Axioms

Logical Axioms

- The subclasses of OWLLogicalAxiom represent the logical assertions contained in the ontology
  - Supers (of classes and properties)
  - Equivalences (of classes and properties)
  - Property Characteristics
    - Functionality, transitivity etc.
  - Facts about particular individuals
    - Types
    - Relationships
    - Values

Annotation Axioms

- An OWLAnnotationAxiom is used to associate arbitrary pieces of information with an object in the ontology
  - Labels or natural language strings
  - Dublin core style metadata, e.g. author or creator information
- Annotation Axioms have no logical significance
  - They do not affect the underlying semantics of the ontology

Change

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Changes

- The API takes an “axiom-centric” view
- There are a limited number of change objects
  - Add an Axiom
  - Remove an Axiom
  - Set the Ontology URI
- Trade off between simplicity and power
  - Change from original API, which had a number of different change objects encapsulating different changes.
  - Change object describes what happened, e.g. add/remove
  - Wrapped axiom describes the change

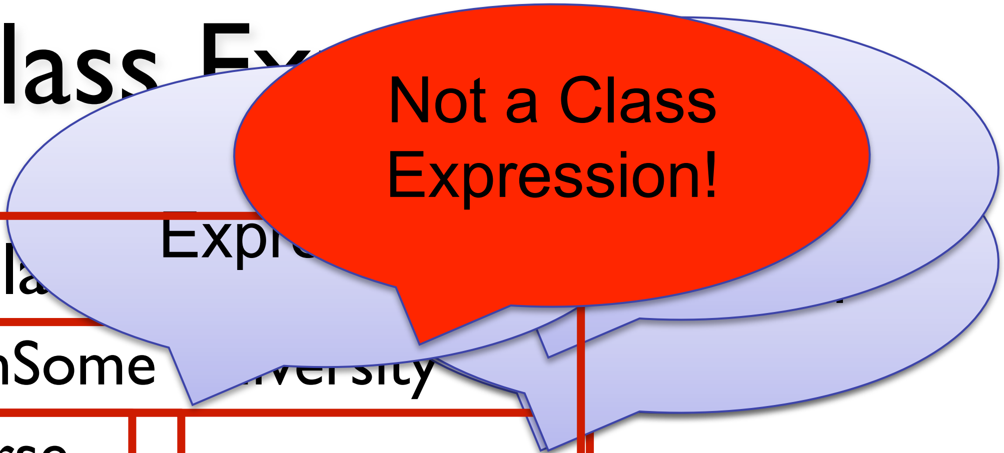
Ontology Formats

- The OWLOntologyFormat class represents a format used for concrete serialisation
  - E.g OWL RDF/XML
- The format may also contain information about the particular serialisation
  - E.g. namespace declarations
  - Ordering
  - Structural information
  - Helps in addressing problems with round-tripping
- If an ontology was parsed, the Manager maintains information about the original format of the ontology

Task 2+3

- Creating Entities and Axioms
- Saving the ontology

OWL Class Ex



- Student EquivalentCla
  Person and isEnrolledInSome
  and attends some Course

- This is an axiom!
- **A statement about the student class**.
- **A class expression** in logical terms is a complex concept (such as an “attends some Course”) or a class name (such as “Person”) and is **used in** axioms
- Axioms can be **true or false**, class expressions have **instances**

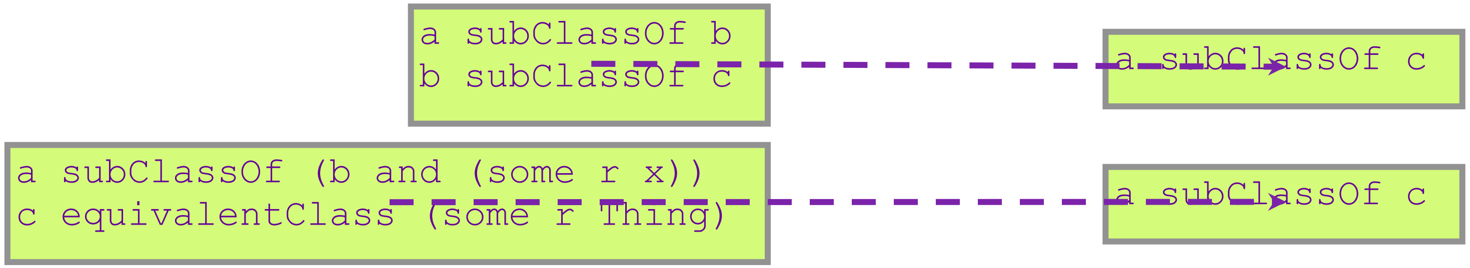
Task 4

- Working with more complicated class expressions and individuals

Inference

Inference

- OWL's semantics allows the possibility to perform inference or reasoning over an ontology
- A reasoner may be able to determine additional facts that follow from the information in the ontology
- How best do we expose this information?
  - Add it into the structure?
  - Provide alternative interfaces?



Reasoner Implementations

- OWLReasoner and OWLReasonerFactory
- Pellet and HermiT
  - Pure Java implementation
  - Implements OWL API reasoner interfaces
- FaCT++
  - C++ Implementation
  - Java wrapper
  - OWLAPI wrapper implementating OWL API interfaces

Nuts and Bolts

- OWL API code is available from github:

  https://github.com/owlcs/owlapi/releases

- Get the Examples.java!
  - https://github.com/owlcs/owlapi/wiki/Documentation
  - Click on Examples for 3.x → Examples.java
- Latest versions are in the git repository.

Task 5-7

- Some advanced things to look at:
  - Using a reasoner
  - Generating class annotations