University of St.Gallen

Institute of Computer Science

Web-based Autonomous Systems, FS2023
Danai Vachtsevanou, Andrei Ciortea
{firstname}.{lastname}@unisg.ch

Exercise 3: Web Ontologies and Knowledge Graphs

Deadline: **March 14, 2023; 23:59 CET**

In this exercise, you will gain hands-on experience with engineering Web ontologies and knowledge graphs. You will:

1.) complete a tutorial for creating an example OWL ontology with the Protégé ontology editor;

2.) design an OWL ontology for a domain of interest following an agile methodology for ontology development (the SAMOD methodology);

3.) use your ontology to populate a knowledge graph in GraphDB;

4.) complete a JaCaMo application in which autonomous agents are able to query a knowledge graph to retrieve knowledge about the world — and to use that knowledge to manage a farm.

(1) **Task 1 (3 points): Your First Web Ontology** Your first task is to familiarize yourself with the Web Ontology Language (OWL), and the Protégé ontology editor. Install Protégé 5.5[1], and then complete the Chapters 1-4 of the practical guide to building OWL ontologies linked to this footnote[2].

(2) **Task 2 (7 points): Design an Ontology for Smart Farming using the SAMOD Methodology**

The *Simplified Agile Methodology for Ontology Development (SAMOD)* is an agile methodology for developing ontologies through an iterative workflow inspired by and similar to test-driven development: new terms (classes and properties) are introduced gradually with the definition of new motivating scenarios. This allows ontology engineers to *define formally* only terms that are clearly motivated and to *test* their ontology against possible inconsistencies.

Your second task is to define formally and test new terms of an ontology for representing knowledge about the agriculture domain. All the required files for this task are available in this SAMOD directory[3] of the project template for this assignment. In a simplified view, the SAMOD methodology includes a sequence of steps to define:

1.) A *motivating scenario* in natural language that uses domain vocabulary in a real-world use case (e.g., a scenario in which a domain expert wants to manage their farm).

2.) A set of *competency questions* in natural language that a domain expert may ask in the context of the motivating scenario (e.g., "What are the dimensions of my farm?").

[1] You can download Protégé at https://protege.stanford.edu/

[2] Michael DeBellis. A Practical Guide to Building OWL Ontologies Using Protégé 5.5 and Plugins, Edition 3.2 (2021). Available online: https://tinyurl.com/NewPizzaTutorialV3-2

[3] SAMOD directory for Task 2: https://github.com/HSG-WAS-SS23/exercise-3/tree/main/SAMOD/agriculture-domain

3.) A *glossary of terms* (concepts and properties) that are required for describing the motivating scenario and defining the competency questions (e.g., `Farm`, `hasDimensions`, etc.).

4.) A *TBox* that defines formally the terminology captured by the glossary.

5.) An *ABox* as an example dataset describing the scenario specifics (e.g. describing that "`Farm` A `hasDimensions` [W,H]".

6.) A set of *queries* in a formal language, such as SPARQL, formalising the informal competency questions for testing the ABox and the TBox.

Task 2.1 (3 points): Define a glossary of terms and the related TBox You are provided with the description of a motivating scenario, a set of competency questions, a *preliminary* glossary of terms, and a *preliminary* TBox that corresponds to the provided glossary for the agriculture domain. Visit the README of the motivating scenario here[4] to read the provided scenario description and competency questions. Extend the glossary of terms in this README to define new terms that are required for describing the motivating scenario and defining the competency questions. Extend the TBox to formally define your new terms. You can open the current TBox file available here[5] in Protégé to work on top of the ontology we provide as a starting point.

Task 2.2 (3 points): Define an ABox and the related SPARQL queries You are provided with a *preliminary* ABox that implements the description that is required for solving the first 3 competency questions. Use the terms you defined for your TBox in the previous step to extend the ABox such that you complete the description of the motivating scenario.

Next, test your ABox. Upload your ontology from Task 1.1 to the GraphDB instance of our research group (use the repository under your name!)[6]. Then, formulate SPARQL INSERT queries to create an instance of your target domain based on your ABox, and execute the queries through the GraphDB interface of your repository. You are provided with example INSERT queries available here[7]. Finally, formulate SPARQL SELECT queries that formalize the competency questions, and execute the queries through the GraphDB interface of your repository. You are provided with example SELECT queries for the first 3 competency questions, available here[8].

Task 2.3 (1 point): Complete a JaCaMo application for the agriculture domain You are provided with a JaCaMo application in which autonomous agents have the design objective of managing a farm. A `moisture_detector` agent uses a tractor to monitor the moisture level of the soil in the land sections of the farm. In case the agent detects that the current moisture level is lower than the moisture level required by the crops growing in a land section, it informs an `irrigator` agent. The `irrigator` agent is responsible for reacting to such events and uses a tractor to irrigate the corresponding land section. Your last task is to complete the JaCaMo application so that agents are able to query your knowledge graph in GraphDB to retrieve knowledge about the farm – and to use the knowledge to achieve their design objective. Visit the exercise template's README[9] for more details about the source files you need to update for this task.

[4] Motivating scenario README: https://github.com/HSG-WAS-SS23/exercise-3/tree/main/SAMOD/agriculture-domain#readme

[5] TBox file: https://github.com/HSG-WAS-SS23/exercise-3/blob/main/SAMOD/agriculture-domain/tbox.ttl

[6] GraphDB: https://sandbox-graphdb.interactions.ics.unisg.ch/ uname/pwd: was-students/knowledge-representation-is-fun

[7] Example INSERT queries: https://github.com/HSG-WAS-SS23/exercise-3/tree/main/SAMOD/agriculture-domain/queries/insert

[8] Example SELECT queries: https://github.com/HSG-WAS-SS23/exercise-3/tree/main/SAMOD/agriculture-domain/queries/select

[9] Exercise README: https://github.com/HSG-WAS-SS23/exercise-3#readme

(3) Hand-in Instructions

By the deadline, hand in via Canvas a **zipfile** that contains:

1.) a Turtle file with a specification of your **OWL ontology for Task 1** ;
2.) a PDF file that includes the link to the GitHub fork containing your **code for Task 2**;
3.) any additional instructions for how to run your code (if non-obvious).