



# Phrase2Onto: A system for Ontology Extension

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## Abstract

Ontologies are used in semantically-enabled applications. However, these applications need high-quality ontologies to get good results. One of the aspects of quality in ontologies is completeness. By focusing on completeness in ontologies, we proposed a tool, *Phrase2Onto*, to support users in extending ontologies using a phrase-based topic model approach. In this tutorial, we demonstrate the latest version of the tool by extending Pizza ontology<sup>1</sup>.

## 1 What is an Ontology?

Ontologies represent a domain of interest by defining its concepts and the relationships that hold between them. They explicitly capture the knowledge for the domain of interest (modeling of knowledge). To illustrate what we mean by ontology, in Fig. 1 we have part of an ontology that model persons in academic environment ([PCROB21]). An ontology have some properties but the ones we will deal with in next steps are as below:

- Concepts (classes): they represent a group of objects (e.g. *Person*, *Student* and *Employee* in Fig. 1).
- Relations: They represent the connection between concepts (e.g. *SubclassOf* in Fig. 1). The kind of relation that has been used in our system, is **is-a**. An **is-a** relation denotes that a set of objects is a subset of another set of objects (Table. 1).
- Axioms: They represent facts that are always true in the area described by the ontology (e.g **Student subclassOf Person** in Fig. 1).

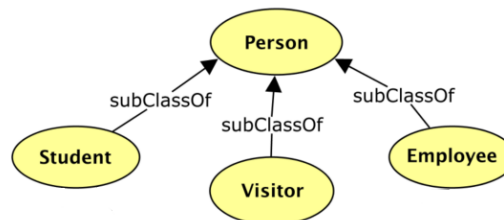


Figure 1: Class hierarchy in person ontology ([PCROB21])

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<sup>1</sup><https://protege.stanford.edu/ontologies/pizza/pizza.owl>

Sub-concept	relationship	super-concept
Pizza	is-a	Food
MargheritaPizza	is-a	NamedPizza
VegeterianPizza	is-a	Pizza

Table 1: Example axioms of Pizza ontology

### 1.1 Why do we need ontologies?

As one of parts of Semantic Technology (link data on the web that machine can understand that), ontologies are part of the W3C standards stack for the Semantic Web <sup>2</sup>. They provide users with the necessary structure to link one piece of information to other pieces on the Web of Linked Data. Because they are used to specify common modeling representations of data from distributed and heterogeneous systems and databases, ontologies enable database interoperability, cross-database search and smooth knowledge management. Moreover, ontologies function like a brain due to work and reasoning with concepts and relationships similar to the way humans perceive interlinked concepts.

### 1.2 What do we mean by ontology extension?

Adding concepts and axioms to an ontology is defined as ontology extension. We assume that we have a developed ontology and the goal is extending it by completing modeling of the knowledge covered by the ontology. Ontology extension is a process that can be done by a domain expert (user) or a group of users and it is not an automatic process. For example, in Fig. 1, we can extend the ontology by defining a new concept as *PhDStudent* and two new axioms as `PhDStudent SubClassOf Student` and `PhDStudent SubClassOf Employee` a subclass of *Student* and *Employee*.

### 1.3 Let us introduce Pizza Ontology!

Pizza ontology is a well-known ontology implemented by University of Manchester to provide an example ontology for educational purposes. It is implemented in OWL format (Web Ontology Language) using protégé which is an editing tool for ontologies. In Fig. 5, Pizza ontology with all its concepts and relations between concepts are shown. Some concepts in Pizza ontology are as *Food*, *Pizza*, *PizzaBase*, *PizzaTopping*. We are interested in extending *Pizza* and *Pizza Topping* concepts with sub-concepts and relations between concepts. For example, in Table. 1 we have three "is-a" relationships as axioms in Pizza ontology (Fig. 5).

## 2 Tutorial

One of the aspects of quality in ontologies is completeness. An ontology with lack of information may lead to missing inferences and thus incomplete results. One way to deal with missing information is extending the ontology. In our proposed tool, we can extend an ontology (e.g. Pizza ontology) by concept discovery and concept hierarchy derivation. One of the techniques that can be used is a phrase-based topic model approach. In this approach frequent phrases are collected from unstructured text (related to the domain of ontology). Further, phrases that often appear together, are collected in sets that represent a topic. These phrases and topics can be used for defining new concepts. In this tutorial, We exemplify the use *Phrase2Onto* using *Pizza ontology*. **Task:** We ask you to read carefully through the tutorial (make yourself familiar with pizza ontology and *Phrase2Onto* purpose).

**DO:** Ask as many questions as you need before and after the actual study.

**DO NOT:** Ask questions during the actual study.

### 2.1 How will we perform the user study?

To perform the user study, the procedure would be as:

- First step: we have provided this document to the user and ask the user to spend some time and go through the document.
- Second step: we will perform the actual study that we have booked the meeting for. In this session, there are some tasks that the user should follow and do them step by step.
- At the end of the actual study, we will ask about the user's reflections by filling out a questionnaire.

<sup>2</sup>The content of this section borrowed from <https://www.ontotext.com/knowledgehub/fundamentals/what-are-ontologies> with minor changes

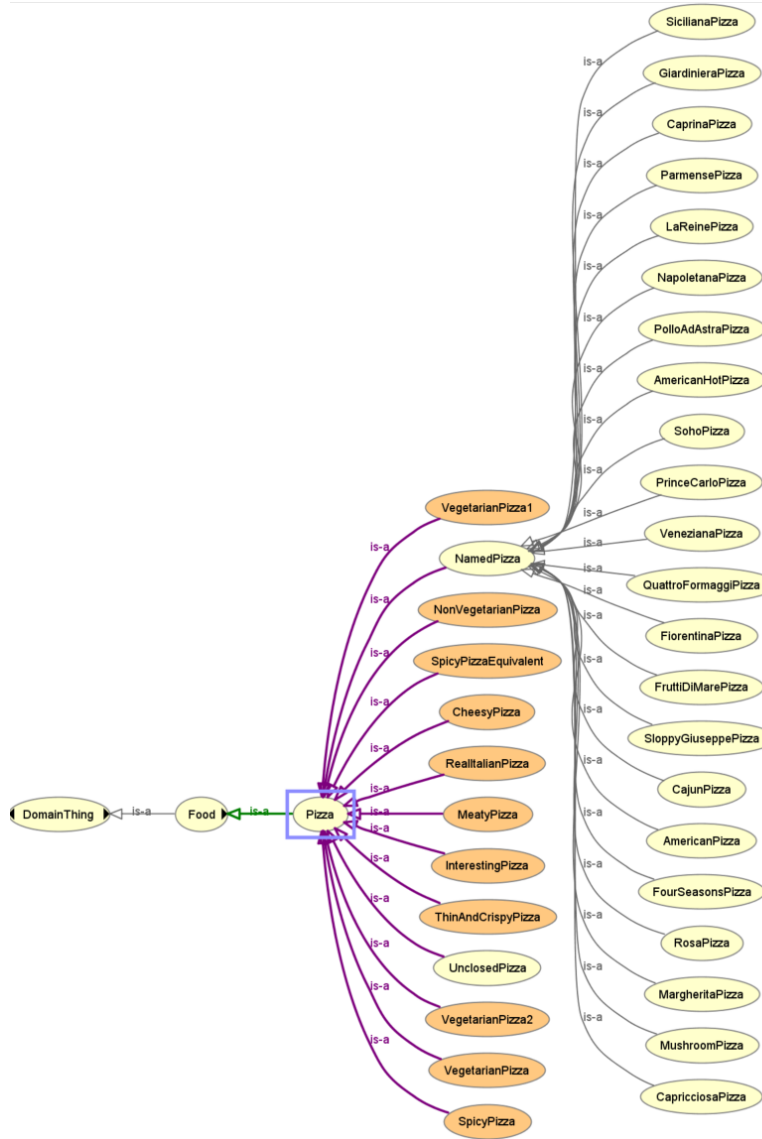


Figure 2: Sub concepts of Named Pizza

### 3 Let us introduce Phrase2Onto!

The purpose of the tool is to support the user in extending an ontology using the results of a phrase-based topic model approach as input. The tool supports the user in creating concepts from phrases and topics as well as in adding subsumption axioms related to the concepts. For example, consider we have phrase *Master Student* and a topic as {*Professor, Associate Professor, lecturer*} related to ontology Fig. 1. Then, we can add *MasterStudent* as a new concept and as sub-concept of *Student*. Moreover, we can define a label for the example topic as *Academic* and add *Academic* as sub-concept of *Employee*.

In *Phrase2Onto*, different steps in the workflow for extending ontologies are represented by five separate tabs: *Set-up*, *Phrases→Concepts*, *Topics→Concepts*, *Concepts* and *Concepts→Axioms* (Fig. 3).

#### 3.1 What are the input files to Phrase2Onto?

The inputs of *Phrase2Onto* are loaded as three categories :

- **The ontology:** this is the ontology that we want to extend and is a single file in OWL format.
- **Frequent phrases:** it is a text file of phrases. There are some methods to extract frequent and significant phrases from text (related to the domain of interest, for example related papers). But we do not explain these methods in this document.
- **Topics:** Each topic is a set of phrases (text file) which are connected to each other in some way. For example, set of all spicy topping for pizza can be a topic.

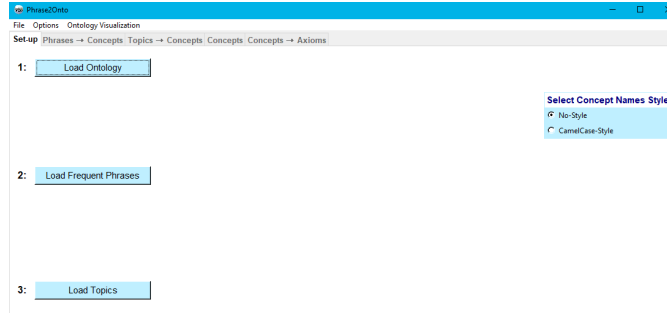


Figure 3: *Set-up* tab as main window of *Phrase2Onto*

We assume frequent phrases and topics are generated before and we just load them in *Phrase2Onto* workspace.

### 3.2 A brief introduction to the workflow of Phrase2Onto

- **Set-up:** In this tab, the ontology, the phrases and the topics are loaded (Fig. 3). Also, the concept name style can be chosen between two available options (This would be applied when defining new concepts).
- **Phrases→Concepts:** The focus of this tab is on defining new concepts based on the phrases. There are two options when defining a new concept based on a phrase as **Use the phrase itself** and **Define new form of the phrase**.
- **Topics→Concepts:** In this tab new concepts can be defined that are related to topics or sub-topics. The user can select phrases from each topic and label them with a *Topic label*.
- **Concepts:** In this tab, new concepts can be defined that are not necessarily connected to a phrase or topic. This was a request by domain experts in previous experiments as they sometimes, when adding concepts connected to the phrases and topics to the ontology, also wanted to add other related concepts to the ontology that were not directly connected to phrases and topics.
- **Concepts→Axioms:** In this tab the user can define axioms (Fig. 4). There are two options that the user can have the selected phrase as sub- or super-concept of the new axiom (Fig. 4).
- **Additional functionalities:** Other functionalities are implemented for creating, opening and saving files, searching phrases, concepts and axioms and displaying information regarding and a simple Ontology Visualization (File, Options and Ontology Visualization in the menu bar in Fig 4).

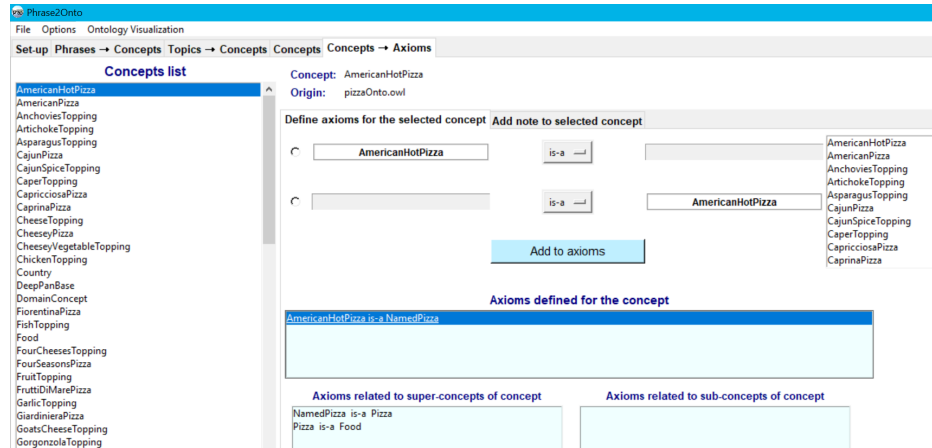


Figure 4: *Concepts→Axioms* tab of *Phrase2Onto*

## References

- [PCROB21] Josué Padilla-Cuevas, José A Reyes-Ortiz, and Maricela Bravo. Ontology-based context event representation, reasoning, and enhancing in academic environments. *Future Internet*, 13(6):151, 2021.

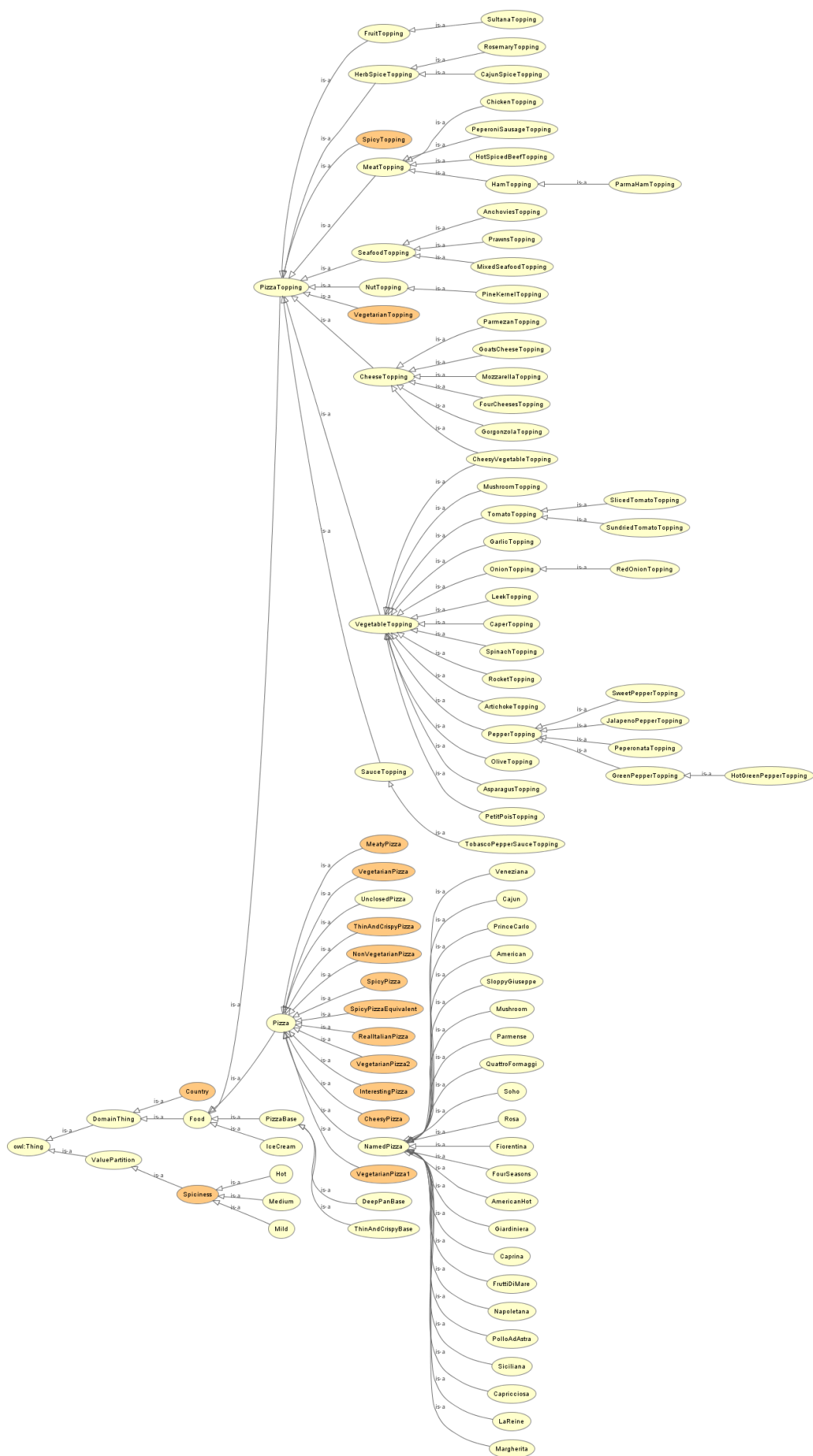


Figure 5: Pizza Ontology

## 4 Tasks

### 4.1 Scenario

In this scenario, you want to extend *Pizza Ontology*. You have an input folder named as **InputFolder** which consists of two files as : *PizzaOnto.owl*, *FrequentPhrases.txt* and a *Topics* folder (a folder of topics which are text files, you will need to load all files in **Topic** when **Load Topics**.).

### 4.2 Task 1

**Purpose: load necessary files and save the project.**

- select **Set-up** tab.
- Load the input requested files (**1: Load Ontology**, **2: Load Frequent Phrases** and **3: Load Topics** buttons) on **Set-up** using the files in **InputFolder**.
- In part **Select Concept Names Style** : We are interested in **No-Style** for concept names.
- Then, save the project as a new project (using the menu bar, **File**→**Save**).

### 4.3 Task 2

**Purpose: Define new concepts based on phrases.**

**Note:** You can use Ctrl+F to open the **Find** window or using the menu bar (**options**). You use **Find** window to search for the phrases or concepts mentioned in some tasks. There are three options you can choose to search for as **Find in Phrases**, **Find in Concepts** and **Find in Axioms**.

- Select **Phrases**→**Concepts** tab.  
Select phrase "**Hawaiian**" from **Phrases list**.  
Select **Define concept from selected phrase** sub-tab.  
Define the new concept "**HawaiianPizza**" (this is a variant of the phrase, so select the correct option as **Define new form of the phrase**).  
Then press **Add to concepts** button. You see that the new concept would be displayed under **Extracted Concepts from Phrase**.
- Go to **Focus on selected phrase** sub-tab.  
Press **Matching** button and find all matched phrases of **Hawaiian** phrase as list **Matched phrases**. You will also have **Matched Concepts** (Please note that these two lists are clickable and you can click on each item that will direct you to the phrase or concept in **Phrases list** or **Concepts list**).
- In **Phrases list**, select "**Hawaiian**" and mark it as done by: using the pop-up menu in **Phrases list** as select the desired phrase first and right-click on selected phrase and choose **Mark as Done** from pop-up menu or using **Mark phrase as DONE** button displayed on top of sub-tab).
- Mark one of the matched phrases with **Hawaiian** phrase as done (You can click on the matched phrase that will direct you to the phrase in **Phrases list** or find it using **Find** window.)
- Add a note to "**Hawaiian**" phrase ("**Hawaiian**" should be selected from **Phrases list** and displayed in front of **Phrase:** on top of the tab), select **Add note to selected phrase** sub-tab and as comment write: **Hawaiian pizza is a pizza originating in Canada, and is traditionally topped with pineapple, tomato sauce, cheese, and either ham or bacon** and then press **Save Note** button.

### 4.4 Task 3

**Purpose: Define new concepts based on phrases**

- Select "**Meatball**" phrase in the **Phrases list** (you can use **Find** window, please note that when you use find, the searched phrase background would be light blue and you should click on it in the list to select it).  
Go to **Define concept from selected phrase** sub-tab, select option **Use the phrase itself** and press **Add to concepts**.
- Select "**Margherita**" phrase from **Phrases list**.  
Select **Define concept from selected phrase** sub-tab.  
In **Relate Concepts to Phrase** part, relate it to "**MargheritaPizza**" concept and press **Assign** button.

- Select **"lemon chicken"** phrase from **Phrases list**.  
Select sub-tab **Focus on selected phrase**.  
Find the matched concepts of **"lemon chicken"** and keep it in mind.  
Then, select **Define concept from selected phrase** sub-tab.  
Relate the matched concepts you found to the phrase.

## 4.5 Task 4

**Purpose: Topic labelling and define concepts from topic labels.**

- Select **Topics→Concepts** tab. From topic list (combo-box), select **"topic2"**.

**Info:** Double click on each phrase or select and right click on it (phrases displayed under **Select the Topic List**) to add it to representative phrases or remove them from representative phrases list if they are already added to it.

- In **Topic Labelling** sub-tab, select **"Vegan sausage"**, **"Vegan pepperoni"** and **"Vegan bacon"** as **"Representative phrases"**, and as **Topic label type "PlantProtein"**.  
As comment write: **"Vegan meat also called faux, fake, mock, meat analogs, or plant proteins."**.  
Then add it to topic labeling list by using button **Add to topic Labelling list**.
- Add **"PlantProtein"** to concepts by select it under **"Topic labels"** part and right-click on it. Then choose **Create concept from topic label**.

## 4.6 Task 5

**Purpose: Add Topic labelling Info**

- Label **"Pepperoni"**, **"Sausage"**, **"Bacon"**, **"Ham"** and **"Salami"** (in topic2) as **"PreservedPork"** (**Topic label**) and add it to topic labelling list.
- **Ohhh, we forget to add a comment to "PreservedPork" topic label.** Please edit the topic label **"PreservedPork"** by selecting it under **Topic Labels** part and right-click on it. As comment write **"From wikipedia: Ham, gammon, bacon, and sausage are examples of preserved pork. Charcuterie is the branch of cooking devoted to prepared meat products, many from pork."**. Then press **Add to Topic Labelling list**.

## 4.7 Task 6

**Purpose: Define a new concept that is not connected to phrases**

- Select **"Concepts"** tab.
- In **Define new concept**, define a new concept as **"GlutenFreePizza"** with comment **"A pizza without wheat flour and contains less than 20 ppm of gluten"** and add it to concepts.
- Define new concept **"KebPizza"** and add it to concepts.
- **Ohhh, no, you do not want to have "kebPizza" in the ontology.** Now, find it in concepts list. Select it and delete it by right-click on it and using the pop-up menu.

## 4.8 Task 7

**Purpose: Define axioms (relationships between concepts).**

- Select **Concepts→Axioms** tab.
- Select **"Hawaiianpizza"** concept from **Concepts list**.  
In **Define axioms for the selected concept**, choose the first option (first radio button).  
In the text box next to **is-a** type **NamedPizza** (you are defining axiom **HawaiianPizza is-a NamedPizza**) and add it to axioms using **"Add to axiom"** button.

- Please answer to this question: What are super concepts of "HawaiianPizza"?  
(You can refer to its axioms which is a clickable list (**Axioms defined for the concept** part). Then click on the displayed axioms. Then related axioms to super- and sub-concepts of it would be displayed in related parts (**Axioms related to super-concepts of concept** and **Axioms related to sub-concepts of concept**))

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## 4.9 Task 8

**Purpose: Display information using menu bar**

- Display topic labelling info (use menu bar, **Options**).
- Export topic labelling info as a text file (use menu bar, **Options**).

## 4.10 Task 9

**Purpose: Work with menu bar and tabs**

- Save the changes to the project (use **File**).
- Now, you want to add a new topic label. Select **Topics→Concepts** tab. Define a topic label for **topic13** with the Representative phrases that you want and write a comment for it.
- Define a topic label for **topic8** with the Representative phrases that you want (optional: write a comment for it).

## 4.11 Task 10

**Purpose: Relate concept to phrase**

- Find phrase "Nutella pizza with bananas and strawberries" in **Phrases list**.
- Find the matched concepts of it (using **Phrases→Concepts** tab, sub-tab **Focus on selected phrase**). Are there any concept that you can relate it to "Nutella pizza with bananas and strawberries" or do you want to add a new concept based on this phrase?

## 4.12 Task 11

**Purpose: Ontology visualization (in menu bar)**

- Visualize the ontology.
- Can you find the concepts you have added to the ontology?

## 4.13 Task 12

**Purpose: Find sub- and super-concepts of a concept**

- Please answer to the following question: What are sub and super concepts of concept "**FishTopping**"? (you can use **Concepts→Axioms** tab)

Sub-concepts: -----

Super-concepts: -----