NeOn: Lifecycle Support for Networked Ontologies

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D4.5.5 Revision and integration of Neon Toolkit plug-ins for visualisation and navigation into NeOn infrastructure

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Change Log

Version	Date	Amended by	Changes
1.0	16-02-2010	Silvio Peroni and Ning Li	Initial draft
1.2	18-02-2010	Enrico Motta and Mathieu d'Aquin	Pre-final draft
1.3	19-02-2010	Enrico Motta	Final draft

Executive Summary

This report describes the revised version of KC-Viz, a plugin for the NeOn Toolkit, which provides an innovative approach to visualizing and navigating ontologies. In particular, this new version of KC-Viz provides a more flexible and comprehensive set of functionalities for key-concept-based navigation of ontologies than the earlier version and also addresses the performance and scalability issues exhibited by it. In addition, this new version is also compliant with the new API of the NeOn Toolkit, which is based on the OWL API. In the document we describe and document all the features of the plugin and as a result this report can also be used as a reference manual for using the tool. In addition, we also provide a brief overview of the application of the Key Concept Extraction (KCE) algorithm, to provide quick visual ontology snaps in Cupboard and Watson.

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1   Introduction

The Semantic Web is growing fast and is rapidly emerging as a large-scale platform for publishing and sharing formalized knowledge models. It already contains a large amount of data, measured in millions of semantic documents and billions of triples. In addition, our analysis of the semantic documents crawled by the Watson Semantic Web search engine[1] shows that hundreds of ontologies containing several thousands of classes have been published online in the last few years. Given such large scale availability of ontologies, ontology reuse is becoming commonplace and indeed tools such as the Watson plug-in for the NeOn toolkit are now available, which facilitate the task of locating and directly integrating ontologies or ontology fragments, which are relevant to an ontology under development.

In this reuse-centric context, it is highly desirable to have mechanisms that can efficiently help users in making sense of the content of an ontology. However, the empirical studies carried out in the NeOn project [2][3] show that the visualization and navigation facilities available in today's ontology engineering environments are not necessarily able to provide effective overviews of ontologies and often end up hindering rather than helping users. In particular our analysis shows that, not surprisingly, this is a problem especially for non-expert users.

To address this issue in NeOn we have developed a novel approach to visualizing ontologies, which exploits automatically created ontology summaries, based on the idea of *key concepts* [5]. Informally, key concepts can be seen as the best descriptors of an ontology, i.e., the most information-rich concepts[2], which are most effective in summarizing what an ontology is about. As described in [5], our algorithm for identifying key concepts in an ontology combines a number of criteria, drawn from cognitive psychology, lexical statistics and from the formal properties of an ontology.

The initial version of the KC-Viz tool for ontology visualization and navigation based on key concepts was presented in the NeOn Deliverable D4.5.4 [4]. In this document we present a revision of KC-Viz, which improves over the earlier version, in particular by providing a more flexible set of functionalities for key-concept-based navigation of ontologies and also by addressing the performance and scalability issues exhibited by the earlier version. In addition, this new version is also compliant with the new API of the NeOn Toolkit, which is based on the OWL API. In what follows we provide an overview of the new version of the KC-Viz plugin, which is compatible with version 2.1 of the NeOn Toolkit, or above.

2   Key Concepts Visualizer (KC-Viz)

2.1 Generating an initial ontology summary

KC-Viz can be installed in the NeOn Toolkit (NTK), just as any other NTK plug-in, by going to "Help > Software Updates > Find and install". Once installed, it can be invoked by right-clicking on an ontology and then selecting the "Visualize Key Concepts" menu item - see figure 1.

As shown in figure 2, a tree comprising 15 classes is produced, which provides an overview of the ontology in question. Here we are using the AKT Portal ontology, an ontology developed in the AKT project[3], which contains 152 classes locally and imports 16 classes from another ontology, called "Support". The ontology summary shown in figure 2 contains concepts from both ontologies. If we wish only to generate a 'local view' of an ontology, we can do so by unticking the option

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[1] http://watson.kmi.open.ac.uk.

[2] In this report we will use the terms "concept", "class", and "node" interchangeably, given that when applying the Key Concept Extraction algorithm to OWL ontologies, the "key concepts" analysed by the algorithm are actually OWL classes, and the KC-Viz tool displays classes/key concepts as nodes in a graph.

[3] http://www.aktors.org.

"Ontology summary considers also imported ontologies" in the KC-Viz preference menu. Analogously, also the number of key concepts used when generating an ontology summary is user-definable and can be set either through the KC-Viz preference menu or when clicking on the "Reset key concepts" button, which is part of the KC-Viz toolbar and can also be used to re-generate an overall ontology summary for the current ontology.
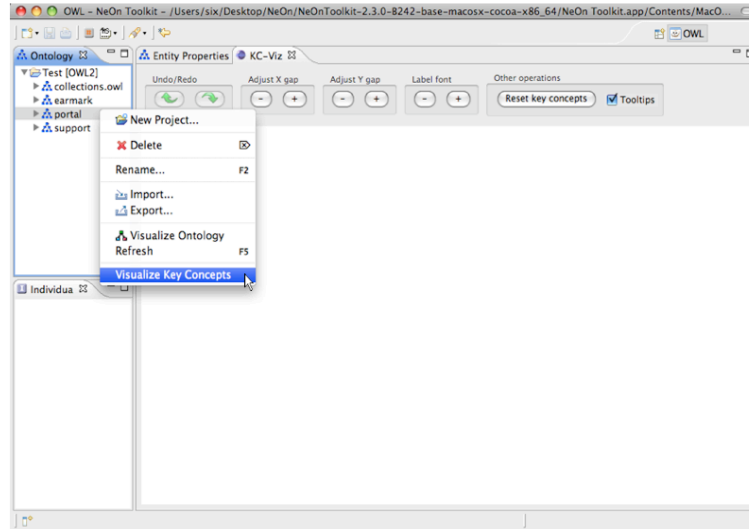

Figure 1. Generating ontology summaries.

Each concept is shown as a blue hexagon of a particular dimension, according to its key concept score, followed by a label containing its name and two numbers in brackets. These represent the number of direct and indirect subclasses of the node in question.
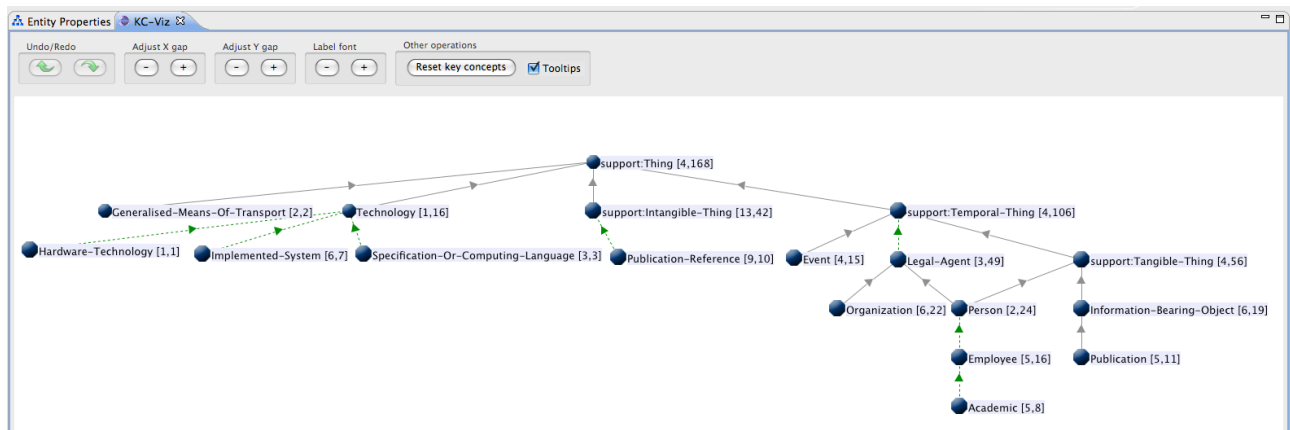

Figure 2. An ontology summary for the AKT ontology.

An important aspect of this new version of KC-Viz is that, when generating ontology summaries, the algorithm may also include concepts whose overall 'importance score' does not necessarily qualify them as key concepts. This can happen for two reasons. Firstly, concepts can be added to improve the topological coverage of the ontology – i.e., to maximise the number of concepts in the ontology which are either subclass or superclass of a concept included in the ontology summary. Secondly, concepts can be added to maximise the topological coherence of the generated ontology summary – i.e., to ensure that no 'islands' exist and that every concept is connected to the other concepts in the summary. Although this hypothesis will have to be verified empirically, our intuition is that maximising coverage and providing an overall coherent taxonomy of concepts is crucial to ensure that the user can get an overall gestalt of the entire ontology, much like coarse-grained geographical maps may only show the key cities, but of course situate them in the overall

context of their countries. An option in the KC-Viz preference menu allows the user to set the maximum number of non-key concepts to be used to maximise topological coverage – the default is 2.

If we hover the mouse cursor on concepts and on indirect subClassOf link, a yellow label appears describing:

- for concepts, its type ("Key concept", "Very important concept", "Quite important concept" or "Not-so-important concept"), its complete URI, and the number of direct superclasses and subclasses linked to it in the ontology ("actual") and in the visualization ("shown").
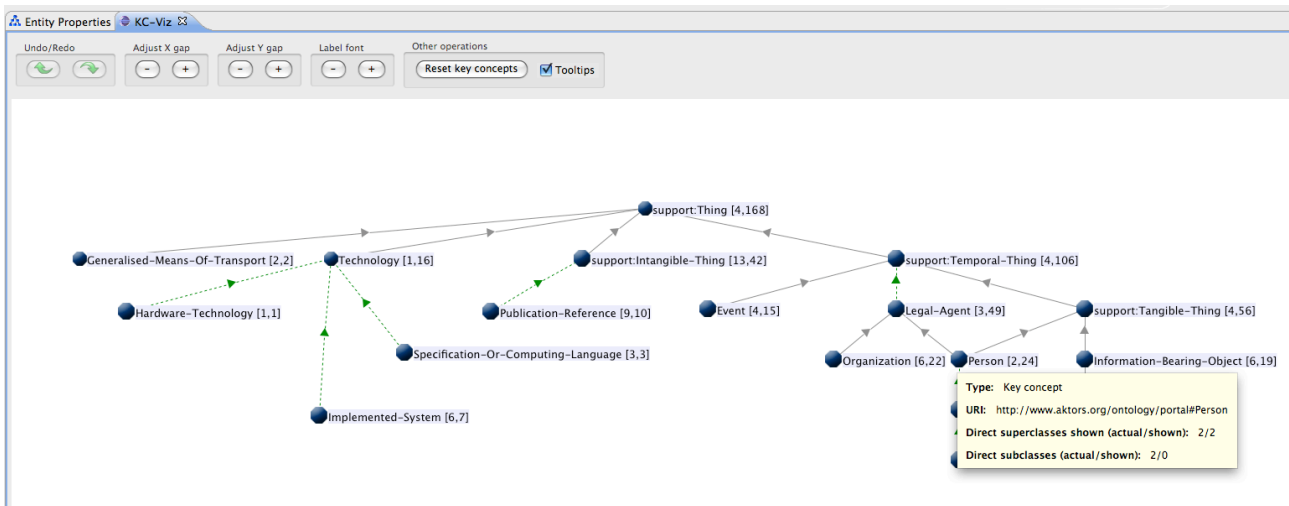- for indirect links, all the subClassOf paths from the source concept to the destination one.

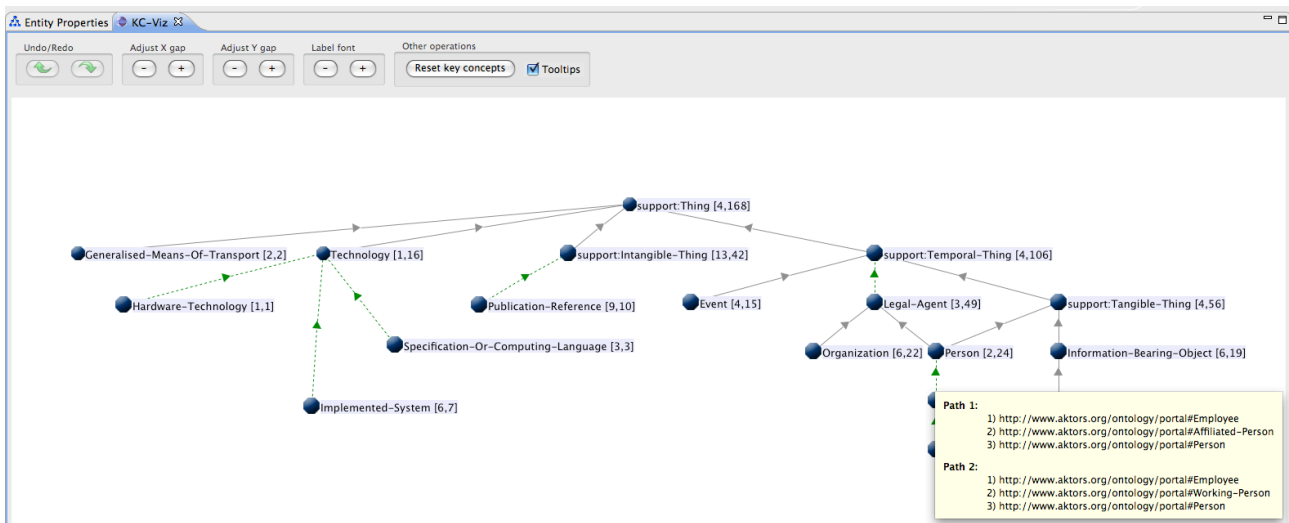**Figure 3.** Summary information about a concept in the visualization.

Figure 4. Detailing indirect subClassOf relations.

2.2 Selection and movement

Selecting concepts can be done in two different ways:

- by clicking on nodes;
- by double-clicking on the background, moving the cursor to enlarge the rectangle in order to enclose the concepts we are interested in and, finally, clicking to terminate the selection[4].

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[4] In order not to lose the current selection, the user can press "Shift" when double-clicking to add a new selection.

For example, figure 5 shows a situation in which we have selected Publication-Reference and we also want to add to the selection part of the subtree of support:Temporal-Thing. Selected nodes are highlighted using a dark-grey background for their labels.
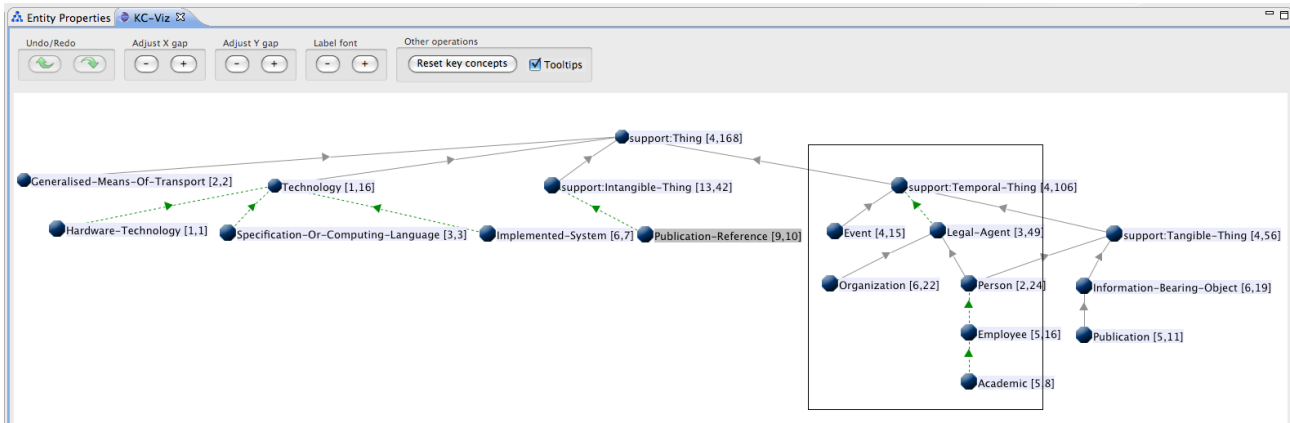
Figure 5. Multiple node selection.

Once one or more nodes have been selected, we can move them simply by clicking left on one of the selected nodes and then moving the cursor to the new desired location for the nodes in question. If we want to move the entire hierarchy, we can do so by clicking on the background and moving the cursor within the pane.

2.3 Operations on concepts

By clicking right on a concept, we have access to the three basic operations on concepts: inspect, expand, hide – see figure 6. These are described in the following sections.
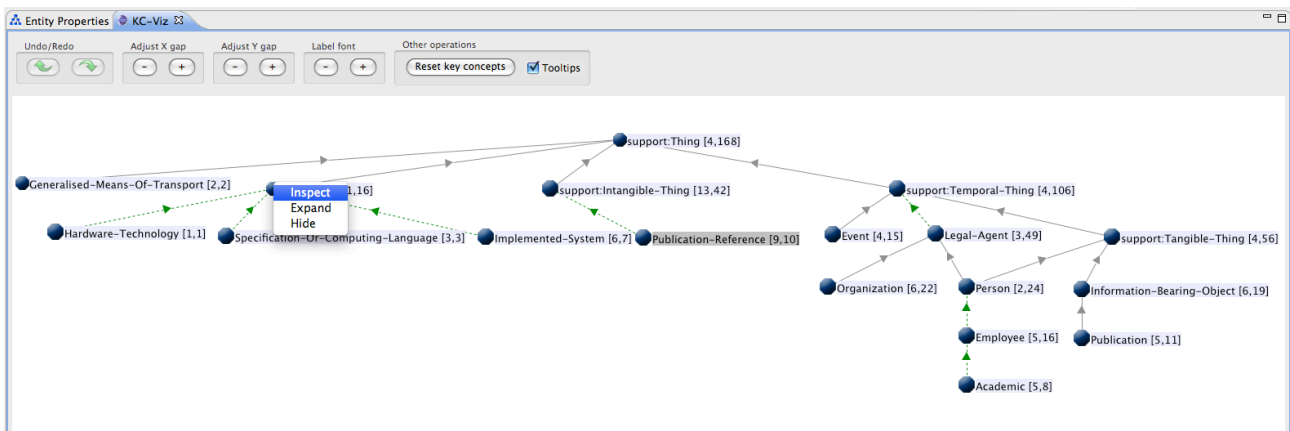
Figure 6. Operations on concepts.

2.3.1 Inspect

This operation does not change the topology of the hierarchy but simply opens the Entity Properties view with the data concerning the concept in question. To perform this operation, we right-click on a concept and select the "Inspect" menu item, as shown in figure 6. As a result, the focus changes and the concept in question can then be inspected through the Entity Properties view of the NeOn Toolkit – see figure 7.
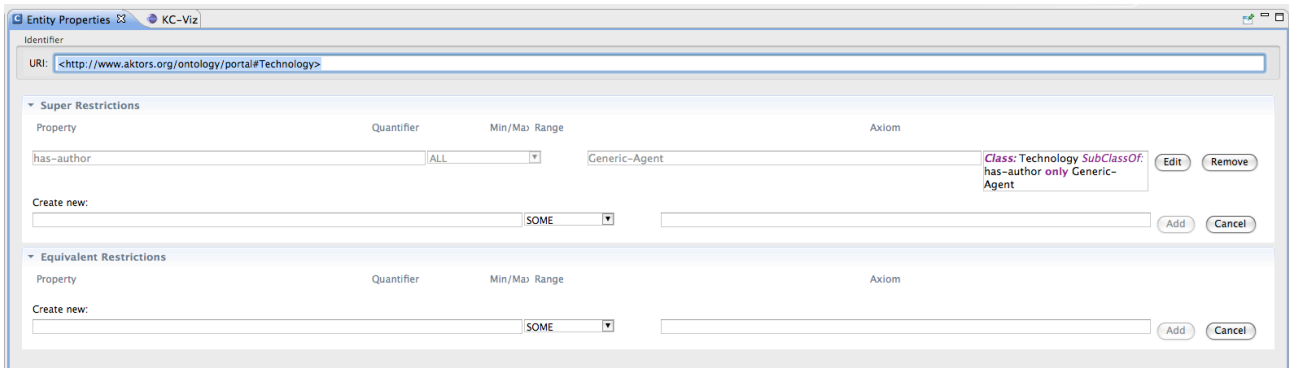
Figure 7. Entity Properties view.

2.3.2 Node expansion

Node expansion is carried out by right-clicking on a node and selecting the "Expand" menu item. In contrast with the "Inspect" operation, which can only be applied to one particular node, multiple nodes can be expanded at the same time. That is, an expansion operation is applied both to the node on which we have clicked to access the "Expand" menu item and also to any other currently selected node.
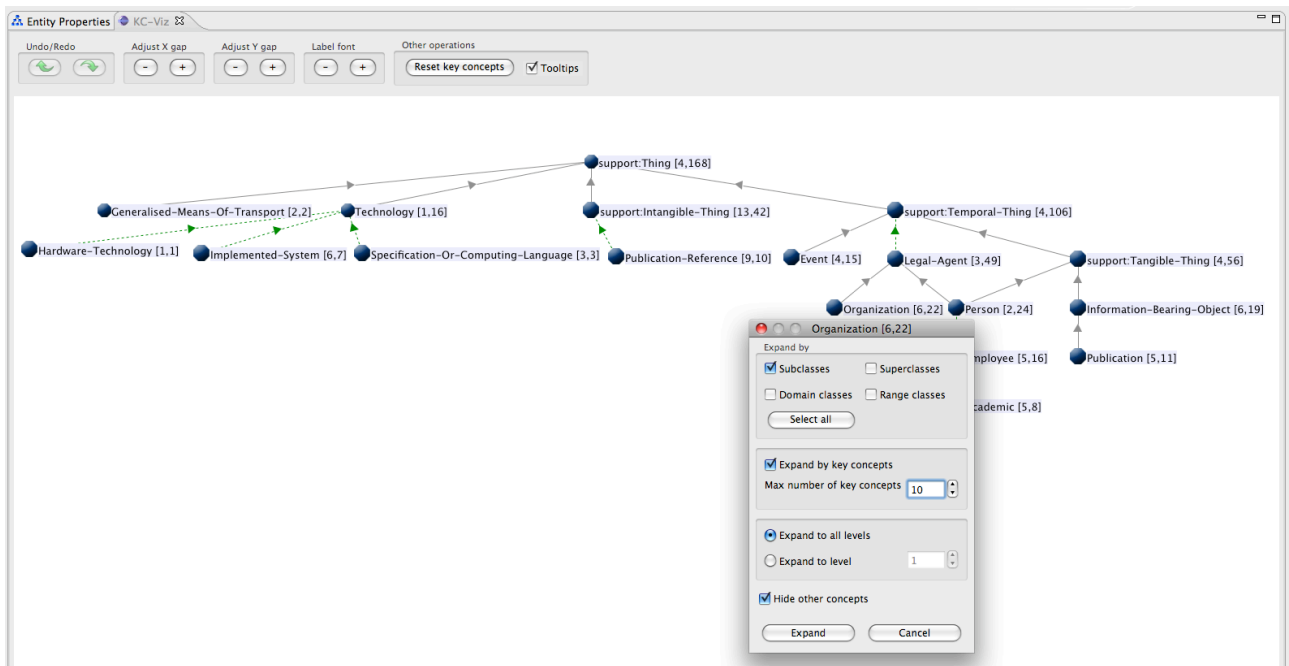

Figure 8. Options for node expansion.

KC-Viz provides a flexible set of options for carrying out node expansion and aims to give the user as much control and flexibility as possible, to support the crucial task of 'zooming in' into a class. Figure 8 shows the menu associated with the "Expand" operation, which provides the following options:

- The option "Expand by" allows us to choose which relations we want to take into account when expanding concepts. We can choose any combination of subclasses, superclasses, domain classes – i.e., all those concepts that are domains of object properties whose range include a concept selected for expansion, and range concepts – i.e., all those concepts that are ranges of object properties whose domain include a concept selected for expansion.

- The option "Expand by key concepts" allows us to choose whether we want to focus expansion on key concepts or not. If we choose this option, we can then specify the size of

the expansion set. If the option "Expand by key concepts" is not selected, then the entire expansion set determined by the other options is returned.

- The two radio buttons in the third pane of the expansion menu allow the user to circumscribe the expansion to a specific number of levels, e.g., only direct subclasses, or to recursively continue the expansion until the leaves (in the case of expansion through subClassOf links) or the root (in the case of expansion through superClassOf links) of the Isa hierarchy below/above the node selected for expansion are reached. It is important to note that in the case of domain/range expansion only level 1 expansion is allowed and therefore this option is not relevant.

- The option "Hide other concepts" makes it possible to hide all the concepts currently shown in the hierarchy that are neither the node selected for expansion or are not included in the set specified by the chosen expansion options. This option is very important to allow user to 'zoom in' on a concept and remove any node from the display, which is not relevant to the current exploration focus.

As an illustration in figure 9 we show the result of expanding class Organization in the AKT ontology, using the options shown in figure 8. Intuitively, what we want to do here is to focus on the subtree under class Organization and get an initial snap of what classes it contains. To do so we choose to expand only by subclasses, we expand at all levels, but we only ask KC-Viz to give us the 10 most important concepts under Organization, thus reducing the size of the resulting subtree by over 50% - the tree under Organization contains 22 classes.
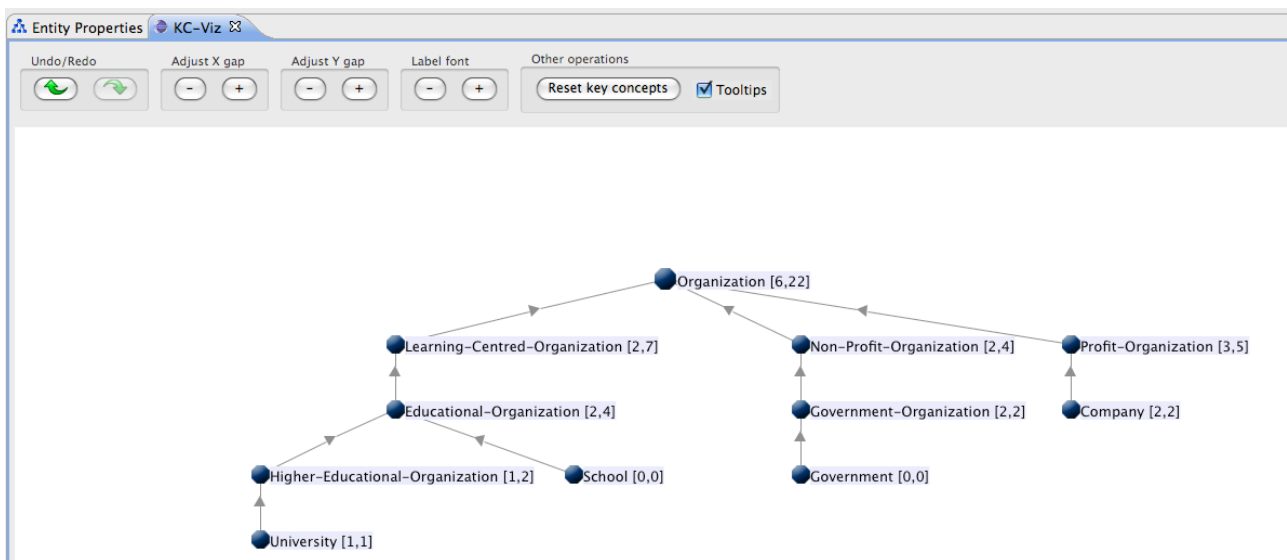

Figure 9. Expanding class Organization

If we also include the option to expand by domain, then the result also includes classes Affiliated-Person and Employee which are linked to Organization by the relations has-affiliation and works-for – see figure 10. As shown in the figure, domain/range relations are displayed as directed links in red. When we hover the mouse cursor over these links, a label appears giving us the URI of the property in question.

Note that double-clicking on a concept results in the execution of the expansion operation with the same setting as the previous one.
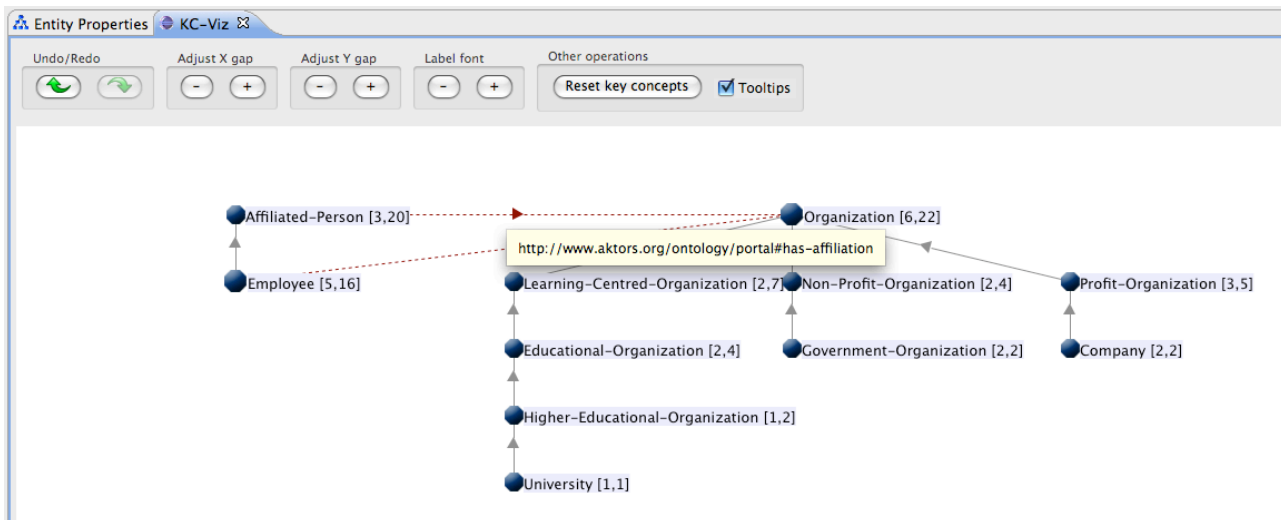
Figure 10. Adding domain links to the expansion of class Organization

2.3.3 Hiding nodes

As in the case of the expansion operation, the "Hide" operation is applied to both the node on which we have clicked to access the "Hide" menu item and also to any other currently selected node. Figure 11 shows the menu associated with the "Hide" operation, which allows the user to specify whether we want to hide the selected class ("Current class" box) and also which relations we want to use to identify other nodes to be hidden. For instance, we can hide all the direct subclasses of a class by selecting the option "subclasses" in the menu. Finally, the option "Hide recursively" repeats the operation recursively, thus allowing, for instance, to remove all subclasses (both direct and indirect) of a node from the display.
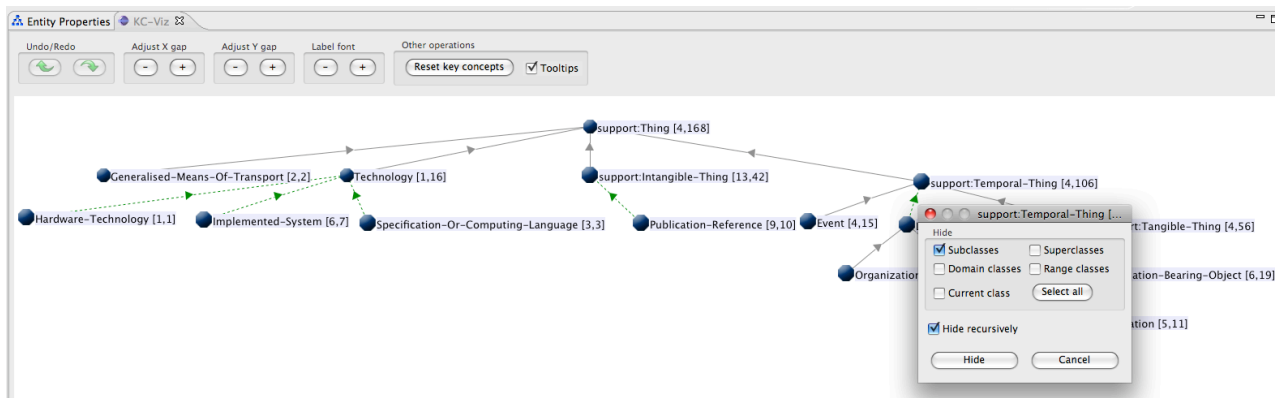

Figure 11. Options associated with the "Hide" operation

Figure 12 shows the result of applying the operation showns in figure 11 – i.e., hiding all subclasses under class support:Temporal-Thing.
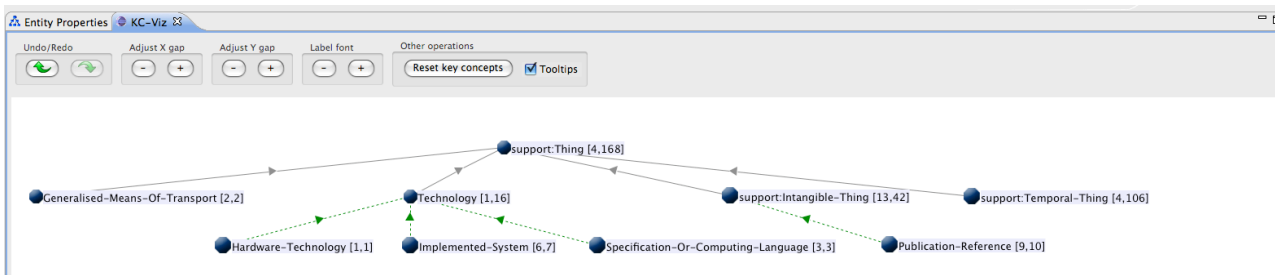

Figure 12. Hiding the subtree under class support:Temporal-Thing

2.4 The KC-Viz toolbar

The KC-Viz toolbar provides the following operations:

- Undo/Redo. These allow the user to undo/redo expansion and hiding operations. However they do not apply to other operations, such as manually moving a node.
- Tooltips. This checkbox allows the user to enable/disable tooltips.
- Adjust X gap. This option adjusts the horizontal distance between nodes at the same level of the currently displayed hierarchy.
- Adjust Y gap. This option adjusts the vertical distance between the different levels in the currently displayed hierarchy.
- Label font. This option makes it possible to increase/decrease the font used for displaying the labels of the nodes.
- "Reset key concepts". This option allows the user to recalculate the ontology summary, possibly modifying key parameters, such as the total number of key concepts and the maximum number of non-key concepts, which are used to ensure the topological coherence of the tree.

2.5 KC-Viz Preferences

The KC-Viz preference menu, which is accessible by clicking on NeOn Toolkit > Preferences, and is shown in figure 13, provides the following options:

- "Max size of ontology summary". The maximum number of key concepts we want to include in the ontology summary.
- "Max number of non-key concepts to be used to maximise coverage of subclass-of tree, when generating ontology summary". This option can be used to specify how many non-key concepts we are prepared to add to the ontology summary, to maximise the coverage of the entire ontology with respect to subClassOf relations.
- "Default size of subtree when expanding class". The default number of concepts to be used when expanding a class, using the subClassOf relation.
- "Use sub-optimal (but very efficient) algorithm when the number of classes in the ontology in higher than". This option allows the user to select a very efficient but sub-optimal version of the algorithm for key concept extraction, which is recommended for very large ontologies.
- "Ontology summary considers also imported ontologies". This option allows the user to specify whether an ontology summary should only include 'local concepts' or whether imported ontologies should be considered as well.
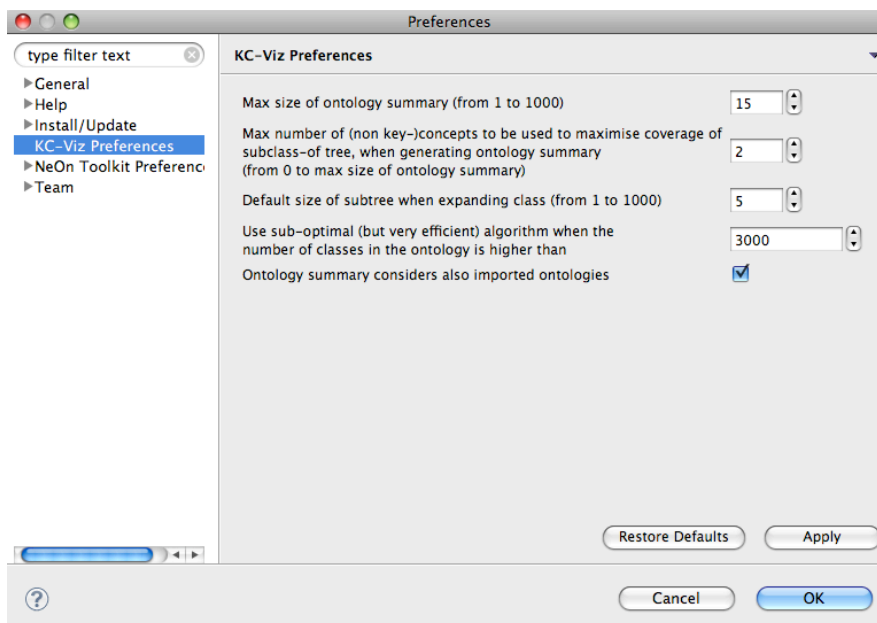
Figure 13. The KC-Viz preference menu

3   Integrating Key Concept Extraction in Cupboard and Watson

Besides providing better support for exploring ontologies within the NeOn Toolkit, an important application of key concept extraction is to offer concise, easy to understand summaries of potentially big ontologies. Such summaries are particularly useful in systems where the user needs to obtain a quick overview of the content of multiple ontologies, for example for the purpose of ontology selection. For this reason, we developed a service to generate small, concise snapshots of key concept-based visual summaries of ontologies, to be used in the Cupboard [1] and Watson systems.

Figure 14. Visual summary of the SWRC ontology, as shown in an ontology space in Cupboard.

In principle, this service is based on ideas similar to the ones implemented by KC-Viz. However, in contrast with KC-Viz, it is limited to providing small, static images that capture what is intended to be the "core" of a given ontology.

The service takes as input the URI of an ontology which has to be present either in Watson or Cupboard, and produces a small image displaying the names of the top six key concepts in this ontology - see Figure 14. The images also display links between the concepts, to represent the fact that they are connected. These links do not represent any particular relation, but give instead an indication of existing relations or paths that connect the two concepts in question. In addition, the size of the label associated to each concept denotes the importance of the concept according to the key concept extraction mechanism.

Technically, this service is implemented as a simple REST API, which takes as parameter the URI of the ontology, and redirects the client to a png image, which is either generated on the fly, or stored as a result of a previous invocation.

Thanks to this service, visual summaries are provided for ontologies included in ontology spaces in the Cupboard system. As an illustration, figure 15 shows part of the ontology space associated with the ontologies for the Semantic Nomenclature case study in NeOn. Hence, the user can get a quick overview of the content of a collection of ontologies, which can be useful to quickly identify a particular ontology in a potentially large collection. The service has also been used in the web interface of Watson, to show a summary of an ontology's content in the page showing the key metadata of the ontology.
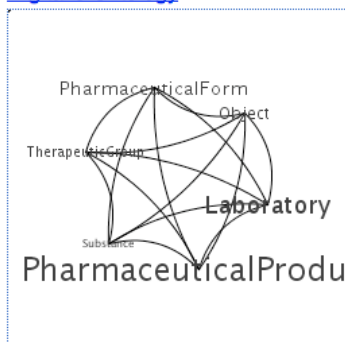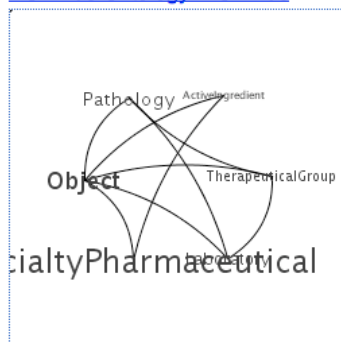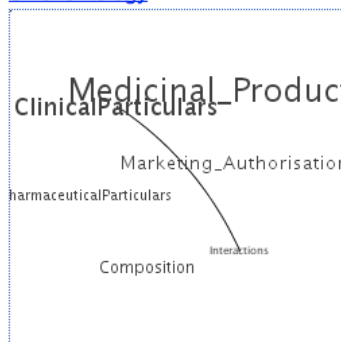

Figure 15. Part of the front end of an ontology space in Cupboard.

4   Conclusions

This report describes the new functionalities implemented in the latest version of KC-Viz, an innovative tool for visualizing and navigating ontologies, which uses the Key Concept Extraction algorithm originally developed in the OpenKnowledge project[5] to provide abstraction mechanisms based on dynamically generated summaries of an entire ontology, a network of ontologies, or the neighbourhood of a class.

Our next step will be then to perform some rigorous empirical studies, to validate our hypothesis that such abstraction mechanisms make it easier for users to make sense of the content of an ontology, especially in scenarios where the ontology is unfamiliar and users need to gain an initial understanding of the scope of the ontology.

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[5] http://www.openk.org.

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[3] Dzbor, M., Motta, E., Buil Aranda, C., Gomez-Perez, J.M., Goerlitz, O., Lewen, H., Analysis of user needs, behaviours & requirements wrt interfaces and navigation of ontologies, Deliverable report D4.1.1, NeOn Project Consortium, August 2006.

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