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INTRODUCTION

The objectives of the International conference on Applied Internet and Information Technologies are aligned with the goal of regional economic development. The conference focus is to facilitate implementation of Internet and Information Technologies in all areas of human activities. The conference provides forum for discussion and exchange of experiences between people from government, state agencies, universities, research institutions and practitioners from industry. Information technologies change during time and this year AIIT conference addressed diversity of ICT application areas and relevant research topics such as:

- Information systems
- Software engineering and applications
- Data science and big data technologies
- Business intelligence
- IT support to decision-making
- Communications and computer networks
- Data and system security
- Distributed systems
- Internet of Things
- Embedded systems
- Software quality
- Software maintenance
- Computer graphics
- IT management
- E-commerce
- E-Government
- E-Education
- Internet marketing

Information technologies enable collaboration across the globe. This year the conference was successfully coorganized by 5 institutions from 4 countries - Serbia, North Macedonia, Russia and Bulgaria. It has been managed in collaboration of 3 co-chairmen from Serbia, North Macedonia and Russia.

International conference on Applied Internet and Information Technologies (AIIT) is an annual conference that was held since 2012, based on successful results of International conference on Information and Communication Technologies for Small and Medium Enterprises in 2011. This year, AIIT2020 it was held on October 16, 2020 in Zrenjanin, Serbia.

Due to a COVID-19 pandemics the conference is held in virtual form, with online presentations with Google Meet, and streaming video and poster presentations available at the web site of the conference (http://www.tfzr.uns.ac.rs/aiit/). There were 54 accepted papers with 125 authors from 21 countries (Serbia, North Macedonia, Montenegro, Bosnia and Herzegovina, Croatia, Slovenia, Romania, Hungary, Bulgaria, Slovakia, Russia, India, United Kingdom, USA, Canada, Sri Lanka, Japan, China, Sweden, Egypt, and Iraq). The papers are presented online, or in video stream and poster sessions. Within the video presentation session, there is a presentations of IT company ACS – Advanced Cyber Security, Belgrade, Serbia.

The AIIT 2020 organizing commitee would like to thank authors of papers for their contribution. All submitted papers were peer reviewed by the members of AIIT2020 program committee. Each submitted paper was assigned to at least two reviewers from different countries and the paper analysis was conducted as double blind review.

Special gratitude is addressed to many reviewers from co-organizing institutions that made great impact on quality of papers. The AIIT organizing commitee specially appreciate IT company' efforts in supporting the conference by its participation.

Information technologies are integrated in every human activity. IT application enhancements are encouraged by university research, business organizations, public institutions and IT industry. The AIIT organizing committee welcomes future presentations of work in this field at next AIIT conference.

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CONTENT

INVITED PAPERS

REGULAR PAPERS

Evaluation of the Ontology Visualization using Key Performance Indicators

B. Grujovski, S. Savoska, A. Bocevska and N. Blazheska Tabakovska
Faculty of Information and Communication Technologies, Bitola, Republic of North Macedonia
"St. Klement Ohridski University" –Bitola
blagojce.grujovski@gmail.com, {snezana.savoska, andrijana.bocevska, natasa.tabakovska}@uklo.edu.mk

Abstract - Semantic Web supports methods that go beyond the traditional web application in a way that it can facilitate machines to understand the meaning of information on the Internet. Ontology is a package of data together with their relationship, structure, and constraints. Ontology makes information a meaningful knowledge which can not only convey semantic meanings but can be interpreted and understood by machines as well. Ontologies are a key technology for the semantic web, as they are responsible for providing this context. Visualization is an important task related to ontologies. Visualization of ontologies is needed for showing their content and relations between their elements. In this paper we generated visual representation of three ontologies using Protégé as one of the most popular tools for ontology visualization. Protégé can be extended with pluggable components to add new functionalities. The evaluation of the ontology visualizations are implemented according Key Performance Indicators (KPIs) such as: interaction possibility, insight in data, interoperability, visibility.

I. Introduction

Ontology is a conceptualization of a domain into a human understandable, machine-readable format [1]. Ontologies are semantic data models that define the types of things that exist in our domain and the properties that can be used to describe them [2]. Basically ontologies are defined model that organizes structured and unstructured information through entities, their properties and the way they relate to one another. There are many reasons why any user could benefit [3]:

- Managing content more effectively;
- Maximizing findability and discoverability of information;
- Increasing and reusing of less seen and unknown information; and
- Improving search engine operations

Before the creation of an ontology, it is necessary to understand its components. An ontology consists of Class, Relationship and Attribute; the components of an ontology allow us to fully define a domain of knowledge context through the entities defined in classes, relationships between classes, and data associated with classes. These three elements allow us to use abilities greater than traditional knowledge organization techniques such as folder structures and taxonomies [4].

Broadly ontologies can be divided into two main categories [5]:

- Lightweight Ontologies: Include class hierarchy or taxonomy of classes, subclasses, values and attributes.
- Heavyweight Ontologies: Represent the domains in depth-wise manner by including axioms and constraints.

Protégé is a free knowledge-modeling tool developed at Stanford University. Ontologies and knowledge bases can be edited interactively within Protégé and accessed with a graphical user interface. Protégé can be extended with pluggable components to add new functionalities and services. There is an increasing number of plug-ins offering a variety of additional features, such as extra ontology management tools, querying and reasoning engines, visualization tools *etc*. There are various forms such as Resource Description Framework (RDF), Ontology Web Language (OWL) and XML Shema in which Protégé ontology can be exported [6].

In this paper we developed an ontology using data that is part of the COST Action CA15211, Atmospheric Electricity Network: coupling with the Earth System, climate and biological systems (Electronet[1]), and we used two other ontologies that are in the same range and are free to download, the Evidence & Conclusion Ontology (ECO[2]) and Exposure Ontology (ExO[3]). These three ontologies are visualized with the same plug-ins in Protégé and some other online tools and programs.

II. Related Woks

In the simplest case [7], an ontology describes a hierarchy of concepts related by subsumption relationships; in more sophisticated models, suitable axioms are added in order to express other relationships between concepts and to constrain their intended interpretation. Broader explanation and term definitions can be found in [7]. In this book, the different ontology types are explained as well as the processes to establish

[1] https://dataspace.atmospheric-electricity-net.eu/
[2] https://www.ebi.ac.uk/ols/ontologies/eco
[3] https://bioportal.bioontology.org/ontologies/EXO

relations between them with the objective of selecting those that are more suitable for the information retrieval context. A study of families and types of ontology models is shown to compare them and detect common characteristics and differences. This analysis has the objective of providing the context in which the terminological ontologies are placed and showing how each model is related to the rest. In [8] a classification of types of ontologies according to the degree of formalism and semantics provided in their specification is proposed. They range from simple lists, passing by subject sets, to complex reasoning models.

A complementary classification is described in [9]. This model focuses on explaining the different types of ontologies from the semantic interoperability point of view and focusing on the ability to express hierarchical relations. The categories range from taxonomies, which are able to express few semantics (subclassification relationship) and only provide syntactic interoperability, to logical theory models, which thanks to their strong semantics provide the most complete form of semantic interoperability. In this categorization, terminological models are those that provide syntactic and structural interoperability, and the axiomatic ones those that provide semantic interoperability.

There exist many different ontologies, built for many different types of applications, and they vary in both the amount of detail they express and the generality of their use [10]. A key feature of ontologies is that, through formal, real-world semantics and consensual terminologies, they interweave human and machine understanding [11]. This important property of ontologies facilitates the sharing and reuse of ontologies among humans, as well as among machines. A major reason for the recent increasing interest in ontologies is the development of the Semantic Web [12], which can be seen as knowledge management on a global scale. Tim Berners-Lee, inventor of the current World Wide Web and director of the World Wide Web Consortium (W3C), envisions the Semantic Web as the next generation of the current Web.

The exponential growth of information available on the Internet makes it increasingly necessary to introduce intelligent agents to facilitate the processing of information and knowledge [13]. Other researches include: Ontology visualization Protégé tools – a review [14] and older approaches of ontology visualization and visualization tools: a survey of the state of the art [15].

III. Ontology Visualization

Although every ontology visualization tool is different and unique and no general formalization exists of the way ontologies are displayed, there can be identified some commonalities between them, forming a so-called ontology visualization method. This classification is based on three main criteria: dimensions used by the visualization method (2D, 2.5D, 3D), graphical elements (node-link) and the layout method used on the elements on the screen (force-directed, treemaps, radial) [15].

A. Ontology visualization tools in Protégé and other web tools

Visualization can contribute a lot, and there are many benefits and advantages like better cognitive memory and resource processing, easier information searching, better pattern recognition, enabling of perception inference operations like close watch mechanism, information coding in manipulation medium, large information processing, easy focus on details and work process monitoring and abstract presenting of a situation by following and annotating information. There are many challenges related to the size of the ontology, the technical aspects and the need for using different techniques for interaction with different use cases.

The continuous daily increasing number of data creates the information flood which brings the need of more effective and efficient methods for handling data. Knowledge is distributed through different media, digital and analog TV, via Internet or physically, newspapers or books. This big volume of information and the fact that information is reproduced easily through the mentioned media, is a great information resource for the human. But with the big volume of information and knowledge, the well known problem of its inefficient use and chaotically structured data that we can not understand has appeared. The visualization of information is brought up as an intuitive alternative and need for comprehension of the data. Visualization in fact means reduction of the time needed for analyzing and kind of "translation" of complex semantic relationships into an interactive visual map that is more readable. Ontologies are a great way of presenting the relationships between data while visualizing them for better understanding and use. In this part we visualize three ontology examples: Electronet, ECO and ExO. All three ontologies are related to ecology data and influence on living beings. The ontologies are visualized using the tools from Protégé and other online tools (WOWL, The Brain, OLS-graphview).

Protégé is designed so everyone can use it and easily create an ontology using OWL. The demand for the ontologies written in OWL is rapidly growing. In this paper the focus is on the ontologies created with OWL. OWL is constructed on top of RDF-Schema, and therefore it shares many RDF properties and it can easily be translated into RDF. Its name suggests that it was designed to be a language for representation of ontologies for the Semantic Web. OWL can be used to code information about its domain, like metainformation about entities, called annotations [16].

Electronet is an ontology that was developed in order to quantify the atmospheric electromagnetic fields and their influence on living organisms and to show data and its relations in a way that they will be more understandable and readable, providing reusability and research of data as shown in Fig. 1. Every tool has different way of visualization and different way of insight in data (zooming, analyzing *etc*.).

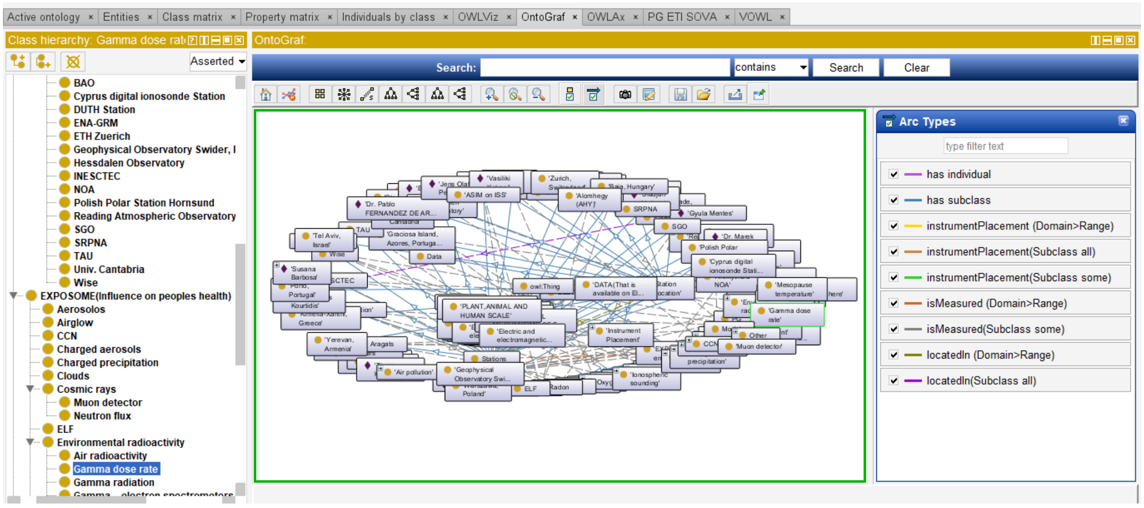

Figure 1. Electronet visualization with the OntoGraf plug-in of Protege

The Evidence & Conclusion Ontology describes types of scientific evidence within the biological research domain that arise from laboratory experiments, computational methods, literature curation, or other sources. Researchers use evidence to support conclusions that arise out of scientific research. Visualization with the tool OWLViz can help the user see the hierarchy in which the ontology is displayed and distinguish classes and subclasses, and their relations, as shown in Fig. 2.

Figure 2. Visualization of ECO with the OWLViz plug-in

The Exposure Ontology was developed to respond to the needs expressed by the National Institute of Environmental Health Sciences (NIEHS) and partner agencies for inclusion of exposure data when prioritizing research and performing toxicity testing. It also addresses the need for centralization of exposure data in a broader biological context and provides "real-world" exposure context for data in The Comparative Toxicogenomics Database (CTD). The resulting resource enables new opportunities for understanding and prioritizing human health effects from exposure and their underlying etiologies, and coordinates data key to enhance the capacity for toxicity prediction and risk assessment. Its visualization is shown in Fig. 3.

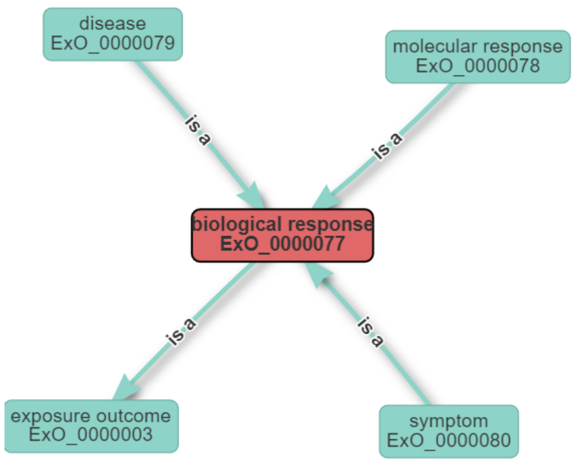

Figure 3. Visualization of ExO biological response class using OLS-graphview

The visualization capabilities are great and while it is easy to create an ontology thanks to the Protégé interface in the background there is code being generated for every class, subclass, data property that we add. This code is written in OWL with the RDF Scheme, Fig. 4, but it also can be translated into OWL with the XML Scheme, Fig.5.

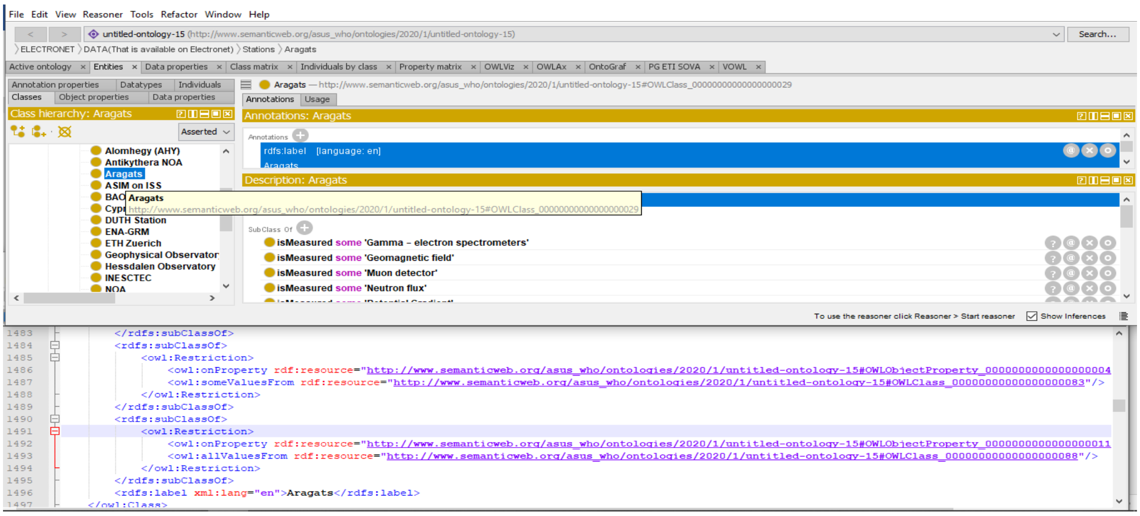

Figure 4. UI view of a class and a code generated in the OWL RDF Schema

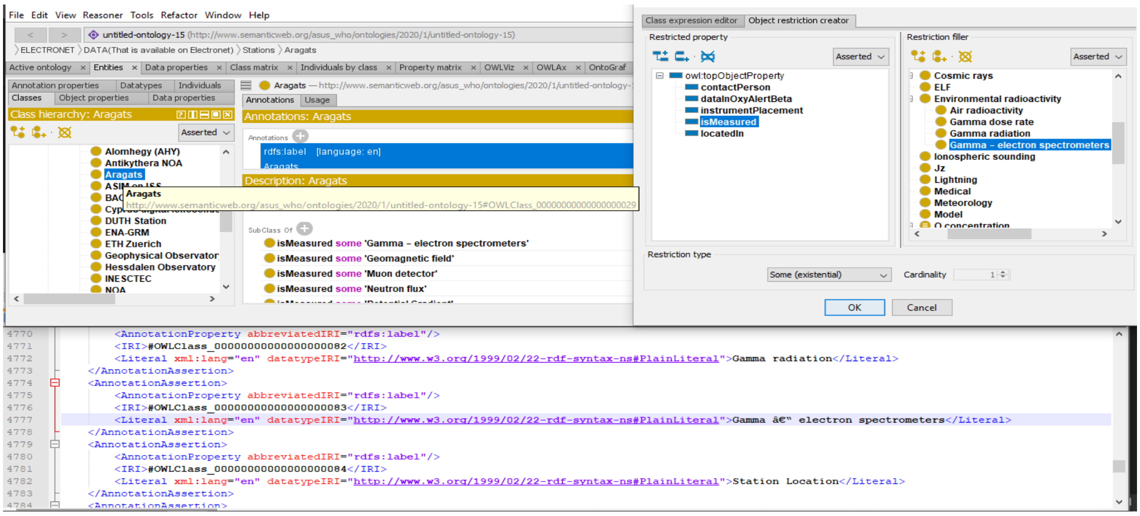

Figure 5. UI view of a class and a code generated in the OWL XML Schema

IV. KEY PERFORMANCE INDICATORS EVALUATION OF THE ONTOLOGY VISUALIZATION

In business and the scientific world, the term KPI refers to measuring the key indicators of performance. According to Oxfords[4] dictionary KPI is a quantifiable measure used to evaluate the success of an organization, employee, *etc*. in order to evaluate the performance of the wanted activities for success. Adequate, clear and relevant information that is obtained and is carefully defined is important information for the course of performance management activities and is more likely to be appropriate so it can be absorbed and acted upon by relevant persons [17].

KPIs are indicators that measure performance according to the key activities and initiatives that are being taken. They follow the intuitive idea that good work will lead to good results. KPIs have clearly defined thresholds for all measured indicators. They can be related to a specific time, shorter or longer, as they are commonly used to observe continuous tasks that may last a shorter or longer period of time. The current importance of KPIs has been extended to the world of facts and science to show the retrieval of evidence as coefficients of evidence reliability derived from existing data with the methods and techniques used to obtain evidence, quantifying the impact of obtaining scientific evidence [18].

KPIs are also important for semantic analysis because business rules and policies are derived from KPI results. However, the information they provide for company purposes does not always have to be accurate, as KPIs measure only a subset of factors that affect the outcome of a Key Result Indicator (KRI) [19].

Many classifications and taxonomic methods used in the visualization of data and information usually start from the data itself and the used techniques. There are many different approaches to create a taxonomy of the three types of visualization (information, data and scientific), according to the preferences of users and developers. It is very difficult to deal with the daily outflow of information, which is subject to analysis by managers and other users. That is why a proactive policy

[4] https://www.lexico.com/definition/key_performance_indicator

is needed to prepare visual reports and effective presentations [20]. KPIs are needed in assessing the impact of ontology visualization on users, their understanding of ontology data and their insight in it, as well as in performing basic statistical or mathematical analyzes.

When creating a KPI for the visualization we need to evaluate the possibility to easily obtain the information and easily access the data, not only by professionals but also by a non-professional user, to assess the visibility of the data, whether it is possible to work with multiple screens, whether there is a possibility to select objects and whether the links between them will be visible and how far can we go through the selected data. The level at which connections can be understood and the ability to discover connections between entities are also important, as well as data aggregation, their clustering, classification or association. These allow hidden links between data to be detected. Data visualization is presented on the so-called visualization wall, which provides opportunities for selection and zooming of a particular cluster, data detection and the ability to analyze them.

Fig. 6 illustrates the use of KPIs needed to evaluate the visualization of ontologies, explaining the indicators and their codes that will be used to evaluate the KPIs according to their usefulness and relevance.

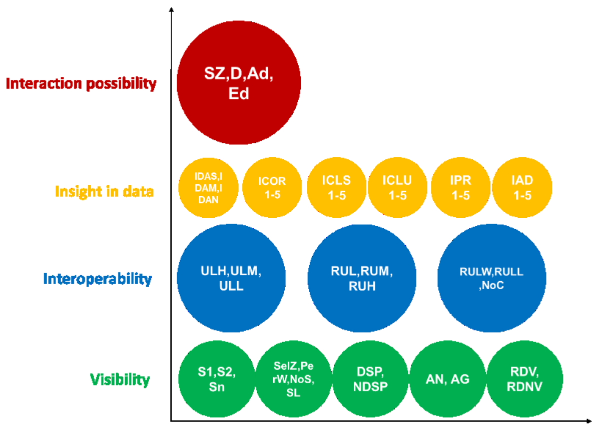

Figure 6. Visual representation of KPI of the second dimension [21]

The selected indicators aim to help assess the success of the ontology visualization. The Visibility indicator is presented as the ability to use one or more visual displays to present data and visualize it, Fig. 6. Another attribute is the possibility to select the navigation object through the made dimensions and calculations, the level of detail of the presented data and the possibilities to display the relations between the data on the diagrams. The Interpretability indicator can be divided into three main components: data comprehension level, link comprehension level and aggregation detection. The insight in data indicator is related to the ability to analyze and detect mathematical and other relationships between data such as statistical indicators, correlations, classifications, rankings, associations. Interaction possibility enables selection, navigation, zooming, filtering of data, selection of analysis attributes and other possibilities of interaction with data.

A. Validation of the visualization of the ontologies made for the needs of the paper

Table I was composed to validate the designed ontology visualizations in order to show how the KPI indicators for an ontology visualization are used in practice.

From this table, it can be seen which visualizations have better KPIs and which are more suitable for different purposes. The value of these KPI estimates can be very useful if correlated with software tools that involve the application of artificial intelligence in estimating the types of ontology visualizations appropriate for a particular user purpose.

The numbers in range from 1-5 are written as a grade to rate our experience and our perception of the used tools in Protégé and online ones. We graded the tools in accordance to the KPIs that have been created; 1 being the lowest grade in our opinion or the tool we recommend less probably. The score goes up to 5, graded as the tool we recommend as the best used for the appropriate KPI.

Related to the visibility, the criterion *Screens* is rated 1 for all tools, because they only support one screen at a time. The grade 4 for *Objects* and *Aggregation* visibility refers to very good object visibility or very good possibilities for gathering and consolidating data, which can still be further improved. For tools with grade 5 for *Relation* visibility relationships are shown and can be distinguished excellently.

The criterion *Data understanding level* for the KPI *Interoperability* is rated 3 when the grouping and arrangement is not that good because of the UI quality of the web page. Relations that are visible but not understandable and have code labels are rated with 3 for *Relationship understanding* level. Some tools are graded with 2 and 3 for the criterion *Aggregation*, based on how though can be the gathering and processing of data for beginners.

For *Insight* in data, some tools are rated 2, due to their lack of operations support, needed for the criterion *Statistics* and mathematics analysis.

Related to *Interaction* possibility, when some selection can be done, the criterion *Selection* is rated 3. The grade 2 for deleting, adding and editing for some tools is given as a result of the interaction, which is provided, but can be improved, because there are other tools that do these operations very good.

TABLE I. EVALUATION AND VALIDATION OF ONTOLOGY VISUALIZATIONS ACCORDING TO THE DEVELOPED KPIS

	Visibility					Interoperability			Insight in data						Interaction possibility			
Ontology Visualization	Screens	Objects	Data Sel.	Agreg. Viz.	Relation Viz.	Data Und. level	Rel. Und. level	Agreg.	Stat. Mat. Analys.	Correlation	Class	Cluster Analysis	Pattern recog.	Assoc.	SZ	D	Ad	Ed
OWLViz in Protégé ELECTRONET	1	4	4	4	5	4	4	3	2	3	4	4	3	3	3	2	2	2
OntoGraf in Protégé ELECTRONET	1	4	5	5	5	5	5	3	4	4	4	4	3	3	4	4	3	4
VOWL in Protégé ELECTRONET	1	4	4	3	4	3	4	3	2	3	4	5	2	3	3	2	2	2
VOWL на Web in Protégé ELECTRONET	1	4	4	4	4	3	4	3	3	4	4	5	3	3	3	2	2	2
OWLAx in Protégé ELECTRONET	1	3	4	3	3	4	4	4	4	4	4	3	3	4	4	4	4	4
The Brain application ELECTRONET	1	5	5	5	5	5	5	4	4	4	4	4	4	4	5	5	5	5
OWLViz in Protégé ECO	1	4	4	4	5	4	4	3	2	3	4	4	3	3	3	2	2	2
OntoGraf in Protégé ECO	1	4	5	5	5	5	5	4	4	4	4	4	3	4	4	4	3	4
OLS-graphview on the Web ECO	1	4	4	3	4	3	3	2	2	4	4	4	3	2	3	2	2	2
OWLViz in Protégé ExO	1	4	4	4	5	4	4	3	2	3	4	4	3	3	3	2	2	2
OntoGraf in Protégé ExO	1	4	5	5	5	5	5	4	4	4	4	4	3	4	4	4	3	4
OLS-graphview on the Web ExO	1	4	4	4	5	4	4	3	2	3	4	4	3	3	3	2	2	2

The average values of the rated KPIs shown in Table I can be used to determine which visualisation tools are more suitable and recommended in our opinion for cetrain ontology visualisations. For example if we add up all the grades for The Brain application with an exception of the first attribute (*Screens*) and we calculate the average grade we get 4.6, which means this application is almost excellent for Electronet ontology visualization. Similarly, OntoGraf is the one most suitable and recommended for ECO and ExO ontology visualisations. Its average value is 4.2 for both ontology visualisations.

V. CONCLUSION

The daily influx of data collection from many sources that have big data features and the amount of data flowing into many distributed systems makes it difficult to process and extract the most important information. Today, when computers are an integral part of our daily lives, we have a way to alleviate the problem of processing and reusing data for analysis in other applications by using ontologies. Ontologies have emerged as a powerful method for sharing and understanding data, primarily because of their ability to link an unlimited amount of metadata with concepts and connections between them, but also with the process of gathering knowledge. Connecting and sorting knowledge leads to its better understanding and faster retrieval of necessary information and creation of domain knowledge.

This paper aims to describe ontologies and their connection to the semantic web as technical and conceptual terms and to show possible ways of their visualization. Ontologies are a great way to show the connections between data and at the same time visualize them in order to gain their reuse and understanding. For the obtained ontology visualizations with the tools and the applications that are used, validation and evaluation was done in Table I according to the previously proposed methodology for ontology visualization. The evaluation was translated into KPI performance indicators of ontology visualizations that are subject to the parameters grade. Scores from 1 to 5 are used for all defined KPIs. Representativeness assessment is performed according to pre-defined KPIs, shown in Figure 6. Tools that we recommend to be used for appropriate KPIs are rated with grade 5.

The development of the semantic web is another reason why ontologies are so popular. They intertwine human and computer understanding of symbols, creating a connection that the human eye and computers can jointly understand and use in practice. In future works the visualization of ontologies can be broaden to other great programs and applications that are being developed every year and can help ontology engineers and knowledge managers to comprehend the daily data income and visualize it to extract as much possible information easily.

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