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Keywords: UNESCO; landmark; Czech Republic; OWL; ontologies; semantic web

Introduction

The tourism is an open complex system consisting of various players and relations between them. Tourism agencies, tourists, locations, accommodation, expenditures and environmental conditions are in close interactions. These interactions are highly dynamic and often unpredictable. They influence the tourism as such together with a society and the environment. The tourism is also perceived as a scientific discipline where its sustainability is one of the research topics. Various techniques and methods of the artificial intelligence are used in the research. Multi-agent systems are one of the examples where a dynamical nature of tourism is studied (Pizzitutti, M., & Walsh, 2014), (Kaur, Kahlon, & Virk, 2014), (Lin, Carley, & Cheng, 2016). Searching for relevant information for realisation of a trip is often time consuming for a traveller. A traveller has to browse a huge amount of (web) sources for answering specific questions which are relevant for a trip. Semantic web technologies extend a traditional World Wide Web where formal structures represent various kinds of data together with their semantics (Berners-Lee, Hendler, & Lassila, 2001). This semantic web-based layer should improve level of understanding of these data by machines and offer a platform for efficient navigation and relevant information by the user. World Wide Web is customised mainly for humans where a visual aspect of presented information is emphasized. Typical non-semantic web pages are hardly understandable by machines because they lack semantics. Web space is enriched by formally represented data layers (ontologies) which can be easily interpretable by machines thanks to the languages where some of them are based on description logics (Brickley and Guha, 2014), (Schreiber and Raimond, 2014), (McGuinness, 2004), ("OWL 2 Web Ontology Language: Document Overview (Second Edition), W3C Recommendation ", 2012). The main aim of the paper is to apply an ontological approach for modelling facts about the UNESCO cultural and natural landmarks which are located in the Czech Republic. The series of web pages about UNESCO landmarks can be found on the web ("World Heritage List,"), but if a user would like to receive an answer on more specific question, this cannot be received immediately, but after reading a lot of web pages. It would be better to receive faster feedback on specific questions in case of the UNESCO landmarks. The paper presents the ontology-based prototype where Czech UNESCO landmarks are modelled. The paper is structured as follows. Chapter 2 introduces where ontologies can be applied in a tourism domain. Chapter 3 presents development of the ontology where Czech UNESCO landmarks are represented. Chapter 4 mentions discussion and future directions. Chapter 5 concludes the paper.

Ontologies in Tourism

The Ontology is a subarea of philosophy – Metaphysics. It comes from the Greek word Ontos (being) and Logos (word, being, speech). The main purpose of this area of the interest is to investigate human being and to answer the most fundamental philosophical questions, e. g.: "*What is a part of a being?*", "*What is the nature of things which are part of our reality?*", *Why does anything exist?*", "*What is the meaning of specific things?*". The ontology does not have a meaning only in the philosophy. This concept was firstly used by J. McCarthy in the computer science, i. e. in the context with the common sense knowledge (McCarthy, 1987). Common sense knowledge is a type of knowledge which is used in our everyday activities for problem solving and decision making. We often do not realise that we use something like common sense knowledge in a situation. As an example, we understand the meaning of the red traffic light or we know that sunset is followed by sunrise. An intelligent system should not fail for unfamiliarity of these „obvious things". It should know how to behave in common situations which are „obvious" for humans. Computer science practitioners aim to encode these more or less familiar facts (pieces of knowledge) into the intelligent autonomous systems to improve their behaviour which should be close to behaviour of humans. T. Gruber is the author of the most known definition of an ontology (Gruber, 1993): "*Ontology is explicit specification of the conceptualisation.*" Explicit specification means that the knowledge should be easily accessible for machines or humans in problem solving and decision making. It should not be saved only in human minds. Conceptualisation is a process of an identification of the most important „things", i. e. concrete or abstract terms which are encoded into the more formal shape – a concept. These concepts represent particular part of the world. This definition was extended by W. N. Borst (1997): „*Ontology is formal specification of shared conceptualisation.*" Ontological structure has various forms. It can be drawn on the paper or it can be designed with a specific software tool. If ontology should be used by the computers, ontology should be formally represented for better understanding by computers. An ontology plays a role of a vocabulary of "things" which is a result of a consensus between interested parties. An ontology improves communication between people,

people and machines and between machines. Some of these ideas often occur in definitions of other authors. Jain and Mishra (2014) explain that "*Ontology provides a means to classify the things, which are exists and also organized in a systematic manner which analyses the existing things in a structured way*". Man (2013) perceives the ontology as *"... a shared vocabulary, which can be used to model a domain that is, the type of objects, and/or concepts that exist, and their properties and relations.*" Roussey, Pinet, Kang and Corcho (2011) do not specify one definition of the ontology, but they propose ontology classifications where we can see that ontology can have a non-formal (e. g. mind maps), a semi-formal (e. g. Unified Modelling Language - UML) or more formal (e. g. Ontology Web Language - OWL) structure. It is obvious that different authors interpret the ontology differently. In the following text, the ontology is perceived as a machine processable formal structure managing information and knowledge about generic or domain-specific area of the interest where semantics of included concepts is represented in the ontological structure.

Formal ontologies are also used in tourism and its sustainability. The OWL ontology supporting cultural tourism is presented in (Salaiwarakul, 2017). This ontology represents pieces of information which relate to the Lower Northern Thailand. The formal structure is used for semantic search for relevant information about Thailand location. A domain-specific OWL ontology called QALL-ME is introduced in (Ou, Ou, Orasan, Spurk, & Negri, 2008). QALL-ME is the EU-funded project with the aim to develop a multi-lingual question-answering system for a tourism domain. The ontology is used for semantic annotations of the data received from the tourism web sites and natural language questions specified by users of the system. QALL-ME ontology is inspired by the Harmonise (Missikoff et al., 2003) and e-Tourism ontology (Prantner, 2004). Harmonise ontology is also developed under the EU project (Harmonise). Its aim is to solve data exchange problems in a tourism domain. The Harmonise ontology is represented by the Resource Description Framework (RDF) model where it supports exchanging data among different tourism organisations. RDF e-Tourism ontology is developed by DERI (Digital Enterprise Research Institute) under the OnTour project. The ontology plays a role of a vocabulary of concepts mainly related with an accommodation and activities mentioned in tourism area. The ontology is used for sources annotations, sharing semantics in a semantic web portal about tourism. TAGA (Travel Agent Game in Agentcities) is an agent-based framework joining agent paradigm with semantic web technologies. It is used for simulation travel market on the web. The framework uses two domain ontologies which are used on simulations (Bachlechner, 2004). The first ontology integrates fundamental tourism concepts including customers, travel services, reservations, itineraries, etc. The second one models roles of participants in travelling, different types of auctions and used protocols. Ontology-based knowledge management system is presented in (Tachapetpaiboon and Kularbphettong, 2015). The OWL ontology represents concepts related to the Dusit district in Bangkok (Thailand). The web application is developed using this formal structure. The authors of the paper (Hua-li and Zhi-jun, 2016) investigate usability of the ontological approach in collaborative filtering for designing of the recommendation-based system for tourism. OntoTRec system is introduced. This system integrates collaborative filtering algorithms providing suitable tourism products. Data layer of this system consists of two OWL ontologies. The first one represents fundamental concepts of tourism, e. g. traffic, attractions, accommodation, diets, shopping, a tour style or weather conditions. The second one integrates facts about tourists, e. g. age, gender, hobbies, travel interests, travel styles, etc. Similar study is presented in (Bahramian and Abbaspour, 2015). The authors present a recommender system providing collection of points of the interest and recommend them on the basis of their preferences. The system uses the ontology for modelling preferences of users and points of the interest. The system is able to calculate similarity between preferences of a user and characteristics of points of interest. Personalised list of these points is provided by this system. Hontology is a domain-specific multi-lingual ontology integrating concepts of other vocabularies as DBPedia, Schema.org and QALL-ME (Ou, et al., 2008). It represents facts about accommodation and concepts relating to accommodation types in four foreign languages – English, Portuguese, Spanish and French. Ontology is available in the OWL format (Chaves, Freitas, & Vieira, 2012). Ontologies cannot be manually created. Specific algorithms are used for (semi-)automatic development of the ontological models. The authors of the paper (Tang and Cai, 2010)present the Tourism Ontology Construction Method (TOCM) using formal concept analysis for domain ontology development where a collection of unstructured texts about tourism is used.

OWL ontology development

Problem Description

UNESCO provides a web-based catalogue (i. e. World Heritage List ("World Heritage List,")) of various countries and regions which are registered under the UNESCO and protected because of their unique natural or cultural value for a society. At present, 167 states parties are registered in this list. Unique sites are categorised into three main groups: cultural, natural and mixed. Cultural heritage sites have specific cultural or archeological value. This group includes historical buildings, towns or archeological sites, sculptures, paintings, churches, castles, etc. Natural heritage sites contain natural phenomena which are unique, rare and have exceptional beauty. This group includes sites where unique animal species live, specific ecological or evolutional processes occur or where there is exceptional biodiversity. Mixed heritage sites are mixtures of both of these sites – the cultural and the natural. Cultural heritage sites are more varied group containing more sites (845) in comparison to the natural (209) and the mixed (38) sites. If we are interested in which heritage sites are registered in a specific country, a list of alphabetically ordered countries is available in the web-based catalogue, see ("World Heritage List,"). We select specific letter and receive the list of heritage sites for the country. Each heritage site contains detailed pieces of information which are textual and visual. Brief description, maps, specific documents, pictures, videos and indicators (reporting trends) are mentioned for particular heritage site, see ("Gardens and Castle at Kroměříž,"). If we want to receive user-specific information, the advanced search can be used. A user can filter the information according to:

- an inscription date,
- a theme (a city, a forest, a cultural landscape, a marine or an earthen architecture),
- a keyword related with the heritage site,
- a category (cultural, natural, mixed),
- an included media in the web (with/without videos or photo gallery),
- an included brief description or without this description,
- a country, a region, a year or a name of the property,
- state parties,
- a region,
- a characteristic of a site (danger, delisted, trans-boundary, nomination),
- a protection by other conservation instruments (specific programmes or elements).

If a user would like to receive more specific information about a heritage site, the UNESCO World Heritage List is not set up for provision fast and efficient feedback. What is the more specific information? If a user would like to receive simple output (an answer) without reading often long textural description of a heritage site then this might be a problem. In other words, a user would like to know:

- Example 01: Which cultural heritage cites of the Czech Republic were built between 15th and 18th century?

- Example 02: Which architects provided plans for realisation of the St. Procopius Basilica in Třebíč in the Czech Republic?
- Example 03: Which natural landmarks were inscribed between 2015 and 2018?
- Example 04: Which cultural landmarks are built in the functionalism architectural style?
- Example 05: Which religion is related with which cultural landmark?

Some of these facts can be found in the description of the specific heritage site, but a text with several paragraphs is provided and a user has to read all until finding concrete information. If we add more formal structure into these texts, a user can receive faster feedback where simple answer can be provided in one line according to specific user needs. Ontological approach can be applied for this purpose.

Analysis of the Application Domain

The main aim of the investigation is to provide a solution where navigation between facts about UNESCO heritage sites can be improved and where a user can receive compact and summarised answers on the questions without information overloading. The developed ontology is restricted on the UNESCO heritage sites which are located only in the Czech Republic because of the author´s experience with majority of these sites. Czech Republic registers 12 UNESCO cultural heritage sites: Gardens and Castle at Kroměříž, Historic Centre of Český Krumlov, Historic Centre of Prague, Historic Centre of Telč, Holašovice Historic Village, Holy Trinity Column in Olomouc, Jewish Quarter and St Procopius´ Basilica in Třebíč, Kutná Hora (Historical Town Centre with the Church of St Barbara and the Cathedral of Our Lady at Sedlec, Lednice-Valtice Cultural Landscape, Litomyšl Castle, Pilgrimage Church of st John of Nepomuk at Zelená Hora and Tugendhat Villa in Brno city. All these historical sites are taken into account for their formal representation in the ontological structure.

UNESCO launched intergovernmental scientific programme MAB (Man and the Biosphere Programme) in 1971. The programme is aimed at the support, improvement and sustaining harmonic relationships between nature and human society. World Network of Biosphere Reserves (WNBR) is a part of the MAB. Biosphere reserve is an ecosystem consisting of plants and animals which are uncommon and which should be protected for their special value. WNBR supports integration of people and nature for ensuring sustainable development with dialogue between interested parties. It contains a network of 686 biosphere reserves in 122 countries all over the world. Czech Republic disposes 6 biosphere reserves, namely: Krivoklátsko, Trebon Basin, Lower Morava, Sumava, Bílé Karpaty and Krkonose. These natural sites are also taken into account for their inclusion into the formal ontology.

Each of the UNESCO landmarks consists of series of facts. These facts are fundamental and should help a reader with receiving the most important information about UNESCO cultural and natural landmark. These facts are mainly focused on the following facts: affiliation with religion, designer of a landmark, type of architectural style of a landmark, a location of a landmark, a structure of a landmark, a year of inscription into the UNESCO registry, a list of criteria which a landmark satisfies, a century in which a landmark has been built, an area of a landmark (in hectares) and a buffer zone in which a landmark is located (in hectares) (if it is mentioned).

The above mentioned facts are clear, but a list of criteria can be less understandable. If it should be decided whether a specific site can be a part of the World Heritage List of the UNESCO, a site has to receive at least one out of ten selection criteria which declares that the site has an exceptional value. Six cultural and four natural criteria are used for evaluation of a site. These criteria are deeply described in ("Operational Guidelines for the Implementation of the World Heritage Convention,").

Design of the Ontology

If we speak about formal ontology, at present, three of the most known formal ontological models (languages) are taken into account. The RDFS (Resource Description Framework Schema) is a standard defined by W3C in 2004 and used for development of formal vocabularies which are machine processable (Brickley and Guha, 2014). It is based on the RDF (Resource Description Framework) model which was specified by W3C in 1999 (Schreiber and Raimond, 2014). It is mainly used for structuring data and metadata on the web with so called RDF statements. Each RDF statement consists of a simple structure, i. e. a subject, a predicate and an object. A subject is everything about what we would like to speak (a resource). An object also represents a resource which is related with a subject by a relation – a predicate. Then an object is a value of this predicate (a property, a relation). All of these components of an RDF statement are represented with the URI (Unified Resource Identifier) because of their manipulation in a web space. An object can be represented as a literal which is used for various values representation (numbers, dates, strings). The RDF can be used for representation of simple statements without representation structure of resources where superclasses and subclasses for these resources are modelled. As an example, we can represent that "*Lilly Reich designed Tugendhat Villa in Brno*." This is a typical RDF statement. We can represent that "*Lilly Reich is a designer*." with the rdf: type RDF property, but we cannot represent that "*a designer is a person*". This structure can be represented with the RDFS. If we need to represent meaning of these classes precisely, RDFS is not enough for this purpose. As an example, we would like to represent what "*a European region*" is in the RDFS. RDFS framework does not have means for representation of these facts, e. g. we cannot represent: disjointness between classes, restrictions for these classes or the expressions statements with logical conjuctions as AND, OR, NOT. More complex statements cannot be expressed with the RDFS. The OWL (Ontology Web) language is a formal language also specified by W3C (McGuinness, 2004). This language extends the RDF and the RDFS. It is based on description logic and used in a semantic web context for modelling more complex statements. This is a reason why the OWL 2 ("OWL 2 Web Ontology Language: Document Overview (Second Edition), W3C Recommendation ", 2012) is used for development of a formal ontology of UNESCO heritages located in the Czech Republic.

The OWL ontology (HeritagesUnescoCR.owl) consists of three layers, see Fig. 1. The first layer contains a structure of resources which is represented by OWL classes (each one represents a category (a group)) which models specific aspect the UNESCO heritage site of the Czech Republic. These OWL classes are structured with the superclass-subclass relations. If we look into specific UNESCO cultural heritage sites, some of them consist of more sites, e. g. Gardens and Castle at Kroměříž. This is the reason why the UNESCOCulturalLandmark OWL class and the UNESCOCulturalLandmarkPart OWL class are represented in the OWL ontology. The first one represents all 12 cultural landmarks according to the UNESCO. The second one represents parts of these cultural landmarks where parts are separately represented, e. g. “Gardens and Castle at Kroměříž has landmark the Flower Garden, the Chateau Garden and the Archbishop´s Chateau”. This is not the case of the UNESCO natural landmarks where each name represents only one individual entity, not more entities.

The second layer represents the OWL individuals - specific instances (individuals) of the OWL classes of the first layer, i. e. the UNESCO cultural and natural landmarks. These OWL individuals are characterised by several object properties and data property assertions. An object property is an OWL construct for modelling relations between OWL classes (individuals) where value of the property is the OWL class or the OWL individual. A data property is an OWL construct used for modelling relations between the OWL classes and data type values (numbers, dates, strings, boolean values, etc.). These assertions of the OWL individuals are included in the information layer, see Fig. 1.

[Figure 1: Structure of the OWL repository with UNESCO heritage sites]

The OWL ontology HeritagesUnescoCR.owl is created in one of the most known ontological editors. The Protégé is an open-source and Java-based platform for building ontological structures which complies with W3C standards. Its architecture uses plugins which can easily extend its functionality. Graphical user interface is based on collection of tabs where each one provides different view on the ontology. The user can customise the working space with these tabs where their positions can be easily changed during ontology development (in the ver. 4.x.x and newer). Protégé 5.2.0 is used for development of the HeritagesUnescoCR.owl where OWL/XML syntax is used.

Ontological structure can be visualised in various ways in the Protégé. The OWLViz plugin provides view on the hierarchy of OWL classes without the OWL individuals where only superclass/subclass relations are visible, see Fig. 2. The OntoGraf plugin (in the Protégé 4.1.0 and newer) visualises the OWL classes, the OWL individuals and relations between them, see Fig. 3. Thanks to these plugins, more complex graphs can be received, see Fig. 4. In this case, acquisition of useful facts from the ontology is difficult due to its complexity. Untangling represented relations between classes or their instances is complicated. Section *Querying of the OWL Ontology* explains how the ontology can be used as a repository for answering specific questions of users. Statistics of the OWL ontology HeritagesUnescoCR.owl is depicted in the Tab. 1.

[Figure 2: OWL class hierarchy of the HeritagesUnescoCR ontology (the OWLViz plugin)]

[Table 1: Statistics of the OWL ontology HeritagesUnescoCR.owl]

[Figure 3: OWL class hierarchy with individuals: Church of St.Barbara (a detail in the OntoGraf)]

[Figure 4: OWL ontology as a complex network in the OntoGraf]

Querying of the OWL ontology

If we want to investigate an inner ontological structure in the Protégé, we can use Class hierarchy tab or plugins similar to the OWLViz or the OntoGraf. These solutions are efficient if the ontology is not complex, because untangling relations between classes and individuals is easier. A user´s queries should be specified in case of complex ontological model. The Protégé (ver. 5.2.0) provides various solutions how to query the ontology. Three of these solutions are introduced and compared in this text. DL Query plugin uses OWL class expressions as a query language where classes, properties, individuals, restrictions and logic expressions are used. The query language is based on the Manchester OWL syntax which is used for expression OWL-DL (description logics) "flavour" of the OWL. Ontology should be classified for querying. The following example demonstrates how to use OWL class expressions in DL Query plugin:

(1) Find all UNESCO cultural landmarks which are built in 18th century.

Solution: `'UNESCO Cultural Landmark' and 'is built in century' value "18"^^xsd:byte`

Output: `'Holy Trinity Column in Olomouc', 'Pilgrimage Church of St John of Nepomuk at Zelená Hora'`

Note: `xsd` is a prefix for the namespace which represents data types

If an ontological element (a class, a property, an individual) has a label, this label is used in queries. Otherwise, identification value (i. e. IRI - Internationalised Resource

Identifier) is applied. More complex queries including filtering, aggregations, ordering, counting or grouping in most cases requires usage of variables. DL Query does not use variables in statements. In this case, SQWRLTab or SPARQL Query plugin can be applied. SQWRLTab uses SQWRL (Semantic Query-enhanced Web Rule Language) (O'Connor and Das, 2009) query language which extends SWRL (Semantic Web Rule Language) (Horrocks et al., 2004) . SWRL is a language for semantic rules expression. It has native support of the OWL, but only individuals can be queried. The structure of a query consists of a series of statements where a statement can consists of a class (e. g. UNESCOCulturalLandmark), a property (e. g. isBuiltInCentury) or a swrl or sqwrl built-in (e. g. swrlb:greaterThan, sqwrl:select). Data are stored in variables which are denoted with ? symbol. Each built-in has specific meaning:

- sqwrl:select: a content of which variable should be given as an output,
- sqwrl:orderByDescending: results ordering in a descending order,
- sqwrl:orderBy: results ordering in an ascending order,
- sqwrl:count: counting of results,
- sqwrl:makeSet: construction of sets,
- (a specific symbol . (a dot) is used for separation of a set declaration from other built-ins),
- sqwrl:groupBy: results grouping,
- sqwrl:size(?varA, ?varB): counting size of a set,
- swrlb:greaterThanOrEqual (or similar): comparing values.

The following examples demonstrate how to express the same queries as in case of the DL Query plugin and how to express additional requirements of queries:

(2) Find all UNESCO cultural landmarks which are built in the 18^{th} century.

Solution: `UNESCOCulturalLandmark(?cl) ^ isBuiltInCentury(?cl, "18"^^xsd:byte) -> sqwrl:select(?cl)`

Note: In case of the SQWRLTab, a data type has to be mentioned in a query in comparison to the DL Query plugin where a data type cannot be mentioned.

SPARQL Query plugin provides functionality for querying in the SPARQL (Simple Protocol and RDF Query Language) language ("SPARQL 1.1 Overview, W3C Recommendation "). The SPARQL is a W3C standardized query language mainly used for querying on data stored in the RDF graphs. It is inspired by the SQL (Structured Query Language) language which is used for storing, manipulating and retrieving data in databases. The SPARQL can also be used for OWL ontology querying because it extends the RDF. Resulted UNESCO ontology is saved in the OWL/RDF syntax. The SPARQL queries are structured into specific parts:

- PREFIXes: specification of namespaces of vocabularies used in a query,
- DATASET definition: what RDF graphs are being queried,
- SELECT part: which data we would like to receive,
- WHERE part: a core of a query, i. e. collection of statements for receiving concrete answer (filtering results is also possible in this part),
- QUERY modifiers: modifiers for grouping, ordering, pagination, filtering results after grouping.

SELECT and WHERE part is required for querying RDF data. The main principle behind SPARQL querying is a comparison of a smaller graph which is specified in a core of a query with whole RDF graph. Results are stored in variables denoted by ? symbol. The examples below demonstrate the same queries which are represented by the SQWRL language mentioned above. PREFIX part is omitted.

(3) Find all UNESCO cultural landmarks which are built in 18th century.

Solution: `SELECT ?culturalL WHERE`

```
{?culturalL a herit:UNESCOCulturalLandmark.
?culturalL herit:isBuiltInCentury "18"^^xsd:byte.}
```

Note: `herit` is a prefix for the namespace which represents the ontology; a letter `a` corresponds to a type relationship

Brief comparison of these three possibilities for ontology querying is depicted in Tab. 2.

[Table 2: Brief comparison of query solutions in the Protégé (ver. 5.2.0)]

Discussion and Future Directions

The OWL 2-based formal ontology representing Czech UNESCO cultural and natural landmarks is developed and presented in the paper. The ontology is restricted to the Czech landmarks. This ontology can be explored with various tools (a desktop or a web-based) supporting the OWL language. The OWL 2 ontology is developed in the Protégé tool. It is not user friendly or suitable for users without background in the ontological engineering. Fact and pieces of knowledge are often spread in various parts of the editor. Ontological hierarchy is easily understandable also by a non-expert in the ontological modelling in the editor, but semantics of ontological classes or individuals is expressed with specific constructs (e. g. logical restrictions, constructors, disjointness, inverse properties) which cannot be known to users. This is the reason why a web application is going to be developed without necessity to use any ontological editor. This web application is going to use developed OWL 2 ontology as a repository of information and knowledge about Czech UNESCO landmarks. Content of the ontology is going to be accessed by methods of the Python-based Owlready2 framework

(Lamy, 2017). SPARQL query language ("SPARQL 1.1 Overview, W3C Recommendation ") is going to be applied for extraction concrete parts of the ontology. SPARQL is chosen especially because of variables support and provision of advanced functionalities in comparison to the SQWRL language, see Tab. 2. The extracted "ontological fragments" are going to be presented in web pages with the methods of the Flask Python-based micro-framework ("Flask web development, one drop at a time,") which is used for dynamical web sites development.

Conclusion

Complexity of tourism is obvious. A lot of players are part of this dynamical system which interacts with each other. This paper is not focused on the modelling of these dynamical interactions or investigation of a tourism development or its sustainability in time. The paper introduces the application of the ontological approach for facilitation findability of information about specific cultural and natural landmarks. Facts about the Czech UNESCO cultural and natural landmarks are integrated into the ontological structure which is represented by the standardised OWL 2 formal language. This formal ontology can be available in a desktop or a web-based tool supporting the OWL 2, not only in the Protégé which was used for conceptualisation of the Czech UNESCO landmarks. The main purpose of this ontology is to provide machine readable and semantically rich structure which provides fundamental facts about Czech UNESCO landmarks where specific answers on users´ queries can be answered. In case of the Protégé tool, three query languages are compared in the paper, i. e. DL Query, SQWRL and SPARQL. All of these solutions have advantages and disadvantages, but the SPARQL-based querying is evaluated as the best choice for querying and the future development. The paper presents the prototype where the main attention is paid to the Protégé environment. Because of the Protégé limitations, the web application is going to be developed with the Python-based Owlready2 framework (Lamy, 2017), FLASK micro-framework ("Flask web development, one drop at a time,"), SPARQL query language ("SPARQL 1.1 Overview, W3C Recommendation ") and OWL 2 formal language ("OWL 2 Web Ontology Language: Document Overview (Second Edition), W3C Recommendation ", 2012).

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Table 1. Statistics of the OWL ontology HeritagesUnescoCR.owl

OWL element	**Count**
OWL classes	26
OWL object properties	10
OWL data properties	5
OWL annotation properties	3
OWL individuals	59
Object property assertions	173
Data property assertions	104
Annotation assertions	167

Table 2. Brief comparison of query solutions in the Protégé (ver. 5.2.0)

Characteristic	**DL Query Tab**	**SQWRL Query Tab**	**SPARQL Query Tab**
		Characteristics of a query language	
Structure of a query	OWL class expressions where classes, properties, individuals, restrictions and logical expressions can be used.	NameOfClass(?variable) nameOfProp(?variable, …) or a built-in (?variable, …) can be used in queries.	Complex structure of a query where SELECT ?variable … WHERE { statementA. statementB. … statementN.} is compulsory.
Output of a query	a superclass, a subclass, an individual, an equivalent class	(an) individual(s)	a superclass, a subclass, an individual, an equivalent class, a property
Variables in queries	No	Yes	Yes
IRI are used in queries	Yes, but if labels are used in an ontology they are used in queries instead of the IRI.	Yes	Yes

Usage of logical operators (AND, OR, NOT)	Yes	Yes (AND) Not directly (OR, NOT)	Yes
Filtering	No	Yes	Yes
Ordering	No	Yes	Yes
Aggregation	No	Yes	Yes
Grouping	No	Yes	Yes
Sets support	No	Yes	Yes
Pagination	No	No	Yes
Eliminating duplicit rows	No	No	Yes
Testing whether a query return a result	No	No	Yes
Insert	No	Not directly	Yes (SPARQL 1.1)
Delete	No	No	Yes (SPARQL 1.1)
Loading data from other graph into the actual graph	No	No	Yes (SPARQL 1.1)
Adding properties for predicates	No	No	No
Characteristics of Protégé plugins supporting a query language			
Auto-completion of a code	Yes	Yes	No
Syntax highlighting	Yes	Yes	No
Error warning before	Yes	Yes	No

running a query			
Saved queries after ontology reopening	No	Yes	No

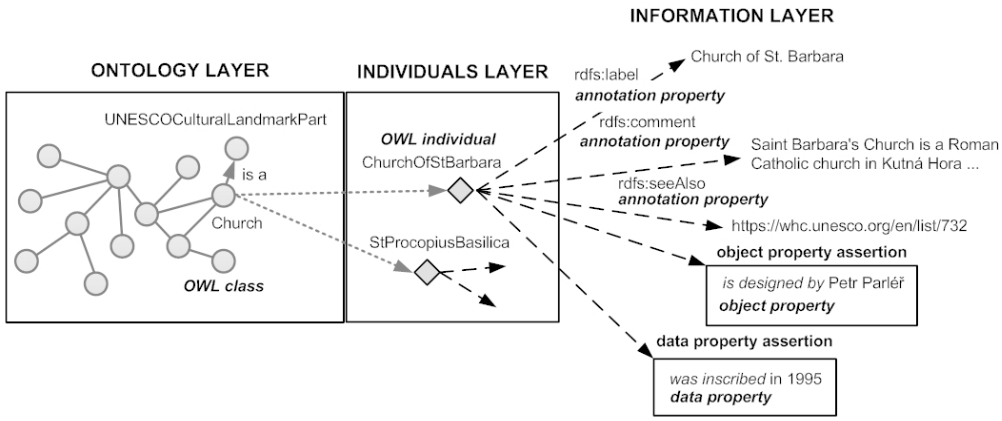

Figure 1. Structure of the OWL repository with UNESCO heritage sites

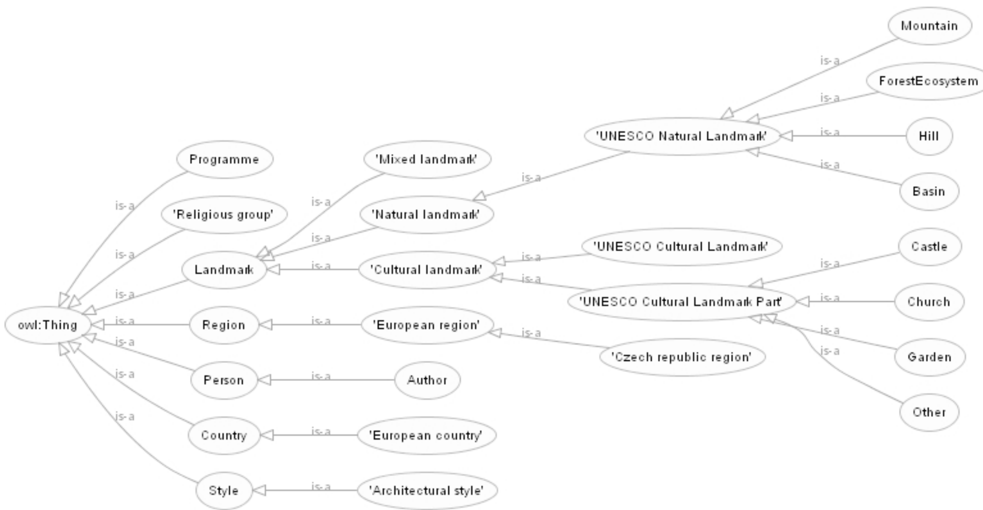

Figure 2. The OWL class hierarchy of the HeritagesUnescoCR ontology (the OWLViz plugin)

275x141mm (72 x 72 DPI)

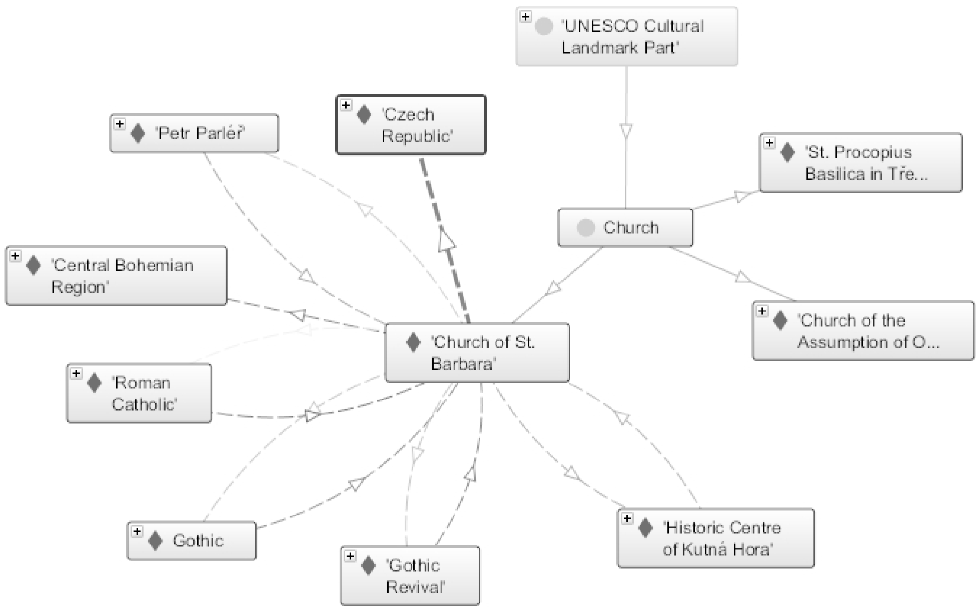

Figure 3. The OWL class hierarchy with individuals: Church of St. Barbara (a detail in the OntoGraf)

243x152mm (72 x 72 DPI)

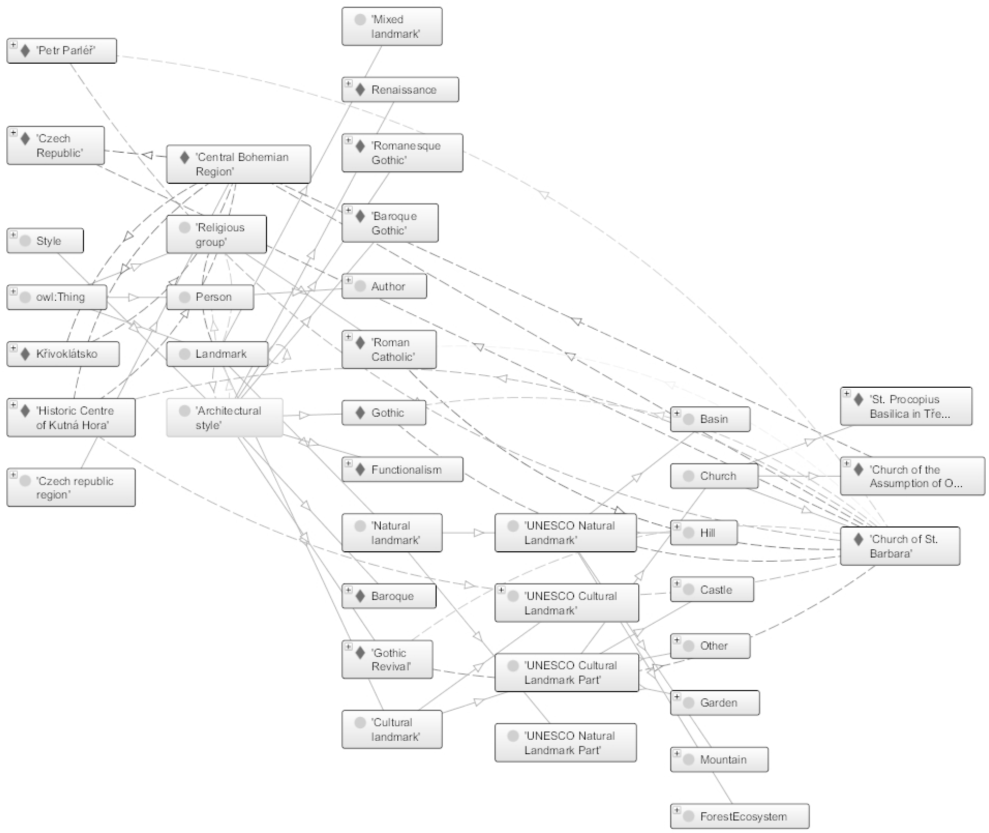

Figure 4. The OWL ontology as a complex network in the OntoGraf