BUILDING BRIEF ONTOLOGIES
A Case Study for Floods Management

Julián Garrido, Ignacio Requena
Department of Computer Science and Artificial Intelligence, Universidad de Granada
C/ Daniel Saucedo Aranda, 18071 Granada, Spain

Stefano Mambretti
Wessex Institute of Technology, Ashurst, Southampton, U.K.

Keywords: Hazards, Floods, Risk management, Knowledge representation, Brief ontology.

Abstract: This paper introduces the generation of brief ontologies as a mechanism to obtain a reduced version of the original ontology. The new ontology includes the relevant knowledge for a given context and thus reduces reasoning time in applications. In order to do so, an automatic selection of the concepts that are included in the brief ontology is done. A case of study for flood management is also presented, creating a brief ontology that contains only knowledge related to floods from a generic ontology of environmental assessment.

1 INTRODUCTION

There have been different attempts of summarizing monolithic semantic networks and ontologies i.e. a methodology for partitioning a vocabulary hierarchy into trees (Gu et al., 1999). This methodology refines a IS-A hierarchy of medical entities according to prescribed rules in a process carried out by a user in conjunction with the computer. In order to reach more simplicity, the methodology aims to create a set of very small trees where each concept has only one parent. However, this simplification makes the model unrealistic. Moreover, they use human evaluation to study how comprehensive are the resulting trees.

A comparison and description of pruning methods for bio-ontologies is done in (Kim et al., 2007). They describe whether a pruning method is more suitable and whether they should be avoided by showing their benefits and drawbacks for the different cases. In general, these methods include two phases: i) the selection phase identifies relevant elements according to the user's goals. ii) The pruning phase uses the selection to remove irrelevant elements. In particular, they describe for each method: the ontology base that the method uses, whether it supports integrity constraints, the level of automation, the type of selection strategy and the size of the final ontology. Although they plan to use metrics to assess the effectiveness of the methods, they also assess the methods showing the results to a group of experts.

Another different approach divides large ontologies into modules using partitioning based on structural properties (Stuckenschmidt and Schlicht, 2009). Its criterion consists of building modules where the semantic connection between concepts in a module is maximized whereas the dependencies with concepts belonging to other modules are minimized. Firstly, it creates a weighted dependency graph, it does a partitioning and finally it optimizes the modules by isolating concepts, merging or duplicating concepts (eventually).

According to (Noy and Musen, 2009), an ontology view is a portion of an ontology that is specified as a query in some ontology-query language (analogously to databases). However, they extend this definition to ontologies that are defined by a traversal specification (concepts, relationships and the maximum distance to traverse along each relationship) or by meta-information. They also present a tool able to accomplish management tasks such as comparing ontologies, merging them together, maintaining and comparing different versions. However, they declare as an open issue pruning the definitions of the concepts.

The concept of brief ontology was firstly introduced in (Delgado et al., 2005). They define a

Garrido J., Requena I. and Mambretti S..
BUILDING BRIEF ONTOLOGIES - A Case Study for Floods Management.
DOI: 10.5220/0003630900280036
In *Proceedings of the International Conference on Knowledge Engineering and Ontology Development* (KEOD-2011), pages 28-36
ISBN: 978-989-8425-80-5
Copyright © 2011 SCITEPRESS (Science and Technology Publications, Lda.)

brief ontology as the ontology which includes a small amount of knowledge referring to concepts existing in more generic ontologies. They introduce this concept to provide relevant access to information in databases for a web services-based and multi-agent architecture. Nonetheless, a formal definition of brief ontology is included in Section 2.

Methodologies like Methontology (Fernández et al., 1999) point out the convenience of reusing other existing ontologies whenever is possible. However, the whole ontology has to be imported even if only a small fraction is relevant for the problem. For this reason, the size of the new ontology may grow with useless conceptualizations from other ontology. This problem worsens increasingly as more ontologies are imported to the new one.

In order to avoid this problem, brief ontologies may be used to obtain reduced versions of the ontology that the user wants to import. If these ontologies contain only the portion of knowledge that the user really needs then the size of the ontology will not increase unnecessarily. By contrast, the objective might be just isolating a portion of the knowledge modelled on the ontology in order to use only the brief ontology without unnecessary knowledge. Our approach presents a traversal method to build brief ontologies using not only concepts but also instances of concepts (individuals) as starter point. Moreover, the method is also fully compatible with pruning definitions of the concepts.

As an example, a case of study for floods management is presented because of the European normative (Directive 2007/60/CE, 2004) that encourages to the assessment of flood risks in order to do an adequate management of the problem. The starting point is an ontology for environmental assessment and a brief ontology for flood management is created as a base of a future knowledge-based system.

The paper is organized as follows, Section 2 introduces the concept of brief ontology, Section 3 describes the procedure for generation of brief ontologies taking into account two different scenarios i.e. the generation based on concepts and the generation based on individuals, Section 4 describe the case of study where a brief ontology for flood management is created. The final sections give the conclusions and list bibliography.

2 BRIEF ONTOLOGIES

According to (Baader et al., 2003), a typical DL (Description Logic) knowledge base comprises the TBox and the ABox. The TBox describes the intensional knowledge (terminology) and it is represented with declarations in order to describe general properties of the concepts.

Operators of the DL knowledge base allow building the terminology and providing meaning to its declarations. For instance, a concept may be defined as the intersection of other concepts. This type of simple definition allows defining a concept in terms of other previously defined concepts. However, the set of operators depends on the type of description logics that the language implements (OWL-DL). This sublanguage implements the $\mathcal{SHOIN}(\mathcal{D})$ logic and it has less expressivity than OWL in order to reduce the computational complexity of reasoning and inferring (Staab and Studer, 2009). It involves operators such as: union, intersection, complement, one of, existential restriction, universal restriction and cardinality restriction.

The ABox contains the extensional knowledge which is the knowledge that is specific to the individuals of the domain. It includes assertions about individuals for example using properties or roles to establish a relationship between individuals.

If an ontology is defined as the union of its TBox and ABox, a brief ontology is another ontology where the extensional and intensional knowledge have been restricted and modified in order to include only the relevant knowledge for a given context. This is formally described in the following definition where the TBox is represented as $O = (K_T$ and the ABox is represented as $K_A)$. However, it is important to clarify before that if two concepts have the same name in O and O^B, then they are referred as equivalent with independence of their definitions. The concept of equivalence has the same consideration for individuals and roles.

Definition 1. For ontology $O = (K_T, K_A)$, a brief ontology is an ontology $O^B = (K_T^B, K_A^B)$ such that $K_T^B \sqsubseteq K_T \wedge K_A^B \sqsubseteq K_A$, and for every concept $C \in K_T$ and its equivalent $C^B \in K_T^B$, the definition of C exactly matches the definition of C^B or the definition of C^B is a generalization of the definition of C. Analogously, for every individual $v \in K_T$ and its equivalent $v^B \in K_T^B$, every assertion of v^B exactly matches the assertion of v or it is a generalization of the original assertion of v.

In other words, the brief ontology is a pseudo-copy of the original ontology that includes only a portion of the knowledge base (a subset of the intensional and extensional knowledge). It is referred as a portion because not all the concepts, individuals and roles of the original ontology are in the brief ontology. Moreover, it is considered a pseudo-copy because the defi-

SCITEPRESS SCIENCE AND TECHNOLOGY PUBLICATIONS

nition of the concepts may be modified or generalized, and because some assertions of the individuals may be also ignored or generalized (Garrido and Requena, 2011b).

The exclusion of elements of the original ontology and the pseudo-copy are accomplished in order to match with the restrictions for the brief ontology and because of the brief ontology pretends to be a simplified version of the original ontology.

3 PROCEDURE OF GENERATION

This section describes the extraction procedure of the brief ontologies. However, some considerations must be taken into account before describing the algorithm.

The brief ontology is built making a selective copy of the original ontology. The goal is to obtain a context-centered ontology where the context is considered the specification of the user for the relevant knowledge.

The extraction procedure is parametrized by this user specification because it is used as criteria to spread a traversal exploration on the original ontology and therefore it is used to decide whether an element of the original ontology is relevant and must be included in the brief ontology.

Traversal algorithms (Aho et al., 1983) are usually used in graphs theory to implement depth first or breadth first searches. These algorithms start at some node and then visit all the nodes that are reachable from the start node. If the graph is weighted then the strength of the relationships between nodes are usually defined with matrix. Therefore, traversal algorithms assist in the task of creating a sub-graph because they establish an order to visit nodes in the graph. Moreover, a threshold is useful to visit only nodes that are strongly connected and thus restricting the concept of reachable node.

Although an ontology is not a graph (Bizer and Seaborne, 2004), a traversal exploration of an ontology implies analogously to consider two types of nodes i.e. concepts and individuals. Moreover, these elements are considered reachable whether there is some kind of relationship between them. It may be a parenthood relationship between concepts or a concept and its individuals, relationships of a concept with the concepts and individuals that are used in its definition and relationships between individuals that are represented in its assertions. Primitive values and datatype properties are not considered nodes and connections between nodes, therefore, those data are components of the node.

Whereas a threshold may be used to limit the nodes that are going to be visited in a weighted graph, other different mechanisms are used in ontologies. In particular, a set of properties are specified to restrict individuals and concepts that are visited during the traversal exploration of the ontology (this set of properties is named relevant properties). If two nodes are related with a property which is not a relevant property then the second node will not be reachable by this connection but it may be by another one.

If a property is relevant then the information that it gives is interpreted as significant for the purpose of the user. For the same reason, if a property is not in this set then all the information or semantic that it provides must be ignored and not included in the brief ontology.

The following subsections describe two different methods to build the brief ontologies. The generation based on concepts should be considered if there is more interest on extracting the taxonomy of concepts rather than the individuals of the ontology. Depending on how the ontology is built, a brief ontology where all the individuals have been rejected is possible. However, if there is special interest in these individuals then the generation based on individuals should be used.

3.1 Generation based on Concepts

Algorithm 1 describes the generic procedure to build a brief ontology when the start set is compound of concepts. Its inputs are the original ontology, the set of main concepts (MC) where the traversal copy starts and the set of relevant properties (RR) to restrict the traversal exploration. The output is a new ontology that contains the relevant knowledge of the original ontology.

First of all, only the relevant properties (RR) will be created in the brief ontology and the rest of properties of the original ontology are ignored. After this, the traversal copy of concepts must be accomplished. This task is done for every concept that belongs to the set MC (first loop).

The traversal exploration of concepts involves spreading the algorithm to all the reachable nodes. In this case, it spreads to concepts and individuals by concept-concept, individual-individual, concept-individual and individual-concept connections. However, only concepts are labeled with positive evaluation to be created at this point. The reason is that the complete taxonomy of concepts for the brief ontology must be created before the creation of individuals, assertions or concept definitions.

In the second loop, a traversal exploration of concepts is started for each concept in MC. The next nested loop starts a traversal exploration of individuals for the ones that were reachable in the previous exploration. The traversal exploration of individuals is done following only individual-individual connections. All the individuals that are reached with the set of relevant properties RR are created in the brief ontology at this point.

All the concepts and individuals that have been included in the brief ontology are visited in the third loop. Firstly, a traversal exploration over the concepts is done in order to create the definition of concepts. Secondly, a traversal exploration over the individuals allows defining their assertions.

```
------------------------------------------------
Algorithm 1
Input: Ontology O, main concepts MC,
       relevant properties RR
Output: brief ontology OB Begin
 Create RR properties
 Foreach concept C in MC Begin
   Traversal exploration of concepts (RR,C)
   Create concepts with positive evaluation
 End For

 Foreach concept C in MC Begin
   Traversal exploration of concepts (RR,C)
   Foreach individual v in the exploration
     Traversal exploration of individuals (RR,v)
     Create individuals with positive evaluation
   End For
 End For

 Foreach concept C in MC Begin
   Traversal exploration of concepts (RR,C)
   Foreach concept with positive evaluation
     Create relevant definitions
   End For
   Foreach individual v in the exploration
     Traversal exploration of individuals (RR,v)
     Create relevant assertions in individuals
     with positive evaluation
   End For
 End For
End
------------------------------------------------
```

Concepts and individuals may be reachable from different concepts and individuals and it may imply several traversal explorations in the same steps. Moreover, cycles may appear depending on the original ontology. In order to solve this problems, if a concept or individual has been computed in a iteration of the traversal algorithm then it does not have to be computed a second time in subsequent iterations.

For this reason, the complexity of a traversal exploration is lineal *O(n)* if the number of relevant properties and main concepts are limited by constants. Hence, the efficiency of the algorithm corresponds to *O(n*m)*, being n the number of concepts and m the number of individuals.

3.2 Generation based on Individuals

Algorithm 2 describes the generic procedure to build a brief ontology when the start set is compound of individuals. Its inputs are the original ontology, the set of individuals (MI) to start the traversal copy and the relevant properties (RR). The output is the brief ontology with the relevant knowledge.

This algorithm also starts creating the relevant properties in the brief ontology. Then, it continues with a traversal exploration of individuals for each individual in MI (first loop). The individuals cannot be created until the class they belong exists in the brief ontology. For this reason, the class of every individual found in the exploration is created in a nested loop immediately before its respective individual. At this point all the direct connections between individuals that start in the MI are created. The next logical step is to spread the algorithm with a traversal exploration of all the concepts that were classes of the individuals. Hence, the complete taxonomy of concepts is in the brief ontology once finished this step.

Although the major part of individuals is already in the brief ontology, the individuals that are connected to concepts by its definition may not have been included. This requires a second loop where all the concepts that are classes of the individuals (which were found in the first loop of the algorithm) are again the starting point of a traversal exploration. Consequently, new individuals may be found in the concepts definition as a result of this exploration of concepts. These individuals are also starting point of a new traversal exploration of individuals and the new ones will be created in the brief ontology.

After finishing this second loop the complete taxonomy of concepts and individuals is in the brief ontology. However, individuals and classes are created empty at first attempt and it requires a second step to include its definitions and assertions. As a general rule, concepts must be created before individuals, these before definitions or assertions, and definitions before assertions.

In the third step, the algorithm consists of two nested traversal explorations of individuals (starting in the set MI) and its concepts. The definitions of the concepts are created at this moment. Nonetheless, it is important to remark that the original definition may be modified according to (Garrido and Requena, 2011b) due to some of the concepts or individuals of the definition may no longer exist in the brief ontology.

In the last step, a traversal exploration starts for

SCITEPRESS SCIENCE AND TECHNOLOGY PUBLICATIONS

every individual of MI and the assertions are created for every individual that is found during the exploration. Exploring the classes of these concepts, new individuals may be found and the algorithm ends creating the assertions for these individuals.

Although this algorithm increases the order of complexity compared to the case that is based on concepts, it has still polynomial efficiency.

```
-----------------------------------------------
Algorithm 2
Input: Ontology O, main individuals MI,
       relevant properties RR
Output: brief ontology OB
Begin
 Create RR properties
 Foreach individual v in MI Begin
   Traversal exploration of individuals (RR,v)
   Foreach individual p with positive evaluation
     Create concept C that is class of p
     Create individual p
     Traversal exploration of concepts (RR,C)
     Foreach concept with positive evaluation
       create concept
     End
   End
 End

 Foreach individual v in MI Begin
   Traversal exploration of individuals (RR,v)
   Foreach individual p with positive evaluation
     Select C that is class of p
     Traversal exploration of concepts (RR,C)
     Foreach individual u in the exploration
      Traversal exploration of individual(RR,u)
      Create individuals with positive evaluation
     End
   End
 End

 Foreach individual v in MI Begin
   Traversal exploration of individuals (RR,v)
   Foreach individual p with positive evaluation
     Select C that is class of p
     Traversal exploration of concepts (RR,C)
     Foreach concept with positive evaluation
       Create definition
     End
   End
 End

 Foreach individual v in MI Begin
   Traversal exploration of individuals (RR,v)
   Foreach individual p with positive evaluation
     Create assertions of p
     Select C that is class of p
     Traversal exploration of concepts (RR,C)
     Foreach individual v in the exploration
       Create assertions of v
     End
   End
 End
End
-----------------------------------------------
```

SCITEPRESS
SCIENCE AND TECHNOLOGY PUBLICATIONS

4 CASE OF STUDY: FLOOD MANAGEMENT

First of all, building a brief ontology from a detailed one according to our needs is done by the generation process described in Section 3. Nonetheless, the complete semi-automatic procedure to obtain a brief model is detailed below.

1. Establish the aim and scope for the brief ontology.
2. Selection of a detailed ontology with knowledge about the aim and scope.
3. Analysis and study of the detailed ontology.
4. Selection of the best type of extraction algorithm for this ontology.
5. Selection of the starter point and relevant properties.
6. Generation of the brief ontology.
7. Evaluation of the resulting model.

4.1 Aim and Scope

Flood is a body of water which overflows its usual boundaries over a land area with other land use, resulting in adverse impacts. The socioeconomic development in the floodplains and the reduction of the natural water retention by the land use increase the consequences of floods. For this reason, a European Directive (Directive 2007/60/CE, 2004) encourages the flood management and risk assessment. This management requires in general prevention, protection and mitigation actions (De Wrachien et al., 2011).

The main goal for this case of study is to build a model for flood management.

4.2 Detailed Ontology

The detailed ontology will be the environmental impact assessment ontology that is originally described in (Garrido and Requena, 2011a). This ontology was built with two purposes. Firstly, in order to provide and establish the conceptual framework of environmental assessment (EA) and secondly, to facilitate the development of methodologies and applications (Garrido and Requena, 2010). Indeed, the ontology was also born to be the knowledge base of an EA system.

Table 1: Set of relevant object properties.

ByMeansOf	characterizeRainfall
characterizeRainfall	dischargeAffectedBy
dischargeProducedBy	floodProducedBy
hasCharacterizingIndicator	hasDataSource
hasMitigatingAction	hasPreventiveAction
hasRecoveryAction	isCharacterizingIndicatorOf
isDataSourceOf	isObteinedWith
isParameterOf	isParametrizedBy
manageedBy	produce
produceDischarge	produceFlood
rainfallCharacterizedBy	use&Need

4.3 Analysis of the Ontology

The EA ontology describes in essence the relationships between industrial activities and environmental impacts considering for instance the environmental indicators that should be controlled for every impact.

Although the ontology is focused on industrial activities and human actions, it is also taking under consideration natural processes and natural events as impacting actions. A natural process or event is considered an impacting action whether they interact with human activities and this interaction implies an increment of its environmental impact.

As a result of the inclusion of natural events, the EA ontology contains knowledge about floods and it allows using this detailed ontology as a base to extract the relevant knowledge about our case of study.

A deeper description of the EA ontology is found in (Garrido and Requena, 2011a). It contains a description for the taxonomy of concepts, the properties and its justification.

4.4 Selection of the Algorithm

The selection of the algorithm may depend on the type of ontology and the portion of the ontology that the user is interested in.

Some ontologies are built only as semantic models where no instances of concepts are stored. In this case, the application of the generation based on concepts is mandatory.

By contrast, other ontologies are used as knowledge base with a high number of instances. In this case, the user may be interested only in the semantic model represented by the taxonomy of concepts or the factual knowledge represented by the instances of concepts. The first case implies the utilization of the generation based on concepts whereas the second case requires the generation of brief ontologies based on individuals.

In our case of study, the generation based on concepts is chosen because of there is no special interest on individuals and we are interested only in the semantic model (taxonomy of concepts with their formal definitions).

4.5 Parameters of the Algorithm

Because of the traversal algorithm based on concepts has been chosen (Section 3.1), the parameters are a set of starter concepts and a set of properties to traverse.

The selection of the starting point and the set of relevant properties of the EA ontology require the study and the analysis of the existing properties that are used in the concept definitions, i.e. studying how the concepts are related by these properties.

A property will be relevant in our domain depending on its semantics and its meaning. There are two different cases: i) The property is specific for the targeted domain. ii) The property has general use in different domains but it is used in concept definitions of the targeted domain.

If the knowledge that the user have about the detailed ontology is not enough to choose the set of relevant properties, a heuristic for the selection of relevant properties consist of the following steps. First, the set of specific properties for the domain (floods) has to be identified. Among them, a group of relevant properties is selected by studying its informal description, domain or range in order to understand its semantics and decide if it is relevant. Then, a temporary brief ontology may be built with this set of relevant properties. The resulting ontology is studied to identify new properties that are not specific in our domain but they are considered also relevant for the concepts of the brief ontology. Finally these properties are added to the set of relevant properties.

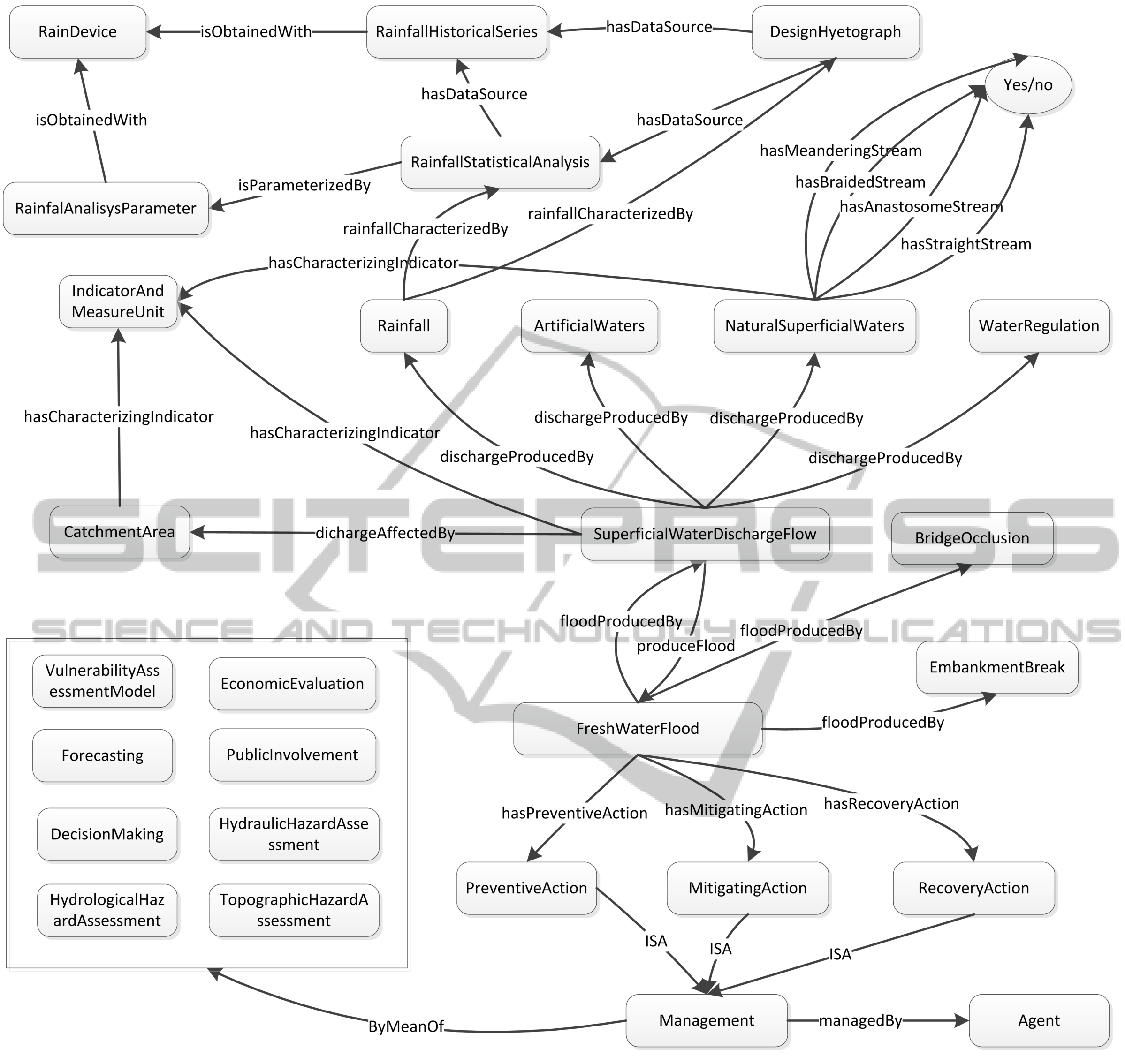
For example, the property *floodProducedBy* has its domain in the concept *Flood* and it allows defining the causes of a flood. This property is considered relevant because it represents knowledge that we want in our brief ontology for floods. The table 1 includes the final set of relevant object properties for our case of study.

Regarding to the starting points or main concepts, the user should try to find some representative concepts in the targeted domain that are not connected by a traversal path with relevant properties. In our case study, the selection of the concept *FreshWaterFlood* is enough because of it is the best concept to represent our targeted domain.

4.6 Generation of the Brief Ontology

The construction of the brief ontology for floods is automatically carried out with the traversal algorithm

SCITEPRESS
SCIENCE AND TECHNOLOGY PUBLICATIONS



SCITEPRESS
SCIENCE AND TECHNOLOGY PUBLICATIONS

Figure 1: Schema of the brief ontology.

once it has the starting point for the algorithm and the relevant properties.

As an example, the concept *DDF*[1] is subclass of the concept *RainfallStatisticalAnalysis* and it has three existential restrictions over the property *isParametrizedBy*. When the concept *DDF* is added to the brief ontology, its relationship with other concepts and individuals is analysed. These connections are represented in the definition below.

```
DDF
⊑ RainfallStatisticalAnalysis
∃ isParametrizedBy.RainfallDepth
∃ isParametrizedBy.RainfallDuration
∃ isParametrizedBy.RainfallFrequency
```

According to the traversal algorithm, because of the property *isParametrizedBy* is included in the set of relevant properties, the concepts *RainfallDepth*, *RainfallDuration* and *RainfallFrequency* will be added to the brief ontology and the traversal algorithm will continue through these concepts.

Figure 1 depicts a schema of the resulting model for flood assessment and management. The schema shows the main concepts and how they are related by the properties.

---

[1] Rainfall statistical analysis whose acronym stands for Depth, Duration and Frequency.

4.7 Evaluation

The interpretation of the model is that floods are produced by a high level of water discharge or isolated events like bridge occlusion and embankment breaks. The discharge may be produced as well by rainfall, artificial water like canals, superficial waters like rivers or bad water regulation but it also is affected by the catchment area. The rainfall, which is usually the main cause of high discharge, is usually characterized by statistical analysis and design hyetograph. Finally, flood management is the union of the preventive, mitigating and recovery actions that must be accomplished. However, the management also involves some processes like forecasting, economic evaluation, etc. (different agents like the municipality are in charge for each process).

The detailed ontology contains 2054 named classes and this number has been reduced to 91 in the brief ontology. Therefore, the brief ontology for floods only includes the relevant knowledge for this case of study.

As (Stuckenschmidt and Schlicht, 2009) says, there is not golden standard to compare the results with and the goodness of the brief ontology depends on the application that will use the ontology. For this reason, the resulting brief ontology has been positively evaluated by several experts in the targeted domain (floods). Nonetheless, the quality of the brief ontology depends totally on the quality of the detailed ontology.

5 CONCLUSIONS

In general, brief ontologies have a wide range of advantages when, for some reason, the user or application does not wish to deal with the whole original ontology. Sometimes, the user is no interested in using all the information or the application is not capable of dealing with such a huge resources.

Moreover, reusing a large ontology when only a small portion is useful and relevant for our applications may involve unfavourable consequences i.e. the reasoning time increases with the size of the knowledge base and this issue may be essential in real-time applications. For this reason, the efficiency of our knowledge base is improved by isolating portions of knowledge from large ontologies in form of brief ontologies.

As an example, a case of study in flood management has been presented. A brief ontology is created specifying the initiator concept (flood) for the traversal algorithm and the set of relevant properties to decide which concepts on the ontology are relevant. The result has been an ontology where the number of concepts has been dramatically reduced and thus it contains only concepts related to flood.

As future work, it is planned to develop metrics to compare the detailed and brief ontologies. For example, the abstraction degree of equivalent concepts in both ontologies or the representativeness of the brief ontology.

ACKNOWLEDGEMENTS

This work has been partially supported by research projects (CICE) P07-TIC-02913 and P08-RNM-03584 funded by the Andalusian Regional Governments.

REFERENCES

Aho, A. V., Ullman, J. D., and Hopcroft, J. E. (1983). *Data Structures and Algorithms*. Addison Wesley.

Baader, F., Calvanese, D., McGuiness, D., Nardi, D., and Patel-Schneider, P. (2003). *The Description Logic Handbook: Theory, Implementation and Applications*. Cambridge University Press.

Bizer, C. and Seaborne, A. (2004). D2rq - treating non-rdf databases as virtual rdf graphs (poster). In *The Semantic Web-ISWC*.

De Wrachien, D., Mambretti, S., and Schultz, B. (2011). Flood management and risk assessment in flood-prone areas: Measures and solutions. *Irrigation and Drainage*, 60(2):229–240.

Delgado, M., Pérez-Pérez, R., and Requena, I. (2005). Knowledge mobilization through re-addressable ontologies. In *EUSFLAT Conf.*, pages 154–158.

Directive 2007/60/CE (2004). Directive 2007/60/CE of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks (OJ L 288, 6.11.2007, p. 2734).

Fernández, M., Gómez, A., Pazos, J., and Pazos, A. (1999). Ontology of tasks and methods. *IEEE Intelligent Systems and Their Applications*, 14(1):37–46.

Garrido, J. and Requena, I. (2010). Knowledge mobilization to support environmental impact assessment. a model and an application. In *Proceedings - international Conference on Knowledge Engineering and Ontology Development, KEOD*, pages 193–199.

Garrido, J. and Requena, I. (2011a). Proposal of ontology for environmental impact assessment. an application with knowledge mobilization. *Expert System with Applications*, 38(3):2462–2472.

Garrido, J. and Requena, I. (2011b). Towards summarising knowledge: Brief ontologies. *Submited to Expert System with Applications*.

SCITEPRESS
SCIENCE AND TECHNOLOGY PUBLICATIONS

Gu, H., Perl, Y., Geller, J., Halper, M., and Singh, M. (1999). A methodology for partitioning a vocabulary hierarchy into trees. *Artificial Intelligence in Medicine*, 15(1):77–98.

Kim, J., Caralt, J., and Hilliard, J. (2007). Pruning bio-ontologies. In *Proceedings of the Annual Hawaii International Conference on System Sciences*.

Noy, N. and Musen, M. (2009). Traversing ontologies to extract views. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 5445 LNCS:245–260.

Staab, S. and Studer, R., editors (2009). *Handbook on Ontologies (International Handbooks on Information Systems)*. Springer.

Stuckenschmidt, H. and Schlicht, A. (2009). Structure-based partitioning of large ontologies. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 5445 LNCS:187–210.

SCITEPRESS
SCIENCE AND TECHNOLOGY PUBLICATIONS