An OWL Ontology and Bayesian Network to Support Legal Reasoning in the Owners Corporation Domain

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Abstract. The paper describes the development of a legal decision support guide for owners corporation cases in the state of Victoria, Australia that uses an OWL ontology and Bayesian Network to perform legal reasoning. The rate of growth of owners corporations (also known as body corporate or strata title properties) has increased significantly in the last two decades. Because of this growth, and the need to manage a rapidly expanding population, the governance and management of these entities has become an important concern for government. Conflict and its management within them is an essential element of this concern. Cases that can't be settled through negotiation are often referred to the Victorian Civil and Administrative Tribunal (VCAT). Using an OWL ontology we have systematically modeled legal arguments and outcomes of past cases heard by VCAT to facilitate both stand alone and Web based information retrieval, extraction and case based reasoning. A Bayesian Belief network is also used to deal with assumptions that tend to be prevalent in commonsense reasoning. Through our system we aim to provide negotiation decision support to help guide owners corporation disputants through the grievance process.

Keywords: OWL ontology, Bayesian network, legal reasoning, Victorian Civil and Administrative Tribunal (VCAT).

1 Introduction

The rate of growth of owners corporations (OC) in Australia, according to the Australian Bureau of Statistics National Census 2006 is about twice that of detached housing since 1981.[1] In the big population centers of Sydney and Melbourne they now comprise approximately a third of all dwellings. Because of this growth and the need to manage a rapidly expanding population, the governance and management of these entities has become an important concern for government. Conflict and its management within them is an essential element of this concern (see [1] and [2]).

Our research aims to promote better management of these conflicts by providing a negotiation decision support guide for property owner disputes that mirrors judicial reasoning practices so that disputants can negotiate more deliberatively before

[1] http://www.abs.gov.au/ Last accessed 3 September 2010.

proceeding to litigation. The system uses an OWL ontology to formalize legal arguments, and a Bayesian Belief Network [3] to infer judicial outcomes for cases heard in Victorian Civil and Administrative Tribunal (VCAT).

The paper commences with a discussion of cased based legal reasoning systems followed by a brief overview of recent initiatives involving the semantic Web and ontologies in the legal domain. Limitations of using ontologies for case based legal reasoning are examined and we describe how Bayesian Belief networks can help improve the inference capabilities. Specific aspects of the Victorian Owners Corporation Act (2006) are then described including the current legislative process for resolving disputes and the role of the Victorian Civil and Administrative Appeals Tribunal (VCAT). We identify factors considered by VCAT members in their discrete areas of decision making and show how these factors have been used to develop an OWL ontology and a Bayesian Belief network for the OC domain. Example queries are then used to demonstrate legal reasoning. The paper concludes with a brief discussion of our industry partner's involvement in the project and our future research plan.

2 Case Based Legal Reasoning

The ways in which past cases are used in arguments has long been of major research interest to practitioners and academics in the field of artificial intelligence (AI) and law. The current best known approach to Case Based Legal Reasoning is to represent cases as collections of factors favoring plaintiff and defendant, e.g. Cato [4] and HYPO [5]. Factors are described by [4] as stereotypical collections of facts that, experts agree, influence the outcome of a case. The presence a factor makes a case stronger or weaker for the plaintiff. These models help to clarify and test hypotheses about processes of reasoning with cases in the legal domain. They also provide a potential basis on which to build software applications [4]. Two key challenges faced in building cased based legal reasoning systems are (1) how to reason about the significance of differences between cases and (2) how to assess the relevance of precedent cases to a given problem situation. A number of approaches aimed at addressing these issues have been explored in the past with varying degrees of success. Hypo for example uses dimensions to generate arguments that compare and contrast hypothetical modifications of a problem, while Cato focuses on background knowledge about the meaning of factors to evaluate the similarity of cases at multiple levels of abstraction and from different viewpoints.

3 Ontologies in the Legal Domain

The Semantic Web is a Collective effort led by the W3C in which an evolved Web describes data in a shared and formal format to be useful for people and machines alike, allowing data to be shared and reused across applications, enterprises, and community boundaries [6]. This opens up new horizons for Web based legal systems with new tools and services focusing on conflict prevention, conflict tracking, debate and negotiation. Ontologies are an essential component of the semantic Web. An ontology defines the basic terms and relations comprising the vocabulary of a topic area as well as the rules for combining terms and relations to define extension to the vocabulary [7]. In the legal domain ontologies have been useful in a number of applications to support information retrieval, extraction, integration and case based reasoning as demonstrated by [8] and [9].

The OWL language became a W3C recommendation for building ontologies in February 2004. The latest version is OWL 2 which provides more modeling primitives, greater cardinality and extended data type and annotation support than the original language specification. There are three sub-species of OWL called OWL Lite, OWL DL and OWL Full; each with increasing expressive power. OWL DL is designed to be classified using a Description Logic reasoner to automatically check for inconsistencies and compute an inferred hierarchy. While OWL DL is a natural framework for representing facts and reasoning about facts, like other forms of deductive logic [10] and [11], it is not capable of dealing with assumptions that tend to be prevalent in commonsense reasoning. An ontology based approach to cased based reasoning works well when facts of a query precisely match the facts of outcomes stored in the cased base. It is difficult to infer judicial outcomes, however, when some facts are known about a case but there is also incomplete information, or alternatively, where some facts are the same as in previous cases but other facts differ. This problem is known as the monotonicity problem [11].

4 Modelling Legal Arguments with a Bayesian Network

Modelling judicial reasoning with a Bayesian network addresses the monotonicity problem by allowing facts to be assertible and retractrible based on what is known about a problem. Bayesian belief networks are graphical tools for specifying probability distributions. They rely on the basic insight that independence forms a significant aspect of beliefs that can be elicited relatively easily using the language of directed acyclic graphs (DAGs). Nodes in a DAG represent propositional variables and edges of the nodes represent direct causal influences among these variables [10]. The network is guaranteed to imply a unique value for each of the network probabilities and in effect forms its own assumptions to fill in the missing facts. Probabilities are then revisable upward or downward depending on what else is known.

5 Current Legislative Process and the Role of VCAT

Owners Corporation disputes that can’t be settled through negotiation are often referred to the Victorian Civil and Administrative Tribunal (VCAT). Under *Section 162* of the Victorian Owners Corporation Act (2006), VCAT may hear and determine a dispute or other matter arising under this act or the regulations or the rules of an owners corporation that affects an owners corporation including a dispute or matter relating to:

a) *the operation of an owners corporation ; or*
b) *an alleged breach by a lot owner or an occupier of a lot of an obligation imposed on that person by this Act or the regulations or the rules of the owners corporation ; or*
c) *the exercise of a function by a manager in respect of the owners corporation.*

It is interesting to observe how the reported cases have managed this schema. The cases available through the Australasian Legal Information Institute (AustLII)[2] provides an overview of the most important and frequent matters coming before VCAT and the Supreme Court[3]. An analysis of these cases indicates at least twelve discrete areas of decision making or issues have emerged as follows:

1) Applications for Unpaid Fees
2) Conduct of Litigation
3) Vexatious and Frivolous Claims
4) Legal and Other Representation
5) Substituted Service of Proceedings
6) Costs
7) Joinder of Parties
8) Overturning Majority Decisions of an OC
9) Appointment and Termination of Managers
10) Issues with Common Property
11) Lot Liability
12) Licenses and Easements

For VCAT there is clearly a two step procedure. First is to determine that there is a "dispute" within the meaning of section 162. If there is such a dispute then section 165 provides that the decision be guided by the principle of "fairness" under which a number of further factors or considerations apply. A hierarchy of factors can thus be discerned which could be defined as a "decision or argument tree" for the guidance of the Tribunal. In this sense the plan of the Act provides a decision tree that could be represented as follows in Table 1. A more detailed discussion of the Victorian Owners Corporation Act (2006) and the role of VCAT in determining OC rulings can be found in [12].

[2] http://www.austlii.edu.au/ Last accessed 3 September 2010.
[3] Available at http://www.austlii.edu.au/ (at this time approximately 85 in number).

Table 1. Principle factor.

Principle Factor: "Presence of a Dispute" per 162
Sub Factors
• *the operation of an owners corporation ; or* • *an alleged breach by a lot owner or an occupier of a lot of an obligation imposed on that person by this Act or the regulations or the rules of the owners corporation ; or* • *the exercise of a function by a manager in respect of the owners corporation .*
Principle Sub Factor – Fairness s165
Considerations
• *the conduct of the parties;* • *an act or omission or proposed act or omission by a party;* • *the impact of a resolution or proposed resolution on the lot owners as a whole;* • *whether a resolution or proposed resolution is oppressive to, unfairly prejudicial to or unfairly discriminates against, a lot owner or lot owners*
Specific Considerations – ss 5 and 122
• *good Faith* • *due Diligence*
Specific Considerations for Managers – s122
• *not to take personal advantage for self or others*

6 A Legal Decision Support Guide for OC Disputes

For the purposes of this paper the issue of what circumstances VCAT would overturn a decision of the OC (number 8 in the list above) is examined. In particular, we are interested in how the decision outcomes are arrived at so as to guide potential disputants in decision making. This category of dispute provides a good background against which to examine how the Tribunal is interpreting and applying the provisions of the Act and in particular the factors outlined in the argument tree in Table 1.

6.1 An OWL Ontology for Legal Reasoning

Our domain expert[4] has modeled judicial reasoning for owners corporations cases heard by VCAT using an OWL ontology to capture the discrete areas of decision making and factors used in legal arguments identified in the previous section. The ontology which is shown in Figure 1 was created using the Protégé ontology editing and acquisition tool. We used the recently released version 4.1 Beta of Protégé which supports OWL 2.

[4] Co-author Peter Condliffe is a Nationally Accredited Mediator and Advanced Mediator at the Victorian Bar and LEADR.

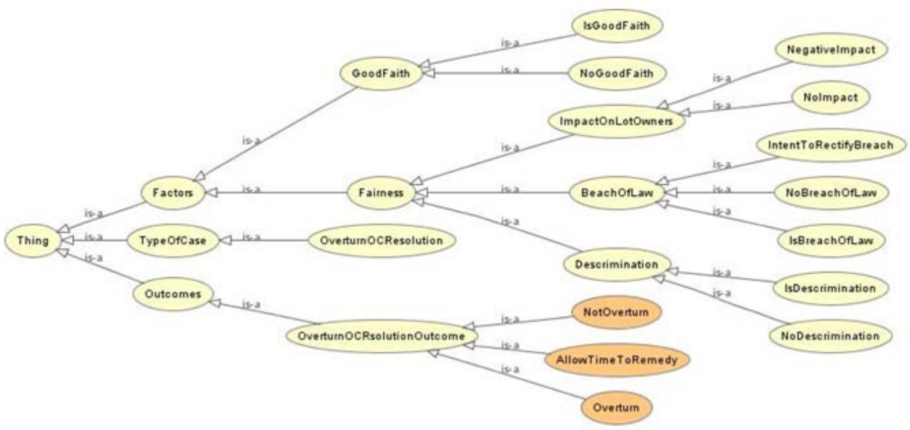

Fig. 1. OWL ontology for the OC domain.

To create a case base, outcomes of all past cases were modeled as *Defined* Classes. Facts of past cases are represented as *Necessary and Sufficient* class restrictions. A *Necessary* data property restriction "hasOutcome" is used to instantiate instances of this class with the string value "Allow time to remedy". Figure 2 shows the defined OWL class "Allow time to Remedy".

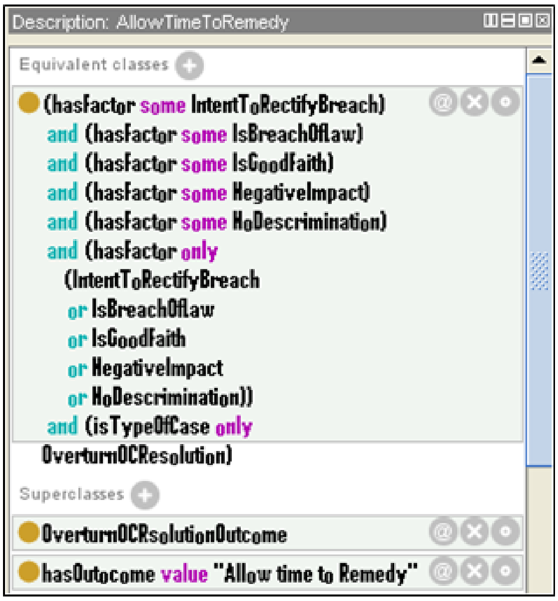

Fig. 2. OWL defined class "allow time to remedy".

The axiom below which forms part of the *Necessary and Sufficient* conditions is called a closure axiom:

```
(hasFactor only
(IntentToRectifyBreach
 or IsBreachOfLaw
 or IsGoodFaith
 or NegativeImpact
 or NoDescrimination))
```

Facts of a query must precisely match the facts of the closure axiom for the query to return the outcome. The reason for using a closure axiom is to prevent an outcome being incorrectly returned when additional facts may have invalidated the result. Figure 3 shows the creation of a query class. A query is created as a *Primitive class* meaning facts are entered as *Necessary* class restrictions.

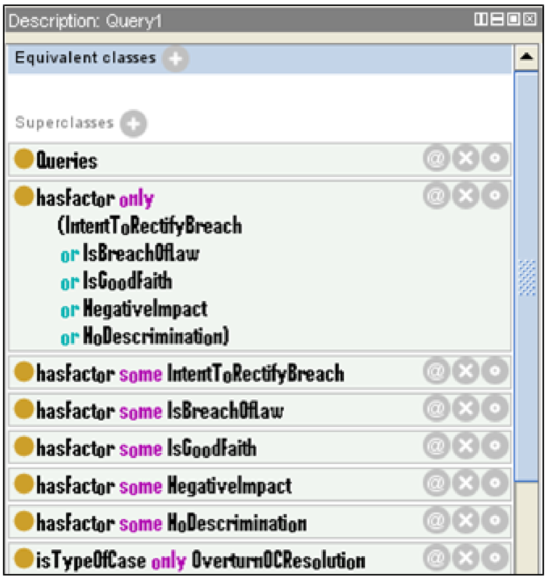

Fig. 3. Query class.

By running the reasoner and classifying the ontology to create an inferred hierarchy Query 1 below is now reclassified under the outcome class “Allow time to Remedy”. The Boswell V Forbes case describe in [12] now appears as an instance of the “Allow time to Remedy” class in the inferred ontology model and is thus instantiated with this outcome by the string data property restriction “hasOutcome”.

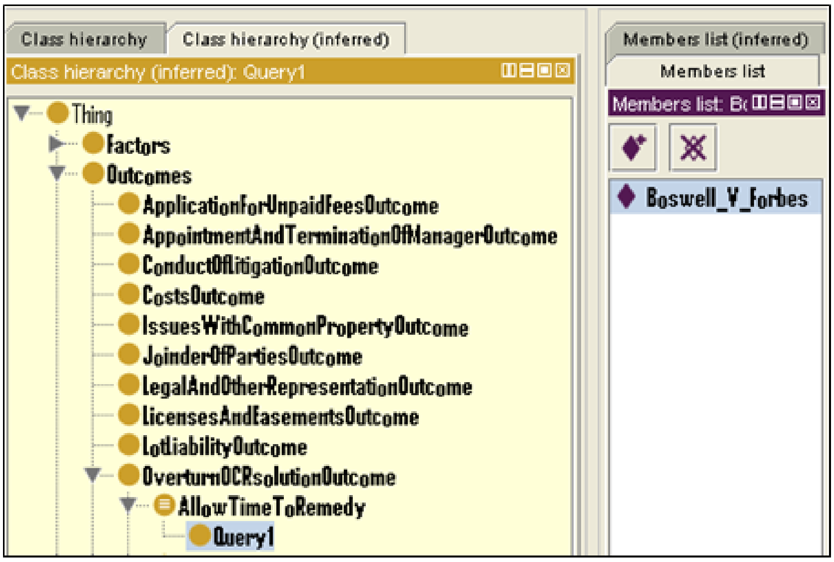

Fig. 4. Inferred hierarchy.

6.2 A Bayesian Network to Reason with Incomplete Facts

As previously noted, the ontology approach to case based reasoning works well when facts of a query precisely match the facts of outcomes stored in the case base. It is more difficult to infer outcomes, however, when there is incomplete information or when there are additional facts that do not match the facts of past cases. To query the case base and infer outcomes for non matching cases, a Bayesian Belief Network is used. Results of queries from the Bayesian network are then used to create *Defined* classes in the OWL ontology so that queries can be processed in the same way as in the previous example. We used the Samiam[5] tool to create separate Bayesian networks for the discrete areas of decision making outlined in section V. Elicitation sessions were conducted with our domain expert[6] in order to define the network structure shown in Figure 5 which differs slightly from that of the OWL ontology. Nodes in the network represent the decision making factors described in section V. Figure 6 is a DAG for cases involving the issue of ‘Overturning Majority Decisions of an OC’. The two nodes at the top of the graph “Overturn OC Resolution” and “Allow OC to remedy” are defined as ‘query variables’. They represent possible outcomes for cases involving a particular issue and are used to query the probability of each outcome occurring given the particular facts of a case. The nodes below this are called ‘evidence variables’. They are used to assert evidence (facts) about a case.

[5] Samiam freeware version is available at: http://reasoning.cs.ucla.edu/samiam/index.php Last accessed 3 September 2010.

[6] Co-author Peter Condliffe is a Nationally Accredited Mediator and Advanced Mediator at the Victorian Bar and LEADR.

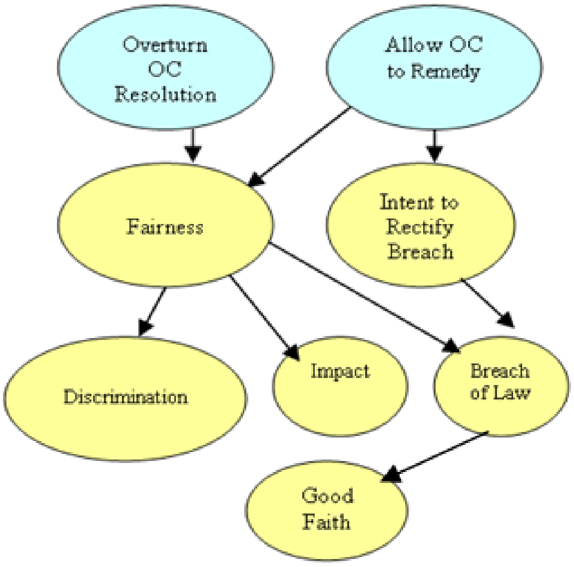

Fig. 5. Network structure

Our domain expert used his knowledge to develop a probability distribution to capture degrees of belief for each node in the DAG's so that *Pr* captures the probability of observing each value *x* of variable *X* with every instantiation *u* of its parents *U*. In this case, the variables *x* have been restricted to Boolean Yes/No values. More fine grained input values with varying decrees of belief can be used if need be. We now demonstrate the use of the network with a hypothetical scenario. Asserted facts for the case are shown in red and display a 100% input value. These are classified as hard evidence. Inferred facts (assumptions) are shown in green and are classified as soft evidence.

Asserted Facts

- There was discrimination against the complainant
- Overturning the decision would impact lot owners as a whole
- There was no breach of law.

Inferred Outcome

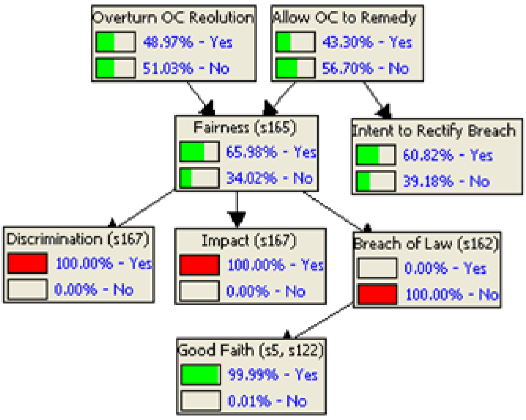

Fig. 6. DAG

In this example the DAG inferred that the resolution should not be overturned. Even though there was discrimination against the complainant, the fact that overturning the decision would impact on lot owner as whole combined with the fact that there was no breach of law tip the balance of probabilities in favor of not overturning the resolution. The inferred outcome can now be created as a Defined ontology sub-class of “Outcomes” in the OWL ontology by inserting the following code into the OWL file using string manipulation and a standard Java “println” command:

```
<owl:Class rdf:ID="NotOverturn">
    <rdfs:subClassOf rdf:resource="#OverturnOCRsolutionOutcome"/>
       <owl:equivalentClass>
          <owl:Class>
              <owl:intersectionOf rdf:parseType="Collection">
                <owl:Restriction>
                    <owl:allValuesFrom>
                    <owl:Class>
                  <owl:unionOf rdf:parseType="Collection">
              <owl:Class rdf:about="#NoBreachOfLaw"/>
             <owl:Class rdf:about="#IsDescrimination"/>
           <owl:Class rdf:about="#NegativeImpact"/>
         </owl:unionOf>
 </owl:Class>
```

Having inserted the above text into OWL ontology the outcome can now be processed as a *Defined* class in the same way as the “Allow time to Remedy” class in Figure 2.

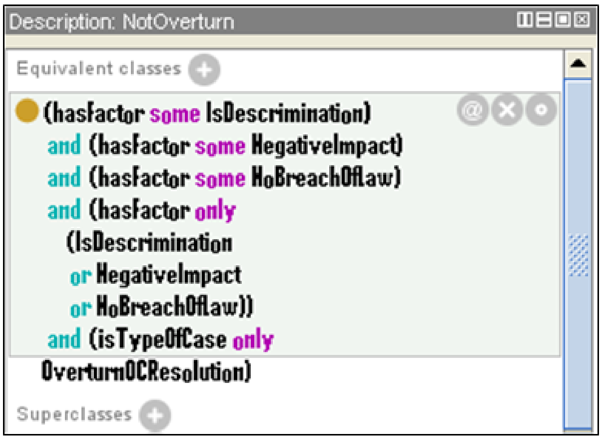

Fig. 7. New defined class

7 Conclusion

With the rapid of growth of owners corporations in Victoria, Australia over the last thirty years, conflict and its management has become an essential element of concern. Current legal remedies, however, are widely seen as inadequate. Our research aims to assist with better management of these conflicts by providing a negotiation decision support guide for property owner disputes that mirrors judicial reasoning practices so that disputants can negotiate more deliberatively before proceeding to litigation. [7] led to the development of the OWL ontology and Bayesian Belief network to be used as a decision support guide for OC cases. Preliminary evaluations have shown the OWL ontology to be capable of precisely replicating the outcomes of past cases when the exact same facts of the real case are entered. Testing with hypothetical cases has also satisfied our domain expert that inferred outcomes obtained from the Bayesian Network are consistent with logical judicial reasoning. The next phase of the research will be to test the robustness of the conclusions drawn using a more formal technique called sensitivity analysis [11] where outcomes are checked against perturbations in the local probabilities. This will be an iterative process with the analysis expected to lead to further refinement of the network structure and adjustment of the conditional probability tables (CPTs). The system will then be deployed as a Web application using the Jena semantic Web framework. Members of the project team were previously successful in developing the AcontoWeb [13] semantic portal using the Jena framework and Pellet reasoner.

[7] http://vbcs.com.au/ Last accesses September 4 2010.

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