Case Base Reasoning decision support using the DecPROV ontology for decision modelling

Nicholas J. Car[1][0000−0002−8742−7730]

CSIRO Land & Water, Dutton Park, QLD, Australia
nicholas.car@csiro.au
http://people.csiro.au/C/N/Nicholas-Car

Abstract. Decisions are modelled using a new, Semantic Web, specialised provenance ontology. This allows for management in graph databases and common instance components to be globally addressed and thus reused. New decisions are compared to those in a Case Base to provide best-practice advice. This is a Decision Support System (DSS) which also assists other DSS by revealing contemporary practice in standardised ways with details for decision categorisation.

Keywords: Decision Modelling · DecPROV · PROV · provenance · Case-Based Reasoning

Fig. 1. A drip irrigation system carrying water to crops via pipes, valves and emitters: modern systems such as these allow for fine-grained irrigation management governed by expert systems. Image curtesy of Irrigation Australia, Pty. Ltd.

1 Decision modelling need and a domain

Decision Support Systems (DSS) encode expert knowledge and perhaps data for decisions to help users a:ain best practice. Few DSS cater for different decision scenarios or even variations within a scenario.

Standardised decision modelling would allow us to articulate many decision types within a domain and variations within a type consistently perhaps allowing DSS designers to be:er cater for decision ranges.

For irrigation decisions by smallholding farmers, perhaps using systems such as that shown in Fig. 1, we would like to characterise decisions they make in a standardised way, knowing that many factors affect their overall practice [9].

2 Standardised PROV decision modelling

DecPROV [2] a specialised version of the PROV Data Model [6] is used to model past decisions. As opposed to other industry or academic decision modelling such as DMN [8] or Decision Modelling Ontology [4], this ontology is both PROV-aligned and uses Semantic Web methods allowing for:

- Sophisticated modelling of complex decisions
  - The Semantic Web has a large range of interoperable models
  - Whole business processes can be modelled & decisions included
- Describing *why* particular decisions were made in PROV-like terms
- Describing different types of decisions within a domain and categorising them with standard taxonomy techniques

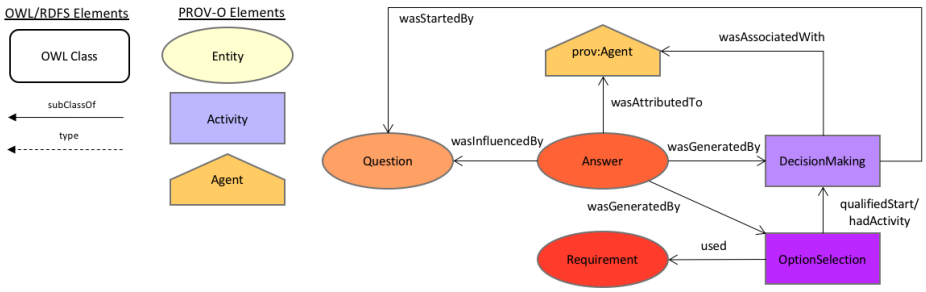

Fig. 2. Classes of DecPROV and their basic relationships. From the ontology documentation at https://promsns.org/def/decprov . DecPROV uses standard PROV-O [5] properties to relate specialised versions of PROV-O classes that describe decision elements in a manner similar to the W3C?s Decision Modelling Incubator Group?s candidate Decision Ontology [7]

3 Case-Based Reasoning with decisions

A way to provide support for a decision without expert systems is to compare them to previous ones using Case-Based Reasoning [1]. Current cases are matched for similarity to previous one whose results must be known, then best

practice advice is offered with the current case then stored for future use. Typically CBR systems use a *cycle*, see Fig. 3., and require a similarity metric to compare cases.

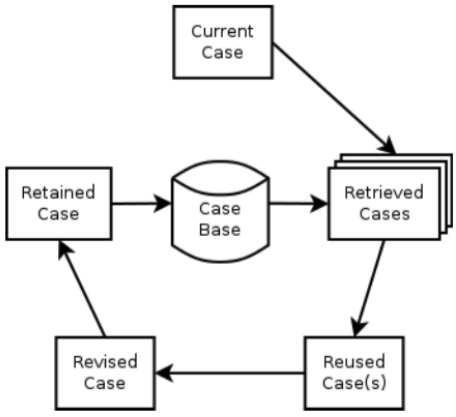

Fig. 3. The CBR cycle, after [1]

Using DecPROV and Semantic Web modelling generally, schema-less RDF triplestores can be used to store decisions and the standardised SPARQL query language used to compare them. For example, a query could find decision outputs (an Answer) sharing datasets of Type X as an input (see Listing 1.1).

```
PREFIX prov: <http://www.w3.org/ns/prov#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
SELECT ?answer
WHERE {
    ?answer prov:wasGeneratedBy ?decision .
    ?optionSelection prov:qualifiedStart/prov:hadActivity ?decision;
                     prov:used/rdf:type :DatasetTypeX .
}
```

Listing 1.1. Example SPARQL query (https://www.w3.org/TR/sparql11-query/) to find a decision using inputs of Dataset Type X

4 Current Work

Currently we are cataloguing and categorising known online irrigation-relevant data sources so decisions using similar input data can be selected for. Without cataloging we can't ascertain data source reuse and without characterisation we can't determine similarity between data sources: multiple, sometimes branded, data sources can deliver similar information.

As we characterise a series of data sources, we are establishing a range of similarity measures to be used in CBR to allow the matching of a Current Case to Past Cases of decisions made. Since the mechanics we are using are RDF triplestores, we are establishing these similarity measures as SPARQL queries.

We are also testing the modelling power of DecPROV: Does it cover all/many irrigation decisions? Does using DecPROV improve data provenance generally to assist with other questions such as those about data quality?

As we characterise decisions made, we are storing anonymised instances of them in a triplestore with a SPARQL endpoint and a wrapping Linked Data layer which publicly lists them with persistent URIs so they can be found, referred to and reused in CBR systems and generally.

5 Future Work

Once a full CBR cycle is implemented, we will begin providing CBR-derived decision support to irrigators. We hope to discover hitherto unknown decision making patterns in irrigation to inform future non-CBR decision support systems. We also hope to expand the use of DecPROV to other decision domains.

References

1. Aamodt, A. and Plaza, E. "Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches", AICom - Artif. Intell. Commun., vol. 7, no. 1, pp. 39-59, 1994.
2. Car, N.J., "Modelling causes for actions with the Decision and PROV ontologies" in MODSIM 2017 - 22th International Congress on Modelling and Simulation. Hobart, Australia, 2017. https://www.mssanz.org.au/modsim2017/C2/car.pdf
3. Car, N.J. and Moore, G.A. "Bridging the gap between modelling advice and irrigator solutions through empirical reasoning techniques" in MODSIM 2011 - 19th International Congress on Modelling and Simulation, Perth, Australia 2011. https://www.mssanz.org.au/modsim2011/B1/car.pdf
4. Kornyshova, Elena, and Rébecca Deneckère. 2010. "Decision-Making Ontology for Information System Engineering". In Conceptual Modeling - ER 2010, 104-17. Lecture Notes in Computer Science. Vancouver, BC, Canada: Springer. https://doi.org/10.1007/978-3-642-16373-9_8
5. Lebo, Timothy, Satya Sahoo and Deborah McGuinness. "PROV-O: The PROV Ontology" W3C Recommendation 30 April 2013. https://www.w3.org/TR/prov-o/
6. Moreau, Luc and Missier, Paolo (eds), "PROV-DM: The PROV Data Model", W3C Recommendation 30 April 2013. https://www.w3.org/TR/prov-dm/
7. Nowara, Piotr, "Decision Ontology". W3C Decisions and Decision Making Incubator Group, 2011 https://promsns.org/def/do
8. Object Management Group. 2016. "Decision Model and Notation (DMN)" OMG specification formal/2016-06-01, Object Management Group. http://www.omg.org/spec/DMN/1.1
9. Whittenbury K. and Davidson P., "Beyond Adoption: The need for a broad understanding of factors that influence irrigators? decision-making" Rural Soc., vol. 19, no. 1, pp. 4-16, Apr. 2009.