Modeling Operational Ontologies from Conceptual Ontologies Using Kinds of Conceptual Contexts

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Abstract. In this paper we report on the current stage of our design of methodologies and techniques to use conceptual ontologies to extract operational ontologies. The work begins from the paper “Using Mathematical Model Theory to Align Conceptual and Operational Ontologies in FIBO” and reports on two major extensions on that work. The first is the addition of a context framework to implement the satisfiability and interpretation requirements of our earlier model. We briefly discuss our current thinking on this context framework. We then work through an example using some of the contexts from the framework to show how this works in the case of an exchange commitment in the air travel industry. This example illustrates the unfolding of commitment at the level of the conceptual ontology into the right commitment and the obligation commitment at the level of the operational ontology. We then reach some conclusions which will direct us to future work.

Keywords: Conceptual ontology, operational ontology, ontological context

1 Overview

The distinctions between kinds of ontologies for different purposes is not always well understood. Some practitioners recognize a distinction between reference ontologies for subject matter concept representation, and operational ontologies for inference processing applications.

Operational ontologies, like any application data model, are necessarily contextual, the context being identified with the use case or competency questions to be addressed by the ontology-based application. This distinction is explored in this paper with reference to the underlying principles of conceptual representation and of application design, as applied to ontologies for Semantic Web applications.

Table 1 - Kinds of Contexts

Contexts Grid						
Who	What	When	Where	Why	hoW	Granularity

Table 1 describes a number of basic ‘contexts’ as identified at the Ontology Summit 2018 [1]. These are the ‘What’, When’ ‘Where’ etc. that would apply to any given operational data model, whether this takes the form of conventional application data or of an OWL ontology for an

inference processing application. The notion of ‘Granularity’ as a kind of context was introduced by Smith [2] at that same Ontology Summit, to account for differences in focus for different applications, for example organisms versus cells versus molecules.
The 6 context Ws in some detail with granularity/specificity folded into each:

1. “Why” is the context of goal and therefore also of risk.
2. “Who” is the context of agency down to the level of task description and program.
3. “What” is the context of objectivity, of “object-ness.”
4. “Where” is the context of location, both geographic and process location.
5. “When” is the context of time.
6. “How” is the context of process.

The “why” in terms of goals extends from the enterprise level of governance and goal setting to the lowest level at which goals are set in the enterprise. It extends down to the standard costs and other standard metrics set by the enterprise for all and any processes and activities. Financial type risk are often pictured as classifications (credit risk, operational risk, etc.) These are classified in our structure as compliance goals that need to be addressed or achieved.

The “who” or agency context includes the typical agency abstractions with specifications down through party in role. As the “what” context is realized through, for instance, a contract type, the agency context can *unfold* to include the sides of the contract. This means that the concept of buyer and seller appear at lower granularity levels in this context. This will include specific performance at even lower levels and will lead into implementation issues when we reach levels of capturing the actual measures of performance attainment.

In the “what” context, resources and entities appear in context. The agent component of the REA model appears in our classification under the “who” context. We develop an example of this later in the paper.

The “where” or location context is fairly straightforward. On the geographical level and taking a USA context, this moves from nation to state to county to city and on down. As a process example we have data flow diagrams and their structure of decomposability.

The time or “when” context includes at least two sub-contexts: duration and specificity. Duration is the length of the context. Specificity includes the increasing granularity of the year, month, day and hour timeline.

The process context is the “how” context. It has some obvious ties to the where and when contexts through the decomposition of the process specification and the timing of the relationships and interdependencies in the process.

2 Extended Example

Criteria:

Make sure it can be expressed both conceptually and operationally
It must be conceptually correct
It must be operationally sound
Expressed in OWL [3] and OntoUML [4] or UMLCMP [5]

Task:

Work out a simple operational ontology representation of some purchasing problem. Derive this ontology from the conceptual ontology. Use the conceptual pieces as building blocks, as if we were drawing them from a palette. During the process, repair or improve the conceptual ontology as needed.

Example

Contexts used: ‘what’ (commitment, rights and obligations)

We used a copy of the existing FIBO framework from recent off-line ingests.

Scenario: You are Imaginair, an airline. You wish to model the payments and transactions for supply of some product or service, at some airport. Possible services in the model include fuel, catering, landing rights possibly including gate access, and baggage handling. We spent some time thinking about the different kinds of supply relationships and what realistically happens before concluding that the real-world specifics are not relevant for this proof of concept. What matters is that, given some assumption about how these things are done in the world, even if those assumptions are wrong, can we model that? Indeed, modeling assumptions wrongly is a key payback from using ontology – any errors in analysis should be detectable to business stakeholders.

Commitment versus Right and Obligation in the 'what' context (see Figure 1): the commitment of a *Fuel supply transaction* in the conceptual ontology becomes the *Right to fuel* and the *Obligation to pay for fuel* in the operational ontology. Furthermore, the relationship of the right and obligation to Fuel Provider transforms into an 'obligation to pay for fuel' as an obligation towards the fuel provider and the 'right to fuel' as a right of the airline, corresponding to an obligation of the fuel provider.

What is missed in the conceptual ontology is that the *Fuel provider* et al are themselves relative things. This means that they should be replaced with a relative class for Fuel Provider along with Business Entity, Organization or a similar concept in the conceptual model. Additionally the property chain from conceptual model party and the *hasIdentity* property defines this.

We can observe that in this case the semantics is unchanged from Conceptual model and ask whether this will be the case for other transformations.

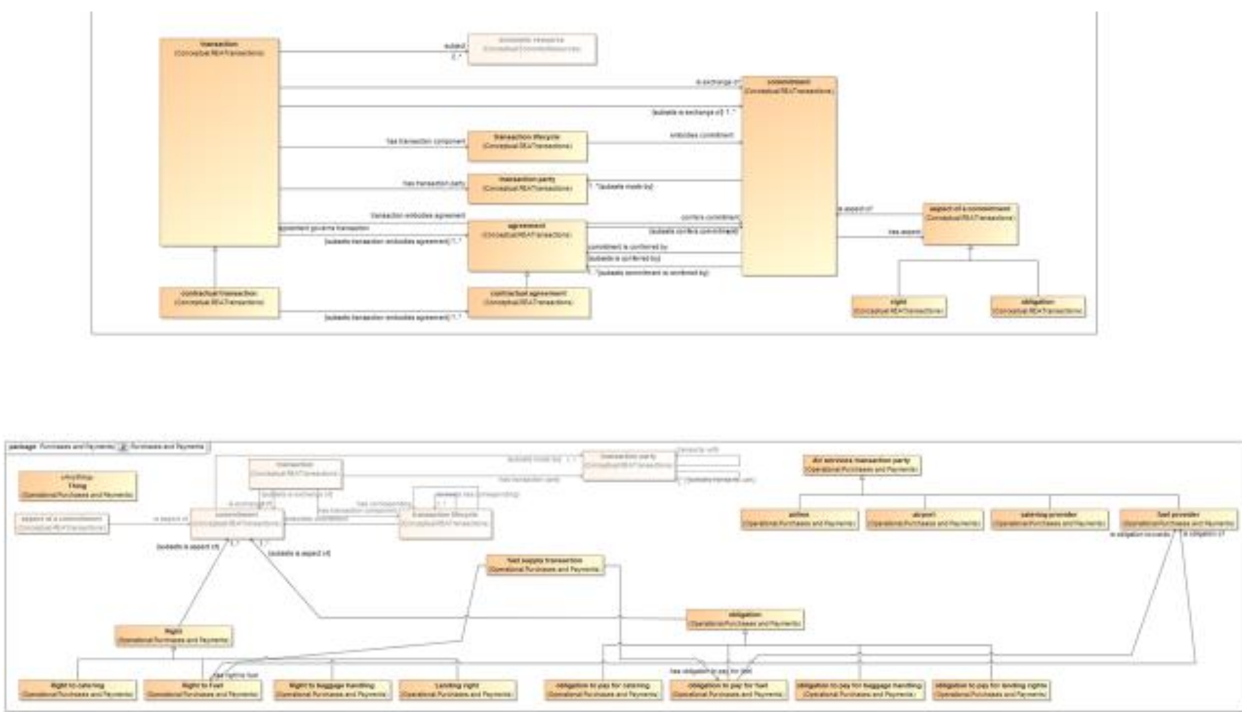

Figure 1 - Conceptual and Derived Operational Ontologies

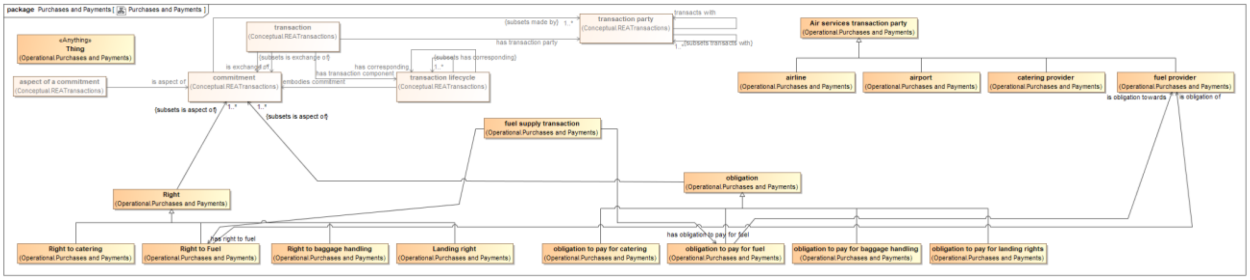

Figure 2 - The Operational Ontology

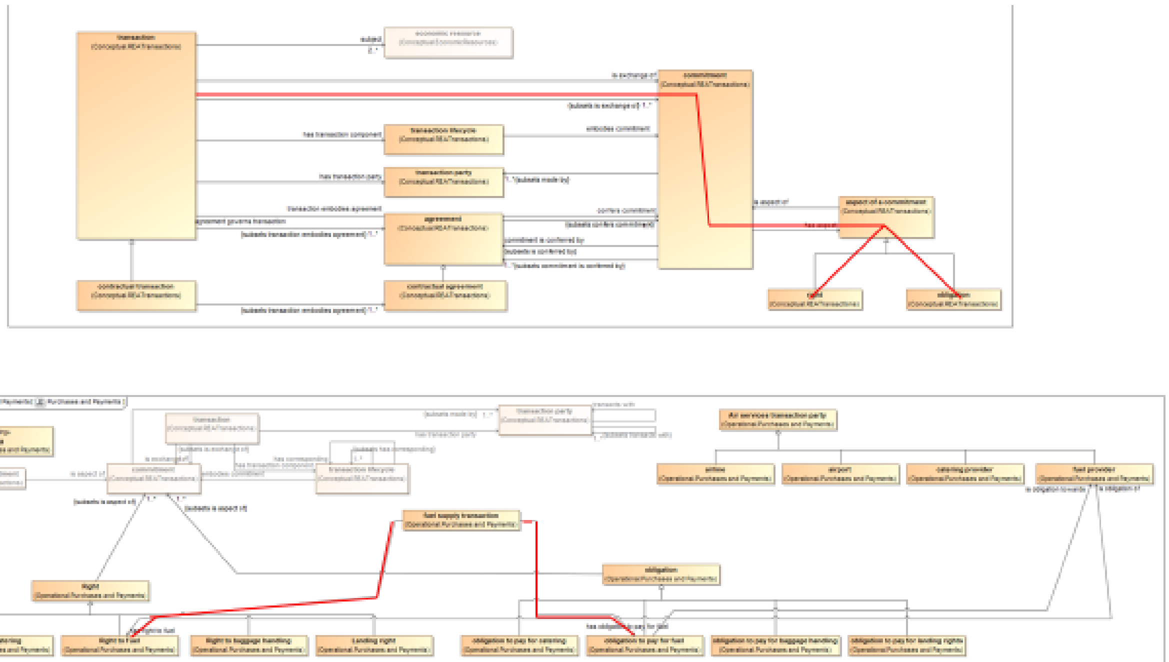

Figure 3 - Property Chains in the Ontologies

Further, the relationship in the operational model seems to be a property chain of properties in the conceptual model (see Figures 2 and 3). The transaction *isExchangeOf* is a commitment and the commitment has the aspect *has Aspect* of *Right*. So, by inheritance, *Fuel Transaction – isExchangeOf – FuelCommitment* and *FuelCommitment – has Aspect – Right To Fuel*. The missing independent thing, *FuelCommitment*, is not needed in the operational model but would be in the corresponding conceptual model.

Observations

Relative things removed along with Commitment needed to take into account that modeling is with reference to the locally contextual matter where rights, obligations, entities are in the ‘what’ context. Additionally, some transformations take the existing semantics from the conceptual model. Some transformations are a property chain of two properties generally inherited from some higher level class. And some transformations might be a longer graph in the conceptual model. The graph includes classes and properties. Sometimes the naming and semantics of the operational ontology properties are determined by classes that are visited in the graph which are usually at the opposite end of the chain of relations. In the future, we need to investigate whether this is a generalizable heuristic.

3 Conclusions

This paper illustrated the application of contexts onto methods and techniques used to derive operational ontologies from conceptual ontologies. We introduced the context framework and briefly described how it works. We then presented an extended example and results. We found that the process can expose weaknesses in the conceptual ontology. We also find that the relationship in the operational model seems to be a property chain of properties in the conceptual model while others take the existing semantics of the conceptual model. Additionally, we find that independent things in the conceptual model are not necessarily needed in the operational model and that this can also be true for relative things.

We have several possibilities for future research. The first is to work through extended examples using the other contexts. This will help to provide evidence as to the appropriateness of our context framework. The second is to consider the cases for all of the combinations of contexts: pairwise, triples, etc. This will help us to see under what operational conditions certain combinations might be useful. The last is to begin to formalize the methodology into the formalisms of mathematical model theory.

References

1. Bennett, M., Upper Ontologies for Specifying Context. Ontology Summit 2018, available at: https://s3.amazonaws.com/ontologforum/OntologySummit2018/UpperOntology/Track+B2--Context+and+Upper+Ontology--Bennett.pptx
2. Smith, B., How BFO Deals with Data from Multiple Contexts. Ontology Summit 2018, available at: https://s3.amazonaws.com/ontologforum/OntologySummit2018/UpperOntology/BFO-context.pptx
3. OWL 2 Web Ontology Language Quick Reference Guide (Second Edition), W3C Recommendation 11 December 2012. Available at http://www.w3.org/TR/2012/REC-owl2-quick-reference-20121211/
4. OntoUML. Available at: http://www.menthor.net/ontouml.html
5. UML Concept Modeling Profile (UMLCMP). Available at: https://spec.edmcouncil.org/UMLCMP/index.html
6. Nehmer, Robert and Mike Bennett. Using Mathematical Model Theory to Align Conceptual and Operational Ontologies in FIBO, VMBO paper, 2018.