Semantic Web Services-based Reasoning in the Design of Software Product Lines

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Research Goal

To evaluate the suitability of the Web Service Modeling Ontology (WSMO) in the encoding of product configurations and related constraints from a software product line (SPL) in such a manner as to better enable reasoning approaches which facilitate higher automation of service discovery, composition, invocation, and monitoring in service oriented architectures (SOA).
Outline

• Background and Motivation
• Feature Models (FM)
• Web Service Modeling Ontology (WSMO)
• Model Transformations
  – FM to WSMO
  – Product Configuration to WSMO
• Orchestration in WSMO
• Reasoning
• Implementation, Conclusion and Future Work
Background Issues

- Impediments to successful implementation of SPL when considering SOA
- Challenges representing SOA as SPL
- Limits to the expressiveness of FM
- Limited reasoning capabilities
- Ontology-related technology exists to support
Deliverables

- Mappings between FM and WSMO
- Transformation implementation
- Reasoning framework
What do the deliverables make possible?

The ability to explore and evaluate:

- accuracy of the mapping possible between the two formalisms.
- level of automation supported during transformation
- support or guidance that the ontology can provide to feature modeling.
Themes of this Workshop

- Variability and variability mechanisms
- Product composition

How does this work relate to these themes?
Overall Flow of Information

[Diagram showing the flow of information from an existing ontology, through WSMO ontology, interface ontology, to product configuration.]
Feature Models

- SPL implementations typically feature-based
- FM ideal representation for SOA
- Using Czarnecki et al. notation and rendering
- Metamodel of FM and product configurations
- Tool support
Feature Model Metamodel

Web Service Modeling Ontology (WSMO)

- Semantic describes all aspects of SWS
- Relatively new framework
- Tool support
- Four core elements
  - Ontologies
  - Web Services
  - Goals
  - Mediators
WSMO Metamodel
Model Transformation

Feature Model
- VirtualWholesale
  - Registration
  - RewardsProgram
  - Provider
    - AtlanticProductsLtd
    - NorthernDesigns
    - LakewoodRefurbishing
    - QualityImportsLtd

WSMO
- ATL
- FM2WSMO : Module
  - OUT : OclModel
  - IN : OclModel
    - FM1 : MatchedRule
    - FM : MatchedRule

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XML Formats

Feature Plugin XML Export

```xml
<feature min="1" max="1" name="VirtualWholesale" type=""/>
<feature min="1" max="1" name="RewardsProgram" type=""/>
<feature min="1" max="1" name="Provider" type=""/>
<featureGroup min="1" max="4" id="group">
  <feature min="0" max="1" name="AtlanticProducts"/>
  <feature min="0" max="1" name="NorthernDesigns"/>
  <feature min="0" max="1" name="lakewoodRefurbish"/>
  <feature min="0" max="1" name="QualityImportsLtd"/>
</featureGroup>
</feature>
```

WSML-in-XML

```xml
<?xml version="1.0" encoding="UTF-8"?>
<wsml>
  <ontology name="http://www.example.org#Virtual">
    <nonFunctionalProperties>
    </nonFunctionalProperties>
    <concept name="http://www.example.org#Virtual">
      <attribute name="http://www.example.org#Register" range="http://www.example.org#RewardsProgram"/>
      <minCardinality>1</minCardinality>
      <maxCardinality>1</maxCardinality>
    </attribute>
  </ontology>
</wsml>
```

ATL

```
FM2WSMO : Module
OUT : OclModel
IN : OclModel
FM1 : MatchedRule
FM : MatchedRule
```
Feature Model to WSMO

wsmlVariant _"http://www.wsmo.org/wsml/wsml-syntax/wsml-flight"

ontology VirtualWholesale

concept VirtualWholesale
  Registration ofType (1 1) Registration
  RewardsProgram ofType (0 1) RewardsProgram
  Payment ofType (1 1) Payment
  Provider ofType (1 4) Provider
  Shipping ofType (1 4) Shipping

concept Registration
concept Payment
concept Provider
concept Shipping
concept RewardsProgram
concept Visa subConceptOf Payment
concept Mastercard subConceptOf Payment
concept AtlanticProductsLtd subConceptOf Provider
concept NorthernDesigns subConceptOf Provider
concept LakewoodRefurbishing subConceptOf Provider
concept QualityImportsLtd subConceptOf Provider
concept CanadaPost subConceptOf Shipping
concept Purolator subConceptOf Shipping
concept FederalExpress subConceptOf Shipping
concept Midland subConceptOf Shipping

axiom DisjointPayment
  definedBy
  !- ?x memberOf Visa
  and ?x memberOf Mastercard.
Product Configuration to WSMO

- Most accurately represented as orchestration.
- Overall executable business process that can be defined through interaction between Web services.
- Choreography may be a factor as well.
Orchestration in WSMO

- Unlike choreography, orchestration in WSMO is still under development
- Both based on abstract state machine
- Composed of state and set of guarded transitions
- State in form of ontology providing
  - Vocabulary for transition rules
  - Set of instances that change state.
Reasoning

• Effects of:
  – Product configuration choices
  – Adding, moving, deleting features
  – Assigning values to attributes

• Guidance for:
  – Constraints in ontology not present in FM
  – FM relationships not represented in ontology
  – Orchestration dependencies
  – Orchestrating services required
Implementation

- Feature Model Plugin
- WSMO Studio and KAON2 Reasoner
- ATL
- Eclipse
Conclusion

• Mappings between FM and WSMO
  – Accuracy of mappings
  – Level of automation attainable
  – Precision of feature discovery
  – Guidance provided by ontology

• Suitability of WSMO
  – Expressiveness
  – Related work
Future Work

- Refine mappings
- Improve transformation
- Explore further the available reasoning
- Integrate the various utilities into comprehensive plugin working in Eclipse environment
Thank you!
Questions?

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