Semantic Interoperability and Knowledge Engineering:
Use of GoodRelations in a Climbing Gear Retail Ontology

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GoodRelations has existed since 2008 to aid businesses in describing their products and services on the web. However, many uses of GoodRelations are simply web-page extensions and the ontologies and individual definitions are not used beyond the page. But, what happens when you combine GoodRelations with a domain-specific ontology related to the products or services being exposed?
Ontologies Overview and Design
Development Goals

- **Learning:**
  - Knowledge engineering
  - Ontology development/definition
  - Ontology integration

- **Definition of general ontology patterns in retail**
  - Brands
  - Products
  - Specific collections (for purpose)
Ontologies

Arrows define “imports”
```
GoodRelations Integration

- **gr:BusinessEntity**, **gr:hasBrand**
  - Used to define the brands of climbing gear
  - Business Entities can also represent retail sellers

- **gr:ProductOrServiceModel**
  - In the products ontology, gives specifics about models (color options, price, weight, etc.)

- **gr:SomeItems**
  - Instances of a model in an inventory
  - Anonymous collection of an item with inventory level

- **gr:Individual**
  - Specific instances of a model in a collection
```
Integration Continued

- GoodRelations “general” concepts such as UnitPriceSpecification, QualitativeValue, ...
  - UnitPriceSpecification used to provide pricing details (amount, currency, valid time periods, ...)
  - QualitativeValue used to create enumerations for product descriptions with qualitativeProductOrServiceProperty

- GoodRelations “general” properties
  - gr:name (equivalent to rdfs:label)
  - gr:description (equivalent to rdfs:comment or dc:description)
  - Height, weight, color properties used to describe models and individuals
  - Literals always defined with language attribute for internationalization
Example Object Property

<http://www.ninepts.com/climb#hasSize>
  rdf:type owl:ObjectProperty,
    owl:FunctionalProperty;
  rdfs:subPropertyOf
    gr:qualitativeProductOrServiceProperty;
  rdfs:label "has size"@en;
  dc:description "Is a relationship between a product
    model and an enumeration that describes
    the size range that the gear fits (i.e., XS, S, M, L, XL)."@en.

*Domain and range defined by qualitativeProductOrServiceProperty
<http://www.ninepts.com/climb#Size>
  rdf:type owl:Class ;
  owl:subClassOf gr:QualitativeValue ;
  rdfs:label "Size"@en ;
  owl:equivVal holdingClass [ 
    rdf:type owl:Class ;
  ].
Example Brand

<http://www.ninepts.com/climbingBrand#BlackDiamond>
  rdf:type owl:NamedIndividual
    gr:BusinessEntity ;
  gr:name "Black Diamond"@en ;
  gr:description "Black Diamond Equipment, Ltd. Since 1957... dedicated to designing and constructing the world's best climbing, skiing & mountain gear."@en ;
Example Product Model

PREFIX climb: <http://www.ninepts.com/climb#>
PREFIX cb: <http://www.ninepts.com/climbingBrands#>

<http://www.ninepts.com/climbingProducts#BlackDiamondATC>
  rdf:type owl:NamedIndividual, climb:TubularDevice,
  gr:ProductOrServiceModel ;
  gr:name "Black Diamond ATC"@en ;
  gr:description "Built to handle ropes ranging in diameter from 7.7mm to 11mm. Belay and rappel with ease."@en;
  gr:color "denim"@en, "ruby"@en, "platinum"@en ;
  gr:hasBrand cb:BlackDiamond ;
  gr:hasPriceSpecification [ rdf:type gr:UnitPriceSpecification ;
  gr:hasCurrency "USD"^^xsd:string ;
  gr:hasCurrencyValue "17.95"^^xsd:float ] ;
  gr:weight [ rdf:type gr:QuantitativeValue ;
  gr:hasUnitOfMeasurement "GRM"^^xsd:string ;
  gr:value "60"^^xsd:float ] ;
  climb:uiaaApproved true .
Individual from Personal Collection

PREFIX climb: <http://www.ninepts.com/climb#>
PREFIX cp: <http://www.ninepts.com/climbingProducts#>

<http://www.ninepts.com/MyCollection#BlackDiamondATC>
  rdf:type owl:NamedIndividual,
  gr:Individual,
  climb:TubularDevice ;
  gr:name "Black Diamond ATC"@en ;
  gr:hasMakeAndModel cp:BlackDiamondATC ;
  gr:color "denim"@en ;
  climb:hasCondition climb:Good .
Individual from Gym Inventory

```xml
PREFIX climb: <http://www.ninepts.com/climb#>
PREFIX cp: <http://www.ninepts.com/climbingProducts#>

<http://www.ninepts.com/GymInventory#BlackDiamondATC-2>
  rdf:type owl:NamedIndividual,
     gr:SomeItems,
     climb:TubularDevice ;
  gr:name "Black Diamond ATC - Ruby"@en ;
  gr:hasMakeAndModel cp:BlackDiamondATC ;
  gr:color "ruby"@en ;
  gr:hasInventoryLevel [ rdf:type gr:QuantitativeValue ;
                         gr:hasValueFloat "0"^^xsd:float ] .
```
Issues with Integration

- Used height (for length) and width (for diameter)
  - Similar but not the same semantics
- gr:condition range is literal
  - Free-form text is not easily checked or integrated
  - Created enumeration of rdf:type gr:QualitativeProperty for climb:Condition (and also defined the property, climb:hasCondition)
- Size, ... not formally defined in GoodRelations
  - Created enumerations (as above) for climb:Size and climb:Design
  - Perhaps the general/customary values could be provided (?)
Integrity Constraint processing in Stardog

- Validation of individuals using constraints modeled as OWL axioms
- Based on the Closed World Assumption and a weak variant of the Unique Name Assumption
- Written in OWL2, SWRL or SPARQL
- For more information:
  - http://docs.stardog.com/#_validating_constraints
  - http://docs.stardog.com/icv/icv-specification.html
Validating Individuals – Examples

- All individuals/items should have the same ClimbingGear ontology class as their referenced ProductOrServiceModel
- All individuals should have only 1 color option, 1 size, ...
- Purchased individuals should be compatible with respect to being “dynamic”
- Personal collection individuals should have a condition
- Inventory items should have a inventory level
SameClimbClass SPARQL Constraint

PREFIX gr: <http://purl.org/goodrelations/v1#>
SELECT ?individual
    ?indClimbingGear
    ?prodClimbingGear
    ('The individual identified as ?individual is a different type of gear than its referenced product. The individual is identified as a
    ?indClimbingGear, but the product is a ?prodClimbingGear.' as ?violation)
WHERE { ?individual a gr:Individual ;
    a ?indClimbingGear ;
    gr:hasMakeAndModel ?product .
    ?product a ?prodClimbingGear .
    FILTER regex(str(?individual), 'MyCollection#') .
    FILTER regex(str(?indClimbingGear), 'climb#') .
    FILTER regex(str(?prodClimbingGear), 'climb#') .
    FILTER (?indClimbingGear != ?prodClimbingGear) . }
Reasoning in Stardog

- Programmatic checks for consistency and satisfiability
- Also define custom rules as SPARQL or RDF/XML SWRL rules
- Can create “intermediate” new individuals
- For more information:
  - [http://docs.stardog.com/#_owl_rule_reasoning](http://docs.stardog.com/#_owl_rule_reasoning)
Infer Sale Item from Over Stock

PREFIX rule: <tag:stardog:api:rule:>

[] a rule:SPARQLRule ;
  rule:content """
  PREFIX gr: <http://purl.org/goodrelations/v1#>
  PREFIX climb: <http://www.ninepts.com/climb#>
  IF { ?individual climb:inventoryLevel ?inventory ;
      ?ps gr:hasCurrencyValue ?price ;
      gr:hasCurrency ?currency .
      FILTER (?inventory >= 10) .
  }
  THEN { BIND (?price * 0.75 AS ?newPrice) .
    BIND (UUID() AS ?salePs) .
    ?salePriceSpec a gr:UnitPriceSpecification ;
    gr:hasCurrency ?currency ;
    gr:hasCurrencyValue ?newPrice .
    ?individual gr:hasPriceSpecification ?salePs .
  }
  """
Understanding/Using the Domain-Specific Ontologies (Via graphs and spreadsheets)
Diagrams

- Class and property hierarchies
- Individuals
- Generated by:
  - Executing a custom (Java) application to create a graphml rendering (Unique outputs for classes, properties or individuals)
  - Loading the graphml into yEd for layout

Searchable descriptions

- Excel spreadsheet
- Generated by:
  - Doing a SPARQL query (with CSV output) to retrieve all classes and properties
  - Importing the CSV into Excel and tweaking the row/column sizes
Classes

Arrows define “subClassOf”
Unmarked arrows define “subClasssOf”

Enumerations

owl:Thing

gr:QualitativeValue

climb:Size
  oneOf
  climb:XS
  climb:S
  climb:M
  climb:L
  climb:XL

climb:Condition
  oneOf
  climb:LikeNew
  climb:Good
  climb:Poor
  climb:Damaged

climb:Design
  oneOf
  climb:Men
  climb:Women
  climb:Youth
Arrows define “typeOf”
Arrows define “typeOf”
# Spreadsheets of Descriptions

<table>
<thead>
<tr>
<th>Class Name</th>
<th>Label</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://www.ninepts.com/climb#AccessoryGear">http://www.ninepts.com/climb#AccessoryGear</a></td>
<td>Accessory Gear</td>
<td>Climbing gear used in combination with wearable gear during rock climbing.</td>
</tr>
<tr>
<td><a href="http://www.ninepts.com/climb#ActiveProtection">http://www.ninepts.com/climb#ActiveProtection</a></td>
<td>Active Protection</td>
<td>A type of protection characterized by having moving parts.</td>
</tr>
<tr>
<td><a href="http://www.ninepts.com/climb#AutoBrakingDevice">http://www.ninepts.com/climb#AutoBrakingDevice</a></td>
<td>Auto-Braking Device</td>
<td>A type of belay device that automatically locks down on the rope when shock-loaded.</td>
</tr>
<tr>
<td><a href="http://www.ninepts.com/climb#BelayDevice">http://www.ninepts.com/climb#BelayDevice</a></td>
<td>Belay Device</td>
<td>A type of accessory gear which controls the rope.</td>
</tr>
<tr>
<td><a href="http://www.ninepts.com/climb#Carabiner">http://www.ninepts.com/climb#Carabiner</a></td>
<td>Carabiner</td>
<td>A type of accessory gear that consists of a metal link with gate used to safely connect components.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Object Property Name</th>
<th>Is a Functional Property</th>
<th>Label</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://www.ninepts.com/climb#designedFor">http://www.ninepts.com/climb#designedFor</a></td>
<td>TRUE</td>
<td>designed for</td>
<td>Is a relationship between a product model and an enumeration that describes the type of person the gear is intended for, i.e. men,</td>
</tr>
<tr>
<td><a href="http://www.ninepts.com/climb#hasCondition">http://www.ninepts.com/climb#hasCondition</a></td>
<td>TRUE</td>
<td>has condition</td>
<td>Is a relationship between an individual piece of gear in a collection and an enumeration that describes the actual state based on use of</td>
</tr>
<tr>
<td><a href="http://www.ninepts.com/climb#hasSize">http://www.ninepts.com/climb#hasSize</a></td>
<td>TRUE</td>
<td>has size</td>
<td>Is a relationship between a product model and an enumeration that describes the size range that the gear fits, i.e. XS, S, M, L, XL.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Datatype Property</th>
<th>Is a Functional Property</th>
<th>Label</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="http://www.ninepts.com/climb#dynamic">http://www.ninepts.com/climb#dynamic</a></td>
<td>TRUE</td>
<td>dynamic</td>
<td>Boolean indicating whether the rope has the ability to stretch when weighted and therefore safely catch a falling climber.</td>
</tr>
<tr>
<td><a href="http://www.ninepts.com/climb#inventoryLevel">http://www.ninepts.com/climb#inventoryLevel</a></td>
<td>TRUE</td>
<td>inventory level</td>
<td>Non-negative integer representing the quantity of an individual product available in an inventory.</td>
</tr>
<tr>
<td><a href="http://www.ninepts.com/climb#locking">http://www.ninepts.com/climb#locking</a></td>
<td>TRUE</td>
<td>locking</td>
<td>Boolean indicating whether a product model of a carabiner has a locking gate, meaning the gate cannot be opened while in the locked position.</td>
</tr>
<tr>
<td><a href="http://www.ninepts.com/climb#synthetic">http://www.ninepts.com/climb#synthetic</a></td>
<td>TRUE</td>
<td>synthetic</td>
<td>Boolean indicating whether the product model of a runner or personal anchor system is designed with synthetic material. If not, the product is designed with nylon.</td>
</tr>
</tbody>
</table>