Ontology Views
An Update

A BISTI Collaborative RO1 with the National Center for Biomedical Ontology

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Motivation

• Large number of application ontologies
• Need to link them together into the semantic web
• Reference ontologies as one way to do this
• But reference ontologies are (or will be) too large for practical use
• How can reference ontologies be made practical for applications, yet retain potential to link application ontologies?
Approach

• Application ontologies as views over one or more reference ontologies
• A view is a query that defines a formal transformation from one or more source ontologies to a target application ontology
Main advantage of views

• View query describes the specific operations used to create the application ontology
  – Therefore the connection to the source(s) are not lost
  – If the query can be made bidirectional (a mapping) then application ontologies can be related to each other via views
Secondary advantages

• View query can be re-run at any time as the reference ontology changes
• The query is formal so can be manipulated by a GUI
• Application ontology need not be materialized, so the update problem is not an issue (but there may be other reasons to materialize views)
anatomist
Q1: What are all the cavities of organ parts?
Q1: What are all the cavities of organ parts?

N=263

- Lumen of fundus of stomach
- Lumen of body of stomach
- Lumen of pyloric antrum
- Lumen of pyloric canal
- Lumen proper of body of stomach
- Lumen of pulmonary artery
- Lumen of right pulmonary artery
- Lumen of left pulmonary artery
- Lumen of right pulmonary vein
- Lumen of left pulmonary vein
- Lumen of left coronary artery
- Lumen of thoracic duct
- Lumen of intestinal lymphatic trunk
- Lumen of lumbar lymphatic trunk
- Lumen of zone of stomach
- Lumen of prostatic duct
- Cavity of organ part
- Lumen of azygos vein
- Lumen of hemiazygos vein
- Lumen of thoracic part of inferior vena cava
- Lumen of abdominal part of inferior vena cava
- Cavity of embryonic cardiac structure
- Lumen of arterial tree (subdivision)
- Lumen of systemic arterial tree (subdivision)
- Lumen of pulmonary arterial tree (subdivision)
- Lumen of venous tree (subdivision)
- Lumen of systemic venous tree (subdivision)
Use case 1: Image annotation

Q1: What are all the cavities of organ parts?
Use case 1: Image annotation

Q1: What are all the cavities of organ parts?

A1

Heart Anatomy

Wrapper

FMA

anatomist
Use case 1: Image annotation

Q1: What are all the cavities of organ parts?

A1: Heart Anatomy

V1: What are the parts of the heart and their types?

Wrapper

FMA

anatomist
Use case 1: Image annotation

Q1: What are all the cavities of organ parts?

A1: Heart Anatomy

V1: What are the parts of the heart and their types?

VGen

A1: Heart Anatomy

Wrapper

FMA

anatomist
Use case 1: Image annotation

Q1: What are all the cavities of organ parts?

A1: Heart Anatomy

V1: What are the parts of the heart and their types?
Use case 1: Image annotation

Q1: What are all the cavities of organ parts?

A1: Heart Anatomy

V1: What are the parts of the heart and their types?

Q2: What are the cavities of organ parts that are parts of the heart?
Q2: What are the cavities of organ parts that are parts of the heart?

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  </result>
  <result>
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  </result>
  <result>
    <heart_cavity>Cavity of left side of heart</heart_cavity>
  </result>
</results>
Use case 1: Image annotation

VQGen

V1

A1

VQP

Wrapper

FMA

anatomist
Use case 1: Image annotation

Features

• View query is a basis for linking
• Application ontologies are always up-to-date
• Application ontologies are composable
Use case 1: Image annotation

A1: Heart Anatomy

anatomist

physiologist
Use case 1: Image annotation

A1: Heart Anatomy

A2: Heart Physiology

VGen

VQP

V1

V2

Wrapper

anatomist

physiologist

FMA

OPB
Use case 1: Image annotation

Use case 2: Model merging

FMA

OPB

anatomist

physiologist
Basic Architecture
Research Issues (aims)

1. How to define the view
2. How to implement the view query processor
3. How to graphically generate views

Driven by and evaluated in terms of use cases
Current Results

• Ontology web services
• Extensions to SparQL
  – Regular path expressions
  – Subqueries and recursive queries
• Graphical view generation
• FMA-RADLEX use case
• Other use cases
FMA in OWL via an Ontology Web Service

Enter SparQL query:

```
PREFIX fma: <http://bioontology.org/projects/ontologies/fma/fmaOwlDlComponent_2_0#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

#Select all regional parts of the heart
SELECT ?object
WHERE
{ fma:Heart fma:regional_part ?object . }
```

<table>
<thead>
<tr>
<th>object</th>
</tr>
</thead>
<tbody>
<tr>
<td>fma:Right_side_of_heart</td>
</tr>
<tr>
<td>fma:Left_side_of_heart</td>
</tr>
</tbody>
</table>

-------------
All the parts of the heart

#Select all parts of the heart
SELECT ?object
WHERE
{
  fma:Heart fma:part ?object .
}

--------
| object |
--------
--------
Gleen: SparQL Regular Path Library
Todd Detwiler

• Property Function library for ARQ/Jena2 (Java)
• Supports processing of regular paths in SparQL queries
  – + : one or more
  – * : zero or more
  – ? : zero or one
  – / : concatenation
  – | : alternation
  – [] : grouping and property delineation
Regional or constitutional parts

#Select either regional or constitutional parts of the heart
SELECT ?object
WHERE
{
}
ORDER BY ?object
<table>
<thead>
<tr>
<th>object</th>
</tr>
</thead>
<tbody>
<tr>
<td>fma:Aortic_valve</td>
</tr>
<tr>
<td>fma:Atioventricular_septum</td>
</tr>
<tr>
<td>fma:Cardiac_vein</td>
</tr>
<tr>
<td>fma:Cavity_of_left_atrium</td>
</tr>
<tr>
<td>fma:Cavity_of_left_ventricle</td>
</tr>
<tr>
<td>fma:Cavity_of_right_atrium</td>
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<tr>
<td>fma:Cavity_of_right_ventricle</td>
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<tr>
<td>fma:Coronary_sinus</td>
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<td>fma:Fibrous_skeleton_of_heart</td>
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<tr>
<td>fma:Interatrial_septum</td>
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<td>fma:Interventricular_septum</td>
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<td>fma:Left_coronary_artery</td>
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<td>fma:Left_side_of_heart</td>
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<td>fma:Mitral_valve</td>
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<td>fma:Right_coronary_artery</td>
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<tr>
<td>fma:Systemic_capillary_bed_of_heart</td>
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<tr>
<td>fma:Tricuspid_valve</td>
</tr>
<tr>
<td>fma:Wall_of_heart</td>
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</tbody>
</table>

Results
Transitive closure

#Select either regional or constitutional parts of the heart
SELECT ?object
WHERE
{
}
ORDER BY ?object
Construct heart parts as either the regional or constitutional parts of the heart

CONSTRUCT
{fma:Heart fma:part ?object}

WHERE
{
}
ORDER BY ?object
### Information about this concept:

**DEFINITION**

A low grade, indolent B-cell lymphoma, usually associated with Helicobacter Pylori infection. Morphologically it is characterized by a dense mucosal and lymphocytic (centrocyte-like cell) infiltrate with often prominent lymphoepithelial lesions and plasmacytic differentiation. Approximately 40% of gastric MALT lymphomas carry the t(11;18)(q21;q21). Such cases are resistant to Helicobacter Pylori therapy. -- 2003

**Synonym with source data**

- Gastric MALT Lymphoma|SY|NCI
- Gastric MALToma|SY|NCI
- Gastric Mucosa-Associated Lymphoid Tissue Lymphoma|PT|NCI
- MALT Lymphoma of Stomach|SY|NCI
- MALT Lymphoma of the Stomach|SY|NCI
- MALToma of Stomach|SY|NCI
- MALToma of the Stomach|SY|NCI
- Primary Gastric B-Cell MALT Lymphoma|SY|NCI
- Primary Gastric MALT Lymphoma|SY|NCI
- Primary MALT Lymphoma of Stomach|SY|NCI
- Primary MALT Lymphoma of the Stomach|SY|NCI

**NCIMETA_CUI**

CL008247

**Preferred_Name**

Gastric Mucosa-Associated Lymphoid Tissue Lymphoma

**Semantic_Type**

Neoplastic Process

**Synonym**

- Gastric MALT Lymphoma
- Gastric MALToma
- Gastric Mucosa-Associated Lymphoid Tissue Lymphoma
- MALT Lymphoma of Stomach
- MALT Lymphoma of the Stomach
SELECT ?prop ?val
WHERE {nci:Gastric_Mucosa-Associated_Lymphoid_Tissue_Lymphoma ?prop ?val}
order by ?prop

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### Gastric Mucosa-Associated Lymphoid Tissue Lymphoma

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</table>

### Relationships to other concepts:

- **Disease_Excludes.Primary_Anatomic_Site**
  - Lymph Node

- **Disease_May_Have.Abnormal_Cell**
  - Neoplastic Monocytoid B-Lymphocyte

- **Disease_Excludes.Finding**
  - Benign Cellular Infiltrate

- **Disease_Has.Primary_Anatomic_Site**
  - Lymphatic System

- **Disease_Excludes.Abnormal_Cell**
  - Neoplastic T-Lymphocyte and Neoplastic Natural Killer Cell

- **Disease_May_Have.Finding**
  - Lymphoepithelial Lesion

- **Disease_Has.Primary_Anatomic_Site**
  - Stomach

- **Disease_Has.Normal_Cell.Origin**
  - Postgerminatal Center Marginal Zone B-Lymphocyte

- **Disease_Has.Associated.Anatomic_Site**
  - Hematopoietic and Lymphatic System

- **Disease_Has.Finding**
  - Primary Lesion

- **Disease_Has.Molecular.Abnormality**
  - Clonal Immunoglobulin Kappa Light Chain Gene Rearrangement

- **Disease_May_Have.Abnormal_Cell**
  - Neoplastic Plasma Cell

- **Disease_May_Have.Finding**
  - Indolent Clinical Course

- **Disease_Has.Abnormal_Cell**
  - Centrocye-Like Cell
SELECT ?prop ?val
WHERE{
}
ORDER BY ?prop
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<td>nci:Disease_May_Have_Molecular_Abnormality</td>
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</tbody>
</table>
CONSTRUCT{ nci:Gastric_Mucosa-Associated_Lymphoid_Tissue_Lymphoma ?prop ?val }
WHERE{
  nci:Gastric_Mucosa-Associated_Lymphoid_Tissue_Lymphoma gleen:OnPath ( 
}
SparQL Extensions: vSparQL

Marianne Shaw and Dan Suciu

- Subqueries
- Recursive Queries
vSparQL Subqueries

• Builds upon CONSTRUCT query

CONSTRUCT { ?subj ?prop ?obj }
FROM < ... >
WHERE { ?subj ?prop ?obj }

• Subqueries treated as data source
  • Named or unnamed data source

SELECT ... 
FROM NAMED <subquery_name> [ 
CONSTRUCT { ... } 
FROM < ... >
WHERE { ... } 
]
WHERE { GRAPH <subquery_name> { ... } }
vSparQL Example Subquery

• Get all of the direct regional_parts of the liver

PREFIX dl: <http://.../fmaOwlDlComponent_2_0#>

SELECT ?obj
FROM NAMED <subquery> [ 
  CONSTRUCT { dl:Liver dl:regional_part ?a } 
  FROM <http://.../fmaOwlFullComponent_2_0> 
  WHERE { dl:Liver dl:regional_part ?a } 
]
WHERE { GRAPH <subquery> { ?subj ?prop ?obj } }
## Results

<table>
<thead>
<tr>
<th>obj</th>
</tr>
</thead>
<tbody>
<tr>
<td>dl:Caudate_lobe_of_liver</td>
</tr>
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<td>dl:Right_lobe_of_liver</td>
</tr>
<tr>
<td>dl:Left_lobe_of_liver</td>
</tr>
<tr>
<td>dl:Quadrate_lobe_of_liver</td>
</tr>
</tbody>
</table>
vSparQL Recursive Subqueries

• Union of CONSTRUCT queries

SELECT ...
FROM NAMED <recursive_subq> [
    CONSTRUCT { ... }  # Base queries
    FROM < ... >
    WHERE { ... }
]

UNION         # Set union

CONSTRUCT { ... }  # Recursive queries
FROM NAMED <recursive_subq>
FROM < ... >
WHERE { GRAPH <recursive_subq> { ... }.
    ...
}]
WHERE { GRAPH <recursive_subq> { ... } }
vSparQL Recursive Query
Regional_parts of the liver, transitive closure

PREFIX dl: <http://.../fmaOwlDLComponent_2_0#>

SELECT ?obj
FROM NAMED <liver> [
  # Base case: get the direct regional_parts of the liver
  CONSTRUCT {dl:Liver dl:regional_part ?z}
  FROM <http://.../fmaOwlFullComponent_2_0>
  WHERE {dl:Liver dl:regional_part ?z .}

  UNION
  # Get all of the regional_parts of the liver recursively
  CONSTRUCT {?c dl:regional_part ?d}
  FROM NAMED <liver>
  FROM NAMED <http://.../fmaOwlFullComponent_2_0>
  WHERE {
    GRAPH <liver> { ?a ?b ?c .}.
    GRAPH <http://.../fmaOwlFullComponent_2_0> { ?c dl:regional_part ?d .}.
  }
]
WHERE { GRAPH <liver> {?subj ?prop ?obj .} }
Results

- Get all of the regional parts of the liver

<table>
<thead>
<tr>
<th>obj</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>dl:Lateral_inferior_area_of_lateral_segment_of_left_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Lateral_superior_area_of_lateral_segment_of_left_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Quadrate_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Caudate_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Left_lobe_proper_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Lateral_segment_of_left_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Medial_segment_of_left_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Quadrate_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Left_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Right_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Caudate_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Medial_superior_area_of_medial_segment_of_left_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Medial_inferior_area_of_medial_segment_of_left_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Posterior_segment_of_right_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Anterior_segment_of_right_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Posterior_superior_area_of_posterior_segment_of_right_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Posterior_inferior_area_of_posterior_segment_of_right_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Papillary_process_of_caudate_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Caudate_process_of_caudate_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Left_segment_of_caudate_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Right_segment_of_caudate_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Anterior_superior_area_of_anterior_segment_of_right_lobe_of_liver</td>
<td></td>
</tr>
<tr>
<td>dl:Anterior_inferior_area_of_anterior_segment_of_right_lobe_of_liver</td>
<td></td>
</tr>
</tbody>
</table>
Current Work

• Investigating different DBMS formats
  – Especially important for recursive queries
• Pushing recursive queries to DBMS
• Combining Gleen with vSparQL
Research Issues (aims)

1. How to define the view
2. How to implement the view query processor
3. How to graphically generate views
Graphical View Generation
Gary Yngve and Linda Shapiro

PREFIX dl: <http://.../fmaOwlDlComponent_2_0#>
SELECT ?obj
FROM NAMED <liver>

[ # Base case: get the direct regional_parts of the liver
CONSTRUCT {dl:Liver dl:regional_part ?z}
FROM <http://.../fmaOwlFullComponent_2_0>
WHERE {dl:Liver dl:regional_part ?z .}

UNION
# Get all of the regional_parts of the liver recursively
CONSTRUCT {?c dl:regional_part ?d}
FROM NAMED <liver>
FROM NAMED <http://.../fmaOwlFullComponent_2_0>
WHERE {
GRAPH <liver> { ?a ?b ?c .}
GRAPH <http://.../fmaOwlFullComponent_2_0>
{ ?c dl:regional_part ?d .}
}
]
WHERE { GRAPH <liver> {?subj ?prop ?obj .} }
The FMA-RadLex Use Case

Onard Mejino and Daniel Rubin

• RadLex
• Need to reorganize
• Use FMA as an organizing framework for the anatomy component
• Don’t need or want all of FMA
• Need a view
• Serves as initial validation for various approaches
Approaches

• Manual generation of the view
• Creating the view using the graphical ontology browser
• Creating the view using vSparQL and GLEEN
Manual Approach

FMA ontology

- Anatomical entity
- Physical anatomical entity
- Material anatomical entity
- Anatomical structure
  - Body
  - Cardinal body part
  - Organ system
  - Subdivision of cardinal body part
  - Organ system subdivision
  - Organ
  - Cardinal organ part
  - Portion of tissue
  - Cardinal tissue part
  - Cell
  - Cardinal cell part
  - Biological macromolecule
  - Acellular anatomical structure
  - Anatomical cluster
  - Vestigial embryonic structure
  - Gestational structure
  - Portion of body substance
  - Anatomical set
  - Immaterial anatomical entity
    - Anatomical space
    - Anatomical boundary entity
    - Anatomical surface
    - Anatomical line
    - Anatomical point
  - Set of immaterial anatomical entities

FMA-RadLex

- Anatomical entity
  - Body
  - Cardinal body part
  - Organ system
  - Subdivision of cardinal body part
  - Organ system subdivision
  - Organ
  - Cardinal organ part
  - Portion of tissue
  - Anatomical cluster
  - Anatomical set
  - Immaterial anatomical entity
    - Anatomical space
    - Anatomical surface
    - Anatomical line
    - Anatomical point

Onard Mejino
Graphical Approach

Onard Mejino
1. Add class/node ‘Abdominal organ’ to class/node ‘Organ’
2. Reassign existing and appropriate organ to ‘Abdominal organ’
3. Reassign all other organs as direct subclasses of ‘Organ’
4. Remove intervening or intermediate classes/nodes
Create new class ‘Abdominal organ’
Organs reassigned to new class ‘Abdominal organ’
Rest of organs are reassigned directly under superclass ‘Organ’
Deleted ‘Solid Organ’
Deleted ‘Cavitated Organ’
Using vSparQL

Marianne Shaw

PREFIX dl: <http://fmaOwlIDComponent_1_4_0#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>

CONSTRUCT { ?d dl:part ?f .
         ?g rdfs:subClassOf dl:Organ .
         ?r rdfs:subClassOf ?j .
 }
FROM NAMED <extracted_ontology> [

CONSTRUCT { ?t ?u ?v . }
FROM NAMED <liver_with_superclasses> [
    CONSTRUCT { ?m ?n ?o . }
    FROM NAMED <liver_with_classes> [
         ?k rdfs:subClassOf ?l .
    }
    FROM NAMED <subclass> [
        CONSTRUCT {?x rdfs:subClassOf dl:Organ .
         dl:Organ rdfs:subClassOf ?w .
         ?y rdfs:subClassOf dl:Cardinal_organel_part .
         dl:Cardinal_organel_part rdfs:subClassOf ?z .
    }
    FROM <http://fmaOwlFullComponent_1_4_0>
    WHERE { ?x rdfs:subClassOf dl:Organ .
         dl:Organ rdfs:subClassOf ?w .
    }
    UNION
    { ?y rdfs:subClassOf dl:Cardinal_organel_part .
         dl:Cardinal_organel_part rdfs:subClassOf ?z .
    }
    WHERE { GRAPH <liver_with_superclasses> { ?m ?n ?o . } }
UNION
    CONSTRUCT {?r rdfs:subClassOf?s .
FROM NAMED <liver_with_superclasses>
FROM NAMED <http://fmaOwlFullComponent_1_4_0>
WHERE { GRAPH <liver_with_superclasses> { ?p rdfs:subClassOf ?r . } .
GRAPH <http://fmaOwlFullComponent_1_4_0> { ?r rdfs:subClassOf?s} .
    WHERE { GRAPH <liver_with_superclasses> { ?t ?u ?v . } .
    }
    WHERE { GRAPH <extracted_ontology> { }
UNION
    {?g rdfs:subClassOf?h .
FILTER (?h = dl:Cavitaded_organ || ?h = dl:Solid_organ) .
    }
UNION
    {?i rdfs:subClassOf ?j .
FILTER (?h != dl:Cavitaded_organ & & ?h != dl:Solid_organ) .
    }
    }\]
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#Right_portal_vein>  
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#part>  
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#Anterior_branch_of_right_portal_vein>  
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#part>  
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#Caudate_lobe_branch_of_right_portal_vein>  
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#part>  
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#Trunk_of_right_portal_vein>  
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#part>  
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#Posterior_branch_of_right_portal_vein>  .

<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#Segment_of_liver>  
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#part>  
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#Subsegment_of_liver>  .

<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#Parenchymatous_organ>  
<http://www.w3.org/2000/01/rdf-schema#subClassOf>  
<http://bioontology.org/projects/ontologies/fma/fmaOwlDICComponent_1_4_0#Organ>  .
Combining vSparQL and GLEEN
Todd Detwiler and Marianne Shaw

PREFIX fma: <http://bioontology.org/projects/ontologies/fma/fmaOwlDLComponent_2_0#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX gleen: <javareu.washington.sig.gleen.>

CONSTRUCT
{
  ?x rdfs:subClassOf fma:Organ .
  ?a fma:part ?c .
}
FROM <http://bioontology.org/projects/ontologies/fma/fmaOwlFullComponent_2_0>
FROM NAMED <via_liver_parts_ont>[
  CONSTRUCT
  {
    ?z rdfs:subOf ?super .
  }
  FROM <http://bioontology.org/projects/ontologies/fma/fmaOwlFullComponent_2_0>
  WHERE
  {
    ?a apf:assign fma:Liver .
  }
]
WHERE
{
  GRAPH <visible_liver_parts>
  {
    ?x apf:assign fma:Liver .
  } UNION {?z rdfs:subClassOf ?super .}
}
WHERE
{
  # find all things with direct superclass Solid_organ or Cavitated_organ
  GRAPH <via_liver_parts_ont>
  {
    { ?super1 apf:assign fma:Cavitated_organ . } UNION { ?super1 apf:assign fma:Solid_organ . }
  }
  # find all things whose direct superclass is NOT Solid_organ or Cavitated_organ
  GRAPH <via_liver_parts_ont>
  {
    FILTER (! fma:Solid_organ || fma:Cavitated_organ).
  }
  # get all regional and constitutional part relations (group as they will be convolved to part)
  GRAPH <via_liver_parts_ont>
  {
    {?a fma:regional_part ?c .
    } UNION {?a fma:constitutional_part ?c .}
  }
}
Initial conclusions from RadLeX Use Case

• Graphical view generation
  – Promising but too “granular”
  – Incomplete and somewhat buggy
  – Does not generate queries

• Queries
  – vSparQL plus GLEEN seems promising
  – Need to look at other use cases
Image Annotation Use Case
Other Use Cases

• Spatial/Symbolic Query Processor
• Dynamic Scene Generation
• Distributed XQuery-Based Data Integration
• Model annotation and merging
• Clinical trials data integration (possible)
Planned work

• Graphical view generation
  – Develop less granular operations
  – Generate view queries
  – Compare with other approaches

• Query generation
  – Extend expressiveness
  – Optimize
  – Explore view composition

• Explore how to integrate with BioPortal
Conclusions

• A query-based approach to deriving application ontologies from reference ontologies
  – Facilitates interoperability and version control
  – Promotes a service-oriented view

• Significant research issues

• Solutions could help to achieve at least part of the vision of the semantic web