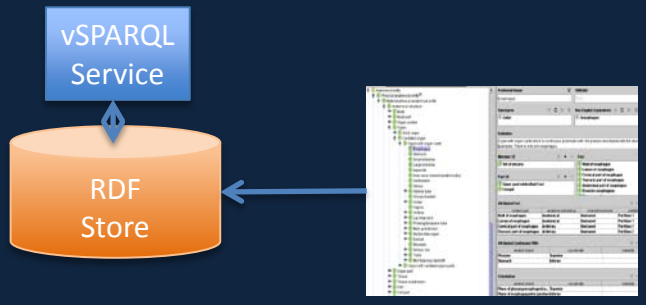
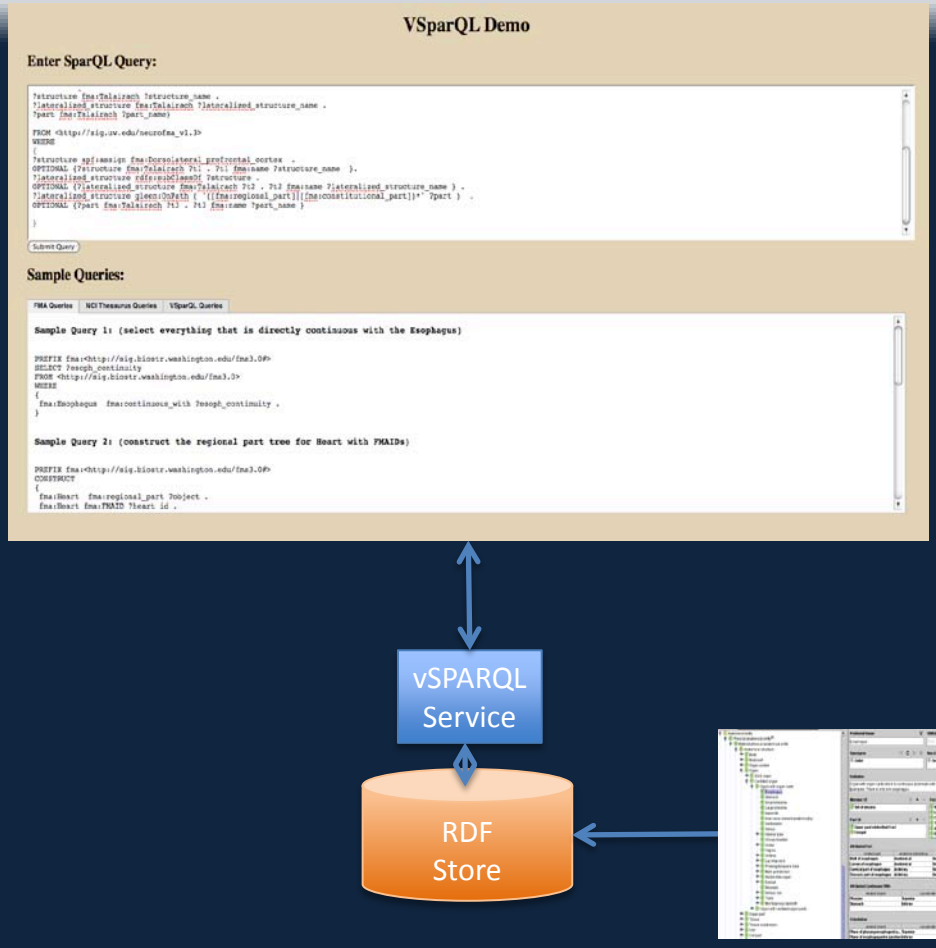
Integration architecture

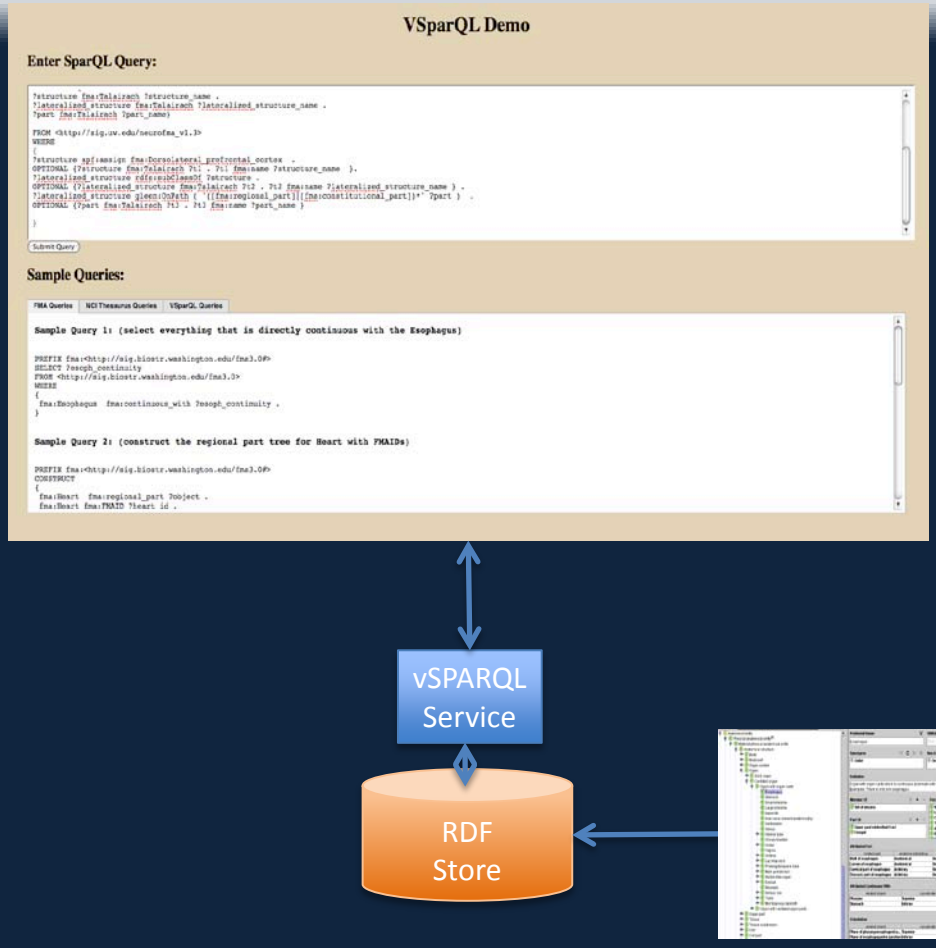
- Queryable sources that generate XML
- Distributed queries over sources
- Query Manager to manage queries
- Saved queries as sources that can also be queried
- Leads to potential for query networks


vSPARQL
Service
RDF
Store


VSparQL Demo
Enter SparQL Query:
Submit Query
Sample Queries:
FMA Queries
NCI Thesaurus Queries
VSparQL Queries
Sample Query 1: (select everything that is directly continuous with the Esophagus)
Sample Query 2: (construct the regional part tree for Heart with FMAIDs)
vSPARQL Service
RDF Store

```
CONSTRUCT {
?structure fma:Talairach ?structure_name .
?lateralized_structure fma:Talairach ?lateralized_structure_name .
?part fma:Talairach ?part_name}

FROM <http://sig.uw.edu/neurofma_v1.3>
WHERE
{
?structure apf:assign fma:Dorsolateral_prefrontal_cortex  .
OPTIONAL {?structure fma:Talairach ?t1 . ?t1 fma:name ?structure_name  }.
?lateralized_structure rdfs:subClassOf ?structure .
OPTIONAL {?lateralized_structure fma:Talairach ?t2 . ?t2 fma:name ?lateralized_structure_name } .
?lateralized_structure gleen:OnPath ( '([fma:regional_part]|[fma:constitutional_part])*' ?part )  .
OPTIONAL {?part fma:Talairach ?t3 . ?t3 fma:name ?part_name }

}
```

```
2-rdf-syntax-ns#"
ofunction.library."
n.edu/tmp#"
leen."
wl#"
rdf-schema#"

w.edu/fma#Brodmann_area_46_of_right_middle_frontal_gyrus">
w.w3.org/2001/XMLSchema#string">Right Cerebrum.Frontal Lobe.Middle Frontal Gyrus.Gray Matter.Brodmann area 46</

w.edu/fma#Brodmann_area_46_of_left_middle_frontal_gyrus">
w.w3.org/2001/XMLSchema#string">Left Cerebrum.Frontal Lobe.Middle Frontal Gyrus.Gray Matter.Brodmann area 46</f

w.edu/fma#Brodmann_area_9_of_left_middle_frontal_gyrus">
w.w3.org/2001/XMLSchema#string">Left Cerebrum.Frontal Lobe.Middle Frontal Gyrus.Gray Matter.Brodmann area 9</fm

w.edu/fma#Brodmann_area_9_of_left_superior_frontal_gyrus">
w.w3.org/2001/XMLSchema#string">Left Cerebrum.Frontal Lobe.Superior Frontal Gyrus.Gray Matter.Brodmann area 9</

w.edu/fma#Brodmann_area_9_of_right_superior_frontal_gyrus">
w.w3.org/2001/XMLSchema#string">Right Cerebrum.Frontal Lobe.Superior Frontal Gyrus.Gray Matter.Brodmann area 9<

w.edu/fma#Brodmann_area_9_of_right_middle_frontal_gyrus">
w.w3.org/2001/XMLSchema#string">Right Cerebrum.Frontal Lobe.Middle Frontal Gyrus.Gray Matter.Brodmann area 9</f
```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Sample Queries:
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VSparQL Queries
Sample Query 1: (select everything that is directly continuous with the Esophagus)
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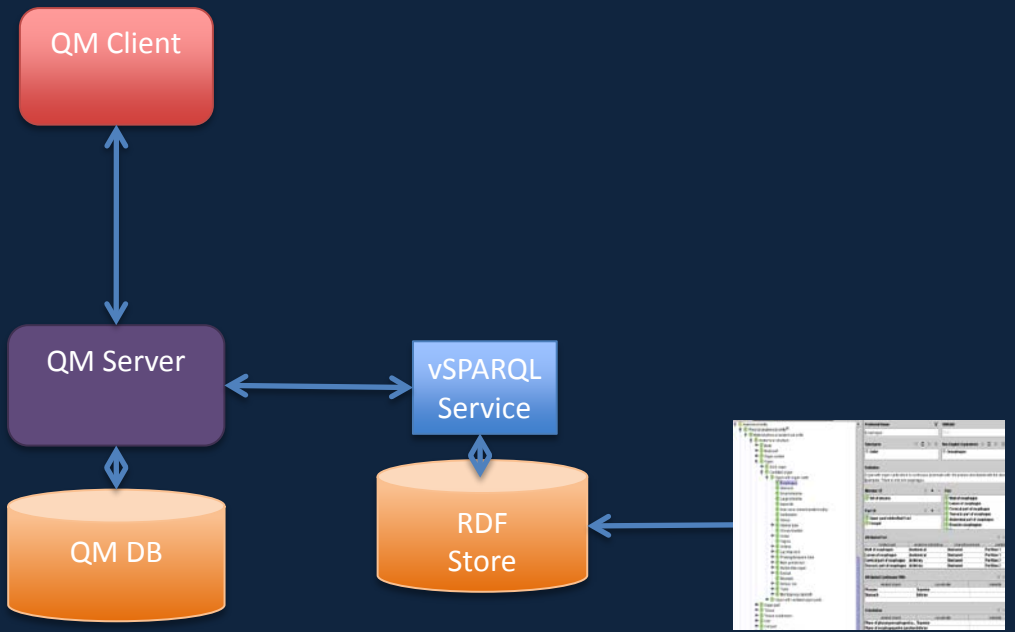
vSPARQL Service
RDF Store


QM Client
QM Server
QM DB
vSPARQL
Service
RDF
Store

Query Manager

Login

Manage Search Edit User Help

Title

74: AMIA 2010: Talairach: Regional or constitutional parts of a structure that has lateralized subclasses: Dorsolateral_prefrontal_cortex

Description

First find direct subclasses, then transitive regional parts, output those that have Talairach labels.
To change structure substitute different structure name for Dorsolateral_prefrontal_cortex

Query

```
PREFIX rdfs:<http://www.w3.org/2000/01/rdf-schema#>
PREFIX rdf:<http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl:<http://www.w3.org/2002/07/owl#>
PREFIX gleen:<java:edu.washington.sig.gleen.>
PREFIX fma:<http://sig.uw.edu/fma#>
PREFIX tmp:<http://sig.biostr.washington.edu/tmp#>
PREFIX apf: <java:com.hp.hpl.jena.query.pfunction.library.>

CONSTRUCT {
?structure fma:Talairach ?structure_name .
?lateralized_structure fma:Talairach ?lateralized_structure_name .
?part fma:Talairach ?part_name}

FROM <http://sig.uw.edu/neurofma_v1.3>
WHERE
{
?structure apf:assign fma:Dorsolateral_prefrontal_cortex  .
OPTIONAL {?structure fma:Talairach ?t1 . ?t1 fma:name ?structure_name  }.
?lateralized_structure rdfs:subClassOf ?structure .
OPTIONAL {?lateralized_structure fma:Talairach ?t2 . ?t2 fma:name ?lateralized_structure_name } .
?lateralized_structure gleen:OnPath ( '([fma:regional_part]|[fma:constitutional_part])*' ?part )  .
OPTIONAL {?part fma:Talairach ?t3 . ?t3 fma:name ?part_name }

}
```

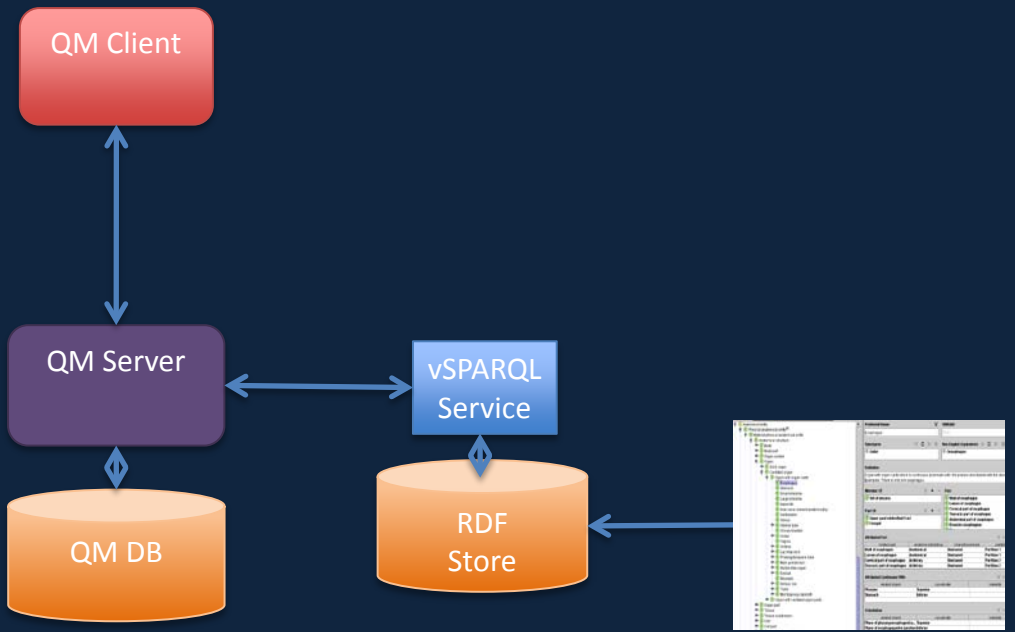
Language VSparQL

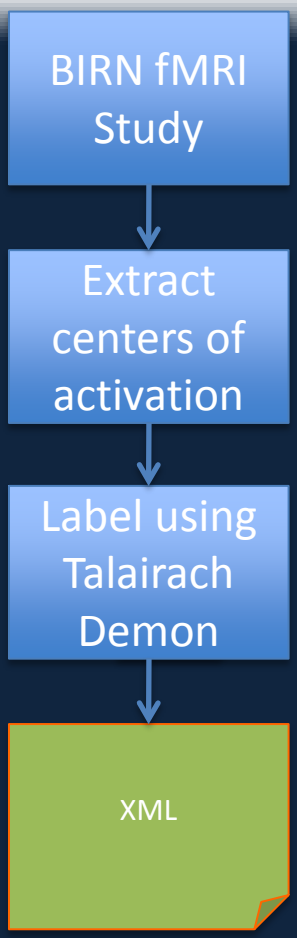
Execute

Query Results


```
<rdf:RDF
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:apf="java:com.hp.hpl.jena.query.pfunction.library."
    xmlns:tmp="http://sig.biostr.washington.edu/tmp#"
    xmlns:gleen="java:edu.washington.sig.gleen."
    xmlns:owl="http://www.w3.org/2002/07/owl#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
    xmlns:fma="http://sig.uw.edu/fma#" >
  <rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_46_of_right_middle_frontal_gyrus">
    <fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Right Cerebrum.Frontal Lobe.Middle Frontal Gyrus.Gray Matter
  </rdf:Description>
  <rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_46_of_left_middle_frontal_gyrus">
    <fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Left Cerebrum.Frontal Lobe.Middle Frontal Gyrus.Gray Matter.
  </rdf:Description>
  <rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_9_of_left_middle_frontal_gyrus">
    <fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Left Cerebrum.Frontal Lobe.Middle Frontal Gyrus.Gray Matter.
  </rdf:Description>
  <rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_9_of_left_superior_frontal_gyrus">
    <fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Left Cerebrum.Frontal Lobe.Superior Frontal Gyrus.Gray Matte
  </rdf:Description>
  <rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_9_of_right_superior_frontal_gyrus">
    <fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Right Cerebrum.Frontal Lobe.Superior Frontal Gyrus.Gray Matt
  </rdf:Description>
  <rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_9_of_right_middle_frontal_gyrus">
    <fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Right Cerebrum.Frontal Lobe.Middle Frontal Gyrus.Gray Matter
  </rdf:Description>
</rdf:RDF>
```


Upload to | Save to File


QM Client
QM Server
QM DB
vSPARQL
Service
RDF
Store

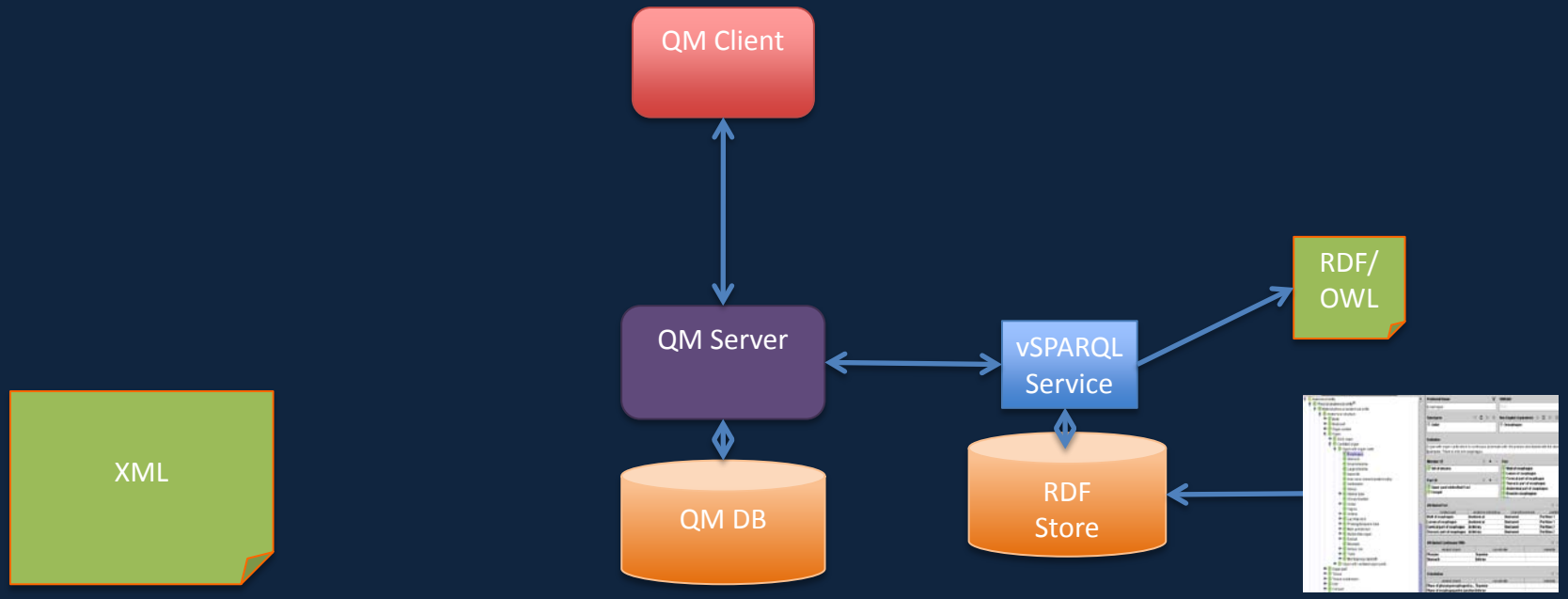


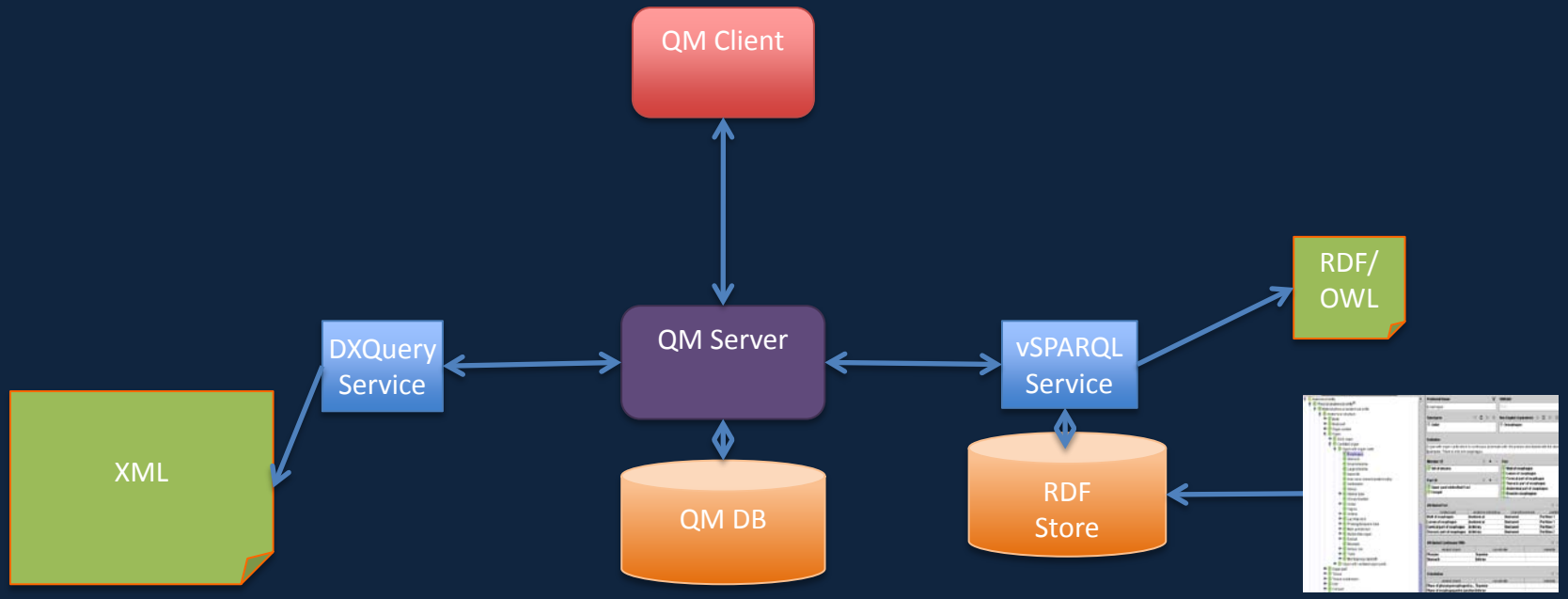
BIRN fMRI Study

Schizophrenics vs Healthy Controls

```
- <results>
  - <site>
      <site_label>301882920_11.4</site_label>
      <BIRN_ID>301882920</BIRN_ID>
      <Diagnostic_group>h</Diagnostic_group>
      <Voxels>475</Voxels>
      <Max_Z>11.4</Max_Z>
      <P>5.96E-8</P>
      <log10P>7.22</log10P>
      <Distance>4</Distance>
    - <Tal>
        Right Cerebrum.Temporal Lobe.Middle Temporal Gyrus.Gray Matter.Brodmann area 22
      </Tal>
      <right_coord>52</right_coord>
      <sup_coord>0</sup_coord>
      <ant_coord>-44</ant_coord>
    </site>
  - <site>
      <site_label>301882920_11.3</site_label>
      <BIRN_ID>301882920</BIRN_ID>
      <Diagnostic_group>h</Diagnostic_group>
      <Voxels>7287</Voxels>
      <Max_Z>11.3</Max_Z>
      <P>0</P>
      <log10P>54.8</log10P>
      <Distance>11</Distance>
    - <Tal>
        Right Cerebrum.Frontal Lobe.Precentral Gyrus.Gray Matter.Brodmann area 6
      </Tal>
      <right_coord>44</right_coord>
      <sup_coord>26</sup_coord>
      <ant_coord>0</ant_coord>
    </site>
```


XML


QM Client
QM Server
QM DB
XML
vSPARQL
Service
RDF/
OWL
RDF
Store


QM Client
QM Server
DXQuery Service
XML
QM DB
vSPARQL Service
RDF/ OWL
RDF Store

Query Manager

Hello Jim Brinkley Logout

Manage Search Edit User Help

Title

Group JessMerged into Sz and Healthy

Description

Create two lists

Query

```
let $act_doc := doc("http://synapse.biostr.washington.edu/~brinkley/dxdemos/JessMerged.xml")

(: now filter by healthy vs sz :)
let $healthy_act := $act_doc//site[Diagnostic_group/text()='h']
let $schizo_act := $act_doc//site[Diagnostic_group/text()='s']

(: add color for display of both groups :)
let $h_color := 'Red'
let $s_color := 'Yellow'
let $shape := 'BIG_SPHERE'
let $size := '1.75'
let $healthy_sites :=
   for $el in $healthy_act
   return
    <site>
      {$el/site_label}
      {$el/BIRN_ID}
     {$el/Diagnostic_group}
     {$el/Voxels}
     {$el/Max_Z}
      {$el/P}
     {$el/log10P}
     {$el/Distance}
     {$el/Tal}
     {$el/right_coord}
     {$el/sup_coord}
     {$el/ant_coord}
    <Color>{$h_color}</Color>
```

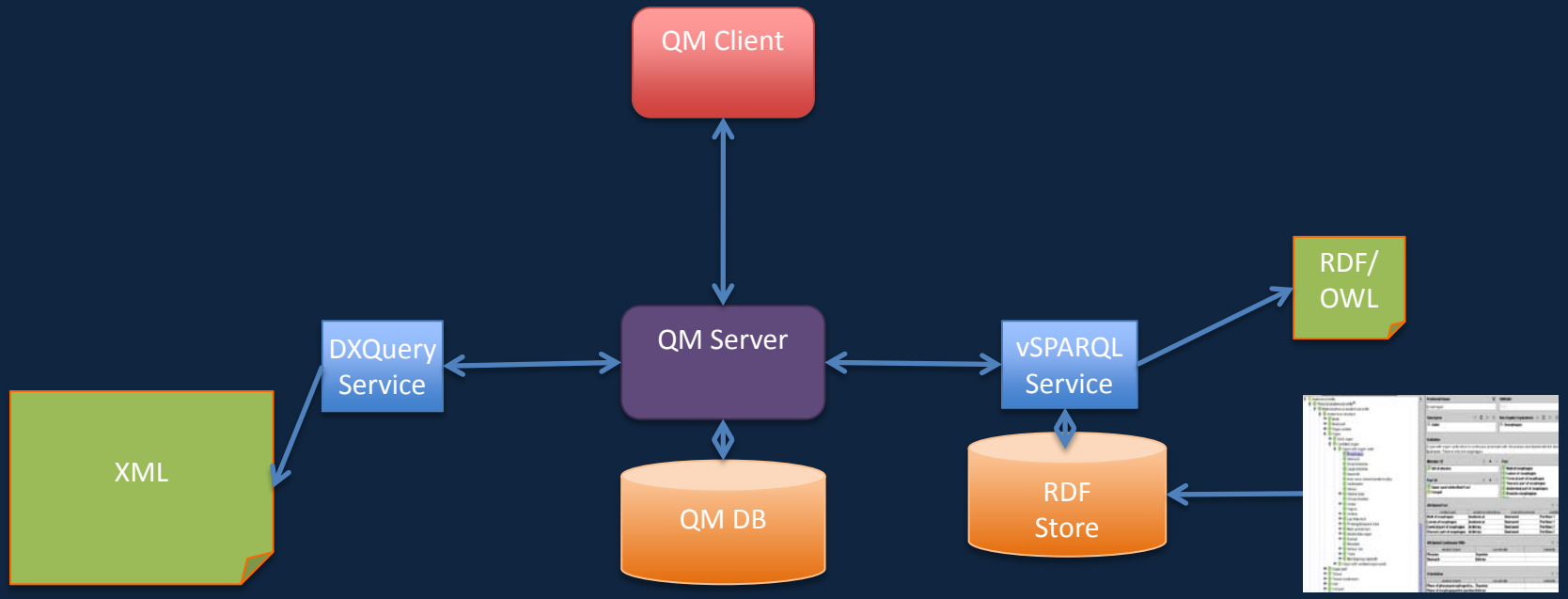
Language DXQuery

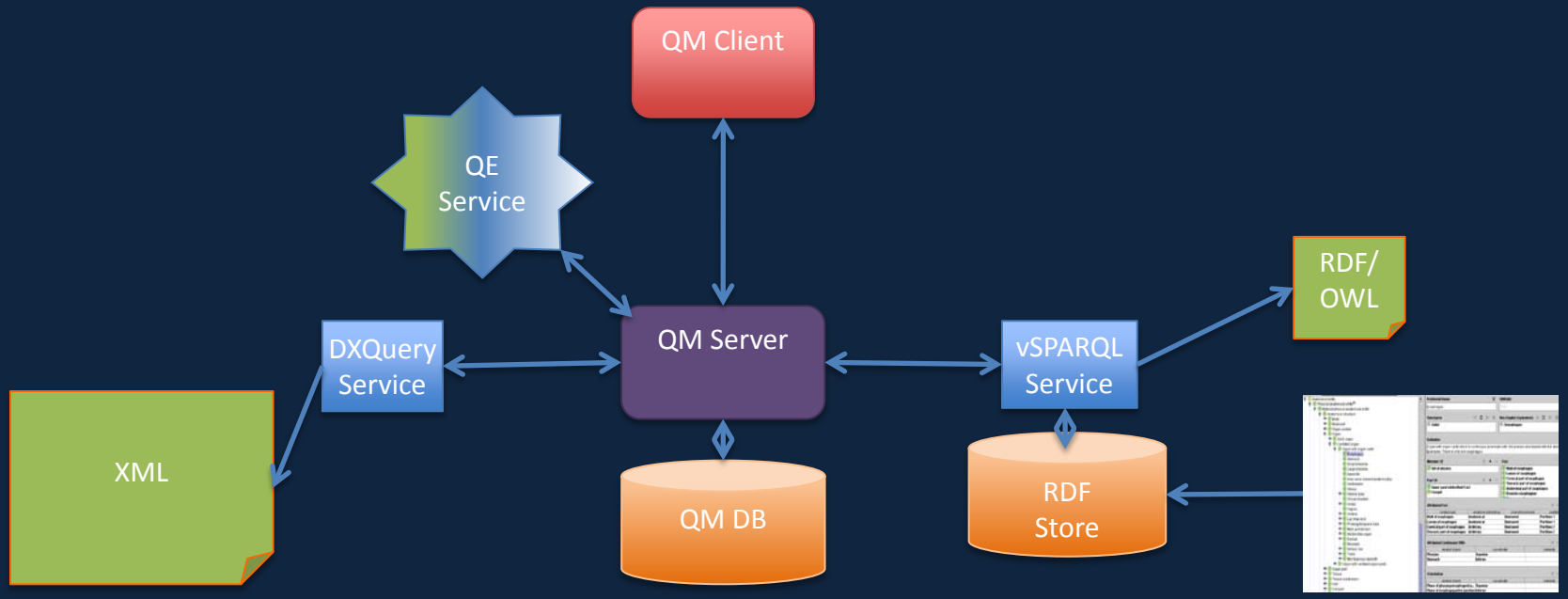
Execute

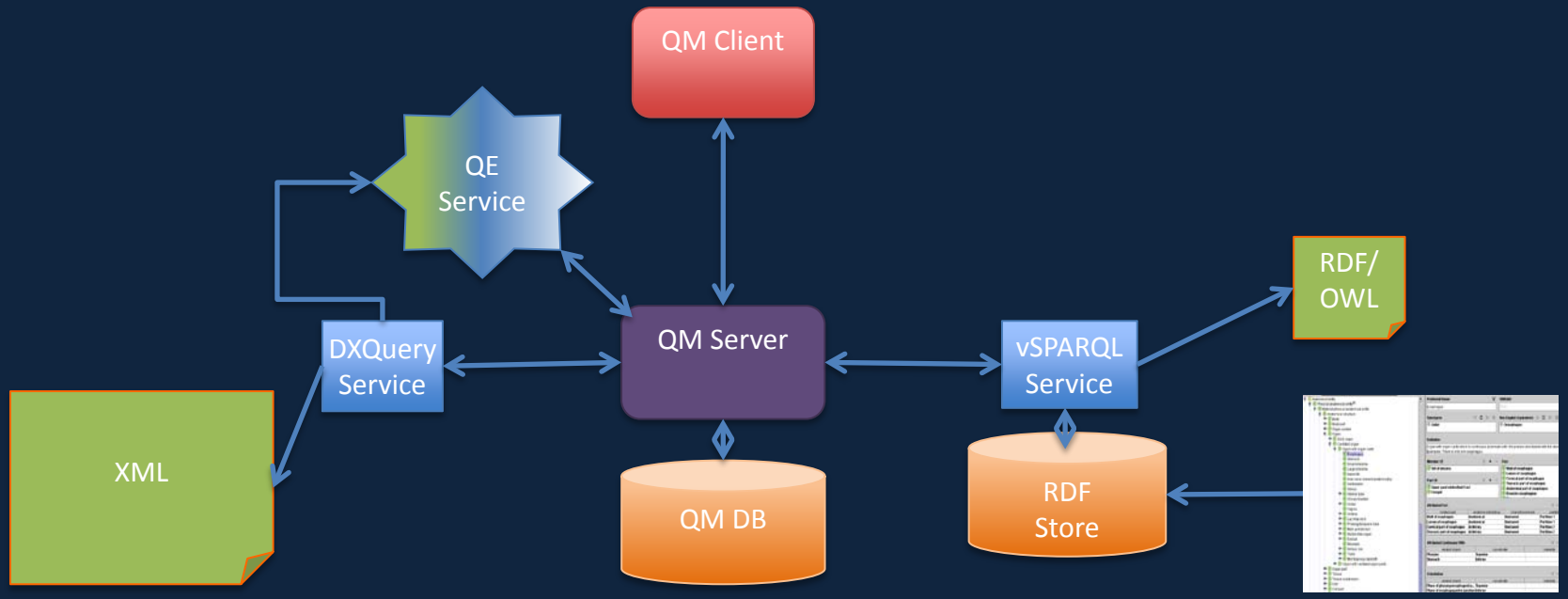
Query Results


```
<?xml version="1.0" encoding="UTF-8"?>
<results>
   <patient>
      <pnum>MNI</pnum>
      <site>
         <site_label>301882920_11.4</site_label>
         <BIRN_ID xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">301882920</BIRN_ID>
         <Diagnostic_group xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">h</Diagnostic_group>
         <Voxels xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">475</Voxels>
         <Max_Z xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">11.4</Max_Z>
         <P>5.96E-8</P>
         <log10P>7.22</log10P>
         <Distance>4</Distance>
         <Tal> Right Cerebrum.Temporal Lobe.Middle Temporal Gyrus.Gray Matter.Brodmann area 22</Tal>
         <right_coord>52</right_coord>
         <sup_coord>0</sup_coord>
         <ant_coord>-44</ant_coord>
         <Color>Red</Color>
         <Shape>BIG_SPHERE</Shape>
         <Size>1.75</Size>
      </site>
      <site>
         <site_label>301882920_11.3</site_label>
         <BIRN_ID xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">301882920</BIRN_ID>
         <Diagnostic_group xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">h</Diagnostic_group>
         <Voxels xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">7287</Voxels>
         <Max_Z xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">11.3</Max_Z>
         <P>0</P>
         <log10P>54.8</log10P>
         <Distance>11</Distance>
         <Tal> Right Cerebrum.Frontal Lobe.Precentral Gyrus.Gray Matter.Brodmann area 6</Tal>
         <right_coord>44</right_coord>
         <sup_coord>26</sup_coord>
         <ant_coord>0</ant_coord>
         <Color>Red</Color>
         <Shape>BIG_SPHERE</Shape>
         <Size>1.75</Size>
      </site>
      <site>
         <site_label>301882920_10.1</site_label>
         <BIRN_ID xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">301882920</BIRN_ID>
         <Diagnostic_group xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">h</Diagnostic_group>
         <Voxels xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">232</Voxels>
         <Max_Z xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">10.1</Max_Z>
         <P>1.39E-4</P>
         <log10P>3.86</log10P>
```

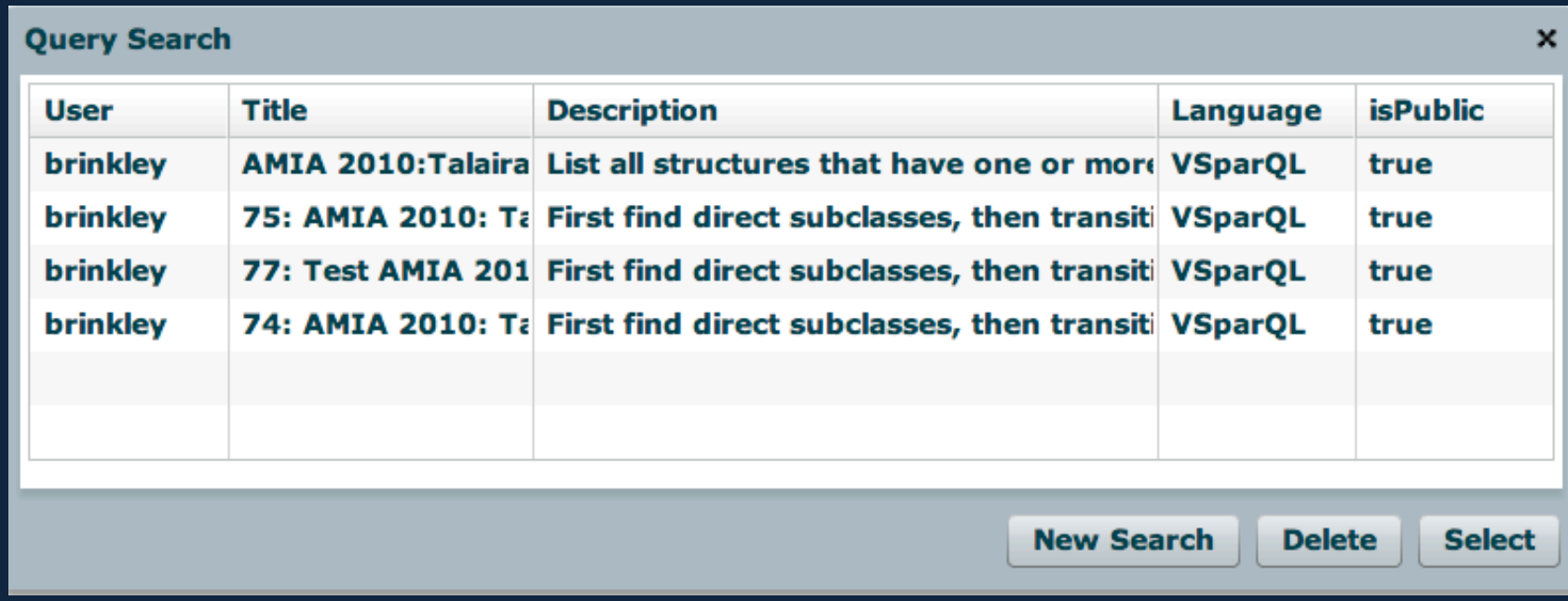

Upload to | Save to File

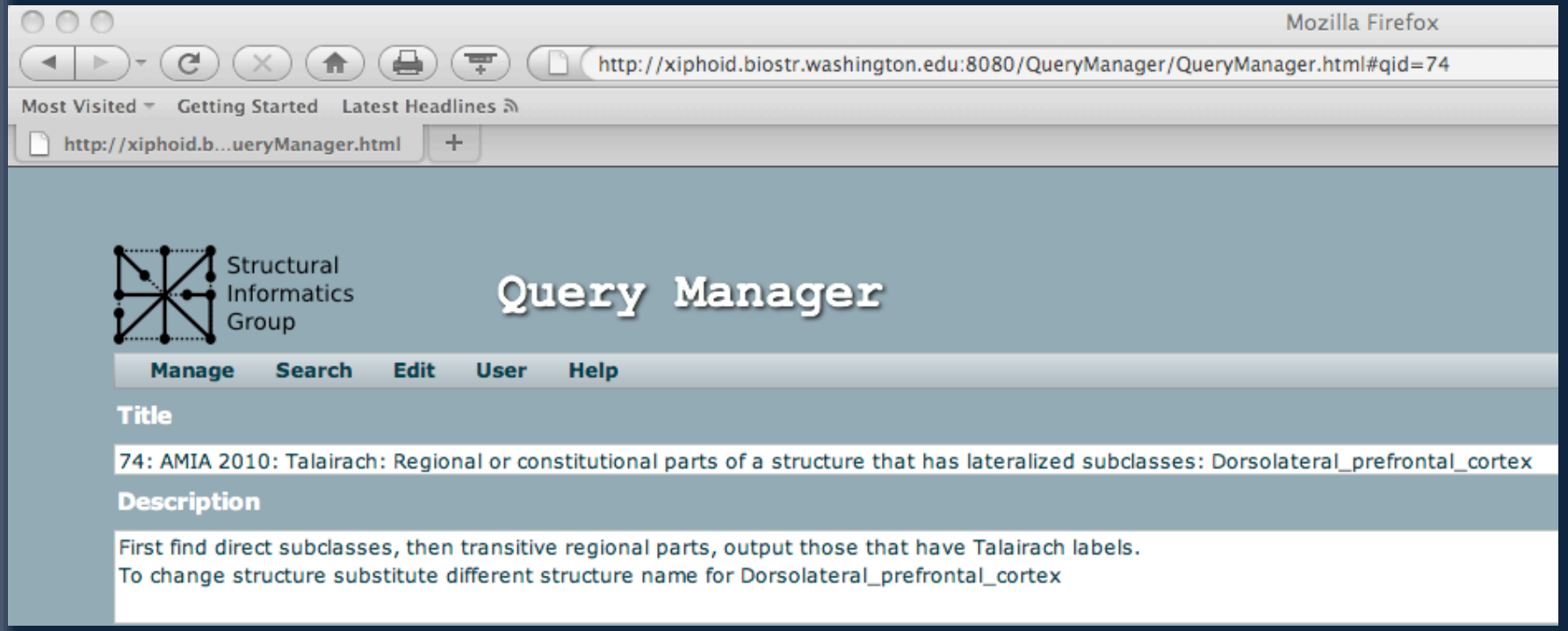

QM Client
QM Server
DXQuery Service
XML
QM DB
vSPARQL Service
RDF/ OWL
RDF Store

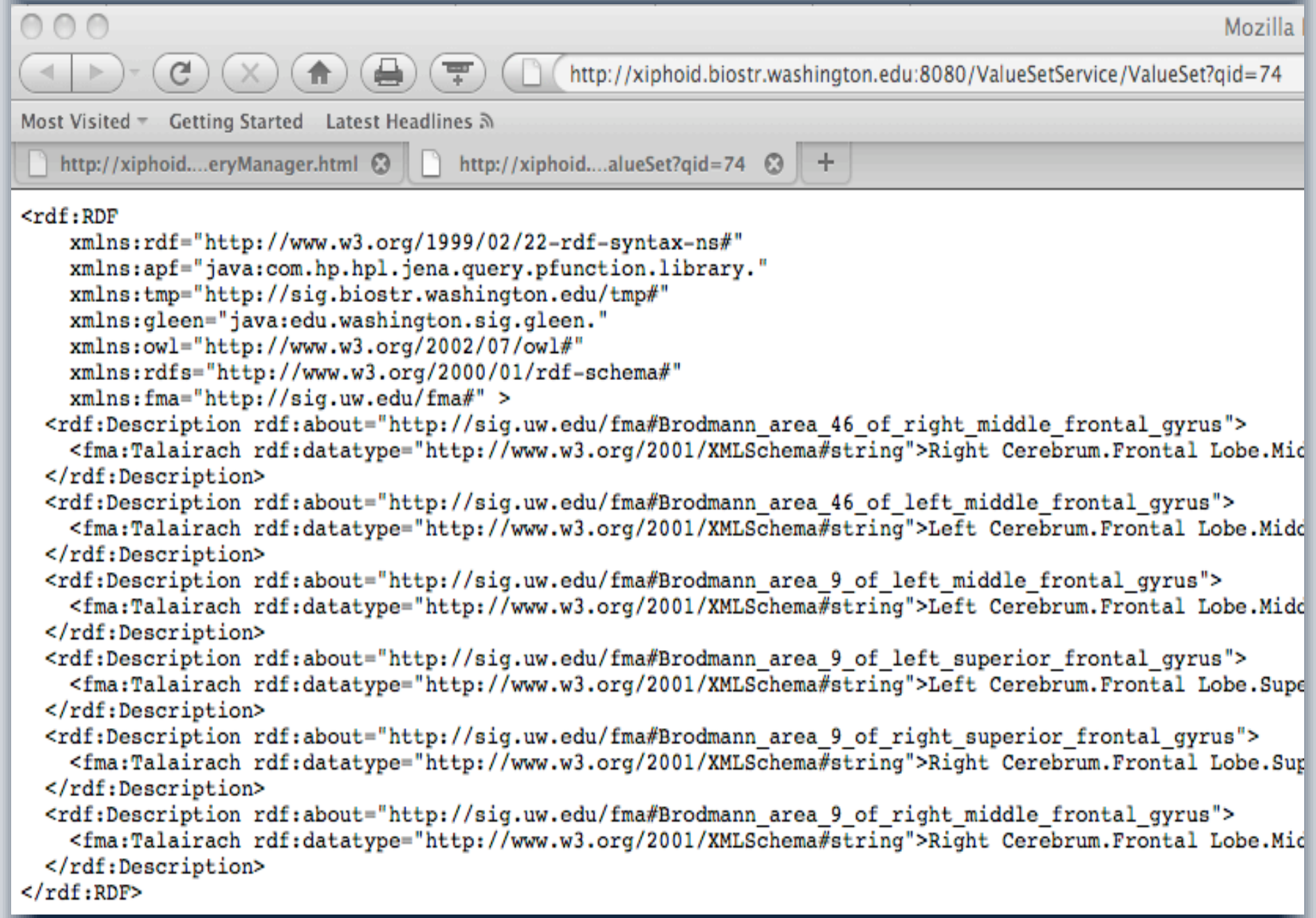

QM Client
QE
Service
RDF/
OWL
DXQuery
Service
QM Server
vSPARQL
Service
XML
QM DB
RDF
Store


QM Client
QE
Service
DXQuery
Service
QM Server
vSPARQL
Service
RDF/
OWL
XML
QM DB
RDF
Store


Query Search
Field:
title
Type:
contains
Pattern:
Talairach
Language:
VSparQL
User:
brinkley
Search


Query Search
User
Title
Description
Language
isPublic
brinkley
AMIA 2010:Talaira
List all structures that have one or mor
VSparQL
true
brinkley
75: AMIA 2010: Ta
First find direct subclasses, then transiti
VSparQL
true
brinkley
77: Test AMIA 201
First find direct subclasses, then transiti
VSparQL
true
brinkley
74: AMIA 2010: Ta
First find direct subclasses, then transiti
VSparQL
true
New Search
Delete
Select

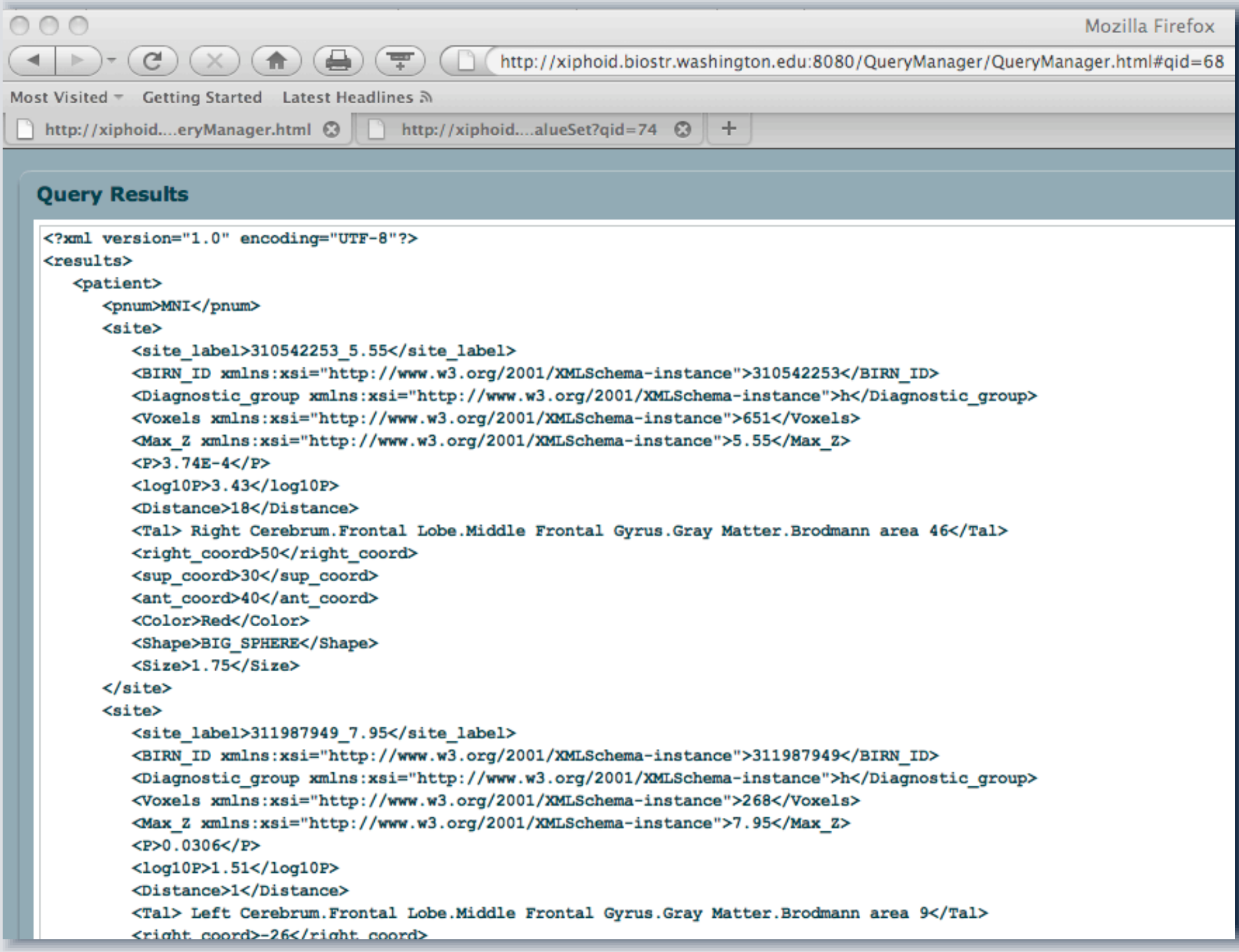

Mozilla Firefox
http://xiphoid.biostr.washington.edu:8080/QueryManager/QueryManager.html#qid=74
Most Visited
Getting Started
Latest Headlines
http://xiphoid.b...ueryManager.html
Structural
Informatics
Group
Query Manager
Manage
Search
Edit
User
Help
Title
74: AMIA 2010: Talairach: Regional or constitutional parts of a structure that has lateralized subclasses: Dorsolateral_prefrontal_cortex
Description
First find direct subclasses, then transitive regional parts, output those that have Talairach labels.
To change structure substitute different structure name for Dorsolateral_prefrontal_cortex


Mozilla
http://xiphoid.biostr.washington.edu:8080/ValueSetService/ValueSet?qid=74
Most Visited
Getting Started
Latest Headlines
http://xiphoid....eryManager.html
http://xiphoid....alueSet?qid=74
<rdf:RDF
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
xmlns:apf="java:com.hp.hpl.jena.query.pfunction.library."
xmlns:tmp="http://sig.biostr.washington.edu/tmp#"
xmlns:gleen="java:edu.washington.sig.gleen."
xmlns:owl="http://www.w3.org/2002/07/owl#"
xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
xmlns:fma="http://sig.uw.edu/fma#" >
<rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_46_of_right_middle_frontal_gyrus">
<fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Right Cerebrum.Frontal Lobe.Mid
</rdf:Description>
<rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_46_of_left_middle_frontal_gyrus">
<fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Left Cerebrum.Frontal Lobe.Midd
</rdf:Description>
<rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_9_of_left_middle_frontal_gyrus">
<fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Left Cerebrum.Frontal Lobe.Midd
</rdf:Description>
<rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_9_of_left_superior_frontal_gyrus">
<fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Left Cerebrum.Frontal Lobe.Supe
</rdf:Description>
<rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_9_of_right_superior_frontal_gyrus">
<fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Right Cerebrum.Frontal Lobe.Sup
</rdf:Description>
<rdf:Description rdf:about="http://sig.uw.edu/fma#Brodmann_area_9_of_right_middle_frontal_gyrus">
<fma:Talairach rdf:datatype="http://www.w3.org/2001/XMLSchema#string">Right Cerebrum.Frontal Lobe.Mid
</rdf:Description>
</rdf:RDF>

```
let $sub_regions_tals := doc("http://xiphoid.biostr.washington.edu:8080/ValueSetService/ValueSet?qid=74")

(: now gather results from activation data :)
let $act_doc := doc("http://synapse.biostr.washington.edu/~brinkley/dxdemos/JessMerged.xml")
(: first filter by Talaraich label that is also in list returned rom vSPARQL query :)
let $act_by_tal :=
    for $act in $act_doc//site
    for  $fmatal in $sub_regions_tals
    return if (fn:contains($fmatal,$act/Tal))
    then $act
    else ()


(: now filter by healthy vs sz :)
let $healthy_act := $act_by_tal[Diagnostic_group/text()='h']
let $schizo_act := $act_by_tal[Diagnostic_group/text()='s']
```



Query Results


```
<?xml version="1.0" encoding="UTF-8"?>
<results>
   <patient>
      <pnum>MNI</pnum>
      <site>
         <site_label>310542253_5.55</site_label>
         <BIRN_ID xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">310542253</BIRN_ID>
         <Diagnostic_group xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">h</Diagnostic_group>
         <Voxels xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">651</Voxels>
         <Max_Z xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">5.55</Max_Z>
         <P>3.74E-4</P>
         <log10P>3.43</log10P>
         <Distance>18</Distance>
         <Tal> Right Cerebrum.Frontal Lobe.Middle Frontal Gyrus.Gray Matter.Brodmann area 46</Tal>
         <right_coord>50</right_coord>
         <sup_coord>30</sup_coord>
         <ant_coord>40</ant_coord>
         <Color>Red</Color>
         <Shape>BIG_SPHERE</Shape>
         <Size>1.75</Size>
      </site>
      <site>
         <site_label>311987949_7.95</site_label>
         <BIRN_ID xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">311987949</BIRN_ID>
         <Diagnostic_group xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">h</Diagnostic_group>
         <Voxels xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">268</Voxels>
         <Max_Z xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">7.95</Max_Z>
         <P>0.0306</P>
         <log10P>1.51</log10P>
         <Distance>1</Distance>
         <Tal> Left Cerebrum.Frontal Lobe.Middle Frontal Gyrus.Gray Matter.Brodmann area 9</Tal>
         <right_coord>-26</right_coord>
```

QM Client

QE Service

XML

DXQuery Service

QM Server

vSPARQL Service

RDF/ OWL

XML

QM DB

RDF Store

Home

The DXBrain Project

• Brain Data Integration with XQuery

Log Out

Title (max 200 chars):

Jess Query 4 using ValueSet service for display

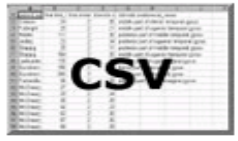
Description (max 400 chars):

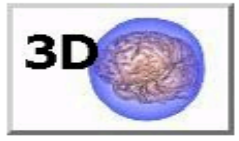
Query

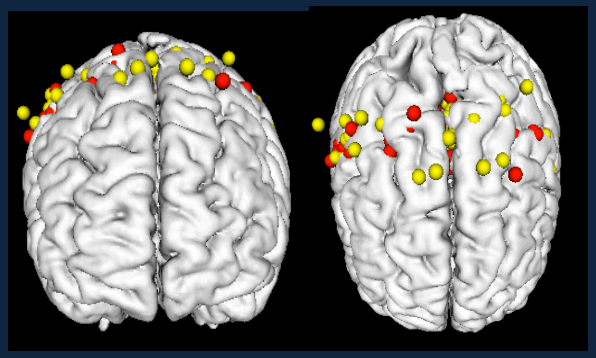
```
let $jess4 := doc("http://xiphoid.biostr.washington.edu:8080/ValueSetService/ValueSet?qid=68")
return
<results>
{$jess4//patient}
</results>
```

Public ◉ Private ○ Save Delete

Select one of the following output formats.

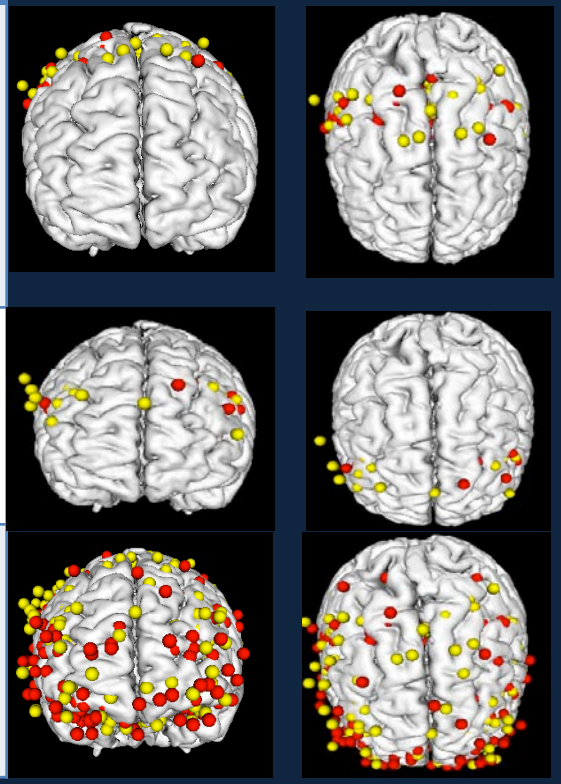






N=1741

Region	Filtered	Healthy (Red)	Schizo-phrenic (Yellow)
Dorso_lateral prefrontal cortex	55	25	30
Brodmann area 6	213	107	106
Frontal lobe	575	288	287



QM Client

QE Service

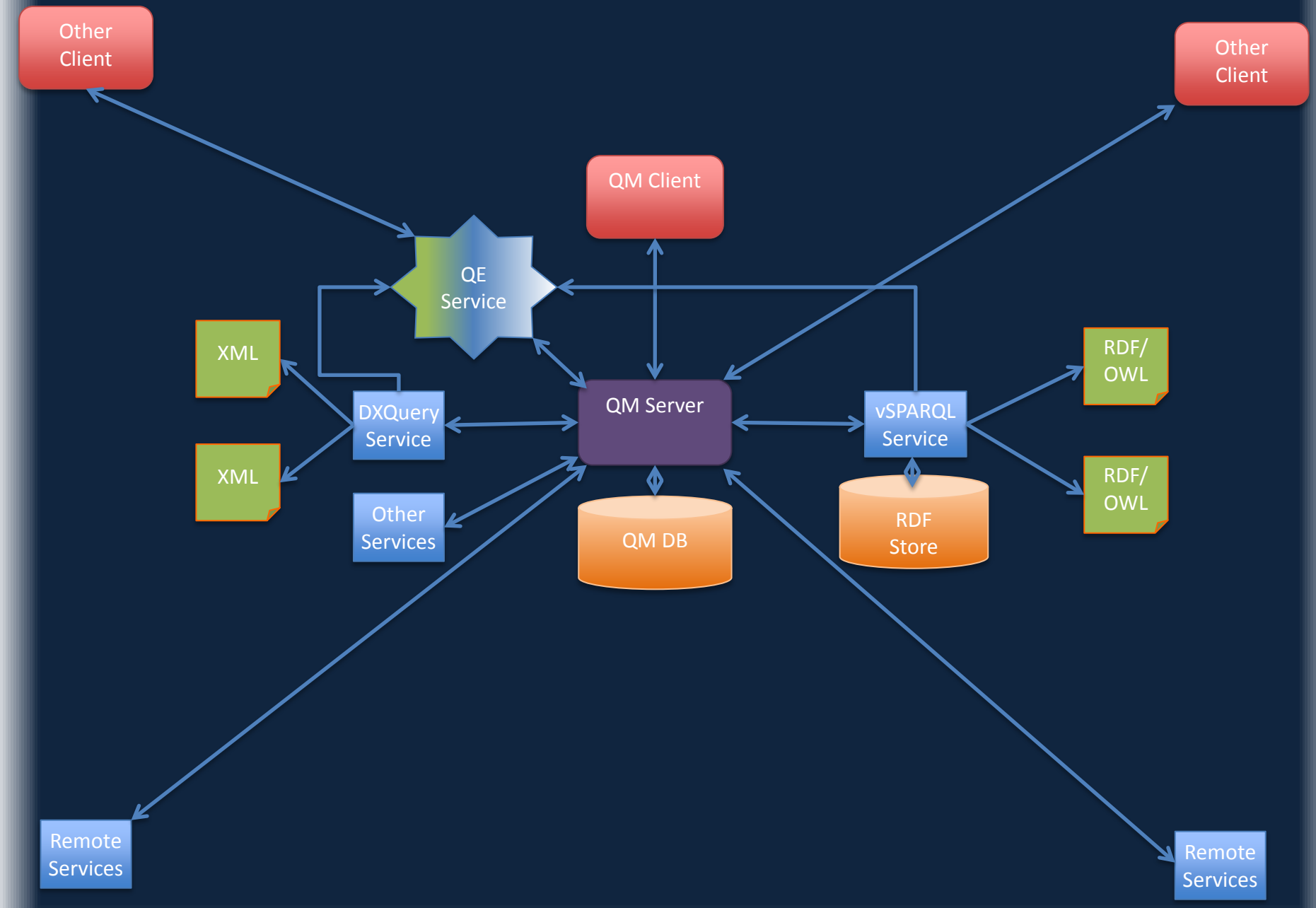
DXQuery Service

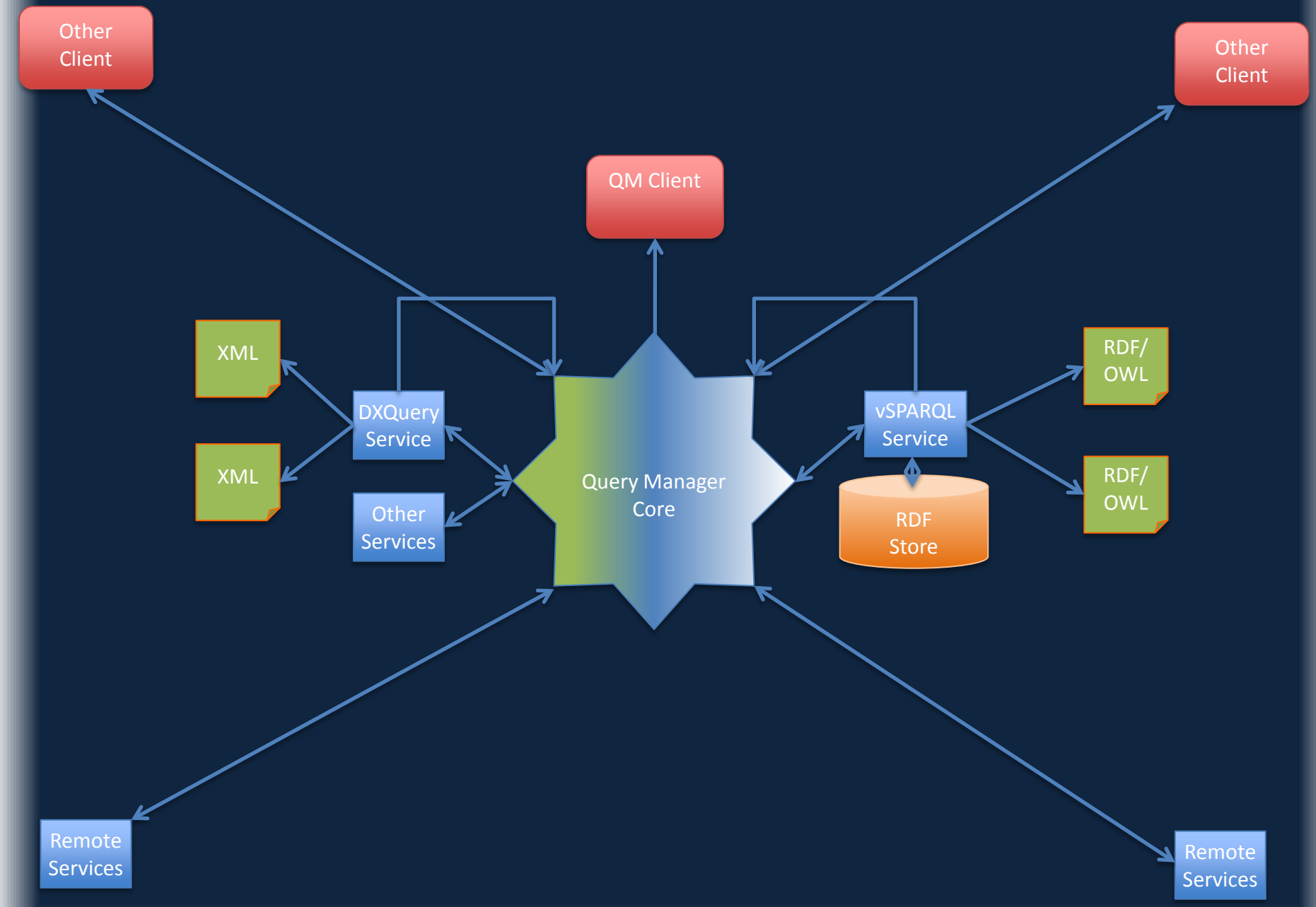
QM Server

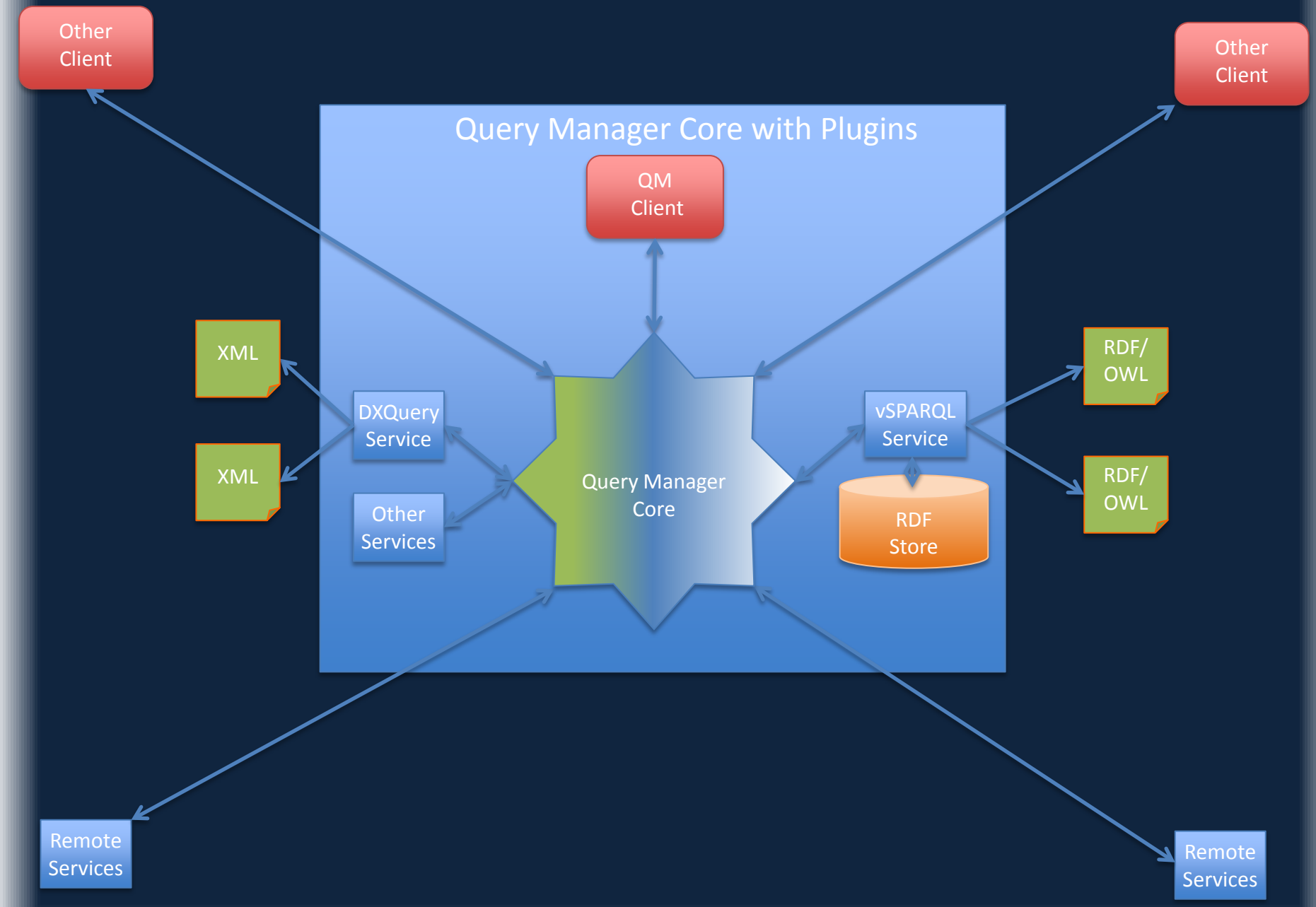
vSPARQL Service

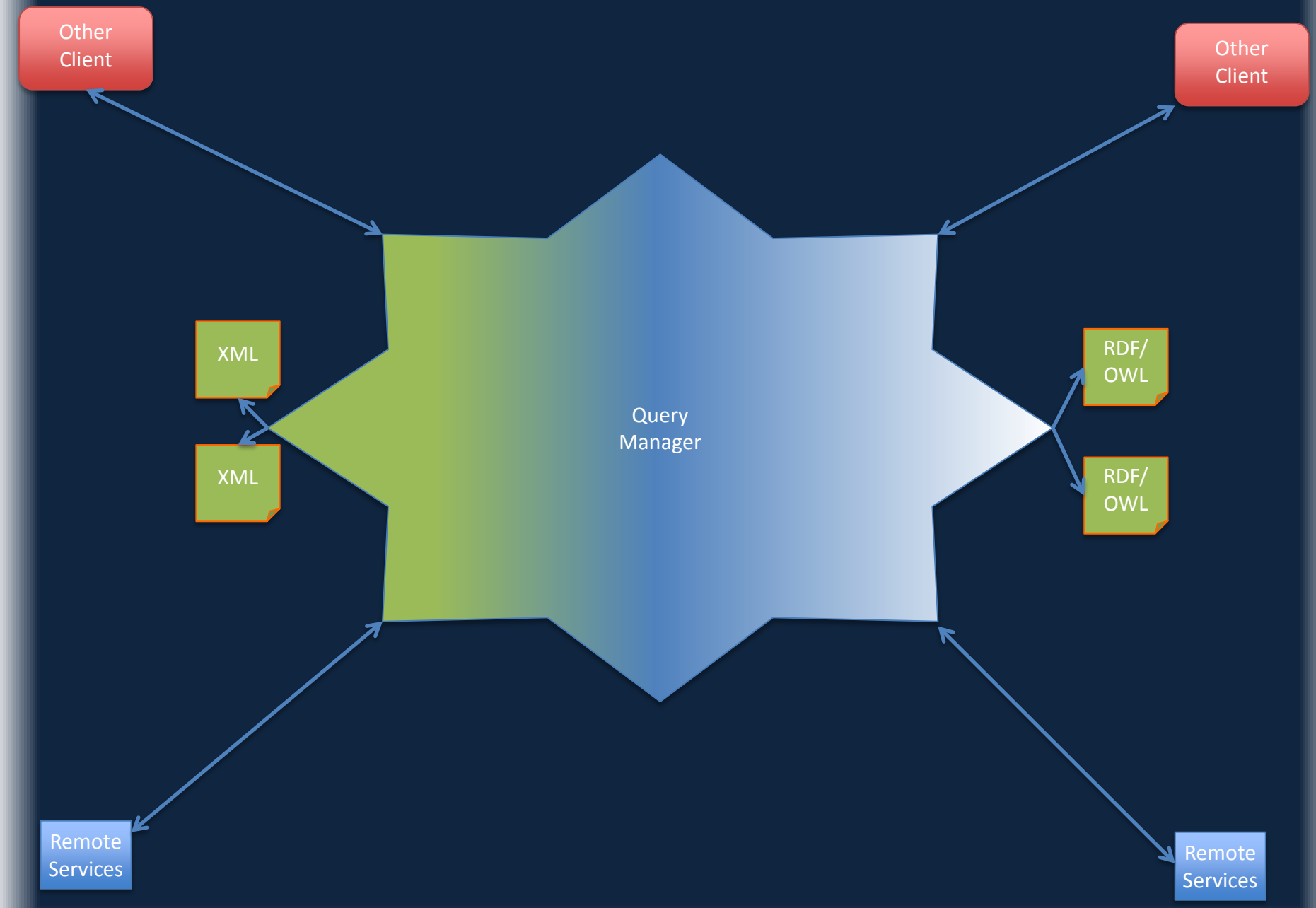
QM DB

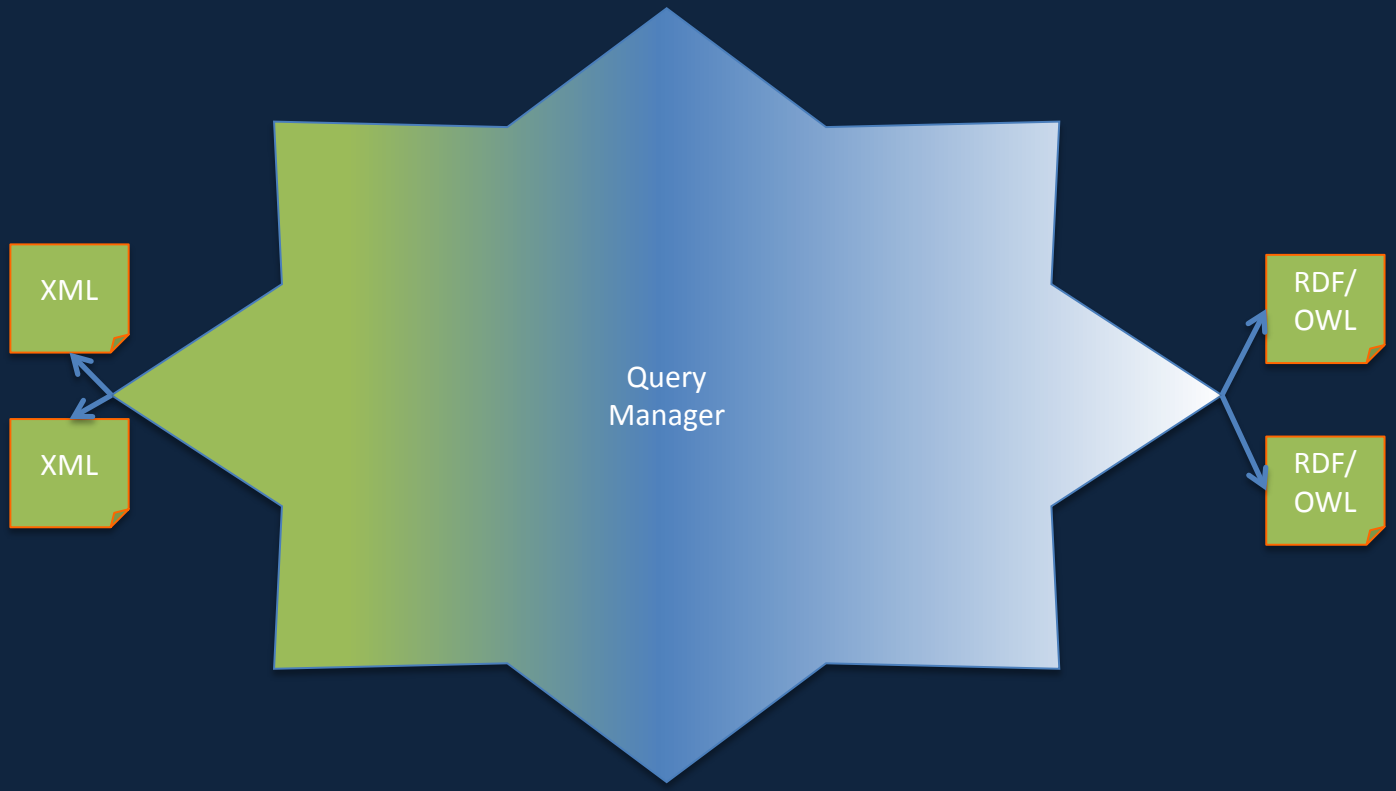
RDF Store


Other Client
Other Client
QM Client
QE Service
XML
XML
DXQuery Service
Other Services
QM Server
QM DB
vSPARQL Service
RDF Store
RDF/ OWL
RDF/ OWL
Remote Services
Remote Services


Other Client
Other Client
QM Client
XML
XML
DXQuery Service
Other Services
Query Manager Core
vSPARQL Service
RDF Store
RDF/ OWL
RDF/ OWL
Remote Services
Remote Services


Other Client
Other Client
Query Manager Core with Plugins
QM Client
XML
XML
DXQuery Service
Other Services
Query Manager Core
vSPARQL Service
RDF Store
RDF/ OWL
RDF/ OWL
Remote Services
Remote Services


Other Client
Other Client
XML
XML
Query Manager
RDF/ OWL
RDF/ OWL
Remote Services
Remote Services


XML
XML
Query
Manager
RDF/
OWL
RDF/
OWL

BIRN fMRI and FMA

BIRN fMRI

Query Manager

FMA

BIRN fMRI, VBM and FMA

VBM

BIRN fMRI

Query Manager

FMA

Electronic Data Capture and Freezer Management

EDC

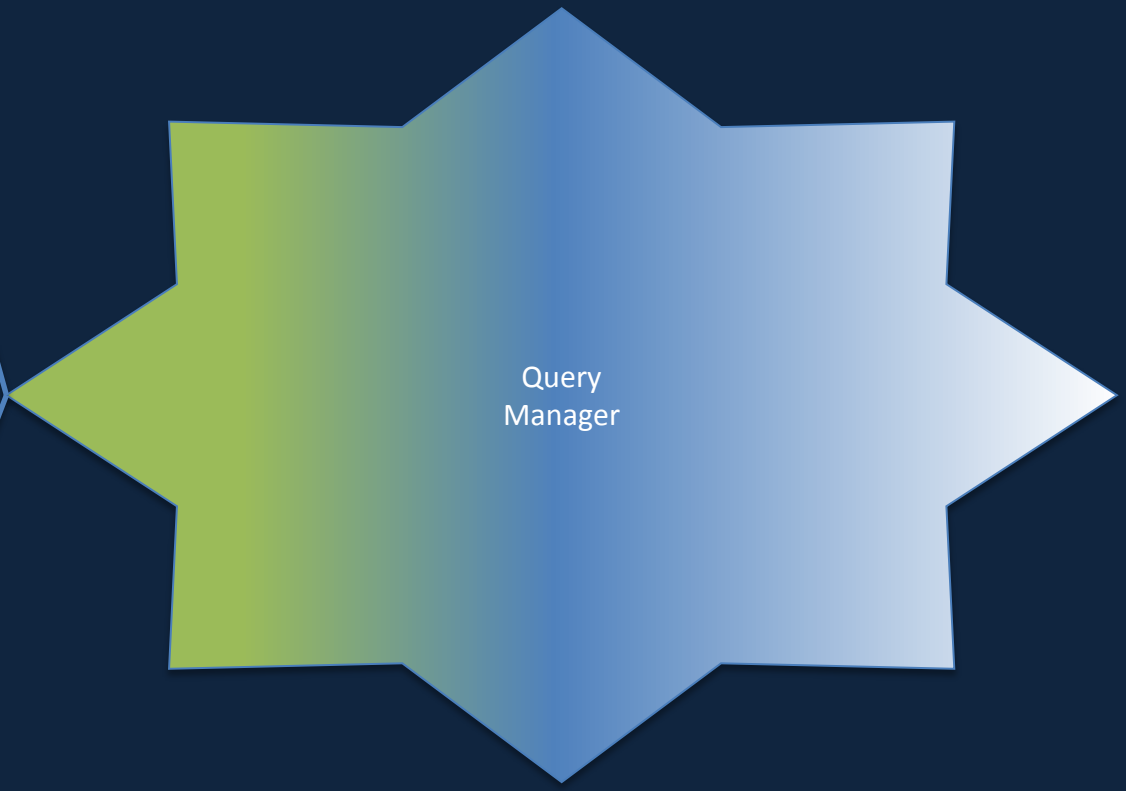
Query Manager

Freezer Management

Biorepositories

Biorepository

Biorepository



Human Studies Database

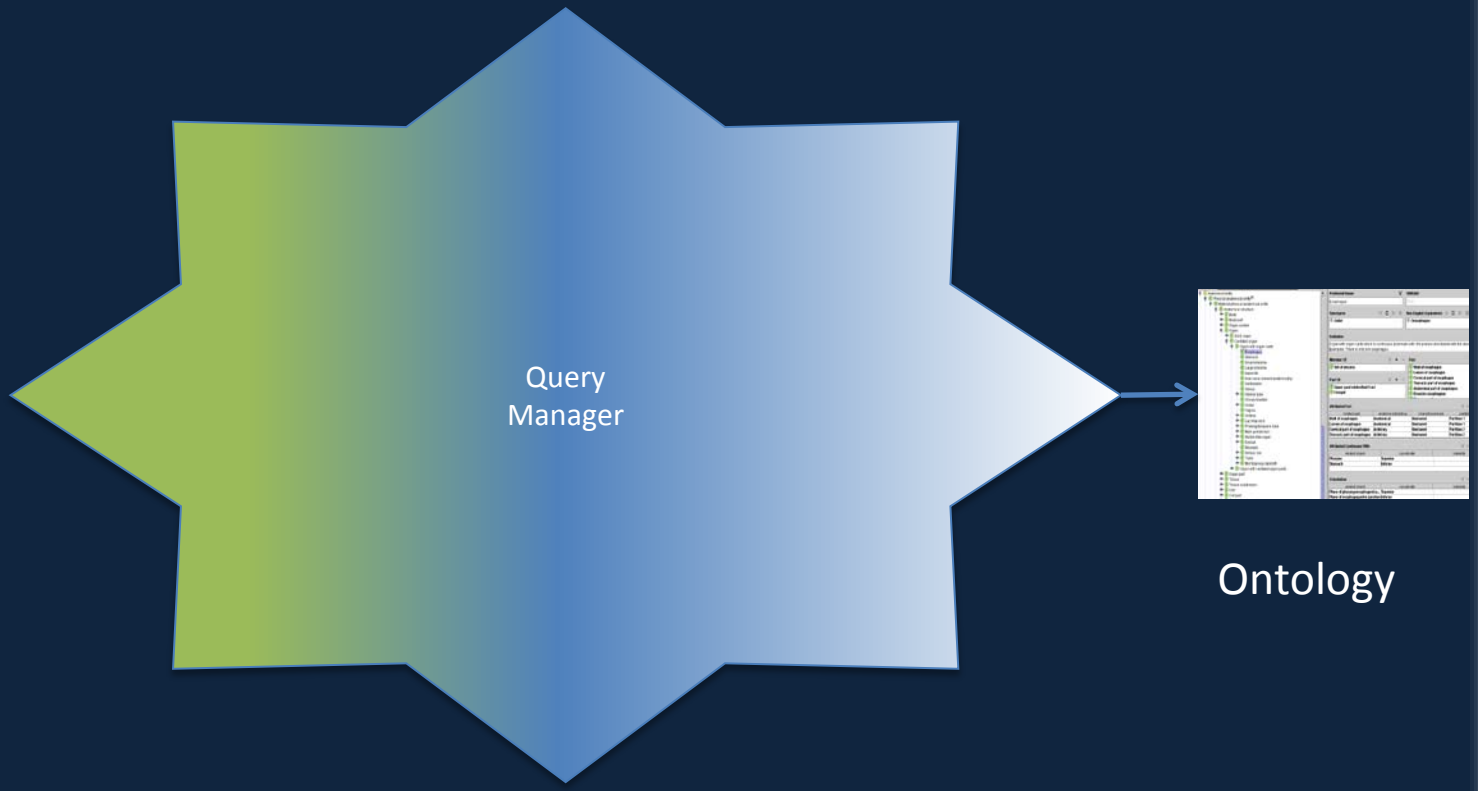
Clinical Trials Metadata

Clinical Trials Metadata

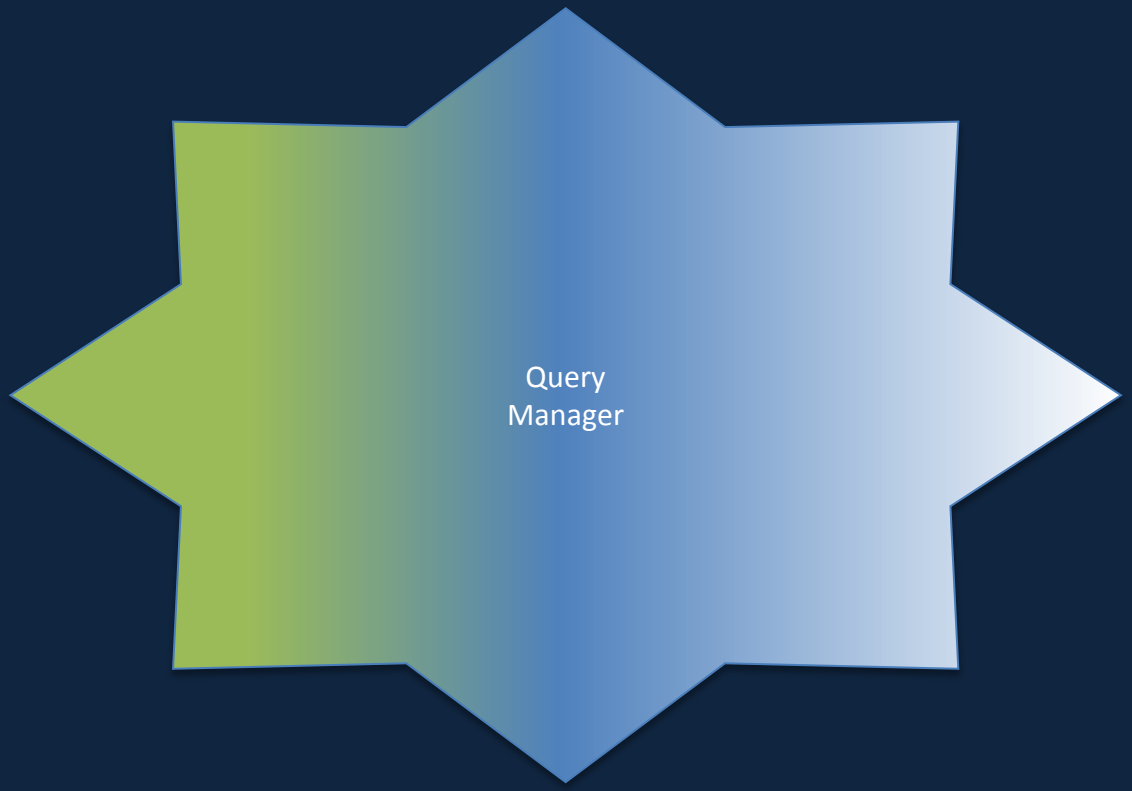
Query Manager

Ontology of Clinical Research

Ontology Views



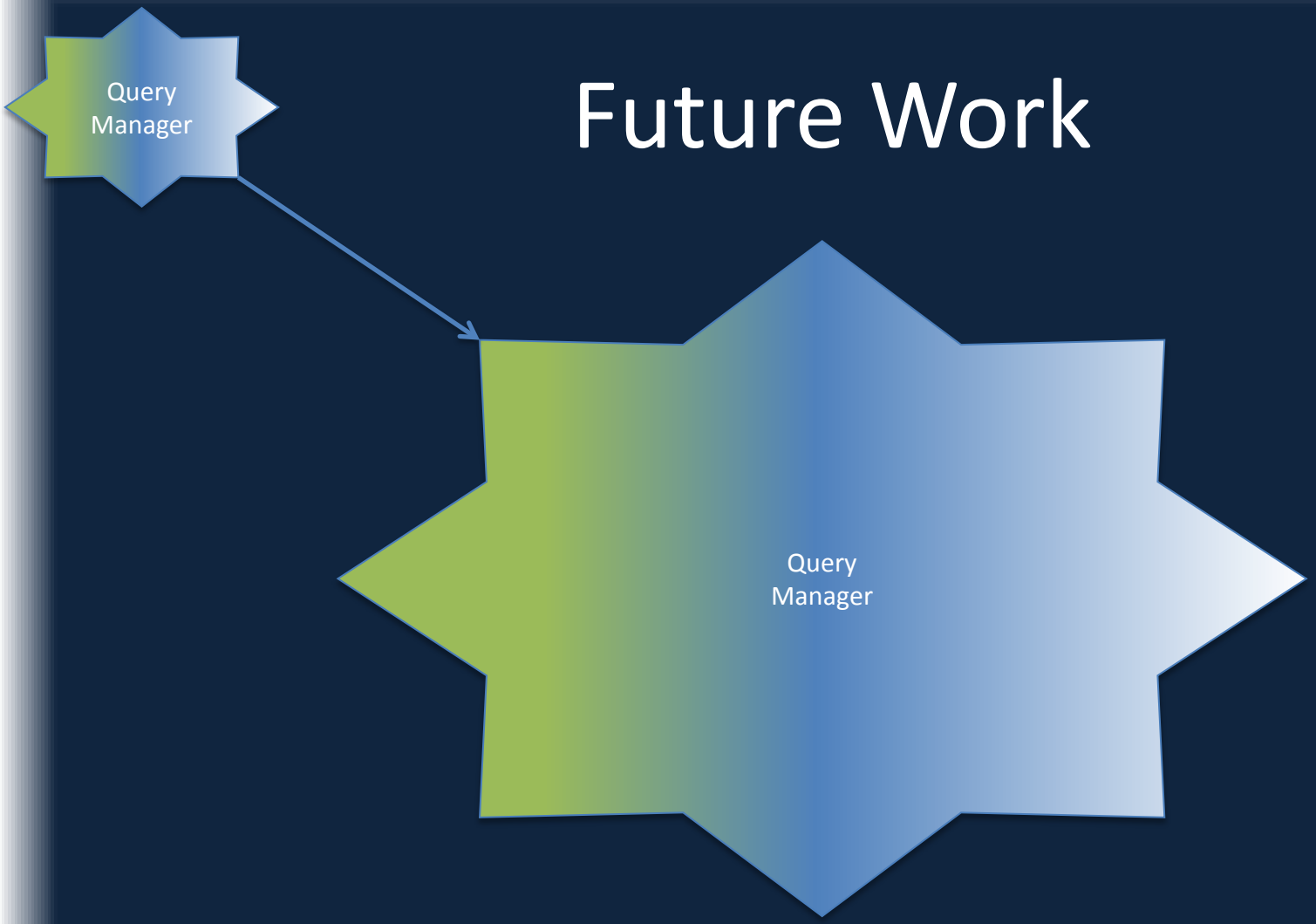
Summary

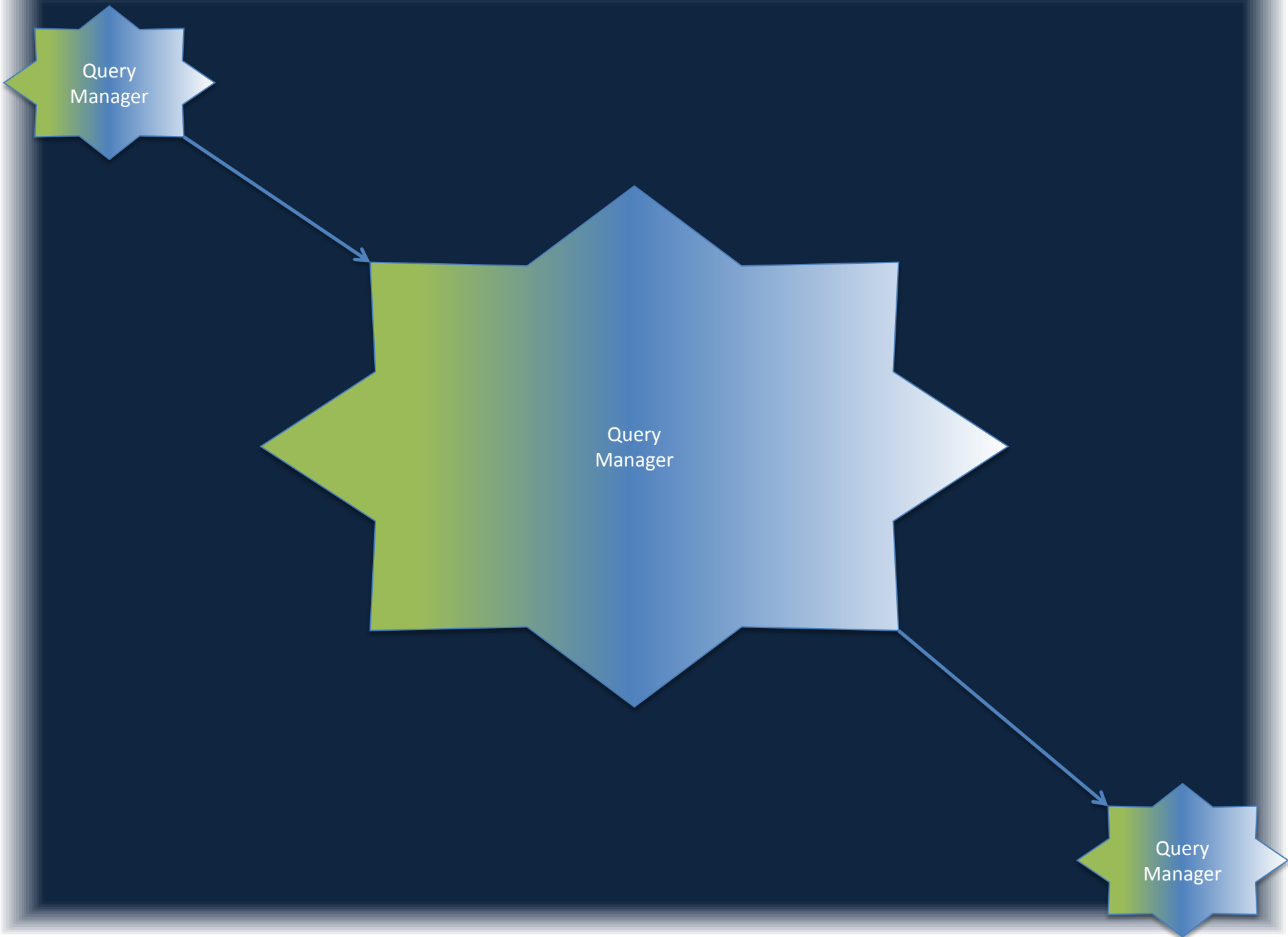


Issues

- Response time
- Reliability
- Security
- Discoverability
- Usability
- Integration with other systems and methods

Future Work

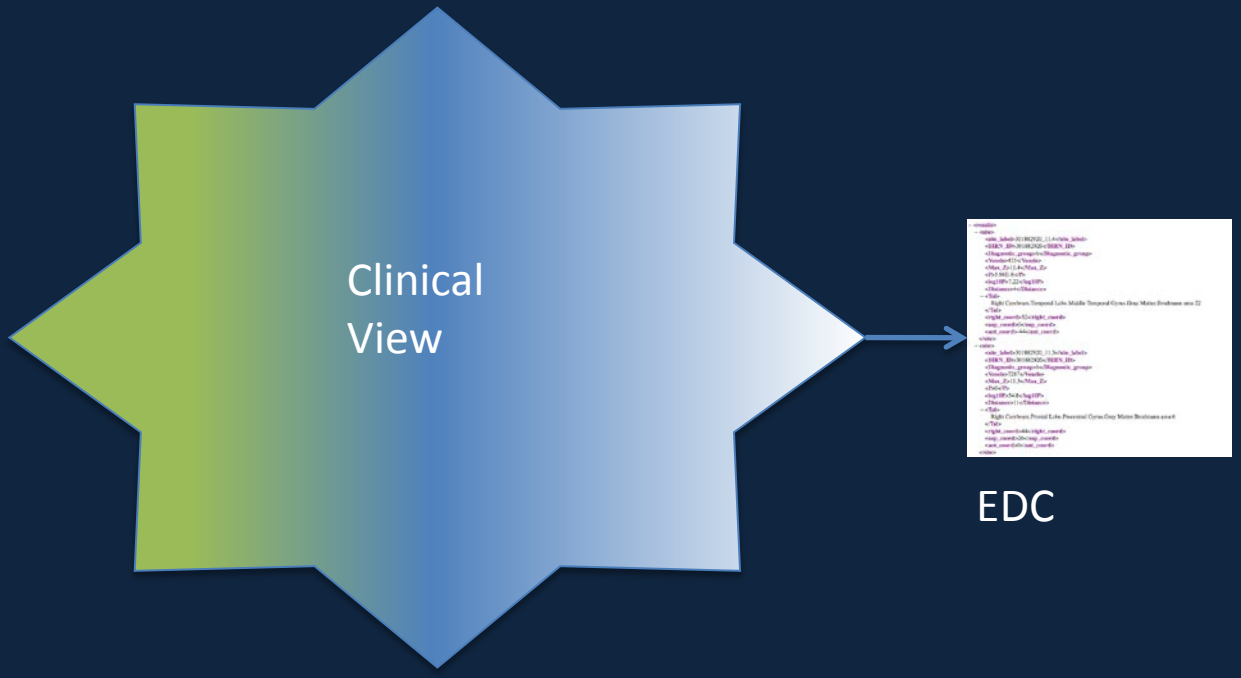


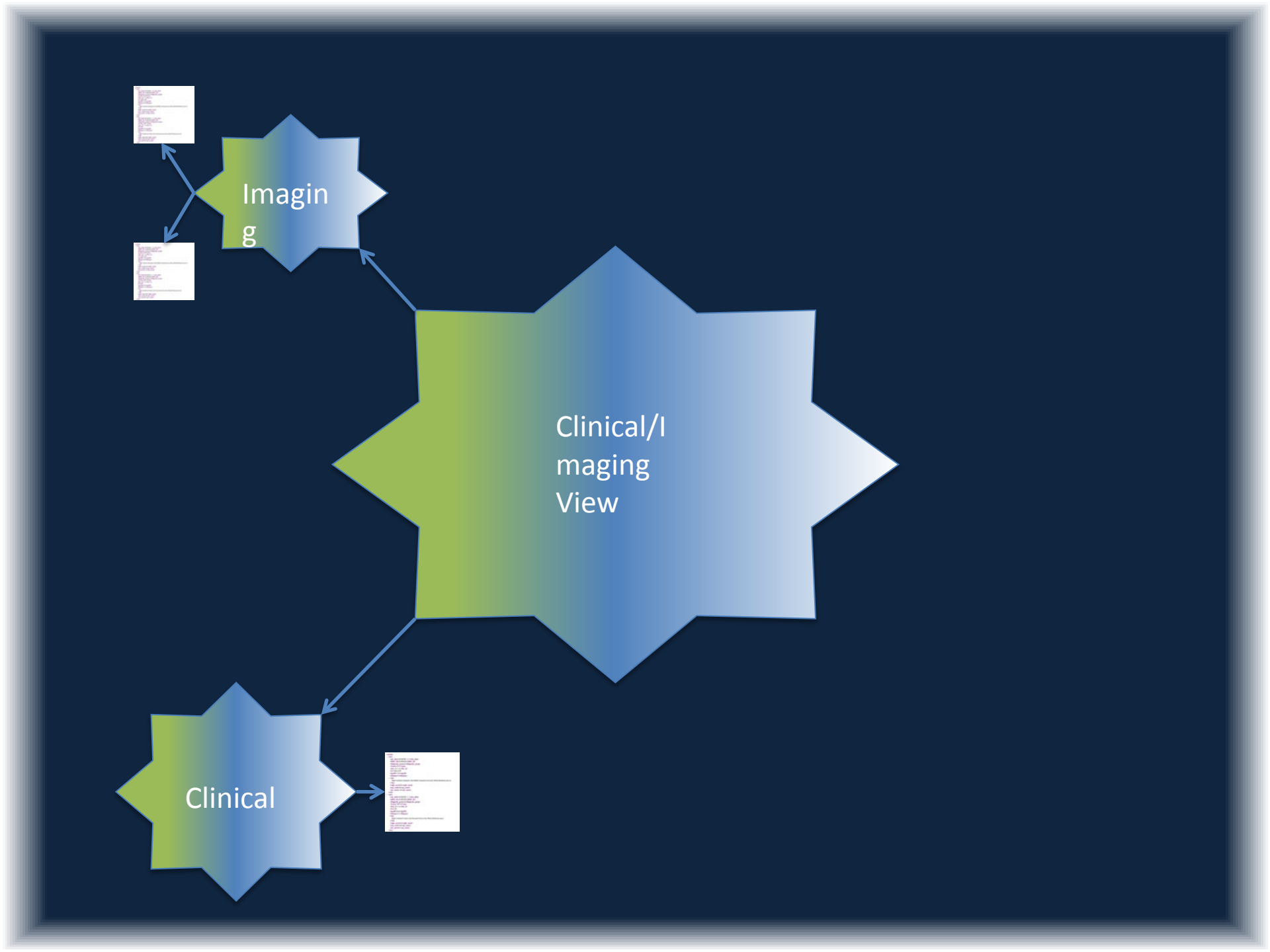

Query
Manager
Query
Manager
Query
Manager

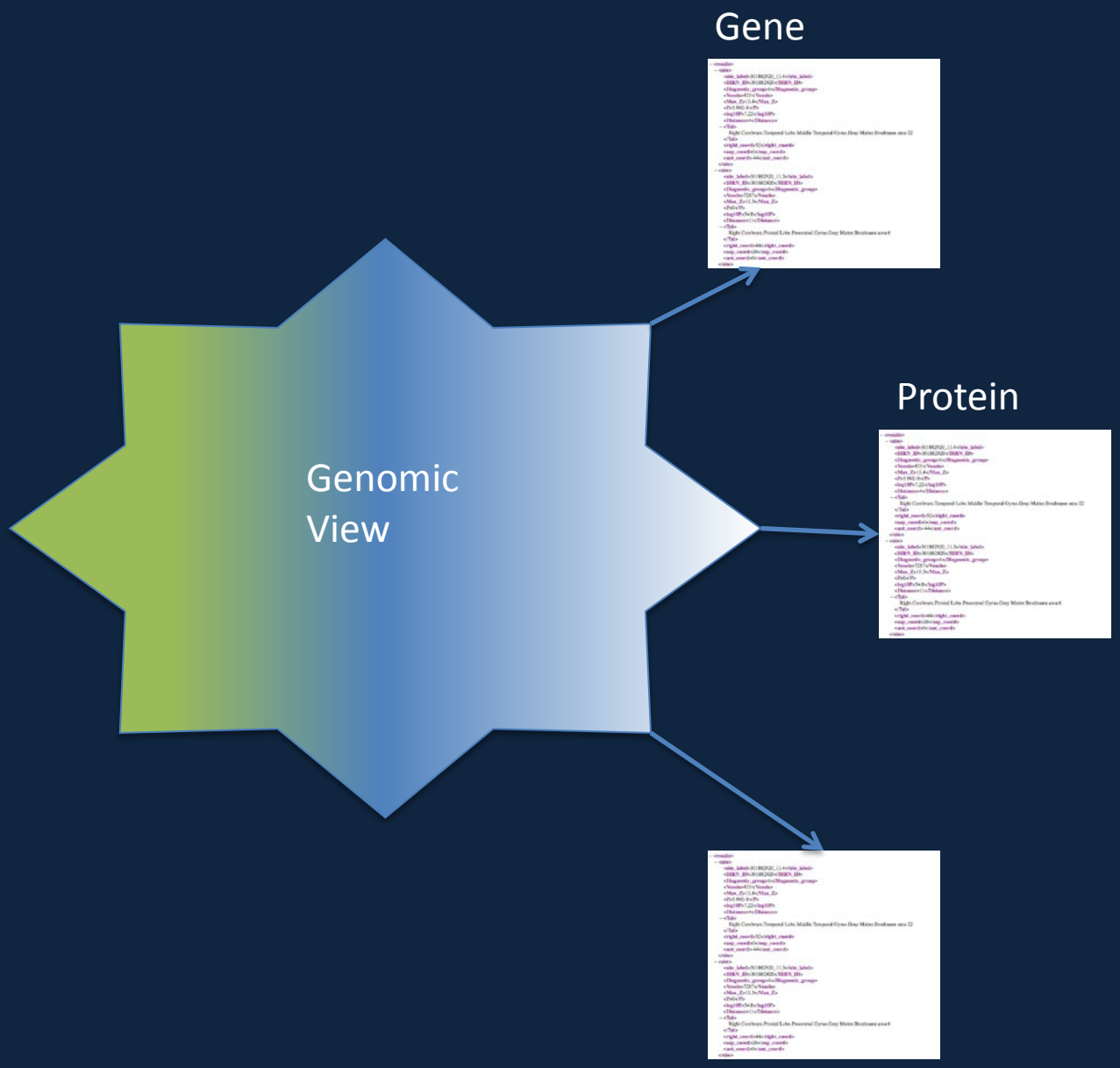
BIRN fMRI

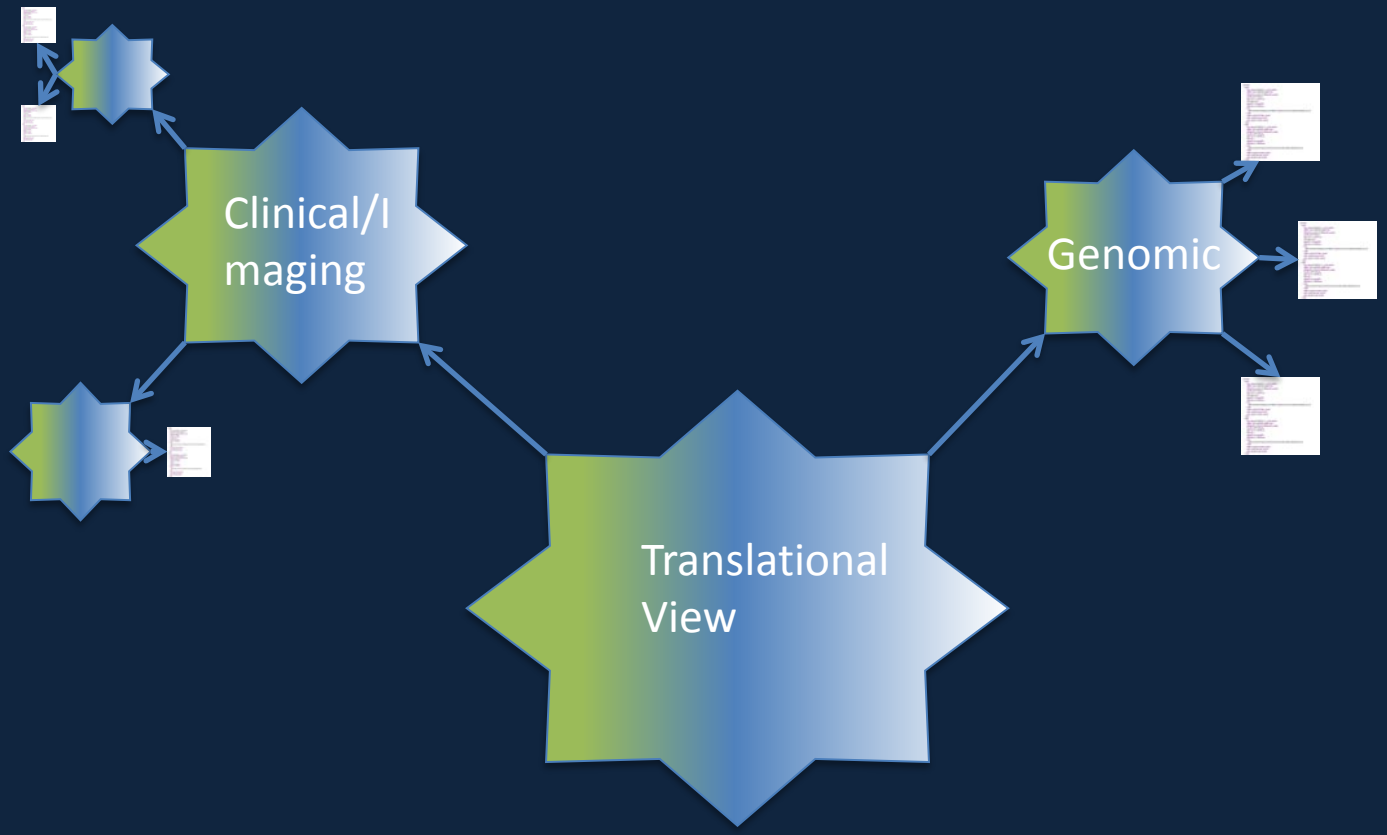
FMA

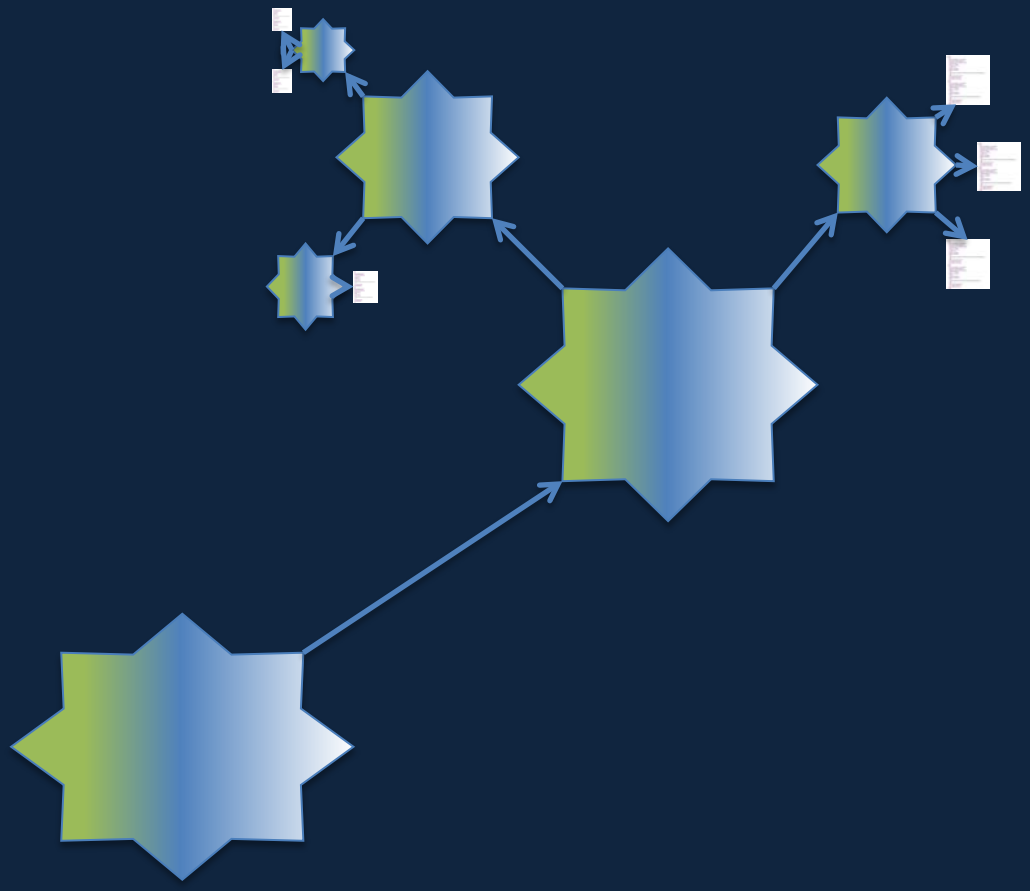
Brain
Imaging
View

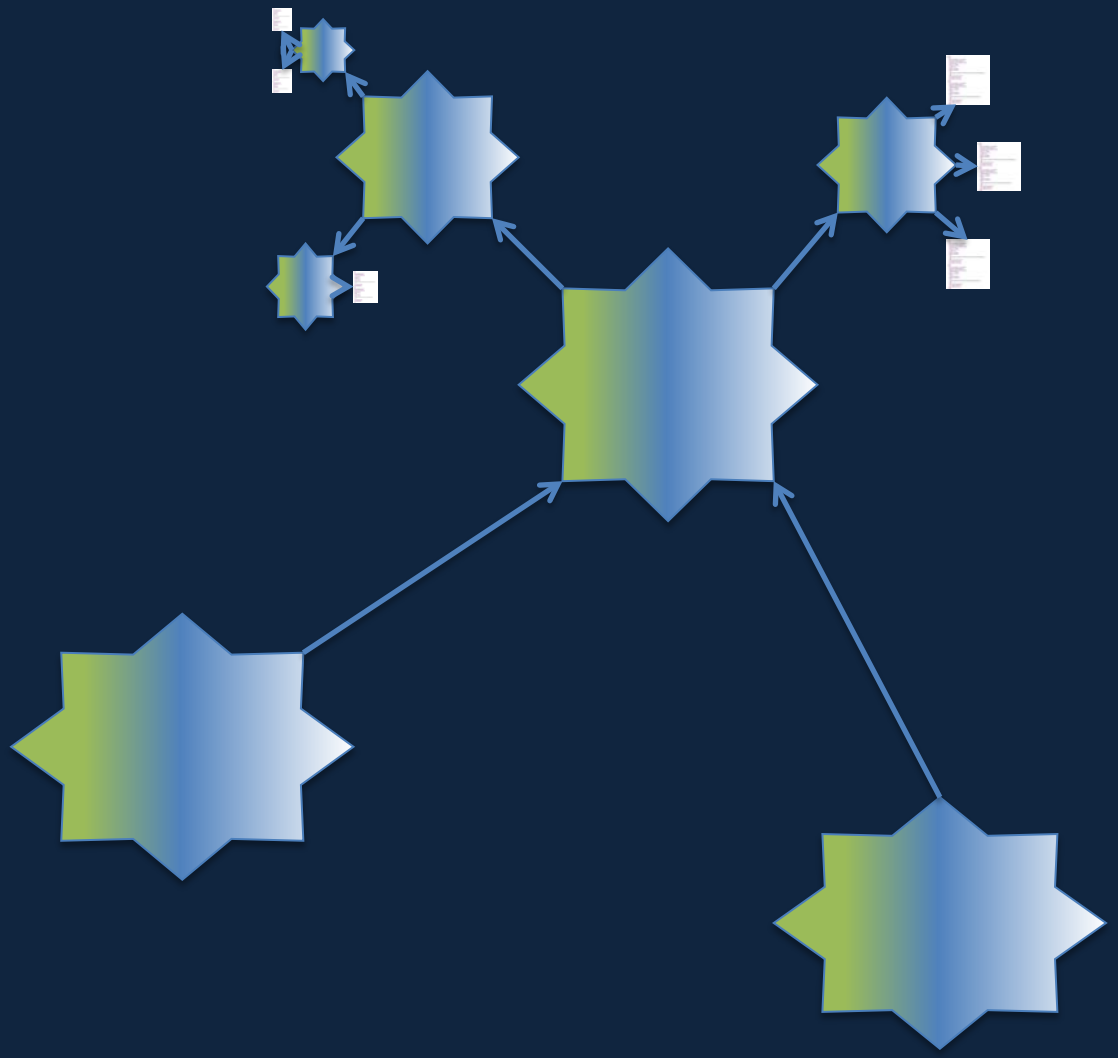

Clinical
View
EDC


Imagin
g
Clinical/I
maging
View
Clinical

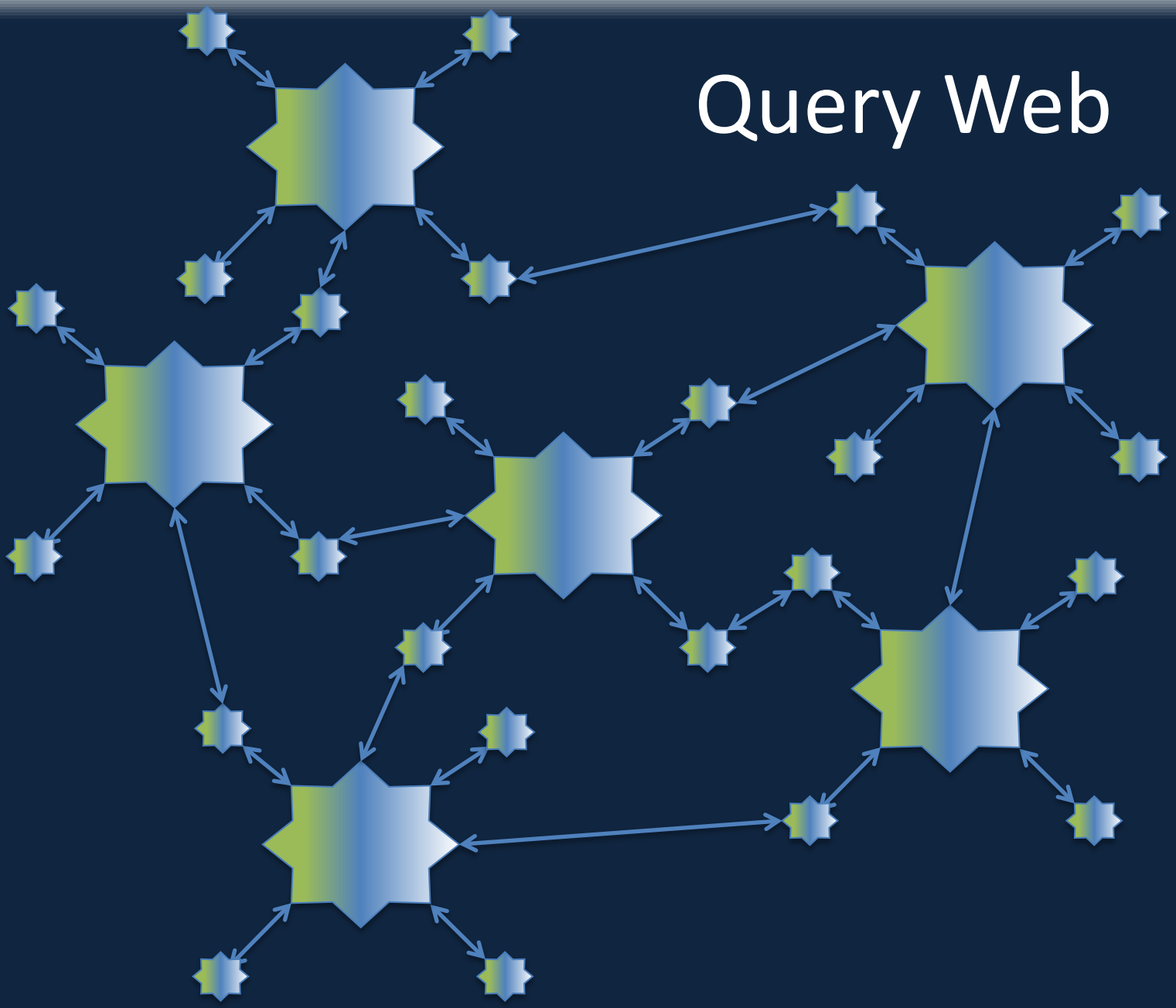

Gene
Protein
Genomic
View
Others….


Clinical/I
maging
Genomic
Translational
View

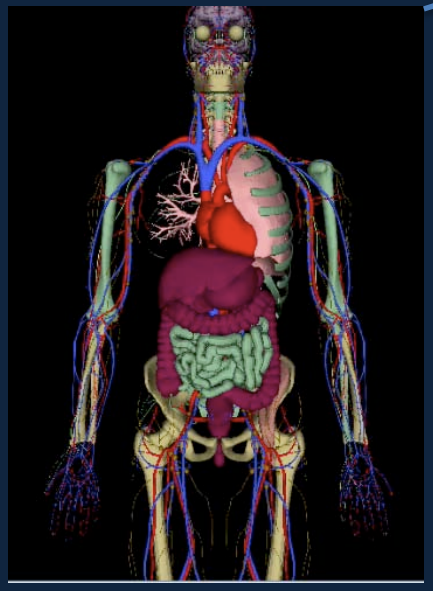


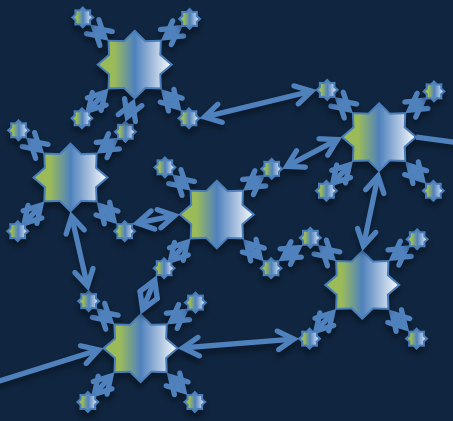


Query Web



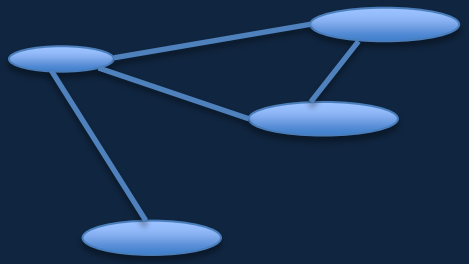
Translational Medicine



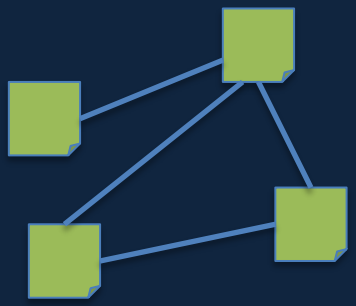


Query Web

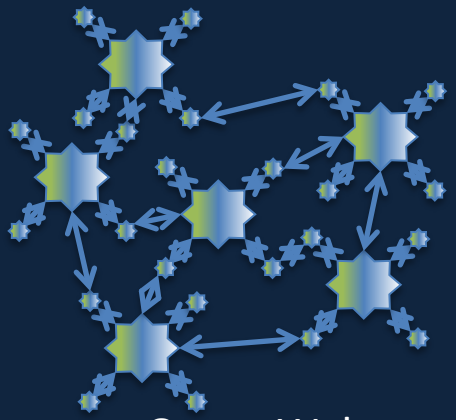
A Network-centric view of information systems



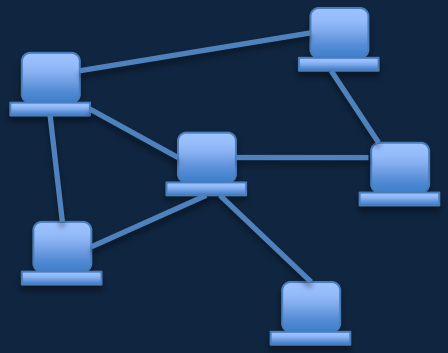
Semantic Web



Web



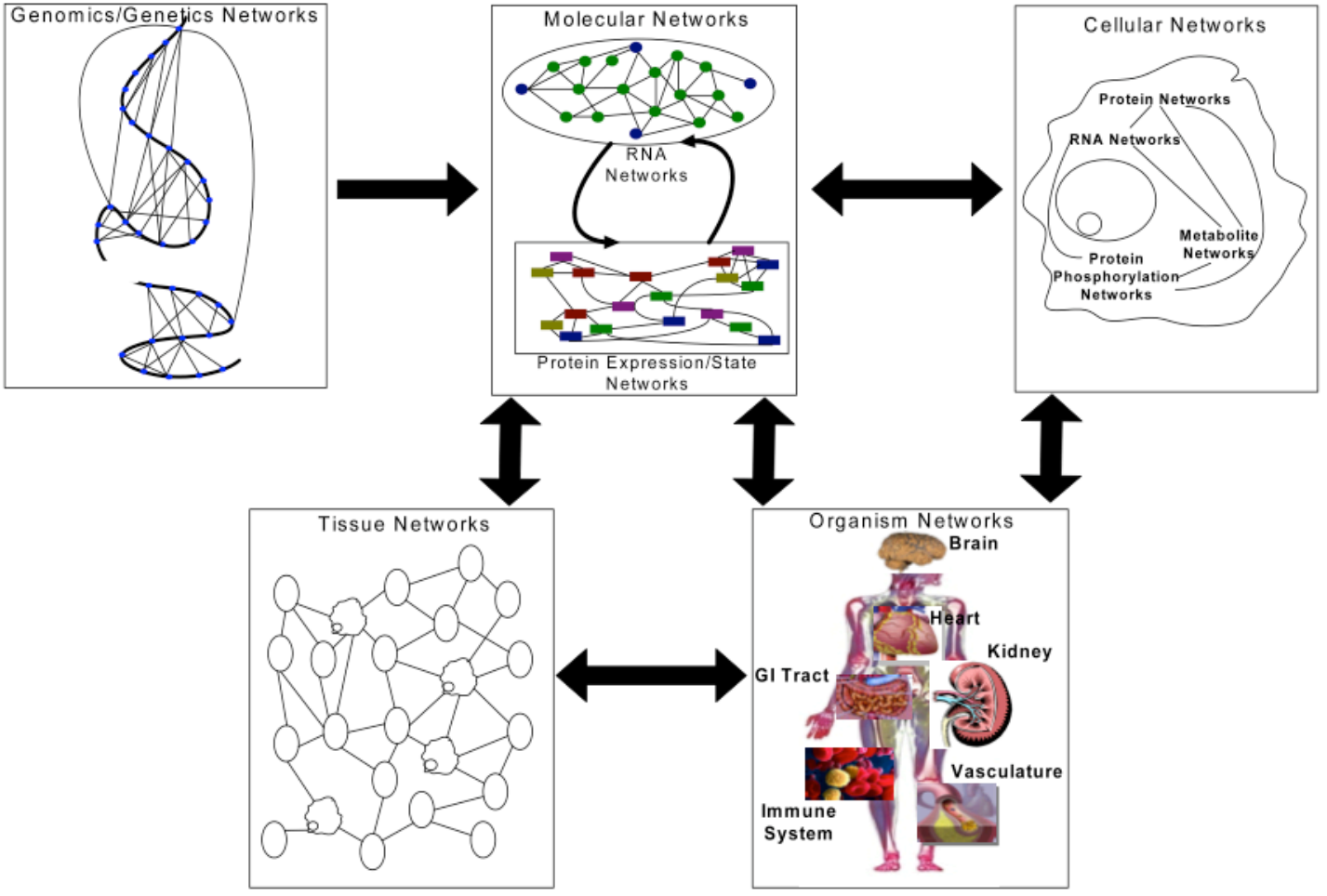
Query Web



Internet

A Network-centered View of Biological Systems

Bin Zhang, PhD



A convergence?

- Biology as an information science
- Information science as biology
- Networks as the link

Credits

- Todd Detwiler
- Onard Mejino
- Joshua Franklin
- Ron Shaker
- Xenia Hertzenberg
- Nolan Nichols
- Marianne Shaw
- Wayne Warren
- Linda Shapiro
- Dan Suciu
- Cornelius Rosse

Funding: NLM, NIMH, NHLBI