Geosemantics : a case study

University Grenoble Alpes

- A major university and scientific center in Europe
  - 6 higher education establishments, 59 000 students, 7 200 foreign students

Laboratoire d'Informatique de Grenoble

- Brings together almost 500 researchers, professors and associate professors, doctoral students, and research support personnel.

- five research areas explored by the 23 teams LIG:
  - Software and Information System Engineering,
  - Formal Methods, Models, and Languages,
  - Interactive and Cognitive Systems,
  - Distributed Systems, Parallel Computing, and Networks,
  - Data and Knowledge Processing at Large Scale.

STeamer Group

- Research Axis: Data and Knowledge Processing (at Large Scale)
  - leads research on Spatial and Temporal Information Systems
  - objective: models, methods and tools for collecting, modelling, querying, reasoning and visualizing spatial and temporal information
- Team composition
  - currently 22 persons:
    - 8 faculty members
    - 5 engineers
    - 8 PhD students
    - 1 post-doctoral student

STeamer Group

- Research Themes
  - STeamer's scientific motivation:
    - representing and reasoning with spatial and temporal information
  - Our research is organized along 3 complementary axes:
    - Spatial and Temporal Semantic Web
    - Mobility and Context-Awareness
    - Spatial and Temporal Analysis and Visualization
  - Two major application domains provide us with concrete problems tackled in the three axes.
    - Territorial Planning
    - Natural Hazards Prevention

Scientific Presentation
Axis: Spatial and Temporal Semantic Web

- Scientific Context
  - The move from the Web of Documents to the Web of Data
    → resources to be shared must be represented in a way comprehensible by humans *and* software agents
  - The Semantic Web = the scientific effort to attach semantics to resources available on the Web

  → categorizing, indexing and linking resources and formally expressing knowledge so that software agents be able to extract, combine and deduce information from published datasets
  - Ontologies (formal and explicit specifications of a shared application domain conceptualization) as a building block of the Semantic Web.

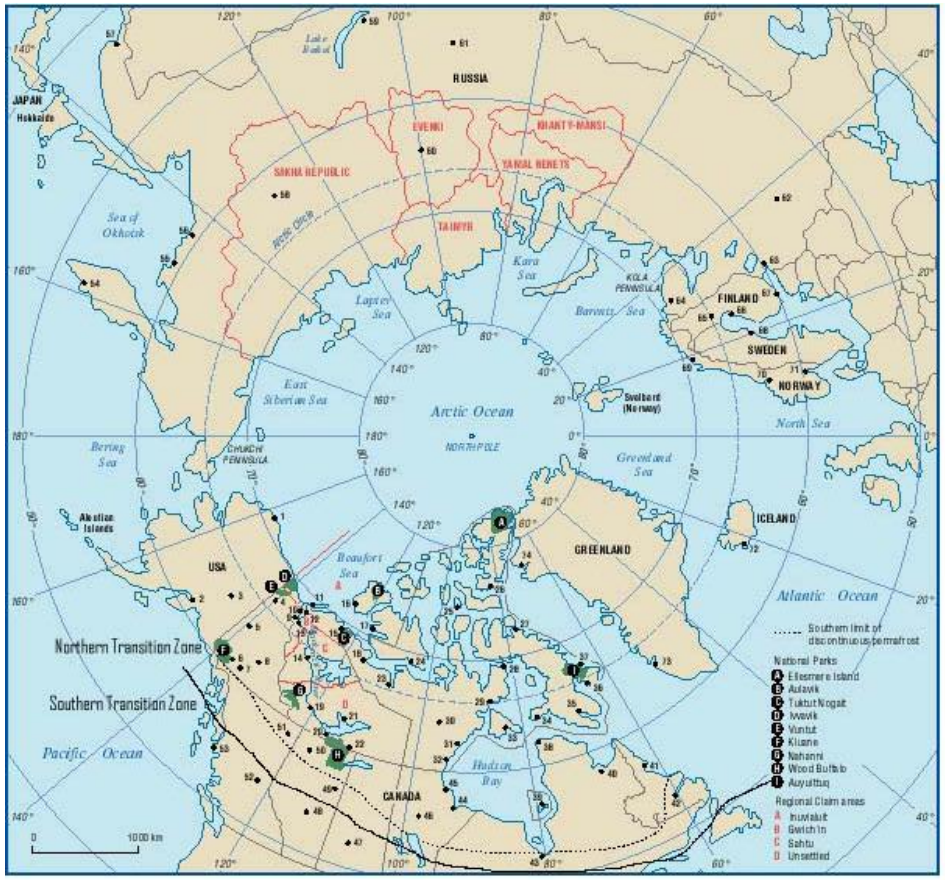
Summary

- Application overview and objectives
- Sample application : MAP-EON
  - Architecture
  - Data and application ontology
  - Domain Ontology
  - Linking to LOD cloud
  - Semantic queries

MAP-EON

Marianne V. Douglas CCI- UofA – Queen's U

Examine the environmental drivers of distribution of lotic (running water) diatoms over a latitudinal gradient of the lower Western Arctic (Alaska, Yukon and the Northwest Territories), with a particular interest in the nuisance species *Didymosphenia geminata*



Canada

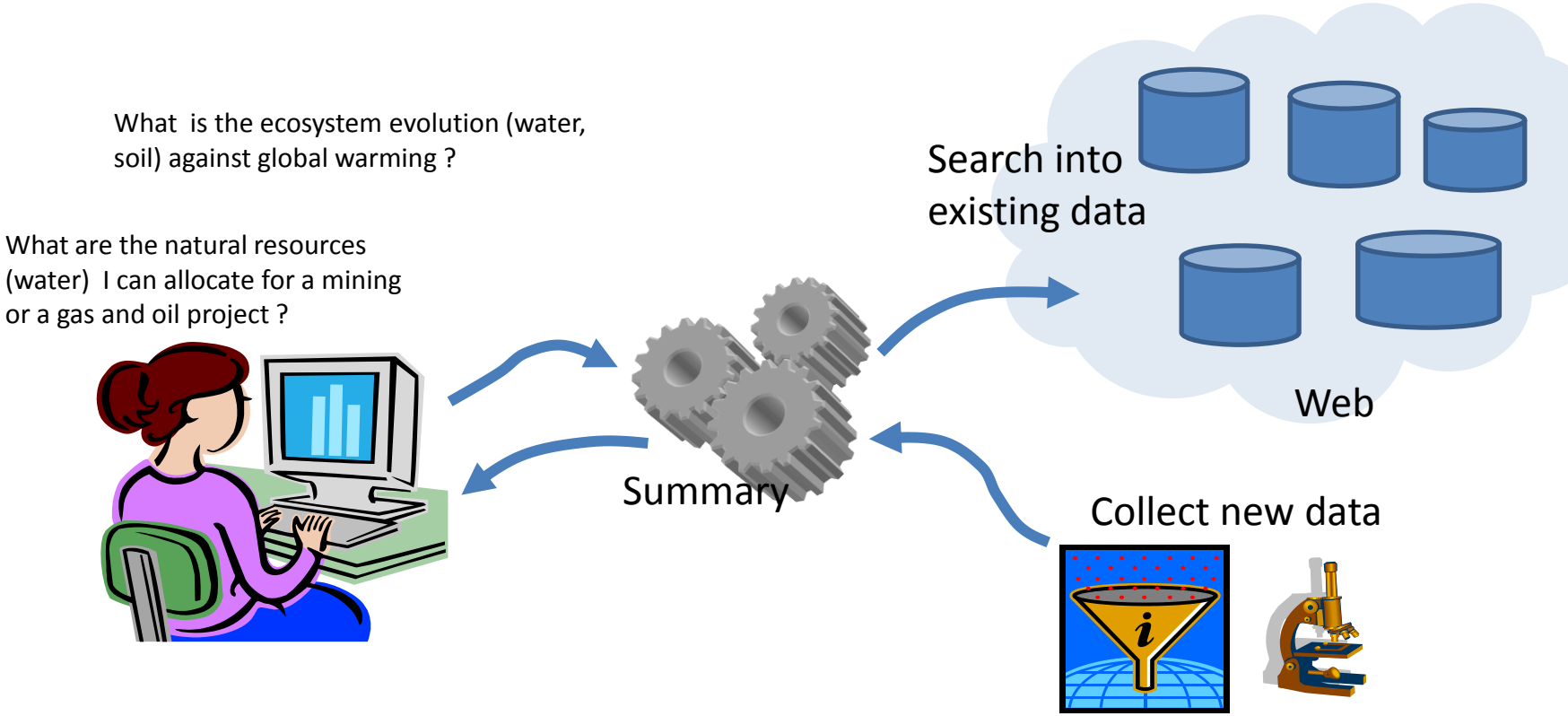
Aklavik, NWT (10)
Arctic Red River, NWT (13)
Arviat, Nunavut (32)
Baker Lake, Nunavut (30)
Bathurst Inlet, Nunavut (23)
Broughton Island, Nunavut (37)
Cambridge Bay, Nunavut (24)
Cape Dorset, Nunavut (34)
Churchill, Manitoba (45)
Coppermine, Nunavut (18)
Coral Harbour, Nunavut (33)
Dawson City, Yukon (5)
Edmonton, Alberta (48)
Faro, Yukon (8)
Fort McMurray, Alberta (49)
Fort McPherson, NWT (9)
Fort Nelson, BC (51)
Fort Simpson, NWT (19)
Fort Smith, NWT (22)
Goose Bay, Labrador (42)
Grise Fiord, Nunavut (29)
Haines Junction, Yukon (6)
Hay River, NWT (20)
High Level, Alberta (50)
Holman, Nunavut (17)
Igloolik, Nunavut (28)
Inuvik, NWT (12)
Iqaluit, Nunavut (35)
Ivujivik, Quebec (38)
Kuujjuaq, Quebec (40)
Moosonee, Ontario (43)
Nain, Labrador (41)
Norman Wells, NWT (14)
Old Crow, Yukon (4)
Pangnirtung, Nunavut (36)
Paulatuk, NWT (15)
Pond Inlet, Nunavut (27)
Port Nelson, Manitoba (44)
Prince George, BC (52)
Prince Rupert, BC (53)
Rankin Inlet, Nunavut (31)
Repulse Bay, Nunavut (29)
Resolute, Nunavut (25)
Sachs Harbour, NWT (16)
Sanikiluaq, Nunavut (39)
Saskatoon, Saskatchewan (47)
Thompson, Manitoba (46)
Tuktoyaktuk, NWT (11)
Whitehorse, Yukon (7)
Yellowknife, NWT (21)

Circumpolar

Anchorage, Alaska (2)
Barrow, Alaska (1)
Fairbanks, Alaska (3)
Helsinki, Finland (67)
Irkutsk, Russia (59)
Krasnoyarsk, Russia (61)
Magadan, Russia (56)
Moscow, Russia (62)
Murmansk, Russia (64)
Nuuk, Greenland (73)
Okhotsk, Russia (58)
Oslo, Norway (71)
Oulu, Finland (66)
Petropavlovsk, Russia (54)
Reykjavik, Iceland (72)
Rovaniemi, Finland (65)
St. Petersburg, Russia (63)
Thule, Greenland (74)
Tromso, Norway (69)
Trondheim, Norway (70)
Tura, Russia (60)
Umeå, Sweden (68)
Vladivostok, Russia (57)
Yakutsk, Russia (58)

- Freshwater biodiversity
- Freshwater chemistry
- Invasive species

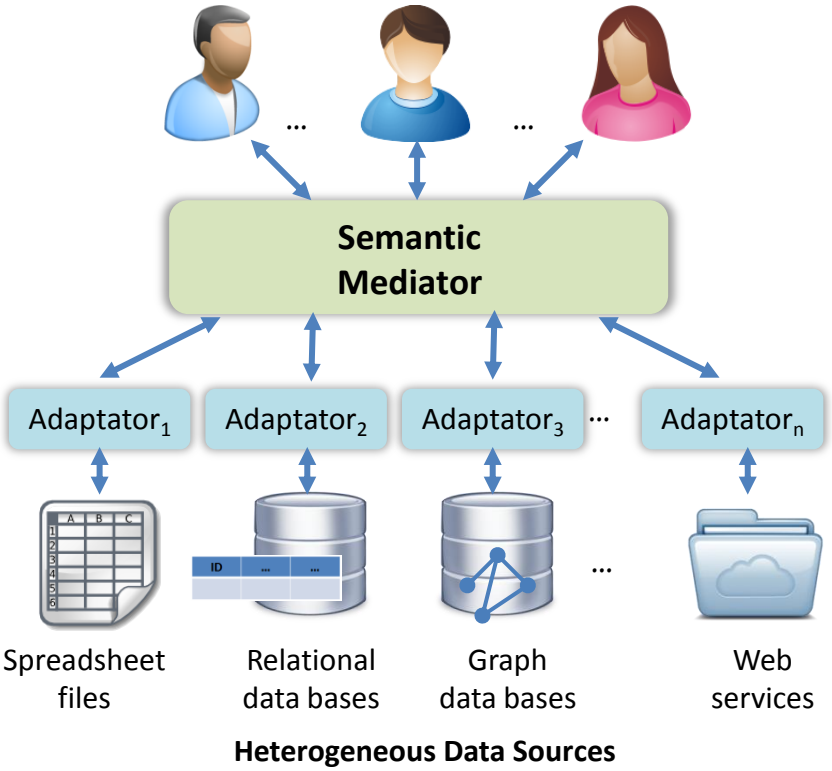
Common characteristics



- Heterogeneous Spatial and temporal data
  - Multi-sites with multi-actors
  - Multi-models
  - Multi-formats

Objectives

- data integration through knowledge representation



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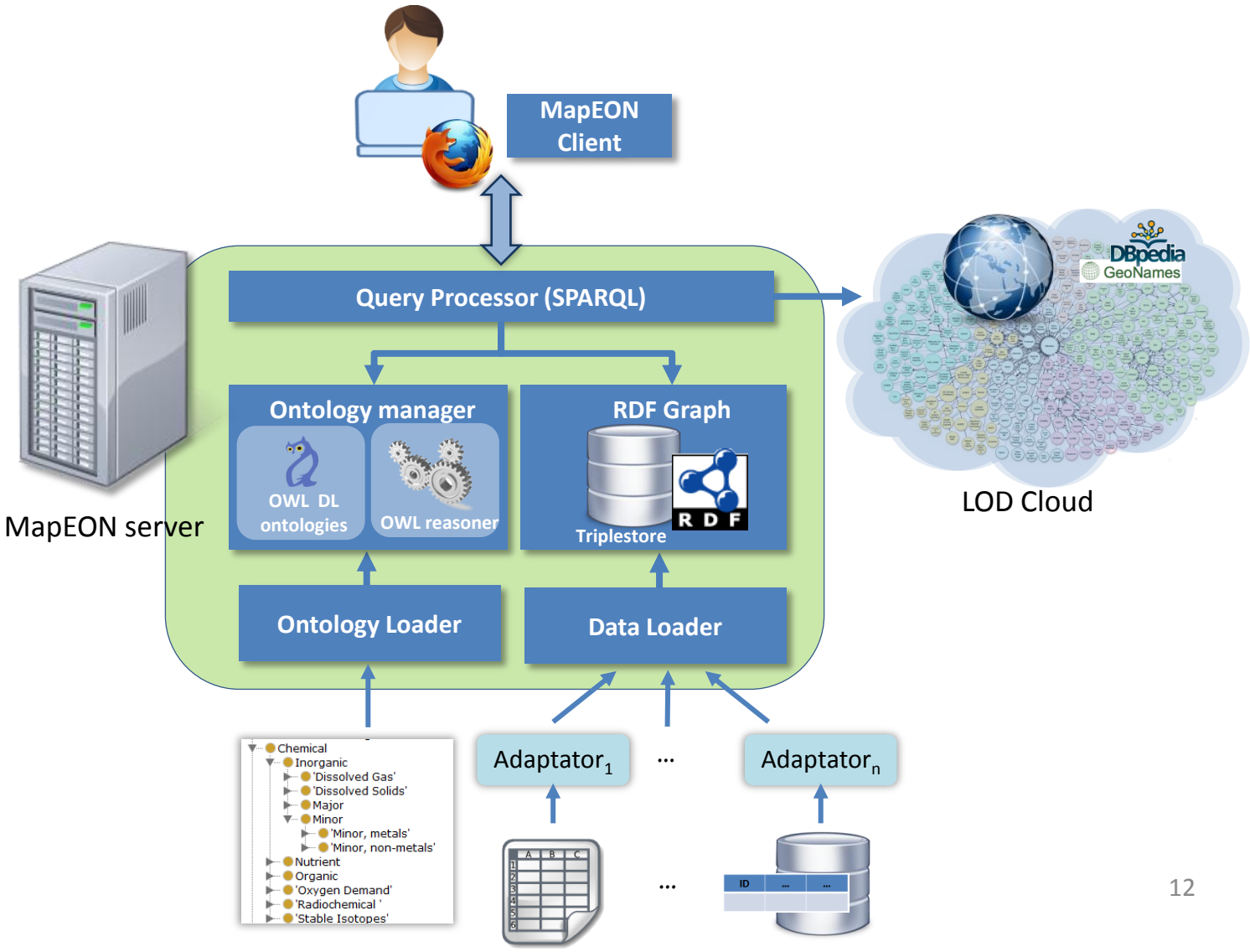
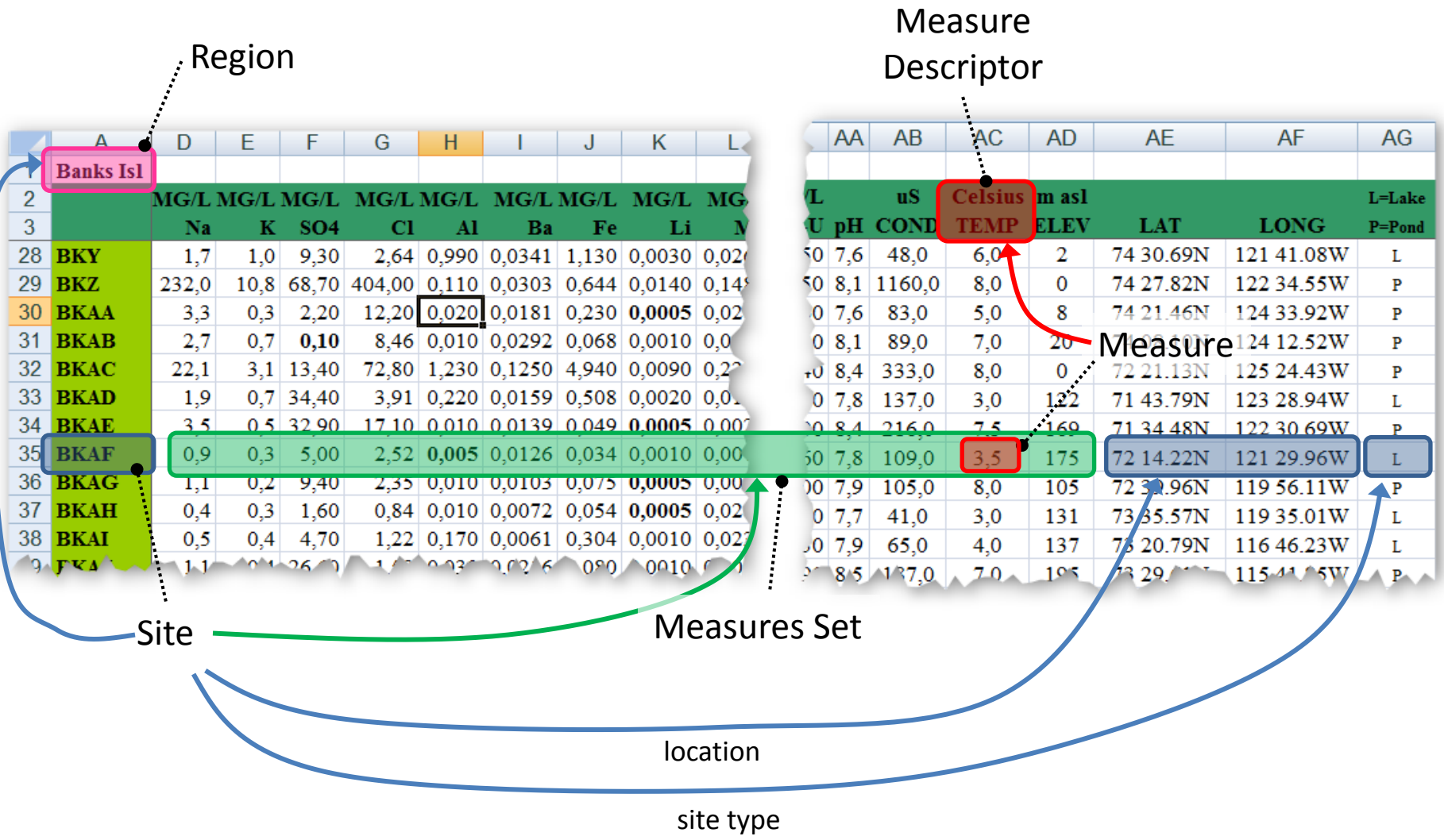
Architecture



Raw Data

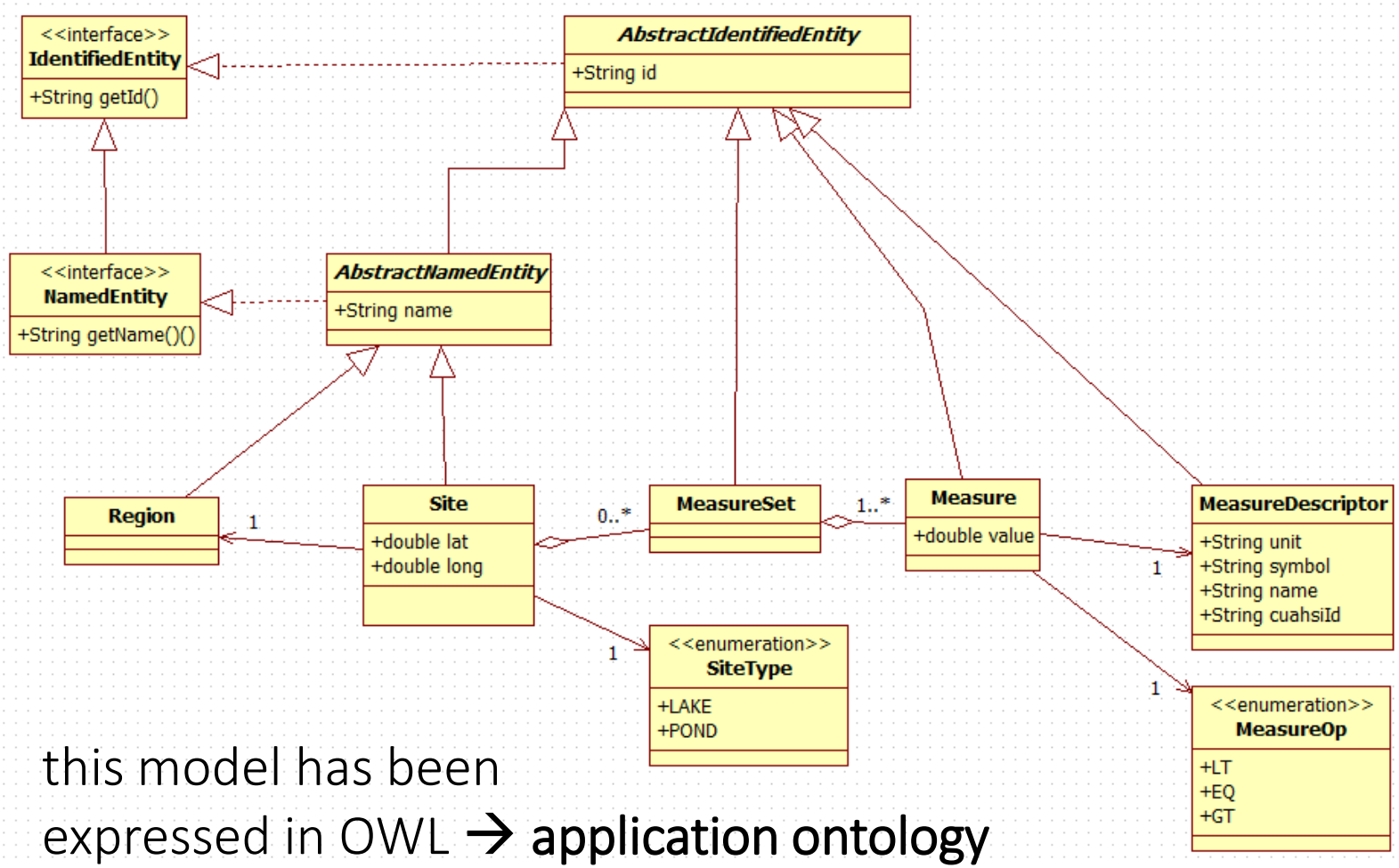
- tabular data (excel file)



	A	D	E	F	G	H	I	J	K	L	AA	AB	AC	AD	AE	AF	AG
1	Banks Isl																
2		MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG/L	MG	/L	uS	Celsius	m asl			L=Lake
3		Na	K	SO4	Cl	Al	Ba	Fe	Li	M	U pH	COND	TEMP	ELEV	LAT	LONG	P=Pond
28	BKY	1,7	1,0	9,30	2,64	0,990	0,0341	1,130	0,0030	0,02	50 7,6	48,0	6,0	2	74 30.69N	121 41.08W	L
29	BKZ	232,0	10,8	68,70	404,00	0,110	0,0303	0,644	0,0140	0,14	50 8,1	1160,0	8,0	0	74 27.82N	122 34.55W	P
30	BKAA	3,3	0,3	2,20	12,20	0,020	0,0181	0,230	**0,0005**	0,02	0 7,6	83,0	5,0	8	74 21.46N	124 33.92W	P
31	BKAB	2,7	0,7	**0,10**	8,46	0,010	0,0292	0,068	0,0010	0,0	0 8,1	89,0	7,0	20	[illegible]	124 12.52W	P
32	BKAC	22,1	3,1	13,40	72,80	1,230	0,1250	4,940	0,0090	0,2	0 8,4	333,0	8,0	0	72 21.13N	125 24.43W	P
33	BKAD	1,9	0,7	34,40	3,91	0,220	0,0159	0,508	0,0020	0,0	0 7,8	137,0	3,0	122	71 43.79N	123 28.94W	L
34	BKAE	3,5	0,5	32,90	17,10	0,010	0,0139	0,049	**0,0005**	0,00	0 8,4	216,0	7,5	169	71 34.48N	122 30.69W	P
35	BKAF	0,9	0,3	5,00	2,52	**0,005**	0,0126	0,034	0,0010	0,00	50 7,8	109,0	3,5	175	72 14.22N	121 29.96W	L
36	BKAG	1,1	0,2	9,40	2,35	0,010	0,0103	0,075	**0,0005**	0,00	00 7,9	105,0	8,0	105	72 30.96N	119 56.11W	P
37	BKAH	0,4	0,3	1,60	0,84	0,010	0,0072	0,054	**0,0005**	0,02	0 7,7	41,0	3,0	131	73 35.57N	119 35.01W	L
38	BKAI	0,5	0,4	4,70	1,22	0,170	0,0061	0,304	0,0010	0,02	50 7,9	65,0	4,0	137	73 20.79N	116 46.23W	L
39	BKA	1,1	0,1	26,0	1,[illegible]	0,03[illegible]	0,02[illegible]6	080	0010	0,0	8,5	187,0	7,0	195	73 29.[illegible]	115 41.[illegible]5W	P

Data model : Application Ontology

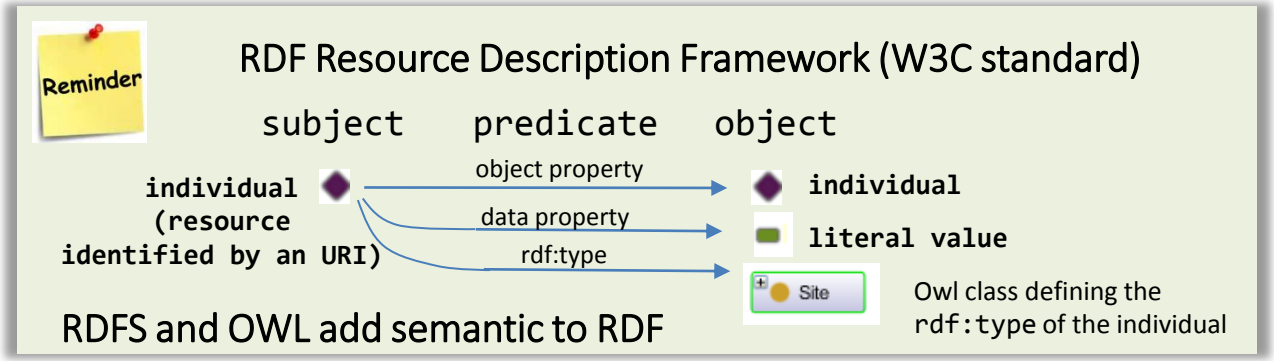
- few classes and relations to model concepts involved in the application



- this model has been expressed in OWL → **application ontology**

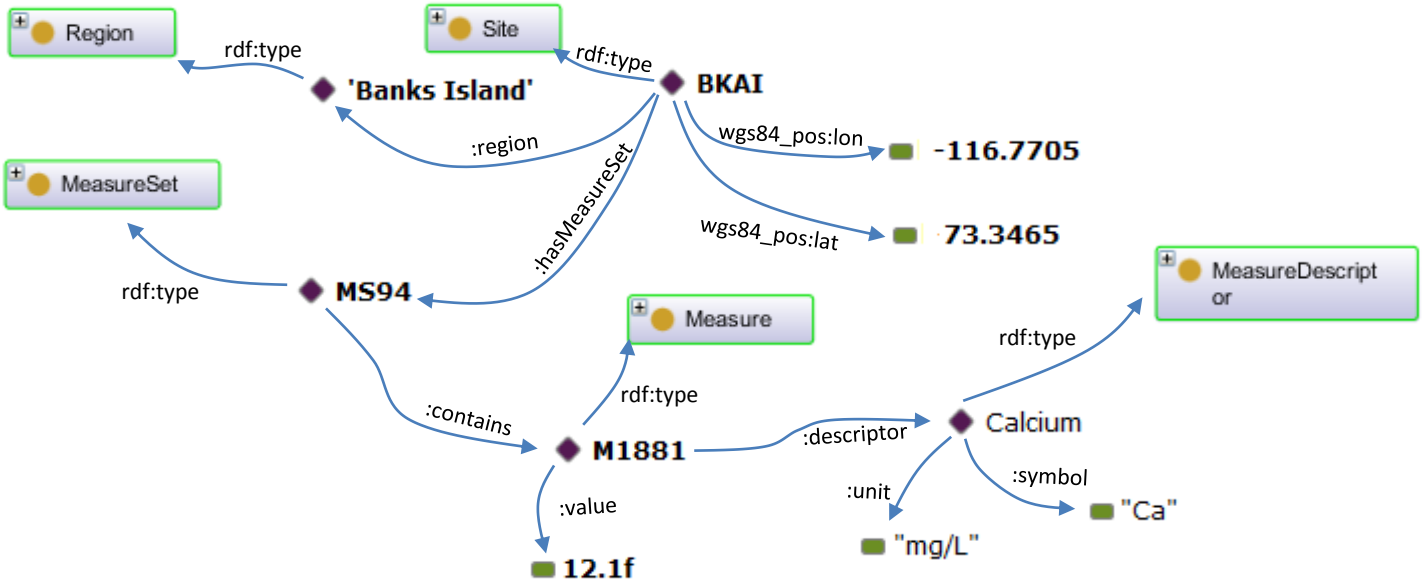
RDF graph

- the data is transformed in a RDF graph using the vocabulary defined by the application ontology.



Banks Isl								
	MG/L Na	MG/L K	MG/L SO4	MG/L Cl	MG/L Al	MG/L Ba	MG/L Fe	MG/
BKAI	0,5	0,4	4,70	12,10	0,170	0,0061	0,304	0,001

	uS	Celsius	m asl				L=Lake
pH	COND	TEMP	ELEV	LAT	LONG		P=Pond
7,9	65,0	4,0	137	73 20.79N	116 46.23W		L



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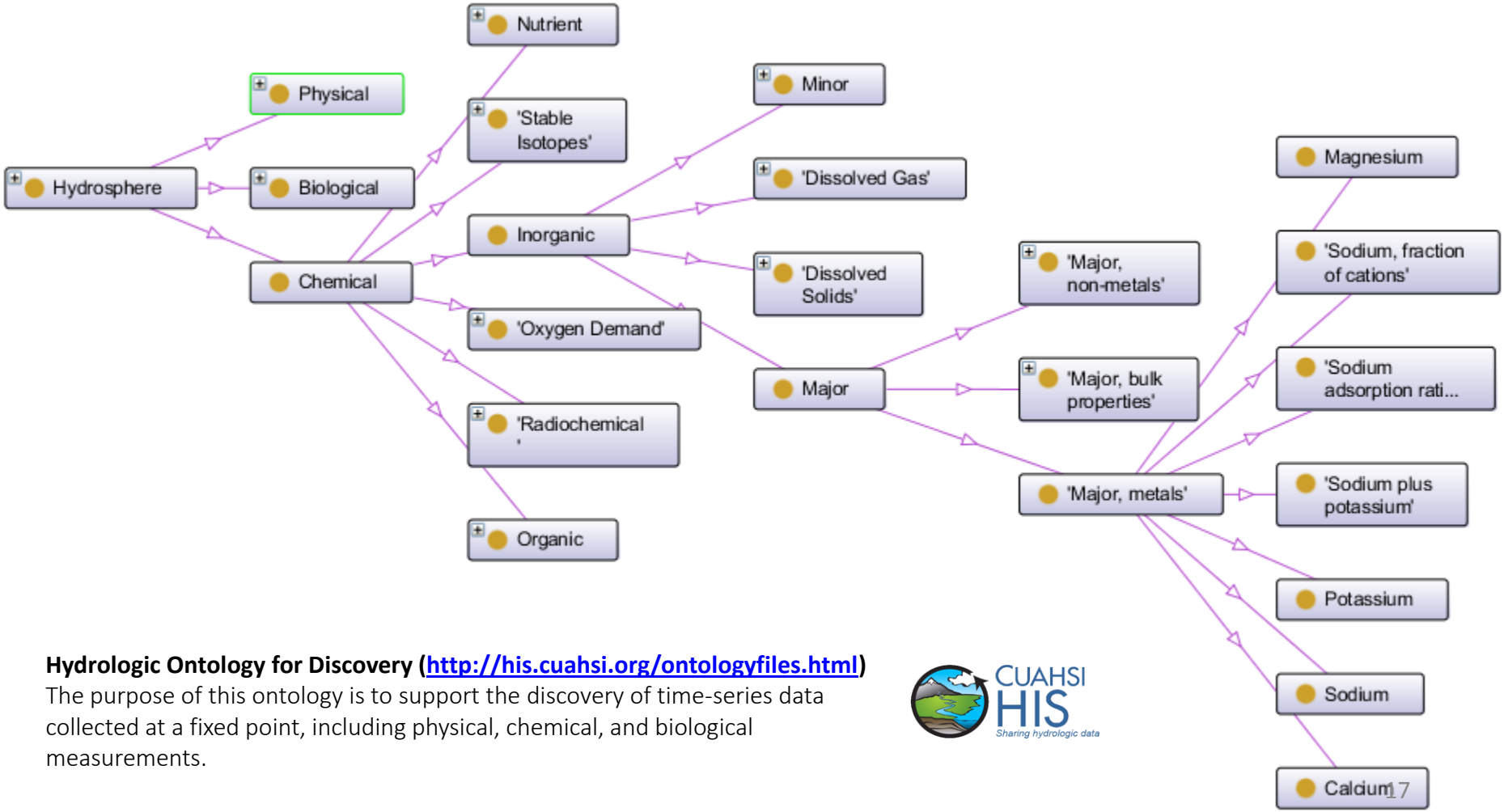
  - Data and application ontology
  - **Domain Ontology**
  - Linking to LOD cloud
  - Semantic queries

Domain ontology

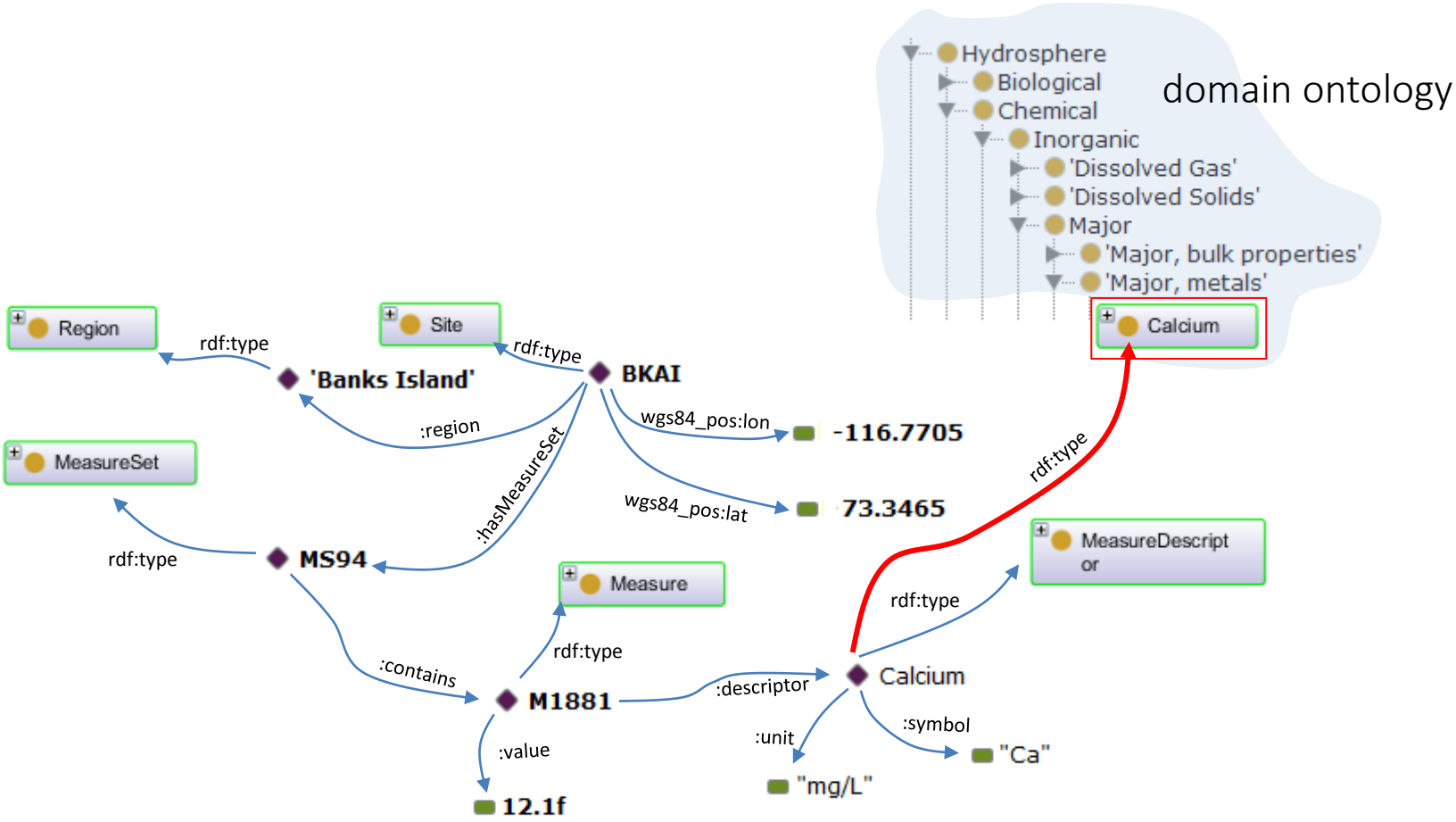
- the graph can be enriched by exploiting some domain ontology



Hydrologic Ontology for Discovery (http://his.cuahsi.org/ontologyfiles.html)
The purpose of this ontology is to support the discovery of time-series data collected at a fixed point, including physical, chemical, and biological measurements.

Application ontology + Domain ontology

- the graph can be enriched by exploiting some domain ontology



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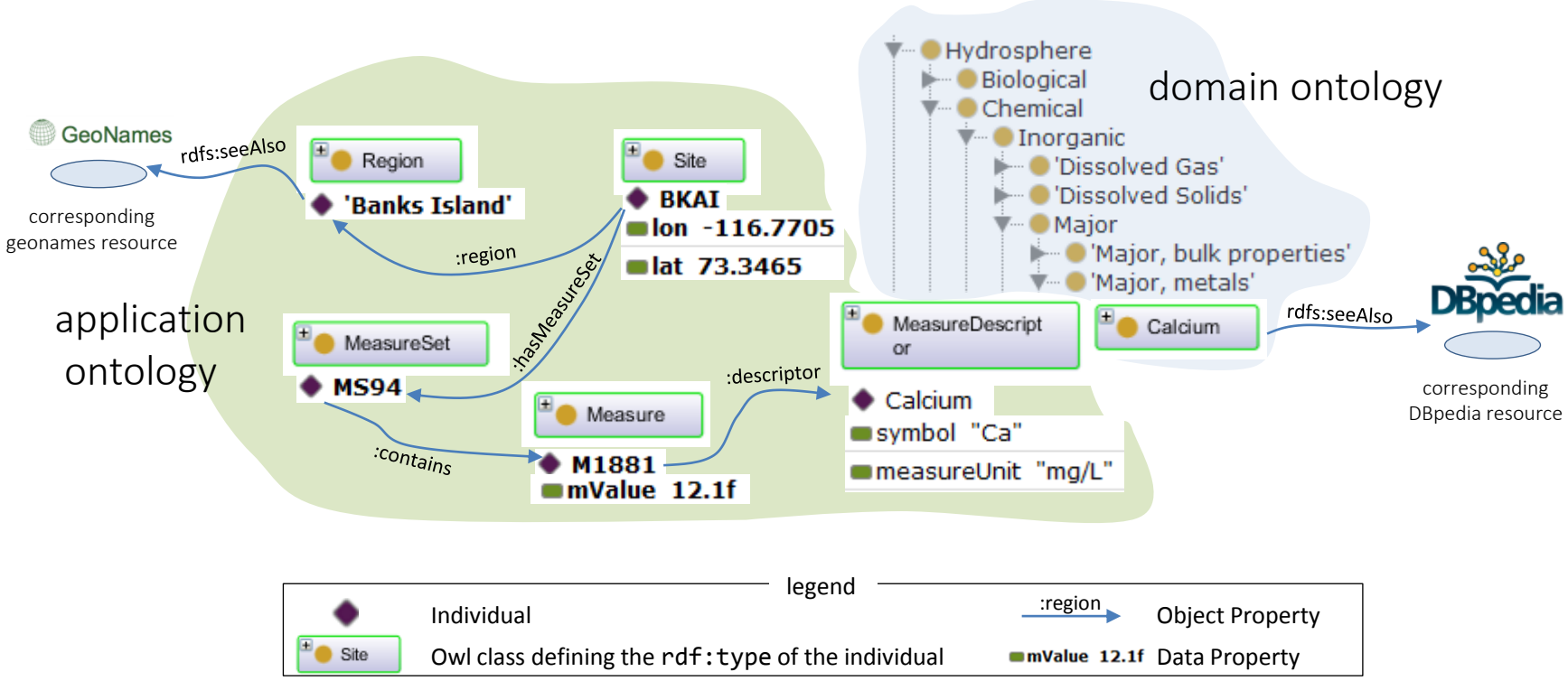
Linking to LOD cloud

- few classes and relations to model concepts involved in the application
- link with domain ontology
- links to Linked Open Datasets



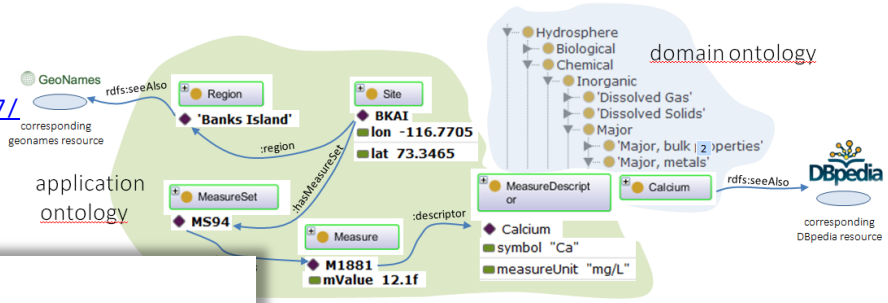
Linking to LOD cloud

- links to geonames rdf descriptions

resource URI

http://sws.geonames.org/5892587/

RDF description




```
<rdf:RDF>
 − <gn:Feature rdf:about="http://sws.geonames.org/5892587/">
     <rdfs:isDefinedBy rdf:resource="http://sws.geonames.org/5892587/about.rdf"/>
     <gn:name>Banks Island</gn:name>
     <gn:featureClass rdf:resource="http://www.geonames.org/ontology#T"/>
     <gn:featureCode rdf:resource="http://www.geonames.org/ontology#T.ISL"/>
     <gn:countryCode>CA</gn:countryCode>
     <wgs84_pos:lat>72.75096</wgs84_pos:lat>
     <wgs84_pos:long>-121.50569</wgs84_pos:long>
     <gn:parentFeature rdf:resource="http://sws.geonames.org/6091069/"/>
     <gn:parentCountry rdf:resource="http://sws.geonames.org/6251999/"/>
     <gn:parentADM1 rdf:resource="http://sws.geonames.org/6091069/"/>
     <gn:nearbyFeatures rdf:resource="http://sws.geonames.org/5892587/nearby.rdf"/>
     <gn:locationMap rdf:resource="http://www.geonames.org/5892587/banks-island.html"/>
     <gn:wikipediaArticle rdf:resource="http://en.wikipedia.org/wiki/Banks_Island"/>
     <rdfs:seeAlso rdf:resource="http://dbpedia.org/resource/Banks_Island"/>
   </gn:Feature>
 − <foaf:Document rdf:about="http://sws.geonames.org/5892587/about.rdf">
     <foaf:primaryTopic rdf:resource="http://sws.geonames.org/5892587/"/>
     <cc:license rdf:resource="http://creativecommons.org/licenses/by/3.0/"/>
     <cc:attributionURL rdf:resource="http://sws.geonames.org/5892587/"/>
     <cc:attributionName rdf:datatype="http://www.w3.org/2001/XMLSchema#string">GeoNames</cc:attributionName>
     <dcterms:created rdf:datatype="http://www.w3.org/2001/XMLSchema#date">2006-01-18</dcterms:created>
     <dcterms:modified rdf:datatype="http://www.w3.org/2001/XMLSchema#date">2014-04-03</dcterms:modified>
   </foaf:Document>
</rdf:RDF>
```

geonames resource describing Northwest Territories

```
<rdf:RDF>
 − <gn:Feature rdf:about="http://sws.geonames.org/6091069/">
     <rdfs:isDefinedBy rdf:resource="http://sws.geonames.org/6091069/about.rdf"/>
     <gn:name>Northwest Territories</gn:name>
     <gn:officialName xml:lang="en">Northwest Territories</gn:officialName>
     <gn:officialName>Northwest Territories</gn:officialName>
     <gn:officialName xml:lang="fr">Territoires du Nord-Ouest</gn:officialName>
     <gn:featureClass rdf:resource="http://www.geonames.org/ontology#A"/>
     <gn:featureCode rdf:resource="http://www.geonames.org/ontology#A.ADM1"/>
     <gn:countryCode>CA</gn:countryCode>
     <gn:population>31247</gn:population>
     <wgs84_pos:lat>69.50061</wgs84_pos:lat>
     <wgs84_pos:long>-121.50445</wgs84_pos:long>
     <gn:parentFeature rdf:resource="http://sws.geonames.org/6251999/"/>
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     <gn:wikipediaArticle rdf:resource="http://en.wikipedia.org/wiki/Northwest_Territories"/>
     <rdfs:seeAlso rdf:resource="http://dbpedia.org/resource/Northwest_Territories"/>
   </gn:Feature>
 − <foaf:Document rdf:about="http://sws.geonames.org/6091069/about.rdf">
     <foaf:primaryTopic rdf:resource="http://sws.geonames.org/6091069/"/>
     <cc:license rdf:resource="http://creativecommons.org/licenses/by/3.0/"/>
     <cc:attributionURL rdf:resource="http://sws.geonames.org/6091069/"/>
     <cc:attributionName rdf:datatype="http://www.w3.org/2001/XMLSchema#string">GeoNames</cc:
     <dcterms:created rdf:datatype="http://www.w3.org/2001/XMLSchema#date">2006-01-18</dcterm
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   </foaf:Document>
</rdf:RDF>
```

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- Application overview and objectives
- Sample application : MAP-EON
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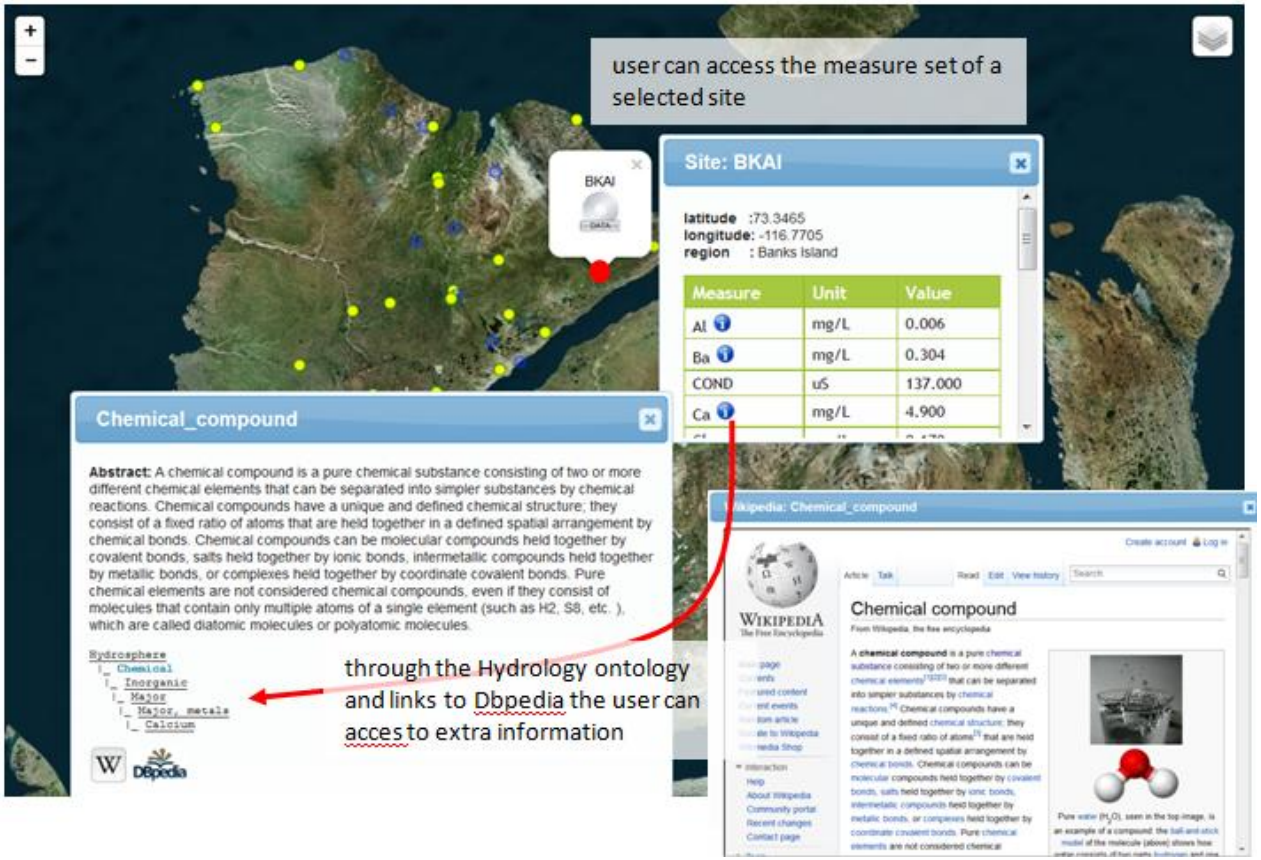
  - Data and application ontology
  - Domain Ontology
  - Linking to LOD cloud
  - **Semantic queries**

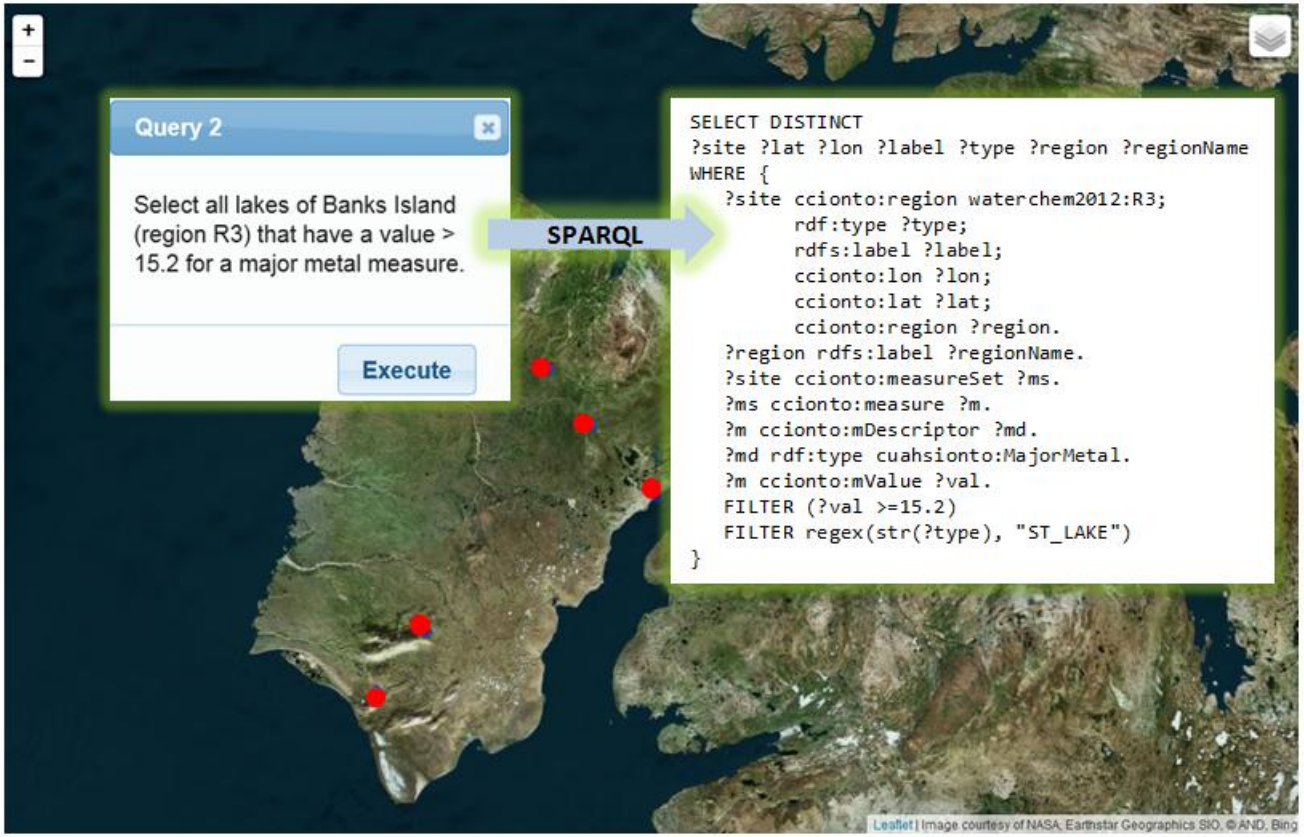
Semantic queries

- access to information inferred from the domain ontology
- access to extra information through linked data



Semantic query

- querying data with inferred knowledge (SPARQL)

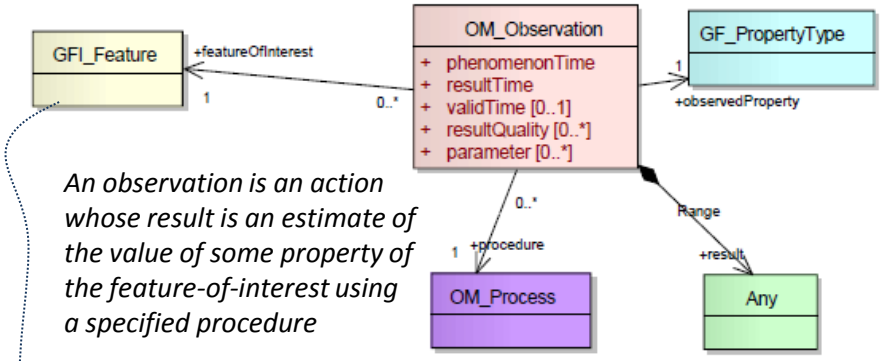


Semantic queries

Application ontology

+ Domain ontology

+ Observations ontology with meta-data information



other specifications:

- ISO 19109 : Feature
- ISO 19107 : Geometry
- ISO 19108 : Temporal
- ISO 19115 : Metadata
- ISO 19103 :Basic datatypes

….

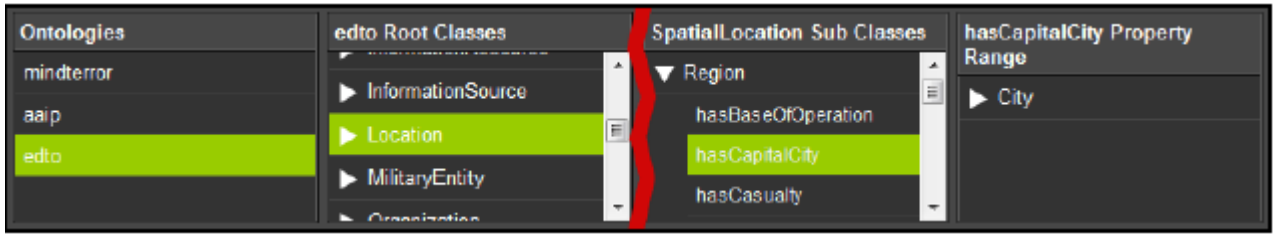
Semantic geospatial query (GeoSPARQL)

- find all the pairs of sites in Northwest Territories that are that are at a distance of less than 15 km

```
SELECT  DISTINCT ?s1 ?s2
WHERE {
        ?s1 rdf:type ccionto:Site;
            rdf:type ccionto:Region ?r;
             geo:hasGeometry ?g1.
        ?s2 rdf:type ccionto:Site;
            rdf:type ccionto:Region ?r;
             geo:hasGeometry ?g1.
       ?r rdfs:seeAlso ?geoNameregion;
       ?geoNameRegion gn:parentADM1 <http://sws.geonames.org/6091069>
        ?g1 geo:asWKT ?s1Geom.
        ?g2 geo:asWKT ?s2Geom.
         FILTER(geof:distance(?s1Geom,?s2Geom,uom:metre) < 15000)
}
```

Semantic query interface

- Query formulation is a key aspect of these projects
  - Define key patterns from queries
  - Graphical tool for semantic query construction



  - Spatial operators (GeoSPARQL)
  - Temporal operators

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  - Semantic queries
- Back to COIN

Semantics queries

Summary

- Application overview and objectives
- Related work
- Sample application : MAP-EON
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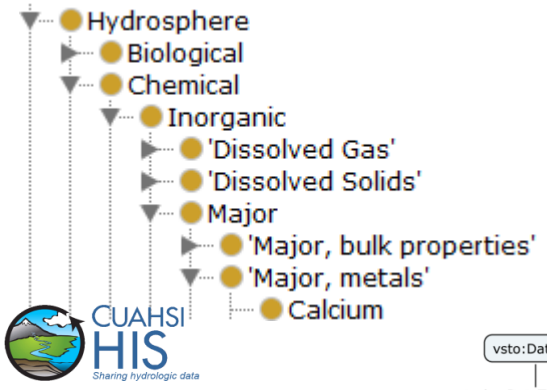
  - Domain Ontology
  - Linking to LOD cloud
  - Semantic queries
- Future work

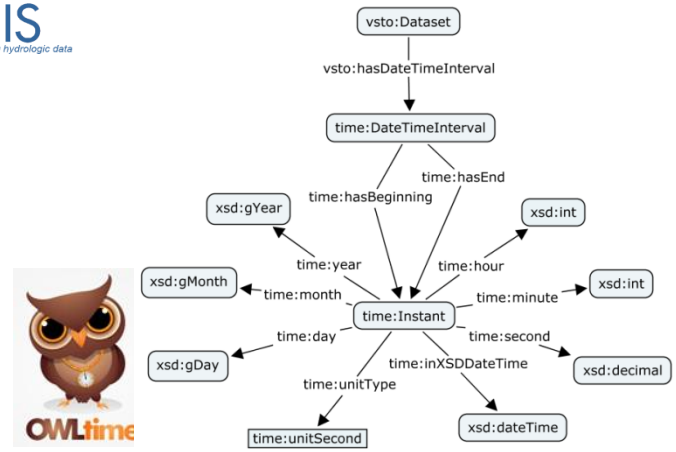
Future work

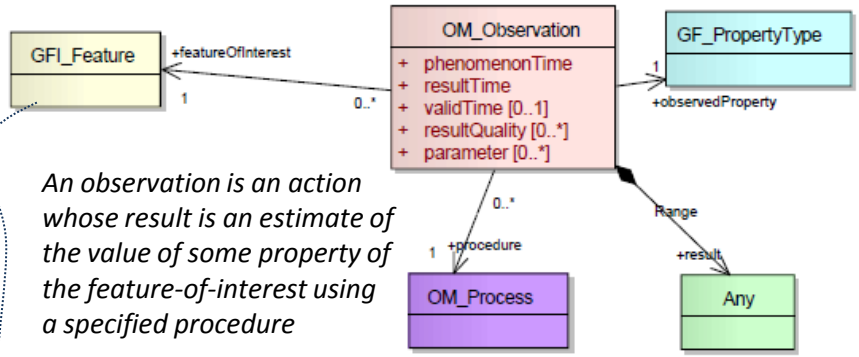
- Better modularization and reuse of ontologies:

Application specific ontology
+ Domain ontology

Application ontology
+ Domain ontology
+ Observations ontology with meta-data information
+ Spatial and Temporal ontology







An observation is an action whose result is an estimate of the value of some property of the feature-of-interest using a specified procedure

ISO 19156 : Observations and Measurement

other specifications:

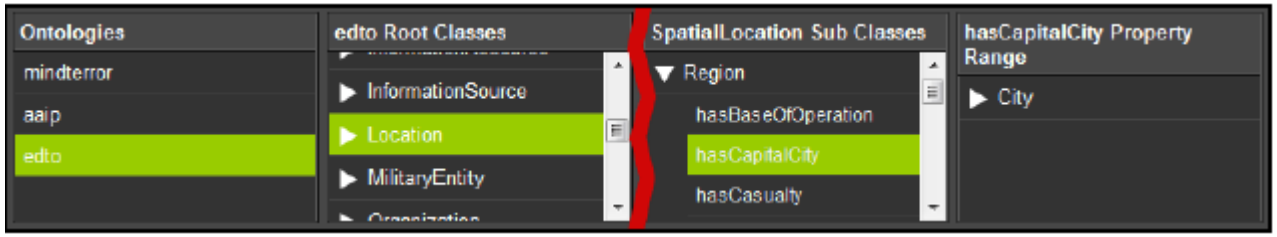
- ISO 19109 : Feature
- ISO 19107 : Geometry
- ISO 19108 : Temporal
- ISO 19115 : Metadata
- ISO 19103 :Basic datatypes

....

CSIRO

Future work

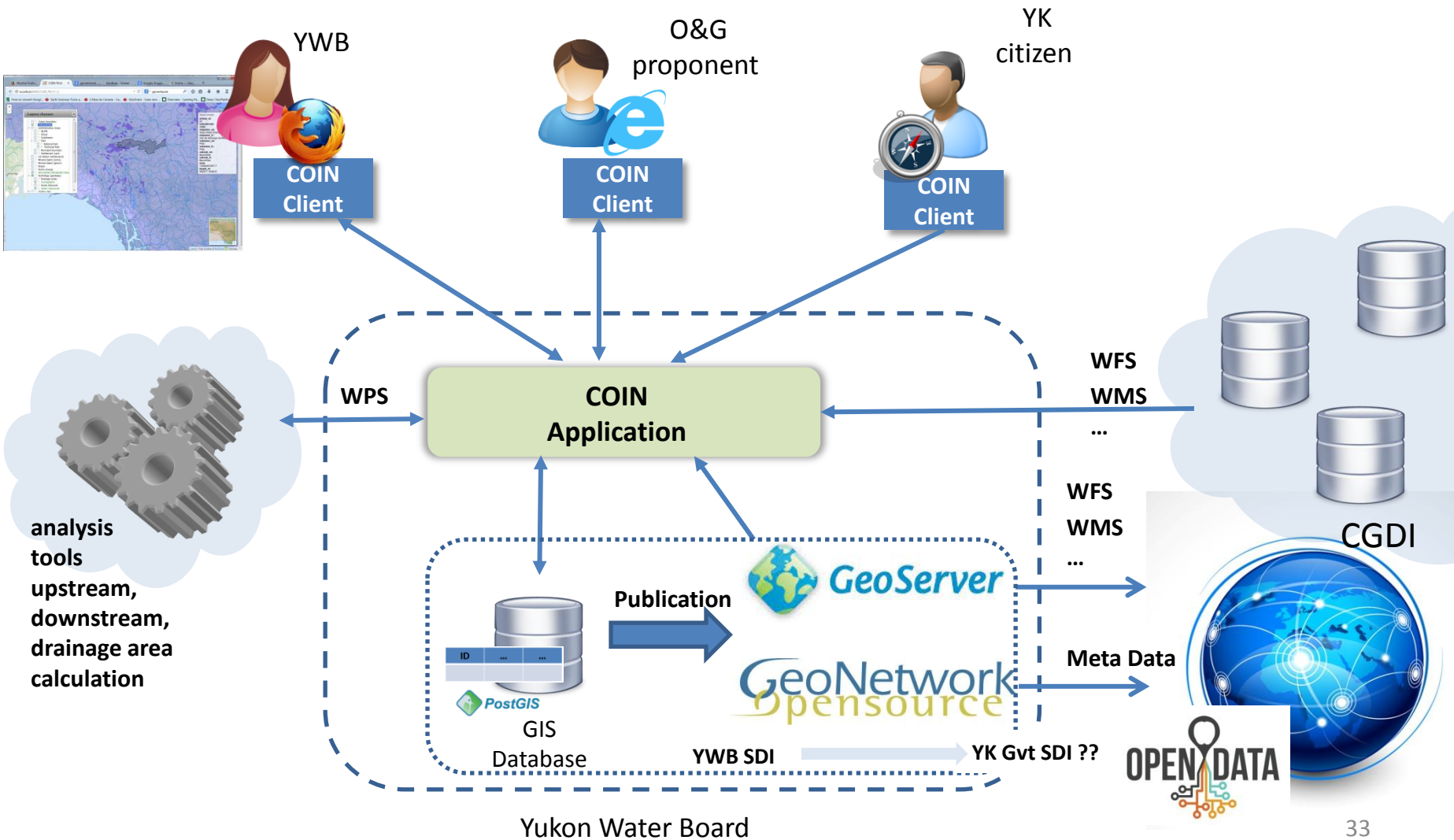
- Query formulation is a key aspect of these projects
  - Define key patterns from queries
  - Graphical tool for semantic query construction



  - Spatial operators (GeoSPARQL)
  - Temporal operators

COIN : Coordinated Online Information Network

natural resource (water) licensing and allocation procedures for O&G



Yukon Water Board

Architecture