turning knowledge into practice

Interoperable Sensor Networks

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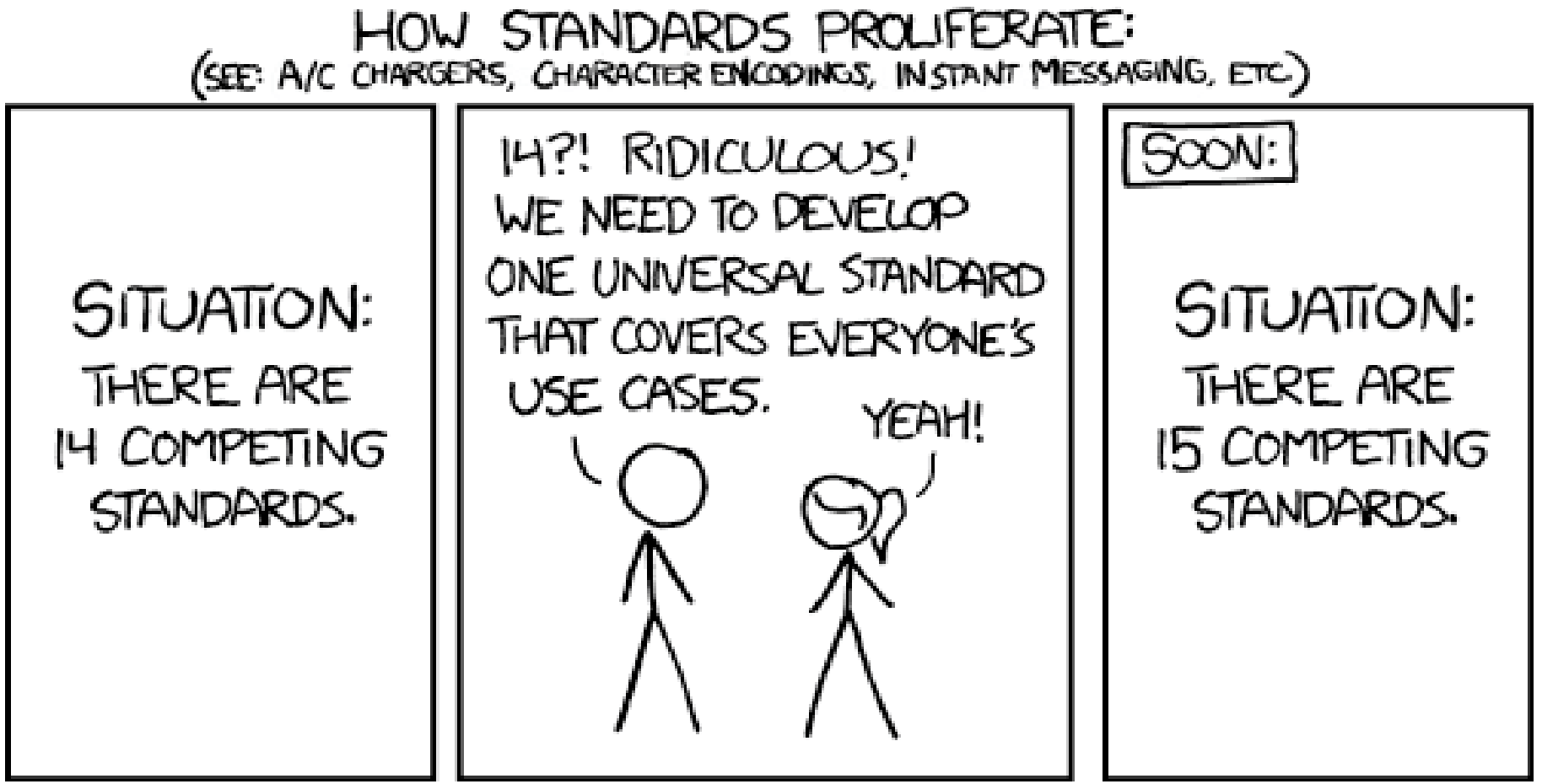
Goals

- Make all sensor data (both quantity and quality) available in common formats using international standards

- Identify and test data standards and approaches that would allow sensors and sensor data management software to directly publish data to the new data sharing network

Standards



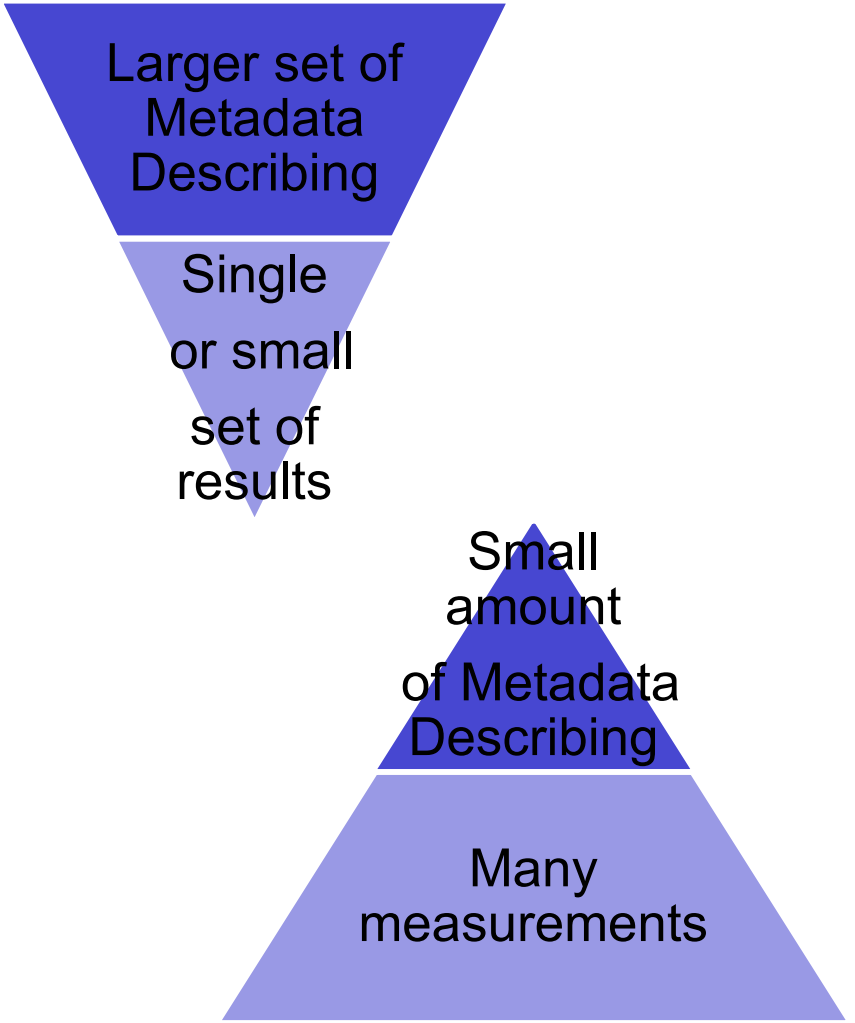
http://xkcd.com

Open Geospatial Consortium (OGC)

- Geography Markup Language (GML)
- Observations and Measurements
- SensorML
- Sensor Observation Service (SOS)
- WaterML
- Web Map Service (WMS)
- Network Common Data Form (NetCDF)

Sampling Versus Monitoring

- EPA's data systems are well-structured to work with discrete (grab sample) data:
  - Each observation is associated with organization, project, location, method, etc.
- Continuous data may have many observations associated with a single metadata record.



WaterML

http://waterservices.usgs.gov/nwis/iv/?sites=08313000&period=P7D&format=waterml,2.0


```
<om:phenomenonTime>
 <gml:TimePeriod gml:id="sample_time.USGS.08313000.00060.9.00000">
  <gml:beginPosition>2016-04-21T12:30:00-06:00</gml:beginPosition>
  <gml:endPosition>2016-04-28T12:00:00-06:00</gml:endPosition>
 </gml:TimePeriod>
</om:phenomenonTime>

<om:procedure>
 <wml2:ObservationProcess gml:id="process.USGS.08313000.00060.9.00000">
  <wml2:processType xlink:href="http://www.opengis.net/def/waterml/2.0/processType/Sensor" xlink:title="Sensor" />
  <wml2:parameter xlink:title="Statistic" xlink:href="http://waterdata.usgs.gov/nwisweb/rdf?statCd=00000"></wml2:parameter>
 </wml2:ObservationProcess>
</om:procedure>
<om:observedProperty xlink:title="Discharge" xlink:href="http://waterdata.usgs.gov/nwisweb/rdf?parmCd=00060" />
<om:featureOfInterest xlink:title="RIO GRANDE AT OTOWI BRIDGE, NM">
 <wml2:MonitoringPoint gml:id="USGS.MP.USGS.08313000.00060.9.00000">
 <gml:descriptionReference xlink:href="http://waterservices.usgs.gov/nwis/site/?sites=08313000&amp;agencyCd=USGS&amp;format=rdb"/>
  <sams:shape>
   <gml:Point gml:id="USGS.P.USGS.08313000.00060.9.00000">
    <gml:pos srsName="urn:ogc:def:crs:EPSG:4326">35.8745 -106.1424444</gml:pos>
   </gml:Point>
  </sams:shape>
 </wml2:MonitoringPoint>
</om:featureOfInterest>
```

WaterML

```
<gml:Point gml:id="USGS.P.USGS.08313000">
   <gml:pos srsName="urn:ogc:def:crs:EPSG:4326">
      35.8745 -106.1424444
   </gml:pos>
</gml:Point>
```

WaterML result

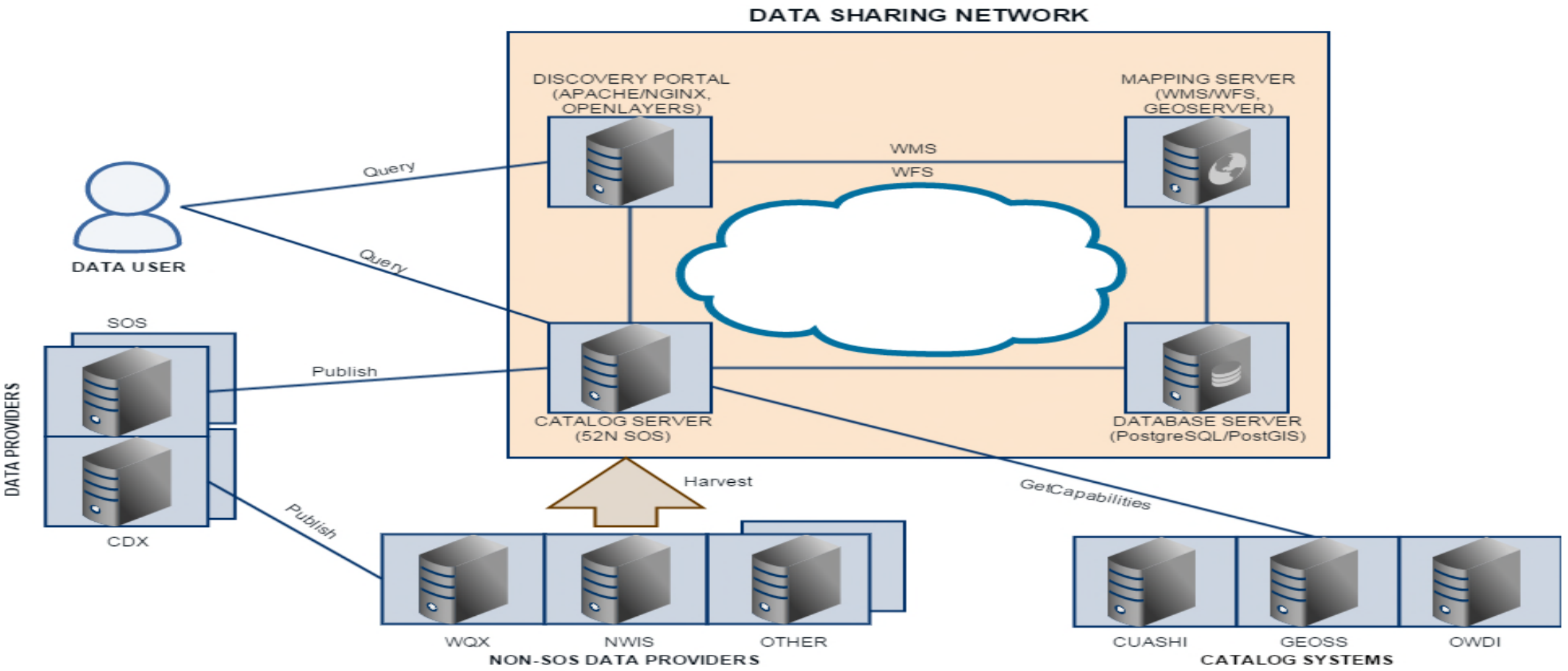
http://waterservices.usgs.gov/nwis/iv/?sites=08313000&period=P7D&format=waterml,2.0


```
<om:result>
 <wml2:MeasurementTimeseries gml:id="TS.USGS.08313000.00060.9.00000">
  <wml2:defaultPointMetadata>
   <wml2:DefaultTVPMeasurementMetadata>
    <wml2:qualifier xlink:title="Provisional data subject to revision.">
     <swe:Category definition="http://waterdata.usgs.gov/nwisweb/rdf?ivQualCd=P">
      <swe:description>Provisional</swe:description>
      <swe:value>P</swe:value>
     </swe:Category>
    </wml2:qualifier>
    <wml2:uom xlink:title="ft3/s" />
    <wml2:interpolationType xlink:href="www.opengis.net/def/waterml/2.0/interpolationType/Continuous" xlink:title="Continuous" />
   </wml2:DefaultTVPMeasurementMetadata>
  </wml2:defaultPointMetadata>
  <wml2:point>
   <wml2:MeasurementTVP>
    <wml2:time>2016-04-21T08:00:00-06:00</wml2:time>
    <wml2:value>1210.0</wml2:value>
   </wml2:MeasurementTVP>
  </wml2:point>
…
```

WaterML result

```
<wml2:qualifier
    xlink:title="Provisional data subject to revision.">
 <swe:Category definition=
    "http://waterdata.usgs.gov/nwisweb/rdf?ivQualCd=P">
   <swe:description>Provisional</swe:description>
      <swe:value>P</swe:value>
 </swe:Category>
</wml2:qualifier>
```

Architecture

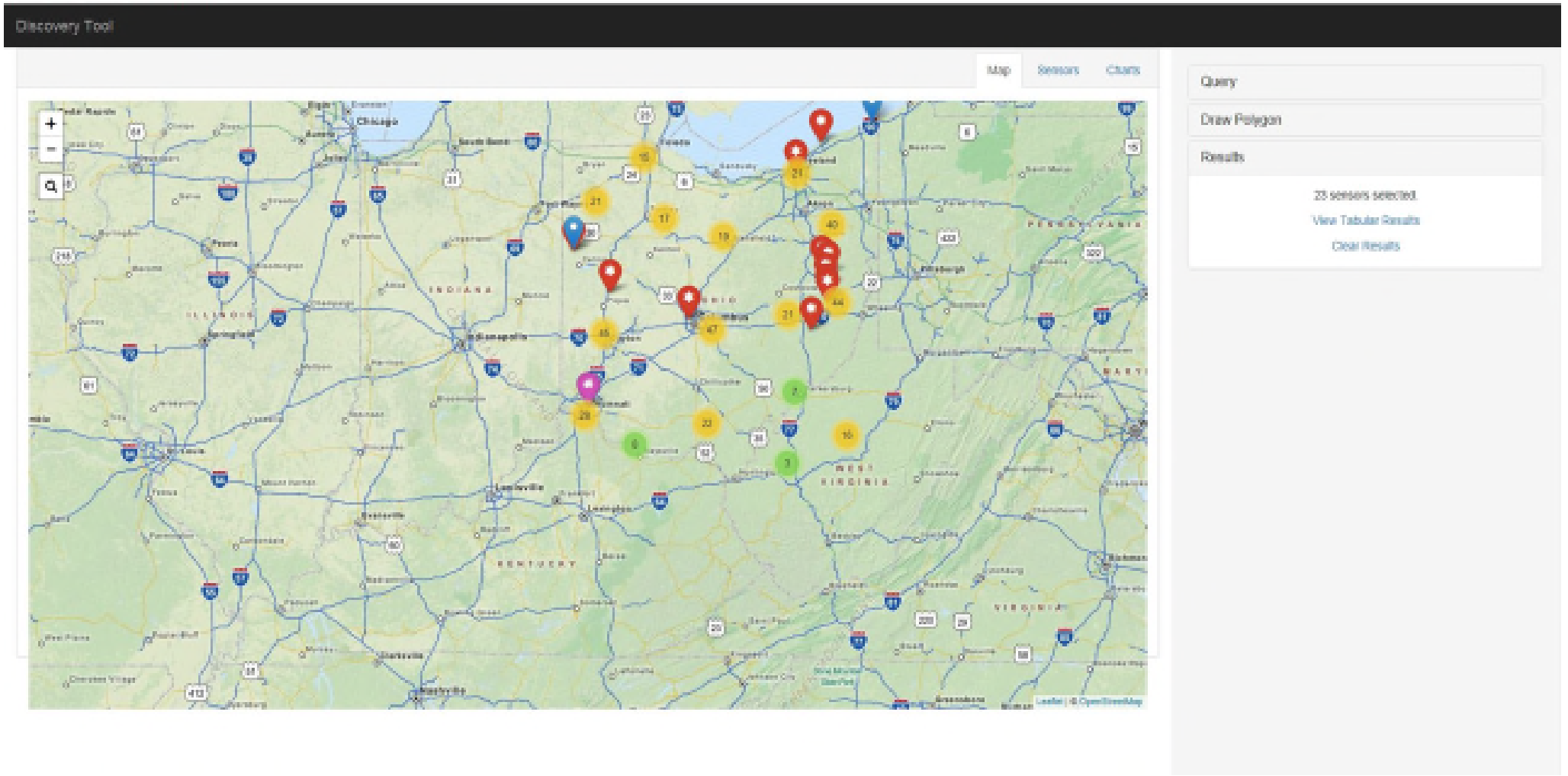


•GetObservation, for requesting the pure sensor data encoded in Observations & Measur

Sensor Observation Service

- **GetCapabilities**, for requesting a self-description of the service.
- **DescribeSensor**, for requesting information about a certain sensor
- **GetFeatureOfInterest**, for requesting the GML 3.2.1 encoded representation of the feature that is the target of the observation.
- **GetObservation**, for requesting the pure sensor data encoded in Observations & Measurements 2.0 (O&M)
- **InsertSensor**, for publishing new sensors.

Discovery Tool



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Discovery Tool

Discovery Tool

Map | Sensors | Charts

Organization	Sensor ID	Parameter	First Observation	Last Observation	Chart	Download
USGS	385655074532501	Air Temperature	2016-01-10	2016-02-09		
USGS	384540074362501	Air Temperature	2016-01-10	2016-02-09		
USGS	03281500	Air Temperature	2016-01-09	2016-02-09		
USGS	01390450	Air Temperature	2016-01-10	2016-02-09		
USGS	402815091114300	Air Temperature	2016-01-09	2016-02-09		
USGS	392239074252401	Air Temperature	2016-01-10	2016-02-09		
USGS	01477120	Air Temperature	2016-01-10	2016-02-09		
USGS	01462000	Air Temperature	2016-01-10	2016-02-09		
USGS	402120091134200	Air Temperature	2016-01-09	2016-02-09		
USGS	01489280	Air Temperature	2016-01-10	2016-02-09		
USGS	400642074024101	Air Temperature	2016-01-10	2016-02-09		
USGS	402156073582001	Air Temperature	2016-01-10	2016-02-09		
USGS	01396582	Air Temperature	2016-01-10	2016-02-09		
USGS	04180565	Air Temperature	2016-01-10	2016-02-09		

Show Selected Parameters Show All Sensor Parameters

Query

Draw Polygon

Results

23 sensors selected.

View Tabular Results

Clear Results

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Discovery Tool

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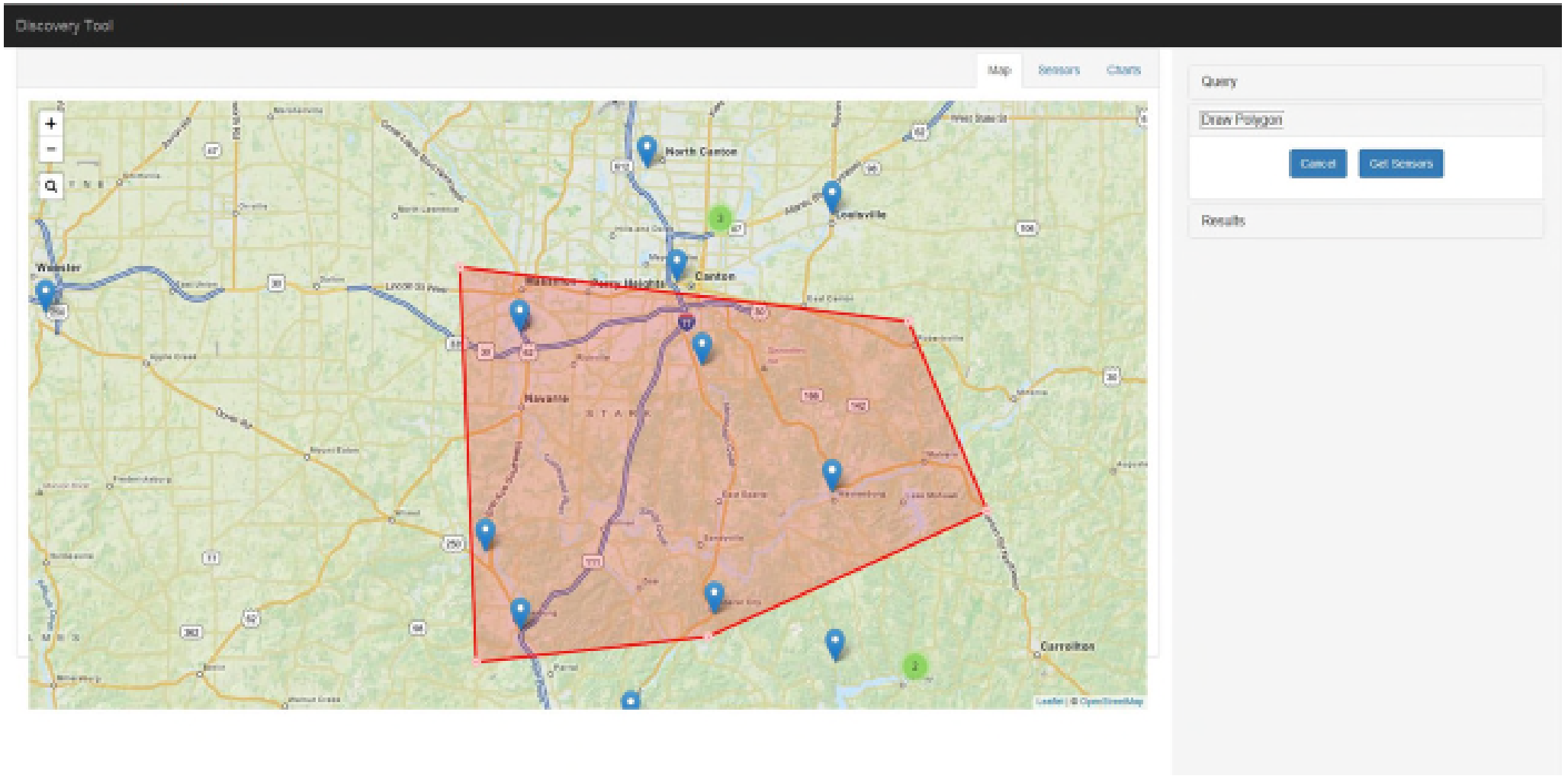
Discovery Tool



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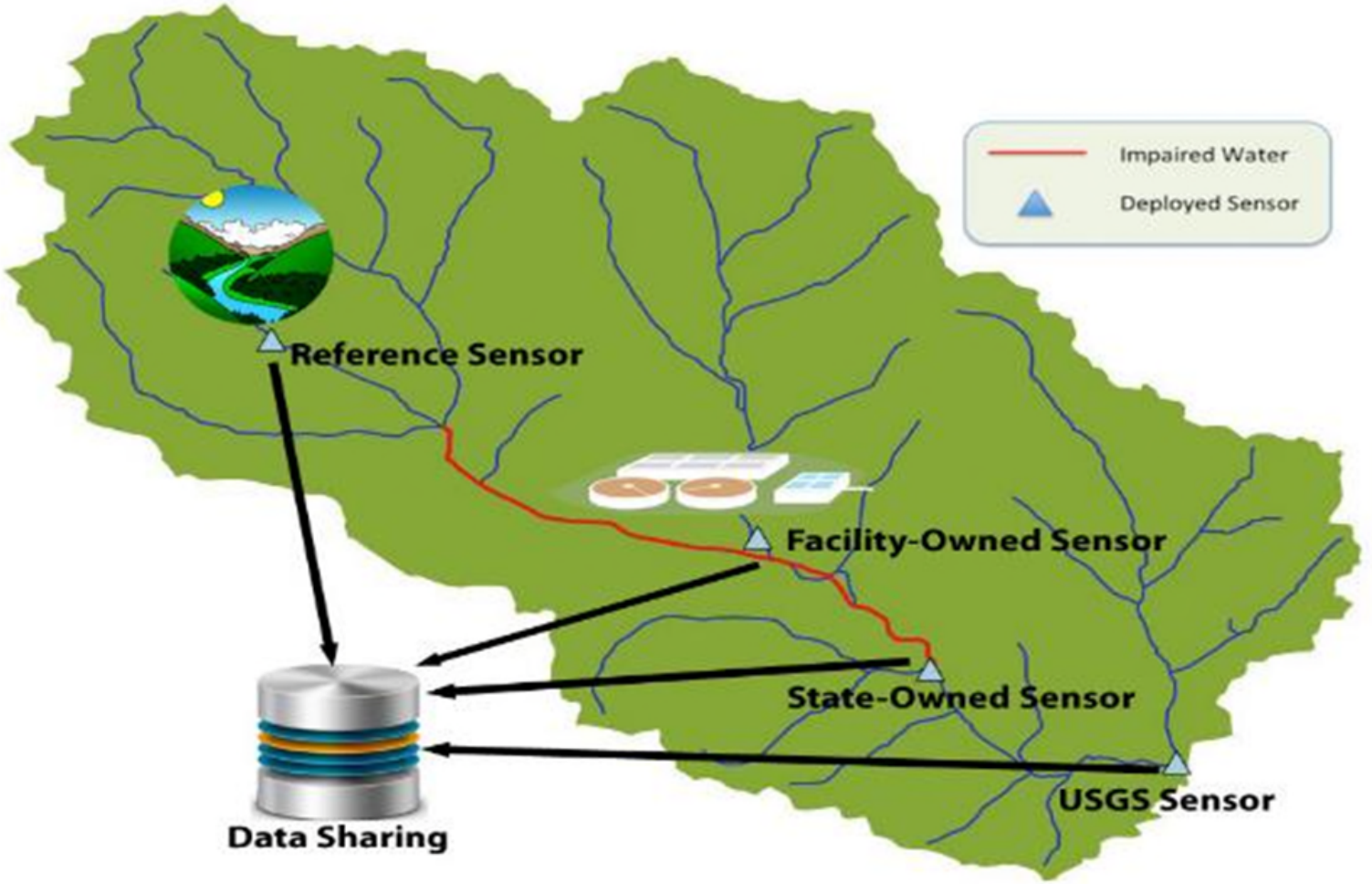
Bringing it all together



Links

- https://www.epa.gov/sites/production/files/2016-02/documents/final_epa_strategy_document.pdf
- http://www.opengeospatial.org/
- http://www.postgresql.org/
- http://postgis.net/
- http://geoserver.org/
- http://52north.org/
- https://ofmpub.epa.gov/sor_internet

Contact Information

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