The Linked Data Paradigm Shift

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Conventional Wisdom

“A data model is a set of constructs for describing and representing selected aspects of the real-world in a computer.” [Geographic Information Systems and Science, Wiley 2005]
GIS Data Modeling

1. conceptual **schemas** are key
2. the **richer** a data model (and schema) the better
3. **semantics** is captured in schemas (based on ontologies)
4. **consistency** rules
5. data get **published** through GML
6. **metadata** shall be produced …
7. data **integration** is hard …
Linked Data

1. data are statements
2. in the simplest possible data model: subject-predicate-object
3. semantics is outside schemas (in shared vocabularies)
4. data are “eventually consistent”
5. data get published by linking
6. metadata are just data (or: data are just metadata)
7. data are integrated by linking
**Data are Statements**

**About: Portsmouth**

An Entity of Type: City status in the United Kingdom, from Named Graph: http://dbpedia.org, within Data Space: dbpedia.org

Portsmouth /poırtsmeθ/ is the second largest city in the ceremonial county of Hampshire on the south coast of England. Portsmouth is notable for being the United Kingdom's only island city; it is mainly

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>dbpedia-owl:PopulatedPlace/areaTotal</td>
<td>40.25</td>
</tr>
<tr>
<td>dbpedia-owl:abstract</td>
<td>Portsmouth /poırtsmeθ/ is the second largest city in the ceremonial county of Hampshire on the south coast of England. Portsmouth is notable for being the United Kingdom's only island city; it is mainly</td>
</tr>
<tr>
<td></td>
<td>Small and relatively easy to explore, Portsmouth is a city of historic and cultural interest. It is also a large port and has a diverse economy. The city is well known for its naval heritage and is home to the Royal Navy's main base. The city is a popular tourist destination, attracting visitors from around the world.</td>
</tr>
</tbody>
</table>

**dbpedia-owl:isPartOf**

- dbpedia:South_East_England
- dbpedia:England
- dbpedia:Hampshire

**dbpedia-owl:governmentType**

- dbpedia:City_status_in_the_United_Kingdom

**dbpedia-owl:governmentAuthority**

- dbpedia:City_status_in_the_United_Kingdom

**dbpedia-owl:areaTotal**

- 402500000.00000 (xsd:double)

**dbpedia-owl:governmentBody**

- dbpedia:City_status_in_the_United_Kingdom

**dbpedia-owl:motto**

- Heaven's Light Our Guide

**dbpedia-owl:populationMetro**

- 1547000 (xsd:integer)

**dbpedia-owl:populationTotal**

- 76 (xsd:integer)

**dbpedia-owl:populationUrban**

- 855669 (xsd:integer)

**dbpedia-owl:areaUrban**

- 20.0 (xsd:double)

**dbpedia-owl:synonym**

- City of Portsmouth

**dbpedia-owl:thumbnail**


**dbpedia-owl:externalLink**

- http://www.cathedralinovationcentre.com
- http://www.portsmouth.gov.uk

**dbpedia-owl:wikiPageID**

- 24207 (xsd:integer)

**dbpedia-owl:wikiPageRevisionID**

- 606755701 (xsd:integer)
City of Portsmouth is a Borough. It contains 14 wards.

Core facts about "City of Portsmouth"

- **Type**: Borough
- **Label**: City of Portsmouth
- **Northing**: 102491
- **Easting**: 464837.2
- **Lat**: 50.818344
- **Long**: -1.08097
- **Area Code**: UTA
- **Gss Code**: E06000044
- **Point**: 50.818344 -1.08097
- **UnitID**: 37254

Objects related to "City of Portsmouth"

- **Extent**: 37254-7
- **Ward**: Hilsea, Cophor, Milton, St. Thomas, Eastney and Craneswater, Charles Dickens, Cosham, Baffins, Fratton, Drayton and Farlington

In European Region: South East

Within: South East

Touched: Fareham
Statements can Contradict

<table>
<thead>
<tr>
<th>Objects related to &quot;City of Portsmouth&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extent</strong></td>
</tr>
<tr>
<td><strong>Ward</strong></td>
</tr>
<tr>
<td><strong>In European Region</strong></td>
</tr>
<tr>
<td><strong>Within</strong></td>
</tr>
<tr>
<td><strong>Touches</strong></td>
</tr>
</tbody>
</table>
Hampshire is a County. It contains 11 districts.

Objects related to "Hampshire"

<table>
<thead>
<tr>
<th>Extent</th>
<th>17765-18</th>
</tr>
</thead>
<tbody>
<tr>
<td>In European Region</td>
<td>South East</td>
</tr>
<tr>
<td>Within</td>
<td>South East</td>
</tr>
<tr>
<td>Touches</td>
<td>West Berkshire, West Sussex, East Dorset, Wiltshire, City of Portsmouth</td>
</tr>
</tbody>
</table>

Core facts about "Hampshire"

<table>
<thead>
<tr>
<th>Type</th>
<th>County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label</td>
<td>Hampshire</td>
</tr>
<tr>
<td>Pref Label</td>
<td>Hampshire</td>
</tr>
<tr>
<td>Northing</td>
<td>127522.3</td>
</tr>
<tr>
<td>Easting</td>
<td>452860</td>
</tr>
<tr>
<td>Lat</td>
<td>51.04463</td>
</tr>
<tr>
<td>Long</td>
<td>-1.247495</td>
</tr>
<tr>
<td>Area Code</td>
<td>CTY</td>
</tr>
</tbody>
</table>
Metadata are Data
# Semantics are Explicit

**Touches**

The boundaries of the two objects intersect but their interiors do not.

### Data about "touches"

<table>
<thead>
<tr>
<th>Type</th>
<th>Object Property</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetric Property</td>
<td></td>
</tr>
</tbody>
</table>

**Label**: touches

**Comment**: The boundaries of the two objects intersect but their interiors do not.

**Is Defined By**: Spatialrelations.owl

**Domain**: Spatial Object

**Property Chain Axiom**

<table>
<thead>
<tr>
<th>Rest</th>
<th>Rest</th>
<th>Nil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First</td>
<td>touches</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First</th>
<th>equal</th>
</tr>
</thead>
</table>

**Range**: Spatial Object

**Sub Property Of**: Top Object Property

**Ontology**

"touches" is defined in the Spatial Relations ontology.

**Classes**

This ontology does not contain any classes.

**Properties**

- 1km Grid Reference
- 20km Grid Reference
- contains
- disjoint
- easting
- equal
- northing
- touches

[http://data.ordnancesurvey.co.uk/ontology/spatialrelations/touches](http://data.ordnancesurvey.co.uk/ontology/spatialrelations/touches)
### Maintenance without Deletion

[Image: Map of deforestation rates from 2002 to 2008 in the Brazilian Amazon rainforest]

<table>
<thead>
<tr>
<th>Year</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEFOR_2002</td>
<td>0.039</td>
</tr>
<tr>
<td>DEFOR_2003</td>
<td>0.0030</td>
</tr>
<tr>
<td>DEFOR_2004</td>
<td>0.031</td>
</tr>
<tr>
<td>DEFOR_2005</td>
<td>0.042</td>
</tr>
<tr>
<td>DEFOR_2006</td>
<td>0.0050</td>
</tr>
<tr>
<td>DEFOR_2007</td>
<td>0.012</td>
</tr>
<tr>
<td>DEFOR_2008</td>
<td>0.0040</td>
</tr>
</tbody>
</table>

[AMZ_LINKED_25K_1000](http://linkedscience.org/data/linked-brazilian-amazon-rainforest/)
Publishing and Integrating by Linking
Athenae

A major Greek city-state and the principal city of Attika.

Locations
Kerameikos, Agora of Athens, Acropolis of Athens, DARE Location, DARMC location 21246, Theatre of Dionysus Eleuthereus, Stoa of Zeus (Eleutherios), Hefaistion, The Erechtheion

Names
- Athenae (750 BC - AD 640)
- Athens (modern)
- Αθήνα (Athina; modern)

Place type:
theatre, theater, agora, forum, plaza, catacomb, cemetery, necropolis, stoa, settlement, temple, sanctuary, shrine, monument, tomb

Makes a connection with:
- Attica

Has a connection with:
Some Open Issues

1. statements vs facts
2. dealing with time
3. dealing with uncertainty
4. dealing with raster data
5. limits of tripling
6. trust and reputation
7. reusing and aligning vocabularies
8. dealing with real-time or near-real-time streams of data
9. efficiency of triple stores.
Conclusions

1. linked data (whether open or not) provide a radically different paradigm for geodata management

2. they solve some of the thorniest problems (metadata, data integration) and provide the basis for solving others (time, semantics, …)

3. the longer we keep celebrating complexity (in geodata, data models, and GIS), the less we benefit from the linked data revolution

4. linked data are (still) best for sharing (as opposed to analysis)

5. linked geodata bridge information silos (organizations, disciplines, …).
Thank You!