An Introduction to The Semantic Web: a knowledge modelling perspective

John Domingue

President STI International
Caveat

- Not an historical overview
- Singular perspective of some underlying motivations and issues related to the Semantic Web
MOTIVATION & APPLICATION SCENARIO
Agenda

• Building K-HAL v1.0
  – Influences
  – Ontology
  – Conceptualisation
  – Knowledgebase
  – Critique

• Building K-HAL v2.0
  – Ontologies
  – Data
  – Getting help

• Building K-HAL v3.0

• Conclusions
Spacecraft piloting and navigation only – the reasoning and knowledge parts

BUILDING K-HAL V1.0
INFLUENCES
Cognitive Psychology

- Has four wheels
- Easy way to travel
- Produces exhaust fumes
- Can be dangerous to one
- Can drive
Semantic Network
Collins and Quillian 1967

```plaintext
Vehicle
  - moves around
  - needs fuel
  - manmade

Link

Node

Car
  - has 4 wheels
  - has engine
  - has windows

Sports car
  - is very fast

Truck
  - more than 4 wheels
  - special toll on German highways

  - transports loads

status symbol
```
Knowledge Level (Allen Newell, 1982)

Knowledge Level
Symbol Level
Physical Level

Diagram:
- Vehicle
- Link
- Node
- Car
- Truck
- Sports car
- more than 4 wheels
- special toll on German highways
- transports loads
- moves around
- needs fuel
- manmade
- has 4 wheels
- has engine
- has windows
- is very fast
- status symbol
Knowledge Level (Allen Newell, 1982)

Knowledge Level

Symbol Level

Physical Level
ONTOLOGY
Informal Ontology Explanation

- Used to structure knowledge
- Facilitates interoperability
- Formal explicit shared conceptualisation of a domain
- A set of concepts, relationships and individuals over which there is an agreed consensus
Ontology Construction

Ontology Management
(Scheduling, controlling, quality assurance)

Feasibility study
(problems, opportunities, potential solutions, economic feasibility)

Ontology Development and Support

Domain analysis
(motivating scenarios, competency questions, existing solutions)

Conceptualization
(conceptualization of the model, integration and extension of existing solutions)

Implementation
(implementation of the formal model in a representation language)

Ontology Use

Maintenance
(adaptation of the ontology according to new requirements)

Use
(ontology based search, integration, negotiation)
Let’s talk to some smart people…
Conceptualisation
Conceptualisation
Re-conceptualisation
Re-conceptualisation
Re-conceptualisation
Re-conceptualisation
Re-conceptualisation
Re-conceptualisation
Re-conceptualisation
K-HAL v 1.0 Ontology (small portion)

Concepts

- Engineered Artifact
  - Rocket
  - Space Ship
- Celestial Body
  - Star
  - Planet
  - Asteroid

Relations

- Agent
  - Crew
  - Human Crew
- Onboard AI
- Has Component
- Generates Thrust
- Has Name
- Has Mass
- Has Volume
K-HAL v 1.0 Ontology (small portion)

**Concepts**
- Engineered Artifact
  - Rocket
  - Space Ship
- Celestial Body
  - Star
  - Planet
  - Asteroid

**Relations**
- Agent
  - Crew
    - Human Crew
- Onboard AI

- Has Component
- Generates Thrust
- Has Name
- Has Mass
- Has Volume
K-HAL v 1.0 Ontology/KB (small portion)

Concepts
- Engineered Artifact
  - Rocket
  - Space Ship
- Celestial Body
  - Star
  - Planet
  - Asteroid
- The Sun
- Jupiter

Relations
- Agent
  - Crew
    - Human Crew
      - Dave Boorman
    - Onboard AI
      - HAL
- Has Component
- Generates Thrust
- Has Name
- Has Mass
- Has Volume
Open CYC v 4.0
239,000 concepts and
2,093,000 facts

Domain-Specific Knowledge
(e.g., Healthcare, Computer Security, Command and Control, Mortgage Banking, ...)

Domain-Specific Facts and Data
K-HAL v 1.0

User

Input/Output
- Vision system
- Speech Generation
- Speech Understanding

Reasoner

Ontology

Knowledge Base
What’s wrong with K-HAL v 1.0?

• ????
BUILDING K-HAL V2.0
Underlying Principles

Be Lazy

Be kind and share
K-HAL V2.0 ONTOLOGIES
Why work when you can Google?
**About: spacecraft**

An Entity of Type: Class, from Named Graph: 
http://dbpedia.org/resource/classes#, within Data Space: dbpedia.org

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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<td>owl:Class</td>
</tr>
<tr>
<td>rdfs:label</td>
<td>spacecraft</td>
</tr>
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<td>dbpedia-owl:MeanOfTransportation</td>
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<td></td>
<td>dbpedia-owl:port1UndockingDate</td>
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<tr>
<td></td>
<td>dbpedia-owl:port2</td>
</tr>
<tr>
<td></td>
<td>dbpedia-owl:port2DockedTime</td>
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<td></td>
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<td>dbpedia-owl:totalMass</td>
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<td>dbpedia-owl:spacecraft</td>
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Solar System SKOS Ontology Model

Abstract:
"This is an ontological knowledge organization system of the planets, dwarf planets, natural satellites, and small solar system bodies in the Solar System using the SKOS, Simple Knowledge Organization System, schema extended. The model defines resources in English, Spanish, Russian, and simplified Chinese. Each resource entry also contains definitions. This facilitates the generation of mono- or multi-lingual glossaries. The concept terms can be used to feed vocabularies to search applications. Mappings are also provided for the NASA Location taxonomy, the International Virtual Observatory Alliance IAU193 thesaurus and to descriptive entries in Wikipedia. Where applicable, the model also provides links to NASA factsheets, the United States Geological Survey Gazetteer of Planetary Nomenclature data sets, and the International Astronomical Union Minor Planet Center orbital data sets, the Sternberg State Astronomical Institute of Moscow State University natural satellite data sets, and the JPL Small-Body Database Browser. Objects are mapped into the multiple taxonomies that have been defined for various solar system objects."

Author: Bill Howard
Link: http://vocabulary.semantic-web.at/SolarSystemSKOSOntologyModel
Topic: astronomy
DDC: 520
Access: Free
Format: Online
  RDF
  SKOS
  XML
Type: Ontology
Language: Chinese
  English
  Russian
  Spanish
Astronomical Objects

Ontology of Astronomical Object Types
Astronomical Ontology (portion)
Space Shuttle Ontology

Aft-Fuselage
Air-Sampling-System
Airlock
Auxilliar-Power-Unit
Avionics-System
Body-Flap
Caution-And-Warning-System
Communication
Crew-Apparel
Crew-Compartment
Crew-Equipment
Crew-Equipment-Stowage
Eletrical-Power-Distribution
Eletrical-Power-System
Emergency-Egress-Slide
Environmental-Control-and-Life-Support-System
Exercise-Equipment
External-Tank
External-Tank-Hardware
Food-System-and-Dining
Forward-Fuselage
Hold-Down-Post
Housekeeping
Hydraulic-System
Hydraulic-Power-Units

Inflyght-Crew-Escape-System
Intertank
Landing-Gear-System
Liquid-Hydrogen-Tank
Liquid-Oxygen-Tank
Main-Propulsion-System
Microcassette-Recorder
Midfuselage
Operational-Bioinstrumentation-System
Orbital-Manuevering-System
Orbiter-External-Tank-Seperation-System
Orbiter-Flight-Crew-Escape-System
Orbiter-Passive-Contro-System
Orbiter-Purge-Vent-Drain-System
Orbiter-Structure
OrbiterManufacturingandAssembly
Payload-Bay-Doors
Personal-Hygiene-Provision
Photographic-Equipment
Radiation-Equipement
Range-Safety-Siystem
Range-Safety-Siystem-Tank
Reach-Aid
Reaction-Control-System
Restraints-And-Mobility-Aids
RSB-Descent-and-Recovery
Secondary-Emergency-Egress
Shuttle
Shuttle-Orbiter-Medical-System
ShuttleName
Sighiting-Aids
Sleeping-Provision
Solid-Roket-Boosters
Sound-Level-Meter
Space-Shuttle-Coordinate-System
Space-Shuttle-Orbiter-System
Space-Transportation-System
SRB-Ignition
SRB-Rate-Gyro-Assemblies
SRB-Separation
Thermal-Protection-System
Thermal-Protection-System-Orbiter
Thrust-Vector-Control
Vertical-Tail
Water-Spray-Boilers
Wicket-Tabs
Windows
Wing
Problems to be resolved (ontology)

• Finding ontologies
• Understanding ontologies
• Connecting ontologies
• Adapting ontologies
• Version control
• Agility
  – New ontologies, changes in used ontologies …
• ……..
Building and Using Ontologies

Elena Simperl Tutorial 10:45am Tuesday
Be Lazy

K-HAL V2.0 DATA
## Solar Objects > 400km Radius

<table>
<thead>
<tr>
<th>Body</th>
<th>Image</th>
<th>Mean radius (km)</th>
<th>Mean radius (R&lt;sub&gt;⊕&lt;/sub&gt;)</th>
<th>Volume (10&lt;sup&gt;9&lt;/sup&gt; km&lt;sup&gt;3&lt;/sup&gt;)</th>
<th>Volume (V&lt;sub&gt;⊕&lt;/sub&gt;)</th>
<th>Mass x10&lt;sup&gt;21&lt;/sup&gt; kg (M&lt;sub&gt;⊕&lt;/sub&gt;)</th>
<th>Mass (M&lt;sub&gt;⊕&lt;/sub&gt;)</th>
<th>Density [note 1] g/cm&lt;sup&gt;3&lt;/sup&gt;</th>
<th>Surface gravity (m/s&lt;sup&gt;2&lt;/sup&gt;)</th>
<th>Surface gravity (⊕)</th>
<th>Type of object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td><img src="image" alt="Sun" /></td>
<td>696 000&lt;sup&gt;[9]&lt;/sup&gt;</td>
<td>109</td>
<td>1,412,000,000</td>
<td>1,304,000</td>
<td>1,989,000,000</td>
<td>333,000</td>
<td>1.409</td>
<td>274.0</td>
<td>28.02</td>
<td>Star</td>
</tr>
<tr>
<td>Jupiter</td>
<td><img src="image" alt="Jupiter" /></td>
<td>69 911 ± 6</td>
<td>10.97</td>
<td>1,431,280</td>
<td>1,321</td>
<td>1,898,600</td>
<td>317.83</td>
<td>1.33</td>
<td>24.79</td>
<td>2.535</td>
<td>Planet (gas giant)</td>
</tr>
<tr>
<td>Saturn</td>
<td><img src="image" alt="Saturn" /></td>
<td>58 232 ± 6 (w/o rings)</td>
<td>9.14</td>
<td>827,130</td>
<td>764</td>
<td>568,460</td>
<td>95.159</td>
<td>0.70</td>
<td>10.445</td>
<td>1.06</td>
<td>Planet (gas giant)</td>
</tr>
<tr>
<td>Uranus</td>
<td><img src="image" alt="Uranus" /></td>
<td>25 362 ± 7</td>
<td>3.98</td>
<td>66,340</td>
<td>63.1</td>
<td>86,832</td>
<td>14.536</td>
<td>1.30</td>
<td>8.87</td>
<td>0.90</td>
<td>Planet (gas giant)</td>
</tr>
<tr>
<td>Neptune</td>
<td><img src="image" alt="Neptune" /></td>
<td>24 622 ± 19</td>
<td>3.86</td>
<td>62,540</td>
<td>57.7</td>
<td>102,430</td>
<td>17.147</td>
<td>1.76</td>
<td>11.15</td>
<td>1.140</td>
<td>Planet (gas giant)</td>
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<tr>
<td>Earth</td>
<td><img src="image" alt="Earth" /></td>
<td>6 371</td>
<td>1</td>
<td>1,083.21</td>
<td>1</td>
<td>5,973.6</td>
<td>1</td>
<td>5.515</td>
<td>9.78033</td>
<td>0.99732</td>
<td>Planet (terrestrial)</td>
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<tr>
<td>Venus</td>
<td><img src="image" alt="Venus" /></td>
<td>6 052 ± 1 (w/o gas)</td>
<td>0.950</td>
<td>926.43</td>
<td>0.657</td>
<td>4,668.5</td>
<td>0.815</td>
<td>5.24</td>
<td>8.872</td>
<td>0.905</td>
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<tr>
<td>Mars</td>
<td><img src="image" alt="Mars" /></td>
<td>3 389.5 ± 0.2</td>
<td>0.532</td>
<td>163.18</td>
<td>0.151</td>
<td>641.85</td>
<td>0.107</td>
<td>3.94</td>
<td>3.7</td>
<td>0.36</td>
<td>Planet (terrestrial)</td>
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<tr>
<td>Ganymede†</td>
<td><img src="image" alt="Ganymede" /></td>
<td>2 634.1 ± 0.3</td>
<td>0.413</td>
<td>76.30</td>
<td>0.0704</td>
<td>148.2</td>
<td>0.0246</td>
<td>1.936</td>
<td>1.428</td>
<td>0.15</td>
<td>Satellite of Jupiter</td>
</tr>
<tr>
<td>Titan†</td>
<td><img src="image" alt="Titan" /></td>
<td>2 576 ± 2 (w/o gas)</td>
<td>0.404</td>
<td>71.52</td>
<td>0.0660</td>
<td>134.5</td>
<td>0.0225</td>
<td>1.88</td>
<td>1.354</td>
<td>0.14</td>
<td>Satellite of Saturn</td>
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<tr>
<td>Mercury</td>
<td><img src="image" alt="Mercury" /></td>
<td>2 440 ± 1</td>
<td>0.363</td>
<td>60.83</td>
<td>0.0562</td>
<td>330.2</td>
<td>0.0553</td>
<td>5.43</td>
<td>3.7</td>
<td>0.36</td>
<td>Planet (terrestrial)</td>
</tr>
<tr>
<td>Callisto†</td>
<td><img src="image" alt="Callisto" /></td>
<td>2 410 ± 2</td>
<td>0.376</td>
<td>56.65</td>
<td>0.0541</td>
<td>107.6</td>
<td>0.018</td>
<td>1.83</td>
<td>1.23603</td>
<td>0.126</td>
<td>Satellite of Jupiter</td>
</tr>
</tbody>
</table>
NASA Space Flight & Astronaut data in RDF

Description

Conversion of various NASA datasets into RDF, starting with the spacecraft data from the NSSDC master catalog.

This dataset consists of a conversion of the NASA NSSDC Master Catalog and extracts of the Apollo By Numbers statistics.

Currently the data consists of all of the Spacecraft from the NSSDC database which is a comprehensive list of orbital, suborbital, and interplanetary spacecraft launches dating from the 1950s to the present day. Entries are not limited to NASA missions, but include spacecraft launched by various agencies from around the globe.

Note this dataset is no longer updated, it was taken off-line during the shutdown of Kasabi. A dump of the dataset has been uploaded to the Internet Archive.

Data and Resources

Dataset export
Dump of the dataset uploaded to Internet Archive
Spacecraft component data
Problems to be resolved

- Finding semantic data
- Transforming unstructured data to a semantic format
- Transforming structured data to a semantic format
- Connecting semantic datasets
- Querying/reasoning over connected semantic data
- Sharing new data
- Agility
  - New datasets, changes in used datasets...
Linked Data Basics

• Fundamentals of Linked Data: main standards & technology components, motivating application scenario
  – Barry Norton Tutorial 10:45am today
• Querying Linked Data: SPARQL 101
  – Irini Fundulaki Tutorial 2pm today
• Semantic Web languages and standards: RDF, RDFS, SPARQL
  – Barry Norton & Irini Fundulaki Hands-on: 3:30pm today
Publishing and Using Linked Data

- Providing and consuming Linked Data
  - Maribel Acosta Tutorial 2:30pm Tuesday

- Publishing and consuming Linked Open Data
  - Maribel Acosta Hands-on 4pm Tuesday
Linked Data and the Unstructured World

• Linked Data for NLP
  – Barry Norton Tutorial Wednesday 10:45am

• Using Linked Data and GATE
  – Barry Norton & Isabelle Augenstein Wednesday 11:30am
Getting everybody to help...

*picture suggested by Dan Brickley
SHAPE
Is the galaxy simply smooth and rounded, with no sign of a disk?

- Smooth
- Features or disk
- Star or artifact
More Zoos

ASTEROID ZOO

MOON ZOO

THE ROYAL OBSERVATORY GREENWICH PRESENTS
SOLAR STORMWATCH

Solar scientists need you!
Help them spot explosions on the Sun and track them across space to Earth. Your work will give astronauts an early warning if dangerous solar radiation is headed their way. And you could make a new scientific discovery.

GET STARTED

PLANE FOUR

Come help explore the surface of Mars

116,539 participants worldwide
4,347,291 NRO images classified
Crowdsourcing AI

Dangerous Waters: Take command in the air, on the ocean, and below the waves!

S.C.S. - Dangerous Waters is the first title of its kind, allowing you total control over multiple air, surface, and submarine platforms in a modern-day naval environment! The game allows you to focus your attention and to take direct control of individual crew stations and also plan and execute combined arms naval strategies from a top-down 'Commander's Eye' perspective.
Getting help tutorials and hands-on

- Social Semantic Web and crowdsourcing
  - Elena Simperl Tutorial Wednesday 2pm
- Using Mechanical Turk to solve Linked Data problems
  - Maribel Acosta Hands-on Wednesday 3pm
K-HAL v 1.0

User

Input/Output
Vision system
Speech Generation
Speech Understanding

Reasoner

Ontology

Knowledge Base
K-HAL v 2.0 Architecture

- Input/Output
  - Vision system
  - Speech Generation
  - Speech Understanding

- Reasoner

- HAL Ontology

- HAL Facts in RDF Store

- Linked Open Data

- Corporate data

- Linked Open Vocabularies

- Crowdsourced facts
What about processes?

BUILDING K-HAL V3.0
Virtual Choir
Choir
Autonomous singers
Available online
Conductor
Dictates song
Common notation
Selects performances
Edits and mixes

Choir
Autonomous singers
Available online
Listener
Has a desire
Has preferences

Conductor
Dictates song
Common notation
Selects performances
Edits and mixes

Choir
Autonomous singers
Available online

The evening hangs beneath the moon
SALAD2014  ESWC2014 workshop  May 26, 2014
Services and Applications over Linked APIs and Data

~ Services and Applications over Linked APIs and Data ~
In its current state the Semantic Web/Web of Data facilitates the re-use of ontologies and data

- Other problems arise associated with ontology and data quality, adapting/aligning ontologies and data …
- Good SW/LD practitioners know online ontologies and datasets as a good researcher knows the related literature
Conclusions (2/2)

Releasing ontologies and data
- Provides a community benefit for expected and unexpected uses
- Can increase the value of the released artifacts
- May be obligated depending on context (e.g. if paid for by public funding)
- Has associated issues related to training, quality, privacy, maintenance….

Be kind and share
THANKS