



STI · INTERNATIONAL

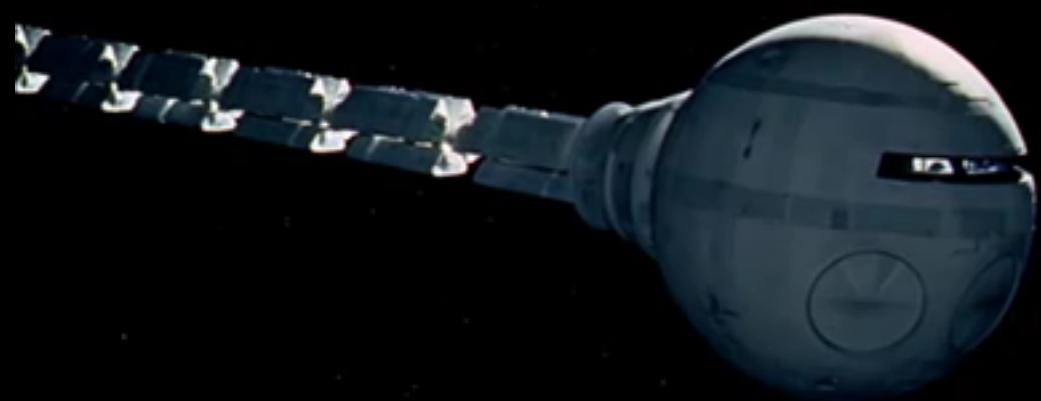
# An Introduction to The Semantic Web: a knowledge modelling perspective John Domingue

President STI International

# Caveat

- Not an historical overview
- Singular perspective of some underlying motivations and issues related to the Semantic Web

# MOTIVATION & APPLICATION SCENARIO





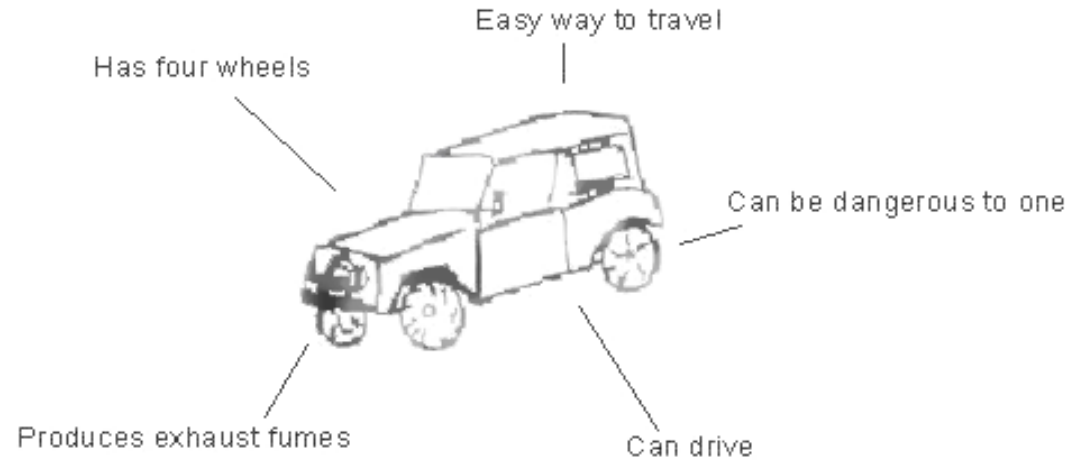
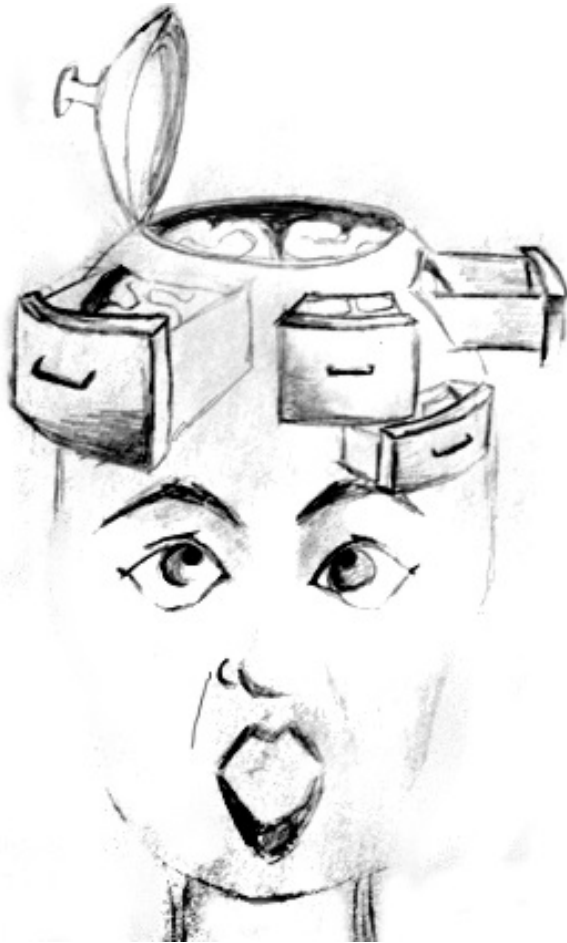
- Building K-HAL v1.0
  - Influences
  - Ontology
  - Conceptualisation
  - Knowledgebase
  - Critique
- Building K-HAL v2.0
  - Ontologies
  - Data
  - Getting help
- Building K-HAL v3.0
- Conclusions



Spacecraft piloting and navigation only – the reasoning and knowledge parts

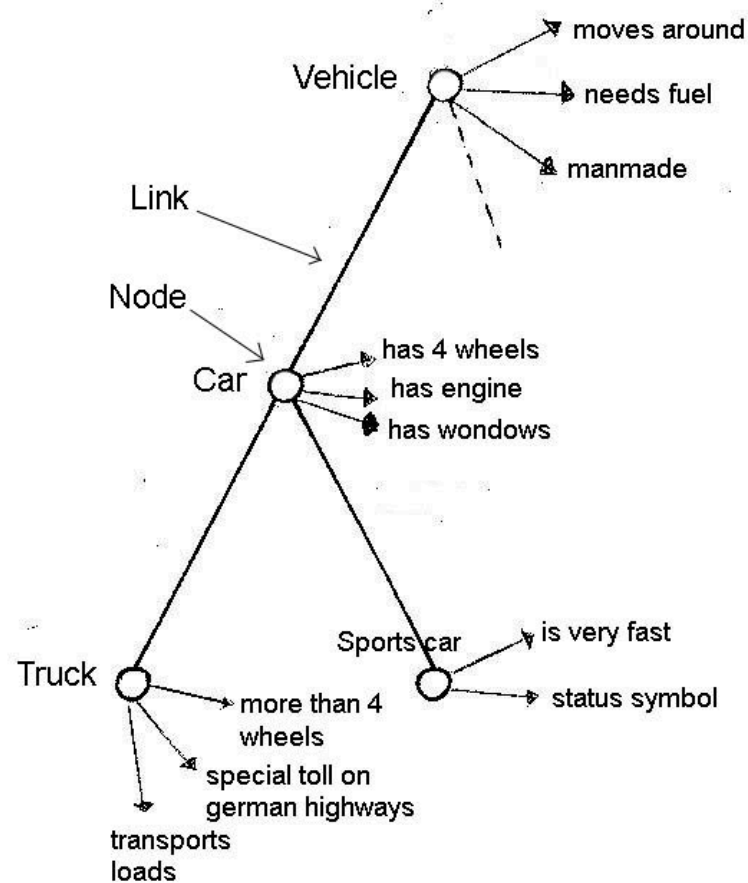
# **BUILDING K-HAL V1.0**

# INFLUENCES



# Semantic Network

## Collins and Quillian 1967

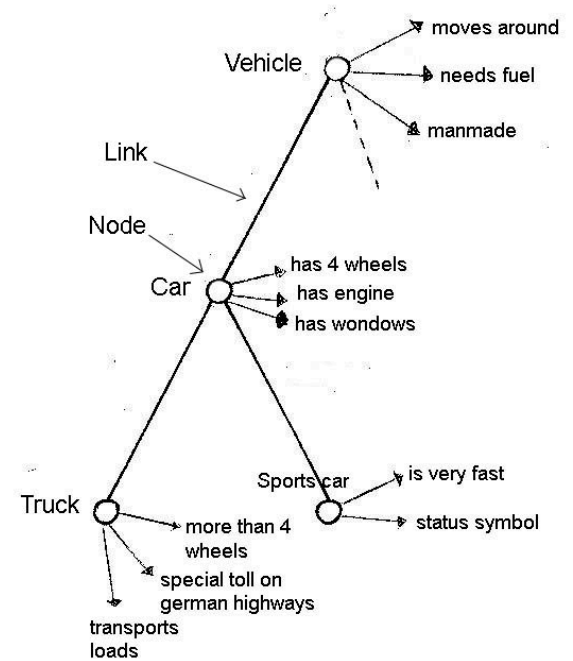


Knowledge Level

Symbol Level

- .
- .
- .
- .
- .

Physical Level



Observer

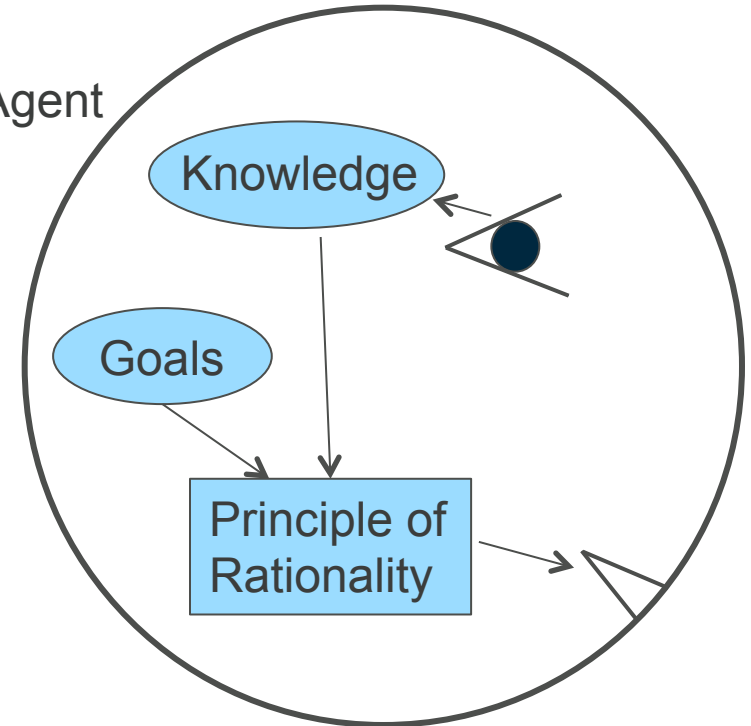
Knowledge Level

Symbol Level

.  
. .  
. .  
. .  
. .

Physical Level

Agent

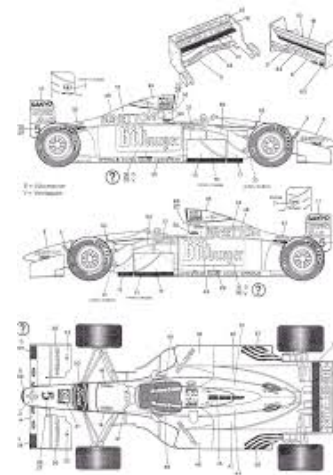


# ONTOLOGY

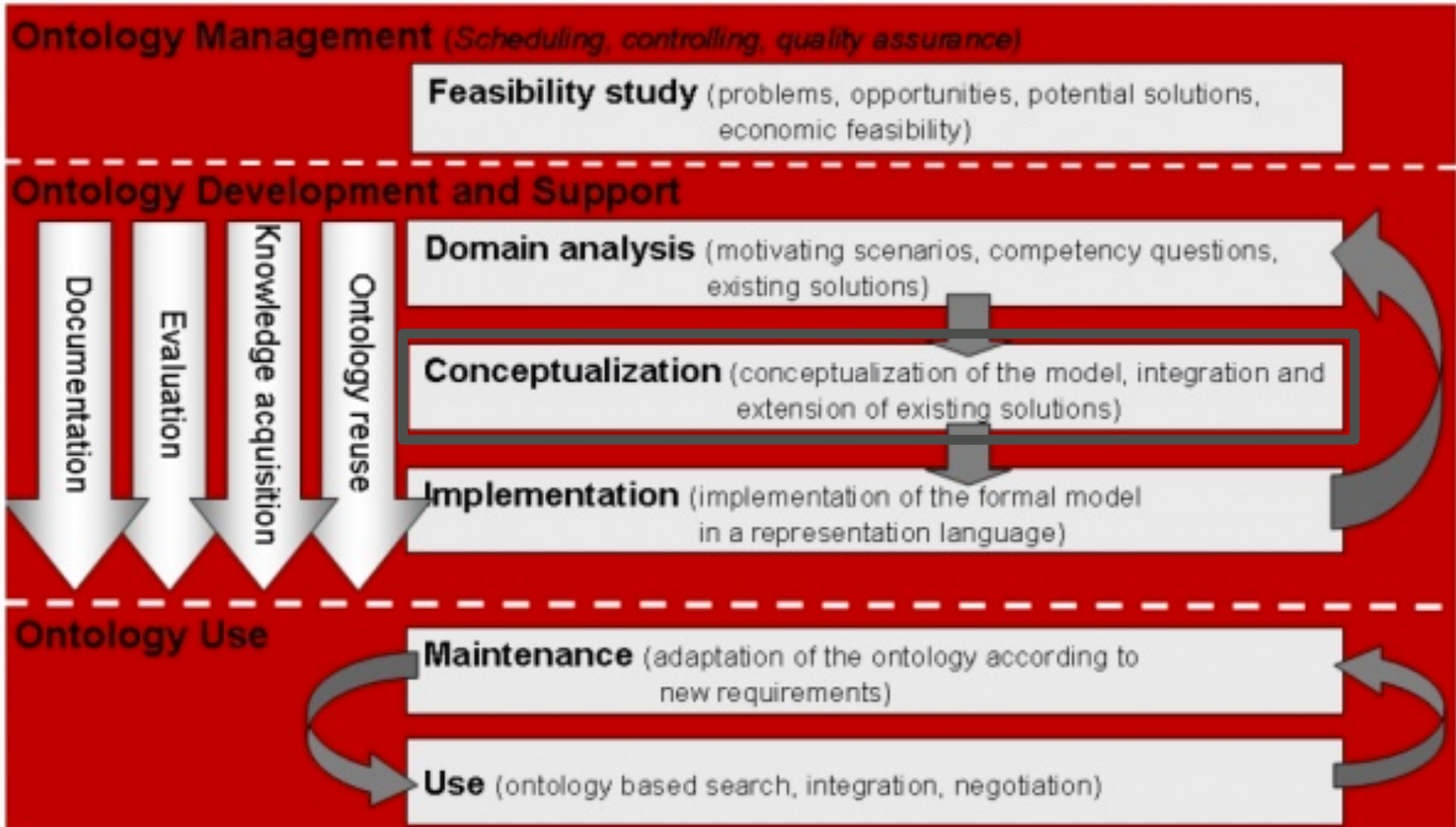


# Informal Ontology Explanation

- 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





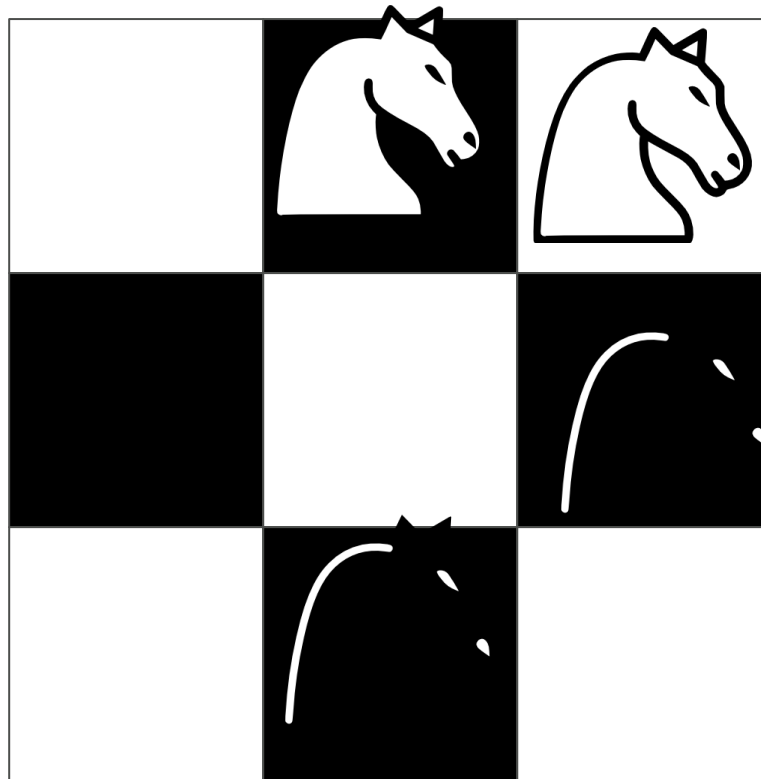
# CONCEPTUALISATION



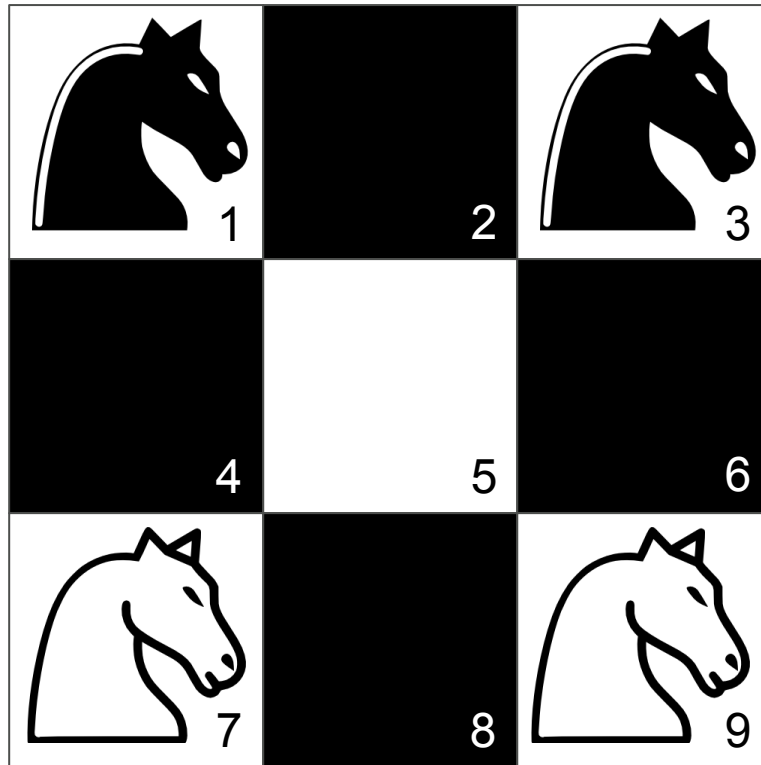
# Let's talk to some smart people...



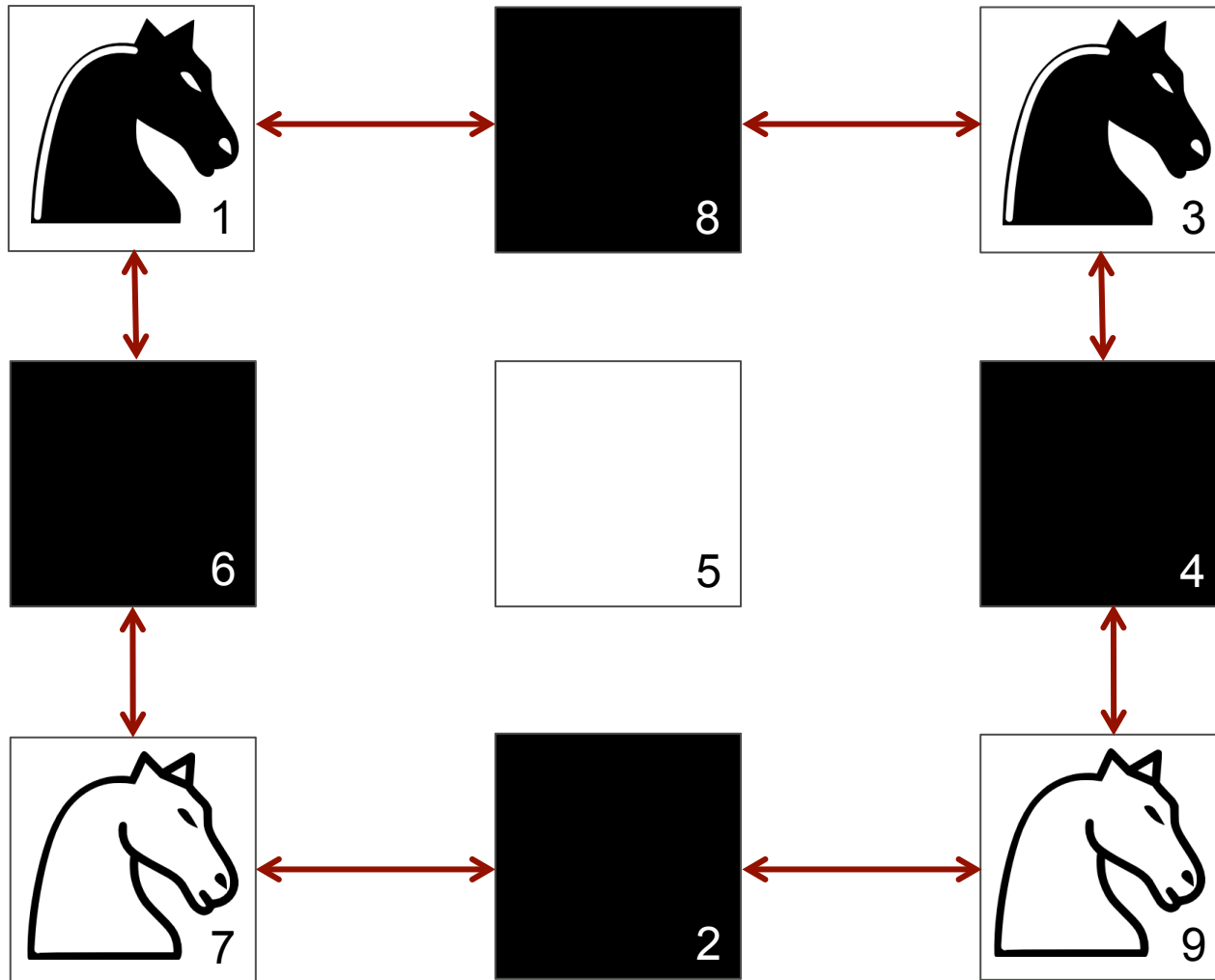
# Conceptualisation



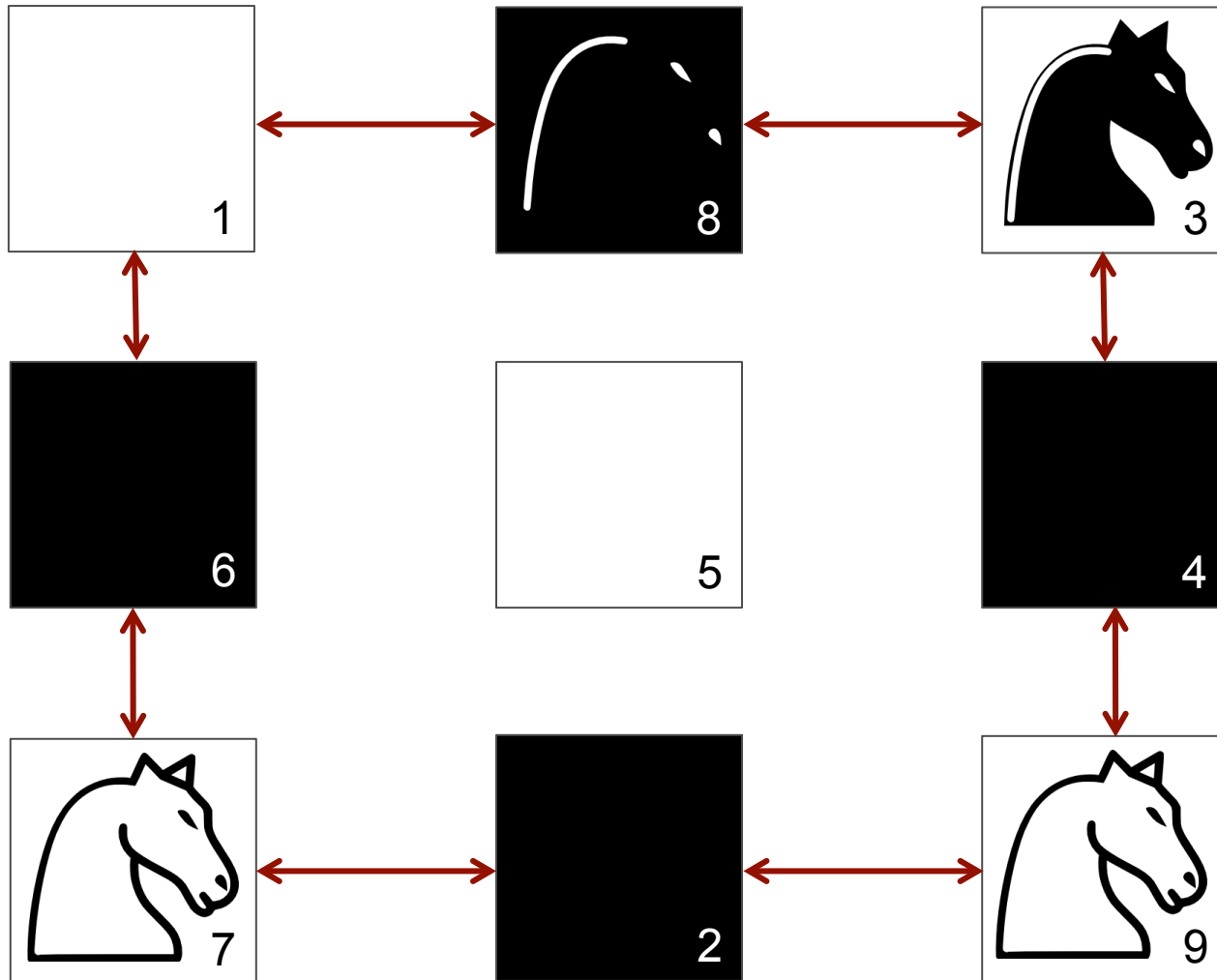
# Conceptualisation



# Re-conceptualisation

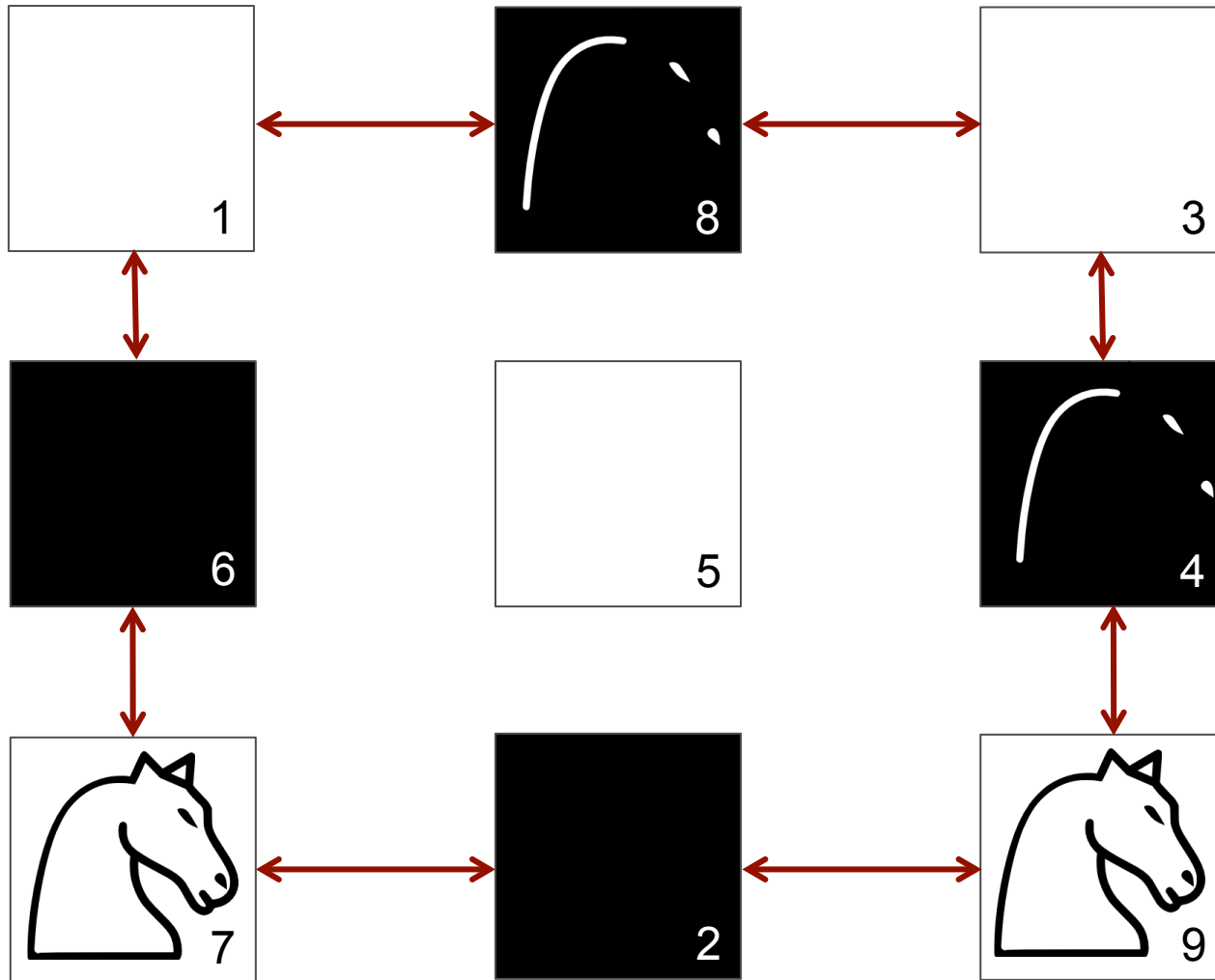


# Re-conceptualisation

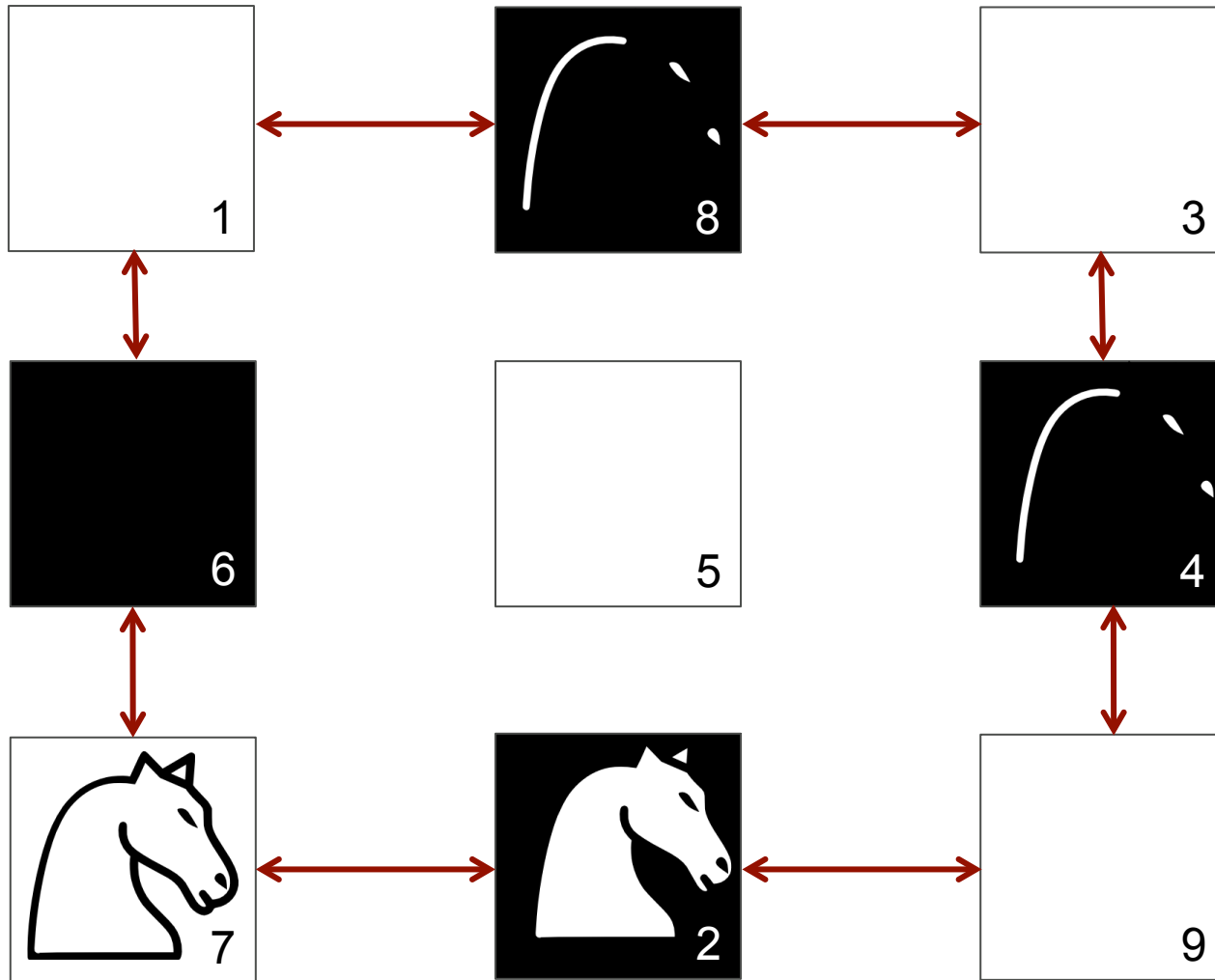




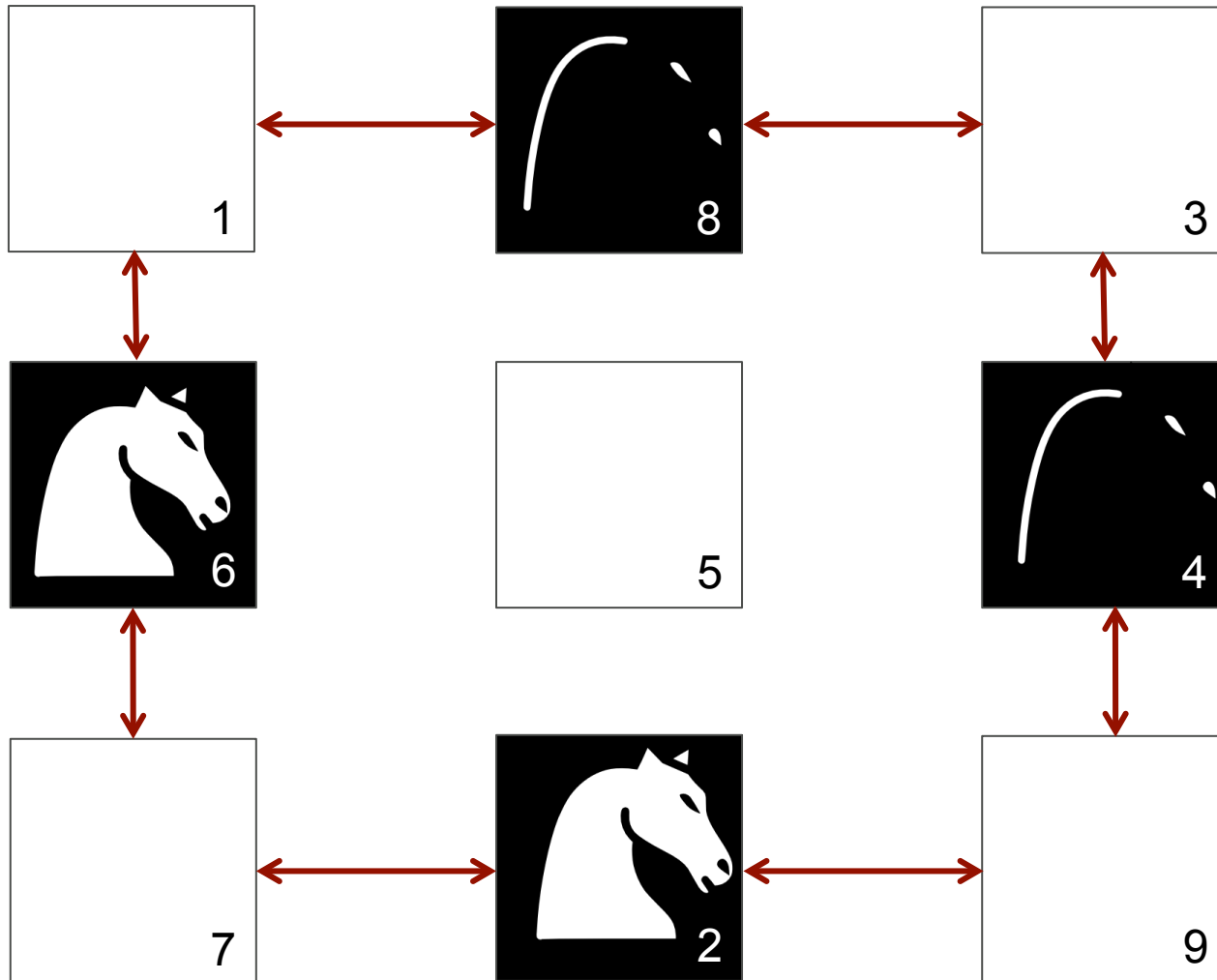
# Re-conceptualisation



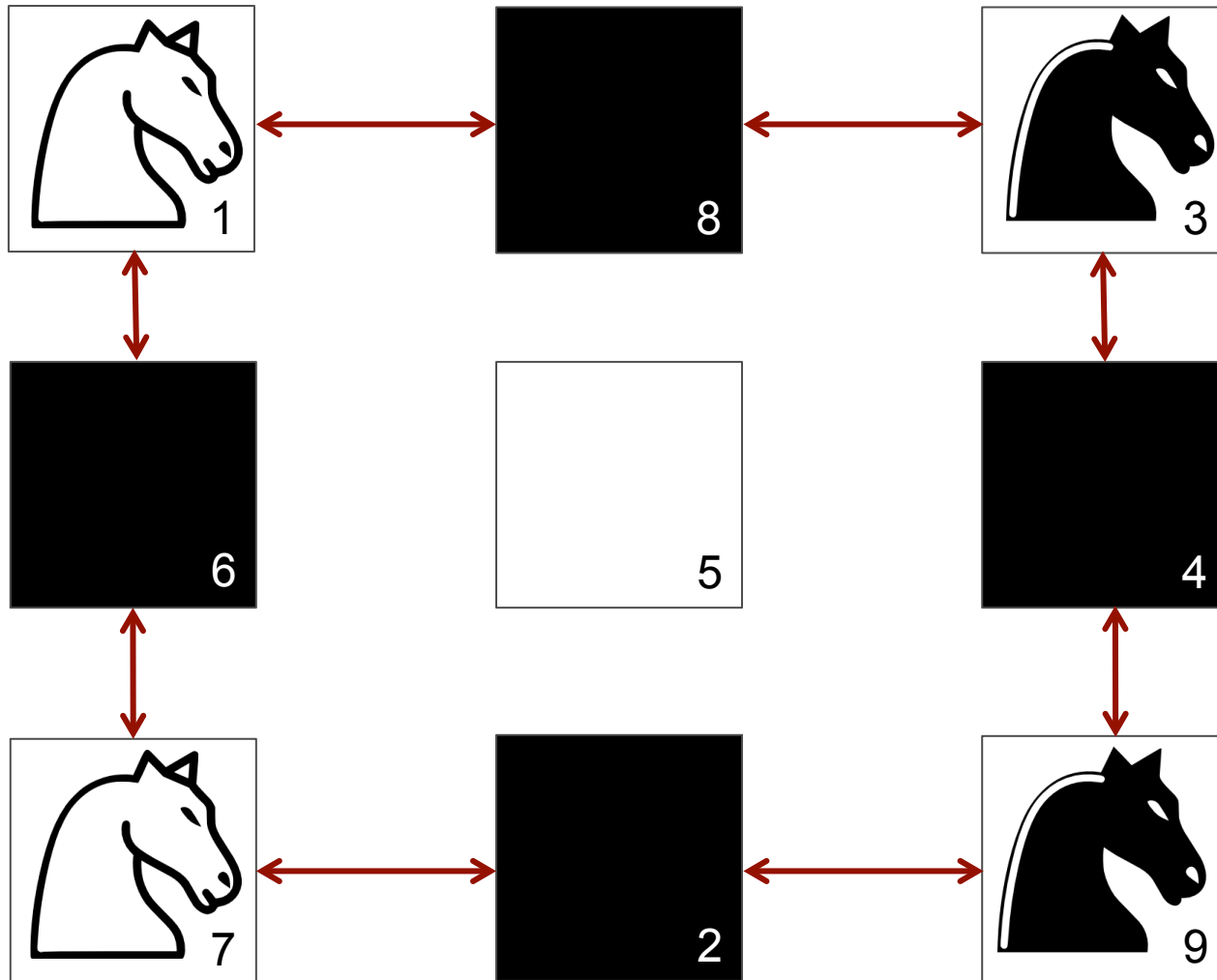
# Re-conceptualisation



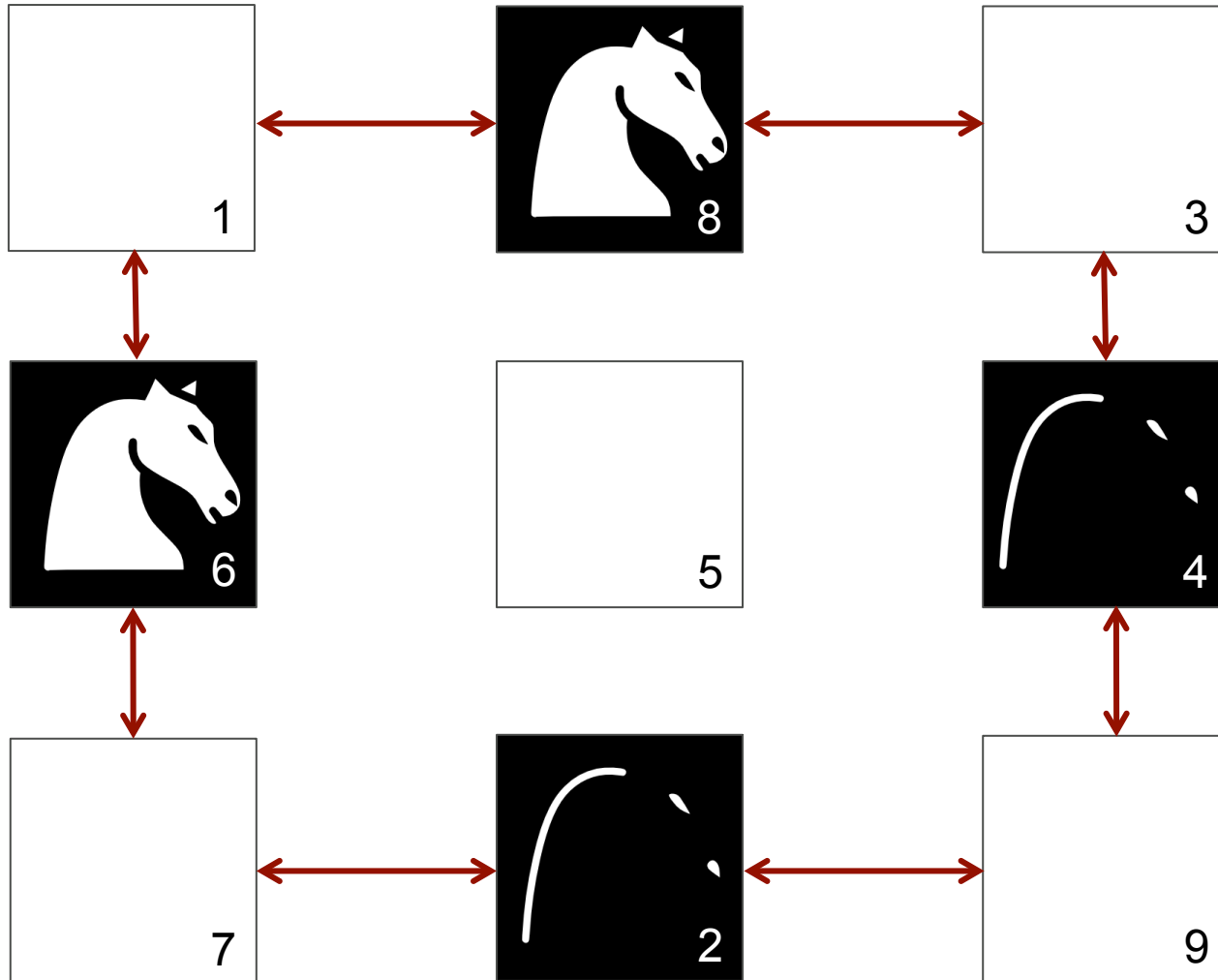
# Re-conceptualisation



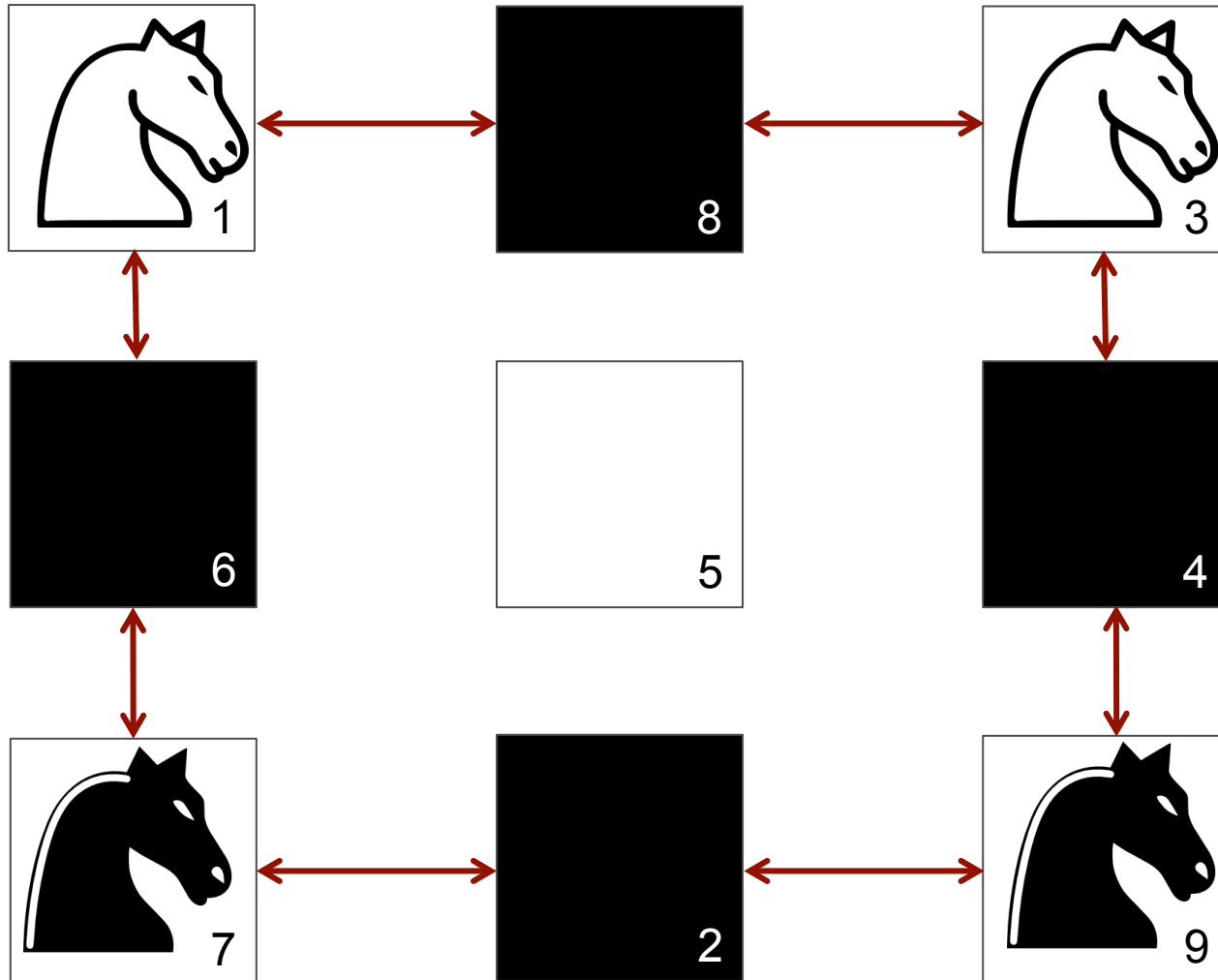
# Re-conceptualisation



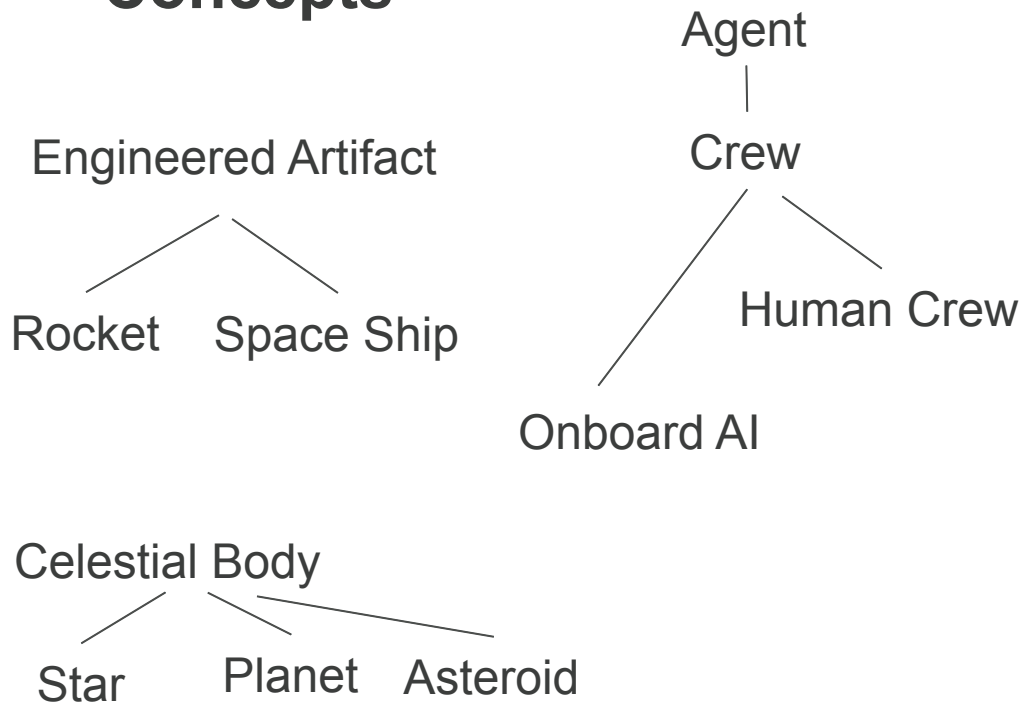
# Re-conceptualisation



# Re-conceptualisation



## Concepts



## Relations

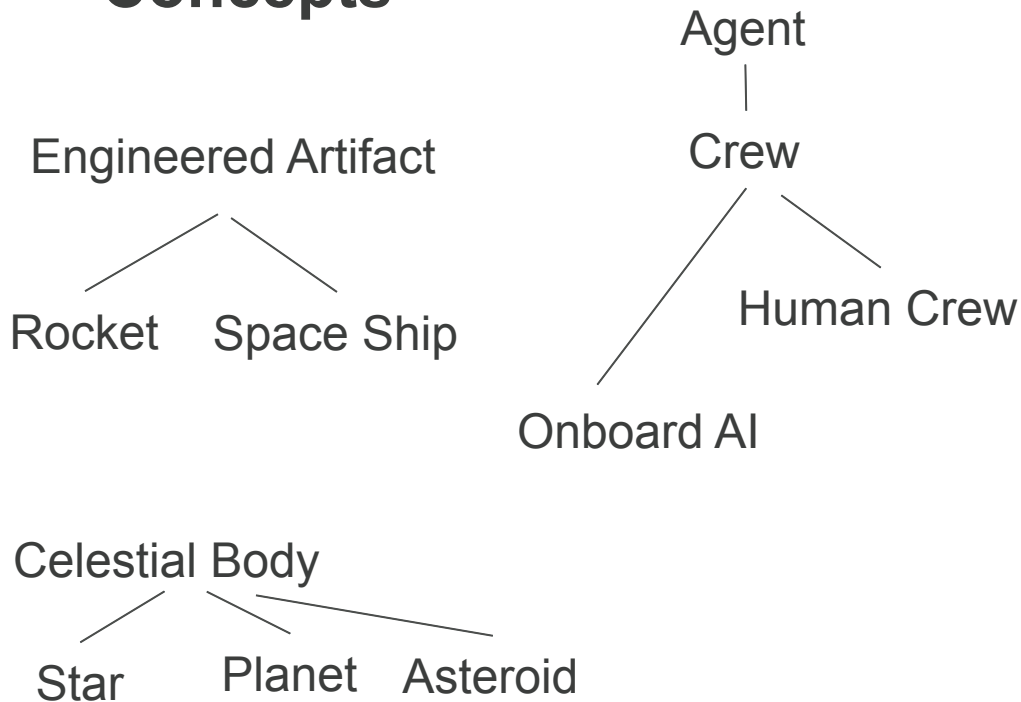
- Has Component
- Generates Thrust
- Has Name
- Has Mass
- Has Volume



# **K-HAL V1.0 KNOWLEDGE BASE**



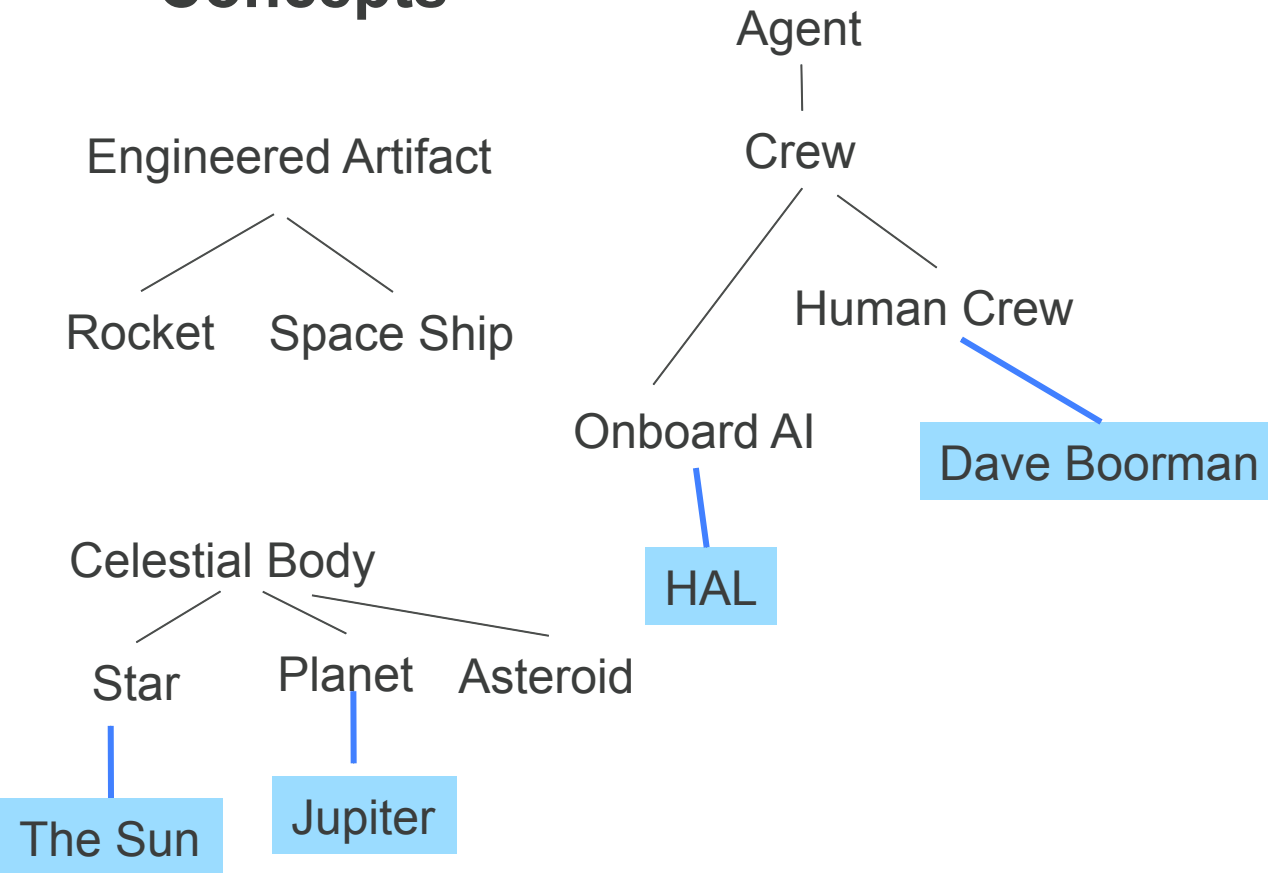
## Concepts



## Relations

- Has Component
- Generates Thrust
- Has Name
- Has Mass
- Has Volume

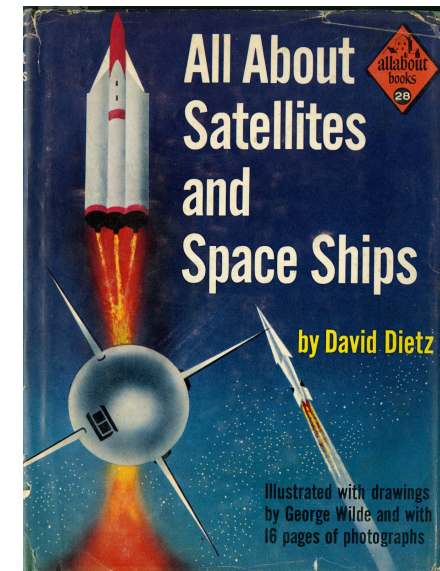
## Concepts



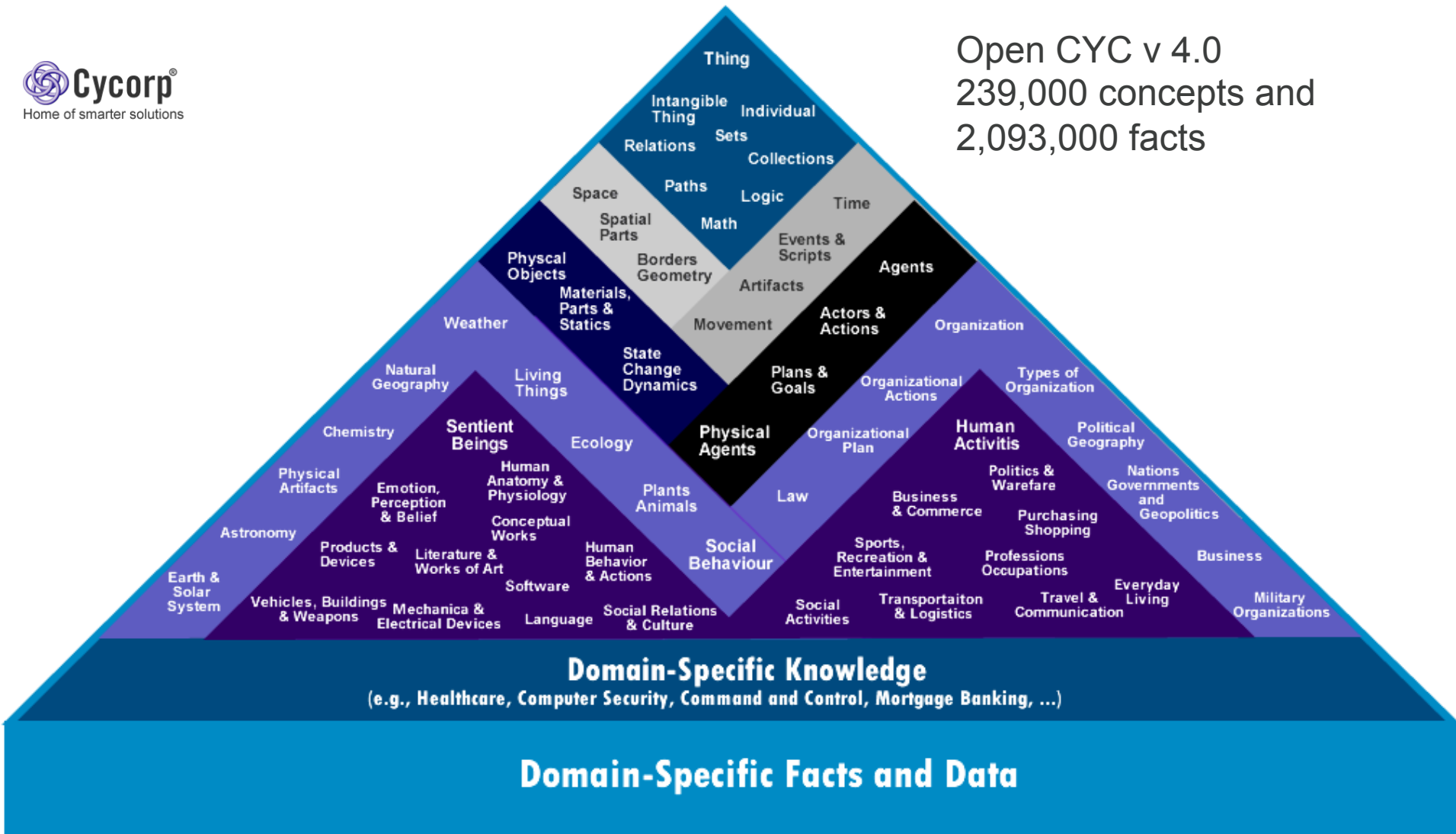
## Relations

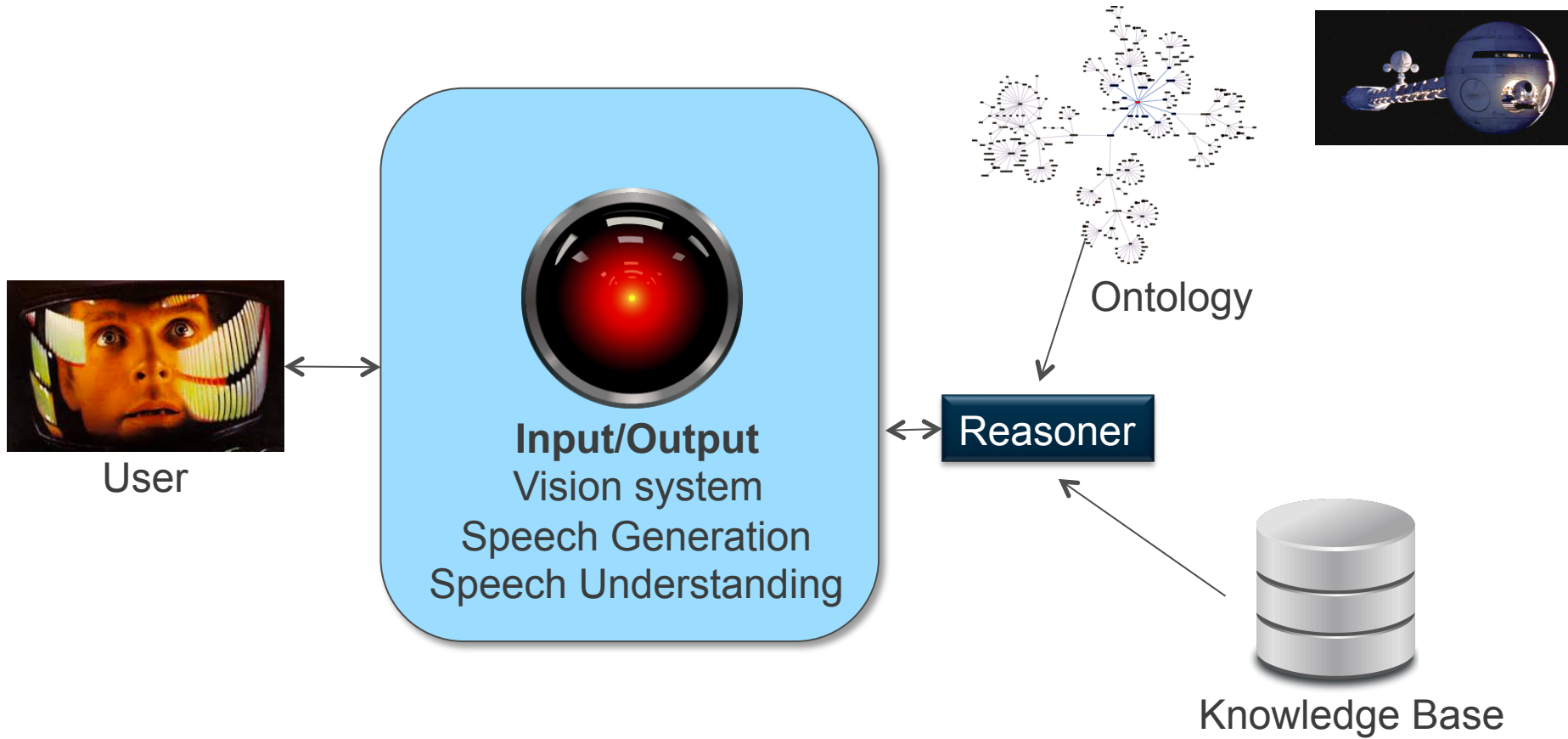
- Has Component
- Generates Thrust
- Has Name
- Has Mass
- Has Volume

# Knowledge Base



Open CYC v 4.0  
239,000 concepts and  
2,093,000 facts





# 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?

ontology space craft  

**Web** Images Videos News Shopping More ▾ Search tools

About 4,080,000 results (0.41 seconds)

**About: spacecraft - DBpedia**  
[dbpedia.org/ontology/Spacecraft](http://dbpedia.org/ontology/Spacecraft) ▾  
About: **spacecraft**. An Entity of Type : Class, from Named Graph : <http://dbpedia.org/resource/classes#>, within Data Space : [dbpedia.org](http://dbpedia.org) · About DBpedia ...

**<http://dbpedia.org/ontology/Spacecraft> - DBpedia Live**  
[live.dbpedia.org/ontology/Spacecraft](http://live.dbpedia.org/ontology/Spacecraft) ▾  
3 Apr 2014 - About: <http://dbpedia.org/ontology/Spacecraft>. An Entity ... spacecraft; ruimtevaartuig; vaisseau spatial; διαστημόπλοιο; 우주선; Raumfahrzeug.

**Ontology - NERD: Named Entity Recognition and ...**  
[nerd.eurecom.fr/ontology](http://nerd.eurecom.fr/ontology) ▾  
The NERD ontology is a set of mappings established manually between the taxonomies of ..... sub-class-of: <http://dbpedia.org/ontology/Spacecraft>: nerd:Product ...

**[PPT] Ontologies and MBSE**  
[www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:ontologies...](http://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:ontologies...) ▾  
**Ontologies** and Model-Based Systems Engineering. 2010-02-06. 1 .... Simple query: find id and name for the component whose name is "**Spacecraft** System".

**[PDF] Introduction to System Modeling and Ontologies - BEAC...**  
[trs-new.jpl.nasa.gov/dspace/bitstream/2014/42081/1/11-1269.pdf](http://trs-new.jpl.nasa.gov/dspace/bitstream/2014/42081/1/11-1269.pdf) ▾  
by S Jenkins - 2011 - Cited by 1 - Related articles  
Space Administration. Jet Propulsion Laboratory. California Institute of Technology. Pasadena, California. 31. Systems + Software. 3. Is This A Model? **spacecraft**.

**[PDF] Ontological Modeling for Integrated Spacecraft Analysis**  
[trs-new.jpl.nasa.gov/dspace/bitstream/2014/43526/1/11-5217\\_A1b.pdf](http://trs-new.jpl.nasa.gov/dspace/bitstream/2014/43526/1/11-5217_A1b.pdf) ▾  
by YW Tung - 2011 - Related articles  
Current **spacecraft** work as a cooperative group of a number of subsystems. ... I have created an **ontology** of functions specific to the modeling system of the ...

## About: spacecraft

An Entity of Type : [Class](#), from Named Graph : <http://dbpedia.org/resource/classes#>, within Data Space : [dbpedia.org](#)



Property	Value
<code>rdf:type</code>	<ul style="list-style-type: none"> <li>owl:Class</li> </ul>
<code>rdfs:label</code>	<ul style="list-style-type: none"> <li>spacecraft</li> </ul>
<code>rdfs:subClassOf</code>	<ul style="list-style-type: none"> <li>dbpedia-owl:MeanOfTransportation</li> </ul>
<code>is rdfs:domain of</code>	<ul style="list-style-type: none"> <li>dbpedia-owl:Spacecraft/apoapsis</li> <li>dbpedia-owl:Spacecraft/cargoFuel</li> <li>dbpedia-owl:Spacecraft/cargoGas</li> <li>dbpedia-owl:Spacecraft/cargoWater</li> <li>dbpedia-owl:Spacecraft/dockedTime</li> <li>dbpedia-owl:Spacecraft/dryCargo</li> <li>dbpedia-owl:Spacecraft/freeFlightTime</li> <li>dbpedia-owl:Spacecraft/periapsis</li> <li>dbpedia-owl:Spacecraft/port1DockedTime</li> <li>dbpedia-owl:Spacecraft/port2DockedTime</li> <li>dbpedia-owl:Spacecraft/totalCargo</li> <li>dbpedia-owl:Spacecraft/totalMass</li> <li>dbpedia-owl:cargoFuel</li> <li>dbpedia-owl:cargoGas</li> <li>dbpedia-owl:cargoWater</li> <li>dbpedia-owl:crew</li> <li>dbpedia-owl:decay</li> <li>dbpedia-owl:dockedTime</li> <li>dbpedia-owl:dryCargo</li> <li>dbpedia-owl:freeFlightTime</li> <li>dbpedia-owl:inclination</li> <li>dbpedia-owl:launch</li> <li>dbpedia-owl:port1</li> <li>dbpedia-owl:port1DockedTime</li> <li>dbpedia-owl:port1DockingDate</li> <li>dbpedia-owl:port1UndockingDate</li> <li>dbpedia-owl:port2</li> <li>dbpedia-owl:port2DockedTime</li> <li>dbpedia-owl:port2DockingDate</li> <li>dbpedia-owl:port2UndockingDate</li> <li>dbpedia-owl:regime</li> <li>dbpedia-owl:rocket</li> <li>dbpedia-owl:targetSpaceStation</li> <li>dbpedia-owl:totalCargo</li> <li>dbpedia-owl:totalMass</li> </ul>
<code>is rdfs:range of</code>	<ul style="list-style-type: none"> <li>dbpedia-owl:spacecraft</li> </ul>



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Voting results

## 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 IAUT 93 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



*International*

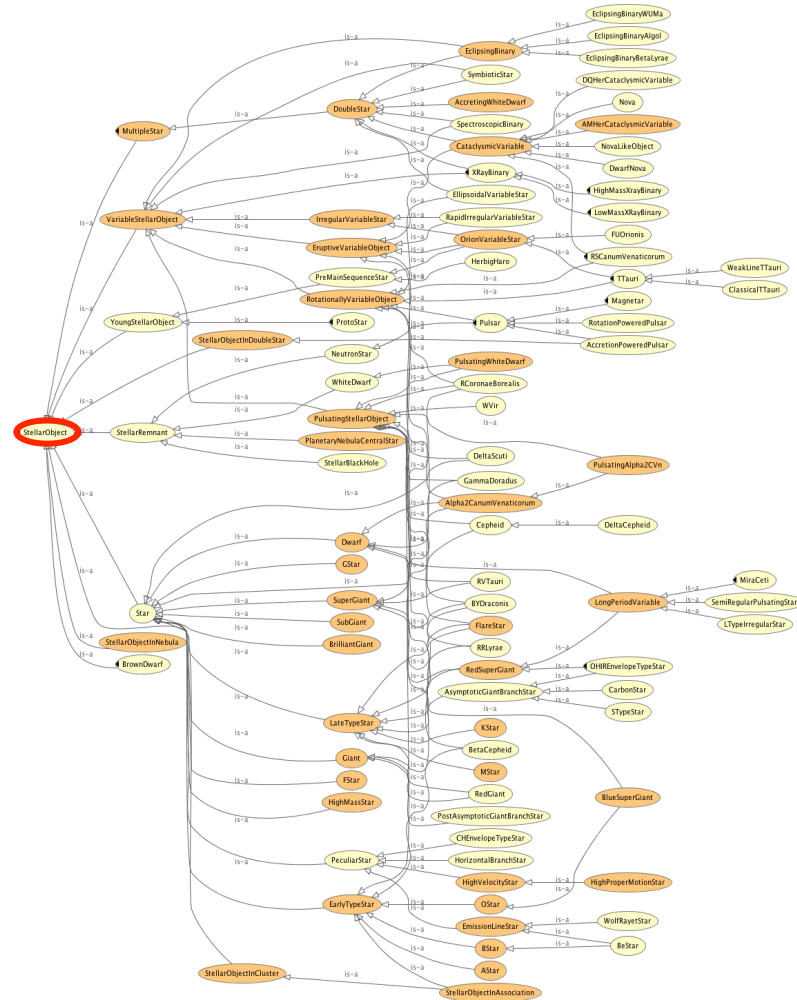
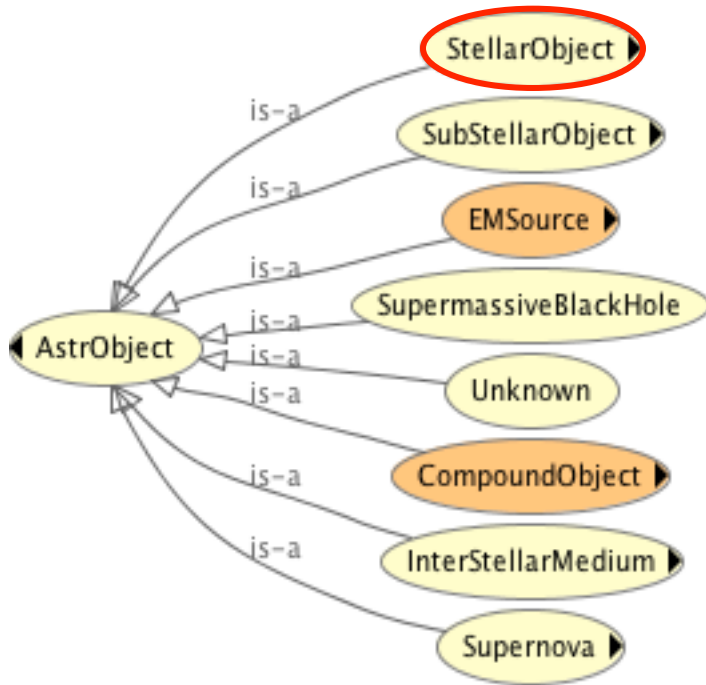
*Virtual*

*Observatory*

*Alliance*

## 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  
Hydaraulic-System  
Hydarulic-Power-Units  
Inflyght-Crew-Escape-System  
Intertank  
Landing-Gear-System  
Liquid-Hydrogen-Tank  
Liquid-Oxygen-Tank  
Main-Propulsion-System  
Microcassete-Recorder  
Midfuselage  
Operational-Bioinstrumentation-System  
Orbial-Manuevering-System  
Orbital-Maneuvering-System  
Orbiter-External-Tank-Seperation-System  
Orbiter-Flight-Crew-Escape-System  
Orbiter-Passive-Contro-Systeml  
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  
Sighting-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

- Finding ontologies
- Understanding ontologies
- Connecting ontologies
- Adapting ontologies
- Version control
- Agility
  - New ontologies, changes in used ontologies ...
- .....





Elena Simperl Tutorial 10:45am Tuesday















Be Lazy

# K-HAL V2.0 DATA

# Solar Objects > 400km Radius



Body	Image	Mean radius (km)	Mean radius (R <sub>⊕</sub> )	Volume (10 <sup>9</sup> km <sup>3</sup> )	Volume (V <sub>⊕</sub> )	Mass ×10 <sup>21</sup> kg (Yg)	Mass (M <sub>⊕</sub> )	Density [note 1] g/cm <sup>3</sup>	Surface gravity (m/s <sup>2</sup> )	Surface gravity (g <sub>⊕</sub> )	Type of object
Sun		696 000 <sup>[9]</sup>	109	1,412,000,000	1,304,000	1,989,000,000	333,000	1.409	274.0	28.02	Star
Jupiter		69 911 ±6	10.97	1,431,280	1,321	1,898,600	317.83	1.33	24.79	2.535	Planet (gas giant)
Saturn		58 232 ±6 (w/o rings)	9.14	827,130	764	568,460	95.159	0.70	10.445	1.06	Planet (gas giant)
Uranus		25 362 ±7	3.98	68,340	63.1	86,832	14.536	1.30	8.87	0.90	Planet (gas giant)
Neptune		24 622 ±19	3.86	62,540	57.7	102,430	17.147	1.76	11.15	1.140	Planet (gas giant)
Earth		6 371	1	1,083.21	1	5,973.6	1	5.515	9.78033	0.99732	Planet (terrestrial)
Venus		6 052 ±1 (w/o gas)	0.950	928.43	0.857	4,868.5	0.815	5.24	8.872	0.905	Planet (terrestrial)
Mars		3 389.5 ±0.2	0.532	163.18	0.151	641.85	0.107	3.94	3.7	0.38	Planet (terrestrial)
Ganymede <sup>†</sup> Jupiter III		2 634.1 ±0.3	0.413	76.30	0.0704	148.2	0.0248	1.936	1.428	0.15	Satellite of Jupiter
Titan <sup>†</sup> Saturn VI		2 576 ±2 (w/o gas)	0.404	71.52	0.0660	134.5	0.0225	1.88	1.354	0.14	Satellite of Saturn
Mercury		2 440 ±1	0.383	60.83	0.0562	330.2	0.0553	5.43	3.7	0.38	Planet (terrestrial)
Callisto <sup>†</sup> Jupiter IV		2 410 ±2	0.378	58.65	0.0541	107.6	0.018	1.83	1.23603	0.126	Satellite of Jupiter

# 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

[More information](#)

[Go to resource](#)

[deref-vocab](#)

[format-dc](#)

[format-foaf](#)

[format-owl](#)

[format-po](#)

[format-rdf](#)

[government](#)

[nasa](#)

[published-by-third-...](#)

[space](#)

# Spacecraft component data



SPACE TECHNOLOGY

INDUSTRIAL SOLUTIONS

COMPANY

CONTACT



SPACE TECHNOLOGY AND INDUSTRIAL SOLUTIONS

- 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...



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



- 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...





Classify



SDSS



Invert

Examples

Restart

**SHAPE**

Is the galaxy simply smooth and rounded, with no sign of a disk?



Smooth



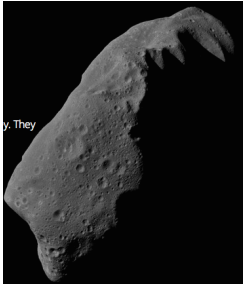
Features or disk



Star or artifact

# More Zoos

## ASTEROID ZOO



## MOON ZOO



THE ROYAL OBSERVATORY GREENWICH PRESENTS

## SOLAR STORMWATCH

HOME

WHY SCIENTISTS NEED YOU

MISSION BRIEFING

SPOT & TRACK STORMS

TALK ABOUT IT

### 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

Photo by NASA

### PLANET FOUR

Classify

About

Profile

Discuss

Blog

A Zooniverse project

Come help explore the surface of Mars

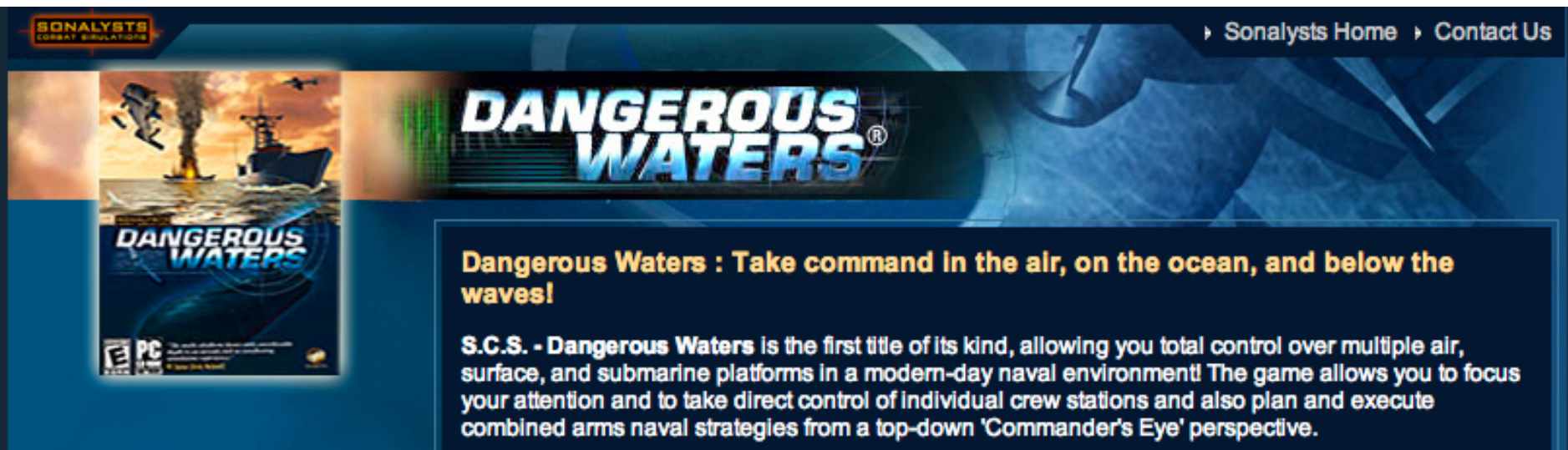
116,539

participants worldwide

4,347,291

MRO images classified





The screenshot shows a website banner for the game 'Dangerous Waters'. At the top left is the 'SONALYSTS COMBAT SIMULATIONS' logo. To the right are navigation links: 'Sonalysts Home' and 'Contact Us'. The main title 'DANGEROUS WATERS' is displayed in large, stylized blue and white letters. Below the title is a description of the game. On the left side of the banner is a small image of the game's PC box art, which depicts a naval battle scene with ships and aircraft.

**DANGEROUS WATERS**

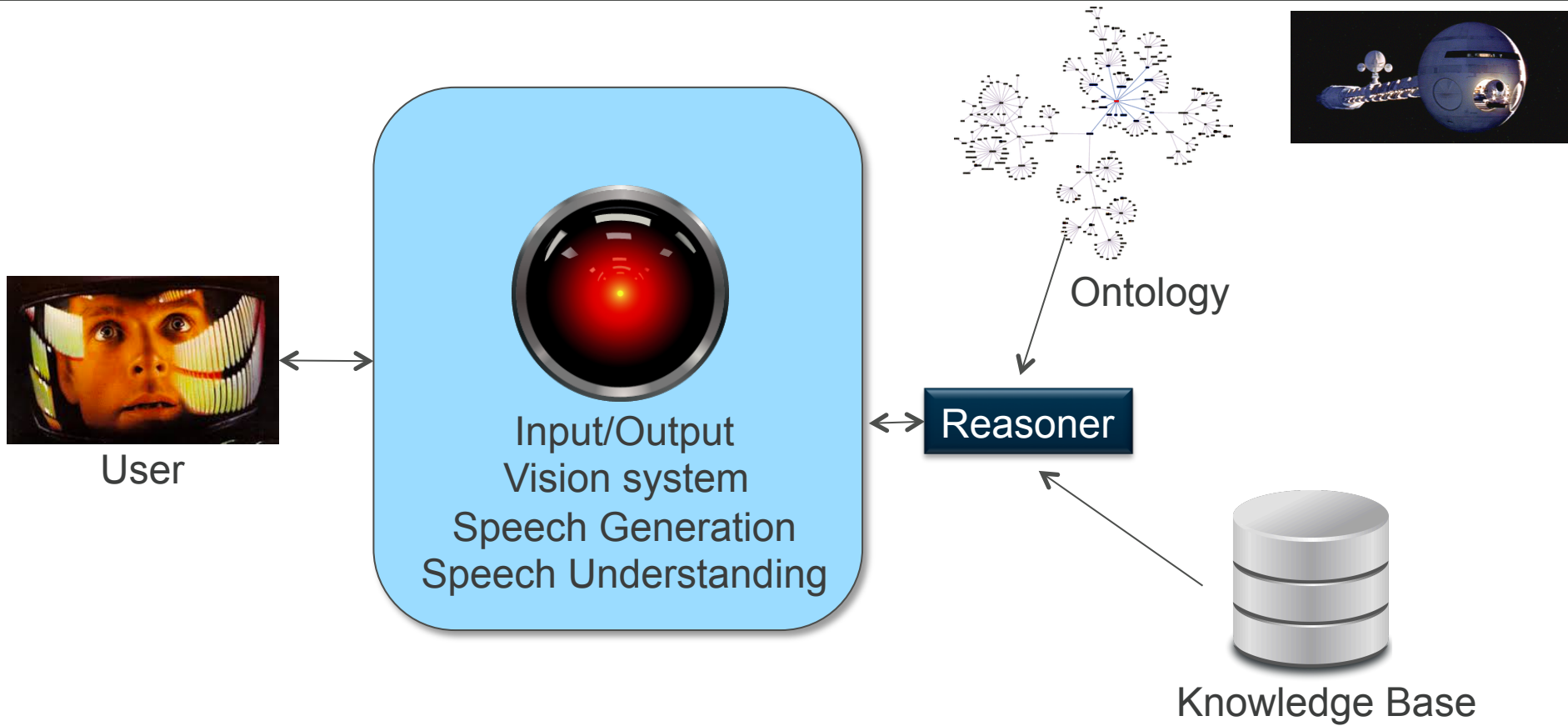
**Dangerous Waters : Take command in the air, on the ocean, and below the waves!**

**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.

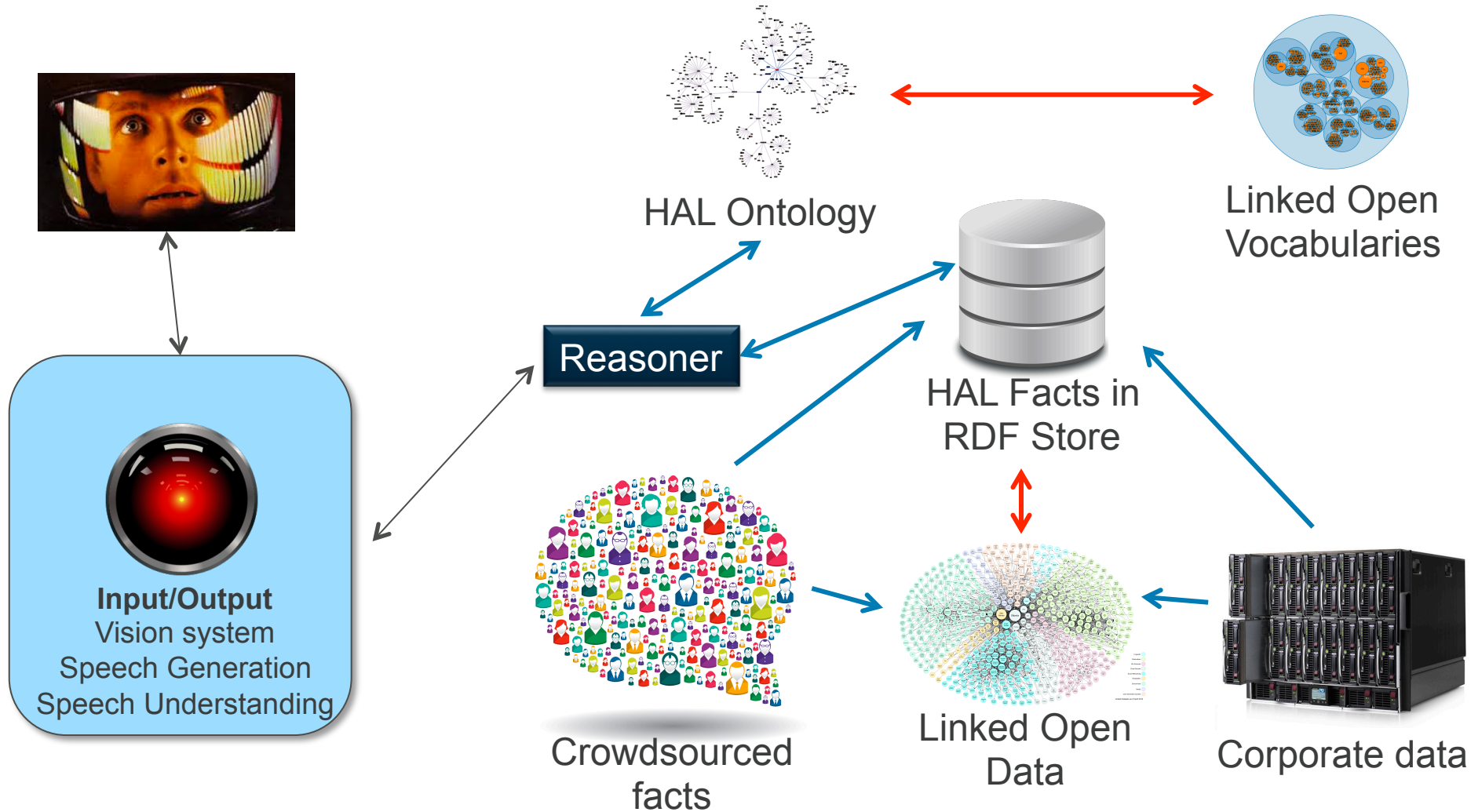
- Social Semantic Web and crowdsourcing
  - Elena Simperl Tutorial Wednesday 2pm
- Using Mechanical Turk to solve Linked Data problems
  - Maribel Acosta Hands-on Wednesday 3pm



# K-HAL v 1.0



# K-HAL v 2.0 Architecture



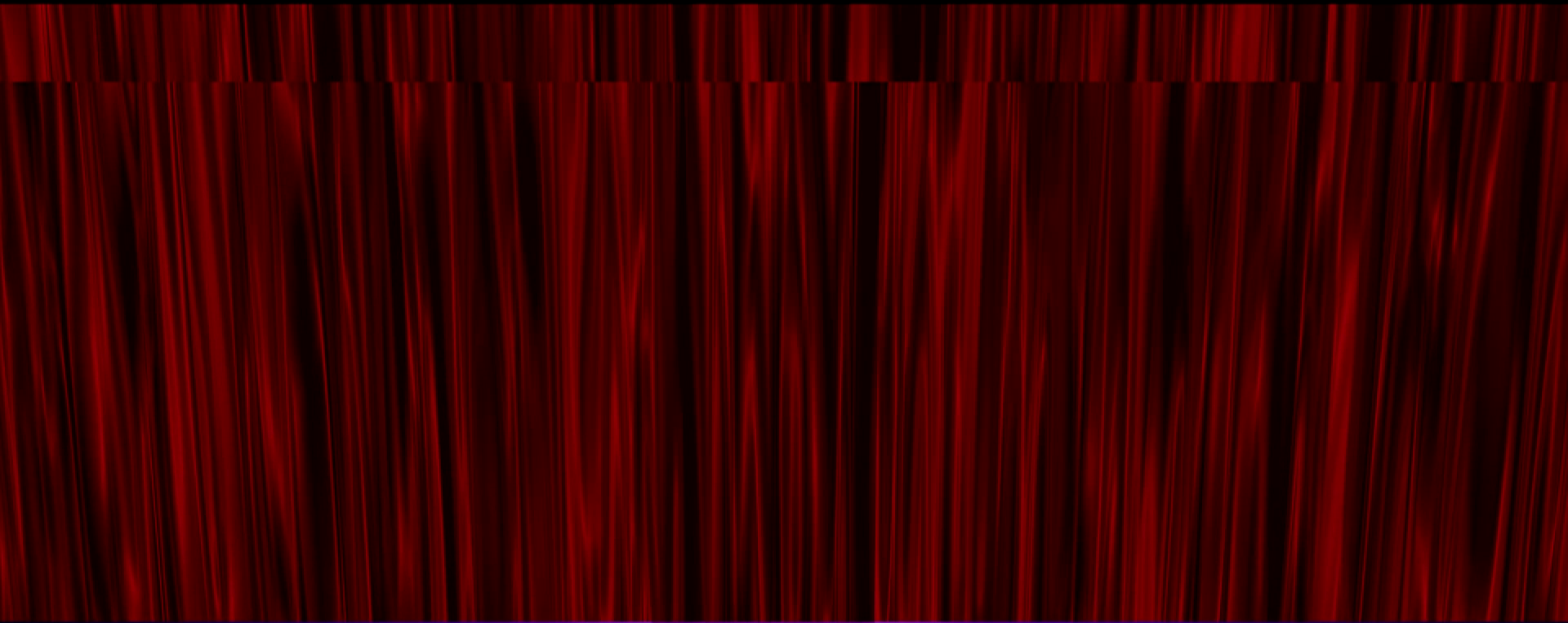


What about processes?

# **BUILDING K-HAL V3.0**



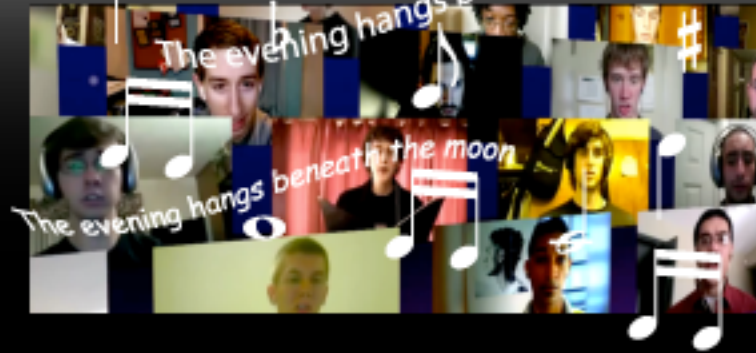
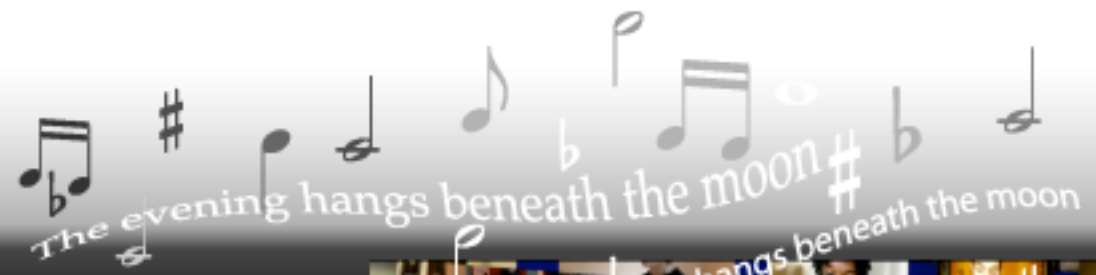
STI · INTERNATIONAL



# Virtual Choir

INTERNATIONAL

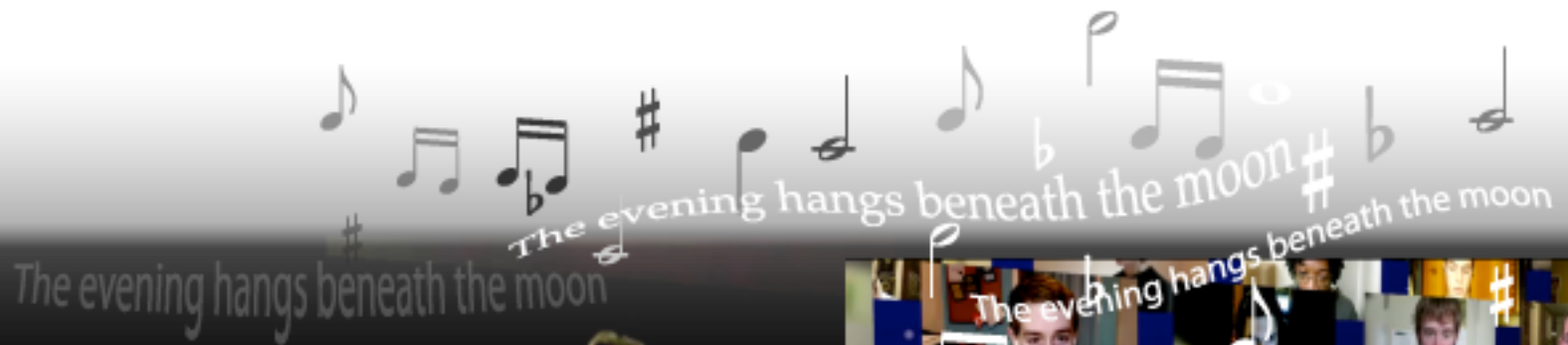




## Choir

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





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# SALAD2014

ESWC2014 workshop  
May 26, 2014

## Services and Applications over Linked APIs and Data

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BONJOUR ♦ APÉRITIF ♦ MENU ♦ A LA CARTE ♦ CHEFS

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~ Services and Applications over Linked APIs and Data ~



Be Lazy

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





Be kind and  
share

### 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....



September 1-6, 2014 | Kalamaki, Crete, GR

# 4th ESWC Summer School

# THANKS