

The background of the slide is a detailed painting. It depicts a character with a black bowl-cut hairstyle and a serious expression, wearing a blue and black uniform. He is positioned in the center, looking towards the viewer. Behind him is a large, arched window or doorway that looks out onto a dark space filled with white crosshair-like patterns, suggesting a starry sky or a technical display. To the right, a desk lamp with a glass globe sits on a wooden surface. The overall style is reminiscent of classic oil paintings but with a sci-fi theme.

# Knowledge Graphs

## Lecture 2 – Basic Knowledge Graph Infrastructure

### 2.6 Logical Inference with RDF(S)

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# Knowledge Graphs

## Lecture 2: Basic Knowledge Graph Infrastructure

- 2.1 How to Identify and Access Things
- 2.2 How to Represent Simple Facts with RDF
- 2.3 RDF Turtle Serialization
- 2.4 Vocabularies and Model Building with RDFS
- 2.5 RDF Complex Data Structures

Excursion 1: RDF Reification and RDF\*

### 2.6 Logical Inference with RDF(S)

Excursion 2: RDFa – RDF and the Web

# What does it really mean?



## We need more semantic expressivity...

# Induction, Deduction, Abduction

- The terms **infer/inference** are often used almost interchangeably with **entail/entailment**.
  - “**entail**” refers conceptually to what follows as a consequence,
  - “**infer**” refers to a process of computing entailments and is very similar to “**reason/reasoning**”.
- **Deductive reasoning** involves applying **rules** over **premises** to derive **conclusions** and is the main subject of **Logic**.
- **Inductive reasoning** involves learning **patterns** from lots of **examples** and is the main subject of **Machine Learning**.
- **Abductive reasoning** involves deriving a likely **explanation** for an observation based on a **rule**.

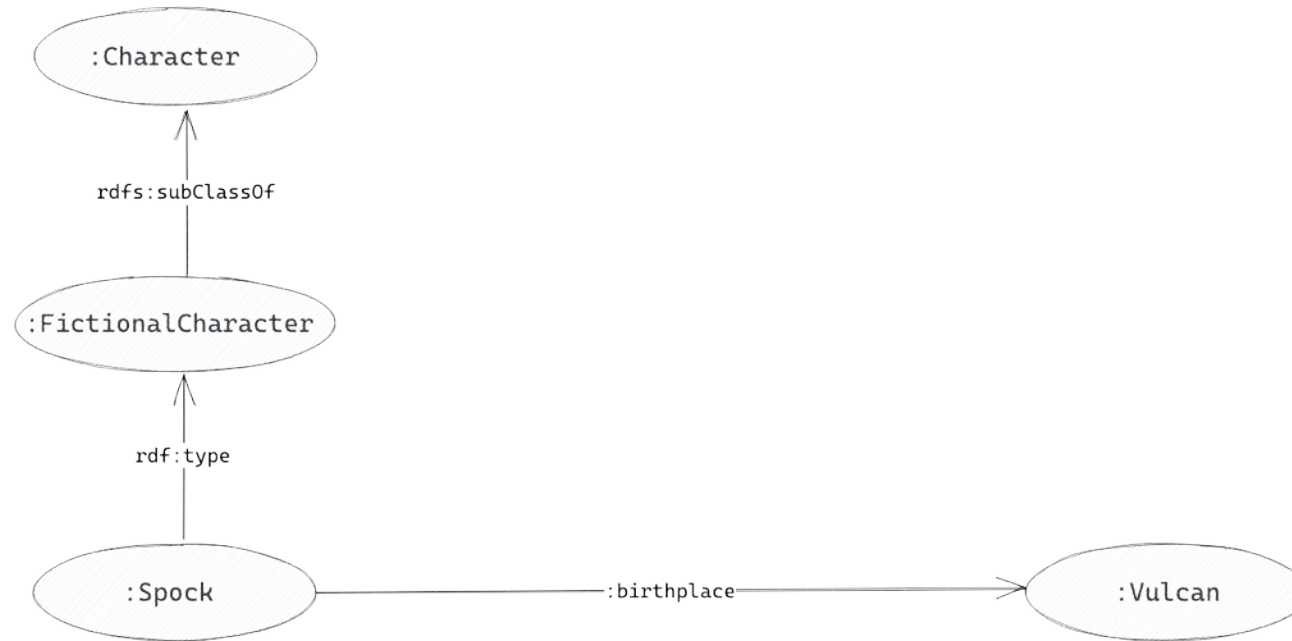
# RDF(S) Semantics

- In contrast to other data definition languages, RDF(S) is based on **formal semantics**.
- Formal semantics enables RDF(S) to draw **valid** and **sound logical inferences**.
- Examples:
  - `:Spock` `rdf:type` `:FictionalCharacter` .
  - `:FictionalCharacter` `rdfs:subClassOf` `:Character` .
  - `:birthPlace` `rdfs:subPropertyOf` `:origin` .

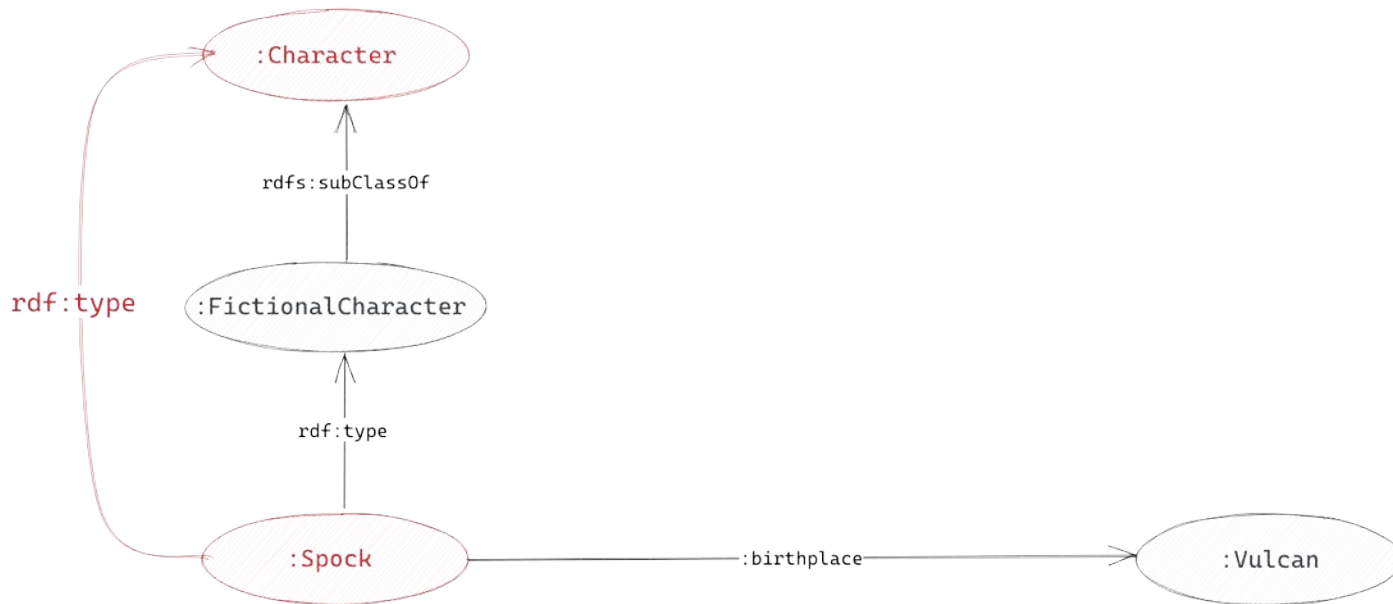
`:Spock`  $\in$  `:FictionalCharacter`  
`:FictionalCharacter`  $\subseteq$  `:Character`  
`:birthPlace`  $\subseteq$  `:origin`

**Model-theoretic Semantics**

# Which Conclusions can we draw with RDF(S)?



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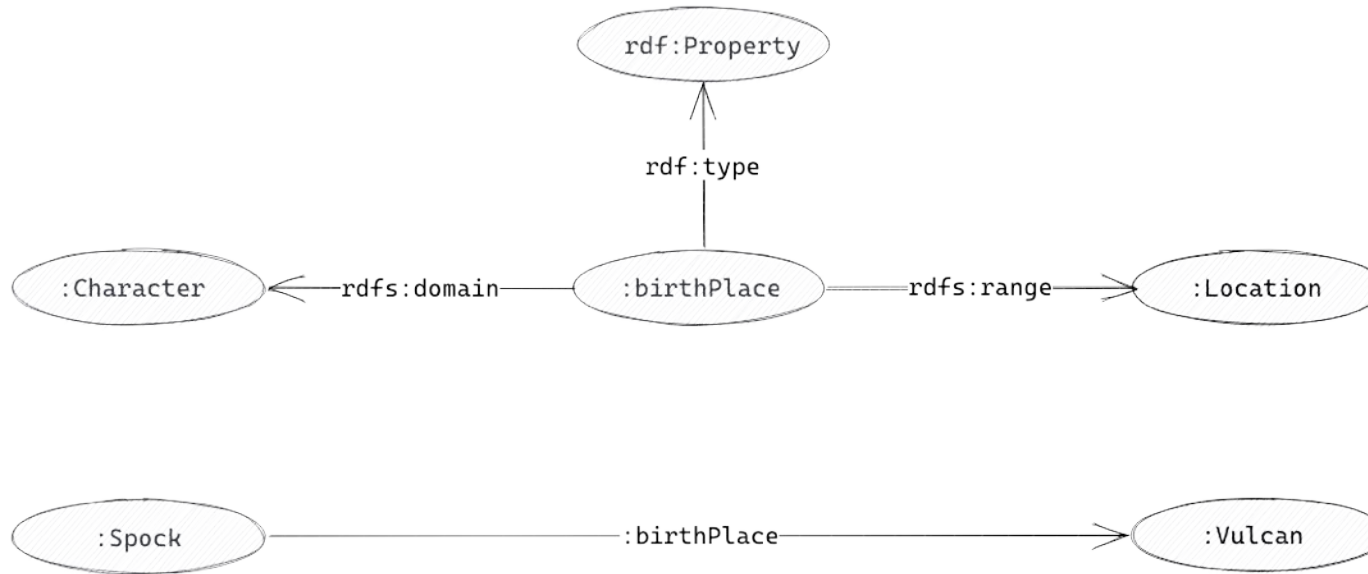


(1) Deduction of **new facts** from a **class hierarchy**.

$$\forall i, c_1, c_2: T(i, \text{rdf:type}, c_1) \wedge T(c_1, \text{rdfs:subClassOf}, c_2) \rightarrow T(i, \text{rdf:type}, c_2)$$

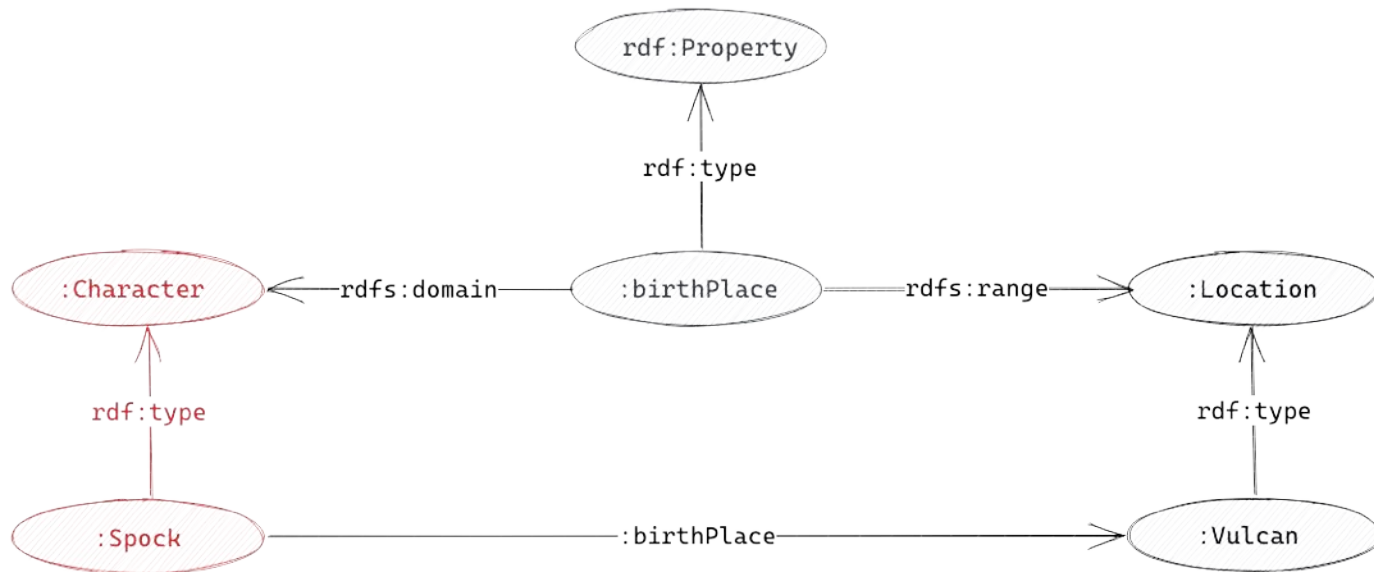


# Which Conclusions Can We Draw with RDF(S)?





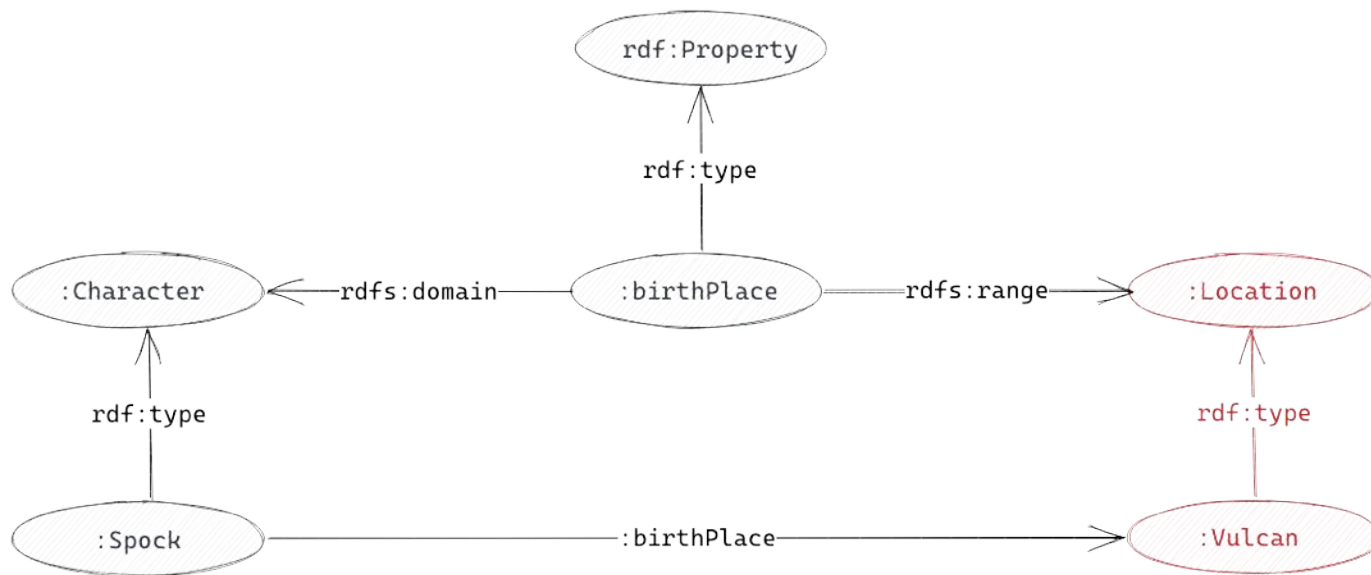
# Which Conclusions Can We Draw with RDF(S)?



(2) Deduction of entity **class membership** from the **domain** of one of its properties.

$$\begin{aligned} \forall i_1, i_2, c_1, c_2, p: & \quad T(i_1, p, i_2) \wedge \\ & \quad T(p, \text{rdfs:domain}, c_1) \wedge T(p, \text{rdfs:range}, c_2) \\ & \rightarrow T(i_1, \text{rdf:type}, c_1) \wedge T(i_2, \text{rdf:type}, c_2) \end{aligned}$$

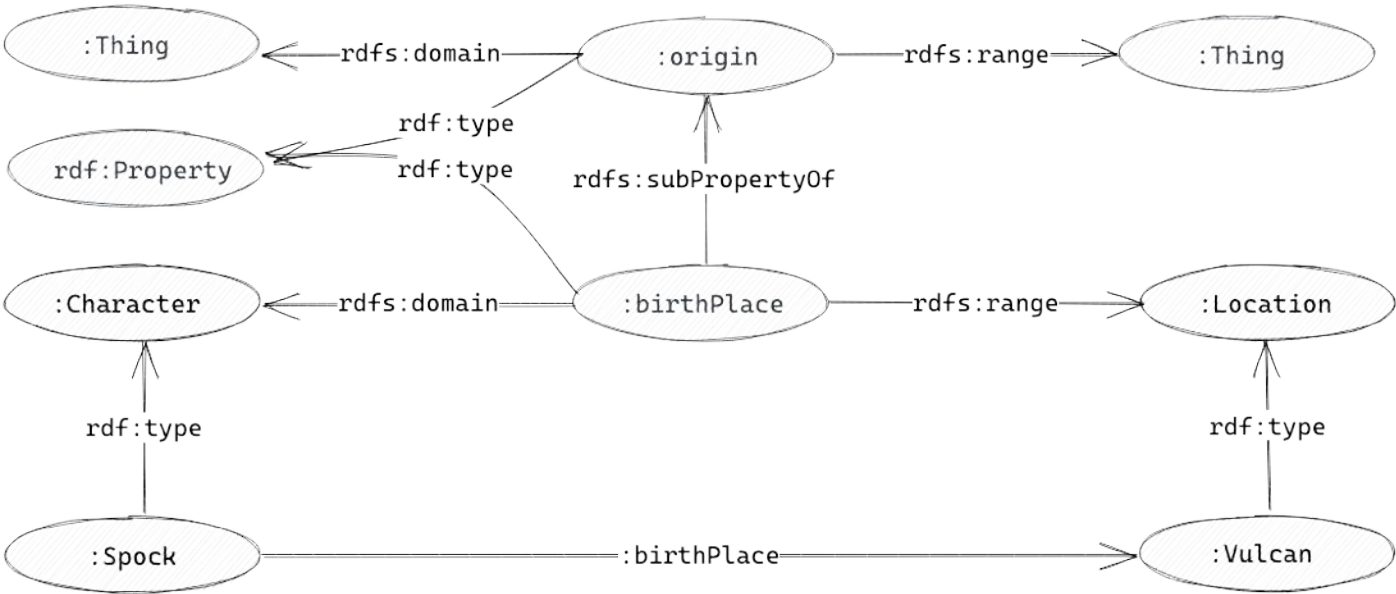
# Which Conclusions Can We Draw with RDF(S)?



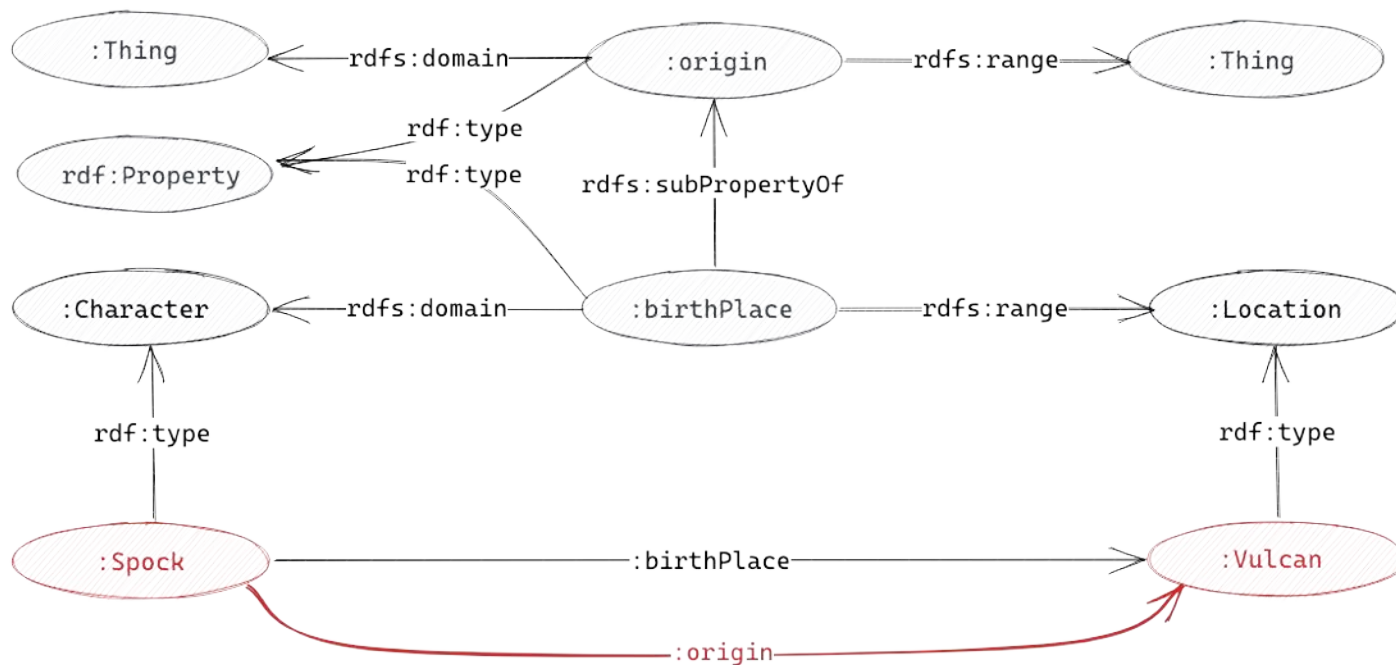
(3) Deduction of entity **class membership** from the **range** of one of its properties.

$$\begin{aligned}
 \forall i_1, i_2, c_1, c_2, p: \quad & T(i_1, p, i_2) \wedge \\
 & T(p, \text{rdfs:domain}, c_1) \wedge T(p, \text{rdfs:range}, c_2) \\
 & \rightarrow T(i_1, \text{rdf:type}, c_1) \wedge T(i_2, \text{rdf:type}, c_2)
 \end{aligned}$$

# Which Conclusions Can We Draw with RDF(S)?



# Which Conclusions Can We Draw with RDF(S)?



(4) Deduction of **new facts** from **subproperty** relationships.

$$\forall i_1, i_2, p_1, p_2: T(i_1, p_1, i_2) \wedge T(p_1, \text{rdfs:subPropertyOf}, p_2) \rightarrow T(i_1, p_2, i_2)$$



# Excursion 2: RDFa – RDF and the Web

Next Lecture...



### Bibliographic References:

- Patrick J. Hayes, Peter F. Patel-Schneider, [RDF 1.1 Semantics](#), W3C Recommendation 25 February 2014.
- Aidan Hogan (2020), [The Web of Data](#), Springer.
  - Chapt. 4.3 RDF(S) Model Theoretic Semantics, pp. 128–170.
  - Chapt. 4.4 RDF(S) Inference, pp. 171–181.

### Picture References:

- [1] “Mr. Spock, science officer of the USS Enterprise in a room with the walls covered with interlinked RDF source code fragments in the style of a High Renaissance painting.”, created via ArtBot, ProtoGen Diffusion, 2023, [CC-BY-4.0], <https://tinybots.net/artbot>
- [2] ““A dystopian city street scene clearly exhibiting the consequences of both unchecked population growth on society and the hoarding of resources by a wealthy minority in the style of a 1960s pulp cover.”, created via ArtBot, Deliberate, 2023, [CC-BY-4.0], <https://tinybots.net/artbot>