

Knowledge Graphs

Lecture 1 – Knowledge Representation with Graphs

1.5 Knowledge Graphs

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Lecture 1: Knowledge Representation with Graphs

1.1 From Data to Knowledge

1.2 Knowledge and how to represent it

1.3 The Art of Understanding

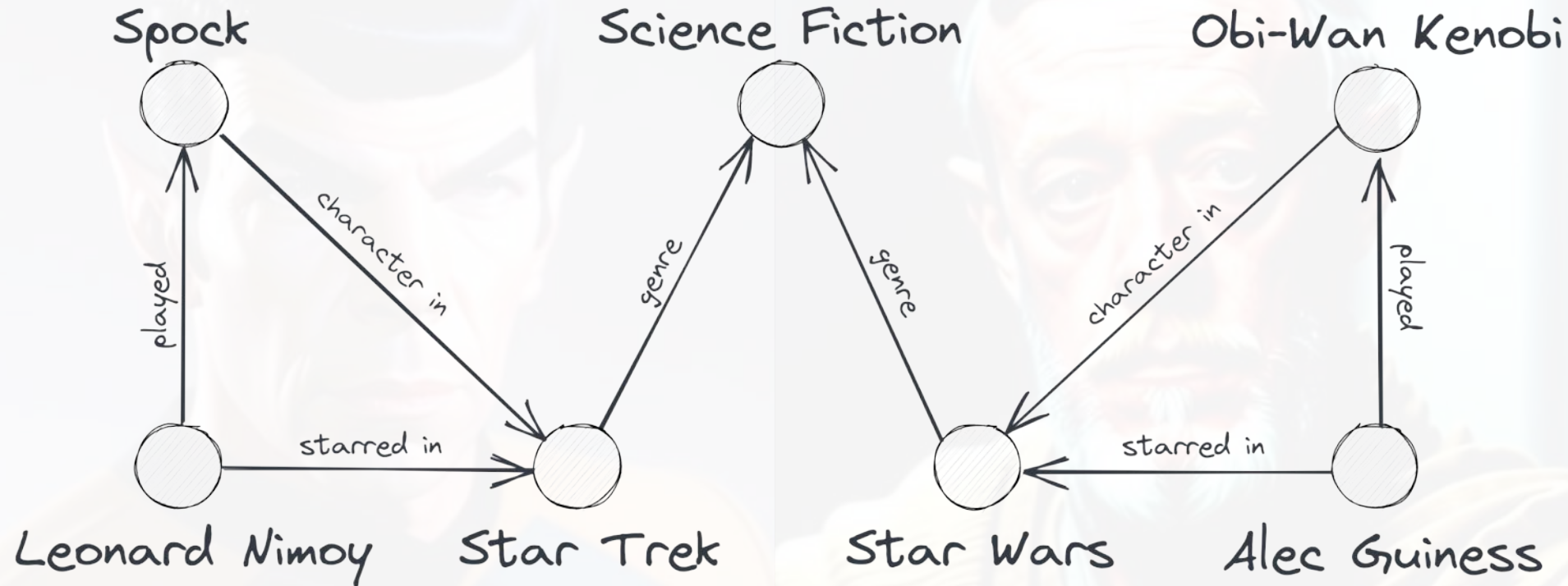
1.4 Graphs and Triples

1.5 Knowledge Graphs

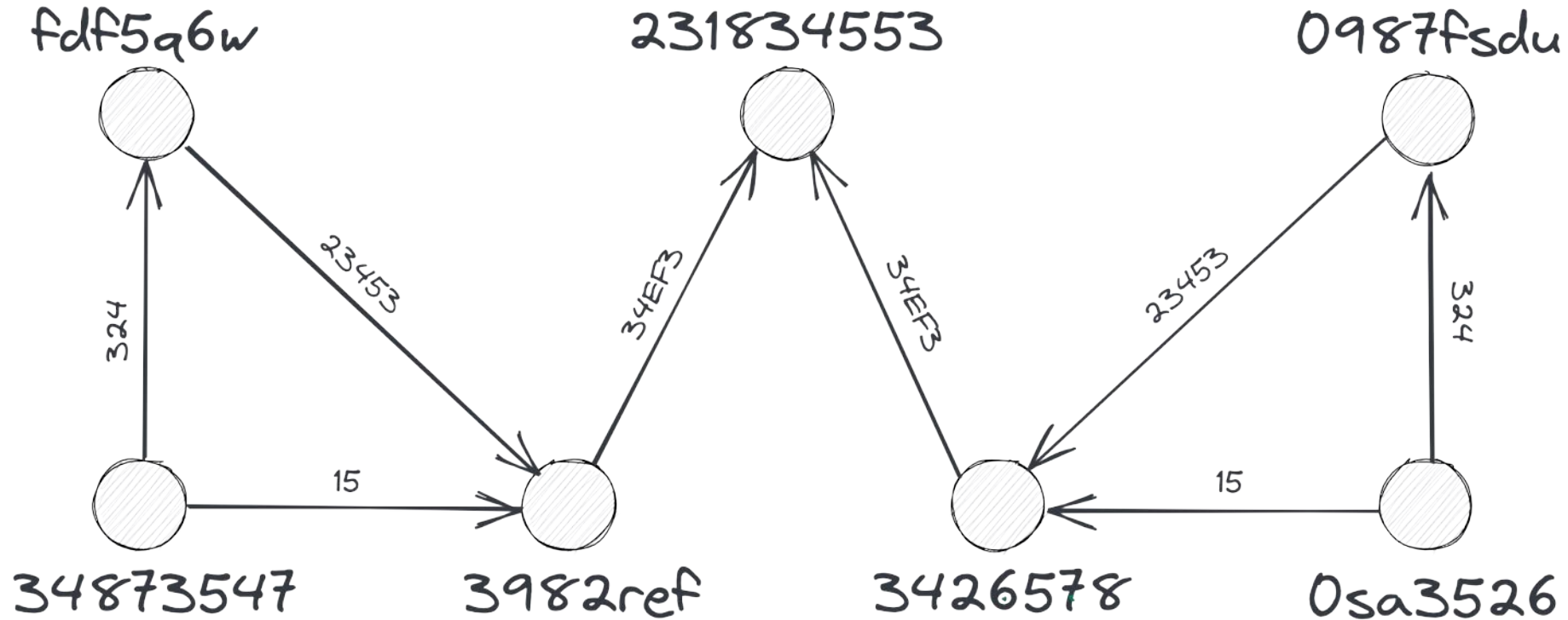
1.6 The Semantic Web

1.7 Linked Data and the Web of Data

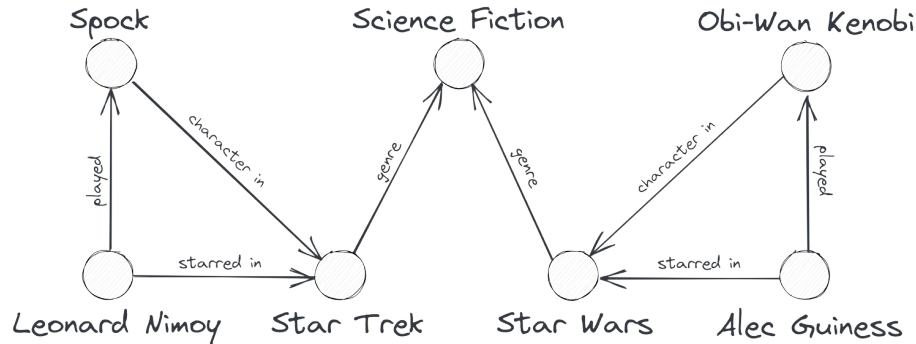
An Intuitive Way to Represent Knowledge



...but what is the Meaning?



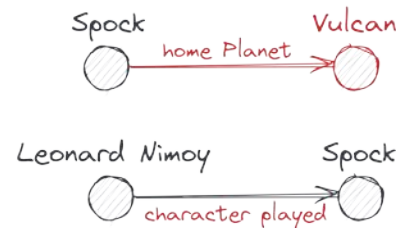
The Traditional Solution



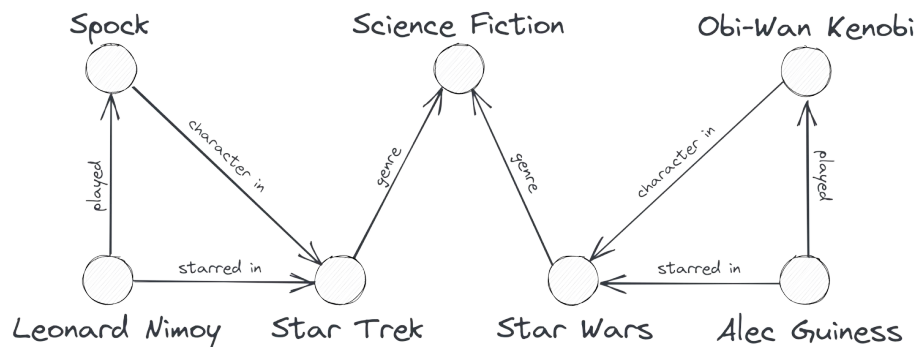
- The **(human)** programmer reads (and understands) the labels.
- The programmer encodes the meaning (as far as she understood it) into **software**.
- Thereby, the software can **interpret the data correctly**.

But beware: **πάντα ῥεῖ; “everything flows”** (Heraclitus, 6th century BCE)

- What if new labels are introduced?
- What if labels are changing?



Implicit vs Explicit Knowledge Representation



- The Semantics is given **implicitly** encoded via **natural language**.
- Prerequisites for **Interoperability**:
 - People prepare natural language definitions for the used terms (**terminology/glossary**).
 - Everybody agrees to apply those terminologies/glossaries (**metadata standardization**).
 - Everybody **interprets** natural language **uniquely in the same way**.



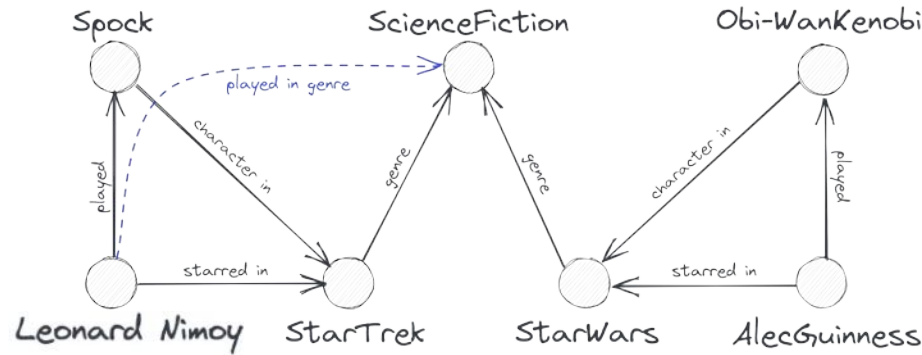
A knowledge graph

- (i) mainly describes real world **entities** and their **interrelationships**
- (ii) defines possible **classes** and **relations** of entities
- (iii) allows for **potentially interrelating arbitrary entities**
- (iv) covers **various topical domains**.

Paulheim (2017)

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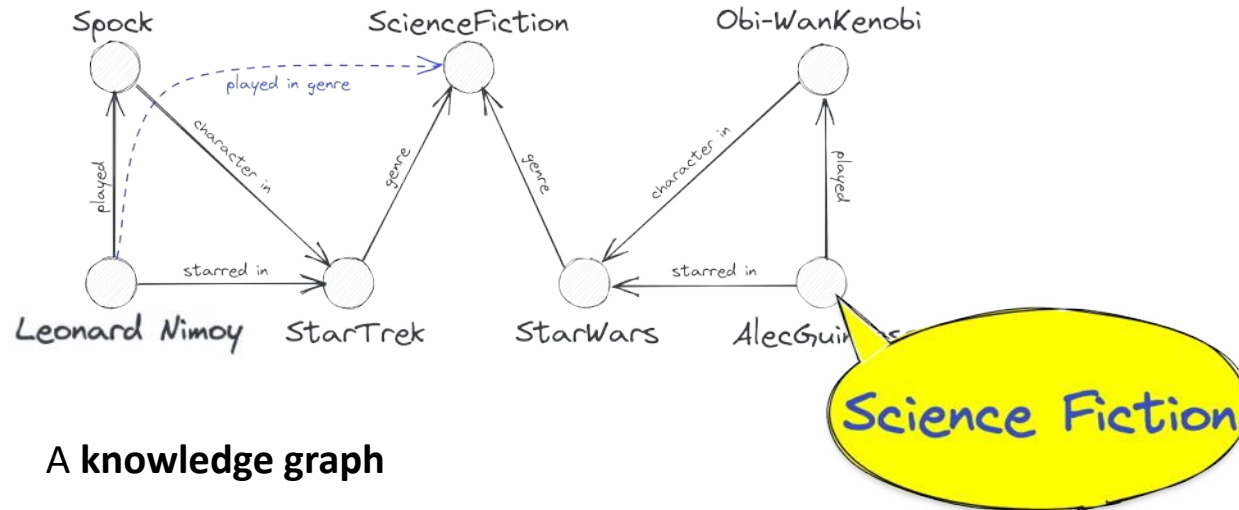
Let's Create a Knowledge Graph



A knowledge graph

- (i) mainly describes real world **entities** and their **interrelations**, **organized in a graph**,
- (ii) defines possible **classes** and **relations** of entities in a **schema**,
- (iii) allows for **potentially interrelating arbitrary entities** with each other and
- (iv) covers **various topical domains**.

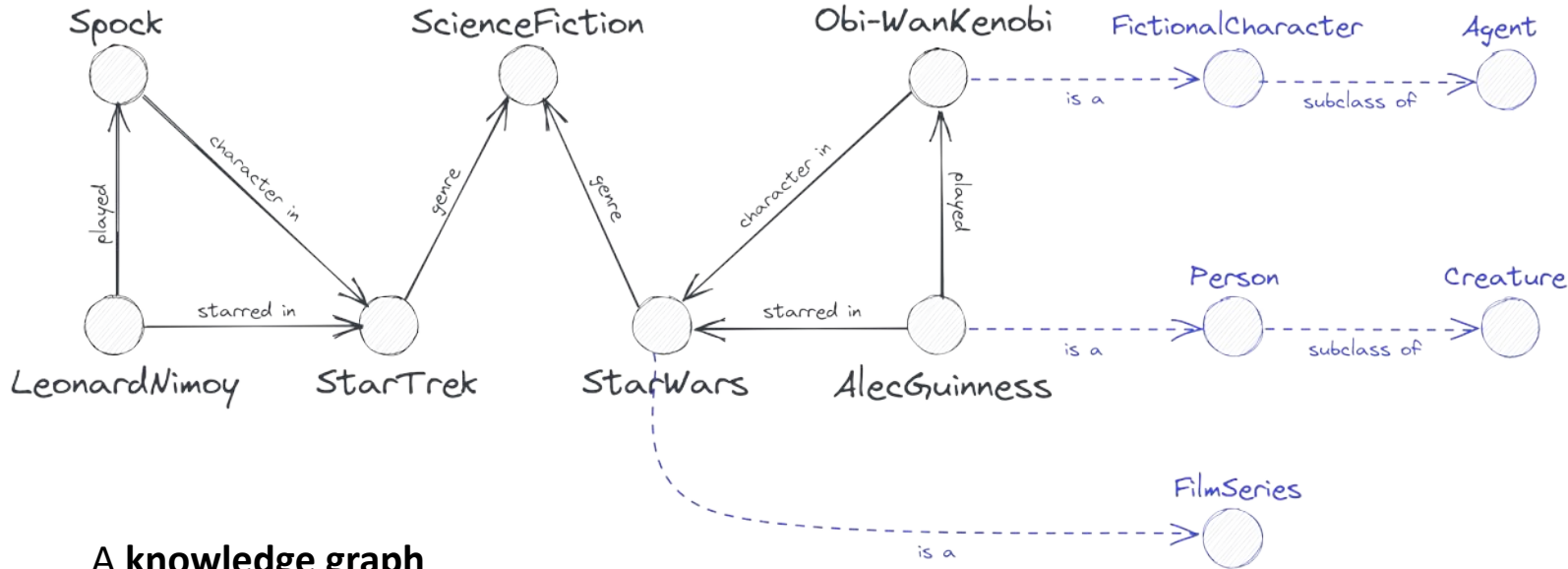
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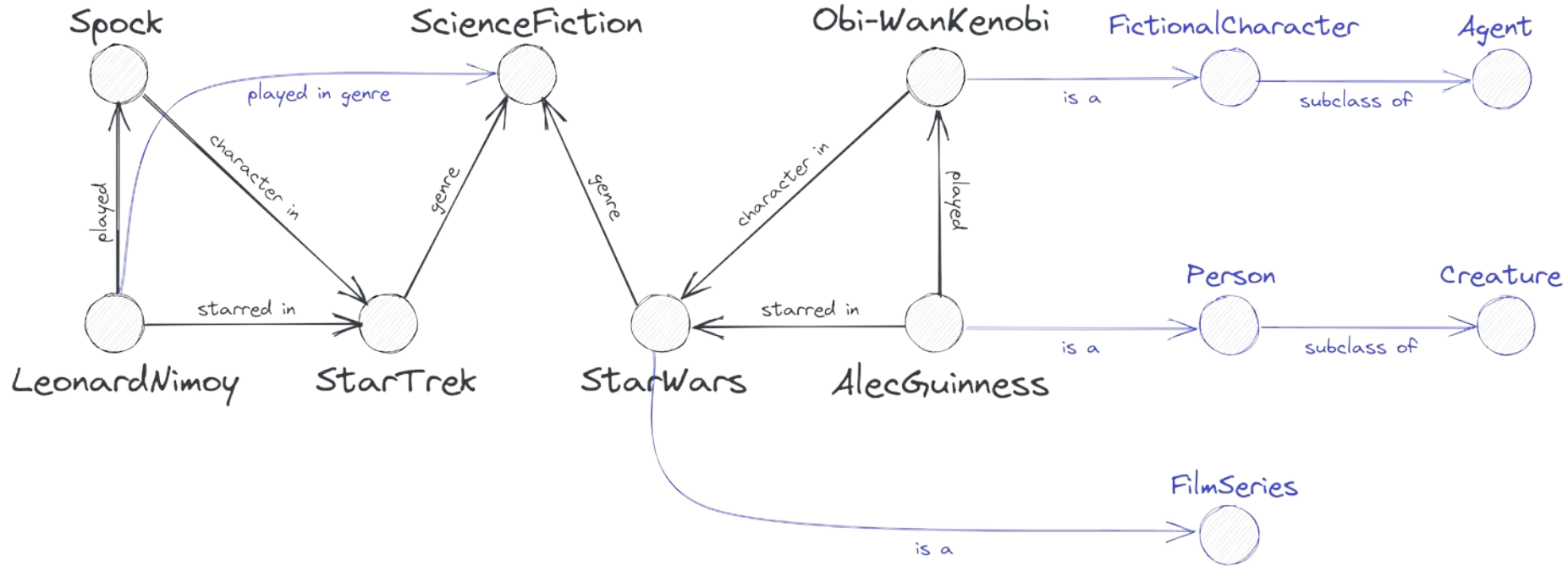
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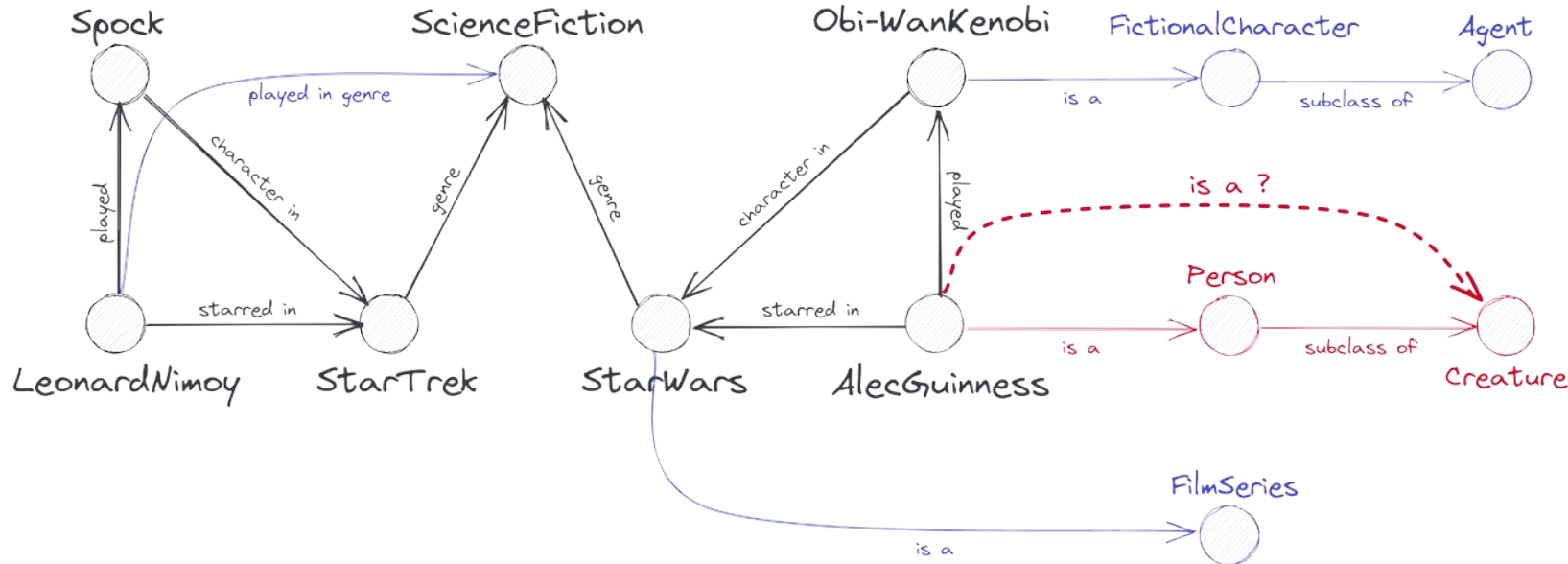
...is this already enough?



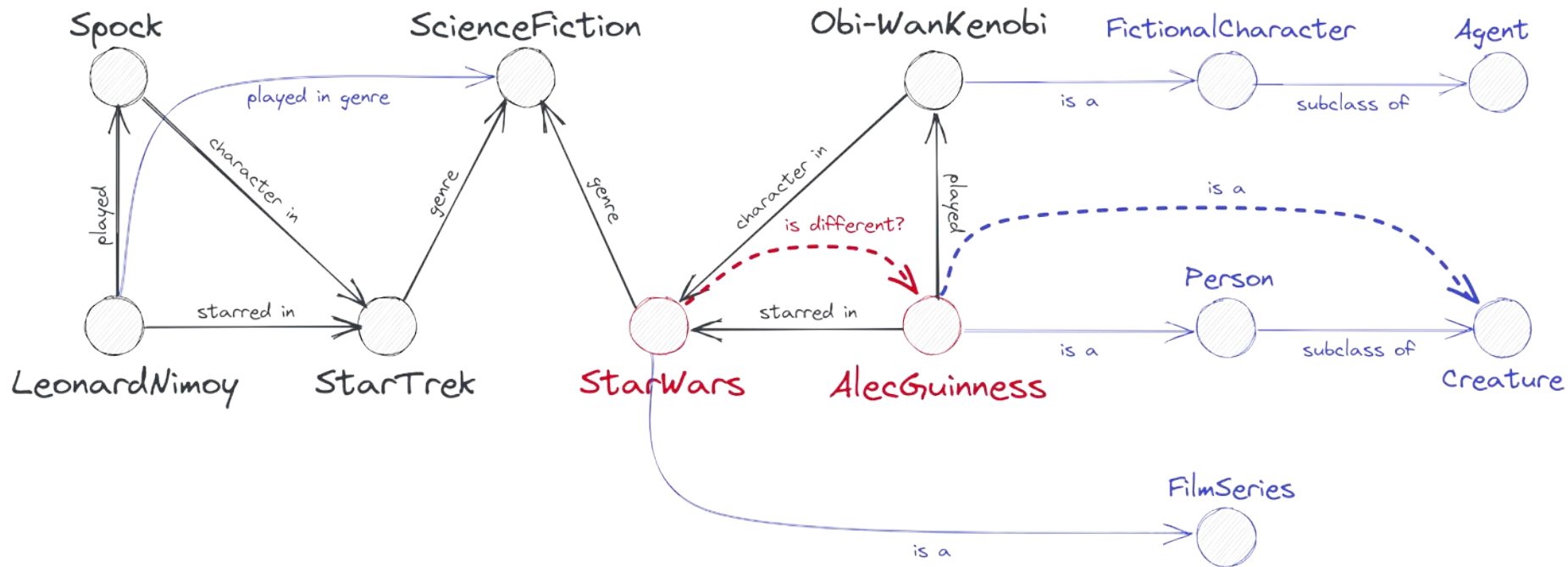
Can we deduce that Alec Guinness is a “Creature”?

Can be solved via individual software code:

```
IF ((Alec Guinness, is a, Person) AND (Person, subclass of, Creature))  
THEN  
  (Alec Guinness, is a, Creature)
```



Is Alec Guinness different from "Star Wars"?

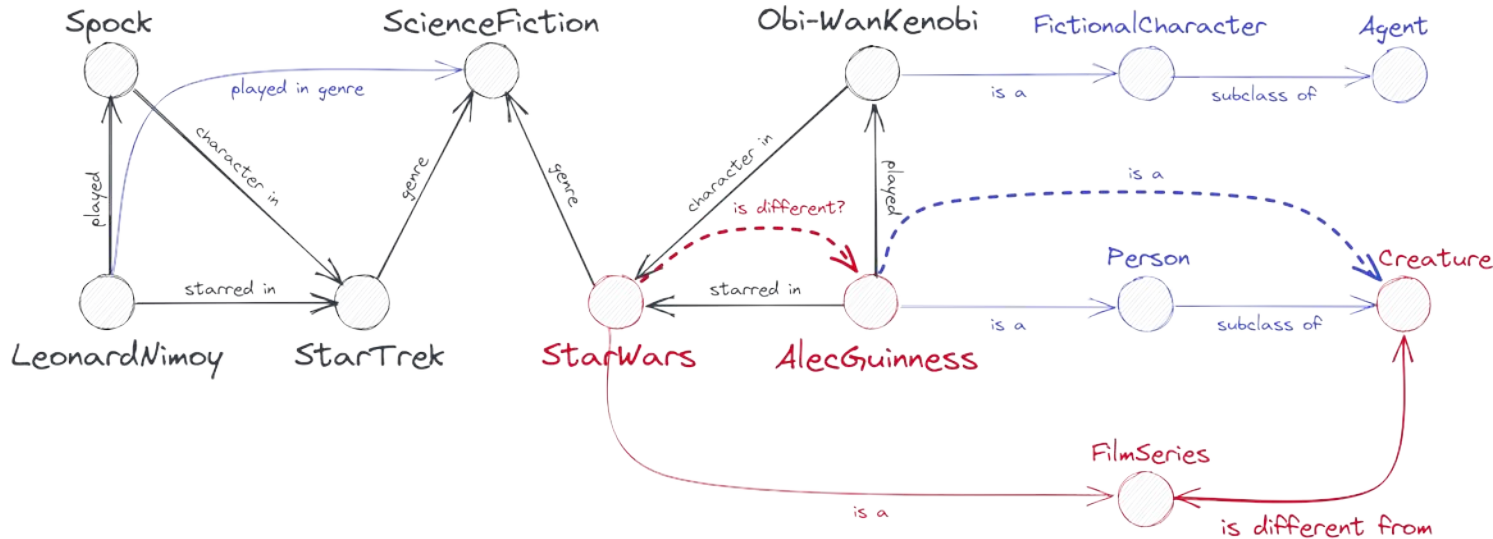


Is Alec Guinness different from "Star Wars"?

Can also be solved via individual software code:

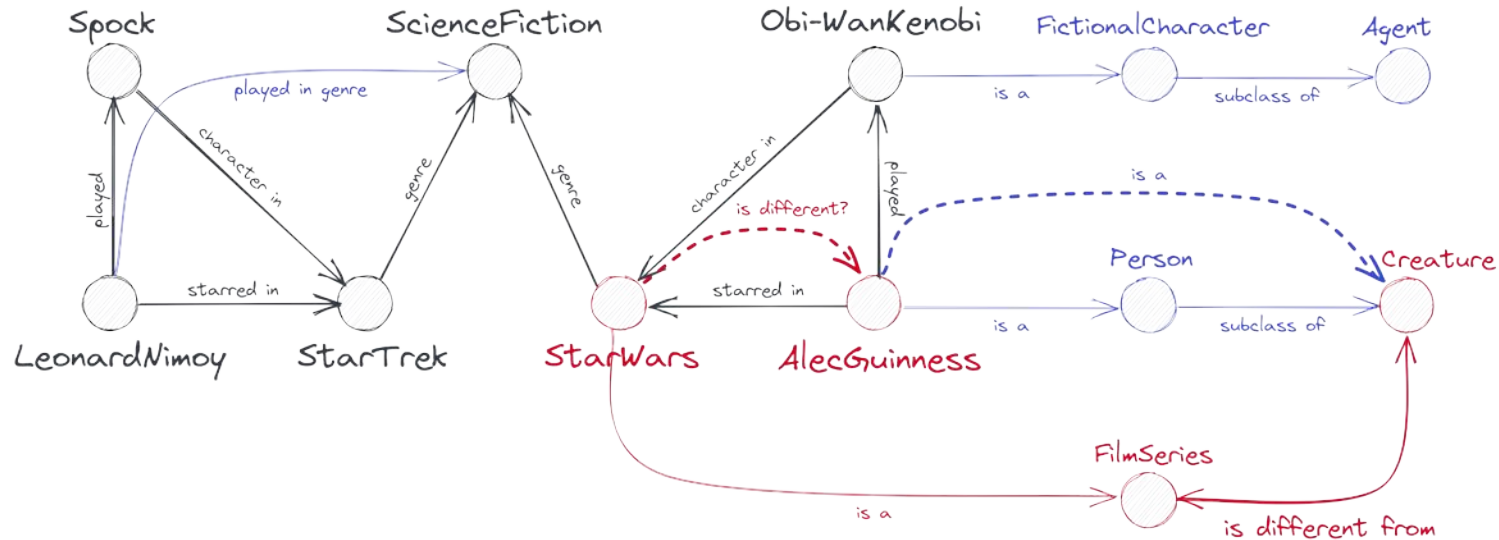
```

IF ((Alec Guinness, is a, Person) AND (Person, subclass of, Creature))
  AND
  (Star Wars, is a, Film Series) AND (Film Series, is different from, Creature)
THEN
  (Star Wars, is different from, Alec Guinness)
    
```



Is “Alec Guinness” different from “Star Wars”?

Again: How do we (or the computer) know the meaning of the labels?

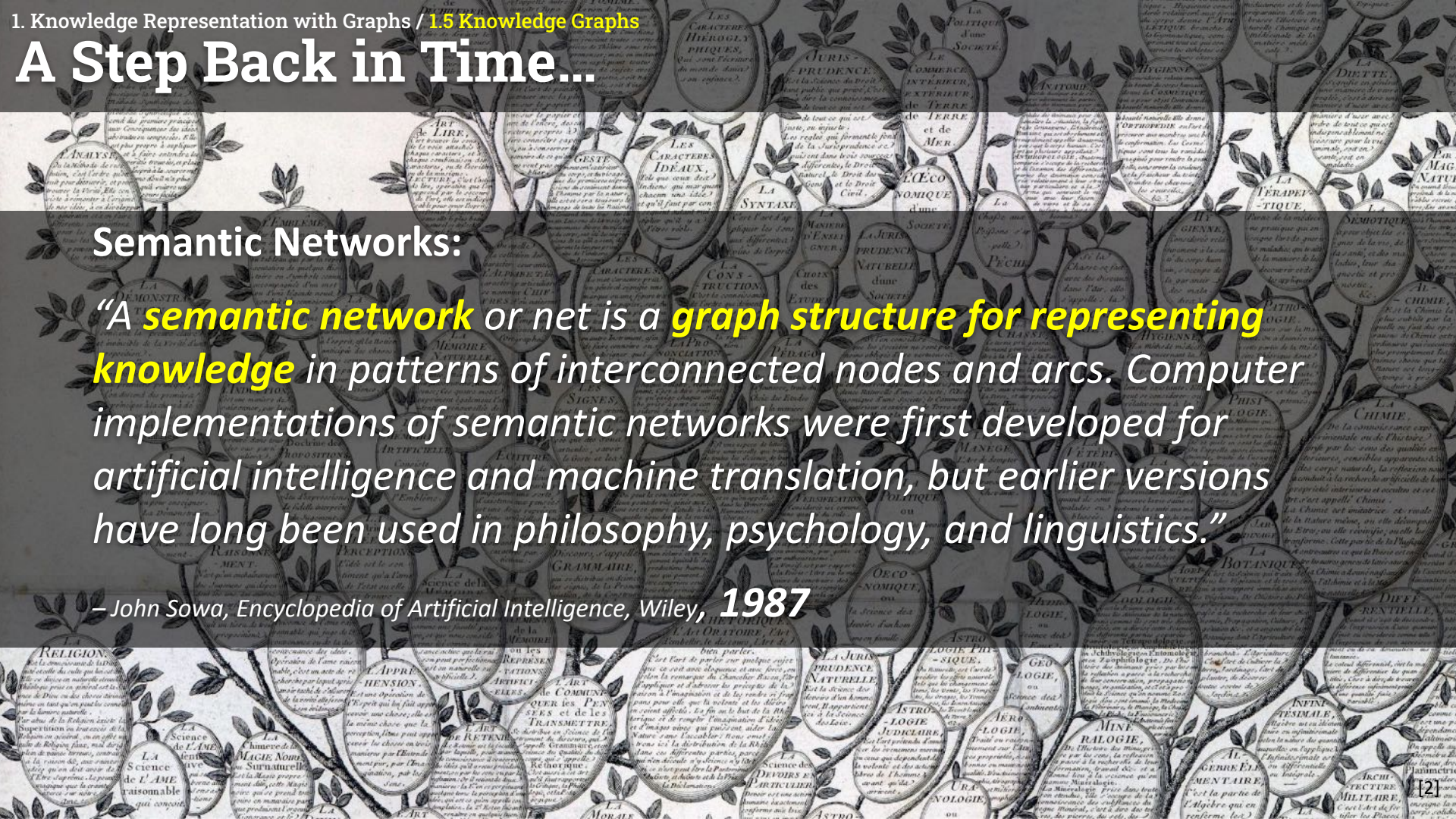


A Step Back in Time...

Semantic Networks:

“A **semantic network** or net is a **graph structure for representing knowledge** in patterns of interconnected nodes and arcs. Computer implementations of semantic networks were first developed for artificial intelligence and machine translation, but earlier versions have long been used in philosophy, psychology, and linguistics.”

– John Sowa, Encyclopedia of Artificial Intelligence, Wiley, 1987



Back to the Start

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To **represent knowledge explicitly** (and to make use of it),
we need a knowledge representation that can be “**understood**” by the computer.

- **Ontologies** based on **Mathematical Logic** as “**formal**” Knowledge Representation.
- **Inference Engine** (Semantic Reasoner) to draw conclusions and inferences.

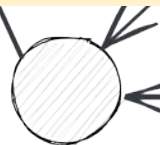


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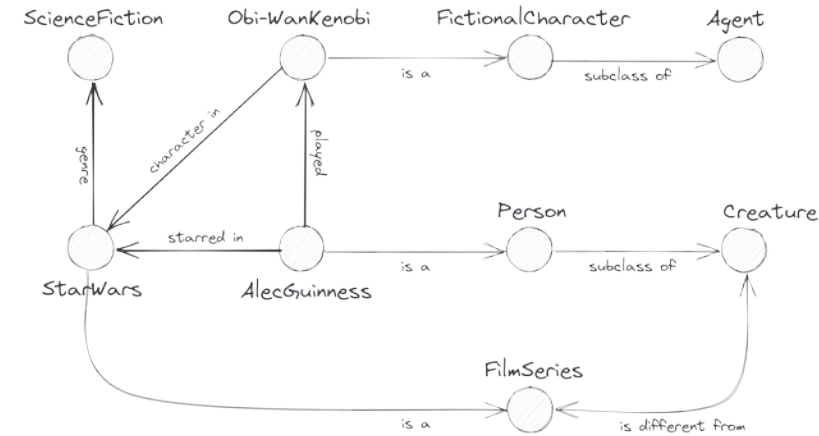
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A Formal Way to Represent Knowledge



Obi-WanKenobi \in FictionalCharacter
AlecGuinness \in Person
StarWars \in FilmSeries

FictionalCharacter \subseteq Agent
Person \subseteq Creature

FilmSeries \cap Creature = \emptyset

Logical Inference

AlecGuinness \in Creature
AlecGuinness \notin FilmSeries
StarWars \notin Creature

Formal Knowledge Representations

What's the difference between **formal knowledge representations** and **traditional data structures**?

1. **Mathematical Logic** provides a framework to **formally express the semantics** of knowledge representations.
2. **Semantics** of knowledge representations can be defined **explicitly**.
3. **Mathematical Logic** enables **logical inferences** and **reasoning** for knowledge representations.

The Semantic Web Technology Stack (not a piece of cake...)

Most apps use only a subset of the stack

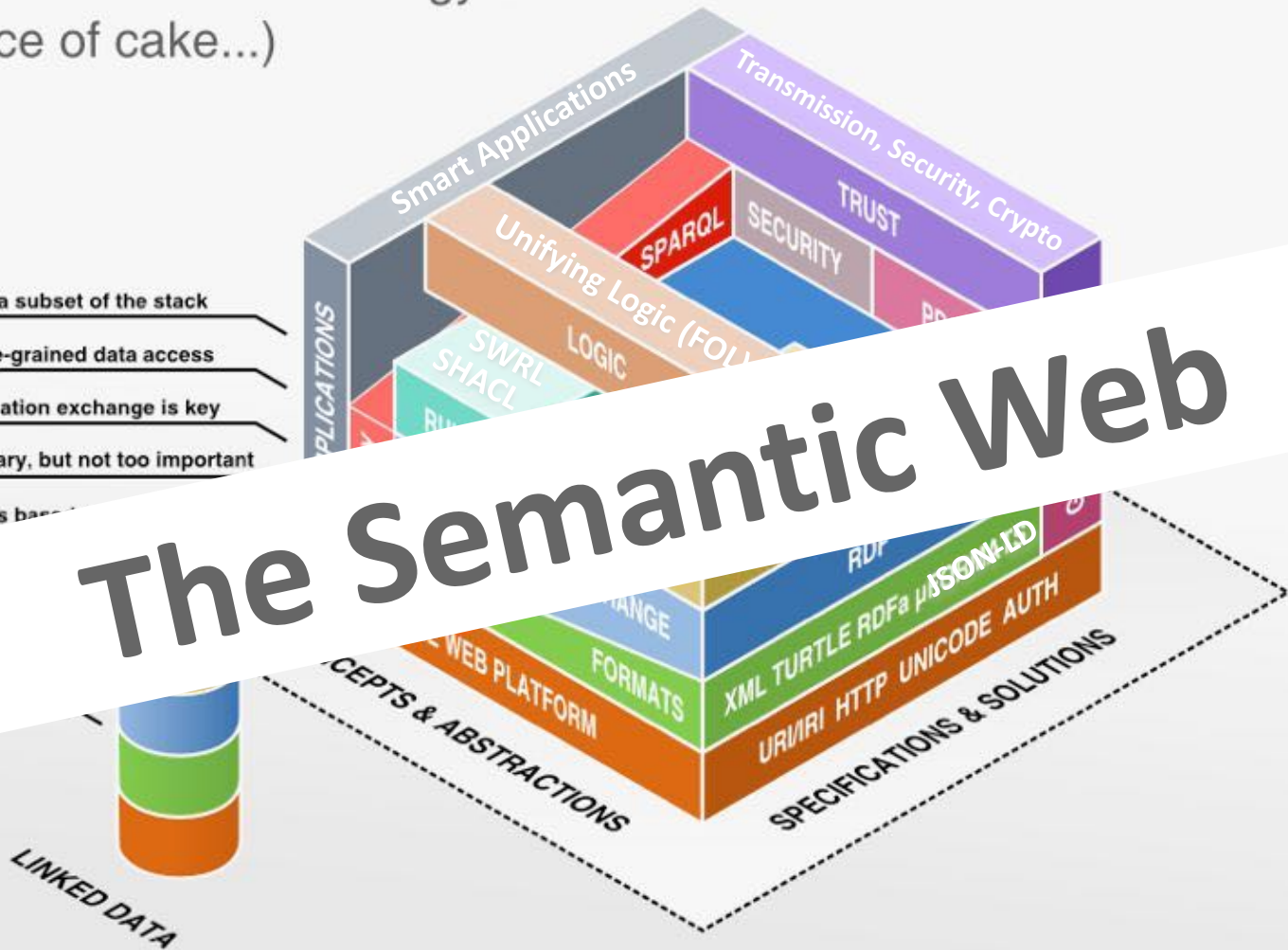
Querying allows fine-grained data access

Standardized information exchange is key

Formats are necessary, but not too important

The Semantic Web is based on

Linked Data uses
selection of tech



Next Lecture...

Bibliographic References:

- Paulheim, Heiko (2017). [*Knowledge graph refinement: A survey of approaches and evaluation methods*](#). Semantic Web 8: 489–508.
- Shapiro, Stuart C. (1987). Encyclopedia of artificial intelligence; vols. 1 and 2. Wiley-Interscience, USA.
- Plato, [*Cratylus*](#), 509a (DK 22A7)
- John Sowa (1987), [*Encyclopedia of Artificial Intelligence*](#), Wiley.

Picture References:

- [1] “An image of the Semantic Web which is an extension of the World Wide Web...”, created via ArtBot, Dreamlike Diffusion, 2023, [CC-BY-4.0], <https://tinybots.net/artbot>
- [2] Spock, created via ArtBot, Dreamlike Diffusion, 2023, CC-BY-4.0, <https://tinybots.net/artbot>
- [3] Obi Wan Kenobi, created via ArtBot, Zeipher Female Model, 2023, CC-BY-4.0, <https://tinybots.net/artbot>
- [4] Benjamin Nowack, The Semantic Web - Not a Piece of cake..., at bnode.org, 2009-07-08, [CC BY 3.0] <https://web.archive.org/web/20220628120341/http://bnode.org/blog/2009/07/08/the-semantic-web-not-a-piece-of-cake>