Semantisches Wissensmanagement im Unternehmen: Konzepte, Technologien, Anwendungen

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Kapitel 3.2: Datenmodellierung mit Semantic MediaWiki

Vorbemerkung

Ein Großteil unseres menschlichen Daseins und Wirken definiert sich über Beziehungen zu anderen "Dingen" (hier im weitest möglichen Sinne zu verstehen). Möchte man diese Gegenstandsbereiche in technischen Systemen möglichst präzise und “naturgetreu” abbilden, so braucht es ausdrucksmächtige Beschreibungsformate und Datenstrukturmodelle. Viele bekannte Datenstrukturmodelle und Formate sind zwar sehr effizient in ihrer maschinellen Verarbeitung, ihnen fehlt es aber an der notwendigen Ausdrucksmächtigkeit und Erweierbarkeit, d.h., diese sind nicht in der Lage, die komplexen Beziehungen zwischen Dingen präzise und widerspruchsfrei (=unambiguitiv) abzubilden.

Beispiel

Versuchen Sie nachfolgend beschriebenen Sachverhalt in einem Datenmodell ihrer Wahl möglichst widerspruchsfrei und eindeutig abzubilden.

“In seiner konstituierenden Sitzung vom 25.03.2019 beschloss der Fachbereichsrat in Bezug auf Berichtspunkt Nr. 5 des Protokolls vom 17.02.2019 mit 10 ‘Ja’-Stimmen, 0 Enthaltungen und keiner Gegenstimme:
Prof. Dr. Kai Renz wird zum kommenden Sommersemester neues Mitglied des Stundenplanerteams.“

Überlegungen zum Datenmodell

Bei der Durchführung des vorherigen Beispiels werden Sie sehr schnell feststellen, dass die Repräsentation in Form eines konzeptuellen Graphen mit Knoten und Kanten die Beziehungen zwischen den “Dingen” in einer natürlichen Darstellung am nächsten kommt.

Mit den Informationen aus "Kapitel 2: Technologische Grundlagen" können wir diesen Graphen weiter verfeinern.

- Ausschnitte aus Gegenstandsbereichen lassen sich am besten unter Reduzierung struktureller Heterogenität als konzeptueller Graph darstellen
- URIs & IRIs ermöglichen die eindeutige Identifizierung von “Dingen” und dienen als Adressierungschemata
- Dinge sind Information- und Non-Information Resources
- Wir unterscheiden zwischen Designator und Designatum
- Zusammen mit dem Konzept der Content Negotiation ermöglichen sie eine Unterscheidung zwischen technischen- und real-weltlichen Repräsentationen
- Zur Beschreibung der Bedeutung einer Beziehung braucht es eine maschinen-verarbeitbare Semantik
- Die Semantik wird durch die Terme und logische Theorie, auf der eine Ontologiesprache definiert ist, festgelegt
- Beziehungen sollten durch wohl-definierte Terme aus bekannten Ontologien oder Vokabularen representiert werden
- Resourcen sollten durch URIs/IRIs von bekannten Domänen (bspw. DBpedia) identifiziert werden
- Beziehungen sollten als First-Class Elemente behandelt werden
- Sachverhalte werden in einem Triple-Pattern kodiert

Wie werden Informationen in SMW kodiert ?

Semantic MediaWiki encodes information in the form of facts

Example: Berlin has a population of 3,520,031 people

A fact can be represented in a **triple-based lingusitic structure**:

1. The subject of a sentence, e.g., "Berlin"
2. The predicate, e.g., "has a population"
3. The object, e.g., "3,520,031 people"

These three parts can be split into a relation and a statement:

- **Relation** ~> Berlin has a population.
- **Statement** ~> The population is “3,520,031”.

A statement consists of a property and its value:

- **Property** (i.e. predicate), e.g. “Has population”
- **Value** (i.e. object or literal), e.g. “3,520,031”

Adding a statement (property-value pair) to a page (the subject) is called annotation.

As a consequence, facts are encoded as **property-value pairs** on wiki pages.

Encoding Facts in Semantic MediaWiki

This triple can be expressed with elements from SMW's Knowledge Representation Framework[1]:

1. Subjects are general **wiki pages** or **subobjects**[2]
   - e.g. a wiki page named `Berlin` in the main namespace
2. Predicates are **wiki pages** in the `Property` namespace
   - e.g., a wiki page named `has Population` in the `Property` namespace
3. Objects are **literals**, **wiki pages** or **subobjects**[2]
   - e.g., value `3,520,031` in case the object is a literal
   - e.g., a page named `Germany` in case the statement's object is another wiki page
   - e.g., an anonymous blank node in case the object is a subobject

Examples

(page – property – value):

```
Cologne   has population   1.017.155
Germany   has capital      Berlin
Spinoza   born on          24 Nov 1632
```

The triple-based model employed by Semantic MediaWiki is inherited from W3C's **Resource Description Framework (RDF)** specification.

A page-property-value triple resembles the subject-predicate-object triple pattern of RDF.

[1] KRF = Knowledge Representation Framework, i.e., a set of rules and description primitives for encoding information in a certain format.

[2] We will learn about subobjects in Lecture 4.

Part 2: How to Encode Information in Knowledge Graphs

Motivating Example

Matthias Frank is an employee of the FZI Research Center for Information Technology working on the BigGIS project.
BigGIS is an ongoing research project started at April 2016 and deals with real-time big data and semantic technologies.

Steps:

1. Identify Instances (Resources)
2. Identify Concepts (Classes)
3. Identify Properties and Data (Numbers, Literals etc.)
4. Represent as Conceptual Graph with Stereotypes
5. Transform into Serialized Graphs using MediaWiki syntax

Step 1: Identify Instances

Matthias Frank is an employee of the FZI Research Center for Information Technology working on the BigGIS project.
BigGIS is an ongoing research project started at April 2016 and deals with real-time big data and semantic technologies.

Step 2: Identify Concepts

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Step 3a: Identify Properties...

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Step 3b: ...and Datatypes

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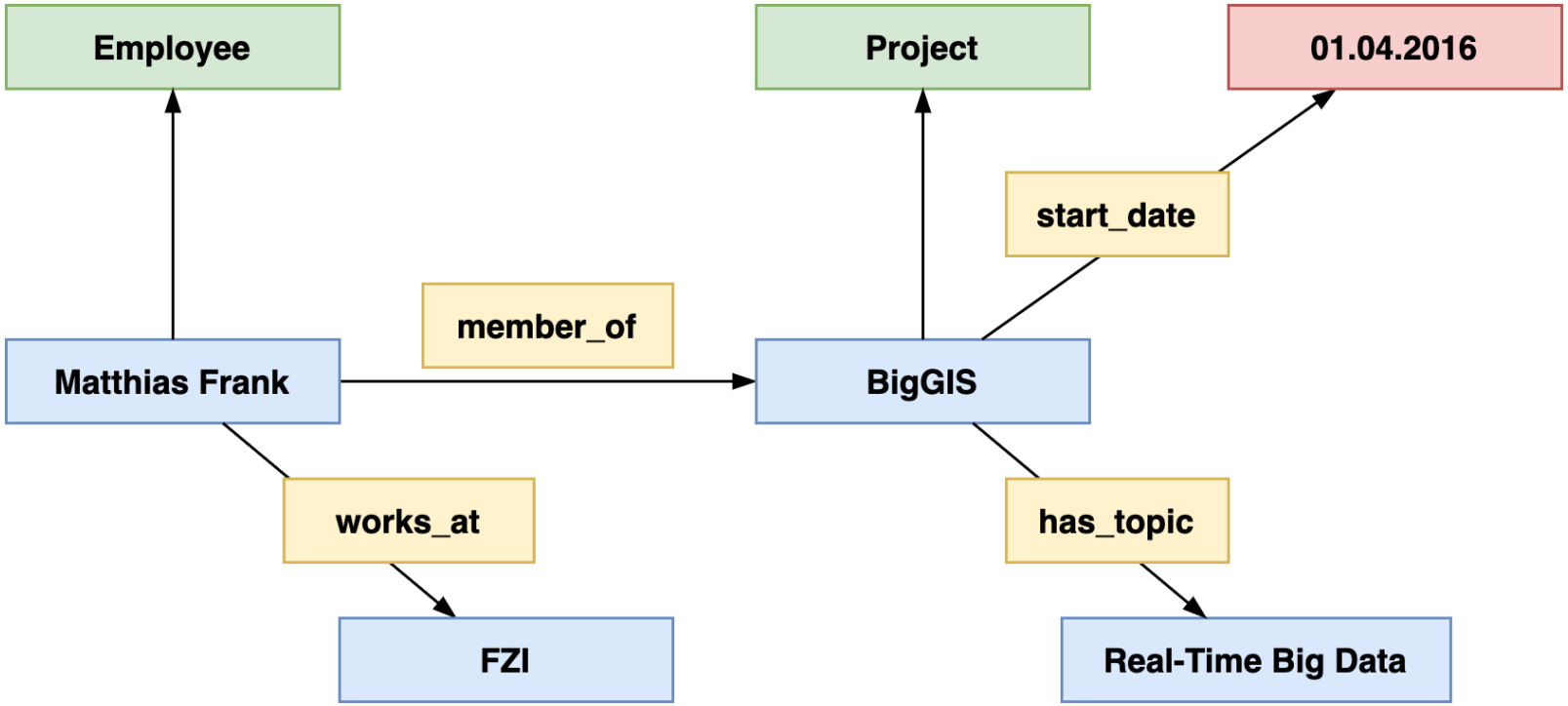
Instances versus Literals

Question: Should an entity be represented as a literal or instance ?

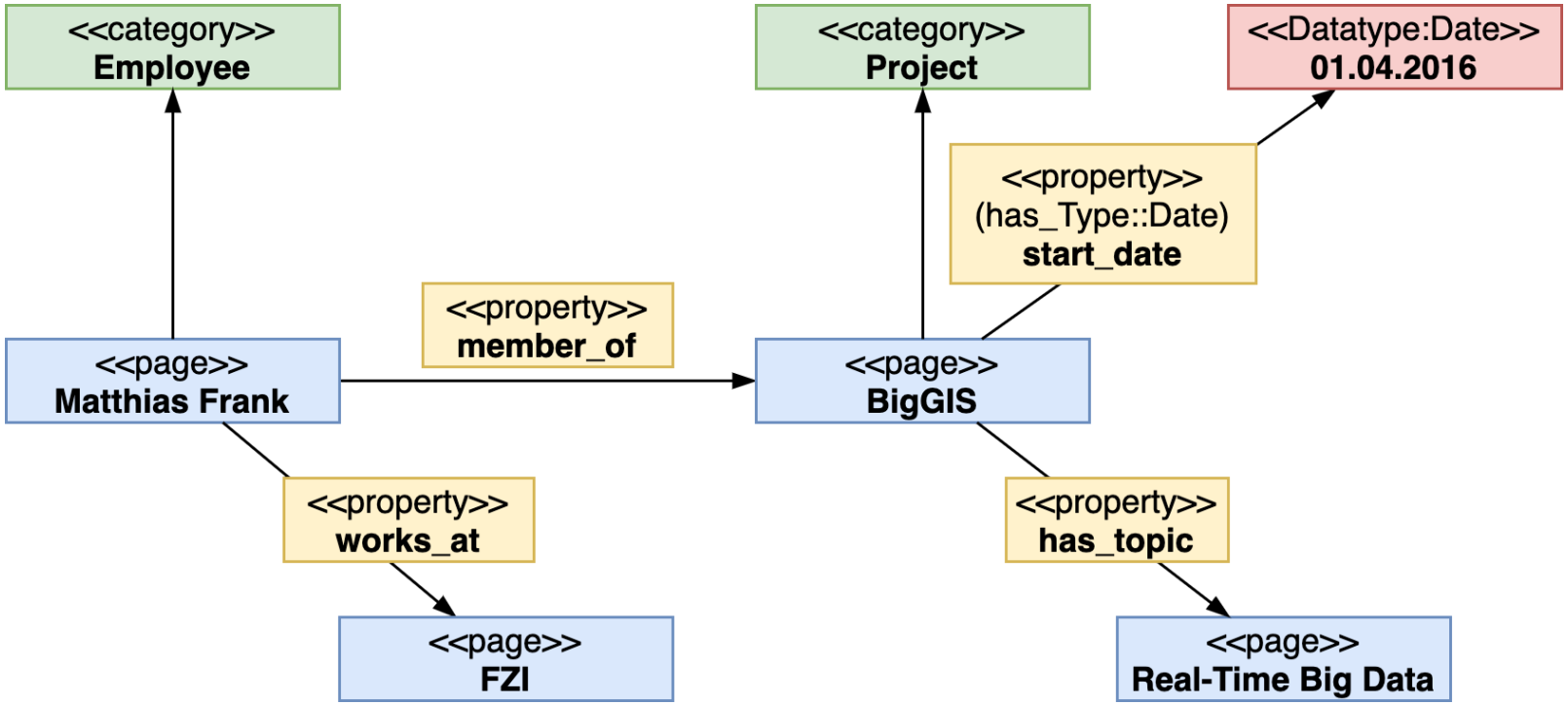
- Sometimes it is difficult to determine whether an entity should be represented as a literal (using the `text` datatype) or as an instance
  - e.g., should a research field be represented as a literal or as an individual page in the system?
- Since this is a **modelling issue** which depends on the situation at hand, there is no definite answer to this question
  - A trade-off in terms of performance versus flexibility and extensibility is necessary.
- Representing an entity as instance (datatype `page` in Semantic MediaWiki) allows for more flexibility and extensibility
  - e.g. the page of a research field can list projects or works in which this research field is used.
  - It can host additional information about the field that can be used in queries
- If no additional information is needed for an entity, it should be represented as a literal
  - This helps save space (disk and memory) and increases query performance on large knowlesge bases

Step 4a: Representation as Conceptual Graph

Matthias Frank is an employee of the FZI Research Center for Information Technology working on the BigGIS project.
BigGIS is an ongoing research project started at April 2016 and deals with real-time big data and semantic technologies.



Step 4b: Conceptual Graph with Stereotypes



Step 5: Transformation into Serialized Graphs

It is important to **separate the facts** on their respective pages and determine the **direction** of a relation.

Syntax on the `Matthias Frank`-Page:

```
[[Matthias Frank]] is an employee of the [[works_at::FZI Research Center for Information Technology]] working on the [[member_of::BigGIS]] project.

[[Category:Employee]]
```

Syntax on the `BigGIS`-Page:

```
[[BigGIS]] is an ongoing research project started at [[start_date::April 2016]] and deals with [[has_topic::Real-Time Big Data]] and [[has_topic::Semantic Technologies]].

[[Category:Project]]
```

Important: Consider the Relationship Semantics

- SMW's Knowledge Representation Framework is a directed Hypergraph
- Therefore, the direction of a relation matters
- The direction of a relation bears certain semantics (structural and model-theoretic)
- These semantics are relevant in **inline queries**
  - e.g. `has_member` versus `is_member_of` – one can be used on employee pages, the other on project pages

Try for Yourself

Bayern Munich is a professional football club based in Munich, Germany, that plays in the Bundesliga.
Bayern Munich was founded in 1900. They play at the Allianz Arena. The club has won 30 national league titles.

Tasks

1. Identify all instances, properties, classes, literals etc.
2. Think about what additional classes, properties and literals are needed
3. Create the conceptual graph
4. Think about what **facts** will be represented on which page
5. Complement the above text using the Semantic MediaWiki syntax of the respective elements

Future Work

Here is a list of further, more advanced **modelling problems**:

- How can we state that Bayern Munich has won 30 Bundesliga Championship titles ?
- How can we express the years in which the Bundesliga titles were won ?
- How can we express in which season + year a Bundesliga title was won ?
- How can we express in which seasons Bayern Munich finished second ?
- How can we count all national and international titles won by a German football club ?

Hint: All the above modelling problems call for the use of subobjects![1]

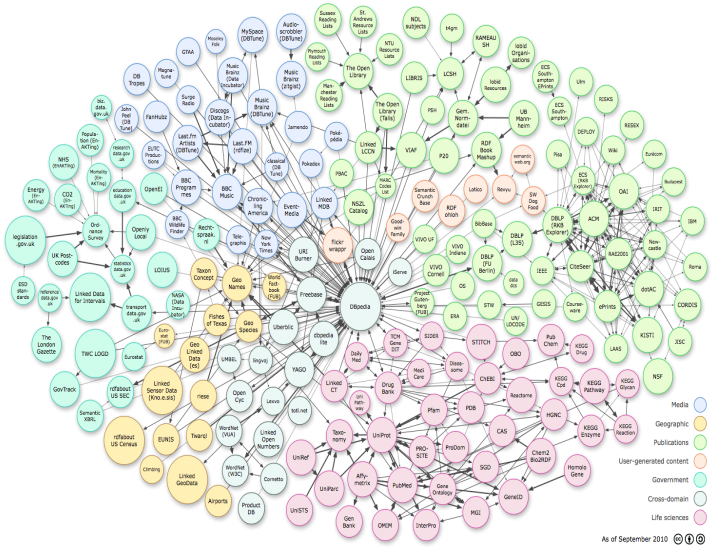
[1] We will learn about subobjects in lecture 4 of this course.

Summary

Why Knowledge Graphs are useful

Knowledge graphs have many advantages

- Like most graph models, it more intuitively captures the way we think about the world as humans (as networks, not as tables), making it easier to design, capture, and query data.
- As a data model supported by W3C standards, it allows us to create interoperable data and systems, all using the same standard to represent and encode data while adressing structural, schema and semantic heterogeneities.



RDF versus Labeled Property Graphs:
There are many other methods that have been developed to handle this kind of complexity in RDF, including singleton properties and named graphs/quads. Additionally, an entirely different type of **non-RDF graph model**, denoted as **labeled property graphs**, allows users to attach properties directly to relationships.
However, labeled property graphs do not allow for interoperability at the same scale as RDF does – it is much harder to share and combine different data sets, and moving data from tool to tool is not as simple and straightforward.

Source: https://enterprise-knowledge.com/rdf-what-is-it-and-why-do-i-need-it/