Semantisches Wissensmanagement im Unternehmen: Konzepte, Technologien, Anwendungen

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Kapitel 3.3: Semantische Suche

Didaktischer Aufbau der Einheit

Dieses Kapitel ist zweigeteilt:

- **Teil 1** behandelt Syntax und syntaktische Beschreibung von Abfragen
- **Teil 2** beschäftigt sich mit dem strukturellen Aufbau von Abfragen aus konzeptueller Sicht

Warum ist eine derartige Betrachtungsweise sinnvoll ?

Vorbemerkungen

SMW verfügt über eine **eigene Anfragesprache**

- Anlehnung an Wiki-Syntax
- interne Umsetzung der Anfragen in Abfragen für den internen Speicher (z.B. SQL bei Verwendung von MySQL als internen Speicher)

Formale Semantik der Anfrage

- durch Abbildung in OWL-DL-Klassenkonstrukte gegeben
  ~> d.h. eine Anfrage ermittelt Instanzen einer entsprechenden OWL-Klasse
- Nutzung der Anfragesprache auf Spezialseite oder in inline queries

Einbindung in Wiki-Seiten

- Anzeige der Abfrageergebnisse auf der Wiki-Seite stets aktuell

Polynomielle Komplexität der Anfragebeantwortung

- Anfragesprache unterstützt daher (wie auch OWL DL) keine benannten Variablen
  (Beispiel: Personen, die in Stadt_x geboren wurden und in Stadt_x gestorben sind) (mindestens NP-hart)

Part 1: Syntax and Semantics

The #ask Query Language (AQL)

Semantic MediaWiki includes an easy-to-use query language called AQL – #ask Query Language, which enables users to access the wiki's knowledge. The syntax is similar to the syntax of annotations. AQL can be used on the special page `Special:Ask`, in concepts, and in inline queries.

Semantic queries specify two things:

1. Which pages or subobjects to select
2. What information to display about those pages

All queries must state some conditions that describe what is asked for.

Pages can be selected by

- name,
- namespace,
- category, and most importantly by
- property values.

Example

`[[Located in::Germany]]`

selects all pages with property `Located in` and value `Germany`.

Anatomy of AQL

Semantic MediaWiki defines its own query language called AQL – #ask Query Language. It allows to retrieve pages (or subobjects) based on the information they contain.

AQL allows to **query** for

- pages (e.g. the wiki pages of all running projects)
- property values (e.g. the full names of all employees of an organisation)
- subobjects (subgraphs embedded in pages ~> will be discussed later in this course)

Main Idea
To ask for pages with some specified annotations in order to retrieve additional information from those pages. Those annotations in question are used as query conditions.

Structure

#ask Queries consist of four parts

1. The `#ask` **parser function**
2. **Query conditions**, i.e., what pages to select
3. **Printout statements**, i.e., data to be displayed
4. **Display options**, i.e., how data are displayed

Example

```
{{#ask:                          <!-- Parser Function -->
 [[Category:City]]               <!-- Query Conditions -->
 [[Located in::Germany]]
 |?Population                    <!-- Printout Statements -->
 |?Area#km² = Size in km²
 |format=ul                      <!-- Display Options -->
}}
```

The Condition Syntax resembles the Annotation Syntax

The markup text for formulating query conditions is exactly similar to the annotations embedded in wiki pages.

The syntax for asking for pages that satisfy some condition is exactly the syntax for explicitly asserting that this condition holds.

The following queries show what this means:

- `[[Category:Actor]]` gives all pages directly or indirectly (through a sub-, subsub-, etc. category) in the category.
- `[[Born in::Boston]]` gives all pages annotated as being about someone born in Boston.
- `[[Height::180cm]]` gives all pages annotated as being about someone having a height of 180cm.

Query Algebra – Conjunctions

Conditions can be combined.

```
[[Category:Actor]] [[Born in::Boston]] [[Height::180cm]]
```

Similar, more readable notation

```
[[Category:Actor]]
[[Born in::Boston]]
[[Height::180cm]]
```

When using **many conditions** in one query, the result is narrowed down to those pages that meet **all** the requirements.
Thus we have a logical AND.

Note that queries only return the articles that are positively known to satisfy the required properties
$\Rightarrow$ If there is no property for the height of some actor, that actor page will not be selected.

Lexical Peculiarities
SMW will ignore some characters such as trailing spaces or comma in numbers depending on the datatype used. SMW also treat synonymous page names as **identical resources** $\longrightarrow$ "Semantic wiki", "Semantic_wiki" and "semantic wiki" all refer to the same page.

Query Algebra – Disjunctions

Disjunctions are OR-conditions that allow several alternative conditions on query results.
A disjunction requires that at least one of the possible alternatives is satisfied (ie. logical OR).

Semantic MediaWiki has two ways of writing disjunctions in queries:

- The operator `OR` is used for taking the union of two queries
- The operator `||` is used for disjunctions in property values, page names, and category names

Examples

`[[Born in::Boston]] OR [[Born in::New York]]`
Describes people who were born in Boston OR New York

`[[Born in::Boston||New York]]`
The same query written in a more concise form

Note that `||` does not always offer an alternative to `OR`.
For example, `[[Born in::Boston]] OR [[Category:Actor]]` cannot be expressed with `||`.

`OR` operates on the query, not on a single element of the query. In the following query, the category name needs to be repeated:
`[[Category:Actor]] [[Born in::Boston]] OR [[Category:Actor]] [[Born in::New York]]`

Wildcards and Search Operators

Wildcards are written as `+` and allow any value for a given condition[1].
For example, `[[Born in::+]]` returns all pages that have any value for the property `Born in`.

Comparators are special symbols like `<` or `>`[2]. They are placed after `::` in property conditions.

- `>>` and `<<`: "greater than" and "less than"
- `>` and `<`: "greater than or equal" and "less than or equal" by default
- `≥` and `≤`: "greater than or equal" and "less than or equal"
- `!`: "not" ("unequal")
- `~`: «like» comparison for texts and pages
- `!~`: «not like» comparison for texts and pages

When applying **comparators** to pages, then the title of the page (without namespace prefix) is used.

Comparators work only for **property values** and not for conditions on categories.

Search Features

SMW provides a number of additional search features, which we will not discuss in the lecture; details are available on the help-pages[1]:

- Search operators shows how to refine search conditions and criteria using operators such as comparators or wildcards.
- Unions (OR) of results describes how disjunctions (OR-conditions) can be used to combine query results on alternative conditions.
- Single page restriction section describes how to directly select some pages, or pages from a given namespace.
- Specify range of pages
- Use namespace restrictions
- Subqueries and property chains
- Work with value substitutions describes how templates and variables can be used in a query to substitute value components
- Distance queries

AQL Inverse Properties

Sometimes, it is necessary to invert the direction of properties in queries, in particular when asking for pages that contain a subobject.

Definition Inverse properties do not ask for pages that contain a matching annotation but for the object value of the annotation on pages, where the property is used.

Quelle: eigene Defintion angelehnt an https://www.semantic-mediawiki.org/wiki/Help:Inverse_properties

Example

```
{{#ask: [[has capital-::Germany]] }}
```

- In this example, we do not ask for the page that contains a property with the given value but rather for the value of the property `has capital` entered to the page `Germany`.
- In consequence `has capital-` has the meaning `is capital of`.

$\Rightarrow$ Inverse properties can be used in all SMW interfaces that take properties, but not when adding data to a page

Part 2: Formulating Query Conditions

Initial Example

Initial Situation

> *A knowledge base contains the profile of all its employees in the form of wiki pages.*
> *The profile pages also contain the information about the research division, an employee belongs to in form of an annotation, the object of which refers to the research division's wiki page.*

Question

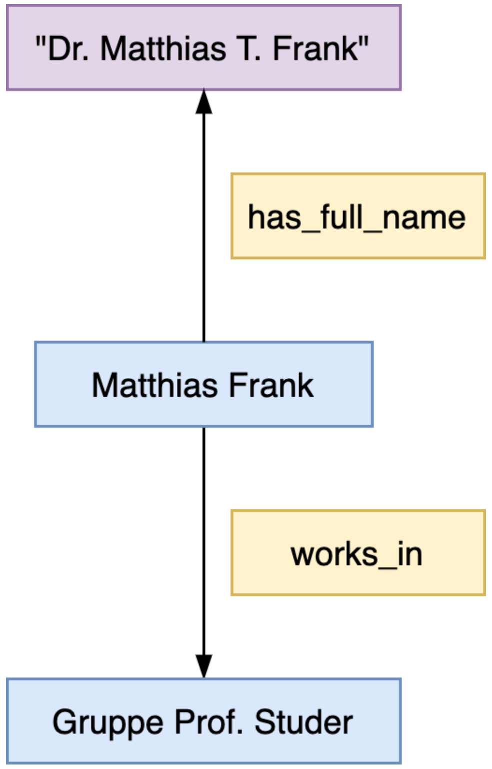
> *How can we find out the employees that belong to a specific research division ?*

...or in other words

> *How can we satisfy the information need of displaying the names of all the employees that belong to a certain research devision, e.g., to Prof. Dr. Rudi Studer's Group ?*

Formulating Queries I

First consider the **structural composition** of the data model used to represent the universe of discourse (or an excerpt of it).



The **instance graph** serves as basis for the formulation of query conditions.

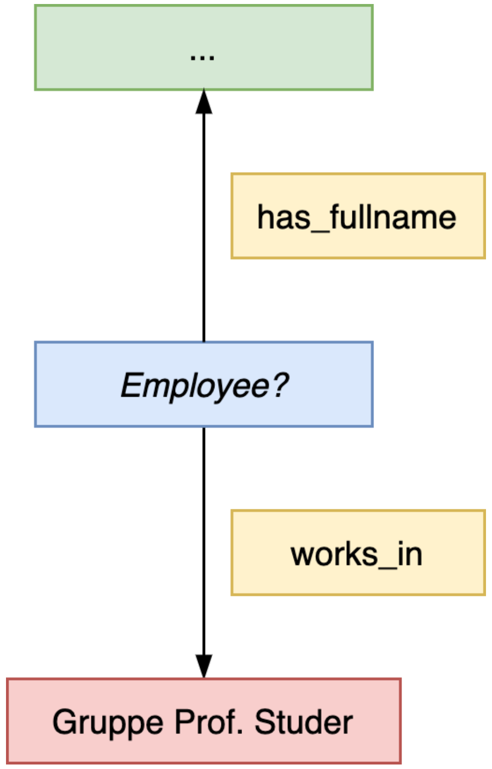
- Therefore, think of query conditions as
  ~> graphs with conditional node values.
- Also consider the structural semantics of involved elements.

Structural Semantics of the knowledge graph

- `Matthias Frank` is a wiki page in the `main` namespace
- The page holds two assertions
  - a `has_full_name`-property the value of which is a Literal (datatype: `Text`)
  - a `works_in`-property the value of which is the wiki page representing Prof. Studer's research group

Formulating Queries I (Part 2)

The structural composition of the instance graph can then be transformed in a query graph



The **query graph** then helps in formulating

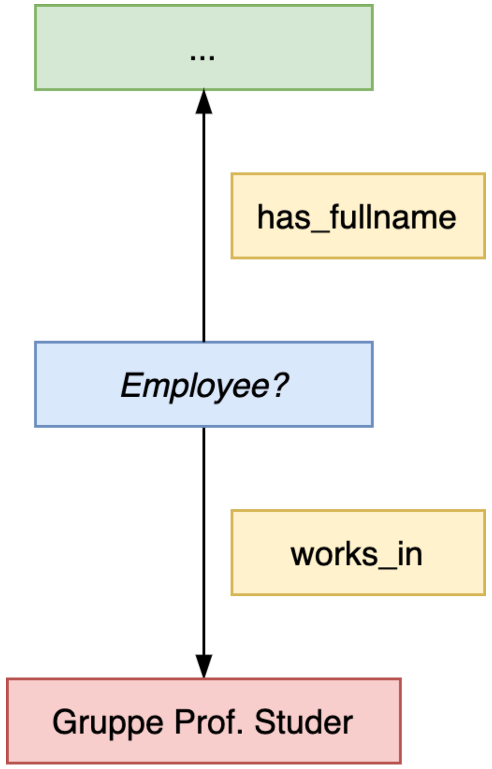
- query conditions and
- the structural components of the universe of discourse

Query Conditions and **structural components**

- Retrieve all pages that are...
  - ...of type `Employee` and
  - ...that participate in a `works_in`-relationship to the `Gruppe Prof. Studer` wiki page.
- From all matching pages...
  - ...retrieve the value (object) of the `has_full_name`-property

Formulating Queries I (Part 3)

Once the structural components of the query graph are clear, the query can be formulated using AQL



Example

```
{{#ask
 [[Category:Employee]]
 [[works_in::Gruppe Prof. Studer]]
 |?has_full_name = Fullname
 |format=ul
}}
```

Description

- Retrieve all pages that are...
  - ...of type `Employee` and
  - ...that participate in a `works_in`-relationship to the `Gruppe Prof. Studer` wiki page.
- From all matching pages...
  - ...retrieve the value (object) of the `has_full_name`-property

Explanatory Information

Consider the following conceptual query graph semantics of the previous example:

- yellow boxes represent properties;
  - properties need to be pre-determined in a query, i.e., you can, e.g., not ask which properties exist between two pages in the main namespace.
- the red box represents a specific wiki page in the main namespace
- the blue boxes represent query variables that are to be filled with the values in the course of evaluating the query conditions
- the green boxes are the results returned by processing the query and that are being displayed.

How to Formulate Query Conditions for Complex Queries

Example
The following domain knowledge is modelled in a Semantic MediaWiki

> *"A research group has a number of employees being members of it.*
> *These employees work in different projects, where each project has different topics it is concerned with."*

Question:

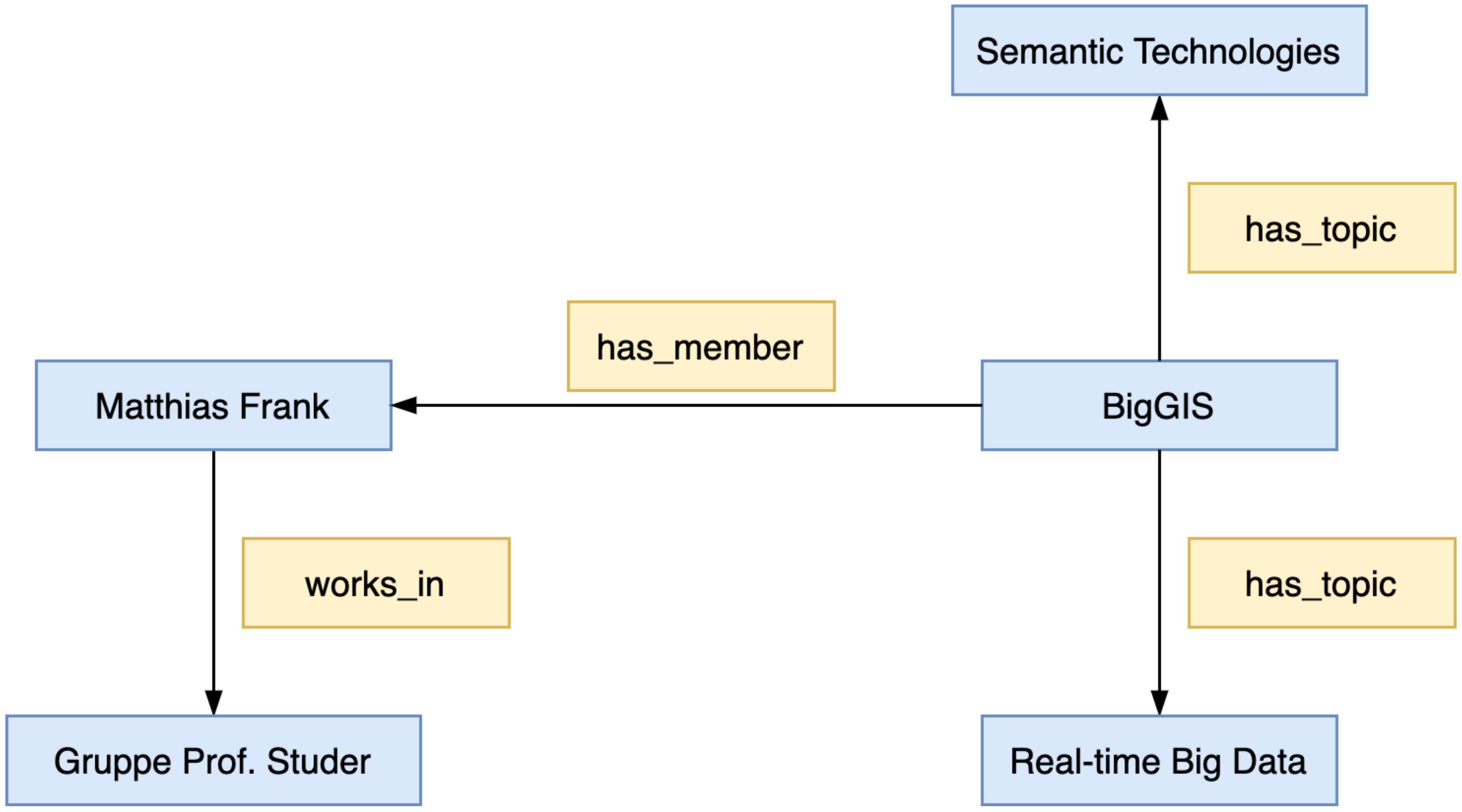
> *How can we satisfy the information need of displaying all the research topics a research group's members are associated with through their project work on the research group's wiki page?*

...or in other words

> *Which topics are a research group working on?*[1]

How can we model and satisfy this information need in Semantic MediaWiki ?

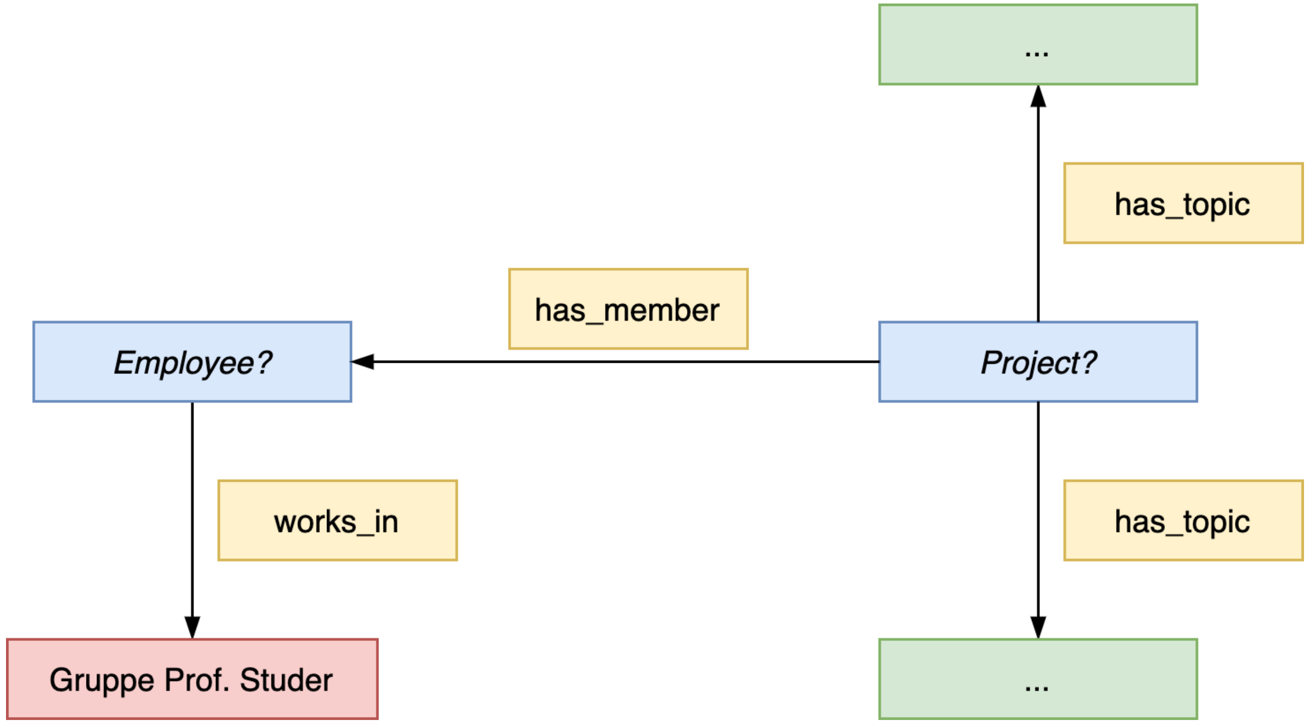
Formulating Complex Queries



- Consider the following excerpt of a **knowledge graph** representing the group an employee works in and a project she is member of together with the topics the project is concerend with.
- Be aware of the **structural semantics** (ie., how pages are linked together) that exists between employees, projects, and topics.

Formulating Complex Queries: The Query Graph

If we want to retrieve all topics, members of Prof. Studer's group are working on, the **query graph** looks as follows:



The **query graph** consists of two variables and thus two subgraphs

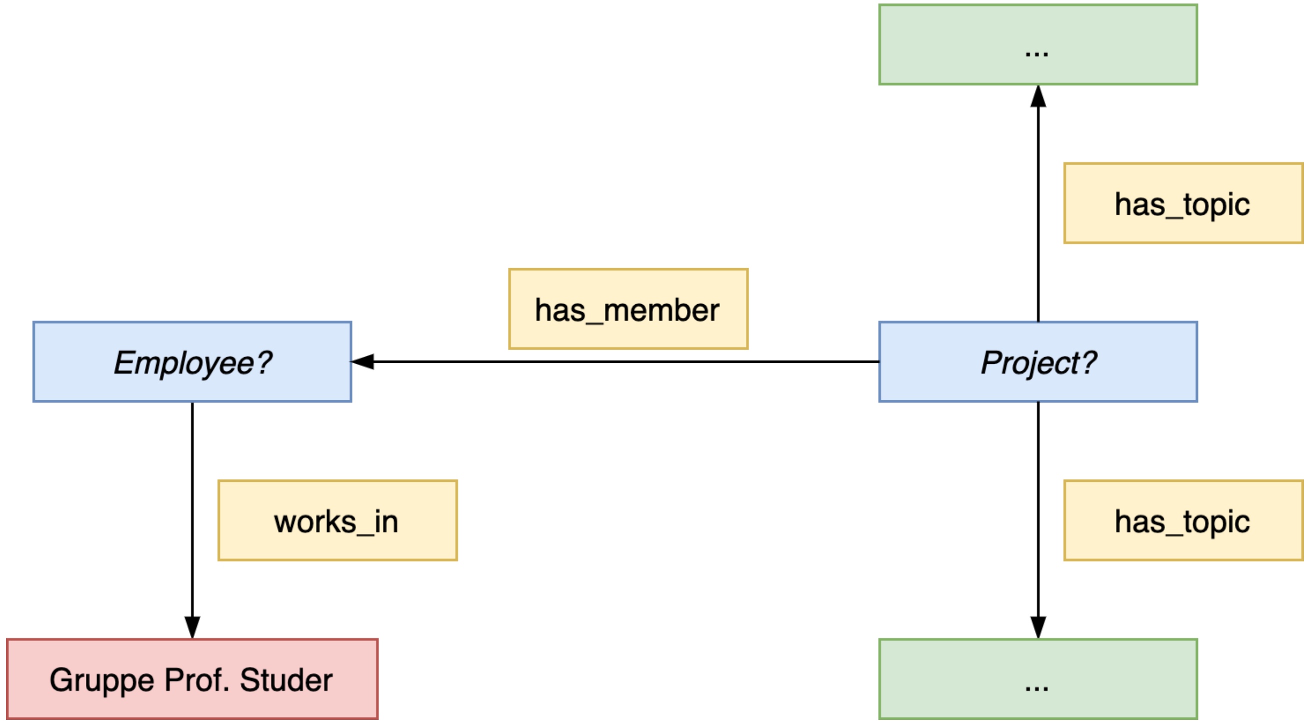
- the `project` subgraph
- the `employee` subgraph

It needs to be transformed into an inner query and an outer query[1]

- the **inner query** represents specific employees[2]
- the **outer query** represents projects they are members of

Formulating Complex Queries: The Query

If we want to retrieve all topics, members of Prof. Studer's group are working on, the **query graph** looks as follows:



The #ask Query[1,2]

```
{{#ask: [[has_member::<q>[[works_in::{{PAGENAME}}]]</q>]]
|?has_topic=
|mainlabel=-
|format=valuerank
}}
```

- The inner query asks for employes working in the group (cf. `works_in`)
- The outer query retrieves projects in which these employes participate (cf. `has_member`)

When formulating queries in Semantic MediaWiki, always consider the **structural semantics** of pages (ie., how pages are linked together via properties).

Queries with Property Chains (1/2)

Queries can become quite complex in terms of formulating query conditions; consider the following example:

Assumption: There is a page that encodes memberships in form of subobjects. Each subobject represents one membership and stores a reference to the person page of each member together with additional information such as their roles (full member, subsititute, chair etc) or their entry dates. Each person page belongs to a specific category (professor, employee, student etc) that reflects their role within an organisation.

Question: How can we filter members based on their organisational role?

Solution: Chaining properties in query conditions.

`[[-member.Role::Ersatzmitglied||Vorsitzender]] [[Kategorie:Professor]]` returns all professors who are either substitute or chair.

Imporant note: Instead of naming the subject (e.g. a page or non-anonymous subobject) directly, it is represented by a set of properties (e.g. `...Role::Ersatzmitglied`) it fulfills.

The correct wording would be: a subject (page or subobject) that participates in a `member` relationship to a page of category `Professor` as well as in a `Role` relationship from itself to the literal `Ersatzmitglied||Vorsitzender`.

Queries with Property Chains (2/2)

Task: Image you want to display all the Persons (professors, employees, students) of an organisation that are members of a specific committee (e.g. Studienausschuss) together with their membership information plus the category (see above) they belong to.

Intuitively, one would formulate the query from the perspective of the membership page (the membership of each person is encoded via single subobjects). However, this is wrong: While membership data can be easily addressed in printout statements, it is not possible to display the category a person's page belongs to.

The better solution is to start from the persons' pages and use property chains with inverse properties to display the membership information hosted on the membership page.

Example:

```
{{#ask:
[[Category:Person]]
[[-member.Role::+]]
[[-member.type::mitglied_studienausschuss]]
|?Has_fullname
|?Category
|?-member.role=Rolle
|?-member.start_date=Eintrittsdatum
|?-member.end_date=Austrittsdatum
|mainlabel=Name
|format=table
|sort=role
|order=desc
}}
```

TODO: add result image