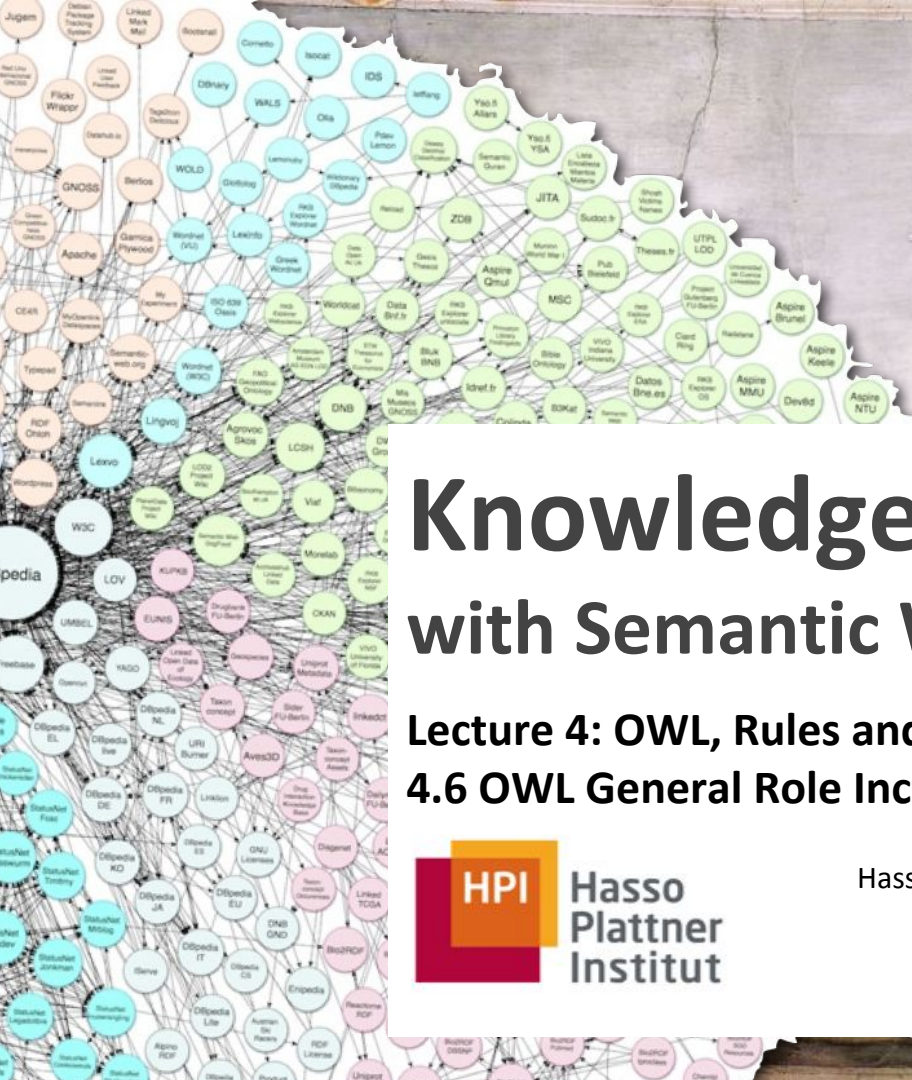




Knowledge Engineering with Semantic Web Technologies

Lecture 4: OWL, Rules and Reasoning 4.6 OWL General Role Inclusion



Dr. Harald Sack
Hasso Plattner Institute for IT Systems Engineering
University of Potsdam
Autumn 2015



OWL Complex Role Inclusion

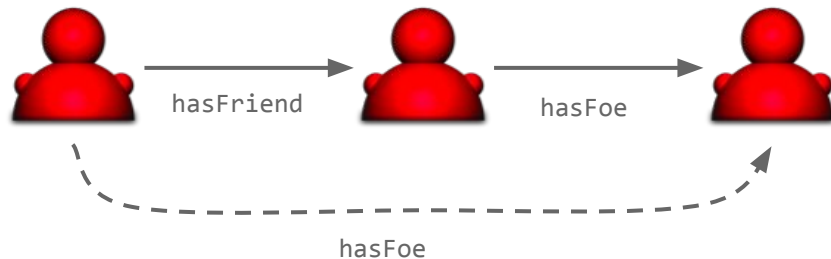
- Complex Roles (properties) can be constructed from simple roles (RBox)

- „*The friends of my friends are also my friends.*“

`hasFriend a owl:TransitiveProperty .`

- But: „*The foes of my friends are also my foes.*“

- cannot be expressed in that way



- in FOL it can be expressed as a rule (axiom):

- $\forall x, y, z: \text{hasFriend}(x, y) \wedge \text{hasFoe}(y, z) \rightarrow \text{hasFriendsFoe}(x, z)$

- $\mathcal{SROIQ}(\mathcal{D})$ enables the construction of arbitrary complex roles via **General Role/Property Inclusion**

General Property Inclusion

- R-Box expressions of the form $R_1 \circ R_2 \circ R_3 \circ \dots \circ R_n \sqsubseteq S$
e.g.: `hasParent` $\circ$ `hasBrother` $\sqsubseteq$ `hasUncle`
 - Semantics: if $(x_0, x_1) \in R_1^I, (x_1, x_2) \in R_2^I \dots (x_{n-1}, x_n) \in R_n^I$,
then it also holds that $(x_0, x_n) \in S^I$
 - E.g.: $(x_0, x_1) \in \text{hasParent}^I$ and $(x_1, x_2) \in \text{hasBrother}^I$,
then it also holds $(x_0, x_2) \in \text{hasUncle}^I$
- BUT: OWL with general property inclusion is UNDECIDABLE !

Restriction to Regular RBoxes

- RBoxes are like grammars for context-free languages

Example

- Grammar for the (context free) language of the words
ab, aabb, aaabbb, ...

$$\begin{array}{l} L ::= ab \\ L ::= aLb \end{array} \quad \blacktriangleright \text{ becomes } \blacktriangleright \quad \begin{array}{l} R_a \circ R_b \sqsubseteq L \\ R_a \circ L \circ R_b \sqsubseteq L \end{array}$$

Restriction to Regular RBoxes

- RBoxes are like grammars for context-free languages
- Emptiness of the intersection of context-free languages is undecidable

Regular RBoxes

- **Property names** are ordered with $<$ (**strict partial Ordering**).
- Each **RBox Inclusion** must be formed like:
 - $R \circ R \sqsubseteq R$
 - $R^- \sqsubseteq R$
 - $S_1 \circ S_2 \circ S_3 \circ \dots \circ S_n \sqsubseteq R$
 - $R \circ S_1 \circ S_2 \circ S_3 \circ \dots \circ S_n \sqsubseteq R$
 - $S_1 \circ S_2 \circ S_3 \circ \dots \circ S_n \circ R \sqsubseteq R$
- Where: $S_i < R$ for all $i=1, 2, \dots, n$
- An RBox is called **regular**, if such a **strict Ordering** $<$ exists.

Regular RBoxes - Examples

- Example:
 $R \circ S \sqsubseteq R \quad S \circ S \sqsubseteq S \quad R \circ S \circ R \sqsubseteq T$
is **regular** with ordering $S < R < T$
- Example:
 $R \circ T \circ S \sqsubseteq T$
is **not regular** (*not allowed inclusion*)
- Example:
 $R \circ S \sqsubseteq S \quad S \circ R \sqsubseteq R$
is **not regular** (*no valid ordering possible*)

Regular RBoxes - Examples (2)

- Example:
hasParent ◦ hasHusband $\sqsubseteq$ hasFather
hasFather $\sqsubseteq$ hasParent
- is **not regular** because regularity would enforce both
hasParent $<$ hasFather
and
hasFather $<$ hasParent
which is impossible because $<$ must be strict

Further Restrictions to Maintain Decidability

- **Simple properties** in $\mathcal{SHOIN}(\mathcal{D})$ are properties without transitive subproperties
- In $\mathcal{SROIQ}(\mathcal{D})$ general property inclusion also has to be considered

Simple Properties

- are all properties that
 - **are not on the right side** of a property inclusion,
 - **are the inverse of** other simple properties,
 - are **only on the right side** of property inclusions $R \sqsubseteq S$,
where **on the left side is a simple property**
- **Non-simple properties** are properties that are directly (or indirectly) dependent of property chains ($\circ$)

Further Restrictions to Maintain Decidability

- The following expressions are permitted **ONLY** for simple properties:

- $\leq n$ R.C and $\geq n$ R.C (qualified number restriction)
- Irreflexive properties
- Disjunctive properties
- $\exists$ R.Self
- $\neg R(a, b)$

- Reason: Saving **Decidability**

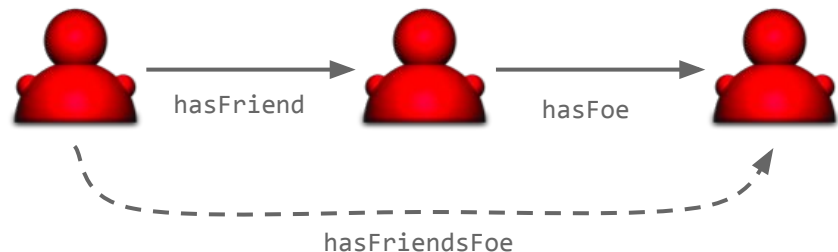
Summary

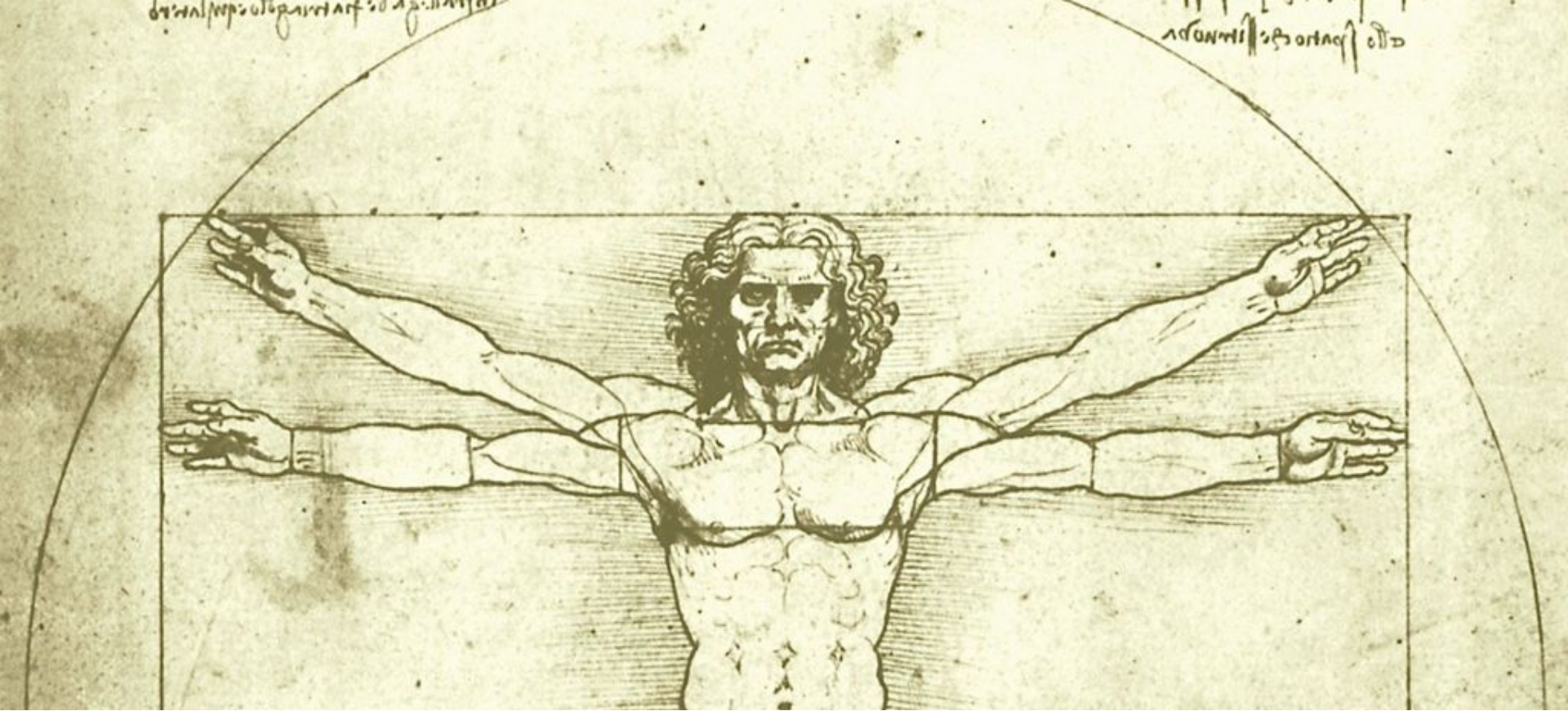
- To ensure **decidability** the following **structural restrictions** must hold for $\mathcal{SROIQ}(\mathcal{D})$:
 - **Regularity**: Restriction of potential interaction of RBox axioms
 - **Simplicity of properties**:
Restrictions of how to apply properties in number restrictions
- Therefore a number of restrictions arise for the overall structure of the knowledge base that have to be considered for all axioms.

- General Role Inclusion (property chaining) in OWL 2

```
:hasFriendsFoe a owl:ObjectProperty ;  
  owl:propertyChainAxiom ( :hasFriend :hasFoe ) .
```

- not allowed for datatype properties





07 Rules - Is this more than Description Logics?

OpenHPI - Course Knowledge Engineering with Semantic Web Technologies

Lecture 4: OWL, Rules, and Reasoning