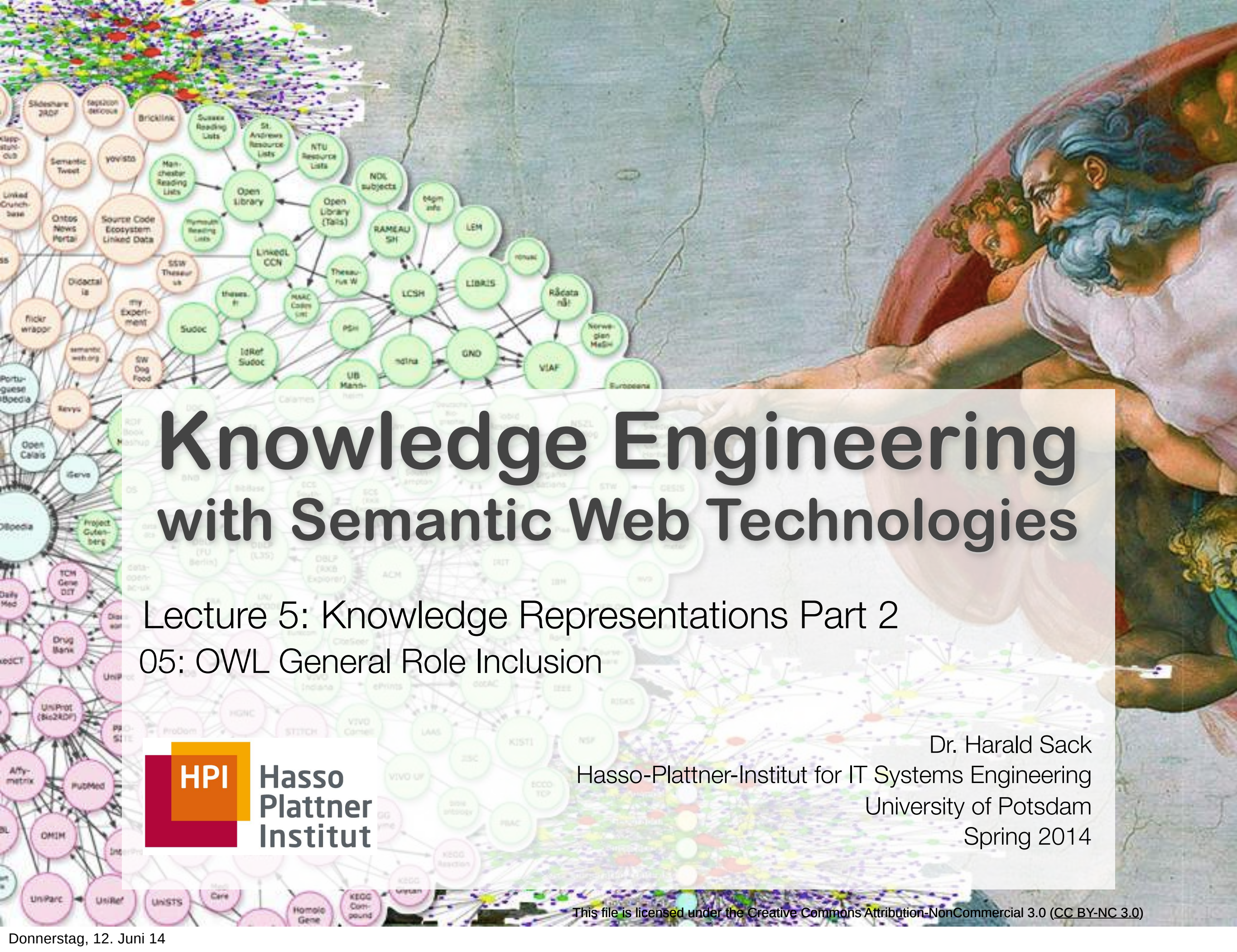




Knowledge Engineering with Semantic Web Technologies

Lecture 5: Knowledge Representations Part 2
05: OWL General Role Inclusion



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Lecture 5: Knowledge Representations II

Open HPI Course: Knowledge Engineering with Semantic Web Technologies



05 OWL General Role Inclusion

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General Role / Property Inclusion

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- Complex Roles / Properties can be constructed from simple roles / properties (R-Box)
 - „*The friends of my friends are also my friends.*“
 - can be expressed as **transitive property**
 - **But:** „*The foes of my friends are also my foes.*“
 - cannot be expressed in that way

- In FOL expressed as a rule (axiom):
 - $\forall x, y, z: \text{hasFriend}(x, y) \wedge \text{hasFoe}(y, z) \rightarrow \text{hasFriendsFoe}(x, z)$



General Role / Property Inclusion

- 5 • $\mathcal{SHROIQ}(\mathcal{D})$ 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.: $\text{hasFriend} \circ \text{hasFoe} \sqsubseteq \text{hasFriendsFoe}$
- 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.: $(x_0, x_1) \in \text{hasFriend}^I$ and $(x_1, x_2) \in \text{hasFoe}^I$,
then it also holds $(x_0, x_2) \in \text{hasFriendsFoe}^I$

BUT: OWL with general property inclusion is UNDECIDABLE !

- Can property inclusion be restricted in some way to stay decidable?
 - Rboxes are like *grammars for context-free languages*
 - Intersection of context free languages is problematic (undecidable)
 - Therefore **restriction to regular languages!**

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 an (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 $\circ$ 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

Restrictions for simple Properties

- Simple properties in $\mathcal{SHOIN}(\mathcal{D})$ are properties without transitive subproperties
- In $\mathcal{SHROIQ}(\mathcal{D})$ general property inclusion 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 ($\circ$)

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- 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

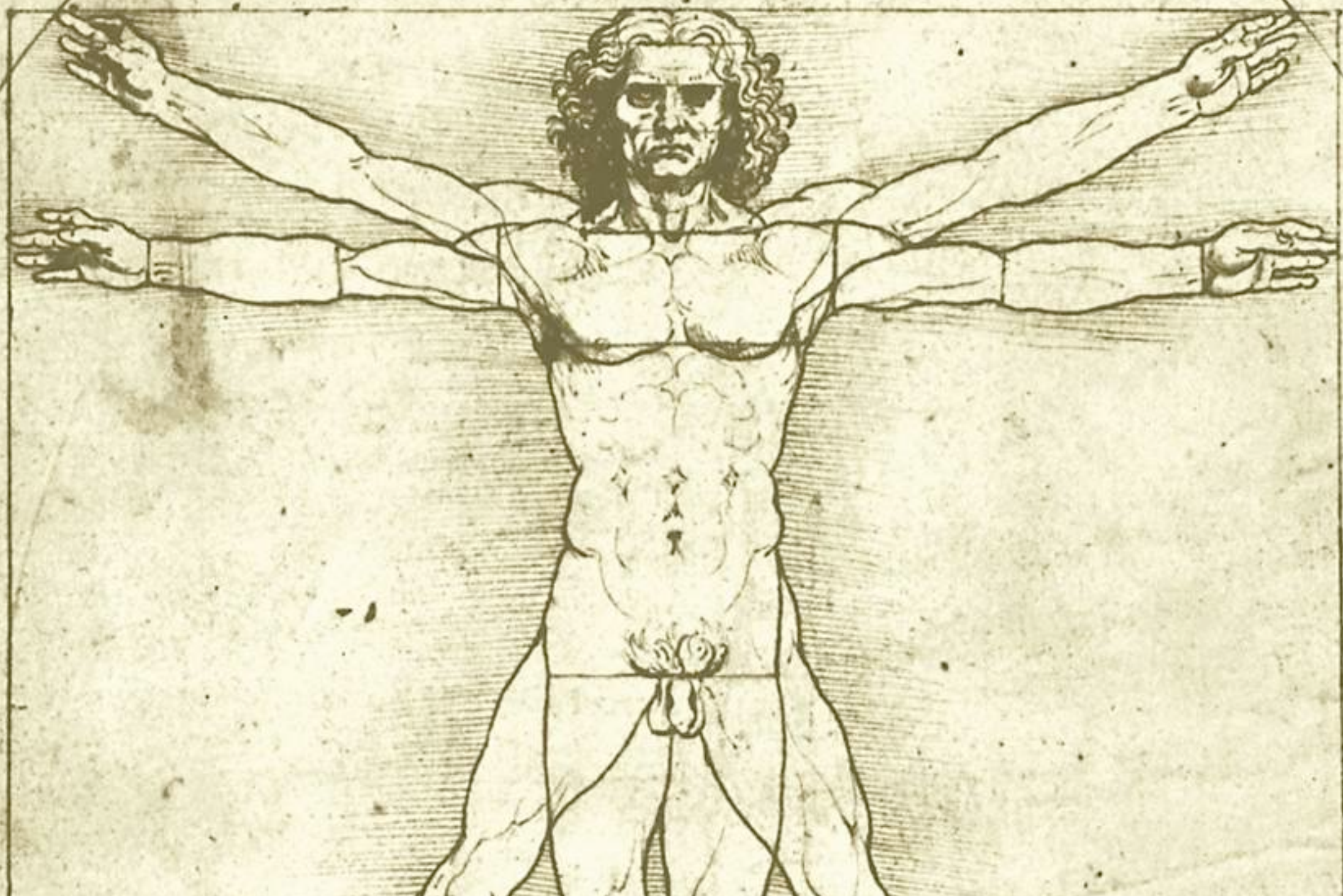
- To ensure **decidability** the following **structural restrictions** must hold or $SHROIQ(\mathcal{D})$:
 - **Regularity**:
Restriction of potential interaction of RBox axioms
 - **Simplicity** of properties:
Restrictions of how to apply properties in number restrictions
- Therefore a number of restrictions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

- 12 • OWL 2 enables **property chaining (general property inclusion)**

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

- Not allowed for datatype properties





06 Rules - There's more than OWL

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