Expressive Description Logics

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Our plan

From \mathcal{ALC} to OWL(2)-DL

Final Remarks



From ALC to OWL(2)-DL



Extending $\dots \mathcal{ALC} \dots$

- We have introduced \mathcal{ALC} , together with a decision procedure. Its expressiveness is higher than propositional calculus, still it is insufficient for many practical applications.
- Let's take a look, how to extend ALC while preserving decidability.



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Extending ... ALC ... (2)

 ${\cal N}$ (Number restructions) are used for restricting the number of successors in the given role for the given concept.

syntax (concept)	sema	ntics
$(\geq nR)$	{a	$\Big \{b \mid (a,b) \in R^{\mathcal{I}}\} \Big \geq n \Big $
$(\leq nR)$	$\left\{ a \right $	$\Big \{b\mid (a,b)\in R^{\mathcal{I}}\}\Big \leq n$
(= nR)	$\left\{ a \right $	$\Big \{b\mid (a,b)\in R^{\mathcal{I}}\}\Big =n$

- Concept $Woman \sqcap (\leq 3 hasChild)$ denotes women who have at most 3 children.
- What denotes the axiom $Car \sqsubseteq (\geq 4 \text{ hasWheel})$
- ... and $Bicycle \equiv (= 2 hasWheel)$



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$(\leq nR)$	$\left\{ a \middle \middle \{b \mid (a)\} \right\}$	$(a,b)\in R^{\mathcal{I}}\}\Big \leq n$
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Q (Qualified number restrictions) are used for restricting the number of successors of the given type in the given role for the given concept.

syntax (concept)	semantics
$(\geq nRC)$	$\left\{ a \middle \left \left\{ b \mid (a,b) \in R^{\mathcal{I}} \wedge b^{\mathcal{I}} \in C^{\mathcal{I}} \right\} \right \geq n \right\}$
$(\leq nRC)$	$\begin{cases} a \mid \{b \mid (a,b) \in R^{\mathcal{I}} \wedge b^{\mathcal{I}} \in C^{\mathcal{I}}\} \leq n \end{cases}$
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- Concept $Woman \sqcap (\geq 3 \text{ hasChild Man})$ denotes women who have at least 3 sons.
- What denotes the axiom $Car \sqsubseteq (\geq 4 \text{ hasPart Wheel})$?
- ullet Which qualified number restrictions can be expressed in \mathcal{ALC}

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Extending ... ALC ... (4)

O (Nominals) can be used for naming a concept elements explicitely.

syntax (concept)	semantics
$\{a_1,\ldots,a_n\}$	$\{a_1^{\mathcal{I}},\ldots,a_n^{\mathcal{I}}\}$

- Concept {MALE, FEMALE} denotes a gender concept that must be interpreted with at most two elements. Why at most ?
- Continent ≡
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$\dots \mathcal{ALC}$, a co dál ? (5)

 ${\cal I}$ (Inverse roles) are used for defining role inversion.

$$\begin{array}{cc} \text{syntax (role)} & \text{semantics} \\ R^- & (R^{\mathcal{I}})^{-1} \end{array}$$

- Role maDite denotes the relationship maRodice.
- What denotes axiom $Person \sqsubseteq (= 2 hasChild^-)$?
- What denotes axiom $Person \sqsubseteq \exists hasChild \cdot \exists hasChild \cdot \top$?



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·trans (Role transitivity axiom) denotes that a role is transitive.

Attention – it is not a transitive closure operator.

syntax (axiom)	semantics
trans(R)	$R^{\mathcal{I}}$ is transitive

- Role isPartOf can be defined as transitive, while role hasParent is not. What about roles hasPart, hasPart⁻, hasGrandFather⁻?
- What is a transitive closure of a relationship? What is the difference between a transitive closure of hasDirectBoss^I and hasBoss^I.



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$R \sqsubseteq S$	$R^{\mathcal{I}}\subseteq \mathcal{S}^{\mathcal{I}}$

- Role hasMother can be defined as a special case of the role hasParent.
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 □ Parent and role hierarchy hasMother
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 ${\cal R}$ (role extensions) serve for defining expressive role constructs, like role chains, role disjunctions, etc.

syntax	semantics
$R \circ S \sqsubseteq P$	$R^{\mathcal{I}} \circ S^{\mathcal{I}} \sqsubseteq P^{\mathcal{I}}$
Dis(R,R)	$R^{\mathcal{I}}\cap \mathcal{S}^{\mathcal{I}}=\emptyset$
$\exists R \cdot \mathit{Self}$	$\{a (a,a)\in R^{\mathcal{I}}\}$

- How would you define the role *hasUncle* by means of *hasSibling* and *hasParent* ?
- how to express that R is transitive, using a role chain 1
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 - SHOIN is a description logics that backs OWL-DL.
 - SROIQ is a description logics that backs OWL2-DL
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 - additional inference rules reflecting the semantics of newly added constructs $(\mathcal{O}, \mathcal{N}, \mathcal{Q})$
 - definition of *R*-neighbourhood of a node in a completion graph. R-neighbourhood notion generalizes simple tests of two nodes being connected with an edge, e.g. in \exists -rule. $(\mathcal{H}, \mathcal{R}, \mathcal{I})$
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Final Remarks



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Person □∃hasAge · 23 represents the concept describing "23-year Gerstne

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Example	

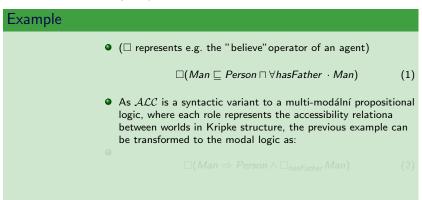
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	 As ALC is a syntactic variant to a multi-modální propositional logic, where each role represents the accessibility relationa between worlds in Kripke structure, the previous example can be transformed to the modal logic as:
	$\Box(\mathit{Man} \Rightarrow \mathit{Person} \land \Box_{\mathit{hasFather}} \mathit{Man}) \tag{2}$

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