

Reasoning on Ontologies in the Description
Logic \mathcal{ALC} with Existential Link Keys
Master II Internship

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$\mathcal{ALC} + \mathcal{LK}$

$\mathcal{ALC} : \sqcap, \sqcup, \neg, \exists, \forall, \sqsubseteq$

- A Description Logic (DL) that can be used to represent knowledge
- “All drugs indicated for diabetes” in \mathcal{ALC} :
 $\text{Drug} \sqcap \exists \text{indication. Diabete}$

\mathcal{LK} : link keys

- Link keys are useful to represent rules as “If two books in EN and FR are written by the same writer and have the same title then they would be the same.”
- $\langle (\text{write, écrit}), (\text{title, titre}) \rangle \quad \text{LK} \quad \langle \text{Book, Livre} \rangle$

Syntax and semantics of link keys

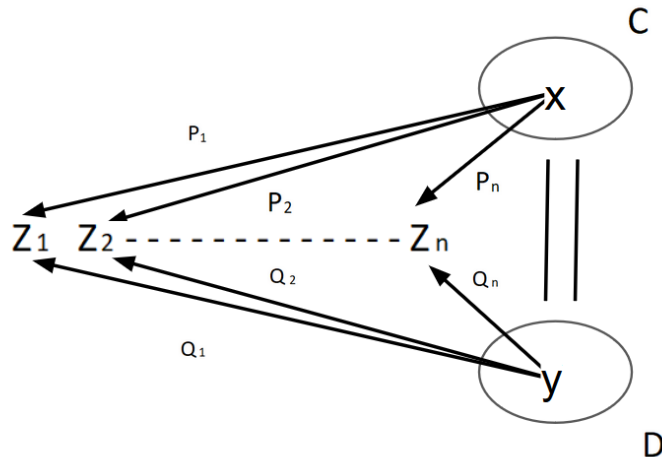
Syntax

$\langle (P_1, Q_1), \dots (P_n, Q_n) \rangle \quad \text{LK} \quad \langle C, D \rangle$

Semantics

$\forall x, y, z_1, \dots, z_n \in \Delta^{\mathcal{I}},$

$x \in C^{\mathcal{I}} \wedge y \in D^{\mathcal{I}} \wedge \bigwedge_{1 \leq i \leq n} ((x, z_i) \in P_i^{\mathcal{I}} \wedge (y, z_i) \in Q_i^{\mathcal{I}}) \Rightarrow x = y$



Link keys are not enough for medical ontologies

Example with link keys

Human(Anna), Human(Tim)
cough(Anna, Dry), fever(Anna, 38°),
cough(Tim, Dry), fever(Tim, 38°)
 $\{\langle \text{cough}, \text{cough} \rangle, \langle \text{fever}, \text{fever} \rangle\}$ LK $\langle \text{Human}, \text{Human} \rangle$

By this ontology with LK, a reasoner would entail Anna = Tim.
But two people have the same symptoms, they are not necessarily identical !

New constructor needed

However, Anna and Tim may have the same disease

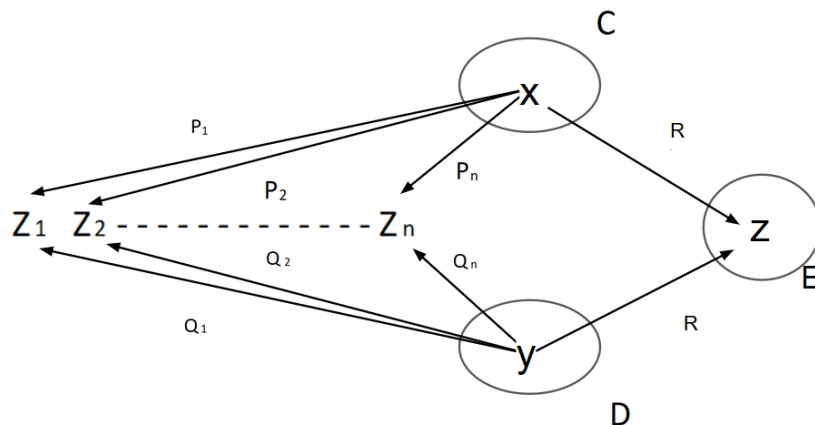
$\mathcal{ALC} + \mathcal{ELK}$

Syntax of existential link keys

$\{\langle P_1, Q_1 \rangle, \dots, \langle P_n, Q_n \rangle\} \text{ ELK } \langle C, D, R, E \rangle$

Semantics of existential link keys

$\forall x, y, z_1, \dots, z_n \in \Delta^{\mathcal{I}},$
 $x \in C^{\mathcal{I}} \wedge y \in D^{\mathcal{I}} \wedge \bigwedge_{1 \leq i \leq n} ((x, z_i) \in P_i^{\mathcal{I}} \wedge (y, z_i) \in Q_i^{\mathcal{I}}) \Rightarrow$
 $\exists z \in \Delta^{\mathcal{I}} : z \in E^{\mathcal{I}} \wedge (x, z) \in R^{\mathcal{I}} \wedge (y, z) \in R^{\mathcal{I}}$

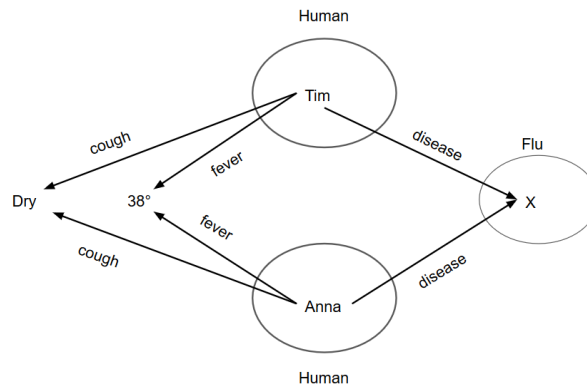


Reasoning in $\mathcal{ALC} + \mathcal{ELK}$

By the following ontology :

$\text{cough}(\underline{\text{Tim}}, \underline{\text{Dry}}), \text{fever}(\underline{\text{Tim}}, \underline{38^\circ}), \text{cough}(\underline{\text{Anna}}, \underline{\text{Dry}}), \text{fever}(\underline{\text{Anna}}, \underline{38^\circ})$
 $\text{Human}(\underline{\text{Tim}}), \text{Human}(\underline{\text{Anna}})$
 $\{ \langle \text{cough}, \text{cough} \rangle, \langle \text{fever}, \text{fever} \rangle \} \text{ ELK } \langle \text{Human}, \text{Human}, \text{disease}, \text{Flu} \rangle$
 $\text{Flu}(\underline{\text{SeasonFlu}}), \text{Flu}(\underline{\text{Corona}})$

a reasoner can entail **new knowledge** : **Tim and Anna got the same flu** (season flu or corona)



Current Task and Future Work

- Current Task :
 - Designing a naive algorithm for reasoning in $\mathcal{ALC} + \mathcal{ELK}$ (decidability)
- Future Work :
 - Discovering existential link keys from medical datasets
 - Implementing the algorithms