MANCHESTER 1824

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A Solution for the Man-Man Problem in the Family History Knowledge Base

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Disclaimer:

the name "Man-Man" for this problem was coined by Michael Schneider in some discussions on public-owl-dev.

The reason for this name will become clear later, but has nothing to do with gender, men, etc.

Robert's Family History Knowledge Base

Robert Stevens

Robert's Family History Knowledge Base

James Alexander Bomaker and Violet Robinson
(with Robert's grandma Iris Ellen)

Robert's Family History Knowledge Base

William Robson and
Elizabeth Frances Jessop.

Robert's Family History Knowledge Base

- Contains facts of 400+ members of Robert's family
  - available at www.cs.man.ac.uk/~stevensr/ontology/family.rdf.owl
- Modest-size TBox in OWL 2
  - ~ 300 axioms that use all SROIQ constructs
  - rich property hierarchy
- Large ABox with "sparse" assertions:
  - *Minimal* number of property assertions
  - No class assertions
- Goal:
  - no duplication information
  - little effort during creation
  - easy to maintain consistency KB consistent
  - rich RBox => many inferences

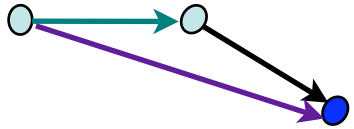
The TBox

- *Every brother is a man*

  Range(hasBrother) = Man

- *A parent's brother is an uncle*

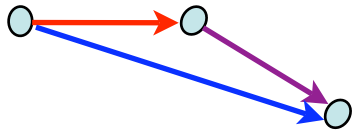
  hasParent o hasBrother ⊑ hasUncle



- *A sibling-in-law is a sibling of a spouse or a spouse of a sibling*

  hasSibling o hasSpouse ⊑ hasSiblingInLaw,

  hasSpouse o hasSibling ⊑ hasSiblingInLaw



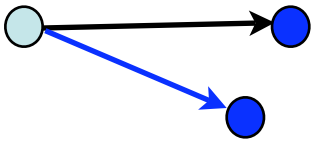
- *A person's male sibling is their brother*

  ???

A person's male sibling is their brother

- A class-level approach:

$$\text{hasSibling some Man} \sqsubseteq \text{hasBrother some Person}$$



- But...
  - *a person having a male sibling is a person having a brother*

    is different from

    *a person's male sibling is **their** brother*
  - ...so this doesn't really work

A person's male sibling is their brother

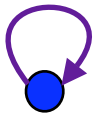
- A rule-based approach:

  hasSibling(x,y), Man(y) --: hasBrother(x,y)

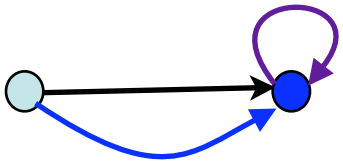
- But...
  - General rules make OWL 2 undecidable
  - As a **DL-safe** rule:
    - does the trick on individuals:
      (Jane, Peter):hasSibling and Man(Peter) entail
      (Jane,Peter):hasBrother
    - But does not affect TBox entailments:
      e.g., O does not entail
      isSiblingOf some father $\sqsubseteq$ hasBrother some Person
  - ...so this doesn't really work

A person's male sibling is their brother

- The ManMan approach [SchneiderPOD,Gasse+2008, Kroetzsch+2008]:
  - Create a new property, ManMan, and add an axiom
    Man ⊑ ManMan some Self



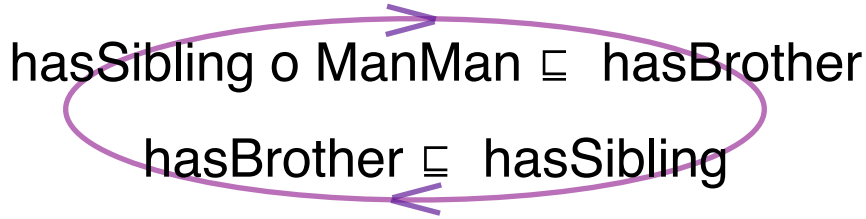
  - further add
    hasSibling o ManMan ⊑ hasBrother



  - works both for individuals and classes
- But, to stay in OWL 2, one has to discard
  - hasBrother ⊑ hasSibling
    - ...so this doesn't really work

A person's male sibling is their brother

- Follow ManMan approach +
  exploit **extended regularity condition** [Kazakov, 2009]:



  - such cycles not necessarily cause undecidability
    FHKB is such an ontology

- ...but:
  - cycle check and
  - implementation
    require significant modification to the existing reasoners
  - No known implementation in OWL 2 reasoners yet

Our approach

- Extend OWL 2 with new property axioms
  - SpecFrom(PropA,Class) $\sqsubseteq$ PropB

with semantics: $\forall$ x,y.PropA(x,y) $\wedge$ Class(x) $\Rightarrow$ PropB(x,y)

  - SpecInto(PropA,Class) $\sqsubseteq$ PropB

with semantics: $\forall$ x,y.PropA(x,y) $\wedge$ Class(y) $\Rightarrow$ PropB(x,y)

  - observe:

SpecInto(PropA,Class) $\sqsubseteq$ PropB

is equivalent to

SpecFrom(Inv(PropA),Class) $\sqsubseteq$ Inv(PropB)

Our approach

- Tableau reasoner is easily extended:

  Dmitry only needed to add

  – 2 new rules to Fact++,
  – similar to existing rules

Spec-apply-rule:

– if SpecFrom(R, C) $\sqsubseteq$ S, x is not blocked,
  $R \in L(x, y)$, $C \in L(x)$, $S \notin L(x, y)$

– then add S to L(x, y)

Spec-choose-rule:

– if SpecFrom(R, C) $\sqsubseteq$ S, x is not blocked,
  $R \in L(x, y)$, $\{C, \neg C\} \cap L(x) = \varnothing$

– then set L(x) = L(x) \cup {D}, where D \in {C, ¬C}

Properties of our approach

- Tableaux algorithms correctly captures semantics
- Solves the problem on both individual and class level
- Pay-as-you-go:

  no rule specialisation axioms ➥ no overhead
- No change to existing tableaux reasoner architecture

Evaluation

- Extended OWL 2 syntax
  - with 2 new constructors
    SpecFrom(Prop,Class), SpecInto(Prop,Class)
- Implemented 2 new rules in FaCT++
- Added four new axioms to FHKB:
  - SpecFrom(isSiblingOf,Man) $\sqsubseteq$ isBrotherOf
  - SpecFrom(isSiblingOf,Woman) $\sqsubseteq$ isSisterOf
  - SpecFrom(hasParent,Man) $\sqsubseteq$ isSonOf
  - SpecFrom(hasParent,Woman) $\sqsubseteq$ isDaughterOf
- Ran some tests on FHKB+

Brother/Sister tests

- Brother1 = Man and (isSiblingOf some Person)
- Brother2 = isBrotherOf some Person
- Sister1 = Woman and (isSiblingOf some Person)
- Sister2 = isSisterOf some Person

Class	Instances in FHKB	Instances in FHKB+
Brother1	160	160
Brother2	152	160
Sister1	163	163
Sister2	153	163

Uncle/Aunts tests

Uncle = isBrotherOf some (hasChild some Person)

GreatUncle = isBrotherOf some (hasChild some (Person and hasChild some Person))

Aunt = isSisterOf some (hasChild some Person)

GreatAunt = isSisterOf some (hasChild some (Person and hasChild some Person))

Class	Instances in FHKB	Instances in FHKB+
Uncle	55	76
GreatUncle	49	67
Aunt	58	77
GreatAunt	55	71

Son/Daughter tests

Son = isSonOf some Person

Daughter = isDaughterOf some Person

Class	Instances in FHKB	Instances in FHKB+
Son	7	202
Daughter	6	208

- Note that
  - FHKB+ entails Son = Man
  - FHKB didn't

BrotherInLaw tests

- BIL1 = Man and
  (isSiblingOf some (isSpouseOf some Person)) or
  (isSpouseOf some (isSiblingOf some Person))
- BIL2 = isBrotherInLawOf some Person

  isBrotherOf o isSpouseOf ⊑ isBrotherInLawOf

  isHusbandOf o isSiblingOf ⊑ isBrotherInLawOf

Class	Instances in FHKB	Instances in FHKB+
BIL1	39	39
BIL2	25	39
SIL1	30	30
SIL2	12	30

Discussion

- FHKB is interesting test case for OWL 2
  - not the best kind of knowledge to represent in OWL,
  - but it works mostly fine
  - stress-tests reasoners: expansion is future work
- New constructors seem
  - nice:
    - help with modeling our family relations
    - we have seen various similar request & questions
  - easy-going:
    - require only simple modification of tableau reasoners
    - other reasoners should be easily extensible as well
  - not as general as extended regularity condition [Kazakov09]
- ...worth considering for OWL 3?