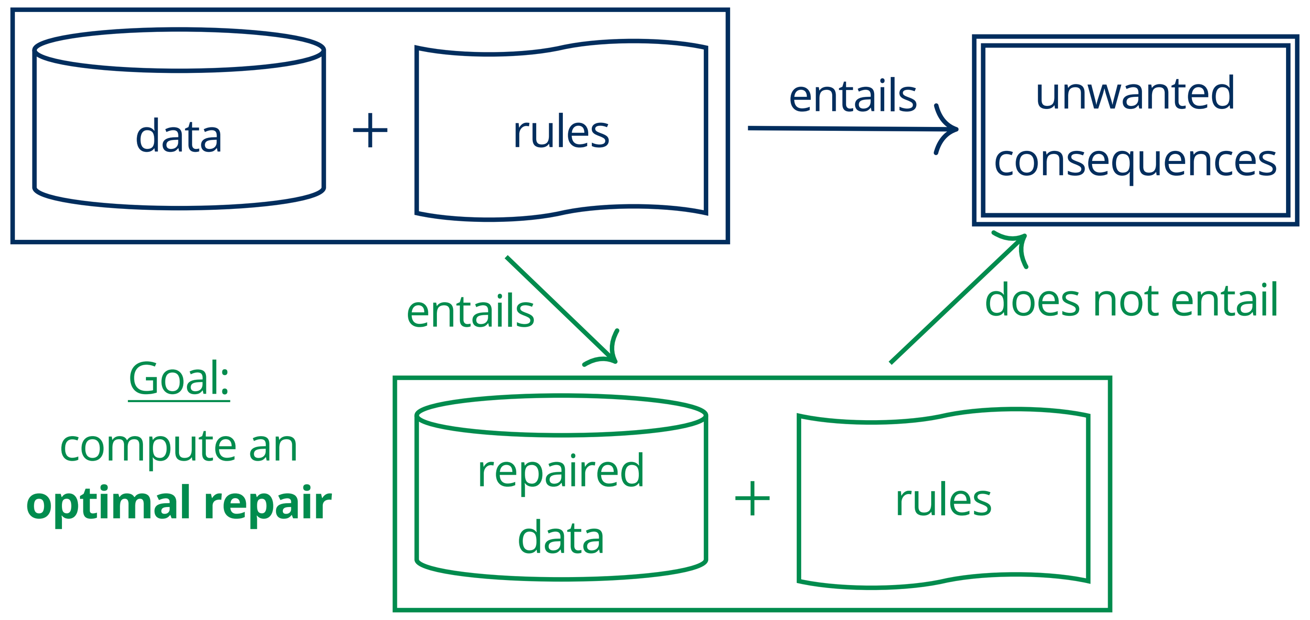
TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Computer Science • Institute of Theoretical Computer Science • Chair of Automata Theory

Computing Optimal Repairs of Quantified ABoxes w.r.t. Static $\mathcal{EL}$ TBoxes

1 Problem Setting



- **Data:** quantified ABox (qABox) $\exists X.\mathcal{A}$
- **Rules:** $\mathcal{EL}$ TBox $\mathcal{T}$
- **Unwanted consequences:** $\mathcal{EL}$ repair request $\mathcal{R}$
- A **repair** of $\exists X.\mathcal{A}$ for $\mathcal{R}$ w.r.t. $\mathcal{T}$ is a qABox $\exists Y.\mathcal{B}$ such that
  - $\exists X.\mathcal{A}$ and $\mathcal{T}$ entail $\exists Y.\mathcal{B}$, and
  - $\exists Y.\mathcal{B}$ and $\mathcal{T}$ do not entail $C(a)$ for each $C(a) \in \mathcal{R}$.
- A repair is **optimal** if it is not strictly entailed by another repair.

2 A Repair Recipe

For each unwanted consequence $C(u)$:

- either choose a concept name $B \in \mathsf{Conj}(C)$ and remove $B(u)$ from $\mathcal{A}$,
- or choose an existential restriction $\exists r.D \in \mathsf{Conj}(C)$ and do the following for each $r(u,v) \in \mathcal{A}$:
  - if $D \neq \top$, then recursively modify $\mathcal{A}$ such that it does not entail $D(v)$,
  - otherwise, remove $r(u,v)$ from $\mathcal{A}$.

3 Taking the TBox into Account

- In order to not lose consequences that follow from removed axioms, but that do not itself violate the repair request, we initially need to **saturate** the qABox by means of the axioms in the TBox.
- When removing an atomic unwanted consequence $B(u)$ or $\exists r.D(u)$, it is also necessary to remove all $E(u)$ where $E \sqsubseteq_{\mathcal{T}} B$ or $E \sqsubseteq_{\mathcal{T}} \exists r.D$, respectively. It suffices to consider concepts $E \in \mathsf{Sub}(\mathcal{T},\mathcal{R})$.

4 Saturations

- The saturation of a qABox depends on the entailment relation.
- **Classical entailment** compares qABoxes w.r.t. their models.
- **CQ-entailment** compares qABoxes w.r.t. which **C**onjunctive **Q**ueries they entail. It coincides with classical entailment (for a fixed TBox!) and is NP-complete.
- To guarantee termination of saturation w.r.t. CQ-entailment, we require that the TBox is cycle-restricted. Specifically, it then terminates in exponential time.
- **IQ-entailment** compares qABoxes w.r.t. which $\mathcal{EL}$ concept assertions (**I**nstance **Q**ueries) they entail. It can be decided in polynomial time.
- Saturation w.r.t. IQ-entailment always terminates, viz. in polynomial time.

5 Canonical Repairs

- Canonical repairs are based on the repair recipe, taking the TBox into account. To achieve **optimality**, we create enough copies of each object in the input and modify each copy in another way.
- Given a qABox, a cycle-restricted TBox, and a repair request, **the set of all optimal CQ-repairs can be computed in exponential time using an NP-oracle.**
- Given a qABox, a TBox, and a repair request, **the set of all optimal IQ-repairs can be computed in exponential time.**

6 Optimized Repairs

- **Problem:** Each canonical repair has exponential size. Thus, it is expensive or even impossible to compute canonical repairs of large ontologies.
- There are examples where an optimal repair need not be exponentially large. In these cases, the canonical repair is already equivalent to a small sub-qABox.
- We propose a rule-based approach to computing optimized repairs, which contain only relevant parts of the canonical repairs.

7 Implementation and Evaluation

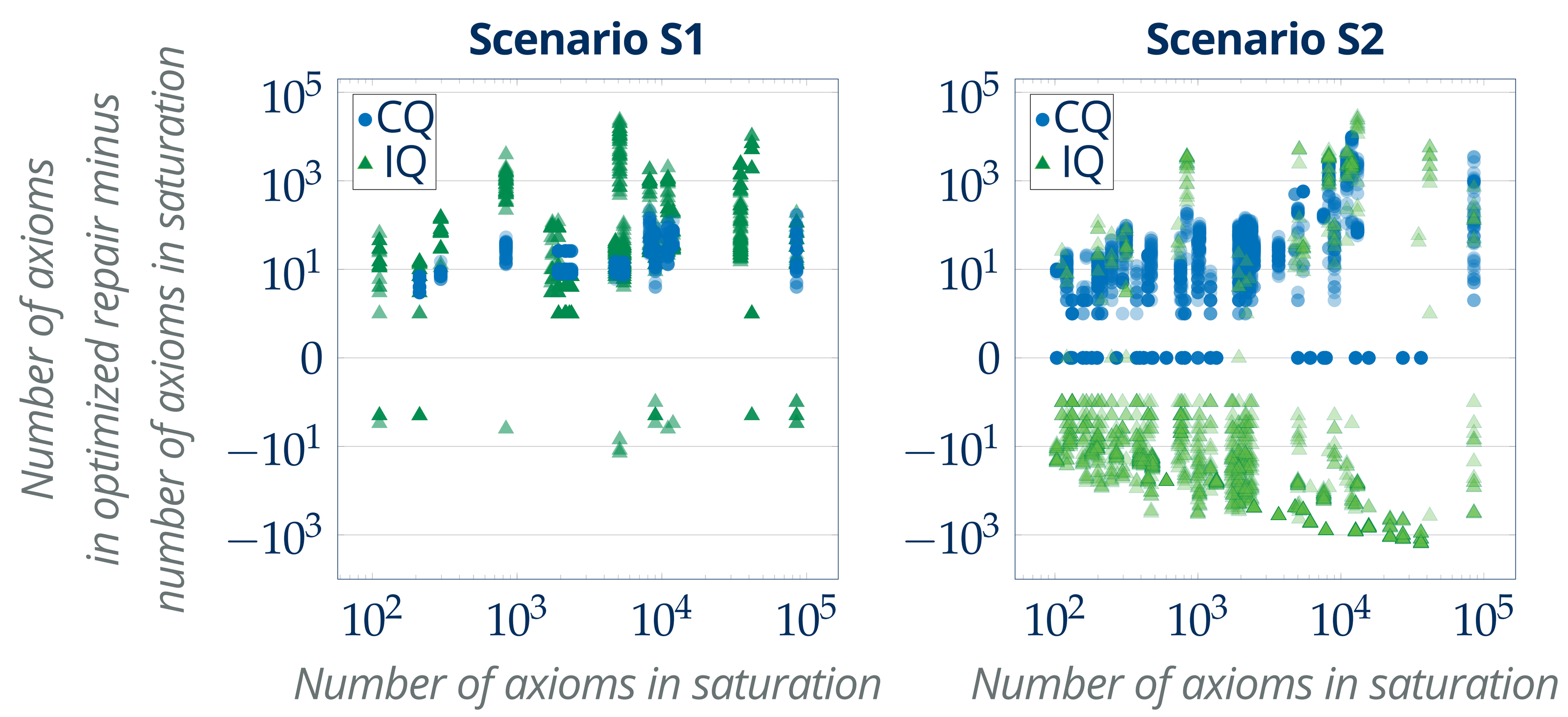
Prototypical implementation:
`https://github.com/de-tu-dresden-inf-lat/abox-repairs-wrt-static-tbox`

Scenarios:

- **S1:** repairing a single unwanted consequence for a single individual
- **S2:** repairing a single unwanted consequence for 10 % of the individuals

Evaluation corpus:

- 80 ontologies
- With up to 100,000 axioms
- Used in the 2015 OWL Reasoner Competition
- Track: OWL EL Realisation
- Cyclic ontologies ignored for CQ-experiments



References

Franz Baader, Francesco Kriegel, Adrian Nuradiansyah, Rafael Peñaloza: **Computing Compliant Anonymisations of Quantified ABoxes w.r.t. $\mathcal{EL}$ Policies.** 19th International Semantic Web Conference (ISWC), Athens, Greece, November 2–6, 2020.

Franz Baader, Patrick Koopmann, Francesco Kriegel, Adrian Nuradiansyah: **Computing Optimal Repairs of Quantified ABoxes w.r.t. Static $\mathcal{EL}$ TBoxes.** 28th International Conference on Automated Deduction (CADE), Virtual Event, July 12–15, 2021.

Technische Universität Dresden
Faculty of Computer Science
Institute of Theoretical Computer Science
Chair of Automata Theory

Franz Baader
Patrick Koopmann
Francesco Kriegel
Adrian Nuradiansyah

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