

Contents

Resumen	i
Abstract	ii
1 Introduction	1
1.1 Main goals	4
1.1.1 Fixed-parameter tractable evaluation of UC2RPQs	4
1.1.2 Containment of regular queries	7
1.2 Contributions	9
2 Background	12
2.1 Relational Databases and UCQs	12
2.2 Graph databases and UC2RPQs	13
2.3 Query evaluation and containment	15
2.3.1 Basic complexity results for (U)CQs	16
2.3.2 Basic complexity results for (U)C2RPQs	17
I Fixed-parameter tractable evaluation of UC2RPQs	19
3 Semantically acyclic UC2RPQs	20
3.1 Interlude on UCQs	22
3.1.1 Acyclic UCQs	22
3.1.2 Semantically acyclic UCQs	23
3.2 Acyclic UC2RPQs	27
3.3 Containment of UC2RPQs	28
3.3.1 Canonical databases and foldings	30
3.3.2 Proof of Lemma 3.14	31
3.4 Approximations of UC2RPQs	37
3.4.1 Approximations: Existence and computation	38
3.4.2 Proofs of results	39
3.5 Semantically acyclic UC2RPQs: Evaluation and verification	49
3.5.1 Basic terminology and insights	49
3.5.2 Evaluation of semantically acyclic UC2RPQs	51
3.5.3 Verification of semantic acyclicity	51
4 UC2RPQs of bounded treewidth modulo equivalence	54
4.1 Known results for UCQs	55

4.2	UC2RPQs of bounded treewidth modulo equivalence: Evaluation is fixed-parameter tractable	58
II	Containment of regular queries	64
5	Containment of regular queries: Elementary complexity bounds	65
5.1	Regular queries and nested UC2RPQs	66
5.1.1	Regular Queries (RQs)	67
5.1.2	Nested UC2RPQs (nUC2RPQs)	69
5.2	Containment of regular queries	69
5.2.1	From nUC2RPQs to flat nUC2RPQs	70
5.3	From flat nUC2RPQs to single-atom C2RPQs/flat nUC2RPQs	72
5.3.1	Construction of $\tilde{\mathcal{A}}$	74
5.3.2	Construction of $\tilde{\Gamma}$	76
5.4	Containment of single-atom C2RPQs in flat nUC2RPQs	84
5.4.1	Cuts	84
5.4.2	Transition System Based on Cuts	86
5.4.3	Cut Automata	96
5.4.4	Main Proof	100
5.5	Putting it all together: Upper and lower bounds for containment of nUC2RPQs	101
5.5.1	Upper Bound	101
5.5.2	Lower Bound	103
5.6	Restrictions and variants of RQs	107
5.6.1	Intensional predicates with unbounded arity: generalized RQs	108
5.6.2	Beyond Graph Databases	110
III	Wrapping up	111
6	Conclusions and future work	112
6.1	Future work	113
	Bibliography	116

List of Figures

- 1.1 A social network represented as a graph database 2

- 3.1 A semantically acyclic CRPQ and its equivalent acyclic query 21
- 3.2 The CRPQ γ_{sa} 50
- 3.3 The acyclic CRPQ that is equivalent to γ_{sa} 50
- 3.4 The CRPQ γ_{na} from Example 3.29 50

- 4.1 The cycle C_5 and a tree decomposition of width 2 56
- 4.2 The grid 3×3 and a tree decomposition of width 3 56