

Contents

Acknowledgments	ix
Abstract	xi
Contents	xix
I INTRODUCTION	1
1 Introduction	3
1.1 Motivation	5
1.2 Problem Statement	6
1.3 Objectives and Research Questions	8
1.4 Research Methodology	9
1.5 Outline	11
II PROBLEM INVESTIGATION	13
2 From Conceptualizations to Ontologies	15
2.1 Ontology Engineers and Domain Specialists	16
2.2 Ontologies Characterization Challenges	17
2.3 Conclusions	24
3 Towards Cybersecurity Ontologies	25
3.1 Identifying the Cybersecurity Experts Roles	26

3.2	Searching for Cybersecurity Ontologies	28
3.3	Cybersecurity Conceptualization Challenges	29
3.4	Conclusions	31
4	State of The Art	33
4.1	FAIR Principles	33
4.2	Ontology Classification	38
4.3	Conclusions	44
III	TREATMENT DESIGN	47
5	The Meta-Ontology to describe Ontologies	49
5.1	Methodology, Stakeholders and Research Questions	50
5.2	Conceptual Characterization of Ontologies	52
5.3	Domain Cloud of Concepts in Conceptual Characterizations	54
5.4	Linguistics in Conceptual Characterizations	56
5.5	Relations Among Ontologies and Ontology Networks	60
5.6	Conclusions	62
6	The Framework for Ontology Characterization	63
6.1	Framework Description	64
6.2	State of The Art	66
6.3	Domain Perspective	67
6.4	Ontological Perspective	68
6.5	Conclusions	72
IV	TREATMENT VALIDATION	73
7	Applications of O4OA and F4OC in the Cybersecurity Domain	75
7.1	An Operational Version of O4OA	77
7.2	A Semi-automatic Support for Ontological Analysis	78
7.3	Applying FO4C on the Cybersecurity Domain	81
7.4	Conclusions	91
V	CONCLUSIONS AND FUTURE WORKS	93
8	Conclusions and Future Works	95
8.1	Answers to Research Questions	96
8.2	Thesis Impact	99

8.3 Future Work	103
Bibliography	105
APPENDIX	135
A Cybersecurity Ontologies TLR	137
A.1 Selection Process	137
A.2 Search Outcomes	138
B Cybersecurity Conceptualization Sources	143
B.1 Cybersecurity Terminology	143
B.2 Cybersecurity Sources	147
C O4OA Documentation Details	151
C.1 Related Ontologies	151
C.2 Competence Questions	152
C.3 Packages	153
C.4 Competence Questions Verification	154
D F4OC Applied to the Cybersecurity Domain	157
D.1 API query in MongoO4OA Tracing Concepts	157
D.2 API query in MongoO4OA Tracing the Concept of Vulnerability	159
D.3 API query in MongoO4OA Tracing the Concept of Risk	163
D.4 API query in MongoO4OA Tracing BRON Relations	171
D.5 CVE Glossary about the Concept of Vulnerability	181
D.6 Summary of BRON Initiative Ontologies Characterization	182