University Academic Curriculum Vitae

The undersigned SAVKOVIC OGNJEN is aware that, in accordance with the artt. 46 e 47 del D.P.R. of 28th December 2000, n. 445, falsification of documents and untrue declarations are punished by the penal code and by the special laws regarding the matter, according to the provisions referred to in the art. 76 del D.P.R. of 28th December 2000, n. 445,

Ognjen Savković, Ph.D. – Curriculum Vitæ

Faculty of Computer Science

DATE: September 21,2022 Free University of Bozen-Bolzano
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Brief Synopsis of the Research Activity

Ognjen Savkovi´c is an assistant professor (RTD-a) at the KRDB Research Centre for Knowledge and Data. Before that, he was a research visitor at Oxford University. He obtained his PhD degree in Computer Science from FUB in 2016 with focus on development and implementation of data-quality-aware business processes. Prior to that, he obtained his European Master Degree in Computation Logic from the TU Vienna and the Free University of Bozen-Bolzano. He also graduated mathematics from the University of Belgrade.

His research activity spans between theoretical and experimental aspects of Semantic technologies, data management, and logic reasoning to understand and improve data quality in KGs and databases. In particular, he contributed with papers in several research areas: semantic technologies [5, 6, 9, 10, 13, 11, 12, 8, 16], foundations of data management and quality [21, 24, 18, 19], reasoning over business processes and data [20, 22] and description logics [26, 14], publishing on top-tier conferences such as SIGMOD, CIKM, ICDT and ISWC.

Ognjen has experience in writing projects and organizing project teams. In last 3 years, he wrote 5 project proposal on University level, ranging from 10k € to 66k €, and is a PI of two another projects, in total budgets of 160k €. Ognjen was also the leading developer and implementer of several demo tool for managing data quality, and has been teaching and supervision of students in the last 5 years as the member of the faculty.

Main Research Interests

- Semantic Web Technologies, Knowledge Graphs and Query Answering
- Foundations of Data Management and Data Quality
- Data-aware Business Processes: Modeling and Verification

EDUCATION

JAN 2012 - OCT 2016 **Ph.D. in Computer Science** at Free University of Bozen- Bolzano.
Title of the thesis: *Process-aware Data Quality Assessment*.
Advisor: Dr. Werner Nutt
Thesis Reviewer 1: Prof. Leonid Libkin (Univ. Edinburgh)
Thesis Reviewer 2: Prof. Victor Vianu (Univ. California, San Diego)
Exam Committee: Prof. Reinhard Pichler (Vienna Univ. Technology), Prof. Francesco Ricci (Free Univ. Bozen-Bolzano), Prof. Matthias Weidlich (Humboldt Univ. Berlin)

Evaluation of the thesis: *Excellent*.
Attachment: In Appendix 2, I provide the report of the final exam made by the exam committee.

Thesis Summary In this work, we provide solutions for two data quality problems. In the first, we consider a dynamic scenario where data is constantly created and updated by an underlying business process. Starting from a business process specification that de- scribes the data evolution in the system, we check whether the answers of a query are reliable. In the second, we consider a scenario where a database is only partially complete because not all data has arrived or because data is integrated from different sources. There we analyze if for certain queries we can guarantee complete- ness of query answers and how to provide suggestions on what to add if data is not complete. For both settings, we propose formalisms that model the problems and we establish algorithms that provide solutions for these problems. To achieve this, we combine techniques from data management, complexity theory, artificial intelligence and business process management.

2009 – 2011 **European Double Master Degree in Computational Logic (EMCL)** at the Technische Universität Wien (2009/2010) and Free University of Bozen-Bolzano (2010/2011)
Thesis Title: *Managing Datatypes in Ontology-based Data Access*
Grade: highest honors (110/110 cum laude)
Supervisor: Prof. Diego Calvanese (Free Univ. Bozen-Bolzano)

Thesis Summary In this work we study the impact of adding datatypes to the ontology-based data access (OBDA) scenario. We introduce a language for datatypes and we define the notion of a datatype hierarchy, constituted by a set of datatypes that depend on each other. We classify hierarchies in three classes according to their distinguishing properties, and we establish a theoretical framework for datatypes in the OBDA scenario, based on three major components: a DL, a class of datatype hierarchies, and a query language. We establish the computational complexity of query answering for various significant instantiations of this framework, as ranging from FOL-rewritable to coNP in data complexity.

2004-2009 **Graduate Mathematician and Computer Scientist** at Faculty of Mathematics, University of Belgrade, Serbia.
GPA: 9.36/10.00 (top 1%)

Study Curriculum: Mathematical analysis I, Linear Algebra, Introduction to programing, Analytical Geometry, Mathematical analysis II, Algebra I, Introduction to Geometry, Introduction to Computer Systems, Introduction to Numerical mathematics, Theory of real and complex functions, Projective geometry, Numerical methods, Theory of Language, Algorithms and Automata, Prgraming languages, Compilers and Interpreters, Operative systems, Foreign language I (English), Introduction to philosophy, Pedagogy, Differential equations, Statistics and probability, Mathematical Logic, Algorithms and Data Structures (selected), Foreign language II (English), Microcomputers, History Of Philosophy and Mathematics, Databases.

PROFESSIONAL EXPERIENCE AND RESEARCH CAREER

MAY 2020- MAY 2023 **Assistant Professor (Free University of Bozen-Bolzano)**
Junior RTD, with a fixed-term contract, at the Faculty of Computer Science of the Free University of Bozen-Bolzano.
Outcome (Ongoing):
Writing project proposals (4 acquired as a PI, currently PI of 6). Established active industrial collaborations Bosch Center for Artificial Intelligence in Heidelberg, Germany. Teaching and development of new courses at bachelor. Acquiring University level projects and supervising postdocs on those projects.
Advisor: Prof. Werner Nutt

MAY 2017- MAY 2020 **Assistant Professor (Free University of Bozen-Bolzano)**
Junior RTD, with a fixed-term contract, at the Faculty of Computer Science of the Free University of Bozen-Bolzano.
Outcome: Writing project proposals (4 acquired as a PI). Established active collaborations with University of Oxford, Oslo, Santiago Chile, and industrial collaborations with Siemens Munich. Teaching and development of new courses at bachelor and master level.
Advisor: Prof. Werner Nutt

JAN 2017 – APR 2017 **Sponsored Research Visitor (Oxford University, UK)**
Outcome: In collaboration with Siemens Munich work on languages for sensor data. In particular, we developed an OBDA-friendly ontological language for sensor analytics. We successfully examined application of this language in data analytics for Industry 4.0 (smart factories), trains and turbines
Advisor: Dr. Evgeny Kharlamov and Dr. Ian Horrocks

JAN 2016 – DEC 2016 **Research Assistant (Free University of Bozen-Bolzano)** AR contract at the Faculty of Computer Science

Outcome: We developed a theoretical framework that describes how processes access and modify relevant data. The framework considers negation in process conditions, cyclic executions, read access to written data, presence of pending process instances, and the possibility to start fresh process instances. Starting from such models we developed algorithms that check whether the answers of given queries are reliable. We identified for which restriction combinations the problem is decidable and for which not. For all decidable cases we provided encodings into suitable variants of Datalog. Also we showed that the encodings are optimal with respect to the worst- case complexity of the problem. We studied complexity measures for all parameters of the problem: database instance, process in- stances, process model, and query.
Advisor: Prof. Werner Nutt

AUG 2016 – SEPT 2016 **Research Visitor (Oxford University, UK)**
Outcome: We developed a technique that uses business process technologies to enhance sensor feature selections in early warning systems for automated conveyors. The aim is to use process models to capture production processes and predict which of the sensor data is final and which not, in order to make better selection of sensor data, and also predict which features are relevant for which production items.
Advisor: Dr. Evgeny Kharlamov and Dr. Ian Horrocks

JAN 2015 – DEC 2015 **Research Assistant (Free University of Bozen-Bolzano)**
AR contract at the Faculty of Computer Science
Outcome: We developed a theoretical framework and implementation technique that leverages meta-information about data to assess completeness of that data. In particular, we developed theorems that provide a syntactic characterization of the reasoning tasks and based on these, we develop encodings of the problems into logic programming formalisms such as Answer Set Programming (ASP). We tested our encoding using two state-of-the-art ASP solvers, dlv and clingo, and one Prolog implementation, swi.
Advisor: Prof. Werner Nutt

OCT 2014 – DEC 2014 **Research Collaborator (Free University of Bozen-Bolzano)**
co.co.pro. contract at the Faculty of Computer Science
Outcome: We made extensions of the demonstrator systems CORNER and MAGIK. In particular, we further implemented a reasoning technique that allows one to analyze in the case that a given query is not complete which are the parts of the data that are missing to complete the query answer. Also, we developed a technique for using ontology-based similarity computation for improving the quality of answers in medical information retrieval.
Advisor: Prof. Werner Nutt

JUNE 2012 – JUNE 2014 **Research Collaborator (Free University of Bozen-Bolzano)**
co.co.pro. contract at the Faculty of Computer Science
Outcome: We developed and implemented methods that analyze chemotherapy data and predict the chemotherapy side effects of a patient based on the patient characteristics.
Advisor: Dr. Mouna Kacimi

NOV 2011 – DEC 2011 **Research Collaborator (Free University of Bozen-Bolzano)**
co.co.pro. contract at the Faculty of Computer Science

Outcome: We studied the impact of adding datatypes to the ontology-based data access (OBDA) scenario. We established the first theoretical framework for datatypes in the OBDA scenario that classifies which properties of datatypes and their usage are admissible and which not for the OBDA scenario.
Advisor: Prof. Diego Calvanese

SEP 2010 – OCT 2010 **Software Developer (Siemens AG - Munich, Germany)** Internship at Corporate Technology department
Outcome: We developed and implemented ontological framework that uses abduction reasoning over an ontology to search for plausible diagnoses of errors in a system. A possible application scenario is Siemens turbine systems. Technology used: JAVA, C#, OWL API and Pallet reasoner.
Advisor: Dr. Mikhail Roshchin

JUNE 2009 – JULY 2009 **Software Developer (ComTrade Group, Belgrade, Serbia)**
Internship at the leading IT Company in Serbia
Outcome: We developed and implemented a server application for SMS-banking.

RESEARCH AND SCHOLARSHIPS GRANTS (AT PUBLIC CALLS)

Format: Period granted, Grant Title, Funding Body and Amount received

MAY 2020 – MAY 2023 Title: University researcher with junior contract (in Italian RTD)
Funding Body: Free University of Bozen-Bolzano; Amount:(salary)

MAY 2017 – MAY 2020 Title: University researcher with junior contract (in Italian RTD)
Funding Body: Free University of Bozen-Bolzano; Amount:(salary)

JAN 2016- DEC 2016 Title: AR position on the project titled: Process-aware Reliability Checking for Information Systems (PARCIS)
Funding Body: Free University of Bozen-Bolzano; Amount:(salary)

JAN 2015 – DEC 2015 Title: AR position on the project titled: Completeness-Aware Querying and Navigation on the Web of Data (CANDy)
Funding Body: Free University of Bozen-Bolzano; Amount:(salary)

NOV 2014 – DEC 2014 Title: A research position on the project titled: MAnaGIng Completeness of Data (MAGIC)
Funding Body: Free University of Bozen-Bolzano; Amount:(salary)

JUN 2014 – JULY 2014 Title: A research position on the project titled: Reducing Antimicrobial Resistance in Bolzano (RARE)
Funding Body: Free University of Bozen-Bolzano; Amount:(salary)

JAN 2012 – DEC 2014 Title: 27th cycle of the Free University of Bolzano PhD scholarship competition
Funding Body: Free University of Bozen-Bolzano Amount: 51.000 €

A.Y. 2010 – 2011 Title: Scholarship award for the top 100 students at international universities
Funding Body: Serbian Ministry of Education; Amount: 5.600 €

A.Y. 2009 – 2010 Title: Scholarship award for the top 100 students at international universities
Funding Body: Serbian Ministry of Education; Amount: 7.000 €

OCT 2009 – SEPT 2011 Title: Scholarship for the European Master Program in Computational Logic

Funding Body: European Commission Amount: 42.000 €

A.Y. 2004 – 2008 Title: Scholarship for young talents
Funding Body: Serbian Ministry of Education; Amount: 1.800 €

Paper and Academic Awards

- **Best paper award** at the International Semantic Web Conference 2019 **(ISWC 2019)** for the paper *Validating Shacl Constraints over a SPARQL Endpoint* (https://iswc2019. semanticweb.org/program/awards/)
- **Best in-use paper award** at the International Semantic Web Conference 2017 **(ISWC 2017)** for the paper *Semantic Rule-Based Equipment Diagnostics* (https://iswc2017. semanticweb.org/program/awards/)
- **"Spotlight Paper"** (shorted list of the paper candidates for the best paper award) at the International Semantic Web Conference 2018 **(ISWC 2018)** for the paper *Semantics and Validation of Recursive SHACL* (http://iswc2018.semanticweb.org/program/)
- **"Best PhD Runner-up"** in the competition for the best PhD thesis at the Faculty of Computer Science at the Free University of Bozen-Bolzano awarded in academic year 2015/2016
- **"Award for Best Presentation"** with title: "Modelling and Reasoning with Business Processes and Workflows", at the Research School *Foundations and Challenges of Change in Ontologies and Databases*, held on 29-31 January 2014 in Bozen-Bolzano, Italy (https: //www.inf.unibz.it/franconispace/?id=organisation:sakt:2013:main_sakt)

Project Acquisition and Roles

Ognjen Savkovi´c has acquired several research projects as a PI and coPI:

- *SPGAS (Smart and Parallel Graph Analytics System)*
  Topics: Graph Analytics, Graph Databases, Query Optimization
  Role: Principal Investigator
  Budget: 66.000 €
  Start as coPI: Aug 2019 (project approved)
  Start as PI: Sept 2021 (started as a PI)
  External Partners: University of Trento, Italy ARM Research, Cambridge, UK Lawrence Berkeley National Laboratory, Berkeley, USA University of Oslo, Norway
  Funding Body: Province of Bozen-Bolzano
- *KGID: Rewritings of OBdA SpecificaTions*
  Topics: Knowledge Graphs, OBDA,
  SHACL Role: Co-Principal Investigator
  Budget: 10.000 €
  Start and Duration: Nov 2017 (24 months)
  External Partners: Birkbeck, University of London, UK; University of Liverpool, UK;
  Funding Body: Province of Bozen-Bolzano
- *ADVANCE4KG (LeArning anD ValidAtiNg SChEmas for Knowledge Graphs)*
  Topics: RDF Constraints, Knowledge Graphs, Data Quality
  Role: Principal Investigator
  Budget: 58.000 €
  Start and Duration: Aug 2018 (21 months)
  External Partners: University of Oxford, UK; Max-Planck-Institut fur Informatik, Saarbrcken, Germany; Pontificia Universidad Catlica de Chile, Santiago, Chile; Siemens AG, Corporate Technology, Munich, Germany
  Funding Body: Province of Bozen-Bolzano

- *QUEST: Quality-aware information models for industrial monitoring systems*
  TOPICS: Sensor Analytics, Semantic Web, OBDA
  ROLE: Principal Investigator
  BUDGET: 10.000 €
  START AND DURATION: July 2017 (24 months)
  EXTERNAL PARTNERS: University of Oxford, UK; Siemens AG, Corporate Technology, Munich, Germany
  FUNDING BODY: Province of Bozen-Bolzano

- *ROBAST: Rewritings of OBdA SpecificaTions*
  TOPICS: Ontology, FO-Rewriting, Description
  Logic ROLE: Co-Principal Investigator
  BUDGET: 6.000 €
  START AND DURATION: Nov 2017 (24 months)
  EXTERNAL PARTNERS: Birkbeck, University of London, UK; University of Liverpool, UK;
  FUNDING BODY: Province of Bozen-Bolzano

- *QUADRO: High Quality Data Integration with Ontologies*
  TOPICS: Data Quality, RDF, Ontology, OBDA, Data Integration ROLE: Co-Principal Investigator
  BUDGET: 10.000 €
  START AND DURATION: July 2018 (24 months)
  EXTERNAL PARTNERS: University of Oxford, UK
  FUNDING BODY: Province of Bozen-Bolzano

TEACHING ACTIVITY

A.Y. 2021/2022 **Main Lecturer (Lectures and Labs)**
Course: *Mathematical Analysis*
Program: 1st year Bachelor in Computer Science University: Free University of Bozen-Bolzano Class size: 70 students
Activity: Further improvements on the course material from the previous year as well as creating weekly assignments and midterm exams.
Credits and Hours: Number of hours: 40 lectures + 20 labs, 6 ECTS Topics: Sequences and series; Univariate functions; Derivatives, differentials and Taylor Theorem; Riemann integral; Logarithmic and exponential functions

A.Y. 2020/2021 **Main Lecturer (Lectures and Labs)**
Course: *Mathematical Analysis*
Program: 1st year Bachelor in Computer Science University: Free University of Bozen-Bolzano Class size: 70 students
Activity: I developed a new course as the first course on calculus; this includes preparation of lectures and labs.
Credits and Hours: Number of hours: 40 lectures + 20 labs, 6 ECTS Topics: Sequences and series; Univariate functions; Derivatives, differentials and Taylor Theorem; Riemann integral; Logarithmic and exponential functions; Normed vector spaces

A.Y. 2019/2020 **Main Lecturer (Lectures and Labs)**
Course: *Programming Data Infrastructures*
Program: 1st year Master in Computer Science
University: Free University of Bozen-Bolzano
Class size: 20 students
Activity: Further improvements on the course for lectures and labs.

Credits and Hours: Number of hours: 40 lectures + 20 labs, 6 ECTS Topics: Programming using Data Access Object patterns (e.g. Hi- bernate), Programming models for data analysis, (e.g., Hadoop), RDD-based programming (e.g., Spark), Parallel programming and functional style (e.g., Scala), Declarative languages for data processing (e.g., LogicBlox, DLV), Architectures for Processing Big Graphs (e.g., Giraph)

A.Y. 2018/2019 **Main Lecturer (Lectures and Labs)**

Course: *Programming Data Infrastructures*
Program: 1st year Master in Computer Science
University: Free University of Bozen-Bolzano
Class size: 20 students
Activity: I developed a completely new course (from scratch) for a new master in Data Science for both lectures and labs.
Credits and Hours: Number of hours: 40 lectures + 20 labs, 6 ECTS Topics: Programming using Data Access Object patterns (e.g. Hi-bernate), Programming models for data analysis, (e.g., Hadoop), RDD-based programming (e.g., Spark), Parallel programming and functional style (e.g., Scala), Declarative languages for data process- ing (e.g., LogicBlox, DLV), Architectures for Processing Big Graphs (e.g., Giraph)

A.Y. 2017/2018 **Teaching Assistant**

Course: *Semantic Technologies*
Main Lecturer: Prof. Enrico Franconi
Program: 2nd year Master in Computer Science
University: Free University of Bozen-Bolzano
Class size: 4 students
Activity: I designed the labs agenda and exercises. Development of student project and conducting oral defense of the projects.
Credits and Hours: Number of hours: 20 labs, 6 ECTS
Topics: Semantic Web, SPARQL, RDF

A.Y. 2017/2018 **Teaching Assistant**

Course: *Logic and Discrete Mathematics*
Main Lecturer: Dr. Oliver Kutz
Program: 1st year Bachelor in Computer
Science University: Free University of Bozen-
Bolzano Class size: 40 students (2 lab groups)
Activity: I designed the labs agenda and exercises.
Credits and Hours: Number of hours: 40 labs, 6 ECTS
Topics: Introduction to Mathematical Logic, Basics of Algebra and Discrete Mathematics

A.Y. 2016/2017 **Teaching Assistant**

Course: *Mathematical Analysis I*
Main Lecturer: Prof. Omar Lakkis
Program: 1st year Bachelor in Computer Science (2 semesters)
University: Free University of Bozen-Bolzano
Class size: 40 students (2 lab groups)
Activity: I designed the labs agenda and exercises, and I run them on my own responsibility.
Credits and Hours: Number of hours: 40 labs, 6 ECTS
Topics: Set Theory, Functions, Reals, Limits, Integrals, Differential

A.Y. 2015/2016 **Tutor**

Course: *Mathematical Analysis I*
Main Lecturer: Prof. Ricardo Pereira (Trento)

Program: 1st year Bachelor in Computer Science (2 semesters)
University: Free University of Bozen-Bolzano
Class size: 40 students (2 lab groups)
Activity: I was organizing and lecturing tutoring lessons that run parallel with the lectures and labs, and that were tailored for students that have difficulties in Mathematical Analysis (which is compulsory to progress in the 2nd year of the program). The lectures are combination of theory and exercises, and often I had to reach beyond the standard curriculum of the course in order to make material comprehensible for the students.
Credits and Hours: Number of hours: 40 labs, 6 ECTS
Topics: Set Theory, Functions, Reals, Limits, Integrals, Differential

A.Y. 2014/2015 **Teaching Assistant**
Course: *Data Structures and Algorithms*
Main Lecturer: Prof. Werner Nutt
Program: 1st year Bachelor in Computer Science (2 semesters)
University: Free University of Bozen-Bolzano
Class size: 20 students (1 lab groups)
Activity: I designed the labs agenda and exercises, and I run them on my own responsibility. Together with other lab assistants, I was designing and evaluating weekly assignments.
Credits and Hours: Number of hours: 32 labs, 6 ECTS
Topics: Recursion, Complexity, Hash, Sorting, Graphs, Spanning tree

Supervision of Research Collaborators and Students

Ognjen Savkovi´c has supervised the research activity of the following collaborators and students:

April 2022 – onging **Tiziano Dalmonte, PhD. Collaborating with an AR contract on project SPGAS.** Work on SPGAS project on develop- ing theoretical foundations for query optimization over knowledge graphs.

January 2020 – January 2021 **Cristine Pereira Griffo, AR on project ADVANCED4KG** Topic: Development of modeling techniques and methodologies for SHACL

April 2020 – Sept 2020 **Luqman Muhammad Shoaib, Master thesis supervision** Topic: Implementing SHACL validation tool using SPARK

Feb – May 2019 **Attaullah Buriro, PhD. Collaborating with an cocopro contract.** Short-term contract at Unibz, Work on ADVACE4KG project on learning techniques for SHACL rules.

2017 – 2019 **Gulnar Mehdi, MSc. Co-supervision of a PhD Student in industry.** Within my industrial collaboration with Siemens, Mu- nich, I co-supervised industrial Phd candidate Gulnar Mehdi. This resulted in a several publication (see publication page) including best in-use paper award at ISWC 2017).

Feb – May 2019 **Sergey Paramonov, BSc (at the time). Co-supervision of a Master Student.** Together with Prof. Werner Nutt, I co-supervised Sergey in during ECML master where he defended his thesis: *Query CompletenessA Logic Programming Approach*. The collaboration resulted in several publications (see publication page)

2012 – 2013 **Paramita Mirza, Msc (at the time). Collaborating with a cocopro contract.** Together with Prof. Werner Nutt, I supervised collaboration Paramita Mirza on project MAGIC in developing demo tools for the project. The work resulted in two demo publications (see publication page).

2012 – 2013 **Alex Tomasi, MSc. Collaborating with an AR contract.** I have co-supervised the work of Mr. Tomasi that was an AR-contractor at Free University of Bozen-Bolzano on implementing the demo-tool called MAGIK (where I was the main developer). The work resulted in one demo publication.

Industrial collaborations

Ognjen Savkovi´c has active industrial collaborations with the the following industrial entities on projects and scientific publications:

FROM 2018 **Bosch Center for Artificial Intelligence, Heidelberg, Germany** Topic: Working on industrial applications of Semantic Technologies. Publication: [6]. The collaboration has restarted in 2022 with several a short, demo and two poster papers accepted for ISWC, CIKM and IJCKG 2022 (still to appear in publication) Contact: Baifan Zhou.

FROM 2016 **Siemens AG, Corporate Technology, Munich, Germany**
Contact Person: Gulnar Mehdi.
Collaboration: Research papers on the topic of diagnostic maintenance using Semantic Technologies applied on the use-cases of trains and turbines [10, 13, 11, 12, 14, 17, 16, 15] including the best
in-use paper at ISWC 2017 [16]

FROM 2019 **Thinkinside SRL (**www.thinkin.io**), NOI, Bolzano, Italy** Topic: Developing an industrial use-case for Knowledge Graphs and Location Services and submitting it as a EFRE project proposals Contact: Iacopo Carreras

FROM 2020 **Telmekom Networks SRL (**www.telmekom.net**), Lana, Italy**
Topic: Developing and submitting joint project proposals on Knowledge graphs for ticketing systems
Contact: Sergio Vemic

External Collaborations

- **University of Oslo, Norway.** Contact Person: Evgeny Kharlamov. Activity: The previous collaboration includes the work on sensor data processing and semantic technologies for industrial applications [10, 13, 11, 12, 14, 17, 16, 15, 16]. Currently we are working on the problem of standardization for Machine Learning pipelines.
- **Pontificia Universidad Catlica de Chile, Chile.** Contact Person: Juan Reutter. Ac- tivity: The work on defining semantics for SHACL [8, 4, 8]. The most recent collaboration is on defining new query languages for graph analytics.
- **Vienna University of Technology, Austria.** Contact Person: Mantas Šimkus. Activity: Foundational work on establishing a correspondence between classical results from database management and datalog with more recent results on schemas for knowledge graphs [2].
- **Max Planck Institute for Informatics, Germany.** Contact Person: Simon Razniewski. Activity: Foundational work on defining a framework for data completeness and query

completeness [19].

- **University of Oxford. UK.** Contact Person: Ian Horrocks. Activity: Work on establishing diagnostics rule-based languages for sensor data using Semantic Technologies [11, 14, 5]

Technology Transfer

- *Property graph group for schema standardization*. I have been a part of this group since 2019 which is organized by Linked Data Benchmark Council (LDBC, https://ldbcouncil. org/) and gathers both academic experts in Knowledge Graphs and leading companies in that area (such as, Neo4j, TigerGraph, Google, etc.) to discusses industrial standards for property graphs. The end goal is to that those standards become implemented into their graph database systems. The publication [1] is one result obtained in this collaboration.

- *Bosch Center for Artificial Intelligence, Heidelberg, Germany*. In Bosh, a complex machine learning pipelines are used to analyze and predict the welding processes. Our collaboration lead to new results (to appear in publication) that provide ways to describe in a standard- ized format for such pipelines using Semantics Technologies (such as SHACL) and that further allows for their validation and execution. Currently, we discussing implementation techniques of such standardization framework and the integration within Bosh machine analytics toolset.

- *Siemens AG, Munich, Germany* . In addition to publications (presented above), the collaboration has also lead to a joint implementation (based on [16]) that become a part of Siemens toolset for signal analytics and processing of turbine sensor data.

Community Service (including PC and sub-reviewing)

Ognjen Savkovi´c has been member of the Program Committee for the following conferences and workshops including reviewing and sub-reviewing roles of journal and conference papers.

2022 PC member for *ICJAI* 2022, *ICDT* 2022 (subreviewer main track)

2021 PC member for *ICJAI* 2021, PC member for *ISWC* 2021, Reviewing for *VLDB Journal*, Reviewing for *Journal of Web Semantics*, Reviewing for *Semantic Web Journal*

2020 PC member for *ISWC* 2020 for main track and demo, *ICJAI* 2020 (subreviewer main track), PC member for *SKALE* 2020, PC member for *JOWO* 2020

2019 Reviewing for *Semantic Web Journal*, PC *ISWC* short and demo, PC *CIKM* short and long

2018 Reviewing for for *Semantic Web Journal*, PC *ISWC* short and demo, PC *CIKM* short papers, *ESWC* (sub-reviewer)

2017 PC ISWC short and demo

- Local organizer for International Conference on Conceptual Structures (ICCS) 2020, and part of organizing team for BOSK 2020, The Bolzano Summer of Knowledge (https://summerofknowledge.inf.unibz.it)

- Starting April 2019, I am an arXiv moderator for AI section of Computer Science (3 people in total, area code: cs.ai). https://arxiv.org/moderators/. The responsibility is to decide if a paper is appropriate one for area cs.ai

Thesis Committees

Ognjen Savkovi´c has been member of the following committees for thesis evaluations:

2020 Thesis reviewer and defense committee member for Mr. Daniel Guimaraes that defended his thesis "Perfomance of Cox Models on Predictive Maintenance of Construction Machines" as part of EU program EMCL (https://www.emcl-study.eu/home. html) at TU Vienna.

2019-ongoing Committee member of MSc in Software and Systems Engineering (SEIS) at UniBZ that is part of Erasmus Mundus program EMSE (http://em-se.eu).

2018-2022 Commission Member for BSc and MSc student defenses at UniBz for session July 2018 and March 2022

Talks and Invited Talks

Ognjen Savkovi´c has given the following talks (format: date, talk title, event and location)

June 2019 **Validation of SHACL Constraints over KGs with OWL 2 QL Ontologies via Rewriting** ESWC 2019, Portoroz, Slovenia

Oct 2018 **Semantics and Validation of Recursive SHACL** ISWC 2018, Monterey, California, United States

Oct 2018 **A Tractable Notion of Stratification for SHACL** ISWC Poster&Demo 2018, Monterey, California, United States

Sep 2018 **Diagnostics of Trains with Semantic Diagnostics Rules** ILP 2018, Ferrara, Italy

June 2017 **Towards Approximating Incomplete Queries over Par- tially Complete Databases** AMW Workshop 2017, Montevideo Uruguay

Nov 2017 **Semantic Rules for Machine Diagnostics: Execution and Management** CIKM 2017, Singapore

Oct 2016 **Process-Aware Data Quality Assessment** PhD Defense, Free Univ. Of Bozen-Bolzano

Sept 2016 **[Invited Talk] Query Stability in Monotonic Data-Aware Business Processes** Information Systems Group (ISG) seminar, Research Visit, Oxford, UK

Aug 2016 **[Invited Talk] Process-aware Data Quality Assessment**
OSSA + ED3 Workshop (Siemens-Oxford workshop), Oxford, UK

Mar 2016 **Query Stability in Monotonic Data-Aware Business Pro- cesses** ICDT, Bordeaux, France

June 2014 **Towards a Theory of Query Stability in Business Processes**
AMW workshop, Cartagena, Columbia

April 2014 **Query Stability in Data-aware Business Processes** EPCL PhD Workshop at TU Dresden, Dresden, Germany

JAN 2014 **Modeling and reasoning with business processes and workflows** Research School on Foundations and Challenges of Change in Ontologies and Databases, Bolzano

DEC 2013 ***[Invited Talk]* Data Quality Aware Querying** DBAI TU Wien Seminar, TU Vienna, Austria

AUG 2013 **Complete Approximations of Incomplete Queries** VLDB demo 2013, Riva del Garda, Italy

JULY 2013 **Make Sense out of Data: Reasoning about Data Quality** EPCL PhD Workshop at TU Dresden, Dresden, Germany

NOV 2013 **MAGIK: Managing Completeness of Data** CIKM 2012, Hawaii, USA

AUG 2012 **A Tool for Managing Data Completeness** Reasoning Web Summer School 2012, Vienna, Austria

AUG 2012 **Introducing Datatypes in DL-Lite** ECAI 2012, Montpellier, France

JULY 2012 **Process-aware Quality Assessment** EPCL PhD Workshop at TU Dresden 2012, Dresden, Germany

DEMOS AND SOFTWARE DEVELOPMENT

Ognjen Savkovi´c lead the development of the following software:

MAGIK *A web-based tool for managing database completeness.*
In short, the tool allows one to keep track of complete database parts by means of meta-information, and based on that infor- mation it can reason about completeness of query answers.
PERIOD: May 2012 August 2012
RESPONSIBILITIES: I was the leading developer and implementer of the tool. I managed a team of 5 people that actively participated in the development and implementation.
TECHNOLOGY USED: ASP, Prolog, Java, JSP, Tomcat, Hiber- nate, SQL
SIZE: 30K+ lines of code
URL: http://magik-demo.inf.unibz.it/

SHACL2SPARQL *A tool for validating SHACL constraints by translating into SPARQL over an endpoint.*
The tool accepts SHACL schema and SPARQL endpoint address on in the input. Then it translates SHACL constraints into "equivalent" SPARQL queries and evaluates them over the endpoint. It parses the retrieved answers are reports reasons for constraints violations if any. The theory behind the trans- lation to SPARQL is accepted at ISWC 2019 as a full paper https://iswc2019.semanticweb.org/accepted-papers/.
PERIOD: March – April 2019 RESPONSIBILITIES: Development and implementation of the algorithm for checking stratified SHACL constraints by translating them into SPARQL queries, that are then executed over Virtuoso Database. Joint work with Julien Corman.
TECHNOLOGY USED: JAVA, Virtuoso Database (SPARQL) SIZE: 3K+ lines of code
CODE:https://gitlab.inf.unibz.it/osavkovic/shacl2sparql

SHACL2SPARK *A tool for validating SHACL constraints using Apache Spark framework for data analytics.*
The tool is developed in collaboration with a student Luqman Muhammad Shoaib as a part of his master thesis. The idea is to benefit from our recent results on rule semantics for SHACL and provide a more direct functional-programming style imple- mentation (as opposed to procedural). The second benefit is that SPARK engine is highly optimized for large data process- ing based on parallelization which provides significant decrease in validation time. PERIOD: April – Sept 2020 RESPONSIBIL- ITIES: Development an implementation technique that trans- lates SHACL validation into a program over a SPARK engine. Supervising implementation of Luqman Muhammad Shoaib and conducting runtime experiments
TECHNOLOGY USED: SPARK, Scala and JAVA
SIZE: 1K+ lines of code
CODE:https://gitlab.inf.unibz.it/osavkovic/shaclspark

TECHNICAL SKILLS

- **Programming**
  - Java, Scala, C, C++, C#, SQL, Sparql, JSP, IA-32 assembler
- **Tool and Technologies**
  - Hadoop, Spark, OWL API, Weka, R
- **AI Tools**
  - Prolog, Answer Set Programming, SMT
- **IDEs**
  - IntelliJ, Eclipse, MS Visual Studio, Prot´eg´e, Matlab, RStudio
- **Web design**
  - JSP, PHP, Java Script, XSLT, WordPress
- **Operating Systems**
  - System programming on Windows and UNIX

Language Skills

- **English**: C1 *Cambridge Advanced Certificate*
- **German**: B1 *TU Wien Language Exam*
- **Italian**: A2 *Language Centre at UniBZ*
- **Serbian**: Mother Tongue

Bolzano, September 21, 2022.

The undersigned declares that the information contained in the curriculum vitae is true. The undersigned gives her permission for the personal details that she has supplied to be processed as per Italian legislative decree 196/2003 for any procedures that are connected to this selection procedure and any contracts that may be drawn up as a consequence.

List of Publications at International Journals, Conferences and Workshops

The list of publications is in the chronological order.

Peer-reviewed publication

[1] Renzo Angles, Angela Bonifati, Stefania Dumbrava, George Fletcher, Keith W. Hare, Jan Hidders, Victor E. Lee, Bei Li, Leonid Libkin, Wim Martens, Filip Murlak, Josh Perry- man, Ognjen Savkovic, Michael Schmidt, Juan F. Sequeda, Slawek Staworko, and Dominik Tomaszuk. "PG-Keys: Keys for Property Graphs". In: *SIGMOD '21: International Conference on Management of Data, Virtual Event, China, June 20-25, 2021*. Ed. by Guoliang Li, Zhanhuai Li, Stratos Idreos, and Divesh Srivastava. ACM, 2021, pp. 2423–2436. DOI: 10.1145/3448016.3457561. URL: https://doi.org/10.1145/3448016.3457561.

[2] Medina Andresel, Julien Corman, Magdalena Ortiz, Juan L. Reutter, Ognjen Savkovic, and Mantas Simkus. "Stable Model Semantics for Recursive SHACL". In: *WWW '20: The Web Conference 2020, Taipei, Taiwan, April 20-24, 2020*. Ed. by Yennun Huang, Irwin King, Tie-Yan Liu, and Maarten van Steen. ACM, 2020, pp. 1570–1580. DOI: 10.1145/3366423.3380229. URL: https://doi.org/10.1145/3366423.3380229.

[3] Julien Corman, Fernando Florenzano, Juan L. Reutter, and Ognjen Savkovic. "SHACL2SPARQL: Validating a SPARQL Endpoint against Recursive SHACL Constraints". In: *Proceedings of the ISWC 2019 Satellite Tracks (Posters & Demonstrations, Industry, and Outrageous Ideas) co-located with 18th International Semantic Web Conference (ISWC 2019), Auckland, New Zealand, October 26-30, 2019*. Ed. by Mari Carmen Suárez-Figueroa, Gong Cheng, Anna Lisa Gentile, Christophe Gu´eret, C. Maria Keet, and Abraham Bernstein. Vol. 2456. CEUR Workshop Proceedings. CEUR-WS.org, 2019, pp. 165–168. URL: http://ceur-ws.org/Vol-2456/paper43.pdf.

[4] Julien Corman, Fernando Florenzano, Juan L. Reutter, and Ognjen Savkovic. "Validating Shacl Constraints over a Sparql Endpoint". In: *The Semantic Web - ISWC 2019 - 18th International Semantic Web Conference, Auckland, New Zealand, October 26-30, 2019, Proceedings, Part I*. Ed. by Chiara Ghidini, Olaf Hartig, Maria Maleshkova, Vojtech Svátek, Isabel F. Cruz, Aidan Hogan, Jie Song, Maxime Lefran¸cois, and Fabien Gandon. Vol. 11778. Lecture Notes in Computer Science. Springer, 2019, pp. 145–163. DOI: 10.1007/978-3-030-30793-6_9. URL: https://doi.org/10.1007/978-3-030-30793-6_9.

[5] Evgeny Kharlamov, Gulnar Mehdi, Ognjen Savkovic, Guohui Xiao, Elem Güzel Kalayci, and Mikhail Roshchin. "Semantically-enhanced rule-based diagnostics for industrial Internet of Things: The SDRL language and case study for Siemens trains and turbines". In: *J. Web Semant.* 56 (2019), pp. 11–29. DOI: 10.1016/j.websem.2018.10.004. URL: https://doi.org/10.1016/j.websem.2018.10.004.

[6] Ognjen Savkovic, Evgeny Kharlamov, and Steffen Lamparter. "Validation of SHACL Constraints over KGs with OWL 2 QL Ontologies via Rewriting". In: *The Semantic Web - 16th International Conference, ESWC 2019, Portoroˇz, Slovenia, June 2-6, 2019, Proceedings*. Ed. by Pascal Hitzler, Miriam Fernández, Krzysztof Janowicz, Amrapali Zaveri, Alasdair J. G. Gray, Vanessa López, Armin Haller, and Karl Hammar. Vol. 11503. Lecture Notes in Computer Science. Springer, 2019, pp. 314–329. DOI: 10.1007/978-3-030-21348-0_21. URL: https://doi.org/10.1007/978-3-030-21348-0%5C_21.

[7] Julien Corman, Juan L. Reutter, and Ognjen Savkovic. "A Tractable Notion of Stratification for SHACL". In: *Proceedings of the ISWC 2018 Posters & Demonstrations, Industry and Blue Sky Ideas Tracks co-located with 17th International Semantic Web Conference (ISWC 2018), Monterey, USA, October 8th - to - 12th, 2018.* 2018. URL: http://ceur-ws.org/Vol-2180/paper-11.pdf.

[8] Julien Corman, Juan L. Reutter, and Ognjen Savkovic. “Semantics and Validation of Recursive SHACL”. In: *The Semantic Web - ISWC 2018 - 17th International Semantic Web Conference, Monterey, CA, USA, October 8-12, 2018, Proceedings, Part I*. 2018, pp. 318–336. DOI: 10.1007/978-3-030-00671-6_19. URL: https://doi.org/10.1007/978-3-030-00671-6_19.

[9] Julien Corman, Juan L. Reutter, and Ognjen Savkovic. “Towards a Robust Semantics for SHACL: Preliminary Discussion”. In: *Proceedings of the 12th Alberto Mendelzon International Workshop on Foundations of Data Management, Cali, Colombia, May 21-25, 2018.* 2018. URL: http://ceur-ws.org/Vol-2100/paper22.pdf.

[10] Evgeny Kharlamov, Gulnar Mehdi, Ognjen Savkovic, Guohui Xiao, Steffen Lamparter, Ian Horrocks, and Arild Waaler. “Towards Simplification of Analytical Workflows With Semantics at Siemens (Extended Abstract)”. In: *IEEE International Conference on Big Data, Big Data 2018, Seattle, WA, USA, December 10-13, 2018*. 2018, pp. 1951–1954. DOI: 10.1109/BigData.2018.8622652. URL: https://doi.org/10.1109/BigData.2018.8622652.

[11] Evgeny Kharlamov, Ognjen Savkovic, Martin Ringsquandl, Guohui Xiao, Gulnar Mehdi, Elem Güzel Kalayci, Werner Nutt, Mikhail Roshchin, Ian Horrocks, and Thomas A. Runkler. “Diagnostics of Trains with Semantic Diagnostics Rules”. In: *Inductive Logic Programming - 28th International Conference, ILP 2018, Ferrara, Italy, September 2-4, 2018, Proceedings*. 2018, pp. 54–71. DOI: 10.1007/978-3-319-99960-9_4. URL: https://doi.org/10.1007/978-3-319-99960-9_4.

[12] Ognjen Savkovic, Evgeny Kharlamov, Martin Ringsquandl, Guohui Xiao, Gulnar Mehdi, Elem Güzel Kalayci, Werner Nutt, and Ian Horrocks. “Semantic Diagnostics of Smart Factories”. In: *Semantic Technology - 8th Joint International Conference, JIST 2018, Awaji, Japan, November 26-28, 2018, Proceedings*. 2018, pp. 277–294. DOI: 10.1007/978-3-030-04284-4_19. URL: https://doi.org/10.1007/978-3-030-04284-4_19.

[13] Ognjen Savkovic, Evgeny Kharlamov, Guohui Xiao, Gulnar Mehdi, Elem Güzel Kalayci, Werner Nutt, Mikhail Roshchin, and Ian Horrocks. “Theoretical Characterization of Signal Diagnostic Processing Language”. In: *Proceedings of the 31st International Workshop on Description Logics co-located with 16th International Conference on Principles of Knowledge Representation and Reasoning (KR 2018), Tempe, Arizona, US, October 27th - to - 29th, 2018.* 2018. URL: http://ceur-ws.org/Vol-2211/paper-33.pdf.

[14] Evgeny Kharlamov, Ognjen Savkovic, Guohui Xiao, Rafael Peñaloza, Gulnar Mehdi, Mikhail Roshchin, and Ian Horrocks. “Semantic Rules for Machine Diagnostics: Execution and Management”. In: *Proceedings of the 2017 ACM on Conference on Information and Knowledge Management, CIKM 2017, Singapore, November 06 - 10, 2017*. 2017, pp. 2131–2134. DOI: 10.1145/3132847.3133159. URL: https://doi.org/10.1145/3132847.3133159.

[15] Gulnar Mehdi, Evgeny Kharlamov, Ognjen Savkovic, Guohui Xiao, Elem Guzel Kalayci, Sebastian Brandt, Ian Horrocks, Mikhail Roshchin, and Thomas A. Runkler. “Semantic Rule-Based Equipment Diagnostic”. In: *Proceedings of the ISWC 2017 Posters & Demonstrations and Industry Tracks co-located with 16th International Semantic Web Conference (ISWC 2017), Vienna, Austria, October 23rd - to - 25th, 2017.* 2017. URL: http://ceur- ws.org/Vol-1963/paper651.pdf.

[16] Gulnar Mehdi, Evgeny Kharlamov, Ognjen Savkovic, Guohui Xiao, Elem Güzel Kalayci, Sebastian Brandt, Ian Horrocks, Mikhail Roshchin, and Thomas A. Runkler. “Semantic Rule-Based Equipment Diagnostics”. In: *The Semantic Web - ISWC 2017 - 16th International Semantic Web Conference, Vienna, Austria, October 21-25, 2017, Proceedings, Part II*. 2017, pp. 314–333. DOI: 10.1007/978-3-319-68204-4_29. URL: https://doi.org/10.1007/978-3-319-68204-4_29.

[17] Gulnar Mehdi, Evgeny Kharlamov, Ognjen Savkovic, Guohui Xiao, Elem Güzel Kalayci, Sebastian Brandt, Ian Horrocks, Mikhail Roshchin, and Thomas A. Runkler. “SemDia: Semantic Rule-Based Equipment Diagnostics Tool”. In: *Proceedings of the 2017 ACM on Conference on Information and Knowledge Management, CIKM 2017, Singapore, November 06 - 10, 2017*. 2017, pp. 2507–2510. DOI: 10.1145/3132847.3133191. URL: https://doi.org/10.1145/3132847.3133191.

[18] Ognjen Savkovic, Evgeny Kharlamov, Werner Nutt, and Pierre Senellart. “Towards Approximating Incomplete Queries over Partially Complete Databases (Extended Abstract)”. In: *Proceedings of the 11th Alberto Mendelzon International Workshop on Foundations of Data Management and the Web, Montevideo, Uruguay, June 7-9, 2017.* 2017. URL: http://ceur-ws.org/Vol-1912/paper9.pdf.

[19] Simon Razniewski, Ognjen Savkovic, and Werner Nutt. “Turning The Partial-Closed World Assumption Upside Down”. In: *Proceedings of the 10th Alberto Mendelzon International Workshop on Foundations of Data Management, Panama City, Panama, May 8-10, 2016*. 2016. URL: http://ceur-ws.org/Vol-1644/paper3.pdf.

[20] Ognjen Savkovic, Elisa Marengo, and Werner Nutt. “Query Stability in Monotonic Data-Aware Business Processes”. In: *19th International Conference on Database Theory, ICDT 2016, Bordeaux, France, March 15-18, 2016*. 2016, 16:1–16:18. DOI: 10.4230/LIPIcs.ICDT.2016.16. URL: https://doi.org/10.4230/LIPIcs.ICDT.2016.16.

[21] Werner Nutt, Sergey Paramonov, and Ognjen Savkovic. “Implementing Query Completeness Reasoning”. In: *Proceedings of the 24th ACM International Conference on Information and Knowledge Management, CIKM 2015, Melbourne, VIC, Australia, October 19 - 23, 2015*. 2015, pp. 733–742. DOI: 10.1145/2806416.2806439. URL: https://doi.org/10.1145/2806416.2806439.

[22] Elisa Marengo, Werner Nutt, and Ognjen Savkovic. “Towards a Theory of Query Stability in Business Processes”. In: *Proceedings of the 8th Alberto Mendelzon Workshop on Foundations of Data Management, Cartagena de Indias, Colombia, June 4-6, 2014.* 2014. URL: http://ceur-ws.org/Vol-1189/paper_23.pdf.

[23] Mouna Kacimi, Ognjen Savkovic, and Manfred Mitterer. “Clinical-based prediction of side effects in colon cancer chemotherapy”. In: *IEEE 15th International Conference on e-Health Networking, Applications and Services, Healthcom 2013, Lisbon, Portugal, October 9-12, 2013*. 2013, pp. 617–621. DOI: 10.1109/HealthCom.2013.6720750. URL: https://doi.org/10.1109/HealthCom.2013.6720750.

[24] Werner Nutt, Sergey Paramonov, and Ognjen Savkovic. “An ASP Approach to Query Completeness Reasoning”. In: *TPLP* 13.4-5-Online-Supplement (2013). URL: http://static.cambridge.org/resource/id/urn:cambridge.org:id:binary:20161018085635834-0697:S1471068413000112:tlp2013005.pdf.

[25] Ognjen Savkovic, Paramita Mirza, Alex Tomasi, and Werner Nutt. “Complete Approximations of Incomplete Queries”. In: *PVLDB* 6.12 (2013), pp. 1378–1381. DOI: 10.14778/2536274.2536320. URL: http://www.vldb.org/pvldb/vol6/p1378-savkovic.pdf.

[26] Ognjen Savkovic and Diego Calvanese. “Introducing Datatypes in DL-Lite”. In: *ECAI 2012 - 20th European Conference on Artificial Intelligence. France, August 27-31 , 2012*. 2012, pp. 720–725. DOI: 10.3233/978-1-61499-098-7-720. URL: https://doi.org/10.3233/978-1-61499-098-7-720.

[27] Ognjen Savkovic, Paramita Mirza, Sergey Paramonov, and Werner Nutt. “MAGIK: managing completeness of data”. In: *21st ACM International Conference on Information and Knowledge Management, CIKM’12, Maui, HI, USA, October 29 - November 02, 2012*. 2012, pp. 2725–2727. DOI: 10.1145/2396761.2398741. URL: https://doi.org/10.1145/2396761.2398741.

Non peer-reviewed publication

[1] Ognjen Savkovic, Elisa Marengo, and Werner Nutt. “Query Stability in Monotonic Data-Aware Business Processes [Extended Version]”. In: *CoRR* abs/1512.06912 (2015). arXiv: 1512.06912. URL: http://arxiv.org/abs/1512.06912.

[APPENDIX 1]

List of 12 Selected Publications (in chronological order) submitted for the evaluation.

Publications marked with (*) are the one where Ognjen Savkovic was the main author.

The publications marked with the star (!) are publications that constitute the main contributions for my PhD thesis work.

The publications marked with the star (#) are publications that constitute the main contributions for my MSc thesis work.

The contributions of authors were equal for all other publications.

[pub 1] Renzo Angles, Angela Bonifati, Stefania Dumbrava, George Fletcher, Keith W. Hare, Jan Hidders, Victor E. Lee, Bei Li, Leonid Libkin, Wim Martens, Filip Murlak, Josh Perryman, Ognjen Savkovic, Michael Schmidt, Juan F. Sequeda, Slawek Staworko, and Dominik Tomaszuk. “PG-Keys: Keys for Property Graphs”. In: SIGMOD ’21: International Conference on Management of Data, Virtual Event, China, June 20-25, 2021. Ed. by Guoliang Li, Zhanhuai Li, Stratos Idreos, and Divesh Srivastava. ACM, 2021, pp. 2423–2436. doi: 10.1145/3448016.3457561. url: https://doi.org/10.1145/3448016.3457561.

[pub 2] Medina Andresel, Julien Corman, Magdalena Ortiz, Juan L. Reutter, Ognjen Savkovic, and Mantas Simkus. “Stable Model Semantics for Recursive SHACL”. In: WWW ’20: The Web Conference 2020, Taipei, Taiwan, April 20-24, 2020. Ed. by Yennun Huang, Irwin King, Tie-Yan Liu, and Maarten van Steen. ACM, 2020, pp. 1570–1580. doi: 10.1145/ 3366423.3380229. url: https://doi.org/10.1145/3366423.3380229.

[pub 3] Julien Corman, Fernando Florenzano, Juan L. Reutter, and Ognjen Savkovic. “Validating Shacl Constraints over a Sparql Endpoint”. In: The Semantic Web - ISWC 2019 - 18th International Semantic Web Conference, Auckland, New Zealand, October 26-30, 2019, Proceedings, Part I. Ed. by Chiara Ghidini, Olaf Hartig, Maria Maleshkova, Vojtech Svatek, Isabel F. Cruz, Aidan Hogan, Jie Song, Maxime Lefrancois, and Fabien Gandon. Vol. 11778. Lecture Notes in Computer Science. Springer, 2019, pp. 145–163. doi: 10.1007/978-3- 030-30793-6_9. url: https://doi.org/10.1007/978-3-030-30793-6_9.

[pub 4] (*) Evgeny Kharlamov, Gulnar Mehdi, Ognjen Savkovic, Guohui Xiao, Elem Guzel Kalayci, and Mikhail Roshchin. “Semantically-enhanced rule-based diagnostics for industrial Internet of Things: The SDRL language and case study for Siemens trains and turbines”. In: J. Web Semant. 56 (2019), pp. 11–29. doi: 10.1016/j.websem.2018.10.004. url: https://doi.org/10.1016/j.websem.2018.10.004.

[pub 5] (*) Ognjen Savkovic, Evgeny Kharlamov, and Steffen Lamparter. “Validation of SHACL Constraints over KGs with OWL 2 QL Ontologies via Rewriting”. In: The Semantic Web - 16th International Conference, ESWC 2019, Portoroz, Slovenia, June 2-6, 2019, Proceedings. 2019, pp. 314–329. doi: 10.1007/978-3-030-21348-0_21. url: https: //doi.org/10.1007/978-3-030-21348-0_21.

[pub 6] Julien Corman, Juan L. Reutter, and Ognjen Savkovic. “Semantics and Validation of Recursive SHACL”. In: The Semantic Web - ISWC 2018 - 17th International Semantic Web Conference, Monterey, CA, USA, October 8-12, 2018, Proceedings, Part I. 2018, pp. 318–336. doi: 10.1007/978-3-030-00671-6_19. url: https://doi.org/10.1007/ 978-3-030-00671-6_19.

[pub 7] Gulnar Mehdi, Evgeny Kharlamov, Ognjen Savkovic, Guohui Xiao, Elem Guzel Kalayci, Sebastian Brandt, Ian Horrocks, Mikhail Roshchin, and Thomas A. Runkler. “Semantic Rule-Based Equipment Diagnostics”. In: The Semantic Web - ISWC 2017 - 16th International Semantic Web Conference, Vienna, Austria, October 21-25, 2017, Proceedings, Part II. 2017, pp. 314–333. doi: 10.1007/978-3-319-68204-4_29. url: https://doi. org/10.1007/978-3-319-68204-4_29.

[pub 8] (*)(!)Ognjen Savkovic, Elisa Marengo, and Werner Nutt. “Query Stability in Monotonic Data-Aware Business Processes”. In: 19th International Conference on Database Theory, ICDT 2016, Bordeaux, France, March 15-18, 2016. 2016, 16:1–16:18. doi: 10.4230/LIPIcs. ICDT.2016.16. url: https://doi.org/10.4230/LIPIcs.ICDT.2016.16.

[pub 9] (*)(!) Werner Nutt, Sergey Paramonov, and Ognjen Savkovic. “Implementing Query Completeness Reasoning”. In: Proceedings of the 24th ACM International Conference on Information and Knowledge Management, CIKM 2015, Melbourne, VIC, Australia, October 19 - 23, 2015. 2015, pp. 733–742. doi: 10.1145/2806416.2806439. url: https://doi.org/10. 1145/2806416.2806439.

[pub 10] (*) (!)Werner Nutt, Sergey Paramonov, and Ognjen Savkovic. “An ASP Approach to Query Completeness Reasoning”. In: TPLP 13.4-5-Online-Supplement (2013). url: http://static.cambridge.org/resource/id /urn : cambridge . org : id : binary : 20161018085635834 - 0697:S1471068413000112:tlp2013005.pdf.

[pub 11] (*)(!)Ognjen Savkovic, Paramita Mirza, Alex Tomasi, and Werner Nutt. “Complete Approximations of Incomplete Queries”. In: PVLDB 6.12 (2013), pp. 1378–1381. doi: 10.14778/ 2536274.2536320. url: http://www.vldb.org/pvldb/vol6/p1378-savkovic.pdf.

[pub 12] (*)(#) Ognjen Savkovic and Diego Calvanese. “Introducing Datatypes in DL-Lite”. In: ECAI 2012 - 20th European Conference on Artificial Intelligence. France, August 27-31 , 2012. 2012, pp. 720–725. doi: 10.3233/978-1-61499-098-7-720. url: https://doi.org/10. 3233/978-1-61499-098-7-720.

Place and date …… Bolzano, 20/09/2022……

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[Appendix 2]

MINUTES OF THE PHD FINAL EXAM

PHD PROGRAM IN COMPUTER SCIENCE

On 14th October 2016, at 14:30 in the premises of the Faculty of Computer Science of the Free University of Bozen-Bolzano, Piazza Domenicani 3, first floor, Seminar Room POS 1.003, the Exam Commission meets for PhD final exams, appointed by decree of the President of the University Council no. 39/2016 of 03.08.2016, pursuant to Ministerial Decree n. 224 of 30.04.1999 and the "Regulations on Doctoral Research" approved by the Executive Committee by resolution no. 99/2003 and subsequent amendments.

The Exam Commission if composed by;

- Prof. Dr. Reinhard Pichler
- Prof. Dr. Matthias Weidlich
- Prof. Francesco Ricci

The President of the Commission is prof. Dr. Reinhard Pichler. The secretary is prof. Francesco Ricci.

The Commission members, reviewed the list of candidates and the abovementioned provisions that regulate the graduation, claim not to be honed or relative up to the fourth grade to the candidate and to each other.

The Commission takes note of the thesis submitted by the candidate:

Ognjen Savković

And decides to adopt the following evaluation criteria:

1. Scientific relevance of the thesis.
2. Originality: the work is an original contribution of the PhD candidate with respect to the state of the art in the field.
3. Quality of the oral presentation and of the answers given during the discussion.
4. Quality of the scientific publications issued during the Doctoral studies.

Examination mode:

- The candidate presents his thesis (45 min.)
- The candidate answers the question by the commission (typically 60 min.)
- The commission evaluates the thesis and the presentation of the candidate with a discussion after the candidate's presentation.

Candidate OGNJEN SAVKOVIC is called and identified by the document: Identity Card nr. AX 4236790, issued on 07 June 2016 by Comune Bolzano (BZ-Italy), expiring on 12 July 2026. He presents his doctoral work and answers questions from committee members.

At the end of the presentations, having noted the originality of the works and their relevance in the context of the topic of the Ph.D., having taken view to the reports of the external reviewers and after listening to the exposure of the applicant, the exam Commission proposes to the Rector

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to award the following candidate with the title of "Philosophiae Doctor in Computer Science – Dottore di ricerca in Scienze e Tecnologie Informatiche":

Ognjen Savković

With the following evaluation:

In his PhD thesis, Mr Savković targets two fundamental questions in data quality management: query stability over databases that are subject to changes by some data handling business process; and query completeness in the presence of table completeness statements and constraints on database keys and attribute domains. The main contribution of the thesis is a comprehensive analysis of the decidability and complexity of various instantiations of these problems, shedding light on the particular conditions that impose undecidability or changes in complexity.

The first part of the thesis is very innovative, since, in general, independent of the question of query stability, there are only a very few models that enable reasoning on the implications of data processing (even if only monotonic) by business processes. Unlike other work in this area, the presented formalisation of data handling by processes is indeed close to common formal methods for the specification of processes, featuring, for instance, an activity-centric definition of control-flow and explicit notions of process instances. As such, the obtained results are of high relevance and inform a broad research field on the data-aware analysis of processes.

As for the question of query stability, undecidability in the general case is not surprising, but carved out in detail in this thesis in order to derive insights on the aspects influencing this result. Subsequently, the problem is investigated for restricted classes of models. While there is a large space of possible restrictions that could be explored, the properties chosen by Mr Savković are reasonable, as they can be motivated either from an application point of view, or can be expected to yield interesting insights into the aspects that dominate complexity. In sum, this part of the thesis presents a detailed assessment of query stability that is nicely grounded in well-established results on the complexity of different variants of Datalog.

In the second part of the thesis, Mr Savković establishes complexity results for the query completeness problem (potentially under key or domain constraints) and develops methods for (overfitting or underfitting) approximations of incomplete queries. The reasoning procedures presented for the query completeness problem are based on encodings in logic programs, which facilitates their implementation using existing reasoners. The latter is demonstrated in terms of a prototype that underlines the general feasibility of the approach.

Overall, a strength of this thesis is the combination of questions (and models) of high practical relevance and their rigorous and well-grounded analysis. It shall further be noted that this thesis is excellent also in terms of structure and presentation. For instance, Mr Savković states explicit observations on problem dimensions, which give the reader an intuition on why particular results hold true. As a consequence, the content of this thesis, despite its technical depth, is well accessible.

On the basis of these comments, the Commission expresses an Excellent evaluation of the thesis of Ognjen Savković.

Thesis Title: **Process-Aware Data Quality Assessment**

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The candidate is called and proclaimed by the President of the Commission.
Bolzano, 14th October 2016

The exam Commission:

Prof. Dr. Reinhard Pichler (chair)

Prof. Dr. Matthias Weidlich

Prof. Francesco Ricci (secretary)

BOLZANO, SEPTEMBER 21, 2022. Ognjen Savkovi´c

The undersigned declares that the information contained in the curriculum vitae is true. The undersigned gives her permission for the personal details that she has supplied to be processed as per Italian legislative decree 196/2003 for any procedures that are connected to this selection procedure and any contracts that may be drawn up as a consequence.