

# Communications in Computer and Information Science

838

*Commenced Publication in 2007*

Founding and Former Series Editors:

Phoebe Chen, Alfredo Cuzzocrea, Xiaoyong Du, Orhun Kara, Ting Liu,  
Dominik Ślęzak, and Xiaokang Yang

## Editorial Board

Simone Diniz Junqueira Barbosa

*Pontifical Catholic University of Rio de Janeiro (PUC-Rio),  
Rio de Janeiro, Brazil*

Joaquim Filipe

*Polytechnic Institute of Setúbal, Setúbal, Portugal*

Igor Kotenko

*St. Petersburg Institute for Informatics and Automation of the Russian  
Academy of Sciences, St. Petersburg, Russia*

Krishna M. Sivalingam

*Indian Institute of Technology Madras, Chennai, India*

Takashi Washio

*Osaka University, Osaka, Japan*

Junsong Yuan

*University at Buffalo, The State University of New York, Buffalo, USA*

Lizhu Zhou

*Tsinghua University, Beijing, China*

More information about this series at <http://www.springer.com/series/7899>

Audrone Lupeikiene · Olegas Vasilecas  
Gintautas Dzemyda (Eds.)

# Databases and Information Systems

13th International Baltic Conference, DB&IS 2018  
Trakai, Lithuania, July 1–4, 2018  
Proceedings

*Editors*

Audrone Lupeikiene  
Institute of Data Science and Digital  
Technologies  
Vilnius University  
Vilnius  
Lithuania

Gintautas Dzemyda  
Institute of Data Science and Digital  
Technologies  
Vilnius University  
Vilnius  
Lithuania

Olegas Vasilecas  
Information Systems Department  
Vilnius Gediminas Technical University  
Vilnius  
Lithuania

ISSN 1865-0929 ISSN 1865-0937 (electronic)  
Communications in Computer and Information Science  
ISBN 978-3-319-97570-2 ISBN 978-3-319-97571-9 (eBook)  
<https://doi.org/10.1007/978-3-319-97571-9>

Library of Congress Control Number: 2018950390

© Springer Nature Switzerland AG 2018

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG  
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

# Preface

The volume gathers the papers presented at the 13th International Baltic Conference on Databases and Information Systems (DB&IS), which was held in Trakai, Lithuania, during July 1–4, 2018. The conference was organized by the Vilnius University, Vilnius Gediminas Technical University, Lithuanian Academy of Sciences, and Lithuanian Computer Society. The Baltic DB&IS 2018 conference continued the series of biennial conferences, which have been held in Trakai (1994), Tallinn (1996, 2002, 2008, 2014), Riga (1998, 2004, 2010, 2016), and Vilnius (2000, 2006, 2012). Since its inception in 1994 by Prof. Janis A. Bubenko Jr. (Royal Institute of Technology and Stockholm University, Sweden) and Prof. Arne Sølvberg (Norwegian University of Science and Technology, Norway) the Baltic DB&IS conference has become an international forum for researchers and developers in the field of databases, information systems, and related areas. This year's submissions represented the five continents. The objective of this conference series is to bring together researchers, practitioners, and PhD students and provide an environment in which they can present their work, discuss current issues, and exchange the ideas.

This volume of Springer's *Communications in Computer and Information Science* (CCIS) continues the initiative, which began at Baltic DB&IS 2016 (held in Riga), of publishing the conference proceedings in this series. For Baltic DB&IS 2018 we received 69 papers from 15 countries. Each paper was reviewed by at least three Program Committee members. The international Program Committee consisted of 91 members from 31 countries. The evaluation process resulted in the selection of 24 papers (acceptance rate of 34.7%), which were accepted for presentation at the conference and publication in this conference proceedings.

The original research results presented in the papers concern well-established fields such as database systems; architectures and quality aspects of information systems; requirements engineering; ontology engineering; business process modeling; applications and case studies; as well as the novel fields, such as cyber-physical systems; Internet of Things; big data processing; big data analysis and semantics; cognitive computing techniques using artificial intelligence, sophisticated pattern, and speech recognition. This volume also includes two plenary session and three keynote talks.

The organizers were pleased to invite four leading experts for keynote addresses: Marlon Dumas, University of Tartu, Estonia; Marko Bajec, University of Ljubljana, Slovenia; Milan Zdravković, University of Niš, Serbia; and Inguna Skadiņa, University of Latvia, Latvia. The conference was preceded by a one-day doctoral consortium chaired by Raimundas Matulevičius, University of Tartu, Estonia.

Finally, as editors of this volume, we express our deep gratitude to the members of the Program Committee and the external reviewers for their time, comments, and constructive evaluations. We also sincerely thank the members of the international Steering Committee for their continued support of the conference. We would like to thank everyone from the Organizing Committee, especially Laima Paliulioniene, for

their time and dedication to help make this conference a success. Special thanks to Prof. Albertas Caplinkas for his sharing of experience and valuable support. We are grateful to the authors and all the participants who truly made the conference a success.

June 2018

Audrone Lupeikiene  
Olegas Vasilecas  
Gintautas Dzemyda

# Organization

## Steering Committee

Janis Bubenko (Honorary Member)	Royal Institute of Technology and Stockholm University, Sweden
Arne Sølvsberg (Honorary Member)	Norwegian University of Science and Technology, Norway
Guntis Arnicāns	University of Latvia, Latvia
Juris Borzovs	University of Latvia, Latvia
Albertas Čaplinskas	Vilnius University, Lithuania
Jānis Grundspenķis	Riga Technical University, Latvia
Hele-Mai Haav	Tallinn University of Technology, Estonia
Ahto Kalja	Tallinn University of Technology, Estonia
Mārīte Kirikova	Riga Technical University, Latvia
Audronė Lupeikienė	Vilnius University, Lithuania
Raimundas Matulevičius	University of Tartu, Estonia
Tarmo Robal	Tallinn University of Technology, Estonia
Olegas Vasilecas	Vilnius Gediminas Technical University, Lithuania

## General Chair

Gintautas Dzemyda	Vilnius University, Lithuania
-------------------	-------------------------------

## Program Co-chairs

Audronė Lupeikienė	Vilnius University, Lithuania
Olegas Vasilecas	Vilnius Gediminas Technical University, Lithuania

## Doctoral Consortium Chair

Raimundas Matulevičius	University of Tartu, Estonia
------------------------	------------------------------

## Program Committee

Rajendra Akerkar	Western Norway Research Institute, Norway
Mehmet Akşit	University of Twente, The Netherlands
Guntis Arnicāns	University of Latvia, Latvia
Liz Bacon	University of Greenwich, UK
Marko Bajec	University of Ljubljana, Slovenia
Romas Baronas	Vilnius University, Lithuania
Josef Basl	University of West Bohemia, Czech Republic
Jānis Bičevskis	University of Latvia, Latvia

Mária Bieliková	Slovak University of Technology in Bratislava, Slovakia
Juris Borzovs	University of Latvia, Latvia
Boštjan Brumen	University of Maribor, Slovenia
Robert Buchmann	Babeş-Bolyai University, Romania
Albertas Čaplinskas	Vilnius University, Lithuania
Grzegorz Chmaj	University of Nevada, USA
Christine Choppy	University of Paris, France
Vytautas Čyras	Vilnius University, Lithuania
Robertas Damaševičius	Kaunas University of Technology, Lithuania
Dalė Dzemydienė	Vilnius University, Lithuania
Johann Eder	University of Klagenfurt, Austria
Flavius Frasincar	Erasmus University Rotterdam, The Netherlands
Wojciech Froelich	University of Silesia, Poland
John Gammack	Zayed University, United Arab Emirates
Jorge Esparteiro Garcia	Polytechnic Institute of Viana do Castelo, Portugal
Jānis Grabis	Riga Technical University, Latvia
Jānis Grundspenķis	Riga Technical University, Latvia
Saulius Gudas	Vilnius University, Lithuania
Sevinc Gulsecen	Istanbul University, Turkey
Giancarlo Guizzardi	Free University of Bozen-Bolzano, Italy; Federal University of Espírito Santo (UFES), Brazil
Hele-Mai Haav	Tallinn University of Technology, Estonia
Władysław Homenda	Warsaw University of Technology, Poland
Zbigniew Huzar	Wroclaw University of Technology, Poland
Ali Hakan Isik	Mehmet Akif Ersoy University, Turkey
Mirjana Ivanović	University of Novi Sad, Serbia
Hannu Jaakkola	Tampere University of Technology, Finland
Andrzej Jarczoch	West Pomeranian University of Technology, Poland
Ignacy Kaliszewski	Systems Research Institute, Polish Academy of Sciences, Poland
Ahto Kalja	Tallinn University of Technology, Estonia
Dimitris Karagiannis	University of Vienna, Austria
Māriķe Kirikova	Riga Technical University, Latvia
Dmitry Korzun	Petrozavodsk State University, Russia
Manolis Koubarakis	National and Kapodistrian University of Athens, Greece
Olga Kurasova	Vilnius University, Lithuania
Michael Lang	National University of Ireland Galway, Ireland
Dejan Lavbič	University of Ljubljana, Slovenia
Innar Liiv	Tallinn University of Technology, Estonia
Grazia Lo Sciuto	University of Catania, Italy
Natalia Loukachevitch	Lomonosov Moscow State University, Russia
Hui Ma	Victoria University of Wellington, New Zealand
Alexander Mädche	Karlsruhe Institute of Technology, Germany
Ka Lok Man	Xi'an Jiaotong-Liverpool University, China



Rainer Manthey	University of Bonn, Germany
Sanda Martinčić-Ipšić	University of Rijeka, Croatia
Saulius Maskeliūnas	Vilnius University, Lithuania
Raimundas Matulevičius	University of Tartu, Estonia
Martin Nečaský	Charles University, Czech Republic
Laila Niedrite	University of Latvia, Latvia
Christophoros Nikou	University of Ioannina, Greece
Boris Novikov	St-Petersburg University, Russia
Jyrki Nummenmaa	University of Tampere, Finland
Vladimir A. Oleshchuk	University of Agder, Norway
Oscar Pastor	Polytechnic University of Valencia, Spain
Justyna	University of Zielona Gora, Poland
Patalas-Maliszewska	
Ivan Piletski	Belarusian State University of Informatics and Radioelectronics, Belarus
Jaroslav Pokorný	Charles University in Prague, Czech Republic
Boris Rachev	Technical University of Varna, Bulgaria
Jolita Ralyte	University of Geneva, Switzerland
Šarūnas Raudys	Vilnius University, Lithuania
Tarmo Robal	Tallinn University of Technology, Estonia
Radi Romansky	Technical University of Sofia, Bulgaria
José Raúl Romero	University of Cordoba, Spain
Gunter Saake	Otto von Guericke University of Magdeburg, Germany
Kurt Sandkuhl	University of Rostock, Germany
Simonas Šaltenis	Aalborg University, Denmark
André Schekelmann	Niederrhein University of Applied Science, Germany
Michał Śmiałek	Warsaw University of Technology, Poland
Lovro Šubelj	University of Ljubljana, Slovenia
Janis Stirna	Stockholm University, Sweden
João Manuel R. S. Tavares	University of Porto, Portugal
Kuldar Taveter	Tallinn University of Technology, Estonia
Ernest Teniente	Polytechnic University of Catalonia, Spain
Jaak Tepandi	Tallinn University of Technology, Estonia
Emiliano Tramontana	University of Catania, Italy
Peter Thanisch	University of Tampere, Finland
Michal Valenta	Czech Technical University in Prague, Czech Republic
Juan Manuel Vara	University Rey Juan Carlos, Spain
Damjan Vavpotič	University of Ljubljana, Slovenia
Benkt Wangler	Stockholm University, Sweden
Katarzyna Wasielewska	State University of Applied Sciences in Elblag, Poland
Hans Weigand	Tilburg University, The Netherlands
Jelena Zdravkovic	Stockholm University, Sweden
Pavel Zezula	Masaryk University, Czech Republic

## **Additional Reviewers**

Dominik Bork	University of Vienna, Austria
Durand Gabriel Campero	Otto von Guericke University Magdeburg, Germany
Marco Franceschetti	Alpen-Adria-Universität Klagenfurt, Austria
Angelos P. Giotis	University of Ioannina, Greece
Vimal Kunnummel	University of Vienna, Austria
Kestutis Normantas	Vilnius Gediminas Technical University, Lithuania
Ruben Salado	University of Cordoba, Spain
Titas Savickas	Vilnius Gediminas Technical University, Lithuania
Giorgos Sfikas	University of Ioannina, Greece
Tatjana Welzer	University of Maribor, Slovenia

## **Organizing Chair**

Saulius Maskeliūnas	Vilnius University, Lithuanian Computer Society
---------------------	---

## **Publicity Chair**

Saulius Gudas	Vilnius University, Lithuania
---------------	-------------------------------

## **Finance Chair**

Snieguolė Meškauskienė	Vilnius University, Lithuania
------------------------	-------------------------------

## **Webmaster**

Laima Paliulionienė	Vilnius University, Lithuania
---------------------	-------------------------------

## **Organizing Committee**

Dalė Dzemydienė	Vilnius University, Lithuania
Justinas Janulevičius	Vilnius Gediminas Technical University, Lithuania
Kristina Lapin	Vilnius University, Lithuania
Jolanta Miliauskaitė	Vilnius University, Lithuania
Laima Paliulionienė	Vilnius University, Lithuania
Raimundas Savukynas	Vilnius University, Lithuania
Aidas Žandaris	Lithuanian Computer Society, Lithuania

## Supporting Institutions and Partners



Vilnius University



IEEE



Springer



Go Vilnius

# Contents

## Plenary Session

Data Science and Advanced Digital Technologies . . . . .	3
<i>Gintautas Dzemyda</i>	
A Light Insight into Latvian and Lithuanian ICT Terminology: Whether Kindred Language Imply Kindred Terminology? . . . . .	8
<i>Juris Borzovs</i>	

## Invited Talks

Business Process Analytics: From Insights to Predictions . . . . .	15
<i>Marlon Dumas</i>	
Towards the Next-Generation Enterprise Information Systems – Research Opportunities and Challenges . . . . .	21
<i>Milan Zdravković</i>	
Languages of Baltic Countries in Digital Age . . . . .	32
<i>Inguna Skadiņa</i>	

## Information Systems Engineering

Towards the Trust Model for Industry 4.0 . . . . .	43
<i>Marina Harlamova and Marite Kirikova</i>	
Towards the Reference Model for Security Risk Management in Internet of Things . . . . .	58
<i>Raman Shapaval and Raimundas Matulevičius</i>	
Information Requirements for Big Data Projects: A Review of State-of-the-Art Approaches . . . . .	73
<i>Natalija Kozmina, Laila Niedrite, and Janis Zemnickis</i>	
Pattern Library for Use-Case-Based Application Logic Reuse . . . . .	90
<i>Michał Śmialek, Albert Ambroziewicz, and Rafał Parol</i>	
Impact of Demographic Differences on Color Preferences in the Interface Design of e-Services in Latvia . . . . .	106
<i>Jurgis Šķilters, Līga Zariņa, Signe Bāliņa, and Dace Baumgarte</i>	

Asynchronous Client-Side Coordination of Cluster Service Sessions . . . . .	121
<i>Karolis Petrauskas and Romas Baronas</i>	

Ping-Pong Tests on Distributed Processes Using Java Bindings of Open-MPI and Java Sockets with Applications to Distributed Database Performance . . . . .	134
<i>Mehmet Can Boysan</i>	

Model Based Approach for Testing: Distributed Real-Time Systems Augmented with Online Monitors . . . . .	142
<i>Deepak Pal and Jüri Vain</i>	

**Knowledge and Ontologies**

Domain Ontology for Expressing Knowledge of Variants of Thermally Modified Wood Products . . . . .	161
<i>Hele-Mai Haav and Riina Maigre</i>	

The Knowledge Increase Estimation Framework for Integration of Ontology Instances' Relations. . . . .	172
<i>Adrianna Kozierkiewicz and Marcin Pietranik</i>	

**Advanced Database Systems**

Proposal of an Unrestricted Character Encoding for Japanese . . . . .	189
<i>Antoine Bossard and Keiichi Kaneko</i>	

Facilitation of Health Professionals Responsible Autonomy with Easy-to-Use Hospital Data Querying Language . . . . .	202
<i>Edgars Rencis, Juris Barzdins, Mikus Grasmanis, and Agris Sostaks</i>	

Efficient Model Repository for Web Applications . . . . .	216
<i>Sergejs Kozlovičs</i>	

**Big Data Analysis and Processing**

Scalable Hadoop-Based Infrastructure for Big Data Analytics . . . . .	233
<i>Irina Astrova, Arne Koschel, Felix Heine, and Ahto Kalja</i>	

Application of Graph Clustering and Visualisation Methods to Analysis of Biomolecular Data. . . . .	243
<i>Edgars Celms, Kārlis Čerāns, Kārlis Freivalds, Paulis Ķikusts, Lelde Lāce, Gatis Melkus, Mārtiņš Opmanis, Dārta Rītuma, Pēteris Ručevskis, and Juris Vīksna</i>	

A New Knowledge-Transmission Based Horizontal Collaborative Fuzzy Clustering Algorithm for Unequal-Length Time Series . . . . .	258
<i>Shurong Jiang, Jianlong Wang, and Fusheng Yu</i>	

Non-index Based Skyline Analysis on High Dimensional Data with Uncertain Dimensions. . . . .	272
<i>Nurul Husna Mohd Saad, Hamidah Ibrahim, Fatimah Sidi, and Razali Yaakob</i>	

## **Cognitive Computing**

Semi-automatic Quasi-morphological Word Segmentation for Neural Machine Translation. . . . .	289
<i>Jānis Zuters, Gus Strazds, and Kārlis Immers</i>	

Effective Online Learning Implementation for Statistical Machine Translation . . . . .	302
<i>Toms Miks, Mārcis Pinnis, Matīss Rikters, and Rihards Krišlaufs</i>	

Investigation of Text Attribution Methods Based on Frequency Author Profile. . . . .	314
<i>Polina Diurdeva and Elena Mikhailova</i>	

Implementing a Face Recognition System for Media Companies. . . . .	328
<i>Arturs Progis, Karlis Freivalds, and Elita Cirule</i>	

## **Applications and Case Studies**

What Language Do Stocks Speak? . . . . .	345
<i>Marko Poženel and Dejan Lavbič</i>	

The Algorithm for Constrained Shortest Path Problem Based on Incremental Lagrangian Dual Solution. . . . .	360
<i>Boris Novikov and Roman Guralnik</i>	

Current Perspectives on the Application of Bayesian Networks in Different Domains. . . . .	376
<i>Galina M. Novikova and Esteban J. Azofeifa</i>	

<b>Author Index</b> . . . . .	391
-------------------------------	-----