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Sven Hartmann · Hui Ma (Eds.)

Database and Expert Systems Applications

27th International Conference, DEXA 2016
Porto, Portugal, September 5–8, 2016
Proceedings, Part II

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Preface

This volume contains the papers presented at the 27th International Conference on Database and Expert Systems Applications (DEXA 2016), which was held in Porto, Portugal, during September 5–8, 2016. On behalf of the Program Committee, we commend these papers to you and hope you find them useful.

Database, information, and knowledge systems have always been a core subject of computer science. The ever-increasing need to distribute, exchange, and integrate data, information, and knowledge has added further importance to this subject. Advances in the field will help facilitate new avenues of communication, to proliferate interdisciplinary discovery, and to drive innovation and commercial opportunity.

DEXA is an international conference series which showcases state-of-the-art research activities in database, information, and knowledge systems. The conference and its associated workshops provide a premier annual forum to present original research results and to examine advanced applications in the field. The goal is to bring together developers, scientists, and users to extensively discuss requirements, challenges, and solutions in database, information, and knowledge systems.

DEXA 2016 solicited original contributions dealing with any aspect of database, information, and knowledge systems. Suggested topics included but were not limited to:

- Acquisition, Modeling, Management and Processing of Knowledge
- Authenticity, Privacy, Security, and Trust
- Availability, Reliability and Fault Tolerance
- Big Data Management and Analytics
- Consistency, Integrity, Quality of Data
- Constraint Modeling and Processing
- Cloud Computing and Database-as-a-Service
- Database Federation and Integration, Interoperability, Multi-Databases
- Data and Information Networks
- Data and Information Semantics
- Data Integration, Metadata Management, and Interoperability
- Data Structures and Data Management Algorithms
- Database and Information System Architecture and Performance
- Data Streams, and Sensor Data
- Data Warehousing
- Decision Support Systems and Their Applications
- Dependability, Reliability and Fault Tolerance
- Digital Libraries, and Multimedia Databases
- Distributed, Parallel, P2P, Grid, and Cloud Databases
- Graph Databases
- Incomplete and Uncertain Data
- Information Retrieval

- Information and Database Systems and Their Applications
- Mobile, Pervasive, and Ubiquitous Data
- Modeling, Automation and Optimization of Processes
- NoSQL and NewSQL Databases
- Object, Object-Relational, and Deductive Databases
- Provenance of Data and Information
- Semantic Web and Ontologies
- Social Networks, Social Web, Graph, and Personal Information Management
- Statistical and Scientific Databases
- Temporal, Spatial, and High-Dimensional Databases
- Query Processing and Transaction Management
- User Interfaces to Databases and Information Systems
- Visual Data Analytics, Data Mining, and Knowledge Discovery
- WWW and Databases, Web Services
- Workflow Management and Databases
- XML and Semi-structured Data

Following the call for papers, which yielded 137 submissions, there was a rigorous review process that saw each paper reviewed by three to five international experts. The 39 papers judged best by the Program Committee were accepted for long presentation. A further 29 papers were accepted for short presentation.

As is the tradition of DEXA, all accepted papers are published by Springer. Authors of selected papers presented at the conference were invited to submit extended versions of their papers for publication in the Springer journal *Transactions on Large-Scale Data- and Knowledge-Centered Systems (TLDKS)*.

We wish to thank all authors who submitted papers and all conference participants for the fruitful discussions. We are grateful to Bruno Buchberger and Gottfried Vossen, who accepted to present keynote talks at the conference.

The success of DEXA 2016 is a result of the collegial teamwork from many individuals. We like to thank the members of the Program Committee and external reviewers for their timely expertise in carefully reviewing the submissions. We are grateful to our general chairs, Abdelkader Hameurlain, Fernando Lopes, and Roland R. Wagner, to our publication chair, Vladimir Marik, and to our workshop chairs, A Min Tjoa, Zita Vale, and Roland R. Wagner.

We wish to express our deep appreciation to Gabriela Wagner of the DEXA conference organization office. Without her outstanding work and excellent support, this volume would not have seen the light of day.

Finally, we would like to thank GECAD (Research Group on Intelligent Engineering and Computing for Advanced Innovation and Development) at ISEP (Instituto Superior de Engenharia do Porto) for being our hosts for the wonderful days in Porto.

July 2016

Sven Hartmann
Hui Ma

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Keynotes

From Natural Language to Automated Reasoning

Bruno Buchberger

We outline the possible interaction between knowledge mining, natural language processing, sentiment analysis, data base systems, ontology technology, algorithm synthesis, and automated reasoning for enhancing the sophistication of web-based knowledge processing.

We focus, in particular, on the transition from parsed natural language texts to formal texts in the frame of logical systems and the potential impact of automating this transition on methods for finding hidden knowledge in big (or small) data and the automated composition of algorithms (cooperation plans for networks of application software).

Simple cooperation apps like IFTTT and the new version of SIRI demonstrate the power of (automatically) combining clusters of existing applications under the control of expressions of desires in natural language.

In the Theorema Working Group of the speaker quite powerful algorithm synthesis methods have been developed that can generate algorithms for relatively difficult mathematical problems. These methods are based on automated reasoning and start from formal problem specifications in the frame of predicate logic. We ask ourselves how the deep reasoning used in mathematical algorithm synthesis could be combined with recent advances in natural language processing for reaching a new level of intelligence in the communication between humans and the web for every-day and business applications.

The talk is expository and tries to draw a big picture of how we could and should proceed in this area but will also explain some technical details and demonstrate some surprising results in the formal reasoning aspect of the overall approach.

The Price of Data

Gottfried Vossen[1,2]

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Abstract. As data is becoming a commodity similar to electricity, as individuals become more and more transparent thanks to the comprehensive data traces they leave, and as data gets increasingly connected across company boundaries, the question arises of whether a price tag should be attached to data and, if so, what it should say. In this talk, the price of data is studied from a variety of angles and applications areas, including telecommunication, social networks, advertising, and automation; the issues discussed include aspects such as fair pricing, data quality, data ownership, and ethics. Special attention is paid to data marketplaces, where nowadays everybody can trade data, although the currency in which buyers are requested to pay may no longer be what they expect.

The term "Big Data" will always be remembered as *the* big buzzword of 2013 and, somewhat surprisingly, of several years thereafter. According to Bernard Marr[1], "the basic idea behind the phrase 'Big Data' is that everything we do is increasingly leaving a digital trace (or data), which we (and others) can use and analyze. Big Data therefore refers to that data being collected and our ability to make use of it." In earlier times, it was not unusual to leave analog traces, like purchase receipts from the grocery store, and neither was the idea to somehow monetize these traces. The owner of the grocery store would know his regular customers, and would try to keep old ones and attract new ones by offering them discount coupons or other incentives. With digital traces, business along such lines has exploded, become possible at a world-wide scale, and has reached nuances of everyday life that nobody would ever have thought of. So it is time to ask whether that data comes with a price tag and, if so, what it says.

This talk looks at the price of data from a variety of angles and application areas for which pricing is relevant. In telecommunication, for example, prices for making phone calls as well as for data (e.g., surfing the Web) have come down enormously over the last 20 years, due to increasingly cheaper technology as well as more and more competition. Search engines have made it popular to make money through advertising, where participants bid on keywords that may occur in search queries, and social networks generate revenue from letting companies have access to their user profiles and all the data that these contain. So what is the value of a user profile?

[1] http://www.datasciencecentral.com/profile/BernardMarr.

Data marketplaces [2, 4, 5, 9], on the other hand, are an emerging species of digital platform that revisits traditional marketplaces and their mechanisms. In a data marketplace, producers of data provide query answers to consumers in exchange for payment. In general, a data marketplace integrates public Web data with other data sources, and it allows for data extraction, data transformation and data loading, and it comprises meta data repositories describing data and algorithms. In addition, it consists of technology for 'uploading' and optimizing operators with user-defined-functionality, as well as trading and billing components. In return, the 'vendor' of this functionality receives a monetary contribution from a buyer. Essentially, everybody can trade data nowadays, and the roles of sellers and buyers may be swapped over time and be exchangeable. For a seller, the interesting issue is the question of how valuable some data may be for a customer (or what the competition is charging for the same or similar data); if that could be figured out, the seller could adapt the price he is asking accordingly.

From a more technical perspective, the pricing problem can be tackled from the point of view of data quality, and here it is possible to establish a notion of *fair pricing*. [6, 8] cast this problem into a universal-relation setting and study the impact of quantifiable data quality; they follow [1] who argue that relational *views* can be interpreted as versions of the 'information good' data and hence study the issue of pricing for competing data sources that provide essentially the same data but in different quality.

Fair pricing has been addressed in depth by [7], by demonstrating how the quality of relational data products can be adapted to match a buyer's willingness to pay by employing a *Name Your Own Price* (NYOP) model. Under that model, data providers can discriminate customers so that they realize the maximum price a customer is willing to pay, and data customers receive a product that is tailored to their own data quality needs and budgets. To balance customer preferences and vendor interests, a model is developed which translates fair pricing into a Multiple-Choice Knapsack optimization problem, thereby making it amenable to an algorithmic solution. The concept of trading data quality for a discount was previously suggested in [10, 11] and applied to both relational as well as XML data.

A final aspect to be mentioned in this context is that of data used in automation. Following [3], automation has become pervasive in recent years and has lead to the danger that people lose their specific abilities when supported or even replaced by machines, robots, or generally automated devices. Carr explains this, for example, with auto-pilots in airplanes: Often pilots are so reliant on an auto-pilot that they do not want to accept the fact the a decision the device has just made is wrong, and he gives examples where this has ended in disaster more than once. Hence the danger is that we overestimate the truth in data, that we trust it too much, so that, as a consequence, the quest for its price becomes obsolete.

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