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Similarity Joins in Relational Database Systems

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Nikolaus Augsten

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Similarity Joins In Relational Database Systems Nikolaus Augsten:

Similarity Joins in Relational Database Systems Nikolaus Augsten,Michael Bohlen,2013-11-01 State of the art database systems manage and process a variety of complex objects including strings and trees For such objects equality comparisons are often not meaningful and must be replaced by similarity comparisons This book describes the concepts and techniques to incorporate similarity into database systems We start out by discussing the properties of strings and trees and identify the edit distance as the de facto standard for comparing complex objects Since the edit distance is computationally expensive token based distances have been introduced to speed up edit distance computations The basic idea is to decompose complex objects into sets of tokens that can be compared efficiently Token based distances are used to compute an approximation of the edit distance and prune expensive edit distance calculations A key observation when computing similarity joins is that many of the object pairs for which the similarity is computed are very different from each other Filters exploit this property to improve the performance of similarity joins A filter preprocesses the input data sets and produces a set of candidate pairs The distance function is evaluated on the candidate pairs only We describe the essential query processing techniques for filters based on lower and upper bounds For token equality joins we describe prefix size positional and partitioning filters which can be used to avoid the computation of small intersections that are not needed since the similarity would be too low *Similarity Joins in Relational Database Systems* Nikolaus Augsten,Michael Bohlen,2022-05-31 State of the art database systems manage and process a variety of complex objects including strings and trees For such objects equality comparisons are often not meaningful and must be replaced by similarity comparisons This book describes the concepts and techniques to incorporate similarity into database systems We start out by discussing the properties of strings and trees and identify the edit distance as the de facto standard for comparing complex objects Since the edit distance is computationally expensive token based distances have been introduced to speed up edit distance computations The basic idea is to decompose complex objects into sets of tokens that can be compared efficiently Token based distances are used to compute an approximation of the edit distance and prune expensive edit distance calculations A key observation when computing similarity joins is that many of the object pairs for which the similarity is computed are very different from each other Filters exploit this property to improve the performance of similarity joins A filter preprocesses the input data sets and produces a set of candidate pairs The distance function is evaluated on the candidate pairs only We describe the essential query processing techniques for filters based on lower and upper bounds For token equality joins we describe prefix size positional and partitioning filters which can be used to avoid the computation of small intersections that are not needed since the similarity would be too low **Non-Volatile Memory Database Management Systems** Joy Arulraj,Andrew Pavlo,2022-06-01 This book explores the implications of non volatile memory NVM for database management systems DBMSs The advent of NVM will fundamentally change the dichotomy between volatile memory and durable storage in DBMSs These

new NVM devices are almost as fast as volatile memory but all writes to them are persistent even after power loss Existing DBMSs are unable to take full advantage of this technology because their internal architectures are predicated on the assumption that memory is volatile With NVM many of the components of legacy DBMSs are unnecessary and will degrade the performance of data intensive applications We present the design and implementation of DBMS architectures that are explicitly tailored for NVM The book focuses on three aspects of a DBMS 1 logging and recovery 2 storage and buffer management and 3 indexing First we present a logging and recovery protocol that enables the DBMS to support near instantaneous recovery Second we propose astorage engine architecture and buffer management policy that leverages the durability and byte addressability properties of NVM to reduce data duplication and data migration Third the book presents the design of a range index tailored for NVM that is latch free yet simple to implement All together the work described in this book illustrates that rethinking the fundamental algorithms and data structures employed in a DBMS for NVM improves performance and availability reduces operational cost and simplifies software development Data Management in Machine Learning Systems Matthias Boehm,Arun Kumar,Jun Yang,2022-05-31 Large scale data analytics using machine learning ML underpins many modern data driven applications ML systems provide means of specifying and executing these ML workloads in an efficient and scalable manner Data management is at the heart of many ML systems due to data driven application characteristics data centric workload characteristics and system architectures inspired by classical data management techniques In this book we follow this data centric view of ML systems and aim to provide a comprehensive overview of data management in ML systems for the end to end data science or ML lifecycle We review multiple interconnected lines of work 1 ML support in database DB systems 2 DB inspired ML systems and 3 ML lifecycle systems Covered topics include in database analytics via query generation and user defined functions factorized and statistical relational learning optimizing compilers for ML workloads execution strategies and hardware accelerators data access methods such as compression partitioning and indexing resource elasticity and cloud markets as well as systems for data preparation for ML model selection model management model debugging and model serving Given the rapidly evolving field we strive for a balance between an up to date survey of ML systems an overview of the underlying concepts and techniques as well as pointers to open research questions Hence this book might serve as a starting point for both systems researchers and developers

Datalog and Logic Databases Sergio Greco,Cristian Molinaro,2022-05-31 The use of logic in databases started in the late 1960s In the early 1970s Codd formalized databases in terms of the relational calculus and the relational algebra A major influence on the use of logic in databases was the development of the field of logic programming Logic provides a convenient formalism for studying classical database problems and has the important property of being declarative that is it allows one to express what she wants rather than how to get it For a long time relational calculus and algebra were considered the relational database languages However there are simple operations such as computing the transitive closure of a graph

which cannot be expressed with these languages Datalog is a declarative query language for relational databases based on the logic programming paradigm One of the peculiarities that distinguishes Datalog from query languages like relational algebra and calculus is recursion which gives Datalog the capability to express queries like computing a graph transitive closure Recent years have witnessed a revival of interest in Datalog in a variety of emerging application domains such as data integration information extraction networking program analysis security cloud computing ontology reasoning and many others The aim of this book is to present the basics of Datalog some of its extensions and recent applications to different domains Instant Recovery with Write-Ahead Logging Goetz Graefe,Wey Guy,Caetano Sauer,2022-05-31 Traditional theory and practice of write ahead logging and of database recovery focus on three failure classes transaction failures typically due to deadlocks resolved by transaction rollback system failures typically power or software faults resolved by restart with log analysis redo and undo phases and media failures typically hardware faults resolved by restore operations that combine multiple types of backups and log replay The recent addition of single page failures and single page recovery has opened new opportunities far beyond the original aim of immediate lossless repair of single page wear out in novel or traditional storage hardware In the contexts of system and media failures efficient single page recovery enables on demand incremental redo and undo as part of system restart or media restore operations This can give the illusion of practically instantaneous restart and restore instant restart permits processing new queries and updates seconds after system reboot and instant restore permits resuming queries and updates on empty replacement media as if those were already fully recovered In the context of node and network failures instant restart and instant restore combine to enable practically instant failover from a failing database node to one holding merely an out of date backup and a log archive yet without loss of data updates or transactional integrity In addition to these instant recovery techniques the discussion introduces self repairing indexes and much faster offline restore operations which impose no slowdown in backup operations and hardly any slowdown in log archiving operations The new restore techniques also render differential and incremental backups obsolete complete backup commands on a database server practically instantly and even permit taking full up to date backups without imposing any load on the database server Compared to the first version of this book this second edition adds sections on applications of single page repair instant restart single pass restore and instant restore Moreover it adds sections on instant failover among nodes in a cluster applications of instant failover recovery for file systems and data files and the performance of instant restart and instant restore Databases on Modern Hardware Anastasia Ailamaki,Erietta Liarou,Pınar Tözün,Danica Porobic,Iraklis Psaroudakis,2022-06-01 Data management systems enable various influential applications from high performance online services e g social networks like Twitter and Facebook or financial markets to big data analytics e g scientific exploration sensor networks business intelligence As a result data management systems have been one of the main drivers for innovations in the database and computer architecture communities for several decades Recent hardware trends

require software to take advantage of the abundant parallelism existing in modern and future hardware The traditional design of the data management systems however faces inherent scalability problems due to its tightly coupled components In addition it cannot exploit the full capability of the aggressive micro architectural features of modern processors As a result today s most commonly used server types remain largely underutilized leading to a huge waste of hardware resources and energy In this book we shed light on the challenges present while running DBMS on modern multicore hardware We divide the material into two dimensions of scalability implicit vertical and explicit horizontal The first part of the book focuses on the vertical dimension it describes the instruction and data level parallelism opportunities in a core coming from the hardware and software side In addition it examines the sources of under utilization in a modern processor and presents insights and hardware software techniques to better exploit the microarchitectural resources of a processor by improving cache locality at the right level of the memory hierarchy The second part focuses on the horizontal dimension i e scalability bottlenecks of database applications at the level of multicore and multisocket multicore architectures It first presents a systematic way of eliminating such bottlenecks in online transaction processing workloads which is based on minimizing unbounded communication and shows several techniques that minimize bottlenecks in major components of database management systems Then it demonstrates the data and work sharing opportunities for analytical workloads and reviews advanced scheduling mechanisms that are aware of nonuniform memory accesses and alleviate bandwidth saturation

Generating Plans from Proofs Michael Benedikt,Julien Leblay,Balder ten Cate,Efthymia Tsamoura,2016-03-15 Query reformulation refers to a process of translating a source query a request for information in some high level logic based language into a target plan that abides by certain interface restrictions Many practical problems in data management can be seen as instances of the reformulation problem For example the problem of translating an SQL query written over a set of base tables into another query written over a set of views the problem of implementing a query via translating to a program calling a set of database APIs the problem of implementing a query using a collection of web services In this book we approach query reformulation in a very general setting that encompasses all the problems above by relating it to a line of research within mathematical logic For many decades logicians have looked at the problem of converting implicit definitions into explicit definitions using an approach known as interpolation We will review the theory of interpolation and explain its close connection with query reformulation We will give a detailed look at how the interpolation based approach is used to generate translations between logic based queries over different vocabularies and also how it can be used to go from logic based queries to programs **Veracity of Data** Laure Berti-Équille,Javier Borge-Holthoefer,2022-05-31 On the Web a massive amount of user generated content is available through various channels e g texts tweets Web tables databases multimedia sharing platforms etc Conflicting information rumors erroneous and fake content can be easily spread across multiple sources making it hard to distinguish between what is true and what is not This book gives an overview of

fundamental issues and recent contributions for ascertaining the veracity of data in the era of Big Data The text is organized into six chapters focusing on structured data extracted from texts Chapter 1 introduces the problem of ascertaining the veracity of data in a multi source and evolving context Issues related to information extraction are presented in Chapter 2 Current truth discovery computation algorithms are presented in details in Chapter 3 It is followed by practical techniques for evaluating data source reputation and authoritativeness in Chapter 4 The theoretical foundations and various approaches for modeling diffusion phenomenon of misinformation spreading in networked systems are studied in Chapter 5 Finally truth discovery computation from extracted data in a dynamic context of misinformation propagation raises interesting challenges that are explored in Chapter 6 This text is intended for a seminar course at the graduate level It is also to serve as a useful resource for researchers and practitioners who are interested in the study of fact checking truth discovery or rumor spreading **Big Data Integration** Xin Luna Dong,Divesh Srivastava,2022-05-31 The big data era is upon us data are being generated analyzed and used at an unprecedented scale and data driven decision making is sweeping through all aspects of society Since the value of data explodes when it can be linked and fused with other data addressing the big data integration BDI challenge is critical to realizing the promise of big data BDI differs from traditional data integration along the dimensions of volume velocity variety and veracity First not only can data sources contain a huge volume of data but also the number of data sources is now in the millions Second because of the rate at which newly collected data are made available many of the data sources are very dynamic and the number of data sources is also rapidly exploding Third data sources are extremely heterogeneous in their structure and content exhibiting considerable variety even for substantially similar entities Fourth the data sources are of widely differing qualities with significant differences in the coverage accuracy and timeliness of data provided This book explores the progress that has been made by the data integration community on the topics of schema alignment record linkage and data fusion in addressing these novel challenges faced by big data integration Each of these topics is covered in a systematic way first starting with a quick tour of the topic in the context of traditional data integration followed by a detailed example driven exposition of recent innovative techniques that have been proposed to address the BDI challenges of volume velocity variety and veracity Finally it presents merging topics and opportunities that are specific to BDI identifying promising directions for the data integration community Query Processing over Incomplete Databases Yunjun Gao,Xiaoye Miao,2022-06-01 Incomplete data is part of life and almost all areas of scientific studies Users tend to skip certain fields when they fill out online forms participants choose to ignore sensitive questions on surveys sensors fail resulting in the loss of certain readings publicly viewable satellite map services have missing data in many mobile applications and in privacy preserving applications the data is incomplete deliberately in order to preserve the sensitivity of some attribute values Query processing is a fundamental problem in computer science and is useful in a variety of applications In this book we mostly focus on the query processing over incomplete databases which involves finding a set of

qualified objects from a specified incomplete dataset in order to support a wide spectrum of real life applications We first elaborate the three general kinds of methods of handling incomplete data including i discarding the data with missing values ii imputation for the missing values and iii just depending on the observed data values For the third method type we introduce the semantics of k nearest neighbor kNN search skyline query and top k dominating query on incomplete data respectively In terms of the three representative queries over incomplete data we investigate some advanced techniques to process incomplete data queries including indexing pruning as well as crowdsourcing techniques **Transaction Processing on Modern Hardware** Mohammad Sadoghi,Spyros Blanas,2022-05-31 The last decade has brought groundbreaking developments in transaction processing This resurgence of an otherwise mature research area has spurred from the diminishing cost per GB of DRAM that allows many transaction processing workloads to be entirely memory resident This shift demanded a pause to fundamentally rethink the architecture of database systems The data storage lexicon has now expanded beyond spinning disks and RAID levels to include the cache hierarchy memory consistency models cache coherence and write invalidation costs NUMA regions and coherence domains New memory technologies promise fast non volatile storage and expose unchartered trade offs for transactional durability such as exploiting byte addressable hot and cold storage through persistent programming that promotes simpler recovery protocols In the meantime the plateauing single threaded processor performance has brought massive concurrency within a single node first in the form of multi core andnow with many core and heterogeneous processors The exciting possibility to reshape the storage transaction logging and recovery layers of next generation systems on emerging hardware have prompted the database research community to vigorously debate the trade offs between specialized kernels that narrowly focus on transaction processing performance vs designs that permit transactionally consistent data accesses from decision support and analytical workloads In this book we aim to classify and distill the new body of work on transaction processing that has surfaced in the last decade to navigate researchers and practitioners through this intricate research subject Data Profiling Ziawasch Abedjan,Lukasz Golab,Felix Naumann,Thorsten Papenbrock,2022-06-01 Data profiling refers to the activity of collecting data about data i e metadata Most IT professionals and researchers who work with data have engaged in data profiling at least informally to understand and explore an unfamiliar dataset or to determine whether a new dataset is appropriate for a particular task at hand Data profiling results are also important in a variety of other situations including query optimization data integration and data cleaning Simple metadata are statistics such as the number of rows and columns schema and datatype information the number of distinct values statistical value distributions and the number of null or empty values in each column More complex types of metadata are statements about multiple columns and their correlation such as candidate keys functional dependencies and other types of dependencies This book provides a classification of the various types of profilable metadata discusses popular data profiling tasks and surveys state of the art profiling algorithms While most of the book focuses on

tasks and algorithms for relational data profiling we also briefly discuss systems and techniques for profiling non relational data such as graphs and text We conclude with a discussion of data profiling challenges and directions for future work in this area **The Four Generations of Entity Resolution** George Papadakis,Ekaterini Ioannou,Emanouil Thanos,Themis Palpanas,2022-06-01 Entity Resolution ER lies at the core of data integration and cleaning and thus a bulk of the research examines ways for improving its effectiveness and time efficiency The initial ER methods primarily target Veracity in the context of structured relational data that are described by a schema of well known quality and meaning To achieve high effectiveness they leverage schema expert and or external knowledge Part of these methods are extended to address Volume processing large datasets through multi core or massive parallelization approaches such as the MapReduce paradigm However these early schema based approaches are inapplicable to Web Data which abound in voluminous noisy semi structured and highly heterogeneous information To address the additional challenge of Variety recent works on ER adopt a novel loosely schema aware functionality that emphasizes scalability and robustness to noise Another line of present research focuses on the additional challenge of Velocity aiming to process data collections of a continuously increasing volume The latest works though take advantage of the significant breakthroughs in Deep Learning and Crowdsourcing incorporating external knowledge to enhance the existing words to a significant extent This synthesis lecture organizes ER methods into four generations based on the challenges posed by these four Vs For each generation we outline the corresponding ER workflow discuss the state of the art methods per workflow step and present current research directions The discussion of these methods takes into account a historical perspective explaining the evolution of the methods over time along with their similarities and differences The lecture also discusses the available ER tools and benchmark datasets that allow expert as well as novice users to make use of the available solutions Answering Queries Using Views, Second Edition Foto Afrati,Rada Chirkova,2022-05-31 The topic of using views to answer queries has been popular for a few decades now as it cuts across domains such as query optimization information integration data warehousing website design and recently database as a service and data placement in cloud systems This book assembles foundational work on answering queries using views in a self contained manner with an effort to choose material that constitutes the backbone of the research It presents efficient algorithms and covers the following problems query containment rewriting queries using views in various logical languages equivalent rewritings and maximally contained rewritings and computing certain answers in the data integration and data exchange settings Query languages that are considered are fragments of SQL in particular select project join queries also called conjunctive queries with or without arithmetic comparisons or negation and aggregate SQL queries This second edition includes twonew chapters that refer to tree like data and respective query languages Chapter 8 presents the data model for XML documents and the XPath query language and Chapter 9 provides a theoretical presentation of tree like data model and query language where the tuples of a relation share a tree structured schema for that relation and the

query language is a dialect of SQL with evaluation techniques appropriately modified to fit the richer schema **Scalable Processing of Spatial-Keyword Queries** Ahmed R. Mahmood,Walid G. Aref,2022-05-31 Text data that is associated with location data has become ubiquitous A tweet is an example of this type of data where the text in a tweet is associated with the location where the tweet has been issued We use the term spatial keyword data to refer to this type of data Spatial keyword data is being generated at massive scale Almost all online transactions have an associated spatial trace The spatial trace is derived from GPS coordinates IP addresses or cell phone tower locations Hundreds of millions or even billions of spatial keyword objects are being generated daily Spatial keyword data has numerous applications that require efficient processing and management of massive amounts of spatial keyword data This book starts by overviewing some important applications of spatial keyword data and demonstrates the scale at which spatial keyword data is being generated Then it formalizes and classifies the various types of queries that execute over spatial keyword data Next it discusses important and desirable properties of spatial keyword query languages that are needed to express queries over spatial keyword data As will be illustrated existing spatial keyword query languages vary in the types of spatial keyword queries that they can support There are many systems that process spatial keyword queries Systems differ from each other in various aspects e g whether the system is batch oriented or stream based and whether the system is centralized or distributed Moreover spatial keyword systems vary in the types of queries that they support Finally systems vary in the types of indexing techniques that they adopt This book provides an overview of the main spatial keyword data management systems SKDMSs and classifies them according to their features Moreover the book describes the main approaches adopted when indexing spatial keyword data in the centralized and distributed settings Several case studies of SKDMSs are presentedalong with the applications and query types that these SKDMSs are targeted for and the indexing techniques they utilize for processing their queries Optimizing the performance and the query processing of SKDMSs still has many research challenges and open problems The book concludes with a discussion about several important and open research problems in the domain of scalable spatial keyword processing **Data Exploration Using Example-Based Methods** Matteo Lissandrini,Davide Mottin,Themis Palpanas,Yannis Velegrakis,2022-06-01 Data usually comes in a plethora of formats and dimensions rendering the exploration and information extraction processes challenging Thus being able to perform exploratory analyses in the data with the intent of having an immediate glimpse on some of the data properties is becoming crucial Exploratory analyses should be simple enough to avoid complicate declarative languages such as SQL and mechanisms and at the same time retain the flexibility and expressiveness of such languages Recently we have witnessed a rediscovery of the so called example based methods in which the user or the analyst circumvents query languages by using examples as input An example is a representative of the intended results or in other words an item from the result set Example based methods exploit inherent characteristics of the data to infer the results that the user has in mind but may not able to easily express They can be useful in cases where a user

is looking for information in an unfamiliar dataset when the task is particularly challenging like finding duplicate items or simply when they are exploring the data In this book we present an excursus over the main methods for exploratory analysis with a particular focus on example based methods We show how that different data types require different techniques and present algorithms that are specifically designed for relational textual and graph data The book presents also the challenges and the new frontiers of machine learning in online settings which recently attracted the attention of the database community The lecture concludes with a vision for further research and applications in this area **Fault-Tolerant Distributed Transactions on Blockchain** Suyash Gupta,Jelle Hellings,Mohammad Sadoghi,2022-06-01 Since the introduction of Bitcoin the first widespread application driven by blockchain the interest of the public and private sectors in blockchain has skyrocketed In recent years blockchain based fabrics have been used to address challenges in diverse fields such as trade food production property rights identity management aid delivery health care and fraud prevention This widespread interest follows from fundamental concepts on which blockchains are built that together embed the notion of trust upon which blockchains are built 1 Blockchains provide data transparancy Data in a blockchain is stored in the form of a ledger which contains an ordered history of all the transactions This facilitates oversight and auditing 2 Blockchains ensure data integrity by using strong cryptographic primitives This guarantees that transactions accepted by the blockchain are authenticated by its issuer are immutable and cannot be repudiated by the issuer This ensures accountability 3 Blockchains are decentralized democratic and resilient They use consensus based replication to decentralize the ledger among many independent participants Thus it can operate completely decentralized and does not require trust in a single authority Additions to the chain are performed by consensus in which all participants have a democratic voice in maintaining the integrity of the blockchain Due to the usage of replication and consensus blockchains are also highly resilient to malicious attacks even when a significant portion of the participants are malicious It further increases the opportunity for fairness and equity through democratization These fundamental concepts and the technologies behind them a generic ledger based data model cryptographically ensured data integrity and consensus based replication prove to be a powerful and inspiring combination a catalyst to promote computational trust In this book we present an in depth study of blockchain unraveling its revolutionary promise to instill computational trust in society all carefully tailored to a broad audience including students researchers and practitioners We offer a comprehensive overview of theoretical limitations and practical usability of consensus protocols while examining the diverse landscape of how blockchains are manifested in their permissioned and permissionless forms Skylines and Other Dominance-Based Queries Apostolos N. Papadopoulos,Eleftherios Tiakas,Theodoros Tzouramanis,Nikolaos Georgiadis,Yannis Manolopoulos,2022-06-01 This book is a gentle introduction to dominance based query processing techniques and their applications The book aims to present fundamental as well as some advanced issues in the area in a precise but easy to follow manner Dominance is an intuitive concept that can be used in

many different ways in diverse application domains The concept of dominance is based on the values of the attributes of each object An object dominates another object if is better than This goodness criterion may differ from one user to another However all decisions boil down to the minimization or maximization of attribute values In this book we will explore algorithms and applications related to dominance based query processing The concept of dominance has a long history in finance and multi criteria optimization However the introduction of the concept to the database community in 2001 inspired many researchers to contribute to the area Therefore many algorithmic techniqueshave been proposed for the efficient processing of dominance based queries such as skyline queries dominant queries and top dominating queries just to name a few **Querying Graphs** Angela Bonifati,George Fletcher,Hannes Voigt,Nikolay Yakovets,2022-06-01 Graph data modeling and querying arises in many practical application domains such as social and biological networks where the primary focus is on concepts and their relationships and the rich patterns in these complex webs of interconnectivity In this book we present a concise unified view on the basic challenges which arise over the complete life cycle of formulating and processing queries on graph databases To that purpose we present all major concepts relevant to this life cycle formulated in terms of a common and unifying ground the property graph data model the pre dominant data model adopted by modern graph database systems We aim especially to give a coherent and in depth perspective on current graph querying and an outlook for future developments Our presentation is self contained covering the relevant topics from graph data models graph query languages and graph query specification graph constraints and graph query processing We conclude by indicatingmajor open research challenges towards the next generation of graph data management systems

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