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# Full-Text (Substring) Indexes in External Memory

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*SYNTHESIS LECTURES ON DATA MANAGEMENT*

M. Tamer Özsu, *Series Editor*

# Full Text Substring Indexes In External Memory Alex Thomo

**Jens Teubner, Louis Woods**



## **Full Text Substring Indexes In External Memory Alex Thomo:**

**Full-Text (Substring) Indexes in External Memory** Marina Barsky,Alex Thomo,Ulrike Stege,2022-05-31 Nowadays textual databases are among the most rapidly growing collections of data Some of these collections contain a new type of data that differs from classical numerical or textual data These are long sequences of symbols not divided into well separated small tokens words The most prominent among such collections are databases of biological sequences which are experiencing today an unprecedented growth rate Starting in 2008 the 1000 Genomes Project has been launched with the ultimate goal of collecting sequences of additional 1 500 Human genomes 500 each of European African and East Asian origin This will produce an extensive catalog of Human genetic variations The size of just the raw sequences in this catalog would be about 5 terabytes Querying strings without well separated tokens poses a different set of challenges typically addressed by building full text indexes which provide effective structures to index all the substrings of the given strings Since full text indexes occupy more space than the raw data it is often necessary to use disk space for their construction However until recently the construction of full text indexes in secondary storage was considered impractical due to excessive I O costs Despite this algorithms developed in the last decade demonstrated that efficient external construction of full text indexes is indeed possible This book is about large scale construction and usage of full text indexes We focus mainly on suffix trees and show efficient algorithms that can convert suffix trees to other kinds of full text indexes and vice versa There are four parts in this book They are a mix of string searching theory with the reality of external memory constraints The first part introduces general concepts of full text indexes and shows the relationships between them The second part presents the first series of external memory construction algorithms that can handle the construction of full text indexes for moderately large strings in the order of few gigabytes The third part presents algorithms that scale for very large strings The final part examines queries that can be facilitated by disk resident full text indexes Table of Contents Structures for Indexing Substrings External Construction of Suffix Trees Scaling Up When the Input Exceeds the Main Memory Queries for Disk based Indexes Conclusions and Open Problems

**Querying Graphs** Angela Bonifati,George Fletcher,Hannes Voigt,Nikolay Yakovets,2018-10-01 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 indicating major open research challenges towards the next generation of graph data management systems

**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 two new 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

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 be 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

**Data Processing on FPGAs** Jens Teubner, Louis Woods, 2013-06-01 Roughly a decade ago power consumption and heat dissipation concerns forced the semiconductor industry to radically change its

course shifting from sequential to parallel computing Unfortunately improving performance of applications has now become much more difficult than in the good old days of frequency scaling This is also affecting databases and data processing applications in general and has led to the popularity of so called data appliances specialized data processing engines where software and hardware are sold together in a closed box Field programmable gate arrays FPGAs increasingly play an important role in such systems FPGAs are attractive because the performance gains of specialized hardware can be significant while power consumption is much less than that of commodity processors On the other hand FPGAs are way more flexible than hard wired circuits ASICs and can be integrated into complex systems in many different ways e g directly in the network for a high frequency trading application This book gives an introduction to FPGA technology targeted at a database audience In the first few chapters we explain in detail the inner workings of FPGAs Then we discuss techniques and design patterns that help mapping algorithms to FPGA hardware so that the inherent parallelism of these devices can be leveraged in an optimal way Finally the book will illustrate a number of concrete examples that exploit different advantages of FPGAs for data processing

Table of Contents Preface Introduction A Primer in Hardware Design FPGAs FPGA Programming Models Data Stream Processing Accelerated DB Operators Secure Data Processing Conclusions Bibliography Authors Biographies Index

*Databases on Modern Hardware* Anastasia Ailamaki, Erietta Liarou, Pinar 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 multsocket 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

**Data Protection from Insider Threats** Elisa Bertino,2012 The problem of how to protect data from theft and misuse is at the forefront of organisations minds Even though data security techniques are available to protect data and computing infrastructures many such techniques are unable to protect data from attacks posed by those working on an organisation s inside This book discusses techniques that can provide effective protection against attacks posed by people working on the inside of an organisation

**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

*The Four Generations of Entity Resolution* George Papadakis,Ekaterini Ioannou,Emanouil Thanos,2021-03-16 This book organizes entity resolution ER into four generations based on the challenges posed by the four Vs Veracity Volume Variety and Velocity Entity resolution 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 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 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

### **Scalable Processing of Spatial-Keyword Queries**

Ahmed R. Mahmood, Walid G. Aref, 2019-02-07 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 presented along 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

*Declarative Networking* Boon Thau Loo, Wenchao Zhou, 2012-01-01 Declarative Networking is a programming methodology that enables

developers to concisely specify network protocols and services which are directly compiled to a dataflow framework that executes the specifications Declarative networking proposes the use of a declarative query language for specifying and implementing network protocols and employs a dataflow framework at runtime for communication and maintenance of network state The primary goal of declarative networking is to greatly simplify the process of specifying implementing deploying and evolving a network design In addition declarative networking serves as an important step towards an extensible evolvable network architecture that can support flexible secure and efficient deployment of new network protocols This book provides an introduction to basic issues in declarative networking including language design optimization and dataflow execution The methodology behind declarative programming of networks is presented including roots in Datalog extensions for networked environments and the semantics of long running queries over network state The book focuses on a representative declarative networking language called Network Datalog NDlog which is based on extensions to the Datalog recursive query language An overview of declarative network protocols written in NDlog is provided and its usage is illustrated using examples from routing protocols and overlay networks This book also describes the implementation of a declarative networking engine and NDlog execution strategies that provide eventual consistency semantics with significant flexibility in execution Two representative declarative networking systems P2 and its successor RapidNet are presented Finally the book highlights recent advances in declarative networking and new declarative approaches to related problems

Table of Contents Introduction Declarative Networking Language Declarative Networking Overview Distributed Recursive Query Processing Declarative Routing Declarative Overlays Optimization of NDlog Recent Advances in Declarative Networking Conclusion

Eventually, you will agreed discover a additional experience and execution by spending more cash. yet when? attain you take that you require to get those all needs following having significantly cash? Why dont you try to get something basic in the beginning? Thats something that will guide you to understand even more as regards the globe, experience, some places, similar to history, amusement, and a lot more?

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