



Analytics Optimization with Columnstore Indexes in Microsoft SQL Server

Optimizing OLAP Workloads

—
Edward Pollack

Apress®

Analytics Optimization with Columnstore Indexes in Microsoft SQL Server

Optimizing OLAP Workloads

Edward Pollack

Apress®

Analytics Optimization with Columnstore Indexes in Microsoft SQL Server: Optimizing OLAP Workloads

Edward Pollack
Albany, NY, USA

ISBN-13 (pbk): 978-1-4842-8047-8
<https://doi.org/10.1007/978-1-4842-8048-5>

ISBN-13 (electronic): 978-1-4842-8048-5

Copyright © 2022 by Edward Pollack

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.

Trademarked names, logos, and images may appear in this book. Rather than use a trademark symbol with every occurrence of a trademarked name, logo, or image we use the names, logos, and images only in an editorial fashion and to the benefit of the trademark owner, with no intention of infringement of the trademark.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

While the advice and information in this book are believed to be true and accurate at the date of publication, neither the authors nor the editors nor the publisher can accept any legal responsibility for any errors or omissions that may be made. The publisher makes no warranty, express or implied, with respect to the material contained herein.

Managing Director, Apress Media LLC: Welmoed Spahr
Acquisitions Editor: Jonathan Gennick
Development Editor: Laura Berendson
Coordinating Editor: Jill Balzano

Cover image designed by Freepik (www.freepik.com)

Distributed to the book trade worldwide by Springer Science+Business Media LLC, 1 New York Plaza, Suite 4600, New York, NY 10004. Phone 1-800-SPRINGER, fax (201) 348-4505, e-mail orders-ny@springer-sbm.com, or visit www.springeronline.com. Apress Media, LLC is a California LLC and the sole member (owner) is Springer Science + Business Media Finance Inc (SSBM Finance Inc). SSBM Finance Inc is a **Delaware** corporation.

For information on translations, please e-mail booktranslations@springernature.com; for reprint, paperback, or audio rights, please e-mail bookpermissions@springernature.com.

Apress titles may be purchased in bulk for academic, corporate, or promotional use. eBook versions and licenses are also available for most titles. For more information, reference our Print and eBook Bulk Sales web page at <http://www.apress.com/bulk-sales>.

Any source code or other supplementary material referenced by the author in this book is available to readers on GitHub at <https://github.com/Apress/analytics-optimization-w-columnstore-indexes-in-microsoft-sql-server>.

Printed on acid-free paper

*For Theresa, Nolan, and Oliver, without whom none of this
would be possible.*

Table of Contents

About the Author	xi
About the Technical Reviewer	xiii
Acknowledgments	xv
Introduction	xvii
Chapter 1: Introduction to Analytic Data in a Transactional Database	1
Where Should Analytic Data Reside?	1
Analytic Data Size	2
Analytic Data Structure	4
Analytic Data Sources	5
Data Warehouse	6
Unstructured Data	6
Third-Party Analytics Software	6
OLAP Data in an OLTP Table in a Transactional Database	7
OLAP Data in an Analytic Table in a Transactional Database	8
Chapter 2: Transactional vs. Analytic Workloads	11
Transactional Data	11
Analytic Data	14
The Need for Two Systems	18
Building Better Analytic Data Structures	19
Chapter 3: What Are Columnstore Indexes?	21
The Limits of Transactional Data Storage	21
Introducing Columnstore Indexes	24

TABLE OF CONTENTS

- Benefits of Columnstore Indexes in SQL Server 26
 - Native Analytic Data in SQL Server..... 26
 - Scalability 27
 - Exceptional Compression 29
 - Faster Analytic Reads 30
 - Faster Data Loads..... 30
- Chapter 4: Columnstore Index Architecture 33**
 - Sample Data..... 33
 - Rowgroups and Segments..... 36
 - The Delta Store 40
 - The Delete Bitmap..... 41
 - Nonclustered Columnstore Index Architecture..... 42
 - Physical Data on Pages..... 43
 - Summarizing Differences..... 47
- Chapter 5: Columnstore Compression 49**
 - Basics of Columnstore Compression 49
 - Columnstore Compression Algorithms..... 51
 - Value Encoding 51
 - Dictionary Encoding..... 54
 - Should String Data Be Normalized? 60
 - Row Order (Vertipaq) Optimization 62
 - Other Compression Algorithms..... 65
 - Columnstore Archive Compression..... 68
 - The Compression Life Cycle 71
- Chapter 6: Columnstore Metadata 73**
 - Available Columnstore Metadata 73
 - Rowgroup Metadata 73
 - Segment Metadata 75
 - Rowgroup Physical Metadata..... 79

Rowgroup Operational Statistics	84
Columnstore Index Memory Usage.....	89
Internal Columnstore Index Objects	93
Chapter 7: Batch Execution	97
Row Mode Execution	97
Batch Mode Execution	100
How Does Batch Mode Work?	105
Batch Mode vs. Row Mode Performance	107
Chapter 8: Bulk Loading Data	111
Bulk Load Processes Explained	111
Bulk Loading into Columnstore Indexes.....	112
Performance of Bulk Loading into Columnstore Indexes	114
Trickle Insert vs. Staged Insert.....	118
Other Data Load Considerations	119
Drop Nonclustered Indexes During Data Loads	119
Columnstore Reorganize Operations with Each Data Load	120
Summary.....	122
Chapter 9: Delete and Update Operations	123
The Cost of Modifying Data	123
Delete Operations	125
Update Operations	128
Chapter 10: Segment and Rowgroup Elimination	137
Segment Elimination	137
Rowgroup Elimination.....	142
Combining Segment and Rowgroup Elimination.....	154
Chapter 11: Partitioning	157
Maintain Hot/Warm/Cold Data	157
Faster Data Movement/Migration	158

TABLE OF CONTENTS

- Partition Elimination..... 159
- Database Maintenance 160
- Partitioning in Action..... 161
- Partitioning Guidelines..... 175
 - Partition and Rowgroup Sizing 175
 - Partition Column Choice 176
 - Storage Choice 176
- Additional Benefits..... 177
- Chapter 12: Nonclustered Columnstore Indexes on Rowstore Tables 179**
 - Use Rowstore Indexes..... 180
 - Separate OLAP and OLTP Processes 183
 - Nonclustered Columnstore Indexes 185
 - Managing Hot, Warm, and Cold Transactional Data 187
 - Compression Delay..... 188
 - Filtered Nonclustered Columnstore Indexes..... 195
 - Code Changes..... 199
 - Vertipaq Optimization for Nonclustered Columnstore Indexes..... 199
 - Testing Nonclustered Columnstore Indexes 203
 - Don't Forget to Drop Unneeded Indexes! 204
- Chapter 13: Nonclustered Rowstore Indexes on Columnstore Tables 207**
 - Using Nonclustered Rowstore Indexes 207
 - Enforcing Constraints..... 212
 - Filtered Nonclustered Rowstore Indexes 214
 - Enabling Vertipaq Optimization 216
 - Add Filters to Nonclustered Rowstore Indexes..... 216
 - Perform Periodic Index Maintenance 216
 - Indexed Views 218
 - Compression for Nonclustered Rowstore Indexes 220
 - Nonclustered Rowstore Index Guidance 222

Chapter 14: Columnstore Index Maintenance	225
What Causes Fragmentation?	225
How Much Fragmentation Is Too Much?	228
Quantifying Deleted Rows	228
Detailing Unordered Data	230
The No-Maintenance Columnstore Index	236
Columnstore Reorganize	237
Reorganize to Remove Delta Rowgroups	239
Columnstore Rebuild	242
Columnstore Reorder and Rebuild	245
Columnstore Index Maintenance by Partition	246
Index Maintenance in Nonclustered Columnstore Indexes	247
Chapter 15: Columnstore Index Performance	249
Columnstore Metadata Reads	249
Columnstore Data Reads	253
Memory Sizing	254
Dictionary Size and Dictionary Pressure	257
Normalizing Wide Columns	258
Add or Change the Columnstore Sorting Column	259
Partitioning	259
Columnstore Indexes on Temporary Tables	260
Memory-Optimized Columnstore Indexes	264
Demonstrating Memory-Optimized Columnstore Indexes	264
Optimization Strategies	274
Index	275