Troubleshooting Oracle Performance

Christian Antognini

Apress®

Troubleshooting Oracle Performance

ISBN-13: 978-1-59059-917-4

ISBN-10: 1-59059-917-9

ISBN-13 (electronic): 978-1-4302-0498-5

Printed and bound in the United States of America 9 8 7 6 5 4 3 2 1

Lead Editor: Jonathan Gennick
Developmental Editor: Curtis Gautschi
Technical Reviewers: Alberto Dell'Era, Francesco Renne, Jože Senegacnik, Urs Meier
Editorial Board: Clay Andres, Steve Anglin, Ewan Buckingham, Tony Campbell, Gary Cornell, Jonathan Gennick, Matthew Moodie, Joseph Ottinger, Jeffrey Pepper, Frank Pohlmann, Ben Renow-Clarke, Dominic Shakeshaft, Matt Wade, Tom Welsh
Project Manager: Sofia Marchant
Copy Editor: Kim Wimpsett
Associate Production Director: Kari Brooks-Copony
Production Editor: Laura Esterman
Compositor: Susan Glinert Stevens
Proofreader: Lisa Hamilton
Indexer: Brenda Miller
Artist: April Milne
Cover Designer: Kurt Krames
Manufacturing Director: Tom Debolski

Distributed to the book trade worldwide by Springer-Verlag New York, Inc., 233 Spring Street, 6th Floor, New York, NY 10013. Phone 1-800-SPRINGER, fax 201-348-4505, e-mail `orders-ny@springer-sbm.com`, or visit `http://www.springeronline.com`.

For information on translations, please contact Apress directly at 2855 Telegraph Avenue, Suite 600, Berkeley, CA 94705. Phone 510-549-5930, fax 510-549-5939, e-mail `info@apress.com`, or visit `http://www.apress.com`.

Apress and friends of ED books 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 Special Bulk Sales–eBook Licensing web page at `http://www.apress.com/info/bulksales`.

A dédichi chésto libro a
chí, che a rasón, i ga l'éva
sü con mí perché a gó metú
tròpp témp par scrival . . .

a Michelle, Sofia, e Elia.

Contents at a Glance

PART 5 Appendixes

Contents

PART 2 Identification

PART 3 Query Optimizer

PART 4 Optimization

Forewords

I think the best thing that has happened to Oracle performance in the past ten years is the radical improvement in the quality of the information you can buy now at the bookstore.

In the old days, the books you bought about Oracle performance all looked pretty much the same. They insinuated that your Oracle system inevitably suffered from too much I/O (which is, in fact, *not* inevitable) or not enough memory (which they claimed was the same thing as too much I/O, which also isn't true). They'd show you loads and loads of SQL scripts that you might run, and they'd tell you to tune your SQL. And that, they said, would fix everything.

It was an age of darkness.

Chris's book is a member of the family tree that has brought to usus . . . light. The difference between the darkness and the light boils down to one simple concept. It's a concept that your mathematics teachers made you execute from the time when you were about ten years old: *show your work*.

I don't mean show-and-tell, where someone claims he has improved performance at hundreds of customer sites by hundreds of percentage points so therefore he's an expert. I mean *show your work*, which means documenting a relevant baseline measurement, conducting a controlled experiment, documenting a second relevant measurement, and then showing your results openly and transparently so that your reader can follow along and even reproduce your test if he wants.

That's a big deal. When authors started doing that, Oracle audiences started getting a lot smarter. Since the year 2000, there has been a dramatic increase in the number of people in the Oracle community who ask intelligent questions and demand intelligent answers about performance. And there's been an acceleration in the drowning-out of some really bad ideas that lots of people used to believe.

In this book, Chris follows the pattern that works. He tells you useful things. But he doesn't stop there. He shows you *how he knows*, which is to say he shows you how *you can find out for yourself*. He shows his work.

That brings you two big benefits. First, showing his work helps you understand more deeply what he's showing you, which makes his lessons easier for you to remember and apply. Second, by understanding his examples, you can understand not just the things that Chris is showing you, but you'll also be able to answer additional good questions that Chris hasn't covered . . . like what will happen in the next release of Oracle after this book has gone to print.

This book, for me, is both a technical *and* a "persuasional" reference. It contains tremendous amounts of fully documented homework that I can reuse. It also contains eloquent new arguments on several points about which I share Chris's views and his passion. The arguments that Chris uses in this book will help me convince more people to do the Right Things.

Chris is a smart, energetic guy who stands on the shoulders of Dave Ensor, Lex de Haan, Anjo Kolk, Steve Adams, Jonathan Lewis, Tom Kyte, and a handful of other people I regard as heroes for bringing rigor to our field. Now we have Chris's shoulders to stand on as well.

Cary Millsap

Cary Millsap is chief executive of Method R Corporation, a software performance company. He wrote *Optimizing Oracle Performance* with Jeff Holt in 2003, which earned Cary and Jeff the *Oracle Magazine* 2004 Author of the Year award. You can find Cary at `http://method-r.com` or `http://carymillsap.blogspot.com`.

I started using the Oracle RDBMS a little more than 20 years ago, and it took about three years for me to discover that troubleshooting and tuning had acquired a reputation verging on the mystical.

One of the developers had passed a query to the DBA group because it wasn't performing well. I checked the execution plan, checked the data patterns, and pointed out that most of the work could be eliminated by adding an index to one of the tables. The developer's response was "But it doesn't need an index; it's a small table." (This was in the days of 6.0.36, by the way, when the definition of a "short" table was "no more than four blocks long.") So I created the index anyway, and the query ran about 30 times faster—and then I had a lot of explaining to do.

Troubleshooting does not depend on magic, mystique, or myth; it depends on understanding, observation, and interpretation. As Richard Feynmann once said, "It doesn't matter how beautiful your theory is; it doesn't matter how smart you are. If your theory doesn't agree with experiment, it's wrong." There are many "theories" of Oracle performance that are wrong and should have been deleted from the collective memory many years ago—and Christian Antognini is one of the people helping to wipe them out.

In this book, Christian Antognini sets out to describe how things really work, what type of symptoms you should be watching out for, and what those symptoms mean. Above all, he encourages you to be methodical and stick to the relevant details in your observation and analysis. Armed with this advice, you should be able to recognize the real issues when performance problems appear and deal with them in the most appropriate way.

Although this is a book that should probably be read carefully from cover to cover, I think different readers will benefit from it in different ways. Some may pick out the occasional special insight whilst browsing, as I did in Chapter 4 with the explanation of height-balanced histograms—after years of trying to find an intuitively clear reason for the name, Christian's description suddenly made it blatantly obvious.

Some readers may find short descriptions of features that help them understand why Oracle has implemented that feature and allow them to extrapolate from the examples to situations that are relevant in their applications. The description of "secure view merging" in Chapter 5 was one such description for me.

Other readers may find that they have a section of the book that they read time and again because it covers so many details of some particularly important, and relevant, feature that they are using. I'm sure that the extensive discussion of partitioning in Chapter 9 is something that many people will return to again and again.

There's a lot in this book—and it's all worth reading. Thank you, Christian.

Jonathan Lewis

Jonathan Lewis is the author of *Cost-Based Oracle: Fundamentals*, also published by Apress. You can find further examples of his work at `http://jonathanlewis.wordpress.com`.

About the Author

Since 1995, **CHRISTIAN ANTOGNINI** has focused on understanding how the Oracle database engine works. His main interests include logical and physical database design, the integration of databases with Java applications, the query optimizer, and basically everything else related to application performance management and optimization. He is currently working as a principal consultant and trainer at Trivadis (`http://www.trivadis.com`) in Zürich, Switzerland.

If Christian is not helping one of his customers get the most out of Oracle, he is somewhere lecturing on application performance management or new Oracle Database features for developers. In addition to classes and seminars organized by Trivadis, he regularly presents at conferences and user-group meetings. He is a proud member of the Trivadis Performance Team and of the OakTable Network (`http://www.oaktable.net`).

Christian lives in Ticino, Switzerland, with his wife, Michelle, and their two children, Sofia and Elia. He spends a great deal of his spare time with his wonderful family and, whenever possible, reading books, enjoying a good movie, riding one of his BMX bikes, or gliding down the Swiss alps on a snowboard.

About the Technical Reviewers

ALBERTO DELL'ERA has spent his entire professional life working in the Italian telecommunications sector since 1996, specializing in Oracle full-time since 1999. He currently works for Etnoteam S.p.A. (a Value Team S.p.A. company, a consultancy of 2600+ employees), where he is mainly responsible for all Oracle-related developments for the flagship customer web portal of one of the largest Italian mobile operators. He is a member of the OakTable Network (`http://www.oaktable.net`), the well-known organization of Oracle professionals, distinguished by its use of the scientific method (and ethics of the scientific community) for all its activities. He holds a degree in electronics engineering and can be contacted at `alberto.dellera@gmail.com`.

FRANCESCO RENNE was born in 1962 in Como, Italy. He studied computer sciences at the University of Milan, and after graduating, he joined Olivetti, working on the development of the Unix operating system. Francesco has been interested in performance since the beginning of his professional career and has worked on Unix internals and Oracle environments in order to achieve the best possible performance in different environments (new products, benchmarks, international real applications on production, and so on).

In 1994, he joined the Banca Popolare di Bergamo, the only bank in Italy that has rewritten its entire information system using Unix and Oracle. He has made major contributions to improve performance over the whole platform.

In 1999, he co-founded ICTeam and is now the company's CEO. He continues to work on performance, especially on Oracle data warehouse environments, for some of the largest companies in Italy.

Francesco lives near Bergamo, Italy, with his wife, Adria, and their two daughters, Viola and Veronica. When not striving to improve something, he enjoys staying with his family, listening to progressive music, and taking pictures.

JOŽE SENEGACNIK has 20 years experience in working with Oracle products. In 1988, he started working with Oracle version 4. Since 1992, he has been self-employed as a private researcher in the field of computer science. Most of his work time is dedicated to solving performance bottlenecks in different application solutions based on the Oracle Database. He is also an international speaker giving talks on the most important Oracle Database–related events worldwide. He conducts well-known performance tuning courses together with Oracle University.

URS MEIER works as an IT consultant and is cofounder of Trivadis, a European IT solution company. He has used Oracle over the past 20 years. During this time, query optimization became one of his favorite topics, since good SQL tuning was often mission-critical for his customers. IT architecture, application design, and agile design principles are his other main interests.

During his professional career, he has worked with many other database systems, but he still likes Oracle because of its cutting-edge technology.

Acknowledgments

Many people assisted me in writing the book you now have in your hands. I'm extremely grateful to all of them. Without their assistance, this piece of work wouldn't have seen the light of the day. While sharing with you the brief history of TOP (*Troubleshooting Oracle Performance*), let me thank the people who made it all possible.

Even though I didn't realize it at the time, this story began on July 16, 2004, the day of the kickoff meeting I had organized for a new seminar, Oracle Optimization Solutions, which I had planned to write with some colleagues of mine at Trivadis. During the meeting, we discussed the objectives and the structure of the seminar. Many of the ideas developed that day and while writing the seminar in the following months have been reused in this book. Big thanks to Arturo Guadagnin, Dominique Duay, and Peter Welker for their collaboration back then. Together, we wrote what, I'm convinced to this day, was an excellent seminar. In addition to them, I also have to thank Guido Schmutz. He participated in the kickoff meeting only but strongly influenced the way we approached the subjects covered in the seminar.

Two years later, in the spring of 2006, I started thinking seriously about writing this book. I decided to contact Jonathan Gennick at Apress to ask for his opinion about what I had in mind. From the beginning, he was interested in my proposal, and as a result, a few months later I decided to write the book for Apress. Thank you, Jonathan, for supporting me from the very beginning. In addition, thanks to all the people at Apress who worked on the book. I only had the pleasure of working with Sofia Marchant, Kim Wimpsett, and Laura Esterman, but I know that several others contributed to it as well.

Having an idea and a publisher are not enough to write a book. You also need time, a lot of time. Fortunately, the company I work for, Trivadis, was able to support me and the project in this way. Special thanks to Urban Lankes and Valentin De Martin.

In order to write a book, it is also essential to be surrounded by people who carefully check what you are writing. Great thanks go to the technical reviewers: Alberto Dell'Era, Francesco Renne, Jože Senegacnik, and Urs Meier. They helped me considerably in improving the quality of the book. Any remaining errors are, of course, my own responsibility. In addition to the technical reviewers, I would also like to thank Daniel Rey, Peter Welker, Philipp von dem Bussche-Hünnefeld, and Rainer Hartwig for reading part of the book and providing me with their comments on and impressions of the text.

Another person who played a central role is Curtis Gautschi. For many years, he has proofread and enhanced my poor English. Thank you so much, Curtis, for assisting me for so many years now. I know, I should really try to improve my English skills someday. Unfortunately, I find it much more interesting (and easier) to improve the performance of Oracle-based applications than foreign languages.

Special thanks also go to Cary Millsap and Jonathan Lewis for writing the forewords. I know that you spent a considerable amount of your valuable time writing them. I'm very much indebted to you both for that.

Another special thank goes to Grady Booch for giving me the permission to reproduce the cartoon in Chapter 1.

Finally, I would like to thank all the companies for which I have had the privilege to consult over the years, all those who have attended my classes and seminars and asked so many good questions, and all the Trivadis consultants for sharing their knowledge. I have learned so much from all of you.

Introduction

The Oracle database engine has become a huge piece of software. This not only means that a single human can no longer be proficient in using all the features provided in recent versions, but it also means that some of them will rarely be used. Actually, in most situations, it is enough to know and take advantage of a limited number of core features in order to use the Oracle database engine efficiently and successfully. This is precisely why in this book I will cover only the features that, based on my experience, are necessary to troubleshoot most of the database-related performance problems you will encounter.

Structure of This Book

This book is divided into five parts:

Part 1 covers some basics that are required to read the rest of the book. Chapter 1, "Performance Problems," explains not only why it is essential to approach performance problems at the right moment and in a methodological way but also why understanding business needs and problems is essential. Chapter 2, "Key Concepts," describes the operations carried out by the database engine when parsing and executing SQL statements. It also introduces some terms that are frequently used in the book.

Part 2 explains how to approach performance problems in an environment that is based on the Oracle database engine. Chapter 3, "Identifying Performance Problems," provides a detailed analysis road map for identifying performance problems. Several tools and techniques that can be used with it are also described.

Part 3 describes the component that is responsible for turning SQL statements into execution plans: the query optimizer. Chapter 4, "System and Object Statistics," describes what system statistics and object statistics are, how to gather them, and why they are important for the query optimizer. Chapter 5, "Configuring the Query Optimizer," covers a configuration road map that you can use to find a good configuration for the query optimizer. Chapter 6, "Execution Plans," describes in detail how to obtain, interpret, and judge the efficiency of execution plans. Chapter 7, "SQL Tuning Techniques," discusses the SQL tuning techniques that are available with the Oracle database engine.

Part 4 shows which features are provided by the Oracle database engine to execute SQL statements efficiently. Chapter 8, "Parsing," describes how SQL statements are parsed and how to identify, solve, and work around parsing problems. Chapter 9, "Optimizing Data Access," describes the methods available to access data and how to choose between them. Chapter 10, "Optimizing Joins," discusses how to join several sets of data together efficiently. Chapter 11, "Beyond Data Access and Join Optimization," describes advanced optimization techniques such as parallel processing and materialized views. Chapter 12, "Optimizing the Physical Design," explains why it is important to optimize the physical design of a database.

Part 5 provides a list of the files used through the book as examples. In addition, a bibliography, containing the sources I used while writing the book, is also provided.

Intended Audience

This book is intended for performance analysts, application developers, and database administrators who are involved in troubleshooting performance problems of applications based on the Oracle database engine.

No specific knowledge in optimization is required. However, readers are expected to have a working knowledge of the Oracle database engine and to be proficient with SQL. Some sections of the book cover features that are specific to programming languages such as PL/SQL, Java, C#, and C. These features are covered only to provide a wide range of application developers with specific information about the programming language they are using. You can pick out the ones you are using or interested in and skip the others.

Which Versions Are Covered?

The most important concepts covered in this book are independent of the Oracle database engine version you are using. It is inevitable, however, that when details about the implementation or provided features are discussed, that some information is version specific. This book explicitly discusses the versions currently available from Oracle9*i* Release 2 to Oracle Database 11*g* Release 1. They are as follows:

- Oracle9*i* Release 2, up to version 9.2.0.8
- Oracle Database 10*g* Release 1, up to version 10.1.0.5
- Oracle Database 10*g* Release 2, up to version 10.2.0.4
- Oracle Database 11*g* Release 1, version 11.1.0.6

If the text doesn't explicitly mention that a feature is available for a specific version only, this means that it is available for all these versions.

Online Resources

You can download the files used through the book as examples at `http://top.antognini.ch`. At the same URL, you will also find addenda and errata as soon as they are available. You can also send any type of feedback or questions about the book to `top@antognini.ch`.

About the OakTable Network

In and by itself, the OakTable network is just a bunch of people who like to talk to and be in contact with like-minded people—that is, people with a scientific approach (and inquiring mind) regarding Oracle's database technology.

It all started sometime in 1998 when a group of Oracle experts, including Anjo Kolk, Cary Millsap, James Morle, and a few others, started meeting once or twice a year, on various pretexts. Each would bring a bottle of Scotch or Bourbon and in return earn the right to sleep on the floor somewhere in my house.

We spent most of our time sitting around my dining table, with computers, cabling, paper, and other stuff all over the place, discussing Oracle, relaying anecdotes, and experimenting with new and better ways of working with the database. By the spring of 2002, the whole thing had grown. One evening, I realized that I had 16 world-renowned Oracle scientists sitting around my dining table. We were sleeping three or four to a room and even had to borrow the neighbor's shower in the mornings. Anjo Kolk suggested we call ourselves the "OakTable network" (after my dining table), and about two minutes later, `http://www.OakTable.net` was registered.

James Morle now maintains the website along with his wife Elain, and although it doesn't get updated with new content perhaps as often as it should, it is useful at least for providing the links, names, and such. We also use it for the Challenge questions and answers.

The Challenge is something we occasionally run during conferences. Ask us anything (technical) about Oracle, and if we can't find the answer (whether it be yes, no, or a solution) within 24 hours, the person who asked the question gets a T-shirt stating that he or she beat the OakTable.

The Challenge, though, is not used as much as we'd like, probably because it looks as if we want to be challenged with questions to which we cannot find answers. The opposite is actually true—the purpose is to answer questions from anybody, regardless of how "simple" or "easy" they might seem.

The Members

I recently read the book *Operation Certain Death*, about an operation in Sierre Leone by the British Special Forces. I want to make perfectly clear that in no way can the physical abilities of the OakTable members be compared to those of the Special Forces. In fact, not at all.

But somewhere in the book the author makes the observation that the Special Forces soldiers are all totally convinced of the maxim that anything can be done with two elastic bands and a piece of rope, if you think long and hard enough about it. In other words, never, ever, give up.

That struck me as something I also have observed with the OakTable members: they all believe that there's always one more option, always one more way of looking at things. It might take a chat with another member, maybe even a Chinese parliament, but the idea of giving up on a problem really is not acceptable, unless you're ordered to.

So, imagine bringing a bunch of people with that attitude (and a tremendous respect for each other) together for even just a few days. It's never boring, and you very rarely see them waiting on an idle wait event, as we put it.

Imagine standing on the cold, gray cement in the exhibition hall at OracleWorld in Copenhagen, realizing that we hadn't paid for carpeting or anything, just 6-by-6 meters of cement floor. Well, it turned out the Intel guys had spare super-quality AstroTurf carpet but needed beer. It was Gary Goodman who brokered that deal within half an hour.

Then Johannes Djernes saw the BMC guys bringing all their advanced exhibition stuff in, placed in two crates that each measured 2.5-by-1-by-1 meters. Two cases of beers later we had borrowed the empty crates. Then Johannes went out and bought various bits and pieces, and within a few hours we had the tallest tower (5 meters high) in the whole exhibition area. It was possibly also the ugliest, but people noticed it.

During the same event, James Morle fought like a lion to establish the World's Biggest Laptop RAC Cluster, using a NetApp filer, a Linux boot CD, and the laptops of anybody who happened to pass by. It was a huge success, but without the "never give up" attitude of James and of others like Michael Möller and Morten Egan, it would never have happened.

A committee, consisting of James Morle, Cary Millsap, Anjo Kolk, Steve Adams, Jonathan Lewis, and myself, review suggestions for new OakTable members. The number of members now exceeds 70, and I have no doubt we will continue to add members with the inquiring, scientific, "never give up" attitude that is the hallmark of this extraordinary group of humans.

The Politics

How often have you heard the phrase "Oracle says that . . ." or "Oracle Support promised . . ."? Well, most of the time it isn't Oracle as a corporation that "says" something but an individual who has an opinion or an idea. I know, because I spent ten years working for Oracle Support, and it is indeed a strange feeling to hear one's own words later repeated as the words of Oracle Corporation (or at least of Oracle Denmark).

It is the same with the OakTable. We don't act as a single body but as individuals. Some (technical) views might be shared, but that's just lucky coincidence. There are no guidelines regarding the individual member's conduct or attitude, except that ideas should be shared and guessing should be eliminated by constantly testing and pushing boundaries.

Sharing ideas openly between peers and striving for scientific methods is what the OakTable network is all about. On those aims there can and will be no compromise.

The Books

One day in Kenilworth, United Kingdom, during an Oracle SIG meeting, James Morle came up with the idea of the BAARF Party (Battle Against Any RAID Five/Four/and err . . . Free) while having a Larson cognac. That same evening we had dinner with Tony Davis from Apress, and that's when James came up with this idea of a press label called OakTable Press. Tony thought that was a splendid idea, and a few days later it was a reality.

The idea was to let OakTable members either write books or at least review books before they were published under this label. At least two OakTable members must review and OK a book before it can be published.

Along with the book you have in your hands now, the current catalog consists of the following:

Expert Oracle JDBC Programming: Oracle and Java expert R.M. Menon shows how to build scalable and highly performing Java applications that access Oracle through JDBC. Rather than take a database-agnostic approach, Menon shows you how to write JDBC code specific to Oracle, and to write it well, ensuring that you can take advantage of all the richness that the Oracle Database platform has to offer.

Mastering Oracle PL/SQL: Practical Solutions: Connor McDonald et al. show you how to write PL/SQL code that will run quickly and won't break in high load, multiuser environments.

Oracle Insights: Tales of the Oak Table: A bunch of OakTable members (including me) present a series of stories about our experiences (good and bad) using the Oracle software: where it's been, where it's going, how (and how not) to use it successfully, and some frightening tales of what can happen when fundamental design principals are ignored.

Peoplesoft for the Oracle DBA: David Kurtz provides a "survival guide" for any Oracle DBA charged with maintaining a PeopleSoft application. The book shows you how to effectively implement common Oracle database administration techniques using the PeopleSoft toolset, how to analyze application activity, and how to obtain the critical data that will allow you to track down the causes of poor performance.

We hope that every book published by OakTable Press will be imbued by the qualities that we admire: they will be scientific, rigorous, accurate, innovative, and fun to read. Ultimately, we hope that each book is as useful a tool as it can possibly be in helping make your life easier.

Mogens Nørgaard
managing director of Miracle A/S
(`http://www.miracleas.dk`)
and cofounder of the OakTable network