THE EXPERT'S VOICE® IN ORACLE

Forecasting Oracle Performance

Use the methods in this book to ensure that your Oracle server can satisfy performance requirements now and into the future.

Craig Shallahamer



Forecasting Oracle Performance



Craig Shallahamer

Apress[®]

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Sometimes the wind blows the majestic across my face. And when I open my eyes, I see wonders of truth, of depth, and mysteries unveiled.

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About the Author



CRAIG SHALLAHAMER has more than 18 years of experience working in Oracle, empowering others to maximize their Oracle investment, efficiencies, and performance. In addition to being a consultant, researcher, writer, and keynote speaker at Oracle conferences, he is the designer and developer of OraPub's Advanced Reactive Performance Management and Forecasting Oracle Performance classes. He is also the architect of Hori-Zone, OraPub's service-level management product.

Prior to founding OraPub in 1998, Craig served for nine years at Oracle Corporation as one of the company's leading system performance experts.

At Oracle, he cofounded a number of leading performance groups, including the Core Technologies Group and the System Performance Group. His love for teaching has allowed him to personally train thousands of DBAs in fifteen countries on five continents.

When not maximizing efficiency, Craig is fly fishing, praying, backpacking, playing guitar, or just relaxing around a fire.

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JARED STILL is a senior DBA at RadiSys Corporation, with several years of experience as both a production and development Oracle DBA. He has successfully used Craig Shallahamer's performance forecasting methods on past projects, and has keenly anticipated the publication of this book. While Jared enjoys exploring the world of databases and the process of turning data into information, he sometimes takes time to pursue other endeavors that get him away from the computer monitor, such as auto racing.

Introduction

Contained in this book are, dare I say, secrets—really. There is a mystery surrounding topics like forecasting, performance management, capacity planning, performance modeling, performance prediction, and managing service levels. Add into the mix a dynamic Oracle system, and you have realities that bring professional capacity planners to their knees. In the pages of this book are the secrets I've uncovered and discovered through more than 20 years of working with literally thousands of IT professionals around the world. My goal is to expose these secrets as plainly and completely as I possibly can.

One of these secrets is unraveling the relationship between service-level management and forecasting Oracle performance. The difficulty lies in the breadth and depth of each of these topics. They are both massive and fork off in a variety of directions. If you are able to bring the two together, you will be able to architect, build, use, and explain to others how they can better manage the delivery of IT services. I will, as clearly as I can throughout this book, present both these areas of IT and then weave them together. The result will leave you with a confident understanding so you can deal with the realities of IT.

At some level, every IT professional (DBA, IT manager, capacity planner, system integrator, and developer) must understand forecasting concepts. Have you ever talked with someone about weather forecasting who does not understand barometric pressure? Just last week, I was talking with a prospective customer (a technical manager) and he asked, "How can you know when performance is going to get bad?" He had no understanding of basic queuing theory, modeling, or the capabilities and limitations of performance forecasting. Before I could answer his question, I had to step way, way back and quickly teach him about fundamental performance management. What compounds my frustration with conversations like these is that someone in his position (technical management) should have a solid understanding of performance management. Reading this book will prevent you from being on the "no understanding" side of that conversation.

Performance forecasting is just plain fun. Seeing into the future is amazing and touches on something very deep in each one of us. Whether forecasting the weather, a company's performance, our work, or response time, we just can't stop trying to predict what is going to happen. So don't fight it. Learn how to forecast performance in a way that adds value to your company and to your career.

Why Buy This Book?

Every capacity planning book I have read leaves me with an uncomfortable feeling. They do not leave me prepared, equipped, and trained to deal with reality. I feel like the authors are in love with mathematics,¹ want to convince me that they are a genius, have to publish a book to keep their professorship, live in a laboratory with little or no responsibilities dealing with Oracle, do not have even a basic understanding of Oracle architecture, certainly do not have to deal with the realities of a complex Oracle environment, and truly believe that management is pleased with statements like, "Our models indicate average CPU utilization will hit 75% in about three months." If you have felt the same way, then buy this book now! My goal is to teach you about real-world Oracle performance forecasting—period. There is no hidden agenda.

Oracle systems are dynamic and contain a wide variety of transactions types. This makes Oracle forecasting notoriously difficult. In fact, if you read books or listen to people speaking about forecasting, it doesn't take long to figure out that Oracle makes their life very difficult. In the past, transactions were clearly defined and forecasting statistics were a part of the operating system. Traditional capacity planners never had it so good. There was little or no caching, delayed block cleanouts, or simultaneous writing of multiple transactions to disk. The idea of writing uncommitted data to disk would send shivers up spines. While times have changed, performance must still be forecasted.

This book is obviously Oracle-focused. I will teach you how to flourish with the complexities of forecasting performance in a dynamic and highly complex Oracle environment. But be warned, this book is not about laboratory or academic forecasting. The solutions to real problems are sometimes kind of gritty and may seem like you're compromising academic purity. If you want to responsibly deal with reality, then this book is for you.

What makes seasoned IT professionals run for cover? Forecasting Oracle performance! While this is a complex topic, it can be very satisfying, very practical, and very valuable to both you and your company. As you read this book, I hope you discover a newfound enthusiasm while forecasting Oracle performance.

What Is the Value to Me?

Within 60 minutes, you will be able to forecast performance and identify risk on you production Oracle database server. I kid you not. Just jump to Chapter 3 and scan the chapter, and you'll be ready to go! Obviously, there is more—a lot more. But value does not suddenly appear after spending hours reading, studying, and practicing. This book is structured so you get value fast, and then get increased value as you study the material.

Forecasting Oracle performance can be incredibly complex. The topics covered in this book and how they are presented are completely focused on making this complex topic as simple as possible to understand and apply. It's all about making the complex simple.

^{1.} Latin *mathematica* was a plural noun, which is why mathematics has an "s" at the end, even though we use it as a singular noun. Latin had taken the word from Greek *mathematikos*, which in turn was based on *mathesis*. That word, which was also borrowed into English but is now archaic, meant "mental discipline" or "learning," especially mathematical learning. The Indo-European root is *mendh*, "to learn." Plato believed no one could be considered educated without learning mathematics. A *polymath* is a person who has learned many things, not just mathematics.

This book will lead you and teach you. While my company does sell Oracle-oriented servicelevel management products, they are not the focus of this book. That gives me tremendous freedom to focus on you, the reader. By focusing on you, I can provide the information you need. There is no need for mathematical derivations and ruminations. What you need is fieldtested, Oracle-focused, and practical. And that's exactly what you'll get.

This book is a kind of training course. After reading, studying, and practicing the material covered in this book, you will be able to confidently, responsibly, and professionally forecast performance and system capacity in a wide variety of real-life situations. You will learn how to use a variety of forecasting models, which will enable you to methodically:

- Help manage service levels from a business value perspective.
- · Identify the risk of overutilized resources.
- Predict which component of the architecture is at risk.
- Predict when the system will be at risk.
- Develop multiple risk mitigation strategies to ensure service levels are maintained.

If you are more management-minded (or want to be), you will be delighted with the material about service-level management. Forecasting performance is just one aspect of service-level management. Separating the two is absolutely absurd. The reason we forecast is to help manage service levels. Understanding service-level management helps you understand how forecasting-related work can provide company value.

This book is about equipping. Without a doubt, you will be equipped to deal with the realities of forecasting Oracle performance. But this book gives you more. Not only will you receive a technical and mathematical perspective, but also a communication, a presentation, and a management perspective. This is career-building stuff and immensely satisfying!

Who Will Benefit?

So many people from a variety of backgrounds need to know about this information, it's difficult to pinpoint just who will benefit. But when pressed for a list of those who will most likely benefit, I would have to say DBAs, IT managers, capacity planners, systems integrators, and developers.

If you're a DBA, you know what it's like to be asked on Friday at 4:30 p.m., "On Monday, we're adding those employees from that acquisition to our system. That's not going to be a problem, is it?" This book will allow you confidently and responsibly answer this question and many like it.

If you're an IT manager who absolutely must manage service levels, you know how difficult it is to determine if significant risk exists, what the risk is, when the risk will occur, and what can be done to mitigate the risk. This book will provide you and your employees with the knowledge, the methods, and the skills to effectively manage risk. What you'll receive is a group of excited employees who will build a service-level management system.

If you're a full-time capacity planner, you know that database optimization features are great for Oracle users, but they're also your worst nightmare. Characterizing even the simplest Oracle workload can be daunting and leave you with an uncomfortable feeling in your gut. This book will teach you just enough about Oracle internals and how to pull from Oracle what you need to develop responsible forecast models. If you're a systems integrator, you need to work with the DBA, IT manager, capacity planner, and developer. You need to help them understand how their systems work together, how to manage performance, and how to optimize performance while minimizing risk and downtime. You are their service-level counselor. This book will give you the hands-on practical insight that truly provides value to your customers.

Most people don't think that developers care about forecasting performance, not to mention performance optimization. But I think the problem is more of a result of management's focus and the pressure managers apply. Developers want to write good code. And good code means code that delivers service amazingly well. But when management heaps on specifications, the release schedule tightens, and only data from emp, dept, and bonus tables is available, service levels will undoubtedly be breached. Deep down, everyone knows this. If you are a developer, the information contained in this book will allow you to better communicate with your management and give you a new perspective into the world of IT. I promise you, your management will take notice.

How This Book Is Organized

I think you get the idea that I want to teach and equip. This book is structured to this end. We'll start at a high level, focusing on service-level management and the essentials for forecasting, and then work our way deeper into using specific forecasting models.

Here is a quick summary of each chapter:

Chapter 1, "Introduction to Performance Forecasting," sets the stage for the entire book. We will focus on the nontechnical areas of forecasting, such as service-level management, risk, and the broad model types. You'll find out why forecasting Oracle performance haunts the seasoned capacity planner. In this chapter, you'll learn what your company needs from forecasting and where the value resides. If you want to be a techno-forecasting-freak, then you might want to skip this chapter. But if you want to truly add value to your company and enhance your career, this chapter will be invaluable.

Chapter 2, "Essential Performance Forecasting," focuses on the key concepts, how they fit together, how they are modeled, and how this works in an Oracle environment. This chapter is the transition from thinking *management* to thinking *technical*. It begins linking Oracle into traditional forecasting techniques.

Chapter 3, "Increasing Forecast Precision," takes the essentials and brings into the mix some of the complexities of forecasting. Fortunately, there are ways to address these complexities. This chapter is important because, many times, a low-precision forecast will not meet your requirements. I'll present ways to increase forecast precision by selecting the appropriate forecast model, choosing the right workload activity, and calculating the deceptively simple term *average*. Along the way, you'll learn some additional technical tidbits.

Chapter 4, "Basic Forecasting Statistics," will protect you and free you. After reading this chapter, you will never casually say, "It will take 3 seconds." You will be able to communicate both the specifics and the meaning of statements like these, without your head coming to a point.

Chapter 5, "Practical Queuing Theory," covers one very important component of forecasting. Because performance is not linear, you must have a good, basic grasp of queuing theory. If you have been bored to death, felt overwhelmed, or just don't see what all the fuss is about, I think you'll appreciate this chapter. Leaving math derivations behind, we focus on the meaning and how to use queuing theory.

Chapter 6, "Methodically Forecasting Performance," is important for successful and consistent forecasting. I present a six-step process that will embrace the natural scientific nature of forecasting, validate the precision of your forecast models, and allow you to explain to others how you structure your work—all without suffocating your creativeness.

Chapter 7, "Characterizing the Workload," is about transforming raw workload data into something we can understand, is useful to us, and is also appropriate for forecast model input. Oracle workloads are notoriously complicated. As a result, the task of grouping—that is, characterizing the workload—can be very difficult. The trick is to create a workload model that embraces the application, Oracle, and the operating system, while respecting their uniqueness, and considers their interaction. When done well, it allows for amazing forecasting flexibility and precision. In this chapter, I will lead you through the process of characterizing a complex Oracle workload.

Chapter 8, "Ratio Modeling," allows you to perform very quick low-precision forecasts. Ratio modeling is absolutely brilliant for architectural discussions, vendor recommendation sanity checks, and sizing of packaged applications. For the laboratory scientist, ratio modeling can be uncomfortable, but for the hands-on Oracle forecasting practitioner, it's beautiful.

Chapter 9, "Linear Regression Modeling," is one of my favorite forecasting techniques. Modeling systems using regression analysis is easy to do and can be automated without much effort. It is statistically sound and incredibly precise. However, this technique can be easily misused, leading to disastrous results. To mitigate this risk, I'll present a rigorous method to ensure regression analysis is being used appropriately.

Chapter 10, "Scalability" is one of those things we wish we didn't have to deal with. Most forecasting modeling techniques do not internally address scalability issues. This means we must do some additional work to ensure a robust forecast. In this chapter, I will present four proven scalability techniques, how to pick the best scalability model for your situation, and how to integrate scalability limitations in your forecasting.

What Notations Are Used?

Table 1 shows the notation used in this book for numbers. Decimal, scientific, and floatingpoint notation are all used where appropriate.

Decimal	Scientific	Floating Point
1,000,000	$1.0 imes10^6$	1.000E + 06
0.000001	$1.0 imes10^{-6}$	1.000E - 06

 Table 1. Numeric Notations Used in This Book

Units of time are abbreviated as shown in Table 2.

Abbreviation	Unit	Scientific Notation
hr	Hour	3600 s
min	Minute	60 s
sec	Second	1.0 s
ms	Millisecond	$1.0 imes 10^{-3} s$
μs	Microsecond	$1.0 imes 10^{-6} s$
ns	Nanosecond	$1.0 imes10^{-9}\mathrm{s}$

 Table 2. Abbreviations for Units of Time

The units of digital (binary) capacity are as shown in Table 3. The corresponding units of throughput are, for example, KB/s, MB/s, GB/s, and TB/s.

Symbol	Unit	Decimal Equivalent	Power of 2 Equivalent
В	Byte	8 bits	2 ³ bits
KB	Kilobyte	1,024 bytes	2 ¹⁰ bits
MB	Megabyte	1,048,576 bytes	2 ²⁰ bytes
GB	Gigabyte	1,073,741,824 bytes	2 ³⁰ bytes
TB	Terabyte	1.0995116×10^{12} bytes	2 ⁴⁰ bytes

Table 3. Abbreviations for Units of Binary Capacity

Table 4 gives an alphabetized list of symbols used in this book. A word of caution: For most symbols, there is no formal standard. This makes relating formulas from one book to another sometimes very confusing. I have tried to keep the symbols straightforward, in line with the standard when there appears to be a standard, and consistent throughout the book.

Symbol	Represents	Example
trx	Transaction	10 trx
λ	Arrival rate	10 trx/s
S _t	Service time	l s/trx
Q _t	Queue time or wait time	0.120 se/trx
R _t	Response time	1.12 s/trx
Q	Queue length	0.24 trx
U	Utilization or percent busy	0.833 or 83.3%
М	Number of servers	12 CPUs or 450 IO devices
m	Number of servers per queue	12 CPUs, or 1 for IO subsystems

 Table 4. Mathematical Symbols Summary

What Is Not Covered?

The more work I do, the more respect I have for scope. There are many topics that are "out of scope," and therefore are not covered or are not covered in depth in this book.

Performance optimization (tuning) is not covered. This includes the many areas of Oracle performance optimization such as instance tuning, wait event analysis, latching, locking, concurrency, and so on. When these areas relate to modeling and scalability, they will be mentioned, but they certainly are not our focus. Oracle response time analysis (which includes a focused analysis of Oracle's *wait times*) relates to forecasting, but is a more reactive, performance management-focused topic. When I mention *response time* in this book, as you will quickly learn, I am not referring to *Oracle* response time analysis.

Some people would like nothing else than to get a nice hot cup of coffee, sit in a cozy chair next to a fire, and study mathematics. Even a phrase like "the mathematical treatments of probability and queuing theory" brings a level of deep satisfaction. This book is not written for these people. This book is about facing and conquering the brutal realities of managing service levels through Oracle forecasting. While mathematics is a significant part of this, mathematical derivations will only distract, defuse, and distance you from your objectives.

Operating system-level memory forecasting is not covered. Low-precision memory forecasts are very straightforward, and high-precision memory forecasts are so packed full of risk I don't go near them. Individual physical disk-level forecasting is not covered. The complexities of modern-day IO subsystems make drilling down to the physical disk with any degree of responsible precision nearly impossible. Fortunately for us, it is extremely unusual that forecasting performance of specific physical devices would be practical and worth anyone's time (in our area of work). However, we will cover how to model and forecast groups of physical disks (think of RAID arrays, volumes, filers, and so on) with a very satisfactory degree of precision.

While I will contrast the differences between benchmarks (stress tests of any kind) and mathematical modeling, benchmarks are not our focus. Keep in mind that when benchmarking, the workload must still be characterized. So if you are benchmark-focused, in addition to the foundational chapters, the chapter about workload characterization (Chapter 7) will be valuable.

This book focuses squarely on the Oracle database server. When mathematical references are made to response time, they specifically refer to the time from/to the Oracle database server machine to/from the Oracle client process. This book does not attempt for forecast true end-to-end response time—that is, from the database server to the end user's experience. However, all the topics presented in this book can be applied to the other computers in your computing environment, not just the Oracle database server. There will surely need to be some modifications, but you should not have any problems making those adjustments.