



Neil J. Gunther

# Analyzing Computer System Performance with Perl::PDQ

2nd Edition

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Neil J. Gunther  
Performance Dynamics Company  
4061 East Castro Valley Boulevard  
Castro Valley, CA 94552  
USA  
<http://www.perfdynamics.com/>

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This book is dedicated to the memory of my father  
Walter August Gunther, *MIEAust*, *CPEng*  
October 23, 1908 – November 16, 2010



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## Preface to Second Edition

### What's New?

It seems fitting that this new edition appears as we pass the centenary of the original paper by Erlang [1909], where he first introduced the concept of a queue. This edition incorporates a considerable number of new features compiled since the publication of the first edition in 2005.

### New Chapters and Partitioning

The amount of additional material means the book now comprises four parts instead of three. In particular, Part I contains new chapters that present a more complete discussion of the underlying concepts used throughout this book.

### Improved Perl Formatting

All listings have a highlighted format to aid readability of PDQ codes.

**Listing 1.** Example of the new PDQ code format

---

```
#!/usr/bin/perl

use pdq;

pdq::Init("Example");
pdq::CreateNode($nodeName, $pdq::CEN, $pdq::FCFS);
pdq::CreateOpen($workName, $arrivalRate);
pdq::SetDemand($nodeName, $workName, $serviceDemand);
pdq::Solve($pdq::CANON);
pdq::Report();
```

---

## Virtualization

A new Chapter 13: *Virtual Machine Analysis with PDQ*, in Part III, presents queueing models of *fair-share scheduling* that underpins all modern virtual machine implementations from hyperthreading to cloud computing.

## PDQ on SourceForge

All PDQ development is now gated through SourceForge [sourceforge.net/projects/pdq-qnm-pkg/](https://sourceforge.net/projects/pdq-qnm-pkg/) under the title *Pretty Damn Quick Queueing Model Package*. PDQ can also be downloaded from the author's distribution page at [www.perfdynamics.com/Tools/PDQcode.html](http://www.perfdynamics.com/Tools/PDQcode.html).

## Why Queues Rule

A new Chapter 1: *Why Queues Rule Performance Analysis*, endeavors to explain why queueing models are so powerful for doing computer performance analysis. See Example 1.2 which presents a PDQ performance and capacity model of servers that are dedicated to filtering email spam.

## PDQ Manual

Part IV comprises a set of appendices. Included there is the PDQ Manual which has been broken out from its previous inclusion in the chapter: *Pretty Damn Quick—A Slow Introduction*. Updates are available online at [www.perfdynamics.com/Tools/PDQman.html](http://www.perfdynamics.com/Tools/PDQman.html).

## CreateMultiNode Function

The latest release of the open source PDQ code now implements multi-server queueing nodes. See Appendix D.3.2 for details.

## Brief History of Buffers

The potted history of queueing theory entitled *A Brief History of Buffers*, that was previously isolated as a separate Appendix, has been updated and now appears at the end of the new Chapter 1.

## Performance Management Tools

The Appendix on performance management tools in the first edition has now been expanded in a new Chapter 2.

## Scalability and Queueing

A new Section 4.11.12 in Chapter 4 shows how the author's *universal scalability law* (developed in the book *Guerrilla Capacity Planning* [Gunther 2007b]) is related to the queueing models presented in this book, viz., the *machine repairman* model [Gunther 2008].

## Jackson's Theorem

Chapter 5 contains a new section explaining the importance of Jackson's theorem for circuits of queues. This concept is vital for constructing performance models of modern multi-tier applications, such as those employed at large-scale web sites.

## Glossary Removed

The Glossary in the first edition became outdated and has been removed in order to accommodate the new chapter content without unduly increasing the size of the entire book.

## Crowd-sourced Corrections

The corrigenda at [www.perfdynamics.com/iBook/ppdqerrata.html](http://www.perfdynamics.com/iBook/ppdqerrata.html) is a testament to the power of the internet for enabling many eyes to spot typos and errors. Every effort has been made to include all the listed errata in this edition.

## Acknowledgments

Phil Feller masterfully applied SWIG ([www.swig.org/](http://www.swig.org/)) to the PDQ function C library in order to programmatically convert it to Perl. Stefan Parvu championed the use of PDQ in the field and provided important feedback for Section 4.11.12. The performance group at VMware Inc., contributed to some very useful discussions that helped to shape Chap. 13.

Once again, I am indebted to the alumni of Performance Dynamics Company classes, and other diligent readers, who contributed errata for the first edition at [www.perfdynamics.com/iBook/ppdqerrata.html](http://www.perfdynamics.com/iBook/ppdqerrata.html). In alphabetical order they are: P. Altevogt, D. Anburaj, W. Baeck, T. Becker, E. Borasky L. Braswell, D. Hagler, E. Juan, S. Kannan, M. Marino, P. Puglia, J. Purinton, T. Sych, I. Tegebo, D. Walter, T. Wilson. In particular, P. Cañadilla did a truly outstanding job, as his record tally attests. If it there is such a thing as a *copy-editor gene*, I believe he has it.

Finally, I am grateful to Ralf Gerstner, my editor, for his patience while I searched for fragmented opportunities to update the manuscript during some difficult periods over the past two years.

Melbourne, Australia  
December, 2010

N.J.G.

```
perl -le `@q=("120\145\162\154", "\120\104\121");
$s="\115\141\171\040\171\157\165\162\040@q\040\bs\040\142\145";
$q[0]=`s/e/ea/;$q[0]=lcfirst($q[0]);@q=reverse(@q);$s.=" @q \bs!";print $s`
```