

Technical, Commercial and
Regulatory Challenges of

QoS

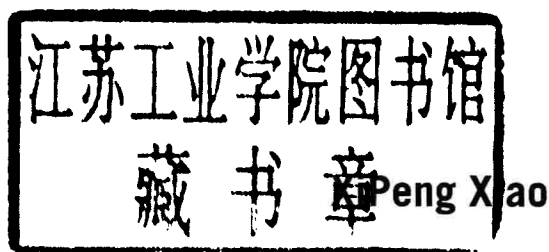
An Internet Service Model Perspective



XiPeng Xiao

Technical, Commercial and Regulatory Challenges of QoS

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List of Endorsements

The topic of QoS is all too often treated as a purely technical issue. In this refreshingly novel and comprehensive book, XiPeng Xiao draws on his own first-hand experience and that of other experts to put the technical issues in their correct commercial and regulatory context. This book is likely to make QoS much more understandable and relevant to a broad audience than it has been to date.

-Bruce Davie, Fellow, Cisco Systems

An admirable effort towards clarifying some of the key issues of Internet QoS.

-Daniel Awduche, Fellow, Verizon Business

I highly recommend this book filled with both technical and business insight.

-Zhiwei Yang, former CTO, China Netcom

Comprehensive and insightful discussion on QoS.

-Roger Wenner, IP Architecture, Technical Engineering Center, Deutsche Telekom

Finally, a QoS book that reflects network reality.

-Waqar Khan, Chief Architect, Qwest Communicating Inc.

It is really a wonderful piece of work. By providing many data network practical evidences, the author clearly explained the pros and cons in execution of net neutrality. This is the most comprehensive book that I have ever read on the net neutrality with a full taxonomy of implications related to users, OTT providers, ISPs and ASPs.

-Zhisheng Chen, Distinguished Member of Technical Staff, Sprint Nextel

The discussion on business model is helpful for the traditionally technical QoS subject.

-Alan Hannan, VP Engineering, Internap

An excellent piece of work from XiPeng, as usual.

-Dave Cooper, VP Network Architecture, Global Crossing

It is an excellent book on the business and technical challenges of QoS.

-Bill St.Arnaud, Senior Director, Advanced Networks, CANARIE

This book meets a real serious need in the QoS literature.

-Andrew Odlyzko, Director, Digital Technology Center, University of Minnesota, Interim Director, Minnesota Supercomputing Institute

This book fills a hole in existing QoS literature.

-Jennifer Rexford, Professor of Computer Science, Princeton University

The book is quite unique and impressive. It is quite readable and answers many questions that an engineer, a manager, a student, and an instructor may have.

-Lionel M. Ni, IEEE Fellow; Chair, Department of Computer Science & Engineering, Hong Kong University of Science and Technology

Comprehensive industrial view on QoS for academic researchers.

-Andrzej Jajszczyk, IEEE Fellow; Professor, AGH University of Science and Technology Poland; Former Editor-in-Chief, *IEEE Communications Magazine*

It is very well written and I can say we have the exactly same view.

-Dave Wang, President, WANDL (Wide Area Network Design Laboratory)

I highly recommend this book for its pragmatic analysis as well as its technical and "big picture" content.

-Arman Maghbouleh, President, Cariden

Preface

Today, the increasing popularity of mobile phones and VoIP generates a large impact on the revenue of traditional telecom service providers. To maintain their subscriber base and average revenue per user, telecom service providers are eager to offer premium services such as IP TV, online gaming, etc. It is assumed that these services will create a large demand for IP QoS. At the same time, there is a trend to use the Internet as the common carrier for all kinds of services, instead of having many special-purpose networks. It is assumed that this will bring the QoS requirement to the Internet. However, after so many years of research, development, and claimed deployment, QoS is still something of the future in the Internet. Among other issues, the service quality of the Internet can still be unpredictable. What makes QoS so elusive? What is missing? What needs to be done to bring QoS to reality?

The current Net Neutrality debate further complicates the matters on QoS. Since the idea of QoS was formed, it has always been taken for granted that if carriers can provide QoS, they can charge users for it. The Net Neutrality debate cast doubt on this belief for the first time. A Net Neutrality legislation can dramatically change the QoS landscape overnight. What is Net Neutrality? How will the debate shape the evolution of QoS? Why should a common person even care?

In this book, we will discuss the technical as well as commercial and regulatory challenges of QoS, and propose a model to overcome these challenges. We will first define what QoS is, and then discuss:

- What are the QoS requirements of common applications?
- What can the Internet offer in terms of QoS today?

This lets us see the performance gap and thus provides a base for subsequent discussions.

We then review the contemporary QoS wisdom, and discuss its commercial, regulatory, and technical challenges. Some of the important topics include:

- The commercial challenges of the traditional QoS wisdom, regarding:
 - Who should pay for QoS, business or consumers, senders or receivers?
 - Why does this matter?
 - What kind of assurance should carriers provide with QoS?
 - Will the attempt to sell QoS increase customer churn, because it is considered as evidence of poor quality for the basic service?
- The regulatory challenges of the traditional QoS wisdom, regarding:
 - What is Net Neutrality and how does it relate to QoS?
 - Will carriers be allowed to charge for QoS?
 - What is the impact of the uncertain government regulation on QoS?

- The technical challenges of the traditional QoS wisdom, regarding:
 - What cooperation is needed among carriers in order to provide QoS? Can they be done at an acceptable cost?
 - Will various QoS mechanisms introduce too much complexity into the network to hurt network reliability and reduce QoS rather than improve QoS?
 - What are the technical challenges to differentiating a higher CoS to a point that the end users can perceive the difference from Best Effort (so that the end users will be willing to buy the higher CoS)?

We will then propose how to improve the current QoS business model to overcome the commercial, regulatory, and technical challenges. On the commercial side, this involves a change to the QoS pricing scheme. On the technical side, this involves comprehensive consideration of all the options available, increased emphasis on certain mechanisms and deemphasis of some other mechanisms. We will go to great lengths to explain why the proposed pricing scheme is better for the industry and for the users, and back it up with a large amount of historic evidences. These evidences include revenue and usage statistics in the postal industry's 200-year history and in the telephony industry's 100-year history. These statistics establish the evolution trend of pricing schemes for communication services. We believe that our rationale for the proposed model becomes clear in light of the historic trend.

Next, we will present two case studies on real-world QoS deployment. One is about Internet2 (<http://www.internet2.edu/>), the next generation Internet test bed in the United States. This case study is written by Ben Teitelbaum and Stanislav Shalunov, formerly of Internet2 and now of Bit Torrent (<http://www.bittorrent.com/>). The other is about Internap, one of the few network service providers in the United States that successfully commercialized QoS (<http://www.internap.com/>). This case study is written by Ricky Duman of Internap. Because these case studies are written by the network operators who did the actual deployment, the readers can hear directly from the horse's mouth about QoS deployment issues in real-world networks, and the lessons they learned. We will also discuss QoS issues in wireless networks. That chapter is written by Dr. Vishal Sharma of Metanoia Inc. (<http://www.metanoia-inc.com/>), a well-known technology consulting firm in Silicon Valley. The contributions of Ben Teitelbaum, Stanislav Shalunov, Ricky Duman, Vishal Sharma, and Abhay Karandikar are gratefully acknowledged. We draw our conclusions at the end.

Throughout this book, there are a number of advanced technical issues that are discussed but are not fully resolved. These are good topics for further research.

Because this is the first book that covers all three important aspects of QoS—technical, commercial, and regulatory—and each aspect has a broad range of topics, we recognize that it is possible that over time, some of our opinions may turn out to be revisable. But we believe that this won't hurt the main purpose of this book, which is to help people see the big picture of QoS, think critically about QoS, and form their own opinion on QoS. With this recognition, we are eager to

hear back from the readers. A web site has been set up at <http://groups.google.com/group/qos-challenges> for discussion. You can present your view points for other people to see.

AUDIENCE

In this book, we will discuss all three major aspects of QoS—technical, commercial, and regulatory—and how they interact with each other. We will first examine the status quo of QoS to show that the contemporary QoS wisdom has not been able to make QoS a reality for the Internet. We will then provide our explanation for this outcome by discussing the technical, commercial, and regulatory challenges. We will then propose a revision to the QoS model; discuss how it can overcome the commercial, regulatory, and technical challenges; and explain why we believe it is better for the industry.

We believe this book has value for the following audiences:

1. For people who are interested in understanding QoS technology, this book is a one-stop place for various flavors of technical QoS solutions, their pros and cons, the major overlooked factors in the current Diffserv/traffic management-centric solution, and the key trade-offs that must be made for a technical solution to be practical. The description is relatively high level so that most people can understand it without difficulty. For people who are interested in knowing the details, the book provides pointers to other references. The case studies about Internet2 and Internap's QoS deployments enable the readers to see QoS deployment issues in real-world networks. People about to deploy QoS can benefit from the lessons they provided. Academic people may also be interested in a number of advanced technical issues that are discussed but are not fully resolved—these can be good topics for further research.
2. For people who are interested in understanding the commercial issues, this book provides a comprehensive discussion about the commercial challenges in selling QoS. The key issues include “What is the effect of Internet users' Free mentality?,” “What QoS assurance should be provided to attract users to buy QoS, soft or hard?,” “Whom should NSPs charge QoS to, business or consumers? Senders or receivers?,” “Will charging for QoS be considered as a sign of poor service quality for the basic service? Will it trigger customer defection?,” “What should the contractual settlement among NSPs be to facilitate interprovider QoS?,” “How much QoS revenue can realistically be generated?” These discussions are particularly useful for people/companies who plan to invest in QoS, for example, either developing QoS features or deploying QoS mechanisms.
3. For people who are interested in understanding the regulatory issues and the Net Neutrality debate, this book provides a succinct summary of the

key issues, and the opinions of both the proponents and opponents on these issues. This saves the readers from having to spend the time to locate the information and follow the discussions. This would help the readers quickly form their own opinions on Net Neutrality.

ORGANIZATION

This book contains three parts. Part 1 discusses the current situation of Internet QoS, and points out that the contemporary QoS wisdom has not been able to make QoS a reality. Part 2 explains this outcome by discussing the commercial, regulatory, and technical challenges. Part 3 proposes a revised QoS pricing scheme and a technical solution, and discusses how they overcome or relieve the commercial, regulatory, and technical challenges.

Part 1 contains four chapters.

- Chapter 2 discusses what QoS means in this book, common applications' requirements on QoS, and the degree that the current Internet meets those requirements. The purpose of discussing the application requirements is to make the objectives of QoS clear. The purpose of discussing the degree that the current Internet meets those requirements is to clarify the gap between what is needed and what is available, so that we know what else may be needed to deliver QoS.
- Chapter 3 discusses the historic evolution of QoS solutions. The purpose is to provide the readers with some technical background and a historic view on various flavors of technical QoS solutions.
- Chapter 4 discusses the “contemporary QoS wisdom,” including its business model and its technical solution. This is to provide a base for commercial, regulatory, and technical examination.
- Chapter 5 discusses the reality related to QoS, especially from a commercial perspective. This is to give us a sense of how well the traditional QoS wisdom works.

Part 2 contains four chapters.

- Chapter 6 discusses the commercial challenges of the conventional QoS business model.
- Chapter 7 discusses the regulatory challenges.
- Chapter 8 discusses the technical challenges.
- Chapter 9 summarizes the key points discussed in this part, and discusses the lessons that are learned.

The purpose of discussing the commercial, regulatory, and technical challenges is to expose the issues of the conventional QoS model. The purpose of discussing the lessons learned is to point out the direction for possible improvement of the QoS model.

Part 3 contains five chapters.

- Chapter 10 proposes a revised pricing scheme for QoS, and discusses how it overcomes or relieves the most difficult commercial and regulatory challenges. To help the readers see the rationale of this revision, we present a large amount of revenue and usage statistics in the postal industry's 200-year history and in the telephony industry's 100-year history. These statistics establish the evolutionary trend of pricing schemes for communication services. Our rationale for the proposed pricing scheme revision becomes clear in light of the historic trend.
- Chapter 11 discusses the revised technical solution and its benefits.
- Chapter 12 presents two real-world QoS deployments at Internet2 and Internap, and the lessons they learned.
- Chapter 13 discusses QoS in the wireless world. Because network resource is much more limited in the wireless world, QoS approaches are very different too. This is another effort to help the readers see the big picture.
- Chapter 14 concludes the book.

It is recommended that this book be read in its entirety, and in the order the chapters are presented. This allows the big picture to manifest in a way that is easier to understand.

Acknowledgements

Writing the acknowledgements is the enjoyable part of this long and laborious journey. This book would not be possible without the help of a number of friends and experts.

First, I would like to thank Dr. Andrew Odlyzko. His Internet economics theory enlightened me. His research work formed the foundation of Chapter 10. He also reviewed the manuscript, provided valuable feedback, and pointed me to other information and subject matter experts.

I would like to thank Zheng Wang and John Yu for the helpful discussions during the conception of this book. Zheng Wang and Angela Chiu reviewed the proposal. Les Cottrell, K. Claffy, and Al Morton provided valuable information on Internet performance statistics and application QoS requirements for Chapter 2. Louise Wasilewski and Mike Benjamin provided early feedback on Net Neutrality. Jon Aufderheide and Brook Bailey provided information on service provider peering and service provider perspective. Dave Wang and Yakov Rekhter provided feedback on the key messages of the book. Zhisheng Chen and Yong Xue took the time to read the whole manuscript and provided valuable feedback. Bill St. Arnaud reviewed the manuscript and provided detailed comments and valuable suggestions for improvement.

Ben Teitelbaum and Stanislav Shalunov wrote the Internet2 Case Study. Ricky Duman wrote the Internap Case Study. These formed Chapter 12. Vishal Sharma and Abhay Karandikar wrote Chapter 13, "QoS in Wireless Networks." Their generous contributions are greatly appreciated.

Rick Adams, Rachel Roumeliotis, and Greg Chalson at Elsevier managed to drag me to the finish line. Without them, this book would still be in writing. Rick was very involved in the development of the manuscript, and provided useful guidance and candid feedback.

Last but not the least, I would like to thank Amy Chen for taking care of our son Alan Xiao, thus allowing me to concentrate completely on the book during the crunching stage.

XiPeng Xiao

About the Author

XiPeng Xiao has a unique background in QoS. He did his Ph.D. thesis on QoS at Michigan State University. This gave him a strong theoretical background on QoS. The author has product management experience with multiple network equipment vendors in Silicon Valley and network operations experience with a global network service provider. This vendor experience let him know the implementation cost of various QoS mechanisms and the hidden caveats behind those mechanisms. The NSP experience let him understand the practical trade-off that network operators must make between the need for network control and the need for network simplicity. The author also participates in international standard organizations such as the Internet Engineering Task Force (IETF), the standard organization that drives the technology development of IP networking. This let him know what's going on in the industry in terms of QoS, and what other people are thinking and doing. But maybe most importantly, he is a technologist-turned-marketing person. At the network equipment vendors, he is responsible for managing product lines for market success. This forced him to look beyond technology and develop the sensitivity to business and regulatory issues. This unique background with research experience, vendor experience, provider experience, standard experience, and business experience enables him to see the big picture of QoS, which comprises of a technical aspect, a commercial aspect, and a regulatory aspect.

With this unique background, the author has made contribution to QoS before writing this book. In 1999, while deploying QoS and MPLS Traffic Engineering in Global Crossing's network, the author and his colleagues discovered a conflict between Diffserv and TCP. They proposed a solution which was eventually standardized as [RFC2873]. This book is his continuous effort to describe the QoS big picture. In 1999, he published "Internet QoS: A Big Picture" in *IEEE Networks Magazine*. According to Google Scholar (scholar.google.com), it is among the most quoted QoS articles. Over the years, the author published multiple RFCs and journal articles in the fields related to QoS. The author also made many presentations on QoS in many industrial forums and conferences.

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