

SpringerBriefs in Electrical and Computer Engineering

More information about this series at <http://www.springer.com/series/10059>

Ying Wang · Wen'an Zhou
Ping Zhang

QoE Management in Wireless Networks

 Springer

Ying Wang
Beijing University of Posts
and Telecommunications
Beijing
China

Ping Zhang
Institute of Network Technology
Beijing University of Posts
and Telecommunications
Beijing
China

Wen'an Zhou
Beijing University of Posts
and Telecommunications
Beijing
China

ISSN 2191-8112 ISSN 2191-8120 (electronic)
SpringerBriefs in Electrical and Computer Engineering
ISBN 978-3-319-42452-1 ISBN 978-3-319-42454-5 (eBook)
DOI 10.1007/978-3-319-42454-5

Library of Congress Control Number: 2016946020

© The Author(s) 2017

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.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

Preface

With the rapid development of technology, there has been a proliferation of new services and applications. The diversity choices of users bring fierce competition as well as huge pressure to service providers. In the meantime, the level of fulfilment of customer demands and user expectations has been the most important indication to distinguish between different providers. Based on this background, the concept of quality of experience (QoE) receives much attention. Moreover, taking advantage of users and services' diversities to smartly design the resource allocation strategy is still one of the most important issues for future wireless networks.

In the past years, we have witnessed rapid progress in the advance of QoE and QoE modeling. However, there still exist some problems. For instance, most literatures on the QoE modelling only focus on the influence of technical parameters and ignore that QoE is multi-dimensional, while the researches emphasizing on various influencing factors do not explain how to model the QoE. Furthermore, how to carry out the QoE management and how to design QoE oriented radio resource management process are still open and challenging tasks. Therefore, this book carries out the study on data-driven QoE management scheme in wireless networks for mobile services.

In Chap. 1, we first give a brief introduction to QoE in wireless communication industry and the necessity to consider user QoE in current mobile service provisioning and transmission. Moreover, personalized QoE management, taking user subjective factors into account, is an emergent topic for refined and better resource utilization. In Chap. 2, QoE definitions are introduced according to different organizations or researchers besides which the state-of-the-art QoE is summarized, including QoE influencing factors, QoE assessment methods, QoE models, QoE management and control applications, and QoE challenges in 5G. To realize personalized QoE management, a data-driven QoE management architecture is proposed in Chap. 3. In Chap. 4, QoE-based resource allocation scheme is studied targeting at QoE maximization. Both conventional non-personalized QoE resource allocation scheme and personalized QoE scheme are presented and a comparison is conducted on simulation results for the two schemes. In Chap. 5, we illustrate how

the data-driven QoE assessment is conducted and some experimental details are given. Finally, the concluding remarks are presented in Chap. 6.

The authors would like to thank Peilong Li, Jiajun Liu, Sachula Meng, Qiping Pi, Haiqing Tao, Huan Yu, Yaning Fan, Mengyu Gao, Wenji Zhang, Lijun Song, Yanjun Hou of Beijing University of Posts and Telecommunications, for their contributions in the presented research works.

Beijing, China
2016

Ying Wang
Wen'an Zhou
Ping Zhang

Acknowledgement

This work is supported by National Nature Science Foundation of China (61372113, 61421061).

Contents

1	Introduction	1
1.1	Mobile Technology Evolution	1
1.2	Motivation for Personalized QoE Management.	2
	References.	4
2	Background and Literature Survey	7
2.1	QoE Definition	7
2.2	Influencing Factors	8
2.3	Assessment Method	10
2.3.1	Subjective Assessment	11
2.3.2	Objective Assessment	11
2.3.3	Hybrid Assessment	12
2.4	QoE Models	12
2.4.1	Mathematic Model	12
2.4.2	Machine Learning Model	13
2.5	QoE Management and Control	14
2.6	Challenges of QoE in 5G.	15
2.6.1	Challenges from Various Communication Scenarios.	16
2.6.2	Challenges Due to Emerging Applications	16
2.6.3	Challenges Related to Big Data	17
2.7	Summary	18
	References.	18
3	Architecture of Data-Driven Personalized QoE Management	21
3.1	Introduction	21
3.2	Framework of Data-Driven Personalized QoE Management.	22
3.2.1	Basic Requirements.	22
3.2.2	Training Module	22
3.2.3	Control Module.	25
3.3	Personalized Character Extraction: User-Service Preference	26
3.3.1	Bayesian Graphic Model (BGM).	26
3.3.2	Context Aware Matrix Factorization Model	28

3.4	Personalized QoE Model and Example User Case	30
3.5	Summary	32
	References.	32
4	QoE-Oriented Resource Allocation in Wireless Networks	33
4.1	Background	33
4.1.1	QoS-Based Radio Resource Management Strategies	34
4.1.2	QoE-Based Radio Resource Management Strategies.	34
4.1.3	Energy Efficiency-Based Radio Resource Management Strategies.	35
4.2	Traditional QoE-Based Resource Allocation Mechanism	36
4.2.1	QoE Metric Model	36
4.2.2	System Model.	38
4.2.3	Problem Formulation.	39
4.2.4	Resource Allocation Strategy	39
4.2.5	Simulation and Analysis	39
4.3	Personalized QoE-Based Resource Allocation Mechanism.	41
4.4	Summary	43
	References.	43
5	Implementation and Demonstration of QoE Measurement Platform.	45
5.1	Introduction	45
5.2	Related Work	45
5.2.1	Measurement Under Commercial Network Environment	45
5.2.2	Measurement Under Laboratory Network Environment.	46
5.2.3	Measurement Under Simulation Network Environment.	47
5.3	Design of Subjective Measurement.	48
5.3.1	QoE Related Factors	49
5.4	Platform Infrastructure on Streaming Media Application Scenario.	50
5.4.1	Supporting System Architecture	50
5.4.2	Functional Modules.	51
5.5	Measurement Procedure	52
5.5.1	Crowdsourcing	52
5.5.2	Measurement Description	53
5.5.3	Measurement Result	53
5.6	Summary	56
	References.	56
6	Conclusion	59
6.1	Conclusion Remarks.	59
6.2	Future Work.	60

Acronyms

ARP	Assignment Reservation Priority
CDMA	Code Division Multiple Access
CLO	Cross Layer Optimization
CMIPC	China Mobile Intellectual Property Center
C-RAN	Cloud-based Radio Access Network
D2D	Device-to-Device
ETSI	European Telecommunications Standards Institute
FEC	Forward Error Correction
GBR	Guaranteed Bit Rate
GSM	Global System for Mobile Communications
HLS	Http Live Streaming
ITU	International Telecommunication Union
LTE	Long Term Evolution
LTE-A	LTE-Advanced
MIMO	Multiple-Input Multiple-Output
MOS	Mean Opinion Score
MPQM	Moving Picture Quality Metric
MR	Measurement Report
MT	Maximum Throughput
OFDMA	Orthogonal Frequency Division Multiple Access
PEP	Packet Error Probability
PF	Proportional Fair
PSNR	Peak Signal to Noise Ratio
PSQA	Pseudo Subjective Quality Assessment
QMF	Quality Management Framework
QoCE	Quality of Customer Experience
QoE	Quality of Experience
QoGE	Quality of Group Experience
QoS	Quality of Service
QoUE	Quality of User Experience

RMSE	Root Mean Squared Error
RNN	Random Neural Network
SMS	Short Messaging Service
SVM	Support Vector Machine
TD-SCDMA	Time Division Synchronous CDMA
TS	Transport Stream
TMF	Tele Management Forum
VNI	Visual Network Index
VQI	Voice Quality Index
VQM	Video Quality Metric
WAP	Wireless Application Protocol
WCDMA	Wideband Code Division Multiple Access
WFL	Weber Fechner Law