

**The Economics
of an
Integrated Services Internet**

DISSERTATION

zur Erlangung des akademischen Grades
doctor rerum politicarum
(Doktor der Wirtschaftswissenschaft)

eingereicht an der

Wirtschaftswissenschaftlichen Fakultät
der Humboldt-Universität zu Berlin

von

Diplom-Volkswirt Hans Björn Rupp
geboren am 12. März 1972 in Düsseldorf

Präsident der Humboldt-Universität zu Berlin:

Prof. Dr. Jürgen Mlynek

Dekan der Wirtschaftswissenschaftlichen Fakultät:

Prof. Dr. Lutz Hildebrandt

Gutachter: 1. Prof. Oliver Günther, Ph.D.

2. Prof. Pravin P. Varaiya, Ph.D.

Tag des Kolloquiums: 19. Oktober 2000

Berichte aus der Volkswirtschaft

Hans Björn Rupp

The Economics of an Integrated Services Internet

Shaker Verlag
Aachen 2001

Die Deutsche Bibliothek - CIP-Einheitsaufnahme

Rupp, Hans Björn:

The Economics of an Integrated Services Internet/ Hans Björn Rupp.

Aachen : Shaker, 2001

(Berichte aus der Volkswirtschaft)

Zugl.: Berlin, Humboldt-Univ., Diss., 2000

ISBN 3-8265-9528-9

Copyright Shaker Verlag 2001

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of the publishers.

Printed in Germany.

ISBN 3-8265-9528-9

ISSN 0945-1048

Shaker Verlag GmbH • P.O. BOX 1290 • D-52013 Aachen

Phone: 0049/2407/9596-0 • Telefax: 0049/2407/9596-9

Internet: www.shaker.de • eMail: info@shaker.de

TO MY PARENTS

Contents

List of Figures	VI
Acknowledgements	VII
1 Motivation	1
1.1 Convergence, Compatibility and Network Growth	1
1.2 Towards an Integrated Services Internet	3
1.2.1 Economics: Network Externalities	3
1.2.2 Technology: Network Service Models	4
1.3 Resource Allocation and Valuation	7
2 Pricing	11
2.1 Pricing Internet Access	11
2.2 Normative Pricing Theory	12
2.2.1 Optimal Efficiency Pricing	12
2.2.2 Nonlinear Tariffs	14
2.3 Pricing Models for Internet Traffic	15
2.3.1 Flat-Rate vs. Usage-Based Pricing	15
2.3.2 Class-Based Pricing and Reservations	16
2.3.3 Auction Mechanisms	17

2.4	A Pragmatic Approach	18
3	Interconnection	21
3.1	The Problem	21
3.2	Access Pricing: Theory	22
3.2.1	One-Way Access Pricing in Regulated Industries	22
3.2.2	Two-Way Access Pricing in Unregulated Competition	26
3.2.3	Network Externalities and Strategic Pricing	28
3.3	Access Pricing: Practice	30
3.3.1	Internet Interconnection Architecture	30
3.3.2	Peering and Settlements	32
3.3.3	Problems and Shortcomings	38
3.4	A Proposal for an Automated Bandwidth Exchange	39
3.4.1	Objectives and Market Organization	39
3.4.2	Auction Design	43
3.4.3	Simulation	51
3.5	A Changing View of Interconnection	57
4	Demand	59
4.1	Background	59
4.2	The Internet Demand Experiment	61
4.2.1	Objectives	61
4.2.2	Experimental Setup	61
4.2.3	Experimental Design	65
4.3	Demand under Different Pricing Schemes	72
4.3.1	Stated Acceptance of Pricing Mechanisms	72
4.3.2	Acceptance of Experiments	74

<i>CONTENTS</i>	III
4.3.3 Demand Change under Usage-Based Pricing	75
4.3.4 User Segmentation	80
4.4 The Case for Quality of Service On Demand	83
4.4.1 Static Service Plans, Quality and Waste	83
4.4.2 User Heterogeneity	84
4.4.3 Activity Heterogeneity	86
4.4.4 Acceptance of QoS on Demand	90
4.5 Implications for a Next Generation Internet	92
5 Conclusions	95

List of Figures

1.1	Economic Characteristics of Layered Networks	2
3.1	Simulation Network Topology	52
3.2	Distribution of Allocation Ranks - Total	55
3.3	Distribution of Allocation Ranks - By Scenario	56
4.1	INDEX Network Transport Layer	62
4.2	User Interface – Choices	63
4.3	User Interface – Settings	64
4.4	Demographics: Income Distribution	66
4.5	Stated Preference Survey: Attitudes to Resource Allocation Mechanisms	73
4.6	Average Connect Time/Bytes Transmitted	77
4.7	Average Expenditure	80
4.8	User Segmentation 1	81
4.9	User Segmentation 2	82
4.10	User Segmentation 3	83
4.11	Expenditure Histogram	86
4.12	Budget for Internet Access	87
4.13	Time of Day Activity	88
4.14	Activity Type	88

4.15 QoS Choices – Per Subject	90
4.16 QoS Choices – Histogram	91