

**Curriculum Vitae of
ARTHUR W. BERGER**

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Computer Science and Artificial
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**PROFESSIONAL
AFFILIATIONS**

Senior Research Scientist at Akamai Technologies.
Research Affiliate in the Advanced Network Architecture Group at the MIT
Computer Science and Artificial Intelligence Laboratory.
Staff Consultant System Architecture at Optodot Corporation.

**RESEARCH
INTERESTS**

Content delivery over the Internet. Routing overlays. Request-routing in
content delivery networks. Measurement and performance in the Internet.
Internet architecture. Design and performance of distributed systems. Optical
transport networks. Quality of service in the Internet. Traffic engineering.
Congestion controls. Stochastic models.

EMPLOYMENT EXPERIENCE

- Nov '99 – Akamai Technologies, Senior Research Scientist.
to date Investigating the performance and improving the design of a new service that provides
application acceleration and is based on a robust, global, routing overlay. Investigated
and improved the routing of requests from web browsers to appropriate Akamai
servers, where key criteria are the latency of file transfers for html content, and the
bandwidth and loss for streaming media, which in turn depend on geography, Internet
topology, server availability and transient traffic conditions.
- Jan '01 – Optodot Corporation, Staff Consultant System Architecture.
to date Designing optical components that exploit recently discovered properties of organic
non-polymeric free radical compounds. Writing patents. Advising the CEO on
strategic and tactical business directions for the company.
- Sept. '01 – MIT Computer Science and Artificial Intelligence Laboratory, Research Affiliate.
to date Advise graduate students and collaborate in research in areas of internet routing,
internet architecture, overlay networks, traffic modeling, data analysis.
- Sept. '98 – MIT Laboratory for Information and Decision Systems, Visiting Scientist.
Sept. '00 In Spring of '99, taught the graduate course 6.262 Discrete Stochastic Processes.
Advised graduate students.
- June '98 – Lucent Technologies, Bell Labs. Distinguished Member of Technical Staff
Nov. '99 PacketStar IP Switch Software & Systems Dept., and
High Speed Networks Research Dept .

Contributed to the design and traffic engineering of a next-generation router with exceptional quality of service features, the PacketStar 6400 Series IP Switch.
Investigated the design and operation of IP over optical transport networks for a future generation of the PacketStar router and for optical switches.
Chairperson of Bell Lab's Ph.D. recruiting team at M.I.T..

1996-June '98 AT&T Labs, Principal Technical Staff Member
1986 - 1996 AT&T Bell Laboratories, Member of Technical Staff,
Teletraffic and Performance Analysis Department.

Collaborated on a team that is investigating mechanisms for providing quality of service in IP enterprise networks. Scope includes a near-term design for a particular financial corporation based on currently available products, and a longer-term, two to three year, horizon.

Determined connection admission control and dimensioning rules for elastic data traffic, where the "load" is expressed in terms of file sizes and think-times, and the resulting flow of packets is dependent on the presence of other flows and on the actions of closed-loop feedback controls such as TCP.

Provided engineering guidelines and congestion control procedures for a new service that integrates a business customer's voice and data services over an Asynchronous Transfer Mode (ATM) access link.

Participated in an AT&T task force on the implementation of voice services over an ATM core network.

From 1990 to 1998, contributed to the formulation of AT&T's strategy on traffic controls and traffic engineering for new telecommunication services based on Broadband-Integrated Services Digital Network (B-ISDN) using ATM.

From 1992 to 1998, key U.S. delegate and associate rapporteur to the International Telecommunications Union (ITU) Study Group 2 on B-ISDN Traffic Engineering. Influence the ITU Recommendations on "User Demand Modeling for B-ISDN," "Network Grade of Service Parameters and Target Values for B-ISDN," "Methods for Traffic Controls for B-ISDN," "Cell Level Measurements Requirements," "Dimensioning Methods for B-ISDN," and "Framework for Resource Allocation on Dimensioning in B-ISDN." As of 1996, appointed to be the coordinator for the traffic engineering recommendations on B-ISDN/ATM.

From 1991 to 1996, key U.S. delegate to the ITU Study Group 13 on B-ISDN resource management. Active in the preparation of ITU Recommendation I.371 on "Traffic Control and Congestion Control in B-ISDN." Successfully led the U.S. effort in the ITU to obtain agreement on the Available Bit Rate and the Statistical Bit Rate (a.k.a. Variable Bit Rate) transfer capabilities. Authored corresponding text for the ITU Recommendation I.371. Was instrumental in obtaining a common format in the ATM Forum, T1S1, and the ITU for the resource management cell that supports the Available Bit Rate transfer capability.

Represented AT&T at the U.S. standards body T1S1 from 1991 through 1996 and at

the ATM Forum from 1992 through 1993 regarding B-ISDN/ATM traffic controls and related topics. For the ATM Forum, co-authored contributions on the Available Bit Rate transfer capability and was a major contributor to the conformance definition that was adopted at the ITU and ATM Forum.

For dimensioning B-ISDN/ATM networks, determined basic properties and engineering guidelines for the effective bandwidth of connections given service priorities at network elements. (Joint work with W. Whitt, AT&T Labs.)

Assessed the efficacy of leaky-bucket and sliding-window traffic descriptors for variable bit rate (VBR) video teleconferencing over ATM networks. Determined statistical multiplexing gains. Evaluated the advantages of two-layer VBR video. (Joint work with A. Reibman and S. Morgan, AT&T Labs./Bell Laboratories.)

Determined conditions on general, algorithmic, traffic descriptors that provide the network operator with relevant information for connection admission control and resource management.

Evaluated the performance of overload-control mechanisms for several components of the 5ESS Switching System. Based on analytic models and simulation, designed enhanced controls. Derived load-service curves for the official 5ESS Switch Administration Guidelines.

1983-86

AT&T Bell Laboratories,
Network Architecture and Performance Center,
Member of Technical Staff.

For AT&T Communications, designed and evaluated AT&T's access networks to the newly divested Bell Operating Companies. Did fundamental work on the economics of shared private networks.

Investigated game-theoretic based pricing schemes for AT&T's shared private networks. Assessed the potential for sharing the capacity of 5ESS's between the AT&T's public switched network and the Enhanced Private Switched Communication Service Network.

Developed a model that evaluates the competitive impact of providing special access to business customers. The model was incorporated into AT&T's Point-of-Presence Evaluation Tool.

Developed guidelines for the economical contracting of facility routes from the Bell Operating Companies.

1981-83

Research Assistant under Yu-Chi Ho, Harvard University and Fred C. Schweppe, M.I.T. Developed theory of real-time pricing mechanisms for the stable operation of electric power systems.

Summer '80

Summer Intern at Bell Telephone Laboratories. Developed algorithms and wrote the code to calculate the expected cost of the Trunk Implementation Plan

1979-83

Teaching Fellow, Harvard University, in courses on optimal control & estimation, on

team theory and incentives, on differential equations, and on advanced calculus.

1977-78 Instructor of mathematics and physics, The International School of Geneva, Vaud, Switzerland. Taught high-school level mathematics and physics and was responsible for creating a structured, home environment for the male boarding students.

1974-77 Instructor of mathematics, The Fieldston School, N.Y., N.Y. Taught high-school level mathematics courses and was elected by the faculty to the four-member executive board, (1976-77), which represented faculty concerns to the headmaster

EDUCATION

Ph.D. Harvard University, Applied Mathematics/Control Theory, June '83.

Thesis title: Pricing Mechanisms in Coupled Dynamic Systems. Doctoral thesis investigates the use of pricing mechanisms to control large scale systems when the subsystems are owned and operated by autonomous decision makers. The results are applied to electric utilities to study the feasibility of independently owned bulk power generation.

M.S. Harvard University, Applied Mathematics/Control Theory, June '80.

B.S. Tufts University, Mathematics, summa cum laude, June '74.

AWARDS Harvard-Danforth Center for excellence in teaching, June '82.
Tufts University's mathematics prize, December '73.
Phi Beta Kappa, December '73.

PUBLICATIONS

X. Yang, D. Clark, & A. W. Berger, "NIRA: a New Inter-Domain Routing Architecture," *IEEE/ACM Transactions on Networking*, Vol.15, No. 4, August 2007, pp: 775 – 788
http://csail.mit.edu/~awberger/papers/NIRA_NewInterDomainRoutingArchitecture.pdf

S. Kandula, D. Katabi, S. Sinha, & A. W. Berger, "Dynamic Load Balancing Without Packet Reordering," *Computer Communication Review*, Vol. 37, No. 2, April 2007, pp. 53-62.
<http://www.sigcomm.org/ccr/drupal/files/p53-v37n2f-katabi.pdf>

R. Beverly, S. Bauer, & A. W. Berger, "The Internet's Not a Big Truck: Toward Quantifying Network Neutrality," *Proceedings of the 8th Passive and Active Measurement Conference*, Louvain-la-neuve, Belgium, April 5-6, 2007, pp. 135-144. <http://www.mit.edu/~rbeverly/papers/truck-pam07.pdf>

R.Beverly, K. Sollins, & A. W. Berger, "SVM Learning of IP Address Structure for Latency Prediction," *SIGCOMM 2006 Workshop on Mining Network Data (MineNet-06)*, Pisa, Italy, Sept, 15 2006. <http://www.sigcomm.org/sigcomm2006/papers/minenet-04.pdf>

H. Rahul, M. Kasbekar, R. Sitaraman, & A. W. Berger, "Towards Realizing the Performance and Availability Benefits of a Global Overlay Network," *Passive and Active Measurement Conference*, Adelaide, Australia, March 30-31, 2006. http://nms.csail.mit.edu/~rahul/rahul_overlay_pam2006.pdf

- S. Kandula, D. Katabi, M. Jacob, & A. W. Berger, "Botz-4-Sale: Surviving Organized DDoS Attacks That Mimic Flash Crowds," *Second Symposium on Networked Systems Design & Implementation (NSDI)*, Boston MA, May 2005. <http://www.usenix.org/events/nsdi05/tech/kandula/kandula.pdf>
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- A. Feldmann, O. Maennel, Z. M. Mao, A. W. Berger, & B. Maggs, "Locating Internet Routing Instabilities," *SIGCOMM 2004*, Portland Oregon, August 30 - September 3, 2004. <http://www.acm.org/sigs/sigcomm/sigcomm2004/papers/p479-feldmann11.pdf>
- J. Jung, V. Paxson, A. W. Berger, & H. Balakrishnan, "Fast Portscan Detection Using Sequential Hypothesis Testing," *Proc. of the IEEE Symposium on Security and Privacy*, May 2004. <http://nms.lcs.mit.edu/papers/portscan-oakland04.pdf>
- J. Jung, A. W. Berger, & H. Balakrishnan "Modeling TTL-based Internet Caches," *IEEE INFOCOM* April 1-3, 2003. http://www.ieee-infocom.org/2003/papers/11_01.pdf.
- A. W. Berger & Y. Kogan, "Dimensioning Bandwidth for Elastic Traffic in High-Speed Packet Networks," *IEEE/ACM Trans. on Networking*, Vol. 8, 2000, pp. 643-654. http://csail.mit.edu/~awberger/papers/ieee_trans_on_networking_dimensioning_bandwidth.pdf
- A. W. Berger & W. Whitt, "Workload Bounds in Fluid Models with Priorities," *Performance Evaluation*, Vol. 41, 2000, pp. 249-267.
- A. W. Berger, "ATM Networks," chapter in: *Compressed Video Over Networks*, M. T. Sun and A. R. Reibman editors, New York, Marcel Dekker, 2000. <http://csail.mit.edu/~awberger/papers/ATMnetworksChapter.pdf>
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- A. W. Berger & Y. Kogan, "Distribution of Processor-sharing Customers for a Large Closed System with Multiple Classes," *SIAM J. on Applied Mathematics*, Vol. 60, No. 4, March, 2000, pp. 1330-1339.
- A. W. Berger, L. Bregman & Y. Kogan, "Bottleneck Analysis in Multiclass Closed Queueing Networks and its Application," *Queueing Systems*, Vol. 31, 1999, pp. 217-237. http://csail.mit.edu/~awberger/papers/queueing_systems_bottleneck_analysis.pdf
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- A. W. Berger & W. Whitt, "A Comparison of the Sliding Window and the Leaky Bucket," *Queueing Systems*, Vol. 20, 1995, pp. 117-138.
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- A. W. Berger & W. Whitt, "Asymptotics for Open-Loop Window Flow Control," *J. of Applied Mathematics and Stochastic Analysis*, Vol. 7, No. 3, Fall 1994, pp. 337-356.
- A. W. Berger, "Desirable Properties of Traffic Descriptors for ATM Connections in a Broadband ISDN," *The Fundamental Role of Teletraffic in the Evolution of Telecommunications Networks (Proc. of the 14th Inter. Teletraffic Congress)*, Ed. J. Labetoulle and J. W. Roberts, Amsterdam: Elsevier, 1994, pp. 233-242.
- A. W. Berger & W. Whitt, "The Pros and Cons of a Job Buffer in a Token-Bank Rate-Control Throttle," *IEEE Transactions on Communications*, Vol. 42, No.2/3/4, February/March/April, 1994, pp. 857-861.
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- A. W. Berger, S. P. Morgan, & A. R. Reibman, "Statistical Multiplexing of Layered Coded Video," *3rd Annual International B-ISDN Workshop*, Mandelieu-la-Napoule, France, April, 1993.
http://csail.mit.edu/~awberger/papers/BergerMorganReibman_StatisticalMultiplexingLayeredVideoOverATMNetworksWithLeakyBucketDescriptors.pdf
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http://csail.mit.edu/~awberger/papers/GLOBECOM92_OnVbrVideoTeleconf_ReibmanBerger.pdf
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A. W. Berger & W. Whitt, "The Brownian Approximation For Rate-Control Throttles and the G/G/1/C Queue," *Discrete Event Dynamic Systems*, Vol. 2, 1992, pp. 7-60.

http://csail.mit.edu/~awberger/papers/BergerWhitt_BrownianApproxForRateControlThrottleAndGG1CQueue_1992.pdf

A. W. Berger, A. E. Eckberg, "A B-ISDN/ATM Traffic Descriptor and Its Use in Traffic and Congestion Controls," *GLOBECOM*, Dec. 1991, Phoenix, Arizona, pp. 266-270.

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A. W. Berger, "Determination of Load Service Curves for Distributed Switching Systems: Probabilistic Analysis of Overload Control Schemes," *Proc. of the 13th International Teletraffic Congress*, June, 1991, Copenhagen, Denmark, pp. 435-440.

A. W. Berger, "Comparison of Call Gapping and Percent Blocking for Overload Control in Distributed Switching Systems and Telecommunications Networks," *IEEE Transactions on Communications*, Vol. 39, No. 4, April, 1991, pp. 574-580.

http://csail.mit.edu/~awberger/papers/ieee_trans_on_comm_comparison_call_gapping_percent_blocking.pdf

A. W. Berger, "Performance Analysis of a Rate-Control Throttle Where Tokens and Jobs Queue," *J. of Selected Areas in Communications*, Vol. 9, No. 2, Feb. 1991, pp. 165-170. An earlier version appeared in *Proc. of INFOCOM '90*, June 1990, San Francisco CA, pp. 30-38.

http://csail.mit.edu/~awberger/papers/ieee_j_selected_areas_perf_anal_rate_control.pdf

A. W. Berger, "Overload Control Using Rate Control Throttle: Selecting Token Bank Capacity for Robustness to Arrival Rates," *IEEE Transactions on Automatic Control*, Vol. 36, No. 2, Feb. 1991, pp. 216-219.

http://csail.mit.edu/~awberger/papers/ieee_trans_auto_control_overload_control_rate_throttle.pdf

A. W. Berger, A. E. Eckberg, T. C. Hou, and D. M. Lucantoni, "Performance Characterization of Traffic Monitoring and Associated Control Mechanisms for Broadband Packet Networks," *GLOBECOM*, Dec. 1990, San Diego, CA.

http://csail.mit.edu/~awberger/papers/GLOBECOM90_performanceCharacterization_BergerEckbergHouLucantoni.pdf

A. W. Berger and W. Whitt, "A Multi-Class Input-Regulation Throttle," *Proc. of the 29th IEEE Conference on Decision and Control*, Dec. 1990, Honolulu Hawaii, pp. 2106-2111.

http://csail.mit.edu/~awberger/papers/multiclass_input_regulation_throttle_CDC_1990.pdf

A. W. Berger, J. S. Kent & M. V. Stein, "Preventing Overload and Verifying Link Stability in an Implementation of the DPNSS Layer 2 Protocol," *GLOBECOM*, Nov. 1989. Dallas, Texas, pp. 175-179.

http://csail.mit.edu/~awberger/papers/GLOBECOM89_preventingOverloadVerifyingLinkStability_BergerKentStein.pdf

A. W. Berger & F. C. Schweppe, "Existence of Coordinating Prices in Dynamic Systems," *Automatica*, Vol. 25, No. 5, 1989, pp. 781-784.

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A. W. Berger & F. C. Schweppe, "Real Time Pricing to Assist in Load Frequency Control," *IEEE Transactions on Power Systems*, Vol. 4, No. 3, 1989, pp. 920-926.

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A. W. Berger, "Pricing Mechanisms in the Control of Linear Dynamic Systems," *Proc. of the 23rd Conference on Decision and Control*, Dec. 1984, Las Vegas, Nevada, pp. 632-633.

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PATENTS

F. T. Leighton, R. Sundaram, A. Soviani, M. Levine, A. Parker, S. Hanono-Wachman, & A. W. Berger, "Method for Predicting File Download Time from Mirrored Data Centers in a Global Computer Network," U.S. Patent No. 7096263, issued August 22, 2006.

S. A. Carlson & A. W. Berger "Electro-optic Reflective Modulators," U.S. Patent No. 6,950,228, issued September 27, 2005.

S. A. Carlson & A. W. Berger "Optical Shutter Assembly," U.S. Patent No. 6,757,094, issued June 29, 2004.

S. A. Carlson & A. W. Berger "Optical Switch Device," U.S. Patent No. 6,724,512, issued April 20, 2004.

S. A. Carlson & A. W. Berger, "Optical Shutter Assembly," U.S. Patent No. 6,583,916, issued June 24, 2003.

A. W. Berger, "Flexible Bandwidth Negotiation for the Block Transfer of Data," U.S. Patent No. 6,504,821, issued January 7, 2003

A. W. Berger & Y. Kogan, "Dimensioning Bandwidth and Connection Admission Control for Elastic Traffic in High-Speed Communication Networks," U.S. Patent No. 6,266,322, issued July 24, 2001.

A. W. Berger & W. Whitt, "Traffic Management in Packet Communication Networks Having Service Priorities and Employing Effective Bandwidths," U.S. Patent No. 6,160,818, issued December 12, 2000.

A. W. Berger, R. A. Milito, & W. Whitt, "Efficient, Rate-Based Multiclass Access Control," U.S. Patent No. 5,274,664, issued December 28, 1993.

CONTRIBUTIONS TO THE INTERNATIONAL TELECOMMUNICATION UNION (ITU) & ATM FORUM

A. W. Berger, "Dimensioning Bandwidth for Elastic Data Traffic in ATM Networks," Contribution to ITU Study Group 2, March 3-13, 1998, document # D.147.

A. W. Berger, "Connection Admission Control in Priority Queueing Systems," Contribution to ITU Study Group 2, March 3-13, 1998, document # D.148.

A. W. Berger, "Proposed Revisions to Draft Recommendation E.72x on Network Grade of Service Parameters and Target Values for B-ISDN," Contribution to ITU Study Group 2, March 3-13, 1998, document # D.150.

A. W. Berger, "Comments on Draft Recommendation E.74x on Measurement Requirements for the B-ISDN," Contribution to ITU Study Group 2, March 3-13, 1998, document # D.151.

A. W. Berger, "Comments on Draft Recommendation E.74x," Contribution to ITU Question 17/2 Rapporteur's meeting, September 15-19, 1997.

A. W. Berger, "Proposed Revisions to Draft Recommendation E.72x," Contribution to ITU Question 17/2 Rapporteur's meeting, September 15-19, 1997.

A. W. Berger, "Proposed Editorial Changes to ITU Recommendation E.735 on Framework for Traffic Control and Dimensioning in B-ISDN," Contribution to ITU Study Group 2, May 20-30, 1997, document # D.68.

A. W. Berger, "Proposed Text on ABR for ITU Recommendation E.736, Methods for Cell-Level Traffic Control in B-ISDN," Contribution to ITU Question 17/2 Rapporteur's meeting, January 6-10, 1997.

A. W. Berger, K. Fendick, & S. Mithal, "Proposed Algorithm for ABR Conformance Definition," Contribution to ITU Question 8/13 Rapporteur's meeting, September 30 – October 4, 1996, and U.S. T1S1, September 16-20, 1996, document # T1S1.5/96-147.

A. W. Berger, K. Fendick, & S. Mithal, "Proposed Enhancements to ABR Source/Destination Reference Behaviors," Contribution to ITU Question 8/13 Rapporteur's meeting, September 30 – October 4, 1996, and U.S. T1S1, September 16-20, 1996, document # T1S1.5/96-148.

A. W. Berger, K. Fendick, & S. Mithal, "Response to Technical Concerns on ABR," Contribution to ITU Question 8/13 Rapporteur's meeting, September 30 – October 4, 1996, and U.S. T1S1, September 16-20, 1996, document # T1S1.5/96-149.

A. W. Berger, "On Approval of ITU Recommendation I.371 on B-ISDN Traffic Control and Congestion Control in B-ISDN," Contribution to ITU Study Group 13, April 29 – May 10, 1996, document # D.1099 (PLEN).

A. W. Berger, "On I.371 Living List Item Regarding ATM Transfer Capabilities and Applications," Contribution to ITU Study Group 13, April 29 – May 10, 1996, document # D.1100 (WP 2/13).

K. Fendick, & A. W. Berger, "Straw Vote Comments on the ATM Forum Traffic Management Specification V4.0," Contribution to ATM Forum, 11-15 December 1995, document # ATM_Forum/95-1667.

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- A. W. Berger, "On Deterministic and Statistical Bit Rate Capabilities," Contribution to ITU Study Group 13, July 10-21, 1995, document # D.891 (2/13).
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- A. W. Berger, F. Bonomi, & K. Fendick, "Clarifications to the ABR Source and Switch Behavior," Contribution to ATM Forum, June 5-9, 1995, document # ATM_Forum/95-0567.
- M. Noorchashm & A. W. Berger, "Coding of Peak-to-peak Cell Delay Variation and Cell Transfer Delay Parameters," Contribution to ATM Forum, May 9-11, 1995.
- A. W. Berger, F. Bonomi, & K. Fendick, "Actions by ITU Question 8/13 on ABR and the RM Cell Format," Contribution to ATM Forum, April, 10-14, 1995, document # ATM_Forum/95-0334.
- A. W. Berger, F. Bonomi, K. Fendick, J. Bennet, R. Y. Awdeh, "Issues and Changes to the ABR Source/Destination Behavior," Contribution to ATM Forum, April, 10-14, 1995, document # ATM_Forum/95-0459.
- A. W. Berger, F. Bonomi, & K. Fendick, "The ABR Conformance Definition: More Motivation and Optimality," Contribution to ATM Forum, April, 10-14, 1995, document # ATM_Forum/95-0481.
- A. W. Berger, "On Conformance Definition for Multiple Flows of an ATM Connection," Contribution to ITU Question 8/13 Rapporteur's meeting, February 27 - March 8, 1995.
- A. W. Berger, "On Terminology for New Bearer Capabilities in Question 8/13," Contribution to ITU Question 8/13 Rapporteur's meeting, February 27 - March 8, 1995.
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- A. W. Berger, "On Statistical Bit Rate Bearer Capability," Contribution to ITU Question 8/13 Rapporteur's meeting, February 27 - March 8, 1995.
- A. W. Berger, "On Selection of Values for Sustainable Cell Rate and Intrinsic Burst Tolerance," Contribution to ITU Question 8/13 Rapporteur's meeting, February 27 - March 8, 1995.
- A. W. Berger, "Coding of Cell Delay Variation and Intrinsic Burst Tolerance," Contribution to ITU Question 8/13 Rapporteur's meeting, February 27 - March 8, 1995.
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