FRANK KELLY: *curriculum vitae and principal publications*

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Home address:	23 Lyndewode Road, Cambridge CB1 2HN, England
Born:	28 December 1950; London, England
Honours:	Davidson Prize 1979
	Guy Medal in Silver of the Royal Statistical Society 1989
	Fellow of the Royal Society 1989
	Lanchester Prize of the Institute for Operations Research and the Management Sciences 1991
	Naylor Prize of the London Mathematical Society 1997
	Honorary Doctorate of Science, Heriot-Watt University 2001
	IEEE Koji Kobayashi Computers and Communications Award 2005
	Companionship of OR, Operational Research Society 2006
Principal lectures:	Clifford Paterson Lecture, Royal Society 1995
	Blackett Memorial Lecture, Operational Research Society 1996
	Naylor Lecture, London Mathematical Society 1997
	Schlumberger Lecture, International Congress on Industrial and Applied Mathematics 1999
	Larmor Lecture, Cambridge Philosophical Society 1999
	Fulkerson Lectures, Cornell University 2002
	Milner Lecture, Edinburgh 2003

EDUCATION

1968–71	Van Mildert College, Durham University
	B.Sc. (Hons), Class 1
	Main subject: Mathematics; subsidiary subject: Economics
	1969-1971: University scholarships awarded
1972–76	Emmanuel College, Cambridge
	1973: Distinction, Part III of the Mathematical Tripos
	Bachelor scholar, Emmanuel College
	1975: Awarded Knight Prize for essay entitled 'Networks of queues'
	1976: Ph.D. (supervisor Professor P. Whittle)
	'The equilibrium behaviour of stochastic models of interaction and flow'

APPOINTMENTS

1971–73	Operational Research Analyst, Applied Management Sciences Division, Scientific Control Systems Limited (half-time 1972–3)
1976–	*University of Cambridge*
	1976–78: University Assistant Lecturer in Operational Research, Control and Management Systems Division, Engineering Department
	1978–86: University Lecturer, Statistical Laboratory, Department of Pure Mathematics and Mathematical Statistics
	1986–90: Reader in Mathematics of Systems, Statistical Laboratory
	1990– : Professor of the Mathematics of Systems
	1991–93: Director of the Statistical Laboratory

	1976– : Christ's College Research Fellow, later Teaching Fellow, then Professorial Fellow. Served variously as Director of Studies in Mathematics, Tutor, and member of Investments Committee and College Council
1986–87	Nuffield Foundation Science Research Fellow
1994–95	Leverhulme Trust Senior Research Fellow
2001–02	Visiting Professor, Graduate School of Business and (by courtesy) Department of Electrical Engineering and Computer Science, Stanford University
2003–06	Chief Scientific Adviser, Department for Transport (half-time appointment)

PROFESSIONAL ACTIVITIES

1981–85:	Member of Royal Statistical Society Research Section Committee
1983–86:	Associate Editor, Stochastic Models
1984–90:	Associate Editor, Annals of Probability
1985–93:	Member of Committee for Conferences on Stochastic Processes and their Applications
1986–90:	Editorial Panel, Journal of the Royal Statistical Society, Series B
1986–97:	Editorial Board, Probability in the Engineering and Informational Sciences
1987–90:	Member of Institute of Mathematical Statistics Steering Committee on Applied Probability
1987– :	Variously speaker, co-organizer, tutorial lecturer, member of Steering Committee for Conferences on Stochastic Networks
1988– :	Member of International Federation for Information Processing Working Group on Computer Systems Modelling
1992:	Member of Mathematics Panel and Statistics and Operational Research sub-Panel for the HEFCE Research Assessment Exercise
1992–96:	Editorial Board, Combinatorics, Probability and Computing
1993– :	Editorial Board of the Oxford University Press Series, Studies in Probability
1993–96:	Member of the Standing Panel of External Experts in Statistics, Board of Advisors, University of London
1994– :	Editorial Board, Queueing Systems: Theory and Applications
1995:	Member of the Review Panel of the Institut National de Recherche en Informatique et en Automatique
1995–97:	Member of the National Academies Policy Advisory Group Working Group on the Treatment of Data by Intelligent Medical Devices
1996:	Member of Statistics and Operational Research Panel for the HEFCE Research Assessment Exercise
1998:	Member of the Review Committee of the University of Oxford's Department of Statistics.
1998–2004:	Member of the Scientific Council of EURANDOM, the European research institute for the study of stochastic phenomena.
1999–2001:	Member of the Council of the Royal Society
2001–04:	Member of the Conseil Scientifique of France Telecom
2002– :	Springer-Verlag: Member of Advisory Board of series on Applications of Mathematics, and Editorial Board of series on Information Science and Statistics
2002–06:	Elected Member of the Council of the Royal Statistical Society
2003– :	Editorial Board of Internet Mathematics
2004–05:	Associate Editor of Mathematics of Operations Research
2005– :	Elected Member of the Council of the London Mathematical Society

University of Cambridge

1989–2001:	Member of Steering Committee, and then Management Committee and co-opted member

Scientific Committee of the Isaac Newton Institute for Mathematical Sciences

1992–93: Member of the University's Committee on Professorships and Readerships ad hominem

1993–94: Member of the Review Committee for the Faculty of Economics
and Politics, including the Department of Applied Economics

1994–2001: Member of Scientific Board of Basic Research Institute in Mathematical Sciences
(joint venture between Newton Institute and Hewlett-Packard Laboratories)

1995–2003: Member of the Advisory Committee for the Department of Applied Economics

1997–99: Chair of the Advisory Board of the University of Cambridge and
Royal Institution Mathematics Enrichment Project, www.nrich.maths.org.uk

1997–98: Member of the Advisory Board of the University of Cambridge PASS Maths Project

1998–2000: Member of the Personal Promotion Boards for Engineering, Computer Science
and Mathematics of the University of Cambridge.

1999–2001: Chair of the Management Committee of the Isaac Newton Institute
for Mathematical Sciences

2002–05: Chair of the Faculty of Mathematics Committee on the Structure of Part II

2006– : Member of the University's Main Committee on Senior Academic Promotions, and
Chair of the Technology Sub-Committee

PUBLICATIONS

Networks of queues with customers of different types. *Journal of Applied Probability* **12**, (1975), 542-554.

Markov processes and Markov random fields. *Bulletin of the International Statistical Institute* **46**, (1976), 397-404.

On stochastic population models in genetics. *Journal of Applied Probability* **13**, (1976), 127-131.

Networks of queues. *Advances in Applied Probability* **8**, (1976), 416-432.

Stochastic models with electrical analogues. *Mathematical Proceedings of the Cambridge Philosophical Society* **80**, (1976), 145-151.

A note on Strauss's model for clustering (with B.D. Ripley). *Biometrika* **63**, (1976), 357-360.

The departure process from a queueing system. *Mathematical Proceedings of the Cambridge Philosophical Society* **80**, (1976), 283-285.

Markov point processes (with B.D. Ripley). *Journal of the London Mathematical Society* **15**, (1977), 188-192.

Exact results for the Moran neutral allele model. *Advances in Applied Probability* **9**, (1977), 197-201.

The asymptotic behaviour of an invasion process. *Journal of Applied Probability* **14**, (1977), 584-590.

Regional taxonomy using trend surface coefficients (with A.D. Cliff). *Environment and Planning* **A9**, (1977), 945-955.

Reversibility and Stochastic Networks. Wiley, Chichester, (1979). (Reprinted 1987, 1994).

Multi-armed bandits with discount factor near one: the Bernoulli case. *Annals of Statistics* **9**, (1981), 987-1001.

How a group reaches agreement: a stochastic model. *Mathematical Social Sciences* **2**, (1981), 1-8.

Markovian functions of a Markov chain. *Sankhya* **44**, (1982), 372-379.

A remark on search and sequencing problems. *Mathematics of Operations Research* **7**, (1982), 154-157.

On optimal search with unknown detection probabilities. *Journal of Mathematical Analysis and its Applications* **88**, (1982), 422-432.

Networks of quasi-reversible nodes. In *Applied Probability – Computer Science: the Interface, Volume I* (eds. R.L. Disney and T.J. Ott). Progress in Computer Science **2**, Birkhauser, Boston, (1982), 3-29.

Eigenvalue inequalities for products of matrix exponentials (with J.E. Cohen, S. Friedland and T. Kato). *Linear Algebra and its Applications* **45**, (1982), 55-95.

The throughput of a series of buffers. *Advances in Applied Probability* **14**, (1982), 633-653.

Invariant measures and the q-matrix. In *Probability, Statistics and Analysis* (eds. J.F.C. Kingman and G.E.H. Reuter). London Mathematical Society Lecture Notes Series **79**, Cambridge University Press, (1983), 143-160.

Sojourn times in closed queueing networks (with P.K. Pollett). *Advances in Applied Probability* **15**, (1983), 638-656.

Nuclear position in the cells of the mouse early embryo (with W.J.D. Reeve). *Journal of Embryology and Experimental Morphology* **75**, (1983), 117-139.

The product form for sojourn time distributions in cyclic exponential queues (with O.J. Boxma and A.G. Konheim). *Journal of the American Association for Computing Machinery* **31**, (1984), 128-133.

An asymptotic analysis of blocking. In *Modelling and Performance Evaluation Methodology* (eds. F. Baccelli and G. Fayolle). Lecture Notes in Control and Information Sciences **60**, Springer-Verlag, Berlin, (1984), 3-20. (A revised version of this paper appeared as:)
Series of buffers. In *Fundamentals of Teletraffic Theory*, Proceedings of the Third International Seminar on Teletraffic Theory (1984). Institute for Problems of Information Transmission of the USSR Academy of Sciences, 229-240.

Blocking, reordering and the throughput of a series of servers. *Stochastic Processes and their Applications* **17**, (1984), 327-336.

The dependence of sojourn times in closed queueing networks. In *Mathematical Computer Performance and Reliability* (eds. G. Iazeolla, P.J. Courtois and A. Hordijk). North-Holland, Amsterdam, (1984), 111-112.

Segregating the input to a series of buffers. *Mathematics of Operations Research* **10**, (1985), 33-43.

Some probabilistic aspects of network flow. In *Computer Communications* (ed. B. Gopinath), Proceedings of Symposia in Applied Mathematics **31**, American Mathematical Society, Rhode Island, (1985), 15-43.

Stochastic models of computer communication systems. *Journal of the Royal Statistical Society Series B* **47**, (1985), 379-395, with Discussion 415-428.

Instability in a communication network. In *Fundamental Problems in Communication and Computation* (eds. T. Cover and B. Gopinath). Springer-Verlag, (1985).

On auto-repeat facilities and telephone network performance. *Journal of the Royal Statistical Society Series B* **48**, (1986), 123-132.

Blocking probabilities in large circuit-switched networks. *Advances in Applied Probability* **18**, (1986), 473-505.

The modelling of communication networks. In *Proceedings of the Second Latin American Congress on Probability and Mathematical Statistics* (ed. E. Cabana), (1986). (A revised version of this paper appeared as:)
Blocking and routing in circuit-switched networks. In *Teletraffic Analysis and Computer Performance Evaluation* (eds. O.J. Boxma, J.W. Cohen and H.C. Tijms). Elsevier, Amsterdam, (1986), 37-45.

Distributed control of routing in circuit-switched networks. In *Proceedings of the 25th IEEE Conference on Decision and Control*, Athens, Greece, (1986), 612-614.

One-dimensional circuit-switched networks. *Annals of Probability* **15**, (1987), 1166-1179.

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The optimization of queueing and loss networks. In *Queueing Theory and its Applications* (eds. O.J. Boxma and R. Syski). North-Holland, Amsterdam, (1988), 375-392.

Routing and capacity allocation in queueing and loss networks. In *Performance '87* (eds. P.J. Courtois and G. Latouche). Elsevier, Amsterdam, (1988), 545-549.

On a class of approximations for closed queueing networks. *Queueing Systems* **4**, (1989), 69-76.

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On critically loaded loss networks (with P.J. Hunt). *Advances in Applied Probability* **21**, (1989), 831-841.

Dynamic alternative routing: modelling and behaviour (with R.J. Gibbens and P.B. Key). In *Teletraffic Science* (ed. M. Bonatti). Elsevier, Amsterdam, (1989), 1019-1025.

Fixed point models of loss networks. *Journal of the Australian Mathematical Society Series B* **31**, (1989), 204-218.

Dynamic routing in fully connected networks (with R.J. Gibbens). *IMA Journal of Mathematical Control and Information* **7**, (1990), 77-111.

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Asymptotic stationarity of queues in series and the heavy traffic approximation (with W. Szczotka). *Annals of Probability* **18**, (1990), 1232-1248.

A paradox of congestion in a queuing network (with J.E. Cohen). *Journal of Applied Probability* **27**, (1990), 730-734.

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Coalitions in the international network (with R.J. Gibbens, G.A. Cope and M.J. Whitehead). In *Proceedings of the Seventh U.K. Teletraffic Symposium*. I.E.E., (1990). (A shortened version of this paper appeared as:)
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Network routing. In *Queueing, Performance and Control in ATM* (eds. J.W. Cohen and C.D. Pack). North-Holland Studies in Telecommunication **15**, Elsevier, Amsterdam, (1991), 249-254.

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Dynamic routing in multi-parented networks (with R.J. Gibbens and S.R.E. Turner). *IEEE/ACM Transactions on Networking* **1**, (1993), 261-270.

Bounds on the performance of dynamic routing schemes for highly connected networks. *Mathematics of Operations Research* **19**, (1994), 1-20.

Tariffs and admission control for multiservice networks. In *Proceedings of the Tenth U.K. Teletraffic Symposium*. I.E.E., (1993). (A longer version of this paper appeared as:)

On tariffs, policing and admission control for multiservice networks. *Operations Research Letters* **15**, (1994), 1-9.

Computational complexity of loss networks (with G. Louth and M. Mitzenmacher). *Theoretical Computer Science* **125**, (1994), 45-59.

Tariffs and effective bandwidths in multiservice networks. In *The Fundamental Role of Teletraffic in the Evolution of Telecommunication Networks* (eds. J. Labetoulle and J.W. Roberts). Elsevier, Amsterdam, (1994), 401-410.

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Dimensioning playout buffers from an ATM network (with P.B.Key). In *Proceedings of the Eleventh U.K. Teletraffic Symposium*. I.E.E., (1994).

Dynamic alternative routing (with R.J. Gibbens and P.B. Key). In *Routing in Communication Networks* (ed. M.E. Steenstrup). Prentice Hall, Englewood Cliffs, New Jersey (1995), 13-47.

Mathematical Models in Finance (editor, with S.D. Howison and P. Wilmott). Philosophical Transactions of the Royal Society, Series A, **347**, (1994). (Reprinted as:)
Mathematical Models in Finance (editor, with S.D. Howison and P. Wilmott). Chapman and Hall, London, (1995).

Stochastic Networks (editor, with R.J. Williams). IMA Volumes in Mathematics and its Applications **71**. Springer-Verlag, New York, (1995).

Dynamic routing in stochastic networks. In preceding volume, 169-186.

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A decision-theoretic approach to call admission control in ATM networks (with R.J. Gibbens and P.B. Key). *IEEE Journal on Selected Areas in Communications* **13**, (1995), 1101-1114.

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Stochastic Networks: Theory and Applications (editor, with S. Zachary and I.B. Ziedins). Oxford University Press (1996).

Notes on effective bandwidths. In preceding volume, 141-168.

Braess' paradox in a loss network (with N.G. Bean and P.G. Taylor). *Journal of Applied Probability* **34**, (1997), 155-159.

Charging and accounting for bursty connections. In *Internet Economics* (eds. L. W. McKnight and J. P. Bailey). MIT Press (1997), 253-278.

Charging and rate control for elastic traffic. *European Transactions on Telecommunications* **8**, (1997), 33-37.

Tariffing in the new IP/ATM environment (with D. Walker and J. Solomon). *Telecommunications Policy* **21**, (1997), 283-295.

Charging schemes for multiservice networks (with D. Songhurst). In *Teletraffic Contributions for the Information Age: Proceedings of the 15th International Teletraffic Congress, Washington, DC* (eds. V. Ramaswami and P.E. Wirth). Elsevier, Amsterdam, (1997), 781-790.

Measurement-based connection admission control (with R. J. Gibbens). In *Teletraffic Contributions for the Information Age: Proceedings of the 15th International Teletraffic Congress, Washington, DC* (eds. V. Ramaswami and P.E. Wirth). Elsevier, Amsterdam, (1997), 879-888.

Rate control in communication networks: shadow prices, proportional fairness and stability (with A. Maulloo and D. Tan). *Journal of the Operational Research Society* **49**, (1998), 237-252.

An intelligent agent for optimizing QoS-for-money in priced ABR connections (with C. Courcoubetis, G.D. Stamoulis and C. Manolakis) *Telecommunications Systems*, Special Issue on Network Economics (1999).

Resource pricing and the evolution of congestion control (with R.J. Gibbens). *Automatica* **35**, (1999). 1969-1985.

Distributed connection acceptance control for a connectionless network (with R.J. Gibbens). In *Proceedings of the 16th International Teletraffic Congress, Edinburgh* (eds. P.B. Key and D.G. Smith). Elsevier, Amsterdam (1999). 941-952.

A study of simple usage-based charging schemes for broadband networks (with C. Courcoubetis, V.A. Siris and R. Weber). *Telecommunications Systems* **15**, (2000). 323-343.

Measurement-based usage charges in communication networks (with C. Courcoubetis and R. R. Weber). *Operations Research* **48**, (2000). 535-548.

A combinatorial auction with multiple winners for universal service (with R. Steinberg). *Management Science* **46**, (2000). 586-596.

An approach to service level agreements for IP networks with differentiated services (with R.J. Gibbens, S.K. Sargood, H. Azmoodeh, R. Macfadyen and N. Macfadyen). *Philosophical Transactions of the Royal Society, Series A***358**, (2000). 2165-2182.

Models for a self-managed Internet. *Philosophical Transactions of the Royal Society, Series A***358**, (2000). 2335-2348.

Distributed admission control. (with P.B. Key and S. Zachary) *IEEE Journal on Selected Areas in Communications* **18**, (2000). 2617-2628.

Fixed-point models for the end-to-end performance analysis of IP networks (with R.J. Gibbens, S.K. Sargood, C. Van Eijl, H. Azmoodeh, R.N. Macfadyen and N.W. Macfadyen). *13th ITC Specialist Seminar: IP Traffic Measurement, Modeling and Management*, Sept 2000, Monterey, California.

Mathematical modelling of the Internet. In *Proceedings of the Fourth International Congress on Industrial and Applied Mathematics, Edinburgh* (1999). 105-116. (A longer version of this paper appeared in:) *Mathematics Unlimited - 2001 and Beyond* (eds B. Engquist and W. Schmid). Springer-Verlag, Berlin (2001). 685-702.

On packet marking at priority queues (with R.J. Gibbens). *IEEE Transactions on Automatic Control* **47** 47 (2002). 1016-1020.

Fairness and stability of end-to-end congestion control. *European Journal of Control* **9** (2003). 159-176.

Fluid model for a network operating under a fair bandwidth-sharing policy (with R. J. Williams). *Annals of Applied Probability* **14** (2004) 1055-1083.

Fair Internet traffic integration: network flow models and analysis.
Integration equitable du trafic dans l'Internet: modeles fluides de flots et leur analyse (with Peter Key, Laurent Massoulie and Alan Bain). *Annales des Telecommunications* **59** (2004) 1338-1352. (An earlier version of this paper appeared as:
A network flow model for mixtures of file transfers and streaming traffic. In *Proceedings of the 18th International Teletraffic Congress*, Berlin, 2003.

Modelling incentives for collaboration in mobile ad hoc networks (with Jon Crowcroft, Richard Gibbens and Sven Ostring). *Performance Evaluation* **57** (2004) 427-439.

Network dimensioning, service costing and pricing in a packet switched environment (with Gareth Davies and Michael Hardt). *Telecommunications Policy* **28** (2004) 391-412.

Fluid and Brownian approximations for an Internet congestion control model (with W. Kang, N. H. Lee and R. J. Williams). In *Proceedings of the 43rd IEEE Conference on Decision and Control* (2004).

Stability of end-to-end algorithms for joint routing and rate control (with Thomas Voice). *Computer Communication Review* **35**:2 (2005) 5-12.

A contract and balancing mechanism for sharing capacity in a communication network (with Edward Anderson and Richard Steinberg). *Management Science* **52** (2006) 39-53.

Data and innovation: the case for experimentation. *Foundation for Science and Technology Journal* **19**:2 (2006) 14-15.

The mathematics of traffic in networks. In *The Princeton Companion to Mathematics* (eds W.T. Gowers and J. Barrow-Green), Princeton University Press.

PATENTS

Telecommunications network and method (with R. Gibbens, P. Key, P.A. Turton, R.R. Stacey and M.J. Whitehead). initially *British Patent Application 8531138, 18 December 1985*, subsequently world-wide patents granted.

Communication network and method. *British Patent Application 8607576, 26 March 1986.*

The routing scheme and optimization procedures described in these patent applications were implemented in British Telecom's UK digital main network and elsewhere.