AD-A187 122 MATHEMATICAL PROBLEMS IN STABILITY CONTROL AND RELIABILITY OF RANDOM ACCE (U) MASSACHUSETTS UNIV AMHERST DEPT OF MATHEMATICS AND STATISTICS W A ROSENKRANTZ 01 JUL 87 AFOSR-TR-87-1467 F/G 25/5 1/1

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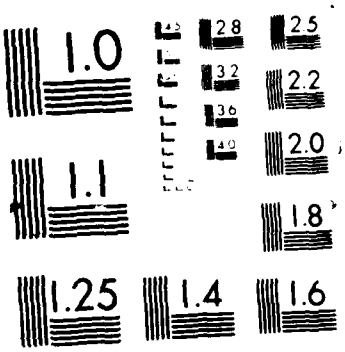
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AFOSR-TR- 87-1467

Final Scientific Report

Period 15 May,1982-14 May,1987 1 July 1987

Title:Mathematical Problems in Stability,Control and Reliability of Random access Communication Systems

Principal Investigator:Walter A.Rosenkrantz.

I.Publications

1983 a) Calculation of the Laplace transform of the length of the busy period for the M/G/1 queue via martingales, Annals of Prob. Vol. 11, #3, 817-818.

1983 b) Diffusion Approximation for a class of Markov processes satisfying a nonlinear Fokker-Planck equation, Nonlinear Analysis, Theory, Methods and Applications, Vol. 7, #10, 1089-1099, (with Li Zhan Bing).

1983 c) On the instability of the slotted ALOHA multiaccess algorithm, IEEE Transactions on Automatic Control, Vol. AC-28, #10, 994-996 (with D. Towsley).

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This is the principal investigator's final scientific report containing: (i) list of publications, (ii) invited lectures, conferences, symposia, (iii) Professional personnel associated with research effort, (iv) Status of current research, (v) list of references to probe further.

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1984 a) Weak convergence of a sequence of queueing and storage processes to a singular diffusion, (Proceedings of the International Seminar on Modelling and Performance Evaluation Methodology, Paris, France), Lecture Notes in Control and Information Sciences #60, 257-272, Springer Verlag.

1984 b) Some theorems on the instability of the exponential back-off protocol. Proceedings of 10th Anniversary Symposium Performance '84, Paris, France, December 1984, 199-205. Edited by E. Gelenbe, Published by North Holland.

1984 c) An operator method for computing the asymptotics of a collision resolution interval, AFOSR 82-0167, No.9

1985 a) A birth and death process approximation for the slotted ALOHA algorithm (with W. Rising) AFOSR 82-0167 Tech. Report No. 12.

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1986 a) Some remarks on the asymptotic behaviour of the lengths of a collision resolution interval, IEEE Trans. on Communications Vo. COM-34, No. 9 Sept. '86 962-965.

1987 a) Approximate counting: A Martingale Approach, Stochastics,Vol.20 111-120.

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1987 b) A direct proof of the exponential limit law for one dimensional small noise diffusion processes,to appear in the Jouurnal of Mathematics and Applications.

1987 c) On the expected time to collapse of the slotted ALOHA protocol, with W.Rising.

II.Invited Lectures,Conferences,Symposia,etc.

i)"Application of Functional Analytic and Martingale methods to Markov processes occuring in Queueing Theory",IEEE Information Theory Group Symposium on Information Theory,Les Arcs,France,21-25 June,,1982.

ii)"Weak Convergence of a sequence of Queueing and Storage Processes to a Singular Diffusion Process",International Seminar on Modelling and Performance Evaluation Methodology,24-26 Jan.1983,Paris,France.

iii)"Some Theorems on the Instability of the Exponential Back-off Protocol",Performance '84 Symposium,19-21 December 1984,Paris,France.

iv)"Modelling and Analysis of Random Access Communication Systems", Imperial College,London,England,14 Nov. 1985

v)"An Operator Method for Computing the Asymptot-

ics of a Collision Resolution Interval"

Cambridge University,Cambridge,England,15 Nov.1985

and

vi)INRIA,France,November 1985

vii)"Recent results of Aldous on Random Access Communication Systems", Univ.de Paris VI,Seminaire de Laboratoire de Probabilites,14 Jan. 1986

viii)"Modelling and Analysis of Communication Protocols for Random Access Communication Systems",Stichting Mathematisch Centrum(CWI) Amsterdam,Holland,14 April 1986

ix)"An operator method for computing the asymptotics of a collision resolution interval",University of Utrecht,Department of Mathematics, 17 April 1986.

x)"A Martingale Approach to Approximate Counting",INRIA(Sophia Antipolis),Journees d'etudes,Modelisation et Evaluation de Systemes Informatiques,29 April 1986.

xi)Mathematical Problems in Random Access Communication Systems" is the title of a lecture that I presented several times including:

a)University of Geneva,Switzerland,10 June 1986.

b)ETH,Zurich,Switzerland,11 June 1986

c)Ecole Polytechnique,France,23 June 1986

xii)I attended the TIMS-ORSA Symposium on Queueing Networks and their Applications,7-9 Jan.1987,New Brunswick,New Jersey.

xiii)"A Direct proof of the Exponential Limit Law for Small Noise Diffusion Processes",Rutgers University,25 March 1987

xiv)"A Martingale Approach to Approximate Counting",Bellcore,Morristown, New Jersey,26 March 1987.

III.Professional Personnel associated with Research Effort

i)Freda Bennett,PH.D Sept.1983

Title of Thesis:"On a sequence of Markov Processes converging to a Multivariate Ornstein-Uhlenbeck Process",AFOSR 82-0167 Technical Report No.6

ii)William Rising,graduate student,is currently working on a PH.D thesis on the mathematical modelling and analysis of the ALOHA and Exponential Backoff (EBO) protocols.Of particular in-

terest are qualitative and quantitative analyses of "bistability",e.g. "the mean time to collapse of ALOHA" and similar questions for EBO.The research also involves devising a numerically stable method for computing first passage times so that we can compare the approximate answers with the exact answers.

IV.Status of Current Research and Future Directions

The new technologies of packet switching,local area networks, satellite communications,load balancing of distributed processors,etc. have spawned a myriad of novel protocols which are not easily analysed via traditional queueing theory methods.The contributions of the principal investigator to these problems are contained in various technical reports and articles listed in Part I(publications) of this report.Future research will focus on ergodicity conditions for a) slotted ALOHA with a finite number of users and infinite buffers, b)EBO with a finite number of users and infinite buffers,c)bistability for EBO,d)performance analysis of load balancing protocols and related questions.Mathematical methods to be used include martingales,diffusion approximations,large

deviations,etc.We point out,however,that these problems cannot be solved via a routine application of martingale theory,say,or the general theory of large deviations.For it is a non trivial task to find the right Lyapounov function,or the correct "rate function" etc.And,finally,one has to validate the proposed model.

To probe further we have prepared the following bibliography:

V.References:

[Al 1987] D.Aldous,"Ultimate Instability of Exponential Backoff protocol...",IEEE TRANS.ON INFORMATION Th. VOL. IT-33 NO.2,pp219 -223,March 1987

[Ca-He 1975] A.B.Carleial and M.Hellman,"Bistable behaviour of ALOHA type systems",IEEE TRANS.Commun.,Vol. Com-23,pp 401-410

[E-L-Z] Eager,Lazowska,Zahorjan "Dynamic Load Sharing in Homogeneous distributed Systems",Tech.Report 84-10-1,Comp. Sci.Dept.,University of Washington,Seattle,Washington

[GGMM 1985] Goodman,Greenberg,Madras,March,"On the Stability of the Ethernet",preprint available from

Bell Labs(A.Greenberg)

[KL-LA 1975] Kleinrock and Lam,"Packet switching in a multi- acces channel:Performance evaluation",IEEE Trans.Commun. Vol.23,pp 410-423,April 1975

[Li-Me] Livny-Melman,"Load balancing in homogeneous broadcast distributed systems",Proc.ACM Computer Network Performance Symposium(April 1982)pp47-55.

[Ma 1985] J.Massey,Guest Editor,"Special issue on random access communications",IEEE Trans.on Information Theory,Vol.IT-31, No.2,March 1985.

[Pa-Sch-Wal 1986] Parekh,Schoute,and Walrand "Instability and geometric transience of the ALOHA protocol",Mem.No.UCB/ERL M86/73,Electronics Research Laboratory,U.Cal.(Berkeley)

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