

AD-A205 060

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified			1b. RESTRICTIVE MARKINGS DTIC FILE COPY	
2a. SECURITY CLASSIFICATION AUTHORITY 10 U.S.C. 2358			3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE				
4. PERFORMING ORGANIZATION REPORT NUMBER(S)			5. MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR-TR-89-0222	
6a. NAME OF PERFORMING ORGANIZATION Computer Science Duke Univ.		6b. OFFICE SYMBOL (If applicable) nm	7a. NAME OF MONITORING ORGANIZATION AFOSR/PRG nm	
6c. ADDRESS (City, State, and ZIP Code) OOLE Allen Building Durham, NC 27706			7b. ADDRESS (City, State, and ZIP Code) Building 410 Bolling AFB, D.C. 20332-6448	
8a. NAME OF FUNDING / SPONSORING ORGANIZATION AFOSR/NM		8b. OFFICE SYMBOL (If applicable) nm	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER AFOSR-84-0132	
8c. ADDRESS (City, State, and ZIP Code) Building 410 Bolling AFB, D.C. 20332-6448			10. SOURCE OF FUNDING NUMBERS	
			PROGRAM ELEMENT NO. 61102F	PROJECT NO. 2304
11. TITLE (Include Security Classification) Reliability Evaluation of Fault-Tolerant Multiprocessor Systems				
12. PERSONAL AUTHOR(S) Kishor S. Trivedi				
13a. TYPE OF REPORT Final		13b. TIME COVERED FROM 86/5/1 to 9/30/88		14. DATE OF REPORT (Year, Month, Day) 88/12/8
15. PAGE COUNT				
16. SUPPLEMENTARY NOTATION				
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB-GROUP		
19. ABSTRACT (Continue on reverse if necessary and identify by block number) See attached sheet				
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL Brian W. Woodruff, Maj., USAF/NM			22b. TELEPHONE (Include Area Code) (202) 767-5025	22c. OFFICE SYMBOL nm

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Major Accomplishments Under AFOSR84-0132

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Under the auspices of this grant, we have developed a hierarchical, combinatorial-Markov approach for solving large reliability/availability/performance models of systems. The approach allows the modeler to combine good aspects of both combinatorial models and Markov models to obtain a cost-effective solution to large models. The approach has been used in two Ph.D. dissertations (LTCL Jim Blake, who studied the performability of multiprocessor interconnection networks and Malathi Veeraraghavan, who modeled many fault-tolerant systems, including Boeing's IAPSA, Draper Laboratories' AIPS). Jim Blake has joined the Army AIRMICS Laboratory and Malathi has joined AT&T Bell Laboratories in Columbus.)

Other methods of dealing with complex system models that we have explored include automated methods of Markov model generation using Stochastic Petri nets. Efficient methods of solving stochastic Petri net models are being investigated by Gianfranco Ciardo in his dissertation. His work also involves applying SPN techniques for the performance analysis of concurrent programs.)

Much of our research deals with the transient solution of large and stiff Markov and Markov reward models. We have developed a decomposition technique for the transient analysis of stiff Markov chains jointly with Dr. A. Bobbio of Institute Ferraris, Torino, Italy. A description of the technique was published in the IEEE Transactions on Computers (September 1986) and is receiving wide attention. We have carried out a thorough comparison of the transient analysis methods of Markov models within the scope of the Ph.D. thesis by Andrew Reibman. This work has received attention in Applied Probability and Operations Research community. Andrew has accepted a position at AT&T Bell Laboratories in order to further utilize this research in solving reliability models of communication systems.

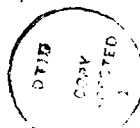
Our work on Markov reward models is important not only because we have developed an efficient algorithm for numerical solution but also because of a large variety of applications we are exploring. The research on Markov reward models consists of interdisciplinary (with Dr. Kulkarni of Operational Research Curriculum at the University of North Carolina) and International (Dr. Francois Baccelli of INRIA, France and Dr. Raymond Marie of IRISA, Rennes, France) collaborations. The applications have addressed the effectiveness evaluation of 16x16 multiprocessor systems with various interconnection schemes, response-time distribution in an M/M/1 queue with processor sharing discipline, distribution of time-averages in queueing systems, and response time distributions of tasks in a system subject to failure and repair. Three Ph.D. dissertations have been completed in this area. One by Victor Nicola, who has joined IBM Yorktown Research Center, second by Roger Smith, who has joined Yale University and the third by Phil Chimento, who will remain at IBM Research Triangle Park.

Another important area of research is in the analysis of the coverage of a fault tolerant system, that is, the probability that the system can recover from a fault. We have studied a variety of models, from simple phase-type models to very complex stochastic Petri net models, and have investigated solution techniques for each model type. Our methodology allows consideration of external events that can interfere with recovery, such as a hard limit on recovery time, or the occurrence of a second near-coincident fault. We discovered that a policy of attempting

transient recovery upon detection of an error (as opposed to automatically reconfiguring the affected component out of the system) may actually increase the unreliability of the system. This result holds if the error detectability is not nearly perfect, so that the risk of producing an undetectable error (if the transient error is present) is greater than the benefit gained by not discarding the component.

A list of all papers and thesis supported in part of by this grant is attached alongwith.

Accession For	
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DTIC TAB	☐
Unannounced	☐
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November 11, 1988

Publications under AirForce Grant AFOSR-84-0132

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