

Swapna S. Gokhale

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RESEARCH INTERESTS

Converged IP/PSTN networks, Wireless networks, Software architecture, Software testing and reliability, Software maintenance, Program comprehension, and Performance and reliability evaluation of computer networks and systems.

EDUCATION

Ph.D. in Electrical and Computer Engineering, Duke University (Sept. 1998)
Dissertation: Analysis of Software Reliability and Performance
Advisor: Prof. Kishor S. Trivedi

M.S. in Electrical and Computer Engineering, Duke University (Sept. 1996)
Thesis Title: Software Reliability Modeling and Validation Techniques
Advisor: Prof. Kishor S. Trivedi

B.E. (Hons.) Electrical and Electronics, BITS, Pilani (Aug. 1994)
B.E. (Hons.) Computer Science, BITS, Pilani (Aug. 1994)

RESEARCH / WORK EXPERIENCE

Aug. 99 - present: **Research Scientist** in the Software Environment Research Group, Telcordia Technologies Inc., (formerly Bellcore), Morristown, NJ.
Research projects include:

- **Commercial Network Auditing for Converged VoIP/PSTN**
The aim of this project is to analyze the architecture, data, and the interfaces of Telcordia's Call Agent to investigate the feasibility of providing auditing and surveillance capabilities, specifically for the detection of malicious intruders and recovery from such intrusions. Telcordia's Call Agent is a class 5 switch replacement that operates on a packet network to deliver voice-over-IP (VoIP) services. This project is sponsored by the Laboratory of Telecommunication Sciences and is conducted in partnership with Lucent Technologies.
- **Solution Modeling**
This project involved experimenting with the tool "BEST/1 for Distributed Systems" from BMC Software to determine if the tool was capable of effectively predicting (a) the performance of a stack of applications using the performance data of each constituent application in the stack, and (b) the impact of changing the class and the number of processors on the performance of an application. Experiments were also conducted to determine if BEST/1 was capable of analyzing the influence of changes in the application workload on performance. A stack of Telcordia's

Operation Support Systems (OSS) applications served as the experimental test bed. Formal analytical modeling approaches were also explored to supplement the analyses carried out using BEST/1.

- **Performance Analysis of an Automated Voice Dialer**

This project involved analyzing the performance data logged during the operation of an Automated Voice Dialer and computing various statistics related to its speech recognition performance. The computed statistics were used to tune the recognition performance of the Voice Dialer.

- **Processing of directory listings**

This project involved processing of directory listings to determine the distribution of various entities such as first names, last names, street addresses, townships, and business words. The analysis revealed that the distribution of the entities is highly skewed, with very few entities covering a large percentage of the total population. Additionally, the distributions were found to be more or less similar across multiple geographic regions. The results of this analysis are being used to guide dialogue design for automated directory assistance. These intelligent dialogues would attempt to maximize the information uncovered from the subscriber thereby maximizing the probability of providing the subscriber with the requested directory number without manual intervention.

- **Integration of architecture specification, testing and performance analysis**

This project focused on developing a methodology to integrate three distinct areas in software architecture, namely, specification, testing and analysis. The methodology consisted of translating an SDL specification of a system to a stochastic Petri net, parameterizing the Petri net using the trace data generated from simulation/testing of the specification, and using the parameterized Petri net to compute various performance measures of interest.

July 98 - Aug. 99: Post Graduate Researcher at the University of California, Riverside.

Research in the area of Wireless and Multimedia Networking, with emphasis on QoS routing.

Supervisor: Prof. Satish K. Tripathi

Research projects included:

- **QoS Routing**

This project involved evaluating (a) the tradeoffs in explicit route support using MPLS, (b) the relationship between the reliability of nodes and links and QoS routing, and (c) architectural designs to support QoS routing.

- **QoS in Wireless Networks**

This project consisted of evaluating the effect of the quality of statistical mobility information on the reliability of the service experienced by the users in mobile networks.

Sept. 97 – May 98: Consultant to Bell Communications Research, New Jersey

Conducted research in the area of software testing and reliability.

May 97 – Aug. 97: Summer Intern, Software Environment Research Group, Bell Communications Research, New Jersey

Development of techniques for component-based reliability prediction.

Supervisor: Dr. J. R. Horgan

Aug. 95 – May 97: Research Assistant, Dept. of Electrical & Computer Engg., Duke University

Research work involved enhancement of non-homogeneous Poisson process (NHPP) software reli-

ability models to incorporate code coverage, and development of models to study the influence of various repair policies on software reliability.

May 96 – Aug. 96: **Summer Intern**, Distributed Software Research Group, Lucent Technologies, Bell Laboratories, New Jersey
Research included developing simulation techniques for predicting software and system reliability, and software quality.
Supervisor: Dr. Michael R. Lyu

May 95 – Aug. 95: **Summer Intern**, Performance Modeling Group, Motorola Inc., Arlington Heights, Illinois
Developed a generic model based on classical queuing theory, which gives an insight into the behavior of a processor under overload conditions.

Aug. 94 – May 95: **Teaching Assistant**, Dept. of Electrical & Computer Engg, Duke University
In charge of grading and laboratory work for an introductory course titled “Switching and Logic Design.” Also assisted in the development of a database program using Curses - the Unix System V terminal screen handling and optimization package.

Jan 94 – June 94: **Undergraduate Intern**, Citicorp Information Technology Industries, Bombay, India. A subsidiary of Citicorp, USA
Design of a test bed for porting VOS libraries to UNIX, and the development of a user interface for source code administration using SCCS.

July 93 – Dec. 93: **Undergraduate Intern**, National Informatics Center, New Delhi, India
Designed a microprocessor based teletext reception meter and card for TV.

May 91 – Aug. 91: **Summer Intern**, Bhabha Atomic Research Center, Bombay, India
Developed a microprocessor based system for the speed control of a DC motor.

PUBLICATIONS (JOURNAL)

1. J. Jobin, S. K. Tripathi, S. Gokhale, and M. Faloutsos, “Using Statistical Data for Reliable Mobile Communications,” in *Journal of Wireless Communications and Mobile Computing (To Appear)*, 2001.
2. W. E. Wong, S. Gokhale, and J. R. Horgan, “Quantifying the Closeness Between Program Components and Features,” in *Journal of Systems and Software*, vol. 54, Number 2, pp. 87-98, October 2000.
3. S. Ramani, S. Gokhale, and K. S. Trivedi, “Software Reliability Estimation and Prediction Tool,” in *Performance Evaluation*, vol. 39, pp. 37-60, 2000.
4. S. Gokhale and K. S. Trivedi, “A Time/Structure Based Software Reliability Model,” in *Annals of Software Engineering*, vol. 8, pp. 85-121, 1999.
5. S. Gokhale, P. N. Marinos and K.S. Trivedi, “Important Milestones in Software Reliability Modeling,” in *Communications in Reliability, Maintainability and Serviceability: An International Journal* published by SAE, 1996.

PUBLICATIONS (REFEREED CONFERENCE / SYMPOSIA PROCEEDINGS)

1. S. Wadekar and S. Gokhale, "Exploring Cost and Reliability Tradeoffs in Architectural Alternatives using a Genetic Algorithm," in *Proc. of Intl. Symposium on Software Reliability Engineering (IS-SRE 99)*, pp. 104-113, Boca Raton, FL, November 1999.
2. W. E. Wong, S. Gokhale, and J. R. Horgan, "Metrics for Quantifying the Disparity, Concentration, and Dedication between Program Components and Features," in *Proc. of METRICS (METRICS 99)*, pp. 189-198, Boca Raton, Florida, November 1999.
3. S. Gokhale and S. K. Tripathi, "Effect of Unreliable Nodes on QoS Routing," in *Proc. of Intl. Conference on Network Protocols (ICNP 99)*, pp. 173-181, Toronto, October 1999.
4. W. E. Wong, S. Gokhale, J. R. Horgan, and K. S. Trivedi, "Locating Program Features Using Execution Slices," in *Proc. of Application Specific Software Engineering and Technology (ASSET 99)*, pp. 194-203, Richardson, TX, March 1999.
5. S. Gokhale, M. R. Lyu, and K. S. Trivedi, "Reliability Simulation of Component-Based Systems," in *Proc. of Intl. Symposium on Software Reliability Engineering (ISSRE 98)*, pp. 192-201, Paderborn, Germany, November 1998.
6. S. Gokhale, M. R. Lyu, and K. S. Trivedi, "Software Reliability Analysis Incorporating Debugging Activities," in *Proc. of Intl. Symposium on Software Reliability Engineering (ISSRE 98)*, pp. 202-211, Paderborn, Germany, November 1998.
7. S. Gokhale and K. S. Trivedi, "Log-logistic Software Reliability Model," in *Proc. of High Assurance Systems Engineering Conference (HASE 98)*, pp. 34-41, Gaithersburg, MD, November 1998.
8. S. Gokhale, W. E. Wong, K. S. Trivedi, and J. R. Horgan, "An Analytical Approach to Architecture-Based Software Reliability Prediction," in *Proc. of Intl. Computer Performance and Dependability Symposium (IPDS 98)*, pp. 13-22, Durham, NC, September 1998.
9. S. Ramani, S. Gokhale, and K. S. Trivedi, "Software Reliability Estimation and Prediction Tool," in *Proc. of Tenth International Conference for Computer Performance Evaluation, TOOLS 98*, pp. 27-35, Palma, Spain, September 1998.
10. S. Gokhale and K. S. Trivedi, "Dependency Characterization in the Path-Based Approaches to Architecture-Based Software Reliability Prediction," in *Proc. of Application-Specific Software Engineering and Technology (ASSET 98)*, pp. 86-89, Richardson, TX, March 1998.
11. S. Gokhale, M. R. Lyu, and K. S. Trivedi, "Model Validation using Simulated Data," in *Proc. of Application-Specific Software Engineering and Technology (ASSET 98)*, pp. 22-27, Richardson, TX, March 1998.
12. S. Gokhale and K. S. Trivedi, "Structure-Based Software Reliability Prediction", *Proc. of Fifth Intl. Conference on Advanced Computing (ADCOMP 97)*, pp. 447-452, Chennai, India, December 1997.
13. S. Gokhale, M. R. Lyu, and K. S. Trivedi, "Reliability Simulation of Fault-Tolerant Software and Systems", *Proc. of Pacific Rim International Symposium on Fault Tolerant Systems (PRFTS 97)*, pp. 167-173, Taipei, Taiwan, December 1997.
14. S. Gokhale, P. N. Marinos, K. S. Trivedi, and M. R. Lyu, "Effect of Repair Policies on Software Reliability," *Proc. of Computer Assurance (COMPASS 97)*, pp. 105-116, Maryland, June 1997.

15. S. Gokhale, T. Philip, P. N. Marinos, and K. S. Trivedi, "Software Reliability Modeling with Imperfect Repair Actions," in *Proc. of GOMAC 97*, Las Vegas, March 1997.
16. S. Gokhale and M. R. Lyu, "Regression Tree Modeling for the Prediction of Software Quality," *Proc. of Third ISSAT Intl. Conference on Reliability and Quality in Design*, Anaheim, California, pp. 31-36, March 1997.
17. S. Gokhale, T. Philip, P.N. Marinos, and K.S. Trivedi, "Unification of Finite Failure NHPP Models through Test Coverage," in *Proc. Intl. Symposium on Software Reliability Engineering (ISSRE 96)*, pp. 299-306, White Plains, NY, October 1996.
18. S. Gokhale, T. Philip, and P. N. Marinos, "A Non-Homogeneous Markov Software Reliability Model with Imperfect Repair", in *Proc.1996 IEEE Intl. Computer Performance and Dependability Symposium (IPDS 96)*, pp. 262-270, Urbana-Champaign, IL, September 1996.
19. S. Gokhale, P.N. Marinos, and K.S. Trivedi, "Important Milestones in Software Reliability Modeling," in *Proceedings of Software and Knowledge Engineering (SEKE 96)*, pp. 345-352, Lake Tahoe, June 1996.

REFEREED TUTORIALS

1. S. Gokhale and K. S. Trivedi, "Architecture-Based Performance and Reliability Analysis of Software Systems," Tutorial presented at *Intl. Symposium on Software Reliability Engineering*, San Jose, CA, October 2000.
2. S. Gokhale, W. E. Wong, and K. S. Trivedi, "Architecture-Based Performance and Reliability Analysis of Software Systems," Tutorial presented at *Intl. Symposium on Software Reliability Engineering*, Boca Raton, FL, November 1999.

INVITED TUTORIALS

1. S. Gokhale, V. B. Mendiratta, and K. S. Trivedi, "Software Reliability Engineering: From Architecture to Deployment," in *Proc. of Lucent Technologies Reliability Information Forum (RIF 99)*, Columbus, OH, April 1999.
2. S. Gokhale, V. B. Mendiratta, and K. S. Trivedi, "Software Reliability Engineering from a Practitioner's Standpoint," in *Proc. of Lucent Technologies Reliability Information Forum (RIF 98)*, Naperville, IL, April 1998.

WORKSHOPS

1. S. Gokhale and S. A. Wadekar, "Reliability Maximization of Component-Based Software Systems," Fast Abstract in *Proc. of Pacific Rim Dependability Conference (PRDC 2000)*, Los Angeles, CA, December 2000.
2. W. E. Wong, S. Gokhale, and J. R. Horgan, "Quantifying the Closeness Between Program Components and Features," in *1999 Workshop on Software Change and Evaluation (SCE 99)*, Co-located with *Intl. Conference on Software Engineering*, Los Angeles, CA, May 1999.

3. S. Gokhale and S. R. Tilley, "On the Unforeseen Consequences of Simple Design Decisions", in *1999 Workshop on Software Change and Evaluation (SCE 99)*, Co-located with *Intl. Conference on Software Engineering*, Los Angeles, CA, May 1999.
4. S. Gokhale, S. Ramani, and K. S. Trivedi, "SREPT: An Integrated Approach to Software Reliability Estimation and Prediction", Fast Abstract in *Proc. of Intl. Symposium on Software Reliability Engineering (ISSRE 98)*, Paderborn, Germany, November 1998.
5. S. Gokhale, M. R. Lyu, and K. S. Trivedi, "Simulation Techniques for Software Reliability Engineering Incorporating Software Architecture", *Proc. of Eighth SRE Workshop*, AT&T Middletown, New Jersey, June 1997.

OTHER PUBLICATIONS

1. S. Gokhale and K. S. Trivedi, "Analytical Modeling," in *Encyclopedia of Distributed Systems*, Kluwer Academic Publishers, 1998.

JOURNAL PUBLICATIONS UNDER REVIEW

1. S. Gokhale, M. R. Lyu, and K. S. Trivedi, "Incorporating Fault Debugging Activities into Software Reliability Models: A Simulation Approach," Submitted to *IEEE Transactions on Reliability*.
2. S. Gokhale, W. E. Wong, K. S. Trivedi, and J. R. Horgan, "An Analytical Approach to Architecture-Based Performance and Reliability Prediction," Submitted to *Performance Evaluation*.

RESEARCH GRANTS

- Co-PI, Proposal submitted to NSF in response to the Next Generation Software Initiative (in collaboration with Duke University and Purdue University).
- Co-PI, Proposal submitted to NSF in response to Trusted Computing Initiative (in collaboration with Duke University).

AWARDS

- Best paper award at ISSRE '98, for the paper titled "Reliability Simulation of Component-Based Software Systems."
- IBM Fellowship, September 1997 - May 1998.
- Recipient of the BITS Merit Scholarship awarded to the top 10 students (all departments), (1989–1993).
- Nominated as the Student Member of the Senate (1 out of 4) for the year 1991-1992.
- J.N. Tata Endowment Fellowship Award, 1994.

PROFESSIONAL ACTIVITIES

- Program Committee member:
 - International Symposium on Software Reliability Engineering (ISSRE 02), Washington, DC.
 - International Symposium on Software Reliability Engineering (ISSRE 01), Hong Kong.
 - International Conference on Computer, Communications and Networks (ICCCN 01), Scottsdale, AZ.
 - International Performance and Dependability Symposium (IPDS 2000), Chicago, IL.
- Reviewed papers for various conferences and journals including:
 - IEEE/ACM Transactions on Networking
 - INFOCOM
 - IEEE Transactions on Software Engineering
 - IEEE Transactions on Computers
 - IEEE Transactions on Reliability.
 - Performance Evaluation
 - International Performance and Dependability Symposium
 - International Symposium on Software Reliability Engineering
- Assisted in the organization of the Program Committee meetings:
 - Intl. Performance and Dependability Symposium (IPDS '96), Urbana-Champaign, IL.
 - Intl. Symposium on Software Reliability Engineering (ISSRE '96), White Plains, NY.
 - Intl. Symposium on Software Reliability Engineering (ISSRE '97), Albuquerque, NM.
 - Intl. Performance and Dependability Symposium (IPDS '98), Durham, NC.

COURSE WORK

- Mathematical Methods of System Analysis, Advanced Computer Architecture, Electromagnetic Fields and Waves, Performance and Reliability of Computer Networks. Statistical Inference, Stochastic Models in Operations Research II. Linear Models, Statistical Laboratory, Data Compression, Random Signals and Noise, Signal Detection and Extraction Theory, Digital Signal Processing, Optical Communication Systems.

UNDERGRADUATE PROJECTS

- Applications of Graph Theory to Combinatorial Operations Research : studied the graph theoretic techniques for solving problems in Switching Theory, Network Flow problems, and the Traveling Salesman Problem.
- Compiler Construction and Design : Studied the various phases of a compiler and implemented a Lexical Analyzer using the Lex and Yacc utilities of UNIX.
- Design of a 4 bit Arithmetic and Logic Unit using n-MOS technology.

- Design of a Gyrator Circuit : A circuit to simulate an inductor using resistors and capacitors.

COMPUTER SKILLS AND TOOLS

- MaRS - Maryland Routing Simulator, originally designed to evaluate the performance of various routing protocols, further enhanced to study performance tradeoffs in QoS routing.
- NS - Network Simulator
- Knowledge of TCP/IP, RSVP, MPLS, SIP, MGCP, H.323, SS7.
- SHARPE : Symbolic Hierarchical Automated Reliability and Performance Evaluator. A software tool used to analyze stochastic models.
- SPNP : Stochastic Petri Net Package, a software tool which automatically generates and solves Markov Models. SPNP can also be used to obtain the transient solution and carry out parametric sensitivity analysis besides obtaining the steady state solution.
- SMERFS: Statistical Modeling and Estimation of Reliability Functions for Software.
- CASRE : Computer Aided Software Reliability Estimation.
- χ Suds - Software Understanding and Diagnosis System developed at Bellcore, included χ ATAC - Coverage analysis tool, χ Slice - slicing tool, χ Prof - profiling tool.
- Nuance Speech Recognition System
- SDL (System Description Language) and SDT simulator from Telelogic.
- Unified Modeling Language (UML)
- BEST/1 for Distributed Systems - A data collection and performance analysis tool used for capacity planning and performance prediction.
- Hardware : SUN SPARC station, DEC 5000 station, IBM Mainframe, HP 1651B Logic Analyzer.
- Software : C, C++, Pascal, Fortran, Assembly Language for 80X86 and 680XX series, Tcl/Tk, XF, Mathematica, Matlab, Splus, SAS, LaTeX, Microsoft Office Products, Framemaker, ViewLogic, Xilinx, Interleaf.
- Operating Systems : DOS, Unix.

VISA STATUS

U.S. Permanent Resident

REFERENCES

- Prof. Kishor S. Trivedi
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