

Douglas Craig Schmidt

Associate Professor
Department of Computer Science
Washington University
Campus Box 1045
One Brookings Drive
St. Louis, Missouri 63130-4899
TEL: (314) 935-7538
FAX: (314) 935-7302
NET: schmidt@cs.wustl.edu
URL: <http://www.cs.wustl.edu/~schmidt/>

Associate Professor
Mallinckrodt Institute of Radiology
Washington University School of Medicine
Electronic Radiology Laboratory
510 South Kingshighway Boulevard, Box 8131
St. Louis, Missouri 63110
TEL: (314) 362-6965
FAX: (314) 362-6971

Educational Background

- **Ph.D. Computer Science**, winter 1994, University of California, Irvine
Dissertation: "An Object-Oriented Framework for Experimenting with Alternative Process Architectures for Parallelizing Communication Subsystems."
Co-advisors: Dr. Tatsuya Suda and Dr. Richard W. Selby
- **M.S. Computer Science**, summer 1990, University of California, Irvine, specializing in software engineering
- **M.A. Sociology**, summer 1986, College of William and Mary, Williamsburg, Virginia
Thesis: "A Statistical Analysis of University Resource Allocation Policies."
Advisor: Dr. Michael A. Faia
- **B.A. Sociology**, summer 1984, College of William and Mary, Williamsburg, Virginia

Professional Experience

- **7/98 – present: Associate Professor**
Currently conducting research on design patterns, implementation, and experimental analysis of object-oriented techniques that facilitate the development of high-performance, real-time distributed object computing systems on parallel processing platforms running over high-speed ATM networks and embedded system interconnects in the Department of Computer Science and the Department of Radiology at Washington University in St. Louis.
- **8/94 – 6/98: Assistant Professor**
Conducted research on object-oriented patterns and techniques for developing highly extensible, high-performance communication frameworks in the Department of Computer Science and the Department of Radiology at Washington University in St. Louis.
- **3/91 – 8/94: Computer System Design Research Assistant**
Developed an object-oriented framework for multi-processor-based communication subsystems with Professor Tatsuya Suda at the University of California, Irvine.

- **8/88 – 3/91: Software Engineering Research Assistant**
Devised measurement-guided software development techniques for large-scale software systems with Professor Richard Selby at the University of California, Irvine.
- **6/88 – 8/88: Research Assistant**
Studied the impact of computing on end-users in forty U.S. city governments with Dr. John King and the URBIS project at the Public Policy Research Organization, University of California, Irvine.
- **1/85 – 8/86: Sociology Research Assistant**
Examined university resource allocation policies via statistical analysis with Dr. Michael Faia at the College of William and Mary, Williamsburg, Virginia.

Awards and Honors

1. The paper “Optimizing the Performance of the CORBA Internet Inter-ORB Protocol Over ATM” was selected as the best paper in the Software Technology Track in the 31st Hawaii International Conference on System Systems (HICSS), Hawaii, January, 1998 (188 submitted, 77 accepted).
2. Listed in Marquis’ “Who’s Who in Media and Communications,” 1997.
3. Panelist for NSF software engineering and programming languages CAREER program.
4. Invited keynote speaker for 2nd Component’s User Conference, Munich Germany, July 1997.
5. Invited to participate in the OO Working Group of the “Strategic Directions in Computing Research” workshop sponsored by ACM at MIT in June 1996.
6. One of two faculty members nominated by Washington University for the Packard Fellowship, May 1996.
7. Received joint appointment to the Mallinckrodt Institute Department of Radiology, Washington University School of Medicine, February 1996.
8. Invited keynote speaker for 1st Component’s User Conference, Munich Germany, July 1996.
9. Invited to write the foreword for Dr. Nayeem Islam’s book on *Distributed Objects: Methodologies for Customizing Operating Systems* (IEEE Computer Society Press, 1996).
10. Invited to serve as program chair for 3rd conference on Programming Languages of Programming, Allerton, IL, USA, August, 1996.
11. Invited to serve as editor-in-chief of the C++ Report magazine, published by SIGS.
12. Invited to serve as program chair for 2nd USENIX Conference on Object-Oriented Technologies, June 1996.
13. Selected to participate in the ACM OOPSLA ’94 Doctoral Symposium.
14. Invited by Dr. Martina Zitterbart to participate in a 4-week international exchange program at the Universität Karlsruhe Institut für Telematik in Karlsruhe, Germany, April 1993.
15. Invited to co-author a regular column on distributed object computing entitled “Object Interconnections” for the C++ Report magazine from July 1994 to present. The co-author is Steve Vinoski, chief architecture for the HP ORB Plus CORBA object request broker product.
16. Invited contributor to the C++ Report magazine from July 1992 to present.
17. Served as elected representative to the Associated Graduate Student organization at the University of California, Irvine from May 1991 to June 1992.

18. Served as elected graduate student representative to the Computer Science Computing Resource Committee at the University of California, Irvine from August 1988 to August 1990.
19. Invited to work with Dr. Peter G. W. Keen at the International Center for Information Technology, Washington D.C. on a project assessing techniques for improving software productivity in the summer of 1987.
20. Awarded Teaching and Research Assistantships in Computer Science at University of California, Irvine during 1986-1994.
21. Awarded Research Assistantship in Sociology at the College of William and Mary during 1985-1986.

Professional Activities

Editorial Activities

1. Co-editor of a book entitled "Object-Oriented Application Frameworks," John Wiley & Sons, 1998 (co-editors Ralph Johnson and Mohamed Fayad).
2. Guest editor of the Special Issue on OO Application Frameworks for the Communications of the ACM, (co-editor Mohamed Fayad), ACM, October, 1997.
3. Guest editor of the special issue on Distributed Object Computing for USENIX Computing Systems Journal, November/December, 1996.
4. Guest editor of a feature topic on Distributed Object Computing for IEEE Communications Magazine, February, 1997.
5. Guest editor of the Special Issue on Patterns and Pattern Languages for Communications of the ACM, (co-editors Ralph Johnson and Mohamed Fayad), ACM, October, 1996.
6. Co-editor of a book entitled "Pattern Languages of Program Design," Addison-Wesley, 1995 (co-editor is Jim Coplien, Bell Labs).
7. Editor of the Patterns++ section of the C++ Report Magazine, April 1997 - present.
8. Editor-in-chief of the C++ Report Magazine, January 1996 - February 1997.
9. Editorial board member of the IEEE Computer Society - Computer Science & Engineering Practice Board.

Program Chairmanships

1. Tutorial chair for the 5th USENIX Conference on Object-Oriented Technologies and Systems, May 3-7, 1999, San Diego, CA.
2. Treasurer for the Fourth International Workshop on Object-oriented Real-time Dependable Systems (WORDS'99) January 27-29, 1999, Radisson Hotel, Santa Barbara, California, USA.
3. Tutorial chair for the 4th USENIX Conference on Object-Oriented Technologies and Systems, April 27-30, 1998, Santa Fe, New Mexico.
4. Co-chair of the mini-track on Engineering Client-Server Systems for the HICSS-31 conference, the Big Island of Hawaii - January 6-9, 1998.
5. Tutorial chair for the 3rd USENIX Conference on Object-Oriented Technologies and Systems, Portland, OR, June 1997.

6. Publicity chair for the 5th IEEE International Workshop on Object-Orientation in Operating Systems, IEEE TCOS and USENIX, Seattle, Washington, October 27-28, 1996.
7. Program chair for 3rd conference on Programming Languages of Programming, Allerton, IL, USA, September, 1996.
8. Program chair for the 2nd USENIX Conference on Object-Oriented Technologies, June 1996.

Program Committees

1. Technical program committee member for the 1999 IEEE Real-Time Technology and Applications Symposium (RTAS99).
2. Technical workshop committee for the International Software Architecture workshop, ACM SIGSOFT's FSE9 conference in Orlando FL, November 1-5, 1998.
3. Technical program committee for the workshop on Software and Performance (WOSP98), Santa Fe, New Mexico, Oct 12-16 1998.
4. Technical program committee for the IFIP International Conference on Distributed Systems Platforms and Open Distributed Processing: Middleware '98. September 15-18 1998, The Lake District, England.
5. Technical program committee for the TOOLS USA'98 conference. Santa Barbara, California, August 3 - 7, 1998.
6. Technical program committee for the IEEE High Performance Distributed Computing conference, Chicago, IL, July 28-31, 1998.
7. Technical program committee for 12th European Conference on Object-Oriented Programming, Brussels, Belgium, July 20 - 24, 1998.
8. Technical program committee for the 3rd EuroPLOP conference, Kloster Irsee, Germany, July 9-11, 1998.
9. Technical program committee of IEEE International Conference on Configurable Distributed Systems (ICCDs '98), Annapolis, MD, May 4-6, 1998.
10. Technical program committee of IEEE IWQoS '98 in Napa Valley, CA, May 18-20, 1998.
11. Technical program committee member for the 4th USENIX Conference on Object-Oriented Technologies and Systems, April 26-29, 1998, Santa Fe, New Mexico.
12. Technical program committee member for the 3rd International Workshop on Software Engineering for Parallel and Distributed Systems, at the 20th International Conference on Software Engineering (ICSE-20), in April 20-21, Kyoto, Japan.
13. Technical program committee for the IEEE Conference on Open Architectures and Network Programming, April 3-4, 1998, San Francisco, CA.
14. Technical program committee for the Workshop on Middleware for Real-Time Systems and Services, held in conjunction with IEEE Real-time Systems Symposium, December 2nd, San Francisco, California.
15. Technical program committee for the Open Signaling for ATM, Internet and Mobile Networks. October 6th and 7th, 1997, Columbia University, New York, NY.
16. Technical program committee member for the 24th International Conference on Technology of Object-Oriented Languages and Systems (TOOLS Asia '97). Beijing, China, September 22 - 25, 1997.
17. Technical program committee for the 4th Pattern Languages of Programming conference, Allerton Park, Illinois, September 3-5, 1997.

18. Technical program committee member for the 3rd USENIX Conference on Object-Oriented Technologies and Systems, Portland, June 16-19th 1997.
19. Session chair of the Patterns technical paper session at ECOOP '97, June 13th, 1997.
20. Technical program committee member for the 1997 European Conference on Object-Oriented Programming (ECOOP), June 9-13, 1997, Jyvaskyl, Finland.
21. Chair of the technical session on "Distributed Object Computing" for the IFIP/IEEE Fifth International Workshop on Quality of Service (IWQoS '97).
22. Technical program committee member for the 2nd International Workshop on Software Engineering for Parallel and Distributed Systems, at the 19th International Conference on Software Engineering (ICSE-19) Sheraton Boston Hotel and Towers, Boston, Massachusetts, USA, May 19 and 20, 1997.
23. Technical program committee member for the 3rd USENIX Conference on Object-Oriented Technologies and Systems, Portland, 1997.
24. Technical program committee member for the 5th IEEE International Workshop on Object-Orientation in Operating Systems, IEEE TCOS and USENIX, Seattle, Washington, October 27-28, 1996.
25. Technical program committee for the 1997 ACM SIGCOMM conference.
26. Technical program committee for the 1995, 1996, and 1997 IEEE INFOCOM conferences.
27. Technical program committee for the 3rd IEEE workshop on Architecture and Implementation of High Speed Communication Subsystems (HPCS '95), held in Mystic, Connecticut, August 1995.
28. Technical program committee for the 8th *IFIP International Working Conference on Upper Layer Protocols, Architectures, and Applications*, held in Barcelona, Spain, June 1 to 3, 1994.

Workshops

1. Organizer and chair of a panel on real-time extensions to OO middleware, OPENSIG Fall '97 workshop on Open Signaling for ATM, Internet and Mobile Networks Columbia University, October 6-7 1997, New York, NY.
2. Co-organizer of a workshop for the 1997 European Conference on Object-Oriented Programming entitled CORBA: Implementation, Use, and Evaluation, Jyvaskyla, Finland, June 10th, 1997.
3. Organizer and chair of a panel on "QoS and Distributed Systems Platforms" for the IFIP Fifth International Workshop on Quality of Service (IWQoS '97), May 22-24th, 1997, Columbia University, New York.
4. Co-organizer of the OOPSLA '95 workshop on "Patterns for Concurrent, Parallel, and Distributed OO Systems" together with Greg Lavender of the ISODE Consortium and Dennis Kafura of Virginia Tech.
5. Co-facilitator of the ECOOP '95 workshop workshop on Pattern Languages of Object-Oriented Programs together with Frank Buschmann of SIEMENS AG Corporate Research and Development, held in Aarhus, Denmark, August 1995.

Reviewer for Professional Submittals

- Refereed papers for the following journals, conferences, and grant review processes:
 1. Next Generation Internet (NGI) networking research review panel, October 1998.
 2. IEE Transactions on Software Engineering, special issue on Configurable Distributed Systems.
 3. Theme issue on Symbolic Modeling in Practice for the Communications of the ACM.

4. "Multimedia DBMS and the WWW" Minitrack at the 32nd Hawaii International Conference on System Sciences, 1999.
 5. "Dependable Distributed Systems" Minitrack at the 32nd Hawaii International Conference on System Sciences, 1999.
 6. IEEE Computer special issue on "Design Challenges for High-Performance Network Interfaces," 1998.
 7. 1998 NSF Experimental Software Systems review panel.
 8. ACM SIGMetrics Conference, 1998.
 9. ACM Transactions on Software Engineering Methods.
 10. Special Issue on Patterns and Pattern Languages for the journal of Theory and Practice of Object Systems, (Stephen P. Berczuk, Editor), John Wiley and Sons, 1995.
 11. Special Issue of Computer Communications on Building Quality of Service into Distributed Systems.
 12. IEEE Communications Magazine.
 13. IEEE/ACM Journal of Transactions on Networking.
 14. Communications of the ACM.
 15. IEE/BCS Distributed Systems Engineering Journal.
 16. Software Practice and Experience, John Wiley and Sons.
 17. 1998, 1997, and 1996 NSF networking program.
 18. 1996 NSF software engineering and programming languages CAREER panel.
 19. 1994 California MICRO (Microelectronics Innovation Computer Research Opportunity) engineering computer network grant review process.
 20. IEEE Conference on Parallel and Distributed Computing Systems, 1994.
 21. IEEE International Conference on Computer Communications and Networks, 1994.
 22. IEEE INFOCOM conference, 1994.
 23. 1993 NASA Applied Information Systems Research grant review process.
 24. 1992 California MICRO (Microelectronics Innovation Computer Research Opportunity) engineering computer network grant review process.
 25. 7th IFIP International Conference on Upper Layer Protocols, Architectures, and Applications, 1992.
 26. The 1992 Special Issue on Measurement for IEEE Journal Transactions on Software Engineering.
- Invited to serve as a reviewer for Addison-Wesley's *Professional Computing Series*, edited by Brian W. Kernighan. Books reviewed include "Object-Oriented Design Patterns" by Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides and "TCP/IP Illustrated," Volumes 1 and 2 by W. Richard Stevens, and "UNIX System V Network Programming" by Steven A. Rago.

Memberships: IEEE, ACM, and USENIX

Courses Taught

1. CS 673 Distributed Systems research seminar, Fall 1997
2. CS 422 Operating Systems Organization, Fall 1997
3. CS 242 Introduction to Software Design, Spring 1997

4. CS 544 Distributed System Design, Fall 1996
5. Ada tasking course for McDonnell Douglas, Fall 1996
6. OO design course for McDonnell Douglas, Spring 1996
7. CS 523 Distributed Operating Systems Organization, Spring 1995
8. CS 242 Introduction to Software Design, Fall 1995
9. CS 673 Distributed Systems research seminar, Spring 1995
10. CS 422 Operating Systems Organization, Fall 1994

Theses Supervised

- *doctoral and masters Committees*

1. Served on doctoral exam committee for Chuck Cranor, July, 1998.
2. Chair of doctoral exam committee for Andy Gokhale, May, 1998.
3. Chair of masters exam committee for Sumedh Mungee, May, 1998.
4. Chair of masters exam committee for Sergio Flores, May, 1998.
5. Served on masters exam committee for Mihai Tutunaru, April, 1998.
6. Served on doctoral exam committee for Michael Plezbert, June, 1997.
7. Served on masters committee for Todd Rogers, June 1997.
8. Chair of masters committee for Prashant Jain, June 1997.
9. Chair of doctoral topic defense for James Hu, February 1997.
10. Chair of masters committee for Tim Harrison, February 1997.
11. Served on masters committee for Robert Engel, January 1997.
12. Served on committee for final doctoral thesis defense of R. Gopalakrishnan, November, 1996.
13. Chair of doctoral topic defense committee for Andy Gokhale, October, 1996.
14. Served on committee for final doctoral thesis defense of Lorrie Cranor, September, 1996.
15. Served on doctoral thesis topic proposal committee for Christos Papadopoulos July, 1995.
16. Served on doctoral thesis topic proposal committee for Charles Cranor December, 1994.
17. Served on oral exam committee for Andy Gokhale December, 1994.
18. Served on doctoral thesis proposal committee for Lorrie Cranor, December, 1994.
19. Served on doctoral final thesis defense committee for Donald Wilcox, November, 1994.
20. Served on masters committee for Madhavapeddi. Shreedhar, September, 1994
21. Served on doctoral thesis topic proposal committee for R. Gopalakrishnan, September, 1994.

- *Doctoral Student Advisees*

1. Chris Gill
2. James Hu
3. Carlos O’Ryan
4. Irfan Pyarali
5. Nanbor Wang

- *Masters Student Advisees*

1. Alexander Babu Arulanthu
 2. Pradeep Gore
 3. Vishal Kachroo
 4. Yamuna Krishnamurthy
 5. Kirthika Parameswaran
 6. Marina Spivak
 7. Nagarajan Surendran
- *Undergrad Student Advisees*
 1. Shawn Atkins
 2. Matt Braun
 3. Darrell Brunsch
 4. Jeff Parsons
 - *Graduated students*
 1. Sergio Flores, masters degree, May 1998, currently working at Microsoft.
 2. Andy Gokhale, doctorate, May 1998, currently working at Bell Labs, Murray Hill, NJ.
 3. Tim Harrison, masters degree, January 1997, currently working at HP Laboratories, Palo Alto, CA.
 4. Prashant Jain, masters degree, June 1997, currently working at Fujitsu in Santa Clara, CA.
 5. Sumedh Mungee, masters degree, May 1998, currently working at Fujitsu in Santa Clara, CA.
 6. Seth Widoff, June 1998, currently a masters student at CMU.

Department/School/Community Service

1. CS committee on recruiting industrial graduate students (RIGS)
2. CEITR: CS Experimental Infrastructure for Teaching and Research
3. Introductory course committee
4. Graduate admission committee
5. CS representative to the CEC advisory board
6. CS departmental chair search committee

Consulting Work

1. ARINC, Fountain Valley, CA
2. ACM, NY, NY
3. Anderson Consulting, Chicago, IL
4. Boeing, St. Louis, MO
5. Credit Suisse, Zurich, Switzerland
6. AG Communication Systems, Phoenix, AZ
7. AT&T Research, Murray Hill, NJ

8. Bellcore, Morristown, NJ
9. Edward D. Jones, St. Louis, MO
10. Envision Inc. St. Louis, MO
11. Ericsson, Cypress, CA
12. Kodak Imaging, Rochester, NY
13. Lockheed Martin Tactical Systems, Minneapolis, MN
14. Lucent Bell Labs, Naperville, IL
15. Lucent Bell Labs, Murray Hill, NJ
16. Lucent, Whippany, NJ
17. McDonnell Douglas, St. Louis, MO
18. Morgan Stanley, New York, NY
19. Motorola Iridium, Chandler, AZ
20. Motorola LAN Mobile Products, Chicago, IL
21. National Security Agency, Ft. Meade, MD
22. Naval Air Weapons Stations, China Lake, CA
23. Nortel, Ottawa, Canada
24. Object Computing Institute, St. Louis, MO
25. Object Technologies International, Ottawa, CA
26. Odetics Broadcasting, Anaheim, CA
27. SAIC, Washington D.C.
28. Siemens Medical Engineering, Erlangen, Germany
29. Siemens Corporate Research, Princeton, NJ
30. SIGS, New York, NY
31. Teradyne, Chicago, IL
32. UC Berkeley Extension, Palo Alto, CA
33. USENIX, Lake Forest, CA

Publications

In Print

- **Refereed Journal Publications**

1. Douglas C. Schmidt and Chris Cleeland, "Applying Patterns to Develop Extensible and Maintainable ORB Middleware," *IEEE Communications Magazine*, to appear, 1999.
2. Irfan Pyarali and Douglas C. Schmidt, "An Overview of the CORBA Portable Object Adapter," Special Issue on CORBA in the *ACM StandardView* magazine, March, 1999.
3. Douglas C. Schmidt, "Evaluating Architectures for Multi-threaded CORBA Object Request Brokers," *Communications of the ACM*, Special Issue on CORBA, ACM, edited by Krishnan Seetharaman, Volume 41, No. 10, October 1998.

4. Prashant Jain, Seth Widoff, and Douglas C. Schmidt, "The Design and Performance of MedJava, A Distributed Electronic Medical Imaging System Developed with Java Applets and Web Tools," *IEE/BCS Distributed Systems Engineering Journal*, to appear, 1998.
5. Developing Flexible and High-performance Web Servers with Frameworks and Patterns, Symposium on Frameworks, *ACM Computing Surveys*, (Fayad and Wegner, eds.) Vol. 30, to appear 1998.
6. Andy Gokhale and Douglas C. Schmidt, "Measuring and Optimizing CORBA Latency and Scalability Over High-speed Networks," *IEEE Transactions on Computing*, April, 1998.
7. Douglas C. Schmidt and James Hu, "Developing Flexible and High-performance Web Servers with Frameworks and Patterns," *Computing Surveys*, ACM, Vol. 29, March 1998.
8. Douglas C. Schmidt, David Levine, and Sumedh Mungee, "The Design of the TAO Real-Time Object Request Broker," *Computer Communications Special Issue on Building Quality of Service into Distributed System*, Elsevier Science, Summer, 1997.
9. Guru Parulkar, Douglas C. Schmidt, Eileen Kraemer, Jon Turner, Anshul Kantawala, "An Architecture for Monitoring, Visualization, and Control and Gigabit Networks," *IEEE Network*, September/October, 1997.
10. Douglas C. Schmidt, "Lessons Learned Building Reusable OO Frameworks for Distributed Software," *Communications of the ACM Special Issue on OO Application Frameworks*, ACM, Vol. 40, No. 10, October, 1997.
11. Douglas C. Schmidt, "Applying Patterns to Meet the Challenges of Concurrent Software," *IEEE Concurrency*, Special Edition on Software Engineering for Parallel and Distributed Systems, Vol. 5, No. 3, August, 1997.
12. Douglas C. Schmidt, Andy Gokhale, Tim Harrison, and Guru Parulkar, "A High-performance Endsystem Architecture for Real-time CORBA," *IEEE Communications Magazine*, Vol. 14, No. 2, February, 1997.
13. Silvano Maffei and Douglas C. Schmidt, "Constructing Reliable Distributed Communication Systems with CORBA," *IEEE Communications Magazine*, Vol. 14, No. 2, February, 1997.
14. Douglas C. Schmidt, "Using Design Patterns to Develop Reuseable Object-Oriented Software," *ACM Computing Surveys*, Vol. 28, No. 4es, December 1996.
15. Irfan Pyarali, Douglas C. Schmidt, and Tim Harrison, "Design and Performance of an Object-Oriented Framework for High-Speed Electronic Medical Imaging," *USENIX Computing Systems*, November/December, Vol. 9, No. 4, 1996.
16. Douglas C. Schmidt, "A Family of Design Patterns for Application-level Gateways," *The Journal of Theory and Practice of Object Systems* (Special Issue on Patterns and Pattern Languages), Wiley and Sons, Vol. 2, No. 1, 1996.
17. Douglas C. Schmidt, "Experience Using Design Patterns to Develop Reuseable Object-Oriented Communication Software," *Communications of the ACM Special Issue on Object-Oriented Experiences*, ACM, Vol. 38, No. 10, October, 1995, pp 65–74.
18. Douglas C. Schmidt and Tatsuya Suda, "An Object-Oriented Framework for Dynamically Configuring Extensible Distributed Systems," *Distributed Systems Engineering Journal* (Special issue on Configurable Distributed Systems), IEE, Vol. 2, December, 1994, pp. 280–293.
19. Douglas C. Schmidt, Donald F. Box, and Tatsuya Suda, "ADAPTIVE: A Dynamically Assembled Protocol Transformation, Integration, and eValuation Environment," *Journal of Concurrency: Practice and Experience*, Wiley and Sons, Ltd., Vol. 5, No. 4, June, 1993, pp. 269–286.
20. Douglas C. Schmidt and Tatsuya Suda, "Transport System Architecture Services for High-Performance

Communication Systems,” *Journal of Selected Areas of Communications special-issue on Protocols for Gigabit Networks*, IEEE, Vol. 11, No. 4, May, 1993, pp. 489–506.

- **Book Publications and Book Chapters**

1. Douglas C. Schmidt and Paul Stephenson, “Using Design Patterns to Evolve System Software from UNIX to Windows NT,” In *The Patterns Handbook*, (Linda Rising, ed.), Cambridge University Press, 1998.
2. James Hu and Douglas C. Schmidt, “JAWS: A Framework for High-performance Web Servers,” *Object-Oriented Application Frameworks* book, John Wiley & Sons, to appear, 1999.
3. Douglas C. Schmidt, David L. Levine, and Chris Cleeland, “Architectures and Patterns for High-performance, Real-time CORBA Object Request Brokers,” *Advances in Computers*, Academic Press, Ed., Marvin Zelkowitz, to appear.
4. Douglas C. Schmidt and Tatsuya Suda, “A Framework for Measuring the Performance of Alternative Process Architectures for Parallel Communication Subsystems,” in *Network Performance Modeling and Simulation*, Walrand, Bagchi, and Zobrist, Ed., Gordon and Breach Publishers, 1998.
5. Douglas C. Schmidt, “Applying Design Patterns and Frameworks to Develop Object-Oriented Communication Software,” to appear in the *Handbook of Programming Languages, Volume I*, edited by Peter Salus, MacMillan Computer Publishing, 1997.
6. Chris Cleeland, Douglas C. Schmidt, and Tim H. Harrison, “External Polymorphism – An Object Structural Pattern for Transparently Extending Concrete Data Types,” *Pattern Languages of Program Design*, (Martin, Buschmann, and Riehl, eds.), Addison-Wesley, Reading, MA, 1997.
7. Timothy H. Harrison, Douglas C. Schmidt, and Irfan Pyarali, “Asynchronous Completion Token – An Object Behavioral Pattern for Efficient Asynchronous Event Handling,” *Pattern Languages of Program Design*, (Martin, Buschmann, and Riehl, eds.), Addison-Wesley, Reading, MA, 1997.
8. Douglas C. Schmidt and Timothy H. Harrison, “Double-Checked Locking – A Optimization Pattern for Efficiently Initializing and Accessing Thread-safe Objects,” *Pattern Languages of Program Design*, (Martin, Buschmann, and Riehl, eds.), Addison-Wesley, Reading, MA, 1997.
9. Douglas C. Schmidt, “Acceptor and Connector – A Family of Object Creational Patterns for Initializing Communication Services,” *Pattern Languages of Program Design*, (Martin, Buschmann, and Riehl, eds.), Addison-Wesley, Reading, MA, 1997.
10. Douglas C. Schmidt and Paul Stephenson, “Using Design Patterns to Evolve System Software from UNIX to Windows NT,” In *Wisdom of the Gurus*, (Charles Bowman, ed.), Cambridge University Press, 1996.
11. Douglas C. Schmidt and Steve Vinoski, “Comparing Alternative Distributed Programming Techniques” in *Wisdom of the Gurus*, (Charles Bowman, ed.), Cambridge University Press, 1996.
12. Douglas C. Schmidt, “A Case Study in C++ Design Evolution” in *C++ Gems*, (Stanley Lippman, ed.), SIGS, NY, 1996, pp. 99–120.
13. Douglas C. Schmidt and Steve Vinoski, “Distributed Object Computing in C++” in *C++ Gems*, (Stanley Lippman, ed.), SIGS, NY, 1996, pp. 303–316.
14. Douglas C. Schmidt and Steve Vinoski, “Comparing Alternative Distributed Programming Techniques” in *C++ Gems*, (Stanley Lippman, ed.), SIGS, NY, 1996, pp. 316–336.
15. Douglas C. Schmidt and Steve Vinoski, “Comparing Alternative Server Programming Techniques” in *C++ Gems*, (Stanley Lippman, ed.), SIGS, NY, 1996, pp. 337–362.

16. Douglas C. Schmidt and Charles D. Cranor, "Half-Sync/Half-Async: A Architectural Pattern for Efficient and Well-structured Concurrent I/O" in *Pattern Languages of Program Design*, (Coplien, Vlissides, and Kerth, eds.), Addison-Wesley, Reading, MA, 1996.
17. R. Greg Lavender and Douglas C. Schmidt, "Active Object: An Object Behavioral Pattern for Concurrent Programming," in *Pattern Languages of Program Design*, (Coplien, Vlissides, and Kerth, eds.), Addison-Wesley, Reading, MA, 1996.
18. Co-editor of a book entitled "Pattern Languages of Program Design," Addison-Wesley, 1995 (co-editor is Jim Coplien, Bell Labs).
19. Douglas C. Schmidt, "Reactor: An Object Behavioral Pattern for Concurrent Event Demultiplexing and Event Handler Dispatching," *Pattern Languages of Program Design*, (Addison-Wesley, 1995), edited by James O. Coplien and Douglas C. Schmidt.
20. Currently under contract with Addison-Wesley to write a book entitled *Object-Oriented Network Programming* as part of the Brian W. Kernighan Professional Computing Series.

• **Refereed Conference Publications**

1. Andy Gokhale and Douglas C. Schmidt, "Techniques for Optimizing CORBA Middleware for Distributed Embedded Systems" Proceedings of INFOCOM '99, March 21-25th, New York, New York.
2. Sumedh Mungee, Nagarajan Surendran, and Douglas C. Schmidt, "The Design and Performance of a CORBA Audio/Video Streaming Service," Proceedings of the 31st Hawaii International Conference on System Systems (HICSS), Hawaii, January, 1999, minitrack on Multimedia DBMS and the WWW, Hawaii, January 1999.
3. Chris D. Gill, David L. Levine, and Douglas C. Schmidt, "Dynamic Scheduling for Avionics Applications," Proceedings of the 17th IEEE/AIAA Digital Avionics System Conference, 31 October - 6 November 1998.
4. James Hu, Irfan Pyarali, and Douglas C. Schmidt, "Applying the Proactor Pattern to High-Performance Web Servers," Proceedings of the 10th International Conference on Parallel and Distributed Computing and Systems, IASTED, Las Vegas, Nevada, October 28-31, 1998.
5. Douglas C. Schmidt, Sumedh Mungee, and Andy Gokhale, "Alleviating Priority Inversion and Non-determinism in Real-time CORBA ORB Core Architectures," Proceedings of the Fourth IEEE Real-Time Technology and Applications Symposium (RTAS), Denver, Colorado, June 3-5, 1998
6. Prashant Jain, Seth Widoff, and Douglas C. Schmidt, "The Design and Performance of MedJava, A Distributed Electronic Medical Imaging System Developed with Java Applets and Web Tools" Proceedings of the 4th USENIX Conference on Object-Oriented Technologies and Systems, Sante Fe, New Mexico, April 1998. This was selected as the best student paper in the conference.
7. James Hu, Sumedh Mungee, and Douglas C. Schmidt, "Techniques for Developing and Measuring High-performance Web Servers over ATM Networks," Proceedings of INFOCOM '98, San Francisco, March/April, 1998.
8. Aniruddha Gokhale and Douglas C. Schmidt, "Optimizing the Performance of the CORBA Internet Inter-ORB Protocol Over ATM," Proceedings of the 31st Hawaii International Conference on System Systems (HICSS), Hawaii, January, 1998. This was selected as the best paper in the Software Technology Track (188 submitted, 77 accepted).
9. Aniruddha Gokhale and Douglas C. Schmidt, "Evaluating the Performance of Demultiplexing Strategies for Real-time CORBA," Proceedings of GLOBECOM '97 conference, IEEE, Phoenix, AZ, November, 1997.

10. James Hu, Irfan Pyarali, and Douglas C. Schmidt, "Measuring the Impact of Event Dispatching and Concurrency Models on Web Server Performance Over High-speed Networks," Proceedings of the 2nd Global Internet Conference (held as part of GLOBECOM '97) in Phoenix, AZ, November 4-8, 1997.
11. Tim Harrison and David Levine and Douglas C. Schmidt, "The Design and Performance of a Real-time CORBA Event Service," Proceedings of OOPSLA '97, ACM, Atlanta, GA, October 1997.
12. Aniruddha Gokhale and Douglas C. Schmidt and Stan Moyer, "Tools for Automating the Migration from DCE to CORBA," Proceedings of ISS 97: World Telecommunications Congress, IEEE Toronto, Canada, September, 1997.
13. Douglas C. Schmidt, Tim H. Harrison, and Nat Pryce, "Thread-specific Storage: an Object Behavioral Pattern for Efficiently Accessing per-Thread State," The 4th annual Pattern Languages of Programming conference in Allerton Park, Illinois, September 1997.
14. Irfan Pyarali, Tim Harrison, Douglas C. Schmidt, and Thomas Jordan, "Proactor: an Object Behavioral Pattern for Demultiplexing and Dispatching Handlers for Asynchronous Events," the 4th annual Pattern Languages of Programming conference in Allerton Park, Illinois, September 1997.
15. Prashant Jain and Douglas C. Schmidt, "Service Configurator – A Pattern for Dynamic Configuration of Services," Proceedings of the 3rd Conference on Object-Oriented Technologies and Systems, USENIX, Portland, OR, June 16-19, 1997.
16. Aniruddha Gokhale and Douglas C. Schmidt, "Evaluating Latency and Scalability of CORBA Over High-Speed ATM Networks," Proceedings of the International Conference on Distributed Computing Systems '97, IEEE, Baltimore, Maryland, May 27–30, 1997.
17. Aniruddha Gokhale and Douglas C. Schmidt, "Performance of the CORBA Dynamic Invocation Interface and Internet Inter-ORB Protocol over High-Speed ATM Networks," Proceedings of GLOBECOM '96, IEEE, London England, November, 1996.
18. Aniruddha Gokhale and Douglas C. Schmidt, "Measuring the Performance of Communication Middleware on High-Speed Networks," Proceedings of SIGCOMM '96, ACM, San Francisco, August 28-30th, 1996.
19. Irfan Pyarali, Tim Harrison, and Douglas C. Schmidt, "Design and Performance of an Object-Oriented Framework for High-Speed Electronic Medical Imaging," Proceedings of the 2nd Conference on Object-Oriented Technologies and Systems (COOTS), USENIX, Toronto, June 18-22, 1996.
20. Douglas C. Schmidt, "A Family of Design Patterns For Flexibly Configuring Network Services in Distributed Systems," Proceedings of the International Conference on Configurable Distributed Systems, IEEE, Annapolis, Maryland, May 6-8, 1996.
21. Douglas C. Schmidt "Using Design Patterns to Develop High-Performance Object-Oriented Communication Software Frameworks," Proceedings of the 8th Annual Software Technology Conference, Salt Lake City, Utah, April 21-26, 1996.
22. Douglas C. Schmidt, Timothy H. Harrison, and Irfan Pyarali, "An Object-Oriented Framework for High-Performance Electronic Medical Imaging," Proceedings of the *Very High Resolution and Quality Imaging* mini-conference at the Symposium on Electronic Imaging in the International Symposia Photonics West 1996, SPIE, San Jose, California USA, January 27 - February 2, 1996.
23. Douglas C. Schmidt and Charles D. Cranor, "Half-Sync/Half-Async: A Pattern for Efficient and Well-structured Concurrent I/O," *The 2nd Pattern Languages of Programs Conference* Monticello, Illinois, September 6-8, 1995.

24. R. Greg Lavender and Douglas C. Schmidt, "Active Object: An Object Behavioral Pattern for Concurrent Programming," *The 2nd Pattern Languages of Programs Conference*, Monticello, Illinois, September 6-8, 1995.
25. Guru Parulkar, Douglas C. Schmidt, and Jonathan S. Turner, "*aI_tP_m*: a Strategy for Integrating IP with ATM," the Symposium on Communications Architectures and Protocols (SIGCOMM), ACM, Cambridge, MA, August 30 to September 1, 1995.
26. Douglas C. Schmidt, Tim Harrison, and Ehab Al-Shaer, "Object-Oriented Components for High-speed Network Programming," *Proceedings of the Conference on Object-Oriented Technologies (COOTS)*, USENIX, June 26-29, 1995 Monterey, California, USA, pp. 21–38.
27. Douglas C. Schmidt and Paul Stephenson, "Experience Using Design Patterns to Evolve Communication Software Across Diverse OS Platforms," *Proceedings of the 9th European Conference on Object-Oriented Programming (ECOOP)*, ACM, Aarhus, Denmark, August, 1995,.
28. Douglas C. Schmidt and Tatsuya Suda, "Measuring the Performance of Parallel Message-based Process Architectures," *Proceedings of the INFOCOM Conference on Computer Communications*, IEEE, Boston, MA, April, 1995, pp. 624–633.
29. Douglas C. Schmidt, "Reactor: An Object Behavioral Pattern for Concurrent Event Demultiplexing and Dispatching," *The 1st Annual Conference on the Pattern Languages of Programs*, Monticello, Illinois, August, 1994, pp. 1–10.
30. Douglas C. Schmidt and Tatsuya Suda, "Experiences with an Object-Oriented Architecture for Developing Dynamically Extensible Network Management Software," *Proceedings of the Globecom Conference*, IEEE, San Francisco, California, November, 1994, pp. 1–7.
31. Douglas C. Schmidt, Burkhard Stiller, Tatsuya Suda, and Martina Zitterbart, "Configuring Function-based Communication Protocols for Distributed Applications," *Proceedings of the 8th International Working Conference on Upper Layer Protocols, Architectures, and Applications*, IFIP, Barcelona, Spain, June 1-3, 1994, pp. 361–376.
32. Douglas C. Schmidt and Tatsuya Suda, "The ADAPTIVE Service Executive: An Object-Oriented Architecture for Configuring Concurrent Distributed Communication Systems," *Proceedings of the 8th International Working Conference on Upper Layer Protocols, Architectures, and Applications*, IFIP, Barcelona, Spain, June 1-3, 1994, pp. 163–178.
33. Douglas C. Schmidt, "ASX: An Object-Oriented Framework for Developing Distributed Applications," *Proceedings of the 6th C++ Conference*, USENIX, Cambridge, Massachusetts, April, 1994, pp. 200–220.
34. Douglas C. Schmidt, Burkhard Stiller, Tatsuya Suda, Ahmed Tantawy, and Martina Zitterbart, "Configuration Support for Flexible Function-Based Communication Systems," *Proceedings of the 18th Conference on Local Computer Networks*, IEEE, Minneapolis, Minnesota, September 20-22, 1993, pp. 369–378.
35. Douglas C. Schmidt and Tatsuya Suda, "ADAPTIVE: a Framework for Experimenting with High-Performance Transport System Process Architectures," *Proceedings of the 2nd International Conference on Computer Communications and Networks*, ISCA, San Diego, California, June 28-30, 1993, pp. 1–8.
36. Donald F. Box, Douglas C. Schmidt, and Tatsuya Suda, "ADAPTIVE: An Object-Oriented Framework for Flexible and Adaptive Communication Protocols," *Proceedings of the 4th Conference on High Performance Networking*, IFIP, Liege, Belgium, December 14-18, 1992, pp. 367–382.
37. Douglas C. Schmidt, Donald F. Box, and Tatsuya Suda, "ADAPTIVE: A Flexible and Adaptive Transport System Architecture to Support Lightweight Protocols for Multimedia Applications on High-Speed Networks," *Proceedings of the 1st Symposium on High Performance Distributed Computing*, IEEE, Syracuse, New York, September 9-11, 1992, pp. 174–186.

38. Richard W. Selby, Adam A. Porter, Douglas C. Schmidt, and James Berney, "Metric-Driven Analysis and Feedback Systems for Enabling Empirically Guided Software Development," *Proceedings of the 13th Annual International Conference on Software Engineering*, IEEE, Austin, Texas, May, 1991, pp. 430–443.
39. Douglas C. Schmidt "GPERF: A Perfect Hash Function Generator," *Proceedings of the 2nd C++ Conference*, USENIX, San Francisco, California, April 9-11, 1990, pp. 87–102.

• **Refereed Workshop Publications**

1. Douglas C. Schmidt, Rajeev Bector, David Levine Sumedh Mungee, and Guru Parulkar, "TAO: a Middleware Framework for Real-time ORB Endsystems," *Proceedings of the Workshop on Middleware for Real-Time Systems and Services*, held in conjunction with IEEE Real-time Systems Symposium, San Francisco, CA, December 2nd, 1997.
2. Aniruddha Gokhale and Douglas C. Schmidt, "Design Principles and Optimizations for High Performance ORBs," *ACM, OOPSLA 97*, Poster Session, Oct 1997, Atlanta, GA, USA.
3. Aniruddha Gokhale, Tim Harrison, Douglas C. Schmidt, and Guru Parulkar, "Operating System Support for Real-time CORBA," *Proceedings of the 5th International Workshop on Object-Oriented Systems in Operating Systems: IWOOS 1996 workshop*, October 27–28, 1996, Seattle, Washington.
4. Douglas C. Schmidt, Guru Parulkar, and Chuck Cranor, "Gigabit CORBA - High-Performance Distributed Object Computing," *Gigabit Networking Workshop (GBN'96)*, 24 March 1996, San Francisco, in conjunction with INFOCOM '96.
5. Douglas C. Schmidt, "Acceptor and Connector: Design Patterns for Actively and Passively Initializing Network Services." *Workshop on Pattern Languages of Object-Oriented Programs at ECOOP '95*, August 7 – 1, 1995, Aarhus, Denmark.
6. Douglas C. Schmidt, "High-Performance Event Filtering for Dynamic Multi-point Applications," *Proceedings of the 1st Workshop on High Performance Protocol Architectures (HIPPARCH)*, INRIA, Sophia Antipolis, France, December, 1994, p 1–8.
7. Douglas C. Schmidt, "Flexible Configuration of High-Performance Object-Oriented Distributed Communication Systems," *9th OOPSLA Conference, invited paper to the Workshop on Flexibility in Systems Software*, ACM, Portland, Oregon, October, 1994, pp. 1–4.
8. Douglas C. Schmidt, "Performance Experiments on Alternative Methods for Structuring Active Objects in High-Performance Parallel Communication Systems," *9th OOPSLA Conference, poster session*, ACM, Portland, Oregon, October, 1994, pp. 1–12.
9. Douglas C. Schmidt and Tatsuya Suda, "Measuring the Impact of Alternative Parallel Process Architectures on Communication Subsystem Performance," *Proceedings of the 4th International Workshop on Protocols for High-Speed Networks*, IFIP, Vancouver, British Columbia, August, 1994, pp. 103–118.
10. Douglas C. Schmidt and Tatsuya Suda, "The Service Configurator Framework: An Extensible Architecture for Dynamically Configuring Concurrent, Multi-service Network Daemons," *Proceedings of the 2nd International Workshop on Configurable Distributed Systems*, IEEE, Pittsburgh, PA, March 21-23, 1994, pp. 190–201.
11. Douglas C. Schmidt, Burkhard Stiller, Tatsuya Suda, and Martina Zitterbart, "Tools for Generating Application-Tailored Multimedia Protocols on Heterogeneous Multi-Processor Platforms," *Proceedings of the 2nd Workshop on High-Performance Communications Subsystems*, IEEE, Williamsburg, Virginia, September 1-3, 1993, pp. 1–7.

12. Douglas C. Schmidt and Tatsuya Suda, "A Framework for Developing and Experimenting with Parallel Process Architectures to Support High-Performance Transport Systems," *Proceedings of the 2nd Workshop on High-Performance Communications Subsystems*, IEEE, Williamsburg, Virginia, September 1-3, 1993, pp. 1–8.
13. Tatsuya Suda, Douglas C. Schmidt, Donald F. Box, Duke Hong and Hung Huang, "High Speed Networks," *Proceedings of the International Computer World Symposium '92*, Kobe, Japan, November, 1992.
14. Hung K. Huang, Douglas C. Schmidt, Donald F. Box, Kazu Shimono, Girish Kotmire, Unmesh Rathi, and Tatsuya Suda, "ADAPTIVE: A Prototyping Environment for Transport Systems." *Proceedings of the 4th International Workshop on Computer Aided Modeling, Analysis, and Design of Communication Links and Networks (CAMAD)*, IEEE, Montreal, Canada, September, 1992.
15. Donald F. Box, Douglas C. Schmidt, and Tatsuya Suda, "Alternative Approaches to ATM/Internet Interoperation," *Proceedings of the 1st Workshop on the Architecture and Implementation of High-Performance Communication Subsystems*, IEEE, Tucson, Arizona, February 17-19, 1992, pp. 1–5.
16. Douglas C. Schmidt and Richard Selby "Modeling Software Interconnectivity," *Proceedings of the 22nd Symposium on the Interface: Computer Science and Statistics*, East Lansing, MI, May, 1990.
17. Richard W. Selby, Greg James, Kent Madsen, Joan Mahoney, Adam A. Porter, and Douglas C. Schmidt "Classification Tree Analysis Using the Amadeus Measurement and Empirical Analysis System," *Proceedings of the 14th Annual Software Engineering Workshop at NASA Software Engineering Laboratory*, College Park, Maryland, November, 1989, pp. 239–250.

• Technical Reports

1. Lutz Prechelt, Barbara Unger, Douglas C. Schmidt. "Replication of the First Controlled Experiment on the Usefulness of Design Patterns: Detailed Description and Evaluation." Technical Report wucs-97-34, 77 pages, Washington University, St. Louis, MO, Dept. of Computer Science, December 1997.
2. Aniruddha Gokhale and Douglas C. Schmidt, "Optimizing the Performance of the CORBA Internet Inter-ORB Protocol Over ATM," Washington University technical report #WUCS-97-10.
3. James Hu and Sumedh Mungee and Douglas C. Schmidt, "Principles for Developing and Measuring High-performance Web Servers over ATM," Washington University technical report #WUCS-97-10.
4. Chris Cleeland, Douglas C. Schmidt, and Tim H. Harrison, "External Polymorphism – An Object Structural Pattern for Transparently Extending Concrete Data Types," The 3rd annual Pattern Languages of Programming conference in Allerton Park, Illinois, September 4-6, 1996, Washington University technical report #WUCS-97-07.
5. Timothy H. Harrison, Douglas C. Schmidt, and Irfan Pyarali, "Asynchronous Completion Token," The 3rd annual Pattern Languages of Programming conference in Allerton Park, Illinois, September 4-6, 1996, Washington University technical report #WUCS-97-07.
6. Douglas C. Schmidt and Timothy H. Harrison, "The Double-Checked Locking Pattern," The 3rd annual Pattern Languages of Programming conference in Allerton Park, Illinois, September 4-6, 1996, Washington University technical report #WUCS-97-07.
7. Prashant Jain and Douglas C. Schmidt, "The Service Configurator Pattern," The 3rd annual Pattern Languages of Programming conference in Allerton Park, Illinois, September 4-6, 1996, Washington University technical report #WUCS-97-07.

8. Douglas C. Schmidt, "Acceptor and Connector: Design Patterns for Initializing Network Services," The EuroPLoP '96 conference in Kloster Irsee, Germany, July 10-14, 1996, Washington University technical report #WUCS-97-07.

Accepted for Publication or In Press

1. Douglas C. Schmidt and Tatsuya Suda, "The Performance of Alternative Threading Architectures for Parallel Communication Subsystems," *Journal of Parallel and Distributed Computing*, to appear.

Submitted for Publication

1. Douglas C. Schmidt, Fred Kuhns, Rajeev Bector, and David Levine, "The Design and Performance of an I/O Subsystem for Real-time ORB Endsystem Middleware," Submitted to the *International Journal of Time-Critical Computing Systems*, special issue on Real-Time Middleware, guest editor Wei Zhao.
2. Andy Gokhale and Douglas C. Schmidt, "Optimizing a CORBA IIOP Protocol Engine for Minimal Footprint Multimedia Systems," submitted to the *IEEE Journal on Selected Areas in Communications* special issue on Service Enabling Platforms for Networked Multimedia Systems.
3. Tim Harrison, Carlos O'Ryan, David Levine, and Douglas C. Schmidt, "The Design and Performance of a Real-time CORBA Event Service," submitted to the *IEEE Journal on Selected Areas in Communications* special issue on Service Enabling Platforms for Networked Multimedia Systems.
4. Chris Gill, David Levine, and Douglas C. Schmidt, "Evaluating Strategies for Real-Time CORBA Dynamic Scheduling," Submitted to the *International Journal of Time-Critical Computing Systems*, special issue on Real-Time Middleware, guest editor Wei Zhao.
5. Douglas C. Schmidt, Sumedh Mungee, Sergio Flores-Gaitan, and Aniruddha Gokhale, "Software Architectures for Reducing Priority Inversion and Non-determinism in Real-time Object Request Brokers," Submitted to the *Journal of Real-time Systems*, Kluwer, 1998.

Presentations

Conference Presentations

1. Aniruddha Gokhale and Douglas C. Schmidt, "Evaluating Latency and Scalability of CORBA Over High-Speed ATM Networks," *Proceedings of the International Conference on Distributed Computing Systems '97*, IEEE, Baltimore, Maryland, May 27-30, 1997.
2. Douglas C. Schmidt and Timothy H. Harrison, "The Double-Checked Locking Pattern," *Proceedings of the 3rd annual Pattern Languages of Programming conference* in Allerton Park, Illinois, September 4-6, 1996.
3. Douglas C. Schmidt, "Acceptor and Connector: Design Patterns for Initializing Network Services," *Proceedings of the EuroPLoP '96 conference*, Kloster Irsee, Germany, July 10-14, 1996.
4. Aniruddha Gokhale and Douglas C. Schmidt, "Measuring the Performance of Communication Middleware on High-Speed Networks," *Proceedings of SIGCOMM '96*, ACM, San Francisco, August 28-30th, 1996.
5. Irfan Pyarali, Tim Harrison, and Douglas C. Schmidt, "Design and Performance of an Object-Oriented Framework for High-Speed Electronic Medical Imaging," *Proceedings of the 2nd Conference on Object-Oriented Technologies and Systems (COOTS)*, USENIX, Toronto, June 18-22, 1996.

6. Douglas C. Schmidt, "A Family of Design Patterns For Flexibly Configuring Network Services in Distributed Systems," Proceedings of the International Conference on Configurable Distributed Systems, IEEE, Annapolis, Maryland, May 6-8, 1996.
7. Douglas C. Schmidt "Using Design Patterns to Develop High-Performance Object-Oriented Communication Software Frameworks," Proceedings of the 8th Annual Software Technology Conference, Salt Lake City, Utah, April 21-26, 1996.
8. Douglas C. Schmidt, Timothy H. Harrison, and Irfan Pyarali, "An Object-Oriented Framework for High-Performance Electronic Medical Imaging," Proceedings of the *Very High Resolution and Quality Imaging* mini-conference at the Symposium on Electronic Imaging in the International Symposia Photonics West 1996, SPIE, San Jose, California USA, January 27 - February 2, 1996.
9. Douglas C. Schmidt and Charles D. Cranor, "Half-Sync/Half-Async: A Pattern for Efficient and Well-structured Concurrent I/O," *Proceedings of the 2nd Pattern Languages of Programs Conference* Monticello, Illinois, September 6-8, 1995.
10. Douglas C. Schmidt, "Acceptor and Connector: Design Patterns for Actively and Passively Initializing Network Services." Workshop on Pattern Languages of Object-Oriented Programs at ECOOP '95, August 7 - 1, 1995, Aarhus, Denmark.
11. Douglas C. Schmidt, Tim Harrison, and Ehab Al-Shaer, "Object-Oriented Components for High-speed Network Programming," *Proceedings of the Conference on Object-Oriented Technologies (COOTS)*, USENIX, June 26-29, 1995 Monterey, California, USA, pp. 21-38.
12. Douglas C. Schmidt and Paul Stephenson, "Experience Using Design Patterns to Evolve Communication Software Across Diverse OS Platforms," *Proceedings of the 9th European Conference on Object-Oriented Programming (ECOOP)*, ACM, Aarhus, Denmark, August, 1995,.
13. Douglas C. Schmidt and Tatsuya Suda, "Measuring the Performance of Parallel Message-based Process Architectures," *Proceedings of the INFOCOM Conference on Computer Communications*, IEEE, Boston, MA, April, 1995, pp. 624-633.
14. Douglas C. Schmidt, "High-Performance Event Filtering for Dynamic Multi-point Applications," Proceedings of the 1st Workshop on High Performance Protocol Architectures (HIPPARCH), INRIA, Sophia Antipolis, France, December, 1994, p 1-8.
15. Douglas C. Schmidt, "Flexible Configuration of High-Performance Object-Oriented Distributed Communication Systems," 9th *OOPSLA Conference, invited paper to the Workshop on Flexibility in Systems Software*, ACM, Portland, Oregon, October, 1994, pp. 1-4.
16. Douglas C. Schmidt, "Performance Experiments on Alternative Methods for Structuring Active Objects in High-Performance Parallel Communication Systems," 9th *OOPSLA Conference, poster session*, ACM, Portland, Oregon, October, 1994, pp. 1-12.
17. Douglas C. Schmidt and Tatsuya Suda, "Measuring the Impact of Alternative Parallel Process Architectures on Communication Subsystem Performance," *Proceedings of the Proceedings of the 4th International Workshop on Protocols for High-Speed Networks*, IFIP, Vancouver, British Columbia, August, 1994, pp. 103-118.
18. Douglas C. Schmidt, "Reactor: An Object Behavioral Pattern for Concurrent Event Demultiplexing and Dispatching," *Proceedings of the 1st Annual Conference on the Pattern Languages of Programs*, Monticello, Illinois, August, 1994, pp. 1-10.
19. Douglas C. Schmidt and Tatsuya Suda, "Experiences with an Object-Oriented Architecture for Developing Dynamically Extensible Network Management Software," *Proceedings of the Globecom Conference*, IEEE, San Francisco, California, November, 1994, pp. 1-7.

20. Douglas C. Schmidt, Burkhard Stiller, Tatsuya Suda, and Martina Zitterbart, "Configuring Function-based Communication Protocols for Distributed Applications," *Proceedings of the 8th International Working Conference on Upper Layer Protocols, Architectures, and Applications*, IFIP, Barcelona, Spain, June 1-3, 1994, pp. 361–376.
21. Douglas C. Schmidt and Tatsuya Suda, "The ADAPTIVE Service Executive: An Object-Oriented Architecture for Configuring Concurrent Distributed Communication Systems," *Proceedings of the 8th International Working Conference on Upper Layer Protocols, Architectures, and Applications*, IFIP, Barcelona, Spain, June 1-3, 1994, pp. 163–178.
22. Douglas C. Schmidt, "ASX: An Object-Oriented Framework for Developing Distributed Applications," *Proceedings of the 6th C++ Conference*, USENIX, Cambridge, Massachusetts, April, 1994, pp. 200–220.
23. Douglas C. Schmidt and Tatsuya Suda, "The Service Configurator Framework: An Extensible Architecture for Dynamically Configuring Concurrent, Multi-service Network Daemons," *Proceedings of the 2nd International Workshop on Configurable Distributed Systems*, IEEE, Pittsburgh, PA, March 21-23, 1994, pp. 190–201.
24. Douglas C. Schmidt, Burkhard Stiller, Tatsuya Suda, and Martina Zitterbart, "Tools for Generating Application-Tailored Multimedia Protocols on Heterogeneous Multi-Processor Platforms," *Proceedings of the 2nd Workshop on High-Performance Communications Subsystems*, IEEE, Williamsburg, Virginia, September 1-3, 1993, pp. 1–7.
25. Douglas C. Schmidt and Tatsuya Suda, "A Framework for Developing and Experimenting with Parallel Process Architectures to Support High-Performance Transport Systems," *Proceedings of the 2nd Workshop on High-Performance Communications Subsystems*, IEEE, Williamsburg, Virginia, September 1-3, 1993, pp. 1–8.
26. Douglas C. Schmidt and Tatsuya Suda, "ADAPTIVE: a Framework for Experimenting with High-Performance Transport System Process Architectures," *Proceedings of the 2nd International Conference on Computer Communications and Networks*, ISCA, San Diego, California, June 28-30, 1993, pp. 1–8.
27. Douglas C. Schmidt, Donald F. Box, and Tatsuya Suda, "ADAPTIVE: A Flexible and Adaptive Transport System Architecture to Support Lightweight Protocols for Multimedia Applications on High-Speed Networks," *Proceedings of the 1st Symposium on High Performance Distributed Computing*, IEEE, Syracuse, New York, September 9-11, 1992, pp. 174–186.
28. Douglas C. Schmidt "GPERF: A Perfect Hash Function Generator," *Proceedings of the 2nd C++ Conference*, USENIX, San Francisco, California, April 9-11, 1990, pp. 87–102.

Invited Lectures

1. "Real-time CORBA for Telecom – Fact or Fiction?," Bellcore, Morristown, NJ, December 1st, 1998.
2. "Design Patterns for Real-time Object Request Brokers," Silicon Valley Patterns Group, San Francisco, November 15, 1998.
3. "Why Reuse has Failed and how to Make it Work for You," Keynote talk at Lucent Software Symposium, October 27th, Murray Hill, NJ, 1998.
4. "Real-time CORBA – Fact or Fiction," Lucent CORBA Forum, Holmdel, NJ, September 29, 1998.
5. "Applying Software Design Patterns and Framework to Telecommunication Applications," Nortel Advanced Software Computing and Technology, Monday, April 6, 1998, Ottawa, Canada.

6. "Patterns and Performance of Real-time Object Request Brokers," University of California, Santa Barbara, February 20, 1988.
7. "Principles and Patterns of High-performance, Real-time Object Request Brokers," University of Frankfurt, Germany, February 12th, 1998.
8. "Principles and Patterns of High-performance, Real-time Object Request Brokers," University of Illinois, Urbana-Champaign November 12th, 1997.
9. "Principles and Patterns of High-performance, Real-time Object Request Brokers," University of Missouri, Kansas City, October 31st, 1997.
10. "Principles and Patterns of High-performance, Real-time Object Request Brokers," IBM T.J. Watson Research, September 15, 1997.
11. "Principles and Patterns of High-performance, Real-time Object Request Brokers," University of California, Santa Barbara, August 21st, 1997.
12. "Principles and Patterns of High-performance, Real-time Object Request Brokers," Lucent Technologies, Naperville, IL August 19th, 1997.
13. "Mastering Software Complexity with Reusable Object-Oriented Frameworks, Components, and Design Patterns," 3rd NSA Software Reuse Symposium, August 20th, 1997.
14. "Principles and Patterns of High-performance, Real-time Object Request Brokers," University of Utah, Salt Lake City, Utah, August 11th, 1997.
15. "Using the ACE Framework and Design Patterns to Develop Object-Oriented Communication Software," CERN, Switzerland, July 18th, 1997.
16. "Principles and Patterns of High-performance, Real-time Object Request Brokers," CHOOSE symposium, Zurich, Switzerland, July 17th, 1997.
17. "Principles and Patterns of High-performance, Real-time Object Request Brokers," Lucent Bell Laboratories, Murray Hill, New Jersey, July 9th, 1997.
18. "Using the ACE Framework and Design Patterns to Develop Object-Oriented Communication Software," Lockheed Martin Tactical Systems, Minneapolis, Minnesota, June 26th, 1997.
19. "Design Patterns and Frameworks for Developing Object-oriented WWW Clients and Servers," Carleton University, April 11th, 1997.
20. "Principles and Patterns of High-performance, Real-time Object Request Brokers," University of Maryland, College Park, Maryland, April 2nd, 1997.
21. "A High-Performance End system Architecture for Real Time COBRA," SPARTAN Symposium sponsored by US Sprint, Lawrence Kansas, March 18th, 1997.
22. "Experience with CORBA for Communication Systems," Motorola, Chicago, January 24th, 1997.
23. "High-performance CORBA," Bay Area Object Interest Group, Stanford Linear Accelerator Center, California, December 5th, 1996.
24. "Gigabit CORBA – An Architecture for High-performance Distributed Object Computing," Numerical Aerodynamic Simulation group, NASA, Moffett Field, California, December 3rd, 1996.
25. "Towards High-performance, Real-time CORBA," Distinguished Lecturer at Kansas State University, Manhattan, Kansas, November 7th, 1996.
26. "Gigabit CORBA – An Architecture for High-performance Distributed Object Computing," University of California, Los Angeles, October 3rd, 1996.

27. "Design Patterns and Frameworks for Object-Oriented Communication Software," NSA Software Reuse Symposium, August 28th, 1996.
28. "CORBA – the Good, the Bad, and the Ugly," Lucent Bell-Labs, Naperville, IL, August 22nd, 1996.
29. "Components: the Good, the Bad, and the Ugly," keynote talk for the 1st Components Users Conference, SIEMENS, Munich, Germany, July 15th, 1996.
30. "Design Patterns for Object-Oriented Communication Software," IONA Technologies, Ltd, Dublin, Ireland, July 12th, 1996.
31. "OO Design Patterns and Frameworks for Communication Software," Siemens Corporate Research, Princeton, New Jersey, June 27, 1996.
32. "OO Design Patterns for Concurrent, Parallel, and Distributed Systems," IBM Centre for Advanced Studies, North York, Ontario, Canada, June 17, 1996.
33. "Distributed Object Computing with CORBA", Bell Laboratories, Murray Hill, New Jersey, June 11-12th, 1996.
34. "Design Patterns for Object-Oriented Communication Software," Carleton University, Ottawa, Canada, May 21st, 1996.
35. "Integrating LAN-WAN-Celestial Networks with Design Patterns," Featured technical session at the Object World East conference, Boston, MA, May 9th, 1996.
36. "Using Design Patterns to Develop Object-Oriented Communication Software Frameworks and Applications," McMaster's University, Hamilton, Canada, May 2nd, 1996.
37. "Towards Gigabit CORBA – A High-Performance Architecture for Distributed Object Computing," University of Nevada, Reno, April 25th, 1996.
38. "Domain Analysis: From Tar Pit Extraction to Object Mania?" invited panelist at the 4th International Conference on Software Reuse, Orlando, Florida, April 25th, 1996. (other panelists include Spencer Peterson, SEI CMU, Mark Simos, Organon Motives Inc., Will Tracz, Loral, and Nathan Zalman, BNR Inc).
39. "Concurrent Object-Oriented Network Programming with C++," Kodak Imaging Technology Center, April 19th, 1996.
40. "Using OO Design Patterns and Frameworks to Develop Object-Oriented Communication Systems," INRS/NorTel Workshop on Telecommunication Software, Montreal, CA, March 14th, 1996.
41. "Concurrent Object-Oriented Network Programming with ACE and C++," for Siemens Medical Engineering, Erlangen Germany, February 15th, 1996.
42. "OO Componentware" invited panelist at the *OOP '96 Conference*, SIGS, Munich, Germany, February 13st, 1996. (other panelists included Michael Stal (Siemens AG) and Frank Buschmann (Siemens AG).
43. "Using Design Patterns to Develop High-performance Object-Oriented Communication Software Frameworks," for the Department of Information Systems, Institute of Computer Science, Johannes Kepler University of Linz, Austria, February 12th, 1996.
44. "The Performance of Object-Oriented Components for High-speed Network Programming," for the Digital Libraries research group at Stanford University, Palo Alto California, February 2nd, 1996.
45. "Distributed Object Computing with CORBA, ACE, and C++," for South Western Bell Telephone advanced distributed systems group, St. Louis, MO., January 26th, 1996.
46. "OO Design Patterns for Large-Scale Object-Oriented Communication Software Systems," AG Communication Systems, Phoenix, Arizona, December 11 – 13th, 1995.

47. "Experience Using OO Design Patterns to Develop Large-Scale Object-Oriented Communication Software Systems," Bell Northern Research, 7th Annual Design Forum, Ottawa, Canada, December 6th, 1995.
48. "Using OO Design Patterns to Develop Large-Scale Distributed Systems," Object Technology International, Ottawa, Canada, November 22nd, 1995.
49. "Design Patterns for Concurrent, Parallel, and Distributed Systems," North Dallas Society for Object Technology, September 13th, 1995.
50. "Using Design Patterns for Iridium Communication Services," at Motorola Iridium, Chandler, AZ, June 30th, 1995.
51. "Object Technology and the World-Wide Information Infrastructure," invited panelist at ECOOP '95, Aarhus, Denmark, August 9th, 1995.
52. "Measuring the Performance of CORBA over ATM Networks," HP Labs, Palo Alto, CA, June 28th, 1995.
53. "Measuring the Performance of Object-Oriented Components for High-speed Network Programming," The C++ and C SIG user group, New York, New York, June 5th, 1995.
54. "An Overview of Design Patterns for Object-Oriented Network Programming," St. Louis Chapter of the ACM, St. Louis, MO, March 13th 1995.
55. "Design Patterns for Concurrent Object-Oriented Network Programming," Distributed Systems group at Siemens Corporate Research Center, Munich, Germany, March 3rd, 1995.
56. "Patterns: 'Eureka,' 'Deja-Vu,' or 'Just Say No'?" invited panelist at the *OOP '95 Conference*, SIGS, Munich, Germany January 31st, 1995. (other panelists included Richard Helm, (DMR), Frank Buschmann (Siemens AG), and Dave Thomas (OTI).
57. "Developing Distributed Applications with the ADAPTIVE Communication Environment," *The 12th Annual Sun Users Group Conference*, SUG, San Francisco, California, June 17th, 1994.
58. "Flexible Configuration of High-performance Distributed Communication Systems," presented at the ETH-Zentrum in the Swiss Federal Institute of Technology, Zurich, Switzerland, May 31st, 1994.
59. "Object Oriented Techniques for Developing Distributed Applications," *Computer Science Department Colloquia*, California State University Northridge, December 7th, 1993.
60. "Hosting the ADAPTIVE System in the *x*-Kernel and System V STREAMS," *The x-Kernel Workshop*, IEEE, Tucson, Arizona, November 10th, 1992.
61. "An Environment for Controlled Experimentation on the Performance Effects of Alternative Transport System Designs and Implementations," IBM T. J. Watson Research Center, Hawthorne, New York, September 10th, 1992.

Colloquia, Seminars, and Tutorials

1. "Using Design Patterns, Frameworks, and CORBA to Develop Object-Oriented Communication Systems," University of California Los Angeles Extension, December 8-10, 1998.
2. "Concurrent Object-Oriented Network Programming and Distributed Object Computing," University of California Berkeley Extension, November 16-18, 1998.
3. "Using Design Patterns and Frameworks to Develop Object-Oriented Communication Software," OOP-SLA '98, October 19th, 1998, Vancouver, British Columbia.
4. "High-Performance CORBA," Lucent CORBA Forum, Holmdel, NJ, September 29, 1998.

5. "Writing Efficient Multi-Thread CORBA Applications," the 3rd Components Users Conference, SIEMENS, Munich, Germany, July, 1998. \dot{P}_i
6. "Using Design Patterns and Frameworks to Develop Object-Oriented Communication Software," UCLA extension course, Milan, Italy, June 29 - July 1, 1998.
7. "Using Design Patterns, Frameworks, and CORBA to Develop Object-Oriented Communication Systems," Lucent, Naperville, IL, June 8-11, 1998.
8. "Patterns and Performance of Real-time Object Request Brokers," Fourth IEEE Real-Time Technology and Applications Symposium (RTAS), Denver, Colorado, June 5, 1998.
9. "Using Design Patterns, Frameworks, and CORBA to Develop Object-Oriented Communication Systems," University of California Los Angeles Extension, June 1-3, 1998.
10. "Patterns and Principles of Real-time Object Request Brokers," NSA, Ft. Meade, MD, March 22, 1998.
11. Using Design Patterns, Frameworks, and CORBA to Develop Object-Oriented Communication Systems, Crosskeys, Ottawa Canada, March 19-21, 1998.
12. "Concurrent Object-Oriented Network Programming and Distributed Object Computing," University of California Berkeley Extension, March 4-6, 1998.
13. "Building Distributed Communication Software with CORBA," the Motorola Systems Symposium, February, 1998, Austin, Texas, USA.
14. "Introduction to Distributed Objects with CORBA," SIGS OOP '98, February 9-13, 1998, Munich, Germany.
15. "Design Patterns for Developing and Using CORBA Object Request Brokers," SIGS OOP '98, February 9-13, 1998, Munich, Germany.
16. Using Design Patterns, Frameworks, and CORBA to Develop Object-Oriented Communication Systems, Lucent Technologies, Whippany, NJ, January 5-6, 1998.
17. "Using Design Patterns, Frameworks, and CORBA to Develop Object-Oriented Communication Systems," University of California Los Angeles Extension, December 10-12, 1997.
18. "Concurrent Object-Oriented Network Programming and Distributed Object Computing," University of California Berkeley Extension, December 10-12, 1997.
19. "Using Design Patterns and Frameworks to Develop Object-Oriented Communication Systems," Motorola Cellular Infrastructure Group, Arlington Heights, Illinois, December 1 - 3, 1997.
20. "Using Design Patterns and Frameworks to Develop Object-Oriented Communication Systems," TOOLS Pacific '97, Melbourne, Australia November 24 - 27, 1997.
21. "Using Design Patterns and Frameworks to Develop Object-Oriented Communication Systems" for the IEEE GLOBECOM '97 conference, Phoenix, AZ, November 4-8, 1997.
22. "High-performance Distributed Object Computing with CORBA," IEEE International Conference on Network Protocols, Atlanta, GA, October 28th, 1997.
23. "Using Design Patterns and Frameworks to Develop Object-Oriented Communication Systems," OOP-SLA '97, ACM, Atlanta, GA, October 6-7th, 1997.
24. "Using Design Patterns and Frameworks to Develop Object-oriented Communication Systems," 24th International Conference on Technology of Object-Oriented Languages and Systems (TOOLS Asia '97). Beijing, China, September 22, 1997.
25. "Principles and Patterns of Distributed Object Computing Systems," for the ACM Principles of Distributed Computing Conference (PODC), Santa Barbara, CA, August 21st, 1997.

26. "OO Design Patterns for Concurrent, Parallel, and Distributed Systems," the 3rd *Conference on Object-Oriented Technology*, USENIX, Portland, Oregon, June 16th, 1996.
27. "Distributed Object Computing with CORBA and ACE," Alta Software, Jacksonville, FL, June 4-5th, 1997.
28. "Distributed Object Computing with CORBA", Object Expo, NY, NY, June 2nd, 1997.
29. "Concurrent Object-Oriented Network Programming and Distributed Object Computing," University of California Berkeley Extension, May 28-30, 1997.
30. "Patterns and Principles of Real-time Object Request Brokers," National Security Agency, Ft. Meade, MD, May 13th, 1997.
31. "Building Distributed Communication Software with CORBA," the Motorola Systems Symposium, March, 1997, Chandler, AZ, USA.
32. "Evaluating Concurrency Models for CORBA Servers," the 2nd Components Users Conference, SIEMENS, Munich, Germany, July 14th, 1997.
33. "Design Patterns for Evolving System Software Components from UNIX to Windows NT," the 2st Components Users Conference, SIEMENS, Munich, Germany, July 14th, 1997.
34. "Techniques and Patterns for Distributed Object Computing with CORBA and C++," University of California Berkeley Extension, December 4-6, 1996.
35. "Design Patterns for Concurrent Object-Oriented Programming with ACE and C++," C++ World, Dallas, TX, November 11th, 1996.
36. "Implementing Concurrent CORBA Applications with Multi-Threaded Orbix and ACE," C++ World, Dallas, TX, November 12th, 1996.
37. "Why Reuse has Failed, and How You Can Make it Work for You," Berne Technology Forum 1996, Berne, Switzerland, October 18, 1996.
38. "Introduction to Distributed Object Programming with CORBA," the Local Computer Networks '96 conference, IEEE, Minneapolis, Minnesota, October 13, 1996.
39. "Object-Oriented Design Patterns for Concurrent, Parallel, and Distributed Systems," the OOPSLA '96 conference, ACM, San Jose, California, October, 1996.
40. "OO Design Patterns Network Programming in C++," Object Expo Europe, London, England, September 23rd, 1996.
41. "Effective Multithreaded CORBA Programming," Object Expo Europe, London, England, September 24th, 1996.
42. "Evaluating Concurrency Models for CORBA Servers," the 1st Components Users Conference, SIEMENS, Munich, Germany, July 15th, 1996.
43. "Design Patterns for Evolving System Software Components from UNIX to Windows NT," the 1st Components Users Conference, SIEMENS, Munich, Germany, July 15th, 1996.
44. "OO Design Patterns for Concurrent, Parallel, and Distributed Systems," the 2nd *Conference on Object-Oriented Technology*, USENIX, Toronto, Canada, June 17, 1996.
45. "OO Design Patterns for Network Programming in C++," the *Object Expo '96 Conference*, SIGS, Sydney, Australia, June 3rd, 1996.
46. "Effective Multi-threaded CORBA Programming Programming," the *Object Expo '96 Conference*, SIGS, Sydney, Australia, June 5th, 1996.

47. "Concurrent Object-oriented Network Programming with C++," University Of California Berkeley Extension, Berkeley, California, May 22nd – 24th, 1996.
48. "Experience Developing Reusable Software Using Object-Oriented Design Patterns and Frameworks," the 4th *International Conference on Software Reuse*, Orlando, Florida, USA April 23-26, 1996.
49. "Using Object-Oriented Design Patterns to Develop Large-Scale Distributed Systems," the *OOP Conference*, SIGS, Munich, Germany, Feb 13th, 1996.
50. "Techniques for Object-Oriented Network Programming," the *OOP Conference*, SIGS, Munich, Germany, Feb 14th, 1996.
51. "Concurrent Object-oriented Network Programming with C++," University Of California Berkeley Extension, Berkeley, California, November 30th-December 1st, 1995.
52. "Using Object-Oriented Design Patterns to Develop Large-Scale Distributed Systems," the 4th *C++ World Conference*, SIGS, Chicago, Illinois, October 31st, 1995.
53. "Techniques for Object-Oriented Network Programming," the 4th *C++ World Conference*, SIGS, Chicago, Illinois, October 31st, 1995.
54. "Experience using OO Design Patterns to Develop Large-scale Distributed Communication Systems," *OOPSLA '95 Conference* in Austin, Texas, October 1995.
55. "Concurrent Object-oriented Network Programming with C++," the 9th *European Conference on Object-Oriented Programming (ECOOP)*, Aarhus, Denmark, August, 1995.
56. "Concurrent Object-Oriented Network Programming with C++," the 1st *Conference on Object-Oriented Technology*, USENIX, Monterey, California, June 23, 1995.
57. "Design Patterns for Concurrent and Distributed Systems," the *Object Expo '95 Conference*, SIGS, New York, NY, June 5th 1995.
58. "Object Oriented Network Programming," the *Object Expo '95 Conference*, SIGS, New York, NY, June 5th, 1995.
59. "Software Construction with Active Objects in C++," the *OOP '95 Conference*, SIGS, Munich, Germany January 31, 1995.
60. "Object-Oriented Concurrent Programming with C++," the *OOP '95 Conference*, SIGS, Munich, Germany January 31, 1995.
61. "Concurrent Object-Oriented Programming," the *Winter USENIX Conference*, USENIX, New Orleans, Louisiana, January, 1995.
62. "Object-Oriented Network Programming with C++," the 3rd *C++ World Conference*, SIGS, Austin, Texas, November 14, 1994.
63. "Object-Oriented Techniques for Dynamically Configuring Concurrent Distributed Applications," the 9th *OOPSLA Conference*, ACM, Portland, Oregon, October 23, 1994.
64. "Object-Oriented Network Programming," the 6th *C++ Conference*, USENIX, Cambridge, Massachusetts, April 11, 1994.
65. "Object-Oriented Techniques for Developing Extensible Network Servers," the 2nd *C++ World Conference*, SIGS, Dallas, Texas, October 19, 1993.

Patents

1. Patent pending: INDIGO – “an Interpretive Network Daemon Implemented by means of an Generic-main Object.” In conjunction with Karlheinz Dorn, Dieter Quehl, Detlef Becker, and Christian Scharf of SIEMENS Medical Engineering, Erlangen, Germany.

Research Support

Grants and Contracts Received

Title	Funding Agency	Duration	Amount	co-PIs
“ACE Enhancements for Windows NT and Windows CE	Siemens Medical Engineering	12/1/98 11/31/99	\$50,000	
“Dynamic Scheduling and Real-time ORB Optimizations	Boeing	10/1/98 9/30/99	\$184,860	
“Distributed Object Computing Middleware”	Nortel	11/1/98 10/31/99	\$75,000	
“ACE subsetting,”	Nokia	10/8/98 4/8/99	\$30,000	
“Boeing Research Fellowship”	Boeing	9/1/98 8/31/00	\$81,486	
“Patterns and Frameworks Reuse Curriculum”	Lucent Bell Labs	9/1/98 12/31/98	\$31,200	
“Patterns, Frameworks, and Components”	Siemens ZT	12/1/98 5/31/00	\$150,000	
“High availability frameworks”	Lucent	9/1/98 8/31/99	\$39,400	
“Real-time Distributed Object Computing”	US Sprint	8/1/98 7/31/99	\$288,194	
“Distributed Object Integration for the Quorum Project”	DARPA S30602-98-C-0187	9/1/98 8/31/01	\$448,643	BBN
“Evaluating a Flexible Framework for Dynamic Distributed Real-Time Scheduling,”	USENIX	unrestricted	\$18,000	
hline “Distributed Object Computing	Microsoft	unrestricted	\$20,000	
“Distributed Object Visualization Environment	Lockheed	5/1/98 to 4/31/99	\$37,000	
“Distributed Object Integration for the Quorum Program	DARPA	9/1/98 to 8/31/01	\$3,600,000	BBN Guru Parulkar
“Real-time CORBA for Telecommunications”	Lucent	12/1/97 to 11/31/98	\$100,000	
“Developing an HLA-compliant RTI with ACE	SAIC	12/15/97 to 1/31/00	\$228,075	
“Real-time CORBA for Wireless	Motorola LMPS	10/15/97 to 10/14/98	\$200,000	
“Real-time CORBA for Avionics”	Computing Devices International	10/15/97 to 10/14/98	\$39,050	
“Dynamic Scheduling of Real-time OFPs”	Boeing	9/1/97 to 8/31/98	\$224,604	
“Distributed Object Visualization”	Siemens MED	10/1/97 to 9/1/98	\$40,000	
“The ADAPTIVE Communication Environment”	Siemens MED	10/1/97 to 9/1/98	\$70,000	
“The Architect’s Assistant”	Siemens Corporate Research	9/1/97 to 8/1/98	\$35,000	
“Monitoring, Visualization, and Control of High Speed Networks”	NSF NCR-97-14698	9/1/97 to 8/31/01	\$1,200,000	G. Parulkar, E. Kraemer, J. Turner, and R. Cytron
“Adaptive Software Technology Demonstration (ASTD)”	Wright Laboratories	9/1/98 to 8/31/02	\$1,200,000	Boeing CDI and Honeywell
“A High Performance Distributed Object Environment with Emphasis on Adaptive End-to-end QoS Guarantees”	DARPA 9701561	8/1/97 to 7/31/00	\$650,000	G. Parulkar, J. Turner, and T. Sandholm
“Patterns, Frameworks, and Components for Multimedia Systems”	Siemens Research	1/97 to 6/98	\$150,000	
“Adaptive Servers for High-Performance Imaging”	Kodak Networked Imaging Tech. Center	11/96 to 11/97	\$40,000	
“Real-time CORBA”	US Sprint	9/96 to 12/97	\$345,000	Dr. Parulkar (co-PI)
“OpenMAP – Object-Oriented	McDonnell	9/96 to	\$241,591	

Total research funding since June 1995: \$7,126,258

- Sole PI: \$3,282,615
- Co-PI: \$3,843,643

Research Summary

Communication software for next-generation distributed applications must be flexible, efficient, and predictable. Flexibility is necessary to respond rapidly to application requirements that span an increasingly wide range of media types and traffic patterns. Efficiency and predictability are necessary to support the quality of service demands of performance-sensitive and time-sensitive applications such as teleconferencing, real-time avionics, high-speed medical imaging, and interactive simulation.

The Distributed Object Computing (DOC) group at Washington University, directed by Dr. Douglas C. Schmidt, is internationally recognized as a leading center of excellence on real-time Object Request Brokers (ORBs) and high-performance object-oriented communication middleware. As director of the DOC laboratory, my research applies experimental methods to enhance the development of communication software for next-generation distributed object computing applications.

Despite dramatic increases in the performance of networks and computers, designing and implementing flexible, efficient, and predictable communication software remains hard. Substantial time and effort is required to develop this type of software. Yet all too frequently communication software fails to achieve its quality of service and functionality requirements.

Our research is motivated by the recognition that advances in communication middleware software can be achieved only by simultaneously investigating techniques, patterns, and tools that simplify software development, optimize system performance, and rigorously measure system behavior to pinpoint and alleviate performance bottlenecks and sources of priority inversion and non-determinism.

The following is a synopsis of our primary research contributions:

Identifying the performance bottlenecks and sources of priority inversion and non-determinism in communication software middleware over high-speed networks: The DOC group has performed extensive experiments with a prototype ATM/middleware testbed environment we've built at Washington University. We have systematically identified the performance bottlenecks and sources of priority inversion and non-determinism in communication middleware software mechanisms on high-speed ATM networks. Our tests range from lower-level middleware (such as socket-based C interfaces and the ACE C++ wrappers for sockets) to higher-level middleware (such as CORBA, which is an emerging open standard for distributed object computing).

Our initial experiments revealed that the lower-level C and C++ middleware outperform the higher-level CORBA middleware significantly. For instance, the end-to-end throughput of early CORBA implementations (such as VisiBroker and Orbix) was roughly 75 to 80 percent of the best C/C++ throughput for sending scalar data types and only around 33 percent for sending structs containing binary fields.

As high-speed networks become ubiquitous, the performance discrepancy between lower-level and higher-level tools will impede the adoption of communication software technologies. This is particularly problematic for performance-sensitive, mission/life-critical application domains (such as real-time avionics and high-speed digital imaging), where the use of low-level tools increases development effort and reduces system reliability and flexibility.

Our middleware performance experiments have been published in top conferences and journals and have received widespread recognition, both in academia and industry. For instance, as a direct result of the analysis in our work, the top CORBA vendors have tuned their Object Request Broker (ORB) implementations to

improve performance considerably. The current generation of CORBA ORBs are now competitive with hand-coded C/C++ TCP/IP implementations.

We are currently expanding the scope of our experimental ATM/middleware testbed to measure additional communication software middleware (such as DCE, DCOM, and other versions of CORBA). We are extending our existing single 155 Mbps ATM switch testbed to include 3-5 gigabit switches based on related work at Washington University. This new testbed will allow us to rigorously evaluate the performance bottlenecks in gigabit multimedia communication systems. In addition, we also developing a testbed that will enable us to precisely pinpoint sources of non-determinism and priority inversion in OO middleware for real-time telecommunications and avionics systems.

Publications related to our middleware performance experiments are available at the following URL: www.cs.wustl.edu/~schmidt/corba-research-performance.html.

Developing optimization techniques and object-oriented frameworks to produce communication middleware software that can achieve gigabit data rates, low latency, and real-time predictability: Our goal in precisely pinpointing the sources of overhead, priority inversion, and non-determinism for communication middleware is to develop a scalable and extensible ORB that can deliver gigabit data rates, low latency, and real-time predictability end-to-end to applications. To accomplish this, we have developed the ADAPTIVE Communication Environment (ACE), which is an object-oriented communication software framework.

ACE provides flexible, efficient, and predictable object-oriented components that automate common communication software tasks such as connection establishment, event demultiplexing, event handler dispatching, message routing, dynamic configuration of services, and flexible management of parallel protocol and service processing.

We have used ACE to develop a high-performance, real-time Object Request Broker (ORB) called TAO (The ACE ORB). TAO and ACE provide a unique contribution to research on communication middleware since they implement the first ORB that provides quality of service for high-performance, real-time environments such as ATM switch management, avionics flight control systems, mobile cellular systems, and distributed interactive simulation.

ACE and TAO are currently used in commercial projects and products by dozens of companies including Ericsson, Bellcore, Siemens, Motorola, Kodak, Nortel, Nokia, Boeing, Lucent, DEC, Lockheed Martin, and SAIC. As a testament to our success in technology transfer, two companies are now providing commercial support for ACE and TAO.

The following is a synopsis of the published research accomplishments of the TAO project thus far:

- A Real-time Object Adapter that supports real-time rate monotonic scheduling and dispatching strategies (including real-time upcalls and real-time threads). TAO is the first ORB with these capabilities. For more information please see the following URL: www.cs.wustl.edu/~schmidt/RT-ORB.ps.gz.
- An active demultiplexing strategy that associates client requests with target objects in constant time. TAO is also the first ORB with these capabilities. For more information please see the following URL: www.cs.wustl.edu/~schmidt/ieee_tc-97.ps.gz.
- A highly optimized CORBA TypeCode interpreter that has an extremely small memory footprint and performs competitively with existing commercial ORBs. For more information please see the following URL: www.cs.wustl.edu/~schmidt/HICSS-97.ps.gz.
- A Real-time Event Service that integrates the features described above in practice. This RT Event Service forms the basis for Boeing's next-generation real-time fighter aircraft infrastructure. For more information please see the following URL: www.cs.wustl.edu/~schmidt/JSAC-98.ps.gz.

Publications related to the TAO and ACE projects are available at the following URLs: www.cs.wustl.edu/~schmidt/corba-research-realtime.html and www.cs.wustl.edu/~schmidt/ACE-papers.html.

Discovering and documenting strategic patterns for concurrent and distributed communication software: Achieving widespread reuse of communication middleware components requires a concerted focus on core design patterns that underly communication software systems. Design patterns represent a solution to a set of forces and problems that arise when building software. Patterns aid the development of communication software by expressing the structure and collaboration of components at a level higher than (1) source code or (2) software design models that focus on individual functions, objects, and classes.

During the development of ACE and TAO, we identified and documented a core group of concurrency and distributed patterns. These patterns include the Acceptor, Active Object, Asynchronous Completion Token, Connector, Double-Checked Locking Optimization, External Polymorphism, Half-Sync/Half-Async, Reactor, Proactor, Service Configurator, and Thread-Specific Storage patterns. Our experience illustrates that these patterns form the software architecture of flexible, efficient, and predictable communication software.

Discovering, articulating, and implementing the key design patterns via ACE and our TAO CORBA ORB will enable the rapid development of statistical real-time (e.g., multimedia applications) and deterministic real-time (e.g., avionics flight control systems) that are more efficient and predictable than is possible using existing communication frameworks. In particular, patterns facilitate reuse of communication software when other forms of reuse were infeasible (e.g., due to fundamental differences in operating system mechanisms or programming language features).

Publications related to design patterns identified as part of the TAO and ACE projects are available at the following URL:

www.cs.wustl.edu/~schmidt/patterns-ace.html.

The following summarizes my accomplishments in the 4.5 years since I joined Washington University in the fall of 1994:

- **Publications** – I’ve had 20 journal papers, 39 conference papers, 19 book chapters, 62 invited talks, and 65 tutorials. Several of the papers appeared in the most selective conferences (ACM SIGCOMM, IEEE INFOCOM, and IEEE Distributed Computing Systems) and journals (IEEE Transactions on Computing and IEEE Journal of Selected Areas of Communications) in my field. These numbers are well above the departmental average in each category.
- **Funding** – Since June 1995 I’ve been a P.I. or co-P.I. for grants totaling ~\$7,126,258. I’ve been the sole P.I. for ~\$3,282,615 of this amount. This amount is well above the departmental average.
- **Advising and supervising** – I am currently advising/supporting 12 graduate students (5 doctoral and 7 masters), advising 4 undergraduates, and supervising 4 full-time staff members. I have graduated 4 masters students and 1 doctoral student.
- **Professional service** – I’ve been guest editor of 4 ACM, IEEE, and USENIX journals, co-edited 2 books, served as associate editor and editor-in-chief of the C++ Report magazine, been program chair for 3 conferences, tutorial chair for 2 conference, and served on the program committees for over 20 IEEE and ACM conferences.

References

Dr. Al Aho
Vice President of Communications Sciences Research Division
aaho@lucent.com
600 Mountain Avenue
Murray Hill, NJ 07974

Professor Doug Lea
dl@g.oswego.edu
Computer Science Department,
111 Snygg Hall,
SUNY Oswego, Oswego, NY 13126
(315) 341-2688

Professor Louise Moser
moser@ece.ucsb.edu
Room 5151, Engineering I
Department of Electrical and Computer Engineering
University of California
Santa Barbara, CA 93106-9560
(805) 893-4897

Professor Adam Porter
aporter@cs.umd.edu
A.V. Williams Building
Department of Computer Science
University of Maryland, College Park
College Park, MD 20742, (301) 405-2702

Dr. Bjarne Stroustrup
bs@research.att.com
AT&T Research
Florham Park
NJ07932-0971

Professor Tatsuya Suda
suda@ics.uci.edu
Department of Information and Computer Science
University of California, Irvine
Irvine, CA 92717, (714) 856-4105