

# Dr. rer. nat. Martin W. J. Schulz

## Personal Information

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## Current Research Interests

- Parallel Architectures, Languages, and Tools
- Memory and Cache Architectures
- SCI-based Multiprocessor Systems and Clusters
- Hybrid Software / Hardware DSM for NUMA architectures
- Shared Memory Programming Models
- Monitoring and Tool Support for Shared Memory Programming
- Distributed and Parallel I/O for Clusters

## Education

- Dr. rer. nat. (in Computer Science), Technische Universität München, Germany, July 2001
- M.S. in Computer Science, University of Illinois at Urbana-Champaign, IL, USA, January 1997
- Vordiplom (Computer Science), Technische Universität München, Germany, October 1994

## Professional Experience

2001- Postdoctoral Assistant at Technische Universität München, Department of Computer Science

1997-2001 Research Assistant at Technische Universität München, Department of Computer Science  
Member of the Lehrstuhl für Rechnertechnik und Rechnerorganisation (LRR-TUM, Prof. Dr. A. Bode)  
For projects see below

1996-1997 Student employment at Technische Universität München, Department of Computer Science  
Tasks included workshop organization and support for dissemination work at high schools.

1996 Research Assistant at University of Illinois at Urbana-Champaign  
Member of the Concurrent Systems Architecture Group (CSAG, Prof. Dr. A. Chien)  
For projects see below

1994-1995 Grader at Department of Mathematics, Technische Universität München

1989-1994 Various Internships at Siemens AG  
Tasks included network administration, database development, software development for PLCs, and support in large projects (e.g. automatization and information flow in breweries and local mass transit systems).

## Professional Associations

Since 1998 Member of ACM  
Member of SIGARCH, SIGMICRO, SIGOS, and SIGPLAN

Since 2001 Member of IEEE  
Member of the IEEE Computer Society

1998/1999 Member of USENIX

Since 2001 Member of IASTED

## Teaching Experience

- 2002 Co-organization of graduate seminar “Grid-Computing”  
Co-organization of graduate seminar “History of Computing”
- 2001/02 Course “Computer Architecture and Networks”, (CSE-program)  
Co-organization of undergraduate seminar “Grid-Computing”  
Co-organization of undergraduate seminar “Palm & Visor: Techniques and Applications”
- 2001 Co-organization of graduate seminar “Ubiquitous Computing”
- 2000 Co-organization of undergraduate seminar “Linux kernel structures”
- 1998 Parts of course titled “Modeling and Simulation of Computer Systems” (including supervision of practical exercises)
- 1998 Co-organization of graduate seminar “Code Optimization Techniques for Modern Computer and Processor Architectures”
- Since 1997 Supervision of student groups in the practical “Technical Foundations in Computer Science”, area “Microprogramming”

## Research Experience

### **SMiLE (Shared Memory in a Lan-like Environment, 1997-present)**

Research project broadly investigating the implementation and exploitation of SCI (Scalable Coherent Interface) based clusters. This includes both the design of hardware and software components. Work within SMiLE includes extensive software development as well as various administrative and strategic tasks.

### **HAMSTER (Hybrid-dsm based Adaptive and Modular Shared memory archiTectuRe, 1999-present)**

As part of SMiLE and as a continuation of part of the efforts in SISCO, this project aims at the development of a programming model independent shared memory framework for NUMA architectures. Tasks include all technical and project management aspects.

### **DIOM (Distributed I/O Management, 2000-present)**

Investigation of efficient parallel I/O for data intensive applications on commodity clusters and implementation of a prototypical I/O management framework. Tasks include all technical and project management issues.

### **Cache Monitoring and Memory Performance Evaluation (2002-present)**

Design and evaluation of novel techniques for monitoring cache activities with the goal of enabling cache optimizations. Tasks include all technical and project management issues.

### **NEPHEW (Network of PC’s Heterogeneous Windows-NT Engineering Toolset, 1999-2000)**

ESPRIT project funded by the European Union to port a graphical parallel programming package to cluster environments and to evaluate it using three real-world applications, including the iterative reconstruction of Positron Emission Tomography images. Tasks included software development, project management, and extensive dissemination. This project was done in cooperation with four partners in four European countries as well as in close cooperation with the department of Medicine at the Technische Universität München.

### **SISCO (Standard software Infrastructure for SCI-based parallel systems, 1997-1999)**

ESPRIT project funded by the European Union to design, implement, and test a software infrastructure for SCI (Scalable Coherent Interface) based commodity clusters. Tasks included software development, project management, and extensive dissemination. This project was done in cooperation with seven partners in four European countries.

### **MORPH: Configurable Computing for Petaflops (1996)**

Design and evaluation of a next generation Petaflop architecture using reconfigurable logic. Tasks included initial design studies and evaluation using simulation.

### **Illinois Concert (1995-1996)**

High-level and object-oriented parallel programming environment deploying both sophisticated compiler technology and efficient runtime mechanisms. Tasks included the work on a large application study (parallel volume rendering using surface extraction) for the Illinois Concert C++ system.

## Professional Activities

### Conference/Workshop Chair

- HIPS: Workshop on High-Level Parallel Programming Models and Supportive Environments, 2003
- SCI-Europe: International Conference on SCI-based Technology and Research, 2001 (Co-Chair)
- HIPS: Workshop on High-Level Parallel Programming Models and Supportive Environments, 2000

### Steering Committees

- HIPS: Workshop on High-Level Parallel Programming Models and Supportive Environments, since 2001
- SCI-Europe: International Conference on SCI-based Technology and Research, since 2000

### Program Committees

- GRID: International Workshop on Grid Computing, 2002
- PDCS/IASTED: Parallel and Distributed Computing and Systems, 2002
- PDCS/ISCA: Parallel and Distributed Computing Systems, 2002
- HIPS: Workshop on High-Level Parallel Programming Models and Supportive Environments, 2000-2002
- SCI-Europe: International Conference on SCI-based Technology and Research, 2000-2001
- DOCS: Conference on Distributed Objects in Computational Science, 2000

### Organizing Committees & Supportive Tasks

- APC: German Conference on Arbeitsplatzcomputer / Pervasive Computing, 2001
- 18<sup>th</sup> PARS Workshop, 2001
- Euro-Par: European Conference on Parallel Computing, 2000
- SCI-Europe: International Conference on SCI-based Technology and Research, 1999-2001
- HIPS: Workshop on High-Level Parallel Programming Models and Supportive Environments, 1997

### Other Activities

- Publications Chair of PACT 2002
- Co-Organizer of the HPCA-8 Work-in-Progress Session (2002)
- Co-Organizer of the PACT 2001 Work-in-Progress Session

## Technical Experience

### Parallel Architectures and Systems

- Extensive experience with PC clusters (esp. SCI-based) and NoWs
- Initial experiences with SGI PowerChallenge and HP/Convex Exemplar

### Programming Languages

- Extensive knowledge in C and C++ (on both UNIX and Windows NT/2000)
- Experience with Java, Fortran, Pascal, Modula, Basic, Lisp, ML, and Step 5

### Programming and System Experiences

- Parallel Programming: PVM, MPI, OpenMP, Pthreads, PeakWare (Graphical Programming)
- Other libraries: OpenGL
- Experience on various UNIX systems (incl. Linux, HP-UX, Irix, and Solaris) and Windows NT/2000
- Kernel programming on both Linux and Windows NT/2000

### Application Experience

- Medical Imaging: Post-processing for Positron Emission Tomography (PET)
- Electric Field Simulation: Electrostatic and –magnetic simulation for high-voltage systems
- Volume Rendering, Surface Extraction Codes
- Genome Sequence Analysis using Maximum Likelihood

## Publications, Tutorials, Talks

### Editor

- Brian Coghlan, Geir Horn, and Martin Schulz. Proceedings of the 4<sup>th</sup> International Conference on SCI-based Research and Technology, SINTEF, Oslo, October 2001.
- Jose Rolim, Martin Schulz, et. al. Parallel and Distributed Processing (15 IPDPS 2000 Workshops, Cancun, Mexico, May 1-5, 2000), Lecture Notes in Computer Science (LNCS) vol. 1800, Springer Verlag, May 2000.

### Chapters in Books

- Martin Schulz, True shared memory programming on SCI-based clusters, in “Scalable Coherent Interface / SCI, Architecture and Software for High-Performance Compute Clusters”, H. Hellwagner and R. Reinefeld (eds.), LNCS State-of-the-Art Survey, vol. 1734, Springer Verlag, October 1999.

### Journals

- Jie Tao, Wolfgang Karl, and Martin Schulz, Memory Access Behavior Analysis of NUMA-based Shared Memory Programs, to appear in Scientific Computing, Special issue on Performance-Oriented Application Development for Distributed Architectures.

### Refereed Conferences

- Carsten Trinitis, Martin Schulz, and Wolfgang Karl, Boosting the Performance of Electromagnetic Simulations on a PC-Cluster, to appear at the International Conference of Parallel Computing in Electrical Engineering (PARELEC), September 2002.
- Martin Schulz, Using Semantic Information to Guide Efficient Parallel I/O on Clusters, to appear in 11<sup>th</sup> IEEE International Symposium on High Performance Distributed Computing (HPDC-11), July 2002.
- Martin Schulz, Jie Tao, Carsten Trinitis, and Martin Schulz, SMiLE: An Integrated, Multi-Paradigm Software Infrastructure for SCI-based Clusters, to appear in 2nd IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGrid), May 2002.
- Jie Tao, Martin Schulz, and Wolfgang Karl, Improving Data Locality Using Dynamic Page Migration based on Memory Access Histograms, to appear in the International Conference on Computational Science (ICCS), session on Tools for Program Development and Analysis, April 2002.
- Martin Schulz, Parallel Volume Rendering based on Isosurface Extraction Using Commodity Clusters, Visualization, Imaging, and Image Processing (VIIP), Marbella, Spain, September 2001 (ACTA Press).
- Jie Tao, Wolfgang Karl, and Martin Schulz, Using Simulation to Understand the Data Layout of Programs, Applied Simulation and Modeling (ASM), Marbella, Spain, September 2001 (ACTA Press).
- Carsten Trinitis, Martin Schulz, Michael Eberl, and Wolfgang Karl, SCI-based LINUX PC-Clusters as a Platform for Electromagnetic Field Calculations, 6<sup>th</sup> International Conference on Parallel Computing Technologies (PaCT 2001), Novosibirsk, Russia, September 2001 (LNCS, vol. 2127, Springer Verlag).
- Martin Schulz, DIOM: Parallel I/O for Data Intensive Applications on Commodity Clusters, Parallel and Distributed Computing and Systems (PDCS), Los Angeles, CA, USA, August 2001 (ACTA Press).
- Wolfgang Karl, Martin Schulz, Martin Völk, and Sibylle Ziegler, Meeting the Computational Demands of Nuclear Medical Imaging using Commodity Clusters, International Conference on Computational Science (ICCS), San Francisco, CA, USA, May 2001 (LNCS, vol. 2074, Springer Verlag).
- Jie Tao, Wolfgang Karl, and Martin Schulz, Visualizing the Memory Access Behavior of Shared Memory Applications on NUMA Architectures, International Conference on Computational Science (ICCS), San Francisco, CA, USA, May 2001 (LNCS, vol. 2074, Springer Verlag).
- Martin Schulz, Efficient Deployment of shared memory models on clusters of PCs using the SMiLEing HAMSTER approach, International Conference on Algorithms and Architectures in Parallel Processing (ICA3PP), Hong Kong, December 2000 (World Scientific Publishing).
- Martin Schulz, Multithreaded Programming of PC clusters, Parallel Architectures and Compilation Techniques (PACT), Philadelphia, PA, USA, October 2000 (IEEE Press).
- Wolfgang Karl, Martin Schulz, Martin Völk, and Sibylle Ziegler, NEPHEW: Applying a Toolset for the Efficient Deployment of a Medical Image Application on SCI-based clusters, Euro-Par 2000, European Conference on Parallel Computing, München, Germany, August 2000 (LNCS, vol. 1900, Springer Verlag).
- Martin Schulz, Efficient Coherency and Synchronization Management in SCI based DSM systems, SCI-Europe 2000, München, Germany, August 2000.
- Jie Tao, Wolfgang Karl, and Martin Schulz, Understanding the Behavior of Shared Memory Applications Using the SMiLE Monitoring Framework, SCI-Europe 2000, München, Germany, August 2000.
- Robert Hockauf, Jürgen Jeitner, Wolfgang Karl, Robert Lindhof, Martin Schulz, Vicente Gonzales, Enrique Sanquis, and Gloria Torralba, Design and Implementation Aspects for the SMiLE Hardware Monitor, SCI-Europe 2000, München, Germany, August 2000.

- Wolfgang Karl, Martin Schulz, and Jie Tao, Using the SMiLE Monitoring Infrastructure to Detect and Lower the Inefficiency of Parallel Applications, HPCN-Europe, Amsterdam, NL, May 2000 (LNCS, vol. 1823, Springer Verlag).
- Wolfgang Karl, Martin Schulz, and Joerg Trinitis, Multilayer Online-Monitoring for Hybrid DSM systems on top of PC clusters with a SMiLE, 11th International Conference on Modeling Techniques and Tools for Computer Performance Evaluation, Chicago, IL, USA, March 2000 (LNCS, vol. 1786, Springer Verlag).
- Wolfgang Karl, Markus Leberecht, and Martin Schulz, Optimizing data locality for SCI-based PC-clusters with the SMiLE monitoring approach, Parallel Architectures and Compilation Techniques (PACT), Newport Beach, CA, USA, October 1999 (IEEE Press).
- Martin Schulz, Martin Völk, Wolfgang Karl, Frank Munz, and Sibylle Ziegler, Running a spectral analysis code on top of SCI shared memory using the TreadMarks API, SCI-Europe '99, Toulouse, France, September 1999.
- Martin Schulz and Hermann Hellwagner, Global Virtual Memory based on SCI-DSM, "SCI-Europe '98", Bordeaux, France, September 1998.
- Martin Schulz, SISCIPthreads, SMP-like programming on an SCI-cluster, HPCN-Europe, Amsterdam, NL, April 1998 (LNCS, vol. 1401, Springer Verlag).
- Xingbin Zhang, Ali Dasdan, Martin Schulz, Rajesh Gupta, and Andrew Chien, Architectural Adaptation of Application-Specific Locality Optimizations, International Conference on Computer Design (ICCD), Austin, TX, USA, September 1997.

### Refereed Workshops

- Martin Schulz, Jie Tao, Jürgen Jeitner, and Wolfgang Karl, A Proposal for a New Hardware Cache Monitoring Architecture, to appear in the ACM SIGPLAN workshop on Memory Systems Performance (MSP), June 2002.
- Martin Schulz, Overcoming the Problems Associated with the Existence of Too Many DSM APIs, to appear in the 2002 International Workshop on Distributed Shared Memory on Clusters, May 2002.
- Jie Tao, Wolfgang Karl, and Martin Schulz, A Novel Approach for Data Distribution on NUMA Machines, to appear in the 6th German workshop on Parallel Systems and Algorithms, April 2002.
- Michael Gerndt, Andreas Schmidt, Martin Schulz, and Roland Wismüller, Performance Analysis of Teraflop Computers – A Distributed Automatic Approach, 10th Euromicro Workshop on Parallel, Distributed, and Network Processing (PDP), January 2002.
- Wolfgang Karl and Martin Schulz, Hybrid-DSM: An Efficient Alternative to Pure Software DSM Systems on NUMA Architectures, 2nd International Workshop on Software DSM, May 2000.
- Martin Schulz, SCI-VM: A flexible base for transparent shared memory programming models on clusters of PCs, High level Programming Models and Supportive Environments (HIPS '99), San Juan, Puerto Rico/USA, April 1999 (LNCS, vol. 1586, Springer Verlag).
- Michael Eberl, Wolfgang Karl, Markus Leberecht, and Martin Schulz, Eine Software-Infrastruktur für Nachrichtenaustausch und gemeinsamen Speicher auf SCI-basierten PC-Clustern, 2. Workshop Cluster Computing, Karlsruhe, Germany, March 1999.
- Wolfgang Karl, Markus Leberecht, and Martin Schulz, Supporting Shared Memory and Message Passing on Clusters of PCs with a SMiLE, 3rd International Workshop on Communication, Architecture and Applications for Network-Based Parallel Computing (CANPC '99), Orlando, FL, USA, January 1999 (LNCS, vol. 1602, Springer Verlag).
- Michael Eberl, Hermann Hellwagner, Bjarne Herland, and Martin Schulz, SISCIP - Implementing a Standard Software Infrastructure on an SCI Cluster, 1. Workshop Cluster Computing, Chemnitz, Germany, November 1997.

### Posters & Exhibitions

- Martin Schulz, Carsten Trinitis, Jie Tao, Wolfgang Karl, SMiLE: An integrated, multiparadigm infrastructure for High Performance Computing on SCI-based Clusters, Supercomputing 2001, Denver, CO, USA, November 2001.
- G. Torralba, V. González, E. Sanchis, J. Tao, M. Schulz, and W. Karl, Data Monitoring in High Performance Clusters, 12<sup>th</sup> IEEE International Congress on Real Time for Nuclear and Plasma Sciences, NPSS, Valencia, Spain, June 2001.
- Martin Schulz, Martin Voelk, Wolfgang Karl, and Sibylle Ziegler, Effiziente iterative PET-Bild Rekonstruktion auf einem Cluster von PCs, Jahreskongresses der DEGRO, ÖGRO, DGMP - Band 176, Sondernummer 1, München, Germany, October 2000.
- Georg Acher, Rainer Buchty, Michael Eberl, Detlef Fliegl, Wolfgang Karl, Markus Leberecht, Martin Schulz, and Carsten Trinitis, High-Performance Cluster Computing, International trade fair CeBIT '99, Hannover, Germany, March 1999.
- Martin Schulz and Hermann Hellwagner, Extending NT Virtual Memory by SCI-based Hardware DSM, Usenix Windows NT Symposium, Seattle, WA, USA, August 1998.

## Theses

- Martin Schulz, Shared Memory Programming on NUMA-based Clusters using a General and Open Hybrid Hardware/Software Approach, PhD thesis, Technische Universität München, July 2001.
- Martin Schulz, Application Study for the Illinois Concert C++, A Parallel Volume Renderer, Master's thesis, University of Illinois at Urbana-Champaign, January 1997.

## Tutorials and Guest Lectures

- Martin Schulz, Shared Memory Programming on SCI-based Clusters, Trinity College Dublin, Ireland (as part of a lecture series for final year students), February 2002
- Martin Schulz and Joachim Worringer, Tutorial: SCI Low-level Programming: SISI / SMI, Held as part of the SCI Summer School 2001, Trinity College Dublin, Ireland, October 2001.
- Martin Schulz, DSM Softwarearchitekturen und Programmierumgebungen, Technische Universität Chemnitz, Germany (as part of the lecture "Cluster and Grid-Computing"), Juni 2001
- Wolfgang Karl and Martin Schulz, Tutorial: SMiLE Shared Memory Programming, Held as part of the SCI Summer School 2000, Trinity College Dublin, Ireland, October 2000.

## Invited Talks

- Martin Schulz, HAMSTER: A Framework for Shared Memory Support in NUMA-based Cluster Environments, Illinois Institute of Technology, Chicago, IL, USA, February 2002.
- Martin Schulz, Cluster Computing mit SCI: Von der Hardware bis zur Anwendung, Informatik Kolloquium, Johannes Kepler Universität Linz, Austria, December 2001
- Martin Schulz, Distributed Shared Memory: Shared Memory für Cluster Umgebungen, 2nd Meeting of the KONWIHR Working Group "Tools for Porting Applications to SMP Clusters", Technische Universität München, München, Germany, December 2001
- Martin Schulz, HAMSTER: A Framework for Shared Memory Support in NUMA-based Cluster Environments, Brown University, RI, USA, November 2001
- Martin Schulz, Shared Memory Programmierung im SMiLE Projekt: Das HAMSTER System, Max-Planck-Institut für neuropsychologische Forschung, Leipzig, Leipzig, Germany, September 2001
- Martin Schulz, Efficient Shared Memory Support in NUMA-based Cluster Environments, IBM T.J. Watson Research Center, Yorktown Heights, NY, USA, June 2001
- Martin Schulz, Efficient Shared Memory Support in NUMA-based Cluster Environments, Lawrence Livermore National Laboratory, CASC, Livermore, CA, USA, June 2001
- Martin Schulz, Shared Memory programming on top of SCI, Open SCI users workshop, Oslo, Norway, August 1999.
- Martin Schulz, The SMiLE project (Shared Memory in a Lan-like Environment), Open SCI users workshop, Oslo, Norway, August 1999.
- Martin Schulz, The SMiLE Project, An overview, Held at CVUT Prag, Prag, Czech Republic, May 1998.

## Unrefereed Newsletters

- M. Schulz, B. Childers, S.A. McKee, Guest Editors, IEEE Technical Committee on Computer Architecture (TCCA) Newsletter, Fall 2001 (Proceedings of PACT'01 WiP Session).

## Advising

### Diplom Thesis (equivalent to a Master Thesis) – titles translated

- Christian Leiter, "Development of a Web-based and Application-oriented Solution for Cluster Management and Monitoring", currently ongoing, expected June 2002.
- Maximilian Schramm, "Comparison of Hardware and Software DSM on an SCI-based Cluster", currently ongoing, expected February 2002.
- Uwe Meisel, "Comparison of several Shared Memory Programming Models using a Radiosity Code", 1999.
- Christian Mailer, "Port and Optimization of a Real-time Volume Visualization Code based on the Shear Warp Algorithm to SCI-based Clusters", 1999.
- Max Walter, "Performance Evaluation of an SCI-based Cluster using the SPLASH-2 Benchmarks", 1997.

### Undergraduate Students

- Tianchao Li, "Simulation Studies of NUMA Shared Memory Architectures" as part of the SMiLE project, 2002.
- Arpiruk Hokpunna, "Evaluation of Different free OpenMP Frameworks" as part of the HAMSTER project, 2001/2002.
- Thorsten Jöhnk, "Cluster Administration and Configuration" as part of the SMiLE project, 1999.
- Detlef Fliegl, "Extended Virtual Memory Management of Windows NT" as part of the HAMSTER project, 1998.