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Research interests

I work in the general area of computer systems. Specific interests include autograding systems, scientific computing, and high-performance computing.

Employment experience

Faculty member (Full Professor), School of Computer Science and Dept. of Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh, PA, 2010–present.

Research Scientist, Intel Labs Pittsburgh, 2010–2011.

Director, Intel Labs Pittsburgh, 2007–2010.

Faculty member (Associate Professor with tenure), School of Computer Science and Dept. of Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh, PA, 2002–2010.

Faculty member (Associate Professor), School of Computer Science and Dept. of Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh, PA, 1998–2002.

Faculty member (Research Scientist), School of Computer Science, Carnegie Mellon University, Pittsburgh, PA, 1992–1998.

Faculty member (Systems Scientist), School of Computer Science, Carnegie Mellon University, Pittsburgh, PA, 1989–1992.

Computer Scientist, GE R&D Center, Schenectady, NY, 1986–1989.

Education

Ph.D., Computer Science, University of Virginia, 1986. Thesis: *An investigation of models of concurrent programs.*, Advisor: Prof. Paul F. Reynolds, Jr.

M.S., Computer Science, University of Virginia, 1983.

B.S., Computer Science (Minor in French), Virginia Tech, 1979.

Awards and honors

Winner, HPC Analytics Challenge (with Hongfeng Yu, UC-Davis), Tiankai Tu, Jacobo Bielak, Omar Ghattas (University of Texas at Austin), Julio Lopez, Kwan-Liu Ma (UC-Davis), Leonardo Ramirez-Guzman, Nathan Stone (PSC), Ricardo Taborda-Rios, John Urbanic (PSC), SC06, Nov, 2006.

Best student paper finalist (Tiankai Tu), SC06, Nov, 2006.

CIT Outstanding Research Award (with Jacobo Bielak, Omar Ghattas, and V. Akcelik), Carnegie Institute of Technology, Carnegie Mellon University, 2004-2005.

SCS Herbert A. Simon Award for Teaching Excellence in Computer Science, School of Computer Science, Carnegie Mellon University, 2004.

Finalist (one of five in Science category), 2004 Computerworld Honors 21st Century Achievement Awards (with J. Bielak, O. Ghattas, and PSC for the Quake project).

Winner (with Jacobo Bielak, Omar Ghattas, and our students) of the 2003 Gordon Bell Award for Special Achievement, *High Resolution Forward and Inverse Earthquake Modeling on Terascale Computers*.

The milestone calculations for the award included:

- The generation of a record unstructured hex mesh (3.7 billion elements, 4 billion nodes)
- The largest unstructured mesh wave propagation simulation (900 million elements, 3.2 billion DOF)
- The largest acoustic wave propagation inverse problem (17 million inversion parameters, 70 billion total unknowns)
- The largest elastic wave propagation inverse problem (275,000 inversion parameters, something like a billion total unknowns).

Program 183.EQUAKE (earthquake ground motion modeling) selected by SPEC (Standard Performance Evaluation Corporation) as one of 14 floating point benchmarks in the SPEC CPU2000 benchmark suite.

Parallelized versions of 183.EQUAKE, called 320.EQUAKE_M and 321.EQUAKE_L selected for inclusion in the SPEC OMPM2001 and OMPL2001 benchmark suites for evaluating shared-memory multiprocessor system performance.

Alan Newell Award for Research Excellence, School of Computer Science, Carnegie Mellon University, 1998.

Thesis advisor for the co-winner of the CMU School of Computer Science Distinguished Dissertation Award (Jonathan Shewchuk), 1997.

National Science Foundation US-India Exchange of Scientists Program Award. Visiting scientist at Indian Institute of Science, Bangalore, and Centre for Development of Advanced Computer Systems, Pune. May, 1992.

Achievement Reward for College Scientists, ARCS Foundation, Washington, DC, 1985.

Current projects

Autolab project. I'm leading a talented group of undergraduate students who are developing a new internet-based service, called Autolab, that provides the capability to offer programming assignments to students around the world.

The service is based on the notion of "autograding", that is, programs evaluating other programs. In this model, teachers select the labs for their classes from a repository of high-quality labs written by other teachers and students. An author whose lab is adopted for a class receives a small royalty payment and community recognition in the form of a public adoptions page. The autograding service provides each student with a virtual machine in the cloud that they can use to store and work on their lab assignments. Each lab is distributed with its own autograder, which students can run at any time to check their progress. The scores from each autograder invocation are streamed back to the autograding service, where they are displayed, anonymized, on a realtime scoreboard (shown) that is visible to everyone in the class. Each time a student hands in their work for credit, the service spins up a new VM and autogrades the student's work in this new VM.

We are actively developing and deploying a local version of the Autolab service at Carnegie Mellon. The system is used by 5,000+ CMU students in 50+ courses each semester. It is currently deployed at CMU by Computing Services and the Eberley Center as a CMU-wide resource like Blackboard.

Besides the impact we've already had within CMU, I expect Autolab to have the following impact:

- *Wider reach for CMU:* With a system like Autolab, students no longer need to be on campus to do the programming assignments for their courses. Autolab could be a crucial part of an infrastructure that would allow CMU to offer courses to more students in more places. For example, in Fall, 2012, CMU provided the autograding services for 170 students at Peking University.
- *Better education for students:* A global autograding service addresses a fundamental and universal issue in undergraduate and secondary education, as well as industry training programs on topics of particular interest to Intel such as parallel computing and security.
- *New reputation-based community for teachers:* A global autograding service will help to create a new world-wide reputation-based community for teachers. Teachers who create great labs will now have a way to share their work with others and be recognized for their contributions.
- *New workload for cloud computing:* Global autograding services are a new and interesting workload for cloud computing. Because students always wait until the last minute to handin, the workload is extremely bursty, and thus is an excellent driver for studying the requirements of elastic resource allocation in the cloud.
- *New research problems:* Global autograding services will drive new basic research on problems such as the design of polymorphic labs that can defeat cheating by tweaking themselves, and on new techniques for dynamically evaluating the correctness of parallel and concurrent codes. The ability to selectively expose autograding tests to students provides some interesting research possibilities: for example, how to create an economic model that encourages students to think actively about testing without giving them the test cases for free? (see autolabproject.com)

Previous projects *Open Cirrus project* (with Intel, HP Labs, Yahoo!, UIUC, Karlsruhe Institute of Technology, MIMOS (Malaysia), Singapore IDA, ITRI (South Korea), Russian Academy of Science) The Open Cirrus project, initiated by Intel, HP, and Yahoo!, is creating a global testbed for cloud computing research. (See opencirrus.org)

Quake project (with Jacobo Bielak and Omar Ghattas). The Quake project is developing the capability to predict earthquake-induced ground motion in large basins such as Los Angeles. (See www.cs.cmu.edu/~quake)

Internet Suspend/Resume (ISR) (with Satya and Intel Research). The ISR project is developing the capability to migrate virtual machines across the Internet. (See isr.cmu.edu)

Computational Database Systems (CoDS) (with Natassa Ailamaki and Greg Ganger). The CoDS project is developing new techniques that enable scientists to perform the entire physical simulation process (octree based finite element mesh generation, solving, visualization) directly on databases.

Seurat project (with Hui Zhang and Michael Reiter). Developed new techniques for detecting system anomalies such as intrusions or misconfigurations by correlating file system changes across both space and time. (See www.cs.cmu.edu/~seurat)

Fx project (with Thomas Gross and Jaspal Subhlok). Helped lead the design and implementation of the Fx parallelizing Fortran compiler and its application to sensor-based applications. (See www.cs.cmu.edu/~fx)

iWarp project (with H. T. Kung and Thomas Gross and in partnership with Intel). Helped lead the design and implementation of the iWarp parallel computer system. (See www.cs.cmu.edu/~iwarp)

Books

BRYANT, R., AND O'HALLARON, D. *Computer Systems: A Programmer's Perspective, 3rd Edition*. Pearson, 2016. *Adopted by hundreds of schools on five continents. Core course at Carnegie Mellon for both SCS and ECE.* (See <http://csapp.cs.cmu.edu>)

O'HALLARON, R., AND O'HALLARON, D. *The Mission Primer: Four Steps to an Effective Mission Statement*. Mission, Inc, Richmond, VA, 2000. ISBN 0-967-66350-4. *Third printing.*

GROSS, T., AND O'HALLARON, D. *iWarp: Anatomy of a Parallel Computing System*. MIT Press, Cambridge, MA, March, 1998, ISBN 0-262-07183-5. *A comprehensive technical and management history of the design and construction of a new computer system.*

Books edited

O'HALLARON, D. (EDITOR) *Proceedings of the 4th Workshop on Languages, Compilers, and Run-time Systems for Scalable Computers*, Lecture Notes on Computer Science, Volume 1511, Springer-Verlag, Oct, 1998.

Journals

AVETISYAN, A., CAMPBELL, R., GUPTA, I., HEATH, M., KOZUCH, S. Y. K. M., O'HALLARON, D., KUNZE, M., KWAN, T., LAI, K., LYONS, M., MILOJICIC, D., LEE, H. Y., SOH, Y. C., MING, N. K., LUKE, J.-Y., AND NAMGOONG, H. Open Cirrus: A global cloud computing testbed. *IEEE Computer* (Apr. 2010).

SATYANARAYANAN, M., GILBERT, B., TOUPS, M., TOLIA, N., SURIE, A., O'HALLARON, D. R., WOLBACH, A., HARKES, J., PERRIG, A., FARBER, D. J., KOZUCH, M. A., HELFRICH, C. J., NATH, P., AND LAGAR-CAVILLA, H. A. Pervasive Personal Computing in an Internet Suspend/Resume System. *IEEE Internet Computing* 11, 2 (Mar/Apr 2007), 16–25.

TABORDA, R., RAMIREZ-GUZMÁN, L., TU, T., KIM, E., LÓPEZ, J., BIELAK, J., GHATTAS, O., AND OHALLARON, D. Scaling up terashake: A 1-hz case study. *Eos Transcripts of the American Geophysical Union* 87 (2006), 52.

SATYANARAYANAN, M., KOZUCH, M., HELFRICH, C., AND O'HALLARON, D. R. Towards seamless mobility on pervasive hardware. *Pervasive & Mobile Computing* 1, 2 (2005).

KOZUCH, M. A., HELFRICH, C. J., AND O'HALLARON, D. R. Enterprise client management with Internet suspend/resume. *Intel Technology Journal* 8, 4 (2004).

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TU, T., O'HALLARON, D., AND LOPEZ, J. Etree – a database-oriented method for generating large octree meshes. In *Proceedings of the Eleventh International Meshing Roundtable* (Ithaca, NY, Sept. 2002), pp. 127–138.

DINDA, P., AND O'HALLARON, D. Host load prediction using linear models. *Cluster Computing* 3, 4 (2000), 265–280. Earlier version published as:

An evaluation of linear models for host load prediction. In *Proc. 8th IEEE Symposium on High-Performance Distributed Computing (HPDC-8)* (Redondo Beach, CA, Aug. 1999).

LOWEKAMP, B., O'HALLARON, D., AND GROSS, T. Direct network queries for discovering network resource properties in a distributed environment. *Cluster Computing* 3, 4 (2000), 281–291. Earlier version published as:

Direct network queries for discovering network resource properties in a distributed environment. In *Proc. 8th IEEE Symposium on High-Performance Distributed Computing (HPDC-8)* (Redondo Beach, CA, Aug. 1999).

BAO, H., BIELAK, J., GHATTAS, O., KALLIVOKAS, L., O'HALLARON, D., SHEWCHUK, J., AND XU, J. Large-scale simulation of elastic wave propagation in heterogeneous media on parallel computers. *Computer Methods in Applied Mechanics and Engineering* 152, 1–2 (Jan. 1998), 85–102.

O'HALLARON, D., WEBB, J., AND SUBHLOK, J. Performance issues in High Performance Fortran implementations of sensor-based applications. *Scientific Programming* 6, 1 (Spring 1997), 59–72.

GROSS, T., O'HALLARON, D., AND SUBHLOK, J. Task parallelism in a High Performance Fortran framework. *IEEE Parallel & Distributed Technology* 2, 3 (Fall 1994), 16–26.

GROSS, T., HINRICHS, S., O'HALLARON, D., AND STRICKER, T., HASEGAWA, A. Communication styles for parallel systems. *IEEE Computer* 27, 12 (Dec. 1994), 34–44.

STICHNOTH, J., O'HALLARON, D., AND GROSS, T. Generating communication for array statements: Design, implementation, and evaluation. *Journal of Parallel and Distributed Computing* 21, 1 (1994), 150–159.

O'HALLARON, D. Uniform approach for solving some classical problems on a linear array. *IEEE Transactions on Parallel and Distributed Systems* 2, 2 (Apr. 1991), 236–241.

NICOL, D., AND O'HALLARON, D. Efficient algorithms for mapping pipelined and parallel computations. *IEEE Transactions on Computers* 40, 3 (Mar. 1991), 295–306.

O'HALLARON, D., AND FIDUCCIA, C. Efficient method for computing double matrix products. *Circuits, Systems, and Signal Processing* 10, 2 (1991), 221–232.

BAHETI, R., O'HALLARON, D., AND ITZKOWITZ, H. Mapping extended Kalman filters onto linear arrays. *IEEE Transactions on Automatic Control* 35, 12 (Dec. 1990), 1310–1319.

O'HALLARON, D., AND REYNOLDS, P. A generalized deadlock predicate. *Information Processing Letters* 23 (Nov. 1986), 181–188.

Journal volumes edited

O'HALLARON, D., AND SZYMANSKI, B., EDS. Software systems for scalable computers, Guest editorial for special issue of *Scientific Programming* 7, nums 3,4 (1999).

Refereed conferences

PARLANTE, N., ZELENSKI, J., ZINGARO, D., WAYNE, K., O'HALLARON, D., GUERIN, J. T., DAVIES, S., KURMAS, Z., AND DEBBY, K. Nifty assignments. In *SIGCSE'12* (2012), pp. 475–476.

LOPEZ, J., RAMIREZ-GUZMAN, L., BIELAK, J., AND O'HALLARON, D. BEMC: A searchable, compressed representation for large seismic wavefields. In *22nd International Conference on Scientific and Statistical Database Management (SSDBM'10)* (Heidelberg, Germany, June 2010).

AVETISYAN, A., CAMPBELL, R., GUPTA, I., HEATH, M., KOZUCH, S. Y. K. M., O'HALLARON, D., KUNZE, M., KWAN, T., LAI, K., LYONS, M., MILOJICIC, D., LEE, H. Y., SOH, Y. C., MING, N. K., LUKE, J.-Y., AND NAMGOONG, H. Open Cirrus: A global cloud computing testbed. *IEEE Computer* (Apr. 2010).

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GONZALEZ, J., LOW, Y., GUESTRIN, C., AND O'HALLARON, D. Distributed parallel inference on large factor graphs. In *Conference on Uncertainty in Artificial Intelligence (UAI)* (Montreal, July 2009).

SCHLOSSER, S. W., RYAN, M. P., TABORDA, R., LOPEZ, J., O'HALLARON, D., AND BIELAK, J. Materialized community ground models for large-scale earthquake simulation. In *Proceedings of SC08* (Austin, Nov. 2008).

MESNIER, M., WACHS, M., LOPEZ, J., SAMBASIVAN, R., HENDRICKS, J., GANGER, G., AND O'HALLARON, D. //trace – parallel trace replay with approximate causal events. In *Proceedings of the 5th Usenix Conference on File And Storage Technologies (FAST'07)* (San Jose, Feb. 2007).

TU, T., YU, H., RAMIREZ-GUZMAN, L., BIELAK, J., GHATTAS, O., MA, K.-L., AND O'HALLARON, D. From mesh generations to scientific visualization: An end-to-end approach to parallel supercomputing. In *Proceedings of SC2006* (Tampa, FL, Nov. 2006). *Best Student Paper Finalist*

PAPADOMANOLAKIS, S., AILAMAKI, A., LOPEZ, J., TU, T., O'HALLARON, D., AND HEBER, G. Efficient query processing on unstructured tetrahedral meshes. In *ACM SIGMOD* (Chicago, IL, June 2006).

NATH, P., KOZUCH, M. A., O'HALLARON, D. R., SATYANARAYANAN, M., TOLIA, N., AND TOUPS, M. Design tradeoffs in applying content addressable storage to enterprise-scale systems based on virtual machines. In *Usenix 2006 Annual Technical Conference* (Boston, MA, June 2006).

TU, T., O'HALLARON, D. R., AND GHATTAS, O. Scalable parallel octree meshing for terascale applications. In *Proceedings of SC2005* (Seattle, WA, Nov. 2005).

TU, T., AND O'HALLARON, D. R. A computational database system for generating unstructured hexahedral meshes with billions of elements. In *Proceedings of SC2004* (Pittsburgh, PA, Nov. 2004).

LOPEZ, J. C., TU, T., AND O'HALLARON, D. R. Big wins with small application-level caches. In *Proceedings of SC2004* (Pittsburgh, PA, Nov. 2004).

TU, T., AND O'HALLARON, D. R. Extracting hexahedral mesh structures from balanced linear octrees. In *Proceedings of the Thirteenth International Meshing Roundtable* (Williamsburg, VA, Nov. 2004).

XIE, Y., KIM, H.-A., O'HALLARON, D. R., REITER, M. K., AND ZHANG, H. Seurat: A pointillist approach to anomaly detection. In *Proceedings of the Seventh International Symposium on Recent Advances in Intrusion Detection (RAID04)* (Sophia Antipolis, French Riviera, France, Sept. 2004).

AKCELIK, V., BIELAK, J., BIROS, G., IPANOMERITAKIS, I., FERNANDEZ, A., GHATTAS, O., KIM, E., O'HALLARON, D., AND TU, T. High resolution forward and inverse earthquake modeling on terascale computers. In *SC2003* (Phoenix, AZ, Nov. 2003). *Winner, 2003 Gordon Bell Award for Special Achievement.*

KIM, H.-A., AND O'HALLARON, D. R. Counting network flows in real time. In *Globecom* (San Francisco, Dec. 2003), IEEE.

XIE, Y., AND O'HALLARON, D. Locality in search engine queries and its implications for caching. In *IEEE Infocom 2002* (New York, June 2002), IEEE, pp. 1238–1247.

XIE, Y., O'HALLARON, D., AND REITER, M. A secure distributed search system. In *Proceedings of the Eleventh IEEE International Symposium on High Performance Distributed Computing* (Edinburgh, Scotland, July 2002), IEEE, pp. 321–330.

LÓPEZ, J., AND O'HALLARON, D. Evaluation of a resource selection mechanism for complex network services. In *Proc. IEEE International Symposium on High-Performance Distributed Computing (HPDC)* (San Francisco, Aug. 2001).

LOWEKAMP, B., O'HALLARON, D., AND GROSS, T. Topology discovery for large ethernet networks. In *ACM SIGCOMM 2001* (San Diego, Aug. 2001).

BRYANT, R., AND O'HALLARON, D. Introducing computer systems from a programmer's perspective. In *Proc. of the 32nd Technical Symposium on Computer Science Education (SIGCSE 2001)* (Charlotte, NC, Feb. 2001), ACM.

YANG, B., SIMMONS, R., BRYANT, R. E., AND O'HALLARON, D. R. Optimizing symbolic model checking for constraint-rich models. In *Proc. of the International Conference on Computer-Aided Verification* (June 1999).

HISADA, Y., BAO, H., BIELAK, J., GHATTAS, O., AND O'HALLARON, D. Simulations of long-period ground motions during the 1995 Hyogoken-Nanbu (Kobe) earthquake using 3D finite element method. In

2nd International Symposium on Effect of Surface Geology on Seismic Motion (Yokohama, Japan, Dec. 1998).

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O'HALLARON, D., SHEWCHUK, J., AND GROSS, T. Architectural implications of a family of irregular computations. In *Fourth International Symposium on High Performance Computer Architecture* (Las Vegas, NV, Feb. 1998), IEEE. pp. 80–89.

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O'HALLARON, D., LIEU, P., J., WITHERS, L., AND WHELCHER, J. Computing the pipelined phase-rotation FFT. In *Scalable High Performance Computing Conference* (Knoxville, TN, May 1994), IEEE, pp. 462–469.

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O'HALLARON, D., AND BAHETI, R. Parallel implementation of a Kalman filter on the Warp computer. In *International Conference on Parallel Processing* (Chicago, IL, Aug. 1988), pp. 108–111.

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Papers submitted or in preparation

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TU, T., AND O'HALLARON, D. R. Balance refinement of massive linear octrees. Tech. Rep. CMU-CS-04-129, Carnegie Mellon School of Computer Science, Apr. 2004.

XIE, Y., O'HALLARON, D. R., AND REITER, M. K. Protecting privacy in key-value search systems. Tech. Rep. CMU-CS-03-158, Carnegie Mellon School of Computer Science, July 2003.

TU, T., O'HALLARON, D., AND LOPEZ, J. The Etree library: A system for manipulating large octrees on disk. Tech. Rep. CMU-CS-03-174, Carnegie Mellon School of Computer Science, July 2003.

YANG, B., SIMMONS, R., BRYANT, R. E., AND O'HALLARON, D. R. Optimizing symbolic model checking for constraint-rich models. Tech. Rep. CMU-CS-99-118, School of Computer Science, Carnegie Mellon University, Mar. 1999.

O'HALLARON, D. Spark98: Sparse matrix kernels for shared memory and message passing systems. Tech. Rep. CMU-CS-97-178, School of Computer Science, Carnegie Mellon University, Oct. 1997.

O'HALLARON, D., AND SHEWCHUK, J. Properties of a family of parallel finite element simulations. Tech. Rep. CMU-CS-96-141, School of Computer Science, Carnegie Mellon University, 1996.

STRICKER, T., STICHNOTH, J., O'HALLARON, D., HINRICHS, S., AND GROSS, T. Decoupling communication services for compiled parallel programs. Tech. Rep. CMU-CS-94-139, Carnegie Mellon University, School of Computer Science, 1994.

HINRICHS, S., KOSAK, C., O'HALLARON, D., STRICKER, T., AND TAKE, R. An Architecture for Optimal All-to-All Personalized Communication. Tech. Rep. CMU-CS-94-140, Carnegie Mellon University, School of Computer Science, 1994.

DINDA, P., GROSS, T., O'HALLARON, D., SEGALL, E., STICHNOTH, J., SUBHLOK, J., WEBB, J., AND YANG, B. The CMU task parallel program suite. Tech. Rep. CMU-CS-94-131, School of Computer Science, Carnegie Mellon University, Mar. 1994.

GROSS, T., HASEGAWA, A., HINRICHS, S., O'HALLARON, D., AND STRICKER, T. The impact of communication style on machine resource usage for the iWarp parallel processor. Tech. Rep. CMU-CS-92-215, School of Computer Science, Carnegie Mellon University, Nov. 1992.

O'HALLARON, D. The Assign parallel programming generator. Tech. Rep. CMU-CS-91-141, School of Computer Science, Carnegie Mellon University, 1991.

O'HALLARON, D., AND REYNOLDS, P. An investigation of models of concurrent programs. Tech. Rep. 86-5, Department of Computer Science, University of Virginia, Charlottesville, VA, Mar. 1986.

O'HALLARON, D., AND REYNOLDS, P. Finite models of cyclic concurrent programs. Tech. Rep. 85-02, Department of Computer Science, University of Virginia, Charlottesville, VA, Mar. 1985.

Invited papers

PARLANTE, N., ZELENSKI, J., ZINGARO, D., WAYNE, K., O'HALLARON, D., GUERIN, J. T., DAVIES, S., KURMAS, Z., AND DEBBY, K. Nifty assignments. In *SIGCSE'12* (2012), pp. 475–476.

O'HALLARON, D. Autograding in the cloud. *IEEE Internet Computing* (Jan. 2011). Interview by Dejan Milojevic, HP Labs.

AESCHLIMANN, M., DINDA, P., KALLIVOKAS, L., LOPEZ, J., LOWEKAMP, B., AND O'HALLARON, D. Preliminary report on the design of a framework for distributed visualization. In *Proceedings of the International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA'99)* (Las Vegas, NV, July 1999), pp. 1833–1839. Invited paper.

Invited presentations

Introducing Students to Computing Systems from a Programmer's Perspective, Virginia Commonwealth University, April, 2016.

Autolab: An Autograding Service for the World's Universities, Peking University, EECS, Beijing, China, Feb 2013.

Introducing Computer Systems from a Programmer's Perspective, Peking University, EECS, Beijing, China, Feb 2013.

Defusing a Binary Bomb or: How I Learned to Stop Worrying and Love the Bomb, ACSM SIGCSE, 2012.

Open Cirrus: A Global Testbed for Cloud Computing Research, MIMOS, Kuala Lumpur, Malaysia, Feb, 2010.

Open Cirrus: A Global Testbed for Cloud Computing Research, Cloud Computing and Applications (CCA'09), Chicago, Illinois, Oct, 2009.

Open Cirrus: A Global Testbed for Cloud Computing Research, Data Intensive Computing Workshop, University of Pittsburgh, Pittsburgh, PA, July, 2009.

Big Data meets Streaming Data, Data Intensive Computing Workshop, CERCS Workshop, Georgia Tech, May, 2009.

Octrees in Computational Seismology, CIG/SPICE/IRIS Workshop on Computational Seismology, Oct 2007.

I/O and Storage Issues in Large Scale Scientific Computing, PDSI Workshop, SC06, Tampa, FL, Nov, 2006.

Hercules: A System for Large-Scale Parallel End-to-end Finite Element Modeling, Advanced Institute of Information Technology, Seoul, Korea, Aug, 2006.

Hercules: A System for Large-Scale Parallel End-to-end Finite Element Modeling, Lawrence Livermore National Labs, Livermore, CA, June, 2006.

Hercules: A System for Large-Scale Parallel End-to-end Finite Element Modeling, Southern California Earthquake Center (SCEC) Annual Meeting, Plenary Session, Palm Springs, CA, Sep, 2005.

Computational Database Systems, Keynote Address, Parallel Data Lab Retreat, Carnegie Mellon University, Sep, 2004.

A Computational Database System for Finite Element Earthquake Ground Motion Modeling, Southern California Earthquake Center (SCEC) Annual Meeting, Plenary Session, Palm Springs, CA, Sep, 2004.

Etree: A System for Manipulating Massive Octree Datasets on Disk, Southern California Earthquake Center (SCEC), March, 2004.

Database Methods for Scientific Computing, Northwestern University, Feb, 2003.

Introducing Computer Systems from a Programmer's Perspective, College of William & Mary, Feb, 2002.

Euclid: Physical Simulation from Databases, College of William & Mary, Feb, 2002.

Dv: A toolkit for building remote interactive visualization services, Lawrence Livermore National Laboratory, Sept, 1999, and NSF Engineering Research Center for Computational Field Simulation, Mississippi State University, July, 1999.

Architectural implications of a family of irregular applications, Los Alamos National Laboratory, May, 1997, Dartmouth University, February, 1997, and Rice University, October, 1996.

Compiler support in Fx for parallel computer vision, International Joint Conference on Artificial Intelligence (IJCAI95), Montreal, Canada, August, 1995.

Tools for simulating physical systems on parallel computers, Workshop on Scientific Supercomputing, Visualization, and Animation in Geotechnical Earthquake Engineering and Engineering Seismology, Pittsburgh, PA, November, 1994.

Communication styles for parallelizing compilers, University of Maryland, College Park, MD, April, 1993.

Parallelizing compiler research at Carnegie Mellon, USAF Workshop on Parallel Processing, Kirtland AFB, Albuquerque, NM, November, 1992.

The iWarp computer system, and applications experience on iWarp. Indian Institute of Science, Bangalore, India, May, 1992 and Centre for Development of Advanced Computer Systems, Pune, India, May, 1992.

Real-time airborne sonar processing on iWarp. iWarp Forum, Washington DC, August, 1991.

Automatic tools for developing fine-grained signal processing programs on multicomputers. Air Force Office of Scientific Research, Washington DC, August, 1991.

Compiling signal processing applications onto multicomputers. Supercomputing Research Center, Bowie, MD, May, 1990.

Fast mapping of a Kalman filter on Warp. Warp User Meeting, Cherry Hill, NJ, June, 1988.

A group-theoretic view of systolic algorithms. College of William and Mary, Williamsburg, VA, April, 1988.

On solving linear systems of equations using Warp. Warp User Meeting, Pittsburgh, PA, May, 1987.

A strategy for AMRF control system evolutions. National Bureau of Standards, Center for Manufacturing Engineering, Gaithersburg, MD, February, 1986.

External committee work

Program Committee Member, 7th Workshop on Many-Task Computing on Grids and Supercomputers (MTAGS), November, 2016.

Program Committee Member, 7th Workshop on Many-Task Computing on Grids and Supercomputers (MTAGS), November, 2015.

Program Committee Member, 6th Workshop on Many-Task Computing on Grids and Supercomputers (MTAGS), November, 2014.

Steering Committee Member, 5th ACM Workshop on Scientific Cloud Computing (ACM ScienceCloud 2014), June, 2014.

External Review Committee Member, 19th ACM SIGPLAN Symposium on Principles and Practice of Parallel Programming (PPoPP), Feb, 2014.

Program Committee Member, 5th Workshop on Many-Task Computing on Grids and Supercomputers (MTAGS), November, 2013.

Steering Committee Member, 4th ACM Workshop on Scientific Cloud Computing (ACM ScienceCloud 2013), June, 2013.

Program Committee Member, 5th Workshop on Many-Task Computing on Grids and Supercomputers (MTAGS), November, 2012.

Program Committee Member, 3rd International Workshop on Data Intensive Computing in the Cloud (DataCloud12), November, 2012.

Steering Committee Member, 3rd ACM Workshop on Scientific Cloud Computing (ScienceCloud 2013), June, 2012.

Steering Committee Member, 2nd ACM Workshop on Scientific Cloud Computing (ScienceCloud 2011), June, 2011.

Program Committee Member, 2011 Open Cirrus Summit, April. 2011.

Program Committee Member, IEEE ICDCS 2010 (International Conference on Distributed Computing Systems), June, 2010.

Program Committee Member, 2010 CCSW (Cloud Computing Security Workshop) at ACM Conference on Computer and Communications Security, Nov 2010.

Steering Committee Member, 1st ACM Workshop on Scientific Cloud Computing (ScienceCloud 2010), June, 2010.

Program Committee Member, ACM Middleware, Nov, 2010.

Technical Lead for Intel, HP/Intel/Yahoo OpenCirrus Cloud Computing Testbed, 2008-2010

Board Member, Project Olympus, 2007-2009.

Advisory Board Member, NSF XD (eXtrem Digital) solicitation, 2008.

Program Committee Member, SC07, Nov, 2007.

Program Committee Member, IPDPS '07, IEEE International Parallel and Distributed Processing Symposium, March 2007.

Program Committee Member, 4th International Conference on Service Oriented Computing (ICSOC), Dec, 2006.

Program Committee Member, SC06, Nov, 2006.

Advisory Board member, Duquesne University, Graduate Program in Computational Mathematics, 2000–2004.

Editorial Board, Scientific Programming, 2000–2004.

Program Committee Member, 6th Workshop on Languages, Compilers, and Run-time System for Scalable Computers (LCR2000), College Park, MD, May, 2002.

Program Committee Member, International Conference on Parallel Architectures and Compilation Techniques - PACT2000, Philadelphia, October, 2000.

Program Committee Member, International Conference on Parallel Processing, (ICPP2000), Toronto, August, 2000.

Program Committee Member (and Exhibits co-chair) 9th International Conference on High Performance Distributed Computing, Pittsburgh, PA, August, 2000.

Program Committee Member, 5th Workshop on Languages, Compilers, and Run-time System for Scalable Computers (LCR2000), Rochester, NY, May, 2000.

Program Committee Member, Seventh International Workshop on Parallel and Distributed Real-Time Systems, San Juan, Puerto Rico, April, 1999.

Program Committee Member, International Conference on Parallel Processing, Chicago, Illinois, August, 1998.

Conference Chair and Program Committee Chair, Fourth Workshop on Languages, Compilers, and Run-time Systems for Scalable Computers (LCR98), Pittsburgh, PA, May 1998.

Program Committee Member, pAs'97: Aizu International Symposium on Parallel Algorithm/Architecture Synthesis, Aizu-Wakamatsu, Japan, March, 1997.

Program Committee Member, International Conference on Parallel Processing, Chicago, Illinois, August, 1996.

Program Committee Member, pAs'95: Aizu International Symposium on Parallel Algorithm/Architecture Synthesis, Aizu-Wakamatsu, Japan, March, 1995.

Computer Measurement Group (CMG) Computer Science Advisory Committee Member, 1995.

Tutorial Subcommittee Member, International Symposium on Computer Architecture, 1992.

Co-organizer (with R. S. Baheti), GE Workshop on Parallel Computing, General Electric R&D Center, Schenectady, NY, 1989.

Consulting

Peking University, EECS, Overseas Advisor, 2013. Invited visitor to Beijing to consult with PKU faculty about their presentation of the Bryant and O'Hallaron CS:APP course.

Peking University, EECS, Visiting Faculty, 2013. Taught a 2-week minicourse on CS:APP Chapter 4: Processor Architecture, to a select group of PKU undergrads.

Intel Research Pittsburgh, Consultant and Visiting faculty, 2006-2007.

Advanced Institute for Information Technology (AIIT), Seoul, Korea, Aug, 2006. Offered a 1-week course that trained 20 Korean university professors how to teach from the Bryant and O'Hallaron CS:APP text.

Intel Research Pittsburgh, 2004–2005. Developed the client program for the Internet Suspend/Resume (ISR) system and lead the pilot deployment of ISR on the CMU campus.

iCarnegie, 2002–2003. Developed new labs for a course offered by iCarnegie, a CMU spinoff that offers Internet based learning and certification.

Review panel chair. Duquesne University, 1999. Led a team of academics and state regulators that reviewed the proposal for a new Computational Mathematics masters program.

Expert witness, U.S. v. Charles Steele, 1996. Pittsburgh, PA. Analyzed diskette evidence in a mail fraud and obstruction of justice case and testified at preliminary hearing and at trial.

Court-appointed expert, US District Court of the Western District of Pennsylvania, Commonwealth v. David C. Copenhefer, 1993-1994. Reviewed FBI's handling of computer evidence in a capital murder case.

Consultant, Norden Systems, Melville, NY, Communication systems for real-time avionics applications, 1992-1993. Developed a proposed architecture for the avionics software in the next-generation aircraft.

Member, United Technologies Board of Directors Technology Review Task Force, Norwalk, CT, 1992-1993. Set directions for new technology development at Norden Systems.

Consultant, E-Systems Inc., Dallas, TX, 1992. Consulted on signal processing using high-performance computer systems.

Consulting, General Electric Corporation, Schenectady, NY, 1991-1992. Consulted on sonar signal processing using high-performance computer systems.

Consultant, National Bureau of Standards, Automated Manufacturing Research Facility. Gaithersburg, MD, 1986. Designed and implemented a real-time manufacturing cell controller.

Reviewing - Journals (partial list)

ACM TOPLAS, 1997, 1998. ACM TOCS, 2002. IEEE Computer, 1992, 1993. IEEE Transactions on Parallel and Distributed Systems, 1990, 1991, 1992, 1993, 1997, 1999, 2000, 2001. IEEE Transactions on Computers, 1991, 1992. Information Processing Letters, 1992. International Journal on Supercomputing, 1990. Scientific Programming, 1995, 2001. Journal on Parallel and Distributed Computing, 1999.

Reviewing - Conferences (partial)

Middleware, 2009. IEEE International Parallel and Distributed Processing Symposium (IPDPS), 2006. SCxy: SC06, 2006. Usenix Symposium, 2004. ACM Symposium on Architectural Support for Programming Languages and Operating Systems (ASPLOS), 1992, 1996. ACM International Symposium on Computer Architecture (ISCA), 1990, 1991, 1992, 1993, 1999, 2002. ACM Symposium on Parallel Algorithms and Architectures (SPAA), 1991. ACM Symposium on Programming Language Design and Implementation (PLDI), 1998. International Conference on Parallel Processing (ICPP), 1989, 1991, 1996, 1998. International Parallel Processing Symposium (IPPS), 1993, 1996, 1997, 1998. ACM

Reviewing - Agencies (partial list) NSF CluE Review Panel, 2008. NSF SEIII Review Panel, 2005, 2006. NSF ACIR Career Panel, 2002, 2003. NFS NGS Review Panel, 2001. NFS Exp Software Systems Review Panel, 1998. NFS ARPA/NSF Review Panel for Millenium Petaflops Point-design, 1996. NFS Small Business Innovation Research Program, 1995. NFS Industry Cooperative Research Centers Program, 1988.

Teaching

15-410, Operating Systems, Fall, 2016.

18-845, Internet Services, Spring, 2000–2007, 2011–2017.

15-213, Introduction to Computer Systems, Fall, 1998–2003, 2005–2006, 2010–2016.

18/15-347, Introduction to Computer Architecture, Spring, 1996, 1997,

20-755, The Internet (Institute for e-Commerce), Summer, 1999.

CS 100/110, Elements of Computer Science/Computer Applications, Spring, 1995 (Duquesne University).

CS 15-840, iWarp: Anatomy of a System, Fall, 1992.

Former Ph.D. students

Hyang-Ah Kim (SCS), Thesis: "Privacy-Preserving Distributed, Automated Signature-Based Detection of New Internet Worms." Graduated Aug, 2010. (Currently at Google)

Tiankai Tu (CS), Thesis: "A Scalable Database Approach to Computing Delaunay Triangulations." Graduated Aug, 2008. (Currently a researcher with D.E. Shaw Research)

Julio Lopez (ECE). Thesis: "Methods for Querying Compressed Wavefields." Graduated May, 2007. (Currently with CMU PDL)

Yinglian Xie (CS), co-advised with Hui Zhang, Thesis: A Spatiotemporal Event Correlation Approach to Computer Security, Graduated August, 2005. (Currently at Microsoft Research, San Francisco)

Peter Dinda (CS), Winner of 1996 Intel Fellowship. Thesis: "Prediction based distributed computing". Graduated May, 2000. (Currently a Professor of CS at Northwestern University)

Bruce Lowekamp (CS), Thesis: "Discovery and Application of Network Information", graduated Dec, 2000 (Currently a software architect with Skype Labs)

Bwolen Yang (CS), Thesis: "Efficient BDD Construction", Graduated May, 1999. (formerly with Google)

Jonathan Shewchuk (CS), co-advised with Gary Miller, Thesis: "Delaunay Refinement Mesh Generation," Graduated May, 1997. CMU SCS Distinguished Dissertation Award. (Currently a tenured Assoc. Prof. at University of California, Berkeley)

Tom Warfel (ECE), co-advised with HT Kung and T. Gross. Thesis: "Tasks and Connection Sets: Choreographed Communication on a Reconfigurable Connection-Based Parallel Computer." Graduated May, 1996. (Currently a radiologist at Southwest Washington Medical Center, Vancouver, WA)

Current Ph.D. students

Ph.D. Thesis committees

Nathan Mickulicz (ECE), Ph.D. thesis committee, proposed 2017. Haydar Karaoglu (CEE), Ph.D. thesis committee, graduated 2014. Dorian Restrepo (CEE), Ph.D. thesis committee, graduated 2013. Yigit Isbiliroglu (CEE), Ph.D. thesis committee, graduated 2013. Akkarit Sangpetch (ECE), Ph.D. thesis committee, graduated 2013. Orathai Sukwong (ECE), Ph.D. thesis committee, graduated 2013. Joey Gonzalez (SCS), Ph.D. thesis committee, graduated, 2012. Wei Yu (ECE), Ph.D. thesis committee, graduated 2011. Ricardo Tabora (CEE), Ph.D. thesis committee, graduated 2010. Nikos Hardavellas (SCS), Ph.D. thesis committee, graduated 2009. Michael Merideth (SCS), Ph.D. thesis committee, graduated 2009. Andrew Klosterman (ECE), Ph.D. thesis committee, proposed 2006. Eno Thereska (ECE), Ph.D. thesis committee, graduated 2008. Efstratios Papadomanolakis (ECE), Ph.D. thesis committee, graduated 2007. Aysegul Askan (CEE), Ph.D. thesis committee, proposed 2005, graduated 2006. Sittipong Jarernprasert (CEE), Ph.D. thesis committee, graduated 2005. John Linwood (ECE), Ph.D. thesis committee, graduated 2004. Ioannis K. Epanomeritakis (CEE), Ph.D. thesis committee, graduated 2004. Greg Steffan (CS), Ph.D. thesis committee, graduated 2003. Eui Joong Kim (CEE), Ph.D. thesis committee, graduated 2003. Antonio Fernandez (CEE), Ph.D. thesis committee, graduated 2003. William Nace (ECE), Ph.D. thesis committee, graduated 2002. Chris Colohan (CS), Ph.D. thesis committee, proposed 2001, graduated 2005. Andrew Willmott (CS), Ph.D. thesis committee, graduated 2000. Thomas Stricker (CS), Ph.D. thesis committee, graduated 2000. Jifeng Xu (CEE), Ph.D. thesis committee, graduated 1998. Hesheng Bao (CEE), Ph.D. thesis committee, graduated 1998. Jim Stichnoth (CS), Ph.D. thesis committee, graduated 1997. Marco Zaghera (CS), Ph.D. thesis committee, graduated, 1997. Susan Hinrichs (CS), Ph.D. thesis committee, graduated 1995. I-Chen Wu (CS), Ph.D. thesis committee, graduated 1993. Jason Fung (ECE), B.S. Honors advisor, graduated 1997.

Master's Students

William Wang (SCS 5th year masters), Thesis committee member, 2011. Kushal Dalmia (INI), Thesis advisor, 2011-2012. Aditya Agarwal (INI), Thesis advisor, 2011-2012. Boris Jabes (INI), Thesis advisor, 2004. Mrinalini Vaidya (INI), Thesis committee member, 2003. Michael Wagner (ECE/Robotics), Project advisor for independent research project, 2000-2001.

Undergraduate Students

Rameez Remsudeen (IS), Autolab developer, 2015-present. Billy Zhu (CS), Autolab developer, 2015-present. Aatish Nayak (ECE), Autolab lead developer, 2015-present. Ilter Canberk (ECE), Autolab lead developer, 2014-2015. Yashas Kumar (CS), Autolab developer, 2014-2015. An Wu (CS), Autolab developer, 2013-2015. Daniel Bucci (CS), Autolab developer, 2013-2015. Jimmy Zong (CS), Autolab developer, 2013-2015. Mihir Pandya (ECE), Autolab systems programmer, 2013-2014. Peter Xiao (CS), Autolab developer, 2012-2013. Ashley Kumar (CS), Autolab developer, 2012-2013. Dylan Swen (ECE), Autolab developer, 2012-2013. Steven Fackler (CS), Autolab developer, 2011-2012. Thomas Abraham (CS), Autolab lead developer, 2011-2013. Abhay Buch (CS), Autolab developer, 2011-2013. Kelly Rivers (CS), Autolab developer, 2010-2012. Ryhan Hassan (CS), Autolab developer, 2011. Adrian Trejo (CS), project advisor for independent study, 2010-2011. Hunter Pitelka (CS), Autolab lead developer, 2010-2011. Chee-Hoon Ha (CS), Project advisor for independent study, 2009. Robert Hansen (CS), Project advisor for Autolab independent study, 2004. Daniel Hannum (CS), Project advisor for the Ion project, a Linux version of the Atom binary rewriting tool, 2000-2002. Michael Schellhase (ECE), Project advisor for winning entry in

IBM Linux Scholar Challenge, 2001. Vishal Soni (ECE), Project advisor for 2nd place finish in CMU Tau Beta Pi Meeting of the Minds Contest, 2000.

Internal committee work

2017: ECE Undergraduate Advising Committee, ECE Curriculum Review Committee, CIT Ad-Hoc Committee

2016: ECE Undergraduate Advising Committee, ECE Curriculum Review Committee, SCS Undergraduate Review Committee (chair),

2015: ECE Undergraduate Advising Committee, ECE Curriculum Review Committee, SCS Undergraduate Review Committee (chair), SCS Fellowship Committee (chair).

2014: ECE Undergraduate Advising Committee, ECE Dept Chair Search Committee, ECE Curriculum Review Committee, SCS Undergraduate Review Committee (chair), SCS Fellowship Committee (chair).

2012: ECE Undergraduate Advising Committee, SCS Fellowship Committee (chair), CSD Fellowship Committee (chair).

2011: ECE Undergraduate Advising Committee, SCS Fellowship Committee (chair), CSD Fellowship Committee (chair).

2010: ECE Undergraduate Advising Committee, SCS Fellowship Committee (chair), CSD Fellowship Committee (chair), SCS Intel Fellowship Committee (chair).

2006: SCS Undergraduate Review Committee (URC), SCS Teaching Excellence Committee (Simon Award), SCS Distinguished Dissertation Committee, SCS Systems Hiring Committee, ECE Undergraduate Advising Committee

2005: SCS Undergraduate Review Committee, SCS Teaching Excellence Committee (Simon Award), SCS Distinguished Dissertation Committee, SCS Systems Hiring Committee, ECE Undergraduate Advising Committee

2004: SCS Graduate Admissions Committee, SCS Distinguished Dissertation Committee, ECE Undergraduate Advising Committee

2003: SCS Graduate Admissions Committee (co-chair), ECE Undergraduate Advising Committee

2002: SCS Graduate Admissions Committee, SCS Systems Hiring Committee (chair), SCS Facilities Committee, ECE Graduate Studies Committee ECE Qualls Committee,

2001: SCS Facilities Committee, SCS Facilities Committee, ECE Qualls Committee, ECE Undergraduate Studies Committee

2000: SCS Systems Hiring Committee, ECE Undergraduate Studies Committee

1999: ECE Undergraduate Studies Committee, Computer Engineering Curriculum Committee (chair)

1998: ECE Undergraduate Studies Committee

Support *PicoCTF*, National Science Foundation, 2014-2017, awarded, **\$225,000** co-PI with David Brumley (CMU ECE).

Amazon Research grant, AWS credits for developing autograding service, June, 2013, **\$2,000**

Research award, Intel Corporation, Cloud computing research, June, 2010, **\$125,000**

Intel equipment grant, Autograding Cluster for 15-213: Intro to Computer Systems, Mar, 2010, **\$50,000**.

Unrestricted gifts, *Anonymous Donor, through the Vanguard Charitable Endowment*, **\$300,000**, 2006–2013.

Towards Petascale Simulation of Urban Earthquake Impacts, National Science Foundation, (OCI-0749227), Sept 2007–Aug 2011, \$1,600,000, co-PI with Jacobo Bielak (CMU CEE), Gregory Fenves (UC Berkeley), Ahmed Elgamal (UCSD), Kwan-Liu Ma (UCSD).

Liberating Personal Computing from Hardware, National Science Foundation, (IIS-0429334), Sept 2004–Aug 2007, \$1,320,000, co-PI with Satya (CMU SCS), Perrig (CMU ECE) and Farber (CMU ISRI).

Deployment-based Insights from Internet Suspend/Resume, Carnegie Mellon CyLab, July 2006 - June 2007, \$60,000, co-PI with Satya.

IBM equipment grant, Blade Center for Internet Suspend/Resume, Aug, 2004, \$130,056, PI, (co-PI: Satya).

Computational Database Systems for Massive Scientific Datasets, National Science Foundation, (IIS-0429334), Sept 2004 - Aug 2007, \$1,320,000, PI (co-PIs: Ganger (ECE) and Ailamaki (SCS))

Seurat: Self-Diagnosis of Network Systems, Carnegie Mellon CyLab, July 2004–June 2005, \$70,000, PI (co-PI: Hui Zhang, CMU SCS).

The SCEC Community Modeling Environment - An Information Infrastructure for System Level Earthquake Research, National Science Foundation, Sept 2001–August 2006, \$395,000. co-PI with J. Bielak (CMU CEE).

Seismic Propagation in Urban Regions, National Science Foundation, Sept 2000–March 2001, \$130,000. co-PI with J. Bielak (CMU CEE).

Large-Scale Modeling and Forecasting of Complex Earthquake Ground Motion in Sedimentary Basins, National Science Foundation KDI award, (CMS-9980063), Sept 1999–Aug 31, 2002, \$2,131,000. co-PI with J. Bielak and O. Ghattas (CMU CE), J. Shewchuk (UC-Berkeley), and S. Day (San Diego State University).

Intel equipment grant, Intel Computer Systems Cluster for CS 213, Aug, 1999, \$101,320, co-PI with Randy Bryant.

Microsoft software grant for Intel Computer Systems Cluster, Aug, 1999, \$49,920, co-PI with Randy Bryant.

Resource Management Under Application Control, Defense Advanced Research Projects Administration (DARPA), Oct, 1996–Sept, 1999, \$2,920,810, co-PI with T. Gross.

Unrestricted Grant for Research in the Performance of Finite Element Earthquake Simulations on Parallel Systems, 1994, *Intel Corp*, **\$40,000**, *PI*.

Equipment Grant for Research in Parallel Scientific Computing(72-node Paragon system), 1994, *Intel Corp*, **\$2,000,000**, *PI*.

Earthquake Ground Motion Modeling in Large Basins., *National Science Foundation Grand Challenge Award (CMS-9318163)*, Sept, 1993–Feb, 1998, **\$2,154,000**, *co-PI with J. Bielak (CE, PI), and O. Ghattas (CE)*.

Automatic Tools for Developing Fine-Grained Signal Processing Programs on Multicomputers., *Air Force Office of Scientific Research (AFOSR)*, Washington, DC, Jan, 1992–Dec, 1994, **\$395,000**, *PI (H.T. Kung, co-PI)*

Unrestricted Grant for Research in Programming Tools for Parallel Computing, *E-Systems Corp, Falls Church, VA*. 1992, 1993, **\$12,000**, *PI*.

Complete Tool Set for Developing Large Scale Signal Processing Applications on Multicomputers., *Office of Naval Research(ONR)*, Washington DC, *Air Force Office of Scientific Research (AFOSR)*, Washington, DC, and *Naval Ocean Systems Center (NOSC)*, San Diego, CA, March, 1989–April, 1990, **\$200,000** (funded by AFOSR), **\$50,000** (funded by NOSC), *co-PI with H. T. Kung*.

Initialization and Restart in Automated Manufacturing Facilities. *National Bureau of Standards, Gaithersburg, MD*, January, 1986, **\$120,000**, *co-PI with P. F. Reynolds, Jr*.