Proceedings of

the Eighth Symposium

on

Operating Systems Principles

14-16 December 1981
Asilomar Conference Grounds
Pacific Grove, California



Special Interest Group on Operating Systems (SIGOPS)
Association for Computing Machinery (ACM)

Vol. 15 No. 5

December 1981

ACM ORDER NO. 534810

OPERATING SYSTEMS REVIEW

A Quarterly Publication of the ACM Special Interest Group on Operating Systems

Chairperson

Dorothy E. Denning Computer Science Dept. Purdue University W. Lafayette, IN 47907

Secretary-Treasurer

Gregory Andrews
Dept. of Computer Science
University of Arizona
Tucson, AZ 85721

V. Chairperson

David Redell XEROX-SDD 3333 Coyote Hill Rd. Palo Alto, CA 94304

Newsletter Editor

William M. Waite
Dept. of Electrical Engineering
University of Colorado 425
Boulder, CO 80309

OPERATING SYSTEMS REVIEW is an informal quarterly publication of the ACM Special Interest Group on Operating Systems (SIGOPS), whose scope of interest includes: Computer operating systems and architecture for multiprogramming, multiprocessing, and time sharing; resource management; evaluation and simulation; reliability, integrity, and security of data; communications among computing processors; and computer system modeling analysis.

Membership in SIGOPS (at \$8 per annum) is open to ACM members and associate members and student members (at \$4 per annum); non-ACM members may join also (at \$22 per annum). Non-members of SIGOPS may subscribe to OPERATING SYSTEMS REVIEW at \$14 per year. All SIGOPS members receive OPERATING SYSTEMS REVIEW.

SIGOPS membership application forms are available from ACM National Headquarters (or see back cover of this issue), 1133 Avenue of the Americas, New York, New York 10036, telephone (212) 265-6300. Change of address and other matters pertaining to the SIGOPS mailing list should be directed to ACM National Headquarters, not to any of the SIGOPS officers.

Contributions to OSR should be sent to the editor, and should not ordinarily exceed 1000 words, and should be single-spaced within a 6½ inch by 8½ inch box with at least one inch top and side (1½ inch bottom) margins and in camera-ready form. All letters to the editor will be considered for publication unless accompanied by a request to the contrary. Except for editorial items, all sources of material appearing in OPERATING SYSTEMS REVIEW will be clearly identified. Items attributed to individuals will ordinarily be interpreted as per sonal rather than organizational opinions. The technical material in this newsletter is not refereed. Deadlines for submitting material are the 14th of March, June, September, and December.

Proceedings of

the Eighth Symposium

on

Operating Systems Principles

14-16 December 1981 Asilomar Conference Grounds Pacific Grove, California



Special Interest Group on Operating Systems (SIGOPS)
Association for Computing Machinery (ACM)

Vol. 15 No. 5

December 1981

ACM ORDER NO. 534810

The Association for Computing Machinery, Inc. 1133 Avenue of the Americas New York, New York 10036

Copyright © 1981 by the Association for Computing Machinery, Inc. Copying without fee is permitted provided that the copies are not made or distributed for direct commercial advantage and credit to the source is given. Abstracting with credit is permitted. For other copying of articles that carry a code at the bottom of the first page, copying is permitted provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center, P.O. Box 765, Schenectady, N.Y. 12301. For permission to republish write to: Director of Publications, Association for Computing Machinery. To copy otherwise, or republish, requires a fee and/or specific permission.

ISBN

0-89791-062-1

Additional copies may be ordered prepaid from:

ACM Order Department P.O. Box 64145 Baltimore, MD 21264 ACM Order No. 534810

Price:
Members \$13.00
Non-Members \$17.00

Eighth Symposium on Operating Systems Principles

General Chairperson

John Howard - IBM Research, San Jose

Program Chairperson

David P. Reed - MIT

Program Committee

David Cheriton - University of British Columbia

Dorothy Denning - Purdue University

Jim Gray - Tandem Computers

John Howard - IBM Research, San Jose

Anita Jones - Carnegie-Mellon University

Butler Lampson - Xerox PARC

Edward Lazowska - University of Washington

Alan Smith - University of California, Berkeley

Local Arrangements

Sara Dake - Registration

Jim Gray - Catering

Gene McDaniel - Wine

8SOSP Referees

Sten Andler Greg Andrews J.L. Baer Joel Bartlett A. Bernstein Andrew Birrell Russ Blake **Toby Bloom** J.C. Browne Roy Campbell David Clark Robert Cook **Geoffrey Cooper** George Cox Doug Currie Yogen Dalal Roger Dannenberg J. Ďemco Ivor Durham Malcolm Easton P.H. Enslow Robert Filman Michael Fischer Brett Fleisch Harry Forsdick Robert Fowler James Frankel W.D. Frazer David Gifford R.L. Gordon Wavne Gramlich P. Harter Andrew Herbert Maurice Herlihy

Thomas H. Hinke Warren Jessop Paul Johnson Dennis Kafura Stephen Kent R.B. Kieburtz Walter Kohler S. Krakowiak David Lamb Gerard Le Lann Keith Lantz Richard Leblanc Roy Levin Henry Levy Bruce Lindsay Steven Lipner Barbara Liskov John Livesey **David Lomet** Allen Luniewski Udi Manber Paul McJones John Metzner Philip Mills M.F. Mitoma R.M. Needham Peter Neumann Jerre D. Noe John Ousterhout J. Peterson Wil Plouffe Michael Powell Ram Rao

Loretta Reid Glenn Ricart William Riddle David Russell Jerome Saltzer M. Satyanarayanan Ashok Saxena Donald Scelza Richard Schantz Robert Scheifler Roger Schell Fred Schneider Michael Schroeder Karsten Schwans Peter Schwarz A. Shaw Mark Sherman J.F. Shoch A. Silberschatz Barbara Simons Karen Sollins Marvin Solomon Eugene Stark Eric Stephenson B. Stroustrup T.J. Teixeira Doug Terry Ken Thompson William E. Weihl Maurice Wilkes Robin Williams Jim Wyllie John Zahorjan

Foreword

Like its predecessors of the past 14 years, the Eighth Symposium on Operating Systems Principles represents the diversity and vigor of the field. The program speaks for itself. I know that I found that reading the papers was fun -- hardly a tedious task at all.

All in all, 103 papers were submitted. The competition was strong — only 23 papers were accepted — less than one in four. Of these, six were nominated to be considered for inclusion in a special issue of *Communications of the ACM*; five of these were accepted by a second refereeing process managed by Anita Jones. Only extended abstracts for those papers appear here.

The refereeing process, conducted under tight timing constraints, went well. Unlike other conferences, SOSP tries to maintain a high standard of refereeing. Most papers were read by four of the program committee members, myself, and two outside referees. Each outside referee who volunteered was given from one to four papers in his/her area. The outside referees often perform a special service that I value highly. They usually provide many helpful comments to the author(s) to aid in revision. However, I have the general impression that the average quality of outside referee reports is decreasing somewhat. This time a larger fraction of the reports received seemed to concentrate on rating the papers only. I hope this is not indicative of a general trend.

Like many conferences, this one could not have been put together without a lot of help. In addition to the referees, I'd like to thank Debra Fagin, whose help has been invaluable.

> David P. Reed Program Chairperson October, 1981

Conference Program

14 December 1981

Session	1:	Verifying Systems Properties			
Session L	_eader:	John Howard			
		erties of Programs with Temporal Logic Paul Harter	1		
Design and Vel John Rus		of Secure Systems	12		
Session	II:	Systems			
Session L	_eader:	Edward Lazowska			
A NonStop TM Joel Bart			22		
Observations o Hugh Lau		velopment of an Operating System	30		
Session	III:	Remote Data Storage			
Session l	_eader:	Butler Lampson			
The FELIX File Marek Fr		Older	37		
		etwork-Based File Servers remy Dion	45		
A <i>Reliable Obje</i> Liba Svol		ted Repository for a Distributed Computer System	47		
Session	IV:	Computer-Computer Communication			
Session L	_eader:	David Reed			
		on Steps in a Network loger Needham	59		
Accent: A Communication Oriented Network Operating System Kernel Richard Rashid, George Robertson					
Performing Rei Alfred Sp	mote Ope ector	erations Efficiently on a Local Computer Network	76		

15 December 1981

Session	V:	Memory Management			
Session I	_eader:	Alan Smith			
		ed System to do Paging in an Architecture Lacking Page-Referenced Bits Nilliam Joy	78		
WSClock A Simple and Effective Algorithm for Virtual Memory Management Richard Carr, John Hennessy					
A Study of File M. Satyaı		d Functional Lifetimes In	96		
Session	VI:	Protection Techniques			
Session l	_eader:	Dorothy Denning			
Hierarchical Ta Matt Bish		t Protection Systems	109		
Cryptographic David Gil		for Information Secrecy and Authentication	123		
Session	VII:	The iMAX-432 Operating System			
Session I	Leader:	Anita Jones			
		plementation for Interprocess Communication in a Multiprocessor Environment n, K. Lai, F. Pollack	125		
K.C. Kah	n, W.M. (r Operating System for an Object- Based Computer Corwin, T.D. Dennis, H. D'Hooge, D.E. Hubka, L.A. Hutchins, .J. Pollack, M.R. Gifkins	127		
The iMAX-432 F. Pollaci		iling System n, Ř. Wilkinson	137		

16 December 1981

5e	ssion	VIII:	Distributed Systems		
	Session L	-eader:	David Cheriton		
The .	Architectu. E. Lazow	re of the i ska, H. Le	Eden System evy, G. Almes, M. Fischer, R. Fowler, S. Vestal	148	
A Dis	stributed U G.W.R. Li	INIX Syste uderer, H	em Based on a Virtual Circuit Switch I. Che, J.P. Haggerty, P.A. Kirslis, W.T. Marshall	160	
LOCUS: A Network Transparent, High Reliability Distributed System G. Popek, B. Walker, J. Chow, D. Edwards, C. Kline, G. Rudisin, G. Thiel					
Se	ssion	IX:	User-Oriented Systems		
	Session L	_eader:	Jim Gray		
Grapevine: An Exercise in Distributed Computing Andrew Birrell, Roger Levin, Roger Needham, Michael Schroeder					
BRU	WIN: An A Norman I	A <i>daptable</i> Meyrowit:	e Design Strategy for Window Manager/Virtual Terminal S z, Margaret Moser	ystems 180	