Sun Labs—The First Five Years: The First Fifty Technical Reports A Commemorative Issue

Jeanie Treichel, Amy Hall, and Ching-Chih Chang

Sun Labs—The First Five Years: The First Fifty Technical Reports
A Commemorative Issue

Jeanie Treichel, Amy Hall, and Ching-Chih Chang, Editors

SMLI TR-98-51 September 1998

Abstract:

This commemorative issue in the technical report series encompasses the first five years of Sun Labs' existence—from 1991 through 1996. In addition to the Abstracts of the first fifty reports, the contents include a list of patents issued during that time, staff presentations at conferences and meetings around the world, and a comprehensive article on the formation of SunLabs as featured on Sun's external Website in February of 1996.

Editor's note:

Until October 1, 1998, Sun Microsystems Laboratories was known as "SunLabs."

M/S MTV29-01
901 San Antonio Road
Palo Alto, CA 94303-4900

email address:
jeanie.treichel@eng.sun.com
oscar.chang@eng.sun.com

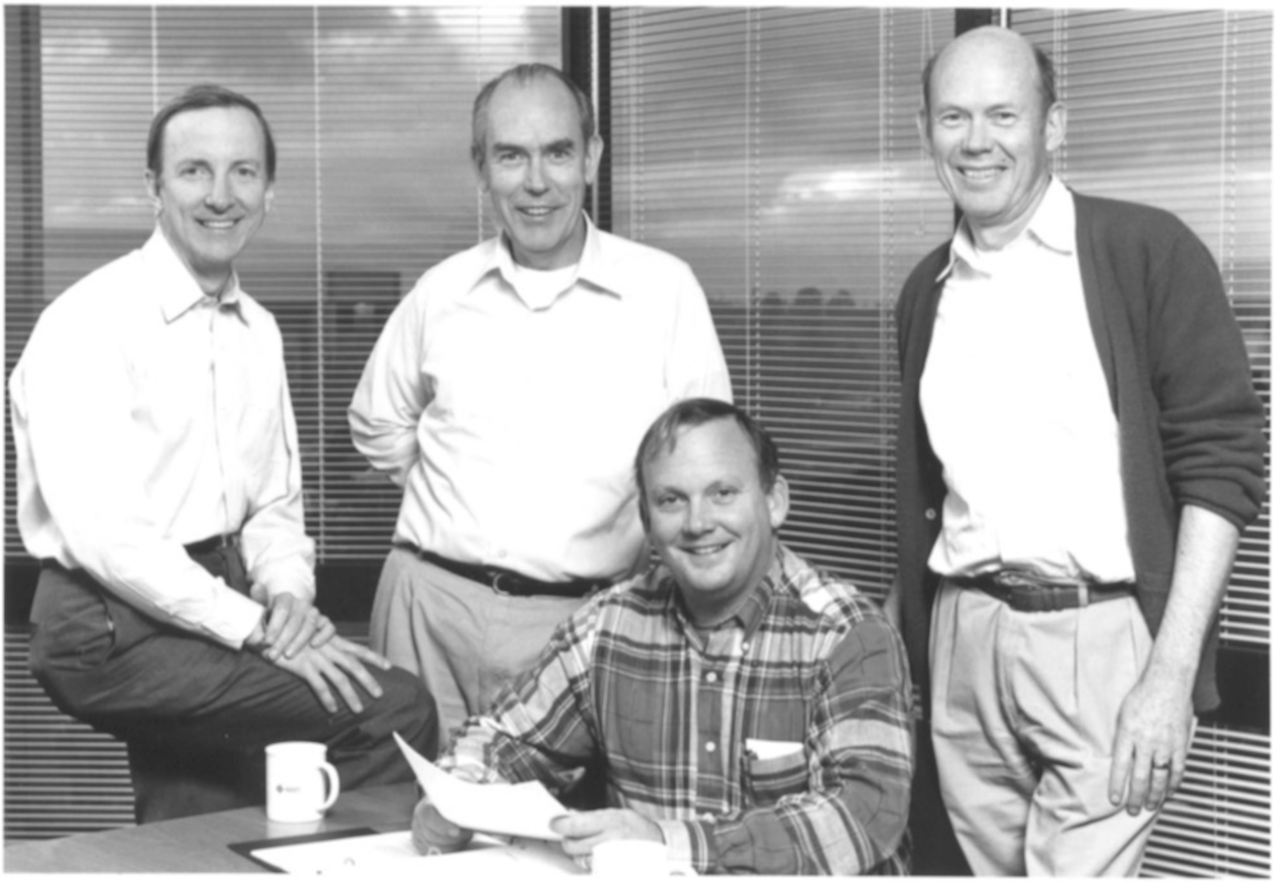
For information regarding the SML Technical Report Series, contact Jeanie Treichel, Editor-in-Chief <jeanie.treichel@eng.sun.com>.

Sun Labs—The First Five Years:
The First Fifty Technical Reports
1991-1996

A Commemorative Issue

Sun Microsystems Laboratories
Bert Sutherland, Director (1994-1998)

Table of Contents



Sun Labs Beginnings

Robert F. ("Bob") Sproull Ivan E. Sutherland William R. "Bert" Sutherland

Wayne E. Rosing (seated)

July 1991

Table of Contents

Preface

Preface

William R. "Bert" Sutherland
Director, Sun Microsystems Laboratories

The whole idea behind publication of technical reports is to document the ideas, work, and progress made by the staff members of Sun Microsystems Laboratories. While the goal is to develop and protect intellectual property for Sun, our engineers and computer scientists must also continue to communicate with their colleagues in other industrial and academic environments. Presenting papers or speaking at conferences is one way of achieving this end. Another is the publication of these technical reports.

While not all of the key projects conducted in Sun Labs are represented in this collection because—of their proprietary nature, in some cases—they do represent a cross-section of the ideas which have made it to the project table over the past five years, and the people who were involved in the evolution and development of these ideas.

Foreword

Foreword

Ever since the incorporation of Sun Microsystems Laboratories (Sun Labs) in February of 1991, technical reports have been published to document some of its technical history.

The Charter stated that Sun Labs was established to develop, demonstrate, and introduce new advanced technologies and technical methodologies for Sun and its subsidiary corporation, and that SunLabs would influence Sun's future business directions by educating the company about technical possibilities. It further stated that a successful Laboratory would have considerable value in projecting the image of Sun as a progressive and aggressive technical leader, and that a world-class Laboratory would provide both internal and external demonstration of Sun's continuing commitment to technical excellence.

A Little History. When Sun Labs came into being as a working entity at the end of June 1991, three staff members—Dave Ditzel, Jim Mitchell and Jeanie Treichel—met to plan a technical report series to capture the results of future research. Jeanie became Editor-in-Chief and later, HayChan Sargent joined the planning and implementation team. She was succeeded by Amy Hall who served as Assistant Editor.

Objectives. The objectives of the technical report series were threefold. First, the documents were to be of high quality, technically competent, significant works representing SMLI's (as it was then called) best efforts, worthy of wide-spread distribution. Secondly, Sun's proprietary interests would be reviewed ensuring that the information divulged conformed with Sun's business perspective. Lastly, there would be no legal booby traps and patent action would be completed before publication. The effect was, as Bert Sutherland, Director of Sun Labs stated, "to release information from its proprietary cloak so as not to lose opportunities in the technical domain." The aim was to achieve the highest standards of excellence.

To implement this goal, the Steering Committee was charged with the establishment of a Review Committee, a legal clearance procedure, and a publishing scheme. Since the SMLI Document System had already been established by Jeanie Treichel and Tom Wadlow, Sun Labs' first network manager, the complete publication process was now in place.

What follows is a compendium of the contributions of the first five years. The papers in their entirety may be viewed on the World Wide Web at www.sunlabs.com/technical-reports/.

Jeanie Treichel, Editor-in-Chief
Amy Hall, Assistant Editor
Ching-Chih Chang, Web Developer

Timeline of Significant Events

Timeline of
Significant Events

First Offsite at Sunrise Winery	August 16, 1990
First Sun Labs presence, Billerica—Dr. R. Sproull	August 1990
First organization chart developed	October 11, 1990
Articles of Incorporation	February 19, 1991

First email:

From root@eng-bb-router4.Eng.Sun.COM Fri May 31 16:12:15 1991
To: sunlabs@arkesden
Subject: The Behemoth Stirs.......
Content-Length: 112
X-Lines: 3

This message comes to you via the embryonic B29 network. Things are coming alive over here..... --Tom Wadlow

---

Charter and Business Description	June 3, 1991
Move into Building 29, Mountain View	June-July 1991
The great Sun Labs-SunSoft waterfight	July 24, 1992
Billerica gives way to Chelmsford	November 23, 1992
Wayne Rosing named President, FirstPerson, Inc.	February 17, 1993
W. R. "Bert" Sutherland named Director, Sun Labs	July 12, 1993

First Offsite at Sunrise Winery

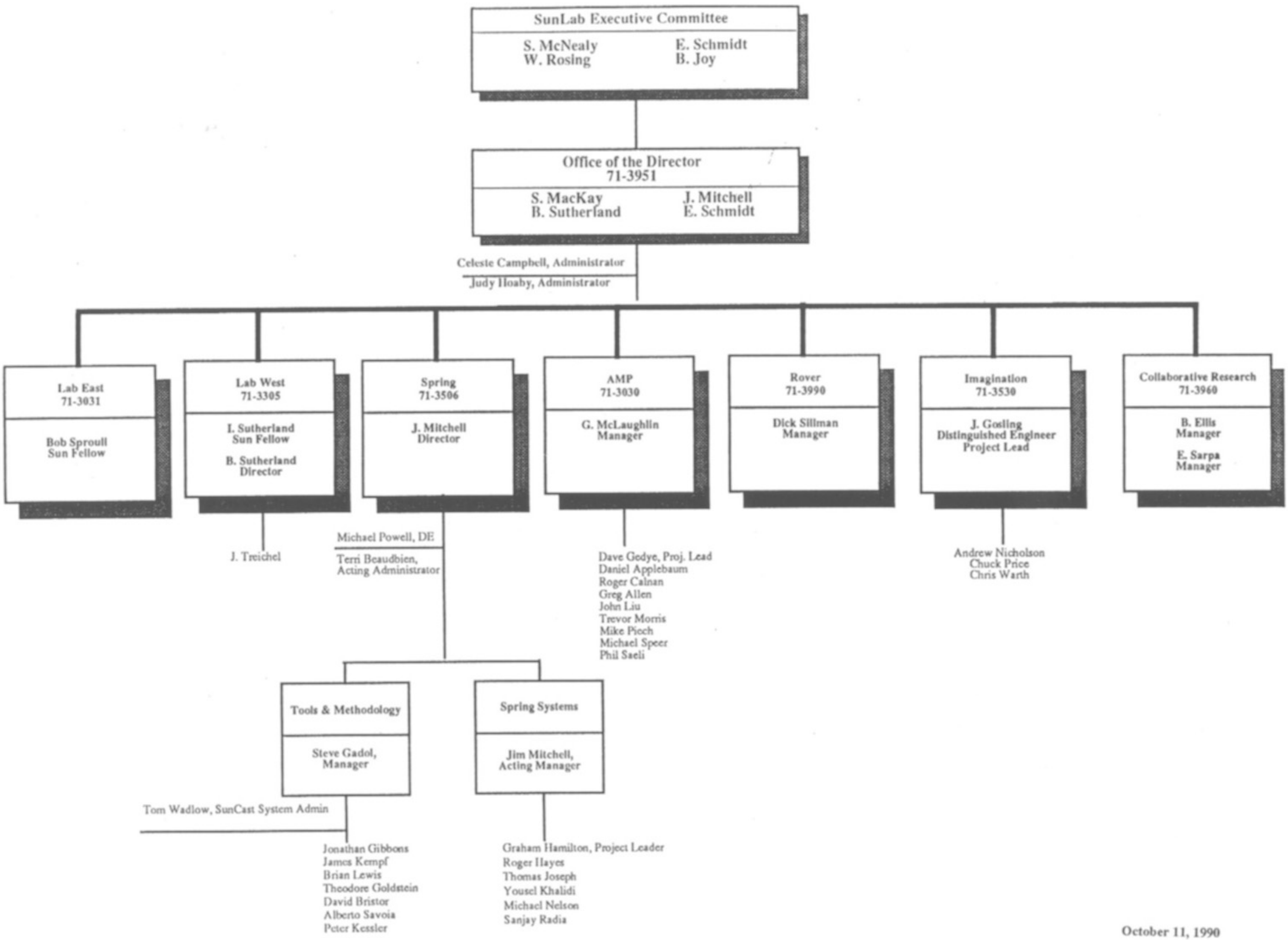
August 16, 1990

(Top row-from left) Yousef Khalidi, Jon Gibbons, Steve MacKay, Michele Huff, Roger Hayes, Jim Kempf, Dave Bristor, Alberto Savoia, unidentified, unidentified, Dena Patterson.

(Middle row-left to right) Steve Gadol, Mike Nelson, unidentified, Ed Frank, Tommy Joseph, Dick Sillman, James Gosling, Emil Sarpa, Bob Ellis, Ted Goldstein, Panos Kougiouris, Bob Sproull, unidentified, Michael Piech, Dan Halpern, Roger Calnan, Trevor Morris, Sanjay Radia, Facilitator, Bert Sutherland, Wayne Rosing, Ivan Sutherland.

(Bottom row-left to right) Greg McLaughlin, Chris Warth, Bill Joy, Laura Tong (Sardina), Brian Lewis, John Chapin, Graham Hamilton, John Gage, Mike Powell, Jim Mitchell, Steve Roberts. (Missing: Cyndi Jung, Jeanie Treichel)

Early Organization Charts



October 11, 1990

Sun Microsystems Laboratories, Inc.

October 29, 1991

Wayne Rosing
Director/President, SMLI
Corporate Executive Officer, SMI

Helen Wikle, Adm. Coordinator
Cyndi Jung, Program Manager

- **Human Resources** — Dena Patterson, HR Manager
  - Stephanie Peters
  - Mark Thomas, Generalist
- **Business Development** — Alex Osadzinski, Director
  - Earl Johnson
  - **Collaborative Research**
  - Kathleen Coakley
  - Bob Ellis, Program Mgr.
  - Emil Sarpa, Program Mgr.
- **Legal** — Michele Huff, Assist. Gen. Counsel
  - Anna Joe, Admin.
- Bert Sutherland, Deputy Director
  - Jeanie Treichel, Prog. Mgr
- Ivan Sutherland, Sun Fellow / VP, SMI
  - Liz Kniss, Admin/Temp
- Peter Deutsch, Sun Fellow
- **Finance** — Charles Tanaka, Finance Manager
  - Joyce Evan, Fin. Analyst
- **CTO** — Bill Joy, Vice President, SMI
  - Taz Kuwano, Admin.
  - Tammy Albers, Adm/Tmp
  - John Gage, Science Officer
  - Laura Tong, Market Segment Mgr.
  - Jim Thompson

- **SMLI BOSTON** — Bob Sproull, Sun Fellow//VP, SMI
  - Bruce Reichlin
  - Nicole Yankelovich
- Bill Woods, Principal Comp. Sci.
  - Ellen Hays
  - Jacek Ambrosiak
  - Peter Norvig
- **AMP** — Greg McLaughlin, Senior Staff Eng / Mgr.
  - HayChan Sargent
  - **DIME**
  - Tom Jacobs (S/W Mgr.)
  - Greg Allen
  - Roger Calnan
  - Gerard Fernando
  - John Liu
  - Trevor Morris
  - Mike Piech
  - Philip Saeli
  - Mike Speer
  - Keith Edwards
  - **COCO**
  - Dave Gedye (SE/Mgr)
  - Amy Pearl
  - John Tang
  - Alan Ruberg
- **Nomadics** — Dick Sillman, Hardware Manager
  - Kathleen Coakley
  - Dave Bagby
  - Marcel Janssen
- Don Jackson, Senior Staff Engineer
  - Kathleen Coakley
- **Special Projects** — Mike Sheridan, Director
  - Faye Baxter
  - James Gosling, (DE)
  - Ed Frank, (DE)
  - Craig Forrest
  - Dave LaVallee
  - Patrick Naughton
  - Christopher Warth
- **Systems & Network Mgmt** — Tom Wadlow, Network Operations Mgr.
  - Angie Besse
  - Barry Riddle
  - Gary Meyers
- **Software & Systems** — Jim Mitchell, Director
  - Angie Besse
  - Michael Powell, (DE)
  - **Spring System**
  - Jim Mitchell (Acting Manager)
  - Graham Hamilton, (SSE/Prj. Ld.)
  - Roger Hayes
  - Tom Joseph
  - Yousef Khalidi
  - Panos Kougiouris
  - Peter Madany
  - Mike Nelson
  - Sanjay Radia
  - **Tools and Methodology**
  - Steve Gadol (S/W Manager)
  - David Bristor
  - John Gibbons
  - Ted Goldstein
  - Jim Kempf
  - Peter Kessler
  - Brian Lewis
  - Luigi Pio Di Savoia
  - John Chapin
- **SELF**
  - Kathleen Coakley
  - John Maloney
  - Randy Smith
  - David Ungar
  - Ole Agesen
  - Lars Bak
  - Bay Wei Chang
  - Urs Hoelzle
- **Advanced Systems** — Dave Ditzel, Distinguished Engineer
  - Lisa Finkelman
  - **High Performance Compilers**
  - George Taylor (Director)
  - Bob Cmelik
  - Shing Kong
  - Steve Richardson
  - Dave Roberts
  - Mark Santoro
  - Lee Tavrow
  - Gary Bewick
  - **Compilers**
  - Dan Grove
  - Dan Scales
  - Steve Tjiang
  - Malcom Wing
  - Michael Wolf
  - **Advanced Technologies**
  - Trevor Burward-Hoy
  - David Chenevert
  - Howard Davidson (DE)
  - Bruce Smith
  - Jim Cherry
  - **SPARC Architecture**
  - Edmond Kelly
  - David Weaver
  - Dave Patterson
  - Guillermo Maturana
  - David Poole
- **HRV** — Curt Thiem, Engineering/Prog. Mgr.
  - Kathleen Coakley
  - Jim Hanko
  - Chris Killingsworth
  - Marc Klingelhofer
  - Eugene Kuerner
  - Dipti Mohapatra
  - Duane Northcutt
  - Steve Tsai
  - Jerry Wall
  - Alan Wilson
  - Paul Chu

Sun Microsystems Laboratories, Inc.

Wayne Rosing
Director/President, SMLI
(Corporate Executive Officer, SMI)

Bert Sutherland
(Deputy Director)

Ivan Sutherland
(Sun Fellow/VP, SMI)
Liz Kniss
Ian Jones

Human Resources
Dena Patterson
(HR Manager)
Cathy Tester
Mark Thomas

Finance
Charles Tanaka
(Finance Manager)
Joyce Evan

Legal
Michele Huff
(Director)
Anna Joe

Greg McLaughlin(SSE/ Mgr.)
Haychen Sargen

Gerard Fernando
Dave Gedye

Helen Wikle (Admin. Coordinator)

Susan Leach

Lab Operations
Jeanie Treichel (Prog. Mgr.)
Cyndi Jung (Prog. Mgr)

Collaborative Research
Kathleen Coakley
Bob Ellis (Program Mgr.)
Emil Sarpa (Program Mgr.)
Earl Johnson

CTO
Bill Joy
(Vice President, SMI)
Taz Kuwano
Tammy Albers

John Gage (Science Officer)
Laura Sardina(Program Mgr.)

Systems & Network Mgmt
Steve Gadol (S/W Mgr.)
Tom Wadlow (Principal IR Manager)
Angie Besse
Sonja Reichenberg

Daryl Williams
Gary Meyers
Dan Fosgett

SMLI BOSTON
Bob Sproull
(Sun Fellow/VP. SMI)
Rita Tavilla

Curt Thiem
Bruce Reichlen
Nicole Yankelovich
Kate Gordon
Charles Molnar
Peter Jones

Vantage
James Waldo
Geoffrey Wyant
Roger Hayes

Bill Woods

Ellen Hays
Jacek Ambroziak
Peter Norvig
Larry Bookman
Carl De Marcken
Scott Hofmeister

Software & Systems
Jim Mitchell
(Sun Fellow/ VP SMI)
Angie Besse
Diana Zupp

Peter Deutsch (Sun Fellow)
Mike Powell (DE)
Bruce Daniels

Spring Base System
Peter Christy
Luis Stevens
Graham Hamilton
Peter Kessler
Yousef Khalidi
Panos Kougiouris
Peter Madany
Mike Nelson
Sanjay Radia

Time Critical Media
Kathleen Coakley
Duane Northcutt
Jim Hanko
Jerry Wall

Prima Vera
Luigi Pio Di Savoia

Roongko Doong
Jos Marlowe
Sriram Sankar

Self
Kathleen Coakley
John Maloney
Randy Smith
David Ungar
Lars Bak
Bay Wei Chang
Urs Hoelzle
Ole Agesen

Clarity
Ted Goldstein
Jon Gibbons
Brian Lewis
Michael Van De Vanter
Geoffrey Phipps
David Bristor

Nomadics
Kathleen Coakley
Dick Sillman
Marcel Janssens
Robert Ellefson

Advanced Systems
Dave Ditzel
(Director/DE)
Lisa Finkelman
Michelle Cortez

Advanced Processors

Steve Richardson
David Poole
Gary Lauterbach
Bob Cmelik
Russell Quong
Michael Wolfe

P1000
George Taylor (Director)
Neil Wilhelm (DE)
James Blomgren
Silvia Mazawa
Paul Hansen
Gary Bewick
Mark Slamowitz
*Myron Shak
*Bill Lynch

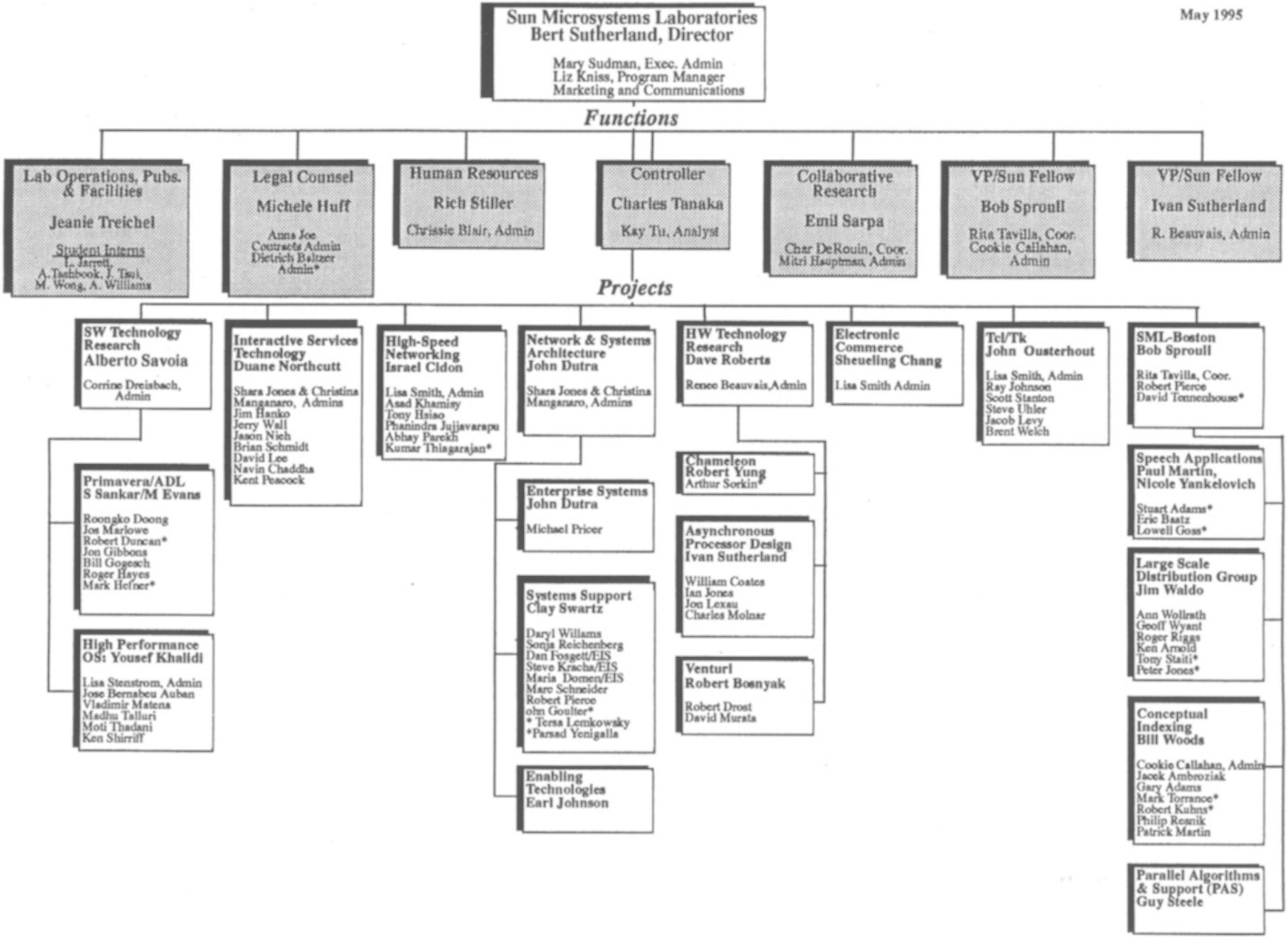
New Technologies
Trevor Burward-Hoy
Howard Davidson (DE)
Edmund Kelly
Bruce Smith
S. Kuishnakumar
Zafar Parvez
Eric Bogatin

SPARC
Dave Patterson
Tom Germond
Shing Kong
David Weaver
Jim Cherry

Project Seven
David Chenevert
Malcolm Wing
Alex Kumets

October 29, 1992

May 1995


Sun Microsystems Laboratories
Bert Sutherland, Director
Mary Sudman, Exec. Admin
Liz Kniss, Program Manager
Marketing and Communications
Functions
Lab Operations, Pubs. & Facilities
Jeanie Treichel
Student Interns
L. Jarrett, A. Tashbook, J. Tsui, M. Wong, A. Williams
Legal Counsel
Michele Huff
Anna Joe
Contracts Admin
Dietrich Baltzer
Admin*
Human Resources
Rich Stiller
Chrissie Blair, Admin
Controller
Charles Tanaka
Kay Tu, Analyst
Collaborative Research
Emil Sarpa
Char DeRouin, Coor.
Mitri Hauptman, Admin
VP/Sun Fellow
Bob Sproull
Rita Tavilla, Coor.
Cookie Callahan, Admin
VP/Sun Fellow
Ivan Sutherland
R. Beauvais, Admin
Projects
SW Technology Research
Alberto Savoia
Corrine Dreisbach, Admin
Primavera/ADL
S Sankar/M Evans
Roongko Doong
Jos Marlowe
Robert Duncan*
Jon Gibbons
Bill Gogesch
Roger Hayes
Mark Hefner*
High Performance OS: Yousef Khalidi
Lisa Stenstrom, Admin
Jose Bernabeu Auban
Vladimir Matena
Madhu Talluri
Moti Thadani
Ken Shirriff
Interactive Services Technology
Duane Northcutt
Shara Jones & Christina Manganaro, Admins
Jim Hanko
Jerry Wall
Jason Nieh
Brian Schmidt
David Lee
Navin Chaddha
Kent Peacock
High-Speed Networking
Israel Cidon
Lisa Smith, Admin
Asad Khamisy
Tony Hsiao
Phanindra Jujjavarapu
Abhay Parekh
Kumar Thiagarajan*
Network & Systems Architecture
John Dutra
Shara Jones & Christina Manganaro, Admins
Enterprise Systems
John Dutra
Michael Pricer
Systems Support
Clay Swartz
Daryl Willams
Sonja Reichenberg
Dan Fosgett/EIS
Steve Kracha/EIS
Maria Domen/EIS
Marc Schneider
Robert Pierce
ohn Goulter*
* Teresa Lemkowsky
*Parsad Yenigalla
Enabling Technologies
Earl Johnson
HW Technology Research
Dave Roberts
Renee Beauvais,Admin
Chameleon
Robert Yung
Arthur Sorkin*
Asynchronous Processor Design
Ivan Sutherland
William Coates
Ian Jones
Jon Lexau
Charles Molnar
Venturi
Robert Bosnyak
Robert Drost
David Murata
Electronic Commerce
Sheueling Chang
Lisa Smith Admin
Tcl/Tk
John Ousterhout
Lisa Smith, Admin
Ray Johnson
Scott Stanton
Steve Uhler
Jacob Levy
Brent Welch
SML-Boston
Bob Sproull
Rita Tavilla, Coor.
Robert Pierce
David Tennenhouse*
Speech Applications
Paul Martin, Nicole Yankelovich
Stuart Adams*
Eric Baatz
Lowell Goss*
Large Scale Distribution Group
Jim Waldo
Ann Wollrath
Geoff Wyant
Roger Riggs
Ken Arnold
Tony Staiti*
Peter Jones*
Conceptual Indexing
Bill Woods
Cookie Callahan, Admin
Jacek Ambroziak
Gary Adams
Mark Torrance*
Robert Kuhns*
Philip Resnik
Patrick Martin
Parallel Algorithms & Support (PAS)
Guy Steele

Highlights of The First Five Years

Highlights of The First Five Years

Sun Labs' Technological Contributions to Sun

This chronicle was prepared for a feature story on Sun Labs which appeared in Sun's Corporate World Wide Web pages *www.sun.com* in February of 1996.

Highlights of Our First Five Years

1990

Sun Labs is established

Sun Microsystems, Inc. establishes a new research and development subsidiary—Sun Microsystems Laboratories, Inc.—as an independent entity. [July]

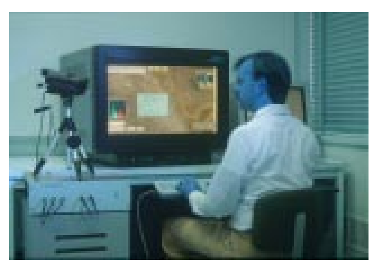
1991

Sun Labs is incorporated and functioning

Initial projects are largely absorbed from ongoing activities already underway in Sun Engineering. A few projects are started by new people recruited from outside Sun. [April]

High Resolution Video (HRV) is demonstrated

Video becomes "just another video type." Sun Labs, in conjunction with the David Sarnoff Research Center and Texas Instruments, completes a DARPA-supported research project to integrate High Resolution Video (HRV) into the distributed workstation computing environment. It demonstrated an alternative application of high resolution displays from the emerging High Definition Television (HDTV) technology. It is used as a platform for further research into system support for time-critical media. [October]



1991 (continued)

Russian scientists project

When the Zelanograd, Russia scientific center lays off half of its staff, Sun is one of the first Silicon Valley companies to hire a team of Soviet scientists to collaborate on advanced computing technologies. Sun Labs contracts with Boris Babaian and his design team in Moscow to design new systems based on Sun's SPARC processor. [October]

1992

Common Objects Request Broker Architecture (CORBA)

In joint partnership with Hewlett-Packard, Mike Powell takes Spring technology and proposes distributed objects as the basis for the Object Management Group's Common Object Request Broker Architecture (CORBA). Sun then begins Project DOE (now called NEO). [March]

CORBA

1993

FirstPerson, Inc. is established

Sun Labs spins off FirstPerson, Inc. (now JavaSoft), to develop software for digital devices. With Wayne Rosing as president, FirstPerson's charter is to develop technologies applicable to the consumer electronics marketplace. This was the successor to Green, started two years earlier, and the precursor to the Java language (via LiveOak)). [March]

FirstPerson

1993 (continued)

Conferencing and Collaboration (COCO)
Digital Integrated Media Environment (DIME)

Desktop workstations with integrated audio and video capabilities offered new opportunities for helping work together. DIME delivers prototype hardware and software that bring integrated multimedia to the SPARC desktop. COCO seeks to understand how to apply this technology to support communication and collaboration among small groups of people. The staff of both DIME and COCO transfer to product development status: DIME to Sun Microsystems Computer Company, and COCO to SunSoft. Sun's product most directly related to this work is the ShowMe product line, which includes video, audio, and shared applications.

COCO

ConfMgr

1994

Spring Operating System transfers to SunSoft

Spring, part of Sun Labs since its inception in 1991, transfers to SunSoft. Late in the year, basic research and the architecture phase of Spring are completed, and begin a transition to the analysis and measurement phase. It eventually ships as a "university release" in 1995.

Spring

Time-Critical Media (TCM)

TCM's goal is to develop the enabling systems technology to make the SPARC/Solaris/Spring platforms the premier base for development and execution of time-critical applications. The project is a major advance in processor scheduling: a new formulation is developed for dealing with time constraints that are not inherent or not easily derived. TCM, one of the initial users of the Spring operating system, adds the support needed for time-critical media applications, and defines a processor scheduling framework to be shared by Spring and Solaris.

TCM

1994 (continued)

Netra Internet Server Ships

Steve Gadol, from the Sun Labs systems support group, works closely with test engineers from Sun's reseller group to implement a server designed to operate as a gateway for PC clients to the Internet. The resulting system, the Netra-i server, is delivered to customers in a package that industry reviews call, "as close to plug and play," as any product they have seen.

World Cup Video Service

Sun Labs hosts the Sun Microsystems Computer Company team that developed the World Cup Video Service. Team members reside and work in the Sun Labs building for several months before the start of the World Cup soccer games, in order to use the ATM expertise and working ATM infrastructure of Sun Labs to solve many problems with this emerging high-bandwidth technology.

Vantage produces Xvan

The Vantage group (now called Large Scale Distribution) introduces Xvan, an enhanced X Windows system server that allows multiple physical screens to be treated as a single logical device. Windows can be moved from screen to screen, appear on multiple screens, and be larger than a single screen. The software is placed on the X Consortium ftp server where it is freely available.

1995

Java™ programming language

Spawned and nurtured in Sun Labs as the Green Project, and then independently in FirstPerson, Inc., the Java language and HotJava™ browser were announced.

Self 4.0 object-oriented programming language

To improve programmer productivity, a language and programming environment is created based entirely on simple objects. It is integrated into the user interface so anyone can modify applications as they are running. The user interface utilizes animation and a uniquel look and feel. The system, called Self 4.0, includes an experimental Smalltalk system and a multi-user, shared 2-D virtual reality.

Electronic Commerce

An experimental infrastructure for electronic services and payments emerges. Sun Labs sponsors Sun's membership in the Financial Services Technical Consortium, an organization of commercial banks and computer vendors focused on standards and protocols for electronic commerce. Sun Labs initiates the electronic check project, providing key hardware and software.

Electronic Commerce

1995 (continued)

Tcl/Tk (pronounced “Tickle/TeaKay”)

The multi-platform Tcl/Tk ships, providing support for safe execution of untrusted scripts from the network and the ability to run GUI applications independent of the platform—UNIX, Microsoft Windows, and Macintosh. The group also ships Safe-Tcl, a way to safely execute untrusted Tcl scripts received from the network.

Video server

An important contribution comes through Jim Hanko’s design and creation of a high-performance video server technology, now Sun’s Interactive Services Group’s high-performance server that is capable of delivering many independent, high-bandwidth data streams. Hanko wins Sun’s President’s Award for this work. In addition, Sun announces the Sun MediaCenter™ video server family, based on desk management, media layout, fault tolerance, and admission control technologies developed by Sun Labs.

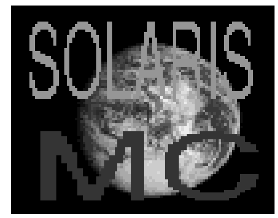
Media-related technologies

Every year, the Interactive Services Technology (IST) group’s projects build on work done in the previous fiscal year. 1995 sees a number of IST’s media-related technologies developed into products. SunTuner, the computer-controlled video tuner, and SlicVideo, the low-cost video capture prototype units are made available via a third party. The first media server product offered by Sun, the MediaCenter video server, is largely designed and implemented by the IST group for SunInteractive.

1995 (continued)

Solaris™ MC Operating System Software

New operating systems' software, Solaris MC, harnesses the power of multi-computer (clustered) systems. The architecture is completed and the design of several major components are finished. An algorithm is devised for sharing page tables that improves the overall performance of the system, especially on large servers. The scheme is particularly suited to modern software-controlled memory management units such as the UltraSPARC™ Memory Management Unit.



SpeechActs

Sun Labs East demonstrates conversational e-mail and other telephone-based SpeechActs applications at Telecom '95. Their goal is to build a robust, effective environment for speech applications.

Assertion Definition Language (ADL)

As the first stage of a collaboration between Sun Labs, X/Open, and IPA, ADL test generation system version 1.0 ships. The ADL compiler turns formal specifications into test programs. The objective is to research and develop software engineering tools and technology aimed at improving software design, development, testing, and maintenance; and to study the applicability of formal methods-based testing technology on large systems. [December]

The First Fifty Technical Reports

List of Technical Reports Published from 1991 through 1995

The First Fifty

TR-92-1	Stephen E. Richardson	Caching Function Results: Faster Arithmetic by Avoiding Unnecessary Computation
TR-92-2	James Kempf and Peter B. Kessler	Cross-Address Space Dynamic Linking
TR-92-3	Yousef A. Khalidi and Michael N. Nelson	An Implementation of UNIX on an Object-oriented Operating System
TR-92-4	Amy Pearl	System Support for Integrated Desktop Video Conferencing
TR-92-5	John C. Tang and Ellen A. Isaacs	Why Do Users Like Video? Studies of Multimedia-Supported Collaboration
TR-93-6	Bob Cmelik	SpixTools - Introduction & User's Manual
TR-93-7	Shing Kong	A Tutorial on CDRAM-Based Memory System Design
TR-93-8	Madhusudhan Talluri, Shing Kong, Mark D. Hill, and David A. Patterson	TradeOffs in Supporting Two Page Sizes
TR-93-9	Yousef A. Khalidi and Michael N. Nelson	The Spring Virtual Memory System
TR-93-10	Michael N. Nelson, Yousef A. Khalidi, and Peter W. Madany	The Spring File System
TR-93-11	Robert F. Cmelik, Shing I. Kong, David R. Ditzel, and Edmund J. Kelly	An Analysis of MIPS and SPARC Instruction Set Utilization on the SPEC Benchmarks

TR-93-12	Bob Cmelik and David Keppel	Shade: A Fast Instruction-Set Simulator for Execution Profiling
TR-93-13	Graham Hamilton, Michael L. Powell, and James G. Mitchell	Subcontract: A Flexible Base for Distributed Programming
TR-93-14	Graham Hamilton and Panos Kougiouris	The Spring Nucleus: A Microkernel for Objects
TR-93-15	Michael N. Nelson and Graham Hamilton	High Performance Dynamic Linking Through Caching
TR-93-16	Sanjay Radia, Michael N. Nelson, and Michael L. Powell	The Spring Name Service
TR-93-17	Yousef A. Khalidi, Madhusudhan Talluri, Michael N. Nelson, and Dock Williams	Virtual Memory Support for Multiple Page Sizes
TR-93-18	Yousef A. Khalidi and Michael N. Nelson	Extensible File Systems in Spring
TR-93-19	Michael N. Nelson, Graham Hamilton, and Yousef A. Khalidi	A Framework for Caching in an Object-Oriented System
TR-93-20	Yousef A. Khalidi and Michael N. Nelson	A Flexible External Paging Interface
TR-93-21	Graham Hamilton and Sanjay Radia	Using Interface Inheritance to Address Problems in System Software Evolution
TR-93-22	Gary Lauterbach	Accelerating Architectural Simulation by Parallel Execution of Trace Samples
TR-94-23	Sriram Sankar and Roger Hayes	Specifying and Testing Software Components using ADL
TR-94-24	Steve Gadol and Mike Clary	Nomadic Tenets—A User’s Perspective
TR-94-25	Robert F. Sproull, Ivan E. Sutherland, and Charles E. Molnar	Counterflow Pipeline Processor Architecture

TR-94-26	Theodore C. Goldstein and Alan D. Sloane	The Object Binary Interface—C++ Objects for Evolvable Shared Class Libraries
TR-94-27	Ole Agesen	Mango—A Parser Generator for Self
TR-94-28	Yousef A. Khalidi, Vikram P. Joshi, and Dock Williams	A Study of the Structure and Performance of MMU Handling Software
TR-94-29	Jim Waldo, Geoff Wyant, Ann Wollrath, and Samuel C. Kendall	A Note on Distributed Computing
TR-94-30	David Ungar and Randall B. Smith	Self: The Power of Simplicity
TR-94-31	Jonathan J. Gibbons and Michael J. Day	Shadows: A Type-safe Framework for Dynamically Extensible Objects
TR-94-32	James Testa	Lowered Supply and Threshold Voltage Effects on CMOS Circuit Characteristics
TR-94-33	Bay-Wei Chang and David Ungar	Animation: From Cartoons to the User Interface
TR-94-34	Sun Microsystems Laboratories Staff	SML Fiscal 1994 Project Portfolio Report
TR-95-35	Urs Hölzle	Adaptive Optimization for Self: Reconciling High Performance With Exploratory Programming
TR-95-36	Jos Marlowe and Doug Lea	PSL: Protocols and Pragmatics for Open Systems
TR-95-37	Israel Cidon, Tony Hsiao, Asad Khamisy, Abhay Parekh, Raphael Rom, and Moshe Sidi	The OPENET Architecture
TR-95-38	Yousef A. Khalidi and Madhusudhan Talluri	Improving the Address Translation Performance of Widely Shared Pages
TR-95-39	Moti Thadani and Yousef A. Khalidi	An Efficient Zero-Copy I/O Framework for UNIX

TR-95-40	Conal Elliott, Greg Schechter, and Salim AbiEzzi	MediaFlow, a Framework for Distributed Integrated Media
TR-95-41	Jeff Johnson and Mark Keavney	A Collection of Papers from FirstPerson, Inc.
TR-95-42	Robert Yung and Neil Wilhelm	Caching Processor General Registers
TR-95-43	Brian T. Lewis, L. Peter Deutsch, and Theodore C. Goldstein	Clarity MCode: A Retargetable Intermediate Representation for Compilation
TR-95-44	Neil C. Wilhelm	Why Wire Delays Will No Longer Scale for VLSI Chips
TR-95-45	Neil C. Wilhelm	The Miller and Anti-Miller Effects
TR-95-46	Ann Wollrath, Geoff Wyant, and Jim Waldo	Simple Activation for Distributed Objects
TR-95-47	Jim Waldo, Ann Wollrath, Geoff Wyant, and Samuel C. Kendall	Events in an RPC Based Distributed System
TR-95-48	Yousef A. Khalidi, Jose M. Bernabeu, Vlada Matena, Ken Shirriff, and Moti Thadani	Solaris MC: A Multi-Computer OS
TR-95-49	Charles E. Molnar and Huub Schols	The Design Problem SCPP-A
TR-95-50	Sun Microsystems Laboratories Staff	Fiscal 1995 Project Portfolio Report

Sun Labs Perspectives Series

List of Publications in the Non-technical Essay Series

Perspectives-1	Ivan Sutherland	Technology & Courage
Perspectives-2	Ivan Sutherland	A View of the Task You Face: A Report to the NRC Committee on Cryptography

Technology and Courage

Ivan Sutherland

Perspectives 96-1
In an Essay Series Published by SunLabs

April 1996

A View of The Task You Face

A Report to the NRC Committee on Cryptography

Ivan Sutherland

Perspectives 96-2
In an Essay Series Published by SunLabs

August 1996

Abstracts – First Fifty Technical Reports

You may view the entire reports by clicking on the titles on the pages following:

Send requests for hard copies to Editor, Technical Reports, Sun Microsystems Laboratories,
901 San Antonio Road, M/S UMTV29-01, Palo Alto, California 94303
For information regarding the SML Technical Report Series, contact Jeanie Treichel, Editor-in-Chief
<jeanie.treichel@eng.sun.com>

Caching Function Results:
Faster Arithmetic by Avoiding Unnecessary Computation

Stephen E. Richardson

SMLI TR-92-1 September 1992

Abstract:

This paper discusses **trivial** computation, where simple operands trivialize potentially complex operations. An example of a trivial operation is integer division, where the divisor is two; the division becomes a simple shift operation. The paper also discusses the concept of **redundant** computation, where some operation repeatedly does the same function because it repeatedly sees the same operands. Experiments on two separate benchmark suites, the SPEC benchmarks and the Perfect Club, find a surprisingly large amount of trivial and redundant operation. Various architectural means of exploiting this knowledge to improve computational efficiency include **detection of trivial operands** and the **result cache**. Further experimentation shows significant speedup from these techniques, as measured on three different styles of machine architecture.

This version of the technical report includes new information as of March 1993. It incorporates material included in a paper published in the 11th Symposium on Computer Arithmetic, sponsored by the IEEE.

Also included is a license agreement for receiving free software from Sun Microsystems Laboratories, Inc.

Categories and Subject Descriptors:

B.6.1 Hardware:
[**Logic Design**]: Design Styles-*Memory used as logic*
F.2.0 Theory of Computation:
[**Analysis of Algorithms and Problem Complexity**]: General
G.0 Mathematics of Computing:
[**General**]

Keywords and Phrases: Memoization, Multiplication, Result cache

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
stever@eng.sun.com

Cross-Address Space Dynamic Linking

James Kempf
Peter B. Kessler

SMLI TR-92-2 September 1992

Abstract:

We describe an algorithm and implementation of dynamic linking that allows one user process to link a program in another address space without compromising the security of the other address space and without requiring the linking process to enter kernel mode. The same technique can also be used to load program code into an existing address space, e.g., for debugging or other purposes. The implementation makes extensive use of objects in the Spring object-oriented operating system. We have extracted the dynamic linking function from our operating system, and have made it available to user programs as a replaceable library service. In the process, we have taken advantage of features present in a modern, object-oriented operating system to simplify the dynamic linker.

Categories and Subject Descriptors:

C.2.4 Computer System Organization:
[**Computer-Communications Network**]: Distributed Systems-*Network operating systems*
D.4.9 Software:
[**Operating Systems**]: Systems programs and utilities-*Linkers; Loadersl*

Additional Keywords and Phrases: Spring operating system; Object-oriented programming

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
james.kempf@sun.com
peter.kessler@sun.com

An Implementation of UNIX® on an Object-oriented Operating System

Yousef A. Khalidi
Michael N. Nelson

SMLI TR-92-03 December 1992

Abstract:

This paper describes an implementation of UNIX on top of an object-oriented operating system. UNIX is implemented without modifying the underlying mechanisms provided by the base system. The resulting system runs dynamically-linked UNIX binaries and utilizes the services provided by the object-oriented system.

Categories and Subject Descriptors:
D.4 Software:
[Operating Systems]: D.4.0 General
D.4.7 Distributed systems
D.4.9 Systems programs and utilities - *Loaders*

Additional Keywords and Phrases: UNIX, Object-oriented operating system, Subsystem, Emulation, Micro-kernel

sun microsystems
Sun Microsystems Laboratories, Inc.
M/S MTV29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
yak@eng.sun.com
mnn@eng.sun.com

System Support for Integrated Desktop Video Conferencing

Amy Pearl

Conferencing and Collaboration (COCO) / Advanced Multimedia Platforms (AMP)

SMLI TR-92-4 December 1992

Abstract:

Desktop computers are increasingly used as communications devices. Advances in digital media are making the integration of video into desktop computers practical, both technically and economically. At the convergence of these technologies is computer-integrated desktop video conferencing. This paper discusses the requirements of integrated desktop video conferencing on a networked set of multimedia-capable workstations. Among these requirements are the following:

Media-intensive parts of applications should be distributed; a multimedia software platform should provide support for this.

Audio and video conferencing require network transparent location and reference of people, media devices, and conferences. The name and remote access reference for a conference must be exportable to client applications.

All group support applications that provide remote access require security services. True in any network application, this is more important with live communication streams, such as audio and video.

Low latency of an audio connection is more important than synchronization of audio with other timecritical communication, such as video conferencing and user gestures in shared interactive applications.

To efficiently support multi-person conferences, multicast networking protocols are essential.

A research prototype multimedia platform was evaluated, based on these requirements. This paper presents the lessons learned about system requirements for video conferencing that are not obviously required for single-user multimedia. It also discusses the motivation and requirements for extending the platform to support shared applications not previously considered to have constraints related to time.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business

M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
amy.pearl@eng.sun.com

Why Do Users Like Video?
Studies of Multimedia-Supported Collaboration

John C. Tang
Sun Microsystems Laboratories, Inc.
Ellen A. Isaacs
SunSoft, Inc.

SMLI TR-92-5 December 1992

Abstract:

Three studies of collaborative activity were conducted as part of research in developing multimedia technology to support collaboration. One study surveyed users' opinions of their use of video conference rooms. Users indicated that the availability of the video conference rooms was too limited, audio quality needed improvement, and a shared drawing space was needed. A second study analyzed videotapes of a work group when meeting face-to-face, video conferencing, and phone conferencing. The analyses found that the noticeable audio delay in video conferencing made it difficult for the participants to manage turn-taking and coordinate eye gazes. In the third study, a distributed team was observed under three conditions: using their existing collaboration tools, adding a desktop conferencing prototype (audio, video, and shared drawing tool), and subtracting the video capability from the prototype. Data was collected by videotaping the team, interviewing the team members individually, and recording the teams' usage of the phone, electronic mail, face-to-face meetings, and desktop conferencing. The team's use of the desktop conferencing prototype dropped dramatically when the video capability was taken away. Analysis of the videotape records showed that the video channel was used to help mediate their interaction and convey visual communication. Desktop conferencing substituted for e-mail usage and perhaps substituted for shorter, two-person meetings.

Keywords: Desktop Conferencing, Remote Collaboration, Use Studies, Video Conferencing

Sun Microsystems
Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
john.tang@eng.sun.com
ellen.isaacs@eng.sun.com

SpixTools
Introduction and User's Manual

Bob Cmelik

SMLI TR-93-6 February 1993

Abstract:

SpixTools is a collection of programs which allow instruction-level profiling of applications programs.

spix creates an instrumented version of the user's application program. As it runs, this instrumented program keeps track of how often each basic block is executed, and writes out the basic block execution counts on termination.

Several tools are provided for displaying and summarizing these counts. *spixstats* prints tables showing opcode usage, branch behavior, register usage, function usage, etc. *sdas* disassembles the application program, annotating the disassembled code with instruction execution counts. *sprint* prints the source code for the application, annotating it with statement or instruction execution counts.

These tools do not allow profiling of system-level code, including instructions executed during system calls made by the application program. Applications must furthermore be statically linked, and not use self-modifying code. Other limitations apply.

This report contains two parts: a tutorial introduction in front, and a reference manual in back.

Sun Microsystems Laboratories, Inc.
M/S MTV29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
bob.cmelik@eng.sun.com

A Tutorial on CDRAM-Based Memory System Design

Shing Kong

SMLI TR-93-7 February 1993

Abstract:

This document attempts to answer the following questions: What is a CDRAM? How does a CDRAM work? And what can we do with a CDRAM? The goal of this report is to give readers an easy-to-understand description of the CDRAM.

sun
microsystems
Sun Microsystems Laboratories, Inc.
M/S MTV29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
shing.kong@eng.sun.com

TradeOffs in Supporting Two Page Sizes

Madhusudhan Talluri
Shing Kong
Mark D. Hill
David. A. Patterson

SMLI TR-93-8 February 1993

Abstract:

As computer system main memories get larger and processor cycles-per-instruction (CPIs) get smaller, the time spent in handling translation lookaside buffer (TLB) misses could become a performance bottleneck. We explore relieving this bottleneck by *(a)* increasing the page size and *(b)* supporting two page sizes.

We discuss how to build a TLB to support two page sizes and examine both alternatives experimentally with a dozen uniprogrammed, user-mode traces for the SPARC architecture. Our results show that increasing the page size to 32KB causes both a significant increase in average working set size (e.g., 60%) and a significant reduction in the TLB's contribution to CPI, CPI_{TLB} (namely a factor of eight) compared to using 4KB pages. Results for using two page sizes, 4KB and 32KB pages, on the other hand, show a small increase in working set size (about 10%) and variable decrease in CPI_{TLB}, from negligible to as good as found with the 32KB page size). CPI_{TLB} when using two page sizes is consistently better for fully associative TLBs than for set-associative ones.

Our results are preliminary, however, since *(a)* our traces do not include multiprogramming or operating system behavior, and *(b)* our page size assignment policy may not reflect a real operating system's policy.

Keywords: Address translation, page size, translation lookaside buffer, virtual memory, working set size.

sun microsystems
Sun Microsystems Laboratories, Inc.
M/S MTV29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
talluri@cs.wisc.edu
shing.kong@eng.sun.com
markhill@cs.wisc.edu
dave.patterson@eng.sun.com

The Spring Virtual Memory System

Yousef A. Khalidi
Michael N. Nelson

SMLI TR-93-9 February 1993

Abstract:

In this document we describe the architecture and the implementation of the Spring virtual memory system. The architecture separates the tasks of maintaining memory mappings and protections from the task of paging memory in and out of backing store. A per-node virtual memory manager is responsible for maintaining the mappings on the local machine while external pagers are responsible for managing backing store. A novel aspect of the architecture is the separation of the memory abstraction from the interface that provides the paging operations. The design supports flexible memory sharing, sparse address spaces, and copy-on-write mechanisms. Support for distributed shared memory and extensible stackable file systems are natural consequences of the design. The architecture is implemented and has been in use for over two years as part of an experimental operating system.

Categories and Subject Descriptors:

D.4 Software:
[**Operating Systems**]: D.4.2 Storage management
D.4.3 File systems management
D.4.6 Security and protection
D.4.7 Distributed systems

Additional Keywords and Phrases: Object-oriented operating system, Distributed shared memory, Memory coherency, Micro-kernel

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
yak@eng.sun.com
mnn@eng.sun.com

The Spring File System

Michael N. Nelson
Yousef A. Khalidi
Peter W. Madany

SMLI TR-93-10 February 1993

Abstract:

The Spring File System supports cache coherent file data and attributes. It uses the virtual memory system to provide data caching and uses the operations provided by the virtual memory system to keep the data coherent. The file system consists of two types of file servers: ones that provide coherent access to files they export and ones that run on each Spring machine and provide caching of data for read and write operations, and has its own private protocol with the remote file servers to cache file attributes.

Categories and Subject Descriptors:

D.4 Software:
[**Operating Systems**]: D.4.2 Storage management
D.4.3 File systems management
D.4.7 Distributed systems

Additional Keywords and Phrases: Caching, Distributed Shared Memory, Object-oriented Operating System, External Pagers

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
yak@eng.sun.com
mnn@eng.sun.com
madany@eng.sun.com

An Analysis of MIPS and SPARC Instruction Set Utilization on the SPEC Benchmarks

Robert F. Cmelik
Shing I. Kong
David R. Ditzel
Edmund J. Kelly

SMLI TR-93-11 March 1993

Abstract:

The dynamic instruction counts on MIPS and SPARC are compared using the SPEC benchmarks. MIPS typically executes more user-level instructions than SPARC. This difference can be counted for by architectural differences, compiler differences, and library differences

The most significant differences are that SPARC's double-precision floating point load/store is an architectural advantage in the SPEC floating point benchmarks while MIPS's compare-and-branch instruction is an architectural advantage in the SPEC integer benchmarks. After the differences in the two architectures are isolated, it appears that although MIPS and SPARC each have strengths and weaknesses in their compilers and library routines, the combined effect of compilers and library routines does not give either MIPS or SPARC a clear advantage in these areas.

sun microsystems
Sun Microsystems Laboratories, Inc.
M/S MTV29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
bob.cmelik@eng.sun.com

Shade: A Fast Instruction Set Simulator for Execution Profiling

Robert F. Cmelik
David Keppel

SMLI TR-93-12 July 1993

Abstract:

Shade is an instruction-set simulator and custom trace generator. Application programs are executed and traced under the control of a user-supplied trace analyzer. To reduce communication costs, Shade and the analyzer are run in the same address space. To further improve performance, code which simulates and traces the application is dynamically generated and cached for reuse. Current implementations run on SPARC systems and, to varying degrees, simulate the SPARC (Version 8 and 9) and MIPS I instruction sets.

This paper describes the capabilities, design, implementation, and performance of Shade, and discusses instruction set emulation in general.

Sun Microsystems
Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
bob.cmelik@eng.sun.com

Subcontract: A Flexible Base for Distributed Programming

Graham Hamilton
Michael L. Powell
James G. Mitchell

SMLI TR-93-13 April 1993

Abstract:

A key problem in operating systems is permitting the orderly introduction of new properties and new implementation techniques. We describe a mechanism, subcontract, that within the context of an object-oriented distributed system permits application programmers control over fundamental object mechanisms. This allows programmers to define new object communication without modifying the base system. We describe how new subcontracts can be introduced as alternative communication mechanisms in the place of existing subcontracts. We also briefly descibe some of the uses we have made of the subcontract mechanism to support caching, crash recovery, and replication.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
graham.hamilton@eng.sun.com
michael.powell@eng.sun.com
jim.mitchell@eng.sun.com

The Spring Nucleus: A Microkernel for Objects

Graham Hamilton
Panos Kougiouris

SMLI TR-93-14 April 1993

Abstract:

The Spring system is a distributed operating system that supports a distributed, object-oriented application framework. Each individual Spring system is based around a microkernel known as the nucleus, which is structured to support fast cross-address-space object invocations.

This paper discusses the deign rationale for the nucleus' IPC facilities and how they fit into the overall Spring programming model. We then describe how the internal structure of the nucleus is organized to support fast cross-address-space calls, including some specific details and performance information on the current implementation.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
graham hamilton@eng.sun.com
panos.kougiouris@eng.sun.com

High Performance Dynamic Linking Through Caching

Michael N. Nelson
Graham Hamilton

SMLI TR-93-15 April 1993

Abstract:

The Spring Operating System provides high performance dynamic linking of program images. Spring uses caching of both fixed-up program images and partially fixed-up shared libraries to make dynamic linking of program images efficient, to reduce the need for PIC (position-independent code), and to improve page sharing between different program images running the same libraries. The result is that with program image caching, dynamically-linked programs have a start-up cost similar to statically-linked programs regardless of the number of unresolved symbols in dynamically-linked program images and shared libraries. In addition, with library and program image caching, we have reduced the need for PIC and have increased page sharing.

Note: Spring is an internal code name only.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
michael.nelson@eng.sun.com
graham.hamilton@eng.sun.com

The Spring Name Service

Sanjay Radia
Michael N. Nelson
Michael L. Powell

SMLI TR-93-16 November 1993

Abstract:

The Spring name service exploits and supports the uniformity of objects in the Spring object-oriented distributed system. The name service can be used to associate any name with any object independent of the type of object, and arbitrary name spaces can be created and used as first-class objects. The same client interface is used not only for all conventional operating system and network naming, but also for other services that support naming-style interaction. The architecture of the name service is open, supporting combinations of trusted and untrusted name servers and object implementations.

The name service integrates access control and persistence for objects in a way that allows object implementations to delegate responsibility to the name service, or to implement their own policies. The interfaces between different name servers and between name servers and object implementations allow a variety of implementation strategies for objects and name servers, providing different levels performance, persistence, robustness, security, and convenience.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
sanjay.radia@eng.sun.com
michael.nelson@eng.sun.com
michael.powell@eng.sun.com

Virtual Memory Support for Multiple Pages

Yousef A. Khalidi
Madhusudhan Talluri
Michael N. Nelson
Dock Williams

SMLI TR-93-17 September 1993

Abstract:

The advent of computers with 64-bit virtual address spaces and giga-bytes of physical memory will provide applications with many more orders of magnitude of memory than is possible today. However, to tap the potential of this new hardware, we need to re-examine how virtual memory is traditionally managed. We concentrate in this note on two aspects of virtual memory: software support for multiple page sizes, and memory management policies tuned to large amounts of physical memory. We argue for the need to examine these areas, and we identify several questions that need to be answered. In particular, we show that providing support for multiple page sizes is not as straightforward as may initially appear.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
yousef.khalidi@eng.sun.com
madhusudhan.talluri@eng.sun.com
michael.nelson@eng.sun.com
dock.williams@eng.sun.com

Extensible File Systems in Spring

Yousef A. Khalidi
Michael N. Nelson

SMLI TR-93-18 September 1993

Abstract:

In this paper we describe an architecture for extensible file systems. The architecture enables the extension of file system functionality by composing (or stacking) new file systems on top of existing file systems. A file system that is stacked on top of an existing file system can access the existing file system's files via a well-defined naming interface and can share the same underlying file data in a coherent manner. We describe extending file systems in the context of the Spring operating system. Composing file systems in Spring is facilitated by basic Spring features such as its virtual memory architecture, its strongly-typed well-defined interfaces, its location-independent object invocation mechanism, and its flexible naming architecture. File systems in Spring can reside in the kernel, in user-mode, or on remote machines, and composing them can be done in a very flexible manner.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
yousef.khalidi@eng.sun.com
michael.nelson@eng.sun.com

A Framework for Caching in an Object-Oriented System

Michael N. Nelson
Graham Hamilton
Yousef A. Khalidi

SMLI TR-93-19 October 1993

Abstract:

Caching is an important technique for improving performance in distributed systems. However, in general, it has been performed on an ad-hoc basis, with each component of the system having to invent its own caching techniques. In the Spring operating system, we provide a unified caching architecture that can be used to cache a variety of different kinds of remote objects. For any given kind of object, this architecture lets different client processes within a single machine share a single cache for accessing remote objects. This caching is performed by a separate cacher process on the machine local to client processes, the caching is transparent to the clients, and the cached information is kept coherent. This architecture has been used to implement caching for files and for naming contexts.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
michael.nelson@eng.sun.com
graham.hamilton@eng.sun.com
yousef.khalidi @eng.sun.com

A Flexible External Paging Interface

Yousef A. Khalidi
Michael N. Nelson

SMLI TR-93-20 October 1993

Abstract:

In this paper we describe an aspect of the Spring virtual memory system that was influenced by the distributed object-oriented architecture of Spring. The virtual memory system supports external pagers like those provided in the MACH® operating system, yet the architecture is more flexible and provides better caching opportunities than is possible in other systems. A novel aspect of the architecture is the separation of the memory abstraction from the interface that provides the paging operations. This separation provides considerable caching opportunities in our file system, and it facilitates our extensible stackable file system architecture. The virtual memory architecture described in this paper is implemented and has been in use for over three years as part of the experimental Spring operating system.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
yousef.khalidi@eng.sun.com
michael.nelson@eng.sun.com

Using Interface Inheritance to Address Problems in System Software Evolution

Graham Hamilton
Sanjay Radia

SMLI TR-93-21 November 1993

Abstract:

Two specific problems faced in large distributed systems are: (1) evolving and managing different versions of an interface while minimizing the impact on existing clients; and (2) supporting the addition of auxiliary interfaces that are orthogonal to the main interface of an abstraction.

In the context of the Spring distributed system, we addressed both problems using an object-oriented interface definition language. Different versions of an interface are represented as different types, with an inheritance relationship that minimizes the impact on existing clients, and allows easy management of versions.

We distinguish between fundamental and auxiliary properties, each of which is defined as a separate type. Rather than use simple root inheritance, we use a combination of root and leaf inheritance. This provides flexibility in supporting auxiliary properties, and allows us to add new auxiliary properties as the system evolves, without forcing the system to be recompiled.

The solutions have been tested and refined through their use in the Spring system.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
graham.hamilton@eng.sun.com
sanjay.radia@eng.sun.com

Accelerating Architectural Simulation by Parallel Execution of Trace Samples

Gary Lauterbach

SMLI TR-93-22 December 1993

Abstract:

In order to quickly decide which architectural features are to be included in future processors, we have developed a simulation approach that uses samples of benchmark program instruction traces. Rather than simulating a proposed architecture on the entire SPEC92 program suite of more than 100 billion instructions, we simulate using a set of samples of the SPEC92 suite containing less than 1% of the total instruction trace. Each of our samples contains a relatively short instruction trace that can be simulated quickly.

The technique described can be applied to existing architectural models to produce significant reductions in simulation time. Existing simulation tools can be leveraged to implement the trace sampling technique described.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
gary.lauterbach@eng.sun.com

Specifying and Testing Software Components using ADL

Sriram Sankar
Roger Hayes

SMLI TR-94-23 April 1994

Abstract:

This paper presents a novel approach to unit testing of software components. This approach uses the specification language ADL, that is particularly well-suited for testing, to formally document the intended behavior of software components. Another related language, TDD, is used to systematically describe the test-data on which the software components will be tested.

This paper gives a detailed overview of the ADL language, and a brief presentation of the TDD language. Some details of the actual test system are also presented, along with some significant results.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
sriram.sankar@eng.sun.com
roger.hayes@eng.sun.com

Nomadic Tenets - A User's Perspective

Steve Gadol
Mike Clary

SMLI TR-94-24 June 1994

Abstract:

This document will attempt to establish some basic tenets on how nomadic computers should operate. These tenets are derived from practical experience gained from using nomadic computers to access the enterprise-wide information resource at Sun®. These tenets are not hard and fast; they are recommendations of how nomadics should work. They will surely be refined as more experience is gained. They do, however, represent a starting point for living and working in a nomadic computing world.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
steve.gadol@eng.sun.com
mike.clary@eng.sun.com

Counterflow Pipeline Processor Architecture

Robert F. Sproull
Ivan E. Sutherland
Sun Microsystems Laboratories, Inc.

Charles E. Molnar
Institute for Biomedical Computing
Washington University

SMLI TR-94-25 April 1994

Abstract:

The counterflow pipeline processor architecture (CFPP) is a proposal for a family of micro-architectures for RISC processors. The architecture derives its name from its fundamental feature, namely that instructions and results flow in opposite directions within a pipeline and interact as they pass. The architecture seeks geometric regularity in processor chip layout, purely local control to avoid performance limitations of complex global pipeline stall signals, and simplicity that might lead to provably correct processor designs. Moreover, CFPP designs allow asynchronous implementations, in contrast to conventional pipeline designs where the synchronization required for operand forwarding makes asynchronous designs unattractive. This paper presents the CFPP architecture and a proposal for an asynchronous implementation. Detailed performance simulations of a complete processor design are not yet available.

Keywords: processor design, RISC architecture, micropipelines, FIFO, asynchronous systems

CR categories: B.2.1, B.6.1, C.1.0

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Ave.
Mountain View, CA 94043

email addresses:
Bob.Sproull@east.sun.com
Ivan.Sutherland@eng.sun.com

The Object Binary Interface—C++ Objects for Evolvable Shared Class Libraries

Theodore C. Goldstein
Alan D. Sloane

SMLI TR-94-26 June 1994

Abstract:

Object-oriented design and object-oriented languages support the development of independent software components such as class libraries. When using such components, versioning becomes a key issue. While various ad-hoc techniques and coding idioms have been used to provide versioning, all of these techniques have deficiencies—ambiguity, the necessity of recompilation or recoding, or the loss of binary compatibility of programs. Components from different software vendors are versioned at different times. Maintaining compatibility between versions must be consciously engineered. New technologies—such as distributed objects—further complicate libraries by requiring multiple implementations of a type simultaneously in a program.

This paper describes a new C++ object model called the Shared Object Model (SOM) for C++ users, and a new implementation model called the Object Binary Interface (OBI) for C++ implementors. These techniques provide a mechanism for allowing multiple implementations of an object in a program. Early analysis of this approach has shown it to have performance broadly comparable to conventional implementations.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
ted.goldstein@eng.sun.com

Mango: A Parser Generator for Self

Ole Agesen

SMLI TR-94-27 June 1994

Abstract:

Mango is a parser generator that is included in Release 3.0 of the Self system. Mango goes beyond LEX/YACC in several respects. First, Mango grammars are structured, thus easier to read and map onto parse trees. Second, Mango parsers automatically build parse trees rather than merely provide hooks for calling low-level reduce actions during parsing. Third, Mango automatically maintains invariance of the structure of parse trees, even while grammars are transformed to enable LR parsing. Fourth, Mango and the parsers it generates are completely integrated in the Self object world. In particular, a parser is an object. Unlike YACC, several independent parsers can co-exist in a single program.

We show how to generate a Mango parser and how to use it by means of an example: a simple expression language. Furthermore, we show how to add semantic properties to the parse trees that the Mango parser produces.

Mango is a realistic tool. A parser for full ANSI C was built with Mango.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
ole.agesen@eng.sun.com

A Study of the Structure and Performance of MMU Handling Software

Yousef A. Khalidi
Vikram P. Joshi
Dock Williams

SMLI TR-94-28 June 1994

Abstract:

Modern operating systems provide a rich set of interfaces for mapping, sharing, and protecting memory. Different memory management unit (MMU) architectures provide different mechanisms for managing memory translations. Since the same OS usually runs on different MMU architectures, a software "hardware address translation" (hat) layer that abstracts the MMU architecture is normally implemented between MMU hardware and the virtual memory system of the OS. In this paper, we study the impact of the OS and the MMU on the structure and performance of the hat layer. In particular, we concentrate on the role of the hat layer on the scalability of system performance on symmetric multiprocessors with 2-12 CPUs. The results show that, unlike single-user applications, multi-user applications require very careful multi-threading of the hat layer to achieve system performance that scales with the number of CPUs. In addition, multi-threading the hat can result in better performance in lesser amounts of physical memory.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
yousef.khalidi@eng.sun.com
vikram.joshi@eng.sun.com
dock.williams@eng.sun.com

A Note on Distributed Computing

Jim Waldo
Geoff Wyant
Ann Wollrath
Sam Kendall

SMLI TR-94-29 November 1994

Abstract:

We argue that objects that interact in a distributed system need to be dealt with in ways that are intrinsically different from objects that interact in a single address space. These differences are required because distributed systems require that the programmer be aware of latency, have a different model of memory access, and take into account issues of concurrency and partial failure.

We look at a number of distributed systems that have attempted to paper over the distinction between local and remote objects, and show that such systems fail to support basic requirements of robustness and reliability. These failures have been masked in the past by the small size of the distributed systems that have been built. In the enterprise-wide distributed systems foreseen in the near future, however, such a masking will be impossible.

We conclude by discussing what is required of both systems-level and application-level programmers and designers if one is to take distribution seriously.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
jim.waldo@east.sun.com
geoff.wyant@east.sun.com
ann.wollrath@east.sun.com
sam.kendall@east.sun.com

Self: The Power of Simplicity*

David Ungar‡
Randall B. Smith‡

SMLI-TR-94-30 December 1994

Abstract:

Self is an object-oriented language for exploratory programming based on a small number of simple and concrete ideas: prototypes, slots, and behavior. Prototypes combine inheritance and instantiation to provide a framework that is simpler and more flexible than most object-oriented languages. Slots unite variables and procedures into a single construct. This permits the inheritance hierarchy to take over the function of lexical scoping in conventional languages. Finally, because Self does not distinguish state from behavior, it narrows the gaps between ordinary objects, procedures, and closures. Self's simplicity and expressiveness offer new insights into object-oriented computation.

* This work was partially supported by Xerox Corporation, and partially by National Science Foundation Presidential Young Investigator Grant #CCR-8657631, Sun Microsystems, Inc., The Powell Foundation, International Business Machines Corporation, Apple Computer, Inc., Digital Equipment Corporation, NCR Corporation, Texas Instruments, Inc., and Cray Laboratories.

‡ At the time of original publication, Ungar was employed at the Computer Systems Laboratory of Stanford University, Stanford, CA, and Smith was employed at Xerox Palo Alto Research Center, Palo Alto, CA.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
david.ungar@eng.sun.com
randall.smith@eng.sun.com

Shadows: A Type-safe Framework for Dynamically Extensible Objects

Jonathan J. Gibbons
Michael J. Day

SMLI TR-94-31 November 1994

Abstract:

In an object-oriented program, it is common to have a collection of interconnected objects of a variety of types. To manipulate such a collection, it is often desirable to be able to extend the functionality of the individual objects, in different ways for different and independent clients, and possibly for more than one client at a time. The complete set of potential clients may not be known when the code for the collection is compiled, or when the collection is actually built. Furthermore, it is desirable to be able to extend the functionality of the various objects in a type-safe manner.

"Shadowing" is a flexible way to solve this problem that permits a collection of objects to be projected from one type-space to another. Internally, a simple form of run-time typing is used to provide type-safety. Both the shadow technology and the run-time typing technology use a specialized utility called `autodefine` that automates many of the implementation details.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
jonathan.gibbons@eng.sun.com
michael.day@eng.sun.com

Lowered Supply and Threshold Voltage Effects on CMOS Circuit Characteristics

James Testa

SMLI TR-95-32 June 1995

Abstract:

Low Power Supply Voltages are currently being investigated in the attempt to lower power dissipation in CMOS ICs. Power dissipation becomes a major concern when both the number of transistors and the operating frequency increase. Lowering the power supply voltage reduces the operating frequency by lowering MOSFET current. MOSFET current can be increased by lowering the threshold voltage, which increases the leakage current. This paper describes the operating limits of some static and dynamic CMOS circuits, as the power supply voltage is lowered and the threshold voltage is decreased and eventually becomes negative. The threshold voltage is theoretically determined where the frequency of operation is maximum for dynamic NOR gates with keeper MOSFETs, from the MOSFET current equations.

Sun Microsystems Laboratories

M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

Animation: From Cartoons to the User Interface*

Bay-Wei Chang
David Ungar

SMLI-TR-95-33 March 1995

Abstract:

User interfaces are often based on static presentations, a model ill suited for conveying change. Consequently, events on the screen frequently startle and confuse users. Cartoon animation, in contrast, is exceedingly successful at engaging its audience; even the most bizarre events are easily comprehended. The Self user interface has served as a testbed for the application of cartoon animation techniques as a means of making the interface easier to understand and more pleasant to use. Attention to timing and transient detail allows Self objects to move solidly. Use of cartoon-style motion blur allows Self objects to move quickly and still maintain their comprehensibility. Self objects arrive and depart smoothly, without sudden materializations and disappearances, and they rise to the front of overlapping objects smoothly through the use of dissolve. Anticipating motion with a small contrary motion and pacing the middle of transitions faster than the endpoints results in smoother and clearer movements. Despite the differences between user interfaces and cartoons—cartoons are frivolous, passive entertainment and user interfaces are serious, interactive tools—cartoon animation has much to lend to user interfaces to realize both affective and cognitive benefits.

Keywords: Animation, User Interfaces, Cartoons, Motion Blur, Self

* This work was originally supported by Sun Microsystems Laboratories, an NSF Graduate Fellowship, National Science Foundation Presidential Young Investigator Grant #CCR-8657631, IBM Powell Foundation, Apple Computer, Inc., Cray Laboratories, Tandem, NCR Corporation, Texas Instruments, Inc., and Digital Equipment Corporation.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
bay@self.stanford.edu
david.ungar@eng.sun.com

Fiscal 1994 Project Portfolio Report

This report summarizes the significant accomplishments of SML for the fiscal year ending June 30, 1994.

SML TR-94-34

Sun Microsystems Laboratories
M/S UMTV29-01
2550 Garcia Avenue
Mountain View, California 94043

Adaptive Optimization for Self: Reconciling High Performance with Exploratory Programming

A dissertation submitted to the Stanford University Department of Computer Science and the Committee on Graduate Studies in Partial Fulfillment of the requirements for the degree of Doctor of Philosophy.

Urs Hölzle

SMLI TR-95-35 March 1995

Sun Microsystems Laboratories

M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
urs@cs.ucsb.edu

PSL: Protocols and Pragmatics for Open Systems

Doug Lea
Jos Marlowe

SMLI TR-95-36 May 1995

Abstract:

Protocol Specification Language (PSL) is a framework for describing dynamic and architectural properties of component-centered open systems. PSL extends established interface-based tactics for describing the functional properties of open systems to the realm of protocol description. PSL specifications consist of logical and temporal rules relating *situations*, each of which describes potential states with respect to the *roles* of components, role attributes, and the issuance and reception of events. A specialized form, PSL/IDL supports design methods and engineering tools for describing protocols in CORBA systems.

Sun Microsystems Laboratories

M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
dl@g.oswego.edu
jos.marlowe@eng.sun.com

The OPENET Architecture

Israel Cidon
Tony Hsiao
Asad Khamisy
Abhay Parekh
Raphael Rom
Moshe Sidi

SMLI TR-95-37 December 1995

Abstract:

ATM networks will soon be moving from the experimental stage of test-beds to a commercial state where production networks are deployed and operated. The progress of ATM networks appears to be at risk due to the lack of a universal, open, and efficient ATM network control platform. The emerging Private Network to Network Interface (PNNI) standard introduces a control platform that can be used as an internetwork and possibly as an intra-network solution. However, the current PNNI still falls short in providing an acceptable universal solution, due to lack of performance optimizations for intra-network operation, limited functionality, and the lack of open interfaces for future functional extensions and services.

OPENET is a common portable, open, and high-performance network control platform based on performance and functional enhancements to the PNNI standard. It is vendor-independent, scalable (in terms of network size and volume of calls), high-performance (in terms of call processing latency and throughput), and extensible (in terms of integrating customer-specific and value-added services). OPENET is designed as an extension to current PNNI so it can serve as a next generation PNNI. It is compatible with PNNI in the internetworking environment allowing large networks to be partitioned according to natural topological or organizational boundaries rather than the artificial use of internetwork interfaces at vendor boundaries.

This report describes the OPENET architecture. The major novelties of the OPENET architecture compared to the current PNNI are: the use of native ATM switching for the dissemination of utilization updates; lightweight call setup; take down and modification signaling; a new signaling paradigm that better supports fast reservation and multicast services; and a rich signaling infrastructure that enables the development of augmented services (such as mobility, directory, etc.), leveraging the existing functions of the network control platform.

Sun Microsystems Laboratories

M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
raphael.rom@eng.sun.com

Improving the Address Translation Performance of Widely Shared Pages

Yousef A. Khalidi
Madhusudhan Talluri

SMLI TR-95-38 February 1995

Abstract:

Operating systems allow multiple processes to share physical objects, e.g., shared libraries, System V shared memory. Many UNIX® implementations allow processes to use different virtual addresses known as aliases to map a shared physical page. Each alias traditionally requires separate page table and translation lookaside buffer (TLB) entries that contain identical translation information. In systems with many aliases, this results in significant memory demand for storing page tables and unnecessary TLB misses on context switches.

This paper first describes a *common-mask* scheme that allows translations from many different virtual address spaces to the same physical address to share a *single* translation entry. It extends the process context id with a bit vector that identifies a set of *common regions* that a process shares with other processes. It requires aliases to use the same virtual address, but aliases with different virtual addresses are still supported in the conventional manner. We then study in detail the implementation and performance effects of applying the common-mask scheme to each level of the translation hierarchy: hardware fully-asociative and set-associative TLBs, memory-based set-associative software level-two TLBs, and finally hashed page tables.

TLB performance improves as processes incur fewer TLB misses on context switches by sharing TLB entries for shared pages. On a set of multi-user benchmarks, we show that the common-mask scheme reduces the number of user TLB misses by up to 50% in a 256-entry fully-associative TLB and a 4096-entry level-two TLB. The memory used to store hashed page tables is dramatically reduced by requiring a single page table entry instead of separate page table entries for hundreds of aliases to a physical page. Common-mask hashed page tables use 97% less memory for an Oracle® Financials database server workload.

The scheme we propose is quite general and applicable in domains other than address translation where multiple keys map to the same data, e.g., virtually-tagged caches, associative processors, and relational databases.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
yousef.khalidi@eng.sun.com
madhusudhan.talluri@eng.sun.com

An Efficient Zero-Copy I/O Framework for UNIX®

Moti N. Thadani
Yousef A. Khalidi

SMLI TR-95-39 May 1995

Abstract:

Traditional UNIX® I/O interfaces are based on *copy semantics*, where read and write calls transfer data between the kernel and user-defined buffers. Although simple, copy semantics limit the ability of the operating system to efficiently implement data transfer operations. In this paper, we present extensions on the traditional UNIX interfaces that are based on *explicit buffer exchange*. Instead of transferring *data* between user-defined buffers and the kernel, the new extensions transfer data *buffers* between the user and the kernel. We study using the new interfaces in typical application programs, and compare their use to the standard UNIX interfaces. The new interfaces lend themselves to an efficient zero-copy data transfer implementation. We describe such an implementation in this paper, and we examine its performance. The implementation, done in the context of the Solaris™ operating system, is very efficient: for example, on a typical file transfer benchmark, the network throughput was improved by more than 40% and the CPU utilization reduced by more than 20%.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
moti.thadani@eng.sun.com
yousef.khalidi@eng.sun.com

MediaFlow, a Framework for Distributed Integrated Media*

Conal Elliott
Greg Schechter
Salim AbiEzzi

SMLI TR-95-40 June 1995

Abstract:

We use the term *integrated media* to encompass both modeled media, and recorded and live natural media. We believe that an integrated media framework is important because natural and modeled media are complementary and are most useful when integrated. Natural media has the property of vividness (since nature is so rich), while modeled has the property of compactness and malleability (since computers are so flexible). While existing multimedia systems have little, if any, support for modeled media, omitting them is abandoning what computers do best, namely computing, mixing, and enhancing.

MediaFlow supports modeled and natural media and the spectrum in between. It is based on the concepts of high-level data types and of omni-grain continuous dataflow. (By "continuous," we simply mean that time is indefinitely refinable.) We treat visual, audible, and gestural flows uniformly. The result is a design that provides uniformity, minimality, and orthogonality and hence, the ease of programming integrated media applications.

* The work described in this paper was done by three former employees of SunSoft™, and is being printed as a courtesy by Sun Microsystems Laboratories to document the work accomplished by this team.

Sun Microsystems Laboratories

M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

A Collection of Papers from FirstPerson, Inc.*

Jeff Johnson
Mark Keavney

SMLI TR-95-41 August 1995

Abstract:

The papers included in this collection are the results of work conducted at the prior FirstPerson, Inc., the group which later produced the interactive browser, HotJava.

The five papers report on experiments conducted:

1) to determine which of several candidate user interfaces for panning is most usable and intuitive;

2) to determine the smallest touchpad that subjects could accurately use to point to objects on a TV-sized video display;

3) to determine the effects of various factors on users' ability to hit an animated character (a sprite) moving across the TV screen, using a touchpad separate from the display;

4) to determine how accurately subjects could use a touch-sensitive remote control to hit targets on a TV screen; and

5) to determine which of several candidate pointing devices is most usable for controlling interactive TV applications.

Because FirstPerson, Inc. is no longer an active business unit, and because of its close association with the Labs, this collection was printed as a courtesy by Sun Microsystems Laboratories to document the results of these experiments.

* FirstPerson, Inc. existed from 1993 to 1994.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
jeff.johnson@eng.sun.com

Caching Processor General Registers

Robert Yung
Neil C. Wilhelm

SMLI TR-95-42 June 1995

Abstract:

VLIW, multi-context, or windowed-register architectures may require one hundred or more processor registers. It can be difficult to design a register file with so many registers that meets processor cycle time requirements. We propose to resolve this problem by taking advantage of register values that are bypassed within a processor's pipeline, and supplementing the bypassed values with values supplied by a small *register cache*. If the register cache is sufficiently small, then it can be designed to meet a fast target cycle time. We call this combination of bypassing and register caching the Register Scoreboard and Cache. We develop a simple performance model and show by simulations that it can be effective for windowed-register architectures.

Sun Microsystems Laboratories

M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
robert.yung@eng.sun.com
neil.wilhelm@eng.sun.com

Clarity MCode: A Retargetable Intermediate Representation for Compilation

Brian T. Lewis
L. Peter Deutsch
Theodore C. Goldstein

SMLI TR-95-43 May 1995

Abstract:

The Clarity C++ programming language is a dialect of C++ being developed in Sun Microsystems Laboratories to support the development of reliable systems and application software, and especially distributed software. We have developed a high-level, machine-independent intermediate representation to compile Clarity that we call MCode (for “middle code”). We use MCode to compile Clarity programs at program runtime (i.e., on-the-fly) into SPARC® code for the Solaris™ operating system. The runtime code generator produces good quality machine code and is designed to be easily retargetable to new machines. We also support an interpreter for MCode that supports full interoperation with C code and existing C libraries. The choice of whether to compile or interpret MCode is done at runtime on a procedure-by-procedure basis. MCode is significantly more compact than native machine code. This fact, plus our ability to selectively interpret seldom-executed code instead of compiling it, means that MCode programs have a smaller working set and run better with less memory than the corresponding native machine code programs. In order to support systems programming, we store MCode in platform-standard object files. This enables MCode programs to fully interoperate with existing C libraries and code. It also allows programmers to use standard linkers and other program development tools with MCode object files.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
brian.lewis@eng.sun.com
lpd@aladdin.com
ted.goldstein@eng.sun.com

Why Wire Delays Will No Longer Scale for VLSI Chips

Neil C. Wilhelm

SMLI TR-95-44 August 1995

Abstract:

Past scaling of VLSI circuits has resulted in wire delays that scale as the square of the scale factor. This has occurred because wires have been much wider than they are thick: their aspect ratio has been (much) greater than one. For today's and future VLSI processes, the aspect ratio of wires will be very near to one, and scaling will no longer produce dramatic decreases in wire delays. Long wires will gain the least from future scaling suggesting that, more than ever, high-speed system designs will have to avoid long-distance communications.

Sun Microsystems Laboratories

M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
neil.wilhelm@eng.sun.com

The Miller and Anti-Miller Effects

Neil C. Wilhelm

SMLI TR-95-45 August 1995

Abstract:

The Miller effect, as it applies to VLSI wiring, is well-known: some combinations of signal values may experience apparent wire capacitances that are much larger than the static capacitances. Less well-known is the "anti-Miller" effect: that some combinations of signal values may experience apparent wire capacitances that are much lower than the static capacitances. The consequence of the Miller and anti-Miller effects is a spread in wiring delays from maximum to minimum that may be three-to-one or more. The spread in wire delays can play havoc with circuits and design practices that depend on wires having near-constant delays.

Sun Microsystems Laboratories

M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
neil.wilhelm@eng.sun.com

Simple Activation for Distributed Objects

Ann Wollrath
Geoff Wyant
Jim Waldo

SMLI TR-95-46 November 1995

Abstract:

In order to support long-lived distributed objects, object activation is required. Activation allows an object to alternate between periods of activity, where the object implementation executes in a process; and periods of dormancy, where the object is on disk and utilizes no system resources.

We describe an activation protocol for distributed object systems. The protocol features overall simplicity as well as applicability to several different activation models. We use the Modula-3 network object system as a base for our implementation; while we make no changes to the underlying network object subsystem, we suggest a minor modification that could be made to the marshalling of network objects to assist in lazy activation, our preferred activation model.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
ann.wollrath@east.sun.com
geoff.wyant@east.sun.com
jim.waldo@east.sun.com

Events in an RPC Based Distributed System

Jim Waldo
Ann Wollrath
Geoff Wyant
Samuel C. Kendall

SMLI TR-95-47 November 1995

Abstract:

In this report, we show how to build a distributed system allowing objects to register interest in and receive notifications of events in other objects. The system is built on top of a pair of interfaces that are interesting only in their extreme simplicity. We then present a simple and efficient implementation of these interfaces.

Next, we show how more complex functionality can be introduced to the system by adding third-party services. These services can be added without changing the simple interfaces, and without changing the objects in the system that do not need the functionality of those services.

Finally, we note a number of open issues that remain, and attempt to draw some conclusions based on the work.

Sun Microsystems Laboratories, Inc.
A Sun Microsystems, Inc. Business
M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
jim.waldo@east.sun.com
ann.wollrath@east.sun.com
geoff.wyant@east.sun.com

Solaris MC: A Multi-Computer OS

Yousef A. Khalidi
Jose M. Bernabeu
Vlada Matena
Ken Shirriff
Moti Thadani

SMLI TR-95-48 November 1995

Abstract:

Solaris MC is a prototype distributed operating system for multi-computers (i.e., clusters of nodes) that provides a single-system image: a cluster appears to the user and applications as a single computer running the Solaris™ operating system. Solaris MC is built as a set of extensions to the base Solaris UNIX® system and provides the same ABI/API as Solaris, running unmodified applications. The components of Solaris MC are implemented in C++ through a CORBA-compliant object-oriented system with all new services defined by the IDL definition language. Objects communicate through a runtime system that borrows from Solaris doors and Spring subcontracts. Solaris MC is designed for high availability: if a node fails, the remaining nodes remain operational. Solaris MC has a distributed caching file system with UNIX consistency semantics, based on the Spring virtual memory and file system architecture. Process operations are extended across the cluster, including remote process execution and a global /proc file system. The external network is transparently accessible from any node in the cluster. The prototype is fairly complete—we regularly exercise the system by running multiple copies of an off-the-shelf commercial database system.

Sun Microsystems Laboratories

M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email addresses:
yousef.khalidi@eng.sun.com
josep@iti.upv.es
vlada.matena@eng.sun.com
ken.shirriff@eng.sun.com
moti.thadani@eng.sun.com

The Design Problem SCPP-A

Charles E. Molnar
Huub Schols

SMLI TR-95-49 December 1995

Abstract:

Much design effort toward a Sproull Counterflow Pipeline Processor has been focused on management of movements of Instructions and Results in the pipelines so that every Instruction and Result that pass one another meet and interact in exactly one stage of the pipeline. The full SCPP design problem poses other requirements as well, such as creation and deletion of items flowing in the pipelines, scheduling of execution of instructions only in stages with the required hardware, and high speed.

Nevertheless, even a simplified version of the design problem that ignores the latter requirements has resisted synthesis using existing formal methods. At a workshop on Asynchronous VLSI Design held in Israel on March 20-22, 1995, Alain Martin of Caltech discussed his synthesis methodology and tools, which he claimed can translate almost any Communicating Sequential Process (CSP) program to a circuit by systematic procedure. Since our essential requirements for movement of Instructions and Results had been expressed by us as a 5-state FSM graph that is easily interpreted as a CSP program, we asked Martin to demonstrate how his method would be applied to this problem.

At the suggestion of the workshop organizer, Dr. Ran Ginosar of the Technion, Dr. Huub Schols presented the challenge to all of the workshop attendees, and produced the careful documentation contained here. Several thoughtful responses to our challenge are cited in the list of references. They lead us to conclude that the problem that we have posed is indeed difficult and worthy of further study and analysis.

Martin has declined to provide us with any information about a solution that he claimed to have found after the workshop.

Sun Microsystems Laboratories

M/S 29-01
2550 Garcia Avenue
Mountain View, CA 94043

email address:
charles.molnar@eng.sun.com

Fiscal 1995 Project Portfolio Report

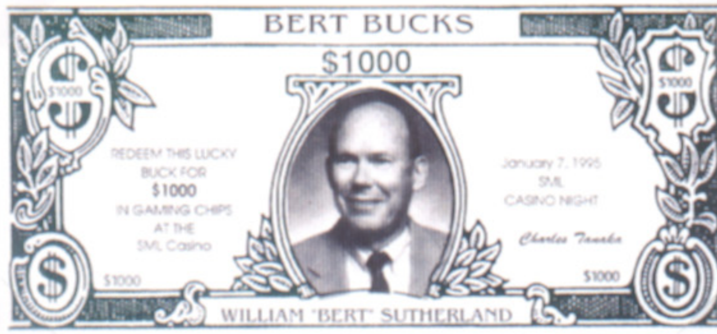
A Summary of Significant Accomplishments

Sun Microsystems Laboratories (SML)
Fiscal year ending June 30, 1995

SMLI TR-95-50

Sun Microsystems Laboratories
M/S UMTV29-01
2550 Garcia Avenue
Mountain View, California 94043

Memoirs



There were
Open Houses,
Picnics,
Holiday Parties,
and the
Great Waterfight
Of '92

Patents Issued

1991-1996

Sun Labs Inventors

Patents Issued 1991

Inventor	U.S. Patent	Date	Title
William N. Joy Serdar Ergene Szucheng Sun James Van Loo	5,043,923	Aug 27, 1991	Apparatus for Rapidly Switching Between Frames to be Presented on a Computer Output Display
Howard L. Davidson	5,053,856	Oct 01, 1991	Apparatus for Providing Electrical Conducts in Compact Arrays of Electronic Circuiting Utilizing Cooling Devices
Howard L. Davidson	5,065,277	Nov 12, 1991	Three Dimensional Packaging Arrangement for Computer Systems and the Like

Sun Labs Inventors

Patents Issued 1992

Inventor	U.S. Patent	Date	Title
Howard L. Davidson	5,079,619	Jan 07, 1992	Apparatus for Cooling Arrays of Electronic Circuitry
Robert Garner William N. Joy	5,083,263	Jan 21, 1992	Risc with Interconnected Ring and Selectively Operating Portion of the Ring as a Conventional Computer
Serder Ergene Susan E. Carrie James Gosling	5,091,717	Feb 25, 1992	Apparatus for Selecting Mode of Output in a Computer System
Edward H. Frank Thomas E. Westburg	5,107,251	Apr 21, 1992	Method and Apparatus for Detecting Cursors
Robert Garner Kwang Gun Tan Donald C. Jackson	5,109,514	Apr 28, 1992	Method and Apparatus for Executing Concurrent Co-Processor Operations and Precisely Handling Related Exceptions
Robert Garner William N. Joy	5,159,680	Oct 27, 1992	Method and Apparatus for Enhancing the Operation of a Reduced Instruction Set Computer

Sun Labs Inventors

Patents Issued 1993

Inventor	U.S. Patent	Date	Title
Howard L. Davidson Satyanarayana Nishtala	5,181,167	Jan 19, 1993	Stacking Heatpipe for Three-Dimensional Electronic Packaging
Ivan Sutherland	5,187,800	Feb 16, 1993	Asynchronous Pipelined Data Processing System
Ehsan Ettehadieh John Schulte Howard L. Davidson	5,216,580	Jun 01, 1993	An Optimized Integral Heat Pipe and Electronic Circuit Module Arrangement
Martin Sodos	5,251,312	Oct 05, 1993	Method and Apparatus for the Prevention of Race Conditions During Dynamic Chaining Operations
Stephen Richardson	5,260,898	Nov 09, 1993	Result Cache for Complex Arithmetic Units
Stephen Richardson	5,262,973	Nov 16, 1993	Method and Apparatus for Optimizing Complex Arithmetic Units for Trivial Operands
Sheueling Chang James Gosling	5,267,054	Nov 30, 1993	Method and Apparatus for the Reduction of Memory Space Required for a Digital Halftone System

Inventor	U.S. Patent	Date	Title
Dave Stewart Robert Sloan Donald C. Jackson Maureen Arios	5,274,779	Dec 28, 1993	Digital Computer Interface for Simulating and Transferring CD-1 Data Including Buffers and a Control Unit for Receiving and Synchronizing Audio Signals and Subcodes

Sun Labs Inventors

Patents Issued 1994

Inventor	U.S. Patent	Date	Title
Graham Hamilton Michael N. Nelson	5,287,507	Feb 15, 1994	Method and Apparatus for Portable Object Handles that Use Local Caches
James B. Mcintyre	5,288,236	Feb 22, 1994	Method and Apparatus for Replacing Electronic Components on a Printed Circuit Board
Graham Hamilton Michael L. Powell John Chapin	5,301,316	Apr 05, 1994	System for Determination of the Equivalance of Two Objects without Compromising then Done by a Third Object Nominated by One and Accepted by the Other
Howard L. Davidson	5,320,098	Jun 14, 1994	Optical Transdermal Link
Luigi A. Pio-di-Savoia Jonathan Gibbons James D. Halpern Roger Hayes	5,357,452	Oct 18, 1994	Automatic Generation of Auto-checking Testing Functions
Luigi A. Pio-di-Savoia Roger Hayes	5,359,546	Oct 25, 1994	Automatic Generation of Test Drivers

Inventor	U.S. Patent	Date	Title
Edmund Kelly Michel Cekleov Michel Dubois	5,361,340	Nov 01, 1994	Apparatus for Maintaining Consistency in a Multiprocessor Computer System Using Virtual Caching
Carolyn Foss Dwight Hare Richard McAlister Tin Nguyen Amy Pearl Sami Shaio	5,367,681	Nov 22, 1994	A Method and Apparatus for Interprocess Message Switching

Sun Labs Inventors

Patents Issued 1995

Inventor	U.S. Patent	Date	Title
Carolyn Foss Dwight Hare Richard McAlister Tin Nguyen Amy Pearl Sami Shaio	5,379,426	Jan 03, 1995	A Method and Apparatus for Object Oriented Interprocess Message Switching
Howard L. Davidson	5,387,259	Feb 07, 1995	Optical Transdermal Linking Method for Transmitting Power and a First Data Stream While Receiving a Second Data Stream
Steve E. Golson John McDonald Edward H. Frank	5,388,200	Feb 07, 1995	Method and Apparatus for Writing Directly to Frame Buffer 1
Robert Yung	5,392,414	Feb 21, 1995	Rapid Data Retrieval from Data Storage Structures Using Prior Access Predictive Annotations
Yousef A. Khalidi Michael N. Nelson	5,396,614	Mar 07, 1995	Method and Apparatus for a Secure Protocol for Virtual Memory Managers that Use Memory Objects

Inventor	U.S. Patent	Date	Title
Carolyn Foss Dwight Hare Richard McAlister Tin Nguyen Amy Pearl Sami Shaio	5,404,534	Apr 04, 1995	A Method and Apparatus for Extensible Inter-Application Link Management
Dave Ditzel Shing Ip Kong Robert Cmelik Edmund Kelly Michael Powell	5,430,864	Jul 04, 1995	Extending Computer Architecture from 32-bits to 64-bits by Using the Most Significant Bit of the Stack Pointer Register to Indicate Word Size
Trevor Burward-Hoy	5,441,102	Aug 15, 1995	Heat Exchanger for Electronic Equipment
Michael Piech Trevor Morris	5,442,744	Aug 15, 1995	Method and Apparatus for Displaying and Editing Multimedia Information
Duane Northcutt David T. Berry	5,442,749	Aug 15, 1995	Network Video Server System
Robert Bosnyak Mark R. Santoro	5,446,686	Aug 29, 1995	Method and Apparatus for Detecting Multiple Address Matches in a Content Addressable Memory
Yousef A. Khalidi Madhusudhan Talluri Dock G. Williams Vikram P. Joshi	5,446,854	Aug 29, 1995	Virtual Memory Computer Apparatus and Address Translation Mechanism Employing Hashing Scheme and Page Frame Descriptor that Support Multiple Page Sizes

Inventor	U.S. Patent	Date	Title
Raphael Rom	5,450,616	Sep 12, 1995	Method and Apparatus for Power Control in a Wireless Local Area Network
Trevor Burward-Hoy	5,452,362	Sep 19, 1995	Method and Apparatus for Cooling with Noise Control
Michael N. Nelson Yousef A. Khalidi	5,452,447	Sep 19, 1995	Method and Apparatus for a Caching File Server
Trevor Burward-Hoy	5,461,766	Oct 31, 1995	Method for Integrally Packaging an Integrated Circuit with a Heat Transfer Apparatus
Ilhun Son	5,469,080	Nov 21, 1995	Low Power, Logic Signal Level Converter
Yousef A. Khalidi Glen R. Anderson Stephen A. Chessin Shing I. Kong Charles E. Narad Madhusudhan Talluri	5,479,627	Dec 26, 1995	Virtual Address to Physical Address Translation Cache that Supports Multiple Page Sizes

Sun Labs Inventors

Patents Issued 1996

Inventor	U.S. Patent	Date	Title
J. Duane Northcutt Gerard A. Wall James G. Hanko	5,506,969	Apr 09, 1996	Method and Apparatus for Bus Bandwidth Management
Raphael Rom	5,515,509	May 07, 1996	Method and Apparatus for Implementing Self Organization in a Wireless Local Area Network
Trevor Burward-Hoy	5,536,685	Jul 16, 1996	Low Heat Loss and Secure Chip Carrier for Cryogenic Cooling
Trevor Burward-Hoy	5,543,622	Aug 06, 1996	Low Heat Loss and Secure Chip Carrier for Cryogenic Cooling
Robert Yung Greg Williams Huoy-Ming Yeh	5,546,554	Aug 13, 1996	Apparatus for Dynamic Register Management in a Floating Point Unit
Robert Yung	5,548,739	Aug 20, 1996	Rapid Data Retrieval From a Physically Addressed Data Storage Structure Using Memory Page Crossing Predictive Annotations

Inventor	U.S. Patent	Date	Title
Yousef A. Khalidi Michael N. Nelson	5,561,799	Oct 01, 1996	Extensible File System Which Layers a New File System with an Old File System to Provide Coherent File Data
Yousef A. Khalidi Graham Hamilton Panagiotis S. Kougiouris	5,566,302	Oct 15, 1996	Method for Executing Operation Call from Client Application Using Shared Memory Region and Establishing Shared Memory Region When the Shared Memory Region Does Not Exist
Charles E. Molnar Ivan E. Sutherland Robert S. Sproull Ian W. Jones	5,572,690	Nov 05, 1996	Cascaded Multistage Counterflow Pipeline Processor for Carrying Distinct Data in Two Opposite Directions

Presentations at Conferences and Meetings Around the World

Staff Presentations at Conferences and Meetings Around the World

1991

Cmelik, Robert F., Shing I. Kong, David R. Ditzel, and Edmund J. Kelly. “An Analysis of MIPS and SPARC Instruction Set Utilization on the SPEC Benchmarks,” ***ASPLOS-IV***, April 8-11, 1991.

1992

Davidson, Howard. “SuperSparc AmCM Development Program,” ***IEEE MCM***, March 1993.

Kempf, James. “Cross-Address Space Dynamic Linking,” ***1992 International Workshop on Object Orientation in Operating Systems (IWOOO ‘92)***.

Khalidi, Yousef A., and Michael N. Nelson. “An Implementation of UNIX on an Object-Oriented Operating System,” ***USENIX Winter 1993***, January 25-29, 1992.

Lewis, Brian. “The Navigator: A Scalable System for Monitoring Distributed Object-Oriented Applications,” position paper for ***2nd Workshop on Objects in Large Distributed Applications***, ***OOPSLA Conference***, Vancouver, Canada, October 18, 1992.

Northcutt, Duane. “System Support for Media Synchronization,” ***Computer Networks***, October 1992.

Northcutt, Duane, and Eugene Kuerner. “System Support for Time Critical Applications,” ***Computer Com.***, October 1992.

Norvig, Peter. “Deftable: A Macro for Implementing Tables,” *Lisp Pointers*, ***ACM SIG Lisp Newsletter***, September 1992.

Pearl, Amy. “System Support for Integrated Desktop Videoconferencing,” ***ACM Conference on Computer Supported Cooperative Work***, November 1992.

Radia, Sanjay. “A Flexible Naming Scheme Supporting Remote Execution,” ***Hawaii Conference***, January 1993.

Smith, Randall B. “Brief Tutorial on Self,” ***Object-World Conference***, San Francisco, July 22, 1992.

Talluri, Madhusudhan, Shing Kong, Mark D. Hill, and David A. Patterson. "Tradeoffs in Supporting Two Page Sizes," ***The 19th International Symposium of Computer Architecture***, Australia, May 1992.

Tang, John. "Study of the Use of Desktop Conferencing Technology to Support a Distributed Team," ***CSCW '92***.

Waldo, Jim. "Blessed Be the Bind that Flies," C++ Advisor Column, ***UNIX Review***, October 1992.

Waldo, Jim. "Run Time Type Identification: The Hydrogen Bomb of C++," ***USENIX C++ Conference***, August 11-14, 1992.

Waldo, Jim. "Global Status," C++ Advisor Column, ***UNIX Review***, August 1992.

1993

Agesen, Ole, Jens Palsberg, and Michael I. Schwartzbach. "Type Inference of Self," ***European Conference on Object-Oriented Programming (ECOOP***), 1993.

Agesen, Ole, Lars Bak, Craig Chambers, Bay-Wei Chang, Urs Hoelzle, John Maloney, Randall B. Smith, David Ungar, and Mario Wolczko. "SELF 3.0 Programmer's Reference Manual."

Chang, Bay-Wei, and David Ungar. "Animation: From Cartoons to the User Interface," ***1993 ACM Symposium on User Interface Software and Technology***.

Davidson, Howard. "Viking SuperSparc: A MCM Development Program, ***IEEE MCM Conference***, Santa Cruz, March 1993.

Davidson, Howard. "Workstation Packaging Trends," ***CHMT***, Phoenix, Arizona, January 29, 1993.

Hamilton, Graham, Michael L. Powell, and James G. Mitchell. "Subcontract: A Flexible Base for distributed Programming," ***SOSP***, December 1993.

Hamilton, Graham and Sanjay Radia. "Types, Versions and Extensibility," **ECOOP**, April 1, 1993.

Hoelzle, Urs. "Integrating Independently-Developed Components in Object-Oriented Languages," ***1993*** **ECOOP**.

Kendall, Samuel C. "Unifying Build-In Operators and User Defined Functions," ***ANSI/ISO C++ Standards Committee***, November 7, 1993.

Kendall, Samuel C. "Expression Attributes," ***ANSI/ISO C++ Standards Committee***, October 12, 1993.

Kendall, Samuel C. “Suggested Changes to Section 3.7, Lvalues,” ***ANSI/ISO C++ Standards Committee***, October 12, 1993.

Kendall, Samuel C. “Type Combinations,” ***ANSI/ISO C++ Standards Committee***, October 12, 1993.

Kendall, Samuel C. “Why Would a Rational Person Vote Against Namespaces?, “ ***ANSI/ISO C++ Standards Committee***, October 12, 1993.

Khalidi, Yousef A., and Michael N. Nelson. “An Implementation of UNIX on an Object-Oriented Operating System,” ***USENIX Winter 1993***, January 25-29, 1992.

Khalidi, Yousef A., “Spring Overview and Status,” presentations at Georgia Tech, DARPA, CMU, HaL, May 1993.

Lynch, William L., Gary Lauterbach, and Joe Petolino. “Low-Latency Cache Indexing: XOR and SAM Caches,” ***International Symposium on Computer Architecture***, October 15, 1993.

Nelson, Michael N., Yousef A. Khalidi, and Peter W. Madany. “Experience Building a File System on a Highly Modular Operating System,” ***SEDMS IU***, September 22, 1993.

Nieh, Jason, James G. Hanko, J. Duane Northcutt, and Gerard A. Wall. “SVR4UNIX Scheduler Unacceptable for Multimedia Applications,” ***NOSSDAV Workshop***, November 30, 1993.

Radia, Sanjay. “The Spring Operating System: An Overview and Status,” talk at Carnegie Mellon (CMU), May 25, 1993.

Radia, Sanjay. “A Flexible Naming Scheme Supporting Remote Execution,” ***26th Hawaii International Conference on System Sciences***, January 1993.

Reichlen, Bruce. “Emulating a Large Display Environment,” ***Virtual Reality Annual International Symposium*** **(VRAIS 1993)**.

Sankar, Sriram, and Roger Hayes. “ADL: An Interface Definition Language for Specifying and Testing Software,” ACM SigPlan, ***Workshop on Interface Definition Languages***, Portland, January 20, 1993.

Sun, Ron, and Lawrence Bookman. “How do Symbols and Networks Fit Together: A Report from the AAAI Workshop on Integrating Neural and Symbolic Processes,” ***AI Magazine***, 1993.

Ungar, David. “Self: Interacting with Objects,” Bell Labs, Holmdel, and Bell Labs, Murray Hill, October, 1993.

Waldo, Jim. “Hold Everything,” ***UNIX Review***, August 1993.

Waldo, Jim. “Don’t Overload Dereferences,” ***UNIX Review***, June 1993.

Wolczko, Mario. “Self Demo,” University of Manchester, U.K., December 21, 1993.

Wolczko, Mario. “Hardware Support for Object-Oriented systems,” ***OOPSLA ‘93*** Tutorial, Washington, D.C., September 26, 1993.

1994

Agesen, Ole. “Constraint-Based Type Inference and Parametric Polymorphism,” ***International Static Analysis Symposium***, September 28-30, 1994.

Bak, Lars. “The Self Project at SMLI,” ***CCI Europe***, Aarhus, Denmark, March 9, 1994.

Bak, Lars. “The Self Language and its Implementation,” Aarhus University, Denmark, March 11, 1994.

Hoelzle, Urs, and David Ungar. “Object-oriented Languages Don’t Need Special Architectural Support,” ***1994 ACM Conference on Architectural Support for Operating Systems and Programming Languages (ASPLOS)***.

Hoelzle, Urs, and David Ungar. “Optimizing dynamically-Dispatched Calls with Run-Time Type Feedback,” ***1994 SIGPLAN Conference on Programming Language Design and Implementation***.

Hoelzle, Urs, and David Ungar. “Third-Generation Self Implementation: Reconciling Responsiveness with Performance,” ***ACM OOPSLA Conference***, October 1994.

Jones, Peter C. “Xvan: A True Multiple Screen X Server,” *Proceedings of* ***8th Annual Technical Conference on the X Window System***, ***X Consordium Annual Conference***, January 24, 1994.

Kendall, Samual C., and Geoff Wyant. “Programming in Modula-3,” ***OOPSLA ‘94***, October 1994.

Kendall, Samuel C. “Summary of Revised Clause 4 [conv]: standard Conversions,” ***ANSI C++ Committee***, June 30, 1994.

Kendall, Samuel C., “A Note on Conversion Sequences,” ***ANSI C++ Committee***, June 30, 1994.

Kendall, Samuel C.,“Type Combinations, Revision 2,” ***ANSI C++ Committee***, May 31, 1994.

Kendall, Samuel C.,“Binding and Combination in C++ Program Databases,” ***USENIX C++***, April 11-14, 1994.

Kendall, Samuel C., and Glenn Allin. “Sharing Between Translation Units in C++ Program Databases,” ***USENIX C++ Technical Conference***, April 11, 1994.

Marlowe, Jos, and Doug Lea. “PSL: Protocols and Pragmatics for Open Systems,” (SUNY at Oswego/NY CASE Center), October 21, 1994.

Martin, Paul, and Andrew Kehler. “SpeechAct: A Testbed for Continuous Speech Applications,” ***Association for Computational Linguistics***, June 1994.

Nelson, Michael N., and Sanjay R. Radia. “A Uniform Name Service for Spring’s UNIX Environment,” ***USENIX***, January 1994.

Ousterhout, John. “Tcl: a Universal Scripting Language,” ***USENIX Symposium on Very High Level Languages***, October 26, 1994.

Resnik, Philip. “Selection without Features,” ***ACL Conference***, Summer 1994.

Smith, Randall B., and David Ungar. “Prototype-Based Languages: Object Lessons from Class-Free Programming, ***OOPSLA-94***, October 1994.

Smith, Randall B., and David Ungar. “Self: Pure, Plastic Programming with,” ***Xerox PARC Forum***, Palo Alto, March 24, 1994.

Sutherland, Ivan E. “Circuit Design for Asynchronous Systems,” ***Sun Annual Conference***, U.K., September 8-14, 1994.

Ungar, David. “Self: A Plastic Medium for Programming,” ***ICSI***, U.C. Berkeley, January 1994.

Van De Vanter, Michael L. “Practical Language-Based Editing for Software Engineers,” ***Workshop on Joint Issues in Software Engineering and Human-Computer Interaction***, September 15, 1994.

Waldo, Jim, Ann Wollrath, Geoff Wyant, and Samual C. Kendall. “Events in an RPC Based Distributed System,” ***USENIX Conference and Proceedings***, Winter 1994.

Waldo, Jim. “R.I.P.,” ***UNIX Review***, August 1994.

Waldo, Jim. “1994 Usenix C++ Advanced Topics Workshop Highlights,” ***USENIX Conference***.

Wolczko, Mario, and John Maloney. “Programming in SELF: The Language and Its Environment,” ***OOPSLA ‘94***, October 23, 1994.

Wolczko, Mario. “Self: The Next Generation,” ***OOPSLA***, October 23, 1994.

Wolczko, Mario. “SELF: The Next Generation (Demo),” ***European Smalltalk Users’ Group***, Summer School, Cork, Ireland, September 8, 1994.

Wolczko, Mario. “SELF: the Language and Its Environment,” ***European Smalltalk Users’ Group***, September 5-9, 1994.

Wyant, Geoff. "Position Paper on 'Experiences with CORBA,'" ***OOPSLA '94 Workshop***, October 1994.

Yankelovich, Nicole, Gina-Anne Levow, and Matt Marx. "Designing SpeechActs: Issues in Speech User Interfaces," October 31, 1994.

Yankelovich, Nicole, and Eric Baatz. "SpeechActs: A Framework for Building Speech Applications," ***Proceedings of AVIOS '94***, San Jose, CA, September 20-22, 1994.

Yankelovich, Nicole. "Talking vs. Taking: Speech Access to Remove Computers," ***ACM SIGCHI, CHI '94 Conference***, Boston, MA, April 24-28, 1994.

Yankelovich, Nicole. "Speech Applications Group: A Retrospective (1994-1997)."

1995

Chaddha, Navin, and Gerald A. Wall. "An End-to-End Software Only Scalable Video Delivery System," ***IEEE-ACM Workshop on Network and Operating System Support for Digital Audio and Video***, March 1995.

Chang, Bay-Wei, David Ungar, and Randall Smith. "Getting Close to Objects: Object Focused Programming Environments," ***Visual Object Oriented Programming***, M. Burnett, A. Goldberg, T. Lewis, eds., Prentice-Hall, 1995.

Jordan, Mick, and Michael Van de Vanter. "Configuration Management in an Object-Oriented Database, ***USENIX COOTS***, June 1995.

Levy, Jacob, and John Ousterhout. "Safe Tcl: A Toolbox for Constructing Electronic Markets," ***USENIX Electronic Commerce '95***, July 11, 1995.

Molnar, Charles E. "The Design Problem SCPP-A," ***Workshop on Asynchonous VLSI***, March 20-22, 1995.

Ousterhout, John. "Scripts and Agents: The New Software High Ground," Talk at ***Xerox PARC***, January 12, 1995; invited talk at ***USENIX***, January 19, 1995.

Resnik, Philip. "Using Information Content to Evaluate Semantic Similarity in a Taxonomy," ***International Joint Conference on Artificial Intelligence***, August 1995.

Resnik, Philip. "Disambiguating Noun Groupings with Respect to WordNet Senses," ***Third Workshop on Very Large Corporations***, MIT, June 30, 1995.

Sankar, Sriram, and Mark Hefner. "Formal Methods Applied to Conformance Testing," ***ICSE-17 Workshop on Formal Methods Application in Software Engineering Practice***, April 24-25, 1995.

Smith, Randall B., and John Maloney. “Directness and Liveness in the Morphis User Interface Construction Environment,” ***UIST ‘95***, November 1995.

Smith, Randall, John Maloney, and David Ungar. “The Self-4.0 User Interface,” ***OOPSLA ‘95***, Austin, Texas, October 1995.

Ungar, David. “Annotating Objects for Transport to Other Worlds,” ***OOPSLA ‘95***, October 1995.

Uhler, Stephen. “A Graphical User Interface Building for Tk,” ***USENIX Tcl/Tk Workshop***, July 1995.

Waldo, Jim. “Hello, I Must Be Going,” ***UNIX Review***, October 1995.

Waldo, Jim. “Trees and Sets,” ***UNIX Review***, September 1995.

Woods, William A. “Content-Based Information Access Using Structured Conceptual Taxonomies,” Panel presentation at the ***4th annual World Wide Web Conference***, Boston, MA, December 1995.

Yankelovich, Nicole, et al. “SpeechActs: A Conversational Speech System (Videotape), ACM ***Multimedia ‘95***, November 1995.

Yung, Robert. “Instruction Level Parallelism,” ***HICSS-28 Conference (IEEE)***, January 3-6, 1995.

1996

Adams, Gary. “Normalizing Multi-Indexed Search Results,” ***W3C Distributed Indexing/Searching Workshop***. April 16, 1996.

Adams, Gary, and W. A. Woods. “Integrating Heterogeneous Search Engines,” ***W3C Distributed Indexing/Searching Workshop***, April 16, 1996.

Agesen, Ole. “Design and Implementation of Pep, a Java Just-In-Time Translator,” October 1996.

Crabbe, Fredrick, Paul Martin, Stuart Adams, Eric Baatz, and Nicole Yankelovich. “SpeechActs: A Spoken Language Framework, ***IEEE Computer***, March 15, 1996.

Doong, Roongko, and Sriram Sankar. “Specification Based Coverage Criteria for ADL,” ***ACM SIGSOFT International Symposium on Software Testing and Analysis***, 1996.

Jordan, Mick, and Michael L. Van de Vanter. “Applications Supported by an Orthogonally Persistent Java System,” ***OOPSLA ‘96*** Demo, October 6-10, 1996.

Hunt, Andrew. “Java Speech: Talking with Java,” White Paper, August 1996.

Levy, Jacob. “A Tk Netscape Plugin Module,” Tcl/Tk 1996 Workshop, ***USENIX***.

Lewis, Brian T. “An On-the-fly Bytecode Compiler for Tcl,” ***4th Annual Tcl/Tk Workshop 1996 USENIX***, July 10-13, 1996.

Molnar, Charles. “ASP* Counterflow Pipeline with Mutual Exclusion,” ***Async Workshop***, October 2-6, 1996.

Molnar, Charles, Bob Sproull, and Ian Jones. “Three SML Memos for Workshop Discussion,” ***International Workshop/Seminar on Asynchronous Systems*** sponsored by SunLabs, Boston, Ma., October 2, 1996.

Ousterhout, John. “Why Threads are a Bad Idea,” Invited talk at 1996 ***USENIX*** Conference.

Riggs, Roger, Jim Waldo, Ann Wollrath, and Krishna Bharat. “Pickling State in the Java System,” ***2nd Conference on Object-Oriented Technologies and Systems,*** May 1996.

Sankar, Sriram. “Introducing Formal Methods to Software Engineers Through OMG’s CORBA Environment and Interface Definition Language,” ***Algebraic Modeling and Specification Techniques,*** July 1-5, 1996.

Smith, Randall B., and David Ungar. “A Simple and Unifying Approach to Subjective Objects,” ***Theory and Practice of Object Systems***, Vol 2(3) 1996.

Sproull, Bob. “Debugging I-nets,” ***Async Workshop/Seminars*** in Boston and Andover, October 2-6, 1996.

Sutherland, Ivan, and Robert Sproull, “Virtual Reality Before It Had that Name,” ***Bay Area Computer History Perspectives***, March 19, 1996.

Thadani, Moti, and Yousef Khalidi. “An Efficient Zero-Copy I/O Framework for UNIX,” ***USENIX 1996 Technical Conference; Australian UNIX Users Group Summer Technical Conference***, February 20, 1996.

Van De Vanter, Michael L. “Whitespace Behavior in the Code Processor: an Advanced, User-Friendly Editor for Programs,” ***CHI ‘96***, April 1996.

Waldo, Jim. “An Introduction to Java,” ***UNIX Review***, January 1996.

Waldo, Jim., “Web Programming with Java,” ***UNIX Review***, January 1996.

Wollrath, Ann, Roger Riggs, and Jim Waldo. “A Distributed Object Model for the JavaTM(tm) System,” ***2nd Conference on Object-Oriented Technology (COOTS)***, June 17, 1996.

Yankelovich, Nicole. “Using Natural Dialogs as the Basis for SUI Design,” ***Using Natural Dialogs as the Basis for Speech Interface Design,*** MIT Press, September 1996.

Yankelovich, Nicole. ”How Do Users Know What to Say?” ***Interactions***, August 15, 1998.

Yankelovich, Nicole. “The Use of Natural Dialogs as the Basis for SUI Design,” Workshop, April 1996.

Yankelovich, Nicole. “Internet Appreciation Day,” (Web pages), March 15, 1996.

Yankelovich, Nicole. “Office Monitor,” ***CHI ‘96 Conference Companion***, January 15, 1996.

"The Future as
Envisioned by SunLabs"

As featured on

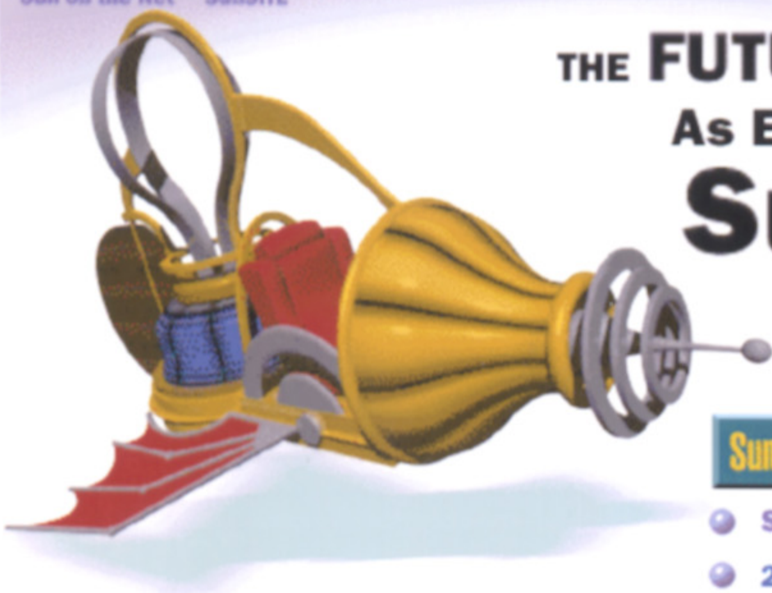
www.sun.com

February 1996

sun microsystems

February 1996

Sun on the Net | SunSITE | Back Issues | Search



THE FUTURE As Envisioned by SunLabs.

Take a trip on our Time Machine.

SunWorld Online

What's New...

- SunExpress on the WWW.
- 24 Hours in Cyberspace.
- Volunteer for NetDay.

Products & Solutions | **Sales & Service** | **Technology & Developers** | **Corporate Overview**

Questions or comments? webmaster@sun.com

Sun Microsystems Laboratories

The Future as Envisioned by SunLabs.

What's on the horizon at Sun for the next three to five years?

While many Sun employees are working on future products and new ways of doing things, the lucky people who get to spend ALL their time thinking about the future are in Sun Microsystems Laboratories, more commonly known as SunLabs.

Founded in 1990, SunLabs is one of the ways Sun invests in the future. The 100 or so employees at SunLabs--located both in Mountain View, California and Chelmsford, Massachusetts--develop, demonstrate and introduce new, advanced technologies and methodologies. Each project starts with a staff of five to 10 people, and grows if it becomes successful. At any given moment, about 12 or 15 projects may be underway. In addition, SunLabs looks into ideas that are outside the company's mainstream. Sometimes, new business opportunities can spring from these ideas. SunLabs also serves as a recruiting magnet for key technologists.

With a staff of 100 people, SunLabs is less than one percent of the company. As Dr. W.R. "Bert" Sutherland, Director of Sun Microsystems Laboratories, says, "That means that the other 99 percent do all the real work in the company--they make the products, they do all the internal administration, they sell the products, they bring in the revenue." SunLabs may originate the idea for a product, but depends on Sun's other business units to turn those ideas into products that are ready for the marketplace.

The last thing you want in a product development project is a nasty technical surprise, something that wasn't understood. But at SunLabs, surprises and mistakes are just another way of learning. "One of our functions is to make the company's mistakes early while they're still cheap," says Sutherland. "We accept that a certain number of our projects will fail."

SunLabs also stays in contact with colleagues in the outside world, importing ideas and technology into the company, then helping the company digest those ideas. Teaching and research have always been coupled, so the Lab influences Sun's future business direction by educating the company about technical possibilities. The Lab does not undertake any basic research such as transistor invention. Instead, it is very focused on practical applications. Some notable successes have come out of SunLabs, for example, the Green Project. It evolved into the First Person organization, which turned it into a very successful product--the Java interactive programming language for the Internet. FirstPerson became the foundation of both Sun's Java organization and the Interactive Services Group, which provides the media servers for Sun. The Netra Internet Server is another example of a product that began at SunLabs, was taken over by other groups within Sun, and eventually debuted as a successful product. This is the model SunLabs strives toward: originating ideas that can be further developed elsewhere within Sun.

SunLabs’ Leadership

Bert Sutherland, Director and VP, SMI
Ivan Sutherland, Fellow and VP, SMI
Bob Sproull, Fellow and VP, SMI

Distinguished Engineers

Duane Northcutt
John Ousterhout
Guy Steele
Neil Wilhelm
Bill Woods

W. R. "Bert" Sutherland

Director, SunLabs, and Vice President, SMI

Interview with Bert Sutherland

Dr. Sutherland is VP of Sun Microsystems, Inc. (SMI), and Director of Sun Microsystems Laboratories--Sun’s research center. He joined the Labs at its inception--in September of 1990. He is also currently a director of John Wiley & Sons, Inc., New York, as well as an advisor to Advanced Technology Ventures of Boston and Menlo Park. Before joining Sun, he was VP of Sutherland, Sproull, and Associates, an information and technology consulting firm. Previously, at the Xerox Palo Alto Research Center (PARC), where he was Manager of the Systems Science Laboratory, he managed some of the seminal research in desktop computer technology.

Earlier, he was Divisional VP and Director of the Computer Science Division of Bolt, Beranek and Newman, Inc., in Cambridge, MA, and an Associate Group Leader of the Digital Computers Group at the MIT Lincoln Laboratory. Dr. Sutherland received his BEE from Rensselaer Polytechnic Institute, and his MS and PhD from MIT. During his military service in the U.S. Navy, he was awarded the Legion of Merit as a Carrier ASW plane commander.

Ivan E. Sutherland

Fellow and Vice President, SMI

Dr. Sutherland is widely known for his pioneering contributions. His 1963 MIT PhD thesis, Sketchpad, opened the field of computer graphics. His 1966 work, with Bob Sproull, on a head-mounted display, anticipated today’s virtual reality by 25 years. He is co-founder of Evans and Sutherland, which manufactures the most advanced computer image generators now in use. As head of the Computer Science Department at Caltech he helped make integrated circuit design an acceptable field of academic study. Dr. Sutherland is on the Boards of several small companies and is a member of the National Academy of Engineering and the National Academy of Sciences, the ACM and IEEE. He was Co-chair, along with Fred Brooks, of the NRC's High Performance Computing and Communications Initiative. He received the Turing Award in 1988 and the Systems Software award in 1993.

Robert F. Sproull

Fellow and Vice President, SMI

Robert F. Sproull is presently Vice President and Fellow at Sun Microsystems Laboratories. He leads a section of the Laboratory in Chelmsford, Mass. that focuses on improving users' coupling to computers and information. Since undergraduate days, he has been building hardware and software for computer graphics: early clipping hardware, an early device-independent graphics package, page description languages, laser printing software, and window systems. He has also been involved in VLSI design, especially of asynchronous circuits and systems. Prior to joining Sun, he was a principal with Sutherland, Sproull and Associates, an associate professor at Carnegie Mellon University and a member of the Xerox Palo Alto Research Center. He is a coauthor with William Newman of the early text, "Principles of Interactive Computer Graphics."

Distinguished Engineers:

Duane Northcutt

Distinguished Engineer Interactive Services Technologies

Duane Northcutt has been an active researcher in the area of real-time and distributed systems since 1977, and for the past six years has been working on providing network and operating system support for digital audio and video. Duane is the principal investigator on a set of research projects that are developing fundamental enabling technologies for the integration of time-critical media into the distributed workstation environment. Previously, he worked on system-level support for multimedia applications as a Senior Research Engineer at the Olivetti Research Center. Prior to this, Northcutt was a member of the research faculty at Carnegie Mellon University's School of Computer Science where he lead a large-scale research project that developed the Alpha real-time operating system and multiprocessor testbed.

Dr. Northcutt received the degrees of PhD and MSEE (Electrical and Computer Engineering) from Carnegie-Mellon University 1986 and 1979, respectively, and a BSEE degree from Auburn University in 1978. He is the author of a book on mechanisms for real-time distributed operating systems, and over two dozen articles and technical reports on time-critical computing, distributed systems, and multimedia.

John Ousterhout

Distinguished Engineer Manager of TCL/Tk Group

John Ousterhout is a Distinguished Engineer at Sun Microsystems Laboratories. Before joining Sun he was a Professor in the Department of Electrical Engineering and Computer Sciences at the University of California at Berkeley. His interests include scripting languages, user interfaces, operating systems, and distributed systems. He is the author of the Tcl scripting language and the Tk toolkit. In the past, he led the development of Sprite, a network operating system for high-performance workstations, and several widely-used programs for computer-aided design, including Magic, Caesar, and Crystal. Ousterhout is a Fellow of the ACM and has received many awards, including the ACM Grace Murray Hopper Award, the National Science Foundation Presidential Young Investigator Award, and the UCB Distinguished Teaching Award. He received a B.S. degree in Physics from Yale University in 1975 and a Ph.D. in Computer Science from Carnegie Mellon University in 1980.

Guy Steele

Distinguished Engineer

Guy L. Steele Jr. is a Distinguished Engineer at Sun Microsystems Laboratories in Chelmsford, Massachusetts, and is responsible for research in programming languages, parallel algorithms, implementation strategies, and architectural and software support. He is currently working with James Gosling and Bill Joy on the detailed specification of the Java programming language. Steele has published more than two dozen papers on the subject of the Lisp language and Lisp implementation, including a series with Gerald Jay Sussman that defined the Scheme dialect of Lisp. He is an ACM Fellow and a Fellow of the AAAI, and was awarded the ACM Grace Murray Hopper Award in 1988 as well as a Gordon Bell Prize in 1990. He designed the original EMACS command set and was the first person to port TeX. Prior to joining Sun, he was a senior scientist at Thinking Machines Corporation, a member of technical staff at Tartan Laboratories, and an assistant professor at Carnegie-Mellon University. He is co-author of three books on programming languages: "Common Lisp: The Language," "C: A Reference Manual," and "The High Performance Fortran Handbook."

Neil Wilhelm

Distinguished Engineer

Neil C. Wilhelm received his BS degree in Engineering from Harvey Mudd College, and his MS and PhD degrees in Electrical Engineering from Stanford University. He has taught electrical engineering and computer science, and he has designed and built instruction sets, processors, computer systems, and CAD tools. His current interests are server systems, fast I/O, and binary translation.

Bill Woods

Distinguished Engineer Conceptual Indexing

Dr. William A. Woods is well known for his research in natural language processing, continuous speech understanding, and knowledge representation. He is currently a Principal Scientist at Sun Microsystems Laboratories in Chelmsford, where he is working on technology to improve people's ability to find information online. After starting out as an Assistant Professor at Harvard University, where he had earned his doctorate, he worked for Bolt Beranek and Newman Inc. (now BBN Systems and Technologies) when the Arpanet (now Internet) was being invented. At BBN, he built one of the first natural language question answering systems (Lunar) to answer questions about the Apollo 11 moon rocks for the NASA Manned Spacecraft Center. Woods became a Principal Scientist at BBN and was Manager of the Artificial Intelligence Department there. At that time, he was Principal Investigator for BBN's work in natural language processing and for its first project in continuous speech understanding. Subsequently, he was Principal Scientist for Applied Expert Systems, Inc., a Gordon McKay Professor of the Practice of Computer Science at Harvard University, and Principal Technologist at ON Technology Inc. He is a past president of the Association for Computational Linguistics, a Fellow of the American Association for Artificial Intelligence, and a Fellow of the American Association for the Advancement of Science.

Mark & Marc Interviews...

Bert Sutherland

Director of Sun Microsystems Laboratories (SunLabs)

by Mark Holt & Marc Sacoolas

Founded in 1990, SunLabs is the applied research and advanced development laboratory at Sun Microsystems, Inc. This interview was done on January 16, 1996 in Bert Sutherland's office in the SunLab building, MTV29.

BACKGROUND ON BERT SUTHERLAND

Could you tell us a little bit about yourself and how long you have been at Sun?

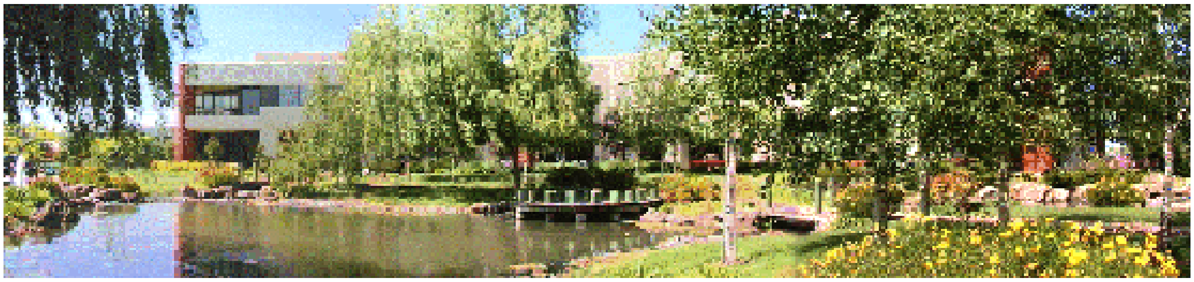
Bert: Sure. I'm Bert Sutherland, the director of SunLabs. I've been at Sun for a little over five years. I came to Sun when the Lab was founded - to join the Lab. I've been in computer research and research management all of my career. My undergraduate degree is from Rensselaer [Polytechnic Institute] in electrical engineering. Then I flew in the Navy, chasing submarines for five years, before going back to M.I.T. [Massachusetts Institute of Technology] where I got my Ph.D. in Computer Science. From there, I went to work at Lincoln Laboratory outside of Boston at Bolt, Beranek, and Newman, Inc. (BBN), in Cambridge, MA, where I ran the computer sciences division. Then I moved to Xerox PARC [Xerox Palo Alto Research Center] in Palo Alto, CA, where I ran the System Sciences Lab, which included Alan Kay and the Smalltalk Group. A lot of interesting things happened. Steve Jobs came to visit and the Macintosh was born. LSI design work was done when Carver Mead was a consultant and Lynn Conway was in my Lab.

In the early 1980's, I left Xerox PARC and became a consultant with my brother, Ivan, and Bob Sproull. We were Sutherland, Sproull, and Associates. We did a variety of consulting work and venture capital activities. In 1990, all three of us came to join Sun and be part of the new laboratory.

Did you specifically come in to run the Lab?

Bert: We came in to join the Lab. When the Lab was founded, it had a Director, Wayne Rosing, who came over in January 1991 during the [Sun] reorganization. Steve MacKay, Jim Mitchell, and I were early members of the Lab. Steve subsequently went on to become Vice President of the Solaris Product Group at SunSoft. Jim, a SunFellow, later went to SunSoft with the Spring project. I was Wayne's deputy before becoming director of the Lab in 1993.

THE LAB - HOW IT ALL STARTED



Sun Microsystems Laboratories Building MTV29, Mountain View, CA

How big was the Lab when it started back in '90?

Bert: The Lab has always been a small organization. When it started, we pulled together 50 or 60 people from various projects at Sun including the Spring Project, Dave Ditzel of the SPARC™ Technology group, Greg McLaughlin and his multimedia work, and Steve MacKay. When we started the Lab, Scott McNealy said, "Well, this is great to have a Lab, but you should stay small to prove your worth for the expenditure before you grow too much." And he said, "One hundred is a nice round number, so why don't you stay at a hundred technical staff?" And, we have been around a hundred ever since. And it has actually been a very good management technique for the Lab because it means that when we start something new, we have to stop something old.

Kind of a fixed number.

Bert: Yes. But Scott was even cleverer than that. He said, "I know how to control the Lab. I'll give you building 29 (MTV29). Don't even think of asking for more space." So, we have a physical [space] limit. We also have a small outpost in Boston, MA, that Bob Sproull runs.

Why was that location selected?

Bert: Sun and Silicon Valley are near Stanford [University]. And, our Boston Lab is near M.I.T. [Massachusetts Institute of Technology].

Conveniently located on purpose?

Bert: Yes, conveniently located.

HOW PROJECTS ARE INITIATED

How does a project get into the Lab?

Bert: Well, research is a very people-oriented activity. To start a new project, you need three things: First, you need a good, new idea...something that's interesting and exciting. Secondly, it needs to be relevant to Sun. We're not doing cancer research or anything like that. So, we try to be pretty practical and apply it. And, thirdly, and most importantly, the idea needs a champion.

A champion?

Bert: Basically, I, as the director, or any of the management in the Lab can say X,Y, or Z is the right thing to work on. But if the project doesn't have a champion, nothing will happen. So the people component of this equation is critical. Each project needs a champion to provide the leadership, the ambition, the drive...someone who stands up and says, "I'm going to put the next couple of years of my career behind this activity."

Right.

Bert: We'd rather do a few projects well than a huge number of projects. There's always a competition of ideas. So, we're generally idea-rich, resource-limited and, even more importantly, we are people-limited. You need leadership to move forward on the projects that are to be developed.

So when somebody gets an idea, do they bring it to their management, or is there a committee vote? Who decides which ideas are developed?

Bert: The process of deciding is fairly informal. As the Lab director, I can make a certain number of decisions, but I really count a lot on the senior people in the Lab. We have two of the five Fellows at Sun. There are also the DEs [Distinguished Engineers] and senior people in the Lab for counsel and advice on what we're going to do. I can't emphasize enough how a lot of the Lab's activities are governed by the people.

Does a project ever come to the Lab as an idea ahead of the technology? What's the balance between a seed of new technology developed into a product, where some marketing person might approach the Lab and say, "We want to do this." And then you guys figure out how to do it?

Bert: Well, that's a good question. The ideas in the company that have come into the Lab have often come with their own champion because there are lots of problems that need solving. But the real question here is who is going to do the solving? So, we fundamentally don't take assignments from marketing because that immediately turns into a recruiting environment assignment. The Solaris MC™ is actually a good example. The leader of that project went with the Spring Group into SunSoft. And he essentially had an idea, made a proposal to me about working on clustering, high performance i/o [input/output], and operating systems. I took him back into the Lab with his project proposal and that has grown into the Solaris MC project. Again, the point I'd like to emphasize is that it's a people-oriented decision. So, we have projects in the Lab that have been started by Sun engineering people coming into the Lab to work on this project. But I can't think of a single project that has come into the Lab as a requirement.

How about any people?

Bert: The project without a champion? I fundamentally declare myself unable to deal with projects without a champion.

Right. Come with somebody excited and let them run with it.

Bert: Absolutely.

How many projects are being worked on at the Lab?

Bert: Well, I don't believe in single-person projects...

Why?

Bert: Because you don't have anyone with whom to argue. You can't lose arguments with yourself all the time. So, most of our projects have three to five people, and sometimes seven or eight. I don't think we have any projects this year as big as 10 or 12 people. And, if you do the numbers on the hundred technical people, that means we have about 10 or 12 active projects. We try to run a portfolio of projects - some are finishing and maturing; other new projects are just starting. We often start projects small with just a few people. Then, as it proves successful and we understand what's involved, we can build a larger, focused product team.

So projects that succeed become real products. What if a project fails? Is there a formal report that is put out to the engineering community so that they can see it has already been tried in the Lab?

Bert: Yes, we have a regular technical report series. And, as part of their termination, the reports are completed to document what is of technical interest. Again, the Lab is much more common-sense focused. We don't do busy work that involves filling out a final report, but we try to provide something that's intellectually valuable back to the community.

TRANSFERRING PROJECTS OUT OF THE LAB

Can you describe the process, from the hand-off of the idea and life-cycle development to engineering design or production?

Bert: Well, there's no formally defined hand-off process. The Lab policy has been to take the people who have worked on a specific project and, as appropriate, move them out into the product-related activities. What they take with them is their knowledge, their know-how, and their accumulated wisdom from all of the successes and mistakes that they made while they were here. These people can sometimes lead a development team, sometimes join a development team, whatever. This is a practical, common-sense approach. There's no magic; the transition [transfer of a project] needs to be sensible.

So it's common for people to leave the Lab with their project?

Bert: Yes. Our focus on moving people out of the Lab and into the company is somewhat unusual. Even I, at times, subsidize the transfer of people and projects out of the Lab. So, instead of my going around and trying to get the operating companies to pay me, sometimes as part of the transfer, I pay them to take my people. I've said all along to the HR [Human Resource] people that the Lab is an open recruiting ground. Anybody in the company is welcome to come along and recruit away anybody who is in the Lab. And sometimes people have moved out on that ground.

Aside from Java, which is probably one of the most successful things that began at the Lab, what else has come out recently?

Bert: The Lab contributed a memory management unit design *[292 kbyte PostScript]* with a flexible software page table structure to the UltraSPARC™ processor.

Another interesting project going on now is Solaris MC [Solaris Multi-Computer] which is working on clustering. The Lab people on this project have dual offices in the Lab and also up in Menlo Park adjacent to the SunSoft people, to absorb this project.

Is that so they can work more closely together, or is it because the project is leaving the Lab and moving to SunSoft?

Bert: It's midway in transition. Some of the people will probably move but not quite yet. We're working jointly to make sure that the information moves from the Lab person's mind to the relevant group of SunSoft people.

Are you working on anything for the entertainment industry, like Sun's Media Server? Video servers or projects for the Internet?

Bert: Well, there's the technology that has already been moved. Actually, the work with the Media Server group was a joint project. Jim Hanko in the Lab and some of the people there worked together on ways of using a larger array of disks and getting several hundred video screens off in rapid fire. That's now out in the [Sun Microsystems Computer Company] business unit. We also worked through the early product stages of figuring out what customers really want and why they buy.

We are also working on an E-Commerce project with the Agoric group. The Lab provided key hardware and software and partnered with the FSTC [Financial Services Technology Consortium], successfully demoing the first electronic check transaction on the Internet.

Leading edge material...

Bert: Yes. Anticipate future needs.

THE PEOPLE AT THE LAB

Are most of the people working in the Lab engineers or Ph.Ds?

Bert: We probably have a higher density of Ph.Ds. Actually, I just tallied it up recently. Out of the hundred people, we have 47 Ph.Ds, which is a fairly high density, and 31 with Masters' degrees. Some of our staffing comes from the outside, some from inside Sun.

Can you elaborate on this?

Bert: A number of people have joined us from inside the company. With a hundred-person limit for transferring the technology, we often move people in projects from the Lab into a Sun company when the project is ready to go. The Spring project was in the Lab for several years before it moved out to SunSoft, Sun’s software company. This whole Java™ [language] phenomenon started with a small project three or four years ago in the Lab. It was called the ’Green project’ because, "It’s green, it’s time." Now the Java language and HotJava™ browser are part of JavaSoft.

Java started as the ’Green project?’

Bert: It was a nondescript title. Maybe it’s appropriate for Kermit [the frog] - "it’s not easy being green." (laughs) The Green project subsequently transitioned to FirstPerson [now JavaSoft]. So, as we discussed earlier, we try to have a flow of people from the Lab into the company [Sun]. A number of the people who transferred into the company have returned to the Lab.

There’s no place like home. And the returnees start over again with a new project?

Bert: Yes, it starts all over again. However, not everybody who is in the Lab and then goes into the company will come back.

Right.

Bert: One of the functions of the Lab is as a recruiting magnet for Sun. We can bring people into the company, let them work here awhile, help them bring their ideas to maturity. Many Lab people really want to see their ideas put into practice and have commercial value - to be utilized by real users out in the world. That’s one of the attractions of Sun as a company. The Lab is actually a place where people can come and see their technical ideas develop into products.

So it’s fair to say that the Lab isn’t just a research lab. Ideas can become products.

Bert: Yes, absolutely. I don’t actually think of the Lab as a "research lab" in the sense of, say, the Bell Labs work or even the Xerox PARC experiences that I have had. I’m trying to run the Lab as a very practical, very applied, and very valuable-to-the-company asset. We are focused on things that Sun can use. Xerox PARC was good at ideas; we are doing things a bit differently here. This is more applied research. And we need to be able to articulate this right from the start, to say why the technology will be useful.

Right.

Bert: By the way, another way to look at our Lab is, as a way for the company to learn about technology. It’s a little glib perhaps, but one of our functions is to make some of the company’s technical mistakes early, while they are still cheap.

That might help.

Bert: That’s right. Warner Von Braun had this wonderful little saying, "If we knew what we were doing, it wouldn’t be research." But, nonetheless, it’s really important that we explore things and find out what works or what doesn’t work, and stop it. John Ellenby at Xerox, who founded Grid and some other companies, really had a nice way of saying it. He said, "Think of uncharted territories and an expedition going through them. If it’s a development expedition and it sees a mountain ahead, the development expedition doesn’t want to go there. It wants to go around the mountain and find a nice, safe, level path to circumvent it. But a research expedition wants to go right to the top of the mountain to see what’s there." So, one of the things that the company gives SunLabs is a greater risk profile than the normal development group. It’s okay for us to make mistakes as long as they’re interesting ones.

Right. It’s okay as long as you can learn from the mistake.

Bert: That’s right. So we’re really in the business of acquiring knowledge for Sun.

PARTNERS AND THE INTERN PROGRAM

Does SunLabs partner with outside groups?

Bert: We have a few joint projects with outside commercial organizations and a larger set of activities with universities. We have a Collaborative Research program where engineering people can contract with universities for particular kinds of work that they want.

Can you elaborate on any educational project?

Bert: Sure. One of the things that we’re working on is using technology for education. Every one of Sun’s customers has an extensive installation of some infrastructure - networks, workstations, servers, etc. And, every one of these customers has a training problem because of the number, variety, and turnover of employees. This is a fast-moving world. One application that we’re exploring is how to use this technology to help people learn. We’re running a pilot project with Cal Poly [California Polytechnic Institute] in San Luis Obispo and Jim Gibbons, the Dean of Engineering at Stanford [University]. We are teaching a group of courses at Cal Poly using a particular methodology for delivering education. It’s an example of the plausibility argument: "Technology can be useful in delivering training education of all kinds to the desktop companies." We’re trying to understand how to do that. And the plausible value to the company is increasing the utility of our products to the customer base.

When you're working in different markets, like education, does the Lab provide the manpower, or does the other partner, for instance Cal Poly, provide the educators?

Bert: The latter. We really like to work and partner with people who complement our skill base.

And what is our skill base in the Lab?

Bert: Most of it is technical, where Sun should be. We are pretty much a cross-section of Sun engineering. We don't even have one psychologist or anthropologist by training. But, we can partner with people who provide that kind of expertise. So, Cal Poly provides an obvious set of students, set of courses, and the willingness to partner with us and to experiment. So we've had a very nice relationship. We've taught a couple of different classes in this experimental way this past Fall. And additional work is going on even as we speak.

I heard the Lab also has a good summer intern program.

Bert: Yes, the Lab has a very strong, extensive summer intern program. It's a wonderful way to rejuvenate our population. The students provide a breath of energy for all of us. Graduate students are fearless; they have no idea that they can't do it. So whatever it is, they just go and do it. And it's wonderful. So out of our 100-person Lab last summer, we had our peak of 30 interns.

That's a third of the employees.

Bert: Yes, we have to stuff everybody into our little building and use every nook and cranny, but it's really very exciting. We had students from Europe and Asia, as well as the United States and Canada. So it's quite an extensive program. From our friends Down Under, we even had a winter intern last year. The Australian student came about Thanksgiving when his summer holiday started, and he left around Valentine's Day when it was time to go back to school. So, we really try to have extensive, personal interaction with universities. Last year we also had two professors, who spent a number of months with us on their sabbaticals. One was from Denmark and one from Spain.

Interesting. Are these professors and students mostly working on Lab projects?

Bert: Yes.

How are they recruited?

Bert: The Lab project leaders do the recruiting. Sometimes Lab people have gotten intern students from their collaborative research partners at universities. Other times, we get summer students on personal referrals. Professor X at University Y says, "I've got the hottest student who would like to come and do a summer in the industry. What about it?" So there's quite a wide variety of different ways they come to us. There's no fixed mechanism.

Are most of them Ph.D. candidates?

Bert: Most of them are graduate students but not necessarily Ph.D. candidates. In the local area around the Lab, we also have some high school interns who come in and learn about work and computers.

Do they have any relation to NetDay ’96?

Bert: Well, the Lab has an active volunteer group for that event. But no, the high school intern program is a thing we’ve had now ever since the Lab was founded.

Interesting. So, you’re cultivating young talent.

Bert: It’s a way of reaching out into the community - tapping people. It’s actually been quite interesting. At one time, we had three Russian immigrants who were in the local school systems here.

Speaking of Russia, do you work with the group of scientists over there that are part of Sun?

Bert: We haven’t recently. One of the initial contacts, several years ago, was by Dave Ditzel when he was in the Lab. It was the Russian group that built their supercomputer, SunLabs actually contracted with them to get that going. When Dave and his group moved into STB [SPARC Technology Business, now Sun Micro Electronics], that connection migrated [to STB] as well. So, as of the last year or so, we haven’t had any additional contact.

So, it’s not just the people that move out of the Lab, it’s the partners...

Bert: Well, partnership is a person-to-person thing. So when the partner moves, then the partnership also has to move. Again, it’s all a matter of what makes sense.

It seems like the Lab isn’t selfish about these things...

Bert: Right. The purpose of the Lab is to help Sun do new technical things. And the numbers are very interesting. With 100 technical people, we are less than one percent of the company [Sun]. So, I tell my people that means all the real work in the company - the money earned, the products designed, the customers serviced - are the other 99 percent. As this little one percent of the company, SunLabs is an overhead item. So, our measure of effectiveness is how well we can get some appropriate part of that other 99 percent to do something different.

Okay.

Bert: Of course, we have to have some technology that they’ll want to use. But, fundamentally we’re effective when we see the company change its behavior.

When the Lab visits a customer, what is their capacity there?

Bert: I'm glad you asked that question. This is, again, part of the difference between our Lab and some of the other industrial labs. One function of the Lab is to try and increase the value of Sun's product downstream to the customer base. And I don't know how my people can work on that without some feeling of the customers' value system. You can go crawl into an ivory tower, but it's much better to go out and try to understand their constraints, their needs, their budgets, their people problems, etc. So, for a long time, we have had a customer visit program in the Lab. If someone from the Lab goes off to a conference, they are encouraged to connect with a local Sun office. For instance, the Lab people will ask the German sales office to take them around to a couple of customers and let them talk about SunLabs. Then when they come back, they write a trip report for all of us in the Lab - to share whatever they learned. And we've found this to be very useful. It's a very valuable experience, and it's also a big help to the field people because they get to talk with people in the Lab and find out what's going on. My Lab people get an appreciation for how Sun's sales reps and SEs [Sales Engineers] are huge secret weapons for the company. It's important that my guys appreciate them. It's also a win-win situation.

It's probably also invaluable to the customers who are able to go to the Lab.

Bert: Yes. Although there's no formal open house day for customers, I don't think there's a week that goes by that we don't have several customers visiting us. It's actually an interesting problem because a lot of the interaction is valuable, but, on the other hand, we could be the Visitors' Center. And then we wouldn't get anything done.

This will really excite people when they see that the Lab contributes to the company's technological future.

Bert: Yes, that's another value of the Lab to Sun. It's a tangible, multi-million dollar demonstration that Sun is actually making investments in its corporate technical future.

Right.

Bert: And I keep telling Scott McNealy, although it's not accounted this way, "We're not an expense, we're an investment."

Bill Gates got cited for his lack of Internet future direction plans. Would you say, if Sun is asked that same question, they could reference SunLabs to the media?

Bert: I would say yes, with a caution that we are by no means the only part of Sun with future vision. The Lab is certainly a "put your money where your mouth is" proof of serious corporate investment in the future of technology. But, again, we are 100 out of Sun's 2500 engineers. And, I can't emphasize enough the larger role in Sun's technical future that the remaining 2,400 engineers play because there are so many more of them. They're incredibly smart and dedicated and the Lab appreciates this relationship.

THE FUTURE OF THE LAB

Where do you see the Lab going in the next few years? How will it grow?

Bert: I see the Lab progressing. I don't think it will grow a lot. My recent recommendation to Scott McNealy and the management of the company is that the Lab not expand in size, but rather that Sun place increasing emphasis on advanced development activities in each operating company. This will give each of them the chance to develop a number of projects that are aimed at risk reduction, at competence, whatever. Traditional projects in the operating companies have been devoted to product development, not to technology exploration or knowledge acquisition. My hope is that Sun will expand these activities, not restrict them to the Lab.

So each Sun operating company could have its own little group that works with the Lab?

Bert: Yes, in fact Sun Microsystems Computer Company already does. They have a technology development department.

It's also like SunSoft, which has places that are working on multi-computing...

Bert: Yes, SunSoft has a few places doing that, and, my recommendation is to strengthen these activities.

SunLabs is here, among other reasons, to help the company's products in three to five years - around the time this millennium ends. We would like to see Sun's products provide more value to customers.

What kinds of tools do you use to decide what's going to happen three to five years out?

Bert: That's a tough question, because three to five years out is pretty murky. And what we realistically can do is try and look at the trends. And then encourage our creative people to follow their noses on what are good ideas. It relates in an interesting way to another aspect of the Lab. I run a very open Lab and we essentially publish almost everything we do. In fact, the only 'stealth' project we have done was the "Green" pre-Java work several years ago.

Otherwise, it's a very public Lab?

Bert: Yes, the Lab has always been very public. When we started the Lab, Bill Joy had a saying, "Innovation happens all over the world. Most of it not at Sun." So, one way of looking at the Lab here is as an intellectual trading post. In addition to inventing whatever wonderful stuff we do, we are chartered to gather information for Sun.

Part of the reason for being open is that we have to give information in order to receive information. Imagine me going to my alma mater, M.I.T., and saying, "I'm from Sun, tell me what you are doing." And all of the professors rattle off the exciting stuff they're doing. And then they turn around, "Okay, Bert, tell us what you are doing in the Lab?" And I respond: "Oh, I can’t tell you. It’s secret." That would be my last visit to M.I.T. on that sort of basis. So, it’s a long tradition of innovation and development. Openness is better.

Right.

Bert: Sun is fundamentally an open company. We will win from the things that we invent or discover. Success comes from being nimble and not from being secretive. We just have to run faster than anyone else.

So our open systems philosophy is shared by the Lab?

Bert: Absolutely. It’s the keystone of how we operate.

Per ardua ad astra!

"Through difficulties to the stars"

Five Year Anniversary Celebration
25 June 1996