LA-13341-C
Conference

Proceedings from the Conference on

High Speed Computing

LANL • LLNL

High Speed Computing and National Security

April 21-24, 1997

Salishan Lodge
Gleneden Beach, Oregon

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

Photocomposition by Annie Loweree, Butler International, for Group CIC-1

Special thanks to Gloria Montoya and Verna VanAken
for coordinating this effort.

LA-13341-C
Conference

UC-705
Issued: July 1997

Proceedings from the Conference on High Speed Computing

High Speed Computing and National Security

April 21-24, 1997

Compiled by
Kathleen P. Hirons
Manuel Vigil
Ralph Carlson

Table of Contents

Conference Program

Monday, April 21, 1997

Keynote Session:

Keynote Address
Andy Heller

Tuesday, April 22, 1997

Session 1: Technologies/National Needs/Policies: Past, Present and Future

National Security Needs: Technologies & Policies
George Cotter, NSA

High Performance Computing's Information Future
John Toole, National Coordination Office for HPCC

Session 2: Information Warfare

A Perspective on the Evolution and Importance of Cryptography in the National Policy Debate
Mike McConnell, Booz, Allen & Hamilton

Update on Information Assurance Efforts and Current Starus
CAPT William Gravell, US Navy

Session 3: Crisis Management/Massive Data Systems

Every Town Hall Needs a Four Gigabit Hard Drive
Paul Fischbeck, Carnegie-Mellon University

Crisis Forecasting
Andy White, LANL

Session 4: Risk Assessment/Vulnerabilities

Computer Crimes 1997
Tom Tauller and Steve Nesbitt, NASA

Banquet

Dreams to Machines and Back
David Urie, Lockheed Skunk Works (Retired)

Wednesday, April 23, 1997

Session 5: Student Session

High Performance Superpiplined Design
Apporv Srivastava, University of Southern California

Parallel Programs from Constraint Specifications
Ajita John, University of Texas, Austin

Session 6: Internet Law/Privacy and Rights of Society

Defining The Rules of the Net: The Visions and Lessons of Self-Governance
Jeffrey Ritter, ECLIPS

Privacy in the Digital Age
Deirdre Mulligan, Center for Democracy and Technology

Thursday, April 24, 1997

Session 7: Challenges to Effective ASCI Programmatic Use of 100 TFLOP/s Systems

The TFLOPS Era is Here
Art Hale, SNLA

ASCI Applications Challenges
Ken Koch, LANL

Day-to-Day Programmatic Usage of 100 TFLOP/s Systems Demands Careful Balance in the Overall Computing Environment
Mark Seager, LLNL

Session 8: New Computing Technologies

Examining ASCI Computing Models
Karl-Heinz Winkler, LANL

Session 9: Future

Use of High Speed Computing in Manufacturing: Godzilla meets King Kong
Gene Meieran, Intel

Proceedings from the Conference on High Speed Computing

High Speed Computing and National Security

April 21-24, 1997

Compiled by
Kathleen P. Hirons
Manuel Vigil
Ralph Carlson

Abstract

This document provides a written compilation of the presentations and viewgraphs from the 1997 Conference on High Speed Computing. "High Speed Computing and National Security", held at Gleneden Beach, Oregon, on April 21 through 24, 1997.

Internet Backbone Observations and Prognostications

- Where is the Internet today and what are the primary forces of change
  - A look from the outside--the uses
  - The Internet today
  - A look from the inside--drivers of increasing bandwidth consumption within existing and new applications including a look at the technical, economic, social and legislative side
- Is NGI enough?
- A Quick Scorecard

The real question

- What is the size of the annual increase in overall bandwidth on the Internet Backbone?
  - 2x?
  - 5x?
  - 10x?
  - 20x?
  - 30x?
- Are there enough things happening to sustain that growth for the 3-5 year period?

General Categories of Usage

- Some big, general categories and some terms of endearment
  - net-balm--(spelling for airports only)
  - net-dregs--(thats de-reg for non-nerds)
  - net-ed-- are you?
  - net-ent
  - net shop--the mall effect
  - net spend--real money
  - net-work

NET-BOMB

- Super MPP on the network
- limited applications
  - ASCI
  - Large scale simulations
  - Engineering problems
  - Weather
  - War Games
  - LNL/LANL type problems
- requires 100's of gigabits to 10's of terabits/second

NET-Deregulation/Telecom 1994

- Competitive pricing along with performance, attachment and comm. improvements opening up massive growth in usage
- Much faster acceptance of INTERNET and WEB than anticipated
- Countries with protected public or private monopolies are rapidly falling behind the rest of the world. Europe (especially France) and Japan beginning to look like 3rd world
- States are entering the fray. Proposals for statewide networks. Reed Hunt look out

More on Deregulation

- If you own a pipeline there's more money in glass than gas
- USA T3 costs are about 1/6 Japan and result in more than 10x per capita penetration, but even Japan being forced to price low. In France, E3 install is more than 3.5 years of DIGEX USA T3
- Technology that enables usage of existing infrastructure evolving rapidly GB on tel. wires
- This is a business thing guys

NET-Ed(ucation)

- Snow-Rockefeller amendment to 1994 communications act
- Major state initiatives TIFF=$1.5B in Texas
- Will accelerate both # of hours and shift in content from dominant text to video, audio and graphics
- Rapid intro. of agent and x-caster technologies
- Use will be both during and after hours-homework
- Requires 10's of megabits/classroom, millions of classrooms in US

NET-ENT(ertainment) the family that Surfs together

- Moving the Internet from the home office and library to the living room and family room
- Major delivery improvements
  - x-DSL and Cable
  - ETHERNET to the home on the phone
- Moving the action to the big screen
  - Nintendo 64, Sony play station, WEB-TV and other network computers (small n&c)
  - Next generation on TV remotes, voice control and game controllers

More NET-ENT

- More focus on Video, teleconferencing, quality audio and graphics, group activities
- More advertising
- More multi-user interactive Network games not just downloaded games
- many more social (video and telephonic) activities
- Targeted advertising and materials delivery, legal to collect usage data in US but not in Europe

Net-Shopping

- Net commerce comes in the form of both shopping and making the buying decision and actually buying (net-spend) the item
- Both home and corporate models already visible
- Movement to much more complex interactions and much more video and graphic content
- Window shopping at home-the sunny day mall
- True comparison shopping and consumer ed
- Find exactly what you want at the best price
- Really let your fingers do the walking

Net-spending

- 1996 estimates on e-commerce range from $100m to $750m
  - ignores fundamentals of using the net to shop and other ways to buy
  - even the net-spend model will pass $150B on a to go basis by YE2000
- Security, clearing house, privacy issues all have solutions that are surfacing
- Complex corporate net shop and net spend applications already launched
- Home shopping for cars, books and computers

More Net-Spending

- Average time on commercial spending e-commerce WEB sites rising from less than 25 minutes to over 1 hour per visit
- Average number of HTML pages for business commerce sites moving from 2-3 for static informational sites to 15-20 for commercial e-commerce sites
- Many (most) commercial sites also have links to legacy DB systems and each HTML user page can require 10-1000 net packets to legacy systems

Net-Work

- Office in the home and Telecommuting
  - telecommuting becoming increasingly more attractive with more MIPS and more bandwidth
  - MPEG, video-teleconferencing and high speed file access rapidly increasing usefulness of office in the home and opening up interpersonal communications
- X-DSL and ETHERNET to the home will rapidly accelerate movement
- Horizontal business model built around WEB systems evolving with potential for increased outsourcing

Internet terminology and background

- ISP---Internet Service Provider
- NAP--- Network Access Point-a smart MAE
- FIX---Federal Internet Exchange
- MAE---MFS corporation network Access Exchange point-2 major 5 minor MAE sites
  - A MAE does no routing-the only devices connected to the MAE are routers generally provided by ISPs
  - MAE WEST sustaining over 180Mbps (6/96) Connected to NASA Ames FIX WEST
  - MAE EAST sustaining over 380 Mbps (6/96)

The Internet Today in the USA

- Europe 5 years behind the USA. As much digital commercial Bandwidth in Austin Texas as all of continental Europe???130K user YE96
- Even with OC12s and OC48s, insufficient bandwidth for current application load
  - Japanese curious about huge OC48 demand
- 35-40M users today adding >500K per month
- Not enough access points in the backbone
  - Many MAEs not profitable
  - NAPs just starting to emerge for other economic reasons than simply providing bandwidth-higher functionality

Changes in the Internet in the USA

- Shift from switched (circuit and virtual circuit) into routed links for better utilization (Except Bells)
- Emergence of more commercial NAPs and replacement of several MAEs
  - Economic viability of new NAPs broader than just backplane access
  - New NAPs take full responsibility for route optimization and protocol conversion
  - More profitable and efficient than old MAEs
- Emergence of Virtual Corporations / Internet based e-commerce as base of all activities

NGI The Next Generation Internet

- Funded for Fiscal 1998 at $100M
  - Split between DOD, DOE, NASA, NSF, COMMERCE
  - From GIGA to TERA bps
- Expect ongoing funding until at least 2004
- Money for pure Optical solutions, mixed optical-electrical solutions and electrical solutions
- Looking at backbone (TERA-BIT+), NAPs, FIXs,etc (100+ GIGABIT), and LANs (1-10 GIGABIT+)

NGI Goals

- 10 Universities/Natnl Laboratories connected together at 1000 times current maximum available bandwidth limits Approx. 1Tbps+
- 100 Universities/Natnl Laboratories connected together at 100 times current available bandwidth Approximately 100Gbps
- ESnet to be part of NGI
- Ties to Accelerated Strategic Computing Initiative (ASCI) may add source of technology and funding
- 100Gb project will likely get some (D)ARPA funds

What's driving growth of Internet traffic?

- User Community Growth
- Attachment speed
- Local Computing power and storage capacity
- Usage profiles
- E-Commerce
- Java
- Telephonics

What's driving growth of Internet traffic?

- User Community Growth >450k/month
  - Universities and Research Labs
  - Engineering and Design shops
  - Programming institutions
  - Large businesses
  - Small businesses and home office
  - K-12 and home personal use
  - 1991/ <5M users, <5% home users
  - End 1996/ 35-40M users, about 25% home and home office use. Home/HO could double by 1998

What's driving growth of Internet traffic?

- Attachment speed
  - Growth of ETHERNET in the office (10Mbps)
  - Hi volume / low cost modems
    - 112 baud in 1968
    - 300, 1200, 2400, 4800, 9600 by 1990
    - 14.4 kbaud in early 1990s
    - 28.8 kbaud by 1995
    - 33.6 kbaud and X2(56 kbaud) by early 1997
    - Average Home/HO already over 14.4
    - Next step is 10Mbps or more using x-DSL or asymmetric (DBS), ETHERNET to the home

What's driving growth of Internet traffic?

- Desktop/LAN compute power and storage capacity
  - 1972 time sharing gave capacity of about 40KIPS to the user and less than 40kflops
  - Original PCs about the same capability through about 1981
  - Early workstations from 1 to 3 MIPS by mid 1980s
  - Average workstation over 100mips/mflop by 1996, desktop PCs over 50 mips, 20 mflops average by YE2000 moving to 400+mips, 200+mflops + DSPs--going from 1GByte to >10 Gbytes storage

What's driving growth of Internet traffic?

- Change in usage of the Internet
  - was dominantly e-mail with some FTP
  - the WEB (browsers) has dramatically increased both number of users on the Internet and the amount of data being moved per interaction
  - Starting to see emergence of more parallelism in usage of the Internet
  - E-commerce starting to become real-not just the same thing as before but done on the Internet. Beginning to see first implementations of "Virtual Corporations"

What's driving growth of Internet traffic?

- META Browsers
  - Natural language query
  - Search of probable WEB sites in parallel
  - Can generate thousands to tens of thousands of requests (agents) in parallel
- E-Commerce-Birth of the Virtual Corporation
  - Growing at very rapid rate-Strong enabling technology in security, authentication and clearing house support
  - Complexity of requests and size of returned data rapidly increasing-Large files being moved

What's driving growth of Internet traffic?

- Net-casting
  - Alerts
  - Information services
  - News
- Use of Internet to replace private nets as functions move from clerks to customers
- Will TELNET still exist as it is today
  - 2 packets/character in the backbone
  - build and tear down 2 virtual circuits per character

What's driving growth of Internet traffic?

- JAVA- Will cause rapid increase in average size of data transferred per WEB interaction- move both data and applet-increase of non-text content
- Improving Internet Telephonics
  - Not very good, extremely cheap
  - approx. 60mb/hr
  - Quality improving, getting to tolerable jitter
  - Cost about $0.01 on the Internet to $1.00 on standard long distance and oversea calling
  - Phone companies very unhappy with the situation-must learn to sell bandwidth

What will happen over the next 3-4 years on the Internet

- Massive growth of Infrastructure
- Major shakeout of ISPs-Merger mania
- E-Commerce carrying significant portion of cost burden-but major consumer
- Major inroads into K through 12 education
- 30-50 million Americans having access at their homes using PCs, NCs, Games, and WEB-TVs for information and commerce
- Massive displacement or functional adjustment of long distance carriers

---

SCORECARD

Function	YE96	YE00	Mult	Wgt	Impct
#of users	*~40m*	*~120m*	*3x*	*1.0*	*3*
B/e-mail	<500	>60k	120x	0.8	300+
cast-k/u/d	<1	>500	500x	0.2	300+
metaBrs M/d	<.01	>20m/d	2000x	0.15	900+
av. modem	~15k	>1.5m	100x	0.6	180+
av.hrs/day	<.2	>2.5	12x	1.0	36
e-$*M	<$750	>150B	200x	4.0*	800+
tele %U	<0.1%	>25%	250x	1.0	250+
NC usage	<0.1	>15	450x	3.0**	1350+

3xU*(20%)*5xpages+40 invisible accesses

**increased video/audio/conference gaming

NATIONAL SECURITY AGENCY

NATIONAL SECURITY NEEDS TECHNOLOGIES & POLICIES

THE CONFERENCE ON HIGH SPEED COMPUTING

GEORGE R. COTTER
22 APRIL 1997

OFFICE OF THE CHIEF SCIENTIST

NATIONAL SECURITY NEEDS - TECHNOLOGIES & POLICIES

OUTLINE

- STATE OF THE HIGH PERFORMANCE COMPUTING INDUSTRY
- NEEDS OF THE NATIONAL SECURITY COMMUNITY
- PERSPECTIVE ON TECHNOLOGIES
- A STRATEGY FOR SURVIVAL

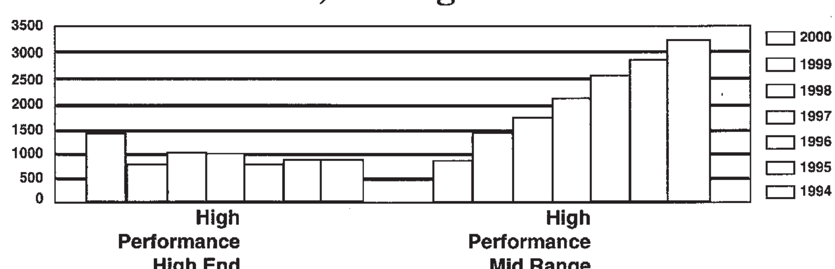
OFFICE OF THE CHIEF SCIENTIST

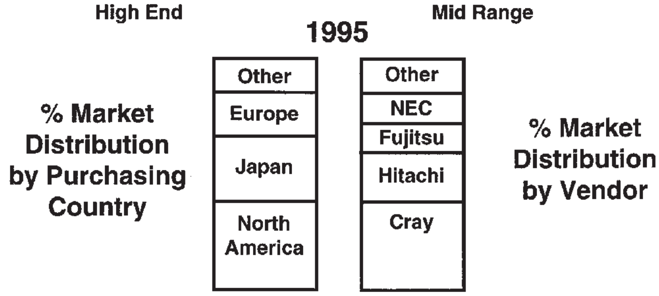
HIGH PERFORMANCE COMPUTING MAJOR CONCERNS

- What are the Critical National Security Needs for High Performance Computing?
- Can the Industry Satisfy our Current and Potential Requirements? If not,
  - What High Performance Computing Technology Program Should the National Security Community Pursue?
- Are HPC Industry Market Trends consistent with our National Security Needs? If Not,
  - What is our Policy with Respect to Industry; its Survival, Leverage of Systems Design, Technology Cooperation?
- What Strategic Relationships within the Federal Government are Critical to Long-Term High Performance Computing Interests of the National Security Community?

OFFICE OF THE CHIEF SCIENTIST

High End Market Flat; Strong Growth in the Mid Range





OFFICE OF THE CHIEF SCIENTIST

WORLD-WIDE TECHNICAL HIGH-PERFORMANCE COMPUTER REVENUE BY SEGMENT, 1995-2001 ($M)

	1995	1996	1997	1998	1999	2000	2001	1996-2001 CAGR (%)
High-Performance Midrange	1,343	1,938	2,422	2,835	3,255	3,666	4,129	16.3
Supercomputers	537	659	719	579	591	600	609	-1.6
Technical Parallel Processors	224	415	436	376	386	357	330	-4.5
Total	2,104	3,012	3,577	3,790	4,232	4,623	5,068	11.0

OFFICE OF THE CHIEF SCIENTIST

HPC Industry Has Had High Casualty Rate

Tried and Failed
- Alliant
- BBN
- CDC
- Denelcor
- Elxsi
- ETA
- FPS
- Goodyear
- Multiflow
- Myrias (Canada)
- Prime
- SCS
- Sequent
- SSI

Recent High End Failures
- CCC
- Intel (SSD)
- Kendall Square
- Maspar
- TMC
- NCube

Mergers	Others
SGI-CRI	IBM
HP/Convex	TERA

OFFICE OF THE CHIEF SCIENTIST

Comparison Japanese and U.S. Systems

High End Competitive PVPs

	FUJITSU	NEC	SGI/Cray
Machine	VPP700	SX-4	T90
Clock	7ns	8ns	2.2ns
Peak Performance (PE)	2.2GF	2.0GF	1.8GF
Size Range (PEs)	8 - 256	8 - 32	1 - 32
Memory/Type	SDRAM/ Dist	SSRAM/ Shared	SRAM/ Shared
PE Technology	CMOS/ Custom	COMS/ Custom	ECD/ Custom

High End Competitive MPPs

	HITACHI	NEC	SGI/Cray	IBM
Machine	SR2201	GENJU-3	T3E	SP-2
Clock	6.6ns	13.3ns	3.3ns	7.4ns
Peak Performance	.3GF	.05GF	.6GF	.48GF
(PE)	32 - 2048	8 - 256	16 - 2048	2 - 512 NODES
Size Range (PEs) Memory/Type	DIST/1 GB (PE)	DIST/64 MB (PE)	DIST/ Global/2 GB (PE)	DIST/2 GB (PE)
PE Technology	RISC/ Custom	RISC/ Custom	RISC/ Custom	RISC/ Custom

OFFICE OF THE CHIEF SCIENTIST

HPC INDUSTRY MARKET TRENDS ARE NOT CONSISTENT WITH NATIONAL SECURITY NEEDS

- Continued growth forecast only for mid-range market
- High end revenues are not sufficient to support essential R&D
  - Too many high-end systems chasing too little revenue:

SGI-CRI	IBM	JAPAN	NEW ENTRIES
T90	SP-2	SX-4	(MTA)
T3E		VPP700	(ORIGIN 2000)
		SR2201	
		CENJU-3	

  - <$100M per system (at high end)
- Little upward mobility evident for mid-range users
  - Architectural confusion?
  - Industry uncertainties?
  - ISV support lacking?
  - Adding mid-range increments?
- Decreasing U.S. government-funded HPC system R&D; acquisitions
- Competition for market share is intense
  - The NCAR Domino
  - Europe as the battleground

OFFICE OF THE CHIEF SCIENTIST

NATIONAL SECURITY HPC REQUIREMENTS SHOULD SATISFY THE FOLLOWING FIRST PRINCIPLES

- Importantly affect the nation's leadership in international security activities.
- Relate directly to major national security programs or capabilities: weapons development, intelligence, countermeasures.
- Meet established standards for critical Defense industrial base.
- Ensure clear superiority for U.S. military forces: training, support, operations.
- Be a critical element of the nation's economic security and competitiveness.

OFFICE OF THE CHIEF SCIENTIST

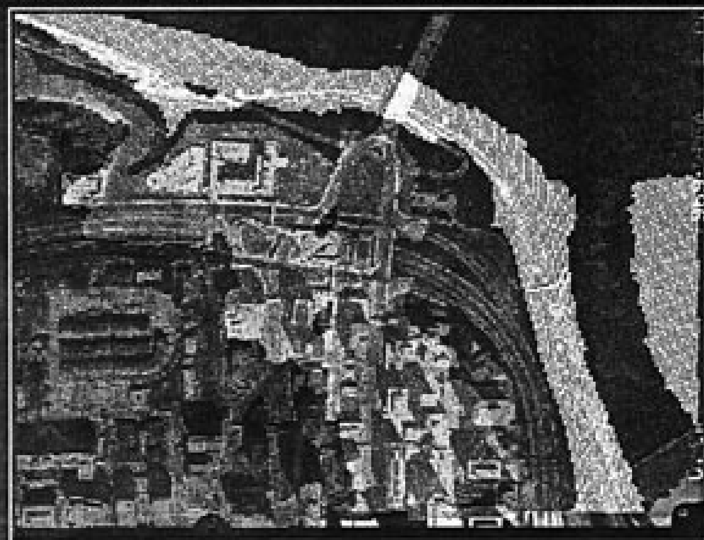
NATIONAL SECURITY NEEDS

- Nuclear Weapons Stockpile Stewardship - DOE ASCI
- Imagery Processing and Correlation
- Cryptology
- High Performance Aircraft Design and Test
- Advanced Weaponry Design and Test
- Battlespace Modeling and Simulation
- Protection of the National Infrastructure
- Information Dominance

Overhead Image - From Stereo Pair
Rosslyn, VA

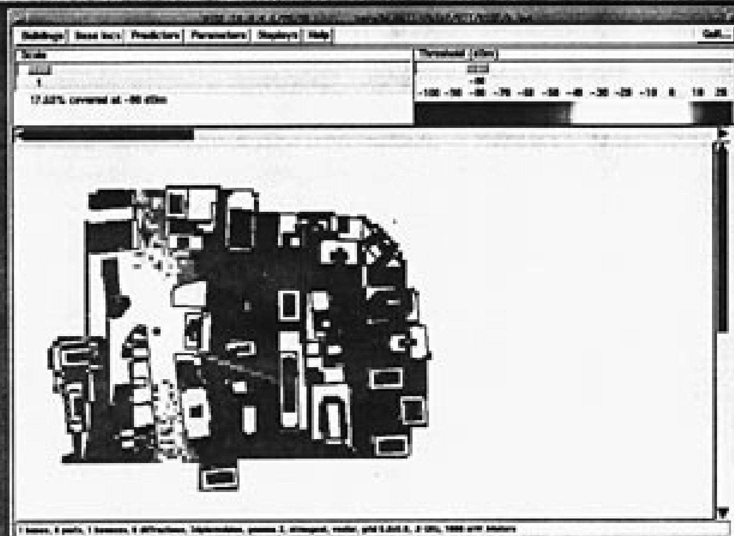
Feature Data
Collected from Stereo Pair

Terrain Data
Autocorrelated From Stereo Pair

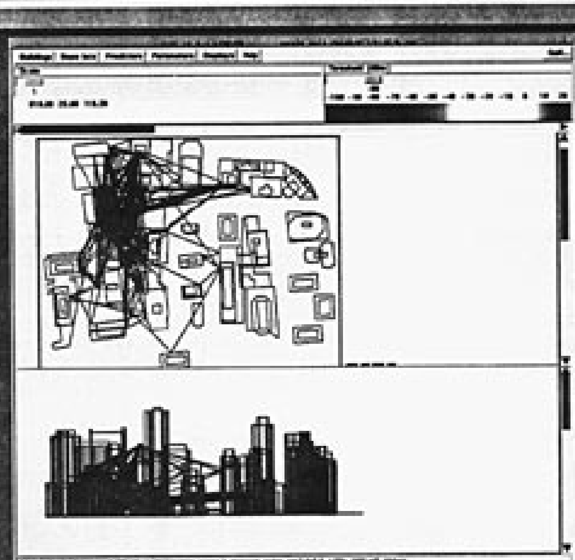


Demonstration of
Single Bounce and Diffraction

Single Bounce EM Wave Prediction Using Rosslyn Feature Data



Demonstration of Multiple Bounces and Diffractions



Multi-Bounce EM Wave Prediction Utilizing Rosslyn Feature Data

OFFICE OF THE CHIEF SCIENTIST

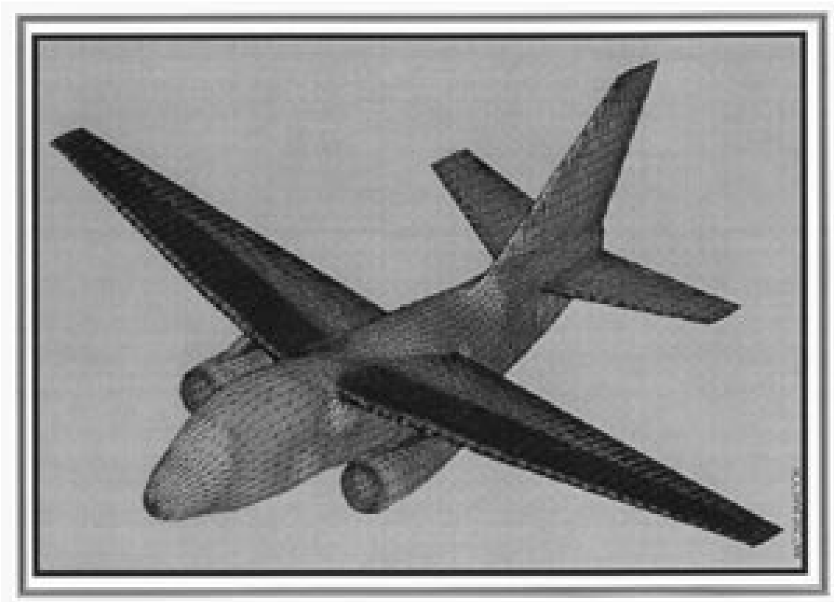
CRYPTOLOGY

- Cryptanalytic problems are among the most computationally intensive HPC applications to be found
- Relaxation of export controls, while inevitable, exacerbate National Security & Law Enforcement problems

AVERAGE TIME FOR BRUTE-FORCE ATTACK - - WORST CASE

Key Length	T3E	10TF	100TF	Petaflop
40	1.125 Min.	8.289 Sec.	.829 Sec.	.0829 Sec
56	1.86 Mo.	6.852 Days	16.44 Hrs	1.644 Hrs.
64	39.69 Yrs.	4.874 Yrs.	7.182 Mo.	21.54 Days

OFFICE OF THE CHIEF SCIENTIST



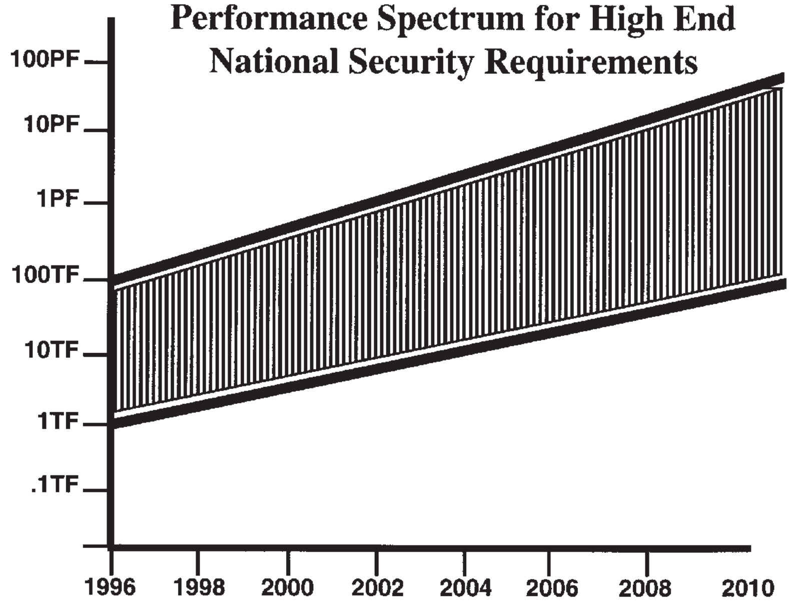
OFFICE OF THE CHIEF SCIENTIST

BATTLEFIELD DOMINANCE

- TARGET DISCRIMINATION
  - Combat Identification
  - Signature Extraction
  - Remote Sensing
  - Real-Time analytic support
- MODELING & SIMULATION
  - Synthetic theater of war
  - Command & Control
  - Mission Rehearsal
  - Decision Support
  - All-source data fusion, retrieval & display
  - Realistic Command Training & Development
- INFORMATION WARFARE
  - Manipulation or massive data sets
  - Dynamic adjustment to information infrastructure attacks
  - Active information operation
  - Integration with other conventional and unconventional warfare

OFFICE OF THE CHIEF SCIENTIST

Performance Spectrum for High End National Security Requirements



OFFICE OF THE CHIEF SCIENTIST

NATIONAL SECURITY POLICY-DRIVEN NEEDS

- High End HPC is a critical element of the National Security Industrial Base
- Essential to continuing world leadership in:
  - Weapons system design & production
  - Intelligence superiority
  - Information age battlefield dominance
  - Meeting major Treaty obligations
  - Development of new & critical Technologies

OFFICE OF THE CHIEF SCIENTIST

TECHNICAL SHORTCOMINGS OF TODAY'S HPC SYSTEMS

- Peak Performance
- Deliverable Performance on Many Applications
- Systems Software (Compilers, Languages, O/S Tools)
- Latency Management (HW & SW Multithreading Support)
- Memory Bandwidth
- I/O Bandwidth
- Processor-Memory Speed Gap

OFFICE OF THE CHIEF SCIENTIST

HPCC WORKSHOPS

Apr 92	Pasadena I	Systems Software & Tools
May 93	Pittsburg	HPC Applications
Feb 94	PetaFlops I	Enabling Technologies
Jan 95	Pasadena II	Systems Software & Tools
Aug 95	PetaFlops	Applications
Apr 96	PetaFlops	Architectures
Jun 96	PetaSoft	Systems Software & Tools
Jan 97	PetaFlops	S/S Architecture Mode
Apr 97	PetaFlops	Algorithms

SUMMARY

PARTICIPANTS: Top HPC People from Academia, Industry, Labs, Govt

GOALS: Exhaustive Examination of Technology, Architectures, Systems SW, Algorithms , Applications Showstoppers

CONCLUSIONS: HW - Systems SW Gap Widening
Fresh, Focused Start Needed
- Fundamental Research
- Technologies
- Architectures

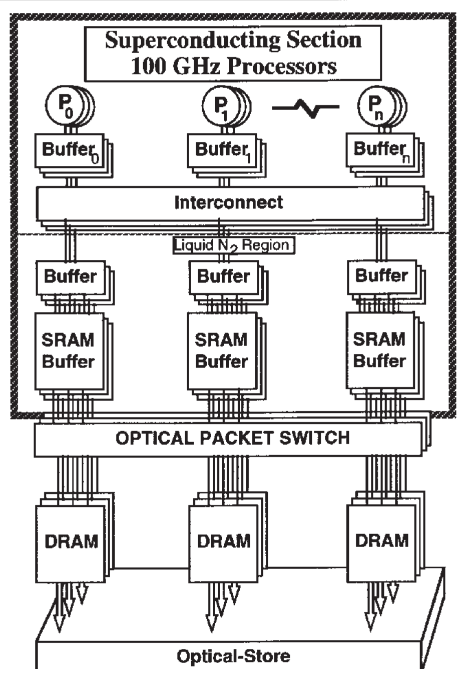
OFFICE OF THE CHIEF SCIENTIST

PETAFLOP POINT DESIGNS

- SP Hardware for Astrophysical Particle Simulations
- I-ACOMA: The Illinois Aggressive Cache-Only Memory Architecture for Multiprocessors
- Hybrid Technology Multi-Threaded Architecture
- MORPH: A Flexible Architecture for Executing component Software @ 100 TeraOPS
- Hierarchical Processors-and-Memory Architecture for HPC
- Scalable-Feasible Parallel Computing Implementing Electronic and Optical Interconnections
- Processors in Memory
- Architecture, Algorithms and Application for Future Generation Supercomputers

OFFICE OF THE CHIEF SCIENTIST

HTMT Architecture



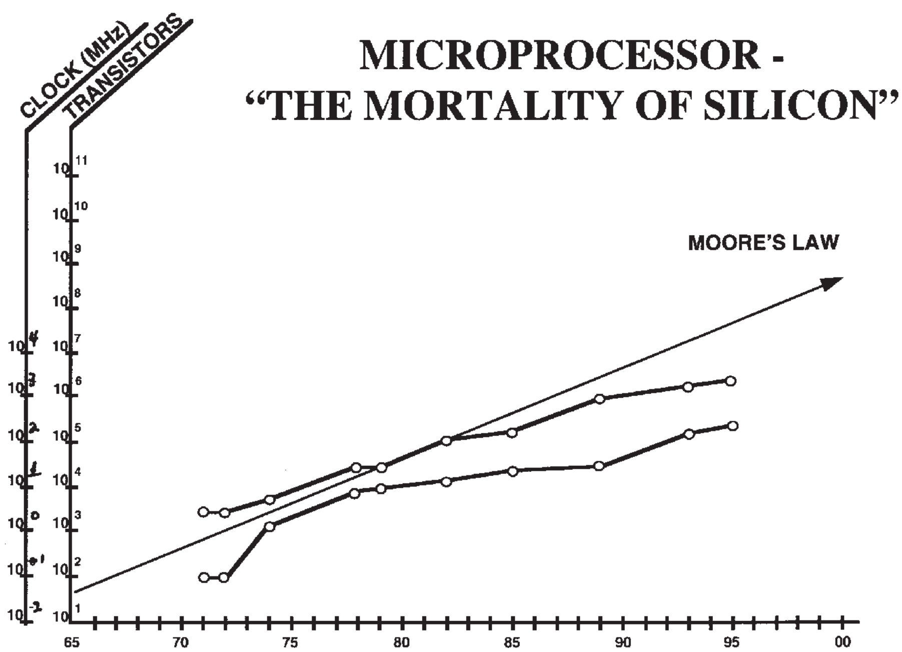
OFFICE OF THE CHIEF SCIENTIST

OVERALL ROADMAP TECHNOLOGY CHARACTERISTICS

Year of First DRAM Shipment Minimum Feature (µ m)	1995 0.35	1998 0.25	2001 0.18	2004 0.13	2007 0.10	2010 0.07	DRIVER
Memory Bits/Chip (DRAM/Flash	64M	256M	1G	4G	16G	64G	D
Logic (High Volume: Microprocessor) Logic Transistors/cm² (packed)	4M	7M	13M	25M	50M	90M	L(µP)
Logic (Low Volume: ASIC) Transistors/cm² (auto layout)	2M	4M	7M	12M	25M	40M	L(A)
Number of Chip I/Os Chip to package (pads) high perf.	900	1350	2000	2600	3600	4800	L, A
Number of Package Pins/Balls							
Microprocessor/controller	512	512	512	512	800	1024	µP
ASIC (high performance)	750	1100	1700	2200	3000	4000	A
Chip Frequency (MHz)							
On-Chip clock, cost-performance	150	200	300	400	500	625	µP
On-chip clock, high performance	300	450	600	800	1000	1100	
Chipt-to-board speed, high performance	150	200	250	300	375	475	L
Chip Size (mm²)							
DRAM	190	280	420	640	960	1400	D
Microprocessor	250	300	360	430	520	620	µP
ASIC	450	660	750	900	1100	1400	A
Maximum Power High performance with heatsink (W)	80	100	120	140	160	180	µP

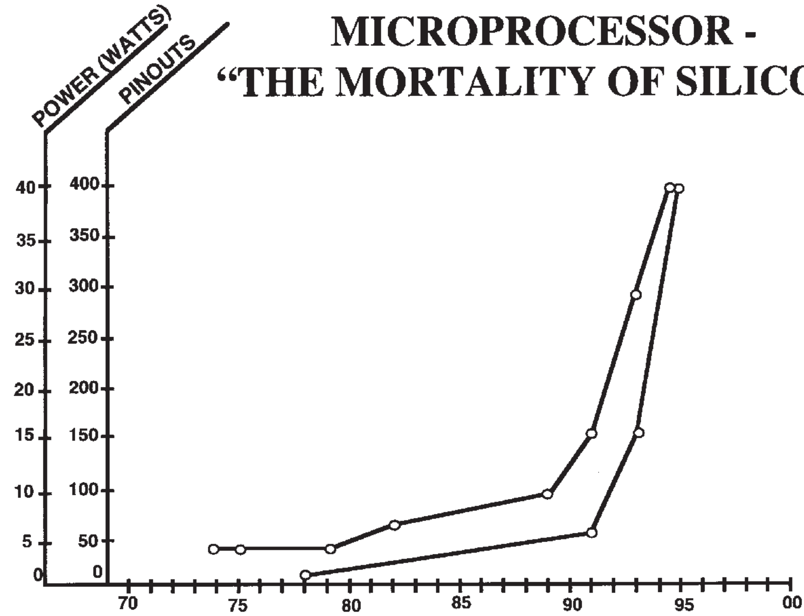
OFFICE OF THE CHIEF SCIENTIST

MICROPROCESSOR - "THE MORTALITY OF SILICON"



OFFICE OF THE CHIEF SCIENTIST

MICROPROCESSOR - "THE MORTALITY OF SILICON"



OFFICE OF THE CHIEF SCIENTIST

The Silicon-Based Microelectronics Patient May Be About To Go On Life Support . . . . .

ISSUES:

- Cost of Fabs ~$10B-Year 2000
- Growing Gap Between Processor & Memory Speeds
- Design Complexity - On Chip Integration
- Major Lithography Roadblock:
  - Extended Ultra Violet
  - Ion Beam
  - 1X Xray
- Impact on Tools
- Quantum Effects ~.05 Micron

WORKAROUNDS:

- Increased Speed; Power
- Multi-Chip Modules
- Microprocessor Parallelism
- 3D Arrays
- PIM

OFFICE OF THE CHIEF SCIENTIST

A STRATEGY FOR SURVIVAL

- Reinforce HPC as a Strategic National Asset
- Recognize High End of HPC is Primarily a Niche Market
- Focus HPC Research & Technology Programs in Critical Performance-limiting Areas
- Invest in Promising New Technologies
  - On critical petaflop path
  - Leverage work of others, e.g.:
    - Processing-in-memory
    - Superconducting processors
    - Optical networks
    - Advanced packaging concepts
    - Advanced interconnection techniques
    - Advanced storage concepts
  - Pursue Alternatives to Silicon aggressively
- Pursue Parallel Initiatives in System Software
- Continue, Enhance Long-term Architecture an System Design Initiatives
- Nurture the HPC Research Community

OFFICE OF THE CHIEF SCIENTIST

NATIONAL SECURITY HIGH PERFORMANCE COMPUTER PROGRAM

OVERVIEW

- GOALS:
  - Survivability, ultimately leadership, for U.S. HPC industry
  - Aggressive architectural & technological evolution to meet future national security mission needs
- COMPREHENSIVE INTEGRATED LONG-TERM EFFORT TO ENSURE:
  - Availability of highest end systems from U.S. industry for national security missions
  - Essential technology undercarriage for high end computing
  - maximum leverage of work of others
  - In partnership with industry
- STRUCTURE OF THE PROGRAM
  - Research Element
  - Technology Base Element
  - Architecture and System Design Element
  - Development and Engineering in Collaboration with Vendors

OFFICE OF THE CHIEF SCIENTIST

NATIONAL SECURITY HIGH PERFORMANCE COMPUTER PROGRAM

RESEARCH ELEMENT

PURPOSE: To challenge the research community to produce basic, enabling breakthroughs in materials, hardware and software, focused on national security system needs; 3-15 years out; Emphasis on proofs-of-concept.

STRATEGY: Maximally leverage work of other research consortia for critical systems software technologies

- Compiler research
- Language research
- Programming interfaces and libraries
- Tools research
- Algorithm research
- Operating systems research

OTHER CRITICAL HIGH-END RESEARCH ISSUES:

- Materials science
- Transition from silicon
- Superconductive processors and memories
- Support for massive multithreading
- Processor-memory imbalance
- Novel component (e.g., WSI, PIM)
- High-Speed interconnects, at several levels
- Advanced computing concepts (quantum, DNA, molecular nanotechnology
- HEC design and development tools

OFFICE OF THE CHIEF SCIENTIST

NATIONAL SECURITY HIGH PERFORMANCE COMPUTER PROGRAM

TECHNOLOGY BASE ELEMENT

PURPOSE: To ensure creation of the crucial building blocks of technologies for hign-end computing to support <u>all</u> program activities. Provide proof-of-value as opposed to proof-of-concept

STRATEGY:

- Fund Technology development as opposed to research, focused 10 years out
- Partnerships across academia, designers, technology industries, and the HPC vendor communities
- Creation of a High-End Computing Research and Technology Center, managing System Software Research Consortia, Supporting Mission-Direct Development and Engineering (MDDE) <u>and</u> Architecture and Design Program elements, strongly linked to HEC industry.

CRITICAL TECHNOLOGY ISSUES:

- Compiler infrastructure, modular, extensible
- Tools and performance monitoring infrastructure
- Integrated set of National Security Benchmarks
- Parallel technologies
- Refinements/improvements of vendors' software
- HEC-specific security systems
- Critical hardware technologies (semi, superconductors, 3-d memories, packaging, PIM, high-speed interconnects, optical components, I/O systems and advanced storage architectures

OFFICE OF THE CHIEF SCIENTIST

NATIONAL SECURITY HIGH PERFORMANCE COMPUTER PROGRAM

ARCHITECTURE AND SYSTEMS DESIGN ELEMENT

PURPOSE: Full-phase investigation of advanced architectures, systems design concepts and prototypes, employing the best-of-breed Research and Technology Base results; focused ahead of vendor products and product plans, up to 10 years out.

STRATEGY:
- Pursue 3 to 4 point designs competitively developed
- 3-year parallel investigative cycles to proof-of concept
- Teaming of architects, materials scientists, component developers, systems software experts and national security mission users
- Subsequent phases for full prototype development
- Bonding with industry for commercialization
- A PetaFLOP goal

FEATURES: Four Design Categories
- Baseline approach (leveraging COTS)
- Advanced hardware technology approach
- Merged architecture approach
- Other Novel approaches

Critical Software Issues
- Immediate software development
- Focused software development efforts
- Layered software architectures
- Targeting of key software show-stoppers

OFFICE OF THE CHIEF SCIENTIST

NATIONAL SECURITY HIGH PERFORMANCE COMPUTER PROGRAM

MISSION-DIRECT DEVELOPMENT AND ENGINEERING

PURPOSE: MDDE would be a critical link between a broad National Security HEC program and industry product-cycle efforts. It has the dual objective of flow-through of the results of the Program Research and Technology Base development efforts into the vendors' product lines <u>and</u> the leverage of vendor technologies into higher levels of performance.

STRATEGY:
- Leverage available commodity components with vendors
- Market results of Research & Technology Base programs into vendor product cycle
- Directly influence and accelerate vendors' systems designs
- Task other Program components for HEC technologies the market will not create.

CRITICAL TECHNOLOGY ISSUES:
- Processor access to memory
- High speed interconnects
- Scalable system software
- HEC tools and performance monitors
- Parallel/scalable I/O
- HEC storage system
- SPD interfaces/standards

OFFICE OF THE CHIEF SCIENTIST

SUMMARY

- HIGH END OF U.S. HPC INDUSTRY IS IN JEOPARDY
  - Cutthroat international competition
  - ROI does not support R&D
  - Research, advanced technology development is almost non-existent
  - One viable high end U.S. vendor survives
- NATIONAL SECURITY HEC MISSION NEEDS ARE BROAD; EXCEED VENDORS PLANS
  - Government market losing leverage
  - ASCI Program only bright note
  - Government R&D investment insufficient and not well focused.
- TECHNOLOGY FUTURES ARE FUZZY
  - Scalable low-mid range systems remains industry strategy for high end
  - HPC workshop results challenge the view
  - HPC will be first casualty of silicon slowdown
- COLLABORATIVE EFFORT BY NATIONAL SECURITY COMMUNITY APPEARS ESSENTIAL
  - Underpin Industry's efforts
  - Get in front in Research Technology Base & New Architectures
  - Very close collaboration with industry