LANL LLNL SNL
The 2004 Conference on
HIGH SPEED COMPUTING

Arctic Region Supercomputing Center (ARSC)

A DOD Resource Center since 1993
Serves DOD & Academe

Location – University of Alaska Fairbanks

Bill Buzbee
Owner, Buzbee Enterprises, LLC
Fellow, Arctic Region Supercomputing Center

Denali—"the Great one," North America's tallest peak, as seen from mile 135 of the Parks highway.
ARSC
Resources

Include

1.6 Teraflop Cray X1
8-processor CRAY SX-6
State-of-the-art Visualization
Sun Storage Servers
Storage Tech Silos

Coming soon – 5.0 Teraflop IBM Power4 System
A Few Words About Yours Truly

1962-87 – LANL, research and management
1987-98 – Director, NCAR Scientific Computing Div

Author/Coauthor ~ 20 refereed papers
   including 3 in *Science*
Numerous Boards and Panels
Charter member of SCxy Steering Committee
Chaired SC92

1998-present –
   Fellow, ARSC
   Owner, Buzbee Enterprises LLC

Soooo, this talk comes to you from retirement land!
Beware!
Beware!

Memory Xing!
Outline of the talk

A Worrisome Trend in the 70s
Options for Circumventing the Trend
Current and Future Challenges
By the Early 70s ..

A Worrisome Trend in the 70s

Genesis of this conference

1980 - Geo Michael becomes head of the Computing Research Group at Livermore
- Visits Los Alamos Computing Division and proposes collaboration
- At that time
  - supercomputing, and especially parallel computing, were novel -- even esoteric -- technologies;
  - the associated communities were relatively small;
  - the associated communities were not networked
So, to foster communication within the High Speed Computing community

George and yours truly sought a conference that

- would have a strong technical content, esp. the interaction of architecture, languages and algorithms
- would educate designers on applications
- would encourage one-on-one interaction
  - limited # of attendees
  - remote, but attractive, location
  - time for D&C (drinks & conversation)
The Site

1st Choice = Caribbean
George sends Gary Rodrigue to check out several possible sites
The Site

1st Choice = Caribbean
  George sends Gary Rodrigue to search
  Gary recommends
    Bluebeard’s Castle on St Thomas
LANL management says,
  “Keep looking.”
Summer ’80 – Amer Math Soc meets at Salishan
  One of George’s staff attends
Spring 81 – 1st conference
The Salishan Conference on High Speed Computing --

Is and outstanding 24 Year Success!

Congratulations and thanks to all who have contributed to it over the past 24 years!
Let’s Give George
A Standing Ovation!
And -- Sharonlee Danielson

To two men outstanding in their field . . .
A Worrisome Trend in the 70s

Options for Circumventing the Trend Included

- Change Device Technology
- Shorten the longest wire
- Incorporate parallelism into the processor
- Use several processors in parallel
Option #1
Change Device Technology

- 70s & 80s: ECL, e.g. Cray-1
- Early 90s: GaAs, e.g. Cray-3 and -4
- mid 90s: CMOS, e.g. SX-4
Top500 Report at SC2003*

*Highlights of the 22nd TOP500 List (Horst Simon/Erich Strohmaier), pa. 15
The March to New Technology Goes On

CMOS life is “around 7 to 10 years inline with the Industry Technology Road Map for Semiconductors.

Beyond CMOS, after 2010 to 2014, there will be new material challenges. …. These include Josephson junction technology, single electron transistor (SET), and single flux quantum (SFQ).”

Source -- Christopher Lazou, “QUANTUM COMPUTING REALITIES,” HPCwire, 01.23.04
Worlton’s Projection for 2000 = 1.0 GHz!

Graph showing the progression of cycles per second from 1950 to 2000. The graph includes two series, Series 1 and Series 2, with data points for AMD and Anthon. The approximation line is indicated by diamonds, and various machines are represented by different markers.
In a recent email, Jack noted, “… the Gompertz curve is used in growth studies where an exponential growth is followed by an approach to a limit; but then the pattern repeats, because some new impetus allows another phase of exponential growth, which also will reach its limit, etc., etc. ”
Option #2

Shorten The Longest Wire

Remember Grace Hopper’s definition of a nanosecond?
The Shrinking Footprint of Seymour’s Designs

Cray X-MP/48 circa 1986
Cray-3 circa 1993

Source -- History of Supercomputing at NCAR
http://www.scd.ucar.edu/computers/gallery/scdhistory.pdf
Thanks to Moore’s Law, The Shrinking Goes On

Overall, In the Past 24 Years

Remarkable progress in shortening the longest wire!

But execution bandwidth has only increased by an order-of-magnitude, e.g. Cray X-MP was a 100 MHz machine.
And Beware of Wirth’s Law*

“Software is slowing faster than Hardware is accelerating.”

Put another way,

“Groves giveth, and Gates taketh away.”

Hence, the need for parallelism.

Option #3
Parallelism in the Processor

- Instruction stack/cache
- Multiple registers/caches
- Multiple scalar units
  - Pipelined
  - Chainable
- Multiple vector units
  - Chainable
- Segmented and/or hierarchical memories

AKA “Superscalar”
## Parallelism in a Processor

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<th>System</th>
<th>Peak Mflops*</th>
<th>MHtz*</th>
<th>Peak Fl. Pt. Ops/cycle</th>
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<tr>
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*Jack J. Dongarra, Performance of Various Computers Using Standard Linear Equations Software, Computer Science Department, University of Tennessee, CS - 89 – 85, January 17, 2004
How Are We Doing?
Quite Well!

Some data from Netlib* for one processor

<table>
<thead>
<tr>
<th>System</th>
<th>Flop/cycle</th>
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</table>

Parallel Processing – Not a New Idea
L. F. Richardson’s Amphitheater

The following passage from Richardson's *Weather Prediction by Numerical Process*, published in 1922, illustrates his farsightedness. It is a description of a huge amphitheater filled with "64,000 computers to race the weather of the whole globe." (In Richardson's day, "computer" still referred not to a machine but to an individual using an abacus, logarithmic table or slide rule.

“...walls.. painted.. map of the globe...”
“...computers... work on... part of the map where each sits...”
“...large pulpit... sits the person in charge...”
“...each region... display.. values that neighboring... can read...”

*http://www.astro.uiuc.edu/classes/archive/astr496/s03_cacgraphics_0124.pdf*
Parallel Architecture – Lots of Academic R&D in the 70/80s

Some presentations at the 1983 PAW

Tagged Token Dataflow Machine - Arvind, MIT
UltraComputer Progress - Allan Gottlieb, NYU
Current Cal Tech Report - Lennart Johnsson, Calif. Inst. of Tech
HEP-1 Architecture - Harry Jordan, U of Colo
Parallel Processing Came of Age in 90s

For example, at NCAR

1988  Semtner-Chervin Global Ocean Model on X-MP/4

1992  Community Climate Model on Y-MP/8

By mid-90s, parallel processing was widely used in the weather forecast centers.
Distribution of Architectures, Top500 Report at SC2003

Ibid, pa 18.
How Well Are We(You) Doing?

Figure 1a. MM5 floating-point performance on various platforms. (1)See notes below. (Updated October 30, 2003).

http://www.mmm.ucar.edu/mm5/mpp/helpdesk/20030923.html
A New Source of Performance Data

“The Applications Performance Matrix project provides a rich source of information on the performance of high-performance computers applied to real science and engineering problems.”

http://www.appsmatrix.info/matrix/index.cgi

This site is maintained by the Krell Institute
Analysis Tools
This tabulation organizes data obtained by numerous investigators according to the manufacturer of the computer that was used. Each cell may collect the results from several experiments using different machines from a vendor running different algorithms applied to different data sets. In most cases it is not useful to read across a row to compare vendor performance for discipline specific computing since rarely do the numbers displayed refer to runs using the same data and algorithms.*

Ibid
Efficiency versus # Processors
All Application Areas
So, We’re Getting Good Efficiencies, The Problem is

<table>
<thead>
<tr>
<th>Science Disciplines</th>
<th>Cray</th>
<th>HP</th>
<th>IBM</th>
<th>NEC</th>
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</tbody>
</table>

NA = No Data Available
OM = Data Available in Other Metric
Current & Future Challenges

Job #1 = Teraflops Capability

It is vital that U.S. scientists and engineers have the best tools available – both in experimental science and in computational science.

Those with the best tools - win!
Current & Future Challenges

Job #2 = User Friendly
Complexity = Cost, In Time and $
“Models and the computational platforms that they run on have become extremely complex, leading to excessive time and resources dedicated to solving computational rather than scientific problems.”

*www.esmf.ucar.edu*
The Civilized Computing Platform

“The time required to learn how to use it is less than the time required to complete a major simulation on it.”

Charbel Farhat
U of Colorado
“Civilization advances by extending the number of important operations which we can perform without thinking about them.”

Alfred Whitehead

*An Introduction to Mathematics.*
And Yogi Concurs!

“Civilization advances by extending the number of important operations which we can perform without thinking about them.”

Alfred Whitehead
An Introduction to Mathematics.

“How can you hit and think at the same time?”

Yogi Berra
Summary – Those With The Best Tools Win!

Over the past 25 years
Tremendous progress in advancing high speed architectures

Over the next 25 years, it is vital that U.S. scientists and engineers have world-class, user-friendly tools – in experimental science and in computational science!
Good Luck and Best Wishes

In advancing high speed computing!

Denali—“the Great one,” North America’s tallest peak, as seen from mile 135 of the Parks highway.