科技资料

Singapore Superc Mputing Conference '90

SINGAPORE
SUPERCOMPUTING
CONFERENCE '90

SUPERCOMPUTING FOR STRATEGIC ADVANTAGE

江苏工业学院图书馆
藏书章

11 – 12 December 1990

Edited by

Kang Hoh Phua and Kia Fock Loe

Department of Information Systems and Computer Science
National University of Singapore

World Scientific
Singapore • New Jersey • London • Hong Kong

Published by

World Scientific Publishing Co. Pte. Ltd.
P O Box 128, Farrer Road, Singapore 9128
USA office: Suite 1B, 1060 Main Street, River Edge, NJ 07661
UK office: 73 Lynton Mead, Totteridge, London N20 8DH

Library of Congress Cataloging-in-Publication Data

Singapore Supercomputing Conference '90
Singapore Supercomputing Conference '90: supercomputing for strategic advantage, Singapore, 11–12 December 1990/edited by Kang Hoh Phua & Kia Fock Loe.
p. cm.
ISBN 981020700X
1. Supercomputers--Congresses. I. Phua, Kang Hoh. II. Loe, K. F. (Kia Fock). III. Title. IV. Title: Supercomputing for strategic advantage.
QA76.88.S56 1990
004.1'1--dc20 91-18998
CIP

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Printed in Singapore by JBW Printers and Binders Pte. Ltd.

Preface

The purpose of the Singapore Supercomputing Conference is to provide an atmosphere in which supercomputing system researchers, designers, developers, managers, users, and engineers can meet and interact. Discussions of new technological developments, exchanging of information and research findings, reporting on advances and experiences, and suggesting of future directions in the supercomputing arena, are encouraged. The theme for the Conference is "Supercomputing for Strategic Advantage". The Conference includes a broad technical program covering current results in a variety of disciplines, in-depth invited addresses by renowned authorities in respective specialized fields, and contributed papers from different countries reporting on effective applications of supercomputing.

This supercomputing conference was jointly organized by the National University of Singapore (NUS), the Nanyang Technological Institute (NTI), the National Computer Board (NCB), and the Singapore Computer Society (SCS). The conference was held at the Pan Pacific Hotel from 11-12 December 1990 and is organized in conjunction with Singapore IT week.

There were more than 300 participants from over 10 different countries participated in this conference. A total of 35 papers were presented at the Conference. This book is divided into 14 sections in accordance with the proceedings of the Conference. Papers are grouped into the following areas:

- o Keynote Addresses
- o Trends in Supercomputing
- o Supercomputing Applications
- o Graphics and Visualization
- o Parallel Algorithms and Scheduling
- o Design and Development

It is hoped that the papers will be of interest to researchers and practitioners in the area of supercomputing and that there will provide some useful information on recent developments in supercomputing.

The Editors

SPEECH BY THE GUEST OF HONOUR, DR LEE BOON YANG, SENIOR MINISTER OF STATE FOR DEFENCE, SINGAPORE, AT THE OFFICIAL OPENING OF THE SINGAPORE SUPERCOMPUTING CONFERENCE '90

Distinguished Guests, Ladies and Gentlemen,

I am delighted to be here today to officiate the opening of Singapore Supercomputing Conference '90, the first of its kind to be held in Singapore. This event marks an important milestone in the efforts by Singapore to harness the power of the computer in our next phase of national development.

We live in a technologically advanced era where high performance computing provides a competitive edge. It solves problems, which cannot be tackled meaningfully or at all on the smaller computers. It can, if used innovatively, eliminate expensive experimentation and the construction of costly physical models. This is most relevant and beneficial to us in Singapore given the limited size and resources of our industries.

In fact, with the entry of the Japanese into the supercomputer market which was formerly the preserve of the Americans, supercomputing has become an issue of national pride and a symbol of technology leadership. While as smaller nations, we cannot aspire to build supercomputers, we can certainly seek ways to effectively use it to advance our industrial and national activities.

A good example of its use is in weather modelling and prediction in meteorology. If it takes 24 hours to compute or predict what happens 12 hours later, then the effort is of no practical relevance. Speedy computation is thus of great significance. The supercomputer would enable such computations to be completed within minutes. This would enable the prediction to be updated more frequently. In addition, the larger memory capacity of the supercomputer would also allow larger and finer modelling to be carried out for better accuracy. Such quality data are most relevant and practical for the movement of airlines and ships, both of which are vital to Singapore. Other potential uses to which supercomputer power can be applied are in the areas of biotechnology to study molecular structures for drug design and in the aerospace industry for aircraft design, just to name a few.

The rapid progress made in using the supercomputer makes the holding of this conference both timely and important. As the cost of the supercomputer declines and the knowhow to use it proliferates, the desire to use the supercomputer

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increases. This is already happening in the developed countries. Fortunately, this trend has also made the supercomputer a tool no longer confined to developed countries. Others can exploit supercomputing too. However, in the case of Singapore, there is a need to create greater user awareness in order to get our industry to make more use of supercomputers. At the moment, most of our users are from the universities and the government sector.

The trend to put supercomputing power into small computers augurs well for its usage. This will put the power into the hands of the end users. It has been predicted that supercomputing power on desktop machines will become a reality within five to ten years' time. In fact, prototype models of such machines have been developed.

In the next stage of our development, I envisage that the distributed computing resources in the country will be linked together in nationwide networks. In this way, not only will supercomputing power be made more accessible to network users, but they will also have access to common and shared databases of knowledge. Singapore will develop into a regional hub. It will also allow Singapore to access knowledge on a worldwide basis to support our research and development of new applications.

However, I foresee three major difficulties that potential users will face: first the access to supercomputing power, second the lack of skilled manpower, and third the initial high entry cost. For the first difficulty, we have encouraged the establishment of the Advanced Computation Centre, a service bureau that has two supercomputers. For the remaining two difficulties, the Government is in the process of establishing the National Supercomputing Resource Centre, which will be tasked with manpower training, the promotion of user awareness, and helping users to explore supercomputing applications through joint projects.

The holding of this conference is an achievement on the part of the pioneers of supercomputing in Singapore. Although we have been using the computer in the last few decades, our foray into the realm of the supercomputer is short. It was barely two years ago that we installed our first supercomputer. And in that short period of time, we have already achieved a fairly wide user base which is sophisticated enough to present a wide range of applications that this conference programme can testify.

I must congratulate the organisers for their achievement in not only organising this conference, but to do so on such a large scale and in an international perspective. They have packed into the two-day programme many interesting topics with speakers from around the world including the United States, the United Kingdom, Australia, Japan, the Netherlands and Indonesia. I have also been told by the organisers that we also have a wide spread of participants from several countries.

Supercomputing is an advanced technology that Singapore and the surrounding region must seek to absorb and use. On this note, I would like to close by wishing you happy and fruitful deliberation on this exciting technology over the next two days.

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NASA's SUPERCOMPUTING EXPERIENCE

F. Ron Bailey
NASA Ames Research Center
Moffett Field, CA 94035, USA

ABSTRACT

A brief overview of NASA's recent experience in supercomputing is presented from two perspectives: early systems development and advanced supercomputing applications. NASA's role in supercomputing systems development is illustrated by discussion of activities carried out by the Numerical Aerodynamic Simulation Program. Current capabilities in advanced technology applications are illustrated with examples in turbulence physics, aerodynamics, aerothermodynamics, chemistry, and structural mechanics. Capabilities in science applications are illustrated by examples in astrophysics and atmospheric modeling. The paper concludes with a brief comment on the future directions and NASA's new High Performance Computing Program.

1. Introduction

The National Aeronautics and Space Administration (NASA) has for many years been one of the pioneers in the development of supercomputing systems and in the application of supercomputers to solve challenging problems in science and engineering. Today supercomputing is an essential tool within the Agency. There are supercomputer installations at every NASA research and development center and their use has enabled NASA to develop new aerospace technologies and to make new scientific discoveries that could not have been accomplished without them.

NASA's experience with advanced supercomputers began in the 1970s with the installation of the Illiac-IV parallel computer at Ames Research Center and the CDC STAR-100 vector computer at Langley Research Center. These two systems were the first of a new generation of high-performance computers designed to achieve dramatic performance increases through the architectural innovations of parallel and vector processing. Although these systems were marginally successful, they provided a valuable testbed environment in which to learn to effectively use parallel and vector computing techniques. Architectural investigations continued into the 1980s with the development of the Massively Parallel Processor, a massively parallel SIMD processor system, at Goddard Space Flight Center, and the Cosmic Cube/Hypercube, parallel MIMD systems, at the California Institute of Technology and NASA's Jet Propulsion Laboratory. In the 1980s NASA also established the Numerical Aerodynamic Simulation (NAS) Program to pioneer supercomputing technologies and make them available to the aerospace community. The NAS Program, for example, acquired the first full-scale Cray-2 and first Cray YMP computer systems and developed the first supercomputer UNIX environment.

NASA's involvement in supercomputing applications also began in the 1970s. Acquisition of the Illiac-IV, STAR-100, and Cray-1 computers spurred the development of innovative parallel computing algorithms. New computational disciplines, such as computational fluid dynamics and computational chemistry soon emerged and it became clear that supercomputers were a truly enabling technology. Today, supercomputers are being applied routinely to advance technologies in aeronautics, transatmospherics, space transportation, and space exploration, and to study the Earth, other planetary systems, and objects in outer space.

The purpose of this paper is to provide a brief overview of selected NASA activities in supercomputing from two perspectives: supercomputing system development and supercomputing applications. The NAS Program is used as an example of NASA's effort to remain at the leading edge of supercomputing system technology and bring this technology to the aerospace research and development community. NASA's use of supercomputers in advanced technology applications is illustrated through examples in turbulence physics, aerodynamics, aerothermodynamics, chemistry, and structural mechanics. Examples in atmospheric science and astrophysics are presented to illustrate supercomputing applications in science. Finally, the paper concludes with a look into future directions in high-performance computing.

2. Numerical Aerodynamic Simulation Program

The NAS Program[1] has two major goals. The first goal is to provide a national computational capability that is available to NASA, Department of Defense (DOD), other government agencies, industry, and universities, as a necessary element in ensuring continued leadership in computational aerodynamics and related disciplines. The second goal is to act as a pathfinder in advanced large-scale computing capability through systematic incorporation of state-of-the-art improvements in computer hardware and software technologies. The NAS Program began full operation in 1986 and today provides service to over 1700 users at 133 locations in the United States.

The NAS complex of computers, called the NAS Processing System Network (NPSN), is shown in Fig. 1. It currently includes Cray-2 and Cray YMP/8128 supercomputers, an Amdahl 5880 mainframe computer and associated mass storage system with 2.3 terabytes of on-line capacity, 5 VAX minicomputers, 80 Silicon Graphics workstations, a 32,000-processor Connection Machine parallel computer, and a 128-processor Intel Touchstone Gamma prototype parallel computer. All computer systems are linked through an extensive local area network combining Ethernet, HYPERchannel, and Ultranet technologies to provide hardware data rates ranging from 10 to 800 mbits/sec. All computers operate under the UNIX operating system with DOD internet (TCP/IP) network communications provided via the well-known Berkeley UNIX "r" commands. Thus, a user can access any computer, run jobs, and transfer data among computers using

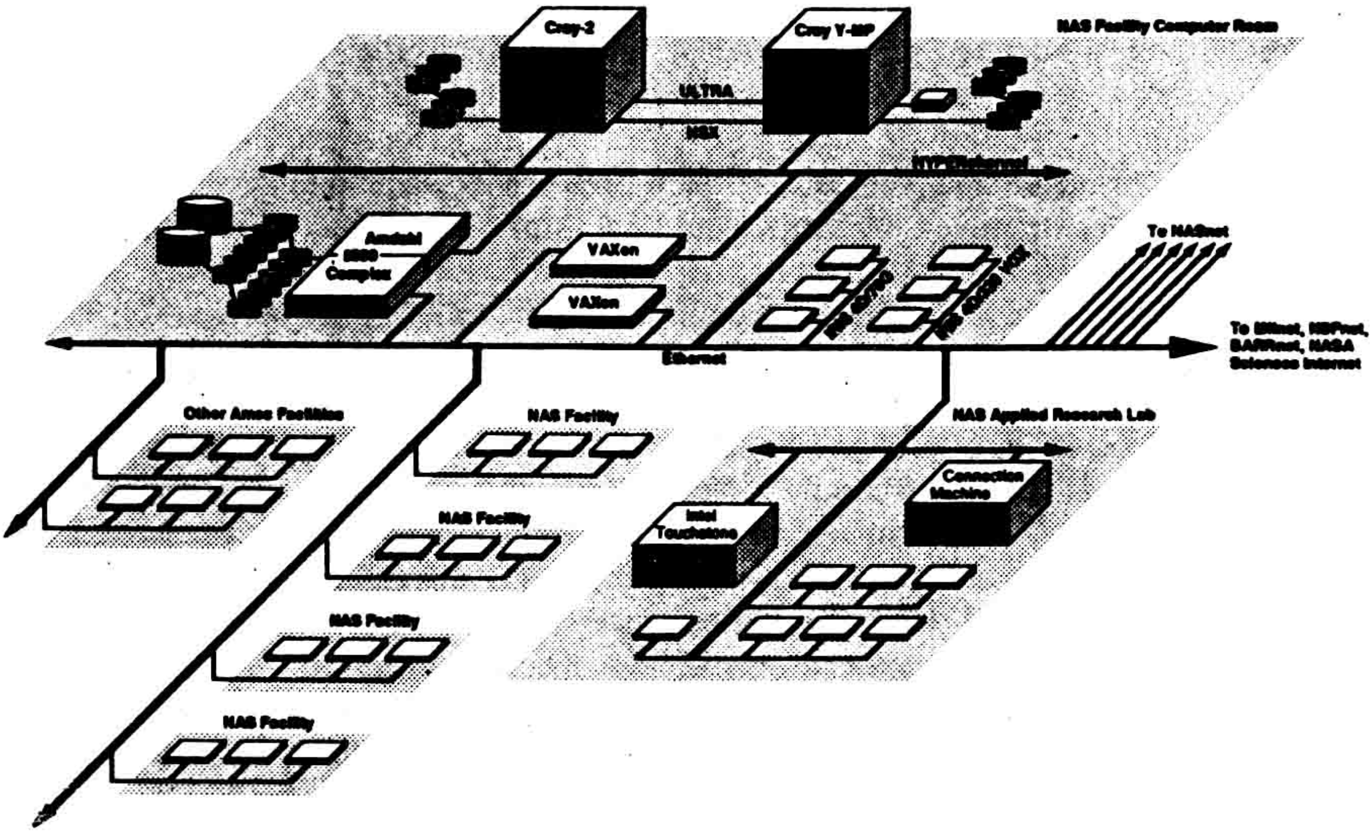

Fig. 1 NAS Processing System Network (NPSN).

a single set of commands on all computers. A more complete description of the NPSN is given in references 2 and 3.

Remote users access the NPSN through a wide choice of existing national communication networks including the DOD-sponsored MILnet, the National Science Foundation-sponsored NSFnet, and NASA's Science Internet. NAS is also a member of the Bay Area Regional Research Network that provides 1544 kbits/sec links between Ames Research Center, Bay Area universities, Department of Energy laboratories, and industry. MILnet is the main communication path to DOD laboratories, while NSFnet, and BARRnet serve the university community. For NASA and aerospace industry users, NAS has developed NASnet. NASnet uses Ethernet bridging technology to provide fast response and high throughput to remote graphics workstation users. NASnet currently serves 31 remote sites at bandwidths ranging from 56 to 1544 kbits/sec.

The NAS Program's experiences in advanced supercomputer technology began in 1984 when it decided to acquire Cray Research, Inc.'s Cray-2 computer, which was in design at the time. NAS, in collaboration with the Department of Energy, began prototype testing in 1985. In late 1985, NAS took delivery of the first full-scale Cray-2 configuration. This system had a memory capacity of 2.048 gigabytes (over 268 million 64-bit words) which was 34 times the central memory capacity of the Cray XMP/48. The Cray-2's very large memory, coupled with its ability to sustain a computing rate of 250 million

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