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The High-Performance Computing Environment and NCHC — Status and Outlook

Abstract

This paper describes the status and plans for the supercomputer application research environment and the role of the National Center for High-performance Computing in Taiwan, Republic of China. A decent high-performance computing environment involves significant planning and investment, and is usually undertaken as a national effort. In Taiwan, Republic of China, the national supercomputing facility began operations in March 1993. This project is carried out by the National Science Council, under which the national laboratory of National Center for High-Performance Computing (NCHC) has been established. State-of-the-art computing systems have been installed in NCHC, and major research universities and institutions in the nation are linked by high-speed networks. These computing facilities and applications software are supported by NCHC staff with expertise in various disciplines of high-performance computing. Equally important to providing computing infrastructure is the high-performance computing development strategy under the fast pace of technological advancement, and NCHC plays a shaping role in this aspect as well. It is expected that, with the founding of NCHC, research infrastructure in Taiwan will be able to catch up and become comparable to advanced international standards, and in the meantime opens the door to effective supercomputing application research in Republic of China.

1. Introduction

In addition to being faster than conventional computing systems, supercomputers are noted for their high speed in certain types of operations, namely, those of vectors and matrices. With special computer architecture combined with fast processing cycle times, the supercomputer outperforms conventional high-end mainframes by a factor of 10 or more in scientific and engineering computations, as more and more business-oriented applications find supercomputers to be equally suitable as well. Moreover, supercomputers are often equipped with multiple CPUs, and parallel processing on a single computing task further stretches the turn-around time benefits. In recent years, the hardward and software on supercomputers have matured and become a daily necessity in certain application fields, such as computational chemistry or computational fluid dynamics, among others.

On the other hand, it is evident that with advances in workstation and massively parallel systems, the term "high-performance computting" will embrace these catagories of technology and become much more cost-effective, and hence will dominate a significant portion of computing in the scientific and engineering fields. Future computing will require proper integration of supercomputers, superworkstations, and massively parallel systems into a single transparent and coherent environment.

2. Background

Japan and the U.S. were among the first nations to set up area centers for high-speed computing. These centers have since become so important in the infrastructure of academic and industrial research that more centers have subsequently been founded. Now the availability of high-speed computing tools stands for the efficiency of research and competitiveness for academia and industry. In Taiwan, R.O.C., the national supercomputer center project was finalized in 1989 after careful studies by first the National Science Council (NSC) and then the Ministry of Education (MOE). These two feasibility studies gave consistent conclusions and recommendations on the establishment of such a center, and the preparation was trusted to the National Science Council because of the flexible nature of the NSC's budget. A detailed proposal was submitted to the Executive Yuan

(EY) in late 1989. The EY committee, consisting of heads of major Ministries, all supported such a national endeavor and requested only minor revisions on the proposal. The final approval was given in early 1991. The proposal calls for a national laboratory, namely the "National Center for High-Performance Computing (NCHC)," to be established under NSC for the preparation, planning, promotion, and operation of the supercomputing facility.

3. Proposal Summary

The goal of NCHC is to provide the research community of academia and industry with the latest high-speed computing tools, to support such research activities with high-quality promotion and consulting, and to lead the research with advanced computing concepts. It is not the goal, however, to build the R.O.C.'s own supercomputer system. The proposal approved gives the suggested configuration of NCHC in five-year stages. The current proposal defines the scope for the fiscla years 1991-1995. In this proposal, it is suggested that NCHC be founded in Hsin Chu Science Park with its own exclusive building, and the total five-year budget is about US$80M. Half of the budget is allocated for computer hardware systems and software.

With a current staff size of 75 as of mid-1994, NCHC will finally be staffed with over 100 personnel, and is similar in scale to the NSF (National Science Foundation) national centers in U.S. NCHC is organized with a full-time director appointed by NSC. Under the director are two deputy directors and five divisions: administration support, operation, systems software, promotion and education (P&E), and research and development (R&D). The last two divisions distinguish NCHC from other computing centers in Taiwan and highlight NCHC's focus in applications.

4. Facilities

The computing engine of NCHC includes a high-end supportcomputer, a front-end minisupercomputer, and various models of high performance workstations. The workstations are used both for computing and visualization. Expansions are made each year to ensure that NCHC systems are at the forefront of the latest mature computing technology, so the research community in Taiwan will always have access to the latest computing tools. Major supercomputer vendors in the world competed aggressively for these computing engines. These vendors were rigorously screened in terms of their hardware and software capabilities,but the final selection was focused on the vendor's commitment to cooperation with NCHC in promoting the high-performance application technology, to be achieved through the use of these proposed computer systems as the medium for reaching the academic and industrial users. The intention is to bring in vendors' application and technical expertise to the local research community. Currently NCHC is equipped with the following facilities:

♦ IBM ES-9000/860: a five-processor vector computer system running native Unix system, AIX / ESA. It contains main memory of 512MB, expansion memory (used for paging / swapping) of 2GB, and disks of over 110GB.

♦ Convex C3840: a four-processor vector computer system running ConvexOS. It contains main memory of 512MB, and disks of over 60GB.

♦ STK Tape-Silo: a robot-operated tape silo system using the UniTree software. Using tape cartridges, this system gives a storage capacity of 4.8TB. The cartridges are bar-coded, and could be automatically identified and retrieved by the robotic arms. Any file in the tape silo may be located within 30-seconds of request. This device is a "near-line" system for user file backup and database archives.

♦ IBM SP1: a 16-node parallel computer system, with each processor containing 128MB local memory and 2GB disk space. Processors are connected with a proprietory FALCON switch. The system has a file server RS6000 / 570 with a disk array of 20GB for fast file access and 12GB for file storage.

♦ Convex Meta Computer: a 8-node parallel computer system, with 128MB of memory and 1GB of local disk in each processor. The processors are connected via a "Shared Memory Interconnect (SMI)" for processor communications.

♦ DEC Alpha-Farm: an 8-node parallel computer system, with 128MB of memory and 1GB of local disk in each processor. In addition, 3GB of disk storage is available on the control file server.

♦ Computing Servers: a number of high-end workstations including IBM-RS6000 (Model 580's and 590's), HP-9000 (Model 735's), and Sun SPARC-10's.

♦ Visualization Servers: a number of Silicon Graphics Incorporated (SGI) workstations.

♦ Video-Taping Facility: a set of video-taping equipment is available and is connected to the NCHC network. Users may submit their image files for producing color hardcopies or videotape production.

♦ File Servers: a number of Sun SPARC's offering user file storage. These systems are also used as the servers for user's environment, such as windows, word processors, e-mail connections. Chinese input output capabilities also exist. Connected to these servers are desktop entry-level workstations in individual offices used by NCHC staff.

♦ Instruction Facilities: all the systems described above are available, in addition to being used for research and instruction classes. They are accessed by and used in conjunction with a number of monochrome and color workstations.

The overall configuration is given in Figure 1.

NCHC is also introducing highly parallel systems with low-cost processor technology. The maturity and potential of these new systems will be examined and will be properly scaled to become an integral part of NCHC's computing environment.

5. Network

Since NCHC serves almost all major universities and industrial research institutions in Taiwan, a fast and stable network is the key factor to the success of NCHC. All major devices in NCHC are networked with FDDI[1], and externally linked by high-speed computer networks with these major institutes. Taiwan has already implemented TANet[2] through MOE's sponsorship and is part of the worldwide Internet. NCHC's contribution to TANet circuits increases the bandwidth and stability of TANet significantly. T3-based and high-speed frame-relay circuits constructed by the Telecommunications Bureau is already in place. NCHC is planning to take advantage of this technology and in

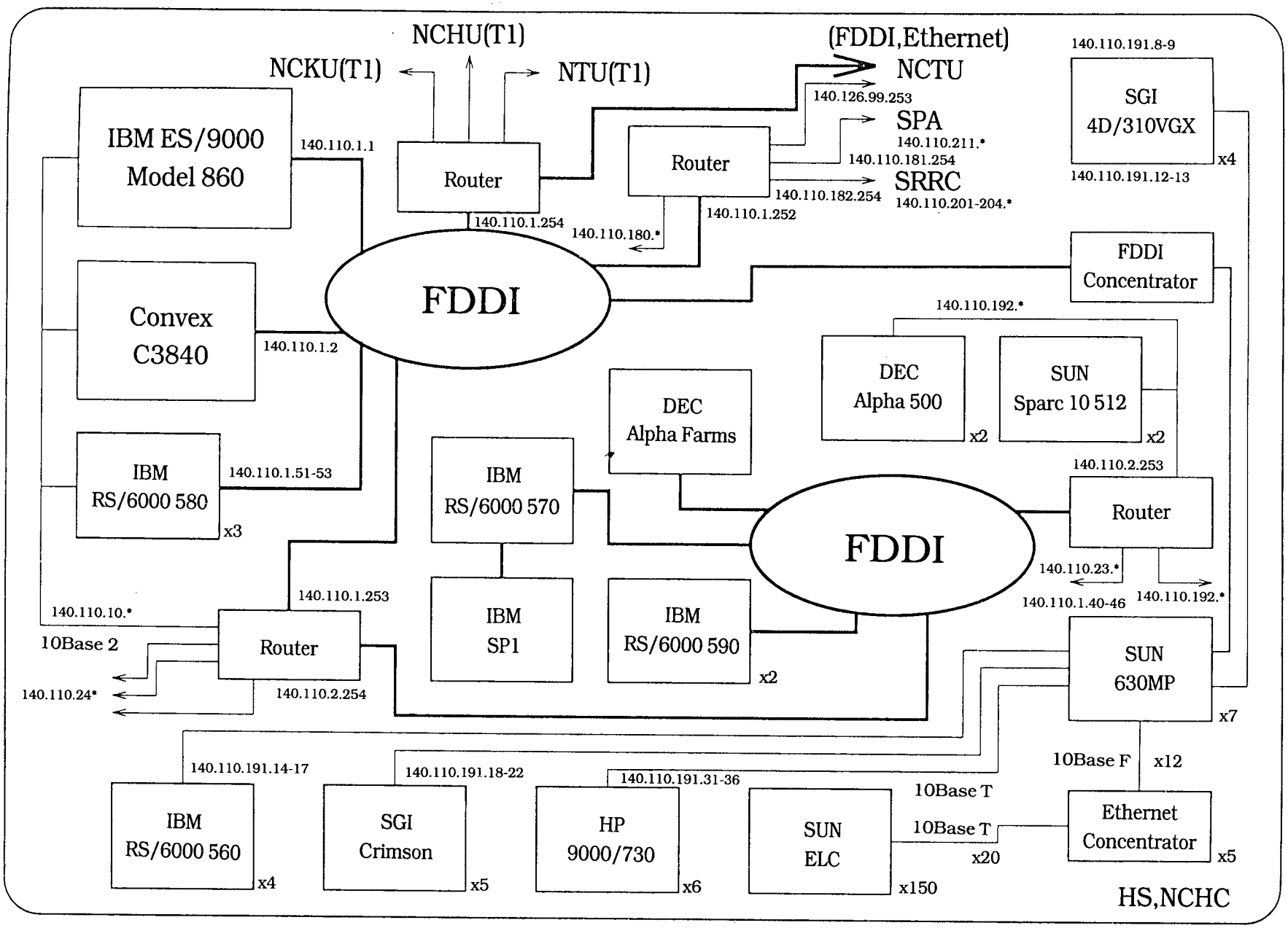

Figure 1. The Network Topology of the National Center for High-Performance Computing

the meantime set up additional dedicate networks for major research institutes.

6. Expertise

Double talents is the basic recruiting requirement for NCHC research and promotion staff. The staff are already trained in a certain application field, such as structural analysis, and have good knowledge about computer architecture and programming. Advanced computing methods will get across to the NCHC enduser more quickly when staff with such abilities are consulting and helping users of similar fields because they speak in the same language. The NCHC staff majors are divided into two catagories: *supporting* and *direct application.* The former consists of fields such as numerical methods, visualization, physics, and computer technology. Current emphasis in the direct application category includes computational chemistry, molecular modelling, structural mechanics, computational fluid mechanics, semiconductor design and simulation, etc.

7. Research Promotion

The field of *computational science and engineering* has come into existence mainly due to the emergence of high-performance computing tools. This field has been non-existent in Taiwan due to a lack of proper research tools. Disciplines of computer applications are largely ignored, and hence expertise on computing methodology and numerical analysis in these application fields are rare. In the process of preparing the NCHC proposal, NSC has created a number of intensive short courses relating to high-performance computing which have been well-received. These courses are still being conducted and have become an integral part of NCHC's service. When the supercomputer begins operations, Taiwan will already have enough people able to use the system properly. By June 1993, both the IBM and the Convex systems were fully loaded. Several measures are being implemented to expedite the progress from *using to researching* high-performance applications.

♦ Funding is given to university faculties in porting and tuning their existing codes for vector and parallel processing to fully utilize the performance potential of the computer systems.

♦ User groups in specific fields are organized by NCHC. These groups identify their hardware and software requirements to NCHC and communicate with each other on effective ways to apply the computing tools.

♦ NCHC is requiring computer vendors to provide application research support strategy and exchange opportunities to the Taiwan academic community. Through this the Taiwan researcher will be able to access worldwide resources and exchange experience with colleagues in their fields, and local researchers will spent leaves in advanced institutes around the world for special topics.

8. Relations with Industry

NCHC has the obligation to promote the use of high-performance computing technology for the purpose of industrial application. This is carried out in the form of training courses, special consulting, and joint projects. NCHC takes advantage of international channels and resources available and applies them to the specific discipline of cooperation. Favorable terms are provided in terms of computing resources and manpower so that lower demands on the initial investment are required from the industry. This allows the industry to expedite the adoption and the application of computing technology to their product development.

9. National Policy

As NCHC is equipped with the most advanced computing platform in the nation, experiments and prototypes of a *balanced computing environment* will be implemented and experience shared with other institutes. Integration of proper computing tools will be demonstrated and implicitly shape the national policy toward effective utilization of available funding and resources. NCHC will also lead the inception of a software park concentrated on high added-value application software. The incentive for software investers to set up development capability around NCHC comes mainly from easy access to advanced computing platforms, support from nearby universities, well-educated manpower of versatile expertise, and various channels available through NCHC. It is hoped that through the establishment of this software park, Taiwan may open the door to a new market of technological concentration.

10. Conclusions

With the founding of NCHC, Taiwanese academic communities will be able to perform efficient and effective research, and industries will be able to upgrade their design methodology. With sound planning and focused investment, NCHC will evolve into an international resource of versatile functions. In a word, the Republic of China joined the international supercomputing community in 1993 and is aggressively trying to evolve into an international member that is not to be overlooked.

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