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Beowulf Cluster Systems in Academic Environment at Kasetsart University

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ABSTRACT

In the past, having a supercomputer seems to be impossible for a university in Thailand due to the high cost of the system. There used to be only one or two supercomputers in the whole country. This situation severely limits the application of computational science for the industry and the growth of researches in this area. Recent adoption of Beowulf clustering technology has changed the situation dramatically, especially at Kasetsart University.

This paper presents the use of Beowulf Cluster System to support academic activities at Kasetsart University, Bangkok, Thailand. The background, history, and development of Beowulf related activities are discussed. Currently, the cluster system has been used to support computer engineering courses and many general-computing services at the university level. In addition, many research projects that never been existed before, have started with the building of this new cluster system. From our experiences, Beowulf cluster systems are very useful tool that open many new opportunities for research and teaching in our organization.

Key words: supercomputer, Beowulf Cluster, clustering technology

INTRODUCTION

Kasetsart University, the second oldest university in Thailand, was established on February 2, 1943. The University curricula cover the areas of all science, arts, social science, humanity, education, engineering, and architecture. Kasetsart University currently consists of 7 campuses around the country of Thailand and the number of enrolled students at all levels of study is around 23,000.

The university computing services such as registration, information services, networking infrastructure are the responsibility of the Office of University Computer Services. There are two main computer programs offered by the University. One is the Computer Engineering Program under Faculty of Engineering. The other is the Computer Science Program offered by the Faculty of Science. Both offered up to Master degree level. By next year, there will be a Ph.D. program by the Department of Computer Engineering. Most of the computing researches have been conducts by these two departments. There are also several HPC research groups working on Computational science related project such as Computational Fluid Dynamics, Chemical Engineering simulation, and Molecular Dynamics.

In the past, High Performance Computing was considered by many as too costly to be widely practiced in Thailand. Most of the high performance computing activity has been done by only a small group of people that use small supercomputing

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machines operated by High Performance Computing Center (HPCC), National Electronics and Computer Technology Center (NECTEC). At that time, there were only few universities that have a small supercomputer. These universities include Kasetsart University, KMIT Ladkrabang, and KMUTT. These supercomputers have about 4-6 processors per machine only and offer computing power less than 2 Gigaflops.

Several problems limit the widespread research on computational science. These problems are:

- The inadequately powerful high performance computing platform to solve large scientific problems. The reason is that supercomputer is too costly for most organization in Thailand.
- The lack of man power in this area. Also similarly to the first problem, it is rather difficult to solve this situation.
- The lack of funding and industrial connection.

As Beowulf class cluster (Stering et al. 1995) becomes widely used by organizations around the world, the problems mention above can be resolved. Because of the high performance and low cost of the system, Beowulf technology seems to be a low-cost supercomputing solution for researchers in Thailand. Hence, there is a need to explore the use of this technology to serve the computing needs in Thailand.

MATERIAL AND METHODS

Beowulf Cluster development at Kasetsart university

To explore the great potential of clustering technology, a research laboratory called Parallel Research Group has been founded in 1996 as part of a main research laboratory named Computer System and Network Research Laboratory. The mission of this research group is to study the use of clustering technology to build a low-cost and high performance computer from commodity components. The research conducts about cluster computing technology have produced many results. Furthermore, many cluster systems have been built with the continuously growing capacity. The computing power of the best cluster system at the time is as shown in Figure 1.

Figure 1 shows the computing power in Megaflops that was measured using Linpack. The first cluster systems has been built in 1996 using five of the thrown away IBM PC 486sx. Since then, increasingly powerful cluster has been built to served the research and teaching requirements. Due to the rapid progress of the commodity hardware, it becomes easier to build a much more powerful cluster system. This year Paralhl Research Group has successfully integrated a large cluster called PIRUN, which consists of 72 nodes. Hence, within only five years, the most powerful cluster is 5000 times more powerful than the first one. The configuration information about current cluster systems in use at Kasetsart University is listed in Table 1.

PIRUN Beowulf Cluster: The fastest supercomputing system in Thailand

To cope with the increasing demand for computing power and Internet access in the university. Kasetsart University decided to build a large 72 nodes PC cluster system called PIRUN (Pile of Inexpensive and Redundant Universal

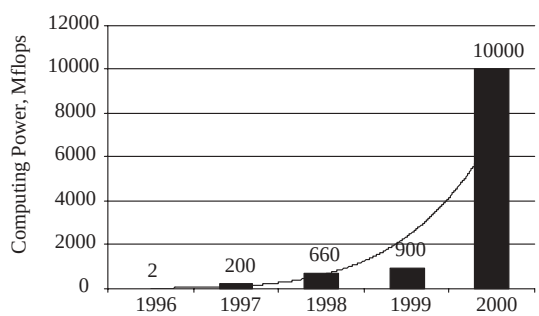

Figure 1 Computing Power of the Best Cluster System from 1996-2000.

Table 1 Current cluster system at Kasetsart university.

System	Nodes	Mem/ Nodes (MB)	Processors type	Interconnection	Total storage	Performance	Usage
PSI	3	64	Pentium Pro200	Fast Ethernet Switch	15Gbytes	150Mflops	General IT, Web
LIFE	4	128	PII450	Fast Ethernet Switch	80Gbytes	400 Mflops	HA +Web Research
AMATA	9	512	8 Athlon 550Mhz + one 1Ghz	Fast Ethernet Switch + Myrinet	400Gbytes	3.1 Gflops	Research in Driver, HA, HPC
SMILE	15	64	Pentium II/350, 400	Fast Ethernet Switch	30Gbytes	900Mflops	Teaching Parallel Programming
PIRUN	72	128	PII500	Fast Ethernet Switch	Diskless node/ Around 200 Gbytes on file servers	10 Gigaflops	Internet server, university general services

Nodes) Beowulf Cluster in 1999. The plan is to use this system as a central computing facility and large-scale test based for clustering technology. This project is the collaboration of KU Research and Development Institute, Faculty of Engineering, and Computing Service Center. The goals of this project are:

- Building a system that serve as a centralize Internet super-server for more than 15,000-20,000 Internet users in Kasetsart University.
- Providing a world class supercomputing facility for researchers in Kasetsart University in the area such as Computational Chemistry, Computational Fluid Dynamics, Bioinformatics, and Computer science.
- Building a large PC Cluster to be used as a test-bed for cluster computing technology.

PIRUN system consists of

- 72 compute nodes of Pentium III 500 MHz, 128 Mbytes RAM per nodes, ASUStech P2B series motherboard that support wake on LAN and hardware monitoring chip.
- 3 file server nodes using DUAL Pentium Xeon 500 MHz Server with hardware RAID. Each server node has about 6 Ultra SCSI disk of 9 Gbytes, which gave a total of 54 Gbytes per node.
- KVM (Keyboard/Video/Mouse) switch with daisy chained capability are used. Total of 10 KVM has been chained to centralize the console access to a single node.
- Four 24 port stackable Fast Ethernet switches 3COM superstackII are used to link the system together.

The decision has bemmach to reduce some cost by having this system consist mostly of the diskless nodes. We developed an in-house tool to aid the installation of the system. By the help of a group of students and faculty members together, it was posible to finish the installation with in a few days.

Figure 2 shows the image of PIRUN Cluster after the installation finished. The system has been tested using SLBench, the parallel Linpack benchmark. The performance result is as shown in

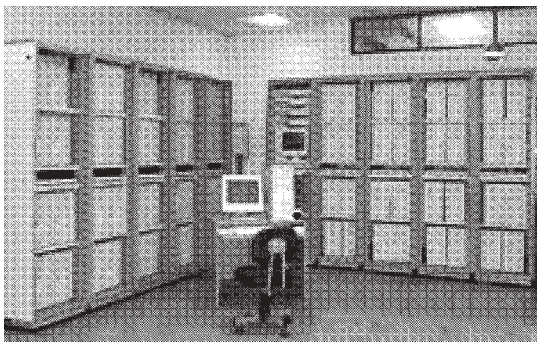

Figure 2 Picture of PIRUN Cluster.

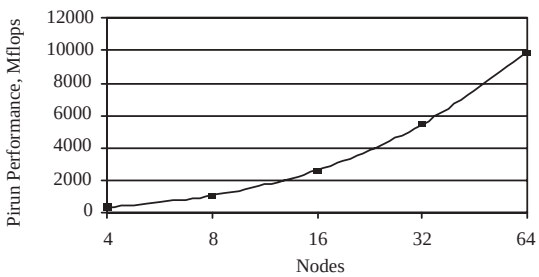

Figure 3 Performance of PIRUN Cluster.

Figure 3. At 64 nodes, the system can execute at 9.884 Gigaflops. This performance makes PIRUN system the fastest supercomputing platform in Thailand. More detail can be found in Uthayopas *et al*. (2000).

RESULTS AND DISCUSSIONS

The use of the cluster systems

Since the cluster, systems have been employed at Kasetsart University, they have Bean used by various groups in the university to serve they computing needs. However, the use of cluster mostly belongs to what listed below.

Teaching activities

One of the problems that formerly prevented us from offering any course in parallel and distributed computing is the lack of real parallel computing platform. After setting up SMILE and AMATA cluster, we are able to open a course in 204534 Introduction to Parallel Computing for graduate level and 204434 Parallel and Distributed Computing in undergraduate level. In Thailand, we expect that the manpower need will be used in the areas of parallel scientific computing and system engineer. Therefore, the courses are more emphasize towards parallel programming and algorithm than to parallel architecture. The topics covered are as follows

- Introduction to Parallel Computing

Focus on the important of computational method for modern scientific exploration, the need for high performance computing, and the important problems that require us to solve, and finally limitation of uni-processor and why parallel computing is needed.

- Basic Parallel Computer Architecture

Explain the basic architecture such as Flynn' s classification, structure of parallel computer, interconnection networks and performance. Also, we mention in detail how to build a cluster to use as a parallel-computing platform.

- Parallel Programming

Explain the basic ideas about parallelism, simple task partitioning such as Domain and functional decomposition, step required to parallelize the sequential application.

- Parallel Programming using MPI

Basics MPI function and how to write parallel program in MPI. This is needed for term project. We also introduce simple parallel algorithm such as matrix multiplication here to be use as case study for the next topic in performance model.

- Performance and Scalability for Parallel Algorithms/System

Explain why parallel program is faster, what is limitation in term of sequential fraction of code (Amdahl's Law), Scale Speedup (Gustafson's Law), Effect of communication network and application communication pattern to performance.

- Parallel Algorithm

Show students more algorithms such as linear

algebra algorithm, graph algorithm, sorting algorithm.

- Special topic and paper, project presentation

Each semester, we assign students to work on coding MPI based parallel program to solve certain problem such as sorting. Also, student will be instructed to measure the performance of their implementation to make them understand the problem and appreciate the power of parallel computing on cluster platform.

The textbooks that we used are listed in the reference (Wilkinson and Allen. 1999; Gropp *et al*. 1999).

Research activities

The interest in cluster computing and the building of cluster infrastructure has created many new kind of research programs. Example of these new researches created by the building of cluster system are as listed below.

- Parallel Software Tools and Environment
  - Cluster administrator tools, cluster integration tools, Cluster Middleware, High Availability.
- Parallel and Distributed Application
  - Internet Search Engine , Parallel Text Search Engine, Web infrastructure.
- Scientific Computing
  - Pollution Modeling , Fluidize Bed Simulation in Chemical Engineering, Molecular Dynamics Simulation, Computational Fluid Dynamics application in vehicle design and heat analysis in electronics industry.

Some of the result has been published in (Uthayopas et al. 2000; Angskun et al. 2000). It is expected that more new research project will start using the new cluster system in the near future. More information about research projects can be found at http://smile.cpe.ku.ac.th

Central computing service facility

For the largest cluster, as PIRUN Cluster, there are many planed applications for this system. At the first stage, the system will be splited into two parts: an Internet server part and supercomputing part.

For Internet server part, every normal university's users will have an account and use this system to store their data, read email, store web page. In order to use the supercomputing part, user needs a special password to gain an access to the batch system. There will be 16-24 nodes with local hard disk. These nodes will be used to run parallel web software and used as a scalable high-load web server for the university tasks. We have a development project to build a parallel web crawler that collect, process and index various information. The power of this system will be used to drive that application. The data collected can be searched using our search engine and parallel search engine under development by Applied Network Research Group, Computer and Network System Research Laboratory, Department of Computer Engineering, Kasetsart University.

Besides using PIRUN system as an Internet Superserver, this system will be employed as a supercomputing facility for research in area such as computational chemistry, computational fluid dynamics, parallel software tools and environment. By having this system, researchers at Kasetsart University will have a very powerful tool to help them tackle difficult research problems.

CONCLUSION

By setting up Beowulf Cluster Systems at the university have learned many valuable experiences. A careful planning proof to be very valuable for the setup of any large Beowulf system. After anything has been carefully planned, this kind of system can be put in place within a short period of time (one or two days).

For the software installation, initial installation can be quickly done due to our expertise in cluster software tool. With out this kinds of

automated script, the installation will be very tedious and long. However, the smooth operation will take a while after really open up the system for users since they are always something miss configure or totally missing. In addition, user feed back is also important to the operation of the system.

Finally, we have a very positive experience and found that the use of Beowulf cluster system bring much have benefit to our organization in terms of cost reduction, producing new expertise, creating new projects. We expect the increases use of this class of system in Thailand in the coming year. There is currently an effort to form a communication of researchers in Thailand. More information about cluster computing activities can be found at http://tfcc.cpe.ku.ac.th.

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