A Proposal of Efficiency Benchmarking Model for Supercomputer Performance Measurement

Nam Gyu Kim and Myoung-Ju Koh

Abstract—The current supercomputer Top500 list the world supercomputer rankings based on the theoretical performance obtained by the sum of the theoretical performance of the CPU and the actual performance which is the result of the execution of the benchmark program. This ranking is closely related to the performance of the central processing unit and the accelerator among the components consisting of the supercomputer. This implies a disadvantage that it does not fully reflect the characteristics of various other components of supercomputers. In this paper, we try to propose a new benchmaring model for supercomputer performance measurement using economical methods not computer science and engineerning methods. And also this effiecny benchmarking model considers several factors that make up supercomputer.

Research Keywords— Supercomputer, Performance, Efficiency

1 INTRODUCTION

Supercomputers generally refer to those computers that have the fastest processing speed and large memory capacity at that time. The TOP500 supercom-puter project started at Mannheim University in Germany in 1993, which measured the performance of supercomputers on the world [1]. This TOP500 list pro-vides details about the world's supercomputers, but the most important information is the theoretical per-formance (Rpeak) and the measured performance (Rmax), which represent the performance of super-computers. Rpeak is the theoretical best performance index represented as double precision floating-point (FLOPS) performed per second in a system. It is calcu-lated by the number of CPU (number of cores), CPU clock speed, and performance factor. Rmax is the per-formance measured by running a High Performance Linpack (HPL) benchmark that solves the high-density system of linear equations.

However, this supercomputer performance indexes only focus on the processing speed and does not reflect the overall performance of the system. In other words, it is criticized that other factors such as power consumption, memory, network, and other factors of the supercomputer system are not considered.

In this paper, we propose a model that measures the efficiency of supercomputer system by using DEA (Data Envelopment Analysis) as a multi-criteria evaluation method for comprehensively considering components of supercomputer. The DEA is a nonparametric method of measuring the relative efficiency of decision making units (DMUs) with multiple inputs and multiple output structures. This methodology is a suitable method for solving these problems to compute various factors and performance indexes consisting of supercomputers at a time.

2 PELATED WORK

2.1 DEA(Date Envelopment Analysis)

DEA is a non-parametric method of measuring the relative efficiency of a set of units called decision making units (DMUs) with multiple inputs and multiple output factors [2]. It is a method developed to measure the relative efficiency of DMUs, espe-cially when there is no market price for in-

- *Nam Gyu Kim is with the Korea Institute of Science and Technology Information, 245 Daehak-ro, Yuseong-gu, Daejeon, 34141, Korea. E-mail: ssgyu@ kisti.re.kr.*
- *Myoung-Ju Koh (corresponding author) is with the Korea Institute of Science and Technology Information, Deajeon, 34141, Ref. of Korea, E-mail: myju.koh@gmail.com*

puts and output factors. The efficiency evaluation is defined as the ratio of the weighted sum of the input fac-tors to the weighted sum of the output factors. To verify relative efficiency, each DMU is relatively compared with other DMUs to obtain efficiency scores ranging from 0 to 1. When the DMU score is 1, it is evaluated to be fully efficient, which is lo-cated at the efficiency boundary determined by the combination of input and output element resources.

The effectiveness of DEA is used in various areas. A. Charnes and W. Cooper E. Rhodes assessed more than 200 bank branches in the Canadian Banks to indicate which branches needed to improve performance and efficiency during specific periods [3]. D. Angelidis and K. Lyroudi analyzed the efficiency of Italian finance with a focus on the relationship between bank size and performance [4].

3 The Effieciency Benchmarking Model

In this study, we apply both the BCC model and the CCR model, which are most used in the DEA evaluation model, and set the following research to overcome the problems of the calculation fac-tors.
A supercomputer is determined by the number of elements such as the number of CPUs and the number of nodes. Therefore, this study measures supercomputer efficiency using input-oriented DEA model. In addition, DEA is divided into two models, CCR and BCC, depending on the assumption of return to scale (RTS). The relationship between input and output is the same constant rate of return (CRS). And the BCC model assuming a Variable Return to Scale (VRS) in which the relationship between inputs and outputs changes with the size.

In the previous study, DEA evaluation was performed using only the number of cores, power, Rpeak, and Rmax basically provided in the TOP500 list [5][6]. However, as metioned above, the components of supercomputers are memory, internetwork, and etc., besides the number of cores per socket, the number of nodes, and etc. Therefore, in this study, efficiency is measured by adding additional memory capacity to the input element. Since the Rpeak value is only a theoretical value calculated by multiplying the number of cores, the CPU speed (Hz) and the performance factor, Rpeak is excluded in this study.

Table 1. Input and Output Factors for the Effieciency Benchmarking Model

Parameter	Values	Unit
Input Factors	Power	kW
	The number of CPU cores	Cores
	The number of Accelerator cores	Cores
	The size of Memory	GB
Output Factors	Rmax Value	GFLOPS

4 Conclusions and Future Work

This study was to propose the model to measure the efficiency of supercomputer system by using DEA based on various input factors and output factors for comprehensively considering the components of supercomputer.

In addition, there is no consideration of the weight for each element at present, but the weight of supercomputer components ire different in super computer application. For example, in the case of machine learning, which is famous for its deep learning methodology such as Alpha Go, performance of accelerators is especially important. Application studies such as genome analysis in the field of bioinformatics have a big influence on the capacity of memory and it is necessary to consider data I/O as a data-intensive field to use large-capacity genome data. Also CPU performance is important in the case of computational thermo-fluid analysis or weather prediction, which is one of the traditional supercomputer fields. Since the data is continuously exchanged between nodes based on MPI the interconnect network performance between computing nodes is also important. Therefore, the significance of elements of supercomputer depends on various applications.

This will allow us to analyze what type of supercomputer is more efficient for which application in future work.

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Nam Gyu Kim obtained his bachelor's degree and master's degree in Computer Science and Engineering at Chung-Ang University in 2000 and 2002 respectively. And now he is a Ph.D candidate in Management of Technology at Sungkyunkwan University. At present he has servning as Senior researcher of Korea Institute of Science and Technology Information (KISTI) in South Korea. He performed lots of SW R&D projects including the national e-Science project, the AMGA development project, and etc. Also he was the collaboration member of LIGO and KEK Belle projects as the site administrator to construct and manage the data grid site in South Korea. Besides I participated in planning the second 5-year national supercomputing in 2017. At present he participates in EDISON (ED-ucation-research Integration through Simulation On the Net) project which is a web-based simulation service for education and research. He is interested in technical policies for HPC and computational science and engineering.

Myoung-Ju Koh received the B.S. degree in Systems Management Engineering from Sungkyunkwan University (SKKU), in 2005 and M.S degree and Ph. D. degree in Industrial Engineering from SKKU, in 2007 and 2014 respectively. She worked in Science and Technology Policy Institute (STEPI) for six years from 2009. She has been serving as a Senior Researcher at Korea Institute of Science and Technology Information (KISTI) since 2015. She does research on research policy and strategy management of Korea National Supercomputing Center