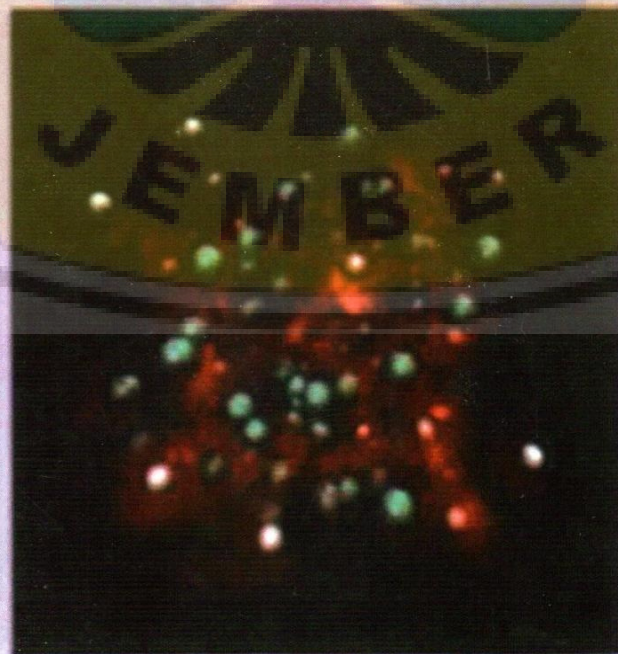# JOURNAL OF PHYSICS: CONFERENCE SERIES

International Conference of Combinatorics, Graph Theory, and Network Topology
(ICCGANT)

Jember, Indonesia
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The 1st International Conference of Combinatorics, Graph Theory, and Network Topology

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The First International Conference on Combinatorics, Graph Theory and Network Topology (ICCGANT)

Dafik

Editor in Chief of ICCGANTs Publication, University of Jember, Jember, Indonesia

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Preface

It is with my great pleasure and honor to organize the First International Conference on Combinatorics, Graph Theory and Network Topology which is held from 25-26 November 2017 in the University of Jember, East Java, Indonesia and present a conference proceeding index by Scopus. It is the first international conference organized by CGANT Research Group University of Jember in cooperation with Indonesian Combinatorics Society (INACOBMS). The conference is held to welcome participants from many countries, with broad and diverse research interests of mathematics especially combinatorical study. The mission is to become an annual international forum in the future, where, civil society organization and representative, research students, academics and researchers, scholars, scientist, teachers and practitioners from all over the world could meet in and exchange an idea to share and to discuss theoretical and practical knowledge about mathematics and its applications. The aim of the first conference is to present and discuss the latest research that contributes to the sharing of new theoretical, methodological and empirical knowledge and a better understanding in the area mathematics, application of mathematics as well as mathematics education.

The themes of this conference are as follows: (1) Connection of distance to other graph properties, (2) Degree/diameter problem, (3) Distance-transitive and distance-regular graphs, (4) Metric dimension and related parameters, (5) Cages and eccentric graphs, (6) Cycles and factors in graphs, (7) Large graphs and digraphs, (8) Spectral Techniques in graph theory, (9) Ramsey numbers, (10) Dimensions of graphs, (11) Communication networks, (12) Coding theory, (13) Cryptography, (14) Rainbow connection, (15) Graph labelings and coloring, (16). Applications of graph theory

The topics are not limited to the above themes but they also include the mathematical application research of interest in general including mathematics education, such as:(1) Applied Mathematics and Modelling, (2) Applied Physics: Mathematical Physics, Biological Physics, Chemistry Physics,(3) Applied Engineering: Mathematical Engineering, Mechanical engineering, Informatics Engineering, Civil Engineering,(4) Statistics and Its Application,(5) Pure Mathematics (Analysis, Algebra and Geometry),(6) Mathematics Education, (7) Literacy of Mathematics,(8) The Use of ICT Based Media In Mathematics Teaching and Learning,(9) Technological, Pedagogical, Content Knowledge for Teaching Mathematics, (10) Students Higher Order Thinking Skill of Mathematics, (11) Contextual Teaching and Realistic Mathematics, (12) Science, Technology, Engineering, and Mathematics Approach, (13) Local Wisdom Based

Education: Ethnomathematics, (14) Showcase of Teaching and Learning of Mathematics, (16) The 21st Century Skills: The Integration of 4C Skill in Teaching Math.

The participants of this ICCGANT 2017 conference were 200 people consisting research students, academics and researchers, scholars, scientist, teachers and practitioners from many countries. The selected papers to be publish of Journal of Physics: Conference Series are 80 papers. On behalf of the organizing committee, finally we gratefully acknowledge the support from the University of Jember of this conference. We would also like to extend our thanks to all lovely participants who are joining this unforgettable and valuable event.

Prof. Drs. Dafik, M.Sc., Ph.D.

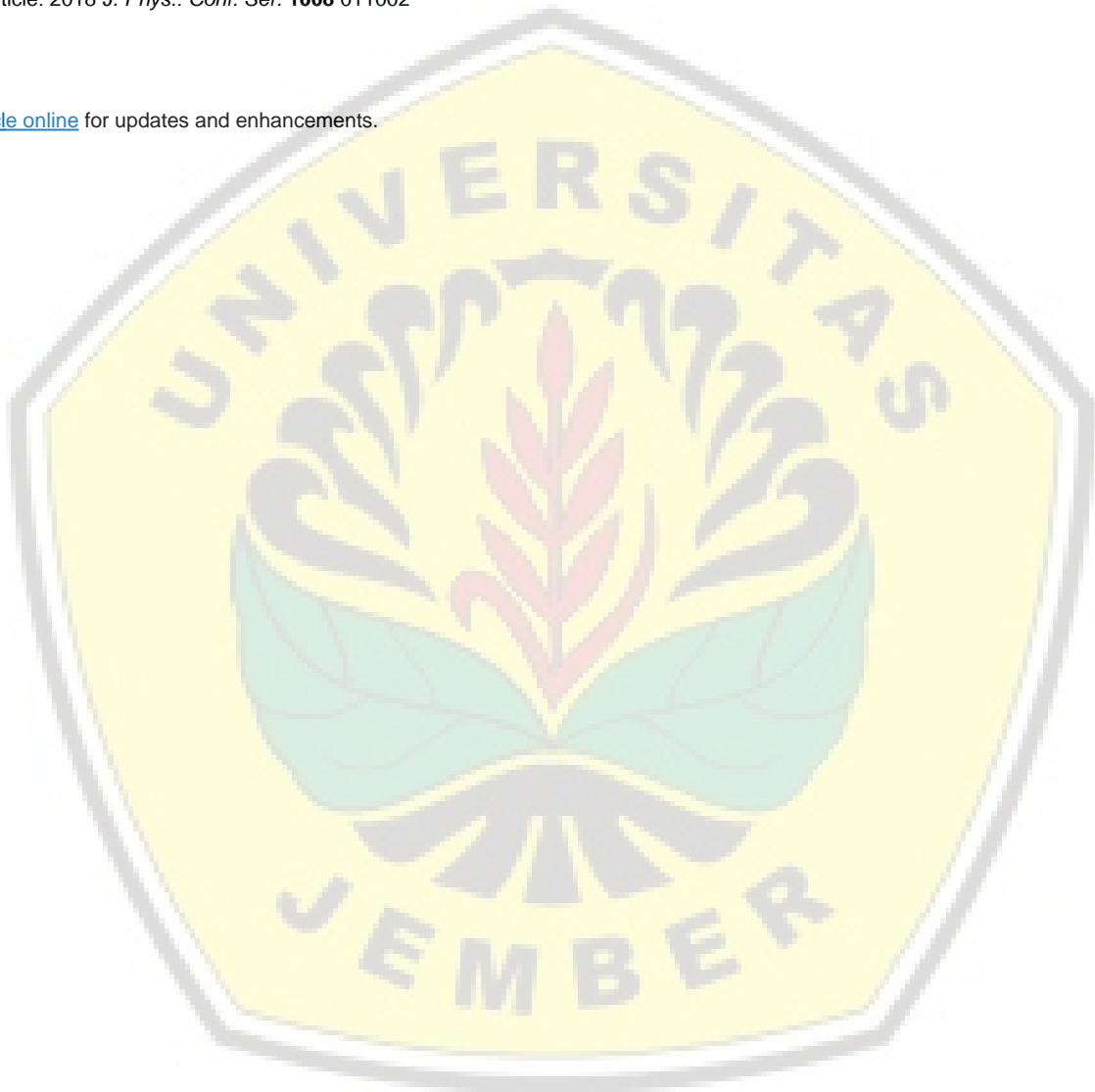# The Committees of The First International Conference on Combinatorics, Graph Theory and Network Topology (ICCGANT)

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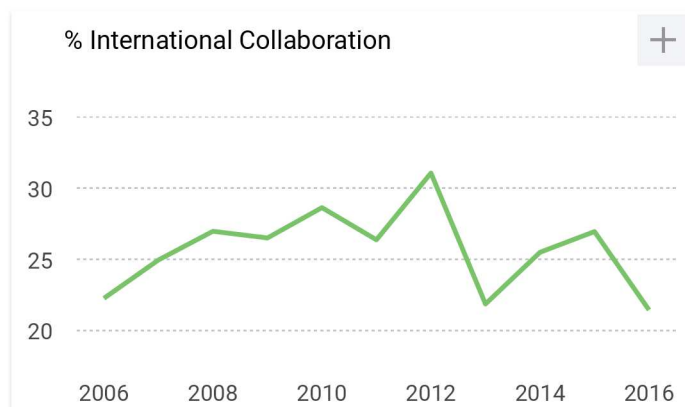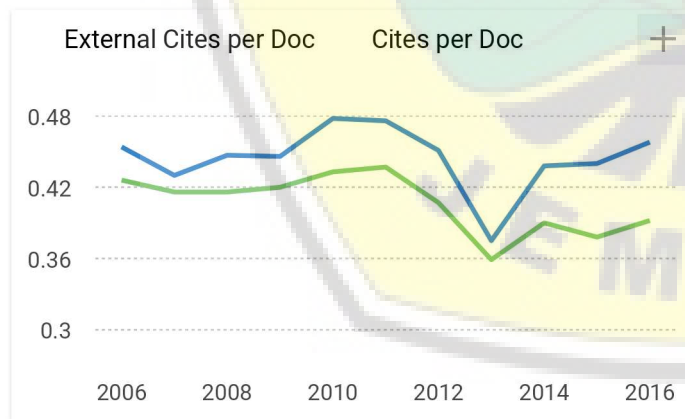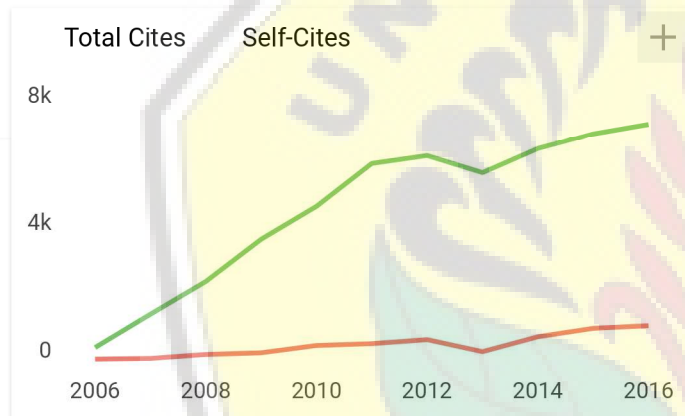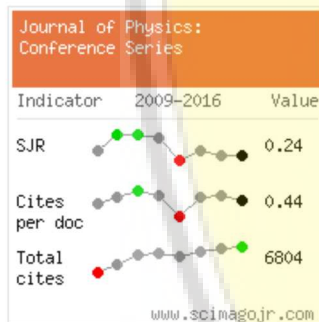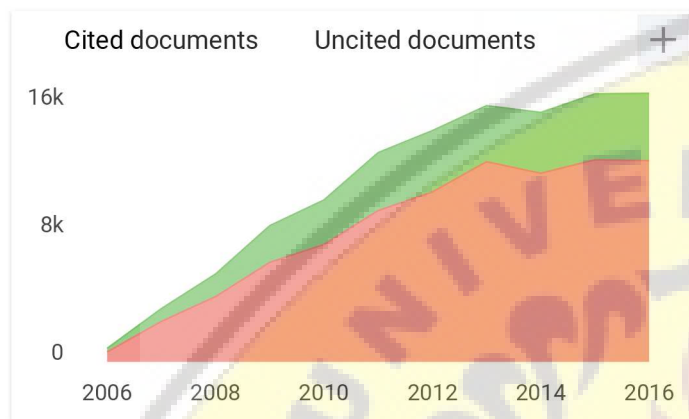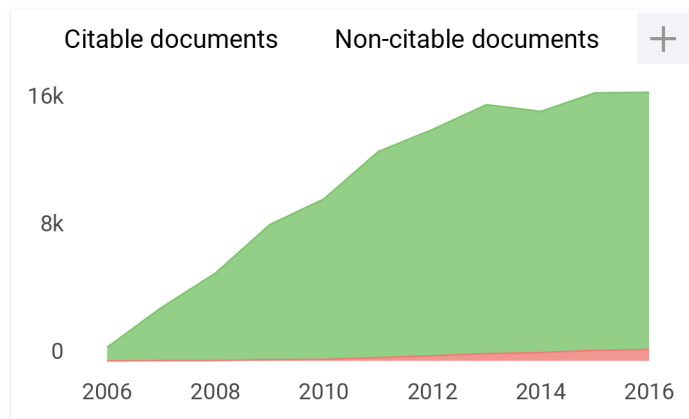
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Performance comparison analysis library communication cluster system using merge sort

D A R Wulandari[1], M E Ramadhan[2]

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Abstract. Begins by using a single processor, to increase the speed of computing time, the use of multi-processor was introduced. The second paradigm is known as parallel computing, example cluster. The cluster must have the communication potocol for processing, one of it is message passing Interface (MPI). MPI have many library, both of them OPENMPI and MPICH2. Performance of the cluster machine depend on suitable between performance characters of library communication and characters of the problem so this study aims to analyze the comparative performances libraries in handling parallel computing process. The case study in this research are MPICH2 and OpenMPI. This case research execute sorting's problem to know the performance of cluster system. The sorting problem use mergesort method. The research method is by implementing OpenMPI and MPICH2 on a Linux-based cluster by using five computer virtual then analyze the performance of the system by different scenario tests and three parameters for to know the performance of MPICH2 and OpenMPI. These performances are execution time, speedup and efficiency. The results of this study showed that the addition of each data size makes OpenMPI and MPICH2 have an average speed-up and efficiency tend to increase but at a large data size decreases. increased data size doesn't necessarily increased speed up and efficiency but only execution time example in 100000 data size. OpenMPI has a execution time greater than MPICH2 example in 1000 data size average execution time with MPICH2 is 0,009721 and OpenMPI is 0,003895 OpenMPI can customize communication needs.

1. Introduction

The technology grows rapidly and new computation paradigms are also being developed. Started by computation process with single processor in the past, recently the usage of multi-processor computers for parallel computing is very common, in order to speed up the computation period. To carry out various kinds of parallel computing, then there is a need for parallel machines infrastructures that consist of a number of computers connected by network able to solve certain problem in parallel.

There are two types of parallel computers, which are Shared Memory Multiprocessor and Distributed Memory Multicomputer. Cluster system belongs to Distributed Memory Multicomputer, which is two or more computers or nodes that are connected into a single integrated system. In a previous study found that the distributed computing make many motivation for implementation because can solve many large problem from large data sets using more than one computers that to be a single integrated resource system. The main point in cluster system is how to the resource sharing all members by efficiently for handling the large problem or data. Each cluster members have each fungtion. there are master and slave. a master node manages the resources needed for the job, divides

the job into parts of the job then assigns the job to each slave. and slave node do task from master node. when the resource is available the task from master gets executed. master give a job to a vailable of members. when there is no available members, a task goes into a work queue. [1]. The most important part of cluster computer is middleware application that is capable to integrate all computer members within the cluster so that they can work together. The main task of middleware is to communicate and synchronize computers within that particular cluster. One famous cluster's middleware is MPI (Message Passing Interface), which is an independent language of communication protocol in parallel programming. Many MPI libraries have strengths and weaknesses in each implementations [2]. There are numerous libraries in MPI, some of them are GridMPI, OpenMPI, MPICH-Madeleine, MPICH-G2, MPICH-VMI, MPICH2, LAM/MPI [2] [3]. all library of MPI have different process management but the purpose is integreted more than one computers or processors to be a single system with parallel process and establishing a portable, efficient, and flexible standard for message passing that used for writing message passing programs from node to node[4] [5].

There are several available libraries that facilitate the implementation of MPI, such as MPICH2 and openMPI. OpenMPI is proven to have the ability to adjust communication management efficiently, based on the characteristics of existing infrastructure [6]. The testing of cluster system performance can be conducted by implementing certain computer program, and in this research was parallel mergesort. Parallel mergesort is a modification of the old sequential mergesort, in which it supports parallel sorting. Parallel mergesort algorithm is relatively easy to set up since it has divide and conquer method, which can work in parallel [7].

In a previous study found that the distributed computing especially cluster make many motivation for implementation. Implementation using PC-cluster. In this research study about performance analysis communication middleware. Communication middleware in cluster system is very important because the cluster system needs communication tools to work together between many computers to be single integrated system resource. This researce compare between MPICH2 and OpenMPI. In a previous study speed-up and efficiency can be parameters of performance when both were solving similar computation process was conducted so this research use speed-up and efficiency to know the parameters both MPICH2 and OpenMPI[8]. In this case, a sorting problem was used. Mergesort was implemented in this research for solving sorting problem. It was used since they are the fastest existing algorithms and is capable of working in parallel. Cluster system was established using virtualization so that it could undertake parallel computing process more efficiently. MPICH2 and OpenMPI were chosen among many other available algorithms for their advantages among their competitors, in which both of them are more well-known and are more commonly utilized.

2. Methods

The analysis of computation process within this research was conducted by comparing the performance of MPICH2 and OpenMPI in solving a sorting problem. In order to carry out the research, the following steps should be conducted:

1. Study related papers about OpenMPI and MPICH2 clustering system, sorting program using mergesort and quicksort methods. and measurement analysis. This literature study was undertaken by utilizing various resources, such as books, journal papers, and electronic documents on the Internet.
2. Design and implement cluster processes, which were conducted in the following orders:
   a. All virtual computers were installed with *distro Linux Ubuntu desktop v.10.04 – Lucid Lynx* operating system. This research use 5 virtual computer for master and slave (slave is member names of this cluster members). Virtual computer from IT as a service cloud computing was used because the cost-efficient of infrastructure [9].
   b. All of computers has conFigured in network connection without coFigured biecause using virtual computere from IAAS cloud system, Figure 1.

c.   identification all node by defining the ip address address and hostname name of each node. Master must know abaout ip address all of member in system for giving their task and each member must know ip address their master for getting their task from master.

d.   Configuring SSH can communicate and conduct data exchange to all nodes without having to provide authentication process. In the implementation master node generates a public key which is a random number. This public key will then be sent to the SSH folder on the slave node. Once the public key of the master node is sent into the SSH folder, the public key is converted into an authorized key so that when the master node performs an SSH connection on the slave node, SSH on the slave node will check whether the computer that will access it has been registered in the authorized keys slave node. If indeed the computer that will access it is listed, then the master node can access without having to enter the slave node password first.

e.   Configuring NFS, In this cluster system, the directory to be shared is the data directory, in this directory is used to store the files used for the test sample. NFS serves to perform a shared directory that will be used for file sharing.

f.   MPICH2 and openMPI were installed and conFigured in five virtual computers. Hence, there are one master computer and four slave computers.

g.   Installation and configuration of Build Essential for running and excuting parallel sorting program using C language program .

3. Implementing cluster system and testing analysis.
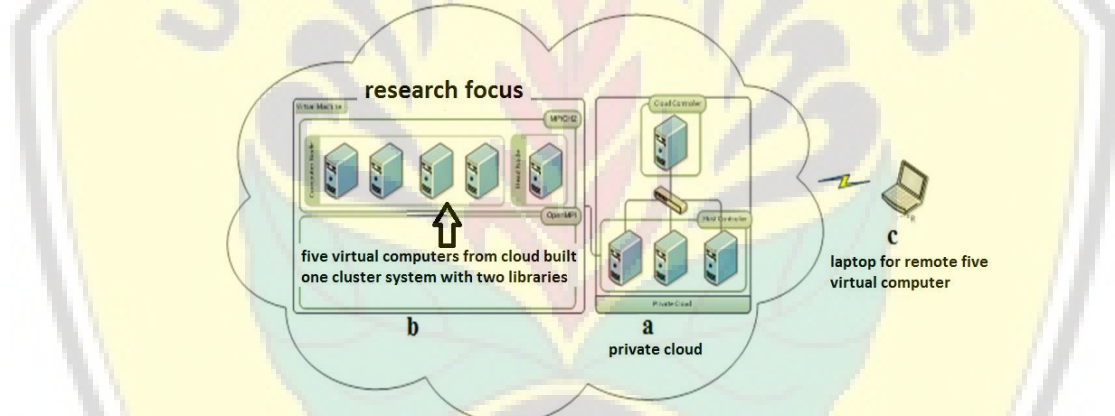
Figure 1. Cluster system design; (a) private cloud computing architecture, (b) focus of this research on cluster system design, (c) notebook as remote controller

The cluster system consisted of five homogeneous virtual computers provided by cloud service. One of those five virtual computers was dedicated as master node and the rest four computers were used as slave nodes. Each node was installed with open source operating system Linux Ubuntu 10.04 LTS (Lucid Lynx). From existing five virtual nodes, it was then possible to establish two cluster system, which were Cluster A implementing MPICH2 library and Cluster B implementing openMPI library. Figure 3.1 describes the architectural design of the cluster system implemented in this research. openMPI library was chosen among other MPI libraries because it is one of most famous libraries in parallel computing and because of its good performance. Both libraries has its own unique characteristics, syntaxes, and advantages that are worth comparing.

4. Cluster system performance test was conducted by executing computation program on cluster system with the following scenario:

The purpose of cluster system performance testing was to understand the performance comparison between MPICH2 and openMPI in terms of speed-up and efficiency. Random number sorting problem was implemented in C programming language to test system performance. Two sorting methods used in this research was mergesort algorithms. Number of tested data was conFigured to be varied, ranging from 100, 1000, 10.000 to 100.000 data size. The data size is number random.

5. Resource monitoring system using HTOP tool.
6. Comparing the result of parallel computing using MPICH2 and that of openMPI, and then deriving conclusion.

       Merge short is used for testing the performance of this cluster system. Mergesort is a sorting algorithm that uses the divide and conguer approach. In a parallel process, the first uncompleted list is divided into two sublists by a single processor, then the sublists are sent to another processor. Each processor handles one sublist. Each sublist is subdivided into two smaller sections, the subdist division is done until the sublist is unbreakable or subdivided, until there is only a number in a sublist. Then each sublist is merged into a new sublist with two numbers then reassembled into each sublist of four numbers until all the numbers on the sublist are combined into one ordered list, Figure 2.
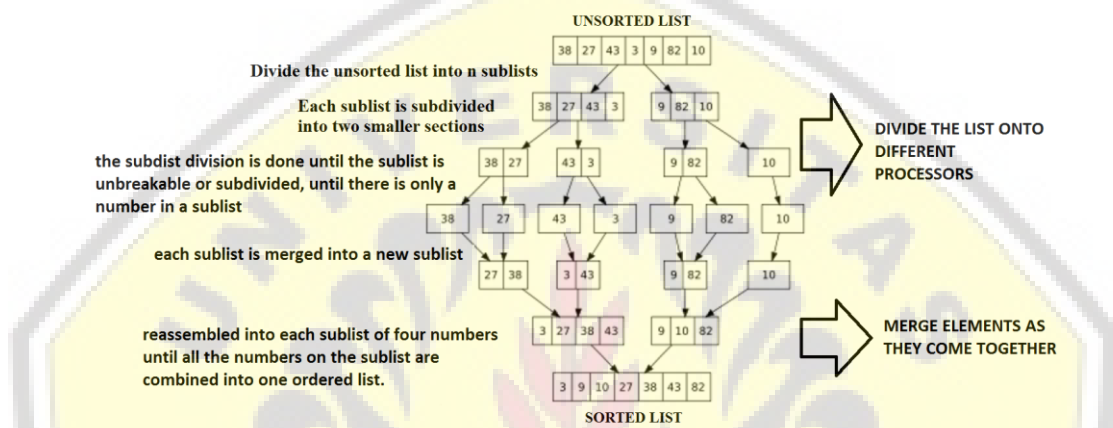
Figure 2. How To Work Parallel Merge Sort

       In this research use three parameters. They are time execution, speed-up and efficiency for testing performance analysis [10]. Speed-up of a program (s_p) is defined as the time it takes a program to execute in serial using one processor or computer (t_s) divided by the time it takes to execute in parallel using many processors or many computer (t_p). The formula for speedup is in equation (1).

$$S_p = \frac{t_s}{t_p}$$
<div align="right">(1)</div>

Another metric to measure the performance of a parallel algorithm is efficiency. Efficiency is speed-up devide processors that this system use. The formula for efficiency is in equation (2).

$$E = \frac{S_p}{p}$$
<div align="right">(2)</div>

3. Result and Discussion

    Cluster system capability testing in computing process on both cluster systems using execution time, speed-up parameters, and efficiency. Cluster testing is done by running some sample array sorting program which contains integer numbers in four scenarios. The mergesort method is chosen because it uses the divide and conquer method approach, including the fastest and stable sorting method. In another research Divide and Conquer has been designed to work in machines with multiple processors. This test is by sorting random numbers of integer types with intervals of 100 to 100000 numbers or data size. This test will be done using several scenarios. That is using one (squential) until five processors or computer (multiprocessors). The selection of data between 100 to 100000 random numbers is intended to show the significant difference in execution time. This scenario aims to see the effect of changing the number of nodes with the large amount of data on the execution time, and know what computing program is appropriate so that the performance of both libraries can work optimally. This research have four scenario. The scenario are executing the random number with interval 100,

1000, 10000, and 100000 data size by using sequential and parallel between two until five nodes. The purpose of this testing is performance of Open MPI and MPICH2 with three parameters. That is speed-up efficiency and execution time. The result of this testing are:

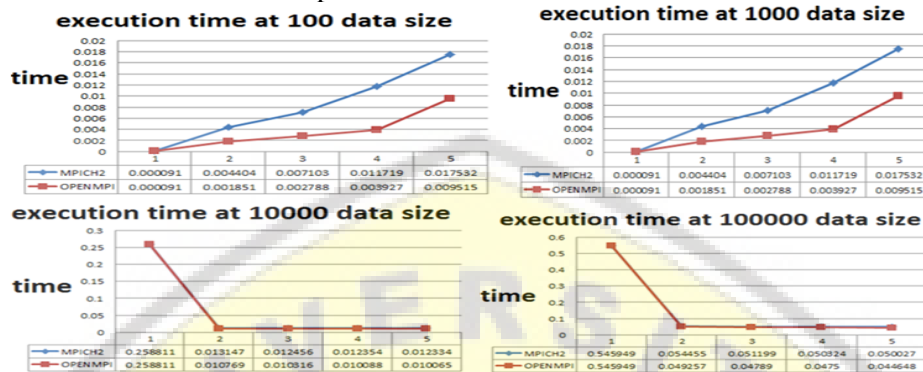1. Execution time base on number of processor

Figure 3. Graphical comparison OpenMPI and MPICH2 on average execution time for mergesort algorithm

Comparison OpenMPI and MPICH2 on average execution time for merge sort at fig 3, show that The sistem cluster have good performance in data size more than 10000 random number because when the increasing processor execution time more faster then sequential, but have bad performance when the data size less than 1000 random number. When the data size less than 1000 random number the sequential performance more better then many processor. In sequential computing applications the resulting process time is computational time, which is the time needed to calculate the steps of computing. In parallel computing applications, in addition to determining computational time also needs to take into account the time required for communication in sending messages to the parallel application. increasing processor can retarded execution time when the data size less than 1000 random number. This incident caused all of processor have communication time for solve sorting number. Communication time be used for sharing data, divison of task each processor. OpenMPI has a execution time greater than MPICH2 example in 1000 data size average execution time WITH MPICH2 is 0,009721 and OpenMPI is 0,003895 OpenMPI can customize communication needs. OpenMPI faster then MPICH2 at 100 until 1000 data size but at 10000 until 100000 data size OpenMPI and MPICH2 have the same performance. This incident caused merge sort method have many communication time for divide and merge list of random number.   This is in accordance with previous research that OpenMPI is able to adjust the communication settings efficiently in accordance with the characteristics of existing infrastructure [6], because in the openMPI architecture there is an MCA as a layer component that provides management services for all other layers [11].

2. Speed-up and efficiency

Figure 4. Graphical comparison OpenMPI and MPICH2 on average execution time for mergesort algorithm

comparison OpenMPI and MPICH2 on speed-up for merge sort at fig 4, show that OpenMPI and MPICH2 have almost the same performance at more than 10000 data size. the speed-up value of MPICH2 is slightly smaller than that of openMPI. However, as the number of random number increased as large as 100,000, the speed-up value of MPICH2 significantly improved, compared to that of openMPI. The speed-up values on both libraries decreased as there were addition of more processors.

3. efficiency

Figure 5. Graphical comparison OpenMPI and MPICH2 on average execution time for mergesort algorithm

Figure 5 described efficiency comparison on both libraries based on the number of nodes. Firstly, the average efficiency rate on program was calculated when using openMPI library. Then, similar process conducted under MPICH2 was also done. The results of those to processes were then compared. Figure 5 showed that efficiency of MPICH2 was less than that of openMPI. Efficiency rates were also decreasing on both libraries as the number of processors increased. The unideal speed-up and efficiency was due to the existence of overhead in parallel system. For example, additional computation which was only required to parallel computing, communication among processors, and synchronization process. Such phenomenon worked on all parallel systems and the speed-up and efficiency trends followed Amdahl's Law. However, speed-up and efficiency would also increase as the data size also getting larger, and that was in parallel with Gustafson's Law. While the addition of processors would decrease efficiency rate, the increase of data size would improve the efficiency [12].

According to Figure four and five, it was clearly seen that as the number of data ranged from 100 up to 10,000, the speed-up and efficiency rate increased as the data grew larger. However, when the random number were as large as 100,000 data, both speed-up and efficiency rare got smaller. Therefore, it was then known that the maximum speed-up and efficiency rate were on 10,000 data size, for all possible test cases scenario, from using two nodes up to five nodes. After conducting this research, it was proven that increasing the size of problem by executing larger data was not necessarily improving speed-up and efficiency. According to Ahmdal's Law, after some certain limit, speed-up and efficiency would decrease because the existence of larger communication time overhead compared to that of computation time on parallel algorithm. It was also possible due to the unpredicted computation task, imbalance of tasks distribution among processors, the existence of excessive sequential code, or the existence of pure sequential code. In some algorithms, the existence of might reduce the average speed-up time. As the data grew, the execution time both on serial and parallel processing would also increase. As the data grew as large as 100.000, the speed-up decreased because execution time on serial and parallel were getting slower, and therefore the difference between the two were smaller.

4. Conclusion

In this paper discuss about performance between two library communication of MPI to handly task in cluster system. There are MPICH2 AND OpenMPI. The task is sorting number 100 until 100000 data size using mergesort methode. Performence parameters use speed-up, efficiency and execution time. The result are when the small data size execute in sequential processing, the performance is better than executing in cluster system using more than one processors / computers. When the data size are large the performance of cluster system more faster than sequential process using one computer or one processor. Execution time of openMPI tends to be faster than that of MPICH2 for small size data, because programs conduct more communication process. However, execution time of MPICH2 tends to be faster as the data gets larger in size, since the increase of computation process reduces the communication effect. The values of openMPI's efficiency rate and speed-up tend to be greater than that of MPICH2 on small size data, ranging from 100 to 10.000 data. In contrary, as the number of data increases, such as 100.000, the values of efficiency rate and speed-up of MPICH2 are better than that of openMPI. Within such scenario, the speed-up difference is 3,1429 and the efficiency rate difference is 0,754. From the result found that implementation library communication of middleware communication have affect in performance of cluster system. Many library communication of middleware communication is in cluster system, but we must to know about suitability between characters of the task and characters of library comunication from communication time parameters for optimation of cluster system . cluster system need communication time to share the task in all members but do not spend long time to communicate between all members because it make decreasing performance, the execution time will be slower, so we need discuss about that in further research
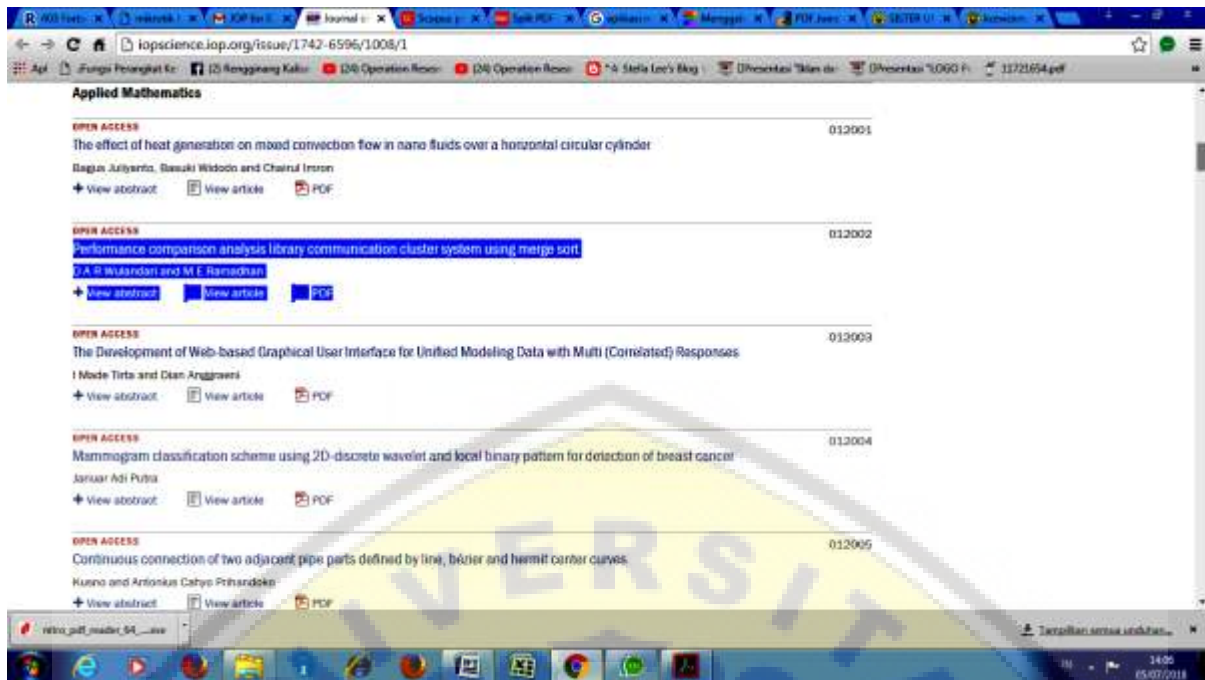
Acknowledgments

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