Province Based Design and Simulation of Indonesian Education Grid Topology

Heru Suhartanto[1], Ivo B. Nugroho[2] and Anisa Herdiani[3]

**[1] Faculty of Computer Science, Universitas Indonesia
Depok, Indonesia**

**[2] Accenture Indonesia
Jakarta, Indonesia**

**[3] Faculty of Information Technology, Universitas YARSI
Jakarta, Indonesia**

Abstract

This paper discusses the design and simulation of an e-learning computer network topology, based on Grid computing technology, for Indonesian schools called the Indonesian Education Grid (IndoEdu-Grid). The grid technology proposed to solve infrastructure problems faced by Indonesian ICT Network (Jardiknas).

In previous study, we designed the topology which based on two scenarios: region based and island based topology. Each scenario run in the simulator using two packet scheduling algorithms, one will be FIFO (First In First Out) Scheduler and the other SCFQ (Self-Clocked Fair Queuing) Scheduler.

In this paper we proposed a different scenario which based on province. The simulation treatments are the same with the two previous scenarios.

The simulation results showed that when using FIFO algorithm, the province based scenario has the best performance compared to Region Based and Island Based. However, this scenario is not competitive with the others when using SCFQ algorithm which is due to higher packet lifetime.

Keywords: *e-learning, grid computing, IndoEdu-Grid, province-based scenario, region-based scenario, island-based scenario.*

1. Introduction

E-learning as a trend has been developed so rapidly that many educational organizations and institutions in numerous countries, including Indonesia adopts it. An example of an infrastructure that can be used for e-learning in Indonesia is Jardiknas(*Jejaring Pendidikan Nasional* or Indonesian ICT Network).

Jardiknas is a national-scaled WAN (Wide Area Network) that facilitates educational activities in Indonesia. This network consists of Institutional/official Jardiknas that serves online data transaction between educational institutions, College Jardiknas–Indonesian Higher Education Networks (INHERENT)–that serves science and technology research and development, School Jardiknas that serves information and e-learning accesses in schools, and Teacher and Student Jardiknas that serves personal information and e-learning accesses (Pustekkom,2009) .

Jardiknas is established with a main purpose to serve administration in central National Department of Education (*Departemen Pendidikan Nasional*) and many domestic or foreign related work units and to serves learning processes in primary, junior high, and senior high schools based on information and communication technology.

Jardiknas covers the whole areas of Indonesia, but it still has some problems as follows.

1. The current network has not been equipped with capabilities to facilitate huge data processing and cannot maximize the distributed potential resource in the whole areas of Indonesia.
2. The number of students and educational institutions that require accesses to Jardiknas will increase every year, so that the needs of wider and easier-to-access network have risen.
3. Educational activities are advancing, where the education subjects (teachers, students, and instructors) will interact with each other, share data, and perform complex calculations and simulations, such as mathematics, physics, or biomolecular models.

To solve these problems, we propose the usage of Grid computing technology for Indonesian Education

Networks–called IndoEdu-Grid based on the structure of the provinces in the country. Grid computing (or Grid) is a system that can provide resources sharing among organizations. Grid infrastructure will provide a capability to connect the resources dynamically as an ensemble to support large-scale, resource-intensive, and distributed applications (Berman, et al, 2003).

2. Related Research

Nugroho (2010) in Design and Simulation of Indonesian Education Grid Topology using Gridsim Toolkit discusses the design and simulation of an e-learning computer network topology, based on Grid computing technology, for Indonesian schools called the Indonesian Education Grid (IndoEdu-Grid).

The simulation, which is built using GridSim toolkit, handle two conditions or scenarios that have different network topologies based on their routers and links configuration. The first scenario is region-based topology, and the second scenario is island-based topology.

Each scenario runs in the simulator using two packet scheduling algorithms, one will be FIFO (First In First Out) Scheduler and the other SCFQ (Self-Clocked Fair Queuing) Scheduler. The processing time of the job's packets were evaluated to determine the most effective network topology.

The simulation result showed that if SCFQ scheduling algorithm is used, then the most appropriate network topology is the topology which allows its packets with the same priorities to have less possibility to collide one another in one router or link, which is the first scenario.

The simulation results also showed that SCFQ scheduling algorithm can reduce the packets lifetime at routers that have very crowded traffics. This fact implies to the decrease of the whole job processing time.

2. GridSim Toolkit

In this study we use GridSim toolkit which is a Java-based simulator and supported with some additional libraries. GridSim is an open-source application and licensed under GPL license, thus it encloses its source codes in its distribution package.

GridSim's rationale is that creating a testbed infrastructure for Grid system is expensive and time-consuming, even an existing testbed infrastructure is also limited in size to a few resources and domains, and testing scheduling algorithms for scalability and adaptability, and evaluating scheduler performance for various applications and resource scenarios is harder and impossible to trace (Buyya and Murshed,2000, Buyya and Murshed, 2002, Sulistio et al, 2005)

2. Method

The design of IndoEdu-Grid consists of four steps : create the entities, designing class diagram, designing topological scenario, and define assumptions in the simulation.

a. The Entities

There are three entities that build IndoEdu-Grid (Nugroho, 2010):

1. Resources
   Resource entities are responsible to perform computation on job entities in form of Gridlets sent by one or more users and send it back to the user.
2. Users
   Users are entities responsible to submit jobs in form of Gridlet objects to the resources.
3. Jobs (gridlets)
   Jobs in GridSim are represented as the objects of the class Gridlet provided by GridSim.

b. The Class Diagram

This simulation consists of four main classes, namely class Main, class Islands, class NetUser, and class Randomizer and several other supporting classes available in Java's default library and the GridSim's additional library, such as `ArrayList`, `Router`, `GridSim`, `GridResource`, and `GridletList` (Nugroho, 2010). Our class diagram is shown in Fig 1.

c. The Topological Scenario

The scenario is a representation of our thought that divides the whole territory of Indonesia directly into 31 province units. Unlike the Region Based and Island Based scenarios in (Nugroho, 2010), in this scenario, the whole territory of Indonesia is seen made up of 31 province units. Fig. 2 shows the network topology for the Province Based scenario.

d. Assumptions in the Simulation

There are some assumptions during the simulation and these are as follows :

1. User location was determined with the router connected to it, e.g. Jateng_User_519 user will be connected to jatengRouter. Thus, the user's geographic position is not simulated.
2. Users select the resources randomly.
3. Users send Gridlets at the same time. Same time in this case means all objects of the NetUser class execute the body method together.

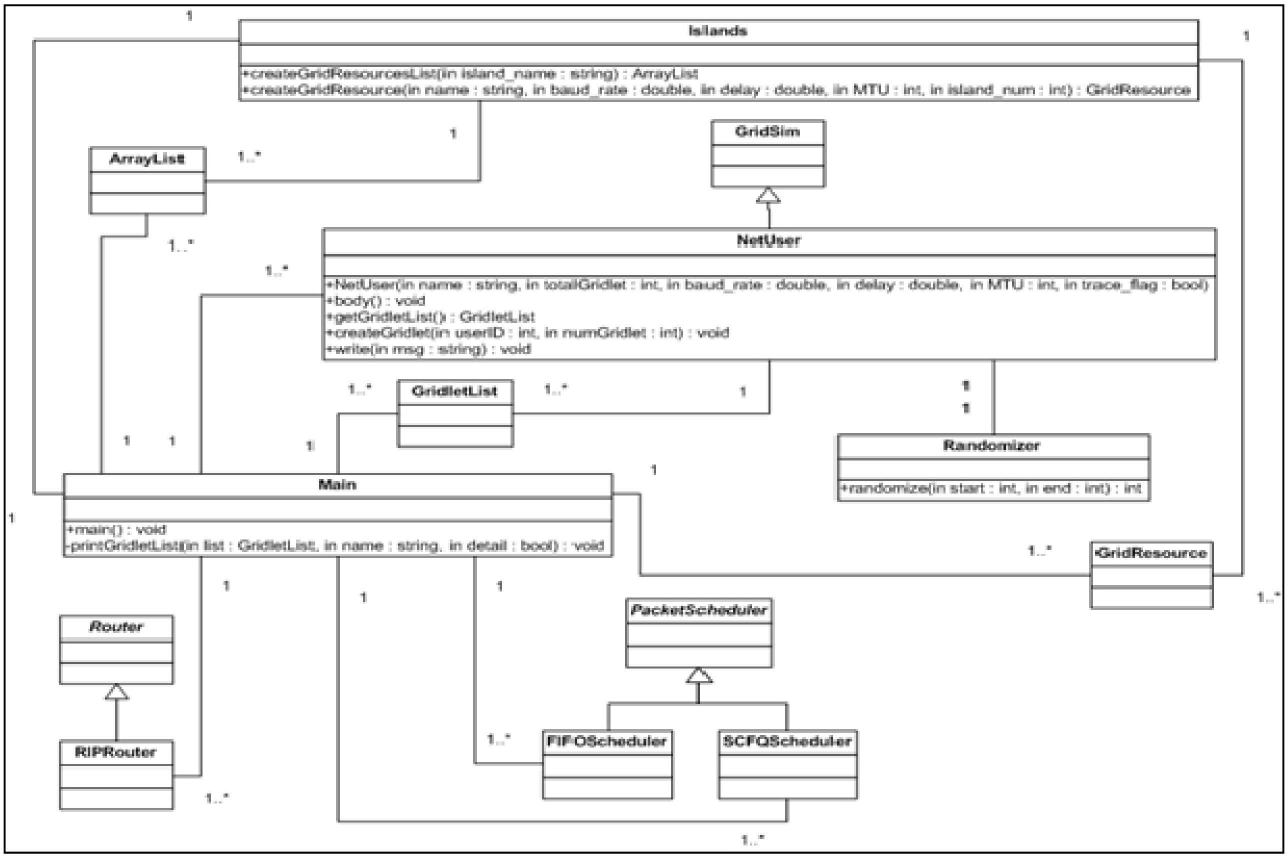

Fig. 1 The Class Diagram for Simulation Program

4. Leaf routers, edge routers, and core routers are only distinguished by entities connected to them and the configuration of the lithe configuration of the links. Leaf routers are connected to the users and GridResource entities and have links with the smallest baud rate. Edge routers are connected to leaf routers and core routers and have links with baud rate greater than the links at the leaf routers. Core routers are connected to edge routers in its area and the other core routers and have links with baud rate greater than the link at the leaf routers. Thus, there is no additional characteristic that distinguishes the functionality of these routers. These three types of router are the objects of the RIPRouter class.
5. The simulation scenarios use FIFO and SCFQ scheduling algorithm to schedule packets on the network.
6. All the resources use time-shared scheduling system.
7. Processing time is measured by obtaining the difference between the sending and receiving time of a Gridlet. Thus, the processing time includes the propagation time of Gridlet packets in the network and execution time of Gridlets. Processing time will be more influenced by the propagation time of packets on the network because the execution time of all Gridlets is the same (all resources have the same specifications of PE). Information was obtained from the CSV files created after the simulation finished.
8. Characteristics of resources–its name, its operating system, its architecture–are static properties of the resource and have no impact in the simulation.

The load of processors used to perform the simulations is ranging from 1% to 10% with the amount of free physical memory is about 43% to 50%.

e. The computing environment.

The simulation is run under Intel® Core™ 2 Duo T5800 processor with 2.0 GHz clock speed, 800 MHz FSB (Front Side Bus), and 2 MB L2 cache 2048 MB RAM (Random Access Memory) with shared dynamically with Mobile Intel® Graphics Media Accelerator 4500MHD; and 320 GB Fujitsu MHZ2320BH G2 SATA harddisk with 5400 rpm rotation speed. While the software are 32-bit Microsoft Windows Vista™ Business operating

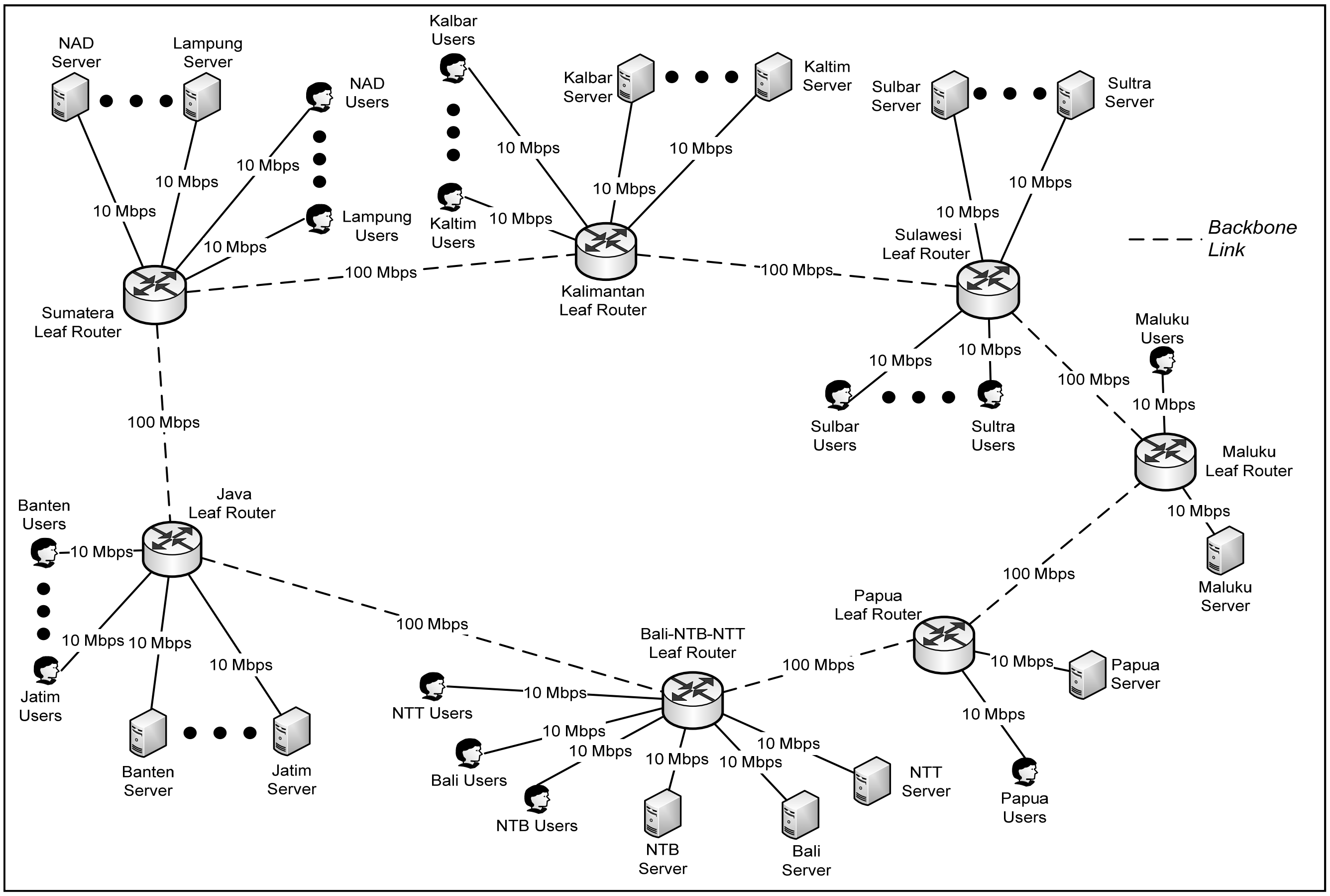

Fig. 2 Network Topology for the Provice-based Scenario

system. JDK (Java Development Kit) version 1.6.0_05 with Java™ Runtime Environment 1.6.0_05-b13. GridSim version 5.0 beta.

4. Result & Discussion

The results of simulation describe average processing time of the three types of Gridlets sent to the resource through province based network topologies. The results are then compared to the region based and island based topology obtained by Nugroho (2010). The simulation will show which topology that produces the lowest and highest average processing time using FIFO and SCFQ algorithm for scheduling packets. The simulation was run 10 times in each scenario to increase the validity of simulation results, and then the results were averaged.

The simulation results data per Gridlet which is the average of all provinces using the FIFO and SCFQ algorithm are shown in Table 1, while the average of all data is shown in Table 2.

Table 1: Average Simulation Results Data for the Entire Provinces per Gridlet Using FIFO and SCFQ Scheduling Algorithm

Scheduling Algorithm	Scenario	Processing Time (in Simulation Seconds)		
		Gridlet#0	**Gridlet#1**	**Gridlet#2**
FIFO	Region Based	239.76471	184.89620	124.45739
	Island Based	240.23045	185.26774	124.11812
	Province Based	237.60240	183.48528	123.93875
SCFQ	Region Based	235.50311	180.73233	124.67395
	Island Based	235.78695	181.59782	124.05540
	Province Based	237.12839	183.29814	123.81650

From Table 2, we find that Region Based with SCFQ algorithm gives the best performance (180.30313 simulation seconds), while Island Based with FIFO gives the worst performance (183.20544 simulation seconds).

Table 2: Average Processing Time for the Entire Provinces and Gridlets Using FIFO and SCFQ Scheduling Algorithm

Scenario	Processing Time (in Simulation Seconds)	
	FIFO	SCFQ
Region Based	183.03943	**180.30313**
Island Based	**183.20544**	180.48006
Province Based	181.67547	181.41435

In Province Based scenario with FIFO algorithm, it appears that the processing time is small enough, i.e. 181.67547 simulation seconds. This processing time is 0,75% lower compared to the processing time of region based scenario, dan 0,84% lower compared to the processing time of island based scenario. This happened because the inexistence of edge router makes the maximum number of hops is 6 hops. By observing Figure 2, this fact can be explained by the following examples. If a user in Lampung wants to send jobs to a resource in Papua, job packets will be propagated through channels as follow :

Lampung_User → Sumatra Leaf Router → Java Leaf Router → Bali-NTB-NTT Leaf Router → Papua Leaf Router → Papua_Res (5 hops)

or

Lampung_User → Sumatera Leaf Router → Kalimantan Leaf Router → Sulawesi Leaf Router → Maluku Leaf Router → Papua Leaf Router → Papua_Res (6 hops)

In addition, the packets just have to be queued at leaf routers, so the overall processing time becomes much lower.

In Province Based scenario with SCFQ algorithm, it appears that the processing time is the largest compared to the rest two scenarios : 0,61% higher than Region Based scenario and 0,51% higher than Island Based scenario. This happened because the additional (overhead) computation done by SCFQ algorithm to select the packets to be processed first. In addition, the packets that have normal priority will have greater chance to collide with other packets that have the same priority as the available routers are only leaf router. In the end, these packets will wait and the performance of the SCFQ algorithm will approach the performance of FIFO algorithm.

Based on the results, it can be concluded that Province Based scenario has the best performance compared to Region Based and Island Based with FIFO algorithm. However, this scenario has worse performance compared to the one using SCFQ algorithm, because packet lifetime is higher.

4. Conclusions

In our work, IndoEdu-Grid network simulation using GridSim toolkit has been conducted. Simulation was conducted with three different types of topologies in terms of link and router configurations and two types of scheduling algorithms–FIFO and SCFQ. The final result of the average processing time is compared to obtain the most effective topology for each scheduling algorithm, while the final results of the packet lifetime is used to analyze the phenomenon happened in the simulation.

The conclusions can be drawn from the results of this simulation are as follows.

1. If the FIFO scheduling algorithm will be used in establishing IndoEdu-Grid network, then the most appropriate topology is the topology that allows the packets to have a low number of hops. In this simulation, the network with the lowest number of hops is provided by the Province Based scenario. The use of topology in the region based and island based scenario only makes the processing time becomes longer because the packets will have a greater number of hops.
2. If the SCFQ scheduling algorithm will be used in establishing IndoEdu-Grid network, then the most appropriate topology is the topology which makes the data packets with the same priorities have little chances to meet each other in a single router or link. In this simulation, topology that meets these conditions is the topology on the Region Based scenario. Topology on the island based and province based scenario does not meet these conditions, so are not appropriate topologies for SCFQ scheduling algorithm.
3. SCFQ scheduling algorithm tends to make packet lifetime in routers with crowded traffic becomes shorter. Packet lifetime shows the difference between the enqueuing and dequeuing time of packets. This is because there are packet priority settings where the packets with higher priority will be served first, so the overall packet lifetime will be reduced.

Based on simulation results in our work, we recommend that the network topology in the Region Based scenario with the implementation of SCFQ scheduling algorithm is used as a reference for establishing IndoEdu-Grid. The Region Based scenario with the implementation of SCFQ scheduling algorithm has the highest level of effectiveness in terms of job packets propagation, although the achieved level effectiveness is very small (less than 1%). This is because this research used the size and number of Gridlets that are not too large (5000 MI, 3000 MI, and 1000 MI), so the savings or effectiveness only slightly visible.

References

[1] Berman, F., Fox, G., & Hey, Anthony J.G., 2003. Grid Computing: Making the Global Infrastructure a Reality. West Sussex: John Wiley & Sons.
[2] Buyya, R. & Murshed, M.,2002. Gridsim: A toolkit for the modeling and simulation of distributed management and scheduling for Grid computing. The Journal of Concurrency and Computation: Practice and Experience, 14, 13-15.
[3] Buyya, R. & Murshed, M.,2000. Using the GridSim Toolkit for Enabling Grid Computing Education, http://www.buyya.com/papers/gridsimedu.pdf
[4] Nugroho, I.B. & Suhartanto, Heru, 2010. Design and Simulation of Indonesian Education Grid Topology using Gridsim Toolkit. Asian Journal of Information Technology, Vol 9, Issue 5.
[5] Pustekkom, 2009. Jardiknas – Indonesian ICT Network, http://jardiknas.depdiknas.go.id/index.php/tentang-kami
[6] Sulistio, A ,Poduval, Gokul, Buyya, Rajkumar, and Chen-Kong Tham, 2005., Constructing A Grid Simulation with Differentiated Network Service Using GridSim, In 6th International Conference on Internet Computing (ICOMP 2005), Las Vegas, NV, http://www.gridbus.org/papers/gridsim_net.pdf., also at http://www.buyya.com/gridsim/doc/slides/GridSim_Net_ICOMP2005.ppt

Heru Suhartanto is a Professor in Faculty of Computer Science, Universitas Indonesia (Fasilkom UI). He has been with Fasilkom UI since 1986. Previously he held some positions such as Post doctoral fellow at Advanced Computational Modelling Centre, the University of Queensland, Australia in 1998 – 2000; two periods vice Dean for General Affair at Fasilkom UI since 2000. He graduated from undergraduate study at Department of Mathematics, UI in 1986. He holds Master of Science, from Department of Computer Science, The University of Toronto, Canada since 1990. He also holds Ph.D in Parallel Computing from Department of Mathematics, The University of Queensland since 1998. His main research interests are Numerical, Parallel, Cloud and Grid computing. He is also a member of reviewer of several referred international journal such as journal of Computational and Applied Mathematics, International Journal of Computer Mathematics, and Journal of Universal Computer Science. Furthermore, he has supervised some Master and PhD students; he has won some research grants; holds several software copyrights; published a number of books in Indonesian and international papers in proceeding and journal.

Ivo B. Nurgoho holds Bsc from Faculty of Computer Sciences University of Indonesia since 2010. He is currently a system integration analyst at Accenture Indonesia and working with Indosat in CRM Project. His main research interest is parallel computing. Together with Heru Suhartanto, he has published an international paper in Asian Journal of Information Technology related with design and simulation of Indo-Edu Grid using Gridsim at 2010.

Anisa Herdiani holds B.Sc. and M.Sci from School of Electrical Engineering and Informatics, Bandung Institute of Technology. She is currently an academic and research staff of Faculty of Information Technology – Universitas YARSI. Her research interests are learning technology, consumer health informatics, and knowledge based systems.