International Journal of Bio-Science and Bio-Technology
Vol.8, No.2 (2016), pp.307-316
http://dx.doi.org/10.14257/ijbsbt.2016.8.2.29

E-Health Grid Network Topology Based on Province in Indonesia

Ummi Azizah Rachmawati[1], Sri Chusri Haryanti[1], Nur Aini[1], Angga Pradipta[1] and Heru Suhartanto[2]

[1]*Faculty of Information Technology, YARSI University, Indonesia*
[2] *Faculty of Computer Science, Universitas Indonesia*
ummi.azizah@yarsi.ac.id; sri.chusri@yarsi.ac.id;
nur.aini@students.yarsi.ac.id; angga.pradipta@students.yarsi.ac.id
heru@cs.ui.ac.id

Abstract

Information and Communication Technology (ICT) has enhanced human life including in health care. Consequently, professional workers in the field of health services are required to improve productivity, accuracy, efficiency and service. The use of ICT for health purposes is known as e-Health. The development of e-Health can use the grid technology for resource sharing and interoperability. The technology can process a very large data for parallel computation. It can also be used to facilitate health practitioners and researchers in the field of health, including to find a new virus, discovery new drugs, disease, an image of organs and to determine the actions for a patient. As an archipelago country where many health services centers distributed in the country, Indonesia needs an appropriate model of e-Health Grid. AS preliminary study, this paper proposes an e-Health Grid network topology based on the province in Indonesia.

Keywords*: e-Health, e-Health Grid, Network, Topology*

1. Introduction

Science and technology development have changed the paradigm of human life. People need an Information and Communication Technology (ICT) to share, obtain and access information quickly and easily. It has changed the pattern of management services in various fields, including in health care services that are known as e-Health. The fundamental consequence is that the productivity should increase without compromising the confidentiality, accuracy, efficiency and prompt service for the patient.

According to World Health Organization (WHO), health is as state of complete physical, mental and social well-being and not merely the absence of disease or infirmity [1]. Factors that interfere health degree in society are attitude, an environment, ancestry and health services [2]. E-Health services including electronic health records, consumer health informatics, telemedicine, health knowledge management, virtual healthcare teams, healthcare information systems, m-Health, and medical research using Grid technology.

The development of e-Health involves the community, hospitals, health centers, universities, drug manufacturers, the pharmaceutical industry, Government, and others. The environment needs resource sharing between those elements. Grid computing systems can resolve the problem of resource sharing such as information, data structures, databases, processor, and storage resources on separate location dynamically using open-standard protocols [3]. It is necessary to use an open-source to meet the requirement of the e-Health. Grid computing system has already designed a set of middleware to support e-Health applications. Grid computing for e-Health can reduce the cost and fully utilize the existing IT resources.

ISSN: 2233-7849 IJBSBT

According to Health Law of Indonesia (UU No. 36/2009), the health sector is the government responsibility. Achieving equitable and affordable health care services need an appropriate planning, actuating, controlling, supervising and monitoring [4]. Indonesia is the largest archipelagic country in the world. The country consists of 17,508 islands with a population more than 237 million people [5]. Sumatra, the biggest island, covers 25.2 percent of the entire Indonesian region and has 21.3 percent of the population. Papua that cover 21.8 percent of the territory has 1.5 percent of the population. While Java that only covers 6.8 percent of the territory has 57.5 percent of the population [6]. In consequence, information and communication are critical aspects to improve the resilience of the country including in the health area.

Data and information integration are critical to health agencies in Indonesia. Many reports said that Indonesia is an epidemic country for several diseases such as dengue fever, tuberculosis, malaria and others, but the data still could not be obtained quickly and accurately. Data interaction and technology collaboration is required to find new methods to improve healthcare services. Interoperability system is necessary for national e-Health development in Indonesia. It can attain an integrated use, secure and efficient data and information. Interoperability also supports a system to share and integrate information and processes using a set of standard work. Grid computing technology is one solution for interoperability problem. Grid computing system integrates services across distributed and heterogeneous virtual organizations on different resources and relationships [7].

In previous work, we have simulated e-Government Grid in Indonesia based on province and population using GridSim toolkit [8]. We perform this study to support the Government for giving good services to people and also to support the health research among researcher, practitioner, University, pharmacist, and government agency.

As a part of the study in implementing Grid technology on e-Health services in Indonesia, we propose topology of e-Health Grid model based on the province in Indonesia. In this study, we designed a topology to form a network between provinces. We use the topology as a reference in building a model of e-Health Grid in the country. We investigate the topology using NS-3.

2. E-Health Grid

2.1. E-Health

Eysenbagh in [9] defined e-Health as "*an emerging field in the intersection of medical informatics, public health, and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology".*

E-Health is expected to increase efficiency and quality of healthcare. E-Health is evidence-based and focused in consumers or patients empowerments. It encourages a new relationship between patients and healthcare worker using online sources. E-Health supports communication and information exchange in a standardized mode [9].

2.2. Grid Computing

According to Foster et. al., a grid computing system is a collection of hardware and software infrastructure that provides reliable, consistent, pervasive and inexpensive access to high-end computational capabilities [10]. The grid computing or the Grids for short, integrate and coordinate resources and users and built-in multifunctional protocols, interfaces, and open standards. Grids allow sharing resources to achieve the quality of services associated with response time, throughput, availability, and security. Multiple types of resources allocations can be used to meet user demand for complex computation.

Berman et al. state that a grid computing infrastructure and data management will provide electronic foundation piles for the global community regarding business, government, research, science, and entertainment [11]. The grid connect and integrate all the resources such as networks, communication systems, computing and information to create a virtual platform that provides support computing and data management.

Buyya *et al.*, define Grids as an infrastructure that includes computers, networks, databases and specialized devices owned and regulated by several organizations that work in an integrated and collaborative nature [12].

The grid is an established concept in IT community. It can ease the collaboration of geographically distributed resources with consistent and secure access irrespective of users' physical location. It is proven to share, select, and aggregate distributed heterogeneous resources, such as storage, data, instruments and software systems as a single and unified resource [13].

2.3. E-Health Grid

Brenton et al. define health grid as the application of grid technologies to the health area [14]. Health grid or e-Health Grid gives an easy integration of distributed medical datasets. E-Health Grid can align a large number of distributed data, a large-scale statistics capacity, and vast epidemiology [15].

E-Health changes health outcomes and decision making. E-Health needs a reliable online system for consultations and education. It is very important to improve the productivity in service, give more access to medical services, and provide a high quality of diagnostic of patient safety. Technology should break down some existing barriers to access e-Health in the world [16].

3. E-Health in Indonesia

Indonesia government announced a Healthy Indonesia 2010 goal to achieve the UN Millennium Development Goals (MDGs). The health-related targets are milestones in the development of national health. Indonesia has been successful in collecting resources for developing public health including funds from the Global Fund to combat AIDS, Tuberculosis and Malaria (GFATM) and other sources. The health sector must strengthen the capacity to develop and utilize mobilized resources [17].

Health services are decentralized in partial health information systems that make the division of reporting responsibilities is not clear. Indonesia does not have a comprehensive data that cover the entire nation to monitor health programs in the whole country [17]. Indonesia needs to build an interoperability system that support resource to handle the health issues in the country.

The Ministry of Health of the Republic of Indonesia in 2015 listed the number of hospitals in Indonesia as 2,228. It consists of 1,718 General Hospital and 510 Specialist Hospital [18]. Table 1 shows the number of hospitals in Indonesia.

In our topology, we considered the government of Indonesia data consisting of 34 provinces. This is due to the agreement between the Parliament and the Government of Indonesia to add North Kalimantan as a new province that is the division of the province of East Kalimantan on October 22, 2012 [8].

4. Simulation

Developing a Grid in a real system is very limited, expensive and time-consuming. In addition to the difficulties to carry out the heterogeneous and dynamic system, we have to deal with different administrative policies at each resource. In this paper, we evaluate and analyze the performance of topology proposed in the simulation. We use NS-3 [19] to build and simulate the topology. We performed some scenarios to see the behavior of the system.

NS-3 is a network simulator. NS-3 is a discrete-event simulator that can be utilized to develop a preferred, simulation environment for networking research. NS-3 software infrastructure supports the development of simulation models that are adequately realistic. One of the advantages of NS-3 is that it can be used as a real-time network emulator, interconnected with the real world. NS-3 allows the operation of many existing real-world protocol implementations. NS-3 simulation supports both IP and non-IP based networks. NS-3 also supports a real-time scheduler that simplifies a number of "simulation-in-the-loop" use cases for connecting with real systems. Real network devices can shed and receive NS-3 generated packets. NS-3 can also serve as an interconnection framework to add link effects between virtual machines [19].

The main goal of this works is modeling an Indonesian e-Health Grid. We divided provinces into four clusters. Cluster I is hospitals located in provinces at Sumatera Island. Cluster I consist of hospitals at province as follows: Nanggroe Aceh Darussalam (NAD), North Sumatera, West Sumatera, Riau, Jambi, South Sumatera, Bengkulu, Lampung, Bangka Belitung Archipelago, and Riau Archipelago.

Cluster II consists of hospitals located in the provinces of Java Island, Bali Island and Nusa Tenggara Archipelago provinces that are Special Capital Region Jakarta, West Java, Banten, Central Java, Special Region Yogyakarta, East Java, Bali, West Nusa Tenggara, and East Nusa Tenggara.

Cluster III consists of hospitals located in the province of Kalimantan Island that are West Kalimantan, Central Kalimantan, South Kalimantan, East Kalimantan, and North Kalimantan.

Cluster IV consists of hospitals located in the provinces of Sulawesi Island, Maluku archipelago and Papua Island that are North Sulawesi, Central Sulawesi, South Sulawesi, Southeast Sulawesi, Gorontalo, West Sulawesi, Maluku, North Maluku, Papua, and West Papua. The network topology based on the province in Indonesia shown in Figure 1.

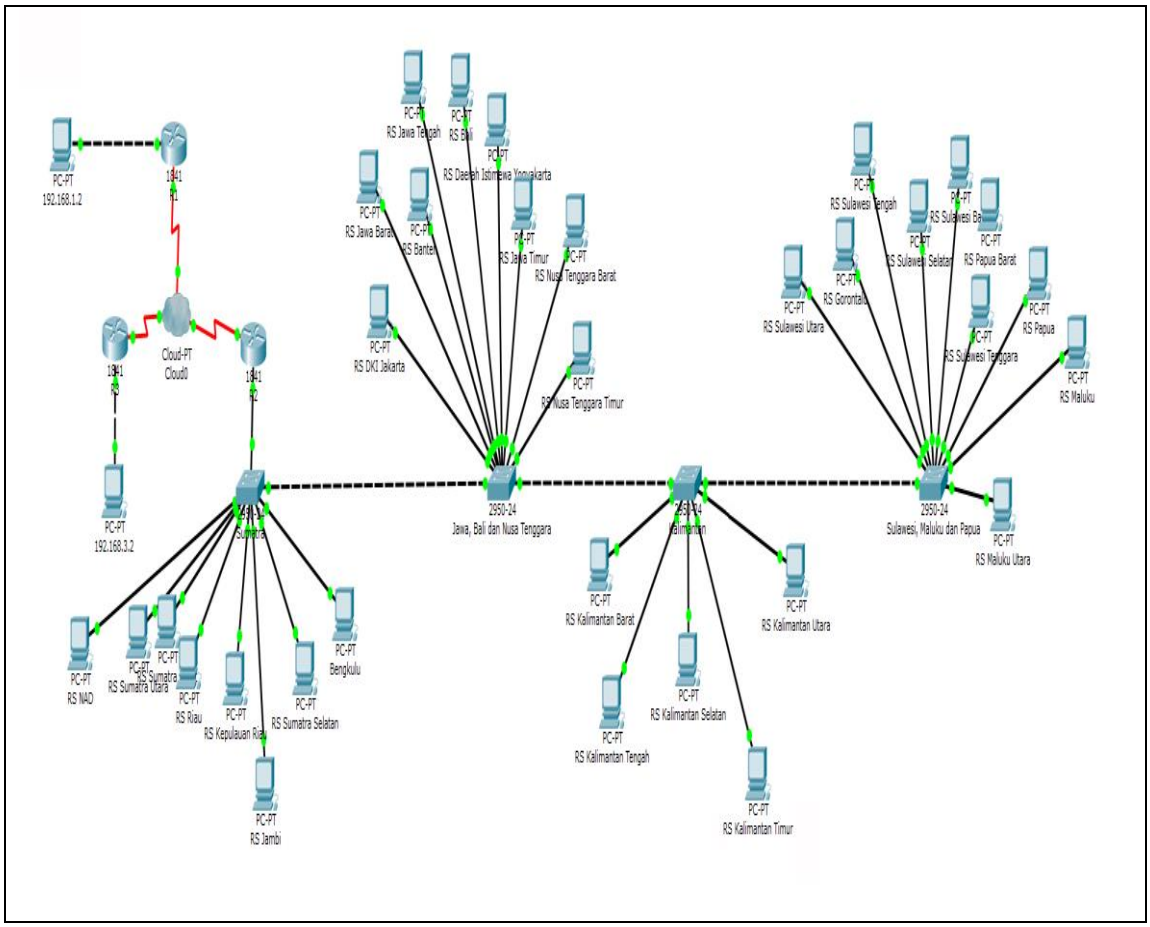

Figure 1. Indonesian e-Health Grid Network Topology

In the simulation, we set the packet rate at 10 Kbps, 20 Kbps, 30 Kbps, 40 Kbps and 50 Kbps respectively. Link rate is set at 50 Mbps and 100 Mbps. The result of this simulation is an animation of the packet link among nodes during the processing time and the trace file of the simulation including latency and throughput as the network performance. Figure 2 shows the illustration of the network topology for the scenario using NS-3 application.

Figure 2 exhibit simulation results of e-health grid network topology using NetAnim in NS-3. The result depicts the position of and communication between nodes in the grid. The real animation in NS-3 of Figure 2 shows the exchange of packets between nodes that occurs in the grid from time to time.

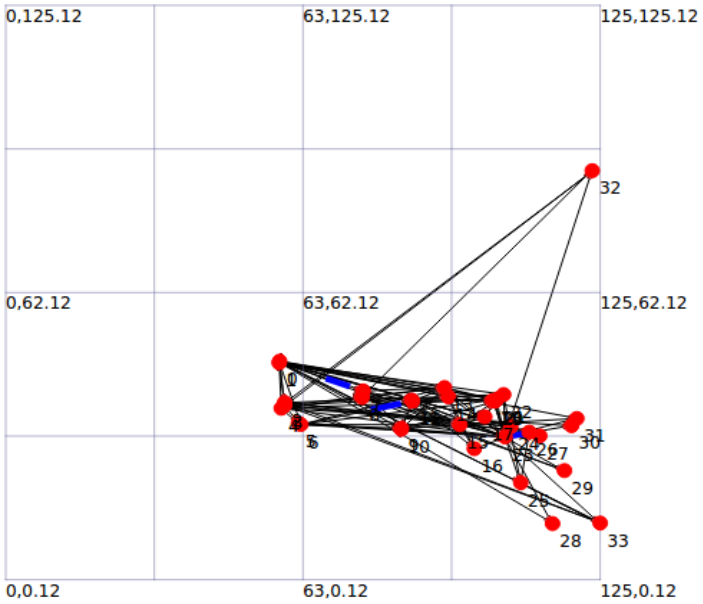

Figure 2. NS-3 Simulation of e-Health Grid Network Topology 34 Node

Figure 3 (a) shows the latency with link rate at 50 Mbps and packet rate at 10 Kbps, 20 Kbps, 30 Kbps, 40 Kbps, and 50 Kbps. Figure 3 (b) shows the latency with link rate at 100 Mbps and packet rate at 10 Kbps, 20 Kbps, 30 Kbps, 40 Kbps, and 50 Kbps.

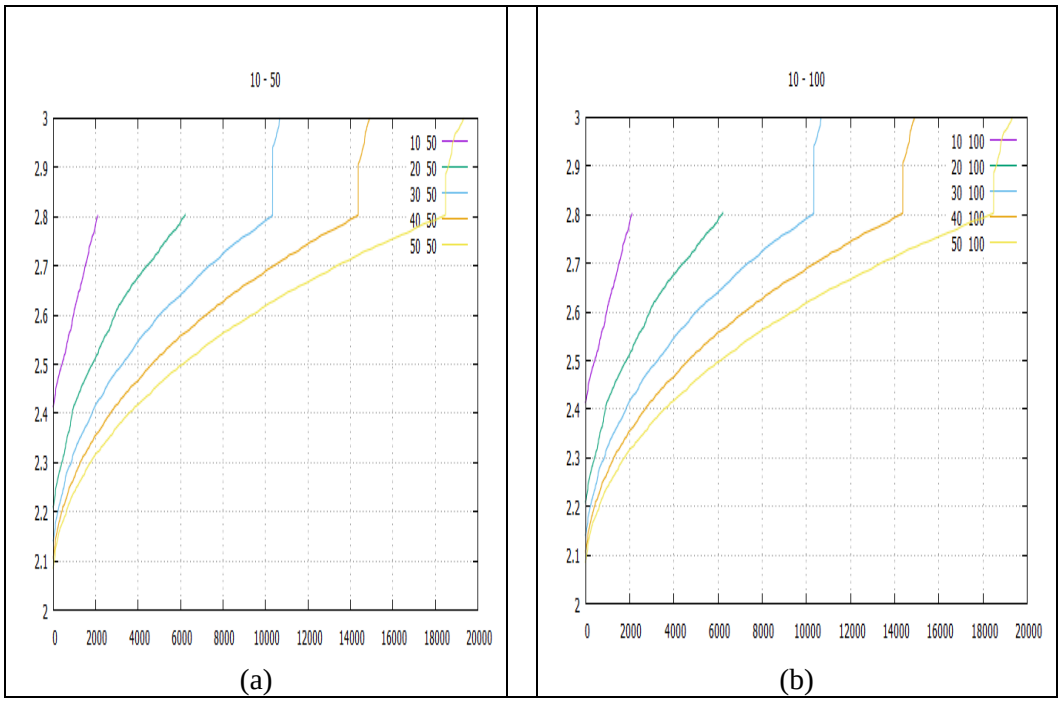

Figure 3. The Latency with Rate 50 Mbps and 100 Mbps

Figure 3 shows that the greater size of the packet will generate the greater of its latency. The throughput results are shown in Figure 4.

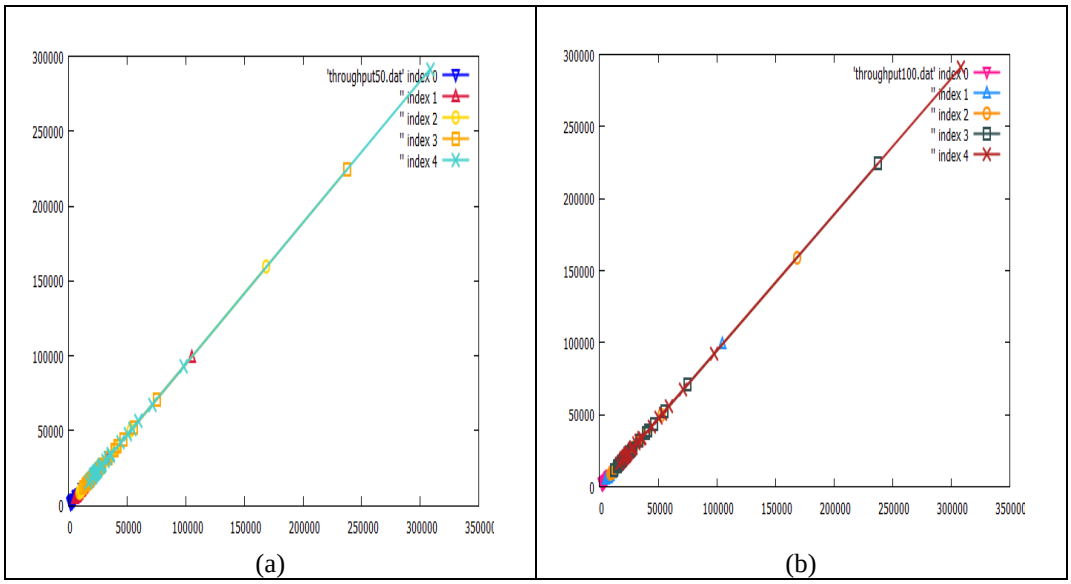

Figure 4. Throughput with Link Rate 50 Mbps and 100 Mbps

Figure 4 shows a throughput graph as a result of data packet transmitted with Link Rate at 50 Mbps and 100 Mbps. It reveals that the processing time depends on the large packet of data transmitted, making it look almost similar between the two link rate results.

5. Conclusion

E-Health Grid network topology based on province has been successfully built and testedin the NS-3 simulator. There is a consistent result on latency and throughput where the processing time depends on the size of the data packet.

6. Future Works

This research aims to model an e-Health Grid in Indonesia. We will continue this work by increasing the size of the data packet and analyze the performance. The analysis can be used to build an e-Health Grid model as a reference when the government decided to develop Grid technology to improve the health services to the citizen.

Acknowledgments

This work under the support of Indonesian Ministry of Research and Technology and Higher Education, Directorate General of Higher Education Excellent Research Grants Number 105/K3/KM/2015.

References

[1] Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force, **(1948)**.
[2] H.L. Blum, Planning for Health Development and Application of Social Change Theory, Human Sciences Press, **(1981)**.
[3] UA. Rachmawati, H. Suhartanto and DI. Sensuse, "Function Group Based of indonesian e-Government Grid Services Topology", International Journal of Computer Science Issues, vol. 9, Issue 2, no. 2, **(2012)**.
[4] Health Law of Indonesia Number 36, **(2009)**.
[5] Statistics Indonesia, 2010 Population Cencus, Retrieved September 20 **(2012)**

[6] U.A. Rachmawati and H. Suhartanto, "Analysis of Indonesia e-Government Grid Services Simulation Based on Population", International Journal of Software Engineering and Its Applications, vol. 8, no. 11, **(2014)**, pp. 89-100
[7] V. Silva, "Grid Computing for Developers", Charles River Media, Hingham, Massachusetts, **(2005)**.
[8] U.A. Rachmawati, X. Li and H. Suhartanto, "E-Government Grid Services Topology Based on Province and Population in Indonesia", International Journal of Advanced Computer Science and Application, SAI Society, vol. 4, no 2, **(2013)**, pp. 122-130.
[9] G. Eysenbach, J Med Internet Res , vol. 3, no. 2, e20, **(2001)**.
[10] I. Foster, C. Kesselman, and S. Tuecke, "The Anatomy of the Grid: Enabling Scalable Virtual Departments", International Supercomputer Applications, 15(3) **(2001)**
[11] F. Berman, G.Fox, AJ.G. Hey, Grid Computing: Making the Global Infrastructure a Reality, John Wiley & Sons, I.c. New York, NY, USA, **(2003)**.
[12] R. Buyya and M. Murshed, "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, **(2002)** , pp. 13-15
[13] E.,Kldiashvili, Grid-New Perspective of e-Health Applications for Georgia **(2005)**. Available at: http://georgia.telepathology.org
[14] V. Breton, K. Dean, and T. Solomonides, "The Healthgrid white paper," In Healthgrid 2005, pp. 249-318. Ios Press, (2005)
[15] P. De Vlieger et al, "Grid-enabled sentinel network for cancer surveillance", Studies in Health Technologies and Informatics 147, 289-94 **(2009)**
[16] E. Kldiashvili, "The Application of Virtual Organization Technology for E-Health" in Grid Technologies for E-Health: Applications for Telemedicine Services and Delivery, IGI Global, USA **(2010)**, ch. 1, pp. 1-17.
[17] World Health Organization (WHO) Country Report **2015**. Available at: http://www.who.int/countries/idn/en/
[18] Department of Health, Republic of Indonesia **2015**. Available at: http://sirs.buk.depkes.go.id/rsonline/report/report_by_catrs_2013.php)
[19] Overview of NS-3. Retrieved April 14 **(2015)**. Available at: https://www.nsnam.org/overview/what-is-ns-3/

Authors

Ummi Azizah Rachmawati, she holds B.Sc. from Informatics Engineering, Sepuluh Nopember Instutute of Technology in 2000 and holds M.Sc. from Magister of Information Technology, Universitas Indonesia in 2003. She holds Ph.D from Faculty of Computer Science, Universitas Indonesia in 2014. She got a Sandwich Program during her postgraduate at Information Technology and Electrical Engineering (ITEE) University of Queensland, Australia. She is an academic and research staff of Faculty of Information Technology, YARSI University, Jakarta, Indonesia. Her main research interests are Data Mining, Grid Computing, Social Network Analysis and e-Government. She has won some research grants on e-Commerce, e-Learning, e-Government, Social Network Analysis and e-Health.

Sri Chusri Haryanti, she received her B.Sc., Master and Doctoral degrees from Department of Electrical Engineering, Faculty of Engineering, Universitas Indonesia. She is an academic and research staff of Faculty of Information Technology, YARSI University, Jakarta, Indonesia. Her research interest includes Mobile Ad Hoc Grid, Mobile Computing, Grid and Cloud Computing.

Nur Aini, she holds her B.Sc. from Department of Informatics Engineering, Faculty of Information Technology, YARSI University, Jakarta, Indonesia. Her research interests are Networking, Grid Computing and High Performance Computing.

Angga Pradipta, he is a student of Department of Informatics Engineering, Faculty of Information Technology, YARSI University, Jakarta, Indonesia. Her research interests are Networking and High Performance Computing.

Heru Suhartanto, he is a Professor in Faculty of Computer Science, Universitas Indonesia (Fasilkom UI). He is currently holding an Honorary Professor at School of Information Technology and Electrical Engineering, the University of Queensland, Australia until 2016. 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 was appointed as Honorary Professor at School of ITEE, The University of Queensland for the period of 2014-2016. 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 Cloud, Grid, High Performance and Numerical Computing. He has won some research grants; holds several software copyrights; published a number of books in Indonesian and international papers in proceeding and journal.