E-Health Grid Network Topology Based on Referral Hospital Clustering in Indonesia

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Abstract: Information and Communication Technology (ICT) has made a great change in human life including in health care area. 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. Grid Technology can be used in the development of e-Health for resource sharing and interoperability. Grid can process a very large data for parallel computation. Grid can be used to facilitate health practitioners and researchers in the field of health to find a new virus, discovery a new drugs, disease, images of organs and to determine the actions for a patient. This paper is the result of health policy study in Indonesia and simulation of network topology based on referral hospital clustering in the country that aims to model e-Health Grid in Indonesia.

Key words: E-Health, grid, network, topology.

1. Introduction

Science and technology become a necessity for human life nowaday. People need to communicate and share many things through technology we called Information and Communication Technology (ICT). Many areas use the ICT to obtain and to access information quickly and easily. These advances have changed the pattern of management services in various fields, including in the health area. The fundamental change is related to productivity that should increase without compromising the confidentiality, accuracy, efficiency and prompt service for the patient. The use of ICT for health services is known as e-Health.

Data and information integration are critical to health agencies in Indonesia since many reports said that the country is an epidemic country for several diseases such as dengue fever, tuberculosis, malaria and others. Data interaction and technology collaboration is required to find new methods to solve health problems.

Interoperability system is necessary for the national e-Health development to attain an integrated use, secure and efficient data and information. Interoperability supports a system to share and integrate information and processes using a set of standard work. Grid technology is one solution for interoperability problem. Grid services integrate services across distributed and heterogeneous virtual organizations on different resources and relationships [1].

We have simulated e-Government Grid in Indonesia based on province and population using GridSim toolkit [2]. We proposed this study to support the Government for giving a better services to people and also to support the health research among researcher, practitioner, university, pharmacist, and government agency.

As Indonesia does not apply Grid technology on e-Health services yet, therefore we propose topology of e-Health Grid model based on Referral Hospital. In this study, we designed a topology to form a network between referral hospitals as a reference in building a model of e-Health Grid in Indonesia. We used NS-3, the third Generation Network Simulator.

2. E-Health Grid

Grid is developing concepts in the IT community. Grid can facilitate the coupling of geographically distributed resources and offer consistent and secure access irrespective of users' physical location or access point. Grid is proven to share, select, and aggregate a wide variety of distributed resources, such as storage systems, data sources, instruments and software systems to be used as a single and unified resource [3].

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 [4].

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 [5].

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 process of national health development. Indonesia has been successful in mobilizing resources for 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 [6].

Health services are decentralization 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 [6]. Indonesia needs to build an interoperability system that support resource to handle the health problem in the country.

Table 1. Hospital Recapitulation by Category of Hospital [7]

Category	Owner	General Hospital	Specialist Hospital	Total
Public Hospital	**Government**	**749**	**89**	**838**
	Ministry of Health	14	19	33
	Province Government	53	43	96
	Regency Government	445	10	455
	Municipal Government	79	13	92
	Other Ministries	3	0	3
	Military	114	4	118
	National Police	41	0	41
	Private Non-Profit	522	202	724
Private Hospital	**Private**	**387**	**212**	**599**
	State-owned Enterprises	60	7	67
Total		**1718**	**510**	**2228**

*Private Hospitals : Company, Individual and others

In this research, we build a scenario using clustering network topology to connect referral hospitals in Indonesia. We considered the referral hospital that authorized by the Indonesia government and we choose a several specialist hospital that become a referral for certain diseases.

Data from the Ministry of Health of the Republic of Indonesia in 2015 put the number of hospitals in Indonesia as 2,228. It consists of 1,718 General Hospital and 510 Specialist Hospital [7]. Table 1 shows the

number of hospitals in Indonesia.

According to Indonesia Ministry of Health Decree No: HK.02.02/Menkes/390/2014, the Government manages authorized 14 national referral hospital. One of the criteria is internationally accredited by Joint Commission International (JCI) [8]. Accreditation status granted hospitals that can provide health services to meet the standards. The Referral Hospital in Indonesia are:

1. Dr. Cipto Mangunkusumo Hospital, Jakarta
2. H. Adam Malik Hopital, Medan, North Sumatera
3. Dr. M. Djamil Hospital, Padang, West Sumatera
4. Dr. M. Hoesin Hospital, Palembang, South Sumatera
5. Dr. Hasan Sadikin Hospital, Bandung, West Java
6. Dr. Sardjito Hospital, Yogyakarta, Special Region of Yogyakarta
7. Dr. Kariadi Hospital, Semarang, Central Java
8. Dr. Soetomo Hospital, Surabaya, East Java
9. Sanglah Hospital, Denpasar, Bali
10. Dr. Soedarso Hospital, Pontianak, West Kalimantan
11. Abdul Wahab Sjahranie Hospital, Samarinda, East Kalimantan
12. Dr. Wahidin Sudiro Husodo Hospital, Makassar, South Sulawesi
13. Prof. Dr. R.D. Kandou Hospital, Manado, North Sulawesi
14. Dok II Jayapura Hospital, Papua

In this study, we add some hospitals that became a reference for certain diseases in Indonesia. It is intended for resource sharing in a particular disease as well as for research into specific diseases. We choose the 8 (eight) hospitals that have become a reference for certain diseases such as:

1. Persahabatan Hospital Jakarta, the national referral hospital for lung diseases
2. Harapan Kita Hospital Jakarta, the national referral hospital for heart and cardiovascular diseases
3. Dharmais Hospital, the national referral hospital for cancer
4. Central National Brain Hospital Jakarta, the national referral hospital for brain diseases
5. Sulianti Saroso Hospital Jakarta, the national referral hospital for infectious diseases.
6. Prof. Dr. Soerojo Hospital Magelang Central Java, the national referral hospital for mental illness
7. PGI Cikini Hospital Jakarta, the national referral hospital for kidney diseases
8. FKG UI Dental Hospital Jakarta

After determining that the hospitals that will be connected in a Grid, we made a point to point topology to connect all the hospitals. We proposed a scenario that divided the country into four clusters. Cluster I is hospitals in the capital city of Indonesia, located in Special Capital Region of Jakarta. Cluster II consists of hospitals located in Java Island aside from the capital city. Cluster III consists of hospitals located in Sumatera and Kalimantan Islands and cluster IV consists of hospitals located in Bali, Sulawesi and Papua Islands.

4. Simulation

The performance of topology should be evaluated and analyzed. It is difficult to carry out heterogeneous and dynamic system. Developing a Grid in a real system is very limited, expensive and time consuming. We have to deal with different administrative policies at each resource. We run a simulation to read up the behavior of the simulated system. We propose a scenario based on referral hospital to see the behavior of the system. In this simulation, we use NS-3 to build and simulated the topology.

NS-3 is a network simulator for Internet systems. NS-3 is discrete-event to develop a preferred, open simulation environment for networking research. NS-3 software infrastructure supports the development of simulation models which are sufficiently realistic. NS-3 can be used as a real-time network emulator,

interconnected with the real world. Ns-3 allows many existing real-world protocol implementations to be reused within NS-3. The NS-3 simulation core supports research on both IP and non-IP based networks. NS-3 also supports a real-time scheduler that facilitates a number of "simulation-in-the-loop" use cases for interacting with real systems. Users can shed and receive NS-3-generated packets on real network devices, and NS-3 can serve as an interconnection framework to add link effects between virtual machines [9]. The main goal of this works is modeling an Indonesian e-Health Grid.

We divided referral hospitals into four clusters. Cluster I is hospitals in the capital city of Indonesia, located in Jakarta. Cluster I consists of Dr. Cipto Mangunkusumo Hospital Jakarta (*Node 0*), Harapan Kita Hospital Jakarta (*Node 1*), FKG UI Dental Hospital Jakarta (*Node 2*), Sulianti Saroso Hospital Jakarta (*Node 3*), Dharmais Hospital Jakarta (*Node 4*), PGI Cikini Hospital Jakarta (*Node 5*), Persahabatan Hospital Jakarta (*Node 6*) dan Central National Brain Hospital Jakarta (*Node 7*).

Cluster II consists of hospitals located in Java Island aside from the capital city that are Dr. Sardjito Hospital Yogyakarta (*Node 8*), Dr. Kariadi Hospital Semarang (*Node 9*), Dr. Hasan Sadikin Hospital Bandung (*Node 0*), Dr. Soetomo Hospital Surabaya (*Node 11*) dan Prof. Dr. Soerojo Hospital Magelang (*Node 12*).

Cluster III consists of hospitals located in Sumatera and Kalimantan Islands that are Abdul Wahab Sjahranie Hospital Samarinda (*Node 13*), Dr. Soedarso Hospital Pontianak (*Node 14*), Dr. M. Djamil Hospital Padang (*Node 15*), H. Adam Malik Hospital Medan (*Node 16*) and Dr. M. Hoesin Hospital Palembang *(Node 17*).

Cluster IV consists of hospitals located in Bali, Sulawesi and Papua Island that are Dok II Jayapura Hospital (*Node 18*), Dr. Wahidin Sudiro Husodo Hospital Makassar *(Node 19)*, Sanglah Hospital Denpasar *(Node 20)* dan Prof. Dr. R.D. Kandou Hospital Manado *(Node 21)*. The network topology based on referral hospital clustering is shown in Fig. 1.

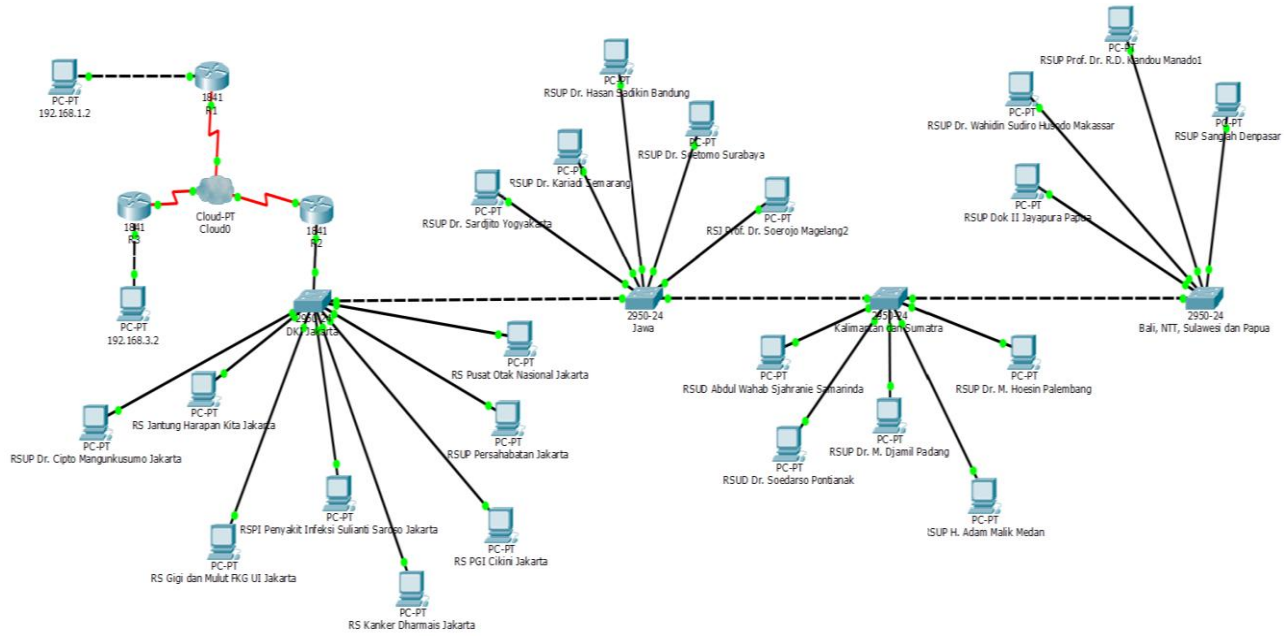


Fig. 1. Network topology.

The next stage is to run the simulation. We set the Packet Rate in this scenario at 10 Kbps (Kilobits per second), 20 Kbps, 30 Kbps, 40 Kbps and 50 Kbps respectively. Link rate is set at 50 Mbps (Megabits per second) 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. Fig. 2 shows the animation of the network topology for the scenario using NS-3 application.

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

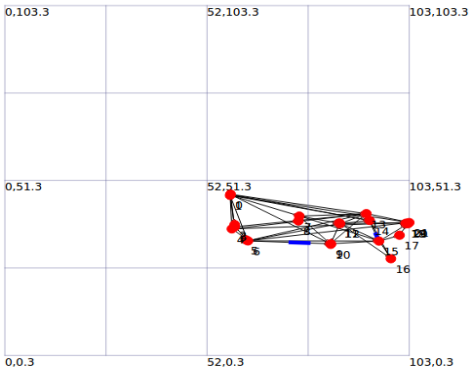
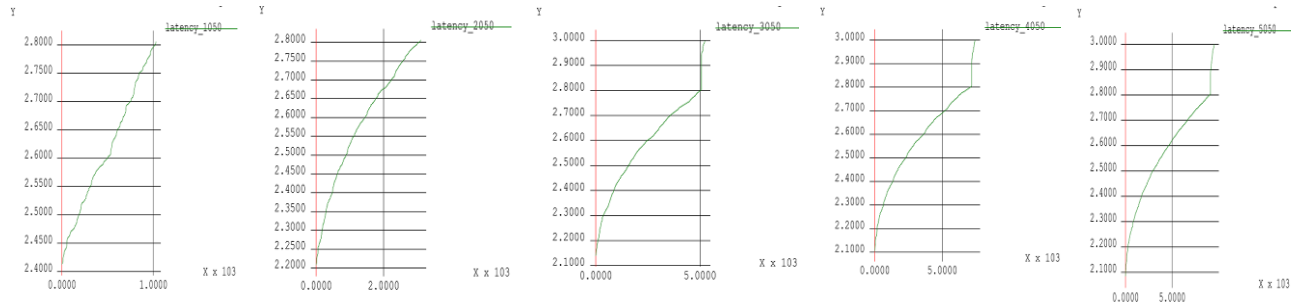


Fig. 2. NS-3 Simulation of e-Health grid network topology.

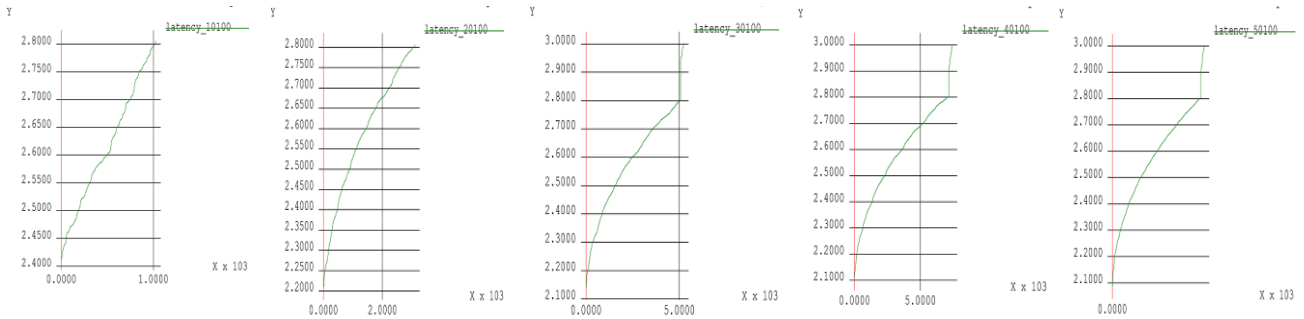
The latency with Link Rate at 50 Mbps and Packet Rate at 10 Kbps, 20 Kbps, 30 Kbps, 40 Kbps, and 50 Kbps are shown in Fig. 3.



(a) (b) (c) (d) (e)

Fig. 3. Graphic of latency with Link Rate 50 Mbps (a) Packet Rate 10 Kbps; (b) Packet Rate 20 Kbps; (c) Packet Rate 30 Kbps; (d) Packet Rate 40 Kbps; (e) Packet Rate 50 Kbps.

The latency with Link Rate at 100 Mbps and Packet Rate at 10 Kbps, 20 Kbps, 30 Kbps, 40 Kbps, and 50 Kbps are shown in Fig. 4.



(a) (b) (c) (d) (e)

Fig. 4. Graphic of latency with Link Rate 100 Mbps (a) Packet Rate 10 Kbps; (b) Packet Rate 20 Kbps; (c) Packet Rate 30 Kbps; (d) Packet Rate 40 Kbps; (e) Packet Rate 50 Kbps.

Fig. 3 and Fig. 4 above show that the greater size of the packet will generate the greater of its latency. The throughput is shown in Fig. 5.

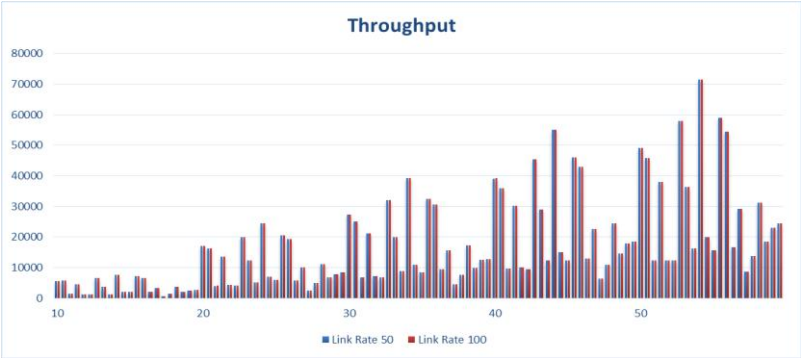


Fig. 5. Graphic of throughput with Link Rate 50 Mbps and 100 Mbps.

The image above 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 referral hospital clustering has been successfully built in the NS-3 simulator. The Hospital that is considered as a referral hospital in this paper is a hospital authorized by the Indonesia government and a specialist hospital for certain diseases. We define 22 referral hospitals and we divide into 4 clusters considering the region of Indonesia.

6. Future Work

This research aims to model an e-Health Grid in Indonesia. We will continue this work by creating some scenarios and analyze the performance. The model can be used as a reference when the government decided to develop an e-Health Grid to improve health services to the citizen.

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