

Software Defined e-Health Grid Networking Design Based on Referral Hospital in Indonesia

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Abstract

Indonesia is an archipelagic country that needs a model of e-Health Grid for connecting and sharing its resources in the health area. The use of Information and Communication Technology (ICT) for health purposes is growing fast as people need for better services in healthcare. Grid computing technology has proven for large parallel data computation process. Health practitioners and researchers can use it to find new invention and to improve services. Our previous research has proposed a topology of Indonesian e-Health Grid based on referral hospital. This paper is the advanced research of our e-Health Grid model. We design a Software Defined Network for Indonesia e-Health Grid. Software-Defined Network (SDN) allows applications to control the network. SDN is expected to be able to facilitate e-Health grid management. We set some scenarios with different link bandwidth and packet rates to evaluate the performance of the system. The result of this research is a design of e-Health Grid networking that can be used to model e-Health Grid in the country based on referral hospital.

Keywords: e-Health, Grid Computing, Software Defined Network, Topology

1. Introduction

Indonesia is one of the most populous country in the world that has vast areas separated by the sea. The distance between islands resulted in differences in access to health care for the urban and rural, including in remote area. Indonesia has health-related targets in the process of national health development to strengthen the capacity for developing and utilizing mobilized resources¹. The country is facing problems on data and information integration that need technology collaboration to resolve². National comprehensive data using Information and Communication Technology (ICT) is necessary to monitor health programs and to improve the quality of health service (e-Health). E-Health improves service, access, diagnostic, and outcomes that help the decision making. The new technology tunes out barriers to access e-Health³.

The stakeholder in health area including hospitals,

pharmaceutical, and health centers must involve along with universities and Government to develop an e-Health that supports resource sharing. Grid computing has been proven to solve the problem of dynamic resource sharing on different location using open-standard protocols with a set of middleware⁴. The Grid computing system can share data, storage, and processor as well. The use of grid technologies in health areas integrates distributed medical datasets on distinct resources^{5,6}. E-Health Grid low the cost by utilizing the existing IT resources.

However, the Grid technology for health purposes is not implemented in Indonesia yet. We have designed a clustering network topology to connect referral hospitals that authorized by the government by adding some specialist hospital for certain diseases and a topology based on the province in Indonesia^{7,8}. In this study, we test the referral hospital network topology using Mininet as the emulator. We map out some scenarios to observe the system performance. The result of this work can be used

as a reference in modeling e-Health Grid in Indonesia in order to increase service quality to citizen and to promote the health research.

2. Related Works

Software-defined networking (SDN) is a new approach in the networking area. It separates data and control plane to a simple packet forwarding devices⁹. The system controlled by a logically centralized software¹⁰. SDN comprises a structure that permits application to manage the network through a well-defined Application Programming Interface (API)¹¹⁻¹³.

Mininet is an emulator to empower research in Software Defined Networking (SDN). It deploys systems on the restricted resources of Virtual Machine (VM) without modeling hosts, switches, links and SDN/OpenFlow controllers^{14,15}. It creates topologies of enormous nodes and performs a test using simple command line tools and API to create, customize, share and test SDN networks¹⁴. It is very low cost, ease of use, and realism. Mininet can utilize as a fast, accurate, and shared hardware test beds. Mininet offers convenience, accuracy of performance and scalability¹⁴.

The Grid computing is an infrastructure to collaborate distributed resources include computers, databases, networks, and devices regulated by several organizations^{16,17}. The Grid built-in multifunctional protocols, interfaces, and open standards to create a virtual platform^{18,19}. It accomplishes the quality of such as throughput, response time, availability, and security of complex computation¹⁸.

We have proposed and evaluated the simulation performance of e-Government Grid service topology based on the existing structure and framework to connect the government agencies in Indonesia²⁰. We also performed a simulation of e-Government Grid based on the province and population in the country²¹.

We continue the works by designing an e-Health Grid model in the country. We proposed a topology based on referral hospital and based on the province and analyzed the performance to see the behavior of the system^{7,8}.

3. Result

The Grid technology facilitates the distributed resources consistently and securely regardless of location or

access point of the users. The characteristics of the Grid technology make it limited, expensive and time-consuming to developing in a real system. It is hard to carry out the varied and dynamic system since it deals with different administrative policies at each resource.

Indonesia has 1,718 General Hospital and 510 Specialist Hospital according to the Ministry of Health of the Republic of Indonesia in 2015²². We design Indonesia e-Health Grid Software Defined Network (SDN) with some scenarios using clustering network topology to connect referral hospitals authorized by the government and some specialist hospital for certain diseases. This work is aim to model e-Health Grid in Indonesia. We use Mininet as the testing platform to test the e-Health Grid Software Defined Networking.

We divided referral hospitals into four clusters⁸.

Cluster I consist of hospitals in the capital city of Indonesia, located in Jakarta (s1). The hospitals are Dr. Cipto Mangunkusumo Hospital Jakarta (**h0**), Persahabatan Hospital Jakarta (**h1**), Central National Brain Hospital Jakarta (**h2**), Dharmais Cancer Hospital Jakarta (**h3**), FKG UI Dental Hospital Jakarta (**h4**), Sulianti Saroso Infectious Diseases Hospital Jakarta (**h5**), Harapan Kita Heart and Cardiovascular Hospital Jakarta (**h6**), and PGI Cikini Hospital Jakarta (**h7**).

Cluster II is hospitals located in Java Island outside the capital city that are Dr. Sardjito Hospital Yogyakarta (**h8**), Dr. Kariadi Hospital Semarang (**h9**), Prof. Dr. Soerojo Hospital Magelang (**h10**), Dr. Soetomo Hospital Surabaya (**h11**) and Dr. Hasan Sadikin Hospital Bandung (**h12**).

Cluster III is hospitals located in Sumatera and Kalimantan Islands that are Abdul Wahab Sjahranie Hospital Samarinda (**h13**), Dr. Soedarso Hospital Pontianak (**h14**), Dr. M. Djamil Hospital Padang (**h15**), H. Adam Malik Hospital Medan (**h16**) and Dr. M. Hoesin Hospital Palembang (**h17**).

Cluster IV is hospitals situated in Bali, Sulawesi, and Papua Island that are Dok II Jayapura Hospital (**h18**), Dr. Wahidin Sudiro Husodo Hospital Makassar (**h19**), Prof. Dr. R.D. Kandou Hospital Manado (**h20**) and Sanglah Hospital Denpasar (**h21**). Figure 1. shows the network topology based on referral hospital clustering.

We evaluate round-trip-time (rtt) and moving standard deviation round-trip-time (mdev rtt) of the **h0** (central hospital) of sending packets to other hospitals. We examine the network performance for link rate 50

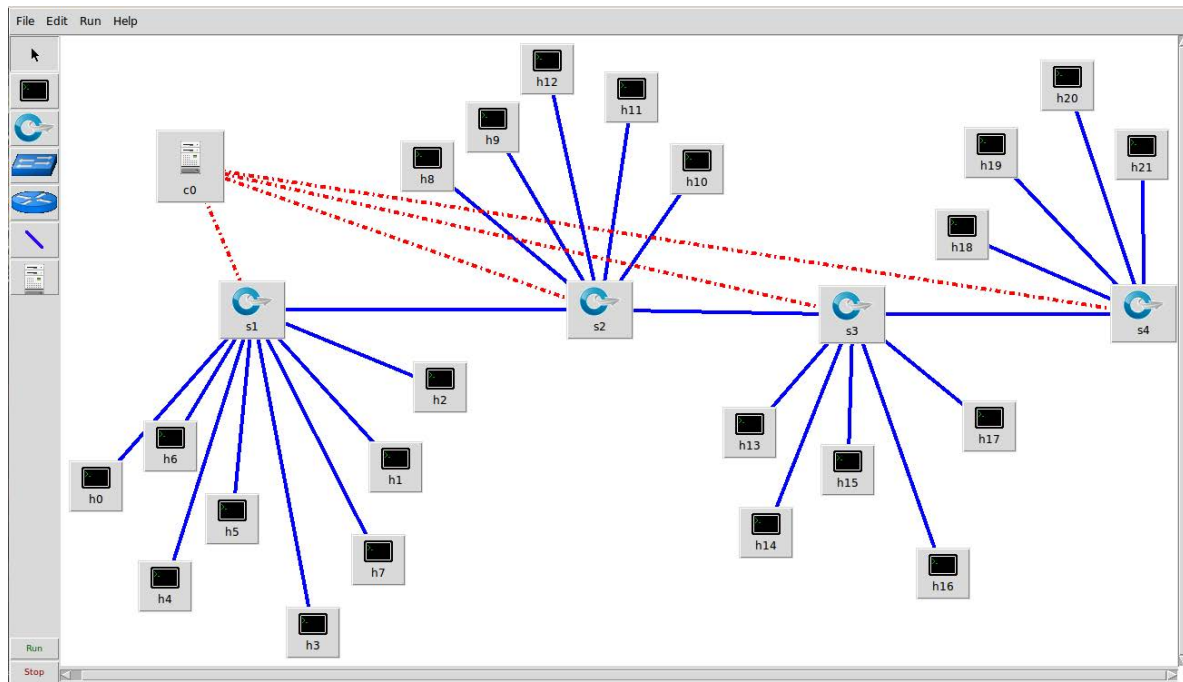


Figure 1. Network Topology.

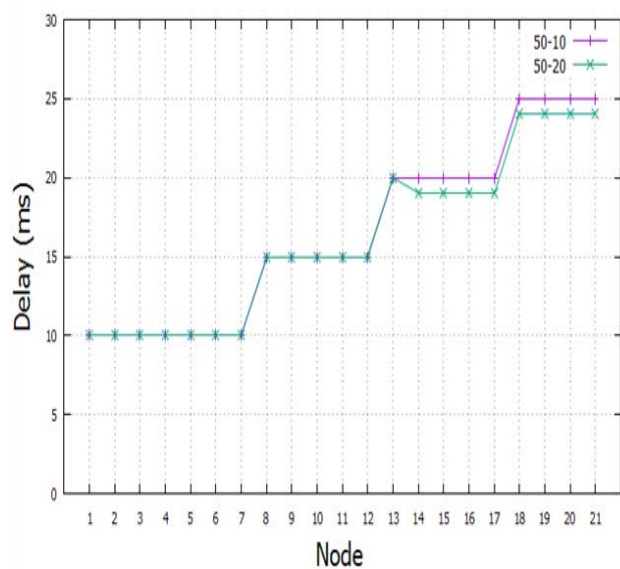
Mbps and 100 Mbps, combined with the packet rate 10 Kbps and 20 Kbps. Figure 2(a) shows the results of rtt for the combination link rate and packet rate at 50 Mbps - 10 Kbps and 50 Mbps - 20 Kbps. Figure 2(b) represents the results of rtt for the combination link rate and packet rate at 100 Mbps - 10 Kbps and 100 Mbps - 20 Kbps. Figure 2(c) exhibits the results of rtt for the combination link rate and packet rate at 50 Mbps - 10 Kbps and 100 Mbps - 10 Kbps. Figure 2(d) shows the results of rtt for the combination link rate and packet rate at 50 Mbps - 20 Kbps and 100 Mbps - 20 Kbps.

Figure 2(a) shows round-trip-time for 50 Mbps bandwidth, while the packet rates are 10 kbps and 20 kbps. The graphs indicate that rtt from h0 to any node in the same cluster e.g. Cluster I (h1 to h7), Cluster II (h8 to h12) are almost the same. Different packet rates give the same rtt from h0 to Cluster I hospitals and similarly from h0 to Cluster II hospitals. Nevertheless, rtt from h0 to Cluster III and Cluster IV hospitals are lower for packet rate 20 kbps compared with packet rates 10 kbps.

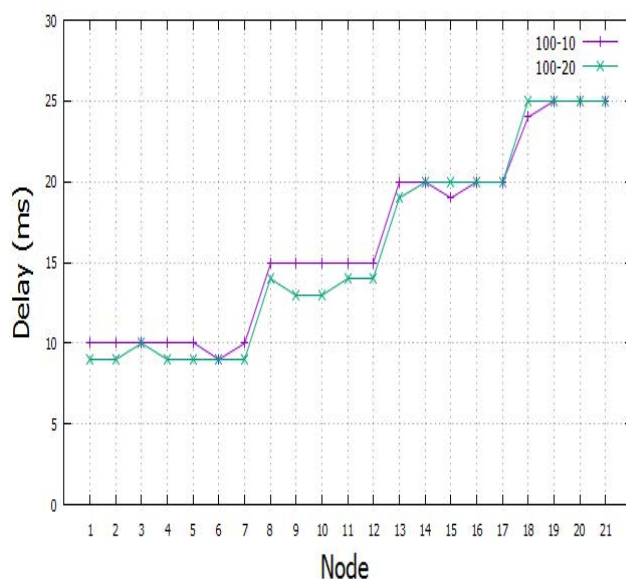
Figure 2(b) shows round-trip-time for 100 Mbps bandwidth. The graphs exhibit that rtt from h0 to Cluster I and Cluster II hospitals with 20 kbps packet rate is lower compared to 10 kbps packet rate. While for Cluster III and Cluster IV, the graphs indicate the opposite, 10 kbps packet rate gives lower rtt compared with 20 kbps packet rate.

Figure 2(c) and Figure 2(d) focus on rtt comparison for different bandwidth (50 Mbps and 100 Mbps). For 10 kbps packet rate, the bandwidth of 50 Mbps and 100 Mbps give almost the same rtt. However, for packet rate of 20 kbps, the use of 100 Mbps bandwidth provides lower rtt for Cluster I and Cluster II, while the use of 50 Mbps bandwidth gives lower rtt for Cluster III and Cluster IV. We can conclude from Figure 2(a) to Figure 2(d) that the recommended bandwidth usage for Cluster I and Cluster II is 100 Mbps, while for Cluster III and Cluster IV is 50 Mbps, both for packet rate 20 kbps.

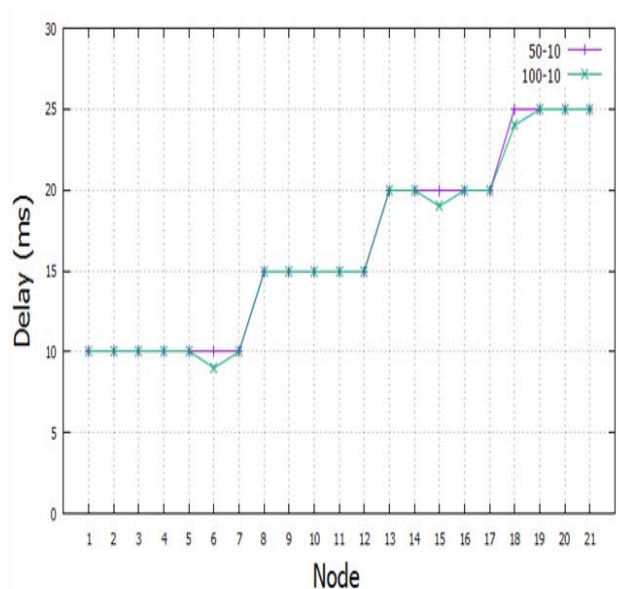
Figure 3(a) to Figure 3(d) show moving standard deviation of round-trip-time for 50 Mbps and 100 Mbps bandwidth, while packet rates are 10 kbps and 20 kbps. Comparing the graphs with the measurement of rtt, we can see that on average the rtt standard deviation are less than 10% of rtt. It is shown in Figure 3(b) and Figure 3(d) that it is something interesting in moving standard deviation of round-trip-time for Cluster IV (node 18, 19, 21 and 21). In Figure 3(b), the combination of 50 Mbps bandwidth and 10 kbps packet rate results lower moving standard deviation of round-trip-time for Cluster IV compared with 100 Mbps bandwidth and 10 kbps. In Figure 3(d), the combination of 100 Mbps bandwidth and 20 kbps packet rate results lower moving standard deviation of round-trip-time for Cluster IV compared with 100 Mbps bandwidth and 10 kbps.



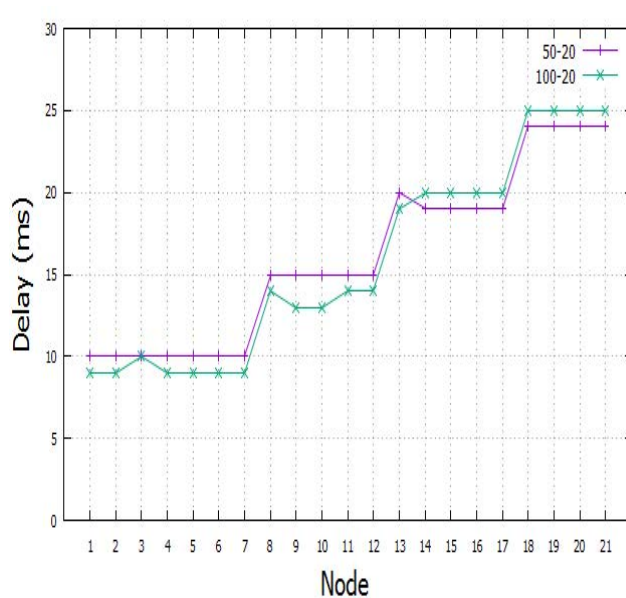
(a) Round-trip-time at bandwidth of 50 Mbps – packet rate of 10 kbps and bandwidth of 50 Mbps -20 packet rate of kbps.



(b) Round-trip-time at bandwidth of 100 Mbps – packet rate of 10 kbps and bandwidth of 100 Mbps -20 packet rate of kbps.

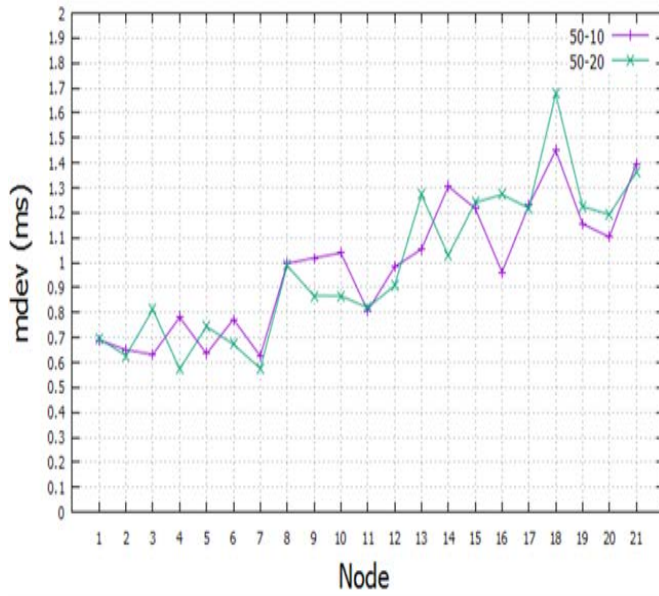


(c) Round-trip-time at bandwidth of 50 Mbps – packet rate of 10 kbps and bandwidth of 100 Mbps -10 packet rate of kbps.

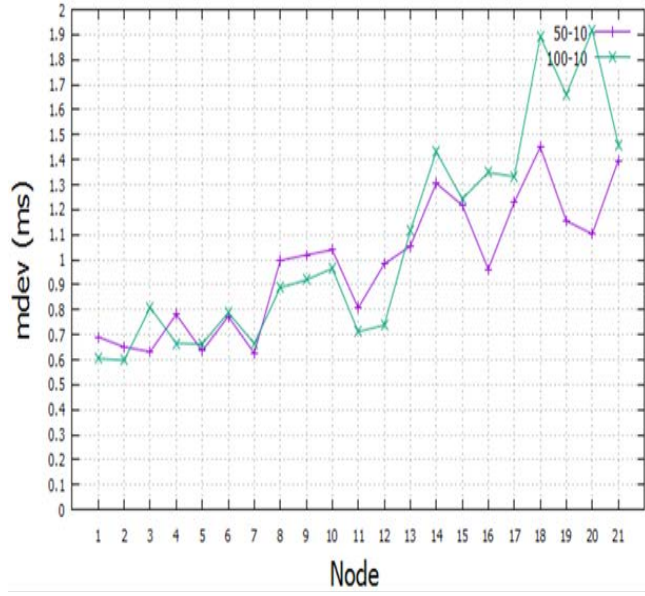


(d) Round-trip-time at bandwidth of 50 Mbps – packet rate of 20 kbps and bandwidth of 100 Mbps -20 packet rate of kbps.

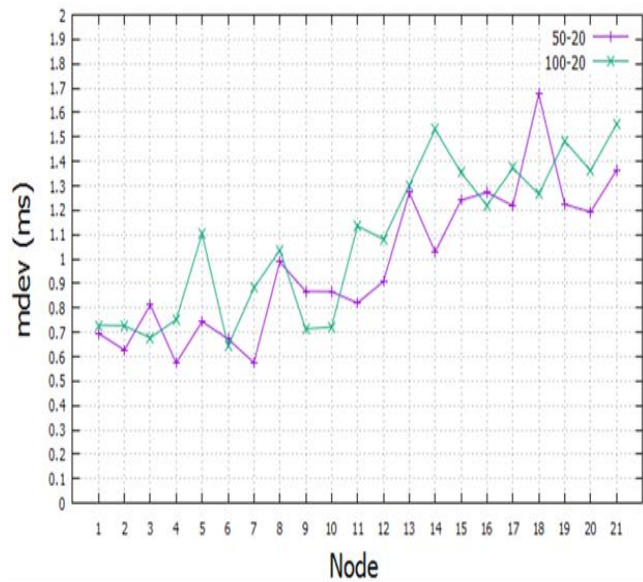
Figure 2. NRound-trip-time of Indonesian e-Health Grid Network Topology for combination of 50 Mbps - 100 Mbps bandwidth and 10 kbps - 20 kbps packet rate.



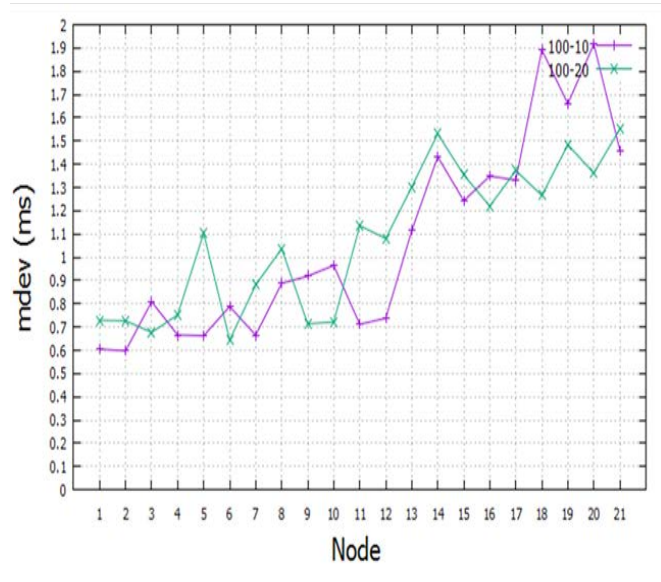
(a) Moving standard deviation round-trip-time at bandwidth of 50 Mbps - packet rate of 10 kbps and bandwidth of 50 Mbps -20 packet rate of kbps.



(b) Moving standard deviation round-trip-time at bandwidth of 50 Mbps - packet rate of 10 kbps and bandwidth of 100 Mbps - packet rate of 10 kbps.



(c) Moving standard deviation round-trip time at bandwidth of 50 Mbps - packet rate of 20 kbps and bandwidth of 100 Mbps -20 packet rate of kbps.



(d) Moving standard deviation round-trip time at bandwidth of 100 Mbps - packet rate of 10 kbps and bandwidth of 100 Mbps -20 packet rate of kbps.

Figure 3. Moving standard deviation of round-trip-time of Indonesian e-Health Grid Network Topology for combination of 50 Mbps - 100 Mbps bandwidth and 10 kbps - 20 kbps packet rate.

4. Conclusion

Software Defined Health Grid Networking Design Based on Referral Hospital in Indonesia has been successfully built and tested using Mininet. The investigation on performances of the topology shows that round-trip-time depends on the bandwidth and packet rate. For the Health Grid Networking Design, the recommended bandwidth usage for Cluster I and Cluster II is 100 Mbps, while for Cluster III and Cluster IV is 50 Mbps, both for packet rate 20 kbps. This recommendation means that bandwidth for connecting Dr. Cipto Mangunkusumo Hospital Jakarta as the center of all the referral hospitals to other referral hospitals in Jawa island is 100 Mbps. On the other hand, for connecting the referral hospitals outside the Jawa Island, the recommended bandwidth is 50 Mbps.

5. Future Works

The objective of this research is modeling an Indonesia e-Health Grid to improve the utilization of ICT in the health area. We will continue this work by implementing to the real system to find the best performance of the model. The model can be used as a reference when the Government decides to implement the Grid technology to improve the health services to the citizen.

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