

ANALYSIS OF *SOFTWARE DEFINED NETWORK (SDN)* USING OPENDAYLIGHT CONTROLLER WITH ANOVA *REPEATED MEASURES*

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Abstract

The rapid development of technology today makes the technology around us also become more advanced and continues to grow, this has an impact on the development of the internet network. Technology such as *Software Defined Network (SDN)* is needed because it results in improved performance in network management, control and data handling that allows it to be managed centrally and more easily by network administrators by separating the control plane and data plane. In this study, an analysis of the SDN architecture was carried out using the Opendaylight controller based on the parameters of throughput, delay and jitter which then can be seen how the performance of the SDN architecture in a topology by increasing the number of nodes. The throughput test shows that the custom topology has a significant increase in value and has a better average throughput value among other topologies. While in the delay and jitter test, the custom topology has a better average value even though it has an insignificant increase in the delay and jitter value when there is an increase in the number of nodes.

Keywords: *Opendaylight, Controller, Software Defined Network, Topology.*

1. INTRODUCTION

The development of technology in this era makes the technology around us also become more advanced and can continue to grow, this of course also has an impact on the development of the internet network. According to a survey by the Association of Indonesian Internet Service Providers (APJII), internet users in Indonesia in 2018 reached 171 million people.

A Software Defined Network architecture was created to replace the conventional network architecture which allows a network to be managed centrally and more easily by network administrators by separating the control plane and data plane on network devices. The concept of Software Defined Network is the centralization of network control with settings in the control plane that can simplify network management.

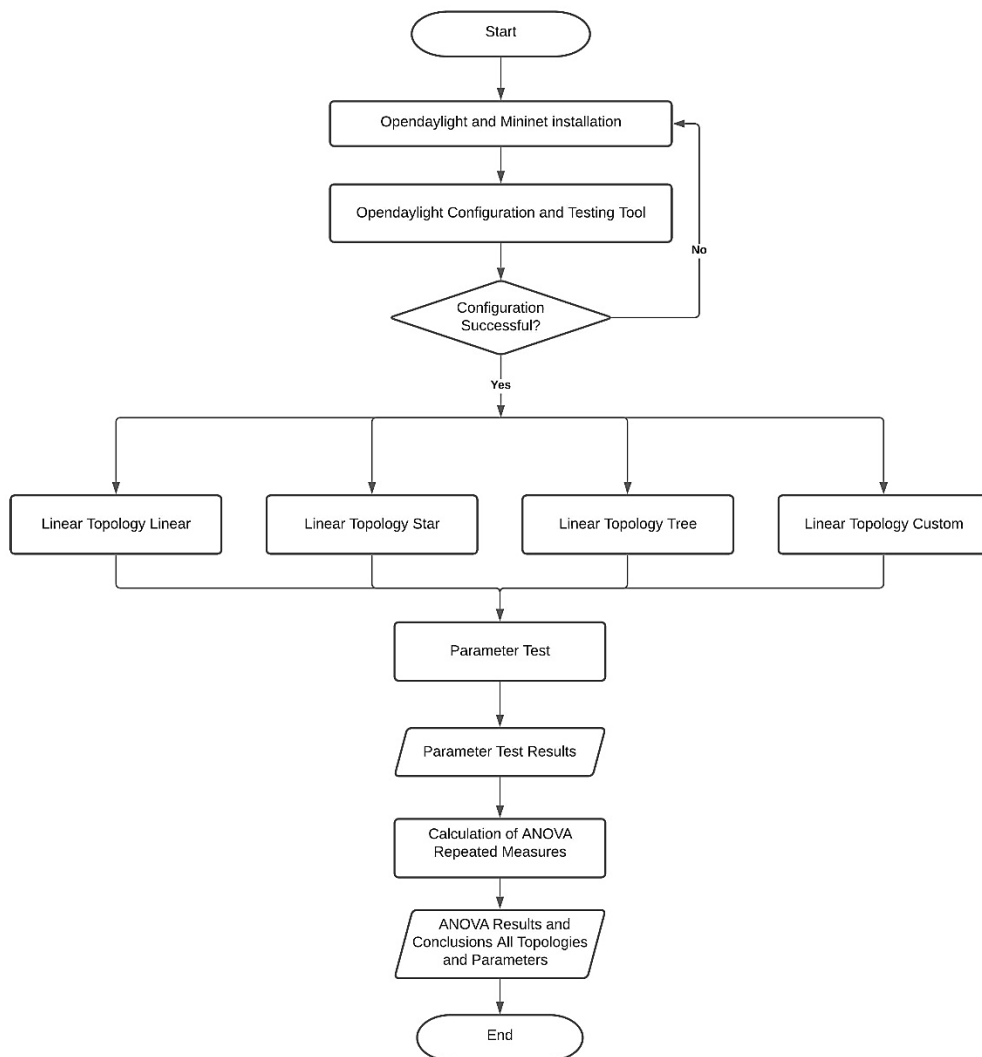
According to Liehuang Zhu and colleagues (2019) who compared the performance of several SDN controllers, they stated that Opendaylight had a better

throughput value than NOX, POX, Ryu and Floodlight. As for the RTT value, Opendaylight has a better value than ONOS which has the highest RTT value among other controllers.

According to Sudarsana Raju (2018) who made a comparison with the title "SDN Controllers Comparison" stated that when SDN separates the control plane and data plane, the control and control functions are in one control plane against more than one data plane called the controller. Opendaylight is a good choice of controller in terms of a controller that has full features and can collect network information and perform analysis by running an algorithm.

Based on the description above, this study will build an SDN network architecture to find out how the SDN architecture affects a network compared to the current use of conventional networks by using a number of scenarios such as linear topology, star topology, tree topology and custom topology and using parameters such as throughput, delay and jitter during the testing process.

2. RESEARCH METHODOLOGY



2.1. Installation

The first step is to install all operating systems and software what is needed is Linux Ubuntu 16.04 LTS, Opendaylight controller and Mininet to run the topology that has been created.

2.2. Test Preparation

Then configure Opendaylight as a controller and then create scenarios using several topologies such as linear, star, tree and custom topologies. Each topology has a greater number of nodes according to a predetermined scenario. The following are some of the test scenarios carried out in this study.

a. Linear Topology

Table 1. Test scenarios on linear topologies

Scenario	Server	Client	Node
1	h1	h50	50
2	h1	h90	90
3	h1	h130	130

b. Star Topology

Table 2. Test scenarios on star topologies

Scenario	Server	Client	Node
1	h1	h50	50
2	h1	h90	90
3	h1	h130	130

c. Tree Topology

Table 3. Test scenarios on tree topologies

Scenario	Server	Client	Node
1	h1	h40	50
2	h1	h80	90
3	h1	h120	130

d. Custom Topology

Table 4. Test scenarios on custom topologies

Scenario	Server	Client	Node
1	h1	h45	50
2	h1	h84	90
3	h1	h120	130

2.3. Scenario Testing

At this stage the test is carried out based on the scenarios that have been made on linear, star, tree and custom topologies that have been run using mininet with iperf and ping commands for 100 seconds.

1. Iperf command on throughput test

```
iperf -s -i 1 > /inetcp
iperf -c 10.0.0.1 -t 100
```

Description :

-s = For host server
 -c = For client server
 -t = Testing time
 10.0.0.1 = Destination ip
 -i = Time interval
 > linetcp = Filename saved

2. Command on delay test

```
ping 10.0.0.1 -c 100 > lineping
```

Description :

-c 100 = Number of packets
 10.0.0.1 = Destination ip
 > lineping = Filename saved

3. Iperf command on jitter test

```
iperf -s -u -i 1 > lineudp  

iperf -c 10.0.0.1 -u -t 100
```

Description :

-s = For host server
 -u = For UDP Protocol
 -c = For client server
 -t = Testing time
 10.0.0.1 = Destination ip
 -i = Time interval
 > lineudp = Filename saved

2.4. ANOVA Repeated Measures

ANOVA Repeated Measures is a statistical analysis method in finding the average variation of three or more samples that is used to compare the final results or change scores between the initial and final measurements between groups. ANOVA calculation analysis was performed using Microsoft Excel software with Add On Real Statistics with a significance level value of $\alpha = 0.025$. Then the data was processed using ANOVA Repeated Measures to determine the effect of increasing the number of nodes on each topology and parameter used.

For testing purposes, criteria are needed in the probability value approach (P-value), if the probability value (P-value) is greater than or equal to the α significance level, then the null hypothesis (h_0) is accepted which means there is no significant difference from the comparison results. However, if the probability value (P-value) is smaller than the significance level, then h_0 is rejected which means there is a

significant difference from the comparison results.

In the past, when statistical software was not widely known and statistical tables were still widely used, this a priori approach was almost always used. In social studies, we recognize setting a significance level of 5% or 1% before statistical tests are carried out. McCall (1970) said that the choice of a significance level of 5% or 1% is simply an agreement that has become a habit among social scientists without any clear basis (Azwar, 2005).

3. RESULTS AND DISCUSSION

3.1. Throughput Analysis Using ANOVA Repeated Measures

Overall, the throughput value in all topologies when the number of nodes increased from 50, 90 and 130 nodes experienced a decrease in the throughput value due to the influence of the increasing number of nodes handled by the controller on the SDN network.

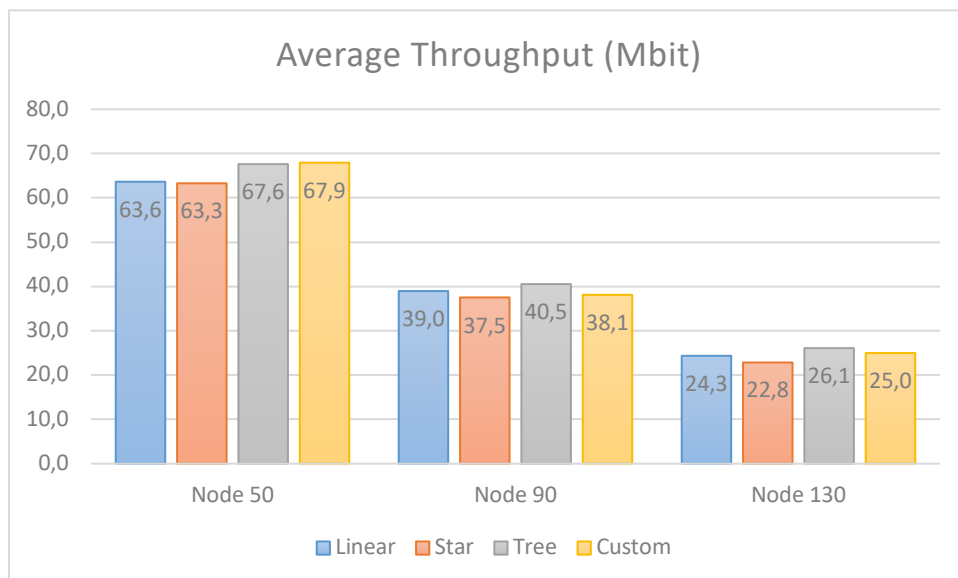


Figure 1. Average throughput value in each topology

Based on the average of each topology, it shows that the tree topology as a whole has a better and significant average throughput value ($P\text{-value} < 0.025$) compared to linear and star topologies, while compared to custom topologies it has an insignificant difference in the average throughput value. ($P\text{-value} > 0.025$). While the star topology has a lower average throughput value among other topologies.

Table 5. Comparison of mean throughput between topologies

(I) topo	(J) topo	Mean Difference (I-J)	P-value
custom	linear	1.361	0.094
	star	2.463*	0.000
	tree	-1.066	0.348

Linear	custom	-1.361	0.094
	star	1.102	0.300
	tree	-2.427*	0.000
Star	custom	-2.463*	0.000
	linear	-1.102	0.300
	tree	-3.529*	0.000
Tree	custom	1.066	0.348
	linear	2.427*	0.000
	star	3.529*	0.000

Based on the data obtained for 100 seconds with a total of 400 data from all topologies, it can be seen from Table 6 using the Bonferroni 97.5% confidence interval shows that the P-value = 2.32E-09, thus the throughput value in each topology is significantly different (P-value < 0.025).

Table 6. The results of the analysis of the throughput value using ANOVA

	SS	df	MS	F	P value	P Eta-sq
Between Subjects	20818.9	399				
- Rows	2145.533	3	715.1775	15.166533	2.32E-09	0.103057
- Error	18673.37	396	47.15498			
Within Subjects	388985.3	800				
- Columns	347898	2	173949	3418.875783	0	0.896196
- Interaction	791.1203	6	131.8534	2.59150884	0.017116	0.019255
- Error	40296.17	792	50.879			
Total	409804.2	1199	341.7883			

Then simple effects are used to determine the effect of increasing nodes in each topology and get the results that the custom topology has the lowest P-value of 1,382E-251, while the linear topology has the highest P-value, which means that the custom topology has a significant increase in throughput between tree, star and linear topology when the number of nodes increases because the P-value < 0,025.

Table 7. Simple effect results on throughput parameters

Topology	P-value	Result
Custom	1,382E-251	H0 rejected
Tree	6,0491E-238	H0 rejected
Star	5,7798E-229	H0 rejected
Linear	7,7966E-220	H0 rejected

3.2. Delay Analysis Using ANOVA Repeated Measures

After being averaged, the delay value in all topologies experienced an increase in the delay value due to the influence of the increasing number of nodes handled by

the controller on the SDN network.

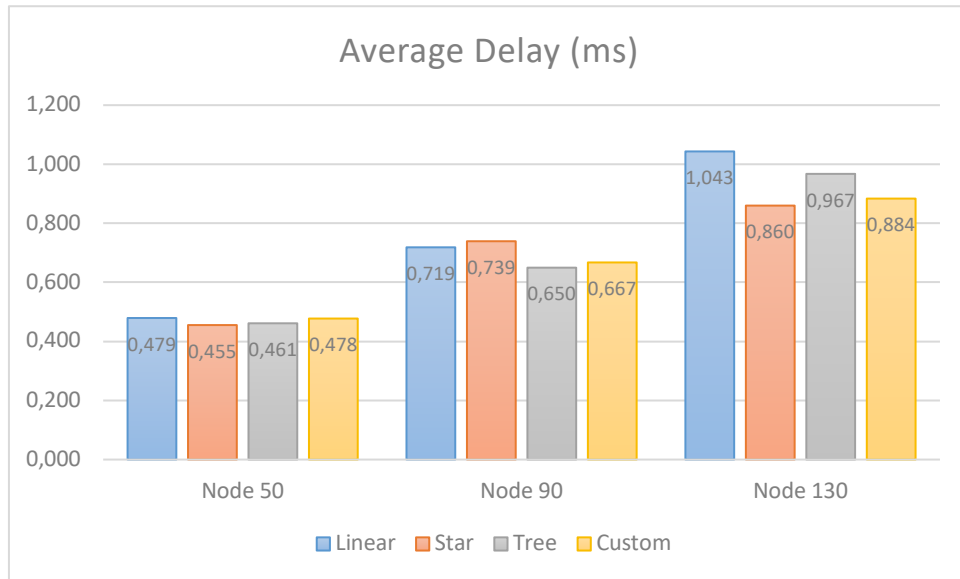


Figure 2. Average delay value in each topology

Table 8 shows that the custom topology has a better and insignificant average delay value (p -value > 0.025) than the star and tree topology, while compared to the linear topology it has a significant average delay value (p -value < 0.025). Overall there is no significant difference in average delay between the topology and the custom topology has a lower delay value than other topologies, which means that the custom topology has a better delay value.

Table 8. Comparison of mean delay between topologies

(I) topo	(J) topo	Mean Difference (I-J)	P-value
Custom	linear	-.0709*	0.001
	star	-0.0087	1.000
	tree	-0.0166	1.000
Linear	custom	.0709*	0.001
	star	.0622*	0.005
	tree	.0543*	0.023
Star	custom	0.0087	1.000
	linear	-.0622*	0.005
	tree	-0.0080	1.000
Tree	custom	0.0166	1.000
	linear	-.0543*	0.023
	star	0.0080	1.000

Based on the data obtained for 100 seconds with a total of 400 data from all topologies, it can be seen from Table 9 using the Bonferroni 97,5% confidence interval shows that the P -value = 0,000606, thus the delay value in each topology is significantly different (P -value $< 0,025$).

Table 9. The results of the analysis of the delay value using ANOVA

	SS	df	MS	F	P value	P Eta-sq
Between Subjects	21.51071	399				
- Rows	0.919728	3	0.306576	5.895981	0.000606	0.042757
- Error	20.59099	396	0.051997			
Within Subjects	84.43713	800				
- Columns	44.24136	2	22.12068	455.7448	0	0.535072
- Interaction	1.754136	6	0.292356	6.02331	3.56E-06	0.04364
- Error	38.44164	792	0.048537			
Total	105.9478	1199	0.088364			

Then simple effects are used to determine the effect of increasing nodes in each topology and get the results that the linear topology has the lowest P-value of $1,07738E-62$, while the custom topology has the highest P-value, which means that the linear topology has a significant increase in delay between tree, star and custom topologies when the number of nodes increases because the P-value $< 0,025$.

Table 10. Simple effect results on delay parameters

Topology	P-value	Result
Linear	$1.07738E-62$	H0 rejected
Tree	$2.38338E-52$	H0 rejected
Star	$6.46696E-36$	H0 rejected
Custom	$1.62306E-34$	H0 rejected

3.3. Jitter Analysis Using ANOVA Repeated Measures

The jitter value in the entire topology when the number of nodes increases from 50, 90 and 130 nodes increases the jitter value due to the influence of the increasing number of nodes handled by the controller on the SDN network.

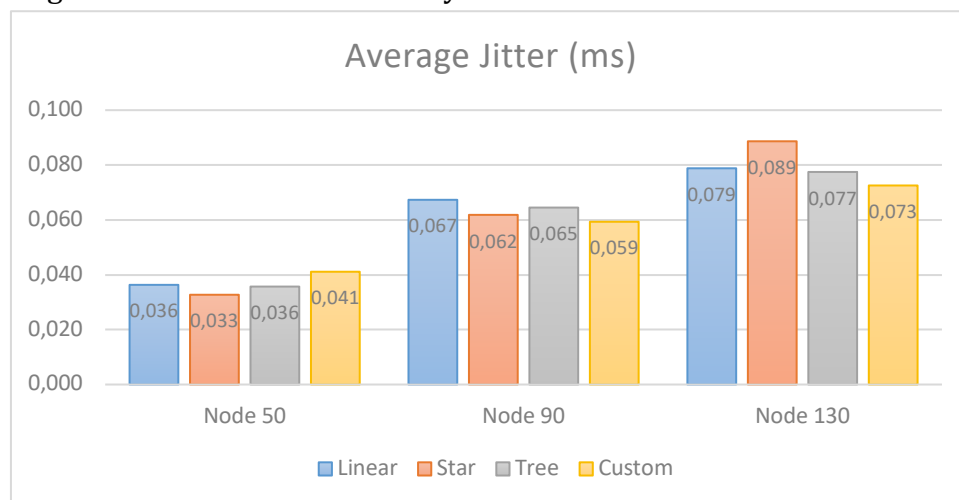


Figure 3. Average jitter value in each topology

Table 11 shows that the custom topology has a better and insignificant average jitter value (p -value > 0.025) than linear, star and tree topologies. This means that there is no significant difference in average jitter between custom, linear, star and tree topologies.

Table 11. Comparison of mean jitter between topologies

(I) topo	(J) topo	Mean Difference (I-J)	P-value
custom	linear	-0.0032	1.000
	star	-0.0034	1.000
	tree	-0.0016	1.000
linear	custom	0.0032	1.000
	star	-0.0002	1.000
	tree	0.0016	1.000
star	custom	0.0034	1.000
	linear	0.0002	1.000
	tree	0.0018	1.000
tree	custom	0.0016	1.000
	linear	-0.0016	1.000
	star	-0.0018	1.000

Based on the data obtained for 100 seconds with a total of 400 data from all topologies, it can be seen from Table 12 using the Bonferroni 97,5% confidence interval indicating that the P-value = 0,900826, thus the jitter value in each topology is significantly different (P -value $< 0,025$).

Table 12. The results of the analysis of the delay value using ANOVA

	SS	df	MS	F	P value	P Eta-sq
Between Subjects	1.542921	399				
- Rows	0.002258	3	0.000753	0.19348	0.900826	0.001464
- Error	1.540662	396	0.003891			
Within Subjects	3.387153	800				
- Columns	0.375869	2	0.187934	49.73575	0	0.111581
- Interaction	0.018588	6	0.003098	0.819852	0.554597	0.006173
- Error	2.992696	792	0.003779			
Total	4.930073	1199	0.004112			

Then simple effects are used to determine the effect of increasing nodes in each topology and get the results that the star topology has the lowest P-value of 1,74483E-09, while the custom topology has the highest P-value, which means that the star topology has a significant increase in jitter between tree topology, linear and custom when the number of nodes increases because the P-value $< 0,025$.

Table 13. Simple effect results on delay parameters

Topology	P-value	Result
Star	1.74483E-09	H0 rejected

Linear	3.63029E-06	H0 rejected
Tree	7.04448E-06	H0 rejected
Custom	0.001511161	H0 rejected

4. Closing

4.1. Conclusion

The Opendaylight controller can work well on linear topologies, star topologies, tree topologies and custom topologies that are simulated using Mininet and are flexible when using various forms of topology with dense networks. On the SDN network, the throughput test shows that the custom topology has a significant increase in throughput value and has the best average throughput value among other topologies. In the delay test, the custom topology has a better average and increasing delay value than the star topology, then the tree is linear. While in the jitter test, the custom topology has a better average value than the tree, linear and star topologies, although the jitter test has an insignificant increase in value when there is an increase in the number of nodes.

4.2. Suggestions

Further research needs to carry out further testing of the SDN architecture by using different scenarios such as using mesh, ring, etc. topologies. besides that it can also be developed by comparing different types of controllers.

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