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Metro Ethernet Backbone Network Design of Semarang City in 2028 using Dysart and Georganas and Hungarian Algorithm and Forecasting Kruithof's Double Factor Methods

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Abstract*—Metro Ethernet technology is a development of IP-based Ethernet technology that can be implemented in the metropolitan area network of Semarang City. The nature of the consumptive society of telecommunication needs causes an increase in the amount of traffic from year to year. This condition encourages telecommunications service providers to plan network infrastructure with good quality. This research focuses on designing the Metro Ethernet backbone network in Semarang for bandwidth requirements in the next ten years. Planning is based on existing nodes in Semarang City and the optimal route to form the ring topology. Traffic forecasting is done by Kruithof's double factor method to obtain point-to-point traffic predictions as the basis for network dimensioning link utilization parameters based on PT. Telkom Area Network Semarang QoS standards to determine link capacity. Metro Ethernet backbone network in Semarang City in the next 2028, 11 nodes form a multi-ring topology. The forecasting results show that the total traffic load in 2028 reached 2,300.37 Gbps. Network planning results show that the most enormous link capacity requirement in 2028 goes 6 x 100 Gb on SPL<->JHR and CDI<->BMK links, and the smallest link capacity is 2 x 10 Gb on the GNK<->MPH and MKG< ->TUG links.*

Keywords*— Metro Ethernet, Traffic forecasting, Network dimensioning, Link utilization*

1. Introduction

Today's telecommunications technology has developed rapidly and become an immediate need for people's lifestyles in Semarang. Moreover, it is supported by the consumptive nature of society which causes an increase in telecommunication traffic burden from year to year. This condition encourages telecommunication service providers to provide network infrastructure that is capable of serving customers with good quality inadequate device capacity.

Metro Ethernet technology is one of the developments of ethernet technology that can cover distances in an urban scale equipped with various features such as ethernet networks in general. Metro Ethernet technology can be used in the Semarang metropolitan area and offers relatively inexpensive manufacturing and maintenance costs. The construction of the Metro Ethernet network infrastructure that can serve customers with good quality service requires good planning so that the investment value is optimally invested..

This study focuses on designing Metro Ethernet backbone network topology in Semarang for the needs of the next ten years based on traffic forecasting and network dimensioning results. The network topology design is based on the existing nodes owned by one of the telecommunications service providers in Semarang City. Traveling Salesman Problems solve the optimal route to support economic factors on network links with the Hungarian method based on consideration of inter-central distance. Traffic forecasting is done by Kruithof's double factor method based on the annual traffic growth rate to determine the point-to-point traffic load forecast in the coming year. Traffic forecasting results are used as the basis of network dimensioning to determine the link capacity needed using the link utilization parameters based on the Quality of Service standard that applies to PT. Telkom Indonesia Area Network Semarang to produce optimal network planning

2. Method

This study focuses on designing Metro EtheThe planning of the Metro Ethernet network in Semarang is based on the flowchart in Figure 1, which is displayed in systematic stages.

2.1 Network Topological Design

In this study, 11 nodes will be designed as a new topology to serve the needs of Metro Ethernet customers in the coming year. The ten nodes are the existing nodes in the Semarang City region whose coordinates follow the current network. One of them is the Semarang District node selected, namely the Ungaran node (UNR), considering the traffic load to the area is quite large. Then it is added with 1 Mijen node (MJN), which is a transfer from the initial node, namely the Boja node (BJA). The transfer was adjusted to the map of Semarang's spatial structure. Figure 3 shows the location of the Metro Ethernet node that will be designed in Semarang City, with the coordinates of the node placement can be seen in Table 1.

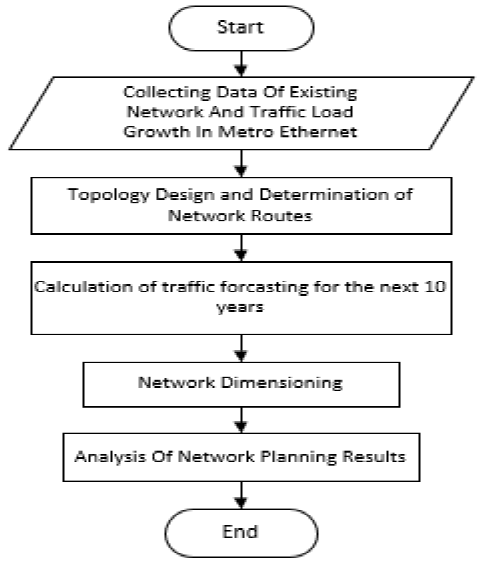

Figure 1 . Metro Ethernet network planning method

Figure 2. Planning the location of the Metro Ethernet nodes in Semarang City.

Table 1. Coordinate of the node location.

No	Node	X (Longitude)	Y (Latitude)
1	CDI	110.4194	-7.0195
2	JHR	110.424830	-6.970389
3	SPL	110.422126	-6.991442
4	MJN	110.315782	-7.054561
5	MKG	110.310282	-6.972696
6	TUG	110.376654	-6.987408
7	GBL	110.426718	-7.045152
8	UNR	110.408861	-7.149660
9	BMK	110.412369	-7.063919
10	MPH	110.460029	-7.007903
11	GNK	110.461154	-6.956602

The chosen route for connecting links is secondary arterial and arterial roads connecting nodes for possible and efficient cables. Calculation of the minimum distance between nodes from the results of google map observations can be seen in Figure 3 with a distance unit in kilometers.

	GBL	JHR	GNK	MPH	CDI	SPL	TUG	MKG	BMK	UNR	MJN
GBL	0	10,7	16,1	9,6	4	7,6	13	21,6	3,5	13	26,5
JHR	10,7	0	4,8	7	6,8	2,9	6,4	14,4	12,2	22,4	18,1
GNK	16,1	4,8	0	10	11	8,9	11	26,9	18	27,4	22,5
MPH	9,6	7	10	0	6,9	5	10,8	18,5	14,1	21,6	22,2
CDI	4	6,8	11	6,9	0	3,9	8,1	17,4	5,5	15	21
SPL	7,6	2,9	8,9	5	3,9	0	5,7	13,8	9,3	18,8	17,2
TUG	13	6,4	11	10,8	8,1	5,7	0	8,3	15	25,3	11,7
MKG	21,6	14,4	26,9	18,5	17,4	13,8	8,3	0	28,3	37,7	11,5
BMK	3,5	12,2	18	14,1	5,5	9,3	15	28,3	0	10,3	23,2
UNR	13	22,4	27,4	21,6	15	18,8	25,3	37,7	10,3	0	21,8
MJN	26,5	18,1	22,5	22,2	21	17,2	11,7	11,5	23,2	21,8	0

Figure 3. Distance matrix between Metro Ethernet nodes.

2.1.1 Determination of Concentrator Nodes

One of the 11 nodes that have been determined will act as concentrator nodes that will connect all nodes to the WAN network. Determining the location of the concentrator in this planning uses the Dysart and Georganas algorithm based on the inter-node distance matrix in Figure 3. Examples of determining the location of the concentrator are as follows:

1. Make a list of 11 (N) nodes in the new topology.
2. Select a number of neighboring nodes k = 2 which have the closest distance from each node.
3. Calculate the number of occurrence frequencies (p) from the 1st to 11th nodes, where (p) = 1,2, ..., 6, with the maximum frequency of occurrence values F = 6.

Table 2. Determining the concentrator location with k = 2.

Node	**Daftar *Node* dan sejumlah 2 *node* tetangga terdekat**	**Frekuensi Pemunculan**
GBL	GBL, BMK, CDI	4
JHR	JHR, SPL, GNK	4
GNK	GNK, JHR, SPL	2
MPH	MPH, SPL, CDI	1
CDI	CDI, SPL, GBL	5
SPL	SPL, JHR, CDI	6
TUG	TUG, SPL, JHR	3
MKG	MKG, TUG, MJN	2
BMK	BMK, GBL, CDI	3
UNR	UNR, BMK, GBL	1
MJN	MJN, MKG, TUG	2

4. All nodes are grouped according to the frequency of appearance (p) each in the list S(p) as follows:
   S(1)= MPH, UNR
   S(2)= GNK, MKG, MJN
   S(3)= TUG, BMK
   S(4)= GBL, JHR
   S(5)= CDI
   S(6)= SPL
5. The location of the first concentrator is the node that has the maximum frequency of occurrence F = 6 in the list S(6), namely the SPL node.
6. Then the next choice is determined by the average appearance frequency plus 1 with KM calculations using equation (2.1), as follows:

$$KM = \left(\frac{(1x2) + (2x3) + (3x2) + (4x2) + (5x1) + (6x1)}{11}\right) + 1$$

$$KM = 4 \quad (1)$$

7. Nodes which are added as options are nodes that have a frequency of appearance (p) where KM ≤ (p) <(F) in the list of S(p) are 4 ≤ (p) <11, then the added nodes are GBL, JHR , and CDI.
8. Next, do a comparison of the concentrator location with a variety of neighboring nodes k = 3, 4, and 5. Then the concentrator node is selected which has the maximum frequency of occurrence between the four variations.

2.1.2 Determination of New Network Routes

The ring topology applied to this plan has a maximum number of nodes connected in one ring is five. Figure 4 shows a grouping of rounds based on three coverage areas in Semarang, namely West Semarang area as ring one symbolized by red nodes, Central Semarang as ring two denoted by yellow nodes, and East Semarang as ring three represented by green nodes.

Figure 4. Distribution of nodes based on ring groups.

2.1.3 Hungarian Method

Nodes divided into each ring area will be routed based on the Traveling salesman problem with the Hungarian method of the distance matrix data between nodes to obtain the minimum cost. Example of route determination for distance matrix ring group 1:

	SPL	TUG	MKG	MJN	Min.
SPL		5,7	13,8	17,2	5,7
TUG	5,7		8,3	11,7	5,7
MKG	13,8	8,3		11,5	8,3
MJN	17,2	11,7	11,5		11,5

Figure 5. Distance matrix ring group 1 of Hungarian method.

Step-1 Subtract each row with the smallest cost value in the row in question.

	SPL	TUG	MKG	MJN
SPL		0	8,1	11,5
TUG	0		2,6	6
MKG	5,5	0		3,2
MJN	5,7	0,2	0	
Min.	0	0	0	3,2

Figure 6. Line reduction matrix of Hungarian method step-1.

Step-2 Subtract each column with the minimum cost value in each column in question.

	SPL	TUG	MKG	MJN
SPL		0	8,1	8,3
TUG	0		2,6	2,8
MKG	5,5	0		0
MJN	5,7	0,2	0	

Figure 7. Column reduction matrix of Hungarian method step-2.

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Step-3 Calculate the zero penalty value in the SPL column by adding the minimum value of the row with the minimum value in the column row

	SPL	TUG	MKG	MJN
SPL		0(8.1)	8,1	8,3
TUG	0(8.1)		2,6	2,8
MKG	5,5	0(0)		0(2.8)
MJN	5,7	0,2	0(2.8)	

Figure 8. Zero penalty value calculation matrix of Hungarian method step-3.

Step-4 Select the route between nodes with closing column lines and rows at zero, which has the highest penalty value and is the only zero value in that row and column.

	SPL	TUG	MKG	MJN
SPL		0(8.,1)	8,1	8,3
TUG	0(8,1)		2,6	2,8
MKG	5,5	0(0)		0(2,8)
MJN	5,7	0,2	0(2,8)	

Figure 9. Route selection of the Hungarian method step-4.

The matrix will decrease to a 3x3 matrix by removing the TUG row and the SPL column that has been selected as the previous route. The SPL line and the TUG column value are left blank because the TUG - SPL route has been selected.

	TUG	MKG	MJN
SPL		8,1	8,3
MKG	0		0
MJN	0,2	0	

Figure 10. Reduction matrix of the Hungarian method step-4.

Step-5 Make sure to return whether each row and column has a zero value; if not, then step 1 and 2 need to be done again for the next step. Optimization of rows and columns and calculation of penalties continue to be made until the matrix continues to decrease and the final results are found to solve the problem of choosing a route that forms a loop for the ring topology.

2.2 Traffic Forecasting

Traffic forecasting is based on annual traffic growth averages using Kruithof's double factor method. Annual traffic growth is obtained by assuming new point-to-point topology traffic assumptions based on existing topologies that are used to estimate total traffic originating and terminating in each center in the coming year. The estimated total traffic is predicted to increase linearly for the next ten years

Table 3. Results of new topology traffic assumptions.

No.	*Link*	Traffic Volume (Gbps)			
		2015	2016	2017	2018
1	SPL –> MJN	18,708	25,386	7,675	14,276
	MJN –> SPL	5,922	9,559	5,722	7,723
2	MJN –> MKG	5,452	7,398	2,554	3,823
	MKG –> MJN	0,058	0,139	1,043	2,414

3	MKG –> TUG	0,005	0,066	0,083	0,954
	TUG –> MKG	0,239	0,324	0,672	1,809
4	TUG –> SPL	0,709	2,486	3,840	5,709
	SPL –> TUG	0,266	0,361	6,715	12,815
5	SPL –> JHR	0,319	0,433	26,595	38,368
	JHR –> SPL	0,234	0,318	22,873	62,670
6	JHR –> GNK	0,201	0,273	1,570	2,412
	GNK –> JHR	0,103	0,440	0,604	1,305
7	GNK –> MPH	0,496	0,674	0,076	0,763
	MPH –> GNK	2,552	3,462	0,312	1,400
8	MPH –> SPL	3,808	5,168	21,228	59,495
	SPL –> MPH	7,435	10,089	25,679	35,664
9	SPL –> CDI	6,894	9,355	16,507	23,427
	CDI –> SPL	3,430	4,955	21,991	57,941
10	CDI –> BMK	13,533	18,664	27,514	73,070
	BMK –> CDI	9,269	12,577	26,836	40,116
11	BMK –> UNR	8,007	10,865	10,128	16,688
	UNR –> BMK	1,424	1,834	2,545	4,817
12	UNR –> GBL	6,169	9,894	14,469	27,323

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	GBL –> UNR	18,345	24,893	26,479	52,876
13	GBL –> SPL	24,194	34,353	10,829	21,059
	SPL –> GBL	4,457	5,950	1,622	5,819
	Total	**142,230**	**199,916**	**286,160**	**574,737**

2.2.1 Kruithof's Double Factor Method

Kruithof's double factor is one of the forecasting methods used to determine future traffic from one place to another (traffic) in the traffic matrix. This method aims to find the best traffic load configuration between 2 nodes/central.

DARI \ KE	1	I	J	N	ΣO
1	$A_{(11)}$			$A_{(1n)}$	$O_{(1)}$
I		$A_{(ii)}$	$A_{(ij)}$		$O_{(i)}$
J		$A_{(ji)}$	$A_{(jj)}$		$O_{(j)}$
N	$A_{(n1)}$			$A_{(nn)}$	$O_{(n)}$
ΣT	$T_{(1)}$	$T_{(i)}$	$T_{(j)}$	$T_{(n)}$	A

Figure 11. Traffic matrix.

where:
$A_{(ij)}$ is traffic from *i* to *j*
$A_{(ji)}$ is traffic from *j* to *i*
$A_{(ii)}$ is central local traffic *i*
$O_{(i)}$ is the sum of all traffic originating central *i*
$T_{(j)}$ is all traffic in central terminating *j*

Future point-to-point traffic is obtained from adjusting to the row with equation (2) and the column using the equation (3)

$$A_{ij}(n) = \frac{A_{ij}(n-1)}{O_i(n-1)} \, . \, O_i(t) \quad (2)$$

$$A_{ij}(n) = \frac{A_{ij}(n-1)}{T_j(n-1)} \, . \, T_j(t) \quad (3)$$

where:
n = iteration to *n*
$O_i(t)$ = traffic originating central *i* in year *t*
$T_j(t)$ = traffic terminating central *j* in year *t*

If the total traffic originating and terminating the *n*th iteration follows the estimated total future traffic, the iteration calculation has ended, and the optimum configuration has been obtained.

2.3 Network Dimensioning

The QoS parameter, the benchmark for conducting network dimensioning, is the link utilization parameter. The value of utilization of each link is influenced by how much the traffic load has burdened the capacity of the link, so the formula for obtaining the results of utilization calculations is:

$$Utilization = \frac{Traffic\ Volume}{Link\ Capacity} \ x\ 100\% \quad (4)$$

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The estimated link capacity in this new topology plan will be adjusted to the utilization of normal conditions. The transmission cable that will be applied is an optical fiber with a capacity of 10 Gb, 40 Gb, and 100 Gb based on the latest technology that has been applied to the existing topology. Utilization parameters based on PT. Telkom Indonesia can be seen in Figure 12.

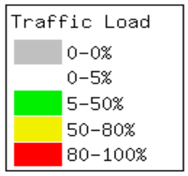

Figure 12. Link utilization standard of PT. Telkom Indonesia [9].

The dimensioning example in Table 4 for the SPL-MJN link. The traffic load between the two directions of the link, which is 79.54 Gbps at most, is assumed to be an average standard utilization of 50%, then the required bandwidth is 79.54 Gbps x 2 = 159.08 Gbps. Determining sufficient link capacity is 2 x 100 Gb. All link dimensions can be seen in Table 4.

Table 4. Dimensioning link capacity.

No	**Link**	**Traffic 2028 (Gbps)**	**Traffic 2028 x 2 (Gbps)**	**Link Capacity**
1	SPL –> MJN	79,54	159,08	2 x 100 Gb
	MJN –> SPL	28,43	56,86	
2	MJN –> MKG	15,84	31,67	1 x 40 Gb
	MKG –> MJN	11,02	22,04	
3	MKG –> TUG	3,38	6,75	2 x 10 Gb
	TUG –> MKG	7,74	15,47	
4	TUG –> SPL	21,69	43,39	1 x 100 Gb
	SPL –> TUG	55,39	110,79	
5	SPL –> JHR	161,99	323,97	6 x 100 Gb
	JHR –> SPL	266,54	533,08	
6	JHR –> GNK	14,04	28,09	1 x 40 Gb
	GNK –> JHR	8,54	17,08	
7	GNK –> MPH	4,41	8,82	2 x 10 Gb
	MPH –> GNK	8,03	16,06	
8	MPH –> SPL	249,38	498,75	4 x 100 Gb
	SPL –> MPH	132,99	265,98	
9	SPL –> CDI	82,13	164,27	4 x 100 Gb

	CDI –> SPL	236,07	472,13	
10	CDI –> BMK	275,12	550,24	6 x 100 Gb
	BMK –> CDI	139,36	278,72	
11	BMK –> UNR	49,21	98,43	1 x 100 Gb
	UNR –> BMK	12,55	25,10	
12	UNR –> GBL	101,43	202,86	4 x 100 Gb
	GBL –> UNR	164,40	328,80	
13	GBL –> SPL	126,94	253,89	2 x 100 Gb
	SPL –> GBL	44,21	88,43	

3. Network Planning Results

3.1 Determining the Concentrator Location

In Table 5, it can be seen that the SPL always has a maximum frequency(p) and is the first choice as a concentrator. Based on the overall results, the SPL node is a node with a strategic location to be used as a concentrator node

Table 5. Results of determining the concentrator node location.

No		**k=2**		**k=3**		**k=4**		**k=5**	
		Node	**(p)**	***Node***	**(p)**	***Node***	**(p)**	***Node***	**(p)**
1		SPL	6	SPL	10	SPL	11	SPL	11
2		CDI	5	CDI	7	CDI	9	CDI	11
3		JHR	4	JHR	5	JHR	8	JHR	10
4		GBL	4					MPH	8

3.2 Determination of Network Routes

The ring 1 group is a West Semarang section ring group with four-node members, namely SPL, TUG, MKG, and MJN nodes, with SPL nodes as concentrators. Route search for ring 1 group with Hungarian method is obtained as follows:

Route 1 = TUG – SPL
Route 2 = MJN – MKG
Route 3 = SPL – MJN
Route 4 = MKG – TUG

The total cost passed according to the SPL-MJN-MKG – TUG-SPL route is 17.2 + 11.5 + 8.3 + 5.7 = 42.7 Km. The SPL-MJN-MKG – TUG-SPL route is the only optimal route for the West Semarang ring topology.

The ring 2 group is the East Semarang ring group which has four node members, namely SPL, JHR, GNK, and MPH nodes, with SPL nodes as concentrators. Route search for ring 2 group is obtained as follows:

First routes:	Second routes:
Route 1 = JHR – GNK	Route 1 = GNK – JHR
Route 2 = MPH – SPL	Route 2 = SPL – MPH
Route 3 = SPL – JHR	Route 3 = JHR – SPL
Route 4 = GNK – MPH	Route 4 = MPH – GNK

The first routes, namely SPL-JHR-GNK-MPH-SPL has a total cost of 2.9 + 4.8 + 10 + 5 = 22.7 km. The second choice route, SPL-MPH – GNK – JHR – SPL has a total cost of 5 + 10 + 4.8 + 2.9 = 22.7 km. The two chosen routes are the same, but only the directions are different; the optimal route selected for the East Semarang regional ring is the first choice route, SPL-JHR-GNK-MPH-SPL.

The ring 3 group is the Central Semarang section ring group which has five node members, namely SPL, GBL, BMK, UNR, and CDI nodes, with SPL nodes as concentrators. Route search for ring 3 group is obtained as follows.:

First routes:	Second routes:
Route 1 = SPL – CDI	Route 1 = CDI – SPL

Route 2 = BMK – UNR	Route 2 = BMK – UNR
Route 3 = GBL – SPL	Route 3 = SPL – GBL
Route 4 = UNR – GBL	Route 4 = GBL – BMK
Route 5 = CDI – BMK	Route 5 = UNR – CDI

The first routes, namely SPL-CDI-BMK-UNR-GBL-SPL has a total cost of 3.9 + 5.5 + 10.3 + 13 + 7.6 = 40.3 km. The second choice route is SPL-GBL-BMK-UNR-CDI-SPL with a total cost of 7.6 + 3.5 + 10.3 + 15 + 3.9 = 40.3 km. The distance between nodes on the first choice route has a maximum value of 13 km, while on the second choice route, the ultimate value is 15 km; the first choice route is the optimal node for the ring in the East Semarang area, namely SPL-CDI-BMK-UNR-GBL– SPL. The minimum distance between nodes will save the installation of transmission cables between nodes.

The results of the overall link route determination for ring topologies based on the Hungarian method of the three-ring group areas that will be applied to the Metro Ethernet network designed can be seen in Figure 13.

Figure 13. Results of the design of Metro Ethernet topology in the city of Semarang.

3.3 Traffic Forecasting

Traffic forecasting results for the next ten years show growth in total traffic on the network and point-to-point traffic. Table 6 is the forecasting result of total traffic in the entire network from the current year, which is 2018 to 2028.

Table 6. Growth in total network traffic load.

No	Tahun	Beban Trafik (Gbps)
1	2018	574,751
2	2019	747,313
3	2020	919,875
4	2021	1.092,437
5	2022	1.264,999
6	2023	1.437,561
7	2024	1.610,123
8	2025	1.782,685
9	2026	1.955,247
10	2027	2.127,809
11	2028	2.300,371

The total traffic load in 2028 is predicted to have a significant increase, reaching 2,300,371 Gbps. The growth of average traffic values every year is constant, increasing by 172.562 Gbps so that it tends to be linear. This growth is because the development of internet traffic will continue to increase along with the increasing number of customers from year to year.

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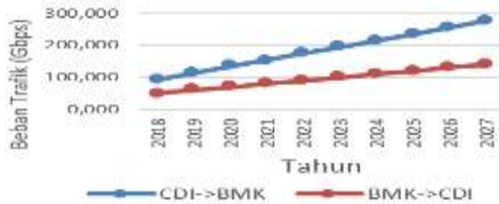
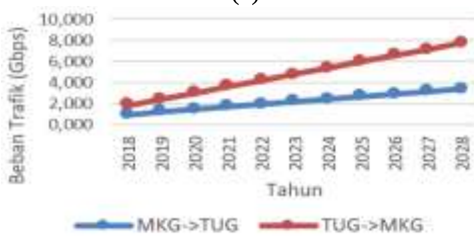


(a)



(b)

Figure 14. Graph of traffic load growth per link for 10 years (a) CDI <-> BMK (b) MKG <-> TUG

The growth of point-to-point traffic in each link has further grown because the traffic load configuration has been optimized with K*ruithof's double factor* method to be adjusted with the estimated total traffic for each year predicted. Figure 25 shows the results of forecasting the overall point-to-point traffic load to increase linearly according to the increase in the estimated total traffic. CDI-> BMK has the most considerable traffic load from forecasting results in 2028, which is equal to 275.118 Gbps; this is because the average traffic load in 2018 on that link is of considerable value, which reaches 75.070 Gbps and has an enormous traffic growth which is increased by 20,205 Gbps per year. While MKG-> TUG traffic is the lowest traffic load in the upcoming 2028, which is 3.377 Gbps, due to the smallest traffic growth, which is an average of 0.242 Gbps per year, with a traffic load in 2018 of 0.954 Gbps.

3.4 Network Dimensioning

The results of network dimensioning are shown in Figure 15 that the overall utilization value is still green, which means that the link is still standard 0-50%, while there are four links SPL-> TUG, MH-> SPL, CDI-> SPL, and GBL-> SPL is yellow because it passes an average of 5% to 13% above the standard limit, where the value does not include a significant value difference.

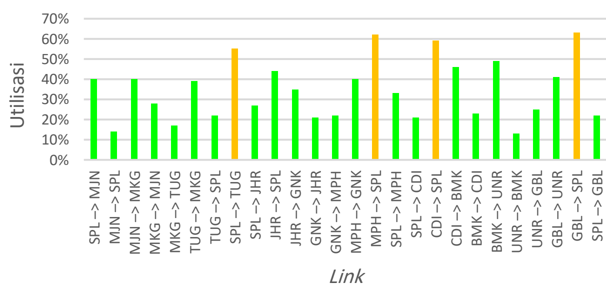


Figure 15. Graph of the value of utilization of each link from the results of dimensioning.

Four links cannot be maximized again in dimensioning to get utilization under normal conditions. The rule of adding link capacity for each link between nodes can ideally be made as much as 2N. If too much capacity is added, there will be waste installing the transmission cable. The four links are included in a warning condition that as long as the network operates it must be monitored for the development of its utilization as traffic loads increase in the following years.

Figure 16 shows that the Metro Ethernet network in 2028 in Semarang City requires bandwidth with the most significant link capacity of 6 x 100 Gb. An enormous link capacity is applied to two links, namely SPL <-> JHR and CDI <-> BMK. While the smallest link capacity needed is 2 x 10 Gb contained in the GNK link <-> MPH and MKG <-> TUG. Based on the predicted link capacity required, the module used in the center is a switch router with a port capacity capable of supporting links with 100 Gbps transmission capabilities.

Figure 16. Results of planning for the Metro Ethernet network in Semarang City in 2028.

4. CONCLUSION

Based on the results of planning and analysis, it can be concluded that the optimal new topology for the metro ethernet backbone network in Semarang forms a multi-ring with Simpang Lima nodes as concentrators that connect three groups of West Semarang, East Semarang, and Central Semarang ring areas with the minimum cost of the route obtained by the Hungarian method. The total traffic forecasting results in 2028 are predicted to increase by 2,300,371 Gbps, with the growth of average traffic each year being 172,562 Gbps constantly. While forecasting results, the biggest point-to-point traffic load occurs on the CDI-> BMK link of 275.118 Gbps, and the MKG-> TUG link has the lowest traffic load of 3.377 Gbps. The biggest link capacity requirement in 2028 reaches 6 x 100 Gb in two links namely SPL <-> JHR and CDI <-> BMK and the smallest link capacity 2 x 10 Gb on the GNK link <-> MPH and MKG <-> TUG. The value of the link utilizationresults from the network dimensioning is as expected because it is following the standard normal conditions between 0-50%, but the SPL-> TUG, MH-> SPL, CDI-> SPL, and GBL-> SPL as crossing the normal limit with difference on average 5% to 13% of the normal limit, where the value does not include a large value difference. The four links only need to be monitored for performance as long as the network operates.

Some suggestions that can be used as input for planning the next metro ethernet network can be made by implementing Packet Optical Transport Network (P-OTN) technology and can also be developed in the planning section of the Metro Ethernet access network. Network planning is then recommended to use network simulation software to find out other QoS performance from the results of network planning.

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