METRO ETHERNET BACKBONE NETWORK DESIGN OF SURABAYA CITY IN 2028 USING HEURISTICS GROOMING ALGORITHM AND FORECASTING RAPP'S FORMULA

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Abstract

Telecommunications service providers are required to provide adequate service infrastructure for the community due to the high demand. Metro Ethernet is one of the solutions chosen in service provision because capacity can be increased easily. Besides, Surabaya is the second largest city in Indonesia after Jakarta, Surabaya is predicted to have very large traffic in the future. This Final Project is designing a metro ethernet backbone network that is able to meet the needs of Surabaya in 2028 with the traffic forecasting method Rapp's Formula and designing topology with Traffic. Furthermore, network capacity dimensioning is conducted to ensure all links have good utilization values. The results show that the traffic volume in 2028 grew up to 3 times from the initial traffic. The results of the topology design have four rings with three connecting nodes, KBL, MNR and RKT nodes. The results of network dimensioning show that the results of network design have a good utilization result between 20% and 50%. Although LKS to KRP link and LKS to KNN link results show not to obtain the expected utilization value, which is 1.68% and 3.27%.

Keywords: Metro Ethernet, Traffic Grooming, Rapp's Formula,Network Dimensioning. Surabaya

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1. Introduction

Along with the development of technology today, the telecommunications needs of the Indonesian people are growing very rapidly. It is undeniable that the community's need for telecommunications is one of the most important needs in life. The telecommunications sector supports almost all community activities, including various trade commodities, government continuity and the entertainment sector. If a Metro Ethernet network is burdened with a lot of traffic and continues to increase over time, the reliability of the Metro Ethernet network can decrease, it may even be that the metro ethernet network is unable to accommodate all the generated traffic [1].
So it is necessary to plan a metro ethernet network that can be used for years to come so that the provision of telecommunications services can be carried out optimally and reliably [2].
This study will focus on planning the metro ethernet network in the city of Surabaya including traffic forecasting, network planning and also the dimensioning of the network in the city of Surabaya in 2028. In addition, an analysis of the utilization value of each link is carried out to determine the performance of each link to ensure that all the link used in the provision of telecommunications services in the city of Surabaya in 2028 has a good performance in serving the demand for telecommunications services from the public.

2. Method

The planning of the metro ethernet network in this research study aims to produce a metro ethernet network for the city of Surabaya to meet the needs of 2028. This plan is composed of several stages [3]. The first stage is traffic forecasting, the second stage is topology planning and the last stage is link dimensioning. From the design, an analysis of the utilization value of the link that has been designed will be carried out. The predicted traffic volume will be charged and the utilization value of each link on the network will be analyzed to determine whether the network has met the criteria as a good network [4].

The planning of the Metro Ethernet network in the city of Surabaya is based on the flowchart in Figure 1 which is displayed in the form of systematic stages.

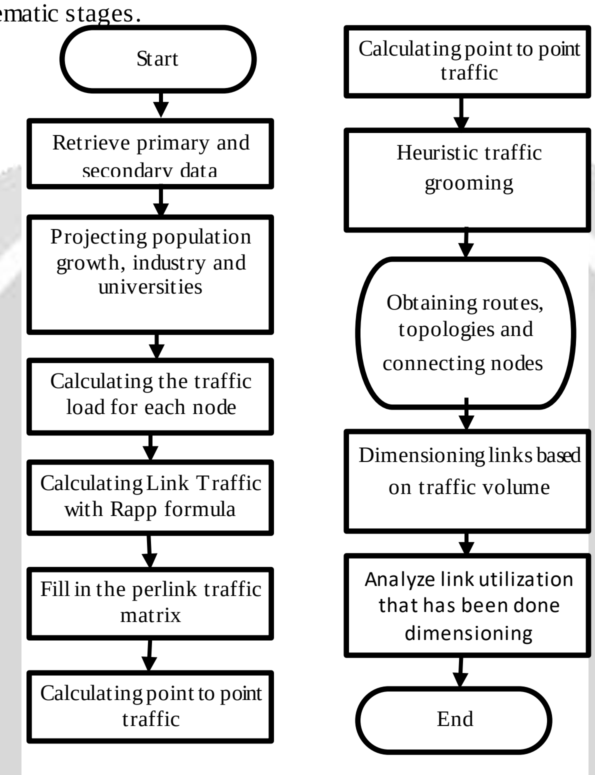

Figure 1. Block diagram of the Surabaya City metro ethernet network planning in 2028.

2.1 Forecasting Surabaya City Traffic in 2028

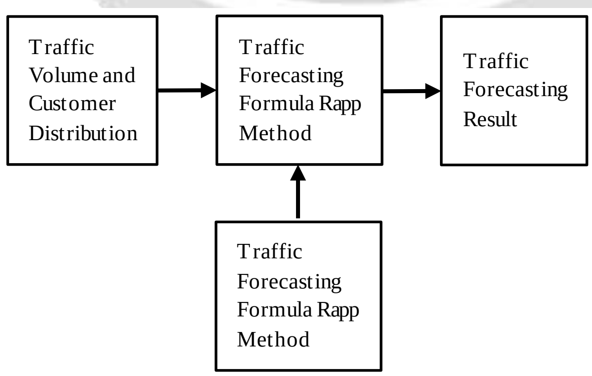

Figure 2. Traffic Forecasting Block Diagram.

2.1.1. Population Traffic Forecast

The following is an example of traffic forecasting calculations for the KBL-RKT link node using the Rapp's 1 method [7][8][9].

$i = Node$ KBL

$t = Node$ RKT

$Aij(0)$ = 178472 $Mbps$

$Ni(0)$ = 50.544 user $Ni(0)$ = 326.497 user

$Nj(12)$ = 72.697 user $Nj(12)$ = 126.882 user

$$Gi = \frac{Ni(12)}{Ni(0)} = \frac{326.497}{50.544} \approx 6 \qquad Gj = \frac{Nj(12)}{Nj(0)} = \frac{126.882}{72.697} \approx 2$$

$$Wi = Ni(12) = 326497 \qquad Wj = Nj(12) = 126882$$

Doing it using Rapp's 2 formula will get the following results:

$$Wi = Ni(12)^2 = 86.390.312.687 \qquad Wj = Nj(12)^2 = 71.401.103.528$$

$$\frac{Ni(0)^2}{2} = 164995 \qquad \frac{Nj(0)^2}{2} = 158517$$

$$Trafik\ 2028 = Aij(0) \times \left\{\frac{(Ni(12)^2 \times Gi) + (Nj(12)^2 \times Gj)}{Ni(12)^2 + Nj(12)^2}\right\} = 1042475\ Mbps$$

2.1.2. Industrial Traffic Forecast

Forecasting point-to-point traffic needs for large and medium-sized industries, the TDS-KLA node is calculated using the Rapp's 2 method, the following is a calculation of point-to-point traffic for large and medium-sized industries:

TDS-KLA point to point traffic for large industries

i= TDS Node

j= KLA Node

Ni= Number of industrial large TDS nodes

Nj= Number of large industrial KLA nodes

$$Aij(0) = 80\ Mbps$$

$$Ni(0) = 21 \qquad Ni(12) = 22$$

$$Nj(0) = 45 \qquad Nj(12) = 46$$

$$Gi = \frac{Ni(12)}{Ni(0)} = \frac{22}{21} = 1{,}032 \qquad Gj = \frac{Nj(12)}{Nj(0)} = \frac{46}{45} = 1{,}032$$

$$Ni(12)^2 = 469.95 \qquad Nj(12)^2 = 2157.93$$

$$\frac{Ni(0)^2}{2} = 21.34 \qquad \frac{Nj(0)^2}{2} = 45.73$$

$$Trafik\ 2028 = Aij(0) \times \left\{\frac{(Ni(12)^2 \times Gi) + (Nj(12)^2 \times Gj)}{Ni(12)^2 + Nj(12)^2}\right\} = 8241\ Mbps$$

TDS-KLA point to point traffic for medium industry

i= TDS Node

j= KLA Node

Ni= Number of medium industry TDS nodes

Nj= Number of medium industries of KLA nodes

$$Aij(0) = 116\ Mbps$$

$$Ni(0) = 33 \qquad Ni(12) = 34$$

$$Nj(0) = 28 \qquad Nj(12) = 29$$

$$Gi = \frac{Ni(12)}{Ni(0)} = \frac{34}{33} = 1{,}03 \qquad Gj = \frac{Nj(12)}{Nj(0)} = \frac{46}{45} = 1{,}03$$

$$Ni(12)^2 = 1156.144 \qquad Nj(12)^2 = 832.339$$

$$\frac{Ni(0)^2}{2} = 35.5 \qquad \frac{Nj(0)^2}{2} = 28.425$$

$$Trafik\ 2028 = Aij(0) \times \left\{ \frac{(Ni(12)^2 \times Gi) + (Nj(12)^2 \times Gj)}{Ni(12)^2 + Nj(12)^2} \right\} = 119083\ Mbps$$

Based on calculations that have been carried out, it can be seen that the point to point traffic for the TDS-KLA node is 8241Mbps for large industries and 119,083 Mbps for medium industries.

2.1.3. Forecasting Higher Education Traffic

According to the results of research on the UMY campus [5] the maximum number of users of the wifi network is 3986 people on weekdays while 2383 people on holidays. The average of these users is about 3185 people. By using the bandwidth calculator, it is known that with 3185 users the required traffic volume is around 4,550 Mbps. The following is the calculation of point to point traffic for the TDS-KLA link in 2028.

Information:
i= TDS Node
j= KLA Node
Ni= Number of medium industry TDS nodes
Nj= Number of medium industries of KLA nodes

$$Aij(0) = 327\ Mbps$$

$$Ni(0) = 4 \qquad Ni(12) = 6$$

$$Nj(0) = 2 \qquad Nj(12) = 3$$

$$Gi = \frac{Ni(12)}{Ni(0)} = \frac{6}{4} = 1{,}511 \qquad Gj = \frac{Nj(12)}{Nj(0)} = \frac{3}{2} = 1{,}511$$

$$Ni(12)^2 = 36{,}530 \qquad Nj(12)^2 = 9{,}132$$

$$\frac{Ni(0)^2}{2} = 5.022 \qquad \frac{Nj(0)^2}{2} = 2.511$$

$$Trafik\ 2028 = Aij(0) \times \left\{ \frac{(Ni(12)^2 \times Gi) + (Nj(12)^2 \times Gj)}{Ni(12)^2 + Nj(12)^2} \right\} = 495\ Mbps$$

From the calculation, it can be seen that the TDS-KLA point-to-point traffic in 2028 is 495 Mbps.

2.2. Network Topology Design

2.2.1. Traffic Grooming

In the first step, traffic is grouped based on two-way traffic and not one-way traffic. Two-way traffic matrix and after sorting it shows that there are 120 traffics with different values, then the 120 traffics will be divided into 4 rings.

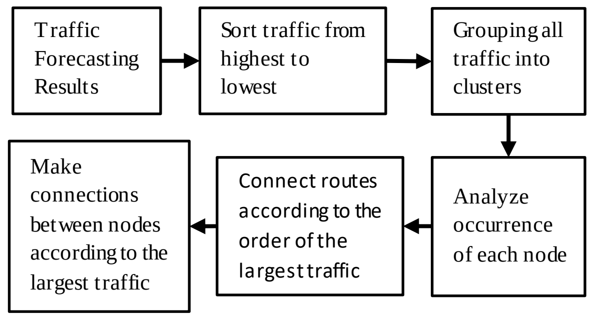

Figure 3. Topology Design Diagram.

2.2.2. Cluster Grouping

Cluster Grouping is intended to divide all existing nodes into a predetermined cluster or ring. The number of rings determined depends on the needs of each network itself. In this study, the entire network is divided into four rings, based on the fact that on the metro ethernet there are a maximum of 5 nodes.

Table 1. Distribution of 2028 traffic in Cluster 1

No.	*Node*		Traffic (Mbps)
1	KBL	RKT	1391518
2	KRP	LKS	158367
3	MNR	RKT	141519
4	LKS	KNN	135002
5	MNR	KTT	127349
6	KBL	KNN	122450
7	KRP	RKT	110418
8	KBL	GUB	95451
9	DMO	RKT	77708
10	KJR	RKT	75867
11	KBL	MGO	74018
12	DMO	MNR	67580
13	KBL	TDS	66517
14	RKT	IJK	64940
15	RKT	KTT	64778
16	KBL	MNR	60409
17	KJR	MNR	58507
18	KBL	KPS	57374
19	MNR	MGO	53594
20	KLA	RKT	51938
21	MNR	KNN	51494
22	KJR	MGO	49581
23	KBL	KTT	47922
24	KBL	KLA	47695
25	JGR	RKT	44050
26	KPS	MGO	42742
27	KJR	KPS	42445
28	MNR	IJK	42053
29	DMO	KTT	41237
30	IJK	KTT	41124
	Total		3505646

2.2.3. Analysis of Node Occurrence & Ring Formation

The nodes with the smallest traffic volume are grouped together. One indicator that this cluster has the smallest traffic value is because this cluster groups traffic with the order of volume link traffic no. 91 to no.120 or the link in the smallest order. Meanwhile, the recapitulation of the frequency of occurrence of nodes is shown in the following table.

Table 2 shows the nodes that have the highest frequency of occurrence among all clusters. The blue node is chosen to be the node that will be used in the cluster because it has the largest occurrence frequency. But of course there are link adjustments, such as in Cluster 3 where the KPS node should have the largest frequency of occurrence, but because the 3rd cluster has more than five nodes, the node with the least frequency of occurrence among other nodes in the cluster will be moved to the cluster that has the least number of occurrences. has the second highest frequency of occurrence.

Table 2. Frequency of occurrence of each node

RING 1		*RING 2*		*RING 3*		*RING 4*	
KBL	9	KBL	4	KBL	2	KBL	0
TDS	1			TDS	1	TDS	10
KJR	4	KJR	6	TDS	3	KJR	3
KPS	3	KPS	4			KPS	3
KRP	2			KPS	5	KRP	10
JGR	1	KRP	0 3	KRP			
		JGR	5	JGR	6	JGR	3
RKT	9	RKT	4	RKT	2	RKT	0
DMO	3	DMO	7	DMO	3	DMO	2
IJK	3	IJK	2	IJK	7	IJK	3
MGO	4	MGO	5	MGO	4	MGO	2
GUB	1	GUB	5	GUB	6	GUB	3
KTT	5	KTT	5	KTT	3	KTT	2
KLA	2	KLA	0	KLA	0	KLA	13
LKS	2	LKS	3	LKS	8	LKS	2
MNR	8	MNR	5	MNR	1	MNR	1
KNN	3	KNN	4	KNN 5		KNN	3

Based on the grouping of these nodes, it can be seen that the ring owned by the metro ethernet network design is as follows:

• Ring 1: KBL nodes, RKT nodes & MNR nodes
• Ring 2: KJR nodes, KPS nodes, DMO nodes, MGO nodes & KTT nodes
• Ring 3: node JGR, node IJK, node GUB & node LKS
• Ring 4: TDS nodes, KRP nodes, KLA nodes & nodes
KNN

The following is a visualization of the results of node planning in each ring on the Surabaya City metro ethernet network

2.2.4. Routing

From subchapter b above, we can know the ring owned by the metro ethernet network in this study. So, the next step is to determine the route that will be chosen to connect each node. Not only that, it is necessary to select the node that is used as a liaison between the rings.

Table 3 describes all possible routes that can be created. This is in accordance with the heuristic algorithm applied where this algorithm makes all the possibilities available for the next best solution to be selected. The route chosen is the route with the largest traffic volume on the link. This is to anticipate small links that are burdened with too much traffic.

(a) (b)

(c) (d)

Figure 4. The results of the division of nodes into each ring (a) Ring 1, (b) Ring 2, (c) Ring 3, (d) Ring 4.

Table 3. Possible links in each ring

Ring	*Node*		Traffic (Mbps)
	Source	Destination	
Ring 1	KBL	MNR	60409
	KBL	RKT	1391518
	MNR	RKT	141519
Ring 2	KJR	KPS	42445
	KJR	DMO	31699
	KJR	MGO	29391
	KJR	KTT	29391
	KPS	DMO	30858
	KPS	MGO	42742
	KPS	KTT	21991
	DMO	MGO	27236
	DMO	KTT	41237
	MGO	KTT	40943
Ring 3	JGR	IJK	18299
	JGR	GUB	16669
	JGR	LKS	20408
	IJK	GUB	19546
	IJK	LKS	22965
	GUB	LKS	23306
Ring 4	TDS	KRP	4062
	TDS	KLA	7483
	TDS	KNN	9405
	KRP	KLA	6187
	KRP	KNN	11313
	KLA	KNN	7436

Table 4. shows the route with the largest traffic priority order. Naturally, the selected link is the link with the largest traffic, but in reality not all the largest links can be selected, this is because the node or link has been connected before. So from the description above, the following routes are obtained:

Table 4. Priority of link order by traffic volume

Ring	*Node*		Traffic (Mbps)	Priority
	Source	Destination		
Ring 1	KBL	RKT	1391518	1
	MNR	RKT	141519	2
	KBL	MNR	60409	3
Ring 2	KPS	MGO	42742	1
	KJR	KPS	42445	2
	DMO	KTT	41237	3
	MGO	KTT	40943	4
	KJR	DMO	31699	5
	KPS	DMO	30858	6
	KJR	MGO	29391	7
	KJR	KTT	29391	8
	DMO	MGO	27236	9
	KPS	KTT	21991	10
Ring 3	GUB	LKS	23306	1
	IJK	LKS	22965	2
	JGR	LKS	20408	3
	IJK	GUB	19546	4

	JGR	IJK	18299	5
	JGR	GUB	16669	6
Ring 4	KRP	KNN	11313	1
	TDS	KNN	9405	2
	TDS	KLA	7483	3
	KLA	KNN	7436	4
	KRP	KLA	6187	5
	TDS	KRP	4062	6

- Ring 1 : KBL ↔ RKT ↔ MNR ↔ KBL
- Ring 2 : KPS ↔ KJR ↔ KTT ↔ DMO ↔ MGO ↔ KPS
- Ring 3 : LKS ↔ GUB ↔ JGR ↔ IJK ↔ LKS
- Ring 4 : KNN ↔ KLA ↔ TDS ↔ KRP ↔ KNN

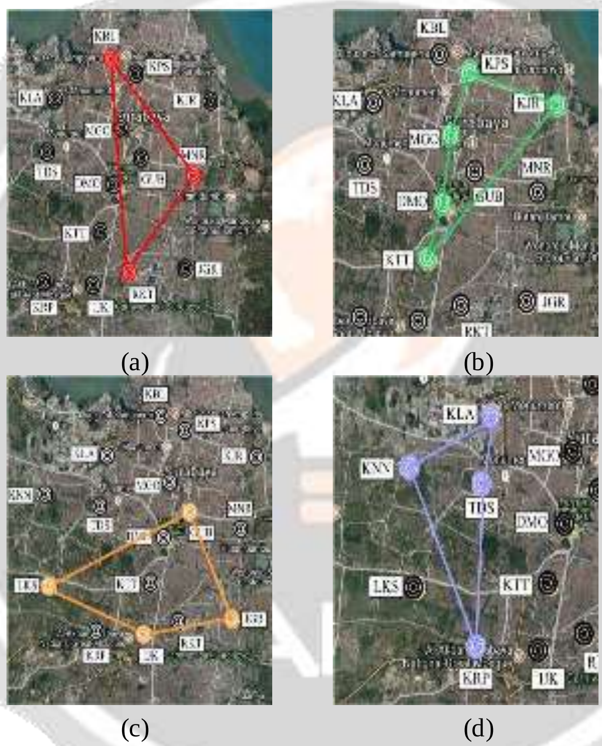

Figure 5. The results of determining the route of each ring (a) Ring 1, (b) Ring 2, (c) Ring 3, (d) Ring 4.

Next, it is necessary to determine the connecting nodes of each ring. The selection of connecting nodes is done by looking for nodes with connecting links that have the largest traffic with the aim of linking with large traffic being able to connect directly.

2.2.5. Connector Node Determination

Furthermore, the traffic with the largest value on each ring connector is regrouped to be selected based on the volume of traffic. The total value of traffic from each ring connecting link can be seen in table 5 below

Table 5. Connecting nodes with the largest traffic.

Ring	*Link* 1	*Link* 2	Trafik *Link* 1 (Mbps)	Trafik *Link* 2 (Mbps)	Total Trafik (Mbps)
Ring 1 dan Ring 2 / Ring 2 & dan Ring 1	MNR ↔ DMO	MNR ↔ KTT	67580	127349	194929
Ring 1 dan Ring 3 / Ring 3 & dan Ring 1	KBL ↔ GUB	KBL ↔ JGR	95451	31325	126776
Ring 1 dan Ring 4 / Ring 4 & dan Ring 1	KBL ↔ KLA	KBL ↔ KNN	47695	122450	170145
Ring 2 dan Ring 3 / Ring 3 & dan Ring 3	KJR ↔ LKS	KJR ↔ IJK	158367	10607	168973
Ring 2 dan Ring 4 / Ring 4 & dan Ring 2	KTT ↔ KNN	KTT ↔ KRP	36844	14072	50917
Ring 3 dan Ring 4 / Ring 4 & dan Ring 3	LKS ↔ KNN	LKS ↔ KRP	135002	158367	293368

From table 5 it can be seen that the connecting link with the largest traffic is owned by the LKS KNN + LKS KRP link that connects ring 3 and ring 4 or vice versa with traffic of 293368 Mbps.
Furthermore, the second largest connecting ring is the link
MNR DMO + MNR Summit connecting ring 1 and ring 2, and the third largest link is the KBL link
KLA + KBL KNN which connects ring 1 and ring 3. By connecting all the rings through connecting nodes, all topological designs have been completed, and the connecting nodes and the results of the ring topology planning on the Surabaya City metro ethernet network in 2028 are illustrated as shown in Figure 6 below.

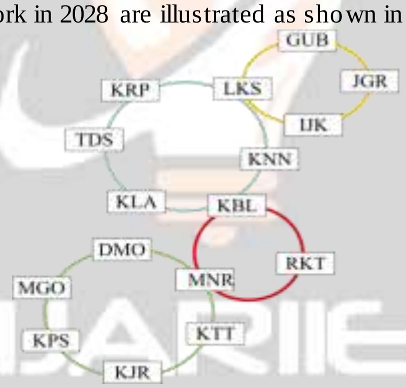

Figure 6. The results of the metro ethernet network topology planning for the City of Surabaya in 2028.

2.3. Link Dimensioning

In this study, with reference to the standards set by Operator A, link utilization is maintained so as not to exceed 50% [4]. The following is an example of calculating the link capacity dimensioning on the JGR GUB link.
The QoS parameter which is 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:

$$Utilization = \frac{Traffic\ Volume}{Link\ Capacity}\ x\ 100\%$$

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 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.

3. Network Planning Results

3.1. Traffic Forecasting

The traffic forecasting results are shown in the traffic in Figure 7 below.

	KBL	KLA	TDS	DMO	KJR	MNR	KPS	KRP	JGR	RKT	IJK	MGO	GUB	KTT	LKS	KNN
KBL	-	23008	33170	18382	13713	30263	18722	7328	11873	663068	13412	37834	11215	23827	18077	63181
KLA	21838	-	2443	8070	8208	7130	3338	3118	3223	28093	4038	3099	2827	3821	4883	3732
TDS	33347	3939	-	18227	4024	34097	2159	2119	4897	8398	3494	3894	3897	10579	3021	4888
DMO	18088	8070	4788	-	14818	33844	13428	7239	14817	39342	13408	13738	16092	20949	11944	14088
KJR	13781	8142	3781	13888	-	24033	23828	6363	14118	43118	11831	26784	18342	17464	9139	13388
MNR	30234	7123	14043	53728	28153	-	18122	10214	20178	78722	21827	26787	18033	41874	38878	23747
KPS	20835	3338	2259	13428	23819	18121	-	8178	12044	18808	10558	11371	14355	10985	9184	13021
KRP	7381	3077	1862	7808	6361	10214	8118	-	3787	19718	3303	8841	8212	7838	123346	3898
JGR	11830	3221	1881	14418	14118	20178	12044	3787	-	22028	8149	10831	8334	34789	10204	8943
RKT	693412	21847	7228	38143	54548	70788	18808	33708	22024	-	38888	16555	11311	22088	13798	14878
IJK	13412	4033	3901	13339	11891	21327	10118	3303	8148	27847	-	15941	8773	19944	8714	8417
MGO	38884	3073	3442	13484	24791	26787	11371	8841	10831	14333	13841	-	11188	10471	17487	12128
GUB	44233	2824	3842	18027	18342	18888	14330	8212	8334	13311	8773	11188	-	14653	11833	8902
KTT	24088	3787	8879	20288	13857	41874	10885	7838	14789	72188	21486	20471	14815	-	12548	13422
LKS	10988	4873	2887	11608	8139	38878	8184	9833	10206	13788	14231	17487	11833	12548	-	8798
KNN	59041	3783	4038	14878	12598	23747	11821	5858	8842	14878	8417	12128	8902	10432	121298	-
Total	2455214	111220	107124	262148	276100	534814	217741	204278	187882	1418988	274213	221333	213147	338735	408158	220082

Figure 7. Matrix of Metro Ethernet network traffic in Surabaya City in 2028.

The results of traffic forecasting are mostly contributed by individuals and universities in 2028 using the Rapp's method as shown in the table 4.4 It is known that the total traffic originating from universities in 2028 is estimated to be quite large. Traffic at universities even exceeds traffic forecasts for medium and large industries. This is because universities have many users that must be served. It can also be seen that there is a link with a value of zero, this is because in 2028 or year 0 there are no universities covered by the node, so no traffic is generated.

3.2. Topology Design

By connecting all the rings through the connecting nodes, the entire topology design has been completed, and the connecting nodes are obtained as shown in Figure 8 and the results of the ring topology planning on the Surabaya City metro ethernet network in 2028 which is illustrated as shown in the figure.

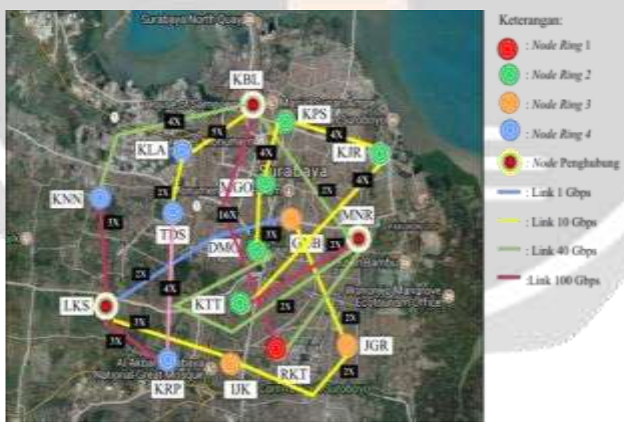

Figure 8. The results of the metro ethernet network topology planning for the City of Surabaya in 2028 with Traffic **Grooming.**

3.3. Network Capacity

In network planning using the Traffic Grooming method, the utilization value of the link is a very important parameter. This is because the traffic grooming method focuses on planning the traffic volume value, so that later the utilization value on the link has a good value. The following is the result of the dimensions of each link.

From table 6 above, it can be seen that each link has a different utilization value from one another. In accordance with the standards set by Operator A, the following is a graph of the utilization value of each link from the dimensioning results.

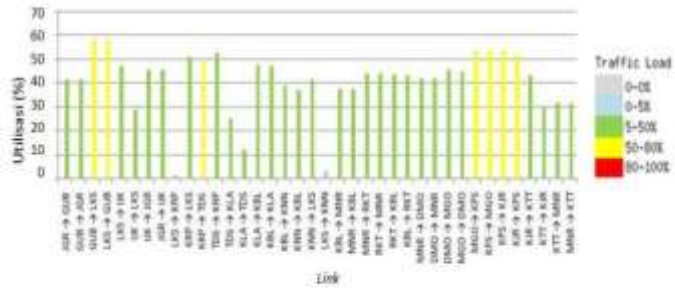

Figure 9 Graph of the utilization value of each link from the dimensioning results.

Table 6. Final utilization value of each link.

No	*Node*		Traffic (Gbps)		*Link Capacity* (Gbps)	Utilizati	
	S	D	In	Out		In	Out
1	JGR	GUB	8.334	8.334	20	41,67%	41,67%
2	GUB	LKS	11.653	11.653	20	58,27%	58,27%
3	LKS	IJK	14.251	8.714	30	47,50%	29,05%
4	IJK	JGR	9.149	9.149	20	45,75%	45,75%
5	LKS	KRP	5.025	153.341	300	1,68%	51,11%
6	KRP	TDS	1.952	2.110	4	48,81%	52,75%
7	TDS	KLA	5.039	2.443	20	25,20%	12,22%
8	KLA	KBL	23.886	23.809	50	47,77%	47,62%
9	KBL	KNN	63.105	59.345	160	39,44%	37,09%
10	KNN	LKS	125.206	9.796	300	41,74%	3,27%
11	KBL	MNR	30.205	30.204	80	37,76%	37,75%
12	MNR	RKT	70.731	70.788	160	44,21%	44,24%
13	RKT	KBL	698.432	693.086	1600	43,65%	43,32%
14	MNR	DMO	33.736	33.844	80	42,17%	42,31%
15	DMO	MGO	13.739	13.496	30	45,80%	44,99%
16	MGO	KPS	21.371	21.371	40	53,43%	53,43%
17	KPS	KJR	21.615	20.829	40	54,04%	52,07%
18	KJR	KTT	17.434	11.957	40	43,59%	29,89%
19	KTT	MNR	63.674	63.674	200	31,84%	31,84%

Based on Figure 9, it can be seen that the results of the utilization value of each link vary greatly and are not in the same level of performance. This is because the traffic values are different and the link capacity is available in a certain size so that it cannot be planned according to the expected capacity value. In addition, there are also links that have very different utilization values for outgoing and incoming traffic. This is because at the time of data retrieval, the link is a link that has just been used or tested so it only has traffic with a small value. In addition, the difference in the value of different in and out traffic causes this to happen because of incoming traffic and incoming traffic. leaving a link has a different value. In addition, on some links there is a poor utilization value, namely on the LKS KRP link where the link in utilization value on the link is very small at 1.68% and on the LKS KRP link it is 3.27%. This is possible because when the data was retrieved, the link was being maintained or was damaged, and it could be that the link is a ring that has just been operated so that it does not yet have a large amount of traffic. Figure 10 shows the final results of the Surabaya City Metro Ethernet network planning in 2028 along with the links used.

Based on Figure 10, it can be seen that the link with the smallest total capacity is owned by the KRP TDS link with a total capacity of 4 Gbps, a link consisting of 4 1 Gbps links.

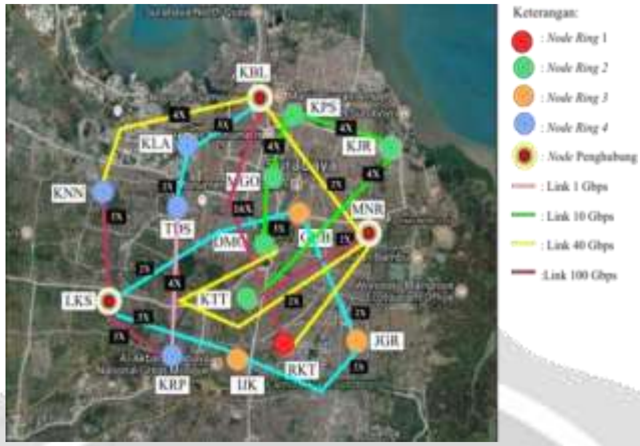

Figure 10. The results of the Metro Ethernet network planning for the City of Surabaya in 2028.

While the link with the largest capacity is owned by the RKT KBL link where the link has a total capacity of 1.6 Tbps consisting of 16 100 Gbps links. It is predicted that in 2028 Metro Ethernet technology in the city of Surabaya will still use various links with different capacities.

4. Conclusion

The results of planning the metro ethernet network in Surabaya in 2028 have traffic of 5.375 Gbps or 5.3 Tbps and traffic growth is 328% of the traffic volume in 2016 which is around 1,640 Gbps or around 1.6 Tbps. The results of the traffic grooming in this plan are divided into 4 rings, the first ring is the ring with the largest traffic consisting of KBL nodes, RKT nodes and MNR nodes. The second ring consists of KJR nodes, KPS nodes, DMO nodes, MGO nodes & KTT nodes. The third ring consists of JGR nodes, IJK nodes, GUB nodes & LKS nodes and the last ring or fourth ring consists of TDS nodes, KRP nodes, KLA nodes & KNN nodes. The results of topology planning with traffic grooming, there are three nodes that are connecting nodes between rings. The KBL node connects ring 1 and ring 4, the MNR node connects nodes 1 and 2, and the LKS node connects ring 3 and ring 4. In link dimensioning, the KBL RKT link has the largest link capacity with a link capacity allocation of 1600 Gbps or 1, 6 Tbps. Meanwhile, the link with the smallest link capacity is the LKS KRP link with a link capacity of 4 Gbps. The majority of the rings in this research plan have utilization values in the range of 50-60%, this is in line with initial expectations where the utilization value of each link is expected to be at a value of 50% to 60%. However, there is a poor utilization value on the LKS KRP link, where the utilization value on the link is 1.68% and on the KNN LKS link, where the utilization value of the link is 3.27%. This can happen because at the time of data collection the link is being repaired or the link is a link that has just been operated.

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