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Fiber to the building network design for tokong nanas building with multi applications

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ABSTRACT

This research aims to implement a Fiber to the Building (FTTB) system using Next Generation Passive Optical Network (NGPON) technology at Tokong Nanas Building, Telkom University. The design focuses on enhancing connectivity and data capacity to meet lecture needs, considering environmental and business aspects, and internet penetration potential in Indonesia. The network implementation starts from the Cijawura Automated Telephone Center (STO) to Tokong Nanas Building using two resilient lines: the Kordon Market line to Optical Distribution Cabinets (ODC) coded as FED, and the Cikoneng line to ODCs coded as FBL. The network extends to the Mini Optical Line Termination (OLT) at the Information Technology Center (PuTI), from the Mini OLT the feeder cables direct to the internal ODC to be flowed into Tokong Nanas Building. The design is create using location and building mapping software and achieves QoS values meeting eligibility standards: Bit Error Rate (BER) ≤ 10^{-9}, Signal to Noise Ratio (SNR) ≥ 21.5 dB, Q-Factor ≥ 6, and Link Power Budget (LPB) below -28 dBm. The Bill of Quantity (BoQ) estimates the design cost through Kordon Market and Cikoneng at Rp7,199,387,990.30, with a total revenue over 10 years of Rp66,948,188,836.00.

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1. INTRODUCTION

Today, the world of telecommunications is growing rapidly and requires quality communication services, so the development of this technology requires a large bandwidth capacity and reliable data transmission speed to serve the public [1]. Network design aims to improve the range and quality of services by expanding the network efficiently. The needs of various lecture activities, Telkom University must provide maximum service at each point of the building by prioritizing parameters such as capacity, quality, and connectivity of data transmission. This includes educational aspects that include improving the quality of service to student activities during lectures, aspects of supporting technology that uses the Next Generation Passive Optical Network (NGPON) which is the development of previous technology and it can supports services that require high bandwidth such as Ultra High Definition Video, Video-on-Demand, and video conferencing by offering bit rates of up to 40 Gbps, environmental aspects that discuss the aesthetics of building governance, and business aspects related to the potential for internet penetration in Indonesia [2][3].

This research focuses on public services with a fiber optic transmission system called Fiber to the Building (FTTB), which is implemented in a high rise building precisely in the Tokong Nanas building. The Tokong Nanas building can accommodate up to 7,500 students. Over time with the increasing quantity of

Telkom University students, especially those who carry out lecture activities in the Tokong Nanas Building by utilizing the Learning Management System (LMS) academic platform and the Integrated Academic Information System (Igracias), it is necessary to have connectivity, capacity and quality that are directly proportional to the quantity of Telkom University students. directly proportional to the quantity of Telkom University students.

The network design solution provided can increase bandwidth requirements with a large capacity in order to serve the needs of internet services, one of which is triple play services. The advantage obtained in this study is that it can help Telkom University and PT Telkom Indonesia in considering fiber optic network planning including Quality of Service (QoS) and Bill of Quantity (BOQ) from specifications based on the design results that have been made.

2. METHOD

This design testing method begins with a Desktop Study using three software solutions in the form of location mapping software, building mapping software, and feasibility simulation software. The results of the three solutions are in the form of as built drawings, Bill of Quantity (BoQ), and calculating feasibility parameters such as Link Power Budget (LPB), Rise Time Budget (RTB), Bit Error Rate (BER), Q-Factor, Signal to Noise Ratio (SNR), and Shannon Capacity.

2.1. Location Mapping Software

The design in the location mapping software aims to design cable lines and optical devices starting from the Local Exchange (STO) can be seen in Figure 1

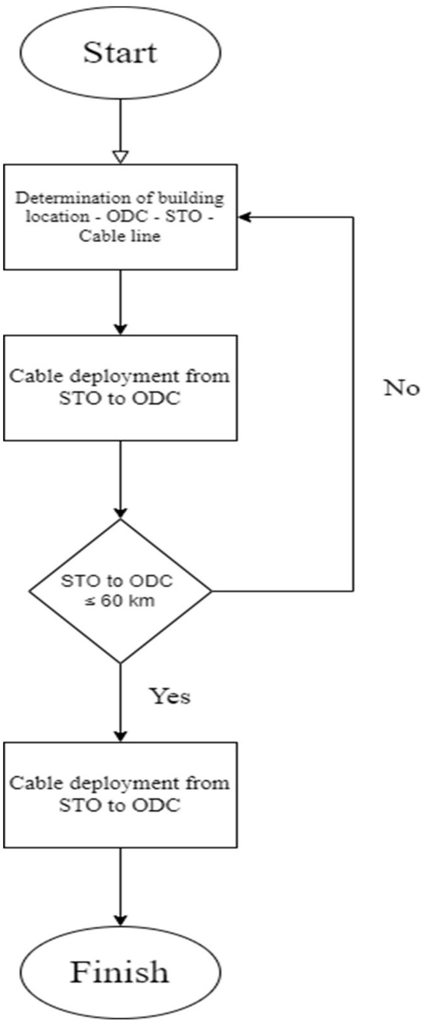

Figure 1. Flowchart of Location Mapping Software

Designing with this software begins with determining the point of the selected Local Exchange (STO). After determining the point of the Local Exchange (STO) in the location mapping software, the feeder cable is deployed from the Local Exchange (STO) to the Optical Distribution Cabinet (ODC). If the distance from the Local Exchange (STO) to the Optical Distribution Cabinet (ODC) ≥ 60 km then a distance analysis can be carried out, if the distance is ≥ 60 km then the location mapping can be carried out again.

2.2. Building Mapping Software

The design in the building mapping software aims to design or design the layout of the distribution line cable implemented in the Tokong Nanas Building from the optical devices used can be seen in Figure 2.

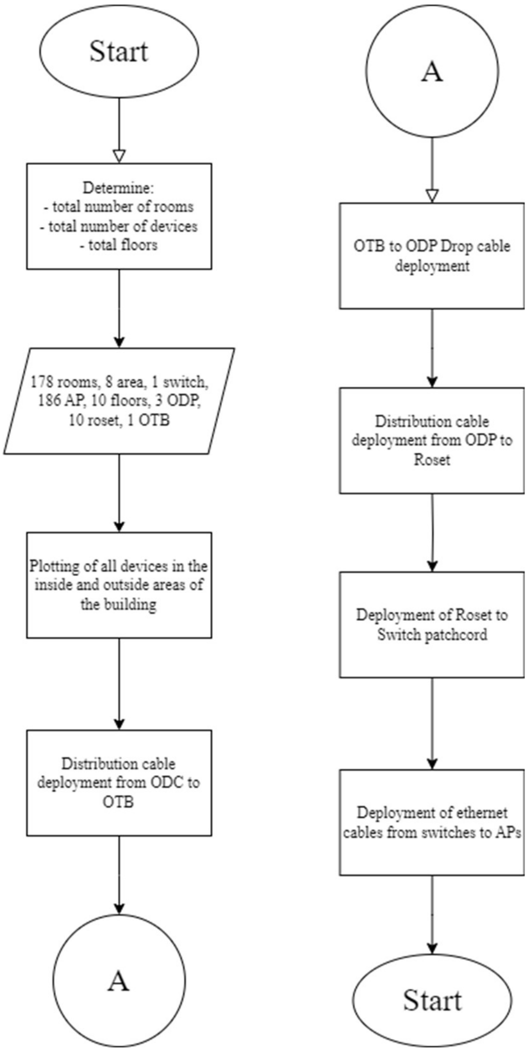

Figure 2. Flowchart of building mapping software

The design starts from making a building plan design including the building area, total rooms and many devices used. Followed by determining the location of optical devices, including Optical Distribution Network (ODN) and Optical Network Terminal (ONT) devices. Then proceed with the design of the cable layout path that connects the optical devices used and continues with the ploting of the Access point device.

2.3. Feasibility Simulation Software

The design in the feasibility simulation software aims to simulate in terms of testing and optimizing optical networks virtually can be seen in Figure 3. This design starts from determining the optical devices used in system feasibility testing.

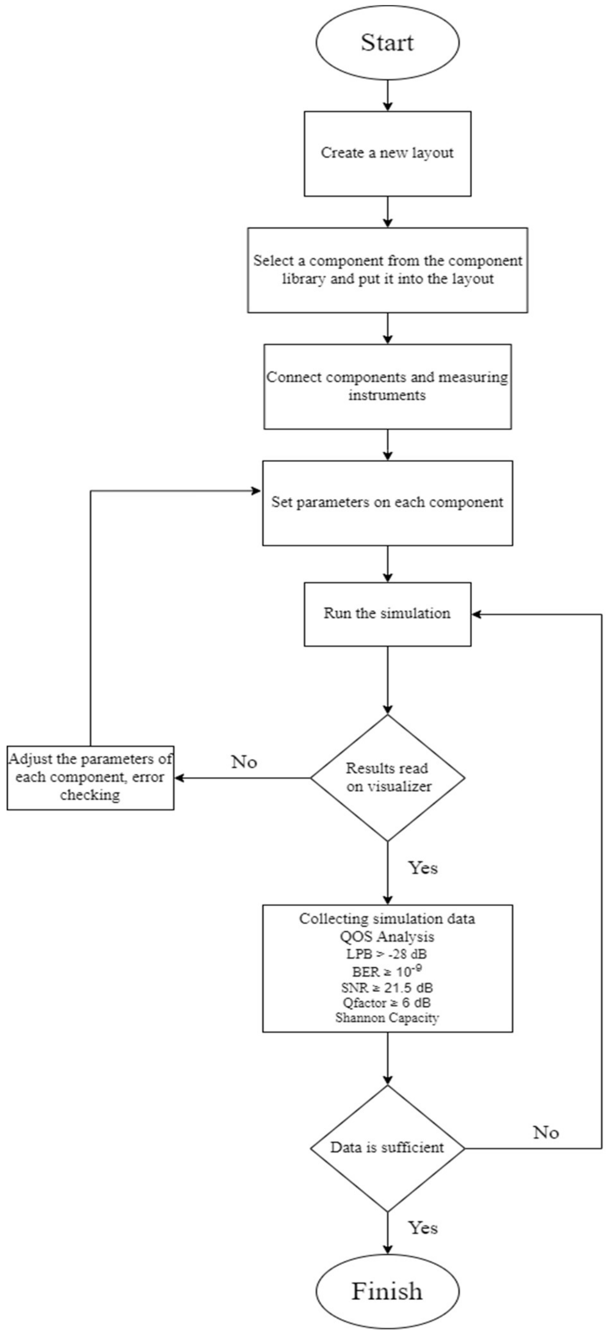

Figure 2. Flowchart Feasibility Simulation Software

The optical devices that have been selected are connected using fiber optic cables. After all optical devices are connected, Quality of Service (QoS) analysis and testing are carried out or system feasibility. System feasibility is determined by the value of the Link PowernBudget (LPB) parameter, Bit Error Rate (BER), Signal to Noise Ratio (SNR), Q-Factor, and Shannon capacity.

2.4. Overall Design Process

Start with determining the location that is used as the object of the Fiber to the Building (FTTB) network design can be seen in Figure 4

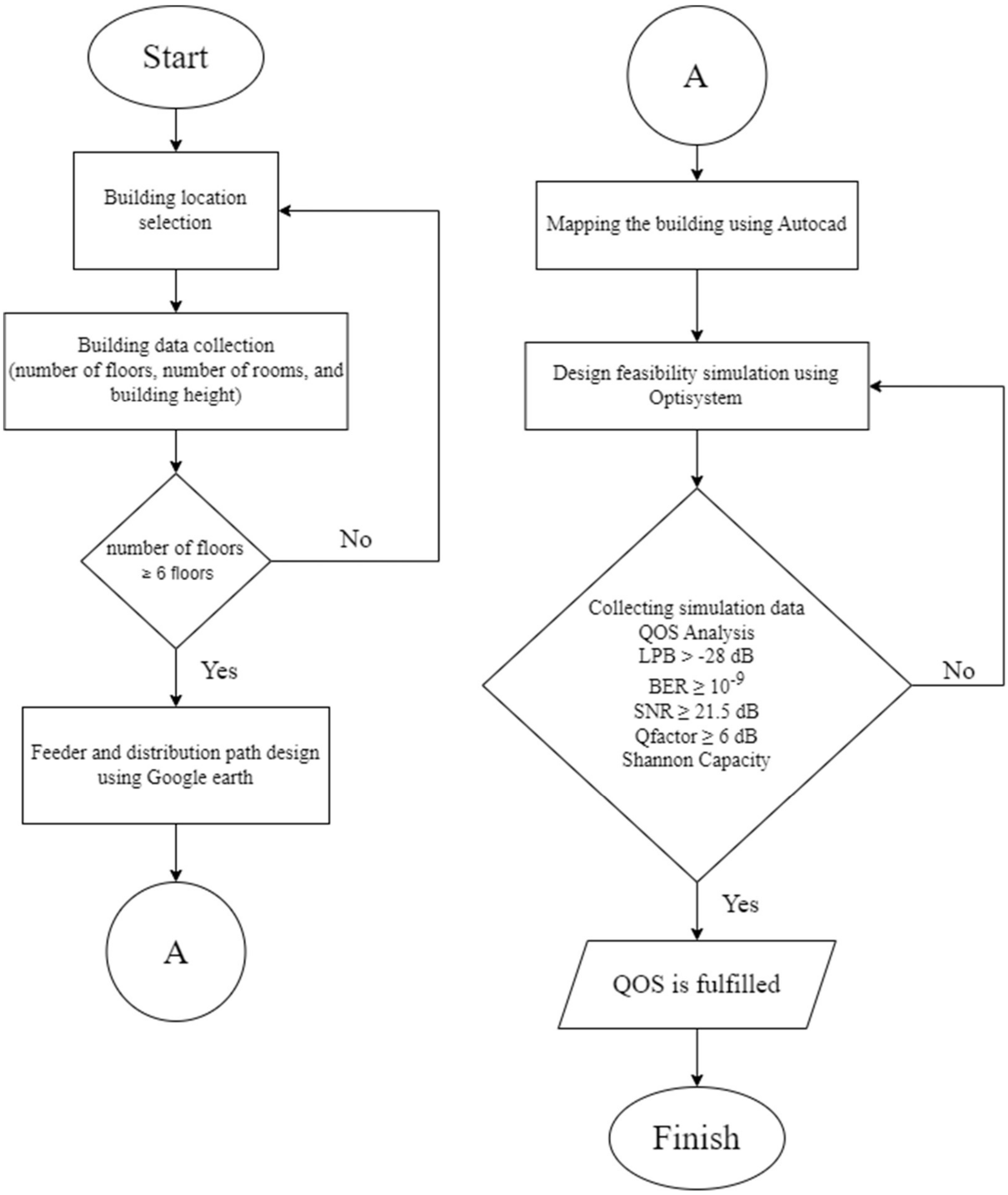

Figure 4. Process flowchart

This design is in the Tokong Nanas Building. Followed by collecting data related to the building and supporting elements of Fiber to the Building (FTTB) design in the building. The first step after obtaining the required data is drafting the cable path used in the design from the Local Exchange (STO) to the Tokong Nanas Building using the location mapping application. The next stage is to map the rooms in the building for fiber optic cable lines using the building mapping application. The next stage is to design simulations using feasibility simulation software to analyze Quality of Service (QoS) in the form of Link Power Budget (LPB), Rise Time Budget (RTB), Bit Error Rate (BER), Q-Factor, and Shannon Capacity to get the appropriate feasibility of 99.99%.

2.5. Quality of Service (QoS)
2.5.1. Link Power Budget (LPB)

Link Power Budget is the power allocation that remains after the optical fiber has suffered losses or losses due to attenuation. According to the standard, the LPB value should not be lower than -28 dB [4]. The LPB value is also affected by the margin system which is 2 dB [5]. The LPB formula is as follows:

$$P_{Rx} = P_{tx} - (\alpha_{tot} + SM) \quad (1)$$
$$\alpha_{total} = (L \text{ x } a_{serat}) + (N_c \text{ x } \alpha_c) + (N_s \text{ x } \alpha_s) + Sp \quad (2)$$

Description:

PRx = Maximum power sensitivity of detector (dBm)
Ptx = Optical source output power (dBm)
SM = Safety margin, 2 dB
α tot = Total source attenuation (dB)
L = Fiber optic length (Km)
αf = Fiber optic attenuation (dB)
Nc = Number of connectors
αc = Connector attenuation (dB/connector)
Ns = Number of connections
αs = Connection attenuation (dB / connection)
Nsp = Number of splitters
αsp = Splitter attenuation (dB)

2.5.2. Rise Time Budget (RTB)

Rise Time Budget is a feasibility parameter used to determine the dispersion limitation of a fiber optic network. Generally, the total transition time degradation of a digital link should not exceed 70% of one bit period for Non-Return-to-Zero (NRZ) or 35% of one bit period for Return-to-Zero (RZ) [4]. The RTB formula is as follows:

$$t_{material} = \Delta\sigma \; x \; L \; x \; Dm \quad (3)$$
$$t_{system} = ({t_{tx}}^2 + {t_{material}}^2 + {t_{intermodal}}^2 + {t_{rx}}^2)^{1/2} \quad (4)$$

Description:

t_{tx} = Rise Time Transmitter (ns)
t_{rx} = Rise Time Receiver (ns)
$t_{intermodal}$ = Zero value (For single mode fiber optic)
$t_{material}$ = Δσ x L x Dm
Δσ = Spectral width (nm)
L = Fiber optic length (Km)
Dm = Material Dispersion (ps/nm.Km)

2.5.3. Signal to Noise Ratio (SNR)

Signal to Noise Ratio is the ratio of signal power to noise at the same point. It shows how much noise or interference occurs in a signal, data, or information sent from the transmitter until it is received by the receiver. The SNR standard in optical communication systems is 21.5 dB, which is set by PT Telkom [6]. In addition, the minimum SNR standard required for signal interference compensation is 20 dB [7]. The SNR formula is as follows:

$$SNR = \frac{Daya\ Sinyal}{\Sigma \text{Noise}} \quad (5)$$

Which can reduce to:

$$SNR = 10 \log \frac{(p_{in}RM)^2}{2qP_{in}RM^2F(M)Be + \frac{4K_BTBe}{R_L}} \quad (6)$$

Description:

P_{in} = Power received by the receiver (P_{rx} in Watts)
R = Responsivity (A/W)

M = Avalanche Photodiode Gain
q = Electron Change (1.69 x 10^{-2}C)
F(M) = Noise Figure
B_e = Bandwidth
K_B = Boltzman Constant (1.38 x 10^{-23}J/K)
R_L = Resistance (Ω)
T = APD Temperature (K)

2.5.4. Qfactor

Q-Factor is the Signal to Noise Ratio (SNR) expressed in the form of current voltage in the decision circuit. The Q-Factor value also determines how good or bad a system is, with a minimum standard of 6 [8]. The Q-Factor formula is as follows:

$$Q = \frac{10^{\frac{SNR}{20}}}{2} \tag{7}$$

Description:
SNR = Value of *Signal to Noise Ratio* (SNR)

2.5.5. Bit Eror Rate (BER)

Bit Error Rate is the ratio of the number of erroneous bits to the total received bits. The BER standard in optical communication systems is 10^{-9} [6]. The BER formula is as follows:

$$\text{BER} = \frac{1}{Q\sqrt{2\pi}} exp^{-\frac{Q^2}{2}} \tag{8}$$

Description:
Q = Q-Factor
π = The phi constant (3,14)

2.5.6. Shanon Capacity

Shannon Capacity is the maximum limit of information transmission speed on a channel without the occurrence of errors [9]. The Shanon Capacity formula is as follows:

C = Bsys log2 (1+SNR) (9)

Description:
C = Channel capacity in bits per second
Bsys = Bandwidth sistem (Hz)
SNR = Signal to Noise Ratio

3. RESULTS AND DISCUSSION

3.1. Results of Location Mapping Software

The fiber optic feeder network design is carried out with ring-shaped resilience, which can be seen in Figure 5. Resilience is carried out using two paths, namely located towards Cikoneng, marked with purple cables and located towards Kordon Market, marked with orange cables.

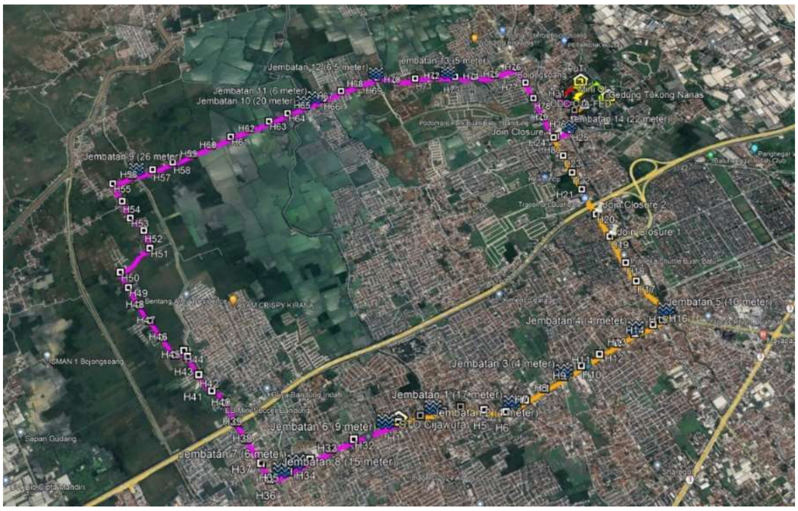

Figure 5. Resilience pathway location mapping

The Cikoneng feeder line starts from Local Exchange (STO) Cijawura towards Cikoneng to ODC-CJA-FBL which is located at Gate 4 Telkom University along 11,432.45 meters. Kordon feeder line starts from Local Exchange (STO) Cijawura towards Kordon Market to ODC-CJA-FED located at Gate 3 Telkom University, 5,894.75 meters long.

Figure 3. Telkom University Feeder Location Mapping

The fiber optic design along the resilience path is divided into three lengths of feeder cables including 288 cores, 96 cores and 48 cores spread to each Optical Distribution Cabinet (ODC) that is passed as indicated in the purple and orange paths in Figure 6. The two ODCs that are passed connect the feeder line from the Local Exchange (STO) to the Mini OLT located at the Server room (PuTI). This design uses handholes as maintenance points and feeder line connection points totaling 80 handholes on two design lines. The Mini OLT is connected to ODC Zone 4 using a 695 meter long distribution cable. The distribution cable in ODC Zone 4 is forwarded using a distribution cable totaling four cores to one Optical Termination Box (OTB) forwarded to the Optical Distribution Point (ODP) which ends at the Access Point in each room.

3.2. Results of Building Mapping Software

The design of the Kordon line fiber optic network starting from the Cijawura Local Exchange (STO) to the Optical Ditribution Cabinet (ODC) coded FED can be seen in Figure 7. There are 28 handholes, with details of fiber optic can be seen in Table 1.

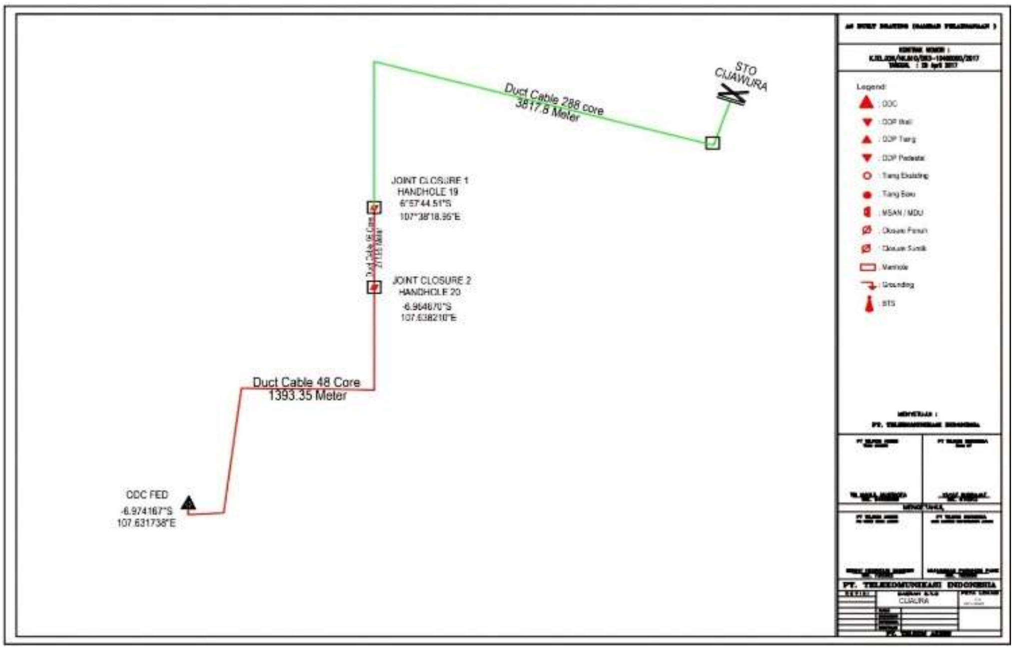

Figure 7. Kordon path mapping

Table 1. Details of Kordon Fiber Optic

Cable type and cable type (Kordon-FED)	Length Initial cable	Length + spare (initial cable length + 5%)
DC-OF-SM-288D	3,636 Meter	3817.8 Meter
DC-OF-SM-96D	259 Meter	271.95 Meter
DC-OF-SM-48D	1327 Meter	139.35 Meter
Cable type and cable type (Kordon-FED)	Length Initial cable	Length + spare (initial cable length + 5%)
DC-OF-SM-288D	3,636 Meter	3817.8 Meter
DC-OF-SM-96D	259 Meter	271.95 Meter
DC-OF-SM-48D	1327 Meter	1393.35 Meter

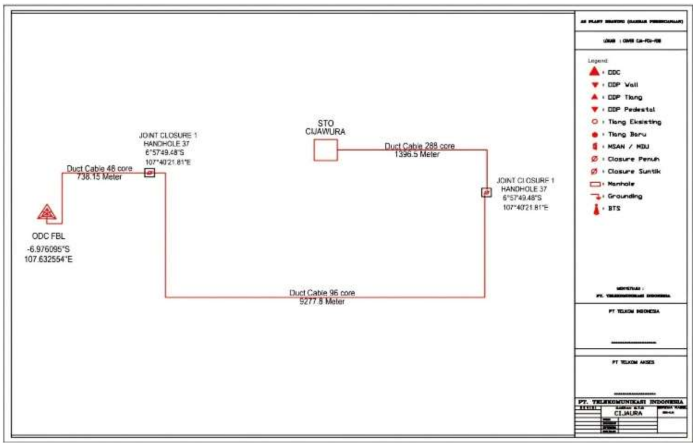

Figure 8. Cikoneng path mapping

The design of the Kordon line fiber optic network starting from the Cijawura Local Exchange (STO) to the Optical Ditribution Cabinet (ODC) coded FBL can be seen in Figure 8. There are 58 handholes, with details of fiber optic can be seen in Table 2.

Table 2. Details of Cikoneng Fiber Optic

Cable type and cable type (Kordon-FED)	Length Initial cable	Length + spare (initial cable length + 5%)
DC-OF-SM-288D	3,636 Meter	3817.8 Meter
DC-OF-SM-96D	259 Meter	271.95 Meter
DC-OF-SM-48D	1327 Meter	1393.35 Meter

3.3 Link Power Budget (LPB)

Accordance with the standard Link Power Budget (LPB) should not be below -28 dB [6]. Table 4 and Table 5 explain the parameters used including the Central to Mini OLT and Mini OLT to the Tokong Nanas Building downstream and upstream.

Table 3. Link Power Budget (LPB) Parameters Local Exchange to Mini OLT

Parameters	Downstream		Upstream	
	Cikoneng	Kordon	Cikoneng	Kordon
Ptx (dBm)	-6	-6	-6	-6
Lfiber (Km)	11,41245	5,8947	11,41245	8.6757
αfiber (dB)	0,23	0,23	0,35	0,35
Connector (pcs)	7	7	7	7
αConnector (dB)	0,25	0,25	0,25	0,25
Splicing (pcs)	7	7	7	7
αSplicing (dB)	0.1	0.1	0.1	0.1

Table 4. Link Power Budget (LPB) Parameters Mini OLT to Tokong Nanas Building

Parameters	Downstream		Upstream	
	Nearest	Furthest	Nearest	Furthest
Ptx (dBm)	3	3	3	3
Lfiber (Km)	0,69875	0,757	0,69875	0,757
αfiber (dB)	0,23	0,23	0,35	0,35
Connector (pcs)	8	8	8	8
αConnector (dB)	0,25	0,25	0,25	0,25
Splicing (pcs)	6	6	6	6
αSplicing (dB)	0,1	0,1	0,1	0,1
Splitter ODC 1:4 (pcs)	1	1	0	0
Splitter ODP 1:4 (pcs)	1	1	0	0
$\alpha Splitter$ 1:4 (dB)	7,8	7,8	0	0

Table 5. Value of LPB

Link Power Budget (LPB) Local Exchange-Mini OLT			
Downstream (dBm)		Upstream (dBm)	
Cikoneng	Kordon	Cikoneng	Kordon
−13.07486	−11.805781	−14.4443575	−12.512145
Link Power Budget (LPB) Local Exchange -Mini OLT			
Downstream (dBm)		Upstream (dBm)	
Cikoneng	Kordon	Cikoneng	Kordon
−17.390	−17.37411	−17.4445625	−17.46495

Table 5 shows that the results of the Link Power Budget (LPB) calculation using the LPB parameters in table 3 and table 4 with equations number (1) and (2) from the central to the Mini OLT and Mini OLT to the Tokong Nanas Building can be said to be good because it is below the maximum Prx determined by ITU-T which is -28 dBm and PT Telkom which is -23 dBm.

3.4. Rise Time Budget (RTB)

The parameters of the Rise Time Budget (RTB) can be seen in Table 6 according to the SFP used.

Table 6. Rise Time Budget (RTB) Parameters

Parameters	Downstream		Upstream	
	Nearest	Furthest	Nearest	Furthest
Bit Rate (Gbps)	10	10	5	5
Rise Time Transmitter (ns)	0,03	0,03	0,03	0,03
Rise Time receiver (ns)	0,03	0,03	0,03	0,03
Spectral Width (nm)	0,1	0,1	0,1	0,1

Lfiber (Km)	0,69875	0,757	0,69875	0,757
Material Dispersion(ns/nm.Km)	0,01675	0,01675	0,01386	0,01386
Tintermodal ()	0	0	0	0

Table 7. Value of RTB

Tsystem (Rise Time Budget)			
Downstream (ps)		Upstream (ps)	
Nearest	Furthest	Furthest	Kordon
42.442539	42.445350	42.437459	42.439378

Table 7 shows that the calculation using the RTB parameters in table 6 with equations number (3) and (4) at the nearest and furthest downstream can use NRZ coding with a value of 70 ps, with the values obtained being 42.442539 ps and 42.445350 ps respectively. While the nearest and furthest upstream T_{system} can use NRZ and RZ coding with a value of 140 ps for NRZ and 70 ps for RZ, The design in the building mapping software aims to design or design the layout of thewith the values obtained being 42.437459 ps and 42.439378 ps respectively. It can be concluded that this system meets the Rise Time Budget.

3.5 Signal to Noise Ratio (SNR), Q-Factor, dan Bit Eror Rate (BER)

The values in Table 8 obtained with the equation number (6), (7), and (8) it can be concluded that a high Signal to Noise Ratio (SNR) value indicates that the received signal is more dominant than noise.

Table 8. Results of SNR, Qfactor, and BER

Parameters	Downstream		Upstream	
	Nearest	Furthest	Nearest	Furthest
SNR (dB)	27,1162	27.0956	24.8203	24.7867
Qfactor	11.3443	11.3175	8.7094	8.6757
BER	4.01×10^{-30}	5.45×10^{-30}	1.55×10^{-18}	2.09×10^{-18}

A low Bit Error Rate (BER) indicates that the number of errors in communication is very small. A high Q-Factor value indicates that the received signal is of very good quality.

3.6 Shanon Capacity

Shannon Capacity calculation serves to calculate the amount of channel capacity used from Mini OLT to Tokong Nanas Building. As equations number (9), this calculation uses the Signal to Noise Ratio value at the farthest distance, namely on the 10th floor with the acquisition of the Signal to Noise Ratio (SNR) value of 27.6038. NGPON design obtained 48.38 Gbps for Tokong Nanas Building can be said to be more optimal than existing conditions.

3.7 Bill of Quantity (BoQ)

The main cost of FTTB projects is the construction of the FTTB network infrastructure [10]. in this design, there are two bills of quantity (BOQ), the first BOQ is the BOQ for PT Telkom Indonesia which includes the design of the The Bill of Quantity (BOQ) that has been made includes the design from the central office to the Mini OLT and the second BOQ is intended for Telkom University including the design from the Mini OLT to the Tokong Nanas Building.

NO	DESIGNATOR	UNIT	VOLUME	Unit Price		ITEMS	JASA	TOTAL PRICE
				Material	Service			
CABLE & SPLICING								
1	DC-OF-SM-12D	Meter	235	Rp6,815.81	Rp2,500.00	Rp1,601,715.12	Rp587,500.00	Rp2,189,215.12
2	DC-OF-SM-48D	Meter	740	Rp12,697.89	Rp2,500.00	Rp9,396,435.05	Rp1,850,000.00	Rp11,246,435.05
3	DC-OF-SM-96D	Meter	9280	Rp21,080.56	Rp2,500.00	Rp195,627,592.16	Rp23,200,000.00	Rp218,827,592.16
4	DC-OF-SM-288D	Meter	1400	Rp67,167.10	Rp3,000.00	Rp94,033,940.00	Rp4,200,000.00	Rp98,233,940.00
5	SC-OF-SM-48	pcs	1	Rp732,892.16	Rp25,000.00	Rp732,892.16	Rp25,000.00	Rp757,892.16
6	SC-OF-SM-96	pcs	1	Rp772,972.20	Rp25,000.00	Rp772,972.20	Rp25,000.00	Rp797,972.20
7	OS-SM-48	Pcs	1	-	Rp2,400,000.00	Rp0.00	Rp2,400,000.00	Rp2,400,000.00
8	OS-SM-144	Pcs	1	-	Rp8,400,000.00	Rp0.00	Rp8,400,000.00	Rp8,400,000.00
9	PC-UPC-657-5	Pcs	4	Rp90,816.53	Rp3,036.00	Rp363,266.10	Rp12,144.00	Rp375,410.10
10	PC-UPC-657-20	Pcs	2	Rp90,816.53	Rp3,036.00	Rp181,633.05	Rp6,072.00	Rp187,705.05
11	PC-UPC-657-10	Pcs	2	Rp90,816.53	Rp3,036.00	Rp181,633.05	Rp6,072.00	Rp187,705.05
12	PC-UPC-657-5	Pcs	3	Rp90,816.53	Rp3,036.00	Rp272,449.58	Rp9,108.00	Rp281,557.58
13	HC-OF-SM-1D	Meter	150	Rp3,413.41	Rp2,500.00	Rp512,011.50	Rp375,000.00	Rp887,011.50
14	DD-BSS-S1	Meter	116	Rp132,132.00	Rp20,000.00	Rp15,261,246.00	Rp2,310,000.00	Rp17,571,246.00
NODE TERMINAL								
15	ODC-C-48 Splitter	Pcs	2	Rp8,115,107.00	Rp1,365,000.00	Rp16,230,214.00	Rp2,730,000.00	Rp18,960,214.00
GALIAN & HANDHOLE								
16	MH-HH1	Pcs	56	Rp5,069,105.44	Rp2,066,404.00	Rp283,869,904.72	Rp115,718,624.00	Rp399,588,528.72
17	BC-TR-5	Meter	1.5	-	Rp37,516.00	Rp0.00	Rp56,274.00	Rp56,274.00

Figure 4. Details of the Cikoneng line device

Figure 9 is a detail of the design of the Cikoneng path where there is a list of devices used and their prices according to what has been planned.

NO	DESIGNATOR	UNIT	VOLUME	Unit Price		Items	Service	TOTAL PRICE
CABLE & SPLICING				Material	Service			
1	DC-OF-SM-12D	Meter	350	Rp6,815.81	Rp2,500.00	Rp2,385,533.15	Rp875,000.00	Rp3,260,533.15
2	DC-OF-SM-48D	Meter	1400	Rp12,697.89	Rp2,500.00	Rp17,777,039.28	Rp3,500,000.00	Rp21,277,039.28
3	DC-OF-SM-96D	Meter	280	Rp21,080.56	Rp2,500.00	Rp5,902,556.66	Rp700,000.00	Rp6,602,556.66
4	DC-OF-SM-288D	Meter	3820	Rp67,167.10	Rp3,000.00	Rp256,578,322.00	Rp11,460,000.00	Rp268,038,322.00
5	SC-OF-SM-48	pcs	1	Rp732,892.16	Rp25,000.00	Rp732,892.16	Rp25,000.00	Rp757,892.16
6	SC-OF-SM-96	pcs	1	Rp772,972.20	Rp25,000.00	Rp772,972.20	Rp25,000.00	Rp797,972.20
7	OS-SM-48	Pcs	1	-	Rp2,400,000.00	Rp0.00	Rp2,400,000.00	Rp2,400,000.00
8	OS-SM-144	Pcs	1	-	Rp8,400,000.00	Rp0.00	Rp8,400,000.00	Rp8,400,000.00
9	PC-UPC-657-5	Pcs	4	Rp90,816.53	Rp3,036.00	Rp363,266.10	Rp12,144.00	Rp375,410.10
10	PC-UPC-657-20	Pcs	2	Rp90,816.53	Rp3,036.00	Rp181,633.05	Rp6,072.00	Rp187,705.05
11	PC-UPC-657-10	Pcs	2	Rp90,816.53	Rp3,036.00	Rp181,633.05	Rp6,072.00	Rp187,705.05
12	PC-UPC-657-5	Pcs	3	Rp90,816.53	Rp3,036.00	Rp272,449.58	Rp9,108.00	Rp281,557.58
13	HC-OF-SM-1D	Meter	150	Rp3,413.41	Rp2,500.00	Rp512,011.50	Rp375,000.00	Rp887,011.50
14	DD-BSS-S1	Meter	39	Rp132,132.00	Rp20,000.00	Rp5,153,148.00	Rp780,000.00	Rp5,933,148.00
NODE TERMINAL								
15	ODC-C-48 Splitter	Pcs	3	Rp8,115,107.00	Rp1,365,000.00	Rp24,345,321.00	Rp4,095,000.00	Rp28,440,321.00
Excavation & HANDHOLE								
16	MH-HH1	Pcs	29	Rp5,069,105.44	Rp2,066,404.00	Rp147,004,057.80	Rp59,925,716.00	Rp206,929,773.80
17	BC-TR-5	Meter	1.5	-	Rp37,516.00	Rp0.00	Rp56,274.00	Rp56,274.00

Figure 10. Details of the Kordon line device

Figure 10 is a detail of the design of the Kordon path where there is a list of devices used and their prices according to what has been planned.The first BOQ can be seen in table 9 which is a grand total of design from the center to the Mini OLT through two lines used including the cordon and cikoneng lines. The total Bill of quantity (BoQ) in this design is Rp7,199,387,990.30 which includes construction work and procurement of telecommunications equipment that has been planned.

Table 9. Bill of Quantity PT.Telkom

Activities	Total
Construction of fiber optic line from Local Exchange - Mini OLT	Rp5,863,626,070.08
Device from Local Exchange - Kordon Market - Mini OLT - Tokong Nanas Building	Rp554,813,221.53
Device from Local Exchange - Cikoneng - Mini OLT - Tokong Nanas Building	Rp780,948,698.69
Total	Rp7,199,387,990.30

NO	DESIGNATOR	UNIT	VOLUME	Unit Price		ITEMS	Service	TOTAL PRICE
CABLE & SPLICING				Material	Service			
1	DC-OF-SM-12D	Meter	693	Rp6,190.00	Rp2,500.00	Rp4,289,670.00	Rp1,732,500.00	Rp6,022,170.00
2	ETHERNET CABLE	Pcs	308	Rp1,081,200.00	-	Rp333,009,600.00	Rp0.00	Rp333,009,600.00
3	RJ 45	PCS	14	Rp690,000.00	-	Rp9,660,000.00	Rp0.00	Rp9,660,000.00
4	PC-UPC-657-5	Pcs	1	Rp82,478.00	Rp3,036.00	Rp82,478.00	Rp3,036.00	Rp85,514.00
5	PC-UPC-657-5	Pcs	10	Rp82,478.00	Rp3,036.00	Rp824,780.00	Rp30,360.00	Rp855,140.00
NODE TERMINAL								
6	ODC-C-48 Splitter	Pcs	3	Rp8,115,107.00	Rp1,365,000.00	Rp24,345,321.00	Rp4,095,000.00	Rp28,440,321.00
7	ODP-A-24	Pcs	3	Rp884,174.00	Rp150,000.00	Rp2,652,522.00	Rp450,000.00	Rp3,102,522.00
8	TC-SM-12	Pcs	1	Rp770,000.00	Rp600,000.00	Rp770,000.00	Rp600,000.00	Rp1,370,000.00
9	RS-IN-SC-1P	Pcs	10	Rp49,200.00	Rp50,000.00	Rp492,000.00	Rp500,000.00	Rp992,000.00
10	RS-IN-SC-1P	Pcs	10	Rp49,200.00	Rp50,000.00	Rp492,000.00	Rp500,000.00	Rp992,000.00
11	RS-IN-SC-1P	Pcs	10	Rp49,200.00	Rp50,000.00	Rp492,000.00	Rp500,000.00	Rp992,000.00

Figure 5. Details of Telkom University's device

Figure 11 is a detail of the design in Telkom University form Mini OLT to Tokong Nanas Building where there is a list of devices used and their prices according to what has been planned.

The BOQ of Telkom University can be seen in table 10 which is the a grand total of design from Mini OLT to the Tokong Nanas building. The total Bill of quantity (BoQ) in this design is Rp385,521,267.00 which includes the procurement of telecommunications equipment that has been planned.

Table 10. Bill of Quantity Telkom University

Activities	Total
Construction of fiber optic line from Server Building - Tokong Nanas Building	Rp385,521,267.00
Total	Rp385,521,267.00

3.8 Revenue

Revenue or income is income obtained from the normal activities of a company and is known by various names, including sales, service income, interest, dividends, royalties, and rent. The total manufacture of two fiber optic lines from the direction of Kordon Market and Cikoneng plus the excavation obtained a total of Rp7,199,387,990.30, then for the total revenue from the first year to the tenth year obtained Rp66,948,188,836.00. It can be concluded from that in terms of business aspects it is very profitable from the side of the Telkom Indonesia Tbk company. Because it is based on the total Bill of quantity (BoQ) which is lower than the revenue value obtained per year.

4. CONCLUSION

This design can implement a Fiber to the Building (FTTB) system in Tokong Nanas Building, Telkom University, using Next Generation Passive Optical Network (NGPON) technology. The design is carried out using three software, namely location mapping software, building mapping software, and feasibility simulation software. The design results show Quality of Service (QoS) values that comply with the standards, including Bit Error Rate (BER) $\leq 10^{-9}$, Signal to Noise Ratio (SNR) $\geq$ 21.5 dB, Q-Factor $\geq$ 6, and Link Power Budget less than -28 dBm. The design cost amounted to Rp7,199,387,990.30 with a total revenue for 10 years of Rp66,948,188,836.00, which shows a business advantage for PT Telkom Indonesia, Tbk.

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