Journal of Electrical Engineering and Computer (JEECOM)
Vol. 6, No. 2 (2024), DOI: 10.33650/jeecom.v4i2
p-ISSN: 2715-0410; e-ISSN: 2715-6427

Fiber To The Home Access Network Planning With Gpon Technology Using Genetic Algorithm Method

Nadia Mardinensi Padjodjang[1], Don E. D. G Pollo[2], Samy Y. Doo[3]
[1]Universits Nusa Cendana, Kupang, Indonensia

Article Info

Article history:

Received September 13, 2024
Revised Oktober 7, 2024
Accepted Oktober 8, 2024

Keywords:

Bit Error Rate
Route
Damping
Genetic Algorithm

ABSTRACT

The purpose of this research is to plan the Fiber To The Home access network at a location in the city of Soe, Kupang, East Nusa Tenggara. This planning is done to facilitate the construction of the Fiber To The Home network from the center to the customer. Researchers conducted a design based on ODP sample point data based on MAPS from the company PT Arsenet Global Solution Soe Branch, the results of simulations conducted in Matlab and OptiSystem software. In this study, the best route search was carried out for the construction of the Fiber To The Home network using the Genetic Algorithm method, the results of the best route search obtained the shortest route as far as 1.6646 km from the center to the customer. Also obtained 7 ODP points with ODP routes starting from ODP points 2-3-4-5-6-7-1 with the distance of each point to the point 0.0045 km - 0.1466 km - 0.1361 km - 0.1042 km - 0.4396 km - 0.8305 km - 0.0031 km. The results of the simulation of the genetic algorithm design in matlab will be simulated in the optisystem 7.0 software to get the receiving power and Bit Eror value. The simulation results using optysystem will be a reference for calculations using the Power Link Budget method. The Power Link Budget calculation shows the total attenuation value from the center to the customer of 18.7925 dB with a power margin of 3.2 dB, Bit Eror of 5.64838 x 10-24 and Q Factor of 10.0288. The results of the calculation of attenuation and power margin prove that the planning is said to be feasible because the total planning attenuation results are below the attenuation standard set by the company PT Arsenet Global Solusi which is a maximum of 28 dB, as well as having a power margin value of more than 0 and a BER value that meets the standard.

Corresponding Author:
Don E. D. G Pollo, ST., MT,
Universitas Nusa Cendana, Kupang, Nusa Tenggara Timur, 86111, Indonesia
Email: don_pollo@staf.undana.ac.id

1. INTRODUCTION

The demand for services such as internet and telephone is growing rapidly. FTTH is built to fulfill infrastructure and information and offer seamless access for users from service providers [1]. Fiber To The

Home is an access network architecture technology that uses optical fiber as its main medium to reach customers. By using fiber optic cable as the main media, FTTH technology has more advantages when compared to network technology that uses copper cable.

FTTH uses GPON (Gigabyte Passive Optical Networks) technology as a standard device developed from JARLOKAF. GPON technology can support transmission with large bandwidth and lower operating costs. This FTTH network planning was built in Soe City, where at that location the network from OLT to the customer's house has not been built. Based on the infrastructure of the ODP candidate [2]. This research was conducted to avoid changes in the path and repetition of infrastructure development in the FTTH network. Therefore, it is necessary to plan using genetic algorithms on the network, so that it can minimize routes that will produce minimal attenuation in accordance with applicable company standards. [3]

To get a quality and fast fiber optic path, the genetic algorithm method and optisystem are used in this problem. Genetic algorithm is an algorithm with solution search technique based on natural selection mechanism. Before planning, a simulation will be carried out first using optisystem to design a fiber optic network. The use of genetic algorithms in this planning is to get the best route with a network that is fast and close to optimal. [5]

1.1 Theoretical foundation

1.1.1 Optical Fiber

Optical Fiber is a cable-shaped transmission medium made of very fine glass and can transmit information with large capacity and at high speed. [3]

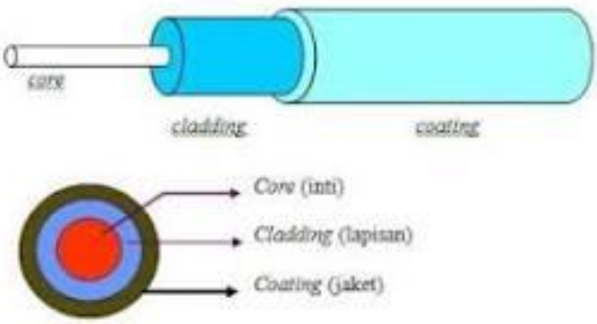

Figure 1 Structure of Fiber Optic Cable

1.1.2 Fiber To The Home

Fiber To The Home (FTTH) is a fiber optic network architecture starting from the central telephone booth (STO) to the customer's device. The application of optical fiber in the FTTH network is an advancement in technological development that can replace the use of copper cables. [4]

1.1.3 Genetic Algorithm

Genetic Algorithm is a search and optimization technique that mimics the process of evolution and changes in the genetic structure of living things. The main principle of how genetic algorithms work is the process of natural selection and the principles of genetics. Genetic algorithms work on a population consisting of several individuals, each of which is represented as a possible solution to an existing problem. Furthermore, the value of the individual is denoted as a fitness value that will be used to find the best solution to the problem. [8]

The evaluation process in genetic algorithms involves assessing the quality of the resulting solution. After a new population is formed through the initialization process, the next step is to evaluate each individual in the new population to obtain its objective value which is the fitness value of the population. This evaluation is done by looking at how well the resulting candidate solutions solve the given problem [13]. This algorithm works on a population consisting of individuals, each of which is represented as a possible solution to the problem. Furthermore, the individual value is denoted as a fitness value that will be used to find the best solution to the problem. [15]

1.1.4 Power Link Budget

Power link budget is the thing that most determines whether an optical communication system can run well or not. Because the power budget guarantees that the receiver can receive the signal optical power needed to get the desired Bit Error Rate (BER) [6]. The purpose of the power budget calculation is to determine whether the selected components and design parameters can produce signal power at the receiver in accordance with the demands of the desired performance requirements. [7]

Bit Error Rate is the rate of bit errors that occur when transmitting a digital signal. Sensitivity is the minimum optical power of the incident signal at the required Bit Error Rate. The need for BER varies with each application, for example, communication applications require a BER of 10-10 or better [14]. Some data communications require a BER of equal or better than 10-12. BER for optical communication systems is no more than 10-9. [12]

The number of bit errors is the number of bits received from a data stream through a communication path that has changed due to noise, interference, distortion or bit synchronization errors.[10]

1.1.5. OptiSystem

Optisystem is software for PCs that is also used to design and simulate fiber optic networks from the central to the end-user, besides that optisystem can also perform network measurements such as power link budget and bit error rate. [11]

2. METHODS

The research method is very decisive for a study, because it involves the correct way of collecting data, analyzing data and drawing conclusions about the results of the research and the stage of the work. To achieve the objectives of the research, a quantitative descriptive method is used by collecting data on the location of the FTTH network planning in the Soe City cluster as follows:

1. Damping standard data from OLT - ONT at PT Arsenet Global Solusi
2. The type of splitter used to design is Passive Spliter 1: 12 and 1: 8.
3. Knector data
4. The wavelength used (Lamda) is 1310

The following is the Research Procedure:

1. Conduct a literature study related to fiber to the home access network planning using the genetic algorithm method.

2. Interview, namely conducting questions and answers with employees at PT Arsenet global solutions about FTTH network planning.
3. Observation to obtain the data needed to design the FTTH network design.

The following is a research flow chart

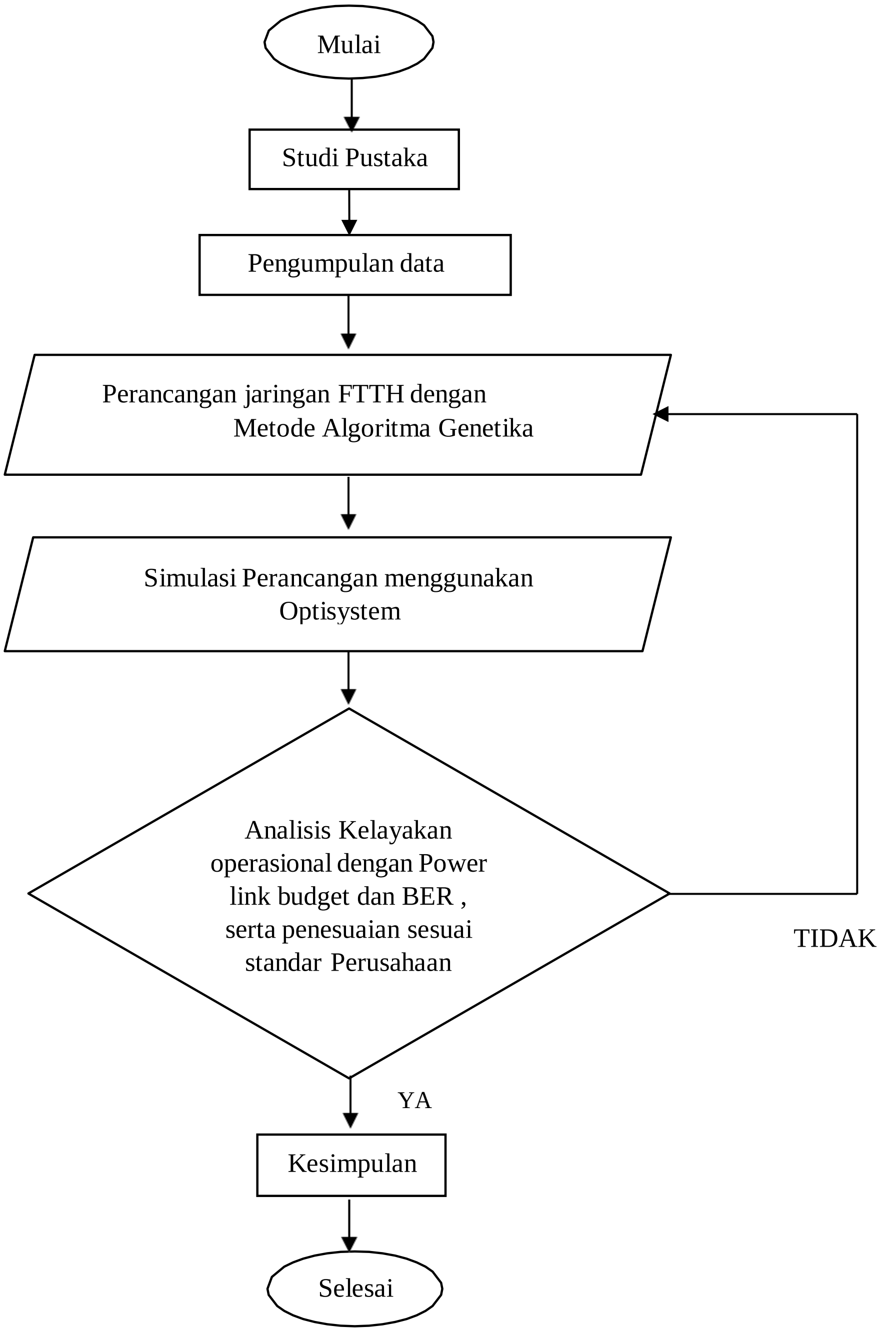

Figure 2 Research Flowchart

3 RESULTS AND DISCUSSION

This research was conducted in Soe City starting with an initial planning location survey conducted using GPS owned by PT Asenet Global Solusi, the survey was carried out by taking marks on infrastructure poles owned by PT AGS with a predetermined mapping area. The purpose of conducting a location survey is to take you on the pole so that it can make it easier to place the ODP location and route the cable line in the design with genetic algorithms and optisystem. The results obtained in the survey are in the form of pole mapping images.

The figure below is a mapping map of ODP candidate poles

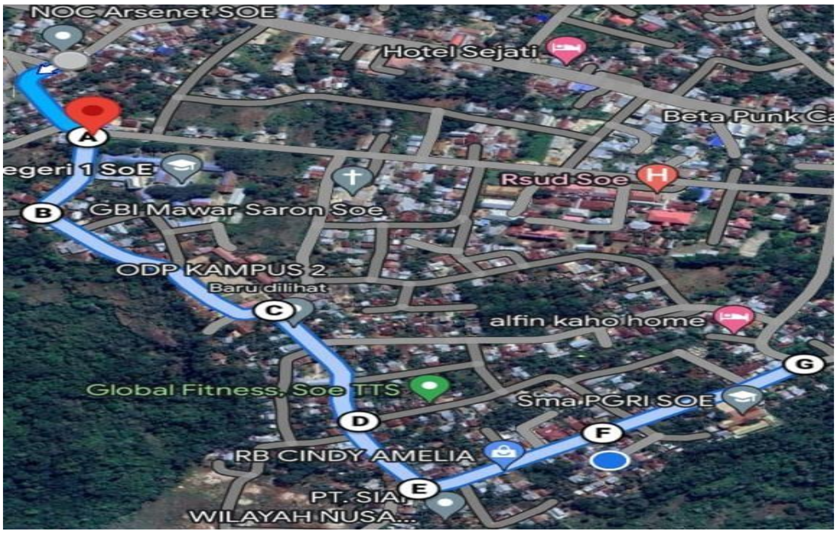

Figure 3 Survey of ODP Candidate Pole Locations Based on Sample Pole Points Using GPS PT. Arsenet Global Solution

Furthermore, the process of finding the best route for FTTH planning in the mapping area. Starting from the OLT which is located in the office space of PT Arsenet Global Solusi SOE City, which is located on jln. Bougenvile, SOE City. Which is at -9.861407, 124.268556. Then from OLT will be connected to OTB using a feeder cable that is in the room of PT Arsenet Global Solusi Kota Soe and then will be connected to ODP using a drop cable that will be spread near the customer in the existing mapping area.

3.1. Data Initialization Process

At this stage, coding is carried out to initialize the city xy which is the pole point coordinate data using the matlab program and get the distance based on the coordinate points as follows:

```
% Inisialisasi dataxykota =
 [
     -986.767 124.269861;
     -985.9365 124.266912;
     -985.9368 124.263850;
     -985.9406 124.261461;
     -986.0872 124.259139;
     -986.2233 124.259449;
     -986.3275 124.258934;
];
jumlah_node = size(xykota, 1);
jarak = zeros(jumlah_node, jumlah_node);
```

3.2 Initial Population Initialization

In this initial population initialization stage to initialize the initial population which aims to create a diverse set of initial candidate solutions for genetic algorithms. At this stage the thing that affects the initialization process is the Population Size, which is an important parameter because a population that is too small can provide a small possibility of forming a diverse initial population. In the case of FTTH route finding, the population size is used: 75. with the input process and initialization process in the matlab program as follows:

```
% Parameter algoritma genetikaukuran_populasi =75;
max_generasi = 100;
prob_crossover = 0.8;
prob_mutasi = 0.2;

% Inisialisasi populasi awal
populasi = zeros(ukuran_populasi, jumlah_node);for i =1:ukuran_populasi
populasi(i, :) = randperm(jumlah_node);
end
```

3.3 Population Evaluation

At this stage, the evaluation process of the population formed from the initialization process is carried out by calculating the fitness value of the population. The population evaluation process can be implemented in a simple function, here is the program code for the population evaluation process:

```
% Evaluasi populasi awal
fitness = evaluasi_fitness(populasi, jarak);
```

The following is the result of the fitness order of each population based on the input population size:

Fitness populasi ke-1 : 1.66462630173585

1.66480086392842

1.66484569791610

1.66489436444349

1.66490831640375

1.66490831640375

1.66678263689835

1.67240186706119

1.87315051908233

1.88075003999956...dst

3.4 Roulette Wheel Selection

At this stage, the parent selection process is carried out with the rouette wheel selection method which is used to select parents based on the fitness value of each individual.

```
% Seleksi orangtua menggunakan metode roulette wheel
orangtua = seleksi_roulette_wheel(populasi, fitness);
```

This function changes the fitness value of all individuals in the population to the smallest value. The smallest value refers to the fitness normalization process, this process is carried out to change the fitness value to be positive. So that all individuals have an equal chance in the selection process. This function returns the selected parents into the Population function.

```
function orangtua = seleksi_roulette_wheel(populasi, fitness)prob_seleksi = fitness ./
    sum(fitness);
    idx_orangtua = roulette_wheel(prob_seleksi);orangtua = populasi(idx_orangtua, :);
end
```

```
function idx = roulette_wheel(probabilitas)nilai_acak = rand;
        total_probabilitas = cumsum(probabilitas);
        idx = find(nilai_acak <= total_probabilitas, 1, 'first');
end
```

This function takes probabilities as input and generates random values, it also calculates the total probability by combining all the probabilities in the 'probability' array. From this process, a suitable individual will be found or called the selected individual parent from the many possible parents that are entered and selected.

3.5 Proses Crossover

This process is carried out to obtain a new individual by moving across from two parents who have been selected as parents through the selection process. In this process, we use crossover with the One cut point crossover scheme, where in this scheme the crossover point in the parents is chosen randomly and the bits to the right of the point are exchanged between the two parents. This results in the formation of two child chromosomes from two parent chromosomes. The following is the program code for the crossover switch process with the one cut point scheme:

```
% Crossover
     anak = crossover(orangtua, prob_crossover);


   function anak = crossover(orangtua, prob_crossover)anak =
      zeros(size(orangtua));
   for i = 1:2:size(orangtua, 1)-1 % Ensure i+1 is within boundsif rand
      <= prob_crossover
   titik_crossover = randi([1, size(orangtua, 2) - 1]);if
      titik_crossover < size(orangtua, 2)
   anak(i, :) = [orangtua(i, 1:titik_crossover),
      setdiff(orangtua(i+1, :), orangtua(i, 1:titik_crossover),
      'stable')];
   anak(i+1, :) = [orangtua(i+1, 1:titik_crossover), setdiff(orangtua(i,
      :), orangtua(i+1, 1:titik_crossover), 'stable')];
   else
   anak(i, :) = orangtua(i, :);
   anak(i+1, :) = orangtua(i+1, :);
   end
   end
   else end
     end
     anak(i, :) = orangtua(i, :);
     anak(i+1, :) = orangtua(i+1, :);
```

The crossover function takes two parameters namely parents and crossover probability, it allocates an empty martix of the same size as `parent` and creates a matrix `child` which will store the child chromosomes. It then iterates over the number of `parent` rows with distance, thus covering all combinations of parent chromosomes. For each iteration, this function sorts out whether the random value between `prob_crossover` is lower or equal to `prob_crossover`. If the random value is lower then it randomly selects a crossover point on the parent chromosome.

The parent chromosome then creates two child chromosomes by combining parts of the parent chromosome to the right of the crossover point. This function returns a `child` matrix containing the resulting child chromosomes.

3.6 Mutation Process

In the gene mutation process, the child chromosomes are mutated by adding a very small random value and a low probability value. In this process, genetic changes are made that are assigned to individual chromosomes to produce child chromosomes.

```
        % Mutasi
        anak = mutasi(anak, prob_mutasi);
    function anak = mutasi(anak, prob_mutasi)for i = 1:size(anak, 1)
        if rand <= prob_mutasi
        titik_mutasi = randi(size(anak, 2));
        anak(i, :) = circshift(anak(i, :), [0, titik_mutasi]);
        end
        end
        end
```

This function allocates an empty matrix of size equal to `child` and creates a `child` matrix that will store the child chromosomes. It iterates through as many rows of `child` with distance . For each iteration, it sorts out whether the random value between `prob_mutation`. If the random value is lower or equal to `prob_mutation` then this function will select a random chromosome in the `child` and `prob_mutation` matrix then change the element with a random value of 0 and the mutation value.

This function merges the original chromosome and the child chromosome using the `cirshift` function, this function shifts the chromosome to the right or back as many points as entered. This process produces a new individual.

3.7 Best Route Results

From the route search process, the best route obtained in the simulation using matlab is as follows:

Tiang ODP	Jarak (km)
	0,0031
2	0,0045
3	0,1466
4	0,1361
5	0,1042
6	0,4396
7	0.8035

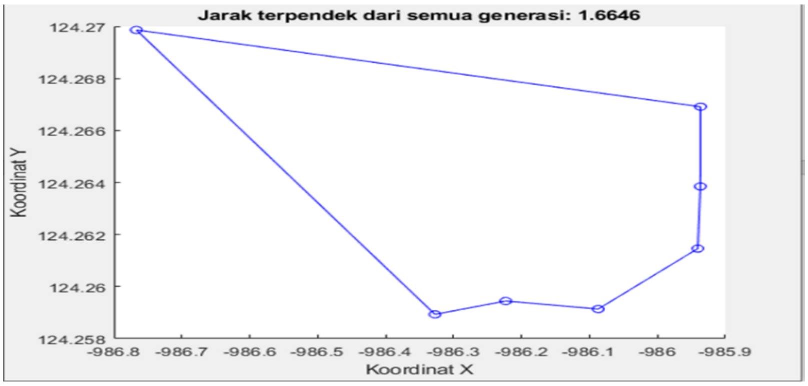

Figure 4 Best Route Results

From the route results, it is found that the shortest total distance for the best route is 1.6646 km with the ODP pole design route: 2-3-4-5-6-7-1 with the distance of each ODP pole from OTB is as follows

3.8 Simulation Results Using Optisystem Software

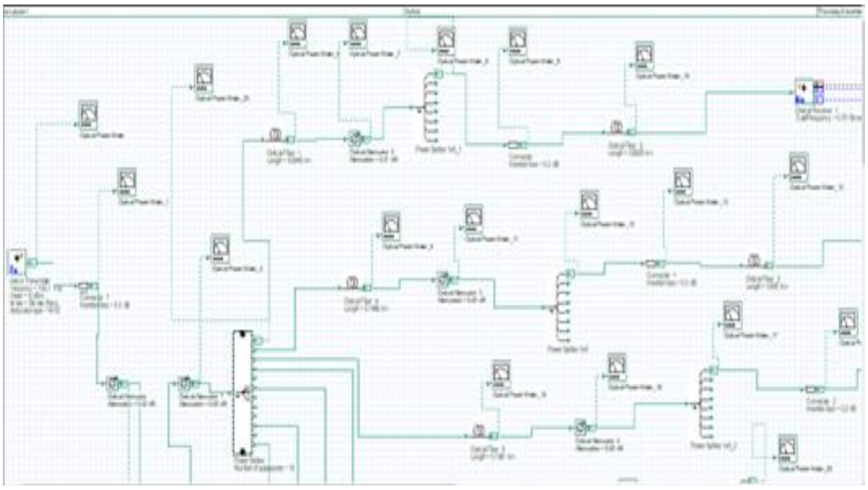

Figure 5 Simulation Using Optisystem

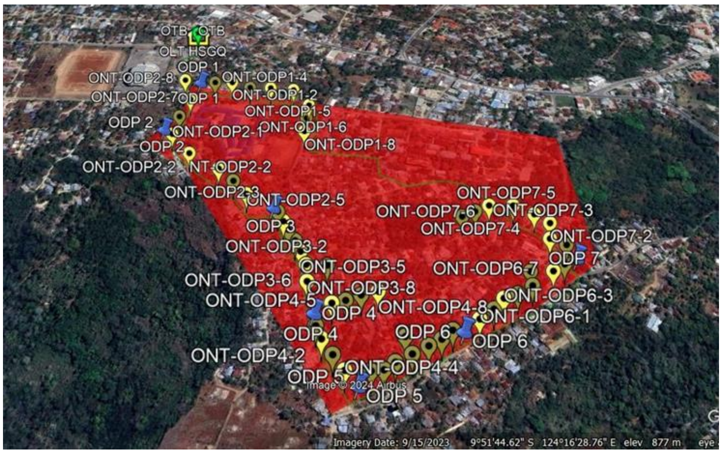

Figure 6 FTTH Network Design Results on Google Earth Pro

3.9 Link Budget Calculation Results

Link Budget calculation on one of the furthest ODP samples with a distance of 0.8307 km. OLT- ODP = 0.8305 km, ODP-ONT distance = 0.002 km:

- Redaman Total

$\alpha total = L.\, \alpha f + N\text{c}.\, \alpha C + Ns.\, \alpha s + Sp$

= (0, 8307× 0,28) + (2 × 0.2) + (1 × 0.1) + (7,68 + 10,38)

= 0,2325 + 0,4 + 0,1 + 18,68

= 19, 4125 dB

- Power Daya Penerima

Pr $= Pt - \alpha total$

= 6 – 19,4125

= -13,4125 dBm

From the calculation of the power link budget above, it can be said that it is feasible because the value of attenuation and received power is still below the maximum standard set by the company.

4. CONCLUSION

Based on the results of the Fiber To The Home network design carried out with the Genetic Algorithm method for finding the shortest route and simulation with Optisystem software to simulate whether the design can be said to be feasible or not by considering the Power Link Budget and BER, it can be concluded that:

1. The results of the design with the Genetic Algorithm method to find the shortest route obtained results as far as 1.6646 km from the center to the ODP Customer with a population size of 75 populations with a generation of 100 and a muasi probability of 0.2 and a crossover probability of 0.8.
2. From the results of the calculation of the power link budget carried out on the sample of the farthest ODP distance from the center, namely ODP 7 with a distance of 0.8305 km, the attenuation value is 18.7925 dB with a power margin of 3.2 dB. These results are said to be feasible because the power margin value is more than 0 and the total attenuation value is below the company's maximum standard of 28 dB. From the results of the Bit Eror Rate value obtained from the sample 5.64838×10-24 and Q Factor 10.0288 is said to be feasible because it meets the requirements of the applicable standards.

ACKNOWLEDGMENTS

The author would like to thank PT Arsenet Global Solution Knator Kupang Branch and POP Soe for accepting and guiding and supporting in the smoothness of data collection until the completion of FFTH network planning in Soe City with Genetic Algorithm Method.

REFERENCES

[1] T. F. Ramadona, A. Sivia and C. , "Perbandingan Algoritma Genetika dan TSP Untuk optimalisasi Jaringan Akses Fiber To The Home," Jurnal Teknik Informatika dan Sistem Informasi, 2017.

[2] I. Manggolo, I. M. Marzuki and M. Alaydrus, "Optimalisasi Perencanaan Jarigan Akses Serat Optik Fiber To The Home Menggunakan Algoritma Genetika," Jurnal Telekomunikasi dan Komputer, 2017.

[3] G. Keiser, Optical Communications Essentials, United States Of America, 2003.

[4] J. Green and E. Paul, Fiber To The Home The New Empowerment, Canada: Johen Wiien & Sons, inc ; Hogoken, New Jersey, 2006.

[5] S. N. Sivanandam and S. N. Deepa, Introduction To Genetic Algorithms, India, 2008.

[6] J. Prat, Next-Generation FTTH Passive Optical Networks, Barcelona, Spain: Universitat Politecnica Catalunya Barcelona, 2008

[7] Tri Nopiani Damayanti, F. A., & Yudha, M. S, Perancanggan Jaringan Fiber To The Home, 2015

[8] Sivanandam, S. N., & Deepa, S. N, Introduction To Genetic Algoithms, India: Evolutionary Computation, 2007

[9] Sitanggang, D, Inisialisasi Populasi Pada Algoritma Genetika Menggunakan Simple Hill Climbing (SHC) Untuk Traveling Salesman Problem (TSP), Jurnal Times, 4:44, 2015

[10] Pratama, A. A, Imansyah, F., & Pontia, T, Perancanggan Jaringan FTTH Dengan Teknologi GPON Menggunakan Algoritma Genetika dan Optisystem, Jurnal Teknik Elektro Universitas Tanjung Pura, 2.1, 2020

[11] Poulose, A, An Optisystem Simulation for indoor visible light communication system, 2017

[12] Mutaharik, Ihsan, M., & Sugito, Perancangan Jaringan Fiber To the Home (FTTH) Menggunakan Teknologi Gigabit Passive Optical network (GPON) Di Central Karawaci, eProceedings of Engineering, 2016

[13] Mitchell. M, An Introductions to Genetic Algorthms. London, England: Genetic Algorithms: An Overview, 1998

[14] Adis, O. R, Analisis Optimasi Signal to Noise Ratio (Snr) Pada Jaringan Fiber to the Home (Ftth) Perumahan Bernady Land Jember Dengan Metode Algoritma Genetika, Repository Universitas Jember, 2020

[15] Ramadona, T. F., Silvia, A., & Ciksadan, Optimasi Rute Teknolohi Indihome Denggan Metode Algoritma Genetika dan TSP (Travelling Sales Man Problem), Jurnal Teknik Telekomunikasi Politeknik Sriwijaya, 2017