Optimization In Develop The LTE Site Planning Jabodetabek Region Using Linear Programming Method In Pycharm And POM-QM Software, Case Study PT. XYZ

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ABSTRACT

PT. XYZ is an open company developed in mobile telecommunication in Indonesia. The company was established to meet the needs of customers throughout all of the region in Indonesia. To determine how many sites should be built with limitations of budget would be the constraints, then it takes the objective function derived from calculations using linear programming methods. In this case, the calculation and analysis which aims to develop the plan of 4G LTE technology which has four types, those are LTE900, LTE1800, LTE2100, and LTE2300 in JABODETABEK region for this study by using pycharm software with PULP package and compared using POM-QM software. The results obtained by using both software shows the same number as follow, LTE types that must be built sequentially from the most to the least are LTE2100 12,580 sites, LTE2300 2.044 sites, LTE1800 390 sites, and LTE900 0 sites. Based on these results, if the company implemented these results in building the site for each type of LTE, then the maximum total revenue that can be obtained by the company is Rp 2.452.380.953.518,722.

Keywords: Linear Programming, Base Transceiver Station (Site), 4G LTE, CAPEX, OPEX, python, pycharm, PULP package, POM-QM.

1. Introduction

Currently PT. XYZ is one of the telecommunication companies in Indonesia that become one of the largest mobile telecommunication operator in Indonesia. PT. XYZ has consistency in implementing mobile technology such as 4G Long Term Evolution (LTE) technology. By the end of December 2016, the company already has 82.6 million users capable of using 3G/4G. Those number shows as much as 47.5% of its total customers (XYZ, 2016). Based on actual data that can be predicted until the end of 2018, the use of mobile communication facilities increased on mobile data using 4G LTE. Therefore, by 2018 PT. XYZ will 100% build 4G LTE only for their company development, while 2G and 3G will only be monitored against existing BTS (site). In the development of 4G LTE is also not limited to one type only because 4G LTE technology have four types, those are LTE 900, LTE 1800, LTE 2100, and LTE 2300 where each types has different functions with different frequencies. In this figure below shows the trend of 2G, 3G, and 4G usage by the data volume (payload) in one year before.
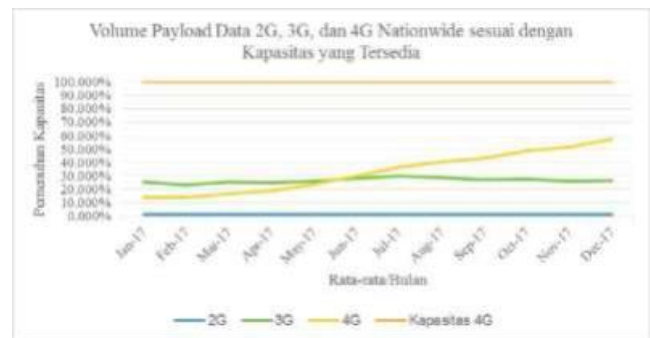
planning to build the sites and increase company's revenue, further analysis is needed in the development planning for the next year. Therefore, it needs more analysis (cause and effect analysis) using fishbone diagrams which can analized the decreased revenue if the company still develop (build) the 2G or 3G sites based on technical aspect, the amount of customer data usage in each BTS and financial aspects, CAPEX and OPEX cost. The both aspects has a significant impact on the effectiveness of the allocation of investment budget in BTS builders. The analysis was done by Fishbone Diagram using four categories, Information, Man Power (People), Method, and Machine/Tool

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(Hekmatpanah, 2011). The figure below is the result of the analysis using fishbone diagram.
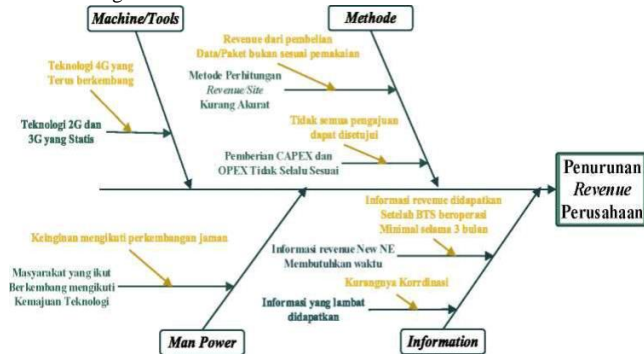

Figure- 2. Root Cause and Effect Analysis using Fishbone Diagram

2. Methods

The methodology used in this research is Linear Programming method using python language in pycharm and POM- QM software to calculate and find the result.

2.1. Data Collection Stage

Data collection is done in network planning and budgeting division in PT.XYZ. The division's job is manage all the money that the company has used to determine the site development plan throughout the region such as the process of controlling the cost of site building, and so on. Specifically, this study focuses on the budgetting to perform all calculations in every programs for the economic scope. In this year, there is a program that is implemented, New Network Element (New Ne) and need to estimate how many new site that PT. XYZ should be build in various types of LTE technology in JABODETABEK region which become the object of this research.

1. Spectrum Network Strategy

The outline of network spectrum strategy owned by PT. XYZ can be describe as below (Adityawan, 2017).

   a. 900MHz

At this time PT. XYZ has 7.5MHz in PBAND and 7.5MHz in EBAND. Then there would be a possibility for this company to have 900 when rearranged with another provider to get 5MHz in PBAND and 10MHz on EBAND. So the LTE900 can be upgraded to 10MHz in the future when the company has nearby 10MHz. LTE900 is one that will be used for coverage solution because of frequency owned by PT. XYZ is too small to be used as a capacity solution.

   b. 1800MHz

This frequency will be used for DCS or which can be called 2G, and LTE. With LTE at frequency of 15 MHz, the DCS will probably have 4/4/4 TRX configuration. Therefore, LTE1800 at 17MHz will enable DCS using LTE band guard to provide 3/3/3 TRX configuration. LTE1800 can be used as a coverage and capacity solution because it has large enough of frequency so that coverage is also quite large with a large enough capacity as well (qualified).

   c. 2100 MHz

The 3G spectrum can be recycled for LTE2100 as a capacity solution, as 3G traffic continues to be decline every year. Therefore, the new L2100 will be implemented this year because the development requires a spectrum of existing 3G. Therefore LTE type revenue needs to be projected from LTE1800 because it is considered to have the same characteristics. LTE2100 is expected to have revenue 20% of LTE1800.

   d. 2300MHz

PT. XYZ also has LTE2300 TDD that will be used as the next capacity solution. LTE2300 owned by the company now has a frequency up to 30MHz which will be designed as 2 carrier that is 10MHz and 20MHz.

2. Network Implementation Strategy

PT. XYZ implements four network types for LTE. One of them is LTE1800 which still based on coverage and capacity it has. Priority for the construction of LTE1800 in a particular location is based on it's over usage capacity, that can be increased to expand its reach. While the L900 will cover areas that can not be reached by LTE1800 to have a more detailed in reaching the hidden traffic. Usage density resulting in data traffic hampering will be met in sequences with L1800 (flexible bandwidth), L2300, L2100 and L900 (Adityawan, 2017).

When PT. XYZ launched the WBB program, then 20MHz will be the capacity layer, while 10Mhz as a special WBB layer. L2100 will allow its use for an area where 3G traffic can allow for renewal. In areas where 3G traffic can still accommodate usage capacity on 2 operators, the L2100 will be an additional capacity layer above L1800. L2100 or L900 can be used also on existing 3G where the site is capable of being used for LTE in rural areas that have new demand in order to meet the initial coverage and capacity activated only by SW, which is suitable for sub-urban & rural outside.

	LTE Types	COVCAP	COV Hole	CAP Ext.	Priority
URBAN	LTE900		5M	5M**	4
	LTE1800	15M		~17M	1
	LTE2100			10M*	3
	LTE2300A			20M	2
	LTE2300B			10M	
	LTE Types	COVCAP	COV Hole	CAP Ext.	Priority
SUB URBAN	LTE900		5M	5M**	4
	LTE1800	15M		~17M	1
	LTE2100	5M		10M*	3
	LTE2300A			20M	2
	LTE2300B			10M	
	LTE Types	COVCAP	COV Hole	CAP Ext.	Priority
RURAL	LTE900	5M	5M		
	LTE1800	10/15M		15M	
	LTE2100	5M		5M*	
	LTE2300A				
	LTE2300B				

Figure- 3. Network Strategy - Deployment Guideline

3. Sitelist Criteria to be built

In each year, development plans in each region require a proposal for submission of sitelist in accordance with the analysis of sales and marketing areas that know the demand site in a particular location directly.

Therefore, the area always give proposal that contains sitelist in each region respectively. The sitelist proposal in one program may exceed the

budget allocation of the RKAP 2018, so a methodology for determining the priority sitelist will be based on a business & technical perspective with the 5 main parameters to be explained in subsequent chapters.

The three main criteria that need to be taken into account when a sitelist is not selected are:
a. Site belongs to non red site and non priority.
b. NPV <0.
c. In matrix 9 (M9) included into red zone.
4. Prioritization Method to be built

This prioritization method involves many parts of the company, including the network, budgeting, sales area, and also marketing. Each section has its own terms and conditions in determining the site to be built during a future term shown in Figure-4 below.

Table- 1 Prioritization Methods Based on Each Part of the Company

Prioritization Method		
Network Trigger		**18%**
Red Site & P1	100%	18%
Red Site & P2 & P3	65%	11%
Red Site & Non Prio	40%	7%
Non Red Site & P1	70%	12%
Non Red Site & P2 & P3	35%	6%
Feasibility		**22%**
NPV>0,	100%	22%
IRR>WACC+3%	80%	17%
Productivity		**24%**
Blue	100%	24%
Green	75%	18%
Yellow	60%	14%
Sales Point of View		**18%**
New Demand	100%	18%
POI 2018	60%	11%
Special Treatment (VLC)	50%	9%
Marketing Point of View		**18%**
City Prio-1	100%	18%
City Prio-2	85%	16%
City Prio-3	70%	13%

5. Type and Amount of Cost incurred

PT. XYZ has four LTE types planned to be built, where each type requires each cost that can be seen through Table-1 below. There are two types of costs, namely CAPEX which consists of the amount of CAPEX itself coupled with the price of antenna and NSR or OPEX.

Table- 2. Type and Amount of Cost incurred for Development Site

Detail Types	Capex	Antenna	Total Capex	NSR (OPEX)
New Site 4G LTE L900	Rp389,448,750	Rp39,000,000	Rp428,448,750	Rp16,500,000
New Site 4G LTE L1800 10 MHz	Rp240,243,031	Rp75,000,000	Rp315,243,031	Rp16,500,000
New Site 4G LTE L2100	Rp179,307,601	Rp0	Rp179,307,601	Rp0
New Site 4G LTE L2300 10 MHz	Rp304,290,000	Rp75,000,000	Rp379,290,000	Rp5,000,000

2.2. Data Processing Stage

Data Processing Stage is the stage where all data from data collection is processed. There are several processes at this stage include calculating the number of all LTE types using linear programming method with python languange and PULP package in pycharm software, calculating calculating the number of all LTE types using linear programming method in POM-QM software. The results of this calculation should be the optimum objective function with maximum total revenue. To get those values, the calculation process needs to generate the optimal amount for each LTE type first.

a. Determine the data processing stage using python programming language using pycharm software with PULP package In this study, the authors choose to use Python Programming Language because python is one of the high level language that can be interpreter, interactive, and object oriented (Kiusalaas, 2010). In the python there are so many package that we can use, buat in this study authors focused to use PULP which match with the method to be used, linear programming (LP). If its compared with other LP modeling tools such as AMPL, GAMS, mathprog, Opc ++, or pyomo and poams, PULP provides many advantages for its users, one of it is having a clear syntax (Mitchell, 2009). The determination of objective function, constraints, and variable declaration is done using python programming language with the help of application of IDE translator (Integrated Development Environment) called Pycharm, where the variables used are x1, x2, x3, and x4 with the definition of x1 is LTE900 , x2 is LTE1800, x3 is LTE2100, and x4 is LTE2300 which can be seen through picture 1.6 below.

Figure- 4. Data Processing Using Pycharm Software with Python Programming Language

b. Determine the data processing stage using POM-QM software

As a comparison of the results as well as searching the right software can be used in solving the case of this study, the author use the software commonly used in calculating the case of Linear Programming called POM-QM software. POM-QM for Windows (also known as POM for Windows and QM for Windows) is the a software that most or commonly used because this is userfriendly software package available in the fields of production and operations management, quantitative methods, management science, or operations research (Malvar, et al., 2018). The following is the determination of variables, constraints, and the objective function in this study are shown using POM-QM software in Figure7 below.

Maximize Revenue

	X1	X2	X3	X4	RHS	Equation form
Maximize	248224400	764070500	115421800	343320100		Max 2 482244E+08X1
Constraint 1	428448700	315243000	179307600	379290000	<= 31543800	4 284487E+08X1 +
Constraint 2	198000000	198000000	0	60000000	<= 20000000..	1 98E+08X1 +
Constraint 3	1	0	0	0	>= 0	X1 >= 0
Constraint 4	0	1	0	0	>= 0	X2 >= 0
Constraint 5	0	0	1	0	>= 0	X3 >= 0
Constraint 6	0	0	0	1	>= 0	X4 >= 0
Constraint 7	1	0	0	0	<= 12580	X1 <= 12580
Constraint 8	0	1	0	0	<= 12580	X2<= 12580
Constraint 9	0	0	1	0	<= 12580	X3 <= 12580
Constraint 10	0	0	0	1	<= 12580	X4<= 12580

Figure- 5. Data Processing Using POM-QM Software

c. Comparing The Result to Know The Computational Efficiency

After the result already obtained using both of software, authors will compare how many times the software takes to solve the problem to get the final result. It aims to know which software would be better to use by comparing the computational efficiency of each software.

3. Result and Discussion

In the way to obtain the best result with the methodology that authors already describe above, it need to generate the number of each LTE type for first, and the input will be shown in Table-2 below.

Table- 3. CAPEX Price and OPEX Cost of each LTE Type

Regional	Detail SoW	Total Capex	NSR (OPEX)
R03 Jabotabek	New Site 4G LTE L900	Rp 428,448,750.00	Rp 16,500,000.00
R03 Jabotabek	New Site 4G LTE L1800 10 MHz	Rp 315,243,031.00	Rp 16,500,000.00
R03 Jabotabek	New Site 4G LTE L2100	Rp 179,307,601.00	Rp 0.00
R03 Jabotabek	New Site 4G LTE L2300 10 MHz	Rp 379,290,000.00	Rp 5,000,000.00

Table- 4. Budget CAPEX 1, Minimum Site, and Maximum OPEX for CAPEX 1

Budget CAPEX 1	Rp 3,154,380,350,058.00
Maximum New NE	12580 buah *site*
Maximum OPEX for CAPEX 1	Rp 200,000,000,000.00

1) Determining the Number of LTE900, LTE 1800, LTE2100 and LTE2300 Shoul be Built Using Pycharm and POM- QM Software

a. Calculation Result Using Pycharm Software, PULP Package for Python

Figure- 6. Running Program Results Using Pycharm Software with Python Programming Language

After determining all of the data in Pycharm Software using PULP Package for Python, the best result obtained a formulation of LTE900, LTE1800, LTE2100, and LTE2300 sequentially should be done by the company is by building 0 X1, 390 X2, 12580 X3, and 2044 X4 with the objective function formula 248224452 X1 + 764070480 x2 + 115421844 x3 + 343320084 x4, so the maximum total revenue that can be achieved by PT. XYZ is Rp 2,452,380,953,518,722.

b. Calculation Result Using POM-QM Software

Li nea r Prog ra m m i ng Resu Its

Maximize Revenue Solution

X1	X2	X3	X4		RHS	Dual		
Maximize	248224400	764070500	115421800	343320100				
Constraint 1	428448700	315243000	179307600	379290000	<=	31543800	.39	
Constraint 2	198000000	198000000	0	60000000	<=	20000000..	3.23	
Constraint 3	1	0	0	0	>=	0	-560441800	
Constraint 4	0	1	0	0	>=	0	0	
Constraint 5	0	0	1	0	>=	0	0	
Constraint 6	0	0	0	1	>=	0	0	
Constraint 7	1	0	0	0	< =	12580	0	
Constraint 8	0	1	0	0	<=	12580	0	
Constraint 9	0	0	1	0	<=	12580	44786340	
Constraint 10	0	0	0	1	<=	12580	0	
Solution	0	390.44	12580	2044.9		24523800..		

Figure- 7. Running Program Results Using POM-QM Software

Based on data processing using POM-QM Software software, we get a formulation of the best function in developing LTE900, LTE1800, LTE2100 and LTE2300 in sequence which should be done by company that is by building 0 X1, 390 X2, 12580 X3, and 2044 X4 with function formula destination 248224452 x1 + 764070480 x2 + 115421844 x3 + 343320084 x4, then obtained the total revenue that can be achieved by the company is Rp 2,452,380,953,518,722.

    c.   Computational Efficiency

Based on the results calculations in the above stages using both software, the results obtained the same number of each types of LTE should be built, 0 X1, 390 X2, 12580 X3, and 2044 X4 and the maximum revenue that can be achieved by the company is Rp 2.452.380.953.518,722. Eventhough the result shown the same, but from the efficiency of the computational that can be done for each software shows time difference in problem solving. The Pycharm Software needs 0.73 seconds to solve the problem and the POM-QM Software only needs 0.28 seconds. So the software better to used for this study is using POM-QM software.

4. Conclusion

So, from the result shown above, the conclusion for this study to determine the number of LTE900, LTE1800, LTE2100 and LTE2300 should company's build using linear programming method and supported by calculation using two software that is pycharm in PULP package with python programming language and POM-QM as comparison of result and comparison of software, got the same result in both software, which is build no site of LTE900, 390 sites of LTE1800, 12580 sites of LTE2100, and 20144 sites of LTE2300. So PT. XYZ gained the maximum revenue for company in amount of Rp 2.452.380.953.518,722. Based on time difference for both software in solving the problem, it shows that POM-QM software could give the faster result in 0.28 seconds. The conclution from the computational efficiency, POM-QM software more efficient than the Pycharm Software.

REFERENCES

[1] Adityawan, K., 2017. LTE Planning and Guideline [Interview] (28 December 2017).

[2] Hekmatpanah, M., 2011. The application of cause and effect diagram in the oil industry in Iran: The case of four liter oil canning process of Sepahan Oil Company. African Journal of Business Management, pp. 10900-10907.

[3] Kiusalaas, J., 2010. Numerical Methods in Engineering with Python 3. United States of America: Cambridge University Press.

[4] Malvar, R. J. et al., 2018. Rice Profit Maximization in Mabitac Laguna Farms in The Philippines. Journal of Fundamental and Applied Sciences, pp. 45-63 .

[5] Mitchell, S., 2009. An Introduction to pulp for Python Programmers. The Python Papers Monograph.

[6] XYZ, P., 2016. Annual Report 2016, Jakarta: PT. XYZ.