Revenue Maximization and Manpower Allocation of Internet Service Provider using Linear Programming

Eloizza T. Caldamo, Kristel Joy A. Bergantiños and Rex Aurelius C. Robielos
School of Industrial Engineering and Engineering Management
Mapua University
Intramuros, Manila, Philippines
racrobielos@mapua.edu.ph

Abstract

Internet Service Providers (ISP) provide high speed internet service and their revenue depends on the data rates that they charge to their customers. ISPs are faced with the challenge of meeting the growing demand of data services usage, using limited resources to maximize revenue, and providing services at reasonable prices. This paper aims to develop linear programming models which will (a) maximize sales and (b) allocate manpower given the limited resources. This paper also utilizes the analytic hierarchy process to help sales personnel rank priority industry selling area to maximize the useful life of network equipment. The sales maximization model has returned the optimal values of the number of ports to be sold and the optimal amount of sales discount for the six industry selling areas for the achievement of the PhP107,300,000.00 sales target of the ISP. Likewise, the manpower allocation model has helped determine the annual sales quota per sales agent which is from PhP2,100,000.00 – PhP4,700,000.00. Lastly, a prioritization of the selling areas is also devised using the AHP model formulated which showed that Business Services sales area has to be prioritized in selling. The results showed that while calculating the optimal number and selling price of products to be sold is relevant in revenue optimization, assigning it to the available manpower makes it more profitable to the company.

Keywords
sales maximization, manpower allocation, linear programming, analytic hierarchy process, internet service provider

1. Introduction
Over the years, the demand for high speed data services in businesses has increased and is expected to increase (Mehmood, Udell, & Cioffi, 2015) and become more prevalent in the coming years. This demand by companies for fast and reliable internet connectivity solution is for the support and continuity of their business needs. In manufacturing companies, for example, steadfast internet connectivity is a requisite in communicating with their suppliers and contractors. In the retail industry, dependable internet is essential for their operations and inventory management. The healthcare sector, financial services, food and hospitality and other industries also require stable and fast internet connectivity in exchanging large files, in handling payments, timekeeping system, marketing, and other operations relevant to the business. Among the challenges faced by Internet Service Providers (ISPs) are providing the aforementioned services at reasonable prices, meeting the growing demand of data services usage, and maximizing limited resources to maximize revenue.

With the increased competition and growing market in the ISP sector, a more strategic sales planning is indispensable to survive the industry. In the ISP industry, however, selling capacity is bounded by the number of ports supported by an ISP infrastructure. The maximum number of ports and its allocated bandwidth determines the maximum network capacity an ISP can offer. In any case, the pricing of services is a function of the bandwidth allocation based on the needs of various client industries. The maximum capacity to sell of an ISP, therefore, puts a cap on the maximum revenue an ISP can generate. The concept of maximum revenue is expounded in (Mehmood, Udell & Cioffi, 2015) as revenue capacity, which is introduced as a useful and meaningful metric for revenue optimization. Revenue capacity, as further defined in the paper, gives an upper bound on the monetary worth of a communication link given a price function.

The maximum network capacity limits the maximum revenue can generate; however, it does not preclude an ISP to draw on the use of sales quotas. In (Good and Stone, 1991), sales quotas are defined to represent a specific sales goal that an individual is responsible for satisfying over a period of time, usually one year. Despite the pervasive use of quotas in sales planning, literatures have contrasting judgment on its effect. Since quotas rely heavily on sales forecasts, inaccurate forecasts bias the management toward a sales target that is either too high or too low (Blessington, 2016). A more accurate quota, on the other hand, can improve sales force motivation, market potential, and territory sizing.

One of the key factors in attaining sales target is its manpower and the allocation of the limited number of salesforce into different selling areas, territory, tasks, or assignment for various objectives such as, most commonly, to maximize sales, to minimize labor costs, to manage work hours, to manage shifts, or to match required skills. This area has become increasingly important due to businesses becoming more service-oriented and cost-conscious (Al-Rawi and Mukherjee, 2019) and transcends to every industry like retail (Lam, Vandenbosch and Pearce, 1998), banks (Bagatourova and Mallya, 2004), defense (Sheridan, 1969), and airports (Chu, 2007). The study of manpower scheduling is a classic operations research study which is analyzed through the use of various mathematical programming models such as linear programming (LP) (Hasan and Arefin, 2017), mixed-integer programming problem (Agrali, Taskin and Unal, 2015), and constraint programming (Kletzander and Musliu, 2019), among many others. The key problem related to manpower scheduling problems in various industries is normally obtaining an optimal solution. In this paper, the key constraint which needs optimization is the number of salesforce existing to focus in six different market areas, so that the overall annual sales target of the ISP as well as the sales quota per sales manpower is achieved.

While businesses value internet connectivity and considering the tough competition among ISP companies in providing fast, reliable and affordable internet connection to companies in different industries, this paper aims to develop a model which will maximize sales given the limited network selling capacity and limited manpower while meeting the sales target of the company and of the sales personnel based on the sales quotas set for the different industry selling areas using linear programming. This paper will also utilize the analytic hierarchy process to maximize the useful life of network equipment.

2. Methodology

2.1. Linear Programming

Linear programming is utilized to obtain the optimized values of decision variables in problems such as sales maximization and manpower allocation. These types of problem often use linear programming because of its effective model and decision-making. Multi-skilled manpower scheduling, shift scheduling, task-based scheduling, and other variations of the manpower allocation problems in various industries are extensively tackled in (Wu, 2007; Al-Rawi and Mukherjee, 2019; Hasan and Arefin, 2017) which have utilized linear programming. Likewise, linear programming is employed with various approaches in profit optimization problems in almost any industry. In (Klein, Hironaka, Heller & Freeze, 1986), as an example, an LP model was developed for selecting maximum profit feeding programs in the dairy industry. In (Haider, Fareed, Tariq, Usman, Ud din and Khan, 2016), on the other hand, the effectiveness of LP in determining the optimal combination of various products that an organization produces to obtain maximum return is highlighted. Oftentimes, these studies would conclude with the optimal values of the decision variables. In contrast to these studies, this paper used linear programming in these two distinct linear optimization problems. It would not conclude with the plain computation of the optimal results of the revenue maximization and manpower allocation models but will use the optimal values to calculate the sales quota on a per sales agent basis.

The data used in this study is from an ISP serving six industry selling areas such as (1) Computer and Electronics, (2) Financial Services, (3) Retail, (4) Business Services, (5) Manufacturing, and (6) Food and Hospitality, including its annual sales quota of sales agents, selling price of products, maximum selling capacity, the allocated no. of sales personnel in every industry and the total no. of available sales personnel, as shown in Table 1. The net selling price multiplied by the number of ports of to be sold would result to the total sales of the ISP. Net selling price is result of deducting the discount from the product selling price. Discount is computed as a percentage of the selling price offered to clients for marketing purposes. The annual unit sales quota and maximum selling capacity determine the minimum and maximum number of ports, respectively, which need to be sold by the sales agents. The available manpower of the ISP is 32 sales agents, while the number of required sales agents which need to focus on the selling areas totals 79. The available number of sales agents needs to be allocated in the different selling area. The annual sales quota of per sales agent per selling area will be utilized in the manpower allocation problem to calculate the total sales quota per sales agent depending on his assigned industry.

Table 1. Data used in the study

Selling area	Selling price per product (in PhP)	Maximum discount (y)	Annual unit sales quota (q)	Maximum selling capacity (c)	No. of required sales agents	Annual sales quota/sales agent (in PhP) (a)
1	31,500.00	20%	476	2,000	10	1,500,000.00
2	8,700.00	5%	1,655	1,840	12	1,200,000.00
3	9,300.00	5%	1,451	1,520	15	900,000.00
4	18,200.00	10%	2,198	2,300	20	2,000,000.00
5	38,900.00	15%	257	800	10	1,000,000.00
6	28,000.00	30%	514	1,000	12	1,200,000.00

Linear Programming model formulation:

Two major problems were identified, and two models were developed to address the problem on Sales Maximization and Manpower Allocation.

2.1.1. Development of Sales Optimization Model

First, a sales maximization LP model is generated to obtain the optimal number of ports to be sold and the amount of net selling price to achieve the sales target of PhP107,300,000.00. The net selling price is computed based on the selling price of product less the optimized discount.

The annual sales $\sum[(n_i-d_i)*x_i]$ of the ISP should equal or exceed PhP107,300,000.00 where

i = industry selling area [1, 2,..6]
n_i = selling price per sales area i
x_i = number of ports sold per sales area i
d_i = amount of discount per sales area i

with the Objective function

$$\text{Max } Z = [(n_1-d_1*x_1] + [(n_2-d_2)*x_2] + [(n_3-d_3)*x_3] + [(n_4-d_4)*x_4] + [(n_5-d_5)*x_5] + [(n_6-d_6)*x_6]$$

subject to the following requirements:

Sales discounts (d) should be equal to or less than the allowable sales discount (y) per sales area (*i*),	$0 \leq d_i \leq y_i$
Unit sales (x) per selling area (*i*) should meet or exceed the annual unit sales quota requirement (q), but should be less than or equal the maximum selling capacity (c)	$c_i \geq x_i \geq q_i$
n_i, x_i, d_i are non-negative	$n_i > 0$, $x_i > 0$, $d_i > 0$

The formula for net selling price, herein denoted as *n*, is selling price less discount, the latter denoted as *d*. The number of ports sold, *x,* multiplied by *n*, yields the annual sales per selling area *i*. The sum of all $n_i x_i$ is the total sales of the company.

2.1.2. Development of Manpower Allocation Model

Each selling area has a required number of sales agents. The required sales agents are: 10 for Computer and Electronics (1), 12 for Financial Services (2), 15 for Retail (3), 20 for Business Services (4), 10 Sales Agents for Manufacturing (5) and 12 for Food and Hospitality (6). The required total number of sales agents is 79 however there are only 32 available sales agents. Another consideration is that the number of selling area per sales agent should be minimum of 2 and maximum of 3.

An LP model is utilized to allocate the available number of sales agents, which is 32, in accordance with the required number of sales agents per selling area to determine their selling area and each agent's respective quota.

Let *j* be the sales agent number and *i* be the selling area so that m_{ji} denotes the assignment of sales agent *j* to selling area *i*. The Objective function of the problem will be:

Min
$$\sum_{j=1}^{32}(m_{j1} + m_{j2} + m_{j3} + m_{j4} + m_{j5} + m_{j6})$$

subject to the following constraints:

$m_{11} + m_{21} + m_{31} + m_{41} + m_{51} + \ldots m_{321} \leq 10$ sales agents assigned in selling area (1)
$m_{12} + m_{22} + m_{32} + m_{42} + m_{52} + \ldots m_{322} \leq 12$ sales agents assigned in selling area (2)
$m_{13} + m_{23} + m_{33} + m_{43} + m_{53} + \ldots m_{323} \leq 15$ sales agents assigned in selling area (3)
$m_{14} + m_{24} + m_{34} + m_{44} + m_{54} + \ldots m_{324} \leq 20$ sales agents assigned in selling area (4)
$m_{15} + m_{25} + m_{35} + m_{45} + m_{55} + \ldots m_{325} \leq 10$ sales agents assigned in selling area (5)
$m_{16} + m_{26} + m_{36} + m_{46} + m_{56} + \ldots m_{326} \leq 12$ sales agents assigned in selling area (6)

2.2. Analytic Hierarchy Process (AHP)

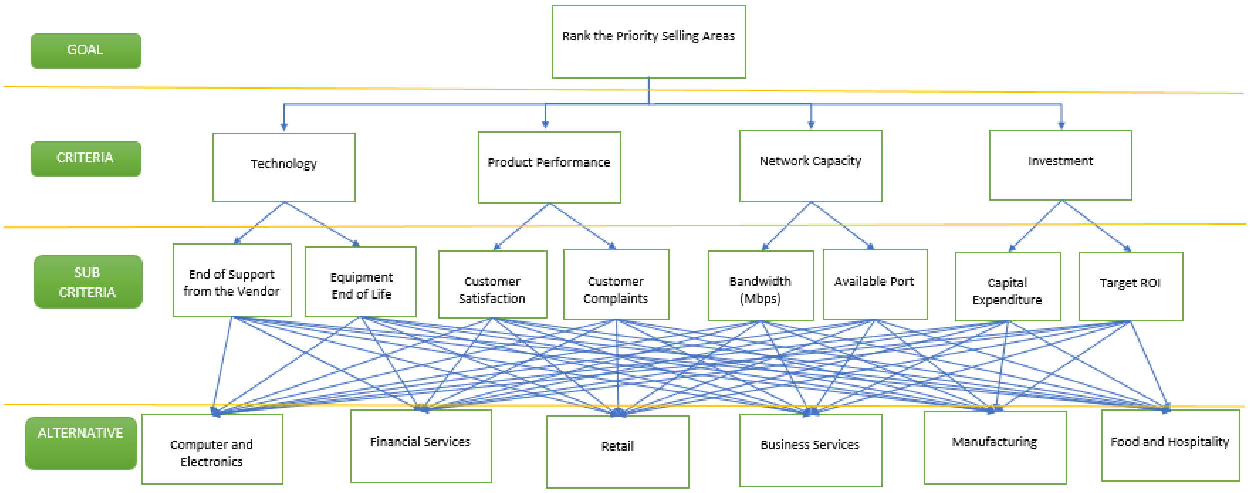
The Analytical Hierarchy Process was utilized to prioritize the selling areas using four major criteria such as (1) Technology, (2) Product Performance, (3) Network Capacity, and (4) Investment. The concept of AHP is introduced in (Saaty, 1990) and is defined as a multi-criteria decision-making approach in which factors are arranged in a hierarchic structure descending from an overall goal to criteria, sub-criteria and alternatives in successive levels. Pairwise comparison matrices are employed to compare the elements in an upper level to compare the elements in the level immediately below it. A scale of numbers, to make comparisons, indicates how many times more important one element is over another element with respect to the criterion to which they are compared (Saaty, 2008). Its importance in the field of decision-making, ranking, or prioritization has been greatly acknowledged in literature for its universal application in various industries and in business processes as well, including revenue maximization such as the discussion of the authors in (Chowdhury, Kundu, Misra & Sanyal, 2011) where AHP is utilized in the pricing strategy in a Broadband Wireless Access System to achieve the highest revenue using their proposed trade-off in price and quality of service to end-users.

The following four major criteria are described as:

(1) Technology. The network technology refers to the use of connected systems either via optic cable, satellite or wireless connections to relay various data. For an ISP company to survive, its products and services should upkeep to the latest technology;
(2) Product Performance. This refers to the performance against its value proposition. To maintain the company's brand and reputation, high performing products should be considered of the same importance in selling;
(3) Network Capacity. This refers to the amount of traffic that a network can handle. It takes years to complete the roll out and build a network infrastructure to have a network capacity. Ideally, the available network capacity should be utilized because the equipment's useful life is depreciating regardless of its usage, and;
(4) Investment. This refers to the amount of money that the company spends to acquire assets such as network infrastructure. ISP companies spend millions of capital expenditures to invest on its network infrastructure to expand its coverage and achieve the expected Return of Investment (ROI).

The identified factors, herein denoted as criteria and their sub-criteria, which affect the goal to rank the alternatives are decomposed into a hierarchy presented in Figure 1. The goal of the AHP is to rank priority selling areas as indicated in the first layer. The main criteria are presented in the second layer which includes Technology, Product Performance, Network Capacity, and Investment. The sub-criteria in the third layer include End of Support from the Vendor and

Equipment End of Life for Technology, Customer Satisfaction and Customer Complaints for Product Performance, Bandwidth and Available port for Network capacity, and; Capital Expenditure and Return of Investment for Product



price. Lastly, the alternatives presented in the fourth level are the six industry selling areas of the ISP, which are Computer and electronics, Financial services, Retail, Business services, Manufacturing, and Food and hospitality.

2.2.1. Pairwise Comparison

The design and principle for the scale construction, in the method of pairwise comparison, is based on the work of (Thurstone, 1927). The author developed a process and model that can be used to scale a collection of elements based on comparisons between paired elements and referred to the formalization of the process as the Law of Comparative Judgement.

In this paper, pairwise comparison is conducted to evaluate the ranking of each criterion. Each of the criteria is matched head-to-head with each of the other criteria. Table 2 and Table 3 shows the Analytical Hierarchy Process Scale and the Sample AHP questionnaire used by the respondents. Nine subject matter experts were asked to thoroughly evaluate each of the criteria in the questionnaire based on business knowledge, experience in the industry and logical reasoning.

Table 2. Analytical Hierarchy Process Scale

Importance	Scale Definition of Importance Scale
1	Equal Importance
2	Equal to Moderate Importance
3	Moderate Importance
4	Moderate to Strong Importance
5	Strong Importance
6	Strong to Very Strong Importance
7	Very Strong Importance
8	Very Strong to Extreme Importance
9	Extremely Importance

Table 3. Sample Analytical Hierarchy Process Questionnaire

Indicators	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Indicators
End of Support from the Vendor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	End of Life
End of Support from the Vendor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Customer Satisfaction
End of Support from the Vendor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Customer Complaints
End of Support from the Vendor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Bandwidth
End of Support from the Vendor	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Available Port
Equipment End of Life	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Customer Satisfaction
Equipment End of Life	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Customer Complaints

3. Results and Discussion

3.1. Sales Maximization using LP

Product pricing is a result of the interplay of demand and supply in the different industry selling areas of the ISP. The pricing model being utilized by the ISP is affected by the maximum discount which can be offered a client. Sales discount offerings are marketing strategies employed to encourage potential clients to buy a certain product. As an example, an agent may offer, at maximum, a PhP6,300.00 discount to sell a product in the computer and electronics industry but may choose not to, as discounts affect the attainment of his quota.

Applying the rationale in the LP model as discussed in the methodology, the results for decision variables x_i, d_i, n_i obtained using Microsoft Excel Solver is shown in Table 4. The result of the values of *x* and *d* are further discussed in Table 6 and Table 7, respectively. Given the results in Table 4, Table 5 presents the breakdown of sales per selling area showing the contribution of the selling areas towards achieving the sales target, amounting to PhP107,300,000.00, of the ISP.

Table 4. Result of variables *x, n, d*

Decision variables	Sales area					
	1	2	3	4	5	6
x_i	595	1,737	1,505	2,300	302	734
n_i (in PhP)	25,210.08	8,290.16	8,970.10	17,391.30	33,112.58	19,618.53
d_i (in PhP)	6,289.92	409.84	329.90	808.70	5,787.42	8,381.47

Table 5 is the tabular representation of the results of the LP model devised in the previous section. The optimal values of the net selling price per product, herein denoted as *n* minus *d*, multiplied by the optimal values of number of ports to be sold, *n*, yields the annual sales per selling area as presented in the Annual sales column. The sum of all $(n_i\text{-}d_i)*x_i$, referred to as the total sales of the company, amounted to PhP107,300,000.00 with an average annual sales in the selling areas amounting to PhP17.8M. It can be observed that the annual sales are driven by the values of *x*, having a positive correlation of 0.74, while it is negatively correlated to *n* at -0.16. The optimal values of *x* are also negative correlated with the optimal values of *n* at 0.74. As such, sales area 4 returned the outstanding highest annual sales of PhP40,000,000.00 while sales area 5 returned the lowest annual sales of PhP10,000,000.00, with the other sales areas returning annual sales amounting to below the average sales.

Table 5. Computation of annual sales

Sales area (i)	Net selling price (n_i-d_i)	Results of x_i	Annual sales
1	25,210.08	595	15,000,000.00
2	8,290.16	1,737	14,400,000.00
3	8,970.10	1,505	13,500,000.00
4	17,391.30	2,300	40,000,000.00
5	33,112.58	302	10,000,000.00
6	19,618.53	734	14,400,000.00
Total			107,300,000.00

Table 6 and Table 7 present the comparison of the results against the set constraints. In Table 6, the returned values of number of ports to be sold, *x*, are shown, wherein the computed number of ports to be sold were above the unit sales quota requirement and below the maximum selling capacity, hence the satisfaction of constraints. *x* has a 0.99 positive correlation to *q* while it has a 0.72 positive correlation to *c*. This shows that optimal values of *x* skewed from the maximum selling capacity, which means it aimed more towards achieving the quota requirement not on maximizing the selling capacity. For this reason, the optimal value of *x* for selling area 4 was maximized while selling area 1 had significant excess selling capacity. The other selling areas, relatively, had minimal excess capacity.

Table 6. Result of *x*-values in *i*

Sales area (i)	Results (x)	Sales quota requirement (q)	Maximum selling capacity (c)
1	595	476	2,000
2	1,737	1,655	1,840
3	1,505	1,451	1,520
4	2,300	2,198	2,300
5	302	257	800
6	734	514	1,000

In Table 7, the computed values of discounts, *d*, were below the maximum allowable sales discounts in each selling area. The optimal values of *d* are important as it affects *n*. *d* has a negative correlation with *x* and *q* at 0.84 and 0.89, respectively. This means that as the optimal values of the number of ports to be sold and unit sales quota increases, the optimal values of *d* decreases. This is because *d* reduces the selling price which is positively correlated with sales.

Table 7. Result of *d*-values in *i*

Sales area (i)	Results (d)	Maximum sales discount(y)
1	6,289.92	6,300.00
2	409.84	435.00
3	329.90	465.00
4	808.70	1,820.00
5	5,787.42	5,835.00
6	8,381.47	8,400.00

3.2. Manpower allocation using LP

The aim of manpower allocation is to optimize the available manpower to fulfill the required number of sales agents in each industry selling area to achieve the overall sales requirement, and for each assigned sales agent to meet the annual sales quota for each selling area. The optimal allocation is then utilized to calculate the sales quota of the sales agents depending on their selling area assignment.

The optimal distribution and amount of sales quota of the 32 sales agents in six sales areas using the manpower allocation LP model is presented in Table 8. As presented in Table 1, the total number of required manpower per selling area would total 79 sales agents. However, the ISP only has 32 available sales force. This table shows the selling area assignment of sales agents. It shows that 17 of the sales agents should be assigned to two sales areas and the remaining 15 sales agents should be assigned to three sales areas. There should be no dedicated sales agent in a certain sales area.

Table 8. Allocation of sales force to six selling areas

Sales Agent	Computer and Electronics	Financial Services	Retail	Business Services	Manu-facturing	Food and Hospitality	No. of Selling Area
1	1	1	-	-	-	-	2
1	1	1	-	-	-	-	2
2	1	1	-	1	-	-	3
3	1	-	1	-	-	-	2
4	1	-	1	-	-	-	2
5	1	1	-	1	-	-	3
6	1	-	1	-	-	-	2
7	1	-	1	-	-	-	2
8	1	1	-	1	-	-	3
9	1	-	1	-	-	-	2
10	-	1	1	-	-	-	2
11	1	-	1	-	-	-	2
12	-	1	1	-	-	-	2
13	-	1	1	-	-	-	2
14	-	1	1	1	-	-	3
15	-	1	1	1	-	-	3
16	-	1	1	-	-	-	2
17	-	1	1	1	-	-	3
18	-	1	1	-	-	-	2
19	-	-	1	1	-	-	2
20	-	-	-	1	1	-	2
21	-	-	-	1	1	1	3
22	-	-	-	1	1	1	3
23	-	-	-	1	1	1	3
24	-	-	-	1	1	1	3
25	-	-	-	1	-	1	2
26	-	-	-	1	-	1	2
27	-	-	-	1	1	1	3
28	-	-	-	1	1	1	3
29	-	-	-	1	1	1	3
30	-	-	-	1	-	1	2
31	-	-	-	1	1	1	3
32	-	-	-	1	1	1	3
Total	10	12	15	20	10	12	79

Table 9 shows the target quota of sales agent per selling area. The result shows that the quota of each sales agent ranges from Php2,100,000.00 – Php4,700,000.00 to reach the goal of Php107,300,000.00 revenues from sales.

Table 9. Target Quota of each Sales Agent to attain the Maximum Sales of Php107,300,000

Sales Agent	Computer and Electronics	Financial Services	Retail	Business Services	Manu-facturing	Food and Hospitality	No. of Selling Area	Total Quota
1	1,500,000	1,200,000	-	-	-	-	2	2,700,000
2	1,500,000	1,200,000	-	2,000,000	-	-	3	4,700,000
3	1,500,000	-	900,000	-	-	-	2	2,400,000
4	1,500,000	-	900,000	-	-	-	2	2,400,000
5	1,500,000	1,200,000	-	2,000,000	-	-	3	4,700,000
6	1,500,000	-	900,000	-	-	-	2	2,400,000
7	1,500,000	-	900,000	-	-	-	2	2,400,000
8	1,500,000	1,200,000	-	2,000,000	-	-	3	4,700,000
9	1,500,000	-	900,000	-	-	-	2	2,400,000
10	-	1,200,000	900,000	-	-	-	2	2,100,000
11	1,500,000	-	900,000	-	-	-	2	2,400,000
12	-	1,200,000	900,000	-	-	-	2	2,100,000
13	-	1,200,000	900,000	-	-	-	2	2,100,000
14	-	1,200,000	900,000	2,000,000	-	-	3	4,100,000
15	-	1,200,000	900,000	2,000,000	-	-	3	4,100,000
16	-	1,200,000	900,000	-	-	-	2	2,100,000
17	-	1,200,000	900,000	2,000,000	-	-	3	4,100,000
18	-	1,200,000	900,000	-	-	-	2	2,100,000
19	-	-	900,000	2,000,000	-	-	2	2,900,000
20	-	-	-	2,000,000	1,000,000	-	2	3,000,000
21	-	-	-	2,000,000	1,000,000	1,200,000	3	4,200,000
22	-	-	-	2,000,000	1,000,000	1,200,000	3	4,200,000
23	-	-	-	2,000,000	1,000,000	1,200,000	3	4,200,000
24	-	-	-	2,000,000	1,000,000	1,200,000	3	4,200,000
25	-	-	-	2,000,000	-	1,200,000	2	3,200,000
26	-	-	-	2,000,000	-	1,200,000	2	3,200,000
27	-	-	-	2,000,000	1,000,000	1,200,000	3	4,200,000
28	-	-	-	2,000,000	1,000,000	1,200,000	3	4,200,000
29	-	-	-	2,000,000	1,000,000	1,200,000	3	4,200,000
30	-	-	-	2,000,000	-	1,200,000	2	3,200,000
31	-	-	-	2,000,000	1,000,000	1,200,000	3	4,200,000
32	-	-	-	2,000,000	1,000,000	1,200,000	3	4,200,000
Total	15,000,000	14,400,000	13,500,000	40,000,000	10,000,000	14,400,000	79	107,300,000

3.3. Prioritization of Sales Area using AHP

This paper used the BPMSG AHP Calculator to compute for the pairwise comparison of the identified criteria and sub-criteria. For the main criteria, the calculator returned the weights presented in Table 10, with a principal eigen value of 5.210 and consistency ratio of 44.40%. The result of the pairwise comparison for the sub-criteria, as well as the computed global weight for each sub-criterion, is presented in Table 11. For the sub-criteria, the calculator returned a principal eigen value of 13.187 and consistency ratio of 52.90%.

Table 10. Main criteria AHP results

Category		Priority	Rank
A	Technology	8.6%	3
B	Product Performance	3.5%	4
C	Network capacity	64.9%	1
D	Investment	22.9%	2

Table 11. Sub-criteria AHP results

Category		Priority	Rank	Global weight
a	End of Support from the Vendor	2.7%	6	0.002322
b	End of Life (yrs)	3.7%	5	0.003182
c	Customer Satisfaction	1.8%	7	0.00063
d	Customer Complaints	1.1%	8	0.000385
e	Bandwidth	17.7%	2	0.114873
f	Available port	38.6%	1	0.250514
g	Capital Expenditure	17.0%	4	0.03893
h	Target ROI	17.4%	3	0.039846

Table 11 shows that Availability of port is of high importance in the ranking of the sub criteria while Bandwidth, Capital Expenditure and Target ROI shows of the same level of importance. Other criteria such as End of life support from the Vendor and Equipment End of life rank is Equal Importance and lastly Customer Satisfaction and Customer Complaints rank in between Equal to Moderate Importance.

From the results obtained, the ranking of priority selling areas is as follows:

Table 12. Ranking of priority selling areas

Selling area	Total weight	Rank
Business Services	0.100328	1
Computer and Electronics	0.088448	2
Financial Services	0.086791	3
Retail	0.075045	4
Food and hospitality	0.059159	5
Manufacturing	0.040911	6

Table 12 presents the order of priority which may be utilized by the sales agents. The result shows that Business Services should the 1st priority, Computer and Electronics should be the second priority, and the third priority is Financial Services. Business Services ranked as the first because of the high result in the availability of port and in the Return of Investment (ROI) sub-criteria.

4. Conclusion

This paper aims to develop a model which will maximize sales given the limited network selling capacity and limited manpower while meeting the sales target of the company and of each sales personnel, based on the sales quotas for the different industry selling areas, using the linear programming model. This paper also utilized the analytic hierarchy process to help sales personnel identify priority industry selling area to maximize the useful life of network equipment.

This study has determined the optimal values of various decision variables of a revenue maximization model and put it to use in the optimal allocation of a manpower allocation model. This highlights the importance of manpower in the achievement of sales targets as enablers and implementers of sales activities. It showed that while calculating the optimal number and selling price of products to be sold is relevant, assigning it to the available manpower makes it meaningful. It aligned the achievement of individual sales quotas of the agents and of the general sales objective of the company while satisfying all the identified constraints. Given the allocation of manpower per selling area; a relevant sales quota per sales agent were arrived at. This quota per sales agent has enabled a more defined quota instead of merely having quota per selling industry. Furthermore, the prioritization schedule devised using AHP will help the manpower to allot their time in focusing on selling first products in the priority industry selling areas. This will enable the sales agents to reach their quotas, as well as contribute in maximizing the useful life of the company's network equipment.

References

Agrali, S., Taskin, Z., and Unal, A. (2015) Employee Scheduling in Service Industries with Flexible Employee Availability and Demand. Omega: The International Journal of Management Science, 66(A), January 2017, 159-169

Al-Rawi, O.Y.M. and Mukherjee, T. (2019) Application of Linear Programming in Optimizing Labour Scheduling. Journal of Mathematical Finance, 9, 272-285. https://doi.org/10.4236/jmf.2019.93016

Bagatourova, O. and Mallya, S.K. (2004) Coupled Heuristic and Simulation Scheduling in a Highly Variable Environment. Proceedings of the 2004 Winter Simulation Conference, Washington DC, 5-8 December 2004, 1856-1860. https://doi.org/10.1109/WSC.2004.1371540

Blessington, M. (2016) Sales Quota Accuracy and Forecasting. Foresight (Winter 2016)

Chowdhury, P., Kundu, A., Misra, I. S., & Sanyal, S. K. (2011). A tradeoff pricing strategy using AHP for revenue maximization in WiMAX networks. 2011 Annual IEEE India Conference. doi:10.1109/indcon.2011.6139428

Chu, S.C.K. (2007) Generating, Scheduling and Rostering of Shift Crew-Duties: Applications at the Hong Kong International Airport. European Journal of Operational Research, 177, 1764-1778. https://doi.org/10.1016/j.ejor.2005.10.008

Good, D.J. and Stone, R.W. (1991) How Sales Quotas Are Developed. Industrial Marketing Management 20, 51-55 (1991)

Haider, Z., Fareed, R., Tariq, M.B., Usman, S., Ud din, N., and Khan, M.S. (2016) Application of Linear Programming for Profit Maximization: A Case of Paints Company, Pakistan. International Journal of Management Sciences and Business Research, Dec-2016 (2226-8235) 5,12

Hasan, M. and Arefin, R. (2017) Application of Linear Programming in Scheduling Problem. The Dhaka University Journal of Science, 65(2): 145-150

Klein, K. K., Hironaka, R., Heller, C. H., & Freeze, B. S. (1986). Profit-Maximizing Linear Program Model for Dairy Cattle. Journal of Dairy Science, 69(4), 1070–1080. doi:10.3168/jds.s0022-0302(86)80503-3

Kletzander, L. and Musliu, N. (2019) Solving the general employee scheduling problem. Computer & Operations Research, 113, January 2020, 104794. https://doi.org/10.1016/j.cor.2019.104794

Lam, S., Vandenbosch, M., and Pearce, M. (1998) Retail sales force scheduling based on store traffic forecasting. Journal of Retailing, 74(1), 61-88. https://doi.org/10.1016/S0022-4359(99)80088-8

Mehmood, H., Udell, M., & Cioffi, J. (2015). Revenue Maximization for Broadband Service Providers Using Revenue Capacity. 2015 IEEE Global Communications Conference (GLOBECOM).

Saaty, T.L. (1990) How to make a decision: The Analytics Hierarchy Process. European Journal of Operations Research 48 (1990) 9-26

Saaty, T.L. (2008) Decision making with the analytic hierarchy process. International Journal of Services Sciences, Vol. 1, No. 1, 2008

Sheridan, T. (1969) Some Linear Programming Models for Forecasting Manpower Requirements of Naval Shore Activities. United States Naval Postgraduate School.

Thurstone, L L. (1927) The Method of Paired Comparisons for Social Values. Journal of Abnormal and Social Psychology, 21, (1927): 384-400

Wu, Y.-K. (2007). On the manpower allocation within matrix organization: A fuzzy linear programming approach. European Journal of Operational Research, 183(1), 384–393. doi:10.1016/j.ejor.2006.09.067

Biographies

Rex Aurelius C. Robielos is the Dean of the School of Industrial Engineering and Engineering Management at Mapua University. Before joining Mapua, he was Section Manager of Operations Research Group, Analog Devices General Trias. He has a BS in Applied Mathematics from the University of the Philippines Los Baños, and a Diploma and MS in Industrial Engineering from the University of the Philippines Diliman. He is pursuing Ph.D in Industrial Management (candidate) at National Taiwan University of Science and Technology in Taiwan. He is the current Secretary of Human Factors and Ergonomics Society of the Philippines and Director of the Philippine Institute of Industrial Engineers and Operations Research Society of the Philippines.

Kristel Joy A. Bergantiños is a graduate of BS Accountancy at Saint Louis University, Baguio City and a candidate of Master in Business Analytics at Mapua University. She is currently working as a State Auditor at the Commission on Audit, the supreme auditing arm of the Philippine Government, practicing fraud evaluation and examination. Prior to joining the Commission, she practiced risk consulting/advisory and financial statements auditing in public accounting and auditing firms.

Eloizza Caldamo is a graduate of Bachelor of Science in Electronics and Communications Engineering at Adamson University, Manila Philippines. She is a Certified Six Sigma Black Belt, an ISO 9001 Quality Management System Certified Lead Implementer and ISO 27001 Information Security Management System Certified Lead Auditor. She started her career in the manufacturing industry and currently she is a Quality Assurance and Business Process Manager in an Internet Service Provider company. She is currently pursuing her Master's Degree in Business Analytics at Mapua University.