# Incident Backlog Analysis in an IT Support Group Using Linear Programming

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Abstract: An IT Support group in an advanced and global organization is a vital unit that safeguards and maintains the productivity of each individual employee by providing uninterrupted Information Technology-related assistance to those that are unable to perform their day-to-day job functions due to a technical problem. With this said, an IT Support group's availability and productivity must be examined and enhanced to see to it that each individual unit within the organization are completely operational and functional. The purpose of this study is to therefore identify and assess the existing opportunities that are impeding the productivity in an IT Support group of a certain organization by comparing its current operational state and productivity against an optimized number of incident assignment per technician with the use of linear programming as the operational research method. This study aims to analyze the gap between the current state and an optimal state to be able to improve the overall operations by minimizing the incident backlogs and maximizing each IT technician's utilization.

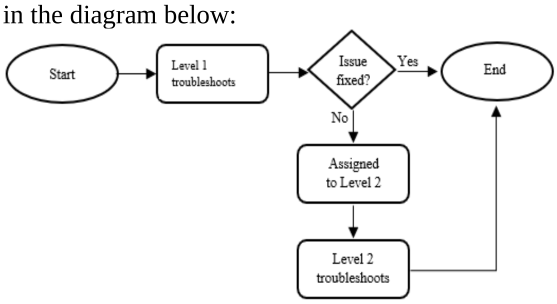
Keywords - IT Support, Optimization, Linear Programming, Backlogs, Level 2 support, Incident Assignment

## 1. Introduction

There can be a variety of naming convention in which an IT Support group in each organization can be associated with. From helpdesk to service desk to on-site support or remote support to level 1, 2 and 3 support teams and so on. These labels may often be perceived to have the same functionality by the end-users that serve as its clients, however, the core functionality of each IT Support group can distinctly differ in various aspects which includes the manner of delivery of support, level of security access, and the knowledge and skills of each technician that belongs to these groups.

For this study, the researcher aims to examine the functionality and processes of an IT Support group performing mainly a "level 2" type of support in which its members are called "technicians" whose roles are primarily involved in interacting with the users to troubleshoot their technical problems by performing a remote session with the use of various company-provided tools. The level 2 group in which this research aims to focus on, is a part of an IT unit in an organization that works hand in hand with the service desk or "level 1" team. The level 1 team are consisting of analysts that are taking phone calls and chat sessions and are in charge of logging the issues of the users in an internal ticketing tool while at the same time attempting to resolve the users' issues. The *users* in this scenario are the company employees who report their technical problems and are asking for assistance for their technical issues. Both the levels 1 and 2 support teams perform troubleshooting activities to the users' issues with the end-goal of supplying a permanent fix so that the users can go back in performing their day-to-day jobs and minimize their unproductive hours. The issues that the users may experience could be categorized as but not limited to the following: malfunctioning and faulty laptops or hardware, monitors and other peripherals issues, telephony, connectivity, network, and application issues.

The synergy between the service desk (level 1) and IT Support (level 2) teams can be best described in the diagram below:




By looking at the diagram, two valid observations can be drawn: (1) that all issues that go to level 2 are the ones that are deemed unresolvable by level 1 and (2) that the level 2 support team must be capable of providing the users with a resolution for *any* given issues, with the exemption of known problems and outages which are handled by the Problem Management and Incident Management teams respectively (Atlassian.com, 2022). One final aspect to consider is that incidents assigned to the level 2 team has spent enough time in the level 1 layer but had remained unresolved and thus, require immediate attention to get the users back up and running soon.

***The issue of the incident backlogs***

The incidents that were assigned to the level 2 support team by the level 1 team will be queueing up in their respective assignment groups or *towers* until a technician is assigned to these incidents. These towers are the level 2 team's categorization by issue type, and they are as follows: *Applications, Connectivity, Citrix, Call Center, Communications, Special Services and Workstation.* For this research, the focus will be on the towers with the most volume of incident numbers as these towers are said to bring significant impact to the overall operations of the level 2 team. For the sake of this study, the said volume driver towers that will be considered are *Workstation, Applications, Connectivity, Call Center*, and the remaining towers will be bucketed in one as *"Other Towers"*.

This research is focused on 4 out of 7 towers due to the volume of incidents they generate. Some towers are driving more volume as compared to others and contributes to about 96% of the total volume. The remaining 4% are generated by the other 3 towers combined. Moreso, these products are significantly lower in volume and does not create significant impact on the backlogs and so the research is based on the success in incident assignment of the primary 4 towers which generates 96% of the volume.

The distribution of volume based on the year-to-date data are as follows:

- Workstation: 35%
- Connectivity: 19%
- Applications:30%
- Call Center: 12%
- Others (Citrix/VDI, Communications & Special Services): 4%

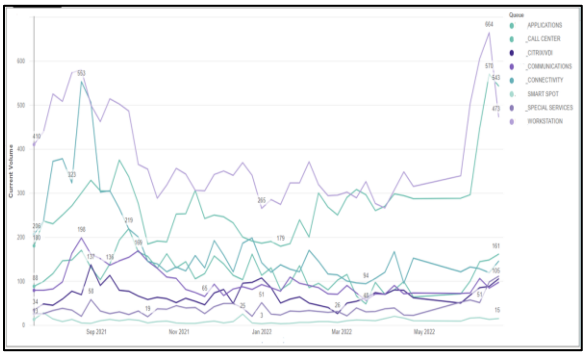


*Figure 1.1 Graphical representation of the Daily Carry Load per Tower*

An incident or mostly referred to as *ticket* without a designated technician will assume a ticket status of "To be worked" and it will only be changed to "Work in progress" once a technician has owned or has been assigned to the ticket. Both the unassigned and assigned tickets are considered as the level 2 support team's "Carrying Load" or work *backlogs*. The carrying load is considered as the team's daily workload and the tickets in this bucket are being considered as backlogs until they are fully resolved by the technicians and their statuses have been updated to "Closed", which also means that the issue has been fully resolved. Backlogs are defined as follows:

- Assigned – incidents already assigned to an existing technician and are on the following state:
    - Awaiting customer response on resolution
    - Awaiting Vendor update (Laptop/Desktop) replacement
    - Waiting for the software deployment to be completed
- Unassigned – these are incidents freshly routed to level 2 from level 1 support.

The backlogs are quantified and monitored in a daily basis to tell both the incoming and current volume of the incidents that are yet to be accommodated and resolved by the team. The carrying load data is the main indicator of the team's productivity or lack thereof, as it gives the leaders the ability to forecast the team's opportunities and potential issues in terms of user dissatisfaction due to a prolonged delivery of resolution and other potential unmet Key Performance Indicators or *KPIs*.

What has been deemed as an *acceptable* norm for the leadership of the average daily carrying load or backlogs ranges from 900+ to 1,499 incidents per day. However, the said range still does not mean that the team is meeting its Service Level objectives and that all of its techs are productive and are properly utilized. Also, by identifying the said acceptable day to day range, it would be then safe to assume that anything above the threshold of 1,499 requires special attention and immediate action from the leadership. Below is a data representation of the average carrying load volume trend of the level 2 team for the past 2 years:

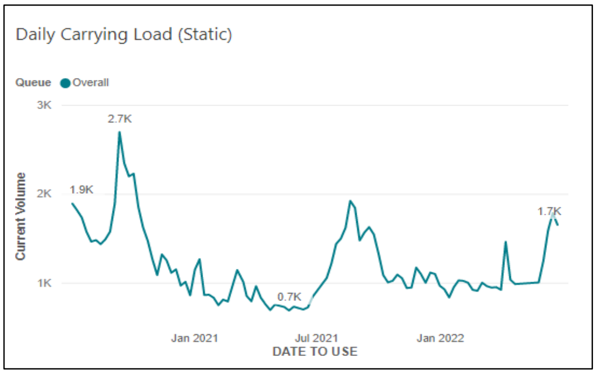



*Figure 1.2 Graphical representation of the Daily Carry Load from July 2020 to Aug 2022*

When the ticket volume reached beyond the acceptable average, the leaders need to pull various levers to attempt to bring the numbers back to the usual acceptable range. These levers are but not limited to the following: offering voluntary overtime to the technicians scheduled in prime shifts, requesting back up assistance from the service desk by training level 1 techs to process level 2 incidents for a specified duration and by cancelling non-productive hours such as meetings, trainings, one-on-ones, etc.

There are also instances where the volume spikes are generated by specific towers. Most of the time the volume generators are between the Applications and Workstation towers. These two queues are the consistent and has highest carrying load as compared to other towers, which means they also demand higher headcount in terms of staffing.

### *Incident Prioritization*

It may be apparent that not all incidents that become backlogs are the same due to the fact that there are different types of issues that could go into different towers. This means that they require different techniques and approach in the troubleshooting process. However, regardless of the type of issue or amount of troubleshooting steps required to resolve one incident, one other critical factor to consider is the *prioritization* of each incident. As defined in the ITIL framework, Incident prioritization decides the impact of the issue to users and on the business and it also dictates its urgency to be attended (Mohr, 2022). In the case of the level 2 support, adhering to a pre-defined timescale and effort to respond to an incident is considered as one of the major metrices of the level 2 support team. Prioritization also determines the Service Level Objectives KPI which is a major determinant of the efficiency of the business as a whole. The following priority levels are the standards across IT Support teams:

| Priority Level | Expected Time of Repair (ETR) |
|---|---|
| Priority 1 | 30 minutes |
| Priority 2 | 4 hours |
| Priority 3 | 24-48 hours |
| Priority 4 | 3-5 business days |
| Priority 5 | > 5 business days |

*Table 1.1. Prioritization Table & ETR*

The agreed SLOs set on each incident are major indicators of the timeliness, efficiency, and effectiveness of the level 2 techs in accommodating and processing their workload. Seeing it on the overall perspective, SLOs gauges the level 2 team as a whole as it measures how effective and timely the team is in delivering service value to the users. A failed SLO, say, in one tower could indicate that that specific tower might be understaffed, has plenty of unprocessed backlogs, under-utilized techs, large shrinkage or staffing concerns, and/or there is a rise of difficult type of incidents to resolve that contributes to longer time for resolution and other possible inefficiencies.

Prioritization of the incidents is directly related to the SLO score. Resolving an incident within the prescribed Prioritization level means that SLO target has been met. The opposite to the aforesaid is also true.

### *Opportunities in the Current Tech Utilization*

To gain a fundamental understanding of the opportunities in the level 2 team, the table below can be examined in which it shows the different parameters being used in calculating the current Utilization score of the level 2 technicians. In order to do so, the technicians' work hours, incident backlogs, the number of staff per each tower, shrinkages and the average *Mean Time to Resolve* (MTTR) per tower are all factored in to achieve the Utilization %.

| | | Breakdown Tower-wise in % | | | | |
|---|---|---|---|---|---|---|
| **Current State** | **Overall** | **WS 33.13** | **Apps 30.10** | **Conn 22.74** | **CC 10.89** | **Etc. 3.14** |
| Backlogs | 1570 | 520.2 | 472.50 | 357 | 171 | 49.3 |
| Current Headcount | 188 | 62 | 41 | 34 | 24 | 27 |
| Total Working hours per Tech | 9 | 9 | 9 | 9 | 9 | 9 |
| Total Break Hrs. | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Total Tech Available in Mins | 84,600 | 22,500 | 21,150 | 12,150 | 13,500 | 15,300 |
| Additional Activities in % | 13.34 | 13.34 | 13.34 | 13.34 | 13.34 | 13.34 |
| Additional Activities in Mins | 60.03 | 60.03 | 60.03 | 60.03 | 60.03 | 60.03 |
| Total Available Net Mins | 73,315 | 19.499 | 18.329 | 10,529 | 11,599 | 13,259 |
| Ave. Time Taken per Incident Based on MTTR | 25 | 27 | 30 | 18 | 18 | 15 |
| Ave Tickets Per Tech | 5 | 5 | 5 | 5 | 5 | 5 |
| **Current Utilization %** | **40.68** | **43.34** | **46.67** | **33.34** | **34.45** | **30.01** |

*Table 1.2. Representation of Tech Utilization*

The following steps have also been taken to calculate the technicians' utilization rate:

- Identify the percentage of breakdown of incidents per tower or *backlogs.*
- Identify the breakdown of incident backlog per priority per tower.

- Assign # of hours spent for “other activities” that are incident related *i.e., waiting for the user to respond etc.*
- Historical data of MTTR (Mean Time to Resolve)

Using the # of hours spent an MTTR, one can identify the number of incidents that can be assigned per technician per tower factoring in the acceptable utilization %.

*Note:* The table below shows a sample of different issues resolved by different knowledge articles which yields different times taken to resolve. The consolidated value of these issues belongs to different towers based on products. All of these were included to determine the Mean Time to Resolve or MTTR which is used to do the time profiling. Since the number of techs required depend on MTTR for individual towers, MTTR is identified as the best way to profile time analysis and profiling tech requirements.

| Product > Knowledge > Resolution > Tech | KnowledgeArticle | KnowledgeBlock | # Incident | MTTR |
|---|---|---|---|---|
| GENERAL TROUBLESHOOTING | General Troubleshooting - Perform General Troubleshooting | Perform general troubleshooting | 492 | 14.34 |
| WINDOWS 10 | Windows 10 - Blurry font in an application | Run ClearType Text Tuner | 174 | 18.81 |
| ESSO ADAPTIVE AUTHENTICATION | eSSO Adaptive Authentication - How to Register Enterprise Secure Sign | Register eSSO | 174 | 23.96 |
| INFORMATIONAL | Informational - Self Resolved Issue | Informational - Resolved with Nc | 71 | 12.35 |
| GENERAL TROUBLESHOOTING | General Troubleshooting - Perform General Troubleshooting | Perform general troubleshooting | 264 | 21.61 |
| INFORMATIONAL | Undefined Product - Unknown Support Structure | Document the procedures perfor | 280 | 12.71 |
| GENERAL TROUBLESHOOTING | General Troubleshooting - Perform General Troubleshooting | Perform general troubleshooting | 289 | 14.23 |
| GENERAL TROUBLESHOOTING | General Troubleshooting - Perform General Troubleshooting | Perform general troubleshooting | 193 | 18.92 |
| MICROSOFT WINDOWS HELLO FOR BUSINESS | Microsoft Windows Hello for Business - Unable to Find Issue | Microsoft Windows Hello for Bu | 243 | 27.10 |
| CISCO ANYCONNECT VPN CLIENT | Cisco AnyConnect VPN Client - Network or Connection Issues | Perform a Power Cycle | 228 | 22.59 |
| DOMAINS | Domains - Any MS Domain Issue | Customer is unable to change or | 199 | 15.75 |
| RXCLAIM BOOK A (BCBS OF MI) | RxClaim Book A (BCBS of MI) - Unable to Login to the Second Login (Rx | Reset Password or Enable Accou | 83 | 11.47 |
| INFORMATIONAL | Informational - Self Resolved Issue | Informational - Resolved with Nc | 211 | 12.86 |
| MICROSOFT WINDOWS HELLO FOR BUSINESS | Microsoft Windows Hello for Business - Forgot PIN or PIN is not Worl | Reset Windows Hello PIN (Windc | 138 | 29.55 |
| CISCO ANYCONNECT VPN CLIENT | Cisco AnyConnect VPN Client - Network or Connection Issues | Perform a Power Cycle | 211 | 18.86 |
| GENERAL TROUBLESHOOTING | General Troubleshooting - Perform General Troubleshooting | Perform general troubleshooting | 119 | 22.35 |
| INFORMATIONAL | Undefined Product - Unknown Support Structure | Document the procedures perfor | 220 | 11.00 |
| GENERAL TROUBLESHOOTING | General Troubleshooting - Perform General Troubleshooting | Perform general troubleshooting | 204 | 15.96 |
| MICROSOFT WINDOWS HELLO FOR BUSINESS | Microsoft Windows Hello for Business - Forgot PIN or PIN is not Worl | Reset Windows Hello PIN (Windc | 207 | 17.57 |
| MICROSOFT WINDOWS HELLO FOR BUSINESS | Microsoft Windows Hello for Business - Forgot PIN or PIN is not Worl | Reset Windows Hello PIN (Windc | 215 | 18.31 |
| DOMAINS | Domains - Any MS Domain Issue | Customer is unable to change or | 160 | 18.89 |
| MICROSOFT WINDOWS HELLO FOR BUSINESS | Microsoft Windows Hello for Business - Forgot PIN or PIN is not Worl | Reset Windows Hello PIN (Windc | 153 | 19.88 |

As captured in the image shown above, based on the incident data of each product under different towers, each tower will have a different Mean Time to Resolve (MTTR) KPI. This is the reason why when the researcher represents the time taken per tower for incidents to be resolved, it was considered ideal to use the “average”. Additionally, as the naming convention suggests the “Mean” Time is the average of all the minutes or hours that the techs had spent to resolve the incidents.

Going back to utilization, it is imperative to know the utilization calculation as it helps identify the level of efficiency and productivity of each tech and business as a whole:

[ Average number of incidents handled by a technician per month x Average incident work time
+
Average number of service requests handled by a technician per month x Average service request work time
+
Average number of tickets handled by a technician per month x Average travel time per ticket ]
÷
[ Average number of days worked per month x Number of work hours per day x 60 minutes/hour ]

*Image by HDI* (Ramburg, www.ThinkHDI.com, 2011)

The Helpdesk Institute (HDI), a known provider of IT support and service management resources across the globe defined utilization as the measurement of percentage of time the average technician is in “work mode” and is not dependent on incident work time or complexity (Ramburg, www.ThinkHDI.com, 2011). It can be observed from Table 1.2. that the overall utilization of the level 2 support is at 40.68%, this rate is considered low and not at par with the industry standard of 74% (Ramburg, MetricNet LLC and UBM LLC, 2013). The utilization rate in the IT support operations must be at the very least 74% to be considered optimum.

Additionally, the importance knowing and achieving an optimum level of utilization is also beneficial to the organization as a whole and this is because when tech utilization is high, the cost per incident processed will be low, and on the contrary, when utilization is low, labor costs, and cost per incident processed will be high. Conversely, it is also important to note that setting an extremely high utilization rate target is not recommended as it can increase employee turnover due to high burnout rate.

## 1.1 Research Objectives

This study aims to identify an optimized number of assigned incident per technician to help boost the level 2 team’s s productivity and utilization rate. This can be done by assessing the current overall performance of the level 2 team, analyze the gaps and formulate an optimized value of incident assignment count per technician that can help the team increase their overall efficiency.

## 1.2. Research Questions

The incident backlogs have not been improving for the recent years, and in a way, it is also affecting the service levels of other IT groups like the service desk or level 1 team, as the outstanding and ageing incidents that are left unassigned and unprocessed are getting converted into backlogs day by day. It is also triggering the end-users to escalate and make follow up contacts to the level 1 team to inquire of the statuses of their outstanding issues. For the same reason, backlogs may also cause a decline with the Customer Experience index and other KPIs like Service Level Agreement and such. Due to these, the acceptable value of incident backlogs may still be optimized to prevent its volume from piling up and further affect other operational metrices. Therefore, this study aims to answer the following questions that may enhance the level 2 team’s overall productivity and performance:

- What is the optimized assigned incident rate per technician and per tower that can minimize the incident backlogs?
- What is the optimal percentage of incidents per tower that must be assigned to avoid backlogs from increasing?

## 2. Related Literature

The primary goal of every organization is to achieve high profit with minimized cost which should boost their financial standing and market competitiveness for the long run. However, it is also not advisable for an organization to rapidly change its business operations and implement holistic organizational strategies that would bring inconvenience to the end-users rather than ease when executing too abrupt changes without performing a comprehensive analysis. The study of Baki and Cheng, (2021), focuses on enhancing the utilization of a company's resources, determining the optimum product combination, while fulfilling the customers' needs in which linear programming method was used. Through this operation research method, the proponents were able to evaluate the different factors that affected the operations of the business and came up with better conclusions on the production planning while practically utilizing the company's resources and maximizing their profit in the process. However, the downside of this technique in the given study is that it cannot alone be used for forecasting both the production capacity and sales volumes and therefore, it was recommended that the company must use hybrid methods such as combination of simulation models and linear programming for production capacity planning. Performing both said methods will aid on maximization of profits and minimizing the company's production costs (Baki & Cheng, 2021).

In maximizing the employee's capacity in handling their day-to-day activities, it is important to determine the daily staff schedule all throughout the week that can help manage the fluctuations of shrinkages in terms of health issues of staff, and other manpower requirements based on specified tasks. As this is supported by the study of Al-rhawi, and Mukherjee, (2019), which focuses on a construction company that needed to operate at a cost-effective labor scheduling requirement. The project manager's inability to manage the manpower requirement resulted to delay, substandard customer service, and mismanagement of its employees. And so the analysis that was conducted had provided an overview of the staffing and scheduling problem in the said organization which showed the following areas where observed issues are evident: (1) minimum requirement of manpower for the proper execution of a job in each shift, (2) the number of temporary employees that need to be hired externally to be able to meet the shift demands, (3) the specific type of "deficit" employee hired and (4) the cost spent on temporary hires were all considered. The constraints identified in the research are the requirement of skilled labor and the type of jobs available, with the aim of maximizing and assigning the schedule shifts equally to each employee, while considering all constraints, thus ensuring the optimum level of employee utilization by balancing their workload that should produce positive outcomes for employees, organization and its customers (Al-Rawi & Mukherjee, 2019).

The aforementioned literatures that had both applied linear programming as an OR methodology to produce an optimized solutions to both of the studies' company problems can be said to be applicable as well in this research due to the fact that similar to the referenced literatures, this study also aims to identify an optimal level of an output which in this case, are the *incident backlogs* to be able to ensure that the technicians in an IT support group are being assigned a fair amount of incidents according to the technicians' skills or towers and that the priority level of each incident from which the Service Levels derived are also being met and therefore, preventing breached incidents in the process by trying to accommodate the influx of incident volume. All of those were factored in along with the limitations of the system in terms of current available overall headcount and the maximum number of incidents that can be processed per tower.

## 3. Methodology

### 3.1. Data Collection

The IT Support group is comprised of 188 technicians in various locations both locally and globally. These techs as previously mentioned, are skilled and categorized into several towers – Applications, Connectivity, Call Center, Communications, Citrix, Special Services and Workstation. The data used for this research is a 2022 year-to-date data, covering January to August 2022 that comprises of the following:

- number of overall backlogs
  - backlogs are both assigned and unassigned *open* incidents.
- number of backlogs per tower
- number of backlogs per prioritization level per tower
- number of unassigned vs assigned incident volume.

*Table 3.1.1. Total Incident Volume Based on Priority*

| | *Overall* | *WS* | *Apps* | *Conn* | *CC* | *Others* |
|---|---|---|---|---|---|---|
| ***Current Headcount*** | *188* | *62* | *41* | *34* | *24* | *27* |
| ***Average Monthly Backlogs*** | ***1570*** | ***520.2*** | ***472.5*** | ***357*** | ***171*** | ***49.3*** |
| ***Overall Backlogs Per Priority*** | | | | | | |
| ***P5*** | *470.8* | *180* | *112.5* | *99* | *67* | *12.3* |
| ***P4*** | *552* | *155* | *180* | *123* | *78* | *16* |
| ***P3*** | *534.2* | *182.2* | *175* | *133* | *23* | *21* |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***P2*** | *13* | *3* | *5* | *2* | *3* | *0* |

*Table 3.1.2. Total Incident Volume – Assigned vs Unassigned*

| ***Assigned*** | ***Overall*** | ***WS*** | ***Apps*** | ***Conn*** | ***CC*** | ***Others*** |
|---|---|---|---|---|---|---|
| ***P5*** | *376.64* | *144* | *90* | *79.2* | *53.6* | *9.84* |
| ***P4*** | *386.4* | *109* | *126* | *86.1* | *54.6* | *11.2* |
| ***P3*** | *427.36* | *146* | *140* | *106.4* | *18.4* | *16.8* |
| ***P2*** | *10.4* | *2.4* | *4* | *1.6* | *2.4* | *0* |
| ***Unassigned*** | ***Overall*** | ***WS*** | ***Apps*** | ***Conn*** | ***CC*** | ***Others*** |
| ***P5*** | *94.16* | *36* | *22.5* | *19.8* | *13.4* | *2.46* |
| ***P4*** | *166* | *46.5* | *54* | *36.9* | *23.4* | *4.8* |
| ***P3*** | *106.84* | *36.4* | *35* | *26.6* | *5* | *4* |
| ***P2*** | *2.6* | *0.6* | *1* | *0.4* | *0.6* | *0* |

***Overall Assigned Volume: 1200.8**

## 3.2. Data Assessment and Evaluation

The data used in the study was also shown in Chapter 1 *Table 1.2 Representation of Tech Utilization* in which the calculation for Tech Utilization of 40.68% was derived. It was also mentioned that the current overall Utilization rate was not at par with the industry standard of 74% (Ramburg, MetricNet LLC and UBM LLC, 2013). With this said, the backlogs per tower and per priority level, both assigned and unassigned will be subjected to analysis to identify how the Utilization rate can increase by identifying the best possible number of tickets assigned to all technician without having to hire more people. The optimal value of the assigned incidents per tech will then be incorporated in the calculation of the Utilization % factoring the historical data of MTTR to ensure the feasibility that the Techs will be able to meet the demand and the study being able to arrive at a fair value of Utilization rate.

### *3.3. Application of the Optimization Model*

#### *3.3.1. Choosing an Optimization Model*

The operational research methodology best suitable for solving the problem in this research *is Linear Programming* as it is an optimization technique that can solve many organizational problems such as optimization issues in staffing, manufacturing, utilization of resources, costing and other high-level business operations. Similarly, since this study aims to maximize incident assignment to individual technicians, the decision variables considered are said to be linear i.e., *the headcount per each tower, the rate of monthly assigned incidents per headcount per tower and per priority level,* and finally, *the total monthly volume of backlogs per tower and per priority level.* Also, the different variables considered in this study are said to have a linear relationship with each other, meaning one variable is connected to a steady amount of change in the other and that a given objective function is needed to be identified by looking into these variables that must either be minimized or maximized to achieve the desired potential optimized solution (Andy Hayes, n.d.).

The type of Linear Programming method that will be used is the Simplex Method: It is an iterative process to get the feasible optimal solution. In this method, the value of the basic variable keeps transforming to obtain the maximum value for the objective function.

## 3.3. Application of the Optimization Model

The following assumptions were satisfied to ascertain the applicability of linear programming technique in this study as per (Satheesh Kumar, 2014)

- *Certainty*. Numbers in the objective and constraints are known with certainty and change during the research period.
- *Linearity or Proportionality*. It must be assumed that proportionality exits in the objective and constraints. This means that if 1 tech can process say 10 incidents per day, then making 10 techs can process uses 1000 incidents.
- *Additivity*. It means that total of all activities shrinks the sum of each individual activity i.e., there is no interaction among all the activities of the resources.
- *Divisibility*. It is normally assumed that the solution needs to be in whole numbers (integers). Instead, they are divisible and may take any fractional value, if product cannot be produced in fraction, and integer programming problem exists.

#### *3.3.3. Steps Performed in Formulating the Linear Programming Model*

The generic mathematical model of a linear programming is:

Optimize (Maximize or Minimize) $Z = C_1 X_1 + C_2 X_2 + \ldots C_n X_n$

Subject to constraints:

$a_{11} X_1 + a_{12} X_2 + \ldots \ldots \ldots + a_{1n} X_n (<,=,>) b_1$

$a_{12} X_1 + a_{22} X_2 + \ldots \ldots \ldots + a_{2n} X_n (<,=,>) b_2 \ldots\ldots\ldots\ldots$

$\ldots\ldots\ldots\ldots a_{m1} X_1 + a_{m2} X_2 + \ldots \ldots \ldots + a_{mn} X_n (<,=,>) b_m$ and $X_1, X_2, \ldots\ldots X_n > 0$

The obtained equation in this study is as follows:

$$z = MAX \sum_{j=1}^{5} \sum_{i=2}^{5} y_{i,j} * x_j$$

Subject to constraints:

$$x_1 + x_2 + x_3 + x_4 + x_5 \leq 188$$
$$\frac{y_{i,j} * x_j}{z_{i,j}} \geq 0$$
$$\frac{y_{i,j} * x_j}{z_{i,j}} \leq 1$$
$$\frac{\sum_{j=1}^{5} \sum_{i=2}^{5} y_{i,j} * x_j}{z_{i,j}} \geq .60$$

The following guidelines for linear programming simplex method are followed to expound the abovementioned LPP equation:

*Step 1:* Establish a given problem. Identifying the constraints and decision variables in the problem based on the available data.

**Decision Variables:**

$x_1 =$ # of headcount for tower 1 (WS)
$x_2 =$ # of headcount for tower 2 (Apps)
$x_3 =$ # of headcount for tower 3 (Connectivity)
$x_4 =$ # of headcount for tower 4 (Call Center)
$x_5 =$ # of headcount for tower 5 (Other Towers)
$y_{i,j} =$ Rate of monthly assignment per headcount for tower **j** and prio **i** , where j $\in$ {2,3,4,5}
$z_{i,j} =$ Average total monthly backlogs for tower **j** and prio **i** , where j $\in$ {2,3,4,5}

*Step 2:* Defining the objective function. In this study, objective function is:

*Maximization of assigned incidents per technician, per tower and per priority*.

**Objective Function:**

$$MAX \sum_{j=1}^{5} \sum_{i=2}^{5} y_{i,j} * x_j$$

*Step 3:* Specifying the constraints to which the objective function will be optimized. Constraints in this study are:

**Constraints**

$$x_1 + x_2 + x_3 + x_4 + x_5 \leq 188$$

$$\frac{y_{i,j} * x_j}{z_{i,j}} \geq 0$$

$$\frac{y_{i,j} * x_j}{z_{i,j}} \leq 1$$

$$\frac{\sum_{j=1}^{5} \sum_{i=2}^{5} y_{i,j} * x_j}{z_{i,j}} \geq .60$$

Which are interpreted as:

- *Overall headcount required to accommodate incidents must be less than or equal to current headcount of 188 techs.*

- *(Sum of incident assigned per tower x Headcount per tower) ÷ Average of monthly backlogs must be* ***greater than or equal to 0****,* or simply put, the model must assign at least 0 incident, this is to eliminate negative (-) value assignment.

- *(Sum of incident assigned per tower x Headcount per tower) ÷ Average of monthly backlogs must be* ***less than or equal to 1****,* or simply put, the model must assign incidents that are less than or equal to the demand.

- *Percentage of incidents per tower that must be assigned to avoid the volume from piling up must be greater than or equal to 60% of the incident tower volume.*

  The current state of average of 5 incidents assignment per tech yields an average 60% of the incidents getting assigned and with only 40% tech utilization. Since this study aims to achieve a model that should exceed the current state output of 60% assigned incidents, it is then necessary to include a constraint in the equation that will help produce an output that will not fall below the current state assignation rate.

  Note that the initial assignment rate or target of **5 incident assignment rate** per tech per day/month, was arbitrarily decided by the decision-makers of the IT support group and the Tech Utilization Rate was not factored into the equation of baselining the said metric.

*Step 4:* Add non-negative constraint from the consideration that the negative values of the decision variables do not have a valid physical interpretation.

With the identified constraints, non-negative is improbable due to the following reasons:

- For the constraint overall headcount required to accommodate incidents must be less than or equal to current headcount of 188 techs: At any given point of time, the IT group will have a staff working on a shift and the possibility of this constraint being negative is highly unlikely.
- For constraint percentage of incidents per tower that must be assigned to avoid the volume from piling up must be greater than or equal to 60% of the incident tower volume. This cannot be a negative constraint as the study is all about minimizing the backlogs. And backlogs as the primary focus of the research is a prevalent issue that is being addressed.
- For constraint (Sum of incident assigned per tower x Headcount per tower) ÷ Average of

monthly backlogs must be less than or equal to 1, or simply put, the model must assign incidents that are less than or equal to the demand. This cannot be a negative constraint as the demand or backlogs is always positive as the influx of incidents are incurred in a daily basis.

It is also worthy to mention that the current unassigned volume is 24% of the overall backlogs while the assigned volume is ~76% of the overall backlogs. The success of the model will be based on the % reduction in assigned backlogs as unassigned are fresh volume coming in every day. Also, the additional success criteria would be the improvement in tech utilization from current Utilization of 40%.

Below is the sample calculation which can validate the tech utilization based on the average assigned incident per headcount.

| Current State | | % Breakup Towerwise | | | | |
|---|---|---|---|---|---|---|
| Key Performance Indicators | Overall | 33.13% Workstation | 30.10% Application | 22.74% Connectivity | 10.89% CC&Comms | 3.14% Others |
| Current Carry Load | 1570 | 520.20 | 472.50 | 357.00 | 171.00 | 49.3 |
| Current HC for ITRO | 188 | 50 | 47 | 27 | 30 | 34 |
| Total Work Hours/Day/Tech | 9 | 9 | 9 | 9 | 9 | 9 |
| Total Break Hours/Day/Tech | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Total Analayst Available Mins | 84600 | 22500.00 | 21150.00 | 12150.00 | 13500.00 | 15300. |
| Additional Activities in % | 13.34 | 13.34 | 13.34 | 13.34 | 13.34 | 13.34 |
| Additional Activities Per Tech in Mins | 60.03 | 60.03 | 60.03 | 60.03 | 60.03 | 60.03 |
| Total Available Net Mins | 73314.36 | 19498.50 | 18328.59 | 10529.19 | 11699.10 | 13258. |
| Average Time Taken per ticket in Mins(Based on MTTR) | 25 | 27 | 30 | 18 | 19 | 15 |
| Tickets that can be Processed | 2979.26 | 722.17 | 610.95 | 584.96 | 615.74 | 883.9 |
| Tickets Per Tech | 5 | 5 | 5 | 5 | 5 | 5 |
| Targeted Occupancy During Net Available Hrs in % | 74 | 74 | 74 | 74 | 74 | 74 |
| Current Utilization | 40.68% | 43.34% | 46.67% | 33.34% | 34.45% | 30.01 |

Moreover, the model will undergo further evaluation by applying the Sensitivity Analysis and finding the Optimum point which will all be presented in the discussion of results in the study.

## 4. RESULTS AND DISCUSSION

### *4.1. Results*

The following results were obtained by applying the linear programming - simplex method with the use of MS Excel Solver:

*4.1.1. Results Table – Optimized Model*

| OPTIMIZED MODEL | *Overall Volume* | *WS* | *Apps* | *Conn* | *CC* | *Othe* |
|---|---|---|---|---|---|---|
| ***Headcount/ Staff*** | *188* | *62* | *42* | *33* | *24* | *27* |
| ***Backlogs*** | ***1570*** | *520.2* | *472.5* | *357* | *171* | *49.3* |
| ***Assigned Backlogs per day*** | ***1288.27*** | *496.8* | *321.7* | *334* | *103.2* | *30* |
| *P5* | *406.48* | *178.56* | *80.43* | *96.80* | *42.88* | *7.81* |
| *P4* | *404.94* | *134.54* | *112.60* | *105.23* | *43.68* | *8.89* |
| *P 3* | *463.95* | *180.74* | *125.11* | *130.04* | *14.72* | *13.34* |
| *P2* | *10.43* | *2.98* | *3.57* | *1.96* | *1.92* | *-* |

*4.1.2. Old Model (Current state of operation)*

| OLD MODEL | *Overall Volume* | *WS* | *Apps* | *Conn* | *CC* | *Other* |
|---|---|---|---|---|---|---|
| ***Headcount/ Staff*** | *188* | *62* | *42* | *33* | *24* | *27* |
| ***Backlogs*** | ***1570*** | *520.2* | *472.5* | *357* | *171* | *49.3* |
| ***Assigned Backlogs per day*** | ***1200.8*** | *400.66* | *360* | *273.3* | *129* | *37.84* |
| *P5* | *376.64* | *144* | *90* | *79.2* | *53.6* | *9.84* |
| *P 4* | *386.4* | *108.5* | *126* | *86.1* | *54.6* | *11.2* |
| *P3* | *427.36* | *145.76* | *140* | *106.4* | *18.4* | *16.8* |
| *P2* | *10.4* | *2.4* | *4* | *1.6* | *2.4* | *0* |

With the new assignment of headcount per tower, the researcher was able to increase the overall monthly average assigned backlogs from *1200* to *1288 or* an improvement of *5.5%*. Therefore, decreasing overall monthly unassigned backlogs by *88 incidents*.

The improvement from the unassigned backlogs of 5.5% can be translated to 36.67 hours or 4.89 days' worth of additional tech manpower increased in the productivity.

The new model produces an 8% increase to the overall Utilization Rate with the breakdown as follows:

*4.1.3. Old Model vs Optimized Model Utilization Rate Comparison*

| *Tower* | *Old Model* | *Optimized Model* |
|---|---|---|
| ***Overall Utilization Rate*** | ***40.68%*** | ***48.28%*** |
| *Workstation* | *43.34%* | *61.40%* |
| *Applications* | *46.67%* | *64.41%* |
| *Connectivity* | *33.34%* | *53.82%* |
| *Call Center* | *34.35%* | *31.50%* |
| *Other Towers* | *30.01%* | *17.04* |

| Current State | | % Breakup Towerwise | | | | |
|---|---|---|---|---|---|---|
| Key Performance Indicators | Overall | 33.13% Workstation | 30.10% Application | 22.74% Connectivity | 10.89% CC&Comms | 3.14% Others |
| Current Carry Load | 1570 | 520.20 | 472.50 | 357.00 | 171.00 | 49.3 |
| Current HC for ITRO | 188 | 62 | 41 | 34 | 24 | 27 |
| Total Work Hours/Day/Analyst | 9 | 9 | 9 | 9 | 9 | 9 |
| Total Break Hours/Day/Analyst | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Total Analayst Available Mins | 84600 | 27900.00 | 18450.00 | 15300.00 | 10800.00 | 12150.00 |
| Additional Activities in % | 13.34 | 13.34 | 13.34 | 13.34 | 13.34 | 13.34 |
| Additional Activities Per Analyst in Mins | 60.03 | 60.03 | 60.03 | 60.03 | 60.03 | 60.03 |
| Total Available Net Mins | 73314.36 | 24178.14 | 15988.77 | 13258.98 | 9359.28 | 10529.19 |
| Average Time Taken per ticket in Mins(Based on MTTR) | 25 | 27 | 30 | 18 | 19 | 15 |
| Tickets that can be Processed | 2979.26 | 895.49 | 532.96 | 736.61 | 492.59 | 701.95 |
| Tickets Per Analyst | 6.39 | 8.01 | 7.66 | 10.12 | 4.30 | 1.11 |
| Targeted Occupancy During Net Available Hrs in % | 74 | 74 | 74 | 74 | 74 | 74 |
| **Optimized Model Utilization** | **48.28%** | **61.40%** | **64.41%** | **53.82%** | **31.50%** | **17.04%** |
| Old Model Utilization Comparison | 40.68% | 43.34% | 46.67% | 33.34% | 34.45% | 30.01% |

### *4.2. Model Evaluation*

The results were analyzed and validated by performing a Sensitivity Analysis of the Linear Programming Model using the MS Excel Solver:

#### *4.2.1. Evaluation of Variables*

*Table 4.2.1.1. Analysis of Decision Variables*

| | *Final* | *Objective* | *Allowable* | *Allowable* |
|---|---|---|---|---|

| Variables | Value | Coefficient | Increase | Decrease |
|---|---|---|---|---|
| *Current Headcount/Staff WS* | *62* | *8.01* | *1E+30* | *0.35* |
| *Current Headcount/Staff Apps* | *41* | *7.66* | *0.35* | *3.36* |
| *Current Headcount/Staff Connectivity* | *34* | *10.12* | *1E+30* | *2.46* |
| *Current Headcount/Staff Call Center* | *24* | *4.30* | *3.36* | *1E+30* |
| *Current Headcount/Staff Other Towers* | *27* | *1.11* | *6.55* | *1E+30* |

| Variables | Upper Limit | Lower Limit |
|---|---|---|
| *Current Headcount/Staff WS* | ∞ | *7.66* |
| *Current Headcount/Staff Apps* | *8.01* | *4.30* |
| *Current Headcount/Staff Connectivity* | ∞ | *7.66* |
| *Current Headcount/Staff Call Center* | *7.66* | - ∞ |
| *Current Headcount/Staff Other Towers* | *7.66* | - ∞ |

*Description:*

- The **Final Value** shows the current number of techs/staffs per tower.
- The **Objective Coefficient** is the average rate of assignment per headcount per tower.
- The **Allowable Increase** and **Allowable Decrease** specify how much the objective coefficient can increase or decrease before the final value changes.

*Findings:*

The current headcount or number of techs per tower that shows as the Final Value is the optimal solution in the equation as it was initially mentioned in the study that the optimization of the incident backlog aims to build an optimized solution that only utilizes the IT group's current resources in terms of workforce. The Objective Coefficient in the model is the average assignment rate per tech, which if multiplied by the Final Value will give the total assigned backlogs of each tower which is equivalent to ~1,288 or around 82% of the overall volume. In the evaluation of the model, it can be inferred that low-volume towers such as Call Center and Other Towers may only have specified allowable increased values and/or upper limits as the incident volumes are not as impacting compared to other towers. On the other hand, the opposite is true with Workstation and Applications towers which have specific allowable values in terms of the allowable decrease and lower limits respectively. This is due to the fact that, these towers have significantly higher incident volumes which comprise of the majority of the overall IT group's incident volume.

The Final Value of headcount and the objective coefficient proves that the model is able to successfully achieve a better number of assigned incident backlogs than the existing environment which is only achieving 60% of the assignment volume as defined earlier in the study.

To ensure that the model is only utilizing the current headcount and still obtaining the optimized output, the following rule must be applied when deciding the simultaneous changes on the assignment per headcount per tower in the model: The 100% rule (Stair & Smith, 1995-2011) which means that sum of ratio proposed changes versus allowable changes are within a hundred percent.

Calculation:

$$\sum \frac{Proposed\ Changed}{Allowable\ Changed} \leq 100\%$$

### *4.2.2. Evaluation of Constraints*

*Table 4.2.2.1. Analysis of Constraints*

| Constraints | Final Value | Assig-nation Buffer | Default Con-straints | Allo-wable Increase | Allo-wable Decrease |
|---|---|---|---|---|---|
| *Percent assigned per tower WS* | *96%* | *0* | *60%* | *36%* | *1E+30* |
| *Percent assigned per tower Apps* | *67%* | *0* | *60%* | *7%* | *1E+30* |
| *Percent assigned per tower Connectivity* | *96%* | *0* | *60%* | *36%* | *1E+30* |
| *Percent assigned per tower Call Center* | *60%* | *-133.60* | *60%* | *11%* | *44%* |
| *Percent assigned per tower Other Towers* | *60%* | *-290.00* | *60%* | *10%* | *39%* |
| *Current Headcount/Staff Total* | *188* | *7.66* | *188* | *17* | *4* |

*Assignation Buffer is labeled as "Reduced Cost" in Excel Solver

| Constraints | Upper Limit | Lower Limit |
|---|---|---|
| *Percent assigned per tower WS* | *96%* | - ∞ |
| *Percent assigned per tower Apps* | *67%* | - ∞ |
| *Percent assigned per tower Connectivity* | *96%* | - ∞ |
| *Percent assigned per tower Call Center* | *71%* | *16%* |
| *Percent assigned per tower Other Towers* | *70%* | *21%* |
| *Current Headcount/Staff Total* | *205* | *184* |

*Description:*

- The **Final Value** in the *constraints* table shows that the resulting percent of assignments from the total backlogs ($\frac{\#\ of\ Assignments}{Total\ Backlogs}$) from headcount/staff per tower determined by the model.

- The **Assignation Buffer** (Shadow Price) shows how much more assignments we could potentially get if we loosen the constraints by 1.
- **Constraint R.H. Side** are the constraints we set prior to running the model.
- The **Allowable Increase** and **Allowable Decrease** shows us how much room the **constraints** can increase or decrease before the **assignation buffer (shadow price)** changes.

*Findings:*

The pre-set constraints of 60% means that the model must assign a minimum of 60% of the incident volume per tower to come up with an optimized model. An optimized model as previously mentioned, is a model with higher assignment rate that will prevent the backlogs of unassigned incidents from piling up.

With the use of the linear programming method, the Final Value for each tower shows that the best possible assignment per tower can still be increased even when not having to hire more staff. The initial average assigned volume that was averaging at 1200 had increased by 5.5% or 88 more incidents processed by the techs after the application of the LP model. the increase thereby improving the tech utilization rate of the techs and the overall efficiency of the IT group.

## *5.* CONCLUSION

Improving the productivity in an IT support group of a certain organization has been the primary objective of the study and the said goal has been achieved by performing the analysis of different variables that directly affects the incident backlogs such as the *number of staff per tower, incident volume per workgroup or tower* and *volume per priority level* with the consideration of the constraints in the equation that were all necessary to identify the answers to the research questions on the optimized *assigned incident rate per technician and per tower* and the *optimal percentage value of assigned incidents per tower in a given day or month*. All of the said factors have been analyzed to ensure that the IT group and all of its staff are well utilized, and that the volume pile up are somehow alleviated. Those are important to maintain the group's efficiency levels in a consistent manner. The study, by use of Linear Programming as an operational research methodology was able to identify an optimized solution that increased tech utilization which in turn results to an improved end-user satisfaction due to minimized downtime.

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