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**VIRGINIA COMMONWEALTH UNIVERSITY**

Prescriptive Analytics (INFO 645)

Office Realignment Project

Phase 2

Submitted by Submitted to

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7. EXECUTIVE SUMMARY

The Ram Wireless home office in Virginia faces inefficiencies in outdated regional service area assignments, increasing travel costs and reducing productivity, particularly in offices like Staunton, Warrenton, Richmond, and Tappahannock. COO Melissa Jones and Regional Manager Vance Larson engaged Verve Consulting to optimize store assignments while balancing costs, staff satisfaction, and productivity.

We are a group of graduate students—Riddhi Rungta, Gauri V Nair, Sarath S, Jesin K Joy, and Adarsh Bharathwaj—pursuing a Master’s in Decision Analytics. This project was assigned as part of our coursework to apply optimization techniques to real-world business problems. Our work was divided into two phases: in Phase I, completed in October 2024, we explored optimization methods using spreadsheet models, and in Phase II, we refined our approach, implemented the model in AMPL, and provided detailed recommendations.

The project aimed to reassign 43 stores to four regional offices—Staunton, Warrenton, Richmond, and Tappahannock—while minimizing travel costs, including mileage and salary for travel time. The solution had to respect feasibility constraints, ensuring that staff hours available at each office were not exceeded. Initial nearest-office assignments violated these constraints, necessitating an optimization model.

Using Mixed Integer Linear Programming (MILP) in Solver, AMPL, and Python, we developed a cost-effective solution that met all constraints. The total optimized cost was $195,479.31, slightly higher than the nearest-office assignment but feasible and practical. Geographic anomalies were identified in six store assignments, with Stafford County notably assigned to Richmond instead of closer Warrenton, despite shorter distance and time. Reassigning Stafford to Warrenton reduced costs but violated feasibility constraints, exceeding available merchandising hours in Warrenton by 98.38 hours.

We recommend optimizing store assignments to minimize costs while addressing capacity constraints, with adjustments for geographically mismatched assignments to improve operational efficiency and alignment.

1. ESSENTIAL COMPONENTS OF THE OPTIMIZATION PROBLEM
   1. Problem Statement

Ram Wireless seeks to realign store assignments for Staunton, Richmond, Warrenton, and Tappahannock regional offices to minimize travel costs, which include both mileage and employee salary expenses. Each store must be assigned to a regional office in a way that reduces unnecessary travel time, allowing employees more time for store-related work. Additionally, each regional office’s available hours for each task area must be respected. This phase extends the analysis by explicitly incorporating constraints related to area-specific availability of hours and examining how the assignment aligns geographically to ensure practical implementation.

* 1. Data Definition

[ Data: [Realignment\_Data](https://docs.google.com/spreadsheets/d/1sTPwyc7ygoGAdVtQGwjI82LMN4XMYFQk/edit?gid=1455537597%23gid=1455537597) ]

be the set of regional offices  
 be the set of stores  
 be the areas for each store.  
 = state mileage rate, which is $0.585 per mile  
 the salary being paid to the employees ($26 per hour)  
the distance in miles from store to regional office   
 time required in hours to travel from a store to a regional office   
 hours required annually by each store in area   
 employee hours available annually in regional office in each area   
number of annual round trips required by store in area

For round trips, we took the annual trips and then in a new sheet, we doubled it to make round trips for our calculation.

* 1. Objective in Words

Decide the assignment of stores to regional office ( i.e., which regional office each store must be assigned to )

Such that the **total cost** ( mileage cost + salary cost ) is **minimized**

Subject to the following constraints:

1. Each store must be assigned to only one regional office
2. The hours required by stores assigned to a regional office for each area must not exceed the hours available in that office for that area.
   1. Assumptions
3. Salary costs for travel are based on annual round trips, doubling the distance to account for return trips.
4. The base hours required for each area (e.g., inventory, payroll) and the number of trips per year are consistent across all stores. This is an estimate given by the employees.
5. External factors such as traffic, weather, or unforeseen delays are not considered in the travel time or cost calculations.
   1. Decision Variables

Let be the binary decision variable such that,

* 1. Algebraic Formulation

**Minimize**   
 **[Total\_Cost]**

**Subject to the constraints**

**AssignEachStoreOnce:**

**HoursConstraint**:

* 1. Modelling Methodology

First, we divided our data in different sheets for the purpose of easy importing. Other than round trips, no other calculation was done in the excel spreadsheet. The optimization problem was approached using **Mixed Integer Linear Programming (MILP)**, which is particularly effective for solving problems with both continuous and discrete decision variables. To ensure robustness and consistency, **Solver, Python, and AMPL** were utilized to model and solve the problem. The results from all three methods aligned, confirming the reliability of the approach.

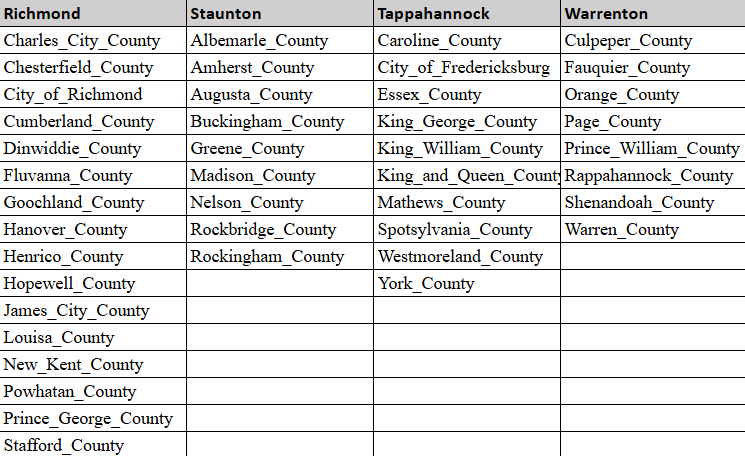
* 1. Implementation

An implementation of the above problem using AMPL and Python is as follows:

* 1. Results

The optimization results indicate that the total cost of $195,479.31 was achieved under the provided constraints. The optimization successfully achieves the objective of minimizing costs while satisfying the operational and assignment constraints.

Assignment of the stores to the regional offices is detailed below:



Employee hours annually used at each regional office in each department area is given below:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Regional Offices** | **Inventory** | **Payroll** | **Hiring** | **Marketing** | **Merchandising** |
| Richmond | 2584.8 | 2730.2 | 1097.58 | 1128.62 | 671.4 |
| Tappahannock | 735.24 | 943.98 | 1783.04 | 374.1 | 708.28 |
| Warrenton | 755.96 | 1418.44 | 1514.58 | 624.9 | 828.78 |
| Staunton | 1836.42 | 3399.58 | 7594.92 | 1075.22 | 457.88 |

1. PART C : UNUSUALITY, MITIGATION AND RAMIFICATIONS

The solution found in Part B for the assignment of stores to regional offices does not entirely make sense when considering the geographic regions demarcated by the assignments. We referred to the [Virginia Map](https://docs.google.com/document/d/1IYXrbYlPBAMLTfh6lAMgo4x8uPYPEa9vv-GEe6TIrA8/edit?tab=t.0) and found the following unusuality. Six counties are not being assigned to the closest regional office, which increases travel time and subsequently raises costs. The most notable one is Stafford County, while the others include Madison County, City of Fredericksburg, Fluvanna County, Greene County, and Spotsylvania County.

Upon further examinations we noticed that these discrepancies arise due to violations of feasibility constraints despite cost reductions when assigning these counties to their closest regional offices.

The most unusual thing we noticed was Stafford County assignment. It was assigned to Richmond rather than Warrenton which was the closest. The mileage to Warrenton was 42 miles and the time taken was 0.96 hours whereas the mileage to Richmond was 67 miles and the time taken was 1.08 hours.

For fixing this issue, we assigned it to Warrenton instead of Richmond. That reduced the costs; however, this allocation violates the feasibility constraint as the required merchandising hours exceed the available hours in the merchandising area in Warrenton by 98.38 hours. This implied that the hours available was not enough for that store to be allocated there. This led to feasibility issues.

Similarly, Madison County could have been assigned to Warrenton instead of Staunton for cost efficiency, but this was infeasible as Warrenton lacked the merchandising hours needed.

The City of Fredericksburg faces a similar issue. Assigning it to Warrenton instead of Tappahannock would reduce costs but exceeds the available hours in both merchandising and inventory areas in Warrenton.

Fluvanna County, if assigned to Staunton instead of Richmond, would have reduced costs but violated the payroll area feasibility constraint due to insufficient available hours in Staunton.

For Greene County, assigning it to Staunton instead of Warrenton would lower costs but violates payroll area constraints in Staunton.

Finally, Spotsylvania County, which could have been allocated to Warrenton instead of Tappahannock for cost reduction, exceeds the available merchandising hours in Warrenton, rendering this allocation infeasible.

In conclusion, while assigning these counties to their closest regional offices would minimize costs, the feasibility constraints related to the availability of resources in merchandising, payroll, and inventory areas necessitated these allocations. These constraints ensure that operational requirements are met, even if it means higher travel costs and less geographic alignment.

Link to the workings for Part C: [Link to the workings for Part C](https://docs.google.com/spreadsheets/d/1v3LyUZ5LWOIbiIU1HZiqS78Tm3NPftgJU7A5fHTmLjQ/edit?gid=0%23gid=0)

1. CONCLUSION

This report addresses the optimization of regional office assignments for the Ram Wireless home office, focusing on minimizing travel costs while considering the capacity constraints of each office. The objective is to reassign stores to regional offices in a manner that reduces unnecessary travel time and costs, ensuring that the allocation of staff hours aligns with each office's available resources.

The report identifies several key issues, including the assignment of certain counties to distant regional offices due to capacity shortfalls in specific program areas, such as merchandising and payroll. The analysis highlights instances where stores like Stafford, Madison, and Fredericksburg were assigned to far-off offices due to insufficient hours in the nearby regional offices, causing inefficiencies in both costs and operations. These inefficiencies led to increased travel time and costs, negatively impacting employee satisfaction due to longer commutes and less time spent on-site at stores. Furthermore, the capacity constraints in certain regional offices resulted in an inability to meet the operational needs of stores, leading to potential service delays and compromised work quality.

The consequences of these challenges included not only higher operational costs but also reduced productivity and employee morale. By addressing the assignment inefficiencies and capacity shortfalls, the Ram Wireless home office can optimize resource allocation, improve service delivery, and enhance overall operational efficiency.

1. RECOMMENDATIONS

To address the unusual regional office assignments of counties, a detailed analysis of the data was conducted. Several counties, including Stafford, Madison, the City of Fredericksburg, Fluvanna, Greene, and Spotsylvania, were assigned to regional offices farther away from their geographic proximity due to insufficient staff hours in critical areas such as merchandising and payroll. To resolve these inefficiencies and improve alignment with geographic proximity, the following recommendations are made:

First, we propose redistributing staff hours between regional offices to address the identified shortfalls. For example, Stafford County was assigned to Richmond instead of the closer Warrenton office due to a shortfall of 119.6 merchandising hours. This can be mitigated by reallocating these hours from Richmond, ensuring Stafford is assigned to Warrenton while minimizing travel costs. Similarly, Madison County, which faced a shortfall of 47.36 merchandising hours in Warrenton, can be reassigned by transferring hours from Richmond or Tappahannock.

The City of Fredericksburg was assigned to Tappahannock instead of Warrenton due to an 81.52-hour shortfall in merchandising. Reallocating approximately 100 merchandising hours from Richmond to Warrenton would enable Fredericksburg to be reassigned to its closer regional office. Likewise, Spotsylvania, with a merchandising shortfall of 103.56 hours in Warrenton, can be reassigned by transferring the necessary hours from Tappahannock or Richmond.

For payroll-related shortfalls, Fluvanna and Greene counties were impacted. Fluvanna was assigned to Richmond instead of Staunton due to a shortfall of 144 payroll hours in Staunton. Similarly, Greene County had a payroll shortfall of 113.74 hours in Staunton. To resolve these gaps, we recommend transferring payroll hours from Richmond to Staunton, ensuring both counties are serviced by Staunton while maintaining proximity.

In addition to redistributing hours, a hybrid optimization approach can be implemented in the Solver model. This approach would incorporate geographic proximity as a weighted constraint along with cost minimization. This ensures counties are assigned based on both proximity and cost efficiency.

Finally, introducing flexible staffing through shared support roles can help address short-term deficiencies. For instance, merchandising staff could float between offices to cover shortfalls in counties like Stafford and Fredericksburg, which together require approximately 304.68 additional hours.

By redistributing hours, optimizing the Solver model, and introducing flexible staffing, these recommendations will improve the assignment process, minimize travel costs, and maintain geographic alignment. These adjustments not only address current inefficiencies but also establish a more resilient system for future county assignments.

1. APPENDIX

Interaction with the AI can be found here:

1. AMPL Code : [AI Interaction](https://chatgpt.com/share/674e0089-dee8-8009-b667-b7753ab2f2dd)
2. Report : [AI Interaction 1](https://chatgpt.com/share/67512865-34e8-8009-ad88-bb7d4dfa5a47)

[AI Intercation 2](https://chatgpt.com/share/675129b7-2df0-800c-80c2-3d8aae142f61)