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# Strategic Decision Support System using a Heuristic Algorithm for Practical Outlet Zones Allocation to Dealers in a Beer Supply Distribution Network

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## Abstract

We consider a two-echelon beer supply distribution network with the brewer replenishing the dealers and the dealers serving the outlet zones directly, for multiple product types. The allocation of the outlet zones to the dealers will determine the quantity of products the brewer replenishes each dealer, which will in turn impact the total warehousing and transportation costs. The mixed integer optimization model formulated is difficult to solve and the model itself does not include practical business considerations in the distribution business. A heuristics algorithm is designed and easily implemented using spreadsheets with Visual Basic programming to effectively and efficiently allocate the outlet zones to the dealers. The spreadsheets model serves as a strategic decision support system that allows the user to play with "What-if" scenarios by flexibly setting the decision to open or close a dealer and assigning outlet zones to several potential dealers, taking into account the practical business considerations. The algorithm will determine the best allocation of the outlet zones, among the potential dealers, to achieve minimum total network costs. With several "What-if" scenarios and their corresponding allocation results, the user can make the strategic decision to select the most suitable scenario.

## Keywords

Supply network, heuristic algorithm, spreadsheets, strategic DSS

## 1. Introduction

Distribution network design problems or network flow problems in supply chains are strategic level, long-term decisions which need to be reviewed and improved only once every few years as customer demand and distribution costs change over time. The decisions include deciding which facility location to open or close, and which customer to be served from which facility, to minimize total costs. Such discrete facility location problems include uncapacitated facility location problem (UFLP) as discussed in Mirchandani and Francis (1990) and capacitated facility location problem (CFLP) in which capacities of the production and/or warehouse facilities are considered, as discussed in Sridharan (1995). For reviews on facility location, interested readers can refer to Owen and Daskin (1998), Klose and Drexel (2005), Sahin, and Süral (2007), ReVelle et al. (2008) and Melo et al. (2009).

Closely related to facility location is the decision on the flow of the products through the network. Ahuja et al. (1993) discussed linear cost network flow problems. However in practice, many distribution costs are concave cost functions which will result in concave cost network flow problems that are NP-Complete. Zangwill (1968), Erickson et al. (1987) and Ward (1999) are examples of work that dealt with concave distribution costs. Apart from concave distribution costs, many complexities involved in the supply chain distribution business in practice can hardly be modeled, and even if modeled, the model will be intractable.

Muriel and Simchi-Levi (2003) mentioned in their book chapter the importance of optimization based decision support systems (DSS) to assist the planner to make decisions in logistics and supply chain problems which are not well defined. This paper focuses on the design and implementation of a DSS for the distribution network design for beer supply, which allows the user to play with "What-if" scenarios by flexibly setting the decision to open or close a dealer and assigning outlet zones to several potential dealers, taking into account the practical business considerations.

## 2. Literature Review

Decision Support System (DSS) is defined as a computer-based system consisting of a language system, a knowledge system, and a problem-processing system (Bonczek et al. 1980). Little (2004) defines it as a model-based set of procedures for processing data and judgments to assist a manager in his decision making. As the focus of the paper is on DSS for strategic supply network design, we will review similar works in DSS to support decisions in this area.

Padillo et al. (1995) discussed a DSS named as the “Manufacturing Enterprise Model” or “MEM” used by strategic planners to make decisions about product allocation and major resources and facilities planning in the semiconductor industry. The MEM is composed of several main elements including the mathematical programming model, optimization solver, input information, and the end-use interface and report generator. Decisions are made based on maximizing the net present value or minimizing cycle time.

Kirkwood et al. (2005) developed a DSS for IBM’s supply chain configuration decisions based on 22 considerations covering cost, quality, customer responsiveness, strategic issues, and operating constraints, through multi-objective decision analysis procedure. These multi-attribute utility analyses incorporated uncertainty through expert estimates of probabilities and were implemented in a spreadsheet environment.

Cheung et al. (2005) presented an intelligent DSS which uses an optimization model and simulation model as a 2-stage methodology for service network planning for a major air-express courier. The optimization model is an MIP model which determines the locations of satellite depots and service centers, their capacities, year of installation, and assignment of shipment routes. The simulation model validates and evaluates the performance of the network at the operational level. An expert system is added into the DSS to execute the 2 models iteratively until satisfied performance measures are obtained.

Kengpol (2008) discussed a DSS that considers both quantitative (costs) and qualitative (satisfaction) viewpoints in logistics distribution network design. The DSS is a combination of analytic hierarchy process (AHP) model, MILP and a transportation model. The AHP model is used to achieve priorities from customers and distribution centers, and the MILP will integrate the priorities to achieve maximum satisfaction. After that, the multi-commodity transportation model calculates the optimum number of products to be transported to the customers at minimum total transportation costs.

Mazini (2012) presented a DSS named as LD-LogOptimizer, for strategic planning, tactical planning and operational planning, in a multi-echelon, multi-stage, multi-commodity, and multi- period production, distribution and transportation system, using a top-down approach. In strategic planning, he proposed an MILP model to minimize total cost. He proposed to reduce the computational complexity by preliminary assignment of customers to regional DCs, using different heuristics namely, maximum critical customer convenience based on cost or distance, and minimum facilities through average convenience based on cost or distance. In tactical planning, he also proposed an MILP model to minimize logistics cost. The LD-LogOptimizer implements two approaches to obtain an optimum solution using the MILP solver, or a near-optimum solution using pre-setting activity to reduce problem complexity. For operational planning, the LD-LogOptimizer uses a two-step procedure where the first step is based on clustering analysis and the second step is routing and tour definition. He implemented the DSS for a luxury company with a three-stage supply chain.

Kristianto et al. (2012) designed a DSS to improve the level of integration in supply chain reconfiguration by incorporating manufacturing and product design into logistic design. The strategic and tactical planning for supply chain configuration chooses a manufacturing option in terms of make-to-stock (MTS), make-to-order (MTO) or assemble-to-order (ATO) for each stage of the supply chain, so as to achieve the product functionality at minimum manufacturing cost and with higher supply chain responsiveness, and reduced safety stock distribution at a lower number of stockholding points.

Table 1: Research Work Comparison

| Research Work | Decision Support | Solution Methodology |
|---|---|---|
| Padillo et al. (1995) | Product allocation, major resources and facilities planning for semiconductor industry at maximum | Mathematical programming, optimization solver |

| | | |
|---|---|---|
| | net present value or minimum cost | |
| Kirkwood et al. (2005) | Supply chain configuration including make-or-buy and regional sourcing decisions, details of supply location and logistics | Multi-objective decision analysis with estimated probabilities |
| Cheung et al. (2005) | Service network planning for air express courier | Optimization, simulation |
| Kengpol (2008) | Number of product to be transported at minimum cost and maximum customer satisfaction | Analytic hierarchy process model, MILP, transportation model |
| Mazini (2012) | Strategic, tactical and operational planning for luxury company at minimum total costs | MILP |
| Kristianto et al. (2012) | Strategic and tactical planning to decide manufacturing options including MTS, MTO or ATO, for each stage of the supply chain | Optimization |
| Cheong (2014) | Strategic planning to decide which dealers to open/close and which outlet zones are allocated to which dealer at minimum total costs | Heuristic algorithm |

The main contribution of this work is the design and implementation of a heuristic algorithm to efficiently and effectively allocate outlet zones to dealers in a beer supply distribution network, overcoming the difficulties of solving a mixed integer optimization model and also taking into account practical business considerations. The algorithm can be easily implemented using spreadsheets and Visual Basic programming to allow the user to play with "What-if" analysis for different scenarios. The scenarios are user-defined in terms of setting the decision to open or close a dealer and assigning outlet zones to several potential dealers to take into account the practical business considerations. The algorithm will determine the best allocation of the outlet zones, one outlet zone to one dealer, among the potential dealers, to achieve minimum total network costs. With several "What-if" scenarios and their corresponding allocation results, the user can make the strategic decision to select the most suitable scenario. Such a DSS empowers the user to control the inputs, visualize the outputs and the results, so as to make informed decisions on the distribution network design.

This work is different from earlier works in terms of the decision making as well as the solution methodology as highlighted in Table 1. It is similar to Mazini (2012) in terms of the pre-setting activity to reduce problem complexity, where in this paper, the user-defined scenarios in terms of pre-setting the decision to open or close a dealer and assigning outlet zones to several potential dealers, also aim to reduce problem complexity. It is similar to Kirkwood et al. (2005) in terms of the implementation using the spreadsheets, as such a DSS will be more user-friendly and straightforward for business users, considering the fact that spreadsheets applications are rampant in the business world.

The rest of the paper is organized as follow. Section 3 describes the optimization model and discusses the difficulty to include the practical business considerations into the model. Section 4 describes the heuristic algorithm in detail, and Section 5 discusses the real business case and the results obtained using the heuristic algorithm. Finally, Section 6 provides the conclusions.

## 3. Distribution Network Optimization Model

Due to the nature of the beer distribution business, many costs involving the warehouse storage and transportation of beer are dependent on the pack types, which can be 33cl can, 50cl can, Pints, Quarts, 20 liters keg or 30 liters keg. The distribution network analysis requires minimizing the total network cost of transporting the beer from the brewer to the dealers, storing the beer at the dealers' warehouses, and transporting the beer from dealers to the outlet zones, plus some fixed costs which differ among the dealers. The optimization model can be represented as follow:

Input parameters
i = index for outlet zone
j = index for dealers
k = index for brewer
m = index for pack type

$W_j$ = warehouse capacity of dealer j (pallet)
$F_j$ = average daily warehouse fixed cost of dealer j ($)
$U_m$ = conversion factor from pack type unit to pallet for pack type m (pallet/unit)
$S_m$ = total daily supply of pack type m from brewer (unit)
$D_{im}$ = daily demand of pack type m from outlet zone i (unit)
$B_{jkm}$ = unit warehousing plus transportation variable cost from brewer to dealer j for pack type m ($/unit)
$C_{ijm}$ = unit warehousing plus transportation variable cost from dealer j to outlet zone i for pack type m ($/unit)

Decision Variables
$X_{jkm}$ = flow quantity from brewer to dealer j for pack type m (unit)
$X_{ijm}$ = flow quantity from dealer j to outlet zone i for pack type m (unit)
$Y_j$ = binary decision variable to denote if dealer's warehouse j is open
$Z_{ij}$ = binary decision variable to denote outlet zone i is allocated to dealer j

Minimize

$$\sum_{j,k,m} X_{jkm} B_{jkm} + \sum_{i,j,m} Z_{ij} X_{ijm} C_{ijm} + \sum_{j} Y_j F_j$$

Subject to,

$$\sum_{j} Z_{ij} = 1 \qquad \forall i \qquad (1)$$

$$\sum_{j} Z_{ij} X_{ijm} = D_{im} \qquad \forall i, m \qquad (2)$$

$$\sum_{i,j} Z_{ij} X_{ijm} = S_m \qquad \forall m \qquad (3)$$

$$\sum_{i,m} Z_{ij} X_{ijm} U_m \leq W_j \qquad \forall j \qquad (4)$$

$$\sum_{i} Z_{ij} X_{ijm} = X_{jkm} \qquad \forall j, m \qquad (5)$$

$$\sum_{i,m} Z_{ij} X_{ijm} \leq M Y_j \qquad \forall j \qquad (6)$$

The optimization model minimizes the total costs which include the transportation costs from the brewer to the dealers, transportation costs from the dealers to the outlet zones, and the fixed costs of the dealers. The constraints include:

- Constraint (1) – ensures that one outlet zone is allocated to one dealer for all the pack types. Note that $Z_{ij}$ simplifies the binary decision variables $Z_{ijm}$ since $Z_{ij1} = Z_{ij2} = \ldots = Z_{ijm}$ for all m for a particular outlet zone i and dealer j.
- Constraint (2) – ensures that the flow quantity of pack type m from all dealers to outlet zone i satisfies the demand required by outlet zone i for pack type m. Constraint (1) will ensure that only 1 dealer is allocated to serve outlet zone i.
- Constraint (3) – ensures that the total flow quantity for pack type m from all dealers to all outlet zones is equal to the total daily supply of pack type m from brewer
- Constraint (4) – ensures that the total flow quantity from dealer j to all the allocated outlet zones i for all pack types m does not exceed the warehouse capacity of dealer j
- Constraint (5) – sums up the total flow quantity from dealer j to all the allocated outlet zones i for pack type m to be equal to the total flow from the brewer to dealer j for pack type m
- Constraint (6) – ensures that allocation for dealer j is possible only when dealer j is open

The optimization model formulation is a mixed integer model due to the objective function and constraints having the term $Z_{ij}$ * $X_{ijm}$, which causes difficulty in obtaining an optimal solution. In addition, even when solved, the model allocates the outlet zones to dealers considering only cost minimization, without considering other practical business considerations. Deliveries businesses are often met with several important practical considerations such as dealer's familiarity with the outlet zone, dealer's having the suitable trucks to serve outlet zones which are in the central business district that restricts certain vehicle types, or outlet zones which are served by roads with narrow lanes that restrict large vehicle, or outlet zones with loading and unloading bays that only allow specific vehicle types. To include these practical business considerations into the optimization model can be done by either converting these practical business considerations into cost penalty equivalents or adding binary decision variables to represent each capability. These conversions and/or additions will increase the model complexity tremendously, and the model will likely end up to be intractable.

## 4. Heuristic Algorithm for Allocation of Outlet Zones to Dealers

In order to implement a solution methodology which will take into account the practical considerations in the real business, a heuristic algorithm is designed to efficiently and effectively allocate the outlet zones to dealers, using the candidate choice approach. In many network design and distribution problems, the distribution hub locations are selected from candidate locations rather than random choices. These candidate locations are pre-selected as possible choices which have the capability to perform the distribution tasks. The capability can be in terms of warehouse space and equipment availability, manpower competencies, and other requirements. A certain quantitative measure, usually cost, is then computed to assist the selection process. The heuristic algorithm designed here adopts the same approach and is explained as follow:

1. Set $Y_j = 1$ for dealers which are to be open. User can play with "What-if" scenarios by setting different subsets of dealers to open to get different possible solutions.

2. Assign the neighborhood for each outlet zone i by setting the parameter $Z_{ij}$. When outlet zone i can be potentially served by dealer j, set $Z_{ij} = 1$, 0 otherwise. This active user setting of the value of $Z_{ij}$ would force the user to take into account the practical business considerations, such that only dealers which are open and are capable of serving outlet zone i will be assigned. Such a design is essential and practical as "*logistics and supply chain management problems are not so rigid and well defined that they can be entirely delegated to computers. Instead, in almost every case, the flexibility, intuition, and wisdom that are unique characteristics of humans are essential to effectively manage the systems*" as mentioned in Muriel and Simchi-Levi (2003). For the algorithm to work, all outlet zones with at least one positive daily demand $D_{im}$ for all pack type m must have at least one dealer assigned to its neighborhood.

3. Compute the effective unit cost $EC_{ij}$ for each outlet zone i to be served by dealer j. $EC_{ij}$ is the average unit cost of each unit of product considering all the different pack types m, and will be used as the quantitative measure to aid selection. This effective unit cost will ensure that the lowest cost dealer j is allocated to serve outlet zone i for all pack types.

$$EC_{ij} = \frac{\sum_m D_{im} C_{ijm}}{\sum_m D_{im}} \qquad \forall i, j \qquad where \quad Z_{ij} = 1$$

   Where,
   $D_{im}$ = daily demand of pack type m from outlet zone i (unit)
   $C_{ijm}$ = unit transportation variable cost from dealer j to outlet zone i for pack type m ($/unit)

4. User decides if outlet zone i which is located in the same zone as dealer j should be allocated first without considering $EC_{ij}$.
   4.1 If yes, for each dealer j, allocate the outlet zone i which is located in the same zone to dealer j.
   4.2 If no, go to step 5.

5. Rank $EC_{ij}$ in ascending order for each outlet zone i.

6. Establish the dealers ranking corresponding to the values of ranked $EC_{ij}$ for each outlet zone i.

7. Assign outlet zone i to dealer j starting from the smallest $EC_{ij}$ value to the largest, for all outlet zones, satisfying the dealer's capacity constraint.

   7.1 For each outlet zone i, identify the smallest $EC_{ij}$ and the corresponding dealer j.

   7.2 For all smallest $EC_{ij}$ identified in step 7.1, determine the smallest value and let it be SBest_$EC_{ij}$ and identify that particular outlet zone i as SBest_i, and its corresponding dealer j as SBest_j.

   7.3 Check that sum of $D_{im}$ for all outlet zones i already allocated to dealer SBest_j, plus the $D_{im}$ for this SBest_i allocation, when converted to pallets, does not exceed the warehouse capacity of dealer S_Best_j.

      7.3.1 If capacity is within limit, set $A_{ij} = 1$ to indicate that outlet zone i is allocated to dealer j.

      7.3.2 Otherwise, check if outlet zone SBest_i has another dealer in the neighbor.

         7.3.2.1 If yes, set its next ranked $EC_{ij}$ as the smallest ECij and identify the corresponding dealer j. Go to step 7.2.

         7.3.2.2 If no, stop the algorithm and prompt the message that outlet zone SBest_i has insufficient dealers assigned to its neighborhood.

8. For $A_{ij} = 1$, assign values $X_{ijm} = D_{im}$ for outlet zone i allocated to dealer j for all pack type m.

9. Compute $X_{jkm} = \sum_i X_{ijm}$

10. Compute total cost = $\sum_{j,k,m} X_{jkm} B_{jkm} + \sum_{i,j,m} Z_{ij} X_{ijm} C_{ijm} + \sum_j Y_j F_j$

This is a greedy algorithm that ensures that the lowest effective unit cost dealer is allocated to serve the outlet zones. When the outlet zone with the next lowest effective unit cost (SBest_i) cannot be assigned because that dealer's capacity (SBest_j) has reached its limit, as in step 7.3.2.2, the algorithm does not attempt to remove earlier allocations to free up the warehouse space in order to allocate outlet zone SBest_i to SBest_j. This is because by doing so, the total network cost will be increased in an uncontrolled and unsystematic manner. When step 7.3.2.2 does occur, it can imply one of two things – one is that dealer SBest_j is the most cost effective dealer where many outlet zones are allocated to it thereby consuming its warehouse space, or two, dealer SBest_j simply has too little warehouse space. This would prompt the user that more dealers which are less cost effective than SBest_j have to be assigned to the neighborhood of outlet zone SBest_i, which will allow step 7.3.2.1 to be executed. Such an additional assignment of less cost effective dealers to the neighborhood is another conscious action that the user should do, so that the practical business considerations can be taken into account with deliberation.

## 5. Business Implementation

With the aim to improve customer service in the face of intense competition, a major brewer hopes to make improvements to its two-echelon supply distribution network within Singapore (see Figure 1). The brewer also serves some key accounts (usually large supermarkets) directly, but this part of the analysis is not within the scope of the paper. The original distribution network has eight dealers located at different parts of the Singapore island and a total of 82 outlet zones that are assigned to the 8 dealers (see Figure 2).

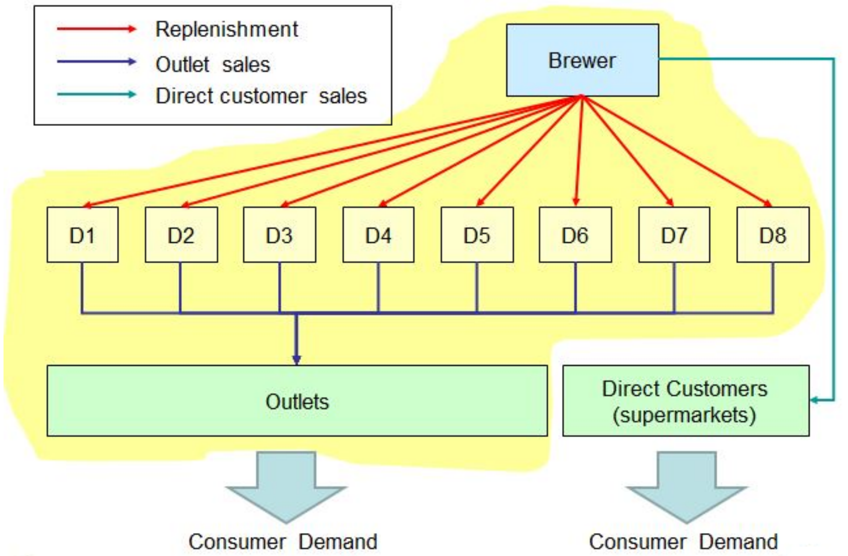


Figure 1: Two-Echelon Beer Supply Distribution Network

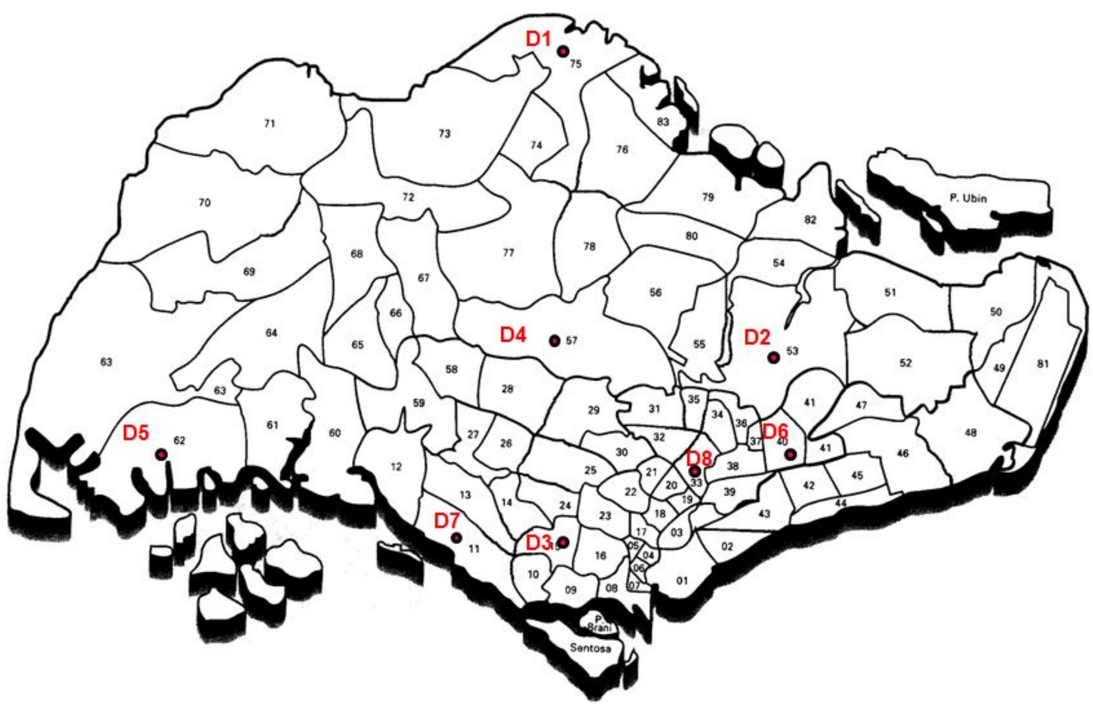


Figure 2: Location of Eight Dealers

Daily replenishments from the brewer will be sent to the 8 dealers by third-party trucking companies. The quantity to replenish is based on demand forecast and current inventory levels at each dealer's warehouse. Each dealer maintains a first-in-first-out policy at the warehouse to ensure the freshness of the beer served at the outlets. Some of the dealers maintain their own fleet of delivery trucks to deliver to the outlets, while some outsource the delivery task to sub-contractors, while others use a mixture of owned and sub-contracted trucks.

The current allocation of the outlet zones is inefficient as can be observed visually in Figure 3. For example, dealer D2 is allocated to serve outlet zones 01, 02, 03, 42, and 43 when dealers D6 and D8 are in fact closer to these outlet zones. This leads to higher total network cost simply due to greater distance covered. In addition, there exists uneven distribution in the warehouse utilization of the dealers (see Table 2), where some dealers experienced high utilization of the warehouse space exceeding capacity limit (e.g. dealer D3 has 148.3% utilization), while other dealers have low utilization (e.g. dealer D5 has 37.9% utilization). Finally, the sum of the total warehouse space of the dealers exceeds the warehouse space needed. Thus, the brewer would like to propose closing 2 non-performing warehouses (dealers D3 and D7), and to efficiently allocate the outlet zones to the remaining 6 dealers to reduce total network cost.

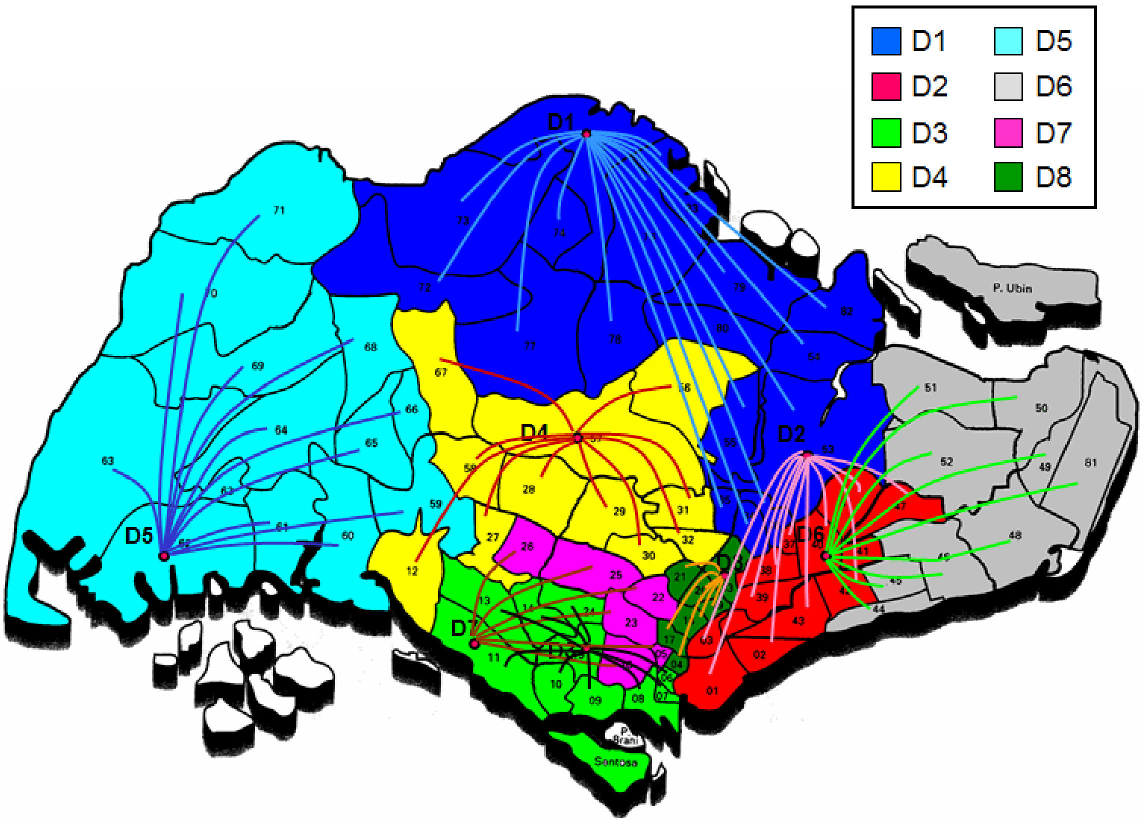


Figure 3: Current Allocation of Outlet Zones to the Eight Dealers

Table 2: Warehouse Utilization Comparison

| Dealers | WH Utilization |
|---|---|
| D1 | 49.6% |
| D2 | 67.2% |
| D3 | 148.3% |
| D4 | 89.0% |
| D5 | 37.9% |
| D6 | 76.4% |
| D7 | 42.8% |
| D8 | 71.7% |

In attempting to improve the distribution network, 5 scenarios are created and their results generated and compared with the current allocation (base scenario) as shown in Table 3. For scenarios with only 6 dealers, dealers D3 and D7 are closed.

Table 3: Base Scenario and 5 New Scenarios

| Scenario # | Number of dealers | Neighborhood assignment (Setting $Z_{ij} = 1$) | Distribution Network |
|---|---|---|---|
| Base | 8 | $Z_{ij}$ not set | Current allocation |
| 1 | 8 | All dealers can serve all outlet zones, that is, all $Z_{ij}$ are set to 1 | Algorithm generated allocation |
| 2 | 8 | Only dealers that can serve the outlet zones are assigned to the outlet zone neighborhood with their $Z_{ij}$ set to 1. See Appendix A for the settings of $Z_{ij}$. | Algorithm generated allocation |
| 3 | 6 | $Z_{ij}$ not set | Random allocation |
| 4 | 6 | All dealers can serve all outlet zones, that is, all $Z_{ij}$ are set to 1 | Algorithm generated allocation |
| 5 | 6 | Only dealers that can serve the outlet zones are assigned to the outlet zone neighborhood with their $Z_{ij}$ set to 1. See Appendix A for the settings of $Z_{ij}$. | Algorithm generated allocation |

The results obtained for each scenario are tabulated in Table 4 showing the total network cost, percentage reduction as compared to the base scenario, as well as the warehouse utilization.

Table 4: Total Network Cost and Warehouse Utilization Comparison

| | 8 dealers | | | 6 dealers | | |
|---|---|---|---|---|---|---|
| | Current | All $Z_{ij}$ = 1 | Some $Z_{ij}$ = 1 | Random | All $Z_{ij}$ = 1 | Some $Z_{ij}$ = 1 |
| **Scenarios** | **Base** | **1** | **2** | **3** | **4** | **5** |
| **Total NW Cost** | $25,327 | $23,721 | $24,410 | $23,440 | $22,448 | $22,880 |
| **% improvement** | | 6.34% | 3.62% | 7.45% | 11.37% | 9.66% |
| **WH Utilization** | **Base** | **1** | **2** | **3** | **4** | **5** |
| **D1** | 49.6% | 6.0% | 22.8% | 54.0% | 6.0% | 22.8% |
| **D2** | 67.2% | 99.5% | 97.1% | 103.1% | 99.5% | 97.1% |
| **D3 (close)** | 148.3% | 99.2% | 95.0% | 0.0% | 0.0% | 0.0% |
| **D4** | 89.0% | 74.3% | 31.2% | 120.7% | 98.7% | 96.6% |
| **D5** | 37.9% | 3.1% | 38.6% | 52.9% | 97.4% | 85.7% |
| **D6** | 76.4% | 89.4% | 92.1% | 81.9% | 99.5% | 98.1% |
| **D7 (close)** | 42.8% | 99.8% | 68.3% | 0.0% | 0.0% | 0.0% |
| **D8** | 71.7% | 99.4% | 95.8% | 80.4% | 99.7% | 95.8% |

The heuristic algorithm resulted in new distribution networks for Scenarios 1, 2, 4 and 5. In Scenarios 1 and 4, all the dealers which are open are able to serve all outlet zones without including the practical considerations since all $Z_{ij}$ are set to 1. These scenarios will result in lowest network costs, since dealers which are more cost effective will be selected regardless of whether they are capable to serve the outlet zones. In Scenarios 2 and 5, the user actively sets the values of $Z_{ij} = 1$ only for dealers which are capable to serve the outlet zones. Since the number of available dealers to serve a particular outlet zone is smaller, the total network cost will become higher. In all the 4 scenarios, the algorithm is able to allocate the dealers to the outlet zones which minimizes the total network cost and ensures that all the warehouse utilizations do not exceed 100%. For Scenario 3, it represents a random allocation of outlet zones to dealers which resulted in dealers D2 and D4 having warehouse utilization exceeding 100% and the total network cost is higher as compared to Scenarios 4 and 5. This shows that the heuristic algorithm generated results are indeed more superior.

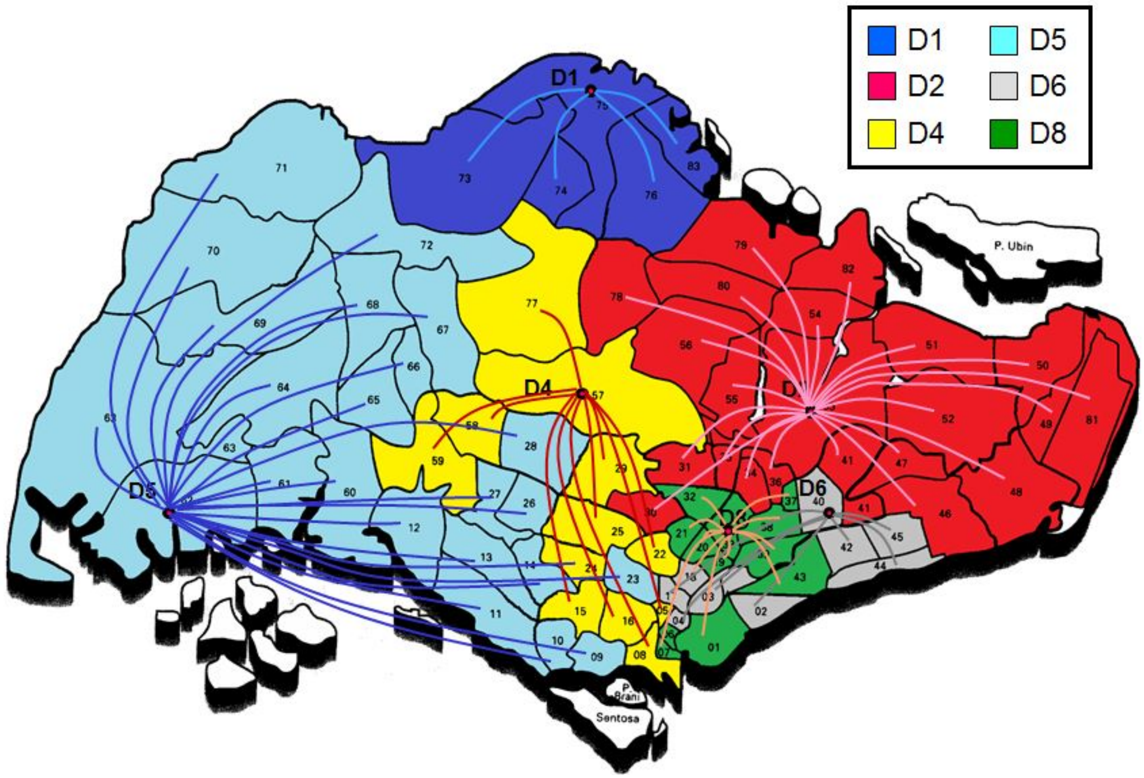


Figure 4: Heuristic Algorithm Allocation of Outlet Zones for Scenario 5

Figure 4 shows the heuristic algorithm allocation of outlet zones for scenario 5. The outlet zones are efficiently allocated to the remaining 6 dealers and the dealers do not experience warehouse utilization exceeding capacity. The warehouse utilization is more evenly distributed among the dealers, with the exception of dealer D1. Dealer D1 has a lower allocation and utilization due to its poor cost effectiveness. In addition, dealer D5 which was previously under-utilized in the Base Scenario (37.9%) is now having a higher utilization (85.7%) due to its cost effectiveness.

## 6. Conclusions

Practical considerations met in the delivery business are difficult to model into the optimization model, and even if included, it will likely result in an intractable model. The heuristic algorithm which adopts the candidate choice approach presents as an alternative method to effectively allocate outlet zones to dealers incurring minimum total network cost while ensuring that warehouse utilizations do not exceed 100%. It allows the user to play with different "What-if" scenarios by deciding which dealer to open or close, and which dealer has the capability to serve which outlet zones, taking into account practical business considerations. From the different results obtained for the different scenarios, the user is empowered to make the strategic decision to select the scenario which is best suited. The heuristic algorithm is easy to implement using spreadsheets and Visual Basic programming and is efficient and effective as a strategic decision support system. The application of the heuristic algorithm to solve the beer supply distribution network for a Singapore based beer brewer with its 8 dealers and 82 outlet zones, shows a reduction of total network cost of 9.66% when the allocations of outlet zones to 6 remaining dealers are effectively executed.

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## Biography

Michelle CHEONG is an Associate Professor (Practice) and the Director of Postgraduate Professional Programmes at the School of Information Systems (SIS) at Singapore Management University (SMU). Prior to joining SMU, she had 8 years of industry experience leading teams to develop complex IT systems which were implemented enterprise-wide covering business functions from sales to engineering, inventory management, planning, production, and distribution. Upon obtaining her Ph.D. in Operations Management, she joined SMU where she teaches the *Business Modeling with Spreadsheets* course at the undergraduate level and is the co-author of the book of the same name. She also teaches in 3 different master programmes on different variants of spreadsheet modeling courses covering financial modeling, innovation modeling and IT project management. She recently designed and delivered an *Operations Focused Data Analytics* course for the Master of IT in Business (Analytics) programme at SIS.

## Appendix A – Settings of Zij Values for Scenarios 2 and 5

| $Z_{ij}$ | Dealers (j) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **i** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1 | | | 1 | | | 1 | | 1 |
| 2 | | | 1 | | | 1 | | 1 |
| 3 | | | 1 | | | 1 | | |
| 4 | | | 1 | | | 1 | | 1 |
| 5 | | | 1 | 1 | | | | |
| 6 | | | 1 | | | 1 | | 1 |
| 7 | | | 1 | | | 1 | | 1 |
| 8 | | | 1 | 1 | | 1 | | |
| 9 | | | 1 | | 1 | | 1 | |
| 10 | | | 1 | | 1 | | 1 | |
| 11 | | | 1 | | 1 | | 1 | |
| 12 | | | | | 1 | | 1 | |
| 13 | | | 1 | | 1 | | 1 | |
| 14 | | | 1 | | 1 | | 1 | |
| 15 | | | 1 | 1 | | | 1 | |
| 16 | | | 1 | 1 | | | 1 | |
| 17 | | | 1 | | | 1 | | 1 |
| 18 | | | 1 | | | 1 | | 1 |
| 19 | | | | | | 1 | | 1 |
| 20 | | | | | | 1 | | 1 |
| 21 | | | | | | 1 | | 1 |
| 22 | | 1 | 1 | 1 | | | | |
| 23 | | | 1 | 1 | 1 | | 1 | 1 |
| 24 | | | 1 | 1 | 1 | | 1 | 1 |
| 25 | | | 1 | 1 | 1 | | 1 | |
| 26 | | | 1 | | 1 | | 1 | |
| 27 | | | 1 | | 1 | | 1 | |
| 28 | | | | | 1 | | | |
| 29 | | | | 1 | 1 | | | |
| 30 | | 1 | | 1 | | | | 1 |
| 31 | | 1 | | 1 | | | | |
| 32 | | | | 1 | | 1 | | 1 |
| 33 | | | | 1 | | 1 | | 1 |
| 34 | | 1 | | | | 1 | | 1 |
| 35 | | 1 | | | | 1 | | |
| 36 | | 1 | | | | 1 | | 1 |
| 37 | | 1 | | | | 1 | | 1 |
| 38 | | | | | | 1 | | 1 |
| 39 | | | | | | 1 | | 1 |
| 40 | | | | | | 1 | | |
| 41 | | 1 | | | | 1 | | |

| $Z_{ij}$ | Dealers (j) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **i** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 42 | | | | | | 1 | | 1 |
| 43 | | | | | | 1 | | 1 |
| 44 | | 1 | | | | 1 | | |
| 45 | | | | | | 1 | | |
| 46 | | 1 | | | | 1 | | |
| 47 | | 1 | | | | 1 | | |
| 48 | | 1 | | | | 1 | | |
| 49 | | 1 | | | | 1 | | |
| 50 | | 1 | | | | 1 | | |
| 51 | | 1 | | | | 1 | | |
| 52 | | 1 | | | | 1 | | |
| 53 | | 1 | | | | 1 | | |
| 54 | | 1 | | 1 | | 1 | | |
| 55 | | 1 | | 1 | | 1 | | 1 |
| 56 | | 1 | | 1 | | | | |
| 57 | | | | 1 | 1 | | | |
| 58 | | | | 1 | 1 | | | |
| 59 | | | | 1 | 1 | | 1 | |
| 60 | | | | | 1 | | 1 | |
| 61 | | | | | 1 | | | |
| 62 | | | | | 1 | | | |
| 63 | | | | | 1 | | | |
| 64 | | | | | 1 | | | |
| 65 | | | | | 1 | | | |
| 66 | | | | | 1 | | | |
| 67 | 1 | | | | 1 | | | |
| 68 | 1 | | | | 1 | | | |
| 69 | 1 | | | | 1 | | | |
| 70 | 1 | | | | 1 | | | |
| 71 | 1 | | | | 1 | | | |
| 72 | 1 | | | | 1 | | | |
| 73 | 1 | | | | | | | |
| 74 | 1 | | | 1 | | | | |
| 75 | 1 | | | 1 | | | | |
| 76 | 1 | | | | | | | |
| 77 | | | | 1 | 1 | | | |
| 78 | 1 | 1 | | 1 | | | | |
| 79 | 1 | 1 | | 1 | | | | |
| 80 | 1 | 1 | | 1 | | | | |
| 81 | | 1 | | | | 1 | | |
| 82 | 1 | 1 | | 1 | | | | |