Vehicle Routing at a Food Service Marketplace

Kavitha Chetana Didugu
Chetan Soman

W. P. No. 2017-04-03
April 2017

INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD-380 015
INDIA

Vehicle Routing at a Food Service Marketplace

Kavitha Chetana Didugu and Chetan Soman
Indian Institute of Management, Ahmedabad

Abstract

In this paper, we explore the case of an aggregator-cum-restaurant that also offers pickup and delivery services to third party restaurants registered with it. The aggregator must decide on its fleet size and the optimal routes to assign to each vehicle deployed. We propose a heterogeneous, compartmentalised vehicle routing model with pickup and delivery for the aggregator involving time windows and source selection, to minimise the route duration (or the total cost) of its fleet. The model accounts for traffic conditions (captured by speed data) over the route, maximum service radius of the fleet and time windows for customers as well as restaurants. This paper, to the best of our knowledge, is probably the first one that deals with vehicle routing problem for an online hyperlocal food service marketplace (also referred to as aggregator) that functions as a quick service restaurant (QSR) as well.

Keywords: Food Service Marketplace, Aggregator, Hyperlocal, Multiple pickups and deliveries, Traffic conditions, Point-to-point delivery

1. Introduction

The digital revolution has transformed physical supply chains into online supply chains. Intermediaries in a physical supply chain have been replaced by infomediaries in the online supply chains. Though the core competence of infomediaries (aggregators) lies in aggregating information and intermediating transactions between customers and sellers/service providers, apart from aggregating relevant information, the aggregators also offer online ordering facility to the customers. Each such entity tries to gain a competitive advantage among its competitors by offering auxiliary services, most common and important one of which is offering their own fleet of vehicles to provide logistics support to the third party service providers registered with it. Aggregators that facilitates purchases (and payments) on their websites are also called (online) marketplaces.

Though the F&B (food and beverages) industry has adopted the e-commerce revolution only recently, there is no dearth of aggregators in the industry worldwide, and in India (Kocchar, 2016). In the race to gain traction among customers, these companies compete on service quality, most importantly on delivery time, while maintaining cost effective logistic operations. Short delivery times are desirable to customers, and can help the aggregators gain a competitive advantage. The aggregators offer their own fleet to provide pickup and delivery services for third party restaurants.

2. Background

As the F&B industry is characterised by numerous online food service start-ups, sustaining operations profitably is the biggest challenge faced by these companies. In order to set themselves apart from their competitors, the food delivery companies promise to deliver food within short lead times, accurately and with acceptable quality. The performance of these companies is measured using a set of metrics (total operating cost, average delivery lead time, average ticket/order size, etc.). Optimising on these metrics, the companies strive to achieve competitive advantage.

Online marketplaces thrive on the customer base they garner; and they are ever striving to increase their customer base. In order to retain their customers, the online food service marketplaces have tried implementing various logistic schemes such as milk runs, hub and spoke models, and even a combination of the two. As we look at local and hyperlocal settings, companies have switched to point-to-point delivery network, which gives more cost effective results over the hub and spoke network for the smaller geography of the hyperlocal setting (Benzi, 2016), (Venugopal, 2016).

This paper focuses on pickup and delivery routing of the online food aggregator's fleet in a hyperlocal setting, with very short time windows (required for food delivery). The rest of the paper is organised as follows. Section 3 provides an insight into relevant literature in this field. The vehicle routing model for the aggregator-cum-restaurant is introduced in Section 4. In Section 5, the model is implemented using an illustrative case example based on an online food start-up operating in Ahmedabad (Western India). Typical inputs and outputs are presented for a better appreciation of the model. Finally, conclusion and future research directions in the emerging business context are provided in Section 6.

3. Literature Review

A strong logistics system could be a deciding factor between the success and failure of an e-retailer. This has resulted in a lot of research in the vehicle routing problem with pickups and deliveries. At the same time, a lot of research attention has been given to the vehicle routing problem with time windows. However, the case of prepared food delivery is different from other products as it is perishable, and demands very short delivery time windows, which corresponds to the product quality window. An introduction to the time dependent vehicle routing problem is provided in the review paper by Gendreau et al. (2015), which documents the evolution and ramifications of the time dependent vehicle routing problem. They describe the differences between a deterministic and a stochastic time-dependent vehicle routing problem in terms of the model formulation, and cite various variations of the generic model such as time dependent quickest path problem, time-dependent least consumption model, etc.

Azi et al. (2004) has looked into vehicle routing for delivering perishable goods with time windows. Their paper deals with attended home deliveries for a multiple vehicle system, starting from a single depot, with an objective to minimise the total transportation cost.

Another interesting aspect of online marketplaces is that they can consolidate sub-orders (subsets of the set of constituents of the order) from various suppliers. For example, if an order placed by a customer contains more than one product, each from a different supplier, then the aggregator sources the products from these suppliers and delivers them to the customer (thereby fulfilling the entire order). Since the online food marketplace under our consideration is also an aggregator, this entity also aggregates sub-orders.

The model presented by Yanik and deKervenoael (2015) represents a VRPPDTW (Vehicle Routing Problem with Pickup and Delivery involving Time Windows), for an e-retailer which produces a standard product, but aggregates premium products from various other retailers. It aggregates the orders of a customer and delivers in a single delivery. However, their model assumes that there is only one aggregator facility. Each third party supplier in the supply network offers only one, unique product. The products offered by the aggregator and the other retailers are considered necessarily different. Though the model formulation includes time windows, they are considered as applicable in the time horizon the authors consider. Hence the results of the VRPPDTW are provided without including the time window constraints.

Similar efforts have been made in the catering industry in the papers by Mathelinea and Mawengkang (2016), and Mawengkang (2016). These papers address the vehicle routing problem with pickup and delivery and time windows using the periodic vehicle routing formulation; that is, the entire planning horizon is divided into multiple discrete sub-units. Vehicle routes are optimised over each sub-unit of time. However, these papers consider a single central kitchen and therefore, there is no aggregation of sub-orders being carried out.

In this paper, we consider the aggregator to be a restaurant as well. The entire supply network is assumed to offer a range of products (menu items) with a few common items. There is information sharing between third party restaurants and the aggregator. This includes information about order data, the restaurant's supply capacity for each of its menu items, etc. In case of standard products (branded chocolates, frozen desserts, etc.), or products where the customer is indifferent to where they are sourced from, the aggregator can decide where to source the product from. This is termed as source selection, or sub-order sourcing (Schonberger et al., 2003). This problem models vehicle routing with source selection as two separate sub-problems: the vehicle routing sub-problem, and the source selection sub-problem. We discuss about the source selection policy in detail in section 4.

Various types of food products have various storage requirements. Hence, having a compartmentalised fleet for food delivery makes sense to the aggregator. Compartmentalised vehicles have only gained attention since the past decade. The most recent paper by Kabcome and Mouktonglang (2015) deals with time constrained vehicle routing problem where the vehicles are heterogeneous, they have multiple compartments, and they carry multiple products. However, literature on compartmentalised vehicle routing, more specifically for food, is limited.

A few clear gaps have been identified in the VRPPDTW literature in the case of food service marketplaces, as observed from the literature review. In this paper, we try to address the combination of the following gaps:

- Time windows for delivery of perishable products
- Compartmentalised vehicles
- Heterogeneous mix of vehicles with compartmentalisation
- Product based pickup and delivery time windows (a few products need very quick delivery, while some need immediate pickup)
- Delivery logistics of prepared meals

4. Problem Description and Model Formulation

4.1. Problem Description

In this paper, we consider an aggregator-cum-restaurant which offers a range of products, which may or may not be produced by the other restaurants. The aggregator guarantees a minimum business to each of its partners over a time horizon. At an operational level, on a daily basis, some of the restaurants might be assigned higher priority. This means that any orders that come up that day will first be sent to the high priority restaurants.

Since the aggregator also has information of the position of its fleet, as well as the capacities of each third party restaurant; the decision of choosing the source for each product in an order is made by the aggregator. Candidate restaurants for sourcing each product are short-listed based on the minimum business guarantee criterion. Order splitting is allowed for the supply network. This means, sub-orders of an order can be picked up by multiple vehicles and delivered at a customer location. Each vehicle makes only one delivery visit to any customer location. The aggregator provides logistic support to the restaurants, aiming to minimise the route duration or the cost to the aggregator.

Routes are devised for the orders placed through the aggregator since the last iteration until the beginning of the next planning period (typically a few minutes). The routes are planned based on the order acceptance time, product preparation time, product availability at restaurants, capacity constraints of the vehicles and restaurants, and delivery time windows. Time windows are set by each member of the network. The suppliers have a time window to pick up the order, while customers have a delivery time window.

4.2. Assumptions

The preparation time for each product varies at each restaurant. If a vehicle arrives at a restaurant before the product has been prepared, then the vehicle has to wait until the food is prepared. Once the food has been prepared, packing and loading the product takes time, which is denoted by the pickup time spent by a vehicle at each restaurant. The time taken to travel from one place to another for a vehicle is denoted using the distance between two points, and the speed of the vehicle on that part of the route. This is to accommodate for the change in travel time due to traffic congestion (denoted by a lower speed) or clear roads (where speed increases).

In this paper, we have assumed the fleet to be heterogeneous, i.e., they have varying capacities. The capacity of a vehicle is measured in terms of volume of products it can contain. Hence a conversion factor is used to convert the quantity loaded into the vehicle from number of units, into the volume it occupies in the vehicle.

The vehicles start from any of the aggregator sites. The restaurants operate with service radius constraints i.e. they do not service orders that arise from customer zones that lay beyond their maximum service radius. Since each online food delivery start-up competes with the others on the delivery time front, the objective of the aggregator is to minimise the route duration of its fleet. Alternatively, the aggregator can also devise optimal routes such that the total cost incurred is minimised. We calculate cost based on the time spent by each vehicle in traversing their respective routes. The aggregator has to ensure that all the time windows and service radius constraints are respected.

4.3. Model Formulation

The objective of this model is to minimise the route duration of the entire fleet of vehicles owned by the Food service marketplace-cum-QSR. The total cost consists of a fixed cost (F) incurred per used vehicle, and a variable cost (c) incurred per unit distance travelled by each vehicle. The city has a set of demand zones (represented by Z), and a set of restaurants (represented by R). A subset of these restaurants is the set of aggregator's facilities (A), since aggregators are also quick service restaurants. There is a set of speciality items P, subsets of which are offered by each restaurant. Cat denotes the product categories. We assume that each product category corresponds to a different compartment in the vehicle. Hence the number of compartments is the same as the number of product categories.

We present a Mixed Integer Linear Programming formulation of the model (in the following page) to solve this problem.

Notations

Z: index set of customer zones- each zone is a cluster of individual demand points (customers) present in a particular location

R: index set of priority restaurant locations (as per minimum business guarantee rule)

A: index of aggregator locations

W: $R \cup Z$

K: index set of vehicles

P: index set of products offered by the network

Cat: index set of product categories

c_{ijk}: cost per unit distance of delivering orders from i to j by vehicle k

F_k:Fixed cost for using vehicle k

s_{ij}: speed of vehicle travelling from location i to location j

d_{ij}: distance between location i to location j

Ord_j: order acceptance time for order placed by customer zone j

P_{jp}: demand (per unit time) from customer zone j for product p

Q_{ip}: capacity at restaurant i for product p allocated for orders placed through aggregator

U_{pc}: product-compartment compatibility matrix

$Prep_i$: time required to prepare the longest time taking product on the menu at restaurant i

$Serv_j$: time required to serve location j (preparation time if $j \in R$, customer service time if $j \in Z$)

M: a very large number

$VCap_{ck}$: Capacity of compartment c in vehicle k in terms of volume

e_i: beginning of the time window at location i

l_i: end of the time window at location i

vol_p: quantity to volume conversion for product p

Decision Variables

x_{ijk}= 1 if vehicle k travels from location i to location j; 0 otherwise

$Pick_{ipk}$: quantity of product p picked up by vehicle k from restaurant i

Del_{jpk}: quantity of product p delivered by vehicle k to customer zone j

$TLoad_{ick}$: total load in compartment c of vehicle k while leaving location i in terms of volume

$Load_{ipk}$: volume of product p on vehicle k as it leaves location i

$TimeA_{jk}$: clock time when vehicle k leaves location j

$TimeB_{jk}$: clock time when vehicle k arrives at location j

$RDur_k$:Route duration for vehicle k

Expressions for alternative Objective Functions	
$TotalDuration = \sum_{k \in K} RDur_k$	Total route duration of the fleet
$TotalCost = \sum_{i \in W} \sum_{j \in W} \sum_{k \in K} x_{ijk} c_{ijk} + \sum_{k \in K} z_k F_k$	Total transportation cost incurred by the aggregator

Vehicle Routing Model:

Min $TotalDuration$

subject to

$$x_{ijk} = 0 \quad e_i + Serv_i + d_{ij} > l_j \quad \forall i \in W, \forall j \in N, \forall k \in K \tag{1}$$

$$\sum_{t \in W} x_{tik} = 0, d_{ji} + d_{ij} > l_j \,\|\, d_{ji} > l_i \quad \forall i \in R \cup Z, \forall j \in A, \forall k \in K \tag{2}$$

$$\sum_{t \in W} x_{itk} = 0, d_{ji} + d_{ij} > l_j \,\|\, d_{ji} > l_i \quad \forall i \in R \cup Z, \forall j \in A, \forall k \in K \tag{3}$$

$$\sum_{j \in R \cup Z} x_{ijk} \leq 1 \qquad \forall i \in W, \forall k \in K \tag{4}$$

$$\sum_{i \in R \cup Z} x_{ijk} \leq 1 \qquad \forall j \in W, \forall k \in K \tag{5}$$

$$x_{iik} = 0 \qquad \forall i \in W, \forall k \in K \tag{6}$$

$$\sum_{j \in W, j \neq i} x_{jik} = \sum_{j \in W} x_{ijk} \quad \forall i \in W, \forall k \in K \tag{7}$$

$$\sum_{i \in W} \sum_{j \in A} x_{jik} = 1 \qquad \forall k \in K \tag{8}$$

$$\sum_{i \in W} \sum_{j \in A} x_{ijk} = 1 \qquad \forall k \in K \tag{9}$$

$$\sum_{i \in A} \sum_{j \in Z} x_{jik} = 1 \qquad \forall k \in K \tag{10}$$

$$\sum_{i \in A} \sum_{j \in R} x_{jik} = 0 \qquad \forall k \in K \tag{11}$$

$$TimeB_{ik} = 0 \quad \forall i \in A, \forall k \in K \tag{12}$$

$$TimeA_{ik} + (d_{ij} / s_{ij}) * x_{ijk} - M(1 - x_{ijk}) \leq TimeB_{jk} \quad \forall i \in W, \forall j \in R \cup Z \mid i \neq j, \forall k \in K \tag{13}$$

$$TimeB_{ik} \leq M(\sum_{jinW} x_{ijk}) \qquad \forall i \in R \cup Z, \forall k \in K \tag{14}$$

$$TimeA_{ik} \leq M(\sum_{jinW} x_{jik}) \qquad \forall i \in R \cup Z, \forall k \in K \tag{15}$$

$$TimeA_{ik} \geq TimeB_{ik} + Serv_i - M(1 - \sum_{j \in W} x_{ijk}) \quad \forall i \in Z \mid i \neq j, \forall k \in K \tag{16}$$

$$TimeA_{ik} - M(1 - \sum_{j \in W} x_{ijk}) \leq TimeB_{ik} + Serv_i \quad \forall i \in Z \mid i \neq j, \forall k \in K \tag{17}$$

$$TimeA_{ik} \geq TimeB_{ik} + Serv_i + Prep_i - M(1 - \sum_{j \in W} x_{ijk}) \quad \forall i \in R \cup A \mid i \neq j, \forall k \in K \tag{18}$$

$$TimeA_{ik} - M(1 - \sum_{j \in W} x_{ijk}) \leq TimeB_{ik} + Serv_i + Prep_i \quad \forall i \in R \cup A \mid i \neq j, \forall k \in K \tag{19}$$

$$TimeB_{jk} \geq e_j * \sum_{i \in W} x_{ijk} \qquad \forall j \in W, \forall k \in K \tag{20}$$

$$TimeB_{jk} \leq l_j * \sum_{i \in W} x_{ijk} \qquad \forall j \in W, \forall k \in K \tag{21}$$

$$l_j - M(1 - x_{ijk}) \leq TimeA_{jk} + (d_{ij} / s_{ij}) \forall i \in R \cup Z, \forall j \in W, \forall k \in K \tag{22}$$

$$TimeA_{ik} + (d_{ij} / s_{ij}) * x_{ijk} - M(1 - x_{ijk}) \leq l_j \quad \forall i \in R \cup Z, \forall j \in A, k \in K \tag{23}$$

$$TimeA_{ik} \leq RDur_k \qquad \forall i \in W, \forall k \in K \tag{24}$$

$$\sum_{p \in P} Load_{ipk} U_{pc} \leq VCap_{ic} \qquad \forall i \in W, \forall c \in Cat, \forall k \in K \tag{25}$$

$$Load_{ipk} + Pick_{jpk} - M(1 - x_{ijk}) \leq Load_{jpk} \quad \forall p \in P, \forall i \in W, \forall j \in R, \forall k \in K \tag{26}$$

$$Load_{jpk} = Pick_{jpk} vol_p \qquad \forall j \in A, \forall p \in P, \forall k \in K \tag{27}$$

$$Load_{ipk} - Del_{jpk} vol_p - M(1 - x_{ijk}) \leq Load_{jpk} \quad \forall p \in P, \forall i \in W, \forall j \in C, \forall k \in K \tag{28}$$

$$\sum_{i \in R} Pick_{ipk} = \sum_{j \in Z} Del_{jpk} \qquad \forall p \in P, \forall k \in K \tag{29}$$

$$TLoad_{ick} \leq VCap_{ck} \qquad \forall i \in W, \forall c \in Cat, \forall k \in K \tag{30}$$

$$VCap_{ck} + M(1 - x_{ijk}) \geq TLoad_{ick} + \sum_{p \in P} Pick_{ipk} vol_p U_{pc} \quad \forall k \in K, \forall i \in R \cup Z, \forall j \in R, \forall c \in Cat \tag{31}$$

$$VCap_{ck} + M(1 - x_{ijk}) \geq TLoad_{ik} - \sum_{p \in P} Del_{ipk} vol_p U_{pc} \quad \forall k \in K, \forall i \in R \cup Z, \forall j \in Z, \forall c \in Cat \tag{32}$$

$$\sum_{i \in R \cup A} Pick_{ipk} vol_p U_{pc} \leq VCap_{ck} \qquad \forall c \in Cat, \forall k \in K, \forall p \in P \tag{33}$$

$$\sum_{k \in K} Pick_{ipk} \leq Q_{ip} \qquad \forall i \in R \cup A, \forall p \in P \tag{34}$$

$$\sum_{i \in R \cup A} Pick_{ipk} \geq \sum_{j \in Z} Del_{jpk} \qquad \forall k \in K, \forall p \in P \tag{35}$$

$$\sum_{k \in K} Del_{ipk} = P_{ip} \qquad \forall i \in R \cup A, \forall p \in P \tag{36}$$

$$\sum_{p \in P} Pick_{ipk} \leq M(1 - \sum_{i \in W} x_{ijk}) \quad \forall j \in R \cup A, \forall k \in K \tag{37}$$

$$\sum_{p \in P} Del_{ipk} \leq M(1 - \sum_{i \in W} x_{ijk}) \quad \forall j \in Z, \forall k \in K \tag{38}$$

$$x_{ijk} \varepsilon \{0,1\} \qquad \forall i \in W, \forall j \in W, \forall k \in K \tag{39}$$

$$Pick_{ipk} \geq 0 \qquad \forall i \in R, \forall k \in K, \forall p \in P \tag{40}$$

$$Del_{ipk} \geq 0 \qquad \forall i \in Z, \forall k \in K, \forall p \in P \tag{41}$$

$$Load_{ipk} \geq 0 \qquad \forall i \in W, \forall p \in P, \forall k \in K \tag{42}$$

$$TLoad_{ik} \geq 0 \qquad \forall i \in W, \forall k \in K \tag{43}$$

$$TimeB_{ik} \geq 0 \qquad \forall i \in W, \forall k \in K \tag{44}$$

$$TimeA_{ik} \geq 0 \qquad \forall i \in W, \forall k \in K \tag{45}$$

Model explanation and interpretation:

Objective function represents minimisation of route duration of the entire fleet. Another objective based on minimisation of total cost is presented as *TotalCost* in the list of Decision Variables and Expressions.

Constraint sets (1)-(3) ensure that vehicle routes will not violate the time window. Vehicles do not serve those locations which take longer to reach a delivery point than the closing time window of that location.

Constraint sets (4)-(5) ensure that there is at most one visit per vehicle at each location.

Constraint set (6) states that a vehicle does not visit from a location to itself.

Constraint set (7) maintains flow balance.

Constraint sets (8)-(9) state that each vehicle starts and ends at the aggregator location.

Constraint sets (10)-(11) state that the last stop before the going back to the aggregator for any vehicle should only be a demand point. This makes sure that the vehicle does not make an unnecessary restaurant visit if it does not have to deliver.

Constraint set (13) updates the time to travel from location i to location j in the route.

Constraint sets (14)-(15) state that time is updated at a location only when a vehicle visits that location.

Constraint sets (16)-(17) update the service time at each demand zone.

Constraint sets (18)-(19) update the preparation and pickup time at the restaurants and aggregators.

Constraint sets (20)-(23) enforce time windows on each vehicle.

Constraint set (24) captures the route duration for each vehicle.

Constraint set (25) restricts the load carried by each vehicle compartment to its capacity.

Constraint sets (27) and (29), and (33)-(36) match vehicle load, quantity picked and quantity delivered by each vehicle, with demand (at each customer location) and restaurant capacity.

Constraint sets (25) and (28) update the vehicle load only if a vehicle visits a location.

Constraint set (30) restricts the total load of each vehicle compartment to its corresponding capacity.

Constraint sets (21)-(32) maintain load balance in each vehicle compartment throughout the route.

Constraint sets (37)-(38) maintain load balance.

Constraints (39)-(45) define the feasible ranges for each variable.

5. Illustrative Case Example

In this section, we demonstrate the vehicle routing model in an illustrative example largely based on a food aggregator cum restaurant serving the western part of the city of Ahmedabad, India. In our illustration, the aggregator operates in two locations in the city. We consider a typical planning window during where orders arise from 5 demand zones. Demand zones are hyperlocal clusters of individual demand points/ customers. Out of all the third party restaurants in tie up with the aggregator, 32 priority restaurants are shortlisted for sourcing based on the minimum business guarantee criterion.

The orders contain products belonging to two products, each belonging to a different category. The aggregator has 2 deployable vehicles during the planning horizon. In this case we have assumed the vehicles to have 2 compartments each (corresponding to the two product categories), with a capacity of 45 units per compartment. Each restaurant has a capacity to produce 50 units of each product.

Based on the above information, the aggregator needs to decide on the number of vehicles to use, the restaurants to be visited by each vehicle, which products of an order are to be picked from which restaurants, and the demand points to be visited. Figure 1 represents the western part of the city of Ahmedabad (copyright Google maps, 2016). The distances between all the location pairs are known.

Model Operationalisation:

The window of order aggregation in our model is taken to be of the order of a few minutes. In order to effectively implement this model, a typical day can be divided into multiple time horizons. Orders are aggregated over each time horizon. This model needs to be implemented for each horizon in a day to account for all the incoming orders. Hence the model needs to be solved more efficiently and quickly. We deployed IBM CPLEX Solver to solve and experiment with the model presented.

Table 1 represents the incoming order data at a decision moment: demand location, products and quantity demanded, and the delivery time windows. The aggregator currently has two deployable vehicles with two compartments each. The capacity of each compartments is 45 units.

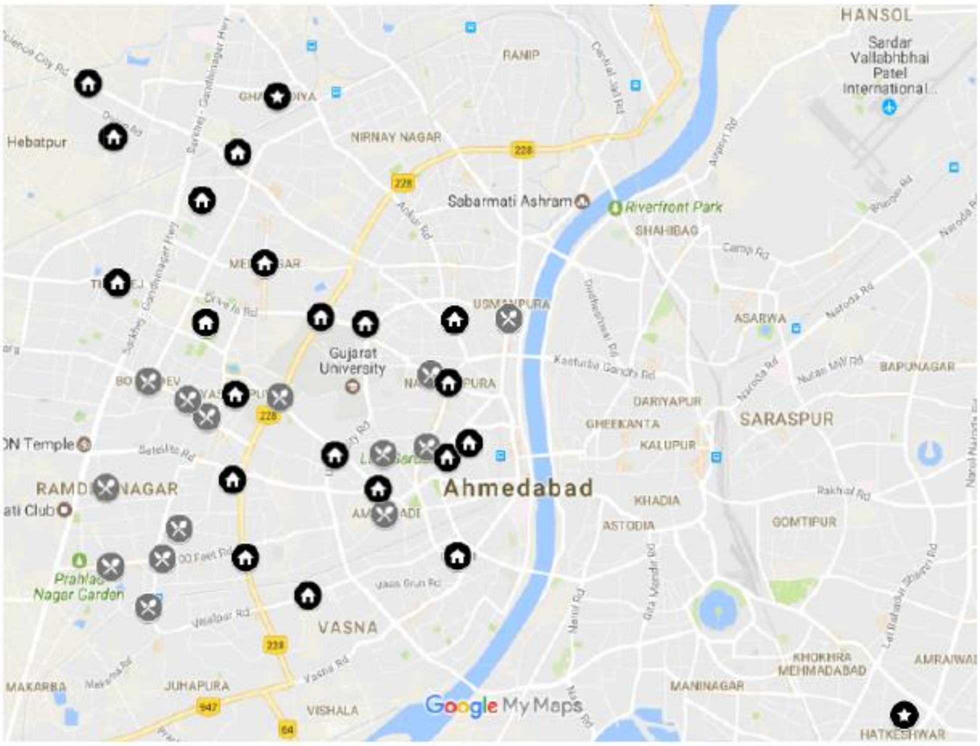

Figure 1: Map of West Ahmedabad with aggregator locations (black star), restaurant locations (grey) and demand zones (home symbols)

Table 1: Aggregated Order Data: Delivery location, Time windows, Products and Product categories

Order	Location	Products	Product Category	Quantity	Delivery time window	
					Earliest	Latest
1	Memnagar	1	1	8	0	60
		2	2	2		
2	Mithakali	1	1	7	0	60
		2	2	9		
3	Paldi	1	1	6	0	60
		2	2	9		
4	Shivranjani	1	1	0	0	60
		2	2	5		
5	Shyamal	1	1	7	0	60
		2	2	9		

We now provide the typical output of the model. The output results for the vehicle routing problem for the above illustrated example are presented in figure 2. The figure shows the optimal route, the values for pickup quantities at restaurants and aggregators, while also showing quantities delivered at the demand zones, thus distinguishing them from each other. The time spent at each location and the movement time is also captured. The results show that both the vehicles are deployed in the routing plan. The vehicle 2, is not picking or delivering any quantity at the Sattadhar location but just passes through that location for optimizing the route duration.

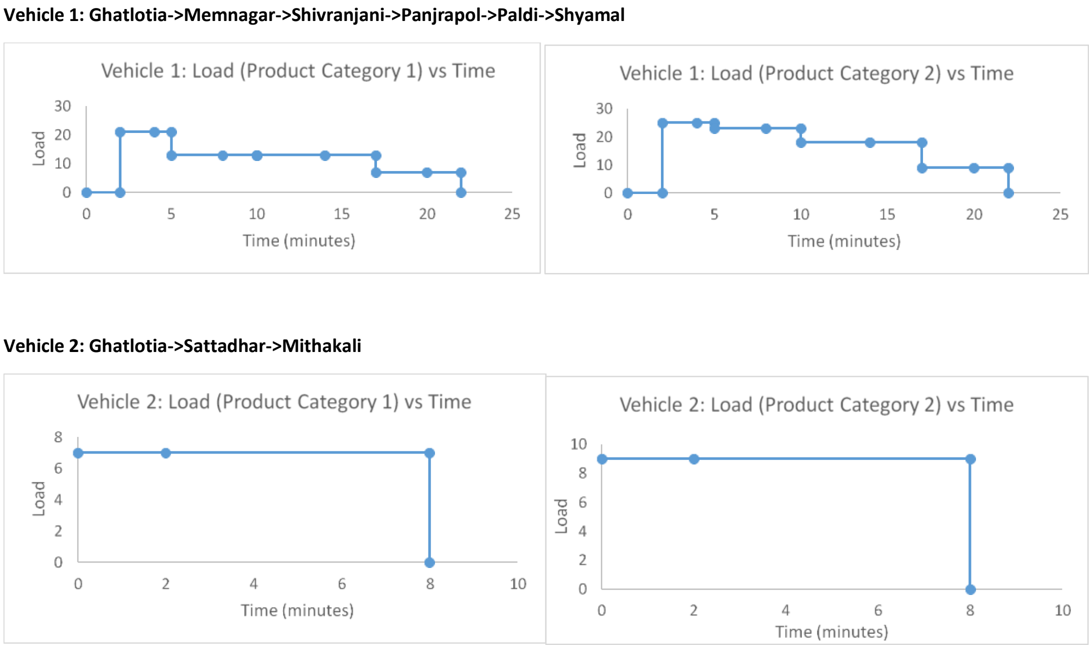

Figure 2: Optimal Route and load for Vehicles

Both the vehicles start from the second aggregator location: Ghatlotia, which is closer to the demand zones. It is observed that though the vehicles have visited a few locations, no activity has taken place. This is because the routes via these locations have reduced the total route duration. The route duration of the first vehicle is 22 minutes (which is well within the delivery window of 60 minutes) and that of the second vehicle is 8 minutes (also within the delivery window of 60 minutes). The total route duration of the fleet is 30 minutes.

7. Conclusion and Future Research

The rise in the number of online food aggregators in the world has given rise to a need for better understanding of their problems by the researchers. The main contribution of this paper is that, to the best of our knowledge, this paper is probably the first attempt at examining the operations of a food service marketplace, especially the case of an aggregator-cum-QSR. We present and demonstrate the route planning; and heterogeneous & compartmentalised fleet deployment decision model for such a company at an operational level. The illustrative case helps in understanding the implementation of the model in a real life scenario and evaluating time-cost trade-offs involved in managing the fleet deployed for food deliveries by aggregators.

Managerial Implications:

This paper provides aggregated routing possibilities as an alternative to the widely deployed Point-to-point method (single pickup and delivery) of food delivery by the restaurants and online food service industry. Although, the point-to-point delivery schemes appear to be effective in reducing the delivery time for each order, it might prove ineffective on the cost front for the service provider. Very marginal efforts are made by practitioners and researchers towards evaluation of aggregation of orders. Most order assignments to vehicles are made in real time with not much of a "look-ahead" strategy. The advantage of aggregation can be better exploited in a vehicle routing scheme that involves visits to multiple demand and supply locations. Hence, we propose our model as an alternative plan to the widely used point-to-point delivery routing.

However, further analysis is required to decide under which scenario our model would fare better than a point-to-point system, and vice versa. We have presented the results of our model with the objective of route duration minimisation. These results need to be compared with the cost minimisation objective to decide which routing strategy would prove more efficient and effective.

Future Research:

In this paper we have introduced the problem of vehicle routing for a food service marketplace involving aggregation of information about incoming orders. We proposed an alternate routing planning model than the currently existing point-to-point method. However, we have provided results for a smaller instance. For larger instances of our food delivery problem where time windows are very short, the computational time (like the VRP problems) on even faster computing machines is, practically, prohibitively large. This can be addressed by developing heuristics to solve larger instances of this problem more efficiently. The constrained programming approaches look promising as well because of their focus on getting feasible solutions quickly.

References

Azi, N., Hsu, C. I., Hung, S. F., Li, H. C., Taillard, ´ E. D., Laporte, G., Gendreau, M., 2004. Vehicle Routing for the Home Delivery of Perishable Products Problem statement. Journal of the Operational Research Society 47 (8), 465–475.

Benzi, R., 2016. Delivery Costs Are Devouring Food Startups [Web Blog Post] Retrieved Dec 31, 2016 from https://techcrunch.com

Gendreau, M., Ghiani, G., Guerriero, E., Dec. 2015. Time-dependent routing problems. Comput. Oper. Res. 64 (C), 189–197.

Kabcome, P., Mouktonglang, T., 2015. Vehicle routing problem for multiple product types, compartments, and trips with soft time windows. International Journal of Mathematics and Mathematical Sciences, 126–131.

Kocchar, S., July 2016. Why food tech in India is more than just a bubble. [online magazine] Retrieved Dec 31, 2016, from https://www.techinasia.com

Mathelinea, D., Mawengkang, H., 2016. A Capacitated Heterogeneous Vehicle Routing Problem for Catering Service Delivery with Committed Scheduled Time. International Journal on Recent and Innovation Trends in Computing and Communication (IJRITCC) (February), 85–88.

Mawengkang, H., 2016. An Integer Optimization Model for the Time Windows Periodic Vehicle Routing Problem with Delivery, Fleet, and Driver Scheduling. International Journal on Recent and Innovation Trends in Computing and Communication (IJRITCC), 126–131.

Schonberger, J., Kopfer, H., Mattfeld, D. C., 2003. A combined approach to solve the pickup and delivery selection problem, 150–155.

Venugopal, C., November 2016. Personal Interview.

Yanik, S., B.B., deKervenoael, R., 2015. A new VRPPD model and a hybrid heuristic solution approach for e-tailing. European Journal of Operational Research 236(3), 1–10.