A Constructive Heuristic for International Freight Transportation and Logistics

Ranjan Das [a,1,2], Priyanka Dahiya [a,2] , Rahul Pandey[a,b]

[a] IGSA Labs, Hyderabad (www.igsalabs.com)

[b] IIM, Lucknow

Keywords: Third party logistics, heuristics, freight consolidation, route optimization, lead time, delivery time constraints, shipping, international logistics

Abstract

International freight logistics involves several variables that are complicated, and which severely affect the distribution of freight, consequently having an impact on the efficiency and the cost effectiveness with which orders are shipped to and from different points across the globe. Freight is moved from one point to multiple points across the globe through a combination of modes like road, rail, ocean and air. Multiple origin-destination (OD) routes exist, with different network nodes in between, and the effort of logistics planning is to select routes which facilitate a cost effective and timely delivery of orders. For small to midsized companies, the most common type of freight transfer is less than capacity load (LCL). Such companies do not own any shipping fleet, and the usual norm is to consult a third party logistics (3PL) provider to achieve freight optimization at a systems level to minimize costs. 3PL providers aim to provide low cost solutions for logistic functions by consolidation of orders from different parties/customers, contractual negotiations with service providers, finding least cost routes for flow of freight etc. Our work proposes an approach which helps the 3PL providers to take decisions in real time, plan the movement of freight from origin to destination, and accommodate additional constraints which may arise at a later time. The heuristic proposed here is currently in development stage.

[1] Corresponding author: ranjan.das@igsalabs.com; ranjand2005@gmail.com

[2] Presenting authors; Presented in SOM Conference 2011 at NITIE, Mumbai.

1. Introduction

Third party logistics (3PL) is the supply chain practice where one or more logistic functions of small or medium sized firms are outsourced. A 3PL firm is an external supplier that performs all or part of the firm's logistics functions. The typical logistics functions which firms prefer outsourcing are primarily inbound/outbound freight, customs and freight consolidation/deconsolidation, warehousing, order fulfillment and distribution. Through 3PL, firms attempt to keep their operations lean and competitive. In addition to basic logistic functions, the 3PL providers also provide additional value added services like packaging and repackaging of products at different points in the network.

One of the primary objectives of the 3PL providers is to arrive at possible ways of shipping smaller freight loads at a price that reflects the size of the shipment. Transporting orders at partial load (LCL) and at full load price is cost prohibitive and is avoided. Thus, the 3PL providers aim to consolidate orders from different parties/customers to achieve full capacity load (FCL), and thus split cost of the full load between the involved parties, and in the process offer them discounts. However, consolidation is subject to a variety of factors and constraints, and may need to be revisited repeatedly at different nodes along a chosen route. Change of carrier modes along different network legs, vessel capacity and type, product types which cannot be consolidated, contractual obligations etc. are some of the factors which may affect consolidation decisions. Along with consolidation a further sub problem may be the packaging of the products (bin packing problem) along the route at different network points based on consolidation or deconsolidation decisions made. And finally, taking all the aforementioned considerations together, the 3PL provider eventually has to find one or more optimal routes which allow for least cost and timely delivery of orders. Thus, optimizing the problem to attain different objectives involves mathematical modeling of the problem, and the subsequent use of algorithms that are flexible and can be "adjusted" to take advantage of the unique problem structure which we describe below.

1.1 Literature Review

Various attempts at suitably selecting the right 3PL provider have been made using mathematical programming techniques, linear weighting techniques, statistical and probabilistic techniques.[1] provides a detailed account of the existing literature in deciding on a particular 3PL provider. Tyan et al[3] describe a mathematical programming model for evaluation of consolidation policies for freight over a selected flight leg. However, the problem does not consider the entire range of complexities that are involved in 3 PL operations and is restricted to evaluating consolidation policies over a single flight leg. Ko et al [4] propose a hybrid optimization/simulation for improving 3PL performance in warehousing and transportation services. However, all such 3PL providers own assets and can provide a limited amount of flexibility in terms of operations and cost reduction. Thus 3PL providers who do not own assets but work in conjunction with providers who own assets (also known as 4PL providers) are in a much better position to chose between options and provide the customers with a more optimized solution. Our work is focused towards optimizing the operations of such 3PL providers by providing a mathematical framework through which the 3PL provider can make an informed decision in an optimal manner. Since the logistics functions between far off nodes involve numerous complexities and a large number of real life constraints, so instead of using mathematical programming techniques, we resort to a heuristic methodology which will facilitate a solution in real time. The methodology proposed in this paper is to be implemented as a decision making tool. The proposed heuristic will provide the tool with the flexibility to be run at different stages of the supply chain

2. Problem Statement

One or more orders (belonging to the same or neighboring OD pair) are identified from a central ordering database. Accounting for commercial agreements between the 3PL provider (user) and service providers on different network legs, available network routes for the given OD pair based on the associated providers, regulations on the different network nodes forming the available routes, a list of routes are to be identified which can route the one or more orders in a cost effective and timely manner. In case of LCL, consolidation of multiple orders of the same or different customers is looked at to achieve economies of scale. All these step requirements necessitate decision making at different network points along the route.

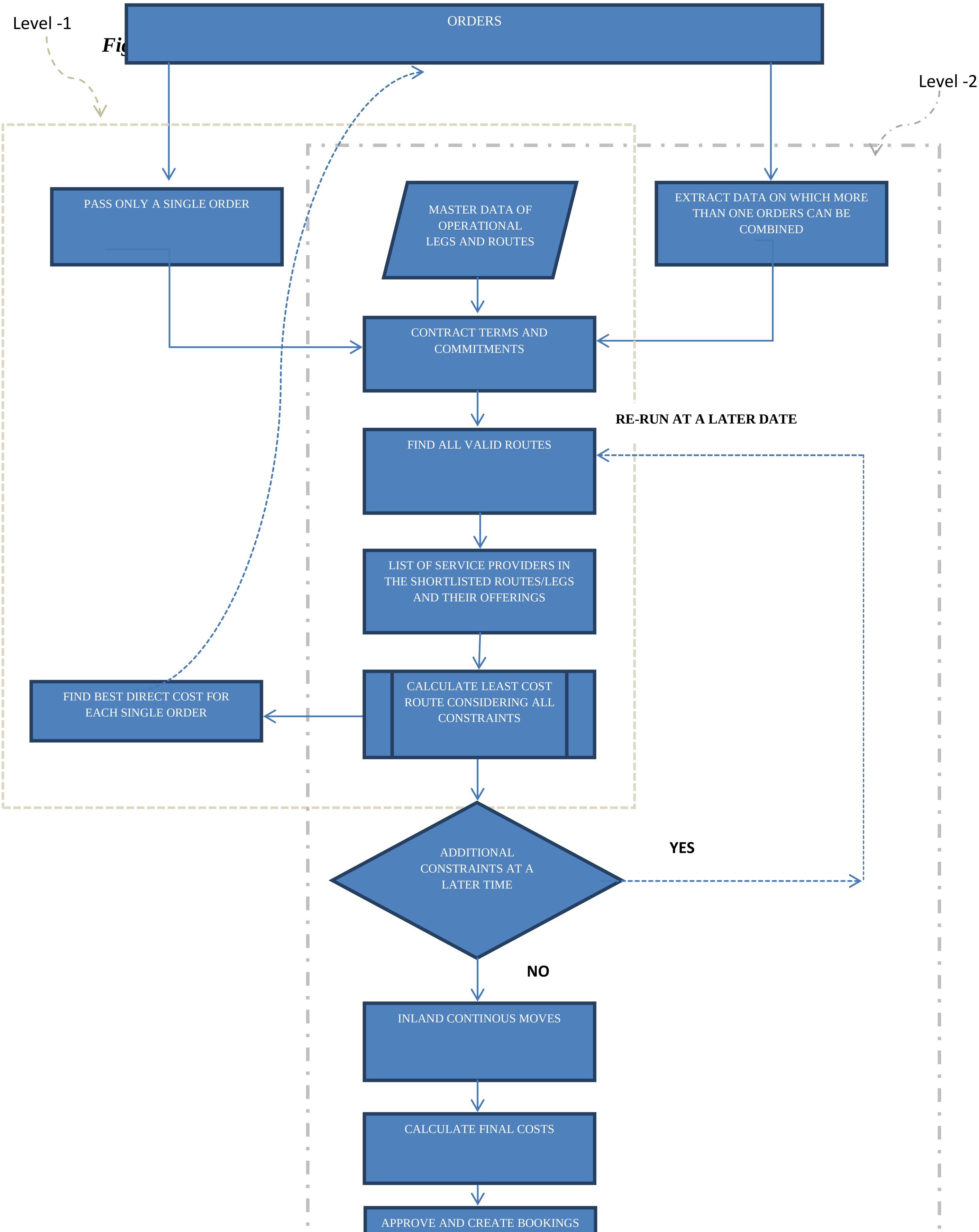
2.1 Structure of problem and involved constraints

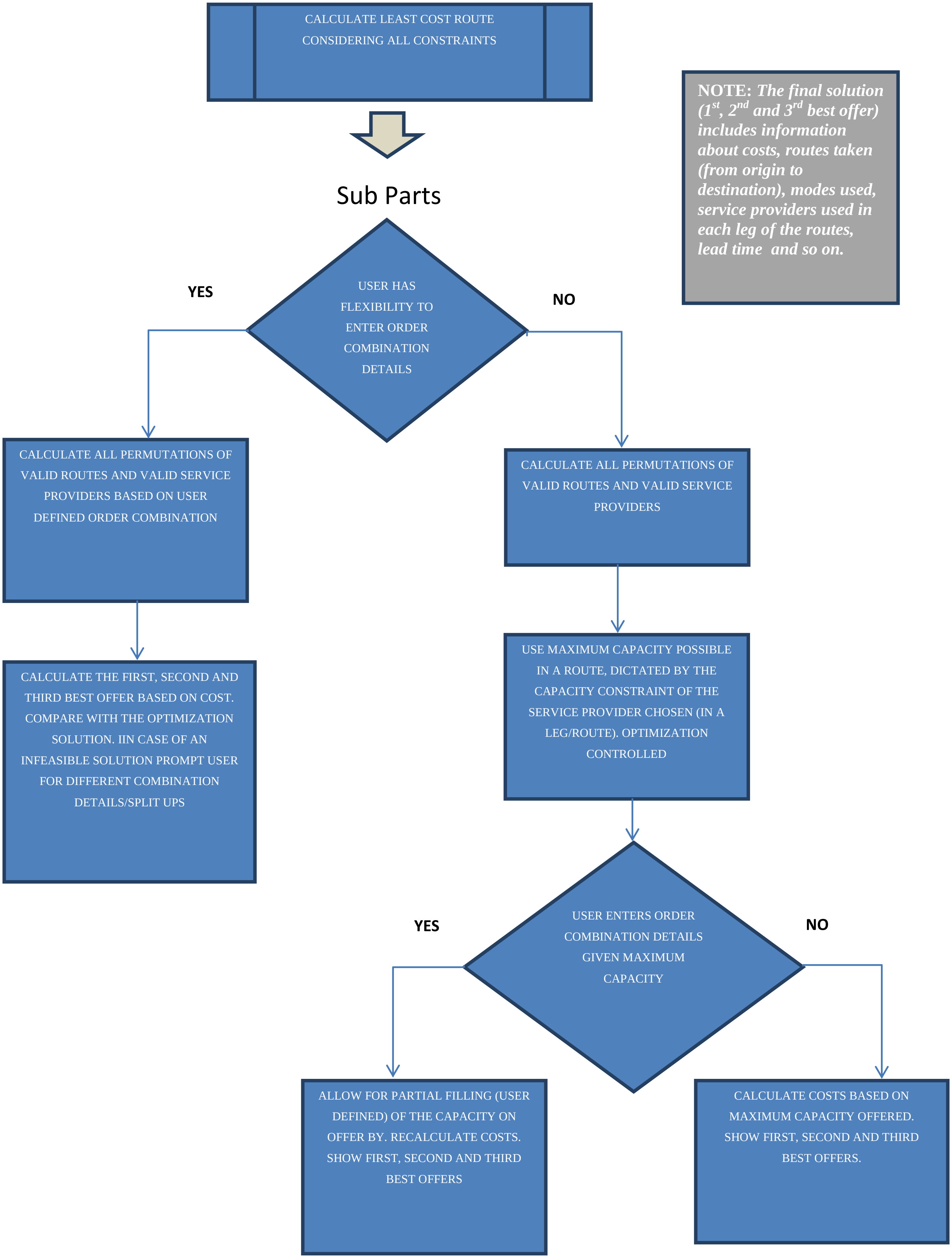
The OD pair comprises of one or more valid routes, which may be composed of multiple legs. On each leg are present a number of service providers who provide access to different modes such as land, air or sea, and associated with each mode are different costs and lead times in addition to other business specific terms and conditions. Intermediate nodes (between an OD) also facilitate consolidation and deconsolidation, and additionally involve handling cost, and time constraints depending on the mode used. Further, constraints like capacity constraints of carrier vessels, travel time constraints, calendar constraints of the intermediate nodes, location constraints, commodity constraints, commodity mix constraints, commitments and contractual obligations contribute to the entire complexity of the problem.

2.2 Methodology

Our effort at finding a workable, time efficient and near optimal solution to the above mentioned problem is best illustrated by the flow chart shown in Fig. 1 below. The flow chart explains the steps which form the core methodology of our constructive heuristic which is to be developed into a tool, capable of providing 1) A user selected parameter based solution, and 2)A complete optimization driven solution, which can then be used by the user to explore the different combinations/levels of consolidations possible. Additionally, at both levels, the tool also provides the flexibility of carrying out "what if" scenarios, where the user can change different parameters (associated with constraints) to arrive at possible feasible solutions which may be of practical interest to the user. In such cases, variation in parameters may be interpreted as how hard or soft a constraint can be to allow for feasible solutions.

The heuristic proposed here is in the initial stage of development and is likely to undergo several modifications in the process of incorporating feedback from the 3PL industry experts.


Level -1
ORDERS
Level -2
PASS ONLY A SINGLE ORDER
MASTER DATA OF OPERATIONAL LEGS AND ROUTES
EXTRACT DATA ON WHICH MORE THAN ONE ORDERS CAN BE COMBINED
CONTRACT TERMS AND COMMITMENTS
RE-RUN AT A LATER DATE
FIND ALL VALID ROUTES
LIST OF SERVICE PROVIDERS IN THE SHORTLISTED ROUTES/LEGS AND THEIR OFFERINGS
FIND BEST DIRECT COST FOR EACH SINGLE ORDER
CALCULATE LEAST COST ROUTE CONSIDERING ALL CONSTRAINTS
ADDITIONAL CONSTRAINTS AT A LATER TIME
YES
NO
INLAND CONTINOUS MOVES
CALCULATE FINAL COSTS
APPROVE AND CREATE BOOKINGS


CALCULATE LEAST COST ROUTE CONSIDERING ALL CONSTRAINTS
Sub Parts
NOTE: The final solution (1st, 2nd and 3rd best offer) includes information about costs, routes taken (from origin to destination), modes used, service providers used in each leg of the routes, lead time and so on.
USER HAS FLEXIBILITY TO ENTER ORDER COMBINATION DETAILS
YES
NO
CALCULATE ALL PERMUTATIONS OF VALID ROUTES AND VALID SERVICE PROVIDERS BASED ON USER DEFINED ORDER COMBINATION
CALCULATE THE FIRST, SECOND AND THIRD BEST OFFER BASED ON COST. COMPARE WITH THE OPTIMIZATION SOLUTION. IIN CASE OF AN INFEASIBLE SOLUTION PROMPT USER FOR DIFFERENT COMBINATION DETAILS/SPLIT UPS
CALCULATE ALL PERMUTATIONS OF VALID ROUTES AND VALID SERVICE PROVIDERS
USE MAXIMUM CAPACITY POSSIBLE IN A ROUTE, DICTATED BY THE CAPACITY CONSTRAINT OF THE SERVICE PROVIDER CHOSEN (IN A LEG/ROUTE). OPTIMIZATION CONTROLLED
USER ENTERS ORDER COMBINATION DETAILS GIVEN MAXIMUM CAPACITY
YES
NO
ALLOW FOR PARTIAL FILLING (USER DEFINED) OF THE CAPACITY ON OFFER BY. RECALCULATE COSTS. SHOW FIRST, SECOND AND THIRD BEST OFFERS
CALCULATE COSTS BASED ON MAXIMUM CAPACITY OFFERED. SHOW FIRST, SECOND AND THIRD BEST OFFERS.

The methodology is executed at two broad levels: Level 1 and Level 2. In Level 1 a single order is considered and the associated cost is calculated. In Level 2, possibility of clubbing multiple orders together is considered, and the associated reduction in costs (compared to the costs if the orders are sent as single orders) is analyzed (which should always be the case when we are considering LCL). The tool also allows for dynamic decision making, wherein it incorporates additional constraints which may be of importance at a later date. Thus, for instance a shipment of orders may have reached a certain point in the network as per the previous drawn up plan. However, a recent development forces a constraint(s) on the route of preference. The tool can be re-run at this point again and can be used to draw up a revised plan (of movement of orders from the current point to the destination) taking the new constraint(s) into account.

3. Advantages of the proposed methodology

The heuristic has been conceptualized but is yet to be tested against real life data. But it is apparent that the heuristic once developed will serve as an invaluable tool for 3PL providers in terms of the following:

1. **Flexibility on offer**

   The ability to run different scenarios, and perform "what if analysis" to identify the second best, third best and subsequent solutions in addition to the best solution available.

2. **Reduced time of execution**

   The use of the tool will cut down on the time required for gathering data, interfacing with service providers etc. Presence of a central data system and use of a structured approach at arriving at a possible solution cuts down on the time of execution of a logistics plan by a major extent.

3. **A more scientific approach to making decisions**

   The tool provides for a mathematical model which performs decision making based on a set of logic and available data rather than rule of thumb which may sometimes be way off mark, and very limited in scope.

4. **Ability to handle larger number of variables and constraints without increase in lead time**

   Use of a constructive heuristic model would mean that the model can be easily scaled up to incorporate additional inputs and constraints with minimal addition to the lead time.

4. Conclusion

Although at this point in time we do not have any test results to show, the proposed methodology clearly provides a lot of advantages to the 3PL providers as mentioned above. The heuristic should be scalable and logistics functions involving larger dimensions and variables should be easy to accommodate and the model run within an acceptable time. Thus, the heuristic provides for a much needed light weight decision making tool which can be used for strategic planning for a 3PL provider, and is at the same time flexible enough to incorporate any updated information which may affect decision making of the 3PL. This lends much needed robustness given uncertain and unforeseen disruptions and delays in the system. We are in the process of interacting with 3PL industry experts and incorporating their feedback to improve the heuristic proposed here.

References

[1] Aicha Aguezzoul, The Third Party Logistics Selection: A Review of Literature, *International Logistics and Supply Chain Congress, Istanbul (2007).*

[2] Jonah C. Tyan, Fu-Kwun Wang, Timon C. Du, An evaluation of freight consolidation policies in global third party logistics, *Omega 31 (2003) 55 – 62*.

[3] Hyun Jeung Ko, Chang Seong Ko, Taioun Kim, A hybrid optimization/simulation approach for a distribution network design of 3PLS, *Computers & Industrial Engineering 50 (2006) 440–449*.