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"The Impact of Wireless Technology in Urban Distribution Management"

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INTRODUCTION

One of the most significant paradigm shifts of modern business management is that individual businesses no longer compete as solely autonomous entities, but rather as supply chains (Lambert & Cooper, 2000). The management of multiple relations across the supply chain is being referred to as supply chain management (SCM). SCM is a business term that has emerged in the last few years and is used to describe the management of material and service flows. These include physical distribution, materials management, production scheduling, logistics, channel management, industrial logistics and logistics of distribution (Ballou, 1999).

The above Supply Chain processes can be classified in two basic categories: *a) Planning* and *b) Execution*. The basic difference between them is that, *Planning* embraces processes such as distribution requirements planning (DPR), Continuous Replenishment planning (CRP) and so on, whereas *Execution* is focused on processes such as production control, stock control, warehouse management, transportation, deliveries and logistics.

Supply Chain Management Planning comprises a traditional field of research in the area of operations management. During the last decades SC *Planning* has attracted a lot of attention due to its importance in supply chain operations. Typical results of the research include the development of various systems such as MRP I, II during the period of 60s and 70s, ERP systems during the 80s as well as integrated SC planning systems.

Although during the 90s, *Planning* has been thoroughly researched, the *Execution* operations have not received similar attention, apart from some specific issues such as stock control and picking (in warehouse management) where various back-office applications have been developed from various software developers such as "Manugistics" and "i2". As far as the distribution sector is concerned, it must be mentioned that although there are some specific software applications for real-time data exchange between the depot and the drivers there is still no system capable to provide an integrated solution in the area of distribution management and logistics.

Distribution is thus a sector that needs further research as it is an emerging area, which embraces various real-life unexpected events (from vehicle mechanical failure to traffic congestions and from unexpected demand to strict delivery windows) that seriously affect both forwarders/distributors and end-customers.

URBAN TRUCK DISTRIBUTION

Distribution is a key decision area within the logistics mix. Except for the cost of purchased goods, distribution absorbs, on the average, a higher percentage of logistics costs than any other logistics activity (Ballou, 1999).

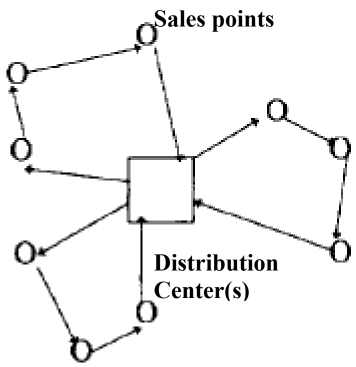
Distribution incorporates a wide range of services, all revolving around the five basic modes: water, rail, truck, air and pipeline. The selection of a mode of distribution or service offering within a mode of transportation depends on a variety of service characteristics, ranging from speed to assistance in problem solving. However, as in this newsletter we are interested in urban (city centre) distribution, we are going to analyse thoroughly the truck mode.

In first instance, in an urban environment there are mainly two ways for distributing goods when a truck is used:

Case 1: Standard Distribution – This applies to the case of a typical delivery network with 1 to N warehouses, which deliver known demand to M customers through a fleet of K trucks.

Case 2: Ex-Van –In this case we have a delivery network with 1 to N warehouses and a fleet of K trucks as in Case 1, but the major difference is that the demand of the M customers is uncertain.

In order to understand the general environment of the urban truck distribution, we will start by giving a fictitious distribution scenario, as illustrated in Figure 1. As it can be seen in this simple case, we are dealing with Standard Delivery (Case 1), there is only one distribution centre (depot), and three trucks are used in order to deliver the goods in pre-defined sales points. Each truck visits once each sale point and comes back to the depot only when it accomplishes all the daily distribution.



The characteristics of the above model include:

- Fixed geographical layout and fixed capacity of the distribution center(s)
- Fixed capacity of the fleet trucks
- Known demand per sales point and per time period (e.g. day)
- The fleet delivers only what has been ordered by the sales points
- There are fixed schedules and delivery time windows
- The truck routes are determined based on demand, network traffic, and other parameters in a near-optimal way.

Conversely, if we transform the aforementioned scenario into the Ex-Van model, the fleet trucks become "moving salespeople". The characteristics of this model are as follows:

- The sales points are not known in advance, however the total sales area is.
- Fixed capacity of the distribution centre(s)
- Fixed capacity of the fleet trucks
- Unknown demand per sales point
- Unknown schedules and delivery time windows
- The distribution of work per truck is not known as more than one vehicles may be called upon in order to cover increased demand in a given sales area (which was initially planned to be serviced by a single vehicle)

Under such conditions, the trucks can be thought of as moving warehouses that return to their base in order to replenish their inventories only at the end of the delivery period.

DISTRIBUTION VARIABLES

According to Min *et al. (*1998), there are 11 basic variables that should be taken in consideration during distribution planning. These are illustrated in figure 2:

I. Hierarchical level: There are two distinct classes of distribution. The *single stage class* is primarily concerned with both the location of facilities serving customers and the establishment of outbound delivery route around those facilities. On the other hand a *two-stage class* expand the case to consider two-layers of the production-distribution network involving both outbound (delivery) and inbound (pickup) distribution.

II. Nature of demand: There are two types of demand: *Deterministic*, where it is assumed that the nature of location/routing parameters such as demand/supply size is known and fixed with certainty and the *Stochastic* demand where an uncertain and random nature of those parameters are considered.

III. Number of facilities: There either can be a *single* facility (one depot) or *multiple* facilities (various depots).

IV. Size of vehicle fleets: Although there are two types of size, *single* and *multiple* vehicles, most of the times the fleet of a distributor consists of multiple vehicles and not just only one.

V. Vehicle capacity: There are two cases: Vehicles can be considered *uncapacitated*, which means that we do not take into account their loading capacity or *capacitated* where the loading capacity of a vehicle is taken into account and is considered as a constraint.

VI. Facility capacity: There are two cases: Facilities can be considered *uncapacitated*, which means that we do not take into account their inventory capacity or *capacitated* where their inventory capacity is taken into account and is considered as a constraint.

VII. Facility layers: There are two layers of distribution facilities: *primary* and *secondary*. A primary facility represents either the origin or destination of a vehicle journey. Some examples of primary facilities are manufacturing plants, hospitals, waste collection centres, airports, and landfills. On the other hand, a secondary facility represents an intermediate or a transhipment point such as a military depot, a warehouse, a distribution centre, a waste transfer station, a consolidation terminal, and a break-bulk terminal.

VIII. Planning horizon: In this case there are two options: In first instance we can have a *single period* where the planning of the period is made at the beginning once and is static (that means that it does not change during the daily distribution). For the case of *multiple periods*, the planning is made in a continuous mode (dynamic), which means that there is nothing predefined and everything are changing according to the current needs for distribution.

IX. Time windows: There are three options:

- *Unspecified time with n deadline:* In this case, time windows are not taken into consideration and the distribution can be made at any time of the day without predefining the exact distribution time.

- *Soft time windows with loose deadlines:* In this case, there is a predefined distribution/delivery time, which can be exceeded (deliver either a bit earlier or a bit later) but there are some penalties (e.g. the distributor sells the products in a cheaper price).
- *Hard time windows with strict deadlines:* In this case, there is again a predefined distribution/delivery time which cannot be exceeded. This means that the distributor should deliver the goods at that specific window otherwise the goods will not be accepted by the customer.

X. Objective function: It can either be *single* or *multiple*. In real-life scenarios the objective function is multiple.

XI. Types of model data: When we use data in order to model a distribution scenario (taking into account all the aforementioned variables), we can either simulate it with data that is generated by a software program or by taking real-life data that is usually stored in a database and is captured for statistics or this type of analysis.

CURRENT URBAN DISTRIBUTION MODEL AND ITS INEFFICIENCIES

According to the current (real-life) distribution model, each driver of the fleet has been handed the day's delivery schedule (which has been developed either manually or using a computerized delivery planning system). Upon commencing the delivery rounds, however, the driver is on his own, in regards to how he will handle dynamic events that could affect his schedule (such as traffic congestion, vehicle breakdown, stock levels in-transit , etc.), apart from limited communication with the base logistics staff. Therefore, possible divergence (limited or extended) from the delivery schedule is not usually handled in real-time, but is managed after the daily schedule has been completed by incorporating the necessary changes in next day's schedule.

The basic inefficiencies that the current distribution model has are mentioned below:

Case 1- Standard Delivery Inefficiencies

Usually in order for the enterprises or 3PL companies to efficiently deliver their goods there is a daily route planning of the trucks, which is based on various inputs such as the geographic distribution of the deliveries, the pre-defined delivery time-slots, the type of customer and so on. If there are no disturbances (e.g. traffic congestion, emergencies) then the delivery of the products can be successfully completed without any need for the delivery staff to communicate with the central warehouse for any further guidance. However, it is common place, that most of the times various unpredictable events occur during the delivery processes. Typical problems are:

1. **Delays in delivering times** due to traffic congestions, or because of depot overload in points of sales (e.g. queuing in delivering depots of supermarkets)

2. **Inability for the truck to follow the pre-defined time – slots (windows) of delivery** because of emergency events (e.g. traffic congestion, mechanical failure of the truck)

3. **Unexpected need for reverse logistics**. There are many cases in which customers (e.g. supermarkets) return either goods that are not appropriate for use or packaging materials (such as pallets, shelves etc) and the truck does not have enough room to respond to these requests.

Case 2: Ex Van Inefficiencies

Many companies nowadays operate ex-van sales. In such a case, a truck operates and is responsible for sales in a specific area of a city with predefined (or not) point of sales. The delivery drivers pay visits to these points of sales where they deliver as well as sell these products. The inventory of goods inside the truck can belong to either the company or the driver. In the first case the driver is just member of the staff of the company whereas in the second case he/she is an entrepreneur (he/she is the customer of the company). The usual problems that ex-van sales face include:

1. Uncertainty in various parameters (e.g. demand of goods, delivery route): This problem raises important issues in the area of planning and rescheduling. For instance let's assume that a truck has disposed its entire inventory (goods) in the first two or three points of sales due to unexpected high demand. In order not to fail fulfilling its customer needs (the remaining points of sales) another truck must be found with excess inventory which can accommodate these needs.

2. The need for the truck to have back-end connectivity with the central company systems in order to support processes such stock control, goods' returns, invoices, orders, deliveries and so on*:* This problem raises planning issues as well as information exchange issues between the delivery truck and the back-end system. For instance, if processes such as credit control can be realised in real-time then we can succeed in having increased sales and cost minimisation.

IMPLEMENTING WIRELESS TECHNOLOGIES IN URBAN DISTRIBUTION

Wireless systems can improve the current distribution model because they consist of the following characteristics (Kalakota & Robinson, 2001):

- *Real-time easy and timely access to information*
- *Ubiquity*
- *Flexibility*

- *Location finding & tracking*

The future distribution model should enrich the current model, by providing the driver with real-time support. This will aid the driver in managing dynamic unforeseen events in a systematic and timely manner, in order to minimize the impact of these events. This model can be realised through the use of mobile technologies, novel real-time decision making methods, and back-office automated processing. In addition to providing the appropriate directions to the driver, the customer base may be kept informed, in regards to all possible changes in the initial schedule, therefore improving the customer relations of the company.

The proposed wireless distribution network includes the following features:

1. **Dynamic reconfiguration of supply chains** to address in real tine unforeseen customer demand or unforeseen events (stemming from external factors)

2. **Two-way data communications** via packet-based mobile networks (GPRS).

3. **Improved fleet operations** via monitoring (and storing) certain information in real time and **rescheduling** the fleet in both typical and ex-van delivery networks.

4. **Real time collection of performance data** (working hours, on-time deliveries, etc.) which can support improved HR management

5. **Informing the customer with his/her order status in real time** using mobile networks

6. **Optimal truck utilization** for fleets that perform both deliveries and pick-ups (for reverse logistics purposes)

7. Using mobile technologies for delivering in a **hard or soft time-window environment**

8. Automating the interface between the proposed system and the company's ERP system (**back end connectivity)**.

EXPECTED BENEFITS FROM WIRELESS DISTRIBUTION MANAGEMENT

The main benefits of implementing wireless technologies in urban distribution can be divided in two categories:

Strategic Benefits

- Reduction of Fleet Costs: by either reducing the number of trucks employed in the fleet, or by better utilization of the current fleet base via advanced deployment methods
- Improved Customer Relations (CR): via the use of more user-friendly interfaces for delivery tracking and notification
- Improved Decision Making: Both real-time decision making to address unpredicted events and managerial decision making based on the collected performance history data
- Value-added Service: Taking into account all the above it can be safely stated that the proposed model will add value to the enterprise, by improving the supply chain activities, and will therefore lead to better customer service, lower costs, and improved utilization of the fixed assets and fleet.

Operational Benefits

- Improved handling of unpredicted events: Utilizing the algorithms and software that will be developed as part of the proposed model, the end-user company will be able to respond optimally to such events.
- More Service up-time: Via the utilization of potential in-truck telematic sensors, the service up-time of the trucks will be improved, since unforeseen breakdowns (and hence reduction of service time, schedule disruption, customer dissatisfaction) could be dramatically reduced
- Performance Monitoring: Driver performance could be closely monitored via the real-time metrics that will be collected continuously. This will ultimate target the identification of bottlenecks in the process, and their elimination
- Real-time Tracking: Via a new user and customer web-interface the company, as well as the customer, will be able to receive real-time information in regards to a specific delivery.
- Improved Management: In relation to the above, Key Performance Indicators (KPIs) will be identified by the end-user companies, and every effort will be made to create metric reports that will synthesize the raw data collected from the model, in a more meaningful format, therefore acting as a Supply Chain M.I.S. (Management Information System).