LOGISTICS AND PROCESS SOLUTIONS FOR SUPPLY CHAIN OF FRESH FOOD IN RETAIL

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ABSTRACT

The present research is related to the implementation and development of new platforms for fresh food and its integration in ERP systems (Enterprise Resource Planning).
This project was motivated by real industrial case and required specific customization, introducing challenging aspects due to the problem size (referring to an industrial case involving one of the most active retail company in Italy) and also to the complexity of the processes in term of interactions.

INTRODUCTION

One of the main objectives of a retail company is to increase profits guaranteeing top levels in customer satisfaction. In this sense, food represents a strategic sector; to increase margins on some specific products such as red and white meat, fruits, vegetables, frozen foods and dairy products, an effective management of the costs of logistic operations and food preparation is needed. Such an approach speedup the distribution processes guaranteeing quick response with drastic cost reduction and it allows also to increases the useful lifetime of the goods, with clear benefits.

Fig.1: Slaughter operators

Among the critical important problems affecting such kind of products it is important to mention:

- They perish fast, so the logistics processes need to be very quick
- It is difficult to avoid direct supply from providers to shops due to existing monopoly/oligopoly conditions
- It is difficult to create an efficient and optimized platform due the interaction among many logistics flows (i.e. many supplier deliveries to be divided and mixed for being shipped to much many shops)
- It is difficult to guarantees to reduce costs, due to the requirements in term of quality and time to market
- They require to keep very high profile from organoleptic quality and freshness point of view
- It is necessary to guarantee traceability of the lots of goods to be distributed.

- Some special process is required for preparing food: for instance slaughtering (as presented in figure 1) or meat cutting, packaging or event modified atmosphere packaging (MAP)

The authors' main goal was to create a control system for the logistics network, including the platform, tailored to be integrated in company ERP. In order to reach such an objective, the researchers have designed the logistics flows and the fresh food platform operation in order to be able to guarantee the respect of all the requirements previously mentioned. Different solution including cross docking, multi-drop and shuttle services have been evaluated to finalize the logistic approach in this case; the authors used M&S (Modeling and Simulation) for analyzing these alternative solutions.

THE DISTRIBUTION APPROACH

Basically, the fundamental idea for improving logistics in this application is to avoid any storage in warehouses, so this is the reason why the introduction of a platform and cross docking processes have been chosen.

Therefore cross docking is a relatively new logistics technique used in the retail sector to rapidly consolidate shipments from disparate sources and to realize economies of scale in outbound transportation. This approach allows to transfer incoming shipments directly to outgoing trailers without storing them in between. In fact, in cross dock, goods arriving from the supplier already have a final destination store assigned, so operators need only to move the shipment from the inbound trailer to an outbound trailer bound for the appropriate destination (as see in figure 2).

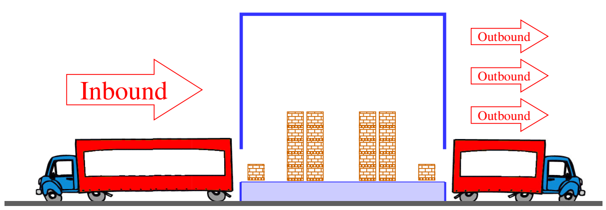

Fig.2: Cross docking example

The process is designed as shown below:

- to receive goods from suppliers,
- to assign to the shops on the basis of their requests with the use of an appropriated algorithm
- to prepare goods
- to deliver goods to sales points

All the steps are processed avoiding any stock on the platform and minimizing handling operations.

This approach allows also to maximize useful lifetime of products and to keep under control quality and safety on the basis of product traceability and acceptance control.

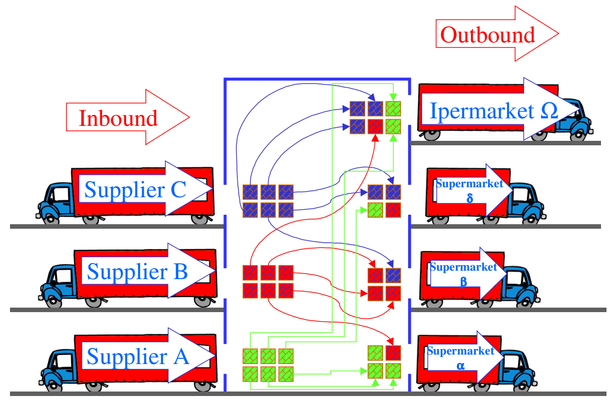

Fig.3 Logistics Flow Intersection

In this retail usually it is necessary to serve different channels (i.e. Supermarkets, Ipermarkets, Discounts, etc); so the supplier flows are mixed in order to satisfy the requirements of each store based on its format that depends on the channel, size, marketing target, region etc. In this case the scheme is synthesized in figure 3.

In addition the working processes on the products can be moved: in the red meat case for instance slaughtering, preparing and portioning as well as packaging can be moved from supplier to the platform to the final store based on the scheme summarized in table I where advantages (Adv) and disadvantages (Dis) for each alternatives are summarized.

Table I - Red Meat Processes

	Supplier		***Platform***		***Store***	
	Adv	*Dis.*	*Adv*	*Dis.*	*Adv*	*Dis.*
Slaughtering		Low Control	High Control	Medium Cost	==	Too Expensive
Portioning	Flexible Response	High Cost	Low Cost	Store Impact on Customers	Good Impact on Customers	High Cost
Packaging	Flexible Response	High Cost	Long Duration	Store Impact on Customers	Longer Duration	Impact on Customer s

The reduction of costs in introducing a logistics platform respect direct shipping to stores from retails is mostly based on the discounts that suppliers offer due to the improvement on their logistics (delivery in a single point respect a large network of destinations).

In addition this process guarantee a more effective control on the respect of delivery times.

In addition the centralization of fresh food preparation allows to improve control over these phase and to reduce costs, moving from a mere logistics platform to a more flexible platform including operations to be completed on-line without requesting real warehousing (eventually very short term storage)as summarized by figure 4.

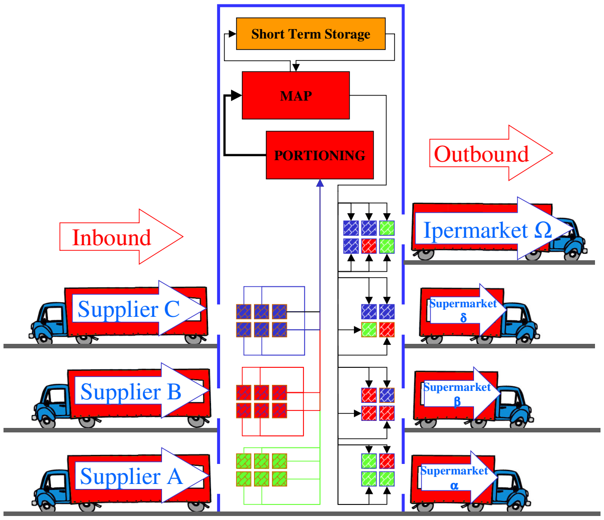

Fig.5 Example of Service Platform of Fresh Meat

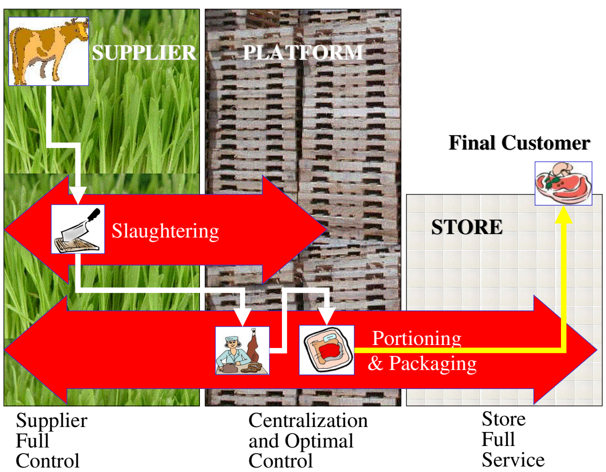

Fig.5 Moving Process along Supply Chain

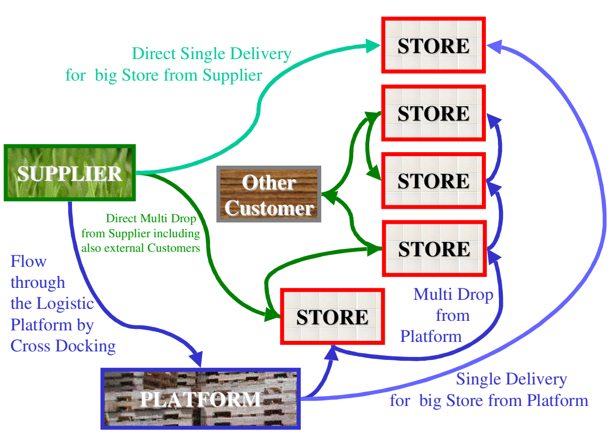

Fig.6 Different Distribution Policies

Finally, customer satisfaction increase due to the fact that products have longer useful lifetime since they don't loose days of storage, delivery is punctual and based on the original request of the shop, reducing any risk of stock out; therefore centralization for this kind of goods move to a more "industrial" process that sometime results to have a negative impact on the customers.

For instance the fact that the butcher is not more active on the store could result in the perception of a less fresh product or can result in loosing expert suggestions on the store desk for choosing and preparing meat.

These aspects deal with marketing and commercial considerations; therefore the authors currently just focus on quantitative logistics and operative aspects, while these not-quantifiable issues need to be evaluated by experts respect the obtained figures related to cost saving and process control improvements.

So the location of fresh food processes need to be fixed among possibilities in term of the general strategy decided (see figure 5) an considering related costs; while from logistics point of view this correspond to different solutions (see figure 6); for instance if all the activities are moved to the supplier, the retail operator just take care of sale activity and direct delivery can make more sense or eventually a "just logistics" crossdocking point can be considered for saving on transportation; while if the goal is to reduce also costs related to processes the platform will have probably to take care also of portioning and packaging at least.

CUSTOMERS' POINT OF VIEW

The authors' approach includes the possibility to manage successive dispatches of goods, from platform to customers, all in the same day, since the latter have limited space available to preserve goods in their coolers. The procedure is the following: the requests must be submitted in time to be received by the logistics operator and then checked and processed. To guarantee that the platform can separate the submittals according to customer needs, such submittals must be separated already during the goods request phase. The dates the goods are delivered to the customers depends on the maximum delivery time by the suppliers and are expressed by the platform in terms of ordinary submittal and delivery calendars. The proposed modeling approach also considers an additional order calendar for such fresh food, in addition to the previous one that combines platform operative times with store requirements. In order to keep under control the quantities ordered, platform operators have to use support list, taking into consideration fundamental "key words" such as product type, quantities and sales points. Such parameters are reported by ERP system where user can change distribution quantities/products (i.e. equivalent products from different suppliers) or add information and to avoid the most common operative mistakes usually related to the following issues: Product Submittal Calendar, Ordered Quantities.

MODELLING ORDERS

In the present research, the authors propose a model that includes direct orders to suppliers: in this case, a list elaboration system has been designed to support transmission of order from stores through central purchasing office to the suppliers.
Such support list system proposes quantities of goods to be ordered, considering:

- original store requests
- available stocks
- backlog orders
- late orders from the store
- assignment percentages
- market price
- special discount from suppliers

Each manager can change such proposals based on his feelings, therefore in order to keep the process under control, the logistics network needs to define rules for assignments and changes (i.e. the maximum change to an original order from a store); these policies strictly depend on the network structure (i.e. stores and platform belonging to the same company) and strategies (i.e. centralized control versus maximum store autonomy/responsibility)
The authors defined for the real a set of algorithms for correlating these factors and generating the proposal; these algorithms operates according to the product mix characteristic and prices and it determines the proposed ordered quantity for each case; for instance the aspect related to multi-supplier for the same item the following strategy is implemented:

Multi Supplier	if several suppliers are associated to the same product and not one of them is identified as the regular supplier, the algorithm assigns a share of the request from the customers in relation to a predefined percentage assigned to that supplier. The residues of the request are assigned to the suppliers for which the proposed quantity is not rounded off to a pallet multiple. Any residues are assigned to the suppliers with a lower purchase price.
Single Supplier	if a supplier is identified as the regular supplier, the algorithm assigns the quantity requested by the sales points to this one.

The overall process can be summarized as the following:
The order is estimated by forecast modesl, so the orders are created by an ERP transaction that generates reports for all the items expected to be demanded by stores and the relative suppliers.
The quantity to be ordered are estimated in order to cover the requests for the good lead time by a predictive algorithms based on a weighted mean of consumption computed over homologous days of the last five weeks and consequently reallocated over the suppliers based on specific shares and delivery calendars.
The sharing of the items among suppliers is determined by an “accumulation mode” that consider the expected ordered quantity based on previously dispatched order.
The orders are automatically submitted, via fax, EDI (electronic data interchange) and e-mail, but it is also possible to manage additional channels. Since availability level can increase or decrease based on many different factors, suppliers are often unable to fully satisfy the requests, for this reason a set of functions to manage this kind of “emergency” has been developed (i.e. extra orders to local suppliers to be delivered directly to stores).
Every day, the suppliers have to notice about unavailability of specific goods by noon, so that the proper corrective actions can be taken: redirection of part of the ordered goods to another supplier, redirection of the request to another similar reference so that the sales points can avoid stock-outs.
If an order is shifted to an unplanned supplier, the quantities delivered have to be used for covering the demand of stores that belong to last leaving mission from platform; this policy is motivated by the fact that such redirected quantities are expected to arrive at the platform among the last goods of the day (being late orders). If it is impossible to compensate the supplier stockout, these quantities unavailable need to be shared over the store network by specific algorithms; the authors developed a special module that includes possibility to manage such problems both manually and by automatic redistribution functions.
Automatic redistribution functions are based on two two different algorithms that can be combined:

- “Card Rule”: it uniformly redistributes the quantities over the sales points as cards are distributed over a deck of players; as consequence of this approach the requests of the smaller sales are usually fully satisfied with detriment of larger ones.
- “Proportional Algorithm with Minimum Threshold”: it distributes products in proportion to the original requests, guaranteeing to satisfy at least a predetermined threshold level. Applying such algorithm it is favorite the satisfaction of sales points requesting huge quantity of goods.

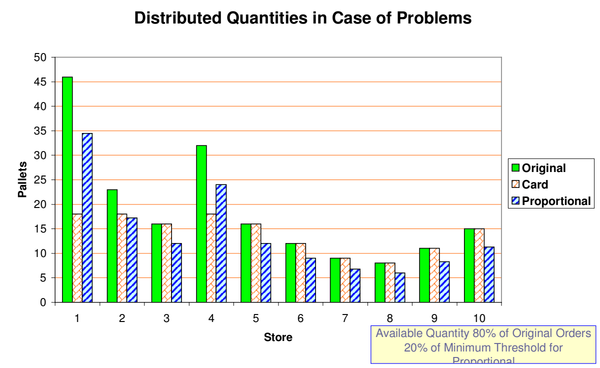

Fig.7 Example of distribution quantities reallocation

In figure 7 it is proposed the result obtained with these two criteria in an hypothetical scenario involving 10 stores.

PROPORTIONAL ALGORITHM WITH MINIMUM THRESHOLD

The Proportional Algorithm was designed in order to operate through a sequence of actions:

1: Request Threshold and Residue Determination

If $PoS_{i,j}^{Request} < Threshold_j$
$\Rightarrow PoS_{i,j}^{Request\ Threshold} = PoS_{i,j}^{Request}$

If $PoS_{i,j}^{Request} >= Threshold_j$
$\Rightarrow PoS_{i,j}^{Request\ Threshold} = Threshold_j$

$$PoS_{i,j}^{Request\ Residue} = PoS_{i,j}^{Request} - PoS_{i,j}^{Request\ Threshold}$$

$$TotalRequestThreshold_j = \sum_{i=1}^{k} PoS_{i,j}^{Request\ Threshold}$$

$$TotalRequestResidue_j = \sum_{i=1}^{k} PoS_{i,j}^{RequestResidue}$$

$PoS_{i,i}$ Good request for j-th item from i-th store
$Threshold_j$ Minimum Threshold for j-th item order

2: Indicator Calculation

$$ThresholdPercentage_j = \frac{Min(ThresholdPercentage_j ; Available_j)}{TotalRequestThreshold_j}$$

$$ResiduePercentage_j = \frac{Available_j - Min(TotalRequestThreshold_j ; Available_j)}{Total\ Request\ Residue_j}$$

$Available_j$ Quantity provided by suppliers of j-th item

If *Residual Percentage*$_j$ is greater than one, this field has to be forced to one and the extra quantities delivered remain in stock in the warehouse.

3: Threshold Assignment and Residue

$$PoS_{i,j}^{Threshold\ Assignment} = int\ (PoS_i^{Request\ Threshold} \cdot Threshold\ Percentage_j)$$

$$TAT_j = \sum_{i=1}^{k} PoS_{i,j}^{Threshold\ Assignment}$$

TAT_j Total Assigned Threshold for j-th item

$$PoS_{i,j}^{Residue\ Assignment} = int(PoS_i^{Request\ Residue} \cdot Residue\ Percentage_j)$$

$$TAR_j = \sum_{i=1}^{k} PoS_{i,j}^{Residue\ Assignment}$$

TAR_j Total Assigned Residue to j-th item
int(z) integer part of z

Subsequent to the previous assignment of quantities, residues to be assigned can remain and will be determined as follows:

$$SDT_j = Min(Total\ Request\ Threshold_j); Available_j) – TAT_j$$

$$SDR_j = Available_j - Min(Total\ Request\ Threshold_j; Available_j) – TAR_j$$

SDT_j Still to distribute $Threshold_j$
SDR_j Still to distribute $Residue_j$

4: Assignment of quantities still to be distributed

It is necessary to scroll down the list of sales points, listed according to priorities until the *Still to Distribute Threshold*$_j$ value is equal to zero.
For each sales point, the *PoS*$_i$ *Threshold Assignment* value increases by one carton, while the *Still to Distribute Threshold*$_j$ field decreases by one carton if its share was not completely satisfied (check that *Whole*$(PoS_{i,j}^{Request\ Threshold}$ *X Threshold Percentage*$_j)$ is less than $PoS_{i,j}^{Request\ Threshold}$ *X Threshold Percentage*$_j$).
After assigning the calculation residues for the threshold, it is necessary to scroll down the list of sales points, listed according to priorities until the *Still to Distribute Residue*$_j$ value is equal to zero.
For each sales points, the $PoS_{i,j}^{Residue\ Assignment}$ value increases by one carton and the *Still to Distribute Residue*$_j$ field decreases by one carton if its share is not completely satisfied (check that $int(PoS_{i,j}^{Residue\ Assignment}$ *X Residue Percentage*$_j$) is less than $PoS_{i,j}^{Residue\ Assignment}$ *X Residue Percentage*$_j$).
After assigning the residues to the sales points as previously mentioned, the total to be assigned for each sales point will be the sum of the assignment of the threshold and of the residue.

DESIGNING THE PREPARATION FROM STOCK PROCESSES

Designing the delivery procedure, it is necessary to take into consideration also the case that a lot remain in storage at the end of the last distribution. Such a lot has to be distributed to the sales points due to the heavy constraints in the expiration date for fresh foods.
In order to avoid that “old” lots could be assigned systematically to the same stores; an ad hoc algorithm have to be developed. Such distribution algorithm is based on saturation of the store request, starting from the sales points not yet served. Therefore, once the system assigns a lot to a sales point, a Boolean variable with “True” value is automatically initialized; the algorithm follows the distribution scheme and establishes a sequence of sales points to be served; before assigning the lot to the sales point, it check that the control variable value is “False” corresponding to not previous assignments of expiring products; periodically these flags are updated.
If the algorithm isn't able to redistribute all the residual product quantities on sales points with a control variable equal to “False”, the last residual quantities are distributed among the stores according to their requests and the distribution scheme, even if they already received such kind of "short life" good s.

GOODS ACCEPTANCE PROCEDURES

The deliveries are received and unloaded based on the distribution plan prepared by a ERP transaction designed in compliance with distribution algorithms
The good receiving procedures are modeled as follows:

- At the vehicle arrival a temperature check is completed and good quality inspection prepared by experts
- The goods are unloaded from the carrier
- Scanners are used to identify the different items (i.e. by EAN code) of the delivered goods
- The goods are subjected to quality check from experts
- Products managed according to variable weight are weighed and checked
- Based on the data acquired from the checks, for each single item delivered by the supplier the goods data are introduced into the system based on the purchase order and the quantity accepted in terms of packages.
- The system creates an item-supplier lot by generating the set of goods entry data.
- After weighing the reference, the same number of labels corresponding to the number of pallets comprising the supplier’s lot for the specific reference will be printed, indicating the number of packages, the total weight and a bar code with the mean weight along with a summary label indicating the number of packages and the weight of the entire lot. The labels with the mean weight are placed on each pallet.
- Based on the Load List, the goods are checked in terms of quantities to be delivered to each store.
- In case the lot delivered by the supplier, consisting of the same item, is distributed over several pallets, each single pallet comprising the lot is weighed.
- Once goods have been accepted, single-product pallets are then prepared for delivery to the stores based on distribution list
- The Load List is completed by using the results obtained from the check, dynamically integrating the planning.
-

Lot are defined and mapped with the following information:

- Item
- Supplier
- Lot Number
- Number of Packages
- Kilograms (for weight-managed goods)
- Sales Price (for priced products)
- Expiration Date

Based on the designed procedures the distribution is transmitted to terminals (based on the data acquired), and/or printed in the for each created lot; then the system upgrade the whole distribution plan utilizing an algorithm defined by the authors in the distribution division settings.
The authors identify two alternative strategies for managing last minute problems: an algorithm, based on “Saturation” of the request of sales points according to the platform scheme, or a Minimum Threshold algorithm, “Proportional” to the sales points request in relation to the quantities loaded into the warehouse.
In any case, if one part of the lot have to be stored, a label will be printed with the lot number and all its identifying information.
Finally the procedure closes with the creation of a delivery note indicating all the data entry information.
It should be noted that depending on the product, labels can have to be printed and placed on the weighed pallet. In fact, for some products, the supplier himself indicates the weight on the package.
For this type of product, if the mean weight value of the single pallet is used, there might be a significant deviation with respect to the actual weight of the single unit handled.

EXPERIMENTAL CAMPAIGN

An experimental campaign has been carried out in order to evaluate the error percentage for charging, instead of the real weight of each unit, the average weight. This data are very important modeling the process in order to tune the parameters of policies and management algorithms by using simulation.
It has been proved that this error is related to the kind of food due to its nature (i.e. poultry and rabbit may be very high) as shown in figure 8.

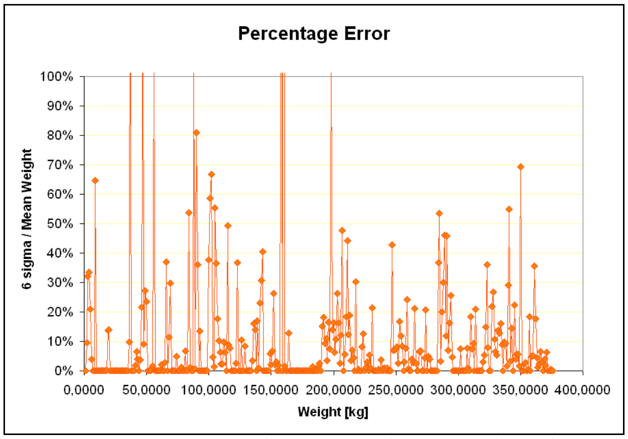

Fig.8 - Error percentage trend of mean weight versus real weight.

PREPARATION PHASE

The distribution scheme was identified based on the previous mentioned analysis.
Concerning the involvement of quantities requested for subsequent submittals, they have to be lined up after the first store request submission, since they are the last quantities to be loaded on carriers.
The procedures are the following:

- The distribution list is sent to a wireless terminal for each lot generated by the system.
- The distribution indicates the quantities to be distributed to the sales points according to the previously defined distribution scheme.
- A label indicating the pallet number is associated to each new pallet to be distributed.
- During preparation for distribution, and before assigning the quantity to the sales points, the operator has to use the wireless terminal to read the numbr indicated on the pallet and then the supplier pallet label indicating the mean weight of the pallet.
- Once the goods have been prepared, the completed distribution data is transferred from the terminals to central system.
- The warehouse operator, once the distribution data has been acquired, has to check and then confirm the data coming from the distribution terminals.
- When the differences in the distribution lists are confirmed, the system automatically adjusts the stocks, depending on the cause assigned by the operator.
- It is also possible to change or add the information transmitted through the wireless terminal.
- While confirming the distribution lists, the system must check that the module of the differences between the kilograms distributed and loaded in the warehouse, does not exceed a predetermined percentage.
- Within the percentage, the higher or lower difference must be redistributed over the sales points deliveries. The mean weight of the lot must be considered as a weight to be charged.
- The deliveries are generated once the distribution lists are confirmed.
- Once the pallets delivered to the sales points are entered, outgoing goods data are registered and the delivery notes printed.
- The printed delivery notes also indicate the number of the pallet on which the goods have been placed.

PLATFORM LOCATION

In order to reduce costs and optimize efficiency of the whole process, the researchers focused on identifying the best solution it is important to deal with multiple correlated problems:

- Supplier assignments: what kind of activity to attribute to suppliers (i.e. buying live cow, quarters, packaged meat)
- platform assignments: what kind of activity to move on the platform (i.e. slaughtering, portioning, MAP)
- Store Assignments: activities for stores (i.e. roast beef preparation or meat portioning)
- Platform Infrastructure: single platform or multiple sites, identification of best location(s)
- Management Algorithms Settings: setting for all the parameters of the above mentioned algorithms
- Logistics Planning: definition of mission for distributing meat from the platform(s) in term of sequence and frequencies, activation of shuttle services for connecting platforms, mix between hub-spoke logistics versus point to point for very big stores

The solutions need to take into account the products demands from the stores, all the boundary conditions (i.e. constraints in term of access to stores) as well as the different alternative process costs and supplier conditions.

For this purpose, a stochastic event driven simulator defined as Traffic Management Simulator (TRAMAS) already developed by the authors has been tailored for introducing all the logistics procedures as well as the food treatment processes.
TRAMAS made possible to evaluate information related to transportation, handling and work process considering the complexity of the real case that includes over 250 stores of three different sale channels over a geographic region and involving distribution of four different kind of fresh goods (meat, fish, poultry and vegetables) each one characterized by several hundreds specific items. In order to simulate all the process and to finally to identify flows integration on the same vehicles in order to verify saturation level and respect of boundary conditions focusing on accessibility and capacity. It is important to outline that several component are subjected to complex statistical phenomena that requires stochastic simulation; among the others stochastic issues includes:

- Final Customer Demand
- Store Order Demand
- Supplier Instantaneous Capability
- Delivery Time Respect
- Travelling Time along Road Network
- Product Weight Changes over the Supply Chain
- Accidents of Trucks Delivering Goods

After completing a statistical validation on the case study devoted to measure the experimental error corresponding to the impact of stochastic factors affecting the real system the model has been used for properly identify the best configuration

CONCLUSIONS

The presented approach has been tailored for a real case and the simulation results has been used to implemented it in a company including customization and parameter setting in the ERP systems and database devoted to support overall management. The development and implementation phase for the real case took about 6 months and was completely and successfully operative after that period. The solution confirmed that it possible to achieve much better control on quality of food and to reduce costs of logistic operations.
This experience showed that the "playing cards rule" (specifically requested by company users) usually don't satisfy the needs of the "strategic" stores (that usually sell major quantities), while using "Proportional with Minimum Threshold" algorithm developed by the authors was much performing respect the network needs combining smaller sales points necessities as well as largest Ipermarkets expectations.

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