# Optimizing Retail Logistics from Store Point of View

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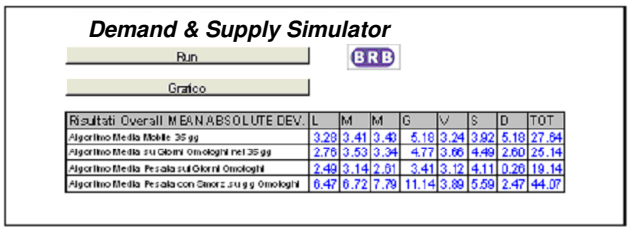
## ABSTRACT

The paper proposes the structure of an articulated Automated Inventory Management system for stores included in a retail network to be integrated in a company ERP; the system required simulation for properly design the policies and procedures and set the related parameters; the proposed case was implemented for a large retail network supporting both Ipermarkets and Supermarkets in a wide set of product categories (i.e. frozen goods, grocery, clothes etc.)

## INTRODUCTION

This work presents the logical and technical approach to realize an ERP-Integrated set of applications for managing goods in retail stores both from the point of view of quantities and values, considering all the possible phases of the process: from the order made by the store to the central warehouses or to direct suppliers, to the invoice process, passing through all movements that are possible (arrivals, selling, transfer between stores, on-store food production, wastes, claims from customers and claims to suppliers, and so on). The algorithms inside the order proposed by the system are chosen by simulating results on a baseline of historical data versus simulated data for the same period, compared with analysis technique (i.e. Mean Absolute Deviation).
The system proposed was challenging due to two main reasons; the first one is due to the size of the problem: the number of stores involved in the network is very high introducing heavy computation issues both for the real system and for the simulation, at the same time number of items to be managed (with a lot of management parameters to be customized store by store) generate an explosion in the system control.




| Risultati Overall MEAN ABSOLUTE DEV. | L | M | M | G | V | S | D | TOT |
|---|---|---|---|---|---|---|---|---|
| Algoritmo Media Mobile 35 gg | 3.28 | 3.41 | 3.43 | 5.18 | 3.24 | 3.92 | 5.18 | 27.84 |
| Algoritmo Media su Giorni Omologhi nei 35 gg | 2.76 | 3.53 | 3.34 | 4.77 | 3.66 | 4.49 | 2.60 | 25.14 |
| Algoritmo Media Pesata sui Giorni Omologhi | 2.49 | 3.14 | 2.61 | 3.41 | 3.12 | 4.11 | 0.26 | 19.14 |
| Algoritmo Media Pesata con Stessi sui gg Omologhi | 6.47 | 6.72 | 7.79 | 11.14 | 3.89 | 5.59 | 2.47 | 44.07 |

*Fig. 1: Simulating Supply and Sales Forecasts*

The second main issue is related to the necessity to design the operative procedures in compliance with company MIS (Management of Information System) and usually with ERP transactional system; this aspect introduces additional complexity not only in relation to the data availability and reliability (i.e. bath procedures for different company software synchronization that affect reliability of data along the day or along the week), but also in relation to the necessity to define procedures able to be implemented in the real MIS and with reasonable performances.

## REDESIGNING STORE MATERIAL MANAGEMENT

The innovative idea proposed by the authors is related to the fact that the store drive the inventory management along the retail supply chain getting the most up-to-date information related to effective customer demand; therefore the proposed architecture is designed as a distributed system that allows to be easily accessible by remote users, but guaranteeing best computation performances from central servers and management optimization by central management by getting opportunities and identifying synergies by merging store requests.
In our case the automated order proposal for a store network overpassing 300 sites for about 20'000 items is

very heavy computational problem; in addition it requires extensive access to historical data, effective GUI (graphic user interface) for being used by responsible working in the stores for introducing their knowledge and feelings, very user friendly interfaces for employers updating and correcting data remotely from the stores, efficient reporting for central management and executive company control, etc.
The system developed was in effect realized for a big company operating in the field of food and no-food retail, with over 350 supermarkets/ipermarkets of various dimensions. The study and the realization of the system started from some basic requirements:

- to create a set of tools able to manage all the aspects related to goods movements inside the stores (quantities and values) in order to build-up the store annual budget and economical report
- to develop all the applications centralized inside the ERP system already used for other applications by the company

The Integrated System is composed by a series of modules and functions:

- Order Proposal for goods managed by company warehouses
- Order Proposal for goods managed by direct suppliers
- Administrative Procedures for on-store operations:
    - Various kind of goods waste declarations
    - Transfer between stores
    - Transfer of goods for internal on-store production of fresh food
    - Claims from customers
    - Errors from cash barrier
    - Inventory management
    - Claims from store to suppliers (warehouses and direct ones)

In order to manage all these operations, the system needs the following input/output:

| **INPUT** | | |
|---|---|---|
| DATA | TIME/Frequency | INTERFACE |
| selling | Each night | Cash barrier to ERP |
| Warehouse Bill | Each night | ERP to ERP |
| Direct suppliers' bills | On store request | Pre-compiled based on the order released by the store |
| Administrative movements of goods | Registered by the store day by day | Data entry or file from scanning devices |

| **OUTPUT** | | |
|---|---|---|
| DATA | TIME/Frequency | INTERFACE |
| Order | According with authorization calendar | Notify from ERP to local store systems (on request) |
| Administrative movements of goods | weekly | From ERP to local Administration tools (to be substituted by ERP Integrated System) |

The transitory situation is characterized by a series of interfaces with local systems that are to be progressively substituted with ERP-integrated tools.
In order to make operations of data entry more user-friendly, it has been integrated on the system the possibility of reading data from a batch wireless barcode scanner programmed in order to collect all the necessary information.
This scanner integrates with various functions:

- Store display creation
- Stock value definition (inventory management)
- Administrative movements (transfers, wastes) with all the particular details of each movement

At the moment there is also in evaluation the possibility of integrating all the system for use on wireless terminals and on palm-PCs
In this moment the ERP-Integrated System for On store Goods Management runs on different kinds of goods (grocery, chemical products, frozen food etc.), on a network involving at present moment 5 warehouses and platforms. These numbers will grow up involving other kind of goods, other platforms and all the stores on the network, divided into IPER markets and SUPER markets and organized into three macro geographical areas.

## LOGICAL FLOW OF OPERATIONS IN THE SYSTEM

The order made by the store is somehow authorized by a calendar of possible transmissions set up by the logistic area (for warehouses) or by the commercial area (for direct suppliers). Each day each store finds in the orders proposal area only the items and the suppliers for which in that day it has the authorization to order. The system automatically pre-proposes the quantity of each item that is necessary for covering the forecasted needs considering:

- Days in which the store is authorized to send orders and related days of delivery of goods (based on lead time of each warehouse/supplier for each store)
- Days in-between the next deliveries in which the store is opened to customers

The coverage considers:

- Minimum stock to be guaranteed for each item
- Stock at the present moment
- Orders to be delivered in the next period
- Forecast of selling in the period
- Other possible correction factors to be defined by the store (multipliers, leveling factors, extra-coverage etc.)

The calculation is the following:

Stock +
Orders to be delivered –
Forecast in the period of coverage –
Minimum Stock guaranteed =

_____

**ORDER PROPOSAL**

The forecast algorithm has been chosen with the use of simulation models as decision support systems

## SIMULATION AS DSS FOR CHOSING FORECAST ALGORITHM

In order to evaluate efficiency and efficacy of different possible algorithms, it has been used a simulation model able to test all possible algorithms with different parameters. The data used for testing the forecast was an historical series of consumption (selling) data for 35 days in the past plus one week to be considered as "future" (total: 42 days) on 5'000 items.
The forecast is evaluated each day for each item for the seven days following based on the 35 days in the past.
The evaluation of performance is based on the Mean Absolute Deviation technique, according with the performance indexes used in the ERP system. The data generated by the simulation run are compared with the real data with the M.A.D. technique

$$MAD = \frac{1}{n} \sum_{i=1}^{n} \left| x_i - \bar{x} \right|$$

By simulation was possible to compare different algorithms such as:

- Moving average on 35 days
- Average of homogeneous days in the week (without weights)
- Average of homogeneous days in the week (with smoothing weights)
- Average of homogeneous days in the week (with smoothing weights, deviations and correction coefficients)

The result has led to the choice of the Average of homogeneous days in the week with smoothing weights.

This algorithm is based on the historical data of past 5 weeks starting from the present date with a scheme such as:

| ***Item. YYY*** | M | T | W | T | F | S | S | |
|---|---|---|---|---|---|---|---|---|
| week. -5 | | | | $V_{13}$ | $V_{14}$ | $V_{15}$ | $V_{16}$ | $V_{17}$ |
| week-4 | | $V_{11}$ | $V_{12}$ | $V_{23}$ | $V_{24}$ | $V_{25}$ | $V_{26}$ | $V_{27}$ |
| week-3 | $V_{21}$ | $V_{22}$ | $V_{33}$ | $V_{34}$ | $V_{35}$ | $V_{36}$ | $V_{37}$ | |
| week-2 | | $V_{31}$ | $V_{32}$ | $V_{43}$ | $V_{44}$ | $V_{45}$ | $V_{46}$ | $V_{47}$ |
| week-1 | | $V_{41}$ | $V_{42}$ | $V_{53}$ | $V_{54}$ | $V_{55}$ | $V_{56}$ | $V_{57}$ |
| Current | $V_{51}$ | $V_{52}$ | | | | | | |

*Current day: Wednesday*
*Day for Item Demand forecasts: Thursday*

In this case weighted average of the selling on the last 5 Thursday per item/sales point, is applied. The weight of each date decreases in proportion to his oldness.
Forecasts for the j-th day of the week

$$\frac{1}{5} \sum_{i=1}^{5} C_i V_{ij}$$

In this case it was used 5 as fixed value, based on a simplified hypothesis that consider this the regular value of corresponding consumption data available on the history; this assumption improve system efficiency and it is reasonable for all the items characterized by low demand. In the case of goods with high demand rates the relation it is similar therefore in this case in this necessary to properly compute effective sale days and to evaluate eventual presence of inter-week closures; due to this fact the fixed value is substituted by the real number n, properly computed, as effective number of historical data available in the dabase over the last five weeks for the corresponding day of the week requested by the forecast algorithm.
The weight are normalized in order to properly proceed in the computation by the following relation

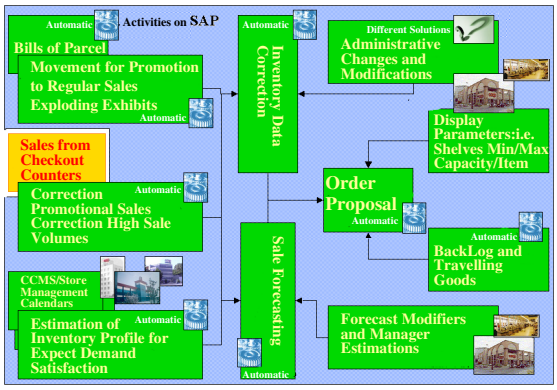
$$1 = \sum_{i=1}^{5} C_i \ .$$

In latest release of these algorithm, implemented for Retail in conjunction with Clipper Databases, the weights was predefined with the following settings moving from most recent week to the oldest:

1.0 - 0.4 - 0.3 - 0.2 - 0.1

The correction of demand is based on the mean value of sales on the corresponding days where no any promotion was active for the item under analysis .

## AUTOMATED STORE ORDER GENERATION




## OPERATION MANAGEMENT SCHEME

The following processes was simulated in order to check the effectiveness of an new Order Automated Proposal (OAP) that elaborates the quantities and it is directly integrated in the company ERP (i.e. SAP R/3 Retail™); at the same time the procedures for the Administrative Module for Order Proposal Management (AMOPM) are designed and tested on the simulator.

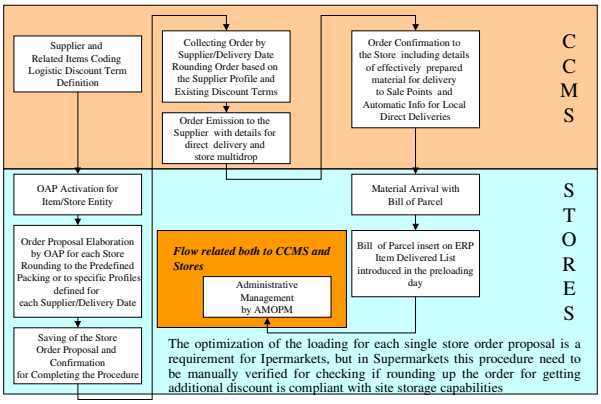
### *ORDERS TO DIRECT SUPPLIERS AND INVOCING*

The Process include the following steps:

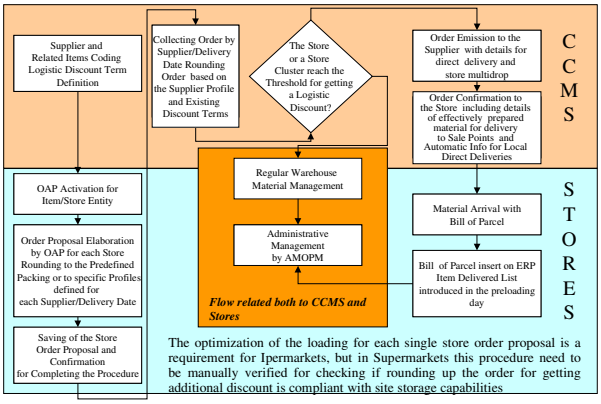
- First data insert related to suppliers in the ERP system
- Order Automated Proposal (OAP) generates the order for each Store based on available data with the same algorithms used for goods managed by the OAP through the central warehouses
- Each Store confirms the order to the Central Company Management system (CCMS)
- CCMS groups all the orders and check for possible synergies on supplier orders (i.e. reaching quantities for getting logistics or commercial discounts)
- CCMS sends to each suppliers the orders with the details for directly delivering the proper quantities to each store or for central delivery on the Central Warehouses (CW)
- The ordered quantities are confirmed by CCMS back to the Stores
- Bills of Parcel are confirmed by CCMS back to the Stores
- Eventual Claim Management
- Eventual Return of goods from Stores to CWs
- Invoice Production (extra OAP/AMOPM)

The centralization of direct delivery from supply includes all the items that usually are managed by CWs but eventually can be directly delivered by suppliers in correspondence of market or logistics opportunities.
This managerial change (from CWs to direct delivery) need to be defined in ERP Item Databases for each item/store entity.

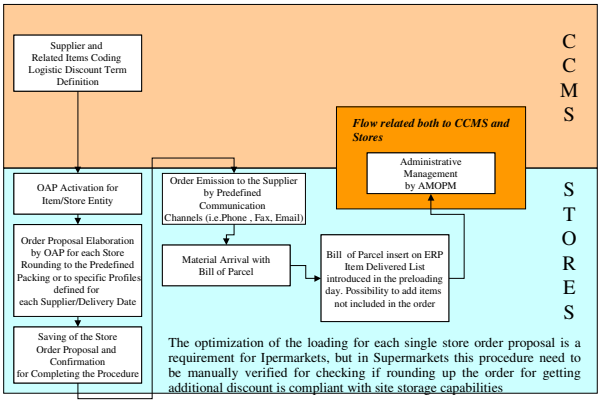
## Direct Deliveries to be Centralized



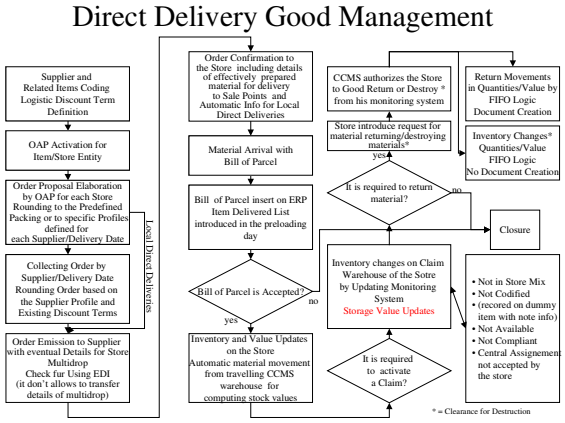

## Occasional Direct Deliveries




## Local Direct Deliveries

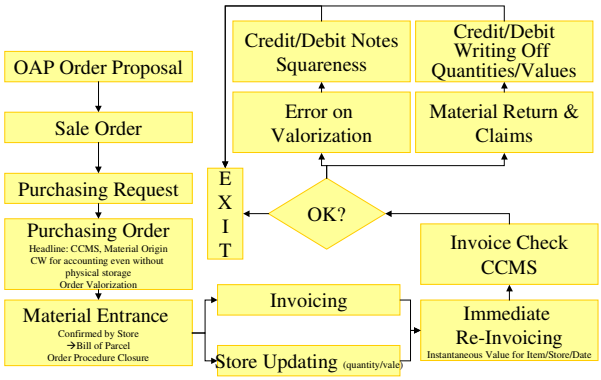


***General Operation Flow Chart***




***GENERAL LOGIC OF OPERATIVE PROCESSES***

The operative logic for direct delivery is based on the following general logic:




***Discharging Operations due to Dispersions***

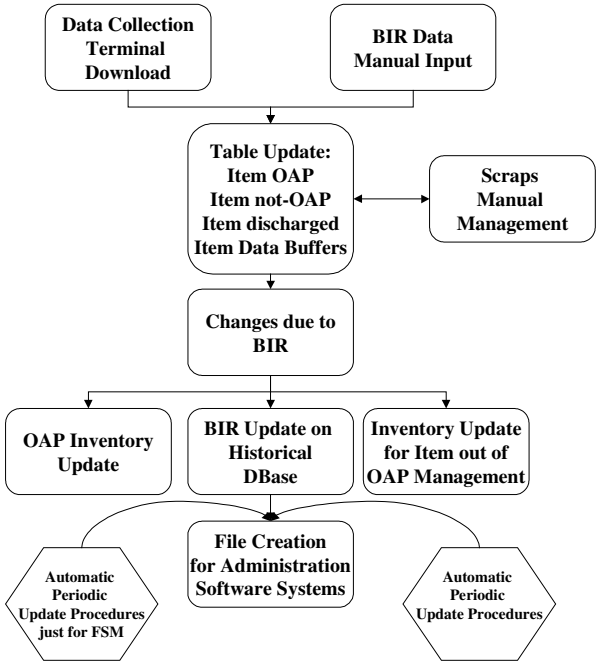
These procedures are devoted to manage case of breaking items or robberies at different management levels and includes:

- Updates on inventory levels for items managed by the OAP and by traditional ERP procedures
- Material Movement Administrative procedures
- Report creation for item breaking and robberies for the following organizational layers:
  - Store level (Summary and Detailed Reports) including just sale price for the items
  - Commercial Level (Summary and Detailed Reports) including also values accredited along supply chain and supplier price.

The changes due to breaking items and robberies (BIR) have different impact on the ERP system; in effect BIR requires:

- Correction of Inventory Levels by the OAP for the items managed by this system
- Recording inventory change due to BIR for administrative purposes and periodic generation of an automated file to be processed by central administration in order to avoid info duplication.
- Recording special causes of BIR (i.e. freezing system malfunctions FSM) for special procedures (i.e. administrative actions with insurances) can be activated as special inventory modifiers

***Operation Flow Chart***




**Material Transfer due to Internal Production activities**

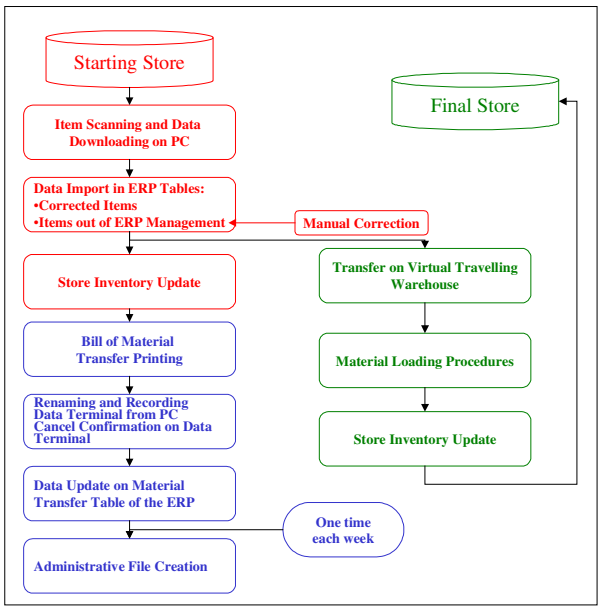
It is required to simulate also material transfer "among Stores" and "among Store Departments" devoted to support internal production activities (i.e. roast beef preparation); these activities require the following procedures:

- Administrative File Support Generation
- Inventory Level Update for Stores and Departments
- Good Value attributed based on lot values using FIFO Logic (first in first out logic).

**Transfer between Stores**

The transfer between stores is due to different motivation and involves complex logistics and administrative procedures for properly attribute the goods value; in effect in this case it is necessary to properly define the procedures in order to guarantee effective management.

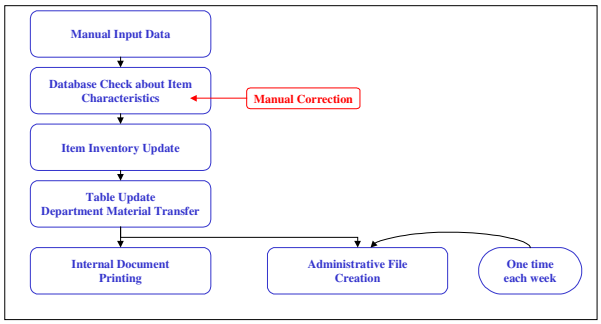
*Operation Flow Chart*




The item list to be shared is downloadable by data collection terminal or directly or can insert in ERP database directly on computers by employers

**Internal Production Transfer**

*Operation Flow Char*

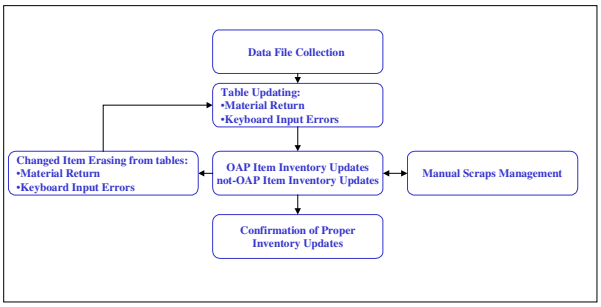



**Return from Customers and Checkout Counter Record Correction**

These procedures need to be simulated for properly check the whole life cycle of the good flows and they include among the others the following issues:

- Inventory level updated for OAP Managed Items
- Inventory level updated for Items managed by traditional ERP procedures
- Scrap Management

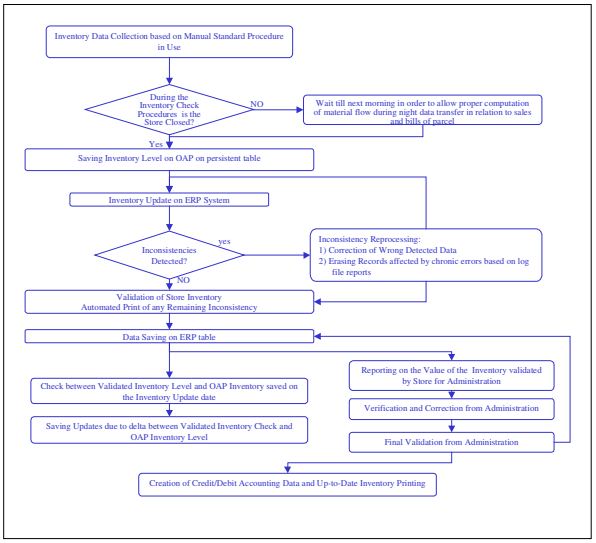
*Operation Flow Chart*




**Inventory Store Check for Material managed by ERP**

This procedure manage the material inventory activity for updating storage level for the items controlled by the ERP both with the OAP and the traditional procedures; the procedures operates applying the following policies

*Inventory Store Check Procedure*




*Claims and Material Return*

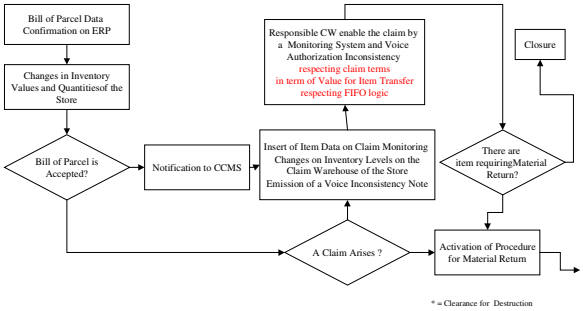
The flow char for operations in this case is based on operative team devoted to design administrative procedures and logistics procedures and includes different phases:

- Confirmation (or not acceptance) of the Bills Parcel
- Claim Management
- Material Return Management
- Invoice Production (extra OAP/AMOPM)

## *Claim Management*

***Claim Characteristics:***
- 48 hours from delivery date for grocery
- 24 h from delivery date from fresh food
- Before Promotion Start Date for Promotional First Lot Delivery

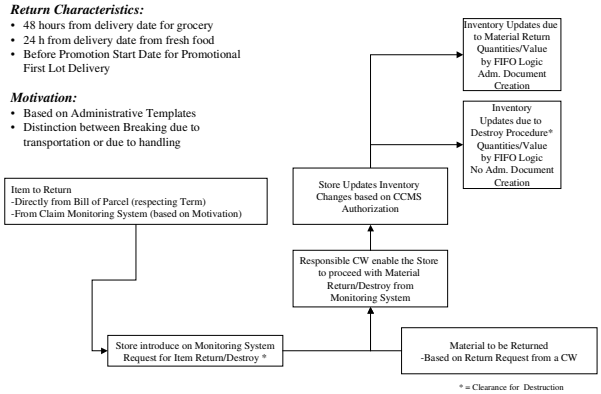
***Motivation:***
- Based on Administrative Templates
- Distinction between Breaking due to transportation or due to handling

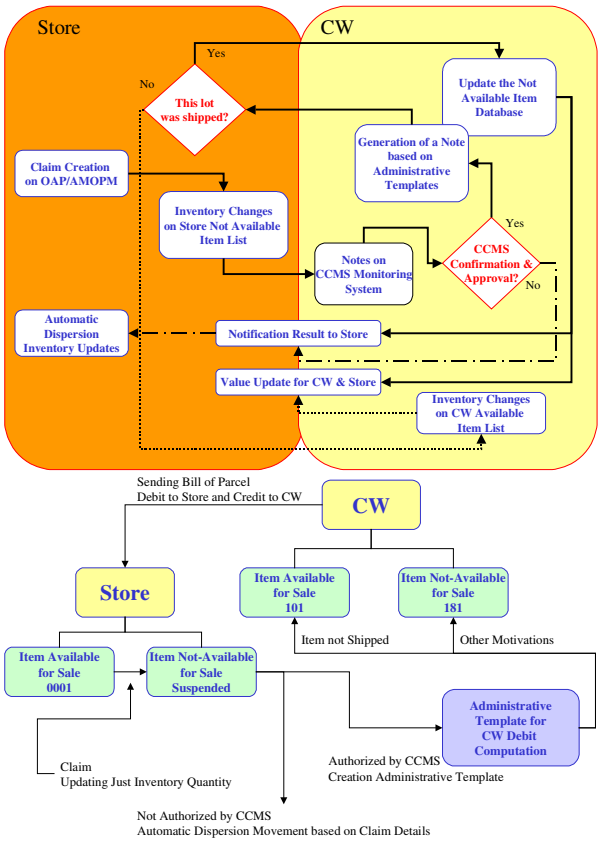



## *Material Return Management*

***Return Characteristics:***
- 48 hours from delivery date for grocery
- 24 h from delivery date from fresh food
- Before Promotion Start Date for Promotional First Lot Delivery

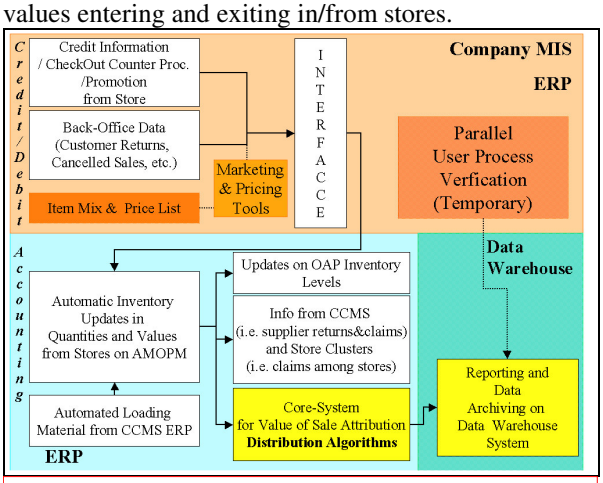
***Motivation:***
- Based on Administrative Templates
- Distinction between Breaking due to transportation or due to handling

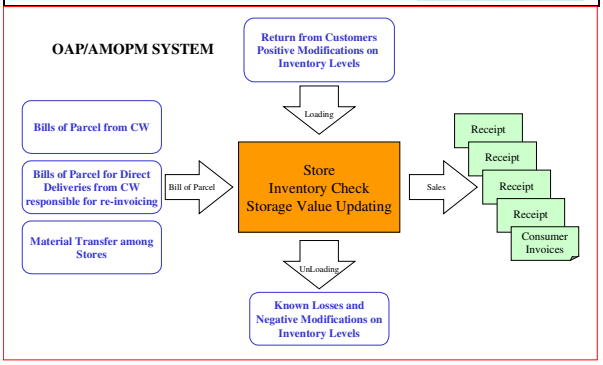


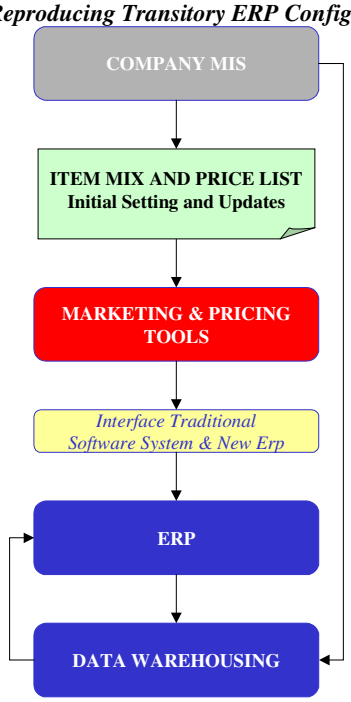

## Value of Inventory Changes for Store Budgeting

One of the main goal for this new system is devoted to develop a Knowledge Management System for consolidating store budgets by dynamic management. This goal is defined as Credit/Debit Accounting and it is developed by a real time computation of the good values entering and exiting in/from stores.

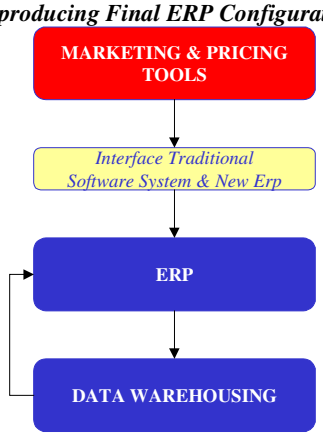



## *Procedure Reproducing Transitory ERP Configuration*



***Procedure Reproducing Final ERP Configuration***




## CONCLUSIONS

The paper propose a general architecture for managing retail networks and generates automatically store requests from ERP data; a simulation model has been developed to properly define the general architecture and the procedures.
The authors implemented some specific tailored solution for large retail companies operating over a big logistic network and currently are involved in extension programs to new business areas.

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