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THEORY AND PRACTICE OF ADVANCED PLANNER AND OPTIMIZER IN SUPPLY CHAIN DOMAIN

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ABSTRACT

This paper describes the Supply Chain Management domain of SAP. It further describes how the SAP APO, the Advanced Planner and Optimization tool set fits in the overall domain of SCM. The founding principles of APO are also presented. Various algorithms used as part of planning and optimization are presented, as well as their relationships with simulation techniques.

1 SCM DOMAIN

Supply Chain Management technology of SAP is a comprehensive tool set which provides solution not only for Supply Chain Planning but also Supply Chain Execution, Supply Chain Coordination and Supply Chain Collaboration. The support provided under each one of these technologies is given in Figure 1, titled Supply Chain Management- Architecture.

Supply Chain Planning	Supply Chain Design	Demand Planning	Supply Planning	Distribution Planning	Production Planning	Transportation Planning

Supply Chain Execution	Materials Management	Manufacturing	Order Promising & Delivery	Warehouse Management	Transportation Execution	Foreign Trade/Legal Services

Supply Chain Coordination	Supply Chain Event Management	Supply Chain Performance Management	Fulfillment Coordination

Supply Chain Collaboration	Supply Chain Portal	Collaboration Processes	Supply Chain Integration

Figure 1: Supply Chain Management Architecture

The placement of this functionality in a full service systems' landscape is as shown in Figure 2.

All the support available from the Supply Chain Planning technology is provided in Figure 3. Also given are the section numbers for each line item, for easy referencing.

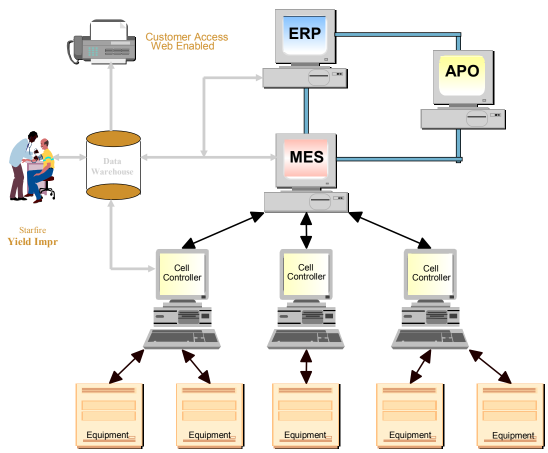

Figure 2: Systems Landscape Architecture

Supply Chain Design
- **Supply Chain Cockpit- 5.1.1.1**
- **Strategic Planning- 5.1.1.2**

Demand Planning
- **Statistical Forecasting- 5.1.2.1**
- **Causal Forecasting- 5.1.2..2**
- **Composite Forecasting- 5.1.2.3**
- **Promotion Planning- 5.1.2.4**
- **Life Cycle Planning- 5.1.2.5**
- **Collaborative Demand Planning- 5.1.2.6**
- **Characteristic-Based Forecasting- 5.1.2.7**
- **Kit Planning- 5.1.2.1**

Supply Planning
- **Supply Network Planning- 5.1.3.1**
- **Safety Stock Planning- 5.1.3.2**
- **Heuristic- 5.1.3.3**
- **Capacity Leveling- 5.1.3.4**
- **Optimization- 5.1.3.5**
- **Demand & Supply Match- 5.1.3.6**
- **Collaborative Supply & Distribution Planning- 5.1.3.7**

Distribution Planning
- **Distribution Resource Planning- 5.1.4.1**
- **Deployment- 5.1.4.2**
- **Transport Load Builder- 5.1.4.3**
- **Replenishment- 5.1.4.4**
- **Vendor Managed Inventory- 5.1.4.5**
- **Collaborative Supply & Distribution Planning- 5.1.4.6**

Production Planning
- **Production Planning- 5.1.5.1**
- **Detailed Scheduling- 5.1.5.2**
- **Capable-To-Match- 5.1.5.3**
- **Materials Requirements Planning- 5.1.5.4**

Transportation Planning
- **Collaborative Shipment Forecasting- 5.1.6.1**
- **Load Consolidation- 5.1.6.2**
- **Mode and Route Optimization- 5.1.6.3**
- **Carrier Selection- 5.1.6.4**
- **Collaborative Shipment Tendering- 5.1.6.5**

Figure 3: Supply Chain Planning Functionality

It would be clearly beyond the scope of this paper to write even the overview of the tool set pertaining to Supply Chain Execution, Supply Chain Coordination and Supply Chain Collaboration. However the pertinent details of Advanced Planning, Scheduling and Optimization, the candidates that is the basis of simulation technology, is given below.

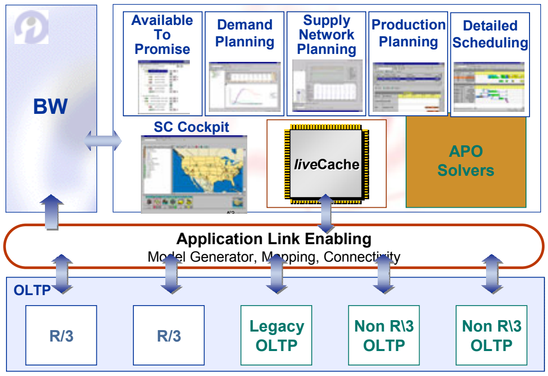

Figure 4: APO Functionality

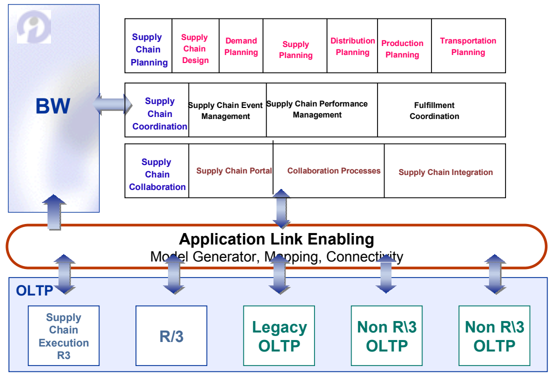

Figure 5: SCM and APO Architecture

2 ADVANCED PLANNER AND OPTIMIZER

The APO technology, most of whose functionality is given in Figure 3 is architecturally given in Figure 4, above.

In Figure 3, BW is Business Warehouse, OLTP is On Line Transaction Processing and R3 stands for SAP's ERP.

Supply Chain Planning layer of Figure 5, is shown by the top right hand block of Figure4. The names of various modules and their detailed descriptive sections are given in Figure 3. However, Solvers contain the Optimization models where as LiveCache contains the data sets for the Solvers to work upon. The LiveCache communicates with BW as well as other OLTP systems to get upto date data to operate upon. The datasets for results and reports are provided by the BW. More on these aspects are given in Section 5.

The relationship of all the SCM modules is given in Figure 5. Here the detailed top right hand side of the block of Figure 4 is replaced by 3 blocks of SCM modules, which are Supply Chain Planning, Supply Chain Coordination and Supply Chain Collaboration. These are more advanced functionalities. Notice, supply Chain Execution block is given in the bottom left hand side in Figure 5. This block replaces one of the R3s that previously had a copy of ERP. This should go to illustrate the fact that this functionality is of legacy nature.

3 FUNDAMENTAL PRINCIPLES OF APO AND SCM

The basic problems of Planning and Scheduling stems from the requirements to compute in a multi product family the requirements for Material, Manufacturing, Distribution, Customers etc., as given in Figure 6. This is further required to be done at the Corporate, Plant and Shop Floor level.

The process flow for the full SCM functionality can be as given in Figure 7.

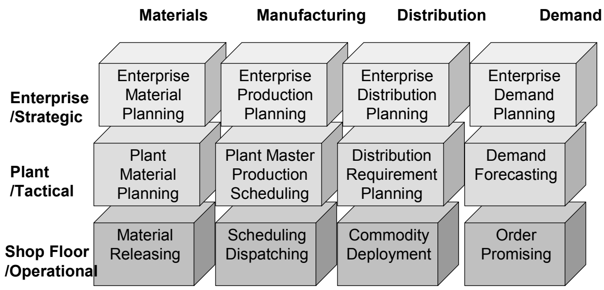

Figure 6: Basics of SCM Functionality

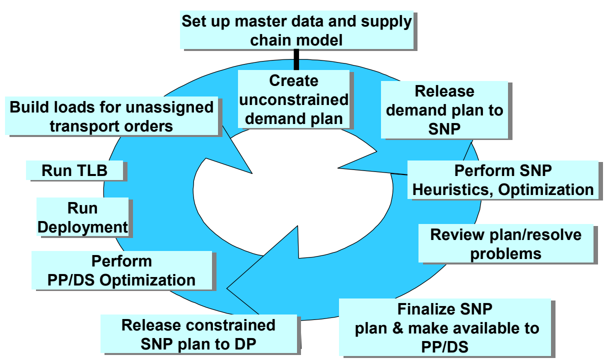

Figure 7: Work Flow in SCM

Some acronyms that are used in Figure 7 are:

- SNP- Supply Network Planning
- PP/DS- Production Planning and Detailed Scheduling
- DP- Demand Planning
- TLB- Transport Load Builder.

Refer to Figure 3 for section numbers where details to these tools are given.

Today's most volatile battle cry in the field of SCM is contained in "Adaptive and Collaborative Supply Chain Management". The reason for its existence is perhaps best represented in Figure 8. It illustrates that there is a natural gap between the Plans and Actual situations as they exist at

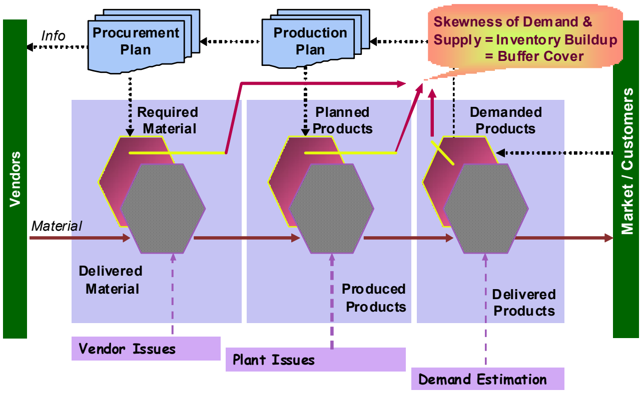

Figure 8: Supply Chain Paradox

every step of the process. This gap is what needs to be controlled and driven to zero.

4 SOLVERS, ALGORITHMS AND SIMULATION

APO functionality is shown in Figure 4. It is supported heavily by Solvers. These are shown in Figure 9. Solvers are advanced algorithms based on Optimization models which mostly are built with deterministic simulations. The entire suite of Supply Chain Planning modules provide support for deterministic simulation technology in optimization, scheduling forecasting and scenario analysis. Transactional simulations are done for scenario analyses. Various algorithms that have gone to support the Solvers, are given in Figure 9. Discrete event based simulation is not explicitly used in APO. But the concepts are applied in deterministic framework for development of schedules in some of the algorithms. Perhaps that is why APO delivers more deterministic results. Perhaps it is worth the mention that:

- Distribution Planning is based on Flow Algorithms.
- Deployment functionality is based on Branch and Bound algorithms.

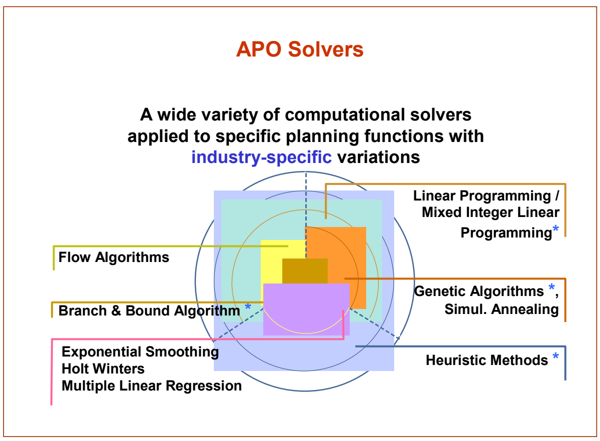

Figure 9: Solvers and Algorithms

- Demand planning sub modules use Exponential Smoothing, Heuristic, Holt Winters and Multiple Regression Analysis methodologies.
- Production Planning modules use Linear Programming and Mixed Integer Linear Programming.
- Detailed Scheduling modules are based on Genetic Algorithm and Simulated Annealing based optimization technology.

A reason so many solvers are used is because there is not one algorithm which performs equally well for all class of problems. Thus Simulated Annealing which provides a better quality of solution is CPU intensive. So to solve this problem Genetic Algorithms are used.

5 SUPPLY CHAIN MANAGEMENT DETAILED

5.1 Supply Chain Planning

This is the technology that is based on Solvers, Algorithms and Simulation. Though it must be mentioned up front that the Optimization Models used here are primarily on deterministic simulation themes. Scenario planning and scenario analyses are used extensively and all the tools and facilities are there if discrete event simulation modeling is desired to be done at some point in the life cycle of the project.

5.1.1 Supply Chain Design

5.1.1.1 Supply Chain Cockpit

Supply Chain Cockpit (SCC), an SAP Advanced Planning and Optimization (APO) application, consists of a highly intuitive, graphical interface that acts as the top enterprise planning layer covering all planning areas such as manufacturing, demand, distribution, and transportation. All employees in the Plan →; Source →; Make →; Deliver cycle of supply chain management can use it to their advantage. As the gateway to APO, the SCC makes dealing with a vast supply chain easier and more manageable. SCC allows you to:

- Create individual work areas so several planners can work simultaneously on different parts of a supply chain.
- View the supply chain from all angles, down to the smallest detail, to minimize the complexity of the relationships among supply chain components
- Retrieve information from the APO system through queries
- Measure supply chain performance with KPIs (key performance indicators) that are stored in the Business Information Warehouse (BW)
- Respond immediately and accurately to new developments by tracking alert situations.
- Retain flexibility in your decision-making process.

- Provides access to a rich collection of data for doing discrete event simulation.

The SCC can be configured to suit conditions within a wide variety of industries and business situations.

5.1.1.2 Strategic Planning

Strategic planning is the key element in a company's long-term success and has a critical impact on its future. Fast-changing market demands and short product life cycles force enterprises to continuously evaluate and optimize their supply chains. Companies have to use marketing and financial plans as a basis for deciding on the sourcing, production, and distribution of products to meet customer requirements at competitive costs. As strategic decisions are linked to costs, it is difficult to change them at short notice. It is therefore vital that companies make their long-term decisions carefully, achieving a long-term cost-effective and profitable solution to guarantee the company's effectiveness.

The following features support strategic planning problems:

- Network Definition: Networks used in demand planning, as well as in supply network planning, reflect a company's supply chain.. It can be used for feeding into simulation models. Planning can be executed based on this network. One can model every part of the supply chain (such as locations, transportation lanes, resources, products, and production process models) using the Supply Chain Engineer. The Supply Chain Engineer allows you to place locations on a map and link them with the corresponding transportation lanes. The direction of the lanes determines the product flow. Using the Supply Chain Engineer, one can drill down to all elements belonging to the supply network. Further, information about single or combined elements in the network, can be requested. For example, one has the ability to see which products belong to a particular location. Products can also be added to this location or modify the locations master data.
- Alerts: The Alert Monitor is a stand-alone component of APO that enables a unified approach to monitor planning situations. It notifies you of any critical situation occurring in one of the APO applications, such as Demand Planning and Supply Planning, Production Planning, and Detailed Scheduling, or Transportation Planning and Vehicle Scheduling. Alerts are displayed in various ways, either directly in the Supply Chain Cockpit, in the cockpits control panel, in the application, or through email. Using a series of event triggers and alarm conditions, the Alert Monitor can automatically identify problems in the supply chain. It can also monitor material, capacity, transportation, and storage constraints. In addition, it can handle metrics such as delivery performance, cost flow, and throughput. It reports exceptions, including orders that exceed forecasts or orders that fall short of forecast and therefore may lead to excess inventory if production is not adjusted accordingly. Based on this monitoring process, one can readjust plans whenever needed.

5.1.2 Demand Planning

5.1.2.1 Statistical Forecasting

Statistical or univariate forecasting predicts future demand based on historical data. As opposed to causal forecasting, other factors are not taken into account. Univariate forecasting provides methods that recognize the following time series patterns as a basis for the forecast. Univariate forecasting provides methods that allow you to forecast the following time series patterns. Constant demand varies very little from a stable mean value. Trend demand falls or rises constantly over a long period of time with only occasional deviations. Seasonal demand has periodically recurring peaks that differ significantly from a stable mean value. Seasonal trends have periodically recurring peaks and troughs, but with a continual increase or decrease in the mean value. Intermittent demand is sporadic. If there is no change from previous years, no forecast is carried out; instead, the system copies the actual data from the previous year.

5.1.2.2 Causal Forecasting

Multiple Linear Regression (MLR) enables you to include causal variables (like climatic conditions, price, advertising) in the forecasting process. MLR investigates the historical influence of these variables on demand to produce a forecast. Simulation scenarios, can be set up, for causal variables to show possible developments taking possible risks and opportunities into account.

5.1.2.3 Composite Forecasting

This function combines forecasts from different individual forecasts (statistical or causal forecasts) for a particular brand, product family, or product. Each individual forecast is based on the same historical data but uses a different technique. The underlying objective is to take advantage of the strengths of each method to create a single "one number" forecast. One can average the forecasts giving each one equal weight, weigh each one differently, or vary the weightings of each forecast over time.

By combining the forecasts, the business analyst's objective is to develop the best forecast possible. The composite forecasts of several methods have been proven to out-perform the individual forecasts of any of those methods used to generate the composite.

5.1.2.4 Promotion Planning

In APO Demand Planning, one can plan promotions or other special events separately from the rest of your forecast. Use promotion planning to record either one-time events, such as the millennium, or repeated events such as quarterly advertising campaigns. Other examples of promotions are trade fairs, trade discounts, dealer allowances, product displays, coupons, contests, free-standing inserts, as well as non-sales-related events such as competitors' activities, market intelligence, upward/downward economic trends, hurricanes, and tornados.

The effect of a promotion is calculated using causal techniques to measure past promotional impact and is projected into designated periods in the future. Manual adjustments to a promotion are made in future periods for planning purposes to reflect new merchandising strategies.

5.1.2.5 Life Cycle Planning

A product's life cycle consists of different phases: launch, growth, maturity, and discontinuation. In this process, you model the launch, growth and discontinuation phases.

A phase-in profile or a phase-out profile for a product or other characteristics, can be defined. A similar function is "like" modeling, which allows one to use the historical data from one product to forecast the demand of another product.

5.1.2.6 Collaborative Demand Planning

Collaborative Demand Planning between manufacturers and their distributors allows both partners to streamline their work processes and ultimately benefit from a more accurate forecast, better market transparency, greater stability, reduced inventory, and better communication. Starting from one forecast, all the partners collaborate to produce a final forecast, which becomes the basis for all further planning in the partner companies.

The APO solution implements the Collaborative Planning Forecasting and Replenishment (CPFR) process that is a cross-company and cross-industry scenario developed by the Voluntary Interindustry Commerce Standards (VICS) association.

5.1.2.7 Characteristic-Based Forecasting

In SAP APO Demand Planning one can create a forecast based on the characteristics of configurable end products; for example, based on the characteristics --color, engine, and air conditioning-- of the end product --car. Moreover, one can forecast the demand for a combination of several characteristics, thus taking into account the mutual interdependency of the demand for these characteristics.

Characteristics-Based Forecasting allows you to forecast many different variants of the same product and react swiftly to changes in market demand. Orders can also be placed with your suppliers for assemblies and components in a timely fashion.

5.1.2.8 Kit Planning

As well as planning demand for a product, one can also forecast dependent demand at different planning levels by exploding bills of material.

This can be used for a kit that consists of several finished products (that can also be sold separately). Planning demand for the kit generates dependent demand that can be combined with the independent demand for the single products. The overall demand by product can then be used for supply, production, and procurement planning.

5.1.3 Supply Planning

5.1.3.1 Supply Network Planning

SAP APO Supply Network Planning integrates purchasing, manufacturing, distribution, and transportation so that comprehensive tactical planning and sourcing decisions can be simulated and implemented on the basis of a single, global consistent model. Supply Network Planning uses advanced optimization techniques, based on constraints and penalties, to plan product flow along the supply chain. The results are optimal purchasing, production, and distribution decisions; reduced order fulfillment times and inventory levels; and improved customer service.

Starting from a demand plan, Supply Network Planning determines a permissible short- to medium-term plan for fulfilling the estimated sales volumes. This plan covers both the quantities that must be transported between two locations (for example, distribution center to customer or production plant to distribution center), and the quantities to be produced and procured. When making a recommendation, Supply Network Planning compares all logistical activities to the available capacity.

The Deployment function determines how and when inventory should be deployed to distribution centers, customers, and vendor-managed inventory accounts. It produces optimized distribution plans based on constraints (such as transportation capacities) and business rules (such as minimum cost approach, or replenishment strategies).

The Transport Load Builder (TLB) function maximizes transport capacities by optimizing load building.

In addition, the seamless integration with APO Demand Planning supports an efficient SOP process.

In Supply Network Planning, you are provided with standard planning books (and views) for each of the various types of planning available (that is, interactive SNP, Sales and Operations Planning (SOP), Distribution Resource Planning (DRP), Transport Load Builder (TLB), Vendor Managed Inventory (VMI) and Scheduling Agreement Processing). You can, however, create your own planning books, using standard planning books as templates when you create your own planning books.

5.1.3.2 Safety Stock Planning

Safety stock is the quantity of additional stock procured and/or held to satisfy unexpectedly high demand. Safety Stock Planning within Supply Network Planning allows you to meet a service level while creating a minimum amount of safety stock throughout your entire supply chain for all intermediate and finished products at their respective locations.

5.1.3.3 Heuristic

The heuristic is used as part of a repair-based planning process consisting of the heuristic, capacity leveling, and deployment. The heuristic process considers each planning location sequentially and determines sourcing requirements. It lumps all requirements for a given material in the location into one requirement for the period. The heuristic determines the valid sources and quantity based on predefined percentages for each source (quota arrangements), or procurement priorities for transportation lanes. Requirements are then passed through the supply chain to calculate a plan; however, this plan is not necessarily feasible. The planner must use capacity leveling to formulate a feasible plan. The following process flow is typical:

- Perform a heuristic run
- Level capacity
- Run deployment
- Run TLB.

5.1.3.4 Capacity Leveling

The Supply Network Planning run produces a plan that meets all the demand requirements (for example, sales orders and dependent demand); however, the resulting plan is not necessarily feasible. Capacity leveling, a function within Interactive Planning, enables you to smooth your production schedule, either manually or using a methods-based approach, based on how the available resource capacity in your supply chain is able to meet demand. With capacity leveling, one has the opportunity to build up inventory or increase capacity to ensure that you can meet demand without overstocking and to avoid periods of resource overload or underuse. One can easily analyze alternatives and re-plan, even re-forecast, before putting the plan into production.

Plan can be adjusted by modifying supply or consumption, or by changing the production and transportation orders manually. Supply can be modified by changing the resource master data. Consumption can be modified by leveling the capacity on the active resource or by using an alternate resource (shift order from one resource to another manually). One can manually edit production and transportation orders.

5.1.3.5 Optimization

The SNP optimizer offers cost-based planning. This means that it searches through all feasible plans to try and find the most cost-effective. Total costs refers to the following:

- Production, procurement, storage, and transportation costs.
- Costs for increasing the production capacity, storage capacity, transportation capacity, and handling capacity.
- Costs for falling below the safety stock level.
- Costs for delayed delivery. Stockout (or shortfall quantity) costs.

In the optimizer view, a plan is feasible when it satisfies all the Supply Chain Model constraints that you activated in a special profile called SNP optimizer profile. The feasibility of a solution can involve due date constraint violations, or safety stock constraint violations. Due dates and safety stocks are soft constraints, or in other words, constraints to which you assign violation costs. The optimizer only proposes a plan that will violate soft constraints if, according to the costs specified in the system, it is the most cost-effective plan.

As part of optimization-based planning, the optimizer makes sourcing decisions. This means that costs are used as a basis to decide:

- Which products are to be produced, transported, procured, stored, and delivered (product mix) and their quantities
- Which resources and which production process models (PPMs) are to be used (technology mix)
- The dates on which products are to be produced, transported, procured, stored, and delivered.
- The locations at which or to which products are to be produced, transported, procured, stored, and delivered
- Alternate resources
- Demand violation penalty costs
- Safety stock violation penalty costs
- Procurement costs
- Shelf life
- Cost multipliers
- Location-specific products.

5.1.3.6 Demand and Supply Match

Capable-To-Match planning uses constraint-based heuristics to conduct multi-site checks of production capacities and transportation capabilities based on predefined supply categories and demand priorities. The aim of the CTM planning run is to propose a feasible solution for fulfilling demands. The CTM planning run is powered by the CTM engine, which matches the prioritized demands to the available supplies in two phases. First, it builds the CTM application model based on the master data that you have entered. It then matches supply to demand on a first come, first served basis, taking production capacities and transportation capabilities into account.

5.1.3.7 Collaborative Supply and Distribution Planning

The starting point of collaborative supply and distribution planning is the Safety Stock Planning. This will combine the pure demands with the company's strategy to guarantee customer satisfaction. Supply Planning tries to satisfy the demand in an optimal way, spreads production to the resources, explodes the bill of materials (BOMs) and organizes the procurement of semi-finished goods or raw materials. Distribution Planning considers the available products and satisfies the real demands due to flexible rules. This includes an optimal filling of the transport vehicles.

5.1.4 Distribution Planning

5.1.4.1 Distribution Resource Planning

In Supply Network Planning, you are provided with standard planning books (and views) for each of the various types of planning available. This planning book is practically identical with interactive Supply Network Planning, however here one can also view the distribution receipts and distribution issues. Ones own planning books can be created, using the standard planning books as templates.

5.1.4.2 Deployment

After production is complete, deployment determines which demand can be fulfilled by the existing supply. If the produced quantities match actual quantities planned in SNP planning, the result of deployment is a confirmation of the supply network plan. If the available quantities are insufficient to fulfill the demand, or exceed the demand, the system makes adjustments accordingly, depending on whether you are running the deployment heuristic or deployment optimization. The deployment run generates deployment stock transfers. The Transport Load Builder (TLB) then uses these stock transfers to generate transportation plans and build transport loads.

5.1.4.3 Transport Load Builder

The primary purpose of the Transport Load Builder (TLB) is to use the results of the deployment run (deployment stock transfers) to create multi-product TLB shipments while ensuring that:

- Means of transport are filled to maximum capacity
- Means of transport are not filled to below minimum capacity.

Minimum and maximum values for capacity (cubic volume and weight) and pallets to build a load are defined in a profile called TLB profile. The system generates as many valid TLB shipments as possible (with regard to the minimum and maximum values). The TLB also checks whether the manually altered TLB shipments respect the minimum and maximum values and if not it generates alerts.

The Transport Load Builder (TLB) combines deployment stock transfers to form feasible transport units. If the deployment stock transfer is for a VMI customer, the results are processed as sales orders in the transactional system. If not, it processes the results as a company-internal TLB shipment. Additional conditions for VMI customers can be specified.

There is no tracking of resource usage and no consideration of product-specific constraints (for example, flavor migration) or special transport requirements (for example, package orientation or refrigeration).

5.1.4.4 Replenishment

There are several possible scenarios for replenishment. One of them is Vendor Managed Inventory (VMI). In general, the scenarios differ by industry. Basic components of a replenishment process are deployment and the transport load builder.

5.1.4.5 Vendor Managed Inventory

Since, for the development of inventory targets, it is necessary to combine forecasts from sales, customers or partners with historical information, this process is well-suited to a collaborative scenario. The classic VMI process, in which vendors plan replenishments for their customers, can be extended to a collaborative replenishment process with more scope for interaction.

5.1.4.6 Collaborative Supply and Distribution Planning

The starting point of collaborative supply and distribution planning is the Safety Stock Planning. This will combine the pure demands with the companies' strategy to guarantee customer satisfaction. Supply Planning tries to satisfy the demand in an optimal way, spreads production to the resources, explodes the bill of materials (BOMs) and organizes the procurement of semi-finished goods or raw materials. Distribution Planning considers the available products and satisfies the real demands due to flexible rules. This includes an optimal filling of the transport vehicles.

5.1.5 Production Planning

5.1.5.1 Production Planning

Production planning enables the planner to create feasible production plans across the different production locations (also with subcontractors) to fulfill the (customer) demand in time and to the standard expected by the customer. For the long and medium-term time horizon, rough-cut planning is based on time buckets and determines requirements of resources (machines, humans, production resource tools) and materials. Solvers, real-time data, and high supply chain visibility (KPIs, alerts) support the planner's decision-making process.

5.1.5.2 Detailed Scheduling

Detailed scheduling delivers optimized order sequences that can be released for production. Solvers simultaneously take into account constraints and costs to schedule the optimized order sequence. Dynamic alerts and order pegging structures improve visibility. Due to the seamless integration with the execution and inventory management system, material shortages or critical resource situations can be seen immediately and the schedules can be manually or automatically adjusted accordingly.

Detailed Scheduling fulfills requirements from the process and discrete industries (takt-based and job scheduling for configurable and non-configurable products in an MTS and/or MTO environment; block planning, campaign planning, push production for process industries.

The APO Optimization Extension Workbench (APX) provides a new means of making optimization strategies more flexible. Transactional simulation capability is provided for scenario analysis and if certain cases are found to be acceptable, they are made executable. The primary purpose of the workbench is to extend the standard planning tools in APO to include user-specific optimization components. These individual optimizers are launched directly from APO. Together with the standard optimizers and heuristics, they form one planning system. This system provides the right degree of flexibility to be adapted to the precise needs of the user.

In addition to the functional integration of the external optimizer in the standard APO component environment, the optimizer is to be incorporated closely so that it can freely use the APO data stock (from the liveCache and the database server). The optimization results can then be returned to the APO dataset.

5.1.5.3 Capable-to-Match

Capable-to-match planning uses constraint-based heuristics to conduct multi-site checks of production capacities and transportation capabilities based on predefined supply categories and demand priorities. The aim of the CTM planning run is to propose a feasible solution for fulfilling demands. The CTM planning run is powered by the CTM engine, which matches the prioritized demands to the available supplies in two stages. First, it builds the CTM application model based on the master data that you have entered. It then matches supply to demand on a first-come, first-served basis, taking production capacities and transportation capabilities into account.

5.1.5.4 Materials Requirements Planning

MRP is part of the production planning process and generates replenishment schedules for all manufactured components, intermediates, purchased parts, and raw materials. MRP sets due dates for production orders and purchase requisitions through lead-time scheduling, depending on buffers, operation times, lot-sizing rules and so on. The planning run is supported by optimization tools when resource situations can be taken into account simultaneously.

5.1.6 Transportation Planning

5.1.6.1 Collaborative Shipment Forecasting

Based on Internet enabled planning books, one can exchange and adjust forecast information between your customers (which will be based on product forecast) and your carriers (who will give you data about the expected number of resources or vehicles they will provide in a specified time frame). This function is supported in APO Demand Planning.

5.1.6.2 Load Consolidation

SCM provides different possibilities to consolidate deliveries and orders to shipments. It is possible to combine orders based on rules and strategies, based on optimization logic in APO. This can also be done interactively and manually in R/3 as well as in APO, and through collaboration over the Internet. If it is decided to rely on your carrier's abilities to consolidate orders to shipments, one can give it access to deliveries over the Internet, where it can consolidate shipments. During Load Consolidation, SCM will consider multi-dimensional capacity constraints of the resources. This function is provided by APO.

5.1.6.3 Mode and Route Optimization

Mode and route optimization is at the heart of transportation planning. The goal is to create a least cost transportation plan while guaranteeing customer service. The system assigns inbound and outbound orders to modes (truck, ship) and creates the needed shipments. The optimization algorithm used to do these assignments is controlled by cost profiles, delivery dates, and constraints of the ship-to and ship-from sites.

5.1.6.4 Carrier Selection

After having created optimized routes (shipments), carriers need to be assigned to these routes. This may be done manually in the execution system (R/3) or in APO. APO offers four options to do so: (1) Priority: Certain carriers have different priorities on certain lanes. (2) Freight cost: The least-cost carrier for this shipment will be selected. (3) Business share: APO assigns shipments in order to ensure that specified carriers receive a defined volume of business. (4) Freight exchange: The shipment data is communicated to a freight exchange that ensures the assignment.

5.1.6.5 Collaborative Shipment Tendering

The assignment of a carrier to a shipment needs to be confirmed by the carrier (tendering). Tendering can be done via Internet dialog or communication via EDI or XML files. The carrier can accept the tender, reject or accept with modifications. Tendering can be done in R/3 or APO.

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