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Squared-set Analyzer for Inventory Management

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ABSTRACT

The actual demand for products can vary significantly from the forecasted demand in terms of time, quantity, mix, etc., leading to un-squared sets of inventory, inventory-holding costs, obsolescence risks, etc. Existing supply-chain tools can check if a certain demand for a set product mix can be met with existing inventory but offer no view into potential mixes of product configurations that can be built from existing inventory. This disclosure describes a squared-set analyzer (SSA), a decision-support tool that aids users in deciding products (and product use-cases and configurations) that can be built from existing and expected inventory. Accounting for competing objectives (cost, fulfillment speed, demand specifications), the many-to-many mapping between components and products, product capabilities and transitions, etc., the SSA 'pushes' supply to be consumed (in contrast to the conventional tools that attempt to 'pull' available inventory based on forecasted demand), enabling a rapid and profitable management of supply.

KEYWORDS

- Supply chain management
- Squared set
- Clear-to-build
- Component fungibility
- Product mix
- Demand shaping

BACKGROUND

The role of the supply chain team in an organization is to drive material to fulfill forecasted demand while accounting for lead times. However, the actual demand can vary from forecasted demand in terms of time, quantity, mix, etc. Material delivery and quantities can also change based on macro/micro conditions resulting in a mixed bag of on-hand material at any given time. This leads to a buildup of perceived un-squared sets of inventory, in turn leading to inventory holding costs, risks of obsolescence, and space constraints.

There are several tools that aim to provide a clear-to-build report. This report is a ‘pull’ based report that confirms whether a certain quantity of demand for a set product mix can be met with existing inventory of materials. However, such tools do not provide a view of the potential mix of viable product configurations that can be built from existing inventory in a ‘push’ format, without any predefined demand or product mix.

DESCRIPTION

This disclosure describes a squared-set analyzer (SSA), a decision support tool that aids users, specifically, inventory planners, product-transition managers, product-engineering or supply-chain executives, etc., in deciding which products can be made from existing and expected inventory. The SSA accounts for multiple factors such as:

- competing objectives, e.g., reduced excess cost, fast fulfillment, meeting demand specifications, etc.;
- a combinatorial number of choices, due to a many-to-many mapping between components and products;
- product capability and transitions, leading to multiple compute and storage fulfillment options; etc.

The described SSA can identify the product configurations, a.k.a. squared sets, that can be made from existing inventory and identify potential use cases for alternate product mixes to build those products. Thus, by pushing inventory from supply (in contrast to the conventional pull-in of inventory per demand), the SSA enables the reduction of excess on-hand inventory.

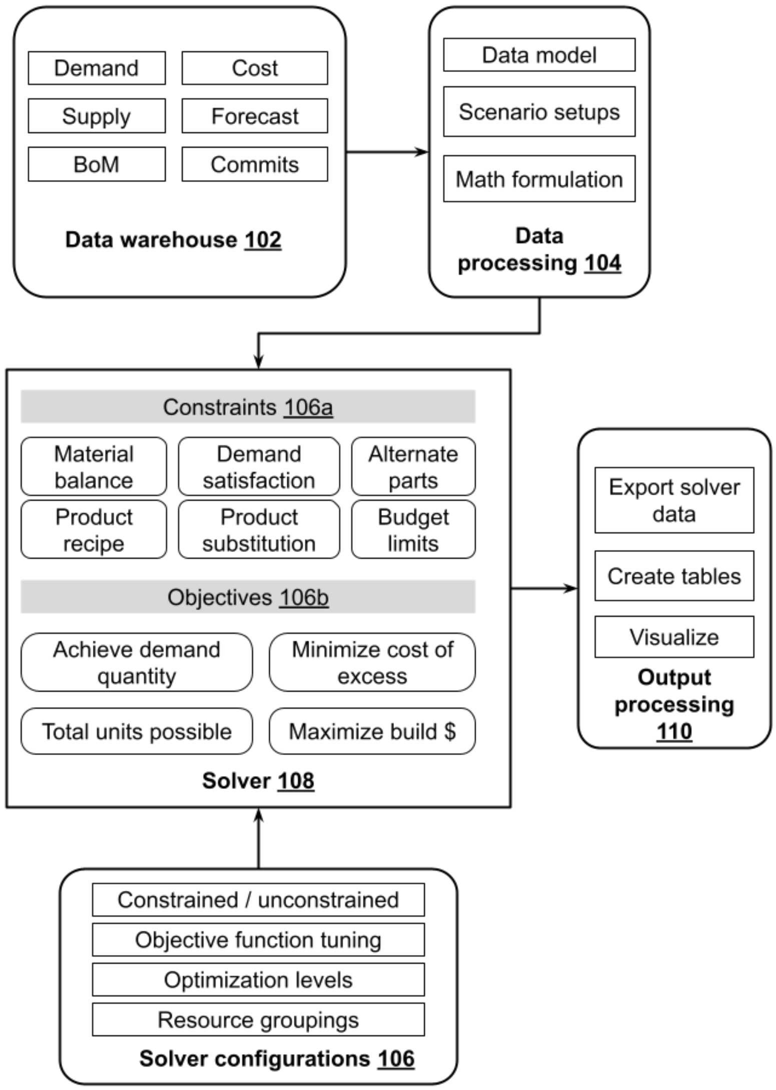

Fig. 1: Building blocks of the squared-set analyzer

As illustrated in Fig. 1, the SSA ingests product bill of material (BoM), time-phased demand, time-phased component inventories, costs, resource-unit information, component fungibility matrices, etc. from a data warehouse (102) to provide:

- an optimal use of inventory to fulfill the stated product-demand mix (pull);
- an optimal use of the remaining inventory to build additional products to forestall inventory-holding costs and to write off risk (push);
- given a budget for component inventory, a simulation of optimal incremental investment to increase product configuration sets to full deployment;
- a solution for an optimal inventory outcome, e.g., one that optimizes for supply and demand of resources at the unit level; etc.

After input data processing (104), the SSA uses linear programming constructs (108, described in greater detail below) to model demand, supply, products' bill of material, products' resource capabilities, costs, etc. The linear programming solver can be configured (106) along various dimensions, e.g., constrained/unconstrained (106a), tuning of objective functions (106b), optimization level, resource groupings, etc. Multiple scenarios can be presented upon output processing (110) in various formats, e.g., dashboards, tables, graphs, visualizations, etc.

At a high level, a linear programming model is formulated, using mixed-integer linear programming constructs such as:

- Demand and forecast

    a. By units → indexed by (SKU *j*, time *t*)

    b. By resource asks → indexed by (resource *r*, time *t*)

- Supply; various types such as on hand, in transit, future commits

    a. By units → indexed by (part *i*, time *t*, supply type *s*)

- Product recipe (BoM)

    a. Units needed to make SKU *j* from subset of parts *i*

    b. Alternate parts to make SKU *j* from subset of parts *i_a*

- Resource matrix (resource capacity)

  a. Resource units *r* produced by each unit of SKU *j*

- Boolean variables indicating whether a target has been met

  a. Demand and forecast → indexed by (SKU *j*, time *t*)

  b. Resource demand and forecast → indexed by (resource *r*, time *t*)

  c. Percentage demand (say 0.25, 0.5, 0.75, 1.0) of demand met → indexed by *f*, fraction

In this manner, the mathematical formulation models unified material, demand and product attribute constraints; demand fulfillment across alternate substitution hierarchies; materials available for push, e.g., where there is no apparent demand; mapping of demand intent to resource capabilities; spend simulations to enable sweep of excess material; etc.

In addition to the traditional supply-demand match across the supply chain, the model leverages the following:

- The product hierarchy is used to promote alternate mixes across SKUs to optimize square sets.
- Besides the unit demand, the product resource matrix is used to map resource demand.
- The cost spend is used to simulate the *marginal square set potential*, the quantum of overall reduction achieved by the spending of the next dollar.
- Incremental solutions are used to meet demand and forecast before consuming excess material.
- Simulated spends are used to determine the root cause of constraints in one or more parts.

From a business perspective, the SSA enables an organization to achieve:

- a capability to build product sets from existing inventory over and above the stated and known demand;

- a capability to build product sets from existing and future supply over and above the stated forecast;
- a profitability arising from a reduction in spending to acquire additional inventory and a reduction in excess/obsolete inventory;
- an optimization of resource units arising from product-build recommendations that are agnostic to SKU configuration and based on resource-unit needs; etc.

Some example use cases along with their critical user journeys are below.

Unified model for all demand categories. A critical user journey can include opening the dashboard and analyzing:

- Demand fulfilled at each level of hierarchy, e.g., type, product family, sub-family, etc.
- Shortages at each hierarchy level vis-a-vis resource asks
- Spend simulation outputs for dollar spend versus demand and resource fulfillment gain.
- Demand-shaping opportunities and simulated budget, demand, product launch/deprecate scenarios.

Design of optimal spend to maximize gaps in squared sets. A critical user journey can include:

- Reviewing the supply shortages per component item.
- Reviewing the suggested material purchase to fill gaps in squared sets.
- Analyzing the demand fulfillment performance.
- Adjusting budget as needed, and re-running.

Use of hierarchical demand models to clearly present demand substitution. A critical user journey can include:

- Opening the demand fulfillment pivot table.

- Analyzing the fulfillment across different demand hierarchy scenarios.
- Reviewing resource capacity attainment for intent demand.
- Simulating different demands and re-running.

Use of gradient approach to compute and present highest impact constraints. A critical user journey can include:

- Reviewing the supply shortages per component item.
- Reviewing the delta per dollar spent.
- Adjusting the budget for components with the highest impacted demand
- Reviewing future supply commitments.
- Re-running with a changed budget and/or pull-ahead of supply commitments.

Some advantages of the described squared-set analyzer include:

- *Unified view of demand*: Both product and intent demand can be presented in one view, such that resources are mapped to products and unsquared inventory minimized.
- *Blending various conditions*: By modeling costs, budgets, resource views of demand, and product/component substitutions, the SSA provides insights into supply-demand links under various conditions, e.g., optimizing tray count and/or unsquared inventory, demand-shaping choices within the product hierarchy, etc.
- *Spend simulation*: The size and composition of the additional spend to draw down excess inventory can be ascertained.
- *Component substitutions*: In contrast to standard tools, the use of component substitutes can be investigated under the conditions of differing costs and inventories in conjunction with overall squared-set attainment. In particular, the described SSA enables an integrative approach, e.g., it enables the dynamic computation of the landed cost of the

finished-goods inventory and the use of alternative options to achieve a squared set without having to upfront specify the priorities of alternatives.

The described squared-set analyzer can function as an independent decision-support tool, aiding in demand shaping and strategic buy decisions. However, it can also be integrated with upstream fulfillment optimization and demand shaping/management/planning tools using application programming interfaces (APIs). The SSA offers a unified modeling approach to demand types, supply availability, cost and product flexibility, and resource capability, and can achieve an efficient reduction in or repurposing of inventory.

CONCLUSION

This disclosure describes a squared-set analyzer (SSA), a decision-support tool that aids users in deciding products (and product use-cases and configurations) that can be built from existing and expected inventory. Accounting for competing objectives (cost, fulfillment speed, demand specifications), the many-to-many mapping between components and products, product capabilities and transitions, etc., the SSA attempts to consume or 'push' inventory from supply (in contrast to the conventional tools that aim to map or 'pull' inventory based on set demand), enabling a rapid and profitable management of supply. .

REFERENCES

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