Enterra®
SOLUTIONS

ENTERRA SUPPLY CHAIN OPTIMIZATION SYSTEM™

An Enterra Solutions White Paper

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Supply Chain Optimization

Planning and optimizations are done in many departments within a business, such as supply, manufacturing, distribution, warehouse, transportation, budget, labor, and so on. Often, departmental planning functions are disconnected from one another and may have conflicting goals. In order to deconflict goals, companies need to create an objective function that balances these goals. Developing an objective function ensures corporate alignment in order to optimize operations and maximize profits.

An objective function scores an outcome's utility so the best outcome can be chosen. For example, manufacturing may be tasked to fill all orders which requires having inventory on-hand in distribution centers. However, distribution centers may be given the conflicting task of minimizing excess inventory space and cost. Without an objective function that spans multiple planning departments, each department's objective function may conflict with others in often subtle ways.

The key function within Supply Optimization is Concurrent Planning, a term that applies to planning by multiple departments simultaneously with consistent objectives. The ultimate goal is having an enterprise-wide planning objective filter down into each department to drive the enterprise supply chain into perfect alignment.

The Enterra Supply Chain Optimization System™

The key to defining any planning optimization is to define:

- The operatingModel(x) that mirrors the business, where the scenario x is a vector of inputs that represents what needs to be planned. The output of the operating model is a vector k of KPIs for that scenario.
- The measurementFunction(k) is used to score the utility of the vector of KPIs so one overall score for the scenario (the Objective Function) can be determined so scenarios can be rank-ordered.
- Any constraints on a scenario or KPIs that need to hold true to be a feasible solution.

We define the objectiveFunction(x) = measurementFunction(operatingModel(x)). The optimization can now be defined as:

Maximizing or minimizing the objectiveFunction(x) subject to the constraints for any scenario x.

Notice that the objectiveFunction(x) becomes increasingly complex as the operatingModel(x) more realistically models the business' intricacies. This can create challenges for the most performant commercial off-the-shelf (COTS) optimizers because they place restrictions on the format of the functions that can be specified (e.g., the objective function must be a quadratic function). These simplifications often force users to over-simplify the operatingModel to the point it is no longer a realistic

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reflection of the business's complexity. These limitations suboptimize planning within each department, and the limitations are exacerbated when departmental plans are sequenced together to form a complete supply chain.

Another planning challenge is creating a balanced measurementFunction. With even a small number of KPIs, it is difficult for business users to define a function that intercombines KPIs and avoids adverse effects (such as telling the system its only goal is to minimize cost – which could unintentionally optimize a plan suggesting the company go out of business!). As a result, companies need a balanced measurementFunction that is able to trade-off cost, revenue, volume, income, machine maintenance, storage space, labor requirements, and so on.

Enterra's Supply Chain Optimization System has the following key components:

- Allows the user to define complex domain models beyond the quadratic limits imposed by the performant COTS optimizers, so they more accurately mirror their business.
- Allows the user to intercombine multiple divisions into one optimization which is solved by a-best-of-breed COTS optimizer (as explained below).
- A tool to help users create the balanced measurementFunction that intermixes KPIs.

The latter tool can also be used to create a balanced measurementFunction at the enterprise level, which encapsulates corporate leadership's directives. Once this enterprise-level measurementFunction is defined, it can be used to help find misalignments in departmental measurementFunctions. We oftentimes refer to this as "overlay optimization" since departmental objective functions are being driven by enterprise level objectives.

Why the Enterra Supply Chain Optimization System is Better than Competitors' Solutions

The features that make Enterra's system distinctive are:

- Enterra's system makes a broader-scope of concurrent planning possible.
- It provides both a tool and methodology for defining a measurementFunction.
- The ability to support more complex domain models beyond quadratic equations, but still use the best quadratic COTS optimizers.
- It helps users create an enterprise level objective function that can be used to align departmental optimizations.
- It comes with world-class professional services to ensure a smooth implementation with customizations.

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The ability to support more complex domain models beyond quadratic, but still use a COTS quadratic optimizer, is accomplished using the mathematical technique of functional projection into a quadratic function space. Imagine a hand puppet's shadow. The hand is a complex 3-dimensional object; however, with a light source optimally positioned, it is able to project a 2-dimensional shadow that retains the key features of a hand's shape to create the puppet. A similar process can be achieved with higher-order functions. In this case, higher-order mathematics are metaphorically "positioning the light source" so the most information possible from the higher-order function is retained within the lower-order quadratic estimation (the "shadow"). This quadratic estimation of the objectFunction (along with its constraints) is the input to the constrained quadratic COTS optimizer.

The tool and methodology used to define a measurementFunction uses adaptive questioning that asks the business person their preference between two different KPI scenarios (also called a "conjoint preference analysis"). With enough preferences ranked, the data points are fit with an estimated menasurementFunction. Subsequent questions are adaptively generated based on prior answers to obtain a quality estimate with the minimum number of questions required.

Lastly, as mentioned earlier, an enterprise-level measurementFunction can be defined and used to help align departmental measurementFunctions by simply providing the enterprise's ranking when an enterprise preference exists between scenarios. While most departmental KPIs will be lower level than the enterprise's measurementFunction, a few KPIs will be analogous or correlated. For example, "Total Production" should be correlated with revenue as more items available to sell should generate more revenue. Values such as "Unused Warehouse Capacity" would not be correlated with expenses, but would be interpreted as analogous to increased expense, as that excess capacity could be released. When a department-level measurementFunction is being defined, if it ranks a scenario differently than the enterprise-level measurementFunction, a user is alerted that a potential misalignment may occur (which, in some cases, may be well-justified). This enterprise viewpoint should help shift the construction of department-level measurementFunctions into better alignment with enterprise goals. In addition, the percentage of misalignments can be tracked overtime. Correlations are easily tested and it may be possible to have the solution's Ontology auto-determine the analogous KPIs.

Concluding Thoughts

Many enterprises face challenges of siloed data and corporate misalignment. The Enterra Supply Chain Optimization System can help overcome these challenges. Intelligent concurrent planning is an important step in an enterprise's digital transformation journey.

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About Enterra Solutions

Enterra Solutions is a leading cognitive computing company providing data-enabled prescriptive analytics and insights for companies across a broad range of industries. The Enterra Cognitive Core™ enables organizations to capture, curate and analyze vast amounts of complex and disparate data. This powerful capability allows clients to uncover and understand inter-relationships that lead to innovative new product development and innovation, heightened consumer understanding, enhanced supply-chain execution, and more efficient and targeted consumer marketing. Enterra's analytics and insights help the world's leading brands and organizations operate smarter by finding higher meaning in their data.

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