An Industry-Proven Multi-Agent Systems Approach to Real-Time Plan Optimization

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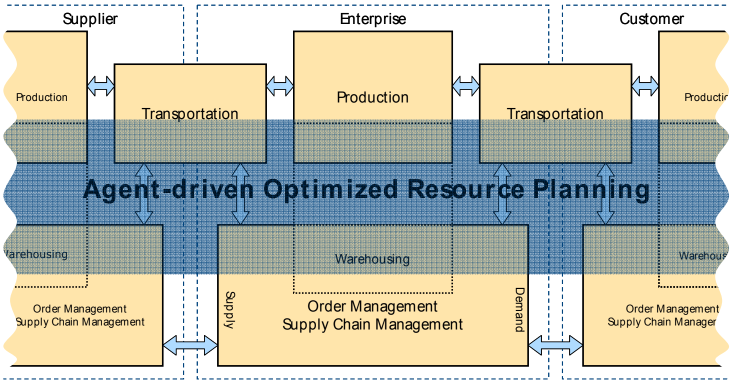
Supply chains are, by definition, an interconnected mesh of relationships between an Enterprise, it's suppliers and customers. It is the objective of our work to create and commercially deploy software-agent based, dynamic real-time resource planning systems capable of optimizing the use of resources throughout the supply chain, as depicted in the figure below.



To date, our focus has been on the transportation component of the supply chain; the optimization of freight delivery plans between an enterprise and its various suppliers and customers. To this end we have developed and commercially deployed a route planning engine for freight dispatching. However we realize that transportation is only one dimension of the overall relationship; therefore building on the commercial success of our transportation plan optimization system we are now embarking on extending the solution to encompass the entire supply-chain ecosystem.

At the heart of our approach is a multi-agent optimization engine wherein goal-directed agents segment and distribute a formulated problem across a population of goal-directed software agents. Built on a bottom-up optimization philosophy, goal-directed agents autonomously interact to solve sub-problems that, when consolidated, result in a solution to the overall problem. Similar to human decision-making, solutions to problems thus arise from the interaction of individual decision makers (represented by software agents), each with its own local knowledge. It is widely recognized that the centralized, batch-oriented nature of traditional IT systems imposes intrinsic limitations on dealing successfully with unpredictability and dynamic change. Multi-agent systems are not restricted in this way because collaborating agents can quickly adapt to changing circumstances and operational constraints. For real-time plan optimization, it is simply not feasible to re-run a batch optimizer to adjust a plan every time a new event is received. Through experience we have found that events such as order changes, cancellations or major delays occur, on average, 1.3 times per order. Distributed, collaborating software processes, i.e., agents, instead work together by partitioning the optimization problem and processing resulting segments in parallel. One agent elects to manage an event, while others continue to process information, thereby solving the optimization in near real-time.

While the optimisation utility function is primarily cost-based, other objectives can also be specified as heuristics that assist with guidance through the plan solution space and thus with avoiding local minima. Also, each optimized solution must satisfy a set of constraints placed on the algorithm when calculating plans. Some of these constraints are considered as compulsory, or *hard*, and others as optional, or *soft.* Finally, our solution also offers the capability of integrating additional, more traditional, optimization mechanisms (e.g., simulated annealing) within the agent-directed solution derivation. Plan optimization results are continuously measured against the active utility functions to select optimal results and optionally tune the optimizer using a decision feedback loop.

The advantages of our particular multi-agent approach, employed in our Living Systems Adaptive Transportation Networks (LS/ATN) product, and the differences with most existing logistics solutions, are summarized as follows: A methodological grounding designed for creating software systems that must operate in dynamic and unpredictable business environments; a distributed, collaboration based infrastructure, unlike the monolithic, centralized approaches of traditional IT systems; superior scalability than traditional IT systems. Software agents can adapt quickly to changing circumstances and do not suffer from a complexity limit; higher cost savings potential than traditional IT systems because agents thrive on complexity; higher potential for scalability pays greater dividends as complexity increases.

As mentioned, we are now turning our attention to extending our approach to the broader supply chain. We intend to illustrate how our approach to continuous dynamic plan optimisation combined with real-time event handling and tracking & tracing lends itself to both the production systems element of enterprise operations and then also to integration across the entire supply chain with the potential for major cost savings.