Supply Chain as a Control Problem

Today's forces of interest for the supplier, manufacturer, and customer require ever-increasing levels of supply chain agility and inventory management to continuously improve operational efficiency. As these forces interact across the supply chains, further refinement of standards in the areas of sensing, measurement, communication, control, decision policy, organizational structure, practitioner responsibility, and implementation practices are required to move supply chain metrics of interest to new levels of performance and reliability.

Grand Control Challenge

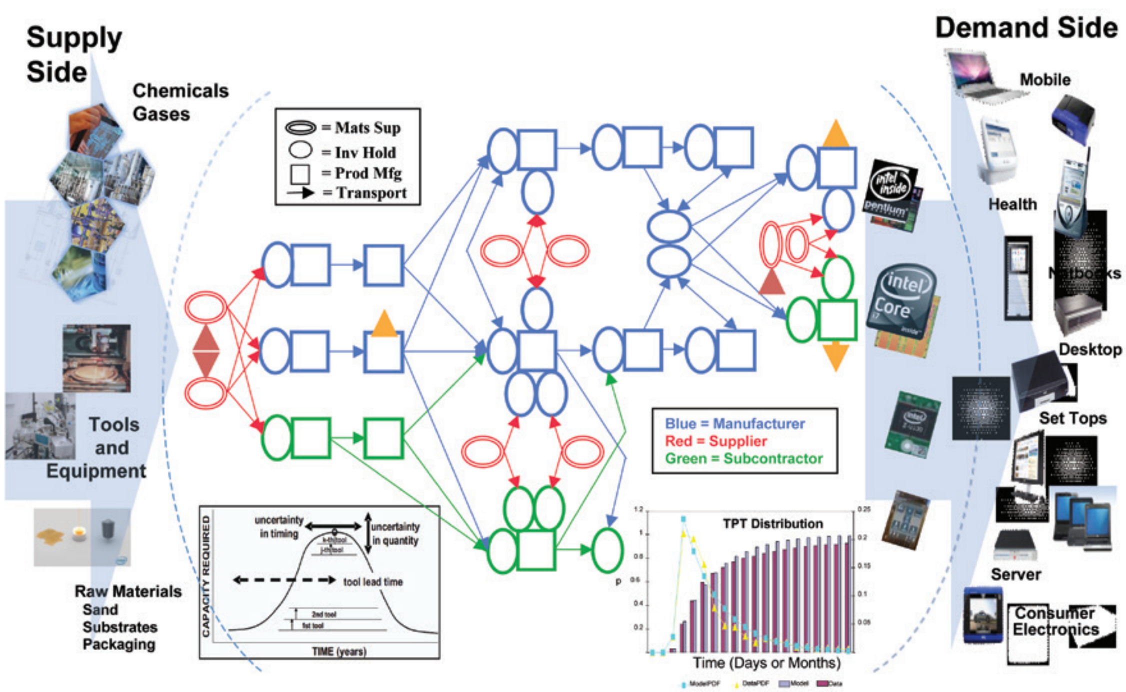
Well-controlled supply chains can deliver

- the right product,
- in the right quantity,
- from the right sources,
- to the right destinations,
- in the right quality/condition,
- at the right time,
- for the right cost

while

- reducing inventories,
- increasing supply chain agility,
- reducing operational cycle time,
- optimizing supply product mix relative to the demand mix, and
- enabling maximum business profitability.

Discrete Supply Chain Example



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Nature of Supply Chain

Multiple Ownership: A company's performance in the supply chain is affected by its suppliers, customers, suppliers' suppliers and customers' customers, and its collaboration with them. Each company has a vested interest in all the links in the supply chain, not just those of direct suppliers and customers.

Constant Evolution: Products and equipment in the supply chain may run their complete life cycles as the overall performance is being improved. Fast ramp-up and ramp-down of products, and their accompanying processes and toolsets, pose challenging transition problems.

Uncertain Dynamics: Supply chains are stochastic, nonlinear, and time varying. In addition to transport and throughput times being affected by "simple" logistical and manufacturing systems and related processing loads, they are affected by weather, politics, culture, innovations, contractual relationships, and other complex human interactions.

Risk Management: Common risk management measures, such as safety stock, contingency systems and procedures, customer and supplier agreements, and shipping time allowance, can greatly affect supply chain agility, maintainability, customer satisfaction, and of course, cost.

Present State of the Art

Modeling: Treating a segment of the supply chain as a network of inventories and specialization processes with preconfigured connections and estimated production dynamics.

Control: Using supply and demand forecasts to specify material processing and distribution rates that mitigate inventory control limit violations. Model predictive control (MPC), for example, has been successfully applied to several segments of the supply chain where traditional supply chain solutions have had difficulty (see figure below).

Optimization: Incorporation of economics and business logic to direct material to locations that maximize agility while minimizing unnecessary processing and shipping. Typically, solutions with longer time horizons and a greater model abstraction (such as planning and scheduling) are implemented as supervisory layers above the control layer.

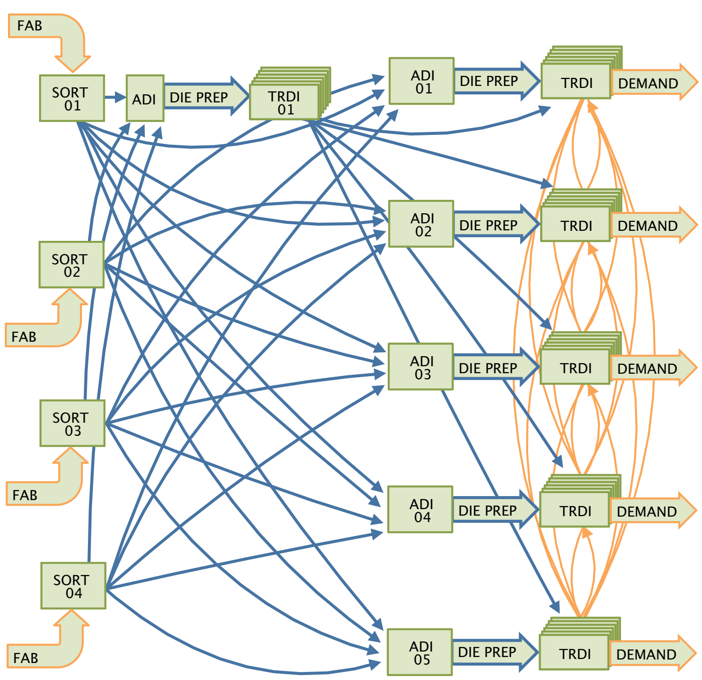
Challenges to be Solved

Crossing Company Boundaries: Incorporate pricing on the supply and demand side while maintaining local autonomy, sharing information, and creating a win-win-win approach among the suppliers, customers, and manufacturer. Moving beyond simple data exchange is deemed essential to executing local optimization in a collaborative manner and to thereby achieving the greater benefits of global optimization.

Demand/Supply Forecast: Accurate forecast models are essential for tight supply chain management. The challenge is how to forecast the supply and demand and quantify and account for uncertainties.

Managing Risks: How should strategic decisions such as system capacity allocations be derived and implemented with a tolerable investment and business risk? What are the optimal uncertainty buffers across the supply, demand, and manufacturing domains? Can options theory, for example, be used to support or even optimize both investment and production decisions?

Supply Chain Cost: How does a specific set of supply chain solutions take into account current business workflow and push the boundary of automating business processes beyond current practices to reduce the overall supply chain cost?



A concept for a model predictive control application for inventory and production management for semiconductor manufacturing. Wafers are sourced from fabrication facilities and go through stages/buffers for sorting, assembly die inventory (ADI), and tape and reel die inventory (TRDI) before finished dies are shipped to meet demand at manufacturing sites. Manipulated variables are shown in blue; feedforward signals in orange. Several such controllers can be coordinated in one application for managing shared inventory space, such as warehouse floor space. Versions of this concept have been implemented with individual controllers manipulating and controlling hundreds of variables each.