# Self-Improving Supply Chains

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Imagine a world where supply chain planning systems can mold themselves into their environment, adapt and improve as the business changes. Imagine systems that can monitor user behavior as well as customer and supplier anomalies and advice accordingly. Imagine applications that can, not just report exceptions but also, offer the best way to resolve the issues and consequences thereof, keeping your objectives in mind. With the advances that have been made in processor speed and abundance of memory, as well as the recent developments in Artificial Intelligence (AI) techniques and ability to search for cause-and-effect relationships in large quantities of data, imagine no more. This luxury is upon us today.

There are specifically 3 areas in AI that are of particular interest to supply chain planning systems. These are:

- Machine learning and inference techniques
- Optimization algorithms including planning and scheduling
- Big data and techniques to uncover hidden information

Supply chain planning systems can greatly benefit from combining above approaches such that they become more intelligent, more dynamic and more user-friendly to the extent that they can even explain their decisions in case the users question the answers! This will result in automation of decision making and less reliance on subjective decisions, much faster analysis and response to changes in the environment and ensuring that every decision gets the organization closer to its goal of profitability, market share or any other objective that maybe right at that point in time.

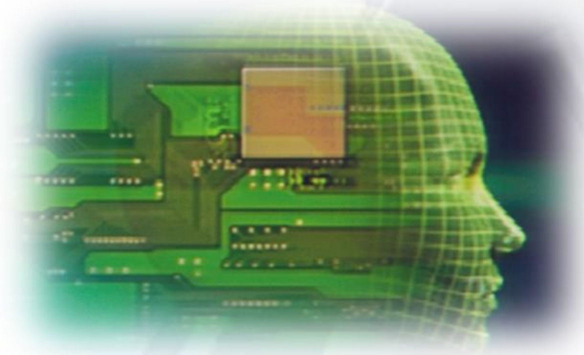
More recently there has been a strong trend in analysis of big data and mining information. As the volume of data keeps growing from 1.8 ZB in 2012 to expected 40 ZB in 2020, there is a need for systems that can analyze data and make decisions even after a trend or pattern is discovered. As an example, Starbucks is planning to connect every coffee machine to its Industrial IoT (Internet of Things) system to collect data so that there is no latency in information needed as to what to buy and what to distribute. In fact, by doing so, this data collection might reveal different habits of regions in the type of coffee preferred as well as what people buy with their coffee. As soon as we are aware of such information, the next step is to plan. That is plan to get what is needed, to source it, to schedule delivery, to make it, and deliver it in an optimized manner in the least amount of time and cost.

Learning systems in AI are intended to make software more and more intelligent by learning from its environment as the system is exposed to more data. A company's model of supply chain can have the ability to constantly change since the supply chain itself is dynamic and the company being modeled is continuously changing. In some cases the changes are subtle such as demand falling slowly over time, or more obvious events, such as losing a customer or a supplier.  How would the models of the supply chain understand these changes and relate to them? Currently this is accomplished with a lot of help from the users and programmers. However, enough intelligence can be built into systems so that they can learn about such behaviors and adjust themselves by understanding the ongoing changes in the environments in which they operate.  Let's assume that we find a supplier which is generally late by an average of 5 days. Or a customer or sales person frequently over-forecasts by 10%. Systems are capable of picking up this trend, confirming it and then account for it in the future decisions automatically. Other examples are changing efficiency of equipment, quality issues and rework, yield, delivery performance, inventory trends etc. Thus the supply chain model is in continuous adaptation to its surrounding and changing as the business changes. We refer to this as Self-Improving Supply Chains. By using techniques in big data and predictive analytics, models are constantly corrected and represent an accurate view of what is actually going on, and then optimization techniques can yield a much better result of what needs to be done using the planning algorithms and heuristics.

Another focus area is the ability to understand clustering of data and predicting the patterns that might be emerging. This information would help us to become more predictive. This type of analysis, however, is done generally on the demand side. Conversely, on the supply side, predictive models of heuristic and mathematical algorithms are available that can predict the potential issues that come up and how to resolve them. More importantly, what solutions are available and what the side effect of each solution might be from an operational or financial side. For example substituting one part for another might cost more, however it might result in better customer satisfaction. Systems can now make these choices and recommend to the users what could be done and the potential ramifications of the action taken so that the users understand why a decision is made.


Furthermore, one can go even further and learn from the users' decisions and choices to the extent that the system can make the "right" decisions even in the absence of the user. This is done through "training" of the system. After a number of instances of an event, certain patterns may emerge that can help the system to make similar decisions. A good example of this is allowing high cost substitute material to customers with (high priority) OR (being more than 5 days late) AND (have a recurring order). These logical Boolean expressions will emerge as constraints to the system hence applied to the planning algorithms. Having the ability to perform Attribute-Based Planning allows formation of such rules. Attributes are used as constraints to come up with a feasible solution. In much the same way, Attributes are now used to perform rules derived from the users of the system and applied as needed.

Inventory has always been the biggest blessing and curse of every company. But now we have techniques that can constantly monitor not just what has been used but also what is expected to be used and based on that recommend what the best levels of inventory must be for every part number at every level of the supply chain. Learning from the past usage leads the system to what the needs of the future are with certain degree of confidence. Based on this, the system makes decisions to ensure on-time delivery at lowest possible cost. Given the millions of parameters involved in such analysis, it is impossible for a human being to make optimal decisions.



Finally, the systems can also be trained by the users to compare progress with the set goals of the management. This is done by predicting what is expected on the supply side and comparing it with what the goals are. With deviations beyond acceptable limits, the system can and will decide on changes to the plan to bring about a more favorable solution. For example, the production of red sweaters turn out to be far beyond the expected quantities, decided earlier. On the other hand green sweaters are not selling as much and expected to be much lower than what was originally decided. By monitoring this trend, the system can replace capacity of one for the other and make adjustments in future plans and expected changes in the financials as a result of such change. This may have implications in the financial results of the company which can be immediately flagged and proactively sent to relevant users with an explanation of what is causing the change.

We are now at an inflection point moving from an information age to decision automation age. With this trend continuing, the human beings may only specify their objectives, and systems will offer solutions that are feasible and the relevant “cost” thereof. In order to do so, systems need to have a realistic understanding of the world around them to know what the options are. Most of this can be accomplished by availability of data and growing use of speech and visual recognition. But there are other relevant factors of relationships, feelings, exceptions, boss’ orders, and other subjective factors that somehow will have to be incorporated into systems, perhaps by better “training” systems to have “feelings!”

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