The Sentient Supply Chain: The Future has Arrived

How advances in the Internet of Things, cloud computing, and predictive analytics are making the Sentient Supply Chain a reality

WHITEPAPER

TRANSVOYANT

The term **"Sentient Supply Chain"** has recently emerged as a way to describe a supply chain that is all-seeing, real-time, predictive, optimized and cognitive.

Sentient

[sen-shuh nt] also [sen-shee-uh nt]
Able to perceive or feel things; conscious.

Think of the Sentient Supply Chain like a network of autonomous vehicles

An excellent metaphor for the sentient supply chain is self-driving cars, or more aptly, a *network* of self-driving, autonomous vehicles like those being actively tested today by Google, Tesla, Uber and other firms. Autonomous vehicles analyze massive amounts of *real-time* data from onboard navigation systems, process control devices and signals from other autonomous vehicles that are both nearby as well as farther ahead on their planned route.

Beyond freeing passengers from the menial task of driving, autonomous vehicles hold great promise with respect to reducing accidents and significantly improving flow on the road. Think of the inefficiencies of our highway systems today resulting from human-guided vehicles.

A simple example is merging traffic. When a stream of cars attempts to merge onto the highway from an on ramp, invariably traffic grinds to a crawl. Some drivers on the on ramp attempt to merge too slowly forcing those on the highway to slow down in turn. Some drivers on the highway accelerate, blocking the entry of the merging traffic. Some drivers on the highway provide too wide a berth for the merging cars than is needed, resulting in a greater delay than needed. Other drivers on the highway swerve left, forcing those behind them to hit their brakes.

In this scenario, one driver has no idea what the other drivers are going to do or when. This uncertainty leads to an abundance of caution, brake lights, mistakes and accidents. These are all inefficiencies. This is 'fat' in the system that in an autonomous world can be all but eliminated.

In the world of self driving vehicles, every car on the road communicates with every other car in real-time.

Each vehicle knows where the other is headed, when it is going to accelerate, turn, brake, merge or exit. Combining this real-time visibility with advanced algorithms, traffic can be efficiently orchestrated and highly optimized. In the highway example, the cars from the on ramp merge perfectly with those on the highway at speed, like two sides of a zipper folding together perfectly. There are no brake lights, no delays and no 'fat' in the system.

And while real-time visibility and communication with vehicles within a localized area are essential for autonomous vehicles to function, there's a bigger picture, with even greater value.

A system of sentient vehicles doesn't just analyze data about activities in one area, or in one's immediate vicinity—it's able to take "the larger view" of virtually everything happening everywhere, and optimize a route from New York to Los Angeles, for example, (or any point to any point) using every option available for maximum efficiency. And it does the same thing by looking ahead in time.

Process control devices automatically predict service requirements, order parts, schedule appointments and drive to the service station closest to the vehicle owner's office after dropping him or her off at work.

In the future, it will be rare for individuals to even own cars, self-driving or otherwise. Rides will be coordinated as a service, such as Uber, except the vehicles won't be driven by people, but by a combination of on-vehicle computers and a central cognitive computer, that can optimize the entire system. In such a world, the cognitive computer will automatically anticipate demand for rides based on an understanding of learned human behavior and the interplay of live and predicted events such as sporting events, holiday airport traffic and rain.

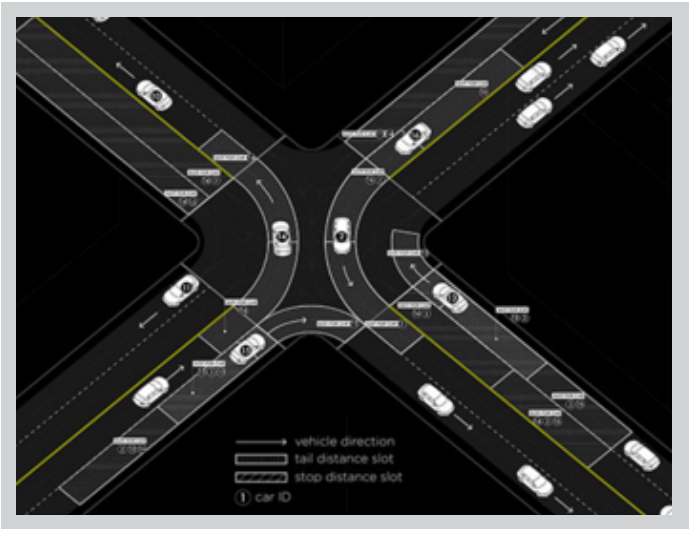


Illustration Source: MIT Senseable City Lab

By seeing the real-time movement of people, as well as the current and predicted influence of events, the cognitive computer can optimally match supply with demand. The efficiency gains from a system of centrally coordinated autonomous vehicles are enormous.

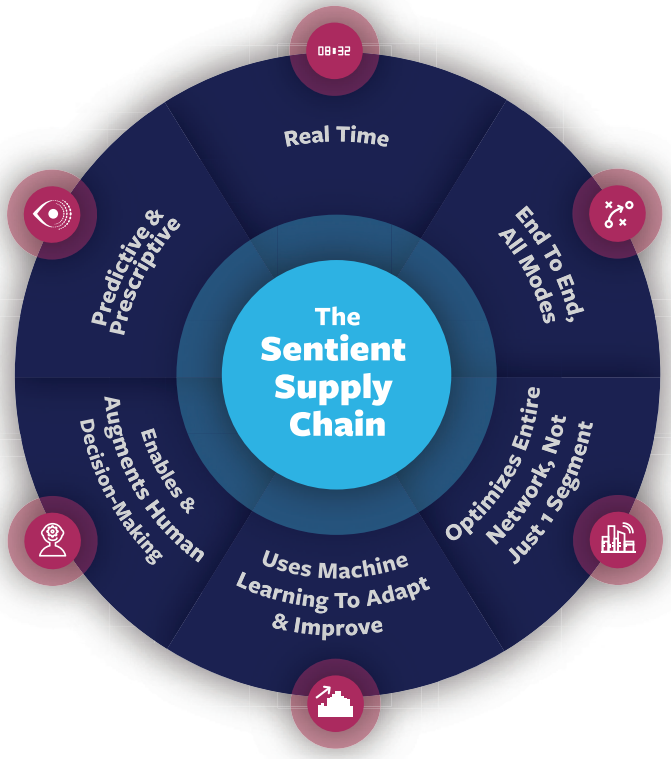
A recent research report by a team from the Massachusetts Institute of Technology quantified those gains. By modeling cars entering a traffic circle, the MIT team determined that wait times could be reduced from 99 seconds to just 2.5 seconds—**a 97% reduction in delay times.**

Think of those gains applied to an organization's supply chain. Rather than cars on the road, however, there are nodes and actions in the supply chain (conveyances, suppliers, warehouses, manufacturing facilities, stores, etc.). Supply chain leaders have gone to great lengths to facilitate communication between these nodes and to better manage activities. They have deployed ERP, SCM and supply chain visibility solutions. They have adopted EDI technologies, as well as supplier and customer collaboration platforms.

These traditional systems have certainly driven value. They've enabled organizations to improve collaboration, shorten cycle times and reduce inventories, but these gains have been limited. They're only as good as the data they can see and analyze (largely internal) and the decisions they can affect (given a company's relative market power).

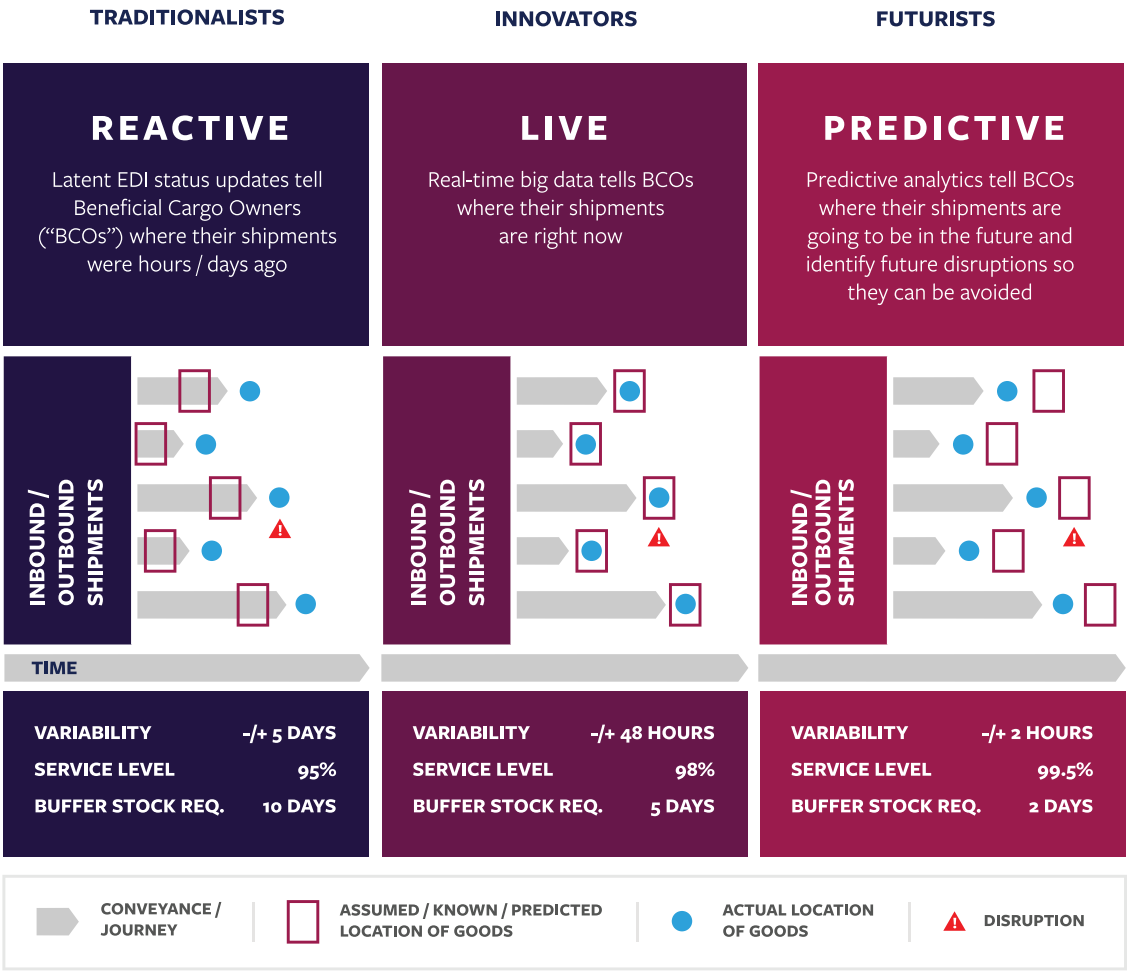
In an attempt to compete with next day delivery competitors such as Amazon, however, and to respond to the "anywhere/anytime" realities of omni-channel, companies have pushed their supply chains to new limits.

Organizations need their supply chains to function more like the highly intelligent, orchestrated, optimized and cognitive global system of autonomous vehicles; they need to be *predictive* and *prescriptive* rather than the plan-driven and reactive supply chains of today.



Latent EDI status updates provided by traditional supply chain visibility solutions are no longer sufficient; organizations need to know where their orders and shipments are in real-time, where they will be in the future and what risks they will face all along the journey. Fulfilling orders from inventory stored in warehouses is no longer sufficient; organizations need to commit inventory in transit—*which they may not even own yet*—in response to dynamic demand signals. Expediting an air shipment to compensate for an ocean shipment that gets delayed due to port congestion is no longer sufficient; organizations need to *predict* and *avoid* these issues *before* they occur.

Because *sentient* supply chains run on real-time information, see and communicate with every other node, sense and respond to changes, and predict and avoid disruptions, they are uniquely suited to answer the call.



When every node in a company's global supply chain (conveyances, suppliers, warehouses, manufacturing facilities, stores) has an understanding of what every other node and actor is doing right now in real-time, what they are planning to do and when, coupled with accurate predictions of what external nodes and actors (ports, roads, labor, customs clearance points, weather, drivers, ship captains) are doing right now and what they will be doing in the future, and advanced machine learning algorithms constantly orchestrating, re-factoring and re-optimizing the system, you have a *sentient supply chain*.

Having a sentient supply chain does not mean all decisions and actions will become 100% automated. Determining which decisions can be made "machine to machine" vs. which still need to be made by humans will still be up to the supply chain professionals and business leaders. The value of sentient supply chains are their ability to analyze massive amounts of real-time data very quickly and to apply advanced machine learning algorithms to those data streams to produce intelligent insights.

Traditional Supply Chains	VS	Sentient Supply Chains
Planning & Reactive		Predictive & Prescriptive
Latent		Real-time
Rule driven from past performance years ago		Machine learning constantly evolving from what changed today
Modal point solutions		All modes
Optimized by node, shipment or order		Optimized across entire supply chain balancing profit and service
Majority human decisions with machine input		Majority machine decisions with human oversight

Within a complex global supply chain, there is simply no way humans can weigh the multitude of constantly changing variables to arrive at optimal decisions in near real-time. *Sentient supply chains can.* They can analyze massive volumes of data, automatically execute many decisions, and highlight the few strategic decisions that may require human intervention.

Sentient supply chains identify real-time and predicted disruptions and behaviors at n-tier suppliers. They continuously model the impact on downstream operations, apply machine learning algorithms to generate optimal remediation scenarios and either automatically execute those scenarios via machine-to-machine integration, or visually present them to supply chain planners for evaluation, modification and execution.

Sentient supply chains track the real-time movement of ocean shipments (and behavior of ship captains), calculate highly accurate times of arrival and automatically trigger dray carriers to meet them just in time. No more containers sitting in the yard waiting for days to be picked up, no more dray carriers showing up to pick up goods that have not yet arrived or cleared customs.

Sentient supply chains track the real-time movement of trucks (and behavior by truck drivers) destined for warehouses, predict traffic delays, sense accidents well down the road as soon as they occur, dynamically re-route shipments and constantly communicate accurate arrival times to the warehouse so dock doors and labor are available to greet them. No more trucks waiting to be unloaded and no more warehouse managers scrambling to respond to surprises.

Sentient supply chains *constantly* monitor real-time consumer behavior via social media and other means, understand what local events will take place in the future, monitor competitive campaigns and ingest POS data. By constantly analyzing these inputs and more with machine learning algorithms, they produce accurate and timely demand signals and allocate inventory to optimize sales.

While early in their adoption, these capabilities are a reality today, made possible by a confluence of events.

Enabling the Sentient Supply Chain

Three factors have been critical in enabling the Sentient Supply Chain to become a reality:

1. The explosive growth of the Internet of Things (IoT);
2. Advances in machine learning and artificial intelligence;
3. The increase in ubiquitous, affordable, distributed computing power.

The growth of the Internet of Things (IoT)

While their estimates vary, industry analysts agree that the number of IoT devices has exploded in the past decade. Gartner estimates there are 6.4 billion IoT devices worldwide (which doesn't include smartphones, tablets, and computers), IDC estimates 9 billion (which also excludes those devices), and IHS estimates 17.6 billion (with all such devices included).

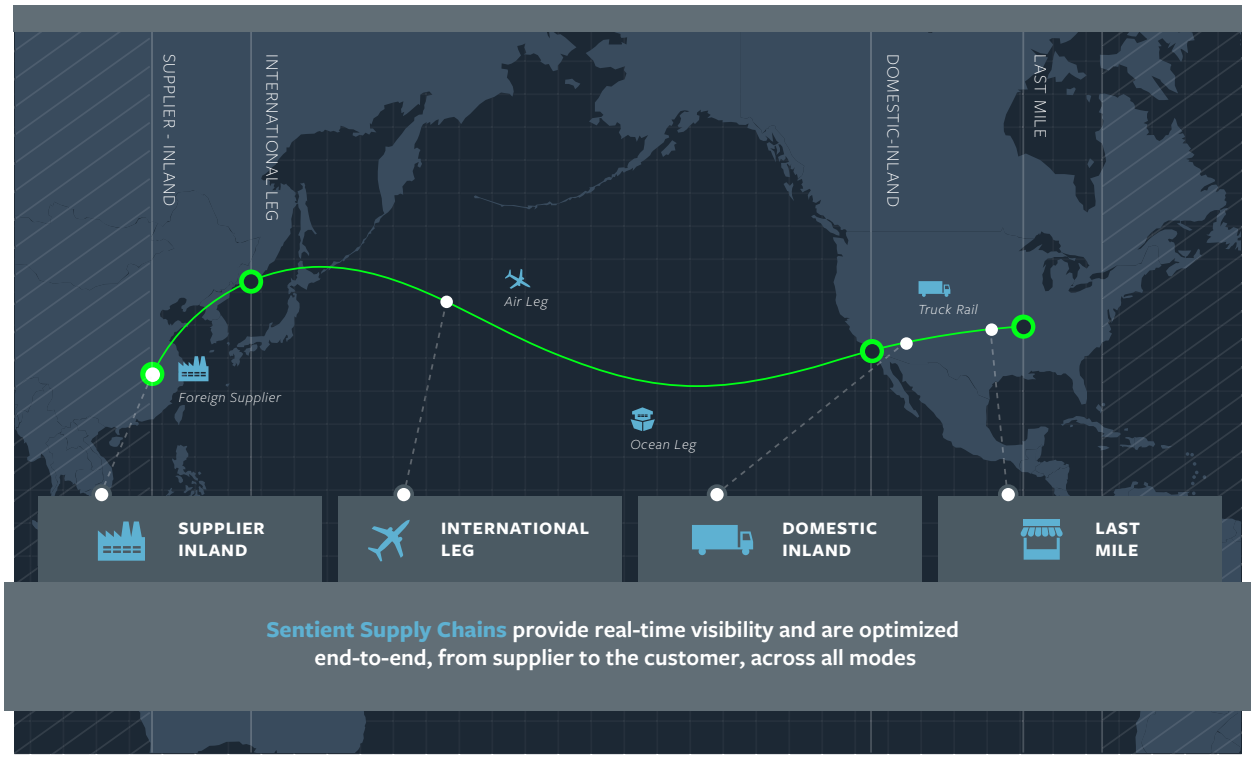
Below are just a few examples of relevant supply chain data, and the IoT sources from which they are collected:

Live Data

- Live aircraft, vessel, truck, railcar locations
- Port congestion
- Vessel schedules
- Air traffic
- Airport congestion
- Flight schedules
- Unpublished layovers
- Weather
- Temperatures
- Wind speeds
- Wave heights
- Natural disasters
- Terrorism threats
- Labor strikes
- Customs clearance times
- Road construction
- Road traffic
- Sun glare
- Price indices
- Geopolitical trends
- Tweets
- Media articles
- Foot traffic

Sources

- Sensors
- RFID
- Satellites
- Radar
- Smart phones
- Meters
- Control devices
- Video cameras
- Drones
- RSS feeds
- News outlets
- Social media



Seeing the real-time global behavior of airplanes, ocean vessels, railcars, barges, trucks and parcel carriers, and knowing what items and orders are on those conveyances is incredibly powerful. Organizations are no longer flying blind or relying on latent EDI status updates to tell them where their goods were hours, days or weeks ago; they know where they are *now*—and where they *will be* in hours and days, based on an understanding of historical behavior combined with the impact of live and predicted events.

Seeing the real-time and predicted behavior of external events such as weather, port congestion, traffic, consumer sentiment, customs clearance times, labor strikes, political unrest and other factors is also extremely powerful. Applying machine learning algorithms, a sentient supply chain predicts the impact of these events on transit times, and automatically makes routing adjustments or modal shifts to avoid disruptions.

Sentient supply chains allocate inventory in transit, strip out buffer stock formerly held to offset uncertainty, significantly reduce expedited shipments and increase asset utilization across the board.

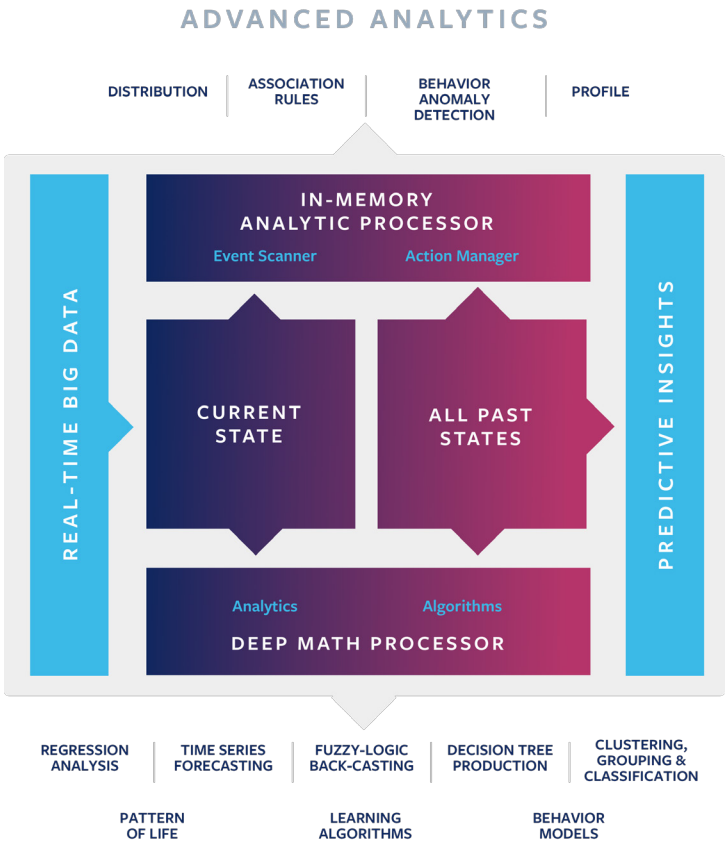
Without real-time data, however, none of this is possible, which makes the proliferation of IoT devices, and the massive amounts of data that comes from them, so important.

The data complexity and volume challenge

While sentient supply chains need massive real-time data streams to operate, the volume and complexity of this data introduces challenges of its own.

Many organizations have been paralyzed by the sheer volume and complexity of the data. *What data streams are best suited to inform what decisions? How can data streams be combined to produce even more high value data streams and what can those new data streams be applied to? How can such massive volumes of data be processed in real-time to produce near real-time insights? How can future outcomes be accurately predicted? How can actionable insights can packaged so they can be quickly operationalized?*

These challenges call for highly sophisticated machine learning algorithms—*and a very sophisticated IT platform*—that can run at staggering speeds, at massive scale. They also call for significant processing power and a great deal of storage space, both of which must be affordable.



Conveniently, these two capabilities—*artificial intelligence* and *cloud computing*—evolved very quickly over virtually the same time period, opening the door for sentient supply chains, and soon to be, sentient organizations.

Advances in artificial intelligence, machine learning and deep learning

The concept of artificial intelligence emerged in the 1950s, followed more recently by the concepts of machine learning and deep learning.

Machine learning is the practice of using algorithms to parse data, learn from it, and make determinations or predictions about something in the world. Instead of writing specific instructions for a computer to direct it to perform a task, the computer is "trained" using large amounts of data and algorithms—so that it develops its own ability to solve a problem, recognize a pattern, spot anomalies, or predict an event.

Deep learning is a particularly fast growing area within machine learning. It focuses some of the core ideas of AI on solving real-world problems with neural networks designed to mimic our own decision-making. Deep learning focuses even more narrowly on a subset of machine learning tools and techniques, and applies them to solving complex problems, such as speech recognition, image recognition and recommendation engines (identifying an optimal action from many choices).

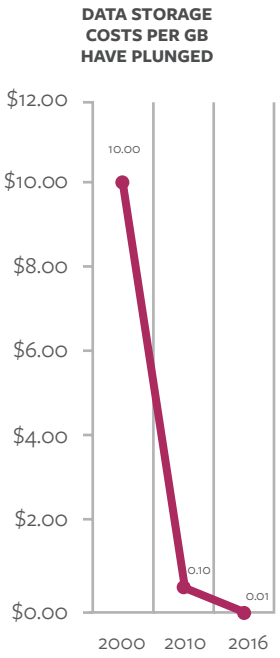
Machine learning is at the heart of a sentient supply chain. So much of the intelligent decision making, optimization and predictive capabilities of sentient supply chains stem from studying and learning the behavior of different nodes, conveyances and dynamic events.

What is normal behavior for a particular ocean vessel on a lane? What percentage of the time does it make an unscheduled stop at an intermediate port, causing it to be delayed at its final destination? Every steamship line behaves differently, of course, based upon the unpublished business objectives of the organization. They even behave differently at different times of the year based on the incremental margins that can be gained.

What is the normal behavior of a port? When does it become overly congested and what happens to dwell times when it does? What is the normal behavior of road traffic, manufacturing throughput, customs clearance times, supplier reliability and consumer demand? What impact does an external event, such as severe weather, natural disaster, price fluctuation or competitive action have on the normal behavior of these entities? How will that affect an organization's ability to source, make and deliver?

Machine learning can also be applied to identifying Patterns of Life, and making predictions that enhance supply chain management on both the supply *and* demand sides. For example, predictive insights can be generated by analyzing satellite photos showing motor vehicle parking volumes and patterns, or vehicle movement patterns.

A sentient supply chain is constantly watching, modeling, re-calculating and learning, so the predictions it makes and the actions it takes tomorrow are even better than the ones it made yesterday.



Source: "Understanding cloud pricing part 6 - big data processing engines." Google Cloud Big Data and Machine Learning Blog. March 17, 2016.

The increase in ubiquitous, affordable, distributed computing power

The growth of cloud computing over the last ten years has been a key enabler to sentient supply chains. A decade ago, the cost of in-house computing required to store and process real-time big data streams was prohibitively expensive. Today, computing power easily and affordably scales to process massive data volumes.

And because this massive and affordable storage and processing is now available in the cloud, maintained and managed by companies like Amazon, Microsoft and Google, it has democratized innovation. High volume modeling used to be limited to the few companies that could afford the in-house server capacity, big network pipes and staff to maintain it all. Today's college student has access to the same stack.

This has cleared the way for innovation, and operationalization.

The Sentient Supply Chain in action

While early adopters are just beginning to scratch the surface of a sentient supply chain's potential, they are realizing some significant early wins. These wins are coming in the form of compressed cycle times and inventory reductions through real-time visibility of inventory in motion; significant cost savings through predicting and avoiding supply chain disruptions; and increased revenues through identifying and exploiting market opportunities that competitors cannot.

Brooks Running is an example of an organization operating a sentient supply chain.

A successful, growing subsidiary of Berkshire Hathway, Brooks ships 750,000 pairs of running shoes and running gear from Asia to the U.S. each month. One of their primary supply chain challenges was the high level of variance in actual in-bound shipment arrival dates at West Coast ports vs. estimated times of arrival (ETAs) coming from carrier-provided EDI data. 94% of shipments arrived early, and 60% arrived *more than* 7 days early. The result was 9 more days of buffer stock than needed.

In 2016, Brooks implemented **TransVoyant P2L** for supply chain visibility, which utilizes real-time big data from the Internet of Things and a cloud-based analytics engine. Within 6 months, Predicted Times of Arrival were 68% more accurate than carrier-provided ETAs; ETA accuracy variance fell from +/- 6 *days* to +/- 8 *hours*, and 60% of purchase orders had an improved availability of 5 days or more. The 5 days reduction in buffer stock translated into a substantial financial benefit and increased Brooks' ability to promise orders to customers from inventory in-transit.

As today's IoT and predictive analytics-based technologies continue to evolve and companies continue to explore the myriad ways they can be applied, the possibilities are nearly endless. Sentient Supply Chains (soon to be followed by Sentient *Organizations*) are the new battleground for competitive advantage and ultimately for survival.

Interested in making your supply chain sentient?

Interested in learning more about the power of IoT data and predictive analytics for your supply chain and operations?

For more information, contact us at:
www.transvoyant.com
703-778-3500

About TransVoyant

From devices such as radar, sensors, satellites, smartphones, meters and other devices that make up the Internet of Things (IoT), TransVoyant collects, cleanses and constantly updates one of the world's largest repositories of real-time big data—over one trillion events each day. By applying advanced machine learning algorithms to these real-time data streams, the company gives organizations a live global picture of their goods in motion, as well as predictive insights that enable them to anticipate and avoid supply chain disruptions resulting from weather, port congestion, natural disasters, supplier failure, road construction and labor strikes, to name a few.