Innovation Insight for Continuous Intelligence in Supply Chain

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Technology advances have made it cost-effective to apply real-time analytics to high-volume data to make faster, better, even autonomous decisions. Supply chain technology leaders seeking to transform their company's performance should look for opportunities to use CI.

Key Findings

- Increasingly, supply chains are getting more complex. Many factors must be taken into account, even more so when profit margins are thin and decision making and timely responsiveness are, therefore, of key importance.
- Finding, gathering and integrating internal data is already a challenge for many supply chain organizations. Expanding that to monitor dynamic events in their extended value chain and share it with ecosystem partners for smart decision making is even more challenging.
- Companies that already leverage early warnings to anticipate significant changes in supply and demand, together with real-time monitoring of supply chain events, show efficiency improvements in their sourcing, manufacturing or sales and distribution activities.
- To make CI initiatives successful in supply chain, an even stronger involvement of business and technology teams, as well as a set of new capabilities, skills and technologies, is prerequisite.

Recommendations

Supply chain technology leaders are now able to catalyze digital business transformation by including CI in their supply chain strategies. In doing so, they should:

- Capture more ROI data points and insights from embedded analytics and intelligence in existing business applications by improving current usage levels and addressing adoption challenges.
- Embed CI deeply in its supply chain and technology context by fostering collaboration with transformation leaders to innovate, redesign and optimize business processes across their ecosystem.

- Identify business moments and use cases where CI creates tangible business value by working with supply chain leaders, subject matter experts and business process analysts.
- Minimize the time and effort required to achieve CI by using COTS packaged applications, SaaS or devices that have embedded CI capabilities.

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Strategic Planning Assumption

By 2022, more than half of major new business systems will incorporate continuous intelligence that uses real-time or near-real-time context data to improve decisions.

Analysis

Embedding continuous intelligence (CI) for operational decision making brings significant and measurable benefits to supply chains, such as enhanced revenue generation, smart resource allocation or improved customer service. It is where real-time data improves the speed, accuracy and effectiveness of business decisions. However, it is not relevant where equally good decisions can be made using historical data that is older than hours, days and more.

Increasingly, supply chains are getting more complex, with many factors that must be taken into account — even more so when profit margins are thin and, therefore, decision making is of key

importance. If that's the case, then providing "only" situation awareness to human decision makers is likely to be insufficient. Instead, the complexity of a richer, more complete and more current situation awareness must be complemented with artificial intelligence (AI)-powered decision automation to make better and faster decisions. This must consider many factors, constraints and objectives to achieve greater optimization across the supply chain.

Definition

CI in supply chain is a design pattern in which real-time analytics are integrated into a supply chain operation. Current and historical data is processed to prescribe actions in response to business moments (see Note 1) and other events along the value chain. CI in supply chain provides decision automation or decision support. CI leverages multiple technologies such as augmented analytics, event stream processing, business activity monitoring (BAM) optimization algorithms and machine learning (ML).

Note that supply chain already leverages such technology capabilities within concepts like "autonomous supply chain," "algorithmic supply chain" or "intelligent supply chain"; hence, the idea here is that the timeliness of data should not be older than a few minutes. Another aspect of interest would be how to distinguish between a local (domain-embedded) decision and an end-to-end (E2E) decision. CI comes in using events that are "young" and goes on to predict and prescribe the impact of these events on the supply chain in near real time.

Description

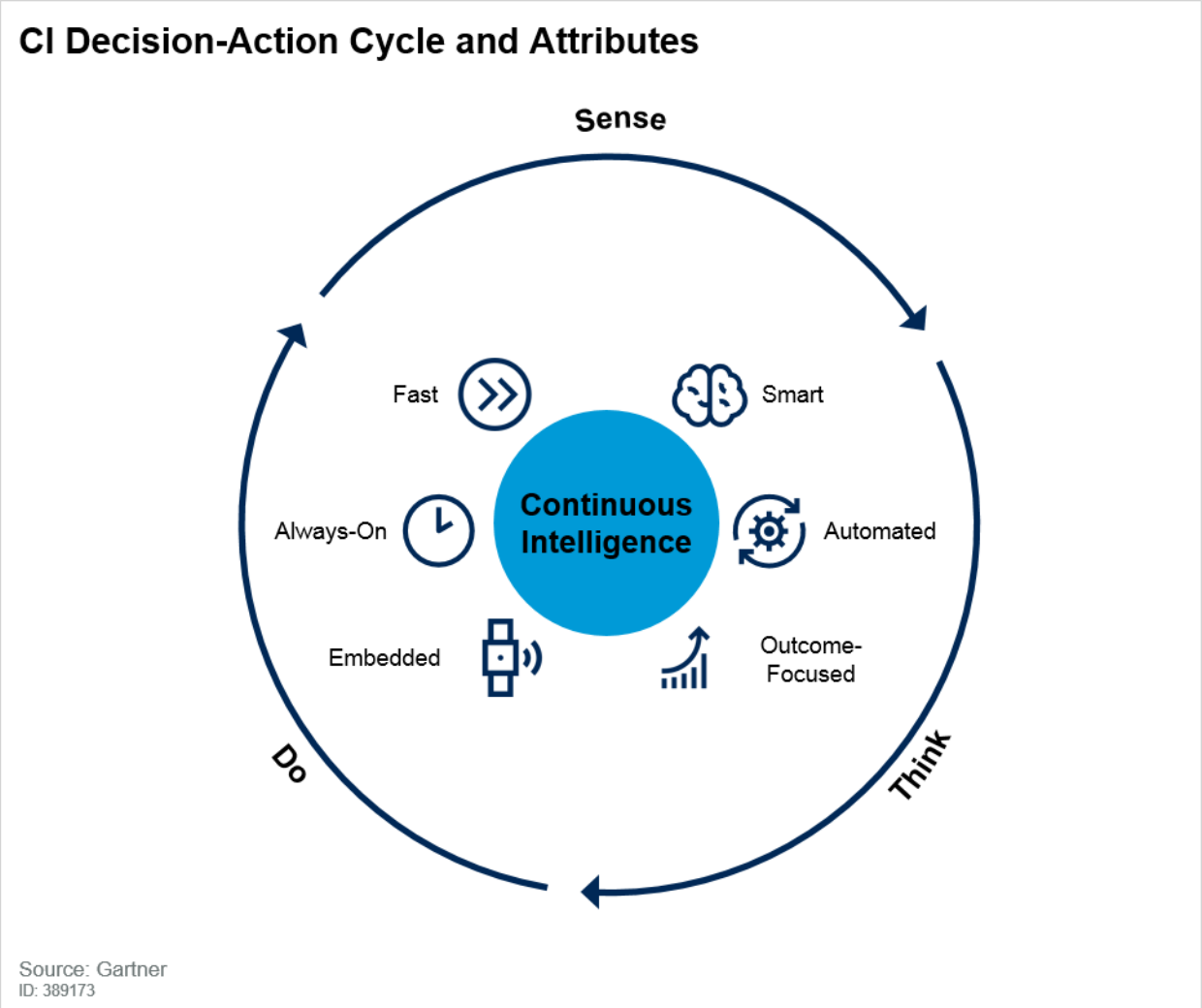
CI is one of the biggest opportunities for supply chain technology leaders to accelerate their organizations' digital transformation. It is founded on the synergy of multiple digital technology innovations, such as event stream processing, real-time data analytics, AI/ML, optimization or the Internet of Things (IoT). Basically, CI is a kind of real-time analytics being applied to operational and executional decisions in supply chain operations, because, by definition, most tactical and all strategic decisions are not made in real time (see "Find Inspiration in 10 Use Cases of Artificial Intelligence in the Supply Chain"). Also, CI goes beyond other established real-time analytics capabilities in two respects:

1. **Data-driven E2E insights:** Besides processing data from a company's core business applications, CI also processes transactional and context data from outside the company, such as sensor data, social media data, location data, news and weather feeds, or other streaming event data. All of this is related to the real-time aspect of data capture, which can considerably improve the quality and accuracy of business decisions.
2. **Data-driven E2E smart decisions:** CI implements decision management through the use of business rule management (BRM), optimization, ML or other prescriptive analytics to determine an appropriate response to the situation. This is on top of descriptive, diagnostic or predictive analytics, which mainly support situation awareness via dashboards and alerts.

Lately, those real-time analytics capabilities are also referred to as "control tower" by end-user organizations as well as vendors (see "Don't Believe the Control Tower Hype — Buyer Beware"). In

powering digital transformation, CI supports the decision-action cycle by leveraging six attributes that describe the characteristics of CI (as shown in Figure 1).

Figure 1. CI Decision-Action Cycle and Attributes



There are three stages of a decision-action cycle:

- **Sense:** Continuously ingest and combine real-time event data from multiple sources. By that, we mean any events in real time or near real time that have occurred within about 15 minutes. CI processes will merge that data with historical data, where needed, to get E2E data-driven insights *("see* more"). Sharing this data about the current supply chain state and relevant events transparently with all relevant actors in the chain provides the foundation for a shared situation awareness ("Think") and coordinated, optimized decision making ("Do").

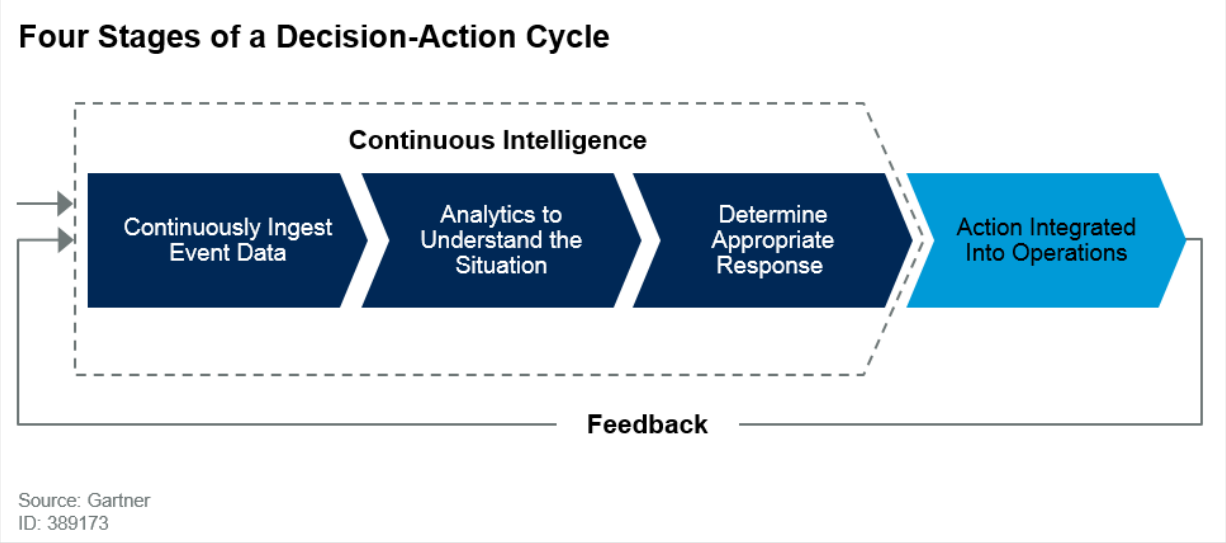
- **Think:** Always-on analytics capabilities to build a shared situation awareness, applying logic and math to derive insights from trends, deviate from normal behavior, or derive other patterns that signify or predict business moments and other events *("know* more").

  In addition, a model of the ecosystem network structure — or interconnections and relations — can be used to understand how an event may propagate or cascade. For example, from one supplier to another supplier to yet another supplier, and, ultimately, from the brand owner to its customers and to its customers' customers. Such a model (aka "digital supply chain twin"; see Note 2) can also be used to correlate multiple events across the ecosystem, or conduct a root cause/impact analysis, relating one event to an earlier event elsewhere.

- **Do:** Determine an appropriate response. The system generates advice (decision support) or fully offloads the decision from a human and triggers an appropriate response (decision automation). In the case of a supply chain, decision support or augmentation may be done either internally in a single firm for local optimization, or — in more innovative cases — collaboratively for more global optimization. Finally, the system, device or human carries out the action *("do* more").

CI leverages a computer's ability to be always-on, collecting and processing detailed data at a faster rate than people can. CI supports the stages of a decision-action cycle (as shown in Figure 2), from ingesting data to analyzing and understanding the situation to determining the appropriate response.

Figure 2. Four Stages of a Decision-Action Cycle



In many cases, of course, the system operates in a closed loop by collecting feedback on the outcome and subsequently becoming input in the iteration of the cycle. Often, this is referred to as the fourth stage, the ongoing "Learn." An emerging trend is that, in some cases — especially in very dynamic ecosystems — even the learning gets automated or augmented by applying adaptive ML.

Here are the six CI attributes:

- **Fast:** Delivering insights and decisions/recommendations/actions in (near) real time.
- **Always-on 24/7:** Available, on demand or based on sense and respond.
- **Embedded:** Integrated into the actual business process, transforming to really and fully digital.
- **Smart:** Leveraging all available data sources and the full spectrum of analytics, all the way to adaptive ML for insights.
- **Automated:** No or limited human interaction to deliver insights and recommendations/ decisions/actions.
- **Outcome-focused:** Creation of measurable value by seizing business moments and responding in a timely manner to opportunities and threats.

Many "visibility" systems only provide situation awareness without giving advice on how to respond. Such systems are appropriate and beneficial for supply chain scenarios in which a person can easily decide what to do without the help of decision management technology. Just knowing what is happening now, or what is predicted to happen soon, is often enough to enable effective human-derived responses, especially for companies in lower supply chain maturity stages. However, scenarios wherein the decisions on what to do involve many different (internal and external) factors and trade-offs, or wherein the decision is automated, require the use of decision management (see "Augment and Automate Supply Chain Decision Making With Advanced Analytics and Artificial Intelligence").

Optimization has roughly two flavors to deal with, for example, the effect of delays on production or logistics, price dynamics, demand fluctuations or other supply chain events. The first flavor is minimizing costs or maximizing profit for a single company, basically moving the negative impact of an event as much as possible to other firms. The other flavor seeks to spread or distribute an event's impact across multiple supply chain partners, taking a more collaborative approach that requires more cross-supply-chain optimization. The choice of flavor very much depends on the business strategy of the firm, and, for example, the extent to which this firm either is able to orchestrate activities or relies on the economic health of its ecosystem partners.

For example, a milestone dashboard that reports order/shipment metrics — such as last checkpoint passed and estimated time of arrival (ETA) based on lead-time calculations — provides basic insights using internal transaction and historical data. However, it can provide more value if it correlates externally sourced context data, such as weather and traffic streams or strike news, to understand delivery problems and predict a more accurate ETA, now becoming predicted time of arrival (PTA). It is even more feature-rich if the system provides decision management to calculate changes to routing strategies, or recommends cutovers to alternate delivery routes.

As a summary, digital business requires companies to have a more complete, extended and up-to-date situation awareness about their business ecosystem. CI is the way to do this, with the abilities to gather, analyze and derive insights from ecosystem-related data in real time or close to real time. CI also enables augmented and automated decision making by leveraging event stream processing, AI and decision management to respond as fast as possible to threats and opportunities.

Benefits and Uses

CI has emerged as a key enabler in support of the digital age, improving the timeliness, competitiveness and efficiency of existing and new business models. Mature cases of CI combine and integrate data from multiple applications to create a situation awareness that is more up to date, complete and detailed. CI is then able to detect more than just isolated applications that focus on only their own narrow slice of reality. It is already used by some highly mature companies in various supply chain operations. Next to established contact center or financial monitoring cases, examples include supply chain visibility, truck fleet management, procurement process tracking or warehouse management. These constitute feature-rich CI if they use context data and provide prescriptive advice or decision automation.

Most processes that employ CI get the intelligence from commercial off-the-shelf (COTS) packaged applications or SaaS offerings that support a single business function. Consumers already use COTS systems with CI (see "Supply Chain Brief: The CSCO Perspective on Supply Chain Business Networks"). For example:

- **Logistics and transportation:** GPS-based navigation software on mobile devices or assets provides advice on what route to take to avoid traffic based on real-time context data (see "Real-Time Transportation Visibility Platforms Provide Transportation Leaders With Supply Chain Efficiencies"). Leveraging real-time monitoring of supply chain occurrences shows efficiency improvements of companies' fulfillment activities. This is feature-rich, prescriptive CI. There is a wealth of new and developing solutions that do not have defined marketplaces. These may be easily integrated into existing COTS or similar systems (such as industrial IoT, asset management, telematics and even AI solutions) that deliver similar outcomes by augmenting with GPS and aligned technology solutions.
- **Asset maintenance:** Condition-based equipment maintenance is a quintessential example of feature-rich CI. It is a rapidly growing kind of IoT application that can supersede traditional machine maintenance practices. Condition-based equipment maintenance is more effective than those traditional practices. Sensors on or near the machine send continuous streams of event data on the operating characteristics of the machine. Always-on real-time analytics monitor the streams to detect signs of incipient failure (see "Cool Vendors in Manufacturing Operations"). When the relevant event pattern appears, a business moment is recognized. The system generates a prescription to replace or repair the affected parts at exactly the right time to maximize the useful life of the parts, minimize the cost of labor and downtime, and improve customer satisfaction.

  Other use cases include:

  - Asset-to-asset communications for optimization and alignment of service-based assets, like wind turbines or solar cell management units
  - Reassignment of human-based asset resources as part of continuous learning and monitoring and alignment between technology-based tools and the need for human intervention, verification or authentication, especially for custom-made or very unique high-value items or products

- **Customer engagement:** Hubs can collect data from e-commerce systems, customer contact centers, campaign management and fulfillment systems, and on-premises location-tracking and retail systems. They exchange and correlate transaction and customer behavior context data across these separate systems. Data from any input channel can be leveraged by any output channel for marketing, sales and service functions. This enables better customer service, more customer satisfaction and precisely designed, tailored offers that lead to higher sales revenue (see "Pave the Way for AI Adoption, Then Use Chatbots as Trailblazers in Supply Chain Customer Fulfillment").
- **Traceability:** Traceability and continuous market vigilance of an asset across its entire life cycle. Traceability capabilities will enable identification of anomalies and incidents, and making responsive improvement recommendations into new R&D cycles (e.g., in implantable medical devices).
- **Workload balancing:** Companies face operational challenges tied to disruptions in their supply chain. Early awareness of any internal or external threats or opportunities through real-time status updates and data streams enables companies to understand the impacts as the basis for optimal data-based decisions and next actions. An example would be the impact of additional demand or options to offload demand to alternative products. This enables benefits such as premium freight reduction, inventory optimization and overall workload reduction.
- **Respond planning:** Within supply chain planning (SCP), the short-term operational/executional planning arena (what Gartner calls "respond planning") is the logical place for CI. Respond planning needs to be tightly aligned with execution, and involves making decisions (aka plans) fast based on near-real-time data. Respond planning is also the planning layer that companies often look to automate more because human decision makers won't be able to keep up with the data streaming out of execution (see "Getting Ready for the Digital Future: Strengthen Your Supply Chain Planning CORE"). The advantage of respond planning is being able to keep in alignment with what is actually happening in the internal and external execution world to maximize service and minimize cost.

Generally speaking, through utilizing AI (see Note 3), companies can achieve benefits in the supply chain along the following (see "Augment and Automate Supply Chain Decision Making With Advanced Analytics and Artificial Intelligence"):

- **Improvements:** Improved demand forecast accuracy, customer service improvement and increased capacity availability
- **Reductions:** Order cycle time reduction, total supply chain cost reduction, inventory level reduction and transportation cost reduction

Adoption Rate

We estimate that more than two-thirds of major business operations in large companies have some real-time intelligence, mostly in limited, single-function "stovepipes." But less than half of those are feature-rich CI in the sense that they use context data and decision management. And less than 5% are custom-built, integrated solutions that support multiple business functions.

Companies are ramping up their use of CI because it has become cost-effective in business processes that were previously too costly to serve. The decreasing costs of sensors and transmitting sensor data are huge factors in enabling IoT-based solutions. Barriers to adoption are also being lowered by:

- The evolution of augmented analytics, ML, AI and decision management services
- The emergence of decision modeling tools
- Improvements in stream analytics and other event stream processing tools

Most future, single-function systems with CI will still be implemented through the use of COTS packaged applications or SaaS because these are the fastest and easiest ways to get the systems into production. Several business application vendors (e.g., in SCP) will add CI capability to their solutions for specific use cases. However, custom-built solutions — even including complicated, integrated, multifunction solutions — are becoming more common as more architects and developers become familiar with relevant design techniques and software tools. And, from a more important business perspective, organizations increasingly want to optimize their operations across multiple functions or multiple internal or external business units. This requires what is also known as an "enterprise nervous system," which enables more holistic situation awareness and more globally optimized decision making. From a supply chain perspective, this enterprise nervous system will leverage digital twins of the supply chain to ensure that local and E2E decision making is properly balanced across the supply chain.

Note that supply chain operations that leverage CI in some of their processes also have some other processes and decisions that don't use CI. Many business decisions do not require (real-time) data from the past 15 minutes or so, in which case CI does not add value. However, prescriptive analytics can still help to improve the quality in decision making, also in non-real-time use cases.

Risks

All companies have the capability to use COTS CI, but many lack the middleware and analytics skills necessary to develop custom-built CI capabilities/solutions. But even COTS solutions can be problematic for companies with limited experience (see "Digital Business Requires Algorithmic Supply Chain Planning"). Real-time integration with other source or target systems and the complexity of decision making algorithms are typical examples of adoption hurdles. Systems that implement decision automation can cause extensive damage quickly if the decision-making algorithms are not well-designed and continuously monitored for accuracy. Companies that deploy systems with automated decisions should implement range checks, facilities for human oversight and other guardrails to reduce the number and severity of potential errors. Within a supply chain context, CI, if not used appropriately, could lead to severe nervousness where automated decision-making causes unintended consequences in other parts of the supply chain, and the need to continuously replan. A combination of localized CI and E2E supply chain optimization will be required to maintain balance. Decision support systems — where CI is provided to a person via a mobile application, real-time dashboard or other application — have less risk because human users can apply common sense before implementing the recommended action.

Recommendations

To strategize and plan for digital business transformation, supply chain technology leaders should do the following:

- First, assess your supply chain maturity and readiness to adopt CI as a key outcome and deliverable, as part of ongoing collaboration both internally and across key supply chain trading partners.
- Embed CI deeply in its supply chain and technology context by fostering collaboration with transformation leaders to innovate, redesign and optimize business processes.
- Target shared value creation opportunities around embedding visibility and interoperability as strong foundations for CI.
- Identify business moments and use cases where CI creates tangible business value by working with supply chain leaders, subject matter experts and business process analysts.
- Minimize the time and effort required to achieve CI by using COTS packaged applications, SaaS or devices that have embedded CI capabilities, where products with those capabilities are available. Also, take cross-function or cross-supply-chain business requirements into account.
- Before investing in additional technology solutions, capture more ROI from embedded analytics and intelligence in existing business applications by improving current usage levels and addressing adoption challenges.
- Consider CI only where a local decision must be made regarding supply-chain-relevant data that is less than 15 minutes old.

Representative Providers

- Aera
- Cognistx
- IBM (Watson Supply Chain Insights)
- JDA Software (Luminate Control Tower)
- OpsVeda
- SAS
- TMC (Navisphere Vision)
- TransVoyant

Gartner Recommended Reading

Some documents may not be available as part of your current Gartner subscription.

“Market Guide for Supply Chain Analytics Technology”

“Deploy Supply Chain Analytical Platforms to Build Flexible Solutions”

“Map Your Journey to Supply Chain Analytics Excellence With Gartner’s Five-Stage Maturity Model”

“Improve Supply Chain Modeling With the Combined Use of Simulation and Optimization”

“Evaluate Four Key Areas for Machine Learning in Supply Chain Planning”

“Current Use Cases for Machine Learning in Supply Chain Planning Solutions”

“Innovation Insight for Continuous Intelligence”

“Building Your Continuous Intelligence Capability for Digital Transformation”

“Business Ecosystems and Continuous Intelligence — How to Use External Data for Competitive Advantage”

“The Importance of Identifying and Classifying Assets Across the Supply Chain”

Note 1 Business Moments

A business moment is a transient opportunity in which people, data, businesses and things work together dynamically to create increased value (see “How CTOs Can Help Their Organizations Exploit Business Moments” and “Jump-Start Your Industrie 4.0 Initiative by Leveraging Business Moments”).

Note 2 Digital Supply Chain Twin

A digital twin is a digital representation of a real-world entity or system. The digital supply chain twin is a digital representation of the physical (often multienterprise) supply chain. It is a dynamic, real-time and time-phased representation of the various associations between the data objects that ultimately compose how the physical supply chain operates. It is the basis for local and E2E decision making for the supply chain, ensuring that this decision making is aligned horizontally and vertically throughout the supply chain. The digital supply chain twin is derived from all the relevant data across the supply chain and its operating environment.

Note 3 Artificial Intelligence

AI is a set of technologies that seeks to mimic the human ability to understand data, find patterns, make predictions and find recommended actions without explicit human instructions. In AI, ML is the most common technique, followed closely by natural language processing (NLP) and cognitive expert advisors (which combine ML and NLP). The usage level of deep learning is significantly lower. This is understandable given the emerging nature of this technique as well as its intensive data and data science requirements.

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