FEATURE

Unlocking end-to-end digital fulfillment

Agile supply chains deliver a seamless experience

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Customers now expect more from their purchasing experience. Exceeding these expectations could require an agile supply value chain—one made possible through digital supply networks.

BEFORE THE ADVENT of digital technologies, fulfillment was largely an exercise in "sell and replenish" for companies. Now, Fourth Industrial Revolution technologies such as artificial intelligence (AI), Internet of Things (IoT) sensors, and robotics have given rise to digital supply networks (DSNs), which are transforming static, linear supply chains into an interconnected ecosystem of nodes that dynamically shape the planning, production, and distribution of products.[1] At the same time, customers are expecting more from how they make purchases and engage with their value chain partners: more individualized products, more transparency in price and process, and personalized services delivered at a faster pace.[2] Meeting and exceeding these new customer expectations may require an agile supplier value chain, one that can only be attained through a complex network of DSN nodes working in concert. For organizations and customers alike, DSNs are ushering in a new era of *digital fulfillment*.

However, as every response in a DSN is connected to countless other end points, digital fulfillment takes more than a single team or functional process simply "going digital" (see the sidebar, "The technologies behind digital fulfillment"). For every digital solution to fully reach its potential, it typically requires integration across the entire user experience. As such, fulfillment is evolving from a series of siloed functions into a synchronized activity, one that is seamless and transparent, and adjusts in real time, dependent on every facet of the organization getting it right (see figure 1).

Organizations that are able to integrate their entire suite of digital solutions into a holistic fulfillment experience are parlaying their enhanced agility into

new value. Specifically, in a world where production, distribution, and transportation constraints exist, digital fulfillment can empower organizations to better respond to the market in several ways:
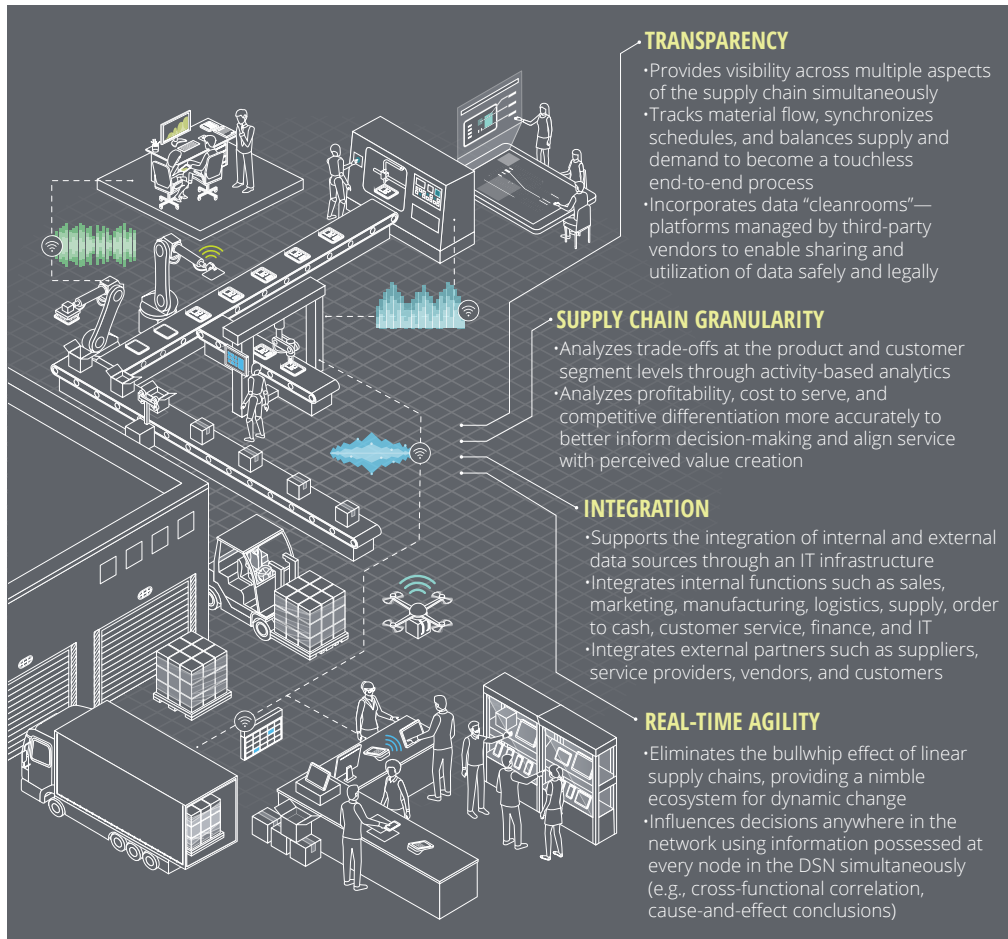
- **Connecting customers to the value chain.** Organizations can sense what their customers will need and make real-time adjustments across the supply chain to best accommodate demand preferences.

- **Redefining supply chain agility.** Digital fulfillment can equip organizations with the knowledge to direct their assets in a manner that best optimizes machines, working capital, and resource allocations to build and supply the products that the market most desires, when they desire them, and as close to the point of consumption as possible.

- **Delivering a seamless experience.** Enhanced visibility of demand signals and added transparency into end-to-end operations often allow companies to optimize their distribution footprint and stage products intelligently, thus providing fast, flexible service options to the customer while reducing overall cost of delivery.

Our article explores two key areas an enterprise should consider addressing to possibly unlock the full capabilities of end-to-end digital fulfillment:

1. Identifying the key functional and technical capabilities an organization needs to transcend beyond simple "sell and replenish" activities

2. Preparing the organization and its people to drive digital fulfillment throughout the DSN

FIGURE 1

Redesigning operations for digital fulfillment has four aspects

TRANSPARENCY
- Provides visibility across multiple aspects of the supply chain simultaneously
- Tracks material flow, synchronizes schedules, and balances supply and demand to become a touchless end-to-end process
- Incorporates data "cleanrooms"— platforms managed by third-party vendors to enable sharing and utilization of data safely and legally

SUPPLY CHAIN GRANULARITY
- Analyzes trade-offs at the product and customer segment levels through activity-based analytics
- Analyzes profitability, cost to serve, and competitive differentiation more accurately to better inform decision-making and align service with perceived value creation

INTEGRATION
- Supports the integration of internal and external data sources through an IT infrastructure
- Integrates internal functions such as sales, marketing, manufacturing, logistics, supply, order to cash, customer service, finance, and IT
- Integrates external partners such as suppliers, service providers, vendors, and customers

REAL-TIME AGILITY
- Eliminates the bullwhip effect of linear supply chains, providing a nimble ecosystem for dynamic change
- Influences decisions anywhere in the network using information possessed at every node in the DSN simultaneously (e.g., cross-functional correlation, cause-and-effect conclusions)

Source: Deloitte analysis.

End-to-end digital fulfillment: A world beyond "sell and replenish"

The complexities associated with DSNs are bringing about new challenges, including shifting demand patterns and channels, evolving service expectations, order management integration changes, complex inventory require-ments, and delivery issues. Addressing these challenges while simultaneously maintaining profit margins and enabling revenue growth cannot typically be achieved without adopting end-to-end digital fulfillment capabilities that are integrated within the entire supply chain.

The good news: Organizations that are able to im-plement digital fulfillment activities are generally able to differentiate themselves in new, powerful ways. These often include giving customers and supply chain partners better insights, greater agility, and a more holistic view of cost to serve.

In this section, we break down some of those most fundamental attributes of digital fulfillment.

FORECASTING THROUGHOUT THE SUPPLY CHAIN

Imagine if an organization *knew* demand because it analyzed consumer drivers, customer inventories, and other levers associated with consumption rates. Then imagine if, rather than relying on qualitative feedback for market intelligence, the organization could sense demand quantitatively based on analysis of traditional datasets coupled with social data, auto-correlated event predictions, and financial indicators. Finally, imagine if those demand signals were instantly coordinated with production assets and reoptimized dynamically to make exactly what the market commanded, when

it commanded it, and in a manner that understood trade-offs, inventories, and optimized costs.

Today, many companies are still generally more adept at shaping supply to meet the needs of customers by altering production schedules and focusing all their energy on improving the forecast. In terms of predictive capabilities enabled by DSNs, one global wind turbine manufacturer continually wrestled with the threat of stockouts due to unforeseen bulk orders for some of its key service parts, leading to service disruptions and supply shortages.[3] Historically, the organization addressed these issues through conversations with field representatives and minimal or incomplete data passed along by engineers. To address its challenges, the manufacturer integrated a number of diverse datasets, including part failure data from the site, life cycle milestones that highly correlated with part failure, external sales data, and warranty information. By leveraging AI and smart sensor technology, the organization was able to relay failure code alerts to the operations center, which, in real time, deployed the necessary parts and scheduled the relevant maintenance in the field. As a result, it was better able to predict demand at a transactional level by algorithmically anticipating demand needs before they fully came to fruition.

Still other companies attempt to modify demand only with broad-stroke price changes. This is rapidly changing as well, as companies adopt digital methods to enhance demand-predicting and -shaping capabilities. In this domain, Amazon may sit at the apex of demand-shaping. By analyzing customer demand, competitor information, and inventory levels, Amazon adjusts prices on products in an attempt to sway customer buying behavior. It has become such common practice that prices change, on average, 2.5 million times a day—which means each individual product's price changes every 10 minutes.[4] These demand-shaping capabilities can redefine entire operating models within companies, forcing them to break down traditional

functional siloes through fully integrated datasets that feed organizationwide strategies.

RESHAPING SUPPLY CHAIN CONNECTIONS

As value chains become more complex to meet the evolving demands of the marketplace, DSNs are helping decision-making become simpler and clearer than ever. Through the broad deployment of IoT sensors throughout the physical supply network and application program interfaces (APIs) connecting disparate data, both structured and unstructured, across systems and value chain parties, companies can collapse the complex flow of information in their value chain into a central hub for visualization, awareness, and decision-making. Below, we discuss a few use cases of how companies can reoptimize the entire value chain by sharing data and integrating it on the cloud to elevate their planning, replenishment, manufacturing, and sourcing functions.

Creating dynamic inventory

Dynamic inventory is contingent on the ability to "virtualize" inventory across the supply chain. In the past, companies would attempt to manage this process through their enterprise resource planning (ERP) systems. But as ordering channels and customer preferences grew more complex, an increasing number of supply chain partners were required to coordinate inventory levels. Yet, giving supply chain partners access to your ERP system can be rather invasive. Now, much of the technology that makes DSNs possible is also creating new ways to share information. For instance, sensors and APIs allow a manufacturer to monitor the location and health of its products without tapping into a dealer network's ERP system to gather the same information. One grocery chain recently developed smart shelves that are equipped with weighted sensors to alert where added inventory is required—before a product shortage occurs.[5] In another case, a business-to-business manufacturer outfitted its dealerships with highly analytical "cockpits" that conducted

in-depth sales analysis to highlight opportunities to reduce stock-keeping unit complexity and anticipate replenishment needs; the cockpits were also equipped with one-touch reorder buttons to easily alert suppliers of part needs.[6] In essence, DSNs are making dynamic inventory a reality.

Transforming planning capabilities

Traditional planning processes rely on monthly cycles that first require reviewing the numerous supply and demand imbalances, and then, using these insights to make strategic decisions. But deciding on supply and demand trade-offs can often be difficult, time-consuming, and human labor–intensive, as there are many cost considerations. In response, companies are gravitating toward supplementing integrated business planning with autonomous planning. This elevates planning from a monthly exercise to a continuous, real-time event by shaping demand and supply through analytics.[7] To this end, companies can leverage a variety of technologies to plan, monitor, and react to events as they unfold. The beauty of this approach is that it can bifurcate the planning process for companies in the foreseeable future, leaving only the more strategic decisions to people (informed by data insights) while automating the countless supply- and demand-balancing decisions that once required human intervention.

Building a dynamic supply base

To increase agility, many companies are turning to new, innovative means of supplying products that both include and go beyond traditional brick-and-mortar locations—all of which maintain the end goals of ensuring the products are strategically placed near final points of delivery to optimize total distribution costs while maintaining or enhancing service to the end consumer. For instance, "pop-up" warehousing is one option to fulfill seasonal demand or speed fulfillment cycles (similar to seasonal Halloween shops).[8] By integrating digital innovation into manufacturing and sourcing, digital fulfillment is creating a truly agile supply chain while simultaneously optimizing costs.

ANTICIPATING LOGISTICS AND AUTOMATING EXECUTION

Advanced transportation management systems can leverage networks of asset-based sensors and machine learning to create ecosystems where suppliers, logistics service providers, and carriers can share information, visualize congestion, and optimize cargo capacity across all modalities to meet delivery demands in near-real time. For example, fleets use telematics to monitor the location, movement, and status of vehicles, building a comprehensive view of their networks, while smart sensors embedded in products and packaging make automatic reorders and replenishment possible.[9] Further, workers can be scheduled at the distribution center or store with precise knowledge of when shipments will arrive.[10]

Even more revolutionary is the future potential of logistics and transportation capabilities through quantum computing and autonomous vehicles (see the sidebar, "The technologies behind digital fulfillment"). Today, our most complex logistics and transportation questions are unsolvable through traditional computing methods, so instead we resort to shortcuts—think relying on GPS navigation solely for route optimization when quantum computing could also incorporate traffic congestion, weather or construction impediments, and predictions of changing customer behavior. With quantum computing, companies can capture data on every turn, the wear and tear of each vehicle, and countless other variables to optimize routes, fleet sizes, and delivery schedules. And a next step is autonomous vehicles, which could be able to both capture data and optimize these dimensions even further. Already, autonomous vehicles are beginning to find use in commercial freight through the usage of platooning (e.g., a connected set of vehicles controlled by a single driver) to increase capacity shipped per mile.

Automation is also extending into our warehouse management and execution systems, making the concept of true "touchless" order fulfillment—in which human intervention is required only by exception—a reality. Presently, e-commerce and traditional brick-and-mortar companies are increasingly deploying stationary and mobile robotic processes alongside a human workforce in the field, and, in some cases, are even operating "lights-out" warehouses (fully automated warehouses, absent of any people) to perform fulfillment activities with minimal manual interference. Still other companies are extending the usage of automation and robotics beyond the warehouse to distribution. These companies are using drones and autonomous fleets to deliver packages,[11] to know where assets are at any point, and to adjust in-transit shipment protocols to quickly react to changes in order patterns or demand signals. The degree to which automation can benefit operations is not solely an efficiency or cost decision, but also one of safety and feasibility. Certain environments such as cold-storage facilities or hazardous or remote destinations are perfect examples of where robotics and digital automated capabilities are being utilized in lieu of humans to minimize risk and ensure continuity of operations.

ELEVATING ORDER-TO-CASH AND THE CUSTOMER EXPERIENCE

Once thought to be a back-office administrative activity, order-to-cash (OTC) capabilities have come to represent the final, and perhaps most complex, stage of the digital fulfillment process—the evolving point of sale and the lasting impression felt by the customer when doing business with a company.

The most sophisticated supply chains in the world can be undermined by a poor customer experience, whether online, in a store, or on mobile or social platforms. Because of this, each customer journey should be thoughtful throughout all aspects of the OTC process, identifying points of differentiation and delivering memorable experiences across order management, customer service, delivery, and invoicing.

On the business side, DSNs provide a more complete picture of what it costs to serve a customer. That means understanding what geographic

locations are more expensive to deliver to, and, as importantly, what the customer values in terms of price, speed, and customization. However, this does not imply that in an era of digital fulfillment, an organization can be "everything to everyone." Instead, it provides a clearer view of how the organization can differentiate its prices and services.

For instance, Timbuk2, a messenger bag manufacturer, allows customers to build customized bags from any of its store kiosks.[12] They are also given the freedom to choose between greater price discounts and delivery speed. In the process, customers are influencing product design and manufacturing processes while simultaneously informing demand planning and delivery schedules. And behind the scenes, Timbuk2 is able to differentiate its price and customization capabilities to better align to customer expectations—without the expectation that it needs to both increase delivery speed and reduce prices for every customer.

Further, organizations are improving the customer experience. Once-manual, reactive, and human-intensive efforts are now becoming more digital, leveraging bots and AI to ingest structured and unstructured datasets to identify patterns, predict and mitigate possible network disruptions or customer issues, and proactively provide automated recommendations to customers. Here are three examples of what this looks like in practice:

- Virtual chatbots, endowed with natural language processing and machine learning capabilities, are automating and improving elements of customer service throughout the fulfillment process—even anticipating complaints or issues before they arise.

- One organization is analyzing customer buying behavior and recommending new subscription contracts that better match their fulfillment needs.

- Auto-replenishment is increasingly becoming part of the customer experience. Consider smart fridges that understand when you are out of yogurt and automatically submit an order on your behalf.

With greater access to understanding cost-to-serve and more customer-orientated technology, organizations are elevating the customer experience throughout the fulfillment process.

BRINGING IT TOGETHER WITH A DIGITAL TWIN

If an organization can accurately forecast and shape demand, optimize inventory, and deliver products in a digital replica or "twin" of the physical world to create a superior customer experience, it will likely need to use concurrent planning. This is a state in which a constant flow of data from throughout the DSN enables organizations to accurately orchestrate the many moving parts.[13] Further, data-gathering capabilities are transforming via tools such as scraping (importing web data into databases) and AI learning, enabling us to build more complex and holistic digital twins. In an interconnected DSN, this filters across to external nodes, enabling suppliers and logistics providers to more accurately plan and execute. The result is more dynamic, flexible, and efficient operations. However, it is important to note that the challenge of information-sharing remains very real: One deterrent to creating a digital twin that spans the full value chain is a reticence to share information, as many companies may fear a loss of competitive advantage.

The people and systems behind the transformation

Digital fulfillment is part of an enterprisewide digital transformation—overhauling business processes and models using advanced technologies. This transformation requires not only

THE TECHNOLOGIES BEHIND DIGITAL FULFILLMENT

Digital fulfillment is made possible by a variety of Industry 4.0 technologies, each resting on the foundation of data. To reach the peak of digital fulfillment capabilities, data must seamlessly integrate a variety of networks (suppliers and distributors), stakeholders (sales and logistics), and formats (structured and unstructured) to produce actionable insights on which systems can act. It is also important to note that these technologies should be considered as part of an interconnected system, or "stack," as opposed to singular applications or package technologies that remain siloed from each other.

With high-quality, usable, fully integrated data as the foundation, organizations can use the following technologies to build digital fulfillment capabilities:

Cloud computing. The sheer number of databases integrated throughout a DSN require an efficient means to aggregate and analyze the information. For this reason, cloud computing provides the computational power necessary to efficiently drive the digital fulfillment process. Cloud computing can properly bring together vast loads of data, analyze it, and enable capabilities.

Artificial intelligence. AI uses pattern recognition and algorithms to interpret data and translate it into real-time insights, collapsing tactical planning and automating much of the decision-making. One AI technique, machine learning, not only analyzes data but refines and optimizes its predictions over time. Fulfillment warehouses may lean on machine learning to not only better forecast demand but also to find the optimal mix of people and machines to meet demand.[14]

Internet of Things. Smart sensors have revolutionized digital fulfillment by enabling monitoring and tracking of assets. These sensors can be embedded in various devices to transform data into insights that can, in turn, drive improvements in digital fulfillment. For example, connected appliances trigger sales at the point of consumption, such as grocery orders.[15]

Robotics. Both virtual and physical robotics can affect digital fulfillment. These technologies include robotic process automation, where tasks are automatically completed based on specific directions; physical robots that can augment the human workforce in warehouses; and fully automated, autonomous robots capable of performing picking, packing, and shipping operations without the need for human operations.[16]

Quantum computing. At the forefront of solving the world's most difficult optimization challenges is the emerging technology quantum computing.[17] By leveraging properties of subatomic particles, quantum computers could solve computational challenges that the most sophisticated computers cannot currently handle.

augmenting, integrating, and upgrading legacy technologies but also updating legacy organizational structures and adopting new approaches to management. We look at some of the main areas that organizations should rethink below.

AUTOMATED DECISION-MAKING

The success of end-to-end digital fulfillment depends on the use of the information flowing among the nodes of the DSN. This digital loop allows information to be shared transparently across all functions and all areas of the supply network to better balance supply and demand and enable holistic decision-making.

The shift from intuitive, experience-based management to data-driven decision-making can be challenging. However, being armed with the

data needed for informed trade-offs can help eliminate decisions based on gut reaction. This is especially useful as many of the decisions automated by algorithms focus on routine tasks (think back-office customer service remediation).[18]

Of course, these algorithms can also help augment human intelligence. For instance, an algorithm may identify which nodes in the supply chain are at the highest risk of disruption (such as due to a natural disaster) and recommend remediation actions that the human worker can review and select. At its core, it is about redesigning work to better facilitate human and machine collaborations that leverage their respective strengths.[19] In fact, one human capital study suggested that 84 percent of companies that expect automation to alter workforce responsibilities are also increasing their investments in reskilling workers.[20] As a result, employee skill sets are shifting from demonstrating analytical expertise to instead interpreting the outputs that machines provide and reacting appropriately.

REDEFINING OPERATIONAL BOUNDARIES

Traditionally, different functions crucial to the optimal operation of the supply chain may have had contradictory priorities. For example, coming to consensus on projected demand for customers may be a tension point between the sales and supply chain functions: The former will often push for optimistic demand plans and the flexibility to have products always available for every customer, potentially driving up inventory, transportation, and production costs. In contrast, the supply chain function prefers lean inventory balances, frozen production schedules, and predictable transportation, which can keep supply chain costs down but may restrict customer flexibility.

The good news is that more supply chain leaders are recognizing the need for cross-functional collaboration and integrated decision-making.

One Deloitte survey highlighted that 45 percent of supply chain executives recognized a greater need to interact with outside suppliers, while 36 percent cited the importance of customer interactions.[21] Eliminating silos can start with sharing digitally derived information about what is possible and optimal in terms of digital fulfillment with all relevant functions. This starts with agreeing on cross-organizational key performance metrics, ensuring proper integration of these metrics with all relevant stakeholders, and putting in place a governance model that reinforces behaviors and incentives aligned to the best interests of the customer and the overarching enterprise. Doing so can align everyone on the same goals and objectives and achieve more optimal outcomes that will drive the business forward.

Thinking ahead

Succeeding at end-to-end digital fulfillment often requires leaders to think big, start small, and begin connecting.

Think big and embrace the customer journey. Customer-centricity is at the core of a digital fulfillment business model. Pave the way to a seamless consumer journey by understanding your consumers and their expectations, and work with your DSN partners to deliver optimal fulfillment options. While embarking on the digital fulfillment journey, embrace change and technology disruption in the marketplace to design state-of-the-art fulfillment capabilities that meet your customers' expectations and become your company's competitive differentiator.

Start small with proof-of-concept pilots. Pick priority digital fulfillment offerings, markets, or cities to get started and establish a proof of concept through agile design thinking and a digital factory delivery model.[22] One option is to pick one of the main attributes that make up

digital fulfillment (e.g., forecasting through the supply chain) and focus on executing in that space first. Identify the trade-offs needed to support fulfillment offerings and adhere to constraints of current existing operations. Avoid a total overhaul until success is measured on a small scale.

Connect the work of others. Digital fulfillment requires many groups working together as integrated channels and supply chains becoming more resilient, connected, and agile. Support omnichannel and cross-functional thinking: Online depends on offline, and vice versa. Strengthen your external network by establishing partnerships with upstream and downstream players—a networked, collaborative organization will outperform siloed and isolated firms.

Companies are turning to digital fulfillment solutions across the end-to-end value chain to harmonize shifting expectations with operational capabilities. By leveraging the latest technologies and innovations in the supply chain, companies can not only better plan for the needs of their customers but can also predict *when* and *where* needs will manifest before the customer even places an order. The future of fulfillment is digitally enabled and always on, bringing the customer closer to your operations than ever before.

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