From the Internet of Things to the
Intelligence of Things

Initially, when technology pundits got the drums rolling for the Internet of Things (IoT), at best, the 'Things' in IoT alluded to 'devices.' By no stretch of imagination did it refer to the prospect of 'talking' strawberries, beer, or wine.

However, with IoT transcending its nebulous stage, the promise of connectedness between anything opens up tremendous possibilities in retail, especially in the area of supply chain.

The next generation retail supply chain, by embracing IoT, is set to become smarter as it enters an era where it deals with smart devices, smart products, and smart warehouses. Connected equipment in a warehouse can help in monitoring movement across the facility, connected products can update real-time inventory, connected workers can pick up orders more efficiently, connected strawberries can talk about their freshness journey from farm to fork; even moving trucks carrying orders can be tracked, managed, and optimized in the most efficient manner.

This article explores how IoT can be leveraged to reimagine every process in the supply chain, augment the entire ecosystem with trending technologies, add value, and eventually change the daily lives of both retailers and consumers.

IoT-Enabled Transformation

IoT enabled transformation is currently focused on improving the tracking and sensing capabilities of the supply chain, impacting both the top line and bottom line across product categories. Although this transformation seems limited in scope now, the proliferation of IoT is imminent, considering the customer value it can generate across the planning and execution functions.

Table 1 and the following sections highlight the potential of an IoT-enabled transformation across the planning and execution functions in a retail supply chain, and the customer value it can generate.

Retail Supply Chain Process Area	Future Trends with IoT-Enabled Transformation
Forecasting	Forecasting demand based on consumption patterns rather than historical sales
Sourcing	Choosing suppliers with high integrity and performance
Replenishment & Allocation	Proactive reordering rather than reactive
Order Management	Prempting orders based on predictive analysis of customer preferences
DC & Fulfillment Operations	Dialog-based interaction among humans-robots-machines
Logistics/Last Mile	From tracking (drivers) to controlling (truck movement) to empowering (end customers) with real-time updates of their orders from farm to fork

Table 1: IoT powered value mapping for retail supply chain processes

Let's explore how some of the core process areas in supply chain can become more efficient and deliver better customer experience when driven by intelligent IoT.

Forecasting: From 'Inside Out' to 'Outside In'

While historical sales data helps arrive at reasonably accurate demand forecasts at the aggregate level, it falls short at the granular level predictions. By providing visibility into the inventory levels at the points of consumption through smart shelves or devices (be it home or business), IoT can enable retailers to understand the consumption patterns of consumers and predict their future needs, moving towards an outside-in approach. This new approach calls for sophisticated forecasting systems that can analyze live streams of high speed, high volume IoT data, and sense demand patterns to predict the expected orders based on lead time requirements, enabling dynamic replenishments.

Sourcing: A Journey Visible to All

Most often, retailers lack visibility into the handling of inbound products until the products reach the retailer's own supply chain. This casts a doubt on both the quality promise made to consumers and the ability to react to changing conditions. By bringing real-time visibility into the in-transit environmental conditions, IoT sensors can help retailers make informed decisions on supplier performance and in-transit inventory. Further, the transparency ingrained by IoT sensors empowers consumers with information about the product journey, allowing them to become important stakeholders in making sourcing decisions. Furthermore, all partners engaged in the supply chain orchestration gain real-time visibility into inventory movement and consumption, bringing a new dimension to Collaborative Planning, Forecasting and Replenishment (CPFR) and facilitating the creation of an agile supply chain.

Replenishment: Auto-Ordering will be the New Way of Life

Smart devices and shelves can track product consumption (weight or units) as well as other attributes that impact shelf life (color, ethylene, etc.). The resulting inventory visibility and demand sensing capability can help retailers enable proactive reordering at the point of consumption—be it at warehouses, store shelves, or customer homes—ensuring optimal inventory levels. This will challenge most of the replenishment systems today which are still based on traditional demand forecast data and a large number of static parameters. Moving to an IoT-enabled replenishment needs nimble systems

and processes capable of handling frequent replenishments based on real-time consumption data that is dynamic in terms of lead time and schedules.

Order Management: An Anticipatory Approach

The ultimate in customer experience would be for products to reach customers' homes without their intervention. By tracking consumption levels, retailers can preempt orders based on the historical patterns of customer orders. For example, a tetra pack of milk that gets consumed in a week (on a regular basis) can be shipped earlier if faster consumption is detected. This in turn, results in a shorter order lifecycle enabling delivery to customers much faster than expected. Retailers can even leverage IoT devices to configure the 'subscribe' feature for automatic orders. This has to be supported by replenishment systems that can initiate the aggregation of anticipated customer orders to the expected fulfillment nodes.

Distribution Center/Fulfillment Operations: Connected and Intelligent Interactions

IoT will elevate machine-robot-human interaction within distribution centers (DCs) to revolutionary levels where products will move across fulfillment operations with little or no centralized intervention. A facility equipped with smart shelves, connected material handling equipment (MHEs), vehicles, and workforce will help self-organize, auto decongest, and balance the workload, enabling superior service level-driven orchestration.

Fleet Management
Vehicle Health Monitoring
Fleet Tracking
Fleet & Trailer Utilization
Maintenance Scheduling
Electronic Seal Monitoring
Load Distribution
Freshness Tracking

Driver Monitoring
Driving Behavior Monitoring
Harsh Driving Alert
Idling & Mileage Tracker
Time Spent at Various Stops
En Route Delays
After Hours Usage
Simplified Document Handling
Special Handling Instructions

Dynamic Routing
Traffic & Weather Monitoring
Ideal Route Assistance
Schedule Rerouting
Route Deviation Detection
Geo-Fencing Alerts
Intelligent Rerouting
Arrival Estimation

Empowered Customer
Dynamic Delivery Slots
Dynamic Schedule Change
Pick Up Point Change
Service Rating
Returns Collection
Delivery Timeliness Tracking
Real-Time Communication

Figure 1: Last mile capabilities of an IoT-based solution

Logistics: From 'In-Transit Blind Spot' to 'Always In-Control'

A connected last mile goes a long way in dynamic fleet and fulfillment management through real-time assistance to drivers and centralized monitoring of delivery progress, trailer environment, and vehicle health. The sensor devices attached to products or packages can help identify potential damage even before the product is received. Making decisions on the fly is more challenging in the context of 'assets in motion' because of the dependency on systems at the corporate center; it can prove to be costly too. When the response time is crucial, localized analysis at the edge can help in reducing latency. Drivers will receive critical alerts even if there is no connectivity with the central cloud; also the reduced amount of data saves the bandwidth and energy used by remote IoT devices. This can be enabled by edge computing applications powered by self-learning algorithms that run directly on IoT devices and only interact with the cloud occasionally. Figure 1 lists the features that can be offered by an

intelligent IoT to enable better last mile control.

Beyond Track and Trace: Data-driven Intelligence

The increasing application of IoT across various touch points of the product journey and associated supply chain operations results in continuous real-time streaming of a high volume of data. The resultant big data is a complex mix ranging from location information to environmental information; inventory/consumable consumption to service needs; and operational interactions to product movement status from connected resources.

This massive data lake of IoT information can be a goldmine, enabling retailers to leverage analytics and learn from historical data to derive patterns. In addition, the ability to build intelligent supply chain processes is amplified by a combination of real- time enterprise supply chain data and external repositories of connected device data, social media, news, events, and weather updates.

Examples of how data-driven intelligence will enhance IoT applications in future supply chains include:

- **Automatic Reordering:** Improved visibility into the customers' inventory (level and conditions) and buying patterns can help predict future orders. Based on this, replenishment systems will be able to initiate pre-picking and shipping to the closest aggregation point. These anticipatory shipments will eventually be consumed by the actual customer orders created through IoT-Order Management System (OMS) interaction.

- **Maximizing Home Life:** Tracking of conditions and location in real time can ensure tight control of the product environment and reduce the supply chain lead time. Thus, the products will be available for a longer time 'to sell by retailer' and 'to consume by customer.' Since sensor data can be leveraged to maintain integrity through freshness monitoring, the life of the products available for use by the customers will be longer. The data can be further leveraged by deploying machine learning to predict the home-life of a product and continuously improve it.

- **Next Gen Logistics:** Next generation delivery enabled by self-driving cars, robots, and drones will leverage AI-embedded IoT devices to navigate congested residential areas. To enable this, computations and processing will need to be done in real time, using edge computing, as any latency could be extremely dangerous or even fatal.
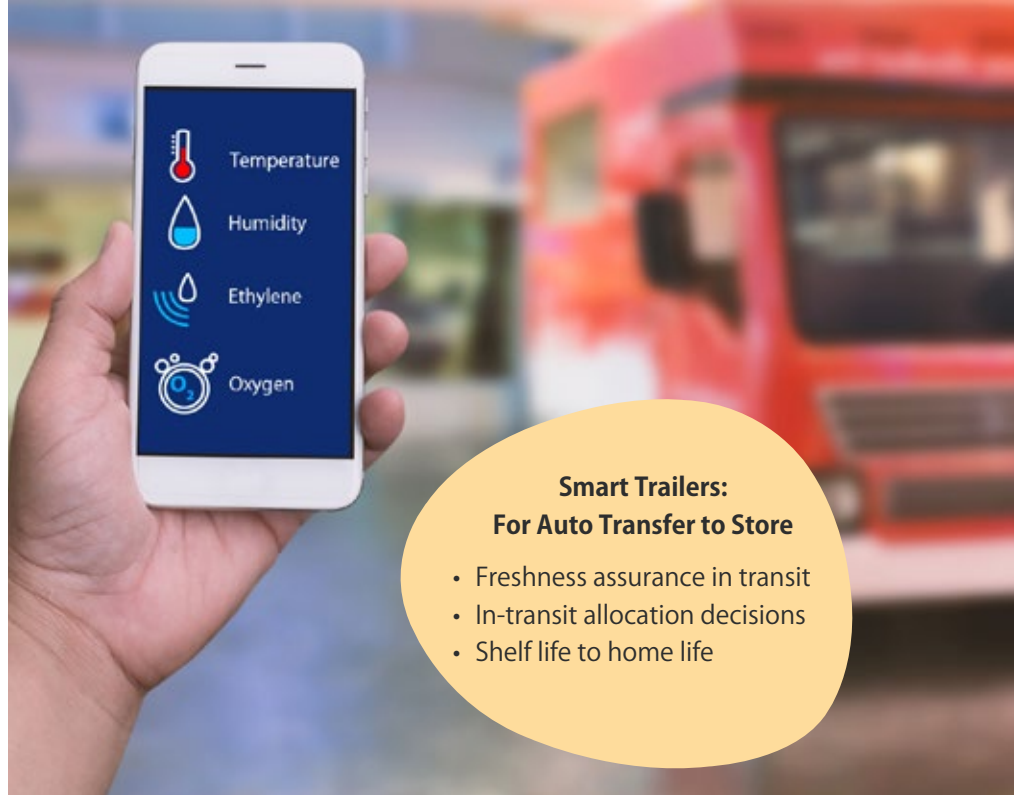
Smart Trailers:
For Auto Transfer to Store

- Freshness assurance in transit
- In-transit allocation decisions
- Shelf life to home life

Enabling IoT: **Prudence is Key**

While the physical-digital connect realized through IoT-enabled platforms is set to change the way supply chains operate, retailers need to approach adoption with a clear understanding of the company's strategic objectives and the changes in business practices and human interactions that will ensue.

- **An over emphasis on IoT may cause retailers to connect and sense all things in the world.** Prioritizing desired data insights from across the supply chain is a critical decision point before implementation. Over emphasis on IoT may cause retailers to invest in widespread IoT networks, resulting in the inability to retrieve costly devices from end points, extreme dependency on connected information for decision making, cost overrun, and security lacunae considering the lack of maturity of IoT platforms and evolving standards. For example, a highly calibrated network with decisions based solely on real-time feeds may potentially lead to situations where a truck (with shipments) waits endlessly for instructions from a centralized control tower because of network failure.

- **IoT cannot be used as a standalone solution, rather it must be integrated with the existing business solutions.** Supply chain is perhaps a singular business area in retail that deals with a large number of physical entities, some of them owned by third parties. Therefore, IoT cannot be used as a standalone solution, but must be integrated with the existing business solutions. This space, is however, heavily dominated by vendors offering specific solutions like Demand & Forecasting, Replenishment, Warehouse Management Systems (WMS), and Transportation Management Systems (TMS).

IoT integration with internal and external data sources can increase the decision making capability of existing solutions to unimaginable levels. For example, congestions detected in a particular port can disrupt the replenishment plan. In such a scenario, integrated IoT can judge deviations

in the trailer environment, initiate the identification of alternate sourcing vendors, and trigger dynamic allocation of fresh produce to the store instead of the warehouse to mitigate reduced shelf life. Recognizing this, many leading solution vendors are partnering with organizations that have deep expertise in predictive analytics and own huge repositories of real-time big data collected from IoT devices around the world.

- **Ensuring security from fraudulent participants becomes very important.** To counter the huge risk of security breaches posed by IoT, it is necessary to create low-powered autonomous IoT mesh networks for data collection. These networks must be able to function without requiring a central network authority; but this is precisely where security can get compromised.

  There has to be a consensus mechanism using cryptography operations to validate whether the participants (sensors) have been tampered with during transaction processing. As the number of intelligent and dynamic decisions being taken by IoT-enabled resources increase, each transaction in the IoT ecosystem must be secured through a decentralized and autonomous platform enabled by blockchain technology.

Conclusion

Undoubtedly, IoT can play a pivotal role in providing an end-to-end visibility to supply chain from 'farm to fork' or 'woods to rooms.' However, retailers are lining up resources to jump onto the IoT bandwagon without a clear strategy to utilize real-time information from the connected entities.

The pervasive IoT ecosystem has huge potential to dynamically alter the course of supply chain operations through proactive and timely decision making capabilities. Such an agile supply chain will become a reality only when IoT touch points are seamlessly interwoven with today's supply chain execution systems. The IoT journey is incomplete if event detections and dynamic decisions continue to rely on static rules. It needs enhanced capabilities to learn and intelligently identify exceptions to be able to eventually self-heal to solve supply chain issues in real time. Clearly, there is an untapped intelligence that IoT can be leveraged to bring acumen to the existing supply chain and facilitate value retailing by maturing from mere sensing to solving business problems.

About the Authors

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Vanshika Sethi is a retail digital functional consultant with over 10 years of experience working with leading global retailers enabling supply chain transformation.

She specializes in logistics and warehousing operations and has been instrumental in conceptualizing and building solutions augmented by next-gen technologies such as IoT and machine learning.

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