sensor-based logistics

IMPROVING EFFICIENCY, VISIBILITY, AND TRACEABILITY IN SUPPLY CHAIN.

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Abstract

Global supply chain's rapid growth pushes companies to look for new ways to improve efficiency, cut waste, and enhance supply chain dependability to deliver a superior customer experience. One tool for accomplishing these goals is sensor-based logistics.

Sensor-based logistics provides full visibility inside shipments while they are in motion, helping to ensure they reach their destination in the customer's anticipated condition.

It is an emerging logistics model in which multiple sensors transmit cargo data to multiple partners, enabling them to collaborate and respond to unexpected situations.

The sensors detect current shipment location and environmental variables inside the containers such as temperature, light exposure, relative humidity,

and barometric pressure among others, then wirelessly communicate these variables to the shipper's management software which displays, stores, and analyzes the data.

By receiving continuous data while shipments are in transit, users can take advantage of intervention services such as re-icing cold chain shipments, inspecting and repackaging damaged goods, or involving law enforcement to pursue stolen products. Sensor-based logistics places control in the hands of the management team to proactively avoid these issues.

Logistics Challenges

To achieve improved efficiency, lower costs, and waste reduction, sensor-based logistics successfully attacks the most important challenges in logistics. These challenges are:

Transparency: This is needed for the overall optimization of SCM and effective use of resources across the entire supply chain. Transparency is in direct relation to trust which is of paramount importance in this sector. Experts propose the use of Blockchain to provide this much needed trust.

Traceability: This is needed to track the movement of products across the supply chain. In food logistics, governments are increasingly legislating for adopting traceability systems to minimize food wastage. Traceability also becomes critical for consumers to know the facts of the product origin and production methods of food items.

Accountability and Liability: Logistics accountability is comparable to answerability; buyer expects service at its best quality for the price paid. Logistics accountability will also have a positive influence on trust.

These challenges can be addressed by employing a robust combination of blockchain based smart contracts, logistics planning, and sensor-based logistics, ***make that smart-sensor-based logistics***.

Logistics is a key business area for every company and plays a critical role in achieving supply chain goals and objectives.

Top 10 Logistics Industry Trends in 2021

Logistics optimization is neither easy nor cheap, but it is the biggest opportunity for most companies to significantly reduce their supply chain costs and improve their performance. For most supply chain and logistics operations there is an opportunity to reduce cost by 10% to 40% by making better decisions.

Trends in the logistics industry are closely tied to the implementation of technology-driven innovations in the business processes. The next-generation logistics management solutions aim to create a more customer-centric and sustainable supply chain.

Detected trends for 2021 are intended to increase productivity and efficiency and improve transparency and traceability to enable and maintain a supply chain that satisfies the needs of ALL stakeholders.

Analyzing different literature and publications on logistics trends, following is a summary of the top 10 trends for 2021.

1. **Internet of Things (IoT)**
2. Artificial Intelligence
3. Robotics
4. Last-Mile delivery
5. Warehouse Automation
6. **Blockchain**
7. Big Data & Data Analytics
8. Cloud Computing
9. Autonomous Vehicles
10. Flexible Logistics

1. Internet of Things (IoT)

IoT in logistics enhances visibility in every step of the supply chain and improves the efficiency of inventory management. Integrating IoT technology into the logistics and supply chain industries improves and enables efficiency, transparency, real-time visibility of goods, condition monitoring, and fleet management.

2. Artificial Intelligence

AI algorithms combined with machine learning support companies to be proactive in dealing with demand fluctuations. For example, AI-based forecasting solutions allow managers to plan supply chain processes and find ways to reduce operating costs. Self-driving AI and smart road technologies are creating a positive shift towards delivery service automation. In addition, AI-based cognitive automation technology brings intelligence to automate administrative tasks and speeds up information-intensive operations.

3. Robotics

Integrating robotics into logistics increases the speed and accuracy of supply chain processes and reduces human error. Robots offer more uptime and higher productivity when compared to human workers. Robots, however, do not take up the jobs of humans but rather work collaboratively alongside

them to increase efficiency. Robots today are used to pick and transport goods in warehouses and storage facilities and perform repetitive and mundane tasks that free up time for human workers.

4. Last-Mile Delivery

The last step of the supply chain, from the warehouse or distribution center to the customer, is often inefficient and comprises a major portion of the total cost to move goods. Last-mile delivery is the most important part of logistics as it is related to customer satisfaction. However, last-mile delivery faces various problems including delays due to traffic congestion, customer nuances, government regulation, and delivery density.

5. Warehouse Automation

Warehouse automation increases efficiency, speed, and productivity by reducing human interventions. Pick and place technologies such as automated guided vehicles (AGVs), robotic picking, automated storage and retrieval systems (ASRS), reduce error rates and increase warehouse productivity. Warehouses require a combination of efficient automation technologies to control their operational logistics costs.

6. Blockchain

Blockchain offers security through an irrefutable decentralized ledger system and addresses pressing traceability and related challenges. This brings transparency of transactions to the entire logistics process. Moreover, smart contracts based on blockchain technology allow for quicker approval and clearance by reducing the processing time at checkpoints.

7. Big Data & Data Analytics

Data analytics provide actionable insights for the improvement of warehouse productivity, performance management, and optimal utilization of logistical resources. The data obtained from monitoring position and weather along with fleet schedules help optimize routes and delivery planning. The analysis of market data supports the further optimization of supplier pricing, inventory levels, and generation of risk management reports. Moreover, advanced analytics provide insights that help identify anomalies and offer predictive maintenance solutions.

8. Cloud Computing

Cloud-based SaaS (Software as a Service) solutions for logistics companies allow for pay-per-use models that require low capital investment. This minimizes the risk and cost of maintaining the IT infrastructure. Cloud-based logistics solutions also address communication hurdles and allow companies to collaborate and share data in a secure way. In addition, cloud-integration allows data collection from management systems to analyze overall logistic processes. Finally, cloud-integrated logistics offers universal accessibility and is not confined to any physical space.

9. Autonomous Vehicles

Autonomous vehicles improve vehicle safety and deliver goods safely by eliminating human errors while driving. They increase the efficiency in the first and last-mile delivery as they are designed to work all day and all night. Moreover, autonomous vehicles improve fuel efficiency by using platooning

techniques for long haul routes, reduce traffic jams, and optimize travel routes by taking advantage of AI-enhanced technology.

10. Flexible Logistics

Elastic logistics enables companies to handle supply chain operations with more efficiency during periods of fluctuation in demand. It helps upscale or downscale the supply chain operations, as required, according to the market demand. Elastic logistics thereby tackle the challenges facing supply chain companies including underutilization of vessels, constraints on warehousing, and overstocking.

With customer expectations continuously on the rise and as interests shift towards product variety and personalized services, the logistics and supply chain sectors face mounting pressures. Rapid advancements in emerging technologies such as the internet of things make companies face a huge dilemma while choosing the most suitable technologies to invest in. As technology progress continues, it is important for companies to be proactive and identify potentially disruptive changes at an early stage.

What is a Smart Sensor?

A sensor is a device that provides feedback on a physical process or substance in a predictable, consistent, and measurable way.

Smart sensors are different from sensors in that smart sensors are advanced platforms with onboard technologies such as microprocessors, storage, diagnostics, and connectivity tools that transform traditional feedback signals into true digital insights.

These smart sensors can provide timely and valuable data to power analytical insights that can in turn drive improvements in ***cost, performance, or customer experience.***

Today's Top Three Trends in Smart Sensor Technology

Sensor-based technology is evolving fast with demand and potential uses outpacing the technology available. Key trends today are:

Miniaturization.

Sensors are proliferating across countless applications as we move to an increasingly connected world. Many of those applications require multiple sensors in a small footprint with no degradation of performance – and often with very low power requirements.

Digitization.

With so many applications playing in the IoT space, the shift to digital is required for intelligent sensors that not only capture sensing data, but also interpret that data for a variety of applications.

Sensor fusion.

As with the trend towards digitization, multi-sensor integration is causally related to IoT proliferation and the expectation that everything is connected. The need to capture multiple types of measurement in extremely small packages is pushing the development of multi-sensing elements.

These three trends often overlap along with a need for higher performance at lower costs.

Recent developments and outlook

The global smart sensor market is growing at a 19 percent annual rate and is expected to reach $60B by 2022.

Technological advances have miniaturized the devices, improved performance and energy efficiency, and reduced production costs. Smart sensor computing capabilities have strengthened substantially, thereby enabling data processing and analysis at or near the source and reducing the amount of data that moves between the device and platform.

Additionally, the introduction of micro-electromechanical systems (MEMS) technology has allowed for more compact, higher functioning smart sensors by effectively incorporating microelectronic functions in minimal space.

A micro-electromechanical system (MEMS) is a technology used to create tiny integrated devices or systems that combine **mechanical** and electrical components. They are fabricated using integrated circuit (IC) batch processing techniques and can range in size from a few micrometers to a few millimeters.

Some examples of current MEMS devices include **accelerometers** for airbag **sensors**, smart sensors, inkjet printer heads, computer disk drive heads, projection display chips, blood **pressure sensors**, optical switches, microvalves, biosensors and many other products that are all manufactured in high commercial volumes

IoT and blockchain for traceability - Simplifying Compliance in Pharma

One of the challenges of implementing traceability systems is compliance, but organizations can simplify the compliance process with blockchain and the use of smart sensors in their end-to-end supply chain for traceability.

The World Health Organization's working document QAS/04.068 on good distribution practices applies to all involved in the distribution of pharmaceutical goods, including manufacturers, suppliers, distributors, brokers, processors, wholesalers, traders, and transport operators. The document provides a template for best practices in each activity in the distribution of pharmaceutical products. It also tasks all organizations with implementing strong manufacturing storage and distribution practices.

IoT is an increasingly common technology for the pharmaceutical industry to trace and track the pharmaceutical goods in a supply chain. In Europe, pharmaceutical organizations must address

compliance issues more vigorously than ever before because of the E.U.'s ***Falsified Medicines Directive*** to prevent falsified medicines from entering legal supply chains in European markets.

Organizations can use blockchain for traceability systems to stay in compliance. Blockchain offers a system of recording supply chain data that can be shared both securely and transparently with multiple parties, thus reducing administrative costs and time delays. In this way, border agents could inspect shipment data of an entire supply chain. Any efforts to tamper with the shipment would be detectable. Items in supply chains already have barcodes added to them, so it is not a giant leap to enter items after they are manufactured into a global blockchain for IoT tracking.

Exporters can upload documentation onto a customs office blockchain to show that they abide with national import rules, such as sanitary and phytosanitary rules. Blockchain provides secure tracking for agents to determine the exact location of goods, consignment contents and payable tariffs. Blockchain for traceability could contribute to overcoming the customs problem, however instances of successful implementations remain few to date.

Paper-based systems are increasingly not fit for tracking. Blockchain's immutable resilient records, secure attribution at the time of creation and the ability to employ ***smart contracts*** can provide a customs border trade oversight efficiently and more transparently. Information on goods -- such as clearance certificates, origin, proof of purchase or a bill of lading -- can be made part of an accessible block for suppliers, transporters, buyers, regulators, and auditors. The increased transparency of using blockchain for traceability leads to lower transaction, auditing, and accounting costs.

The European Union's trust-based authorized economic operator system gives exporters with a proven track record faster customs clearance. Blockchain could provide the structure for authorized economic operator systems more efficiently and can lead to savings, such as a change in tariffs when the destination of goods change. Blockchain records the updates, making prepay maximal tariffs no longer necessary and smart contracts automatically calculate new tariffs.

Smart Sensors in Logistics

Integrating smart sensors throughout the supply chain can decrease operating costs, increase asset efficiency, improve demand planning, and provide critical insight into customer behavior. As centralized platforms and communication networks continue to evolve for the purposes of IoT devices, companies should consider the variety of smart sensors available and determine how to better sensor-enable their supply chains.

The most common types of sensors used today in logistics are:

SENSOR TYPE	DEFINITION	EXAMPLE
Acoustic	Recognize audio vibration or frequency to determine activity, location, intensity	Piezo microphones, electret microphones, condenser microphones
Chemical	Measure fluid composition and concentration of biological/chemical compounds	MEMS technology, fuel cell
Electrical	Identify and examine changes or disruptions in electrical or magnetic	Voltage, current, power

	signals based upon environmental inputs or conditions	
Environmental	Monitor and assess deviations in physical state, conditions, or surroundings	Temperature, humidity, color, moisture, light, pressure, liquid flow, air flow, heat, surface temperature
Image	Convert light waves into electrical signals to constitute a digital, optical form for visible condition monitoring	Infrared, ultraviolet (UV), visible spectrum camera
Motion and force	Measure static and dynamic objects to determine the amount, type, and rate of change to physical properties	Proximity (ultrasonic/acoustic, infrared), strain/weight, vibration, accelerometers, shock accelerometers, gyroscopic, position, motion, magnetic field, rotational
Touch	Detect body capacitance during physical contact between objects	Capacitive touch, resistive touch

Benefits of Sensors in Logistics

The key advantages of sensors include improved sensitivity during data capture, almost lossless transmission, and continuous, real-time analysis.

Constant evolution of sensing technology has resulted in today's smart and intelligent sensors. Smart sensors contain electrical circuits, allowing them to take measurements and output values as digital data. These sensors feature embedded microprocessor units and have a number of sensing devices mounted on a signal converter.

Smart sensors can carry out several intrinsically intelligent functions, such as the ability to self-test, self-validate, self-adapt, and self-identify. They understand process requirements, manage a wide range of conditions, and can detect conditions to support real-time decision making. These intelligent sensors are programmed for several process conditions, allowing executives to derive the most benefit.

Some of the benefits obtained in logistics from the use of sensors include:

1. Processes are accelerated and made more accurate
2. Transit and cargo environmental conditions data are collected in real time
3. Data is processed faster and more accurately enabling better decision making
4. Processes and cargo are both accurately, reliably, and continuously tracked and measured
5. Sensor generated data feeds a blockchain which helps in pinpointing accountability and responsibility in supply chains with many different participants and goods changing hands very quickly.
6. Increase productivity
7. Waste reduction
8. Lower operating costs
9. Increased visibility
10. Enhanced traceability
11. Increased predictability accuracy
12. Improved equipment utilization
13. Better resource planning (timing, quantity, type, etc.)

14. Process optimization
15. Gap detection and elimination
16. Improved inventory management
17. Reduced procurement costs
18. Better risk management
19. Higher product availability
20. Reduced cash-to-cash cycle
21. Increased customer service
22. Improved relationship with suppliers
23. Improved collaboration between all participants in the operation (buyer, seller, transport companies, insurance companies, financial institutions, manufacturing team, distributors, end-customers)
24. Cost effective. The cost of sensors compared to the cost of wastage and its impact on company reputation is minimal.
25. Savings in energy and fuel skyrocket.
26. Supports agile decision-making
27. Drives performance optimization.
28. Sustainability is easier to achieve due to waste reduction in the end-to-end process.
29. … and many more

The Future of Smart Sensors

Forrester Research predicts that smart sensor-based, track-and-trace and smart products will be the fastest-growing use cases, with 24.2% and 24% compound annual growth rates, respectively. But the applications will not stop there.

Sensors are increasingly being built into products at the point of manufacture. Industrial equipment, trains, planes and buildings increasingly arrive with hundreds or even thousands of sensors already connected.

Smart sensors are not limited to only new products.

Today, a logistics company might install sensors in a truck, tomorrow it may be cost-effective to install sensors in every pallet or even every package.

The arrival of 5G will eventually make it easier to work with many sensors, even in environments where data latency causes problems today.

Also of note is the increased use of edge computing. As more analytics, including the use of machine learning and artificial intelligence, is run at the point of data collection, organizations, or the sensors themselves, will be able to make decisions faster and more effectively.

The continued miniaturization of sensors will change the future sensor landscape. Sensors will continue to get smaller over time and more capable in terms of computational capability.

Sensors will also offer more functions in the same platform, serving different sensing categories from the same devices.

Sensors will be installed in more and more devices, with everything from wearables to special-purpose sensors linking observations from our environment to a computing platform.

Estimates expect that the total number of IoT devices will triple in the next four years, with roughly 25 billion devices today, growing to 75 billion devices in 2025.

Conclusion

This is an incredibly exciting time in digital revolution. Those in the industrial market are poised to reap many of the benefits of the use of smart sensor and its interconnection with IoT if they have the patience and passion to weather the immediate challenges.

There is so much to gain and very little to lose for those willing to jump in headfirst to ensure a competitive advantage.

Consider Maersk Line, which is one of the world's leading shipping companies. It added sensors to its refrigerated shipping containers that transmit vital information – like temperature and location – to a central hub where a team of employees can now manage issues as soon as they arise, regardless of the container's location. As a result, containers require less manual inspection and are arriving to their destinations with consistently fresh produce.

There are still many limitations, common to any new technology, including delays in data transmission from the sensors to the hub (latency) due to cargo passing through areas of no signal or high interference levels meaning there might be interruptions in the flow of data, lack of capacity to analyze the huge amount of data produced which in turn causes delays in adopting the right course of action to correct unexpected, undesirable, changes in the cargo's environment, lack of staff with the proper set of skills to manage the new technology, common internal struggles between operations and IT teams, and of course security is a top concern in connecting so many different parts of your company's infrastructure to the digital world.

In my opinion, the greatest risk is staying behind in what will surely be an unprecedented period in supply chain management.

We are closing into a future with no barcodes, no more manual inspections, no more lost cargo, no more overripe produce, no more machine downtime or parts delays. IoT and smart-sensor-based logistics are taking us rapidly into a more efficient manufacturing and connected supply chain.

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