

Constantly Connected

How Cellular is Enabling the Digital Supply Chain

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Abstract

Supply chains grow more and more complex every day. In response, manufacturers and shippers have been eagerly exploring digital tools that provide actionable insight into the location and condition of in-transit goods. Although there are many technology options when it comes to building a digital supply chain, one type of solution stands out as the most reliable and cost-effective: cellular. Today, supply chain managers are already enjoying the many benefits of cellular-based visibility solutions, and with future advances in technology and infrastructure, those benefits will only continue to grow. Cellular is the foundation of an effective digital supply chain, and the key to keeping managers constantly connected to their shipments — from end to end.



Introduction

For decades, companies have sought after the holy grail that is supply chain visibility. Visibility enables reduced product damage and delays, a better customer experience, and ultimately, increased revenues.

Of course, there is no one-size-fits-all solution for today's complex, global supply chain. For example, some companies have embraced RFID tagging solutions, which provide a low-cost option for applications in which real-time data is not necessary. Other companies may opt for Bluetooth or WiFi solutions, which are effective for real-time tracking of goods that stay in close proximity to a gateway or hub. However, when it comes to global supply chain tracking, cellular-based tools are now emerging as the winning solution.

Cellular offers reliable global coverage at a low cost, without many of the drawbacks of competing technologies. In addition, as cellular networks and technologies continue to improve, so will supply chain tracking solutions based on these frameworks, helping companies to reach new levels of visibility into every part of their supply chain. In this white paper, we discuss the various digital supply chain technologies on the market, the benefits of cellular, and the exciting future in store for the constantly connected supply chain.

What A Digital Supply Chain Means For Shippers

A digital supply chain can give companies access to new data sources, enabling new levels of visibility into the location and condition of in-transit goods. But what does that mean for the supply chain manager? Here are three of the key benefits that manufacturers and shippers can achieve through the implementation of a digital supply chain:



Connected sensors can monitor everything from location to temperature, humidity, vibration, and more.

Reduce Product Damage

From pharmaceuticals to electronics to industrial equipment, in-transit damage to high-value goods is a big deal. Greater visibility into the supply chain can help companies to reduce their current levels of damage, and mitigate the effects of whatever damages do occur.

For example, a washing machine or refrigerator that has been handled roughly en route may be unsaleable upon arrival, resulting in lost profits and unhappy customers. With a digital supply chain, shock-detection sensors attached to the shipment can send real-time alerts as soon as damage occurs. Similarly, connected temperature sensors can give immediate warning if a pharmaceutical shipment experiences harmful temperatures, or tilt sensors can send an alert if sensitive electronics are dropped. This new visibility makes it possible to identify the exact time and location of an incident, helping managers to pinpoint and eliminate the root cause of the issue (be it a bumpy route, a bad vendor, or a faulty shipping process). In addition, with real-time awareness of product damage, the manufacturer can dispatch replacement goods right away, reducing delays and improving the customer's experience.

Improve Inventory Management

In addition to reducing product damage, a digital supply chain can also help companies to lower safety stock levels without sacrificing acceptable risk tolerances. With a digital supply chain, managers have real-time insight into the precise location of every shipment. If a manager knows exactly when a key shipment will arrive, they can proactively reroute shipments or reschedule labor to avoid delays and inefficiencies without relying on large quantities of safety stock as a buffer. Similarly, if a manager knows that product is likely to arrive damaged, they can expedite replacements, again

without relying on safety stock. Reducing safety stock reduces facility costs, labor costs, and of course the cost of all that extra inventory.

Improve Customer Satisfaction

Ultimately, the benefits of a digital supply chain boil down to a better customer experience. Customers expect that when they order a product, it will arrive on time and undamaged. End-to-end supply chain visibility enables the shipper to deliver on that expectation. Instead of finding out from a customer that the product was delayed or damaged in transit, real-time alerts give companies the information they need to solve the problem — often without the customer ever even realizing that there was an issue. Even if damaged or delayed product cannot be replaced in time, real-time visibility makes it possible for manufacturers to alert their customers of any unexpected delays, so they can plan around the issue in advance.



Responsible for 100s of shipments travelling all around the world, managers need real-time data to inform decisions.

How Tracking Technologies Stack Up

It's clear that digital visibility tools are vital for the modern supply chain. But within the world of digital supply chains, there are many different technology options, each optimal for different industries and applications. Below, we provide an overview of the key technologies in this space, as well as the advantages and ideal applications of each option.

Credit **RFID** for promising the original supply chain of the future, giving shippers a glimpse into the status of their cargo. An RFID system can provide precise data on inventory in a warehouse or distribution center, but it is completely incapable of providing real-time data. RFID tags must be scanned in order to access the data, meaning that they can't proactively call home to report sudden changes. In addition, RFID is generally limited to basic location data, and provides little to no insight into product condition. As such, RFID can be a good low-cost solution if real-time monitoring and alerting isn't a priority, but it has limited effectiveness for many supply chain applications.

Bluetooth solutions require very little power and are relatively inexpensive. However, they only work over short distances, and they must be connected to a powered gateway or hub. This requires significant

investment into gateway infrastructure (any truck, ship, or container in which the goods travel would need its own powered gateway), which is infeasible for most supply chain applications in which goods travel through hundreds of different routes via many different modes of transit.

Wi-Fi is a powerful tool to pinpoint location with greater accuracy than GPS in urban and suburban areas. But once a shipment travels out of range of a Wi-Fi router, it becomes invisible. Furthermore, although Wi-Fi is extremely prevalent, most connections require a password or a subscription to connect, which is prohibitive for most supply chain tracking applications.

Satellite tracking offers visibility over almost the entire globe, but it can only relay coordinates, not data on a shipment's condition. Satellite also requires line of sight, which is impossible for most containerized cargo, and most satellite solutions are prohibitively expensive. In addition, satellite solutions are very power-hungry and require very large batteries, making them hard to handle and impractical for anything that travels by air.

Cellular networks are ubiquitous in every populated area of the world. They offer global coverage, low power consumption, and access to reliable location and condition data, all at a relatively low cost. Most importantly, cellular is the only option that offers active, real-time data transmission (as opposed to a passive technology like RFID) without requiring expensive gateway infrastructure. Although cellular does not provide coverage in the air or on the ocean, it provides nearly universal coverage everywhere else, making it the best solution for end-to-end supply chain visibility.

Cellular, Past And Present: The Evolution Of A Global Network

In the past, cellular technologies were limited in applications due to inadequate coverage area, high data plan cost, and limited battery life. But over the last several decades, a variety of technology and infrastructure developments have led to significant improvements. Today, cellular offers an unparalleled level of global ubiquity, performance, and cost effectiveness, making it the superior choice for global supply chain applications.

Coverage

In the early days of cellular, service was strong only in dense urban areas. In less developed areas, dead spots or weak zones were common. But over the last few years, carriers have invested heavily in infrastructure, building more base stations in more locations. According to a recent report from GSMA Intelligence, today 90% of the world's populated areas have cellular coverage. That makes cellular an excellent option to keep tabs on goods, wherever they roam.

Of course, useful service is not just a matter of infrastructure. The other key piece of the cell service equation is access to networks. For much of their history, the world's cellular carriers charged roaming fees for customers of competing networks. Using a device from carrier A on carrier B's network could be incredibly costly, and since global cargo tracking necessitates roaming over numerous carriers to maintain connectivity, the cost was prohibitive for most applications.

Fortunately, a combination of government and industry initiatives have changed everything. The EU voted to abolish roaming charges in 2015, and similar policies have been implemented in China and other key areas. At the same time, carriers themselves have also sought to eliminate roaming charges. The global surge in demand for IoT products requires a way for devices to stay connected as they move across coverage boundaries, and this represents a huge market opportunity for carriers. To enable IoT solutions, international carriers have created mutual agreements that eliminate roaming charges and provide global coverage at a fixed monthly cost.

Finally, although much of the world hasn't yet fully adopted the latest 4G and LTE cellular standards, many tracking sensors work on 3G or older networks. This allows them to operate even in parts of the world without the latest infrastructure.



SMOOTH SAILING AHEAD

There are two common situations in which cellular devices cannot connect to a tower: while in an airplane or on a ship. But this is actually almost never a problem. Most shipping issues (temperature excursions, shock events, late arrivals) occur either en route between facilities, or at port. Once a shipment is at sea or in the air, it is highly unlikely that its status will change. As a result, the lack of cell service in air and at sea doesn't meaningfully impact cellular's usefulness for supply chain tracking. Plus, some carriers have begun installing cellular base stations on board airplanes and ships. Once these on-board connectivity solutions are fully implemented, cellular trackers will be able to provide uninterrupted connectivity even while at sea or in the air.

Data Plan Cost

In the past, data plans were primarily designed for high-bandwidth smartphone activities, such as streaming video or downloading large files. Although this was great for consumers, it meant that there were very few options for low-cost, low-bandwidth data plans. While streaming video may require millions of bytes of data, transmitting a temperature or location reading takes only a few bytes. Plus, with hundreds or thousands of devices spread out across a global supply chain, paying for individual data plans for each device would quickly become extremely expensive. Fortunately, in response to growing demand for low-cost, low-bandwidth data plans for IoT applications, carriers began offering cost-effective small data plans (on the order of a 1MB or less) that can be pooled across many

devices. So if a company has to monitor a hundred containers, each with its own tracking device, they can all operate under the same joint, low-cost 1MB data plan.

By 2020, an estimated 2.5 billion cellular IoT devices will be in use.

Tracker Battery Life

One of the biggest factors for cellular supply chain tracking is device lifetime. While a cell phone might be considered impressive with a battery life of a few days, a supply chain tracking device will need to last the length of an entire supply chain: several weeks or even months, end-to-end. In the past, this was a serious hurdle for cellular-based tracking solutions. But today, a handful of factors have enabled trackers to have extremely long battery lives.

> " Newer technologies will provide a longer battery life, and that will enable [significant growth for] cellular-enabled IoT devices"
>
> *Chris Penrose, SVP of AT&T Mobility's IoT Solutions, interviewed by FierceWireless: Tech*

On the device side, manufacturers of cellular components have made tremendous improvements in efficiency. Batteries have gotten smaller and more power dense, and cellular chipsets have become smaller and less complex, lowering their power consumption requirements and enabling longer device lifetimes.

In addition, two key infrastructure changes are further decreasing power consumption rates for cellular-connected devices. First, carriers used to only focus on supporting high bandwidth (20MHz+) transmissions, because smartphones' high volume data transmission requires these higher bandwidths. However, to enable IoT devices, carriers are adopting standards that use bandwidths as low as 200kHz. These lower bandwidths require less processing power and fewer, smaller components, which leads to lower power consumption and longer device lifetime.

Second, carriers have developed new communication protocols optimized for low-power IoT applications. Traditional cell networks were designed to provide continuous connections to multiple cell towers, so that users could experience non-stop connectivity and continue a call as they traveled from one tower's range to another. This required that devices communicate every few seconds with a tower, which consumed a great deal of energy. Today, carriers have optimized base station equipment and firmware for

use by IoT devices, which transmit data much less frequently and have no need for a continuous keep-alive connection to a tower. This means that IoT devices can utilize the same global network infrastructure as mobile phones, without being tied to phones' power-heavy communication protocols.

EFFICIENCY AS RULE OF LAW

The confluence of two phenomena is enabling new levels of device efficiency: Moore's Law states that transistor size will halve every two years, while Koomey's Law predicts that power efficiency will double every 18 months. Chipsets are becoming smaller and more power efficient every day, and the tipping point has arrived: long-lasting, compact cellular tracking devices are now a reality.

Cellular Tomorrow: Every Advantage Gets Amplified

These benefits are just the beginning. Innovation in the cellular space continues at a rapid pace, fueled in large part by growing demand for components and infrastructure optimized for IoT.

Better Batteries

One major area of continued development is battery technology. Key players in the battery industry are researching new solutions that will enable ever smaller, longer-lasting devices. According to a recent report from SAP, researchers are experimenting with new materials such as sodium, graphene, and even 3D-printed copper foam as replacements for today's liquid lithium ion standard. These new materials could enable dramatically increased battery efficiency for a variety of applications. As energy density improves, battery size will be further reduced, opening the door to small, long-lasting sensors for a wider range of supply chain applications.

> "For many businesses, low power, wide area connectivity will be a game-changer, enabling a high degree of automation and yielding valuable insights that can save precious time and very significant sums of money"
>
> *Angel David Garcia Barrio, Vice-President M2M, Etisalat, quoted in GSMA Mobile IoT Industry Paper*

New global modem technologies make it simple to connect anywhere in the world, on any frequency.

Cheaper Components

Another important development will be the dropping cost of IoT components as manufacturers begin to offer more products optimized for IoT instead of for mobile phones. For example, most chipsets available today fall in the $35-$50 range (SnapDragon's popular X16 4G LTE mobile phone chipset is estimated to cost around $40). Part of the reason for the high price tag is that these chipsets are designed for smartphones, and so they must support high-bandwidth, processor-intensive tasks such as sharing large files and streaming videos.

Supply chain tracking devices have far lower performance requirements, and so they only need select components from a phone's chipset. Today, chipset manufacturers are developing low-cost chipsets optimized for IoT, which will significantly reduce the price of the chipsets necessary for cellular connected supply chain trackers. According to industry leaders, IoT chipsets will soon be available for around just $5 — one tenth the price of many mobile phone chipsets.

In addition, component manufacturers are also making great strides in global modem technology. Specifically, companies are developing modems built on new, innovative RF technologies to support communication on all frequency bands, without requiring the device to contain different modules and different RF front ends for each band. This means that IoT devices will be able to maintain global coverage across a variety of frequencies without relying on multiple expensive modules, further reducing the price of a global IoT tracking system. These component cost reductions will be passed on to supply chain managers, trimming the cost and improving ROI of implementing a cellular supply chain visibility solution.

Future network enhancements like 5G will increase the number of devices that can connect simultaneously without congestion.

5G Infrastructure

Looking even further into the future, improvements in cellular infrastructure will complement battery and component development to enable even greater growth in the cellular IoT space. By late 2018, some networks will begin to incorporate 5G technology, and by 2022, Gartner research director Sylvain Fabre believes 5G will be widely available. 5G has the potential to dramatically improve the scalability of IoT solutions, since the higher bandwidth connection will enable more devices to connect simultaneously without network congestion. One analyst writing for IEEE's blog Spectrum suggested that 5G has the potential to handle "1000 times more mobile data than today's cellular systems" — a staggering improvement which could pave the way for the next generation of widespread IoT devices.

Finally, it is important to remember that connected tracking devices are just one spoke on the hub of an IoT-powered supply chain. With the development of smart factories, vehicle-to-vehicle communication, autonomous vehicles, and connected roadways, all these new technologies will need a common network through which to share data. Cellular is the ever-present link that will close the loop.

Conclusion

Manufacturers and shippers looking for a competitive edge must maintain end-to-end visibility over their supply chains — or be left behind. The supply chain of the future will require a digital, always-connected solution, powered by on-board sensors that collect and share vital data about every shipment. This connected supply chain will smooth the flow of goods, and arm supply chain management teams with the actionable intelligence they need to avoid unpleasant surprises and stay ahead of the game.

The success of this new data-driven paradigm will rest on the network that connects each distributed piece to the cloud. Cellular, thanks to its ubiquity, scalability, performance, and low cost, is best positioned to bring that data — and the world's shipments — home.

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Tive helps companies eliminate surprises in their supply chain by providing real-time visibility of the location and condition of their shipments. Tive's combination of cellular-connected trackers and cloud-based software enables customized alerts, reporting and analysis on shipments across all modes of transport. As a result, companies are never caught off guard by damage or delays, helping them improve customer service while reducing disruptions and logistics costs.

+1 (617) 6-GO-TIVE | team@tive.co | tive.co