The Value of Monitoring in Supply Chains

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ABSTRACT

Logistics providers process millions of packages daily and collect an incredible amount of data from these shipments. As new sensors are added to more and more packages, companies will now have increasingly fast access to even more data. However, how will logistics companies leverage this idea of big data to generate the most business value for their customers? Using a qualitative approach by interviewing current users of real-time monitoring devices, we were able to understand how customers perceive the value added by this technology. Moreover, we scoured a significant amount of literature on sensors, the logistics industry, and upcoming technological breakthroughs. We quickly discovered that customers do not perform extensive quantitative analysis to determine the trade-offs and financial benefit of using real-time sensors in their shipping processes. Additionally, we found that customers are unwilling to analyze this big data themselves, but instead want their logistics provider to interpret the data to provide value-added services. Therefore, logistics providers should leverage all of the data they collect, instead of simply creating value when shipments become exceptions, e.g. out of temperature range. We propose using smart contracts on a permissioned blockchain to automate business processes and reduce frictions within the shipping parties and other intermediaries.

Thesis Supervisor: Dr. Bruce Arntzen

Title: Executive Director, Supply Chain Management Program
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1. INTRODUCTION

Monitoring in today’s world is ubiquitous. Smart phones are equipped with GPS and users can navigate their way through a new city without any qualms. When consumers order something online they expect to know exactly when the product will arrive at their doorstep. Consumers want to know the exact status of their shipment all the time. An Uber user wants to know the arrival time of his car by the accuracy of a minute. All these examples describe only location monitoring. In some not so ubiquitous applications consumers are monitoring temperature, pressure and many other parameters of their items. This change has happened in less than 15 years and the pace at which lives of millions of people have been influenced is extraordinary.

Moreover, as supply chains are getting more and more global with longer transit times, the condition of shipments is sometimes unknown. At the same time, companies are looking at all business functions, including supply chains, to gain a competitive advantage in the marketplace. This means that there is a greater need for businesses to invest in monitoring technologies to increase transparency throughout their convoluted network. In addition to location monitoring, there are a lot of applications in temperature monitoring of perishable goods. Additionally, monitoring other parameters such as light exposure could potentially assist companies understand if their shipments have been opened in transit.

Despite the increased availability of sensor technology and clear use cases in supply chains, its use has been fairly limited. Traditionally, companies have used passive tracking devices which record the information collected by the sensors in their packages. Upon delivery of the shipment, the data from these devices is then analyzed to understand if there were any issues during transit. However, recent advances in technology have enabled our thesis sponsor company (a global logistics provider) to develop a sensor device that reports data in real-time.
Therefore, the focus of our research is to understand how real-time monitoring technologies can add value to customers. We approached this problem from an empirical point of view and interviewed customers of our sponsor company in order to understand how real-time monitoring devices are currently being used. We also interviewed potential customers of a real-time monitoring device to understand their inhibitions to adopt such a technology.

Furthermore, we focused on how businesses currently use the monitoring technology to solve their supply chain problems. We outlined customers’ largest concerns with real-time tracking of their shipments. Next, we summarize the impact of blockchain technology in the world of sensor-based logistics. Primarily, blockchains offer the possibility to streamline business processes and to create new business models. Finally, we present a system dynamics model to understand the drivers behind customer adoption for a real-time tracking device.
2. LITERATURE REVIEW

2.1 Conceptual ideas and RFIDs

Research in the field of supply chain monitoring can be traced back to the late 20th century. Papers during this period discussed the idea of using a monitoring system in various parts of supply chain management, e.g. warehouse management, tracking of goods, inventory visibility for production and transport fleet management. For example, Sheffi and McFarlane (2003) used a simple categorization of supply chain operations to identify areas of automatic identification (Auto ID) deployment. They also discuss the longer-term reengineering of different sections of supply chain with Auto ID. They focus on examining the potential ways to enable new services to the customers, in addition to improving supply chain operations. One key challenge of supply chain is the management of variability inherent in its operations. Trends like globalization, outsourcing, SKU proliferation and shorter product lifecycles are making variability management increasingly critical. Companies have realized that a highly reactive capability is important to manage variability. To be responsive, one should be able to detect variability, investigate its cause and act swiftly. The earlier the variability is detected, the more time the company gets to react. The weak link of this approach is data acquisition. This is where Auto ID can add crucial value to the supply chain. Sheffi and McFarlane take an elemental model of supply chain and identify various ship/receive pairs where Auto IDs can play a role. Shipping, transportation, receiving and internal processes are the four categories in which operations are divided. This way a distinction is made between internal and external processes which can help in the implementation strategy. Auto IDs can also open a flood of new opportunities in customer offering. In a future store, continuous shelf inventory checks can be done and replenishment can be more responsive. This will lead to reduced shelf space requirements and higher service levels. Similar use cases can be built in manufacturing and warehousing.
One of the drivers of the increased interest in supply chain monitoring in the early 2000s was the technological progress made with Auto ID devices, leading to more reliable and cheaper radio frequency identification (RFID) devices. RFID was also a leap from its predecessor, the barcode. RFID tags could be scanned without direct line of sight and could store more information on them. In some ways, RFID also required less manual intervention than barcodes. In June 2003, Walmart mandated its top 100 suppliers to start using RFIDs on pallets and cases. It planned to push all its suppliers to use RFID by the end of 2006. This news created a storm in the retail and consumer packaged goods industries. The main reason for initial confusion among suppliers was the lack of understanding of the new technology. After Walmart’s mandate, the top suppliers started discussing various hurdles in the implementation of the initiative. High cost of the RFID tag was one of the primary concerns which weakened the business case for RFID. Additionally, there were issues with tag readability from products with high metal or water content. In some cases, a packaging redesign was required from the suppliers’ end to make RFIDs feasible. Moreover, while it is quite clear when a barcode fails to scan, it is much harder to know when RFID tags fail given that they are passively scanned. Therefore, the whole initiative started falling apart by the beginning of 2007. By February 2009, P&G had pulled out of Walmart’s RFID program. It could be said that the technology was not quite ready when Walmart imposed the requirement on its suppliers. Walmart’s failure also warrants a further analysis of how the value of monitoring can be quantified. Also, we need to understand what additional burden monitoring puts on each player in the supply chain. (www.scdigest.com, 2009)

A lot of research was happening on specific applications of RFID while Walmart was pushing its initiative. Many of the research papers focused on RFID applications in food supply chains. The logistics chain for chilled food is more and more complex every day. The origin is far
away from the destination, involving on board handling in ships, air transport, etc. Government officials and industry leaders concerned with ensuring food quality are exploring means to provide more information and control on sourcing, processing and distribution of food products.

The work of E. Abad et al. (2009) validated the use of RFID for real-time traceability in cold chain food application. The sensor tracked light intensity, temperature and humidity when inserted into a polystyrene box containing fresh fish. The sensor-logged data could then be stored in the device’s memory, together with traceability data. The sensor developed in Abad’s work presents important advantages. The main one is that this is an automated system that integrates online traceability data and cold chain conditions monitoring. Moreover, a key aspect of this RFID system is the fact that the data can be read-out at any time of the logistic chain without opening the box. Many tags can be read at the same time as they pass through a reader in a fully automated way. These RFID tags can also measure and resist temperatures below 0°C, so they can be very useful to monitor frozen foods logistic chains. The integration of a humidity sensor makes the system especially useful to changes in the storage conditions of shipments.

2.2 The Internet of Things

The Internet of Things (IoT) presents a unique technology transition that will have huge implications for the business of logistics: “...6.4 billion connected things will be in use worldwide in 2016, up 30 percent from 2015, and will reach 20.8 billion by 2020. In 2016, 5.5 million new things will get connected every day” (“Gartner Says 6.4 Billion Connected,” 2015). This visibility will transform how logistics providers make decisions about how goods are stored, routed, and delivered to customers. Furthermore, the proliferation of IoT for our
homes, work environments and cities creates opportunities for new business models in logistics. This thesis project seeks to understand these new opportunities for logistics companies to create long-lasting customer value using sensor-based supply chain monitoring devices. The next few paragraphs cover how monitoring devices are currently being used in supply chains, as well as potential future applications.

With the advent of IoT, Internet connections now extend to physical objects that are not computers in the classic sense. So far, less than one percent of all physical objects that could be connected to the Internet are currently connected. In numbers, that means of the roughly 1.5 trillion items on Earth that could benefit from an IP address, just under 15 billion are connected to the Internet today. The average consumer in a developed nation is surrounded by dozens of connectable items, such as computers, consumer electronics and smartphones. By 2020, computers (including PCs, tablets, and smartphones) will represent just 17 percent of all Internet connections, with the other 83 percent coming from IoT (Manyika et al., 2015).

In the world of logistics, IoT will be about “sensing and sense making”. “Sensing” is the monitoring of different assets within a supply chain through different technologies and mediums. “Sense making” is concerned with handling vast amounts of data sets that are generated as a result, and then turning this data into insights that drive new solutions. There is a clear technology push through the rise of mobile computing, consumerization of IT, 5G networks, and big data analytics. As well, customers are increasingly demanding IoT-based solutions. Combined, these factors are enabling logistics providers to adopt IoT at an accelerating rate (Raz, 2013).
IoT is "SENSING & SENSE MAKING" in the world of logistics

<table>
<thead>
<tr>
<th>Technology push</th>
<th>Need for logistics solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Mobile computing growing steadily with more mobile phones expected in 2020 than people in the world</td>
<td>* High need for transparency and integrity control (right products, at the right time, place, quantity, condition and at the right cost) along the supply chain</td>
</tr>
<tr>
<td>* Due to the consumerization of IT, sensor technology has become more mature and affordable to be used for industry purposes in logistics</td>
<td>* End consumers are asking for detailed shipment tracking to have transparency in real time</td>
</tr>
<tr>
<td>* With the move towards 5G, wireless communication will reach a new level of maturity connecting everything anytime</td>
<td>* Business customers are asking for integrity control especially for sensitive goods</td>
</tr>
<tr>
<td>* Cloud computing and big data technologies will enable new data-based services</td>
<td>* Logistics companies need transparency of networks and assets being used for ongoing optimization of efficiency and network utilization</td>
</tr>
</tbody>
</table>

Figure 1 - Sensing & Sense Making (DHL, 2015)

But just how promising is IoT in logistics? Many of the technologies behind IoT — including sensors, microprocessors and wireless connectivity — have been in use in logistics applications for years already, per a Deloitte report on IoT (Mariani, Quasney, & Raynor, 2015). The logistics industry was among the first adopters of IoT technologies in operations, from the introduction of handheld scanners that digitized the delivery process to the multiple sensors that monitor cargo integrity and delivery truck performance.

2.3 Key use cases for IoT in the logistics industry

With hundreds of thousands of ocean, air, and road assets, freight transportation presents great potential for IoT networks. DHL believes that IoT in freight transportation will move beyond track and trace. Today it is already possible to track and monitor a container in a freighter anywhere in the world, and shipments in a cargo plane midflight. However, we expect IoT to provide the next generation of track and trace: faster, in real-time, more accurate and predictive, and more secure. The National Cargo Security Council (NCSC) estimates that the global financial impact of cargo loss exceeds $50 billion annually. Through IoT, logistics providers
will gain clear visibility on the movement of goods as well as item-level condition monitoring to ensure that goods arrive in time, at the right place, and intact ("Shipping smarter," 2015).

Additionally, installed throughout the cold chain, these IoT sensors can continually monitor temperature, automatically logging the resulting data. Beyond real-time data capture, however, these sensors could also be easily programmed to generate an alert if a product moves outside a specified temperature range. For example, if it is removed from a refrigerated environment and is not promptly placed into a shipping container or if there's a refrigeration malfunction that causes a temperature spike. As a result, cold chain companies now have the technological tools to ensure a product's integrity and safety, which protects customer confidence in the product and the overall brand (Haan, van Hillegersberg, de Jong, & Sikkel, 2013).

Moreover, IoT in the last mile can connect the logistics provider with the end recipient in exciting ways as it drives dynamic new business models. One IoT-enabled use case for the last mile creates optimized collection from mail boxes. Sensors placed inside the box detect whether it is empty and, if so, transmits a signal that is then processed in real-time. The delivery person can then skip that box for collection, thereby optimizing daily collection routes. However, as letter volumes decrease and parcel volumes increase, we can imagine a future in which temperature-controlled smart lockers eventually replace traditional mailboxes ("Postybell - The first post box sensor that works from any distance," 2016).

Finally, additional services can also be introduced with the rise of item-level tagging. In the future, as RFID or other sensory tags become ubiquitous, a single product will be monitored via a printed NFC smart label that incorporates sensors to monitor temperature and humidity.
The proliferation of these low-cost printed smart labels will allow consumers to gain next-generation visibility on the products they have purchased (Kavis, 2015).

2.4 Success factors for IoT in logistics

This review has focused on individual use cases along the supply chain. However, this is not a fully exhaustive list of potential applications. Companies looking to leverage IoT in their operations should not just consider implementing a single use case within warehousing, transportation, or last-mile delivery. The key to success lies in understanding the convergence of these use cases with one another. One challenge facing the logistic industry is that many existing solutions are proprietary, stand-alone solutions that are not connected to each other. New platforms need to be created that combine various existing hardware and software solutions for end-to-end integrity control of supply chains (“Shipping smarter,” 2015).

Finally, connecting what has been previously unconnected may, in some circumstances, highlight new security vulnerabilities. As we interconnect IoT devices, for example, there may be new points of ingress for hackers, cybercriminals, and others who wish to do harm. It is therefore vital that all actors within the supply chain, including governments and the high-tech industry, collaborate to ensure IoT security is prioritized. Indeed, if IoT is to reach its full potential, it will be essential to address the legitimate concerns of citizens and policymakers about the privacy and control of personal information. The pace of innovation in recent years, particularly the proliferation of embedded sensor technology, has already caused incredible change in just a few short years. The remaining parts of this thesis project will explore what the world of logistics will look like in the future when more and more devices are interconnected. This thesis will outline the new business models and use cases where companies can truly add value to their customers.
3. METHODOLOGY

Our sponsor company, one of the largest logistics companies in the world, is interested in understanding the different ways real-time monitoring can add value to different supply chains. Providing this knowledge is the purpose of this project. The methodology used for the purpose of our research was largely qualitative. We interviewed subject matter experts and supply chain professionals from industry to understand how real-time tracking of goods can add value to their business. It is important to understand the method of qualitative data collection as we based the conclusion of our work primarily on what we learned from the interviews. In this section, we will discuss various methods of qualitative evaluation as described by other researchers, followed by our approach of qualitative data collection.

3.1 Qualitative data collection methods

Qualitative data are in narrative form, that is, in the form of words rather than numbers. Researchers collecting qualitative data tend to have a flexible, unstructured approach. They often rely on ongoing insights during data collection to guide the course of further data collection rather than having a formal instrument or even a fixed upfront plan about the data to be gathered. Key issues of concern in collecting qualitative data are that the data are credible (generate confidence in their truth value), dependable (stable and reliable), and authentic (communicate the mood, experience, language, and context of the participants).

Another important dimension of data collection methods concerns the basic mode. The modes of data collection most frequently used by researchers are self-reports and observations. Self-reports involve the collection of data through direct questioning of people about their opinions, characteristics, and experiences. When self-reported data are gathered in an unstructured way, the researcher typically does not have a specific set of questions that must be asked in a specific order or worded in a given way. Instead, the researcher starts with some general questions and
allows respondents to tell their stories in a natural, conversational fashion. Methods of collecting qualitative self-report data include completely unstructured interviews (conversational discussions on a topic), focused interviews (conversations guided by a broad topic guide), focus group interviews (discussions with small groups), life histories (narrative, chronological self-disclosures about an aspect of the respondent's life experiences), and critical incidents (discussions about an event or behavior that is critical to some outcome of interest). Although most unstructured self-reports are gathered orally, a researcher can also ask respondents to write a narrative response to broad open-ended questions or to maintain a written diary of their thoughts on a given topic.

3.2 Quantitative data collection methods
In order to understand the quantitative value of real-time monitoring in supply chains, it is important to attribute a monetary value to the purchasing decision. Naturally, if the price of the device outweighs the potential financial benefit, then a rational buyer would not purchase this device. However, after speaking with the sponsor company, it became very clear that this type of data was not being collected. Therefore, a quantitative analysis of this decision making process would not be possible in this project.

3.3 Scope identification and data confidentiality
In trying to understand the value of real-time monitoring in logistics, it is clear that there is a wide variety of sensor technology available to businesses. In order to maximize the value of our research, we limited the type of sensor under investigation and limited the scope of our research to advanced sensors that measure multiple parameters, such as location, shock and temperature. This will enable us to concentrate our efforts on technology that is most similar
to the sponsor company’s device. Consequently, low-cost, disposable or one-way-use, as well as single parameter sensors are all outside of the scope of this thesis.

Since this thesis is to become a public document, some sensitive details are kept confidential. We have guaranteed all interview participants the preservation of their anonymity, to ensure their voluntary, honest, and unbiased contributions. Except as required to fulfill the above conditions, the data presented in this research is free from manipulation.
4. DATA COLLECTION

In order to collect data for our thesis, we interviewed many of our sponsor company’s real-time monitoring customers, as well several other of their customers who do not use this type of services. Many interviewees confirmed that real-time monitoring of shipments is crucial in supporting niche business operations for any company. Performance is primarily judged by on-time delivery, however customers are increasingly interested in knowing, for example, if their shipment suffered excess vibration or was exposed to too much light. Therefore, this has incited them to want to truly understand how to create value for customers through real-time tracking of shipments. This chapter’s primary purpose is to provide an in-depth explanation of the results we collected throughout our various interviews with industry experts. Our intent is to look critically at the transcripts of each interview, and to distill the key challenges and learnings that can be garnered from these conversations. This will allow us to truly understand how to create the most value for customers who use sensor-based logistics services.

4.1 Overview of interview findings - Pharmaceuticals

Today’s pharmaceutical environment has become increasingly complex, with more specialty products like biologics, injectable and clinical trial drugs, being shipped than ever – which in turn raises the stakes, and the costs, of mishandling. There is a greater need for more sophisticated and personalized temperature control solutions, and one solution will not fit all distribution models. Better temperature control and the right packaging is essential to keeping product integrity intact. According to Pharmaceutical Commerce’s annual Cold Chain Sourcebook, the overall cold chain market is growing at double the rate of conventional pharma products, and will reach $288 billion (out of a $1.3-trillion) global biopharma market in 2017 (Markmann, 2016). As per the customers we interviewed, the main need for real-time sensors in their businesses is to ensure that the products shipped stay within temperature range. Without
it, there is no way for them to know in real-time and instead they rely on data-loggers which they track after the fact. Therefore, if a customer receives a medication where the icepack melted, and the temperature went out of range, then the shipping client must tell them to discard the product and the shipper replaces it at cost. However, if customers are able to tell in real-time that a package’s temperature is slipping out of range, they can work with the logistics provider to remedy the situation. For example, an interviewee described this exact situation and explained how they were able to contact the carrier to add more ice packs to the package while in transit. This allowed the shipment to remain within temperature range, which in turn prevented the roughly $10,000 shipment from being scrapped.

On the other hand, many interviewees described their use of passive temperature loggers as a more cost-effective solution because the carriers were very reliable and shipments rarely went out of temperature range. However, many expressed concerns that increased regulatory pressure in their industry would soon mandate the need for real-time tracking devices. Additionally, they confirmed that efficient supply chain monitoring would definitely create a competitive advantage for their businesses, however it would also lead to more operating costs. Given that their margins are already very thin, these extra operating costs would undoubtedly then be passed on to patients. Therefore, many interviewees felt that if there is no critical regulatory or business need, then a company will not be willing to invest in real-time monitoring.
4.2 Overview of interview findings - General

The following table summarizes the rest of the concerns expressed from the interviewees:

<table>
<thead>
<tr>
<th>Managing the Devices</th>
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<tbody>
<tr>
<td>• Who will interpret the data and generate analytical insights?</td>
</tr>
<tr>
<td>• Who will manage the reverse logistics and ensure that devices are fully charged?</td>
</tr>
<tr>
<td>• Who will ensure that device inventory is balanced throughout their network?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Security and Trust</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What data is collected about their shipment?</td>
</tr>
<tr>
<td>• Who is this data shared with?</td>
</tr>
<tr>
<td>• How secure and reliable is this data?</td>
</tr>
<tr>
<td>• Should they be afraid of hacking?</td>
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<table>
<thead>
<tr>
<th>Device Interoperability</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Can this device connect to their existing enterprise systems?</td>
</tr>
<tr>
<td>• Can these trackers connect to other IoT devices</td>
</tr>
</tbody>
</table>

Moreover, many claimed to be uncertain how often their shipments fell out of range, but this could be simply because of a lack of information sharing within their organizations. Also, one respondent mentioned that his business currently uses the same process to insure high and low value products because of a lack of knowledge of the actual shipping conditions. Therefore, he believes that there is an opportunity for insurance companies to offer better premiums if they have real-time information of package conditions.

Finally, many real-time tracking device customers did not perform extensive quantitative analysis to justify their purchase. After speaking with several real-time tracking sales reps, it appears that sales are made using a much more qualitative approach than expected. Customers are sold on these devices after being told to think of worst-case scenarios, not necessarily because they have fully understood the financial breakdown of their decision-making. Sales reps use very rudimentary estimations to justify that the devices essentially pay for themselves. There is definitely no extensive quantitative modeling being done, even though it would be
expected given the qualitative sales approach, similar to the insurance industry. Insurance companies calculate very complex loss probability models, however the logistics industry does not appear to be doing these types of calculations for real-time sensor devices at this time.
5. DATA ANALYSIS AND FINDINGS

After doing many interviews with professionals who use real-time tracking devices in their operations, as well as industry experts to gather information on the problems they are facing in their supply chains, we identified five general categories where real-time sensors are being used. Additionally, interviewees confirmed that the use of sensors in their logistics operations, combined with data and analytics, opens up opportunities for new business models and increased productivity. The following sections provide an in-depth analysis of these opportunities, as well as a summary of our findings.

In Figure 3 below, we present a brief overview of the five general categories of shipments which can benefit from real-time monitoring. This list is far from exhaustive and simply covers the categories we encountered within the customer base of our sponsor company.

<table>
<thead>
<tr>
<th>Example</th>
<th>Critical spare part (arrival time)</th>
<th>Cold-chain shipment (environment)</th>
<th>Security</th>
<th>High Value</th>
<th>Sensitive documents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spare part needed urgently</td>
<td>Human kidney being transported</td>
<td>Repeated cargo theft</td>
<td></td>
<td></td>
<td>Military documents</td>
</tr>
</tbody>
</table>

| Key factors                  |                                     | GPS location                      | GPS location   | Exposure to Light |
|------------------------------|                                     |                                   |                 |                  |
| Delayed                      | · Temperature out of range           |                                   |                 |                  |
| Out of path                  | · Exposure to light                 |                                   |                 |                  |
|                              | · Excess vibration                  |                                   |                 |                  |

<table>
<thead>
<tr>
<th>Ability to intervene</th>
<th>End the delay</th>
<th>Correct the parameter (more ice, more padding, etc.)</th>
<th>Contact authorities to intercept shipment</th>
<th>Peace of mind</th>
<th>Contact authorities to intercept shipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Send another shipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potential savings if you can intervene</th>
<th>Save 24hrs</th>
<th>Save a life</th>
<th>Cost of the shipment</th>
<th>Cost of the shipment</th>
<th>Cost of the shipment</th>
<th>Maintain document confidentiality</th>
</tr>
</thead>
</table>

*Figure 3 - Overview of Intervention Potential for Five Use Cases*
Moreover, after surveying all of the sponsor company’s customers (N = 69) who use real-time tracking devices, it appears that not every feature is being used by every customer. Figure 4 below briefly describes each feature of the device. Subsequently, Figure 5 summarizes how often each feature is used by customers. The most important feature to customers is location (GPS), which suggests an interesting opportunity to offer a device with only real-time GPS tracking capabilities in order to serve the majority of the customer base. The next most important features are temperature, geo-fence (essentially a subset of GPS) and exposure to light.

Current Location
- Know where your shipments are in near real-time

Accurate Temperature
- Verify the temperature of sensitive shipments, and receive notifications if the temperature diverges from a customized range

Exposure to Light
- Receive alerts of a potential security breach, compromised packaging, or upon delivery

Relative Humidity
- Stay up-to-date on moisture levels inside your shipments

Barometric Pressure
- Detect changes in the levels of atmospheric pressure

Shock
- Monitor and receive alerts for shock events

*Figure 4 - Description of Each Feature*

<table>
<thead>
<tr>
<th>% of Customers Using Feature</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Location (GPS)</td>
<td>99%</td>
</tr>
<tr>
<td>Temperature</td>
<td>45%</td>
</tr>
<tr>
<td>Geofence</td>
<td>43%</td>
</tr>
<tr>
<td>Light</td>
<td>41%</td>
</tr>
<tr>
<td>Location (LBS)</td>
<td>26%</td>
</tr>
<tr>
<td>Timeliness</td>
<td>20%</td>
</tr>
<tr>
<td>Safety/Security</td>
<td>15%</td>
</tr>
<tr>
<td>Environmental Triggers</td>
<td>16%</td>
</tr>
<tr>
<td>Shock</td>
<td>14%</td>
</tr>
<tr>
<td>Humidity</td>
<td>12%</td>
</tr>
</tbody>
</table>
Moreover, working alongside the real-time tracking device sales reps, we were able to identify how often each customer uses real-time tracking for each of the categories we defined. Figure 6 summarizes the findings for all of our sponsor company's customers:

![Bar Chart - Where are Customers Using These Devices?](chart.png)

<table>
<thead>
<tr>
<th>Category</th>
<th>Usage Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold-chain shipment (environment)</td>
<td>37%</td>
</tr>
<tr>
<td>Critical spare part (arrival time)</td>
<td>34%</td>
</tr>
<tr>
<td>Repeated cargo theft (security)</td>
<td>14%</td>
</tr>
<tr>
<td>Important/ Sensitive documents</td>
<td>9%</td>
</tr>
<tr>
<td>Box of diamonds (high value)</td>
<td>6%</td>
</tr>
</tbody>
</table>

*Figure 6 - Understanding the Context for Real-Time Tracking Devices*

Therefore, given that the two largest categories account for 71% of total usage, it reinforces the importance of the location and temperature sensors, which are key elements of the critical spare part and cold-chain shipment categories.

Finally, as mentioned previously, this is not an exhaustive list of every potential use case. Ultimately, every shipment in every industry is a potential market for real-time tracking devices. The most critical element that hinders or aids in adoption is eventually cost. Potential customers need to justify the investment from a financial perspective, therefore the price has to be right for them and they need to understand the potential added value that can be created by these devices.
5.1 The importance of cost

When speaking with supply chain professionals about using real-time monitoring in their business, one of the most common questions that came up was how much this service would cost. The cost of the service (real time monitoring) should not be more than the benefit it offers or the problem it solves. So, the real question is how much savings does this service bring to the business? One of the direct cost saving opportunity brought up by interviewees was transit insurance cost. With the improved visibility of the shipment using a real-time tracking device, the chances of shipment losses reduce because in some cases the shipper/receiver will be able to intervene. With fewer cases of shipment loss, the shipper/receiver should be able to negotiate a lower transit insurance cost. Additionally, by taking actions to avoid known delays, the efficiency of operations is improved. Reduction in insurance cost and known delays are the only factors which decision makers think of while making a decision whether or not to use a real-time monitoring service. In the following subsection, we will discuss a broader approach to define the value of a real-time monitoring service.

5.2 Defining value

We start our analysis by identifying ways to define the value of monitoring. We have identified four types of value addition which real-time monitoring can offer businesses. It is important to note that not all types of value addition are straightforward to quantify. In the following sections, we will discuss each one of the four types.

5.2.1 Insurance cost reduction

Shipping insurance, like any other insurance, is simply a form of protection against a possible risk. As insurance companies improve business efficiency and performance, the ability to access, analyze, and manage vast amounts of data while rapidly evolving has proven critical.
With data collected from a real-time monitoring device, insurance companies increase the amount of information they have about each shipment. For example, if a customer places a fraudulent insurance request, claiming their perishable item has spoiled, an insurance company can easily access the temperature conditions throughout the journey and know, in real-time, if the shipment actually fell outside of the specified temperature range. Therefore, not only does this increase claims transparency, but it also leads to faster claims processing because insurers don’t have to wait for the user to provide the data manually.

Moreover, logistics providers usually don’t sell insurance coverage on shipments, but instead offer declared value coverage up to a certain amount (Morran, 2013). Unfortunately, there is inherently very little transparency in this process because it is up to the shipper to declare an honest value. However, real-time sensor data allows insurers to perform risk assessments based on actual characteristics of the shipment rather than proxy data. For example, in commercial insurance, deploying sensors on shipping containers and transport vehicles could provide insurers with the opportunity to enhance shipping insurance coverage. The ability to better detect and model risks due to theft or damage could move the pricing of these products from an actuarial exercise to one that better assesses risks and losses in real-time.

5.2.2 Interventions for known delays and peace of mind

In many situations, receiving a package is only a small step in the entire chain of operations. However, non-arrival of the package can disrupt the whole operation because the subsequent steps depend on its arrival. However, in many instances, if the delay is known beforehand, then actions can be taken to mitigate the disruption. For example, if a raw material is needed for a production process, then the production will halt if the raw material does not arrive. Also, let us assume that the raw material comes from an overseas supplier, but higher cost local suppliers
with lower lead times are also available. If the manufacturer knows about the delay beforehand thanks to a real-time tracking device, then he can procure a small amount of raw material from the local supplier to keep the factory running until his delayed shipment arrives. The same logic applies for other types of issues, such as security concerns or changes in environmental conditions of packages.

Finally, in some instances a sender sends a very important package and is very concerned about not losing it. The package can be of low value or high value but it is important for the sender to make sure it is safe, e.g. an old souvenir or an important document. In such cases, there is a need for the sender to be able to track the package in real-time to ensure peace of mind. It is not possible to put a dollar value on this peace of mind, however, there exists a need for it that inherently makes the service valuable.

5.2.3 Analytics for optimization

With the increase in data collection at various levels of business operations, there is a growing opportunity to use analytical tools to optimize operations. For example, data from real-time tracking of shipments can add insights into what routes to take to avoid traffic or even in which locations the temperature of the shipment goes out of range. However, collecting all the data in the world means nothing if you can’t interpret it and generate business value with it. With increased computing power, it is important to have predictive analytics in place to understand when, where and why a shipment is falling outside of pre-established control limits. Additionally, as more and more customers use real-time monitoring devices, logistics companies will collect more and more data, which will enable them to strengthen their predictive analytics business. Presently, sensor data is used mostly to detect and control anomalies, not for optimization and prediction which provide the greatest value. As sensor
adoption matures, logistics providers can learn from a growing number of journeys. This will allow them to calculate probabilities of millions of other potential scenarios and then generate dynamic forecasts in real-time for a variety of other scenarios as well.

5.2.4 Reducing business frictions

With real-time tracking of the location and the condition of the package, opportunities open up for automating operations and reducing business frictions. Today a number of frictions, of varying degrees of importance to different industries, add costs and remain a drag on global business and trade (see Figure 7).

Figure 7 - Three Types of Business Frictions ("Fast forward," 2017)

For example, transaction costs: the cost of conducting business is a function of its complexity and grows with scale, its size and the resources that need to be managed, including intermediaries. In almost every case, the cost of complexity yields diminishing returns. Also, as digital platforms connect more and more disparate parties, delays remain due to arcane business processes. Business transactions take days and are costly to manage via multiple intermediaries. However, it would be very beneficial for a logistics provider to offer its customers the ability to tap rules-based intelligence to perform business functions. Recent technological advances have enabled the creation of intelligent, embedded and trusted program
code, letting participants build terms, conditions and other logic into contracts and other transactions. It allows business partners to automatically monitor prices, delivery times and other conditions, and automatically negotiate and complete transactions in real-time. This reduces transaction costs, maximizes efficiency and allows customers to use data in different ways. It also opens the door for machine-to-machine transactions across the IoT. These capabilities enable the transformation of a traditional supply chain, where transaction documents and contracts must be maintained by each partner’s purchasing, accounting or legal department. Indeed, with a new groundbreaking technology called blockchain, all transactional elements are stored on decentralized computing nodes by various partners. Blockchain is an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way (Christidis & Devetsikiotis, 2016). An in-depth analysis of how real-time tracking devices enable the use of blockchain in supply chain management is covered in the following section.
6. CREATING VALUE: BLOCKCHAIN

Michael Casey, a senior advisor at the MIT Media Lab’s Digital Currency Initiative, describes blockchain as a technology that ensures a trusted, secure and transparent ecosystem. He believes it has the potential to fix many of the current problems with supply chains today. With blockchain technology, the core system that underpins the digital currency Bitcoin, computers of separately owned entities follow a cryptographic protocol to constantly validate updates to a commonly shared ledger. A fundamental advantage of this distributed system, where no single company has control, is that it resolves problems of disclosure and accountability between individuals and institutions whose interests are not necessarily aligned. Mutually important data can be updated in real time, removing the need for laborious, error-prone reconciliation with each other’s internal records. It gives each member of the network far greater and timelier visibility of the total activity (Casey & Wong, 2017).

Today, as in Figure 8, transactions between different companies are recorded in multiple ledgers. Each one captures a moment in time and reflects the information held by a single party: Company Y shipped product X, for example.

*Figure 8 - Transactions Recorded in Multiple Ledgers ("Fast forward," 2017)*
However, these separate ledgers do not record every step between partners, suppliers, and consumers in the transaction. Moreover, they are prone to human error and vulnerable to tampering. By contrast, as in Figure 9, distributed ledgers can be shared and updated in near real-time across a group of participants. Every transaction becomes part of the permanent record and can be examined by those that have permission and relevant information can be shared with others based on their roles and access privileges. In addition, the immutable and cryptographically secured nature of operations on the blockchain makes it nearly impossible to compromise or hack the blockchain ("Fast forward," 2017).

![Figure 9 - Transactions Recorded in a Distributed Ledger ("Fast forward," 2017)](image)

Ultimately, this technology allows much more information to be exchanged between parties in a global supply chain. We believe that logistics providers, as the intermediary between many different parties in every industry, are uniquely positioned to benefit from this technology. Specifically, logistics providers who provide real-time monitoring devices now offer their customers significantly more data with which they can now create new business opportunities, which will be discussed further in the following section.
6.1 Creating value for real-time monitoring using smart contracts

The current approach to creating value for customers using a real-time monitoring device is detailed below in Figure 10:

![Diagram showing Total Addressable Market for Creating Value](image)

It is clear that the total addressable market shrinks as we go down the pyramid. Therefore, there will inherently be less value to create for customers if logistics companies only try to focus on this area. Instead of marketing these real-time tracking devices as solutions to resolve problems and exceptions, logistics companies should seek to use all of the tracking data to benefit themselves and their customers. The best way to do this is by using self-enforcing smart contracts.

In a blockchain implementation, a blockchain based smart contract can trigger automatic value transfers based on conditions. Smart contracts represent a next step in the progression of blockchains from a financial transaction protocol to an all-purpose utility. They are pieces of software, not contracts in the legal sense, that extend blockchains’ utility from simply keeping...
a record of financial transaction entries to automatically implementing terms of multiparty agreements. Smart contracts are executed by a computer network that uses consensus protocols to agree upon the sequence of actions resulting from the contract’s code. The result is a method by which parties can agree upon terms, and trust that they will be executed automatically, with reduced risk of error or manipulation. For example, a monitoring device in a package could trigger a payment that is instantly settled on a blockchain once the GPS location of the package proves that it has reached its destination. This ability to tap rules-based intelligence to perform business functions would be ground-breaking. Blockchains enable the creation of intelligent, embedded and trusted program code, letting participants build terms, conditions and other logic into contracts and other transactions. It allows business partners to automatically monitor prices, delivery times and other conditions, and automatically negotiate and complete transactions in real-time. This reduces transaction costs, maximizes efficiency and allows manufacturers to use data in different ways. It also opens the door for machine-to-machine transactions across the IoT. These capabilities enable the transformation of a traditional supply chain, where transaction documents and contracts must be maintained by each partner’s purchasing, accounting or legal department.

Importantly, before blockchain, this type of smart contract was impossible because parties to an agreement of this sort would maintain separate databases. With a shared database running a blockchain protocol, the smart contracts auto-execute, and all parties validate the outcome instantaneously and without need for a third-party intermediary. However, when should companies employ blockchain-enabled smart contracts rather than existing technology? They can be a worthwhile option where frequent transactions occur among a network of parties, and manual or duplicative tasks are performed by counterparties for each transaction. The blockchain acts as a shared database to provide a secure, single source of truth, and smart
contracts automate approvals, calculations, and other transacting activities that are prone to lag and error.

For a wide range of potential applications, blockchain-based smart contracts could offer a number of benefits:

<table>
<thead>
<tr>
<th>Speed &amp; Real-Time Updates</th>
<th>Smart contracts use software code to automate tasks, which can increase the speed of business processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>Automated transactions are not only faster, but less prone to manual error</td>
</tr>
<tr>
<td>Lower Execution Risk</td>
<td>Decentralized process of execution virtually eliminates the risk of manipulation, nonperformance, or errors, since execution is managed automatically by the network rather than an individual party</td>
</tr>
<tr>
<td>Fewer Intermediaries</td>
<td>Smart contracts can reduce or eliminate reliance on third-party intermediaries that provide trust services such as escrow between counterparties</td>
</tr>
<tr>
<td>Lower Cost</td>
<td>New processes enabled by smart contracts require less human intervention and fewer intermediaries and will therefore reduce costs</td>
</tr>
<tr>
<td>New Business Models</td>
<td>Provide a low-cost way of ensuring that the transactions are reliably performed as agreed upon, which will enable new kinds of businesses (peer-to-peer renewable energy trading to automated access to vehicles, etc.)</td>
</tr>
</tbody>
</table>

*Figure 11 - Benefits of Smart Contracts (Schatsky, 2016)*

### 6.2 Example use case of a smart contract in logistics

Consider the typical supply chain example that is used to highlight the value of a blockchain: a container leaves the manufacturer’s site (point A), gets transported via railway to a neighboring port (point B), then gets shipped to a destination port (point C), gets transported again to the distributor’s facilities (point D), until it finally reaches a retailer’s site (point E). This process involves several stakeholders and checks along the way, all of them depicted in Figure 12a. Each stakeholder usually maintains their own database to keep track of the asset, which they update based on inputs from the other parties along the chain. A blockchain network
though, that is set up to track this asset would mean that there is now one shared database to keep track of, where updates come with cryptographic verifiability, get propagated along the network automatically, and create an auditable trail of information. For example (Figure 12b), when the shipping carrier reaches the destination port, they send a signed message to a predetermined and agreed-upon smart contract to allow everyone on the chain to know that the container is now at point C. Since the transaction is signed, it acts as a cryptographically verifiable receipt of the shipping company’s claim that the container has reached the destination port. The receiver at the port posts to the same smart contract to confirm that it is in possession of the container (Christidis & Devetsikiotis, 2016).

![Figure 12 - Using a Smart Contract in Logistics (Christidis & Devetsikiotis, 2016)](image)

### 6.3 Limitations and strengths of blockchain systems

Blockchain technology in itself does not address the reliability of its records. Reliability (in recording) is not a core part of blockchain technology. Often a person acting as a trusted third party records the information on the blockchain. In the case of tracking slavery or other unethical business practices, an individual can simply enter into the blockchain system that the business is legitimate and upstream actors can thus be fooled. Therefore, assuring record liability is a major limitation of blockchain systems (Lemieux, 2016). However, by offering a real-time tracking device in shipments, logistics providers can improve the reliability and
transparency of the transaction data being shared between supply chain agents. Maintaining the authenticity and integrity of this data is the core capability of blockchain technology. This is considered the major opportunity blockchain technology promises to deliver. (Nakamoto 2008)

6.4 Current blockchain uses in logistics

The shipping company Maersk has now announced that it has been working with IBM to use the blockchain to keep track of marine shipments. This is not the company keeping track of the metal boxes themselves, but rather their contents. The company claims that a single container being hauled from East Africa to Europe might require paperwork to be dealt with by as many as 30 different people, spread across 200 or more interactions (Condliffe, 2016). So with IBM it has built a tool based on blockchain that allows every participant in a supply chain to see the progress of a shipment, including where the container is and the status of its documents. The hope is that shippers can reduce the weight of paperwork that needs to be done, while customs officials and clients can see where goods are at all times. However, it is important to note that none of these ideas could be executed efficiently without a sensor device collecting and sharing shipment information in real-time.

Maersk is not alone in using the blockchain to keep track of products. As the New York Times points out in a piece describing IBM’s foray into blockchain, IBM is working with 400 different organizations to apply the technology to different situations. That includes Wal-Mart, which announced last year that it was using blockchain to record and log the origins of produce in order to improve health and safety standards. Additionally, IBM recently unveiled their take on Blockchain-as-a-Service, a public cloud service that customers can use to build secure blockchain networks (Miller, 2017).
7. SYSTEM DYNAMICS APPROACH

In this chapter, we will briefly discuss the dynamics of customer adoption of a real-time monitoring device (referred to as ‘RTM device’ in the remainder of the text) by using a system dynamics approach.

7.1 What is system dynamics and why use it?

System dynamics (SD) modeling is an approach used to understand the dynamics of complex systems. It has been applied to issues ranging from corporate strategy to the dynamics of diabetes, from the cold war arms race between the US and USSR to the combat between HIV and the human immune system. System dynamics can be applied to any dynamic system, with any time and spatial scale. In the world of business and public policy, system dynamics has been applied to industries from aircraft to zinc, and issues from AIDS to welfare reform. To briefly explain, a system dynamics model breaks down the model into various independent components. These components include stock variables which are to be measured, e.g. number of potential customers, and factors which may affect the dynamics, e.g. appeal of the product. The components are then connected to one another using causal links. Once the system is modeled, we identify reinforcing and balancing forces in the model. We can also run simulations on the model to understand the effect of each component on one another. We are attempting to capture the dynamics of RTM device adoption by using a system dynamics model. This approach will allow us to capture how different components interact with each other and to identify key components which affect the success or failure of the whole system (Sterman, 2014).
7.2 Adapting the Bass Diffusion model for a RTM device

The Bass Diffusion model, developed by Frank Bass, is a model used to describe the adoption of an innovation. At the very core of the model is the premise that increased interaction between adopters and potential adopters leads to more adoption. It uses simple differential equations to model the adoption process. It is widely used in new product sales forecasting and technology forecasting. The initial adopters are described as innovators and the laggards are termed imitators. Initially, there are very few innovators and therefore the rate of adoption is low, due to less interaction between potential adopters and innovators. As the number of adopters increases, the adoption rate increases and reaches a maximum point. At this point, adoption rate is primarily driven by the remaining stock of potential adopters. As the stock of potential adopters depletes with time, the adoption rate slowly drops to zero. At this stage, the aggregate adoption saturates and flattens out. Therefore, the complete adoption curve follows a typical S-shape. Given that real-time monitoring devices are at a very nascent stage in their product lifecycle, we believe the Bass Diffusion model is an excellent tool to better understand customer adoption.
7.3 System Dynamics model for a RTM device

The complete model is shown in the above diagram (Figure 13). In this section, we will describe the model and understand the important forces contributing to the adoption of a RTM device. Central to the model are three stocks, depicted by rectangles, connected by flows as shown in the following figure (Figure 14):

There are three pools of customers represented by the box variable in the above figure. Potential adopters consist of all the customers who can theoretically benefit from a RTM device but have not adopted yet because of various reasons. The reasons can be higher cost, lack of an appealing feature, non-disposability of the device or various others. Adopters are the current customers of a RTM device. Defectors are the customers who have tried a RTM device and decided not
to continue using it. The reason for customers becoming defectors is twofold: customers needed a device for a limited testing period or customers were unsatisfied after using the device. Moreover, the three box variables are connected by two flow arrows. The first, adoption rate, represents customers flowing from potential customers to adopters and the second, defection rate, denotes customers flowing from adopters to defectors.

Next, we look at the top portion of the model (shown in Figure 15 below). ‘Support infrastructure for intervention’ is an extrinsic variable which directly affects ‘Probability to intervene’. If a logistics provider has more infrastructure and resources in place, this means that they will have a higher likelihood of successfully intervening if a real-time monitoring customer notices an issue with one of their shipments. As the probability to intervene increases, customer reviews and peace of mind increase. Additionally, as mentioned previously in this paper, logistics providers can potentially reduce insurance costs with these real-time monitoring devices, leading to increased customer savings. Finally, increases in these variables lead to an increase in the adoption rate, and increased peace of mind leads to a lower defection rate.

![Diagram of factors affecting the adoption rate](image-url)

*Figure 15 - Factors Affecting the Adoption Rate*
Figure 16 below shows the left portion of the whole diagram. Here we capture the elements which define the market size for a RTM device. Businesses ship product from one location to another. We define shipment failure as an event leading to an undesirable outcome, e.g. theft, spoilage of product during shipment, non-arrival of shipment on time, etc. All the shipment failure instances lead to losses. Some losses are easy to quantify, such as the value of the product lost, but some losses like the stoppage of a production line due to non-arrival of a spare part could be difficult to quantify. Also, depending on the specific industry (pharmaceutical, diamond, etc.), the magnitude of loss could range from a few dollars to millions of dollars.

![Diagram](image)

Figure 16 - Factors Affecting Potential Adopters

Next, we explain the bottom part of the model (Figure 17). There are three reinforcing loops in the following diagram – Word of Mouth (WoM), Marketing and Appeal (product). In the WoM loop, more adopters will create more awareness for the potential customers, and that will eventually increase the adoption rate. In the Marketing reinforcing loop, more revenue from increased adoption will lead to increased advertising spending which will then increase awareness. Increased awareness will lead to an increase in adoption rate. In the Appeal loop, over time, the product improvements will lead to an increase in appeal (cost, quality, ease of use) of the product. The adoption rate will increase with higher appeal of the product.
7.4 Takeaways from the SD model

In the SD model, we have captured most of the important factors which might affect the adoption of a RTM device in the real world. Also, an important aspect of the model is the interaction between different factors leading to the formation of reinforcing loops. The primary purpose of modelling is to be able to pinpoint key factors whose values will determine success or failure. To visualize the effect of the key factors, we can change their input values and see differences in the resulting adoption graph.

Based on the understanding gathered from customer interviews and other sources, we conclude that Appeal, Awareness and ‘Support infrastructure for intervention’ are the three most important factors which affect the outcome of the adoption model. Product appeal encapsulates the price and usability aspects. Reducing price will of course make more potential consumers adopt a RTM device. However, at the same time, disposability of the device, greater network coverage, smaller size and better battery life are some other important factors which improve the appeal of the device. Awareness can be increased by targeted marketing to potential customers, which creates opportunities and incentives for current customers to speak to more
potential customers. ‘Support infrastructure for intervention’ is the backend process which helps customers intervene after they identify any type of failure with their shipment. Investment in the infrastructure to ensure that logistics providers can actually intervene will make the device much more valuable to customers. Finally, there is enormous potential to drastically increase the appeal to customers by creating new business models with data collected by a real-time monitoring device. However, this was discussed extensively in the previous chapter of this work.

7.5 Further work on the model – Quantifying variables

The present model is only an empirical representation of the interaction between different factors leading to adoption of the RTM device. We need further work on the model to put numerical values to all the variables and run simulations. By running simulations with different input values, we can measure the impact of each variable on the adoption rate. To do this, we would start with a very simplistic model with only stock variables and add the rest of the variables one by one. It is important to note that to quantify some variables, we would need industry level data. For example, the percentage of shipments lost over time in the pharmaceutical industry. Thus, our model can be used as a starting point for modelling adoption of any RTM device.
8. CONCLUSIONS AND RECOMMENDATIONS

As identified in the previous section, logistics providers should use their resources to strengthen three aspects of their real-time monitoring offering – Product appeal, Customer awareness and Intervention infrastructure. This will enable fast adoption of the RTM service. Once a critical adoption volume is established, the logistics provider can act as an industry leader to enable the shift towards the IoT space and acceptance of blockchain technology.

Why now? An array of innovations across the technology landscape have converged to make smart, connected products technically and economically feasible. These include breakthroughs in the performance, miniaturization, and energy efficiency of sensors and batteries; cheap connectivity ports and ubiquitous, low-cost wireless connectivity; big data analytics; and a new IPv6 internet registration system opening up 340 trillion potential new internet addresses for individual devices, with protocols that support greater security and allow devices to request addresses autonomously without the need for IT support (Porter & Heppelmann, 2014).

Real-time monitoring devices enable the comprehensive monitoring of a product’s condition, operation, and external environment through sensors and external data sources. Monitoring also allows companies and customers to track a product’s operating characteristics and history to better understand how the product is actually used. Monitoring data may also reveal warranty...
compliance issues as well as new sales opportunities, such as the need for additional product capacity because of high utilization.

Ultimately, products can function with complete autonomy, applying algorithms that utilize data about their performance and their environment, including the activity of other products in the system, and leveraging their ability to communicate with other products. One challenge facing the logistic industry is that many existing solutions are proprietary, stand-alone solutions that are not connected to each other. However, as mentioned previously, smart contracts on a permissioned blockchain, which is platform agnostic, enable the automation of business processes and the reduction of frictions within the shipping parties and other intermediaries.

Additionally, after conducting many customer interviews, it became clear that every industry and every shipment is a potential market for a real-time monitoring device. However, customers need to see the value generated by this device, before they commit to using it on an on-going basis. Customers struggle to see any value in real-time monitoring devices because they feel that their logistics provider should already be responsible for perfect shipments, every time. Moreover, collecting all the data in the world doesn’t mean anything unless you can take action with it, just as a fitness tracker does not actually turn someone into an elite athlete. As these real-time monitoring devices become more ubiquitous, it will be critical for logistics providers to ensure that they are differentiating themselves with the services they offer, not with these physical sensor devices. Logistics providers’ core business and expertise is moving product efficiently, not designing and launching state-of-the-art pieces of technology. As with the Internet itself, smart connected products reflect a whole new set of technological possibilities that have emerged, but global logistics providers’ ability to leverage their core strengths will be the key to taking advantage of this emerging technology.
REFERENCES


