



**TDWI** E-Book

MAY 2016

# Four Use Cases Show Real-World Impact of IoT

IoT in Retail 1

The Connected Vehicle: How Data Analytics  
Enables Innovation 4

Smart Cities and Smart Grids: Enabling and  
Empowering Citizens and Communities 8

Planning for the Paradigm Shift of the  
Connected Factory 11

About SAS 16

Sponsored by:





EXPERT Q&A  
**IoT IN RETAIL**

The Internet of Things can bring big benefits, but what is IoT and how are retailers taking advantage of it? For answers, we turned to Dan Mitchell, industry advisory consultant for SAS Global Retail Practice.

**TDWI:** Please define the Internet of Things and what it means for retailers.

**Dan Mitchell:** At its most basic definition, IoT is a network of connected physical objects embedded with sensors. IoT allows these devices to communicate, analyze, and share data about the physical world around us via networks and cloud-based software platforms.

**What are the retail “things” you’re speaking of?**

In the case of retail, they could be many different things, such as RFID inventory tracking chips, traditional in-store infrared foot-traffic counters, cellular and Wi-Fi tracking systems, digital signage, a kiosk, or even a customer’s mobile device.

**Based on what you are hearing from your retail customers, what is the main driver for IoT?**

With the rapid growth of online shopping, retailers are very keen to bring the frictionless customer experience of online shopping into the store wherever they can. They want access to the same type of rich data and high-performance analytics that retailers use to drive websites and mobile shopping trips. Retailers’ goal is to have that same limitless control to craft a customer experience and collect detailed data to help them predict how customers will shop.

## What are the major considerations retailers need to understand about the “analytics of things”?

When we focus on the analytics or intelligence of things, we need to think about three areas: sensing, understanding, and acting.

*Sensing:* As retailers, we need to distinguish between the signals and the noise so we can be sure we're sensing what is right and relevant for our business. We have to examine a variety of factors and multiple sources, from event stream processing to machine-to-machine communications. Key to our understanding of these data streams is mastering how to apply intelligent filtering on the fly so we're not overwhelmed by all the data.

*Understanding:* We need to analyze IoT data to detect patterns of interest as they occur throughout the connected ecosystem of things. That can come to retailers from many sources: the analytics of things, edge computing, even dynamic streaming analytics with an enriched customer or in-store context. That's a lot to digest, I know. You can think of analytics as a powerful lens that helps you distinguish meaningful events in this sea of data.

*Acting:* Once we filter out the noise and acquire and analyze the right data, we have to act on it. We need to trigger the ideal response accurately with minimal latency. That's why you've seen a lot of interest in understanding customer context, real-time marketing, and decision management. Retailers need to communicate with the customer at the time and place where a shopping decision is about to be made.

## What is driving the adoption of the Internet of Things? Is IoT a necessity or an opportunity?

IoT is driven in large part by the growth of mobile cross-channel shopping. There are many touchpoints for our customers and we need to gather data from them all. To maintain a competitive advantage, we have to keep an eye on the *relevancy imperative*. As retailers we have to be mindful of how we are spending our consumers' time. In retail, IoT gives us the opportunity to zero in on only the customers that are interested and only *when* they are interested.

## What are some of the key applications areas?

You'll find IoT in supply chain, connected consumer, and smart-store applications. We can take advantage of IoT in many areas, such as predictive maintenance, smart transportation, demand-aware warehouses, the connected customer, and the smart store.

## What kinds of things can retailers do that they couldn't do before?

Take predictive equipment maintenance, which you can see applied in energy management, predicting equipment failure, or detecting other issues. For example, in every grocery store there's lots of complex equipment—most people recognize refrigeration units. When these units are instrumented with sensors, we can predict maintenance issues that might affect power consumption for savings or monitor temperature fluctuations to ensure food safety.

Moving merchandise more efficiently is one of the goals of smart transportation applications in retail, and IoT can come into play with the maintenance of transport, tracking, and route optimization. We know many retailers have been using GPS to track and route trucks in the last couple of years. With IoT, we are able to understand to a much higher degree of accuracy how close a pallet of merchandise is to a given store.

When it comes to demand-aware warehouse fulfillment, we're talking about warehouse automation and robotics driven by online and in-store shopping demand. IoT allows us to monitor sales opportunities in real time and track missed in-store sales. It is important not to forget that RFID is a well-tested part of IoT that can be used for inventory management and more accurate service-level optimization. Currently, a typical distribution center or warehouse is organized by aisle and shelves based on a fixed schematic. The warehouse of the future will be open space where automated pallets self-organize based on real-time demand.

Increasingly, the connected consumer is having an impact on brick-and-mortar locations. Retailers understand that customers are able to check in-store pricing and local inventory levels from their mobile devices. Imagine if we could make a customized best-price offer or offer location-based services right in the store. What if we could target our high-value, loyal

customers with concierge services? In the past, it was accepted as the norm that we would send mass promotions to customers with the expectation that some acceptable percentage might be interested in that promotion. With IoT, we can now understand the context (the time and the place of the customer) to identify when we are certain the customer needs help or an incentive to purchase, and we can respond proactively.

In a smart store, mall traffic can be analyzed across several retailers so we understand the entire shopping journey. In the past, we had to run expensive survey projects to understand if store associates were being responsive to customer service needs and then enact elaborate staff training programs. Now, within smart stores, we will be able to use video or Wi-Fi foot-traffic monitoring to see if customers dwell over a product area and then, in real time, direct an associate to help that customer or analyze that information later to adjust store layouts for more efficient customer visits.

In addition, by monitoring store traffic and customer demand in real time, we can customize the current in-store shopping experience. That gives us the opportunity to implement rich digital marketing inside the store or announce events to customers via their mobile devices.

**More data and devices on a network increase the challenges of security. Please give us an overview of the problem and what it takes to address it.**

Retailers need to consider both privacy and security in concert; they are at the core of all retailers' IoT initiatives and both elements need to be incorporated into IoT projects with great care from the onset. For privacy, we need to guard and respect our customer's information; for security, we need to protect against remote and physical attacks on these devices.

In the case of privacy, it is best to adopt a strict discipline of only keeping the data we need. To personalize an in-store experience, we might collect volumes of data in real time, but once a customer makes a purchase and leaves the store, we need to challenge ourselves to *not* just drop the data into the data lake.

When it comes to security, one of our biggest challenges is the number and variety of these "things." To that end, security needs to be baked into every layer of IoT. If we cannot secure a device or feature 100 percent, we should not deploy it. Inherently the power of the things and devices is that they are networked and constantly communicating; that's a lot of communication. To wrangle all of that communication, we need to perform statistical analysis to quickly surface chatter between devices that is out of the norm. Looking only for threats we have seen in the past will not suffice.

**What are some pitfalls that retail executives and technologists need to look out for with respect to IoT?**

First, we need to be sure our focus is on the customer, not on device technology or the limitations we face today. We are still in the early days of this technology.

Second, big data skills alone are not enough. From the IT side, we really need a new set of skills that can help us make sure we are best handling all of those machine-to-machine dialogs, data streams, and data stores—in the cloud, on disk, or in memory.

**What are some key things that retail executives and technologists need to know and do to drive business value with IoT?**

Our organizations' expertise to sense, understand, and act with analytics to better serve our customers and create value is where our intellectual property or differentiation will be defined. It won't be in the technology of devices or the IoT plumbing.



## THE CONNECTED VEHICLE: HOW DATA ANALYTICS ENABLES INNOVATION

**New connected vehicles will transform the driving experience for consumers, but the predictions and insights derived from the data produced will transform every aspect of the automotive industry.**

Imagine, if you will, the connected vehicle. It's a comfortable environment in which the kids aren't crying, clamoring, or chronically registering complaints. It's a mobile command-and-control center—one in which driver and car (or driver/less car) can proactively, even automatically, adjust to the vicissitudes of the road. From freeway jams to vehicles drifting into the next lane, impending mechanical failure, and a slew of other potential disruptions, the connected vehicles have it covered.

The connected vehicle is a home away from home where music, podcasts, and—for passengers, at least—movies and television episodes can be cued up by verbal command. It's a man cave on wheels—a safe, cozy capsule that permits driver and passenger to exercise granular control over their increasingly connected lives. Simply put, the connected vehicle changes everything—for the better.

“The connected vehicle might allow me to know as I'm pulling up to a parking garage not only how many spots are left but where those spots are. It could inform me where the first available spot is, or if I'm pulling up to a red light that's going to go green in a few seconds, it can let me know that. Now I can just coast and successfully ease through that interchange,” explains Lonnie Miller, a principal industry

consultant for SAS Institute Inc. “It’s also about vehicles talking to each other so one vehicle can say: ‘Hey, you’re getting too close, you need to adjust.’ It’s targeted, location-specific advertising. It’s intelligent, preventive maintenance that can save you from breaking down on the interstate.”

The connected vehicle isn’t a pipe dream. Its enabling technology exists today. Auto manufacturers and auto parts suppliers, along with a host of new players hailing from inside and outside the automotive industry, are building sensors, signalers, and other smart components into cars and aftermarket parts. To be successful, it takes both smart technology and effective use of the opportunities the technology introduces to the market.

### The Potential of Data

Behind the scenes, a simply shocking amount of people, process, and technology orchestration has to come together for the connected vehicle to do its thing. It requires coordination among automotive and part manufacturers, entertainment companies, information services, and an array of other players. It requires companies to invest in new technologies and new technological infrastructure, as well as to develop new kinds of skills and expertise.

It requires, above all, a capacity to ingest, process, and analyze—that is, to *make sense of*—an unprecedented amount of data. In addition to the telemetry data used to monitor and assess the performance of a car or truck, the vehicle can also be a source of extremely detailed information that can reveal patterns and possibilities that automotive manufacturers (and their partners) can use to enhance the car-going experience for both driver and passengers. From serving up prerelease video streams—*Zootopia* for the kids, *Deadpool* for the adults—or targeted, location-specific ads, the connected vehicle will be that rarest of things: a win-win-win for manufacturers, service providers, and consumers.

To provide all of these services, the connected vehicle will generate a staggering amount of data. It’s estimated that a single connected car will produce approximately 25 GB of data per hour of use. That works out to about 130 TB of data per vehicle per year, which works out to 33 zettabytes (ZB) of data per year for the 253 million light vehicles in the United States.

To put that figure into perspective, networking powerhouse Cisco Systems projected that total IP traffic—inclusive of public and private networks—would reach 1 ZB in 2015. In Cisco’s forecast, that number is expected to double by 2019.

Over time, the mainstreaming of these vehicles will alter Cisco’s projections by at least one order of magnitude—more likely, two. In the near term, of course, connected-vehicle adoption will be slow and steady. In the space of two decades, however, most of the cars on the road will be connected. (According to a mid-2015 report by IHS Automotive, the average age of road-going light vehicles was 11.5 years.)

The availability of connected features will vary from manufacturer to manufacturer, as well as up and down product lines. Thus far, connected features have debuted in luxury models, but this probably won’t always be the case. Automotive manufacturers (along with companies that supply automotive parts and services) might offer financing, discounts, and other incentives to buyers or lessees in exchange for the opportunity to collect more data about what they do while traveling in their cars.

It’s likely, too, that the connected vehicles of the future will produce vastly more data than first-generation models do. As far as automotive manufacturers, their resellers, and their partners are concerned, the data produced by the vehicle will be an engine for business growth. It will be a catalyst for realignment across verticals. It will improve safety for drivers, passengers, and pedestrians alike.

It will also fundamentally transform the mobile experience. With always-connected, always-on access to information and services, the connected vehicle is, in a sense, the consummation of every marketer’s dream: a well-understood—and, let’s be honest, relatively *captive*—audience for everything from targeted, location-specific advertisements and promotions to custom-tailored products and services.

### The Predictive Imperative to Drive Relevant Behaviors and Recommendations

All of this assumes that automotive manufacturers and their partners will be able to collect, process, and, most important, analyze all of the data produced by the connected vehicle.

Custom-tailored services aren't just plucked from thin air, after all. In most cases, they must be *predicted*.

Prediction of this kind depends on a slew of variables, such as the vehicle's location, speed, and temperature; its historical and current operating telemetry; its operating condition (e.g., whether fault codes are signaling a pending electronic or mechanical malfunction); the duration of travel up to that point; the overall projected duration of travel; and the amount of time since the vehicle last stopped.

This information must, in turn, be transmitted, received, processed, and analyzed before prediction of any kind can occur. Prediction in this context is also incredibly time sensitive: a connected vehicle on the interstate is traveling at 55 to 75 miles per hour, sometimes with several miles between exits. Sometimes exits are bunched up; in many cases, traffic and operating conditions can change in a split second. A timely suggestion to exit the interstate can—literally—be a lifesaver. The upshot, Miller stresses, is that informative and relevant recommendations based on predictive analytics must be served up as quickly as possible.

“Companies will want to be able to make use of all of the data they have an opportunity to collect. This will require robust predictive analytics that businesses can use to make really timely decisions based on the data they're getting,” Miller observes. “For many companies, this is fundamentally a new kind of evidence-based decision making—decision making that's persuasive or action oriented, as opposed to just reporting on what has happened. This uses a lot of math and statistics.”

Math, statistics, and predictive analytics are subjects SAS knows more than a little about, he points out, referring to its background (the name SAS derives from its flagship product, the “Statistical Analysis System”), its 40 years of innovation, and its breadth of function- and domain-specific advanced analytics product offerings. “We're uniquely positioned to help manufacturers and other players in the auto industry get that data under control, [such that] they're better able to understand what types of decisions they can make with it,” he says.

“All of the business development and collaboration between companies we've been talking about creates more data points. The challenge for these companies is how to interpret all of these data points toward a financial benefit. In doing so, automotive organizations advance their innovation objectives by making progress in doing business differently with their customers.”

This data will be used to underpin a number of critical initiatives, such as the development and monetization of new business models or the kick-starting of multimodal product usage efforts. On a practical level, it will help business leaders determine which makes and models of connected vehicles to outfit with the most advanced connected features. Predictive insights will enable business leaders to make value-driven decisions based on a detailed understanding of the data involved.

That's just the beginning, however. Behind the scenes, automotive manufacturers (and their partners) will need to build out a technology infrastructure capable of ingesting, processing, extracting, and analyzing sensor data at unprecedented scale. They'll need to promote cultures of data democracy in which predictive insights—and their implications—can be communicated and put into practice.

---

Connected vehicles will make the roads safer and the in-vehicle experience of drivers and passengers more pleasurable based on thoughtful uses of technology.

---

For these and other use cases, they're going to need help from solution providers such as SAS.

As an example, Miller cites the case of Navistar International Corporation, a *Fortune* 500 company that (among other things) manufactures buses and trucks, along with vehicles for the defense industry. Navistar has made innovative use of predictive insights to radically aid its preventive maintenance regimen, Miller says. “They're able to identify which vehicles should be looked at for preventive maintenance. This isn't just about cost

savings, although that's a huge component. It also speaks to helping make the roads safer by preventing breakdowns," he explains.

Today, Navistar is able to extract an enormous amount of information from its trucks based on their operating telemetry. As a result, the company has the ability to fine-tune its response to almost any conceivable disruption, from a faulty batch of parts to region- or location-specific conditions.

### Conclusion

If the connected vehicle itself will transform the on-road experience of its occupants, the predictions and evidence-based insights derived from the data it produces will transform every aspect of the automotive business.

To cite just a few examples, predictions will radically improve R&D and quality control, along with product planning and engineering. Predictive insights will wholly upend—for the better—sales and marketing, customer experience and customer care, and, not least, after-sales. Prediction leading to relevant recommendations and alerts will completely recast retail development, along with the process of planning retail networks.

Finally, predictive analytics will be an essential complement to securing and protecting both the enterprise and the connected vehicle itself. "The other business group or function that really cares about connected vehicle initiatives is the enterprise security team. They have to worry about malicious cyberattacks in the form of system and data breaches. Right now, the few vehicle hacks that have been done have been done safely with a testing intent only to make a point. That won't always be the case. Cybersecurity and the use of predictive analytics to detect, prioritize, and respond to attacks will be critical," Miller indicates.

Fundamentally, these vehicles will make the roads safer and the in-vehicle experience of drivers and passengers more pleasurable based on thoughtful uses of technology. "A great example of advice-oriented action tied to video monitoring is that some premium SUV models manufactured today use an in-dash camera. That camera is watching you as you drive, monitoring your face and body behavior. If it thinks you look tired or if it detects some adverse driving behavior, it will suggest an intervention—such as pulling over to rest or drink coffee," he points out.

"It is about making money, and it's also about feeling good and being relevant and raising the bar about knowing how to react to what's happening outside and inside the vehicle. If the customer experience is good, it will create a competitive edge for automotive manufacturers."



EXPERT Q&amp;A

# SMART CITIES AND SMART GRIDS: ENABLING AND EMPOWERING CITIZENS AND COMMUNITIES

Does a “smart city” incite visions of “The Jetsons”? Think again. The technology—along with smart grids—is already in use in dozens of municipalities and doing amazing things.

What technology makes a “smart” city “smart”? What’s the impact on business processes and what’s the benefit to citizens and businesses alike? To learn more, we turned to Mike Smith, principal industry consultant in the utilities group at SAS (he is responsible for aligning client and industry needs with SAS solutions) and Jennifer Robinson, senior industry consultant in the state and local government practice at SAS (she assists local governments in becoming more effective through the use of analytics).

**TDWI:** What does it mean to be a smart city?

**Jennifer Robinson:** A smart city is a local government that uses information technology to enhance the quality of life for its citizens. Although most people think of a smart city as a sophisticated metropolis, a smart city can be a municipality, county, or region of any size that employs technologies to improve the efficiency and effectiveness of its operations.

Any government function in which data is or could be collected for the sake of answering a question, refining a process, or solving a problem is suitable for a smart city solution. Examples of solutions include the installation of utility meters to capture consumption information, employment of analytics to identify children who are most at risk of abuse or neglect, and the use of software to understand and prevent crime.

The operational improvements from smart city solutions lead to an array of impacts including safer neighborhoods, reduced congestion, healthier living, better environmental stewardship, more informed citizenry, and economic prosperity.

**What is smart grid and what is its relationship to smart cities?**

**Mike Smith:** The smart grid movement preceded the smart city movement. The smart grid provides electric utilities with the intelligent infrastructure that enables a broad array of capabilities and services across the entire utility enterprise.

The smart grid's digital, two-way communications laid over the "heavy metal" electromechanical grid enable much of what is core to the changing energy landscape. Integration of renewables? Smart grid. Deeper customer insights and engagement? Smart grid. More efficient and reliable grid operations? Smart grid.

With the emergence of smart cities, the smart grid is a foundational component for the launch into the smart cities era. Examples here include enabling electric vehicle charging-station networks and intelligent energy use facilitating more efficiency and reliability across many municipal services (including street lighting, water utility operations such as pumping, and mass transit, to name a few).

### What technologies are employed in smart grids and smart city solutions?

**Jennifer:** Smart solutions involve a wide breadth of technologies that play a role in the collection, communication, analysis, and dissemination of data. Sensors, meters, and Web applications collect data. Wired and wireless devices, fiber optics, and satellites transport data. Analytics makes sense of data collected, provides insight, predicts future performance, and provides optimizations. Finally, software on the Internet, in kiosks, and on phones conveys information to decision makers, citizens, customers, and stakeholders.

Some, but not all, smart solutions may involve the Internet of Things (IoT). The IoT is a network of objects that collect, communicate, and process information without human intervention. Objects such as street lights and trash cans that were previously inert and noncommunicative now contain technology that allows them to assess conditions and, with the aid of telecommunications and software, communicate and process the collected information. Cities will, for example, apply IoT technologies to monitor traffic at intersections so that signal timing can be dynamically adjusted to reduce congestion.

### What are some of the business process implications of the smart grid and smart city era?

**Mike:** I used to run an organization that looked at data and analytics and their impact on utility operations. We used to

have a saying: "The soft stuff is the hard stuff." In other words, deploying technology is not enough. A lot of thought and effort needs to be focused on business processes, skill sets, and the organization. For instance, it is a fair assumption that any utility that has made the smart grid leap will also need skills in data management, business intelligence, and analytics, but where do these skill sets reside in the organization and how are they most effectively deployed across the enterprise?

### Drilling a little deeper, how have processes changed in utility grid operations and customer operations as a result of the smart grid?

**Mike:** We can look at two examples. On the grid side, utility maintenance practices on assets on the grid are typically years or decades old. In today's data-rich environment, those maintenance practices need to change to realize the benefits of the availability of data and the resulting intelligence. On the customer side of the house, utility-customer engagement has historically been executed in wide swaths of the customer base. Today's deeper customer knowledge and insights allow for more targeted engagement and marketing for programs such as energy efficiency or special rates.

### You have talked about using meaningful information to improve operations, maintenance of assets, and customer or citizen interactions. How will advancements in analytics technology change cities and utilities?

**Jennifer:** Advancements in analytics technology will change how cities and utilities operate. In particular, the advent of event stream processing with real-time analytics and analytics at the edge are changing the speed at which decision making occurs.

Traditionally, data is pulled to a central location for analysis. Event stream processing with real-time analytics allows for the analysis of high-velocity data while it's still in motion and before it is stored. Together, these technologies will enable organizations to maintain fleets and infrastructure with accuracy such that they will be able to optimize performance and prevent equipment failures.

These technologies are also enabling communication between vehicles (vehicle-to-vehicle or V2V) and between vehicles and infrastructure (V2I). Analytics at the edge is the use of analytics to decipher data as close to the collection device as possible. This allows for decisions to be made at the point of data collection so that action may be taken immediately. This will enable cities and utilities to better apportion their assets and services, be more targeted with conservation measures, and be more responsive to citizens' needs.

### The smart grid is generally viewed as a big leap forward in how technology is deployed at utilities. What are the impacts on utilities as business organizations?

**Mike:** Much of what has passed for conventional wisdom over the years needs to be rethought. For instance, when it comes to the masses of data generated across the smart grid, it's not as simple as "more data equals more servers." A lot of thought and foresight needs to be directed at information architectures along with the many business process and organizational considerations we've noted.

One other consideration in the executive suite is to step back and consider the ROI on these massive technology investments. A healthy dose of "we don't always have the answer"—not as easy as this may sound in the highly controlled utility operating environment—leads to exploring new approaches that often yield unexpected benefits.

### Are cities challenged in a similar manner with information architectures?

**Jennifer:** Because local governments are comprised of many departments with vastly different responsibilities, they are prone to having disorganized and duplicated data storage. For example, the police, public works, and parks departments each call a citizen by a different name. Before analysis can be run across departments, data needs to be cleaned up. Trying to do a smart city solution with disorganized databases is the equivalent of trying to throw a party when the house is a mess. Under the "think big, start small" premise, cities can use a smart project as a means of getting data in order. With each

project, slowly build a central, organized store of data for the organization.

### What is the value of partnerships in smart solutions?

**Jennifer:** There are three types of partnerships that have value in smart solutions. First, partnerships among businesses enhance the power of smart solutions. These corporate partnerships allow a city to use a best-in-class approach for their solution. A second valuable partnership exists among local governments. Sharing data among cities allows a city to benchmark its performance, identify universal trends and correlations that can benefit more than one city, and share best practices to save cities from "reinventing the wheel." Third, local governments benefit from partnering with businesses, nonprofits, and academic institutions that can collaborate in the development of new technologies.

### What's next vis-à-vis the smart grid and smart cities?

**Mike:** Anybody who tells you that they have the answer to that question should not be believed! We *can*, however, speak to developments that are "directionally correct." One area that is just starting to be tapped is the marriage of data from the smart grid and smart meters with data from other sources. Being able to draw intelligent correlations from these multiple data sources creates countless opportunities for operational, customer, financial, and regulatory improvements. How does weather impact energy usage in near real time? How do demographic and real estate data matter in planning and deploying customer or citizen programs? The answers to these and other questions are still "out there," and finding their answers is part of what make this an exciting time for the utilities and cities.



with information from other sources to create a richer, more contextual representation of their business reality—one with more explanatory and predictive power.

### IloT Is a Catalyst for Reducing Costs and Maximizing Revenue

Many people remember the holdouts of the nineties: Those who said, “I don’t need a website—I have what every retailer wants: location, location, location!” Many of those businesses, stuck in the business models of the past, went bankrupt and are the footnotes of history. Others, though, such as Amazon, started small and then went big-bigger-biggest. As early adopters are discovering, as with early Internet business models, one of the biggest, most immediate challenges of IloT is one of scale.

The factory floor is home to hundreds, even *thousands*, of machines, each of which is—or can be—outfitted with dozens, even hundreds, of sensors. Every one of these sensors is a potential signaler. On the one hand, this presents an enormous problem of data diversity: manufacturers must collect and analyze data—in something close to real time—from thousands or even tens of thousands of points. On the other hand, this presents a basically unprecedented data management problem. We can’t always know how much information the signalers that comprise the connected factory will generate per second, per minute, per hour, or per day.

What we *do* know, based on examples from early adopters in other industries, is that the use of IloT in manufacturing will present unprecedented problems of scale. Consider:

- A twin-engine Boeing 737 aircraft produces 333 GB of data per minute per engine. For a flight from Los Angeles to New York, that aircraft will generate roughly 200 TB of data.
- In the oil and gas industry, an IloT-ready drilling rig produces 7–8 TB of operational data per day.
- In the U.S., connected automobiles already generate over 1 petabyte (PB) of operational data per day.

For context, 1 PB equals *1 million* GB. That works out to about 62,500 16 GB iPhones. The technological complexity involved in ingesting, processing, and analyzing data at this scale is nothing less than staggering. For example, making effective use of IloT involves ingesting (i.e., loading and processing) data at rates that far exceed what is usual or customary today. It likewise upends the dominant analytical pattern, which expects to operate on data at rest—data that’s loaded into and consolidated in a single place at one time. Analysis in the context of IloT shifts the emphasis to *data in motion*—what’s called “streaming analytics.” This shift requires new technologies, new skills, new resources, and lots of learning.

The potential payoff is no less staggering, according to Marcia Walker, a principal consultant for energy and manufacturing with SAS Institute Inc. “By analyzing data up front, organizations can take immediate, appropriate action in response to changing conditions or events *and* decide what data is worth keeping for further analysis and what is just noise.”

She cites equipment maintenance as one example. All companies perform preventive maintenance on manufacturing equipment. To a degree, the timing of this maintenance is based on hard data, such as the equipment’s operating guidelines or a company’s own historical analysis of equipment downtime. IloT permits more granular analysis of a machine’s operating parameters and use, and this changes the game.

“It’s moving from looking in the rearview mirror and dashboard—what *has* happened, with a limited perspective on what is happening—to actually predicting what *will* happen,” she explains.

“Being able to avoid unplanned downtime is critical. In the past, this was done based on timed maintenance intervals that were (in many cases) the result of guesswork: if we service this every three months, we can avoid unplanned downtime. With IloT and predictive models, you might be able to anticipate that Production Line 1 is more likely to break down this week because it produced X, Y, and Z with Crew A, whereas Line 2 was only producing Product X with Crew B, so the model indicates it can wait four more months for maintenance.”

IIoT will also transform product development, product support, warranty service, and other critical function areas, Walker says. “Manufacturers are building more sensors into the products they manufacture. They’re able to use [i.e., glean insights from] those sensors after they’ve shipped these products. This lets them determine how a product is performing and what sort of environmental factors or usage characteristics are affecting its performance. They can even determine how products are being used—whether operators are using certain features,” she indicates.

“This opens up new business models. Companies can start offering service contracts or they can offer subscription services for maintenance. The possibilities are almost endless.”

### IIoT Case Studies

“Adding context to current measures of yield, overall equipment effectiveness, and so on can bring surprising insights,” says Walker. “One chemical manufacturer was challenged to identify why batches were failing intermittently. Data from the plant floor was combed through and no clear patterns emerged. Only when weather data was added to the model did it become clear that humidity levels external to the factory were the biggest predictor of batch failure.

“Now they’re able to alter their production schedule when the weather forecast calls for high humidity. This saves them money because they aren’t creating bad batches in the first place.”

Imagine the connected factory, a state-of-the-art facility in which assembly-line robots, arc welders, milling machines, lathes, conveyer belts, palletizers, shrink-wrap machines, motors, light curtains—you name it—are sources of detailed information, as well as consumers of contextual information from related entities. The circle of relevant information broadens with surprising speed, from a specific piece of equipment to the skill sets of the person operating the machine to the ambient temperature, humidity, and other information in the building, through the supply chain and reaching back to information about consumer demand. In the connected factory, usage characteristics of connected machines can be continuously monitored and their performance dynamically adjusted in highly

granular ways. How best to position those machines to respond requires ever-increasing quantities of data.

It will likewise be a factory for the production of predictive insights, with the potential to improve production yields and quality control *and* maximize equipment performance, optimize preventive maintenance schedules, revolutionize power consumption, and boost profitability.

“A truck company is collecting data from onboard sensors every five minutes across a fleet of 40,000 trucks. This data is integrated with warranty claims, with data from the global positioning system, with other vehicle attribute data,” explains Walker. “We worked with this company to create SAS predictive models based on its own historical data—our models took into account both good conditions and poor—and then deployed them to catch signals and drive decisions.” This type of approach allows companies to predict failure and avoid breakdowns, provide diagnostics in the field to shorten service visits, minimize recall campaigns, and improve customer satisfaction.

### Transforming Manufacturing as We Know It

IIoT will permit manufacturers to reduce energy, water, and other resource costs, optimize preventive maintenance and equipment replacement schedules, improve equipment uptime and production yields, and improve employee performance, among other benefits. The potential to save money is real and significant.

So, too, is the potential to *make* money. Walker compares IoT to the evolution of the e-business paradigm of the mid-1990s. By any definition of the term, e-business was a disruptive force. Ultimately, it played a role in turning a struggling personal computing pioneer—Apple Computer—into the most visible consumer brand in the world. “Who would ever have thought Apple would get a significant portion of its revenue from music and media? Nobody. You just couldn’t imagine it,” she points out.

The same is true of IIoT, Walker argues. We don’t have a clear picture of just what IIoT disruption will look like. We don’t

yet know which new markets will open up or which will be obliterated. We don't yet know which of today's successful companies will be outstripped, which struggling players will be revitalized, and which upstart entrants will have outside impacts. The one thing we *do* know, based on the patterns of paradigm shifts past, is that all of these things can and probably will happen.

"You're trying to make a business case for something that's invisible. It's new. It's white space. It's something people haven't really done before. So you can't say with confidence, 'I know the ROI is going to be this,' or 'I know the revenue is going to be this.' You're going to have to take a leap of faith of some kind," Walker says. She describes one of the new monetization models IIoT will permit.

"Imagine you're a company that manufactures laundry soap. You might say to your customers: 'How about I give you a free washing machine and we'll give you a monthly subscription service for soap?' From my perspective as a manufacturer, I'm not just switching over to a more stable, more predictable subscription service revenue model. I now have a connected washing machine that's potentially collecting a staggering amount of data in the home of each and every customer. I wasn't in the washing machine business before—I made soap. Now both of us—the washing machine manufacturer and the soap manufacturer—have to change our business models. It's a huge learning curve and a significant change-management issue."

Walker's example introduces another of the biggest challenges of the IIoT model. Much of what an enterprising manufacturer might do depends on what society—or at the very least, a company's customers—will permit. The insights the soap manufacturer gleans from its connected washing machine could be used to create an intimate portrait of all of the people in a household. This information would be of considerable value. At the very least, it will help the manufacturer improve its sales and marketing efforts. With a little effort, it will also permit the manufacturer to tweak its product development efforts. Packaged carefully, IIoT data will likewise be *salable*—to buyers

inside and outside of the manufacturing vertical—if customers (or regulators) don't object.

"Nobody really knows what the comfort level of various consumers is with this kind of connected infrastructure. The technical capabilities to make those things happen exist today. Whether it makes sense business-wise is exactly the kind of research these companies are trying to undertake," she says.

"There's a business-to-consumer side, which is the washing machine example, but there's also a business-to-business angle. If you're a manufacturer of excavating equipment and in the past you tended to sell your products to mining companies, now you're able to run that piece of equipment from a remote center with no driver, so it's a driverless truck. Do you want to go into the business of excavation-as-a-service? Should that become your new business model?"

### A Technological and Cultural Challenge

Extracting meaningful insights from streaming data will require purpose-built applications such as SAS's Quality Analytic Suite, which addresses perceptual and production quality, field quality, and asset performance analytics. The solutions bring together several enabling technologies, from streaming analytics to rule-driven decision automation capabilities, in the context of a single product offering. Without such a platform, organizations struggle to cobble together an IIoT-enabled infrastructure from scratch and can quickly become overwhelmed by the large array of disparate technologies required to enable data management, model development, model deployment, and model management.

To be sure, it's possible to assemble a homegrown IIoT-enabled infrastructure from scratch—along with an IIoT-ready predictive analytics foundation—but doing so isn't for the faint of heart, involving as it does the use of a large array of disparate technologies. These include Apache Kafka, Apache Apex, Apache Flink, or Apache Spark Streaming, among others, all of which are used for streaming ingest and stream processing.

Companies must also develop new practices for dealing with streaming data at massive scale. In many if not most cases, these practices won't already exist inside the organization;

more important, they can't easily be supported using open source technologies, which lack critical data management and governance features. Aside from the challenge of custom building an IIoT program from scratch, there's the no less significant problem of *maintaining* a program.

Because of the rapid pace of change in the open source world, applications, services, projects, and APIs are rapidly deprecated (i.e., phased out) and replaced. If you custom build a solution, the onus for maintaining your IIoT infrastructure is on you. When features are deprecated or removed, you'll have to code work-arounds.

For most manufacturers, then, it will make more sense to partner with one or more leading vendors for IIoT. Take SAS, for example, which has developed a range of industry-specific deep analytical models for IIoT. SAS has four decades of experience in developing solutions for statistical analysis, data mining, predictive analysis, and all forms of advanced analytics, supported by a foundation of strong data management expertise.

The technological challenges are only the tip of the proverbial iceberg, however. There's a parallel and equally daunting problem of managing and, in a sense, driving cultural change.

In the first place, would-be IIoT-ers must acquire or cultivate the human expertise and skill sets necessary for success. It's likewise critical to develop and implement change management processes to promote alignment up and down (and across) the organization. The cultural challenges are many and varied, Walker explains. "It's critical to articulate a road map for how you're going to evolve into an analytics-enabled organization. This could mean consulting with a company that specializes in this on an analytics maturity model, which gives you a means to assess where you are, where your competitors are, where [IIoT] leaders are—and where you need to get to.

"You should also prioritize [the formation of] an Analytic Center of Excellence. If you think about it, you probably have people who have great analytics capabilities and knowledge somewhere [in your organization]. Right now, you don't know who these people are or where they are. You don't have a

way to take what they know and share it broadly across the organization," she notes.

One thing is clear: IIoT will transform manufacturing, providing opportunities for industrial organizations to innovate their historical business models into profit centers in ways we may not yet even imagine. The ability to sense the right data at the right time, understand it in context in a diverse ecosystem, and act in a timely manner is critical to success. It's time to start planning for these changes.



[www.sas.com/iot](http://www.sas.com/iot)

SAS is the leader in analytics. Through innovative software and services, SAS helps customers at more than 80,000 sites around the world make better decisions faster.

SAS Internet of Things (IoT) analytics delivers intelligence in the connected world. Our solid foundation of sophisticated streaming technology, mature analytics, and proven domain expertise provides users with meaningful, specific capabilities to make sense of IoT data.

Analytics technologies are critical for turning the tide of IoT streaming source data into informative and useful knowledge. SAS software analyzes data as it streams nonstop from sensors and devices, making it possible to identify and examine patterns as data is created—in real time. Before the data is stored in the cloud or in any high-performance repository, it's processed automatically.

With advanced techniques from SAS, data-stream analytics moves beyond monitoring existing conditions and evaluating thresholds to predicting future scenarios and examining complex questions. Our high-performance technologies identify patterns in your data as they occur. Then metrics embedded into the data stream drive automatic adjustments in connected systems or initiate alerts for immediate actions and better decisions. This is how SAS helps you assess likely future events and plan for countless what-if scenarios. Learn more: [www.sas.com/iot](http://www.sas.com/iot).



Advancing all things data.

[tdwi.org](http://tdwi.org)

TDWI is your source for in-depth education and research on all things data. For 20 years, TDWI has been helping data professionals get smarter so the companies they work for can innovate and grow faster.

TDWI provides individuals and teams with a comprehensive portfolio of business and technical education and research to acquire the knowledge and skills they need, when and where they need them. The in-depth, best-practices-based information TDWI offers can be quickly applied to develop world-class talent across your organization's business and IT functions to enhance analytical, data-driven decision making and performance.

TDWI advances the art and science of realizing business value from data by providing an objective forum where industry experts, solution providers, and practitioners can explore and enhance data competencies, practices, and technologies.

TDWI offers five major conferences, topical seminars, onsite education, a worldwide membership program, business intelligence certification, live webinars, resourceful publications, industry news, an in-depth research program, and a comprehensive website: [tdwi.org](http://tdwi.org).

© 2016 by TDWI, a division of 1105 Media, Inc. All rights reserved.  
Reproductions in whole or in part are prohibited except by written permission.  
Email requests or feedback to [info@tdwi.org](mailto:info@tdwi.org).

Product and company names mentioned herein may be trademarks and/or registered trademarks of their respective companies.

SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc. in the USA and other countries. ® indicates USA registration. Other brand and product names are trademarks of their respective companies.  
108267\_G28131.0516