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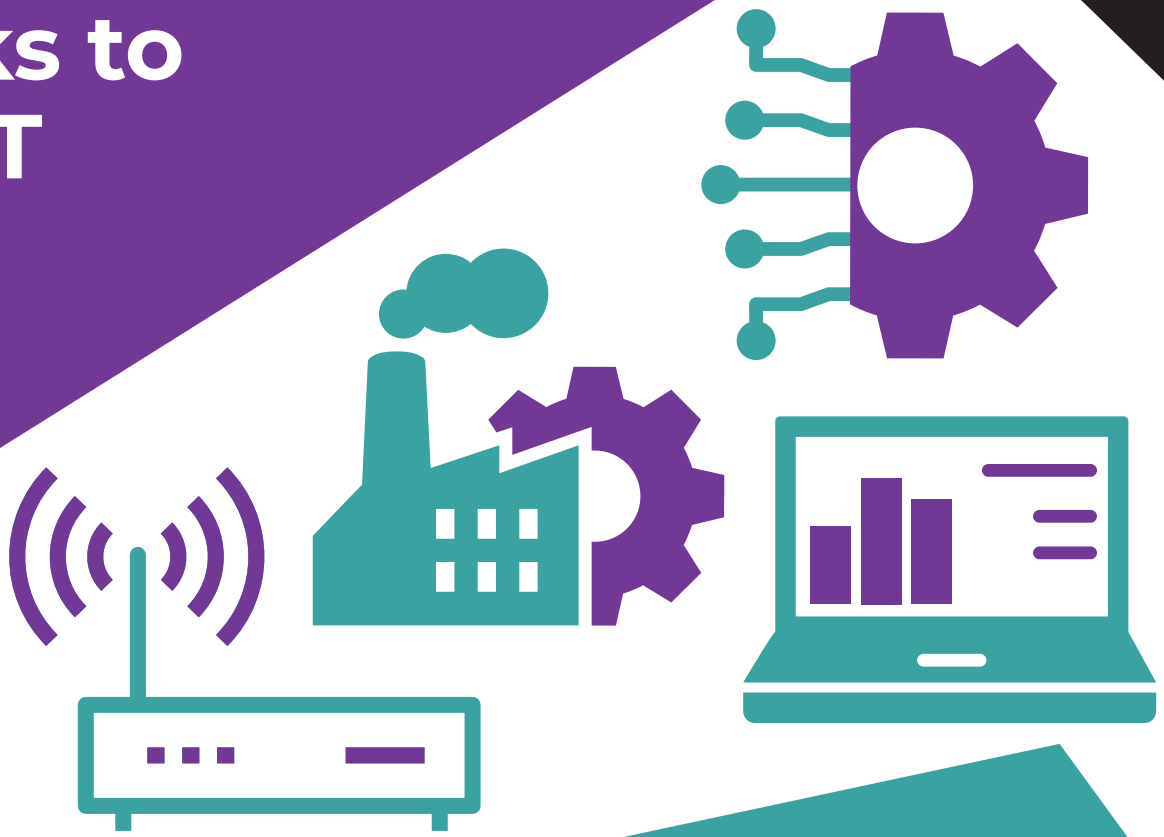
The Next Product You Design Might Be a Service Thanks to the IoT



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BACKGROUND

Much has been made of the trend that sees consumers shifting from buying capital goods and towards the sharing economy, where they rent the capacity they need. The chronicles of jet engine manufacturers selling power by the hour (as opposed to selling engines) have been told many times, and we're all familiar with the Uber/Lyft story as well.

There are many more examples of these "products-as-a-service" that move the risk of performance from the customer to the manufacturer, such as industrial and agricultural robots, compressed air, valves, water pumps, smart lighting systems, and even passenger trains. The enabling technologies—the Internet of Things (IoT), machine learning, and the digital twin—are rapidly becoming mainstream, leading to a potential surge in products delivered as services.

For this report, the editors of engineering.com interviewed companies on the leading edge of implementing products as a service with a view to describing and categorizing the types of products that can be delivered as a service and the technologies that make it possible—one company in high-tech manufacturing, another who helps ensure access to clean water in developing nations, and a third in the mass transportation industry. We explore the reasons for delivering their products as services and examine the processes by which they moved to that business model.

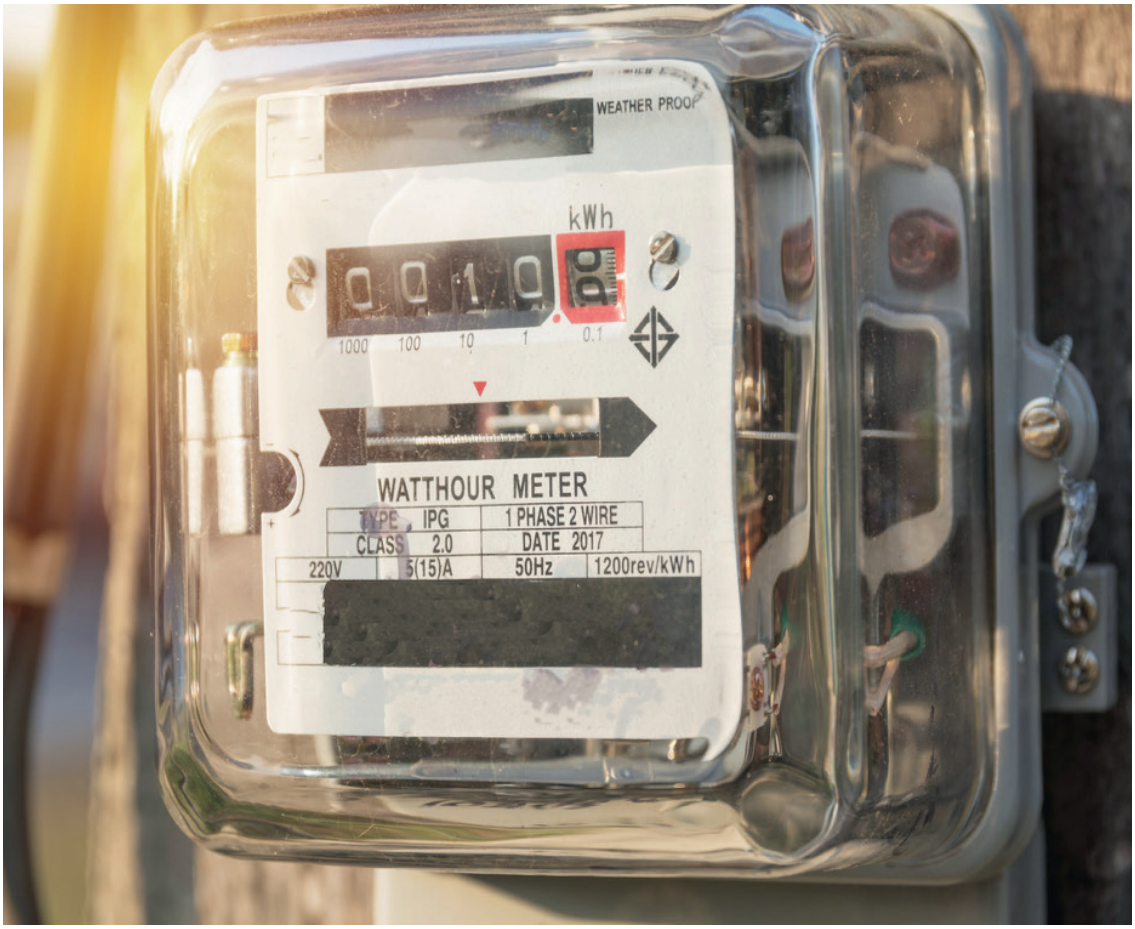
Upon reading this report, product managers, CXOs and design engineers should be able to:

- appreciate the role of IoT in creating products-as-a-service
- conceive of ways to repackage existing products into services
- recognize the importance of a full-featured IoT development platform

WHAT IS PRODUCT-AS-A-SERVICE?

Product-as-a-Service(PaaS) is a business model that allows a customer to pay for a desired result rather than purchasing the equipment that delivers the result. For example, a manufacturing operation may need two pieces of metal welded together. In the traditional model, the manufacturer would buy a welding robot. In the PaaS model, the company would purchase a certain number of welding operations, not the robot itself. As we'll see, this model offers benefits to both the customer and the provider.

Closer to home, most people are familiar with the PaaS model through our utility companies. Very few people own generators; instead, we purchase electricity by the kilowatt-hour. This frees the customer from having to purchase, operate, and maintain the generating equipment, while it provides the power company with a consistent revenue stream.



Original analog electric meters.

Similarly, urban dwellers don't necessarily need a car; they simply need transportation from Point A to Point B. Rather than purchasing a vehicle, they can use mass transit systems, taxis, or a ride-sharing service like Uber or Lyft, on a pay-per-use plan.

PaaS is still in its infancy, but it's already helping companies increase productivity, improve efficiency, and capture additional market share. As the Internet of Things (IoT) continues to mature and gain acceptance, PaaS is poised to become a more common business model.

WHAT IS IOT?

The IoT, a big part of what is being referred to as "the Fourth Industrial Revolution" and "Industry 4.0," combines the power of embedded controllers with the convenience of affordable sensors and wireless communication, allowing engineers to create products that can be monitored and controlled remotely, with or without human intervention. Although the term "Internet of Things" is only two decades old, the concept of electrically-connected devices was predicted by Nikola Tesla almost a century ago. The first IoT product—a vending machine outfitted with sensors so researchers could keep an eye on inventory status from their desktop terminals—debuted at Carnegie Mellon University in the early 1980s. (Necessity isn't always the mother of invention; sometimes it's an engineer saying, "Wouldn't it be cool if...")

The first ever IoT product was a vending machine developed by Carnegie Mellon University's Computer Science department in 1982. (Image courtesy of Carnegie Mellon University.)

Nearly forty years after Tesla's prognostication became "the real thing," the IoT wave is building, as more and more devices are monitored and controlled from a distance. Riding this wave is PaaS. Businesses can jump in and convert their products into services and consumers can purchase services instead of buying products. With this report, engineering.com hopes to help you navigate the waters.

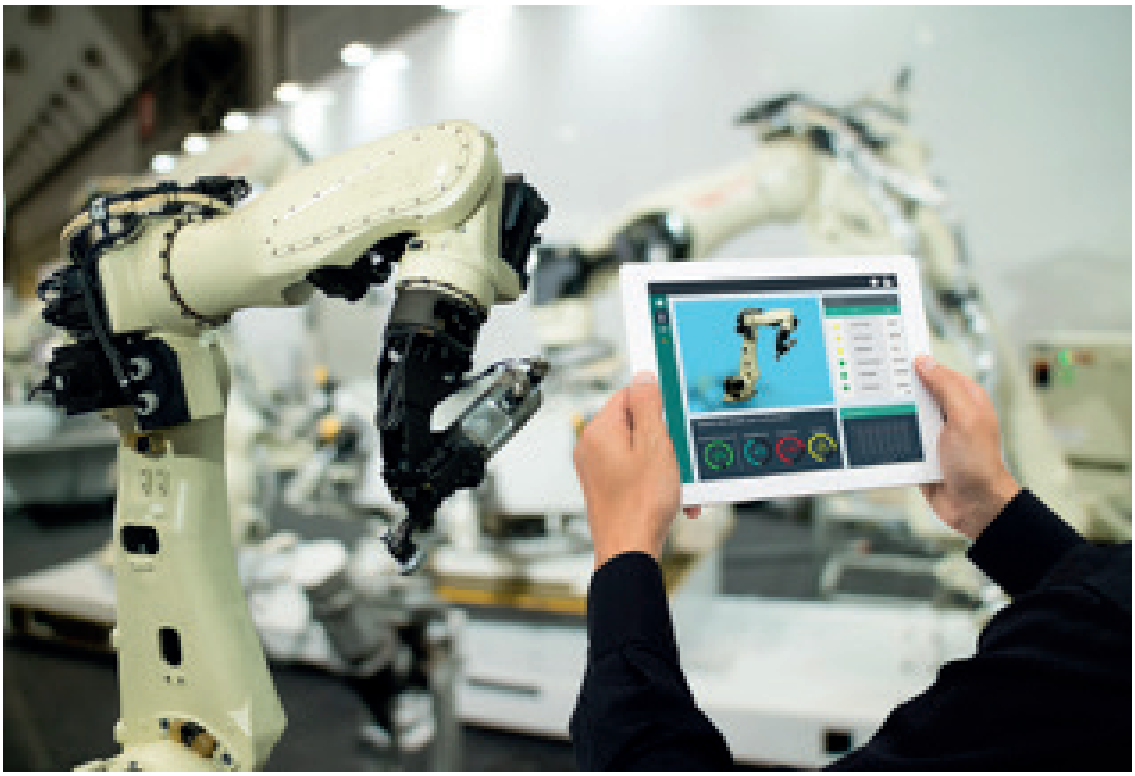
HOW DOES IOT ENABLE PAAS?

There's an old adage that says, "If you can measure it, you can improve it." PaaS takes it a step further: "If you can measure it, you can sell it." Looking back at the previous examples, we already pay for products as services through the use of electric meters that measure power consumption and taxicab meters that measure travel distances. In a manufacturing environment, robots can now be outfitted with sensors that monitor cycles, allowing the customer to pay for repetitions rather than robots. And while the first two instances once required human intervention—a meter reader going door-to-door or a cab driver reading a meter—wireless communication and embedded controllers allow the process to be automated, which greatly expands the realm of products that can be sold as services while decreasing the cost of delivering those services.

A "Smart Meter" measures electric usage and can upload data wirelessly.

But wait... there's more! Machine learning algorithms can perform various types of data analysis, which provides a whole new level of value attached to the services. For example, a smart electric meter not only measures total consumption over a billing cycle, it also knows what time of day that power was used. This allows customers to choose billing plans that offer discount rates for using power during low-demand periods and provides data to help utilities balance supply and demand. As a result, the use of smart meters flattens the power consumption curve, reducing the need for utilities to increase capacity. On the industrial side, analyzing a robot's behavior can facilitate predictive maintenance, reduce machine downtime, and optimize production.

Before delving into the details of PaaS, let's look at a few businesses that are benefiting from the PaaS model.



IoT enables remote monitoring in the manufacturing industry.

EXAMPLES OF PAAS

Engineering.com spoke with several industry experts, including engineers who have implemented PaaS and executives from PaaS companies. We learned about the products, services and technologies, and gained insight into the obstacles and rewards of selling services in lieu of products.

CASE STUDY: HAM-LET INDUSTRIAL VALVES

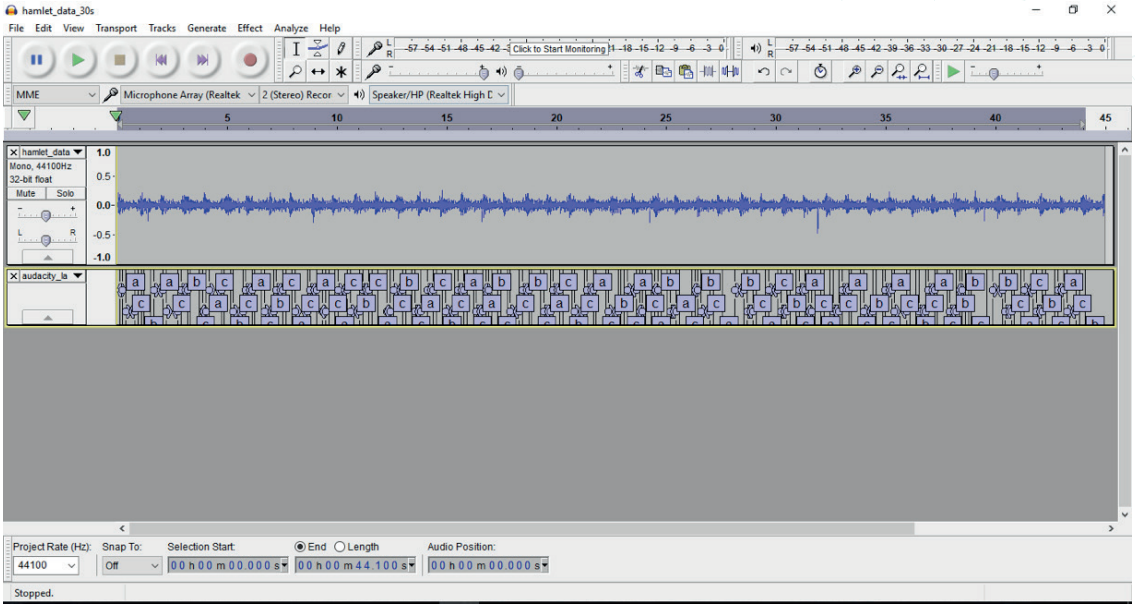
Ham-Let produces industrial valves that are equipped with IoT sensors. (Image courtesy of Ham-Let.)

Since 1950, Ham-Let has produced and sold valves, fittings, and hoses for a variety of industrial purposes. Their business is moving toward the PaaS model, a few parts at a time. We spoke with Felix Shestatski, VP of Marketing, and Arik Mimran, VP of Engineering R&D, who described the company's evolution from products, to products enhanced with IoT, and finally, PaaS. We'll take a look at Ham-Let's ultra-clean valve (UCV), which is used in semiconductor manufacturing.

A Ham-Let ultra-clean valve (UCV) in a clean room. (Image courtesy of Ham-Let.)

In the semiconductor industry, gasses are used to "grow" circuits on a wafer. Gas flow is regulated by an ultra-clean valve (UCV), which consists of a metal diaphragm that's designed to last for several million open-close cycles. Engineers have incorporated a strength gauge that measures the strength of the valve's diaphragm. This helps the company determine when a valve may need replacing, allowing technicians to change from scheduled maintenance to predictive maintenance, eliminating unnecessary replacements and preventing costly downtime due to valve failure.

Ham-Let also listens to the valve—literally—by employing a microphone to capture the sound as the valve opens and closes. This tells engineers about its response time and gives an audio signature that's analyzed to detect anomalies that may indicate issues with health and status of the valve.



Valve audio signature analysis. (Image courtesy of Ham-Let.)

The company uses a combination of edge-based and cloud-based machine learning to process the enormous volume of information that the sensors produce. Large blocks of data, including the audio signatures, are analyzed at the edge, using gateway computers at the manufacturing facility. Then, once or twice a minute, the gateway sends a snapshot to the cloud for additional analysis.

Ham-Let needed an out-of-the-box solution for its data analytics, so they partnered with an IoT provider, whose PaaS platform, MindSphere, handles all of the communication, data security, and data analytics. It also provides a customized dashboard that allows engineers to securely monitor the system from a console, tablet, or smartphone. Mimran stated, "We wanted to add some gauges in the interface. We asked for it, and said, 'This is how it should look,' and boom, we had it. I think also the fact that MindSphere uses the concept of a store, kind of an app store for IOT applications, was very beneficial. We were able to integrate with a third-party company that actually provided response time of our valve based on a microphone, based on the sound that we transferred."

IoT engineer Shay Benchorin worked with Ham-Let to develop the valve-to-cloud interface. He described the role of each company in the process: "The nature of the partnership between the two companies is that they [Ham-Let] are masters in manipulating metal and they have a lot of experience and a lot of products. We are masters in providing cloud services. So, we kind of divided the work so that they build the valves and we build all the software that is outside of the valves that sits in the gateway or edge, including analytics, and of course all the cloud services."

Since the company started with an existing product and adopted an off-the-shelf PaaS platform, the product-to-service migration only took about six months from concept to completion. Ham-Let is offering three of its valves under the PaaS model (in addition to the traditional model) but has yet to convince its customers to purchase the services instead of the valves. Remote monitoring is helping the company make its case, as they can show customers data from actual valves in the field and explain the benefits of remote monitoring and PaaS.

CASE STUDY: SWEETSENSE REMOTE SENSING

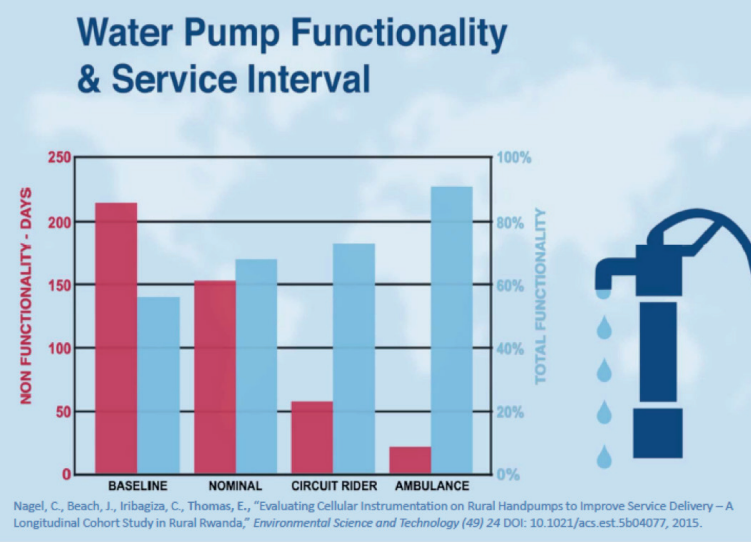
While some businesses sell products and services to high-tech industries, SweetSense, a Colorado company whose Board of Directors includes a former NASA astronaut, serves the people of developing nations, helping to ensure access to clean water in remote villages. SweetSense uses a combination of sensors, IoT, and its own proprietary PaaS platform to track water usage, monitor pumps, and provide scientific data for researchers. Engineering.com interviewed SweetSense engineer Taylor Sharpe, who told us about the company's transition from selling products to delivering products as services.

SweetSense IoT-Based water meter. (Image courtesy of SweetSense.)

The past few decades have brought increased drought conditions to countries in Africa, forcing people to rely more on groundwater supplies, overtaxing the pumps that deliver the water. SweetSense found that, at any given time, nearly half of the pumps were not functional and typically took many months

to repair. Sharpe told us, “The original mission of each of these installations isn’t being fulfilled unless we find better feedback systems for repairing operations and maintenance. You’ve got this existing piece of technology or infrastructure that previously was meant to stand on its own, but it turns out it doesn’t work with the current feedback systems. We use IoT as a feedback system that can maintain these pieces of infrastructure.”

The remote locations and great distances between pumps made maintenance costly and challenging, so SweetSense developed a line of IoT-based sensors to help them monitor the equipment from afar. After the sensors had been installed, repair times were reduced to 23 days; consequently, the pump failure rate is now less than 10 percent.



PaaS reduces downtime. (Image courtesy of SweetSense.)

SweetSense also makes a filter with an integrated flowmeter to track water filter usage, which helps scientists determine the effectiveness of water filters on water-borne diseases. Sensors give actual data, so researchers don’t have to rely on people responding to surveys. Also, when residents can see their own usage statistics, they’re more likely to use the filters regularly.

On a global scale, SweetSense formed a partnership with NASA to work on the Surveyor program. Sensors monitor the flow from well pumps, which NASA then correlates with regional precipitation data to see how rainfall (or lack thereof) affects groundwater usage.

Measuring groundwater usage. (Image courtesy of SweetSense.)

A SweetSense flowmeter is connected to a communication module consisting of a weatherproof enclosure, an embedded controller, a battery, and a wireless communication module, which typically employs cellular technology.

Flow Sensor and IoT module. (Image courtesy of SweetSense.)

CASE STUDY: RENFE PASSENGER RAIL SERVICE

Passenger railways have a difficult time competing with airlines due to their slower speeds and frequent delays. In Spain, the route between Madrid and Barcelona was dominated by air travel, which accounted for nearly 80 percent of the passengers. Renfe, the Spanish national rail operator, decided to increase its market share by offering a guarantee: if the train runs more than fifteen minutes late, customers get a full refund. As rail services operate with minimal profit margins, this was a very risky proposition, so Renfe improved its timetable reliability by teaming up with several "railroad as a service" providers, delivered the hardware, software, and brainpower to keep the trains running on schedule.

This train is a product as a service. (Image courtesy of Railway Gazette.)

The providers equipped trains and rails with sensors that monitor, record, and transmit millions of data points every day. This information is analyzed in an IoT platform that uses the digital twin to evaluate performance, data analytics to perform predictive maintenance, and supply chain management to ensure that repairs are done promptly. As a result, the rail service has experienced only one significant delay in over 2300 trips. Due to the company's guarantee and improved service, Renfe now carries more than 60 percent of the passengers between Madrid and Barcelona, capturing a big share of the market from the airlines. One might say that PaaS helped the train in Spain regain business from the planes.

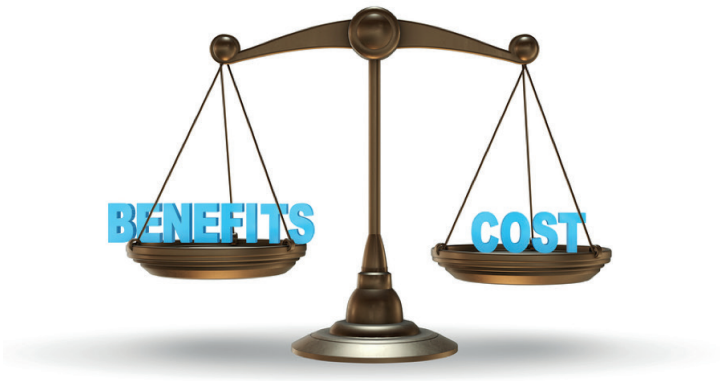
IoT industry consultant Joe Barkai told us how they did it. "They commissioned companies who built the trains and maintain the cars and the tracks to provide uptime. So there are two complementary contracts, one of them between Renfe and the manufacturers to provide uptime, another one between Renfe and the customers to provide on-time arrival."

Barkai continued, "Instrumentation and remote connectivity allow IoT companies deep insight to formulate a service agreement that provides a high level of service to Renfe and, at the same time, is highly profitable. For Renfe, it's more than about being reimbursed. It's really capturing market share; it's really positioning. Before this system was put in place, most of the traffic in this Madrid-Malaga-Barcelona route was done by air and now more than 60 percent of the passengers along these routes take the train."

Data analytics keeps the trains on schedule. (Image courtesy of Siemens.)

WHAT'S IN IT FOR YOU?

On the surface, PaaS appears to be little more than a shift from buying to leasing. But dig a little deeper and we discover the buried treasures: consistent revenue streams for providers and enhanced services for clients. Those benefits, however, come with costs, so it's important that both sides minimize their risks in order to reap the rewards.



PaaS has both costs and benefits.

To contrast PaaS with simple leasing, let's look at a buy versus lease model that most of us are familiar with: automobiles. For the sake of argument, let's assume everyone pays cash. When you purchase a car, you make a one-time payment to the dealer. You've incurred a large capital expense and received a valuable piece of hardware in return. You own the car, so you don't have to make monthly payments on it. But all maintenance is your responsibility, so you will have some routine maintenance expenses as well as the cost of major repairs after the warranty expires. You can do the repairs yourself, hire an independent mechanic, or bring the car to the dealership. It's conceivable that you could keep the car for a decade, even two, but as it ages, it will become less reliable. You also won't take advantage of the latest and greatest features offered by the automotive industry. In short, when you buy, you pay less and get less.

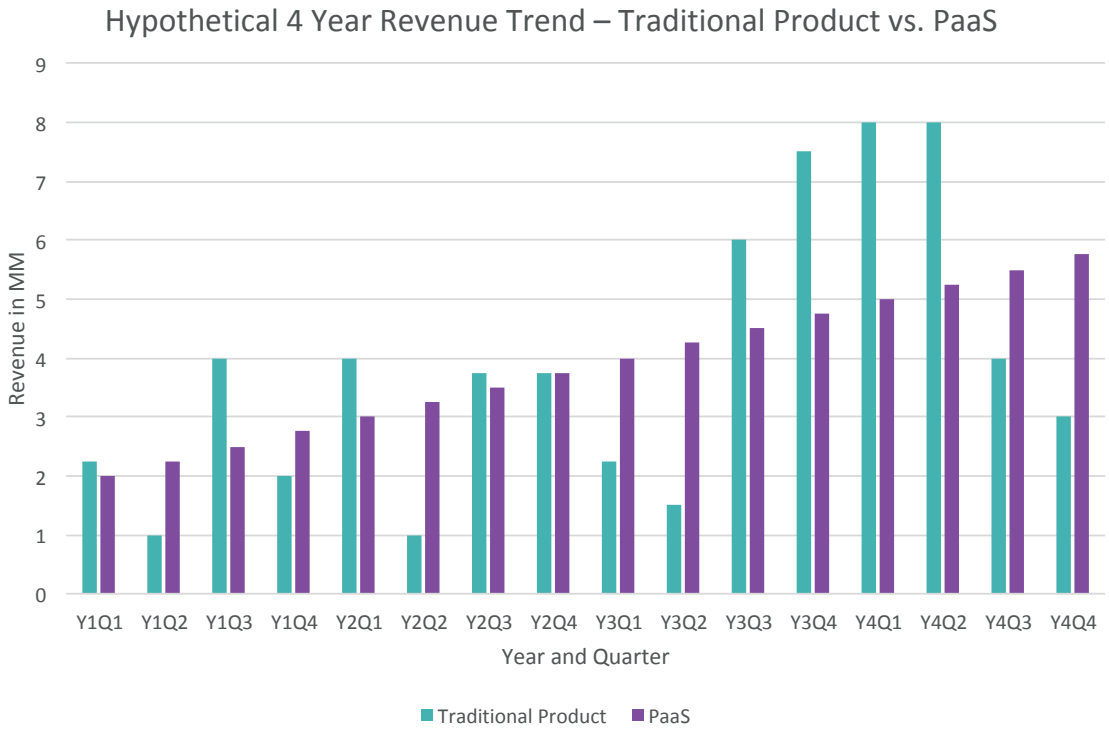
Why would someone lease a car instead? One benefit of leasing is that you don't have to put up as much money up-front; instead, you agree to make small, monthly payments. Of course, the trade-off is that at the end of the lease (which often coincides with the warranty period), you don't own the car, so you sign up for another lease on a new car which, in the long run, costs more money. On the positive side, the newly leased car will have the bells and whistles that everyone is excited about and it won't suffer the woes of elderly vehicles. Leasing a car costs more money but delivers more value to the customer.

One way in which the PaaS model differs from a car lease is that someone who leases a car is still responsible for the service and maintenance of the vehicle. Although the warranty will cover some of these expenses, routine maintenance like oil changes, fluids, and air filters are the customer's responsibility. As we'll see, that's not the case for PaaS.

BENEFITS FOR PAAS PROVIDERS

You design a product. You build it, sell it, and you've made your money. Now what? Obviously, you make and sell more of them. But do you know how the product is being utilized? Is it being operated and maintained correctly? Are customers using it in applications for which it was never intended? Have they found shortcomings? How would you know? Some companies may send out surveys asking customers some of these questions, but they can only expect a ten percent return rate filled with answers that are highly subjective.

Engineering.com spoke with industry veteran Marc Lind, senior vice president of Strategy at Aras, who told us that the existing manufacturing model is becoming obsolete. "Selling an asset, 'one and done', is increasingly not the way to ensure long-term profitability—I have to keep pumping out more units and selling them in order to make revenue. This is not a particularly predictable revenue model. Whereas with selling a subscription, now I have a backlog of revenue that I can count on coming my way and I can look for opportunities through the use of data analytics to enhance the value my customer receives and provide additive revenue for myself."



PaaS helps the revenue stream grow.

Oleg Shilovitsky, CEO and founder of OpenBOM, elaborated on increasing the value to the customers through IoT. "If I have any kind of equipment running in the field, I can get additional information about how this equipment is performing and based on this information I can improve quality of the product, the service, and the user experience."

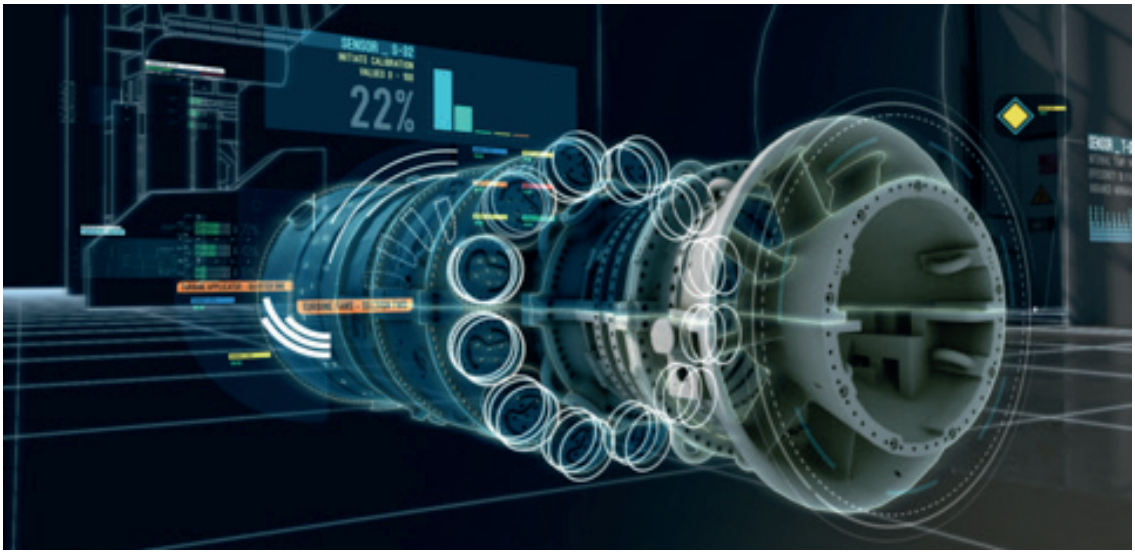
BENEFITS FOR CUSTOMERS

If customers are going to buy into the PaaS model, they'll need compelling reasons to do so, as it could cost more money in the long run. By enhancing the customer experience, PaaS becomes an investment rather than an additional expenditure.

Since the IoT capabilities inherent in PaaS provide measurement, communication and data analytics, PaaS providers can monitor a product's performance in the field, convert costly scheduled maintenance into lean "just-in-time" field servicing, and reduce a customer's risk by guaranteeing uptime for the product.

Performance Monitoring and Improvement

What can a jet engine manufacturer provide for airline companies? Propulsion, obviously, but why stop there? If the engine is outfitted with—you guessed it—multiple sensors, engineers can learn more about how the engine is performing in the field. By comparing actual performance with digital twin models developed by the designers, engine manufacturers can help its customers save money through optimization.



Digital twin. (Image courtesy of newsandpr.com.)

Lind explained "One of the strongest value propositions for a PaaS business model is not just the change in the financial relationship between the seller and buyer or user, it's the company offering the ability to provide new levels of optimization or savings in other areas of the operation. Examples of this include Rolls Royce, Pratt and Whitney, and GE providing jet engines. They're not just selling power by the hour—they're taking that data and then providing feedback to the airline to help them optimize fuel consumption. The airline customer has more efficient and cost-effective operations. That goes straight to the bottom line: the value proposition of the aircraft engine manufacturers is not just 'you don't have to buy and maintain the engine yourself,' but 'we'll take care of that for you and we'll help you make your operations more efficient.'"

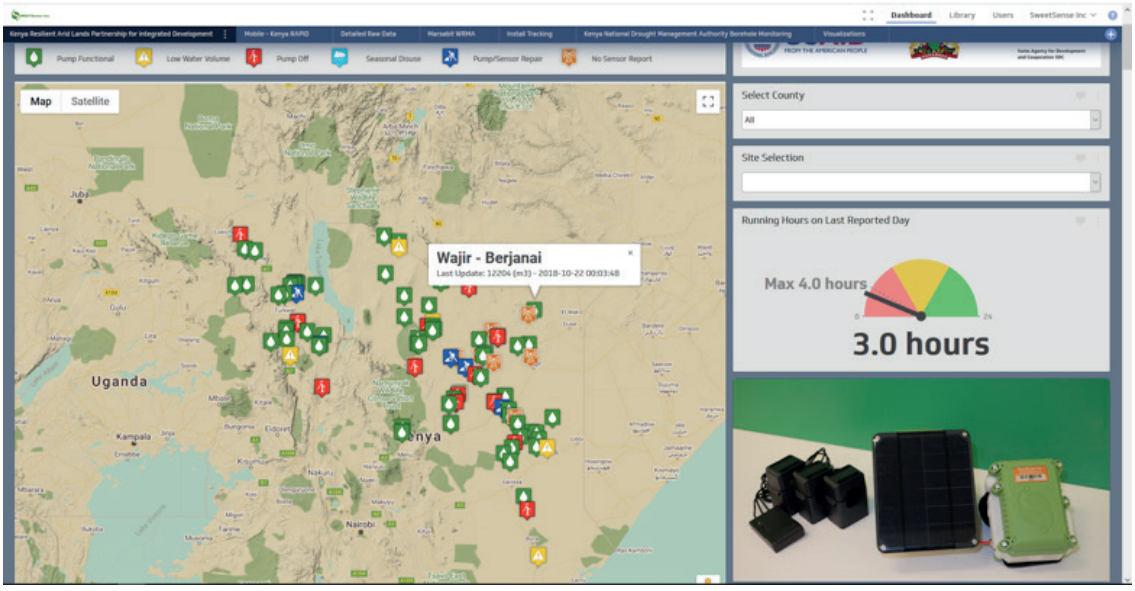
More Business, Less Risk, Smarter Investments

Renfe dramatically increased its market share through its timetable guarantee and offloaded the risk by purchasing a product, in this case a train, as a service. The rail operator also shifted capital expenses (trains and infrastructure) to operating expenses (its service contract with the PaaS provider). The deal allows Renfe to concentrate on its core business—passenger service—while outsourcing the engineering aspect to the experts.

While avoiding the capital expense by purchasing a service rather than a product, there's still a trade-off involved: more money is spent in the long run. The key is getting more value from the service than you would have from just the product. Lind tOLD us, "It's very easy to just say CapEx [capital expenditure] to OpEx [operating expenditure], however, that's an accounting way of thinking. The context and nature of one's business model itself fundamentally changes. As the company that's buying this product as a service, do I believe that I'm going to be able to deliver new value or derive new value, which will enhance my revenues?" Renfe increased its market share through PaaS, so the increased revenue more than made up for the added expense.

Remote Monitoring and Smart Connectivity

Companies that deliver a product as a service can, through IoT technology, monitor the product in the field to see how it's performing and how customers are employing it, which gives insight into potential quality issues, design modifications, and feature enhancements. "Remote monitoring has been around in some industries for a long time, but now it's becoming ubiquitous," said industry consultant Peter Bilello, President of CIMdata, Inc. "Today, it's in so many different products, so the ability to understand what's going on and better manage the product has increased significantly. It's much easier to do it today."



A dashboard shows water pump status. (Image courtesy of SweetSense.)

Predictive Maintenance

In the beginning, there was reactive maintenance, also known as “when it breaks, fix it.”

Then came preventative maintenance, or “replace parts at scheduled intervals, before they break.”

Reactive maintenance results in unplanned, and often costly, downtime, and preventative maintenance is based on statistics; something could fail prematurely and still result in downtime, or a healthy component could be replaced needlessly. IoT gives us a better option: predictive maintenance. By monitoring the behavior of the machine itself, we can more accurately predict when a component failure is imminent and call for repairs just in time.

Mimran explained how Ham-Let uses predictive maintenance to “listen” to the health of one of its valves: “We collect the data and with machine learning, correlate it to the actual health of the valve. The main value of such a system is to provide very accurate real-time data (such as response time) and predictive maintenance that allows you to know when you need to replace the valves. And if there’s a safety issue coming because something bad happened in the system, the valve tells you that something in the system behavior is abnormal.”

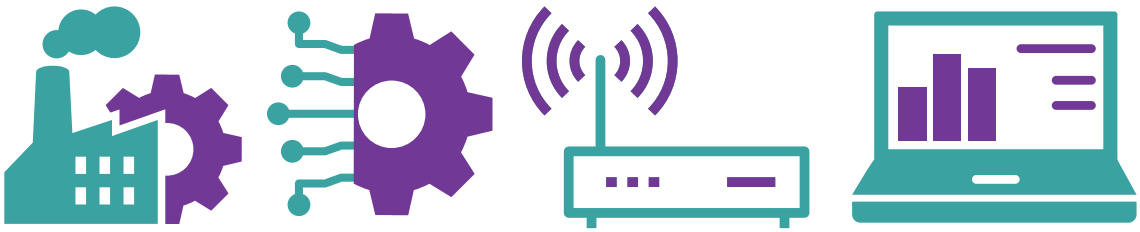
PaaS enables predictive maintenance.

PAAS CHALLENGES

Converting a product to a service can be a daunting challenge. The good news is that it's not an abrupt step; it can be a gradual evolution. PaaS may be new to you but it's also new to your customers, so you can build services and tailor them to the customer's exact needs with both the provider and the clients growing into the new business model together. Based on our conversations with the experts, we've come up with a list of common challenges and ways in which you can address those issues.

CHANGING BUSINESS MODELS

Converting a product to a service isn't as simple as saying, "Hey, how about renting our product instead of buying it?" There has to be an additional value to the customer. This has significant implications for the provider. Lind told us, "The ability to receive new levels of information from the utilization of the product or asset enables companies to not just provide the base capability, but increasingly companies are able to deliver new forms of value to the client, which will differentiate their product or offering from others in that field."



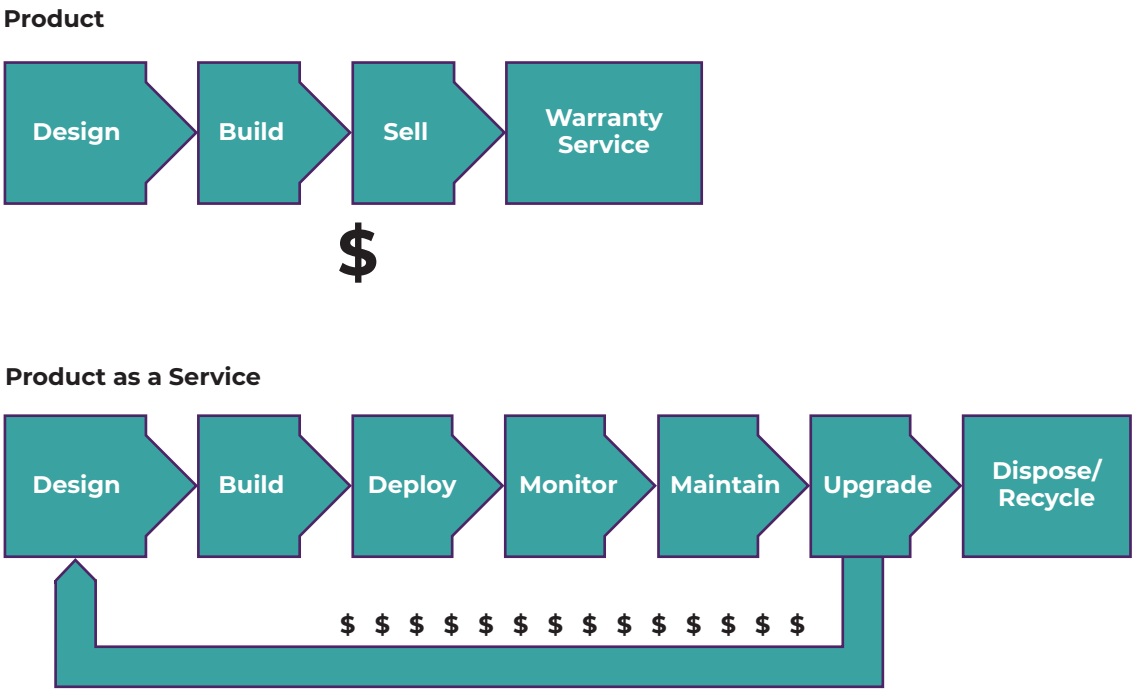
Services add value to products.

CUSTOMER NEEDS

How do you build a new business model and monetize it? How do you know how much the customers will pay? You can start by offering a service along with the product, such as connecting and monitoring the product. Use that data to gain insight on efficiency, predictive maintenance, etc. Then you can build digital services on top of that—services that will enhance the customer experience.

PRODUCT DESIGN/LIFECYCLE MANAGEMENT

A manufacturer builds and sells a product. What happens after the warranty expires? From the manufacturer's standpoint, that's known as SEP, or somebody else's problem. That's not the case in the PaaS model, as Peter Bilello explained "PaaS changes the way companies design their products to some extent. For example, how they manage the product, how they deal with maintenance. If they're maintaining it versus someone else, they'd probably have a different set of key characteristics that they're looking for. For example, when the automobile industry changed the way they were looking at warranty, from a 30,000-mile to a 100,000-mile warranty, they had to design cars differently. They had to install mufflers that don't fall apart in 30,000 miles, 50,000 miles. They were no longer going to make you replace your spark plug every 30,000 miles. It just didn't make economic sense."

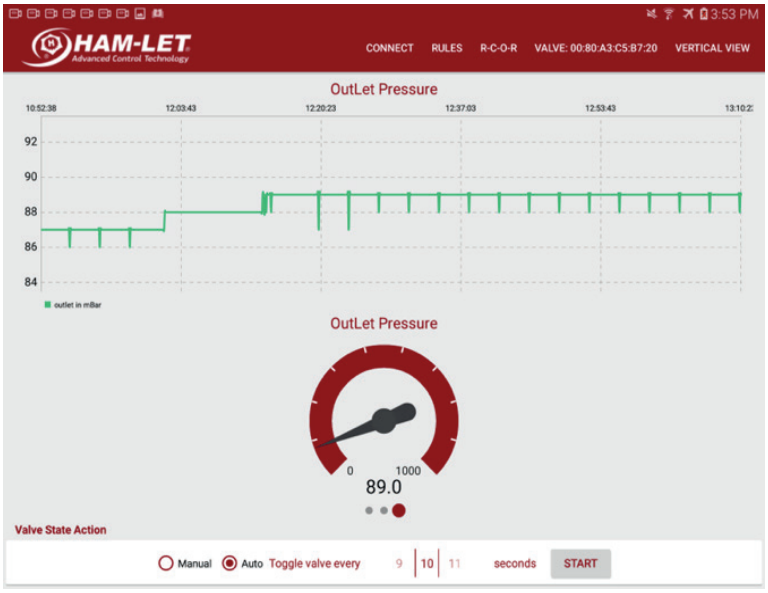


PaaS changes product lifecycle management.

Lind gave another view on product life-cycle management, including the revenue aspect. "In the old way of manufacturing, I design and build a product and then I sell it. Once sold, I don't have any responsibility for it, and I've made my money. This [PaaS] is different for me as a manufacturer not starting to make any money until the product is actually being used in the field. And that has profound design implications for design, manufacturing, and build relative to the ongoing operation of that asset and its serviceability. As a manufacturer in a PaaS model, I now need to 'own the lifecycle'. We would talk about this at Aras as the 'digital thread,' or the necessity for the digital thread, having that traceability back from operations in the field, to understand not just the design intent, but also the closed-loop ability to improve the product, so you can enhance your profitability during that later stage of operations, which is where you actually make your money."

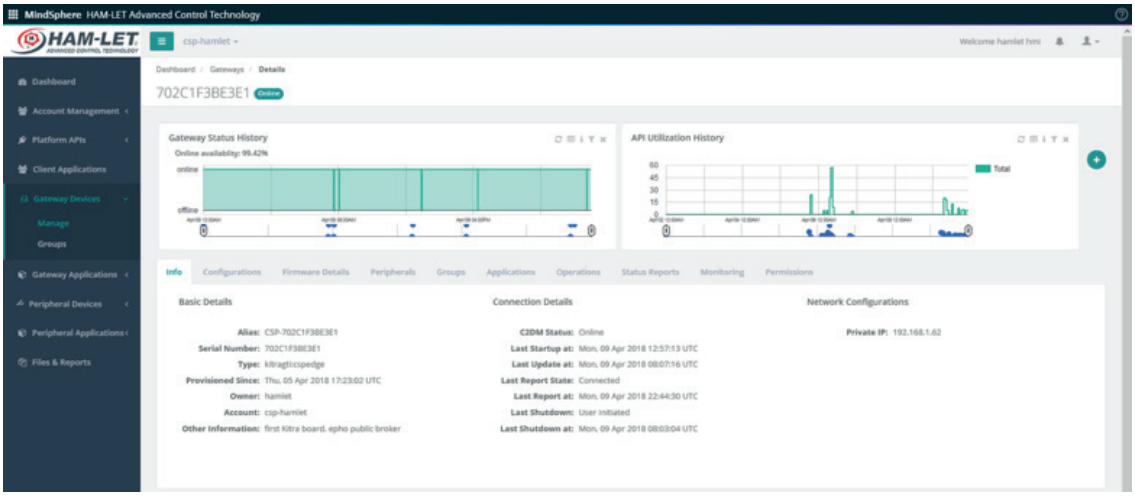
DATA ANALYTICS AND SECURITY

Most of the added value in a PaaS involves information, from basic predictive maintenance all the way to advanced efficiency recommendations. With millions of data points available, effectively processing, storing, communicating, and securing the data is no easy task. Fortunately, all PaaS platforms have built-in applications that are virtually plug-and-play, allowing PaaS providers to customize the handling of data.



Dashboard showing valve pressure. (Image courtesy of Ham-Let.)

To reduce bandwidth, the bulk of the data processing is handled at the edge, using the sensor's built-in embedded controller or an industrial computer (the "gateway") at the facility. Brief snapshots showing the big picture can be sent to the cloud for further analysis, but the more data that's processed locally, the better.

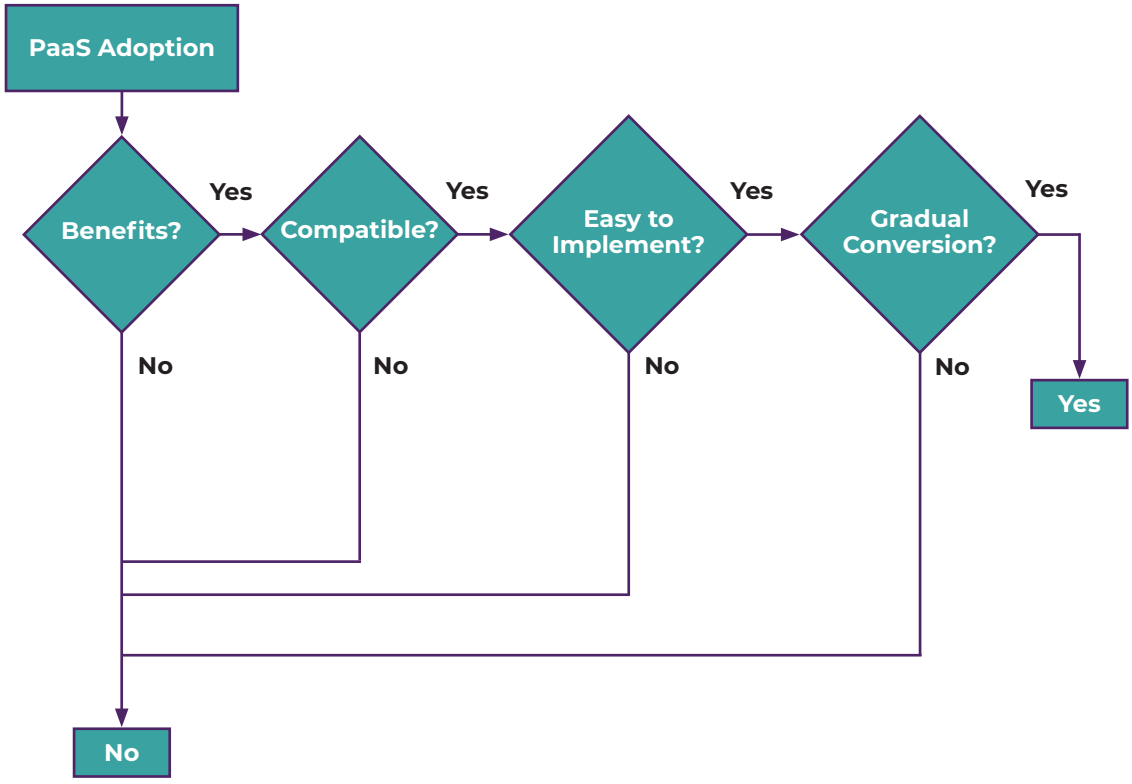


Dashboard showing cloud-based activity. (Image courtesy of Ham-Let.)

RESISTANCE TO CHANGE

As we saw in the Ham-Let case, the company is moving toward PaaS. Customer acceptance of PaaS is another matter. In order for customers to adopt an innovation, several factors must be addressed. First, and most obvious, they need to see the relative advantage of adopting it. Why is it better to buy into a service agreement when I could just purchase the product? Providers need to make it very clear that the service adds value to the product and that it can increase the customer's bottom line.

Next, businesses most find the innovation to be compatible with their needs, values, and past experiences. Smaller businesses tend to have less reluctance to change, since they don't have deeply established infrastructures. Larger companies often find it difficult to make drastic changes. Even Siemens, a PaaS platform provider, found that its manufacturing and information technology groups weren't quick to embrace the PaaS model. Brenda Discher, Senior VP of Business Strategy and Marketing, "explained "Larger enterprises, because they already have existing systems and existing processes, are struggling a little bit more. They also have a culture shift they need to make. This is even true inside the walls of Siemens, where we've been doing things a certain way with a very, very standardized process. SaaS (software-as-a-service) and PaaS allow you to rethink the way you do things and enable access to information and data in ways that I think people have become really quite surprised and shocked at how quickly data can be shared, consumed, and distributed instantaneously to people anywhere, any place, any time."



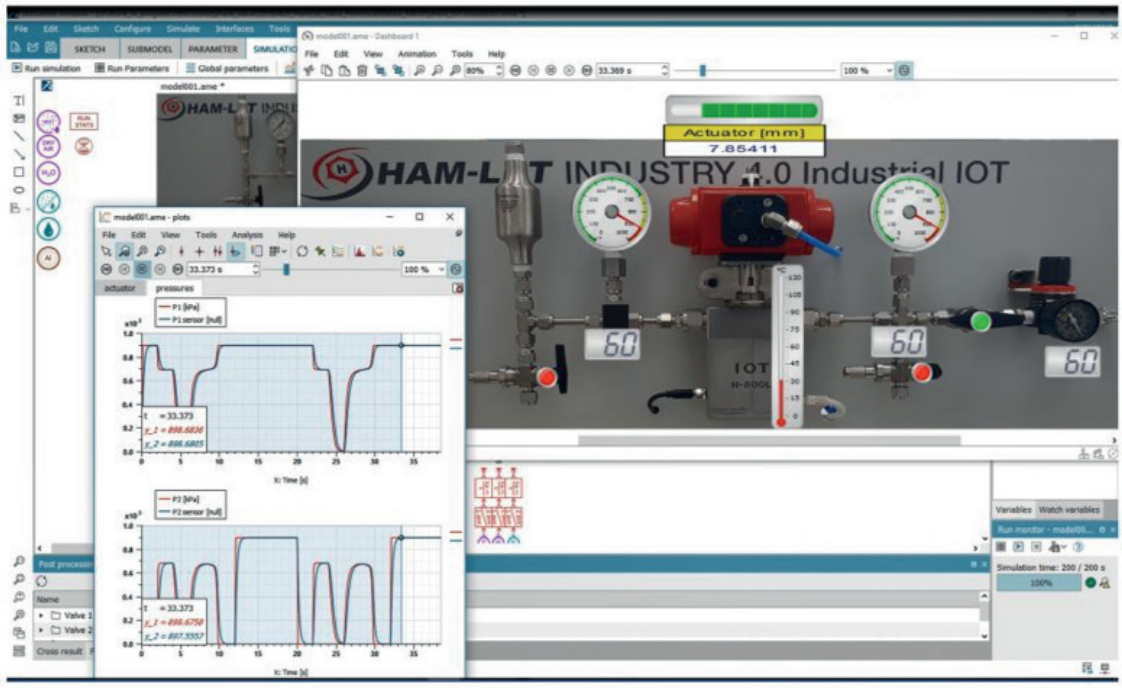
Innovation adoption flowchart for PaaS.

Let's say a business sees the relative advantage of PaaS and it's compatible with their needs. The next question they'll ask is, "How difficult is it to implement PaaS?" A manufacturer converting its product to a service would be wise to work with a PaaS platform provider, allowing the producer to focus on its core strength—the product itself—without massive investments in infrastructure and PaaS expertise.

Innovations are more likely to be adopted in stages rather than a whole. Ham-Let is offering three valves as services, even though their catalog includes thousands of products. On the customer side, they're gradually adding features, such as remote monitoring, to products in order to allow their customers to sample the services.

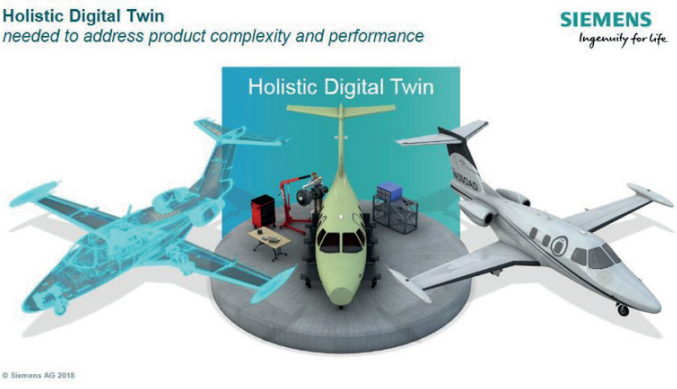
PAAS PLATFORM FEATURES

Whether they're home-grown or off-the-shelf, PaaS platforms all provide a common set of tools. At the most basic level, a product will include sensors and IoT technology, allowing it to be remotely monitored on a dashboard. Most platforms allow the manufacturer/provider to customize the dashboard using a drag-and-drop interface that requires no coding skills. Off-the-shelf apps, either built into the platform or developed by third parties as add-ons, provide data analysis capabilities.



Custom dashboard. (Image courtesy of Ham-Let.)

Moving up the scale, machine learning algorithms offer more in-depth data interpretation, often providing customers and manufacturers with insights about the product's use, performance, and environmental conditions. This can lead to design and implementation changes that increase efficiency and reduce costs.



Digital Twin. (Image courtesy of Siemens.

New product developers can take advantage of the digital twin, a modeling and simulation system that lets engineers compare a product's actual performance with its design specifications. In-situ measurements can lead to better software models of the product, which improves product design in a highly iterative process.

SUMMARY

Product as a Service (PaaS) is a business model that allows a customer to pay for a desired result rather than purchasing the equipment that delivers the result. PaaS offers benefits to both the customer and the provider by freeing the customer from having to purchase, operate, and maintain machinery, while producing a consistent revenue stream for the service provider.

Examples of products as services, which shift the risk of performance from the customer to the manufacturer, include jet engines, robots, compressed air, valves, water pumps, smart lighting systems—and even passenger trains.

The Internet of Things (IoT) enables PaaS, thanks to low-cost sensors, powerful embedded controllers, and wireless communication. In addition to remote monitoring of equipment, PaaS provides edge computing and cloud-based computing that perform data analysis, which facilitates predictive maintenance, reduces machine downtime, and optimizes productivity.

Machine learning algorithms give a more in-depth data interpretation, often providing clients and manufacturers with insights about the product's use, performance, and environmental conditions. This can lead to design and implementation changes that increase efficiency and reduce costs, delivering additional value to the customers and the providers.

PaaS platforms include off-the-shelf and customized applications so PaaS providers don't need to build everything from scratch. In many cases, providers can convert their product to a service in just a few months with no investment in infrastructure and minimal risk. Custom dashboards are created with a drag-and-drop interface that requires no coding skills, allowing engineers to easily monitor equipment in the field through secure internet channels using any connected device.

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