PTC Live 2015: Bridging the Physical and Digital Worlds

By Bill McBeath

At their annual conference, PTC showed how it is making big strides to their ultimate vision of smart connected products and the end-to-end product lifecycle systems that make that vision possible.

Getting to 100% Digital … for Manufacturers

Our research[1] has shown that progressive companies are striving to get to '100% digital,' getting rid of all paper and manual re-entry of data, so that all document flows and workflows are 100% digital end-to-end. But what does '100% digital' mean for a company that manufactures things, since their products are by nature *physical* (even if they have embedded processors and software in them). This is where the uniting of the physical and digital realms becomes key. That concept was a central theme of PTC Live 2015.

Bridging the Physical and Digital Worlds

Jim Heppelmann, PTC's CEO, opened up the conference with an illuminating keynote address on "*Bridging the Physical and Digital Worlds*." He talked about how almost all manufactured items start out being designed in the form of digital 3D models filled with valuable descriptive information related to form, function, and process information about how to manufacture it. However, once the physical product is built, shipped, and out in the world there is (for pre-IoT[2] products) little or no visibility into what the product is doing until your customer calls to tell you something is wrong or broken. There is no feedback loop … until we add sensors, intelligence, and connectivity; in other words IoT capabilities. Now the product is both physical and digital in nature, married together, and PTC has fully moved to support this new way of doing things.[3]

[1] In *The Rise of the Agile Networked Platform*, we look at what it takes to get to a 100% Digital network with suppliers. For another perspective, see "*Towards the 100% Digital Enterprise.*"

[2] IoT = Internet-of-Things

[3] See Alive at LiveWorx 2015 for a summary and analysis of PTC's IoT Conference, LiveWorx

Dashboards, Twins, and Augmented Reality—Digitally Representing Physical Reality in Real-time

This feedback loop—the product providing continuous information about what is going on out in the field—changes everything and provides an opportunity for companies to completely rethink not just their CAD and PLM system, but customer service, new business models and offerings, and the core of what it is they do (for more on how companies think through this transformation, see *The IoT Impact*). PTC has recently taken this physical-digital connection one step further by providing the concepts of Product Dashboards, Digital Twins, and Augmented Reality. Information from sensors on a physical product becomes tightly coupled with the digital model of that product (based on the 3D CAD model and other digital information representing that product). Each physical product has a digital representation of it that goes *way* beyond static information such as its serial number and 'as-serviced BOM.' It can now capture moment-by-moment how the product is being used, where it is at each moment, the stresses and forces on it, the temperature—anything that the manufacturer deems worth instrumenting on the product.

Remote Monitoring Dashboard

To demonstrate the concept, a Santa Cruz mountain bike was brought on stage during the keynote address. It had been retrofitted with about $150 of off-the-shelf components including a battery, Raspberry Pi processor, and sensors for the speed of each wheel, the rider's pedal cadence, compression of the suspension, and the angle of the steerer tube.[4] The data from these sensors was sent in real-time over the cloud and superimposed on a 3D digital rendering of the bicycle (which had been completely modeled in CREO), so that as it was being ridden, there were gauges showing the readings of the various sensors, such as the RPM of the wheels or the amount of compression on the forks. There was also a very simple real-time calculation done to compare the front and back wheel RPM—when they were different beyond a certain threshold, a yellow "skid slip" indicator icon appeared. This bike (or a fleet of bikes, each with its own corresponding individual representation dashboard) could now be monitored from thousands of miles away.

[4] The steerer tube is the top part of the bicycle fork which connects to the handlebar at the top and the wheels at the bottom.

Figure 1 – Remote Monitoring Dashboard Demo at PTC Live

The Digital Twin

Taking it one step further, the information can be fed into a model to create the 'digital twin'—an exact digital representation of each unique physical bike. The digital twin on the screen shows the wheels spinning, the angle of the front wheel changing, the suspension going up and down, as the bike is being ridden, so that the digital twin is exactly mimicking what is happening in the physical world. The digital twin displayed in the demo also showed reaction forces, using CREO Simulate, which took the front and rear fork displacements and showed the amount of force using big red arrows.

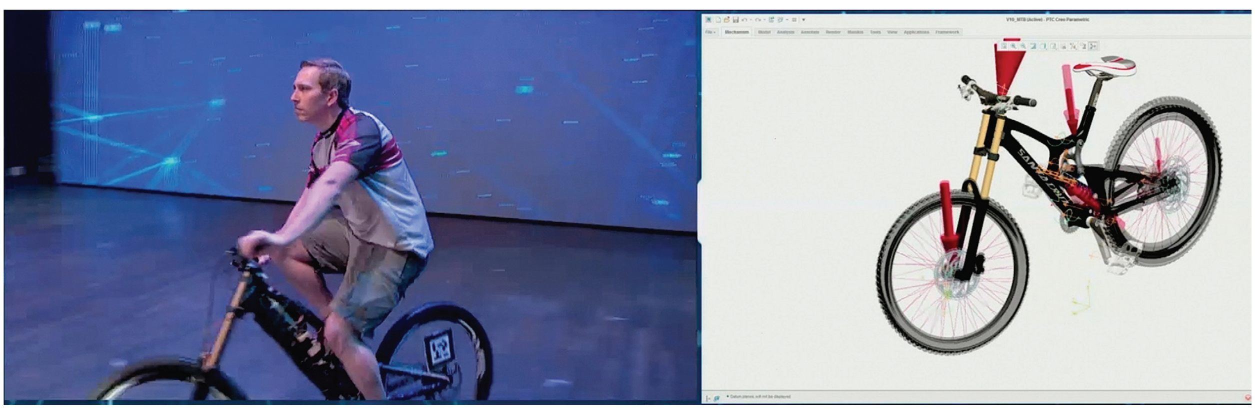

Figure 2 – Digital Twin Demo at PTC Live

These real-time readings can be stored as a continuous historical data stream about exactly what was happening with the product. This data can be played back within CREO using the original design to understand and visualize the movements and use CREO to provide insights into the forces on the bike. The dashboard and digital twin are powerful concepts with many implications and potential uses:

- **Real-time Monitoring and Alerts**—End customers, third-party service providers, the manufacturer, and any other interested and authorized party could monitor actual usage and be alerted as soon as something needs attention. Combined with analytics, this could include predictive maintenance and actual equipment failure alerts, security and safety alerts (potential theft or accident happening), ‘running late/behind schedule’ alerts for vehicles and processes, patient condition alerts (e.g. fall, heart attack, blood sugar, etc.) … the possibilities are only limited by the imagination.

- **Failure Analysis**—The historical data is powerful. Each time a failure happens, the prior history before the failure could be analyzed and played back to determine what factors led to the failure. This analysis could be done across all failures to determine most common causes and zero in on various ways to prevent future failures, such as design changes, better education for users on proper usage, possibly designing different models for different environments and use-cases, and so forth. Liability could be assigned if abusive practices[5] are objectively recorded.
- **Fleet-wide Analytics**—Things become really interesting when data across the whole fleet out in the field is combined and analyzed. Trends and outliers can be identified. For example in a fleet of trucks, you could identify over and underperforming vehicles and drivers. Top drivers could not only be rewarded, but interviewed and their best practices propagated to the rest of the drivers. Poorly performing drivers can be coached to improve safety, fuel economy, and efficiency. Poorly performing equipment can be identified, even in the absence of predictive maintenance indicators, just by virtue of benchmarking it against the rest of the fleet and then the problem could be diagnosed and fixed. As a result, the performance of the entire fleet could be improved.

Augmented Reality

In the final part of the mountain bike demo, an iPad was used to capture the serial number on the bike and thereby identifying which specific bike it was. Then the iPad’s camera was used to view the bike as the rear wheel was spun and various forces put on it with the readings from the sensors super-imposed on the bicycle image in the iPad in real time.[6] This leveraged the CREO model and a complete ‘digital understanding’ of the bike to gauge the reaction forces and superimpose them at the correct places on the image of the bike.

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[5] Such as lack of maintenance or usage outside of spec (too fast, too hot/cold, too much load, etc.)

[6] Here is a short video showing the bike and augmented reality view on iPad.

Figure 3 – Augmented Reality: Mountain Bike with Real-time Sensor Readings Superimposed
(on iPad Screen at Right)

To show how this might play out with more real-world examples, a video was shown of a big Generac backup generator, located at PTC's headquarters, on which was superimposed an 'X-ray vision' view of the actual generator inside, with various conditions, alerts, and predictive maintenance information that might be useful to a service technician, to give them rich information without even having to open up the unit.

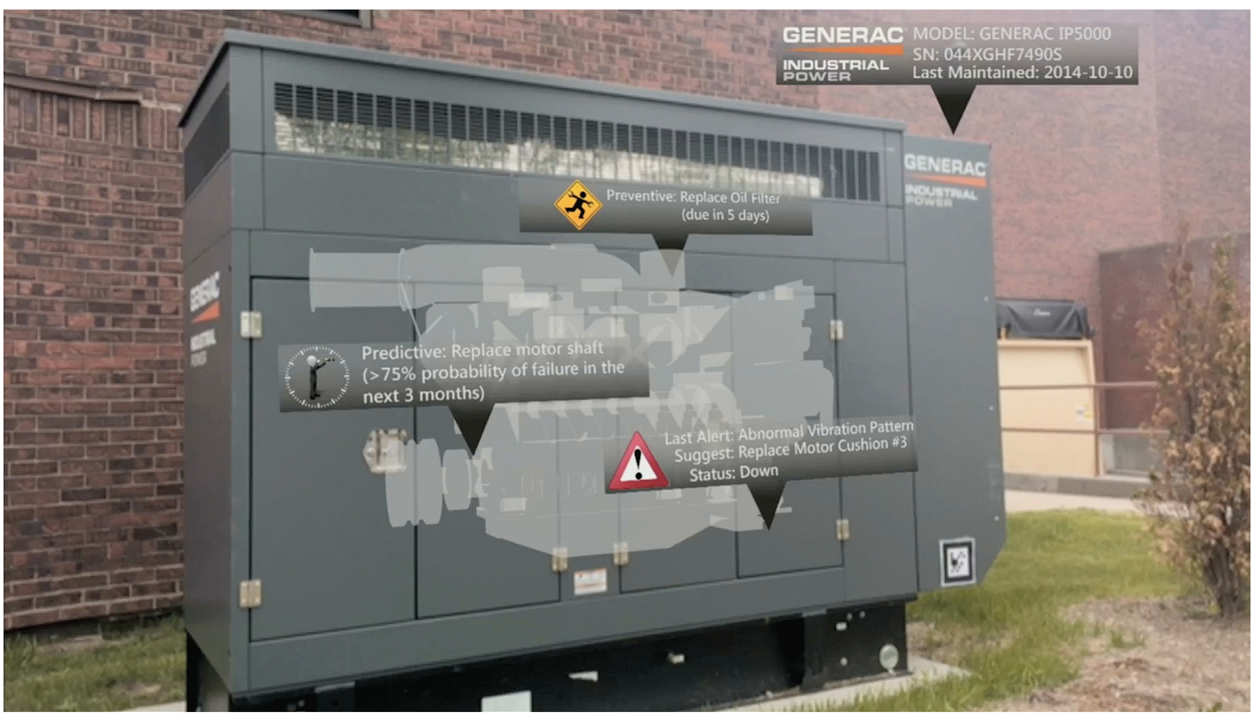

Figure 4 – Augmented Reality Example: Service Information and See-Through View of Generator

Finally, a video was shown of a Bobcat front-end loader that needed repair to its hydraulic system, using CREO Illustrator to superimpose real-time visual instructions showing exactly how to disassemble it.[7] Making this kind of documentation available in the field to service technicians is invaluable. It doesn't require any translation into other languages and is *much* easier to create and to understand than written documentation.

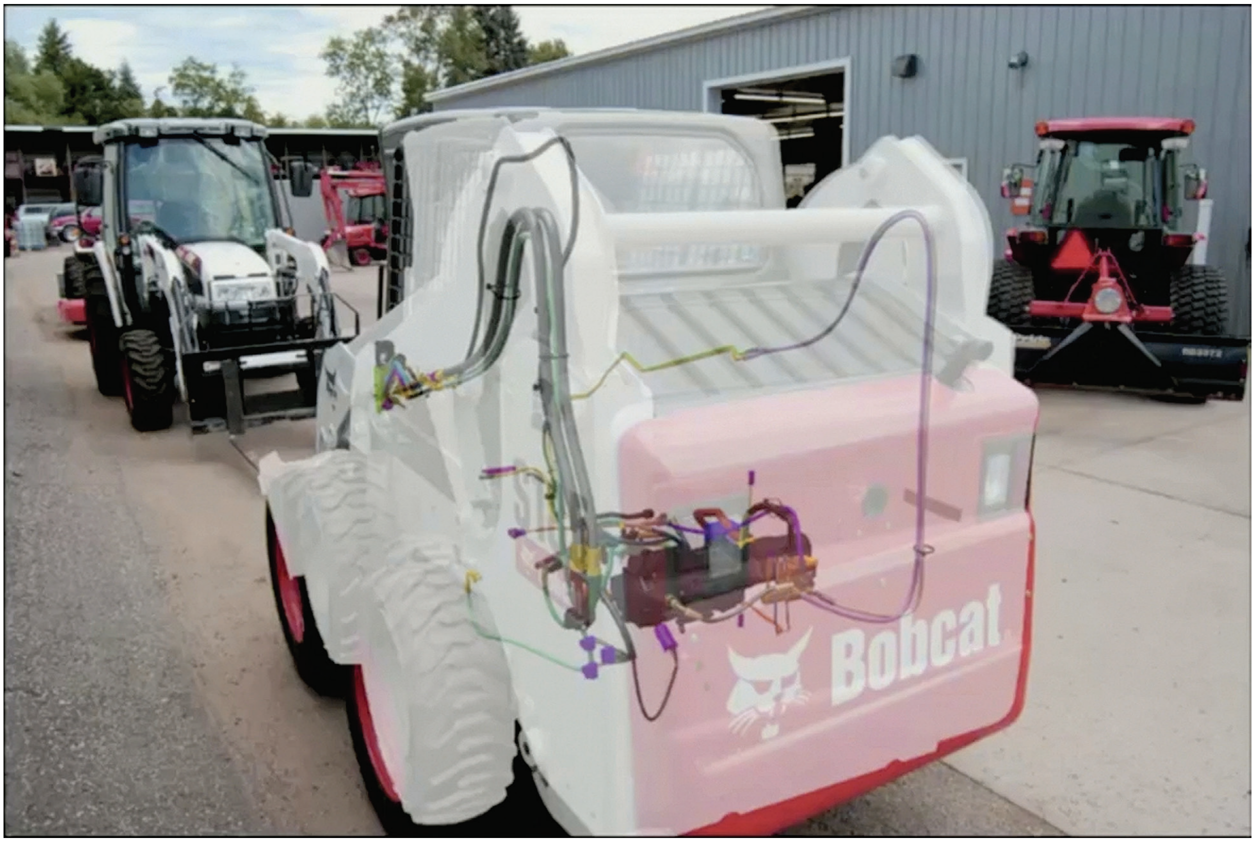

Figure 5 – Hydraulic System Superimposed on Bobcat for Real-time Visual Repair Illustration

Retrofitting Existing Products

An important point from the bike demonstration was that manufacturers, service providers, and equipment owners do not have to wait for some future generation of IoT-enabled products. Existing equipment in the field can be retrofitted with the requisite sensors, processors, and communications equipment and IoT applications can be created using that data right now. This is especially relevant to long-life, high-value assets, such as large vehicles and vessels, heavy machinery, and large fixed plants (manufacturing, office buildings, oil rigs, etc.).

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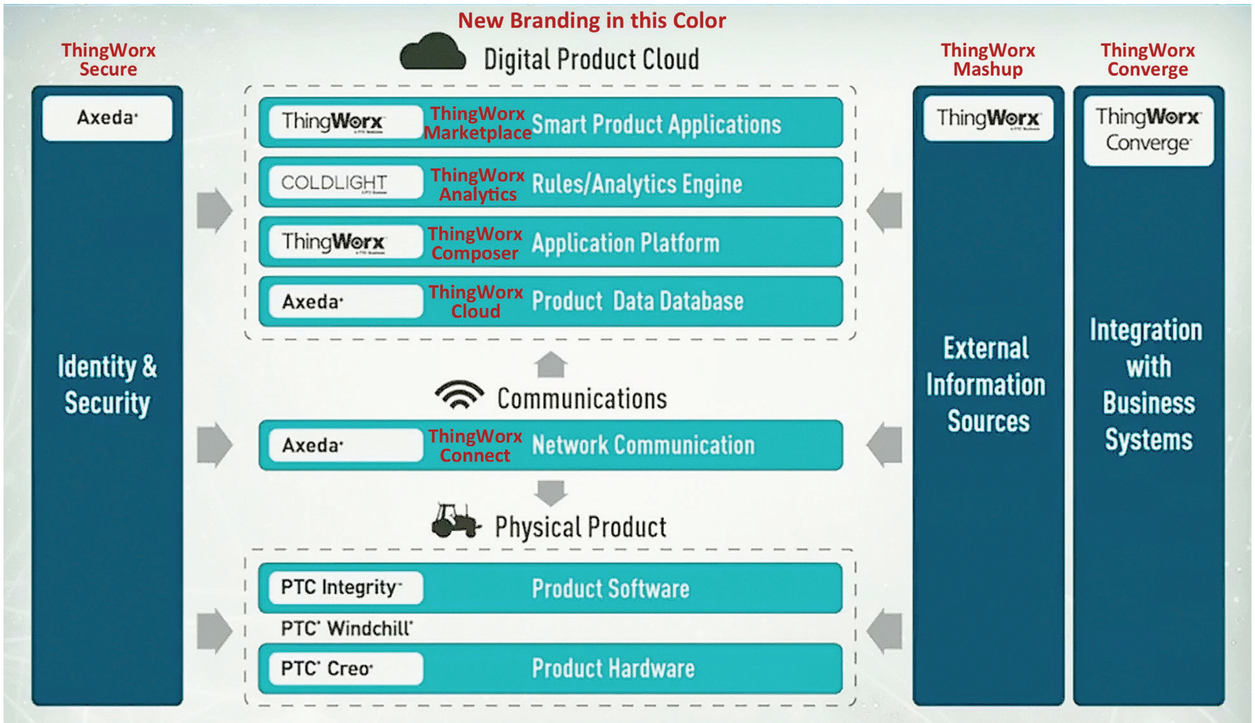
[7] Similar to the clip we showed here under '*Digitization of Manufacturing*,' in the article *PTC's Journey From CAD/CAM Pioneer to Enabler of the 'as-a-Service Economy*,' except that this one was superimposed on a live view of the Bobcat.

PTC Investing Heavily in IoT

One striking statistic brought up was that PTC has spent over $500M of dollars in acquisitions and R&D over the past 18 months, including acquiring ThingWorx (IoT development platform), Axeda (device connectivity cloud), and ColdLight (automated predictive analytics based on IoT data streams and other data). Heppelmann announced the rebranding of these IoT components to be all under the ThingWorx moniker.



Source: PTC (modified by ChainLink. overlaying new brand names)

Figure 6 – PTC Solution Stack with Rebranding of IoT components to ThingWorx brand

The Whole Portfolio

When these IoT capabilities are combined with PTC's existing enterprise products, it represents a very complete set of capabilities to support this new way of doing things throughout the lifecycle, starting with the requirements management, moving into 3D models and digital prototypes, through to testing, manufacturing, and service in the field. At its core, PTC serves companies that make physical products (which today almost always have a large set of software components too). Manufacturers are facing the challenges of ever-increasing product complexity, multiplied now by the need for software, cloud, IoT, and service components, as well as by increasing requirements such as regulatory constraints, new materials, and integration into larger systems such as smart cities, potentially involving many partners.

Meeting these challenges was the theme of the second part of the keynote address, delivered by PTC's senior executives.[8]

End-to-End Traceability and Coherence of Data

A cornerstone of how PTC helps its customers meet the challenges of defining, designing, and developing complex products is by bridging customer requirements to the functional design at successive levels of details, modeling the interactions of systems with each other and with the users and environment, and maintaining a traceable map of the connections from requirements through the design through to the actual tests. This means that at any point, including planning and actual execution of the tests and back into the engineering change process, everything is connected and can be traced; flowing from requirements, through systems modeling and verification and validation. This is needed to support the Digital Twin concept—combining the IoT/smart connected product capabilities connected back to the data and context provided by CAD, PLM, ALM, and SLM systems in a completely consistent way. It also requires the ability to pull data from other systems such as ERP, supply chain, and external systems.

Enterprise BOM Management

A further key element to realizing the digital twin vision is effective management of the enterprise BOM throughout the product lifecycle. Many companies don't have a single source of truth for product information, but rather have silos of information with brittle connections, preventing the creation of a true digital twin. PTC's PLM system, Windchill, provides the single source of truth with a robust, connected change management process, that can track and manage the eBOM (engineering bill-of-materials), mBOM (manufacturing BOM), as well as sBOM (as-serviced BOMs for each instance out in the field). This is critical in order for the digital twin to be an accurate and up-to-date representation of the actual physical product out in the field.

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[8] Brian Shepherd (EVP Enterprise Segments), Rob Gremley (EVP Technology Platforms), and Mike Campbell (EVP CAD segment)

Establishing a Model-Based Enterprise

PTC brings all these pieces together—the interconnected BOMs with 3D models. On top of this, they provide extensive tools to annotate and capture critical information in the 3D model, such as documenting assembly level information (for example how tightly to torque bolts that hold a pump to its housing). CREO can validate that all of the required annotation has been created, so users have consistent information available downstream—for example the proper torque and other key repair parameters will consistently be there for technicians to view in the repair animation.

Executing the Vision

Jim Heppelmann and the PTC team have articulated a cohesive and compelling vision for manufacturers. At PTC Live, with the impressive progression of acquisitions and the progress made on integrating all the pieces together, we see remarkable progress towards the fulfillment of that vision. I expect more exciting developments from PTC in the future as they make more and more of this vision a reality for more and more of their customers—who in turn are creating increasingly innovative new services and products that are actually transforming the world we live in before our eyes.

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