OPTIMAL
Manufacturing Intelligence

Listening To the Voice of Your Product

White paper

LISTENING TO THE VOICE OF YOUR PRODUCT

Much has been said and written about the business values of the Industrial Internet of Things (IIoT). Through connecting the manufacturing elements (machines) on the factory floor, and collecting and analyzing their data, , manufacturers can significantly improve the efficiency and profitability of their operations through intelligent predictive maintenance of equipment and optimal equipment utilization. These aspects of the IIoT can be viewed as listening to the voice of the machine.

As valuable as listening to the voice of the machine is, it enables only a fraction of the full potential of the IIoT. A manufacturing environment can be utilized optimally and its machines maintained when and as needed, but products coming out of it may still have serious quality issues; just consider the recent recalls of smartphones and cars, and the severe financial reprecussions and reputation damages they inflicted on their brand owners.

Therefore, in order to harness the full value of the IIoT, both for OEMs/brand owners and for manufacturers, it is critical to perform product analytics and not just process analytics. Listening to the voice of the product improves profitability as well as revenue; boosts operational efficiency and reduces product cost; and augments performance, quality, and brand protection. The voice of the product represents the next level in achieving the promise of the IIoT.

Product Analytics vs. Process Analytics

The most basic elements of all electronic systems, from phones to cars and from servers to industrial robots, are semiconductor chips. We can therefore look at chips to illustrate the differences between process and product analytics, or the differences between the voice of the machine and the voice of the product.

One of the main pieces of equipment in manufacturing a chip is a stepper. A typical IIoT implementation in a chip factory (known as a foundry) will ensure steppers are properly maintained and optimally utilized. But a specific stepper in a specific foundry may be used in the manufacturing of many different chips from different customers. Those can vary from application processors for smartphones to communications chips for routers to graphics processors for PCs or cars. No analytics of the stepper itself, or of any other equipment used in the manufacturing and testing of chips, can guarantee the quality of each application processor, the performance of each communications chip, or the yield, and hence cost, of each graphics processor.

Product analytics on the other hand, when done properly, can guarantee all these and much more. Here are some examples:

- **Product analytics of a chip check "is a chip tested as good really good"?**
  By performing this product analytics procedure, you can identify test escapes, prevent chips that are not really good from shipping, and thus improve quality and reliability, reduce customer returns and associated costs, and improve brand reputation.
- **Product analytics of a chip check "is a chip tested as bad really bad"?**
  Performing this analysis enables the identification of false test results (e.g. due to a tester issue), prevents good chips from being scrapped, and thus improves yield and product cost.
- **Product analytics of a chip know that there may be grades of "good" and "bad".**
  A chip may be good when combined with another chip and bad when combined with another different chip. Or it can be good in one customer system and bad in another customer system. Knowing about different grades of "good" supports smart binning of chips, which can be used for things like smart pairing of chips in a system (improve system performance) and adaptive Test Time Reduction (improve cost).

But there is much more. Consider the value chain of a system with electronics content. Wafers are manufactured in foundries and sent to packaging houses. The packaged chips are then installed on boards, boards go into sub-systems, and these go into end-systems such as cars or phones. Each step is completed by a different company and sometimes by more than one company. Each of these companies often has several facilities, usually in different locations. Different types of tests are conducted throughout the process using a variety of test equipment and producing huge amounts of test data. Traditional IIoT implementations that focus on process analytics can optimize each step separately but they do not and cannot accompany the product itself throughout its entire value chain or throughout its lifecycle. Here too comes the unique value of product analytics, as the same concepts described for chips also apply to boards, sub-systems, and end systems. As an example of the power of this capability, consider the case where in certain circumstances a call made on the cellular phone of a car "randomly" drops when the car stereo system is operating. Comprehensive product analytics throughout the car value chain can show that those "random" drops happen systematically when certain combinations of chips are used on a specific version of a board in the car infotainment unit. Such analytics will eliminate the problem in the future and improve the customer experience with the car.

Lifecycle Product Analytics

A product return by a customer is a brand owner's worst nightmare. It has financial implications, it requires quick and tough decisions (recall or not? All products or a subset?), and it severely impacts customer satisfaction and brand reputation. Consequently, any brand owner must seriously consider the following questions:

- How do I minimize quality and reliability problems in my product?
- If customers return my product, how can I can I limit the recall to the absolute minimum?
- How can I quickly find the root cause of the problem and ensure it doesn't happen again?

We already saw above how product analytics can help improve quality and reliability by ensuring that products tested as "good" are really good. Beyond that, since product analytics can be performed at the chip, board, sub-system, and system level, the analytics results provide visibility into product genealogy at every level, and full traceability throughout the value chain. The product genealogy, combined with all the test results collected throughout the value chain, and the respective environmental data, create a "product DNA". And as is the case with any forensic investigation, DNA is extremely helpful. The visibility and traceability provided by product analytics can help correlate between customer returns and specific boards and chips, manufactured by specific suppliers in the product value chain, in specific locations and at specific times. Multi-variate analysis can quickly identify the root cause of an issue, determine corrective action, and point to whether a recall is needed and if so – which specific products should be recalled, avoiding the need for a mass recall which any brand owner dreads, and is often the default in the absence of detailed analytics.

Lifecycle product analytics doesn't only help deal with issues like customer returns. One of its great potentials is in taking advantage of in-use data. For starters, there is no fundamental difference between collecting and analyzing test data during product manufacturing and doing these when the final product is in use in the field, as long as there are mechanisms for collecting such data, as is the case with Telematics Control Units (TCU) in cars. Assume the in-use data shows that in certain circumstances one of the car systems is heating up, not to a point of system malfunction but causing some performance degradation. Or that in certain circumstances the cellular or Bluetooth connections in the car are randomly dropped. Genealogy-based product analytics can show that while each chip by itself is meeting its specifications, as do all the boards, certain combinations of specific chips in specific boards are behaving in undesirable ways. Such analytics can lead to smarter pairing of chips or to modifications of boards, to ensure these problems are eliminated.

In general, while many quality issues or in-use phenomena seem stochastic when observed at the end system level, multi-variate analytics of its components may reveal systematic failures

at the chip, board, or module level, and especially at combinations of these. Holistic product analytics that are based on data throughout the product lifecycle and value chain can turn stochastic phenomena into clear systematic ones, thus helping find root cause and enabling quick and thorough resolution.

NPI and Simulation

The competitive nature of most end markets puts huge pressure on companies to improve time-to-market and introduce products to the market as early as possible. However, this cannot come at the expense of quality. This, along with the ever-increasing product complexity makes New Product Introduction (NPI) increasingly challenging.

One way designers are trying to address the challenge is by running more, and more sophisticated simulations prior to product introduction. Simulation tool providers continuously improve their offerings mainly by improving modeling techniques. However, today there is no easy way to close the loop between product in design and product in production or in the field, which limits the value of simulation. The concept of a "digital twin", where a real product has a companion simulation model, is an attempt to address this problem. Product analytics is a critical ingredient for making this concept a success, as it provides product information throughout its value chain and throughout its lifecycle, enabling faster and more accurate updates of simulation models, thus helping NPI of next generation products.

Product Analytics Is Hard To Do

Process analytics is usually confined to a limited manufacturing environment such as the machines on a specific factory floor, or the factory floors of a specific manufacturer. Contrary to that, as described earlier, good product analytics is holistic in several dimensions – throughout the value chain from chips to boards to systems, throughout the product lifecycle from design to introduction to volume production, and across the entire supply chain. As such, product analytics can provide much more insight and much more value, but is also much harder to do. Consider the following:

- **Sheer amount of data.** Clearly, collecting, cleaning, managing, and analyzing data throughout the value chain and the product lifecycle, requires true big data capabilities.
- **Need for an information highway.** Holistic product analytics require collecting and analyzing data from both suppliers and customers, and from a variety of organizations

(e.g. R&D, Test, Operations). This in turn requires an infrastructure to connect all these in an efficient and secure manner, as well as capabilities such as Data Feed Forward and Data Feed Backward. One specific and challenging element of such an information highway that connects multiple companies and organizations is the need to normalize all that data and create a "single point of truth" for all product data throughout its lifecycle and value chain.

- **Type of analysis.** Holistic product analytics that covers the entire value chain and product life cycle enable unique analysis capabilities, such as product genealogy, which is not possible otherwise.
- **Specific domain expertise.** Consider the example mentioned earlier in this article of a stepper in a semiconductor foundry. It is one of the most advanced and expensive pieces of equipment on the manufacturing floor. It is used in the manufacturing of a variety of products from many different customers. Process analytics in the foundry will surely focus on all the data collected about the stepper to ensure it is optimally operated and maintained. However, that type of analytics is agnostic to the products that go through the stepper. Product analytics, on the other hand, is specific to each product, and improving the product quality, yield and performance requires intimate domain expertise.

Listening to the Voice of Your Product with Optimal+

Since its founding in 2005, Optimal+ has established a unique leadership position in big data analytics for the semiconductor industry. Optimal+ software is installed in more than 90% of the semiconductor foundries and OSAT (Outsourced Assembly and Test) facilities, and is used by most of the top semiconductor companies, both fabless and IDMs. Recently, Optimal+ has started to leverage its capabilities and experience to expand to electronics systems in markets that care a lot about quality, performance, and cost such as automotive, mobile, and data center. About 50B chips and systems are analyzed by Optimal+ annually, and this number keeps growing.

By sitting on testers and collecting test data directly from the product at every test step, along with all the relevant genealogy and environmental data, Optimal+ knows each product's DNA at any point throughout its lifecycle and along its value chain. The Optimal+ Big Data Highway is already connecting suppliers and customers, which provides the necessary infrastructure for holistic product analytics.

SUMMARY

As valuable as process analytics is, to get the full potential value of the IIoT it must be accompanied by product analytics. It is critical to listen to the Voice of Your Product in order to improve performance, quality, reliability, yield, and brand protection. Optimal+ is at the forefront of extending the IIoT to its full potential.

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