Unlock the power of Industrial IoT with analytics

IIoT and analytics fundamentals, use cases, and approaches to help organizations lower costs, drive new efficiencies, and find new business opportunities

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Executive summary

This white paper outlines the current Industrial Internet of Things (IIoT) market landscape and key challenges that analytics can address. It introduces streaming analytics for IIoT, summarizes customer problems ideal for streaming analytics, and provides industry use cases to give life to these concepts. It is intended to provide a blueprint for how analytics can help deliver on the promise of IIoT.

With IIoT, a robust ecosystem can provide solutions that work together to solve manufacturers' challenges. Siemens and SAS have recognized the complexity of these challenges and have partnered to provide IIoT and analytics capabilities in Siemens MindSphere. Leveraging streaming analytics both on the edge and in the cloud leads to the broadest set of opportunities for maximizing business value.

Market landscape and IIoT challenges

Today, manufacturers around the world are seeking new ways to meet market needs, improve products, optimize operations, increase revenues, and reduce costs and risk.

Automation, digitalization, and the adoption of IIoT are important requirements for companies that wish to lower costs, drive new efficiencies, and find new business opportunities. The ever-changing landscape and shifting dynamics in today's market has made the road to success more complex.

Organizations strive to meet aggressive production schedules and customer expectations, with success directly tied to the overall availability and reliability of capital assets; product quality; the performance efficiency, safety, and satisfaction of their workers; and customer satisfaction. Equipment and worker performance can make or break operations. Unplanned downtime due to equipment outages can mean missed commitments and millions in lost opportunity. Degradations in equipment performance and worker inefficiencies or errors can steal profits and inflict unnecessary costs.

There are many IIoT challenges and opportunities related to analytics. We will now discuss a selection of the most impactful challenges.

Digitalization and IIoT

IoT across industries relies on advanced data analytics, digital twins, and closed-loop integration – all important aspects of digitalization projects. Digitalization in manufacturing and other industries is evolving toward the as-a-service economy, but there are challenges that need to be addressed. For example, some digital transformation project goals target the level of improved efficiency, cost reduction, or in more advanced stages, solutions that promise new revenue sources. All that happens in a time where data and the insight gained from it become the new currency in the industry.

Industries are currently experiencing uncertain times. Unpredictability in spending and the larger geopolitical and macroeconomic pictures add to the difficulties in making decisions about digital transformation projects. At the same time, if approached correctly, IIoT offers the right and mature capabilities to achieve successful business impact. At the core of it all is IIoT's capabilities to create actionable insight from data that can come from various sources in OT and IT systems.

Data proliferation

Continued investments in automation and connectivity, including sensor deployments, have resulted in increased data from core manufacturing systems. Although compromised quality and reliability can come from many sources, there are subtle ways that this can occur. Very often, these subtleties can only be seen in the data.

This expansion of useful data represents a major opportunity to make existing operations – along with design and engineering – more reliable and/or efficient. Doing so unlocks pathways to improve profit margins. Currently, many manufacturers have not captured – or have only partially captured – the opportunities provided by IIoT data and supporting systems.

Analyzing data

According to industry analysts[1], by 2020, 30 billion devices will be connected, and by 2025, the global volume of data will soar to 163 zettabytes. Those IoT devices create large amounts of data that need to be analyzed to derive business value. Analyzing

1 EY report on IDC, Internet of Things: Human-machine interactions that unlock possibilities, 2016; Cave, Ande, What Will We Do When The World's Data Hits 163 Zettabytes In 2025?, April 2017; (both studies based on MacGillivray, Carrie, Worldwide Internet of Things Forecast Update, 2015-2019, International Data Corporation (IDC), February 2016.)

the data closest to its source is the most cost efficient and solution effective, speeding up decisions and reducing data transport and storage costs. Analyzing that enormous amount of data in real time and closest to its source is challenging.

IIoT initiatives give manufacturers the opportunity to get to the next level of operational excellence and address challenging markets in a profitable way. Analytically driven manufacturers will enjoy a competitive advantage by capturing major opportunities for improved asset performance, better quality, increased production yield, and greater throughput of industrial installations. Companies that do not act now will be left behind and will increasingly struggle to remain competitive with their analytically enabled peers.

Project scaling and rollout

One operational aspect that we want to touch upon is related to "project scaling and rollout" challenges, which we have observed in discussions with many customers. An important observation is that many companies initiate proofs of concept (POCs) but fail to fully operationalize the solution. Why do so many of these projects get stuck in that phase? To better understand the reasons, Siemens and SAS analyzed many IIoT projects. It became clear that one significant aspect was often ignored: POCs should always deliver answers related to the business impact of a commercial deployment, as well as the expected improvements on the business outcome (e.g., a measurable increase in profitability or improvement in operational efficiency). However, the reality is that POCs often focus on evaluating technology and do not include planning for deployment into the operational infrastructure. While technology evaluation remains important, the business outcome must take a prominent role in POC selection as well. Projects cannot be one-time initiatives. Operationalizing the solution for sustained value at enterprise scale is critical.

Shortage of data and analytics experts

Another challenge in today's market is the significant shortage of skilled data scientists or analytics experts. Many organizations simply don't have access to enough people with that skill set. So we asked if there was a different path that could be taken to address this. We observed that most organizations have access to information workers and business analysts, people who could become "citizen data scientists" if given access to the right tools. Gartner has also seen this evolving trend, observing that "Through 2020, the number of citizen data scientists will grow five times faster than the number of expert data scientists."[2]

Taking advantage of this resource shift is a good path forward, but what does access to the right tools mean? For example, web-based visual composition workflow tools may be used by business analysts to interpret data and apply the results as benefits to other line-of-business users. And web-based communities and ecosystems offer resources for technical support, training, and best practices. Collaboration-friendly components enable rapid interactions among citizen data scientists, data scientists, data engineers, and business managers in an intuitive context. Templates and accelerators are available for common scenarios, including predefined business use cases in customer analytics and technical areas such as data preparation, data engineering, and model deployments for operations.

30 billion

By 2020, 30 billion devices will be connected.

163 zettabytes

By 2025, the global volume of data will soar to 163 zettabytes.

2 Gartner. "Gartner Identifies the Top 10 Strategic Technology Trends for 2019." October 15, 2018. https://www.gartner.com/en/newsroom/press-releases/2018-10-15-gartner-identifies-the-top-10-strategic-technology-trends-for-2019

IIoT analytics

IIoT analytics enable companies to efficiently analyze and manage the creation of real-time information from IIoT device data and other data sources.

Companies can benefit from a solution partner's broad IIoT analytics portfolio, along with deep industry expertise, as they can then better manage, optimize, and predict business operations and processes, and ultimately improve efficiency and profitability.

These tools allow companies to easily create insights from machine, production line, or plant data. For example, trend detection can provide the calculus for individual or multiple time-series streams by applying algebra and statistics, such as mean, sum, and variance. In addition, advanced capabilities are available to execute complex analytics and machine-learning (ML) techniques.

IIoT analytics domains

These capabilities are provided across three analytics domains.

Democratize data analytics

This analytics domain is all about increasing data availability to people who need it, along with simplified, self-service analytic tools. By simplifying the process to derive meaningful insights using templates, accelerators, and intuitive self-service tools, team members are empowered to make data-driven decisions. Data can be multiphase, persistent, in-motion, and event-based.

Enable edge-through-cloud model management

In this domain, meaningful analysis is performed where and when needed. A flexible modeling environment is essential from the cloud to edge or endpoint devices. The environment should also enable model deployment in an automated and scheduled fashion. Pattern recognition, anomaly detection and diagnosis, and execution analytics are performed. Data movement is minimized while providing faster access to the insights to support operational decisions.

Drive fast, adaptive decisions and actions

The third analytics domain focuses on enabling decisions. Dashboards and advanced data visualization from data sets simplify actionable information. KPIs can be compared to continuously evaluate opportunities and risks. Individuals at all levels of ownership and responsibility are empowered to use the data in their decision-making, significantly reducing time to decision and action.

IIoT benefits of analytics

IIoT data provides a greater fidelity of operations and asset performance, which can provide the following benefits from data analysis:

Increased production yield: reduced scrap, waste, and rework; reduced warranty claims; fewer aftersales defects; and lower safety stocks

Increased production throughput / lower energy use: higher production line throughput; lower energy use and pollution to produce the same amount of end product

Increased end-product quality: higher customer satisfaction, unit margins, and brand value by enabling products with first-class quality, which are available on time and meet or exceed customer expectations; reduction in number of warranty claims and/or product recalls

Reduced capital risk and cost related to failures, accidents, and sanctions: predicting upcoming, possibly catastrophic equipment or process incidents; reducing exposure to field quality issues

Streaming analytics for IIoT

Organizations are investing heavily in IIoT. In the process they are capturing and storing an increasing amount of data with the goal of extracting valuable information while it's still in motion, as close as possible to the event's occurrence.

By waiting to analyze data after it is transferred and stored, it will take too long to react to deviations on the shop floor, which could lead to quality-related event issues. In many ways, IIoT promises to create a highly efficient world, but achieving it demands constant analysis of the state of events based on the sensor and machine communications happening all around us.

The way to get there is with event stream analytics software that can process millions of events per second, before they are persisted in a data store. Data transformations and analytics used inside event streams help organizations accurately and quickly detect patterns and anomalies in multiple sets of data. This enables operators to understand what is about to happen, make immediate adjustments, generate notifications, prevent failures, minimize security risks, and make decisions before an event or opportunity is over. Streaming analytics can help organizations decide when to take action, what to ignore, and what should be stored, as well as provide streaming event insights to traditional business applications.

Streaming analytics delivers continuous streaming analysis for low-latency decision-making in-stream, out-of-stream, or on the edge.

Multiphase analytics in-stream, out-of-stream, and edge

Reduced time to decision for better business outcomes

High volume and performance execution

Open APIs, SAS, and open-source model support

Considerations

To take full advantage of data streams in IIoT, organizations must understand the exploding number of ways IIoT data needs to be filtered, mashed up, compared, contrasted, interpolated, and extrapolated. Consider the following:

- **Volume:** Can today's massive amounts of data be quickly accessed, processed, stored, and analyzed?
- **Variety:** New types of IoT data are still emerging. Can all the different types of data and its varied formats – structured, unstructured, semi-structured – be managed as it happens?
- **Velocity:** Think about how quickly text, image, and video data is generated. How quickly can that data be captured and analyzed?
- **Veracity:** In its raw form, IIoT data is "dirty;" it hasn't been filtered, validated, profiled, or cleansed. Making IIoT data trustworthy, so it can be used as the basis for data-driven decision-making requires data management standards for data quality and data governance.
- **Variability:** IIoT trend analysis over a period of time helps identify subtle differences between a defined product specification and an actual product characteristic caused by unknown factors that result in a steady but random distribution of output around the data's average. Deviations may be from part-to-part, line-to-line, or plant-to-plant.

Event stream processing

Event stream processing plays a vital role in handling IIoT data from the connected world. It can detect events of interest and trigger appropriate action, along with pinpointing complex patterns in real time by monitoring aggregated information, cleansing and validating sensor data, and enabling predictive and optimized operations.

Key event stream processing features include:

Monitor aggregated information

Event stream processing continuously monitors sensor data from equipment and devices, looking for trends, correlations, or defined thresholds that indicate a problem. In turn, an operator can be alerted to act before damage occurs.

Cleanse and validate sensor data

There can be many sources of dirty data, including sensors. It is common to have missing bits from time-sequence data, and data may also be corrupt or unavailable. Often network issues can cause missing time stamps for a single sensor. When multiple sensors are monitored as a collection, formats and transmission timing can vary between sensors. As a result, sensor data may be incomplete or contain inconsistent values. Delayed data might indicate a potential sensor failure, or it could simply be the result of a drop in a mobile network. A variety of techniques, embedded directly into data streams, can detect patterns and examine the erroneous nature of data issues.

Enable real-time predictive and optimized operations

Streaming data combined with analytics reveals patterns that empower real-time decisions. Advanced analytics and mathematical algorithms are developed using rich histories of stored data that can be encoded into data streams, enabling continuous scoring of streaming data.

Progress from predictive to prescriptive analytics has been slow as companies struggle with data complexities and with how artificial intelligence (AI) and ML can coexist with existing statistical models. The MindSphere analytics portfolio solves the data complexity issue across the entire lifecycle to create a full, closed-loop decision environment for continuous optimization throughout all aspects of the engineering, production, and service lifecycle and value chain. This can translate to millions in cost savings by reducing unplanned downtime, improving operational efficiencies, and creating opportunities for differentiated customer experiences.

To give users the full flexibility of where to run major computation steps – directly on an edge server, on an edge gateway, or in the cloud – seamless processing of data streams on edge devices and cloud services needs to be configurable with one management tool. It is further suggested that dashboards that contain any given data or event streams can help visualize data streams in detail. This puts the user in control to build applications that leverage high-frequency input data (e.g., vibration analysis, geolocation from trains or cars, log-data, or other sensor signals). Data connectors and adapters need to be available for both edge and cloud integration.

For even more flexibility, data stream process must be able to integrate analytics code from Python, R, or C in easy steps. Therefore, the analytics platform must support a complex, diverse environment where users can seamlessly embed open-source code within analysis and call algorithms. Whether it's Python, R, Java, Lua, or Scala, modelers and data scientists can access analytical capabilities from their preferred coding environment. This provides the opportunity to fully leverage the entire ecosystem to maximize the analytics platform investment.

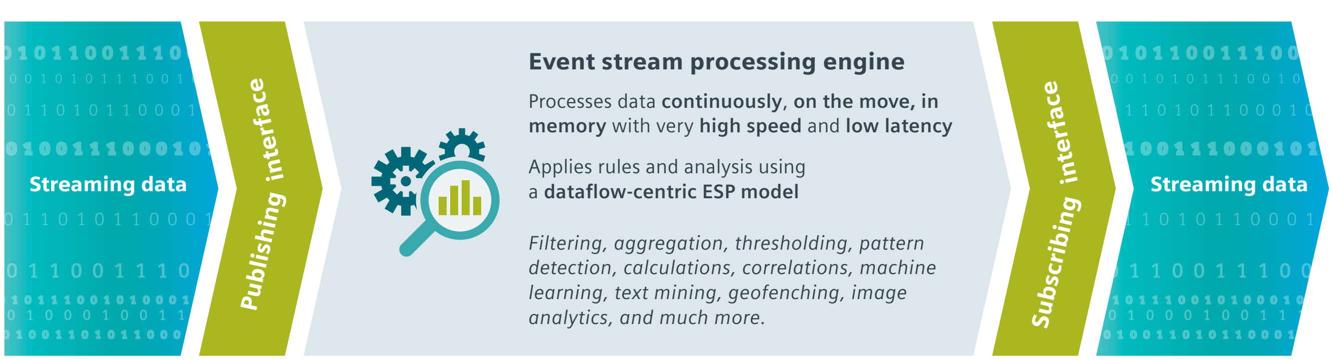
Customer problems ideal for streaming analytics

Leveraging streaming analytics on the edge and in the cloud leads to the broadest set of opportunities for maximizing business value. Customers demand the ability to support high-volume, real-time streaming analytics both close to the machine and on an aggregated level to derive actionable insights that help solve problems and improve operations. These requirements demand low latency, minimal data movement, and high-aggregation summation from the analytics platform and related deployment, for example, at the edge.

Due to data volume and frequency, transmitting all real-time machine data to analytics engines in the cloud is often cost and time prohibitive. Additionally, latency is often too high for the quick reaction required in automation processes. On the other hand, analytics over an entire fleet of assets must be run at a centralized level, which the cloud platform provides. Both levels must be in sync, and the load on a link and the data transport volume must be optimized. In an IIoT environment, it is of critical importance that access to edge-to-cloud streaming analytics capabilities are available.

Another important requirement is minimizing data transport cost, especially across cellular networks between the edge and the cloud platform. This is achieved by applying filters or summarizing data at the edge, so that only relevant data needed for analysis, by the application logic or for regulatory purposes, is pushed up to the cloud.

Event stream functional architecture



Siemens’ streaming analytics solution approach

Customer value

- Develop, deploy, and manage streaming analytics models from a common cloud backend
- Visually develop workflows or include externally generated analytics models
- Reduce decision latency through near real time processing of streamed data (edge- or cloud-based)
- Reduce bandwidth required for up-streaming through edge-based processing of analytics models

Key capabilities

- High-performance streaming engine for edge, fog, or cloud
- Visual modeler for developing and testing workflows
- Visualization tool for analyzing any given data point of deployed workflows online
- Management of model deployment – including automation capabilities – and monitoring of edge device health

IIoT and streaming analytics use cases

Streaming analytics can provide significant benefits across a wide range of manufacturing industry sectors, including electronics and semiconductor, aerospace and defense, industrial machinery and heavy equipment, and automotive. The following examples focus on a subset of industries that can benefit from leveraging the capabilities of IIoT and streaming analytics.

Automotive manufacturing

Paint Shop Spray Optimization

Description

In the automotive painting process, one of the largest drivers of unplanned cost is the need to rework paint defects to meet quality standards. Manufacturers need to monitor paint drop parameters based on laser interferometry to derive preventive actions directly on the shop floor level. Only by having this done in near real time near the paint booth operator can the manufacturer successfully reduce the defect rate.

Challenges

- Reduce paint defects
- Speed up reaction to deviations

Results

- Analytical models are trained by leveraging historical data, which enables scaling to additional factory lines through standardized onboarding, modular workflows, and data mapping.
- Ability to aggregate real-time data in the booth with other sources of data (i.e., paint defect definitions and vehicle design data) enables new insights

Semi-trailer truck manufacturer

Truck Engine Diagnostics and Monitoring

Description

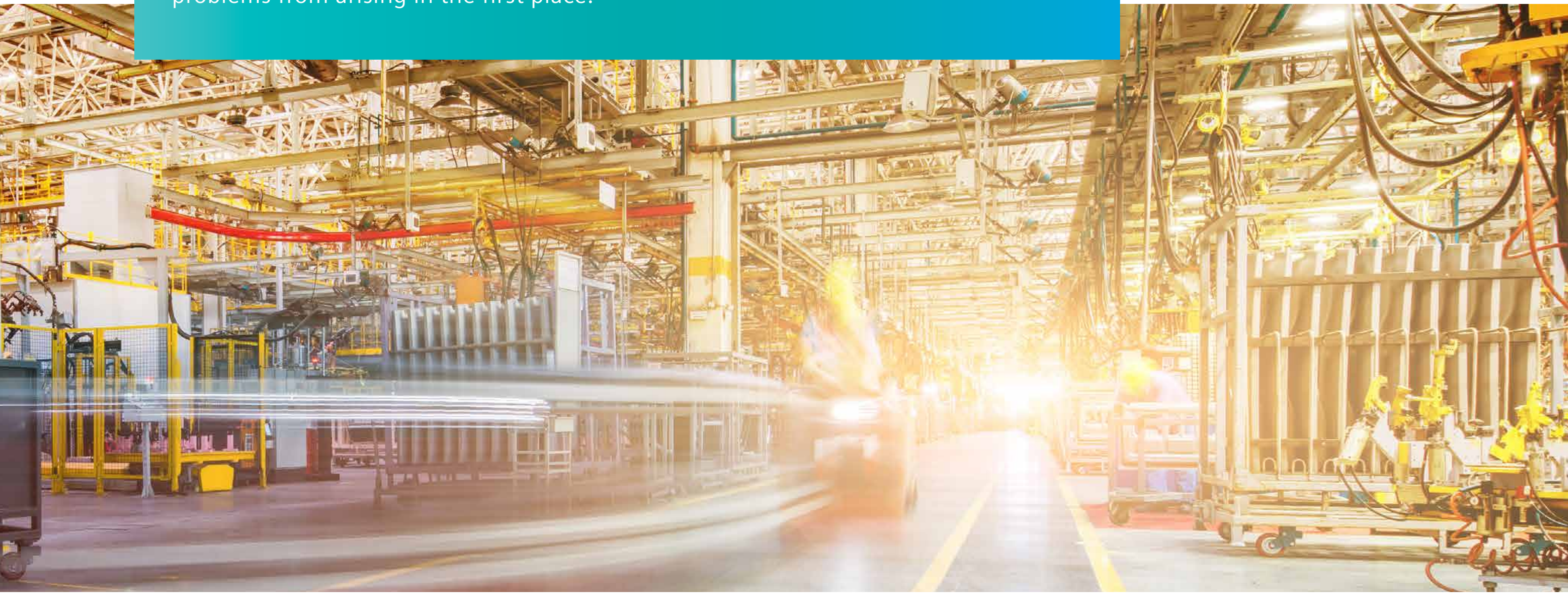
Truck operators drive profits by keeping their trucks on the road. One operator estimated a loss of $1,100/day for a truck being out of service. To minimize the time trucks are off the road for maintenance, operators need access to data and improved analytic capabilities. These capabilities allow for migration away from a purely scheduled maintenance routine with ad-hoc visits for unplanned mechanical failures to a conditioned-based maintenance methodology, which extends intervals and enables better predictions of potential failures thus moving the unplanned activity to a scheduled activity.

Challenges

- Enhance remote diagnostics and monitoring of critical engine, transmission, and after-treatment trouble codes
- Minimize unplanned downtime, which creates a tremendous toll on fleet operators and their customers who depend on timely deliveries
- Improve vehicle efficiency and uptime to keep trucks running – or ensure the least disturbance to the business if something happens on the road

Results

Millions of records from 175,000 trucks are processed instantaneously, reducing diagnostic time by 70% and repair time by 25%. Thousands of sensors on each truck collect streaming IIoT data in real time to provide the context needed for more accurate diagnosis. Vehicle uptime is maximized, and service disruptions are minimized by servicing connected vehicles more efficiently, accurately, and proactively. Operators are able to recover from problems faster and prevent problems from arising in the first place.



Electronics

Printed Circuit Board (PCB) Yield Improvement

Description

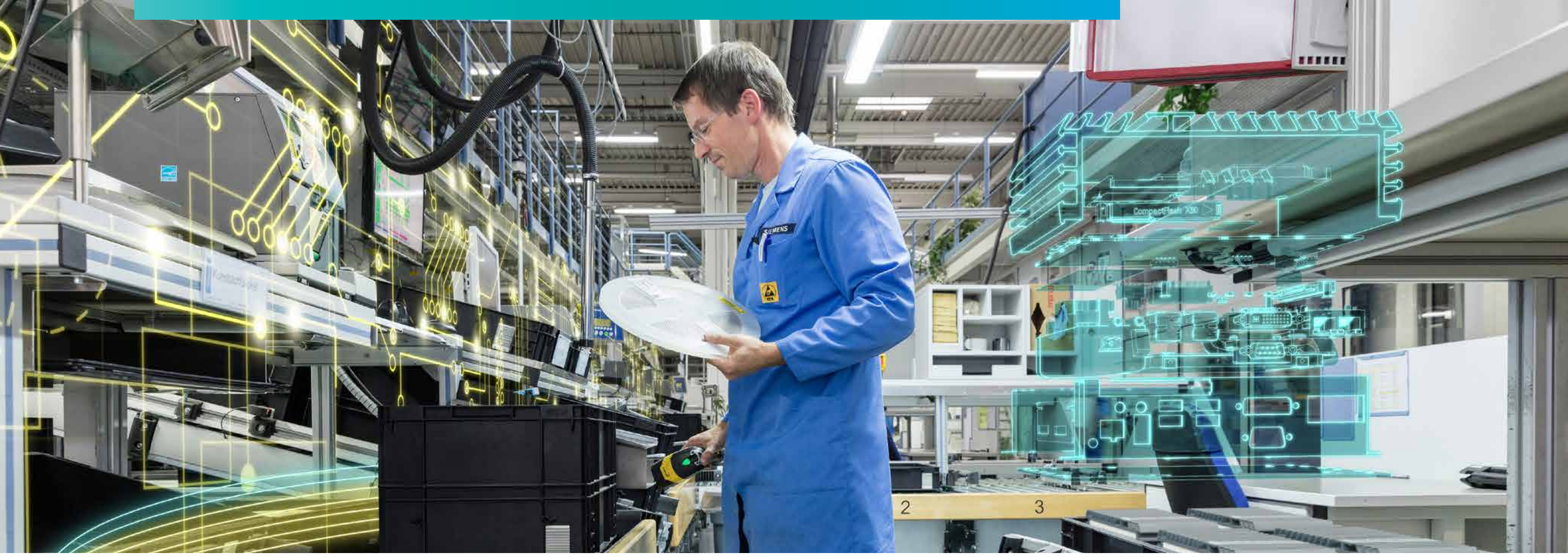
In a modern printed circuit manufacturing facility, it is common to see more than 80 different lines producing more than 10,000 PCBs daily. These PCBs have intricate designs with tight placement of surface-mount integrated circuits and other components. Although it is a high-speed manufacturing process, it is also very precise, and several quality checks are made along the line to ensure only fully functional boards are shipped. One such check is the in-circuit-test (ICT), which checks the resistances of traces among a multitude of test points on each board design. In this test, there are more than 500 measurements per board, and it can be challenging to leverage the information gathered in this test to identify upstream quality issues.

Challenges

- 700 variants of PCBs across 50 product lines
- Two-minute takt time on ICT test machines
- Multiple data sources (ICT data, error code definition database, design data for XY coordinates of components and test points)
- Desire for real-time multivariate analysis with available results
- Unacceptable first pass yield (FPY)

Results

Leveraging a flexible streaming analytics platform, operators can develop optimized models for multivariate analysis that can be executed in near real time with results presented to manufacturing engineers within minutes. Manufacturing engineers can configure and customize alerts based on their knowledge of each line. These capabilities enable faster correction to line issues and in turn, improve FPY.



Aerospace manufacturer

Aircraft Predictive Maintenance

Description

Deliver innovative, next-generation products and services from AI, ML, and IIoT analytics deployed throughout the value chain. Help customers solve their toughest problems and achieve critical missions.

Challenges

- A wide variety of aircraft designs with different measurement types
- Lack of a central data repository for aggregation of data from more than 400 aircraft
- No failure propensity modeling for a wide array of parts
- Spare parts inventory gaps (i.e., too much or too little inventory)

Results

Used AI, IIoT, and advanced analytics to predict when parts will fail, keeping more aircraft airborne for vital missions worldwide. Reduced data cleanup times by up to 95%, allowing the company to spend more time on the actual analysis.

IIoT analytics examples

Turbine engines

Model drivers of unscheduled downtime.

Identify optimal maintenance scheduling.

Predict failures.

Wind turbines

Identify turbines performing below average.

Model drivers of capital component failures.

Improve planned maintenance.

Gas treatment

Identify predictors of failure.

Identify optimal operational parameters.

Optimize amine utilization.

Oil wells

Identify wells performing below expectations.

Model drivers of pump failures.

Automate early warning detection.

Identify optimal operational parameters.

Siemens MindSphere and IIoT analytics

MindSphere is a cloud-based, open IoT operating system from Siemens that connects products, plants, systems, and machines, enabling companies to harness the wealth of data generated from virtually any number of connected intelligent devices, enterprise systems, and federated sources with advanced analytics and digital twins.

MindSphere enables industries worldwide to link their machines and physical infrastructure to the digital world easily, quickly, and economically.

MindSphere provides a wide range of device and enterprise system connectivity protocol options, industry applications, advanced analytics, and an innovative development environment that utilizes multitenant, open Platform-as-a-Service (PaaS) capabilities along with access to native AWS cloud services.

MindSphere securely connects, transforms, aggregates, analyzes, and visualizes asset sensor, operational, plant production, and performance data, making it accessible through digital applications. This information can be used to optimize products, production assets, and manufacturing processes along the entire value chain to support more insightful and faster business decisions. Real-time telemetric data may be collected from static and in-motion assets like motors, generators, robots, cars, time-series data, and geographical data. The data is used for condition and event monitoring, energy optimization, preventive and predictive maintenance, and closed-loop feedback to digital twin 1D/3D simulation models to optimize engineering products, manufacturing production, and in-field service performance.

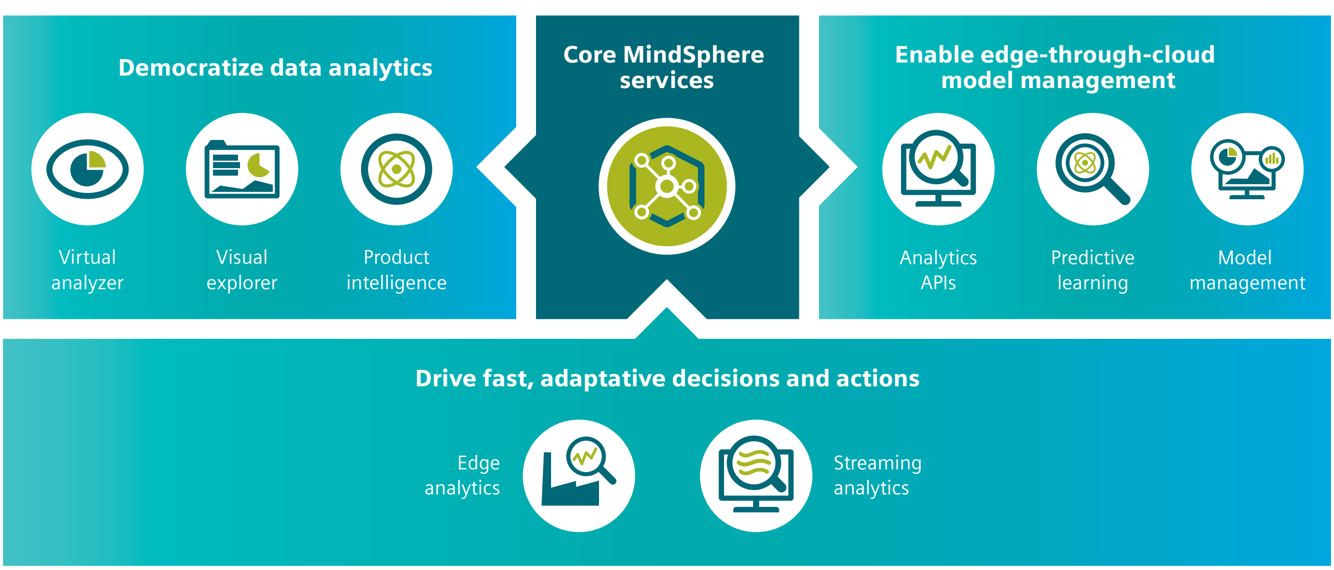
Through these closed feedback loops, MindSphere enables bidirectional connections and data flow between production and development; connects real things to the digital world; and provides powerful industry applications and digital services to help drive business success.

The MindSphere federated architecture builds connectivity and applications on top of an open Platform-as-a-Service

Key MindSphere capabilities

- Secure connection to local and remote assets and fleets via open interfaces, protocols, hardware, or software connectivity solutions
- Open interoperability through a broad spectrum of MindSphere services and APIs, including analytical services
- Data visualization and exploration based on KPIs and dashboards
- Automated insights from production and product performance data
- Ability to extend capabilities by using out-of-the-box applications or easily developing applications and solutions with low-code tools
- Support of AWS, Azure, and Alibaba IaaS platforms
- Large ecosystem partners and developers offering industry-specific solutions and applications

MindSphere analytics portfolio



Siemens and SAS IIoT analytics partnership

Siemens and SAS are partnering to deliver AI-embedded IIoT analytics for the edge and the cloud. By providing SAS streaming analytics technology within MindSphere, customers benefit from the growing demands for IIoT analytics with AI and ML capabilities. The collaboration creates the most comprehensive, open-compatible AI framework for IIoT.

The partnership aims to help companies create new IIoT edge and cloud-enabled solutions by applying SAS streaming analytics and industrial device management through Siemens' MindSphere. Users gain access to industry-leading SAS advanced and predictive analytics in MindSphere, which can accelerate the adoption of ML and AI in IoT environments. Increased productivity and reduced operational risk through powerful predictive and prescriptive maintenance and optimized asset performance management are just some of the ways these new solutions can benefit customers working in a range of industries.

Siemens Digital Industries Software

Siemens Digital Industries Software, a business unit of Siemens Digital Industries, is a leading global provider of software solutions to drive the digital transformation of industry, creating new opportunities for manufacturers to realize innovation. With headquarters in Plano, Texas, and over 140,000 customers worldwide, we work with companies of all sizes to transform the way ideas come to life, the way products are realized, and the way products and assets in operation are used and understood.

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SAS

SAS is the leader in the advanced and predictive analytics category, with a market share more than twice that of the next closest competitor. Through innovative software and services, SAS empowers and inspires customers with the most trusted analytics. SAS embeds AI capabilities in its software to deliver more intelligent, automated solutions that help boost productivity and unlock new possibilities. From machine learning, deep learning, computer vision, and natural language processing (NLP) to forecasting and optimization, SAS' AI and IoT technologies support diverse environments and scale to meet changing business needs. SAS is used at more than 84,000 sites in 145 countries worldwide, including 92 of the top 100 companies on the Fortune 500® list. Our vision is to transform a world of data into a world of intelligence.

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Christoph Inauen

Vice President of Strategy for MindSphere

Siemens Digital Industries Software

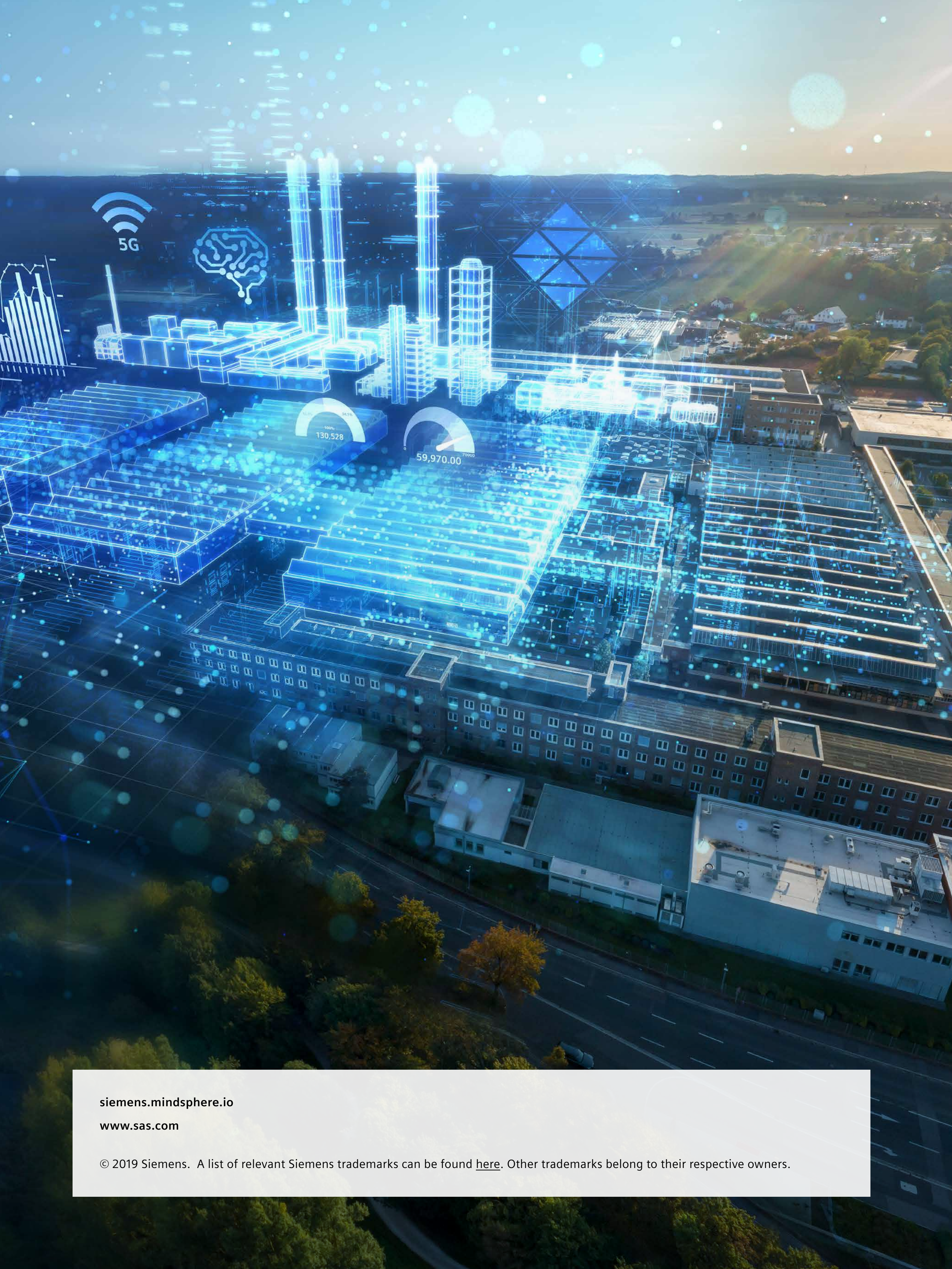
As Vice President of Strategy for MindSphere at Siemens, Christoph Inauen is responsible for defining and executing the MindSphere technology in close collaboration with Siemens Business Units and the MindSphere ecosystem. Prior to joining Siemens in 2017, Christoph held a variety of executive roles including vice president of IoT strategic partnerships and vice president of product management for the SAP IoT Cloud Platform Services Suite. Previously, he was vice president, IoT global business incubation at SAP and worked at Nokia Networks for 14 years in Switzerland, the U.K., and the U.S. Positions included head of Network Solutions North America and leadership positions in product and system marketing and network architecture design. Earlier in his career he worked as a system engineer at Schindler. Christoph resides in the Dallas, Texas area.

Jason Mann

Vice President of IoT

SAS

As Vice President of IoT at SAS, Jason Mann is responsible for growing IoT revenue and providing global focus, strategic direction, and alignment across the SAS IoT analytics portfolio. He oversees research and development, product management and marketing, and execution of the sell-through strategy across the portfolio. Previously, Jason served as director of product management for industry solutions and IoT, where he set the strategic IoT direction for SAS and was responsible for product management of the manufacturing and supply chain, retail, energy, and health and life sciences industry solutions. Prior to that, he served as manufacturing industry strategist, where he led the internal and external positioning of SAS' distinctive competence and value to the manufacturing industry. Jason also worked at Nortel Networks for 10 years, where he led the multiyear design and implementation of global manufacturing operations and order management systems. Jason resides in Cary, North Carolina.



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