Entering the Digital Factory Era:

Industry 4.0, the Digital Thread and how to get started managing, and making sense of manufacturing data

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INTRODUCTION - the business CHALLENGE

Complex discrete manufacturing processes require consideration of massive and ever-growing volumes of data, variables and constraints, as well as real-time decision making. Increased manufacturing complexity alongside with cost and quality pressures coming from OEMs, became part of the routine existence of many manufacturers. On-time and on-quality delivery constraints forces them to reduce rework and get the work done right the first time and pushes advance manufacturers to pursuit a system to intelligently optimize their operations, data control and efficiencies.

With the rapid expansion of connected devices and sensors, the sheer volume of data being collected on the factory floor dramatically increases. Large-scale manufacturing facilities depend upon numerous complex processes and systems, most of which are either manually handled or poorly connected to one another. Many times, these enterprise-level systems, do not function optimally together, affecting the productivity and efficiency of manufacturing processes, and, consequently, the margins.
Moreover, in many cases the several facilities of the same manufacturer are disconnected, leading to no, or low, supply chain standardization and communication.

Low visibility into existing systems during the product design phase and on the production floor, prevents industrial enterprises from gaining valuable actionable insights from their business operations. Failing to extract context out of data at the granular level, prevents them from generating meaningful actionable intelligence that otherwise facilitates quick and optimized decision-making. Poorly connected systems on the manufacturing floor compel industrial manufacturing enterprises to rely upon manual touch points to fill the gaps between systems, affecting the operational efficiency of industrial processes.

OVERVIEW OF CURRENT PRACTICES

As mentioned, the current common manufacturing processes for advanced manufacturers components, relies extensively on manual labor and the use of paper trails to manage and track operational phases from raw material to end products, and to optimize the production environment. Manual and semi-manual processes offer limited real-time visibility and control of the production floor and production overview and are prone to errors due to reliance on self-reporting and human input of information. Selection and use of materials, maintenance of tools and scheduling of production processes are tracked and handled almost entirely by paper-based ‘travel documents’ and a combination of bar-code scanners that depend on shop-floor personnel input.

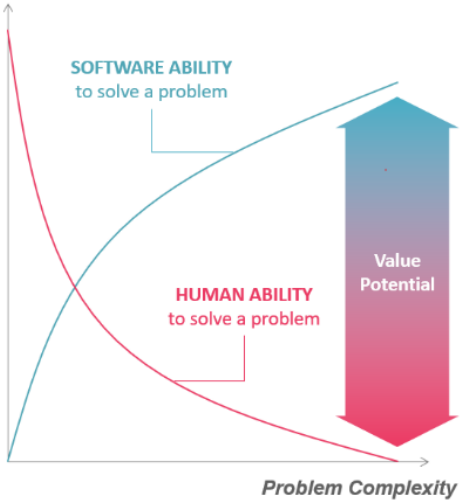

Figure 1: As the problem becomes more complex,
the human ability to deal with it decrease, and
the potential value of software increase.

The manually recorded and stored information is not always visible to production floor staff during selection of material, the availability of tools and machines – as well as

their need to undergo preventative maintenance - is not known before entering production, and future consumption

needs of raw materials are not always considered during the decision-making processes since the information is not available in real-time. Thus, extended production times or a need for an unavailable tool can cause longer manufacturing cycle leading to production delays that impact the entire production floor, increasing costs and reducing overall efficiency, all while risking the manufacturer's ability to meet strict quality and on-time delivery demands. Furthermore, current practices lack the real-time holistic overview of the factory floor as a whole and does not provide with managers and operators valuable insights critical during production.

THE SOLUTION - EMBRACING THE POTENTIAL OF Industry 4.0 & IIOT-BASED TECHNOLOGY

Embarking on their digital journey, industrial enterprises are embracing the Industrial Internet of Things (IIoT) and Industry 4.0 technologies in their manufacturing environments to optimize the operational efficiency of their businesses and record high margins.

Cloud computing technologies enable storing mass of data and offer computing power to handle it. However, for Industry 4.0 and Industrial IoT to live up to its promise, and provide valuable insights of potential improvements, highly sophisticated Artificial Intelligence (AI) is required.

Innovative Artificial Intelligence algorithms can collect IoT-based data, analyze data trends, raise alerts and recommendations, or even independently take optimal actions, all while maintaining full genealogical database, weaving a digital thread from the raw material stage to the end-product, guaranteeing highest levels of quality and quality control.

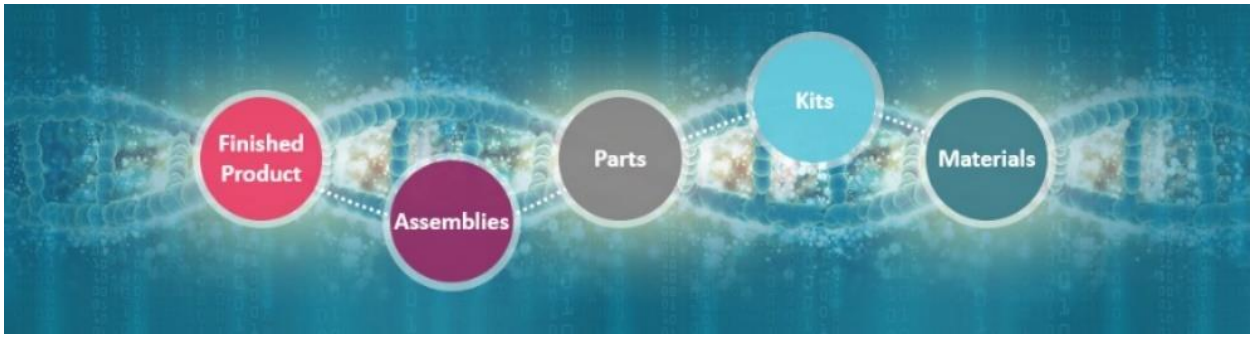

Figure 2: Innovative Artificial Intelligence algorithms maintain full genealogical database, weaving a digital thread from raw material to end-product.

Technology of such type allows manufacturers the eminent ability to use intelligent 'Digital Assistants' supporting production floor staff and managers with their daily decisions and actions, ultimately driving production optimization. The digital assistants automatically provide real-time smart, actionable recommendations. These capabilities directly enhance manufacturers' ability to meet strict quality, quality-control, cost-reduction and on-time delivery requirements, while remaining profitable and competitive.

Running on the cloud, a software-based platform offers enterprises end-to-end visibility throughout the product manufacturing cycle by gathering data from sensors embedded not only on the machines and raw materials, but also on the finished products. Putting the collected data in the product development context, enables manufacturers to keep a digital, real-time tab on the performance of manufacturing processes, technologies, and resources, such as raw materials and parts. In essence, the solution automatically collects data from numerous connected sensors on the factory floor to generate actionable insights, alerts and recommendations. For example, the predictive alerts that manufacturers receive make them aware of the quality and utilization status of raw materials or tools being used in the production process of each specific part. If any quality issue is identified, it can be immediately addressed to prevent it from snowballing causing a defect at the end of the manufacturing cycle or affecting new parts. This not only optimizes production time and resources, but also cuts down on the cost of identifying faults late in the process and rework.

The following examples will discuss some of these techniques and their applications:

1. MATERIAL & ASSET TRACKING

The system integrates with a variety of factory floor sensors (RFID, BLE, Barcode scanners), collecting real-time data on all assets' location & condition as they move from one station to another throughout the entire manufacturing process.

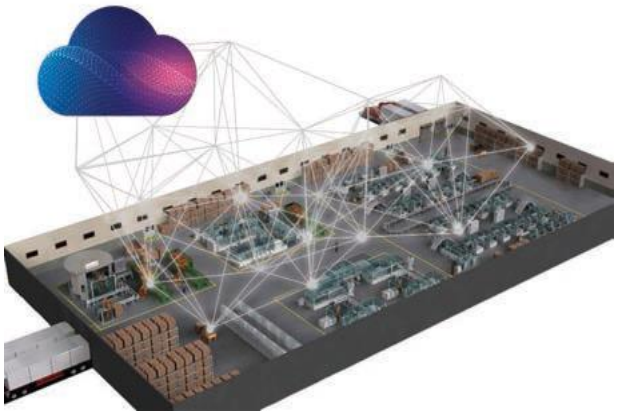

Figure 3: Could-based real-time material and asset tracking application

2. WIP (WORK IN PROCESS) OPTIMIZATION

The system tracks all forms of WIP (Work In Process), raw materials, kits, finished goods & shipments. Designed to reduce errors, promote accuracy, reduce carrying costs, paperwork, administrative costs and to allow greater visibility through the entire order fulfillment cycle. Empowers factory operators to transact with existing legacy ERP systems through a single user interface in a secure, intuitive application.

3. TOOL TRACKING & UTILIZATION

The system brings real-time visibility of tools' location, condition, status, availability and number of autoclave cycles, creating an automated log of each tool's usage and maintenance data. Tracks all high-value mobile assets including layup molds & dies, tool kits, machining & assembly fixtures, trim & drill tools, calibration and more.

Figure 4: Real-time visibility of the production floor as a whole

4. QUALITY CONTROL & AUDIT

The system digitally logs every step in the production process, allowing for significant improvement of quality control and audit readiness at all times, by maintaining full traceability of the Digital Thread from raw material to end-product and back.

5. MATERIAL SHELF LIFE MANAGEMENT

The system automatically calculates exposure time and expiration of composite material. It extends shelf life parameters based on authorization control and triggers alerts on assets that are close-to or exceeded expiration date and exposure time, helping manufacturers make the right decision, improve material utilization and reduce scrap.

6. SUPPLY CHAIN COLLABORATION

Spanning the Digital Thread beyond the factory across the entire supply chain, increases visibility and ensures on-time delivery of work orders. Factories, suppliers and distribution centers can all be part of the tracked chain resulting in manufacturing efficiency and uniformity across all production sites.

7. EASY INTEGRATION & SMOOTH DEPLOYMENT

The system quickly integrates with ERP, MES, Inventory Management Systems and other existing systems to ensure the continuity of information flow with absolutely no disruption to the manufacturer's on-going production.

Summary

In this paper we have discussed a set of Industry 4.0 AI techniques demonstrating how AI-based digital assistants can create value: when data collected by IoT sensors, combined with Cloud Computing and Artificial Intelligence algorithms, holistically analyzing large data sets and leveraging rich digital context into intelligent automation and predictive analytics.

The rapid integration of connected devices and sensors in advanced manufacturing environments has a direct impact on the ability of manufacturers to improve production processes, become more efficient and shorten manufacturing cycles while not compromising on quality and quality control. As OEMs quality and cost demands become stricter and production volumes and complexity increase, it becomes difficult, if not impossible, for the human mind to compute all the critical information necessary to make the optimal decision without the use of AI algorithms and relying on IIoT and connected devices.

The modernization of discrete manufacturing plants and digitization of tasks previously manually managed is transforming the industry. Manufacturers today are seeking to adapt smart Industrial IoT software for manufacturing optimization, delivering AI-driven actionable insights, alerts, recommendations & predictions. As Digital Assistants based on AI algorithms increase in their ability to process information and execute optimal decisions through the use of IIoT and connected devices, factory floors continue to increase their reliance on technology to transform their manufacturing processes and supply chain management. The Digital Assistant therefore is not a luxury anymore but is becoming a necessary tool for manufacturers to conduct their factory of the future, to make sense of their data, meet OEMs' strict requirements and remain viable and competitive.