THE OT DATA REVOLUTION

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Operational Data (OT Data), the Foundation of Industrial Digital Transformation

In the past, the ones with the fastest, the most advanced, and the most automation equipment would have stood head and shoulders above the crowd in the industrial automation game. However, with the surfacing of issues such as increasing labor cost, an aging population, the reduction of available land, and the emerging awareness of environmental protection, the original strategy of simply increasing production lines is simply not viable enough anymore. Fortunately for the industry, another door has opened thanks to the rapid development of technologies such as cloud computing, big data analysis, artificial intelligence (AI), and machine learning. As a result, "digitalization" and "intelligence" have emerged as the next big things in industrial automation development and are set to lead new advancements in the industry. This is the reason why Industrial Digital Transformation (Industrial DX) is considered to be significant by many.

The Three Stages of Industrial DX

Industrial DX is a gradual process that is divided into three stages:

- **Digitization:** Digitization involves converting the physical state (temperature, voltage, etc.) from an analog format to a digital format. Once information is digitized, it can then be collected, stored, processed, and analyzed in mass quantities by network transmission and computing technologies in real time.
- **Digitalization:** The establishment of an automated process or system on top of digitization is called digitalization. Examples of digitalization can be found in a digital dashboard responsible for collecting and analyzing the utilization rate of production equipment in a factory, a secure digital network for remote maintenance, or a system that monitors the connection between a traditional power grid and renewable energy sources. The purpose of these digital systems is to allow faster decision-making and more efficient management.
- **Digital transformation:** This refers to the process that involves comprehensively collecting, integrating, and analyzing different types of relevant data in a system. Subsequently, it creates a new digital-based operation and business model. Digital transformation can be used to improve user experiences. For example, maintenance costs can be reduced by using big data analysis to anticipate equipment failure. Thus, the maintenance behavior can be upgraded from periodic maintenance to predictive maintenance. Another example is where electricity customers can benefit from new charging models based on the actual energy generation and consumption, as opposed to the original fixed cost to purchase various green energy equipment.

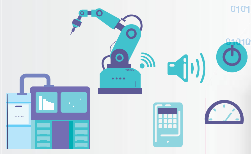
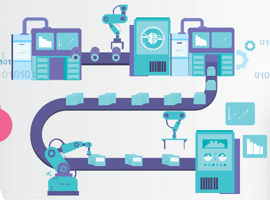
The Three Stages of Industrial DX	Digitization **OT Data** 	Digitalization **Information** 	Digital Transformation **Intelligence** 
Objectives	▪ Adding sensors to generate the necessary data ▪ Converting the analog signal derived from sensors into a digital format ▪ Converting the status of the industrial equipment and controllers into a digital format	▪ Establishing an automated digital work process through data ▪ Replacing the inefficiencies of manual labor with the capabilities of digitalization and processing large volumes of data at a frenetic speed	▪ Combining the original digital process with new digital technologies, such as the IIoT, big data analytics, AI, machines learning, etc., to identify cross-systemic problems, optimize operational efficiency, and create new commercial applications.
Examples	▪ Adding a thermo sensor to measure temperature or a meter to measure power consumption ▪ Converting the analog signal into digital data ▪ Collecting the equipment's operating status from meters, programable logical controllers (PLCs), distributed control systems (DCSs), etc.	▪ A factory's manufacturing execution system ▪ A highway's gateway control system ▪ A continuous environmental monitoring system	▪ Smart manufacturing simulation ▪ A smart microgrid or virtual power plant ▪ Preventative maintenance for equipment

Table 1 : The three stages of Industrial DX

The Pillar of Transformation: OT Data

Simply put, the key to successful Industrial DX lies in OT data. Let's consider the three stages of Industrial DX. Digitization is the collection of a large amount of OT data. Digitalization is the transformation of the said data into necessary operational and managerial information. Digital transformation is the derivation of unique business intelligence from complex operational information. With each successive stage, more value is added to the existing OT data. Therefore, connecting OT data is the first critical step in the process. Imagine digital transformation as something similar to a baby's journey from the crawling phase to the walking phase. Connecting OT data would be like "getting up." Furthermore, enterprises would only be able to successfully transform and "run" with Industrial DX by establishing a firm foundation, characterized by comprehensive knowledge and control of the OT data.

What equipment produces OT data?

- **Sensors:** They transform the physical state of an industrial site or equipment into a signal that can be processed. For example: thermo-hygrometers, ammeters, barometers will convert the physical state into voltage or a current signal for controllers to read.
- **Instrumentation:** Instrumentation will turn the signals received from sensors into digital data that can be read by on-site personnel immediately or be processed by controllers and/or monitoring systems. For example, an electrical or water meter can show on-site personnel how much electricity or water is consumed and let the control or monitoring system read the value.
- **Imaging devices:** With the advancement in processing chips and reduction in cost, more automation systems are requiring imaging equipment, making image data a new and important source of OT data.
- **Controllers:** A controller in industrial applications usually refers to a PLC, DCS, or intelligent electronic device (IED), etc. A controller receives sensor signals or meter measurement data, and it then controls on-site industrial equipment according to a set program or logic. For example, the controller will dictate the operation of a motor pump operation, tying it to water level in the tank.
- **A data acquisition and control system, or supervisory control and data acquisition (SCADA):** A man-machine interface used for automation management and control normally installed in industrial computers. For example, operators can use Power SCADA to monitor or directly control the on-site power system as well as manage a variety of important devices.

The OT Data Revolution:

Qualitative and Quantitative Changes

Industrial DX is a process in which value is continuously added to OT data, fundamentally changing OT data across multiple dimensions, specifically in terms of its quality and quantity. These changes help managers make informed decisions based on data analysis instead of a hunch. Understanding these fundamental shifts in OT data helps you gain a better perspective of the potential problems in the transformation process and set up contingency plans for these issues.

Qualitative Changes to OT Data

Industrial digital transformation has brought a "qualitative" change to OT data. We can consider these changes from two different dimensions:

The Purpose of Obtaining Data: From Monitoring to Optimization

Originally, OT data was obtained to monitor and control an automation system. Its purpose was to ensure that the system can meet the expected requirements or goals, such as:

- **Monitoring whether the equipment or system is operating accordingly,** for example, confirming the speed of a train, checking whether the valve of the sewage treatment tank is open or closed, keeping track of the operating status of a factory tooling machine, etc.
- **Controlling the equipment's operating efficiency to meet expected goals,** for example, the flow rate of an oil pipeline, the daily output of production equipment, and the power generation of a thermal power generation system, etc.

However, in the Industrial DX era, the purpose of obtaining OT data has since changed from monitoring and controlling to optimization. Such optimization creates tailored, long-term strategies that are evidence based. Through in-depth analysis of OT data's composition and modification, the key factors affecting operational performances could be indicated and managed for a better system. In more developed Industrial DX projects, common optimization goals include:

- **Improving reliability:** Preventive maintenance can be implemented to improve the reliability of equipment, as well as anticipate and prevent anomalies from occurring
- **Optimizing overall equipment effectiveness (OEE):** Identifying idle equipment in the factory to improve OEE
- **Reducing cost:** Let's take the example of a water pump. Instead of starting the pump whenever necessary, it is adjusted to pump water during those periods when high demand forecasts overlap with the seasonal electricity discounts to reduce costs

Thus, the chance of bringing forth an innovative and competitive business model transformation depends largely on users having the ability to reduce costs and increase efficiency through analysis and optimization.

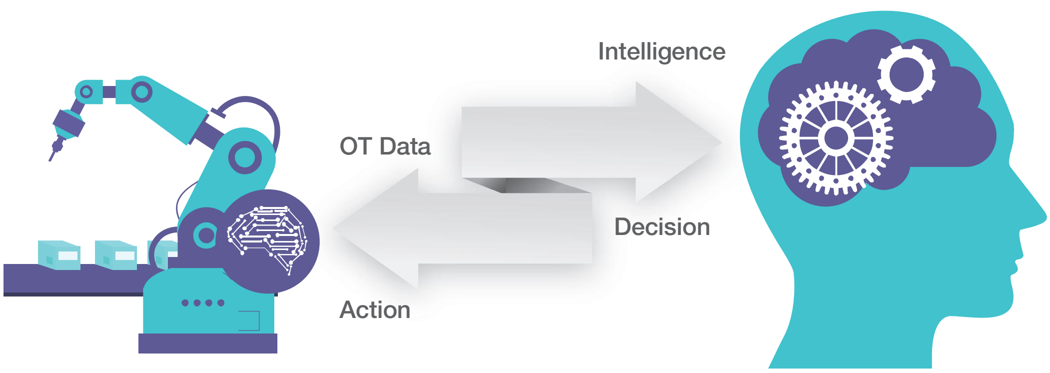
Client Case Study: Chung Hsin Electric & Machinery Mfg. Corp., South Africa

Chung Hsin Electric & Machinery Mfg. Corp integrated IIoT technology with hydrogen power generation systems to simultaneously improve efficiency and reduce maintenance costs. In the future, it could introduce a new charging plan that will transform the traditional one-time, set-price purchase of generators into a "Machine-as-a-Service" model, with monthly bills based on the actual electricity consumption. (Learn more)

The Impact of Data: From The Edge to The Core

Traditionally, OT data refers to data that exists in sensors, meters, controllers, or monitoring platforms, such as SCADA. Most of the data is discarded if the operating system is running smoothly. The small fraction of data that isn't discarded will be collected. However, instead of being stored systematically, it is usually scattered across different servers or in engineers' laptops, resulting in its eventual abandonment. In other words, in the past, OT data was either overlooked or was solely used at a very specific moment for a very limited purpose. During this period, most of the efforts were focused on ensuring OT data's reliability as it was the key to uninterrupted and efficient operations. Hence, maintaining OT data's reliability was the main goal for OT engineers.

As mentioned, OT data, however, is about to be taken to a new level. The biggest difference between the OT data of the past and the OT data of the Industrial DX era is the latter has been shaped into an integral part of an enterprise. Compared to its old self, OT data is now a digital asset meant to be used by other digital systems and can generate higher values through various interactive analysis and integration. Therefore, corporate executives are now investing in digital corporate operation dashboards, which instantly display the operational statuses of equipment in factories and other businesses. Data analysis systems such as AI and machine learning, which help companies react promptly and make the right calls, are also popular technologies executives are investing in. Thus, OT data's influence has increased exponentially by moving away from its original purpose of simply ensuring smooth system operations to playing an integral part in business decision-making. With the growth in its importance, simply maintaining the stability of OT data is no longer enough. For enterprises to step into Industrial DX smoothly, "high-quality" data is now required. But what is considered "high-quality" for OT data? Find out in the next chapter.



OT data's reach has expanded from controlling end devices to business decisions

Quantitative Changes of OT Data

In addition to qualitative changes, OT data has also undergone "quantitative" changes. We can consider these changes from four different dimensions:

Variety: Require “Deeper” and “Wider” Data

The traditional control system already relies on a large amount of OT data to operate. Operational data, which is used to indicate the operating status of a system at a certain time, can be simple, such as the position of a water gate and daily oil production, or it can be complex, such as production recipes, processes, etc. However, Industrial DX requires more diverse data on two levels:

- **"Deeper" data:** Take the predictive maintenance of CNC machines as an example. To accurately predict when certain machines would require maintenance or provide preemptive upkeep, more in-depth information is required. In addition to the basic machine operating status, the vibration frequency and current value of the motor must also be collected for analysis. However, the general CNC processing machine does not provide these two kinds of data sets in an easily comprehensible way. Therefore, in this case, additional vibration sensors or meter measuring instruments are needed to obtain the “deeper” data.
- **"Wider" data:** “Wider” data is basically cross-spectrum data that needs to be analyzed with other systems or even third-party data. For example, to accurately anticipate and make the subsequent adjustments to ensure overall power grid stability, traditional power companies need the power output estimations from renewable energy companies. To make these estimations, renewable energy companies have begun to incorporate weather forecasts as an important reference. Individually, each data set is not meaningful for power generation, but together, they form a clearer and more valuable view of the power grid. Hence, to garner information for the power grid that is both useful and comprehensible, data needs to be pulled from a wide spectrum. measuring instruments are needed to obtain the “deeper” data.

The foundation of Industrial DX is built on data that is not just found at the core of a control system control, but also “deeper” in critical equipment of the same system, and “wider” from other systems.

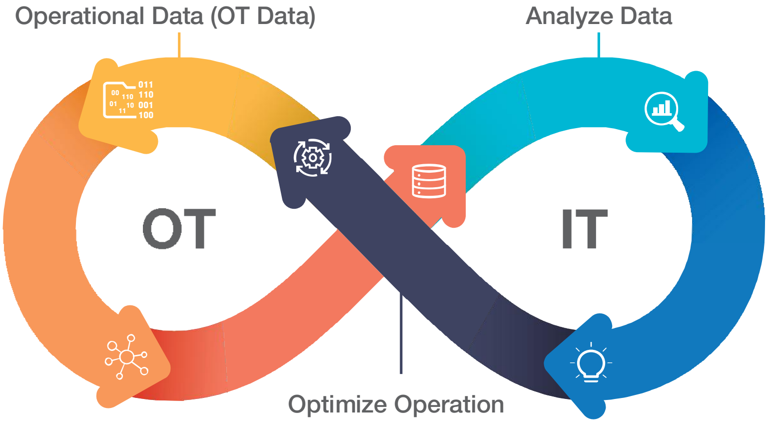
Examples of the types of new OT data needed, and how to acquire it, include:

- Installing an electricity meter to analyze the relationship between production capacity, system power consumption, and electricity cost.
- Installing temperature and humidity sensors to analyze the effect these environmental factors have on production efficiency or output quality.
- Installing a remote I/O to read and record the operating status of production equipment (running, standby, fault, etc.).
- Reading the historical usage of methanol in fuel cells in remote areas to estimate future usage and arrange replenishment plans.
- Using aerial cameras to obtain images of solar panels on the ground to analyze the relationship between the degree of solar panel pollution and power generation to set up maintenance plans.

Velocity: Require Circular Feedback of Data

The main reason traditional automation systems focus on real-time data is to gain better control of the devices. In this case, OT data only represents a specific state in this linear control process. When the process is over, the OT data disappears because it has served its sole purpose. Often, the only time this data is retrieved is when a major problem occurs. In case of an anomaly, the OT data, in essence treated as historical data. is retrieved for postmortem analysis.

Real time in industrial digital transformation refers to the promptness in displaying, analyzing, and feeding back OT data. By combining the capabilities of big data processing and maturing edge computing technology with faster network transmissions, a large amount of OT data can be converted into a format that allows for real-time or near-real-time streaming. This creates a continuous and accelerating OT data cycle, which starts from the equipment and flows continuously to the IT system for analysis. The analytic results are then immediately fed back to optimize the operating efficiency of the OT equipment. Thus, an effective circle of life for OT data is born.



Large Volumes: Require Reliable Network to Stream More Diverse Data

A large-scale automation system (for example, the distributed control system of an oil refinery) could already process hundreds of thousands of data per second in Industrial 3.0. However, once the machines stopped working, the data lost its value. In other words, when the devices stopped working, so did the data.

Digital transformation makes sure no data is left behind. By obtaining large amounts of data, digital transformation seeks the meaning beyond the surface value and the potential influences between a wide variety of data so that it would keep working and create value, even when machines are not. Similar to a mutual communication platform that helps employees in cross-departmental collaborations work together effectively, a mutual network that can easily transmit a large amount of OT data is needed in order for each system to obtain and share each other's OT data. The two requirements to build this network are a high transmission volume and stable streaming.

Regarding the former, the need for diverse and real-time OT data has increased its volume. In addition, as high-definition images gradually become an important source of OT data, the number of transmissions has doubled.

Regarding the latter, as Industrial DX applications require a comparatively longer period for data analysis, the analysis could be inaccurate if the collection process is constantly interrupted or incomplete. Therefore, building an OT transmission network that can provide a stable stream over long periods in an outdoor or harsh setting (extreme temperatures, electromagnetic interference, etc.) will be necessary.

However, providing an OT transmission network that offers stable and uninterrupted transmission of massive volumes of OT data is a challenge still waiting to be resolved.

Veracity: Require The security of Data and Networks

Digital transformation is a data-driven movement, thus, elevating the importance of the accuracy and security of data. Though not as sensitive as personal privacy, OT data may include information regarding special production processes (for example, a company's secret sauce recipe) or even operational details of the monitoring equipment of key infrastructure or manufacturing facilities (such as water plants, power grids, oil refineries, etc.). If this important information is incorrectly or maliciously tampered with, it could cause immeasurable loss.

Therefore, the protection of the basic data transmission network between IT and OT is critical. Connecting a variety of OT equipment with IT systems for data transmission normally results in a much more complicated network that is vulnerable at many entry points to cyberattacks. For example:

- Wireless networks are used to collect equipment data, yet the equipment is not authenticated and managed
- Performing remote maintenance without protective cybersecurity
- Connecting high-risk devices to the internal OT network without scanning for viruses
- OT maintenance personnel lacks cybersecurity awareness and unintentionally downloads malicious software.

In recent years, the reported cases of cybersecurity attacks on factories and infrastructure have increased tremendously. These attacks have often caused the loss of millions to tens of millions of dollars. Therefore, ensuring the security of OT data is a critical lesson every company must prepare for prior to entering the Industrial DX arena.

Client Case Study: OT Cybersecurity Pushes Collaborations Between OT and IT, Asia

A leading semiconductor company and a leading transportation company experienced similar situations when they wanted to enhance the cybersecurity of their OT automation systems. Sorting out which department—OT or IT— should take the lead was the first hurdle to overcome. Each IT department believed it could not manage the equipment on the respective production line or traffic monitoring system. On the other side, both OT departments argued that cybersecurity was not within their job description. To solve the issue, each OT department recruited a cybersecurity expert who was also familiar with industrial control systems. On their part, the IT departments invested effort into gaining more visibility on the security status of the OT system. Now, both departments in each company are working together to prepare the security requirements for Industrial DX.

Changes	Factors	Before	After
Qualitative Change (P&I)	Purpose	• Monitoring and controlling automation systems	• Decision making and optimization
	Impact	• Reliable OT data • OT data only impacts solitary equipment or a system • OT data is only circulated internally where the equipment is located, and it will not be transmitted off-site	• High quality OT data • OT data impacts the operation of multiple equipment or systems • OT data is regularly used by more systems and will be transported from a site to cloud platforms
Quantitative Changes (4Vs)	Variety	• Data is only created by equipment or the core devices in the system • Only data directly connected to the control system or operational results is needed	• The original data needs to be combined with outside or third-party data for overall operational purposes • Deeper: Data related to the operating device or system, such as voltage, currency, temperature, etc., during operations • Wider: The third-party data related to the operating efficiency of the equipment, such as weather, electricity, transportation, or information related to the operation
	Velocity	• Focus on real-time control • Data analysis only used for postmortem (weekly/monthly reports) or only when problems occur.	• Focus on the real-time display of OT data • Focus on real-time analysis and feedback of OT data • Real-time data streaming from the ground to the cloud
	Volume	• Data volumes vary according to the complexity of the control system. The more complex the control system, the more data is required. • Most of the data does not need to be stored or transmitted to other systems for analysis	• The variety of high-frequency and real-time OT data increases data transmissions • Large volumes of data require storage, including historical data • Large volumes of data transmit between systems to enhance efficiency
	Veracity	• Relies on physical security systems, such as access control. Believes that once the door is closed, it's safe. • Cybersecurity and network security are nice to have. They are IT's responsibility, however	• Industrial DX opened the door for cyberattacks on OT/IT networks; factories and key infrastructures are constantly under attack • Traditional industrial network equipment lacks the necessary security mechanisms to protect against cyberattacks • Cybersecurity becomes a must-have for industrial networks. It requires the collaboration between IT and OT

Table 2: The qualitative changes (P&I) and quantitative changes (4Vs) of OT data brought forth by Industrial DX

What Can We Do Going Forward With the Qualitative and Quantitative Changes of OT Data?

The qualitative changes of OT data brought forth by the Industrial DX are prompting organizations to set new goals. Subsequently, enterprises must now consider how to make corresponding changes. Most companies that have successfully pushed through transformation have adopted the following strategies:

- **Set clear long-term goals for the organization:** As meaningful changes take time, there is the risk of losing sight of the original goal down the line. Hence, organizations must first set clear, long-term goals to ensure that everyone is onboard before each department sets its own priorities, so that everyone can gradually move cohesively towards the finish line.
- **Set KPIs to help with cross-departmental integration:** Set up cross-departmental collaboration projects related to OT data and monitor the outcome. Joint projects such as these break down the barriers between departments and help employees at different organizational levels understand the benefits of digitalization and cross-departmental integration.
- **Start small:** Test run with a small project. Small projects often reflect what works and what doesn't within an organization relatively quickly. Dynamic adjustments can then be made accordingly when problems are identified. This would allow the enterprise to find the right path to digital transformation efficiently.

When facing the four quantitative changes in OT data (variety, velocity, volume, and veracity), enterprises must adapt the attitude of continuously learning and embracing digital technology. This will help you transition smoothly into digital transformation.

Variety

Facing challenges from the so-called “variety” changes, consider adding two OT data-related skills:

- **Analog/digital conversion:** To obtain more in-depth operating data from key equipment, especially ones without digital format conversion capabilities, consider installing new industrial-grade sensors, supplemented by remote I/O devices with analog/digital conversion functions.
- **OT equipment communication protocol conversion:** Since different equipment or OT systems use different proprietary data communication protocols, cross-schematic OT data acquisition can be a challenge. In these cases, consider using industrial protocol gateways and industrial IIoT gateways to convert the data hidden in different industrial equipment, controllers, and human-machine interfaces into a single data format for transmission and analysis.

Velocity

Facing the challenges from the so-called “velocity” changes, focus on establishing a fully automatic OT-IT data circulation channel to reduce manual interventions. OT data can be continuously added through the three major stages of the process (display, analysis, and feedback). The two most common issues to consider when establishing this cycle of OT data are:

- **Seamless conversion of IT/OT data streams:** For OT data to be successfully analyzed by the IT system, a slew of background information, such as data source, data unit, data format and collection time, etc., needs to be provided. If this data isn’t properly converted, manual intervention will be required, causing the system to lag.
- **Smart edge-cloud integration:** Use AI at the edge to resolve on-site issues in real time without relying on a cloud analytic system to come up with a solution.

Volume

Facing challenges from the so-called "volume" changes , it is necessary to construct a high-speed and stable OT data transmission network. Two points should be noted when building this network:

- **Use data transmission technology with high bandwidth and a backup mechanism:** Technologies such as 10 Gigabit ultra-high-bandwidth industrial Ethernet, time-sensitive network (TSN), Wi-Fi 6 or industrial 5G, and other new-generation wired/wireless communication devices are recommended.
- **Manage the volume and flow of data:** When dealing with the flow of large volumes of data, a unified, cross-unit OT data management platform or visualization tool should be established to systematically store and manage the data. This will enable different departments to meet each other's data application requirements.

Veracity

Facing challenges from the so-called "veracity" changes, it's important to first understand that there is no perfect solution for cybersecurity. Nothing is 100% secure. The only thing to do is to effectively reduce risks through good management. The following three aspects need your serious consideration:

- **Security comes from design:** The strength of a system's security is predetermined at conception. Therefore, it is necessary to preemptively think about the situations where cyberattacks may occur, and when designing or updating a system, it is crucial to also incorporate the corresponding cybersecurity protocols.
- **Supplier security management:** Besides managing the security of the company's own system, many cybersecurity incidents are caused by the products or services provided by third-party suppliers. These suppliers could create vulnerabilities within the company's system by accident (for example, by providing computers containing ransomware).
- **Improving staff cybersecurity awareness and crisis management ability:** It is necessary to provide appropriate cybersecurity training for IT and OT maintenance personnel to improve awareness and avoid being the source of cybersecurity vulnerabilities.