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Create Value for Your Mass Customization with Manufacturing Strategies

Multiple Production Strategies for Mass Customization

Tips for How to Roll Out CPS-based Mass and Customized Smart Production

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Create Value for Your Mass Customization with Manufacturing Strategies

Abstract

Industry 4.0 is revolutionizing production systems and reshaping the manufacturing landscape. The introduction of cyberphysical systems (CPS), Industry 4.0, and the Industrial Internet of Things (IIoT), has opened up the possibility of mass customization across production lines. Mass customization is becoming increasingly important for the manufacturing industry because it creates the possibility of IIoT-ready and CPS-based smart production, which provides manufacturing firms with opportunities to carry out multiple production strategies. In addition, manufacturing firms can improve their competitive position by allowing them to react quicker to changing consumer demands.

Multiple Production Strategies for Mass Customization

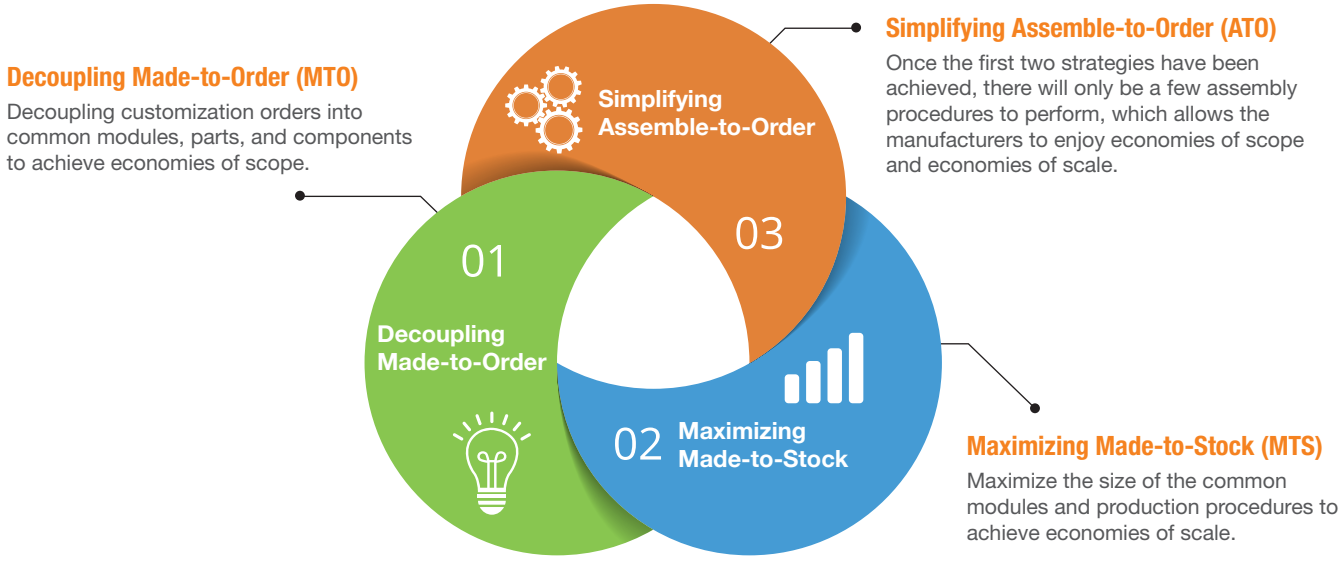


Figure 1: Multple Production Strategies for Mass Customization

Mass customization can be achieved by integrating three strategies that will increase the value for both manufacturers and customers. The first manufacturing strategy is Made-to-Order (MTO), whereby the production begins by intelligently combining orders from multiple customers, which are then decoupled into common modules, parts, or components to allow for economies of scope. One of the main advantages of economies of scope is that it opens up the possibility to create diverse product designs and offerings and allows businesses to create more value for their customers.

The second manufacturing strategy is Made-To-Stock (MTS), which involves the common modules being made as close to complete as possible. The reason for this is that when the customer places their customized order, most of the product has already been made and there is a minimal amount of work to perform until the product is finished. By following this work procedure allows customized orders to be fulfilled much quicker than if the process starts from scratch after a customized order is received. For this strategy, the modules must be identical, so the manufacturer has to ensure that quality assurance is to the highest standards. This strategy allows the manufacturers to enjoy economies of scale, which significantly reduces their production costs.

The last strategy that manufacturers can take advantage of is Assemble-To-Order (ATO), which is achieved by combining the product's previously produced modules on custom production lines. As the modules have already been made, it requires minimal time and effort to meet the customer's specific order, which allows the manufacturer to enjoy both economies of scope and economies of scale. Since this tailor-made production only requires minimal effort to combine modules when an order from a customer is received, it eliminates problems that often occur in the manufacturing industry such as stockpiling or surplus stock.

Changing Industrial Landscapes

One of the leading trends to emerge from the IoT and IIoT is digital transformation. The manufacturing industry has eagerly embraced digital transformation and is already being revolutionized by it. It is predicted that worldwide spending on the IoT will continue to be hundreds of billions of dollars in 2018, with around a quarter of that being spent on the manufacturing industry. The manufacturing industry is eagerly embracing IoT technologies because of a strong desire among business owners to streamline production systems and deploy cyber-physical systems to connect factories. In order to achieve this, factories have to connect more of their machines and equipment to the Internet as well as ensure that their devices can perform more intelligently and operate with greater autonomy, which will in turn allow business owners to react to any changes that their customers request. Only when they have achieved this, will they have a mass-customization production model.

Under the multiple strategies of mass customization, it is recommended to design and deploy flexible, connected, and modularized smart production lines. Combing CPS and IIoT technologies is beneficial because infrastructure based on CPS can be easily integrated with other systems such as MES and WMS. This ensures that the key factors that are required for mass customization such as flexibility, modularity, and connectivity are available for the manufacturers to meet the customer's requests quickly. The CPS- and IIoT-integrated smart production lines can then connect physical processes and systems to facilitate product design that is independent from the control center. The result is improved data transparency, enhanced security, and ease of access. Furthermore, the connected smart production lines can communicate with each other and with human operators in real time, which streamlines and simplifies various manufacturing processes.

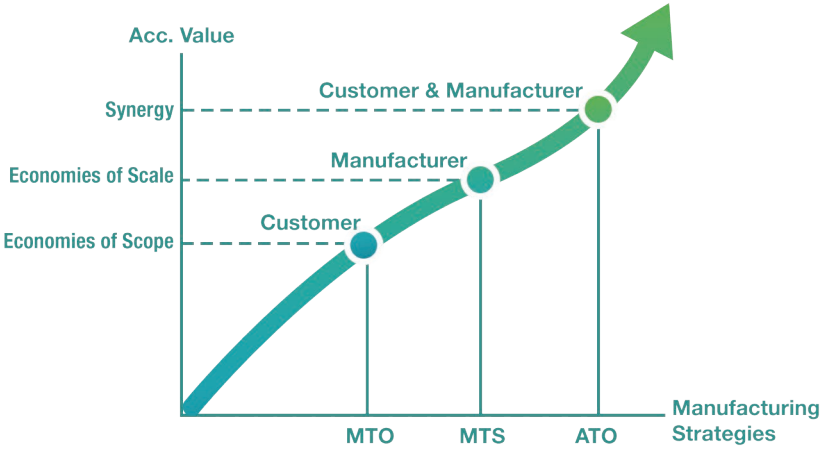


Figure 2: The Accumulative Value from Mass Customization Strategies

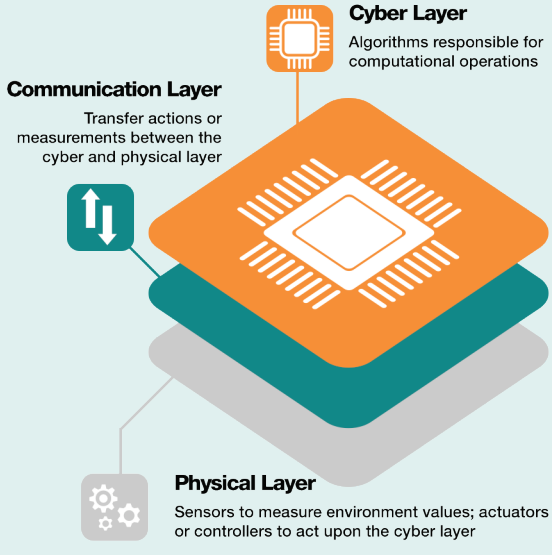
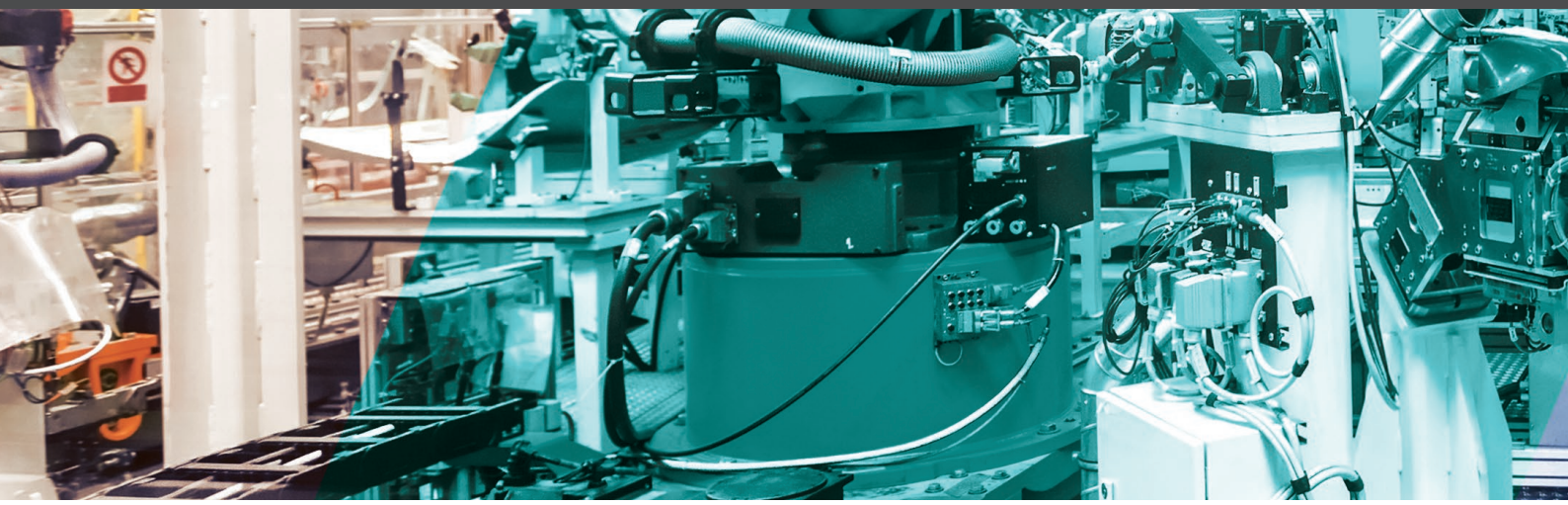


Figure 3: Cyberphysical System Structure

About Cyber-Physical Systems

Cyber-Physical Systems (CPS) send signals from the physical world to the digital world. CPS combines communications, control, and data acquisition technologies to develop the entire system for IIoT applications. A CPS structure is comprised of three main layers: physical, cyber, and communication. The three layers each perform different functions. The physical layer is where sensors measure parameters such as temperature, vibration, power, and images to ensure operations are normal. These readings are then acted upon by actuators or controllers in the cyber layer, which are controlled by algorithms. Finally, the communication layer uses IIoT technologies and devices such as Ethernet switches, serial device servers, protocol gateways, and I/O devices to transfer data and commands from the physical to the cyber layer.

Due to the advances of CPS and IIoT technologies, mass customization is now playing a major role in the evolution of production systems. Being able to customize the color, function, feature, or style of a product allows manufacturing firms to maintain their advantages in competitive environments.



Tips for How to Roll Out CPS-based Mass and Customized Smart Production

In smart factories that are capable of mass customization, the mass production line and custom production lines are connected at both the physical and the cyber layer to carry out the three strategies. After decoupling the modules from the customization orders, the components, parts, and materials that are required will be allocated accordingly by the Enterprise Resource Planning (ERP) system. After this, the customization orders will automatically be converted into Bill of Materials (BOM) and production orders, so that the Product Lifecycle Management (PLM) and Advanced Planning and Scheduling (APS) systems can generate production plans. With the systems connected, the production plans will then be automatically implemented by the Manufacturing Execution System (MES) and start production to bulk produce the uniform modules that are as closed to finished as possible. Finally, different modules will then be sent to the assembly lines to perform customized assembly procedures for different models.

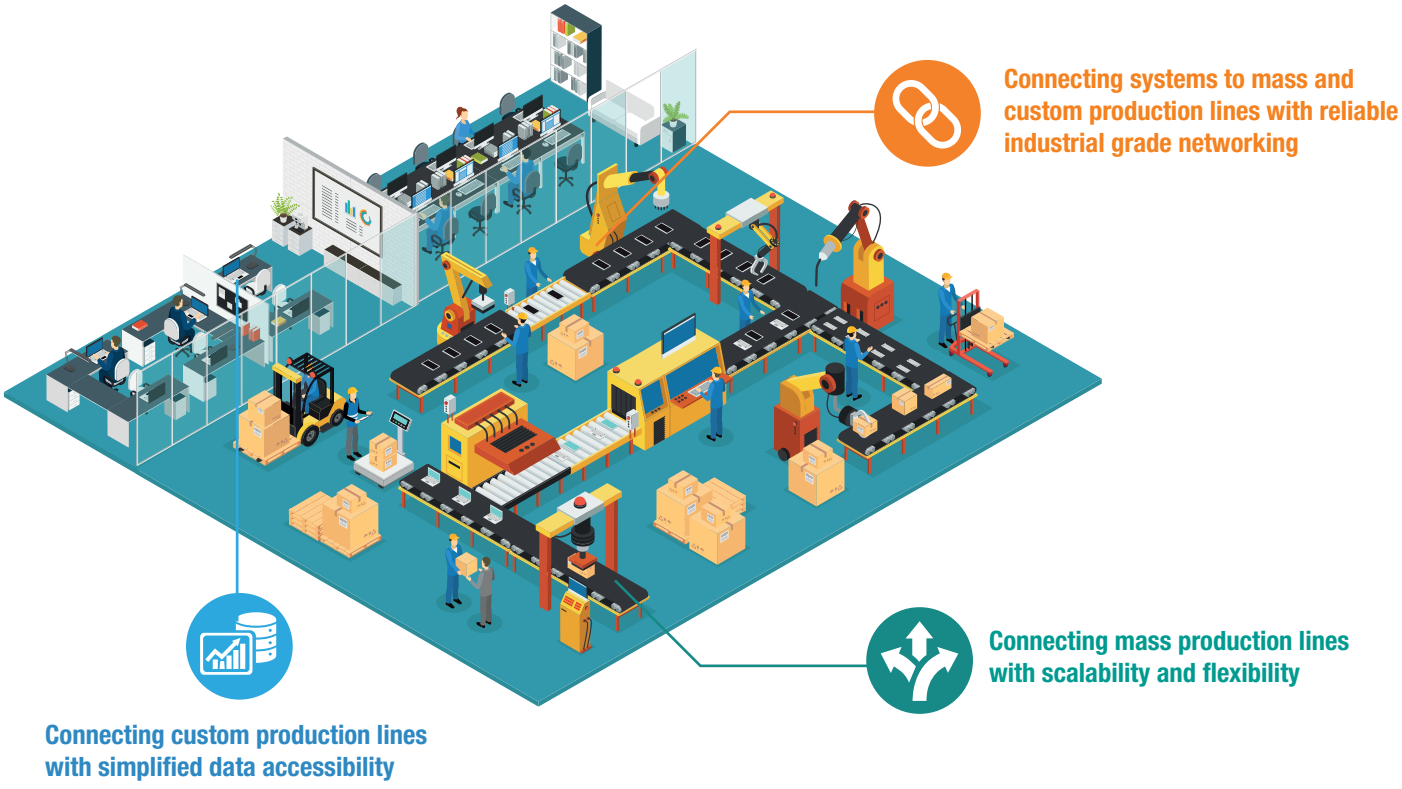
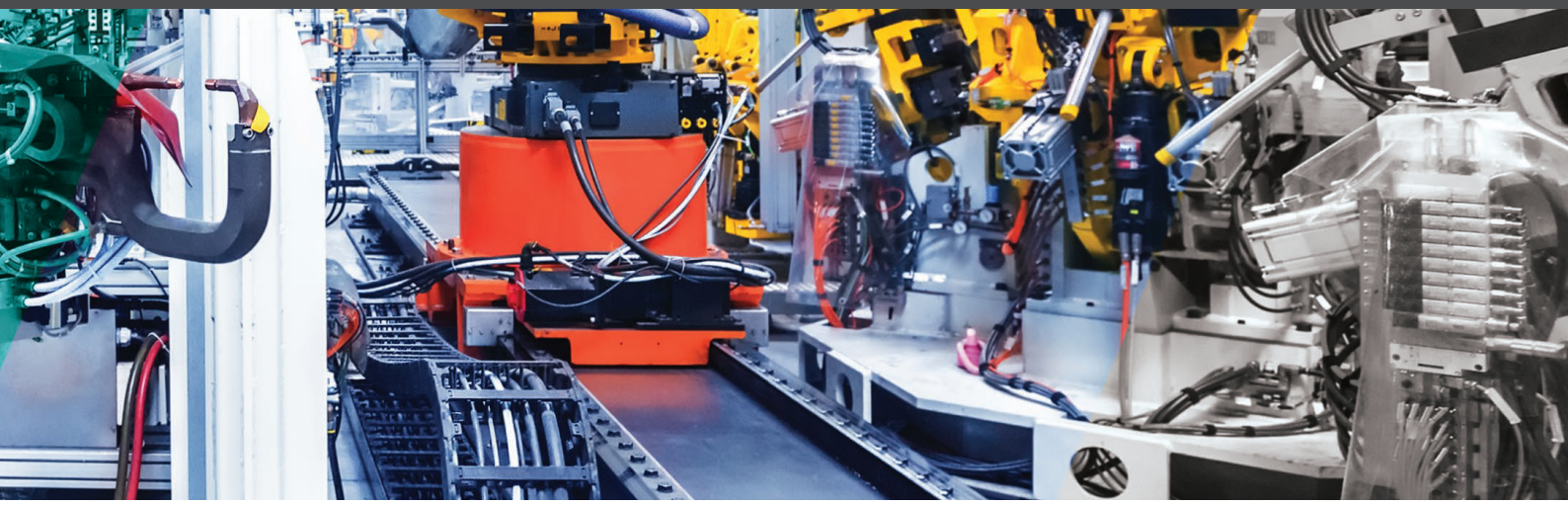


Figure 4: CPS-based Smart Production for Multiple Mass Customization Production Strategies



Connecting Mass Production Lines

In the real world where mass customization takes place, machine fleets are often located in discrete areas of the shop floor or even across factories in different locations. Connecting the machines with reliable wired and wireless industrial networking solutions will give business owners the flexibility to dispatch receipts and orchestrate changeover remotely easily.

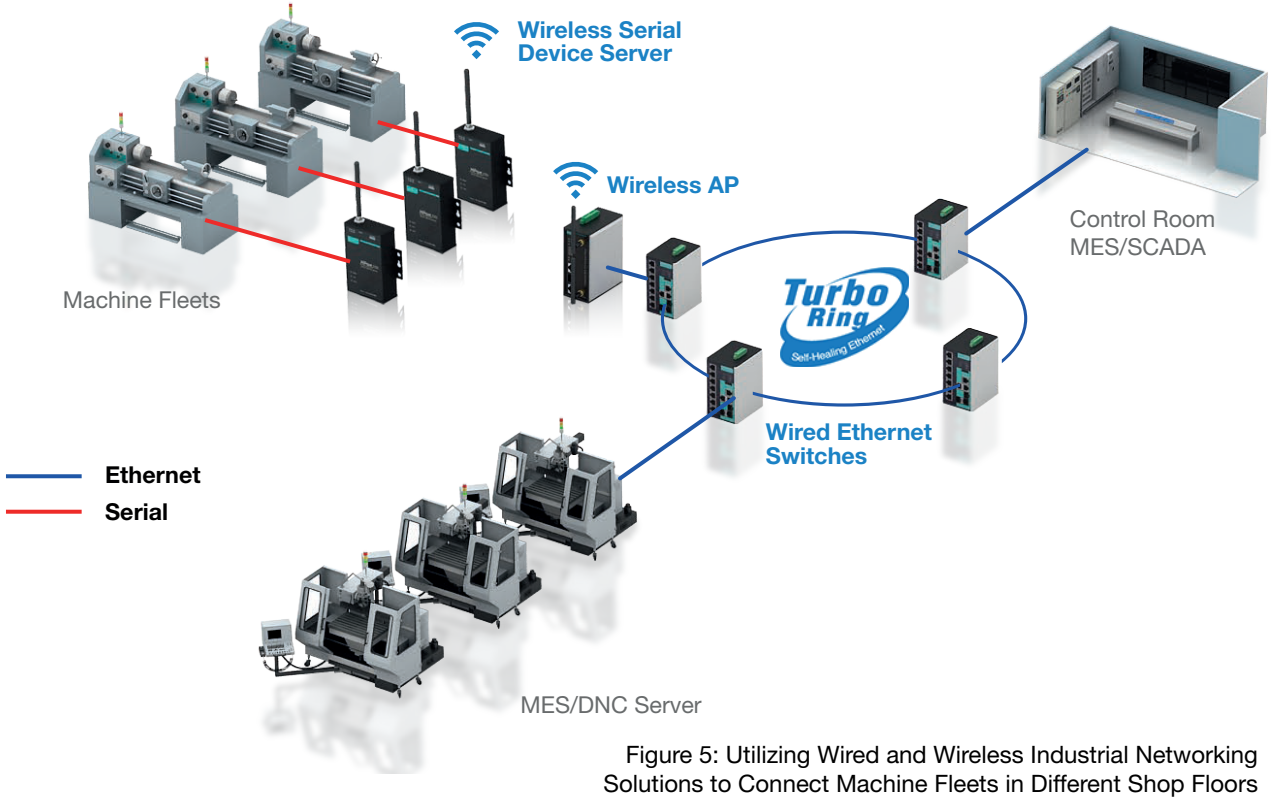


Figure 5: Utilizing Wired and Wireless Industrial Networking Solutions to Connect Machine Fleets in Different Shop Floors

In order to achieve scalability, the machine fleets have to be grouped or regrouped easily in the system to ensure smooth auto-changeover. An easy-to-configure and scalable networking system with technologies such as Network Address Translation (NAT) can help the production manager regroup or scale-up machines in production lines quickly.

Connecting Customized Production Lines

Customized production lines utilize Standard Operating Procedures (SOPs) that involve robots performing complex assembly processes automatically to assemble different modules for the respective models. After this process has taken place, the finished goods will be packed according to the orders that were placed by the customer. This is a complex process that requires the production lines to have a variety of sensors, machines, and equipment to work together on both the physical and cyber layers. Here, it is very important that all of the sensors, machines, and equipment that use different protocols and interfaces can communicate with each other. Therefore, data accessibility plays a vital role to the success of the ATO manufacturing strategy. For mass customization, the system has to optimize production schedules and coordinate processes effectively between mass and customized production strategies. During the mass customization process, delays and stoppages cannot be tolerated, as the process is very heavily reliant on data from the machine fleets. An interoperable connectivity strategy that includes protocol conversion, media conversion, and data aggregation considerations can significantly reduce the amount of effort required to access the data.

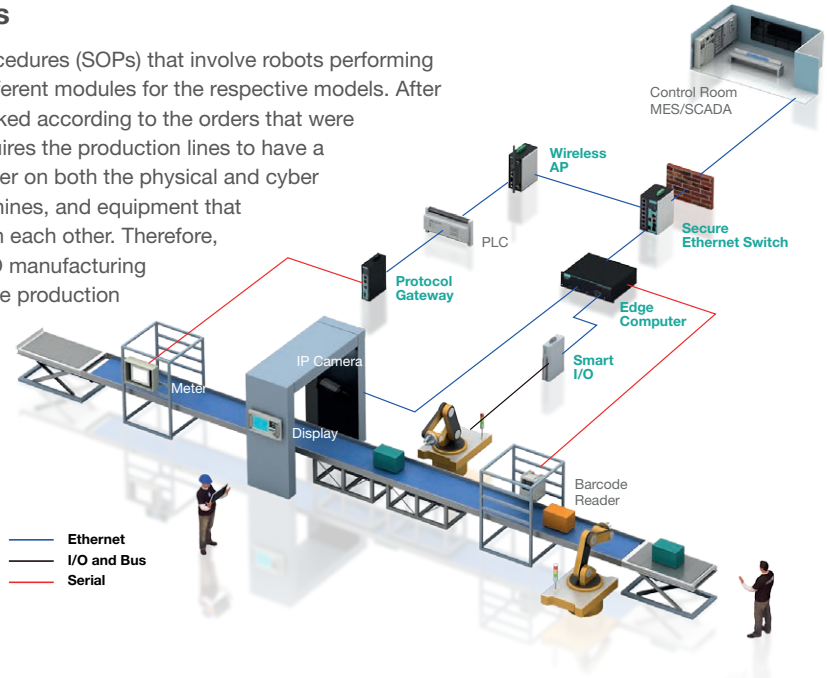


Figure 6: Utilizing Protocol Gateways, Serial Device Servers, and Edge Computers to Convert Protocols, Interfaces, and Aggregate Data in Customized Production Lines to Simplify Data Access

Reliable Connection for Smart Production Lines

Data transmission across smart production lines involves multiple types of data and mainly occurs in real-time or near real-time. When this data transmission involves image processing, larges amount of data are transmitted. On smart production lines, if data is lost during the communication process, it is likely to cause system errors that result in unplanned stoppages that delay the schedule, waste materials due to mistakes being made by machines not receiving the correct data, as well as requiring extra effort by personnel to reconstruct or realign the data.

In order to prevent the above issues from occurring, Moxa's Turbo Ring technology supports up to 20 ms fast recovery times, ensuring that, when the network is down, any unicast or multicast data transmission can immediately go through a new path.

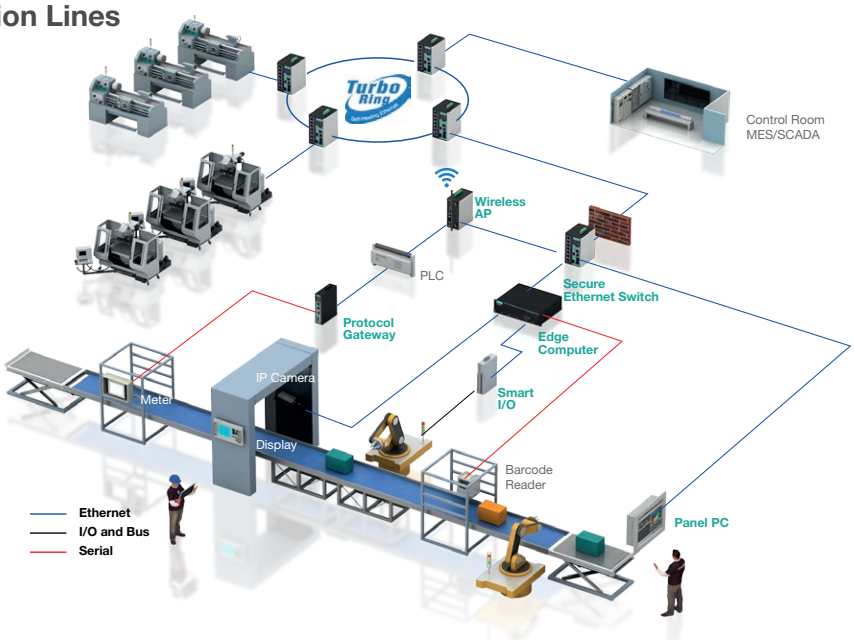


Figure 7: Utilizing Turbo Ring Technology to Build Redundancy for Connecting Mass and Custom Production Networks

About Multicast Traffic Recovery

Programmable Logic Controller (PLC) networks rely on the IGMP (Internet Group Management Protocol) for multicast transmissions to check the availability of the system between PLCs and devices. However, IGMP requires up to 125 seconds to update multicast transmission paths. When the network is down, the ring transmission path changes immediately, but the multicast transmission path does not. When proprietary redundancy technologies are used, the multicast traffic can recover in 50 ms, which significantly decreases the risk of system failure.

Connect Smart Production Lines for Mass-Customization

Mass customization is imperative to ensure that manufacturers have a competitive advantage but it is essential that they have identified and assessed the challenges and opportunities and understand how Industry 4.0 technologies can assist them to achieve their goals. Business owners should start by defining the scale and scope of their hybrid production strategy and then connect mass production and customized production lines in order to improve the efficiency of their operations.

Mass-Customization Hybrid Production Strategy		
Decoupling MTO	**Maximizing MTS**	**Simplifying ATO**
Decoupling customization orders into common modules, parts, and components	Maximizing common modules and production processes	Simplifying assembly procedures to combine maximized common modules accordingly
Value to Customer and Manufacturer		
Economics of Scope	Economics of Scale	Synergy
Connecting Tactics for Hybrid Production Strategy		
Connecting ERP, PLM, APS, and MES to mass and custom production lines with reliable industrial-grade networking	Connecting mass production lines to ensure scalable and flexible solutions	Connecting custom production lines by utilizing simplified data accessibility
Key Considerations for Connecting Strategies		
• Wide operating temperature capability • Industrial grade EMI/EMC certificates • Supports industrial communication protocols • Industrial redundancy technologies	• Flexible wired and wireless industrial networking • Easy-to-configure and scalable industrial networking system	• Easy for different protocols and interfaces to communicate

Your Trusted Partner in Automation

Moxa is a leading provider of edge connectivity, industrial computing, and network infrastructure solutions for enabling connectivity for the Industrial Internet of Things. With over 30 years of industry experience, Moxa has connected more than 50 million devices worldwide and has a distribution and service network that reaches customers in more than 70 countries. Moxa delivers lasting business value by empowering industry with reliable networks and sincere service for industrial communications infrastructures.

The Americas

Moxa Americas
Toll Free: 1-888-MOXA-USA
Tel: +1-714-528-6777
Fax: +1-714-528-6778
usa@moxa.com

Moxa Brazil
Tel: +55-11-95261-6545
brazil@moxa.com

Europe

Moxa Germany
Tel: +49-89-37003-99-0
Fax: +49-89-37003-99-99
europe@moxa.com

Moxa France
Tel: +33-1-30-85-41-80
Fax: +33-1-30-47-35-91
france@moxa.com

Moxa UK
Tel: +44-1844-355-601
Fax: +44-1844-353-553
uk@moxa.com

Asia-Pacific

Moxa Asia-Pacific and Taiwan
Tel: +886-2-8919-1230
Fax: +886-2-8919-1231
asia@moxa.com
japan@moxa.com
taiwan@moxa.com

Moxa India
Tel: +91-80-4172-9088
Fax: +91-80-4132-1045
india@moxa.com

Moxa Russia
Tel: +7-495-287-0929
Fax: +7-495-269-0929
russia@moxa.com

Moxa Korea
Tel: +82-2-6268-4048
Fax: +82-2-6268-4044
korea@moxa.com

China

Moxa Shanghai
Tel: +86-21-5258-9955
Fax: +86-21-5258-5505
china@moxa.com

Moxa Beijing
Tel: +86-10-5976-6123/24/25/26
Fax: +86-10-5976-6122
china@moxa.com

Moxa Shenzhen
Tel: +86-755-8368-4084/94
Fax: +86-755-8368-4148
china@moxa.com

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