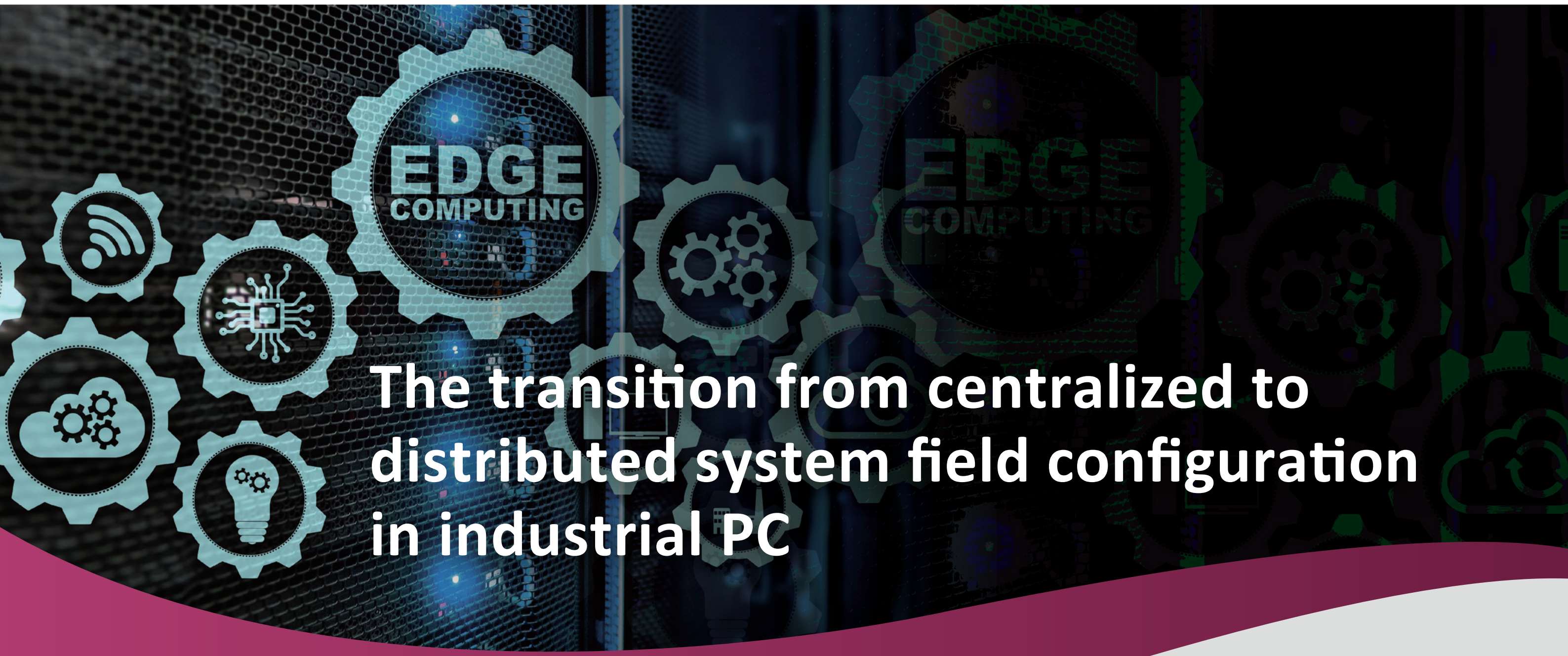

The transition from centralized to distributed system field configuration in industrial PC

White Paper

Introduction

In terms of industrial computing field configurations, system integrators and end users prefer distributed systems over centralized systems, which can be seen in almost every application, especially in recent years. The transition brings advantages in many aspects and the following contents introduce them and provide real a case study.

In brief, the trend is that users deploy more edge systems for different functions respectively, to replace only one high-performance system for all the workloads. Moreover, utilizing edge systems brings countless advantages including minimizing latency, bandwidth efficiency, redundancy, and even deploying AI at the edge.

Also, each system can be tailor-made in configurations to optimize performance and scalability. The multiple individual systems can also be upgraded and repaired individually. What's more, the redundancy allows the systems to replace the function for each other when failure happens. With the flexibility, the whole solution could reduce messy wiring as well and be more cost-effective. The various form factors of the systems also require smaller space than centralized systems.

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Advantages of Distributed Systems in Field Configuration

Taking smart city and technology enforcement for an easy example; a few cameras at an intersection share an edge system to process the images of anomalies such as traffic violations and accidents. Once the images are processed at the edge, the packet would be much smaller and the transmission to the server in the control room would be much faster. Therefore, this leads to more real-time responses, potentially saving lives.

Since the packet is smaller, no matter whether it is transmitted via a wired network, 4G LTE or even 5G, the overall cost can be lower.

On the contrary, without edge systems on-site, the surveillance cameras have to transmit large volumes of data to the server. Hence, the transmission and analysis can take much more time and computing power for the tasks. (Figure 1.)

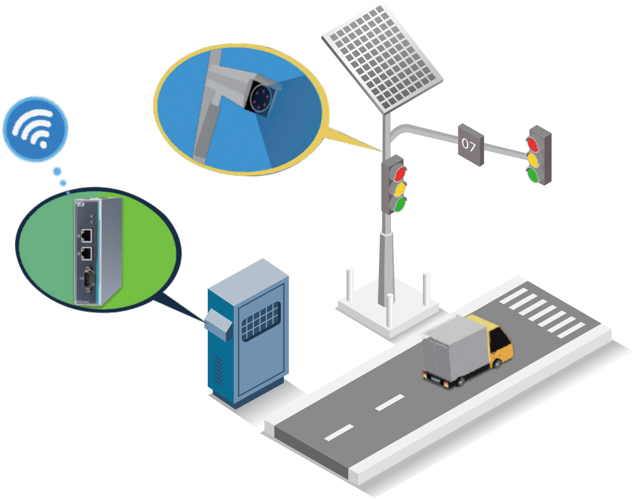


Figure 1. As the data is processed at the edge, the application can achieve real-time response with smaller data packets and less demand for net bandwidth.

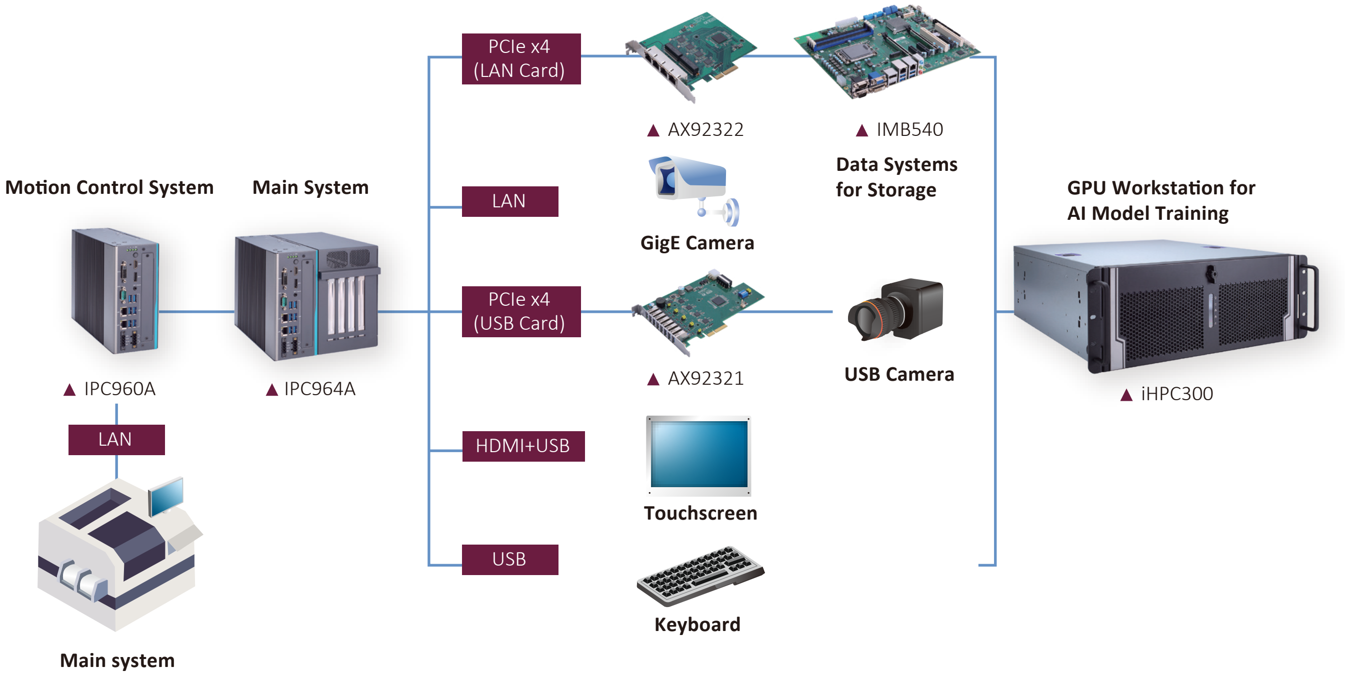
Challenges of Centralized Systems: Upgrades and Accidental Failures

Witha centralized system field configuration, it saves costs of systems, power, and space while one system can multitask with several AI models.

However, this configuration, while efficient and cost-effective, presented its own set of challenges. The foremost concern was processing power. Running four AI algorithms simultaneously demanded a more sophisticated CPU or refined models. This also made future upgrades a tricky proposition, as a single system might not be scalable enough to handle heavier workloads. Any inevitable upgrades would result in additional costs and complexities.

In the event of system failure, the centralized setup meant that all algorithms were at risk of going offline simultaneously, potentially causing significant disruptions to operations. Similarly, individual updates or maintenance of AI algorithms became more challenging when tightly integrated into a single embedded system, possibly requiring the entire system to be halted.

Case Study of Distributed System: Wafer AOI systems



Deploying multiple edge systems in a distributed manner significantly enhances the efficiency and performance of automation applications. In an automated optical inspection (AOI) system for wafer fabrication, various IPC industrial systems are strategically positioned at the edge to maximize functionality and performance.

Motion Control System - IPC960A

The motion control system governs the precise movements ofrobotic arms responsible for placing wafers onto inspection platforms. For this critical step, the recommended choice is the fanless IPC960A. It boasts a 12th/13th gen Intel® Core™ processor, offering robust computational power. The inclusion of 2.5G and GbE LAN ports facilitates high-speed communication. Then, they enable seamless coordination with the main controller, while also supporting diverse motion control protocols.

Main System - IPC964A/ IPC970

Functioning as the cornerstone of the solution, at the mainstream level field configuration, the main controller executes AI algorithms and collaborates with the motion control system to execute automated optical inspection tasks. The system is meticulously designed to meet and exceed industry standards, including EN 61000-6-4 and EN 61000-6-2, ensuring seamless performance in even the most challenging electromagnetic environments.

The IPC964A, equipped with a formidable 12th/13th gen Intel® Core™ processor and dual DDR5 slots, perfectly aligns with these demanding requirements. The IPC964A supports a half-size accelerator card, allowing it to connect to a GPU and various types of cameras (GigE/USB 3.0) via a frame grabber. This enables real-time AI visual recognition and control with I/O cards.

Its triple display capability and M.2 Key B for the 5G module enable real-time on-site and remote monitoring, while the six USB 3.2 Gen2 ports effortlessly connect to cameras or edge devices. Streamlining maintenance processes, our software-enabled USB power control facilitates remote diagnostics, preventive routines, and centralized management, minimizing downtime and enabling efficient firmware updates. With customizable automation and enhanced security measures, our solution reduces physical access requirements, making maintenance more proactive, secure, and seamlessly integrated into your operational workflows.

For a more advanced configuration, if the end users require a more sophisticated solution, they can turn to a more advanced version with the IPC970. With an Intel® Xeon CPU and four DDR4 up to 128G and support of a full-size accelerator card, it can also function as a higher-performance main system to deal with more demanding tasks, with similar configurations.

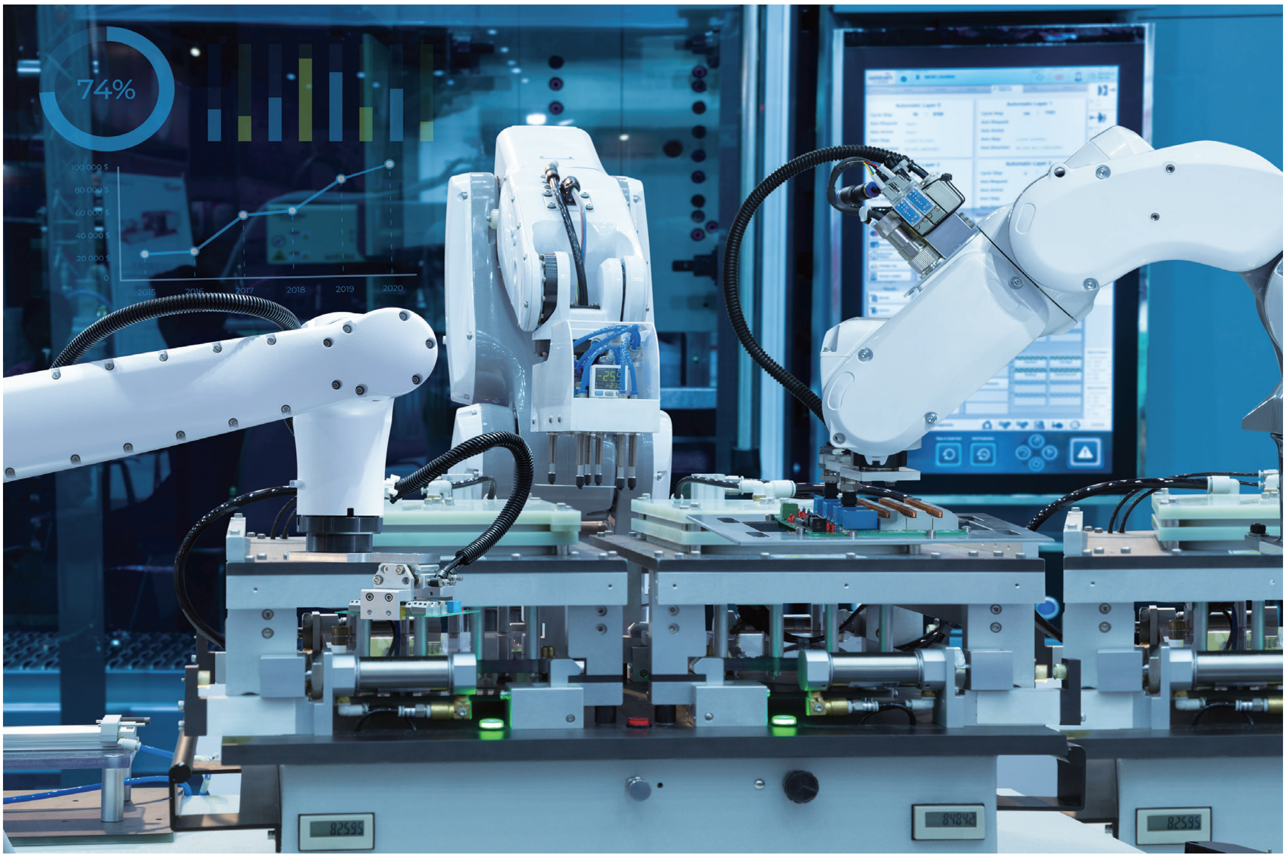
Also, a high-wattage power board ensures reliable operation by accommodating multiple high-power peripherals and devices in demanding industrial environments. The cooling design can support high-end GPUs.

Data Systems for Storage - IMB540

The image and data collected during inspection are transmitted to dedicated data systems for secure storage. To further enhance the inspection solution through AI model training, these systems facilitate seamless data transfer to a high-performance server. For data storage demands, the ATX motherboard IMB540 supports not only the 13th gen Intel® Core™ i9 processor but also accommodates up to 128GB of memory, ensuring high-performance capabilities. Most importantly, it supports four SATA-600 with RAID 0/1/5/10 for a large amount of data.

GPU Workstation for AI Model Training - iHPC300

At the back end, the iHPC300, an ultimate GPU workstation powered by the 3rd Generation Intel® Xeon® Scalable processor, is deployed for continuous AI model training and optimization. With three PCIe x16 and three PCIe x8 slots, it accommodates multiple accelerator cards, delivering unparalleled processing performance. Equipped with six DDR4 slots and a memory capacity of up to 384 GB, the iHPC300 adeptly handles large volumes of data and demanding AI workloads. Additionally, it offers six SATA3 ports and an M.2 Key M slot for NVMe module, making it an ideal choice for storing and analyzing real-time data from multiple sources.



Case Summary

In this optimized solution, Axiomtek recommends a range of platforms with cost-effective configurations tailored to meet specific needs and effectively manage workloads in automated optical inspection for wafer fabrication.

Distributed control systems employ strategically positioned edge platforms and devices, each dedicated to specific functions such as data storage, process control, and real-time data processing across a field site. These systems seamlessly interconnect through high-speed communication protocols, fostering collaboration and ensuring optimal performance.

This approach streamlines maintenance, allowing for targeted interventions without the need for a complete system shutdown. This minimizes downtime and bolsters overall system reliability. Moreover, the adaptability of distributed systems enables customization, resulting in cost savings through tailored solutions that eliminate superfluous features, providing a highly cost-effective solution.

Axiomtek once had a case where it needed a centralized setup for the field operations to maximize functionality while keeping system deployment minimal. With a centralized system field configuration, it saves costs of systems, power, and space while one system can multitask with four AI models.

In this scenario, they opted for a special embedded system that could handle four AI models within an oil and gas complex. The embedded system was stationed on-site, tasked with running four crucial AI models: number plate recognition and access control for the complex, monitoring the smart fence in restricted areas, analyzing potential dangers, and preventing anomalies.

Equipped with multiple IP cameras, the system monitored vehicle and personnel movements at the complex entrance and exit points, effectively blocking unauthorized vehicles from gaining access. Beyond this, it not only kept an eye on who entered restricted zones but also ensured they were equipped with the necessary safety gear. In cases of emergencies like gas leaks, unauthorized access, or individuals entering restricted areas without proper safety gear, the system triggered alarms with safety in mind.

Furthermore, the edge computing system gathered data for in-depth analysis, enhancing AI model performance through machine learning and proactively preventing similar public safety incidents in the future.

This configuration, while efficient and cost-effective, presented its own set of challenges. The foremost concern was processing power. Running four AI algorithms simultaneously demanded a more sophisticated CPU or refined models. This also made future upgrades a tricky proposition, as a single system might not be scalable enough to handle heavier workloads. Any inevitable upgrades would result in additional costs and complexities.

In the event of system failure, the centralized setup meant that all algorithms were at risk of going offline simultaneously, potentially causing significant disruptions to operations. Similarly, individual updates or maintenance of AI algorithms became more challenging when tightly integrated into a single embedded system, possibly requiring the entire system to be halted.

Conclusion

Both centralized to distributed system field configurations have their pros and cons and are expected to be used in the foreseeable future. Before deciding which to choose from, there are so many factors to consider such as type of applications, net speed, configuration complexity, security and budget. Distributed system field configurations are closer to the trend of processing data at the edge for real-time transmission.

However, centralized systems field configurations still have some upsides, including simplicity of deployment, cost-effectiveness, easier maintenance and upgrades and resource sharing.

As a result, end users and system integrators could tailor-made the solutions that best fit the field site and the most crucial demands.

	Distributed system	Centralized system
Advantages	Faster processing Shorter latency Reduced downtime	Easy to manage Cost-effective at first deployment
Disadvantages	Complicated configurations	Single point of failure Additional costs for upgrades

Deploying edge systems brings several advantages. By processing data closer to where it's generated, there's less latency, making things like smart cities and autonomous applications work faster. It also saves internet bandwidth as only important data goes to the cloud, useful where the internet is limited.

Edge computing is safer, keeping sensitive data local for privacy and it uses less energy. Also, edge systems make real-time decisions and can operate independently, enhancing overall performance in various applications. In simple terms, edge IoT makes things work faster, saves internet space, keeps data safe, works efficiently, uses less energy, is reliable, and decides things quickly.