White Paper of
Edge Computing Consortium

Edge Computing
CONSORTIUM

Introduction

Today’s transformation of industries using the Internet of Things (IoT) and other sensor technologies can gain great benefits through the use of versatile edge computing. This computing capability can be implemented as an open platform at the network edge near “things” or data sources. Edge computing integrates networking, computing, storage, and application capabilities and provides edge intelligent services. Benefits include agile connections, real-time services, data optimization, and smart application, as well as security and privacy protection.

Six industry entities have joined together to establish the Edge Computing Consortium (ECC) to help integrate resources in government, vendor, academic, research, and customer sectors, as well as promote innovation, the industrial application of edge computing, and advance the sustainable development of all enterprises. The entities include Huawei Technologies Co., Ltd., Shenyang Institute of Automation of the Chinese Academy of Sciences, China Academy of Information and Communications Technology (CAICT), Intel Corporation, ARM Holdings, and iSoftStone Information Technology (Group) Co., Ltd.

This white paper outlines edge computing trends and major challenges, and elaborates on the definition and content of edge computing. This paper also describes the ECC’s top-level design and operation mode, and provides a reference architecture and technological framework for edge computing to guide the ECC’s future development.

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1 Industry Trends and Major Challenges

As “things” are incorporated into smart interconnection, coordination and convergence of Operational Technology (OT) and Information and Communications Technology (ICT) help improve industrial automation. More broadly, these technologies meet the customized requirements of particular products and services, promote full-lifecycle transformation of products to service operations, and trigger innovations in products, services, and business models. These developments have a lasting impact on value chains, supply chains, and ecosystems.

The benefits of applying ICT can be seen in a variety of places, including predictive maintenance in the aviation industry, smart elevator operation, smart metering in the energy field, and full process tracing in the logistics industry. We feel that the smart interconnection of things will continue to transform industries as varied as manufacturing, energy, public utilities, transportation, health, and agriculture. This trend is reflected in industrial planning and implementation policies such as Made in China 2025, Industrial Internet of the United States, and Industry 4.0 of Europe.

According to IDC, there will be over 50 billion terminals and devices that connect to the Internet by 2020. More than 50% of the data will be analyzed, processed, and stored at the network edge. Against this background, the network edge of smart interconnection is facing the following challenges:

- **Making numerous and heterogeneous connections**

  The network is the cornerstone of system interconnection as well as data aggregation and transmission. With the increase in connected devices, network Operations and Maintenance (O&M), flexible extension, and reliability encounter severe challenges. Moreover, there have always been numerous heterogeneous bus connections in industrial sites, and industrial Ethernet networks of multiple modes have coexisted for a long time. It is urgent to ensure the compatibility of multiple real-time and reliable connections.

- **Providing real-time services**

  Real-time performance is required for detection, control, and execution of industrial systems. Some scenarios require a response within 10 ms. If data analysis and control logic are implemented in the cloud, they are unlikely to meet the requirements of real-time services.

- **Making applications smart**

  Service process optimization, O&M automation, and service innovation drive applications to be more smart. Edge intelligence can bring significant benefits to both efficiency and cost. The smart application scenarios that are characterized by predictive maintenance are pushing industrial transformation into new service and business models.

- **Optimizing data**

  Currently, a large amount of diversified heterogeneous data exists in industrial sites. Data optimization is required to enable aggregation, unified presentation, and openness of data, serving smart edge applications.

- **Protecting security and privacy**

  Security must be managed in the context of cloud computing and edge computing, which both require end-to-end protection. The network edge is closely related to IoT devices. Therefore, the network edge imposes higher requirements for coverage as well as access control and defense against threats. Edge security involves device, network, data, and application security. Integrity and confidentiality of key data, and protection of numerous data items concerning production or personal privacy are also focused in the security domain.

2 Edge Computing Definition

Edge computing is performed on an open platform at the network edge near things or data sources, integrating network, computing, storage, and application core capabilities and providing edge intelligent services. Edge computing meets the requirements of industrial digitalization for agile connections, real-time services, data optimization, smart application, security and privacy protection.

2.1 Coordination of Edge Computing and Cloud Computing

The coordination of edge computing and cloud computing enables the digital transformation of a wide variety of enterprise activities. Cloud computing can focus on non-real-time and long-period Big Data analytics, and supports periodic maintenance and service decision–making. In contrast, edge computing emphasizes real-time and short-period data analysis, and supports real-time smart processing and execution of local services.

Cloud computing and edge computing closely interact with each other. Edge computing is near executing units and can collect high-value data required by the cloud. This edge capability supports the Big Data analytics of cloud applications. Through Big Data analytics and optimization, cloud computing delivers service rules to the network edge. Based on these service rules, edge computing optimizes service execution.

2.2 Three Development Phases of Edge Computing

As digital transformations continue, edge computing technology will also expand, driven by technology and business. Generally, the development of edge computing can be understood in three phases:

- **Connection**

  Numerous heterogeneous, real-time connections between terminals and devices will serve edge computing, as will automatic network deployment and O&M. Additionally, security, reliability, and interoperability of connections should be guaranteed. A typical application in this phase is remote automatic meter reading, in which the number of electric meters may reach millions or even tens of millions.

- **Smart**

  In this phase, data analysis and automatic service processing capabilities are applied to the network edge, and local service logistics are executed smartly.

This capability significantly improves efficiency and reduces costs. A typical application of this phase is predictive maintenance of elevators. The fault auto-diagnosis and alarming system cuts down the cost of manual Predictive Maintenance Inspection (PMI).

- **Autonomy**

  Enabled by new technologies such as Artificial Intelligence (AI), edge intelligence will develop further. Edge computing carries out autonomous service logic analysis and computing, as well as implementing dynamic, real-time self-optimization, and executing policy adjustments. A typical application of this phase is an unattended factory.

3 ECC Profile

3.1 Intentions

As the focus of an emerging industry, edge computing has broad application prospects. It covers multiple fields including Operation Technology (OT), Information Technology (IT), and Communications Technology (CT). Further, edge computing involves many industry chain roles such as network connection, data aggregation, chip design and fabrication, sensing, and applications for a variety of purposes.

To promote in-depth industry coordination, accelerate innovation, and boost the application of edge computing, six industry entities have joined together to establish the ECC: Huawei Technologies Co., Ltd., Shenyang Institute of Automation of the Chinese Academy of Sciences, China Academy of Information and Communications Technology (CAICT), Intel Corporation, ARM Holdings, and iSoftStone Information Technology (Group) Co., Ltd. The ECC is dedicated to advancing cooperation among industry resources from government, vendor, academic, research, and customer sectors, and pushing forward the sustainable development of the edge computing industry.

3.2 Position

The ECC serves as an edge computing industry cooperative platform, which promotes open cooperation in the OT and ICT fields, nurtures the industry’s best application practices, and advances sound and sustainable development of the edge computing industry.

3.3 Vision

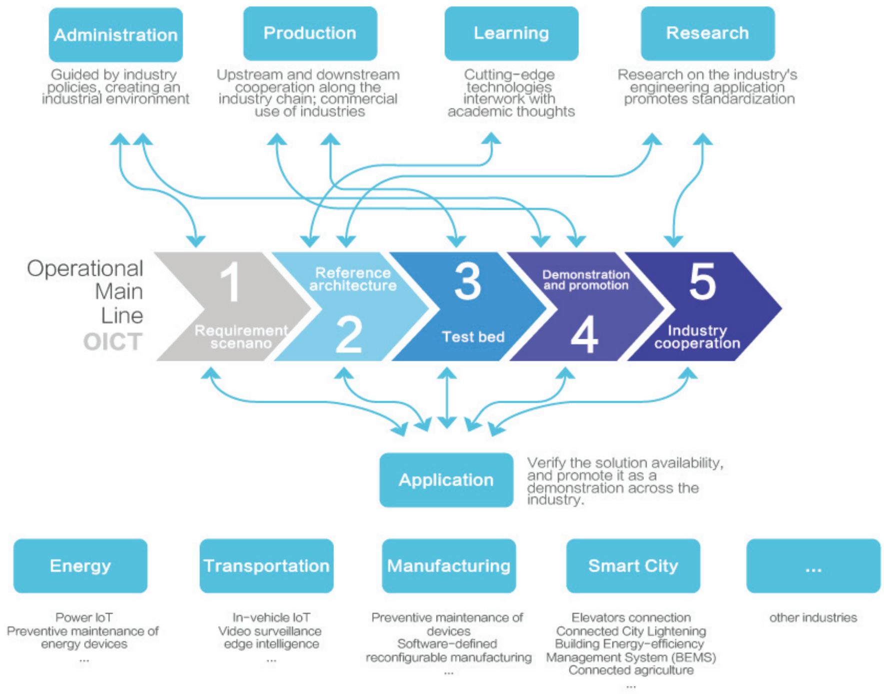
The ECC drives the prosperity of the edge computing industry, and deepens the industry’s digital transformation.

3.4 Purpose

The ECC’s purpose is to foster industry coordination in an open and innovative way, and promote prosperity and development for all parties.

3.5 Top-Level Design

The ECC adheres to the OT & ICT (OICT) concept, and combines government, vendor, academic, research, and customer sectors for cooperation. The ECC performs its duties according to the operational main line illustrated in the following figure. This main line includes a requirements phase, reference architecture, test bed, demonstration and promotion, as well as industry cooperation.



3.5.1 OICT Value: Consensus, Unity, and Win-Win Cooperation

According to the OICT concept, OT, IT, and CT resources should integrate and coordinate with each other. In the spirit of consensus, unity, and win-win cooperation, we drive forward the ECC's healthy development in several ways:

- **Industry cooperation to reach consensus**

  Reaching consensus on opportunities, orientation, and objectives of the edge computing industry is the basis of cross-domain OICT cooperation and ECC operation. This cooperation helps ensure that all parties have the same working orientation.

- **Technological cooperation to display unity**

  The OT field has many device sensing and control technologies, while the ICT field has a variety of information and communications technologies. Technological cooperation and separate advantages will support the ECC's reference architecture design, evolution roadmap of functional areas, and industry solution design and implementation.

- **Business cooperation to achieve a win-win result**

  Edge computing will have a long and deep impact, resulting in a stream of business opportunities. OICT-based coordination and an orderly division of labor will help us seize business opportunities to benefit each link in the industry chain and achieve win-win business outcomes.

3.5.2 Coordination of Government, Vendor, Academic, Research, and Customer Sectors

The ECC offers a close cooperative mechanism to integrate resources from the following sectors:

- **Government**

  Formulating industry policies and creating an industry environment.

- **Vendors**

  Close cooperation in the industry chain realizes the commercial use of technologies.

- **Academics**

  Cutting-edge technology often depends on academic research and conceptual development.

- **Research**

  Research into engineering applications promotes standardization.

- **Customers**

  By verifying solution viability, customers help promote the technology and demonstrate its uses.

3.5.3 Five Steps of the ECC's Operational Main Line

① **Requirement scenario**

In this phase, ECC members carry out requirement analysis on edge computing, collect information, and summarize key requirements. The output is a technical architecture based on analysis of various edge computing applications.

② **Reference architecture**

Unified language and architecture achieves horizontal hierarchical decoupling and openness. The reference architecture implements positioning and division of labor for upstream and downstream vendors of the industry chain. This positioning promotes cross-domain industry cooperation and ecosystem development.

③ **Test bed**

In this phase, ECC members perform edge computing verification tests, advance innovation of technical products and applications, and formulate test standards and norms for product interconnection. This process includes sharing of test cases, developing test cooperation, and promotion based on resources provided by members.

④ **Demonstration and promotion**

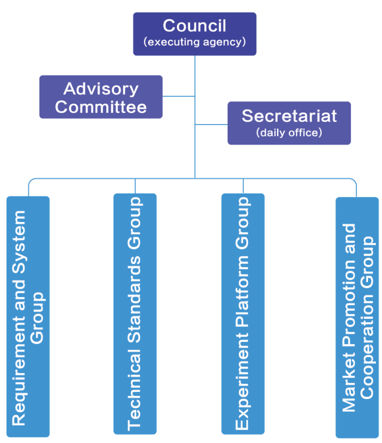
In this phase, members initiate marketing activities about edge computing and form a combined force to develop market expansion and brand promotion. These activities will increase the value of edge computing through joint marketing activities, attracting more attention across a variety of enterprise sectors, and build a larger market space for further development.

⑤ **Industry cooperation**

Edge computing will benefit from communication and cooperation between the ECC and third-party standards organizations as well as international platform organizations.

3.6 ECC's Management and Organizational Structure

The ECC's organizational structure comprises a council, advisory (expert) committee, working groups, and a secretariat under the council, as shown in the following organizational chart.



3.6.1 Council

The council is the ECC's leadership body, with the following functions and powers:

- Planning and executing the ECC's major tasks such as strategies.
- Nominating, electing, and dismissing the Chairperson, Vice Chairs, Secretary General, and Deputy Secretary Generals.
- Deciding on the appointment of a Director and Vice Directors of the advisory committee.
- Discussing, formulating, and deciding the ECC's key annual activities.
- Determining and reviewing the setup of working groups, personnel appointments, and important proposals submitted by working groups or members, as well as formulating resolutions.
- Determining the ECC's financial plan for the current year, reviewing the finances for the previous year, and deciding on the amount of annual membership fees.
- Supervising and guiding work of the ECC secretariat, as well as reviewing work reports from the secretariat.
- Determining and reviewing other important matters.

3.6.2 Expert Committee

Members of the advisory committee are selected and hired by the council, comprising well-known technical experts, managerial experts, economic specialists, and policy research professors in the edge computing industry inside and outside China. Their major responsibilities are as follows:

- Providing specialized advice and guidance for the ECC's development and important decisions.
- Proposing important research projects and implementing technology checks for verification and review of major projects.
- Providing suggestions for the council on making crucial decisions.
- Providing specialized and advisory inputs for council members.

3.6.3 Secretariat

The ECC sets up the Secretariat as its office for handling day-to-day affairs, appoints the Secretary General and Deputy Secretary Generals, and implements the Secretary General accountability system under the leadership of the Chairperson. The Secretariat's major responsibilities are as follows:

- Executing all resolutions from the council, and organizing, managing, and coordinating the tasks of the ECC.
- Preparing and holding the general meeting and the council meetings.
- Making drafts of the council's annual working plans and implementing the plans.
- Processing accession and exit applications of council members.
- Carrying out project cooperation with governments and other enterprises and institutions.
- Working with the market promotion and cooperation team to carry out promotion activities through media and exhibitions, as well as communication and workshop discussions.
- Processing other matters assigned by the general meeting and the council.

The ECC can establish, manage and supervise branch offices or representative agencies.

4 Reference Architectures

The ECC needs to define a reference architecture to achieve three main goals:

- **Unify terminology**

  By developing terminology for edge computing, the ECC can form a solid foundation for dialogue and cooperation. Terms are needed to cover common issues of the edge computing core, such as network connections, data aggregation and analysis, security, and privacy protection.

- **Unify architecture**

  By providing standardized functional domains for reference, the ECC can support interconnection and interoperation among systems and promote horizontal decoupling. Domains include the application, data, network, and device domains. Based on hierarchical open cooperation, all parties can make full use of their resources to facilitate reasonable division of labor and orderly cooperation.

- **Facilitate cooperation**

  The reference architecture will be a foundation for cooperative design. Considering customer demands, best industrial practices, and successful commercial cases, the ECC integrates the resources of governments, vendors, academic institutions, researchers, and customers. This integration promotes open cooperation and coordination of technical solutions and standards, and application ecosystems.

4.1 Edge Computing Reference Architecture 1.0

Based on hierarchical design, the edge computing reference architecture 1.0 contains four functional domains:

- **Application domain**

  Based on open interfaces provided by the device, network, and data functional domains, the application domain enables edge industry applications and supports edge service operation.

- **Data domain**

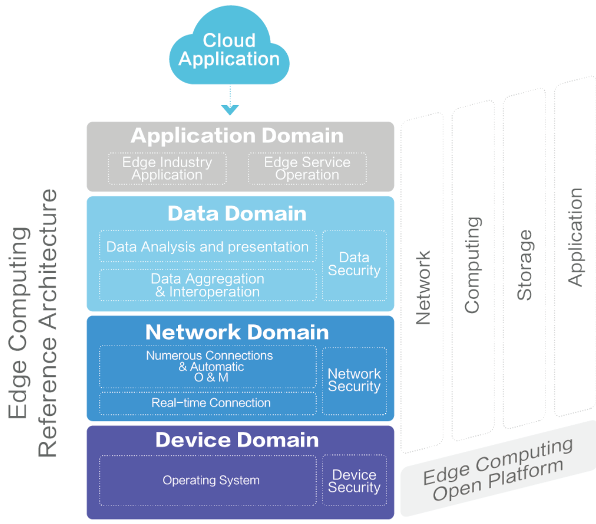
  This domain provides full-lifecycle data optimization services such as extraction, aggregation, interoperation, semanticization, data analysis, and data presentation, as well as ensuring data security and privacy.

- **Network domain**

  This domain provides services for system interconnection, data aggregation, and data transmission.

- **Device domain**

  This domain includes discrete or embedded on-site nodes such as meters, robots, and other devices to support real-time smart interconnections and applications.



4.1.1 Application Domain

The application domain enables applications to operate at the network edge and provides full-lifecycle management of applications. This domain also supports highly efficient operation and visualized management of edge services.

4.1.2 Data Domain

The data domain covers the following functions:

- **Data aggregation and interoperation**

  The mainstream architectures of data aggregation include OPC-UA and Data Distribution Service (DDS). To realize cross-vendor data interoperation and analysis, unified semantic meanings are required. It has been a consensus across the industry that building a unified information model architecture helps realize compatibility of multiple information models.

- **Data analysis and presentation**
  The data domain adapts to data analysis models, performs real-time data cleansing and analysis, and triggers pre-defined service response policies based on data analysis results. This domain also provides data computing results for the application domain, and supports flexible and unified data presentation modes.

4.1.3 Network Domain

The network domain covers the following functions:

- **Numerous connections and automatic O&M**
  Software-Defined Networking (SDN) is becoming a mainstream technology that separates the control plane from the forwarding plane to make the network programmable. Applying SDN to edge computing enables millions of devices to access the network and supports flexible scalability. SDN provides highly efficient and low-cost automatic O&M, and realizes policy collaboration and convergence of network and security.

- **Real-time connections**
  Network connections must guarantee time accuracy and data integrity. The Institute of Electrical and Electronics Engineers (IEEE) formulated Time-Sensitive Networking (TSN) to unify technical standards for key services such as real-time priority and clocks. These standards indicate the future development of industrial Ethernet connections.

4.1.4 Device Domain

The device domain covers the following functions:

- **Operating system**
  Operating systems can support two different scenarios. One scenario is characterized by lightweight devices with low power consumption that supports Zero Touch Provisioning (ZTP), self-networking, and cross-platform capabilities. The other scenario is for real-time computing that supports multi-

task and priority-based scheduling capabilities to enable event response and task processing within given real-time requirements.

- **Device security**

  When designing and implementing the operating system, middleware, and upper-layer applications of a device domain, developers must consider security defense capabilities. The root key, software, firmware, and configurations must be protected from malicious tampering. In scenarios that require higher security, chip-level protection is required to ensure secure root key system and data storage.

5 Summary

The ECC is committed to becoming an open, innovative organization for collaboration. The ECC expects to attract and combine with more partners for the robust and sustainable development of edge computing.

6 Appendix: Typical Application Scenarios

Edge computing applies to many scenarios that have enormous technical and market value. Edge computing supports business innovation, enabling transformation from a product-oriented model to a service-oriented model. Edge computing also enables customized and smart products and services. Three typical application scenarios are predictive maintenance, energy and efficiency management, and smart manufacturing.

6.1 Predictive Maintenance

Traditional industrial maintenance was either retrospective or preventive. During retrospective maintenance, services are interrupted. Preventive routine maintenance is performed manually, which increases maintenance costs. Taking elevators as an example, over 15 million elevators are in use around the world. Elevator maintenance and after-sales service are huge business opportunities. More elevator vendors are integrating industry chains and increasing revenue by providing O&M services. However, the traditional maintenance cost still remains high, and the first maintenance success rate is below 20%. Therefore, aiming to improve O&M efficiency and lower O&M costs, digital transformation must be introduced into traditional elevator maintenance. Edge computing can help elevator vendors upgrade from the traditional preventive maintenance to next-generation real-time predictive maintenance, extending value from products to services:

- **Reducing costs**

  A large number of sensors can monitor the elevator's status in real time. A local edge computing converged gateway can provide data analysis capability that detects potential device faults early. This model provides local resilience. If the gateway fails to connect to the cloud, data can be stored locally. After the connection is restored, the stored local data can be synchronized to the cloud automatically to ensure that the cloud can generate a complete view of each elevator.

  Predictive maintenance can reduce the labor workload, strengthen device reliability to prolong service life, improve device utilization, and thus cut maintenance costs. All these capabilities lift the overall competitiveness of enterprises.

- **Security assurance**

  Predictive maintenance provides multiple-level protection that covers terminal devices, gateway chips and OSs, networks, and data.

- **Product-to-service extension**

  Elevator vendors' research and development teams can improve their product quality and after-sales services. With predictive maintenance, building owners and property management agencies can provide emergency rescue services. Further, elevators can serve as media platforms for advertising.

Typical industrial application scenarios include elevators, special-use vehicles, Computer Numerical Control (CNC) machines, secondary pressed water supply devices, and energy systems.

6.2 Energy Efficiency Management

With global economic growth, the contradiction between intensive needs and limited energy resources becomes acute. A critical question arises: How do people manage buildings and resources to reduce the energy consumption of devices, including air conditioners, streetlights, and office equipment, while improving users' satisfaction. In answering this question, enterprises and organizations can transform from a product orientation to service orientation. For example, 80% of the world's streetlight vendors are preparing to provide smart streetlights. Some countries and international organizations have developed standards for green energy. The Climate Group initiated a 10-year smart streetlight restructuring plan to save 50% of the energy cost for the whole world.

Lighting, refrigeration, and electrical devices are overused, wasting a large amount of electricity. Additionally, traditional manual control cannot adjust the lighting and refrigeration in real time based on changing situations. Lights and air conditioners may be on even if no one is using them, wasting large amounts of resources. Based on energy-efficiency control polices and specific environmental requirements, edge computing can realize refined management and synchronize with the cloud periodically.
Edge computing can improve energy and efficiency management as follows:

- **Lower energy consumption**

  Real-time energy and efficiency control can reduce buildings' energy consumption and costs. According to the data of a project in Melbourne, Australia, the Building Energy-efficiency Management System (BEMS) Solution reduces total energy consumption by about 60%.

- **Lower maintenance costs**

  Automatic energy information collection reduces manual collection costs and maintenance costs. The Connected City Lighting Solution can reduce maintenance costs by 80%.

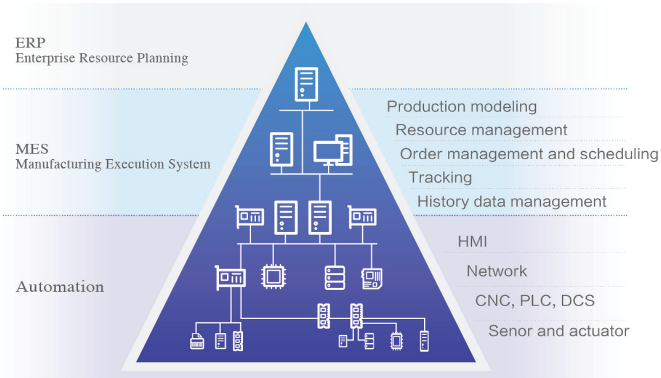
- **Higher reliability**

  Multi-level reliability assurance is provided. Control planning and policy synchronization are stored at the network edge, which ensures correct operations and management in case of cloud faults. At the same time, the edge can monitor the status of devices such as streetlights, switches, and air conditioners, perform predictive maintenance, and adjust policies in real time if device faults occur.

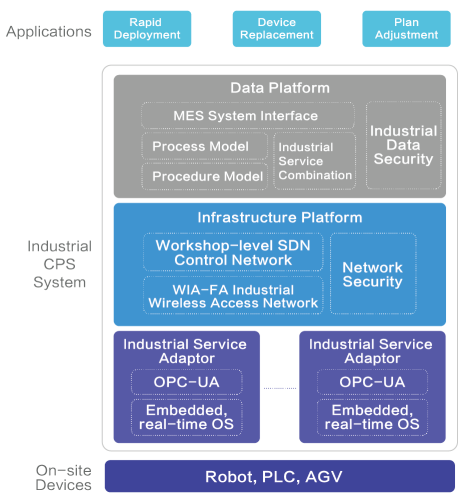
Typical industrial application scenarios include buildings' energy and efficiency management and smart streetlights.

6.3 Smart Manufacturing

With increasing customer demands, product service life is dramatically shortened. Customers tend to choose customized products, and this situation will continue. As for customization production modes, small-quantity and multi-batch modes are now replacing high-volume manufacturing to some extent. The previous hierarchical architecture based on traditional manufacturing systems can no longer meet current needs (as shown in the following figure). For example, an electronic production line used to utilize the PLC + OPC mode. However, with order types increasing and single batch quantities decreasing, production parameters are changed more frequently, which requires 1 or 2 days to transfer a purchase order to production per week. Additionally, procedure upgrading usually happens at least three times a year, and device replacement takes place nearly 100 times a year. These changes might cause control logic and procedure operations to reset, which usually takes 5 to 12 weeks, deteriorating the efficiency of new product provisioning. Smart manufacturing will lead the future development of China, America, Germany, and other manufacturing giants in the next 10 years. For example, by 2025, the main sectors of China's manufacturing industry will fully embrace smart transformation. This change will decrease trial projects' OPEX by 50%, shorten products' manufacturing cycle by 50%, and lower the defective product rate by 50%. The flexible interactions between ICT systems and OT systems must be enhanced for smart manufacturing, as traditional manufacturing systems cannot support smart transformation.



Edge computing can help realize smart manufacturing. In an industrial system, edge computing can be seen as an industrial CPS system. At the bottom layer, the system encapsulates on-site devices as web services through industrial service adaptors. At the infrastructure layer, edge computing connects on-site devices to the industrial data platform using flattened interconnection over industrial wireless and SDN networks. On a data platform, based on the production procedure and process models, edge computing dynamically manages and schedules on-site resources, and connects to systems such as MES. The industrial CPS system supports flexible production plan changes based on changing production line resources. Using this approach, outdated manufacturing devices can be replaced rapidly, and new devices can be provisioned.



Edge computing can promote manufacturing as follows:

- **Flexible device replacement**

  Procedures are reset using web interoperation interfaces, realizing the plug-and-play function for new devices. This approach reduces workload by 50%

because OPC configurations are canceled.

- **Flexible adjustments on production plan**

  Production cycles and material supply modes can automatically adapt to multiple plan adjustments every day, saving I/O configuration time caused by models shifting and material route switching.

- **Rapid deployment of new processes and models**

  Adaptive web-based process model adjustment saves time for PLC reprogramming, powering on/off, and resetting hundreds of OPC variants brought by new process deployment (possibly involving hundreds of logic modules and a dozen nested management devices). Therefore, the time needed to deploy new process is reduced by over 80%.

Typical industrial application scenarios include software-defined reconfigurable manufacturing systems.

7 Glossary

No.	Term	Definition
1	Cloud Computing	Referred to as “the cloud,” this technology enables “pay by use” to provide on-demand computing resources ranging from applications to data centers. Cloud deployment modes include public cloud, private cloud, and hybrid cloud.
2	Edge Computing	Edge computing is performed on an open platform at the network edge near “things” or data sources, integrating network, computing, storage, and application core capabilities, and providing edge intelligent services. Edge computing meets the key requirements of agile connection, real-time services, data optimization, smart application, security, and privacy protection.
3	Software-Defined Networking	SDN is a network architecture that separates a network’s control plane from its forwarding plane to make the network programmable. In a typical SDN architecture, the top layer is the application layer, including various services and applications. The control layer is responsible for orchestrating resources on the data plane and maintaining the network topology and status information; the infrastructure layer processes and forwards data, and collects status information based on flow tables.
4	Industrial Ethernet	This Ethernet technology is used to ensure the certainty and real-time capability of communications under industrial circumstances. These networks include multiple types such as EtherCAT, EtherNet/IP, PROFINET, POWERLINK, SERCOS III, and Modbus/TCP. Due to the different definitions of the transmission layer and application layer, the two layers are incompatible with each other, hampering interconnections between systems.
5	Time-Sensitive Networking	The IEEE provides a technical standard for real-time priority and clocks. This standard can support Ethernet scenarios such as manufacturing system interconnections and vehicle system interconnections, and these are trends of the future.
6	Interoperability	This term refers to information exchange between two or more systems. These systems can use each other’s information and carry out coordination.
7	Information Model	This modeling expression has a data semantic meaning, covering a concept, relation, restriction, or operation. A data model realizes information sharing and organization.
8	Data Distribution Service	This service is defined by the Object Management Group (OMG) and refers to a distributed data exchange protocol that enables scalability, real-time capability, high performance, and data interoperations.
9	Root Key	Public key cryptography is the core of the Public Key Infrastructure (PKI). PKI defines the technology and standards of the security infrastructure platform. The root key is the base of the entire PKI secure operation, concerning its security and proper running. Therefore, the PKI puts high demands on generation and backup of the root key. It is recommended that the root key be generated through hardware encryption module computing.
10	Smart Manufacturing	Based on the IoT, Big Data, and cloud computing, smart manufacturing involves the design, production, management, and services during manufacturing procedures. Smart manufacturing can make decisions in a smart, optimal manner and provide accurate control. Smart manufacturing is a generic term for this advanced manufacturing process, system, and mode.

8 Acronyms and Abbreviations

No.	Acronym or Abbreviation	Term
1	AGV	Automated Guided Vehicle
2	CNC	Computer Numerical Control
3	CPS	Cyber-Physical System
4	CT	Communications Technology
5	DCS	Distributed Control System
6	DDS	Data Distribution Service
7	ECC	Edge Computing Consortium
8	ERP	Enterprise Resource Planning
9	HMI	Human Machine Interface
10	ICT	Information and Communications Technology
11	IDC	Internet Data Center
12	IT	Information Technology
13	MES	Manufacturing Execution System
14	OICT	OT & ICT
15	OLE	Object Linking and Embedding
16	OPC	OLE for Process Control
17	OPC-UA	OPC Unified Architecture
18	OS	Operating System
19	OT	Operation Technology
20	PLC	Programmable Logic Controller
21	SDN	Software-Defined Networking
22	TSN	Time-Sensitive Networking
23	WIA-FA	Wireless Network for Industrial Automation – Factory Automation
24	WIA-PA	Wireless Network for Industrial Automation – Process Automation

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