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# PUBLICLY AVAILABLE SPECIFICATION

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## Functional architecture of industrial internet system for industrial automation applications

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IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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CONTENTS

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# FUNCTIONAL ARCHITECTURE OF INDUSTRIAL INTERNET SYSTEM FOR INDUSTRIAL AUTOMATION APPLICATIONS

## FOREWORD

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| The text of this PAS is based on the following document: | This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document |
|---|---|
| **Draft PAS** | **Report on voting** |
| 65/927/DPAS | 65/933/RVDPAS |

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# INTRODUCTION

For traditional plants, each piece of equipment is isolated, and the production data of equipment is collected manually, while the efficiency of manual statistics is also very low. With the continuous development of industrial automation, digitalization, and intelligent technologies, the intelligent and connected plant combined with "end-edge-cloud" collaboration extends the scope of the original plant and builds close ties between people and production equipment via data. In this way, it realizes the whole process with real-time interconnection between users, equipment and products, achieving zero distance between them, with transparent visibility of the whole process. In addition, the in-depth application of artificial intelligence and big data technologies in the industrial field contributes a large number of algorithms for intelligent optimization and decision-making, thus providing critical solutions for upgrading toward intelligent industrial systems.

# FUNCTIONAL ARCHITECTURE OF INDUSTRIAL INTERNET SYSTEM FOR INDUSTRIAL AUTOMATION APPLICATIONS

## 1 Scope

This document defines the functional architecture and functional model of the industrial internet system for industrial applications. It presents the models, structures, activities, and interaction contents between layers of the end, edge, and cloud: infrastructure as a service (IaaS), platform as a service (PaaS), and software as service (SaaS), respectively.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62264-1:2013, *Enterprise-control system integration – Part 1: Models and terminology*

IEC 62264-2:2013, *Enterprise-control system integration – Part 2: Object and attributes for enterprise-control system integration*

IEC 62264-3:2016, *Enterprise-control system integration – Part 3: Activity models of manufacturing operations management*

## 3 Terms, definitions, abbreviated terms, and acronyms

### 3.1 Terms and definition

For the purposes of this document, the terms and definitions given in IEC 62264-1, IEC 62264-2 and IEC 62264-3 as well as the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org
- ISO Online browsing platform: available at http://www.iso.org/obp

**3.1.1**
**industrial application**
software which is based on the industrial internet, carries industrial know-how and experience, and meets specific needs

**3.1.2**
**industrial big data**
generic term of industrial data including enterprise informatization data, industrial IoT data, and external cross-field data

**3.1.3**
**industrial internet system**
industrial cloud system that builds a service system based on massive data collection, aggregation, and analysis, and supports the ubiquitous connection of manufacturing resources, flexible supply, and efficient allocation

**3.1.4**
**platform as a service**
**PaaS**
business model providing the operation and development environment of application services as a cloud service

Note 1 to entry: PaaS is located between the IaaS and SaaS models and provides the development and operating environment for applications.

**3.1.5**
**software as service**
**SaaS**
model of providing software through the internet

Note 1 to entry: The vendor deploys applications on its own servers. Customers may order the required application services from vendors via the internet according to their actual needs, pay the vendor according to the number of services ordered and the period of services, and obtain the services through the internet.

**3.1.6**
**infrastructure as a service**
**IaaS**
model of utilization of all computing infrastructure as a service, including processing CPU, memory, storage, network, and other basic computing resources

Note 1 to entry: In this model, users are able to deploy and run any software, including operating systems and applications. Customers do not manage or control any cloud computing infrastructure, but are able to control the choice of operating system, storage space, deployed applications, and potentially obtain the control of restricted network components (such as routers, firewalls, and load balancers).

**3.1.7**
**data management**
process of efficiently collecting, storing, processing, and applying data using computer hardware and software technologies

**3.1.8**
**microservice**
independently deployable artifact providing a service implementing a specific functional part of an application

[SOURCE: ISO/IEC TS 23167:2020, 3.15]

**3.1.9**
**microservices architecture**
design approach that divides an application into a set of microservices

[SOURCE: ISO/IEC TS 23167:2020, 3.16]

**3.1.10**
**cloud service**
one or more capabilities offered via cloud computing invoked using a defined interface

[SOURCE: ISO/IEC 20924:2018, 3.1.8]

**3.1.11**
**software defined networking**
set of techniques that enables to directly program, orchestrate, control and manage network resources, which facilitate the design, delivery and operation of network services in a dynamic and scalable manner

[SOURCE: ISO/IEC TR 22417:2017, 3.9]

**3.1.12**
**data processing**
systematic performance of operations upon data

[SOURCE: ISO/IEC 2382-1:1993]

### 3.2 Abbreviated terms and acronyms

For the purposes of this document, the abbreviated terms and acronyms given the following apply.

| | |
|---|---|
| API | Application Programming Interface |
| DCS | Distributed Control System |
| EAL | Edge Application Layer |
| ECS | Elastic Container Service |
| EFL | Edge Foundation Layer |
| EIP | Elastic IP |
| IaaS | Infrastructure as a Service |
| IP | Internet Protocol |
| LAN | Local Area Network |
| LoP | List of Properties |
| OPC UA | OPC Unified Architecture |
| PaaS | Platform as a Service |
| PLC | Programmable Logic Controller |
| PLM | Product Lifecycle Management |
| SaaS | Software as a Service |
| SLB | Server Load Balancer |
| SDN | Software Defined Networking |
| TSD | Time series data |
| TSN | Time Sensitive Networking |
| VPC | Virtual Private Cloud |
| VPN | Virtual Private Network |



## 4 General

### 4.1 Function and architecture

#### 4.1.1 Hierarchy

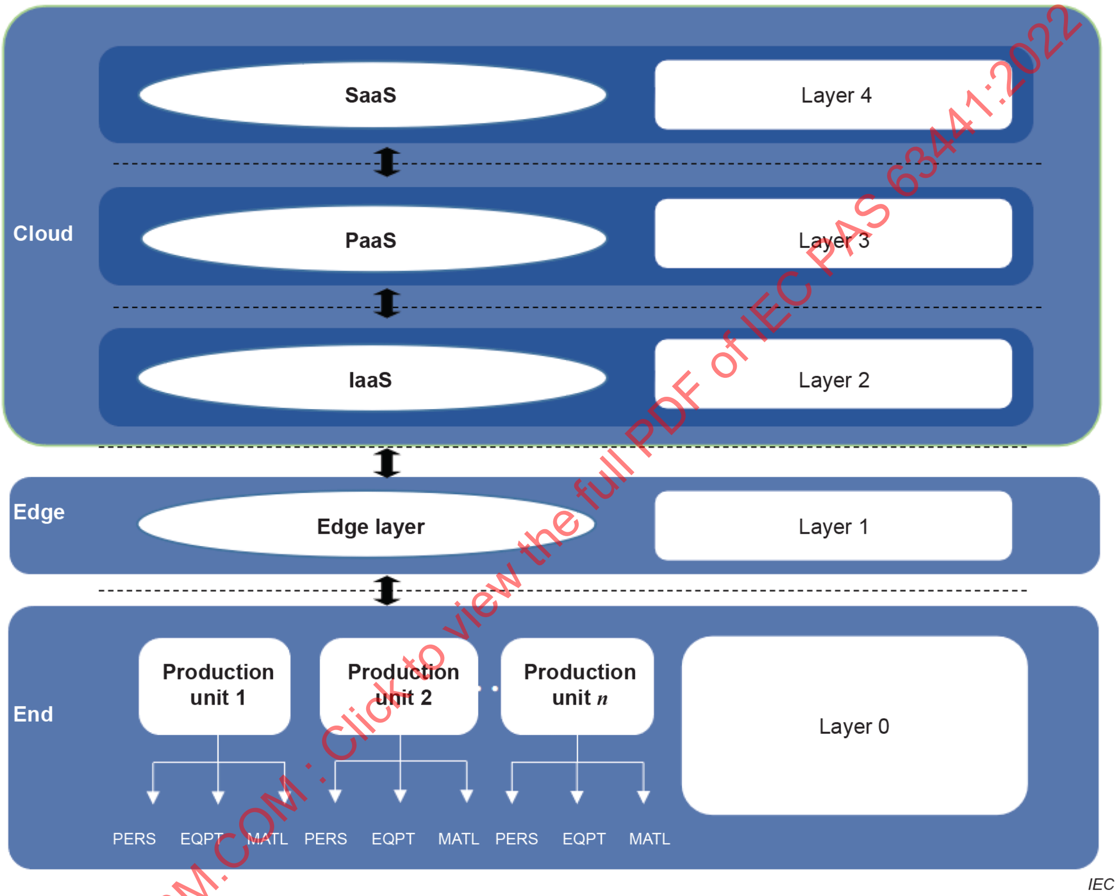
The overall functions of the industrial internet system include:

– Synchronous collection and transmission of multi-source heterogeneous data, such as industrial process data, video, and audio;
– Edge data processing and real-time condition perception: Use edge equipment to realize the connection and unified management of industrial process related equipment;
– Visual analysis and know-how database construction combining industrial mechanism with big data, so as to ensure data association analysis;
– Design, management and decision-making based on industrial data analysis to support personalized service requirements.

The industrial internet system includes end, edge, and cloud architecture. It is divided into 5 layers:

– Layer 0: end layer;
– Layer 1: edge layer;
– Layer 2: IaaS layer;
– Layer 3: PaaS layer;
– Layer 4: SaaS layer.

See Figure 1.






**Key**

PERS persons
EQPT equipment
MATL material

**Figure 1 – Overall architecture of industrial internet system**

### 4.1.2 Activities of End Layer (Layer 0)

Main activities of end layer:

– Provide data perception, collection, and storage in the process of industrial production activities;
– Provide equipment connection and network transmission environment in industrial production activities;
– Perform the tasks of production units in industrial production activities.

#### 4.1.3 Activities of Edge Layer (Layer 1)

Main activities of edge layer:

– Provide pre-processing of multi-source heterogeneous industrial data and guarantee real-time;
– Provide the functions of isolation and protection between industrial applications and industrial internet infrastructure (such as terminal devices and servers).

#### 4.1.4 Activities of IaaS Layer (Layer 2)

Main activities of IaaS layer:

– Provide computing resources, network resources, storage resources, and related resource services, and serve as the basis for the operation of the industrial cloud layer.

#### 4.1.5 Activities of PaaS Layer (Layer 3)

Main activities of PaaS layer:

– Provide the service environment and tools for the whole life cycle of industrial products;
– Provide the conversion, cleaning, hierarchical storage, analysis and mining, and visualized processing of the industrial big data;
– Encapsulate the processes, data, and models in industrial production and IT technologies, know-how, and methods into industrial microservices and micro-components;
– Access various industrial resources, and process, combine and optimize them to form modular manufacturing capability.

#### 4.1.6 Activities of SaaS Layer (Layer 4)

Main activities of SaaS layer:

– Realize the whole life cycle coordination and management of industrial products from requirement interaction, design, manufacturing, all the way to sales;
– Realize the effective integration of industrial production resources, simplify enterprise processes, and reduce costs;
– Enhance the utilization rate of resources and production efficiency of industrial enterprises by offering services.

#### 4.1.7 Security

Security requirements should be considered in the process of design, implementation, and operation, at all levels of the industrial internet, including risk assessment and privacy management:

– Data collection, storage, and processing;
– Network transmission;
– Data and application services.

See relevant requirements specified in IEC 62443, ISO 27000, ISO/IEC 27005:2018, ISO/IEC 20547-4, ISO/IEC 14888-3, ISO/IEC 19944, ISO/IEC 17788, ISO/IEC 17789, ISO/IEC 27017, ISO/IEC 27018, and ISO/IEC 27002.

### 4.2 Functional Model

See Figure 2 for the functional model of the industrial internet.

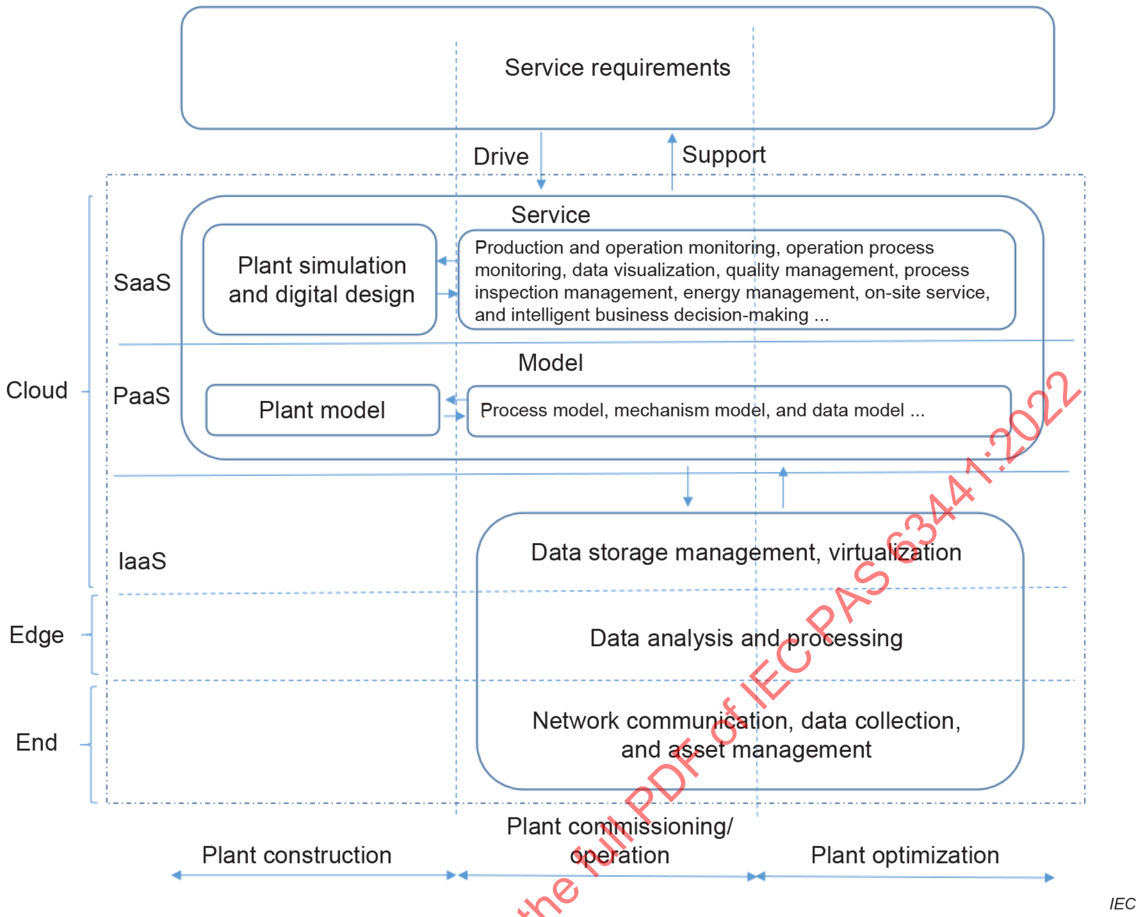



**Figure 2 – Functional model of industrial internet**

Service requirements of the industrial internet include:

– Realize the networking allocation, collaborative R&D, and production of resources in the whole production process in cross-industry chains, between enterprise departments, and between production units within enterprises;

– Meet the requirements of mass customization;

– Meet the management requirements of production efficiency, cost, product quality, safety, and energy efficiency;

– Realize intelligent operation and maintenance management of equipment;

– Realize the interconnection of production resources (personnel, equipment, materials, etc.) with models and services.

The hierarchical model and requirements of the industrial internet for industrial applications can be divided into end, edge, cloud, and service requirements from the system level.

From the perspective of the whole life cycle of the plant, it can be divided into three stages according to the construction progress of the plant:

a) plant construction;

b) plant commissioning/operation;

c) plant optimization.

In the plant construction stage, the digital model of the overall design, process flow, and layout of the plant for service requirements based on the plant simulation and digital design system is built; the simulation visualizes the production process data and helps to optimize the production process. This stage also creates a network architecture model for plant communication to realize the information interconnection between various links of the manufacturing process, such as process, production, inspection, and logistics, and between the manufacturing process and the data collection and monitoring system, manufacturing execution system, and enterprise resource planning system. A digital model of production planning, scheduling, and execution is built to realize analysis and decision making, quantitative process management, dynamic cost and quality tracking, and collaborative optimization from raw materials to finished products.

In the plant commissioning/operation stage and the optimization stage, the data about personnel, equipment, materials, etc., are collected and related assets are managed at the end layer. In the meantime, such data are interconnected through industrial network technologies, passed to the edge layer for real-time data analysis and processing, and interoperated through OPC UA, TSN, SDN, and other technical means. Moreover, data storage management and virtualization are realized at the IaaS layer. Then, combined with industrial models such as process model, mechanism model, and data model, big data analysis technologies are applied to process and integrate the collected data to provide such services as production and operation monitoring, operation process monitoring, data visualization, quality management, process inspection management, energy management, on-site service, and intelligent business decision-making, so as to meet the service requirements of users and drive the optimization and upgrading of services based on service requirements.

# 5 End layer

## 5.1 Overview

The end layer, represented by Figure 3, performs manufacturing tasks directly at the industrial field, and interacts with personnel, equipment and materials involved in the manufacturing process. The sensors in the end layer collect information about personnel, equipment, and materials from the industrial field and provide it to the upper layer for analysis and decision making. Meanwhile, the manufacturing system in the end layer executes commands from the upper layer to realize the execution and control of the manufacturing process.

## 5.2 Model and architecture

The end layer, which is located in the industrial field of the manufacturing enterprise's workshop, uses the production resources on the site to complete the production process through production management and control.

The functions of the management layer include:

– Management: complete the production process management, including the collaborative management of manufacturing data, production scheduling, and planning and scheduling, to achieve the production informatization management at the workshop level of an enterprise;
– Optimization: improve the control execution process and data collection;
– Decision-making: identify, diagnose, and give feedback on problems that exist in the production process of the industrial field;
– Interaction: realize information interaction between the end layer and the edge layer.

The functions of the control layer include:

– Control execution: perform control of the production process;
– Data collection: collect the production data and equipment status information by sensors in the industrial field, including images, videos, and audios;
– Data storage: record the data collected from the industrial field in some format on a storage medium.

The field layer contains production resources, which refer to the personnel, equipment and materials necessary to complete the production process.

Figure 3 represents the end layer structure.

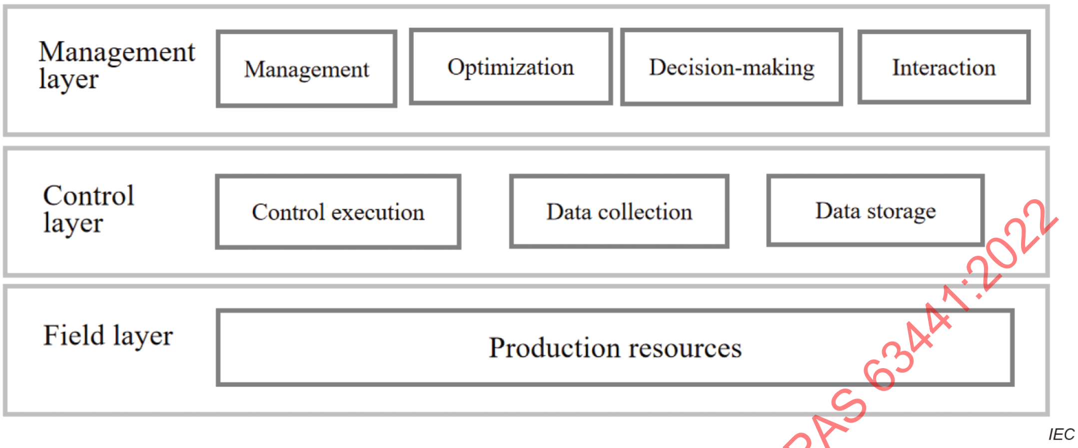



**Figure 3 – Structure of end layer**

## 5.3 Activities of End Layer

The end layer is located at the industrial field. It provides task execution and data collection in the manufacturing process to achieve manufacturing goals, digitizes key information of production equipment and process, and accesses the industrial internet through the edge layer, thus providing the information interaction with other layers of the industrial internet, as well as the linking and sharing between the service and management on the cloud and the manufacturing resources and data on the end layer.

The activities of the end layer mainly include:

– Perception and storage of industrial data: collect production process information and status information of production objects, production equipment, production environment, etc., by using sensors configured at the industrial field, so as to realize the collection, pre-processing, storage, and transmission of such information;

– Connection and management of production resources: connect industrial field equipment to the network through proper network communication mode, and implement the connection management of the equipment in the network, so as to realize the information interaction between the field equipment and the upper layers;

– Execution and control of the industrial manufacturing process: through the operation management on the production site, the manufacturing process is controlled to realize the task execution, process management and monitoring of the running status of the production equipment during manufacturing.

## 5.4 End Supports to Edge

The supports provided by the end layer to the edge layer include:

– The data provided to the edge layer can fully reflect relevant information of production resources such as personnel, equipment, and materials;

– Data are complete, accurate and effective, and the data transmission meets the time deterministic requirement;

– The real-time communication for different application scenarios (burst control, closed-loop control, open-loop control, alarm, logs, etc.) meets the control requirements of the edge layer for field devices;

– Have security measures for communication.

# 6 Edge Layer

## 6.1 Overview

The edge layer is used to expand the capability to process and compute unstructured data, which is not supported by traditional control systems. It integrates the four core capabilities of network, computing, storage, and industrial application, and can process structured and unstructured data and transmit them to the cloud.

## 6.2 Model and architecture

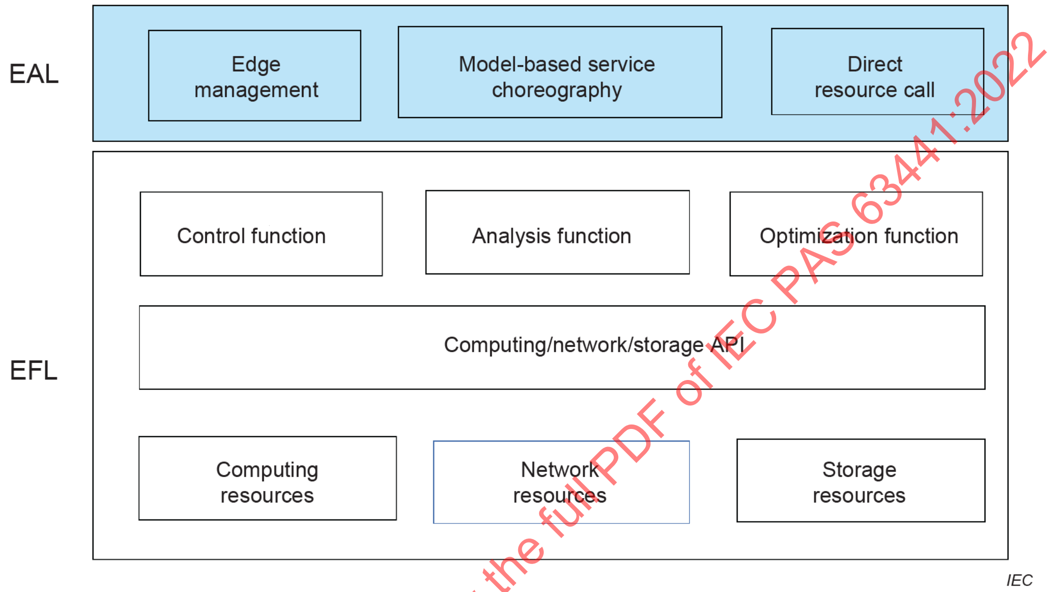





**Figure 4 – Functional model of edge layer**

As shown in Figure 4, the edge layer provides modelled open interfaces, which are divided into Edge Application Layer (EAL) and Edge Foundation Layer (EFL) with the following functions.

The functions of EAL include:

– Edge management: manage all physical entities and computing/network/storage resources, such as edge servers, edge gateways, and edge controllers;
– Model-based service choreography: provide a visual workflow definition tool to complete the semantic check and policy conflict detection;
– Direct resource call: call computing/network/storage resources directly through code management, network configuration, database operation, etc.

The functions of EFL include:

– Control function: including perception and execution of industrial production process, real-time communication, entity abstraction, control system modelling, equipment resource management, and program execution;
– Analysis function: including analysis of industrial process data and field video/audio/image, intelligent computing, and industrial data mining;
– Optimization function: including optimization of measurement and execution, optimization of environment and equipment safety, optimization of control strategy, optimization of collaborative control, optimization of real-time parameters, and optimization of production unit scheduling;
– Application programming interface (API): For computing/network/storage call;
– Basic resources, including computing resources, network resources, and storage resources:

- Computing resources: including key computing hardware units on the edge layer, which support the processing of massive structured and unstructured data;
- Network resources: including OPC UA, time sensitive networking (TSN), and software defined networking (SDN), which support the access and expansion functions for a massive number of network devices;
- Storage resources: including temporal databases that support fast writing, persistence, and aggregated query of temporal data.

### 6.3 Activities of Edge Layer

For industrial processes, the activities of the edge layer include:

– Data pre-processing: including the processing of data such as production process variables, monitoring, logistics, suppliers, customers, environment, process sensor flow data, images, sounds, text, and operation records;

– Operation status identification: the operation status of industrial equipment and production lines are identified according to the industrial big data and mechanism analysis, including:

  - Intelligent perception of multi-source heterogeneous information;
  - Causality mining based on dynamic characteristics of industrial big data;
  - Operation condition identification.

– Optimal control for multi-source heterogeneous operation.

Under the condition of safe operation, the automatic industrial process control system needs to be able to:

a) Improve the operation indexes that reflect the product quality and efficiency;

b) Reduce the operation indexes reflecting the consumption of the product production and processing process;

c) Realize the operation optimization control of the entire industrial production process.

The control system should specifically include:

- Mechanism to model the material transformation process;
- Intelligent modelling based on machine learning and mechanism analysis;
- Optimized working condition identification and self-optimization correction.

### 6.4 Edge Supports to IaaS

The supports provided by the edge layer for the IaaS layer include: device access, protocol parsing, and edge data processing:

– Device access: connection and unified management of a large number of devices in the process of industrial production;

– Protocol parsing: utilize protocol conversion to realize the interconnection and interoperability of large quantities of industrial data;

– Edge data processing: utilize edge computing technologies to realize the pre-processing for the elimination of incorrect industrial data, industrial data caching, and edge real-time analysis.

### 6.5 Edge Supports to PaaS

After plant construction, the edge layer starts to provide the following support to PaaS:

– Resource management: provide data from physical entities (such as edge servers, edge gateways, and edge controllers) and from computing/network/storage resources;

– Edge control: provide the abilities of perception, execution, and optimization in industrial production processes.

# 7 IaaS Layer

## 7.1 Overview

In the IaaS layer, the infrastructure provider provides virtualized resources and services for the building and operating industrial platforms and provides infrastructure resources for the functional operation and services of PaaS and SaaS layers.

## 7.2 Model and architecture

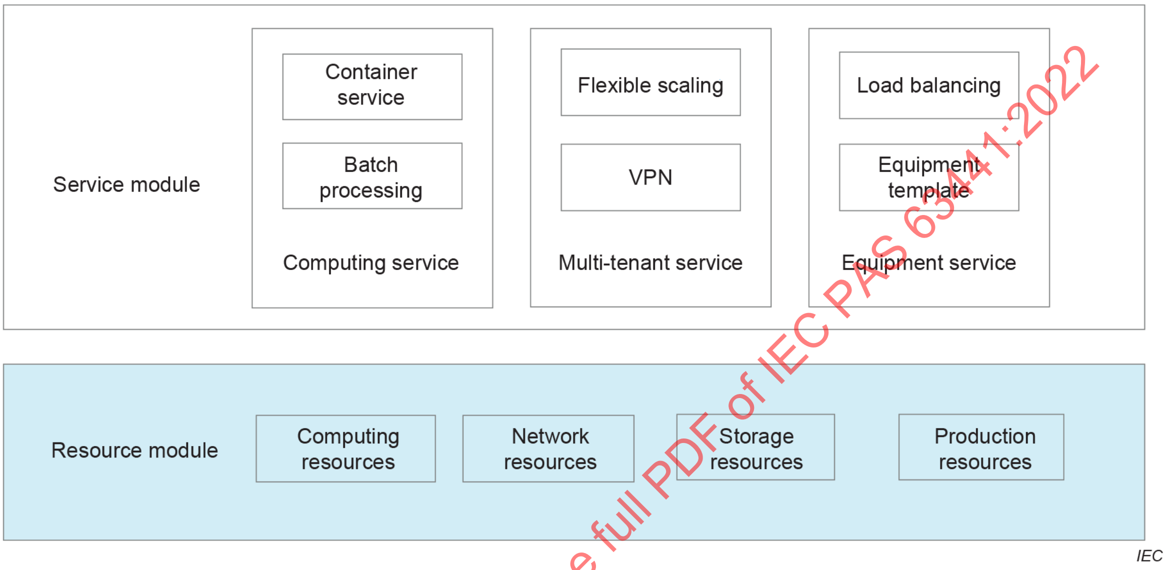





**Figure 5 – Functional structure of IaaS**

As shown in Figure 5, the IaaS layer consists of hardware and software resources and has such functions as processing, computing, storage, and virtual mapping. It provides a development framework that supports multiple application types, an operating environment, and seamlessly integrated available support components matching basic resources. It supports secure remote operation and maintenance, and provides an application development environment, with the following functional modules:

– Resource module: provide infrastructure such as storage resources, computing resources, network resources, and production resources, as detailed below:
  - Storage resources: provide a distributed or centralized shared storage environment for industrial applications;
  - Computing resources: provide computing conditions for service management for industrial applications;
  - Network resources: provide private lines, virtual machines, and other related network facilities for industrial applications;
  - Production resources: provide the attribute list (LoP) for industrial infrastructure.

– Service module: Including computing service, multi-tenant service, and equipment service, as detailed below:
  - Computing service: including container service and batch processing service;
  - Multi-tenant service: realize resource sharing in a multi-user environment, and provide services such as flexible scaling and VPN;
  - Equipment service: including load balancing and equipment template.

### 7.3 Activities of IaaS Layer

The IaaS layer mainly abstracts, optimizes, and virtualizes resources, provides hardware and expansion conditions for industrial internet systems, including computing, storage, and network resources and hardware infrastructure, and provides an interactive portal for managing virtual users, manages and schedules resources, and provides virtualized resources for industrial applications. The main activities include:

– Computational optimization activities: The flexibly configured acceleration services meet the requirements of data computing;

– Storage management activities: Including the management and storage of industrial demand files and data;

– Multi-tenant management activities: Support access to a massive number of devices and provide two-way communication and IP address rental services;

– Virtual network management activities: Build and accelerate the virtual LAN, provide load balancing for the virtual LAN, and solve network congestion;

– Hardware infrastructure: Provide hardware conditions for computational optimization and management.

### 7.4 IaaS Supports to PaaS

The IaaS layer provides PaaS with the necessary storage capacity, computing capacity, and network communication capacity for its normal operation. The PaaS layer should support the scheduling management, multi-user management, and portal system for IaaS, and realize high customization and resource control. The supports provided by the IaaS layer to the PaaS layer include:

– Storage, access, and sharing of infrastructure facilities and other resources;

– Availability of required resources, including redundant network connections, resource cluster support, storage availability support, and fault isolation of virtual machines;

– Computing services to ensure the stability of data flow from creation to use;

– Virtual resources, including virtual machine deployment and disaster recovery, on-demand resource allocation, network expansion, and load balancing;

– Required management, including system vulnerability management, fault management, script automation management, state monitoring management, topology management, history record management, and multi-tenant management;

– A unified equipment template and the definition of a common attribute set and information model.

## 8 PaaS Layer

### 8.1 Overview

The PaaS layer provides open and scalable industrial service and system capabilities, which integrate industrial technology principles, industry know-how, and basic models based on rules, software, and modules, and encapsulate them into reusable and flexibly called components. Components include know-how, algorithms, and models.

## 8.2 Model and Architecture

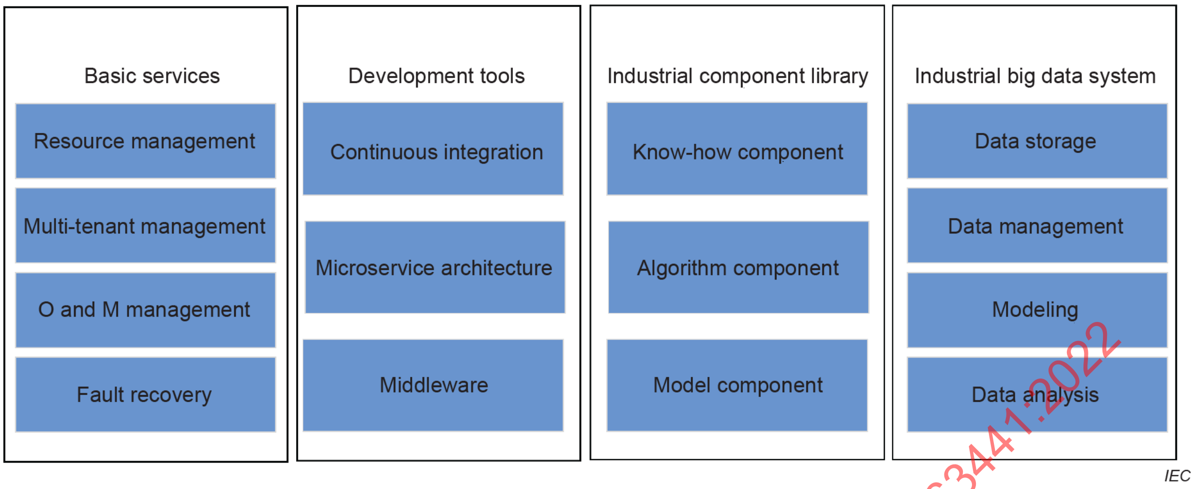



**Figure 6 – Functional model of PaaS layer**



The PaaS layer includes basic services, development tools, industrial component library, and industrial big data system, as shown in Figure 6:

– Basic services involve such functions as resource management, multi-tenant management, operation and maintenance management, and fault recovery, which are used to support the basic operation of the platform layer:
  - Resource management: allocate and apply middleware and components required for supporting platform applications;
  - Multi-tenant management: realize platform component sharing in the multi-user environment, and ensure data isolation among users;
  - Operation and maintenance management: maintain platform logs and realize real-time monitoring;
  - Fault recovery: help to quickly recover the platform in case of any fault of the platform.

– Development tools: provide support for development tools, provide management mechanism and operating environment covering service registration, discovery, communication, and calling, and support component-based development and deployment:
  - Continuous integration: support rapid iteration of platform applications;
  - Microservice architecture: support the development and deployment of applications using the microservice architecture on the platform;
  - Middleware: provide public middleware services such as registration center, cache, and message required by applications.

– Industrial component library: provide various knowledge, algorithm, and model components that can serve the industrial field:
  - Know-how components: maintain and manage the knowledge databases of various industrial fields, and accumulate and share industrial know-how;
  - Algorithm components: maintain and manage various industrial algorithm libraries. Users can build their own algorithm libraries on the platform, or use algorithms provided by other users on the platform;
  - Model components: maintain and manage various industrial model libraries. Users can build their own model libraries on the platform, or use models provided by other users on the platform.

– Industrial big data system: by utilizing specialized expertise in various fields and combining with practical experience in industrial production, the system constructs various models to realize storage, management, modelling, and analysis of data:

- Data storage: provide the storage service for various types of big data including relational data, non-relational data, and stream data;
- Data management: provide data cleaning, data archiving, and other data management services;
- Modelling: use models to describe industrial processes according to related mechanisms;
- Data analysis: support analysis of industrial data from personnel, equipment, materials, methods, and environment.

### 8.3 Activities of PaaS Layer

The activities of the PaaS layer include: application development, application deployment, data modelling, data storage and management, data analysis, and operation and maintenance:

- Application development: the PaaS layer follows the microservice development architecture. With the middleware such as message queue, cache, data storage and continuous integration tools provided by the platform, the PaaS layer enables developers to realize rapid development of applications;
- Application deployment: the container, virtualization, and other technologies are used to achieve operation and iteration of industrial applications;
- Data modelling: industrial processes are described and analyzed to finally form industrial models, which include plant models, process models, equipment models, quality analysis models, fault monitoring models, and predictive maintenance models;
- Data storage and management: support storage of structured data and unstructured data, and support data model management, data asset management, data quality management, and data security management;
- Data analysis: perform integration, computation, and result visualization of structured data and unstructured data in industrial processes;
- Operation and maintenance: support monitoring, optimization, and troubleshooting for middleware and components.

### 8.4 PaaS Supports to SaaS

The PaaS layer provides component sharing, middleware services, and application deployment for the applications in the SaaS layer. The PaaS layer mainly supports the SaaS layer in the following aspects:

- Provide application development tools that support optimization and decision-making;
- Provide an application operating environment that supports optimization and decision-making;
- Provide the big data services.

## 9 SaaS Layer

### 9.1 Overview

The data driven SaaS layer is used to evaluate and optimize the plant operation process, to complete operation monitoring and decision-making, and to meet service requirements.

## 9.2 Model and architecture

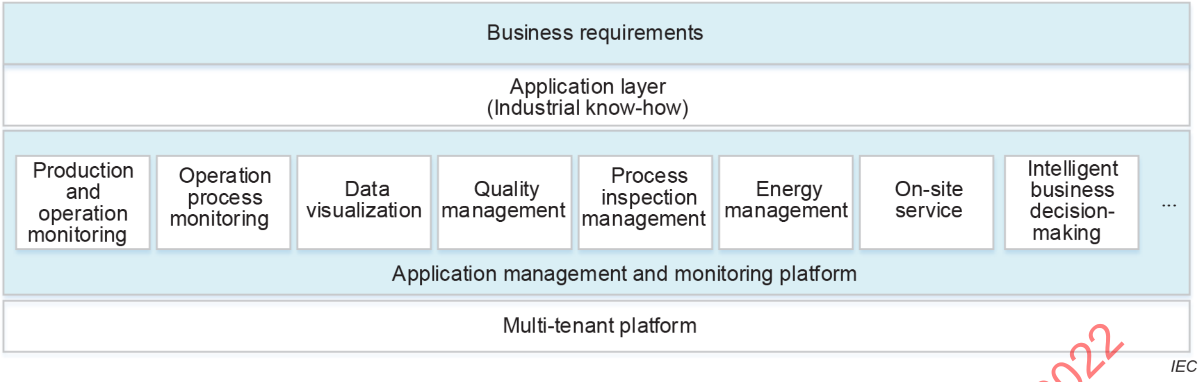



**Figure 7 – Functional model of SaaS**

As shown in Figure 7, a hierarchical architecture is supported by SaaS, including:

– Application layer: support know-how for different industrial fields;

– Application management and monitoring platform: support production and operation monitoring, operation process monitoring, data visualization, quality management, process inspection management, energy management, on-site service, intelligent business decision-making, etc.; each functional module is packaged as an industrial application;

– Multi-tenant platform: allow multiple users to order software application services on demand.

NOTE See 4.2 for service requirements.

## 9.3 Activities of SaaS

The activities of the SaaS layer mainly include:

– Industrial know-how: digital expression of industry differentiated demands and specific practices;

– Production and operation monitoring: the real-time management of production and operation is realized by monitoring the group, enterprise, and production unit layer by layer;

– Operation process monitoring: including production scheduling, production warning, control index management, process management, and equipment management;

– Data visualization: integrate DCS and PLC data from each production equipment, display the panorama of production processes and the status of production links and equipment in real time, and multidimensionally analyze production operations;

– Quality management: monitor the analysis data of products, raw materials, and intermediate processes through the online analysis of quality data;

– Process inspection management: compare the abnormal data with the operational data during process inspection, and manage the process control indexes;

– Energy management: including scientific planning, organization, inspection, control, and supervision of the energy production, distribution, conversion, consumption, and recycling;

– On-site service: including on-site personnel management calendar, planning, tasks, queries, and collaboration;

– Intelligent business decision-making: make correct operational decisions by utilizing the modern data warehouse technology, the online analysis and processing technology, and data mining;

– Multi-tenant management: share application services among multiple users and ensure service isolation among them;

– Others, including warehouse logistics management, spare parts management, and lean production.

# Annex A
(informative)

# Architecture Case of Industrial Internet System

## A.1 Overview

This section describes the field implementation case of an industrial internet system for an enterprise. This system consists of the industrial edge layer, IaaS layer, PaaS layer, and SaaS layer, as shown in Figure A.1. The system provides an integrated solution from real-time data collection, secure data transmission and storage, data modelling and analysis in the industrial field to in-depth industry application.

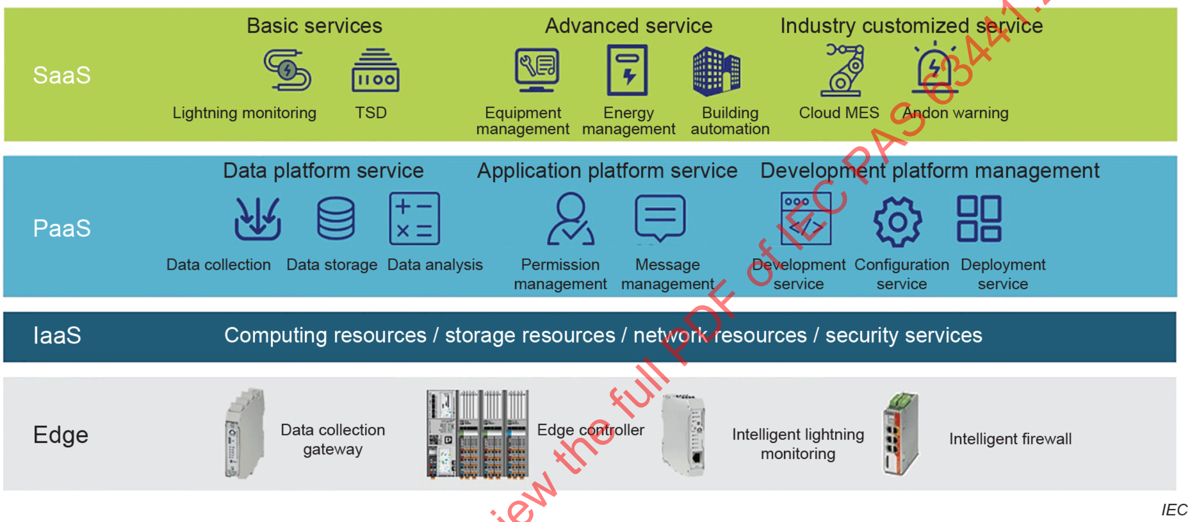



**Figure A.1 – Overall architecture of the industrial internet system in this case**

## A.2 Application cases

### A.2.1 End and Edge Layer

Taking the new-generation PLC product system as the core, the end and edge layer uses open development platforms and a variety of model libraries to provide full lifecycle services covering the development, integration, simulation, verification, and release of models and applications. See Figure A.2.

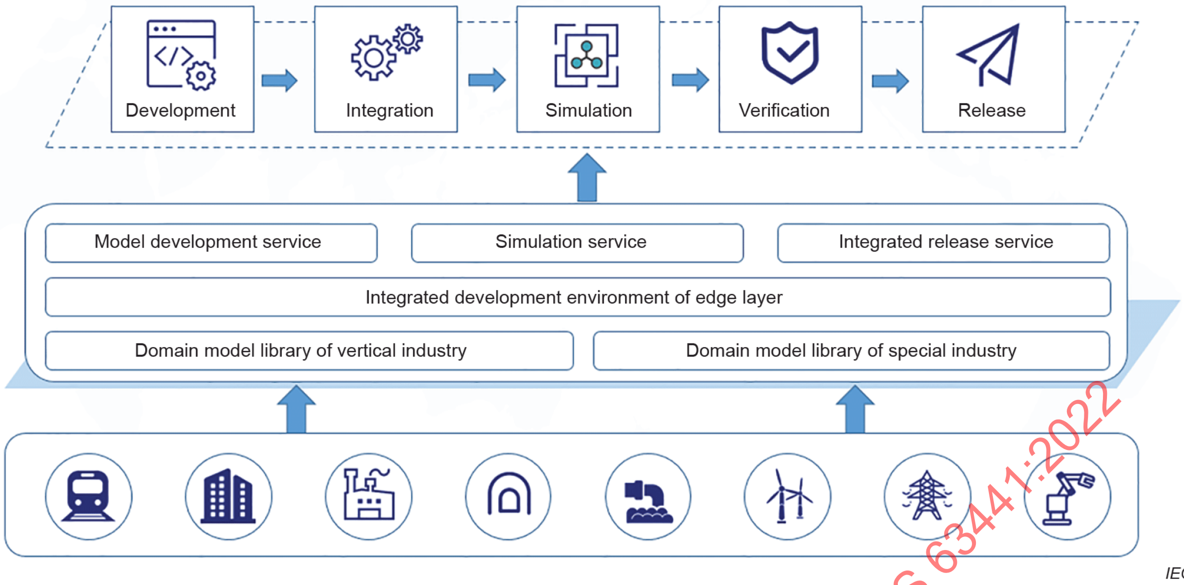



**Figure A.2 – Full lifecycle service framework of the end and edge layer**

### A.2.2 IaaS Layer

The IaaS layer supports functions such as processing, computing, storage, and virtual mapping. The storage resources (databases such as Redis, PostgreSQL, and Cassandra) provided by the platform make available a shared storage environment for industrial applications; the computing resources (dynamically configured ECS) provide elastic computing services for industrial applications; the network resources (VPC and EIP) provide private lines, virtual switches, virtual routers, and other related network facilities for industrial applications. Meanwhile, when the number of users suddenly increases in the multi-tenant management mode, the built-in auto scaling can dynamically adjust the number of ECS resources and relieve the load pressure of the server in combination with SLB. See Figure A.3.

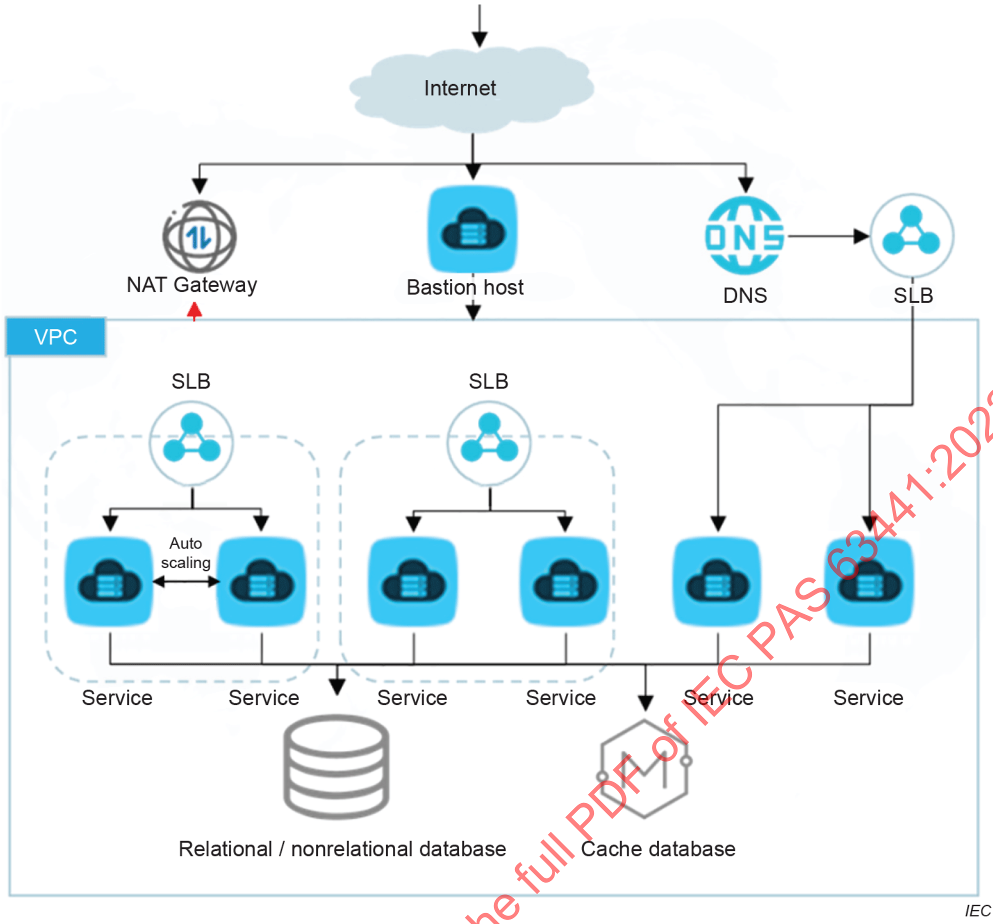



**Figure A.3 – IaaS framework**

### A.2.3 PaaS Layer

The PaaS layer integrates existing service capabilities, which can be categorized as application server, service capability access, and service engine. Downward, it measures basic service capabilities according to service capability needs and calls hardware resources through the API provided by the IaaS; upward, it provides the service scheduling and routing service, monitors various resources of the platform in real time, and opens these resources to SaaS users through the API. See Figure A.4.

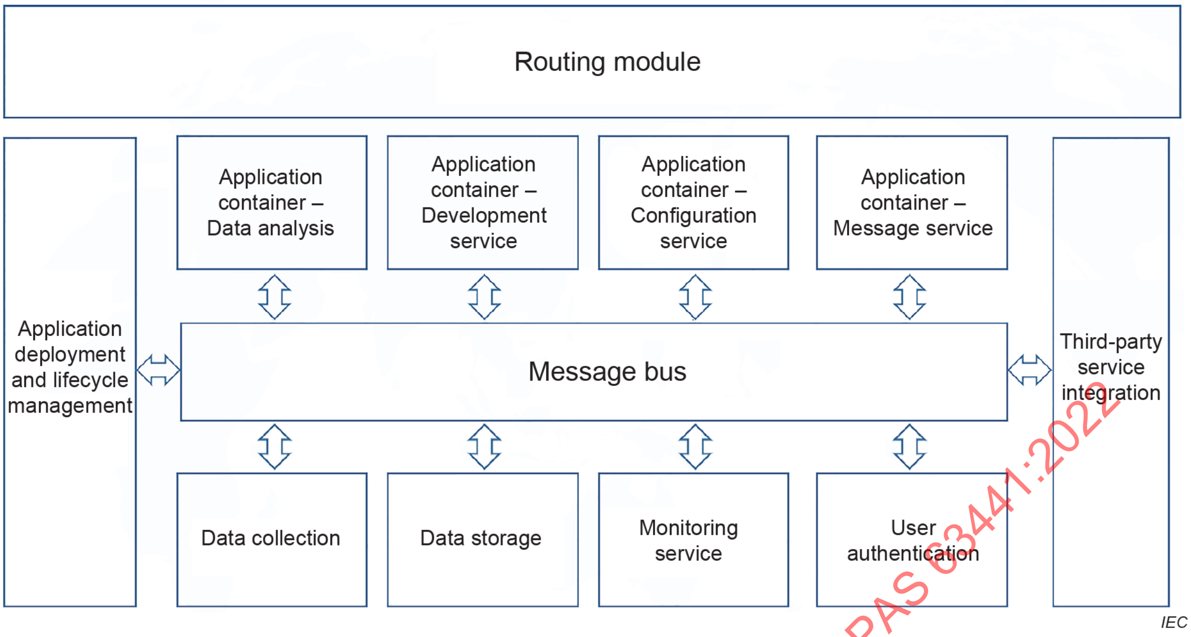



**Figure A.4 – PaaS service architecture**



The PaaS platform implementation mainly consists of the following parts:

– Routing module: the routing module routes the user request to the corresponding server instance and provides functions such as dynamic application registration;

– Application container: as the core of the PaaS platform, the application container mainly manages the application lifecycle and reports the running status of applications;

– Application deployment: during application deployment on the PaaS platform, the application needs to be packaged into a release package that can be directly deployed. The module is the key to develop the PaaS platform. It supports multiple programming languages and frameworks such as Java, Python, Ruby, and PHP. When an application is released, the platform needs to package the application into a generic release package according to different programming languages and then pass it to the container module for deployment;

– Monitoring module: the module continuously monitors the running status of applications; for example, health status (survive or not), resource utilization (such as CPU, memory, hard disk, and network), and availability. These indicators are the key to the operation and maintenance of the entire PaaS platform, and also lay the foundation for auto scaling;

– Message bus: the message bus is the core communication module of PaaS to ensure communication among all services.

### A.2.4 SaaS Layer

The SaaS layer can deploy applications on the industrial cloud server in a unified manner. Customers may order the required application services from vendors via the internet according to their actual needs. Users only need to pay the fee according to the number of services ordered and the period of services, and obtain the services through the internet. Instead of buying software, users rent web-based software from the industrial cloud platform to manage the business operation activities, and do not need to maintain the software. Vendors have full authority to manage and maintain the software. Figure A.5 shows the service pattern framework.

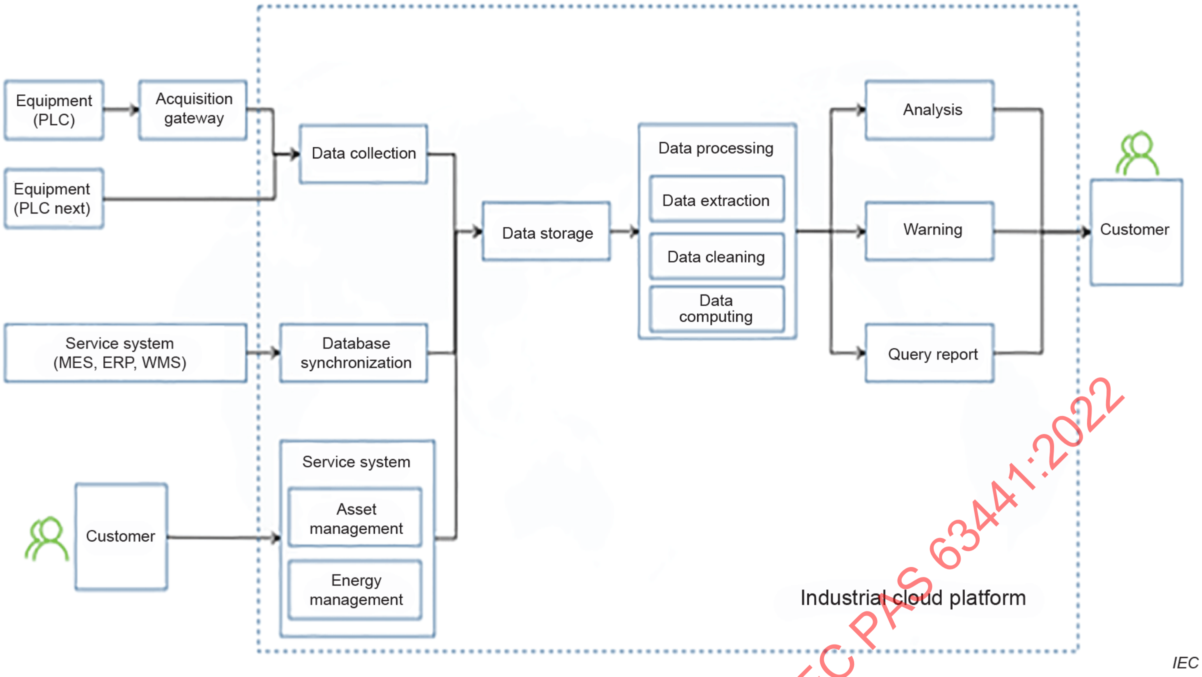



**Figure A.5 – Service pattern framework of SaaS**

### A.2.5 Smart Application Implementation of SaaS Platform

#### A.2.5.1 Smart Service: Equipment Management

The equipment management system takes the equipment asset account management as the basic knowledge database of equipment maintenance, and uses modules such as work order management, standard work, spare parts management, spot-check management, and preventive maintenance to implement maintenance. The equipment management system has a clear idea of continuous improvement. Relying on the built-in technical standard system, this system realizes a comprehensive continuous improvement closed-loop composed of "technical standard for equipment – service module – equipment account effect analysis – technical standard for equipment". See Figure A.6.