



WISE-PaaS IIoT Cloud Platform Architecture and Service

V1.0.0

Revision History

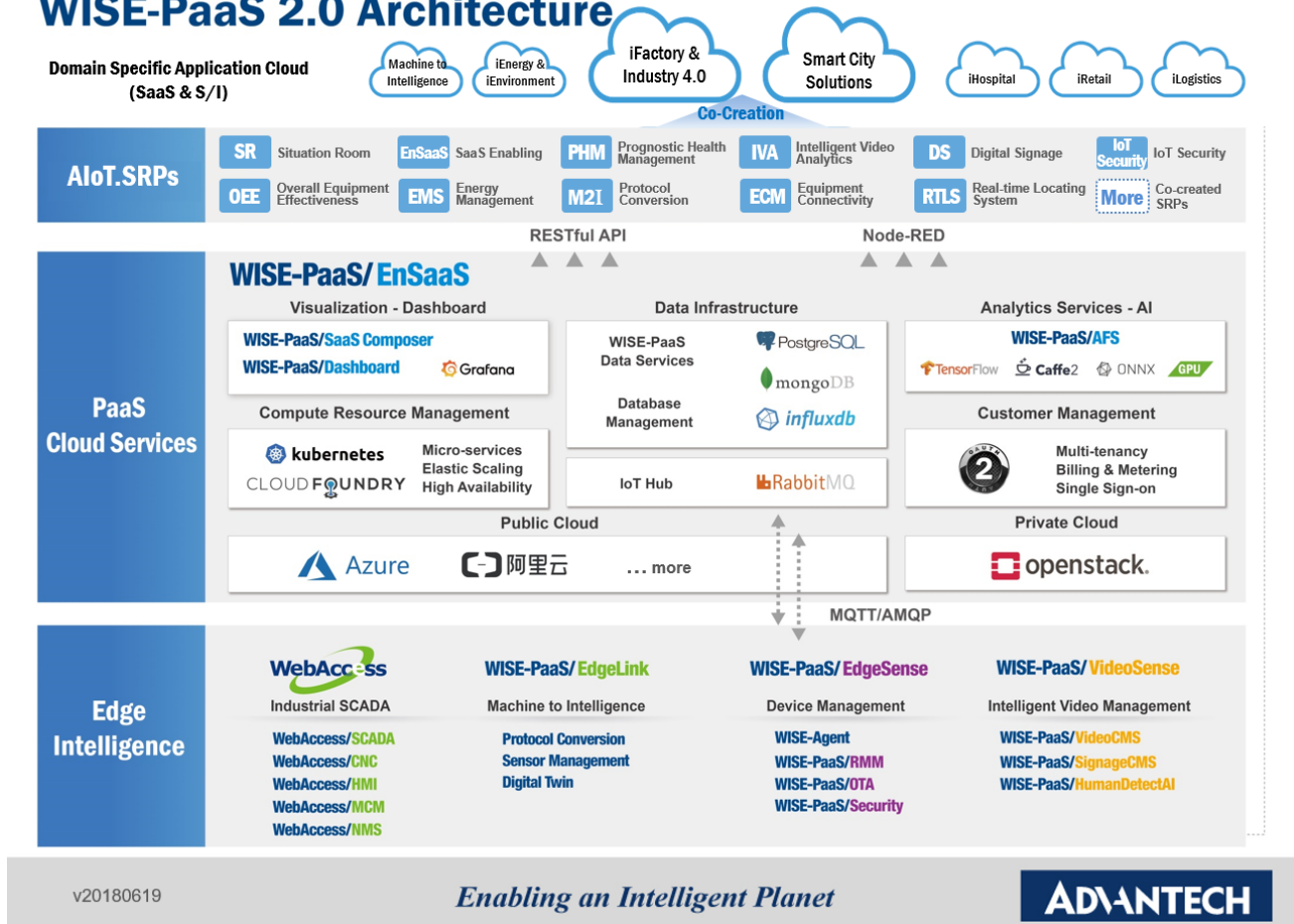
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1 Architecture Overview

WISE-PaaS 2.0 Architecture



WISE-PaaS IIoT Cloud Platform, (hereafter the "WISE-PaaS Cloud Platform" or the "Cloud Platform") is an integrated IoT service platform designed to provide an operational insight from the edge to the cloud. It allows you to easily and securely connect, manage and collect massive IoT data, as well as process and analyze/visualize data in real time. Through a comprehensive set of development tool kit, the WISE-PaaS Cloud Platform simplifies the deployment of IoT solutions, allowing you to dedicate resources to your area of expertise.

1.1 WISE-Agent

WISE-Agent is a software development framework that enables communication and information exchange between edge devices and the WISE-PaaS Cloud Platform. It has WISE-Agent SDK, a set of development kits that contains core codes that help devices and applications connect quickly to the WISE-PaaS Cloud Platform which in turn manages them.

1.2 Connectivity Service

WISE-PaaS Connectivity is a comprehensive management service that enables secure and reliable two-way communication between cloud-based IoT Hubs, edge gateways, and IoT sensing devices.

1.3 Device Management

The WISE-PaaS Cloud Platform provides a set of features and applications for device-side and back-end developers to develop robust and reliable device management solutions. By using the dashboards and applications built to the Cloud Platform, developers can easily manage, browse, configure, monitor, and detect the managed IoT devices.

1.4 Cloud Platform

The WISE-PaaS Cloud Platform is a highly innovative IIoT cloud platform designed and optimized for factories, logistics, environmental protection, energy, retail and medical industries. It synergizes platform as a service (PaaS) scalable infrastructure as a service (IaaS). It provides a host of industrial Internet cloud services that developers can easily integrate to build applications for various businesses in different industrial contexts.

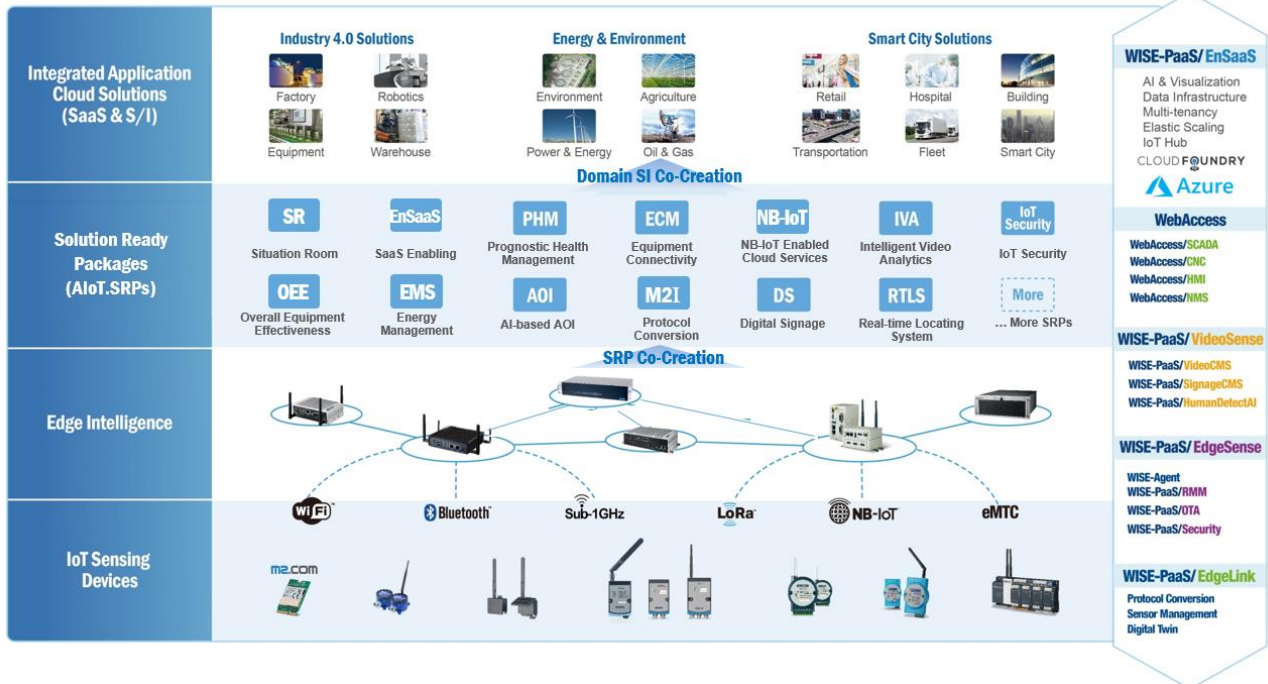
1.5 Industrial Service Set

The WISE-PaaS Cloud Platform provides a set of industrial services for developers to build, test, and run IIoT applications. The Cloud Platform also comes with visualization tools, through which developers can visually develop the real-time and historical data of the devices connected to the platform. One of such tools enables data flow control, expediting the visual development of various business logics.

1.6 Solution Suite (SRPs)

The WISE-PaaS Cloud Platform uses pre-configured and integrated IoT solutions with Cloud and Edge ready packages, so called Solution Ready Packages (SRPs) to provide cloud, security, and WISE-PaaS IoT services for specific domains.

Advantech IoT Solution Architecture



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Enabling an Intelligent Planet

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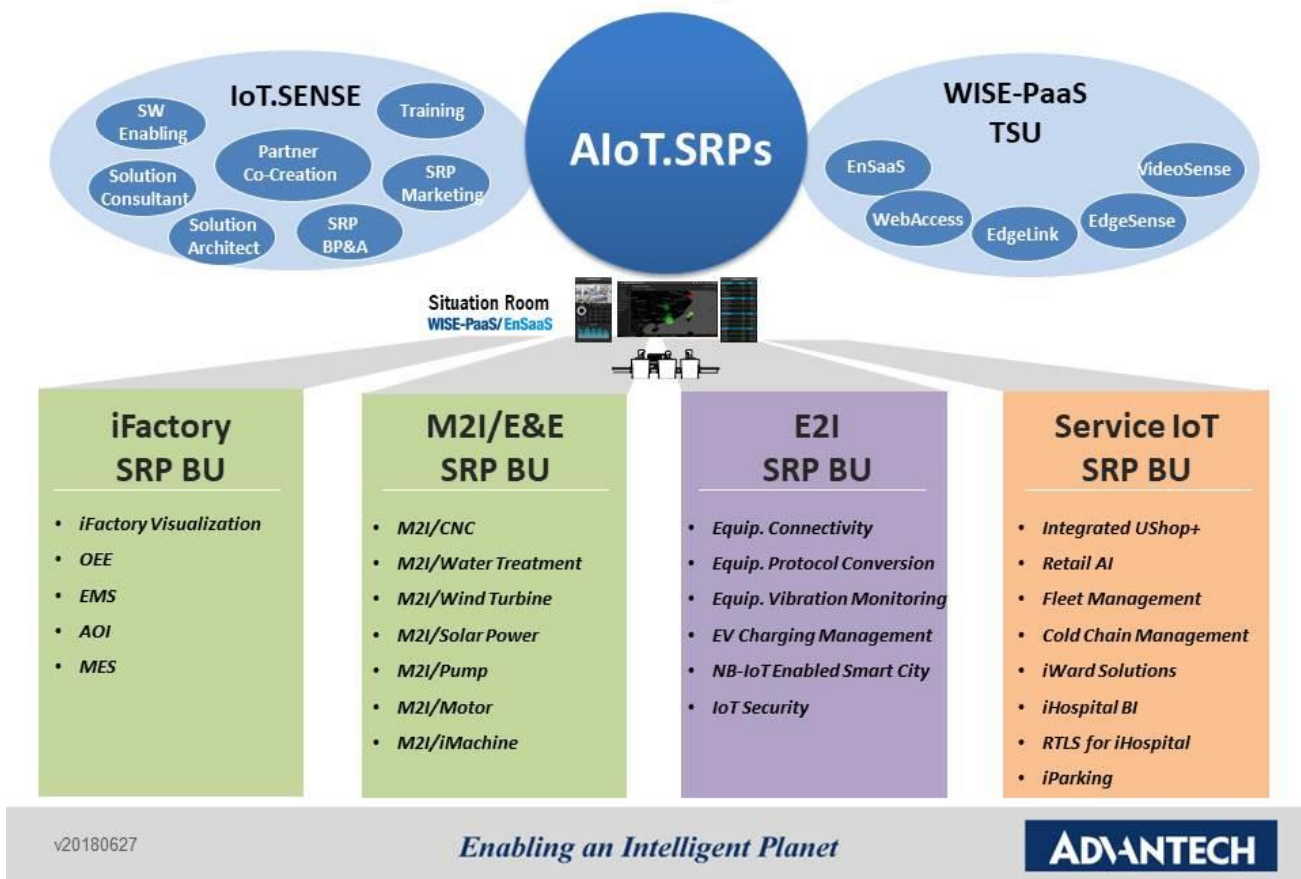
The IIoT solution must involve collecting the data of various standard on-site industrial devices, edge computing, and wireless communication device management, performing data fusion and visualization on a cloud platform, establishing artificial intelligence (AI) models based on industry expert knowledge. The solution must also meet the laws of the countries or territories where it is adopted, or the principles of data storage location management under corporate policy, and entail establishing a rigorous platform and a trustworthy asset security mechanism and combining the know-how of experts from a variety of disciplines to develop a “co-creation model.”

Such a model has proved to create mutual benefits and win-wins.

To meet the diverse criteria for what constitutes an IIoT solution, Advantech has exploited data-driven cloud service technology as a framework to develop the WISE-PaaS Cloud Platform, which supports multiple cloud infrastructures (AliYun, Amazon Web Services, Azure, Google Cloud Platform, and OpenStack on private solution), features flexible scalability, multi-tenancy, and high reliability, and provides diverse database services, a framework for AI model training and deployment, a visual management dashboard, and a multi-level asset security management service.

Advantech and its partners has used WISE-PaaS to develop all kinds of IIoT industry solutions. Through an innovative industrial cloud service business model, they have embarked on a third digital revolution.

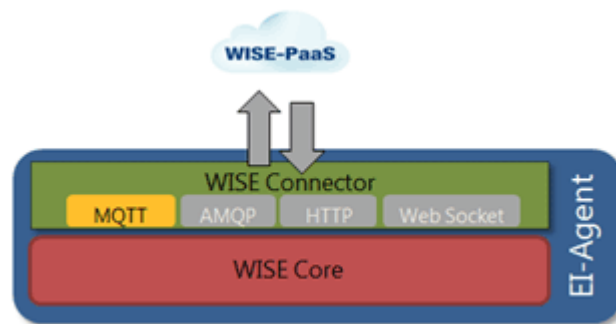
AloT.SRP Co-Creation & Ecosystem



2 WISE-Agent

WISE-Agent is a software development framework for enabling communications between edge devices and the WISE-PaaS Cloud Platform. This framework provides a large number of user-friendly, intelligent, and integrated interfaces which streamline development processes and enhance security so that two-way connections can be easily established between device proxy applications and the WISE-PaaS Cloud Platform.

Devices and data sources involved in IoT solutions range in type from simple network-connected sensors to powerful standalone computing devices. However, these devices may be limited in processing capability, memory capacity, bandwidth, and protocol support. Overcoming these limitations, WISE-Agent, which is written in the C programming language and follows the ANSI C standard, allows you to compile cross-operating system and cross-platform client applications that cater to all these devices.



Lightweight WISE Core

WISE Core extracts the core functions into a library, focusing on a handshake protocol that communicates with the WISE-PaaS Cloud Platform. This makes it easy for developers to integrate this small library into resource-constrained platforms.

WISE Connector

To support different connection protocols, WISE Connector provides developers with a universal connection API. By changing the connector module during compiling,

developers can easily connect devices to the cloud via different protocols.

3 Connection

WISE-PaaS IoT Connectivity consists of cloud connections and edge device connections and works in a such a manner that: Upward, cloud connections (IoT Hub) establish reliable and secure two-way communications between millions of IoT edge devices and cloud IoT centers and, downward, intelligent edge gateways provide connectivity support for traditional industrial devices via wired or wireless technology.

WISE-PaaS IoT Connectivity integrates IoT device technologies and various Internet protocols (IPs) to run applications in a variety of domains, collect and aggregate sensor data, and send the data to the cloud.

3.1 Cloud Connectivity

WISE-PaaS Cloud Connectivity, also known as IoT Hub, is a scalable, high-throughput, and two-way message bus that supports a number of typical standard IoT communication protocols (e.g., MQTT, AMQP, HTTP, and NB-IoT) which allow devices to easily and quickly access the Cloud Platform. It is built on RabbitMQ, an open, high-throughput messaging system that provides a low-latency platform for processing real-time data. It uses open protocols to link microservices, connect stream data and analysis, and provide event data to multiple applications to respond in real

time. It can also connect to your on-premise cloud messaging infrastructure to create a hybrid cloud IoT solution.

Moreover, IoT Hub ensures that data is isolated, protected, and properly sent to the assigned customer's tenant space. In addition to sharing the services of the IoT center, IoT Hub can be deployed to the customer's dedicated IoT space, so that the space can be exclusively used as an instance of standalone or clustered IoT Hub.

3.2 Edge Connection

WISE-PaaS edge connection includes two layers of protocol adapters: the southbound adapters and the northbound ones. The southbound adapters provide M2I (machines to intelligent gateways) connectivity through industrial communication protocols, such as Modbus, OPC-UA, Lora, and Sub-1G, and collect sensor data from IoT endpoints.

The northbound adapters provide IPs for edge devices to the WISE-PaaS Cloud Platform and send IoT data to the Cloud Platform. The adapters support a variety of IPs, such as MQTT, AMQP, HTTPS, and WebSocket, thus considerably enhancing industrial connectivity for the uploading of edge device data onto the Cloud Platform.

Furthermore, increasing the configuration of the IoT Hub cluster can raise the number of devices that can be concurrently accessed to over 50,000.

An edge device supports real-time and time-lapse messages. The time-lapse message is sent when the connection between the device and the Cloud Platform is interrupted, and the data message is subsequently cached at the edge level of the intelligent gateway or device. When the device is reconnected to the Cloud Platform, data will be matched with correct time and transmitted to the Cloud Platform through the time-lapse message.

4 Device Management (DM)

WISE-PaaS enables DM by hosting DM services on the platform and DM agents on devices to enhance the capability of the IoT platform to manage devices. Therefore, WISE-PaaS incorporates IoT devices ranging from limited sensors and single-use micro-controls to powerful communication gateways between clustered devices.

One of the keys to building a successful enterprise IoT solution is to provide a strategy that allows operators to manage running devices in a centralized way. Armed with DM messages from agents to services, IoT operators and developers can conveniently develop available and reliable tools and applications that enable them to focus on more strategic aspects of their products. The WISE-PaaS Cloud deliver the following DM functions:

- **Provisioning:** Securely provisioning new devices to IoT Hub and allowing operators to immediately identify the functionalities of the devices.
- **Configuring:** Facilitating bulk configuration changes and firmware updates to devices while maintaining both health and security.
- **Monitoring:** Monitoring the overall status of devices and the status of ongoing operations, and alerting operators to issues that might require their attention.
- **Retiring:** Replacing or decommissioning devices following a failure, a periodic upgrade, or the end of their service lifetime. Use a device twin to maintain device info if the physical device is being replaced, or archived if being retired. Use the IoT Hub identity registry for securely revoking device identities and credentials.
- **Rebooting/Resetting:** The back-end application directly informs the device through a direct method that it has initiated a reboot or reset.
- **Updating firmware/Software:** The back-end application informs the device through a direct method that it has initiated a firmware update.
- **Predictive Maintenance:** Determining the condition of in-service devices to predict when maintenance should be performed.

5 Cloud

The WISE-PaaS Cloud Platform is an innovative IIoT platform that combines platform as a service (PaaS) with scalable infrastructure as a service (IaaS). It provides a rich set of industrial Internet cloud services that developers can easily integrate to build applications for various businesses in different industrial contexts.

5.1 Cloud Architecture

For the IIoT to materialize, objects within the IoT must be effectively identified, data be managed on a massive scale, IIoT strategies be combined with existing infrastructure, and cloud computing be harnessed properly. The IIoT connects all machines and devices within an industrial site to produce valuable data or information used for analysis and exchange between the industrial environment and customers. Normally, an IIoT system cannot identify whether data is related to things or people. As the scale of data processing increases, it becomes increasingly complicated to generate valuable analysis results. Such data can be attributed to the integration of real-time production data, users, software and machines. IIoT materialization also entails integrating IIoT strategies with existing systems, which include machine-to-machine communications, big data analytics techniques, network security, human-machine interface systems, and SCADA.

The WISE-PaaS Cloud Platform architecture boasts a number of features, such as safeguarding data in the platform, providing integrity protection when collecting data, protecting edge-device nodes, and enabling platform scalability for mass data processing and system compatibility of industrial equipment. The Cloud Platform is highly focused on big data and AI technology. It provides a data analysis framework and a smart visual dashboard. The Cloud Platform works with providers of major cloud services, such as Amazon Web Services (AWS), Google Cloud Platform (GCP), and Microsoft Azure, to build a private cloud infrastructure that can optimize industrial loads. The Cloud Platform also leverages the Cloud Provider Interface, which acts as an abstraction layer above IaaS to allow the platform to be easily migrated to local host servers to deliver private or hybrid cloud services.

5.2 Cloud Foundry

The WISE-PaaS Cloud Platform is based on Cloud Foundry and allows you to rapidly create, deploy and manage your cloud applications. Cloud Foundry does not specify any particular cloud provider, nor does it confine you in any software environment or cloud infrastructure. So, it can run in public and private clouds, as well as VMWare, Azure, AWS, GCP, OpenStack and other clouds. Cloud Foundry abstracts the underlying infrastructure that is needed to run a cloud, thus allowing you to focus on building

cloud applications. Providing a flexible choice of development frameworks, including Spring for Java, .NET, Ruby on Rails, Node.js, Grails, Scala on Lift, as well as frameworks (such as Python and PHP) from partners, Cloud Foundry greatly improves the flexibility of the platform. It also supports MySQL, MongoDB, PostgreSQL, Redis, RabbitMQ, and other custom services.

5.3 Security and Privacy

Security and privacy are highly important and sensitive because the IoT, in addition to processing a large amount of sensitive data (such as those about individuals and businesses), is capable of controlling devices and may have an impact on the natural environment. Therefore, a network's physical environment must be protected from malicious attacks. The WISE-PaaS Cloud Platform protects you from security threats through the following measures:

- Decreasing the number of public IPs and external accessible ports in every possible way to minimize externally accessible internal networks.
- Isolating client applications and data in containers;
- Encrypting connections;
- Providing application security services. A set of secure industrial application services are established through user account and authentication (UAA) services.

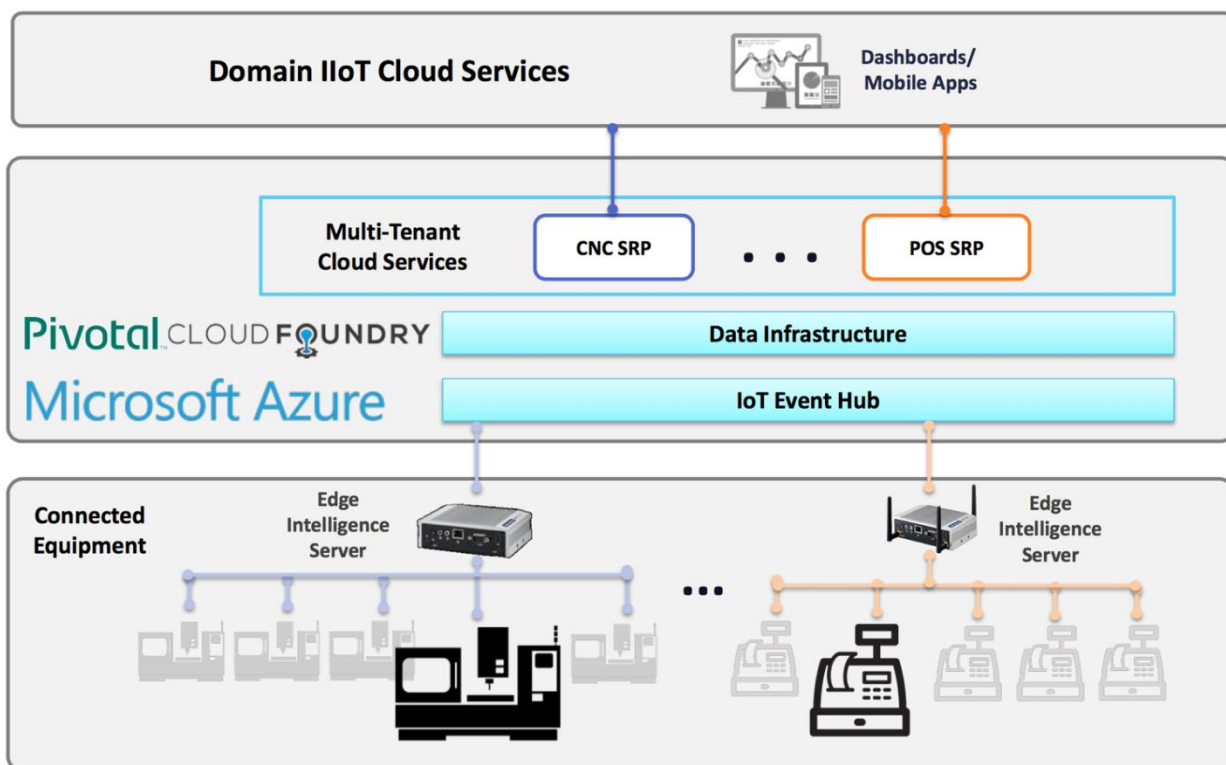
- Enabling role-based access control to implement fine-grained control over user-accessible permissions and ensuring that users can only view the space to which they are granted access and use authorized resources;
- Ensuring the security of application binary resources in multi-tenant environments; and
- Avoiding resource exhaustion due to distributed denial-of-service attackers.

5.4 Scalability

In general, it is difficult for typical enterprise application developers to build scalable applications. They usually have to use high-end, expensive hardware devices to handle the highest expected load, although such an approach is too costly and difficult to implement because developers will have to increase capacity again when it is necessary to perform computation on a larger scale. Yet, the WISE-PaaS Cloud Platform can eliminate the need for investing heavily in hardware to test or run new applications. Instead, it will manage everything for you, charging only for the resources you actually use. You can develop applications in a bordless cloud, where you can connect your private service to the public WISE-PaaS service. You and your team can access the applications, services, and infrastructure in the WISE-PaaS Cloud Platform and use existing data, systems, processes, PaaS tools, and IaaS tools.

Cloud computing addresses many difficulties, but developers still need to do a lot of work to manage application layer scalability. The WISE-PaaS Cloud Platform solution provides developers with the tools they need to create cloud-native, scalable applications. The 12 Elements of Cloud Native Applications is arguably the best practice guide for developing such applications.

WISE-PaaS manages complex platform environments and resource expansion issues, allowing developers to focus on creating applications that can contribute to industries and bring cloud computing to the industrial world in a reliable and cost-effective manner.



5.5 Platform Access Control

SSO (Single Sign-On) is used to manage resource access permissions under the Cloud Platform account. It allows you to control resource permissions for each account through identity management and strategy, and users to use resources (including applications and services) on all platforms by logging in once.

The WISE-PaaS Cloud Platform provides multi-tenant services, and the permissions and data are completely isolated between tenants. There are multiple instances of application services and solution packages (SRPs) under your account deployed in different tenant management spaces (Organization/Space). In order to strengthen access control and authorize resources, as a tenant administrator (a role assigned and authorized by the platform management), you can create sub-accounts to bind different authorization roles including the platform administrator, tenant administrator, tenant developer, and SRP user.

- The tenant administrator acts as the platform's tenant and can manage authorized Organizations, including account and resource management in organizations. The administrator can add/read/update/disable accounts with roles of tenant/developer/srpUser within the authorized organization (Organization).

- The tenant developer is the developer of the platform and develops application.
The developer is created through the account with the tenant role. The created account will be authorized with appropriate privileges. It is allowed to add an account with the srpUser role in the authorized organization (Organization/Space).
- srpUser is the role created specifically for an application. An application can use srpUser to perform user authentication consistent on the platform to deliver the SSO function. Then the srpUser is authorized through the app to determine the functions that the srpUser can operate in the application. This role is created through a user-developed app which grants appropriate account permissions. This means that an SSO service is provided through the platform to manage your account. You can contact the system administrator as needed. srpUser is allowed to add an account with the srpUser role.

5.6 Platform Attack Defense

The attack defense of the Cloud Platform provides you with customized security protection configurations through cooperation with third parties. In terms of infrastructure, Azure is mainly responsible for providing protective measures, such as network, storage and computing security, in line with international standards:

- Implementing network boundary division, logical isolation and access control;

- Dividing the Cloud Platform's infrastructure network domain and production data network domain on virtual machine servers, deploying the cloud Web application firewall, setting up external read-only control strategies for a production data server, and preventing the data from the server from being maliciously tampered with;
- Performing penetration testing, intrusion detection, DDoS protection, auditing and logging;
- Security incident response, definition and commitment of common responsibility.

Cloud Foundry implements the following measures to mitigate security threats on the Cloud Platform:

- Limiting the exposure of regulatory network interfaces;
- Isolating customer applications and information in containers;
- Online encryption;
- Role-based user access management and application, as well as the corresponding relation between role and permission specification, ensures that users can only view and affect the space to which they are granted access;
- Ensuring app security in a multi-tenant environment;

- Preventing possible DDoS attacks initiated through resource starvation by signing an authentication (or authorization) token (Access Blocking).

Providing security testing tools for McAfee and Acronis on the platform to select from:

- Using McAfee to timely scan virtual machines (VMs) or device-side viruses, Trojans, worms, and malicious codes, and create a whitelist to protect the entire operating system;
- The Acronis backup scheduler can timely restore system services in the event of a disaster;
- Monitoring the use of all VM resources on the platform in real time, analyzing the system log regularly to determine whether there are signs of intrusion, and then offering real-time response and isolation.

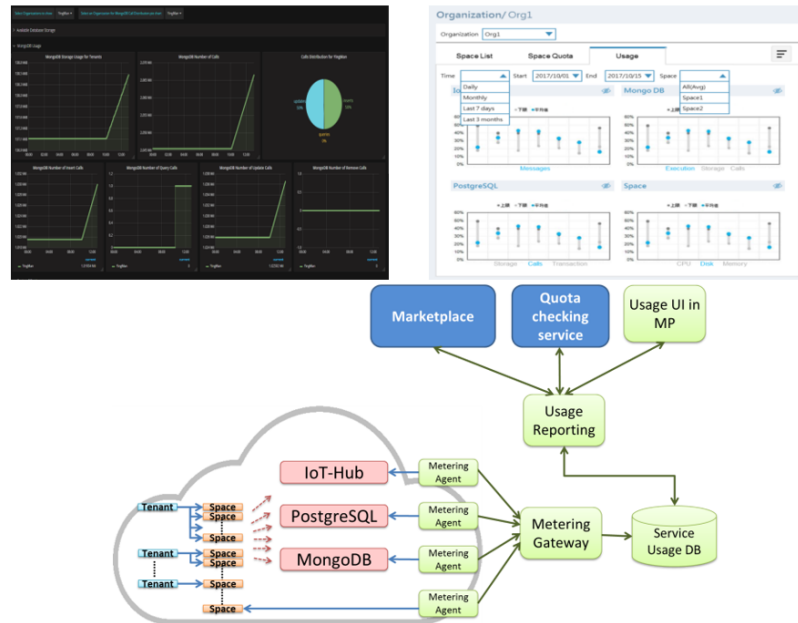
5.7 Measurability of Platform Services

Metering Service

Meter WISE-PaaS/EnSaaS resource usage of each tenant account and use it for billing. Including (1) graphical metering console, and (2) usage query functions

Features

- Meter WISE-PaaS resource usage of each tenant separately, and display results with dashboard.
- Calculate tenant's real-time WISE-PaaS/EnSaaS resource usage with distributed metering agent.
- Tenant can query resource usage by specific service or period.



● The Measuring and Billing System

The measuring service of the WISE-PaaS Cloud Platform calculates the resource usage of each tenant on the Cloud Platform in real time. It further serves as a basis for billing and includes two major features: graphical usage monitoring interface and elastic usage query:

- 1) Calculating the resource usage of each tenant and present the resource usage data on a visual dashboard;
- 2) Measuring users' cloud resource usage in real-time through a distributed

measurement agent mechanism;

- 3) The query function allows the user to query individual resources in terms of resource usage or service time.

- **Measurement Methods and Units**

The resources used by the tenants are measured based on the number of messages transmitted monthly by IoT Hub, the memory quota applied in the dedicated space, and the size of database storage space occupied. IoT Hub is measured in millions of messages; the memory quota applied in the dedicated space in 2G memory; the database in 50 Gigabytes of storage space.

- **Payment Mode**

- 1) The platform provides a one-month trial. You can get assistance from a specially-assigned representative by joining MyAdvantech ;
- 2) The platform service billing is based on WISE-Point and applies different prices to Regular, VIP and Premier members. Users can get WISE-Point only when they are enrolled as one of the three member statuses.
- 3) The platform provides three Packages (Entry, Value, and Economic), corresponding to different numbers of database, memory, and IoT Hub Messages. PAYG (Pay As You Go) is used if the amount in the Package is exceeded.

4) At the end of each month, the bill will be settled, and the usage points of the month will be deducted from the user. Users will be notified if their points are insufficient.

- Retention Time of the Originally Measured Log

The platform retains the daily resource usage measurement logs of the most recent year for tenants.

6 Service

For system integrators and developers, WISE-PaaS provides a set of off-the-shelf services for system integrators and developers, so you no longer have to bother installing software, processing virtual machine images, or hardware. As a leader in industrial computer manufacturing, the Cloud Platform also takes full advantage of its understanding of various industrial devices and protocols. Therefore, WISE-PaaS provides not only cloud services, but also an extensive portfolio of cloud-edge integration services to make it more convenient for customers to develop IoT solutions.

The Cloud Platform provides three key components to achieve a comprehensive IoT solution:

- IoT sensing devices: provide device-sensing services, including monitoring, industrial protocol connectivity, and data plug-ins;
- Edge Intelligence Servers (EIS): Provide intelligent edge services, including edge-side flow analysis, data acquisition, device management, and protocol connectors;
- Cloud Services: provide end-to-end security services, data infrastructure services, data analysis services, visualization services, and operation and maintenance deployment services.

WISE-PaaS Marketplace, an IoT software shopping website, features various clouds and software solutions that are offered by Advantech's IoT partners to help customers accelerate tool development and upgrade existing systems to the cloud.

6.1 Edge Intelligence Service

The WISE-PaaS Cloud Platform provides IoT solutions through IoT sensor devices, the edge intelligence service and cloud services. The Cloud Platform focuses on the research and development of edge devices and provides an EIS software suite, which comprises southbound (downward) connections for sensing devices that process Modbus, OPC, BACnet, wireless IP/non-IP, and many other sensing protocols. These

protocols have their own plug-in modules for data communications with the Cloud Platform, monitoring sensor status and processing data formats.

The EIS handles northbound (upward) cloud connections, device intelligence, and management services for different cloud platforms and different devices by microservice container-based modules. The EIS intelligent facility also uses microservice containers to preprocess and cleanse data. The most valuable element of the EIS software suite is flow analysis. The Cloud Platform provides PMQ (Predictive Maintenance and Quality) functions for IPC industrial computers; it also delivers MCM (Machine Condition Monitoring) functions to acquire vibration signals acquisition, thus preprocessing and extracting feature values; they can perform real-time analysis on edge devices. The container-based microservice on the cloud will constantly update container-based modules for different business purposes. The updated modules can then be applied to edge devices. Users can use the EIS open standard architecture to implement their own analysis modules, predictive maintenance diagnostic modules, and so on. The entire open standard will follow the MQTT protocol and Docker container technology that serve as the basic framework.

The Edge interface provides RESTful API, MQTT and Node-RED for the client's developers to develop their own applications. Node-RED features a highly user-friendly UI where solutions can be quickly developed in a few simple steps. In addition, the MQTT SDK sample code and RESTful API and documentation provide advanced developers with the required technical data.

6.2 End-to-end Security Services

The WISE-PaaS Cloud Platform provides multiple layers of security strategies and services that application developers can use to protect their end-to-end applications.

These include:

- **Platform Security**

The Cloud Platform combines user account and authentication (UAA) and single sign-on (SSO) to provide security platform services. UAA complies with the OAuth 2.0 specification and supports all core OAuth 2.0 token issuance types. By default, UAA uses a Base64-encoded JSON token and a JSON-based Web Token (JWT) specification.

WISE-PaaS adopts role-based access control, and specified Organization or Space permissions are precisely divided for each role.

- **Data Security**

The platform provides SSL/TSL security mechanisms for data communications, and

whitelist protection is enabled on edge devices to provide data security management from devices to the cloud.

- Application Security

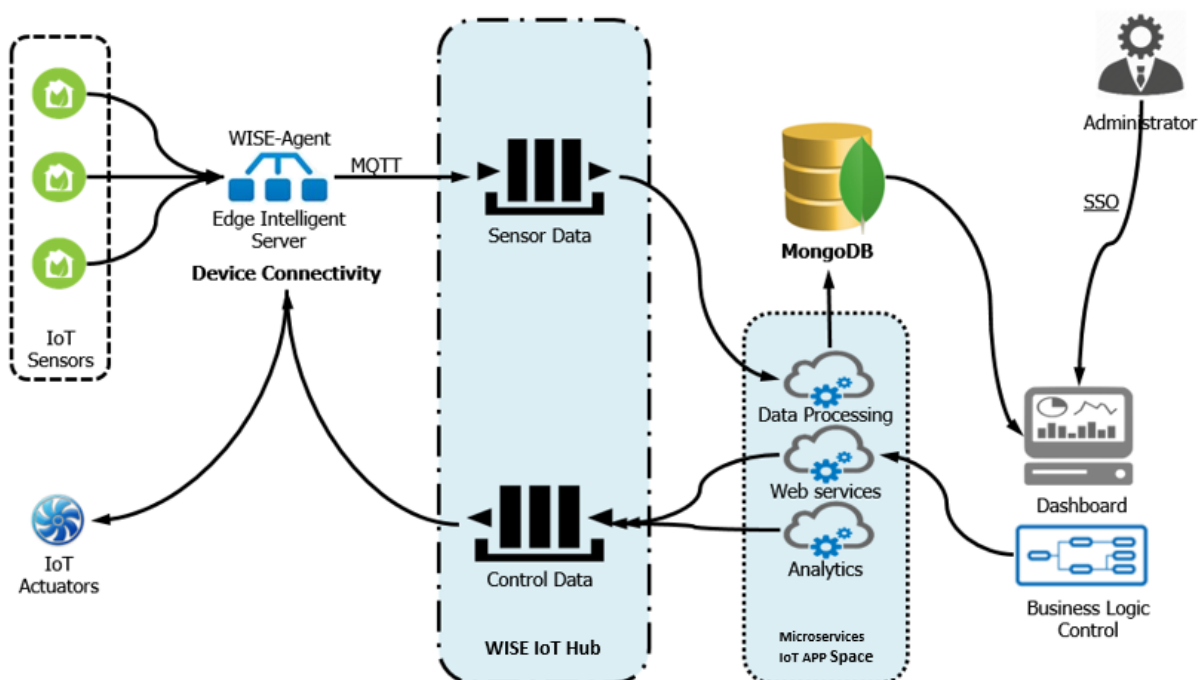
The platform runs applications in a secure container and protects the container by:

- 1) Running app instances in non-privileged containers and enhancing security by eliminating the threat of root privilege escalation by default.
- 2) Limiting the container's capabilities and access permission to reduce the likelihood that the container will be breached and attacked;
- 3) Allowing only public address connections from app containers. This is a default setting, and administrators can change the Azure Application Security Groups (ASGs) through configuration. For more information on ASGs, refer to the topic of the Application Security Group.

6.3 Data Infrastructure Service

The data infrastructure service enables IoT app developers to store data on the WISE-PaaS Cloud Platform and these data services to connect to their industrial apps. Data may be transmitted from edge devices. These devices provide a local intelligent processing mechanism that can pre-cleanse and aggregate data, and send data to the Cloud Platform through WISE-Agent. The Cloud Platform provides a space for IoT

applications. Developers can deploy the back-end microservice to receive and process data. They can also develop applications such as WEB service and data analysis. Finally, they store data in appropriate types of data storage, whether it is NoSQL (non-relational database) and TSDB (time series database) for sensor data storage, or RDBMS (relational database management system) for data application and management. PostgreSQL and Mongo NoSQL DB are standard products that are currently available and they support the integration of Open Database Connectivity interfaces. In addition, these data can be incorporated into various dashboard tools.



6.4 Data Visualization Service

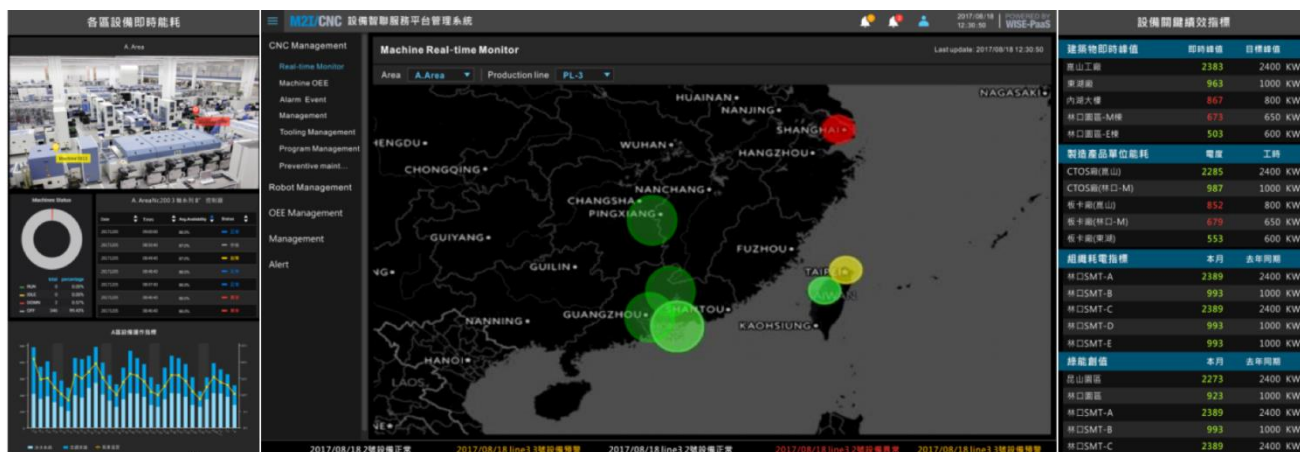
The data visualization tool provides an intuitive analysis that gives an organization's staff a firm grasp of its operation. The dashboard will be the last mile of the IIoT application. The WISE-PaaS Cloud Platform's data visualization service is easier to operate than earlier versions of traditional statistical analysis software or business intelligence software. This makes it possible to implement a data visualization interface based on a certain business scenario without having to enlist IT professionals.

Data visualization also plays an important role in big data and advanced analysis projects. As companies continue to accumulate data, they need to employ visualization tools as a convenient means to get an overview of their data.

WISE-PaaS/Dashboard is based on the secondary development of Open Source Grafana, and it provides artistic and diverse forms of data presentation and supports numerous data sources and databases, as well as various forms of data presentation.

The data source and display component support the development and expansion of plug-ins, and they provide a variety of official and community-developed plug-ins, and plug-ins are customized through various cloud platforms based on various IIoT business scenarios.

WISE-PaaS/Dashboard contains a lot of features that are applicable to IIoT scenarios on the basis of Grafana, allowing it to seamlessly access platform data and quickly create a variety of commercial intelligent dashboards or information situation rooms.



6.5 Data Analytics Framework Service



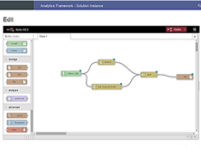




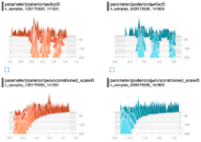

WISE-PaaS IIoT Cloud Platform's data analytics framework service (hereinafter the AFS) provides a simple drag-and-drop interface for developers to assemble analysis modules into solutions. It integrates a variety of machine learning function libraries, such as Spark Mllib and TensorFlow, to easily invoke back-end distributed computing resources and reduce the R&D threshold. The main functions of the data analysis service of the WISE-PaaS Cloud Platform include:

- 1) Analyzing module/solution management, and providing complete life-cycle management of analysis modules/solutions, including subscription, verification, and release;

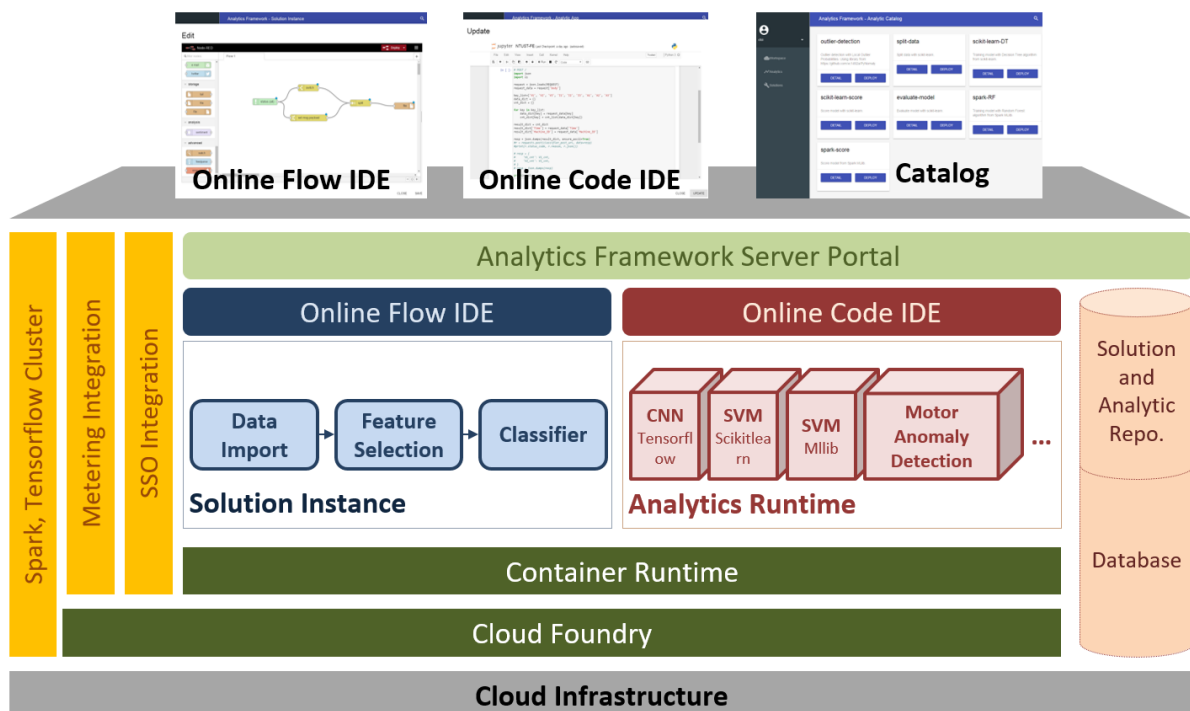
- 2) Developing solutions online and providing drag-and-drop interfaces to assemble multiple analysis modules for solution development;
- 3) Developing analysis modules online and providing an online integrated development environment to develop analysis modules, which are then deployed to the Cloud Platform;
- 4) Providing a variety of algorithms and high-speed computing modes for analysis.

WISE-PaaS/Analytics Framework Services(AFS) Modules

**From data simulation, exploration, machine learning model training
to edge deployment inference engine**

Backend	Online Code IDE	Online Flow IDE	Catalog	Inference Engine
<p>Supports various development frameworks</p> 	<p>Develop analytic modules</p>  <p>Code → Analysis Modules</p>	<p>Design online solutions</p>  <p>Process → Solutions</p>	<p>Ready-to-use packages</p> 	<p>inference engine remote deployment</p>  <p>WISE-PaaS/RMM WISE-PaaS/OTA</p>
Firehose	Trigger	Board	SDK	Integration
<p>Stream/batch data bridging</p>  <p>IoT Hub Database WISE-PaaS/Dashboard</p>	<p>Automatic task trigger</p>  <p>IF THIS THEN THAT</p>	<p>Model performance</p> 	<p>Software Development Kit</p> 	<p>Full Integration with WISE-PaaS</p> <ul style="list-style-type: none"> Multi-tenancy Management Portal Single-sign-on(SSO)

Under previous architectures, developers not only write relevant analysis program codes but also deal with various operation and maintenance-related issues, such as OS security and the expansion of application services. The AFS spares developers these issues, allowing them to focus more on the logic design of analysis programs. Other issues related to server operation and maintenance are addressed through the Cloud Platform. This can speed up development and allow developers to quickly translate an idea into a real service. The AFS drives the implementation of technology through event. Developers can set some conditions, and when these conditions are met, a series of processes and analyses will be triggered to reduce the idle time of computing resources.



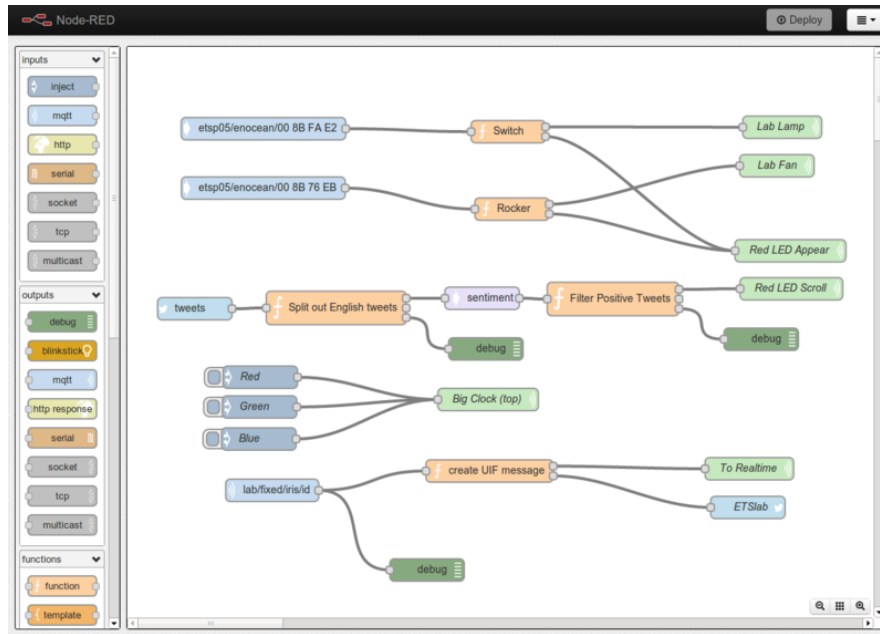
6.6 Microservice Development Framework Support

Premised on the Spring Cloud microservice development framework, the Cloud Platform helps developers construct a microservice programming framework which reduces the development threshold. At the same time, there are flexible mechanisms for service discovery, load balancing, service management, and configuration center functions of microservice. The underlying service support of high-availability and high-performance makes it easy for developers to develop microservice architecture applications on the platform.

6.7 Visual Data Flow Control

The WISE-PaaS Cloud Platform also contains a visualization tool, Node-RED, which is an open source visual editor developed for the IoT. It provides a browser-based editor, so the user can select various feature-rich nodes in the panel and easily connect these nodes together. Once you have edited the nodes, click "Deploy" to execute them.

Node-RED in the Cloud Platform is encapsulated into an application service and can be deployed into developers' IoT application space. With Node-RED, developers can receive data from the IoT Hub, process data, control rule-based data flow, and execute their own business logic. These steps can be completed in minutes, even without writing codes.



6.8 Platform Management Service

WISE-PaaS provides cloud platform management tools that allows you to manage the space resources, services, and applications of each tenant, whether it is on a public or private cloud.

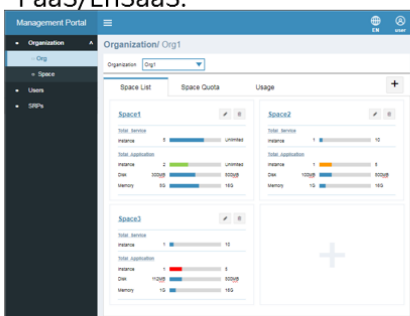
WISE-PaaS Management Portal presents an interactive UI. Users can manage applications, services and exclusive spaces in real time and quickly create a development and management environment, thus reducing the overall development time and workload. Through the service subscription management function, application back-end services can be quickly provided to shorten development time. The visual interface enables users to easily manage the life cycle of their own applications and monitor the operating status of the applications in real time.

App and Service Management Console

Interactive GUI for tenants to manage apps, services, and subscribed space, to help them build up developing environment quickly and also reduce lead time

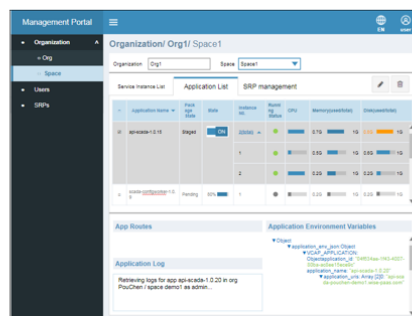
Space Management

Tenant users can allocate space by themselves for solutions on WISE-PaaS/EnSaaS.



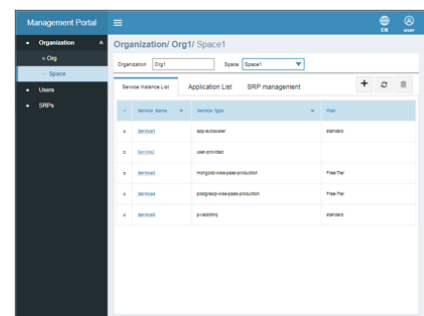
App Management

Manage app lifecycle with graphical interface, and monitor function status.



Service Management

Easily and Quickly provide backend services by subscribe/un-subscribe function.



6.9 Online Application Market

An online application market built through the WISE-PaaS Cloud Platform, WISE-PaaS Marketplace features Advantech's exclusive software services, various IoT cloud services, IoT security services, WISE-PaaS IoT software services, and pre-built-in Advantech EIS Solution Suite. WISE-PaaS Marketplace offers various cloud and software solutions, which are provided by Advantech IoT partners to help customers accelerate tool development and upgrade existing systems to the cloud. After customers join WISE-PaaS and become VIPs, they can use WISE-Points to order

WISE-PaaS market-related services to obtain cloud-based software solutions for IoT innovation.

Customers can discover excellent software solutions on WISE-PaaS Marketplace, and they can quickly and automatically deploy them to their own spaces. The application market provides industrial vertical applications such as WebAccess, EdgeSense, EdgeLink, VideoSense, and other solution suites.

6.10 Developer Knowledge Center

WISE-PaaS Technical Portal provides platform developers with comprehensive and detailed documentations and sample programs, and facilitates application development or migration.

7 Solution Suite (SRPs)

The WISE-PaaS Cloud Platform includes a pre-configured solution suite that provides cloud, security, and WISE-PaaS IoT services need to achieve specific solutions.

7.1 WebAccess (Industrial Data Acquisition and Visualization)

WebAccess Cloud Platform is the world's first HMI/SCADA graphic control software developed on a full-browser architecture that can be seamlessly integrated with relevant Cloud Platform IIoT products. It is divided into two main categories: intelligent

infrastructure and intelligent manufacturing, both of which form the IoT architecture for the Cloud Platform under intelligent automation. Moreover, WebAccess Cloud Platform is fundamental to the IoT architecture and platform solutions. It allows users to acquire and analyze data provide them with IIoT solutions. It supports open APIs for secondary development and enterprise-level system integration. It offers a cross-browser dashboard interface that allow all on-site statuses to be easily monitored and controlled, and processed anytime, anywhere through a PC, smartphone, or tablet computer. And they can be easily integrated into the WISE-PaaS IIoT Cloud Platform. WebAccess-related products include:

- WebAccess/SCADA: Data Acquisition and Supervisory Control System
- WebAccess/CNC: Digital Machine Tool Control System
- WebAccess/HMI: Human Machine Interface
- WebAccess/NMS: Network Management System
- WebAccess/MCM: Predictive Maintenance System Configuration System

7.2 WISE-PaaS/EdgeSense (Edge Intelligence and Sensing Integration)

WISE-PaaS/EdgeSense is a software solution for edge intelligence and sensor integration. It combines sensor data acquisition, wireless software real-time updates, edge analysis, cloud applications, and end-to-end data protection to implement

intelligent device-to-cloud operation in real time.

The EIS collects sensing data and analyzes lightweight data of the underlying devices, but in order to expand the application of edge intelligence, the Cloud Platform reshapes related services for edge intelligence operations again, strengthens hardware and software integration from the end to the cloud and launches

WISE-PaaS/EdgeSense, which is defined as a software service platform integrating device networking and wireless sensing. WISE-PaaS/EdgeSense expands the size of edge intelligence computing services and allows solutions to no longer just add value to software for a single application. Instead, it integrates all edge-related functions and services into the platform. This highly modular software stack architecture may expedite development and integration. WISE-PaaS/EdgeSense opens a gate for cascading the terminal and the cloud, allowing smoother communication from the end to the cloud. Its role definition can be divided into two aspects, namely, downward integration and serial connection for device sensors, networking between devices, data acquisition, and how edge devices can be used intelligently. Upward, it is cloud management and data analysis. Through software value addition on the WISE-PaaS/EdgeSense platform, data visualization, AI analysis, and machine learning applications can be implemented, or commands can be sent back downwards to the

terminal through cloud analysis results, allowing the EIS to perform local computation or operation to optimize edge intelligence.

WISE-PaaS/EdgeSense also features a high degree of integration to meet the needs of different industries. Customers can combine it with relevant application services for different uses. For example, in the context of smart retailing, WISE-PaaS/EdgeSense can be integrated with WISE-PaaS/VideoSense and imported into applications for image analysis, and in the factory floor, it can be integrated with SCADA or HMI in WebAccess. EdgeSense-related products include:

- WISE-PaaS/RMM: Remote Device Monitoring and Management System
- WISE-PaaS/OTA: Remote Software Upgrade Management System
- WISE-PaaS/WISE Agent: Gateway Connection SDK
- WISE-PaaS/Security: Centralized IoT Device Security Management
- WISE-PaaS/ESL: Electronic Tag Management System

7.3 WISE-PaaS/VideoSense (Intelligent Video and Multimedia Resource Management)

WISE-PaaS/VideoSense is an IoT intelligent imaging application service platform that provides intelligent management systems (such as data sensing, image analysis, data visualization, and instant delivery playback) and important image technology modules

for industrial security, retail logistics, transportation, and healthcare.

VideoSense-related products include:

- WISE-PaaS/VideoCMS: Video Content Management System
- WISE-PaaS/SignageCMS: Digital Content Management System
- WISE-PaaS/HumanDetectAI: High Precision AI Video Analysis Engine for Human Body Recognition

7.4 WISE-PaaS/EdgeLink (Edge Device Wiring Connection)

WISE-PaaS/EdgeLink provides a smart-linked software service platform for edge devices, and hardware and software solutions for the intelligent device connections, thus equipping device manufacturers of all sizes with simple, scalable and cost-effective solutions to bridge gaps among machines, sensors, and IT applications and achieve the transformation of Industry 4.0. WISE-PaaS/EdgeLink utilizes a powerful device driver library which includes sensors, meters, controllers, and device I/O access. Through simple configuration, it enables comprehensive sensing of complex field devices. From a simple sensor to a more complex device system, a complete and interoperable twin of device and digitalization can be established through WISE-PaaS/EdgeLink. There is no need to change the application platform, or upgrade and replace the machines and production systems, in order to achieve the digital

transformation of Industry 4.0. Moreover, the cost of device integration, operation and maintenance is minimized. WISE-PaaS/EdgeLink, as the vital software technology of the IIoT edge, provides an integrated wired/wireless network solution. It can easily establish a data path between the edge device and the cloud according to different field networks, and realizes interoperability between the existing devices and information technology systems, and in the process of data transmission and access, security access mechanisms are added to ensure secure and stable data transmission.

8 Conclusion

The WISE-PaaS IIoT Cloud Platform provides IoT service components which allow you to quickly assemble industrial solutions that suite your desired scenarios to support any possible load. On the WISE-PaaS Cloud Platform, you will find a set of highly available services that are designed as a series of complex, yet easy-to-integrate and scalable applications. You can draw on the data and operational capabilities of intelligent devices to meet the needs of different industrial contexts, improve business processes, and enhance analysis and predictive maintenance for real-time asset optimization. Also, a secure connection between industrial devices and cloud platforms can be established to access highly durable storage, low-cost computing, high-performance databases and management tools. All of these IoT services entail no

cost, and you pay only for the resources you use. These services can help business organizations to faster mobilization, reduce IT costs, and grow in scale.

Appendix 1 : Glossary

Term	Definition
Advanced Message Queuing Protocol (AMQP)	The AMQP is an advanced application layer standard message queuing protocol that provides unified messaging services and serves as an open standard for application layer protocols designed for message-oriented middleware. Clients and message-oriented middleware based on this protocol can deliver messages and they are not limited by different products, development languages and other conditions of the client/middleware.
Analytics visualization	Visual analysis is an analyzer that is used mainly for analyzing the relationships between massive datasets. It can assist manual operations to make data correlation analysis and create a complete analysis chart.
Application Security Groups (ASGs)	Azure Application Security Groups.
Azure	Microsoft's Public Cloud Service Platform.

Amazon Web Services (AWS)	AWS is a professional cloud computing service provided by Amazon.
Billing	Billing System.
Cloud Foundry	Cloud Foundry is an open source PaaS cloud platform that supports multiple frameworks, languages, runtime environments, cloud platforms, and application services, enabling developers to deploy and expand applications in seconds without having to worry about any infrastructure issues.
Container	Container is a type of virtualization (also called "operating system virtualization") which makes an operating system independent of applications.
Dashboard	It is an information system visualization module.
Digital signage	It is a professional multimedia audiovisual system that displays commercial, financial, and entertainment information through large-screen terminal display devices.
Device management (DM)	Device Management System

Energy and Environment (E&E)	Energy and Environment: Intelligent Energy and Environmental Management
Edge Device	<p>An edge device refers to the open platform device that uses the network, computing, storage, and application core capabilities as a whole on the side close to the things or a data source to provide nearest-end services nearby. Its applications are launched on the edge, resulting in faster network service response. It can meet the industry's basic requirements in real-time business, application intelligence, security and privacy protection.</p> <p>Edge computing occurs between physical entities and industrial connections or at the top of physical entities.</p> <p>Cloud computing can still access the historical data of edge computing.</p>
Edge intelligence and sensing integration	Edge intelligence and sensing integration
Edge Intelligence Server (EIS)	The EIS provides intelligent edge services, including edge-end flow analysis, data ingestion, device

	management, and protocol connectors.
Elastic scaling	<p>Elastic scaling Involves adjusting computing resources based on business requirements and scaling strategies.</p> <p>You can set timing, period, or monitoring strategies to increase or decrease instances as needed and complete instance configuration to ensure smooth and healthy business operations. At the peak of demand, the number of instances can automatically be increased through elastic scaling to ensure that performance is not affected; when demand is low, the number of instances is decreased to reduce costs.</p>
Global asset management	Global asset management.
Google Cloud Platform (GCP)	GCP provides IT infrastructure services.
Graphics processing unit (GPU)	<p>The GPU (also known as the graphics core, visual processor, and graphics chip) is a microprocessor that performs image computing specifically on PCs, workstations, game consoles, and mobile devices (such</p>

	as tablet computers and smartphones).
Grafana	Grafana is a visual dashboard with aesthetic charts and layouts as well as full-featured metric dashboards and graphics editors, and it supports data sources such as Graphite, Zabbix, InfluxDB, Prometheus, and OpenTSDB.
High Availability (HA)	HA refers to the ability of a system to perform its functions without being interrupted and represents the degree to which the system is available.
Human-machine interface (HMI)	The HMI (also known as the user interface) is the medium for interaction and information exchange between the system and the user. It realizes the transformation between the internal form of information and the form acceptable to human beings. This interface enables human and machine to interact.
Infrastructure as a service (IaaS)	IaaS refers to services that are provided to consumers. The services utilize CPUs, memory, storage, networks and other basic computing resources. Users can deploy and run any software, including operating systems and

	<p>applications. Consumers do not manage or control any cloud computing infrastructure, but choose between operating systems, storage space and applications that are deployed, and may also control restricted network components (such as routers, firewalls and load balancers).</p>
Industrial data acquisition and visualization	Industrial data acquisition and visualization.
InfluxDB	<p>InfluxDB is an open source distributed chronological database written in Go and designed to effectively querying and storing chronological data. This database is widely used in monitoring the data of storage systems, real-time data of IoT industry, and other scenarios.</p>
Intelligent video and multimedia Management	Intelligent video and multimedia management.
IoT Hub	<p>IoT Hub is a scalable, high-throughput, two-way message bus. WISE-PaaS IoT Hub ensures that data is</p>

	<p>isolated, protected, and properly sent to the specified customer's tenant space. In addition to sharing the services of the IoT center, IoT Hub can also be specifically deployed to the customer's dedicated IoT space, so that the space can be used exclusively as an instance of stand-alone or clustered IoT Hub.</p>
IoT sensing device	IoT sensing device.
LoRa	<p>LoRa is an ultra-long-distance wireless transmission scheme based on spread-spectrum technology. The LoRa network is mainly composed of terminal (with optional built-in LoRa modules), gateway (or base station), server, and cloud. Application data can be transmitted in two ways.</p>
Machine-to-Machine/Man (M2M)	<p>M2M is a networked application and service centered on the intelligent interaction of machine terminals. The M2M protocol specifies the communication protocols that human-machine interactions comply with.</p>
Machine condition	Machine Condition Monitoring: Predictive Maintenance

monitoring (MCM)	System Configuration System
Microservice	Microservice architecture. The principle behind microservice is considering creating applications around business components that can be independently developed, managed, and accelerated. Applying microservice cloud architectures and platforms in decentralized components can make deployment, management, and service delivery easier.
Modbus	The Modbus protocol is a universal language used in electronic controllers. Through this protocol, controllers can communicate with each other, and communicate with other devices via a network (such as Ethernet). It has become an industry standard. With it, control devices produced by different manufacturers can be connected to an industrial network for centralized monitoring. This protocol defines a message structure that a controller can recognize and use, regardless of the network through which they communicate. It describes

	<p>how a controller requests access to other devices, responds to requests from other devices, and detects and records errors. It sets out a common format for message domain pattern and content.</p>
MongoDB	<p>MongoDB is a document-oriented database management system written in C++. It is used to addresses a large number of real-world problems in the application development community.</p>
Message Queuing Telemetry Transport (MQTT)	<p>MQTT is a "lightweight" communication protocol based on the publish/subscribe mode. The protocol is built on the TCP/IP protocol, which was published by IBM in 1999. The biggest advantage of MQTT is that it provides real-time and reliable message services for connecting remote devices with minimal codes and limited bandwidth. As an instant messaging protocol with low-overhead and low-bandwidth occupancy, it has uses in the IoT, small devices, and mobile applications.</p>
Multi-tenancy	<p>Multi-tenancy is a software architecture technology</p>

	<p>designed to allow the same system or program component to be used in a multi-user environment while ensuring data isolation between users.</p>
Narrow-Band Internet of Things (NB-IoT)	<p>The NB-IoT is a technical standard defined by the 3GPP standardization organization and a narrow-band radio frequency technology designed for the IoT. It has four major features: (a) providing wide coverage that offers improved indoor coverage and gaining 20 dB more than the existing network at the same frequency band, equivalent to increasing area coverage ability by 100 times; (b) handling massive connection, with every sector of the NB-IoT supporting up to 100,000 connections with low latency sensitivity, ultra-low device cost, low device power consumption and optimized network architecture; (c) consuming low power (the NB-IoT terminal module's standby time spans up to 10 years); and (d) reducing module cost (so that the cost of a company's expected single sequential module can stay</p>

	below \$5.
Network management (NM)	Network management system.
Node-RED	It is an open source visual editor. It provides a browser-based editor that presents various feature-rich nodes in the panel and allows the user to connect these nodes easily. Once you have edited these nodes, click "Deploy" to execute the nodes.
Open Authorization (OAuth)	OAuth is an open standard that allows the user to grant permissions to third-party applications to access private resources (such as photos, videos, and contact lists) that the user has stored on a website, without having to provide a username and password to the applications.
OPC Unified Architecture (OPC-UA)	It is industrial automation standard and liaises between machines
OpenStack	OpenStack is an open source cloud computing management platform project composed of several major components that each have a specific task to

	<p>perform. It supports almost all types of cloud environments, with the aim of providing a cloud computing management platform which uses diverse functions and universal standards to enable easy implementation and large-scale expansion. OpenStack provides Infrastructure as a Service (IaaS) solutions through various complementary services.</p>
<p>Platform-as-a-Service (PaaS)</p>	<p>PaaS is a cloud computing service that provides a computing platform and solution services. In the typical hierarchy of cloud computing, the PaaS layer exists between software as a service and infrastructure as a service (IaaS).</p> <p>PaaS allows users to deploy and create cloud infrastructure on clients, or to obtain and use programming languages, libraries, and services. Users need to control the upper application deployment and application hosting environment without managing and controlling the cloud infrastructure (including network,</p>

	server, operating system, or storage).
PostgreSQL	PostgreSQL is a free object-relational database server (database management system) issued under a flexible BSD-style license.
Predictive maintenance	Predictive maintenance ensures that potential failures can be analyzed and maintenance be performed in advance.
Private Cloud	<p>Built for the exclusive use of one customer, a private cloud compares favorably to public clouds in protecting data, security, and service quality. Since the private cloud is exclusive to a given customer, users have the basic settings for building the cloud and can control the way an application is deployed on this technology configuration.</p> <p>In the private cloud mode, the resources of the cloud platform are dedicated to a single organization that includes multiple users. A private cloud can be owned, managed, and operated by the organization, a third</p>

	party, or both. Private cloud deployment sites can be internal or external.
Protocol Conversion	Protocol conversion
Public Cloud	Public cloud is a service that provides computing resources to the general public. In the public cloud mode, Internet data center (IDC) service providers or third parties provide resources such as applications and storage, which are deployed at the site of the service provider. Users can access these resources via the Internet. Amazon, Google, Microsoft, Alibaba Cloud, and Tencent Cloud, are all public cloud service providers.
R	R is a programming language and operating environment for statistical analysis and drawing. A free open-source software that belongs to the GNU system, it is a suite capable of data manipulation, computing, and graphic presentation. It has effective data storage and processing functions, a complete set of array (especially matrix) calculation operators, a complete

	<p>system of data analysis tools, a powerful graphics function for data analysis and display, a set of (from S language) perfect, simple and effective programming languages (including conditions, loops, custom functions, input and output functions).</p>
RabbitMQ	<p>RabbitMQ is a popular open-source message queuing system developed in Erlang. RabbitMQ is a standard implementation of AMQP (Advanced Message Queuing Protocol). It also supports multiple message protocols, including MQTT.</p>
RESTful API	<p>Representational State Transfer (REST) refers to a set of constraints and principles for infrastructure. The application or design that meets these constraints and principles is RESTful.</p> <p>RESTful API complies with RESTful standards. The REST infrastructure is based on the performance of the HTTP protocol. In other words, the HTTP protocol is a design pattern of the REST infrastructure. For example, Stateless</p>

	and Request-response.
Software-as-a-Service (SaaS)	SaaS can be referred to as "on-demand" software, which is used upon request. It is a software delivery model in which the cloud hosts software and associated data in a centralized way and the software can be used only through the Internet without being installed. Users typically use a thin client to access SaaS via a web browser.
Supervisory Control And Data Acquisition (SCADA)	SCADA is a computer-based distributed control system (DCS) and electric power automation monitoring system. It has a wide range of applications and can be used to perform data acquisition, supervisory control, and process control in electricity, metallurgy, petroleum, chemicals, fuel gas, railways and many other fields.
Sensor Fusion	Sensor fusion combines sensor data or data generated from disperse sources so that the resulting message is less subject to uncertainty when used independently.
Spark	Apache Spark is a fast and versatile computing engine

	designed for large-scale data processing.
SRP	Solution Ready Platform Solution Suite
Single-Sign On (SSO)	SSO is used in numerous application systems to allow users access all trusted applications by logging in only once. It includes a mechanism that can map this main login to other applications for the same user to log in.
Sub-1G	Sub-1 G refers to wireless communication technologies with a frequency band of below 1GHz.
TensorFlow	TensorFlow, which takes its name from its eponymous operating principle, is Google's second-generation AI learning system that is developed based on DistBelief.
User Account and Authentication (UAA)	UAA is integral to security systems, and can be used as an identity provider (IdP for short, which services as an identity source) to provide authentication, authorization, and management of user identities, or as a service provider (SP for short, which serves as a service provider), to obtain user identity information from other IDPs, such as Microsoft Active Directory.

Virtual Machine (VM)	Virtual Machine
VMware	VMware, Inc (Virtual Machine Ware) is a "Virtual PC" software company that provides server and desktop virtualization solutions.
Web Socket	Web Socket is a network protocol based on the TCP. It realizes full-duplex communication between the browser and the server—allowing the server to actively send message to the client.
ZigBee	ZigBee is a low-power LAN protocol based on the IEEE802.15.4 standard. As defined in the international standard, it is a short-range and low-power wireless communication technology.