AI-Driven

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Intralogistics Equipment Cloud

Solution Whitepaper

Intralogistics is a new form of infrastructure that integrates next-generation information and communications technologies with the industrial economy. It is also an essential application area for China's industrial internet and its development as a manufacturing powerhouse.



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01

Overview

Background

BACKGROUND

On May 19, 2015, China's State Council released Made in China 2025, the first ten-year action plan for the strategy of building a manufacturing powerhouse. The plan proposed three stages: entering the ranks of manufacturing powers by 2025; bringing China's manufacturing industry to an intermediate level among the world's manufacturing powers by 2035; and becoming a leading manufacturing power in overall strength by 2050. On February 1, 2016, the Alliance of Industrial Internet held its founding conference in Beijing. Its establishment supported Made in China 2025 and the integrated development of the internet and industry.

The industrial internet is a new infrastructure, application model and industrial ecosystem that deeply integrates next-generation information and communications technologies with the industrial economy. By connecting people, machines, objects and systems, it builds manufacturing and service systems covering the entire industrial and value chains, enabling digital, connected and intelligent industrial development. It is an important foundation of the fourth industrial revolution. With networks as its foundation, platforms as its hub, data as a key resource and security as a safeguard, it supports industrial digitalization, connectivity and intelligence. It also integrates the internet, big data and artificial intelligence with the real economy, forming new businesses, industries, ecosystems, supply chains and industrial chains.

The development of logistics and warehousing affects the wider economy and strongly supports manufacturing. However, manufacturers, equipment types and user industries lack unified standards. This hinders data exchange and limits the ability to extract useful information and support business decisions. Standards for intralogistics equipment provide guidance for equipment manufacturers, hardware suppliers and users, supporting coordinated development across the value chain and improving service capabilities. As an important part of industrial production, intralogistics equipment is widely used across industries, creating a stronger demand for standards than many other sectors. Intralogistics differs from core production processes: it is an important cost component, involves fewer commercial secrets and gives businesses a greater willingness to move equipment to the cloud.

Development in China

DOMESTIC DEVELOPMENT

China's 14th Five-Year Plan and Long-Range Objectives Through the Year 2035 called for faster development of a modern industrial system, consolidation of the real economy, accelerated digital development and a Digital China. It specifically proposed building international-standard industrial internet platforms and digital-transformation promotion centers in key industries and regions, and advancing the digital transformation of industrial parks.

China's industrial internet was developing rapidly and becoming an important tool for industrial transformation. Yet industrial transformation and equipment cloud adoption commonly faced inconsistent digital-management practices and incompatible equipment data formats. Fragmented information, high communication costs and slow execution constrained digital transformation. Standards for bringing intralogistics equipment to the cloud can improve industrial data acquisition and help organizations achieve their data goals.

Significance and Value

MEANING AND VALUE

In 2017, the State Council issued guidance on deepening the integration of the internet with advanced manufacturing and developing the industrial internet. The guidance called for stronger resource aggregation on industrial internet platforms: bringing together data from product design, production processes, equipment operation and business management, and sharing resources such as design capabilities, production capacity, software tools, knowledge and models. It also encouraged cross-industry and cross-scenario applications, including equipment health management, process optimization, collaborative design and manufacturing, and sharing manufacturing resources.

China has an installed base of more than 4 million intralogistics machines in China, with more than 800,000 additional units in 2020, setting a new annual record. These figures reflected rigid demand even in the COVID-19 pandemic. Yet only around 10% of intralogistics machines are connected to the cloud. Equipment manufacturers sought higher profit per unit, while equipment users needed practical guidance on how to use and manage assets, integrate logistics systems, connect supply chains and support both domestic and international economic circulation.

Warehousing is a key link in logistics and a bridge between smart factories and intelligent production. As industrial growth stabilizes, improved logistics efficiency becomes an important source of profit. Cloud-connected intralogistics equipment is a foundation for transformation; its functions and benefits have a decisive influence on digitalization and intelligence, and help strengthen industrial competitiveness.

Purpose and Benefits

- Integrate logistics systems, improve overall logistics efficiency and effectiveness, and reduce the total cost of logistics across society.
- Connect supply chains and share information to stimulate upstream and downstream development and improve industrial-chain efficiency.
- Support domestic and international economic circulation, upgrade intralogistics industries and strengthen the industrial internet value chain.

02

Intralogistics Cloud Standards

Reference Architecture

SUMMARY

The reference architecture for connecting intralogistics equipment to the cloud consists of four layers: perception, transport, model and application.

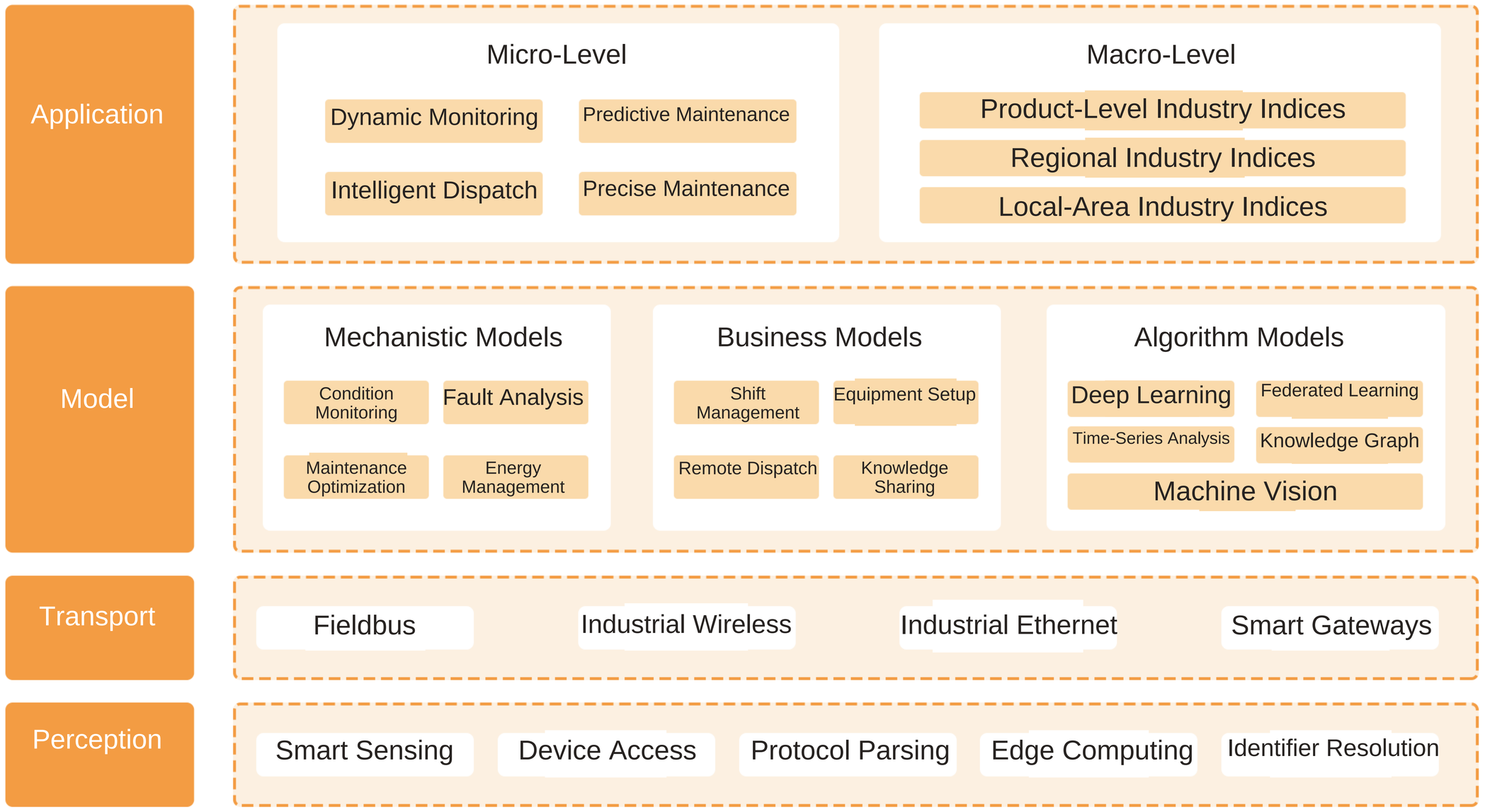


Figure 1. Reference architecture for cloud-connected intralogistics equipment

Perception Layer

PERCEPTION LAYER

(1) Intelligent Sensing

Deploy sensors and other sensing equipment at the network edge, close to devices or data sources. Connect large volumes of heterogeneous data and acquire data accurately, in real time and efficiently.

(2) Device Access

For devices with network-access capabilities, build network infrastructure in warehouses or industrial parks to connect them.

(3) Protocol Parsing

Protocol compatibility and conversion address diverse protocols, inconsistent data formats and interoperability difficulties, making data from multiple device sources and heterogeneous systems collectable, exchangeable and transferable.

(4) Edge Computing

High-performance chips, real-time operating systems and edge analytics support data preprocessing, storage and intelligent analysis near devices or data sources. This improves response sensitivity and reduces task latency.

(5) Identifier Resolution

The national industrial internet public identification system applies a one-object, one-code approach. Each device receives a globally unique identifier, replacing fragmented private enterprise identifiers and enabling data circulation and sharing.

Transport Layer

TRANSPORT LAYER

(1) Fieldbus

Common industrial protocols such as Modbus and CAN connect large numbers of devices, enabling information exchange and system integration.

(2) Industrial Wireless

Deploy 4G, 5G, Wi-Fi and other wireless networks at production sites such as warehouses and industrial parks. Flexible, mobile, high-bandwidth, low-latency and reliable networks meet production-system requirements.

(3) Industrial Ethernet

Industrial Ethernet supports high-speed data transmission and seamless integration with higher-level information networks.

(4) Intelligent Gateways

Host systems and industrial internet platforms use unified protocols and information models to communicate with different devices and systems. This simplifies integration and enables remote monitoring, fault diagnosis, configuration downloads and remote management.

Model Layer

MODEL LAYER

(1) Mechanistic Models

Build models from equipment data, including condition monitoring, fault analysis, maintenance optimization and energy management.

(2) Business Models

Combine equipment operating data with business data to build models for shift management, equipment configuration, remote dispatch, knowledge sharing and business forecasting.

(3) Algorithm Models

Use artificial intelligence to optimize the use and management of intralogistics equipment, including deep learning, federated learning, time-series algorithms, machine vision and knowledge graphs.

Application Layer

APPLICATION LAYER

(1) Micro-Level Applications

Develop industrial applications within an enterprise to achieve the intended goals of equipment cloud adoption, including dynamic monitoring, predictive maintenance, intelligent dispatch and precise operations and maintenance.

(2) Macro-Level Applications

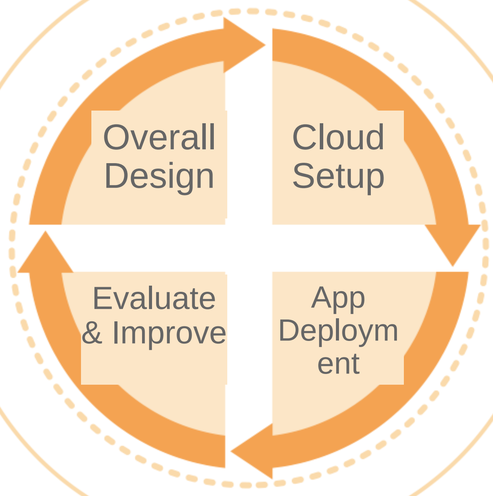
Use new industrial indices to support development across industries and regions, including product-level, industry-level and regional-level indices.

Key Steps

KEY STEPS

- System Assessment
- Requirements Analysis
- Cloud-Adoption Planning
- Benefit Analysis

- Equipment Retrofit
- Data Acquisition
- Cloud Access
- Application Development
- Security Protection



- Outcome Monitoring
- Performance Evaluation
- Continuous Improvement

- Device-Level Applications
- Enterprise-Level Applications
- Value-Chain Applications

Figure 2. Key steps for cloud adoption

03

Overall Solution

General Solution Architecture

GENERAL SCHEME ARCHITECTURE

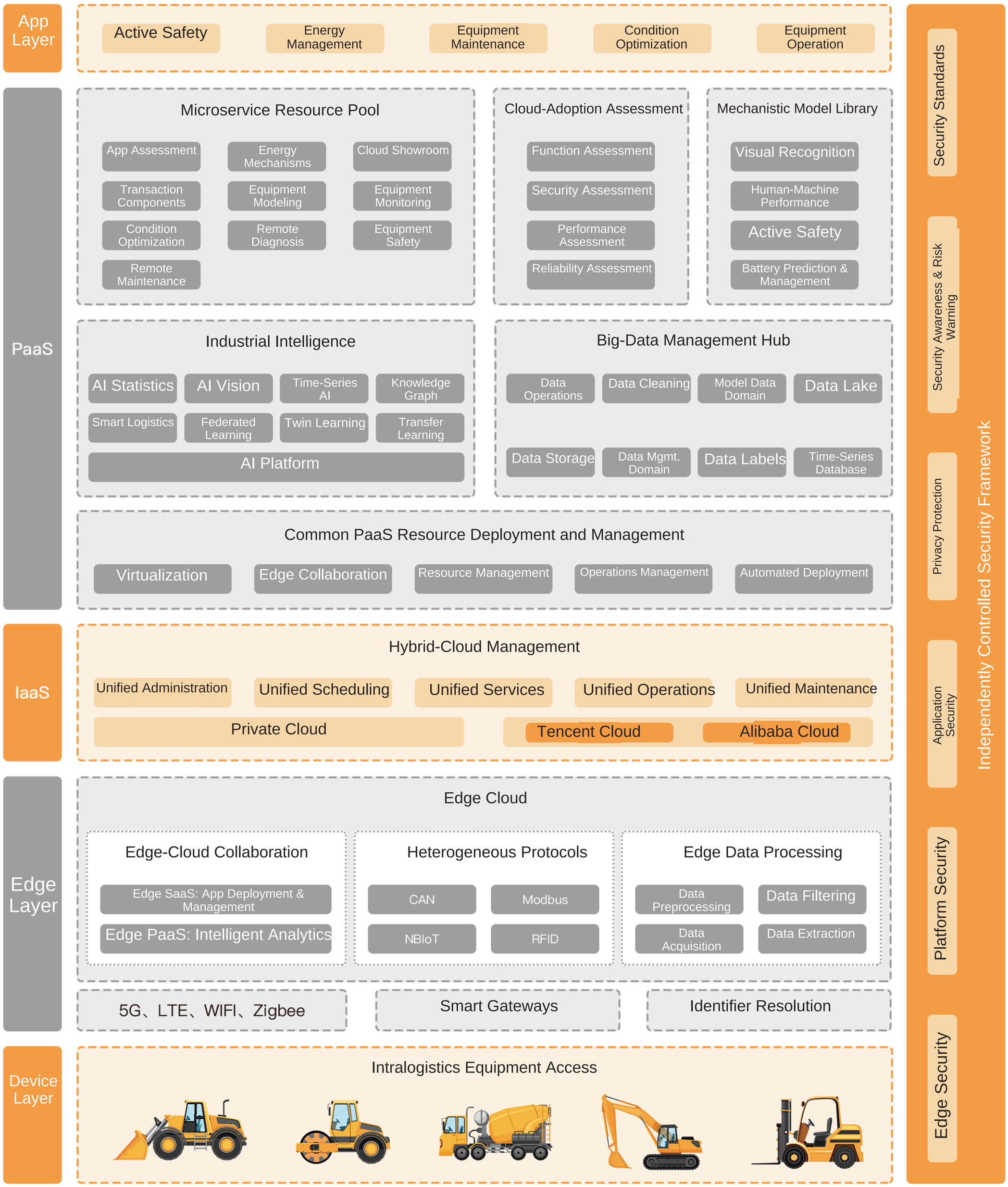


Figure 3. Solution Architecture

Cloud-connected intralogistics equipment is built on an industrial internet architecture that fully connects data-driven physical systems with digital space and enables deep collaboration between them. Network, platform and security systems connect equipment assets, management systems and resource applications; data integration and analysis link these three systems. Essential capabilities include managing large volumes of industrial data and equipment models, as well as modeling and analysis. Functionally, the general solution comprises the device, edge, PaaS and application layers, with IaaS and security services running throughout.

Device Layer

This is the physical system of the industrial internet. It combines foundational technologies in materials and processes from mechanical, electrical and chemical engineering with industrial vision and measurement sensors, plus actuation, automatic control, monitoring and acquisition technologies. Industrial edge operating systems and open BOM acquisition systems complete data collection and integration for on-site equipment.

Edge Layer

Extensive, detailed data collection, protocol conversion and edge processing of heterogeneous data form the industrial internet platform's data foundation. Edge-cloud architecture connects production equipment through industrial Ethernet, industrial fieldbus and wireless protocols such as 4G, 5G and NB-IoT. Protocol parsing and middleware support Modbus, OPC, CAN, Profibus and other industrial protocols and software interfaces, enabling seamless conversion and normalization of data formats. HTTP and MQTT transmit collected device data from edge nodes to the cloud for remote access.

Platform Layer

A general PaaS foundation is combined with industrial big-data platforms, application-development platforms and industrial microservice libraries to create an extensible, open cloud operating system. First, cloud-computing and PaaS technologies schedule system resources and manage operations, integrating edge-cloud collaboration, blockchain, big data and microservices to support business functions. Second, industrial data management uses distributed file systems, SQL and NoSQL databases, in-memory computing and stream processing to store and process massive data efficiently. Data labeling, sharing and visualization supply high-quality inputs for modeling and analysis, while data-lake architectures improve performance and management efficiency. Third, industrial intelligence and digital twins combine deep learning, transfer learning and federated learning with industrial mechanistic modeling, application simulation, business processes, statistical analysis and scientific modeling to extract deeper value from industrial data.

Application Layer

Industrial intralogistics applications and public services provide certification, demonstration and distribution of mature industrial apps. They offer integrated equipment-management and service solutions for upstream and downstream users, manufacturers, system integrators and government regulators. Functions include application monitoring, cloud-adoption assessment, public services, precise maintenance, energy monitoring, equipment operation and operating-condition monitoring. These industrial SaaS services and apps deliver the ultimate value of cloud-connected equipment. IaaS infrastructure and system-wide security, standards and operations management support the platform through hybrid-cloud management, security zoning, dedicated networks, horizontal isolation and vertical authentication.

Key Technologies

KEY TECHNOLOGY

Edge Computing and Intelligent Gateways for Equipment Access and Data Acquisition

Edge computing enables large numbers of intralogistics machines and sensors to connect securely and quickly to the industrial internet. More devices can convert production activities into digital information economically. Data is processed at the edge, transmitted through the network and aggregated in the cloud, forming a solid foundation for the equipment-cloud platform. Pervasive sensing upgrades equipment and collects information about heterogeneous systems, operating environments and people efficiently in real time. Cloud aggregation improves sensor coordination and equipment intelligence, addresses insufficient data volume, limited data types and low precision, and supports real-time analysis, intelligent optimization and informed decisions.

Edge-Cloud Collaboration

Edge devices combine low network latency, access to large data volumes and elastic infrastructure with stream analytics to process data as it arrives. This reduces transmission time and delays at routers and network equipment, enabling rapid responses to events and changing business conditions. Distributed edge nodes provide elastic, virtualized computing, networking and storage near the data source. They exchange data and knowledge, scale computing and storage horizontally, and perform local decisions and optimization. Non-real-time data is aggregated and sent to the cloud, enabling edge-cloud collaboration and reducing transmission and processing pressure.

Industrial Mechanism Analysis with Big Data and AI

The equipment-cloud platform collects industrial data and uses artificial intelligence, including deep learning, transfer learning and reinforcement learning,

together with big-data frameworks such as Spark, Hadoop and Storm to mine or extract anomalies. Historical data is used for feature extraction and model training; real-time data is then introduced to detect abnormal conditions. This addresses difficult diagnostic, predictive and optimization problems in equipment cloud adoption, extending traditional solutions by integrating knowledge, experience, industrial mechanisms and algorithm models. Deeper integration of data and algorithms supports digital twins built on accurate modeling, efficient analysis and real-time optimization, providing comprehensive insight into equipment and industrial processes. Numerical simulation, electrical-mechanism models and industrial big-data analytics create digital twins for physical-digital mapping, real-time monitoring, intelligent diagnosis and collaborative optimization, enabling simulation and optimization of industrial entities and processes.

Industrial Modeling Integrating Physical and Business Processes

Data analysis and machine learning quantify and jointly model relationships between physical quantities and business-process variables such as product quality, production efficiency and equipment reliability. Industrial production experience is combined with domain knowledge in intralogistics. Models based on known industrial mechanisms and specific scenarios support analytical applications, extend the knowledge available to production personnel and make process traces visible.

Microservice-Based Industrial Application Development

Microservices divide an application into smaller, fully independent functional components, improving agility, scalability and availability. Industrial apps can call these services through an industrial internet platform, creating reusable components that turn industrial technology, experience, knowledge and best practices into models, software and reusable packages. Loosely coupled microservices are easy to develop, deploy and extend. Combined with industrial application-development tools, they enable flexible configuration, continuous updates and rapid deployment, representing a new stage in industrial software.

Cloud Infrastructure with Independently Controllable Domestic Software

Against the backdrop of China's Internet Plus initiative, cloud adoption for intralogistics equipment was becoming an inevitable trend. To address industrial users' IT-construction and business-support needs, the industrial internet infrastructure platform uses a fully domestic cloud foundation and adapts to domestic hardware. Load balancing, elastic computing, multiple storage technologies and network modes provide unified IT-resource management, meeting requirements for independent control, security and efficiency.

Functional Description

FUNCTION DESCRIPTION

The system connects diverse data sources: relational and non-relational database tables, files in different formats, data streams, data transformed by ETL tools and data obtained through application APIs. It automatically generates metadata so that data entering the lake is described, and provides unified access through an API or interface. Large, diverse data lakes require heterogeneous storage such as HDFS, HBase and Hive, with rapid search across massive datasets. The system extracts and stores metadata centrally, labels and classifies it, builds a unified catalog and data lineage, and maps upstream and downstream relationships. These capabilities support issue tracing, change-impact assessment and data-value evaluation. Data time travel provides different versions for retrieval and analysis. Quality controls validate fields and completeness, monitor processing tasks and prevent unfinished jobs from producing incomplete data. Access permissions are supervised; sensitive data is masked and encrypted. Analysis tools enable automatic discovery through federated analysis, interactive SQL, machine learning and BI reports.

Equipment Operation Monitoring

Traditional equipment without information systems often relies on handwritten records, which can be lost or expose confidential information. When production anomalies occur, businesses cannot change processes promptly, and change methods are cumbersome. Intelligent acquisition terminals and sensors supply operating data; the cloud integrates detailed efficiency and operating records. Trend analysis assesses equipment utilization and performance. The platform supports seamless remote collaboration across departments and remote control of leased equipment between enterprises. For example, if a logistics company becomes insolvent and continues using leased vehicles without paying rent, the lessor can remotely lock the vehicles through the platform when assets cannot immediately be recovered, protecting them from loss.

Energy Management

Battery power is an important trend in manufacturing and production. Zero-emission battery-powered equipment supports sustainable intralogistics, making battery health a key aspect of energy management. Repeated charge-discharge cycles cause capacity to decline and internal resistance to rise; batteries eventually need replacement. Predicting remaining useful life (RUL) supports timely replacement and smooth production. Data-driven models are increasingly used to predict battery RUL.

The data-driven approach has two main parts. First, measurements such as battery terminal voltage, current and temperature are used to establish a health index (HI). Second, the estimated HI becomes the model input; its changes are analyzed with deep learning to predict subsequent behavior.

Operating-Condition Optimization

(1) AI-Assisted Decisions

Lifecycle models for key components use sensor measurements of vibration, sound, current, voltage and other signals during operation. Machine learning or deep learning then builds the models.

(2) AI Safety

Collision recognition has significant potential for safer driving. It can protect drivers and reduce damage to enterprise assets. When a collision occurs, machine learning identifies and records the event, reminds the driver to stay focused and address faults, and quickly informs managers so the vehicle can be repaired and hazards removed. Models typically combine feature extraction and machine learning. Real-world collisions can resemble jolts or vibration; machine-learning models can distinguish them and identify actual collisions.

(3) AI Face Recognition

On factory production lines, face recognition can register personnel arriving at work for safety management. For special posts, it can verify qualifications, monitor time on duty and warn when a post is unattended. Face recognition therefore plays an important role in factory production safety.

04

Application Cases

Industrial Vehicle Monitoring

APPLICATION CASE OF INDUSTRIAL VEHICLE EQUIPMENT MONITORING

Application Background

A large integrated logistics provider operates many forklifts for daily cargo handling in its logistics park. As workloads grew, problems became increasingly evident: low handling efficiency, weak prevention and control capabilities, and a lack of remote collaboration. The company urgently needed effective intelligent management to improve handling efficiency and achieve lean production.



Implementation

An industrial vehicle solution comprising intelligent terminals, a web management portal, mobile applications and cloud services improved fleet operations management. Intelligent terminals solved data-acquisition challenges across different vehicle models, enabling fleet information and record management, data statistics, operating-status monitoring, remote control and dispatch.

Value Delivered

The industrial vehicle management platform improved safety and efficiency in interactions between goods and vehicles, people and vehicles, and vehicles themselves. It enabled digital operations across the fleet's full workflow and supported the company's transformation and upgrading.

Unmanned Handling Equipment Monitoring

APPLICATION CASE OF UNMANNED INTELLIGENT HANDLING EQUIPMENT MONITORING

Application Background

A well-known vehicle manufacturer was building an Industry 4.0 production base where manually driven and unmanned material-handling equipment operated together. Unmanned equipment could transport goods between points A and B, but lacked monitoring of turnover efficiency and operating status. The site could not monitor and dispatch all handling equipment centrally, resulting in low asset turnover. Multiple workshops needed interconnection and collaboration among people, equipment and information systems to support digital, networked and intelligent transformation.





Implementation

Intelligent edge terminals parse heterogeneous protocols from unmanned handling equipment supplied by different manufacturers, uploading efficiency and operating data to the cloud. Manually driven vehicles are also fitted with edge terminals. The platform connects centrally to the warehouse management system (WMS). A visual cloud control platform dispatches unmanned and manually driven equipment together; the WMS sends tasks to terminals so assets work collaboratively and equipment receives digital maintenance management.

Value Delivered

Unified dispatch of automated and manually driven logistics equipment, a 14% year-on-year improvement in efficiency, proactive maintenance services and a 20% reduction in maintenance costs. Management collaboration improved substantially, supporting intelligent manufacturing collaboration across the customer's factory.

Equipment Energy Management

APPLICATION CASE OF ENERGY CONSUMPTION MANAGEMENT OF ON-SITE LOGISTICS EQUIPMENT

Application Background

A major Chinese contract-logistics company aimed to become a world-class logistics provider. Its warehouses covered millions of square meters and its operations spanned most of China. Equipment used electricity, diesel, gasoline and natural gas. Energy waste, inappropriate use, fuel theft and unauthorized fuel removal occurred frequently. The company lacked real-time energy-management tools and needed to reduce losses while supporting safe operations, energy savings and emissions reduction.



Implementation

A comprehensive energy-management platform was established for intralogistics equipment. Intelligent terminals collect data from equipment using different energy sources, with monitoring tailored to each business scenario:

(1) Electric equipment: monitor and analyze incomplete charging and excessive discharge; dynamically analyze battery life and records of improper use to reduce unnecessary loss of asset residual value.

(2) Fuel-powered equipment: monitor fuel-consumption records, prolonged idling and abnormal large fuel losses; issue alerts to reduce unnecessary fuel waste and emissions.

(3) Gas-powered equipment: monitor pressure changes and build safety-warning models to prevent incidents caused by gas leakage.

Value Delivered

The energy-monitoring platform displays real-time consumption statistics and analytical reports, enabling warnings and decision support. It reduces loss of residual value in energy-storage assets and lowers energy consumption, contributing to carbon-peaking and carbon-neutrality goals.

Equipment Safety Management

ON SITE LOGISTICS EQUIPMENT SAFETY MANAGEMENT APPLICATION CASE

Application Background

A food company with many international brands established several large warehouses in Beijing for food production, packaging and transportation. Each transport workshop operated dozens of forklifts for loading, unloading, stacking and short-distance transport. Rapid business growth increased transport volumes. Narrow aisles, accumulated goods, speeding and blind spots kept collision rates high.



Implementation

Edge AI terminals were combined with a cloud algorithm engine. Cameras mounted at different positions on vehicles detect, recognize, track and locate surrounding people and objects in real time. When a potential collision risk is detected, audible, visual and electronic warnings and vehicle speed control help prevent collisions and protect vehicle operations.

Value Delivered

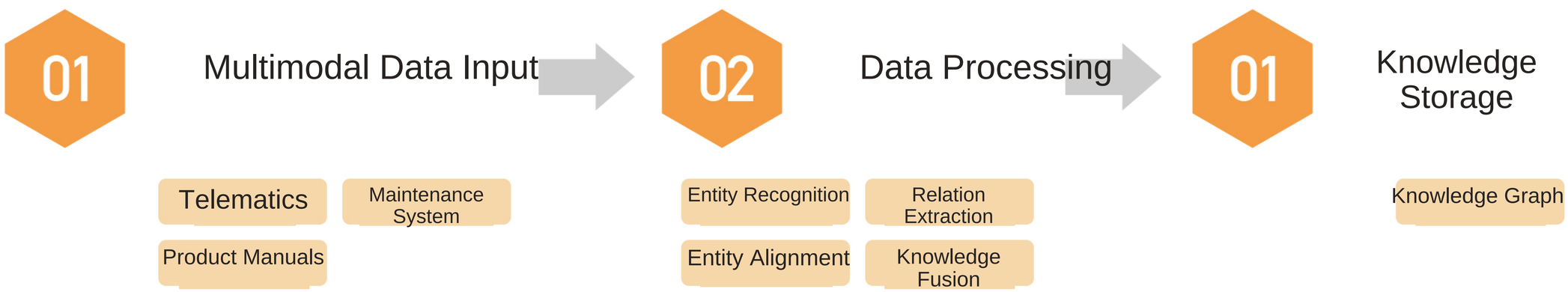
A multi-level warning system identifies potential risks, helps avoid collisions, removes hazards, monitors vehicle safety and encourages appropriate driving behavior. It reduces incidents, supports incident traceability and clearer responsibility assignment, and lowers operating costs.
Multi-dimensional data analysis enables risk assessment, improves employees' safe-driving awareness and strengthens management.

Knowledge-Graph-Based Intelligent Maintenance

APPLICATION CASE OF INTELLIGENT OPERATION AND MAINTENANCE OF ON-SITE LOGISTICS EQUIPMENT BASED ON KNOWLEDGE MAP

Application Background

A leading Chinese manufacturer of high-end industrial vehicles previously did not collect forklift fault codes in the cloud after delivery. When customers reported faults, engineers had to diagnose them on site. Repair cycles and customer downtime were long, and the after-sales lost-order rate was high. The company urgently needed a cloud maintenance platform for proactive warnings and remote diagnosis and repair.



Implementation

Working with a digital-service provider in the industrial vehicle sector, the manufacturer fitted intelligent terminals to its entire forklift range before delivery. This enabled lifecycle digital management from the start of operation and uploaded operating data and fault codes. A vehicle maintenance service platform based on multimodal data and knowledge graphs delivered:

(1) Monitoring and analysis models for different fault-code types. Potential faults trigger monitoring alerts before engineers intervene for maintenance.

(2) After a customer reports a fault, engineers at the manufacturer's control platform collect vehicle fault data and remotely access the vehicle, locate the issue before visiting and bring the required parts for on-site repair.

(3) Historical work orders and engineers' experience are refined into an AI knowledge-graph maintenance system. Intelligent repair plans reduce training barriers, standardize service and improve repair efficiency and quality.

Value Delivered

For industrial vehicle manufacturers, the solution improves engineering efficiency and maintenance efficiency, supports flexible spare-parts supply, strengthens customer relationships and expands aftermarket revenue. For vehicle users, it reduces downtime losses and loss of vehicle residual value and lowers repair costs.

Drive social progress with AI and become a benchmark in digital intelligence.

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