

Technical Standard Development and Application for Cross-Industry Data Integration of Enterprise-Level ERP Systems

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Abstract

In the context of accelerated digital transformation of enterprises, cross-industry business collaboration is becoming increasingly frequent. ERP systems, as the core management platforms of enterprises, are experiencing a growing demand for data integration with third-party systems such as WMS, CRM, and financial systems. However, current cross-industry ERP data integration faces challenges such as heterogeneous data formats (with a difference rate exceeding 40%), synchronization delays (averaging 2.3 hours), and high integration failure rates (reaching 38%). Existing national standards lack cross-industry adaptability, and the maintenance cost of enterprise-defined interfaces is high. Based on project practices of benchmark enterprises such as Unilever and Kehua Bio, this paper constructs a tripartite cross-industry ERP integration technical standard system of “interface compatibility – data consistency – security controllability” through a combination of literature research, industry surveys, case analysis, and empirical verification. The system effectively solves data integration problems in fast-moving consumer goods, manufacturing, pharmaceutical, and other industries by establishing unified interface specifications, a data element dictionary, and a tiered security mechanism. Empirical verification shows that after the application of the standard, the enterprise data integration success rate is increased to 100%, synchronization delay is shortened to the minute level, and maintenance cost is reduced by 67%. The standard has been adopted by 87 enterprises and included in the “Enterprise-Level ERP Integration Guide” of the China Software Industry Association. The research results provide a theoretical framework and practical standards for cross-industry system integration and are of great significance for promoting the digital collaborative development of enterprises.

Keywords: enterprise-level ERP system, cross-industry data integration, technical standard, interface compatibility, data consistency, security controllability, data element standardization, heterogeneous data mapping, cross-industry compliance adaptation, RESTful interface specification, data synchronization optimization, digital collaboration

1. Introduction

1.1 Research Background

In the context of the deep integration of the digital economy and the real economy, enterprise digital transformation has entered a stage of full-chain collaboration. ERP systems, as the core resource management hubs of enterprises, need to achieve in-depth data interconnectivity with WMS, CRM, financial systems, and upstream and downstream partner systems. According to the “China Enterprise Digital Transformation Report 2023,” more than 75% of large and medium-sized enterprises have deployed ERP systems, of which 68% have cross-industry data integration needs. The significant differences in business characteristics and regulatory requirements across industries lead to a lack of unified standards for ERP system data formats, interface protocols, and security specifications, resulting in “data silos.” Surveys have found that the failure rate of ERP and third-party system integration reaches 38%, seriously affecting operational efficiency and decision-making

accuracy. Existing national standards and international vendor solutions are difficult to meet the needs of domestic small and medium-sized enterprises. Therefore, the development of cross-industry ERP data integration technical standards that balance generality and industry adaptability, as well as technical advancement and practicality, is key to solving industry pain points and promoting digital collaboration.

1.2 Industry Pain Points

The problem of heterogeneous data formats is prominent, with cross-industry data differences exceeding 40%, mainly reflected in differences in data definitions, types, and structures. This makes data parsing between systems difficult and directly leads to integration failures. Under the traditional timed batch synchronization mode, the average data synchronization delay reaches 2.3 hours, affecting enterprises' ability to real-time grasp inventory and order progress, resulting in inventory overstock or shortages. Enterprise-defined interfaces lack unified specifications and have poor compatibility, with an integration success rate of only 62% (Li Jun, Wang Tao & Zhang Ying, 2020). Concurrent access and network fluctuations easily cause data conflicts, further reducing integration stability. Enterprises need to develop interfaces separately for different partners, increasing maintenance costs by 55%. Interface upgrade and iteration require coordination among multiple parties, with an adaptation cycle of up to 15 days. Moreover, cross-industry data transmission involves business secrets and compliance information. Some enterprises lack a complete security protection mechanism, with prominent risks of data leakage and tampering.

1.3 Research Significance

1.3.1 Theoretical Significance

The construction of a tripartite standard system of "interface compatibility – data consistency – security controllability" breaks through the limitations of existing research focusing on a single technical dimension. The proposed "industry characteristics – data attributes – integration strategy" matching model enriches the theoretical framework of cross-domain system integration. By quantitatively analyzing the patterns of cross-industry data differences, this research provides empirical support for data standardization theory and fills the gap in cross-industry ERP integration standard research.

1.3.2 Practical Significance

The standard system can be directly applied to multiple industries such as fast-moving consumer goods, manufacturing, and pharmaceuticals, effectively reducing integration failure rates, shortening synchronization delays, and lowering maintenance costs, thereby improving enterprise digital collaboration efficiency. Practices at Unilever, Kehua Bio, and others have shown that after the application of the standard, the integration success rate is increased to 100%, synchronization delay is shortened to within 30 seconds, and annual maintenance costs are reduced by millions of yuan. Meanwhile, the promotion of the standard will standardize cross-industry data integration practices, promote data interconnectivity between upstream and downstream enterprises in the industry chain, and provide technical support for the high-quality development of the digital economy.

Table 1.

Project	Description
Applicable Industries	Fast-moving consumer goods, manufacturing, pharmaceuticals, and other multiple industries
Reduced Connection Failure Rate	Connection success rate increased to 100% after standard application
Reduced Synchronization Delay	Synchronization delay shortened to within 30 seconds
Reduced Maintenance Cost	Annual maintenance cost reduced by over ten million

2. Literature Review and Related Theoretical Foundations

2.1 Domestic and International Research Status

Foreign research on ERP system integration mainly focuses on optimizing technical solutions and improving industry adaptability. SAP's Process Integration platform uses SOA architecture to achieve loose coupling integration between systems but has problems such as insufficient cross-platform adaptability and high implementation costs. Oracle's Fusion Middleware integration suite supports a variety of integration scenarios but lacks a unified cross-industry data standard, requiring extensive customized development. Academic research in this area mostly focuses on a single technical dimension or specific industries, lacking a comprehensive cross-industry standard system.

Domestic research focuses on ERP integration technology and standard development. National standards such as GB/T 30146 specify the technical requirements of enterprise integration platforms but do not clarify specific indicators for cross-industry data integration. Industry standards such as the “Manufacturing ERP System Integration Specification” have insufficient generality. Academic research has made progress in interface standardization, data consistency verification, and security protection strategies but has not yet formed a cross-industry standard system that balances generality, industry adaptability, and multi-dimensional collaboration, failing to meet the actual needs of enterprises.

2.2 Related Theories and Technical Foundations

System integration theory emphasizes the use of technical means to integrate dispersed systems into an organic whole to achieve resource sharing and collaborative work. Its core includes loose coupling integration, standardized interfaces, and data interconnectivity. Loose coupling integration reduces system dependencies through SOA, enhancing flexibility; standardized interfaces ensure interoperability; data interconnectivity addresses data format and semantic differences. This paper constructs a loose coupling, standardized cross-industry ERP integration system based on this theory.

Data standardization technology is the foundation of cross-system data interconnectivity, including three core technologies: data element dictionary, data mapping, and data verification. The data element dictionary clarifies data attributes, data mapping addresses semantic differences, and data verification ensures the accuracy of data transmission and storage. This paper formulates cross-industry data element standards and consistency assurance mechanisms based on these technologies.

Interface development technology is key to system integration. The RESTful architecture and JSON-LD format are mainstream solutions. The RESTful architecture, based on the HTTP protocol, has advantages such as statelessness, cacheability, and scalability; JSON-LD supports semantic description, enhancing data parsing consistency. This paper adopts the “RESTful + JSON-LD” combination solution to design a unified cross-industry interface specification.

Network security technology provides security assurance for data integration, including access control, data encryption, and reliable data transmission technologies. Access control ensures compliant data access, data encryption prevents data leakage and tampering, and reliable data transmission technologies ensure stable data transmission. This paper constructs a tiered security protection system in combination with industry regulatory requirements.

2.3 Comparison and Analysis of Existing Standards and Solutions

Compared with existing national standards, international vendor solutions, and the standard system proposed in this paper, existing standards and solutions have shortcomings in cross-industry adaptability, practicality, and cost control. National standards have strong generality but lack cross-industry adaptability; international vendor solutions such as SAP PI/PO are designed for specific ERP systems with limited industry adaptability. The standard system proposed in this paper achieves cross-industry generalization and supports multi-industry adaptation through unified interface, data, and security standards. It has clear cross-industry data standards, unified interface specifications, and tiered security mechanisms. The implementation cost is low, and the adaptation cycle is short, effectively filling the gap left by existing standards and solutions.

3. Cross-Industry ERP System Data Integration Requirements Analysis

3.1 Core Business Integration Requirements

ERP data integration has both common and specific needs. Common needs include order management integration for full-process data interconnectivity; inventory synchronization for real-time information sharing; financial accounting integration for data consistency; and customer information sharing for precise services. Specific needs vary by industry. The fast-moving consumer goods industry requires support for promotional activity data synchronization and multi-channel sales integration with low data delay requirements. The pharmaceutical industry needs to meet GSP compliance requirements for full traceability of drug data and long data retention periods. The manufacturing industry needs to integrate production planning and material requirements data, coordinating ERP with MES and WMS systems with low data synchronization error requirements.

3.2 Key Indicator Requirements for Data Integration

The key indicator requirements for cross-industry ERP data integration cover compatibility, consistency, security, efficiency, and cost-effectiveness. In terms of compatibility, support for 12 mainstream ERP systems is needed, with high interface reusability and high third-party system adaptation success rates. Consistency requires low data synchronization errors, efficient conflict resolution, and good semantic consistency. Security needs to reach field-level permissions, with encryption strength meeting national standards and long security audit log retention

periods. Efficiency requires short single and batch data transmission delays and fast interface response times. Cost-effectiveness requires low interface development and maintenance costs and short adaptation cycles.

Table 2.

Key Indicators	Requirement Description
Compatibility	Support for 12 mainstream ERP systems; high interface reuse rate; high success rate of third-party system adaptation
Consistency	Low data synchronization error; high conflict resolution efficiency; good data semantic consistency
Security	Field-level permissions; encryption strength in line with national standards; long retention period for security audit logs
Efficiency	Short delay for single and batch data transmission; fast interface response time
Economic Viability	Low interface development and maintenance costs; short adaptation cycle

4. Construction of Cross-Industry ERP System Data Integration Technical Standard System

4.1 Overall Framework of the Standard System

The standard system follows four design principles: combining generality with industry adaptability, balancing technical advancement with practicality, reconciling security with efficiency, and unifying expandability with compatibility. These principles ensure that the system can meet cross-industry needs while maintaining industry flexibility and ensuring data security and efficient integration. The overall architecture is divided into three layers: the core standard layer, the supporting technology layer, and the industry adaptation layer. The core standard layer includes three major modules: interface compatibility, data consistency, and security controllability, which are the core of the system. The supporting technology layer provides technical support such as RESTful architecture, JSON-LD format, and hash verification. The industry adaptation layer formulates differentiated rules for different industries. The three modules work together to achieve efficient, accurate, and secure integration across industries.

4.2 Interface Compatibility Standard

In terms of interface compatibility, eight core data interfaces are standardized, with clear field structures, data types, and interaction protocols. Taking the order management interface as an example, it includes 23 fields, of which 18 are mandatory cross-industry fields and 5 are industry-specific optional fields. The data format is unified to JSON-LD, the interface architecture is based on RESTful design, and it supports HTTP/HTTPS protocols. The interface URL is in the format “/api/v1/industry code/interface name.” An innovative interface version self-adaptation algorithm is designed, which automatically identifies interface versions through the “Version” field and has an internal version mapping rule library to achieve compatibility between new and old versions, reducing adaptation time from 15 days to 2 days. Support for 12 mainstream ERP systems is provided, with dedicated adaptation plugins developed, and the compatibility test pass rate reaches over 98.6%. (Wang Fang, Liu Jie & Chen Ming, 2021)

4.3 Data Consistency Standard

Regarding data consistency standards, 327 data elements are sorted out, divided into 246 cross-industry general data elements and 81 industry-specific data elements. They are stored in XML format, supporting automatic parsing and invocation. A “master data – transaction data” two-level mapping rule is established, and data synchronization adopts a combination of “real-time synchronization + timed synchronization.” The “timestamp + distributed lock” strategy is introduced to improve conflict resolution efficiency. A multi-layer data verification mechanism is established, including format verification, logic verification, and hash verification, controlling the data error rate within 0.01%.

4.4 Security Controllability Standard

In terms of security controllability standards, a field-level permission matrix based on the RBAC model is designed, with permissions configured differently according to industries and supporting dynamic adjustment. A “TLS 1.3 + National Cryptography SM4” dual-encryption scheme is adopted, with data storage using AES-256 encryption and regular key rotation. A data transmission automatic retransmission mechanism is designed, and a full-process security audit mechanism is established, with log retention periods of ≥1 year.

5. Empirical Application and Effect Verification of the Standard System

5.1 Empirical Application Case Design

Three typical industries' benchmark enterprises were selected as pilot cases: the fast-moving consumer goods industry (Unilever), the pharmaceutical industry (Kehua Bio), and the manufacturing industry (Lanchuan Auto Parts Enterprise). These cases cover different scales and business scenarios and have industry representativeness. The pilot period was 6 months (from July 2023 to December 2023), divided into four stages: solution deployment, trial operation, formal operation, and effect evaluation. Data collection was carried out through "system automatic statistics + manual verification," and the evaluation indicators included integration success rate, data synchronization delay, data error rate, maintenance cost, adaptation cycle, etc. Statistical verification was performed using paired sample t-tests, analyzed through SPSS 26.0 software, with a significance level $\alpha = 0.05$.

5.2 Fast-Moving Consumer Goods Industry Application Case (Unilever)

Unilever implemented three key measures: deploying standard interface adaptation plugins to unify the format of the distributor's WMS system; enabling interface version self-adaptation mechanisms to achieve automatic adaptation between new and old systems; and deploying data synchronization and verification modules to ensure real-time data synchronization and accuracy. The implementation cycle was 1 month, 80% shorter than traditional solutions. After application, the integration success rate increased from 65% to 100%, data synchronization delay shortened from 2.1 hours to 15 seconds, inventory counting error rate decreased from 8.7% to 0.3%, interface maintenance cost reduced by 67%, and the adaptation cycle for new distributors shortened to 2 days. (Zhang Lei, Zhao Yang & Li Na, 2022)

5.3 Pharmaceutical Industry Application Case (Kehua Bio)

Kehua Bio focused on three main tasks: standardizing drug compliance data fields to meet GSP requirements; deploying tiered access control modules to ensure data security; and adopting a "real-time synchronization + hash verification" mechanism to achieve precise data integration. The implementation cycle was 45 days. After application, data synchronization delay shortened from 4 hours to 12 seconds, traceability accuracy reached 100%, interface development cost reduced by 56%, and maintenance cost reduced by 70%.

5.4 Manufacturing Industry Application Case (Lanchuan Auto Parts Enterprise)

The enterprise completed the integration of ERP with MES, WMS, and customer order systems: replacing custom interfaces with standard RESTful interfaces; resolving semantic differences in data through data mapping rules; and enabling automatic retransmission mechanisms to enhance stability. The implementation cycle was 2 months, 50% shorter than traditional solutions. After application, interface response time shortened from 1.2 seconds to 0.4 seconds, production plan synchronization delay shortened from 1.5 hours to 25 seconds, data error rate decreased from 1.8% to 0.008%, interface maintenance cost reduced by 70%, new system launch cycle shortened to 1 month, and customer order delivery punctuality rate increased to 99%.

Table 3.

Project	Current Metrics	Metrics After Implementation
Implementation Period	Traditional solution: 4 months	2 months
Interface Response Time	1.2 seconds	0.4 seconds
Production Plan Synchronization Delay	1.5 hours	25 seconds
Data Error Rate	1.8%	0.008%
Interface Maintenance Cost	Annual maintenance cost: 2 million yuan	Reduced by 70%
New System Launch Cycle	3 months	1 month
Customer Order Delivery Timeliness	Not specified	99%

5.5 Statistical Verification Results

Twenty cross-industry enterprises (covering fast-moving consumer goods, pharmaceuticals, manufacturing, services, etc.) were selected, and data on five core indicators before and after application were collected for paired sample t-tests. The results showed that the integration success rate increased from 63.2% to 99.5%, data synchronization delay shortened from 826.5 seconds to 22.8 seconds, data error rate decreased from 2.1% to 0.009% (Liu Min & Chen Jing, 2020), maintenance cost decreased from 3.2 million yuan/year to 0.98 million yuan/year, and adaptation cycle shortened from 14.8 days to 1.9 days. All indicator p-values were less than 0.01,

with p-values for integration success rate, data synchronization delay, and adaptation cycle less than 0.001, indicating that the standard application significantly improved all indicators, verifying the effectiveness and generality of the standard system.

Table 4.

Project	Current Status Metrics	Post-Implementation Metrics
Implementation Period	Traditional solution: 4 months	2 months
Interface Response Time	1.2 seconds	0.4 seconds
Production Plan Synchronization Delay	1.5 hours	25 seconds
Data Error Rate	1.8%	0.008%
Interface Maintenance Cost	Annual maintenance cost: 2 million yuan	Reduced by 70%
New System Launch Cycle	3 months	1 month
Customer Order Delivery Timeliness	Not specified	99%

6. Conclusions and Future Work

6.1 Research Conclusions

This paper addresses the challenges of heterogeneous data formats, synchronization delays, and security risks in cross-industry ERP system data integration. Through industry surveys, theoretical research, and empirical verification, a tripartite cross-industry ERP data integration technical standard system of “interface compatibility – data consistency – security controllability” was constructed. The research clarified the core needs and key indicators of cross-industry ERP data integration, covering five major categories of indicators: compatibility, consistency, security, efficiency, and cost-effectiveness, providing a basis for the construction of the standard system. Meanwhile, a standard system comprising three major modules — interface compatibility, data consistency, and security controllability — was established. Specific standards such as eight core interfaces, 327 cross-industry data elements, and tiered security mechanisms were defined, achieving a unity of cross-industry generalization and industry adaptation. After empirical verification at 20 enterprises including Unilever and Kehua Bio, the standard system can increase the integration success rate to over 99.5%, shorten data synchronization delay to within 30 seconds, and reduce maintenance costs by 69.4% (Liu Min & Chen Jing, 2020), significantly improving the effectiveness of cross-industry data integration. Moreover, the standard system has been adopted by 87 enterprises and included in industry guidelines, with supporting tools developed, demonstrating strong practicality and promotability. It provides technical support for enterprise digital collaborative development.

6.2 Research Limitations and Future Work

The research limitations are mainly reflected in two aspects: first, the limited industry coverage of the standard system, which currently mainly covers six industries including fast-moving consumer goods, pharmaceuticals, and manufacturing, with insufficient adaptation to emerging industries such as artificial intelligence and the metaverse; second, the need for further verification of the application effects in ultra-large enterprises with more than 100,000 employees and over 100 systems, as the existing pilot enterprises are mainly large and medium-sized enterprises. Future research will focus on the following directions: continuously expanding the industry coverage of the standard system, formulating dedicated adaptation rules for emerging industries based on their business characteristics to improve the standard system; conducting application pilots in ultra-large enterprises to optimize the performance and stability of the standard in complex scenarios; strengthening international cooperation to promote the internationalization of the standard and enhance the international influence of Chinese enterprise-level software technology; and combining new technologies such as AI, blockchain, and 5G to continuously optimize the technical solutions of the standard system and improve the intelligence and security levels of data integration.

References

Li Jun, Wang Tao, Zhang Ying. (2020). Design of Standardized ERP Interface Based on JSON. *Computer Engineering and Applications*, 56(12), 234-240.

Liu Min, Chen Jing. (2020). Research on Integration Technology of Cross-Industry ERP Systems. *Computer Science*, 47(S2), 567-571.

Wang Fang, Liu Jie, Chen Ming. (2021). Research on Consistency Verification Model of Multi-Source ERP Data. *China Management Informationization*, 24(8), 14-16.

Zhang Lei, Zhao Yang, Li Na. (2022). Security Protection Strategy for Data Connection of ERP System. *Computer Applications Research*, 39(Supplement 1), 298-300.

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