

Modular Design-Driven Lightweight Deployment Suite for SMEs' SAP System: Development, Performance Optimization, and Industrial Validation

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Abstract

Against the backdrop of global digital transformation, Small and Medium-sized Enterprises (SMEs) face a paradox: they urgently need Enterprise Resource Planning (ERP) systems represented by SAP to enhance operational efficiency, yet they are constrained by limited budgets, weak technical capabilities, and low server configurations, making it difficult to adopt full-version SAP systems. This study proposes a modular design-driven lightweight SAP deployment suite to address the core pain points of high deployment costs, poor resource adaptability, and complex operations in SMEs' SAP adoption. First, based on a demand survey of 120 manufacturing SMEs across the Yangtze River Delta, Pearl River Delta, and Bohai Rim regions, the core functions of the SAP system were decomposed into three core modules (Master Data-FI Basic Linkage, Lightweight Maintenance, Procurement-Sales Basic) and two expandable components (Inventory Early Warning, Simple Report Generation), eliminating 17 redundant sub-modules with a demand rate of less than 8%. Second, a Dynamic Resource Allocation Algorithm (DRAA) was developed, which adjusts cloud server CPU/memory resources in real time based on business volume fluctuations (e.g., order processing volume, inventory update frequency), and a Module Interface Adaptation Protocol (MIAP) was designed to achieve 99.8% data synchronization accuracy between modules with a delay of ≤ 5 minutes. Finally, through code compression (removing 32% of redundant ABAP code) and cache preloading technology, the module initial loading time was optimized. A 6-month controlled experiment was conducted on 30 manufacturing SMEs (covering electronics, machinery, and food industries) in three major economic belts. The results showed that compared with the traditional streamlined SAP version: (1) the annual deployment cost of the experimental group was reduced from 520,000 CNY to 198,000 CNY, with an optimization rate of 61.9% ($p < 0.01$); (2) the deployment cycle was shortened from 45 days to 14.2 days, a reduction of 68.4% ($p < 0.001$); (3) the peak server CPU utilization rate dropped from 80% to 42.3%, a decrease of 47.1% ($p < 0.01$); (4) the order processing response time was reduced from 3.5 seconds to 1.1 seconds, an improvement of 68.6% ($p < 0.001$). (Xiong, X., Zhang, X., Jiang, W., Liu, T., Liu, Y., & Liu, L., 2024) The suite has been incorporated into Accenture's "Global SME SAP Implementation Toolkit" and promoted in 217 SMEs, creating direct economic benefits of over 65 million CNY. Future work will integrate a generative AI-driven fault diagnosis module to further reduce SMEs' annual maintenance costs by an estimated 25-30%.

Keywords: small and medium-sized enterprises (SMEs), SAP system, modular design, lightweight deployment, dynamic resource scheduling, data synchronization, digital transformation, ERP

optimization

1. Introduction

1.1 Research Background

In the global digital economy, ERP systems have become a core infrastructure for enterprises to achieve process standardization and data-driven decision-making. SAP, as a leading global ERP solution provider, has a market share of over 38% in the global mid-to-high-end ERP market. However, the “high threshold” of SAP systems has become a major barrier for SMEs, which account for 99.8% of the total number of enterprises worldwide.

According to the 2023 White Paper on Digital Transformation of Chinese SMEs released by the China ERP Industry Alliance, the SAP adoption rate among Chinese SMEs is only 15.2%, which is 62 percentage points lower than that of large enterprises (77.2%). In-depth interviews with 50 SME managers and IT directors revealed three core bottlenecks: (Liu, Z., 2022)

- **Cost Burden:** The average annual cost of traditional SAP deployment (including software licensing, hardware procurement, and maintenance) is 523,000 CNY, accounting for 41.3% of SMEs’ annual IT budgets, and 37% of SMEs reported that “cost exceeds affordability”.
- **Resource Mismatch:** 68% of SMEs use entry-level servers (CPU: Intel Xeon E3, memory: $\leq 16\text{GB}$), which cannot support the full-version SAP system (minimum requirement: CPU Intel Xeon Gold, memory $\geq 32\text{GB}$), leading to an average of 4.2 system crashes per month and 12.5 hours of business interruption (Survey data of this study, 2024).
- **Operational Complexity:** The full-version SAP system has 1,200+ functional nodes, but SMEs only use 28.7% of the core functions (e.g., purchase order management, financial cost accounting). The training cost for employees to master the full system is 86,000 CNY per year, and the error rate in daily operations is as high as 18.3%.

These pain points not only restrict the digital transformation of SMEs but also hinder the

overall improvement of industrial digitalization. Therefore, developing a lightweight SAP solution that is “cost-controllable, resource-adaptable, and easy to operate” has become an urgent demand in both industry and academia.

1.2 Literature Review

Existing research on SME ERP optimization can be divided into three directions:

- **Cost Reduction through Cloudization:** Wang et al. (2022) proposed a cloud-based ERP deployment model, which reduced hardware costs by 35% but failed to solve the problem of functional redundancy, resulting in a 23% increase in cloud resource waste.
- **Functional Simplification:** Lee et al. (2023) streamlined the SAP FI module, removing 40% of non-core functions, but the lack of a modular interface led to data silos between modules, with a data synchronization error rate of 12.7%.
- **AI-Driven Maintenance:** Antonova et al. (2024) integrated AI into ERP maintenance, reducing fault handling time by 40%, but the high AI deployment cost (average 180,000 CNY/year) made it unaffordable for SMEs.

In summary, current studies lack a systematic solution that integrates “functional modularization, resource dynamic scheduling, and low-cost maintenance”. This study fills this gap by developing a lightweight suite that balances cost, performance, and usability.

1.3 Research Significance and Innovations

1.3.1 Theoretical Significance

- Construct a **SME-oriented SAP Modular Decomposition Framework** based on demand frequency and business criticality, providing a theoretical basis for the lightweight design of large-scale ERP systems.
- Propose the **Dynamic Resource Allocation Algorithm (DRAA)** considering SME business volatility, enriching the theoretical system of cloud resource scheduling for

small-scale enterprises.

1.3.2 Practical Significance

- The suite reduces SMEs' SAP deployment costs by over 60% and shortens the cycle by nearly 70%, making SAP systems accessible to more SMEs.
- The promoted application in 217 SMEs has improved their order fulfillment rate by 18.5% and reduced inventory turnover days by 12.3%, directly driving industrial efficiency improvement.

1.3.3 Key Innovations

- **Demand-Driven Modular Decomposition:** Based on a multi-regional survey of 120 SMEs, redundant modules with a demand rate of <8% are eliminated, and the module reuse rate reaches 89.2%.
- **High-Precision Data Synchronization:** The designed MIAP protocol achieves 99.8% data synchronization accuracy between modules, which is 15.6 percentage points higher than the industry average.
- **Cost-Effective Resource Optimization:** DRAA reduces annual cloud costs by 32.7% for SMEs, which is 8.3 percentage points higher than the cloud resource scheduling

algorithm proposed by Aktürk (2021).

2. Modular Architecture Design of the Lightweight Deployment Suite

2.1 Modular Decomposition Based on Demand Mining

To ensure the suite meets the actual needs of SMEs, a **three-dimensional demand mining method** (business process analysis + user interview + data statistics) was adopted for 120 SMEs in three major economic belts (Yangtze River Delta: 50, Pearl River Delta: 40, Bohai Rim: 30). The results showed that SMEs' demand for SAP functions is concentrated in 4 core scenarios: financial cost accounting (demand rate 92.5%), procurement-sales order management (88.3%), system basic maintenance (76.7%), and inventory monitoring (62.5%), while functions such as multinational compliance verification (5.8%) and multi-language adaptation (4.2%) have extremely low demand. (APA Huang, J., & Qiu, Y., 2025)

Based on this, the full-version SAP system was decomposed into **3 core modules** and **2 expandable components**, with the specific structure shown in Table 1.

Table 1. Specific Structure

Module/Component	Core Functions	Demand Rate of SMEs (%)	Technical Basis
Master Data-FI Basic Linkage	Automatic synchronization of material master data and financial accounts; Basic cost accounting (material cost, labor cost allocation)	92.5	Integration of the core logic of the "SAP Master-FI/CO Real-time Linkage System"
Lightweight Maintenance	Monitoring of 3 key indicators (CPU utilization, database connection count, inventory data update frequency); Mobile real-time early warning	76.7	Extracted from the "SAP Maintenance Intelligent Monitoring System" and simplified
Procurement-Sales Basic	Purchase order creation, approval, and tracking; Sales order fulfillment status query; Automatic matching of purchase and sales data	88.3	Retained core functions of SAP MM/SD modules, removed production plan linkage
Inventory Early Warning (Expandable)	Threshold-based inventory shortage warning; Overstock analysis report	62.5	Developed based on SAP WM module lightweight API
Simple Report Generation (Expandable)	Customizable financial statements (profit and loss statement, balance sheet); Procurement-sales trend	58.3	Integrated with SAP Crystal Reports lightweight engine

	analysis chart		
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2.2 Module Compatibility Design: Module Interface Adaptation Protocol (MIAP)

To solve the problem of “module isolation and data inaccessibility” in traditional modular solutions, MIAP was designed, which includes three core mechanisms:

- **Standardized Data Interface:** Defines 18 data interaction formats (e.g., material master data XML format, financial account JSON format) to ensure consistent data transmission between modules.
- **Real-Time Data Synchronization:** Adopts a “trigger + polling” hybrid synchronization mechanism. When core data (e.g., material unit price) changes, a trigger is initiated to synchronize data within 1 minute; for non-core data (e.g., inventory update records), polling is performed every 5 minutes. The actual test shows that the average data synchronization delay is 2.3 minutes, and the accuracy rate reaches 99.8%.
- **Dynamic Expansion Support:** Provides a module registration center, allowing SMEs to add new modules (e.g., production management) without modifying existing module code. The expansion success rate in the test reached 100%, and the average expansion time was 4.5 hours.

3. Core Technologies for Performance Optimization

3.1 Dynamic Resource Allocation Algorithm (DRAA)

Aiming at the problem of low server configuration and high cloud cost of SMEs, DRAA was developed, which realizes

“on-demand allocation of cloud resources” through three steps:

- **Business Volume Prediction:** Uses a Long Short-Term Memory (LSTM) network to predict the next 24-hour business volume (e.g., order processing volume, inventory query frequency) based on the past 3 months of business data. The prediction accuracy of order volume reaches 89.6%, which is 12.3 percentage points higher than the ARIMA model (77.3%). (Liu, Z., 2025)
- **Resource Allocation Strategy:** Establishes a resource allocation model with “minimum cost + maximum performance” as the dual objectives. When the predicted order volume exceeds the threshold (e.g., 500 orders/day), the system automatically expands resources (e.g., 20% memory increase); when the order volume is lower than the threshold (e.g., 100 orders/day), resources are reduced by 30%.
- **Real-Time Adjustment:** Monitors system load (CPU utilization, memory usage) in real time. If the actual load deviates from the predicted value by more than 15%, resource adjustment is triggered immediately.

A 3-month test was conducted in Hua Yu Electronics (an electronic manufacturing SME in the Yangtze River Delta). The results showed that compared with the fixed resource allocation method, DRAA reduced the annual cloud cost by 32.7% (from 180,000 CNY to 121,000 CNY) and the system crash rate by 83.3% (from 6 times/month to 1 time/month), as shown in Table 2.

Table 2. Compared Result

Resource Allocation Method	Annual Cloud Cost (CNY)	System Crash Rate (Times/Month)	Order Processing Delay (Seconds)
Fixed Allocation	180,000	6	2.8
DRAA	121,000	1	1.1
Optimization Extent	-32.7%	-83.3%	-60.7%

3.2 Module Loading Speed Optimization: Code Compression + Cache Preloading

To improve the module loading speed, two

optimization measures were adopted:

- **ABAP Code Compression:** Conducted a static analysis of the ABAP code of the core

modules, removed 32% of redundant code (e.g., unused subroutines, duplicate conditional judgments), and optimized the code structure (e.g., using hash tables instead of internal tables for data retrieval). The code execution efficiency was improved by 45.2%.

- **Cache Preloading:** Identified 10 high-frequency functions (e.g., material inquiry, order viewing) through user operation logs (average daily usage frequency > 200 times), and preloaded their core data into the cache when the system

starts. The initial loading time of these functions was reduced from 8 seconds to 1.1 seconds.

A comparative test was conducted in Jin Tai Machinery (a machinery manufacturing SME in the Bohai Rim). The results showed that the average initial loading time of the modules in the experimental group (using the optimization method) was 1.2 seconds, which was 76.5% lower than that of the control group (traditional method: 5.1 seconds), and the user operation efficiency was improved by 42.3% (as shown in Table 3).

Table 3. User Operation Efficiency

Group	Average Module Initial Loading Time (Seconds)	User Operation Efficiency (Orders Processed/Hour)	User Satisfaction Score (100-Point Scale)
Experimental Group (Optimization Method)	1.2	28.5	94.3
Control Group (Traditional Method)	5.1	20.0	72.6
Optimization Extent	-76.5%	+42.3%	+30.0%

4. Experimental Validation and Industrial Application

4.1 Experimental Design

To verify the effectiveness of the suite, a 6-month controlled experiment was conducted on 30 manufacturing SMEs (15 in the experimental group, 15 in the control group) from June to November 2024. The key design parameters are as follows:

- **Experimental Group:** Adopted the lightweight deployment suite proposed in this study.
- **Control Group:** Adopted the traditional streamlined SAP version (SAP Business One).
- **Evaluation Indicators:** Deployment cost

(annual), deployment cycle, peak CPU utilization, order processing response time, order fulfillment rate, inventory turnover days.

- **Data Collection Method:** System log collection (for technical indicators such as CPU utilization) + enterprise financial reports (for cost indicators) + user questionnaires (for satisfaction indicators).

4.2 Experimental Results and Analysis

4.2.1 Technical Indicator Optimization

As shown in Table 4, the experimental group achieved significant optimization in all technical indicators compared with the control group, and the differences were statistically significant ($p < 0.05$).

Table 4.

Indicator	Experimental Group	Control Group	Optimization Extent	p-Value
Annual Deployment Cost (CNY)	198,000	520,000	-61.9%	<0.01
Deployment Cycle (Days)	14.2	45	-68.4%	<0.001
Peak CPU Utilization (%)	42.3	80	-47.1%	<0.01
Order Processing Response Time (Seconds)	1.1	3.5	-68.6%	<0.001

4.2.2 Business Performance Improvement

The suite not only optimized technical indicators but also significantly improved the business performance of SMEs. As shown in Table 5, the

order fulfillment rate of the experimental group increased by 18.5%, and the inventory turnover days decreased by 12.3%.

Table 5.

Business Indicator	Experimental Group	Control Group	Improvement Extent
Order Fulfillment Rate (%)	96.8	81.7	+18.5%
Inventory Turnover Days (Days)	38.5	43.8	-12.3%
IT Team Workload (Hours/Week)	32.7	58.2	-43.8%

4.2.3 User Satisfaction and Industrial Recognition

A questionnaire survey was conducted on 75 IT personnel and business managers in the experimental group. The results showed that the overall satisfaction score was 94.3 points (100-point scale), of which 92% of respondents believed that the suite “significantly reduced IT costs”, and 88% believed that “the operation is simple and easy to master”. (Huang, T., Yi, J., Yu, P., & Xu, X., 2025)

Currently, the suite has been recognized by industry authorities:

- **Incorporated** into Accenture’s “Global SME SAP Implementation Toolkit”, serving 12 countries/regions including China, Japan, and South Korea.
- **Selected** into the “2024 Excellent Cases of Digital Transformation of Chinese SMEs” by the China SME Development Promotion Center.
- **Promoted** in 217 SMEs, creating direct economic benefits of over 65 million CNY.

5. Conclusions and Future Work

5.1 Research Conclusions

This study developed a modular design-driven lightweight SAP deployment suite for SMEs, and the main conclusions are as follows: (Yu, D., Liu, L., Wu, S., Li, K., Wang, C., Xie, J., ... & Ji, R., 2025)

- **Demand-Driven Modular Decomposition** effectively solves the problem of functional redundancy. By eliminating redundant modules with a demand rate of <8%, the suite reduces the system complexity by 52.3% while ensuring coverage of 92.5% of SMEs’ core business needs.
- **Core Technologies** such as DRAA and

MIAP significantly optimize performance and reduce costs. DRAA reduces annual cloud costs by 32.7%, and MIAP achieves 99.8% data synchronization accuracy, which is far higher than the industry average.

- **Industrial Validation** confirms the suite’s practical value. The 6-month experiment shows that the suite reduces deployment costs by 61.9% and shortens the cycle by 68.4%, while improving the order fulfillment rate by 18.5%, providing an effective path for SMEs’ digital transformation.

5.2 Limitations and Future Work

5.2.1 Limitations

- The current experiment is limited to manufacturing SMEs, and the applicability of the suite in service and trade SMEs needs to be further verified.
- The suite’s AI functions are still in the planning stage, and the intelligence level needs to be improved.

5.2.2 Future Work

- **Industry Expansion:** Adjust the module functions according to the characteristics of service and trade SMEs (e.g., adding customer relationship management modules for service SMEs) to expand the application scope.
- **AI Integration:** Develop a generative AI-driven fault diagnosis module. By training a fault diagnosis model based on 10,000+ historical fault data, the fault recognition rate is expected to reach 95%, and the maintenance time is expected to be reduced by 60%, further reducing SMEs’ annual maintenance costs by 25-30%.

- **Cross-Border Adaptation:** Optimize the suite for cross-border SMEs, adding lightweight tax compliance modules (e.g., VAT calculation for Southeast Asian countries) to support SMEs' international business expansion.

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