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Application of cloud computing technology in enterprise resource management

Ziqi Wang

College of Engineering and Applied Sciences, Stony Brook University, New York 11790, United States

ziqi.wang.3@stonybrook.edu

Abstract. The progress of intelligent manufacturing has made enterprise resource planning (ERP) an essential core technology in the field of intelligent manufacturing. In the process of technology development, enterprises have been looking for a more optimized ERP architecture, and cloud-based ERP is one of the practical and efficient solutions. However, for the application of cloud computing in ERP, the current summary analysis based on this field is not comprehensive enough. In this paper, a comprehensive examination of the real-world implementation of cloud computing in ERP is conducted. It delves into the practical utilization and transformation of service-oriented architecture (SOA) and Model View Controller (MVC) within the context of ERP, while also providing an overview of the merits and drawbacks of SOA technology. At the same time, it summarizes the concept of layering and the practical application of cloud computing in different layers for human resource management system of enterprises. In addition, this paper summarizes the practical applications and development prospects of cloud computing in enterprise resource management, such as resource sharing and virtualization. Finally, the paper summarizes the full text, and puts forward a summary and prospect of the combination and future development of cloud computing and enterprise resource management.

Keywords: cloud computing, enterprise resource management, SOA, MVC, human resource management.

1. Introduction

Nowadays, ERP (Enterprise Resource Planning) has emerged as a leading information solution within the domain of intelligent manufacturing. Through a series of developmental phases, it has firmly solidified its position as an essential foundational software in the manufacturing industry [1-2]. In the process of science and technology development, enterprises are looking for more optimized ERP architecture, and cloud-based ERP is one of the practical and efficient ones. In broad terms, cloud computing encompasses the seamless evolution and commercialization of cutting-edge information technology across various domains, including distributed computing, parallel computing, grid computing, network storage, and expansive data warehousing [3]. From a technological advancement standpoint, cloud computing presents a holistic remedy for users seeking to harness extensive network resources [3].

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ERP systems that operate on cloud platforms utilize cloud servers to host both the system and databases. This setup allows users to access online ERP services via a range of external end devices, including smartphones, laptops, tablets, and desktop computers [1]. This kind of architecture greatly improves the flexibility and accessibility of enterprises, and brings unprecedented opportunities for the information construction of enterprises. ERP system based on cloud computing provides manufacturing enterprises with more flexible, efficient and secure information solutions. With the continuous development of the manufacturing industry and the advancement of digital transformation, cloud-based ERP systems will play an increasingly important role in enhancing enterprise competitiveness and optimizing resource allocation. The research in this field has important practical significance. With the acceleration of the transformation and upgrading of the manufacturing industry, enterprises urgently need to adapt to flexible and efficient solutions in the information construction. Cloud-based ERP systems have great potential to meet these needs. Therefore, in-depth exploration of the practical application of cloud computing in ERP is helpful to provide better information solutions for manufacturing enterprises and promote the innovation and development of manufacturing industry.

This paper aims to explore the application and advantages and disadvantages of ERP system based on cloud computing in manufacturing industry. We will delve into the practical application of cloud computing in ERP development. Through this study, we aim to summarize the method of combining cloud computing and ERP, point out the advantages and disadvantages, and provide guidance and suggestions for the development of enterprise informatization.

2. Cloud computing in enterprise resource management

In today's digital age, cloud computing has led the transformation of enterprise resource planning (ERP) and human resource management system (HRM). Cloud computing not only provides powerful infrastructure and capabilities, but also gives these systems the ability to operate more efficiently and flexibly. This section will explore in depth how to optimize ERP platforms through cloud computing and how to apply key technologies in cloud-based enterprise HRM systems, especially service-oriented architecture (SOA) and Model View Controller (MVC), to improve resource management and system security.

2.1. Optimization of ERP platform

The ERP system hosted on a cloud computing platform involves deploying both the system and database on cloud servers. Users can then access these cloud servers using peripheral terminal devices like smartphones and laptops, enabling them to access ERP services online [1]. Important ERP modules include SOA and MVC. Cloud computing helps enterprises to introduce SOA functions so as to plan resource delivery and allocation, realizing cross-platform communication as well. Moreover, in order to separate the user interface, data processing and application logic, so that each component can be independently developed and maintained, cloud computing introduces MVC functionality to help each departments of enterprises operate independently and maintain the system. The following will describe the application of these two aspects in detail.

2.1.1. Application of SOA (Service Oriented Architecture). The ERP platform uses SOA to enable collaborative cloud-based resource management. The platform is designed as a collection of loosely coupled services that can be accessed by other software components using standard communication protocols. In this platform, an enterprise service bus (ESB) serves as a service transit hub, handling all web service requests [2]. The service registry center operates in a manner similar to a DNS system, enabling the SOA runtime infrastructure to dynamically discover and connect with deployed services and their endpoints [2]. This SOA framework within the ERP platform is depicted in Figure 1 [2].

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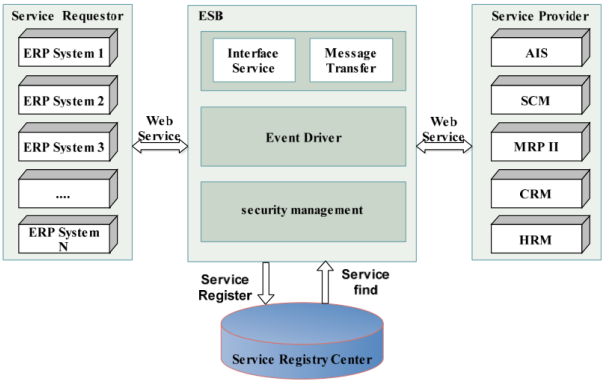

Figure 1. SOA diagram.

By deploying resource management systems on the cloud, enterprises can enable resource sharing and remote collaboration. Individual plants and departments can access the same platform to coordinate orders, inventory, and production planning. Enterprises may use multiple software systems, such as production planning, inventory management, order processing, and more. Using SOA means that users can separate the functionality of different systems into services, with changes to one service having no direct impact on the others, allowing for greater flexibility and maintainability. By applying these concepts to manufacturing enterprises, companies can achieve more efficient resource management and business process optimization. For example, when a customer places an order, the order system can pass the order information to the inventory management system and the production planning system through the ESB. These systems can work independently through an SOA approach, and thanks to the support of a service registry, they can automatically discover and connect to each other.

However, conventional SOA solutions designed to synchronize interorganizational processes fall short in accounting for the decentralized structure of service networks [4]. Frequently, these solutions emphasize solely orchestrating standardized processes that can be entirely predetermined. This approach overlooks the inherent dynamic nature of such networks. specifications. For instance, Some enterprises have a supply system, and the supply chain network of enterprises is usually composed of multiple partners (such as suppliers, manufacturers, distributors, etc.), distributed around the world. At the same time, these supply chain activities may be affected by multiple factors such as market demand, supplier availability, and cargo transportation, resulting in dynamic changes in demand and resources. To make matters more complicated, different partners may have different business processes and requirements. Traditional SOA may focus primarily on harmonizing standardized processes, ignoring the specific needs of each partner. Traditional SOA may struggle to adapt to such changes and requirements.

2.1.2. MVC (Model View Controller) for maintaining system safety. The ERP platform uses MVC to implement the program flow of the platform. When a user makes a request, the request is intercepted by a privilege interceptor, which checks the user's login status and authorization. If the user is authorized, the request is passed to the DispatcherServlet, which calls a controller to handle the request [2]. The controller interacts with the model and view to process the request and return a response to the user. So, MVC is used for checking the permissions of users, preventing enterprise sources from being intrude by hackers or competitors. Cloud-computing use MVC to ensure the preservation and maintenance of enterprise resources.

Cloud computing is intertwined with MVC and plays a key role in maintaining and protecting enterprise resources. An illustrative example involves a business that leverages a cloud-based ERP system to manage customer feedback and reviews. Here, the MVC model protects the process. The model functions as a repository for customer feedback data, carefully validating and cleaning user input before the data is stored to prevent any malicious scripts from infiltrating. View segments facilitate the

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display of customer feedback and apply appropriate text escape and filtering mechanisms to counteract script injection - a key attribute of MVC to ensure security.

In a competitive enterprise dynamic environment where rival companies may try to insert malicious comments, the MVC architecture shines by being flexible in defending against such attempts. When a customer submits feedback or comments, the controller intercepts and validates the input. Any sign of suspicious script code triggers processing that prevents malicious script execution, ultimately leading to secure data storage in the model. This meticulous approach effectively maintains the security of the system and the reputation of the enterprise.

In summary, using the MVC architecture in an ERP system provides several security advantages. Its validation and cleansing processes prevent the introduction of harmful code, while text escape and filtering ensure data integrity. However, it is important to recognize that the effectiveness of MVC in terms of security is closely related to its proper implementation. Flaws in its design or execution could potentially undermine its security benefits. Thus, while MVC can be a robust security measure when implemented well, its overall security effectiveness depends on the thoroughness and attention to detail that is performed during its integration into the system.

2.2. The cloud-based HRM (Human Resource Management) system for enterprises. A cloud-based HRM information system comprises cloud service providers, HRM users, and a cloud service platform (middleware) [3]. These service providers offer a range of resources, solutions, and services to enterprises [3]. Service providers offer a diverse range of cloud services to meet enterprise requirements through the system's cloud platform. Enterprises can request customized services to suit their specific needs and can also utilize shared human resources available on the platform [3]. The HRM information system's structure comprises six tiers, ranked from top to bottom: user access layer, interaction layer, transport layer, software as a service (SaaS) layer, platform as a service (PaaS) layer and infrastructure as a service (IaaS) layer. The system can invoke resources from top to bottom levels on demand, with customers requesting services from below [3]. The structure of HRM is shown in Figure 2 [3].

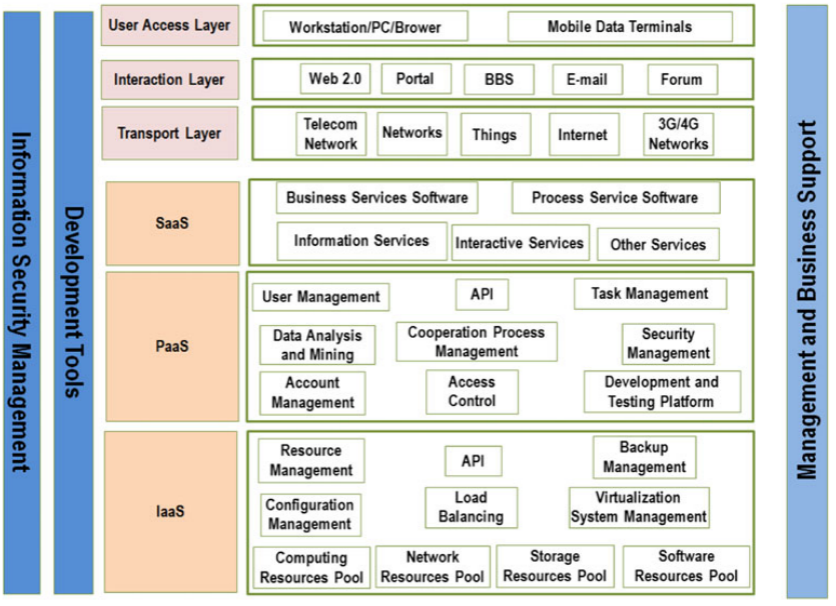

Figure 2. HRM basic structure.

Human Resource management systems (HRM) include multiple layers to achieve efficient functionality:

User Access Layer: This layer allows employees and managers to access the system through a variety of devices, providing easy access to information such as leave requests, company updates, and personnel

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changes. Cloud computing provides employees and managers with a convenient way to access systems anytime, anywhere through a user interface or application provided by a cloud service provider.

Interaction Layer: This layer facilitates interaction between users and systems through interfaces and mobile applications, enhancing user experience and actual human-computer interaction. Cloud computing ensures smooth communication and data transmission between users and the system by providing reliable network connections and communication mechanisms.

Transport Layer: The transport layer ensures secure data transmission across different tiers, facilitating data transmission, job and staff allocation, and inter-departmental coordination. Cloud computing also ensures the security of data in transit through encryption and network security protocols, facilitating collaboration across different levels.

Software as a Service-SaaS Layer: This represents the central layer of the system, delivering functionality for routine HR activities, including employee management, performance assessments, and recruitment procedures. Cloud computing provides these functions as cloud services, making it easy for organizations to access and use these critical functions.

Platform as a Service-Paas Layer: The Platform as a Service layer gives developers the ability to customize HR tools to meet enterprise needs, such as customizing department-specific training management, enhancing integration and access. Cloud computing offers development environments and tools that simplify the process for developers to create and tailor HR solutions.

Infrastructure as a Service (IaaS) Layer: Within the IaaS layer, adjustable resources like computing power, storage, and networking are offered to enhance resource allocation and uphold enterprise adaptability and scalability. By providing a virtualized infrastructure, cloud computing helps organizations flexibly manage resources and scale up or down infrastructure as needed.

These features help to improve the efficiency and flexibility of human resource management systems, enabling organizations to better meet changing needs.

3. Common applications and development trends of cloud computing technology in enterprise resource management

3.1. Common applications

3.1.1. Virtualization and resource sharing. Enterprises broadly benefit from virtualization in cloud computing. For example, consider a company that virtualizes its servers and storage resources. Through the transformation of these physical assets into virtual resources, it becomes possible to operate multiple virtual machines on a single physical server, thus optimizing resource utilization effectively. This approach allows companies to share resources across different departments or projects, increasing flexibility. For example, the marketing team may need more computing resources and a department budget during the launch of an event, and the IT department can temporarily allocate additional virtual machines to keep the event running, reducing the additional hardware investment.

In addition to facilitating resource sharing, the application of cloud computing in virtualization also protects enterprise resource security. Resources in the enterprise that are not easy to share with each other require confidential storage, so these resources can be stored in the virtual cloud, avoiding unknown access from the outside world. Meanwhile, because enterprises share resources and other network information transactions, and the network environment is exposed and interaction is frequent, virtualization technology in cloud computing can help filter bad interactions in order to ensure enterprise cloud security. For example, providing monitoring of the network makes it easier to manage the security of complex departments, servers, and infrastructure [5].

3.1.2. Flexibility and scalability. Cloud computing platforms provide resilience and scalability, allowing enterprises to quickly adjust and scale their resources as needed. Whether increasing or reducing resources, cloud computing platforms can automatically adjust according to enterprise requirements, providing better flexibility and efficiency. Imagine an e-commerce business experiencing

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a spike in user traffic during a seasonal spike in sales, such as a holiday promotion. Cloud computing has continuous availability and scalability, so work and assigned tasks no longer need to wait in queues for hours or days (or even months for the initial commissioning of a new cluster) [6]. With cloud computing, the company can easily scale resources during peak hours to handle the increased user load. After the sale, resources can be scaled back to save costs. This flexibility ensures optimal performance without over-providing hardware resources.

3.1.3. Data storage and backup. Cloud computing technology provides reliable storage and backup solutions. Enterprises can store their data on a cloud platform, reducing the need for local storage, and ensuring data security and availability. In addition, the cloud computing platform also provides data backup and disaster recovery functions to help enterprises better protect their data. Enterprises can use cloud computing for data storage and backup. By securely storing customer privacy information and the allocation and flow of company resources on the cloud, the organization reduces its reliance on on-premises storage systems and the risk of data loss due to hardware failures. In addition, the cloud platform offers automatic data backup and disaster recovery options. In the event of a system failure or data breach, the agency can quickly recover critical data, ensuring consumer information remains accessible and secure.

3.1.4. Software as a Service (SaaS). The SaaS model is one of the most common applications in cloud computing. In the architecture of Software as a Service (SaaS), both applications and infrastructure are shared among multiple customers. This implies that this innovative architecture influences how customers perceive both opportunities and risks [7]. Companies can subscribe to a variety of enterprise applications, without having to deploy and maintain them. SaaS models can reduce IT costs for enterprises and provide faster application deployment and updates. For example, a company that needs to effectively manage its inventory and supply chain. Instead of buying standalone inventory management and supply chain software, the company opted to subscribe to a cloud-based inventory management and supply chain solution. With this SaaS model, companies can access the functionality they need through a web browser. Maintenance, upgrades, and security of software are taken care of by service providers, allowing companies to pay attention to their core business while reducing the cost of software implementation and maintenance.

3.1.5. Edge computing. The rise of edge computing technology has broadened the capabilities of cloud computing, enabling it to extend to the edges of wireless access networks. This extension facilitates rapid, high-bandwidth, and low-latency access to wireless network resources [8]. It pushes computing power to the Internet of Things (IoT) devices and edge devices. By deploying applications and services on edge devices, enterprises can achieve lower latency and a better user experience, and process large amounts of real-time data. Imagine a smart home company that makes smart home devices like smart light bulbs, smart sockets, etc. By putting some of the computing tasks on these smart devices, such as smart light bulbs that respond more quickly under user control and don't need to rely on cloud computing all the time, users' needs can be better met while also reducing latency.

3.2. Development trends

3.2.1. Hybrid and multi-cloud environments. Enterprises are gradually adopting hybrid and multi-cloud environments, combining private cloud, public cloud and edge computing resources to meet different business needs. Such hybrid and diverse deployment models can provide greater flexibility and scalability. An international manufacturing company may need to establish branches in various regions and countries. By adopting hybrid and multi-cloud environments, companies can deploy applications on different suitable cloud platforms based on the regulations and needs of each region, while ensuring data security and compliance in different regions. Moreover, a multi-cloud environment enriches the interaction between enterprises and consumers by allowing applications not only to operate on resources

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from a single provider but also to leverage resources from multiple cloud providers. Given the developing intricacies within the cloud market, consumer decision support can be facilitated through cloud agent mechanisms that engage with multiple cloud providers on behalf of consumers [9].

3.2.2. Security and compliance. Cloud computing's widespread adoption has shifted enterprises' attention towards security and compliance. Cloud service providers and businesses need to work together to ensure data security and comply with relevant regulations and standards. Any company needs to follow the rules to protect the privacy of its customers. When adopting cloud computing, companies need to ensure that their cloud service providers meet security and privacy requirements to protect customers' private data from outside access.

3.2.3. Containerization and microservices. Containerization and microservice architecture are becoming a major trend in cloud computing applications. Microservices are small-scale applications designed for a single purpose, permitting self-sufficient deployment, scalability, and testing [10]. This architecture can provide higher deployment efficiency, scalability, and resilience, and support rapid application development and delivery. Companies can adopt containerization techniques to divide their applications into small, independent microservices. As a result, each microservice can be developed independently, accelerating application iteration and updating. At the same time, when some applications fail, specific programs can be maintained to maintain the stability and maintainability of the overall system.

In general, the application and development of cloud computing technology in enterprise resource management show a trend of increasingly extensive and diversified. By making full use of cloud computing technology, enterprises can achieve greater efficiency, flexibility, and innovation capabilities.

4. Conclusion

In conclusion, the integration of cloud computing technology with ERP systems has revolutionized the landscape of modern manufacturing and enterprise resource management. Cloud-based ERP systems offer enhanced flexibility, accessibility, and efficiency for manufacturing enterprises. The utilization of SOA and MVC principles has empowered seamless resource management and security implementation. Furthermore, the adoption of cloud computing has extended beyond traditional ERP systems to encompass HRM solutions, revolutionizing employee access, interaction, and service delivery.

The common applications of cloud computing in enterprise resource management, such as virtualization, scalability, data storage, and SaaS, have revolutionized the way companies handle their operations. The trends shaping the future, including hybrid and multi-cloud environments, security and compliance measures, and the adoption of containerization and microservices, are set to further optimize resource management and propel businesses into an era of unparalleled agility and innovation. As the manufacturing industry continues to evolve, cloud-based ERP and HRM systems, coupled with these emerging trends, will be instrumental in driving competitiveness and efficiency, ensuring the seamless adaptation of enterprises to the digital age.

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