A Survey on Blockchain-Enabled ERP Systems for Secure Supply Chain Processes and Cloud Integration

Varun Bitkuri[1], Raghuvaran Kendyala[2], Jagan Kurma[3], Jaya Vardhani Mamidala[4], Avinash Attipalli[5], Sunil Jacob Enokkaren[6],
[1]Stratford University, Software Engineer.
[2]University of Illinois at Springfield, Department of Computer Science.
[3]Christian Brothers University, Computer Information Systems.
[4]University of Central Missouri, Department of Computer Science.
[5]University of Bridgeport, Department of Computer Science.
[6]ADP, Solution Architect.
Email ID: Varunbittu452@gmail.com

Abstract

Modern businesses are significantly reliant on integrated technologies to enhance the performance of their supply chains, operational efficiency, and decision-making capabilities. To manage client relationships, finances, inventory, procurement, and other tasks, businesses require Enterprise Resource Planning (ERP) systems. But in complicated and dispersed supply chains, typical ERP systems struggle with transparency, security, and scalability. A new answer has arisen: blockchain technology. It provides immutability, decentralization, and safe data interchange. Smart contracts built on the blockchain enable automated processes, enforce compliance, and foster improved confidence among stakeholders. Cloud computing has revolutionized ERP implementation with its scalable, affordable, and real-time accessible solutions. However, it does come with some new integration and security problems. The convergence of blockchain, cloud computing, and ERP systems provides a framework for secure, transparent, and adaptable supply chain processes, enhancing procurement, logistics, financial management, and cross-organizational collaboration. This paper presents a systematic survey of blockchain-enabled ERP systems, examining technology foundations, integration architectures, application domains, and critical challenges such as interoperability, scalability, and user adoption. By synthesizing recent literature, this study highlights research gaps, offers insights into practical implementation, and identifies opportunities for future research, including the integration of AI and IoT to further enhance automation, predictive analytics, and trust in supply chain ecosystems.

Keywords: Blockchain, Enterprise Resource Planning (ERP), Cloud Integration, Supply Chain Management, Smart Contracts, Digital Transformation.

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I. INTRODUCTION

Digital technology has grown quickly and has changed the way that businesses operate and how supply chains integrate into the globe. Enterprise resource planning (ERP) systems are now essential to the functioning of many organizations in areas such as accounting, logistics, procurement, purchasing, finance, and standard data definitions (Nasiri, 2020). ERP systems provide a platform to integrate company operations and visibility into the operations of information employed in decision-making on the operations of the company. Although the use of ERP systems is prevalent, they have their limits. Traditional ERP systems are rigid in their integration across a complex, distributed supply chain, while providing insecure and little transparent environments.

Blockchain technology has garnered significant interest as a potential solution to address these limitations. As a digital, distributed ledger, blockchain offers immutability, decentralization, and secure data exchange features that enhance ERP functionalities within supply chain contexts. By utilizing blockchain with an ERP solution, issues such as data tampering, fraudulent transactions, and stakeholder trust can be addressed (Viriyasitavat & Hoonsopon, 2019). Furthermore, with blockchain-based smart contracts available, there are avenues for automating ERP workflows and achieving compliance across multi-stakeholder supply chain networks.

The widespread adoption of cloud computing has further accelerated the adoption of ERP systems. A company may respond swiftly and efficiently to shifting market dynamics using cloud-based ERP thanks to scalability, cost efficiency, and real-time accessibility (Zeebaree *et al.*, 2020; Rao, 2009). Cloud ERP also presents security and integration challenges, especially in processing sensitive supply chain data. One way to keep things running smoothly while also bolstering digital supply chain ecosystems is to employ blockchain technology to make cloud-based ERP systems legitimate and trustworthy.

Growing academic and industrial interest in blockchain-enabled ERP and the opportunities and challenges it offers | in supply chain management (Dutta, 2020). Cloud ERP user adoption, smart manufacturing blockchain reference architecture ideas, ERP-blockchain comparisons, ERP's impact on user performance and operational efficiency, and other related themes have been the subject of research. All of these contributions have demonstrated the opportunities and challenges of using blockchain and ERP in cloud-based supply chains.

Blockchain-enabled ERP systems for secure supply chain processes and cloud-based integration. The systematic overview examines the technological foundations of blockchain and ERP, analyzes the architecture of effective integration, and explores application domains within procurement, logistics, manufacturing, and financial management processes (Kenge, 2020). Scalability, interoperability, security threats, and user acceptance are all part of the comprehensive overview, which also points out unfilled research gaps. For the purpose of creating blockchain-based ERP systems that are secure, transparent, and efficient, this review compiles findings from a variety of recent studies.

A. Structure of the paper

The paper is organized as follows: Section II reviews ERP systems in supply chains; Section III covers cloud integration, benefits, and security issues; Section IV discusses blockchain integration and smart contracts; Section V presents a literature review highlighting key contributions and research gaps; and Section VI concludes with insights and future research directions.

II. ERP SYSTEMS AND SUPPLY CHAIN PROCESSES

ERP systems' effects on the efficiency of supply chains. The goal is to determine the circumstances in which ERP can either greatly facilitate or significantly hinder the achievement of exceptional supply chain performance (Akkermans, 2003). From a business point of view, a technical point of view, or a functional point of view, ERP can be defined differently. It goes into some depth about each of these points later on. Business processes and information technology come together in ERP, according to one interpretation. One US-based ERP system integrator, for instance, defined ERP as an umbrella term for enterprise resource planning (ERP) software that controls the shop floor, handles financial accounting, and drives a company's data structure. Management functions across complex diverse networks and geographic areas are bound together by it. British consultancy firm JBA takes a more strategic view of ERP, viewing it as an approach to business that originates in the executive suite and spreads across the entire company. To put it simply, an ERP system's main purpose is to facilitate the control and administration of a single company's resource deployment. Products, services, abilities, time, money, etc. all fall within this category of resources. To a large extent, this goal is advanced by the three main kinds of features offered by modern ERP systems:

- An enterprise-wide data management system that facilitates integrated transaction processing;
- Operations related to workflow management regulate the many business process flows, including the purchase and order-to-cash cycles;

- Performing an Available-to-Promise (ATP) check or an MRP run are two examples of decision support tasks that can help with plan building or choosing whether to accept a certain client order.

A. Enterprise Resource Planning (ERP) System

ERP is a system that enhances the efficacy of a company by integrating distinct, autonomous business functions and processes, as illustrated in Figure 1. Despite claims to the contrary, ERP systems are not the "end all" or "be all" of any given business, but rather a platform that facilitates communication across departments including accounting, finance, production, purchasing, and customer care (AlMuhayfith & Shaiti, 2020; Balasubramanian, 2019). Attempting to retrofit the company to ERP should not consume too much time for companies. It is recommended to extend ERP if it does not fulfill the organization's requirements. To get ERP's full potential, it needs to be extended beyond the typical initial phase. To "mobilise" the system, it is necessary to take advantage of modern technology. To be effective, extensions must be built upon a solid ERP base or backbone. Including project management in the overall business plan is a key factor that significantly impacts ERP rollouts. Companies nowadays must have the ability to respond swiftly to market developments; consequently, they must set up an IS that can facilitate this capacity. The purpose of identifying CSFs is to provide managers with the tools they need to influence an effort's result by proactive action in the areas that matter most.

Fig. 1. ERP System Overview

B. ERP Modules Impacting Supply Chain

The integration of functional modules into ERP systems is a crucial component of supply chain management. The most relevant modules include:

- **Inventory Management**: Ensures accurate tracking of stock levels, demand forecasting, and timely replenishment to avoid shortages or overstocking.
- **Procurement and Supplier Management**: Facilitates vendor selection, purchase order processing, and supplier relationship management for efficient sourcing.
- **Logistics and Distribution**: Manages transportation, warehousing, and delivery processes, enabling timely and cost-effective product movement.
- **Production Planning**: Aligns manufacturing schedules with supply chain requirements to optimize resource utilization and reduce delays.
- **Customer Relationship Management (CRM)**: Enhances demand visibility by capturing customer orders, feedback, and market trends.
- **Financial Management**: Provides transparency in costing, billing, and payments, ensuring financial control across supply chain operations.

C. Security Vulnerabilities in Modern Supply Chains

Supply chain networks are excessively complex because they involve several individuals, organizations, governments, and maybe even states. Many problems plague supply chains, including difficulties in building confidence among all parties involved, cyberattacks, theft of shipments, counterfeiting, and numerous other issues. Although pharmaceuticals and electronics are the most costly stolen products, food and drink are the most commonly stolen goods overall (Hassija, 2020). To put it another way, the more

complicated a supply chain is, the more vulnerable it is to different types of security threats; in other words, the more security dangers there are, the more complex a supply chain is. Supply chain activities are susceptible to these dangers, which can impact numerous weak spots.

- The usefulness and satisfaction of products can be diminished when they are tampered with or fraudulently substituted.
- The supply chain as a whole may not adhere to the same security protocols, particularly when it comes to third-party service providers.
- Cybersecurity is a top priority since IT systems now power significant portions of the supply chain. The chain runs the risk of being affected by the single point of failure problem if it relies too much on interconnected IT systems. Intruders may be able to access other protected areas after gaining access to just one system.

III. CLOUD INTEGRATION IN ERP SYSTEMS

The cloud" is a model for network-based services that facilitates on-demand, easy access to a shared pool of configurable computer resources (such as servers) via the internet. Server, storage, or software-related specialized services delivered via the internet are also part of this approach. Quickly adapting to this new technology, ERP vendors began building their systems around cloud computing models and services. The process of migrating an ERP system to the cloud is called cloud ERP (Bahssas, 2015; Balasubramanian, 2019). This hosting can be accomplished through two models: IaaS and SaaS. By "infrastructure as a service," mean the ability to rent or lease servers and other necessary hardware through the internet. Purchasing or leasing cloud-based services, such storage or software, is known as SaaS. Cloud ERP makes use of SaaS, which assumes control of the whole solution's IT infrastructure (including servers, OSes, databases, and other related components) and procedures. The numerous benefits of cloud ERP include a smaller workforce, greater mobility, easier scalability, lower costs, and reduced overall expenses. Cloud ERP on demand was launched in response to business challenges and customer demand for cloud technology.

A. Cloud ERP Overview

ERP systems are enterprise-wide, cross-functional computer programs that run on an assortment of interconnected modules to facilitate the routine business operations of a company. Standard functions included in the ERP system make it applicable to a wide range of industries (Bjelland and Haddara, 2018). By incorporating data and cross-functional procedures, an ERP system aims to assist the company's fundamental operations and daily transactions. Nowadays, ERP systems can be rented as hosted software through cloud computing. Cloud computing allows users to access storage capacity, systems, and hardware through a vendor, with users having very little to no control over the administration of these components. Adopting an ERP system is usually driven by a desire to cut costs, enhance decision-making with greater reporting capabilities, strengthen relationships with customers, comply with market and legal requirements, and streamline processes. Organizations can have access to an ERP system hosted by a third party via the Internet via a cloud-based ERP system.

B. Benefits of Cloud-Based ERP

There are several advantages to implementing cloud-based ERP systems, including cost savings in both initial setup and ongoing operations, ease of use, speed of deployment and upgrades, improved communication and cooperation among supply chain participants, and scalability regardless of location (Elmonem, 2016).

- **Lower upfront costs:** Businesses only have to pay to access their computer resources through the internet; they no longer have to pay to develop the environment. This is all because of the separation of computing resources from the location of the firm.
- **Lower operating costs:** The responsibility for running and providing the cloud services that separate the enterprise's operations and their associated expenses from the cloud rests with the cloud service providers (CSP).

- **Rapid implementation:** Enterprises can get what they need among the extensive ERP options offered by CSPs. The needs of the enterprise firm determine the solutions and products that are chosen. This selection process expedited the implementation.
- **Scalability:** Cloud services are very elastic; allowing businesses to increase or decrease the number of resources they consume based on their actual demands.
- **Focus on core competencies:** The use of cloud ERP solutions allows businesses to better manage their operations while freeing up resources to focus on core strengths.
- **Using advanced technology:** The business can tap into specialized technologies and advanced computer resources that are accessible through cloud computing.

C. Security Concerns and Solutions in Cloud ERP

The scalability and adaptability of cloud-based ERP systems aren't without their security risks, which must be adequately addressed if supply chain activities are to remain risk-free. The major security challenges of cloud-based ERP included data breach, where confidential organizational and customer information could be accessed by an unauthorized entity; multi-tenancy risks, meaning that shared infrastructure could create possible vulnerabilities between clients and provide risk as a third-party database; data loss or leakage, which could result from bad backups or hostile third-party attacks; or compliance challenges, as the organization must comply with stringent regulations, such as GDPR and ISO when handling cloud-hosted data (Hrischev, 2020). Several options were proposed and solutions already operationalized to address these challenges. For example, the use of encryption techniques could protect data at rest, while it is in a cloud environment and when transferring over a network; MFA could strengthen access control; security audits and regular monitoring could assist in the initial identification of vulnerabilities, and RBAC to give explicit rights to users to access specific ERP functions.

IV. BLOCKCHAIN INTEGRATION WITH ERP SYSTEM

A blockchain platform that is synchronized with a normal ERP database architecture was suggested as part of the system design (Banerjee, 2017). The primary goal of the blockchain was to verify and log all transactions before they were entered into the ERP system. Here, the authors' reference to access controls as a "single point of failure" in the traditional ERP architecture is replaced with a smart contract stored in the blockchain. Only specific data would be added to the blockchain to meet the high transaction throughput demands of ERP systems. It was also said that to make the system manageable, only essential information should be added to the blockchain. Additionally, blockchain nodes would employ buffers to streamline user-initiated transactions. Last but not least, the seamless experience for the end user would be handled by the client application. Similar to the previously mentioned method, this idea proposes synchronizing the blockchain with a traditional ERP database. An additional point brought up by the writers is the idea of using smart contracts to integrate the ERP system's business rules into the blockchain. Also, the security of sensitive ERP data would be handled by smart contracts, which would also handle the access control procedures.

A. Architectural Approaches for Integration

Integrating blockchain technology with ERP systems requires clear architectural strategies to ensure security, scalability, and interoperability (Zhou, 2020; Rajavel, 2016). Broadly, these approaches can be classified into on-chain, off-chain, and hybrid architectures.

- **On-Chain Integration**: This method uses the blockchain ledger to directly store some ERP records and transactions. This ensures immutability and transparency but may face challenges related to scalability, storage limitations, and transaction speed. It is most suitable for critical operations such as supplier agreements, compliance checks, and high-value transactions.
- **Off-Chain Integration**: Here, ERP data remains within the traditional system, while only transaction proofs or hashed references are recorded on the blockchain. This reduces data load on the blockchain while maintaining integrity and auditability. Off-chain integration is widely adopted when large volumes of operational data are involved.

- **Hybrid Models**: These combine on-chain validation with off-chain data management. Sensitive or compliance-critical data is stored on-chain, while routine ERP operations remain off-chain. Middleware solutions and APIs are often employed to synchronize data between ERP modules and blockchain networks, enabling flexibility without compromising performance.

This layered integration architecture not only enhances security and traceability but also allows enterprises to gradually transition from legacy ERP systems toward blockchain-enabled solutions.

B. Logical Architecture of An ERP System

Logical and physical architectures, sometimes known as tiered architectures, are the two most common approaches to designing enterprise resource planning systems. Figure 2 illustrates the logical architecture, which explains how the system is designed to meet the functional needs of the business and its end-users. references (Amini & Abukari, 2020; Thapliyal, 2009). A layer above the most basic hardware infrastructure and database systems is where the core business logic resides; it embodies the actual rules and constraints of the company. In the fourth level, find the specifics of the ERP system including practical business applications. Interactions between end users and enterprise applications are mediated via client user interfaces. The system takes care of everything a user does when engaging with it. Users are thus unaware of the deployment of extra layers.

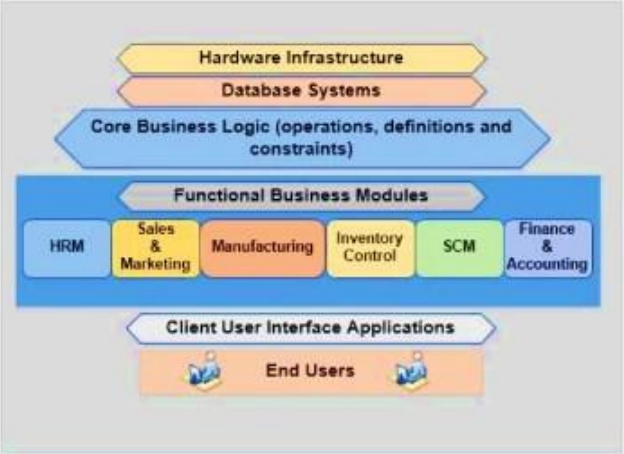

Fig. 2. Logical Architecture of an ERP System

C. Smart Contracts in ERP

Smart contracts are computer programs on the blockchain that can automatically process conditions when triggers have been met, usually without any manual involvement or third-party verification. The ability to automate essential business activities in an ERP system is made possible by this. These processes include procurement, payment, and supply chain scheduling. For example, whenever goods are delivered and confirmed received, the smart contract can disburse payments and update the ERP inventory module automatically, thereby ensuring accuracy and efficiency. Moreover, smart contracts foster greater trust, transparency, and compliance through immutable transactions recorded on a blockchain, which reduces the likelihood of fraud and disputes among stakeholders. Specifically, smart contracts in SCM can enable buyers to enforce service-level agreements regarding supplier delivery timelines and quality assurance, as well as clause penalties for suppliers who fail to meet the delivery timeline. Incorporating blockchain smart contracts with ERP modules: finance, logistics, and procurement can be automated into workflows, tends to lower operational costs and enhance accountability and documentation throughout an organization.

V. LITERATURE REVIEW

The reviewed literature highlights progressive developments in ERP and blockchain integration, emphasizing cloud migration, user adoption, performance impact, manufacturing efficiency, and smart

supply chain applications, while identifying challenges and future opportunities for secure, transparent, and efficient enterprise systems.

TABLE I. COMPARATIVE ANALYSIS OF BLOCKCHAIN-ENABLED ERP SYSTEMS FOR SECURE SUPPLY CHAIN

Author	Study On	Approach	Key Findings	Challenges	Future Directions
Alhanatleh & Akkaya (2020)	Convincing users to switch from on-premises ERP to cloud-based ERP	Used TAM model to examine adoption factors	Identified user satisfaction and managerial decision-making as key to Cloud ERP success	Employee resistance to shifting from traditional ERP; lack of training	Enhance adoption by focusing on training, change management, and user-centric design
Zuo (2020)	Blockchain in Industry 4.0 for ERP and supply chains	Proposed blockchain reference architecture for smart manufacturing	Blockchain enhances transparency, efficiency, and automation in smart factories	Scalability, interoperability, and integration with legacy ERP	Develop lightweight blockchain protocols and standardized integration frameworks
Sokolov & Kolosov (2019)	Integrating ERP and Blockchain Technologies	Comparative survey of ERP vs blockchain	Blockchain offers security, transparency; ERP provides structured operations	Lack of maturity in blockchain adoption; unclear applicability	Hybrid ERP–blockchain systems with clearer implementation guidelines
Ullah et al. (2018)	ERP systems' impact on user performance	Literature review on ERP adoption and benefits	Users play a critical role in assessing ERP effectiveness	Ongoing debate on ERP's actual contribution to performance	More empirical studies on ERP–blockchain synergy and user-centric evaluation
Oman et al. (2017)	MES and ERP integration in automotive supply chain	Developed embedded interface with IDoc messaging	Improved performance indicators: velocity, cost, and asset efficiency	Integration complexity; need for real-time synchronization	Broader application of ERP-MES integration with blockchain-enabled traceability
Madanhire & Mbohwa (2016)	ERP framework for shop floor and inventory optimization	Designed ERP framework to reduce waste and cycle time	ERP improved efficiency, reduced WIP, and enhanced collaboration	Implementation complexity; alignment of processes	Expand framework with blockchain for supply chain transparency and data integrity

Alhanatleh and Akkaya (2020) provided the option to switch from an ERP system hosted on-premises to one hosted in the cloud, and the majority of employees are already comfortable with the former. During the operational phase, to maximise the efficacy and efficiency of the Cloud ERP system. Organisations should prioritise research on the aspects that affect customer satisfaction and managerial decision-making. Many earlier studies have employed a technology acceptance model (TAM) to assess the rate of adoption

of ERP systems by end-users. As a result, this study also used the TAM model to look into what influences users' adoption of Cloud ERP processes (Alhanatleh & Akkaya, 2020).

Zuo (2020) a comprehensive examination of blockchain technology in the context of Industry 4.0, encompassing its applications, structural components, methodologies, and potential challenges for future research. To guide discussions on integrating blockchain technology into smart supply chains and factories, a blockchain reference design for smart manufacturing can be offered. Blockchain is a decentralized digital ledger system that allows users to conduct trustworthy and transparent transactions with one another. A highly efficient and productive automated decentralized smart manufacturing system has been developed using blockchain technology, which has found numerous applications in the manufacturing sector (Zuo, 2020).

Sokolov and Kolosov (2019) evaluated the differences and similarities between ERP systems and the Blockchain platform. People are curious about the potential applications of blockchain technology in their work, especially when compared to traditional software products, even though discussions regarding its widespread adoption are still in their early stages. The ERP system is one such offer. Many industry professionals now hold divergent views on the potential uses and benefits of blockchain technology. ERP systems and blockchain technology are defined here, along with their primary terms, benefits, applicable domains, and drawbacks. Moreover, this analysis details the various areas in which ERP systems and Blockchain platforms might be utilised. The findings highlight the unclear nature of blockchain platforms as they stand right now. The research paper's findings also highlight some characteristics of ERP systems (Sokolov and A. Kolosov, 2019).

Ullah et al. (2018) conducted a literature review on ERP systems with respect to the effect these systems have on user performance. They are well-versed in the current state of knowledge regarding user performance roles in ERP systems, and they propose that users can assess the systems' value to companies that have deployed or are planning to use such systems. Because users utilise ERP systems and judge the actual benefits and influence on them, the discussion surrounding the contribution of these systems to performance continues (Ullah, 2018).

Oman et al. (2017) the results for a medium-sized business in the car supply chain of integrating MES with ERP technologies. The two databases were able to communicate with each other in both directions thanks to an in-built interface. An IDoc message serves as a go-between for the two systems, facilitating data transmission. An analysis of the impacts of MES-ERP integration was conducted using the VRM, which provides quantitative indications in multiple dimensions. Looked at two processes before and after integration to see how they performed in terms of speed, expense, and assets. It was determined that the chosen key performance metrics had improved (Oman, 2017).

Madanhire and Mbohwa (2016) Inventory and work-in-progress on the shop floor were intended to be diminished by the ERP system. To reduce working capital, several factors were taken into consideration, including the integration of business activities, intra-organizational communication, and increased cooperation. Streamlined operations by eliminating inefficiencies in material or energy use, inventory, quality, or capacity. Rooms have been rearranged to better accommodate employees, machinery, and desks; Streamlined manufacturing by coordinating machine maintenance with set-up and production procedures; decreased product cycle times (Madanhire and Mbohwa, 2016).

Table I presents a comparative summary of key studies on blockchain-enabled ERP systems, highlighting research focus, approaches, major findings, challenges, and future directions in supply chain and cloud integration.

VI. CONCLUSION AND FUTURE WORK

In the contemporary digital era, enterprises increasingly rely on integrated technologies to enhance operational efficiency and supply chain performance. This review investigates blockchain-enabled ERP systems with cloud integration as a pathway toward secure, transparent, and adaptive enterprise processes. Traditional ERP systems, while widely adopted, often encounter challenges related to scalability, data security, and transparency, particularly in complex and distributed supply chains. Blockchain technology,

with its decentralized ledger, immutability, and smart contract functionalities, provides a promising solution to address these challenges. When combined with cloud integration, ERP systems gain enhanced scalability, real-time accessibility, and cost efficiency, enabling more agile and collaborative supply chain operations. The integrated framework of ERP, blockchain, and cloud has significant potential to improve procurement, logistics, inventory management, financial operations, and cross-network collaboration. Despite these advantages, several barriers remain, including interoperability issues, resistance to adoption, and limited technological maturity. This study is further constrained by the reliance on literature up to 2020 and the limited availability of empirical large-scale implementations. Future research should focus on developing standardized hybrid integration models, enhancing interoperability, and validating the adoption of blockchain-ERP through empirical studies. Additionally, combining blockchain with AI and IoT could enhance predictive analytics, automation, and trust, further strengthening supply chain resilience and efficiency.

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