

Real World Asset (RWA) Supply Chain for Smart Factory

Ray Wai Man Kong¹

¹ Adjunct Professor, City University of Hong Kong, Hong Kong

¹ Modernization Director, Eagle Nice (International) Holding Ltd, Hong Kong

DOI: <https://doi.org/10.5281/zenodo.16836199>

Published Date: 13-August-2025

Abstract: This research proposes integrating real-world assets (RWAs) into a blockchain-based supply chain to address traditional challenges of transparency, inefficiency, and security. The framework supports both centralized and decentralized operations within a consortium, ensuring flexibility for diverse organizational needs. Security features include private transactions via Quorum and Hyperledger Besu clients, asymmetric encryption for app-to-app messaging, and confined nodes/services to specific environments. Scalability is achieved through multiple blockchain networks with firewall isolation, while optional cloud integrations enhance efficiency. Organizational identities are managed securely using digital certificates, and a granular block explorer ensures transparency and accountability. This integration improves efficiency, transparency, and trust in food supply chains, benefiting all stakeholders.

The proposed RWAs system in the case study is designed with flexibility in mind, allowing for both centralized and decentralized consortium operations. This dual capability ensures that organizations can choose the operational structure that best suits their needs, whether controlled by a single entity or shared across multiple participants. Additionally, the system supports tiered subscriptions within a consortium, enabling diverse organizations with varying requirements to coexist harmoniously.

In conclusion, this research demonstrates how integrating real-world assets into a blockchain-based food supply chain can significantly improve efficiency, transparency, and trust. By addressing critical challenges through innovative use of technology, the proposed system offers a robust framework for modernizing food supply chains, ultimately benefiting all stakeholders from producers to consumers.

Keyword: Real World Assets, Supply Chain, Smart Factory, Automation.

I. INTRODUCTION

A. Introduction to Real World Assets and Supply Chain in Smart Factories

In the era of Industry 4.0, the integration of advanced technologies into manufacturing processes has transformed traditional factories into smart factories. A key component of this transformation is the concept of Real World Assets (RWAs) and their management within the supply chain. RWAs refer to physical assets that are essential for production, such as machinery, equipment, and inventory, which are increasingly being equipped with sensors and IoT (Internet of Things) capabilities. This connectivity allows for real-time data collection and analysis, enabling manufacturers to optimize operations, enhance decision-making, and improve overall efficiency. In a smart factory, RWAs are seamlessly integrated into the supply chain, creating a dynamic ecosystem that responds to market demands and operational challenges with agility and precision.

The benefits of Real World Assets in Supply Chain Management for Smart Factories are shown in the following:

- **Enhanced Visibility and Transparency:**

The integration of RWAs into the supply chain provides manufacturers with real-time visibility into their operations. Sensors and IoT devices enable continuous monitoring of asset performance, inventory levels, and production processes. This transparency allows for better tracking of materials and products throughout the supply chain, facilitating timely decision-making and reducing the risk of disruptions.

- **Improved Efficiency and Productivity:**

Smart factories leverage data from RWAs to optimize production schedules, reduce downtime, and streamline workflows. By analyzing real-time data, manufacturers can identify bottlenecks, predict maintenance needs, and allocate resources more effectively. This leads to increased operational efficiency and higher productivity, ultimately resulting in cost savings and improved profitability.

- **Data-Driven Decision Making:**

The wealth of data generated by RWAs enables manufacturers to make informed decisions based on accurate insights. Predictive analytics can be employed to forecast demand, optimize inventory levels, and enhance supply chain planning. This data-driven approach minimizes the reliance on intuition and guesswork, leading to more strategic and effective decision-making.

- **Agility and Responsiveness:**

In a rapidly changing market environment, the ability to respond quickly to customer demands is crucial. Smart factories equipped with RWAs can adapt to fluctuations in demand and supply chain disruptions more effectively. Real-time data allows manufacturers to adjust production schedules, manage inventory levels, and coordinate logistics in response to changing conditions, ensuring that they remain competitive.

- **Sustainability and Resource Optimization:**

The integration of RWAs in smart factories also supports sustainability initiatives. By monitoring asset performance and resource usage, manufacturers can identify opportunities for waste reduction and energy efficiency. This not only contributes to environmental sustainability but also enhances the overall cost-effectiveness of operations.

- **Enhanced Collaboration and Integration:**

The connectivity of RWAs fosters collaboration across the supply chain. Manufacturers can share real-time data with suppliers, logistics providers, and customers, creating a more integrated and cohesive supply chain ecosystem. This collaboration enhances communication, reduces lead times, and improves overall supply chain performance.

The integration of Real World Assets into the supply chain is a fundamental aspect of the smart factory paradigm. By leveraging advanced technologies and real-time data, manufacturers can enhance visibility, improve efficiency, and make data-driven decisions that drive competitiveness and sustainability in an increasingly complex and dynamic market. In the rapidly evolving landscape of the apparel industry, the integration of automation technologies has become essential for enhancing productivity, improving quality, and reducing operational costs. One of the most significant advancements in this domain is the development of automated seam folding and sewing machines. These innovative machines streamline the garment manufacturing process by automating critical tasks that were traditionally performed manually, thereby increasing efficiency and consistency in production.

B. Process Flow and Mechanism of Real World Assets Supply Chain in a Smart Factory

The integration of Real World Assets (RWAs) into the supply chain of a smart factory involves a sophisticated process flow that leverages advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and data analytics. This process flow enhances operational efficiency, improves decision-making, and fosters agility in responding to market demands. Below is an overview of how the process flow and mechanisms work in the context of RWAs within a smart factory supply chain.

1. Asset Identification and Integration

Asset Tagging: Each RWA, such as machinery, equipment, and inventory, is tagged with sensors or RFID (Radio Frequency Identification) devices. This enables real-time tracking and monitoring of the asset's location, status, and performance.

Data Connectivity: These assets are connected to a centralized data platform, often referred to as a Manufacturing Execution System (MES) or an Enterprise Resource Planning (ERP) system. This connectivity allows for seamless data exchange between assets and the central system.

2. Data Collection and Monitoring

Real-Time Data Acquisition: Sensors embedded in RWAs continuously collect data on various parameters, including operational performance, energy consumption, and maintenance needs. This data is transmitted to the central system for analysis.

Condition Monitoring: The system monitors the condition of assets in real-time, identifying any anomalies or deviations from normal operating parameters. This proactive monitoring helps in predicting maintenance needs and preventing unexpected breakdowns.

3. Data Analysis and Decision Support

Predictive Analytics: Advanced analytics tools analyze the collected data to identify trends, patterns, and potential issues. Predictive models can forecast equipment failures, optimize maintenance schedules, and improve inventory management.

Decision-Making Support: The insights generated from data analysis provide decision-makers with actionable information. This enables them to make informed decisions regarding production planning, resource allocation, and supply chain management.

4. Production Planning and Scheduling

Dynamic Scheduling: Based on real-time data and predictive analytics, the smart factory can dynamically adjust production schedules to optimize resource utilization and meet changing demand. This flexibility allows for quick responses to market fluctuations.

Inventory Management: The system tracks inventory levels in real-time, ensuring that raw materials and components are available when needed. Automated reordering processes can be triggered based on predefined thresholds, reducing the risk of stockouts.

5. Execution and Operations

Automated Workflows: The smart factory employs automated workflows that guide the production process. This includes automated material handling, assembly, and quality control, all of which are monitored through the central system.

Real-Time Adjustments: Operators can make real-time adjustments to production processes based on data insights. For example, if a machine is operating below optimal efficiency, adjustments can be made to improve performance.

6. Supply Chain Collaboration

Integrated Communication: The smart factory facilitates communication and collaboration with suppliers, logistics providers, and customers. Real-time data sharing enhances transparency and coordination across the supply chain.

Demand Forecasting: By analyzing market trends and customer preferences, the smart factory can forecast demand more accurately. This information is shared with suppliers to ensure timely delivery of materials and components.

7. Feedback Loop and Continuous Improvement

Performance Monitoring: The performance of RWAs and the overall supply chain is continuously monitored. Key performance indicators (KPIs) are tracked to assess efficiency, quality, and responsiveness.

Continuous Improvement: Insights gained from performance monitoring are used to identify areas for improvement. This feedback loop fosters a culture of continuous improvement, enabling the smart factory to adapt and evolve in response to changing market conditions.

Conclusion

The process flow and mechanism of Real World Assets in the supply chain of a smart factory create a highly interconnected and responsive manufacturing environment. By leveraging real-time data, predictive analytics, and automated workflows, smart factories can optimize operations, enhance decision-making, and improve collaboration across the supply chain. This integration not only drives efficiency and productivity but also positions manufacturers to meet the demands of an increasingly dynamic market landscape.

II. LECTURE REVIEW

A. Conceptual Framework of Real World Assets

The concept of Real World Assets (RWAs) has gained traction in the context of Industry 4.0, where physical assets are integrated with digital technologies. According to Kamble et al. [1], RWAs encompass machinery, equipment, and inventory that are equipped with IoT devices, enabling real-time data collection and monitoring. This integration allows for enhanced visibility and control over manufacturing processes, which is critical for the efficient operation of smart factories.

B. Impact on Supply Chain Efficiency

Numerous studies have explored the impact of RWAs on supply chain efficiency. Kayapinar Kaya et al. [2] is to establish a research model and conduct an empirical analysis to comprehend blockchain technology adoption's transformational potential in the supply chain environment. By providing real-time insights into asset performance and inventory levels, manufacturers can optimize production schedules and reduce waste. This aligns with Prof Ray Wai Man Kong [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17] who emphasized that Lean Practice, production planning and automation facilitate better inventory management and demand forecasting, leading to improved responsiveness to market changes as well as RWAs can improve the invoice and asset ownership, and its operation flow.

C. Blockchain technology in the supply chain

In the work of Maher A.N. Agi and Ashish Kumar Jha [18], blockchain technology is explored in the context of supply chain management. A supply chain is generally comprised of independent organizations that are involved in the upstream and downstream flows of products, services, finances, and information, facilitating the journey from source to customer, as noted by Mentzer et al. [19]. Effective supply chain management hinges on the cooperation and mutual information sharing among its members, as highlighted by Gunasekaran et al. in 2001 [20]. In this context, blockchain technology offers significant improvements to supply chain management and helps achieve performance objectives by providing a platform for direct interaction among supply chain participants, allowing them to exchange credible and tamper-proof data. One of the primary advantages of this technology is its capability to enable complete product traceability and enhance visibility throughout various stages of the supply chain, as stated by Babich and Hilary in 2020 [21]. For example, the UK-based blockchain solutions provider Provenance successfully utilized smart tagging and blockchain technology to track fish caught by fishermen in Indonesia, offering robust proof of compliance with standards from the origin through the supply chain to the end consumers (<https://www.provenance.org>).

D. Adoption of blockchain technology in the supply chain

The innovative nature of blockchain technology and its potential for improving supply chain management has piqued the interest in investigating the challenges and enablers of its adoption in the supply chain context. In a pioneering work, Casey and Wong (2017) [22] discussed the obstacles related to blockchain technology adoption in global supply chains and highlighted the challenges related to the interoperability between different blockchains and the complexity of the rules and regulations that govern contracting and commercial exchange, especially across national borders. Thus, to further encourage blockchain adoption in global supply chains, the authors advocate agreeing on standards and rules for interoperability between blockchains, as well as adapting current regulations and industry practices to the new dematerialized, automated and global nature of blockchains.

The literature on Real World Assets in the supply chain of smart factories underscores their critical role in enhancing efficiency, enabling data-driven decision-making, and fostering collaboration. While the integration of RWAs presents significant opportunities for manufacturers, it also poses challenges that need to be addressed. Continued research in this area will be essential for unlocking the full potential of RWAs in the evolving landscape of smart manufacturing.

III. CASE STUDY OF THE BLOCKCHAIN OF FOOD MANUFACTURING

A. How to implement the Blockchain-based food supply chain model

From Antier Solutions company, the blockchain solution can benefit food manufacturing, as shared in the case study. The role of blockchain technology in improving Food safety and efficiency. This case study could examine how blockchain can enhance food safety in the manufacturing sector. It might include discussions on traceability, transparency in the supply chain, and how these factors contribute to minimizing foodborne illnesses and ensuring product quality. Cost efficiency and blockchain in food manufacturing explores how implementing blockchain solutions can lead to cost savings for food

manufacturers. The essay could highlight specific use cases where blockchain reduces waste, improves inventory management, and streamlines processes, thereby optimizing overall operational costs. The challenges and limitations of implementing blockchain in food manufacturing. The following procedures could discuss the potential challenges that food manufacturers may face when adopting blockchain technology. The challenge issues could include technological barriers, regulatory compliance, the cost of implementation, and resistance to change within organizations.

This case study, provided by Antier Solutions, outlines the food manufacturing process through a detailed exploration of its five key stages.

Stage 1: Farmers update information on the Blockchain

Blockchain solutions designed for the food supply chain enable farmers to securely store detailed information about their crops. This includes data on origin, type, harvest dates, and the various processes used for sowing, storage, and handling. All parties within the network can easily access this information through a mobile application or a designated center on the blockchain.

Additionally, farmers can upload images of their crops, enabling factories and production companies to make informed decisions regarding the crop's quality. Smart contracts are in place to ensure compliance with regulations, while seamlessly integrating data into the blockchain.

Stage 2: Food processing companies record the processing details on the Blockchain

Once the crops are harvested, they are forwarded to the next stage: processing by factories or food processing companies. These companies participate in bidding for the crops using smart contracts. Once a bid is accepted, they proceed with food processing and record the relevant information on a public Blockchain. This transparency enables retailers and consumers to verify whether the food has been processed properly. Additionally, as regulations are incorporated into smart contracts, compliance with food safety standards will be ensured at every stage of the processing.

Stage 3: Wholesalers bid for the processed products using smart contracts on the blockchain of RWAs

Once the food item is fully processed by companies, they are put out for bidding. Wholesalers bid through smart contracts. After the company accepts the bid, food processing companies ship the processed food items to the wholesaler. Parties involved within the food supply chain Blockchain system can track the product journey at each stage without worrying about security.

Stage 4: Finished products are shipped through IoT-enabled vehicles to retailers to update in blockchain

Upon receiving the food items, the wholesaler enlists a logistics service provider to distribute the products to retailers. These food items are transported using IoT-enabled vehicles designed to keep them safe under controlled temperatures, minimizing the risk of spoilage and preserving product quality. The sensors within these IoT vehicles provide real-time updates on the temperature and location of the food items, which are then recorded on a Blockchain dedicated to the food supply chain. This information allows retailers to effectively track the food items they are set to receive.

Stage 5: Consumers receive the final product

Blockchain development for the food supply chain represents a significant advancement, enhancing transparency from source to destination. Within this Blockchain-based supply chain system, essential information about food products—such as transportation details, batch numbers, factory and processing data, farm origin details, storage temperature, and expiration dates—is recorded at every stage. All transactions are validated by the stakeholders involved in the network to achieve consensus. This allows end consumers to access detailed product information and trace its journey, enabling them to make informed decisions about their purchases.

RWAs can combine blockchain technology with tokenizing physical assets in raw materials and finished goods to serve as a payment and decentralized Finance with contracts in the blockchain, as referred to the source of Antier Solutions in Fig. 1.

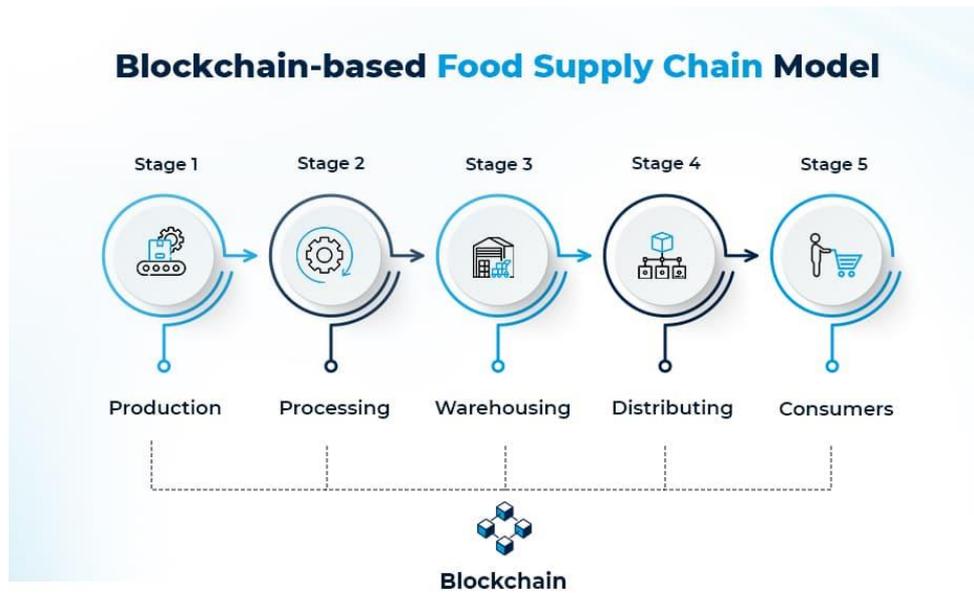


Figure 1: Blockchain-based food supply chain model

Real World Assets (RWAs) can be applied to blockchain for factory supply chains, offering benefits like increased transparency, efficiency, and security. Tokenizing physical assets, such as raw materials or finished products, allows for digital representation on the blockchain, enabling features like tracking, ownership transfer, and even fractional ownership. This can streamline processes, reduce fraud, and improve overall supply chain management.

- **Tokenization:**

Physical assets are converted into digital tokens on a blockchain, representing ownership or other rights.

- **Supply Chain Tracking:**

These tokens can be used to track the movement of goods, from origin to destination, providing real-time visibility and traceability.

- **Smart Contracts:**

Smart contracts, self-executing agreements on the blockchain, can automate tasks like payment processing or inventory management upon fulfillment of predefined conditions.

- **Decentralized Finance (DeFi):**

Tokenized assets can be used as collateral in DeFi platforms, unlocking new financing options for supply chain participants.

B. Benefit of Blockchain-based food supply chain model

Real World Assets (RWAs) with a blockchain-based food supply chain model provide significant advantages, including enhanced transparency, improved efficiency, and bolstered security, as demonstrated below:

- **Food Traceability**

The development of blockchain technology for the food supply chain represents a groundbreaking method for achieving comprehensive traceability throughout the system. This distributed ledger technology enables users to monitor the journey of food items from farm to table, providing access to critical information such as product origins, production methods, transportation, and storage conditions. Enhanced traceability mitigates the risks of food fraud and recalls while improving overall food safety and quality.

- **Transparency**

Food supply chain Blockchain solutions provide a shared record of all transactions. Hence, it increases transparency in the supply chain and bolsters trust among different parties, such as farmers, processors, wholesalers, retailers, and

consumers. Anyone with permission can verify the information about a product on this shared ledger. The transparency in the food supply chain also helps identify and address the issues related to food quality, safety, and sustainability.

- **Improved Inventory Management**

The role of food supply chain Blockchain solutions can also be observed in improving inventory management. It enables real-time tracking of food products throughout the supply chain and allows stakeholders to easily predict demand and reduce waste. It also helps reduce several common issues, such as double-counting or underestimating inventory levels.

- **Supply Chain Efficiency**

Blockchain development for the food supply chain helps streamline various processes. It reduces the time required for manual record-keeping and data sharing. Additionally, it eliminates the need for brokers, distributors, or other intermediaries in the food supply chain, reducing the cost and bringing maximum efficiency as transactions can be done in a faster and secure manner.

- **Better Compliance with Regulations**

Blockchain technology provides immutable records and data that are easily accessible for audits and inspections, helping organizations comply with various regulatory requirements. Furthermore, this technology ensures that sensitive data, such as compliance and quality reports, is stored securely and is readily accessible to authorized parties.

C. Challenges and Considerations:

In a blockchain-based food supply chain model, Real World Assets (RWAs) play a crucial role by representing the physical components of the supply chain that are managed and tracked through advanced digital technology. The challenges and considerations are the main concern in the case study.

- **Initial Investment:**

Implementing IoT devices and integrating data into the blockchain system requires significant upfront investment.

- **Security Concerns:**

Ensuring the security of the blockchain is crucial to protect high-value RWAs from potential breaches.

- **Adoption and Collaboration:**

All stakeholders must adopt the same blockchain platform and standards, which may require overcoming existing silos and resistance to change.

Hence, integrating RWAs with a blockchain-based food supply chain model leverages physical assets with digital technology to enhance traceability, transparency, efficiency, and compliance. Successful implementation demands careful planning, technological investment, and collaborative efforts among all stakeholders.

IV. FORMULATION OF REAL-WORLD ASSETS IN A BLOCKCHAIN-BASED FOOD SUPPLY CHAIN MODEL

Each RWA is assigned a unique identifier that links it to its physical counterpart. This ensures traceability and uniqueness within the blockchain system.

- **Integration Process:**

RWAs are registered onto the blockchain through standardized methods to ensure interoperability. This involves encoding asset details into digital records stored on the decentralized ledger.

- **Updates and Changes:**

Transactions involving RWAs, such as location changes or status updates, are recorded either manually by supply chain participants or automatically via IoT devices feeding data into the blockchain.

- **Middleware and Tools:**

Specific platforms and tools are used to bridge the gap between physical assets and digital records. These middleware solutions facilitate seamless integration and help manage potential bottlenecks.

- Security Measures:

Security is paramount, with encryption techniques and multi-party consensus mechanisms in place to protect RWA records from unauthorized access or tampering.

- Scalability Considerations:

The blockchain architecture is designed to handle increased data volume and transaction frequency efficiently, ensuring performance remains robust as more RWAs are integrated.

- Real-World Applications:

Case studies and examples of successful RWA integration into blockchain-based supply chains provide valuable insights and best practices for others looking to adopt similar systems.

The formulation of RWAs in a blockchain-based food supply chain involves creating unique digital identifiers, integrating assets through standardized methods, managing updates with secure mechanisms, utilizing middleware tools, ensuring scalability, and learning from real-world applications. This comprehensive approach ensures that physical assets are effectively managed and tracked within a secure and efficient digital framework.

Referred to the source from the RWAs' solution provider, the Kaleido company, the RWAs' platform can provide the blockchain technology to the RWAs platform to build a blockchain network, communication bridge and node for exchanging the token of supply chain among customer, manufacturer and distributor.

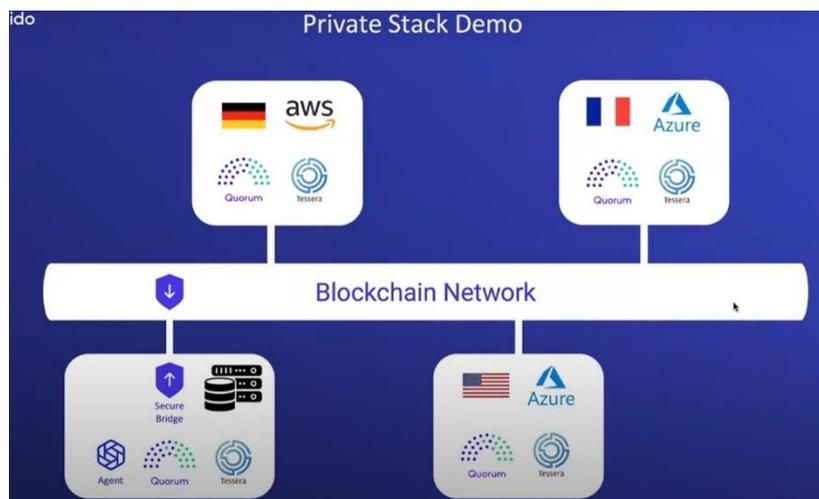


Figure 2 The private stack demonstration of the blockchain network schematic diagram

The system offers a comprehensive SaaS platform, as illustrated in Fig. 2, that is hybrid-enabled and designed to streamline the creation of consortia and the deployment of private blockchain networks. This service features a "permissioned" version of the Ethereum protocol, where member participants operate under authenticated identities supported by digital certificate chains. The trust and transparency provided by the platform maximize transaction finality and speed through the use of efficient consensus algorithms that are typically unavailable in public or anonymous blockchains. Users can configure environments to utilize one of three consensus algorithms: Proof of Authority, Raft, or Istanbul BFT; it also supports both public and private transactions through the Quorum client and its associated Tessera module. This flexibility in protocol and transaction classes is particularly advantageous for enterprise operations, where not all participants may be fully trusted and certain data must be kept confidential within the broader network.

Diverse business networks bring their pre-existing investments in cloud, IT structures, operating preferences and data residency requirements. Decentralized ownership of the network across clouds, regions, and companies' private nodes is a foundational enterprise blockchain requirement. The platform offers hybrid deployment to uniquely fill this need, providing a truly integrated and seamless experience across Amazon Web Services, Microsoft Azure, and on-premises data centers that enable borderless blockchain for an accelerated pace of adoption by global networks. Start on your cloud of choice and expand the user network seamlessly and securely with a single experience across leading cloud providers and geographic regions.

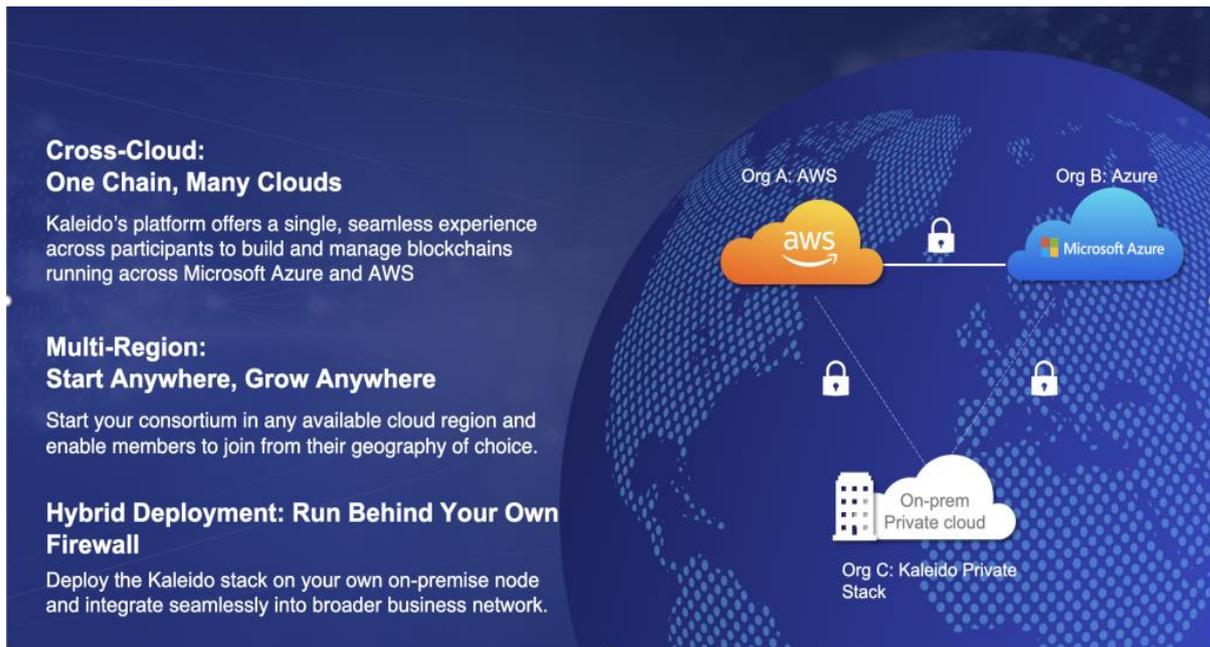


Figure 3 The Borderless Blockchain schematic diagram

The borderless blockchain depicted in Fig. 3 has opted for the cloud as its hosting solution, specifically within the AWS cloud infrastructure. Each region consists of three underlying availability zones designed for fully-managed high availability, disaster recovery, synchronized file system replication, and proactive auto-scaling. For this study, the AWS cloud encompasses the following regions.

1. US-East-2 (Ohio)
2. EU-Central-1 (Frankfurt)
3. AP-Southeast-2 (Sydney)
4. AP-Northeast-2 (Seoul)

In addition to the AWS cloud, Microsoft Azure offers hosting regions within its cloud infrastructure. Each region comprises three underlying availability zones, ensuring fully managed high availability, disaster recovery, synchronized file system replication, and proactive auto-scaling. For this study, the Microsoft Azure cloud is hosted in the following regions.

1. West-US-2 (Washington)
2. NEW France-Central (Paris)

Once the cloud network was chosen for implementation, the platform was designed to provide the choice and flexibility that modern business networks require. With simple click-button functionality, you can easily select from protocols like Ethereum, Hyperledger Fabric, and Corda.

Clients have the option to choose from Geth, Quorum, or Hyperledger Besu node clients, along with consensus algorithms such as Clique PoA, Raft, or Istanbul BFT, allowing for various levels of privacy and performance.

The business network simplifies the process for members, enabling them to select the cloud provider and deployment option that best aligns with their needs. This facilitates seamless participation among supply chain partners, including customers, distributors, manufacturers, and agencies.

Enterprise decentralized applications (DApps) feature a fundamentally different architecture and design compared to traditional applications. At their core, they utilize a shared ledger through blockchain technology, enabling communication both on-chain and off-chain among multiple participants. This orchestration supports end-to-end business transactions while capturing certain data as immutable proofs, as illustrated in Fig. 4 of the full-stack blockchain for a modern business network.

Full-Stack Blockchain for the Modern Business Network

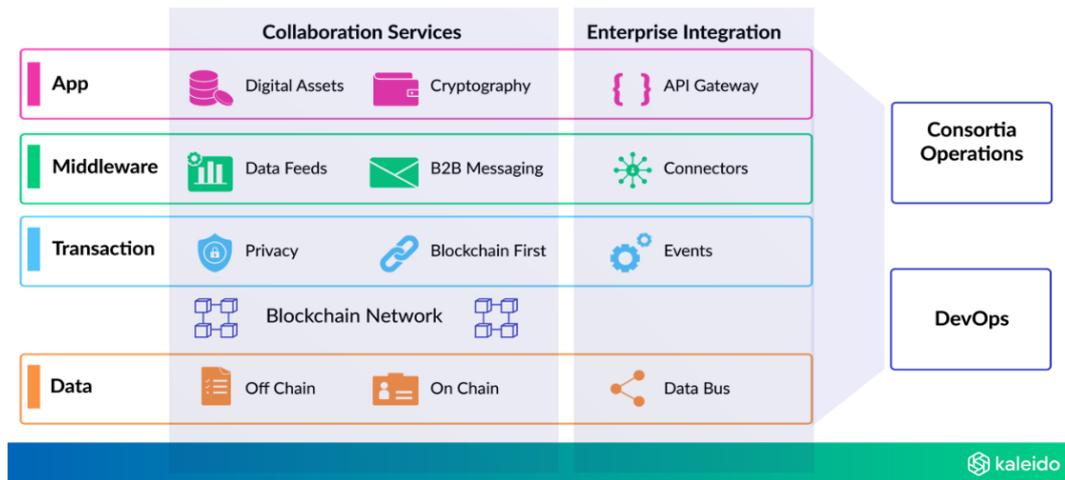


Figure 4 Full-Stack Blockchain for the Modern Business Network diagram

The application is built on fundamental Blockchain programming concepts, such as 'tokens,' which are used to link assets and data from external systems to a unique 'hash' on the blockchain. Actions and data are tied to organizational identities, and in some cases, these identities are masked for privacy. However, they can still be traced back to real business entities that are granted permission to access the business network.

Additionally, there is a business-to-business application stack that has been developed based on extensive experience in implementing modern business networks. This stack provides a comprehensive suite of tools that enterprises need to fully harness the potential of Blockchain for their specific use cases.

Digital asset tokenization has recently gained popularity in the enterprise blockchain space. The term "token" is no longer limited to the concepts associated with public chain-based cryptocurrencies and Initial Coin Offerings (ICOs). Due to their clearly defined attributes and lifecycle, tokens simplify the management and exchange of digital assets among parties in a shared business network.

The fundamental concept of tokens is fungibility, which can be loosely defined as "being exchangeable." Currency, for example, is a fungible asset class because all U.S. dollar bills hold the same value; you do not need a specific dollar bill to realize that value. Conversely, a real commodity is classified as a non-fungible asset class because each part is unique. Even if two machineries have identical designs, their values can differ significantly based on location.

Typical features of a token include:

1. Ownership: Identifies who owns a particular token (non-fungible) or the amount of tokens (fungible).
2. Transfer: Allows digital assets to be traded.
3. Minting: Enables the creation of new tokens for circulation.
4. Burning: Owners can "burn" tokens, particularly in cross-chain trades. Tokens are burned on the sender's chain and minted on the receiver's chain since they cannot transfer directly across chains.
5. Custody: Owners can authorize certain accounts to manage a portion of their tokens. In scenarios involving an escrow, the escrow account can be approved by the token's owner as a custodian.

The simplicity of tokens also permits the use of advanced cryptographic techniques such as zero-knowledge proofs and homomorphic hashes to enhance privacy.

The Ethereum community is recommended significant advancements in token contract design to support various use case scenarios, ranging from fungible to non-fungible and partially fungible token specifications. This has resulted in a diverse array of token contracts that meet real-world requirements.

The Ethereum protocol has distinct advantages regarding tokens. Smart contracts on Ethereum can serve as mutually trusted escrow, making it easier to implement scenarios where token trades must be facilitated by a trusted third party. Many decentralised exchange services leverage this capability. It also plays a crucial role in popular techniques, such as Atomic Swaps, which use Hashed Timelock Contracts to facilitate token trades between different token contracts on the same blockchain or across different blockchains.

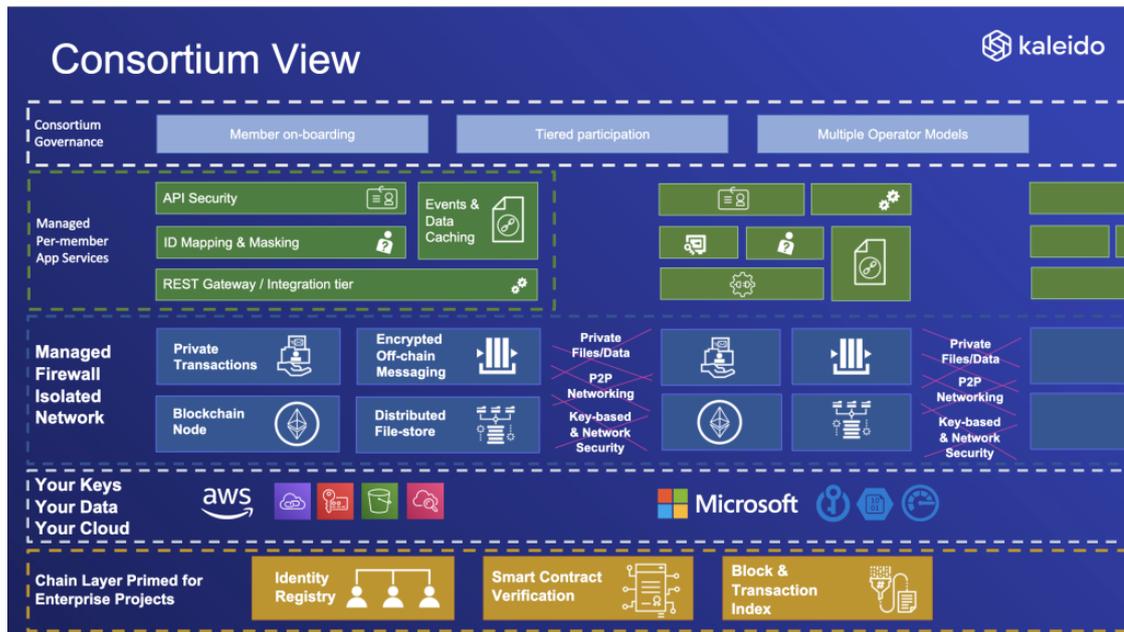


Figure 5 Decentralization model diagram

In the decentralization model of Fig. 5, the need for secure, efficient, and scalable systems has never been more critical. The advent of blockchain technology offers a transformative solution, particularly for supply chain management, where transparency and trust are paramount. This essay explores a comprehensive blockchain platform designed to address these needs, highlighting its features and their significance in enhancing operational efficiency.

The importance of secure and efficient systems in modern business operations cannot be overstated. Supply chains, in particular, require robust infrastructure to ensure smooth operations, maintain security, and enhance transparency. Blockchain technology presents an innovative solution by offering a decentralized, transparent, and tamper-proof ledger system. This essay delves into the features of a blockchain platform tailored for supply chain management, discussing how it revolutionizes traditional methods.

One of the standout features of this platform is its simplified email-based member on-boarding process. By allowing members to join using just their email, the system ensures ease of access while maintaining security through configurable permissions. This flexibility enables organizations to set up different levels of access based on roles or needs, ensuring that sensitive information remains protected.

The platform offers a choice between centralized and decentralized consortium models. In the centralized model, a single organization owns and operates network resources, providing a straightforward structure for smaller entities. Conversely, the decentralized model allows shared ownership across multiple entities, making it ideal for larger consortia where collaboration is key. This flexibility accommodates diverse organizational structures and needs.

Another notable feature is the ability to have organizations with different tiered subscriptions coexist within the same consortium. This setup ensures that businesses of varying sizes and requirements can operate under one umbrella without conflicts, promoting inclusivity and scalability.

Member services such as REST Gateway resources, HD wallets, and IPFS nodes are secured with basic authentication credentials. These services are controlled unilaterally by the owning member, ensuring that each organization maintains control over its assets and data.

The platform supports hosting multiple blockchain networks within a single consortium, each isolated by firewalls to prevent cross chatter or data leakage. This feature is crucial for organizations requiring separate environments for different operations, ensuring security and preventing unauthorized access.

Utilizing Quorum and Hyperledger Besu clients, the platform supports private transactions with state information stored in a separate Patricia state trie. This ensures that non-privy participants cannot decrypt transaction payloads, maintaining privacy and confidentiality for sensitive operations.

The system facilitates secure app-to-app communication through asymmetrically encrypted payloads sent via the Kaleido backbone. Outbound messages are encrypted using the recipient's digital certificate, ensuring that only the intended party can access the information.

Nodes, services, and security credentials are confined to their respective environments, enhancing security by preventing unauthorized access across different networks within the consortium.

Optional integrations with native cloud services such as Key Management Stores and Backup utilities provide added flexibility and convenience. These integrations enhance data security and operational efficiency, making the platform more robust and user-friendly.

Each organization's identity is securely tied to the blockchain through digital certificates managed by a registry service. This ensures authenticity and trust within the network, crucial for maintaining integrity in transactions and operations.

The block explorer tool allows detailed examination of transactions, blocks, and smart contracts, with support for source code verification. This feature is essential for auditing and ensuring that all activities on the blockchain are transparent and functioning as intended.

This comprehensive blockchain platform in RWAs offers a cutting-edge solution for supply chain management by providing flexibility, security, and scalability. Its features, such as simplified member on-boarding, configurable permissions, centralized and decentralized consortium options, and private transaction support, address common challenges in traditional supply chains. By enhancing transparency, efficiency, and trust among stakeholders, this platform represents the future of secure and efficient business operations.

V. CONCLUSION

The Application of Real World Assets in a Blockchain-Based Food Supply Chain has applied the blockchain technology has emerged as a transformative force across various industries, particularly in supply chain management. In the food industry of this case study, where transparency and traceability are paramount, blockchain offers a robust solution to enhance efficiency and trust among stakeholders. This essay explores how Real World Assets (RWAs) are integrated into a blockchain-based food supply chain model, highlighting its benefits, challenges, and the technical infrastructure supporting it.

Real World Assets (RWAs) in the Blockchain-Based Food Supply Chain have defined the role of RWAs. In the context of a blockchain-based food supply chain, Real World Assets refer to physical items such as raw materials, finished products, or even specific processes within the supply chain. These assets are represented digitally on the blockchain, allowing for seamless tracking and management throughout the production and distribution phases.

The benefits and challenges of RWAs in the Blockchain-Based Food Supply Chain are shown in detail above. The integration of Real World Assets into a blockchain-based food supply chain model offers significant advantages, including enhanced traceability, transparency, efficiency, and compliance. However, challenges such as initial investment costs, security risks, and adoption barriers must be addressed to fully realize these benefits. The robust technical infrastructure supporting this model, encompassing secure onboarding processes, flexible consortium structures, private transactions, encrypted messaging, cloud integrations, identity management, and advanced block explorer tools, lays a solid foundation for its successful implementation.

In the applied research case of the food industry continues to evolve, embracing blockchain technology with RWAs can lead to more transparent, efficient, and secure supply chains, ultimately benefiting all stakeholders from producers to consumers.

Thanks for the source of documentation and application from Kaleido Solution Inc.

REFERENCES

- [1] Kamble, S. S., Gunasekaran, A., & Gawankar, S. (2020). Industry 4.0 and the Future of Supply Chain Management: A Review of the Literature. *International Journal of Production Research*, 59, 5119-5140
- [2] Kayapinar Kaya, Sema & Paksoy, Turan & Garza-Reyes, Jose Arturo. (2020). The Impact of the Internet of Things on Supply Chain 4.0. 10.1201/9780429327636-6. <https://doi.org/10.1201/9780429327636-6>
- [3] Kong, R. W. M., Liu, M., & Kong, T. H. T. (2024). Design and Experimental Study of Vacuum Suction Grabbing Technology to Grasp a Fabric Piece. *OALib Journal*, 11, 1-17. Article e12292. <https://doi.org/10.4236/oalib.1112292>
- [4] Kong, R. W. M., Kong, T. H. T., & Huang, T. (2024). Lean Methodology For Garment Modernization. *INTERNATIONAL JOURNAL OF ENGINEERING DEVELOPMENT AND RESEARCH*, 12(4), 14-29. Article IJEDR2404002. <http://doi.one/10.1729/Journal.41971>
- [5] Kong, R. W. M., Kong, T. H. T., Yi, M., & Zhang, Z. (2024). Design a New Pulling Gear for the Automated Pant Bottom Hem Sewing Machine. *International Research Journal of Modernization in Engineering Technology and Science*, 06(11), 3067-3077. <https://doi.org/10.56726/IRJMETS64156>
- [6] Kong, R. W. M., Ning, D., & Kong, T. H. T. (2025). Mixed-Integer Linear Programming (MILP) for Garment Line Balancing. *International Journal of Scientific Research and Modern Technology (IJSRMT)*, 4(2), 64-77. <https://doi.org/10.5281/zenodo.14942910>
- [7] Kong, R. W. M., Ning, D., & Kong, T. H. T. (2025). Innovative Line Balancing for the Aluminium Melting Process. *International Journal of Mechanical and Industrial Technology*, 12(2), 73-84. <https://doi.org/10.5281/zenodo.15050721>
- [8] Prof. Dr. Ray Wai Man Kong, Ding Ning, & Theodore Ho Tin Kong. (2025). Innovative Line Balancing for the Aluminium Melting Process. *International Journal of Mechanical and Industrial Technology*, 12(2), 73–84. <https://doi.org/10.5281/zenodo.15050721>
- [9] Kong, R. W. M., Ning, D., & Kong, T. H. T. (2025). Line Balancing in the Modern Garment Industry. *International Journal of Mechanical and Industrial Technology*, 12(2), 60-72. <https://doi.org/10.5281/zenodo.14800724>
- [10] Kong, R. W. M., Ning, D., & Kong, T. H. T. (2025). Innovative Vacuum Suction-grabbing Technology for Garment Automation. In K. M. Batoo (Ed.), *Science and Technology: Developments and Applications* (Vol. 6, pp. 148-170). BP International. <https://doi.org/10.9734/bpi/stda/v6/4600>
- [11] Kong, R. W. M. (2025). INNOVATIVE AUTOMATED STRETCH ELASTIC WAISTBAND SEWING MACHINE FOR GARMENT MANUFACTURING. *International Research Journal of Modernization in Engineering Technology and Science*, 7(3), 7347-7359. <https://doi.org/10.56726/IRJMETS70275>
- [12] Kong, R. W. M., Ning, D., & Kong, T. H. T. (2025). AI Intelligent learning for Manufacturing Automation. *International Journal of Mechanical and Industrial Technology*, 13(1), 1-9. <https://doi.org/10.5281/zenodo.15159741>
- [13] Ray Wai Man Kong, Ding Ning, & Theodore Ho Tin Kong. (2025). AI Intelligent learning for Manufacturing Automation. *International Journal of Mechanical and Industrial Technology*, 13(1), 1–9. <https://doi.org/10.5281/zenodo.15159741>
- [14] Kong, R. W. M. (2025). AI Magnetic Levitation (Maglev) Conveyor for Automated Assembly Production. *International Journal of Mechanical and Industrial Technology*, 13(1), 19-30. <https://doi.org/10.5281/zenodo.15599657>
- [15] Kong, R. W. M. (2025). Woven Air Permeability Textile Fabric for Garment Automation. *International Journal of Mechanical and Industrial Technology*, 13(1), 31-45. <https://doi.org/10.5281/zenodo.15806556>
- [16] Kong, R. W. M. (2025). Innovative Technology Strategy in Hong Kong and China of the Asia Industries. *International Journal of Social Science and Humanities Research*, 13(3), 103-116. <https://doi.org/10.5281/zenodo.15911676>
- [17] Kong, R. W. M. (2025). Automated Seam Folding and Sewing Machine on Pleated Pants for Apparel Manufacturing. *International Journal of Mechanical and Industrial Technology*, 13(1), 58-70. <https://doi.org/10.5281/zenodo.16607787>

- [18] Maher A.N. Agi, Ashish Kumar Jha (2022). Blockchain technology in the supply chain: An integrated theoretical perspective of organizational adoption, *International Journal of Production Economics*, Volume 247, 2022, 108458, ISSN 0925-5273, <https://doi.org/10.1016/j.ijpe.2022.108458>
- [19] J.T. Mentzer, W. DeWitt, J.S. Keebler, S. Min, N.W. Nix, C.D. Smith, Z.G. Zacharia (2001). Defining supply chain management, *Journal of Business Logistics*, 22 (2) (2001), pp. 1-25, <https://doi.org/10.1002/j.2158-1592.2001.tb00001.x>
- [20] A. Gunasekaran, C. Patel, E. Tirtiroglu (2001). Performance measures and metrics in a supply chain environment, *International Journal of Operations Production Management*, 21 (1/2) (2001), pp. 71-87, <https://doi.org/10.1108/01443570110358468>
- [21] V. Babich, G. Hilary (2020). Distributed ledgers and operations: what operations management researchers should know about blockchain technology, *Manufacturing Service Operation Management*, 22 (2) (2020), pp. 223-240, <https://doi.org/10.1287/msom.2018.0752>
- [22] Casey, M. J., & Wong, P. (2017). Global supply chains are about to get better, thanks to blockchain. *Harvard Business Review*, 13(3), 2018. <https://hbr.org/2017/03/global-supply-chains-are-about-to-get-better-thanks-to-blockchain>