

Trusted Industrial Infrastructure: An Efficient and Secure Consortium Blockchain System



南京理工大学
NANJING UNIVERSITY OF SCIENCE & TECHNOLOGY

Pengcheng Xia, Jun Li, Hansen Zhong, Huaxin Xu, Jin Ma, Jingyu Wu, and Long Shi

School of Electrical and Optical Engineering, Nanjing University of Science and Technology, Nanjing 210094, China

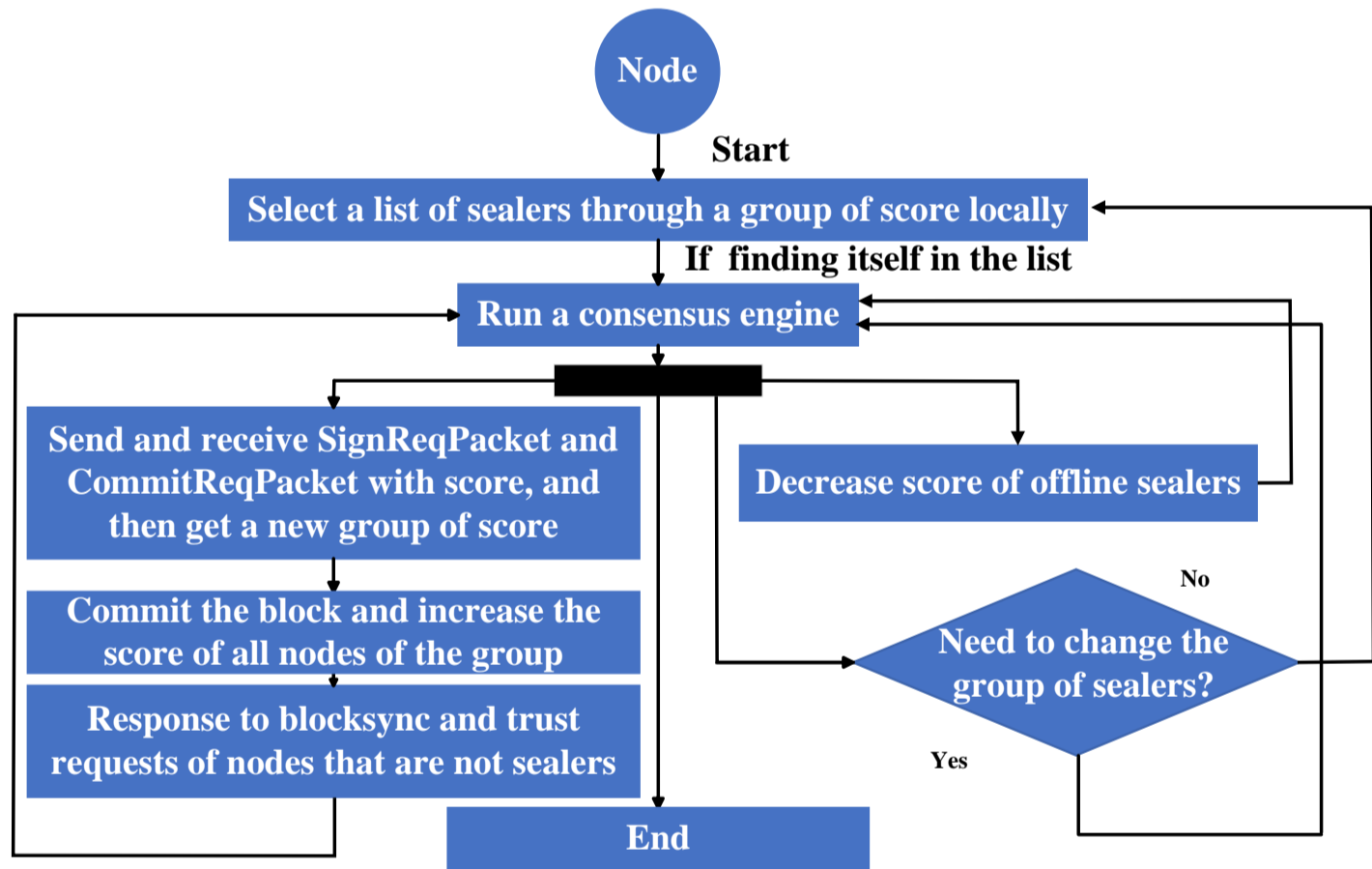
Background and Aim

As the demand for data circulation and sharing between enterprises in the industrial production process has boosted, blockchain technology has been extensively applied. However, traditional blockchain systems have shown limitations in several aspects.

- Traditional consensus algorithms (e.g., POW, PBFT) have low throughput and high transaction processing latency, and cannot meet the application requirements of industrial data transaction scenarios.
- Industrial data comes in various types (e.g., images, videos, time series data), and there is a lack of a unified smart contract application framework to support on-chain data storage.
- Traditional smart contract execution methods lack security and consistency.
- Efficient application modes for blockchain systems in industrial data circulation scenarios have not been effectively developed.

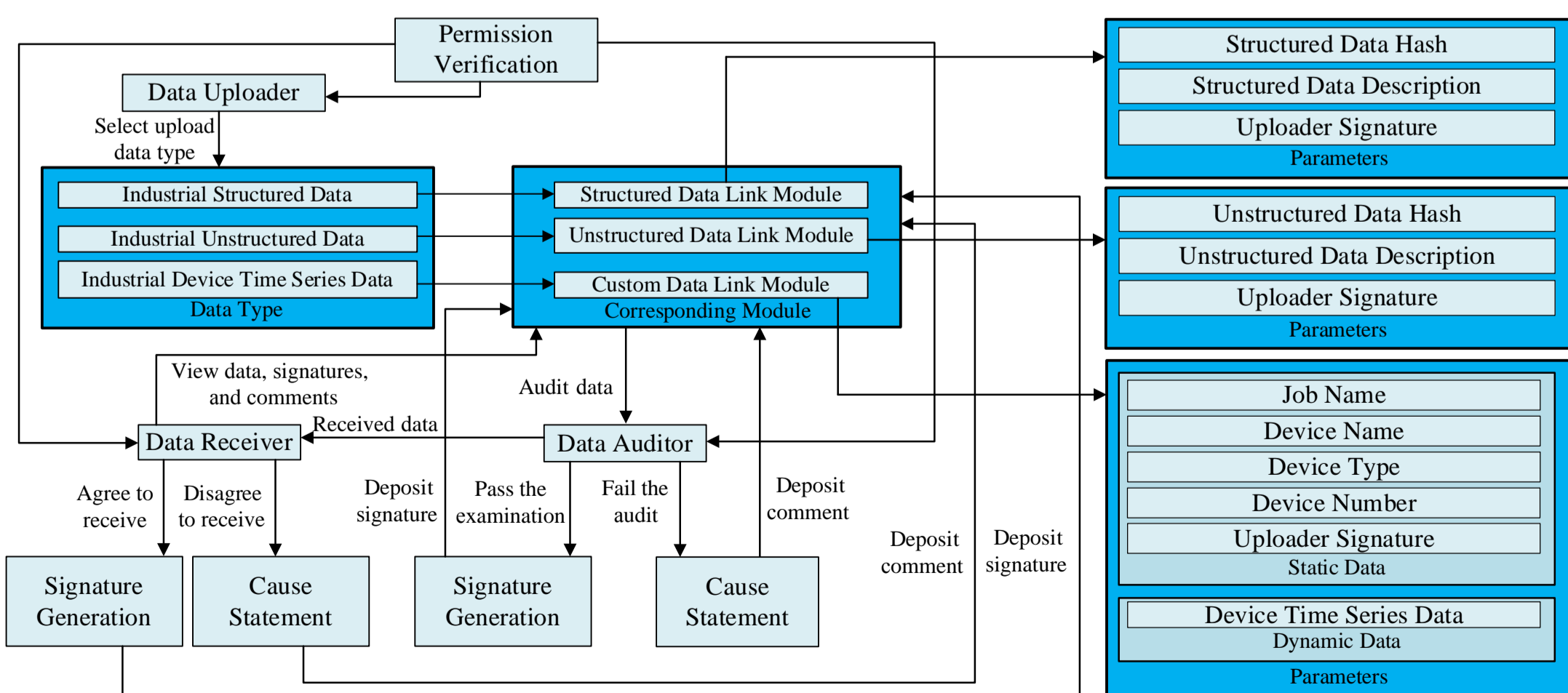
In this work, we develop an efficient and secure industrial consortium blockchain (ICB) system to provide trusted infrastructure services for cooperative transactions and data interactions among industrial enterprises.

Reputation-aided Lightweight Consensus Algorithm



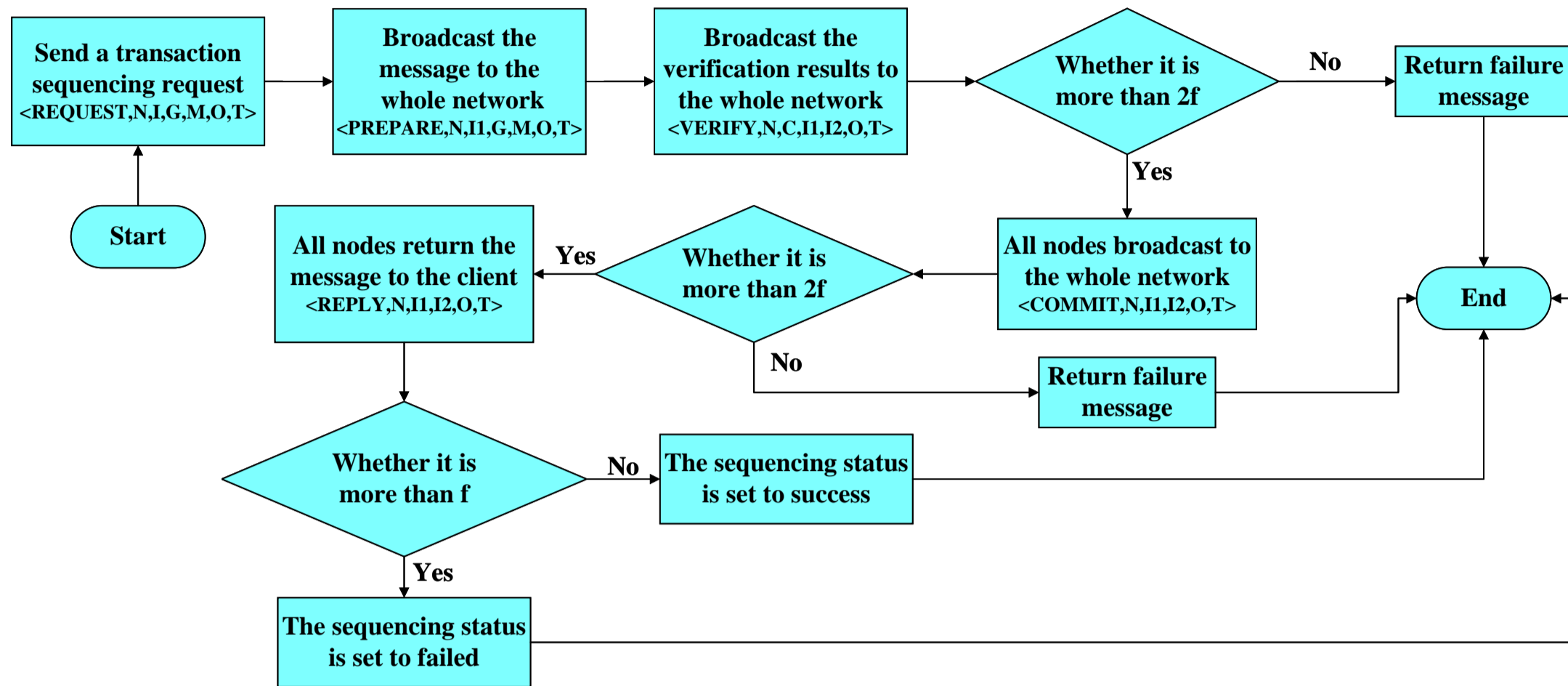
- Adding a reputation mechanism to PBFT;
- Improving throughput and reducing latency by decreasing sealers;
- Increasing or decreasing node reputation value through receiving messages and detecting offline status;
- Synchronizing the reputation value by backup nodes after synchronizing blocks.

An Industrial Data Trusted Storage Framework



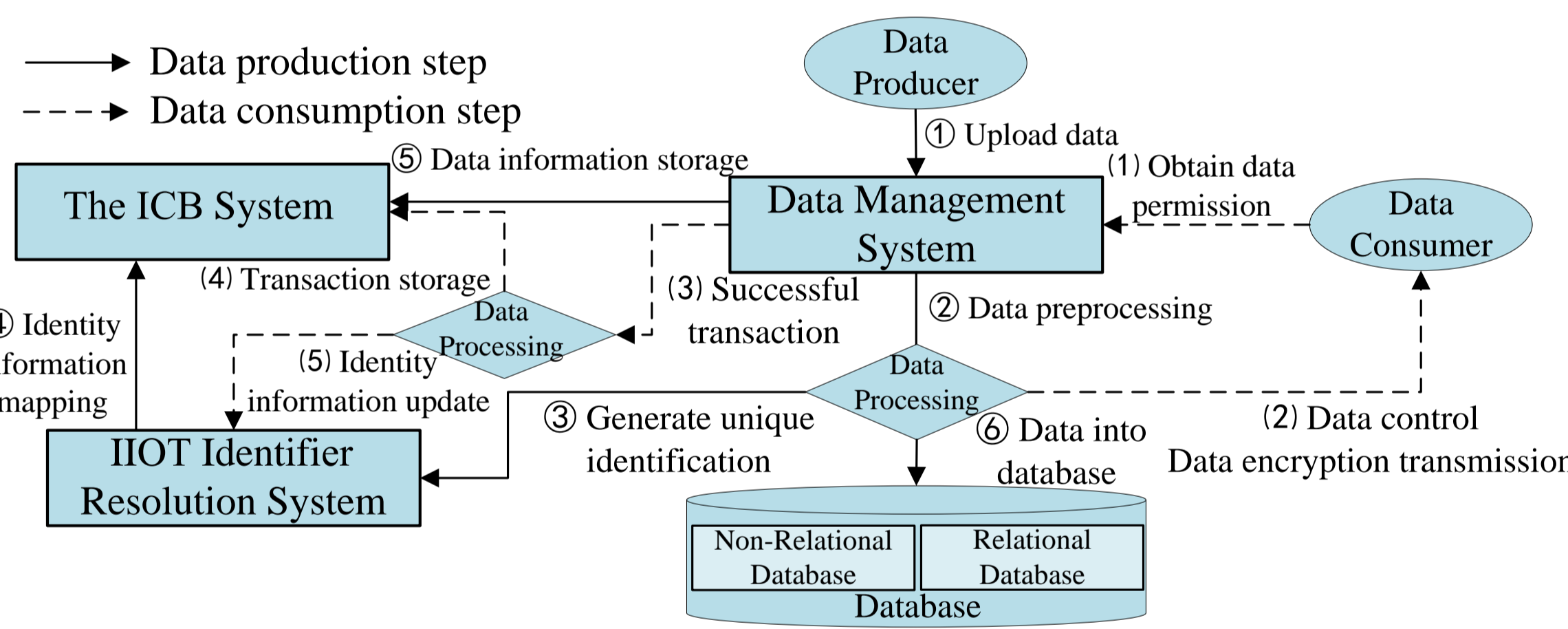
- The framework supports various types of industrial data, including time-series data, text, images, videos, etc.
- The framework provides a unified paradigm for trusted storage of industrial data based on smart contracts.

Transaction Sequencing Algorithm for Smart Contracts



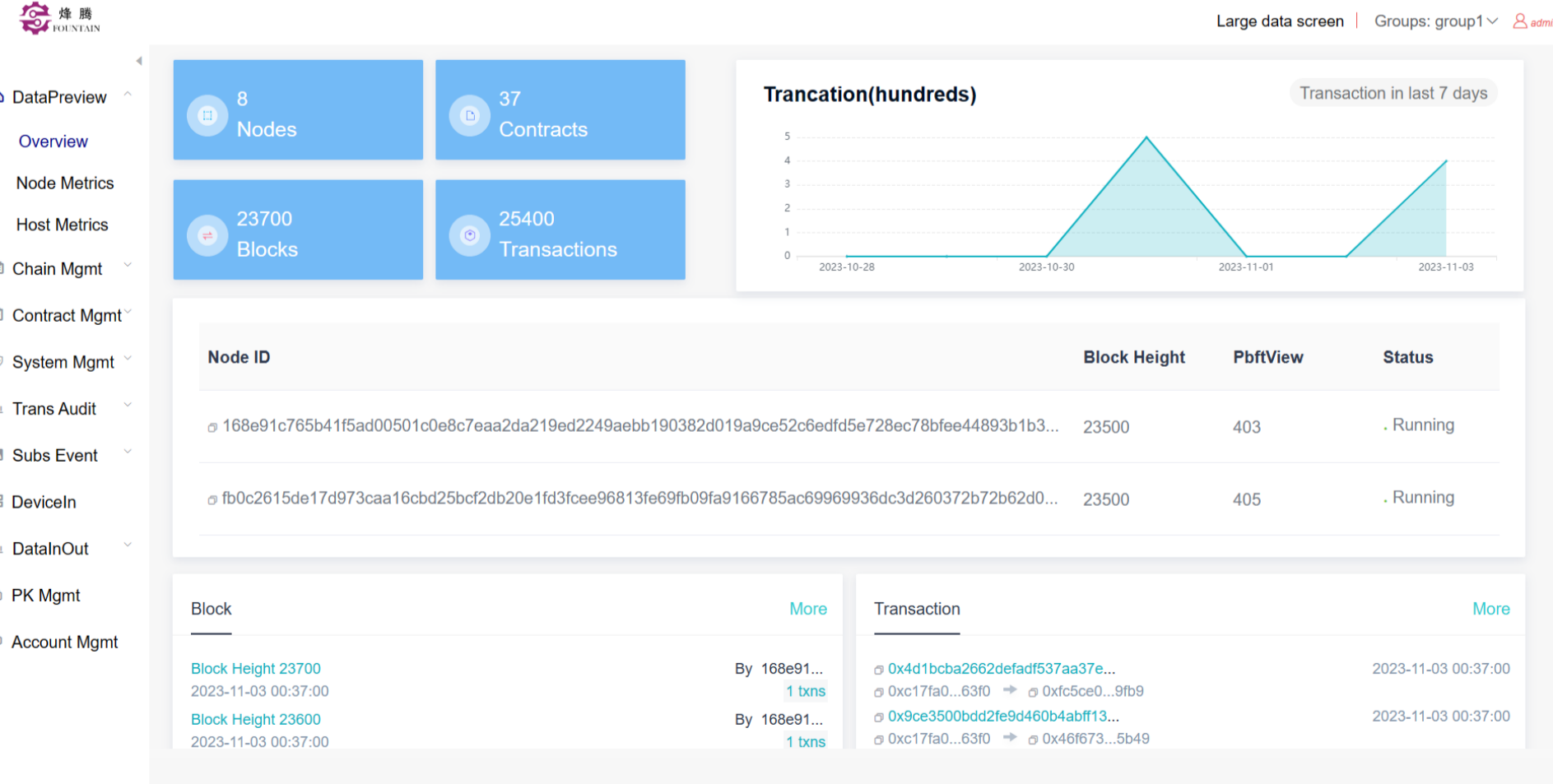
- The algorithm is used for the execution sequencing of smart contracts and consists of five stages: Request, Preparation, Validation, Submission, and Response.
- The algorithm ensures the consistency and security of smart contract execution in industrial application scenarios.

Application Architecture for Industrial Data Circulation



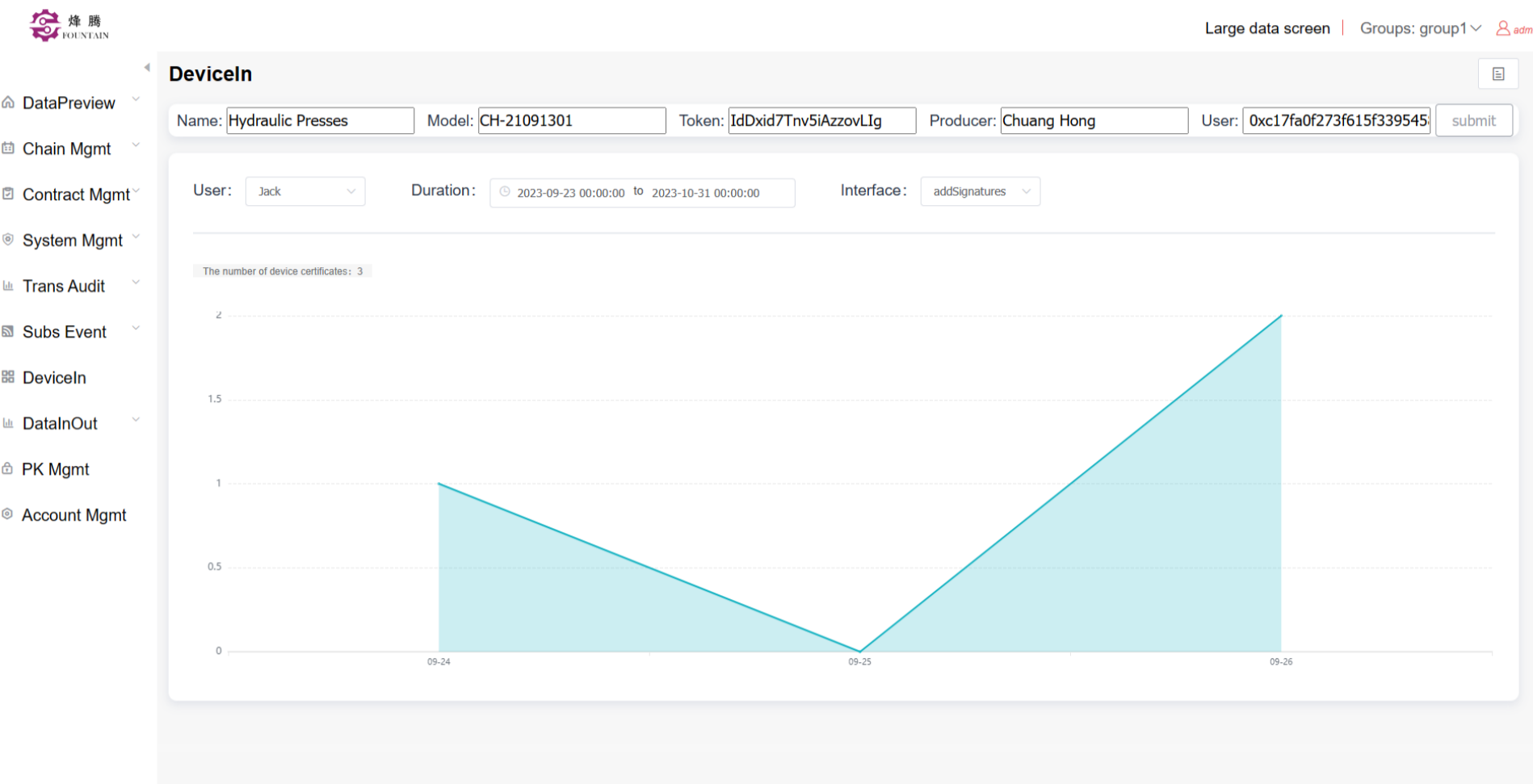
- *The ICB System*: Providing services of data circulation smart contracts, identifier data evidence storage, and trusted storage of transaction data.
- *IIOT Identifier Resolution System*: Providing identifier/resolution services for industrial resources.
- *Data Management System*: Providing services for industrial data storage, transmission, and erasure.

Industrial BaaS Platform for Consortium Blockchain



The BaaS platform of the ICB system provides a visual operation interface service for industrial enterprise users. The platform has functions such as node management, chain monitoring, and smart contract management, and also provides industrial-related blockchain application services.

Trusted Access for Industrial Equipment



The BaaS platform enables trusted access and management of industrial equipment. Additionally, the platform provides services such as trusted storage of industrial data, trusted auditing of industrial transaction orders, and alert subscriptions.

Performance Evaluation

Utilizing the proposed lightweight consensus algorithm, the ICB system exhibits significantly improved throughput and reduced transaction processing latency compared to traditional blockchain systems. Moreover, its performance remains consistently stable even with an increase in the number of nodes.

The ICB system was subjected to high-concurrency stress tests under conditions with 4 nodes and 16 nodes. The test results are presented in the table below.

Number of nodes	Throughput (tx/s)	Transaction latency (ms)	Transaction success rate (%)
4	14604	59.63	99.98
16	13471	64.13	99.98

Consistency: Based on the proposed smart contract execution sequencing algorithm, the ICB system can ensure that each node executes all transactions in the correct and identical order, thereby guaranteeing data consistency within the system.

Security: The ICB system can avoid issues caused by abnormal smart contract execution, thus enhancing the security and stability of the system.

Application Prospects

The system can also be applied in the following areas:

- *Supply chain management*: Ensuring the traceability and transparency of supply chain data, and enhancing the efficiency and reliability of the supply chain.
- *Industrial resources trading*: Providing trusted data storage for trade orders and financial transactions, allowing swift auditing in the event of transaction disputes.
- *Distributed manufacturing*: Achieving trusted and consistent sharing of production-related data, and monitoring the entire lifecycle of industrial products.

In the future, we will delve into exploring the cross-chain interoperability of this system with various blockchain systems to adapt to more application scenarios.