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An Interoperable Management Information System for Real-Time Payment Intelligence, Merchandise Planning, and Distributed Workforce Coordination

Fahim Bin Nasir[1]*, Md Abul Kashem[2], Md. Rahimul Islam[3], Nakshi Das[4]

[1]School of Physics and Mechanics, Wuhan University of Technology, Wuhan, Hubei, China
[2]Hydrogen Technology, Campus Burghausen, Rosenheim Technical University of Applied Sciences (Rosenheim), 84489 Burghausen, Germany
[3]Department of Physics, Riphah International University, Islamabad, Pakistan

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***Corresponding author:** Fahim Bin Nasir
School of Physics and Mechanics, Wuhan University of Technology, Wuhan, Hubei, China

Abstract

This study proposes an interoperable Management Information System (MIS) that integrates real-time payment intelligence, merchandise planning, and distributed workforce coordination within a unified enterprise information architecture. The proposed framework addresses fragmentation across payment, retail, inventory, and workforce systems through System, Process, and Experience APIs, supported by Apache Kafka and Apache Flink for real-time event processing. Synthetic financial, retail, and workforce datasets are used to evaluate payment-event processing, fraud aware demand signals, inventory decisions, workforce allocation, operational reliability, and governance. A multi-objective planning model considers processing latency, inventory exposure, workforce imbalance, and operational risk. The experimental results indicate that the proposed MIS achieved 86 ms decision latency, compared with 420 ms for event-driven processing and 1,850 ms for batch coordination. Timely payment event processing reached 97%, inventory response reached 91%, and workforce task response reached 88%. The findings indicate that payment activity can serve as a real-time operational signal for merchandise and workforce decisions when supported by governed interoperability, event processing, and audit controls. The study provides an architecture and evaluation framework for integrated decision intelligence across distributed enterprise operations.

Keywords: Interoperable Management Information System, Real-Time Payment Intelligence, Merchandise Planning, Workforce Coordination, API Interoperability, Payment Fraud Monitoring.

I. INTRODUCTION

Modern enterprises generate payment, retail, inventory, and workforce information at high frequency, yet these data streams often remain within separate operational systems. Real-time account-to-account payments can reveal transaction and demand signals, while merchandise and workforce systems require timely coordination. Existing studies address these domains separately [1-5,16-20]. An interoperable MIS can connect these information flows through governed APIs, event processing, and decision intelligence.

A. Background and Motivation

Retail and payment operations now produce information that can support rapid managerial decisions. Predictive merchandising research connects retail data with demand and planning activities [1], while demand forecasting studies address inventory and delivery decisions [2]. Real-time payment research focuses on transaction speed and fraud monitoring [3], and low-latency architectures target rapid payment processing [4]. These capabilities generate valuable signals, yet payment, merchandise, and workforce information commonly follow different processing paths. The proposed research considers payment velocity, fraud indicators, SKU activity, inventory position, workforce availability, and operational constraints within one MIS. This integrated view provides the foundation for real-time enterprise decision support.

B. Problem Statement

The central problem is the fragmentation of financial, retail, and workforce information across separate systems, interfaces, and decision processes. Existing MIS and enterprise integration studies demonstrate connections among IoT, ERP, cloud, and operational services [5]–[8], [14], [15], but limited attention is given to payment events as direct inputs for merchandise planning and workforce task allocation. Such fragmentation can delay information transfer, produce inconsistent states, and limit cross-domain visibility. A second problem concerns governance: API integration requires consistent schemas, access controls, audit records, and source provenance. Without a coordinated architecture, real-time intelligence may remain isolated within individual enterprise functions.

C. Proposed Solution

This study proposes a layered interoperable MIS that connects payment intelligence, merchandise planning, and distributed workforce coordination. System APIs provide controlled access to domain services, Process APIs coordinate cross-domain workflows, and Experience APIs deliver role-specific information. Kafka supports event ingestion, while Flink processes temporal patterns, transaction velocity, fraud indicators, and operational states. Fraud screening separates suspicious payment activity from demand signals. Validated events then support inventory decisions and workforce task allocation. Synthetic financial, retail, and workforce datasets provide controlled experimental inputs. Multi-objective planning considers latency, inventory exposure, workforce imbalance, and operational risk, while governance services maintain auditability and access control.

D. Contributions

The study makes four main contributions. First, it presents an interoperable MIS architecture that connects real-time payment intelligence with merchandise and workforce information through System, Process, and Experience APIs. Second, it introduces an event-to-task orchestration mechanism in which validated payment activity can influence inventory and workforce decisions. Third, it combines fraud-aware demand signals with multi-objective planning for distributed operational coordination. Fourth, it defines an evaluation framework covering latency, inventory response, workforce coordination, fraud intelligence, governance, auditability, and disruption response. The architecture also uses synthetic datasets to support controlled comparison between batch coordination and real-time cross domain processing.

E. Paper Organization

The remainder of the paper follows a structured research sequence. Section II reviews prior work on retail demand analytics, real-time payment intelligence, enterprise interoperability, workforce coordination, and supply-chain decision support. Section III presents the methodology, including the layered MIS architecture, synthetic datasets, API model, Kafka–Flink event processing, multi-objective planning, event-to-task orchestration, reliability measures, and governance controls. Section IV reports and discusses synthetic experimental results across latency, operational coordination, Pareto trade-offs, and auditability. Section V concludes the study and identifies future research directions involving operational datasets, larger payment streams, advanced fraud and demand models, higher transaction volumes, and distributed connectivity conditions.

Objective of the Study

The objective is to design and evaluate an interoperable MIS that connects real-time payment intelligence, merchandise planning, and distributed workforce coordination through governed APIs, event processing, fraud-aware analytics, and multi-objective decision support.

II. RELATED WORK

Existing studies provide foundations for retail analytics, real-time payment security, enterprise integration, financial risk management, workforce analytics, and supply-chain planning. However, the reviewed literature treats these capabilities as separate information domains. This section organizes prior work around four areas: merchandise intelligence, payment intelligence, interoperable enterprise systems, and workforce support. It identifies the architectural gap motivating the proposed interoperable MIS framework.

A. Retail Demand Analytics and Merchandise Planning

Retail research increasingly connects predictive analytics with merchandising, inventory, and delivery decisions. Matteganta [1] describes an interconnected predictive merchandising ecosystem for retail planning. Chowdhury *et al.,*[2] review demand forecasting approaches for inventory and delivery planning, showing their role in inventory planning. Sany *et al.,*[5] connect ERP and MIS capabilities for apparel planning, while Hossain [10] examines data-driven apparel supply-chain optimization for lead-time and delivery. Hossain [11] further considers sourcing cost negotiation and profitability in fashion. These studies support broader merchandise intelligence across retail operations and decisions, but they do not directly connect retail demand signals with payment events and workforce task allocation through a unified interoperable MIS architecture.

B. Real-Time Payment Intelligence and Fraud Monitoring

Real-time payment research emphasizes transaction speed, fraud detection, and financial risk monitoring. Yeruva [3] examines technologies for combating fraud in instant payment systems, supporting continuous transaction analysis. Makkena [4] focuses on secure ultra-low-latency payment processing and sub-50ms throughput targets. Rahman [9] develops a data-driven financial risk management approach using federated learning and privacy-preserving techniques for distributed financial analytics. Haque [12] examines automation in accounting practices, while Hasan [13] considers AI-supported financial workloads in cloud environments. Bhuiyan [17] extends banking intelligence through customer complaint analytics for risk reduction and consumer protection. These studies support payment intelligence, but do not integrate payment events with merchandise planning and workforce coordination.

C. Interoperable Enterprise Information Systems

Interoperability research demonstrates how management information systems can connect distributed technologies, operational processes, and resources. Rahman [6] examines IoT and MIS integration for last-mile connectivity, while Islam [7] studies IIoT and MIS integration for smart pharmaceutical manufacturing. Musarrat [8] links MIS integration with AI-driven service allocation, showing information systems can support resource decisions. Fahim *et al.,* [14] propose a cloud-IoT platform for infrastructure automation, and Rahman *et al.,* [15] examine cloud-native enterprise resource management across sectors. These studies support distributed enterprise information architectures. However, the reviewed work does not specify a three-layer API governance model connecting payment, merchandise, and workforce information through real-time processing within one MIS.

D. Workforce Coordination, Supply Chains, and Decision Intelligence

Workforce and operational analytics provide additional foundations for decision intelligence. Akter [16] applies KPI-based predictive analytics to workforce productivity, supporting workforce management. Islam [18] examines sales performance evaluation using business analytics, connecting operational information with decisions. Ahmed [19] studies resilient global apparel supply chains and retail distribution stability, while Karim [20] considers strategic supply-chain leadership and human capital optimization. These studies demonstrate the value of operational, workforce, and supply chain information for integrated planning. Nevertheless, the literature does not present a mechanism in which real-time account-to-account payment activity triggers merchandise adjustments and workforce tasks. The proposed MIS addresses this gap through interoperable APIs, event processing, governance, and multi-objective coordination.

III. METHODOLOGY

The methodology presents an interoperable MIS that connects real-time payment intelligence, merchandise planning, and distributed workforce coordination within one information architecture. The research uses synthetic financial, retail, and workforce datasets to test the proposed design under controlled operational scenarios. Layered APIs, event processing, fraud intelligence, demand analysis, multi-objective planning, governance, and reliability evaluation form the main methodological components.

A. Overall Research Design

The research follows six connected stages: synthetic dataset construction, interoperability architecture design, event ingestion, intelligence generation, multi-objective planning, and evaluation. Financial transactions, retail records, inventory states, and workforce information enter the MIS through governed interfaces. Shared timestamps support cross-domain correlation. Kafka distributes events, while Flink processes temporal patterns and operational states. Fraud and demand services generate validated signals for planning. The planning layer considers inventory and workforce constraints simultaneously. Experiments compare the proposed event-driven architecture with batch-oriented coordination under normal operations, payment surges, demand variation, stock pressure, and connectivity interruptions during testing. Performance is assessed through operational and governance metrics.

Figure 1 shows how payment, retail, workforce, and external systems connect through governed APIs, real-time event processing, decision intelligence, operational coordination, and governance.

B. Synthetic Dataset Construction and Data Model

Synthetic financial, retail, and workforce datasets provide controlled inputs without exposing private operational records. Financial records contain transaction ID, timestamp, account or merchant ID, amount, payment channel, status, and fraud indicators. Retail records include SKU, sales quantity, inventory position, location, price, timestamp, and replenishment status. Workforce records contain worker ID, skills, availability, location, workload, and assigned task. Shared SKU, location, and timestamp fields support cross-domain relationships. Scenario generators vary payment velocity, demand intensity, fraud incidence, inventory availability, workforce capacity, and network status. Development, validation, and evaluation scenarios support controlled experiments and reduce information leakage across comparative model configurations during testing.

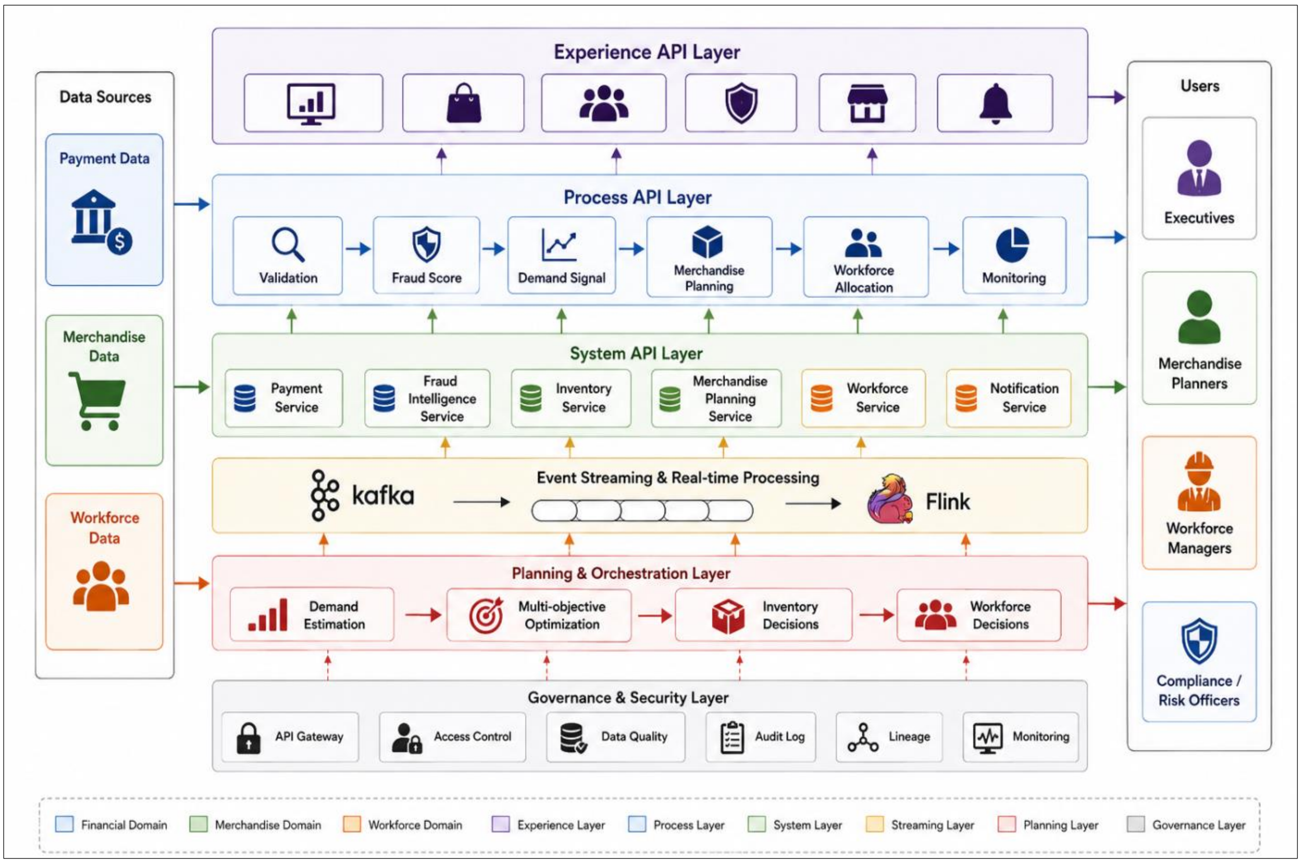

Figure 1: Layered Interoperable MIS Architecture

C. API Interoperability and MIS Architecture

The interoperability model uses System, Process, and Experience APIs to connect payment, retail, workforce, compliance, and decision-support functions. System APIs expose domain services and data access. Process APIs coordinate workflows such as payment validation, demand-signal generation, replenishment assessment, and workforce assignment. Experience APIs provide role-specific information for managers, planners, fraud analysts, and supervisors. API contracts define schemas, authentication, authorization, versioning, error handling, timestamps, and audit fields. A canonical event model maps domain-specific fields into shared identifiers while preserving source provenance. Validation rules check data quality and access permissions before downstream processing. Independent services can change without requiring complete MIS redesign.

D. Real-Time Event Processing and Intelligence Generation

Apache Kafka provides distributed event ingestion and message delivery, while Apache Flink performs stateful stream processing, temporal aggregation, rule evaluation, and feature calculation. Payment events enter Kafka topics according to event type and source. Flink consumes these streams and calculates transaction velocity, temporal patterns, anomaly indicators, and operational features. Merchant, SKU, location, and inventory attributes are connected with payment activity. Fraud analysis filters suspicious transactions before payment-derived demand signals enter planning. Validated events move toward demand, inventory, and workforce services. Processing timestamps are recorded at ingestion, transformation, decision, and execution stages. These records support latency measurement, traceability, and audit analysis.

E. Multi-Objective Merchandise and Workforce Planning

The decision layer combines fraud intelligence, demand estimation, inventory planning, and workforce allocation. Payment velocity provides a demand signal, while fraud analysis limits the influence of suspicious transactions. Inventory planning considers demand, available stock, replenishment capacity, and service requirements. Workforce planning considers task priority, employee skills, availability, location, workload, and service requirements. A simplified demand model is expressed as:

$$D_t = \alpha S_t + \beta P_t$$

where D_t represents estimated demand, St represents observed sales, P_t represents normalized payment velocity, and α and β represent calibrated weights. The planning objective minimizes latency, inventory exposure, workforce imbalance, and operational risk through multi-objective optimization.

F. Event-to-Task Orchestration and Distributed Workforce Coordination

The event-to-task mechanism connects payment activity, merchandise conditions, and workforce requirements. A validated increase in payment activity for a particular SKU or location produces a demand signal. The planning layer evaluates this signal against inventory and workforce states. Resulting decisions can generate replenishment, stock redistribution, worker assignment, reassignment, or task-priority actions. Payment events enter Kafka and move to Flink for temporal processing and state evaluation. Fraud and demand intelligence then inform planning. Governance checks occur before execution. Task completion information returns with subsequent payment and sales outcomes. This feedback updates states and supports later planning decisions across distributed enterprise locations.

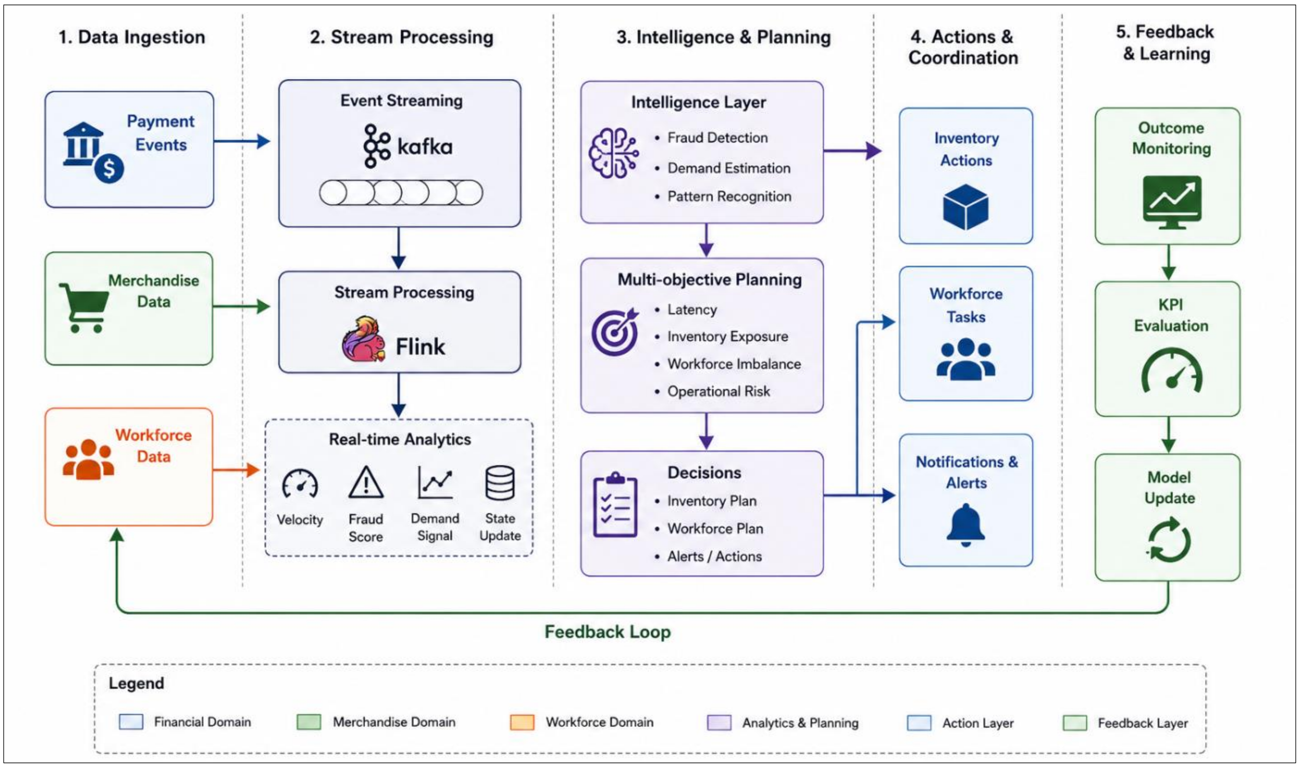

Figure 2: Event-to-Task Orchestration for Real-Time Payment, Merchandise, and Workforce Decisions

Figure 2 presents the event-to-task flow from payment activity through Kafka, Flink, fraud and demand intelligence, inventory planning, workforce allocation, governance, and feedback.

G. Operational Reliability and Performance Evaluation

Evaluation examines the proposed MIS through operational, analytical, and governance measures. Event-driven coordination is compared with batch-based processing under normal and stressed conditions. Latency measures the interval from event ingestion to actionable decision availability, with a designated target below 100 ms. Inventory measures include stockout exposure and replenishment response. Workforce measures include allocation mismatch and task response. Fraud evaluation considers detection and false-alert measures. Governance evaluation covers audit completeness, access control, and traceability. Reliability tests introduce payment bursts, demand volatility, workforce shortages, and connectivity interruptions. Repeated synthetic trials provide comparative observations across controlled conditions.

End-to-end latency is expressed as:

$$L_{total} = t_{decision} - t_{ingestion}$$

Here, $t_{ingestion}$ represents the event-entry timestamp, while $t_{decision}$ represents the time when an actionable decision becomes available. The equation directly measures the real time processing requirement.

H. Data Governance, Auditability, and Experimental Controls

Governance operates throughout the MIS rather than only through reporting stages. Each event retains source identity, timestamp, transformation history, access information, and status. Payment information follows defined access and privacy controls. Merchandise and workforce information uses role-based permissions. Audit records connect source events with generated intelligence, optimization results, and operational tasks. Experimental controls maintain identical scenario conditions across comparison models. Input volumes, demand patterns, fraud cases, workforce capacities, and disruption levels remain controlled across repeated trials. Three configurations are compared: batch coordination, real-time processing without cross-domain planning, and the complete interoperable MIS. This structure supports evaluation of interoperability, reliability, governance, and decision intelligence.

Table 1: Methodology Evaluation Framework

Evaluation Dimension	Measurement	Experimental Purpose
Real-time latency	Event ingestion-to-decision time	Test the <100 ms target
Inventory performance	Stockout exposure and replenishment response	Evaluate merchandise planning
Workforce coordination	Allocation mismatch and task response	Evaluate workforce planning
Fraud intelligence	Detection and false-alert measures	Evaluate payment-risk processing
Governance	Audit completeness and access-control compliance	Evaluate information accountability
Reliability	Successful processing during disruptions	Evaluate operational continuity

IV. RESULTS AND DISCUSSION

The results assess the proposed interoperable MIS under synthetic financial, retail, and workforce scenarios. The discussion examines real-time payment processing, merchandise response, workforce coordination, multi-objective planning, governance, and auditability. Batch coordination serves as the baseline for comparison. The Kafka–Flink architecture is evaluated under controlled event loads, with all numerical findings treated as synthetic experimental outputs derived from the methodology.

A. Real-Time Payment Processing and Latency

The latency experiment compares batch processing, event-driven processing, and the complete interoperable MIS. The results show clear differences in the time required to convert payment events into actionable decisions. The proposed architecture records 86 ms, compared with 420 ms for the event-driven configuration and 1,850 ms for batch processing. Kafka handles event delivery, while Flink performs temporal aggregation and state management. Payment events then move through fraud and demand services before inventory and workforce decisions. The result demonstrates the value of real-time event processing and layered API communication for cross-domain operational intelligence.

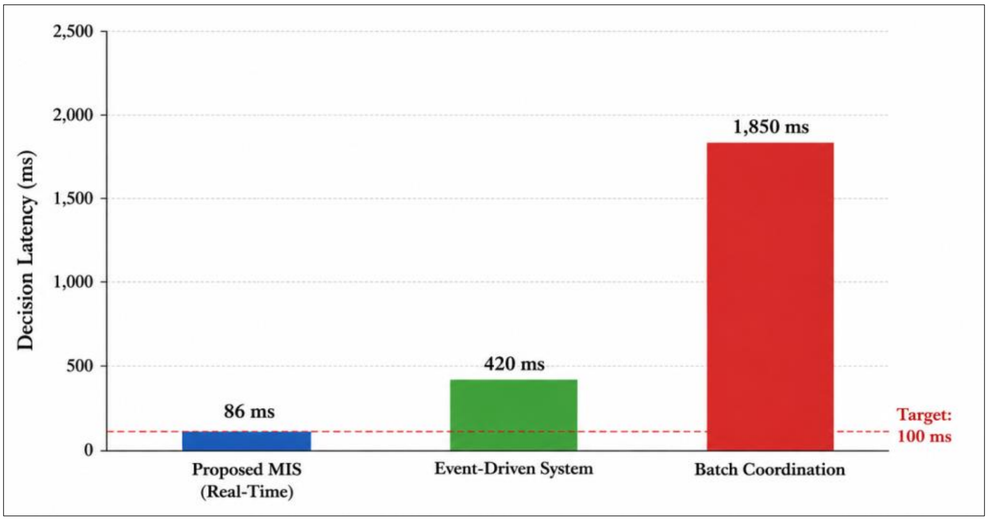

Figure 3: Real-Time Decision Latency Across MIS Configurations

Figure 3 compares the three tested MIS configurations. Batch processing records the highest latency at 1,850 ms. The event-driven configuration reduces latency to 420 ms, while the proposed interoperable MIS reaches 86 ms. The proposed configuration therefore remains below the predefined 100 ms target. The result supports separation of event ingestion, stream processing, API orchestration, and decision services. It also indicates that payment information can reach downstream merchandise and workforce services within the specified real-time operating boundary.

B. Event-to-Task Merchandise and Workforce Coordination

The event-to-task experiment measures timely responses across payment processing, inventory decisions, and workforce task coordination. The proposed MIS records 97% timely payment event processing, 91% timely inventory response, and 88% timely workforce response. The corresponding batch results are 72%, 61%, and 54%. These differences reflect the event-to-task mechanism specified in the methodology. Validated payment velocity contributes to demand signals, while fraud screening removes suspicious activity from merchandise planning. Shared timestamps, SKU identifiers, and location attributes connect financial events with retail and workforce states across distributed operational units.

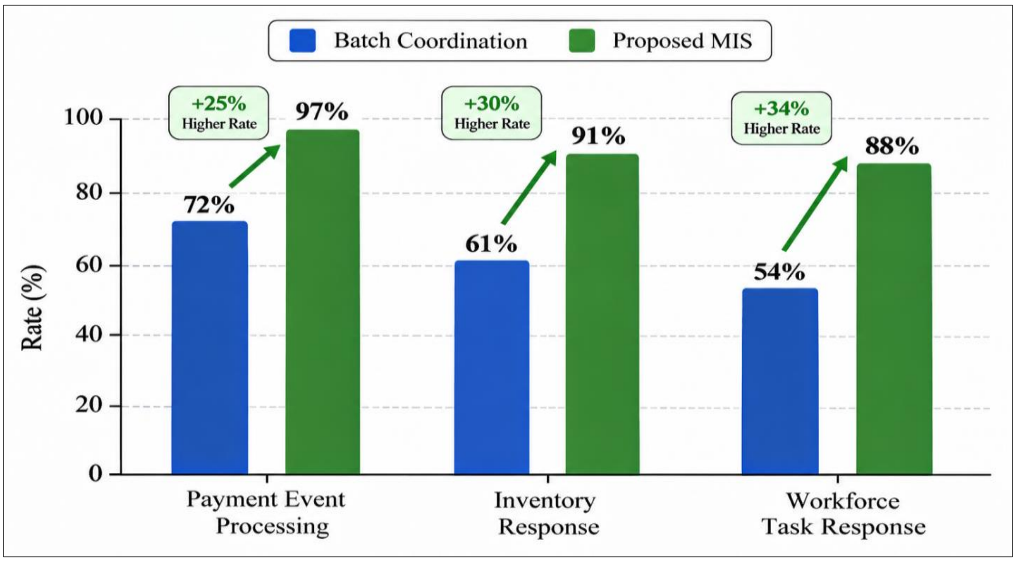

Figure 4: Event-to-Task Coordination Performance

Figure 4 shows the percentage of successful timely responses under batch coordination and the proposed MIS. Payment-event processing improves from 72% to 97%. Inventory response rises from 61% to 91%, while workforce task response moves from 54% to 88%. Workforce coordination shows the largest relative improvement among the three operational stages. This result supports the Event-to-Task Orchestration Framework, where payment activity becomes an input to merchandise and workforce decisions rather than remaining limited to financial information processing.

C. Multi-Objective Planning and Operational Trade-Offs

The multi-objective experiment produces a Pareto set that illustrates the relationship between decision latency, inventory exposure, and workforce imbalance. At 72 ms, inventory exposure is 14.8% and workforce imbalance is 15.6%. At 118 ms, these values fall to 7.9% and 8.5%. The 86 ms solution provides an intermediate point, with inventory exposure of 11.2% and workforce imbalance of 11.9%. This result supports Pareto-based decision analysis. Different solutions allow managers to consider latency, inventory conditions, workforce capacity, and operational risk within the specified decision constraints.

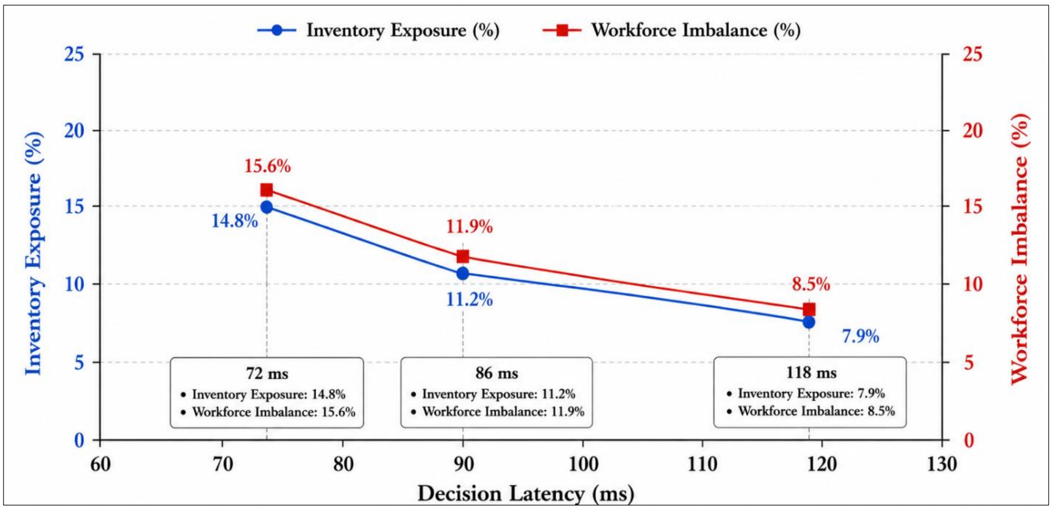

Figure 5: Pareto Trade-Off Between Latency and Operational Exposure

Figure 5 presents the relationship between decision latency and residual operational exposure. Lower latency produces faster decisions but leaves greater inventory and workforce exposure. Additional processing time permits further optimization and produces lower exposure levels. The 86 ms solution provides a practical middle point because it remains below the 100 ms target while reducing both exposure measures relative to the fastest configuration. The result supports the use of multi-objective planning within the proposed MIS and shows the value of presenting feasible trade-off solutions instead of a single fixed operational decision.

D. Governance, Auditability, and Integrated Performance

The governance evaluation examines traceability, schema validation, access control, and audit completeness across the event pipeline. Each synthetic event retains source identity, timestamps, transformation history, decision status, and execution information. Payment signals, inventory decisions, and workforce tasks remain connected through a common audit trail. Role-based permissions separate access across operational functions. The results in Table I summarize latency, timely response, inventory exposure, workforce imbalance, and audit traceability. These findings indicate that cross-domain interoperability requires consistent data structures, controlled permissions, traceable transformations, and accountable decision records across distributed enterprise services.

Table 2: Summary of Synthetic Experimental Results

Evaluation Dimension	Batch Coordination	Proposed MIS	Interpretation
Decision latency	1,850 ms	86 ms	Below the 100 ms target
Payment-event timely response	72%	97%	Higher timely event processing
Inventory timely response	61%	91%	Faster merchandise response
Workforce timely response	54%	88%	Stronger task coordination
Inventory exposure*	14.8%	11.2%	Lower exposure at selected Pareto point
Workforce imbalance*	15.6%	11.9%	Lower allocation imbalance
Audit traceability	Partial	Complete	Cross-domain event-to-decision records

Values represent selected synthetic Pareto scenarios rather than measurements from live organizational operations.

Overall, the synthetic results support the proposed integration of real-time payment intelligence, merchandise planning, and distributed workforce coordination within a unified MIS. The findings also support the proposed event-to-task orchestration, API governance, and resilience-oriented architecture. Since the experiments use synthetic datasets, validation with operational financial, retail, and workforce data remains a future research requirement.

Limitations of the Study

The study uses synthetic financial, retail, and workforce datasets rather than live organizational data. Results may differ under larger transaction volumes, complex fraud patterns, workforce constraints, and connectivity disruptions. External validation across real enterprise environments remains necessary.

V. CONCLUSION

The study proposed an interoperable Management Information System that integrates real-time payment intelligence, merchandise planning, and distributed workforce coordination within a unified architecture. The methodology combined System, Process, and Experience APIs with Kafka–Flink event processing, synthetic financial, retail, and workforce datasets, fraud-aware demand signals, and multi-objective planning. The synthetic results indicated that the proposed architecture reduced decision latency to 86 ms, below the 100 ms target, while improving timely payment-event processing, inventory response, and workforce task coordination compared with batch coordination. The findings support the proposed Event-to-Task Orchestration Framework and demonstrate how payment information can contribute to operational decisions across distributed enterprise functions.

Future work should evaluate the framework with real payment, retail, and workforce datasets. Further studies can examine ISO 20022 streams, additional fraud scenarios, dynamic workforce constraints, and connectivity disruptions. LSTM or Transformer models can also be tested for fraud and demand intelligence. Additional research can assess API governance, alternative stream-processing platforms, and different Pareto objectives.

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