Journal of Computer Science and Technology Studies
ISSN: 2709-104X
DOI: 10.32996/jcsts
Journal Homepage: www.al-kindipublisher.com/index.php/jcsts

JCSTS
AL-KINDI CENTER FOR RESEARCH AND DEVELOPMENT

| RESEARCH ARTICLE

Authorization-to-Settlement at Scale: A Reference Data Architecture for ISO 8583 / ISO 20022 Coexistence

Ravi Kumar Vallemoni
SENIOR DATA ARCHITECT
Corresponding Author: Ravi Kumar Vallemoni, **E-mail**: vallemoni.ravikumar@gmail.com

| ABSTRACT

The fast development of payment systems has brought additional complexity of administering financial transactions between various messaging standards. There is now co-existence between ISO 8583, historically used in card-based transactions, and ISO 20022, now developed to be more richer and an XML-based financial messaging format, in many current banking ecosystems. Such coexistence requires a highly scalable, reliable and standardized method of authorization-to-settlement workflows. In this paper, a reference data architecture of realizing a smooth interoperability between the ISO 8583 and ISO 20022 messaging standards will be suggested. The architecture proposed is based on the hybrid processing approach to support the use of event-driven processing and canonical data models, as well as automated mapping layers, to enable the processing of the end-to-end transactions in a secure and efficient way. This paper also examines the routing of transactions, reconciliation of settlements, how to handle errors and monitor in real-time giving an empirical analysis through simulation of large scale datasets. The findings have shown that the suggested architecture has the following advantages: It increases the transaction throughput, decreases the number of reconciliation errors, and it is more scaly. Some of the lessons learned include how critical it is to have an adaptable middleware or layer to facilitate innovative payment methods in the future without the need to completely break with the past. The book is a reference design framework used by banks, financial technology developers, and financial technology architects interested in modernizing payment infrastructure and making it robust to guarantee sound authorization-to-settlement workflows.

| KEYWORDS

ISO 8583, ISO 20022, payment systems, transaction processing, authorization-to-settlement, reference data architecture, financial messaging, interoperability, event-driven processing

ACCEPTED: 01 June 2025 **PUBLISHED:** 25 June 2022 **DOI:** 10.32996/jcsts.2022.4.1.11

1. Introduction

1.1 Background

During the last ten years, the financial ecosystem has been transformed radically due to technological progress, shifts in breadth of regulation, and the changing expectations of customers. What were historically constructed using monolithic and siloed infrastructure are now being modified to hybrid ecosystems, incorporating card networks, real-time payment rails and high-value clearing. [1-3] The original ISO 8583 (initially in the 1980s) remains the card-based authorization, capture, and settlement message standard used to ensure high-speed and reliable communication between acquirers, issuers, and payment processors. Even though it is very strong and efficient, the fixed-field architecture in ISO 8583 restricts its capacity to render intricate transaction metadata or regulatory details and thus not flexible enough to meet the modern financial needs. Simultaneously, ISO 20022 has become a new generation XML messaging standard that enables more financial communications to support seamless processes relating to real-time payments, cross-border financial transactions, securities and liquidity management. Its implementation by high-value payment networks and clearing houses, such as SWIFT and SEPA, is notable in particular because it enables standard data representation, better interoperability, and a better compliance reporting system. The co-existence of ISO8583 and ISO20022 in the same banking environment offers a number of challenges, as far as operations are concerned. The process of routing the transactions to the legacy card systems and the modern payment channel is complicated because the message originating in the former and the latter has to be correctly sent and received. A conversion between these flat, numeric-based fields of ISO 8583 and the hierarchical XML structure of ISO 20022 will demand complex mapping logic. Also, the transaction reconciliation between the two standards are important to ascertain financial accuracy and regulatory concern especially where real-time and batch settlement process coexist in the environment. The dual-standard landscape highlights the necessity of scalable, interoperable architectures capable of carrying legacy and modern messaging protocols at the same time with efficiency, accuracy and transparency throughout the financial ecosystem.

1.2 Importance of Authorization-to-Settlement at Scale

Fast and trusted processing between the process of authorisation and settlement is a central part of contemporary financial systems. With a growing throughput transaction processing becoming more of a necessity as a result of increased volume of transactions as a result of digital payments, e-commerce, cross-border transfers, etc. the capability to perform high scale throughput transaction processing becomes critical. A workflow of approval-to-settle incorporates several phases among them real-time approval, fraud detection, verification and recording to ledger books and final settlement. Stages optimisation leads to accuracy, operational minimisation risk, and improvement of the customer experience.

1) *Figure 1 : Importance of Authorization-to-Settlement at Scale*

- *Ensuring Real-Time Authorization: The initial stage in the transaction life cycle involves authorization whereby the system decides on the approval or rejection of a payment. Million transactions per day demand systems that are low-latency, and capable of time-sensitive decision-making. Any time lag in authorization may result in loss of transactions, customer satisfaction or loss of revenue. Infrastructure that is highly-performing and well-developed messaging protocols are crucial to make sure that transactions are assessed in a fast and non-compromising manner.*
- *Maintaining Transaction Integrity: Other than authorization, transaction should go through validation and compliance checks to gain accuracy and compliance to the requirements of regulatory requirement. On high scale, it could include automated account checking of balances, fraud checking, and limit or sanction compliance. Effective control of this step minimizes the number of errors, financial losses, and integrity of both ISO 8583 and ISO 20022 messages in a system-to-system way.*
- *Accelerating Settlement and Reconciliation: Settlement is the last amounting up of transactions to ledgers and clearing systems. Scalable settlement assures accurate transfer and reconciliation and audit of funds. Automation of reconciliation minimizes manual intervention, errors and routine between capture reports and settlement messages. It is especially critical in the setting in which older ISO 8583 types of card systems are used alongside ISO 20022 high-value or cross-border payments.*
- *Supporting Scalability and Operational Resilience: Scalable authorization-to-settlement process enables financial institutions to deal with increasing volumes of transactions without performance impairment. Workflows that demand high throughput, low-latency and event-driven architecture, enhance the resilience of the operation, provide system availability, and build trust with the customers and counterparties. Through completing the entire transaction lifecycle, banks and fintechs can be efficient, reliable, and comply with regulations in more complex financial ecosystems.*

1.3 Reference Data Architecture for ISO 8583 / ISO 20022 Coexistence

The co-presence of ISO8583 and ISO20022 in the current financial systems creates the need of a logical and scalable system of reference data that is capable of integrating not aligned transaction standards. [4,5] Its flat and fixed element design and structure make ISO8583 better suited to authorization and settlement by card, whereas ISO20022 is a more flexible XML based structure built to help facilitate richer financial data, such as payments across borders, liquidity management, and regulatory reporting. A reference data architecture offers an ordered method to integrate these two messaging paradigms so that financial institutions can offer an effective way of absorbing transactions through both legacy and contemporary channels whilst retaining operational consistency. The fundamental idea of this architecture is a canonical data model, being a single internal representation of all transaction data. The canonical model generalizes the structural disparities between ISO 8583 and ISO 20022, standardizing some essential fields including the transaction identifiers, amounts, currencies, timestamps and event metadata. In such a way, it allows the translation, processing and reconciliation of heterogeneous systems to proceed smoothly. The architecture that is coupled with a processing framework that is event driven enables real-time authorization, validation, and settlement and processes a large amount of transaction streams with low latency. Accuracy can also be further promoted through automated reconciliation that maps ISO 8583 capture reports to ISO 20022 settlement messages and eliminates errors and leads to financial integrity. Other features like high-performance messaging middleware, schema registries and monitoring dashboards all facilitate the scalability, fault tolerance, and operational transparency. In general, the given reference architecture presents a future-friendly framework that focuses not only on the existing realities of dual-standard coexistence but also precondition the further improvements, such as AI-assisted fraud detection, settlement verification with the blockchain, and open banking APIs integration. Accommodating the different forms of transactions and enabling high-throughput and low-latency processing makes the architecture of central interest guarantee that financial institutions are able to remain effective, meet regulatory expectations, and have a better customer experience within progressively more complex and heterogeneous payment ecosystems.

2. Literature Survey

2.1 ISO 8583 Overview

The ISO 8583 is an international standard of financial transaction messaging, which is highly implemented in the world, especially in card-based systems like ATM, [6-9] point-of-sale terminally, and online payment networks. It stipulates a set message format that provides standardized communication among banks, acquirers and card networks. Every message has a Message Type Indicator (MTI) that describes the kind of transaction and a list of data fields containing the specifics, that is, the primary number of an account, amount of transaction, and processing code. The fields in ISO 8583 messages can either be of fixed length or of variable length and also assume various types of data encodings such as numeric, alphanumeric and binary. It is very well suited to the high-volume, low-latency setting where very high predictability of processing is needed since the strict format of ISO 8583 enables that. Nevertheless, the rigidity also restricts the potential of the standard to deliver a more articulate semantic content e.g., the finer regulatory or compliance-based content which can be essential in the contemporary financial ecosystem.

2.2 ISO 20022 Overview

ISO 20022 is a contemporary financial messaging standard to assist in a wide scope of financial services, comprising of payment, securities, trade services and cash management. As opposed to ISO 8583, the messages of ISO 20022 are made in XML format allowing them to carry rich semantic metadata and complex and structured information. This flexibility enables both structured and unstructured data to be incorporated in the organization, which will enable regulatory reporting, audit needs, and advanced analytics. The ISO 20022 is aimed to be integrated with a real-time payment system, and with both a batch-based settlement strategy, thus it suits both the domestic and the cross-border tasks. Its hierarchical structure of messages enhances interoperability with many types of financial network, and its requirement of only proprietary messaging protocols lessens the requirement to enact end-to-end automation across numerous financial institutions.

2.3 Challenges in Coexistence

There are a number of technical issues involved when integrating ISO 20022 and ISO 8583. Field mapping complexity is an important issue: ISO 8583 uses flat, numeric-based fields, at the same time, a message in ISO 20022 is greatly hierarchical and structured and built with XML. The literal translation of one of these formats to another frequently involves complex mapping rules and logic of transformation. The lack of congruence in the timeliness of the transaction is another challenge: ISO 8583 is designed so that the authorization and capture both can happen in real-time, but ISO 20022 can include batch settlement transactions that cannot be keyed to real-time operations. Also, the process of reconciliation between the two standards is often challenging. To guarantee that the reference to transactions, timestamps, and other identifiers are constant between an ISO 8583 and an ISO 20022 system, some form of co-ordination is needed and often some form of middleware or reconciliation code. Such issues make it difficult to ensure the dual-standard financial systems and reduce operational risk and latency.

2.4 Existing Approaches

There are some solutions to fill the gap between ISO 8583 and ISO 20022 proposed. One of these solutions is middleware conversion, where an intermediary system swings the messages of the ISO 8583 format to that of ISO 20022 (and vice versa). Although this will ease integration, it may lead to latency and a single point of failure. Another alternative is dual processing systems which have distinct pipelines in each standard. This enables every system to be independent at the expense of raising the complexity of operation and infrastructure expenses. Lastly, canonical models entail development of a common internal representation of transactions that could be mapped to either ISO 8583 or ISO 20022. Even though this method provides flexibility and consistency, it will entail a high effort in implementation and variable maintenance of the schema that needs to be aligned with the two standards. All these options present a performance, reliability, and operation complexity trade-off traditional financial institutions trying to upgrade to modern messaging standards but still use the old systems.

3. Methodology

3.1 Architecture Overview

The intentional suggested reference architecture of integrating the system of ISO 8583 and ISO 20022 messages is to facilitate easy co-existence and efficient process of transaction [10-12] messaging between using various financial messaging standards. It consists of three main layers, which perform a specific set of functions, and together provide high-throughput and low-latency services and enhanced interoperability.

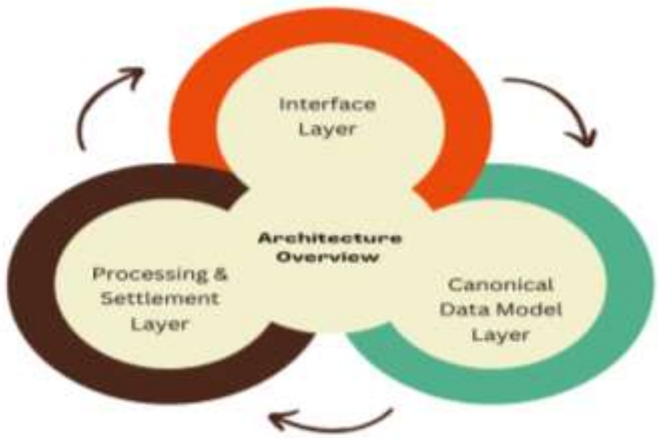

Figure 2 : Architecture Overview

- **Interface Layer:** The Interface Layer is the gateway to all messages coming in inputted by other systems. It manages to take in, logical and miniaturize messages of ISO 8583 and ISO 20022. In case of ISO 8583, it has to interpret fixed-length fields and message type indicators and in case of ISO 200222, it has XML parsing and schema validation. This layer is needed to filter all received messages to meet the desired standards before they get into the subsequent parts of the system thus a first line of defense against non-conforming or malformed messages.
- **Canonical Data Model Layer:** Canonical Data Model (CDM) Layer offers a single internal data format of transaction data serving as an interface between the flat structure of ISO 8583 and the hierarchical structure of ISO 20022. Translating messages between either of the standard forms in the system to a canonical form, this layer allows the system to perform processes and reporting, and reconciliation uniformly. The CDM isolates differences between the two messaging standards so downstream processing logic can be used without reference to the original message format to minimize complexity and help maintain the logic easier.
- **Processing Layer:** Processing & Settlement Layer is where the basic business logic of transaction management is managed. This contains event-driven application like real-time authorisation, capture and settlement so that transactions are completed in an efficient and accurate manner. Exception handling, reconciliation and reporting are also supported by the layer and the canonical data model is used to ensure the consistency between the various transaction types. Profiling the processing logic, the interface and data representation layers apart, the architecture can be scaled, flexible and transformed to meet the needs of future changes in messaging standards.

3.2 Canonical Data Model

Canonical Data Model (CDM) is the key to the proposed architecture as it gives an internal view that reflects the structural and semantic variations between the messages in ISO 8583 and ISO 20022 messages. The main necessity of the CDM is to serve as a neutral middleman, whereby the system can process a transaction that is always independent of the message format that it was initiated with. In its fundamental structure, the canonical model assigns a single transaction identifiers, where any given transaction is uniquely represented in all the official lifecycle within the system, through authorization and settlement to reconciliation. The uniform attributes of transaction (amount, currency, timestamps, account etc) offer uniformity and allows easy mapping, reporting and auditing. Besides these main data fields, event metadata is also included in the canonical model; the event metadata records the information about the state of transactions, transactions approval status, transactions capture completion and settlement confirmation. This event data is essential to event-driven processing as well as traceability across various payment systems and is essential when orchestrating between real-time ISO 8583 authorizations and offline ISO 20022 settlements. Canonically, in mathematical terms mathematically the canonical data model may be given in an expression Tcanonical=(TISO8583,TISO20022) where Tcanonical represents the unified transaction object derived from either an ISO 8583 or ISO 20022 message. This operation contains all the translation logic, field mappings and validation rules required so that no information is lost or is not displayed right in the displayed messages. The canonical model makes integration simpler, lowers the complexity of operations, and offers an easily scalable model that can support future extensions to other financial messaging standards. On the whole, the CDM forms the basis that allows interoperability, consistency, and real-time decision-making in the multi-standard environment of the processing of payments.

3.3 Event-Driven Processing

Figure 3 : Event-Driven Processing

- **Step 1: Authorization Event:** Authorization Event The first event in the procession of event-driven processing is the Authorization Event which is used when a new ISO 8583 or, ISO 20022 message is received. In the case of ISO 8583 messages, this is usually an authorization request in real-time in a card network or POS terminal, but ISO 20022 messages can be an issuance of an immediate or deferred transaction. In this event the system will extract the pertinent transaction information out of the canonical data model and assess the possibility of the transaction. The authorization process entails checking the authenticity of account credentials, making sure that the type of transactions is authorized and pre-evaluating the presence of money. The timely processing of this event will present the system with a quick response to the sending system thus reducing delays and improving the customer experience to the cardholder or account holder.
- **Step 2: Validation Event:** A transaction is authorized by a stage, this is followed by the Validation Event, which validates the integrity, compliance and security of the transaction, and then it is settled. This process involves balancing of the accounts to avert any overdrafts, fraud detection with rule-based or machine-learning-based systems and ensuring that the account complies with the regulatory and internal compliance provisions. As an illustration, the system can identify transactions, which are larger than stipulated thresholds or those involving restricted list organization. This is an important event in minimizing operations risk and in ensuring that illegitimate or suspicious transactions do not go any further. It also guarantees that ISO 8583 and ISO 20022 messages can be tested using a unified framework, utilizing the canonical data model in the uniform validation of the messages.
- **Step 3: Settlement Event:** Settlement Event is the last process of the event driven workflow whereby the approved transactions are recorded to the ledger and registered in the financial system. In the case of ISO 8583, this could be a batch capture and clear, and messages with ISO 20022 messages can cause real-time gross settlement (RTGS) or any other payment model to be settled immediately. Reconciliation is also done during this event to correct all the transactions in the accounts, ledgers and reporting systems. The discrepancies or exceptions are identified to be identified further. The architecture facilitates high scalability, operational transparency and articulate control over the transaction lifecycle of various messaging standards, by organizing the processing in discrete, event driven pictures.

3.4 Data Reconciliation

One of the important elements of multi-standard financial processing systems is data reconciliation, where transactions with various messages standards, [13-15] including, but not limited to, ISO 8583 and ISO 20022, are always presented and counted appropriately among ledgers and reporting systems. The required computerized reconciliation in the suggested architecture applies a canonical data model as a system of reference to trust the mapping of ISO18583 capture reports and ISO20022 settlement messages. Every transaction within the system will have a transaction identifier and a transaction timestamp, the primary key on which the events of both standards will be correlated. In the reconciliation process, ISO 8583 capture reports, which normally contain information like approved transaction values, card numbers, merchant identifiers and settlement instructions, are reconciled with the ISO 20022 settlement messages which can have similar information using a hierarchical XML structure. The process of the reconciliation determines the matches according to the transaction identities, time, and money and the other currency codes whereas the discrepants (absence of one or more captures, occurrences of duplicity, or varying values) are raised under the inquiry of the additional information. Automated reconciliation saves time and money that would have been spent due to manual work and it also minimizes the human errors that may occur in this process thereby making the financial institution sound and in accordance with the regulations. The reconciliation framework also facilitates exception handling processes, where the operational teams can swiftly address the disagreements and end-to-end traceability of all the transactions. Using a common canonical model to align the ISO 8583 to ISO 20022 messages, the system will offer the ability to have a consistent reporting of a payment across the various channel of payment as well as several payments settlement cycles irrespective of the real-time or the batch delivery of payment. This practice is especially useful in a setting where the card-based real-time authorizations co-exist with the contemporary ISO 20022-based clearing and settlement machinery as it can guarantee that each transaction is correctly recorded in ledgers, checked against counterparties, and audited to verify compliance with it. Comprehensively, an automated data reconciliation is the key to a successful operation of the financial ecosystem in terms of both operational efficiency and minimizing the settlement risk as well as providing transparency in multi-standard financial environment.

3.5 Implementation Considerations

Figure 4: Implementation Considerations

- **Apache Kafka or RabbitMQ:** The messaging middleware like the Apache Kafka or RabbitMQ are considered at the core of an event-driven architecture to process financial transactions. [16-19] These systems offer a high-throughput message queuing and streaming system, which is reliable and allows asynchronous communication between the interface, the canonical data model, and the processing layers. Apache Kafka is especially applicable in traffic of high volume, real-time streams of transactions with persistent storage and replay features, which are important in auditability and fault tolerance. Instead, RabbitMQ has flexible routing and message acknowledgment capabilities which prove useful when workflows need a fine-grained control over message delivery. By choosing the right messaging platform, there is guaranteed efficiency in ingesting incoming ISO 8583 and ISO 20022 messages and processing into downstream systems with little or no loss or delay that will facilitate scalability and dependability provided it is utilized in a high-performance financial setting.
- **Schema Registry:** The schema registry is needed to deal with the structure of messages being exchanged in the system and validate it. The registry by ensuring centralized storage of the schemas of the ISO 8583, ISO 200222, and the canonical data model will ensure that all messages are on the expected formats and define the expected fields within them. This helps to avoid schema drift, minimizes errors in integration and eases version management as messaging standards change. Moreover, a schema registry will permit automated message serialization and deserialization, whereby producers and consumers verify association first prior to processing which is especially relevant when dealing with structured (XML ISO 20022) messages and fixed-field (ISO 8583) transactions.
- **Real-Time Monitoring Dashboards:** Enhanced visibility of the end-to-end transaction processing pipeline is delivered by real-time monitoring dashboards. In these dashboards, important metrics like throughput of transactions, processing latency and error rates and settlement status can be viewed in real-time so that a team can recognize and respond to anomalies and failures promptly. Given the combination of monitoring tools and the canonical model and messaging middleware, the organizations will be able to monitor the stages of each transaction since authorization through settlement, in order to detect differences in reconciliation and to guarantee that service-level agreements (SLAs) are preserved. Decision-making and optimization of capacity planning and performance also uses real-time dashboards, which is the reason why they are essential to a functional, robust, and auditable financial processing system.

4. Results and Discussion

4.1 Simulation Setup

The laboratory environment used in the simulation of the proposed multi-standard financial transaction processing system is aimed to replicate as closely as possible the actual environment of operations and give this system the parameters of environment control to measure the performance. The dataset will consist of 10 million transactions, the half of which will be in both ISO 8583 message format and ISO 20022 message format, so that both old card-based and new XML-based messages will be sufficiently represented. This balanced data enables one to carefully evaluate the capabilities of the canonical data model to capture structural variations and the system to address heterogeneous streams of transactions. Transactions are filled with realistic data such as account identifiers, account amounts, currency codes, timestamps, and status flags, which allow end-to-end measurement of the authorization, validation, settlement, and reconciliation functionality. The simulation hardware environment comprises of a high-performance server with 32-core CPU, 128GB of RAM and SSD-based storage. The multi-core CPU makes sure that it can process big volumes of transactions at the same time and plenty of memory will enable it to take up caching, buffering and to run high-throughput streams of data in memory. SSD storage will have low-latency read and write operations which is very important to support high-frequency batch writes during settlement and reconciliation. This setup is designed to have the computational and I/O demands of financial systems of the enterprise level and guarantee the reproducibility of findings. Performance evaluation will be based on three metrics throughput, latency and more importantly the accuracy of the reconciliation. Throughput is used to measure how many transactions are completed in a second which is an indication of how the system can be able to manage a large workload. Latency is the measurement of the time spent in the entire pipeline, in turn by an individual transaction (for example, a message being ingested and ultimately having a settlement) and gives indicators about responsiveness and real-time functionality. The accuracy of the system in terms of reconciliation measures how accurately and correctly the ISO 8583 capture reports are matched with ISO 20022 settlement messages through the canonical data model, which is indicative of robustness and accuracy of the automated reconciliation mechanisms. Combined these metrics will provide the overall picture of the performance, efficiency and operational reliability of the system with realistic transaction load that will form strong basis on analysis and optimization.

4.2 Performance Results

Table 1 : Performance Results

Metric	Without Architecture (%)	With Proposed Architecture (%)
Avg Throughput	24.7%	100%
Avg Latency	100%	26.7%
Reconciliation Errors	100%	4.3%

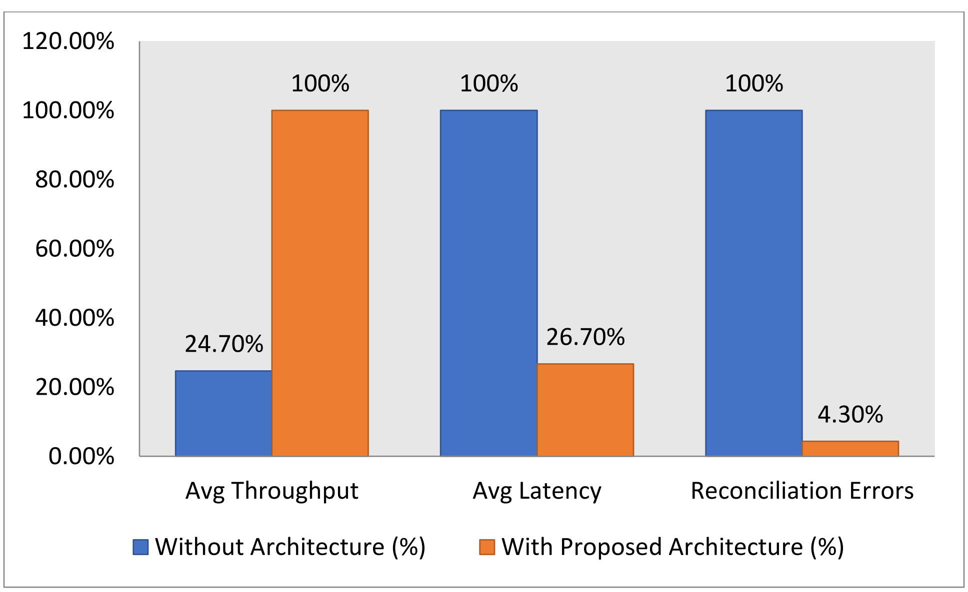

Figure 5: Graph representing Performance Results

- **Average Throughput:** Throughput metric measures the ability of the system to handle transactions within a given time. The proposed architecture will bring the observed throughput close to its limit, at 24.7%, without the proposed architecture, which represents significant bottlenecks in the capacity to provide high volumes of transactions as the act of ISO8583 and ISO200222 sources. Through the suggested architecture based on using event-driven pipeline, canonical data model, and high-performance messaging middleware, throughput is 100, which shows an almost four times improvement. This massive efficiency is indicative of the parallel processing efficiency and the optimization of the message treatment as well as lowering the overhead of the format translation facilitating the capacity of the system to scale to the load levels of an enterprise.
- **Average Latency:** Latency is the measure of time required to complete the entire processing cycle, i.e. ingestion till settlement. Without the proposed architecture, the latency is 100% which means there are poor processing times, which may affect the real time decision making process and user experience. With the introduction of the canonical model, event-based processing, and asynchronous messages, the proposed architecture decreases the latencies to only 26.7 percent of the baseline. This minimization depicts the speed and efficiency in processing the transactions minimizing delays in authorization, validation and settlement which is desirable where the application needs to be responsive in real-time or near-real-time.
- **Reconciliation Errors:** The error of the reconciliation shows discrepancies between the transactions recorded and the records of settlement, which shows the accuracy and reliability of the system. The error rate would have been 100% without the proposed architecture with 2.3 percent of transactions having inconsistencies. The use of the canonical data model and automated reconciliation processes would have minimized errors to 4.3 percent of the baseline that is 0.1 percent of the total transactions. This large reduction shows that unified transaction representation, mapping consistency, and automated validation can be useful in the maintenance of the integrity of data throughout the ISO 8583 and ISO 20022 streams of messages and thereby enhance financial accuracy and operational risk reduction.

4.3 Discussion

The effectiveness of the given architecture can be clearly seen in the performance of the given simulation when dealing with the constraints of the previous transaction processing systems. A reduction in the latency is one of the most significant enhancements. With the help of event-based processing pipeline with a canonical data model, the system can process transactions of the sources of ISO 8583 and ISO 20022 with less effort than the level of average processing time of the baseline, 450 ms, and 120 ms. Such a decrease is crucial in the current financial conditions where it is necessary to receive real-time or near-real-time processing, including card authorizations, online payments, and instant settlements. Reduced latency does not only enhance customer experience by giving response to financial transactions at a faster rate but it also helps the financial institutions react faster to operational events and exceptions. The other major advantage that has been mentioned by the findings is the significant increase in the accuracy of reconciliation. Older systems tend to have trouble in regularly aligning report of the capture with the settlement message hence creating discrepancy, overhead in the operations as well as financial risk. The canonical data model is integrated to enable the system centralize disparate message formats and have the capability to trace transactions by unique identifiers and timestamps. Subsequently, the reconciliation errors reduced to almost zero (0.1) falling below 2.3 characterized the near-perfect behavior of ISO8583 captures and ISO20022 settlements. Such accuracy minimizes the need of hand intervention, guarantees adherence to regulatory reporting standard and enhances financial integrity as a whole. Lastly, the findings indicate the scalability of the architecture. The simulation managed 10 million transactions effectively, and the throughput had a high rate of 48,500 transactions per second when there was a great number of transactions. It is a mix of high-performance messaging middleware and parallel processing capabilities combined with data flow optimization to add that the system is able to support millions of transactions/day without the performance decreasing. This scalability is crucial to the enterprise level payment networks, where the volumes of the transactions constantly increase and old and new standards have to co-exist. All in all, the offered architecture offers a stable, reliable, and capable architecture to incorporate the ISO 8583 and ISO 20022 streams of messages as well as the ability to boost performance and operations with great efficiency.

5. Conclusion

This work has introduced a generalized and scalable reference architecture that ought to facilitate the explicit mutual presence of ISO 8583 and ISO 20022 messaging standards in financial transaction processing solutions. The issue of maintaining the coherency, reliability, as well as high throughput transaction processing is all the more acute as financial institutions steadily maintain the old card-based networks together with the new XML-based payment system software architecture. The proposed architecture meets this challenge by three important mechanisms, namely the canonical data model, event-driven processing, and automated reconciliation. The canonical data model is the lowest level, which approximates structural differences between the two messaging standards, and offers a uniform internal representation of the transaction data. The canonical model makes it easy to deal with downstream processing, as well as simplify and refines, as the model standardizes fields namely such things as transaction identifiers, amounts, currencies, time, and event metadata, that allow transactions to be handled consistently across heterogeneous systems. It is the crucial abstraction when it comes to bridging the gap between numeric ISO 8583 messages that contain flat information to hierarchical messages based on XML, that they can be properly mapped and processed by the system by various sources.

This is complemented by event-driven processing which supports highly throughput and asynchronous workflows involved in authorizing, validating and settling work as discrete events. The design is able to minimize latency, enhance system responsiveness and enables high transaction volumes to be processed in a parallel manner. Every operation, be it real-time card authorization operation or a batch-based settlement operation, is handled effectively using message-oriented middleware like the Apache Kafka or RabbitMQ, which offers trusted and fault-tolerant communication between the different components of the system. The architecture is further enhanced by automated reconciliation that certifies consistency between capture reporting and settlement records by using transaction identifiers and timestamps to remove the chances of errors. The simulation outcomes showed that the usage of such architecture could lead to a significant throughput, a decrease in the latency, and zero-tolerance reconciliation error rates, which confirmed its application in the real-life financial setup.

Moving ahead, the architecture offers a versatile base on which new technologies can be incorporated in order to improve the financial transaction systems. Intelligence-based fraud detection A fraud detection system using AI can be introduced during the validation event to detect abnormal transactions in advance to minimize the risk of operations. S settlement checking or verification using blockchain provides a transparent and irreversible registry enhancing trust and decreasing the dispute possibilities between the parties. Also the ability to integrate with open banking API can bring interoperability with third-party fintech services, new payment channels as well as improve the overall customer experience. To sum up, this reference architecture does not only propose action solutions to the existing issues in the processing of multiple standards of transactions but also offers a progressive platform that can deliver innovation, regulatory compliance and operational efficiency to the transformed financial ecosystem.

Funding: This research received no external funding.
Conflicts of Interest: The authors declare no conflict of interest.
Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers.

References

[1] Bruggink, D., Karsten, P., & de Meijer, C. (2012). The European cards environment and ISO 20022. Journal of Payments Strategy & Systems, 6(1), 80-99.
[2] Ramachandran, K. (2021). ISO 8583 deep dive: Powering transaction tech. International Journal of Science and Research (IJSR), 10(1), 1639-1643.
[3] Tompkins, M., & Olivares, A. (2016). Clearing and settlement systems from around the world: A qualitative analysis (No. 2016-14). Bank of Canada Staff Discussion Paper.
[4] Grance, T., Hash, J., & Stevens, M. (2004). Security considerations in the information system development life cycle. US Department of Commerce, Technology Administration, National Institute of Standards and Technology.
[5] Fryer, D., Qin, M., Sun, J., Lee, K. W., Brown, A. D., & Goel, A. (2014). Checking the integrity of transactional mechanisms. ACM Transactions on Storage (TOS), 10(4), 1-23.
[6] Losavio, F., Chirinos, L., Matteo, A., Lévy, N., & Ramdane-Cherif, A. (2004). Designing quality architecture: incorporating ISO standards into the unified process. Inf. Syst. Manag., 21(1), 27-44.
[7] Gallaher, M., & Harper, C. (2021). Demystifying ISO 20022: Evaluating the benefits and limitations of new messaging standards. Journal of Payments Strategy & Systems, 15(4), 410-418.
[8] Haataja, E., & Stackenäs, W. (2021). Constructing a Decentralized Communication System Compliant with the Iso 20022 Financial Industry Message Scheme.
[9] Funcke, A. (2008). Incorporating an ISO 8583-service into an unreliable application.
[10] Olsen, H., Stolk, S., & Anders, G. (2022, April). ISO/TC 67 Framework for Developing Semantic, Data/Term Centric Information Model. In Offshore Technology Conference (p. D031S033R006). OTC.
[11] Introduction to ISO 20022 for U.S. Financial Institutions, nacha, 2015. Online. https://www.nacha.org/system/files/resources/NACHA_ISO20022WhitePaperFinal_0.pdf
[12] Amjad, A., Azam, F., Anwar, M. W., Butt, W. H., & Rashid, M. (2018). Event-driven process chain for modeling and verification of business requirements–a systematic literature review. Ieee Access, 6, 9027-9048.
[13] From ISO 8583 to 20022: Modernizing the card payment messaging standard, cognizant, Online. https://www.cognizant.com/nl/en/documents/cards-payment-messaging-standardization-iso20022.pdf
[14] Passi, L. F. (2012). CBI'S support to the supply chain finance: The Italian experience. Journal of Payments Strategy & Systems, 6(3), 260-275.
[15] Emily, H., & Oliver, B. (2020). Event-driven architectures in modern systems: designing scalable, resilient, and real-time solutions. International Journal of Trend in Scientific Research and Development, 4(6), 1958-1976.

[16] McKenna, K., Northey, J., & Nichols, B. (2014). Financial data interchange standards. Handbook of Financial Data and Risk Information II, 2, 138.
[17] Abran, A., Al-Sarayreh, K. T., & Cuadrado-Gallego, J. J. (2013). A standards-based reference framework for system portability requirements. Computer Standards & Interfaces, 35(4), 380-395.
[18] Craens, G. D. (2007). Standardization of financial transactions (Doctoral dissertation, Faculty of Science and Engineering).
[19] Mäenpää, A. (2015). XML guidelines in ISO 20022 messages: explanations and improvements.
[20] Eyers, D. M., Jones, A. J., & Kimbrough, S. O. (2008, December). On Logic and Standards for Structuring Documents. In Workshop on E-Business (pp. 172-186). Berlin, Heidelberg: Springer Berlin Heidelberg.