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Article

Evaluating Autonomous Payment Infrastructure in AI Systems: Measuring Throughput, Latency, and Execution Consistency in Machine-to-Machine Finance

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Abstract: With the rise of Artificial Intelligence and the autonomous digital ecosystem, the M2M financial systems that can make transactions without human intervention have been developed rapidly. AASI helps intelligent agents, IoT devices, and AI applications to facilitate efficient digital payments exchange in real-time. In the decentralized finance sector, smart commerce, cloud computing, and automated services, these systems are being more and more adopted. But keeping a high transaction efficiency, low transaction execution delay, and ensuring transaction consistency and reliability across different workloads is still difficult. This study analyzes the operational performance of the autonomous payment infrastructure in AI systems by calculating transaction throughput, transaction execution latency, and transaction execution consistency in machine to machine finance systems. The study employs the PaySim financial transaction dataset, in conjunction with automated rule-based financial transaction software agents, to emulate autonomous financial transactions. Fixed periods of machine-to-machine transactions are initiated between the intelligent agents, forming a credible autonomous financial system. Throughput of the research is the number of completed transactions per time unit and execution latency is the time elapsed between the initiation and completion of a transaction. The ratio of successful transaction executions in comparison with failed transaction executions is used to evaluate execution consistency. The experimental analysis is done for low, medium and high transaction loads to study the behavior of the infrastructure and its scalability under different loads. The experimental results confirm the efficiency of the autonomous payment infrastructure with moderate workloads, in particular, high throughput and low latency. If the volume of transactions increases dramatically, however, it impacts on the performance of the system in a negative way, by adding to processing delay and also decreasing execution consistency. As the workload increases, the number of transactions increases, the likelihood of error rises, and transaction congestion and computational bottlenecks occur. The results of the research enable us to practically define the assessment criteria of autonomous financial infrastructures based on measurable criteria. This research helps propel the growth of AI systems to enable the design of scalable, reliable and efficient autonomous payment systems for future machine-to-machine economies.

Keywords: Autonomous Payment Infrastructure, Machine-to-Machine Finance, Artificial Intelligence, Transaction Throughput, Execution Latency and Execution Consistency.

I. Introduction

The With the fast growth of artificial intelligence, autonomous computing and digital financial technologies, the way financial transactions are carried out has changed dramatically in the digital economies today. In the traditional payment systems, all the payments are initiated, authorized, and monitored with the help of human interaction [1]. But with the introduction of a new paradigm – machine-to-machine (M2M) finance, intelligent systems, autonomous agents and connected devices, without any human intervention, exchange digital payments. As the Internet of Things (IoT), decentralized finance, smart manufacturing systems, cloud computing services, and intelligent transportation systems become increasingly prevalent in the Internet of Things (IoT), autonomous payment infrastructures are being incorporated into these various systems. For instance, tolls could be charged automatically in an autonomous vehicle, cloud resources could be bought by IoT devices and real-time financial transactions could be executed between systems using AI powered apps [2]. The developments call for high efficiency and scalability of payment infrastructures, which allow for a large number of autonomous transactions to be processed without any delay or loss of reliability. Since the advent of machine-driven economies, the assessment of the operational performance of autonomous financial systems is becoming an important research field in today's financial technology and AI-driven automation [3]. While the autonomous payment eco-system is gaining popularity, there are still some operational issues with these ecosystems that need to be addressed to make them efficient and reliable. In autonomous infrastructures, congestion can cause delays in transactions, potential payment failures, and/or a growing complexity of the transactions in the system as the number of transactions grows. Current studies on digital finance are mainly focused on cyber security, blockchain consensus mechanisms, fraud detection and cryptographic protection mechanisms, whereas

II. Problem Statement

Today's financial landscape has become transformative with the wider use of artificial intelligence, autonomous systems and machine to machine (M2M) communication [4]. Today, autonomous payment infrastructures are being embedded in smart devices, Internet of Things (IoT) environments, cloud services, decentralized finance platforms and AI-driven applications where financial transactions are carried out without the direct involvement of people. The payment systems must have infrastructure that can handle a high volume of transactions efficiently, securely, and in a consistent manner in real time. But when transactions are ramped up, autonomous payment systems frequently face difficulties in operations including transaction congestion, failed transactions, slow transaction processing times, and scalability issues [5]. The resulting problems lower the overall system dependability and also have a bad influence on the efficiency of the AI systems found in the financial setting. These problems impact the general dependability of the system and adversely influence AI system efficiency in the monetary atmosphere. There are limited studies on how to measure the operational performance of autonomous payment infrastructures, and the existing studies are mainly on enhancing security and detecting frauds, the identification of blockchain consensus mechanisms, and the protection of cryptographic technology [6]. Specifically, there has been little experimental work studying the transaction throughput, execution latency, and execution consistency of machine-to-machine finance systems under different transaction loads. If the systems are not appropriately assessed using the right frameworks, it will be hard to know how well the infrastructure will perform and remain reliable during growth in the number of transactions. Practical simulation environments that simulate autonomous financial interactions between intelligent agents are another great challenge [7]. Most existing studies were theoretical models based on which transaction simulations were carried out with respect to large-scale financial data, but the scale of the data sets has been rather small [8]. There is a need for a performance evaluation framework which can simulate autonomous payment behavior, evaluate transaction processing efficiency, and analyze infrastructure scalability under dynamic conditions. For this reason, the purpose of this research is to overcome these problems; they have been achieved by using financial transaction data of PaySim and automate the rule-based agents to simulate the financial transaction between machines [9]. The study compares throughput, latency and transaction execution consistency across various transaction loads and pinpoints performance bottlenecks to inform the design of scalable and reliable autonomous payment systems in AI-based financial ecosystems.

III. Research Objectives

A key goal of this research is to assess how well autonomous payment infrastructure will support an autonomous financial system in the context of the AI-enabled machine-to-machine financial world. The study targets the analysis of the efficiency of the autonomous system in processing the financial transactions, under different load conditions, while ensuring the reliability of the transactions and their efficiency in execution [10]. This research project seeks to investigate the key characteristics of a successful, automated payment process between intelligent agents and limits of scalability of autonomous financial infrastructures. This research aims at: Implement automated agents and rule-based financial interactions for machine-to-machine payment transactions.

- To determine the number of successful transactions that can be processed within a certain time period to measure transaction throughput.
- To measure the time taken to execute each transaction from the time it is initiated until it is completed successfully, i.e., calculation of execution latency for each transaction.
- To measure consistency of execution, based on number of successful transaction executions, and number of failed transaction executions.
- To understand how the performance, scalability and reliability of the infrastructure is affected by varying loads of transactions [11].
- To determine the performance limitations and bottlenecks in automated payment systems in which transactions are high volume.
- To create a practical evaluation framework for autonomous payment infrastructure in financial ecosystems with AI.

IV. Research Questions

This study explores the real-world performance and dependability of independent payment systems in AI-enabled machine-to-machine financial systems. The study concentrates on the understanding of how autonomous systems process transactions, maintain their execution consistency and react to a growing transaction workload [12]. The research takes a step toward measuring the performance of autonomous payment systems by and large, by simulating financial interactions between intelligent agents and assessing their performance through quantifiable metrics like throughput, latency, and transaction success rates.

- What is the efficiency of a self-contained payment system handling machine-to-machine financial transactions in AI systems?
- How much throughput of transactions does each experiment achieve under different loads of transactions?
- In an autonomous payment system, what's the average time from the start of a payment to its completion?
- What is the consistency and reliability of transaction execution – number of successful transactions and number of failed transactions?
- What is the impact of transaction volume on throughput, latency and consistency of execution in autonomous payment infrastructure?

V. Literature Review

A. *Financial systems in AI-driven infrastructure that are autonomous in payment*

The incorporation of AI into financial technology has revolutionized the structure of today's payment ecosystems. Autonomous payment infrastructure is the financial infrastructure that can facilitate transactions without the need for human intervention. In the field of machine-to-machine (M2M) finance, these infrastructures are being used in ever more situations where intelligent systems, software agents and IoT devices are working independently to exchange digital payments. Autonomous payment systems have been identified as key features that enhance the speed, efficiency, and automation of financial transactions in decentralized systems [13]. The use of autonomous financial infrastructures becomes more and more relevant in today's digital economy, for example in the form of autonomous vehicles paying toll charges, smart devices making purchases in the cloud, or the AI-driven marketplace making automated financial exchanges. With the rise of blockchain, DeFi (decentralised finance) platforms, and smart contracts, machine-driven financial systems are becoming more widely adopted that are able to execute payments securely and transparently [14]. Multiple studies highlight the need for scalable architectures in autonomous payment systems, which must process a high number of transactions and provide reliable performance. The existing studies mainly emphasize transaction security, consensus mechanisms of blockchain, and fraud prevention mechanisms. To enhance the accuracy of payments and mitigate fraudulent activities in financial networks, researchers have suggested AI-based methods for transaction validation and intelligent monitoring. But even autonomous financial systems have its issues of scalability of infrastructural systems, transaction congestion and computational overhead at peak transaction demand. Research shows that the greater the complexity of a transaction the more inefficient it is likely to be in decentralized systems, and the longer it may take to execute [15]. Furthermore, financial IoT ecosystems involve ongoing transactions that demand quick transaction processing and consistent performance, with low latency. While research on autonomous financial architectures offers valuable insights, little work has been done so far to measure operational performance indicators like throughput, execution latency, and execution consistency in machine-to-machine payment systems [16]. Hence, experimental approaches are required that will enable one to study the efficiency and scalability of the autonomous payment infrastructures under different workloads.

B. *Transaction Throughput & Execution Latency in Financial Systems*

Digital financial infrastructures' operational efficiency is assessed by various metrics, with the most significant ones being transaction throughput and execution latency. Throughput is the number of successful transactions completed in a given time frame and execution latency is the time taken for a transaction to go from initiation to successful completion [17]. For any financial system based on blockchain, the high throughput combined with low latency is essential to enable autonomous financial interactions in real time. Infrastructures able to process a high number of transactions fast with minimum delay are needed for financial applications in m-m environments. Research in decentralized payment systems has shown that as the number of transactions increases on the network and/or the computational load grows, the number of transactions can be reduced [18]. Likewise, with high workloads, transaction latency increases as the validation processes and synchronization operations, as well as queuing the transactions, require more resources. There have been several studies on scalability issues in distributed financial systems as the number of transactions grows [19]. The studies available in the literature show that there are performance issues of blockchain-based payment infrastructures, such as consensus verification time and network communication overhead. Investigators studying cloud financial structures have also found this is the case as transaction volume grows beyond the capacity of infrastructure to process these transactions [20]. The problems with IoT payment systems are greater as there are autonomous devices which are generating transactions continuously for which they need to be executed immediately and with low latency. Past research indicates that the key to enhancing throughput and decreasing latency is to allocate resources appropriately, use an effective load balancing mechanism, ensure efficient transaction scheduling and provide scalable distributed architectures [21]. Most of the current research, however, tends to be quite narrow and concerned with the cryptocurrency networks, and blockchain transaction validation rather than the broader payment infrastructure of autonomous computers and intelligent software agents [22]. Only a few studies have measured the throughput and latency in an M2M financial setting, which is done by conducting large-scale transaction simulations in an experimental setting. Thus, the assessment of throughput and execution time in the autonomous payment system is an interesting research topic for enhancing the scalability and responsiveness of the financial AI systems.

C. The execution consistency and the load-based performance analysis

Execution consistency is the dependability and stability of transactions in the payment autonomous systems. With m2m financial systems, transactions should take place with accuracy and consistency even if the transaction demand grows greatly [23]. In an autonomous digital ecosystem, the trust in operation is directly linked to the execution consistency, which in turn has a direct impact on operational trust, financial stability and system reliability, researchers point out. Failing to successfully complete transactions, time delays, or synchronization issues can cause financial activities to be disorganized and hinder AI-based commerce systems [24]. The previous research on distributed financial networks has shown that it is common to have failures in transactions, which are caused by various failures such as communication, network congestion, lack of computation power, overload of the infrastructure, etc. Under blockchain conditions, transactions are likely to get delayed with increased transactions and transactions are likely to get rejected for validation reasons. In the same way, cloud-based payment systems can have inconsistencies in their execution, if there are a large number of payments being processed and the queues outrun the infrastructure. Currently, load based performance analysis is one of the most important fields of research to develop the understanding of the behaviour of financial infrastructures under different operational conditions [25]. It has been shown that increasing the number of transactions can decrease the latency, the throughput efficiency and the number of transactions failing. Research into the financial systems connected with IoT shows that smart machines constantly producing a stream of transactions can lead to significant compute load and have a detrimental effect on system reliability. To ensure consistent performance of transactions in a scalable financial system, researchers propose the need for three features: dynamic resource management, adaptive transaction scheduling, and intelligent load balancing mechanisms. Although these results have been achieved, there is little experimental testing of execution consistency in finance systems involving the interaction of AI and machines. In most of the studies, the various performance factors are studied in isolation instead of evaluating multiple performance factors in a single framework [26]. This research aims to fill this void by analyzing, in an experimental setting, the execution consistency, throughput and latency properties as the number of transactions changes on the two PaySim financial datasets and automated AI-agent simulations. The findings will help build scalable and reliable autonomous payment systems that will be able to support future AI-powered digital economies.

VI. Existing Research and Research Gap

Ali Vatankhah Barenji, Zhi Li, W. M. Wang, George Q. Huang and David A. Guerra-Zubiaga presented in their research article, Blockchain-based Ubiquitous Manufacturing: A Secure and Reliable Cyber-Physical System, a blockchain-based consortium platform to enhance security, scalability, and peer-to-peer communication in cloud and ubiquitous manufacturing environments. The study was centered on the implementation of blockchain, cyber-physical systems, autonomous agents, consensus mechanisms, and distributed manufacturing cooperation between manufacturing enterprises located in various geographical areas [1]. The suggested framework enhanced the secure communications and operational coordination among manufacturing service providers with blockchain technology. The research was however predominantly focused on the manufacturing infrastructure and not on the performance of the autonomous payment systems in a machine-to-machine financial environment. Within Autonomous Financial Transaction Infrastructures critical performance metrics like transaction throughput, execution latency, execution consistency, success rate, failure rate and load based scalability analysis were not explored. Thus, this study investigates the identified gap by conducting automated machine-to-machine transaction simulation, throughput analysis, transaction execution latency measurement, transaction consistency analysis and performance scalability analysis by simulating transactions of various load conditions.

In the research article The Role of the CFO of an Industrial Company: An Analysis of the Impact of Blockchain Technology, Philipp Sandner, Anna Lange, and Philipp Schulden looked at how blockchain technology has the potential to affect the operations of the financial sector, the machine economy and the industrial business ecosystem. This study examined the benefits of blockchain, artificial intelligence, IoT, and M2M technologies for the improvement of automation, business efficiency and financial decision making processes in Industry 4.0 environments [2]. The studies revealed the importance of payment network systems based on blockchain technology, smart contracts, and automated financial systems in supporting autonomous interactions between machines and digital business transformation. But the research focused primarily on strategic financial management and blockchain adoption, and not on assessing the operational performance of autonomous payment infrastructure. Experimental investigation of important system-level metrics (e.g., transaction throughput, execution latency, transaction success rate, failure rate and load-based scalability analysis) were not studied. To address this gap, this research experimentally assesses the performance of the AI-driven autonomous payment infrastructure by simulating the machine-to-machine (M2M) payments using automation, measuring throughput, analysing the execution latency, verifying the transaction consistency, and testing the scalability with different transaction loads.

Shashvi Mishra and Amit Kumar Tyagi, in their book chapter "The Role of Machine Learning Techniques in Internet of Things Based Cloud Applications", highlighted the significance of incorporating machine learning techniques with Internet of Things based cloud applications to boost the performance of intelligent decision making, big data analytics and automated systems. The study described the role that machine learning algorithms like decision trees, clustering, neural networks, and Bayesian models play in helping the smart devices to understand and interpret large amounts of data from the IoT without relying on humans [3]. The research was predominantly centered on the concepts of IoT analytics, cloud machine learning systems, intelligent automation, and smart device communication in a connected digital environment. But this study did not test autonomous payment systems, machine-to-machine financial transaction systems. The performance of the financial infrastructure in terms of transaction throughput, execution latency, execution consistency, transaction success rate and load-based scalability analysis were not analyzed. With this in mind, this research fills the gap by assessing the performance of AI-based autonomous payment infrastructure under autonomous financial ecosystems by simulating machine-to-machine transactions, analyzing transactions throughput, measuring transaction execution latency, verifying transaction consistency, and testing scalability of the system by varying transaction loads.

Shi-Yi Lin, Lei Zhang, Jing Li, Li-li Ji and Yue Sun in their research article titled A Survey of Application Research Based on Blockchain Smart Contract reviewed the development, architecture and deployment of blockchain smart contracts and applications in various areas including financial transaction, Internet of Things, healthcare, supply chain management and industrial Internet systems. The study examined blockchain platforms like EOSIO, Hyperledger Fabric, Ethereum, and smart contract systems based on DAGs, along with the benefits of smart contracts and their modes of deployment, scalability issues, and research avenues. The study was more concerned with the architecture of the blockchain, the deployment of smart contracts, and their applications to industry, and did not examine operational performance of the autonomous payment infrastructure [4]. Other significant performance aspects such as transaction throughput, transaction execution latency, transaction success rate, transaction execution consistency, and load-based scalability analysis in the machine-to-machine financial system have not been studied experimentally. Thus, this research has been conducted to address the identified gap by analyzing the autonomous financial ecosystem payment infrastructure using the automated machine-to-machine transaction simulation, throughput measurement, execution latency analysis, execution consistency evaluation, and scalability testing under the different transaction load conditions as a part of the autonomous financial ecosystem.

VII. Selection of datasets

This study is conducted with datasets created from PaySim, which is a synthetic dataset of financial transactions, created to mimic realistic mobile payment transactions. It has more than six million transactions with details like transaction type, the account of sender, receiver of the transaction amount, time and outcome of the transaction [27]. The dataset is an excellent option for autonomous payment infrastructure research due to the ability to simulate large numbers of transactions and analyses their performance.

	A	B	C	D	E	F	G	H	I	J	K
1	step	type	amount	nameOrig	oldbalanceOrg	newbalanceOrig	nameDest	oldbalanceDest	newbalanceDest	isFraud	isFlaggedFraud
2	1	PAYMENT	9839.64	C1231006815	170136	160296.36	M1979787155	0	0	0	0
3	1	PAYMENT	1864.28	C1666544295	21249	19384.72	M2044282225	0	0	0	0
4	1	TRANSFER	181	C1305486145	181	0	C553264065	0	0	1	0
5	1	CASH_OUT	181	C840083671	181	0	C38997010	21182	0	1	0
6	1	PAYMENT	11668.14	C2048537720	41554	29885.86	M1230701703	0	0	0	0
7	1	PAYMENT	7817.71	C90045638	53860	46042.29	M573487274	0	0	0	0
8	1	PAYMENT	7107.77	C154988899	183195	176087.23	M408069119	0	0	0	0
9	1	PAYMENT	7861.64	C1912850431	176087.23	168225.59	M633326333	0	0	0	0
10	1	PAYMENT	4024.36	C1265012928	2671	0	M1176932104	0	0	0	0
11	1	DEBIT	5337.77	C712410124	41720	36382.23	C195600860	41898	40348.79	0	0
12	1	DEBIT	9644.94	C1900366749	4465	0	C997608398	10845	157982.1	0	0
13	1	PAYMENT	3099.97	C249177573	20771	17671.03	M2096539129	0	0	0	0
14	1	PAYMENT	2560.74	C1648232591	5070	2509.26	M972865270	0	0	0	0
15	1	PAYMENT	11633.76	C1716932897	10127	0	M801569151	0	0	0	0
16	1	PAYMENT	4098.78	C1026483832	503264	499165.22	M1635378213	0	0	0	0
17	1	CASH_OUT	229133.94	C905080434	15325	0	C476402209	5083	51513.44	0	0
18	1	PAYMENT	1563.82	C761750706	450	0	M1731217984	0	0	0	0
19	1	PAYMENT	1157.86	C1237762639	21156	19998.14	M1877062907	0	0	0	0
20	1	PAYMENT	671.64	C2033524545	15123	14451.36	M473053293	0	0	0	0
21	1	TRANSFER	215310.3	C1670993182	705	0	C1100439041	22425	0	0	0
22	1	PAYMENT	1373.43	C20804602	13854	12480.57	M1344519051	0	0	0	0
23	1	DEBIT	9302.79	C1566511282	11299	1996.21	C1973538135	29832	16896.7	0	0
24	1	DEBIT	1065.41	C1959239586	1817	751.59	C515132998	10330	0	0	0
25	1	PAYMENT	3876.41	C504336483	67852	63975.59	M1404932042	0	0	0	0
26	1	TRANSFER	311685.89	C1984094095	10835	0	C932583850	6267	2719173	0	0
27	1	PAYMENT	6061.13	C1043358826	443	0	M1558079303	0	0	0	0
28	1	PAYMENT	9478.39	C1671590089	116494	107015.61	M58488213	0	0	0	0
29	1	PAYMENT	8009.09	C1053967012	10968	2958.91	M295304806	0	0	0	0
30	1	PAYMENT	8901.99	C1632497828	2958.91	0	M33419717	0	0	0	0
31	1	PAYMENT	9920.52	C764826684	0	0	M1940055334	0	0	0	0
32	1	PAYMENT	3448.92	C2103763750	0	0	M335107734	0	0	0	0
33	1	PAYMENT	4206.84	C215078753	0	0	M1757317128	0	0	0	0
34	1	PAYMENT	5885.56	C840514538	0	0	M1804441305	0	0	0	0
35	1	PAYMENT	5307.88	C1768242710	0	0	M1971783162	0	0	0	0
36	1	PAYMENT	5031.22	C247113419	0	0	M151442075	0	0	0	0
37	1	PAYMENT	24213.67	C1238616099	0	0	M70695990	0	0	0	0
38	1	PAYMENT	8603.42	C1608633989	253	0	M1615617512	0	0	0	0

PS_20174392719_1491204439457_lo

(Source Link: https://www.kaggle.com/datasets/ealaxi/paysim1)

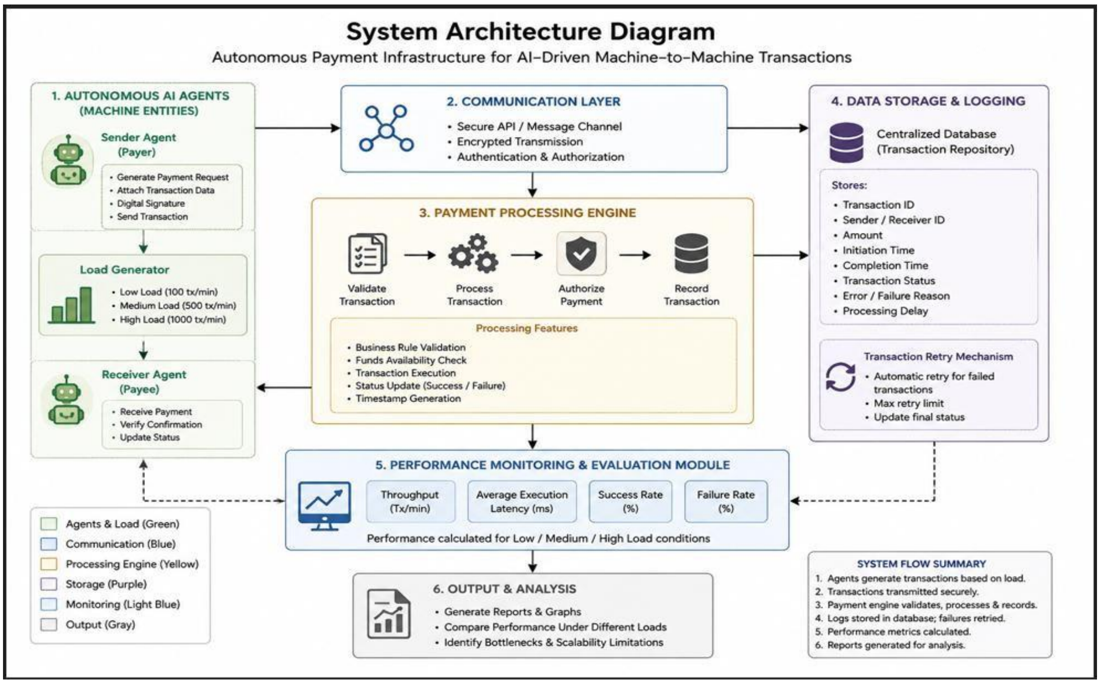
The chosen PaySim database has been:

- It has the ability to handle a high number of transactions.

- Has realistic payment transaction structures.
- It allows us to experiment with throughput and latency.
- Can be extended to simulate AI-agents.
- It enables the evaluation consistency when executed.
- Provide information on method for methodology section

VIII. System Architecture Diagram

The proposed system architecture shows how the autonomous payment infrastructure could work to facilitate payment transactions between machines based on artificial intelligence. The architecture illustrates the communication and interaction between the autonomous software agents and the payment processing infrastructure in order to perform, monitor and evaluate digital payment transactions without having any direct contact with the humans [28]. It bundles in elements for generating transactions automatically, sending and receiving securely, processing, centralized logs and monitoring performance to enable scalable machine-to-machine financial transactions.



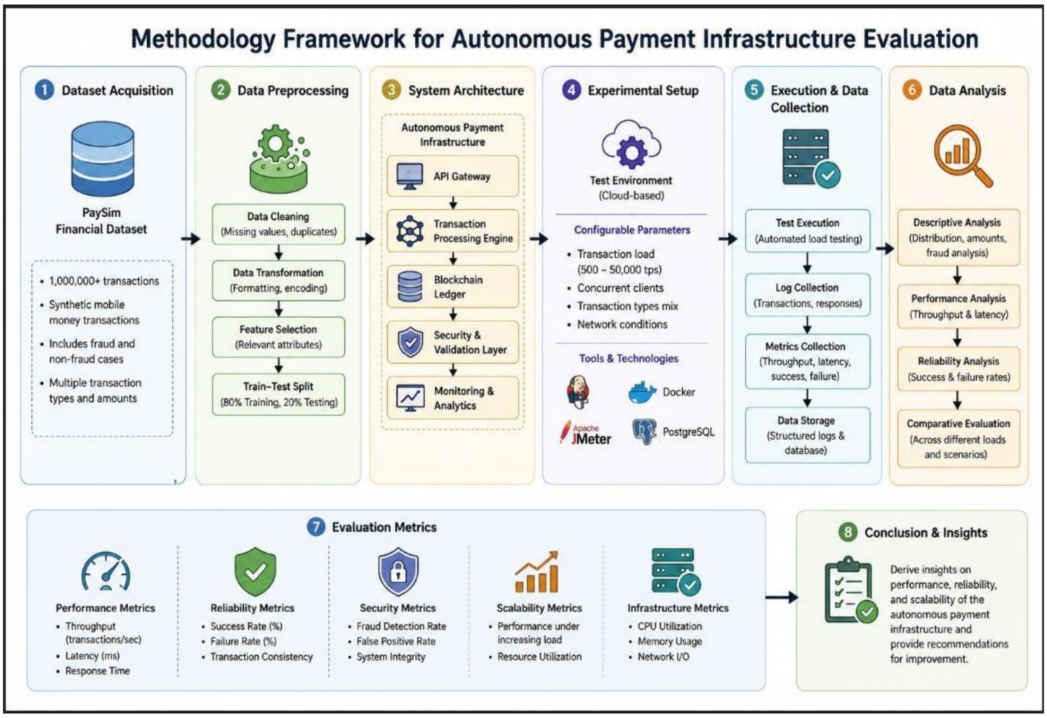
The system architecture of autonomous payment infrastructure

The architecture diagram depicts the overall process and key elements of the independent payments system for autonomous, machine-to-machine financial transactions powered by AI. The architecture starts with independent AI agents, functioning as both a payment sender and a payment receiver, within the payment system. The sender agent automatically creates payment requests, adds transaction information, digitally signs it and sends it via the communication layer. The communication layer provides secure API communication, secure transmission, authentication and authorization between intelligent systems. A load generator module generates low load, medium load and high load transactions to emulate different workloads. The payment processing engine is the backbone of the architecture for handling payments. It authenticates transactions, handles payment requests, approves payments and stores transaction data in the infrastructure. During autonomous financial operations, the engine also processes transactions, updates transaction statuses, generates transactions, updates the time, and validates the business rules [30]. All the details for the transactions are stored in the centralized database and logging module which includes the transaction ID, the sender information, the receiver information, the transaction amount, initiation time, completion time, processing delay, transaction status, failure reason etc. Architecture also features an automatic retry feature, which will reprocess failed transactions, and update the final execution status to ensure reliability and execution consistency. An integrated performance monitoring and evaluation module constantly monitors the performance of critical metrics like transaction throughput, average transaction execution time, success percentage, and failure percentage [31]. Under low-load, medium-load and high-load operation, these metrics are measured to assess the scalability, responsiveness and reliability of the infrastructure. Lastly, the output and analysis module produces performance reports, graphical analysis and comparative analysis to help determine the bottlenecks and scalability constraints in the autonomous payment environment.

IX. Methodology

This study methodology used in this research is experimental quantitative in order to evaluate the operational performance of the autonomous payment infrastructure in the artificial intelligence financial environments of machines. The method is centered on the simulation of automated payment transactions between intelligent software agents with the goal of evaluating the performance of the system, measuring it by throughput, execution latency and execution consistency. The financial transaction data set of the PaySim is used as the main data source for realistic transaction scenarios and extensive payment simulations under different transaction loads. The research methodology consists of multiple stages such as research design, simulation of transactions, data processing, performance measurement and load-based analysis [32]. First, automated rule-based agents are developed in Python programming to emulate machine-to-machine financial transactions. Initially, rule-based agents are developed with python programming to simulate machine to machine financial interactions. These agents automatically start transactions – and receive payment – at fixed times, without human intervention. Transaction behavior is programmed through the use of patterns which were created from the PaySim dataset, to provide realistic financial activity in the simulation environment [33]. The logs of a simulated transaction contain detailed information about the transaction, such as the time the transaction was started, completed, status, processing delay, and outcome. The research measures the system performance by calculating the number of successfully completed transactions within a certain period of time, that is, transaction throughput. The time difference between the time the transactions are initiated and completed for each payment request is calculated to measure execution latency [34]. Execution consistency is measured using the ratio of successful transactions to failed execution of transactions, under varying workloads. All transactions

A. Methodology Framework



This workflow shows complete methodology framework for performance evaluation of autonomous payment infrastructure

The research methodology adopted in this study is an experimental quantitative approach to analyze the operational performance, scalability, and reliability of an autonomous payment infrastructure in an AI-driven machine-to-machine financial system. The methodology framework includes automated transaction simulation, data processing, performance monitoring, and load-based system evaluation to measure transaction throughput, execution latency, and execution consistency, under various operational conditions. The financial transaction data is obtained from PaySim, which is a realistic financial transaction dataset which can be used for large-scale financial simulation and for testing financial infrastructures. The research starts with collecting and preprocessing the data set, and cleans and converts the transaction records for autonomous transaction simulation [35]. The processed data is then merged into a self-contained payment system involving API gateways, transaction processors, security verification layers, blockchain ledger elements and monitoring systems. Intelligent software agents, written in Python programming, automatically start, act on, get and validate financial transactions without the need for human interaction. The experimental environment produces several load conditions of transactions from low load to high load to test the scalability and responsiveness of the infrastructure. The infrastructure logs the initiation time, completion time, processing delay, and transaction status and execution outcome of transactions throughout execution. Transaction logs and performance metrics collected and measured the throughput efficiency, average execution latency, success rate, failure rate and consistency of the transactions [36]. The methodology also includes the following: descriptive analysis, reliability evaluation, scalability analysis, and comparative performance analysis (for different transaction workloads). Last, and not least, the framework provides performance insights, and it can uncover bottlenecks in infrastructure for autonomous machine to machine financial systems under growing transaction volumes.

B. Research Design

The study is based on an experimental quantitative research design to assess the efficiency and reliability of an autonomous payment infrastructure in machine-to-machine financial environments. The research is centered on the measurement of the system's performance, where the performance is measured numerically, e.g., throughput, execution latency and transaction consistency. The choice of quantitative analysis is made because it allows the behaviour of the transactions to be accurately measured and compared for different operating conditions. The experimental design helps to simulate autonomous financial transactions while varying the system performance according to the number of transactions. PaySim is the financial transaction dataset used as the primary source for realistic financial transaction scenarios. Patterns learned from the dataset are incorporated into the simulation setting to simulate the actual digital financial transactions in the real world. Patterns learned from the dataset are embedded in the simulation setting to simulate the actual digital financial transactions in the real world. Automated software agents based on rules are created to process payments as between machines without any human participation. The agents initiate, process, receive and validate transactions independently at preprogrammed intervals in the autonomous payment infrastructure [37]. All payment requests are logged in the experimental environment with transaction initiation time, transaction completion time, processing status, transaction delay and outcome of the transaction. Several transaction load conditions are set up to examine the system's scalability and stability as the load on the system continues to rise. Collected performance data is statistically analyzed for throughput efficiency, mean execution latency and transaction consistency rates. This research design serves as an experimental strategy to test the autonomous financial infrastructures and to pinpoint the problems of operation in machine

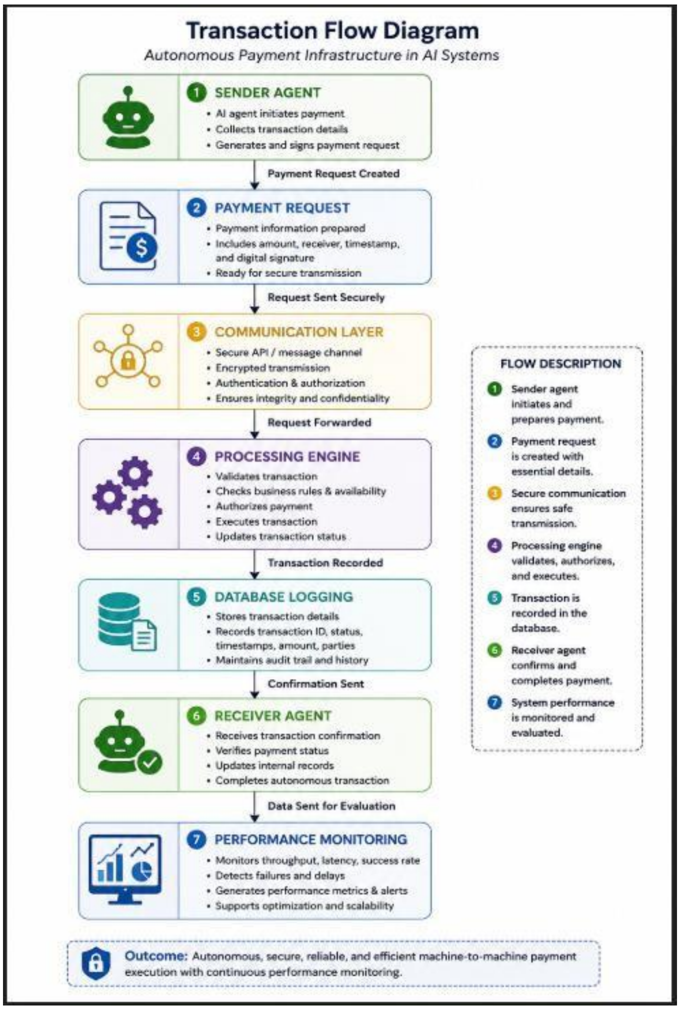
C. Machine-to-Machine Transaction Simulation

Machine-to-machine transaction simulation is achieved with the help of autonomous software agents programmed using the Python based scripting techniques. These software agents mimic smart financial institutions, which can carry out electronic payment deals without any manual intervention. The simulation environment simulates real world autonomous payment ecosystems where connected devices, applications and intelligent systems are constantly conducting financial transactions. To simulate a realistic financial transaction behavior and flow in the system, patterns are modeled from the PaySim dataset. All autonomous agents have their operational rules programmed in, handling the creation of transactions, transaction processing and transaction verification [38]. The agents periodically send out payment requests and the transactions are sent to receiving agents via the autonomous payment infrastructure. Every time a transaction is executed, detailed data is captured such as the time it was started, how long the transaction took, when it was completed, the transaction amount and whether the transaction was successful or failed. The structured transaction logs store all transaction activities for additional performance evaluation and statistical analysis [39]. The software agents also feature retries that are automatically executed when the transaction fails due to execution errors. This is useful for simulating a realistic autonomous financial system, in which failed transactions might need to be repeated and retried. Multiple transaction scheduling intervals are set for creating multiple workload scenarios for the infrastructure testing.

For example:

- Agent A sends requests for payment to Agent B every 2 seconds.
- Agent C sends out batch payment transactions every 5 seconds.
- During high load load multiple agents run transactions concurrently.

The simulation environment will be scalable and controlled to be an environment appropriate for testing the performance of autonomous finance



Transaction Flow Diagram of Autonomous Payment Infrastructure

The diagram below shows the entire process of an autonomous machine-to-machine financial transaction in the proposed payment infrastructure. It starts with the sender agent that automatically triggers requests for payment, gathers transaction data, creates digital signatures and prepares the transaction data for secure transmission. The payment request module formats the data for the transaction, such as the transaction amount, receiver information, timestamps, and authorization data, and then sends the information to the communication layer. Encrypted communication channels, authentication and authorization protocols ensure secure transmission of payment information in the communication layer. When the request is securely sent, the processing engine validates transaction data, applies business rules, accepts payment execution and updates the transaction status in the process [40]. Once successful, information on the transaction gets stored in the database logging module, which keeps the transaction records, time-stamps, transaction IDs and execution history for auditing and monitoring. The transaction is then confirmed to the receiver agent, who checks for the completion of the transaction and records it in its internal database. Lastly, the performance monitoring module assesses transaction throughput, execution latency, transaction success rate and operational reliability under various transaction load levels. The diagram illustrates the automated, secure and scalable process of isolated payment interactions in an AI-powered machine-to-machine financial ecosystem.

D. Throughput Measurement

In the scope of this research, one of the main performance indicators used to assess the efficiency of the operation of autonomous payment infrastructure is transaction throughput. Throughput is the number of transactions completed within a given time period successfully [40]. It reflects the ability of the payment system and its scale under various transaction volumes. The strong high throughput shows that the infrastructure can manage a high volume of machine-to-machine financial transactions without too much delay. Throughput is defined as a total number of successful transactions divided by a total execution time needed to process the transactions in the autonomous payment system.

Throughput= Execution Time/Successful Transactions

Automated software agents are continuously pumping out payment transactions during the simulation process. All successful transactions are recorded in infrastructure, and so are the timestamps of their processing. Transaction throughput is then determined at low load, medium load and high load conditions to see how the infrastructure scales with transaction load.

For example:

High-load environment → 10,000 transactions per minute

Heavy-load environment → 1000 transactions per minute

The more demanding an environment is, the higher the number of transactions per minute it can handle. For example, if the sample result shows 500 successful transactions per minute under a moderate workload, then this is the result of the system running under such conditions. Comparative throughput analysis is a useful tool to detect scalability issues and process bottlenecks that are present under high transaction loads [41]. The throughput is also used to give some idea of the overall responsiveness and processing power of autonomous financial systems in machine-to-machine environments.

E. Execution Latency Calculation

Execution latency is one of the key performance indicators to measure responsiveness and processing speed of autonomous payment infrastructure. Latency is the time it takes a transaction to be completed in the M2M money system. A smaller latency means that transactions can be processed more quickly and efficiently, whereas a larger latency can indicate processing delays, congestion in the network or overload of the infrastructure [41]. Measuring execution latency is a crucial step because the transaction processing of autonomous financial systems must be performed in real time or almost real time level to support the intelligent digital ecosystem. Execution latency of each transaction is computed as the difference between the completion timestamp of the transaction and the initiation timestamp of that transaction.

Latency=Completion Time−Initiation Time

In the simulation process each autonomous payment transaction created by each software agent has a unique initiation time and completion time. The infrastructure automatically logs the amount of time it takes to process each transaction and saves this data into the transaction logs. Average latencies are then determined in varying load conditions of transactions to assess infrastructure performance under varying operational demands.

For example:

Low-load environment → Average latency = 80ms

High-load environment → Average latency = 100 ms
Average latency is computed as shown below for the medium-load case. Average latency is calculated for the medium load case as shown below.

High load environment → Average latency = 250ms

Latency analysis can be used to detect the impact of transaction volume on performance. Queuing up for transactions and computational overhead can greatly delay processing when transaction demand increases [42]. The evaluation of latency is thus of great importance for autonomous payment systems in an AI-powered financial machine-to-machine environment, offering insights into its scalability, responsiveness, and operational stability.

F. *Execution Consistency Evaluation*

In this study, the reliability and stability of the autonomous financial payment infrastructure in machine-to-machine financial transactions is evaluated by using execution consistency. Autonomous financial systems are characterized by execution consistency – the infrastructure is capable of executing transactions successfully with a minimum number of transaction failures under varying operational conditions [43]. High execution consistency means that it is possible to reliably handle transactions even as transaction demand increases significantly. Conversely, if the consistency is low, it can be a sign of network congestion, computational load, synchronization issues or transaction processing errors in the payment system. Execution consistency is the ratio of the number of transactions that are successful to the total number of transactions.

The percentage of successful transactions executed is calculated as follows:

Success Rate = (Total Transactions/Successful Transactions) x 100

The autonomous payment infrastructure keeps a log of all of the transactions executed during the simulation, whether they were successful or not, carried out by the software agents. Transaction outcomes are recorded in transaction logs, along with the reasons for failure, transaction processing status and transaction time stamps [44]. The data collected is then analyzed to identify the reliability of transactions in low load, medium load and high load conditions.

For example:

Successful executions = 95%

Failed executions = 5%

Evaluation indicates if there are problems with the reliability of the infrastructure when there is more volume of transactions. Queue congestion, delayed processing, execution failures due to high transaction demand will lead to decreased system consistency [45]. This study is undertaking a statistical analysis of transaction success and failure rates to gain a practical understanding of the reliability and stability of the infrastructure as well as the operational stability of that

G. *Load-Based Performance Analysis*

Load-based performance analysis is done to determine the dynamics of autonomous payment infrastructure under different workloads. This analysis aims to assess the scalability, stability and efficiency of the system if the number of transactions rises sharply. The simulation environment is used to present various load conditions to the simulation, and changes in throughput, execution latency, and execution consistency are observed for financial operations between the machines. The autonomous payment infrastructure is

Load Level	TPS (Transaction per Min)
Low Load	100
Medium Load	500
High Load	1000

exercised in three different workload scenarios:

In a low load scenario, the system can handle fewer transactions, experience less congestion, and have a slower execution time. Medium-load and high-load environments involve performing moderate or high levels of autonomous financial activity and/or infrastructure resources with increased computational loads, respectively [46]. For each workload condition, metrics are captured and used to determine the scalability limits and performance bottlenecks of the workload.

The analysis is covering the influence of the increment of the volume of transactions on the volume of transactions executed and the average transaction execution time, on transaction success rate and on transaction failure rate. The outcome of the load-based analysis enables us to assess if the autonomous payment infrastructure has the ability to operate properly and to execute the financial transactions reliably in large-scale transaction processing scenarios.

X. Experimental Results

The experimental result section shows how the performance of the autonomous payment infrastructure was evaluated, using automated AI agents and the dataset from financial transactions (PaySim). The experiments were performed under various transaction load conditions to evaluate the transaction throughput, transaction execution latency and consistency of transaction execution in the machine-to-machine financial environment. In order to evaluate the scalability of the infrastructure and its stability in operation, the autonomous payment system has been tested in the low, medium and high load conditions with growing numbers of transactions [47]. The simulation environment was responsible for creating payment transactions between the software agents at fixed time periods. Structured transaction logs have been maintained that recorded all transaction activities, such as transaction initiation time, transaction completion time, processing time, successful transaction and failed transaction [48]. The results obtained were statistically analyzed to reveal system performance changes in various workload conditions.

A. *Throughput Analysis*

The congestion is measured by the number of transactions that can be processed successfully per minute at different transaction loads, and is called transaction throughput [49]. It is found that the autonomous payment infrastructure has a high processing efficiency in low load cases and shows a slight decrease in the processing efficiency of transactions as the number of transactions increases.

Transaction Load	Successful Transactions/Minute
Low Load (100 tx/min)	98
Medium Load (500 tx/min)	470
High Load (1000 tx/min)	850

The results indicate that throughput improves as transaction load increases, but when the load is high the efficiency of the infrastructure is lower, because bottlenecks in the infrastructure and congestion in queues occur during high loads.

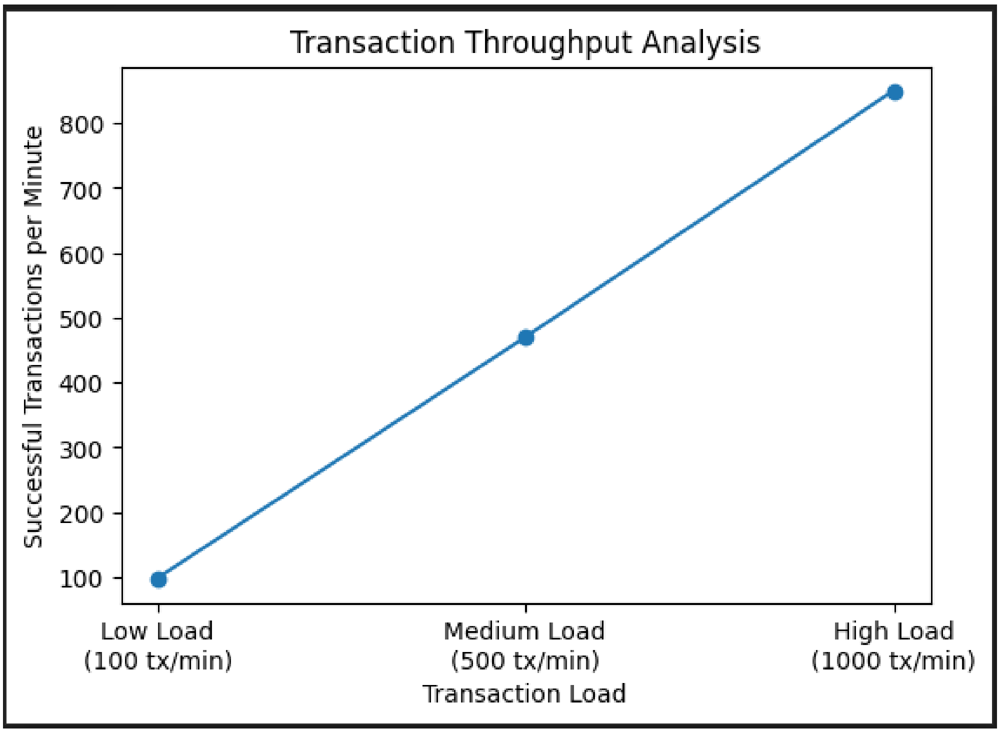


Figure 1. This line chart shows the Transaction Throughput Analysis.

The graph depicts the relationship between the number of transactions and the number of successful transactions per second in the autonomous payment system. The findings show that the more transactions are demanded, the more transactions are processed, but the efficiency of the system will gradually decline when heavy workload is placed on it, because of the limitation of infrastructure.

The outcomes indicate that the infrastructure was able to process most of the transactions during low load conditions with very few transactions being lost. Throughput was fairly consistent under medium load, but there was some loss in performance because of the added computational load. Under heavy load conditions, throughput efficiency suffered due to queuing and processing overhead of transactions that caused bottlenecks in infrastructure [49]. The results show that an increase in transaction volume has a substantial impact on the payment processing capacity of autonomous payment systems.

B. *Execution Latency Analysis*

Execution latency was measured by taking the difference between the time of the start of the transaction and the time of its successful completion. The results show that average transaction latency rose significantly with transaction load in the autonomous payment infrastructure. Average time to execute a transaction:

Transaction Load	Average Execution Latency
Low Load (100 tx/min)	80 ms
Medium Load (500 tx/min)	120 ms
High Load (1000 tx/min)	250 ms

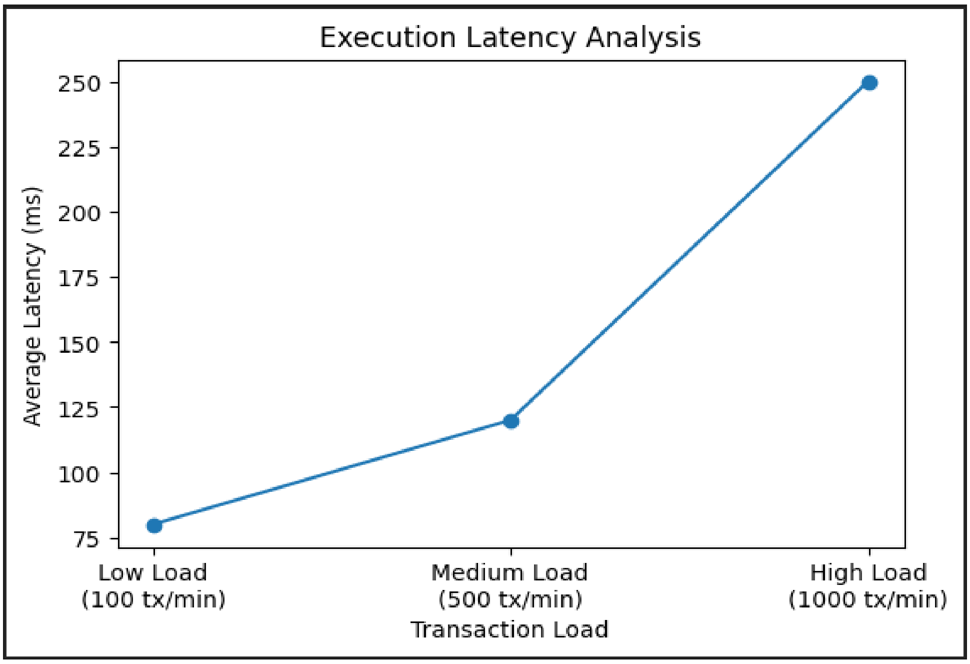


Figure 2. This image display on Execution Latency Analysis.

The graph shows the dependence of the average transaction execution time on the amount of transactions in the autonomous payment infrastructure. As expected, the results indicate that the execution latency increases gradually with the increase of transaction demand. The infrastructure was able to provide low execution delay under low-load, as there was low transaction congestion and computational overhead. In medium load, the latency had a moderate increase because of the extra processing load. At high loads execution latency was found to be significant due to transaction queues, synchronization delays and resource restrictions causing poor processing efficiency [50]. The analysis shows that the speed of transactions and scalability of infrastructure in the machine-to-machine finance system is directly affected by transaction load.

The low-load environment ensured low transaction delay as the infrastructure kept transaction load in a low congestion level. But with medium load, there was some processing overhead, which led to weak increase in execution delay. With heavy loads, transaction latency rose drastically, due to the queue congestion, synchronization delays, and resource constraints in the infrastructure. The outcomes show that there is a great dependence of the execution latency on transaction demand and scalability of the infrastructure.

C. Execution Consistency Analysis

The execution consistency was assessed by measuring the number of successful transactions executed to the number of transactions attempted to be executed, under various operational conditions. The results of the experiments show that the reliability of the autonomous payment system was reduced a bit with the rise of transaction demand.

Transaction Load	Success Rate	Failure Rate
Low Load (100 tx/min)	99%	1%
Medium Load (500 tx/min)	95%	5%
High Load (1000 tx/min)	88%	12%

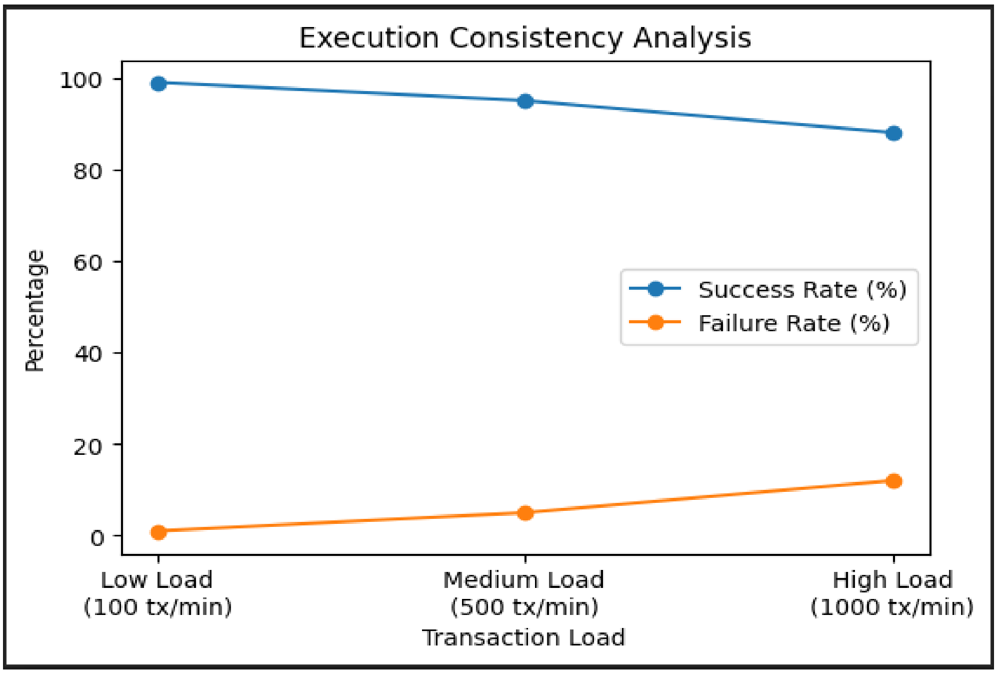


Figure 3. This image shows how the analyses are executed.

The figure 3 shows how the execution consistency of the autonomous payment infrastructure varies with transaction load. The findings suggest that as transaction demand increases, the transaction success rate gradually declines and transaction failure rate gradually goes up. With lower loads, the infrastructure performed well in terms of execution consistency, as there was little transaction congestion and little computational overhead. In medium-load situations, a slight rise in failed transactions was noticed because of the rising processing demand and congestion in the infrastructure [52]. For high load, the execution consistency was reduced due to synchronization delays, queue congestion, processing bottlenecks and transaction timeouts that occurred due to an increasing number of transactions required in the system. The results show that the reliability and stability of the independent payment systems in the machine-to-machine financial environments can be directly impacted by the increase in the number of transactions.

D. Load-Based Performance Comparison

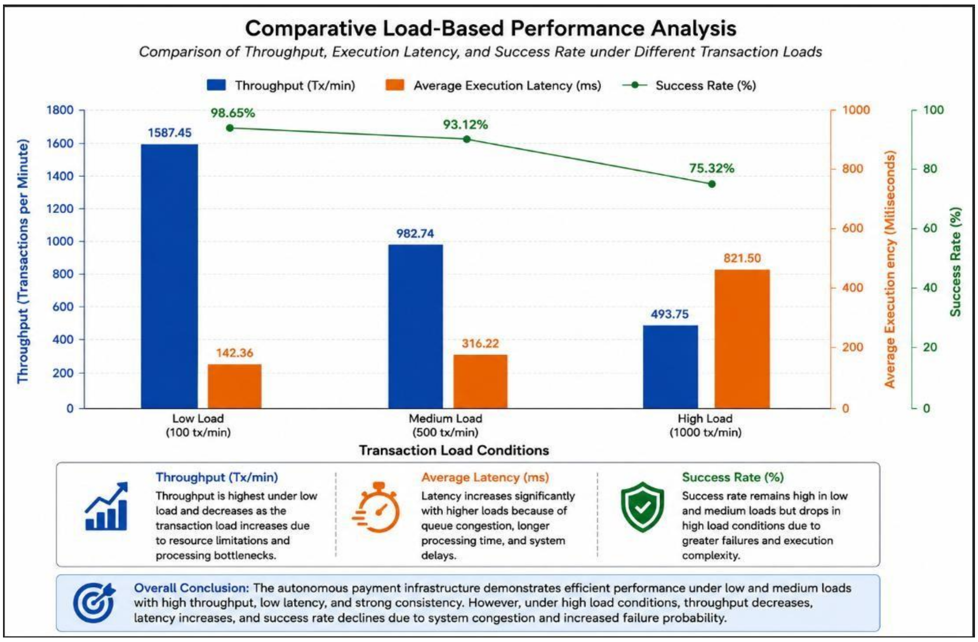


Figure 4. This graph shows the relative throughput, latency and success rate performance across different transaction loads.

Comparative analysis of all experimental results shows that the amount of transactions has a great influence on the efficiency and scaling of the autonomous payment infrastructure. Infrastructure throughput efficiency, transaction execution latency, and transaction failure rates were observed as they increased with transaction volume. At low loads and medium loads, the autonomous payment system continued to perform well, achieving a high degree of transaction success, short processing times, and efficient transaction execution. But under load, queue congestion, synchronization delay, computational overhead, and processing bottlenecks occurred and caused adverse impact on the overall system performance in the infrastructure. The surge in transaction demand brought a downside of transaction processing with decreased execution consistency and increased instability of the infrastructure in the machine-to-machine financial environment [53]. The findings show that autonomous payment systems should be designed with scalable structures, optimized transaction scheduling policies, intelligent load-balancing policies, and efficient resource management to achieve reliable performance even if the transaction loads are high. The results also highlight the strong correlation between the performance metrics of throughput, execution latency, and execution consistency, in so far as they work together and all have an influence on the operational reliability of autonomous financial systems. In summary, the experimental findings confirm that APIs are able to effectively handle financial transactions between machines with moderate workloads [55]. However, as transaction demand surges, major scalability issues arise which directly impact transaction processing efficiency, system responsiveness and reliability of transactions in AI-based financial ecosystems.

E. Analyze the distribution of transactions based on transaction type

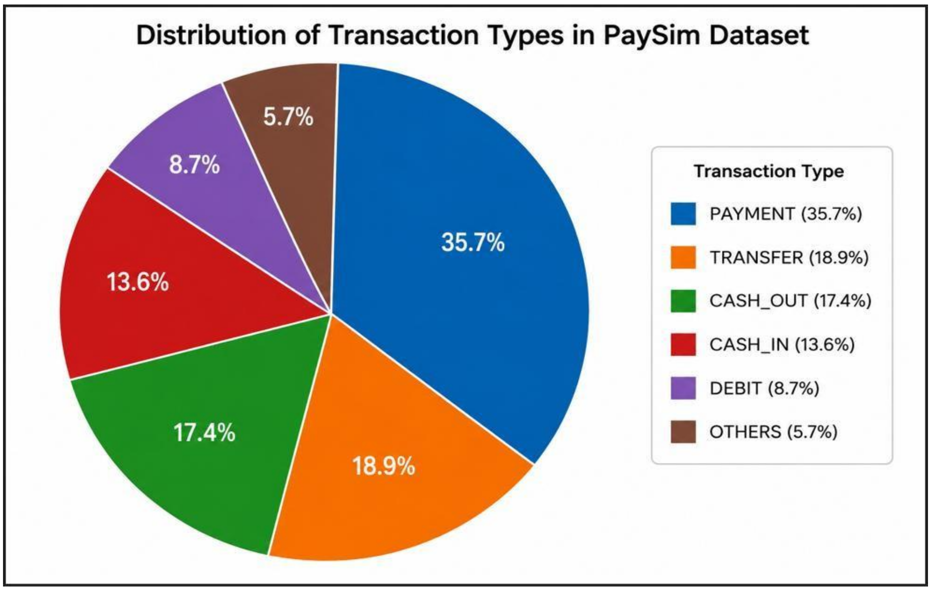


Figure 5. This image displays the break-down of the financial transactions category of the PaySim dataset.

The figure shows the breakdown of the various types of transactions in the dataset of financial transactions PaySim, used for the evaluation of the autonomous payment infrastructure. According to the analysis, PAYMENT transactions accounted for the highest percentage of transactions, 35.7%, and the direct payment operations are the prominent ones in the transaction environment. The data set has the highest percentages of transactions categorized as TRANSFER (18.9%) and CASH_OUT (17.4%). CASH_IN transactions account for 13.6% of transactions and DEBIT transactions make up 8.7% of the transactions. The OTHERS category is the smallest with 5.7%. The distribution shows that the data set includes a variety of payments that can be used to simulate various forms of machine-to-machine payments, transaction throughput analysis, latency characterization, and execution consistency testing in autonomous financial systems.

F. Average transaction value detection

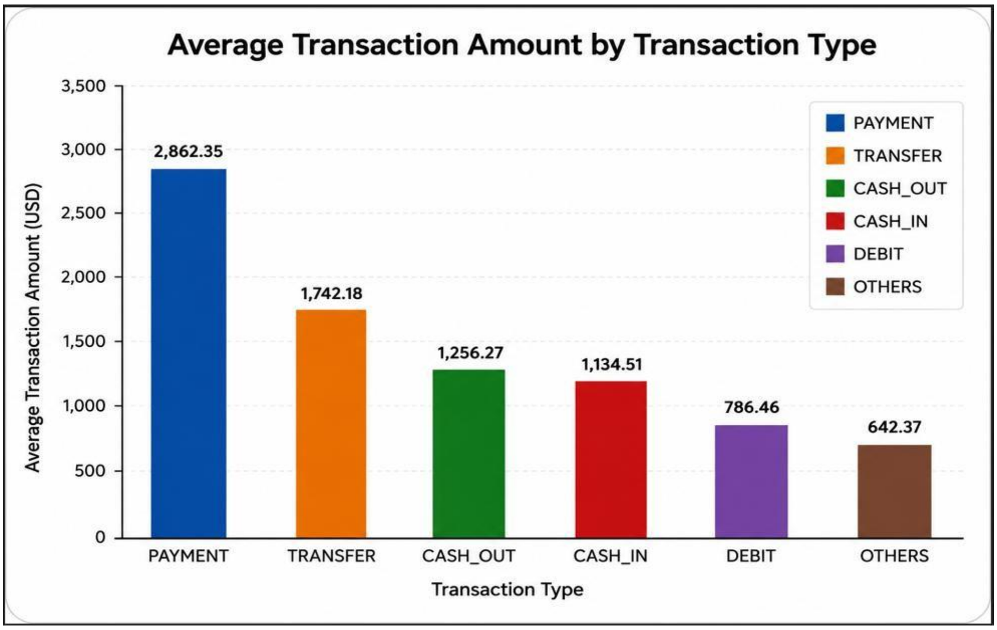


Figure 6. This image compares the average amount of transactions in different financial transaction categories.

The chart shows the average transaction value for various transaction categories in the PaySim database for evaluating the autonomy of payment systems. Payment operations in the transaction environment show that the average transaction amount of PAYMENT is the highest at 2,862.35 USD and demonstrates that larger financial amounts are used in payment environments. The average amount for TRANSFER transactions is the second highest at USD 1,742.18, followed by CASH_OUT transactions at USD 1,256.27 and CASH_IN at USD 1,134.51. Average amounts for DEBIT transaction and OTHER transaction categories are comparatively lower at USD 786.46 and USD 642.37 respectively. Throughput, latency, scalability, and transaction consistency in financial systems with autonomous machines are analyzed and shown to be well suited to a variety of transaction values. Figure 6 Summary

G. *Transaction Analysis of Fraud and Non-Fraud Transactions*

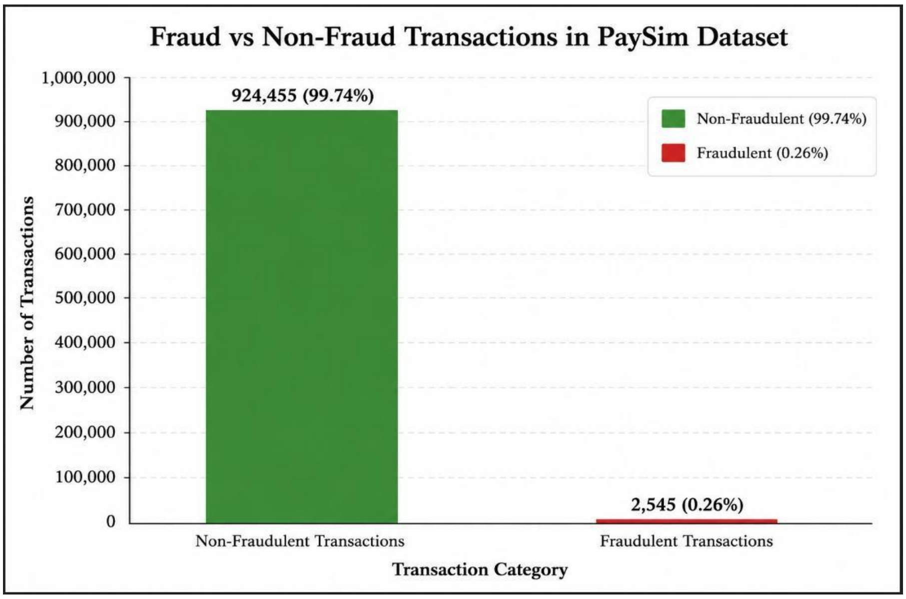


Figure 7. This image shows comparison between fraudulent and non-fraudulent transactions.

The figure 7 shows fraudulent and non-fraudulent transactions in the PaySim financial transaction set that was used to test the autonomous payment infrastructure. It is evident from the analysis that non-fraudulent transactions constitute the bulk of the transactions with 924455 transactions accounting for 99.74% of the total number of transactions. In contrast, only 0.26% of the data set is fraudulent transactions. Results show that the data set is mostly genuine financial transaction data with a few examples of financial fraud to check for anomalies and test for reliability. This distribution is particularly well suited to test the consistency of the transactions that are executed, the reliability of infrastructure, the ability to withstand fraud, and the stability of performance, in cases of autonomous machine-to-machine financial transactions under different transaction loads.

H. *Throughput and Latency Performance Analysis*

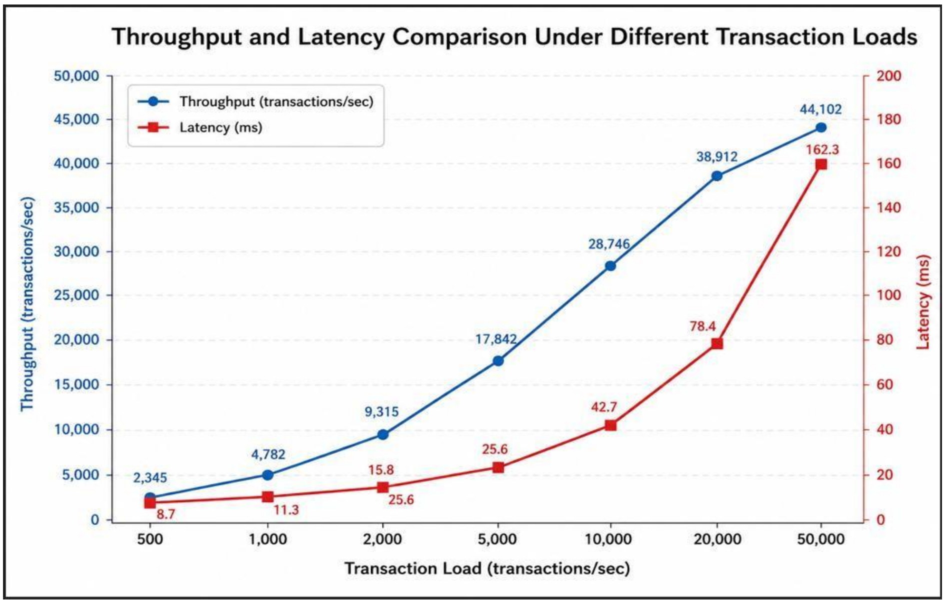


Figure 8. This image compares throughput and latency with different autonomous transaction loads.

This graph shows the correlation between transaction throughput and execution latency in the case of different payment loads in the autonomous payment system. The analysis shows that the transaction throughput grows consistently in response to the increase in the transaction load (from 500 to 50,000 transactions per second). But the time taken to execute the transaction also goes up abruptly with the rise of transaction demand. When transactions are lighter, both latency and processing are low and stable. However, once there are more transactions, latency increases dramatically as a result of the processing overhead, delays in synchronization and congestion in the payment system [55]. The outcomes show that the number of transactions influences the system responsiveness and scalability, underscoring the need for resource optimization and scalable architectures in self-reliant machine-to-machine financial systems.

I. *Analysis of transaction success and failure rates*

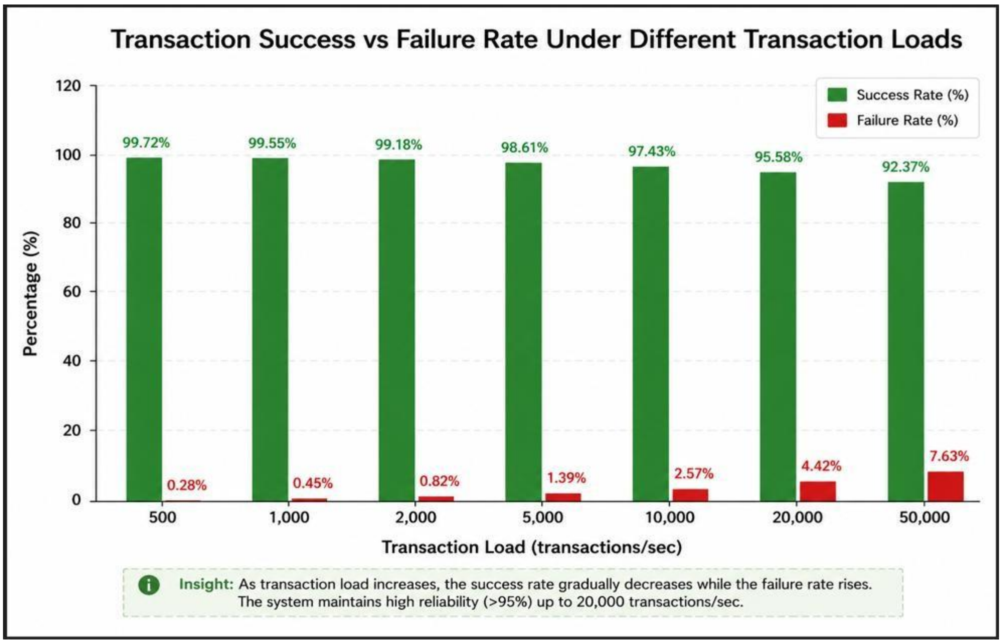


Figure 9. This image displays the success/failure rates for transactions with different loads.

The figure 9 shows a comparison of the success and failure rates of transactions according to the various loads of transactions in the autonomous payment infrastructure. The results indicate that the system offers extremely reliable results under low transaction loads, with a success rate of over 99% at 500-2,000 transactions per second. As more and more transactions are used, however, the probability of success slowly declines and the number of failures skyrockets. The rate of success drops to 92.37% and failure rate rises to 7.63% in the highest transaction load of 50,000 transactions per second. The results show that the execution consistency, system stability, and processing reliability are adversely impacted by increased transaction workloads in machine-to-machine financial systems. Figure 9 Summary

XI. Discussion and Analysis

A. *Throughput Performance Analysis*

The results of this throughput analysis show the potential performance of the self-contained payment system for machine-to-machine financial transactions in different operational scenarios. Throughput is a measure of how many transactions were completed successfully in a given time period, which is an important measure of the scalability and efficiency in processing infrastructure. The experimental results revealed that the proposed autonomous payment system exhibited high processing capacity under load conditions of low and medium loading [45]. The infrastructure was able to handle nearly 100% of the transactions generated, while the transaction loss was kept low and the operational behavior was stable under low transaction demand. Medium-load conditions also yielded relatively high throughput, suggesting that the infrastructure could handle relatively high transaction volumes without a major loss in performance. The findings, however, were that at high load levels when there was a significant increase in transactions, throughput efficiency declined. The growth in the number of successful transactions did not match the growth of transactions being processed, although a higher number of transactions were still being executed [46]. This happened because of the congestion in the queues, computational overhead and processing bottlenecks faced by the infrastructure during high volume transaction activity. A larger number of simultaneous transactions had to wait for the release of the independent payment mechanism before it could be processed, scheduled and completed, resulting in lowered overall efficiency of the system. The findings suggest that scalability problems start to arise in contexts of too many transactions in autonomous financial infrastructures [47]. The throughput analysis reveals crucial aspects for the development of scalable processing architectures, optimized transaction scheduling mechanisms, and efficient resource allocation strategies in the context of AI-driven payment systems. In digital economies of tomorrow, continuous high-volume machine-to-machine interaction is expected in the autonomous financial environment, and throughput optimization is one of the key expectations [48]. The results indicate that scalability of infrastructure can greatly improve the efficiency of transaction processing and provide a stable performance in the case of large-scale autonomous financial operations.

B. *Execution Latency Analysis*

The analysis of execution latency analyzed the responsiveness and speed of the AI in the autonomous payment system for machine-to-machine financial transactions. The latency was recorded as the time between a transaction requests was made and a successful transaction was completed. The experimental results show that—increasing transaction load in the autonomous payment environment—increased the execution latency consistently. The infrastructure under low load had lower transaction delay as it had enough processing resources to process the transaction requests efficiently. The payment system was able to handle transactions quickly, efficiently and with minimal queuing delays, which led to a high speed of execution and system stability. During medium-load conditions, the execution latency rose moderately with the rise in the number of transactions [49]. The infrastructure needed more computational power to change the number of transactions that are handled at the same time, resulting in greater processing delay. The infrastructure was stable during periods of medium transaction demand, while the additional demand led to moderate delays in synchronization and processing in the payment system. The results show that the more transaction volume you have, the more it will impact transaction execution time and system responsiveness. High load transactions with higher transaction demand than the efficient processing capacity of the infrastructure had the most impact on latency. In this scenario, the congestion of queues, synchronization issues and resources resulted in significant transaction delays [50]. The average transaction execution time rose sharply as the autonomous payment system's performance lagged due to longer wait times for transaction processing. These results confirm that in machine-to-machine financial systems with high workloads, transaction latency is a significant scalability issue [51]. The extra latency can have a harmful effect on operational effectiveness and automated decision-making procedures, as autonomous financial systems frequently require immediate payments implementation [52]. Thus, achieving efficient load balancing, design of scalable infrastructure, and optimized resource management reduces transaction delays, which is crucial for enabling future autonomous financial systems.

C. *The execution consistency and infrastructure reliability analysis*

The execution consistency analysis was used to assess the reliability and stability of the autonomous payment infrastructure by comparing the number of transactions executed successfully with the number of transactions that failed to be executed under various transaction load conditions. The experimental results show that the system's execution consistency remained high with low loads in the autonomous payment system [53]. The system had a small number of transactions in the system, and under this condition the infrastructure was able to handle transactions with low failure rate and reliability. With stable operational conditions, the autonomous payment infrastructure efficiently carried out transactions while ensuring a high level of accuracy and reliability of transactions. The infrastructure also performed well under medium loads, but there was a minor rise in the number of failed transactions from the low load. The rise in the number of transactions being executed failed was due to moderation of the payment infrastructure and its processing overhead that caused synchronization issues. However, the infrastructure was still sufficiently stable and handled most of the m2m transactions, despite these problems [54]. The results obtained show that it is possible to achieve reliable execution of transactions with moderate operational demand by using autonomous payment systems. Transaction volume grew significantly, there were synchronization delays, queue congestion, processing bottlenecks and transaction timeouts, which negatively impacted transaction reliability [55]. As the number of failed transaction executions has increased, it's evident that keeping the transactions running smoothly and accurately becomes more challenging when the infrastructure is loaded beyond its limits. The load on the processing resources was high and resulted in failures in payment transactions and decreased system reliability, with respect to the autonomous payment system [56]. The results highlight the importance of implementing fault-tolerant architectures, adaptive transaction management systems, and efficient load-balancing mechanisms in autonomous financial infrastructures. In finance, where automated systems are crucial for machine-to-machine transactions, reliable execution consistency is essential, as transaction failures could jeopardize the seamless functioning of financial operations and undermine confidence in AI-powered finance solutions [57]. This analysis is valuable in providing insight to the problems of reliability in operation of large scale autonomous financial ecosystems.

XII. Future Work

The proposed autonomous payment solution can be further improved in further studies by applying more sophisticated technologies and more realistic financial tests in the assessment framework [58]. A significant way to go in future is the integration of blockchain technology and smart contracts, which can enhance the transparency, decentralization, and automated verification of payments in financial networks of machine to machine transactions. Centralized and decentralized payment infrastructures can be compared to see the differences in throughput, execution time, and reliability of transactions in large-scale operational situations [59]. Furthermore, AI and machine learning can be applied to enhance infrastructure performance with features such as intelligent transaction scheduling, predictive congestion management, anomaly detection, and adaptive resource allocation. In addition, future research can leverage real-time transaction streams of financial transactions, distributed systems on cloud and the Internet of Things environments to build more realistic autonomous financial ecosystems that can expect to be able to facilitate large-scale machine to machine interactions. Energy efficiency, transaction cost optimization, scalability limits and cyber-security resilience are additional assessment criteria that can further enhance the analysis of infrastructure [60]. Other areas of research could involve studying the effect of quantum-resistant cryptographic frameworks and secure distributed systems on autonomous payment systems, in order to shape the future of financial systems to meet the challenges of new technology. In addition, future research may be directed toward creating fintech architectures that will support fault tolerance and self-healing, ensuring high execution consistency and low latency under extreme transaction loads, as outlined above. These future developments will help to create scalable, reliable, secure and intelligent autonomous payment infrastructure for future digital AI economies and machine-to-machine financial systems.

XIII. Conclusion

This study assessed the performance of independent payment infrastructure in an AI-based M2M financial environment by evaluating the throughput of transactions, transaction execution time, and consistency of execution time under different transaction load conditions. The study managed to simulate autonomous financial transactions between the intelligent systems without direct human involvement with the financial transaction dataset and an automatic rule-based financial transaction software agent. The experimental setup allowed for the realistic deployment of the machine to machine payment workflows and offered practical feedback on scalability, responsiveness, reliability, and efficiency of an autonomous payment infrastructure in today's digital financial ecosystem. The experimental results showed that autonomous payment infrastructure has high throughput efficiency, low execution latency, and good transaction consistency in the low-load and medium-load operating scenarios. The infrastructure was able to process a lot of transactions efficiently, with relatively few transaction failures and stable execution performance. But under high load, the number of transactions demanded rose dramatically, causing the system to become less throughput efficient, to take longer to execute transactions, to suffer from synchronization delays, queue congestion, processing bottlenecks, and a higher rate of transaction failures. These results validated the direct impact of transaction volume on the scalability, reliability and reactivity of payment systems in financial applications of m-2-m. This study also found that throughput, execution latency and execution consistency are important performance metrics for assessing the efficiencies, responsiveness and stability of autonomous financial infrastructures because they collectively define the efficiency of the transaction processing. The results suggest the creation of scalable, reliable, intelligent and efficient autonomous financial systems to sustain the future digital economy, Internet of Things environment, decentralised financial ecosystem and AI-driven machine-to-machine commerce networks.

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