Risk Ordering Relation and Risk Control for P2P Lending Platforms: A Multi-Agent Systems (MAS) Approach

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Abstract

In the context of Peer-to-Peer (P2P) lending, risk controls are required, and they usually refer to a set of procedures and operations that aim to protect the integrity of data, particularly for accurate financial representation within the platform. Risk control procedures need to be in place to ensure accountability and fairness in risk and return trade-offs on federated platforms. This will foster trust among participants, especially when multiple fraud cases in the past, such as Enron, Madoff Investment Securities, and WorldCom, have accentuated the importance of a robust internal control mechanism in maintaining the credibility of the financial ecosystem. Stakeholders in the P2P lending industry are becoming increasingly concerned about the issue of trust, necessitating a re-evaluation of internal control frameworks to uphold objectivity and reliability. With the growth of the P2P lending industry as an alternative lending and borrowing platform and the requirement of an autonomous P2P lending platform, complexity arises, and autonomous entities (i.e., MAS) working together to assess, monitor, and mitigate risks is the only solution for such complexities. The orchestration of MAS plays a pivotal role in facilitating and mitigating risks. This study aims to provide a process methodology for fostering collaborative dynamics within the P2P lending domain. A state diagram approach is presented, where state orders (SO), lending approvals, risk graphs, risk ordering relations, and risk bands (RB) are introduced for MAS to assume certain roles or tasks. For each task, controls for the segregation of duties are presented as well. Given the absence of proper autonomous systems for decision-making, robust internal control methods are necessary for controls to execute federated trust on lending platforms. Our approach will significantly improve investors' confidence meant to achieve this goal.

1- Introduction

Trust and reliability in the financial sector have been tainted by high-profile corporate scandals, such as Enron, Madoff, and WorldCom, just to name a few. These scandals have shown how financial statements can be manipulated to hide the true financial health of a company. Enron, previously a major player in the energy sector, managed to conceal staggering liabilities and financial losses through elaborate accounting schemes and off-balance sheet transactions. Despite undergoing rigorous audits by reputable firms, the true extent of Enron's financial misdeeds remained hidden until the company's eventual collapse in 2001. Similarly, a prominent figure on Wall Street, Bernie Madoff, orchestrated one of the largest Ponzi schemes in history, deceiving investors and regulators for decades. Madoff managed to avoid detection by fabricating fictitious investment returns and maintaining a facade of legitimacy. These scandals, along with others like WorldCom, where financial irregularities led to bankruptcy, have severely damaged the credibility of audited financial reports. Stakeholders increasingly hesitate to place unwavering trust in audit assurances, recognizing the limitations and potential vulnerabilities in the audit process [1, 2].

With the growth of FinTech and the absence of a robust deposit security mechanism, potential investors have concerns regarding the possibility of defaults. In the context of P2P lending platforms, depositors assume a substantial portion of the risk, compounded by the opacity surrounding default rates and credit rating methodologies [3]. These factors often make it difficult for informed investors to make sound decisions. This uncertainty serves as an obstacle to the expansion of investor participation in digital platforms in growing economies like Malaysia [4].

The absence of deposit security measures within digital platform investments fosters a palpable sense of vulnerability and risk among prospective depositors. The ongoing digital transformation is fundamentally reshaping the landscape of banking, heralding a discernibly distinct trajectory for the industry. Faced with intensified competition, evolving consumer preferences, and the proliferation of innovative business paradigms, banks are compelled to embrace process automation to engender trust and confidence among their clientele [5].

Moreover, recent corporate scandals involving entities such as Enron, Madoff Investment Securities, and WorldCom have precipitated a further erosion of trust in the financial sector, a trend underscored in the Edelman Trust Barometer report. Illustratively, Table 1, presented herein, encapsulates data spanning from 2011 to 2022, which delineates the financial services sector, inclusive of banking, as consistently ranking as the least trusted among the eight industries surveyed. Despite witnessing a modest upsurge from 37% in 2011 to 56% in 2022, this ameliorative trend pales in comparison to advancements observed within other sectors, as depicted in Figure 1.

Table 1. Edelman and Trust Report on Trusted Industries (2011 to 2022)

| Sector/Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Technology	68%	79%	73%	79%	78%	74%	75%	75%	78%	75%	68%	74%
Food & Beverage	65%	64%	62%	66%	67%	64%	66%	66%	69%	67%	65%	68%
Consumer Packaged Goods	47%	62%	60%	65%	66%	61%	63%	61%	65	62%	60%	61%
Telecommunications	38%	60%	60%	60%	63%	60%	63%	64%	67%	65%	61%	64%
Automotive	55%	66%	66%	70%	71%	60%	65%	63%	69%	67%	60%	66%
Energy	45%	53%	57%	59%	60%	58%	62%	63%	65%	63%	59%	62%
Healthcare	56%	56%	57%	59%	61%	53%	53%	65%	68%	67%	66%	69%
Financial Services	37%	45%	46%	48%	54%	51%	54%	55%	57%	56%	52%	56%
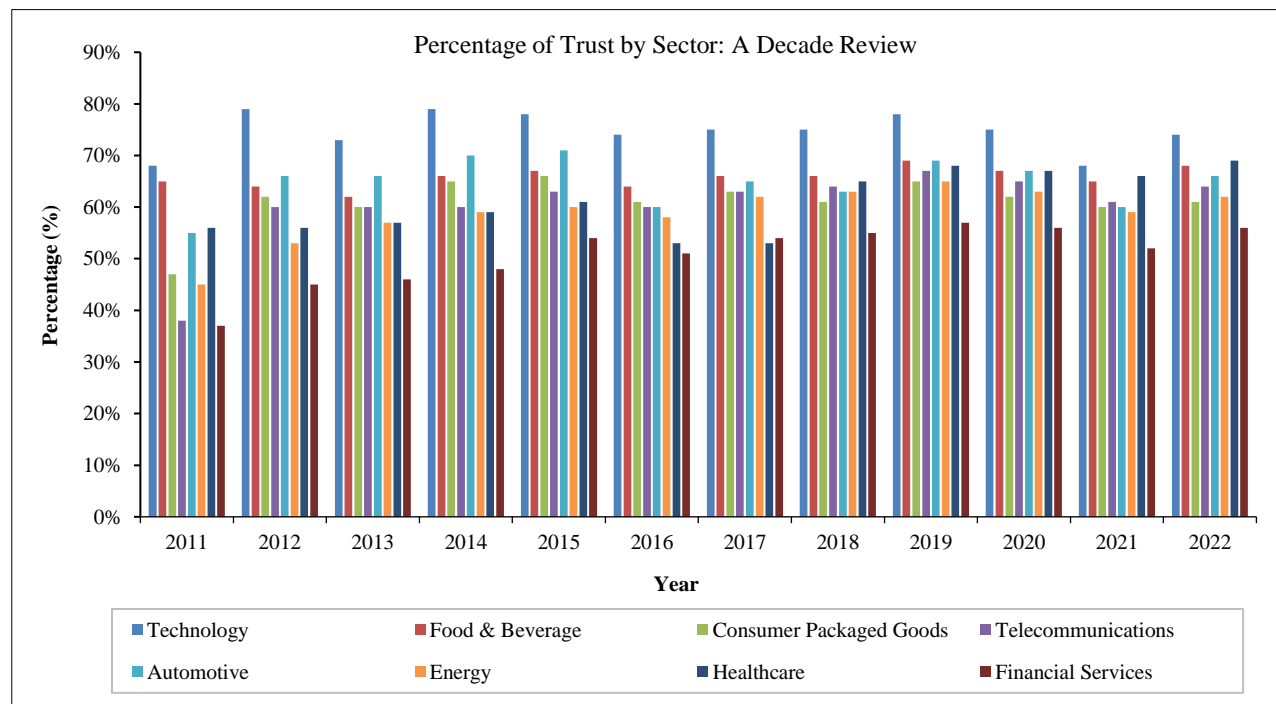
Figure 1. Edelman and Trust Report by Sector from 2011 to 2022

P2P lending platforms in Malaysia typically operate in the following manner:

- *Loan Origination*: SMEs or individuals seeking financing submit loan applications to the P2P platform, providing details such as the purpose of the loan, amount requested, and relevant financial information [6, 7].

- *Risk Assessment*: The P2P platform conducts due diligence and risk assessment on loan applications, evaluating factors such as creditworthiness, business viability, and financial stability. This process may involve the use of credit scoring models and proprietary algorithms to assess the credit risk of potential borrowers.

- *Loan Listing*: Approved loan applications are listed on the platform's marketplace, where investors can review detailed loan profiles, including risk ratings, interest rates, and borrower information.

- *Investor Participation*: Individual investors can browse through available loan listings and choose to invest in loans that match their risk appetite and investment preferences. Investors have the flexibility to diversify their investments across multiple loans to spread risk.

- *Funding and Disbursement*: Once a loan is fully funded by investors, the P2P platform disburses the funds to the borrower. Loan agreements are executed electronically, outlining the terms and conditions of the loan, including repayment schedules, interest rates, and any applicable fees.

- *Repayment and Monitoring*: Borrowers make regular repayments according to the agreed-upon schedule, which is collected by the P2P platform and distributed to investors. The platform also provides ongoing monitoring and updates on the status of loans, including delinquencies or defaults.

- *Secondary Market (Optional)*: Some P2P lending platforms may offer a secondary market where investors can buy and sell existing loan investments, providing liquidity and flexibility for investors to manage their portfolios.

2- Literature Review

Peer-to-peer (P2P) financing, which is supervised by the Securities Commission Malaysia (SC), has facilitated over RM 1 billion in financing to small and medium-sized enterprises (SMEs) since the onset of the pandemic. According to SC chairman Datuk Syed Zaid Albar, fintech could play a crucial role in revitalizing Malaysia's economy as the country emerges from the pandemic [8]. The P2P framework enables eligible businesses and companies to access market-based financing for their projects or businesses through electronic platforms [9]. In Malaysia, there are numerous platforms that support P2P lending, each offering distinct features and services. This alternative source of financing is gaining popularity, as it allows individuals and small businesses to lend and borrow directly from each other through an online platform, bypassing traditional financial institutions. P2P lending platforms in Malaysia rely on online platforms to facilitate direct lending between individual investors (lenders) and borrowers, typically SMEs or individuals in need of financing. These platforms act as intermediaries, matching lenders with borrowers through their online marketplace [10].

As of 2018, Funding Societies, B2B Finpal, and Fundaztic commanded the largest market shares in Malaysia. Funding Societies leads the pack, having raised over RM4.97 billion in funds to date [11]. However, Fundaztic exhibits a higher default rate, standing at 8.72% since inception and 1.94% in the past year, compared to Funding Societies' 3.27% since inception. This discrepancy may indicate that Fundaztic is assuming higher-risk loans, potentially yielding higher interest returns if borrowers meet their payment obligations. Two primary factors contribute to the robust growth of P2P lending platforms: the reduction in interest rates by Bank Negara Malaysia from 3% to 1.75% between December 2019 and July 2020, and the increased utilization of digital platforms during the pandemic. Consequently, P2P lending platforms emerge as appealing alternative investment avenues, offering substantially higher average net returns ranging from 8.2% to 28% per annum across the eleven platforms [12]. Table 2 summarizes P2P lending platforms in Malaysia [11].

Table 2. Peer to Peer lending platform in Malaysia

Recognized Market Operator (RMO)	Default Rate	Minimum Investment	Fees	Average Net Returns
Capbay	<0.1%	RM10,000	10% to 30% of interest earned	8.2% p.a.
CapSphere	0%	RM200 initial deposit RM50 per campaign	1 to 2% of monthly repayments	not stated
QuicKash	1.34%	RM100	1.35% - 1.50% per repayment	not stated
B2BFinPal	3.15%	RM1,000 initial deposit RM100 per campaign	30% of interest earned	10.9% p.a.
Funding Societies	3.27%	RM100 initial deposit, RM100 per campaign	- Business term financing: 2% p.a. of each repayment - Accounts receivable financing: 15% of interest earned - Accounts payable financing: 30% of interest earned	not stated
Fundaztic	8.72%	RM2,000 initial deposit (if using "Smart Invest" feature); otherwise, no initial deposit required, RM50 per campaign	- Monthly repayments: 2% of repayment amount - Bullet repayments: 1% of repayment amount	27.88% since 2017
Alixoco	2.59%	RM500	0.35% to 2% of repayment	12% p.a.
MicroLEAP	0%	RM50	2% of first monthly repayment of each campaign	not stated
Nusa Kapital	not stated	RM500	10% of returns	not stated
Money Save	not stated	RM5	Up to 15% of interest payment; up to 50% on prepayment	not stated
Cofundr	not stated	RM1,000 initial deposit, RM100 per campaign	- For investments that are 12 months or under: 20% of interest - For investments that are over 12 months: 2.0% p.a. on principal	not stated

Broadly defined, P2P lending involves investors providing funds to individuals and businesses through online platforms [11], offering borrowers an alternative to the stringent criteria imposed by traditional banks. While P2P lending typically yields higher returns than conventional investments, it also entails heightened risk for investors. Similar to traditional financial institutions, P2P lending platforms determine interest rates for potential investors based on the risk profile of borrowers [11]. However, there seem to be no clear guidelines for potential investors to compute default rates, and the financial data provided is often limited to carrying out any sort of analysis. In contrast, banks prioritize risk minimization due to regulatory requirements, which mandate a capital reserve of 5% to 20% to cover short-term expenses like customer withdrawals.

To ensure stability and loan repayment, banks scrutinize applicants based on credit history, employment status, and collateral. Unlike banks, P2P lending platforms assume minimal risk as intermediaries, allowing lenders to individually assess risk levels. This flexibility enables individuals with poor credit histories to access capital from lenders willing to accept higher risk for greater returns. P2P lending platforms face lower risk levels compared to banks, providing opportunities for excluded customer segments who are unable to meet banks' risk requirements. However, the absence of deposit security mechanisms on digital platforms exacerbates the susceptibility and exposure of prospective depositors, thereby intensifying apprehensions surrounding potential defaults [13, 14].

This flexibility enables individuals with poor credit histories to access capital from lenders willing to accept higher risk for greater returns [15]. Unlike banks, P2P platforms decentralize [16] risk to users rather than accumulating it on their balance sheets. P2P lending platforms face lower risk levels compared to banks, providing opportunities for excluded customer segments unable to meet banks' risk requirements [17]. P2P lending platforms face lower risk levels compared to banks, providing opportunities for excluded customer segments who are unable to meet banks' risk requirements. However, the absence of deposit security mechanisms on digital platforms exacerbates the susceptibility and exposure of prospective depositors, thereby intensifying apprehensions surrounding potential defaults.

To address these transparency issues and enhance risk mitigation mechanisms, regulators like the Securities Commission (SC) in Malaysia have established a regulatory framework for P2P lending under the Guidelines on Recognized Markets under Section 377 of the Capital Markets and Services Act 2007 (CMSA). The introduction of P2P lending in Malaysia occurred in 2016 following approval from the Securities Commission Malaysia (SC), which outlined registration requirements and operational obligations for P2P operators in the revised Guidelines on Recognized Markets of 2016. P2P lending platforms in Malaysia are regulated by the Peer-to-Peer Financing Act 2017. SC Malaysia ensures investor protection and platform transparency, fostering a healthy and sustainable industry while providing access to financing for underserved segments of the population. As of 2022, the SC in Malaysia has granted licenses to 11 peer-to-peer (P2P) lending platforms as Recognized Market Operators (RMO) [12].

3- Process Methodology–State Diagram Workflow for Risk Controls

State diagrams have been used for understanding flow sequences of state machines or finite systems, which are essential for the execution of MAS transaction and authorization process flows. State diagrams are an extension of Finite-State Machines (FSM) with enhanced capabilities where states can be sequentially tagged to tasks. State diagrams are very useful for depicting directed networks and understanding sequence structures among objects [18]. Transitions of processes from one state to another are also commonly shown in state graphs. State diagrams are a visual representation of the behavior of MAS. They're particularly useful in modeling the behavior of complex systems, where they represent computation consisting of a finite number of states, transitions between those states, and actions associated with those transitions [19].

In state diagrams, each state represents a specific condition or mode that the system can be in, and transitions between states represent events or conditions that cause the system to change its state. What sets state diagrams apart from basic FSMs is their enhanced capabilities, which allow for richer modeling of system behavior. Figure 1 shows detailed states for a P2P lending scenario, and Table 3 illustrates what constitutes the "actions and outcomes" in each state. State diagrams depict transitions from one state to another; for example, there are 13 states as depicted in Figure 1, which reflect tasks to be completed. The statement "states can be sequentially tagged to tasks" suggests that in state diagrams, states can be associated with tasks or actions that need to be performed when the system is in that state [13].

Table 3. P2P Lending State Orders

State Order	State Name	State Description	Actions	Outcomes
1	Start	The process begins when an investor agent decides to explore P2P lending as an investment option.	Research various P2P lending platforms.	Investor agent gains an understanding of P2P lending and its potential benefits.
2	Research Platforms	The investor agent researches various P2P lending platforms available in the market.	Evaluate interest rates, borrower profiles, platform reputation, and risk assessment methods.	Investor agent identifies platforms that align with their investment goals and risk tolerance.
3	Register	Once the investor agent selects a platform, they register an account.	Provide personal and financial information to create an account.	Investor agent gains access to the platform's features and functionalities.
4	Deposit Funds	The investor agent deposits funds into their P2P lending account.	Transfer funds via bank transfers or designated payment methods.	Investor agent's account balance reflects the deposited funds.
5	Browse Listings	The investor agent browses through loan listings provided by the platform.	Review loan details including borrower profiles, loan purposes, requested amounts, interest rates, and risk grades.	Investor agent identifies potential investment opportunities based on their criteria.
6	Select Loans	Based on their investment strategy and risk tolerance, the investor agent selects specific loans.	Choose loans to invest in and diversify investments across multiple loans.	Investor agent has a diversified portfolio of selected loans.
7	Investment Confirmation	The investor agent confirms their investment choices.	Review and adjust investment allocations if necessary.	Investor agent's investment choices are finalized.
8	Funding Period	The P2P platform aggregates funds from multiple investor agents to fully fund each loan.	Wait for the funding period to end successfully.	Loan reaches its funding goal and moves to the next stage.
9	Funds Disbursement	After the funding period ends successfully, the P2P platform disburses the loan amount to the borrower agent.	Monitor status for disbursements	Borrower agent receives the funds and begins utilizing them for the intended purpose.
10	Repayments and returns	As borrowers make repayments, the investor agent receives returns on their investment.	Monitor repayments and returns on the investment portfolio.	Investor agent receives returns in the form of principal and interest payments.
11	Monitor and reinvest	The investor agent monitors their investment portfolio and may reinvest returns into new loans.	Regularly track repayments, defaults, and overall portfolio performance.	Investor agent makes informed decisions regarding reinvestment or withdrawal of funds based on portfolio performance.

In the context of P2P lending, robo-advisory MAS, which utilize automation and algorithms to provide financial advice and manage investments, the concept of a finite number of states refers to the distinct conditions or modes that the system can be in regarding transaction processing, risk-return trade-offs, default rates, and other relevant factors. This means that not only do state diagrams capture the different states a system can be in, but they also specify what actions or tasks should be executed in each state. The table below illustrates state conditions for MAS for P2P lending. As such investment workflows for P2P lending platforms must include risk scales so that assigning roles could prove to be a better solution [19]. Risk scales can be directly related to approval tasks listed in Table 1. Increasing complexity or risk within a task (t) necessitates heightened levels of risk assessment and scrutiny this is denoted as the risk band (RB).

This study adopts state diagrams (to show P2P lending tasks), risk graph (which shows different levels P2P lending risk), MAS task delegation policy and permission-role assignment [18] which we apply onto MAS risk ordering relation. Each state shows a transition from one point to another, for example once state order 1 (S1) is complete then state order 2 (S2) begins. Therefore, the 13 states shown in Figure 2 relates to a maximum of thirteen state orders. Table 3 highlights all thirteen state orders relevant for P2P lending platforms. In the context of Peer-to-Peer (P2P) lending platforms and the implementation of autonomous risk management is tailored to an individual investor's risk profile. MAS encompasses the following components:

a) *Agents*: These are the fundamental entities within the MAS framework, each serving specific roles and functions.

b) *Interactions*: Refers to the dynamic exchanges and collaborations among agents within the MAS, essential for achieving desired outcomes.

c) *Communication Protocols*: Establish structured channels for information exchange and coordination among agents, ensuring seamless operation and alignment of objectives.

d) *Risk and Mitigation*: Encompasses mechanisms and strategies embedded within the MAS to identify, assess, and mitigate various risks inherent in P2P lending operations, safeguarding the interests of stakeholders [20].

MAS is designed for a P2P lending platform holds the potential to streamline lending activities, fostering efficiency and transparency, while concurrently addressing and mitigating risks [13] associated with peer-to-peer lending.

Crucially, regular monitoring, evaluation, and adaptation of the MAS are imperative to uphold its efficacy and resilience amid the fluid dynamics of financial environments [19]. Agents within the MAS framework include:

a) *Borrower Agents:* Within the domain of Peer-to-Peer (P2P) lending platforms, borrower agents serve as representatives for individuals or businesses seeking financial assistance. Functioning as intermediaries between

borrowers and the lending platform, these agents are tasked with the submission of loan applications, furnishing requisite financial documentation, and articulating the purpose and terms of the loan request. Throughout the lending process, borrower agents engage in negotiations, facilitate communication, and manage the repayment process, thereby assuming a pivotal role in the borrower-lender relationship dynamics.

b) *Lender Agents:* Lender agents, comprising both individual investors and institutional entities, play a foundational role in the capital provisioning mechanism of P2P lending platforms. These agents extend financial resources by participating in loan transactions facilitated through the platform. Employing discerning investment strategies informed by risk assessment methodologies and borrower profiles, lender agents allocate capital across diverse loan opportunities, aiming to optimize returns while managing risk exposure. Their engagement in the lending process entails the evaluation of loan proposals, investment diversification, and monitoring of portfolio performance over the loan term.

c) *Risk Assessment Agents:* Operating at the nexus of financial risk management and credit evaluation, risk assessment agents are entrusted with the critical task of evaluating the creditworthiness of prospective borrowers. Leveraging sophisticated data analytics and predictive modelling techniques, these agents conduct comprehensive assessments of borrower profiles, financial histories, and risk indicators to ascertain the likelihood of loan default and establish suitable loan terms. Their role extends beyond credit evaluation to encompass the formulation of risk mitigation strategies and the calibration of loan terms in alignment with borrower risk [21] profiles, thereby contributing to the overall risk management framework of the lending platform.

d) *Matching Agents:* In the context of P2P lending platforms, matching agents assume the role of intermediaries tasked with optimizing the allocation of capital by facilitating the alignment of borrowers with compatible lenders. Employing algorithmic matching algorithms and user preferences, these agents orchestrate the efficient deployment of funds by pairing borrowers with lenders whose risk preferences, investment objectives, and loan criteria closely align. Their endeavours contribute to enhancing liquidity [22], facilitating timely loan fulfilment, and fostering equitable borrower-lender relationships within the P2P lending ecosystem.

e) *Transaction Agents:* Integral to the operational infrastructure of P2P lending platforms, transaction agents oversee the end-to-end management of loan transactions, encompassing loan origination, disbursement, repayment processing, and interest calculation. Charged with ensuring adherence to regulatory frameworks and contractual obligations, these agents play a pivotal role in safeguarding the integrity and transparency of loan transactions. Their functions encompass regulatory compliance, risk monitoring, and the resolution of transactional disputes, thereby upholding the operational efficiency and trustworthiness of the lending platform.
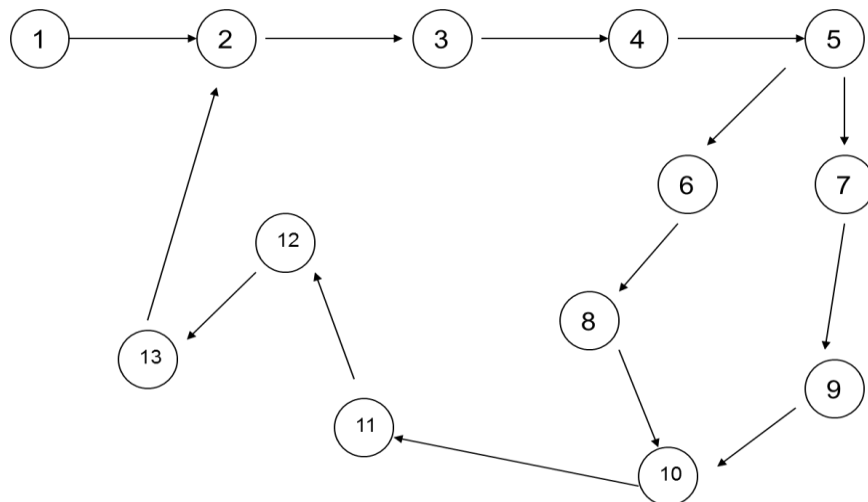

Figure 2. State Diagram

The designed MAS for a P2P lending platform can facilitate efficient and transparent lending activities while addressing and mitigating various risks associated with peer-to-peer lending operations. Regular monitoring, evaluation, and adaptation of the system are essential to ensuring its effectiveness and resilience in dynamic financial environments.

Table 4 describes the different tasks that are related to internal controls of processing lending approval tasks on P2P lending platforms. Various tasks have been indicated below and risks related to these tasks also show that some tasks may require more scrutiny compared to others [19]. An intuitive method is shown in Figure 2 to highlight risks, levels of risks. The concept of risk band (RB) is used to illustrate the risks from 1 to 6 using a risk graph shown in Figure 3 [23, 24].

Table 4. P2P Lending Approval Tasks

Task Name	Task Details	Description / Process	Risk Band
t1	Sets up account	Opening account	Low risk
t2	Review listing	Browsing investment listings	Low risk
t3	Review borrower profile	Industry	Low to medium risk
t4	Select investment	Term/duration and industry	Medium risk
t5	Set up expected return	Calculate risk/return trade off portfolio's return (Rp) risk-free rate (Rf), portfolio's excess return (σp)	Medium to high risk
t6	Decide investment amount	Payment record query	Medium to high risk
t7	Examine default rate	Setting auto invest preferences	Medium to high risk
t8	Confirm selection	Payment processing	High risk
t9	Make the investment	Investing in listings	High risk
t10	Reinvest and monitor	Integrity and transparency of loan transactions	High risk

According to the risk assessment, task 2 (review listing) is associated with the lowest level of risk, which is RB 6 (refer to Figure 3 and Table 4). On the other hand, task 8 (confirm selection) and task 10 (invest) are associated with the highest risk level, which is RB 1. Tasks 6, 7, and 9 are comparable in terms of risks, as they are all located in the same risk band, RB 2. However, tasks with non-comparable risks are those that belong to different risk bands, such as T10 and T9.

Table 5. P2P Lending Task and MAS Functionality

Task Name	Task Details	Description / Process	Role of MAS (Agents)
t1	Sets up account	Opening account	Lender agent
t2	Review listing	Browsing investment listings	Lender agent
t3	Review borrower profile	Industry	Borrower agent
t4	Select investment	Term/duration and industry	Matching agent
t5	Set up expected return (review market, regulatory and liquidity risk)	Optimize risk/return i.e. portfolio's return (Rp) risk-free rate (Rf) and portfolio's excess return (σp)	Risk assessment agent
t6	Decide investment amount	Payment record query	Matching agent
t7	Examine default rate	Setting auto invest preferences	Risk assessment agent
t8	Confirm selection	Payment processing	Transaction agent
t9	Make the investment	Investing in listings	Transaction agent
t10	Reinvest and monitor	Integrity and transparency of loan transactions	Transaction agent

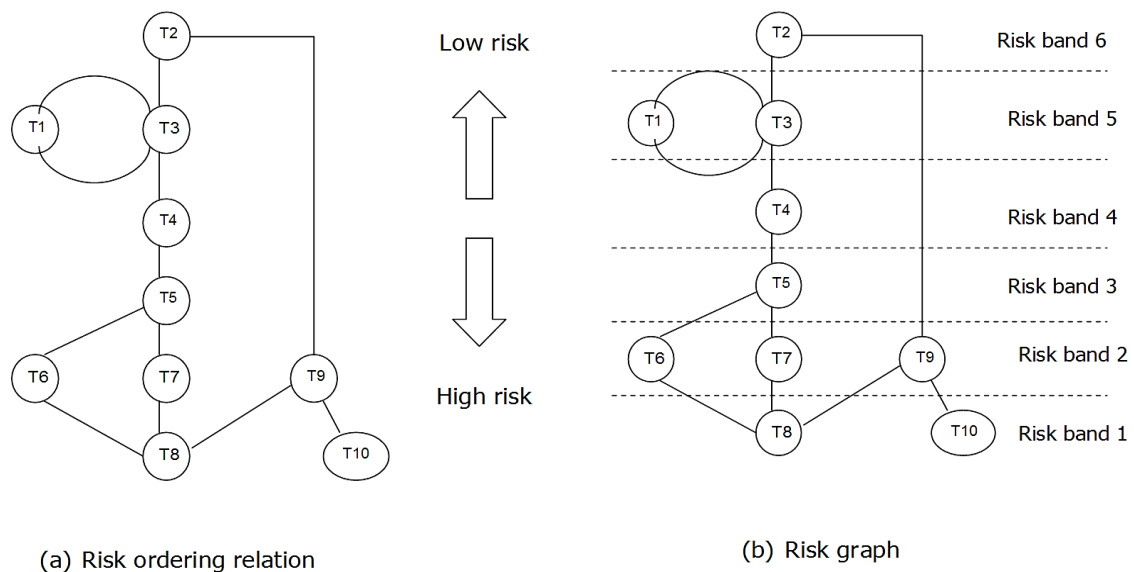(a) Risk ordering relation

(b) Risk graph

Figure 3. Risk Ordering Relation and Risk Graph

Figure 3 shows that there is no differentiation of roles in the process. The agent is only assigned to one role, which is opening an account (t1). There are nine tasks (t1 to t9) involved in investing in P2P lending platforms. These tasks have varying levels of risk, and by comparing the risk bands, we can assess the relative risk levels of transactions in task 8 (t8) to task 9 (t9). For example, the risk level of "make the investment" transaction (t9) is like that of a transaction in t8, as they both fall within the same risk band. This comparative analysis helps us understand the risk distribution within the loan processing framework. Tasks t1, t2, and t4 fall under Risk Band 6 (RB = 6), which represents high-risk transactions, while tasks t8 and t9 are under Risk Band 1 (RB = 1), which represents relatively low-risk transactions.

4- Multi Agent Systems Data Points and Reference Check

As per the process methodology for risk ordering and risk relation [19], the MAS (Multi-Agent System) performs a reference check on notes available for t3, t4, t5, t6, and t7 before moving to t8. If an agent processes a transaction with a higher risk than RB = 1, it undergoes intense scrutiny. In other words, when an agent performs one transaction and moves to another, the MAS moves between risk bands (RB1 to RB6). This concept is also applicable in real-world scenarios when tasks can be delegated between MAS. The risk level increases with the increase in the gap between risk bands. Therefore, when an agent moves between t1, t2, and t4, they belong to the same risk level (RB = 6).

In a similar way, RB = 3 indicates that when an agent moves between transactions t3, t5, and t6, the same effect occurs. The same situation arises when agents move between t8 and t9. As the level of risk changes, permission assignment can be done with greater accuracy for both risk and internal controls. Table 6 outlines the tasks for states or tasks and the relevant internal controls executed for dedicated roles performed by MAS.

Table 6. Tasks for MAS

Task Name	Finite State Tasks/Role	MAS Role
t1	Confirm selection	Transaction agent (B)
t2	Examine default rate	Risk assessment agent (M)
t3	Select borrower profile	Borrower agent (T)
t4	Select investment	Transaction Lender agent(T)
t5	Review borrower profile	Transaction Lender agent (T)

Scenario 1. Factsheet A vs. Factsheet B

Table 7 presents a comparison between Factsheet A and Factsheet B. Both documents share the same financing notes, MBAP, and a payment term of 120 days. However, they differ in terms of interest rates. Factsheet A offers an interest rate of 4.33%, while Factsheet B proposes a higher rate of 5.60%. It is important to note that Factsheet B operates within the consumer electronics sector which is known for its high level of competition and growth potential, whereas Factsheet A belongs to the agriculture industry. Furthermore, Factsheet B has a history of being struck off or winding up, while Factsheet A has only encountered instances of bankruptcy or winding-up. Taking these factors into account, Factsheet B appears to be a high-risk investment opportunity, as evidenced by its market position, likelihood of default, and industry context. As a result, the higher interest rate associated with Factsheet B is not an over-promising or under-promising scenario for investors.

Table 7. Factsheet for Risk Comparison on P2P Lending Investment Notes

Details	Factsheet_MBAP-23110024	Factsheet_MBAP-23110032	Factsheet_MBIAP-23110040	Factsheet_MBIAP-23110018
	Factsheet A	Factsheet B	Factsheet C	Factsheet D
Terms of Payment (days)	120	120	30	30
Interest Rate	4.33%	5.60%	0.85%	0.90%
Note Grade	CC	DD	B	No Grade
Market Standing	C - There is a trace of bankruptcy/ wound-up	D - Applicable for companies that have been struck off or winding up. To refer to the company status.	B - There is a trace of litigation	Multiple Notes are currently outstanding
SME Credit Score	No Score	330	335	314
Probability of Default	Company/Business score couldn't be generated due to insufficient information	2.56% - 3.09%	1.25% - 2.47%	3.86% - 5.19%
Industry	Agriculture	Consumer Electronics	Technology, Media & Telecoms	Food & Beverage
Competitive risk and growth assessments	Intermediate risk	Moderately high risk	Moderately high risk	Intermediate risk

Scenario 2. Factsheet C vs. Factsheet D

Table 7 compares Factsheet C and Factsheet D, focusing on their financing notes and MBIAP. Both factsheets offer a payment term of 30 days, but their interest rates differ slightly. Factsheet C has an interest rate of 0.85%, and Factsheet D has an interest rate of 0.90%, which is only a difference of 0.05%. However, the risk profiles between the two companies are vastly different. Factsheet C has a minor history of litigation, while Factsheet D currently holds several outstanding investment notes on the platform, which significantly increases its default risk. Factsheet D's probability of default is notably higher, ranging from 3.86% to 5.19%, compared to Factsheet C's 1.25% to 2.47%. Additionally, Factsheet C operates in the Technology, Media, and Telecoms industry, known for its competitiveness and growth potential, while Factsheet D operates in the Food and Beverage sector, which is characterized by lower competitiveness and growth prospects. Considering these factors, Factsheet D is a significantly higher-risk investment than Factsheet C. The small difference in interest rates between the two factsheets is justified by the substantial differences in risk. Therefore, the higher interest rate offered by Factsheet D is reasonable and aligns with its higher risk profile. This ensures that investors are not over-promised or under-promised in terms of potential returns.

5- Risk Graphs and Role Functions

This approach highlights how agent role delegation works in accordance with risks associated for improving risk controls [11]. Tables 4 and 5 show how permission assignments are based on roles and relative risk levels when tasks are delegated from superiors to subordinates. Table 6 lists the tasks for MAS, with each role having designated functions. Higher roles can inherit the functions of lower roles, which can result in a decreased level of risk. For example, when M executes teller transactions (t5), categorized as (M, t5), it falls under RB = 3 for M but under RB = 1 for T. Figure 4 illustrates a risk graph featuring multiple agent roles classified into three categories: transaction lender agent (T), risk assessment agent (M), and transaction agent (B). These roles possess delegable responsibilities. The transaction agent (B) can undertake managerial tasks, effectively substituting for the risk assessment agent (M) without escalating the risk level, maintaining it at risk band 2 (RB=2). However, if the situation were reversed, with a transaction lender (T) agent undertaking a task typically handled by a transaction agent (B), the risk for that task would be recalculated. In such a scenario, the risk band would increase to band 4 (RB=4).
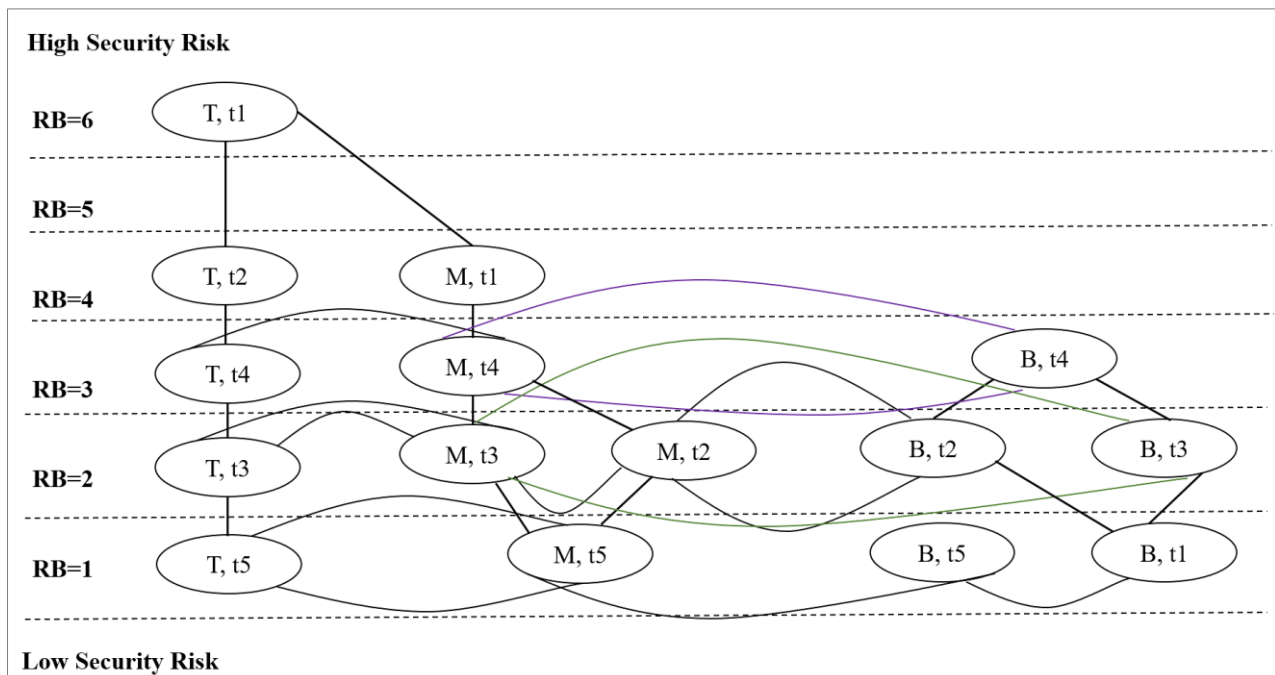

Figure 4. Risk Graph with Role Function

6- Conclusion

The Peer-to-Peer (P2P) lending industry is growing rapidly, and it is crucial to have robust internal controls to maintain transparency, accountability, and fairness. This study highlights the importance of comprehensive control mechanisms to prevent fraud and preserve the integrity of financial reporting, reinforcing trust among platform users. The proposed state diagram approach, along with the introduction of state orders, lending approval, risk graphs, risk ordering relations, and risk bands, provides a structured methodology for Multi-Agent Systems (MAS) to assume specific roles and tasks. This system also establishes effective controls for the segregation of duties. Each element of this methodology enhances the platform's ability to manage and mitigate risks effectively. For example, state orders guide

the sequence of actions, while risk bands categorize the level of risk associated with different tasks. As P2P lending continues to shape the future of alternative lending and borrowing, the proactive implementation of advanced internal controls and collaborative frameworks is crucial. These mechanisms promote trust, reliability, and sustainability within the industry, ensuring that P2P lending remains a viable and secure alternative in the financial landscape. This approach not only supports the resilience of financial operations but also fosters a collaborative environment that enhances overall compliance and system reliability.

7- Declarations

7-1- Author Contributions

Conceptualization, S.M. and N.T.P.L.; methodology, Y.V.C. and T.O. K.Z.; validation, S.M. and Y.V.C.; formal analysis, S.M.; investigation, S.M.; writing—original draft preparation, S.M. and T.O.K.Z.; writing—review and editing, T.O.K.Z.; supervision, S.M. and N.T.P.L.; All authors have read and agreed to the published version of the manuscript.

7-2- Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7-3- Funding and Acknowledgements

7-4- Institutional Review Board Statement

Not applicable.

7-5- Informed Consent Statement

Not applicable.

7-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

8- References

[1] Dongyu, C., Gezhi, C., Jie, D., Sujuan, J., & Jiangang, S. (2011). Antecedents of initial trust in the online peer-to-peer lending marketplace. ICSSSM11. doi:10.1109/icsssm.2011.5959503.

[2] Aaqib, M., Ali, A., Chen, L., & Nibouche, O. (2023). IoT trust and reputation: a survey and taxonomy. Journal of Cloud Computing, 12(1), 42. doi:10.1186/s13677-023-00416-8.

[3] Klein, G., Shtudiner, Z., & Zwilling, M. (2023). Why do peer-to-peer (P2P) lending platforms fail? The gap between P2P lenders' preferences and the platforms' intentions. Electronic Commerce Research, 23(2), 709-738. doi:10.1007/s10660-021-09489-6.

[4] Chen, X., Jin, F., Zhang, Q., & Yang, L. (2016). Are investors rational or perceptual in P2P lending? Information Systems and E-Business Management, 14(4), 921–944. doi:10.1007/s10257-016-0305-z.

[5] Shi, X., Wu, J., & Hollingsworth, J. (2019). How does P2P lending platform reputation affect lenders' decision in China? International Journal of Bank Marketing, 37(7), 1566–1589. doi:10.1108/IJBM-11-2018-0309.

[6] Rosavina, M., Rahadi, R. A., Kitri, M. L., Nuraeni, S., & Mayangsari, L. (2019). P2P lending adoption by SMEs in Indonesia. Qualitative Research in Financial Markets, 11(2), 260–279. doi:10.1108/QRFM-09-2018-0103.

[7] Nemoto, N., Huang, B., & Storey, D. J. (2019). Optimal Regulation of P2P Lending for Small and Medium-Sized Enterprises. SSRN Electronic Journal. doi:10.2139/ssrn.3313999.

[8] Capbay. (2021). Budget-2022-boosts-peer-to-peer-financing-p2p-industry. Capbay, Petaling Jaya, Malaysia. Available online: https://capbay.com/budget-2022-boosts-peer-to-peer-financing-p2p-industry/ (accessed on July 2024).

[9] Chen, X., Chong, Z., Giudici, P., & Huang, B. (2020). Networking with peers: Evidence from a P2P lending platform. 1080. Asian Development Bank Institute (ADBI) Working Paper Series, Tokyo, Japan.

[10] Havrylchyk, O., & Verdier, M. (2018). The financial intermediation role of the P2P lending platforms. Comparative Economic Studies, 60, 115-130. doi:10.1057/s41294-017-0045-1.

[11] Lim, J. L. (2020). What You Need to Know About P2P Lending in Malaysia. iMoney, Kuala Lumpur, Malaysia. Available online: https://www.imoney.my/articles/p2p-lending-guide (accessed on June 2024).

[12] Nguyen, L. T. P., Kalabeke, W., Muthaiyah, S., Cheng, M. Y., Hui, K. J., & Mohamed, H. (2022). P2P lending platforms in Malaysia: What do we know? F1000Research, 10, 1088. doi:10.12688/f1000research.73410.2.

[13] Muthaiyah, S. (2019). Blockchain for Audit Provenance and Trust: Push Factors, Value Creation and Challenges. International Journal of Auditing and Accounting Studies, 1(1), 13-25. Available online: https://arfjournals.com/image/34432_2_saravanan.pdf (accessed on May 2024).

[14] Huang, R. H. (2018). Online P2P lending and regulatory responses in China: Opportunities and challenges. European Business Organization Law Review, 19, 63-92. doi:10.1007/s40804-018-0100-z.

[15] Gai, K., Qiu, M., & Sun, X. (2018). A survey on FinTech. Journal of Network and Computer Applications, 103, 262–273. doi:10.1016/j.jnca.2017.10.011.

[16] Sriman, B., & Kumar, S. G. (2022). Decentralized finance (deFi): the future of finance and deFi application for Ethereum blockchain based finance market. International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI), 1-9. doi:10.1109/ACCAI53970.2022.9752657.

[17] Hu, R., Liu, M., He, P., & Ma, Y. (2019). Can investors on P2P lending platforms identify default risk?. International Journal of Electronic Commerce, 23(1), 63-84. doi:10.1080/10864415.2018.1512279.

[18] Harel, D., & Naamad, A. (1996). The STATEMATE Semantics of Statecharts. ACM Transactions on Software Engineering and Methodology, 5(4), 293–333. doi:10.1145/235321.235322.

[19] Muthaiyah, S., Anbananthen, K. S. M., & Phuong Lan, N. T. (2021). Orchestration of autonomous trusted third-party banking. F1000Research, 10, 899. doi:10.12688/f1000research.72987.1.

[20] Tavares, F. O., Almeida, L. G., & Cunha, M. N. (2019). Financial literacy: Study of a university students sample. International Journal of Environmental and Science Education, 14(9), 499-510.

[21] Liu, H., Qiao, H., Wang, S., & Li, Y. (2019). Platform Competition in Peer-to-Peer Lending Considering Risk Control Ability. European Journal of Operational Research, 274(1), 280–290. doi:10.1016/j.ejor.2018.09.024.

[22] He, Q., & Li, X. (2021). The failure of Chinese peer-to-peer lending platforms: Finance and politics. Journal of Corporate Finance, 66, 101852. doi:10.1016/j.jcorpfin.2020.101852.

[23] Dammag, H., Nissanke, N. (2003). A Mathematical Framework for Safecharts. Formal Methods and Software Engineering. Springer, Berlin, Germany. doi:10.1007/978-3-540-39893-6_35.

[24] Muthaiyah, S. (2007). Propagation and Delegation of Rights in Access Controls and Risk Assessment Techniques. Web Services Security and E-Business, 328–337, IGI Global Publishing company, Hershey, United States. doi:10.4018/978-1-59904-168-1.ch018.