

A Design Science Study of Blockchain-Based Governance and Incentive Architectures for Ride-Sharing Platforms

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Abstract

Ride-sharing platforms have transformed urban mobility but continue to face persistent challenges related to high commission structures, algorithmic opacity, regulatory fragmentation, and limited stakeholder participation. Adopting a Design Science Research approach, this study proposes and evaluates a blockchain-based ride-sharing framework that integrates Decentralised Autonomous Organisation (DAO) governance and token-based incentive mechanisms to address these structural limitations. A proof-of-concept artefact was developed using a Parity Substrate blockchain with a Proof-of-Authority (PoA) consensus model, incorporating modular components for ride management, decentralised governance, cooperative finance, identity verification, and incentive distribution. The artefact was evaluated through simulated performance testing involving 2000 transactions and qualitative validation via focus group discussions with drivers, transport union representatives, and regulators in Nairobi. Results indicate sustained throughput of approximately 140 transactions per second with low transaction costs, alongside improved stakeholder perceptions of transparency, fairness, and participatory governance compared to conventional ride-hailing platforms. While the findings are exploratory, they suggest that permissioned blockchain architectures combined with cooperative governance and intrinsically utilitarian token models may offer a viable pathway for reconfiguring ride-sharing platforms toward more inclusive, accountable, and context-sensitive mobility systems, particularly in emerging-market environments.

Keywords

Decentralised Ride-Sharing, DAO Governance, Tokenomics, Blockchain Mobility, Equitable Transportation, Smart Contracts

1. Introduction

The sharing economy, characterised by peer-to-peer sharing and collaborative consumption, represents a significant shift in how resources are distributed in the modern world. This shift, driven by emerging technological advancements and shifting consumer perceptions of ownership versus access [1], leverages advanced digital platforms to facilitate new forms of international sharing of underutilised resources, services, and skills.

Ride-sharing has emerged as a disruptive force within this transformative landscape, fundamentally restructuring urban transportation systems. Enabled by digital platforms that connect individuals offering and seeking rides, the sector expanded significantly through advancements in information technology and widespread smartphone adoption [2]. Its most apparent societal benefit is dramatically improved resource use: By matching passengers with drivers heading in the same direction, platforms convert unused car capacity into income while reducing empty seats. Ride-sharing offers multiple advantages, including measurable reductions in city traffic (approximately 22% on busy routes) and significant decreases in per-passenger emissions. Union of Concerned Scientists documents a 17% - 43% decrease [3]. Beyond environmental gains, these services expand mobility options, especially in areas lacking public transportation, while allowing drivers to earn extra income or build full-fledged businesses [4].

1.1. Systemic Challenges and Structural Limitations of Centralised Ride-Sharing Platforms

Ride-sharing platforms such as Uber and Lyft have played a central role in transforming urban transportation and are frequently cited as flagship examples of the sharing economy. However, research increasingly suggests that their rapid expansion has been accompanied by structural vulnerabilities related to governance, labour relations, and long-term financial sustainability. [5] argues that Uber's early narrative of mutual benefit for drivers and riders weakened over time as the firm's growth strategy relied heavily on regulatory arbitrage and favourable capital market conditions. Disclosures associated with the Uber Files further revealed practices including regulatory evasion and aggressive lobbying, prompting public scrutiny and raising questions regarding platform legitimacy and trust. As a result, these platforms are increasingly viewed not only as technological innovators but also as organisational models whose economic and ethical foundations remain contested.

One of the most prominent areas of concern relates to algorithmic governance and driver compensation. App-based workers are subject to opaque, proprietary algorithms that influence ride allocation, pricing, and earnings, often without clear explanations or avenues for contestation [6]. Variability in per-ride commissions and pricing structures can limit drivers' ability to anticipate income or engage in long-term financial planning. Several studies further indicate the potential for algorithmic wage differentiation, whereby drivers performing similar tasks

may receive unequal compensation due to dynamic pricing mechanisms. While such systems are designed to optimise platform efficiency, their opacity concentrates decision-making power within platform operators and contributes to asymmetries between platforms and workers within the gig economy.

Regulatory and legal challenges have further exposed tensions inherent in centralised ride-sharing models. A landmark 2021 ruling by the UK Supreme Court reclassified Uber drivers as workers rather than independent contractors, directly challenging assumptions underpinning the platform's labour model [5]. In the United States, enforcement actions by the Federal Trade Commission (FTC) have addressed concerns related to deceptive billing practices and barriers to subscription cancellation [7]. Lyft has similarly faced regulatory scrutiny, including settlements over misleading income representations to drivers [8] and allegations of coordinated practices affecting driver pay in specific jurisdictions [9]. These cases illustrate the persistent friction between platform business models and evolving regulatory expectations, particularly where risks and costs are disproportionately borne by workers.

Beyond labour and governance concerns, centralised data architectures introduce additional systemic vulnerabilities. Traditional ride-hailing platforms collect and retain extensive volumes of personal, financial, and geolocation data, creating concentrated repositories that may be susceptible to misuse, manipulation, or security breaches [10]. Although companies have implemented comprehensive security frameworks aligned with standards such as NIST, the fundamental risks associated with data centralisation remain. As user bases expand, these data repositories become increasingly attractive targets, amplifying privacy and security concerns. Consequently, the efficiencies gained through centralised data aggregation may also generate structural weaknesses that are difficult to fully mitigate within conventional platform architectures.

1.2. Blockchain as a Potential Solution

Addressing these systemic challenges, blockchain technology presents a viable alternative by leveraging its core attributes: decentralised consensus mechanisms, cryptographic transparency, and programmable trust-minimising systems. Immutable distributed ledgers could streamline regulatory oversight through secure, auditable records of driver credentials, insurance status, and operational histories. Smart contracts' self-executing code deployed on-chain offers the potential to automate payments, verify safety compliance protocols, and enforce equitable profit distribution, thereby reducing intermediary dependencies [11]. These capabilities could redistribute power dynamics by enabling more democratic governance structures and participatory ownership models.

To realise this potential, this research investigates:

- 1) How can Decentralised Autonomous Organisations (DAOs) effectively address power imbalances in ride-sharing?
- 2) What token-based systems (covering incentives, rewards, and value distribu-

tion) can fairly compensate stakeholders while keeping platforms viable and competitive?

3) What are the primary interoperability challenges, regulatory barriers, and adoption hurdles that hinder blockchain integration into existing transportation systems?

This paper addresses these challenges through the design and evaluation of a blockchain-based proof-of-concept incorporating reputation-informed governance mechanisms, empirical testing within a rapidly growing Global South urban context specifically Nairobi and an analysis of policy considerations relevant to the legal recognition of DAO-based governance in transportation systems. While technical, regulatory, and adoption challenges remain, the findings suggest that blockchain-enabled platforms may support value redistribution through disintermediation, enhance stakeholder participation via decentralised governance, and provide verifiable trust mechanisms through cryptographic enforcement, thereby offering a potential pathway toward more transparent and inclusive models of platform-mediated mobility.

2. Literature Review

Traditional platform-based services are often described as “disruptive” due to their ability to displace incumbent industries through digital intermediation and scale efficiencies [5]. In contrast, Web3-based platforms propose a more fundamental transformation that extends beyond market displacement to the reconfiguration of value creation, distribution, and governance structures. [12] argues that decentralised platforms seek to redesign economic coordination by embedding governance and ownership mechanisms directly into technological infrastructures. This shift enables the emergence of new business and community relationships, including community-driven transport fleets that prioritise shared ownership and collective benefit [13].

Rather than replicating existing ride-hailing models through incremental efficiency gains, Web3 approaches emphasise participatory governance, incentive alignment, and decentralised control. In this sense, Web3 does not merely aim to produce more efficient versions of incumbent platforms but instead seeks to establish alternative institutional arrangements that redistribute power among participants and support more equitable and sustainable mobility ecosystems.

2.1. The Critical Role of Tokenomics

Tokenomics refers to the rules governing the creation, distribution, and use of tokens within decentralised systems and constitutes a foundational component of Web3 platforms [14]. Effective tokenomic design plays a central role in aligning stakeholder incentives, encouraging constructive participation, and supporting long-term ecosystem sustainability.

In Web3 ride-hailing platforms, tokens typically serve multiple economic and governance functions. These include facilitating decentralised peer-to-peer pay-

ments between drivers and riders without reliance on centralised payment processors [15]; conferring governance rights that allow token holders to participate in decisions related to platform upgrades, operational rules, and economic parameters [15]; and rewarding user participation through incentives linked to service provision, referrals, and community engagement [15]. Additional mechanisms such as staking enable participants to lock tokens in exchange for rewards while contributing to network stability [14]-[16]. Some platforms also employ promotional incentives such as “Share2Earn” models and allow tokens to function as collateral or to unlock reduced transaction fees, thereby enhancing user retention and system resilience [17].

A growing body of literature emphasises that the long-term viability of token-based systems depends less on speculative value and more on the intrinsic utility of the token within the platform’s operational ecosystem. [18] highlights that tokens derive sustainable value only when they are tightly coupled to meaningful economic functions and participation incentives. In contrast to traditional ride-hailing platforms that rely on commission-based revenue models and discretionary bonuses often criticised for opacity and driver dissatisfaction [19] tokenomics explicitly links participation to ownership stakes and governance rights [20] [15]. This shift represents a move away from principal-agent relationships toward stakeholder-oriented ownership models, with the potential to foster stronger engagement and mitigate the “crowding-out effect”, whereby participation is driven solely by extrinsic monetary incentives [17].

2.2. Decentralised Autonomous Organisations (DAOs) for Governance

Decentralised Autonomous Organisations (DAOs) provide the governance framework underpinning many Web3 platforms. DAOs operate through predefined rules encoded in smart contracts, with tokens typically representing membership and voting rights [17] [21]. Their primary objective is to distribute decision-making authority among participants rather than concentrating control within a central managerial entity.

DAO governance generally follows a structured, multi-stage process in which token holders submit proposals that are discussed within community forums prior to formal voting. Proposals that meet predefined quorum and majority thresholds are subsequently executed automatically via smart contracts [21]. In the context of ride-hailing, DAOs offer a mechanism for organising platform governance more transparently and democratically, enabling drivers and riders to collectively influence platform policies, fare structures, and development priorities [20].

Despite their theoretical appeal, DAOs face well-documented implementation challenges. [22] indicates that fully decentralised governance structures may lead to system rigidity or, conversely, the re-concentration of power among large token holders or technically sophisticated participants [17]. Additional challenges in-

clude governance complexity, low participation rates, and difficulties in achieving consensus among heterogeneous stakeholder groups [20]. Consequently, effective DAO design requires careful selection of voting mechanisms, delegation structures, and institutional safeguards to prevent the reproduction of existing power asymmetries.

2.3. Case Studies: Lessons from Web3 Ride-Hailing Initiatives

The practical application of Web3 principles in ride-hailing can be examined through contrasting initiatives such as Drife, an actively deployed platform, and Lazooz, an early but discontinued project. Together, these cases provide insight into both the opportunities and limitations of decentralised mobility models.

2.3.1. Drife: Zero-Commissions and Token-Based Coordination

Drife directly addresses one of the most frequently cited concerns in traditional ride-hailing driver earnings by implementing a zero-commission model that allows drivers to retain the full value of fares [15] [19]. Platform operations are supported by the DRF token, which facilitates peer-to-peer payments, governance participation, and incentive distribution through mechanisms such as staking, referrals, and community engagement [15]. A capped token supply and controlled issuance are intended to support long-term economic sustainability. Rather than relying on per-ride commissions, Drife's revenue model depends on token value appreciation and auction-based pricing mechanisms. While the platform has launched in cities such as Dubai and Bangalore, its long-term viability remains contingent on achieving sufficient user adoption to sustain its token economy.

2.3.2. Lazooz: Early Innovation and Structural Constraints

Founded in 2014, Lazooz represented one of the earliest attempts to develop a decentralised, community-owned ride-sharing platform [23]. The project introduced a novel "proof-of-movement" mechanism that rewarded users with tokens for driving, sharing rides, or contributing to platform development. However, Lazooz faced challenges common to early decentralised applications, including limited funding, scalability constraints, token volatility, and regulatory uncertainty [23]-[25]. Without sufficient capital or a clear path to achieving network effects, the project was ultimately discontinued.

2.3.3. Key Lessons: Balancing Idealism and Pragmatism

The contrasting trajectories of Drife and Lazooz highlight several lessons for Web3 ride-hailing initiatives. First, clearly articulated and immediately tangible value propositions such as zero commissions appear critical for user adoption. Second, tokenomics must be structured around concrete utility rather than abstract incentives. Third, bootstrapping two-sided marketplaces remains exceptionally challenging without substantial capital or viral growth strategies [23]. Finally, scalability, security, and regulatory compliance continue to pose significant barriers across decentralised transport platforms [26].

2.4. Thematic Synthesis and Design Requirements Derivation

A systematic thematic synthesis was conducted to consolidate insights from prior studies. **Table 1** summarises key themes, Core Arguments/Findings, Identified Gaps/Limitations, and their implications for this research. The synthesis suggests that Web3-based alternatives to centralised ride-hailing depend on robust governance, intrinsic token utility, and regulatory alignment.

Table 1. Systematic synthesis of web3 ride-sharing literature.

Theme	Core Arguments/Findings	Identified Gaps/Limitations	Implications for This Study
Platform Disruption vs Structural Transformation	Traditional platforms disrupt markets but retain centralised control over value and governance. Web3 proposes deeper transformation by embedding ownership and governance into infrastructure.	Limited empirical validation of Web3 platforms at scale; conceptual emphasis outweighs operational evidence.	Justifies examining blockchain not as incremental efficiency, but as a structural alternative to centralised Ride-sharing.
Community-Driven & Cooperative Mobility Models	Decentralised platforms can enable community-driven fleets and shared ownership models.	Governance mechanisms often under-specified; real-world adoption challenges not fully addressed.	Motivates integrating SACCO-style cooperatives and DAO governance into ride-sharing design.
Tokenomics as Incentive Alignment Mechanism	Tokenomics aligns stakeholder incentives by linking participation to ownership, rewards, and governance rights. Long-term viability depends on intrinsic token utility.	Risk of speculative tokens; lack of consensus on optimal token design for gig platforms.	Informs multi-utility token design (payments, governance, staking, cooperative access) in proposed framework.
Decentralised Payments & Reduced Intermediation	Tokens enable peer-to-peer payments, eliminating intermediaries and reducing commissions.	Regulatory uncertainty around crypto payments; volatility concerns.	Supports design choice of low-fee, protocol-based payments rather than commission-heavy models.
Governance via DAOs	DAOs provide transparent, rule-based governance through smart contracts and token voting.	Risks of plutocracy, voter apathy, governance complexity, and elite capture.	Justifies hybrid governance (PoA validators + token voting + reputation weighting).
DAO Governance Challenges	Fully decentralised systems may become rigid or re-centralised among large token holders.	Limited empirical evidence on effective DAO governance in regulated sectors.	Necessitates cautious DAO design and inclusion of institutional actors (e.g., unions, regulators).
Web3 Ride-Hailing in Practice: Drife	Zero-commission model improves driver earnings; token supports governance and incentives.	Long-term sustainability depends on user adoption and token stability.	Demonstrates feasibility of commission-free models but highlights adoption risks.
Web3 Ride-Hailing in Practice: Lazooz	Early decentralised ride-sharing pioneer using proof-of-movement token mining.	Failed due to lack of funding, scalability limits, token volatility, and regulatory ambiguity.	Highlights importance of pragmatism, scalability, and regulatory alignment in system design.
Bootstrapping Two-Sided Markets	Decentralised platforms struggle to overcome cold-start problems without capital or viral growth.	Limited strategies proposed for overcoming incumbents' network effects.	Informs focus on emerging-market pilots and hybrid Web2.5 onboarding strategies.
Gig Economy Power Asymmetries	Centralised platforms externalise risk, create income instability, and limit worker agency.	Policy solutions often lag technological change.	Positions blockchain-based governance as a socio-technical intervention, not just a technical upgrade.

Overall, the literature suggests that Web3-based platforms may address persistent gig-economy challenges such as income instability, limited worker autonomy, and opaque governance by integrating tokenisation with decentralised governance mechanisms [20]. Although these approaches remain socio-technical experiments rather than fully mature solutions, they signal a shift toward alternative models of platform-mediated labour and mobility systems.

2.4.1. From Literature Synthesis to System Design: Design Justification

Building on the systematic synthesis presented in **Table 1**, this study translates identified theoretical gaps and empirical insights into concrete system design choices. **Table 2** maps key literature themes to corresponding architectural components (“pallets”) within the proposed blockchain-based ride-sharing framework, demonstrating how governance, incentive alignment, and cooperative principles are operationalised directly within the technical architecture. This mapping ensures that the system design is explicitly grounded in prior research and addresses documented limitations of existing platforms.

Table 2. Mapping literature themes to system pallets.

Literature Gap/Theme (from Table 1)	Identified Limitation	Design Requirement	System Pallet/Component
Centralised value extraction	Platforms retain control over pricing and commissions	Reduce intermediary control over fare distribution	Ride Core Pallet (transparent pricing & matching logic)
Opaque incentive mechanisms	Drivers lack clarity on earnings and rewards	Provide auditable, rule-based incentives	Reward Coin Pallet
Speculative or weak token utility	Tokens lack intrinsic value	Embed tokens in core platform operations	Reward Coin Pallet (payments, staking, governance)
Governance asymmetry	Drivers and riders excluded from decision-making	Enable participatory governance	DAO Governance via Treasury Pallet
DAO plutocracy risks	Power concentration among large token holders	Introduce hybrid governance and safeguards	PoA Validators + Token Voting + Reputation Weighting
Absence of worker financial safety nets	Gig workers exposed to income volatility	Enable cooperative financial support mechanisms	SACCO Co-op Pallet
Centralised identity and data risks	Data breaches and privacy concerns	Provide privacy-preserving identity verification	Identity Pallet (DIDs + ZK Proofs)
Scalability constraints of blockchains	High latency for real-time matching	Offload computation while preserving trust	Off-Chain Workers
Regulatory uncertainty	DAOs lack institutional legitimacy	Incorporate identifiable, accountable actors	PoA Consensus with Institutional Validators

2.4.2. Design Requirements

Based on the literature synthesis and system mapping presented in Section 2.4, a set of design requirements (DRs) was derived to guide the development of the proposed ride-sharing framework. These reflects both socio-technical objectives and operational constraints identified in prior research.

(i) DR1 Transparent and Auditable Pricing: The system shall provide transparent ride-matching and fare calculation mechanisms to address concerns regarding opaque algorithmic control in centralised ride-hailing platforms.

(ii) DR2 Fair and Predictable Compensation: The platform shall ensure that drivers retain a clearly defined share of fare revenue, with minimal protocol fees and auditable payment records.

(iii) DR3 Participatory Governance: The system shall enable drivers and riders to participate meaningfully in platform governance, including decisions related to pricing rules, protocol upgrades, and treasury allocations.

(iv) DR4 Intrinsic Token Utility: The native token shall have clearly defined, non-speculative utility embedded within core platform functions, including payments, governance, staking, and access to cooperative services.

(v) DR5 Cooperative Financial Support: The platform shall support cooperative financial mechanisms, such as pooled savings, emergency loans, and insurance schemes, to mitigate income volatility among drivers.

(vi) DR6 Privacy-Preserving Identity Management: The system shall implement decentralised identity mechanisms that verify credentials and reputation without exposing sensitive personal data.

(vii) DR7 Scalability and Low Latency: The architecture shall support transaction throughput and response times suitable for real-time ride-hailing use cases in urban environments.

(viii) DR8 Regulatory Compatibility: The system shall incorporate governance and validation structures that enable regulatory oversight and legal accountability without reverting to full centralisation.

Grounded in the identified design requirements, this study adopts a design science research approach to develop and evaluate a decentralised ride-sharing framework. The focus is on translating theoretical insights into a functional system artefact and assessing its technical feasibility and stakeholder acceptance. The following section presents the methodology and system architecture, outlining the rationale for selecting a Parity Substrate blockchain, a Proof-of-Authority consensus mechanism, modular system pallets, and off-chain workers to address scalability constraints. Together, these design choices operationalise the literature-derived requirements and provide the basis for empirical evaluation.

3. Methodology and System Architecture

This study follows a Design Science Research (DSR) methodology, combining the construction of a functional technical artefact with empirical evaluation to assess its feasibility and relevance. Consistent with DSR principles, the research comprises (i) artefact design and implementation, and (ii) mixed-method evaluation through simulation testing and qualitative stakeholder analysis.

3.1. Technical Framework: Parity Substrate and Proof-of-Authority

The proposed ride-sharing platform was implemented as a blockchain-based

proof-of-concept using Parity Substrate, a modular framework for developing application-specific blockchains. Substrate was selected for its flexibility, extensibility, and support for custom runtime modules (pallets) tailored to domain-specific requirements.

The system employs a Proof-of-Authority (PoA) consensus mechanism, utilising the Aura (Authority Round) protocol for block production and GRANDPA for finality. Alternative consensus mechanisms were considered but found unsuitable for the application context. Proof-of-Work (PoW) introduces prohibitive latency and energy costs, while Proof-of-Stake (PoS) may exacerbate governance concentration by privileging capital-intensive actors such as large fleet operators.

Proof-of-Authority (PoA) was selected because it enables a permissioned validator set composed of identifiable and accountable entities, including transport unions (SACCOs), regulatory agencies, and accredited technical partners. This design aligns with the regulatory requirements of public transport systems while delivering low latency (less than two seconds) and high throughput suitable for real-time ride matching and settlement. As illustrated in the system design (Figure 1), this architectural choice contributes to Design Science Research by demonstrating the feasibility of permissioned app-chain architectures for regulated, high-frequency mobility services.

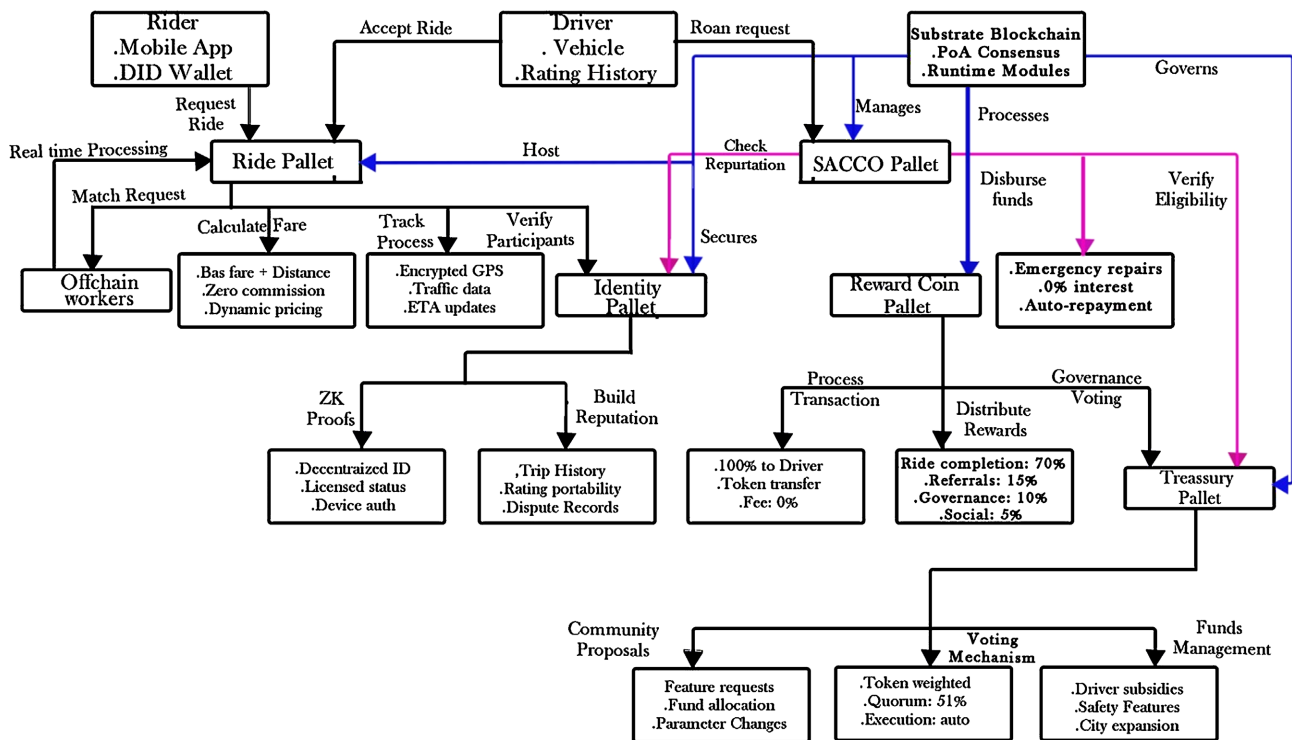


Figure 1. High-level system architecture of the proposed blockchain-based ride-sharing platform

3.2. System Architecture and Functional Components

The platform architecture is composed of specialised Substrate pallets, each addressing a distinct functional or governance requirement.

3.2.1. Treasury Pallet

The Treasury Pallet implements a decentralised, community-governed fund to support platform operations and collective welfare initiatives. Funds sourced from optional protocol fees are allocated through on-chain proposals and token-weighted voting. This mechanism enables transparent participatory budgeting for purposes such as safety enhancements, driver support programmes, and platform maintenance. Prior research suggests that decentralised treasuries can enhance accountability and ecosystem sustainability when aligned with DAO governance principles.

3.2.2. Ride Core Pallet

The Ride Core Pallet constitutes the operational backbone of the platform, managing ride requests, driver-rider matching, fare computation, and ride lifecycle tracking. Matching and pricing logic are implemented through auditable smart contracts, enabling transparency in dispatch and remuneration processes. This design responds to documented concerns regarding opaque algorithmic decision-making in conventional ride-hailing platforms.

3.2.3. Reward Coin Pallet

The Reward Coin Pallet introduces a native utility token that serves both transactional and governance functions. The token supports peer-to-peer payments, governance participation (one-token-one-vote), staking-based security incentives, and access to cooperative benefits through SACCO membership as shown in **Figure 2**. By embedding multiple utility functions, the design aligns with tokenomics research emphasising intrinsic utility as a determinant of long-term system viability [16].

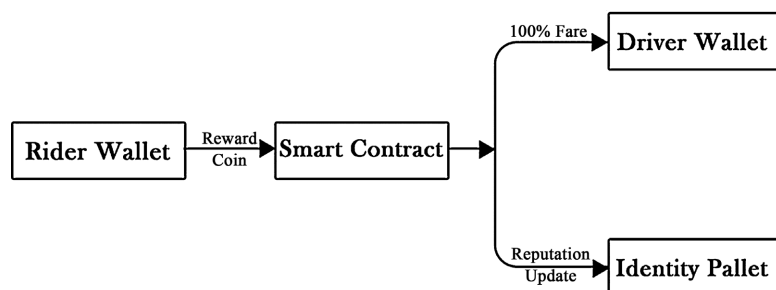


Figure 2. Reward coin interaction.

3.2.4. Identity Pallet

As illustrated in **Figure 3**, the Identity Pallet provides a privacy-preserving trust layer using decentralised identifiers (DIDs) and zero-knowledge proofs. It enables credential verification without exposing sensitive personal data and anchors tamper-resistant reputation records to digital identities. This supports regulatory compliance (e.g., KYC/AML) while mitigating risks such as fraud and Sybil attacks.

3.2.5. SACCO Cooperative Pallet

The SACCO Cooperative Pallet operationalises cooperative financial mechanisms

on-chain, allowing drivers to participate in shared savings, insurance pools, and emergency financing schemes as illustrated in **Figure 4**. By formalising cooperative governance within the platform, this module addresses income volatility and limited access to financial safety nets commonly experienced by gig workers.

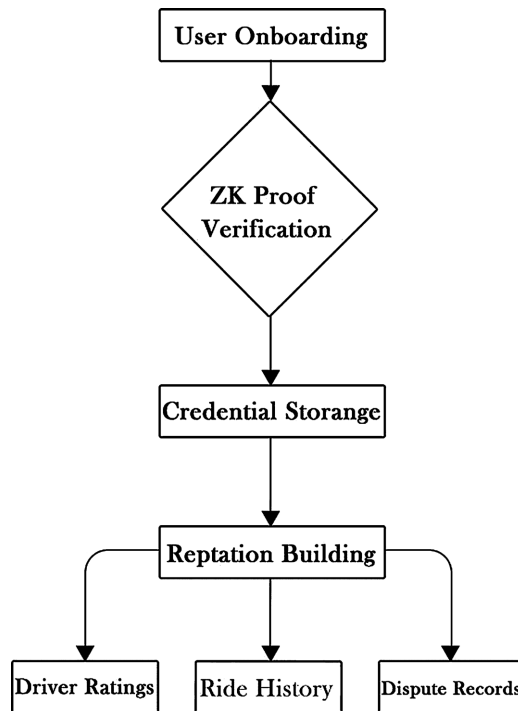


Figure 3. Identity pallet interaction.

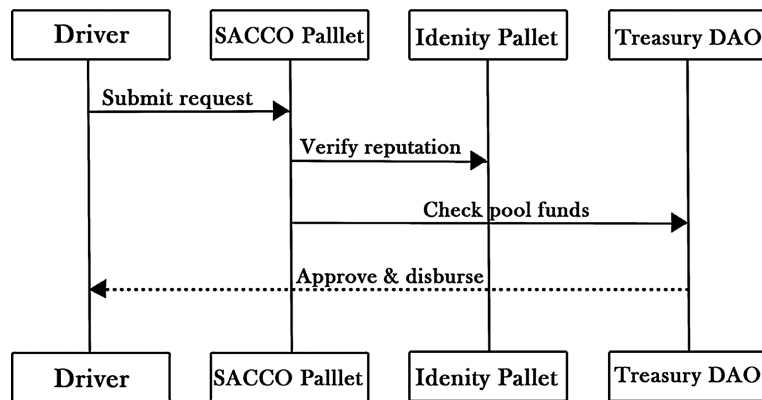


Figure 4. Sacco pallet example interaction.

3.2.6. Off-Chain Workers

To address scalability constraints inherent in blockchain systems, the architecture incorporates off-chain workers to handle computationally intensive and time-sensitive tasks. Core governance and settlement logic remains on-chain, while data processing and external integrations are executed off-chain as shown in **Figure 5**. This hybrid design mitigates the blockchain trilemma by improving throughput and reducing costs without compromising decentralised governance.

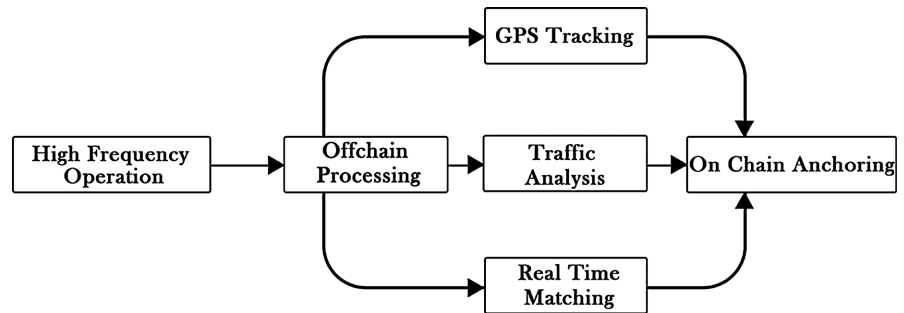


Figure 5. Off-chain worker interaction.

3.3. Data Collection and Evaluation

Artefact evaluation followed a mixed-method approach, consistent with DSR evaluation guidelines.

(i) Simulation Testing: The system was benchmarked using Hyperledger Caliper on a simulated 10-node network. A dataset of 2000 synthetic ride transactions was executed to measure throughput, latency, and transaction costs.

(ii) Qualitative Evaluation: Focus group discussions were conducted with 50 stakeholders (35 drivers, 10 transport union representatives, and 5 regulators) in Nairobi. A Likert-scale instrument was used to assess perceptions of pay fairness, algorithmic transparency, and dispute resolution, aggregated into a composite *Driver Trust Index*.

4. Results and Evaluation

Consistent with Design Science Research methodology, this section evaluates the proposed artefact against the design objectives derived from the literature. The evaluation focuses on three dimensions: technical feasibility, governance transparency, and stakeholder acceptance, combining quantitative performance benchmarking with qualitative stakeholder feedback.

4.1. From Design Requirements to Evaluation Objectives

The eight design requirements (DR1-DR8) derived from the literature synthesis (Section 2) capture interrelated socio-technical and operational concerns rather than independent system properties. To enable a focused and analytically tractable evaluation consistent with Design Science Research principles, these requirements were synthesised into four higher-level evaluation objectives. This synthesis preserves traceability between theory, system design, and evaluation outcomes while reducing redundancy.

Specifically, requirements related to transparent pricing and privacy-preserving identity (DR1 and DR6) were synthesised under an objective concerned with embedding governance and trust mechanisms within the technical architecture. Requirements addressing fair compensation, intrinsic token utility, and cooperative financial support (DR2, DR4, and DR5) were grouped under an incentive-alignment objective reflecting economic participation and value distribution. Participatory governance

and regulatory compatibility (DR3 and DR8) were consolidated under an objective focused on accountable and inclusive decision-making. Finally, scalability and low-latency performance requirements (DR7) were retained as a standalone objective due to their critical importance for real-time ride-hailing systems.

Accordingly, the artefact was evaluated against the following Design Science evaluation objectives:

(i) **EO1:** Embed governance and ownership mechanisms within the technical architecture.

(ii) **EO2:** Align economic incentives with participation and platform utility.

(iii) **EO3:** Enable transparent, accountable, and participatory governance.

(iv) **EO4:** Achieve sufficient performance and usability for real-world ride-hailing contexts.

The evaluation results are presented in relation to these objectives.

4.2. Technical Performance Evaluation (EO4)

4.2.1. Throughput and Latency

Simulation testing using Hyperledger Caliper evaluated system performance under a simulated 10-node Proof-of-Authority network. The artefact sustained an average throughput of approximately 140 transactions per second (TPS) for application-level transactions, including ride matching and booking operations.

Block finality was consistently achieved within 6 seconds, resulting in end-to-end latency suitable for near real-time ride dispatch. While this throughput is lower than that of globally centralised platforms operating at hyperscale, it exceeds the estimated peak demand of city-scale deployments such as Nairobi, where ride-hailing requests are estimated at approximately 20 transactions per second during peak periods. This provides a substantial operational buffer while preserving decentralised governance characteristics.

4.2.2. Transaction Costs

Effective protocol fees were maintained below 10% of fare value, representing a significant reduction relative to the commission-based models commonly reported for incumbent platforms. Importantly, transaction costs remained stable under increasing load, indicating that the combination of PoA consensus and off-chain workers effectively mitigates congestion-related cost volatility.

4.3. Governance and Transparency Evaluation (EO1 & EO3)

On-Chain Governance and Treasury Control

Evaluation of the Treasury Pallet confirmed that resource allocation decisions were executed exclusively through on-chain proposals and token-weighted voting. All proposals, voting outcomes, and fund disbursements were immutably recorded, enabling full auditability.

Stakeholder feedback indicated that the visibility of financial flows and the ability to participate in allocation decisions were perceived as significant improvements over opaque, centrally administered revenue models. This finding aligns

with prior research suggesting that decentralised treasuries can enhance perceived legitimacy and accountability when properly governed.

4.4. Incentive Alignment and Token Utility (EO2)

The Reward Coin Pallet was evaluated based on its functional utility rather than speculative valuation. The token successfully enabled:

- (i) Peer-to-peer fare settlement without intermediaries.
- (ii) Governance participation via voting rights.
- (iii) Staking-based security incentives.
- (iv) Access to cooperative financial services through SACCO membership.

Participants reported that the coupling of economic rewards with governance rights increased perceived fairness and engagement. Notably, drivers emphasised the importance of predictable earnings and visible rule enforcement over token price appreciation.

4.5. Stakeholder Perceptions and Trust Evaluation

Driver Trust Index

Qualitative evaluation was conducted through focus groups involving 50 stakeholders (drivers, union representatives, and regulators). Responses were aggregated into a composite *Driver Trust Index* measuring perceptions of pay fairness, algorithmic transparency, and dispute resolution mechanisms.

The decentralised platform achieved a reported 92% positive trust perception, compared to a reported baseline of dissatisfaction commonly cited in studies of conventional ride-hailing platforms. Participants attributed improved trust primarily to transparent fare calculation, auditable decision rules, and participatory governance mechanisms.

While these findings are exploratory and context-specific, they suggest that governance transparency and stakeholder participation may significantly influence trust perceptions.

4.6. Synthesis of Evaluation Outcome

Table 3 consolidates the evaluation outcomes for each Design Science objective,

Table 3. Synthesis of evaluation outcomes against design science objectives.

Evaluation Objective	Evaluation Outcome	Verdict	Evidence
EO1: Embedded governance	Governance mechanisms were technically effective and transparent, though long-term participation dynamics require further study	Supported	On-chain treasury, DAO voting
EO2: Incentive alignment	Token utility was directly linked to platform participation and governance rather than speculative incentives	Supported	Multi-utility token, stakeholder feedback
EO3: Transparent governance	Participatory governance and algorithmic transparency were positively associated with perceived trust	Supported (exploratory)	Trust index, auditability
EO4: Technical feasibility	The artefact demonstrates technical feasibility for high-frequency mobility services at city scale	Supported	TPS, latency, cost stability

including the observed results, evaluative verdicts, and supporting evidence.

4.7. Evaluation Limitations

Several limitations must be acknowledged. First, performance evaluation was conducted in a simulated environment rather than a live production deployment. Second, stakeholder feedback was collected within a single urban context, limiting generalisability. Third, long-term governance dynamics such as voter fatigue, token concentration, and validator collusion could not be empirically assessed within the study timeframe. These limitations suggest that while the artefact demonstrates feasibility and relevance, further longitudinal and cross-context evaluations are necessary to assess sustainability at scale.

5. Contributions and Implications

This study contributes to Design Science Research by demonstrating how decentralised technologies can be systematically applied to reconfigure governance, incentives, and coordination in platform-mediated mobility services. Rather than proposing blockchain as a generic solution, the research advances a context-aware artefact designed for regulated, high-frequency ride-sharing environments. The contributions and implications are discussed across design knowledge, theory, practice, and policy.

5.1. Design Science Contributions

5.1.1. Artefact Contribution

The primary contribution of this study is the development and evaluation of a permissioned, application-specific blockchain artefact for ride-sharing. Implemented using Parity Substrate and Proof-of-Authority consensus, the artefact integrates governance, identity, incentive distribution, and cooperative finance directly into the platform's technical architecture.

Unlike prior conceptual proposals, the artefact demonstrates that decentralised ride-sharing can be operationalised at the protocol level without sacrificing performance, accountability, or regulatory compatibility. The modular pallet architecture provides a reusable design pattern for other platform-mediated services operating in regulated domains.

5.1.2. Design Principles and Prescriptive Knowledge

Based on the artefact design and evaluation, the study contributes the following prescriptive design principles:

(i) **DP1 Embed governance into the core system architecture:** Governance mechanisms should be implemented as first-class technical components rather than external organisational processes.

(ii) **DP2 Couple economic incentives with participation and ownership:** Tokens should derive value from concrete utility, governance rights, and cooperative benefits rather than speculative dynamics.

(iii) **DP3 Balance decentralisation with institutional accountability:** Permis-

sioned validator models can preserve decentralised coordination while satisfying regulatory and safety requirements.

(iv) DP4 Combine on-chain governance with off-chain computation: Hybrid architectures are necessary to meet performance requirements in high-frequency service environments.

These principles extend existing DSR knowledge by demonstrating how decentralisation can be pragmatically adapted to socio-technical systems constrained by regulation and real-time operational demands.

5.2. Theoretical Implications

From a theoretical perspective, the findings contribute to the literature on platform governance, gig-economy labour, and digital cooperativism. The study supports emerging arguments that many challenges in ride-sharing platforms such as opaque decision-making and labour precarity are rooted in architectural and governance choices rather than isolated policy failures.

By operationalising DAOs, tokenomics, and cooperative finance within a single artefact, the study provides empirical support for theories that view Web3 platforms as mechanisms for institutional redesign rather than incremental technological upgrades. In particular, the results suggest that decentralised governance structures can influence stakeholder trust and perceived fairness when governance rules are transparent and enforceable at the system level.

5.3. Practical Implications

5.3.1. Implications for Platform Designers and Developers

For system designers, the research demonstrates that decentralised ride-sharing platforms can achieve real-time performance while maintaining participatory governance. The pallet-based architecture offers a blueprint for integrating identity verification, incentive mechanisms, and cooperative finance without introducing excessive complexity. Developers can apply the design patterns presented in this study to other platform-based services, including logistics, delivery, and freelance marketplaces, particularly where trust, transparency, and worker participation are critical.

5.3.2. Implications for Transport Operators and Worker Organisations

The proposed architecture highlights opportunities for transport unions, cooperatives, and driver associations to participate directly in platform governance rather than operating as external advocacy bodies. By embedding SACCO-style cooperative mechanisms on-chain, the platform enables collective risk-sharing, access to financial services, and democratic control over platform resources.

This model offers an alternative pathway for organising gig work that complements, rather than replaces, existing labour institutions.

5.4. Policy and Regulatory Implications

From a policy perspective, the study illustrates how decentralised platforms can

be designed to align with regulatory requirements for accountability, transparency, and consumer protection. The use of identifiable validators and auditable governance processes suggests a potential framework for recognising DAO-based entities within existing transport regulation regimes. For regulators in emerging markets, the findings indicate that decentralised mobility platforms could support inclusive innovation if accompanied by adaptive regulatory frameworks that recognise cooperative ownership models and programmable governance.

5.5. Limitations and Directions for Future Research

While the artefact demonstrates technical feasibility and stakeholder acceptance, several limitations remain. The evaluation was conducted in a simulated environment and within a single urban context, limiting generalisability. Long-term governance dynamics such as voter participation, token concentration, and validator behaviour were not observable within the study timeframe.

Future research should examine longitudinal deployments, cross-city implementations, and comparative evaluations against centralised platforms. Further work is also needed to explore hybrid “Web2.5” interfaces that reduce user friction while preserving decentralised governance guarantees.

5.6. Summary

In summary, this study contributes to Design Science Research by developing and evaluating a validated artefact and a set of prescriptive design principles for decentralised ride-sharing platforms operating in regulated environments. Through the design and assessment of a blockchain-based proof-of-concept, the study demonstrates how decentralised governance mechanisms can mitigate power imbalances, how intrinsically utilitarian token systems can align incentives and support fair compensation, and how hybrid technical and institutional architectures can address key interoperability, regulatory, and adoption constraints. By translating theoretical insights from Web3, cooperative governance, and platform economics into an executable system, the research illustrates how decentralisation can be applied pragmatically to address structural challenges in platform-mediated mobility.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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