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HIGH-PERFORMANCE DECENTRALISED SYSTEMS FOR COMPUTER GAME BACKENDS USING SOLANA

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The paper substantiates the justified use of decentralised distributed systems in computer-game backend architecture and argues that such systems should be employed selectively rather than as a universal substitute for conventional server infrastructure. The research addresses the problem of balancing performance, operational simplicity and low latency with the need for verifiable ownership, transparent settlement, trustworthy event histories, reliability and secure handling of critical records. The study's tasks are to compare centralised and decentralised backend models, to identify game-industry processes for which decentralisation is functionally warranted, and to assess Solana as an example of a high-performance blockchain platform suitable for hybrid game backends. It is shown that the most justified areas of application include financial operations, management of scarce digital assets, secondary marketplaces, transfer of avatars and other digital entities, and registration of economically significant events. The paper concludes that Solana can be considered an efficient infrastructural component of a hybrid backend in which transparency, data integrity, and resilience against unilateral record manipulation are required.

Modern computer games are increasingly organised as long-term service ecosystems in which the backend performs far more functions than simply storing user progress. It coordinates player authentication, matchmaking, game-state synchronisation, anti-cheat procedures, telemetry collection, monetisation workflows, community interactions, and the circulation of digital assets. Under these conditions, the architectural design of backend services influences not only technical stability but also the credibility of economic and social relations within a game environment. The problem considered in this paper lies in the fact that centralised infrastructures remain the most efficient solution for the majority of latency-sensitive operations, whereas some economically significant and legally sensitive processes require stronger guarantees of integrity, transparency, auditability and trusted ownership than a purely centralised server can provide on its own [1-3].

To address this problem, the paper solves several interconnected tasks. First, it differentiates between centralised and decentralised approaches to backend construction in the context of computer games. Secondly, it identifies the classes of game-related operations for which decentralisation is not merely fashionable but functionally justified. Thirdly, it clarifies which reliability and data-security properties of blockchain-based systems are relevant for practical game development and operation. Finally, it evaluates Solana as a concrete technological example of a high-performance blockchain that may be incorporated into a hybrid backend model. Such a formulation is important because it focuses not on blockchain as an autonomous ideology, but on technology-driven innovation in game mechanics and backend engineering.

From a systems engineering standpoint, a complete migration of game logic to a blockchain is rarely rational. Real-time gameplay loops, combat interactions, positional updates, voice communication, rapid synchronisation, session management and most anti-cheat checks require low latency, predictable throughput and direct operator control. In these domains, conventional centralised services remain more appropriate. Decentralised systems introduce consensus overhead, more demanding key-management procedures, smart-contract auditing requirements, higher operational complexity and, in many cases, additional financial cost per recorded transaction [3-5]. For this reason, the use of decentralisation in games should be based on the principle of justified

necessity: a decentralised mechanism is reasonable only where the architectural properties of distributed trust, immutable history or independently verifiable ownership are genuinely required.

The first such area is financial and settlement-related activity. Transactions involving players, tournament rewards, creator royalties, marketplace payments, peer-to-peer exchange and settlement between platform actors benefit from a ledger that records operations in a verifiable and tamper-resistant manner [3, 4, 6]. In a traditional centralised environment, the operator may unilaterally alter or suppress transaction histories, which can lead to disputes over balances, withdrawals, prize distributions, or compensation for digital goods. A decentralised ledger provides a common, auditable record that multiple participants can verify, thereby increasing confidence in economically significant interactions. This is particularly relevant in game ecosystems that include user-generated content, competitive rewards, persistent digital economies or cross-border microtransactions.

A second justified area concerns scarce digital assets and the confirmation of ownership rights. Modern games increasingly contain avatars, skins, unique items, access keys, tickets, badges, land plots, collectable objects and other digital entities that acquire economic or symbolic value for players. Where such entities are intended to be transferable, tradable, persistent across updates, or visible beyond a single local database, a blockchain-based representation becomes functionally attractive [7, 8]. The chain can provide proof of issuance, proof of transfer and an accessible history of ownership. This is especially important for secondary markets and cross-platform ecosystems, where the same avatar or item must be recognised by multiple services. In such cases, decentralised records reduce dependence on a single database administrator and make the circulation of high-value digital objects more transparent. At the same time, the paper stresses that only the critical ownership record should be placed on chain, whereas bulky media files and transient gameplay metadata should remain off-chain.

A third area is the registration of significant game events. Competitive gaming, live-service titles and digital economies frequently involve actions whose consequences extend beyond a single short session. These include asset issuance, tournament reward allocation, rare-achievement registration, the provenance of limited objects, and other events that may later become subject to dispute or economic exploitation. A decentralised ledger can operate as a trusted register for such events without replacing the full operational backend. In this sense, blockchain should be interpreted as a specialised infrastructural layer for confirmation and audit rather than as a substitute for all forms of game-state management [6, 8].

An important addition to this argument is that blockchain-based decentralised systems contribute to data reliability and the security of data use. Their reliability is linked to replicated storage, consensus-based state transitions, and the absence of a single point of mutation in the authoritative record. Their security value derives from cryptographic verification, append-only record structures and the difficulty of undetected retrospective tampering [1, 2, 9]. Consequently, such systems can strengthen integrity guarantees for critical records, support audit trails, reduce the risk of unilateral falsification by an operator, and improve evidentiary quality in disputes over digital assets or settlement operations. Nevertheless, these properties must not be idealised. Smart-contract defects, wallet compromise, inadequate access control, privacy leakage and regulatory constraints remain serious risks [7, 9]. Therefore, data security in blockchain systems is best understood not as absolute invulnerability, but as a different security model in which some risks are reduced while other risks shift towards contract design, key custody and interface security.

Within this framework, Solana is noteworthy as a representative high-performance platform whose architecture was designed to reduce coordination overhead in a Byzantine fault-tolerant replicated state machine and to support high throughput with comparatively low transaction costs [10]. Its relevance to computer-game backends lies not in the claim that every game should become blockchain-based, but in the possibility of integrating a performant, decentralised layer for high-load asset operations, auditable settlement, persistent identity-linked records, and the transparent circulation of valuable in-game entities. In combination with conventional servers, Solana can support a hybrid architecture in which centralised services preserve responsiveness and flexible

game administration, while decentralised modules provide trusted ownership, reproducible ordering of critical records and higher resistance to unilateral data manipulation [6, 8, 10].

Thus, the study concludes that decentralised distributed systems are justified in computer-game backend architecture only for a limited yet strategically important set of tasks. Their principal value emerges where financial accountability, verifiable ownership, secure use of critical data, marketplace transparency and long-term auditability are indispensable. For the purposes of section 4, this allows blockchain technology to be interpreted as an element of technological innovation and modern game mechanics rather than as an isolated financial trend. Owing to its performance-oriented design, Solana may serve as an effective infrastructural component of such solutions, provided that developers adopt a hybrid model and place on-chain only those processes for which decentralisation yields a clear functional advantage.

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