Advancing Traditional Player Participation in Blockchain Games: Engaging Native Game Mechanics

Hao Wu
School of Science and Engineering
The Chinese University of Hong Kong, Shenzhen
Shenzhen, Guangdong, China
haowu3@link.cuhk.edu.cn

Yueyao Li
School of Science and Engineering
The Chinese University of Hong Kong, Shenzhen
Shenzhen, Guangdong, China
yueyaoli@link.cuhk.edu.cn

Yan Zhuang
School of Science and Engineering
The Chinese University of Hong Kong, Shenzhen
Shenzhen, Guangdong, China
yanzhuang@link.cuhk.edu.cn

Xinyao Sun
Matrix Labs Inc.
Vancouver, BC, Canada
University of Alberta
Edmonton, Alberta, Canada
asun@matrixlabs.org

Wei Cai*
School of Engineering and Technology
University of Washington
Tacoma, WA, USA
weicaics@uw.edu

Abstract

As an emerging video game genre in recent years, blockchain games have attracted substantial attention due to the strengths of blockchain technology and the popularity of Web3 ideals. However, blockchain games have encountered a dilemma due to the inability to attract traditional video game players. In this paper, we compare data gathered from Twitter, webpages, and research literature through the grounded theory (Glaserian approach) to uncover that the key to transcending the current state lies in the innovation of native and engaging game mechanics. We propose a design framework for blockchain game mechanics derived from the concept of emergent games, which integrates the basic elements of emergent games with the unique features of blockchain technology, discussing its potential design directions. Finally, we implement a high-fidelity prototype to serve as a case, instantiating a novel mechanic based on this framework and providing early proof of feasibility.

CCS Concepts

• **Human-centered computing → Human computer interaction (HCI)**.

Keywords

blockchain game, Web3 game, game mechanics, collaboration

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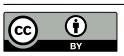
*Wei Cai is the corresponding author (weicaics@uw.edu).



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1 Introduction

The evolving demand for ownership and control over online data and assets has catalyzed a transition from the centralized Web 2.0 to the more decentralized ecosystem of Web3 (a.k.a. Web 3.0) [2]. Initiated by Gavin Wood in 2014, Web3 introduces a decentralized network built on blockchain technology, deviating significantly in digital interaction paradigms [62]. Since 2021, this shift has spurred breakthroughs of digital art and business in the metaverse [12, 22], and notably the game industry by facilitating a unique blockchain game ecosystem [39]. This new ecosystem enables genuine digital asset ownership through technical innovations like smart contract and non-fungible tokens (NFTs), fulfilling a crucial aspiration of gamers for autonomy from centralized gaming platforms and companies [37]. Furthermore, scholars have categorized blockchain games primarily from the perspective of such asset ownership [37, 43, 49].

Despite the relatively short history of blockchain games, they have rapidly proliferated to over 3,000 titles by 2021 [7], attracting a total investment of $5.3 billion in the same year [28]. Their range extends from basic online casinos [8] to complex platforms like AXIE INFINITY[1], offering varied engagement methods and financial returns for players. For instance, the play-to-earn (P2E) model enables players to translate in-game achievements into real-world value via fungible tokens or NFTs [14, 27]. However, the prevailing focus on the economic aspect of blockchain games overshadows the gameplay experience, risking transient popularity [26] and skepticism among traditional gamers [21, 58]. Starting from 2023, the development of the blockchain industry has encountered obstacles, exhibiting a significant downward trend [7, 28].

In this paper, we employ the Grounded Theory (Glaserian approach), a qualitative research methodology particularly suited for exploring nascent and rapidly evolving fields where existing theories may not fully capture the phenomenon [4, 19, 20]. Blockchain game, currently in its early stages and undergoing rapid development, exemplifies such a field. Through a series of systematic processes (data collection, constant comparison, and conceptualization,

[1] https://axieinfinity.com/

etc.), grounded theory enables researchers to develop contextualized insights grounded in empirical evidence, identifying root causes of challenges and potential solutions.

Following the principles of grounded theory, we collect and analyze 5,854 data from three sources: Twitter, webpage, and research literature, resulting in corresponding conceptual relationships. Then, there are two crucial discoveries emerged: Firstly, the primary reason for the deadlock faced by blockchain games is their inability to attract traditional video game players, which arises from the lack of enjoyment caused by rigid game mechanics and the poor user experience resulting from the limitations of blockchain technology. Among them, such rigidity in mechanics can be largely attributed to the excessive focus on homogeneous economic designs and the unimaginative gameplay directly migrated from Web2 games without innovative adaptation of the Web3 ecosystem. Secondly, the current mainstream blockchain game mechanics is P2E. Its success lies not only in the drive for economic incentives but also in effectively connecting blockchain technology with game mechanics, providing players with a blockchain-oriented native game experience.

To break the impasse of blockchain games failing to attract traditional gamers, we adopt the design methods from emergent games, which are widely recognized for fostering game mechanics innovation and enhancing player enjoyment [1], to improve the rigid mechanisms. Additionally, the generative logic of successful P2E in conceptual relationships underscores the importance of blockchain features in the design of game mechanics. It shows the potential of native blockchain game experiences, leveraging the unique features of blockchain technology, to attract participants. Therefore, we have proposed a design framework that integrates the basic elements of emergent games with the features of blockchain technology. This framework aims to cultivate intriguing and native blockchain game mechanics to rejuvenate the blockchain game.

Building upon this integrated design framework, we have further discussed four promising directions for designing engaging native blockchain game mechanics:

- **Dynamic physics with decentralization and transparency**: In traditional games, physics rules are often fixed. Introducing decentralization and transparency allows players to autonomously decide on rule combinations and adjustments through mechanisms like voting, creating a more engaging game experience.
- **A highly enabled internal economy with immutability, transparency, and decentralization**: Leveraging these blockchain characteristics enables the verification of actual ownership and value of in-game assets, permitting verifiable exchanges with real-world currency on a global scale.
- **Greater depth tactical maneuvering with immutability and transparency**: Utilizing a dual-platform architecture, consisting of the blockchain layer and game application layer, fosters more complex strategic layers, offering different levels of action for the game and expanding the overall possibility space of gameplay.
- **High-trust social interaction with immutability and transparency**: All player information on-chain, including transactions, interactions, and data storage, is transparent and immutable. Such mechanisms can rapidly develop cooperative relationships, potentially propelling social interaction models into new depths. For example, inheritance collaboration, where participants inherit and extend the achievements of predecessors, allows subsequent players to further develop their outcomes.

These engaging mechanics have the potential to advance traditional player participation. Furthermore, we implements a high-fidelity tower defense game prototype with inheritance collaboration as the core mechanism to provide instantiated validation for the design framework and the game mechanics directions discussed, exemplifying the process from the design framework to a game. This prototype can be played solely through the smart contract or the game website.

In sum, the main contributions of this paper include: (1) The first to utilize the grounded theory for large-scale data collection and coding in the context of blockchain games, constructing the conceptual relationships to shed light on its dilemmas. (2) The first to propose a design framework oriented towards blockchain games from the perspective of mechanics. (3) Validating the feasibility of the design framework through a high-fidelity prototype.

2 Background

2.1 Web3 and Blockchain

The terms “Web 1.0”, “Web 2.0”, and “Web 3.0” are often deemed as three generations of the web [24]. Web 1.0 is referred to as the read-only web, which was a static platform. This generation of the web was primarily used for publishing information and did not support user-generated content [48]. Web 2.0 is considered a read-write network, where users serve both as consumers and creators[30]. Companies can benefit by aggregating user data and services into platform ecosystems [32, 53]. However, the relationship between these platforms and users is not entirely equitable, as companies wield centralized authority over these ecosystems.

Web 3.0 is expected to be the next stage in the evolution of the Web. In its early conception, Web 3.0 was defined from a semantic perspective as semantic Web technologies integrated into, or powering, large-scale Web applications [23]. However, since 2014 when Gavin Wood first proposed that Web3 (a.k.a Web 3.0) should be a decentralized ecosystem based on blockchain, Web3 and Web 3.0 have taken on new definitions [62]. Due to the increasing problems of centralization in Web 2.0, such as loss of democracy, censorship, bandwidth, and security threats [2, 33, 42], many researchers have endorsed Gavin Wood’s perspective of Web3 as a web platform that grants individuals direct control over their data and information [12, 22, 39]. Researchers and relevant professionals believe that this decentralized paradigm of Web3 can mitigate the aforementioned issues of centralization by leveraging blockchain technology [2, 46, 47, 60]. The foundational ethos of Web3 is to embrace decentralization and prioritize user autonomy, instead of relying on centralized intermediaries and institutions [64]. In the context of this paper, the term "Web3" refers exclusively to the blockchain-based Web3 described above. Blockchain technology is a public, decentralized database enabling secure and distributed record-keeping across computers, without relying on centralized authorities for verification and control [35]. All information recorded

on the blockchain and network nodes is public and transparent. Once information is appended to the blockchain, it is hard to modify without consensus among all nodes [41]. Blockchain has the characteristics of decentralization, transparency, and immutability [9, 67]. In addition, blockchain enables anonymity, owing to the employment of security technologies such as hash chained storage and anonymous signatures [66].

Applications built on blockchain architectures are often referred to as decentralized applications. With respect to decentralized applications, smart contracts, as autonomous programs encapsulating data and logic, play a pivotal role. As programs residing on the blockchain, smart contracts enable contractual agreements between parties without necessitating trusted intermediaries. When executed, the state of a smart contract can be updated on the blockchain [63]. Inheriting the foundational blockchain attributes, smart contracts exhibit the features of decentralization, transparency, immutability, and anonymity [40]. Moreover, building upon smart contracts, NFTs are another important component of the Web3 ecosystem as a form of cryptocurrency [18]. NFTs are commonly implemented as mappings where the key is a token ID and the value is the associated unique metadata. With their non-fungible uniqueness, NFTs are well-suited for representing distinctive digital assets. Through NFTs, asset ownership of the owner can be readily proven for digital content like videos and images [59].

2.2 Blockchain Game

In traditional Web 2.0 platforms, player data is owned by game companies rather than players themselves. a major event demonstrating the problems of centralized game companies occurred in January 2023, when Blizzard closed services in the Chinese region, resulting in millions of players losing game accounts they had built up over 20 years [57]. The original motivation for blockchain games is that people wanted control over their in-game digital assets. In the early stages of blockchain games, Min et al. have categorized games into four types based on the advantages of blockchain technology, specifically focusing on ownership and transparency: "Rule Transparency", "Asset Ownership", "Asset Reusability", and "User-Generated Content" [37]. This classification has been widely accepted by subsequent researchers when analyzing blockchain games typologies [43, 49].

Drawing from the statistical findings of Chen et al. [11], Fred Ehrsam was the first to propose combining blockchain technology with games. In February 2017, Ehrsam has believed blockchain's decentralization and digital asset ownership could present new opportunities for games [17]. In November 2017, CryptoKitties[2] was officially launched, enabling players to earn profits through breeding and selling NFTs. After one month, its transaction volume accounted for over 10% of Ethereum's traffic [5]. Five months later, its total turnover reached 43,067 ETH, approximately 200 million dollars [37]. CryptoKitties' success gained significant public attention to blockchain games. According to Tingbits[3], a blockchain gaming data aggregator, the number of blockchain games grew from the launch of CryptoKitties in 2017 to around 300 by 2019. With the rise of Web3 concepts, this number skyrocketed to over 3,000 in 2021 [7]. In parallel, corporate investment and market share of blockchain games have gradually increased. The total annual investments increased from $88 million dollars in 2020, to $4 billion in 2021, and $5.3 billion in 2022, according to statistics by BlockchainGamer.biz [28]. Although gaining popularity, most games on the market still revolve around P2E mechanics with selling NFTs or earning tokens [16, 27, 37], resulting in boring experience. Additionally, the limitations inherent in blockchain technology, such as insufficient blockchain throughput and high costs [25], lead to flaws in the games themselves. While L2 solutions have partially ameliorated these issues [65], blockchain games continue to lag traditional Web2 video games regarding user experience. In the absence of enjoyment game mechanics alongside subpar experience, the primary appeal of many blockchain games lies solely in financial rewards from P2E as well as ownership of digital assets.

This status quo has provoked opposition from industry experts, who argue current blockchain games resemble Ponzi schemes, and non-Web3 games can also achieve what these games promote [21, 58]. Compared to video games, blockchain games are more akin to financial products. Many players overlook enjoyment and only focus narrowly on profits. As Jiang et al. pointed out, CryptoKitties presents a typical example where players will leave the game when they realize they cannot earn monetary returns [26]. Nevertheless, blockchain gambling games have become an independent branch separate from other blockchain game genres, due to their overly simple mechanics and purely profit-driven nature. For them, blockchain technology provides a suitable platform for development and growth [43].

With the decline of the 2021 Web3 hype, the problems with blockchain games have gradually emerged. Tingbits noted that as of March 2023, only 526 of 3,629 tracked blockchain games were playable, the remainder being discontinued, in development, or pre-selling. Moreover, data from the Big Blockchain Game List[4] reveals that the number of blockchain games in the first half of 2024 only increased by 276. According to BlockchainGamer.biz, total corporate investment in the sector decreased to $1.7 billion in 2023. As of September 2024, investment has only reached $734 million [28]. These figures collectively point to blockchain games facing substantial hurdles. The industry landscape fixated exclusively on monetary profits, alongside research directions focused on optimizing economic mechanisms, may not suffice to sustain the continued development of blockchain games.

3 Method

Grounded theory functions as both an approach for conducting qualitative research and a methodology for developing inductive theory [4, 20]. It is defined as "a research strategy derived from systematically gathered and analyzed data through an iterative research process aimed at generating theory" [44, 50]. Two primary schools exist within grounded theory [31]: The Glaserian approach (proposed by Barney Glaser) embraces flexibility and theoretical sensitivity [19], whereas the Straussian approach (pioneered by

[2]https://www.cryptokitties.co/
[3]https://tingbits.com/
[4]https://bigblockchaingamelist.com/

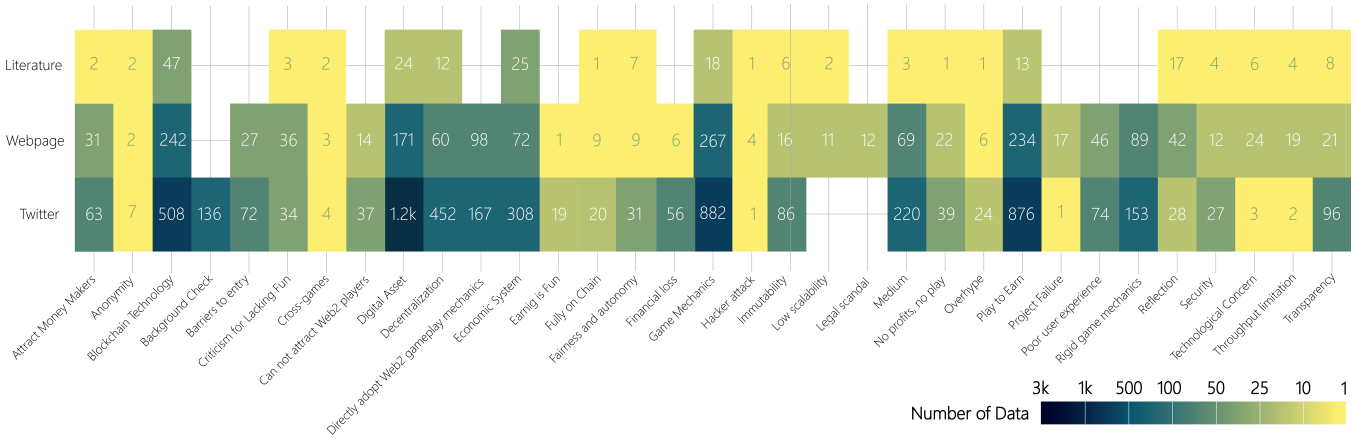

Figure 1: Data collection from three channels

Anselm Strauss) promotes prescriptiveness and formulaic guidelines [52]. In order to uncover the reasons behind and explore solutions to the current dilemma facing blockchain games, with greater creativity and fewer constraints, this paper adopts the Glaserian approach.

3.1 Procedure

In grounded theory research, data collection and analysis are viewed as concurrent events, with the "constant comparison" process guiding the ongoing data collection [20, 54]. From Glaser's perspective, following an initial phase of open and inclusive data collection and analysis that provides researchers with preliminary concepts and theory, the grounded theory methodology emphasizes theoretical sampling. Theoretical sampling refers to the strategy of collecting data to further develop theory, which means that coding and analysis guide subsequent data collection [19]. Specifically, when employing theoretical sampling, data collection focuses on the social processes that appear inherently most interesting. After gathering and analyzing the related data, researchers compare the emergent concepts to selectively expand data collection and refine the concepts further. This process iterates continuously until additional data no longer provides new insights, indicating that theoretical saturation has been reached [4].

Moreover, the Glaserian approach focuses on integrating multiple methods for data collection [19]. To mitigate potential grey literature bias, the data sources in this paper are not limited solely to research literatures, but also encompass a broader range of online data, including game player comments, industry reports, etc. Given the internet-based ecosystem of blockchain games, these online sources are likely to exhibit more diverse and comprehensive characteristics.

3.1.1 Data Collection. This research originates from the objective fact that the popularity of blockchain games is currently on the decline, as evidenced by their lackluster market performance. As this phenomenon narrows the scope for preliminary data collection, it prompts us to focus more on identifying the causes behind this status quo, specifically the existing criticisms of blockchain games, in order to seek breakthroughs. However, to maintain an open perspective and avoid overlooking other factors, our search terms are not limited to criticisms, although this type of information is prioritized during the coding process. Currently, there is no consensus on terminology for games built using blockchain technology. In our initial data collection, which was not guided by specific theoretical sampling, we use "blockchain game(s)", "crypto game(s)", and "Web3 game(s)" as keywords for searching. The time frame for these collection period spans from January 2021, when blockchain games began to gain significant market traction, to April 2024, when we started to adopt the grounded theory.

The Web3 ecosystem is still in its nascent stages. Despite the absence of separate, large player forums specifically for blockchain games, we introduce Twitter as the repository for amassing player commentary data, since as a dominant social media conduit in the Web3 realm [10], Twitter offers information of experience and opinions shared by players. For academic literature data, we use the Google Scholar and the Web of Science (WOS) as the collection channels. Furthermore, in an effort to preserve a balanced view that encompasses not only the Web3 community but also the broader Web2 user base's insights on blockchain games, we extend the search scope beyond just a few major Web3 news platforms. We employ Google for keyword searches to gather prevalent open source intelligence [6]. This strategy helps ensure we don't overlook valuable data from interviews or industry conferences.

With data collection and analysis occurring simultaneously, in the process of reaching theoretical saturation, we collect a total of 5,854 data, consisting of 4,949 from Twitters, 837 from webpages, and 68 from research papers, as shown in Figure 1. The data are individually collected and conceptualized by three authors, who then reach consensus on categorizing the data into 33 concepts. Furthermore, the information from the same source can be split into multiple data for different concepts. For instance, one Twitter post is conceptualized into four aspects: "Play to Earn", "Criticism for lacking fun", "Poor user experience", and "Barriers to entry".

> "*I couldn't even start the game after this screen! No Tutorial! Gosh make it easier to start playing the game guys. Do people play only to earn and no fun?*"

It is worth noting that during the data collection process, we discovered a significant amount of advertisements in the information obtained from Twitters (2102) and webpages (327) channels. As the selling points highlighted in advertising content often represent what the project team considers to be the most critical and attractive features of blockchain games, this valuable information should be further conceptualized into other meaningful concepts. Rather than dismissing these advertisements, we continued to treat them as valid data sources. Additionally, we suspect the amount of negative player comments was underestimated during data collection due to Twitter removing extreme content. Despite losing money as an acutely adverse and common experience in Web3 projects [11], only a handful of non-English speakers are observed venting outrage across tweets regarding money losses. Presently, most of the collected negative data are relatively objective critiques and reflections regarding the current state.

3.1.2 Coding Process and Division of Labor. In the beginning, the three authors independently embark on initial data collection and open coding, adhering to the Glaserian grounded theory approach. This process emphasizes conceptualizing data without preconceptions, grouping similar or identical pieces of information together while identifying new concepts wherever disparities emerged. Each author explores various sources, including Twitter, webpages, and literature, bringing unique insights and findings to collective discussion. Upon aggregating the coding outcomes, we enter a consensus achievement phase, determined by a criterion where no new concepts could be identified from collecting new data points from each mentioned channel by any author. During this phase, each concept identified by an author is described in detail. Authors then review each other's conceptual interpretations and data, identifying and discussing any contentious or uncertain data points. Any piece of data not reaching consensus requires a joint discussion to decide whether it fits within an existing concept or necessitates the formation of a new one. Furthermore, for every concept identified, we deliberate whether parallel concepts identified by other authors are indeed distinct or if they can be consolidated into a singular concept.

After the aforementioned process, the three authors collectively scrutinize the relationships between concepts and identify missing links in the logical chain to supplement with additional content needed for succeeding theoretical sampling cycles. The data collection and conceptualization process in theoretical sampling is consistent with the above process, still conducting independent collection and conceptualization first, then achieving consensus. This iterative process continues until a comprehensive and coherent map of conceptual relationships is constructed.

3.2 Conceptual Relationships

In the constant comparison process of concepts, we gradually constructed the conceptual relationships with two core concepts, **blockchain technology** and **game mechanics**, as shown in Figure 2 (the concepts appearing in Figure 2 will be displayed in bold). These two cores are relatively independent, with minimal intersections between them.

3.2.1 Blockchain Technology as a Core Concept. The blockchain games data gathered from the three channels demonstrates substantial attentiveness to blockchain technology itself. Based on the characteristics of technology, we can categorize the collected concepts related to blockchain, according to the rationale behind using blockchain. The **economic systems** (token economies) and **digital assets** (NFTs) in blockchain games thrive on decentralization, immutability, and transparency, providing the reason why users can trust in the reliability of the financial constructs and the genuine ownership of their digital assets. The **fairness and autonomy** of game communities also relies on the decentralized and transparent attributes of blockchain. The heightened **security** of blockchain games stems from the decentralization, immutability, and anonymity afforded by blockchain. These emerging performances in blockchain game, distinct from traditional Web 2.0 games, are underpinned by blockchain technology as an indispensable foundation. It should be noted that these correspondences between technological features and related concepts are not purely derived through reasoning. Many games explicitly state which advantages of blockchain technology are adopted to fulfill certain concepts, when advertising their games. Taking the fairness and autonomy as an example:

> "*X Fully on-chain gaming unpacke! Transparency: Every move, mechanic and outcome? It's all on the blockchain for clear fairness checks. Decentralization: No central power means players drive the game's evolution.*"

Among the above concepts, digital assets and economic systems have garnered special attention, as evidenced by the copious data collected across the different channels in the Figure 1. Undeniably, these traits have contributed substantially to the current allure of blockchain games. Numerous advertisements emphasize and capitalize on these two attributes as a key approach to attract players:

> "*A is a blockchain game that features adorable NFT creatures called B that can mine tokens for their owner. It is an economic game that combines a clever economic system with a modern and visually design.*"

The ownership of digital assets enables players to truly own their in-game assets and has the potential to allow these assets to be used across different games (**cross game**). Meanwhile, the blockchain-based economic system provides the foundation for players to convert such in-game items into fiat currency, thus realizing the concept of (**P2E**). While the economic system brings real benefits to players, it also introduces the risk of financial loss. Researchers have highlighted the striking similarities between the architecture of blockchain games and traditional gambling systems [49]. Considering the concerns arising from potential financial losses and their negative impact on player experience, some researchers and industry practitioners have begun to **reflect** on how to construct better economic systems. For instance, they explore strategies for maintaining a balance between supply and demand, and preventing revenue concentration among a small subset of players [26]. Despite these efforts for improvement, the focus on economic factors of blockchain games still led to a series of **scandals**, primarily stemming from the concepts of **overhype** (many blockchain games

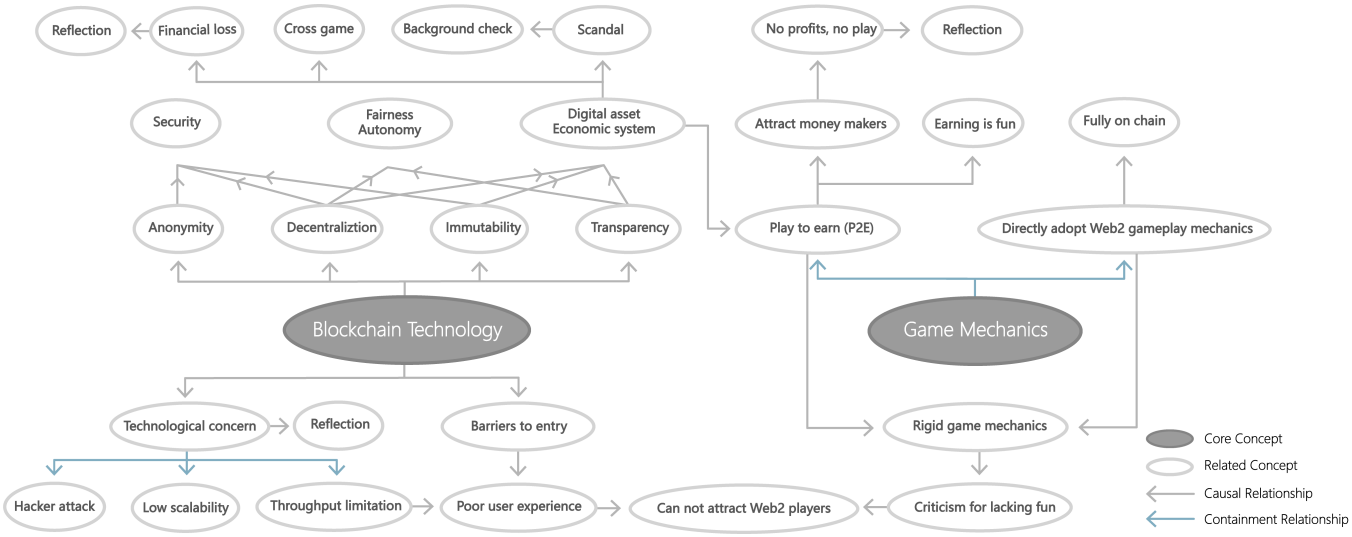

Figure 2: Conceptual relationships in blockchain game

exaggerate their earnings potential in their promotions, creating unrealistic and hard-to-achieve expectations for players), **project failure** (the short life cycle of many games, with a large number shutting down during Web3 bear markets, exacerbating the financial risks discussed above and leading to significant asset depreciation for players), and **legal scandal**(the misalignment between existing legal frameworks and the blockchain-based economic ecosystem, coupled with the allure of substantial profits through minimal development costs, has incentivized some developers to engage in risky or unethical practices). Further theoretical sampling, based on these open coding results, reveals that many players engage in background investigations (**background check**) on developers before participating in a game.

Additionally, some concerns exist regarding the limitations of blockchain technology technological concern and the **barriers to entry**. The **technological concerns** chiefly concentrate on the **throughput limitation, Low scalability, and hacker attack**. The high barriers manifest in the configuration of web3 tools and the costs involved. For instance, in order to play most blockchain games, non web3 users have to set up a wallet, fund it with corresponding tokens, and pay gas fees to execute on-chain operations. Through additional theoretical sampling, we discover that despite some blockchain game developers **reflecting** and attempting to improve experience through different mediums (mobile, VR) and high-performance chains, non web3 users still find themselves bereft of the seamless user experience epitomized by traditional video games. Such imparity in experience (**poor user experience**), alongside the currently over-simplistic blockchain game mechanics, has elicited skepticism from web2 game players. As one commented:

> "*Blockchain games are so bloody dumb. Firstly, 99% of the time they are super unwieldy on mobile, meaning it's a terrible gaming experience. Secondly the games are pretty barebones, so even calling it a game is a stretch, it's just a pc of shit with tokenomics.*"

3.2.2 Game Mechanics as a Core Concept. Compared to the high diversity of concepts derived from blockchain technology, the conceptual relationship stemming from game mechanics is relatively simple, indicating the neglect of this aspect. However, blockchain games have given rise to a widely known and influential game mechanic called **P2E**. It effectively combines game mechanics with the decentralized, immutable, and transparent characteristics of blockchain technology by leveraging digital assets and economic systems. There are two mainstream P2E mechanisms: One is to construct an economic system around the sale and nurturing of NFTs, using rarity as the value standard, with CryptoKitties[5] being a classic example. The other is to build a more complex economic system that supplements NFT-related mechanisms with circulating fungible tokens serving as traditional in-game currency, exemplified by Axie Infinity[6]. The concept of P2E offers a native experience unique to blockchain games [15], allowing players to manage their in-game assets without centralized constraints, ensuring immutable mechanic implementation and operation records, and enabling transparent in-game economic systems and related behaviors [37]. These factors collectively facilitate the circulation of value both within and outside the game in a decentralized state, which is difficult to achieve in traditional Web2 video games. According to statistics from Tingbits, almost all blockchain games on the market have adopted P2E mechanics, which is widely considered the most important feature of blockchain games. Additionally, we also conduct theoretical sampling to collect data on its effects to delve deeper into the impacts of P2E on related concepts. The results reveal that, from the perspective of motivation, while a minority of players find earning money enjoyable (**earning is fun**), a significant proportion of blockchain game players engage primarily for financial gain rather than recreational purposes (**attract money makers**) [27]. In one blockchain gamer's view:

[5]https://www.cryptokitties.co/
[6]https://axieinfinity.com/

> ‘*As a rule, as soon as I realize the game's earning potential isn't there or very minimal I stop playing it. If I wanted to play a fun game with no earning potential, there are thousands of candidates already out there, so I don't waste my time on blockchain games with no earning potential.*"

Such mentalities resemble work more than leisure activity. During the COVID-19 pandemic, many people engaged with AXIE INFINITY as a form of employment [36]. The lifecycle of blockchain game is generally brief, with users departing once profits diminish (**no profits, no play**) [37].

With P2E ideals permeating the mindset, blockchain game developers tend to prioritize the design of economic models over the crafting of engaging gameplay. As shown in Figure 1, there is a considerable amount of introduction about blockchain game mechanics mentioned on Twitters and webpages. Nevertheless, most blockchain games **directly adopt Web2 gameplay mechanics**, without any innovative adaptations to suit the Web3 ecosystem. These games fail to showcase their uniqueness or provide compelling reasons for Web2 video game players to join. The crudely combining such gameplay with nearly identical P2E mechanics results in **rigid game mechanics** of blockchain games. For example, collectible card games merely replace cards with NFTs and substitute tokens for in-game rewards, without any real innovation to the core gameplay mechanics of card games. Although some developers are attempting to employ **fully on chain** games to inspire innovative blockchain-oriented game mechanics, such undertakings have thus far failed to generate the intended results. Meanwhile, in the related research field, the design of blockchain game mechanics primarily focuses on educational or serious games, without demonstrating innovation in gameplay [3, 13, 34, 45]. The current mainstream blockchain games, characterized by their rigid game mechanics that focus on making money without any innovation, have received **criticism for lacking fun**, becoming the primary point of conflict between the traditional and blockchain gaming communities. As stated by Sega executive Shuji Utsumi:

> "*The action in play-to-earn games is boring. What's the point if games are no fun?*"

Many players concur with his viewpoint:

> "*Many blockchain games focus on how people can make money by playing. Unfortunately, they usually neglect to make gameplay mechanics enjoyable. As a result, playing them feel like chores.* "

Despite the potential for blockchain games to provide economic benefits and integrate certain Web3 characteristics such as decentralized player communities and digital asset ownership, the lack of enjoyment combined with the inferior user experience inherent to current blockchain technology limitations renders it an arduous undertaking for blockchain games to attract a substantial number of traditional Web2 players (**can not attract Web2 players**). According to a survey by Chainplay[7], 81% of the total 2,428 blockchain game investors start to prioritize the fun factor over earnings when considering future projects. While this survey finding does not align with the prevailing ethos in the market, it nonetheless highlights that not only Web2 players but also Web3 practitioners have begun to focus on the recreation value of blockchain games. Enhancing the entertainment of blockchain games may prove the critical breakthrough required to extricate blockchain games from their present inability to attract traditional players.

[7]https://chainplay.gg/state-of-gamefi-2022/?msID=f39a9fdf-6834-4d77-ab7d-3b74f67c8403

4 Design Framework of Native Blockchain game Mechanics

The Conceptual Relationships obtained in the previous section can lead to two conclusions: First, the stagnation within blockchain games, in terms of failing to attract traditional video game players, is primarily due to an overemphasis on economic-centric game mechanics over playability-focused design. This rigidity in-game mechanics deters broader player engagement; Second, the proven mainstream blockchain game mechanic is P2E, which succeeds partly due to its economic allure and crucially, by effectively integrating two core concepts of conceptual relationship: game mechanics and blockchain technology, presenting a novel and native Web3 experience. Hence, the approach to engaging traditional video game players should also be divided into two parts. Initially, we need to find more flexible and interesting mechanics design methods for the current predicament outlined in the first conclusion. Subsequently, we should refer to the generative logic of existing successful mechanics (P2E) and adopt a cross-thinking method to form a design approach specialized for blockchain games. To this end, it would be constructive to explore from the perspective of game mechanics design.

Given the extensive data sources collected through the grounded theory approach, to prevent conceptual deviation of "game mechanics" between the data and game design domains, this paper adheres to the widely applicable definition of game mechanics by Sicart et al. [51]. They define game mechanics as methods that enable agents (whether players or non-players) to interact with and influence the game environment. These mechanics determine how players perform actions, make decisions, and achieve objectives within the game, thereby directly shaping the flow of the player's experience. In the field of game design, game genres that are more likely to generate innovative game mechanics and offer greater design flexibility are widely recognized as emergent games [56], which are constituted by fewer rules, many interrelated game elements, and large probability space [1]. Notably, such game genre is more prone to producing high degrees of enjoyment and replay value through the complexity and unpredictable phenomena emerging from internal interactions between various game components [1, 29, 55]. However, pure emergent games are uncommon. Most current games feature a combination of both emergent and progressive mechanics. For instance, in The Legend of Zelda series, combat skills learning and strategic adaptations represent mechanics of emergence, while story backgrounds and plot developments constitute mechanics of progression. In order to explore the native mechanics innovations of blockchain games, we focus on the theoretical framework of emergent games.

Drawing on findings from the field of complex systems research, Adams et al. summarize three structural qualities in games that contribute to the high quality emergence phenomenon [1]:

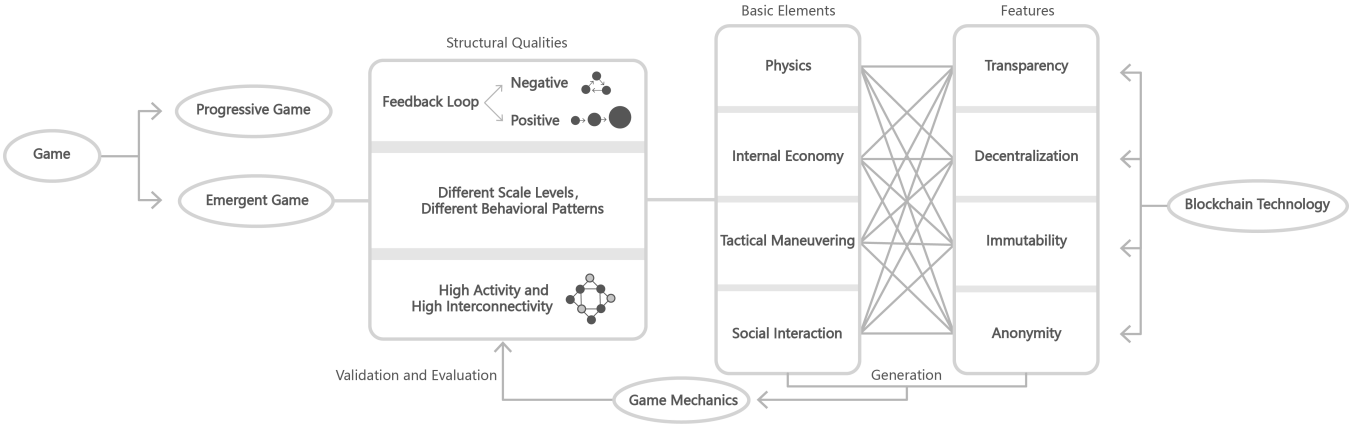

Figure 3: Design framework of native blockchain game mechanics

(1) **A feedback loop refers to a situation where a change in one part of a system leads to effects that eventually cycle back and influence the original part after some time lag** [38]. Feedback loops that maintain system equilibrium are called negative feedback loops. For instance, in the "Civilization" video game series, population growth leads to increased food demand, which is then constrained by food production capacity, resulting in the stabilization of population size. While negative feedback loops manifest dynamic equilibrium, positive feedback loops serve to break stalemates. Through reinforcing effects, positive feedback loops intensify themselves and accelerate the game outcome. For example, in chess, capturing one opponent's piece makes it easier to capture the next.
(2) **The different scale levels can give rise to varying behavioral patterns**. Specifically, in the game "Pac-Man", each individual ghost pursues the player based on simple, fixed chasing rules. However, when multiple ghosts gather together, they may exhibit behaviors resembling coordinated encirclement.
(3) **High activity and high interconnectivity among the basic units** [61]. High activity refers to frequent state changes of the units, while high interconnectivity means that the changes resulting from high activity can influence the state alterations of other components farther away in time or space . Tower defense games often possess this trait, with the movements of enemies and reactions of defense towers exemplifying high activity levels. Meanwhile, the enemies' destruction of the endpoint and the turrets' counterattacks against the enemies can manifest high interconnectivity.

Additionally, at a more microscopic level, Adams et al. also indicated that emergent games should consist of four fundamental constitutive elements. Since these elements are broad and abstract concepts rather than precise and concrete descriptions, it is imperative to explicate them to preclude subsequent misconceptions [1]:

(1) **Physics.** Physics refers to the scientific study of motion and forces, including character actions, object collisions, and more. Evidently, the simulated physics in games can diverge from real world physics, as exemplified by rocket jumps.
(2) **Internal economy.** The internal economy in games often comprises common resources like money, energy, ammunition, etc. Additionally, apart from these tangible items, abstract concepts like health, reputation, and magic power are also part of the internal economy.
(3) **Tactical maneuvering.** The strategic significance of each unit in every possible position is often explicitly defined. This enables players to maneuver units to specific spots on the map to gain offensive or defensive advantages.
(4) **Social interaction.** The communicative actions engaged in by players during the game, and the resultant collective behaviors that may emerge such as affiliation formation and contention between alliances.

While the potential of Adams et al.'s emergent game design framework addresses the rigid and monotonous mechanics in block-chain games, the generative logic of successful P2E (Figure 2) must also be considered, as it emphasizes the close integration of game mechanics with blockchain features to present native on-chain experiences.

The four fundamental elements of emergent games should be combined with the four key features of blockchain technology (decentralization, immutability, anonymity, and transparency) in the process of using the design framework. This ensures the resulting mechanics are intrinsically tied to blockchain, in other words, they would be adversely affected without blockchain support. In addition, maintaining adequately extensive and diverse design scopes from the outset mitigates the risk of rigid mechanics arising from highly identical starting points. This further underscores the necessity for native blockchain game mechanics to evolve from the fusion of foundational elements with blockchain features. In light of the aforementioned concepts, the design framework for native blockchain game mechanics is depicted in Figure 3, comprising emergent game and blockchain technology. Furthermore, the mechanics designed from this framework need to conform to one or more structural traits of emergent games that validate complexity and safeguard the resultant enjoyment.

5 Native Blockchain Game Mechanics

In this section, based on the design framework proposed previously, we discuss the potential directions for designing native and fun blockchain game mechanics by combining the basic elements of emergent games and the features of blockchain. The possible combinations exhibit considerable diversity. Specifically, a particular mechanic can stem from fusing either a single element with a single attribute, or a single element with multiple attributes. Furthermore, the same amalgamations may also give rise to diverging mechanics. Hence, this discourse delineates some promising orientations rather than formulating comprehensive and novel mechanics.

Dynamic physics with decentralization and transparency. Typically, the physics rules within a game are fixed and implicit. As exemplified in Angry Birds 2[8], the physics dictating each bird's behavior rules are immutable and lurk implicitly within starter tutorials. Comprehending the specific manipulations of these physics conventions to attain designated gaming objectives still necessitates continual experimentation by players Changes to the physics rules will lead to changes in related mechanisms and manipulation. While such domino effects satiate the high interconnectivity degree, which introduces components of unpredictability and recreation, it is an infrequent incidence, particularly regarding multiplayer games, to incorporate dynamic and frequent modifications upon their physics rule. The predominant rationale is that alterations may heighten player learning expenditures and invalidate previously efficacious gaming strategies, which manifest as negatively perceived consequences that designers generally abstain from incurring. The advent of decentralization and transparency has introduced the possibility of dynamically updating physics rules. By clearly accessing the details of physics rules and leveraging voting or other decentralized means, players can autonomously decide combinations and adjustments of the rules, thereby avoiding potential criticism associated with unilateral changes made by developers. For instance, imagine if the physics rules in MMORPGs like Final Fantasy XIV[9] were changed weekly through the consensus of players, producing unconventional phenomena such as inverted terrain or reverse rivers. Players would be both creators of dynamic physics and responders to its ever-evolving nature. Such dynamic physics may constitute an engaging and native focal point for designing blockchain game mechanics.

A highly enabled internal economy with immutability, transparency, and decentralization. These three features of on-chain data confer verifiable ownership and recognized value upon assets in blockchain games, thereby ensuring the exchangeability of digital assets for global real-world currency and interoperability across different games [59]. Compared to traditional games, current blockchain games have facilitated more profound investigations into in-game economic architectures. However, as mentioned above, the majority of extant explorations primarily focus on tokens used as in-game currency and NFTs representing in-game items, while overlooking other data expression forms. The expansive definition of internal economy incorporates narrow in-game economic systems, alongside abstract data manifestations like health and reputation. Given the underscored ownership and value of data, abstract data have the potential for spurring innovative game mechanics. For instance, game reputation can be tokenized, enabling its conversion into fiat currency or its use across multiple games.

Greater depth tactical maneuvering with immutability and transparency. Regarding the tactical maneuvering architectures, the dual platform architecture encompassing both the blockchain layer and game application level, can engender enhanced strategic intricacy. Specifically, certain hidden tactical information resides on the blockchain layer, distinct from the visible game interface. For example, the game interface shows a normal chess game, but a special victory condition coded into smart contracts requires forming a certain pattern with chess pieces on that board. The immutability and transparency of blockchain can ensure concealed tactical data persist invariably while actualizing universal accessibility among players. Such multidimensional tactical configurations can inspire different gaming behaviors on different levels, thereby broadening the probability spaces of overall gameplay. For particular game genres like hardcore or puzzle, this proposes a promising design direction worthy of further analysis. Additionally, **uncertain tactical maneuvering with anonymity** is another potential orientation. The inherent anonymity attributes of blockchain can conceal the process of manipulation and the identities of opponents, forming a purer uncertain situation compared with traditional games. The more extreme unknown combined with certain game mechanics that require identity and behavior obfuscation, such as the Werewolf or fog-of-war elements, may produce innovation.

High-trust social interaction with immutability and transparency. As all players on-chain information including transactions, interactions, and data storage, remain transparent and immutable, accessing each gamer's account unveils their comprehensive and genuine historical activities. With a proven track record of integrity, fellow players can promptly develop cooperative rapport. Such expedited and reliable trust may stimulate deeper social interaction modes in collaboration between people, as exemplified by inheritance collaborations where participants collectively inherit and expand on the achievements of their predecessors, and successors can choose their results for further development. Furthermore, integrating principles of decentralization and transparency into games opens up possibilities to create **a fair and equitable decentralized player organization** through social interactions. As decentralized autonomous organizations(DAO) in Web3 ecosystems demonstrate, users can autonomously organize themselves into decentralized communities, wherein the authority of decision is distributed based on demonstrated contributions, fostering a fairer governance structure [11]. In the gaming context, players may establish similar groups that diverge structurally from traditional, hierarchy-bound guilds. Instead of relying on status or other external elements, a player's influence corresponds to their proven expertise and contribution to the game. Exploring social mechanics distinct from traditional gaming guilds could be a promising research direction, potentially reshaping the dynamics of player collaboration and community organization.

6 Prototype

We believe that even a preliminary design framework requires some empirical validation to demonstrate feasibility. Hence, to lend

[8]https://www.angrybirds.com/games/angry-birds-2/
[9]https://eu.finalfantasyxiv.com/

Figure 4: The smart contract interface, game homepage, and interior level of tower defense mode

credence to the proposed design framework and potential game mechanics discussed in Section 5, we develop a high-fidelity game prototype centered around the relatively unexplored element of social interaction. This prototype as an experiential case enables preliminary showcasing of the design procedure of the framework while verifying the discussion of assumptions in blockchain games' social interaction. Though further validation remains in the future, this early case helps transform abstract frameworks into playable environments, in order to discover issues and inadequacies throughout the process of designing native blockchain game mechanics.

6.1 Core Game Mechanics

According to the previous discussion, the two potential design orientations of social interaction are inheritance collaboration and decentralized player organization. Given decentralized governance has proliferated across copious applications within Web3, we elect to explore the more nascent notion of inheritance collaboration, in hopes of catalyzing pioneering mechanics. Consequently, the prototype adopts such collaborative approach as the cardinal tenet guiding its design of game mechanics.

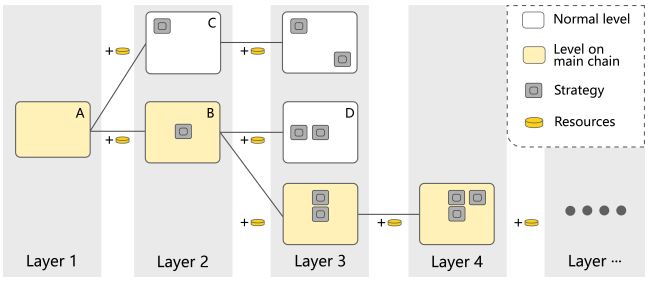

Figure 5: The chain structure of game mechanics in tower defense mode

As shown in Figure 5, we have devised a tower defense game featuring unlimited layers, commencing from the initial level (A) on the first layer with a completely blank map. The first player is tasked with strategically placing defensive turrets on the blank map of the initial level (A) to fend off monsters from the second layer, thereby constructing a level (B) on the second layer. The second player faces a dual choice: either formulating a distinct defense strategy different from that of the first player on the initial level (A), thus generating a new level (C) on the second layer; or, alternatively inheriting the defensive strategy of the first player while incorporating their own unique defensive methods to construct a level (D) on the third layer. Each player has the option to perform these operations multiple times, thereby creating higher-layer levels based on any existing ones. Additionally, with each creation of a higher-layer level, the in-level resources for placing defensive turrets increase and the invading monsters become stronger. Players may choose to expend more resources on setting additional turrets or conserve resources providing a broader array of strategic options for subsequent players. Similar to conventional tower defense games, if monsters successfully pass all defensive turrets, the level will incur a certain percentage of health loss (full health is 10000).

Additionally, in order to further expand the probabilistic space of the game and increase gameplay depth, we introduced an oppositional identity that can set debuffs against participating tower defense players. The debuffs set by this group correspond one-to-one with the types of defense towers, to hinder the growth of the tower defense chain. The mechanics of debuffs still conform to the aforementioned inheritance collaboration, existing in the form of levels. Similar to the chain structure shown in Figure 5, it starts with a blank level. Players can choose any existing level to enhance one type of debuff once, creating a new level with a higher layer. The last level in the chain likewise represents the debuff strategies of all players across the entire chain. Differently from the tower defense mode, the longest debuff chain is endowed with special functionalities, whereby only debuffs on levels of the longest chain can influence all levels of the corresponding layer on the tower defense chain. Under such mechanics, players of the debuff chain can frequently establish new longest chains to interfere with tower defense strategies. In response, tower defense players also need to strategically adapt by observing the strategies employed in the debuff chain and selecting defense tower types that offer advantages against them.

This inheritance collaboration manifests as a chain-like structure. To facilitate smoother progression, players are tasked with selecting levels that harbor superior strategies, integrating their unique defensive layouts to create higher-layer levels. In instances where multiple players opt to expand from the same level, forks emerge within the chain. Levels boasting superior strategies will attract more players, thereby extending the chain. The level at the

terminus of each chain thoroughly amalgamates the collective contributions of players along that specific chain. Furthermore, the lengthiest chain within the game assumes the role of the main chain, distinguished by a distinctive coloration. If players discern strategic shortcomings in the main chain, they retain the flexibility to select any preceding level and initiate a new branch for modification, progressively extending the branch chain until it eventually assumes the mantle of the new main chain.

The mechanics of this game prototype align with the emergent game structure qualities illustrated in Figure 2, utilized for validation and assessment. The structural qualities consist of three parallel aspects. The first aspect is the feedback loop. Within the prototype, players have the flexibility to expand strategy based on preceding levels at any time, irrespective of the sequential order in which players created. This flexibility implies that if there are deficiencies in a player's strategy and subsequent players encounter challenges as the layers progressively advance, they can opt to recalibrate their strategies based on prior levels. Additionally, the different modes of debuffs and tower defense have also constructed an independent negative feedback loop. For instance, if tower defense players heavily set a certain type of defense tower, debuff players can target that type with debuffs and make the corresponding chain longest. Subsequently, tower defense players would then change their strategy and set other types of defense towers, while debuff players would make aligned adjustments. This process can cycle continually, hence the proportional distribution of defense tower types would not become imbalanced. The above cyclic patterns, where strategy-related issues cyclically influence the initial point of origin over time, aligns with the definition of a feedback loop. Strategy-related adjustments are expected to be a common phenomenon within the game mechanics of this prototype, requiring players to continuously engage in trial and error to dynamically achieve near-optimal strategies

The second aspect pertains to the emergence of varying behavioral patterns from different scale levels. The game mechanics of the prototype can be distinct in two different scale levels. Taking tower defense mode as an example, where tower defense represents the most fundamental core mechanics and corresponds to the low scale level. The behavioral pattern corresponding to this scale level is the most basic tower defense strategy layout, where players place different functional defense towers based on their personal strategies. When multiple tower defense strategies appear, they can be linked together with the inheritance collaboration mechanics, forming a higher scale level based on the low scale level. It manifests as a chain-like structure behavioral pattern. Thus, the game mechanics in the prototype satisfactorily exemplify the description of the second aspect.

The third aspect concerns the presence of high activity and high interconnectivity among the basic units. In the prototype, the concrete basic units denote the defense tower units in tower defense. Once a level is chosen for inheritance, the strategic layout and defense tower units in that level will be permanently inherited by subsequent levels. Therefore, the basic units in previous levels can always be in an activated state, maintaining a high level of activity. Similarly, due to inheritance, the layout of any level in the chain, which is the properties and placement of the defense towers, will affect the layout strategies of subsequent levels and participate in the process of attacking monsters and protecting the home. Previous units as part of the new level numerically affect the monsters, other defense towers, and the health of the home, forming high interconnectivity.

6.2 Implementation

In order to fully leverage the advantages brought by blockchain features, all data computation and storage in the prototype occur fully on chain. All interactions involving data modifications in the game, such as creating levels, adding defensive turrets and debuffs, or upgrading existing ones, directly connect with smart contracts. It can be understood that the backend of the prototype essentially exists as the smart contracts on the blockchain. In terms of blockchain selection, to provide players with a low-entry and zero-cost experience, we choose Zero Chain [10], a high-performance blockchain built by AltLayer[11], featuring an operational blockchain explorer and zero gas fees. Meanwhile, to accommodate the usage habits of players in the existing market, we also provide the currently affordable and prevailing Polygon mainnet[12] as an optional chain. In a fully on-chain game, different blockchain networks function similarly to different game servers in traditional video games. Furthermore, we utilize Unity WebGL to construct a high-fidelity web game interface (http://www.branchclash.com/) with features like a beginner tutorial, main interface, and interfaces within levels for enhancing the usability of this prototype and acquiring genuine and comprehensive player feedback in the future. Moreover, we design related elements such as the game's background story, models of tower defense models, and environmental scenes. The monsters in levels are set at a higher difficulty to encourage players to focus on forming optimal strategies through the inheritance collaboration of core mechanics.

Certainly, the fully on-chain approach presents the challenge of slow data retrieval, significantly impacting the player experience, which is one of the technical concerns raised in section 3.2.1. To address this, we implement a centralized server as a cache for on-chain data to expedite data retrieval on the game website. It's essential to clarify that the centralized server is solely used for storing and backing up on-chain data and has no authority to modify any data. The game website can operate normally without utilizing this server, although the loading time may increase. In summary, to accommodate both hardcore and casual players, the game provides two access points, as illustrated in Figure 4. Participants can either directly interact with smart contracts through a blockchain explorer or engage in the game using the website.

7 Limitation and Future work

This paper employs the grounded theory (Glaserian approach) to uncover the underlying causes and probe prospective resolutions targeting the pressing predicament confronting contemporary blockchain games. Despite the result of the grounded theory approach pointing to the rigidity of game mechanics as a barrier to traditional video gamer engagement, it's undeniable that blockchain games' unique appeal lies in their ability to profit through digital

[10]https://zero-explorer.alt.technology/
[11]https://altlayer.io/
[12]https://polygonscan.com/

ownership. This intriguing evidence includes that many players voiced via Twitter that their participation would cease without financial rewards. Therefore, we see profit-focused users driven by P2E mechanics dominating blockchain game markets. Our proposed design framework exhorts developers and researchers to re-focus innovations on the gameplay itself, crafting native and enjoyable blockchain game experiences over mere monetization.

However, this ethos may not align with prevailing market sentiments. Thus, in the foreseeable future, advances in blockchain game mechanics through the lens of our framework will remain concentrated on internal economies enabling immutability, transparency, and decentralization, complemented by combinations with other essential elements and blockchain features. In other words, playability anchored on the highly enabled internal economy will continue dominating. Nevertheless, we hope that surfacing alternative focal points to P2E via our design framework sparks renewed attention and native innovation, elevating the appeal of blockchain games as games, not just money-makers, demonstrating strengths over incumbent digital titles. Even if near future blockchain games still orbit profits, broadening mechanical possibilities could break the bottleneck facing user adoption and expand scholarly attention to diversify further foundations supporting game research.

Furthermore, although we develop a high-fidelity prototype as an empirical validation of the framework's feasibility, instantiating one potential direction of native blockchain game mechanics stemming from the framework, this merely substantiates the capacity for achieving a native blockchain game building upon the framework and suggested mechanics direction. Further validation of the design framework's effectiveness is still necessary. The current conclusion remains a preliminary framework induced via theorization and discovery. In future work, we should leverage this prototype to amass gameplay data from both traditional gamer groups and Web3 gamer populations, conducting quantitative analysis of behavioral data to verify assumptions in the prototype's core mechanic design concerning structural qualities. Additionally, qualitative research on player experience is needed to verify the playability of the mechanics using the enjoyment-related questionnaire and to gauge the impact of the mechanics proposed by the design framework on the retention rate of traditional gamers. Corresponding the evaluations of player experiences should undergo granular motivation classifications, preempting interference from inherent blockchain technology limitations, such as tedious on-chain interactions, to truly validate the effectiveness of this design framework.

As the aforementioned user studies toward framework validation compose a complete and sophisticated process, we deem such efforts beyond the scope of an initial framework, warranting an independent research initiative. Although this paper merely conducts early empirical validation of framework feasibility, its principal ambition is to provide a new perspective for researchers and practitioners, expanding the current narrow economic-centric status quo and broadening the discourse on alleviating bottlenecks facing blockchain games.

8 Conclusion

Facing the deadlock encountered by blockchain games in the industry and research field, this paper proposes a design framework that integrates the basic elements of emergent games with blockchain technology features to foster intriguing and native blockchain game mechanics. Employing grounded theory, we gather data from three sources: Twitter, webpages, and research literature, continuously comparing and exploring conceptual relationships. The crucial discovery is that the current blockchain games struggle to attract the traditional video gamer community due to a lack of engaging native game mechanics. Therefore, we construct a design framework by amalgamating emergent games and blockchain, supplemented by structural qualities for validation, to discuss potential design directions for future blockchain game mechanics. Additionally, focusing on one of the basic elements, social interaction, we implement a high-fidelity tower defense game prototype to provide instantiated validation for the design framework, exemplifying the process from the framework to a game. The prototype can be played either solely through the smart contract or the game website. In comparison to the majority of blockchain game researches that focus on building a better economic system, this paper delves into the pain points of blockchain games and approaches it from the game design perspective, exploring a native mechanics design method that spans both blockchain and game dimensions.

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