

# Research opportunities in the application of blockchain in video games: A scoping review

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**Abstract**—The study of blockchain (BC) technologies has been applied to a wide breadth of research fields in recent years, chasing the realization of its full potential. Among them, video games have become a very eager adopter of blockchain in many of its different facets: cryptocurrencies, Non-Fungible Tokens (NFTs), and smart contracts. This paper presents the results of a scoping review in order to answer the research question "What is the current state of academic research in blockchain applied to video games?". After a thorough search in a diverse set of scientific databases, a total of 39 fitting publications were methodically retrieved, studied and categorized. The results draw a clearer picture of the current state-of-the art, as well as the identification of relevant trends and opportunities in this topic.

**Keywords**—video games, blockchain, study, review, NFT, smart contracts, cryptocurrency

## I. INTRODUCTION

The rapid growth in popularity of blockchain technologies in recent years has spurred the interest in academic research. Indeed, the study of the application of blockchain technology has pushed through its initial inception as a means to an electronic cash system and set new trends and research challenges [1]. Among the industries with an eager interest in researching the application of blockchain technologies, video games have become a very strong proponent.

It is necessary to advance until 2017 to find video games that, albeit still niche in the broad gaming landscape, have sparked the interest of the industry at large, with its use of NFTs and smart contracts as the means to manage virtual items. However, it is only by the start of 2022 that big mainstream companies, such as UbiSoft or Square Enix, have started declaring their intentions to use blockchain in their products. However, the fact that the main push comes from the industry does not mean that there is no research work in the academic community. As the topics of blockchain and gaming become more and more entangled, it becomes necessary to provide the big picture of this research and detect which are the current trends and opportunities.

This paper presents a scoping review [2] on the current state of academic research in blockchain technologies in the context of video games. Even though a thorough survey exists on video games that are based on blockchain [3], in the short time span

since its publication, many new relevant actors have entered the field. But most importantly, up to our knowledge, there are no studies focused on analyzing the scientific literature (i.e. academic peer-reviewed papers). A scoping review approach has been chosen since it is commonly used to examine the extent, and nature of the research activity in a topic area, in order to assess the potential and cost of undertaking a full systematic review at a later time.

This paper is structured as follows. In Section II the methodology for the study is presented, including search strategy, result eligibility criteria and the paper screening and data extraction process. Section III shows the results, providing references to all the publications included in the study and their categorization according to several properties. Detected key messages, trends and research opportunities are discussed in Section IV, providing insights on what is the state of current research in blockchain technologies in the context of video games and which are the open challenges or opportunities for those who want to further study this topic. Finally, Section V concludes this paper, summarizing its main findings and suggesting future work.

## II. METHODOLOGY

The review process was composed of four stages: 1) search and compilation of publications through scientific databases, 2) a first screening to filter results that actually aligned with the topic at hand, as well as possible duplicated results, 3) a review of the remaining results, reading the full text of the papers, and 4) categorization and synthesis of the content.

### A. Search Strategy

The search strategy relied on the topic keywords "video games" AND ("blockchain" OR "nft" OR "smart contract"). Variations of these terms were also used, taking into account singular/plural and the possible use or not of blank spaces between some words (e.g. "video games"). A diverse spectrum of scientific databases was chosen in order to achieve a broad search coverage, mainly Web of Science, Scopus, ScienceDirect, ProQuest, IEEE Xplore and the ACM Digital Library. These searches were further complemented with

Google Scholar. However, given the vast range of results using this search engine, the analysis was limited to the few first pages, once it was easily detected that results quickly diverged from the topic at hand. All searches were performed during December 2021.

### B. Selection of studies and eligibility criteria

The initial study population was the combined list of publications extracted from all the search processes, regardless of field of knowledge, after eliminating repetitions. Each result was categorized and summarized independently by two researchers who consolidated their findings, one with a background specialized in blockchain and another in video games, but both with a basic understanding of each other's fields.

In a first iteration, papers were assessed only by title, abstract and keywords. In a second iteration, the full paper content was read and analyzed. During each iteration, a more thorough selection process was performed, only considering eligible to this study papers a) where the topic was strictly the interaction of blockchain technologies in video games, and b) that were the result of a proper peer-review process (i.e. not editorials, columns, or self-published books).

It must be noted that, as will be shown in Section III, we deviated from the defined protocol and made some minor exceptions for criterion b). This was the case of a book chapter and two M.Sc. Thesis with a clear research focus and a well-defined methodology, that were considered worth including nevertheless, just for the sake of the completeness of the study.

### C. Paper Screening and data extraction

In order to homogenize the categorization and summarization process among the reviewers, a data extraction form was created, which included a set of open and closed questions.

On one hand, the open questions allowed reviewers to identify the stated goals (i.e. research questions) of the publications, their most significant contributions, what kind of experiments or analytical data (if any) it included, and a short list of other interesting topics discussed.

On the other hand, closed questions delimited very specific characteristics, such as what kind of games were mentioned, type of blockchain and the focus within the blockchain ecosystem (e.g. currency, NFT, smart contracts), and whether the paper focused on technological or social aspects. The closed questions also included the compilation of standard bibliographical data, such as year of publication, country of origin of the corresponding author, type of publication, publisher, list of keywords, and number of cites.

## III. RESULTS

After the iterative selection process, 39 publications were considered eligible for this review. A summary of all the extracted data is shown in Table I, ordered by paper relevance using the descending number of cites. For each paper, the table summarizes its main properties.

Regarding the type of study, we have classified the papers in four different categories: analytical, experimental, technical

proposal, or descriptive. We have considered as analytical the papers where the authors gather data from an existing system (e.g. transactions from the game CryptoKitties recorded in the Ethereum blockchain), analyze them, and extract some conclusions. On the other hand, we have considered as experimental the papers where the authors have designed an experiment, implemented a proof-of-concept or interacted in some way with the studied system to get some results and withdraw conclusions. We have classified papers as technical proposals when the goal of the paper is to present a new development. Finally, we have classified as descriptive all the papers that just provide a description of one or several systems, without interacting or extracting data from them to withdraw new conclusions. Figure 1, shows the total amount of papers published per year and their distribution considering this classification.

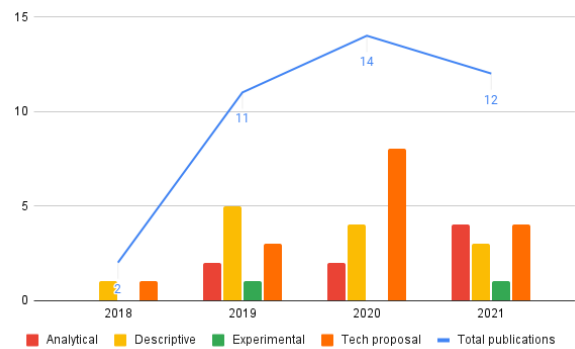


Fig. 1. Types of paper per year.

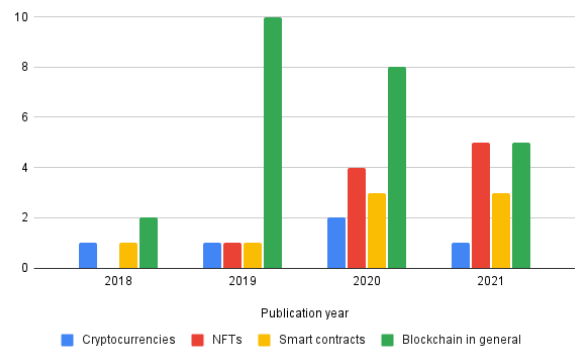


Fig. 2. Focus of the papers per year.

Also, we have classified the papers according to the main blockchain technology used or analyzed in each case. In most of the cases, the papers study an application or a game implemented on a single blockchain (generally Ethereum), although other blockchains may be mentioned in the paper. In certain cases, the authors study several applications from various blockchain systems. In other cases, the authors study some applications built on top of a blockchain, without specifying the underlying one.

Table I and Figure 2 also show the focus of the paper. Here, each paper was tagged with a key concept from the blockchain context, if the concept has a relevant part in the content of the paper. The tags that we considered are: cryptocurrencies (CrCurr), smart contracts (SC), non-fungible tokens (NFT), and “blockchain in general” (BC) for those papers not focused enough in any of the previous topics (e.g. papers analyzing several aspects of a game, papers showing the development of a proof-of-concept application, etc.).

#### IV. DISCUSSION

Once a general overview of the current academic research has been presented, this section discusses in more detail the most recurrent and evident topics detected upon the assessment of all the works included in the study. The main goal is to answer the research question “*What is the current state of academic research in blockchain applied to video games?*”, thus providing the ability to detect research gaps and opportunities that can be used to further progress this field of study.

##### *Discussing the potential of cryptogames*

Since the corpus of review encompassed all areas of knowledge where the words blockchain and video games were related, the results are very heterogeneous. Nevertheless, a very important part of the current research on video games and blockchain is dedicated to dissertations or studies on exploring its potential, seeking to suggest how to extend the functionalities of the blockchain in this context. They tend to provide a general idea about how it works, but without going into the technical details. The most usual topics are social or legal issues, such as in [4], [8], [21], [40], for instance. These works are evenly distributed between the years 2019-2021, discussing the potential of new trends related to blockchain, as they appear. Whereas the older publications tend to discuss the potential of blockchain in general, the most recent ones from 2021 tend to focus on NFTs, a hot topic in the video game industry at the time of this writing [36], [40]. Generally speaking, this kind of papers provide a very good entry point to researchers who want to get an overview, and are a part of the literature open to new contributions, as new subtopics become popular.

##### *Expanding the technology*

Another very important part of the literature, just above an even split with the previously mentioned dissertation works, is the one related to purely technological proposals. In this case, most papers are from 2020 and the general preferred topics in general are interoperability, some relevant examples are [6], [9], [27], or presenting fully fledged blockchain based games, such as in [14], [23]. Again, a raise in the relevance of papers related to NFTs and virtual item trading is detected in the latest publications [34], [35].

Maybe the most surprising result from the study of more technological-oriented works is the lack of experimental data. Only a minority of the works included in this study, such as [24], [28], [31], proposes an experiment or provides any

kind of analytical data supporting its effectiveness or adequacy (such as Response Time, Throughput or gas cost). Nevertheless, some of them, more oriented to protocol security, provide formalization [13], [39]. In fact, several works do not go beyond the proof-of-concept stage or a very simple sketch of the architectural design, just 2-3 pages long, such as [9], [34], [41], for instance. Therefore, this is an obvious gap that authors of future technological proposals should take into account.

##### *Observing the technology*

Speaking of works that put an emphasis in empirical data, the ones that exist are mostly related to the analysis of existing platforms, assessing player behavior or transaction traffic, such as in [7], [10], [30], [33]. However, some papers that want to study very specific aspects of blockchain, such as security or transaction delay of Distributed Ledger Technologies (DLT), create their own prototypes or emulation layer, instead of using existing platforms, to perform experiments [17], [26]. In that regard, from the results, it looks like there is a wide field of potential research opportunities in the studying the behavior of existing games, both from a technological or sociological standpoint, and especially given what will be immediately commented in the following subsection.

##### *Moving beyond CryptoKitties*

Among all games mentioned or studied in the literature, with no doubt *CryptoKitties* has the most relevance, appearing in 27 out of 39 works. In most of the cases, this game is mentioned in passing, as the main example of the application of blockchain in video games. But some works are devoted to discussing its aspects in much more detail. On one hand, several papers present such details as a proof on how to introduce blockchain technologies in the game industry, and its implications [4], [11], [16], [18], [22], [37]. On the other hand, a few works focus on studying how it works, or its user behavior [10], [19].

This trend is especially interesting since, actually, *CryptoKitties* has been in obvious decline for some time. In January 2022, it ended in the 193rd position of most popular crypto games<sup>1</sup>, and its number of users was very low, moving between a range of 43 and at 97. However, it is still being included in works that are very recent, related to the time of writing of this review. In contrast, the most popular games during this period are seldom mentioned in the literature, even in the most recent papers. Among the top five games mentioned in the literature, only *Gods Unchained* is in the top 25 (in the 24th position, to be specific). From the top ten, only *Axie Infinity*, a game released in 2018 and boasting among 47k and 56k players in the same time period, is only briefly mentioned in three papers, from 2019 and 2021. Even the most cited paper in this study, a very thorough survey from 2019 [3], is mostly outdated in that regard. This trend shows how fast the field of cryptogames is moving, while presenting a clear research gap in studying the heirs of *CryptoKitties*.

<sup>1</sup><https://dappradar.com/rankings/category/games>

TABLE I

SUMMARY OF THE SELECTED PAPERS. THE FOCUS OF THE PAPER HAS BEEN ABBREVIATED TO: CRYPTOCURRENCIES (CrCurr), SMART CONTRACTS (SC), NON-FUNGIBLE TOKENS (NFT), BLOCKCHAIN IN GENERAL (BC).

<i>RefId</i>	<i>Country</i>	<i>Year</i>	<i>Publication</i>	<i>Publisher</i>	<i>Type of study</i>	<i>Blockchain</i>	<i>Focus</i>	<i>Cites</i>
[3]	China	2019	Conference	IEEE	Descriptive	Various	BC	39
[4]	Finland	2021	Journal	SAGE	Descriptive	Ethereum	BC	21
[5]	UK	2019	Conference	ACM	Descriptive	Ethereum	BC	18
[6]	France	2019	Conference	IEEE	Tech proposal	Unspecified	BC	16
[7]	China	2019	Conference	IEEE	Analytical	Various	SC	15
[8]	UAE	2018	Book chapter	IntechOpen Ltd.	Descriptive	Unspecified	CrCurr	14
[9]	China	2019	Conference	IEEE	Tech proposal	Various	BC	9
[10]	S. Korea	2019	Conference	Springer	Analytical	Ethereum	BC	7
[11]	Belgium	2019	Journal	Cambridge University Press	Descriptive	Various	BC	6
[12]	USA	2020	Conference	ACM	Descriptive	Various	BC	4
[13]	Japan	2018	Conference	Springer	Tech proposal	Various	SC	3
[14]	China	2019	Conference	ACM	Tech proposal	Ethereum	BC	3
[15]	India	2020	Conference	IEEE	Tech proposal	Ethereum	NFT	3
[16]	Japan	2021	ArXiv	ArXiv	Analytical	Ethereum	SC	3
[17]	Sweden	2019	M.Sc. Thesis	Halmstad University	Experimental	Various	BC	2
[18]	Finland	2020	Conference	ACM	Descriptive	Ethereum	NFT	2
[19]	China	2021	Journal	Frontiers in Physics	Analytical	Ethereum	NFT	2
[20]	Hungary	2019	Journal	HeinOnline	Descriptive	Various	BC	1
[21]	USA	2019	Journal	HeinOnline	Descriptive	Various	CrCurr, NFT	1
[22]	Finland	2020	Conference	DiGRA	Descriptive	Ethereum	BC	1
[23]	China	2020	Conference	ACM	Tech proposal	Unspecified	BC	1
[24]	Finland	2020	Journal	IEEE	Tech proposal	Hyperledger	NFT, SC	1
[25]	Poland	2020	Conference	IEEE	Tech proposal	Ethereum	SC	1
[26]	Greece	2021	Journal	MDPI	Experimental	Various	BC	1
[27]	Thailand	2020	Conference	IEEE	Tech proposal	Ethereum	BC	0
[28]	S. Korea	2020	Journal	Soc. of Digital Pol. and Man.	Tech proposal	Ethereum	BC	0
[29]	Thailand	2020	Conference	IEEE	Tech proposal	Various	SC	0
[30]	Finland	2020	M.Sc. Thesis	University of Oulu	Analytical	Various	BC	0
[31]	China	2020	Conference	ACM	Tech proposal	Ethereum	CrCurr	0
[32]	Brazil	2020	Conference	SBC	Descriptive	Various	NFT	0
[33]	UK	2020	Journal	PLOS	Analytical	Ethereum	CrCurr	0
[34]	Greece	2021	Conference	IEEE	Tech proposal	Ethereum	NFT, SC	0
[35]	Brazil	2021	Conference	Springer	Tech proposal	Various	CrCurr	0
[36]	USA	2021	Conference	AoIR	Descriptive	Ethereum	NFT	0
[37]	Finland	2021	Conference	IEEE	Analytical	Ethereum	NFT	0
[38]	China	2021	Journal	Emerald Pub.	Analytical	Unspecified	BC	0
[39]	Poland	2021	Conference	IEEE	Tech proposal	Ethereum	SC	0
[40]	N. Zealand	2021	Conference	ACM	Descriptive	Ethereum	NFT	0
[41]	Russia	2021	Conference	ACM	Tech proposal	Various	BC	0

## V. CONCLUSIONS

This paper presented a clear overview of the current academic research and interests in the topic of how blockchain technologies can be applied to the field of video games. A trend starting from 2018 and, albeit still niche in the general field of blockchain research, it is slowly gaining momentum, especially in the industry. Using a scoping review methodology, the most relevant topics and opportunities for research were identified. From the study results, and beyond the topics enumerated in the discussion, it is also possible to conclude which are some of the upcoming challenges that scientific research could try to provide an answer to, given its recurrence in some parts of the literature.

On one hand, an obvious one would be interoperability. Blockchain, and especially NFTs, are touted in the context of video games as a method of decentralization where the user is

the real owner of virtual assets, out of the company's control. However, this is made irrelevant if the use of in-game assets is still limited to a single game, allowing companies to act as gatekeepers of the content. This is an interesting challenge that has no easy solution at this moment. On the other hand, further research on Smart Contracts as a means to fairness could become very useful, especially in games where randomness plays a big role (as the saying goes, "*Code is law*"). However, understanding the code gives you an edge, and thus game creators always have the upper hand. Is it possible to balance healthy gameplay and fairness, from a technical standpoint? A different matter is whether game companies would want to give up their house edge, of course, regardless of their talk.

Nevertheless, apart from these complicated challenges, the field of video games and blockchain is a very young discipline, full of potential, that can provide a wide breadth of oppor-

tunities in what has turned out to be a very heterogeneous research field, not purely tied to technological proposals. Once a preliminary scoping review has been finished and the potential of the topic has been assessed, further work would be to undertake a full systematic review at a later time.

## VI. ACKNOWLEDGEMENTS

\* This work is partly funded by the Spanish Government through grant RTI2018-095094-B-C22 “CONSENT”.

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