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Using Blockchain for Video Game Distribution

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Abstract

Video game developers will often have to rely on third party platforms for the distribution of their games; this comes at a large monetary cost to the developer and leaves users at a greater risk of censorship and with weak digital ownership that is reliant on the platform staying active. This project uses the Ethereum blockchain to facilitate the large-scale distribution and continuous updating of video games that allows developers to directly interact with their users, who will now have true digital ownership.

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Contents

Chapter 1

Problem Statement

Video games are often large and highly popular pieces of software that are typically distributed for developers by a third party platform like Steam or Epic Games. Whilst these platforms provide benefits such as availability, and some social features they have some major downsides that includes:

(a) taking a large cut of all revenue,
Steam take a 30% cut
(b) being vulnerable to censorship from governments, and
The Chinese version of Steam is heavily censored
(c) the user's access to their games is linked to the platform.
If the platform shuts down, the user loses all their games

A blockchain-based platform will provide greater profits to the developer, eliminate the need for trust in a third party platform, and allow users greater control over the games they own as their access is not directly linked to one service.

1.1 Goals

The goal of this project is to implement a large-scale distribution platform that will allow game developers to release and continuously update their games on a public network by directly interacting with their users. This aims to boost revenue for the developer, reduce the risk of censorship, and improve the rights of the user in terms of digital ownership. The design should include:

- how data is shared between nodes in the network,
- how downloaded data can be verified using the network,
- how users can be incentivised by developers to help distributed their games,
- how users can prove their contribution,
- how users can prove they have purchased a game.

The application will consist of a set of smart contracts, written in Solidity, as well as an interface to the blockchain written using TypeScript, with libraries such as Web3. Tools like Truffle and Ganache will also be helpful during development.

1.2 Scope

This project will look at how the Ethereum blockchain and smart contracts can be used to create a large-scale distribution platform for video games. This be deployed to a 'testnet',

where Ether has no value and applications can be tested in a live environment.

Chapter 2

Background Research

2.1 BitTorrent

BitTorrent [6, 13] is the most popular p2p file-sharing platform, in which users will barter for chunks of files by downloading and uploading them in a tit-for-tat fashion, such that peers with a high upload rate will typically also have a high download rate. For a user to download data from BitTorrent they would:

2.1.1 Download Protocol

1. Find the corresponding torrent file that contains metadata about the torrent such as the location of a tracker, file information such as name, size and path in the directory.
2. The user will find peers also interested in that torrent through a tracker and will establish connections with them.
3. The data is split into constant-sized blocks and are downloaded individually. BitTorrent uses a tit-for-tat mechanism that incentivises users to contribute by providing preferable treatment to nodes who upload data as well.
4. The user will download blocks based upon the following priority:
   (a) **Strict Priority** Data is split into pieces and sub-pieces with the aim that once a given sub-piece is requested then all of the other sub-pieces in the same piece are requested
   (b) **Rarest First** Aims to download the piece that the fewest peers have to increase supply.
   (c) **Random First Piece** When a peer has no pieces, it will try to get one as soon as possible to be able to contribute.
5. The node will continuously upload blocks it has while active.

2.1.2 Availability

It is commonly suggested that availability of torrents is the biggest issue surrounding BitTorrent as *'38% of torrents become unavailable in the first month'* [6] and that *'the majority of users disconnect from the network within a few hours after the download has finished'* [13]. This paper [12] looks at how the use of multiple trackers for the same content and DHTs can be used to boost availability.

2.2 Ethereum

Ethereum is a Turing-complete, distributed, transaction-based blockchain that allows the deployment of decentralized applications through the use of smart contracts. Ether is the currency used on Ethereum and can be traded between accounts and is used to execute smart contract code on the network.

2.2.1 Smart Contracts

A smart contract is an executable piece of code that is used to automate processes and enforce agreements between two or more parties. This code is then executed by every node on the ethereum network using the EVM.

Gas is a unit of measurement that is used to specify the computational effort required to execute operations on the Ethereum network. Each transaction must set a limit on the amount of gas can be used during code executing, and this is paid using ether. However, this can lead to smart contracts failing to execute due to *running out of gas*. By tying the computational effort of a smart contract to ether, the Ethereum network reduces the risk of DoS attacks as an attacker will likely not have the funds to perform such an attack.

Chapter 3

Literature Review

3.1 Blockchain-Based Cloud Storage

Blockchain technology can be leverage for large-scale, distributed cloud storage to allow data to be stored across the network and provide public and private storage. In table 3.1, I detail some examples of how blockchain has been used to create cloud storage platforms or supplement existing ones:

One gap found when researching these solutions was that

Paper	Description of Solution
Blockchain Based Data Integrity Verification in P2P Cloud Storage [19]	This paper uses Merkle trees to help verify the integrity of data within a P2P blockchain cloud storage network as well as looking at how different structures of Merkle trees effect the performance of the system.
Deduplication with Blockchain for Secure Cloud Storage [9]	This paper describes a deduplication scheme that uses the blockchain to record storage information and distribute files to multiple servers. This is implemented as a set of smart contracts.
Block-secure: Blockchain based scheme for secure P2P cloud storage [8]	A distributed cloud system in which users divide their own data into encrypted chunks and upload those chunks randomly into the blockchain, P2P network.
Blockchain-Based Medical Records Secure Storage and Medical Service Framework [2]	Describes a secure and immutable storage scheme to manage personal medical records as well as a service framework to allow for the sharing of these records.
A Blockchain-Based Access Control System for Cloud Storage [16]	This paper describes a method for using blockchain to facilitate the access control over a cloud storage system. The blockchain stores an immutable record of all '*meaningful security events*', such as key generation, access policy, assignment, etc.

Cloud Data Provenance using IPFS and Blockchain Technology [4]	Uses blockchain technology and IPFS to provide an efficient way to securely store provenance [1] data such that it is out of reach of adversaries, but can be used to verify the integrity of data on a cloud storage system.

Table 3.1: *Examples of blockchain cloud storage systems [15]*

3.2 P2P File Sharing

These applications involve a distributed network of computers that share data with each other without the need for a central party to facilitate. Table 3.2 shows some example p2p file-sharing networks.

One of the main issues with these networks come from their anonymity property in that you can never fully trust that what you're downloading isn't malicious. Using blockchain can add a layer of trust by allowing users to identify the author of an upload and match that to a real world entity, such as a company, or to their history of uploads within the network,

System	Description of Solution
IPFS [1]	IPFS is a content-addressable, block storage system and forms a Merkle DAG, which is a data structure that allows the construction of versioned file systems, blockchains and a Permanent Web. IPFS
BitTorrent [13]	BitTorrent is a p2p file-sharing system that has user bartering for chunks of data in a tit-for-tat fashion, which provides incentive for users to contribute to the network. Information about data is stored in .torrent files that can be found online and these help a user find other users interested in the same content they are. It is estimated that tens of millions of users use BitTorrent every day [17].
AFS [11, 5]	The Andrew File System was a prototype distributed system by IBM and Carnegie-Mellon University in the 1980s that allowed users to access their files from any computer in the network.
Napster [14]	Napster uses a cluster of centralized servers to maintain an index of every file currently available and which peers have access to it. A node will maintain a connection to this central server and will query it to find files; the server responds with a list of peers and their bandwidth and the node will form a connection with one or many of them and download the data.

[1] Provenance data are access logs of stored data that can trace the integrity of data and will contain private user information.

Gnutella [14]	Gnutella nodes form an overlay network by sending *ping-pong* messages. When a node sends a *ping* message to their peers, each of them replies with a *pong* message and the *ping* is forwarded to their peers. To download a file, a node will flood a message to its neighbors, who will check if they have and return a message saying so; regardless, the node will continue to flood their request till they find a suitable node to download off of.

Table 3.2: *Various global distributed file systems.*

3.3 Digital Ownership on the Blockchain

Digital ownership is important to this project as it can be used to prove who actually owns the game being distributed and allow that user to provide access rights to other users for access to it. Table 3.3 looks at how various projects have handled the digital ownership of goods.

One main issue with digital ownership has and always will be piracy. Many papers talk about solutions to reduce it but this is typically at the expense of the user's ownership or rights to access it.

Paper	**Description of Solution**
A digital rights management system based on a scalable blockchain [3]	This paper describes a DRM (Digital Rights Management) system that restricts access of online content to authorized users and uses digital watermarking to reclaim copyright ownership following a content leak. The motivation behind it comes from the idea that content is more valuable the less accessible it is.
The Blockchain-based Digital Content Distribution System [7]	This content distribution system gives full control over the access rights of content to the owner....
Visibility and digital art: Blockchain as an ownership layer on the Internet [10]	This paper talks about how blockchain can enable the secure attribution, transfer and provenance of digital property, which allows for unique and valuable pieces of digital content. They also mention how machine learning can be used to show how and where pieces of content are being used on the internet.
Non-Fungible Token (NFT): Overview, Evaluation, Opportunities and Challenges [18]	This paper looks at the NFT ecosystem, where an NFT is a unique piece of content that has value on the blockchain based upon its properties. These allow creators to easily prove the existence and ownership of digital assets and provide them with royalties for any future exchanges of it. NFTs are based on Ethereum and use smart contracts.

Chapter 4

Design

4.1 Stakeholders & Requirements

4.1.1 Stakeholders

Game Developers These primary stakeholders will use the application to release their game and its subsequent updates to their users. These developers could be publishing individual projects or be a part of a major games studio.

Players These primary stakeholders will use the application to download and play games published to it. They will also help distribute the game for incentives provided by developers.

4.1.2 Functional Requirements

ID	Description
	Must
F_M1	Store software metadata on a blockchain, including a reference to a previous block where appropriate
F_M2	A node must request individual shards from its peers
F_M3	A node must be able to discover peers relevant to the software it wants
F_M4	Software must be updatable through the blockchain
F_M5	A node must be able to upload software
F_M6	A node must be able to download software in its entirety from nodes in the same network.
F_M7	A node must be able to verify the integrity of each block it downloads
F_M8	The application should run on the Ethereum network
	Should
F_S1	Allow users to restrict their software to only a specific set of nodes
F_S3	Allow a node to prove they have helped distribute software
	Could
F_C1	Allow users to request specific software versions

F_C2	Allow nodes to join groups for automatic identity verification

4.1.3 Non-Functional Requirements

ID	Description
	Must
NF_M1	The application is decentralized and cannot be controlled by any one party
NF_M2	Any user must be able to join and contribute to the network
NF_M3	Users should remain anonymous to other nodes in the network. However, to provide incentives and proof-of-purchase nodes will need to be identified by an uploader.
	Should
NF_S1	This application must be scalable, such that many users can upload and download the same software at the same time.
	Could

4.2 Design Considerations

4.2.1 Type of Blockchain

It is clear by **NF_M2** that the blockchain must be public. Some of the benefits we would gain from a public blockchain are that it:

- will result in a larger set of users, which will boost the availability of software,
- will reduce the risk of censorship as no one set of nodes will have authority over the network, and
- results in greater data integrity.

The Ethereum blockchain provides an extensive platform for

4.2.2 Verifying Integrity

As per **F_M7**, a node must be able to verify the integrity of each shard of data. To do this, the application will leverage blockchain's inherent immutability property and store the hash data of all files in the body of each block.

Figure 4.1 shows how shard hashes are stored. Hashes are stored in a tree, which mimics the folder layout of the software such that the leaves are hashes and all other nodes represents directories or files.

4.2.3 Downloading Content

To achieve **F_M1**, **F_M2**, and **F_M6**, software in the application will be content addressable and nodes will communicate with each other to collect shards. In Section **??**,

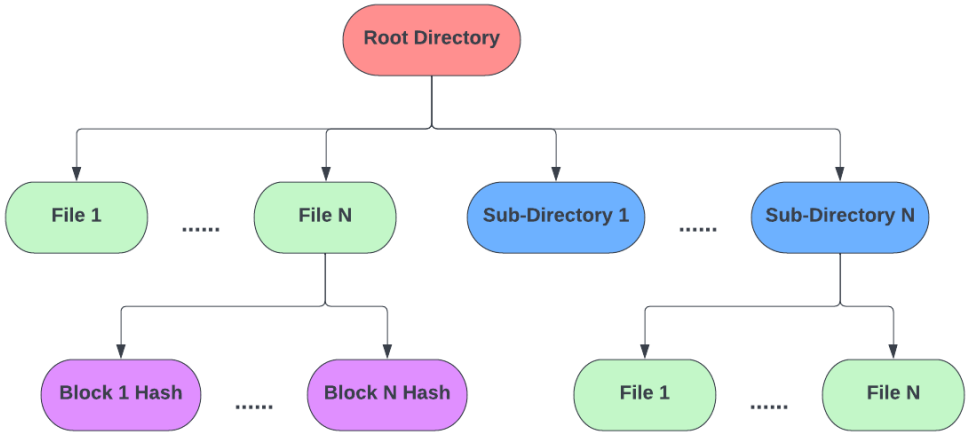

Figure 4.1: *How shard data is stored.*

I mentioned how BitTorrent nodes choose, which shards of data to request first and this application will use a similar model. The general steps for downloading data are:

1. A node will find the block containing information about the software they want,
2. They send out a discover request using the root hash to find peers that are also interested in the same software and then will form connections,
3. The node will then barter for shards of data by downloading and uploading with peers,
4. The node will download the entirety of the software and will continue to upload it.

4.2.4 Updating Software

As per **F_M4**, software must be updatable through the network. To do this, when a block represents an update to a piece of software it will include the hash of the block containing the previous version of the software.

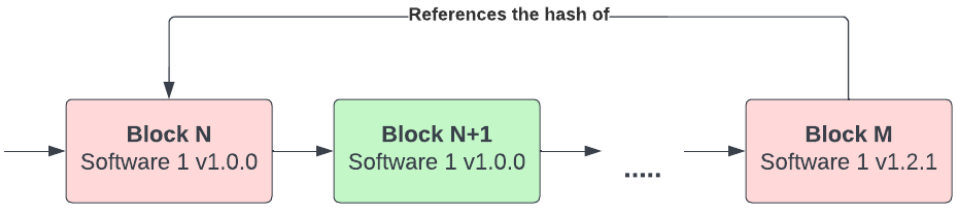

Figure 4.2: *How blocks can relate to older blocks.*

Each update to the software should contain its own complete directory tree, similar to Figure 4.1, but will likely contain duplicate hashes. When an update is released, a node will look for changes in the directory tree and request the corresponding shards. According to **F_C1**, shards from old versions of software could be persisted but this should be down to the choice of the user.

4.2.5 Digital Ownership

Software is a digital asset, in which users will pay developers for the right to download and play their game. Only the uploader will own the game and have permission to distribute access rights.

4.3 Limitations

One of the major limitations of this project is that it will not support any of the social features, such as achievements, message boards, friends, etc., of platforms like Steam. Whilst, many of these can be supplemented through social platforms, like Discord, it may provide a disconnected social experience for playing games.

On top of this due to the discontinuous nature of P2P file-sharing, the long-term availability of games is dependant on an active community or the developers ability to upload themselves. This means that as games get older or support from developer is discontinued, a game may no longer be available to download at all.

Chapter 5

Project Management

5.1 Risk Assessment

Risk	Loss	Prob	Risk	Mitigation
Laptop damaged or lost	3	1	5	All work is stored using version control and periodic backups will be made and stored locally and in cloud storage. I have other devices that could be used to continue development.
Difficulty with blockchain development	2	3	6	I will seek advice from my supervisor about how to tackle certain problems and if necessary, what aspects of my project I should change.
The application is not finished	1	3	3	Using agile development will ensure that I will at least have a minimal working application. If I feel that I am running out of time, I will focus on expanding test cases and improving the write-up.
No suitable large scale test environment	2	5	10	I do not have the infrastructure to test this project on a large network, however small scale tests will be possible.
Personal illness	3	2	6	Depending on the amount of lost time, I may have to not complete some of the SHOULD or COULD requirements.

Table 5.1: *The risk assessment of this project.*

5.2 Work to Date

My work has primarily been on research, looking at how blockchain has been used to build and supplement cloud storage systems as well as how various peer-to-peer functioned and

performed. I have proposed a design for the application to be built on the EVM.

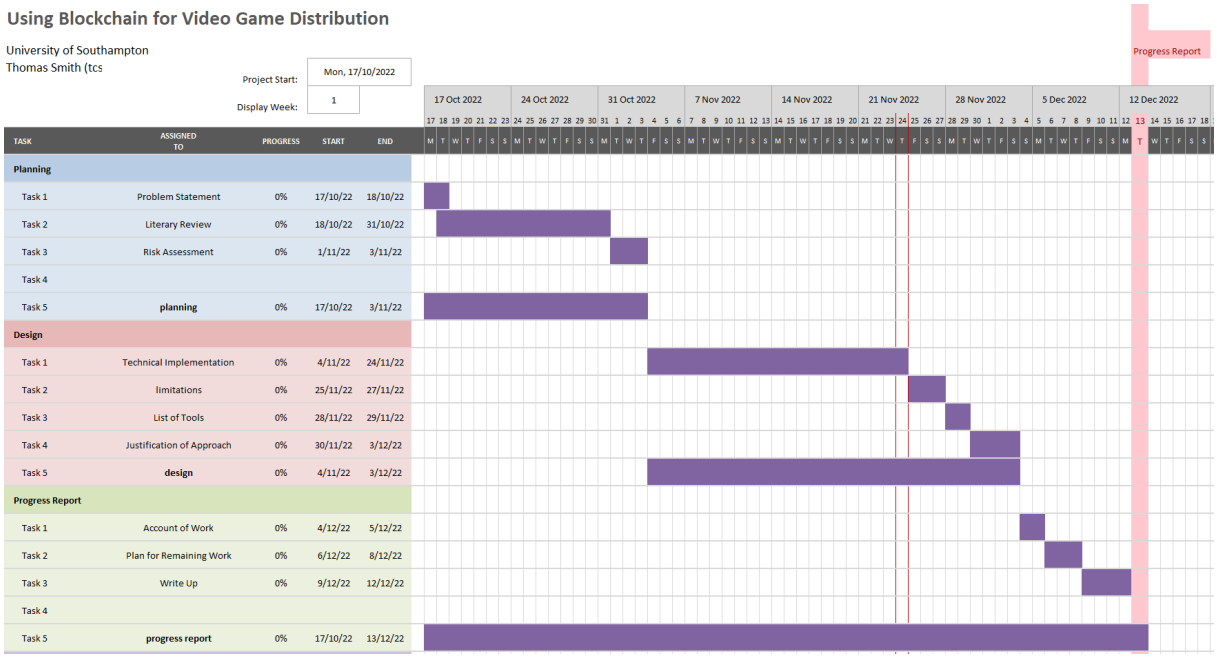

Figure 5.1: *A Gantt chart for my work up until the progress report.*

5.3 Plan of Future Work

My project is now split into the following remaining phases:

Implementation & Testing This phase will use agile-based, test-driven development to incrementally deliver functionally and robust pieces of code. The initial sprint will focus on the underlying architecture and provide a base system for the platform to run on, whilst later sprints will focus on improving and adding new functionality. This will also include a write-up after every sprint of what was accomplished and what wasn't.

Testing Strategy and Results This phase will be used to reflect on how test-driven development affected my project and what strategy I commonly used during development. It will also be used detail how my application fared against the tests and any problems that I am aware of with the application that I was unable to fix.

Evaluation This phase will focus on me critically evaluating the success of my project as a solution to the problem that it set out to solve. It will be used to compare it as a standalone platform and in comparison to other competitors and similar works.

Bibliography

[1] Benet, J. IPFS - content addressed, versioned, p2p file system.

[2] Chen, Y., Ding, S., Xu, Z., Zheng, H., and Yang, S. Blockchain-based medical records secure storage and medical service framework. 5.

[3] Garba, A., Dwivedi, A. D., Kamal, M., Srivastava, G., Tariq, M., Hasan, M. A., and Chen, Z. A digital rights management system based on a scalable blockchain. 2665–2680.

[4] Hasan, S. S., Sultan, N. H., and Barbhuiya, F. A. Cloud data provenance using IPFS and blockchain technology. In *Proceedings of the Seventh International Workshop on Security in Cloud Computing*, SCC '19, Association for Computing Machinery, pp. 5–12.

[5] Howard, J. H., Kazar, M. L., Menees, S. G., Nichols, D. A., Satyanarayanan, M., Sidebotham, R. N., and West, M. J. Scale and performance in a distributed file system. 51–81.

[6] Kaune, S., Rumín, R. C., Tyson, G., Mauthe, A., Guerrero, C., and Steinmetz, R. Unraveling BitTorrent's file unavailability: Measurements and analysis. In *2010 IEEE Tenth International Conference on Peer-to-Peer Computing (P2P)*, pp. 1–9. ISSN: 2161-3567.

[7] Kishigami, J., Fujimura, S., Watanabe, H., Nakadaira, A., and Akutsu, A. The blockchain-based digital content distribution system. In *2015 IEEE Fifth International Conference on Big Data and Cloud Computing*, pp. 187–190.

[8] Li, J., Wu, J., and Chen, L. Block-secure: Blockchain based scheme for secure p2p cloud storage. 219–231.

[9] Li, J., Wu, J., Chen, L., and Li, J. Deduplication with blockchain for secure cloud storage. In *Big Data*, Z. Xu, X. Gao, Q. Miao, Y. Zhang, and J. Bu, Eds., Communications in Computer and Information Science, Springer, pp. 558–570.

[10] McConaghy, M., McMullen, G., Parry, G., McConaghy, T., and Holtzman, D. Visibility and digital art: Blockchain as an ownership layer on the internet. 461–470. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/jsc.2146.

[11] Morris, J. H., Satyanarayanan, M., Conner, M. H., Howard, J. H., Rosenthal, D. S., and Smith, F. D. Andrew: a distributed personal computing environment. 184–201.

[12] Neglia, G., Reina, G., Zhang, H., Towsley, D., Venkataramani, A., and Danaher, J. Availability in BitTorrent systems. In *IEEE INFOCOM 2007 - 26th IEEE International Conference on Computer Communications*, pp. 2216–2224. ISSN: 0743-166X.

[13] Pouwelse, J., Garbacki, P., Epema, D., and Sips, H. The bittorrent p2p file-sharing system: Measurements and analysis. In *Peer-to-Peer Systems IV*, M. Castro and R. van Renesse, Eds., Lecture Notes in Computer Science, Springer, pp. 205–216.

[14] Saroiu, S., Gummadi, P. K., and Gribble, S. D. Measurement study of peer-to-peer file sharing systems. In *Multimedia Computing and Networking 2002*, vol. 4673, SPIE, pp. 156–170.

[15] Sharma, P., Jindal, R., and Borah, M. D. Blockchain technology for cloud storage: A systematic literature review. 1–32.

[16] Sukhodolskiy, I., and Zapechnikov, S. A blockchain-based access control system for cloud storage. In *2018 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus)*, pp. 1575–1578.

[17] Wang, L., and Kangasharju, J. Measuring large-scale distributed systems: case of BitTorrent mainline DHT. In *IEEE P2P 2013 Proceedings*, pp. 1–10. ISSN: 2161-3567.

[18] Wang, Q., Li, R., Wang, Q., and Chen, S. Non-fungible token (NFT): Overview, evaluation, opportunities and challenges.

[19] Yue, D., Li, R., Zhang, Y., Tian, W., and Peng, C. Blockchain based data integrity verification in p2p cloud storage. In *2018 IEEE 24th International Conference on Parallel and Distributed Systems (ICPADS)*, pp. 561–568. ISSN: 1521-9097.