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UNIVERSITÀ DI ROMA

DEPARTMENT OF COMPUTER SCIENCE

**TruthHub**  
BLOCKCHAIN AND DISTRIBUTED LEDGER  
TECHNOLOGIES

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# 1 Preface

## 1.1 Brief presentation of the protocol

The **TruthHub protocol** presented in the report proposes a censorship resistant solution to spread and monetize news.

Thanks to its **decentralized** and **community-centered** nature, TruthHub propose itself as the solution to the uncontrolled spread of fake news and as a place in which everyone can have the possibility to speak freely without the fear of censorship.

## 1.2 Team members and main responsibilities

- **Weidong Cai** front-end & back-end interaction designer, report reviewer
- **Lucia Fores**: back-end designer and developer, front-end designer and developer, report reviewer
- **Elena Jiang**: diagrams, front-end & back-end interaction designer, report reviewer

## 1.3 Outline of the report

The report is in this way structured: in the **Background** section ([section 2](#)) is given an introduction on the blockchain technology, on which TruthHub lays its foundation, and the domain of the application is presented; in the **Presentation of the Context** section ([section 3](#)) the aim of the DApp is presented together with the type of blockchain used in the production of the project; in the **Architecture** section ([section 4](#)) the software architecture of the protocol is presented together with all the needed diagrams; in the **Implementation** section ([section 5](#)) sample of the demo of the DApp are presented and all the technical details of the implementation are illustrated; in the **Known Issues and Limitations** section ([section 6](#)) all the issues and limitations found during the project are presented

# 2 Background

## 2.1 Blockchain Technology

*”Blockchain is an open and distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way”* [1]

Starting from the provided definition of the **Blockchain** we can highlight the fundamental concepts of this technology:

- The blockchain is an ***open and distributed ledger***: this means that it is a distributed system which relies on a network of **nodes** that collaborate in order to maintain the same version of the **ledger**; a **ledger**, in the blockchain case, is an append only totally ordered without complement set of **transactions**. A ledger is made up of totally ordered **blocks**; blocks are used as a **time unity**. The blockchain is described as **open** because everything that happens on it is actually **transparent** to the user.
- The blockchain ***can record transactions between two parties efficiently and in a verifiable and permanent way***: the record of the transaction is made up by storing them into a block and connecting all the blocks by having a reference of the previous block (the **block hash**) inside the following block header; the transaction, given the immutability nature of the ledger, are stored permanently inside it once they are deemed **verified**.

By going deeper in the description of the blockchain we can talk about the main **consensus mechanisms**: the two main consensus mechanisms are the **Proof of Work** (used by Bitcoin) and the **Proof of Stake** (used by Ethereum).

### 2.1.1 Ethereum Blockchain

*Ethereum is a network of computers all over the world that follow a set of rules called the Ethereum protocol. The Ethereum network acts as the foundation for communities, applications, organizations and digital assets that anyone can build and use. [2]*

The **Ethereum** blockchain is a **Proof of Stake** (PoS) blockchain that uses \$ETH as native coin. The strength of this blockchain is the introduction of **smart contracts**, pieces of code that users can deploy and use on blockchain in order to create custom action to be performed on the blockchain.

### 2.1.2 Smart Contracts

*Smart contracts are the fundamental building blocks of Ethereum's application layer. They are computer programs stored on the blockchain that follow "if this then that" logic, and are guaranteed to execute according to the rules defined by its code, which cannot be changed once created. [3]*

**Smart Contracts** are **deterministic** piece of code that operates **on-chain** and are called off-chain. They execute a function only when they are called.

The execution of the smart contract on the **Ethereum Virtual Machine** (EVM) is paid in **Gas**: each action is tied to a specific immutable cost.

Once written the smart contract must be **deployed** on the blockchain and once deployed the function of the smart contract can be triggered thanks to the transactions

### 2.1.3 Token ERC standard

Another characteristic of the Ethereum Blockchain is the possibility to create **user-custom asset** called **tokens** [4] through the use of smart contracts.

The token standard on Ethereum useful for our project are:

**ERC-20** The ERC-20 is the standard for **Fungible Tokens** on Ethereum. ERC-20 tokens can be used to create interoperable assets that behaves in the same way for every ERC-20 token created. [5]

**ERC-1155** The ERC-1155 is the standard for the **Multi-Token**. Thanks to this interface it is actually possible to manage any combination of fungible, non-fungible and semi-fungible tokens. [6]

## 2.2 Application Domain

In this section we will explain in which context our protocol fits and why we decided to create TruthHub as a solution for the problem we identified.

We started by studying the problems surrounding the social media platforms: nowadays on social media is full of **fake news** that are always more difficult to be identified and spread always faster and faster [7]. Moreover we found out that social media platforms themselves play a bigger role in the diffusion of fake news by implicitly **rewarding** the users who spread them. [8] We then focused on seeing which were the problems related to the **communication** on social media platforms: we found out that users are always more influenced by social media *influencers* in their behaviors; naturally this could lead in spreading news and finance project just because they have been advertised by the *influencer* even though the outcome may not be as positive as it was advertised [9]. Moreover, as stated by Imperati et al. in [10] social medias are also widely used to spread monetization campaigns based on fake news and conspiracy theories. We finally investigated how powerful the **censorship mechanism** can be over content that is posted online especially in countries in which the government have the possibility to actually checks everything that people post online [11]. After investigating all the problems that harass the dissemination of information on social media we came up with the TruthHub protocol.

## 3 Presentation of the Context

### 3.1 Aim of TruthHub

As stated in subsection 2.2 the idea of TruthHub came after the investigation of the problems that harass the news spread on social media.

TruthHub wants to be a protocol that helps users in mitigate or even resolve the problem presented before; specifically:

- **Censorship Problem:** One of the aims of TruthHub is to provide to users a place in which no one can be censored for what they say; in order to do that we will make use of **Nostr**, a censorship-resistant distributed protocol [12] thanks to which people will have the possibility to post their textual content;
- **Funding requests with transparency leaks:** In order to overcome this problem we will make use of the **Ethereum blockchain** thanks to which we will provide to the users the certainty that the fund sent will actually be received by the person who asked for them;
- **Funding independent authors:** We will provide to the users and to the authors the possibility to make (and ask) for financing;
- **Spread of fake news:** Thanks to the **community-centered nature** and to our voting and rewarding system (discussed in subsection 3.2) the spread of misinformation will be sensitively reduced making in this way TruthHub the right place in which people will have the possibility to speak freely and read true news

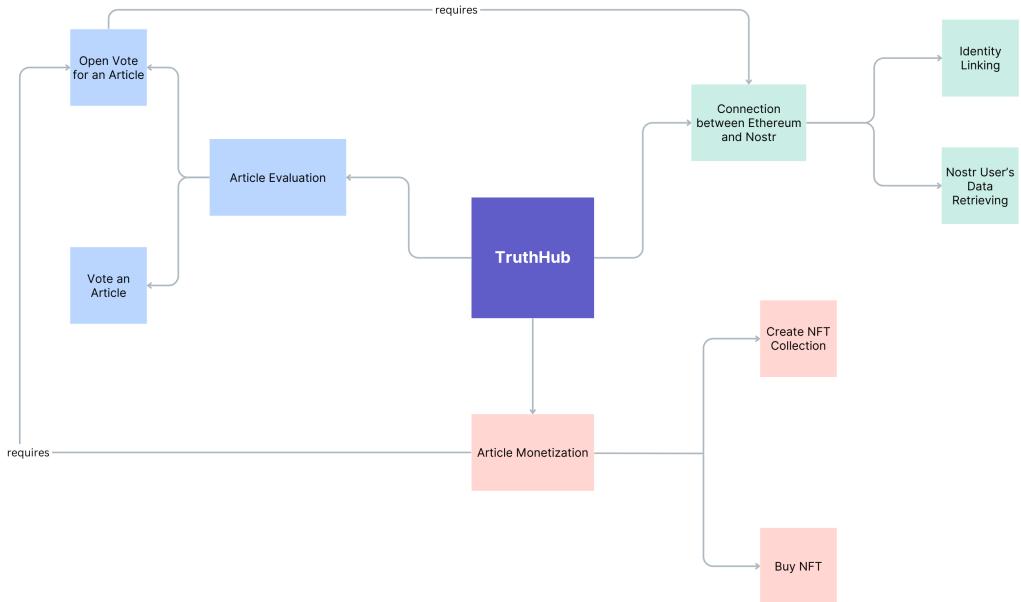


Figure 1: TruthHub Concept Diagram

The concepts on which our protocol relies can be looked in [Figure 1](#). Users will have the possibility to use TruthHub in two different ways: as **authors** or as **readers**; on TruthHub authors will have the possibility to open funding for articles they wrote (and posted) on Nostr: by opening a funding, the article will become eligible

to be voted by the community that will have the possibility to express their vote over the article by sending an **upvote** or a **downvote**. After the ending of the vote every reader who voted the article and the author itself will have the possibility to observe the outcome of their behavior: assuming that most of the users of TruthHub will be not malicious, the **reliability** of the article will be computed by the votes collected; if the majority of the votes will be upvotes the author will be rewarded for their good behavior in not spreading misinformation else it will be penalized. In any case all the readers who voted in the majority will be rewarded.

By having always a good behavior, authors will increase their **reputation** and by increasing it enough they will become **top authors** of the platform: top authors will have special privileges like the possibility to sell their articles as NFTs and in this way get back direct financial support by the readers.

On the other hand readers will have the possibility to read and vote articles in the platform and to buy NFTs: also readers will be tied to a **reputation** mechanism and every time that they will vote for an article in the minority their reputation score will be lowered.

## 3.2 Use Cases

In [Figure 2](#) the use cases of our protocol are presented; we have three possible actors that can behave in the following way:

- **Reader:** a simple user of our protocol, they can **read an article, vote an article, check the reliability of an author or of an article, buy a NFT and claim a reward**
- **Author:** a user who have the possibility to monetize their article, they can **link their Nostr and Ethereum addresses, open the vote for one of their article**
- **Top Author:** an author whose reliability is over a specific threshold, they can **create NFT from their articles**

### 3.2.1 Scenarios

Following are depicted the main scenarios of usage of the protocol; notice that in order to execute any of the following the user must be authenticated with **Metamask** and so this passage will be not repeated every time.

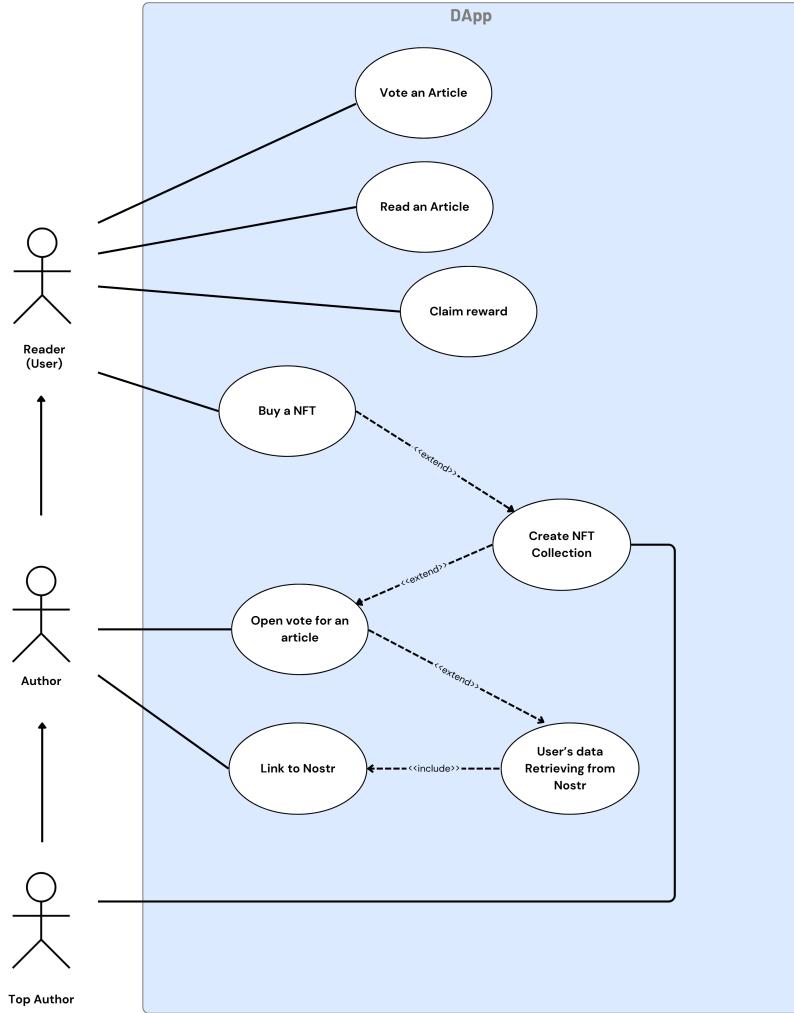


Figure 2: TruthHub Use Cases

**User becomes an author** (Figure 6a) In order to become an author a user **links together** their Nostr and Ethereum profile, in order to do that it sends to the contract a **cryptographic proof** (consisting in their Ethereum public address signed with the **Schnorr cryptography** by using the Nostr private key) and the **Nostr public key**; upon receiving them the contract decrypts the cryptographic proof thanks to the Nostr public key and checks that the content of the message matches with the sender of the transaction: in this way we have the certainty that the **signature has not been spoofed** by anyone and that the sender of the transaction is the **owner of the two accounts** (meaning that it actually has both private keys)

**User publishes an article** (Figure 6b) After posting a content on Nostr the author has the possibility to **publish** the article on TruthHub (starting in this way the **monetization** on it); in order to do that it is required that the user sends the **Nostr event id** and an **amount of Ether** (Table 1)

Reputation	Min ETH Publish Price	Min ETH Vote Price	Vote Weight	Max Veri Boost	Max Boosted Vote Weight
1	0.02	0.002	5	5	10
51	0.01	0.001	10	10	20
101	0.005	0.0005	20	20	40

Table 1: Publish prices, vote price and vote weights

**Article is open to vote** ([Figure 6c](#)) During a **span of time** (computed in **number of blocks**) that goes from a minimum of 4 days to a maximum of 7, the article can be voted by the community; in order to do so a reader must have not voted already for the article and must not be the author of the article. The vote goes on necessarily for the **minimum amount of time** (4 days) but it can be closed before if the vote reaches the **maximum amount of vote possible**: every article in fact can reach up to an amount of a total weighted vote of 500; the weight of a vote is affected not only by the reputation of the reader but it can be boosted by the users by spending an amount of \$VERI, the token of the platform ([Table 1](#)). By reaching the end of the vote the article starts to be **claimable** for all the users that are part of the majority

**User claims their reward** ([Figure 6d](#)) There are three possible outcomes of the vote: *equality between majority and minority*, *majority on the upvotes*, *majority on downvotes* (for the specific rewards check [Figure 3](#) [Figure 4](#)) Since no one in the minority will get anything back and they will not be stimulated to claim, every user in the majority will take care of lower the reputation of a part of the minority users by one: for every user they took care of they will get an amount of \$VERI token; notice that the mentioned *proportional amount of \$VERI tokens* depends on the initial stake and on how many user of the minority the user took care of

**Top author creates NFT** ([Figure 6e](#)) Once becoming a **top author** (meaning that the author **reputation** of a user is **over 90**) they will have the possibility to sell their articles as NFT getting in this way a direct support in \$ETH by the other users. In order to do so the author will decide for which of their article mint an NFT and the amount of NFT to be minted. The mint has a **fixed price** to be paid in \$VERI

**User buys NFT** ([Figure 6f](#)) The users will have the possibility to buy an amount of NFT from the ones that has been created by the authors. By buying a NFT the user will pay the fixed amount of \$ETH and will get in return the NFT and the \$VERI amount paid by the user to mint that amount of NFT

Article Validated	Majority	Reward	Reputation
Yes	Upvotes	ETH staked + minority ETH staked + proportional amount of Veri token	+1
No	None	ETH staked	Not changed
No	Downvotes	None	-1

Figure 3: Author Vote Rewards

Article Validated	Majority	Vote	Reward	Reputation
Yes	Upvotes	upvote	ETH staked + proportional amount of Veri token	+1
Yes	Upvotes	downvote	None	-1
No	None	upvote downvote	ETH staked	Not changed
No	Downvotes	downvote	ETH staked + proportional amount of ETH staked by upvoters and author + proportional amount of Veri token	+1
No	Downvotes	upvote	None	-1

Figure 4: Reader Vote Rewards

### 3.3 Why use blockchain?

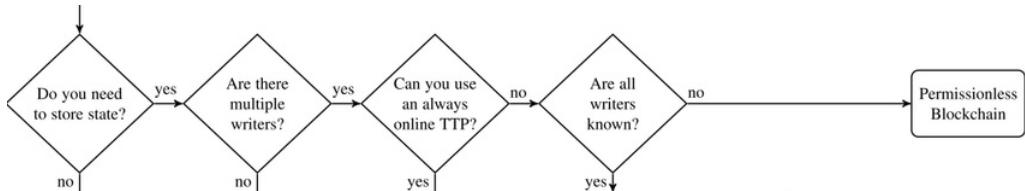


Figure 5: Blockchain flow chart (Wüst & Gervais)

In order to understand if we needed (and if so what type) the blockchain in our project we followed the Wüst & Gervais model [13] (Figure 5) and we ended up understanding that: **We need to store state** since we need to have an immutable and tamper-resistant transparent ambient for our project; **We have multiple writers** namely all our users that can write the blockchain with the publication of new articles, by expressing their vote or by creating/buying NFTs; **We can't use an always online TTP** because one of the focus of our project is to create a decentralized protocol; **We do not know our writers** in fact anyone who is in possess of an Ethereum address can be a user on our platform. Given our needs we will use a **permissionless blockchain**, specifically Ethereum.

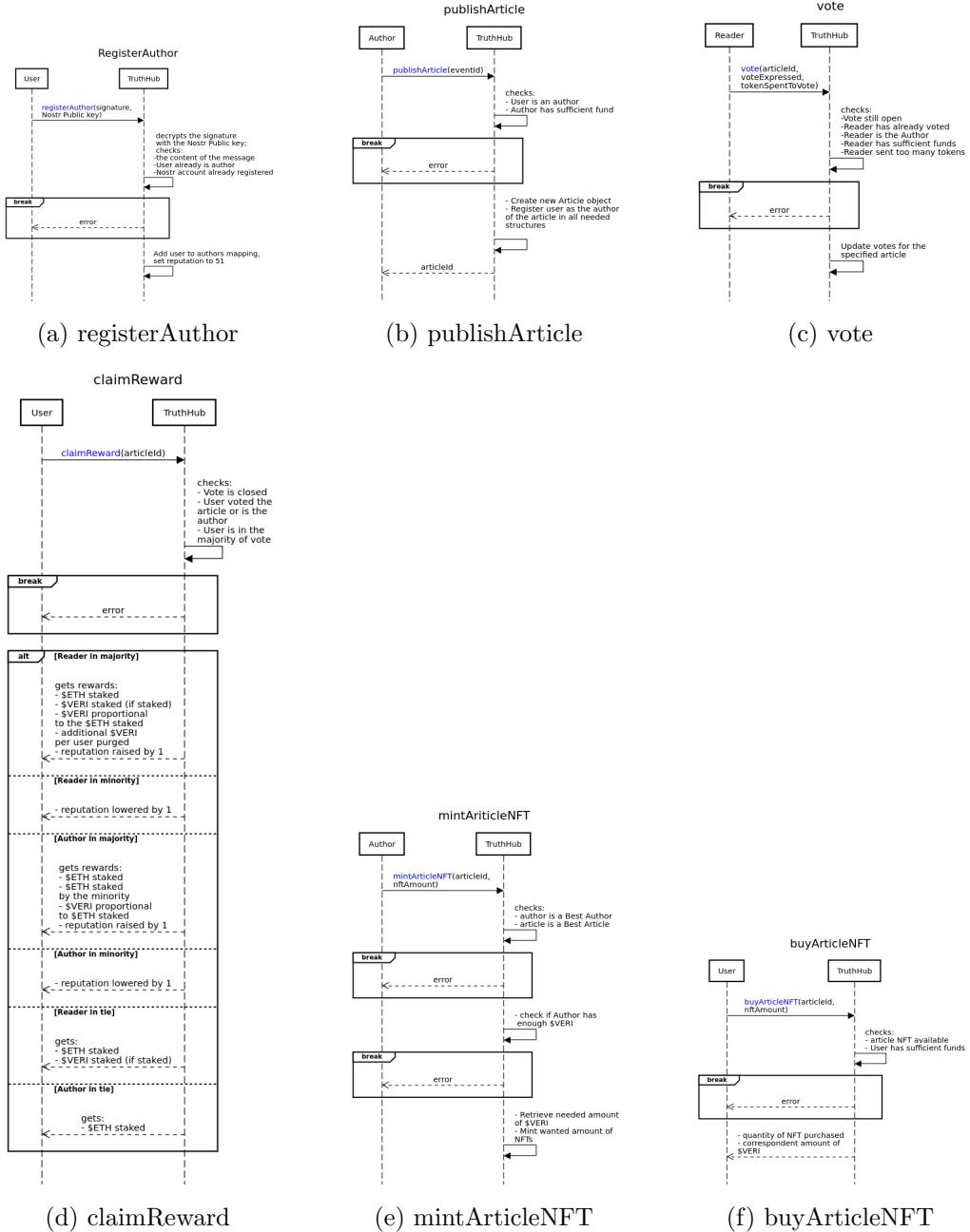


Figure 6: Use-Case sequence diagrams

## 4 Software Architecture

In this section we show in detail the architecture of TruthHub and the design choices behind it. In [Figure 7](#) is presented the architecture of TruthHub.

The entire protocol is open source and can be consulted on Github [\[14\]](#) and it is possible to interact with all the contract code thanks to the TruthHub DApp ([section 5](#)) or thanks to the Etherscan Interface ([TruthHub](#), [VeriToken](#), [ArticleNFT](#)).

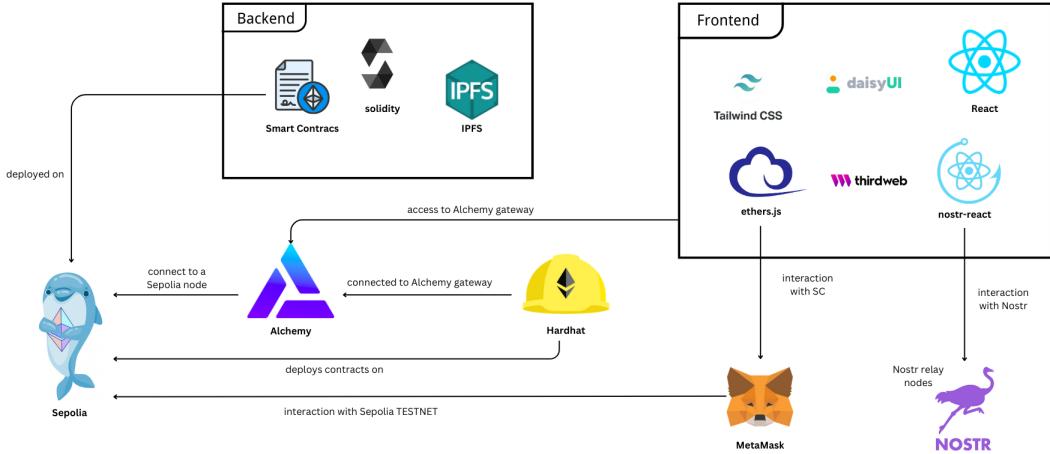


Figure 7: TruthHub Architecture Diagram

#### 4.1 Tools used

For the realization of TruthHub we relied on **Node.js** [15] in order to use the following npm packages:

- **@openzeppelin/contracts**: we built our contract on the audited code of this library [16]
- **hardhat**: used as the development environment [17]
- **@nomicfoundation/hardhat-toolbox**: used to deploy on Sepolia TestNet and verify the contracts on Etherscan [18]

Thanks to the **Alchemy API** [19] and to the **Sepolia Faucet** [20] we managed to deploy the contract on **Sepolia TestNet** [21]; thanks to the **Etherscan API** [22] we managed to verify the contracts. **Remix** [23] was used as the editor to write the contracts that were compiled with **solidity compiler 0.8.22** (and overall TruthHub can run on solidity versions  $\geq 0.8.9$ )

#### 4.2 Protocol Blueprint

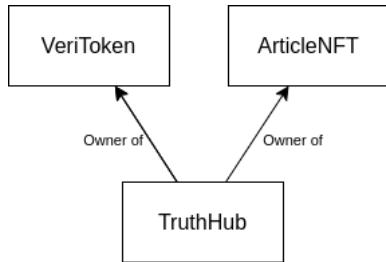


Figure 8: Protocol Blueprint

In Figure 8 is shown the protocol blueprint; **TruthHub** is the contract that handles all the protocol logic and is also the owner of the **VeriToken** contract (the contract of

the ERC-20 token of the platform), in this way can mint new token for the users when needed, and the owner of the **ArticleNFT** contract (the contract of the ERC-1155 NFTs of the articles)

### 4.3 VeriToken

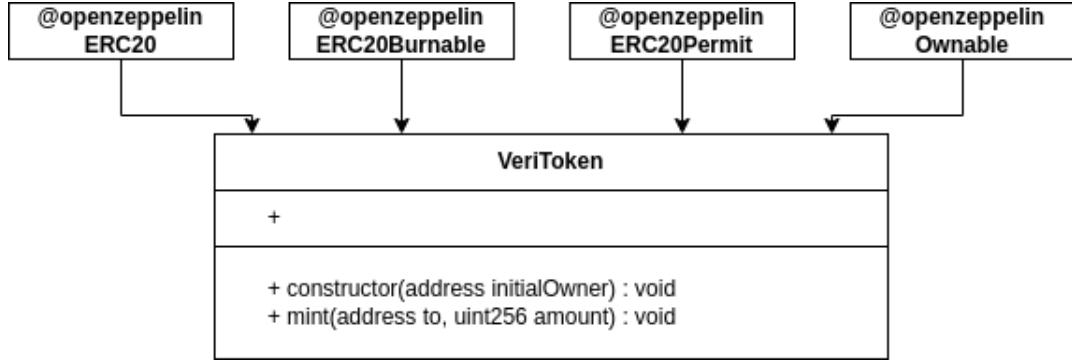


Figure 9: Class diagram of VeriToken

In [Figure 9](#) is shown the class diagram for the contract **VeriToken**.

Veri (\$VERI) is the platform tokens and is implemented as an ERC-20 token mintable only by the owner of the contract and burnable by everyone; inside the economy of the platform, \$VERI are used to boost the vote weight of an user by making it at most the double of the initial weight of the vote and to create NFTs by the top authors of the platform.

Veri starts with a capital of zero and are minted only following the closing of a vote

### 4.4 ArticleNFT

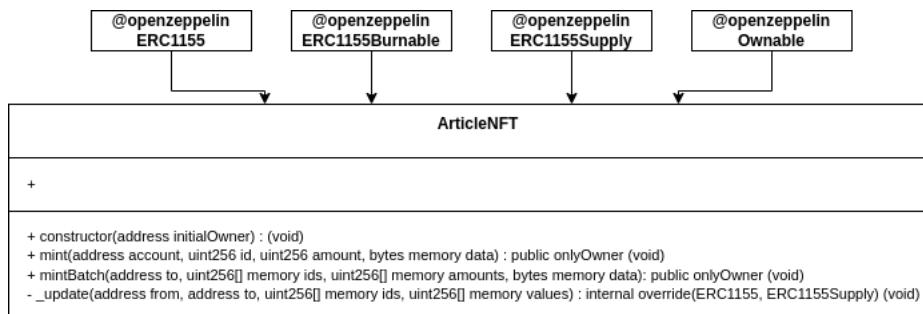


Figure 10: Class diagram of ArticleNFT

In [Figure 10](#) is shown the class diagram of the contract **ArticleNFT**.

ArticleNFT is an **ERC-1155** token whose supply can be monitored, minted only by the owner and burnable by everyone.

Inside the economy of the platform the Articles NFTs represent the tool thanks to

which users can directly support the best authors: in fact they will have the possibility to mint an amount of NFT for their best articles by paying a fixed amount of \$VERI, when bought by an user, the correspondent amount of \$ETH paid by the user will be given to the author and the user will receive the amount of NFT bought and the correspondent amount of \$VERI paid by the author

## 4.5 TruthHub



Figure 11: TruthHub class diagram

In Figure 11 is shown the class diagram of **TruthHub** the main contract of our project.

As stated before TruthHub maintains and manage the entire logic of the project (section 3)

## 4.6 Why not Oracles?

Even though our project relies on the use of a protocol external to the blockchain (which is Nostr) we decided to create a protocol that didn't need oracles in order to manage the interaction with the external protocol; in fact we decided to create solutions to these problems thanks to our UI and to design choices in our protocol. Specifically:

- **Closing of the vote:** in order to know when a vote is closed we decided to make all the vote equally long; specifically we decided to represent a minimum block threshold starting from which, if the total sum of the weighted vote reached the wanted threshold, the vote would have been considered closed and a maximum block threshold, starting from which, even though the weighted sum of the vote did not reach the wanted threshold the vote would have been considered closed anyway. In order to implement this we also made use of custom modifiers that checked if the vote was still open or closed
- **Sending rewards:** to do so we decided to implement the reward distribution as an action that the user must trigger; the idea behind this solution is the fact that if a user is part of the winners would naturally trigger the action and get their reward but since there would not be any motivation for which the losers of the vote would trigger it, we decided to make the winners take care of the losers by giving them in return other \$VERIs
- **Malicious users who stole articles:** it can happen that a malicious user steal the content that another user posted on Nostr (by getting the relative event id) and then post it on TruthHub as if it was their content; in this case our UI comes in hand, in fact, at the moment of the render of the page for the article read, the DApp will communicate with Nostr to retrieve the textual content of the article and at the same time will check if the original author has the same Nostr public key of the author on TruthHub: in case of a mismatch the article will be flagged as "posted by a malicious user" on our platform

## 5 Implementation

### 5.1 Tools used

In this section we show the tools used in order to implement the front-end of our DApp

- **React** is a JavaScript library to build user interfaces; given its strong object oriented nature, React let users build their application by programming specific components that are then rendered when the page is loaded. Given its large

community and wide range of third-party libraries React was the optimal choice when thinking about the UI of our project [24]

- **Tailwind CSS and DaisyUI** both are styling libraries used in the project [25] [26]
- **nostr-react** a React library needed to easily retrieve data from Nostr relays [27]
- **Ethers.js** a JavaScript library for interacting with the Ethereum Blockchain and its ecosystem used to create decentralized applications (DApps), wallets (such as MetaMask) and other tools and simple scripts that require reading and writing to the blockchain. Ethers.js gave us the possibility to easily interact with the ABI of our contracts and in this way create a connection between our front-end and back-end [28]
- **thirdweb** a development framework that allowed us to easily build most of the web3 functionality in our application [29]
- **MetaMask** a cryptocurrency wallet that comes in the form of a web extension that allowed us to easily interact with our protocol and the Ethereum blockchain. The users could manage their balances and approve easily transaction all by never leaving our DApp [30]
- **UnDraw** an open-source illustration library from which we took the assets for our website [31]

## 5.2 TruthHub DApp

In this section we will analyze all our front-end by showing also screenshots of our DApp from our demo.

### 5.2.1 Home page

In the home page ([Figure 12a](#)) we presented our protocol with a brief description by also giving users the possibility to easily go to any of our main use cases each one also described briefly. In this way also users who are not familiar with the protocol can quickly understand the main concepts behind it. The page also show a navbar (present in all the pages of the website) to let the user navigate quickly in every part of the site and a button to let the user connect with their MetaMask wallet. In the footer of the page all the links to the contracts clear code verified on Etherscan can be found

### 5.2.2 Author Registration

Since some of our functionalities are restricted to users who are registered as authors on TruthHub, we provided a page ([Figure 12b](#)) in which a user can perform the link between the Ethereum address and the Nostr Public Key: in order to do that we ask the user to provide the signature ([subsubsection 3.2.1](#)) and the Nostr Public Key and then we call the needed contract function thanks to the provided button. The author registration is available only for users who are connected with the MetaMask wallet

### 5.2.3 Publish Article

Once becoming an author, users can have the possibility to publish ([Figure 12c](#)) one of their Nostr post as an article on TruthHub and so open the monetization for it. In order to do that a user must be connected with the MetaMask wallet and registered as an author and then provide the Nostr Event Id of the post to be published together with the amount of Ether that wants to put in stake for the article ([Table 1](#))

### 5.2.4 Read Articles

In this page ([Figure 12d](#)) every user with a MetaMask wallet connected can read the articles published by the authors: the articles are presented sorted by the closest vote ending and for each article the user have the possibility to express their vote (by choosing to upvote or downvote it and send sending the amount of \$ETH to stake for the vote and eventually the amount of \$VERI to boost the vote - [Table 1](#) -), read all the article information and the true article content. Moreover the article shown to the user are the only one for which they still express a vote meaning that as soon as the vote for an article closes or the user vote an article it will disappear from the page; also a flag system to show which article are from a malicious user ([subsection 4.6](#)) is presented to the user

### 5.2.5 NFTs

This page ([Figure 12e](#)) has different sections depending on the user who visualize it: if a user which is not a best author of the platform (meaning that the author reputation of the user is lower than 90) connected with MetaMask visualize the page, it will be able to choose the amount of NFT to buy from the ones that are available; if a best author visualize the page it also have access to the section in which it can decide for which of their verified articles (articles whose vote ended with a majority of upvotes) mint the wanted amount of NFT

### 5.2.6 User Profile

The profile of a user in the platform ([Figure 12f](#)), it contains all the useful information about the user; specifically by connecting a MetaMask wallet the user will visualize their own statistics (the reputation, the amount of ether needed to publish an article and to vote it, the maximum boost in \$VERI that can be given to a vote), the articles in which is involved (the one published or voted) and their state (which can be pending if the vote isn't finished or claimable if the user is in the majority of users that can claim the rewards - [Figure 3](#), [Figure 4](#) -) and the owned NFTs. It is important to notice that if an article vote is finished but the user is not in the majority the article won't be shown to the user

## 6 Known Issues and Limitations

Our DApp presents some tasks that we still need to implement or fix; specifically:

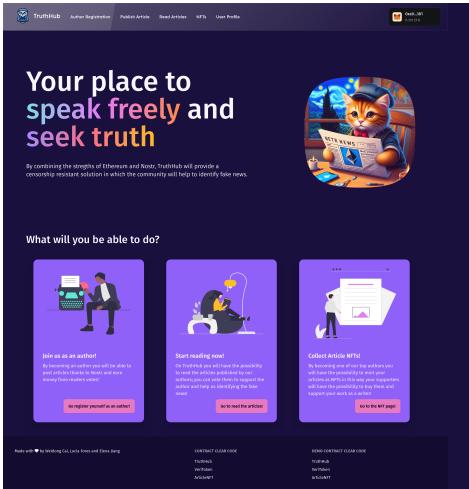
- **Signature:** we weren't able to implement the cryptographic proof based on our idea and so in this version of the protocol the user register itself as an author by only putting the Nostr public key at the moment of the registration
- **Article Modals:** we created some modals useful to summarise all the article information outside the page in which articles can be read; unfortunately the modals works only with the first article of the list

## 7 Conclusions and Future Remarks

We presented TruthHub, a decentralized protocol for the news monetization and spread and for the control of the spread of fake news. TruthHub design allow authors to monetize their article by staking a little amount of \$ETH that will be given back to them, together with other rewards, if they behave correctly and allow the community to create a report system, based on the vote of the articles, needed to maintain the platform free from malicious users.

In short we briefly summarized the TruthHub protocol in its design, implementation and functionalities by addressing all the main problems of the present media platforms that we managed to resolve thanks to the use of the blockchain and distributed protocols.

Thanks to TruthHub, authors and readers will have a space in which **speak freely**, **find the least amount of fake news** possible and be **rewarded for their good behave** and not for the engagement that their actions bring to the platform.



**Your place to speak freely and seek truth**

By combining the strengths of Ethereum and Nostr, TruthHub will provide a compelling alternative solution in which the community will begin to identify free news.

**What will you be able to do?**

- Join us as an author! By becoming an author you will be able to publish your article on TruthHub and earn rewards from readers' votes!
- Start reading! On TruthHub you will have the possibility to read the latest news from all over the world. You can also choose to support the authors you like by supporting their articles.
- Collect Article NFTs! By becoming one of our top authors you will receive a unique NFT that you can sell or trade on the market. You can also mint your own NFTs to earn rewards and support your favorite authors.

[Join us as an author!](#) [As a reader!](#) [As to the NFT page!](#)

Auth with: By Holding Cat, Liane Evans and Eliza Jang  
CONTACT CLEAR CODE  
TruthHub  
Twitter  
GitHub  
LinkedIn  
Email  
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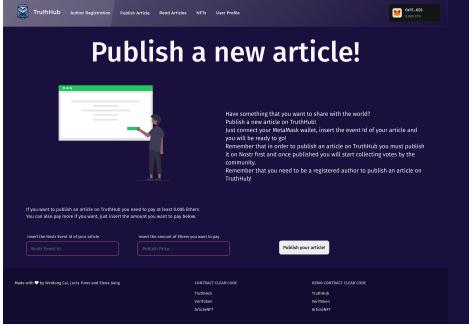
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(a) Homepage

(b) Registration



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**Article Info:**

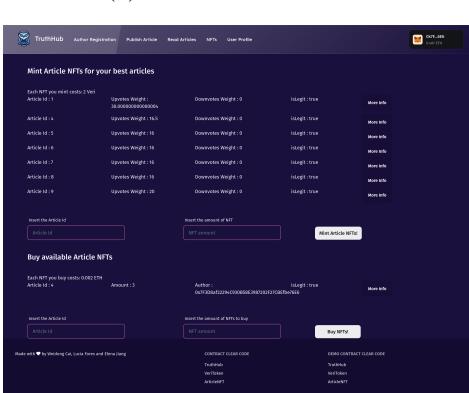
Author: 0x70d04a2209ac081864236120527287e466	Min Weight: 0	Max Weight: 10	Max Red Weight: 10
Author: 0x70d04a2209ac081864236120527287e466	Min Weight: 0	Max Weight: 10	Max Red Weight: 10
Author: 0x70d04a2209ac081864236120527287e466	Min Weight: 0	Max Weight: 10	Max Red Weight: 10
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(c) Article Publication

(d) Read articles



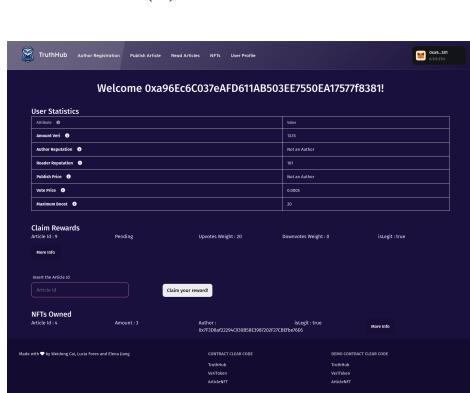
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Article ID: 1	Upvotes Weight: 10	Downvotes Weight: 0	Integral: 1000	More info
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Article ID: 7	Upvotes Weight: 15	Downvotes Weight: 0	Integral: 1000	More info
Article ID: 8	Upvotes Weight: 10	Downvotes Weight: 0	Integral: 1000	More info
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Article ID: 1	Author: 0x70d04a2209ac081864236120527287e466	Integral: 1000	More info
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(e) NFT

(f) User profile

Figure 12: Website Pages

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