When Blockchain meets Online Social Networks

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Abstract

Online Social Networks (OSNs) have become one of the most popular application of the daily life of users in the worldwide. Today the number of Social Media users is about 3 billion, and this trend increases year per year with high impact on the privacy issue. During the last years, decentralization of social services has been considered a big opportunity to overcome the main issues in OSNs. Blockchain technology represents today the most well known decentralized technique, which has been taken into account to develop the new generation of decentralized social platforms. Nevertheless, the real benefit of the introduction of blockchain technology in real social platforms is still unknown.
In this paper we propose an overview of the main Blockchain-based Online Social Media platforms. We describe in detail these platforms by highlighting the main features and services they offer, but also the common drawbacks of these platforms. Finally, we propose a new model of Blockchain-based Online Social Network, which takes into account the role of the user as the center of the system, instead of the role of the content as in current proposals.

Keywords: Blockchain Technology, Blockchain-based Online Social Networks, Blockchain-based Online Social Media, Online Social Networks, Online Social Media, Decentralized Online Social Networks

1. Introduction

People use Online Social Networks (OSNs) to share their personal information, as a daily activity. Today the number of Internet users is more than 4 billion, and the number of social media users is about 3 billion. This trend increases year per year by giving to Social Media and Social Networks a high importance, in particular in respect to the management of the privacy issue. In fact, current popular OSNs are centralized which means they are based on centralized servers storing all the information of the users. The centralized structure has several drawbacks because data can be managed, sell, or stolen without an active control of the owner of the data. The major scandal which involved Facebook, one of the most used Social Network, is the Cambridge Analytica's

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scandal[1]. About 87 million of Facebook users used an application published on Facebook which was able to collect profiles of users and friends. Data were delivered to Cambridge Analytica which analysed them for political goal. This is one of the main example of privacy disclosure, but it is not the only problem. Indeed, another problem of current social platforms is the censorship. Facebook has been banned in some countries, such as in China, Tunisia, Iran, etc.., only to mention a specific case. All presented scenarios represent the main motivation which have lead to a decentralization of the social services. A Distributed Online Social Network (DOSN) [1] is an Online Social Network implemented on a distributed platform, such as a network of trusted servers, P2P systems or an opportunistic network. During the last ten years, several DOSNs have been proposed [2, 3, 4, 5], and these platforms represents the first evolution towards a new generation of Online Social Networks.

However, decentralization techniques has been radically changed during the last few years, in particular when the Blockchain technology has been taken into account in several research fields, as the main revolution to overcome several issues concern the centralization. A blockchain is essentially a public distributed ledger of records that are shared among participating parties, and it can be referred as a chain of blocks. The first major application of the Blockchain technology was Bitcoin [6], which can be considered the motivation of why blockchain are so famous today. The other major application is Ethereum[2], which was launched in 2015 with the novelty of *smart contracts*, pieces of code describing self-executing contracts with the terms of the agreement between buyer and seller.

The lack of success of DOSNs, and the increase of problems concerning OSNs, such as fake news or data disclosure, has been the primary motivation to combine social platforms with the blockchain technology. Several applications have been proposed. The most famous one is Steemit[3], which has today more than 1 million of users. The principal common motivation shared between all these proposals is the need to give value into generated content. Social Networks and Social Medias represent a goldmine of data, which are usually used by the centralized providers to enrich themselves. Instead, these platforms provide a way to give a reward to the content creator.

Nevertheless, the real benefit introduced by the blockchain in a social environment is still unclear, because the behavior of these platforms is unknown due to the lack of a real analysis, and in some cases, like Steemit, the introduction of the rewarding process seems change the real behaviour of a social platform (in example the usage of bots to retrieve more tokens).

In this paper, we propose an overview of the main Blockchain-based Online Social Media platforms by highlighting the common characteristics of them.

[1] https://www.vox.com/policy-and-politics/2018/3/23/17151916/facebook-cambridge-analytica-trump-diagram

[2] https://www.ethereum.org/

[3] https://steemit.com/

We describe in detail why these platforms are Social Media instead of Social Networks by describing the different between Social Networks and Social Media. To better explain how these systems work, we describe in detail each presented platform to show the main features and services proposed. We propose an overview of the main limitation of Blockchain-based Online Social Media and which problems are still open. Finally, we propose a new model of Blockchain-based Online Social Network, which takes into account the role of the user as the center of the system, instead of the role of the content as in current proposals.

The rest of the paper is organized as follow. In Section 2 we propose the state of art of Online Social Networks and Decentralized Online Social Networks, and overview of the blockchain technology. In Section 3 we describe the different between Social Networks and Social Media to clarify why current proposals can not be considered Social Networks. In Section 4 we propose an overview of the current Blockchain-based Online Social Media, their characteristics and the open problems of this research field. In Section 5 we propose a first model for Blockchain-based Online Social Networks which exploits the blockchain technology as a tool to manage the access control problem. Finally, in Section 6 we summarize our work by providing a list of conclusion and future works.

2. Background

In this section we propose an overview of the state of art of current Blockchain-based Online Social Media by introducing the blockchain technology with specific focus on the main characteristics and the main applications. Furthermore, we propose an overview of the main concepts and technology used in current Decentralized Online Social Networks (DOSNs) by introducing the main Online Social Network problems. In detail, we describe the first decentralized solutions proposed to face the privacy problem of centralized Online Social Networks, which represent the background of the Blockchain-based Online Social Networks, as concerns the decentralization.

2.1. Blockchain Technology

A blockchain is essentially a public distributed ledger of records that are shared among participating parties. It can be referred as a chain of blocks where each block is built on top of the previous block. Indeed it contains the cryptographic hash of the previous block, a timestamp, and transaction data. After a block is added to the chain, it is impossible to tamper blocks because the ledger is distributed and can be viewed by all users, which are continually update and kept it synchronized. Indeed, when a new transaction needs to be added to the ledger, the transaction is encrypted and verified by the other users in the network. Thanks to a consensus protocol, if there is a consensus among the majority of users, the transaction is considered valid and added to the ledger. The distributed consensus protocol and the anonymity property can be considered the two important characteristics of the blockchain technology.

The version of Blockchain proposed by [6] combines three distinct technologies: Byzantine fault-tolerant systems, Digital time-stamping, and cryptography

primitives. More in general, several features of Blockchain protocols are listed in [7]:

- Immutable. It means that it is really difficult to tamper or alter a block. Data written to a blockchain can never be changed.
- Distributed. It means that a copy of the ledger is distributed among all the members of the network.
- No Centralized Authority. The structure does not depend on a central server, but it relies to a P2P network.
- Resilient. It shows that it is not prone to theoretic attacks.

Blockchains can be divided into two major categories. It can be either permission-less, allowing anybody to use them, or private and permissioned, where a designated set of authorized validator nodes (i.e., miners) is allowed to participate in the block validation process.

As concerns the applications, Bitcoin [6] is the most popular one. However, in the last years, Ethereum [8, 9] has gained several popularity thanks to the possibility of define smart contracts. Smart contracts are basically programs that can automatically execute the terms of a contract.

Despite cryptocurrencies and financial applications have been the main examples of blockchain applications, other important research fields have tried to use this disruptive technology [10, 11, 12, 13]. One of the main prominent research field is the IoT [14, 15].

2.2. Toward the decentralization of OSNs

Current OSNs are based on centralized platforms, and they suffer of several problems including scalability, dependence on a provider, and privacy, as explained in [1, 16]. In particular, the rise and quick development of OSNs has led to two important phenomena: the user privacy disclosure and the rapid spread of information. OSNs have become the epicentre through which individual privacy is violated. The last scandal concerning users' data is the well known Cambridge Analytica scandal[4] erupted in early March 2018. In detail, the company had acquired and used personal data about Facebook users from an external researcher who had told Facebook he was collecting it for academic purposes. Personal data of millions of Facebook users, in detail 87 million users, were acquired[5] through a Facebook application called "This Is Your Digital Life".

To overcome the main problems of OSNs, and in particular the privacy issue, decentralized solutions have been proposed. Decentralized Online Social Networks (DOSNs) [16] are Online Social Networks implemented by exploiting

[4] https://www.theguardian.com/news/series/cambridge-analytica-files

[5] https://www.nytimes.com/2018/04/04/technology/mark-zuckerberg-testify-congress.html

the decentralization of social services thanks to distributed platforms. By decentralizing OSNs, the concept of a service provider is changed, as there is no single provider but a set of peers that take on and share the tasks needed to run the system. This has several remarkable consequences: in terms of privacy and operation, no central entity that decides or changes the terms of service exists. Moving from a centralized web service to a decentralized system also means that different system models become possible, as delay-tolerant social networks and/or P2P networks, to name some of them.
During the last ten years several DOSNs have been proposed [1]. Most of them rely to a P2P networks, and are focused on the privacy problem. The first big project in this area is Diaspora [17], founded in 2010 by four students. Safebook [4] aims to solve privacy issues focusing on communication anonymisation by using the Matryoshka overlay network, which are particular structures providing end-to-end confidentiality and distributed data storage with privacy. LifeSocial [18, 19] provides a plugin/based architecture in which user data are stored in a Distributed Hash Table (DHT) structure, and are accessible from various plugin-based applications. PeerSoN [5] exploits a two-tier architecture in which a DHT is used as a lookup service to find content stored on users local devices. My3 [3] uses approach where users' data are hosted on a set of self-chosen trusted peers among their friends. DiDuSoNet [2] proposes to exploit relationships and the concept of trust to define a Dunbar-based Social Overlay where specific storage policies are defined. With the introduction of the blockchain technology, also the idea of a DOSN has been re-thinking by introducing this technology in two ways: as the baseline structure or as a support. Finally, a new generation of DOSNs is proposed in [20, 21]. HELIOS represents a people-oriented social platform, which can be adapted to the user behaviour by exploiting the smart environment. The main principles of HELIOS are: human-centric computing, computational trust by exploiting interpersonal trust models, and contextual networking.

3. Blockchain-based Social Networks or Social Media?

A common trend is to think that the terms Social Media and Social Networks are synonyms, instead they are referred to different concepts. The definition of social media is not a formal definition, indeed it is considered a web-based or mobile application that allow the creation and exchange of User Generated Content. A Social Network, on the other hand, is a social structure with people who are joined by a common interest. For sake of readiness, Social media is a place where you send information to other people, usually by sharing content. Indeed, the content is the baseline of a social media. Instead, Social Networks focus on people and their interconnections with the main goal to connect people. They put attention on the human side, instead Social Media on the content side. The common definition of Online Social Network is defined in [22], where it is described as an online platform that provides services for a user to build a public profile and to explicitly declare connections between his/her profile and those of other users. Moreover, an OSN enables a user to share content that are

not only public but also private or restricted to a subset of users. By taking into account this difference, we can say that current Blockchain-based social applications are not Social Networks, but Social Media platforms, and we refer to them as Blockchain-based Online Social Media (OSM). Reddit[6] is the Social Media Platform taken as example to define most of the current Blockchain-based Online Social Media. In Reddit, content is public, accessible to everyone without the concept of relationships and friends. It does not require users to establish connections to use the service.

4. Blockchain-based OSM proposals

Today, the blockchain technology is applied to several research fields, and during the last few years several Blockchain-based Social Media have been proposed [11, 23]. Several of them are still under development, but platforms such as SteemIt, have surpassed more than 1M of users[7]. The main aim of all these platforms is to overcome the problems of current OSNs, in particular Facebook. We identify four common points which represent the main characteristics of these platforms:

- *No Single-Point of Failure.* Current OSMs are centralized and this means that they are vulnerable to attacks, such as data breaches and hacks. Instead, Social Media platforms based on blockchain do not have a single point of failure, thanks to the decentralization of data. Indeed, the decentralize nature eliminates the control by a single entity, and since every transaction is tracked, it becomes impossible to tamper with data.

- *No Censorship.* In countries like China, North Korea and Syria there is an active block of social media websites. This means that citizens can be blocked by the government from accessing social media and certain content. The concept of decentralized content offers a possible solution to overcome the problem of censorship, even if each user can still be found through the location, IP addresses, etc.

- *Rewards for Valuable Content.* A content creator or a simple social media user can be rewarded for valuable content with cryptocurrency payments. Thanks to the blockchain, the rewarding phase is transparent because transactions are tracked and audited by everyone. This represents one of the main points of a blockchain-based OSM because rewarding is considered the success key to give value to content, to build an economy model, etc.. In particular, most of the current platforms take inspiration from the attention economy [24] and the token economy [25].

- *Content Authenticity.* People have been exposed to fake news, and current OSMs do no have specific solutions to face this problem. Instead, the

[6] https://www.reddit.com/
[7] https://btcmanager.com/steemit-announces-over-1-million-users/

usage of the blockchain technology is useful to treat this problem by using economic incentive to both rank and reward content.

All the Blockchain social proposals are based on these four common points. In detail, the Single-Point of Failure problem is faced by exploiting the blockchain technology which is decentralized. Thanks to the blockchain, also the problem of No Censorship is faced. Indeed, The immutability of the blockchain means total freedom from censorship, and people are free to share information. As concerns the other two points, they are strictly correlated to the content. The Content Authenticity is faced by introducing specific rewarding systems, instead to evaluate the value of a content specific mechanisms are proposed, such as the dislike button. In the rest of the section, we propose an overview of the principal Blockchain-based OSM platforms in order to highlight the principal characteristics and how those platforms are facing the main drawbacks of current OSNs. Furthermore, we describe the social characteristics of Blockchain-based Social Media by listing a set of properties obtained from the centralized Social Media. Finally, we highlight the main characteristics about the decentralization of these platforms.

4.1. SteemIt

SteemIt[8] is a social media platform where everyone can receive a reward for creating and curating content, in the form of the Steem cryptocurrency [26]. Today, SteemIt is the most well-known Blockchain-based OSM with more than 1 million of users [23]. A difference between Steemit and other platforms is that there are three different kinds of currency units: Steem, Steem Power (SP), and Steem Dollars (SBD). Steem is the unit that is bought and sold for actual money on the open markets. It represents the principal cryptocurrency of the network and the other two kind of units are dependent on it. Steem Power is a kind of long term investment because people can not sell this unit for 2 years. Who has the Steem Power Units has also the ownership in the network. Indeed, 90% of the new Steem unit generated every day is distributed among who already hold Steem Power Units. Moreover, the more Steem Power Units a user has, the more the user vote will count, as we explained in detail below. Steem Dollars are a stable currency which never looses its value, and people can sell it at any time. The main concept is that the community should be recognized for the value it adds. Indeed, the platform is based on three important principles, as emerged from [27]. The most important key principle is that who contributes with content should receive payment, or debt from the venture. The second principle is that all forms of capital are equally valuable, and the third is that the community creates value which is useful for the members of the community. The platform is based on the Steem blockchain, which is a social blockchain developed to support distributed social media applications. In SteemIt, the

[8]https://steemit.com

usage of the blockchain provides a robust platform without a single point of failure. Indeed, SteemIt is fully distributed. Steem is built upon Graphene[9], which is able to sustain over 1000 transactions per second on a distributed test network. The first consensus protocol used was the Proof-of-Work (PoW), instead today, Steem uses the Delegated Proof of Stake (DPoS)[28], and it does not have miner, but witnesses to produce blocks. Block production is done in rounds, and for each round, 21 witnesses are selected to create and sign blocks of transactions. The 21 witnesses are shuffled every round to prevent one witness from constantly ignoring blocks produced by the same witness placed before [27]. Any witness who misses a block and has not produced in the last 24 hours will be disabled until its block signing key will be updated [27]. A witness who is not able or do not want to produce blocks can set its block signing key to the null public key, and it will no longer be scheduled. As concerns the reward, 10% of the block reward goes to the witnesses and 90% of the block rewards goes to content creators, curators. In Steemit, users play a key role in distributing rewards that depend only on their votes. The protocol that regulates the rewarding process is called Proof of Brain. The rules of the protocol define that the value of a content is based on users votes, and afterwards the total value of the content is distributed among the users who contributed to its creation and curation. Steemit operates on the basis of one-STEEM, one-vote, instead of one-user one-vote, as in other platforms. Within this model, individuals who have contributed the most to the platform have the most influence over how contributions are scored. Content value is determined by the votes it received after 7 days from its creation. There are two types of vote: *upvote*, that increases the content value, and *downvote*, that decrease it in order to manage the fake news issue (a user can express that the content is not good enough). In addition to the number of upvotes and downvotes, the value is also influenced by curators Steem Power and by how many *Voting Power* they decide to give to their vote. *Voting Power* (VP) is a mechanism to limit the number of contents voted by a user in a limited period of time. Each user has his own VP, or *Voting mana*, and, for each vote he gives, a curator can set a weight w, from 0% to 100%, to associate with it. The higher w is, the more influential the vote will be. The total payout for a content is

$$RS \cdot \frac{rb}{rc}$$

where RS is the total rshares accumulated by the votes, rb is the reward balance, and rc is the recent claims and they are global variables.
A peculiarity of the SteemIt community is that users are divided into categories based on their amount of Steem Power:

- *Plancton:* They are the newly registered users on the network, with less than 25 SP.

[9]https://objectcomputing.com/resources/publications/sett/march-2017-graphene-an-open-source-blockchain

- *Minnow:* With an amount of Steem Power between 25 and 500
- *Fish:* They are the users with at least 500 of Steem Power, but less than 5,000. This is an important result for many users, because whoever has at least 500 SP can decide what weight to give to their vote.
- *Dolphin:* This category contains users with a SP amount between 5,000 and 50,000. These users have some influence within the network and their 100% vote is worth at least 0.1$.
- *Orca:* Some of the most influential users of the network, with an amount of Steem Power between 50,000 and 500,000; their votes have a value greater than or equal to 1$.
- *Whale:* They are the most influential users of the network, with more than 500,000 Steem Power. Their vote is worth at least 10$, which is why they often grant it only upon payment.

The inequality of this classification is one of the most important criticisms made of SteemIt.

4.2. Lit

Lit[10] is a platform created to integrate social media services and cryptocurrencies, similar to Instagram and SnapChat. The main feature of Lit is that users can share stories via Lit Stories and their stories permit to obtain Mithril tokens (MITH), taken by considering the impact and influence of these stories across the network. Stories are any content a user can share: photos, slideshows, videos, posts etc [29]. Lit platform is based on the Ethereum Blockchain, and all transactions will be secured and verified via Ethereum smart contracts. The consensus protocol is the PoS The rewards of valuable content is based on the social mining concept. Social mining represents the key concept, and it is based on the idea that users who produce content should be rewarded by taking into account several factors. Indeed, the more network value users bring to the platform, the more MITH they will earn.

The rewarding value, as visible in Figure 1, has a combination of various parameters: views, likes and watches, selected to evaluate the popularity of a content and to compute *ore*. *ore* is defined as raw mined number of some sort of scores that can be exchanged for real tokens. Special weight functions are added to the function that defines *ore* to give a different importance to the three parameters. In the example showed in the Figure 1 and taken from the whitepaper, there are three users: David, Bob, and Carol. They are new users to Mithril and have 0 MITH each. During the daily activity and in the span of one week, David contributes 4 stories and receives 400 views and 0 hearts, Bob contributes 5 stories and receives 200 views with 80 hearts, and Carol contributes

[10] https://mith.io/en-US/

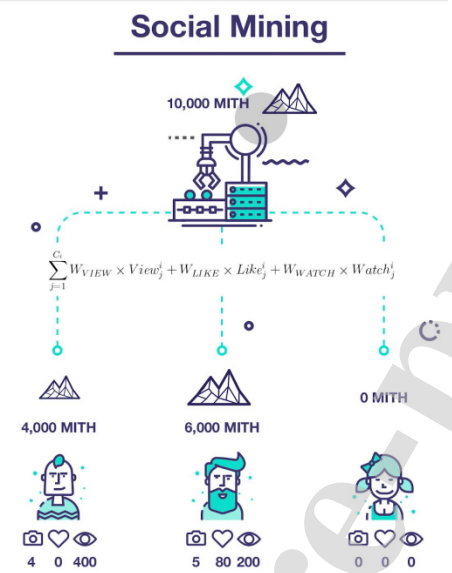

Figure 1: Social Mining

nothing to the network. Using the social mining algorithm, and by fixing the per view weight at 1 and the per heart weight at 5, David will have mined 400, Bob at 600, while Carol has mined 0. Through a specific computation, the total Mithril Reward for one week was automatically determined to be 10000 MITH: 4000 MITH to David, 6000 MITH to Bob, while Carol will receive nothing.
Beside the *ore* score, there is the *Purity* score that distinguishes the share of creator's contribution from all other contributions within a defined period, the number of all tokens distributed among content creators during a period of time, and finally the number of tokens, received by the content creator. The Social Mining mechanism is not transparent, and can be changed at any time. Moreover, the system does not include any mechanics to defend from Sybil attacks, so we can not be sure that there is an honest distribution between the content producers who create valuable content. At the best of our knowledge, no explicit mechanism for content authenticity are proposed. This means that the only way to evaluate a content is the like button, and that negative impression about a specific content can not be expressed. MITH tokens are stored in the Mithril Vault and they can be used to pay for services, or they can be exchanged for Bitcoins (BTC) and Ethereum tokens (ETH). As concern the content storage, it is not clear which technology is used, but it is clear that content is stored outside the blockchain. Probably, the platform uses a distributed file system, like IPFS [30].

4.3. HyperSpace

HyperSpace, previously Synereo, is defined as a blockchain-based OSM based on the *Attention Economy* to reward valuable content. HyperSpace offers community-owned spaces where registered users can create and share content which has a value inside the community. Indeed, users are rewarded and recognized for their activity. The attention economy is a subset of the information economy which concerns in the definition of a marketplace where consumers agree to receives services in exchange for their attention [24]. In [31] the logic behind the attention is connected to both the quality and quantity of information. The problem of attention affects Social Media in general, and in particular blogs [32]. HyperSpace is at the forefront of integrating Universal Basic Income (UBI) into the attention economy space. UBI is a mechanism for distributing financial power among people equally, allowing them a minimal participation in the economy. The cryptocurrency used inside the system is *AMP*. The latest version of the system is based on WildSpark, which works as a distributed meta layer. Wildspark is a new innovative decentralised platform which allows to easily reward people who share content. It allows content creators to monetize their existing works without relying on centralized platforms [33]. HyperSpace does not provide detailed information about the rewarding system. When a user discovers a good online content, the Attention Economy Layer enables he/she to invest a certain amount of AMPs and share it with other users in the platform. "Amplifying" is an action available to each user that means voting a content, as the classic like button. Amplifying a piece of content on Wildspark means that a user is able to share a link concerning the published content with others. Friends and followers, who receive and click on the link, will be directed to this content embedded in WildSpark. Thanks to the amplification process, one third of the amplification goes to the creator of the content, another third to the curator who shared it, and the remaining AMPs go to a common pool called *Fractal Reserve* [34]. Thanks to the Amplifying action, users can be rewarded for their content. In detail, the model provides: the 60% allocated to the creator, the 20% allocated to post engagement participants split between the top ten contributors, the 18% allocated for Space Managers and the Space Admin, and finally the 2% is allocated to help that the HyperSpace economy and the number of AMPs circulating stay proportional to the amount of activity taking place. Additionally, people can share content from HyperSpace to other social networks, and creators are rewarded when a friend, of another social network, clicks on the link and amplifies the post. The creator gets 85% and the friend obtains the 15%. For sake of readiness, the amplyfying action is the only way to guarantee the authenticity of the content. Top contributing users are obtained by exploiting the User Power. The User Power score is updated every time an engagement event occurs involving the user. To avoid that the same users remain dominant due to their past activity, the User Power decays over time.
The system is a little contradictory as concerns the no censorship problem even if the blockchain helps to face that problem, because the system provides the possibility to create a personal space, and the moderator of the space can approve post manually.

At the best of our knowledge, data are stored in a decentralized cloud, in detail IPFS. A new post is uploaded to HyperSpace's centralized server as well as to HyperSpace's IPFS node. The post is disseminated to other IPFS nodes and becomes retrievable from the cloud. The main issue of the system is that the system is not completely distributed due to the centralized server, needed for quickly response. This means that it could be a potential single point of failure, even if the decentralization of data permits to easily restore the system.

As concerns the blockchain, HyperSpace have changed few technologies. At the beginning, it used the *RChain* blockchain. Afterwards, the platform has been renamed, from Synereo to HyperSpace, and launched, in Beta, at the beginning of 2019. It is based on Omni layer[11], which is a software layer built on top of the Bitcoin blockchain. Omni transactions are Bitcoin transactions.

4.4. Sapien

Sapien is a social news platform with the principal aim of fighting fake news by giving users more control over their data. Instead of using Twitter, YouTube, Facebook, etc. for different forms of news and media, users can use Sapien for everything. Users are able to determine which personal information they share and with whom. Moreover user have the power to control the information they receive by tailoring received news with their interest. One of the fundamental principles of the platform, in terms of fake news and valuable content, is to organize the first Democratized Autonomous Platform. This means that users are able to vote on proposals within a virtual community, facilitating democratic decisions at the community level. The Sapien platform is flexible and allow users to have a public or private identity. This means users can operate with their real identities or in anonymity whenever they want. Indeed, Sapien enables storage of identities on the Blockchain for the purpose of identification. Sapien uses the Ethereum blockchain and introduces a new cryptocurrency, the SPN token. In order to be rewarded for contributions, a user must have staked SPN. Unstaked SPN can be staked by locking it into a separate smart contract for a fixed duration of one year [35]. Upon completion of the staking contract the SPN will be returned to its unstaked form. A peculiarity of Sapien is the Content Authenticity. Indeed, to protect the works of the content creators on the platform, users found guilty of leaking premium content, will have 100% of their tokens frozen, the account banned, and IP address permanently blacklisted. The rewarding system is based on the Proof-of-Value. The Proof-of-Value protocol is the main approach to distinguish and reward valuable content by preventing the proliferation of fake news. Contributions of users are evaluated and users accumulate a score that reflects the reputation they have. Reputation is represented by a reputation score that is stored in the SPN token, and it is initially set to one. The value of the reputation score can increase or decrease depending on the value the user adds to the platform. In order to provide a more accurate representation of the value of a contribution, user votes are weighted by taking

[11] https://www.omnilayer.org/

into account the user's perceived value within a community. The reputation system implements the Proof-of-Value protocol by using the Backfeed Protocol[12]. Rewards are distributed by a voting process, called Charges. Charges are votes assigned to users based on their Sapien Staking Tier. The more Charges a post receives, the more SPN Rewards that post will receive. Charges are also the sole deciding factor on how a content is valuable or not. Indeed, when a user gives a post a Charge this means that specific post is adding value to a community and it deserves to be rewarded. Another important feature is the introduction of a marketplace. Indeed, users are able to purchase and sell physical and virtual goods, services and content on the marketplace using SPN tokens. Reputation scores are integrated into the marketplace, enabling users to be confident that the vendor they are purchasing from is reliable [35].

4.5. SocialX

SocialX, as all the previous platforms, is decentralized and allows users to give feedbacks to content and reward tokens. SocialX is fully decentralized as described in [36], which means that all media (photos and videos) and data (messages, posts, etc.) are stored in a decentralized manner. The principal goal of the platform is to face the problem of fake accounts, fake followers, and fake votes (likes, etc.). Indeed, the decision power is given to communities, which can decide what content is valuable. The community is the main concept which can decide which content can be rewarded because the platform has the property of self-governance.

Figure 2 shows the decentralized infrastructure of SocialX, which uses database peers to store data. Database peers save the social data (user data, post data, and comments) and distribute it to the users. Media data, e.g. photos and videos, are stored in the IPFS. In detail, when a user uploads a content, SocialX reads it as a raw file, and creates a replica to optimize the performances of the platform (Figure 3). Then, the application uses IPFS to decentralize and store the two files, in particular Infura[13], which is a hosted Ethereum node cluster that lets users run the SocialX application without requiring them to set up their own Ethereum node or wallet. Blockchain nodes are used to save transactional operations and to operate smart contracts. Finally, the application uses peers and super peers nodes in the architecture in order to have enough computational power and storage, allowing SocialX to run as efficiently and safe as possible. In terms of privacy, SocialX uses zero knowledge proof technology to achieve bi-directional encryption, and to allow one party to verify what the other party is saying without actually trusting that party.

The token used inside the system is SOCX, which is a unique token that can be used in various ways: to interact with your friends on SocialX, or to make purchases. The evaluation of a valuable content and the content authenticity are strictly correlated, and they evaluated by taking into account the community.

[12] https://backfeed.cc/
[13] https://infura.io/

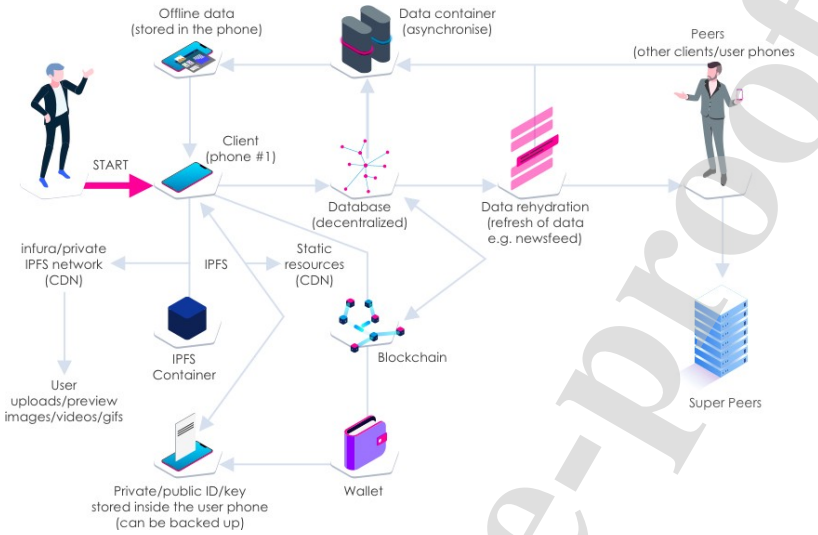

Figure 2: The decentralized process in SocialX

Indeed, SocialX provides to the user the choice of a normal like, Superlikes and Dislikes. Whenever a user is rewarded through the upvote system, the transaction is recorded on the Ethereum blockchain. No all actions can be rewarded, for example registration and dislikes are not rewarded, because SocialX defines Dislike and Superlike as special actions which can be given to users in a limited amount. For this reason, users can like as many photos and videos they want, but they have only a limited amount of Superlikes and Dislikes. The number of Superlikes and Dislikes can increase based on the amount of followers an individual user has, as well as, based on how a user is connected in the SocialX community. The Dislike function is helpful to identify spamming, low-quality content, license abuses or inappropriate content, fake news, etc. Unfortunately, the details about how the rewarding system is implemented are still unknown. Censorship is not allowed thanks to the decentralization of data, as for the other platforms. The judge of the content is the community which can forbid content that does not respect the community guidelines by using tools and algorithms to easily access content and flag it as inappropriate.

4.6. FORESTING

FORESTING[14] is a new Blockchain-based Social Media consisting of the social media "FORESTING", the digital banking services for participants, "FORESTING Bank" and the "FORESTING Lab" to support the community and content

[14]https://foresting.io/

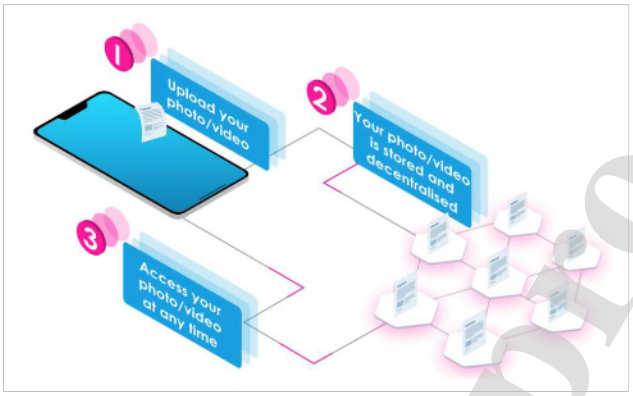

Figure 3: SocialX: Network Infrastructure

creators [37]. The system, as all the other platforms presented before, is principally focused to reward valuable content and to guarantee content authenticity. FORESTING relies on blockchain to deliver and reward valuable content by using a distributed consensus protocol. In FORESTING, users can benefit economically just by getting 'Likes', called PICK, through the blockchain. PICK counts should be used wisely as each user is given 24 PICKs a day. By clicking PICK, a user can increase the value of his/her favorite contents. Charging time is 1 PICK per hour. Users can also tap "Shooting" to donate to their favorite contents and content providers. This feature is one of the way to directly support other users and can be sent with a message.

The rewarding system of the platform is based on how active users are. Content creators receive Berry rewards based on how many PICKs (votes) they collect. The system uses the FORESTING Interaction (FI) index to evaluate the entirety of each user's activeness and the reactions they receive for their contents. The user's level increases based on the FI index, and Berrys are rewarded according to the level the users reaches. In short, the higher the level a user reaches, the greater the benefits the user receives. FORESTING Network is based on the PTON Token. Users do not receive PTON for their social activity. Indeed, they collect Berrys which is a point obtained in Foresting by PICKing others' contents, being PICKed by others, and receiving Shooting. Berrys can be exchanged for PTON. The rewarding system provide the 50% of the value to the creator of a content, the 25% to the curators, and the last 26% to all the partecipants.

The purpose of FORESTING Bank is to support financial services required by users. Indeed, users can contribute to the platform through a variety of activities, and the contribution is computed by using a new contribution assessment model presented by FORESTING Bank.

The FORESTING Lab is an offline collaborative space for users which is accessible to any participant of the FORESTING Network. This space provides a place for users to create good quality content to provide support for content

creation.

The initial FORESTING system is built on the Ethereum blockchain, and all the activities are recorded on the it. If a malicious user posts too much, or goes beyond the limits of the activity that the blockchain can serve, the service may become paralyzed. For this reason, the number of posts that an individual can produce is limited.

One of the main goal of FORESTING is improving the performance of the PoS consensus algorithm by minimizing the discarded blocks that appear while creating blocks via stake. It also boosts the synchronization speed and throughput rate among nodes by minimizing the generated blocks by delayed nodes.

The other main strong points of FORESTING are:

- Real-time Trade Function through Embedded Exchange. Provide real-time trading function by embedding major exchanges around the world;
- Master Node-based P2P Transaction. Minimum of 10 coin openings per user. There is an RPC module provided for each coin access. It provides basic operations and master nodes for node operation. These master nodes, or wallets, can be connected to FORESTING by payment channels, state channels, etc.;
- Coin Shooting. In addition to the 'PICK' button, users can also donate Berrys by the Shooting action;
- Open Market Advertising. Advertisers and advertising agencies can upload their advertisements and advertising proposals to the advertising pool category. Content creators can select the advertisements they want and post it on their content pages for rewards.

4.7. Minds

Minds is a free, encrypted, and reward-based social networking platform based on Ethereum, and launched in 2015. Minds has been developed as a blockchain application with the intent to face the censorship problem. Indeed, content are free, without the risk to be censored or subverted. As for the other Blockchain Social Media, the blockchain technology guarantees the decentralization by excluding the single point of failure, and the immutability property helps to face the censorship. Today, Minds has over 1.5 million registered users. For what concerns the other two important points, listed at the beginning of Section 4, Minds rewards users for their activities on the site. In particular, the current rewarding system has been proposed in 2018, and the tokens, called Points, are built upon the Ethereum ERC-20 standard. Each action on the site is worth a different number of points. These points are then added up to the daily contribution total and the total amount of tokens are given by the following Equation:

$$UserTokens = (\frac{User\_Contribution\_Score}{Totale\_Network\_Score}) * Daily\_Reward\_Pool \quad (1)$$

If the contribution of a user consists of a considerable amount of actions on a slow day, the user get more tokens than he/she would by contributing the same amount on a busy day. Points can be exchanged for additional exposure on your content, to have a guaranteed number of views (1point = 1 view). Specifically, the daily accumulated points are converted as followings:

- 1 point for 1 upvote
- 2 points for 1 comment on your posts
- 4 points for a subscriber or shared
- 10 points for an invitation using a referral code (new user)
- 2 points for every time you check-in

Furthermore, users may 'wire' points to other users/channels as a tip, or to pay for a premium subscription, to exclusive content and unlock rewards. Minds Wire is the P2P payment system that enables users to exchange their Points and USD for exclusive content, premium content, and rewards.
A characteristic of Minds is that users can choose between OnChain and OffChain transactions to mitigate the latency and cost for on-chain payments and transactions. OnChain transactions benefit from being published and secured on the public blockchain, while OffChain transactions benefit from speed and no transaction fees. OffChain tokens are stored on the Minds servers and can be used just as Points are used. OnChain tokens, in contrast, are stored on the Ethereum public blockchain, and are accessible outside of Minds.

4.8. Social properties of BOSM

The proposal platforms are defined as Social Media platforms because, as just explained in Section 3, there is a big difference between Social Media and Social Networks. For sake of readiness, Social Networks can be considered as a specific type of Social Media. Indeed, Social Media can be classified into 13 different types, as described in [38], and the Social Network is a type.
Social Media platforms have several social properties strictly related to the provided social services [39, 40]. We identify a set of social characteristics, which can be identified in current BOSM, in order to better characterized the social value present in BOSM. Table 1 reports the identified social characteristics. In detail, we analyse the content visibility, which is really important in terms of privacy. Indeed, current OSNs give the possibility to decide the type of visibility a content has: public, which means that the content is visible for every user of the platform; protected, which means that the visibility can be restricted to a subset of friends explicitly selected by the content owner; finally private means that the content are accessible only by the owner. Furthermore, we analyse the Social Media communication model ("Comm. model" field): symmetric, as in Facebook, where a relationship between two users is established when the two users accept to be friend; asymmetric, as Twitter, where users can follow other users without them following back. Then, we evaluate the integration

with current OSNs ("OSMs Links" field) to share content outside the BOSM. We evaluate the type of Social Media by taking into account the 13 different types presented in [38]. We analyse if the proposed platforms provide mobile application ("Mobile App." field). This is an important feature by considering that more than 3.4 billion people in the world's social media users, access social platforms via mobile devices[15]. Finally, we highlight which OSNs are taken as model to develop the BOSN in order to understand the social activity of the platform ("Inspirational OSM" field). Instead, the others are classified as Discussion forum because the provided social services are similar to Reddit, Medium, etc.

Table 1: Social Characteristics of Blockchain-OSMs

Platform	Characteristics					
	Content Visibility	Comm. model	OSMs Links	SM Type	Mobile App.	Ispirational OSM
Steemit	Public	Asymmetric	No	Discussion forum	No	Reddit
SocialX	Not Specified	Asymmetric	No	Media sharing	Yes	Instagram
HyperSpace	Public	Asymmetric	Yes	Discussion forum	No	Reddit
Lit	Public	Asymmetric	No	Media sharing	Yes	Instagram
Sapien	Private/Protected	Asymmetric	Yes	Discussion forum	No	Reddit
FORESTING	Public	Asymmetric	Yes	Media sharing	Yes	Instagram
Minds	Public	Asymmetric	No	Community blogs	Yes	Reddit, Medium

A common trend of BOSNs, as highlighted in Table 1 is the adoption of the asymmetric communication model, which is useful and fast to start relationships in those new environments. Furthermore, content are public for the majority of BOSM, without a choice about the level of visibility. Only Sapien provides the choices protect the content by sharing it only with followers, or store content in a private way. Finally, as just expressed, Reddit is the first Social Media model, but during the last year, all the platforms have considered to extend the sharing options to multimedia content. In particular, SocialX, Lit, and FORESTING are classified as multimedia sharing networks because they are similar to Instagram, which means that they are completely focused on multimedia content.

4.9. Summary and open problems

Blockchain-based OSMs are different from most of the other blockchain applications, such as BitHealth as health-records storage, BitCongress as voting system, or BitCoin and Ethereum, because users do not need to sacrifice money or hardware to earn a significant profit. The main aim is to provide meaningful and interesting contents rewarding with tokens by taking into account the social impact of content in the network. The analyisis of the platforms provided in Section 4 has highlighted two important technical considerations concerning the usage of the blockchain and the level of decentralization. In details, there are different levels of decentralization and different types of usage of the blockchain,

[15]https://wearesocial.com/blog/2019/04/the-state-of-digital-in-april-2019-all-the-numbers-you-need-to-know

which we evaluate in Table 2. For sake of readiness, with the term "Integration" we refer to how the platform is integrated with a blockchain. Indeed, most platforms are only partially integrated, other platforms are not using the blockchain at all, and another set of platforms entirely runs on the blockchain. Furthermore, with the term "Decentralization" we refer to the fact that many platforms need to start off much more centralized, and the decentralization is fully or partially integrated. The evaluation provided in Table 2 considers two different states for both Blockchain Integration and Decentralization level: Partially or Fully. As we can see, Steemit and FORESTING are the only analysed platforms which exploit a fully distributed architecture and they are fully integrated with the Steem Blockchain. The other platforms are classified as Partially, because in some cases, they store data offchain and only during a second step, data are stored in the blockchain. HyperSpace is the worst one due to the possibility to approve every post manually given to the moderators, which drastically reduce the level of decentralization.
Furthermore, as concerns the problem of fake news and the quality of content, only a subset of the proposed platforms provide a way to express a negative opinion. SteemIt, SocialX, Sapien, FORESTING, and Minds provide the downvote action. In particular, SteemIt provides a weighted downvote, where the weight can be decided by taking into account the user's category (whales, dolphins, etc.). For all the other platforms, the only way to express a negative opinion on a content is the not voting. This means that a negative opinion is equal to a neutral opinion.

Table 2: Overview of current Blockchain-OSMs characteristics

Platform	Characteristics					Decentralization details	
	Year	Consensus	Blockchain	Storage	Fake News	Integration	Decentralization
Steemit	2016	Delegate PoS	Steem	Blockchain + IPFS	Downvote	Fully	Fully
SocialX	2017	PoS	Ethereum	IPFS + Zero Knowledge DB	Downvote	Partially	Partially
HyperSpace	2018	PoS	Ethereum	Distributed File System	No Action	Partially	Partially (Low)
Lit	2018	PoS	Ethereum	External Storage	No Action	Partially	Partially
Sapien	2016	Proof Of Value	Ethereum	External Storage	Downvote	Partially	Partially
FORESTING	2019	PoS + PBFT	Ethereum	IPFS	Downvote	Fully	Fully
Minds	2015	PoW	Ethereum	IPFS	Dislike	Partially	Partially

To summarize the main goal of this analysis, there are a plethora of new blockchain-based OSM platforms which really re-thinking the way a content can be shared and who should be the main beneficiary. To focus our attention on current proposals, and in particular on the characteristics listed in Table 2, we highlight a list of problems:

- Identity checking. The blockchain is an open database and anyone can register more than one account, but also bots programmed to have specific malicious behaviour. Few blockchain-based OSMs are facing this problem seriously. Steemit's solution at the beginning, to avoid Sybil attacks, was to have people who have staked a lot of tokens to get more rewards and dictate the hot/trending feed. But that completely destroy the ability of the system to find the best content as Reddit does(aka the Wisdom of

the Crowd). So the solution to solve abuse while providing high-quality content to the end users as yet to be found and implemented.

- Scalability. In OSNs, the frequency of the user activity is very high. For example, Facebook has about 52000 likes per second, without include posts, comments, replies, or shares. Blockchain social platforms should take into account this high content creation by facing the problem of finding a scalable blockchain technology.

- Decentralization of content. The problem of using a blockchain as storage is that the content could be to large in terms of size to be stored on it. For this reason, several current proposals rely on distributed storages, like IPFS. This is similar to the previous approaches proposed in DOSNs [1], in which Distributed Hash Table are used to store or to index content. This does not resolve the problem of control over data, because also in this way users need to trust in users who store data.

- Content Visibility. As described in Table 2, the visibility of content is public in each current proposals described in Section 4. This is good for the monetarization of content, but it is completely in contrast with the socialization of users which should provide public communications, but also private ones.

- Blockchain technology. Another problem is the choice of the blockchain technology. Current proposals use Ethereum, but they show the drawback of this choice. Indeed, they are still investigating a specific solution. There is the need to find the best blockchain technology and the best consensus algorithm, which takes into account the need of social network users, which spend several minute per day on these platforms, but the session length is short [41, 42].

- No censhorship. The problem of using the blockchain is that a concrete control of data is necessary to verify the legality of content. This does not mean that there is the need of a centralized control, because the users partecipation can help to retrieve illegal content. However, when a content is published, it is stored into the blockchain, and by considering the immutability property, it can not be deleted. The user can be banned, but the content is still available. This a big problem concerning the no censhorship adopted in those systems. For sake of readiness, Steemit is the most popular front-end interface to the Steem blockchain. SteemIt would have banned a controversial user, censoring his content, which, however, is still available on Steem's blockchain.

These open issues represent real problems which do not provide a clear motivation to the need of blockchain as storage or as support to provide a public view of the content. Furthermore, these platforms are not completely decentralized which means that one of the four common points is not completely faced. This means that the problem of the single point of failure can not be excluded.

Steemit is the only platform which relies to the Steem blockchain in a fully decentralized way. The main different between all the platforms concerns the rewarding system used to reward users. The analysis of the details of which rewarding system is the best one is out of the scope of this paper, however we can say that the introduction of cryptovalues changes the main goal of these platforms which are principally based on the rewarding without an attention to the quality of content, as instead BOSNs want to do.

5. A Blockchain-based Decentralized Online Social Networks

Users need a platform to connect with other users, where share content, but in particular where define relationships, communities, etc.. As described in Section 2.2, DOSNs have been proposed in order to model Online Social Networks by facing the problem of privacy disclosure. There is the need to understand if and how a blockchain can be helpful in this field. Current BOSMs use the blockchain to store public data, to run smart contract, and in particular to reward users. Indeed, the rewarding of users is considered the main motivation to have valuable content without fake news. The evaluation of the content is produced by all the users in the BOSMs, which are moved from the point of view of retrieving gain. Blockchain as storage for social data, and the choice to have public data seems to change the perception of Social Media, where the reward affects the quality of the content in a wrong way. At the best of our knowledge, a possible Blockchain-based Online Social Network is far from what current blockchain-based OSMs are and propose, even if blockchain can be really face the problem of privacy in OSNs, as also treated in [43]. Consider what an Online Social Network is, a possible Blockchain-based Online Social Network should fix the attention around the user, as addressed by the current BOSMs, but without a blockchain as platform, or by using external storages. For this reason, and thinking to current blockchain limitations, we propose a possible model which is thinking an alternative approach of current Blockchain-based Online Social Network, and where the blockchain is used as a tool to manage privacy problems. In detail, users should be able to decide the visibility of their content, as in a common Online Social Network, where users have the possibility to restrict the visibility of a content. For this reason, our model guarantees this property by checking the access to the content.

As shown in Figure 4, a possible model could use as underline networks, a DOSN. The problem of the visibility of content can be faced by exploiting one of the three classifications proposed in [1]. The choice of this infrastructure guarantees a fully distributed solution thanks to the P2P technology exploited in DOSN. For sake of readiness, data can be stored in a distributed way by relying on nodes in the network (a DHT-based DOSN). To store social data, encryption is required. Furthermore, an SO-based DOSN can be a good solution when the system requires a certain level of trust between nodes and their storage nodes [44]. Finally, an External resource-based DOSNs is a solution where data are stored in off-blockchain storages, like a DHT [45] or cloud storage, or IPFS as used by the current BOSNs. This solution is in part adopted current BOSNs,

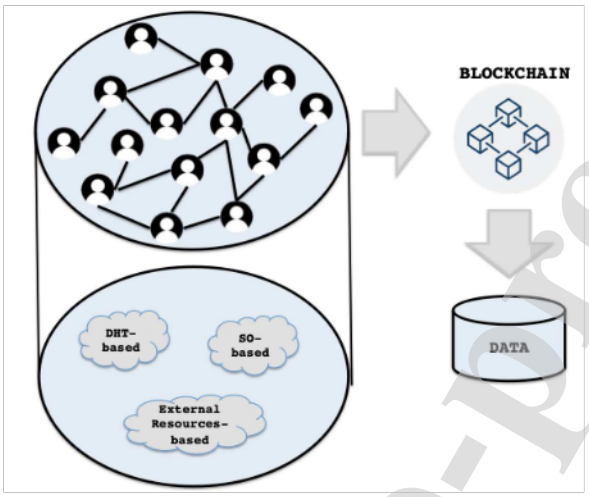

Figure 4: A possible model to design a new Blockchain-based Distributed Online Social Network where the blockchain is used as content access control.

even if they do not use a fully distributed environment and the privacy problem is still open. A personal storage is considered a good solution as concerns the usage of external storage.

In a distributed social environment, the blockchain technology is prominent to manage the content access control. In literature there are several proposals which rely on blockchain for the access control in various scenarios, such as for the IoT [46]. We identify two possible proposals which can be easily integrated in the model proposed before: the first one based on encryption and the second one based on privacy policies.

The first possible approach is shown in [47], where the blockchain is used to manage the personal data protection. Data is encrypted using a shared encryption key and sent to the blockchain, which subsequently sent the data to the external storage, an off-blockchain key-value store implemented by Kademlia [48], by retaining only a pointer to the data on the public ledger. The second one is presented in [49], where the blockchain technology is used to to store the representation of the right to access a resource. Both approaches can be easily introduced as a tool in all the possible DOSNs structure: DHT-based, SO-based, and External Resources-based. Another open point is the rewarding system. In this simple approach we do not provide any detail about a possible rewarding system, because it is out of the scope of the article due to the need to study in detailed all the current solution, and to evaluate which new solution can can be used. However, as highlighted in the article, a rewarding system based on cryptocurrencies seems to change the way of how users interact with social media. Indeed, an approach based on reputation could be a good solution.

6. Conclusions

Blockchain technology is considered one of the main disruptive technology of the millennium. Several research fields have tried to use it by exploiting its intrinsic characteristics. In this paper, we propose a survey of Blockchain-based Online Social Media, by explaining the main characteristics both technical and social, and we described the current platforms. We listed several current problems of these platforms and we proposed a possible new model which faces the problems listed above concerning the usage of the blockchain. In particular, the content visibility and the privacy issue. We described how the proposed model represents an extension of the Decentralized Online Social Networks and how the Blockchain, as a tool to manage the access control. We are analysing the proposed model, in another work, in order to evaluate the impact of privacy policies on Social Media. We plan to evaluate various privacy policies approaches, and we plan to investigate more in detail current BOSNs, such as Steemit, by retrieving data from the blockchain in order to evaluate how the social activities of BOSM's users is far from the current OSN one.

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