Ethereum-based Quadratic Funding Of Public Commodities

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Abstract—Crowdfunding is a process of generating funds by receiving small chunks of money from public by showcasing the project any creator desires to execute. Donation based crowdfunding is a popular fundraising technique where contributions made by the public are labeled as donations without any rewards in return. Match funding is an extension of the crowdfunding mechanism but with the involvement of a rich individual/organization willing to match 'x' amount from the donations made by the general public. But, the problem of fundraising for project through such means is that there is an inconsistent & non-transparent exchange of information about a project at regular intervals among creator and its contributors. The current system also lacks in focusing towards the desired area of interest of the contributors. Therefore, it's needed to improvise this flaw of the current crowdfunding scenario. This paper proposes a system which aims to give more importance to contributor & his/her contribution by using their donation amounts to identify the match amount for a project & it also involves contributors in the decision-making process for projects thereby creating a decentralized governance. The proposed system incorporates the benefits of crowdfunding & match funding along with the utilization of a concept called Quadratic Funding for calculating project's final disbursement amount. The given system focuses only on the donation-based mechanism for funding public goods i.e., the goods which are vastly beneficial to the general public and are non-rivalrous and non-excludable in nature. The system is implemented using the blockchain technology.

Keywords—Blockchain, Crowdfunding, Public Goods, Quadratic Funding, Weighted Averaging, Ethereum

1. Introduction

1.1. Crowdfunding

The method or procedure using which an individual founder or an organization raises capital for his/her projects which may be spread across several domains is known as crowdfunding. The motive behind crowdfunding may be towards social welfare, gaining profit, client engagement, exemplifying the demand of the product which was put up for crowdfunding etc.

The scale at which a crowdfunding campaign may exist could range from a small project to entrepreneurs looking out for people to fund their newly-desired ventures. There are several types of crowdfunding like equity-based crowdfunding, reward-based crowdfunding and donation-based crowdfunding [1]:

- In equity-based crowdfunding, the investors or the people who contribute receive monetary payback in exchange for their contribution over a period of time.

- In reward-based crowdfunding, a reward is re-

ceived in return by the contributing entity which could be in the form of a service or a product.

- In donation-based crowdfunding, donations are done by the people with absolutely no expectations of achieving any return.

An example of an application which implements the practice of crowdfunding is Kickstarter. Over here on this platform, the project creators post their projects along with its specifications, updates and the potential risks associated with it. The contributors can then contribute to the projects of their choice at a large scale. Initially, the project creators set a monetary goal along with a deadline associated with it. The contributors pledge money towards the projects and if the goal is NOT met by the deadline, then the contributor would not receive any money for his/her project.

1.2. Match Funding

The activity which basically extends the crowdfunding activity where the matching of the already generated crowdfunded amount is done is known as match-funding. The motive behind implementing match-funding is to uplift the already generated donation amount because the more the number of parties/organizations involved, the better the split up of the amount to be generated. Also, the inclusiveness of more and more organizations ensures better collaboration thereby leading to higher chances of the developing project to succeed [2]. Match-funding also plays a key role in accumulating more funds due to the fact that more people tend to contribute to several projects in case they get to know that those projects are going to be match funded with the reason being that match funding entities are themselves renowned and trustworthy.

A notable example of Crowdfunding and Match Funding being implemented together would be in the year 2018 where the amount of money was being raised for victims of Hurricane Florence in the United States of America. For every dollar that was being donated (i.e., contributed as a crowdfund amount) upon any platform, companies like Walmart, Google pledged to match the amount to twice its value.

1.3. Issues within the Conventional Fundraising Applications

The conventional crowdfunding applications do offer a large-scale exposure for the enrolled projects to fulfill their monetary goals, but eventually lack in providing a stable base with suitable security and trust for such exchange.

- Compelling usage of resources such as money, time is needed for the apt exposure of the project which is to be put up on the crowdfunding platform lest the noticeability of the project would take a hit.
- Other problems such as provision of donated amount in a single chunk, leviation of extra charges for hosting of projects by the crowdfunding campaigns [3] and the slow process of transferring the donation amount to the project creators [4] add to the existing woes.
- Another important issue to be addressed is the refund scenario because in case the project does not fulfill its specified target, then there exists no way to obtain a refund of the contributed amount for the contributor on the existing crowdfunding platforms.
- The concept of match funding also looks promising, but it emphasizes more on the money a crowdfunded project receives rather than focusing on unique contributors for every project to determine the match amount a project would receive and thus it alone cannot act as a

viable parameter in the judgment of a project's way of audience targeting.

- There may even be cases where the match-funding entity may participate as 'all-or-nothing' just because he/she has to even support other projects due to which the current project may not receive any amount via match-funding in case it fails to impress the match-funding entity.

So, there exists a need of having a platform capable of not only fulfilling absolute fundraising requirements of numerous listed projects but also with the consideration of how many unique backers(contributors) does every project have. There also exists a need of having a security mechanism to safeguard the donations made by the contributors in case a project fails in delivering its commitment. The proposed solution aims to play down all the essential security and trust concerns by bringing all the involved participants (i.e contributors, project creators etc) together in a peer to peer (P2P) network. It also stresses on avoiding either overvaluation or undervaluation of every project. Only the open source softwares (an example of public good) are currently being considered for fundraising. Our system creates a virtual network accessible to everyone for making information and monetary transactions completely transparent thereby planting the seed of trust between the participants. The proposed system focuses on incorporating the benefits of both crowdfunding and match funding along with some additional modifications. Blockchain technology is used as the backbone of our system as it helps in creating a decentralized network with capability of immutable transacted data which is stored in a distributed fashion [5].

1.4. Blockchain

The public ledger which keeps hold of all the transactions that have been executed amongst the parties participating in a decentralized network is known as blockchain. It is a peer-to-peer distributed network consisting of participants who communicate with each other. The public blockchain network is the one accessible to everyone from all around the globe. This encourages a democratic decision-making in lieu of centralized one.

The blockchain consists of chain of blocks inter-linked to one another in a sequence. Each block contains a collection of transactions initiated by the participating nodes within the network. The transaction may include exchange of not only money but also information (in certain public networks like Ethereum) between one or many nodes. Each transaction describes its source address, destination address, value, data, timestamp etc. Before appending a block to the network, each transaction within the new block is verified by the special nodes within the network called as miners.

After successful validation, the block is appended at the end of the chain and linked to the previous head of the chain as shown in Figure 1. The information is immutable once it has been entered in the public ledger because the chain of blocks is distributed in nature i.e a copy of chain of blocks is available to all the nodes. [6]

1.5. Quadratic Funding

Quadratic Funding is the optimal technique of funding of public goods in a democratic community where the decision with respect to the amount being donated towards the good depends upon the number of contributors interested in the good.
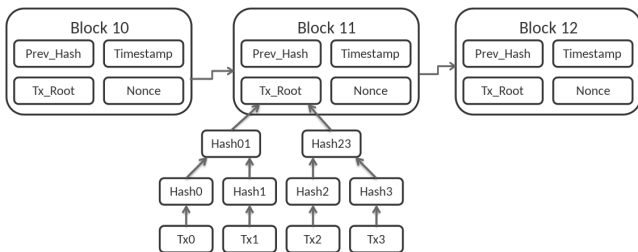
Figure 1. Depiction of what each block consists of and how blocks are linked in Blockchain.

This technique thereby incorporates the benefits of both crowdfunding as well as match funding. The nature of this mechanism thereby aids in providing much greater funding to the projects which are small in terms of scalability but have a great potential in the eyes of customers [7].

2. Literature Review

Crowdfunding is basically a way to finance or capitalize an enterprise so that the projects helmed by them can be achieved properly without any hindrances. The entire process of crowdfunding happens in an online manner. The funds for a project or a campaign are raised here by a group of people instead of established entities like banks or loan providers [3].

One of the main advantages of crowdfunding is that the project founder can reach out to the public in a short span of time due to which a good amount of money can be raised. Besides quick money, crowdfunding may also aid in non-financial benefits such as feedback/publicity with respect to the project involved.

The main issues of crowdfunding are fraud, incompetence of originators, and project risk. Money

Laundering is also another major problem faced upon Crowdfunding platforms. Also, the impact of money laundering on restrictive crowdfunding increases the costs of operations through the approvable platforms.

Blockchain is considered to be both alluring and critical for ensuring enhanced security and (in some implementations, non-traceable) privacy for diverse applications in many other domains. Avoiding challenges like this could be as simple as implementing a blockchain-based crowdfunding campaign. Traditional transaction and platform fees typically associated with other crowdfunding sites, such as Kickstarter, are eliminated by using Peer to Peer smart contracts for crowdfunding [8].

Blockchain-based crowdfunding overcomes the shortcomings of the existing system identified in the paper such as non-tracking of monetary records, non-transparency, and lapse of communication between the investors and the creators who develop the project [1]. Proof of concept is discussed here [4]. However, these solutions did setup a backbone for a new way of fundraising but could not highlight an optimized way for distribution of funds.

Buterin, Hitzig, Weyl proposed in their paper a new optimized fundraising mechanism that focuses on achieving optimality on the distribution of available money between the required public goods in a flexible and decentralized manner. This paper highlights the importance of having a mechanism that is economically feasible for large scale transactions over the public goods. Public goods are special category of goods that are neither rivalrous nor excludable i.e everyone has access to it all the time [9]. It eliminates the denial of access of such goods for common public.

There are 2 major ways of making a financial

decision within the funding ecosystem of public goods. First is the conventional way of allowing people to donate small chunks of money for the development of a public good. But this approach suffers from free rider problem which states that, large part of those benefiting from a resource might be underpaying or not paying at all for the development. This happens because of a common assumption which is, as other people are already contributing then there is no need for me to contribute. Other way involves 1 person 1 vote system where financing is done by someone else but the decision to proceed with the development of public good is taken by general public altogether. This approach unfortunately suppresses the voice of minorities even if they have great value and eventually gives them less importance.

To overcome such challenges, concepts of Quadratic Funding and Capital Liberal Radicalism (CLR) matching were introduced within this paper. Liberal Radicalism is the concept of achieving funding in a decentralized manner along with the involvement of an external philanthropic sponsor. Quadratic Funding [10] is the mathematical expression that helps in giving importance to individual contributions for a public good that helps in generating an output amount which is retrieved from the matching pool.

Matching Pool is a collection of donations from sponsors wishing to facilitate funding of multiple public goods. This helps in identifying the importance of a public good from the eyes of the general public. One example of an application applying such concepts is Gitcoin which is an Ethereum based financing platform. This application uses Quadratic Funding in identifying the match amount for every registered Ethereum-based decentralized application.

3. Methodology

The given implementation currently allows the fundraising of only open-source projects. Open-source projects are an example of public goods which means no one can be excluded from accessing it at any given time. This category encourages the general public to support by making contributions to such projects, which when developed would be beneficial to them. Exchange of money is carried using native Ethereum Platform currency i.e Ethers. This adoption increases the speed of cross border transactions between the parties. There are 3 types of people who would be interacting with the given system.

A. Project Creators:
These individuals create an entry of one or many projects (entering details about the project) to receive financial assistance for the development of their project. After the completion of a fundraising round, creators are forced to showcase the progress of their project at regular intervals to their contributors, as the final donation amount estimated for a project is not transferred in one chunk but is instead handed over in a milestone fashion.

B. Match Fund Organizations (Sponsors):
Sponsors are the individuals/organizations with big financial resources who wish to contribute to multiple projects but lack in determining the size of pie each project would get. So, they contribute to something called a matching pool that amplifies every project's donation amount after an accurate evaluation of a project.

Sponsors are also involved in key decision-making processes i.e deciding over the existence of a project after it has been enrolled. The concept of weighted averaging algorithm is used by sponsors

within a round to create a governing mechanism for each project which is to be judged upon a set of parameters.

C. Contributors (General Public):

These individuals include the common public who would contribute small chunks to their desired projects. They also handle verification of every project's progress at regular intervals to which they have contributed. The final distribution amount for every project is calculated using Quadratic Funding which is discussed later.

3.1. Onboarding of Sponsors & verification, Enlisting of projects

The proposed flow of the system is segregated into two parts i.e., 'project set-up and verification' and 'project distribution and fund distribution'. The first part briefs on how a project is listed and is verified by sponsors using a multi-criteria decision-making mechanism [11]. This is clearly indicated in Figure 2.
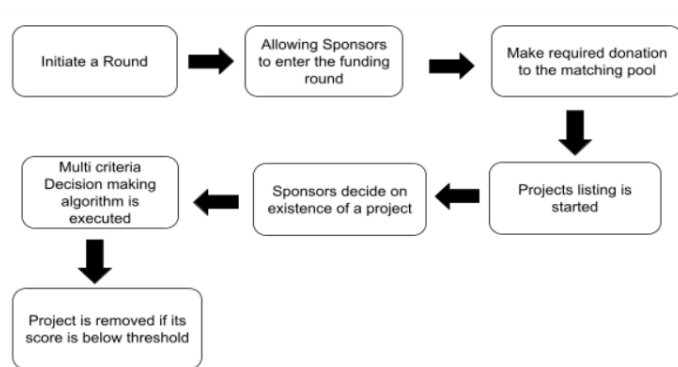

Figure 2. Depiction of how a round gets initiated and how the Onboarding of Sponsors takes place in our system.

Initially at regular intervals, a round with a limited time duration is created over the platform. This enables the invitation for the sponsors who wish to contribute to the projects through this platform. To help the upcoming listing of projects receive more than what they received from the common public, each participating sponsor donates a small fund into the matching pool before a new project listing starts.

Project listing is started for project creators to create an entry of one or many projects to receive financial assistance for the development of their project. As a sponsor of a particular funding round, they must also verify the listed projects based on specific parameters which assist in defining the quality of the project. If a particular project proposal fails to satisfy the sponsors that project is discarded from the ongoing round.

3.1..1 Adaptive Decision Making (ADM)

The project approval revolves around a few parameters which assist a group of developers to take their project idea further. The sponsors of the match-funding round are provided the will to either accept or reject the project at the start of the round and the weighted averaging method assists in such decision making [12]. Listed below is the procedural flow for the same.

1 Each project is judged based on certain parameters and through the weighted averaging method each such parameter is assigned with a numerical (non-binary) weight.
2 Each sponsor judging the project will provide a certain weight for each parameter; later averaging of those weights results in a quality measure score (score determining the quality of the project).
3 The same procedure is executed by every sponsor and the quality measure score of the individual sponsor is received.

4 If this individual score reaches a certain threshold, this denotes approval from the respective sponsor for the project.

For example, a new project has been listed. Sponsors of the funding round are notified and asked to judge the project based on A- depth of the problem statement, B- applicability of the problem statement, C- uniqueness of the problem statement, D- creator's domain expertise and E- Fundraiser financial requirements.

Each of these parameters is non-binary (i.e., it takes a value between 0-1,1-10, etc.) So, values entered are, A-5, B-6, C-2, D-7, and E-6 entered by the sponsor. Later, averaging of these weights is done which results in a quality measure score, 5.2 in this case. The same process is executed by every sponsor and the quality measure score of the individual sponsor is received. If this individual score reaches a certain threshold, this denotes approval from the respective sponsor for the project. This is clearly indicated in Figure 3.
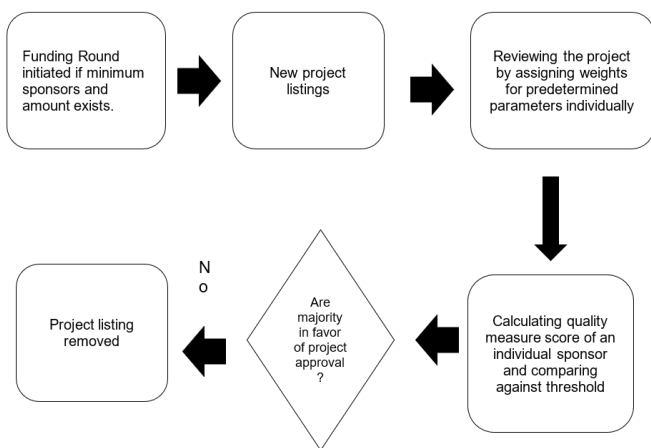

Figure 3. In case a non-favourable project gets listed on our system, this is how it gets removed from the funding round.

3.2. Distribution of Funds & Project Tracking

The second part of our system deals with interactions between the ongoing projects and the contributors. After the successful completion of Part 1 i.e verification and enlisting of projects, remaining projects are opened to the common public for contribution. The common public can make any amount of contribution to their desired project until the end of the round.

Following the completion of a round, the final distribution amount which is to be given to the project creator is calculated using Quadratic Funding. The final distribution amount is not transferred in one chunk to the project creators but is given in a milestone fashion as shown in Figure 4. where project creators need to showcase their progress to its contributors to receive an approval for rolling the current installment amount.
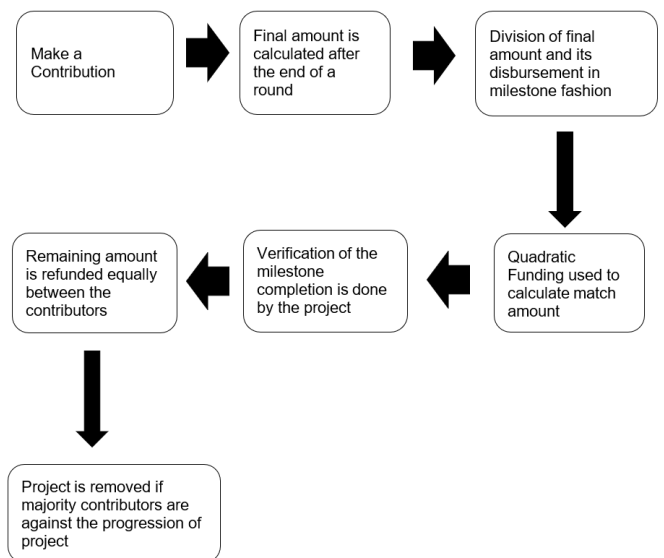

Figure 4. The process of making a contribution towards a particular project is depicted here.

This is done at regular intervals in order maintain the transparency between creator's work and contributors. If the majority of contributors are not

satisfied with the current work over the respective project, then they can perform the termination of that project resulting in a refund. The refund amount is distributed to all project contributors with respect to their earlier contribution amount from the remaining final crowdfund amount of the terminated project.

The decision over a project's progression is undertaken by implementing a decentralized voting mechanism where all contributors are allowed to cast their vote either in favor of continuing with the project or against the continuation of the project [5].

Every contributor uses their assigned token (ERC-20 tokens equal to the number of installments that are allocated to contributors after they contributed to a project for the first time) to vote only once every installment.

Real-time example with respect to implementation of Quadratic Funding:

Quadratic Funding (QF) is a different way of calculating the final amount that a particular project would receive. It not only focuses on 1 to 1 match like match funding but also stresses on the fact that how many people have contributed thereby transferring some amount from the matching pool. Quadratic Funding (QF) is a more democratic and scalable form of match funding for public goods. This helps the projects valuable to large groups of people and accessible to the common public receive a bigger match amount from the sponsors [7].

Final amount = The amount obtained via crowdfunding + the amount obtained from matching pool

The amount obtained from matching pool for every project is calculated using Quadratic Funding i.e square of sum of individual square roots of contributions.

Example:

From the Figure 5, we can observe the importance of unique contributors (backers) for every project as it helps in receiving a bigger pie from the matching pool, assuming the crowdfund amount (i.e., sum of donations from the general public) is not enough. This is why Project C receives the biggest amplification based on its crowdfund donation & on the number of unique contributors giving it the highest cumulative final amount.

	Project A	Project B	Project C
Crowdfunding	1000	1000	1000
Contributors	5	2	20
Individual contribution amount	200	500	50

Assuming the matching pool funds to be initially 1,000$

Match amount for project A = $(\sqrt{200} + \sqrt{200} + \sqrt{200} + \sqrt{200} + \sqrt{200})^2$
= 5000$
Match amount for project B = $(\sqrt{500} + \sqrt{500})^2$
= 2000$
Match amount for project C = $(\sqrt{50} + \sqrt{50} + \sqrt{50} + ...)^2$
= 20,000$

But match amount of could be more than the entire available matching pool amount.

Therefore,

Match amount for project A = (5000/ (20,000+2000+5000)) *1,000
= 185.185$
Match amount for project B = (2000/ (20,000+2000+5000)) *1,000
= 74.074$
Match amount for project C = (20,000/ (20,000+2000+5000)) *1,000
= 740.740$

	Project A	Project B	Project C
Crowdfunding	1000 $	1000 $	1000 $
Match Amount	185.185 $	74.074 $	740.740 $
Total distribution amount	1185.185 $	1074.074 $	1740.74 $

Figure 5. Depiction of how Quadratic Funding amplifies the final amount.

4.   Implementation

The Ethereum Platform is used to create the suggested Decentralized Application (DAPP). Solidity is used to write the smart contract for the specified DAPP. Currently the Smart Contract is deployed only on the Ethereum Rinkeby Testnet.

Technologies such as ReactJS, NodeJS, and Redis were employed in the creation of the Web Application.The Interplanetary File System (IPFS) has been integrated into the Ethereum network to aid in the storage of complicated types of data. We used Infura services to establish a virtual node and perform Blockchain transactions using the Web3 library from the web to connect the web application with the Ethereum network.

To connect with the Ethereum network from the web, only the Metamask wallet is presently available. Metamask is a crypto wallet available as a Chrome extension that can be used to not only send and receive crypto tokens, but also to sign DAPP transactions.

Our implementation consists of the following modules in it:

Homepage:
Users can start using the platform by connecting with the MetaMask wallet (via a Chrome Extension). The homepage provides the status information about 2 scheduled tasks: i.e., the time left in sponsor enrollment and time remaining for the completion of the ongoing round.

Register Sponsor:
This page allows the sponsors to register within the platform for the ongoing round by contributing an amount within the matching pool. Sponsor enrollment is possible only within the enrollment cycle of the given round.

Create Project:

Over here, if a round is currently ongoing, then the project creators can list their projects initially by providing specific details for approval from the sponsors & then for fundraising if authorized.

Listed Projects:
This page would show all the listed projects within the given round. Here, the information regarding each project's raised amount, its creator information, the number of days since its creation and its end goal which it aims to achieve would be shown.

Project Details:
This page would show the information regarding the Project i.e., the project description, the amount it has raised till now, creator information, the amount it would receive from the matching pool, the amount it aims to achieve, updates received by it and the backer list. Contributions towards the current project can also be done from here.

Project Review (ADM):
The 'Project Review' tab is present within every project's detailed description and it allows the registered sponsors to evaluate every project based on the specified parameters. It helps in filtering out the projects which do not appeal to the sponsors.

My Contributions:
A user specific collection of recently made contributions and their associated details is shown on this page. If any project gets terminated after a mutual voting between the contributors, status of the contribution made on the terminated project changes. Also, the procedure of initiating a refund for the terminated projects can be done over here.

My Projects:
This page showcases every project creator with more detailed information about their listed projects. The retrieval of funds after every installment is possible through this page. It also enables the creators to provide an update over the current status of their

project at regular intervals.

4.1. Results

The Figure 6 depicts how the partial integration of both crowdfunding & match funding along with the utilization of an optimized grant calculation method i.e., Quadratic Funding elevates the possibility for all the projects to meet their financial goals.

Figure 7. Graph-based evaluation of the different amplified amounts

Assuming the Matching Pool = 1,000$	Project A	Project B	Project C	Project D
Crowdfunding	1000$	1000$	1000$	1000$
Total Unique Contributors	5	2	20	10
Match Amount	135.14$	54.05$	540.54$	270.27$
Total distribution grant amount	1135.14$	1054.05$	1540.54$	1270.27$

Figure 6. Evaluation of different projects receiving different amplified amounts based on their number of contributors.

The given Figure 7 indicates the level of amplification Projects A, B and C receive if they are enlisted on the platform which is backed by a fusion of crowdfunding, match funding & quadratic funding. Sponsors who match the donation amount of the general public in match funding also get assured about the worthy distribution of their funds between the deserving projects because of the change in importance from the donation amount to unique contributors.

To evaluate the performance of the proposed solution we need to compare the outcome of fundraising with different strategies of same projects. Within the given graph a comparison is showcased between Crowdfunding technique, Match funding technique and the given solution i.e EthQF with respect to the funds raised along with the unique backers of every project.

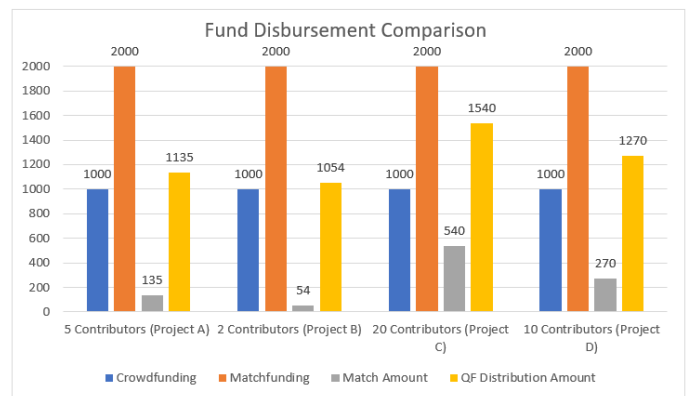The crowdfund donation received by every project

is 1000$ and as we can see it might not be enough to meet monetary goals of some projects. The alternative method i.e match funding where sponsors are responsible for increasing the final donation amount does yield better for many project's fundraising requirements.

The philanthropic entities pledge an amount which is to be donated to the presently crowdfunded projects in order to increase the overall funds received by them. A 1 to 1 matching with the current crowdfunding amount is done to facilitate the same. This is what leads to the matchfunding amount to be 2000$ in case of the crowdfund amount being 1000$.

But it does it without emphasizing on how many unique backers (contributors) does every project have thereby not giving enough importance to the public opinion. The uplifting performed by match funding also might not be possible in case numerous projects have not met their fundraising goals.

However, we can see from the given Figure 8 that with minimal donation within the matching pool i.e just 1000$, there exists a rightful distribution of those funds among the listed projects thereby not only relieving the dependency of the amplification

from the sponsors but also ensuring credibility of projects with respect to their backers.

The matching pool amount is used to calculate the match amount for every project which in turn is later used to calculate the final Quadratic Funding distribution amount (i.e. Crowdfund Amount + Match Amount) for that project.

Traditional Fundraising Platforms	EthQF
Convenience Charge = 5% of raised amount Payment Fees = 3% of raised amount	Transaction fees per contribution / transaction = 0.01$ (on Polygon network)
Time taken to transfer the amount raised by the creator = 14 days.	Instant transfer if approved by backers.
No mechanism to identify the sources of spending made by the project creators through the raised money.	Division of final amount in installments & the installment amount is transferred if it is approved by a majority of backers.
No refund mechanism	Refunds are initiated if backers wish to NOT proceed with the development of a project.

Figure 8. General comparison between the traditional fundraising system and our proposed system

The above comparison helps in differentiating the proposed solution with the traditional fundraising systems. Within the fundraising concept the goals are : maximize the donations received by the creators and provide a sense of security to the backers by performing periodic validation of every project. These objectives are addressed within the proposed solution to a greater extent then they were in the traditional systems.

5. Limitations

Although the idea of integrating blockchain within the crowdfunding domain seems exciting, the complexity and uniqueness of blockchain means end users would find it hard getting used to decentralized applications, thereby having a steep learning curve. This would result in underappreciation of the benefits provided by Blockchain technology. Quadratic Funding is prone to Sybil attacks wherein one person can create multiple pseudo-anonymous accounts and make small contributions to his/her projects using each of the anonymous accounts [13]. This would change the distribution of funds for every project from matching pools (that are used to amplify a project's donation amount) resulting in a positive shift within the attacker's favored projects.

6. Conclusion

The idea behind the given proposed system is to create a platform capable of handling the complex crowdfunding exchanges which involve transactions like donations to a project, verification of project creators' identity etc, in a transparent manner. The conventional crowdfunding systems are unable to provide a mechanism capable of helping the listed projects reach their financial goals with respect to their community support. Blockchain Technology helps us in establishing a decentralized governance for making key decisions involved within the platform. The immutability and permissionless nature of blockchain also assists in keeping all communications fully observable for all the people engaging in the system. The concept of weighted averaging algorithm used by sponsors within that round creates a governing mechanism for each project which is to be judged upon a set of parameters. The use of Quadratic Funding enables the rightful distribution of funds from the matching pool created by sponsors between the listed projects, taking the people's support into consideration.

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