Model for improvement of nonprofit student organizations funding by machine learning and digital transition to blockchain

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Abstract. *Most student organizations can be classified as nonprofits. Sponsorships are their main source of income and fundraising is a key activity responsible for allocating sufficient funds required for project realization. Typically, companies are the principal outside stakeholders concerned with the success of student organizations' projects and their main sponsors. Financial transparency and accountability for nonprofits are crucial for their public image, mission, and achievement of planned goals. Student organizations cannot be successful and build long-term relationships with enterprises without being transparent in how the donated funds are being spent. By introducing the blockchain-based smart contracts model a student organization could publicly declare the amount of capital required for every project, its distribution as well as fundraising deadlines. As the data on the blockchain is completely transparent it can be effortlessly utilized as an input data set for building machine learning models. By employing the proposed model fundraisers could maximize project income and reduce costs by using generated predictions.*

Keywords. blockchain, machine-learning, fundraising, smart-contract, non-profit organization

1 Introduction

Recently, an increasing number of academic institutions recognize the opportunities student organizations can bring them. While attending universities or colleges, students gain valuable hard skills, professional and scientific knowledge, but often find themselves lacking management and soft skills. By enrolling in student organizations, students get a chance to organize projects, communicate with companies, take courses, and, most importantly, network with their colleagues and potential future partners.

All this gives the utmost value to the importance of academic curricula. Otherwise, only a handful of students would get a chance to try managing projects without any work experience. However, there is a downside to student organizations. Members who are leading a student organization must take care of the organization's liquidity as well as profitability, keep up with bookkeeping and different legal requirements. These tasks are not only time-consuming but also bring additional costs to the organization itself. The problem is even greater because most of the student organizations are nonprofits, and they get funded through various partnerships and projects.

Partnerships are agreed with companies, which in return get brand visibility and get in touch with potential future employees. Planning and conducting a profitable fundraiser requires a lot of planning, thinking ahead and understanding the reasons for success, or failure, of previous fundraising attempts. These problems become even greater due to frequent changes of project organizers and organization leads being replaced almost every college semester. Organizers often have little to no experience and can have a hard time collecting and understanding previous processes and fundraising tactics. As even the leading student organization members have short mandates, it is almost impossible to transfer all gained experience each time to the next leading members and to project organizers.

However, these problems can be solved by an intelligent digital platform utilizing machine learning algorithms. First, in this process, a suitable machine learning model must be constructed that describes the fundraising process of a nonprofit student organization. Secondly, data from each workshop have to be fed to the previously developed model. Then, the model could make predictions about overall project funding and make useful analytics that will make it easier for organizers to get insight into historical data. The model can also determine key points for successful fundraising and bring organizers' attention to those particular elements.

After the key elements of the fundraising process are recognized, the process itself can be upgraded even further by moving away from traditional financial institutions to blockchain-based funding. Blockchain

reduces costs, paperwork and increases transparency and trust between organizations and their partners. By having all the data publicly available on the blockchain, the data can be fed to the machine learning model which would make further predictions.

Such a machine learning model, together with an accompanying intelligent digital platform, is described in this paper.

As fundraising and donations are the only way organizations of this type can get liquidity, reducing costs by removing middlemen like banks is beneficial. Furthermore, by leaving raised liquidity in the blockchain ecosystem, various opportunities, such as the use of decentralized finance platforms, open a wide spectrum of different possibilities for the utilization of such financial assets.

The remainder of this paper is organized as follows; Section 2 provides basics of machine learning predictions in fundraising, Section 3 introduces decentralized finances as an alternative to traditional banking system, following with Section 4 which provides an example of fundraising on the blockchain. Sections 5 and 6 describe implementation of Ethereum smart contract and a connection with Ethereum blockchain using Python. Section 7 provides a new source of financing by the use of decentralized landing platforms and Section 8 highlights the potential risks associated with this approach. Finally, Section 9 concludes the paper.

2 Machine learning fundraising prediction

Before describing the optimization of the fundraising process, it is important to utterly understand the current process. Around five months before the workshop should take place, the organization team is elected, and project details are agreed upon. The very next thing is to plan fundraising tactics for the project; types of partnerships (benefits and prizes), category of targeted companies (area of expertise), company size, deadlines etc.

Once the partnership details are agreed upon, the tender can be formed and sent out to targeted companies. If the company shows interest, the terms of the agreement are discussed, and the final agreement can be sent out to them. They are obligated to sign the contract in order to receive the invoice and proceed with the deal. The agreement consists of the details about both sides, the student's organization, and the company, following obligations with both sides and finished off with the contract date and responsible people and their signatures.

As mentioned in the Introduction, partnerships on workshops represent the main source of funding for student organizations. Therefore, they need to be well understood and analysed to optimize the fundraising process and bring more funds as a result. Given that the representatives of the association, as well as the organizers of the workshops, often change, it is very difficult and time-consuming to analyse historical workshop data. Furthermore, the complete data can only be found in the bookkeeping records of the association since every partnership equals one invoice. It would be necessary to go through all the invoices over the years before planning the fundraising process and the organizational process in general. Each workshop and all its parameters would be analysed to be able to predict, for example, how much funding to expect, which companies would be interested in partnering in that exact workshop and so on. This is where machine learning comes to place.

Leading banks and financial services companies apply artificial intelligence technologies, including machine learning (ML), to simplify their processes, optimize portfolios, reduce risk, and secure loans, among other things. All of that prompted the development of a machine learning model to aid financial flows management in student organizations, especially its most important part — fundraising.

The first and most important thing to predict is the overall funding of the given workshop. This can help the cost management and all the activity planning for the workshop. Due to its specificity and adaptation to this task, a linear regression model has been selected, i.e., a multiple linear regression model (Tranmer & Elliot, 2008).

Linear regression is a well-known machine learning algorithm based on supervised learning that performs the regression task. Regression models predict the target value, a real number, which is based on independent variables. It is used to determine the relationship between variables and predictions. Different regression models differ based on the type of relationship between considered dependent and independent variables and the number of independent variables used. Since the main goal is to predict the overall funding for the workshop based on given parameters, a multiple linear regression model will be used.

The first step in building a quality model is to understand the data. As stated before, only the bookkeeping records are the ones that every organization must track and gather over the years, so the based on the data found on invoices will be used to design the model. Each invoice is law regulated and thus contains the same mandatory data. The data on the legal entity with which the contract is concluded, the cause and the amount of the concluded contract can be recognized as the most relevant ones. The proposed solution would be to gather all the invoice data in one file to make it easier to manipulate the data and prepare it for the model fitting.

The next step would be to ensure that only relevant data is fed into the machine learning model. All the data containing empty values should be removed, following with the attributes that do not contribute to the calculation. Since machine learning models can

only consume numerical data, it is crucial to make all the necessary transformations to the data. Workshop name values can only take a certain finite number of values, as for the company data. Therefore, these values are converted to discrete values with the help of the dummy variable principle. To avoid the consequences of the multicollinearity of the independent variables, one of the categorical levels will be omitted.

The data will now be separated into two groups, one for model training and the other for model testing, with a suggested ratio of 80 to 20. Now the model can fit with the given training and test data, and it is ready to make predictions. Models should be evaluated with the help of the Mean squared error method to make sure that the generated predictions are valid (Franzese & Kam, 2009).

After the model has been created, the preprepared data can be used for various analytics and visuals to help organizers have a better insight into historical data. For example, it is very helpful to have a better understanding about the correlation of organized workshops and partnering companies' area of expertise.

3 Moving away from the traditional banking institutions

Users of everyday centralized finance systems still must deal with disparate legal jurisdictions and heaps of paperwork, albeit the use of technology in financial services is far from a novelty. Banks and central authorities control who can invest, borrow, and what interest can be charged. They also approve or reject the transmission of money, as well as other goods and services. Not only, this type of system can greatly slow down business deals between large enterprise companies along with overseas money transfers, but it can also have a tremendous impact on smaller entities, like student organizations. Moreover, those organizations are often left with minimal interest rates given by banks that fade away with expenses related to bank account maintenance and card issues. In addition, traditional banks often pay large fees for one's insight into his financial transactions. For nonprofit organizations, this can become costly and troublesome very soon. As chairmen of such organizations are prone to change quite often, sometimes every college semester, many people must be gathered, and a lot of paperwork ought to be signed. As a result, central institutions have a hard time keeping track of active administrators. Prolongation of closing deals between student associations and companies is highly likely in that state; thus, organizing various workshops and events can be delayed. On the other hand, decentralized finance is completely open for everyone to use (Holotiuk, Pisani & Moormann, 2017). Transfers can be made instantly; they are fully transparent and visible to anyone (Leonhard, 2019). Importantly, in this process, no paperwork is required, nor there are any additional costs intended for middlemen or institutions.

Decentralized finance, DeFi for short, is an emerging phenomenon and a state-of-the-art strategy to enable financial services anywhere to anyone, regardless of ethnic affiliation, age, or cultural identity (Chohan, 2021). The services of decentralized finances are mainly built on top of public blockchains (Chohan, 2021) (Nofer et al., 2017). One of the most established services that decentralized finance on the Ethereum blockchain offers is lending platforms (Leonhard, 2019) (Buterin, 2014). In essence, lending platforms connect borrowers and lenders of cryptocurrencies and different types of tokens. Users can earn interest by lending the assets that they do not need at the moment to those who do (Amler et al., 2021). Just like traditional finance institutions encourage people to put their money in a bank by giving interest in return, these platforms work similarly. The main idea is not to keep cryptocurrencies and tokens in cold storage because they cannot earn interest and holders are left with the hope that the value will appreciate in value over time (Harvey, Ramachandran & Santoro, 2020). In the case of holding stable coins, that appreciation of value cannot be expected at all (Moin et al., 2020) (Klages-Mundt et al., 2020).

The openness of the system enables users to deposit and withdraw their money when they choose to, without any penalties. Capital is earning interest in real-time, per block. The interest is calculated based on both the initial amount of deposit and the accumulated interest from previous blocks (Leshner & Hayes, 2019) (Boado, 2020) (van der Merwe, 2021). To put it in another way, the interest is compounding. There is no need to lock in funds for longer periods, like one year, to earn interest, so users can at any point in time transfer their capital to another platform which generates a higher yield.

4 Implementing blockchain-based fundraising for nonprofits

An alternative fundraising method can be blockchain-based (Grigo & Hansen, 2020) (Hartmann et al., 2019). Any trust issues can be bypassed using smart contracts. By definition, smart contracts are computer programs stored on a blockchain that are used to automate agreements between two or more parties (Buterin, 2014) (Schär, 2021). Data about workshops, like workshop name, running dates and distribution of funds, can be placed inside a smart contract. Everything predefined in a smart contract is available for everyone with view-only access. The predefined information in a smart contract cannot be denied or changed afterward. In the case of a project cancellation, funds will be automatically returned to initial owners. Expenses related to banking and

accounting will be completely discharged. This kind of model does not require an understanding of accounting nor law regulations regarding contracts and invoices.

Regarding the machine learning model, the data about companies can be found directly on a public blockchain as well as transaction details related to workshops (Zheng et al., 2017). All stated leads to a constant format of the data, as it is defined by blockchain transactions, and in the end, it is only necessary to export this data to all existing workshop data. The model will continue generation predictions regardless of the underlying transaction system used.

Additionally, project sponsorship can be in a form of an ICO which is also known as a token sale (Chen, 2018). For instance, a special type of token can be minted for every contracted sponsorship. This way, each sponsor can get a unique token that represents that sponsorship and signifies participation in a project that is permanently stored on a blockchain, like a digital medal available for anyone to see. Upon minting the token, the sponsor becomes a token holder, and no one can take that token from them or create another token just like that one.

Blockchain tokens can represent a wide range of scarce assets, such as currencies, securities, properties, loyalty points, and gift certificates, among others. In general, there are two major types of tokens that can be found on a blockchain: currency and token. Currency is native to a blockchain. The most popular example is, undeniably, Bitcoin (BTC), which is the native currency of the Bitcoin blockchain (Nakamoto, 2019). Another example is Ether (ETH), which is the native currency of the Ethereum blockchain (Buterin, 2014). These currencies are called cryptocurrencies and they are used as the main means of payment on its blockchain. The other type, a token, is not native to a blockchain but is created on top of an already existing blockchain. On the Ethereum blockchain, existing tokens are following the common standards, called ERC-20 and ERC-721 standards (Norvill, et al., 2019). The mentioned standards are at heart smart contracts that keep track of token owners and theirs balances (Chen et al., 2020).

The ERC-20 standard is designed with an idea of representing fungible tokens - tokens which are equal one to another (Dyson, Buchanan & Bell, 2020). Cryptocurrencies, for example, are fungible, meaning they can be traded or exchanged for one another; one Bitcoin is always equal to another Bitcoin. Physical money is also fungible, one dollar is always worth another dollar. On the other hand, the ERC-721 standard describes non-fungible tokens, NFTs for short. Each NFT is one of a kind, and it has a unique identifying cryptographical code (Wang et al., 2021) (Nadini et al., 2021). For illustration, Leonardo da Vinci's Mona Lisa is unique as only one exists in the whole world. Even though someone can print the photograph of the painting or create a masterful fake, it cannot be sold or replaced with the original; hence it is non-fungible.

As sponsors seek brand visibility, having been listed as NFT holders for various workshops goes hand in hand with getting attention from freshmen students and young graduates. The very nature of blockchain protects from delisting or hiding a credible project's sponsors. In the same way, phony sponsorships will not be an option as cryptography prevents them from creating fake evidence.

5 Implementation of fundraising smart contract

In this paragraph, a simple smart contract for fundraising will be designed and implemented in programming language for Ethereum Virtual Machine – Solidity. The fundraising process will be divided into six sections, and each section will be explained as verbosely as possible. For some crucial parts of the smart contract, examples of Solidity code will be attached to the text and briefly described. Essentially, the fundraising smart contract will operate in the following way and as illustrated with UML activity diagram in Figure 1:

1. A student organization starts a fundraising project, defines the project goal, required funds and a deadline for fundraising based on the results of the machine learning model described in Section 2.
2. Sponsors send the funds. In this case, it will be the native cryptocurrency of Ethereum, Ether.
3. If the project was cancelled or the funding goal was not met, sponsors can withdraw their funds.
4. Once the fundraising deadline has passed and the funding goal is met, the organization is able to create requests in order to take and spend the given funds.
5. Sponsors will vote in favour of each spending request if they agree with the organization's intention of spending the funds, otherwise they will deny the request. If more than 50% of sponsors vote in favour, the smart contract will approve the organization to withdraw the money. Otherwise, the organization will have to create another request.
6. For every sponsor, a unique NFT token will be created, and the sponsor will be assigned as a token holder.

Primarily, as depicted in Figure 1, to initialize a new fundraising project, a new smart contract must be created and deployed to the Ethereum blockchain. Contract has its local variables and a constructor function which is called upon the deployment.

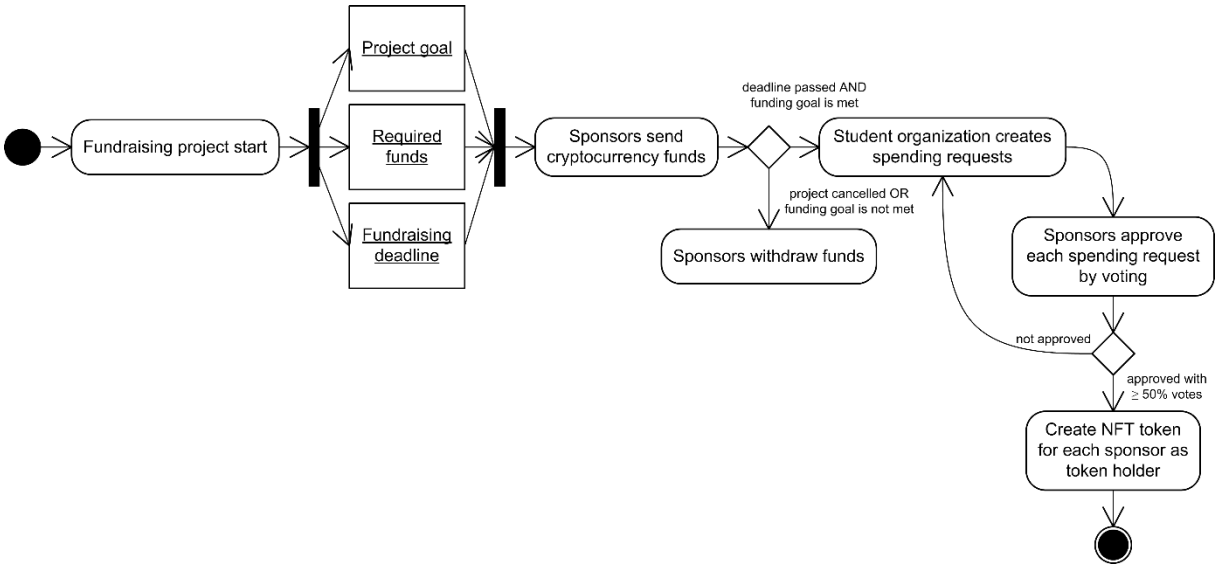

Figure 1. UML activity diagram illustrating the process of creating a blockchain fundraising smart contract.

The following data is being stored in local variables: Ethereum address of the contract owner, apropos deployer, Boolean to keep track of project cancellation, project description as a string, funding goal, currently raised amount of funds (initially set to 0), fundraising deadline, category of the partner company, an associative array of sponsor addresses as keys and their sponsorships as values. Variable "numberOfSponsors" keeps track of how many sponsors participated in the fundraising. The constructor function takes project description, minimum funds required, and the expected fundraising duration as parameters. The deployer of the contract calls the constructor functions and becomes the contract owner. Variable "msg" is the contract's global variable, and it includes data about the Ethereum transaction, such as transaction sender. The contract owner will be able to create spending requests down the road. The deadline is calculated by adding the fundraising duration to the time of the deployment (block.number).

In the second step, sponsors call the function "sponsorProject" in order to send Ether to the smart contract. The function first verifies that it was called before the fundraising deadline has expired and then saves the mapping of the sponsor's Ethereum address to the amount of sent Ether. Value of sent Ether is accessible from "msg.value" field. The total number of sponsors and the value of raised funds are increased accordingly.

Thirdly, in the case of project cancellation or unsuccessful fundraising, sponsors call the function "refundSponsorship" in order to withdraw their initial investment (Figure 1). The function, firstly, asserts that the project has been cancelled or that fundraising failed by not raising enough capital before the deadline, and secondly, verifies that the sponsor who is calling the function has indeed sent the funds to the contract. After all conditions have been met, the initially sent Ether value will be read from the sponsorship associative array and transferred back to the sponsor. The value in the associative array for that sponsor will be reset to zero, so the sponsor cannot ask for more funds than he/she initially sent.

In order to spend raised funds, the organization ought to create a spending request. Each spending request is in the form of a structure which holds the description of how the funds are intended to be spent, the total amount, Ethereum address of the recipient, Boolean whether the request was executed or not, an associative array of voters' addresses as keys and their votes as values and the total number of voters (Figure 1). The address of the recipient is quite important, as upon request approval, the smart contract will send the funds to that address. This behaviour prevents the organization from saying they will use the funds for one thing, and later, when sponsors approve the request, they actually spend the money on something entirely different. The function to create a new request asserts that the caller of the function is the contract owner, so the request cannot be created by anyone else, as well as that the fundraising deadline has passed and the fundraising has met its goal.

In the fifth step, sponsors are able to see each spending request and give a vote whether they agree or not. The voting function also prevents anyone who is not on the list of sponsors from giving a vote. After the voting has finished, funds are sent to the recipient's address if the total number of voters in favour exceeds 50% of the project sponsors. After the funds are sent, the Boolean variable "executed" is set to true, so the request cannot be called again, therefore sending the funds more than once.

Finally, the process of listing sponsors as NFT holders is quite trivial. NFTs, in essence, are smart contracts as well, and they have their owner and a unique ID. To give ownership of NFT to the sponsor, designated in Figure 1, it is required to iterate through

the list of project sponsors' addresses and assign each address as NFT contract owner. As creating NFTs from sponsorships is not the main goal of this paper, it will not be explained in detail, but only mentioned as an idea for future work.

6 Ethereum blockchain as a data source for machine learning model

Since the smart contracts are now deployed on the Ethereum blockchain, it is necessary to change the data source for the machine learning model accordingly. Regarding the model itself, it does not have to be modified as the smart contract contains the corresponding data.

Conceptually, it is necessary to connect to the Ethereum blockchain and call the functions of a desired smart contract in order to read the content of its variables that will be further used by the model. The Ethereum blockchain is basically a network of nodes, which all share a copy of all the data on the blockchain, so it is possible to talk to the single node in the network to find the data from desired smart contracts (illustrated in Figure 2). As the machine learning model was developed with Python, the easiest way to interact with the blockchain is to use a Python library that serves as an interface for communication with a certain node. This is where Web3.py comes into place.

Web3.py is a Python library for interacting with Ethereum blockchain using RPC protocol, and it is commonly used in decentralized apps to help sending transactions, interacting with smart contracts, reading block data, and a variety of other use cases[1]. Web3.py can be easily installed using pip or any other Python package manager.

The connection to a remote node can be established with Web3.py by specifying an endpoint. The endpoint can be provided either by running a private Ethereum node or connecting to public and free-to-use remote node providers, such as Infura. Infura provides full access to the Ethereum blockchain after the creation of a free account. In order to read the data from a desired smart contract, its address, and an ABI (application binary interface) have to be specified. Both of these are available after smart contract deployment to the blockchain.

Now, public variables mentioned in Section 5 can be read by their name. The required are workshop name, the category of the partner company, and the volume of gathered funds. From here on, the data, along with historical data, can again be fed into the already developed machine learning model. The results of the machine learning model can further be used to determine the next project's goal.

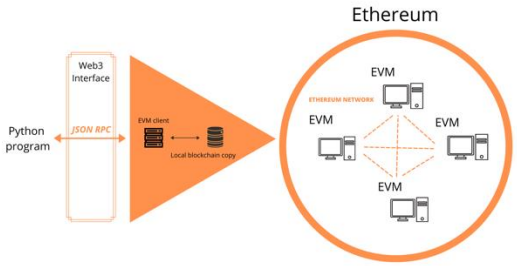

Figure 2. Python interaction with blockchain via Web3.js.

7 Finding additional funding sources

Systems like DeFi come with countless features and utilities which extend far beyond the scope of this paper. However, there is one more element that should be mentioned - borrowing against your own collateral. In DeFi, users do not have any kind of credit score required to take out a loan, and as nonprofit organizations are not able to take out any loans in the real world, this already sounds appealing.

At its most basic level, users post collateral into the platform and then take out a loan. Firstly, the user would have to give a pledge in the form of some cryptocurrency or token he owns, and, secondly, he would be able to take a loan in the form of some other cryptocurrency or token. The amount of required collateral depends on the type of given cryptocurrency or token. So, in case the user gives some kind of a stablecoin as a pledge, he will have to lock a minimal percentage in the platform in order to borrow as it is not expected for a stablecoin to be volatile. At the same time, if he gives a highly volatile cryptocurrency or token, that percentage will differ. These values are calculated algorithmically by decentralized platforms. For each loan, there is a liquidation threshold which ensures there are always sufficient funds locked into the protocol. If someone refuses to pay the debt, his pledge will be liquidated and the debt paid automatically (Boado, 2020) (Leshner & Hayes, 2019) (Leonhard, 2019) (Gudgeon et al., 2020).

Taking this even further, some decentralized finance platforms provide the functionality of repaying the debt with earned interest automatically. In other words, the loan pays itself off. As the protocol repays the debt, users can raise a loan. Of course, sometimes it is not idealistic to wait for a long period of time for the loan to be repaid, so it is possible for users to settle the debt earlier. This idea was started by a yield-backed synthetic tokens platforms such as Alchemix (2021).

As nonprofit organizations rarely have access to considerable liquidity, one should be careful before taking these kinds of loans and not risk life and limb

[1] https://web3py.readthedocs.io/en/stable/

for some extra cash. All in all, taking a small loan that can repay itself in a realistic timeframe sounds like a viable option as it can easily cover smaller costs without the organization losing money down the drain. To give an example, say a nonprofit organization has 2,000 tokens at its disposal and is earning 5% annual interest on those tokens on one of the lending platforms. Let us also assume that the cost of a custom T-shirt's print is 10 tokens. A loan of 10 tokens could be taken immediately, while 2,000 tokens will still raise the interest. With a 5% annual interest rate, the loan will be repaid in a little more than a month. Therefore, the money was taken upfront, and the loan was paid automatically without any initial fund movement, consequently costing the organization to print the T-Shirts.

8 Risks in blockchain-based funding for nonprofits

The described model has its own drawbacks. First, even though the model should be applicable to most nonprofit organizations because it relies on data gathered from invoices that are regulated by law, there is always a chance some organizations want or practice different methods of fundraising and business models. Additionally, some organizations may have very little data, which can lead to inaccurate models. For instance, low lifespan organizations may encounter such difficulties. Data can also be inconsistent due to not organizing all workshops at regular intervals or simply dropping some workshops altogether. All the above can result in the model not fitting a particular organization's business case, therefore it cannot help with optimizing anything. Secondly, blockchains are still in an early phase of existence, so it could be considered quite risky to transfer entire organization's finance to such an ecosystem. In contrast, nonprofit organizations could be pioneers in embracing blockchain as they require the simplest finance mechanism and generally dispose of the least amount of money in comparison to other organizations.

9 Conclusion and future work

To sum up, student organizations play a very important role in the everyday life of most college students. They give students great opportunities, such as taking project organization responsibilities, engaging in project management tasks, and networking. Fundraising plays a crucial role in the operation of student organizations and maintaining student organizations' financial liquidity. Fundraising makes workshops possible and financially supports all other organizations' expenses. Since the members of organizations are regularly changing, it is challenging to optimally pass on the best fundraising practices.

The usage of machine learning algorithms in blockchain-based funding for nonprofit organization is important. Usage of machine learning keeps track of organized workshops' historical data and lowers the gap in required expertise of new members by suggesting decisions like targeted companies and expectations of earnings. Machine learning also helps with recognizing the most important data about partnerships. As blockchain sheds a light on a new way of processing payments, that data can be incorporated into smart contracts and completely move away from traditional banks and all kinds of middlemen. Partners can get a unique cryptographical, digitally verified warranty in addition to previously agreed benefits. Blockchain enables complete transparency of one organization, therefore lowering trust issues with current and future partners. Machine learning algorithms also get a consistent and verified data source in a predefined format. Blockchain based decentralized finance platforms provide a brand-new way of managing the budget and additional source of funds. Further, we believe that the development of such platforms follows principals of development of primary and secondary experience of adaptive information systems supporting knowledge transfer (Lugović, Dunđer & Horvat, 2015a) (Lugović, Dunđer & Horvat, 2015b) (Lugović, Dunđer & Horvat, 2017).

Although there are many obvious benefits of this model, there are also some risks associated with it and they should be taken into consideration. Most risks come from uneven business models and therefore require further analysis before bringing this model to practice. Blockchain presents another risk as it is still evolving and often falls into the grey area of legal regulations in many countries.

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