UTILIZING BLOCKCHAIN TECHNOLOGY TO TACKLE FOOD WASTE IN SMART CITIES

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ABSTRACT

Food waste is a major global issue and responsible for significant environmental and socio-economic repercussions, while millions of people worldwide, are affected by food insecurity. Food insecurity occurs even in large cities with high economic growth, where at the same time there is a large number of catering businesses and restaurants, which due to wrong forecasting and their effort to meet the predicted demand, prepare more fresh meals than necessary. As a result, quality food ends up in the garbage, in a daily basis. The research presented in this paper introduces a solution, based on Blockchain technology, that allows food-service establishments to offer the extra meals they have already prepared and would otherwise be disposed of, to food insecure people. The project's research focuses on the one hand on mitigating the food waste phenomenon in urban areas with high number of businesses providing fresh meals and on the other hand, on providing free, safe and nutritious meals to food insecure people. The integrated system ensures continuous communication between both parties and optimizes the allocation of food surplus and thus, minimizes food waste. The aim of the project is to develop a unique marketplace for food surplus, through a mobile platform and application, that can be utilized in the concept of smart cities, in order to mitigate the food waste phenomenon and actually contribute to the well-being of insecure members of our society, with the discretion and anonymity that is offered by the Blockchain characteristics.

KEYWORDS

Food Waste, Food Insecurity, Blockchain, Decentralized Applications, Tokens

1. INTRODUCTION

Food waste is a major global problem with multidimensional consequences. According to the Food and Agriculture Organization of the United Nations (FAO), one third of the global production, or else approximately 1.3 billion tons of edible food are lost or wasted every year (Ishangulyyev et al., 2019), creating a series of serious environmental and socio-economic impacts (Martin-Rios et al., 2018). Apart from the immediate consequences of the wasted resources, the problem acquires a moral component, due to the fact that 828 million people worldwide faced hunger in 2021 (FAO, 2022). Food waste occur mostly in developed countries (Buzby & Hyman, 2012), as the geographic profile of the phenomenon is heavily influenced by the level of income and the urbanization (Chalak et al., 2016). The above profile matches the description of smart cities, a term that represents a plethora of cities around the world with high levels of economic growth, trying to transform and upscale their services to their citizens, through the utilization of new technologies. In this context, such cities are capable of finding solutions to address the food waste problem, even through the use of technologies that they are not yet familiar with, such as Blockchain.

The alleviation of the food waste phenomenon in cities can be achieved through focusing on food waste taking place at the final stage of the food supply chain, the consumption stage. In particular, in food service establishments of a developed country, half a pound of food waste is created per meal served (Bloom, 2012), which indicates that for every 4 meals consumed, almost a kilogram of food is wasted. The waste is generated from food scraps either from customers, after completing their meal, or from the kitchen, due to ineffective demand forecasting. In the first case, awareness has to be raised against food waste among consumers that paid for it and they can easily avoid it, by packaging, freezing and consuming it, at some other time. However, the solution to the problem in the latter case is not simple, as demand cannot always be predicted with absolute precision. It is therefore imperative to create an integrated, clearly defined system through which food providing establishments, such as restaurants, cafes, pubs, etc., can find new ways to deal with food that is not

consumed, such as the solution presented in this paper that offers them the capability to donate the generated surplus to food insecure people.

2. PROPOSED SOLUTION

Blockchain is a distributed ledger shared among the members of a network and is continually updated with the recording of all transactions transmitted by the network's nodes (Christidis & Devetsikiotis, 2016). The first Blockchain network (Bitcoin) was presented by Nakamoto (2008), but its operation is based on the combination of many pre-existing technologies and concepts, namely Peer-to-Peer networks, hash functions, public key cryptography, digital signatures and consensus mechanisms. This decentralized technology offers the opportunity to create self-executing contracts between parties (smart contracts) and create tokens (tokenization), which can function as the digital representation of real-world assets on the Blockchain network. The project presented in this paper takes advantage of the tokenization capabilities and develops a decentralized application (dApp), with a back-end based on an existing public Blockchain network.

The project's research focuses on the intersection of two rapidly growing areas of scientific interest i.e., Food Waste management and Blockchain technology, in order to simultaneously mitigate the food waste problem and provide safe and nutritious meals to food insecure citizens and their families. The decentralized ledger provided by the Blockchain technology is utilized to ensure the anonymous two-way communication between food establishments (suppliers) and citizens (food seekers), in order to optimize the allocation of the prepared meals surplus. In a high level, the solution in this paper can be described as a standard digital marketplace offering supply and covering demand. The sole product exchanging between the users are the meals prepared from food establishments that would be otherwise disposed of, in the end of the day. So, the suppliers connect to the project's database to upload data about the meals they would like to donate and the users pick up the food of their preference, anonymously, with the necessary discretion. The completed transactions are transmitted and verified transparently by the Blockchain network, and every transaction triggers the project's smart contract, that donates tokens to both parties rewarding them for their active participation in the effort to tackle the food waste problem. The food seekers can use the new tokens to purchase food again and the suppliers can donate their tokens to food insecure citizens or spend them in other businesses that also participate in the project's ecosystem against food waste, by offering discounts at their products and services, in exchange for the project's token.

The integrated system is composed of the three following subsystems:

- A data collection subsystem, gathering data streams such as photos and nutrition information, pertinent to the available portions of food, for visualization purposes, in the application's interface. The food establishments, upon their registration are connected to the project's network and upload this data about the meals to the subsystem, where they are processed using appropriate data analysis tools. This data, combined with data from external sources with an emphasis on geospatial computing, are analyzed for real-time decision-making and visualizing information.
- A blockchain subsystem, through which food donations are monetized, by providing tokens, as a reward, to the contracting parties, thereby creating a co-operative incentive. Every decision that saves a portion of food, by providing it to a user of the application, will be recorded in the blockchain network and will be translated into tokens.
- An application subsystem, enabling the visualization of the information gathered and offering value-added services to both food establishments and food insecure users of the application. The project's application is a dApp, which means that the front-end is designed like any other common app, but the back-end is running on a blockchain network, not a central server.

Any user of the application, either a citizen looking for meals, or a supplier offering the daily surplus, is able to proceed with the registration instantly through the mobile application. With the registration, a new anonymous account is created in the project's public Blockchain network, which means that the user is a new node of the network, with the same capabilities like any other node of the blockchain. If the user has already an account in the same public Blockchain, it is possible to use it as well, without a registration. With the blockchain account activated and registered in the mobile application, the user has to define the user profile, either as a food seeker or as a supplier, during the logging in process. The new food seeker accounts will receive tokens with their registration, in order to use them for their first meal. In the case of the suppliers, they have to

provide basic information about their establishment (Name, Cuisine, Address, Work hours, E-mail, Telephone number etc.). Indicative screenshots are presented in Figure 1.

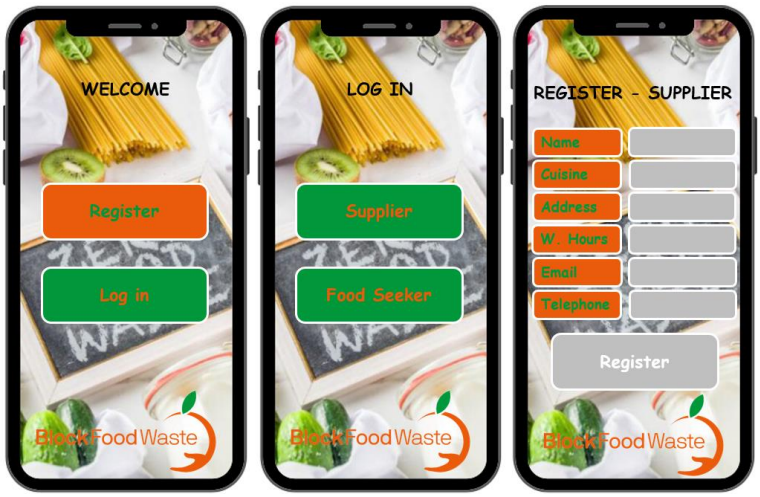

Figure 1. Application's interface (register and log in)

As a result, depending on the user profile, the application's interface is customized accordingly. For the food seekers, upon opening the application and activating geolocation using GPS, a map is loaded and displayed, highlighting the location of the user's closer suppliers, who offer at least one free meal available, in real-time. Through the mobile application the food seekers are easily informed about all the available choices from of all suppliers (with photos, food ingredients etc.) and then, they are able to select one of the available meals, taking into account both the distance to the establishment and the nutritional needs. The interface offers a booking option for the meals, as well as the option to navigate to the restaurant's location, in order to calculate the exact distance and expected time of arrival at the destination, based on the current traffic volume, using maps and routing services. The user selects the type of meal he/she wishes to consume, by making a reservation for it, with a validity period limited to one hour. In case the meal is not picked up after this time, it will be available again through the app, automatically. With the reservation, the user is provided with a QR code, which is required to be scanned by a food establishment's employee, in order for the transaction to be completed and verified in the Blockchain. Every QR is generated uniquely by the application and is related to one specific transaction. The QR code is the main oracle for the proper operation of the project's smart contract. Indicative screenshots for food seekers' interface are presented in Figure 2.

Figure 2. Application's interface (food seeker)

In the use case of suppliers, two options are presented in the application's interface: a) the uploading of new donations and b) the mechanism for the declaration of the completed pick up. The first option concerns fresh meals, which the supplier thinks should be distributed freely to consumers through the application, due to a poor forecast of daily demand. By selecting the listing of food for free distribution in the application interface, two columns are displayed, one for the type of food and one for the quantity of meals per type. Correspondingly, the meals become available and visible to application's users. When a food seeker arrives for the pickup, the supplier's employee uses the application's mechanism (scanner) to scan the QR code provided by the citizen and instantly the transaction is finalized and transmitted to the Blockchain network and is removed from the list of available products. Indicative screenshots of the application for the suppliers' interface are presented in Figure 3.

Figure 3. Application's interface (supplier)

The benefits of the integrated solution are not limited to just those involved in the marketplace through the dApp. Municipalities, NGOs, and other charitable organizations, which until now, have been exclusively responsible for providing food to people in need, through soup kitchens and donations in a centralized way, will be significantly relieved. Also, in addition to the decentralized operation of the application, the solution proposes also a decentralized last mile management, which is extremely important for the success of the project as a whole. Most of the restaurants have just a very small number of portions to offer every day and it would be too expensive logistics-wise to be transferred in centralized location to be distributed. With the project's solution restaurants can participate with even one meal, since the last mile is handled by the citizen that choses to reserve it.

The authors are currently in the phase of developing the final version of all the subsystems of the project and designing the specifications and scenario details for the project's large-scale pilot program. At the same time, the authors are already working to release another version of the dApp in order to create a complete ecosystem around the project's token targeting all citizens, by providing cheaper prices for those interested in paying less for food and helping to tackle food waste, at the same time. The project partners aspire to add businesses selling packaged food products close to their expiration date, which are also an important form of food waste.

3. CONCLUSION

The effort to reduce food waste is imperative, and the aim of the solution presented in this paper is a step towards that direction. Blockchain plays a cardinal role in the integrated system, due to the anonymity that provides to food insecure citizens and its tokenization capabilities. With the project's token, an ecosystem around food waste is created and also incentives are offered to food establishments, in order to participate in the program. The project, therefore, aims to contribute decisively to the fight against the phenomenon of food

waste and to provide relief to a significant part of the food insecure population of the cities, with a simple mobile application.

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