BIOTS - Blockchain and Internet of Things School

Food-Saviours

A real world approach to reducing food waste using the Potential of Blockchain

FuturICT Token Obtain Challenge

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April 30, 2018

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Declarations

This project report was written as part of the spring 2018 course 'Blockchain And the Internet of Things (851-0591-01L)' run by M. Dapp, S. Klauser, and D. Helbing.

The software code which is part of this report is open source and available at https://github.com/ETHBiots2018/Food-Saviours.

1 Introduction

The supply chain for food consists of several elements, starting from agriculture and ending at the household level (Fig. 1.1). At each level of the supply chain, a part of the food is wasted due to different reasons (explained in the next section). As a result, an estimated 33 % of the whole production is wasted, with higher shares for fresh vegetables (63 %), potatoes (61 %) and bread (56 %) [1]. The overall amounts of food waste are guessed to be 2.3 million tons in Switzerland [1] and 1.3 billion tons worldwide per year [2].

However, this amount of food waste must not be mistaken as 100 % edible food. Rather, the waste can be categorized in the following categories [3]:

- Avoidable losses: f.ex. consumers buy too much food; over-production; wrong storage conditions
- Possibly avoidable losses: f.ex. taste preferences; quality sorting
- Unavoidable losses: f.ex. contamination; inedible parts; weather conditions

The respective share of these three categories varies between food categories and also between the different levels of the supply chain. For the example of bread, avoidable food losses in the processing industry are around 1 %, while they amount to 36 % in households [3].

Wasting food has severe ecological, social and economic consequences [1]. First, food waste equals resource depletion, as large amounts of water and land area are necessary to produce the food. Further, production, processing and transport of food cause CO2-emissions, such that an estimated 5 % of global greenhouse gases are related to food waste [4]. Second, wasting food increases inequalities, as the wasted food resources increase the demand and hence the prices on the global market for staple food. As a consequence, the food supply of millions of people in the Global South is endangered, with 1 billion people suffering from hunger. Third, throwing food away also has economic consequences, as every Swiss household wastes food worth 1000 CHF per year.

It is hence evident that food waste affects many aspects of our path to more sustainability. As a consequence, the United Nations include the goal 'By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses' as Target 12.3 of the Sustainable Development Goal 12 'Ensure sustainable consumption and production patterns' [5]. In accordance to that, the goal of this work is to develop an incentive scheme to reduce food waste on the level of food industry and retail sale. Agriculture and households are not included at this stage as quantities and qualities of food waste are hard to estimate for these levels; the whole sale was excluded due to its small contribution to the overall food waste. These elements of the supply chain can, however, be included in the present system by extending the incentive scheme.

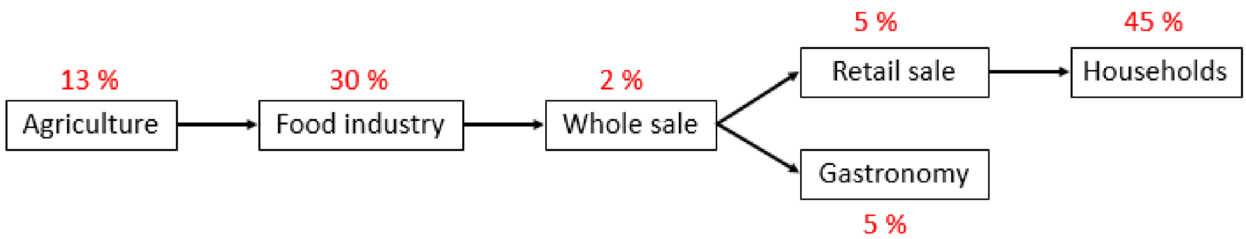

Fig. 1.1: Food supply chain. Percentages given refer to the contribution of each element to the overall food waste which could be avoided [1] [3].

2 Literature Review

2.1 Background: Food Waste in Germany

The German Federal Ministry of Food, Agriculture and Consumer Protection has issued a study which gives a good overview of food wastage at different parts of the food supply chain in Germany [6]. The following summary focuses only on the system elements that are addressed in this project (food industry and retail sale).

For the **food industry**, food is wasted if it does not fulfill certain quality parameters; when samples are taken for quality control of the products; if irregular demand of the retail sale leads to over-production; if technical failures lead to perished products. A substantial amount of food is wasted due to legal regulations or norms imposed by the retail sale.

According to the report, the food industry can avoid food wastage by optimizing their production processes; by creating a network or an association that provides advice on resource-efficient management to small and medium-sized enterprises which often lack the capacities to implement optimization measures; by committing to voluntary undertakings.

On the level of the **retail sale**, most food is wasted if it is not 'marketable' anymore. This can happen if the 'best before'-date is reached; if it does not fulfil the customers' expectations in terms of freshness and/or visual appearance; as the retail sale wants to offer a huge variety of products and as shelves have to be always full; as it is difficult to align the amounts of ordered food with the customers' consumption behavior; if food is not stored or handled properly.

In terms of recommendations to avoid food waste from the retail sale, the study lists the marketing of regional products (less wastage during transport); highlighting bargains for products close to best-before date; selling products without packaging, thus allowing consumers to buy only as much as they need; further developing logistic and ordering tools to optimize the ordering system; introducing a happy hour when products close to expiry date are offered at sharply reduced prices.

2.2 The Potential of Blockchain Technology in the Food Industry

The use of blockchain technology and a token system in the food industry can be expanded from the use of an incentive system to include more ways to combat food waste. Blockchain technology has the potential to create a uniform, easily accessible tracing system for producers, retailers and customers. There are many ways how this tracing system could make the food chain more efficient. [7]

An example for an improvement in the food production and transportation sector could be the use of smart contracts to redistribute food shipments dynamically. If a shipment of food fails to meet some quality criteria from a certain buyer, it could be automatically transferred to another buyer with different standards.

For the supermarkets, a blockchain-based tracing system could prevent food waste due to contaminated or otherwise impaired products. Since the affected product could be traced back to its origins, mistakes along the supply chain could easily be identified, and safe products could remain in the shelves rather than be eliminated as a safety precaution. [8]

However, many aspects and potential difficulties of introducing blockchain technology to transform the food industry remain to be considered. In order to create an extensive and reliable tracing system for food products, many different parties would need to be mobilized.

A major issue of using blockchain technology to track products would be to find a balance between transparency and confidentiality, as many organizations would have to reassess the security and privacy of their contracts. The open and freely accessible information about their products may pose a major problem for a lot of companies in the food industry. For a token and information based system to fully work, companies would have to see blockchain technology as an opportunity to increase their competitiveness, rather than a threat. [9]

2.3 Status Quo

Several major retail and food companies have started to explore the potentials of blockchain technology for their businesses.

An example of this is Walmart, an American retail corporation, which has been collaborating with IBM, a multinational technology company, since 2016 to introduce a blockchain based food tracing system for their stores. [10]

A pilot project aiming to assess the use of a blockchain based food tracing system was run in December 2016 by Frank Yiannas, Walmart's vice president of food safety. His team was tasked to measure the time it took to trace a package of Mexican mangoes (purchased in a Walmart store by Yiannas) back to its origins.

Before the introduction of the tracing system, it took the team just under a week to trace the mangoes back from the store to the supplier. However, after a test run using a blockchain framework called Hyperledger Fabric, which tracked and recorded food shipments, it took a mere 2.2 seconds to trace the exact path of a package of mangoes from the Mexican farm, through the manufacturing and storing process, and finally to its distribution to the Walmart store. [11]

Another prominent example of blockchain technology in the food industry is TE-FOOD, the world's largest publicly accessible food traceability system.[12]

Originated in Vietnam, TE-FOOD's ultimate goal is to decrease the risk of food-borne diseases, prevent fraud, decrease the overuse of antibiotics in animals, and reduce migration caused by climate change. They use blockchain technology to trace the path of individual animals from their primary producers, through different stages of processing, to the consumer, which can then access the data via an app by scanning the bar code of the product. At the moment, this system is limited to meat and eggs, but it is planned to be expanded to fish, fruit and vegetables in the near future. [13]

TE-FOOD has introduced a token-based tracing system to improve communication and transparency along the different layers of the supply chain. The TFOOD token will be used by the different businesses involved in food production to record vital information for each item. It is planned that companies can purchase additional valuable information on the products they receive. Consumers are rewarded for using the TE-FOOD app to scan barcodes by receiving TFOOD tokens. The TE-FOOD system has therefore combined blockchain technology with an incentive system intended to make the supply chain safer and more efficient.[14]

3 Conceptual Model

3.1 Conceptual Background

3.1.1 System Overview

Fig. 3.1 gives an overview of the conceptual system which was created to reduce foodwaste on the level of suppliers, supermarkets and consumers. At each level, different actions should be incentivized aiming at reducing foodwaste. Depending on these actions, four different kinds of tokens are generated: Reputation, Advertisement, Engagement and Food Coins. These coins are either used by the system administrators to rank suppliers and supermarkets, or they can be used by the actors to obtain different advantages. The detailed functioning of the system will be explained in the following sections.

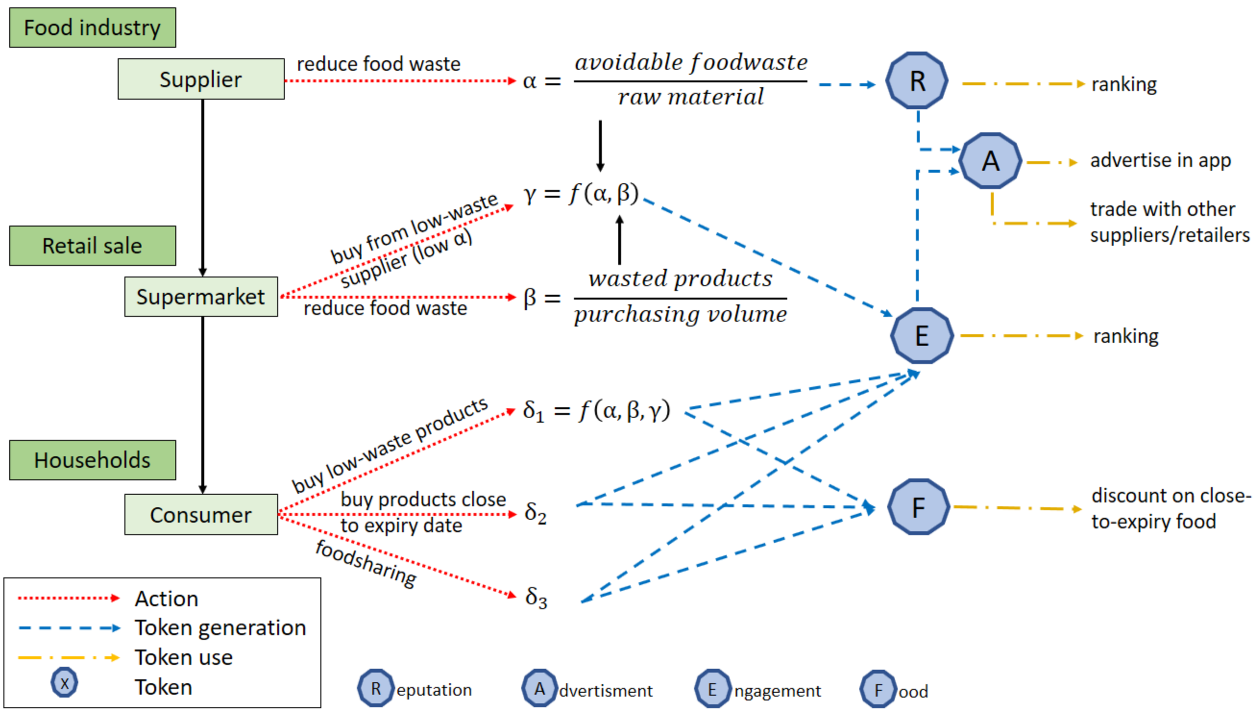

Fig. 3.1: Overview of the conceptual model of the created incentive system. Indicated are the actions that should be incentivized on the three levels of the food supply chain as well as the resulting tokens.

3.1.2 Supplier Level

As shown before, the food industry is on the one hand responsible for a large portion of the overall foodwaste, but also has a lot of possibilities to reduce it. Suppliers should be motivated to make use of these. The performance of each participating company is measured by the ratio $\alpha = avoidable\ foodwaste/raw\ material$. As some industries have a higher share of unavoidable foodwaste than others, only the avoidable part is considered here which can actually be influenced by the companies.

Depending on the α-value, the supplier receives Reputation-coins which serve to establish a ranking of all participating suppliers: the more reputation coins a company has earned, the higher it is listed. As the ranking is published online, consumer perception pushes suppliers to achieve a good image by reducing foodwaste. As the reduction of foodwaste for the food industry-level is mainly achieved by middle- to long-term measures (cf. section 2.1), the Reputation-coin is only issued every three months; it decays at a rate of 1/8 per quarter, meaning that it lost its value after two years.

In addition and linked to the Reputation coin, also an Advertisement coin is distributed to the suppliers. Whereas the Reputation coin is only used to create the supplier-ranking, the Advertisement coin can actually be used actively by the companies: they can exchange the tokens against advertisements in the smartphone app which supermarkets and consumers use to manage their tokens. As advertising might not be attractive to all companies/brands, the Advertisement coins can also be traded to other suppliers against hard currency. Both issuing and decay of the Advertisement token are coupled to the Reputation coin.

3.1.3 Supermarket Level

On the supermarket level, two different considerations can be made in order to incentivize less production of foodwaste throughout the supply chain:

First, the supermarket itself produces avoidable food waste by discarding products that are considered non sellable to consumers, for example fresh fruit or vegetables, which might not look immaculate anymore. As this data is recorded by the supermarkets, it can be used to obtain a ratio of waste and total products in stock ($\beta = wasted\ products/purchasing\ volume$).

Secondly, the supermarkets should also be rated on how much food of which quality they order from the suppliers. α_{tot}, the weighted mean of all purchased products and their ratios α_i, is calculated as follows:

$$\alpha_{tot} = \frac{1}{a}\sum_{i=1}^{a} \alpha_i n_i$$

where n_i represents the amount of products bought, α_i their corresponding production efficiency and a the total number of products. From the two factors α and β, the total efficiency γ of the supermarket is calculated. Due to the fact that more foodwaste originates from the suppliers than from the supermarkets ([1] [3], also see Fig. 1.1), a weighting of 1:3 for β and α_{tot} is proposed to strongly encourage supermarkets to buy from suppliers that are active against foodwaste:

$$\gamma = \frac{1}{4}(3\alpha_{tot} + \beta) \quad \rightarrow \quad \#\mathbb{E} = (1-\gamma)\cdot x \tag{3.1}$$

Based on this factor, a number of Engagement-Tokens are issued. The lower the value of γ is, the more coins are paid out, where x is a fixed number which each supermarket can get at maximum. Again, Advertisement-tokens are issued in the same way as described for the supplier-level.

We suggest that the Engagement-token is issued weekly and decays with a factor of $1/52$ per week, taking into account the mean payouts of the preceding year. Through this creation and decay rate, it can be assured that the supermarkets are required to perform well and buy 'good' products continuously. Also, taking a mean for the decay amount, it is made sure that short-term fluctuations in both the supermarket performance (β) and supplied goods (α_{tot}) do not have a too strong impact on their rating. Additionally, Engagement-Tokens can be obtained through customer action, which is explained in section 3.1.4.

What would incentivize the operator of a supermarket to participate? This can be answered using social and monetary arguments: consumers will, with increasing force, demand the transparency and 'greenness' of their supermarkets. As the proposed system catches drive within the market, this creates a social pressure which will have an impact on their revenue, thus it will be in their own interest to participate. This very argument also holds for suppliers, because the market is consumer-driven, who again are influenced by the 'greenness' of the supermarket and the corresponding supplier.

3.1.4 Consumer Level

The main goal on the consumer level is to provide information to the consumers and incentivize them to buy products close to expiry date. These aspects are realised through an app with which the user can interact and a monetary token that rewards him for doing predefined "good" actions, including buying well rated food, using foodsharing or buying food close to expiry date. Those are just a few examples that were discussed during the development of this project, of course the range of positive actions could easily be extended.

While shopping in a store, the consumer can check the information about a product (eg. origin) by scanning a bar-code and decide which product to buy based on this information. The rating of a bought product transforms into an amount of tokens the buyer receives when checking out, paid out by a smart contract. The amount of tokens depends on the 'quality' of the bought product (α_i) and the 'greenness' of the supermarket (γ). This way, the consumer should be motivated to buy 'green' products in 'green' supermarkets:

$$\delta_1 = \frac{1}{2}(\alpha_i + \gamma) \quad \rightarrow \quad \#\mathbb{F} = (1 - \delta) \cdot x \tag{3.2}$$

We assume that all information and transactions are stored and executed on a blockchain to which we have unlimited access. The tokens the user receives are named Food-Token $\mathbb{F}$ and have a monetary value such that they can be used to buy products on the day of expiry in a participating store. Further, it can be exchanged at bakeries and restaurants for food that would otherwise be wasted, with the shops deciding themselves which products they want to offer. We propose conversion rates to real money of about $1/20$ and $1/50$ for restaurants and supermarkets, respectively.

The Food-Token does neither expire nor inflate, but a upper limit of coins per user could prove reasonable to encourage people to actually spend it. It is created upon a buy, and destroyed when exchanged for goods.

In addition to this Food-Token, an Engagement-Token is issued when a consumer buys products at the store; similarly, the store receives more tokens the better the bought product is rated. This incentivizes sellers to actually promote well-rated products and increases the possibilities to receive tokens for them.

3.2 Data Acquisition and Handling

The data flow describes when and who supplies which data to the system. Data comes from both the suppliers and the supermarkets, which state the amount of waste they produce and their total production output. This is saved on the blockchain. From this, we derive the production efficiency (α) and are able to base the system on hard data. For our proof of concept/simplified use case, we assume that the data that is being supplied is correct. Of course, this assumption will not always hold true in a real-world application.

In the case of supermarkets, the data acquisition could be done using the internal ware database: For this, there are two possible cases: for one, the whole database could be stored on a blockchain, making it both easier for the supermarket to manage their data and simplify their ordering process, maybe even by using smart contracts. As a downside, it is not clear who would pay for the computing power for this (if it is not a private blockchain). The other case would be that the data from the supermarkets could be fetched via an oracle, that for example monitors the excess food that leaves the supermarket.

Nevertheless, this heavily relies on trust in the participating parties, that they provide correct data, which is a clear downside of the system.

A possible solution to this problem on the supplier side could be that IoT devices are being used, for example smart scales. They measure the weight of trucks entering and leaving the production center as well as the amount of organic waste, from which the total foodwaste production could be deduced. Companies which use these devices could also get a bonus in the ranking as it increases the reliability of their data.

3.3 Software Implementation

3.3.1 Overview

In order for our project to be successful, there has to be an easy way to join the program and enough incentive for consumers to keep using it. Therefore, a focus has to be laid on the intersection between content and user actions.

In this case, we need an interface that is easily accessible, provides a pleasant overview with the option to get more details and is user-friendly. Accordingly, the obvious solution is a smartphone application, which is available everywhere and whenever the user wants or needs it, to provide the interaction with the consumer involved. Additionally, a more detailed web application for companies taking part in the program is needed, such that they can handle large amounts of data.

Core features of a fully developed customer app would include account management with settings, an overview of the personal token wallet, an advertisement system and a feature for information retrieval, possibly through scanning a code. These functions are essential to provide the basic usability of our token system. In addition this app would allow various extensions as educational content for users, consisting of videos or articles, an online ordering service for participating companies or a gamificated ranking system where a comparison with friends and the larger community would be possible. Further attractiveness could be achieved by integrating foodsharing or community platforms to the app.

On the industrial side, i.e. supermarkets, producers and suppliers, it is favourable to make the entry barriers as low as possible, while the benefits have to be maximized. Therefore a web app would have to include information about the project and how a company can profit from it, data standards, a displayed rating as well as some statistics that may be relevant to the companies at hand. For this, data integrity and transparency has to be guaranteed, which to a large extent is handled by the blockchain technology used.

In the course of the hackathon, we decided to use the Genesis framework provided by the FuturICT team to implement a small subset of our ideas mentioned above into a functional app that would get our idea across with the BIOTS community. Our approach and the extent of our implementation will be elaborated in the following sections. For a more thorough view on our implementation, please visit our GitHub repository under https://github.com/ETHBiots2018/Food-Saviours. Here, our code as well as our conceptual work (in handwritten form) can be found.

3.3.2 User Interface

Using the 'Market' interface of the GenesisApp, a simulation environment of our model can be reached by the click of a button.

Here, a subset of our model containing three producers is implemented. First, the user of the simulation can insert numbers for the three producers' wastage of raw material. These numbers are merely supposed to give the user an idea of our model and are hence arbitrarily chosen, as are the company names and the according numbers in Fig. 3.2.

Given these numbers, a ranking of producers is created according to the description in sections 3.1.2 and 3.3.4. This ranking can be observed in the following page of the simulation environment. Due to some difficulties (cf. section 3.3.5) that occurred during the implementation phase, the app is only functional up to this point. Hence, parts of Fig. 3.2 are not functional in the final application that was published on GitHub. More information regarding the functionality of the app can be found in section 3.3.4.

Using this ranking, the user can take the role of a supermarket and decide from which producer three given supermarkets buy a given product. Using these user-based decisions, a supermarket ranking is generated according to section 3.1.3.

Based on this ranking, consumers are able to decide which supermarket they opt for to buy a given product. The conceptual overview on this part of the user interface can be found in the handwritten work published on GitHub as we were not able to implement this due to time constraints.

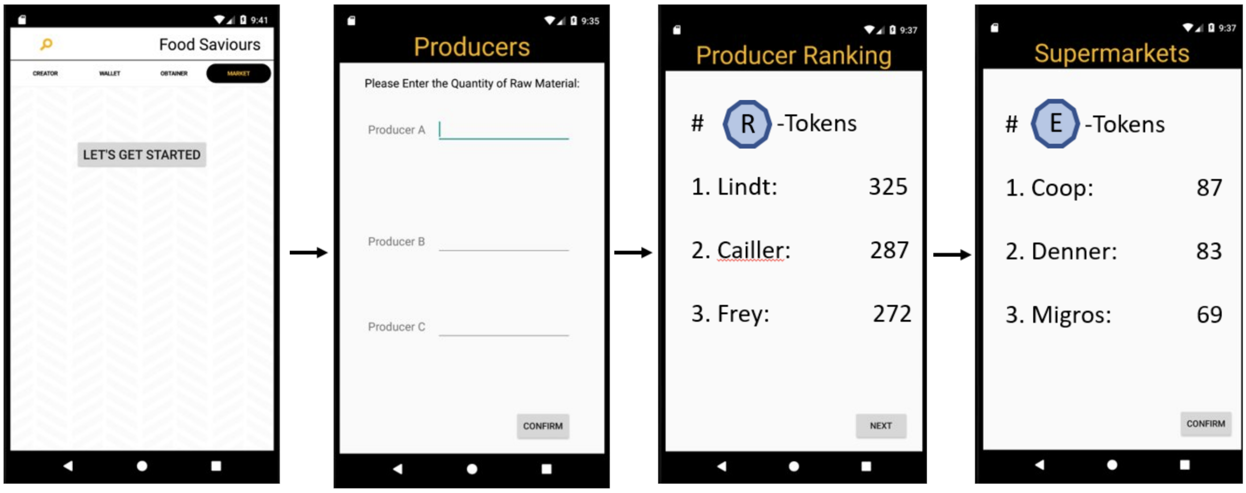

Fig. 3.2: The general idea of the UI and the simulation environment of our model. This is only an implementation of a subset of our model as a means of demonstration.

3.3.3 Backend

The backend or the database is the part that remains on the blockchain network and connects with the frontend to provide its necessary functions. The backend is built using smart contracts, in other words, a software code that executes on the blockchain. To this end, we used the Genesis library developed by the FutureICT team and extended the functionality of Basic SQL Contracts to implement the conceptual model of our project. The main point of this implementation is to design a multi-token system by taking into account certain aspects of monetary theory, financial economics, and game theory. We used the SQLite implementation of the IRepository interface with the assumption that operations are stored on the Distributed Ledger Technology (i.e. Ethereum). We developed the tables in traditional relational databases for suppliers, supermarkets, products and customers, along with the core functionalities, to logically connect our business model.

- **SupplierTable**: It represents suppliers with different properties and underlying operations.
- **SuperMarketTable**: It saves the attributes of super markets in the system with Token ID, Waste and Total Products.
- **CustomerTable**: It allows to add new customers in the system and perform relevant operations.
- **ProductTable**: It stores the information about all products with Token ID and rating of the product in the market.

This will essentially provide a decentralized multi-level token generation control mechanism and maintain a status of products in a trustless environment among the food producers and consumers. In practice, Smart Contracts can be coded in Serpent, Viper, Solidity etc. The User interface will display all different types of tokens, the balance of the user and the user will be able to select a token in the view. As a futuristic application in food waste management, automated smart contracts and analytics relating to products could enhance the productivity and promote the high quality control over supply chain activities.

3.3.4 Functionality

In the interface that we developed, due to the time constraints and difficulties according to 3.3.5, we could not write the code to implement a more generic rating system (cf. section 3.1.1). But instead, we used the Tokens of each item multiplied by a constant as the rating in both cases

(Producer and Supermarket ratings). What we had in mind was a rating system based on colors that could help to choose good items and also provide more competition among the items. We intended to implement **Algorithm 1** for Supplier level at the time. The same Algorithm (with small modifications) can be used for the Supermarket level.

We were planning to add more functionality to the Genesis library as well. Here, some function bodies with comments about their purpose were added. In some cases the implementation was completed, in other cases the exact implementation is missing but can be found in pseudo-code in the handwritten work on GitHub. We generally refer to the published work on GitHub for a more detailed view on our conceptual and practical development work as it would be out of the scope of this report to go into those details.

Algorithm 1 Rating using Colors

procedure RANKING($list\ Suppliers, list\ Ratios$) ▷ Ranking of Suppliers based on The ratios
  $max \leftarrow \max(Ratios)$
  $min \leftarrow \min(Ratios)$
  $rangeFrac \leftarrow (max - min)/3$
  $Ranges[3]$ ▷ Save start of Three ranges in this array
  for $i \leftarrow 0, 3$ **do** ▷ Initialize Ranges
    $Range[i] \leftarrow min$
    $min+ = rangeFrac$
  end for
  for $i \leftarrow 0, Suppliers.size()$ **do** ▷ Give each Supplier a color
    if $Range[0] \leq Suppliers[i].ratio < Range[1]$ **then**
      $Suppliers.color \leftarrow "red"$
    else if $Range[1] \leq Suppliers[i].ratio < Range[2]$ **then**
      $Suppliers.color \leftarrow "yellow"$
    else
      $Suppliers.color \leftarrow "green"$
    end if
  end for
  return
end procedure

3.3.5 Difficulties

During the implementation phase of our model, we ran into multiple issues that prevented us from carving out a more sophisticated end product.

Firstly, due to the large scale of our proposed model (cf. section 3.1.1), we struggled to decide which parts we should and would be able to realistically implement and to which extent. This led to some confusion and discussion over how we should approach the implementation of our model resulting in some loss of time.

Secondly, once we started to work on the simulation environment that was shown in the sections above, we ran into some compatibility issues with the provided Genesis framework. Our original plan was to embed the implementation into the 'Market' section of the GenesisApp, however due to issues related to the Activity Lifecycle and Fragments we were unable to do so. After a rather long time trying to debug these issues, we decided to outsource our simulation environment to a new Activity altogether as a makeshift solution. This cost us a lot of time that could have been used otherwise. Generally, time constraints were a big difficulty as this was the first hackathon experience for some of our development team, due to which issues with time were underestimated.

All in all, with a slightly better approach at the beginning and more experience a better outcome and end product could have been accomplished. However, we absolutely believe that with more time our model can be fleshed out into a well-functioning end product as described in section 3.3.1.

4 Evaluation

The project at its current state has to be regarded as a mostly conceptual and visionary system. Many questions could not be solved definitively and due to the very broad, encompassing approach there was not enough time to find solutions for all detailed problems. It depends on a great amount of assumptions, such as availability of producer data through blockchain storage, and relies heavily on trust into food producing/selling companies. Especially gathering valid and trustworthy data at a producer level is a challenge, as long as the manufacturing is not fully automated and digitally monitored yet.

Another question that arises is the one about participation, as it is a key point for our model to start working: why should a company or a consumer participate in this project? How can they profit from it? A lot of options were discussed and finally two main incentives emerged: for the consumer the most important reason to participate is a financial advantage they get by buying food close to expiry date. Furthermore, regarding people who try to live ecologically, the system provides information and transparency so they can make their decisions based on real-time data. What motivates the producers and sellers to participate in the project is the renown and positive reception from the consumers by being part of it. This could be part of a marketing strategy to shape the image of their company. The latter would also lead to social pressure on companies that do not yet take part in the system, as consumers will start to demand such a rating as it becomes more widely spread.

If testing showed that these incentives alone do not encourage enough businesses to join the project, there are several minor additional benefits that could be added in order for the idea to be more attractive. Given enough personal power on the provider side, special blockchain experts could help a company to improve data flow and production management based on the rating system. Most probably this leads to financial benefits for the participant, which is generally considered the most effective incentive there is. In addition, a company can learn a lot about its customers' shopping behavior, which can be very valuable information. In order not to violate the privacy of the involved users, these data transactions would have to be as transparent as possible while sharing as little personal data as possible.

5 Conclusion and Outlook

To summarize, what is the plausibility of the whole proposition? We think, aside of all the aforementioned challenges that would still have to be tackled and the many open questions and ideas, that need to be refined, our system is capable of developing enough drive to be self maintaining and gain enough importance to be a valuable long-term solution to the worldwide problem of food waste. As our approach is based on an existing economical cycle and on already in-place practices, imposing these ideas will be comprehensible and feasible for all participating parties.

But not only this: The potential benefits of using blockchain technology in the food industry also includes using an incentive system to encourage companies and consumers to invest in "green" products. It brings along increased transparency, easier access to product information, and more straightforward communication and flexibility between the different trading stages of the food production chain. Moreover, the rating and information app for consumers can help spread knowledge about food waste. All effects combined, the blockchain technology proves to have considerable potential to make food production safer, more efficient, and more sustainable.

Once the token system is established for food waste, it could potentially be extended to other sustainability dimensions, such as water use, energy consumption or working conditions. On the long run, this could lead to a profound improvement of the whole supply chain.

References

[1] http://foodwaste.ch/was-ist-food-waste/, accessed 26.02.18

[2] FAO. 2011. Global food losses and food waste - Extent, causes and prevention. Rome.

[3] Beretta, C., Stoessel, F., Baier, U. and Hellweg, S. (2013) Quantifying food losses and the potential for reduction in Switzerland. Waste Management 33(3), 764-773.

[4] Hic, C., Pradhan, P., Rybski, D. and Kropp, J.P. (2016) Food Surplus and Its Climate Burdens. Environmental Science & Technology 50(8), 4269-4277.

[5] http://www.un.org/sustainabledevelopment/sustainable-consumption-production/, accessed 26.02.18

[6] Kranert, M., Hafner, G., Barabosz, J., Schuller, H., Leverenz, D., Kölbig, A., Schneider, F., Lebersorger, S. and Scherhaufer, S. (2012) Ermittlung der weggeworfenen Lebensmittelmengen und Vorschläge zur Verminderung der Wegwerfrate bei Lebensmitteln in Deutschland, Bundesanstalt für Landwirtschaft und Ernährung (BLE), Stuttgart.

[7] https://news.trust.org/item/20171019113446-58t02, accessed 16.02.18

[8] http://www.fao.org/save-food/resources/keyfindings/en/, accessed 16.02.18

[9] https://theconversation.com/how-blockchain-technology-could-transform-the-food-industry-89348, accessed 16.02.18

[10] https://newfoodeconomy.org/blockchain-food-traceability-walmart-ibm/ accessed 23.02.18

[11] http://fortune.com/2017/08/22/bitcoin-ethereum-blockchain-cryptocurrency/ accessed 23.02.18

[12] https://www.coinist.io/te-food/ accessed 23.02.18

[13] https://www.te-food.com/ accessed 23.02.18

[14] https://hackernoon.com/blockchain-technology-is-transforming-the-food-industry-food-for-thought-ce6b46804245 accessed 23.02.18