Framework for Surplus Food Management using Data Analytics

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Abstract: Food wastage is a major problem faced by the entire world in various facets. The food waste not only impacts a country's economy financially, but also environmentally. The food waste leads to wasteful use of fertilizers and pesticides. More fuel is used for transporting the food to markets and surplus of it to garbage dumps. The wedding parties and functions in India stand as a prestige icon spending money lavishly on large number of variety dishes leading to food wastage. The rotten food creates methane – one of the most harmful greenhouse gases that contribute to climate change and global warming. Methane is twenty-three times more effective than CO_2 as a green house gas. A problem properly addressed is a problem half solved. Moreover, a solution to one problem can indirectly solve many other potential problems. Research is being done on how to minimize the food loss and wastage at the supply chain level but no models are developed to channelize the surplus food generated for its prompt utilization. There is an immense need of models that would facilitate the surplus food management to minimize the food loss and wastage with the community contribution and collaboration.

Keywords: Surplus Food, Supply Chain, Food Wastage, Data Analytics, Optimum Utilization, Cluster Pivot, Clustering, Decentralization.

Introduction

Food – the basic necessity of every living being has become a barely available luxury for many of the people across the world. According to the World Food Program's (WFO) hunger statistics, approximately 795 million people in the world do not have enough food to lead a healthy and active life. It is literally one in nine people across the world suffer from hunger [1]. The large volume of the world's hungry population lives in developing countries. Two thirds of the total hungry people live in Asia. 66 million primary school age children attend their classes hungry across the developing world, with 23 million in Africa alone [2]. [3] stated that the global food security crisis of 2008-09 led to deep and growing concerns about how to sustainably increase food productivity in the present scenario of continuous rapid population growth and worsening climate change. The most landmark study on international food waste, the UN Food and Agriculture Organization claims that "roughly one-third of the edible parts of food produced for human consumption gets lost or wasted globally, which is about 1.3 billion ton per year [4]." All the world's nearly one billion hungry people could be lifted out of malnourishment on less than a quarter of the food that is wasted in the Unites States [5].

Indians by nature are known to spend lavishly on weddings and parties on a large scale. In some cases, the waste is to the extent of 20-25 percent when the number of dishes exceeds the number of guests. A survey shows that annually, Bengaluru alone wastes 943 tons of quality food during weddings which is enough to feed 2.6 crore people a normal Indian meal.

The surplus food with function halls, restaurants, college hostels etc. if properly channelized would satiate the hunger of many people those who doesn't have access to proper food. This paper proposes a model for decentralized surplus food distribution which makes the entire process optimal, quick, and enables maximum utilization. Next sections cover about the literature review, proposed framework, the process overview, the role of data analytics in the optimization of the application, limitations of the model, future enhancements and thus bringing us to the conclusion.

Literature Review

According to the CSR Journal, Indians waste as much food as the whole of United Kingdom consumes. Food wastage is an alarming issue in India. According to the UNDP (United Nations Development Programme), up to 40% of the food produced in India is wasted. In fact, according to the estimates of the agriculture ministry, Rs. 50,000 crore worth of food produced is wasted every year in the country. India ranks 63 among 88 countries in GHI (Global Hunger Index) published by International Food Policy Research Institute (IFPRI). 300 million barrels of oil are used to produce food that is ultimately wasted.

[6] The way of functioning of the food supply chain results in the food loss and waste, culturally, economically, and technically. Loss occurs in storage, transport, and processing in the low income countries and investments are required to develop the value chain. Loss is at the retailer and consumer levels in high-income countries and requires distinct strategies to mitigate waste. There are a number of ongoing private-public, and public partnerships tackling wastage of food at the country level demonstrating the concern towards addressing the issue.

In [7], the authors emphasized the Micro economic conditions like the production theory and consumer theory, and Macro economic conditions like infrastructure, urbanization and socio-economic growth, trade and globalization, and unemployment that would culminate to food losses and wastage. They also stressed on the non economic conditions like culture and societal norms, social aspects, environment and climate, policy, legislation, and private standards that would result in food losses and wastage.

Besides the micro and macro economic conditions that lead to food loss and waste, its impact on economy and environment is negative and threatening. With respect to economy, they represent a wasted investment that can reduce farmers' incomes and also increase consumers' expenses [8]. With respect to environment, food loss and waste pose a host of impacts, including unwanted greenhouse gas emissions and inefficiency in usage of water and land which in turn can lead to degraded natural eco systems and the quality of services they provide.

Research and subsequent actions are in progress to address the food loss and wastage at the food supply chain level, and to mitigate its affect on the environment and economy. In [9], the author analyses the role of food banks in Canada in terms of advancing the human right to food, their effectiveness in achieving food security and the extent to which they contribute to the increasing emphasis by governments on welfare reform policies informed by neo-conservative ideology.

The India Food Banking Network (IFBN) is evolving an ecosystem for food security to support number of feeding programmes in India by bringing the private sector, government sector, and NGOs together under one roof to fight hunger and malnutrition in India. IFBN aims to achieve this by establishing an efficient and strong network of food banks throughout the country, so that every district has access to minimum one food bank by 2020 [10]. IFBN's stakeholders constitute global, domestic, and local community partners who voluntarily contribute to support its development and humanitarian projects. IFBN invites organizations and individuals to collaboratively work with them to eliminate hunger in India. The IFBN runs on donations from companies involved in large scale processed food production. They support IFBN by giving food which is stocked as unsaleable and can't be put into supply chain. This stock is perfectly good for consumption and put across all food quality checks. Sam Pitroda, Chairman, Food Security Foundation India, India FoodBanking Network, urges the need to focus on hunger with a community driven responsibility.

The above studies discuss about the food loss and wastage at different levels of food supply chain but the problem of dealing with the surplus food that is being thrown into the garbage dumps which would otherwise feed lots of needy people is not being addressed adequately. The food wastage in mostly not because it is stale but it is made in excess sometimes because of wrong predictions about the intake quantity and sometimes as a result of status icon that increases the number of dishes than the number of guests. There is a clear research gap for the optimization of this surplus food distribution process in India. There are some organizations that collect surplus food and distribute it to the needy but they are dedicated to specific localities and most of the work is being done manually. This makes the distribution process slow, transportation costs higher and the food may be spoiled before it reaches the targeted people. Moreover, the amount of surplus food generated can't be predicted before hand to make necessary preparations for its distribution.

This paper proposes a framework for surplus food management as an easy to use mobile application that decentralizes the entire process with minimal administration but maximum outcome.

The Proposed Framework

In this paper, we refer to the excess food as not waste food but surplus food as it deserves a respectable mention because it can satiate the hunger of people who are in real need of it. The model proposed by this system makes the distribution process easier and faster before the food gets spoilt and enables proper utilization of the same. It involves the citizen volunteers as part of the process who can understand the value of food.

The model constitutes four modules – the registration module, the communication module, the logistics module and the data analytics module.

The Registration Module

The module allows three types of users to register namely, the Donor, the Volunteer and the Receiver. Figure 1 depicts the users of this application.

The ***Donor*** can register with the details like name of the organization or function hall or restaurant or hostel, address with PIN code, contact number, volume of surplus food that would be available and the pickup time at which it can be collected. The advantage of this application is that the donor need not register long before to utilize the service of the volunteers. They can check the approximate amount of food that will be left out in next one or two hours and then register for the services. Already registered users can utilize services by submitting context specific details.

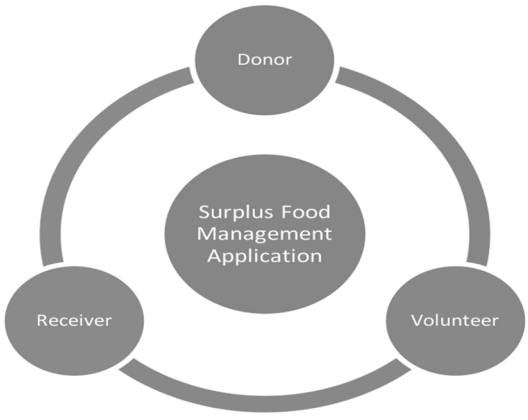

Figure 1. The users of the application

The ***Volunteer*** is any common man who is interested to serve voluntarily with his time as a valuable investment. The volunteer registers with his/her name, address with PIN code, contact number, contact time (during which he/she would be able to serve a delivery), and vehicle type (two-wheeler or a four-wheeler) which they possess to estimate the capacity to deliver.
The ***Receiver*** which may be Non Government Organizations (NGOs), Non Profit Organizations (NPOs), orphanages, old age homes, food banks etc. can register with their organization name, address with PIN code, contact number, and number of benefiters in their organization or through their organization.

The Communication Module
The module communicates the availability of surplus food with any organization, to the volunteers after some data analysis (discussed in the next sections) so that all the nearest volunteers get the "Accept Delivery" message with the source and delivery addresses. Depending on the number of volunteers required, when the module receives the number of required "Request Accepted" notifications from the volunteers, it will immediately communicate to the rest of the volunteers in the cluster that the delivery is accepted and their services will be utilized next time. The communication module also notifies the receivers through a message about the food to be supplied so that they can make necessary arrangements to utilize it within the organization or dispatch it externally to the targeted people after performing quality checks for the food received.

The Logistics Module
The logistics module deals with minimizing the transportation cost for the volunteers by selecting the nearest volunteer and connecting him to the nearest receiver, and ensures maximum comfort while delivering by assigning the delivery quantity to the volunteer based on the vehicle type or capacity the volunteer posses and the address to which it has to be delivered.

The Data Analytics Module
The crucial part of the entire system is the data analytics module which needs special emphasis in the next sections.

The Process Overview

The role of Data Analytics in decentralization and optimization process of Surplus Food Management is of ample importance as the delegation and distribution process makes the model more effective with good impact on the users and benefiters of the application.
Let us consider pin code value around which the cluster is built as the **cluster pivot.** After each registration by the user is completed, the algorithm for the clustering process will run creating clusters as follows:

Algorithm: Cluster_Formation
Input: Record of the registration details of the donor or volunteer or receiver.
Output: New cluster is formed or existing cluster is updated.

1: The PIN code attribute is compared with existing cluster pivots.
2: If the PIN code = = cluster pivot then go to step 3 else go to step 4.
3: Assign cluster ← input record.
4: Create a new cluster with PIN code value as the cluster pivot.

The clusters are activated when minimum one donor, one receiver and multiple volunteers are added to it. Otherwise they remain passive till they reach the minimum requirement. The outcome of the algorithm can be depicted as shown in Figure 2a.

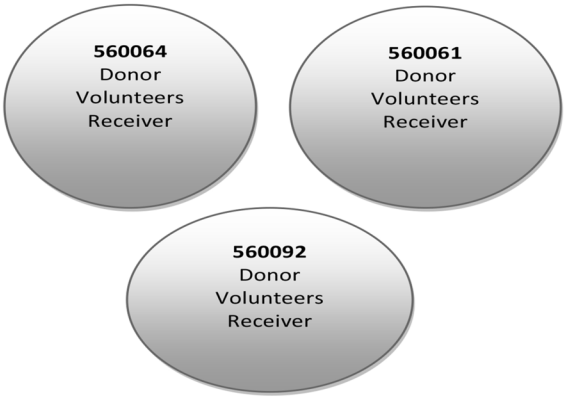

Figure 2a. The Clustering Process output based on PIN code as the cluster pivot

It is ensured that the members of a cluster belong to the same PIN code. This helps in minimizing the pickup and delivery time and also to minimize the cost of transportation for the volunteer. Further the Volunteers are formed into sub clusters as shown in Figure 2b, based on their contact time so that they will not be disturbed with any SMS in other timings. The same cluster formation algorithm discussed above applies to the sub-clustering process also, this time the cluster pivot being the contact time of the volunteers.

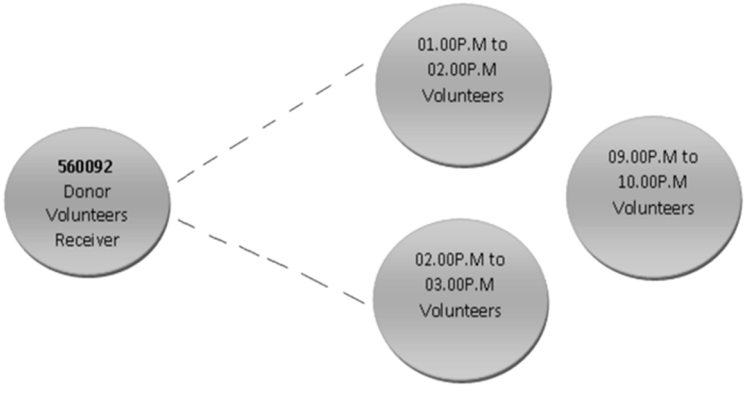

Figure 2b. The Sub Clustering Process based on contact times of the Volunteers

The volunteer sub-clusters will have a separate mechanism deployed for receiving the messages. When the message is received from the donor about the surplus food availability, the application links it to the appropriate cluster. The cluster generates a call to the Message_Volunteer procedure of the sub-cluster. It sends a notification to all the volunteers matching the pickup time with the donor to the contact time of the volunteers with a request to accept the delivery. The number of volunteers required per request is decided by the amount of surplus food available with the donor and the vehicle type available with the volunteer.

Procedure: Message_Volunteer
Input parameters: Pick-up time, Volume of surplus food

1: [Initialize] i=1;
2: Repeat
    If ((pick_up = = contact_time) && (volume = = delivery_capacity)) then
        Notify the volunteer;
    Else

Continue with the next iteration;
Until the total number of volunteers are notified;

Once the required number of acceptances from the volunteers is received, rest of the volunteers will receive another notification that the request is responded and their services will be utilized for the next time. This enables prompt usage of the volunteer services avoiding multiple responses. The application simultaneously messages the receiver about the surplus food availability so that they make necessary preparations for using it internally or distributing it externally. The receivers make the food received pass through quality checks before distributing the same.

The process flow is depicted by Figure 3.

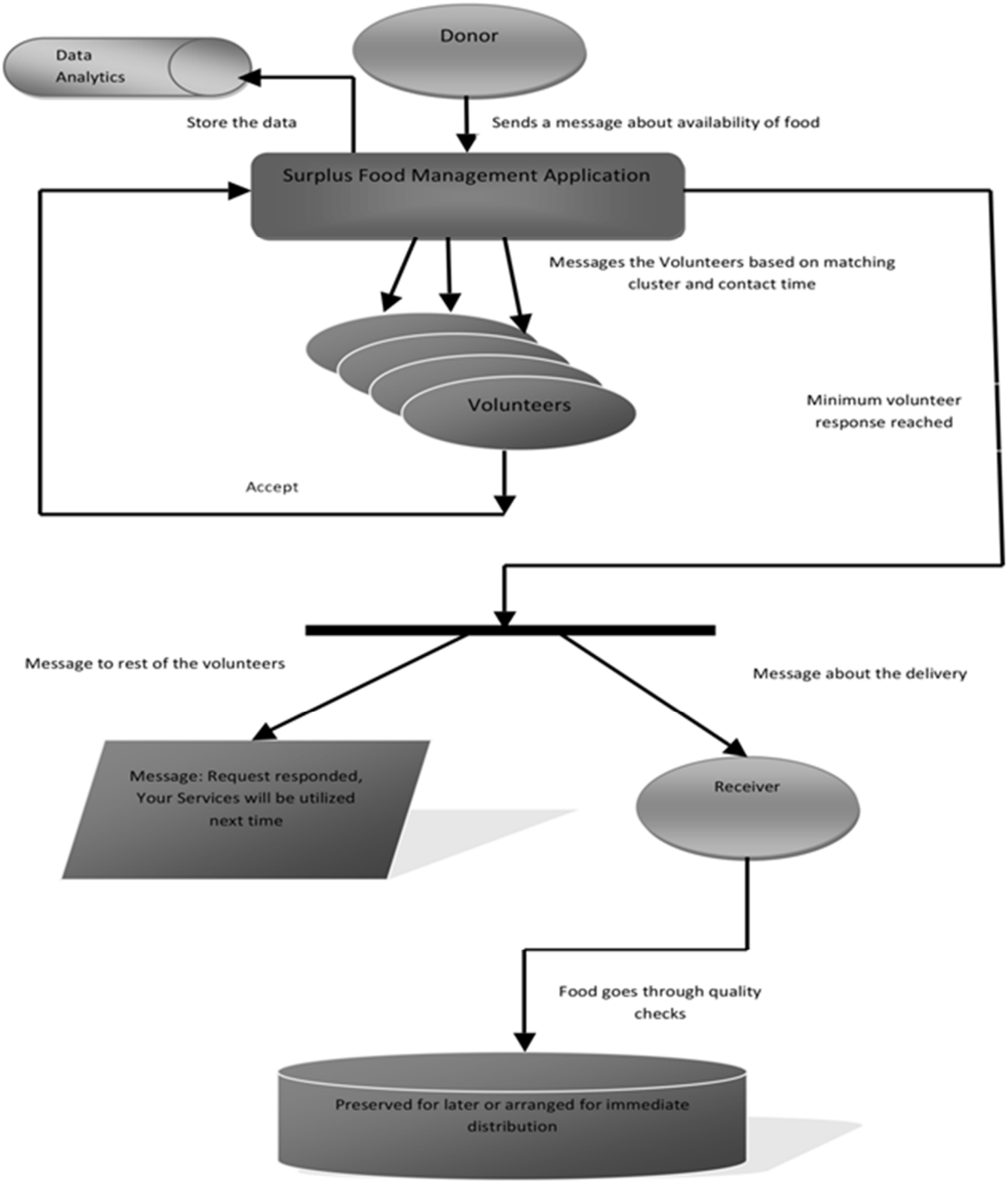

Figure 3. The Process Flow

Role of Data Analytics in Optimization of the Application

The data about the donors, volunteers, receivers, and each of the transactions is recorded for further analysis. The framework uses Multidimensional Online Analytical Processing (MOLAP) server which uses multidimensional storage engines that are array-based for multi-dimensional views of the data. The storage utilization will be low with multidimensional data stores if the data set is sparse. This works efficiently with passive clusters and saves the storage till they become active. The data analytics part uses various OLAP operations such as Roll-up, Drill-down, Slice and Dice, and Pivot to unveil and answer interesting questions like–

- Which season of the year is maximum surplus food generated?
- Who are the volunteers that contribute most of the time and what is their profile?
- Which type of donor generates most of the surplus food?
- How much food is being saved from being dumped into garbage?
- How well the process can be optimized to allow inter-cluster contribution if excess surplus food is being generated within one cluster?

These questions can help the application to reorganize the clusters for improving the efficiency of the system. For inter-cluster contribution, the data points can be temporarily reorganized to share the surplus food with other clusters if more surplus food is available within one cluster. The model thus refines itself periodically to give optimal performance and optimum utilization of surplus food.

Limitations of the Model

- Distributed architecture works well only if there are sufficient number of data points in each cluster.
- Application success depends on the committed participation of the citizen volunteers.
- The clusters remain passive till the minimum requirement for the cluster formation is met.

Future Enhancements

More work has to be done on the cluster reorganization and inter-cluster sharing of the surplus food. Inter-cluster communication and sharing becomes a complex objective to be achieved as the pin code values which serve as cluster pivots do not exactly represent adjacent or nearby areas. This makes balancing surplus food among the clusters a challenging task. In this scenario, an alternative for cluster pivots have to be selected that enable inter-cluster sharing easier and cluster reorganization smoother.

Conclusion

The model proposed in this paper tries to address the problem of surplus food management in a decentralized and efficient way with the community collaboration. The entire process is decentralized to ensure quick and optimum distribution and utilization of the surplus food. The clustering concept used for grouping the donors, volunteers, and receivers will help the application to reduce the transportation cost, and delivery time. Moreover it requires minimal administration as the process is decentralized. The data analytics help the application to iteratively refine itself for reorganizing the clusters to enable inter-cluster collaborations in instances when some of the clusters generate more of the surplus food than what is utilized within the cluster. The application has to be intensively publicized before it is released so that the community collaboration is maximized for the expected outcome.

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