An IoT Based Business Strategy to Minimize Inefficiency in Food Supply Chain: Feed the Hunger

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Abstract: To answer these questions, today, the emergence of the Internet of Things (IoT) based mobile technology can help resolve the inefficiency in food supply chain and it provides a solution to feed the hunger problem. The IoT based mobile technology can connect intelligent and sensor devices to communications networks. Therefore, this research paper offers an IoT mobile technology based business strategy to minimize the waste in food supply chain. It also suggests an innovative solution to use the remaining food to feed the hungers while maintaining the food's high quality and optimal delivery time.

Key words: Food waste, food management, food shortage, food waste, internet of things, IoT, mobile apps.

1. Introduction: Food Insecurity and Waste in the U.S.

People still face food shortages and food insecurity, a concern where people do not know where their next meal will come from - or whether they will be able to afford to eat their next meal. In 2015, 42.2 million people in the U.S. suffered some aspect of food insecurity, whether for a day, week or year. The 42.2 million people account for 13% of households in the U.S; about one-third of the affected are children. States with the highest food insecurity rates are: Mississippi, Arkansas, Louisiana, Alabama and Kentucky.

Although food insecurity varies regionally, it is a problem that affects all states and territories within the United States.

There are tremendous inefficiencies within all facets of food production. Retail and commercial customers are critical of misshapen or bruised produce and meats. Perishables are given conservative "sell by" and "expire by" dates, and often, fruits and vegetables decay and rot right where they are grown, without ever being harvested. Corn, soybeans and wheat account for the biggest crop production, while chicken and cattle account for the biggest meat production.

The states with the highest food production are: California, Iowa, Texas, Nebraska and Illinois. According to the USDA, 27% of all the food produced each year in the United States is lost at the retail, consumer and foodservice levels. The loss accounts for nearly 1.5 tons of wasted food per year which could help sustain every man, woman and child in the United States who face hunger. In other words, the citizens of the United States throw away about 263 million pounds of food every single day. More telling, much of what is wasted is surplus food that is perfectly edible. Food companies spend millions of dollars in research aiming to attract customers who buy in bulk, yet never finish consuming their products before expiration. On the reverse side, there are unfortunate individuals who are having a difficult time simply meeting their dietary caloric and/or nutritional needs. According to Material Impact Inc., "food waste is an environmental, social,

financial, and health problem", and according to a report from the USDA that was released in February 2014, "…31 percent—or 133 billion pounds—of the 430 billion pounds of the available food supply at the retail and consumer levels in 2010 went uneaten (in the United States)".
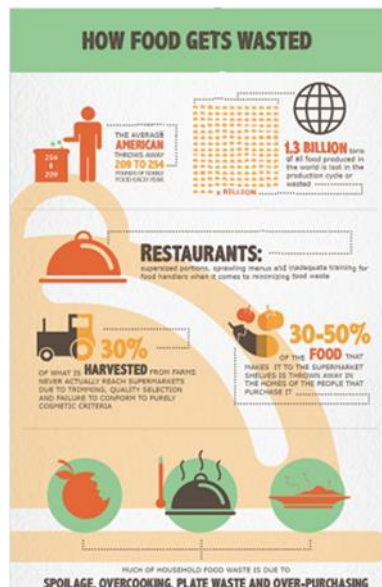

Fig. 1. Food waste in the U.S.

In this study, we propose a cloud based the Internet of Things (IoT) business strategy to food cycle management (FCM) that collects, inspects and distributes food to people in need. This IoT based business strategy will ensure food is of the highest quality, delivered on time and prepared in optimal settings.

The proposed solution will assist with the collection and delivery of edible foodstuffs fit for human and animal consumption. Food that has been healthy and deemed inedible for human consumption can be collected and sold to zoos, farms, and even companies, which produce organic fertilizer.

Therefore, objective of this study is to offer an IoT technology –based business strategy to provide and distribute so-called waste foods to the people in needs. According to Zhibo Pang et.al [1], the revenue accumulated from our customer-base will cover operational expenses and provide the necessary infrastructure to support our cause.

2. The Internet of Thing (IoT) and Food Supply Chains Management

The term the Internet of things was first used by Kevin Ashton of MIT in one of his seminal articles about this subject [2], [3].

Todays, there are tremendous interests in the Internet of things (IoT) within academia and industry, who are interested in connecting intelligent and sensor-enabled devices to telecommunication networks, including or the Internet. According to Michael Miller, "The Internet of Things combines a variety of technologies into a semi-autonomous network" [4]. These networks can be the Internet, clouds, wired, or wireless networks [4], [5]. According to European Commission's Information Society in 2008 strategy [6], the term IoT is associated a cyber-physical system (CPS) and its key enabling technologies include information and communications technology (ICT), wireless sensor networks, radio frequency identifications devices (RFID), Machine-to-Machine communications (M2M), and human-machine interactions. The IoT or CPS senses, gathers, sensor data from variety of sources, then, it stores, processes and transforms it into them into useful information in cyber world, and finally it transmits through any telecommunications or cloud networks for appropriate applications [1].

Furthermore, today, the IoT applications are becoming increasingly pervasive that include environmental and energy management, healthcare, smart cities infrastructure, particularly in food supply chains management [3], [4]. The IoT's applications will continue to grow particularly in smart cities smart infrastructures development, environmental and energy management and supply chains management. The applications of IoT in food supply chains have been in recent years in various studies [1]. However, its comprehensive applications in food supply chains are still in early stages of maturity [1], [7]. Therefore, the existing IoT based business strategies can resolve only a part of the food supply chains management problems. According [8]. Martinzes-Sala *et al.* and Jones [9], a number of existing studies of IoT's benefits to users are limited only to RFID technology [8], [9]. Furthermore, Zhibo Pang *et al.* [1] have studied the applications IoT in only supply chains management. But, so far exciting studies of food supply chains management do not offer IoT technology–based business strategy to provide and distribute so called waste foods to the people in needs.

Therefore, this study attempts to overcome the above drawbacks. In particular, we intend to propose a cloud IoT based business strategy to design a better solution to resolve the waste food supply problems in a more comprehensive way.

Applying the IoT services to feed the people in needs has many benefits including: it is beneficial in protecting our environment; and it helps us to save some portions of the edible (healthy part) so called waste foods to minimize the level of hunger in communities.

3. The IoT Based Business Strategy

The core activities of Food Cycle Manager are Collection, Inspection, and Distribution. The actors involved in the system are the producers (restaurants and homes), sellers (food markets), consumers (households, restaurants, animals and zoos), volunteers/employees, technical support, and marketing. Technology has always been a vital part of the business, but with the advent of IoT and mobile social media, organizations have revolutionized its way of business. In food cycle management, IoT based solution becomes the interface to the business. It is the single most important asset to the organization that helps keep all parties connected. Food cycle management also serves as the backbone of the business from collection to distribution. IoT based business strategy for food is comprised of several modules, which keep all parties well informed and connected.
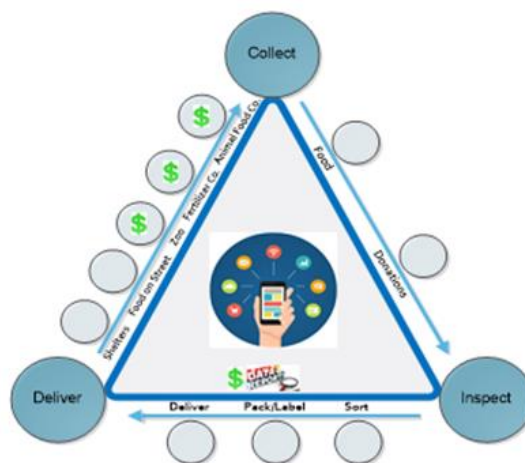

Fig. 2. Activities of food cycle manager.

3.1. Customer Module

The first module pertains to the customer. The customers will likely be diverse with industries spanning across zoological realms, animal processing factories (such as Purina, IAMS, etc.) and organizations, which produce bi-products from unconsumed food. The entire process begins with customer data collection, which can be utilized by the marketing department to make informed decisions about when food should be collected and when to issue discounts or coupons to customers. The customer is the primary point for collection and distribution of food.

3.2. Customers Relationships Module

Relationships explored with the customers will become the lifeline of this project. Well-trained staff will be responsible for serving existing customers and bringing in new customers. The Customer Relationship Module of the strategy will allow both parties to conduct business with informed decisions. Customer's expectations and trust will be maintained for all services we provide. Food Cycle will inspect sealed packages and foodstuffs that have been opened will be ground up and sold as feed for animals. Additionally, food consumption trends among our customers will be collected and aggregated for comparison analysis. Data analytic solutions can be used to rank the customers. The customer can also earn a rank based on the amount of waste they produce and how much food is cycled. All of this information will be stored securely within a cloud-based infrastructure.

3.3. Resource and Channels Modules

Key resources to be used with the Food Cycle Manager will include various food markets, fast food franchises, restaurants, and simple donations from individuals.

The collection and distribution of foodstuffs will be accomplished through the use of special trucks equipped with refrigeration systems to keep the food from spoiling. Distributed food will be recorded through the use of label scanners and barcodes affixed to the packaging. The labels will serve to inform inspectors and customers of what products are due to be delivered.

3.4. Key Activities Module

Key activities include food collection based on smart routing, inspection of foodstuffs by certified inspectors, grouping, sorting, packaging and distribution. These activities can be further sub-divided into detailed tasks. For example, after inspection a package can go to a company that makes animal feed, or it can be delivered to a homeless shelter for dinner. If the food is fresh enough, it can be delivered at the street level to a hungry individual or group.

3.5. Revenue Streams

Considering business prospects, the revenue avenues are based on carefully chosen geographic locations. Also, the central office and equipment will be arranged appropriately to keep customers and potential opportunities in mind. The primary source of income will be the companies that produce foodstuff waste. When FCMMA matures, raw data and canned reports can be sold to research organizations, used for marketing purposes, by medical companies, or other consumers of raw data. Advertisements of business partners can also bring residual additional income. A small percentage of this would come from either foodstuff or monetary donations.

4. IoT Based Food Cycle Management Infrastructure

In order to collect accurate and quantifiable data from IoT based food supply chain, there must be sufficient cloud-based resources that are highly available (HA), redundant, and secure.

Reliability and availability are a critical element in food business safety is an important issue. Therefore,

reliable communication is a key factor in service provisioning. Food supply chain utilizes cloud based IoT services to facilitate the safety of foods and effective communications in food distributions.

There are significant advantages to hosting the infrastructure in the cloud; chiefly lower costs, rapid scalability and ease of collaboration. The database will be clustered and will have set replication intervals between multiple nodes to ensure data is readily available no matter what site the information is pulled from.
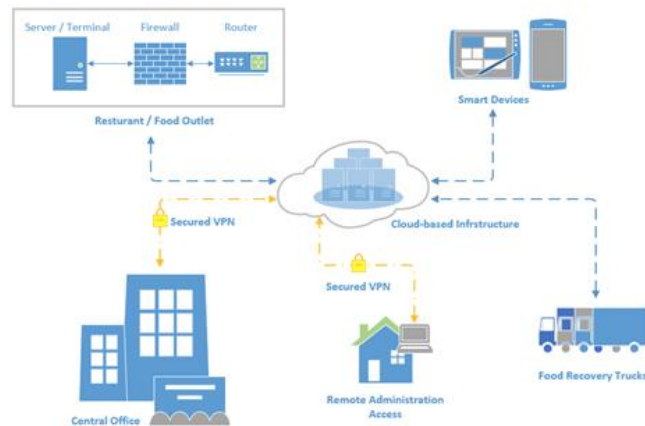

Fig. 3. IoT cloud-based infrastructure.

Infrastructure security is of paramount importance. Using private cloud services can also enhance the IoT services' security. The private cloud services offer secure communications among the mobile devices.

As hackers continue to successfully gain access to corporate resources throughout the world; it is important that FCCMA harden administrative access to our infrastructure. One of the biggest known attack vectors is when a logon account becomes compromised. It is planned to utilize two protective mechanisms, which aim to minimize logon risk: Utilizing One-Time Passcodes (OTP) for multi-factor authentications and VPN tunneling.

These two technologies work together by providing a secure two-way connection whenever access is negotiated remotely. For example, an Administrator who decides to work offsite when conducting work will start a VPN connection. First, the admin will be presented with a logon prompt requesting his/her username and password. Once submitted, this information is sent to the firewall/VPN appliance and checked against a directory for validity. If valid, an acknowledgement will be sent back presenting the admin with a request to enter a One-Time Passcode. Once entered, this secondary information is checked against a Radius server for validity and access is either granted or rejected.

5. The Mobile IoT Applications

At the core of the business we need to have the mobile IoT application that keeps all parties connected throughout the supply chain. The Internet of Things products based on smart phones or tablets are highly mobile. Therefore, the solution proposed in this study provides high mobility to its users and functional operators. This solution also supports the Food Cycle Managers internal processes as well as its' external processes for food donors and recipients alike. To maximize the potential reach of our customer base, the mobile IoT services will be optimized for iOS and Android devices. The mobile IoT supports collection processes by connecting donors (producers, sellers, consumers) with valid collection points. The mobile IoT will also convey to the customer at which transition point the food is at from inspection to distribution. Food not fit for human consumption will be repurposed to feed or fertilizer and will be sold through

distribution channels from within food supply chain. Once food is available, customers have the ability to search for food nearby, query our database for applicable recipes and view personal health recommendations based on collected user data and existing FDA guidelines.
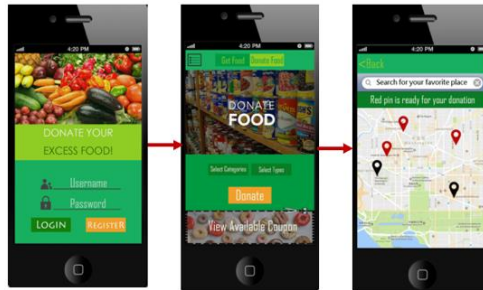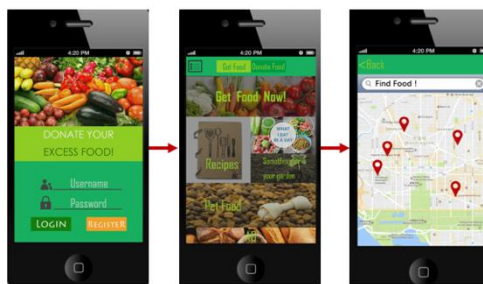

Fig. 4. Donating food into FCMMA.

Fig. 5. Locating food for pick-up within FCMMA.

To get started, users of the IOT based food supply chain must create accounts with a username and password and supply general health information in order to provide a customized experience. Once logged in, users can navigate between two main screens: 'Get Food' and 'Donate Food'. Donors can navigate to 'Donate Food' and have the ability to tag donations by food type and level of freshness. After the donations have been tagged with metadata, will utilize the Geospatial Information System (GPS) chip built-in the customer's device to locate the nearest donation centers and drop-off points. After which the process flow completes, donors can expect to collect coupons.
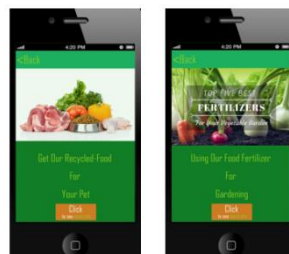

Fig. 6. Locating deliveries within FCMMA.

Once logged in, customers can toggle to the 'Get Food' screen to search for food based on their current location or variety. Customers can also view proper food storage techniques, purchase low-cost animal feed

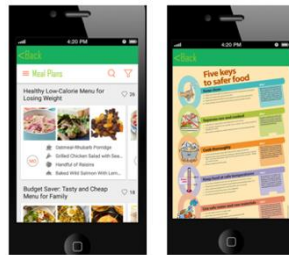and organic fertilizer, or make use of health education tools.

Fig. 7. Generating profit and providing education.

This screen features the in-app advertisements of mobile IoT, which aim to offset the costs, associated with developing and maintaining the food cycling program and related infrastructure.

6. Conclusion

Today, food supply's efficiency and food wasting have been problematic. This problem contributes to increasing number of people who suffer from famine. Therefore, the efficient use of so called waste food and distributing it appropriately among the people that need it or using the wasted food in other areas, such as agriculture, have always been ineffective at best, many times accounting for the leading cause of death and starvation throughout the world. Unfortunately, even with the technology available today, food distribution remains a problem both locally and abroad.

The adoption of IoT based mobile technology can help those in need. This study offered an IoT based business strategy to minimize the inefficiencies in food supply chains. This technology based business strategy will ensure food is of the highest quality, delivered on time and prepared in optimal settings.

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