A Cloud-Based Vegetable Production and Distribution System

Alireza Ahrary and D.A.R. Ludena

Abstract The new paradigm of Big Data and its multiple benefits have being used in the novel nutrition-based vegetable production and distribution system in order to generate a healthy food recommendation to the end user and to provide different analytics to improve the system efficiency. As next step in this study, a new multidimensional matching algorithm was proposed in order to provide the end user with the best recommendation. The new multidimensional matching algorithm is 10 times faster than the standard algorithm based on the test with sample data. Also, different version of the user interface (PC and Smartphone) was designed keeping in mind features like: easy navigation, usability, ergonomics, etc.

Keywords Big data · Computer science · Data systems · IoT · Data analysis

1 Introduction

IoT share a common agreement regarding its definition, as we could express it as the seamlessly integration of internet-based sensors and devices in a wide area network that interact with a much more advanced Personal Area Network, allowing us to recognize in a much more detail manner the surround environment and interchange information with it, in an automatic manner. The future applications and research based on IoT will aver a profound impact in the user side, since most of its application will be in areas like: domotics, health, agriculture, intelligent services, etc.

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Although IoT research is in its early stage in terms of development, it represents a challenge from the ethical and technological point of view.

Standardization is a mayor issue in IoT, different companies as well as independent organizations has tried to solve this problem with no success so far, or with no general agreement about a single methodology [1–5].

2 ICT Agriculture in Japan

Only industrialized countries were able to afford the high cost required to implement ICT solutions in agriculture. In that context Japan was one of the first countries to adopt and research about the introduction and use of ICT in Agriculture.

Japan represents a unique set of characteristics in the case of farming, among several we can extract the most important:

1. Difficult Geography

Japanese geography is one of the most challenging in the world due to the mountainous characteristic of the land. Japanese farmers had to create innovative methods in order to take the most of the restricted area useful to grow crops.

2. Farmers' aging society

One of the biggest problems for farmers and for the Japan in general is the fast peace growing age society. Specifically, farmers are used to pass their knowledge from generations, but the current scenario is leaving farmers with few or no generations, since their kids decide to migrate to the city on order to find a working position in manufacturing companies. This phenomenon is reducing at an alarming peace the number of young farmers putting in risk the continuity of the business.

3. Globalization

Japanese agriculture has key products in the year, their high quality means high prices in most of them and together with a strict quality control of the produce by the governmental regulator, creates a challenging scenario for farmers all around Japan. This scenario selects the best products at a high price but the ones that slightly do not accomplish its high standards are not selected and farmers have to find the way to commercialize these products.
The former scenario is becoming even more challenging since the Japanese government decided to sign different Free Trade Commerce (FTC) Agreements with different countries, specially in the Pacific Rim area, to provide Japan with different types of produce at lower prices than the local farmers. This increasing competition is making even more challenging the scenario for Japanese farmers.

3 The Academic Point of View

Japanese Academic institutions decided to use cutting edge technologies in order to provide the better solutions in the near future. Among those technologies are;

1. Sensor Networks

The use of different specific-application designed sensor in a network array connected to a high-speed networks, allow information exchange among different business partners. This sensor network is the core of multiple application layers that will be built over the information provided.

2. Cloud Computing

Many current applications, from storage to Software As a Service (ASA) are using this common affordable platform in order to reduce their hardware expenses. The information retrieved from the sensor networks could be processed or stored in the cloud for future purposes.

3. Augmented Reality (AR) Solutions

Using AR solutions, farmers could retrieve information on their lands effortless and in real-time. The crop information is retrieved from the sensor networks. A good example of this is the use on the field of Google Glasses, which can use the retrieved information previously stored in cloud-based databases, or to process it as well in the cloud.

4. Use of Unmanned Air Vehicles (UAV)

For supervisory/monitory purposes a new trend is the use of UAVs. Among the supervisory applications are: monitor plant growth, insect pests, plant and animal diseases, natural disasters, etc. the low-cost of this solution could serve as a good replacement for satellite-based applications.

5. Control Area Network (CAN)

The data generated by the different agriculture machines, e.g. yield of pesticides, production, etc., can be stored in the cloud as well.

The main disadvantage in the case of Academic ICT for Agriculture projects is the development cost and cost performance. For small size lands, the development cost is high compared to their large size counterparts and the cost performance is low. Another problem academic projects faced is the lack of long term research funding. Due that a highly politicized area like Agriculture in Japan is, research funding suffers the same issue.

4 Project Description

Farmers have been facing different challenges related to their business due to different reasons. In order to solve part of their problems and to create a new business platform the project "Novel nutrition-based vegetable production and distribution system" was created. The initiative of the project was to help farmers with their produce commercialization through the use of technology [7–10].

The creation of this innovative business model required the execution of different steps shown in this section.

Members and their functions and interconnections are defined as a first step.

1. Farmers
   In addition of representing the main project's benefits users, farmers represent the most important information provider. The information provided is vital in order to make the project work.

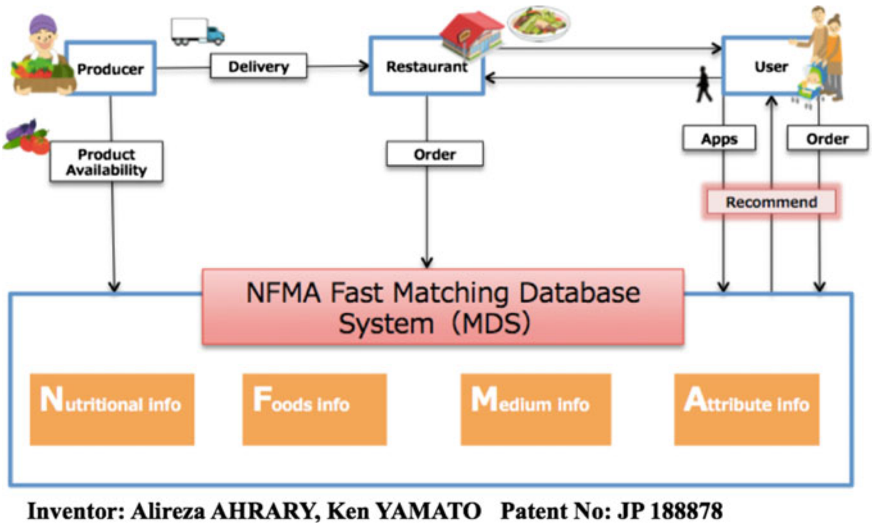

Fig. 1 Project perspective

2. End Users
   Although farmers are the ones that will benefit from the project, en users will be the ones taking most of the total benefits. Since the project is based on the use of the platform by end users.
3. Restaurants
   The "Ready meal" option represent here by the restaurants uses the vegetables provided by local farmers.

4. Knowledge Based Database Creators
   Two (2) databases were created during the project development.
   4.1. Nutritional requirement information
        User's nutritional information, e.g.: user's physical information, status information, physical condition, nutritional requirement, etc.
   4.2. Food information
        Food/vegetable information, like: nutritional calories, traceability, seasonal information, etc.
5. Project Integrator
   Sojo University represents the Project Integrator, meaning it will receive the different information presented previously and generate two additional databases:
   5.1. Platform information
        User's device details e.g.: mobile, tablet, Web, downloaded application, etc.
   5.2. Attribute information
        Information used at the registration procedure, e.g.: gender, age, family structure, etc.
   5.3. Recommendation generation algorithm
        A recommendation algorithm is designed in order to correlate the different created databases previously mentioned. Its objective is to generate a recommendation to relieve the user's symptoms based on the information provided by the user.

A project perspective is shown in Fig. 1.

5 Possible Threats Against IOT

For the specific purposes or the project we focus on the security analysis on two main aspects: authentication and data integrity.

Authentication and data integrity are two of the major problems related to IoT. Authentication is difficult in IoT due to its infrastructure requirements and servers that perform the authentication process through the information exchange with other nodes. In an IoT environment this could result not practical due to that RFID tags cannot exchange too many messages with the authentication servers because their issues related to energy management and messages standardization, this issue applies as well to sensor networks. Energy issues are one of the most difficult to overcome in RFID networks as well as sensor networks, due that there are scattered over a wide area and sometimes unmonitored, energy management is a key factor in order to ensure a long device life as well as usability. In the same manner, some authentication protocols could not be used due to their lack of standardization.

In this context, several approaches were developed for sensor networks [78 reference paper]. In these cases gateways that are part of the sensor networks are required to provide connection to the Internet. In the IoT scenario sensor nodes must be seen as nodes in the Internet, therefore authentication is required in order to differentiate them from sensors in the same area but not belonging to the same network.

In the case of RFID several approaches were presented, but most of them have serious issues, some of them mentioned in [6].

The "Man in the middle" attack is considered one of the biggest threats against wireless networks as well to IoT networks. Data integrity solutions should guarantee that the data in transaction cannot be modified and the system must be able to detect this situation. Data integrity as a issue has been extensively studied for standard network applications and communication systems and early results are related to sensor networks [11]. But, when a RFID networks with their own unique characteristics are included in the current Internet paradigm, different problems arise as well as unforeseen problems related to their use. Several approaches are developed or under research to solve the different new RFID related issues i.e. EPCGlobal Class-1 Generastion-2 and ISO/IEC 18000-3, both of them working in different process to protect the device memory. These approaches also consume large amount of the resources in encryption processes needed. The main used resources are: energy and bandwidth, both of them in the destination. Therefore, even using these approaches specific related problems with RFID still remain.

6 Matching Algorithm

Relational database (RDB) represent a one data management method that is most commonly available in the data warehouse (DWH) database. Relational databases (RDB) stores data in, such as with spreadsheet software Excel Table (Table) structure. The table is a "column pattern" specifying the data item. If, for example, food and beverage stores sales specification, sales date and store name, time stamp, membership number, customer name, primary contact, cashier, menu, quantity, tax amount, consumption tax, such as the total amount of money, etc. represent the data items. Each of the record in a form of a value represents a "row pattern".

Large amount of data is accumulated in time series in data warehouses (DWH). When data is analyzed, a pattern is often uses for that purpose. Focusing on the former characteristic, the speed of the aggregation process is an important issue. The proposed algorithm uses a space-filling curve version of the three-dimensional Hilbert curve (Fig. 2a). When storing a multidimensional value, it calculated whether the attribute value is the ordinal number on the Hilbert space-filling curve and store it as a key. Next, generated keys are stored in a three-dimensional space to perform a multi-dimensional search procedure (Figs. 3 and 4).

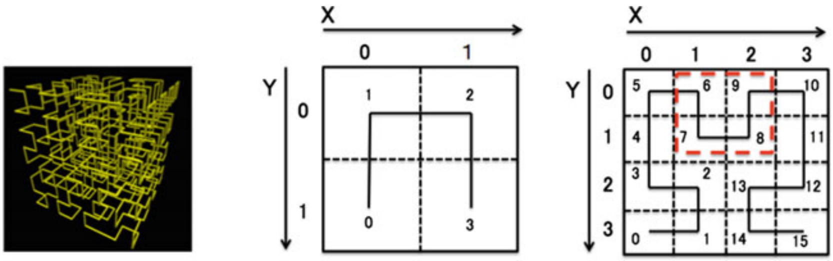

Fig. 2 (a) 3D Hilbert Curve (b) 2D Hilbert Curve (c) Search range example

Furthermore, close areas properties are defined and indexed in one table. Seeking the maximum key value in the search range, and the output is mapped into one dimension.

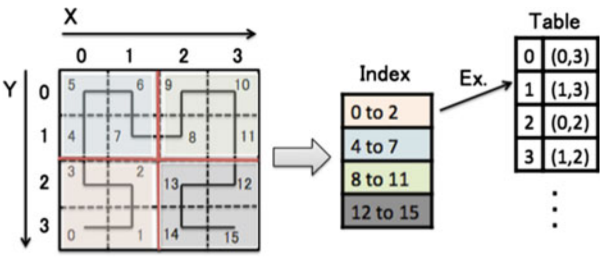

Fig. 3 Table registration

The proposed algorithm performed 10 times faster than the conventional method (KVS-HBase).

In addition, it is possible to dynamically register: restaurants, recipes (independent of the number), ingredients, and dynamically perform associations between each database (Independent of the number) to design the cloud-based system. Having an increase in the registered information will not require any modification in the system, making it elastic. 25 users, 20 recipes and its association with 15 food items are the target numbers in this stage of the project, The cloud-based system is designed to analyze the increment of the user (consumer) load, implementing load balancing procedures and a Web server.

For server administration purposes, a load balancing was implemented and the server specs increased.

Also, aware of the load balancing issue, a Master-Slave DB (Database) architecture was implemented. The Master DB performed the daily search and update procedures, meanwhile the Slave DB performed high-speed data retrieval. Implementing the MDS System in the server, the system was ready for the pilot stage.

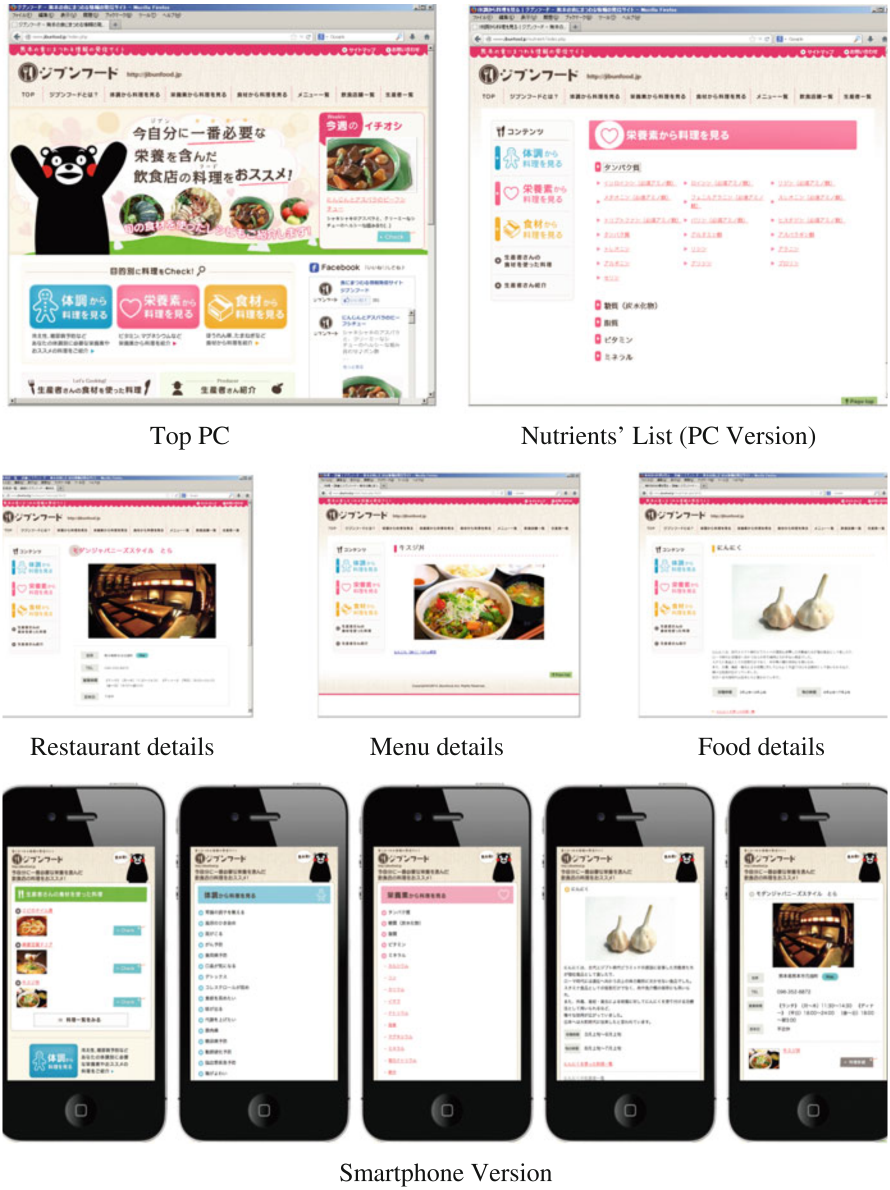

Fig. 4 User interface designs

7 Interface Design

Because of the limited screen size on the Smartphone edition of the user interface, priority was given to the user's information input.

A high visibility and easy to navigate interface was designed with all navigation features like: search from symptoms list and nutrients. Extensive use of Java Script from the second navigation layer. For the PC version, it was designed in order to allow making an easy icon selection with a reduced directory structure. For display purposes, e.g.: food, nutrients, symptomology, etc. that contains large contents a matching program was built in order to provide specific information to the user's needs.

8 Conclusions and Future Work

Farmers have been facing some difficulties regarding their business because of weather change, price instability and constant financial problems due to foreign competition. Therefore, an expensive service like this could be only available to big producers in which case, markets are completely ensured long time contracts.

Academic and Company based research initiatives haven shown different issues that jeopardized their continuity, which affects directly to the farmer. Being the biggest issue in academic research: budget and availability of multidisciplinary human resources needed for the correct project development; and in the case of company based research, their cost, which could not be affordable by the farmer.

Big Data analytics allowed us to have a better understanding of the user needs and requirements regarding the project objectives.

The new IoT parading is becoming a part of the current and future Internet. The current Internet paradigm will drastically change into a much more personalized experienced with our surroundings that will lead to much more richer experience.

In the case of applications, is necessary to make a deep analysis of the requirements needed to be implemented, in order to specifically use what could result much more beneficial for a specific project purpose.

In the case of our project, IoT could bring not only automatic updates regarding key issues of the project, but allow us to drastically improve the user experience through different new services.

IoT Security as a new paradigm and new potentially useful research area must address its security concerns in order to show a more reliable platform for the user that, currently, could resist a functional initiative. Due that a single security incident could damage permanently the infinite benefits IoT could bring to the society.

A new multidimensional matching algorithm was proposed in order to provide the end user with the best recommendation. The new multidimensional matching algorithm is 10 times faster than the standard algorithm based on the test with sample data.

A redundant Master-Slave Database system is use in order to provide the maximum efficiency to the cloud-based system.

Different version of the user interface (PC and Smartphone) was designed keeping in mind features like: easy navigation, usability, ergonomics, etc.

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