AgroTRACE: A Complete Fresh Fruits and Vegetables Traceability System

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Abstract

The fresh food industry recognizes the importance of traceability and food safety; however, some sectors are considered more advanced than others in implementing the relevant processes throughout the supply chain. At the international level, the branches of industry and the key players in the management of the supply chain work together to co-create an integrated and consolidated traceability process in order to benefit all the subcategories of fresh food products, such as seafood, dairy, baked goods, meat, poultry, fruits and vegetables.

Therefore, an effective tracking process needs to be based on a standard approach to fresh produce and its location recognition, while at the same time remaining flexible in the individual roles and responsibilities of the various links in the supply chain within the ecosystem. While many trading partners already have interfaces with external systems and processes for some level of traceability of their products, the next necessary step towards an integrated approach is to identify interoperability opportunities between internal and external processes across the food industry. Towards this direction, the AgroTRACE system aims to achieve end-to-end traceability of a fresh product supply chain through the deployment system, which combines internal and external tracking processes, so that each user is able to identify the immediate source and immediate recipient of the products. The system applies the "one step up, one step down" principle to provide effective tracking in the supply chain. In particular, each distinct product is recognized globally and in a unique way so that it can be located upstream and downstream of the supply chain. The innovation of the proposed system is further enhanced by the fact that the tracking will go beyond the route from field to field and covers the part of recycling (biomass, compost, etc.), in the context of the circular economy. That is, implement traceability from the field-to the shelf-to the field.

Keywords

Traceability, agrologistics, supply chain, fresh fruits, fresh vegetables

1. Introduction

The fresh food industry recognizes the importance of food traceability and safety; however, some sectors are considered more advanced than others in implementing relevant processes throughout the supply chain [1-3]. Internationally, industry sectors and key players in supply chain management are working together to co-create a comprehensive and integrated traceability process that can benefit all fresh food product sub-categories such as seafood, dairy, bakery, meats, poultry, fruits, and vegetables

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Additionally, the global players in the fresh produce industry realize the need to align their supply chain practices with tried and proven processes. These processes have already been established and successfully used by food companies in the food retail media. The common denominator in all these supply chain practices is the use of GS1 standards that act as a catalyst to drive the industry toward an integrated and interoperable food traceability process [6,7]. In short, the fresh food industry is ripe to reap real business results from the transformative effects of using GS1 standards as the foundation of food traceability and safety.

The two main guides for the promotion of traceability in the fresh fruit and vegetable industry are the legislation (e.g., EU regulation 543/2011) and the increase in consumer demand for accurate and complete information about the food they consume, mainly fresh foods that are more prone to spoilage [8-10]. In order to face these challenges, the different sectors of the industry are design separate - often parallel - paths to define traceability guidelines and to address the particular aspects of food safety related to the special characteristics of individual supply chains. At the international level, it is clear that product identification and the standardized exchange of product data contribute to food safety while establishing cost-effective business processes to disseminate information to all supply chain stakeholders.

In this direction, the proposed AgroTRACE system aims to achieve “end-to-end” traceability of a fresh product supply chain through the deployment system, which combines internal and external tracking processes, so that each operator is able to identify the immediate source and immediate recipient of the products. The system applies the “one step up, one step down” principle to provide effective tracking in the supply chain. In particular, each distinct product is recognized globally and in a unique way so that it can be located upstream and downstream of the supply chain.

2. Material and Methods

The proposed AgroTRACE system aims to support both internal traceability within businesses, as well as overall (external) traceability of fresh fruit and vegetable products throughout the supply chain. More specifically, internal traceability is to include packaging processes to link the identity of lots of fresh fruit and vegetables with lots that take the form of packages, boxes and pallets. Accordingly, external tracking is to include communication between trading partners regarding the identity of products, as well as their transportation. In this direction, product identification codes are communicated to those involved in the distribution network, on product labels and related electronic documents. The above are required to link the physical products with information required for their traceability. GS1 standards were used to provide the common language that enables trading partners to exchange data and their information systems to process and manage said data.

End-to-end traceability of a fresh produce supply chain is achieved through the system to be developed, which combines internal and external traceability processes so that each user is able to trace the direct source and direct recipient of the products. The system applies the principle of "one step up, one step down" to provide efficient tracking in the supply chain. More specifically, each distinct product is globally and uniquely identified so that it can be traced up and down the supply chain. All participants in the distribution network are able to use the system to implement internal and external traceability practices, and in addition, internal traceability is implemented in such a way as to ensure that the necessary links between inputs and outputs are maintained. The implementation of traceability in a supply chain relies on the participants of the distribution network, who collect, record, store and share relevant information.

More specifically, the proposed integrated AgroTRACE System consists of 3 main parts:

1. ***IoT & Event Capturing Application Platform***: This platform is the point of data and events gathering, processing, and storing that is received by different Event Capturing applications, IoT applications and networks, but also by third-party applications that have the necessary APIs. The system incorporates 2 indicative Event Capturing applications and 5 IoT applications (Figure 1). The Event Capturing applications are connected with the IoT applications to serve specific use cases. The Even Capturing applications are a) Optical reading application for smart devices for the field-to-packing route and b) Optical reading application for smart devices for

management at the retail point of sale. While the five IoT applications are a) Use of RFID technologies on the field-packaging plant route, b) Use of RFID technologies within the packaging plant, c) Use of RFID and beacon technologies during the transport of the products, d) Use of RFID and beacon technologies inside the store and e) Use of RFID technologies at the level of organic waste management.

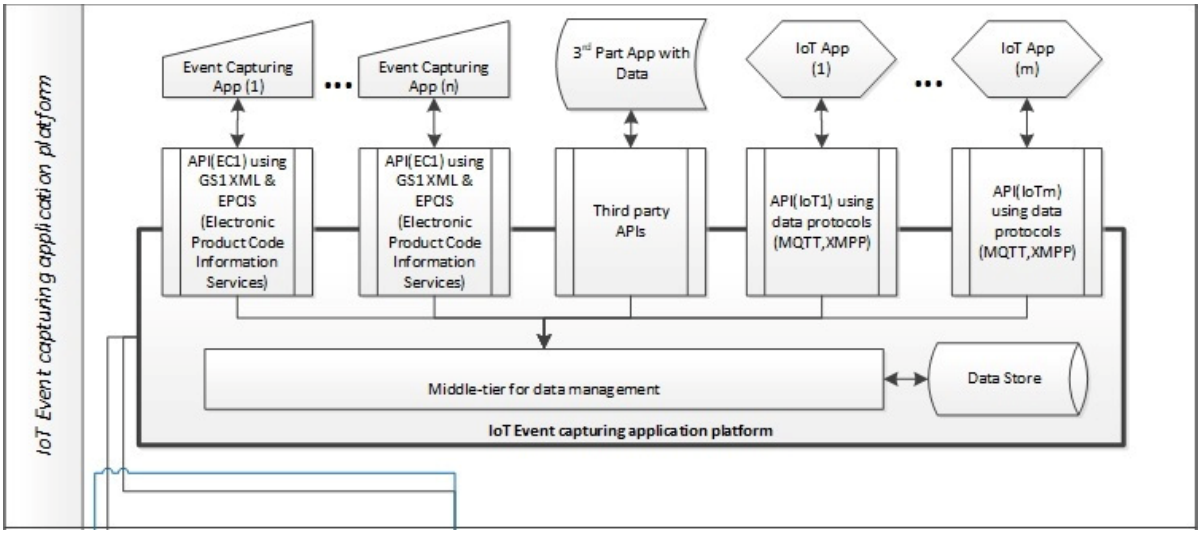

Figure 1: IoT & Event Capturing Application Platform.

2. ***Transaction Support & Information Management Information System:*** This system consists of 4 individual sub-systems, which utilize the information collected by the IoT & Event Capturing Application Platform to implement the tracking processes. (Figure 2). These sub-systems are a) Information Management System, b) Physical Entities Information Management System, c) Supply Chain Function Assessment System and d) Partners Transaction Support System.

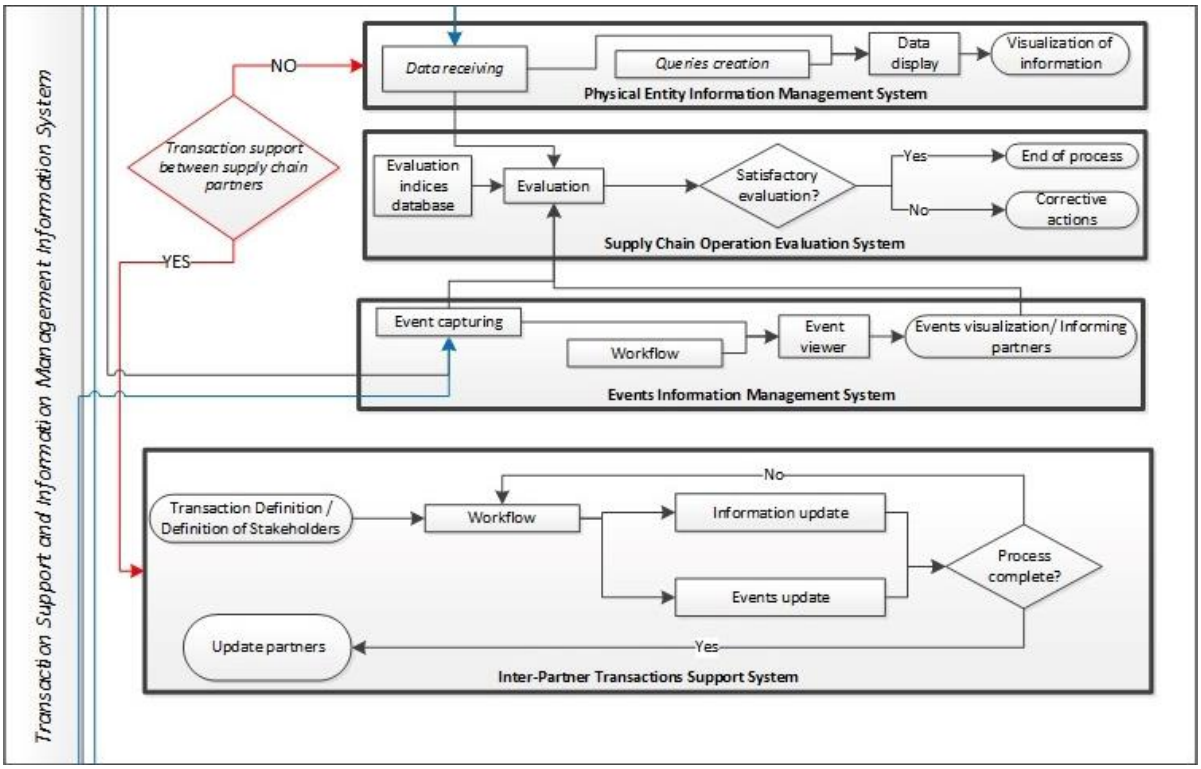

Figure 2: Transaction Support and Information Management Information System

3. ***Interoperability with other systems:*** The information that is produced both on the platform and in the 4 subsystems is standardized using the GS1 standards, so that information can be shared with other systems, within and outside of each supply chain partner. In this way, the information could function as reference knowledge (benchmarking) through its widespread (knowledge diffusion) (Figure 3).

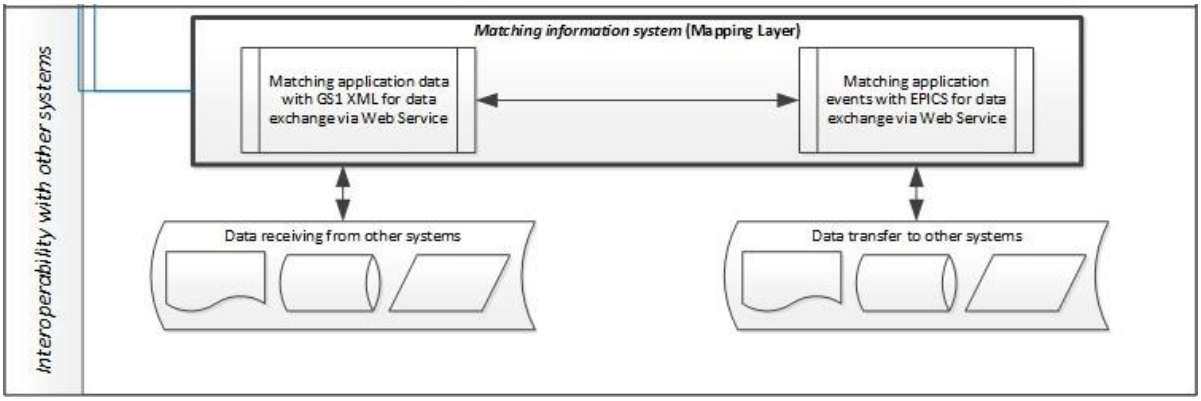

Figure 3: Interoperability with other systems.

The main aim of the proposed system is to support a more effective and accurate traceability procedure through a 4-step process:

1. Recognition: Following the GS1 standards, the system discriminates all fresh products, infrastructures, sites and so on, from the cultivator to the consumer. These numbers provide links between the fresh product and the product-specific information.
2. Recording: GS1 system data carriers are used for data management to meet different supply chain process needs for different products. The EAN / UPC barcodes are used for scanning at retail outlets. The GS1-128 barcodes are used to identify product units in packaging and pallets to help inform product information and monitor their movement. GS1 DataBar barcodes that carry the same – and in some cases larger volumes – information in less space than the UPC barcodes are also used. The data encoded in GS1 system carriers not only identify the products (and product units) but allow the trading partners to share large volumes of data (batch number, date of production, packaging information, etc.).
3. Evaluation: The information gathered will be evaluated against the objectives expressed in the form of Performance Indicators (KPIs) set by the supply chain partners. In addition, the system enables KPIs from the SCOR (Supply Chain Operations Reference) model to enable "anonymous" benchmarking of chain partners' performance.
4. Sharing: The interoperability of the system facilitates the smooth exchange of information in trade transactions. The following GS1 interface templates are used: GDSN (Global Data Synchronization Network): GDSN connects trading partners to the GS1 Global Registry® via GS1 Certified Data, allowing the immediate electronic exchange of standardized, up-to-date and verified information.

More and more bibliographic reports appear regarding traceability systems using IoT technologies, however, the available integrated systems are few and even in an initial commercial stage. However, there are already in the US market some early efforts of integrated systems that support the implementation of traceability plans using IoT technologies. The proposed open modular structure as well as the integrated system approach, which is based on open and transparent interoperability standards, allows faster control of the correct operation and integration of our system into the product tracking processes and therefore the faster gradual integration into production. The following table presents a comparative evaluation of the proposed system with the integrated systems currently on the market (Table 1):

Table 1
Comparison of the proposed system with others integrated systems

System	Supply Chain	Minimum reference level	Data transmission technologies	Modular Structure	Open architecture
AgroTRACE	Field - Consumer - Field	Product	RFID, LoRaWAN, Beacons (BLE)	Yes	Yes (XML, web services)
GR-LIVE [11]	Field - Retailer	Product	RFID	Yes	No
iApp (ORBCOMM) [12]	Packaging plant - Retailer	Container	RFID, Satellite, BLE	Yes	No
AutoSense [13]	Packaging plant - Retailer	Container	RFID, NFC, GSM	Yes	No
HarvestMark [14]	Packaging plant - Consumer	Product	RFID	No	No
FoodLogiQ's Track + Trace [15]	Field - Retailer	Product	No M2M	No	No
Iris [16]	Packaging plant - Consumer	Product	No M2M	No	No

From the above table, can be concluded that the proposed system incorporates all the best features that cover the different systems and additionally uses for the first time an open architecture that clearly differentiates it in terms of interoperability.

3. Conclusion

In conclusion, the main outcome of the proposed system is the development of an innovative Tracking System for Fresh Fruits & Vegetables using IoT technologies and an integrated Event Capturing and IoT Application Management Platform with a focus on interoperability. An important part of the system is the proposed Transaction Support & Information Management Information System, which addresses all partners in the supply chain of fresh fruits and vegetables, starting from the field and reaching the management of organic waste in the framework of a circular approach economy. The information system consists of 4 distinct subsystems, which, due to the modular architecture that was followed during their design and implementation, are able to be used independently, meeting the relevant needs. Alongside the system, an IoT & Event Capturing Application Platform was developed, within which 2 Event Capturing applications and 5 IoT applications are available. The proposed system can significantly contribute to the better and more efficient operation of the entire fresh fruit and vegetable supply chain through continuous improvement processes.

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