Inventory transparency for agricultural produce through IOT

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Abstract. Re-structuring the practices of traditional inventory management is becoming more essential to optimize the supply chain transparency and accuracy of agricultural produce. A flexible and transparent inventory management system is becoming the need of any agricultural commodity. It was noticed that the major setback for the farmers who are the suppliers of the farm produce is due to poor supply chain integration. The recent advent technologies and IT explosion can bring up a greater impact in the process of storing, tracking, distributing and monitoring perishable agriculture produce of day to day life. The primary focus of this paper is to integrate IoT into inventory management and other inbound logistics management of agriculture produce. The unique features of agricultural produce like a prediction of supply, demand, the location of warehouses, distribution and tracking of inventory can be integrated through IoT. This paper proposes a conceptual framework for inventory management transparency involved in the supply chain of agriculture produce.

1. Introduction
India with 127, 0272105 people is the second largest populous country in the world. India’s total gross area of 3287260 KM² and total cropped area is about 19202 million hectares, and the net sown area is 140 million acre. The supply chain of agricultural produce has grabbed a full consideration as most of the agricultural produce is ordained for human nurturing. Cultivation of vegetables in peri-urban or urban areas is recognized for its potential role in increasing food security, poverty alleviation, employment and income generation, community resource development, waste management and environmental sustainability [1]. The eclectic changes in the current human era, where much importance is given to health, consumers are mandated to be concerned with all processes like cultivation, storing, distribution and marketing of the agricultural produce [2]. To note another, the farmers who are the suppliers of the agricultural products falls out with a financial set-back, due to poor supply chain integration [3]. All this put together creates a must essential transparency during the inventory management of the agricultural produces especially perishable produces with reasonable lead time and very less shelf life in the warehouse or at retailer’s occupancy.

The recent advent technologies and IT explosion can bring up a greater impact in the process of storing, tracking, distributing and monitoring perishable agriculture produce of day to day life. The use of Information and Communication Technology (ICT) in the supply chain provides significant benefits...
in the process of involving information exchange to centralized data storage cloud storage [4]. The availability of information will be helpful in the decision-making process of planning and forecasting supply and demand for agricultural produce [5]. The current Internet technologies can also be used for the operational management of food supply chain [6][7].

The primary focus of this paper is to integrate IoT (Internet of Things) into inventory and other inbound logistics management of agriculture produce. The integration of IoT layers, like the data transmission layer, the storage layer in the cloud and visibility of data collected through mobile applications can provide the inventory transparency between different actors in the supply chain. As a consequence, the use of IoT in the supply chain of agricultural produce will bring out the required transparency in inventory and logistics level.

2. Methodology

2.1. Traditional inventory practices issues
Availability of rail, road and air transport, cold storage, processing units, export houses and well-established market network, will be helpful for taking up vegetable cultivation in peri-urban areas of metro cities in an organized way. A huge quantity of solid waste generated during handling and marking of fresh vegetable produce in metro cities, creating health and environmental hazards, can be used or recycled to vermicompost for use in organics vegetable cultivation and distribution. Vegetable quality needs to be maintained since harvest. Growers must take care of harvesting, storing, packing and transporting fresh produce to prevent damage and maintain quality. Compared to manufacturing products agriculture products supply is unpredictable, inelastic demand and price and inventory are uncertain. The decision on how much to sell is a major issue in the agriculture produce.

Leafy vegetables kept in the shade will maintain their quality longer than those exposed to full sun. Many growers put their newly harvested leafy greens in large polyethylene bags, during the transport the leaves may be bruised or crushed. Bamboo baskets are not suitable for packing soft fruit vegetables such as tomato due to the rough surface may damage the produce. Rigid containers with smooth surfaces reduce crushing, bruising and damage. Many cities cannot cope with the massive growth of its population which leads to a decrease in urban shelter and security of basic services, increasing inequality and segregation, degradation of the urban environment and growth in poverty, malnutrition and food insecurity. The transparency in Cultivation, storage, and distribution is becoming a need of the hour to avoid these issues [8]. The problems related to this perishable agricultural produce is mentioned in Figure 1.

![Figure 1. Inventory issues.](image-url)
2.2. Inventories

There are two different strategies related to finished goods inventory holding at manufacturing sites: make-to-stock (MTS) versus make-to-order (MTO) [9]. MTS decisions refer to decisions to produce finished goods to stock based on planning and forecasts. Under make-to-order production starts when a customer order arrives [10]. In regards to MTS vs. MTO decisions, there are some variables related to them such as obsolescence, perishability, lead time ration, as well as the coefficient of variation of sales state that insufficient information sharing and transparency is a key issue for companies that strive to increase coordination and integration in their supply chains [11] IT facilitates transparency and coordination for efficient implementation of various supply chain processes. There was even no Central logistics department that would be in charge of coordination of inventory management and optimizing finished goods inventory stocks at the company’s subsidiaries. And there was in general lack of knowledge of inventory management and lack of educated people within logistics [12].

2.3. Inventory methodology

Researchers have developed a variety of robust optimization techniques for inventory problems when the distribution is not known [13]. In this model a container based approach is proposed which is suitable for IoT-based inventory management.

Number of Containers to maintain smooth operations

Number of container units = demand in the cycle size of each container

\[ K = \frac{D*(TP+TD)}{C} \]  

\[ C = \text{number of units held in each container} \]
\[ TP = \text{time container spends in production part of a cycle (waiting, being filled and moving to the Store of work in progress)} \]
\[ TD = \text{time container spends in demand part of a cycle (waiting, being emptied and moving to the Store of work in progress).} \]
\[ \text{Total cycle length} = TP + TD \]

\[ K < D*(TP+TD) * (1+SF)/C \]  

\[ \text{Number of container units with safety factor SF = safety factor (generally less than 0.1)} \]
\[ \text{Maximum stock of work in progress} \]

\[ \text{Maximum stock level} = K \times C = D \times (TP + TD) \times (1 + SF) \]

2.4. Inventory transparency issues in agriculture field

The inventories should meet the need for transparency, accuracy, completeness, consistency and comparability. It can be labelled and transformed by microscopic electronic devices, genetic markers for agricultural products. The barcodes which can read with smartphones combine with the internet technology can contemplate more sophisticated ways to monitor and reveal the agricultural produce. RFID (Radio Frequency Identification) tags were smaller, cheaper and flexible. Near Field Communication (NFC) is a short-range wireless technology which is based on the existing standards of RFID A tag can hold a unique identifier which acts as a basis for a vast amount of web-based supporting data. The mobile apps in which the consumers can readily access this internet of things (IoT) gathering provenance information not just at the generic level of the item category but for the particular item.

Providing online verification codes to end users is an easy way to make the supply chain network transparent. The NFC readers provided by the mobile phone manufacturers are allowing customers to
link the data to know about produce origin, inventory, certification, price and distributor details. Visual reader technologies in smartphones are more common nowadays.

3. Internet of things and cloud platform
Internet of Things and cloud computing together brands a new revolution of the Internet, whose goal is to enable things/objects to get connected using any wired or wireless connections without concerning the place, time and the object/anyone of communication [14]. IoT makes communication possible through the Internet where data exchange happens using MQTT (Machine to Machine Authentication Protocol) protocol, which makes the IoT devices to act smart. The flow of data between the objects through various platforms supports the tracking, control, and management of them. Deployment of Cloud computing IOT framework can resolve many issues that get raised during the supply chain management. Efficient knowledge management of agricultural information can support the decision-making process of farmers and consumers.

An automated and highly interactive system for an agriculture produce system planning on the operational level is being developed for use in the Mobile phone. This provides both distributor and farmers enables to design and quickly construct demand and supply framework.

As the capacity planning of the warehouse was developed as a part of a whole system to access the scenarios for cost reductions in harvesting and transport. This proposed model measures and impacts the Harvesting, Storage and time to harvest. This shown in figure1 would help avoid many obstacles in the system which are experienced by harvesters requiring deliveries at inefficient times, the start of the delivery and the best overall coverage of demand and supply.

3.1. Near field communication
Near Field Communication is a short-range wireless technology which is based on the existing standards of RFID. Compared to RFID, in NFC there is no strict difference between the reader and transponder. NFC capable device can read data from an NFC tag and can also write data into NFC tag. The reusability and the cost effective factor of NFC have influenced its usage in a wide range of applications.

3.2. Android device
An Internet-enabled Android device equipped with NFC reader can use any GSM/cellular network to communicate information through the Internet, which can be made accessible to the user through any platform. The Android device with GPS antenna can be used to communicate the vehicle/truck tracking information to the cloud storage database.

4. System description: architecture and components
The system architecture explains the four different stages of this inventory management system which includes farmer-supplier unit, truck–tracking and monitoring unit, Cloud storage and processing unit and Storage facility/Retailers unit as illustrated in figure 2.

4.1. Android application
The agricultural produce harvested by the farmers are loaded with the delivery boxes each of which is tagged with an NFC tag. The NFC tags are then stored with the following information: Agricultural produce a name, date of harvest, box number, through the NFC reader embedded in the Android device with the help of the android application as shown in figure 3. The farmer details, agricultural produce details, location information, are also sent to the cloud backend through the
Figure 2. Architecture of proposed system.

Android application as shown in figure 3, through a mobile internet connectivity. The demand of the consumers managed in the cloud storage will be invoked as orders to the farmers, who then initiate the delivery of the agricultural produce through the transportation provided by the warehouses.
4.2. Identification and tracking through NFC
The Box identification is mapped with the truck through the NFC reader enabled Android device present in the vehicle. The ECU (Engine Control Unit) is paired with an Android device, to fetch the ECU data. The GPS data that provides the location of the truck along with the ECU data are sent to the cloud backend to ensure the security, visibility of the agricultural produces on track. Figure 4 shows how the goods in the truck are tracked with the help of GPS.

4.3. Data storage and processing- cloud platform
The instance of the cloud platform provides with a database service (server) which stores the IoT data (supply chain data) which can be accessed from anywhere, anytime and by any actor of the supply chain, by which the visibility and transparency of the inventory process are maintained. The web service (server) handles the request coming from the outside world to redirect it to the application and database server. The truck tracking data stored in the cloud will be used to track the product in transport. The delivery time of the orders can be predicted, and Optimized supply based on cost and distance parameters for the required demand is anticipated through Machine learning algorithms, and further notification of the rules is responded to the Android application.

5. Conclusion
This proposed model of Inventory modeling using IoT is a part of the whole system of supply chain network planning. This reduces the unnecessary costs & time in the agricultural supply chain. The agriculture produce spends time waiting for inventory storage space, locomotives, Transport system, etc., can be addressed transparently. Through linking with grower’s data and end users data the agriculture produce inventory model will show the consequences across the full industry value chain of proposed inventory information arrangements. The model is data sensitive, the use of geographical information systems and vehicle tracking system has made it possible to generate the model inputs.
accurately and show solutions in the simpler way for farmers, distributors, and resellers in their smartphones.

References

[1] Stelvia Matos and Jeremy Hall 2007 Integrating sustainable development in the supply chain: The case of life cycle assessment in oil and gas and agricultural biotechnology Journal of Operations Management 25 pp 1083–102

[2] O Ahumada and Villalobos J R 2009 Application of planning models in the agri-food supply chain: A review European Journal of Operational Research 196(1) pp 1-20

[3] S P Srinivasan and P Malliga 2003 An Optimal Jatropha Seed Warehouse Location Decision Using Myopic and Exchange Heuristics of P Median Proceedings of 2012 3rd International Asia Conference on Industrial Engineering and Management Innovation (IEMI2012) pp 439-49

[4] Auramo J, Kauremaa J and Tanskanen K (2005) Benefits of IT in supply chain management: an explorative study of progressive companies International Journal of Physical Distribution and Logistics Management Vol 35 No 2 pp 82-100.

[5] Yandra Rahadian Perdana 2012 Logistics Information System for Supply Chain of Agricultural Commodity Procedia - Social and Behavioral Sciences 65 pp 608 – 613

[6] C N Verdouw, A J M Beulens, H A Reijers and J G A J v d Vorst 2015 A control model for object virtualization in Supply chain management Computer Industry 68 pp 116–31

[7] C N Verdouw, J Wolfert, A J M Beulens and Rialland 2016 Virtualization of food supply chains with the internet of things Journal of Food Engineering 176 pp 128-36

[8] Widodo K H, H Nagasawa, K Morizawa and M Ota 2006 A periodical flowering–harvesting model for delivering agricultural fresh products European Journal of Operational Research 170 pp 24–43

[9] Wanke P F and Zinn W 2004 Strategic logistics decision making International Journal of Physical Distribution and Logistics Management 34(6) pp 466-478

[10] Zaerpour N, Rubanni M, Gharehgozli A H and Tavakkoli-Moghaddam R 2008 Make-to-stock or make to-order decision by a novel hybrid approach Advanced Engineering Informatics 22(2) pp 186-201

[11] Dreyer H C, Alfnes E, Strandhen J O and Thomassen M K 2009 Global supply chain control systems: a conceptual framework for the global control centre Production Planning and Control 20(2) pp 147-157

[12] AJ Higgins and LA Laredo 2006 Improving harvesting and transport planning within a sugar value chain Journal of the Operational Research Society 57 pp 367–76

[13] C J M Ondersteijn, J H M Wijnands, R B M Huirne and O van Kooten 2006 Quantifying the agri-food supply chain, Springer pp 117-32

[14] Ovidiu Vermesan, SINTEF Norway and Peter Friess 2013 EU, Belgium, Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems ISBN: 9788792982735