



**Hybrid Communication Network Architecture for Palm Oil Supply Chain Traceability (POSCT) System**

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**Abstract:** Malaysian Palm Oil Industry is one of the top most oil industry in the world. The POSCT starts from the harvesting and ends on delivery of oil product to the customer after passing through a chain of processes. Due to the sensitive chemical features of palm oil, it is important to send palm seeds from field to palm oil making mill within 24 hours, otherwise, palm oil quality will be compromised. In order to trace the palm fruit from the harvesting stage up to the mill, in this paper, we proposed a hybrid communication network architecture exploiting RFID and XBee technologies for designing a POSCT system. More in detail, in the system, RFID tags will transmit the required information to the distributed data base with the help of wireless mesh network. The aim of this work is to track all the information generated during the transportation of the palm fruit not only for the traceability but also for the enhancement and optimization of the oil making quality. All the data generated by the said traceability system will be stored in the dedicated centralized data bases accessible by the concerned authorities.

**Keywords:** Palm Oil, Supply Chain, Traceability, RFID, XBee.

**1. INTRODUCTION**

The fruit of Palm tree is use for making vegetable oil which is mostly grow in tropical countries. Besides use as vegetable oil t is also used for making biodiesel fuel (Chin 2011). Malaysia is one of the top country in the work who grow Palm Trees and convert their Palm Tree crops in to Oil. This is the reason that 44% of Malaysia export is based on palm oil and all over the work it produce 39 % palm oil which is more than 13 million tons of crude palm oil (MPOC 2016).

To manage this high production of palm Oil for the world the use of Palm Oil Supply Chain Traceability (POSCT) is most import for its intensive care the worth and standards of the oil. Also, traceability is already explored research area, where researchers studied it in different applications that are referred in Section II of this paper. Moreover, it can be incorporated in palm oil making in order to improve the making quality. However, according to our knowledge, no paper has address this issue. In view of aforesaid, in this paper we are proposing a hybrid communication model for POSCT with the integration of RFID and XBee technologies. The said devices will help in continuously monitoring and tracking of the processes involved in the Supply Chain (SC) i.e. from the harvesting of the fruit till it reaches the mill for making of oil.

The rest of the paper is organized in a manner that in Section II, the fundamental and related works are discussed while Section III will give a little premise of

traditional POSCT followed by in Section IV, we talked about some existing wireless technologies that can be suitable for designing POSCT communication network. In Section V, we discussed about the proposed technologies for POSCT along with some issues and challenges while in Section VI, we are presenting the proposed POSCT hybrid communication model. Section VII is related to the implementation phase of POSCT and at last with Section VIII we conclude the paper.

**2. RELATED WORKS**

With the progression of remote correspondence, the employments of remote gadgets have expanded immensely. New innovations are being presented, for example, RFID, ZigBee, XBee, LTE, WiMax and so on for building a system so as to accomplish specific objective.

The Radio Frequency Identification (RFID) development has been utilized in different territories, for example, in exploring gear and individuals, human services, security, portable mechanical technology, carriers, for different purposes. Lehtonen, Michahelles and Fleisch (2007) made RFID-based thing approval structure in which it is talked about that security is essential for the item confirmation framework. Byunggil and Howon (2006) exhibited an anchored RFID application show for astute structures by using RFID alongside the framework comprising of the sensors. Mori et al (2008) made framework for objects

in view of RFID (a DBMS in which data is spoken to as protest simply like question arranged programming). As indicated by Pileggi, Palau and Esteve (2010), with the incorporation of RFID and Wireless Sensor Network (WSN) an adaptable outlining should be possible which can be an answer for some applications and situations. Utilization of RFID innovation for mechanization is finished by Ramamurthy et al (2005). Acierno et al (2010) utilized RFID innovation in the field of bio innovation.

In SCM, individuals are getting advantage from this advancement to monitor pig meat SC framework by putting the RFID labels on a pig ear to track its exercises and for the traceability of meat in the wake of butchering (Fenu and Garau 2009).

WSN for intra-vehicular correspondence was planned by Rahman (2014). Consequently, framework was proposed by Bektas and Korkmaz (2016) utilizing the innovation of RFID and XBee to wipe out the event of human mistakes in set away activities. As mistakes, can cause serious issues that can produce troubles in SC. To provide food for these entanglements, a framework was conceived with the assistance of the aforementioned advancements for the mechanized confirmation and position of items.

For SC frameworks, very little work is finished in the past by misusing the mix of RFID and XBee advances. Also, after the investigation of related works, we arrived at the end that no examination is done in the past with RFID or by its incorporation with XBee innovation for POSCT. In this paper, we will propose RFID and XBee based cross breed correspondence framework for the palm oil age.

To do look into one needs to dive deep in evaluating and breaking down the examination identified with the picked point. The same is actualized in our examination. According to the related works depicted above we have concocted the similar examination synopsis connected to the SC as appeared in (Table 1).

**Table 1: SC Related Comparative Study**

Reference	Works of SC	RFID	ZigBee	XBee
Fenu and Garau (2009)	Pig Meat SC	Yes	No	No
Ren (2015)	RFID Enabled Food SC	Yes	No	No
Rahman (2016)	RFID Enable Wine SC	Yes	No	No
Bektas and Horkmaz (2016)	Warehouse Running System	Yes	No	Yes

Linhai and Lingling (2009)	Post-Olympic Food SC	Yes	No	No
Elshayeb, Hasnan and Yen (2009)	RFID and ZigBee use in SC Systems	Yes	Yes	No
Wong and Guo (2014)	SC in Textile and Fashion	Yes	No	No
Ghelichi and Abdelgawad, (2014)	Inventory Running System	Yes	No	No
Andriana et al (2014)	RFID in SC	Yes	No	No
POSCT		No	No	No

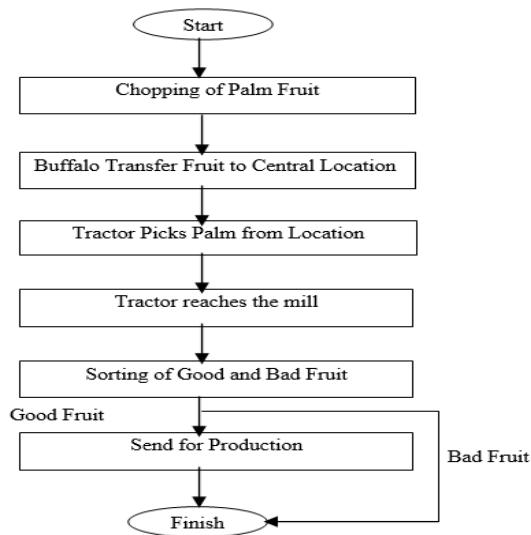
As per the reviews completed in this paper. No work has yet been done on POSCT. Moreover, there are very less works related to SC with the integration of RFID and XBee. In view of aforesaid, following sections will explain as how the traceability can be done for POSCT.

### 3. TRADITIONAL POSCT

Malaysian palm oil age is typically utilizing a manual technique for following of the palm foods grown from the ground. Fundamentally, the procedure begins from the hacking of the palm natural product. After the said arrange the palm organic product is exchanged to focal area through a wild ox where tractor will pick the foods grown from the ground take it to the factory.

As palm organic product is the centre thing which is to be followed in light of the fact that it is concentrated with the oil substance. In perspective of aforementioned, it is basic to convey it with full data to the factory inside 24 hours in the wake of reaping. After the said time the nature of the organic product will be disintegrated. Similarly as with the progression of time the measure of free unsaturated fats (FFA) will increment in the organic product which are bad for the wellbeing. To ensure the nature of item there must be some mechanized framework for the traceability. Palm oil age till now doing the things physically. The focal point of this paper is to make traceability workable for this stage is from the gathering of organic product from the backwoods till it achieves the factory for the oil making.

As shown in (Fig.1), the manual process starts from the chopping of palm fruit which is done by the staff under the supervision of the experts. Next, the fruit is transported to the central location nominated by the supervisor with the help of buffalo. In subsequent step, the farmers will load the fruit on the tractor for taking it to the mill. In the mill, the tractor will be unloaded and the fruit will be checked by the supervisor and will be sorted as good and bad fruit. After the sorting process, good fruit will be sent for the making.



**Fig. 1: Traditional Manual POSCT**

According to the manual process discussed above only the fruit is assessed by a single person in the mill as good or bad. In view of aforesaid, it is necessary to make a traceability system for palm oil generation to ensure that quality fruit is used to produce the oil.

#### **4. EXISTING TECHNOLOGIES FOR POSCT**

This section discusses about the existing technologies that can be incorporated in this POSCT processes.

##### **4.1 Long Term Evaluation (LTE)**

LTE is basically a standard for high speed communication of mobile device. It uses network technologies like GSM/EDGE and UMTS/HSPA. The main target for the innovation of this technology is to deal with the vehicular speed mobility and side by side have good compatibility with the existing networks (Rahman 2014). The technology does not suit POSCT as it will increase the network price and moreover, we are not dealing with the high-speed movement's.

##### **4.2 Worldwide Interoperability for Microwave Access Network (WiMAX)**

WiMax technology support high speed up to 75 Mbps with a range up to 30 kilometers. Also, it supports high data rates over a long distance by using bandwidth efficiently. The most prominent features that makes WiMax a viable technology are high throughput, mobility, low price and high coverage. Moreover, WiMax can work in both bands (licensed and unlicensed). This technology, like LTE gives high data rates that is good for the fast-mobile communication.

##### **4.3 Wireless Fidelity (Wifi)**

Wi-Fi uses the standard IEEE 802.11 having subclasses like 802.11 a/b/g/n/ac for wireless operating local area network (WLAN). Specifically, "n" and "ac" being the advanced versions are used now a day for getting high performance. In 2009, the standard IEEE 802.11 n was released in the market with latest specification and features in comparison with the older versions. The characteristics that made standard unique were Multiple Input and Multiple Output (MIMO) techniques, Orthogonal Frequency Division Multiplexing (OFDM), space time block coding and cyclic delay diversity. The said features increased the throughput of the network and coverage up to 150 Mbps and 250 m respectively. For achieving the throughput up to 6.77 Gbps, 802.11 ac was released in 2013 with the feature of multi user MIMO. Talking of POSCT, the Wi-Fi technology is suitable as far as throughput is concerned. However, in terms of communication range this technology does not suite our system.

##### **4.4 Radio Frequency Identification Module (RFID)**

RFID system consists of RFID tags, readers and middleware for sorting of meaningful data that is to be transferred to the server. RFID tags contain unique information for recognition and also can send that data remotely to computer databases and systems for traceability (Kumar 2014).

RFID tag is a kind of modified information gadget involves a coupling segment, a low-control Complementary Metal Oxide Semiconductor (CMOS) and Integrated Circuit (IC). They come in two classes, for example, dynamic and detached labels.

RFID peruser is a gadget used to accumulate data from RFID label whose part is to track the articles. It has two essential parts, for example, the peruser itself and a radio wire.

The middleware layer is utilized to extricate important business data from the flood of crude perusing occasions. Its capacity is to guarantee that just the helpful material be exchanged to the organization's frameworks to keep the information flood or clog.

##### **4.5 ZigBee**

ZigBee is a remote innovation based on IEEE 802.15.4 norms which is savvy with the capacity to work for quite a long time or years on minimal effort batteries (Elshayeb, and Yen 2009). It is being used in vast range of products and applications worldwide because of its reliability.

ZigBee innovation comprise of three kinds of gadgets i. e ZigBee Coordinator (ZC), ZigBee Router (ZR), ZigBee End Device (ZED).

ZC is Fully Function Device (FFD) with the activity of by and large controlling of the system. Each system comprises of precisely one facilitator. It performs capacities like determination of channel for organize, begins the system, offers authorization to the gadgets either to join or leave the work arrange, holding a rundown of switches and so forth.

ZR is FFD and is utilized to upgrade the inclusion territory of the work arrange. The universally useful of ZR is to locate the most ideal course for the conveyance of message to the goal. Its obligation is to exchange the data from end gadget to the organizer. A switch is a gadget that plays out every one of the assignments same like facilitator yet it doesn't build up a system.

ZED is Reduced Function Device (RFD) with the capacity to converse with its parent gadget just, for example, ZC and ZR. It can't speak with the other ZED. It devours less power since it just performs work identified with joining or leaving the system and to exchange application parcels.

According to the above stated facts ZigBee is a good choice for the implementation in POSCT by considering its reliability.

**4.6 XBee**

The XBee convention resembles ZigBee. It has the information rate of 250 kbps with the utilization of Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) method. The topology bolstered by XBee is likewise work and therefore it can stretch out its inclusion up to 1.6 km utilizing steering methodologies, for example, multi bounce. Besides, as ZigBee, this convention likewise utilizes similar gadgets for the work correspondence. As per our POSCT display, XBee suits more as contrast with ZigBee in light of its more inclusion zone.

The outline of examination between existing advancements as far as their highlights are appeared in (Table 2).

**Table 2: Comparison of Some Wireless Technologies**

Technology	Frequency	Data Rate	Coverage
LTE	1.25-20 MHz	326 Mbps	5 K. Meters
WIMAX	10-66 GHz	32-75 Mbps	Up to 30 Miles
WiFi	2.4-5.35 Ghz	150 Mbps	250 Meter
RFID	Up to 5.875 GHz	Up to 4 Mbps	Up to 5 Meters
ZigBee	2.4 GHz	20 to 250 Kbps	10-150 Meters
XBee	2.4 GHz	250 Kbps	1.6 K. Meters

**5. PROPOSED TECHNOLOGIES FOR POSCT**

As discussed earlier, the focus of this paper is to propose a system for traceability of the palm fruit from the chopping site up to the making mill. Before discussing the proposed technologies, we will first give a brief view of some issues and challenges (technical and non-technical) related to our model.

One of the major technical challenge for POSCT is related to node distances. Due to very huge palm plantation fields, the placement of nodes and distance between them is of great concern. Moreover, if node placement will not be managed properly it can lead to the signal attenuation that can affect the data transmission.

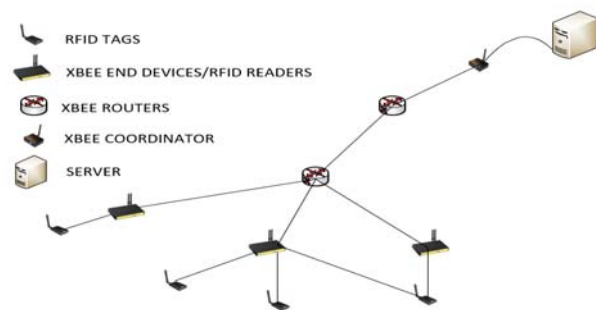
Another challenge is the signal reflection that can occur due to very high trees. To overcome the issue, routers must be placed in a planned manner.

Moreover, there are many making mills with huge palm plantation in the country. To plan a framework so that the data is accessible to every one of the workplaces in various urban communities is a testing undertaking.

All the more in this way, among the non-specialized difficulties is adoptability of the general population towards framework. As for the most part, the general population don't prefer to be followed for some reason.

Presently going to the proposed advancements for POSCT. RFID and XBee are two remote advancements that have numerous applications free of each other. Every ha the preferences with XBee bolsters WSN and RFID is reasonable for remote following of articles and individuals. With the mix of these two innovations, it is especially conceivable to create XBee Mesh Network.

As illustrated in (Fig. 2), RFID tags are sending the information to the readers that will pass the received information to the nearest XBee router. The router will forward the data to the coordinator that will finally send the received data to the server.



**Fig. 2: Hybrid XBee and RFID Communication System**

**6. POSCT HYBRID COMMUNICATION SYSTEM**

The proposed communication network for POSCT for this paper is shown in (Fig. 3). POSCT correspondence organize in Fig.3 comprises of RFID label appended to the tractor that will send the data to the RFID peruser coordinated with XBee end gadget. The information from the peruser will be exchanged to the incorporated end gadget for sending to the switch lastly the data will be passed to the facilitator through switches for the servers.

So also, Fig. 4 delineates the least difficult type of system correspondence stream for POSCT. It begins from the transmission of data to RFID peruser through RFID tag. Peruser in the wake of getting the remarkable id will send the data to the coordinated XBee end gadget that will forward the got information to the closest switch. The switch will send the got information to the facilitator that at long last passes the information to the database server.

**7. IMPLEMENTATION**

In this section, we examine about the implementation of POSCT using RFID and XBee wireless mesh network device which are the key components for designing POSCT.

In Malaysia, there are thick woods of palm trees. So far as that is concerned the area of switches are of incredible concern. One next to the other the outlining of remote work organize remembering the idea of woodlands will be an incredible test. In the event that we discuss the usage, the reason served by RFID innovation is very same as barcoded frameworks generally being utilized in relatively every shop of any commercial center. Be that as it may, the working rule of RFID is unique in relation to scanner tag and has more preferences. The first favorable position of RFID peruser is the simple joining capacity with XBee gadget. As cost, continually being the principle worry for any age. Subsequently, XBee is the best decision as it is an ease, low-control gadget with 70000 hub arrangement capacity. The convention utilized by the XBee is IEEE 802.15.4. XBee has low information rate i.e. around 250 Kbps. In addition, the working of POSCT for execution will be in three levels i.e End Node Level (End Node i.e RFID Tag, RFID Reader and XBee End Device), Router Level, Coordinator Level (XBee facilitator joined with the server).



Fig. 3: POSCT Communication Network

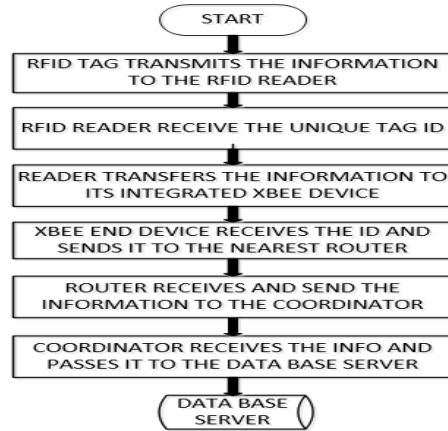


Fig. 4: POSCT Network Communication Flow

The concept of cognitive radio networks, specialty TV White Space, can be incorporate with the proposed network to design an efficient system, which will be the future direction of this paper (Rahman et al 2010; Cacciapuoti et al 2015, 2016).

**8. CONCLUSION**

In this paper, we have discussed about the traceability of Palm Oil Supply Chain. For the said purpose, we have gone very deep in our research as how traceability can be done for the palm oil generation in Malaysia. By doing extensive surveys and interviews with the generation experts we concluded that it is quite possible to implement the POSCT system. In view of aforesaid, we have proposed a Hybrid Communication System with the integration of RFID and XBee modules for Palm Oil Supply Chain. Though, there are some implementation challenges that can create difficulties such as covering of huge area of palm oil generation throughout the Malaysia and the adaptability of people towards the system etc. However, besides the challenges, the bright angle of the picture is that the implementation of proposed POSCT system will become an immense contribution to the palm oil generation of Malaysia. This system will help the generation in terms of the authorities will remain in picture of every step related to SC. Subsequently, the making quality and quantity will be improved and generation will be benefited more in terms of profits.

**9. ACKNOWLEDGEMENT**

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