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Towards a Framework for Embedded Weight Comparison Algorithm with Business Intelligence in the Plantation Domain

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***Abstract*—**Embedded systems have emerged as important elements in various domains with extensive applications in automotive, commercial, consumer, healthcare and transportation markets, as there is emphasis on intelligent devices. On the other hand, Business Intelligence (BI) has also been extensively used in a range of applications, especially in the agriculture domain which is the area of this research. The aim of this research is to create a framework for Embedded Weight Comparison Algorithm with Business Intelligence (EWCA-BI). The weight comparison algorithm will be embedded within the plantation management system and the weighbridge system. This algorithm will be used to estimate the weight at the site and will be compared with the actual weight at the plantation. The algorithm will be used to build the necessary alerts when there is a discrepancy in the weight, thus enabling better decision making. In the current practice, data are collected from various locations in various forms. It is a challenge to consolidate data to obtain timely and accurate information for effective decision making. Adding to this, the unstable network connection leads to difficulty in getting timely accurate information. To overcome the challenges embedding is done on a portable device that will have the embedded weight comparison algorithm to also assist in data capture and synchronize data at various locations overcoming the network short comings at collection points. The EWCA-BI will provide real-time information at any given point of time, thus enabling non-latent BI reports that will provide crucial information to enable efficient operational decision making. This research has a high potential in bringing embedded system into the agriculture industry. EWCA-BI will provide BI reports with accurate information with uncompromised data using an embedded system and provide alerts, therefore, enabling effective operation management decision-making at the site.

***Keywords*—**Embedded business intelligence, weight comparison algorithm, oil palm plantation, embedded systems.

I. Introduction

EMBEDDED systems are special purpose systems that are specifically designed to perform certain activities. These systems are a set of instructions that are compressed in a device that will control the devices functionality. Embedded systems are being widely used in almost all domains and extensively used in technology-related industry to simplify the daily operational activities [32]. Standards are determined based on which assumptions are made and computation is performed using an embedded system to attain accuracy with a level of tolerance that is acceptable by the industry or the domain. Similarly, BI has also been in the industry for a few decades, and this technology has now become an essential part of all domains, especially the agricultural domain [29]. Over the past couple of decades, embedded systems have gained significance based on the numerous automations that have simplified complicated tasks. Such embedded systems have not only improved the performance time, but also improved data accuracy [31]. The EWCA-BI will enable data transmission from various locations and devices, the combination of controlling both hardware and software devices will assist in providing real-time information that will assist in decision making. It is believed that automation reduces human errors by providing reliable information that is used to make appropriate, timely decisions to avoid cost outages. The aim of this research is to create an embedded weight comparison algorithm that would be used to estimate the weight of the oil palm fruit bunches. By using this algorithm, real-time BI reports will be created to assist in operational decision-making at the plantation site.

In the agriculture domain, very few attempts are made towards developing and using embedded systems. The benefits of embedded systems are compressing the computer system completely into a device that is specific to a given requirement. Many devices are used in plantation management to monitor and support plantation activities [33]. The major shortfall in all these devices are that they are not integrated and embedded, the general practice in most plantations is that data are either migrated or transferred into another device, as secondary data. Due to this shortfall, there is delayed access to real-time information. Data accuracy and integrity problems have resulted in wrongful decision-making.

The objective of this research is to create an embedded weight comparison algorithm to measure the weight of the FFB at the estate with that of the actual weight at the weighbridge and to generate BI report with primary data source that is captured by system embedding. The embedded BI will create a platform for plantation managers to have access to real-time, accurate and uncompromised information at any point of time.

The oil palm is scientifically known as *Elaeis guineensis*, originated in the tropical rain forests of West Africa. Processing of oil palm fruits for edible oil has been under practice in Africa for thousands of years. The vegetable oil that is extracted from the oil palm fruits is highly colored and

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flavored. The oil palm is cultivated in many other countries, especially in the tropics, and is an extremely high potential commodity [1] in these regions. The fruits produce two distinct oils, palm oil and palm kernel oil, both of which are an important commodity used for trade. The ideal composite of palm fruit bunches is 23-27 Kg/ bunch.

Agricultural investments into Asian regions are increasing and there is a rapid expansion of the oil palm sector that stands out. Palm oil is a vegetable oil that is extracted from the fresh fruit bunch (FFB) of the oil palm tree - it is one commodity that has a worldwide demand. Global palm oil production has quadrupled from some 61 million to almost 260 million tons of palm oil from 1990-2012. Asia is the largest producer of palm oil fruits [2]. The palm oil industry has gone through a huge change with the use of information technology and automation, all the way from monitoring the yield or FFB, to monitoring fertilizer application and transportation of FFB. FFB is transported from estates to refinery mills; at the refinery mills, the weight of the harvested FFB is ascertained using a weighbridge system. At the entrance of the mill, weighbridge scales are located on the ground, and the weight of each vehicle that passes through the weighbridge is captured and stored for future reference. Industries around the world including the fresh milk industry, cross border freight transportation, pine wood harvest industries and many others, use weighbridge systems as a part of their production or harvest to determine the weight of a load or harvest.

II. Problem Definition

Palm oil is one of the major export commodities in Indonesia and Malaysia, and this research aims to reduce data capture time and reduce data inaccuracy, thus contributing to the economy of the plantation industry. Due to the unavailability of integrated, accurate and real-time information, effective decision-making becomes a challenge. There is very few evidence that shows that the weight measured at the collection point are managed and measured on a real-time basis. Since the data is not available on a real-time basis, the discrepancies are not alerted on time, thus leading the plantation companies to incur major cost outages due to wrongful decisions made based on inaccurate or insufficient data. Generally, BI reports are generated at the headquarters based on the consolidated data from secondary data sources, and usually this is with some latency. Therefore, the EWCA-BI has great potential, and the aim of this research is to realize an embedded system that would enable managers to make more effective and timely decisions.

The usual practice is that the data are captured from various sources and stored in various locations, and consolidated. Decisions are made based on the secondary data, and this consolidated data, which is usually associated with a time lapse. The actual data is compared and decisions made based on delayed information are not effective, as the quality deteriorates with time. Over the last decade BI has emerged and penetrated almost all areas of business. It has now become an essential part of any reporting requirement for top management, as [18] states that "the primary activities of business intelligence are getting data in and getting data out". Getting data in involves moving data from a set of source systems into an integrated data warehouse, where it has a limited value to an enterprise. In order to release the full value, users need to have access to information that is useful for decision making, and this is where the data is getting out and carries a higher value. This kind of reporting will be engaged in this research to encapsulate the information and drill it down when necessary by management to make effective decisions. With the help of the proposed EWCA-BI, plantation operational resources will be managed more effectively.

A. Research Objective

To develop an embedded weight comparison algorithm with embedded BI. EWCA-BI would provide uncompromised timely information to improve operational activities on site. EWCA-BI will have iPlantation and Weighbridge system embedded with the weight comparison algorithm into a portable device, minimizing human intervention in data entry and capture data. By embedding iPlantation and Weighbridge system within a portable device, the data from various sources are captured automatically and BI reports are generated using this set of uncompromised data, thus enabling better decision making.

- The embedding of the weight comparison algorithm into the iPlantation system and Weighbridge system will enable a comparison of the weight captured at the estate collection point with that of the actual weight measured at the weighbridge located at the mill.
- The data entry is reduced and discrepancies will be triggered with an alert, and a BI report will be generated that is embedded in the weighbridge system
- This will also check and balance the operational activities in terms of harvesting details and the wages can also be cross checked for data accuracy and correct payment.
- To ensure that less time consumed during data capture and minimum errors are committed during data entry. Currently, data that are captured at various locations is consolidated and transferred into another software package to create intelligent reports. By doing so, there is delay in getting the reports, and usually, this consolidation occurs at the plantation headquarters and estate managers seldom get to see up-to-date comprehensive reports.
- Since data are keyed-in by mill operators there is often a tendency for data mismanagement and incorrect input. In a single day, large volumes of data are keyed-in to the system that is based on the yield sent to the mill. This is a time consuming process, and after performing data entry for some time, operators tend to get tired and the data entry process slows down, which creates a huge backlog at the weighbridge location. The congestion at the weighbridge could be reduced if the system is automated, reducing not only congestion, but also wrongful data entry. This would in-turn would ensure data accuracy since there would be less human intervention.

III. Related Research

The proposed system comprises of several components that are inter-related with embedded system, weighbridge system and BI reporting.

A. Embedded System

Embedded systems generally involve both significant hardware and software design; a significant portion of a designer's task is to research the balance between their sequential and parallel execution forms [21]. For real time functions such as signal processing, designers often allocate concurrent tasks to distinct processors. A framework is also stated as a set of constraints on components and their relevant interaction based on that array of benefits that are derived from those constraints. A framework is a computation model that governs the interaction of components.

- A study was conducted in Malaysia [19] to monitor the plantation using various devices that can be integrated with an Android smartphone. The smart agriculture monitoring system uses electronic devices and Android-based smartphones for monitoring purposes, and lists all the pros and cons of the devices. However, the researcher was suggesting this could be developed as an Internet of Things application in the future.
- A research was conducted with the aim of improving the efficiency of milk collection for the dairy industry in Ireland [34]. The management decided to replace the traditional manual process with an integrated decision support system with the weighbridge system to provide effective milk collection operation. As the milk collection tanker passed through the weighbridge, data such as the farm name, volume of milk and temperature at the time of collection, was recorded. The Decision Support System (DSS) was used as an input to the scheduler and a Global Positioning System (GPS) to improvise the route and milk collection, not depending on the driver and other resources. However, the researchers reported that the study failed to meet the research objective, as the integrated system could not manage or plan the collection routes and drivers' schedules. No empirical evidence was recorded in the study.
- In China [6], research in weight monitoring and a control system that was conducted for a mining railway aimed to integrate the railway weighbridge and video monitoring. Each time an abnormal weight was recorded the system created alerts for the authorities. However, the success of the system was not evaluated and business intelligence reporting was conducted using the captured data.

B. Weight Comparison Algorithm

Most computer-based research comprises algorithms, which are used to prove the concept of the research and involve a number of steps to achieve the desired analysis as a result. This research applies an algorithm to determine the weight of the FFB that is estimated at the collection point at the estate. Later, this weight is compared with the actual weight at the weighbridge to check for discrepancies, and uses the embedded BI to report the discrepancies. Over the past few decades, many researches were carried globally to estimate the weight of FFB bunches. Most of the researches are based on the image processing and vision system [14]. The approach engaged for this research is the conventional method to determine and estimate weight; based on the actual weight, the accuracy of weight estimation can be calibrated over a period of time. Below are some of the studies that were performed to determine the bunch weight.

- Most of the algorithms that are used for identifying the weight of the fruits use image processing, the research from UPM [14] was conducted to produce high-resolution spectral bands using a visual system for imaging systems or hyperspectral sensing. The sensor systems investigate the FFB and determine the grading of the fruits using optical RGB cameras and hyperspectral imaging cameras. Although there is accuracy with a certain tolerance level, the prototype was engaged to prove that by using the automation process, the right fruits can be harvested.
- Research was conducted in Malaysia [4] to detect ripe fruits before harvesting; the prototype was designed for the tomato and various other fruits, including the FFB of oil palm. The outdoor vision system detected the ripeness of the fruits based on color, edge and orientation. The results indicated a 95% accurate extraction rate using the RGB camera for fruit detection. The research uses image processing to extract data such as color, shape and size to determine the quality of the fruit harvesting; however, the research states that additional attributes could be added to ensure greater accuracy.

C. BI

BI is a process that comprises of two main activities such as getting data, which is referred to as warehousing and involves transferring data from the original systems into an integrated data warehouse system. BI is now widely used and is part of analytic applications [18]. The value of the data is determined only when users and applications access the data and use it to make decisions. BI usually consists of users and systems accessing the data from the data warehouse to perform enterprise reporting, OLAP, querying, and predictive analytics.

- Research was conducted in India [20] on oil palm plantations to provide optimized soil conditions to maximize yield. The system consisted of many databases, BI, Knowledge Management and a user interface. The objective of the research was to compute the soil water content change, as an important ecological index, with respect to time. The integrated information system can extract data that will be used for agriculture decision-making; however, this research focused mainly on the water retention and no evidence of integration was stated.
- A BI journal [22] reported that BI existed from 1988 using data warehouse architecture and transformed in 1993 to layered data warehouse architecture. In the same research, the business needs for the 21st century were stated as a concept of operational BI and unstructured

content analytics. It also describes that knowledge density is perceived based on the usage and timeliness and the level in which data is granulized. The business integrated insight architecture describes the single, consistent and integrated set of information used in an organization for timely operational and strategic decision-making.

- In a whitepaper by Devlin [23], the roadmap of the existence of a data warehouse and how it has changed along the years based on the decision making necessity is described. The study also describes that BI architecture has three main components such as business information resources, business function assembly and personal action domain. The case study was conducted to reduce the current costs of enterprise-wide data infrastructure by diverting investment into a new opening that will enhance information usage and derive better decision-making throughout the organization.
- A study conducted in Indonesia and Malaysia [11] on best management practice (BMP) to maximize yield, by used BMP to address the inefficiencies during various stages of plantation operations. The FFB production from the BMP implemented location had better results compared with the non-implemented location.
- A research in India described the life cycle of BI and various phases that are involved in developing BI systems [25]. It further elaborated that there are many ways to apply tools and technology to better understand the insight of the operation in a business by gathering information from disparate internal and external data sources; the attained data are then interpreted with various data analytics to enable more accurate decision-making. People from various sectors have perceived BI in different forms, but the key is to gather information from disparate systems, and consolidate and perform data analytics to support decision making. Small and medium enterprises are looking out for relevant information and all types of business opportunities. The research highlights that BI is crucial to performing business activities effectively.
- A research on risk management [26] emphasizes that risk can be analyzed based on the data analytics that are generated with the related industry or business data. Risk is classified into field-based and property-based; the property-based risk is for the rest of the non-financial business and industry. From engineering to knowledge management, all industries require data that will be used to address risk, and BI is a vital part of any decision making process.
- A research on integrated frameworks presented various approaches to BI infrastructure [27]. The three main approaches were outlined in the research and their respective BI frameworks were explained. The integrated presentation has two separate systems for structured and unstructured system, upon capturing the data it is coupled to navigate and provide search functionalities. The systems are then integrated at the presentation layer. The second approach is an analysis on content collection, and this describes unstructured data such as metadata details that are extracted and combined with the structured data. Later, this combined data are transferred into the analysis layer to perform data analysis. The third approach is the distribution of the analysis results and creating an analysis template. The BI framework has three layers; data layer, logic layer and access layer.
- A study into real-time BI for adaptive enterprise [28], highlights the challenges faced during the process of providing real-time BI related information in business. The research describes that most real time BI systems require many tools and technology, and in addition it has to interoperate with many systems to provide real time BI. The relationship between the above is grouped into three layers. The analytic layer requires experts to configure the system and manage the information data in order to make decisions, and generally there is a time lag in getting the data on time. In order to remove the time lag, it was proposed that a high degree of automation is performed in this layer. The data integration layer consists of unstructured data, such as metadata, which is coupled with the structured data. The data warehouse is built in this layer based on the streamlined development life cycle. The third layer is the operational layer, business processes are not automated, and it is expensive and time consuming due to its complexity. However, this research provided an insight with real-time BI, with vendors approaching a solution to provide real-time BI. Microsoft has proclaimed the age of BI for the masses.
- Cloud computing is commonly used in this decade and BI has been in existence since 1988, and today, organizations and businesses are motivated to become BI experts in order to achieve greater competitiveness. [24]. There are many failed BI implementations, the research states that the reasons were unclear business requirement, multiple diversified data source, proprietary technology standards, and off-the shelf BI solutions, and further adds that the hardware and software costs are too high. The usage of information technology in business has reformed its strategic relationship by reintroducing grid computing, otherwise known as cloud computing that is flexible and scalable in terms of data and storage. In the research it is also cited that the investment cost was reduced since the hardware and software were shared. The survey results revealed the preference of Chief Information Officers (CIO)'s and their inclination towards the usage of cloud and BI. The cost benefits in terms of flexibility of implementation, availability and speed of implementation, was an advantage; however, the major concern was to access the cloud BI. The major disadvantage is the speed of data access due to the data processing taking place on the server side. Another drawback mentioned was that BI offered as service is limited and made available only to established vendors. Also, access availability is a challenge to attain real-time data analysis with data residing at the clients' side.

D. Weighbridge System

The weighbridge system has been used by various industries for load sensing by using both a portable and fixed weighbridge located at a strategic position to monitor a vehicle load. The weighbridge system is used to measure the load of vehicles passing through the weighbridge and stores the data.

- In Tanzania, research was conducted to check on vehicle overload on the trunk road [17], the study showed a significant number of vehicles were carrying overload on these roads. Due to this, the trunk roads were damaged and rework was often called for. To avoid such road damage, the weight of the vehicles was measured, and whenever a weight was detected above the specified range given by the authorities, an alarm was triggered by the control system. The owners of the overweight vehicles were fined. The data obtained were used at that location to raise alerts; however, it was not integrated with any other reporting system, nor was it transferred to other site for further analysis.
- Research was conducted in India on weighing in-motion [3] to capture the weight of a vehicle while on the move and not stationary. The weighbridge system has the vehicle stationed on the weighbridge scale during the weight capture. But in-motion weighing determined the weight of the vehicle based on the velocity of the vehicle and the number of axles, as it passes through the weighbridge. The record of vehicles passing through the system were stored and later viewed by the authorities. This research captured the aggregate weight of the vehicle and it was a proposed solution at the toll-plazas, since the focus was on number of axles and its approximate weight.
- A research was conducted in Malaysia [5] to automate in-field weighing of FFB using a one-ton trailer. The research conducted linked the FFB with the location and was used to track the FFB movement and generate reports at the plantation. The objective of the study was to automate the in-field weighing of the FFB. Data obtained were used to track and monitor the FFB evacuation and to prevent FFB theft in transit. However, they did not attempt to integrate with any other plantation system.
- The Mackay Sugar Co-operative Association Limited, a sugar factory in Australia [7] use the weighbridge system to harvest and transport sugarcane to the processing facility. The research was conducted at the sugar factory to improve safety and operations at harvest, as well as the transportation sector. This case study integrated various systems, and weighbridge was one of the systems. The weighbridge system was used to capture the load of the vehicle that carried the sugarcane at the entrance of the sugar mill.
- Oil palm plantations are huge and the coverage is vast, the quality of the fruits will deteriorate if there is a delay in sending the fruits to the mill; the extracted quality will curbed due to the delayed fruits. Significance was given to the integration of harvesting and transportation operations and the various technologies that were used to improve the efficiency of the system. Any problems that are encountered at the plantation and are not addressed immediately will affect the grading of the oil. The compelling issues, in terms of shortage in labor, the regulations with strict rules, added to the dynamics of environmental conditions, have driven up production costs [8]. The Malaysian Palm Oil Board (MPOB) has taken initiatives to develop a centralized motor control system to monitor the motors and devices used in palm oil production. An alarm sounds when the device detects an abnormal reading, demanding necessary action. Through this research, MPOB also developed a system that provided FFB grading analysis. The analysis is performed on FFB that are dropped onto a conveyor belt. According to the researchers, the grading was not accurate as the vision system excludes the fruits sampling which are hidden under the visible bunches of fruits in a clump. There has been no attempt to integrate the weighbridge system at the site and generate intelligent reporting.
- In research conducted in South Africa at mill laboratories for the sugar industry [9], data captured in the weighbridge were used as an input to the laboratory in the mill; this system integration involved Program Logic Unit (PLC) with the relevant hardware. The data that were captured during this process were stored in the device at the weighbridge location for display purposes and was not used for any type of analysis; the data were not stored in the device as a factor of display for user reference and indication. The Visual Display Unit alone was not enough for the user and it was integrated or built with a data storage unit to store the data in terms of the number of vehicles that passed over the weighbridge, the load, source and destination.
- A research in South Africa [10] on border post-cargo clearance used an automated identification card for tracking the cargo. It was stated that to improve the operational efficiency of cargo at the border, RFiD were used. The researchers stated that the inefficacy in human operations was addressed by the use of RFiD and automating the cross-border transport complementing the logistic industry. The data were stored at the weighbridge location for future reference. This study used the RFiD to capture the information at the weighbridge and store data such as weight, the origin of load (from which location), as well as the supplier and driver details. This weighing is part of a weighbridge system that would be embedded in a plantation operations system.
- A research on bio-physical determinants of production [12] was conducted in the ASEAN region that was based on eucalypt plantations. This study identified factors that have a major impact on production using the company's inventory data to assess growth rates, and based on the variation and trends, productivity was assessed. Data collected in various forms are gathered and compared against productivity. The rotation of plantation period and what is the first crop that needs to be planted is calculated. For this research, data were collected from Indonesia, Vietnam and China. The study highlighted the growth rate

of both eucalypts and acacias per hectare and stated that the growth was related to the planting routine. Those plantations that were managed by an individual company showed better results.

- A research in Australia on pine plantations in regards to productivity and cost of harvesting [13], compares the harvesting cost of the cut-to-length harvesting method and steam-wood biomass product. The conventional harvesting operations were to record the weight of the product and product log data, which were stored at the weighbridge located at the plantation site. Likewise, the chipped produce (by-product) weight information was stored at the customer (destination site) weighbridge. The weight extracted at both locations are mapped with the respective location. Although the mapping was a tedious process since the weight is extracted at various locations. Data were transferred to a single location and mapping was inaccurate due to the loss of information and data miss-match.
- A study conducted in Sub-Saharan Africa on freight transportation [10] shows that there was inefficiency in road freight transportation operations. One of the primary factors was the long delays at border posts that slowed the average movement of freight. Usually cross-border operations are tedious and cumbersome because of the conflicting security objectives of customs authorities versus the efficiency objectives of transport operators. Add to that, the system suffers from illegal practices involving truck drivers and customs officials. The efficacy of the operation can be improved if the systems are integrated. All the stakeholders come to a common conscious, data transfer could happen using the RFID and speed the movement of vehicles over the border can be managed.
- In order to meet the requirements of the metallurgical industry by integrating process information and monitoring the production process, a web-based system was developed to integrate the two processes using a network based on Ethernet for data transmission [15]. The data transmission channel was developed to have a real-time database to share the information of the production process and the data from laboratory. Although the system was integrated, it has to tap the weighbridge to get the information, the real time was possible only after the data was collected from the weighbridge. Although the monitoring system captures data, there is shortfall in the integration of the operation system and there is less evidence on analytical reports being created if there was a need for one.
- One of the researches conducted in bioengineering on agricultural fleet management was referred to as farmers' decision-making that was concerned with resource allocation, scheduling, routing, and real-time monitoring of vehicles and materials [16]. The researchers used fleet management tools for decision support in order to improve scheduling, routing and other operational measures for a fleet of agricultural machines. The main focus of the research [16] was to address administrative functions that included coordination and dissemination of tasks and related information to solve heterogeneous scheduling and routing problems.

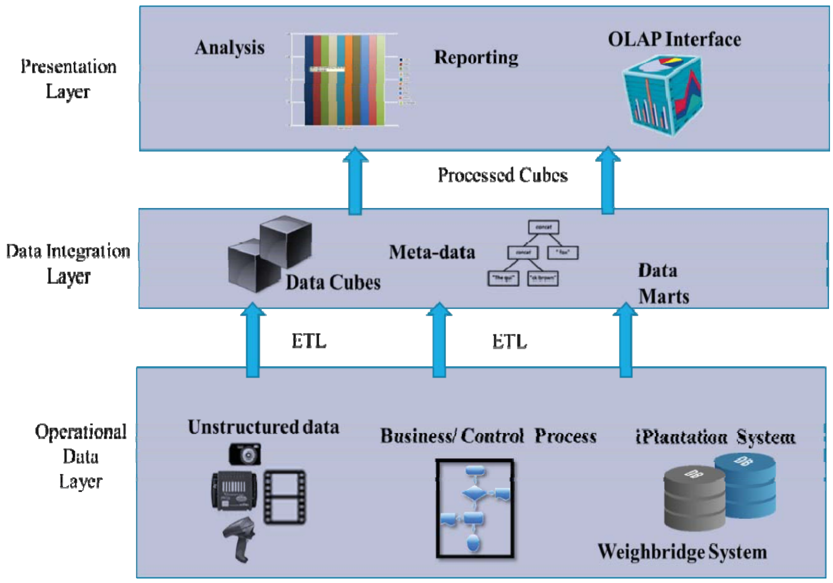

Fig. 1 System Architecture

IV. Architecture

The presented EWCA-BI would be a system that compares the data from the weighbridge with the data captured in the portable device that combines all the data of various forms and sources. The data captured from various sources are synchronized with the primary data. The EWCA-BI system consists of various components that interact with each other within and outside the specified layers, as shown in Fig. 1. The components within the layers in the system are described below:

- The operational data layer consists of unstructured data that is captured from the weighbridge controller, camera and portable device. The embedded system is programmed in governance with the business process controls in place. The iPlantation system and the weighbridge system will comprise of the weighbridge system and plantation operation data. This layer will consist of data from the weighbridge controller and barcode scanner. The weighbridge controller will capture the weight of the FFB. The embedded weight comparison algorithm captures supplier, vehicle and driver details; and the barcode scanner captures the load details in terms of the origin of the load, as well as the type of load. The system is designed to collect data from a barcode, and the embedded device will be synchronized with the weighbridge system and iPlantation system data. The plantation operation system consists of various modules capturing all operation related information. Some of the main modules in iPlantation are the Checkroll module that captures harvesting and field work information such fertilizer spraying and maintenance of the plantation. The Store module stores inventory details including tools, raw materials and utilities used in the fields. The Vehicle module contains information about vehicle running costs; this is done based on the usage of the vehicle at the relevant estate and the charging of the fuel within the estate and on the field. The weighbridge system stores data about the load and the load distribution details i.e. the FFB origin data with FFB grading, along with the weight.
- The data integration layer is the layer in which most of the processing takes place; this layer couples the metadata with the structure data. There are many ETL tools (extract, load, transform are tools used to collect data, load the data and represent the data in various forms) available to develop this layer. Based on this, the instruction is given to the data storage that assists in data cubes creation and data warehousing is performed in this layer. The Independent data mart and data warehousing used for this research is to couple the structured and unstructured data into meaningful information. Data warehousing is generated with the data from the weighbridge system and iPlantation system. This layer will remove ambiguity, transform data, and create dimensions based on the collected data. The data is then loaded onto the data mart, which will then be expanded (detailed) and summarized based on the requirement. This is called transformation of data from data marts.
- The presentation layer is exposed to the end user and enables the user to access the information in multi-dimensional forms. The BI reporting will provide the end user with adequate information to make real-time operation decision. The consolidated data are processed or automated into analytical reports and usually presented in the dashboard. This will provide a high-level data view and also drilldown (details data) to the smallest of information if there should be any action required. The end user will use the presentation layer through a Graphical User Interface (GUI) to interact with the data mart to pull and represent information in various forms to generate meaningful reports. The queries will be modelled based on the kind of information available from the data source, the results set will be extracted and loaded on to the data mart to easily access information on a real-time basis. The embedded BI reporting is a reporting tool that is loosely coupled by synchronizing the iPlantation system and weighbridge system data.

V. EWCA-BI Design

The iPlantation system has operational data that are captured on a daily basis. Data such as FFB harvesters' details, workers' attendance, fertilizer usage and spraying, as well as vehicle usage and maintenance details, are captured at the estate. The main data, which is the master table details, are decided and keyed into the system at the headquarters, are synchronized with the estate database, and the transactional data are captured at regular intervals during a day. The usual practice is that data are entered at the end of every day or they are carried forward to the next day. In order to perform this research, we embedded a console in a transportation vehicle (lorry) that carries the harvested fruits to the mill. This portable console consists of an embedded weight comparison algorithm with an embedded weighbridge and the iPlantation system; this console is installed in a lorry that enters the estate FFB collection point/area. At the collection point, the harvesters, field, driver and bunch details are captured while exiting the estate, the device will pass by the estate office where data are downloaded using the wireless network. The data that are captured at the collection point will estimate the weight of the load based on the algorithm and the system will attach an estimated weight for every load that is carried out of the estate.

Upon reaching the mill, the lorry load is measured at the weighbridge; this is instantly compared with the estimated weight and if the weight variance is beyond the tolerance, the necessary action will then be taken based on set conditions. The vehicle can be stopped immediately; once the data reaches the weighbridge, the data from the console will be synchronized with the weighbridge system. The BI reports will be able to show the discrepancies and an alert will be triggered for action. Fig. 2 shows the illustration on how the data are synchronized between estates and mills.

The components that are used to capture data are an embedded weight comparison algorithm that enables to capture the vehicle and driver details, the weighbridge controller to capture the load of the vehicle, the CCTV to capture the type of load, bar code scanner to scan the load details such as which fields and estates the load is from, and the router and the printer to connect to the network and print tickets. The harvesters' data captured at the estate are explained in the section algorithm design. Every transaction will be paired with entry and exit vehicle details; this will give the net weight of the load. The determined load will then be distributed to the individual estates.

The aim of this research is to embed the iPlantation system with the weighbridge system. The embedding of the two systems will be done onto a handheld device; this device will synchronize data in order to provide real-time information, as shown in Fig. 2. Using the real-time data, BI reports are generated, which would assist authorized personnel to make effective and timely decision. Based on the initial study, the usual practice in every plantation site or mill is that the weight of the load is captured at the weighbridge that is located at the entrance of the mill. The data are then migrated into the iPlantation system and verified with the harvester's details to check for discrepancies. During the migration process, some of the orphan records are omitted due to data miss-match (data being keyed in wrongly into the system). The loading information and some of the data are editable and prone to tampering, thus leading to data integrity issues. Data entry at the entrance of the mill takes five minutes, which is considered time consuming in this environment. In a day, the number of lorry trips are determined based on the yield for the day, if the transaction is time consuming then the trips will be hampered due to the back log at the entrance caused by slow data entry. This research aims to reduce the transaction time by embedding the iPlantation and weighbridge system; thus, reducing the data integrity issue. Embedding the two systems will reduce human intervention and provide real-time data. The data that is captured using this embedded system will be synchronized and BI reports can be generated to enable better decision-making.

The embedded weight comparison process in Fig. 3 shows the steps that could solve some of the problems that were highlighted during the interview conducted at the site. The highlighted problems were delayed reports, and time consuming data entry at the entrance and exit of the mill, thus leading to a huge backlog at peak hours, data integrity issues and data inconsistency.

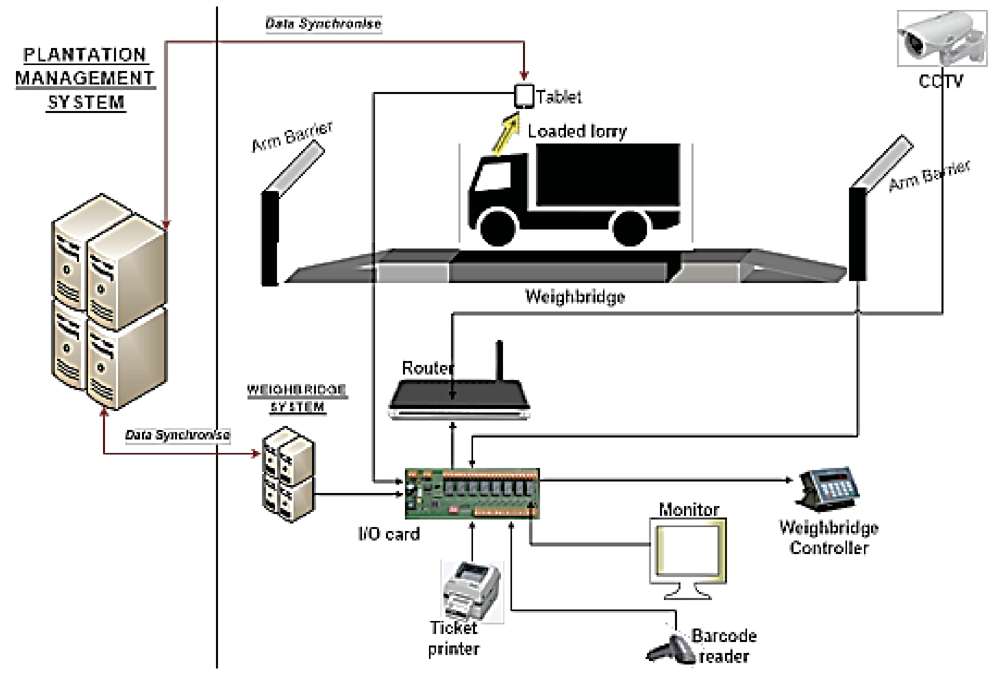

Fig. 2 EWCA-BI Overview

The embedded weight comparison algorithm is a method that will be carried by all the registered vehicles that enter the collection point on the estate. This device will have an embedded weighbridge and iPlantation system. At the collection point the driver will use this device.

To scan all the bunch receipt chits which store information about the field with regard to the respective bunch and harvesters details. The driver will have the total number of bunches at each collection point, which will later be compared with the harvesters collection chit. The collection point will also store the GPS coordinates to indicate the collection location. If the lorry is not full then the driver goes to another collection point to collect fruits until the lorry is full. Once the collection is complete, based on the number of bunches from the respective fields, it will estimate the average bunch weight of each field and the weight of load the vehicle is carrying.

Upon the collection of bunches at each collection point, a printout will be issued using the barcode printer. This Collection Advice Note (CAN) will display TPH, field/ block, supplier, vehicle, average bunch weight, and GPS coordinates. The load estimation is done based on the above mentioned algorithm, the average bunch weight is estimated with the actual weight that is captured from the weighbridge and its distribution based on CAN that will be scanned at the entrance and exit of the mill. The initial design was done based on RFiD to identify the vehicle and collect vehicle, driver and load details; however, along with the design and building of the portable embedded weight, the comparison algorithm will identify the vehicle, driver and will be able to do more than gather the limited data that could be carried by the RFiD tags. This was also a part of the contribution to embed the iPlantation with the weighbridge system within the embedded weight comparison algorithm. Every time the lorry with the embedded weight comparison algorithm passes by the estate office the master and transaction data are synchronized via a Bluetooth connection.

The data is entered into the system for checkroll calculation. Then it is verified with the bunch receipt chit to cross check the actual collection. Upon completing this task, the lorry leaves to the mill, then the handshake between the weighbridge system and the embedded weight comparison algorithm happens to synchronize the data into the system.

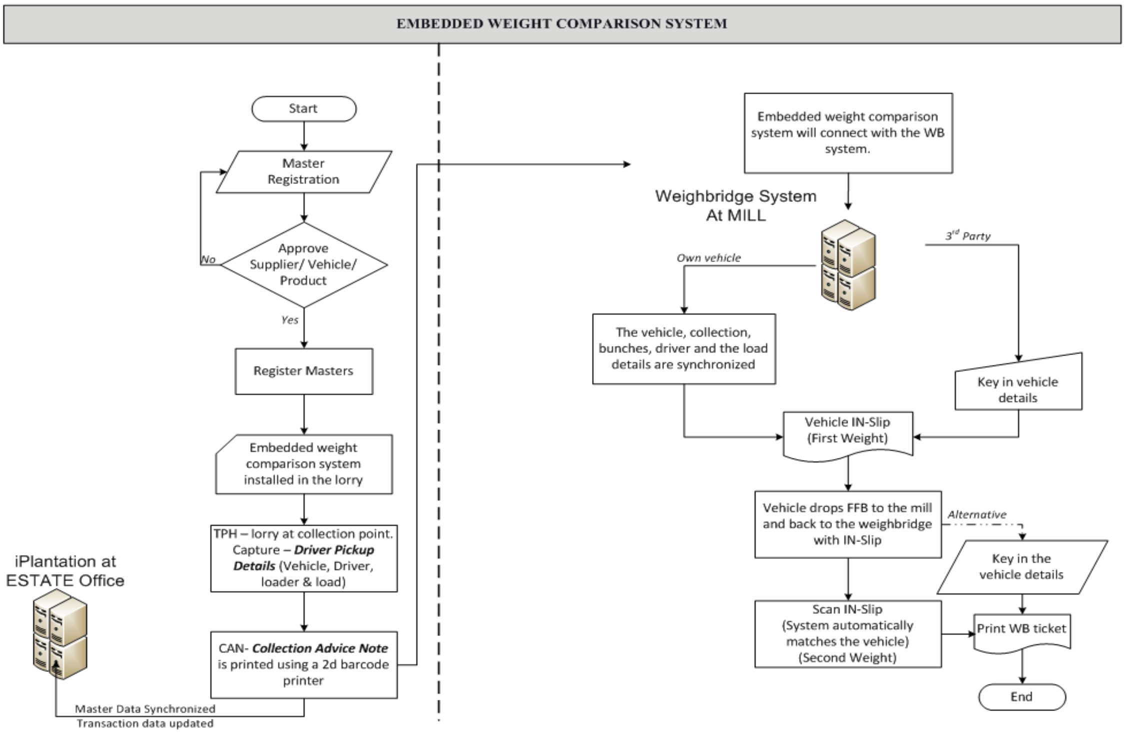

Fig. 3 Process Flow-Plantation Operations Embedded in Weighbridge System and Embedded Intelligent Reporting System

Generally, all the mills will have a weighbridge at the entrance and exit, and data for every vehicle load and load type will be captured and stored. The weight of the vehicle when it enters the mills is captured (first weight is the IN-SLIP) and when the vehicle leaves the mill, the weight (second weight is the WB ticket) of the empty vehicle is captured. The vehicle with the first weight is matched with the same vehicle of the second weight and the load weight is determined by the difference in both measurements. This information is stored at the mill and will be transferred into the iPlantation system on a periodic basis. The transfer of information is performed either by a flat file, migrating the data into the iPlantation system in order to generate a meaningful report. The limitation of this system is inaccurate information as the vehicle, supplier and the load information is manually captured at the mill. Since every transaction is time consuming, there is usually a huge back log at the weighbridge. Data is mismatched between suppliers and vehicle leading to compromised load calculation and data integrity, which is a one of the current problems. The outcome from the interview conducted with the operators and managers confirmed the limitation of the earlier process such as slow transaction period, and concerns over data integrity and reports delayed.

Following the interview outcome, a new process flow, as shown in Fig. 3, describes the registration of the supplier and vehicle, which are approved at the headquarters. After the vehicle and the suppliers are registered, each of entity is provided with an embedded weight comparison algorithm, which is a small electronic device that includes Bluetooth to synchronize data. For this research, the device is used for identifying the supplier, vehicle and driver details. As the vehicle enters the mill the supplier, vehicle and driver details are captured at the entrance. The driver will provide a document containing the load origin information. If the vehicle is a plantation-owned vehicle then the information is automatically captured, and if it is a third party vehicle the data entry staff manually key in the information.

After the data entry is done, a Vehicle IN-SLIP is printed. The IN-SLIP will contain information about the first weight, the vehicle and the load of the vehicle that is commissioned from the weighbridge controller. The driver takes the IN-SLIP, drops off the load at the specific place and drives back at the exit of the mill. The IN-SLIP is scanned using the barcode (a small image of lines called bars with spaces in between and with numbers written at the bottom of each bar. In the research, this technology is used to identify the document that contains the details of the FFB and its origin, such as the load weight and its source details), the relevant details are retrieved from the system and the details are tagged with the second weight. The difference between the first weight and second weight will give the net weight and weighbridge ticket is printed with the weight of the load that was carried by the vehicle.

The iPlantation system is embedded in the weighbridge system to synchronize the prime information that is unique and is maintained at headquarters and some of the information to the weighbridge system. The operation at the mill is captured using the embedded weight comparison algorithm, all approved suppliers are registered and their information is stored in the iPlantation system.

The data capturing process is automated by commissioning information from the weighbridge system, embedded weight comparison algorithm and barcode, to reduce the data capturing time that will be recorded to show the difference before the system and after the system, as well as to automate intelligent reporting based on the data that is captured at the weighbridge. The embedded weight comparison algorithm will transmit plantation operation information into the weighbridge system to avoid human error by reducing the need for manual keying in of information. Improving data integrity and generating real-time intelligent reporting for plantation managers to make immediate and timely decisions.

VI. Algorithm Design

The oil palm estate is generally divided by division and block, which are also known as fields. The BMP is the naming conviction of the field that will determine the year of planting, division and block of a plantation. The iPlantation system is a system that assists in the daily operation of the planation. All the master data (the data that is configured based on the individual plantation management practice) will be used as references during the weight determination.

Each estate will have its own collection point, the harvested fruits will be piled at a designated area, and usually it is like a grid within the estate. The harvesting of FFB will be determined based on the schedule and upon completion of harvesting; the lorry will go to each and every collection point to collect the harvested FFB. The lorry will pass through the estate office for every collection before reaching the mill where the actual weight is measured through the weighbridge.

Before getting the harvested FFB to the weighbridge, a number of incidents reportedly can happen, and loss of fruit is one of the major issues that are addressed by various means. Numerous attempts were performed to monitor the FFB and the lorry routing, and since it is a remote location, much of the time there was no GPS connection and the signal was lost. The tracking system was also not able to figure the weight differences. Many other weight measuring studies were used to measure the weight at the site, but apparently they were not real-time scenarios and the weight comparison was done with some latency.

The weight comparison algorithm measures the weight at the site based on the standards and compared with the actual weights recorded once the FFB is sent to the mill. Each harvester will record details such as the number of bunches, the field where the harvesting is done and which gang the harvester belongs to. The information regarding the field will determine the year of planting (YOP), which will in turn determine the size of the bunch that will attribute to the grading. This information will be gathered at the collection point and stored using the embedded system, and when the lorry reaches the mill, the actual weight is measured using the weighbridge. The algorithm will specify if there is a weight discrepancy, a weight difference of ± 5% is within the tolerance level. Should the weight be less or more than the tolerance level then the BI system will provide alert and the necessary decision and steps can be taken.

Generally, an entire field is planted in the same year; this is the BMP that is engage for many years in the palm oil plantation domain for easy tracking [2]. The average bunch weight is 27 kg and the table that is averaged based on the initial calculation is shown below

Each collection point will have more than one harvester's details all these data are collected and scanned into the system along with the working paper as a proof. Approximate weight will be determined based on the data provided by the harvester's chit. The harvester's data is used for many purposes, one to calculate the salary and also to distribute the operational cost in terms of lorry, fuel and rest of the operational cost.

FFB load (bunch weight) = bunch weight 1 (based on YOP) from harvester 1+bunch weight 2 (based on YOP) from harvester 2+bunch weight 3 (based on YOP) from harvester 3.

The standard weight is extracted, as stored in Table I. The table has block master data with the respective bunch weight with measure units in kilograms; this historical weight data is obtained from the average bunch weight based on the actuals and are updated in the Weighbridge system and iPlantation system.

TABLE I
Weight by Block Details

Block Number	Bunch weight (Kg)
B1	b1
B2	b2
B3	b3
B4	b4
…	…
Bn	Bn

The bunch weight of the FFB will depend on the age of the tree that is determined using the YOP, as listed in Table 2, and the weight also varies based on the soil type, rainfall and fertilizer being used. The average bunch weight, as listed in Table 3, stores the block number with the average bunch weight that is used as a reference to calculate the bunch weight that is harvested and collected from the collection point as described above. Usually the standard table will be updated using three methods;

Method 1: The bunch weight, which is collected at the collection point, will be measured at the weighbridge, and then this weight is then averaged based on the collected bunches from the same field and stored.

Method 2: Sampling of the weight is performed using the weighing scale, which is the manual checking to create a balance in the weight.

Method 3: The bunch weight that is stored in the average bunch weight master is averaged based on three months of gathered data and the average bunch weight is then updated with this new average weight.

TABLE II
BLOCK MASTER

Block Number	YOP (year of planting)
B1	2009
B2	2010
B3	2012
B4	2014

Block number with respective year of planting, will enable to determine the age of the tree that is used as a factor to calculate the average bunch weight.

The age of the tree = Current year – YOP

The weight variance = actual weight – FFB bunch weight

Assumptions, variables and tables

The Table 3 block number with the average bunch weight is calculated using one of the methods as stated above, for this research we are using Method 1.

TABLE III
Average Bunch Weight Master

Block Number	Weight (kg)
B1	5
B2	7
B3	10
B4	12
B5	16
B6	18

The process flow for the algorithm as shown in Fig. 4 has the below listed variables. Each of the variables will store different data. "i, j, x, y, k, l, m, n, p" are parameters that are used to store data in the form of variables.

x = number of harvesters; y = number of bunches; k = number each block; l = field number; n = weight; p = total weight; m = standard weight from Table III.

Option 1.
example
x= 3
y=3
k_1 *= (11,10) // 1 set of number / block*
k_2 *= (10,15) // 1 set of number / block*
k_3 *= (12,15) // 1 set of number / block*
Block numbers
l_1 *= (B1,B2) // field number*
l_2 *= (B2,B3) // field number*
l_3 *= (B1,B3) // field number*
Weight based on Block numbers
m_1 *= (20,15)*
m_2 *= (15,25)*
m_3 *= (20,25)*
p=0
for (i=1;i<=x; i++)
for (j=1;j<=y; j++)
$\{n_j = (k_{j1}\ X\ m_{j1}) + (k_{j2}\ X\ m_{j2})\ p=p + n_j\}$

The algorithm process flow in Fig. 4 describes the steps shown in Option 2.

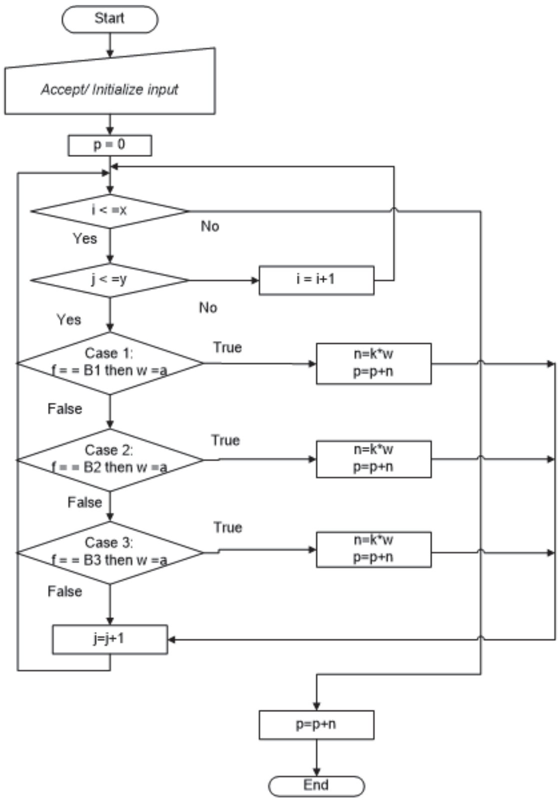

Fig. 4 Algorithm process flow

Option 2.
Dim CaseNumber
Dim NetWeight
Number = 2
Select Case Number
Case 1 // block 1
weight = bunches * ABW
NetWeight = weight + Netweight
Case 2 // block 2
weight = bunches * ABW
NetWeight = weight + Netweight
Case 3 // block 3
weight = bunches * ABW
NetWeight = weight + Netweight
End Select

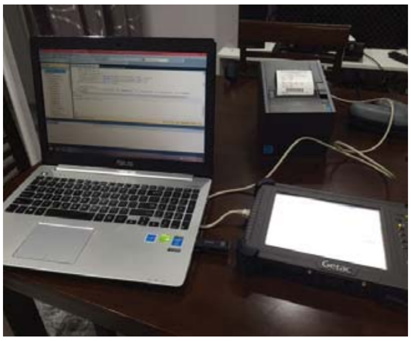

Fig. 5 Prototype – EWCA-BI

The EWCA-BI prototype was developed based on the design and the algorithm stated above and is shown in Fig. 5. Data captured from the EWCA-BI is compared has reduced the data capture time at the weighbridge, as the data is not entered manually by an operator. The data from the portable device synchronizes the data and the weight comparison takes place with the actual weight during this process, the abnormal weight will initiate the BI report that shows the discrepancies in the weight and the necessary decision can be taken based on the report instantly on site. The system will generate the ticket at the site after the data is captured at the weighbridge and the printout is given, as shown in Fig. 6. Upon measuring the second weight, the BI report will be generated, as shown in Fig. 7. This report provides the FFB bunch weight based on the block and the year of planting. There are many reports generated using the embedded BI, Fig. 7 shows one of the reports from the entire list of BI reports.

Fig. 6 2D scanner print out

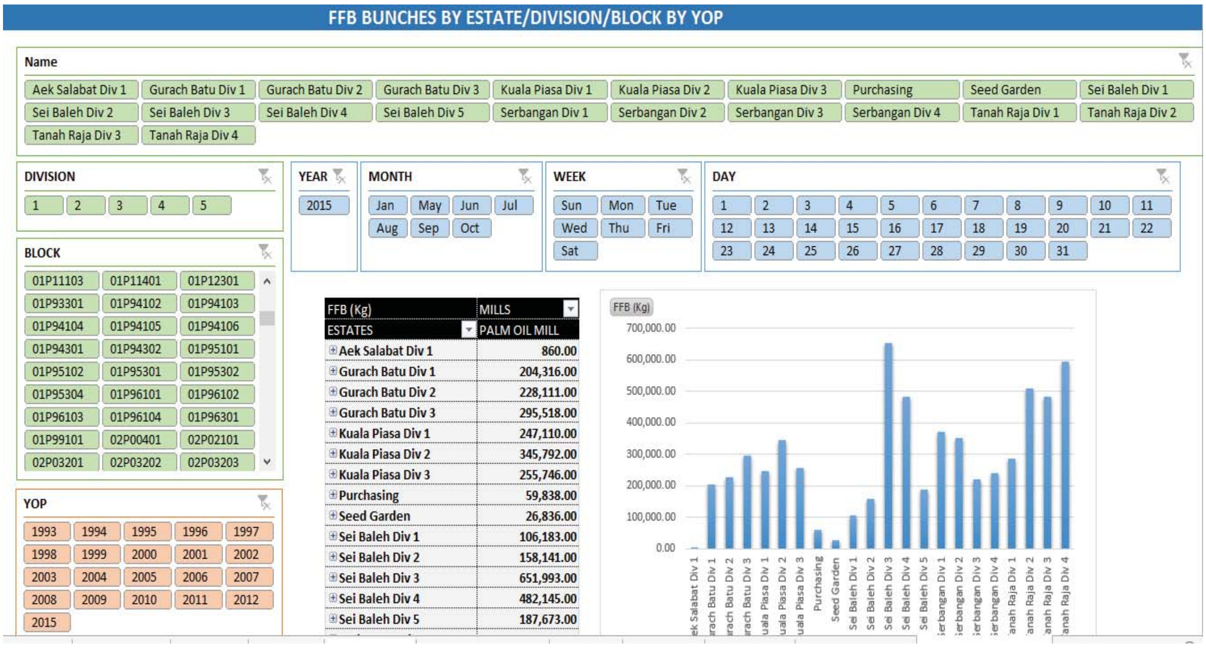

Fig. 7 BI Report

VII. Conclusion

The aim of this research is to provide a framework for embedding a weight comparison algorithm with business intelligence. As stated earlier, there is a lot of potential in embedding reporting system, as this result will provide real-time business intelligent reporting on site. Oil palm being a commodity industry requires instant decision-making based on the real-time available information, which will contribute to the economy by reducing the cost outages. The data for the embedded BI will be attained by embedding the weight comparison algorithm within the iPlantation and Weighbridge system, and the portable device would include the algorithm that will estimate the weight and compare it with the actual weight of the FFB being carried by the lorry in which the device is installed. This approach will remove the general way of data capturing done using various legacy systems with some integration, this leads to data inconsistency and ambiguity. In order to get timely information, data has to be transferred to a reporting system on a periodic basis, causing delayed reports.

The EWCA-BI will provide accurate and real-time data for better decision making, with data gathering at the weighbridge system embedded with the planation management system, where users such as mill managers, estate managers, mill operators and operation assistant will be able to get reports that will assist in addressing the current issues, whilst waiting for top management to assist them with countermeasures.

The EWCA-BI aims to reduce errors through having less human intervention and improve each transaction time. When the embedding is done, then the data capture will be done using the embedded weight comparison algorithm to capture most of the data in terms of the supplier, vehicle number and driver details. This will also be integrated with the bar code scanner that will scan and capture the block and field details from where the fruits are harvested, as well as the driver assigned to the vehicle. The second significant contribution is to embed the weight comparison algorithm with the Weighbridge system and iPlantation.

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