D3.5 – Integrated Traceability System

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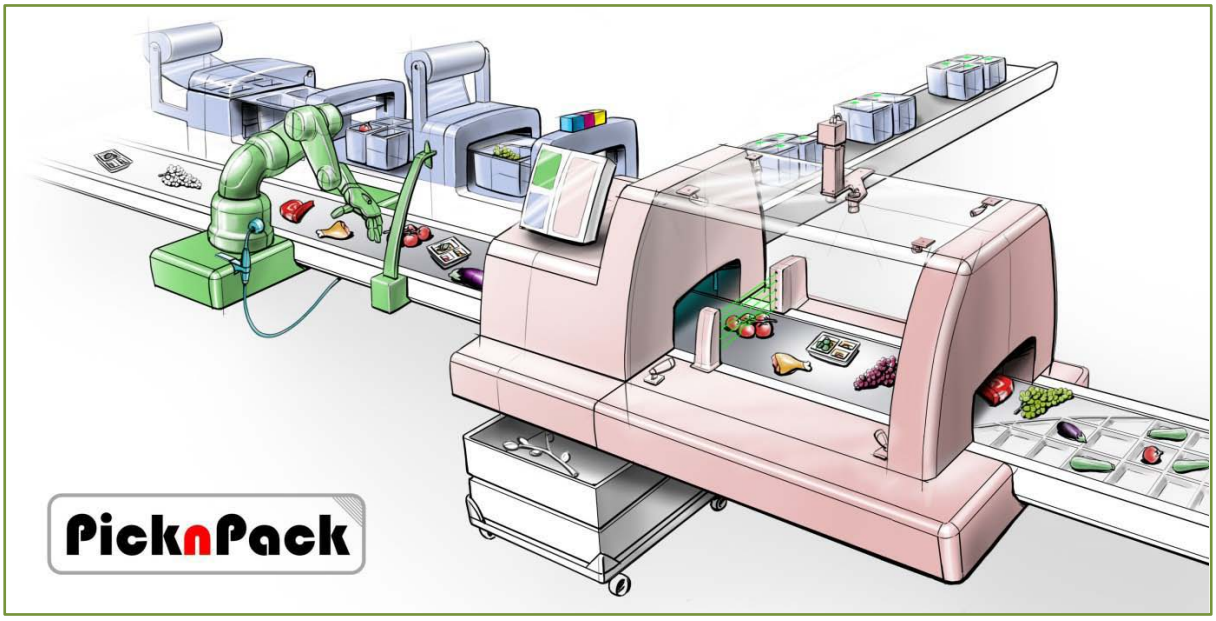

Flexible robotic systems for automated adaptive packaging of fresh and processed food products

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Dissemination level		
PU	Public	X
PR	Restricted to other programme participants (including the EC Services)	
RE	Restricted to a group specified by the consortium (including the EC Services)	
CO	Confidential, only for members of the consortium (including the EC Services)	

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1. Introduction

This document outlines the operation of the integrated traceability system, relating to the delivery of:

- D3.5: Integrated traceability system (M30)
- D3.6: Report on traceability systemintegration (M30)

The associate milestoneis:

- M3.4: Optimised and complete integrated operating system (M36)

The integrated traceability system has been developed as the outcomeat M30. The system is achieved by implementing the application interfaces integrating the RFID enabled traceability system (outcome of M3.3)interfaced with the Database system to the production line.

This report illustrates the functions and operations of the integrated traceability system. A brief introduction of the system architecture and functions is given, and the details of the operation steps are provided in the following sections.

2. The IntegratedTraceability System

The integration work in the current stage mainly focuses on the software interfaces to interact with the line controller, share data in Database with other modules, and request data from other modules. For compatibility and interoperability of the modules in the line, the standard TCP message protocol ZeroMQ (ZMQ or 0MQ) and data format JavaScript Object Notation (JSON) are employed in the traceability system. The events and actions handling is based on the Life Cycle State Machine (LCSM).This section illustrates the system architecture, functionality, and process model of the RFID traceability system.

2.1 System Architecture

In the RFID traceability system, the RFID readers with multiple antennas located in the production lines are interfaced to a local area network with a router. The RFID traceability software application manages the RFID readers and receives tag information obtained from the readers. All traceability information is stored in the database. The user can search current and history information with the traceability application and handheld reader application.

Fromthe data flow perspective, the functional modules can be described with diagram in Figure 1. The traceability system mainly consists of four modules: traceability software application, handheld reader application, database, and RFID module.

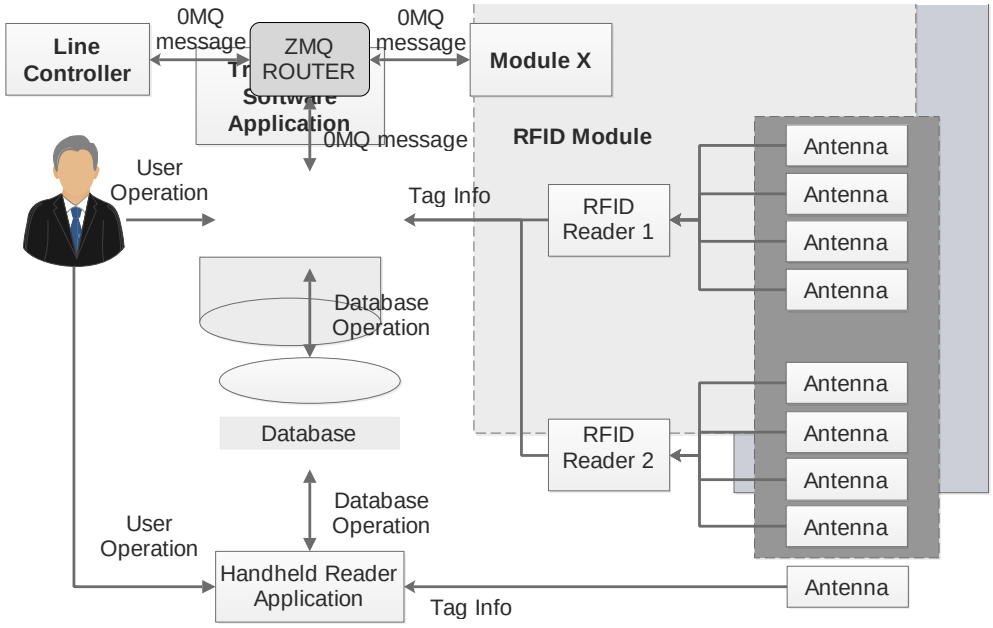


Figure 1Diagramof the Functional Modules

When integrated to the line, the traceability system communicates with the line controller and other modules for command request and information sharing through ZMQ messages. The information in the Database can be requested by other modules, and the traceability system can request data from other modules also.

2.2 Application Interface for Integration

The ZMQ based message interface for data request operation is as shown in Figure 2.

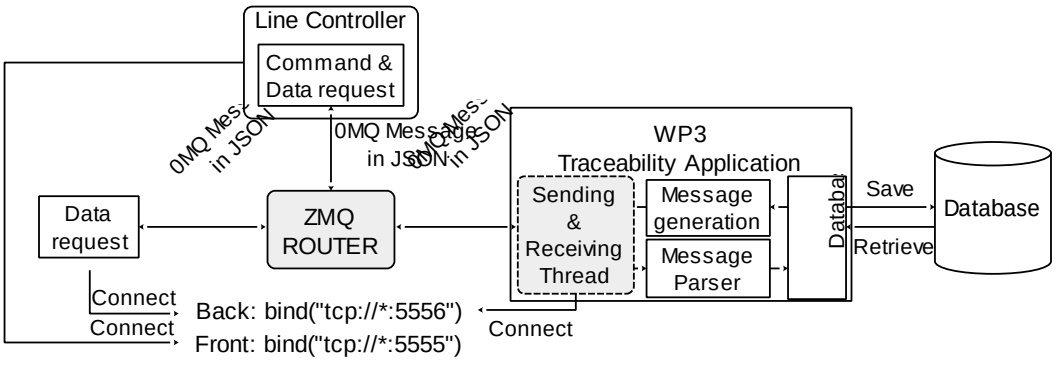


Figure 2ZMQ Interface for Data Request

As shown in Figure 2, the traceability application connects to a TCP ports as a ZMQ DEALER, and modules requesting data are also connect to a ZMQ ROUTER. The modules send a ZMQ message in JSON to the traceability application. The traceability application receives the message, parses the JSON message, executes the request, wraps the data in JSON, and then replies the message to the requester. On the other hand, the traceability system can also request data from the other modules in the line. The line controller works as a ZMQ Client.

In the data interface, the ZMQ ROUTER plays a very important role. It forwards module X's request to the traceability application and the forwards traceability application's reply back to module X. It also forwards traceability applications data request to module X and forward back module X's reply. In addition, it forwards traceability application's broadcasting information to all connected modules.

2.3 Functionality

The traceability system is required to be able to track the product information automatically when the production line is running. By locating the antennas in the production lines, the product with RFID tags are recorded and stored to the database automatically. Then, all related information such as supplier information, weight and quality, price, logistic unit information, and other optional information are linked together with few human assistants.

The function of the RFID tracking system is to record a tag ID of the production line, and then provide all related information linkedto the tag ID. Before the main operation process, the preparation work needs to be done in the background:

- Monitor the RFID readers and configure them
- Monitor ZMQ command messages from the line
- Monitor the ZMQ data request message from other modules and reply

When the registered containers are ready, the main operation process for information trackingcan be started:

- New material subdivision - With the RFID detected containers, the source material can be put into containers before packaging.
- Packaging - After providing the product information in 'Batch Setting' and 'Package Setting', user can start the system for packaging recording to create records in database. Unique IDs detected are broadcast to the line.
- Logistic unit - User can select detected available containers and register selected containers as a logistic unit.
- Delivery - User can select a customer and sending place to create a database record of dispatching a logistical unit.
- Scan and Query - With unique RFID tag IDs, all related information stored in database can be retrieved with the traceability application or a handheld reader. User can also request information of a product from other modules, such as WP4 DAQ module.

In all the above steps, the RFID tag ID is used as a unique information to associate different processes and track the objects automatically in the production line.

2.4 Process Model

With RFID devices implemented in the traceability system, the production line process is then assisted with the RFID modules and product information is recorded in database automatically. The process model is designed as shown in Figure 3. The components with RFID icons are the processes enhanced with RFID tracing, and those without RFID icons are operated by human only.

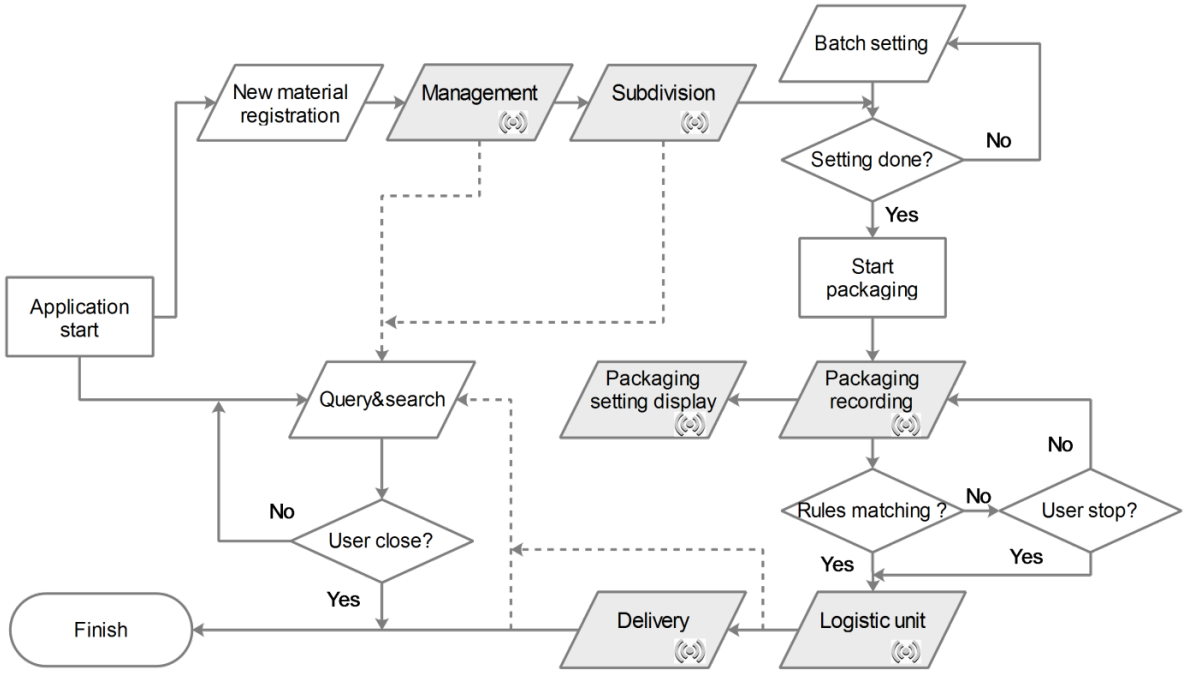


Figure 3Process Model of the RFID Traceability System

When new material for packing arrives, user needs to manually register the materials with the system. The containers are also registered with RFID tags in the management process. Then, after the batch setting, the packaging job can be started by clicking on the 'Start' button. The packaging stops when user set rules are satisfied or the user manually stops it. The RFID tagged containersavailable can be registered as logistic units by clicking on 'Register' button. User can then select a valid customer and a sending place to create a record of dispatching a logistic unit by clicking on 'Send' in delivery window.

Through the process, the user can observe the information by query & search function, and command and data request from the line and other modules are handled. The records of registered containers in management, containers for subdivision, packing jobs, logistic units, and sent delivery units can be searched and checked by object ID or tag ID.

3. Operation Steps

This section provides the steps on how to use the RFID enabled traceability system. There are 8 steps using the RFID traceability system: RFID configuration, container registration,

new material registration, subdivision, packaging, logistic unit, delivery, and scan and query. Details of functions and operations in each step are described in the sub-sections. Screenshots of the operation interfaces are provided as well.

There are operational interfaces for all the above steps in the main interface (as shown in Figure 4) of the RFID traceability system. The operation interface for each step of function can be called out by clicking on the buttons on the top of main interface.

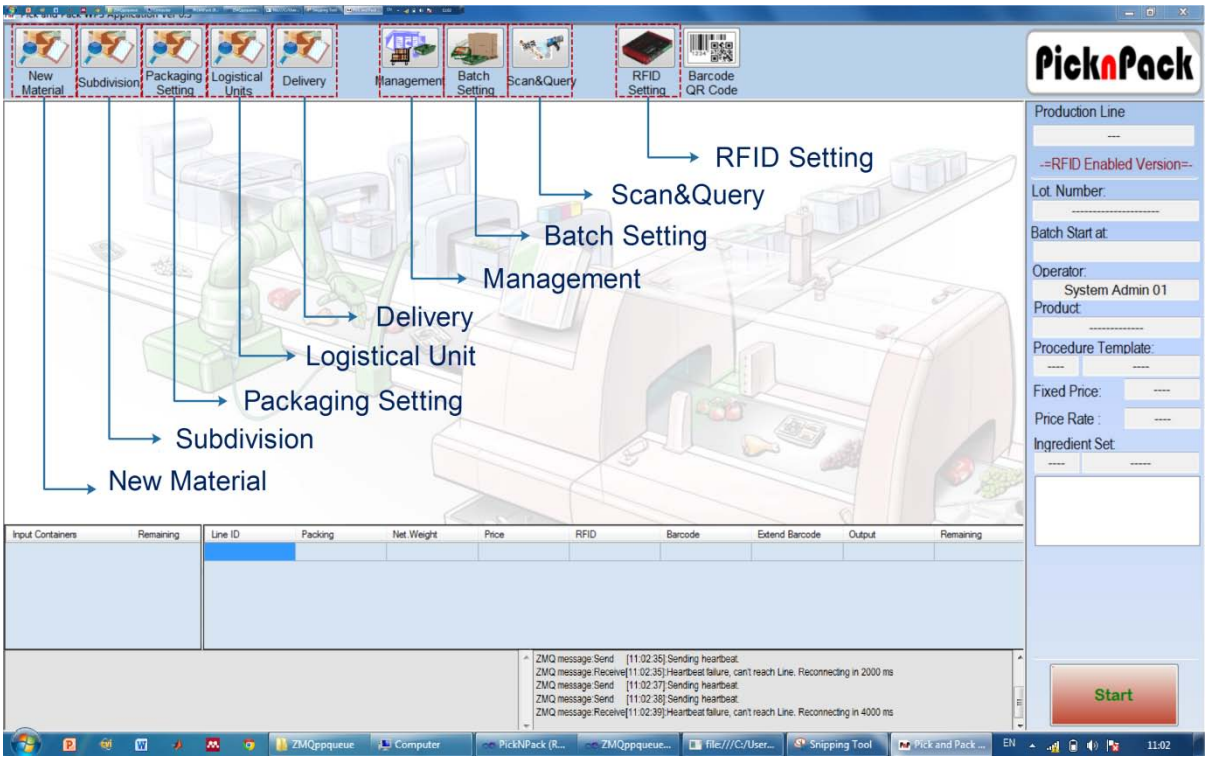


Figure 4Main Interface of RFID Traceability System

Different from the previous version, the integrated version added a textbox on the bottom right to display line command and data request messages, heartbeating,and reply of the traceability system.

3.1 RFID Configuration

Before the RFID hardware modules can be used for information tracking, they need to be configured. The configuration consists of two steps:

- RFID reader initialisation, and
- Reader/antenna location setting

RFID reader initialisation is to connect to the RFID reader and set some parameters with protocols and command sets of the reader. This process is completed with a background thread automatically without user' attention. When the initialisation is finished, the readers and their state are shown in the interface for the user to perform the further operations.

In order to provide an interface for the user to observe the RFID readers and the tags recognised, a 'RFID Configuration' window is designed as shown in Figure 5. This interface, (1) shows the reader information, (2) lists the state change of the readers with timestamp, (3) shows the raw tag messages, (4) gives the unused tag items with locations, (5) presents the object item messages, such as small packages, internaland external containers.

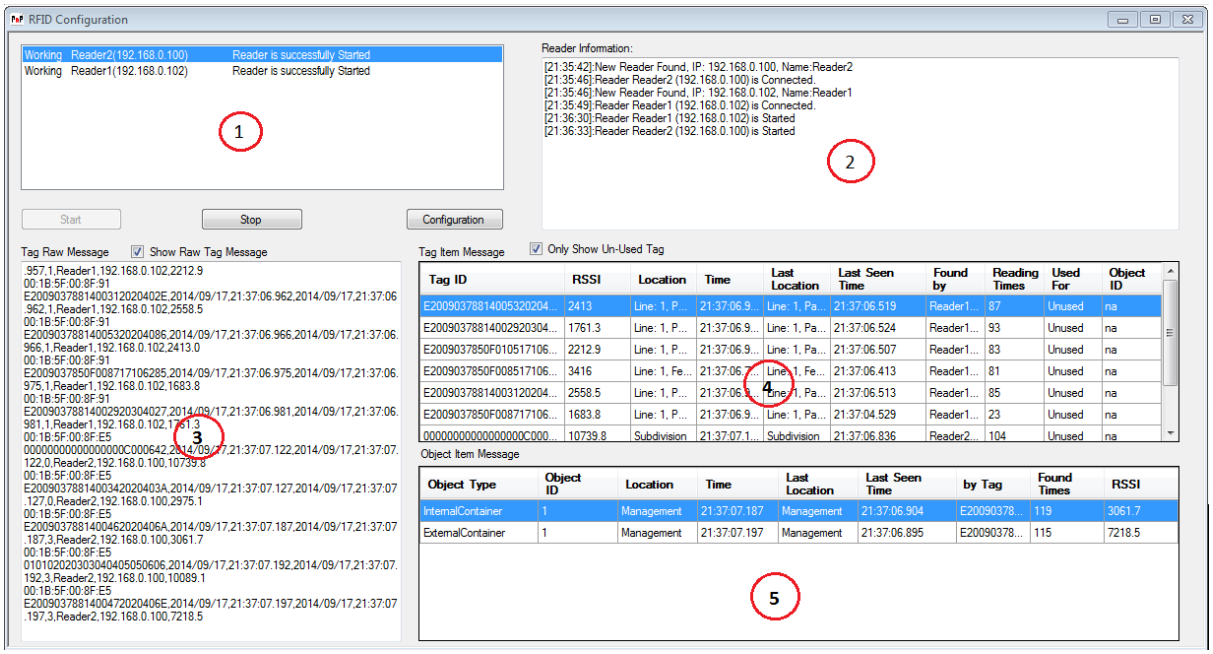


Figure 5RFID Configuration Interface

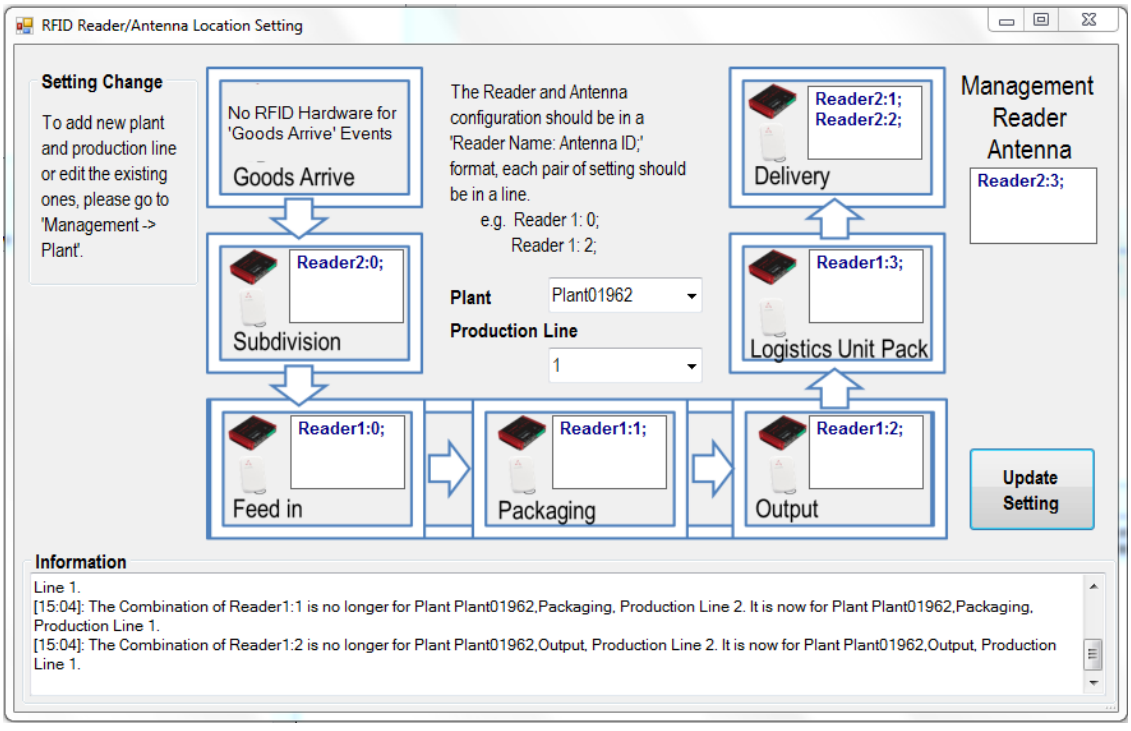


Figure 6RFID Reader/Antenna Location Setting

Figure 6gives the operation interface for reader/antenna location setting in the production line. The user can specify the plant and production line first, and then set the reader and antennas in the format 'Reader Name:Antenna ID;'. The input data is accepted as the valid setting for the operations and the data is stored until new setting is initiated.

3.2 Container Registration

The container registration interface is in the 'Management Window', which could be called out by clicking on the 'Management' button in the main interface of the traceability system.

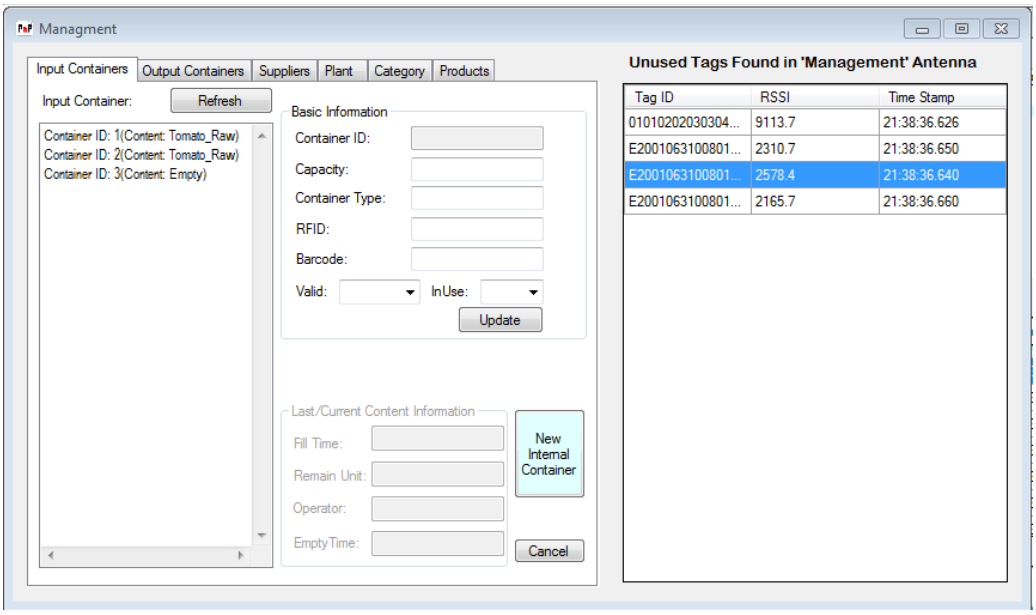


Figure 7Input Container Registration Interface

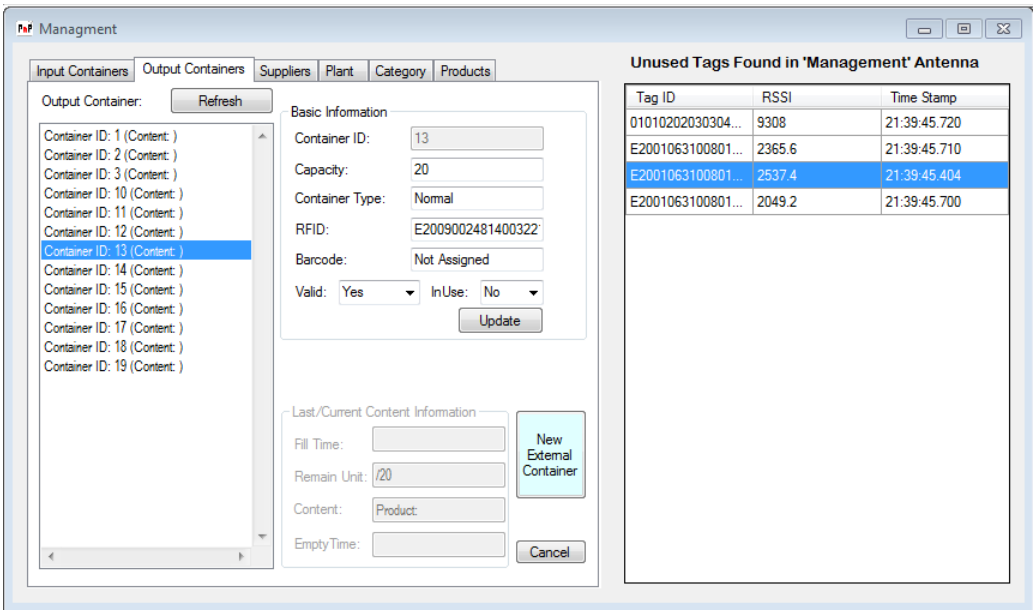


Figure 8Output Container Registration Interface

As shown in Figures 7 and 8, on the left are the input/output containers and on the right are the list of detected tag IDs. User can select a container and then assign a tag ID by double clicking on one of the IDs in the list and click 'Update' button to confirm. Only the unused tag IDs are displayed in the list and it is updated in real-time.

In addition to container registration, the user can create new suppliers, plants, production lines, and product information by manual inputs in the 'Management Windows'.

3.3 New Material Registration

Before subdivision and packing, the incoming new material needs to be registered manually by the user to create records for the incoming goods batch.

As shown in Figure 9, the 'New Goods Registration' interface can be called out by clicking on the 'New Material' button in the main interface. The information to input is:supplier information, weight and quality information, logistic unit information of the batch, and other optional information. The records for incoming goods batch can be created by clicking on the 'Update' button when all necessary information is provided.

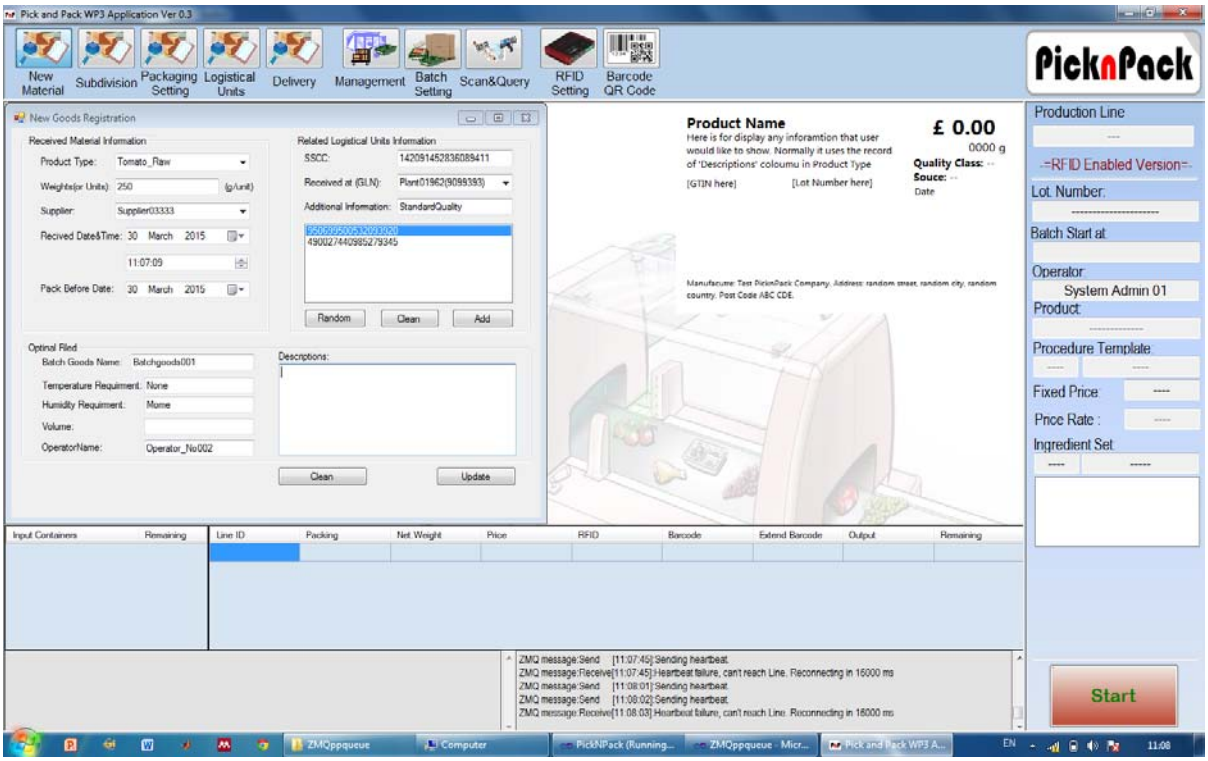


Figure 9New Material Registration Interface

3.4 Subdivision

The source material needs to be put into containers before it is used for packing. This activity is referred to as 'Subdivision'. The subdivision interface as shown in Figure 10can be called out by clicking on the 'Subdivision' button in the main interface.

Before the subdivision, the incoming goods batch should be selected. The user can query the last 10 incoming goods batches by clicking on the 'Show Recent 10 Batches' button, or searching goods batches by date.

Whenthe user selects a goods batch from the searched results, a list of valid containers is showing up in 'Detected Container Section'. The list shows containers detected in subdivision location only and it is updated in real-time. The user can pick up a container from the list and click on the 'OK' button to confirm the 'Subdivision'.

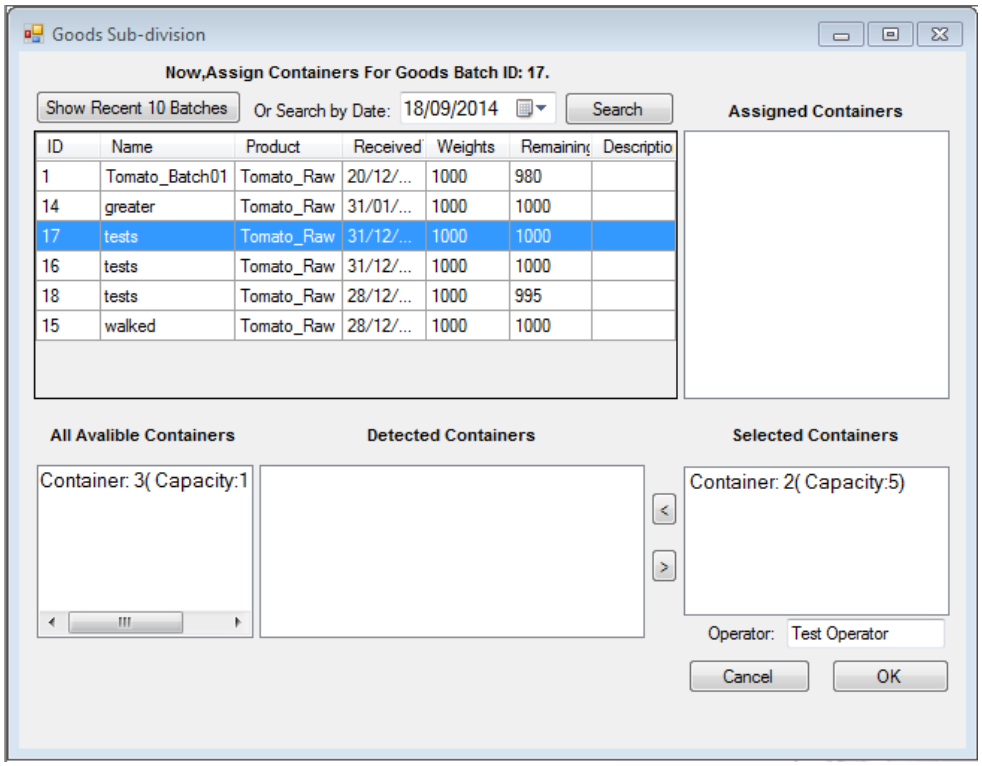


Figure 10Subdivision Interface

3.5 Packaging

(1) Batch/Lot Setting

Before packaging record can be started, the user needs to configure the job setting which can be found in the 'Batch/Lot Setting' window as shown in Figure 11.

Four kinds of information are required in the batch setting: name of product, production line information, procedure set, categories of ingredients, and output product type and its GTIN number.

The production line is then ready for recording the packaging activities when the user clicks on the 'OK' button to confirm the provided information. The main window is also updated as shown in Figure 12.

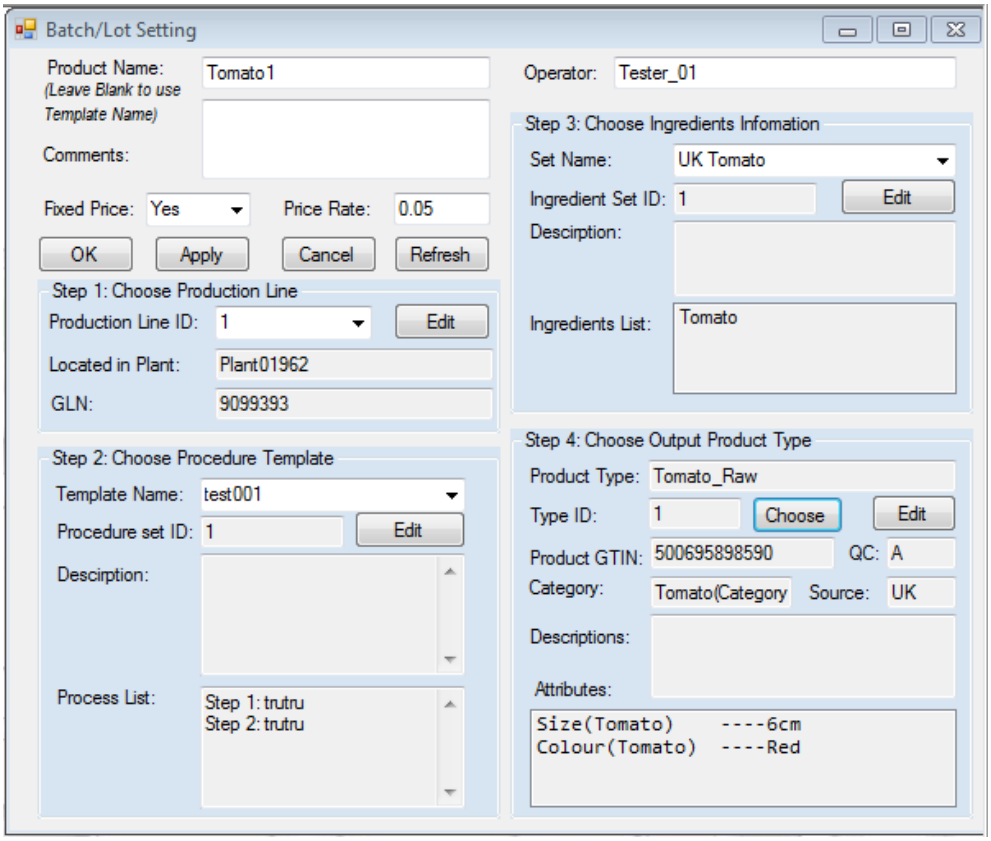


Figure 11 Batch/Lot Setting Interface

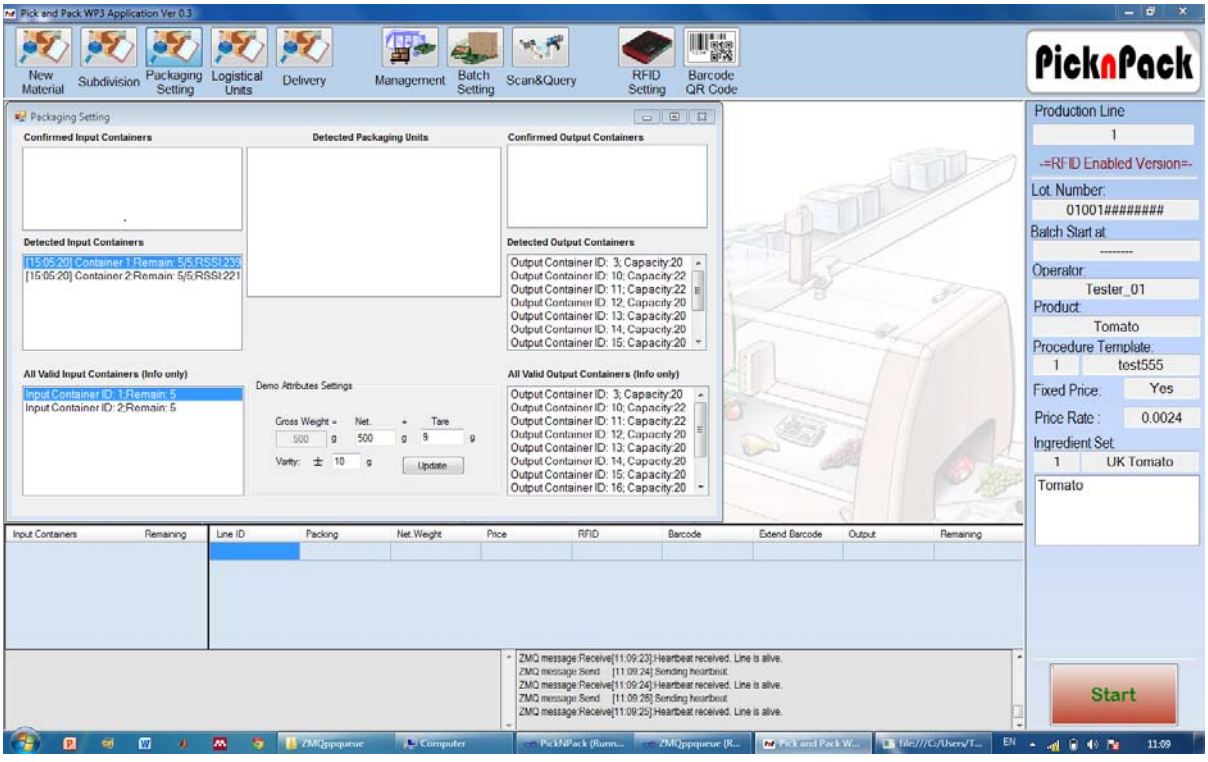


Figure 12Updated Main Interface after Batch/Lot Setting

(2) Packaging Setting

The ‘Packaging Setting’ window is used to observe the RFID modules and display them in real-time. The interface can be called out by clicking on ‘Packaging Setting’ button in the main interface.

When the packaging recording is started, the application will select all detected input containers as the ‘source’ and a container with the greatest RSSI listed in the output containers as the output container. The process is as shown in Figure 13.

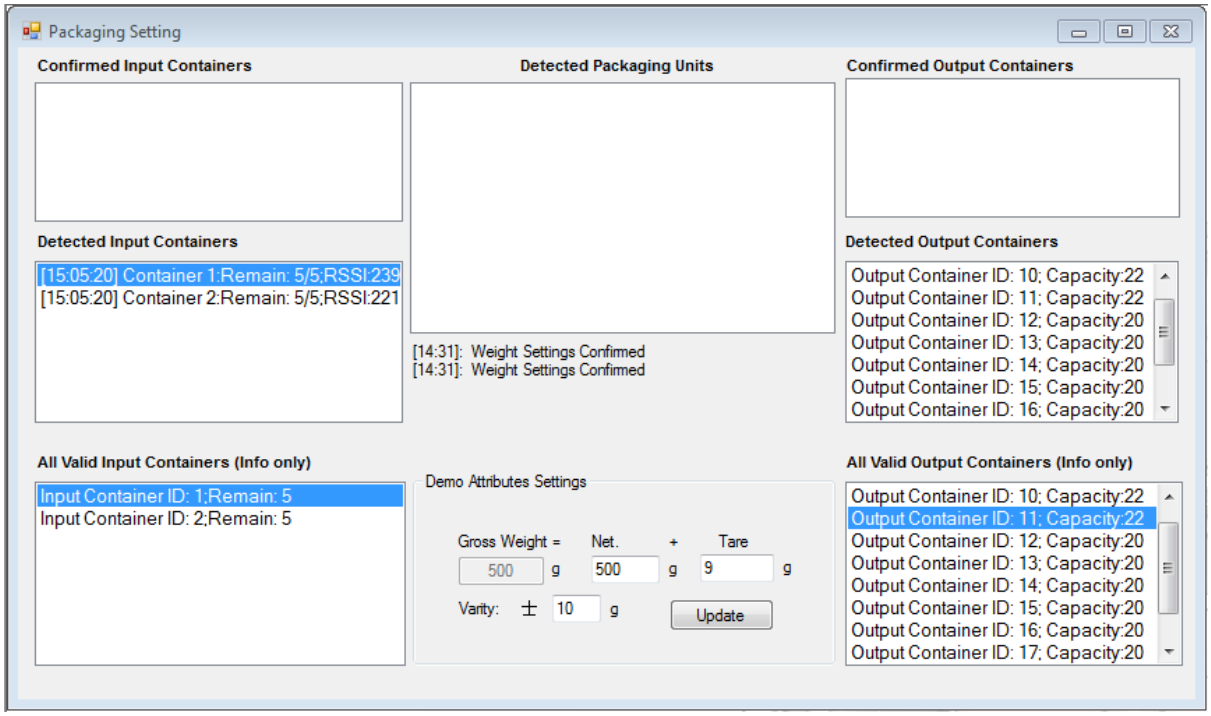


Figure 13 Input and Out Containers are Automatically Selected by the System

(3) Packaging Recording

The function of detecting and recording a product package relies on the RFID module. Each package should be assigned a RFID tag, and the RFID detection needs to follow the rules as below:

- The tag is new with no record in the database
- The tag is detected in the location of ‘Package’
- The packaging job is running
- The input containers and output containers are both confirmed

If above rules are matched, a package is confirmed and a record is created in the database. The display in the interface is also updated as shown in Figure 14. Packaging will be stopped

if the rules are not matched. An example of packaging stop due to lacking of input container is as shown in Figure 15.

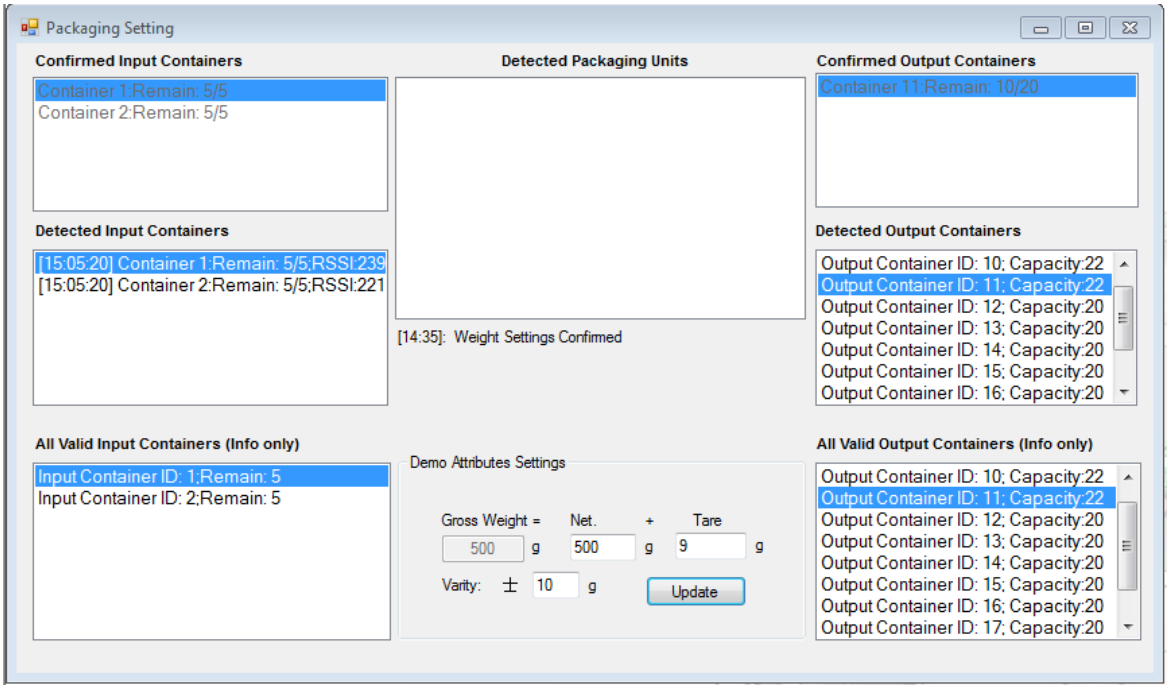


Figure 14Packaging Recording Interface

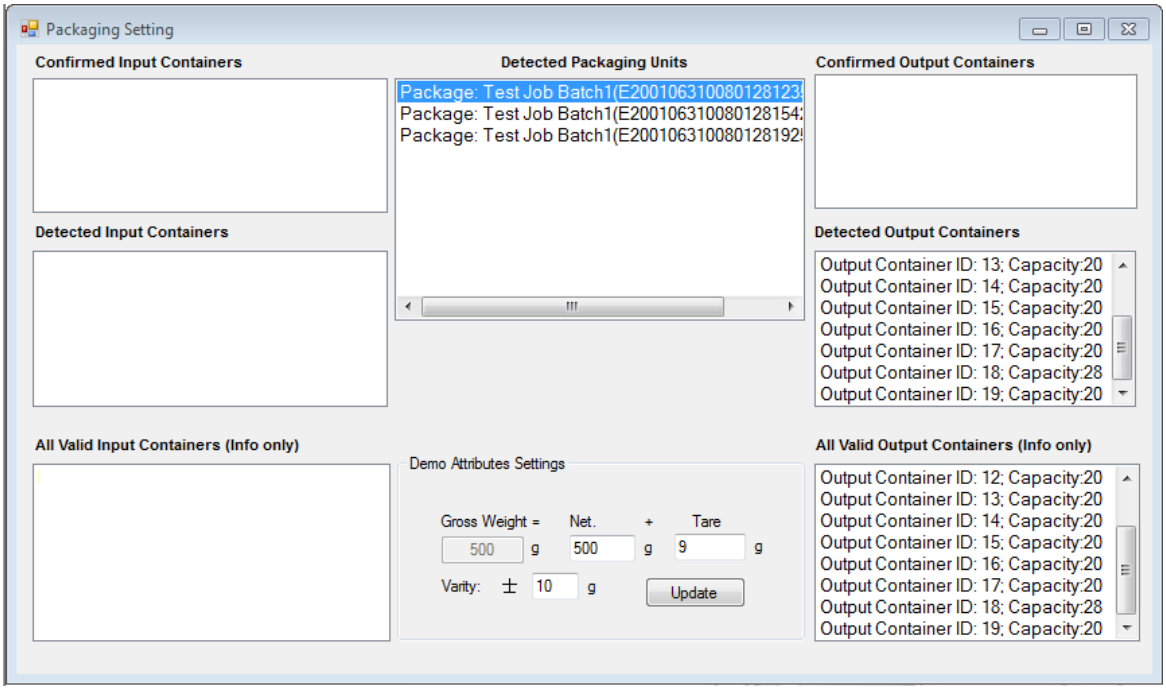


Figure 15Packaging is Stopped

When the system is packing, the ID of the new found product isbroadcast to the line. The broadcasting message format is as shown in Figure 16.

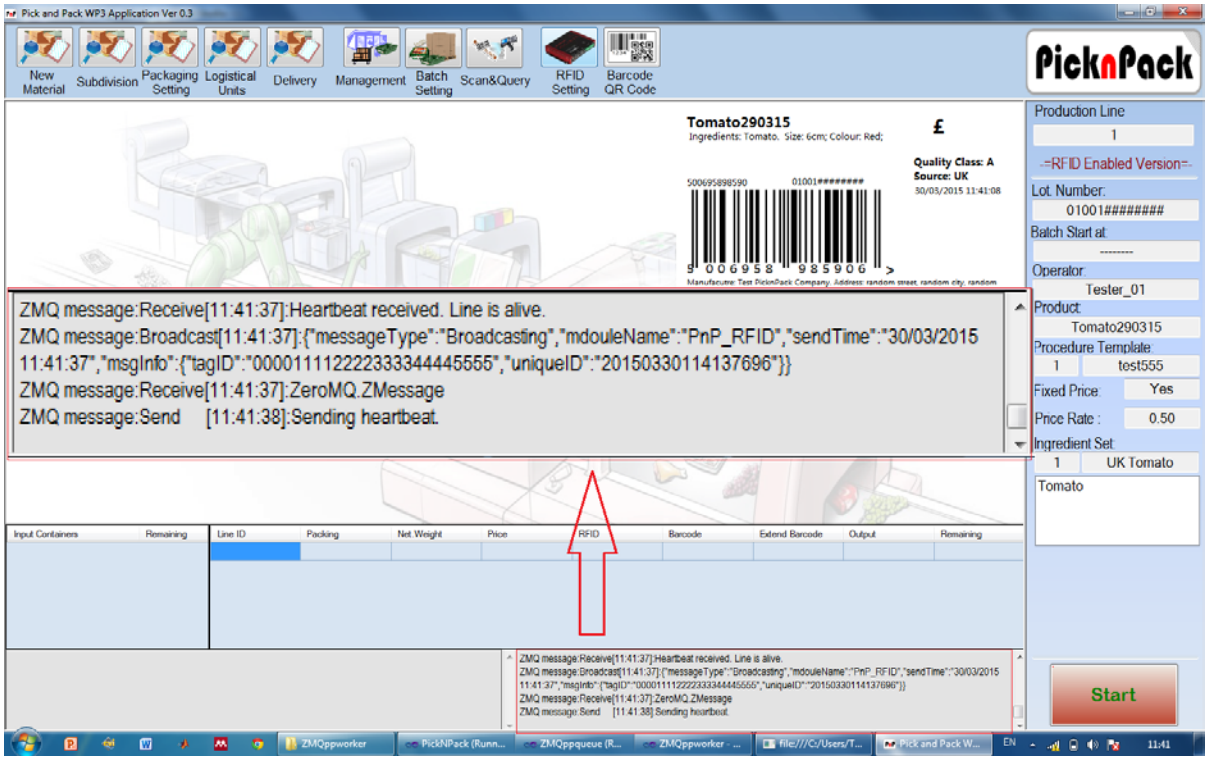


Figure 16Unique ID Broadcasting

3.6 Logistic Unit

The function of logistic unit is to package the external containers into a logistic unit for delivery. The user can select the valid output containers in the list.

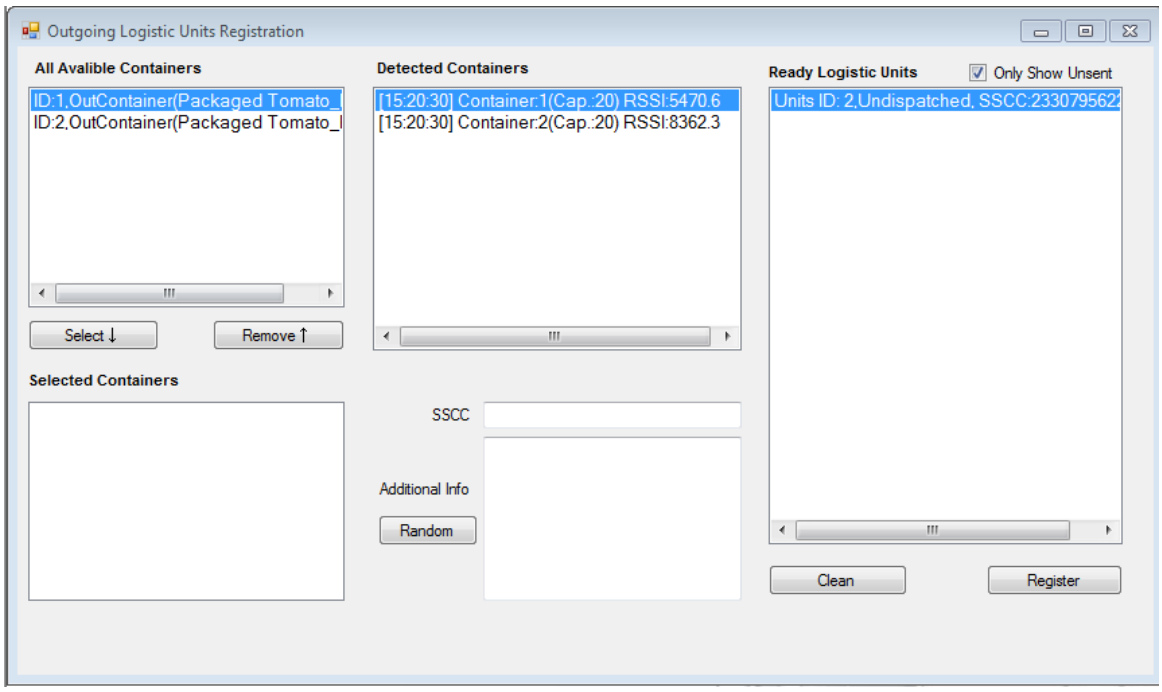


Figure 17Logistic Unit Interface

As shown in Figure 17, the detected containers and those available are listed in the 'Logistic Unit' window, and the list is updated in real-time. The user can select one or more containers from the 'Available Containers' section or 'Detected Containers' section. The selected containers can be registered as a logistic unit by clicking on the 'Register' button.

3.7 Delivery

The prepared logistic units are then displayed in the 'Delivery' window as shown in Figure 18. In order to create a record of logistic unit for dispatching, a valid customer and sending place must be selected. Then, a record in the database is created by clicking on the 'Send' button if all necessary information is provided.

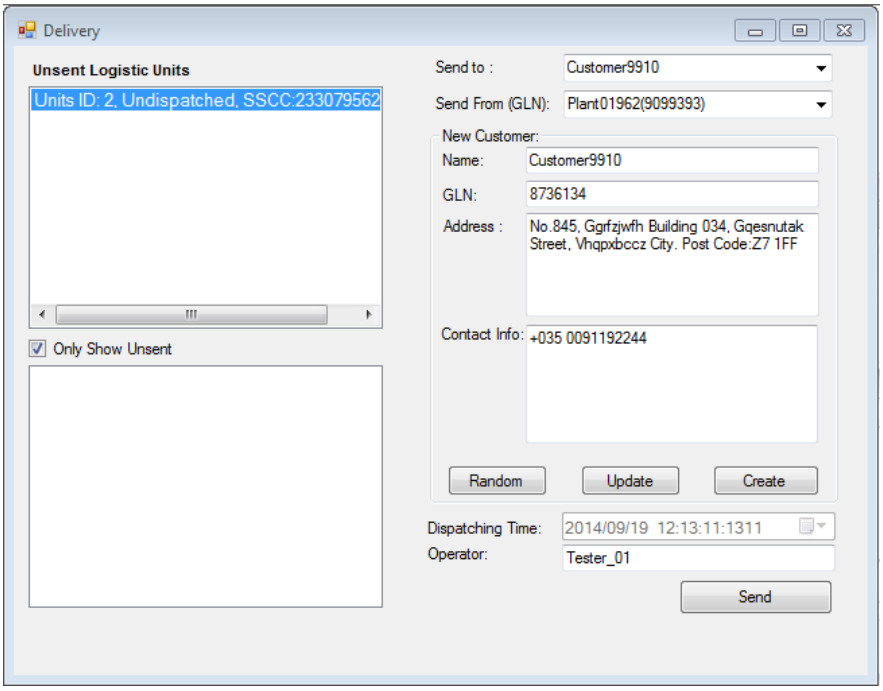


Figure 18Delivery Interface

3.8 Query &Search

The query and search function can be performed by both the traceability software application and the handheld RFID reader application.

(1) Query & Search with Traceability Software Application

The 'Query & Search' function is used for the user to look up the information of a certain object. The interface of 'Query & Search' function is shown in Figure 19.

The user can input specific tag ID, barcode, or other object ID to search the detailed information. The user can also retrieve details of objects by double clicking on the object IDs list on the bottom of the window detected by the RFID readers when the packing job is running.

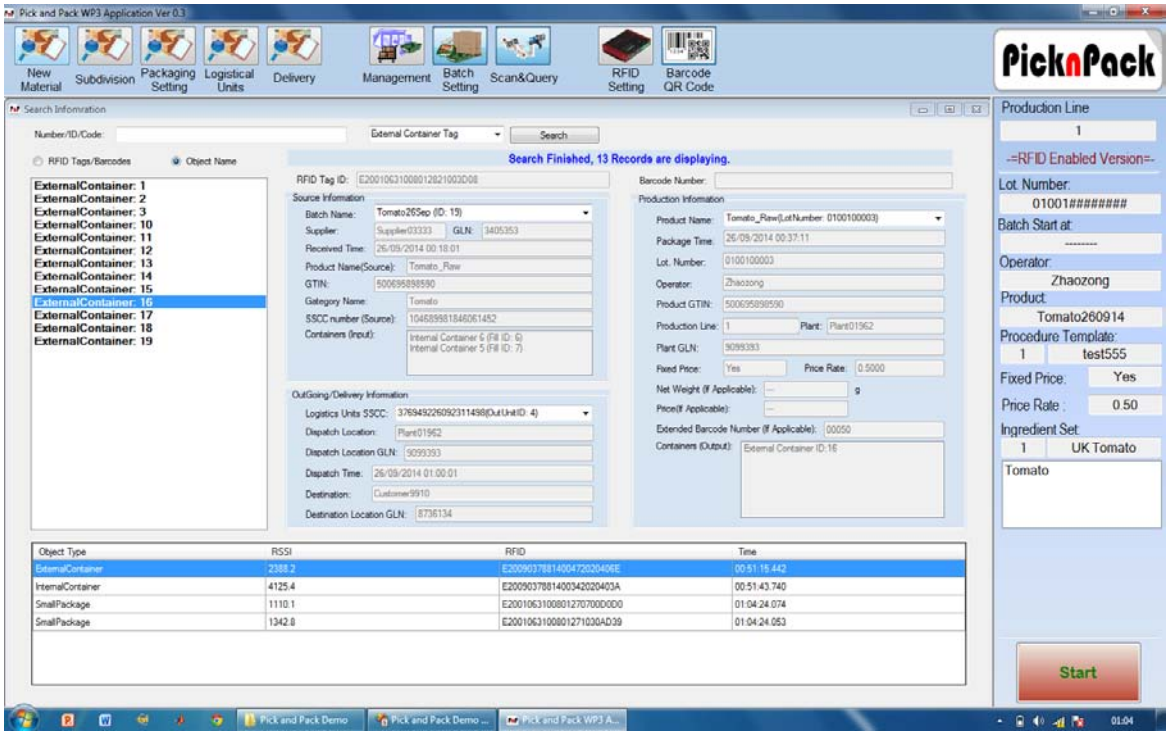


Figure 19 Query Interface

In addition to query the information saved in the Database, the traceability system can also request data from other modules. The data request message is as shown in Figure 20. Reply messagesfrom other modules will be parsed and presented on the user interface.

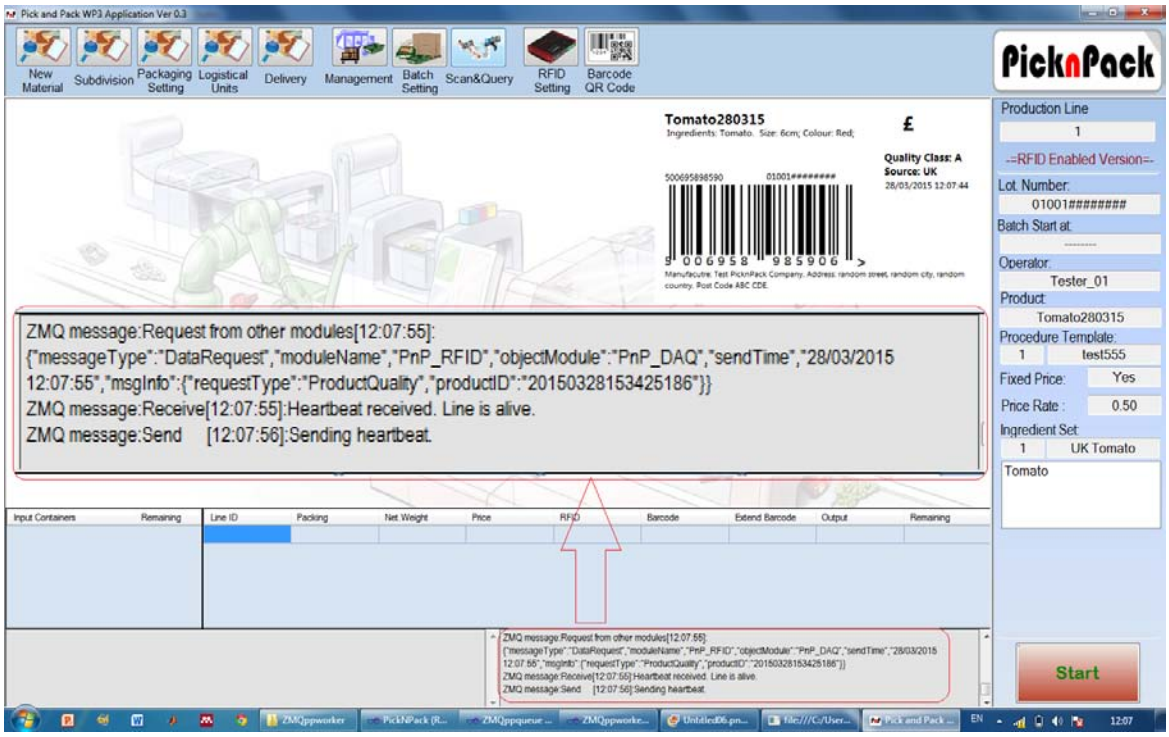
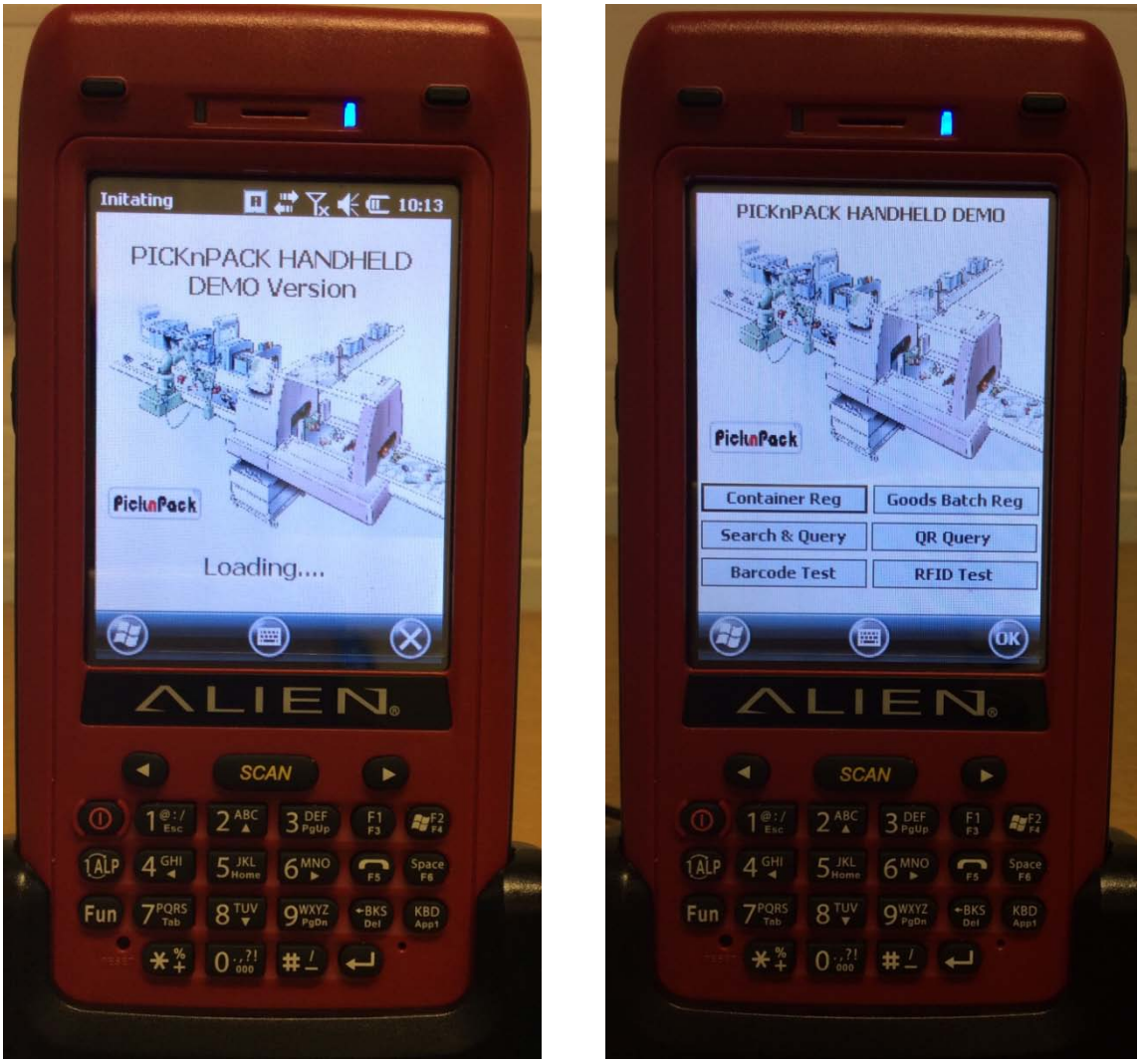


Figure 20 Request Data from other Modules

(2) Query&Search with Handheld Reader Application

Since the handheld reader is of lightweight, portable, and convenient, it is very useful for query & search in some situations where fixed readers are not available. The handheld reader application starts automatically when the handheld device is turned on as shown in Figure 21 (1). The main interface is as shown in Figure 21(2).



(1) System Booting (2) Main Interface

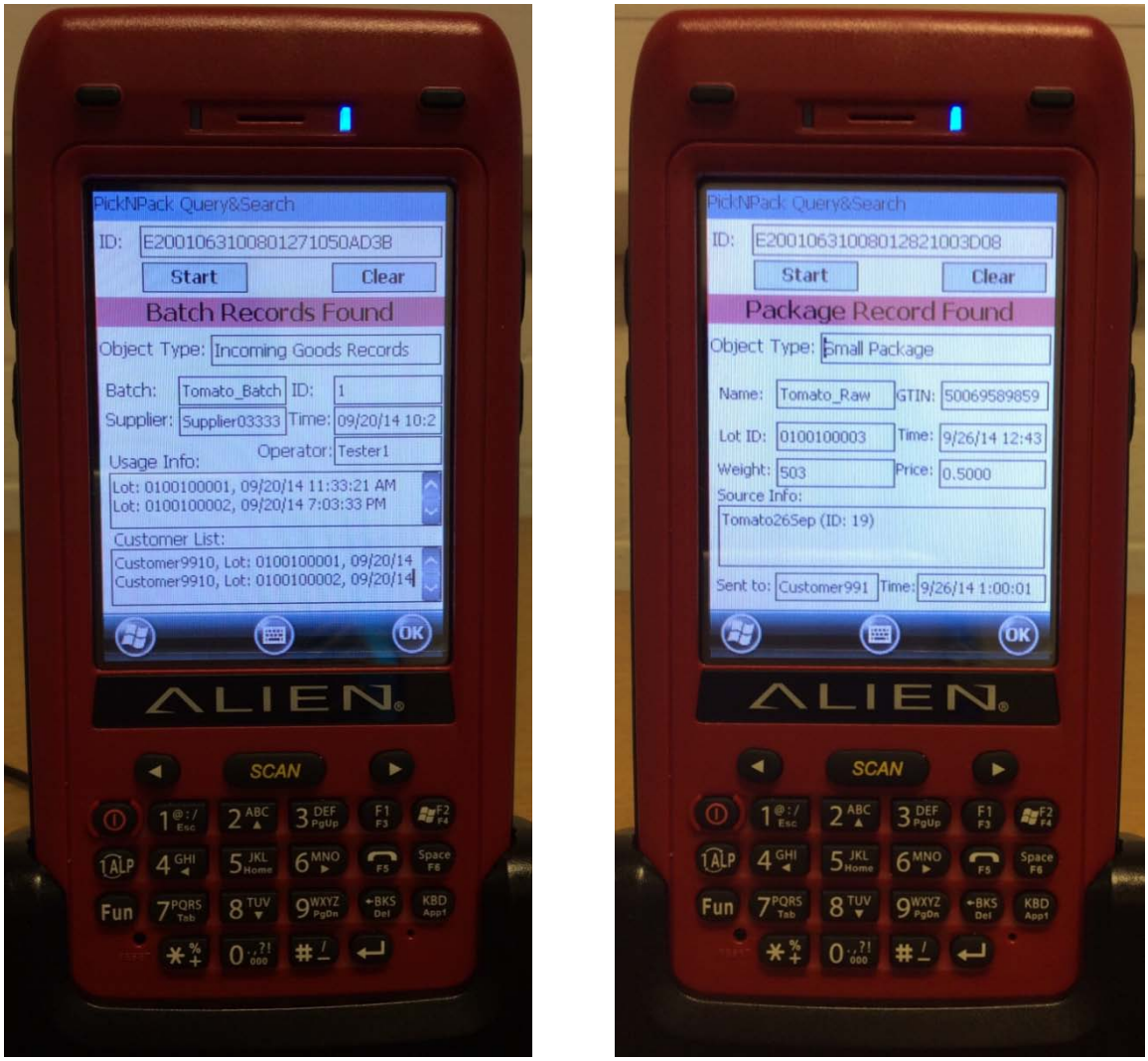
Figure 21 Start Page and Main Interface of Handheld Reader Application

The application provides functions to scan RFID tags and QR code for product line information tracking. By scanning the tag and QR code on the containers with the handheld reader, the information of the object is displayed for the user.

(1) RFID Tracking with Handheld Reader

Shown in Figure 22(1)and (2) are the results of incoming goods and small package information tracking with handheld RFID reader. When RFID tags on the objects are recognised, the information of the object is retrieved from the database and displayed

immediately. Since the handheld reader is WiFi and 3G enabled, the application can be used for remote tracking.



(1) Incoming Goods Tracking (2) Small Package Tracking

Figure 22 Information Tracking with Handheld Reader

(2) Barcode Tracking with Handheld Reader

In addition to RFID tracking, QR code is another efficient way supported by the handheld devices with a built-in camera. The product information is encoded in the QR code with the traceability software application in production line. Then, the user at a later stage can obtain the encoded information with the handheld reader conveniently. The QR code method is a flexible way for end users of products to access product information with consumer electronics like smartphones. Example of QR code tracking is given in Figure 23.

Figure 23 QR Code Information Tracking

4. Summary

This document reportsthe integrated traceability system, and illustrates the operation steps to use the system. By integrating the traceability system to the packaging line,the system can receive command and data request from the line and other modules and shares the data in the Database with them. It can also request data from other modules in the line. In addition, it broadcasts IDs of the new found products to the line for synchronisation. The functions implemented need to be further tested and optimised within the line.