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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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.

From the 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 linked to 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.

P	RFID Configuration												2
	Working Reader 2/192 168 0 100) Reader is successfully Started		Reader I	Informati	ion:								
	Working Reader1(192.168.0.102) Reader is successfully Started		[21:35:4 [21:35:4 [21:35:4	12]:New 16]:Read 16]:New	Reader Found, I der Reader2 (192 Reader Found, I	P: 192.168.0.1 .168.0.100) is P: 192.168.0.1	00, Name:Rea Connected. 02, Name:Rea	der2 der1					
	1			19]:Read 30]:Read 33]:Read	der Reader1 (192 der Reader1 (192 der Reader2 (192	. 168.0. 102) is . 168.0. 102) is . 168.0. 100) is	Connected. Started Started	2					
	Start	Configuration											
	Tag Raw Message 🛛 Show Raw Tag Message	Tag Item Message	Only Sł	now Un-	-Used Tag								
	.957,1,Reader1,192.168.0.102,2212.9 00:18:5F:00:8F:91	Tag ID	R	SSI	Location	Time	Last Location	Last Seen Time	Found by	Reading Times	Used For	Object ID	
	E2009037881400312020402E,2014/09/17,21:37:06.962,2014/09/17,21:37:06 .962,1,Reader1,192.168.0.102,2558.5	E20090378814005320	0204 24	13	Line: 1, P	21:37:06.9	Line: 1, Pa	21:37:06.519	Reader1	87	Unused		
	00:18:5F:00:8F:91 E20090378814005320204086.2014/09/17.21:37:06.966.2014/09/17.21:37:06.	E20090378814002920	0304 17	61.3	Line: 1, P	21:37:06.9	Line: 1, Pa	21:37:06.524	Reader1	93	Unused	na	=
	966,1,Reader1,192.168.0.102,2413.0	E2009037850F010517	7106 22	12.9	Line: 1, P	21:37:06.9	Line: 1, Pa	21:37:06.507	Reader1	83	Unused	na	
	E2009037850F008717106285,2014/09/17,21:37:06.975,2014/09/17,21:37:06.	E2009037850F008517	7106 34	16	Line: 1, Fe	21:37:06.7	Line 1, Fe	21:37:06.413	Reader1	81	Unused	na	
	975, 1, Reader 1, 192, 168,0, 102, 1683,8 00:18:5F:00:8F:91	E20090378814003120	0204 25	58.5	Line: 1, P	21:37:06.	Line 1, Pa	21:37:06.513	Reader1	85	Unused	na	
	E20090378814002920304027,2014/09/17,21:37:06.981,2014/09/17,21:37:06. 981 1 Beader1 192 168 0 102 124 3	E2009037850F008717	7106 16	83.8	Line: 1, P	21:37:06.9	Line: 1, Pa	21:37:04.529	Reader1	23	Unused	na	
	00:18:5F:00:8F:E5	000000000000000000000000000000000000000	2000 10	739.8	Subdivision	21:37:07.1	Subdivision	21:37:06.836	Reader2	104	Unused	na	Ŧ
	122,0,Reader2,192.168.0.100,10739.8	Object Item Message											
	00:18:5F:00:8F:E5 E2009037881400342020403A.2014/09/17,21:37:07.127.2014/09/17,21:37:07	Object Type	Object ID		Location	Time	Last Location	Last Seen Time	by	Tag	Found Times	RSSI	
	.127,0,Reader2,192.168.0.100,2975.1 00:18:5F:00:8F:E5	InternalContainer	1		Management	21:37:07.187	Manageme	ent 21:37:06.904	E200	190378 1	19	3061.7	
	E2009037881400462020406A,2014/09/17,21:37:07.187,2014/09/17,21:37:07 .187,3,Reader2,192.168.0.100,3061.7	ExternalContainer	1		Management	21:37:07.197	Manageme	ent 21:37:06.895	E200	190378 1	15	7218.5	
	00:18:5F:00:8F:E5 0101020203040405050606.2014/09/17,21:37:07.192,2014/09/17,21:37:07. 192 3 Bander 2 192 168 0 100 1008 1						~						
	00:18:5F-00:8F:E5 E2009037881400472020406E.2014/09/17.21:37:07.197.2014/09/17.21:37:07 .197.3.Reader2.192.168.0.100.7218.5					(5)						

Figure 5RFID Configuration Interface



Figure 6RFID Reader/Antenna Location Setting



Figure 6 gives 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.

Input Container ID: 1(Content: Tomato, Raw) Container ID: 2(Content: Tomato, Raw) Container ID: 3(Content: Empty) Container ID: 3(Content: Empty) Container Type: RFID: Barcode: Valid: InUse: Update	Tag ID 01010202030304 E2001063100801 E2001063100801 E2001063100801	RSSI 9113.7 2310.7 2578.4 2165.7	Time Stamp 21:38:36 626 21:38:36 650 21:38:36 660 21:38:36 660
Container ID: 1(Content: Tomato, Raw) Container ID: 2(Content: Tomato, Raw) Container ID: 3(Content: Empty) Container ID: Capacity: Container Type: RFID: Barcode: Valid: Update Update	01010202030304 E2001063100801 E2001063100801 E2001063100801	9113.7 2310.7 2578.4 2165.7	21:38:36.626 21:38:36.650 21:38:36.640 21:38:36.660
Container ID: 3(Content: Tomato, Raw) Container ID: 3(Content: Tomato, Raw) Container ID: 3(Content: Empty) Container Type: RFID: Barcode: Valid: InUse: Update	E2001063100801 E2001063100801 E2001063100801	2310.7 2578.4 2165.7	21:38:36.650 21:38:36.640 21:38:36.660
Container ID: 3(Content: Empty) Capacity: Container Type: RFID: Barcode: Valid: Update Update	E2001063100801	2578.4 2165.7	21:38:36.640 21:38:36.660
Container Type: RFID: Barcode: Valid: InUse: v Update	E2001063100801	2165.7	21:38:36.660
RFID: Barcode: Valid:			'
Barcode: Valid: v InUse: v Update			
Valid: In Use: Update			
Valid: Valid: Update			
Update			
- Last /Current Content Information			
Fill Time: Internal			
Remain Unit: Container			
Operator:			
Operator:			

Figure 7Input Container Registration Interface

nput Containers Output Container	rs Sup	pliers Plant Cate	gory Products	Unused Tags Fo	bund in Man	agement Antenna
Output Container: Refres	h	Basic Information		Tag ID	RSSI	Time Stamp
Container ID: 1 (Content:)	*	Container ID:	13	E2001063100801	2365.6	21:39:45.720
Container ID: 3 (Content:)		Capacity:	20	E2001063100801	2537.4	21:39:45.404
Container ID: 10 (Content:)		Container Type:	Nomal	E2001063100801	2049.2	21:39:45.700
Container ID: 12 (Content:)		RFID:	E2009002481400322			
Container ID: 13 (Content:)		Barcode:	Not Assigned			
Container ID: 15 (Content:)		Valid: Yes	✓ InUse: No ✓			
Container ID: 16 (Content:) Container ID: 17 (Content:)			Update			
Container ID: 18 (Content:)						
existence to: In (contain,)	Ŧ	- Last/Current Contern Fill Time: Remain Unit: [20 Content: Produ EmptyTime:	nt Information External Container			

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.

PicknPack

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.

Pick and Pack WP3 Application Ver 0.3	the state of the s			and the second				
New Subdivision Packaging Logi	istical Delivery Managem	ent Batch Scan&d	Nuery RFID E Setting G	Barcode				PicknPack
New Goods Registration Received Material Information	Related Logistical Units	l Information		Product Here is for would like t	t Name display any inforamtion to p show. Normally it use	hat user	£ 0.00	Production Line
Product Type: Tomato_Raw Weights(or Units) 250	SSCC: (g/unit) Received at (GLN):	142091452836089411 Plant01962(9099393)	-	of 'Descript [GTIN here]	ions' coloumu in Produc [Lat Numbe	ouce:	-=RFID Enabled Version=	
Suppler: Suppler03333	Additional Information	StandardQuality						Poteb Start at
Recived Date&Time: 30 March 2015 11:07:09	4900274409852793	45						Operator
Pack Defore Date: 30 March 2015	Dester 1	0		Manufacutre country. Post	Tast PicknPack Company, An Code ABC CDE.	dress random snaat	random city, random	System Admin 01 Product
Optinal Filed	Descriptions:	Gean Not			-2/1	1		Procedure Template
Temperature Requiment. None	1				77			Fixed Price
Humidly Requiment. Mome Volume:			1					Price Rate :
OperatorName: Operator_No002	Ösan	Update						
nput Containers Remaining Lir	ie ID Packing	Net.Weight Pri	e BED	Barcode	Extend Barcode	Output	Remaining	-
								-
			 ZMQ message:Send ZMQ message:Receive ZMQ message:Send ZMQ message:Send ZMQ message:Send ZMQ message:Receive 	(11:07:45) Sending hearbeat (11:07:45) Hearbeat failure, can (11:08:01) Sending hearbeat (11:08:02) Sending hearbeat (11:08:02) Hearbeat failure, can	treach Line, Reconnecting	in 16000 ms in 16000 ms		Start
	7147	A Conserver	- I	ck/Russian 7310c	annua Mar I an	Bishard Back W	TA EN	1 0 do 10 11/00

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.

When the 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'.

🖳 (🖳 Goods Sub-division 💿 📼 🖾								
	Now,Assign Containers For Goods Batch ID: 17.								
S	how Recent 10 Batches	Or Search b	y Date: 18	/09/2014		Search	Assigned Containers		
10) Name	Product	Received	Weights	Remaining	Descriptio			
1	Tomato_Batch01	Tomato_Raw	20/12/	1000	980				
14	greater	Tomato_Raw	31/01/	1000	1000				
17	7 tests	Tomato_Raw	31/12/	1000	1000				
16	i tests	Tomato_Raw	31/12/	1000	1000				
18	tests	Tomato_Raw	28/12/	1000	995				
15	i walked	Tomato_Raw	28/12/	1000	1000				
A	All Availble Containers Detected Containers						Selected Containers		
C	ontainer: 3(Capacity	:1				<	Container: 2(Capacity:5)		
							Operator: Test Operator		
							Cancel OK		

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.

* * * * * * * Profestimeter * * *	PicknPack
--	-----------

Product Name: (Leave Blank to use	Tomato 1	Operator: Tester_01
Template Name)		Step 3: Choose Ingredients Infomation
Comments:		Set Name: UK Tomato
Fixed Price: Yes	✓ Price Rate: 0.05	Ingredient Set ID: 1
ОК Ар	ply Cancel Refresh	Descirption:
Step 1: Choose Pro	duction Line	
Production Line ID:	1 - Edit	Ingredients List: Tomato
Located in Plant:	Plant01962	
GLN:	9099393	
Step 2: Choose Pro	cedure Template	Step 4: Choose Output Product Type
Template Name:	test001 -	Product Type: Tomato_Raw
Procedure set ID:	1 Edit	Type ID: 1 Choose Edit
Descimtion:		Product GTIN: 500695898590 QC: A
Description.		Category: Tomato(Category Source: UK
		Descriptions:
D	· ·	Attributes:
Process List:	Step 1: trutru A	Size(Tomato)6cm

Figure 11 Batch/Lot Setting Interface

Pick and Pack WP3 Application Ver 0.3			- 0 >
New Subdivision Packaging Logistir	Cal Delivery Management Batch	Scan&Query RFID Barcode Scting QR Code	PicknPacl
Packsging Setting			Production Line
Confirmed Input Containers	Detected Packaging Units	Confirmed Output Containers	1
			-=RFID Enabled Version
			Lot. Number:
			01001########
Detected Input Containers		Detected Output Containers	Batch Start at
150520 Container 1 Remain 5/5 RSSI239		Output Container ID: 3; Capacity 20 .	Operator
[15:05:20] Container 2:Remain: 5/5(RSSI:221		Output Container ID: 10; Capacity 22 Output Container ID: 11; Capacity 22	Tester_01
		Output Container ID: 12, Capacity 20 Output Container ID: 13; Capacity:20	Product:
		Output Container ID: 14, Capacity 20 Output Container ID: 15: Capacity 20 *	Tomato Drogoduro Tomplato
			1 test555
All Valid Input Containers (Info only)	Demo Attributes Settings	All Valid Output Containers (Info only) Output Container ID: 3: Canacity 20	Fixed Price. Yes
Input Container ID: 2;Remain: 5		Output Container ID: 10; Capacity 22	Price Rate : 0.0024
	500 g 500 g 9 g	Output Container ID: 12, Capacity 20	Ingredient Set
	Varity: ± 10 g Update	Output Container ID: 13; Capacity:20 Output Container ID: 14; Capacity:20	1 UK Tomato
		Output Container ID: 15: Capacity:20 Output Container ID: 16: Capacity:20 ~	Tomato
			1
out Containers Remaining Line ID	Packing Net.Weight /	nce RFID Barcode Extend Barcode Output Remainin	0
		* ZMQ message:Receive[11:09:23]Heartbeat received. Line is alive.	•
		ZMCq metricage Send 11 00 243 Sending Insufficial ZMCq metricage Relevels (10 524) Inserbast received. Line is alive. ZMCq metricage Send (11 00 253) Sending hostibuti ZMCq metricage Receivels (10 525) Inserbast received. Line is alive.	Start

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.

Packaging Setting		
Confirmed Input Containers	Detected Packaging Units	Confirmed Output Containers
Detected Input Containers [15:05:20] Container 1:Remain: 5/5;RSSI:239 [15:05:20] Container 2:Remain: 5/5;RSSI:221	[14:31]: Weight Settings Confirmed [14:31]: Weight Settings Confirmed	Detected Output Containers Output Container ID: 10; Capacity:22 Output Container ID: 11; Capacity:22 Output Container ID: 12; Capacity:20 Output Container ID: 13; Capacity:20 Output Container ID: 14; Capacity:20 Output Container ID: 15; Capacity:20 Output Container ID: 16; Capacity:20
All Valid Input Containers (Info only) Input Container ID: 1:Remain: 5 Input Container ID: 2:Remain: 5	Demo Attributes Settings Gross Weight = Net. + Tare 500 g 500 g 9 g Varity: ± 10 g Update	All Valid Output Containers (Info only) Output Container ID: 10; Capacity:22 Output Container ID: 11; Capacity:22 Output Container ID: 12; Capacity:20 Output Container ID: 13; Capacity:20 Output Container ID: 14; Capacity:20 Output Container ID: 15; Capacity:20 Output Container ID: 16; Capacity:20 Output Container ID: 17; Capacity:20

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.

🖳 Packaging Setting		
Confirmed Input Containers	Detected Packaging Units	Confirmed Output Containers
Container 1:Remain: 5/5 Container 2:Remain: 5/5		Container 11:Remain: 10/20
Detected Input Containers		Detected Output Containers
[15:05:20] Container 1:Remain: 5/5:RSSI:239 [15:05:20] Container 2:Remain: 5/5:RSSI:221	[14:35]: Weight Settings Confirmed	Output Container ID: 10; Capacity:22 Output Container ID: 11; Capacity:22 Output Container ID: 12; Capacity:20 Output Container ID: 13; Capacity:20 Output Container ID: 14; Capacity:20 Output Container ID: 15; Capacity:20 Output Container ID: 16; Capacity:20
All Valid Input Containers (Info only) Input Container ID: 1:Remain: 5 Input Container ID: 2;Remain: 5	Demo Attributes Settings Gross Weight = Net. + Tare 500 g 500 g 9 g Varity: ± 10 g Update	All Valid Output Containers (Info only) Output Container ID: 10; Capacity:22 Output Container ID: 11; Capacity:22 Output Container ID: 12; Capacity:20 Output Container ID: 13; Capacity:20 Output Container ID: 14; Capacity:20 Output Container ID: 15; Capacity:20 Output Container ID: 15; Capacity:20 Output Container ID: 16; Capacity:20

Figure 14Packaging Recording Interface

Confirmed Input Containers	Detected Packaging Units	Confirmed Output Containers
	Package: Test Job Batch1(E200106310080128123 Package: Test Job Batch1(E200106310080128154 Package: Test Job Batch1(E200106310080128192	
Detected Input Containers		Detected Output Containers
	4	Output Container ID: 13; Capacity:20 Output Container ID: 14; Capacity:20 Output Container ID: 15; Capacity:20 Output Container ID: 16; Capacity:20 Output Container ID: 17; Capacity:20 Output Container ID: 18; Capacity:28 Output Container ID: 19; Capacity:20
Il Valid Input Containers (Info only)	D	All Valid Output Containers (Info only)
	Demo Attributes Settings Gross Weight = Net. + Tare 500 g 500 g 9 g Varity: ± 10 g Update	Output Container ID: 12; Capacity:20 Output Container ID: 13; Capacity:20 Output Container ID: 14; Capacity:20 Output Container ID: 15; Capacity:20 Output Container ID: 16; Capacity:20 Output Container ID: 17; Capacity:20 Output Container ID: 18; Capacity:28 Output Container ID: 19; Capacity:28

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.



M Pick and Pack WP3 Application Ver 0.3	
New Material Subdivision Packaging Logistical Delivery Management Batch Setting Scan&Query RFID Setting Barcode RFID RFID RG Code RG Code RG Code RG Code	PicknPack
Tomsto200215 c	Production Line
Ingredients: Tomato. Size: Scriv Colour: Red;	1
Quality Class: A	-=RFID Enabled Version=-
500057589590 01001####### 50Urce: UK 10005	Lot. Number:
	01001########
	Batch Start at
S* 000 6958 ** 985 906 ** > Mandrouw Ten Elivation Company Address random etc. random etc. random etc. random etc. random etc. random etc. random	Operator:
ZMO messane:Receive(11:41:37):Heartheat received. Line is alive	Product
ZNO message Decident(1:41:27): "messageTupo" Readenting: "mdauloNamo" "DeD. DEID" "condTimo" "20/02/2015	Tomato290315
Zive message. Broadcasi(11.41.37); { message type : Broadcasing , modelevane : Phr_RPiD , Send Time : 30/03/2013	Procedure Template:
11:41:37","msgInto":{TagID":"000011112222333344445555","uniqueID":"20150330114137696"}}	1 test555
ZMQ message:Receive[11:41:37]:ZeroMQ.ZMessage	Fixed Price: Yes
ZMQ message:Send [11:41:38]:Sending heartbeat.	Price Rate : 0.50
	- Ingredient Set
	1 UK Tomato
	Tomato
Input Containers Remaining Line ID Pocking Net Weight Price PFID Barcode Extend Barcode Output Remaining	_
	-
2700 managed Garaviert 19727 Managed Reported To a state	
Device measure interaction of presentements can be addressed by the second seco	
1114147, magime (1900-1000) 2000 mesage/Record(11412)/2000/2004/2004/2004/2004/2016/2016/2016/2016/2016/2016/2016/2016	Start
ZMQ message: Send [11.41.38] Sending hearboat.	
🤧 🛿 🍕 🕅 🗴 🔼 💿 🔢 ZMQppworker 💿 PickNPsk (Runn or ZMQppqueve (R or ZMQppqworker 🗖 Hie///C/Users/T 💌 Pickand Psak W 🛛	EN 🔺 🚽 🖯 🌒 👧 🛛 1141

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.

🖳 Outgoing Logistic Units Registration			
All Avalible Containers	Detected Containers	Ready Logistic Units	Only Show Unsent
ID:1,OutContainer(Packaged Tomato_	[15:20:30] Container:1(Cap.:20) RSSI:5470.6 [15:20:30] Container:2(Cap.:20) RSSI:5470.6	Units ID: 2,Undispatch	ed, SSCC:2330795622
D.2,Outcontainer(Packaged Tomato_i	[15.20.30] Container.2(Cap20) R551.6362.5		
< •			
Select Remove ↑			
	•		
Selected Containers			
	SSCC		
	Additional Info		
	Random	•	•
		Clean	Register

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.

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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.

🖳 Delivery					×
Unsent Logistic Units	Send to :		Customer9910		•
Units ID: 2, Undispatched, SSCC:233079562	Send From (GL	N):	Plant01962(9099393)		•
	New Customer	r:			
	Name: 0	Custo	mer9910		
	GLN:	8736	134		
4 III +	Address :	No.84 Street	45, Ggıfzjwfh Building 034 t, Vhqpxbccz City. Post Co	, Gqesnutak ode:Z7 1FF	
☑ Only Show Unsent	Contact Info:	+035	0091192244		
	Random		Update	Create]
	Dispatching Time	e: [2014/09/19 12:13:11:	1311 📃	-
	Operator:		Tester_01		
				Send	
					_

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.



tenai Setung On	as c	setting	setting functione	
arch Information			0	Production Line
Number/1D/Code:	External Container T	ag 👻 Search		1
RFID Tags/Barcodes Object Nam		Search Finisher	d, 13 Records are displaying.	-=RFID Enabled Version
ExternalContainer 1	RFID Teg ID: E20010631008012821	903D08	Barcode Number:	Lot Number
ExternalContainer: 2	Source Information		Production Information	01001#########
ExternalContainer, 3	Batch Name: Tometo26Sep (D	15)	Product Name Tomato_Rew(LotNumber: 0100100003)	* Batch Start at
ExternalContainer: 11	Suppler: Suppler03333	GLN: 3405353	Package Time 26/09/2014 00:37:11	Datur Start at
ExternalContainer: 12	Received Time: 26/05/2014 00.18	01	Int Number 0100100003	Operator
ExternalContainer: 14	Product Name(Source): Tomato_P	aw	Denter Phannes	Zhaozong
ExternalContainer: 15	Grine: 500655855550		Operator: Ziniozong	Product
ExternalContainer: 17	SSCC mather (Source) 10453993	1846061450	Product G TIN: 500695898590	Tomato260914
ExternalContainer: 18	Containers (input)	vetacour & (Fill ID: 6)	Production Line: 1 Plant: Plant: Plant01962	Procedure Template:
ExternalContainer, 19	Internal C	intainer 5 (Fill ID: 7)	Plant GLN: 9039333	1 test555
			Fixed Price: Yes Price Rate: 0.5000	Enerd Driver Xo
	OutGoing/Delivery Information		Net Weight (F Applicable):g	Fixed Price.
	Logistics Units SSCC 3769492260	92311498/DatUneID: 4)	Pitce(if Applicable) -	Price Rate : 0.5
	Dispatch Location Plant01952		Estended Barcode Number (# Applicable): 00050	Ingredient Set
	Depatch Location GLN: 9099393		Containers (Output): External Container ID:16	1 UK Tomat
	Departure Time 26/05/2014 01:00	01		Tomato
	Designed rate: 2010020140100	ų i		
	Destration: Columner 39 10			
	Destination Escation GEN: (673613	•		
Object Type	RSSI	RFID	Time	
EdemalCortainer	2388.2	E2009037881400472	020406E 00 51 15 442	
InternalContainer	4125.4	E2009037881400342	020403A 00:51:43.740	
	1110.1	E2001063100801270	01:04:24:074	
SmallPackage				

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.

ck and Pack WP3 Applicatio	in Ver 0.3										-	
New Subdivision Pi	ackaging Log	istical Delivery	Management Batch	Scan&Query	RFID	Barcode QR Code					Pick	Pac
	county o			9	Caning		Tomato 2	90315			Production L	ine
							Ingredients: T	omato. Size: 6cm; Col	lour: Red;	£		1
										Quality Class: A	-=RFID Ena	bled Versio
	Line						500695898590	01001		Source: UK 28/03/2015 12:07:44	Lot Number	n Pac
											01001	annanan
											Batch Start at	
											-	
							5 0069	58 9859	06">		Operator.	
							country. Post Co	de ABC CDE.	oren. rendom tr	reec random cry, random	Tes	ter_01
		199 A	11		-	- K	-				Product	
MO message F	Request fr	om other mo	dules[12:07:55]	•							Dressdure T	to280315
moceanoTuno	"-"DataDe	auget" "mor	uloNamo* "DoD	PEID" "of	holdhoir	ulo"."DeD	DAOT TO	ondTimo" "?	0/02/20	15	1	test555
messager ype	Dalaria	quest, mot			Jectiviou	DODATO A	_DAG , S	enurime, z	0100120	10	Eivad Drica	Ye
2:07:55°, msgi	nto :{ req	uesti ype ::	Productiquality",	productin.	20150	32815342	25186-}}				Fixed Flice.	
MQ message:	Receive[1	2:07:55]:He	artbeat received	 Line is aliv 	ve.						Price Rate :	0.5
MQ message:	Send [1	2:07:561:Se	nding heartbeat								Ingredient Se	at
											1	UK Tomati
						*	-				Tomato	
						\wedge			1 2010			
Containers R	emaining Lit	ne ID Par	king Net Weight	Price	RFJÓ		Barcode	Extend Barcode	Output	Remaining	_	
											-	
					1							
				* ZM	Q message:Requ	sest from other mod	tules[12.07.55]				*	
				("m 12)	essageType"."D 07.66", "msginto"	ataRequest", "modu ("requestType", "P	aeName", "PnP_RFI roductQuality", "prod	D", objectModule" "PnP suctD", 2015032815342	_DAQ', 'sendTi (5186'))	me", "28/03/2015		
				ZM	Q message Rece	ive[12:07:55] Hea	rbeat received Line	e is alive.			S	tart
				- 24	u messager:Sent	112:07:50[:966	ong nearbeat					
	4 70	5 N/200	worker PickNPack	18. ZMOnn	OUR IS	ZMOnework e	Janie D	hon Ditie///	/User	Destand Park	0.00.00	12-0

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.

			_			
					-	
PIEKI	Pack Que	ryssearc	n 071050	i DOD		
ID:	Start	100801	.2/1050/	Clear		
	Batch	Recor	ds For	und		
Obj	ect Type:	Incomino	Goods F	Records		
Bat	tch: Tom	ato Batch	ID: 1			
Sup	oplier: Supp	olier03333	Time: 09	/20/14 1	10:2	
Us	age Info:	Ope	erator: Te	ster1		
Lo	t: 01001000 t: 01001000	01, 09/20/ 102, 09/20/	14 11:33: 14 7:03:3	21 AM 3 PM		
	ustomer Lis	t:				
0	istomer9910 istomer9910), Lot: 010), Lot: 010	0100001, 0100002,	09/20/14 09/20/14		
	2	E		6		
6	9	e	9	6	9	
	\wedge		EI	1.		
		SCA	N			
	1@:/	SCA 2 ABC	N 3 DEF PgUp	F1 F3	₽₽ ^{F2}	
()	1@:/ 1 ^{@:/}	SCA 2 ABC 5 JKL	3 DEF Paup	F1 F5	F2 F4 Space F6	
	 1^{@:/} Esc 4^{GHI} → 7PORS 	SCA 2 ABC 2 ABC 5 Home 9 TUV	3 DEF 9 Pgup 6 MNO 0 WXYZ	F1 F3 F5 +BKS	Space F6 KBD	1
() (Ali	Т 1 е:/ 1 е:/ 4 сні 7 родяз тавь	SCA 2 ABC 2 ABC 5 Home 8 TUV	A DEF Poup 6MNO 9WXYZ 9Popn	F1 F3 F5 +BKS Del	Space F6 KBD App1	



(1) Incoming Goods 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.



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Figure 23 QR Code Information Tracking

4. Summary

This document reports he 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.