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Experimental Results of EPCglobal Phase 2 Pilot with Active RFID

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Abstract- **Passive RFID and barcode system and are adopted to supply chain market and logistic service. However, barcodes can only be read at close proximity. Passive RFID relies on RF energy transferred from the reader to the tag to power the tag, so they can be read at short distances. This limits the usage of tag for certain applications. On the other hand, active RFID that has a battery increase the read range and reliability, it is promising for supply chain management and logistics. In 2007, EPCglobal[1] that is the global RFID standards organization announced to experiment with active and passive RFIDs attached to pallet and items from Shanghai to Long beach by air. We implemented new active RFIDs for this trial experiment. Our new active RFID has an LF (Low Frequency) module, HF (High Frequency) module, UHF (Ultra High Frequency) module, sensors, and a logger that is installed in an actual pallet for air transportation with the function to be activated and/or be slept by HF Reader. The results of the pilot confirmed that our new active RFID has the enough functions for air transportation and logistics service with low power consumption.**

Keywords: Active RFID, EPCglobal

I. INTRODUCTION

Passive RFID and barcode system and are adopted to supply chain market and logistic service. However, barcodes are not reliable in many cases; they are easily damaged, and can only read at close proximity. Passive RFID does not contain a battery, so it relies on RF energy transferred from the reader to the tag to power the tag. Therefore they can be read at short distances. This limits the usage of tag for certain applications.

On the other hand, active RFID that has a battery increase the read range and reliability, it is promising for supply chain management [2]. However it has some disadvantages; larger size and cost and limited operational lifetime. To overcome limited lifetime, active RFID should turn on and off power supply circuit. This intermittent operation of RF transceiver keeps the average of power consumption of the RFID quite low. However, receiver (Rx) of UHF of RFID needs more than 10mA [2]. For lower consumption of the RFID, lower carrier frequency is more suitable for receiving.

To solve the problem, we implemented a new type of active RFID combined the merit of active RFID and passive RFID. Our new active RFID has three wireless interfaces; UHF transceiver for beacon transmission, HF receiver for data transmission and LF receiver for tag control. HF receiver and LF receiver turns on and off intermittently to decrease power consumption. Furthermore, our new active RFID has a logger to save the information of sensor data, time, the ID of gate, and passive tag IDs by HF.

In this paper, we first introduce the previous phase1 pilot and phase2 pilot overview in section2. In section 3, specification of our new active RFID for EPC pilot is presented. In Section 4, experimental results are presented. Finally, we present conclusions and introduce next pilot 3 in Section 5.

II. EXPERIMENTAL SYSTEM OVERVIEW

A. Phase 1 overview

The first phase of the pilot was completed on February 2007. This pilot demonstrates how RFID can be applied in transportation and logistics from a terminal port in Hong Kong to a port in Japan [4]. This phase will assess the use of both active and passive RFID for sea shipment of cartons and containers between the two regions. Associated data will be exchanged through EPCIS. The Hong Kong EPC networks developed will be used to communicate with other EPCIS networks in Japan. The results of phase 1 are as follows.

-Demonstrate RFID applications in the transportation and logistics

-Interoperability among multiple trading partners and service providers

-Prepare and investigate shipment info used for import/export declaration

-Proof of concept using active RFID technologies as a foundation for phase 2 pilot.

B. Phase 2 overview

The second phase of the pilot was completed on January 2008. From factory in Hangzhou, China to distribution center in Long Beach, CA, laptop computers were transported via air. This phase 2 pilot was funded by METI (Ministry of Economic, Trade and Industry) in Japan.

According to the pilot logistics flow from supplier's factories in China to consignee warehouse in the US, the products are transported to Shanghai by truck. From Shanghai to Los Angeles, they are carried by air, including transshipment at Tokyo. Finally they are also delivered from LAX airport to consignee warehouse in Long Beach by truck as shown in Fig1.

The objectives of phase 2 pilot are as follows.

-Expand trade lanes and modes of transportation to include both air freight and transcontinental shipment

-Enable increased visibility at critical events in the supply chain
-Test and develop requirements for passive RFID and active RFID and the integration of these tags with associated technologies
-Identify standards opportunities for transportation and logistics providers
-Share results and information with the EPCglobal member community

Fig1. Experimental map

C. Details of Passive and Active RFID for Pilot

In this phase 2 pilot, we used passive RFID and 4 kinds of active RFID as shown in Fig2 and Fig3.

(1) Passive RFID

Passive RFID was printed on the carton. SGTIN (Serialized Global Trade Item Number) is recorded.

(2) Active RFID for Pallet (*Tag A*)

Cartons were loaded on the plastic pallet at Hangzhou. We attached active RFID (*TagA*) to the plastic pallet. This active tag contains a vibration sensor, and sends beacons when it detects the vibration as long as it wakes up. SSCC(Serial Shipping Container Code) is recorded.

(3) Active RFID for Pallet with HF logger (*Tag B*)

This active RFID has a temperature and humidity sensor and logger to save the sensor data as shown in Fig4.

(4) Active RFID for Truck (*Tag C)*

This active RFID is same as *TagA* and attached to the truck. At the gate of Hangzhou and Shanghai, active RFID reader can read the beacon from *TagC* to know the situation that truck has approached the gate. GLN (Global Location Number) is recorded.

(5) Active RFID for Air Pallet (*Tag D1,D2*)

When the pallets are loaded to the ULD (Unit Load Device), the pallets are put on the air pallet (metal board) and wrapped by net as shown in Fig5. Tag D is attached to this net. *Tag D1* is used from Shanghai to Narita, and *Tag D2* is used from Narita to LAX. GRAI(Global Returnable Asset Identifier) is recorded.

	Hangzhou		Shanghai		Narita		Los Angele		Long Beach
Tag A	○	↔	↔	↔	↔	↔	↔	↔	○
Tag B	○	↔	↔	↔	↔	↔	↔	↔	○
Tag C	○	↔	○						
Tag D1			○	↔	○				
Tag D2					○	↔	○		

Fig2. Four active RFID and read points

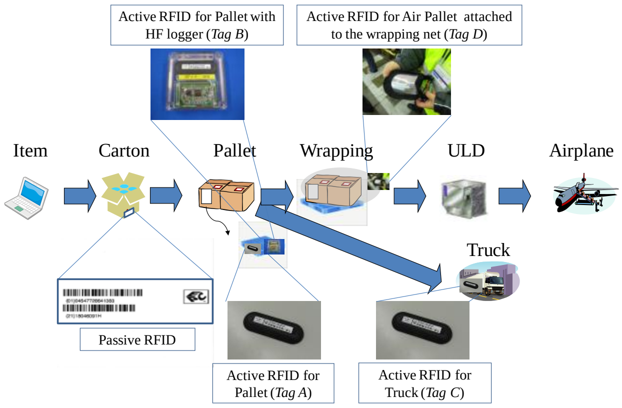

Fig3. RFIDs and Units of transportation

Fig4. Active RFID for Pallet with HF logger

Fig5. Active RFID for Air Pallet

D. Details of phase 2 pilot

Procedure of phase 2 pilot is as follows.

<u>1) Maker warehouse at Hangzhou</u>

-Packing into the carton and slap barcode
-Palletize
-Print and apply passive RFID
-Slap on carton and read passive RFID then wrapped
-Commission SSCC with *Tag A* and read
-Aggregate *Tag A* with passive RFIDs
-Commission truck number with *Tag C*

-Load into the bonded truck and read
-Aggregate *Tag A* with *Tag C*
-Read *Tag C* and *Tag A* leaving from warehouse

2) Gate
-Custom clearance at EPZ customs office
-Gate out of EPZ and read active RFID for pallet and *Tag C*
-Bonded drayage (Pass through without unloading items from pallet)

3) Air Cargo Terminal at Shanghai
-Unload from truck
-Receive and export documentation
-load into truck
-bonded drayage
-Read *Tag C* for truck on arriving at warehouse
-Disaggregate *Tag C* with *Tag A*
-X-ray inspection
-Receive and read *Tag A*
-Hand over cargo to carrier
-Receive and read *Tag A*
-Loading in air pallet and wrapping
-Commission air pallet n umber with *Tag D1*
-Aggregate *Tag A* with *Tag D1*
-Sleep all active RFIDs
-Load into aircraft

4) Air Cargo Terminal at Narita
-Receive and activate all active RFIDs
-Read *Tag D*
-Break air pallet for transship and disaggregate *Tag D1* with *Tag A*
-Read *Tag A*
-Reloading transship on another air pallet and wrapping
-Commission air pallet number with *Tag D2* and read
-Aggregate *Tag A* with *Tag D2*
- Sleep all active RFIDs
-Load into aircraft

5) Air Cargo Terminal at Los Angeles
-Unload from aircraft
-Receive and activate all active RFIDs
-Read *TagD2*
-Break air pallet and disaggregate *TagD2* with *TagA*
-Read *TagA*
-Load into truck
-Read all active RFID on leaving from warehouse

6) Forwarder Warehouse at Los Angeles
-Unload from truck
-Receive and import documentation
-Load into truck

7) Final Warehouse
-Arrive at warehouse
-Receive and read *TagA*
-Break pallet and disaggregate *TagA* with passive RFID
-Tally and read passive RFID
-Inspection and read passive RFID

III. Specification of Active RFID for Pilot

In this section, we introduce the specification of our new active RFID. The specification of *Tag B* is shown in Table 1.

Table1. Specification of active RFID

UHF Part	Frequency	433.92MHz
	Data rate	38.4kbps
	Modulation	FSK
	Power	0dBm
LF Part	Frequency	125kHz
	Data rate	0.3kbps
	Modulation	OOK
HF Part	Frequency	13.56MHz
	Data rate	26.48kbps
	Modulation	PPM
Sensor	Temperature&Himidity	
	Vibration	
	Tamper	
	LED (3colors)	

Our active RFID is composed of three parts; UHF transceiver, LF receiver, and HF transceiver.

In UHF part, we use 433MHz as transceiver with RFIC [5]. It sends a beacon packet to the reader, and receives an acknowledgement packet form the reader.

In LF part, we use 125kHz frequency band as receiver. A coil that resonates 125kHz is built in the active RFID. It receives the packet for stop/awake from the interrogator. With this function, we can stop the beacon from active RFID in the restricted area such as on the airplane.

In HF part, we use 13.56MHz frequency band as transceiver. Our active RFID can read ISO 15693. Furthermore, to decrease the average consumption power, HF receiver turns on the radio with 10msec and sleep 990msec in 1sec. In the gate, the HF transmitter sends the beacon intermittently to activate the active RFID. When the active RFID receives the beacon from the HF transmitter, it sends “wake-up” beacon with its ID to inform the existence of the active RFID. Furthermore, it sends the sensor data stored in its logger when the handy HF reader sends the specific packet and supply power.

Temperature, humidity and vibration sensor are installed in our active RFID. Our active RFID acquire temperature and humidity sensor data was acquired ever one minute. On the other hand, when the vibration sensor detects the vibration, it sends signal to CPU (MSP430) of our active RFID. Receiving the signal from the vibration sensor, the CPU sends the UHF beacon that indicates moving. However if the active RFID is on the truck and moving, it sends the beacon continuously with this function. Therefore, the CPU has a timer and judges to send the beacon or not according to the time of present received signal and former signal. When the RFID is put on the truck and is moving, it does not send the beacon. When the truck stops, it sends the beacon once. The average of power consumption can be suppressed by this function.

IV. RESULTS

A. *Overview of Results*

Objective A: Utilize RFID Technology components and EPCglobal standards on air transport

-All passive RFID and active readings were successfully captured

-Especially, active RFIDs ware also workable in the air supply chain including stop/awake functions during the actual air transportation.

-Passive RFID was also worked well

-All EPC identifier data which includes SGTIN, SSCC, GRAI, and GLN shared, queried and subscribed between TLS(Transportation Logistics service) EPCIS and CE(Consumer Electronics) EPCIS

Objective B: Enable visibility at critical events in the air supply chain

-Specified a use case of air LCL(Less than Container Load) transport from China to USA including transshipment in Japan

-Visibility was successfully secured in carton, pallet, ULD and vehicle levels through EPCISs among multiple trading partners

Objective C: Apply RFID Technology to a LCL case

-LCL transshipment at Narita Airport was completed without any problems, which included aggregating and disaggregating RFIDs

-Consecutive supply chain information within EPCISs was also effectively exchanged even after transship

-SSCC acted as Information Bridge between manufacture and TLS provider and its interoperability was surely maintained

Objective D: Consider a specific chain of custody between TLS and CE industries

-Manufacturer consigned their cargo to TLS provider with SSCC level meaning that CE EPCIS exchange data only under SSCC level. On the other hand, TLS EPCIS tracked and traced it with SSCC and over

Objective E: Prepare and investigate shipment and commercial information in order to take advantage of RFID/EPC technology for import/export procedure.

-Investigated the possibility of customs office's cooperation bay means of system connection, but failed eventually

-Found that container physical entry into bonded area its information captured by RFID would be a potential trigger that customs broker could start import/export procedure.

Fig7 shows the sensor data with *Tag B* of EPC pilot from Jan-22 to Jan-25. The reason for blank area of the graph is that *Tag B* was slept and it did not acquire any data on the airplane in this pilot. From this figure, we can see that our active RFID can acquire all data in the entire process of this pilot. Mining the position of the reader, sensor data and acquisition time, we can grasp the place and situation of the item in real time easily.

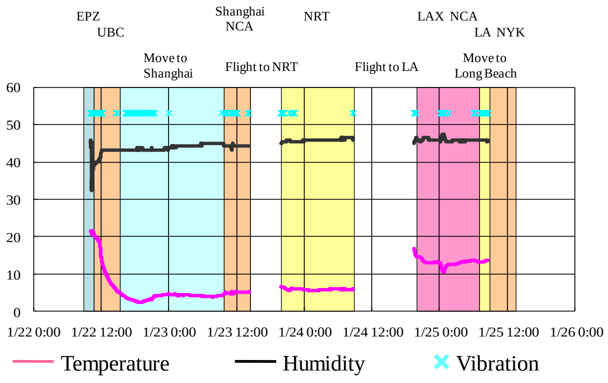

Fig6. History of sensor data of our active RFID

V. CONCLUSION AND NEXT PILOT

We implemented and provided new active RFID for EPC global phase2 pilot. The results of the pilot confirmed that our new active RFID has the enough functions for air transportation and logistics service with low power consumption.

In this year, phase 3 pilot will be planned. In this pilot, the number of RFIDs, cartons and containers will be greatly increased compared to previous two pilots assuming the environment of actual transportation and logistics services. From these three pilots, we hope active RFID systems will be used for logistics all over the world.

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