

RFID Ecosystem for Storage Facilities

Field of Invention

This invention creates a Radio Frequency Identification (RFID) ecosystem for any storage facility (e.g. warehouses, airfreight terminals) to allow locations of transport-units (e.g. pallets, cage-pallets, bins) and locations of items (e.g. carton boxes of soft-drinks, carton boxes of stationery, packs of rice) within these transport-units to be tracked.

This invention combines the use of state-of-the-art Active and Passive RFID technology in a unique fashion, to deduce the locations of all transport-units and items within these transport-units.

Background

In shop-floors of storage facilities, locations of transport-units and items are tracked by using conventional warehouse management systems (or WMS). To assign a location to a piece of item (or transport-unit), conventional WMS makes use of handheld computing devices to perform scanning of barcodes labels or RFID tags that are attached on items (or transport-units), and subsequently the user keys in the scanned item's (or transport-unit's) location using the touch-screen of the handheld device. In another setting, each location of the facility is attached with a barcode label or RFID tag, and the keying in portion is replaced by a simple scan on the location's tag to perform association. In settings where RFID tags (of locations, items, and transport-units) are to be scanned, the power setting of the handheld computing device has to be set to a lower level, so that the device does not pick up unintended RFID tags that are near the vicinity. Also in this setting, filters have to be applied via software in handheld device by manual eyeball check followed by manual deletion (on the touch-screen of the handheld) of unintended scanned tags from the list of scanned tags detected by the handheld device.

There exists current state-of-the-art Active RFID Tracking Solutions, whereby each item (or transport-unit) is attached with an Active RFID Tag, which is powered by battery, enabling it to transmit data packets to nearby Active RFID Readers. The Active RFID Readers, which are normally mounted high up on pillars or walls of the facility, will relay the received packets' Received Signal Strength Indicator (RSSI), back to a central server to calculate the item's (or transport-unit's) location with the use of Triangulation and/or Trilateration. To date, Active RFID solutions are still unpopular among tracking of low cost items (e.g. carton boxes of soft-drinks, stationery etc.) due to the high unit cost per tag, and due to the need to change tag batteries.

There exists current state-of-the-art Passive RFID Tracking Solutions (e.g. US 20100176922 A1 – Mobile RFID Reader System), whereby each transport-unit is tagged with a Passive RFID Tag, each shelf location is tagged with Passive RFID Tag, and forklifts are being mounted with Passive RFID Readers and Antennas to perform association of the transport-unit to its destination location tag, so that the system is able to track the last known location of where the transport-unit is moved to by the forklift. This solution did not address items (e.g. carton boxes of soft-drinks, stationery etc.) that are within these transport-units. To track such inventory, association between each transport-unit and its items has to be performed manually, or by the use of RFID handheld devices. This solution also did not cater for open floor locations that are susceptible to impact of a moving, loaded forklifts.

In response to Singapore Government's productivity drive, Daifuku Mechatronics (Singapore) Pte Ltd has developed a RFID Warehouse Ecosystem to minimize manual intervention needed in the tracking and recording of every piece of item's and transport-unit's location in a typical storage facility, like warehouse or airfreight terminals.

Summary

In any typical storage facility (e.g. warehouses, airfreight terminals), transport-units (e.g. pallets, cage-pallets, bins) and its items (e.g. carton boxes of soft-drinks, carton boxes of stationery, packs of rice) within it are moved with the use of forklifts, and are typically stored on shelf or floor locations.

This invention creates an ecosystem in any storage facility (e.g. warehouse or airfreight terminals) for tracking locations of any transport units (e.g. pallets, cage-pallets, or bins), and any items (e.g. carton boxes of soft-drinks, carton boxes of stationery, packs of rice) inside these transport-units using a unique combination of state-of-the-art RFID solutions.

By creating this invented RFID ecosystem, we attempt to eliminate manual effort needed to record and update locations of transport-units and items inside these transport-units. This invention reduces error-prone manual keying in of locations, and significantly reduces manpower in a community that is experiencing labor-crunch.

Brief Description of Drawings

For better understand of the RFID Warehouse Ecosystem, the below drawings are provided. The following briefly describes the content of the drawings.

FIG. 1 shows the invented RFID Warehouse Ecosystem.

FIG. 2 shows the how each piece of information is associated to eventually deduce locations of transport-units and items within it.

Detailed Description

In any typical storage facility (e.g. warehouses, airfreight terminals), transport-units (e.g. pallets, cage-pallets, bins) and its items (e.g. carton boxes of soft-drinks, carton boxes of stationery, packs of rice) within it are moved with the use of forklifts, and are typically stored on shelf or floor locations.

This invention creates an ecosystem in any storage facility (e.g. warehouse or airfreight terminals) for tracking locations of any transport units (e.g. pallets, cage-pallets, or bins), and any items (e.g. carton boxes of soft-drinks, carton boxes of stationery, packs of rice) inside these transport-units using a unique combination of state-of-the-art RFID solutions.

Invention #1

In this invention, each transport-unit (e.g. pallets, cage-pallets, or bins) contains one or more items (e.g. carton boxes of soft drinks, carton boxes of stationery, or packs of rice). Every item is attached with a Passive RFID Tag (or a plurality of Passive RFID Tags) that uniquely identifies each piece of item using its Electronic Product Code (or EPC).

Each transport-unit (e.g. pallets, cage-pallets, or bins) is attached with an Active RFID Tag (or a plurality of Active RFID Tags) that transmits data packets periodically to Active RFID Readers that are installed high up at walls or pillars of the warehouse. The received packets at the Active RFID Readers generates a Received Signal Strength Indicator (RSSI), which is then transmitted back to a Server Computer via WIFI Ethernet for calculation of the Active RFID Tag's zone location. A zone location is defined as a portion of the floor area in the warehouse that has its perimeter carved out.

Each transport-unit is also attached with a Passive RFID Tag (or a plurality of passive RFID tags), whereby the passive RFID tag's unique EPC will be associated with its active RFID tag's unique ID (e.g. MAC Address of active RFID tag) in the Server Computer.

Each forklift is installed with a Passive RFID Reader, one or more Passive RFID Antennas, and a mobile computer with a touch-screen for interaction with the forklift driver. The reader is connected to the antennas via RF Coaxial cables, and it is connected to a mobile computer via Ethernet LAN cable. The mobile computer and RFID reader draws power from the forklift's batteries either directly or with the help of some electrical converters. The RFID antennas can be mounted onto any part of the forklift, including but not limited to the forklift's carriage, overhead guard, back rest, mast, and control panel. The mobile computer is connected to a Server Computer wirelessly via WIFI Ethernet, so that computation can be performed and stored at the Server Computer.

In the warehouse, transport-units containing multiple items are moved around using forklifts. Whenever forklifts load a transport-unit onto its fork, its Passive RFID antennas will pick up the EPC of passive RFID tag (or tags) from the transport-unit, and EPCs of passive RFID tags attached on all items within it, and performs association between the transport-unit and all the items in it. The forklift's Passive RFID antennas send detected EPCs to its Passive RFID Reader which in turns sends these EPCs to its mobile computer, which then relays the EPCs back to the Server Computer wirelessly for association of the transport-unit to the items within it. Once the transport-unit is associated with all items within, the items' location will be associated to be the same as that of the transport-unit's zone location that is constantly being updated by the Active RFID Tag attached on the same pallet.

Invention #2

In another variation of invention #1, the storage-facility has two or more types of transport-units (e.g, cage-pallets and normal-pallets).

The first type of transport units are attached with Active and Passive RFID Tags, with the former being used for tracking of its zone location, and the later being used for association with items within the transport unit. And location tracking of items within this type of transport-units follows that of invention #1.

The second type of transport-units are attached with only a Passive RFID Tag (or a plurality of tags), and its location, and locations of items within it will be calculated as follows:

1. The storage facility is being divided into floor locations and shelf locations. Each floor location will be attached with a Passive RFID Floor Tag (or a plurality of Floor Tags). The floor tag has very low profile, and is capable of withstanding impact from a moving loaded forklift. Each shelf location will be attached with a Passive RFID Shelf Tag (or a plurality of Shelf Tags). All Passive RFID Tags (Shelf and Floor), will possess a unique EPC to uniquely identify each location. The unique EPC will also be unique amongst all Passive RFID tags used in the storage-facility.
2. The same RFID-enabled forklifts mentioned in invention #1 will also be used to move the second type of transport-units in the storage facility. When a forklift loads a transport-unit onto its fork, association will be performed between the Passive RFID tag (or plurality of tags) on this transport-unit to that of all items within it, in a similar manner as that described in invention #1. When a forklift unloads a transport-unit onto a shelf (or floor) location, the EPC of this shelf (or floor) location tag, and the EPC of the transport-unit's tag will both be captured by the forklift's antennas, which further relays it to the forklift's RFID reader, which then sends it to its mobile computer, and eventually reach the Server Computer via WIFI Ethernet. The Server Computer will then assign the shelf (or floor) location to the transport-unit, which subsequently assigns this shelf (or floor) location to all items within this transport unit.

Invention #3

In another variation of invention #2, instead of attaching both Active and Passive RFID Tags onto the first type of transport units, only Active RFID Tags are attached.

The RFID-enabled forklifts mentioned in invention #2 are installed with an additional Active RFID Reader (or plurality of Active RFID Readers). The Active RFID Reader can be mounted onto any part of the forklift, including but not limited to the forklift's carriage, overhead guard, back rest, mast, and control panel. The Active RFID Reader draws power from the forklift's batteries either directly or with the help of some electric converters. The Active RFID Reader reads nearby Active RFID Tags and relays the Active RFID Tags' unique IDs back to the forklift's mobile computer via either WIFI Ethernet or Cabled Ethernet LAN cable.

When a forklift loads the first type of transport-unit onto its fork, the forklift's Active RFID Reader (or plurality of readers) will read the transport-unit's Active RFID Tag, and relay its unique ID (e.g. MAC Address of Active RFID Tag) to the forklift's mobile computer. Upon receipt of this unique ID, the mobile computer activates the forklift's Passive RFID Reader and antennas to scan for Passive RFID Tags in an attempt to detect all Passive RFID Tags attached on items within the transport-unit. Once scanned, the mobile computer sends all EPCs of the items' Passive RFID tags, and the unique ID of the transport unit's Active RFID Tag, back to the Server Computer via WIFI Ethernet. The Server Computer subsequently associates the items to the scanned transport-unit.

This association is subsequently utilized by the Server Computer to further associate the items' location to be the same as the transport-unit's zone location, which is constantly being updated by the Active RFID Tag attached on the transport-unit.

Invention #4

In another variation of invention #2, the methodology used to track locations for the first type of transport-units (and items within it) is not used in the storage facility. Instead, their locations are tracked using the same methodology as that of the second type of transport-units (and items within it) described in invention #2.

Claims

(1) Any storage facility that tracks location of items and transport-units using the following methodology:

Each transport-unit is attached with an Active RFID Tag (or a plurality of Active RFID Tags), and is uniquely identified by its unique ID (e.g. MAC Address of Active RFID Tag). The Active RFID Tag is battery-powered, and sends data packets at regular intervals to Active RFID Readers that are mounted high up on walls or pillars of the facility. The received packets at the Active RFID Readers generates a Received Signal Strength Indicator (RSSI), which is then transmitted back to a Server Computer via WIFI Ethernet for calculation of the Active RFID Tag's zone location. A zone location is defined as a portion of the floor area in the warehouse that has its perimeter carved out.

Each transport-unit is also attached with a Passive RFID Tag (or a plurality of passive RFID tags), whereby the passive RFID tag's unique EPC will be associated with its active RFID tag's unique ID in the Server Computer.

Each forklift is installed with a Passive RFID Reader, one or more Passive RFID Antennas, and a mobile computer with a touch-screen for interaction with the forklift driver. The reader is connected to the antennas via RF Coaxial cables, and it is connected to a mobile computer via Ethernet LAN cable. The mobile computer and RFID reader draws power from the forklift's batteries either directly or with the help of some electrical converters. The RFID antennas can be mounted onto any part of the forklift, including but not limited to the forklift's carriage, overhead guard, back rest, mast, and control panel. The mobile computer is connected to a Server Computer wirelessly via WIFI Ethernet, so that computation can be performed and stored at the Server Computer.

In the facility, transport-units containing multiple items are moved around using forklifts. Whenever forklifts load a transport-unit onto its fork, its Passive RFID antennas will pick up the EPC of passive RFID tag (or tags) from the transport-unit, and EPCs of passive RFID tags attached on all items within it, and performs association between the transport-unit and all the items in it. The forklift's Passive RFID antennas send detected EPCs to its Passive RFID Reader which in turns sends these EPCs to its mobile computer, which then relays the EPCs back to the Server Computer wirelessly for association of the transport-unit to the items within it. Once the transport-unit is associated with all items within, the items' location will be associated to be the same as that of the transport-unit's zone location that is constantly being updated by the Active RFID Tag attached on the same pallet.

(2) The methodology in claim 1, wherein:

The storage-facility has two or more types of transport-units (e.g, cage-pallets and normal-pallets).

The first type of transport units are attached with Active and Passive RFID Tags, with the former being used for tracking of its zone location, and the later being used for association with items within the transport unit. And location tracking of items within this type of transport-units follows that of claim 1.

The second type of transport-units are attached with only a Passive RFID Tag (or a plurality of tags), and its location, and locations of items within it will be calculated as follows:

1. The storage facility is being divided into floor locations and shelf locations. Each floor location will be attached with a Passive RFID Floor Tag (or a plurality of Floor Tags). The floor tag has very low profile, and is capable of withstanding impact from a moving loaded forklift. Each shelf location will be attached with a Passive RFID Shelf Tag (or a plurality

of Shelf Tags). All Passive RFID Tags (Shelf and Floor), will possess a unique EPC to uniquely identify each location. The unique EPC will also be unique amongst all Passive RFID tags used in the storage-facility.

2. The same RFID-enabled forklifts mentioned in claim 1 will also be used to move the second type of transport-units in the storage facility. When a forklift loads a transport-unit onto its fork, association will be performed between the Passive RFID tag (or plurality of Passive RFID tags) on this transport-unit to that of all items within it, in a similar manner as that described in claim 1. When a forklift unloads a transport-unit onto a shelf (or floor) location, the EPC of this shelf (or floor) location tag, and the EPC of the transport-unit's tag will both be captured by the forklift's antennas, which further relays it to the forklift's RFID reader, which then sends it to its mobile computer, and eventually reach the Server Computer via WIFI Ethernet. The Server Computer will then assign the shelf (or floor) location to the transport-unit, which subsequently assigns this shelf (or floor) location to all items within this transport unit.

(3) The methodology in claim 2, wherein:

Instead of attaching both Active and Passive RFID Tags onto the first type of transport units, only Active RFID Tags are attached.

The RFID-enabled forklifts mentioned in claim 2 are installed with an additional Active RFID Reader (or plurality of Active RFID Readers). The Active RFID Reader can be mounted onto any part of the forklift, including but not limited to the forklift's carriage, overhead guard, back rest, mast, and control panel. The Active RFID Reader draws power from the forklift's batteries either directly or with the help of some electric converters. The Active RFID Reader reads nearby Active RFID Tags and relays the Active RFID Tags' unique IDs back to the forklift's mobile computer via either WIFI Ethernet or Cabled Ethernet LAN cable.

When a forklift loads the first type of transport-unit onto its fork, the forklift's Active RFID Reader (or plurality of Active RFID Readers) will read the transport-unit's Active RFID Tag, and relay its unique ID (e.g. MAC Address of Active RFID Tag) to the forklift's mobile computer. Upon receipt of this unique ID, the mobile computer activates the forklift's Passive RFID Reader and antennas to scan for Passive RFID Tags in an attempt to detect all Passive RFID Tags attached on items within the transport-unit. Once scanned, the mobile computer sends all EPCs of the items' Passive RFID tags, and the unique ID of the transport unit's Active RFID Tag, back to the Server Computer via WIFI Ethernet. The Server Computer subsequently associates the items to the scanned transport-unit. This association is subsequently utilized by the Server Computer to further associate the items' location to be the same as the transport-unit's zone location, which is constantly being updated by the Active RFID Tag attached on the transport-unit.

(4) The methodology in claim 2, wherein:

The methodology used to track locations for the first type of transport-units (and items within it) is not used in the storage facility. Instead, their locations are tracked using the same methodology as that of the second type of transport-units (and items within it) described in claim 2.