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G08B 13/24 (2006.01) ***G06Q 20/32*** (2012.01)

(56) Documents Cited:
WO 2015/121833 A1 **WO 2015/112446 A1**
WO 2012/135115 A2 **US 20020186133 A1**

(58) Field of Search:
INT CL **G06K, G06Q, G08B**
Other: **WPI; EPODOC**

(54) Title of the Invention: **Security system for a retail environment**
Abstract Title: **Retail security system disarms alarm on detection of purchased item**

(57) A security system within a retail environment comprises a plurality of first tags 108-112 (i.e. RFID tags) concealed within an item 101-105 to be sold, a plurality of second tags 114-117 (i.e. Bluetooth (RTM) enabled for providing product information) which communicate with a customer's mobile device 118-119 to facilitate purchase of the item 101-105, and a data communication apparatus which controls exit gate 120-121 to raise an alarm upon detecting a first tag 108-112 on an item 101-105, wherein the item's second tag 114-117 has not completed a sale, or to raise no alarm upon detecting a first tag 108-112 on a purchased item 101-105. Also provided is a security system which further dynamically displays each selected item 101-105 on the mobile device 119 using positional data of the item and the mobile device. The selection of the user's preferred item may be made by a physical interaction with a second tag 114-117, i.e. an impact between the tag and the mobile device 119, and the second tag 114-117 may include an indicator to invite the user to remove the second tag, as well as a removal detection device.

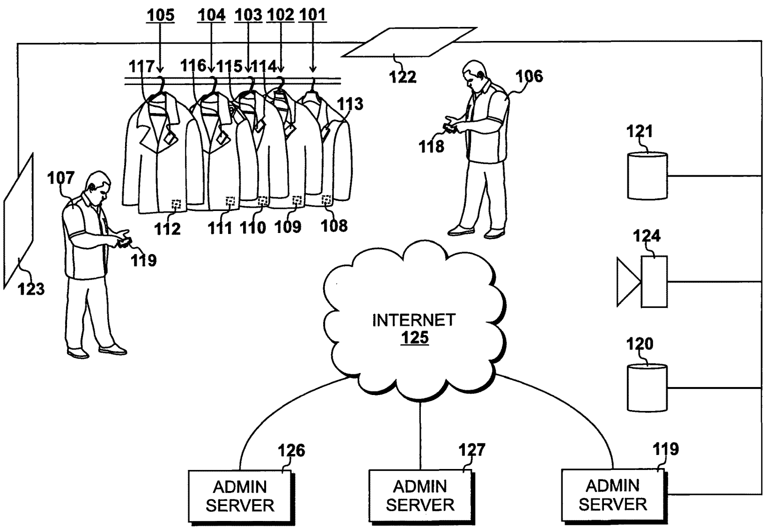

Fig. 1

GB 2548992 A

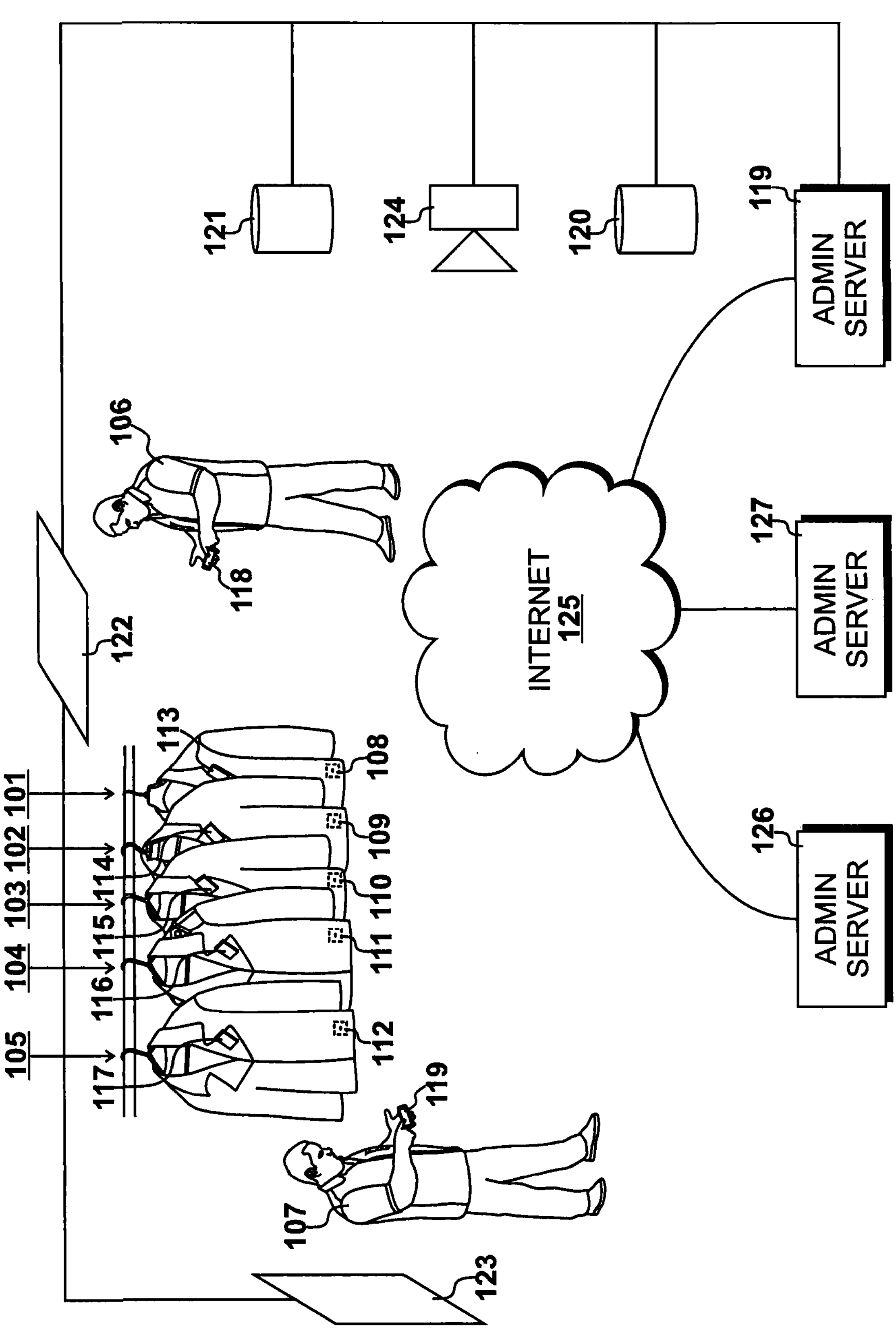
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
INTERNET
125
ADMIN SERVER
119
ADMIN SERVER
127
ADMIN SERVER
126

Fig. 1

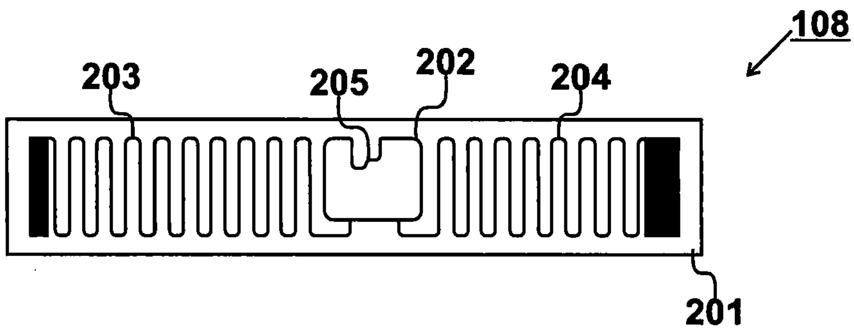
108
203
205
202
204
201

Fig. 2

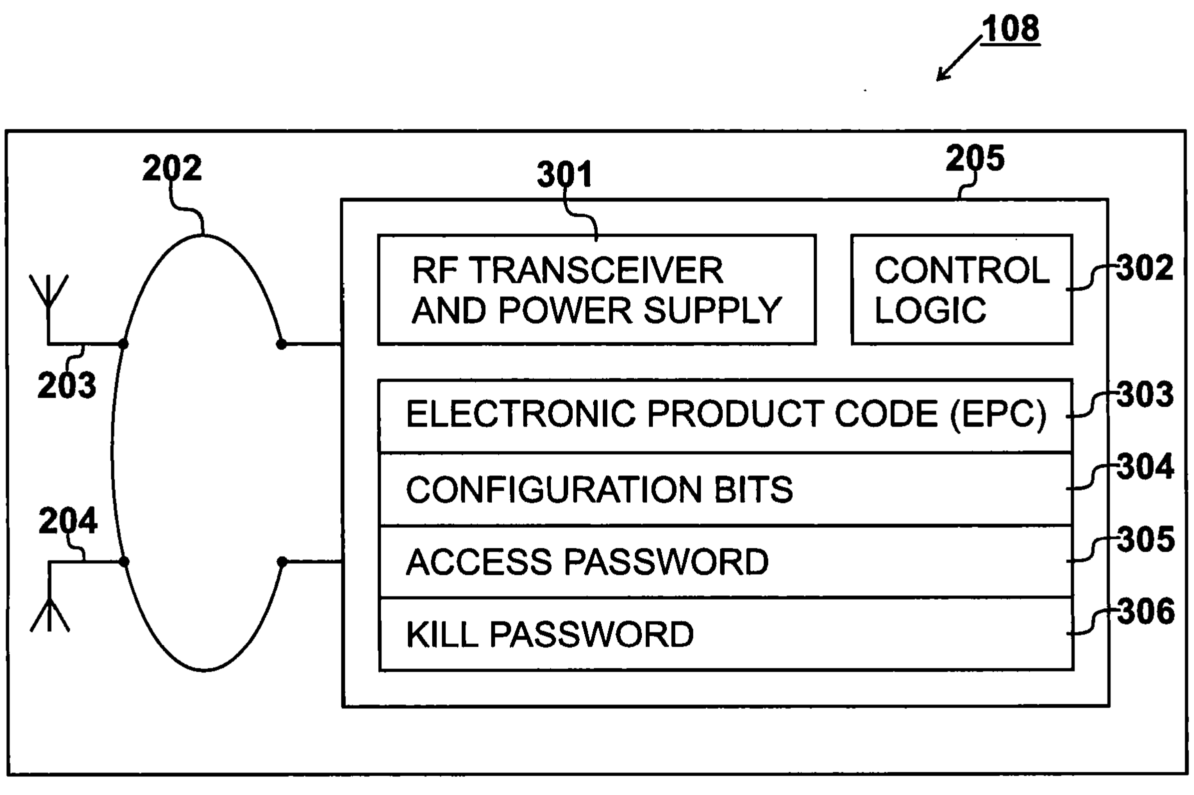
108
202
301
205
RF TRANSCEIVER AND POWER SUPPLY
CONTROL LOGIC
302
203
ELECTRONIC PRODUCT CODE (EPC)
303
CONFIGURATION BITS
304
204
ACCESS PASSWORD
305
KILL PASSWORD
306

Fig. 3

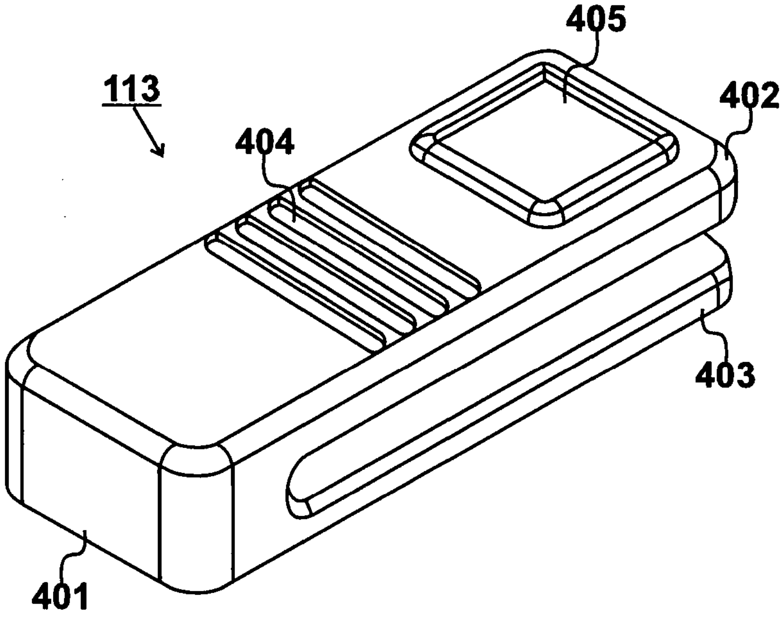

Fig. 4

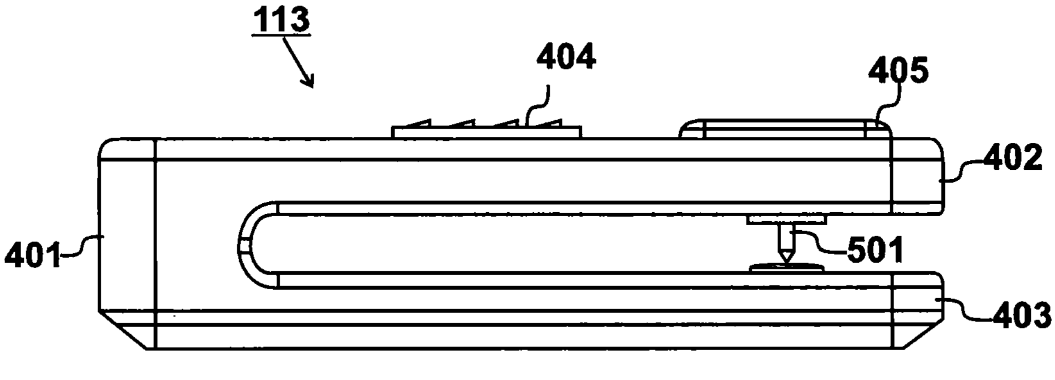

Fig. 5

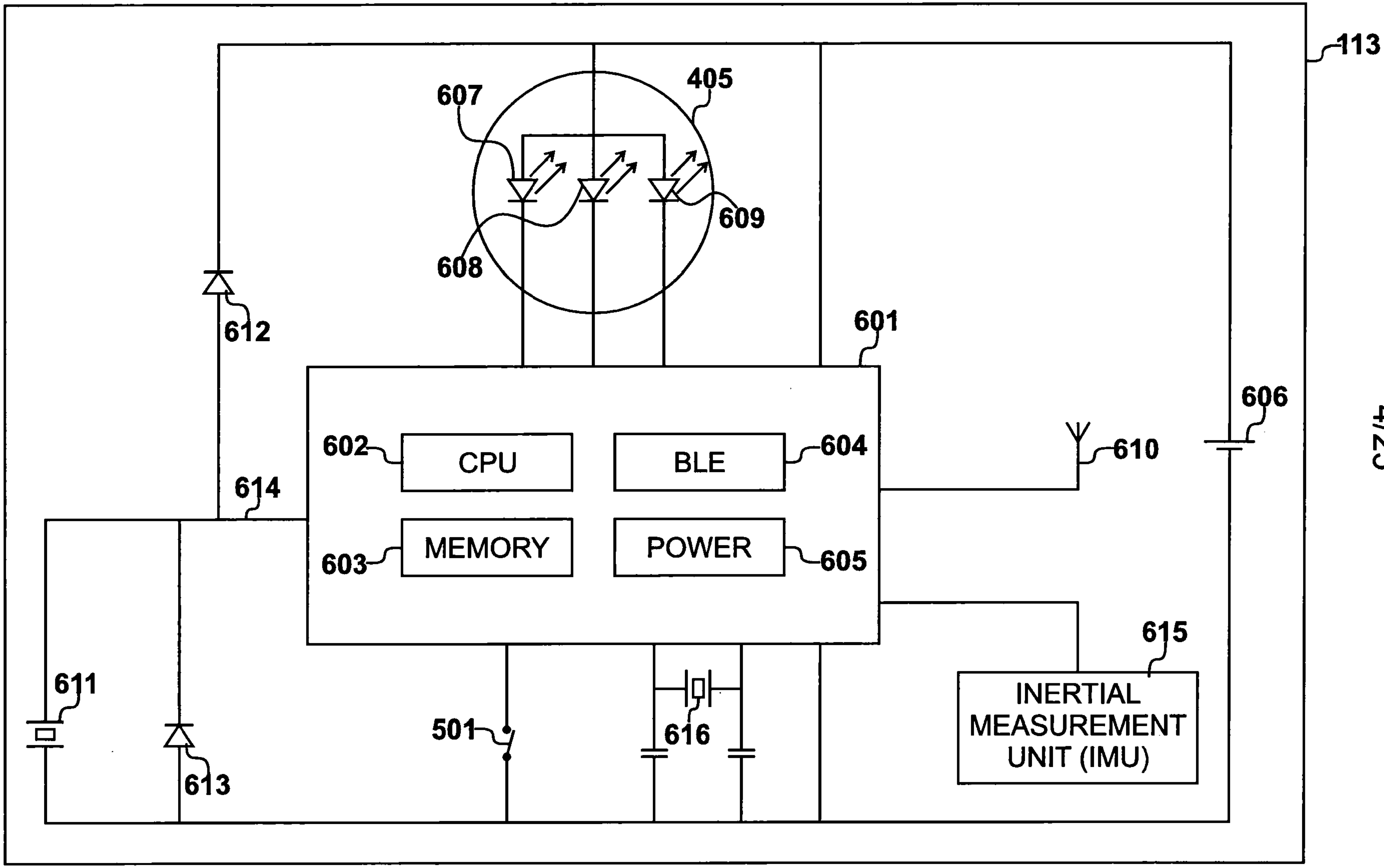
113
405
607
608
609
612
601
602
CPU
604
BLE
603
MEMORY
605
POWER
614
606
610
615
INERTIAL MEASUREMENT UNIT (IMU)
611
613
501
616

Fig. 6

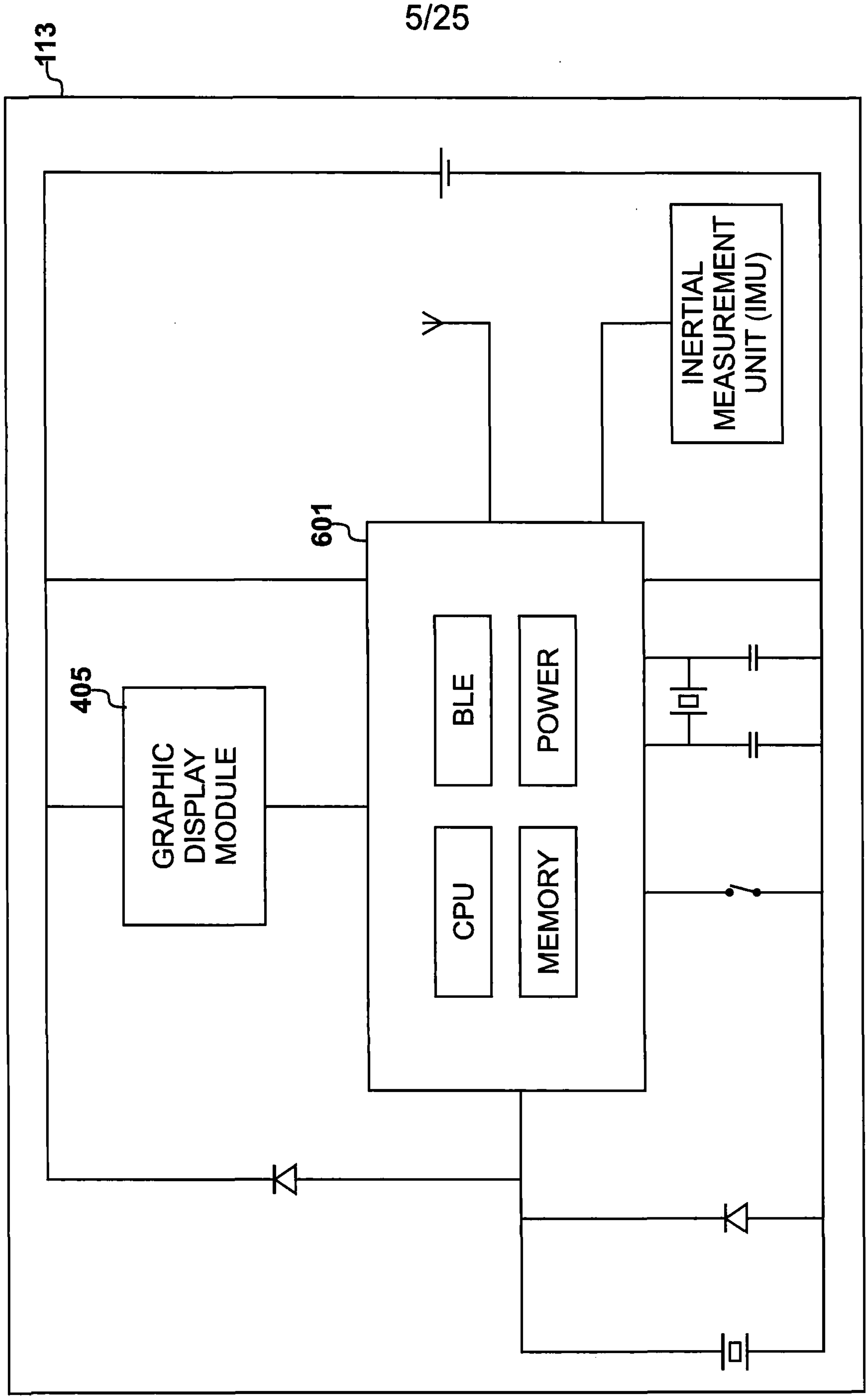
113
601
405
GRAPHIC DISPLAY MODULE
BLE
POWER
CPU
MEMORY
INERTIAL MEASUREMENT UNIT (IMU)

Fig. 7

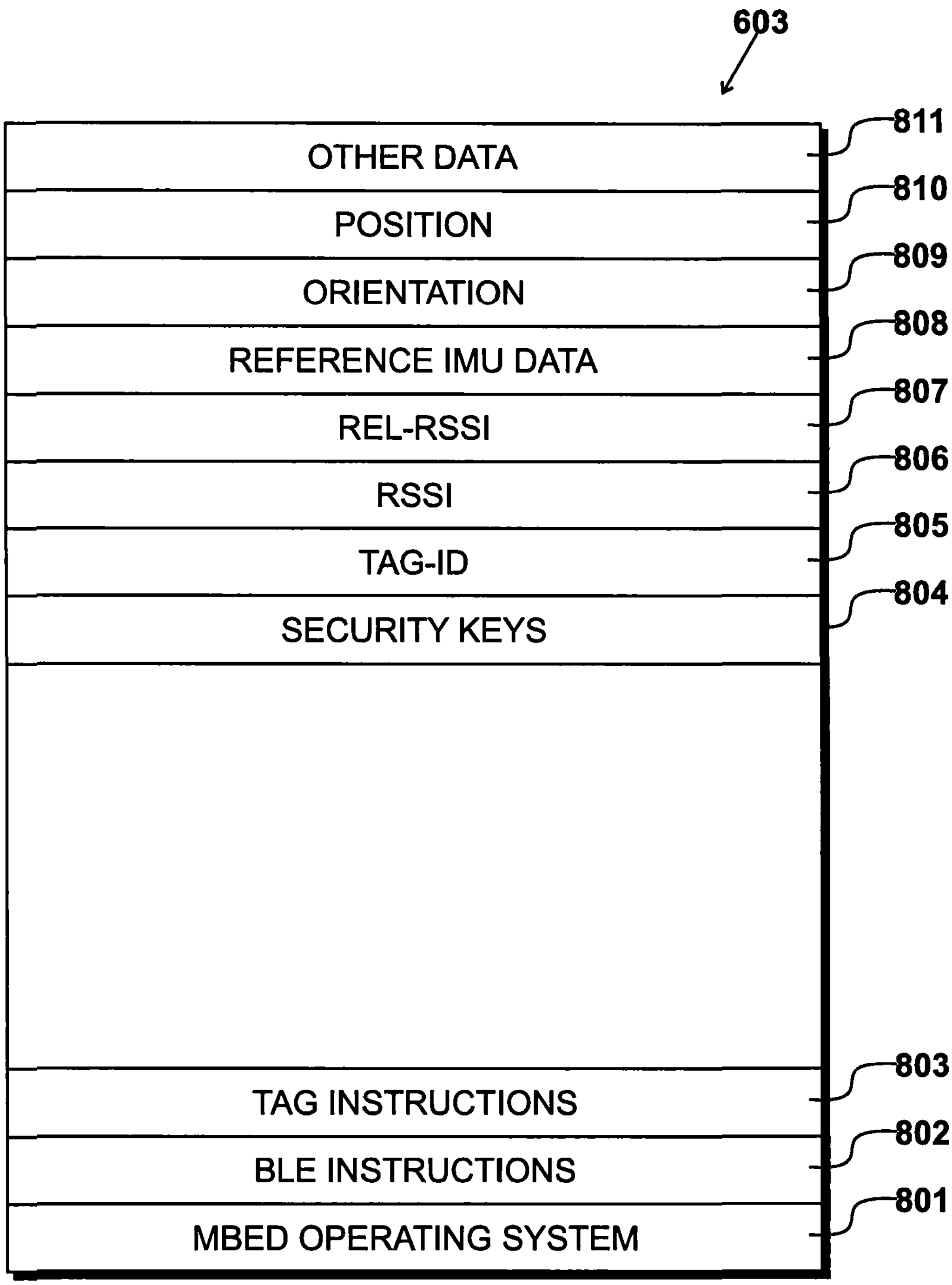
603
OTHER DATA
811
POSITION
810
ORIENTATION
809
REFERENCE IMU DATA
808
REL-RSSI
807
RSSI
806
TAG-ID
805
SECURITY KEYS
804
TAG INSTRUCTIONS
803
BLE INSTRUCTIONS
802
MBED OPERATING SYSTEM
801

Fig. 8

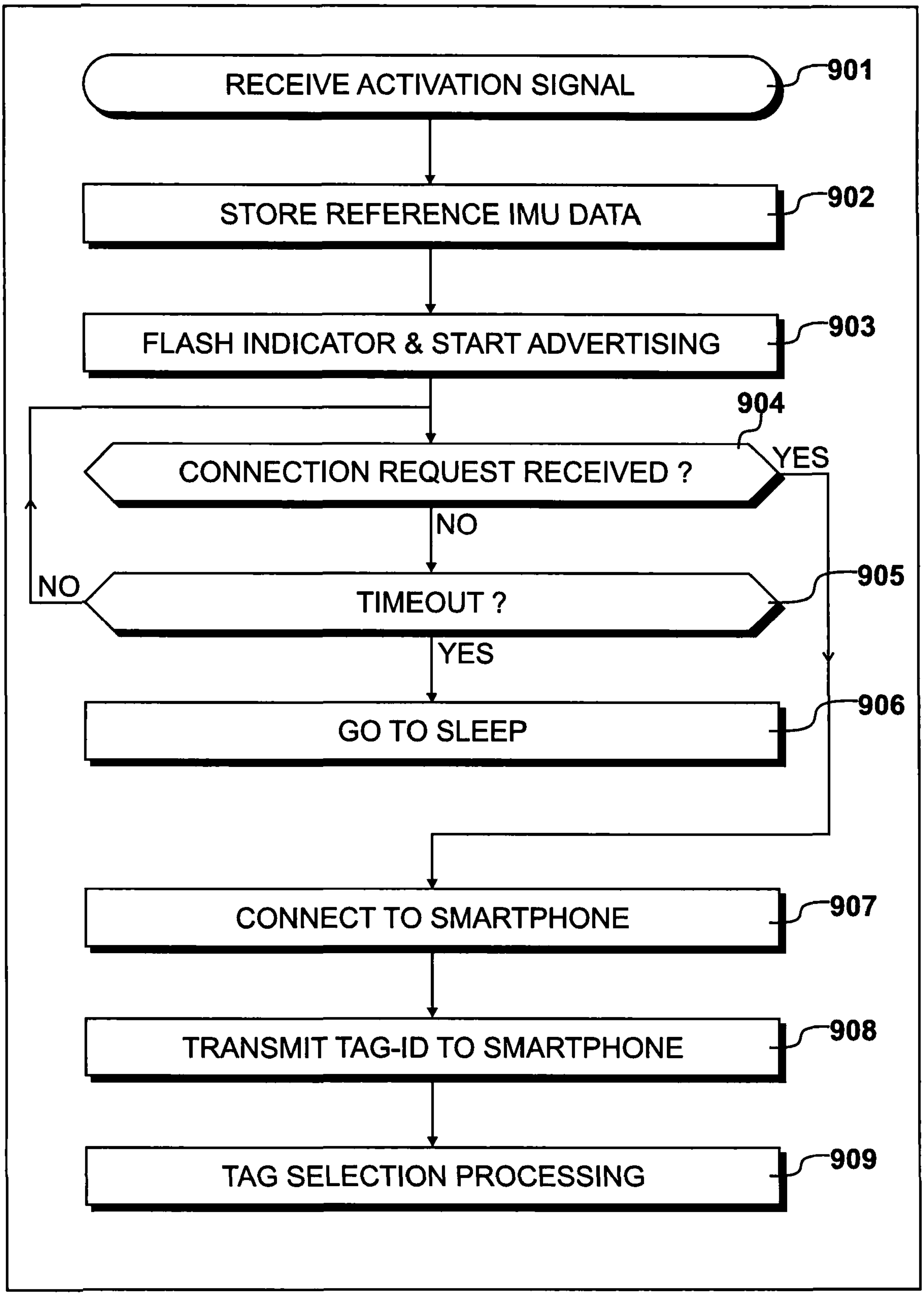
RECEIVE ACTIVATION SIGNAL
901
STORE REFERENCE IMU DATA
902
FLASH INDICATOR & START ADVERTISING
903
904
CONNECTION REQUEST RECEIVED ?
YES
NO
NO
TIMEOUT ?
905
YES
GO TO SLEEP
906
CONNECT TO SMARTPHONE
907
TRANSMIT TAG-ID TO SMARTPHONE
908
TAG SELECTION PROCESSING
909

Fig. 9

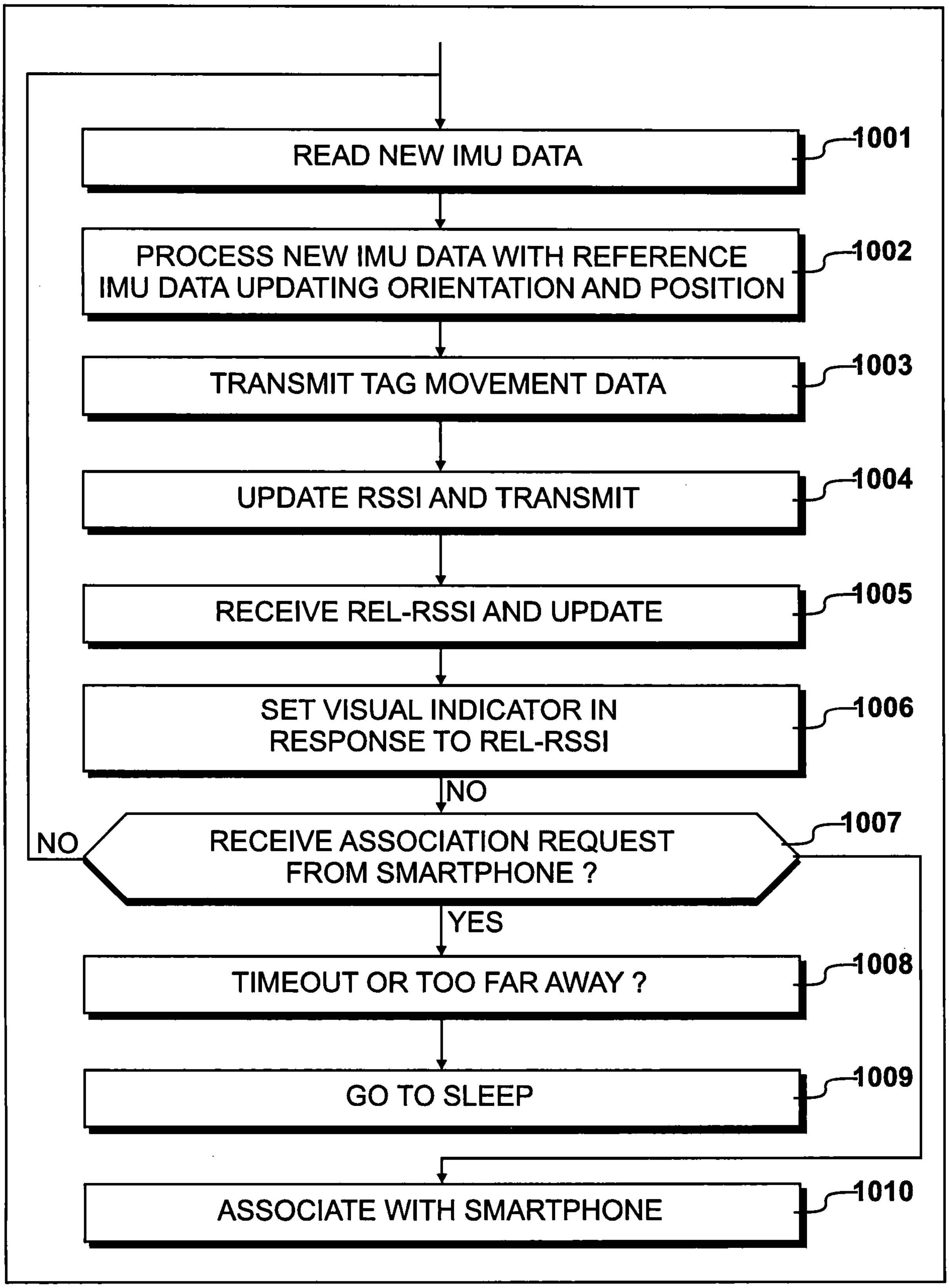
READ NEW IMU DATA
1001
PROCESS NEW IMU DATA WITH REFERENCE IMU DATA UPDATING ORIENTATION AND POSITION
1002
TRANSMIT TAG MOVEMENT DATA
1003
UPDATE RSSI AND TRANSMIT
1004
RECEIVE REL-RSSI AND UPDATE
1005
SET VISUAL INDICATOR IN RESPONSE TO REL-RSSI
1006
NO
NO
RECEIVE ASSOCIATION REQUEST FROM SMARTPHONE ?
1007
YES
TIMEOUT OR TOO FAR AWAY ?
1008
GO TO SLEEP
1009
ASSOCIATE WITH SMARTPHONE
1010

Fig. 10

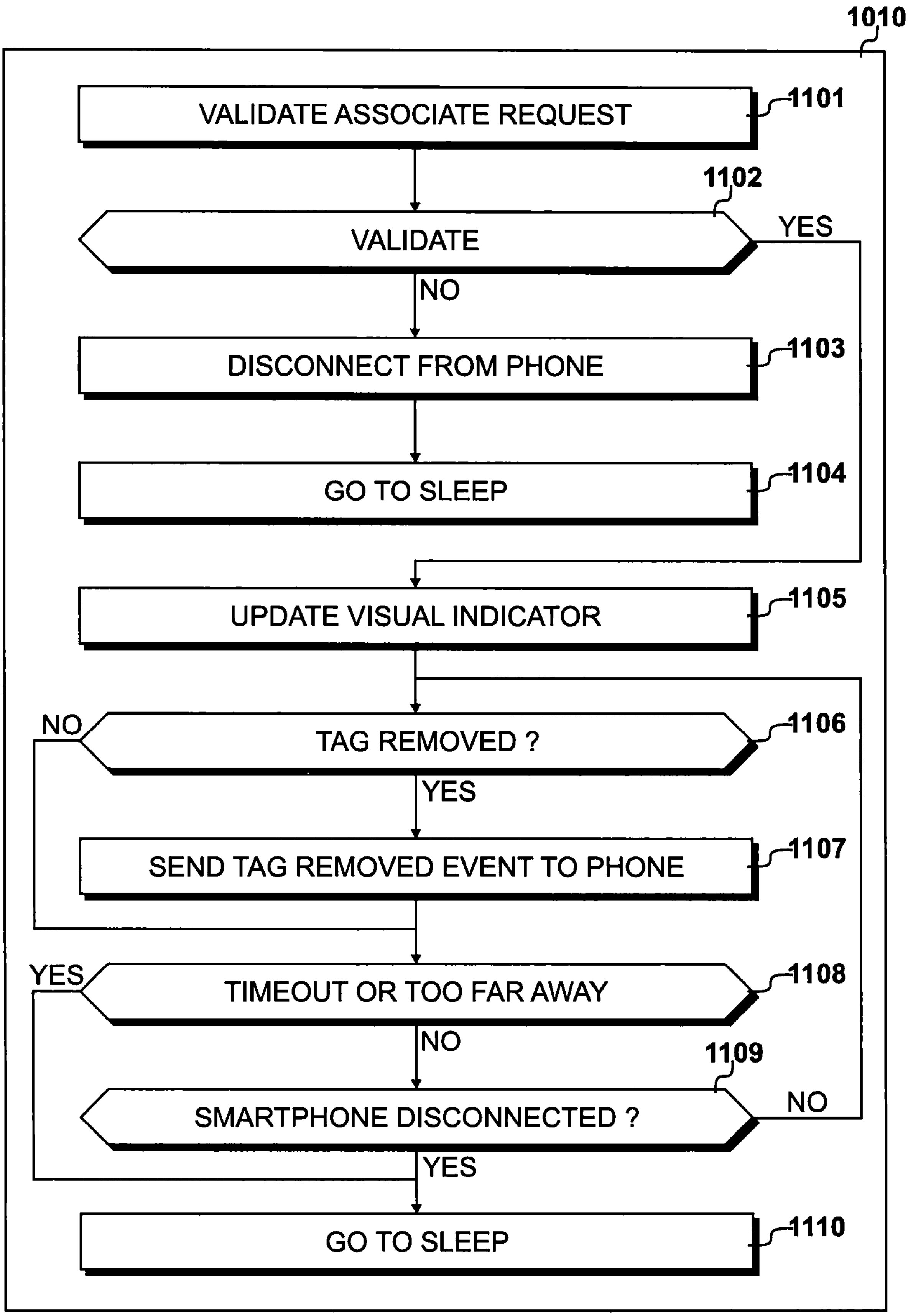
1010
VALIDATE ASSOCIATE REQUEST
1101
1102
VALIDATE
YES
NO
DISCONNECT FROM PHONE
1103
GO TO SLEEP
1104
UPDATE VISUAL INDICATOR
1105
NO
TAG REMOVED ?
1106
YES
SEND TAG REMOVED EVENT TO PHONE
1107
YES
TIMEOUT OR TOO FAR AWAY
1108
NO
1109
SMARTPHONE DISCONNECTED ?
NO
YES
GO TO SLEEP
1110

Fig. 11

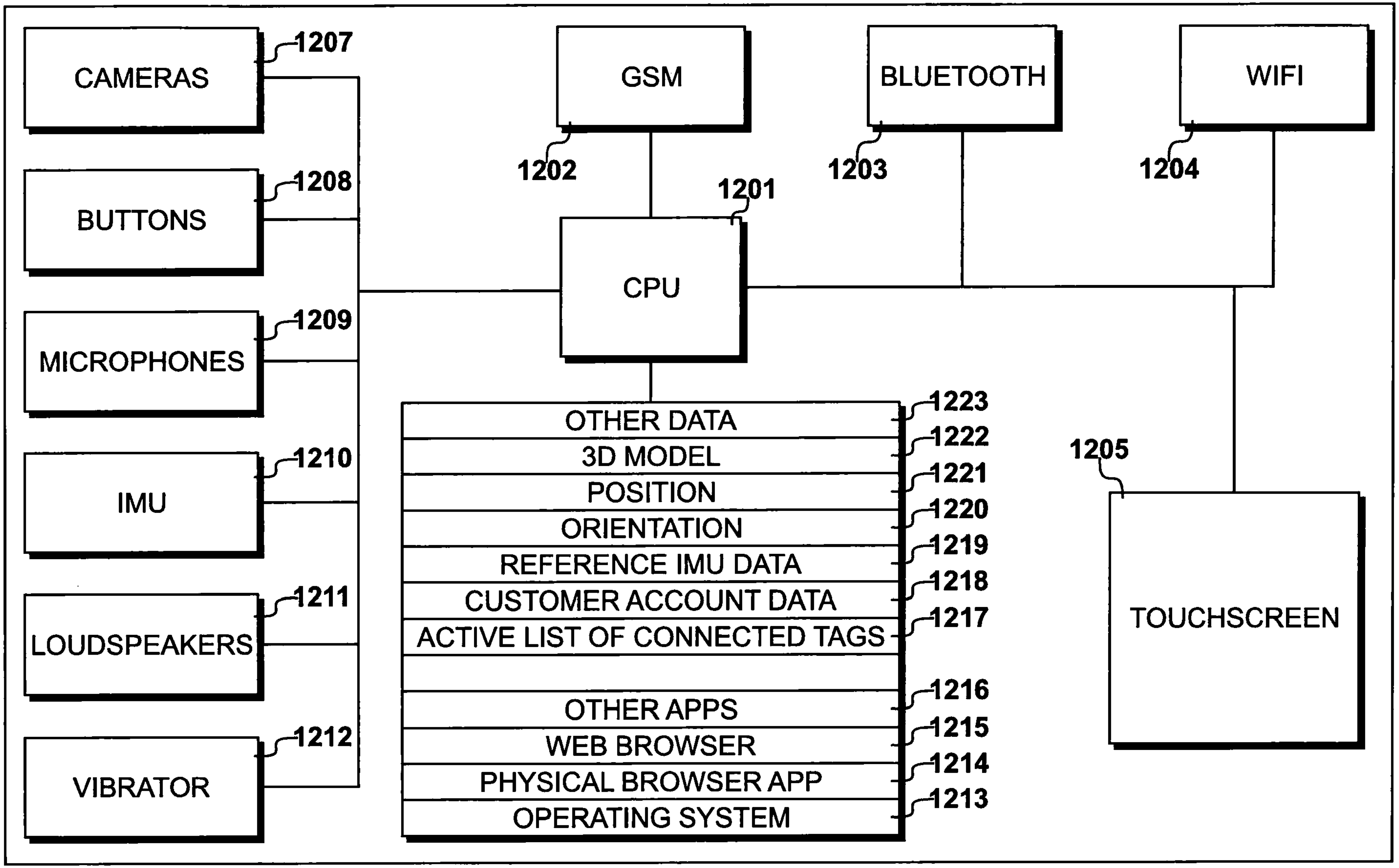
CAMERAS
1207
BUTTONS
1208
MICROPHONES
1209
IMU
1210
LOUDSPEAKERS
1211
VIBRATOR
1212
GSM
1202
BLUETOOTH
1203
WIFI
1204
CPU
1201
OTHER DATA
1223
3D MODEL
1222
POSITION
1221
ORIENTATION
1220
REFERENCE IMU DATA
1219
CUSTOMER ACCOUNT DATA
1218
ACTIVE LIST OF CONNECTED TAGS
1217
OTHER APPS
1216
WEB BROWSER
1215
PHYSICAL BROWSER APP
1214
OPERATING SYSTEM
1213
TOUCHSCREEN
1205

Fig. 12

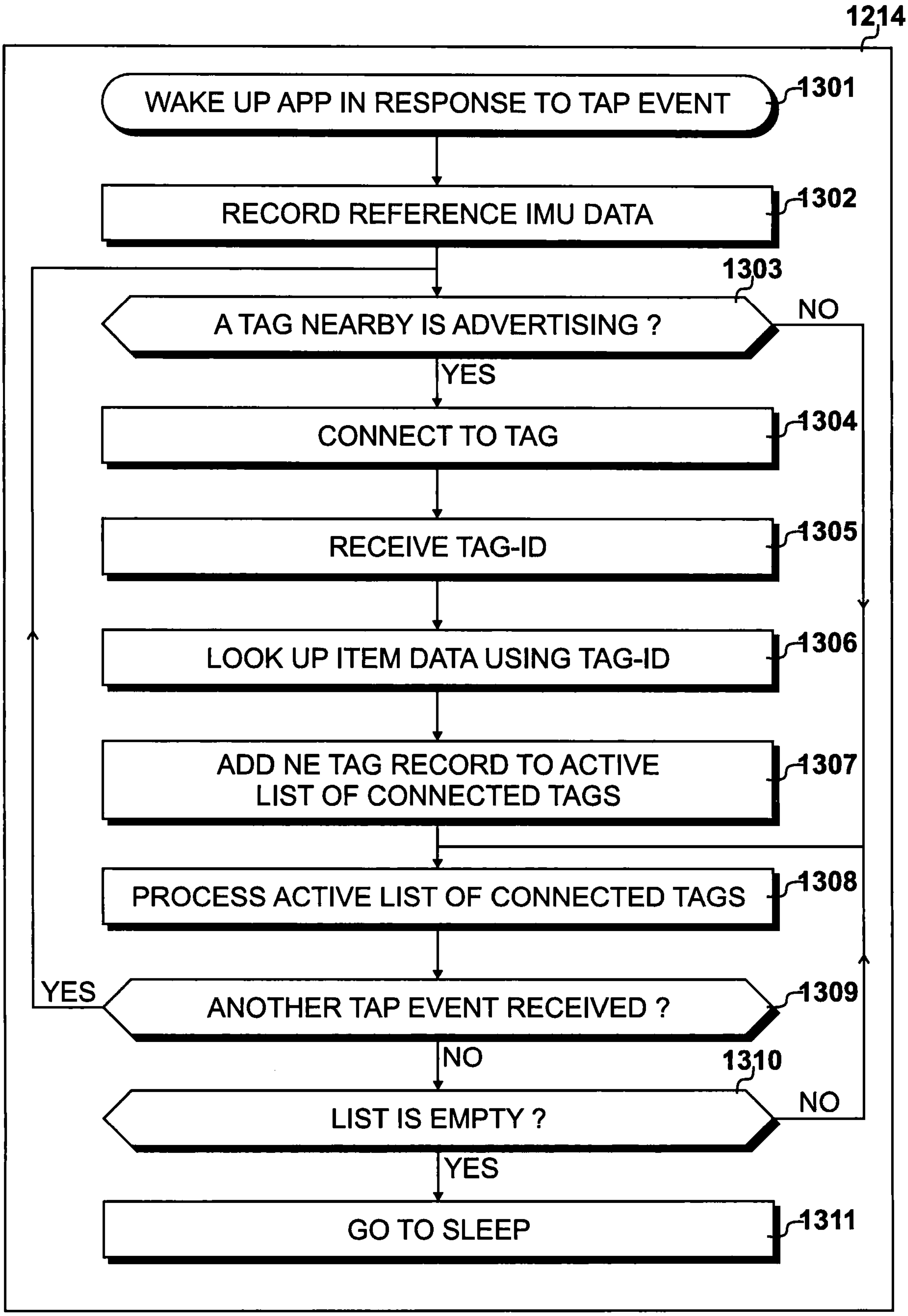
1214
WAKE UP APP IN RESPONSE TO TAP EVENT
1301
RECORD REFERENCE IMU DATA
1302
1303
A TAG NEARBY IS ADVERTISING ?
NO
YES
CONNECT TO TAG
1304
RECEIVE TAG-ID
1305
LOOK UP ITEM DATA USING TAG-ID
1306
ADD NE TAG RECORD TO ACTIVE
LIST OF CONNECTED TAGS
1307
PROCESS ACTIVE LIST OF CONNECTED TAGS
1308
YES
ANOTHER TAP EVENT RECEIVED ?
1309
NO
1310
LIST IS EMPTY ?
NO
YES
GO TO SLEEP
1311

Fig. 13

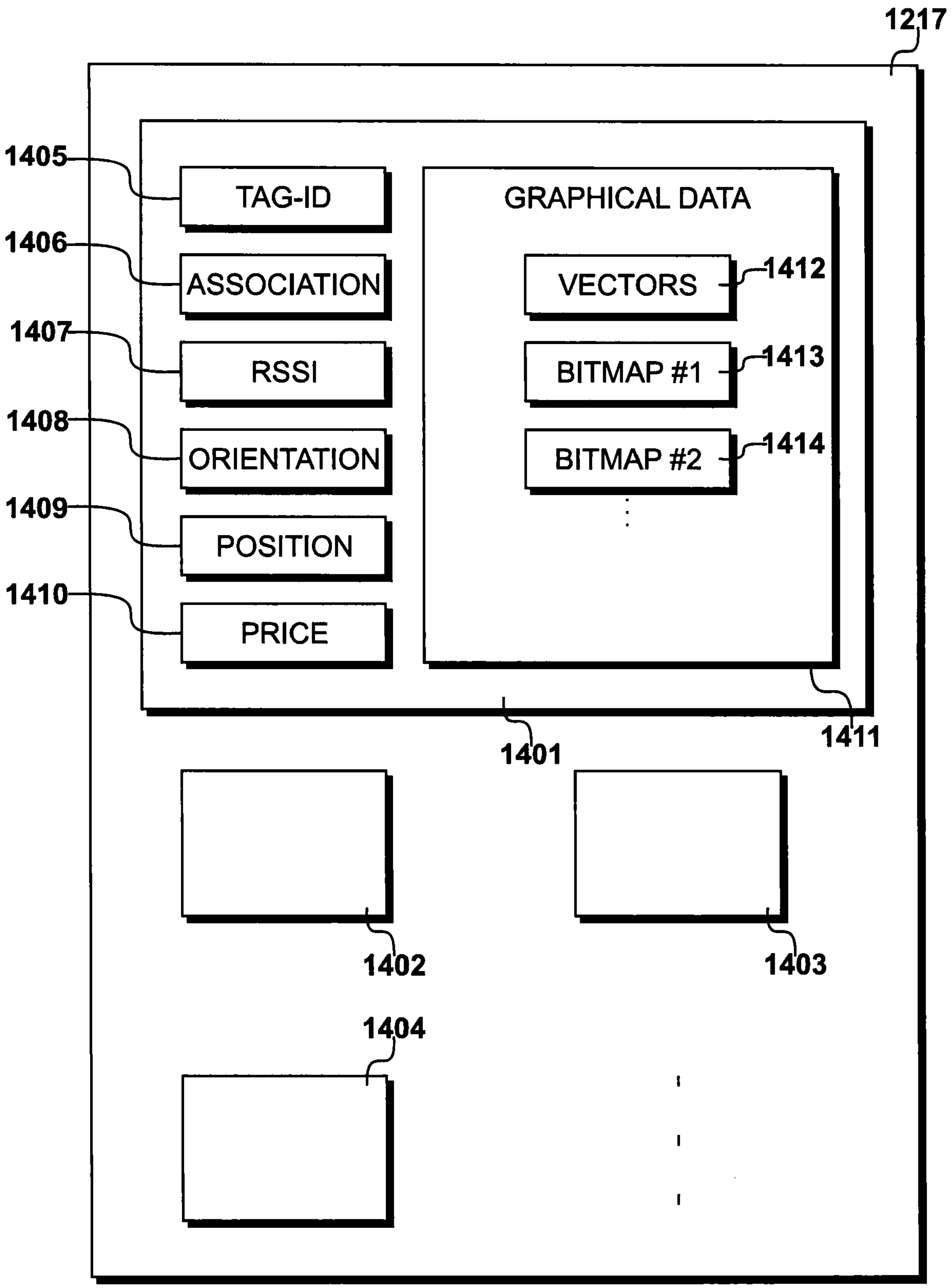
1217
1405
TAG-ID
1406
ASSOCIATION
1407
RSSI
1408
ORIENTATION
1409
POSITION
1410
PRICE
GRAPHICAL DATA
VECTORS
1412
BITMAP #1
1413
BITMAP #2
1414
1411
1401
1402
1403
1404

Fig. 14

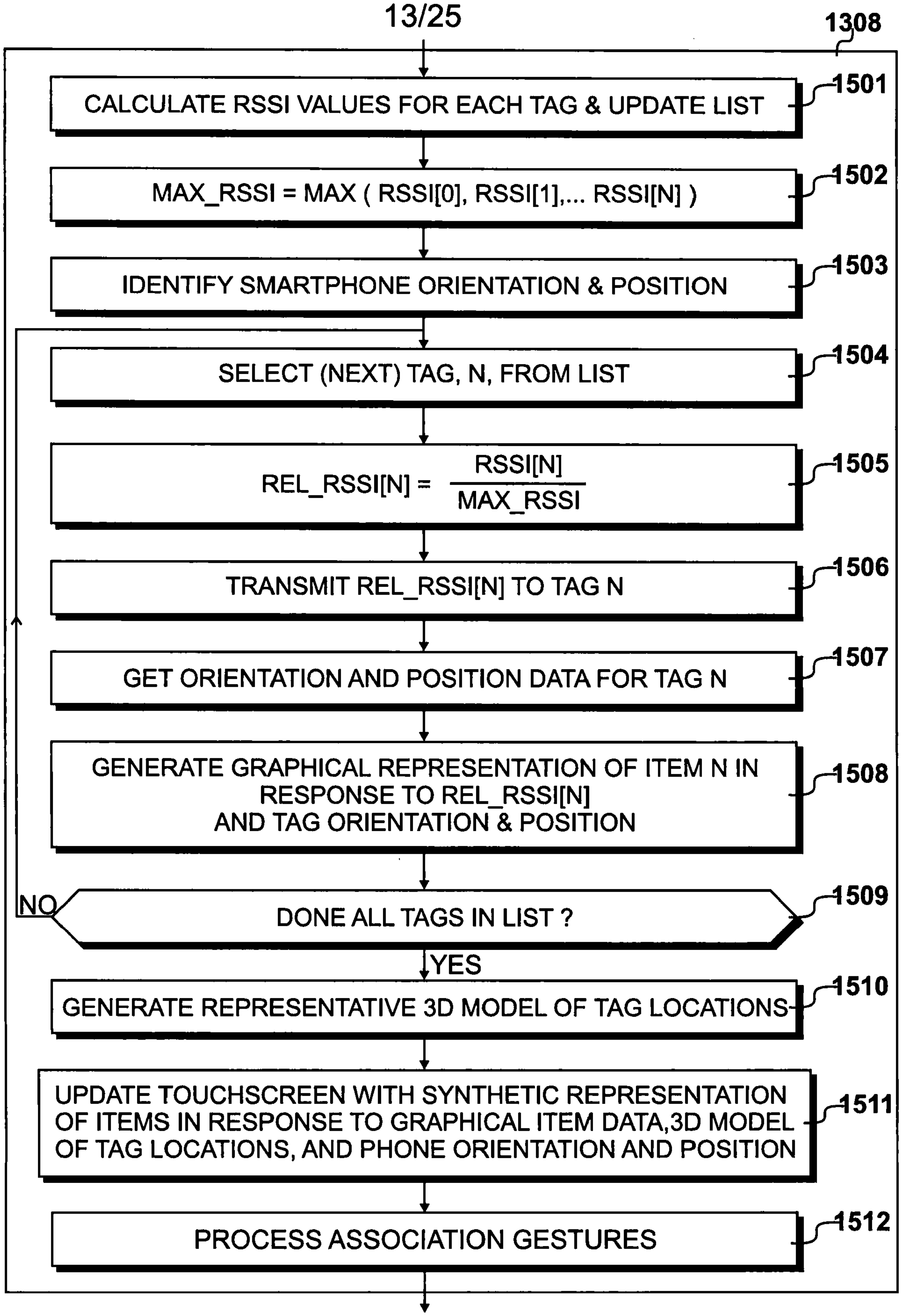
1308
CALCULATE RSSI VALUES FOR EACH TAG & UPDATE LIST
1501
MAX_RSSI = MAX (RSSI[0], RSSI[1],... RSSI[N])
1502
IDENTIFY SMARTPHONE ORIENTATION & POSITION
1503
SELECT (NEXT) TAG, N, FROM LIST
1504
REL_RSSI[N] = RSSI[N] / MAX_RSSI
1505
TRANSMIT REL_RSSI[N] TO TAG N
1506
GET ORIENTATION AND POSITION DATA FOR TAG N
1507
GENERATE GRAPHICAL REPRESENTATION OF ITEM N IN RESPONSE TO REL_RSSI[N] AND TAG ORIENTATION & POSITION
1508
DONE ALL TAGS IN LIST ?
1509
NO
YES
GENERATE REPRESENTATIVE 3D MODEL OF TAG LOCATIONS
1510
UPDATE TOUCHSCREEN WITH SYNTHETIC REPRESENTATION OF ITEMS IN RESPONSE TO GRAPHICAL ITEM DATA,3D MODEL OF TAG LOCATIONS, AND PHONE ORIENTATION AND POSITION
1511
PROCESS ASSOCIATION GESTURES
1512

Fig. 15

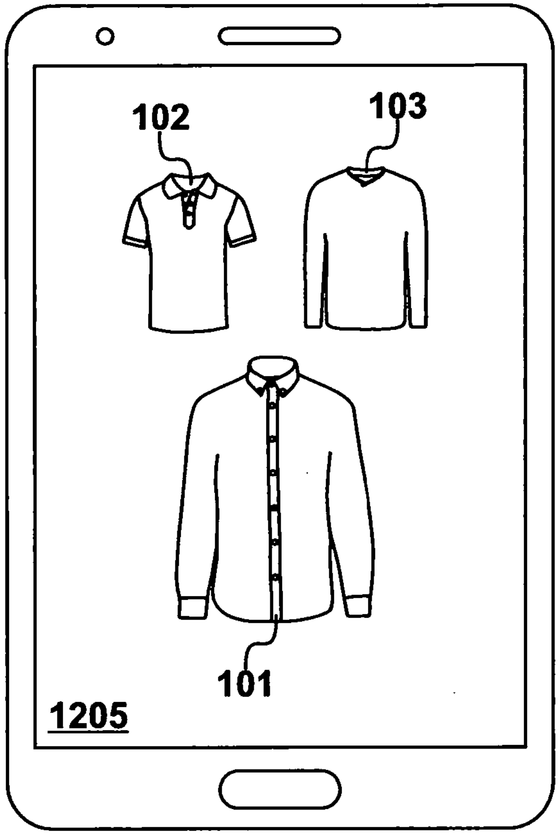

Fig. 16

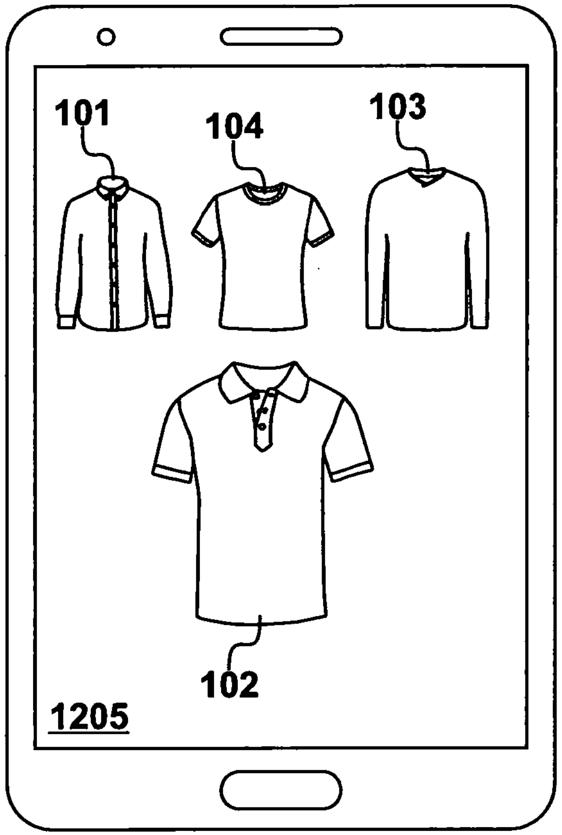

Fig. 17

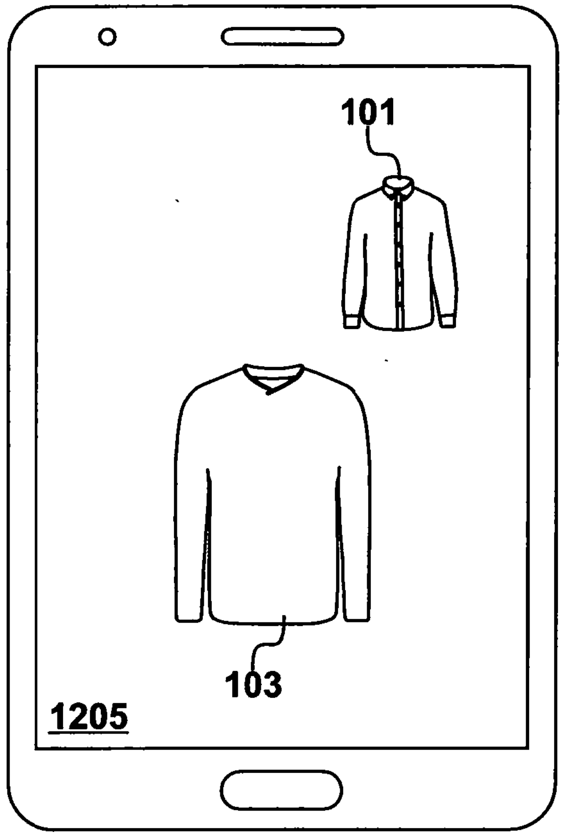

Fig. 18

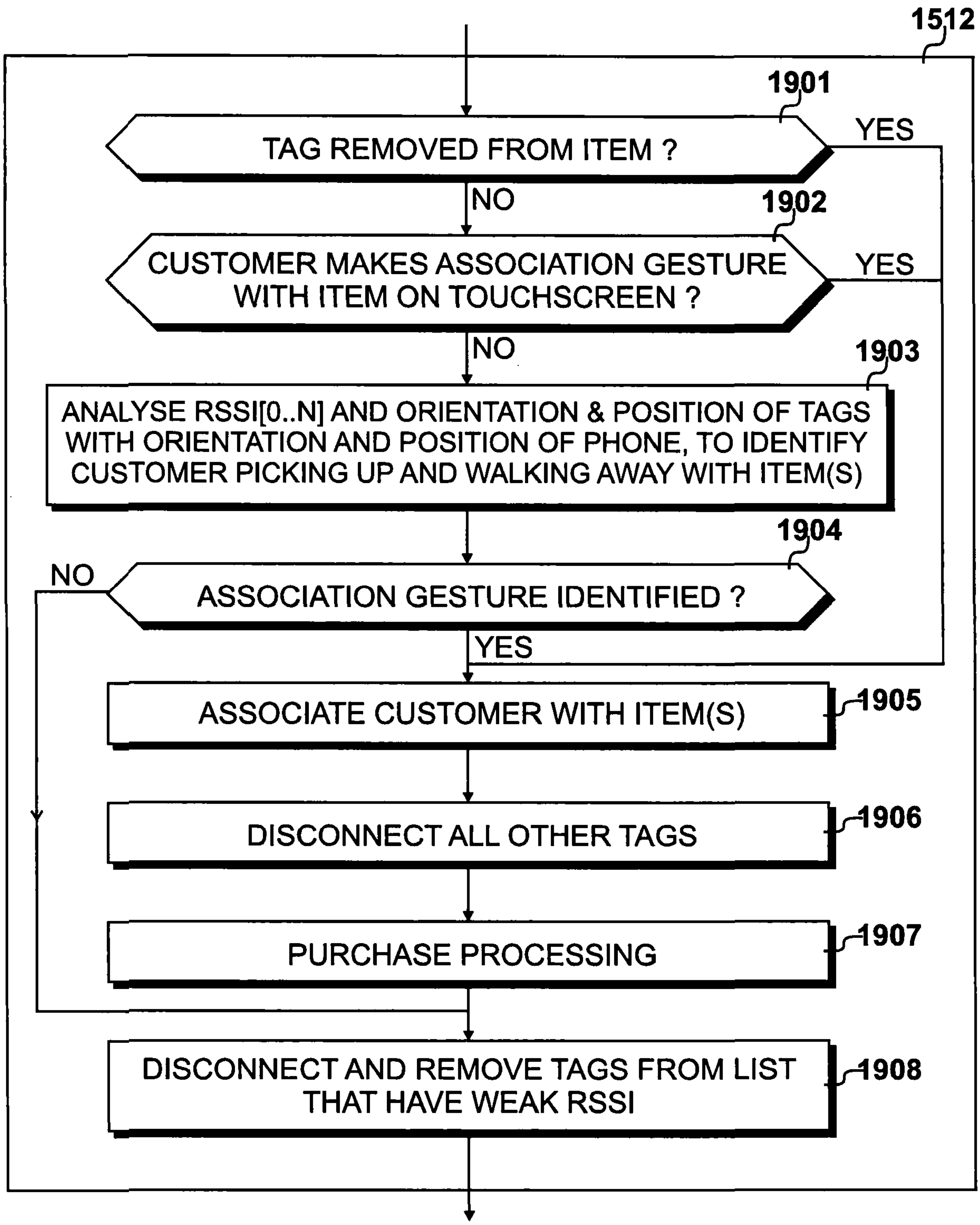
1512
1901
TAG REMOVED FROM ITEM ?
YES
NO
1902
CUSTOMER MAKES ASSOCIATION GESTURE WITH ITEM ON TOUCHSCREEN ?
YES
NO
1903
ANALYSE RSSI[0..N] AND ORIENTATION & POSITION OF TAGS WITH ORIENTATION AND POSITION OF PHONE, TO IDENTIFY CUSTOMER PICKING UP AND WALKING AWAY WITH ITEM(S)
1904
NO
ASSOCIATION GESTURE IDENTIFIED ?
YES
ASSOCIATE CUSTOMER WITH ITEM(S)
1905
DISCONNECT ALL OTHER TAGS
1906
PURCHASE PROCESSING
1907
DISCONNECT AND REMOVE TAGS FROM LIST THAT HAVE WEAK RSSI
1908

Fig. 19

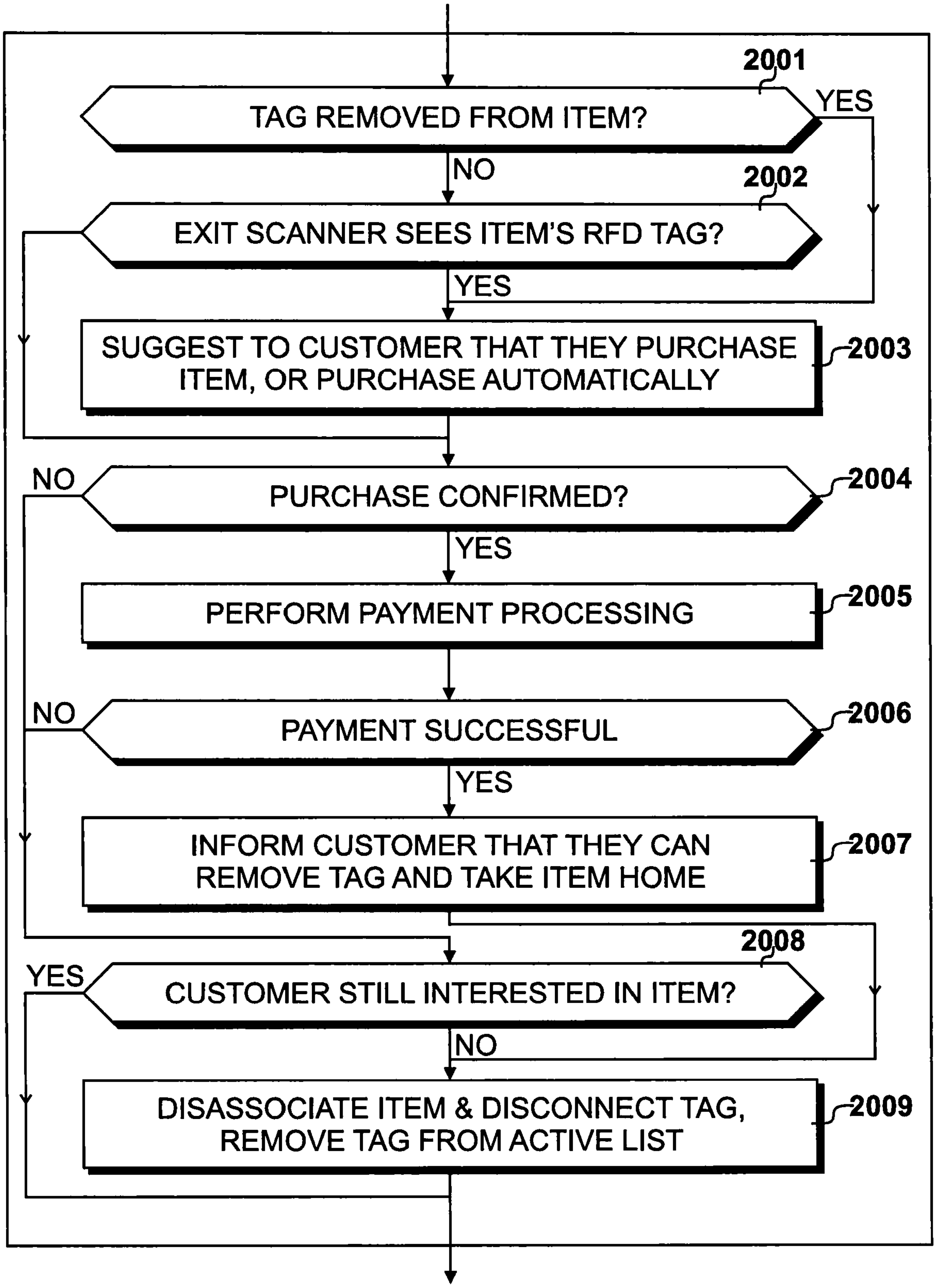
TAG REMOVED FROM ITEM?
2001
YES
NO
EXIT SCANNER SEES ITEM'S RFD TAG?
2002
YES
SUGGEST TO CUSTOMER THAT THEY PURCHASE ITEM, OR PURCHASE AUTOMATICALLY
2003
NO
PURCHASE CONFIRMED?
2004
YES
PERFORM PAYMENT PROCESSING
2005
NO
PAYMENT SUCCESSFUL
2006
YES
INFORM CUSTOMER THAT THEY CAN REMOVE TAG AND TAKE ITEM HOME
2007
2008
YES
CUSTOMER STILL INTERESTED IN ITEM?
NO
DISASSOCIATE ITEM & DISCONNECT TAG, REMOVE TAG FROM ACTIVE LIST
2009

Fig. 20

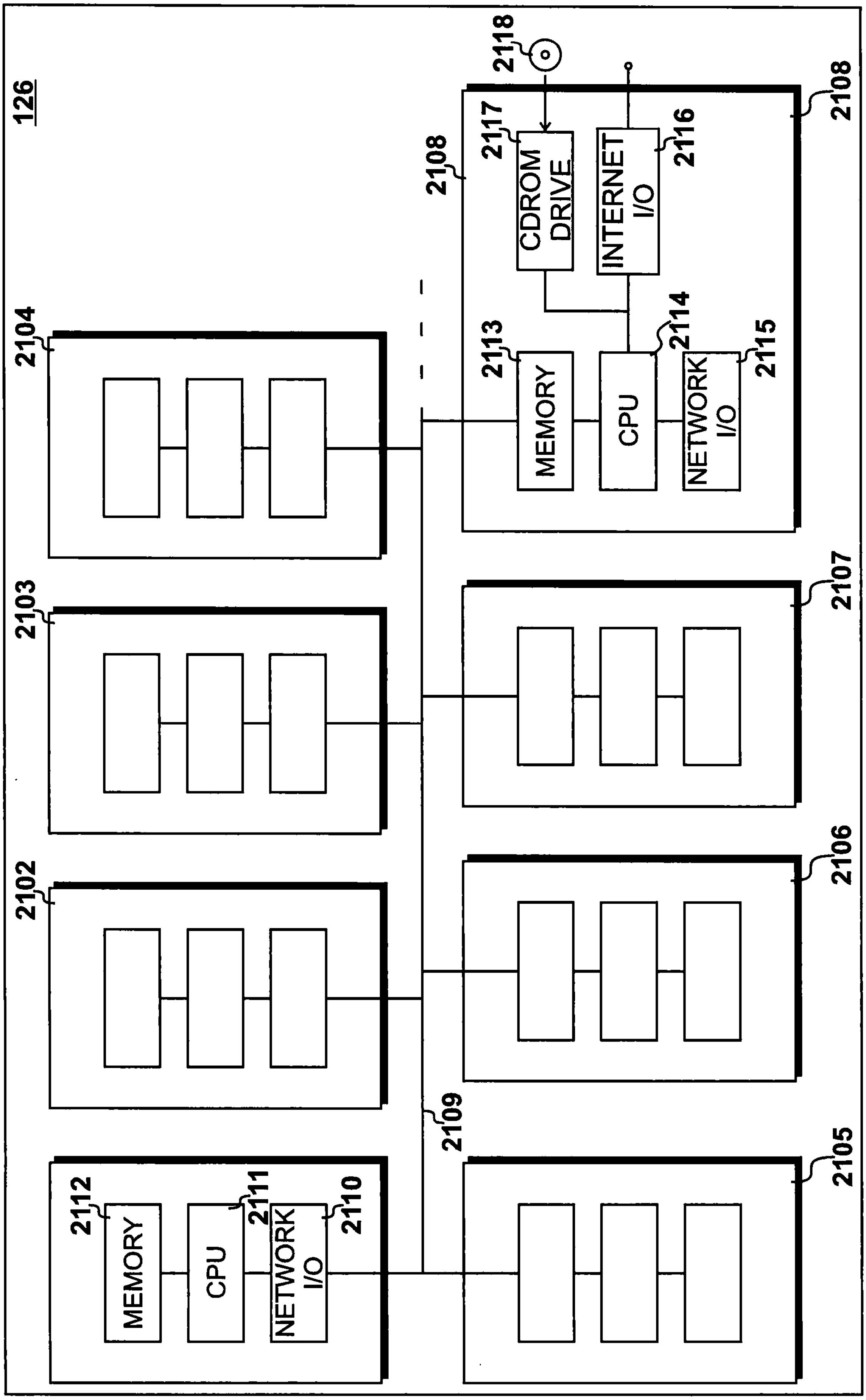
126
2104
2103
2102
2108
2118
2117
CDROM DRIVE
INTERNET I/O
2116
2113
MEMORY
CPU
2114
NETWORK I/O
2115
2107
2106
2109
2105
2112
MEMORY
CPU
2111
NETWORK I/O
2110

Fig. 21

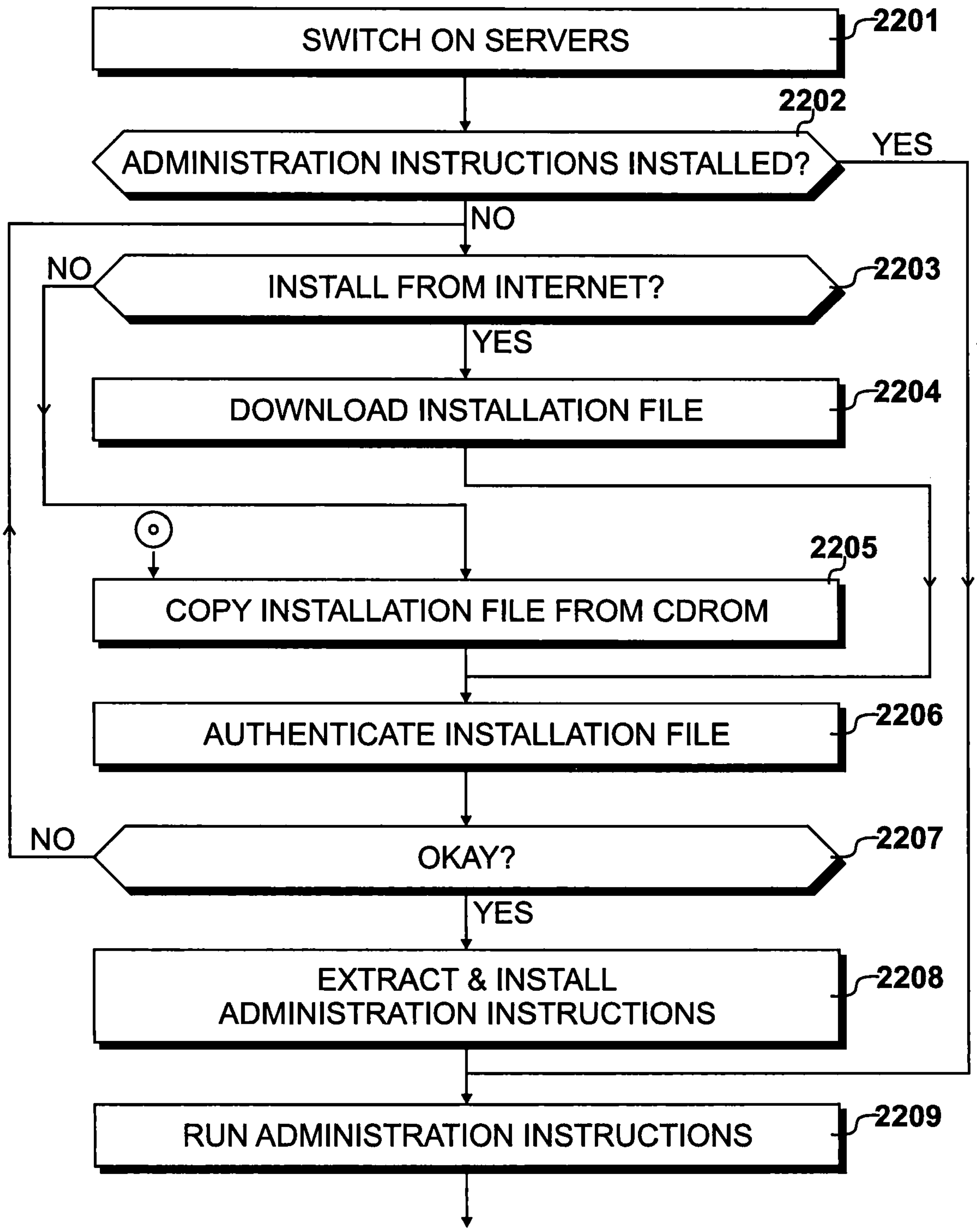
SWITCH ON SERVERS
2201
2202
ADMINISTRATION INSTRUCTIONS INSTALLED?
YES
NO
NO
INSTALL FROM INTERNET?
2203
YES
DOWNLOAD INSTALLATION FILE
2204
2205
COPY INSTALLATION FILE FROM CDROM
AUTHENTICATE INSTALLATION FILE
2206
NO
OKAY?
2207
YES
EXTRACT & INSTALL
ADMINISTRATION INSTRUCTIONS
2208
RUN ADMINISTRATION INSTRUCTIONS
2209

Fig. 22

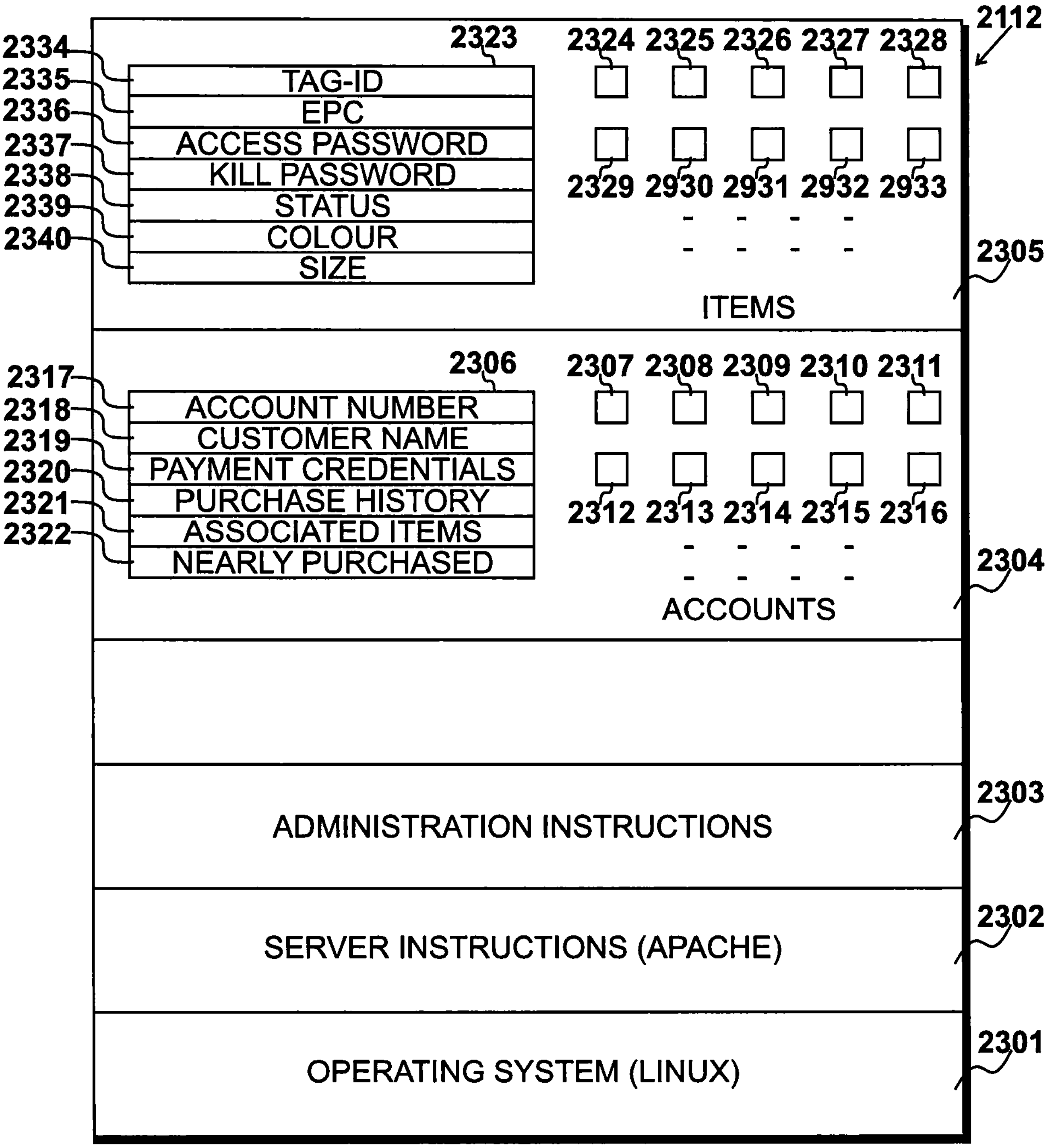
2112
2334
2335
2336
2337
2338
2339
2340
2323
TAG-ID
EPC
ACCESS PASSWORD
KILL PASSWORD
STATUS
COLOUR
SIZE
2324 2325 2326 2327 2328
2329 2930 2931 2932 2933
ITEMS
2305
2317
2318
2319
2320
2321
2322
2306
ACCOUNT NUMBER
CUSTOMER NAME
PAYMENT CREDENTIALS
PURCHASE HISTORY
ASSOCIATED ITEMS
NEARLY PURCHASED
2307 2308 2309 2310 2311
2312 2313 2314 2315 2316
ACCOUNTS
2304
ADMINISTRATION INSTRUCTIONS
2303
SERVER INSTRUCTIONS (APACHE)
2302
OPERATING SYSTEM (LINUX)
2301

Fig. 23

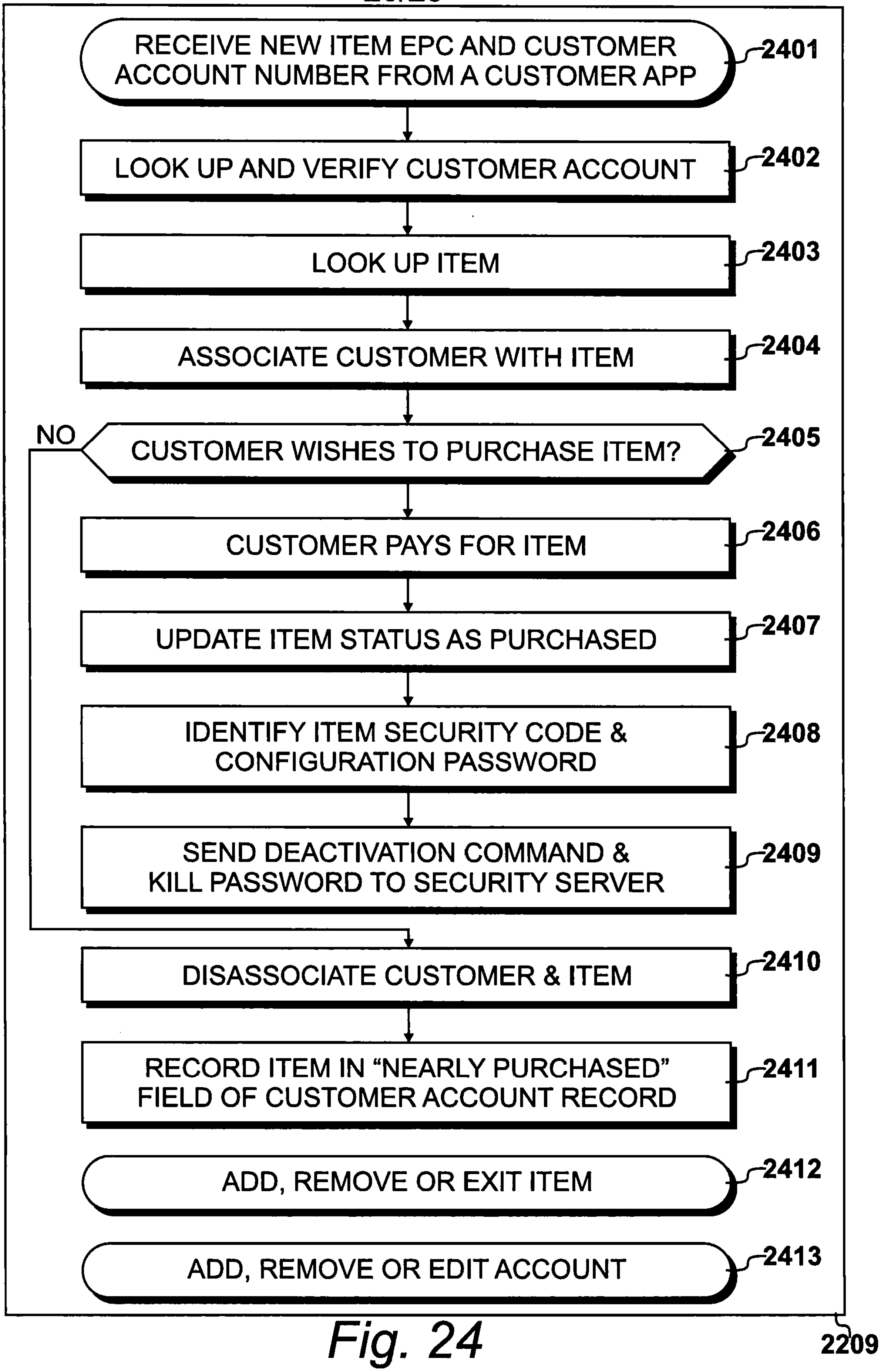
RECEIVE NEW ITEM EPC AND CUSTOMER ACCOUNT NUMBER FROM A CUSTOMER APP
2401
LOOK UP AND VERIFY CUSTOMER ACCOUNT
2402
LOOK UP ITEM
2403
ASSOCIATE CUSTOMER WITH ITEM
2404
NO
CUSTOMER WISHES TO PURCHASE ITEM?
2405
CUSTOMER PAYS FOR ITEM
2406
UPDATE ITEM STATUS AS PURCHASED
2407
IDENTIFY ITEM SECURITY CODE & CONFIGURATION PASSWORD
2408
SEND DEACTIVATION COMMAND & KILL PASSWORD TO SECURITY SERVER
2409
DISASSOCIATE CUSTOMER & ITEM
2410
RECORD ITEM IN “NEARLY PURCHASED” FIELD OF CUSTOMER ACCOUNT RECORD
2411
ADD, REMOVE OR EXIT ITEM
2412
ADD, REMOVE OR EDIT ACCOUNT
2413
2209

Fig. 24

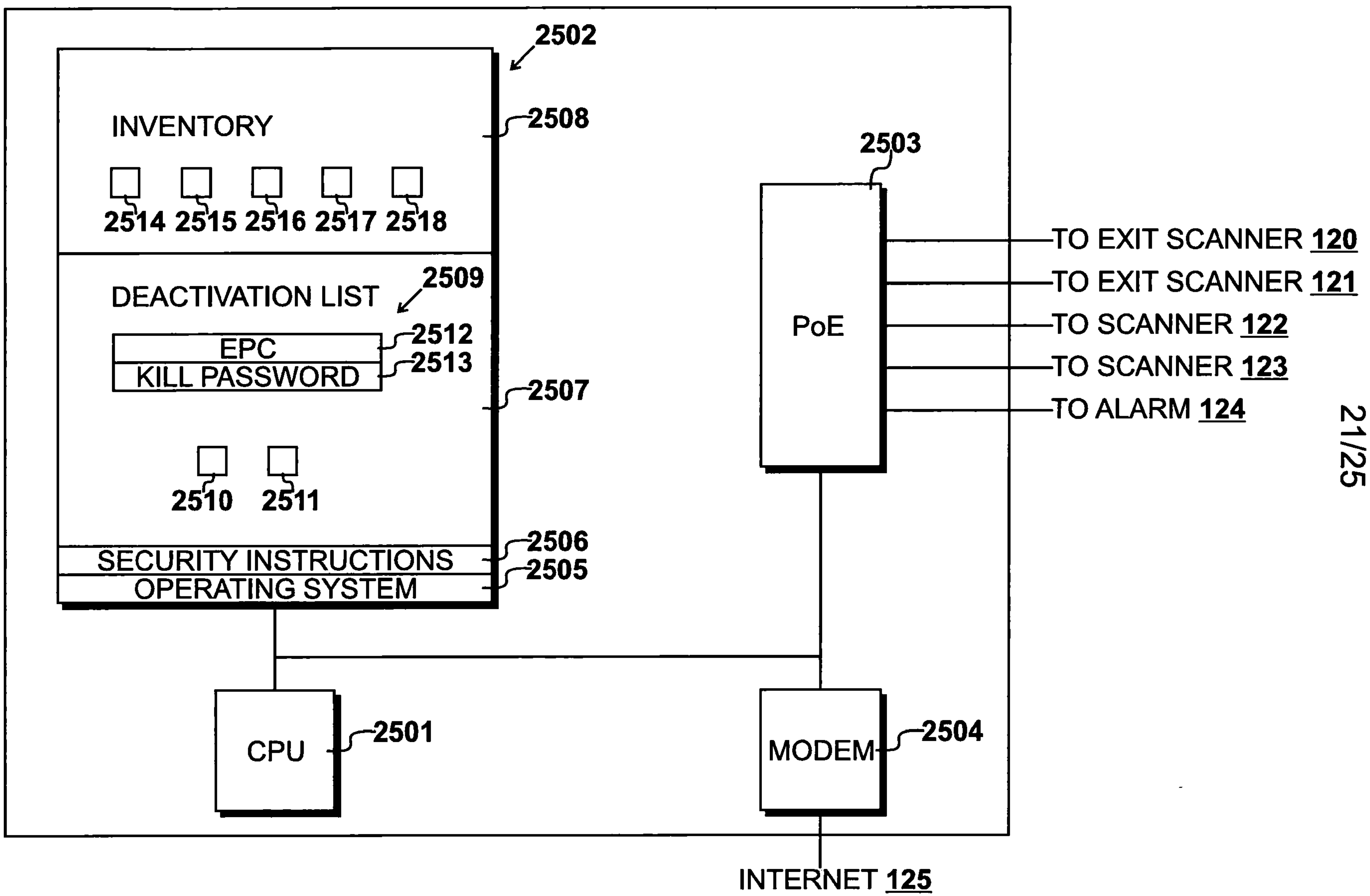
2502
INVENTORY
2508
2514 2515 2516 2517 2518
DEACTIVATION LIST
2509
EPC
KILL PASSWORD
2512
2513
2507
2510 2511
SECURITY INSTRUCTIONS
OPERATING SYSTEM
2506
2505
CPU
2501
PoE
2503
TO EXIT SCANNER 120
TO EXIT SCANNER 121
TO SCANNER 122
TO SCANNER 123
TO ALARM 124
MODEM
2504
INTERNET 125

Fig. 25

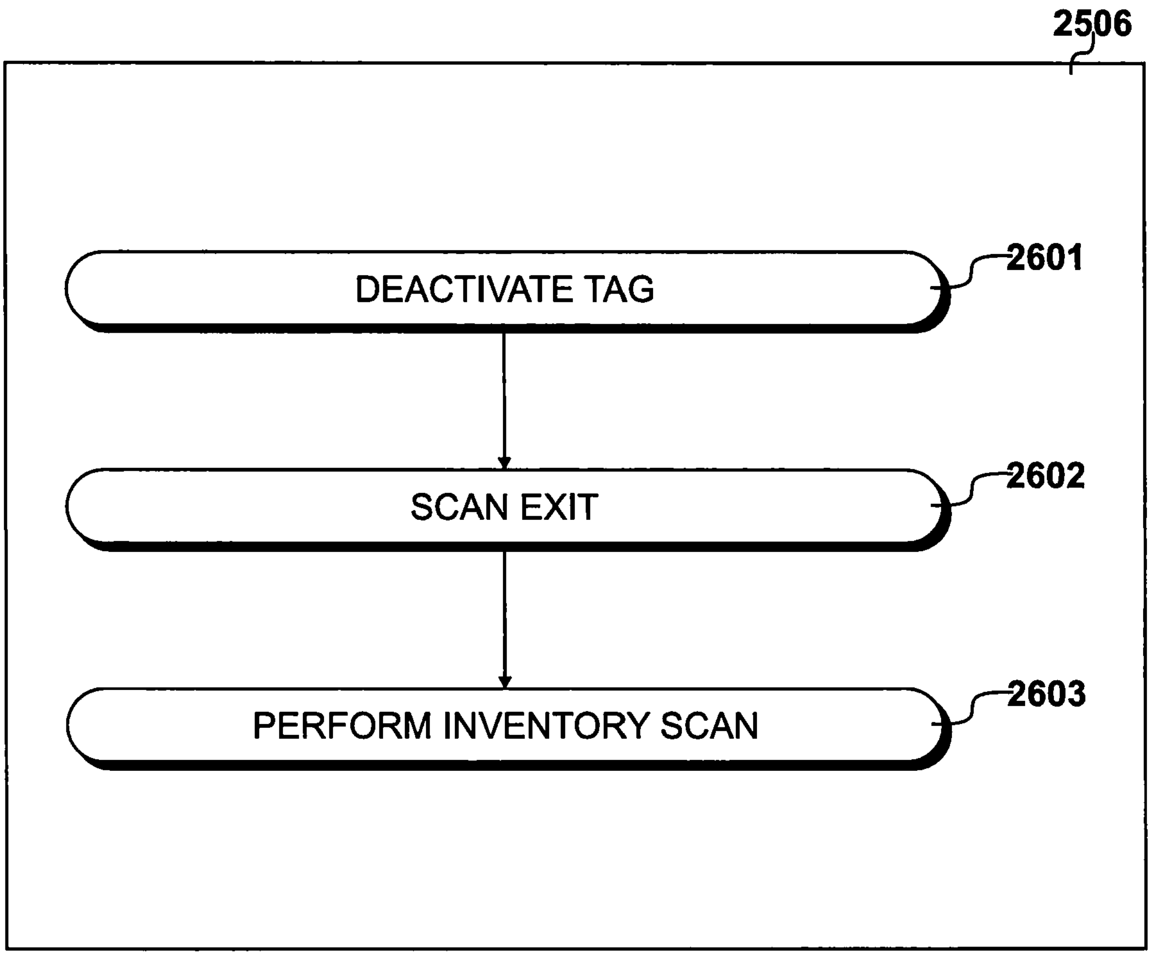
2506
DEACTIVATE TAG
2601
SCAN EXIT
2602
PERFORM INVENTORY SCAN
2603

Fig. 26

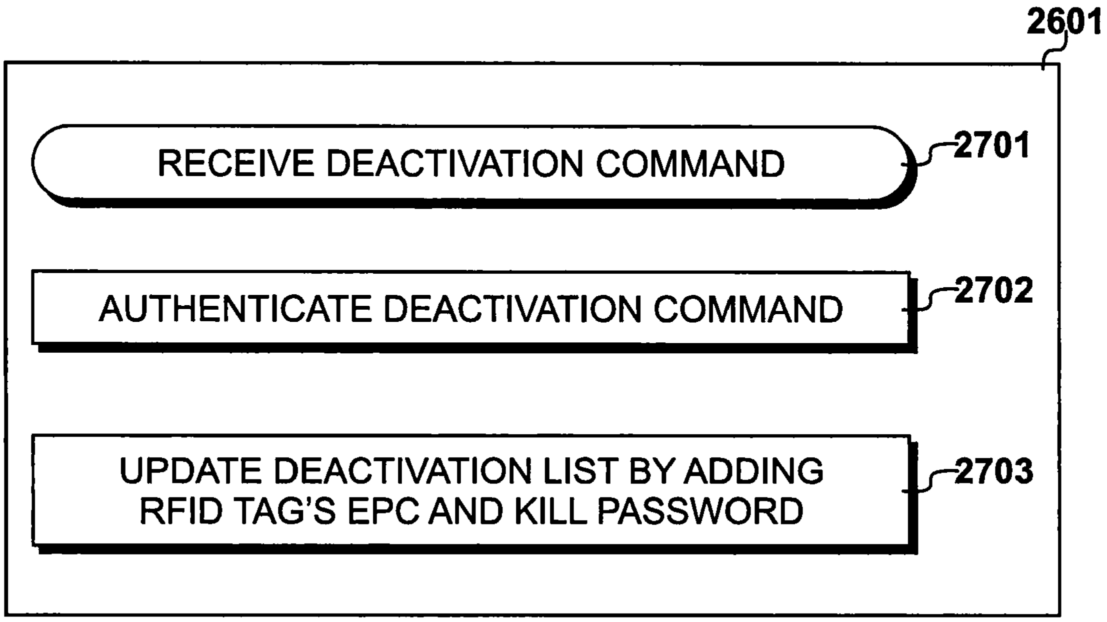
2601
RECEIVE DEACTIVATION COMMAND
2701
AUTHENTICATE DEACTIVATION COMMAND
2702
UPDATE DEACTIVATION LIST BY ADDING RFID TAG'S EPC AND KILL PASSWORD
2703

Fig. 27

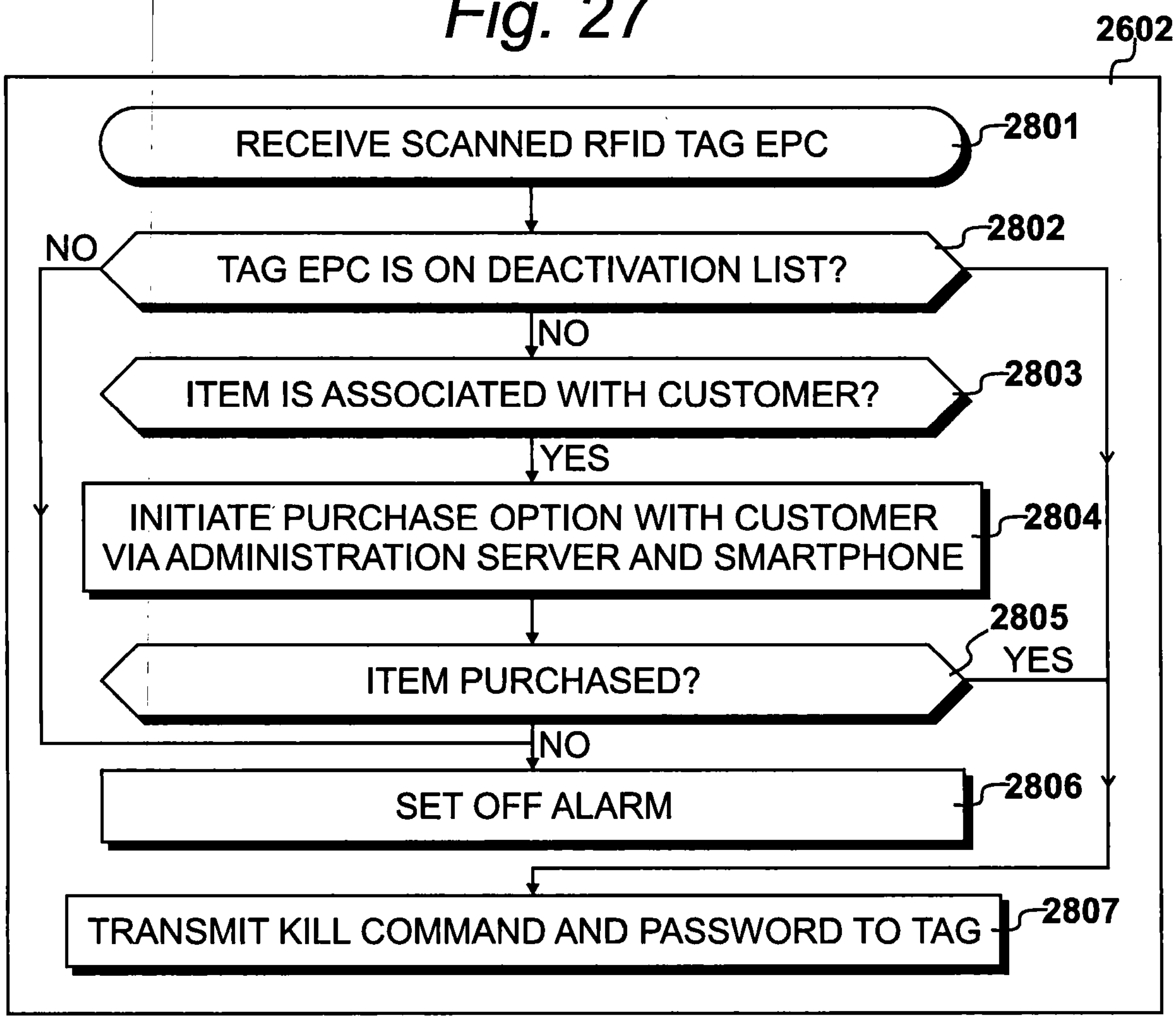
2602
RECEIVE SCANNED RFID TAG EPC
2801
TAG EPC IS ON DEACTIVATION LIST?
2802
NO
NO
ITEM IS ASSOCIATED WITH CUSTOMER?
2803
YES
INITIATE PURCHASE OPTION WITH CUSTOMER VIA ADMINISTRATION SERVER AND SMARTPHONE
2804
ITEM PURCHASED?
2805
YES
NO
SET OFF ALARM
2806
TRANSMIT KILL COMMAND AND PASSWORD TO TAG
2807

Fig. 28

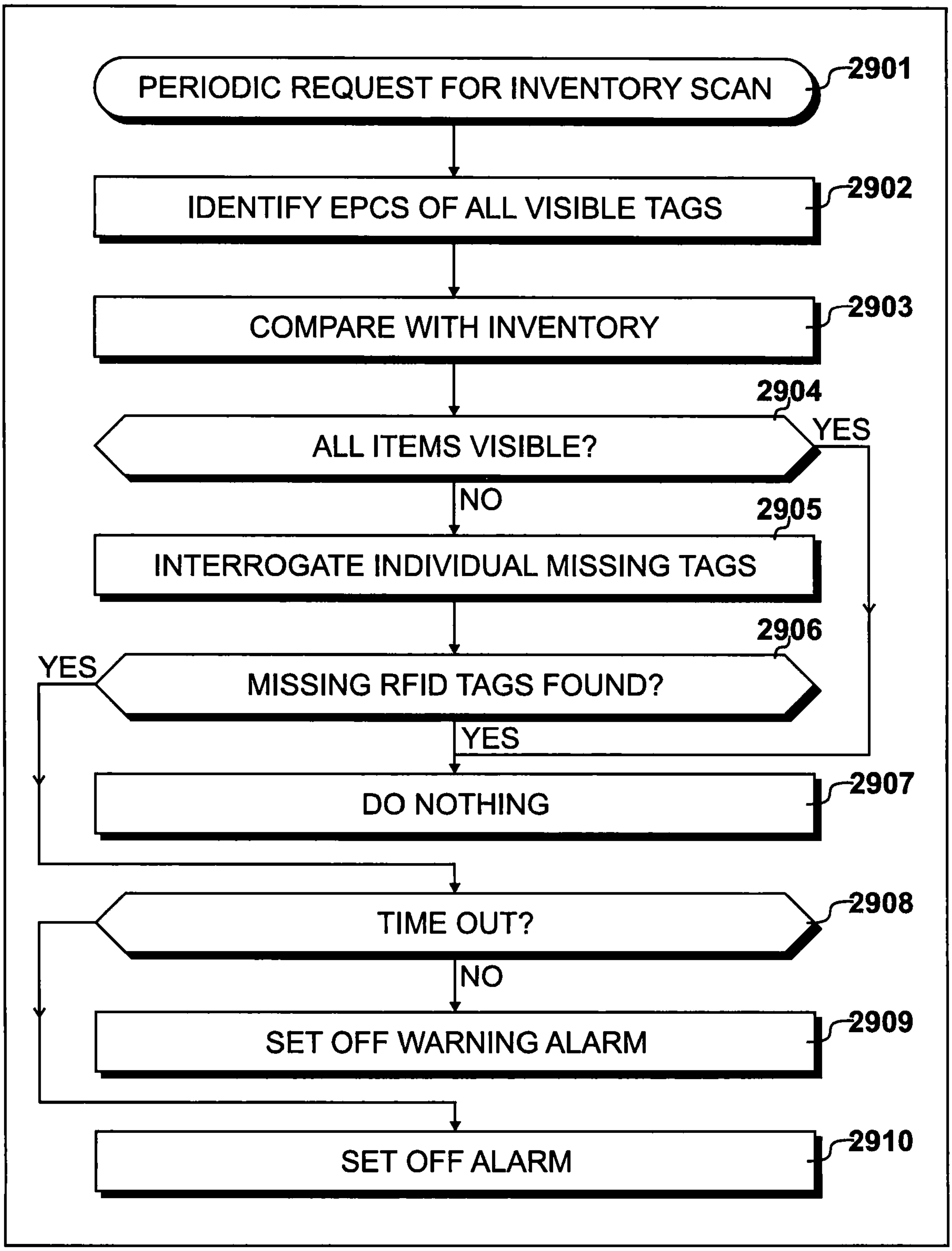
PERIODIC REQUEST FOR INVENTORY SCAN
2901
IDENTIFY EPCS OF ALL VISIBLE TAGS
2902
COMPARE WITH INVENTORY
2903
2904
ALL ITEMS VISIBLE?
YES
NO
2905
INTERROGATE INDIVIDUAL MISSING TAGS
2906
YES
MISSING RFID TAGS FOUND?
YES
DO NOTHING
2907
TIME OUT?
2908
NO
SET OFF WARNING ALARM
2909
SET OFF ALARM
2910

Fig. 29

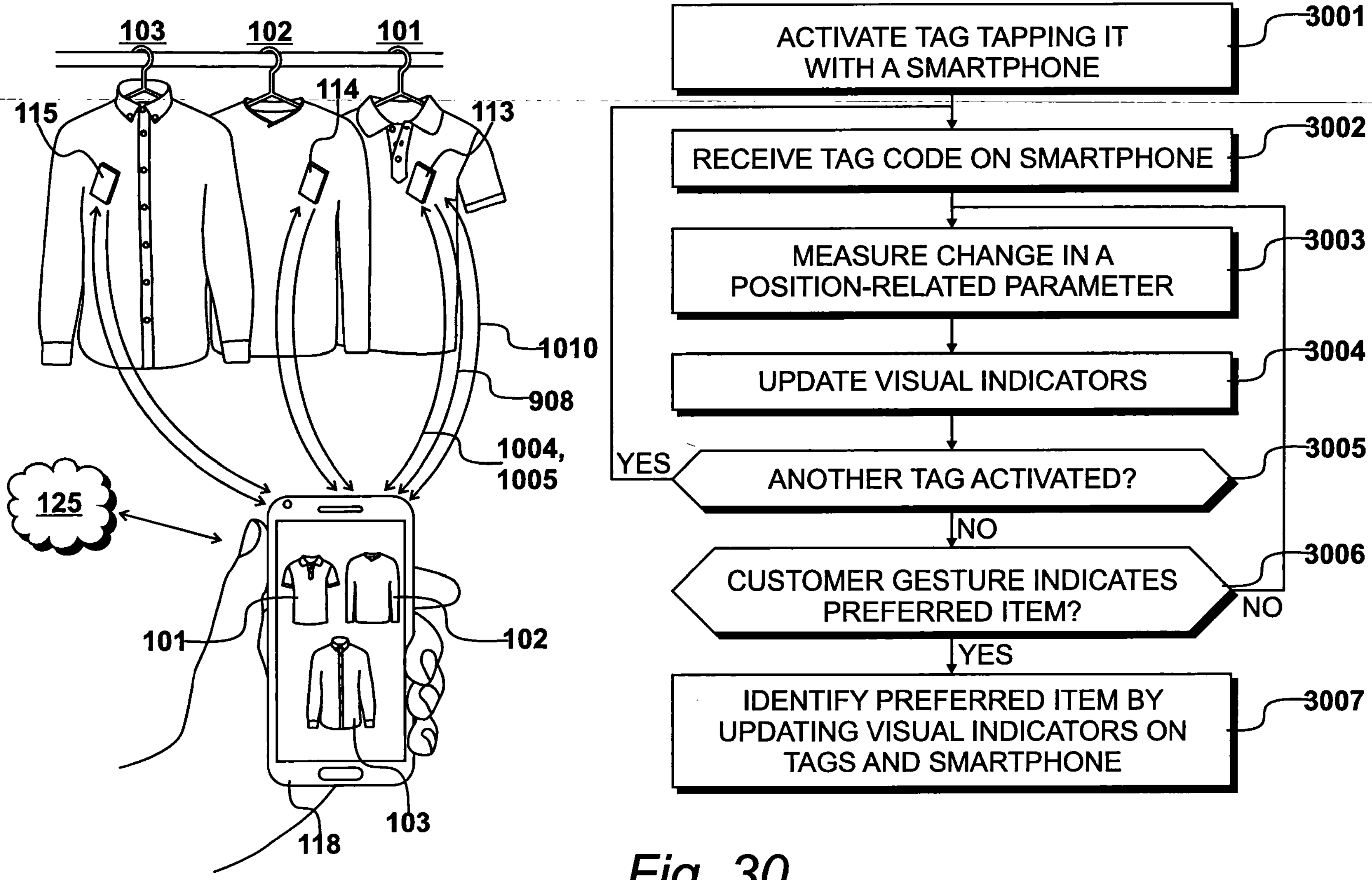
103
102
101
114
115
113
1010
908
1004,
1005
125
101
102
103
118
ACTIVATE TAG TAPPING IT WITH A SMARTPHONE
3001
RECEIVE TAG CODE ON SMARTPHONE
3002
MEASURE CHANGE IN A POSITION-RELATED PARAMETER
3003
UPDATE VISUAL INDICATORS
3004
ANOTHER TAG ACTIVATED?
3005
YES
NO
CUSTOMER GESTURE INDICATES PREFERRED ITEM?
3006
NO
YES
IDENTIFY PREFERRED ITEM BY UPDATING VISUAL INDICATORS ON TAGS AND SMARTPHONE
3007

Fig. 30

The following terms are registered trade marks and should be read as such wherever they occur in this document:

“Alien” – page 8
“Higgs” – page 8
“Nordic Semiconductor” – page 11
“Bluetooth” – pages 11, 14, 15, 16, 18, 37
“MBED” – page 14
“ARM” – page 18
“GSM” – page 18
“Android” – page 18
“Linux” – page 28
“Apache” – page 28

Security System for a Retail Environment

The present invention relates to a security system for deployment within a retail environment.

It is known to attach security tags to items of merchandise in retail environments. Traditionally, tags of this type are detected at an exit gate when an item has not been purchased.

Proposals have also been put forward for using security tags to assist with the actual purchasing of merchandise. Thus, a more sophisticated type of tag may be included that allows communication with a mobile phone that may in turn communicate with instore security systems for achieving an automated sale of the item. Further proposals have been put forward to the effect that the tag may automatically release when a sale has taken place. However, problems have been identified in terms of devising a tag that can be released easily when a sale has been made but at the same time achieves conventional security levels to prevent unauthorised removal. Further problems have been identified in that customers often express an initial interest in several items, not just one, and an appreciation has been made to the effect that, from a marketing perspective, it is useful to identify items that were nearly sold in addition to those that we actually sold.

A first aspect of the present invention provides a security system for deployment within a retail environment. The system facilitates the detection of unauthorised removal of items and in addition it facilities the automated sale of items which may then be removed without alerting the security system. To overcome problems associated with a single tag providing all of this functionality, a plurality of first tags, are provided with each being arranged to be concealed with an item of merchandise such that it is not visible to potential customers. The first tags are configured to transmit a first signal that is in turn modulated to specify a first tag code in response to being energized at an exit gate. Furthermore, second tags are provided and each second tag is independently attached to the items of merchandise at positions that are visible to potential customers. The second tags are configured to communicate with mobile devices to facilitate a purchase. Within the facility, a data communication apparatus is provided for communicating with mobile devices and controlling responses of the exit gate when detecting output signals from the first tags. The second tags are configured such that a user selects a tag which then transmits a second output signal modulated by a unique second code to a mobile device, in response to a user interaction. When a mobile device receives a second output signal, the mobile device relays the second code to the data communication apparatus. Upon receiving this code, the data communication apparatus initiates a procedure to facilitate a purchase of an item to which an interacted second tag has been attached, resulting in a sale being completed or a sale failing to be made. The data communication apparatus controls the exit gate so as not to be responsive to raise an alarm on detecting a respective first tag concealed within a purchased item. However, the exit gate will raise an alarm if a first concealed tag is detected when a respective second tag attached to the same item has not completed a sale.

The first tags may include radio frequency identification devices and in some applications, these devices may remain active after the item has been removed from the retail environment. In these circumstances, the device will have been detected at the exit gate but the communication apparatus is aware that the item has been purchased (based on receiving a second code) such that the alarm system is effectively disabled. However, in situations where concealed tags may create a privacy issue, it is possible for the communication device to control the exit gate in order to deactivate first concealed tags in items that have been purchased.

In a second aspect of the present invention, a security system is provided for deployment within a retail environment. The system includes a plurality of first tags for concealment within an item of merchandise for detection at an exit gate. In addition, there are provided a plurality of second tags, wherein each second tag is independently attached to an item and is configured to communicate with mobile devices to facilitate a purchase of an item via a mobile device. A data communication apparatus communicates with mobile devices and controls responses of the exit gate when detecting output signals from the first tags. A plurality of user selected second tags transmit second output signals to a mobile device in response to respective user interactions, where each second output signal is modulated by a unique second code. The mobile device relays the received second codes to the communication system and the data communication system returns product data for the plurality of selected tags. Each product data includes a graphical representation of each selected item. The mobile device is configured to dynamically display each of these graphical representations of selected items. In addition, the mobile device dynamically positions the graphical representations in response to positional data identifying a relative position of each of the selected item to the mobile device. The mobile device is then configured to further communicate with the communication system to initiate a sale of a preferred item chosen from the displayed selected items.

In an embodiment, the positional data is derived from an evaluation of signal strengths of respective second output signals.

The invention will now be described by way of example only with reference to the accompanying drawings, of which:

Figure 1 shows a retail environment, including tagged items having a first type of tag and a second type of tag, a customer's mobile device, an security server, an administration server and a payments server;

Figure 2 details the first type of tag shown in Figure 1;

Figure 3 shows a schematic of the tag shown in Figure 2;

Figure 4 shows a view of the second type of tag shown in Figure 1;

Figure 5 shows another view of the second type of tag shown in Figure 1;

Figure 6 shows a schematic of the second type of tag shown in Figure 1, including a memory;

Figure 7 shows an alternative schematic of the second type of tag shown in Figure 1;

Figure 8 details the contents of the tag memory shown in Figure 6, including tag instructions;

Figure 9 details the tag instructions shown in Figure 8, including a step of tag selection processing;

Figure 10 details the step of tag selection processing shown in Figure 9, including a step of associating with a mobile device;

Figure 11 details the step of associating with a mobile device shown in Figure 10;

Figure 12 details components of the customer's mobile device shown in Figure 1, including a physical browser app, an active list of connected tags and a touchscreen;

Figure 13 details steps performed by the physical browser app shown in Figure 12, including a step of processing an active list of connected tags;

Figure 14 details the active list of connected tags shown in Figure 12;

Figure 15 details the step of processing an active list of connected tags, shown in Figure 13, including a step of updating the touchscreen shown in Figure 12 and a step of processing association gestures;

Figure 16 shows the effect of the step of updating the touchscreen shown in Figure 15;

Figure 17 shows another effect of the step of updating the touchscreen shown in Figure 15;

Figure 18 shows a further effect of the step of updating the touchscreen shown in Figure 15;

Figure 19 details the step of processing association gestures shown in Figure 15, including a step of purchase processing;

Figure 20 details the step of purchase processing shown in Figure 19;

Figure 21 details components of the administration server shown in Figure 1, including a server unit memory;

Figure 22 shows steps performed to initialise the administration server shown in Figure 21, including a step of running administration instructions;

Figure 23 details the server unit memory shown in Figure 21;

Figure 24 details the step of running administration instructions shown in Figure 22;

Figure 25 shows components of the security server shown in Figure 1, including security instructions;

Figure 26 details the security instructions shown in Figure 25, including a process of deactivating a tag, a process of scanning exits, and a process of performing an inventory scan;

Figure 27 details the process of deactivating a tag shown in Figure 26;

Figure 28 details the process of scanning exits shown in Figure 26;

Figure 29 details the process of performing an inventory scan shown in Figure 26; and

Figure 30 summarises operations performed with the mobile device shown in Figure 1.

Figure 1

A retail environment is shown in Figure 1. Several physical items **101** to **105** are on display to customers **106** and **107**. The retail environment is a part of a clothing store, and the items **101** to **105** are items of apparel. The first physical item **101** includes a first type of tag **108** embedded within it. The second item **102** also includes a first type of tag **109** embedded within it. Items **103**, **104** and **105** also include a first type of tag **110**, **111** and **112** respectively. The first physical item **101** also includes a second type of tag **113** visibly attached to it. Similarly, items **102** to **105** include a second type of tag **114**, **115**, **116** and **117** respectively. Tags **108** to **112** of the first kind will be referred to as first tags, and tags **113** to **117** of the second kind will be referred to as second tags. Thus each physical item on sale in the retail environment of Figure 1 has a first tag and second tag attached to it.

The first tags **108** to **112** are retained within the respective physical item, and cannot be easily removed. The second tags, **113** to **117** are highly visible and can be removed by a customer when appropriate. The first customer **108** has a mobile device **118** which is used to facilitate browsing of the items **101** to **105**, followed by an optional purchase. The mobile device **118** is a smartphone **118**, although other types of mobile device may be used, including a mobile device specifically designed for the purpose. However, the availability of low cost smartphones makes these the preferred mobile device for use in this environment.

The second customer **107** also has a smartphone **119**, which is used similarly. It will be appreciated that a typical retail environment may include hundreds or thousands of physical items tagged as described.

The retail environment includes a security system **119** to **124**, comprising a security server **119** connected to a first exit scanner **120** and a second exit scanner **121**. Exit scanners **120** and **121** scan exits of the retail environment, identifying the presence of any first tags **108** to **112**. This enables identification of the presence of items **101** to **105** near an exit. The scanner may also be able to determine direction of movement of a first tag **108**, so that movement of an item **101** out of the retail environment can be identified. The security server **119** is further connected to inventory scanners **122** and **123**, which identify the presence and approximate location of items **101** to **105** in the retail environment. The inventory scanners **122** and **123** make it possible to perform stock-taking and checking, and to identify movements of items prior to purchase. An alarm **124** is activated if an unusual movement or disappearance of the respective item is observed, or if an item **101** is taken past an exit scanner **120** or **121** prior to purchase.

In order to disable the exit alarm **124** for an item **101** to **105**, it is necessary for a customer **106** or **107** to purchase the item **101**. Operation of the system will be described by way of example. The customer **106** activates an app on the smartphone **118** to facilitate item browsing. In an embodiment, the app may be activated automatically to run in the background, for example as a component of a payment application or other retail environment application.

The customer **106** then finds an item **101** to be of interest, and taps the smartphone **118** lightly against the second tag **113** of the first item **101**. The second tag **113**, now activated, communicates with the smartphone **118**. The tag's communication includes transmission of a second tag code, which is then transmitted from the smartphone **118**, via the Internet **125**, to an administration server **126**. The administration server **126** then looks up information about the item **101**, and transmits this item-related information back to the smartphone **118**, for display to the customer **106**. During communication between a tag **113** and the customer's mobile device **118**, a position-related parameter is measured. An example of such parameter to measure is the Received Signal Strength Indication (RSSI) of wireless signal. This position-related parameter is then used to update a visible indicator on each activated tag and the touchscreen of the mobile device **118**, thereby facilitating real time visible update in response to movement of the customer's mobile device **118**.

Subsequently, the customer indicates a preferred item by making an association gesture. As a result of this gesture, the customer **106** becomes associated with the item **101**, and can now pay for the item using their smartphone if they wish. During payment, the administration server **126** directs smartphone communications to a payments server **127**. After a successful payment has been made, the administration server **126** transmits identifying information for the first tag **108** to the security server **119**. The security server then disables alarms for the first tag **108**, so that the customer may exit the retail environment without activating the alarm **124**. Furthermore, upon exit with a purchased item **101**, the first tag **108** is permanently disabled by a transmission from an exit scanner **120** or **121**, thereby alleviating customer concerns about tracking outside the retail environment. The customer may easily remove the second tag **113** from the item **101**, and place it in a bin located in the retail environment. The customer may be given a discount if the second tag **113** is returned to the retail environment.

The first tag **108** facilitates inventory and theft-prevention. For example, the second tag **113** could be removed prior to purchase, but the item **101** retains the first tag **108**, preventing it from being removed from the retail environment without setting off the alarm **124**.

The second tags **113** to **117** enable purchases to be made, by acting as a bridge between customers' mobile devices **118** and **119** and the first tags **108** to **112** which are used for item identification by the security system **119** to **124**. The second tags **113** to **117** are removable and reusable.

Figure 2

The first tag **108** shown in Figure 1 is detailed in Figure 2. The following description applies to the structure and functionality of the other first tags **109** to **112** of Figure 1. In this example, first tag **108** is a passive RFID tag operating at a range of frequencies between **865**MHz and **928**MHz in the Industrial, Scientific and Medical (ISM) band. A suitable tag of the kind shown in Figure 2 is the ALN-**9710** available from Alien Technology Corporation, **18220** Butterfield Blvd., Morgan Hill, CA **95037**, USA. The tag **108** comprises a flexible plastic substrate **201**, upon which are printed a conductive ink pattern forming a resonant inductor **202**, a first tuned antenna **203** and a second tuned antenna **204**. Connections are made between the resonant inductor **202** and a Higgs™ 4 RFID chip **205**, which is also available from Alien Technology™ at the aforementioned address. The RFID chip **205** is approximately 0.5mm by 0.5mm in area, and 0.1mm thick, making it possible to mount the chip on a flexible substrate while maintaining a consistent electrical connection to the resonant inductor **205**. The overall size of the RFID tag **108** is 45mm by 15mm. It is designed to be retained within an item, such as an item of apparel **101**, and is cheap enough to be retained within the item, even after purchase. For example, the RFID tag **108** may be retained within the lining, seam or label of the item **101**.

Figure 3

A schematic representation of the RFID tag **108** detailed in Figure

2 is shown in Figure 3. The RFID chip **205** includes a radio-frequency (RF) transceiver and power supply **301** connected to two antennas **203** and **204** via the resonant inductor **202**. The RF transceiver and power supply **301** derives power from transmissions from the scanners **120**, **121**, **123** or **124** shown in Figure 1, and facilitates reception of commands from a scanner, and transmission of data to a scanner using modulated backscatter in accordance with ISO-**18000**-6C, available from http://www.iso.org.

Commands received by radio transmissions from a scanner **120** to **123** are interpreted by a control logic circuit **302** enabling reading and, in some cases, writing of the RFID chip non-volatile registers. These include a **128**-bit Electronic Product Code (EPC) **303**, configuration bits **304**, a 32-bit access password **305** and a 32-bit kill password **306**. The EPC is a code that includes two parts: a first part describing the type of product, known as the Global Trade Item Number (GTIN), and a second part which is a unique serial number, different on every RFID chip and therefore unique to each item tagged with such a chip. In combination, these two parts are known as a Serialised GTIN, or SGTIN, and are unified according to the EPC Tag Data Standard, available at www.gs1.org/epc/tds. The EPC is associated with the item **101** in which the first tag **108** is embedded; and this association information is available to the administration server **126**.

The configuration bits **304** determine operation of the chip. The access password **305** makes it possible to limit interactions with the RFID chip unless a scanner correctly supplies a matching password. The kill password **306** makes it possible for a scanner, such as the exit scanner **120**, to permanently disable the RFID chip **108**, by sending a kill command followed by the kill password to the RFID tag **108**. The passwords **305** and **306** are stored securely on the administration server **126** shown in Figure 1, and are only transmitted to the security server **119** after the item **101** has been purchased.

Communication with the RFID tag **108** is possible over distances of up to ten meters from the scanners **120** to **123**. Systems are known in which the distance between a scanner **120** and a passive RFID tag **108** can be roughly estimated. A first known method uses the received signal strength (RSS) of the backscatter modulation from the RFID tag **108** to estimate distance. Such a method has a typical accuracy of about one meter, but is subject to variations in the alignment of the RFID tag, multi-path reflections and occlusions. Improved accuracy is obtained using spread spectrum techniques with widely available low cost UHF RFID tags **108** to **112**, as described in "Spread-Spectrum Based Ranging of Passive UHF EPC RFID Tags" by Holger Arthaber et al. in IEEE Communications Letters, Vol. 19, No. 10, October **2015**. Using the spread-spectrum method, distances can be more consistently estimated to an accuracy of about twenty-five centimetres. Ranging accuracy of one centimetre or less is possible using a hybrid Ultra Wide Band (UWB) UHF RFID tag as described in "Hybrid UHF/UWB Antenna for Passive Indoor Identification and Localization Systems" by Catarina C. Cruz et al, in IEEE Transactions on Antennas and Propagation, Vol. 61, No. 1, January **2013**.

Such ranging methods enable systems as shown in Figure 1 to identify first tag distances from scanners. Furthermore, the use of multiple scanners **120**, **121**, **123** and **124**, facilitates localization of passive tags **108** to **112** in two or three dimensions, thereby making it possible to fully identify locations of items **101** to **105** in the retail environment, and obtain an inventory of them. It will be appreciated that RFID systems may become capable of higher spatial resolution than those currently commercially available, and the costs of such systems are likely to decrease.

Figure 4

A problem with the RFID tags **108** to **112** shown in Figure 1 and detailed in Figures 2 and 3, is that a standard smartphone **118** or **119** is unable to communicate directly with them. Therefore, there is no possibility of using an unmodified smartphone **118** as a point-of-sale (POS) device in an existing retail environment where items are equipped with passive RFID tags. This is unfortunate, as RFID tags are increasingly being used for the purposes of stock-taking, inventory management and theft-prevention.

The second type of tag **113** shown in Figure 1 is detailed in Figure 4. The tag **113** comprises a U-shaped plastic shell **401** having an upper section **402** and a lower section **403**, between which part of the physical item **101** is located. The upper section **402** includes a release button **404** which is used to manually release the second tag **113** from the item **101** after it has been purchased. The upper section **402** also includes a visual indicator **405** which provides visual indications to the customer **106** during communications between the smartphone **118** and the second tag **113**, thereby facilitating interactions between the customer **106** and the second tag **113**.

Figure 5

The second tag **113** shown in Figure 4 is shown in cross-section in Figure 5. In this view a retention pin **501** can be seen, which passes through part of the item **101**. Activation of the release button **404** results in retraction of the retention pin **501** so that the item **101** can be separated from the tag **113** without damage to either. It is possible for a customer to remove the tag **113** prior to purchase of the item **101**. However, the customer will not be able to remove the item **101** from the retail environment without activating the alarm **124**, due to the presence of the first tag **108**, which is retained in the item **101**. The first tag **108** is detectable by an exit scanner **120** or **121**, resulting in activation of the alarm **124** upon detection of items that have not been purchased.

Figure 6

The electronic components of the second tag **113** are shown schematically in Figure 6. A nRF**52832** microcontroller **601** provides the majority of the circuitry. The nRF**52832** is available from Nordic Semiconductor ASA, P.O. Box **436**, Skøyen, **0213** Oslo, Norway. The microcontroller **601** includes a Central Processing Unit (CPU) **602**, memory **603**, a Bluetooth™ Low Energy (BLE) transceiver **604** and a power regulation and management circuit **605**. The second tag **113** is powered by a 3.7V Lithium Ion coin cell **606**.

The visual indicator **405** comprises a red Light-Emitting Diode (LED) **607**, a green LED **608** and a blue LED **609**. The LEDs **607** to **609** can be driven by the microcontroller **601** with a variable pulse width ratio, thereby obtaining any colour in the RGB gamut. The microcontroller's BLE circuit **604** is connected to an antenna **610**, which facilitates transmission and reception with other BLE-equipped devices, including the smartphones **118** and **119** shown in Figure 1.

A piezo-electric transducer **611** generates a brief alternating high voltage whenever an impact is imparted to the case **401** of the second tag **113**, for example, an impact by a user's smartphone **118**. This high voltage is limited by diodes **612** and **613** to prevent damage to the microcontroller **601**. The limited piezo-electric signal is supplied to an input/output (I/O) pin **614** on the microcontroller **601**, thereby providing a wake-up activation signal for the microcontroller **601**. The microcontroller **601** is configured such that it normally consumes negligible power and is effectively switched off most of the time. When activated by the piezo-electric signal on the I/O pin **614**, the microcontroller **601** starts operating, and initialises circuits, including internal oscillator circuits and the BLE circuit **604**, for operation. Thereafter it executes microcontroller instructions.

After a while, depending upon interactions with a smartphone **118** or **119**, the microcontroller **601** switches off again, until another impact occurs. In this way, the circuit of the second tag, as shown in Figure 6, consumes negligible power until a user physically interacts with it. It will be appreciated that known BLE circuits are operated as continuously active BLE beacons, whereas the tag of Figure 6 operates in a fundamentally different way. The tag **113** only becomes active for a limited time following a physical interaction. In an embodiment, an alternative physical interaction sensor may be used in a similar way to activate the tag.

The release pin **501** shown in Figure 5 is connected to the microcontroller **601** in a normally-on configuration. The release pin **501** illustrates a simple, low-cost method of detecting removal of the second tag **113**. When the release button **404** is pressed, the pin **501** breaks its connection temporarily, resulting in activation of the microcontroller **601** such that it can determine that a tag release has occurred or been attempted. If the release was not authorised as a result of payment for an item, various appropriate actions can be taken, including, but not limited to, activation of the piezo transducer **611** as an alarm, and a BLE broadcast transmission of an alarm signal. While advantageous in drawing attention to unauthorised removal of second tags, such alarms are not required for theft-prevention, due to the presence of the first type of tag **108**, which is retained within the physical item **101**.

An Inertial Measurement Unit (IMU) **615** provides monitoring of acceleration and rotation of the tag **113**, so that gestures and other movements made with the tag can be detected. A quartz crystal **616** provides a stable frequency reference for the BLE transceiver **604** and instruction sequencing and timing of the CPU **602**. Additional components such as decoupling capacitors, additional timing reference crystals and so on, are omitted, as these are standard components and are known in the art.

Figure 7

An alternative embodiment of the tag schematic shown in Figure 6 is shown in Figure 7. In the alternative circuit, the visual indicator **405** comprises a graphical display module utilising Electronic Ink (E-ink). Information about the item **101** can be displayed on the graphical display module **405**, including pricing and so on. A known advantage of E-ink is that it consumes very little power, and information remains on display even when power consumption is reduced to almost zero, thereby making such a solution suitable for an embodiment of the second tag **113**, as indicated in the schematic of Figure 7.

Figure 8

The functionality of the microcontroller **601** shown in Figure 6 is largely determined by the contents of its memory **603**, which are summarised in Figure 8. The microcontroller memory **603** comprises two types: volatile static memory and non-volatile flash memory. However, in practice the volatile memory contents may often be considered as recently cached contents of flash memory, and it is sometimes helpful to ignore the distinction between these two types of memory for the purposes of clarity. It will be appreciated that instructions for the microcontroller are generally stored in flash memory, and loaded into static memory in small recently accessed chunks, to provide the most efficient usage of the available silicon.

An MBED™ Operating System (OS) **801** provides hardware abstraction and basic event management suitable for an embedded microcontroller. The MBED OS is available for download at https://github.com/ARMmbed/mbed-os. Bluetooth Low Energy (BLE) instructions **802** facilitate bidirectional wireless data communications between the second type of tag **113** and other BLE-equipped devices. Tag instructions **803** facilitate operation of the second type of tag **113** in order to communicate and interact with customers' smartphones **118** and **119**.

Data in the tag memory **603** includes security keys **804**, for maintaining secure communications over a BLE wireless connection. Tag data includes a tag identity code (TAG_ID) **805**, a Received Signal Strength Indication (RSSI) field **806**, and a relative Received Signal Strength Indication (REL_RSSI) field **807**. Reference IMU data **808** includes data derived from the Inertial Measurement Unit (IMU) **615** shown in Figure 6, including orientation derived from static acceleration due to gravity, and other data that defines the orientation, acceleration and/or position of the tag at the moment of activation. Orientation data **809** describes the current orientation of the tag **113**. Position data **810** describes the current position of the tag **113**, if known. Other data **811** includes temporary data used by the microcontroller **601**.

Figure 9

Details of the tag instructions **803** shown in Figure 8 are shown in Figure 9. At step **901** a piezo-electric signal is received on the I/O pin **614** shown in Figure 6, resulting in an activation signal **614** being supplied to the microcontroller **601**. The activation signal typically results from a mutual impact between a customer's smartphone **118** and the second tag **113**. This deliberate mutual impact occurs when the smartphone **118** is lightly tapped against the second tag **113**. At this point, it remains to be determined whether or not the impact was a mutual impact with the smartphone **118** or simply an accidental impact that can be ignored.

At step **902** the reference IMU data **808** of the tag **113** is updated by acquiring data from the IMU **615**. IMU data includes acceleration data due to static and or dynamic acceleration of the tag **113**, as well as rotation data measured by one or more gyroscopes in the IMU **615**.

At step **903** the visual indicator **405** is made to flash so that the customer **106** is able to see that the second tag **113** has been successfully activated. Simultaneously, the BLE module **604** is instructed to start transmitting advertising packets, thereby making the tag **113** connectible to the smartphone **118**. The advertising packets include identification data such that the smartphone will recognise the tag as being a tag of the second type **113**, and that it supports the operations to be described below. In an embodiment, the advertising data may include the TAG_ID **805**.

At step **904** a question is asked as to whether a valid Bluetooth connection request has been received from a smartphone **118** or **119**. If so, control is directed to steps **907** onwards, to establish a connection. Alternatively, a question is asked at step **905** as to whether a timeout has occurred. The timeout at step **905** is half a second, as a connection request from a smartphone **118** should be received as soon as it receives an advertising packet from the tag **113**. Steps **904** and **905** repeat until either a valid connection request is received or a timeout occurs. In the event of a timeout, control is directed to step **906**, where the microcontroller **601** is returned to a sleep state, thereby consuming very little power until another activation signal is generated by the piezo transducer **611**.

At step **907** a connection is made with the smartphone **118** and at step **908** the TAG_ID **805** is transmitted to the smartphone **118**. At step **909,** tag selection processing is performed. It will be appreciated that, as a result of the steps of Figure 9 being performed more than once, more than one second tag **113**, **114** can be connected to the smartphone **118** at any particular time.

Figure 10

The step **909** of performing tag selection processing shown in Figure 9, is detailed in Figure 10. At step **1001** new acceleration and rotation data is obtained from the IMU **615**. At step **1002** the new IMU data is processed to update the current orientation **809** and, if available, current position data **810**. These are processed with the reference IMU data **808** in order to identify relative movement of the tag **113**. The resulting movement data is transmitted to the smartphone **118** at step **1003**.

At step **1004**, the RSSI of the smartphone's Bluetooth signal is obtained from the BLE circuit **604** and the RSSI field **806** is updated. The RSSI value is then transmitted to the smartphone **118**. It will be appreciated that measurement and transmission of RSSI data can be performed out of sequence in response to a request by the smartphone **118**.

At step **1005**, relative RSSI data is received from the smartphone **118** and the REL_RSSI field **807** is updated. At step **1006** the tag's visual indicator **405** is set in response to the updated REL_RSSI field **807**. As a result, the visual indicator **405** generates its visual indication in response to changes in a relative RSSI value calculated by the smartphone **118**, rather than a specific RSSI relating solely to the wireless connection between the connected tag **113** and the smartphone **118**.

This has significance when the smartphone **118** is connected to more than one tag, such as tags **113** and **114**. When more than one secondary tag **113**, **114** has been connected to the smartphone **118**, movement of the smartphone **118** between the two tags **113**, **114** results in a clearer indication from their respective visual indicators **405** than would be the case if absolute or normalised RSSI **806** alone were used. The relative proximity of the smartphone **118** is indicated by the level of brightness of LEDs **405**, thus aiding the interaction with the customer. This improves clarity of identification of a particular tag in relation to others that have been activated, and thereby makes selection of an individual tag more intuitive.

At step **1007** a question is asked as to whether an association request has been received from the connected smartphone **118**. If not, control is directed to step **1008**, where a timeout of one minute is applied. If a timeout has not occurred, control is directed back to step **1001**. Alternatively, in the event of a timeout, or if the smartphone **118** has moved too far away, the microcontroller **601** is returned to a low power sleep state at step **1009**. Alternatively, if an association request has been received, control is directed to step **1010**, where the tag **113** is associated with the connected smartphone **118**. It will be appreciated that the association is a specific state which occurs as a result of a specific deliberate intent by the customer **106** showing interest in a particular item **106**. Furthermore, it is possible for a customer to be associated with more than one item at any one time.

Figure 11

The step **1010** of associating the tag **113** with the smartphone **118**, shown in Figure 10, is detailed in Figure 11. At step **1101** the association request received at step **1107** is validated. Validation includes receiving a digital signature from the smartphone **118** that authenticates an association. At step **1102** a question is asked as to whether validation has been successful. If not, the BLE connection to the smartphone **118** is broken at step **1103**, and at step **1104** the microcontroller is returned to a low power sleep state.

Alternatively, in response to a successful validation, control is directed to step **1105**, where the visual indicator **405** is updated to indicate the associated state by lighting the green LED **608**. Subsequent steps **1106** to **1109** are repeated in a loop until various exit conditions occur. At step **1106** a question is asked as to whether the tag **113** has been removed from the physical item **101**. This condition is detected by the conduction state of the retention pin **501**. If the pin **501** is open circuit, the tag has been removed or an attempt has been made to remove it and control is directed to step **1107**, where a tag removed event is transmitted to the smartphone **118**. Alternatively, this step is skipped. At step **1109** a question is asked as to whether the smartphone has disconnected from the tag **113**. If not, control is directed back to step **1106**. Alternatively, the microcontroller **601** is returned to a low power sleep state at step **1110**.

Figure 12

A schematic representation of the smartphone **118** shown in Figure 1 is detailed in Figure 12. A quad core 64-bit ARM Central Processor Unit (CPU) **1201** is connected with a GSM voice and data telephony module **1202**. The CPU **1201** is further connected to a Bluetooth wireless module **1203**, capable of communications in accordance with Bluetooth version 4.2, which includes Bluetooth Low Energy (BLE). A touchscreen **1205** provides the primary means by which the customer **106** interacts with the smartphone **118**. The CPU **1201** is also connected to memory **1206**, cameras **1207**, buttons **1208**, microphones **1209**, an Inertial Measurement Unit (IMU) **1210**, loudspeakers **1211** and a vibrator **1212**.

For simplicity in the following explanation, the memory **1206**, as before, is shown without distinction between volatile and non-volatile types. The memory **1206** includes instructions **1213** to **1216**, including an Android™ operating system **1213**, a physical browser app **1214**, a web browser **1215** and other apps **1216**. The instructions **1213** to **1216** are executed by the CPU **1201** in order to define the operations of the smartphone **118**.

The memory **1206** also includes data **1217** to **1223**, including an active list of connected tags **1217**, customer account data **1218** relating to the customer **106**, reference IMU data **1219**, orientation **1220**, position **1221**. The orientation **1220** and the position **1221** are considered to be position-related parameters. A 3D model **1222** describes relative locations of second tags **113** to **117**, and other data **1223** is used by the CPU **1201** to perform intermediate calculations.

Figure 13

The physical browser app instructions **1214**, shown in Figure 12, are detailed in Figure 13. During normal use of the smartphone **118**, the physical browser app **1214** remains in memory **1206** without affecting other functions of the smartphone **118**, such as making and receiving phone calls, browsing the Internet and running other apps **1216**.

When the smartphone **118** is tapped against an object, such as the second tag **113**, signals from its microphones **1209** and Inertial Measurement Unit (IMU) **1210** are analysed to determine whether it is possible that the smartphone has been tapped against a tag. If such a possibility is judged to exist, the physical browser app **1214** is woken up at step **1301**.

At step **1302**, IMU data is obtained from the IMU **1210** and stored as reference IMU data **1219**. At step **1303** a question is asked as to whether a nearby tag **113** is advertising. If not, steps **1304** to **1307** are skipped and control is directed to step **1308**. Alternatively, if an advertising signal is detected from a tag **113**, at step **1304** a BLE connection is made with the tag **113**. At step **1305** the TAG_ID **805** is received from the tag **113**. This may take the form of a Universally Unique Identifier or similar number unique to the second tag **113**. In an embodiment, this may alternatively comprise or be derived from the EPC **303** of the first tag **108** retained within the item **101**. In a further embodiment, step **1305** is unnecessary, because the TAG_ID **805** or its equivalent was transmitted as part of BLE advertising data, which has already been received by the smartphone **118**.

At step **1306** the TAG_ID is used to look-up item data on the administration sever **126**. The item data includes graphical and geometric data for drawing a representation of the item **101**, price data for display to the customer **106** on the touchscreen **1205**, availability data for other sizes and colours, and so on.

At step **1307** a new record is generated for the newly connected tag **113**, which is then added to the active list of connected tags **1217**. The new record includes the TAG_ID **805** along with the data obtained at step **1306**.

At step **1308** the active list of connected tags **1217** is processed. During this step, it is possible for one or more tags to be removed from the list **1217**. At step **1309** a question is asked as to whether another tap event has been identified from a background analysis of signals from the microphones **1209** and the IMU **1210**. If so, control is directed back to step **1303**, where the possibility of another tag-activation is considered. Alternatively, control is directed to step **1310** where a question is asked as to whether the active list of connected tags **1217** is empty. If not, control is directed back to step **1308**, resulting in a loop in which the list **1217** is processed, and a check is made to see whether new tap events have been received, and whether the list **1217** has become empty. If no tags are present in the list **1217**, control is directed to step **1311**, where the app is put to sleep, for subsequent waking at step **1301** in response to another tap event.

The steps of Figure 13 result in connection to one or more second tags **113** to **117**, in response to a mutual impact between the second tag, such as tag **113**, and a mobile device, such as the smartphone **118**.

Figure 14

The active list **1217** of connected tags shown in Figure 12 is detailed in Figure 14. Each list item **1401**, **1402**, **1403** and **1404** is a record for a respective connected tag **113**, **114**, **115** and **116**. Records may be added to or removed from the list dynamically, while the customer **106** physically browses items **101** to **105** in the retail environment. Record **1401** is for second tag **113**, and includes a copy **1405** of the TAG_ID **805**. The record **1401** further includes an association flag **1406**, which is initially clear. This indicates whether the item **101** has been associated with the customer **106**. The record **1401** also includes an RSSI field **1407**, which is derived from RSSI values in both directions between the smartphone **118** and the tag **113**. An orientation field **1408** and a position field **1409** are updated from tag movement data transmitted from the tag **113** at step **1003**. Thus, the RSSI **1407**, the orientation **1408** and the position **1409** are all considered to be position-related parameters.

A price field **1410** is updated from an enquiry made to the administration server **126** at step **1306** using the TAG_ID **805**. In response to the request of step **1306**, the administration server **126** also provides graphical data **1411**, including vector data **1412** and bitmaps **1413**, **1414**. The graphical data makes it possible to draw an accurate visual representation of the item **101** on the touchscreen **1205** of the smartphone **118**. Other records **1402**, **1403** and **1404** include similar data for their respective items **102**, **103** and **104**.

Figure 15

The step **1308** of processing the active list of connected tags, shown in Figure 13, is detailed in Figure 15. At step **1501** the RSSI value for each tag is calculated, and the relevant field **1407** is updated. This calculation takes the RSSI in both directions between a tag **113** and the smartphone **118** and takes the effective average. At step **1502** MAX_RSSI is calculated as being the largest of all the RSSI values calculated at step **1501**. At step **1503** the orientation **1220** and position **1221** of the smartphone

118 are obtained. It is difficult to obtain the position of the smartphone **118** or any of the second tags **113** to **117** to a high degree of accuracy, so a low-pass filtered approximation or assumption is used.

At step **1504** the first of the second tag records **1401** to **1404** in the list **1217** is selected. At step **1505** the relative signal strength, REL_RSSI[N], for a tag is calculated, based on previously calculated values for RSSI[N] and MAX_RSSI. The REL_RSSI is considered as a position-related parameter, which may be used to update the visual indicators **405** of connected tags, and or affect display of items on the touchscreen **1205**. At step **1506** REL_RSSI[N] is transmitted to its respective tag. This is received by the second tag **113** at step **1005** in Figure 10. At step **1507** the orientation and position data for the currently selected tag are obtained. As with smartphone position, tag position is unlikely to be available to a high accuracy, and so this is generated based on some assumptions, and then heavily filtered. At step **1508** a graphical representation of the tagged item is generated in response to REL_RSSI[N] and the tag's orientation and position.

At step **1509** a question is asked as to whether all tag records in the list **1217** have been considered. If not, control is directed back to step **1504**, and the next tag record is processed. Alternatively, control is directed to step **1510**.

At step **1510** a representative 3D model **1222** of tag locations is generated. The representative model **1222** is partially or entirely arbitrary, depending upon the quality and availability of tag position data. Tag position data is primarily derived from RSSI, including REL_RSSI[N] calculated at step **1505**. From the perspective of a customer **106** using their smartphone **118**, what is required is an intuitive and clearly prioritized display of items **101** to **105**; their relative locations do not have to be topographically correct. The 3D model **1222** generated at step **1510** is largely independent of the actual orientation and or position of the smartphone **118**. Changes in orientation, position and RSSI are used to control changes in the 3D model **1222**, as well as the intensity of the visual indicator **405** on each of the respective tags **113** to **117**.

At step **1511** the touchscreen **1205** is updated with a synthetic representation of items **101** to **105** in response to respective graphical item data **1411**, the 3D model **1222**, and the orientation **1220** and position **1221** of the smartphone **118** identified earlier at step **1503**. At step **1512** association gestures are processed. The steps of Figure 15 are repeated several times a second, resulting in smooth animation of physical items **101** to **105** on the touchscreen **1205** as the customer rotates and moves the smartphone **118**. However, the topographical arrangement of the items **101** to **105** is not physically accurate, and is deliberately distorted in order to prioritize the nearest item **101**, and to facilitate easy display of additional information **1410** for that item **101**. As the customer moves the smartphone **118** to another item **102** whose second tag **114** is activated, the touchscreen **1205** smoothly updates in response to smartphone movements, zooming in on the item **102**.

Figure 16

The effect of the steps of Figure 15 is illustrated in Figure 16. Having activated tags **113**, **114** and **115**, the customer **106** sees the touchscreen **1205** of the smartphone **118** showing the first item **101** in the foreground with the second item **102** and third item **103** in the background. The arrangement of the items **101**, **102**, **103** in the 3D representation on the display **1205** is not necessarily the same as that of the physical arrangement of the items in the retail environment. The smartphone **118** is closest to the first item **101**, and so this is displayed most prominently.

Figure 17

A different view is shown in Figure 17, where the customer has activated the fourth tag **116** but has subsequently moved their smartphone **118** nearer to the tag **118** of the second item **102**. The second item **102** is in the foreground of the simulated 3D representation on the touchscreen **1205**, and the three other items are displayed at a smaller size in the background.

Figure 18

A further view is shown in Figure 18, where the customer has deactivated the second and fourth tags **114** and **116**. The third item **103** is in the foreground of the simulated 3D representation on the touchscreen **1205**, and the first item **101** is displayed in the background. It will be appreciated that the views shown in Figures 16 to 18 are updated continuously at a high frame rate, resulting in a smooth animation in real time, in response to movements and gestures of the smartphone **118**.

Figure 19

The step **1512** of processing association gestures, shown in Figure 15, is detailed in Figure 19. At step **1911** a question is asked as to whether the second tag **113** has been removed from the item **101**. If so, this is considered as an association gesture made by the customer **106**, showing that they wish to purchase the item **101**. In this case, control is then directed to step **1905**. Alternatively, control is directed to step **1902**, where a question is asked as to whether the customer **106**, who is the user of the smartphone **118**, has made an association gesture with the item's graphical representation on the touchscreen **1205**. If so, control is directed to step **1905**.

Alternatively, control is directed to step **1903**, where an analysis is made of the RSSI of each activated tag **113** to **116**. This analysis is combined with tag orientation **1408** and position **1409** with respect to the smartphone orientation **1220** and position **1221** over a period of several seconds, thereby making it possible to identify a gesture of the customer **106** picking up the item **101** and walking away with it. In other words, the item **101** is moved from its original location beside other items **102** to **105**. The analysis **1903** includes gait analysis in combination with orientation and movement analysis. The analysis may be performed with limited information.

For example, if the tag **113** doesn't have an IMU, the proximity of the tag **113** to the smartphone **118** may be estimated from the RSSI **1407**. The smartphone includes an IMU **1210**, and can perform gait analysis. If footsteps or similar movement patterns are detected while the RSSI of one tag **113** remains high and the RSSI of other tags diminishes, this is interpreted at step **1903** as a picking up and walking away gesture for the item **101**.

At step **1904** a question is asked as to whether an association gesture was identified. If not, control is directed to step **1908**. Alternatively, control is directed to step **1906**, where BLE connections with all other activated tags **114** to **116** are disconnected. At step **1907** purchase processing is performed. At step **1908**, activated second tags **113** to **116** that have consistently weak signal strengths are disconnected and removed from the active list of connected tags **1217**.

Figure 20

The step **1907** of purchase processing, shown in Figure 19, is detailed in Figure 20. At step **2001** a question is asked as to whether the second tag **113** has been removed from the associated item. If so, control is directed to step **2002**. Alternatively, at step **2002** a question is asked as to whether an exit scanner **120**, **121** has seen the item's first tag **108**. This information is obtained by a communication between the smartphone **118** and the administration server **126**, which communicates with the security server **119** in order to determine when a first tag **108** to **112** has been identified near one of the exit scanners **120**, **121**.

If an exit scanner has not detected the first tag **108**, control is directed to step **2004**. Alternatively, at step **2003** a suggestion is made to the customer **106**, via the touchscreen **1205**, that they purchase the item **101**. Depending upon customer preferences for the physical browsing app **1214**, the decision to make a purchase may be made and confirmed automatically as a result of an association **1905**. At step **2004** a question is asked as to whether the purchase has been confirmed. If not, control is directed to step **2008**.

At step **2005** payment for the item **101** is processed using a connection between the smartphone **118** and the payments server **127**. As a result of this payment, the administration server **126** will be informed, securely, that the item **101** has been purchased by the customer **106**.

At step **2006** a question is asked as to whether payment has been successful. If not, control is directed to step **2008**. Alternatively, at step **2007**, the customer is informed that they can remove the second tag **113** and take the item home. If the second tag has already been removed from the item, step **2007** is simplified to a confirmation of purchase of the item **101** being displayed on the smartphone's touchscreen **1205**. Furthermore, a digital receipt of purchase is issued to the customer, to the customer's mobile device and by email.

If a purchase has not been made, a question is asked at step **2008** as to whether the customer **106** is still interested in the item **101**. This can be answered by analysing RSSI, orientation and position information for the tag **113** and the smartphone **118**. If the tag is some distance away from the phone, and is in a static position, it is decided that the customer is no longer interested in the item and control is directed to step **2009**. Alternatively no further action is taken, in case the customer **106** decides subsequently to purchase the item **101**. At step **2009**, the item **101** and the customer **106** are disassociated, the tag **113** is disconnected, and the tag's record **1401** is removed from the active list of connected tags **1217**.

Figure 21

The administration server **126** shown in Figure 1 is detailed in Figure 21. The server **126** comprises a number of server units **2101** to **2108** connected to a Local Area Network (LAN) **2109**. Server unit **2101** comprises a network I/O circuit **2110**, facilitating network communications with a Central Processing Unit (CPU) **2111**, which is connected to memory **2112**. The memory comprises non-volatile FLASH and volatile RAM components, and will be treated as unified for the purposes of this description. Server units **2102** to **2107** have an identical construction to the first server unit **2101**.

Server unit **2108** is a routing server, comprising a network I/O circuit **2113**, a CPU **2114** and memory **2115**. It further comprises a CDROM drive **2117** in which a CDROM **2118** can be placed to install instructions in the memory **2115**, from where the instructions will be copied onto the memories of the other server units **2101** to **2107**. A direct high bandwidth connection to the Internet **125** is facilitated by an Internet I/O circuit **2116**, thereby providing connection between all the server units **2101** to **2108** to other devices attached to the Internet **125**, including customer smartphones **118** and **119**, the payments server **127** and the security server **119**. The routing server **2108** receives incoming HTTP requests from the Internet **125**, and routes these requests to the remaining server units **2101** to **2107**, in such a way as to balance the request and processing load evenly across the servers. In this way, the administration server units **2101** to **2108** provide a load-balanced high capacity administration system **126** capable of handling thousands of simultaneous customer interactions.

Figure 22

Operation of the administration server **126**, shown in Figure 21, is detailed in Figure 22. At step **2201** the server units **2101** to **2108** are switched on. At step **2202** a question is asked as to whether administration instructions have been installed. If so, control is directed to step **2209**, and the administration instructions are run. Alternatively, control is directed to step **2203**, where a question is asked as to whether the instructions should be installed via the Internet **125**. If so, control is directed to step **2204**, where an installation file is downloaded, and control is directed to step **2206**. Alternatively, control is directed to step **2204**, where an installation file is read from the CDROM **2118**. At step **2206**, the installation file is authenticated.

At step **2207** a question is asked as to whether the authentication performed at step **2206** was successful. If not, control is directed back to step **2203** so that a new installation file can be obtained. Having successfully authenticated the installation file, administration instructions are installed at step **2208** by a process of multiple file extraction from the installation file. The extracted instructions are copied onto the routing server memory **2115**, and from there are copied to the memory **2112** of the first server unit **2101**, and the memories of the other server units **2102** to **2107**. At step **2209** the installed administration instructions are executed by all of the servers **2101** to **2108**, effectively in parallel.

Figure 23

The contents of the memory **2112** of the first server unit **2101** shown in Figure 21, during the running of administration instructions **2209**, are shown in Figure 23. A Linux™ Operating System (OS) **2301** provides hardware abstraction, task management, and other common utilities. Apache™ Server instructions **2302** handle HTTP requests forwarded from the routing server **2108**. Administration instructions **2303** define the operation of the servers. Customer account data **2304** stores account data for customers wishing to perform physical browsing with their smartphones **117** and **118** or other mobile devices. Item data **2306** stores data for all of the individual items tagged, in one or more retail environments.

The customer account data **2304** includes individual customer accounts **2306** to **2316**. Each account includes an account number **2317**, a customer name **2318**, payment credentials **2319**, purchase history **2320**, associated items **2321** and nearly purchased items **2322**. Nearly purchased items are identified as those whose second tags **114** to **117** have been activated, but which were subsequently not purchased.

The item data **2305** includes individual item records **2323** to **2333**. Each item record **2323** to **2333** corresponds to a particular physical item in a retail environment. The item record **2323** corresponds to physical item **101**, item record **2324** corresponds to the physical item **102**, and so on.

The record **2323** for the first item **101** includes a copy **2334** of the TAG_ID **805** that is also stored in the memory **603** of the second tag **113**. Also included is the item's EPC **2335**, which is stored **303** in the memory of the first tag **108**. Further item data includes a copy **2336** of the access password **305** and a copy **2337** of the kill password **306** of the first tag **108**. A status field **2338** determines whether an item **101** is currently associated with a customer, how many customers have associated with this item, whether it has been purchased, and so on. Descriptive data including colour **2339** and size **2340** are also stored.

Figure 24

The step **2209** of running administration instructions, shown in Figure 22, is detailed in Figure 24. At step **2401** data is received in the form of a request from a customer's physical browsing app **1214** running on the smartphone **118**. The data specifies the TAG_ID **805** of the second tag **113** and the customer's account number **2317**.

At step **2402** the customer's account **2306** is looked-up and verified. At step **2403** the item's record **2323** is looked up using the TAG_ID **805** as an index. At step **2404** the customer **106** is associated with the item **101**. At step **2405** a question is asked as to whether the customer wishes to purchase the item. The answer to this question is provided by the physical browsing app **1214** running on the customer's smartphone **118** in accordance with the steps detailed in Figure 20.

If the customer does not wish to purchase the item, control is directed to step **2410**. Alternatively, control is directed to step **2406** where payment by the customer is established and confirmed, by initiating secure communications between the admin server **127** and the customer's smartphone **118** and waiting for a cryptographic confirmation that payment has been made.

At step **2407** the item's status **2338** is updated as purchased. At step **2408** the item's EPC **2335** and kill password **2337** are identified. At step

2409 a deactivation command for the first tag **108** is transmitted to the security server **119**. The deactivation command includes the first tag's EPC **303**, so that, when the item's RFID tag **108** comes near a scanner **120** to **123**, the tag **108** will be recognised but the alarm **124** will not be set off. Data transmitted in step **2409** includes the kill password **2337**, which will subsequently be transmitted by a scanner **120** to **123** to the tag **108** after detection, in order to permanently disable it. This prevents the tag **108** from being scanned and detected in future.

If the customer does not wish to purchase the item **101**, at step **2410** the customer and the item are disassociated by updating the status field **2338**. At step **2411** the item is recorded as having been nearly purchased by updating the nearly purchased field **2324** of the customer's account **2306**.

Separate event-driven processes **2412** and **2413** facilitate maintenance of the data structures of the administration server **126**. Process **2412** allows administration staff to add, remove or edit items from the item records **2305**. Process **2413** enables customer records to be added, removed or edited, via an interface provided in the customer's physical browsing app **1214**.

It will be appreciated that writing to an item **2323** in memory **2112** results in updates to other instances of the same cached data structure on other server units **2102** to **2108** in the administration server **126**. Those skilled in the art will be able to implement a coherent shared database of this kind by known methods.

Figure 25

The security server **119** shown in Figure 1 is detailed in Figure 25. The security server **119** comprises a CPU **2501**, volatile and non-volatile memory **2502**, a Power over Ethernet (PoE) interface **2503** and a modem **2504**. The PoE interface provides connections and power to the RFID scanners **120** to **123**, and the alarm **124**. The modem **2504** provides Internet connectivity.

The memory **2502** includes Linux operating system instructions **2505** and security instructions **2506**. Data in the memory **2502** includes a deactivation list **2507** and an inventory **2508**. The deactivation list **2507** includes records **2509**, **2510** and **2511** for items which have been purchased and whose first tags **108**, **109**, **110** have not yet been deactivated. Each item in the deactivation list includes an EPC **2512** which is a copy of a first tag's EPC **303**, and a copy **2513** of its kill password **306**. Other data may also be included, such as the access password **305**. The inventory **2508** includes records **2514** to **2518** for all the items **101** to **105** in the retail environment. Each inventory record **2514** to **2518** includes the same data **2512**, **2513** as a record in the deactivation list **2507**.

In an embodiment, the deactivation list **2507** is cached locally at each scanner **120** to **123**, so that high speed interaction and decision making can occur during the short time when a tag **108** is activated. For the purposes of clarity, the following description will describe the relevant functionality as if implemented on the security server **127**.

Figure 26

The security instructions **2506** shown in Figure 25 are summarised in Figure 26. Three parallel processes are shown. These include an event-driven deactivate tag process **2601**, a continuous scan exit process **2602** and a continuous inventory scan process **2603**.

Figure 27

The deactivate tag event-driven process **2601**, shown in Figure 26, is detailed in Figure 27. At step **2701** a deactivation command is received by the security server **119** from the administration server **126**. At step **2702** the deactivation command is authenticated, to ensure that it has been sent by administration server **126**. At step **2703** the deactivation list **2507** is updated by adding a record **2509** containing an RFID tag's EPC **303** and kill password **306**.

Figure 28

The continuous scan exit process **2602**, shown in Figure 26, is detailed in Figure 28. At step **2801** the security server **119** receives a scanned RFID tag's EPC **303** from one of the exit scanners **120**, **121**. At step **2802** a question is asked as to whether a record containing the EPC is on the deactivation list **2507**. If so, control is directed to final step **2807** at which a kill command and password **2513** are transmitted back to the scanner nearest to the tag, thereby disabling the first tag **108** permanently. Alternatively, if the tag is not in the list **2507**, control is directed to step **2803**, where a question is asked via the administration server **126** as to whether the tagged item **101** is associated with a customer **106**. If so, communications are sent to the administration server at step **2804** to initiate a request for the customer to purchase the item, or possibly to return the item, if it is not of interest.

At step **2805** a question is asked as to whether the item has now been purchased. If not, the alarm **124** is set off. Similarly, if the item was found not to be associated with a customer at step **2803**, control is directed to step **2806**, where the alarm **124** is set off.

Furthermore, if the item was successfully purchased at step **2804**, or the tag was already on the deactivation list as previously mentioned, control is directed to step **2807** which causes the tag to be deactivated. Deactivation of the tag has the desired effect of deactivating the alarm **124** so that the customer **106** can exit the retail environment with the purchased item **101**, without the alarm **124** going off.

Figure 29

The continuous inventory scan process **2603** shown in Figure 26 is detailed in Figure 29. At step **2901** a periodic request for an inventory scan is made. At step **2902** the EPCs of all visible RFID tags **108** to **112** are identified using scanners **120** to **121**. At step **2903** the visible RFID tags are compared with the inventory **2508**. At step **2904** a question is asked as to whether all items in the inventory are visible. If not, control is directed to step **2905**, where missing tags are interrogated individually to see if they can be found. If the missing tags are found, control is directed to step **2907**, where nothing further is done, because the inventory **2508** matches the visible tags..

Alternatively, if some RFID tags remain missing, control is directed to step **2908** where a timeout is tested. If the timeout is less than ten seconds, control is directed to step **2909**, where a silent warning alarm is provided to staff in the retail environment, by transmitting a text message to their mobile devices, or by some other convenient silent process. Alternatively, if one or more RFID tags has gone missing for a sustained period of time, the main alarm **124** is set off at step **2910**.

Figure 30

The actions performed with respect to the retail environment of Figure 1 and following Figures are summarised in Figure 30. Initially the second tags **113**, **114** and **115** are deactivated. At step **3001** a tag **113** is activated in response to a customer interaction in the form of a physical gesture where the customer's mobile device **118** is tapped lightly against the tag **113**. The energy of this impact is translated into electrical energy by the piezo transducer **611**, thereby activating the tag **113** by waking up it's microcontroller **601**.

At step **3002** the TAG_ID is received on the smartphone **118** as a unique tag code identifying the tag, enabling the phone to obtain information about the tagged item **101** from the administration server **126** via the Internet **125**. At step **3003** a change in a position-related parameter, based on RSSI, is measured. This measurement of change is implicit, since the normalisation calculation shown at step **1505** in Figure 15 has the effect of causing visual indicator updates to occur in response to change, rather than absolute values. In an embodiment, measurements of change are obtained by an explicit calculation of a change in a position-related parameter over time. For example, this may be achieved by subtracting samples of a position-related parameter from one or more previous values.

At step **3004** visual indicators are updated in response to the measured change. The visual indicators updated include the visual indicator **405** on each of the activated second tags **113**, **114**, **115**. The touchscreen **1205** on the customer's mobile device **118** also facilitates a visual indicator that is updated. In an embodiment, either the tag visual indicator **405** or the touchscreen visual indicator is not updated, or is not physically provided. At step **3005** a question is asked as to whether another tag **114** or **115** has been activated. If so, control is directed back to step **3002**. Alternatively, control is directed to step to step **3006**, where a question is asked as to whether the customer **106** has made a gesture indicating a preferred item. A preferred item is indicated by the customer by making one of the association gestures described with reference to Figure 19 and Figure 20. One type of association gesture is to pick up the item **101** and take it away from the vicinity of the other tagged items **102** and **103**. If no preference is indicated, control is directed back to step **3003**.

Steps **3003** to **3006** form a loop which repeats several times a second, updating visual indicators **405** on the second tags **113**, **114** and **115**, once those tags have been activated. Also updated are areas of the touchscreen **1205** on the customer's mobile device **118**. By performing these repeated updates, the customer **106** is able to immediately see the effect of movements of their mobile device **118** with respect to the locations of tags **113** to **115** on the items **101** to **103**. Visual indications from the tags **113** to **115** as well as the touchscreen **1205** provide an intuitive feedback mechanism for physical browsing of items.

During physical browsing, items **101** to **103** displayed on the mobile device **118** change in size, to further improve the feeling of physical interaction. The item **101** nearest the mobile device **118** may be displayed with additional information, such as price and availability of colours and sizes. As the customer moves the mobile device **118** closer to another item

102, the display of such additional information is modified and updated with information for the second item **102**. This provides the customer **106** with an intuitive way of obtaining detailed information about multiple items.

At step **3007**, a preferred item is identified by changing the visual indicators **405** on the tags **113** to **115** appropriately. The preferred item's tag is then indicated by a bright white colour, and the other tags are deactivated to save power. Also, the touchscreen **1205** of the mobile device **118** is updated to show that the preferred item **101** has been selected. This identification of a preferred item by an association gesture may result in an immediate payment for the item, if automated purchase has been selected as an option by the customer **106**.

CLAIMS

1. A security system for deployment within a retail environment, comprising:

a plurality of first tags, wherein each said first tag is concealed within an item of merchandise and is configured to transmit a first signal modulated to specify a first tag code in response to being energized at an exit gate;

a plurality of second tags, wherein each said second tag is independently attached to a said item of merchandise and is configured to communicate with mobile devices to facilitate a purchase of a said item via said mobile device; and

a data communication apparatus for communicating with said mobile devices and controlling responses of said exit gate when detecting output signals from said first tags, wherein:

a user selected second tag transmits a second output signal modulated by a unique second code to a mobile device in response to a user interaction;

said mobile device relays a received second code to said data communication apparatus;

said data communication apparatus initiates a procedure to facilitate a purchase of an item to which an interacted second tag is attached, resulting in a sale being completed or a sale failing to be made, such that:

said data communication apparatus controls said exit gate so as not to raise an alarm upon detecting a respective first tag concealed within a purchased item; and

said exit gate raises an alarm in response to first concealed tags when respective second tags attached to the same item have not completed a sale.

2. The system of claim **1,** wherein said first tags includes a radio frequency identification (RFID) device.

3. The system of claim **2**, wherein said communication apparatus controls said exit gate in order to de-active first tags concealed in items that have been purchased.

4. The system of claim **1**, wherein said second tags communicate with mobile devices using a Bluetooth protocol.

5. The system of claim **1**, wherein a user selection is made by a physical interaction with a second tag.

6. The system of claim **1**, wherein each said second tag includes an indicator, wherein said indicator is activated after an item to which said tag is attached has been purchased, thereby inviting a user to physically remove the attached second tag.

7. The system of claim **5**, wherein said second tag includes an impact detector for generating an activation signal in response to an impact between said second tag and a mobile device.

8. The system of claim **1**, wherein said second tag includes a removal detection device.

9. A security system for deployment within a retail environment, comprising:

a plurality of first tags, wherein each said first tag is concealed within an item of merchandise for detection at an exit gate;

a plurality of second tags, wherein each said second tag is independently attached to said item and is configured to communicate with mobile devices to facilitate a purchase of a said item via said mobile device; and a data communication apparatus for communicating with mobile devices and controlling responses of said exit gate when detecting output signals from said first tags, wherein:

a plurality of user selected second tags transmit second output signals to a mobile device in response to respective user interactions, wherein each said second output signal is modulated by a unique tag code;

said mobile device relays said received second codes to said data communication system;

said data communication system returns product data for said plurality of selected second tags, wherein said product data includes a graphical representation of each selected item;

said mobile device is configured to dynamically display each said graphical representation of selected items;

said mobile device is configured to dynamically position said graphical representations in response to positional data identifying a relative position of each said selected item with respect to the mobile device; and

said mobile device is configured to further communicate with said communication system to initiate a sale of a preferred item chosen from said displayed selected items.

10. The system of claim **9,** wherein said positional data is derived from an evaluation of relative signal strengths of respective second output signals.

11. The system of claim **9**, wherein said positional data is derived from an evaluation of orientation data derived from devices resident within the mobile device.

12. The system of claim **11**, wherein said devices resident within the mobile device include accelerometers.

13. The system of claim **11**, wherein a preferred item is selected by impacting a mobile device upon the second tag attached to the preferred item.

14. The system of claim **11**, wherein a preferred item is chosen by receiving input commands to remove graphical representations of other non-chosen selected items.

15. The system of claim **11**, wherein a preferred item is chosen by moving the selected item with the mobile device away from the non-chosen selected items.

16. A security system for deployment within a retail environment, comprising:

a plurality of first tags, wherein each said first tag is concealed within an item of merchandise and is configured to transmit a first signal modulated to specify a unique first tag code in response to being energized at an exit gate;

a plurality of second tags, wherein each said second tag is independently attached to a said item of merchandise and is configured to communicate with mobile devices to facilitate the purchase of a said items via said mobile device; and

a data communication apparatus for communicating with said mobile devices and controlling responses of said exit gate when detecting output signals from said first tags, wherein:

a plurality of user selected second tags transmit second output signals to a mobile device in response to respective user interactions, wherein each said second output signal is modulated by a unique second code;

said mobile device relays said received second codes to said data communication system;

said data communication system returns product data for said plurality of selected second tags, wherein said product data includes a graphical representation of each selected item;

said mobile device is configured to dynamically display each said graphical representation of selected items;

said mobile device is configured to dynamically position said graphical representations in response to positional data identifying a relative position of each said selected item to the mobile device;

said mobile device is configured to further communicate with said communication system to initiate a sale of a preferred item chosen from said displayed selected items; and

said data communication apparatus controls said exit gate so as not to raise an alarm in responsive to identifying a respective first tag concealed within a purchased item.

17. The system of claim **16**, wherein said communication apparatus controls said exit gate in order to de-activate first tags concealed in items that have been purchased.

18. The system of claim **16**, wherein said positional data is derived from an evaluation of relative signal strengths of respective second output signals.

19. The system of claim **16**, wherein a preferred item is selected by impacting a mobile device upon the second tag attached to the preferred item.

20. The system of claim **16**, wherein a preferred item is chosen by moving a selected item with the mobile device away from the non-chosen selected items.

Application No:	GB1704501.4	**Examiner:**	Miss Samantha Henry
Claims searched:	1-8 and 16-20	**Date of search:**	31 May 2017

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	WO 2012/135115 A2 (VISA INT SERVICE ASS) See EPODOC abstract, figures 2E-2F, 4, 14, paragraphs [0063], [0076]-[0083] in particular. Note particularly anti-theft tag 257, QR code, mobile device 201, theft pillar 261, audio siren 263.
A	-	WO 2015/121833 A1 (VISA INT SERVICE ASS) See figure 1, paragraphs [0053], [0084], [0086]-[0088], [0090], [0092], [0094] in particular.
A	-	WO 2015/112446 A1 (TYCO FIRE & SECURITY GMBH) See figure 1, paragraphs [0034], [0037], [0040], [0042], [0049]-[0050] in particular. Note particularly price tag 118, EAS element 134, self-checkout POS device 36.
A	-	US 2002/186133 A1 (LOOF) See EPODOC abstract, paragraphs [0012], [0028] in particular.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

G06K; G06Q; G08B

The following online and other databases have been used in the preparation of this search report

WPI; EPODOC

International Classification:

Subclass	Subgroup	Valid From
G08B	0013/24	01/01/2006
G06Q	0020/32	01/01/2012