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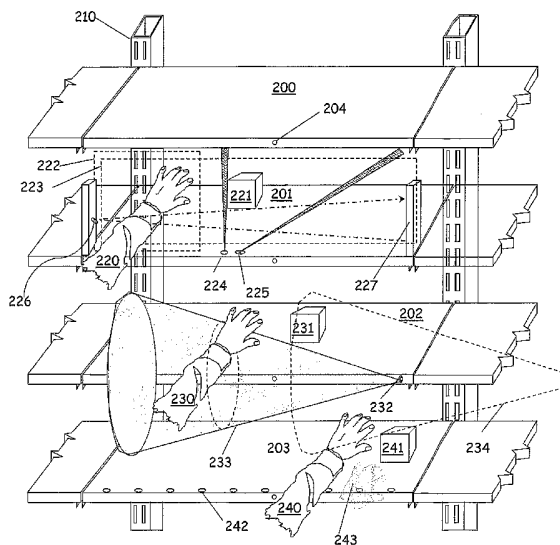
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JECT



(57) Abstract: Methods, systems, and articles of manufacture for assigning priority to antennae are disclosed. In accordance with a preferred embodiment of the invention, the proximity of an object (e.g., in relation to one or more of a plurality of predetermined locations) is determined. Sensors can be utilized to provide information regarding the proximity of the objects. In accordance with a preferred embodiment, a priority order can be assigned to the reader antennae based on the proximity information or other information regarding the location and other characteristics of the objects and/or their environment. A polling sequence for reading the reader antennae can be determined according to the priority order.

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SYSTEMS AND METHODS FOR PRIORITIZING ANTENNAS ACCORDING TO THE PROXIMITY OF AN OBJECT

[0001] This application claims the benefit of prior U.S. Provisional Application No. 60/536,704, entitled, "SYSTEMS AND METHODS FOR PRIORITIZING ANTENNAS ACCORDING TO THE PROXIMITY OF AN OBJECT," filed January 16, 2004, which is hereby incorporated by reference in its entirety.

BACKGROUND

[0002] Radio frequency identification (RFID) systems typically use one or more RFID reader antennae to send radio frequency (RF) signals to items tagged with RFID tags. The use of such RFID tags to identify an item or person is well known in the art. In response to the radio frequency (RF) signals from an RFID reader antenna, the RFID tags, when excited, produce a disturbance in the magnetic field (or electric field) that is detected by the RFID reader antenna. Typically, such tags are passive tags that are excited or resonate in response to the RF signal from an RFID reader antenna when the tags are within the detection range of the RFID reader antenna.

[0003] The detection range of the RFID systems is typically limited by signal strength to short ranges, for example, frequently less than about one foot for 13.56 MHz systems. Therefore, portable reader units may be moved past a group of tagged items in order to detect all the tagged items, particularly where the tagged items are stored in a space significantly greater than the detection range of a stationary or fixed single RFID reader antenna. Alternately, a large RFID reader antenna with sufficient power and range to detect a larger number of tagged items may be used. However, such an antenna may be unwieldy and

may increase the range of the radiated power beyond allowable limits. Furthermore, these RFID reader antennae are often located in stores or other locations where space is at a premium and it is expensive and inconvenient to use such large RFID reader antennae. In another possible solution, multiple small antennae may be used but such a configuration may be awkward to set up when space is at a premium and when wiring is preferred to be hidden.

[0004] Current RFID reader antennae are designed so that a sufficient read range may be maintained between the antenna and associated tags, without running afoul of FCC limitations on radiated emissions.

[0005] Resonant RFID reader antenna systems are currently utilized in RFID applications, where numerous RFID reader antennae are connected to a single reader. Each RFID reader antenna may have its own tuning circuit that is used to match to the system's characteristic impedance. An RFID reader or interrogator may be connected to more than one antenna, for example, to save cost or complexity of using many readers, particularly if a fast read rate is not necessary. However, sharing a reader means that a given antenna may not be read as often. It may be desired however to know immediately when an item is removed from the vicinity of an antenna, or at least to monitor the antenna for a time thereafter. It may therefore be useful to develop methods that allow the RFID reader to prioritize the order in which antennae are read.

SUMMARY

[0006] Methods, systems, and articles of manufacture for assigning priority to antennae are disclosed. In accordance with a preferred embodiment of the invention, the proximity of an object (e.g., in relation to one or more of a plurality of predetermined locations) is determined. Sensors can be utilized to provide information regarding the proximity of the objects. In accordance with a

preferred embodiment, a priority order can be assigned to the reader antennae based on the proximity information or other information regarding the location and other characteristics of the objects and/or their environment. A polling sequence for reading the reader antennae can be determined according to the priority order.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a block diagram depicting an exemplary system in accordance with a preferred embodiment of the invention;

[0008] FIG. 2 illustrates a side view of customers interacting with exemplary predetermined locations (e.g., shelves) having a variety of sensors affixed thereto in accordance with preferred embodiments of the invention; and

[0009] FIGs. 3-4 illustrate top views of exemplary predetermined locations (e.g., shelves) having a variety of sensors affixed thereto in accordance with preferred embodiments of the invention.

DETAILED DESCRIPTION

[0010] Preferred embodiments and applications of the invention will now be described. Other embodiments may be realized and changes may be made to the disclosed embodiments without departing from the spirit or scope of the invention. Although the preferred embodiments disclosed herein have been particularly described as applied to the field of RFID systems, it should be readily apparent that the invention may be embodied in any technology having the same or similar problems. Furthermore, while the examples herein are particularly described in relation to a shelf system, for example, in a facility such as a retail store, it should be readily apparent that the invention may be embodied in other forms and in other facilities.

[0011] An exemplary embodiment of the invention may be implemented in Customer Detection System 100 as illustrated in FIG. 1. The exemplary Customer Detection System 100 preferably includes a Controller 110 coupled to a Local Database 115, a Reader 140, and User Interface Devices 130. In this embodiment, Controller 110 may include one or more central processing units (CPUs) or other calculating or processing devices to provide processing of input/output data between Customer Detection System 100, Network 160, Local Database 115, a Reader 140, and User Interface Devices 130.

[0012] Preferably, Controller 110 executes one or more computer-executable programs stored in memory (e.g., Local Database 115, etc.). Local Database 115 can include one or more memory devices comprising any recordable or rewritable medium for storing information (e.g., hard drive, flash RAM, optical disc, compact disc, memory card, DVD, etc.). User Interface Devices 130 include any device that can be used to enter information (e.g., commands, data, etc.) into Controller 110 (e.g., keyboard, touchscreen, wireless device, PDA, infrared device, radio frequency device, etc.).

[0013] In a preferred embodiment of the invention, Customer Detection System 100 may further include Reader 140. Reader 140 can be used to interrogate, read, or otherwise activate one or more reader antennae (e.g., Reader Antenna 151-153) coupled to Reader 140. In this exemplary implementation, Reader Antennae 151-153 are incorporated in shelf 105 and may include tuning circuitry as described in US Patent Application No. 10/338,892, which is incorporated herein by reference in its entirety. Reader 140 transmits the information obtained from Reader Antenna 151-153 to Controller 110 in a manner well known in the art.

[0014] In a preferred embodiment, Reader Antenna 151-153 are preferably RFID reader antennae capable of generating radio frequency waves 50. The radio frequency waves 50 interact with RFID tags 60 which can be affixed to, integrated with, or otherwise coupled to an object (e.g., product, employee, customer, etc.). An RFID tag 60, when excited by radio frequency waves 50, produces a disturbance in the magnetic field (or electric field) that is detected by RFID reader antennae. Preferably, reader 140 may be instructed by Controller 110, for example, to interrogate one or more reader antennae (e.g., Reader Antennae 151-153) according to a priority order in a particular polling sequence. For example, Controller 110 may instruct Reader 140 to interrogate Reader Antennae 151-153 by reading Reader Antenna 153 followed by Reader Antenna 152 followed by Reader Antenna 151. As discussed herein, in accordance with a preferred embodiment of the invention, the priority order can be assigned based on the location of Item 70 or Customer 80 (e.g., the proximity of the Item 70 or Customer 80 to Reader Antenna 152, etc.).

[0015] In accordance with a preferred embodiment of the invention, the reader antennae may be affixed to a mobile or stationary object. As depicted in the exemplary implementation of FIG. 1, Reader Antennae 151-153 are affixed to a product support structure such as Shelf 105. Reader Antennae 151-153 can be used to communicate by, for example, radio frequency waves 50 with RFID tags such as RFID 60, shown attached to item 70. In accordance with a preferred embodiment, sensors are utilized (e.g., affixed to a mobile or stationary object) to provide additional information regarding the environment of objects being monitored or their surroundings. In this exemplary implementation, Sensors 121-123 are affixed to Shelf 105 and provide additional information to Controller 110. Sensors 121-123 can include any known sensors such as weight sensors, pressure sensors, pushbutton sensors, vibration sensors, infrared sensors, optical

sensors, audio sensors, etc., or combinations thereof. In a preferred embodiment, other sensing signals 85 can provide additional information to Controller 110 which can be combined information from Sensors 121-123 or independently provided to Controller 110. In accordance with a preferred embodiment of the invention, the information provided by sensors can be used to affect the priority assigned to different reader antennae as described herein.

[0016] In a preferred embodiment of the invention, customer detection system 100 can incorporate a video system (e.g., digital video camera, analog video camera, web cam, etc.) used to monitor and transmit information regarding the presence of an object (e.g., customer, employee, product, etc.) in the proximity of a predetermined location. The video information can be sent, for example, from Sensors 121-123 to Controller 110. Controller 110 can include a video analyzer module for interpreting the video information to determine: the presence of a person or another object; the proximity of the person or object relative to a predetermined location; or other information useful in the assignment of priority to different reader antennae. For example, the video analyzer module can compare video information from each of Sensors 121-123 and determine the closest predetermined location to the object. In a preferred embodiment of the invention, the person or object can have an RFID tag, bar code, or other identifier attached. The video analyzer module can recognize the identifier and determine the presence of a particular person or object. In another embodiment of the invention, the identifier can be affixed to a particular location that a customer or object might obstruct (e.g., a bar code affixed to an advertisement located on the floor). The obstruction of the identifier from the view of the video system signals the presence of a person or object in proximity to a predetermined location (e.g., the shelf adjacent to the advertisement located on the floor).

[0017] Customer Detection System 100 may be connected directly or indirectly (e.g., through network 160, as shown in FIG. 1) to one or more Remote Applications 170 coupled to Main Database 180. Network 160 may represent any type of communication configuration that allows Customer Detection System 100 and Remote Application 170 to exchange information. For example, network 160 may be a Local Area Network (LAN), a Wide Area Network (WAN), Bluetooth™, and/or a combination of networks, such as the Internet. Network 160 may also include the infrastructure that allows Customer Detection System 100 and Remote Application 170 to exchange information using wireless based communications.

[0018] Preferably, Local Database 115 and Main Database 180, in each instance, may include one or more storage device systems (e.g., internal hard drive, external hard drive, flash RAM, ROM, memory card, and optical disk, etc.) that store information (e.g., computer executable programs, data regarding products and/or facilities, etc.) used by Customer Detection System 100 and/or Remote Application 170. The term "database" can refer to the means for storage of more than one data file, computer executable program, or table. In a preferred embodiment, Local Database 115 and/or Main Database 180 may comprise more than one database or a series of databases housed locally or in a remote location. Such databases may be controlled, for example, by a database server (not shown), such as an SQL database server. A Java DataBase Connectivity (JDBC) driver for the SQL server may also be used to access the SQL server database. Local Database 115 and/or Main Database 180 may be embodied within Customer Detection System 100, or external to Customer Detection System 100, for example, on a server (not shown). Furthermore, Local Database 115 and/or Main Database 180 may be shared with more than one Customer Detection System 100.

[0019] In accordance with a preferred embodiment, Local Database 115 and/or Main Database 180 may be used to store item or object information (e.g., identification information regarding an item such as Stock Keeping Unit (SKU) data, etc.). The SKU information may include item type, manufacturer and origin, size, color, style, as well as a wide variety of other types of information that are understood by those skilled in the art. Such item information may be stored, for example, in tables maintained on Local Database 115 and/or Main Database 180 or in a remote or local database or system. Examples of item information include, but are not limited to:

[0020] (1) A Uniform Product Code (UPC) and/or an Electronic Product Identification Code (EPIC). It should be understood that items made by a certain manufacturer in a certain size, color, etc. may have all the same UPC but each may have a unique EPIC;

[0021] (2) Current price of the item;

[0022] (3) Seasonality of the item. A seasonality indicator may represent a relationship between an item and a period of time associated with different events or seasons, such as holidays, a time frame surrounding a certain date of a special event (e.g., the Super Bowl), etc. For example, a soap product may have a seasonality indicator representing no seasonal characteristics, such as "no season," wreaths may have a "Christmas" indicator, charcoal may have a "summer" indicator, etc. Further, promotional items (e.g., those items that are being specially marketed by a manufacturer or retailer) may have a seasonality indicator associated with a time frame (e.g., "July 2003"). The seasonality indicators may be used to determine when to remove or restock certain items in inventory; and

[0023] (4) Shelf life of the item. The term "shelf life" can refer to a period of time that an item may be allowed to be included in inventory. For example, perishable products, such as milk, may have a limited period of time that they may be presented on a shelf for sale to a customer. Non-perishable products may also have a limited period of time to be present in inventory based on one or more factors, such as previous sales of items of a similar type, limited promotional time frames, etc.

[0024] Additionally, for an item collection of a certain type (e.g., an individual box of any type of item), examples of stored item information include, but are not limited to, the following:

[0025] (1) The EPIC of the item;

[0026] (2) The UPC of the item which can be associated with the SKU information described above;

[0027] (3) Other types of information not directly known from the SKU (e.g., color, style, size);

[0028] (4) A serial number associated with the item (if other than the EPIC);

[0029] (5) A cost of the item to a business entity associated with its use, such as a retailer;

[0030] (6) A date the item was first placed in a particular location or locations;

[0031] (7) The expiration date of the item (if any);

[0032] (8) Item location information representing a current physical location of the item (or if sold, the last known location of the item);

[0033] (9) The price at which an item was sold (if already sold);

[0034] (10) The date the item was sold (if already sold);

[0035] (11) The preferred customer number of a purchaser (if already sold) representing a unique number assigned to a user that purchases or may purchase items; and

[0036] (12) A unique serial number associated with the RFID tag 60, for example, an identification number written to the RFID tag 60 by its manufacturer.

[0037] One skilled in the art will appreciate that the above examples of item information are not intended to be limiting. Local Database 115 and/or Main Database 180 may include more or fewer tables or other configurations of item information used by Remote Application 170 and/or Customer Detection System 100. Some or all of the information in Main Database 180 may also be stored in Local Database 115.

[0038] In accordance with a preferred embodiment, the priority order can be determined in a variety of manners influenced by a variety of factors (e.g., data derived from sensors, reader antennae, historical data, and marketing data). The term “priority order” refers to a relative positioning or arranging of objects (e.g., reader antennae, fixtures, and objects, etc.) in an ordered sequence. The term “priority order” may also refer to a length of time to be spent (e.g., monitoring) on a given object. The term “object” refers to any tangible item capable of being detected (e.g., customer, a product, a basket, a cart, etc.). An

object can be associated, for example, with an RFID tag or another identifying tag. The term "predetermined criteria" refers to a factor or factors that differentiate the characteristics of one object from another object. For example, objects can be arranged in a priority order according to predetermined criteria (e.g., weight, size, density, etc.). For example, heavier objects can have a higher priority with respect to lighter objects. Thus, in this exemplary priority order, objects are arranged in a priority order from the heaviest object to the lightest object. An object that is assigned a higher "priority" or "level" in the priority order can, for example, have a higher position in a priority order compared to an object assigned a "lower" priority or "level." Predetermined criteria can also be weighted with respect to each other. Thus, the weight of an object can influence its position in a priority order twice as much as its size.

[0039] An object that is assigned a higher level in a priority order is also said to have a higher preference level than objects at lower levels in the priority order. The term "preference level" refers to the relative value assigned to an object compared to other objects in a group or groups of objects. In one preferred embodiment of the invention, preference levels can be assigned to objects according to any given basis (e.g., predetermined criteria, randomly, equal frequency, etc.). A priority order can then be arranged by comparing the preference levels assigned to various objects, and a priority order can be determined by arranging the objects according to their preference levels (e.g., from highest to lowest, lowest to highest, etc.). For example, a priority order can be arranged for 100 objects with each object being assigned a mutually exclusive preference level from 1-100. In this example, an object with a preference level of 1 will have the highest priority in the priority order, while an object with a preference level of 100 will have the lowest priority in the priority order. After

the preference levels of the 100 objects have been assigned, they can be arranged in an exemplary priority order from 1-100. To the extent preference levels are not assigned on a mutually exclusive basis, relative priority of objects may be assigned arbitrarily or using any other additional basis.

[0040] In a preferred embodiment of the invention, the priority order can be arranged without reference to preference levels. For example, a priority order can be arranged randomly, according to predetermined time schedule, or any other suitable factor. In another preferred embodiment of the invention, a priority order can be arranged according to multiple predetermined criteria. For example, objects can be arranged according to both their size and weight. Predetermined criteria can also be weighted with respect to each other. Thus, the weight of an object can influence its position in a priority order twice as much as its size.

[0041] In a preferred embodiment of the invention, a first reader antenna having a higher preference level is assigned a higher priority than at least a second reader antenna having a lower priority. In this embodiment, a preference level is assigned to each antenna and the antennae are arranged in a priority order according to their relative preference levels. An antenna with higher preference level has a corresponding higher priority than an antenna with a lower preference level.

[0042] In a further preferred embodiment of the invention, reader antennae are read or interrogated according to their priority order. Thus, an antenna having a higher priority (e.g., based on being assigned a higher preference level) is read or interrogated before an antenna having a lower priority (e.g., having a corresponding lower preference level).

[0043] In another preferred embodiment of the invention, preference levels can be assigned according to the object or objects detected by each of the plurality of reader antennae. For example, the presence of a particular product having an identifying tag may result in a higher preference level assigned to the corresponding antenna. Assignment of a higher preference level of an antenna may result in being assigned a higher position in a priority order. A store manager, for example, may want to closely monitor the stock of a particularly popular item in order to provide accurate and up to date information regarding the supply to customers. In another preferred embodiment, a first reader antenna that detects a larger number of products is assigned a higher preference level than at least a second reader antenna that detects a smaller number of products.

[0044] In another preferred embodiment of the invention, a probability that a detected product will be moved from a predetermined location can be used as predetermined criteria for assigning preference levels (or otherwise setting priority order). The probability that a product will be moved can be determined in a variety of ways. It can be, for example, calculated by detecting movement frequency of the plurality of products from a predetermined location during a predetermined time interval and calculating the average movement frequency of the plurality of products from the predetermined location during the predetermined time interval. In a preferred embodiment, a preference level can be assigned to each of the plurality of reader antennae according to the probability the object will be moved. In this example, a higher preference level corresponds to a higher position in a priority order. Using this preferred embodiment of the invention, a store manager can calculate the number of popular items moved from a particular shelf in an hour to determine how many items need to be replaced.

[0045] In another preferred embodiment, the preference level can be assigned according to a preference factor. The term "preference factor" refers to predetermined criteria used to assign a preference level to an object. Preference factors can include, but are not limited to, movement of an identifying tag associated with a reader antenna, proximity of a customer to a reader antenna, proximity of an employee to a reader antenna, and proximity of a product to a reader antenna. For example, if an identifying tag or group of identifying tags is moved out of the range of a reader antenna, the reader antenna can be assigned a higher preference level than an antenna where identifying tags have not been moved. A priority order can be arranged according to, for example, frequency of identifying tag movement where increased movement of identifying tags corresponds to a higher priority than decreased or no movement of identifying tags.

[0046] In another preferred embodiment of the invention, preference levels or priority order can be assigned based on a triggering event or input data from a device such as a computer server, a computer workstation, a handheld device, a telephone, a wireless device, etc. In this example, priority can be assigned manually or according to a time interval. Thus, a store manager or a company manager located in a remote location can interrogate a reader antenna e.g., associated with a particular shelf to monitor the movement of a popular item at a particular time of day or during an important time period (e.g., Christmas shopping season).

[0047] In another preferred embodiment of the invention, preference levels or priority order can be assigned to reader antennae based on input data from a sensor. For example, a sensor may be an optical sensor, a vibration sensor, an audio sensor, a pressure sensor, a pushbutton sensor, etc., indicating

an event (e.g., the presence or absence of a customer, employee, particular product etc.). The sensor can be used to assign a preference level to reader antennae. For example, if a sensor detects the presence of a customer, the antenna associated with the sensor can be assigned a higher preference level and a corresponding higher position in a priority order than an antenna that is not associated with the presence of customer.

[0048] In a preferred embodiment of the invention, the priority order can be stored in a table (e.g., in Local Database 115) for use (e.g., by Controller 110) in determining a polling sequence for interrogating reader antennae. The term “polling sequence” refers to the order (or length of time) in which reader antenna are read or interrogated. The polling sequence can be arranged according the priority order, preference levels, or any other suitable factor or factors.

[0049] Preferred embodiments of the invention and the steps for assigning preference levels to reader antennae, determining a priority order, and/or determining a polling sequence can be embodied in a computer executable medium stored in a computer readable medium (e.g., hard drive, flash drive, memory card, RAM, ROM, DVD, CD, optical disc, etc.). The computer readable medium can be used in, for example, Controller 110 according to preferred embodiments of the invention described herein.

[0050] In an exemplary implementation of a preferred embodiment of the invention, the priority order is equal to the summation of individual factors that may be weighted according to predetermined criteria as set forth below:

[0051]
$$\text{Read Priority} = P_m = \sum_{i=1}^n X_{im} \times W_{im}$$

[0052] where P_m = Read Priority for antenna m

[0053] n = Number of rules for prioritization

[0054] X_{im} = i th priority factor associated with m th
antenna

[0055] w_{im} = i th weighting factor associated with m th
antenna

[0056] In one application of this exemplary implementation, for example, each antenna is assigned a preference level based on how often the inventory of tagged objects or items inside the antenna's range is moved. For example, let t_i be the time of read event i . The term "event" in this example preferably refers to a change in inventory (e.g., increase, decrease, change to the identifying tag, etc.). For example, the disappearance of a tagged item from the range of an antenna is defined as a read event since the event is viewed by the antennae as a change in inventory. In this implementation, the priority order can be defined as follows:

[0057] $t - t_i$ is the elapsed time since read event i ;

[0058] α and β are constants;

[0059] Let $\Phi_i = \alpha + (t - t_i)$ or $\Phi_i = \alpha + \beta (t - t_i)$

[0060] At the moment read event i occurs, Φ is defined and has a value of α . As time continues the value of Φ_i grows linearly. The priority value γ_m for antenna m is defined as:

[0061] $\gamma_m \equiv \sum_{i=1}^{N_m} \exp\{-\Phi_i\}$ where N_m is the total number of read events on

record for the antenna m . Preferably, user-defined criteria may be defined to limit the number N_m . For example, N_m might only include events within the last hour, last 15 minutes, or other time span, or only the most recent 10 events for each antenna.

[0062] In this preferred implementation, γ_m will be largest for antennae with a large number of recent read events. Antennae can receive a read priority from largest γ_m to smallest γ_m . Other formulas may also be used for γ_m . For example,

[0063] $\gamma_m \equiv \sum_{i=1}^{N_m} (1/\Phi_i)$ where, if a large time interval elapses without

reading a particular antenna, greater priority may be placed on reading that antenna. For example, a function ε could be defined as

[0064] $\varepsilon \equiv \delta(t - t_{last})$ where t_{last} is the time of the last read event and δ is a constant. The read priority for an antenna can be based on the sum of ε and γ_m . In this example, the equation will balance the need to read some antennae more frequently with the need to read all antennae occasionally.

[0065] In accordance with a preferred embodiment of the invention, specialized prioritization rules can be developed and implemented (e.g., programmed into system 100) to aid in the determination of a priority order. As an example, a prioritization rule can be developed in which an antennae or sensor can be desensitized to multiple events by "debouncing" the antenna or sensor. For example, where shelf 105 (FIG. 1) is implemented in a retail store environment having a sensor in the form of a customer request button, and that

button is pressed multiple times within a given time interval (e.g., 10 seconds), the button can be considered to have been pressed only once.

[0066] Another prioritization rule may be developed, for example, in which a particular event (e.g., a customer is detected near a monitored object by a sensor) will result in assigning the highest priority to any reader antenna associated with that event. The rule may further specify that the absence of the event (e.g., the detection of a customer) will incrementally decrease the priority assigned to the associated antennae.

[0067] It should be understood that the prioritization cycle and the read cycle may run at different speeds and not necessarily in sequence, since while the antennae may be read in a particular prioritized sequence, it may be possible or desirable to monitor other sensors at different speeds. This prioritization cycle may be run continuously, or periodically. If run periodically during business hours, the periodic interval may be relatively short. On the other hand, during non-business hours, it may not be necessary to run the read prioritization cycle, but may be preferable, for example, simply to read all antennae at the same priority.

[0068] Additional preferred embodiments of the invention include inactivating or otherwise refraining from interrogating reader antennae. For example, a reader antenna can be inactivated if its position in a priority order is below a threshold level. In another preferred embodiment of the invention, a reader antenna can be inactivated in response to inactivation signals (e.g., detecting movement of an identifying tag, proximity of a customer to a reading antenna, proximity of an employee to a reading antenna, and proximity of a product to a reading antenna). Inactivation signals can temporarily inactivate a

reader antenna or a group of reader antennae. For example, a reader antenna can be shut down if an employee (e.g., wearing an RFID tag) is re-stocking a shelf.

[0069] Preferred embodiments of the invention are directed to methods of and systems for prioritizing a plurality of predetermined locations containing one or more reader antennae by determining the priority order of the plurality of predetermined locations in the same (or similar) manner described above. The priority order, for example, may be determined in accordance with a preference level assigned to each of the plurality of predetermined locations. A polling sequence for reading the antennas of the predetermined locations can be established, for example, according to the priority order. For example, locations can be prioritized according to predetermined criteria (e.g., proximity of customers to a location or locations). Preference levels can be assigned to each location according to the predetermined criteria. A priority order can be determined according to the preference level assigned to each location and a polling sequence can be established according to the priority order.

[0070] In another preferred embodiment, the proximity of an object in relation to a plurality of predetermined locations is determined and preference levels for each of a plurality of predetermined locations containing one or more reader antennae can be assigned according to the proximity of the object in relation to each of a plurality of predetermined locations. For example, the location of an object can be determined using a sensor (e.g., an RFID antenna, an electrical switch, a strain gauge, a force sensor, a pressure switch, an infrared sensor, an ultrasonic sensor, a motion sensor, an audio sensor, a vibration sensor, etc.). The sensors can be arranged in any suitable configuration on or near a predetermined location or object. For example, a force sensor or pressure switch can be installed under a predetermined location in a floor near a fixture (e.g.,

shelf, light, and door). In another preferred embodiment, the sensor can be installed in a remote area and detect objects in multiple predetermined locations. For example, an infrared sensor can be installed on a ceiling and adjusted to detect objects in a plurality of predetermined locations.

[0071] In a preferred embodiment of the invention, the RFID reader antennae among (and/or within) each location can be read according to a polling sequence. The polling sequence can be determined in accordance with a priority order assigned to each location. The priority order assigned to each location can be determined according to a preference level assigned based on predetermined criteria (e.g., proximity of an object to a location). For example, a location associated with a higher number of customers (e.g., as determined by a sensor) can have a higher preference level than a location associated with fewer customers. Predetermined locations with a higher preference level can be assigned a higher priority. In another preferred embodiment, a first predetermined location assigned a higher preference level has a higher priority (and is therefore read before) a second predetermined location assigned a lower preference level.

[0072] FIG. 2 depicts preferred embodiments of the invention as implemented in a shelf system of a retail store. As shown, four shelves, 200-203, are supported on vertical brackets 210. Each shelf may have a button 204 for a customer to request attention. Button 204 may be a mechanical button, a proximity switch, or other suitable mechanism. When a customer (e.g., Customer 220) presses, pushes or in some other manner activates button 204, a signal is transmitted to Controller 110 (FIG. 1) indicating the presence of Customer 220 in proximity to, for example, Shelf 201. Controller 110 can initiate interrogation of one or more antennas in Shelf 201 to determine the inventory remaining on Shelf

201. In another preferred embodiment of the invention, Controller 110 interrogates one or more antennas in Shelf 201 after a predetermined period of time following the activation of button 204. In another preferred embodiment of the invention, Controller 110 "desensitizes" button 204 and does not respond to repeated activation of the button within a predetermined time interval (e.g., 30 seconds following the first activation of button 204). One or more buttons may be included on each shelf. Controller 110 can assign a preference to the one or more antennas in Shelf 201 depending on the number of times button 204 is activated in a given time interval. Alternative sensors or switches (e.g., electrical switch, pressure switch, temperature gauge) may be used to signal activation to Controller 110. In one preferred embodiment of the invention, for example, the switch is a pressure sensor which can be located in the floor and react to pressure applied by a customer or a shopping cart.

[0073] FIG. 2 further depicts an exemplary implementation in which Customer 220 is shown reaching for Merchandise Item 221 on Shelf 201. Customer 220, optionally, can be detected or sensed by pressing button 204, or breaking some monitored planes on or around Shelf 201. Breaking Vertical Plane 222 or 223, for example, could indicate the presence of a customer, for example, within the width of one antenna zone for interrogation by a reader antennae fixed to Shelf 201.

[0074] In this exemplary implementation, one or more detectors 224 (such as a narrow beam sensor) can be installed on the top surface of the shelf 201, close to the front edge, to be used in monitoring Vertical Plane 222 or 223. Detector 224 in this exemplary implementation, but not a limitation, is assumed to be a focused infrared detector such as the Sharp GP2D15 detector with a 4-30" range and a 2-degree beam width. The infrared beam emitted from detector 224

will be reflected back from the customer's arm and/or the merchandise item being removed, as either object passed through the Vertical Plane 222 or 223. If narrow enough, the beam can be projected through the Vertical Planes without giving false alarms by reflections from merchandise near the front of the shelf. Although only one detector 224 is shown, several sensors or detectors may be required per shelf to properly monitor Vertical Planes 222 or 223, and to avoid "dead" zones having no sensor coverage.

[0075] One or more detectors or sensors may be employed at an angle as shown by detector 225. Angled detectors may cover more area. One or more detectors may also be employed to direct sensing beams across the width of the shelf (as shown by direction arrow 226). Such detectors may require attachments 227 on the shelf ends. Detectors or sensors may also be positioned to utilize reflections from the shelf (or other) structure (e.g., from the shelf end, from a surface of an opposing shelf, etc.) or from reflective material placed on such structure.

[0076] FIG. 2 additionally depicts an exemplary implementation in which Customer 230 is shown reaching for Merchandise Item 231 on Shelf 202. In addition to (or in lieu of) other detectors described herein (e.g., 224, 225, etc.), a wide beam detector 232, which may be, for example, an ultrasonic rangefinder detection sensor (e.g., Devantech SRF08 (having a range of 1 inch to ten feet or more with the width of a conical beam being about 45 degrees)) may be employed to cast a wide beam such as that shown as Beam 233. In this embodiment, Detector 232 can send out an ultrasound pulse, receive back multiple echoes, and report the distance of a plurality of objects. In another preferred embodiment, Detector 232 is positioned such that Beam 233 is aimed slightly forward from the shelf to reduce number of possible false alarms from

merchandise near the front of Shelf 202. Detector 232 could also be positioned such that Beam 233 could be directed, for example, along Shelf 202 and out into the aisle as shown in FIG. 2. In another preferred embodiment, the sensor range of Detector 232 can overlap with the coverage range of another sensor (not shown), as illustrated with Beam 234 on the same or different shelves. Where overlapping coverage of multiple shelves occurs, additional information (e.g., range finding data) may be used to facilitate the identification of the shelf being accessed by the customer.

[0077] FIG. 2 also depicts an exemplary implementation in which Customer 240 is shown reaching for Merchandise Item 241 on Shelf 203. In this implementation, one or more Light Sensors 242 (e.g., photodiodes or other sensors) are used to measure light flux (e.g., from overhead store lighting) on or around shelf 203. When Customer 240 reaches his hand through the front plane of the shelf, one or more Sensors 242 will detect a reduction in the light flux received (e.g., from overhead store or shelf lighting), as illustrated by Shadow 243. This reduction can be taken (e.g., by Controller 110) as an indication of the presence of Customer 240 in proximity to Shelf 203. One or more of the outputs of the multiple Light Sensors 242 can be combined to provide one or a few inputs to Controller 110, as desired.

[0078] FIG. 3 provides an overhead view of the sensing zones for certain sensors shown in FIG. 2. In a preferred embodiment of the invention, Infrared Proximity Sensors (224, 225, and 226) have a given range (e.g., up to 2.5 feet) and focus (e.g., a narrow focus of about 2 degrees). In the illustrated implementation, the focus of Infrared Proximity Sensors 224, 225, and 226 is sharp enough to detect movement through the front plane of individual shelves.

Nevertheless, several sensors may be added to provide a wider sensor range (e.g., four sensors 225 arranged at an angle within the front plane).

[0079] In embodiments where it is sufficient to determine the location of one or more customers nearby a group (e.g., gondola) of shelves, one or more Infrared Sensors 228 may be located along a shelf edge (of one or more shelves), projecting outward into the aisle (e.g., using, for example, one IR sensor per foot of horizontal shelf space). A customer in front of a given shelf would activate one or more Sensors 228 so as to detect the presence of a customer near the predetermined location (e.g., gondola).

[0080] FIG. 4 provides an overhead view of the sensing zones for certain sensors shown in FIG. 2. A Beam 233 such as from Sensor 232 will detect the presence of customers standing in front of a shelf even if they are not reaching for any merchandise. While a given Sensor 232 (as implemented) may not have narrow selectivity (i.e., only being activated when a customer reaches for an item on a given shelf), it can be used, for example, to trigger Controller 110 to perform some ancillary action (e.g., present or project an advertisement when the customer activates Sensor 232). For example, by projecting the ultrasonic beam horizontally, and about 25 degrees out into the aisle (to avoid "hitting" merchandise on the shelf), a single sensor might serve an entire 4-foot long section of a predetermined location (e.g., aisle or gondola).

[0081] In another preferred embodiment of the invention, sensors for detecting customers in a shorter or narrower range are employed. As shown in FIG. 4, for example, Sensor 232 can be used to determine unambiguously that Customer (a) stands close to the shelf on which the sensor 232 is located. In this preferred embodiment, a shorter range is preferred because it avoids ambiguity that may be caused by the presence of other customers close to Customer (a). For

example, Customer (b) may be detected 3-4 feet away from the sensor although the sensor may not be able to determine whether Customer (b) is near this shelf, or across the aisle as at customer position (c). In another example, Customer (d) may not be detected by Sensor 232 because he is outside the Beam 233. However, Customer (d) may be detected by Beam 234 from a sensor in the next shelf along the aisle. Echoes from Customer (d) may be masked by echoes from the opposite shelf area 235 which is the same distance away.

[0082] These ambiguities can also be avoided by using the configuration of another preferred embodiment of the invention. For example, wide-angle sensors on Shelves 236 and 237 can be placed on opposite sides of an aisle. Customer (e) standing at Shelf 236 is detected by wide angle Beam 238 projected from that shelf. However, Customer (f) standing further down Shelf 236 can be detected by a wide-angle Beam 239 from Shelf 237. In this example, there is no ambiguity regarding the presence of the customer near a predetermined location.

[0083] In another preferred embodiment of the invention, additional sensors (e.g., Hall-effect switches, capacitive switches, and other types of electrical switches) may be positioned in, on or near the shelves or the floor in front of the shelves to detect the presence of a customer or object. The shelves may also be fitted with weight, force, or pressure sensors that detect differences in the mass of merchandise on the shelves which are indicative of removal or addition of product from the shelves. A microphone or vibration sensor may be used to detect small sounds indicative of merchandise being moved from or to the shelf. Because these sensors may produce a continuous signal while a customer is in range, the controlling software may have trigger and reset modes

so that only one electronic response is given, or one response is given every N seconds.

[0084] Once the presence of a customer or customers has been detected, preferred embodiments of the system can make inferences about other locations that may immediately or in the near future receive attention from the customer, and which therefore may warrant a higher interrogation priority of individual reader antennae, groups of antennae, etc. For example, if the customer is detected at a certain location, for example a certain shelf, it is likely that the customer may also observe or handle merchandise at nearby locations (e.g., adjacent shelves). The system can also track the location or locations of customers, based on the customer detection devices, to deduce store or shelf locations that will next receive the customer's attention, and which therefore may warrant a higher read priority. Such tracking, for example, could be done by a computer system utilizing information from the customer detection devices and/or the RFID reader antennas.

[0085] While preferred embodiments of the invention have been described and illustrated, it should be apparent that many modifications to the embodiments and implementations of the invention can be made without departing from the spirit or scope of the invention. For example, although embodiments and implementations of the invention have been specifically illustrated herein as applied to reader antennae for RFID tags placed on an item, the invention may easily be deployed or embodied in any form of (RF- or non-RF-based) antennae. Although only a single Customer Detection System 100 has been illustrated, it should be apparent that there may be a plurality of Systems 100, and when implemented, one or more of the Systems 100 may be connected (directly or indirectly) with one or more shelves 105 (or other components or

modules). In addition, one or more of sensors 121, 122, 123, 224, 225, 232 and 242 may take the form of a low powered laser. The various detectors and sensors illustrated in FIG. 2 may be used individually, all together, with one or more omitted, or in any combination in a single or multiple structures beyond that specifically described herein. Although only shown as used in the front plane of a shelf, the sensors may be incorporated to provide monitoring of any one or more planes in any location of a structure, as desired.

[0086] To the extent the illustrated embodiments have not specified the type of communication medium (or protocol) used to connect the various modules (e.g., shown in FIG. 1), it should be apparent that any known wired/wireless technology may be used to implement the various embodiments of the invention (e.g., PCI bus, FireWire, USB, Internet, intranets, private bulletin boards, individual local or wide area networks, proprietary chat rooms, ICQ, IRC channels, instant messaging systems, WAP, Bluetooth, etc.) using real-time or non-real-time systems alone or in combination.

[0087] In accordance with a preferred embodiment, one or more of the same or different user interfaces (e.g., user interface device 130 (FIG. 1)) are provided as part of (or in conjunction with) the illustrated systems to permit one or more users to interact with the systems. Individual ones of a plurality of devices (e.g., network/stand-alone computers, personal digital assistants (PDAs), WebTV (or other Internet-only) terminals, set-top boxes, cellular/PCS phones, screenphones, pagers, kiosks, or other known (wired or wireless) communication devices, etc.) may similarly be used to execute one or more computer programs (e.g., universal Internet browser programs, dedicated interface programs, etc.) to allow users to interface with the systems in the manner described.

[0088] The modules described herein, particularly those illustrated or inherent in, or apparent from the instant disclosure, may be one or more hardware, software, or hybrid components residing in (or distributed among) one or more local and/or remote computer or other processing systems. Although the modules may be shown or described herein as physically separated components (e.g., Controller 110, Local database 115, User Interface 130, Reader 140, etc.), it should be readily apparent that the modules may be omitted, combined or further separated into a variety of different components, sharing different resources (including processing units, memory, clock devices, software routines, etc.) as required for the particular implementation of the embodiments disclosed (or apparent from the teachings herein). Indeed, even a single general purpose computer (or other processor-controlled device) executing a program stored on an article of manufacture (e.g., recording medium such as a CD-ROM, DVD-ROM, memory cartridge, etc.) to produce the functionality referred to herein may be utilized to implement the illustrated embodiments. User interface devices may be any device used to input and/or output information. The user interface device may be implemented as a graphical user interface (GUI) containing a display or the like, or may be a link to other user input/output devices known in the art.

[0089] In addition, database, storage, and other memory units described herein may be any one or more of the known storage devices (e.g., Random Access Memory (RAM), Read Only Memory (ROM), hard disk drive (HDD), floppy drive, zip drive, CD-ROM, DVD-ROM, bubble memory, redundant array of independent disks (RAID), storage accessible network (SAN), network accessible storage (NAS), etc.), and may also be one or more memory devices embedded within a controller or CPU, or shared with one or more of the

other components. These units may be disposed locally, remotely, distributed, or otherwise logically or physically configured to practice the invention.

[0090] Moreover, the operational flows and methods inherent from the description provided herein can be modified to include additional steps, to change the sequence of the individual steps as well as combining (or subdividing), simultaneously running, omitting, or otherwise modifying the individual steps shown and described in accordance with the invention. Numerous alternative methods may be employed to produce the outcomes described with respect to the preferred embodiments illustrated above or equivalent outcomes. It should be apparent to those of ordinary skill in the art that method steps inherent or apparent from the disclosure herein of various physical systems (or components thereof) may be implemented using the disclosed (or any other systems) in accordance with the invention. Detailed descriptions of such method steps therefore need not be provided herein.

[0091] It is to be understood therefore that the invention is not limited to the particular embodiments disclosed (or apparent from the disclosure) herein, but only limited by the claims appended hereto.

CLAIMS

[0092] What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A method of prioritizing a plurality of antennas, the method comprising:
 - determining a priority order of the plurality of antennas according to a preference level assigned to each of the plurality of antennas; and
 - setting a polling sequence for reading the antennas according to the priority order determined in said determining step.
2. The method of claim 1, further comprising the steps of :
 - detecting proximity of an object in relation to one of a plurality of predetermined locations; and
 - assigning a preference level to each of the plurality of antennas according to the detected proximity of the object in relation to one of the plurality of predetermined locations.
3. The method of claim 2, wherein said detecting step uses a sensor selected from the group consisting of an RFID antennae, an electrical switch, a strain gauge, a force sensor, a pressure switch, an infrared sensor, an ultrasonic sensor, a motion sensor, an audio sensor, and a vibration sensor.

4. The method of claim 2, wherein said detecting step detects an object selected from the group consisting of a customer, a product, a basket, or a cart.
5. The method of claim 2, wherein said assigning step randomly assigns a preference level to each of the plurality of antennas.
6. The method of claim 2, further comprising the step of providing a fixture having a plurality of RFID reader antennae for each of the plurality of predetermined locations.
7. The method of claim 6, wherein said providing step includes providing a plurality of products supported by at least one fixture, each of the plurality of products being associated with an RFID tag.
8. The method of claim 7, further comprising the step of reading the plurality of RFID reader antennae according to the polling sequence.
9. The method of claim 7, wherein said assigning step assigns a higher priority to a first group of antennas at a first predetermined location than a second group of antennas at a second predetermined location.
10. The method of claim 7, further comprising the step of inactivating an RFID antenna.
11. The method of claim 10, wherein said inactivating step is triggered in response to activation of one of: the movement of an RFID tag; the

proximity of a customer associated RFID tag; the proximity of an employee associated RFID tag; and the proximity of a product shelf RFID tag.

12. The method of claim 6, further comprising the step of reading the plurality of RFID reader antennae of at least one fixture at an equal frequency.
13. The method of claim 7, wherein said assigning step further comprises assigning the preference level according to the number of the plurality of products detected by each of the plurality of RFID antennae.
14. The method of claim 13, wherein said assigning step further comprises assigning a first RFID antenna that detects a larger number of the plurality of products with a higher priority level than at least a second RFID antenna that detects a smaller number of the plurality of products.
15. The method of claim 7, wherein said assigning step further comprises assigning the preference level according to a probability that products detected by an RFID antenna will be moved from a predetermined location.
16. The method of claim 15, wherein said assigning step includes determining the probability by calculating the average movement

frequency of the plurality of products from a predetermined location during a predetermined time interval.

17. The method of claim 7, wherein said assigning step further comprises assigning the preference level according to a preference factor selected from the group consisting of the movement of an RFID tag, the proximity of a customer associated RFID tag, the proximity of an employee associated RFID tag, and the proximity of a product shelf RFID tag.
18. The method of claim 7, wherein said assigning step further comprises assigning the preference level according to a command from a device selected from the group consisting of a computer server, a computer workstation, a handheld device, a telephone, and a wireless device.
19. A method of prioritizing the reading of a plurality of RFID antennae, the method comprising the steps of:
 - providing a plurality of product support structures, wherein each product support structure is associated with at least one RFID antenna;
 - placing a plurality of products on at least one of the product support structures wherein each of the plurality of products is associated with an RFID tag;

detecting the proximity of an object in relation to each of the plurality of product support structures;

assigning a preference level to each of the plurality of RFID antennae according to the proximity of the object in relation to each of the plurality of product support structures;

determining the priority order of the plurality of RFID antennae according to the preference level assigned to each of the plurality of RFID antennae;

setting a polling sequence for reading the plurality of RFID reader antennae according to the priority order; and

reading the plurality of RFID reader antennae according to the polling sequence.

20. A customer detection system comprising:

a plurality of product support structures, wherein each product support structure is associated with at least one RFID antenna;

at least one detecting device for detecting the proximity of an object in relation to at least one of the plurality of product support structures;

a controller device, wherein said controller device assigns a preference level to each of the plurality of RFID antennae according to

the proximity of the object in relation to each of the plurality of product support structures, determines the priority order of the plurality of RFID antennae according to the preference level assigned to each of the plurality of RFID antennae, and sets a polling sequence for reading the plurality of RFID reader antennae according to the priority order; and a reader device, wherein said reader device reads the plurality of RFID reader antennae according to the polling sequence.

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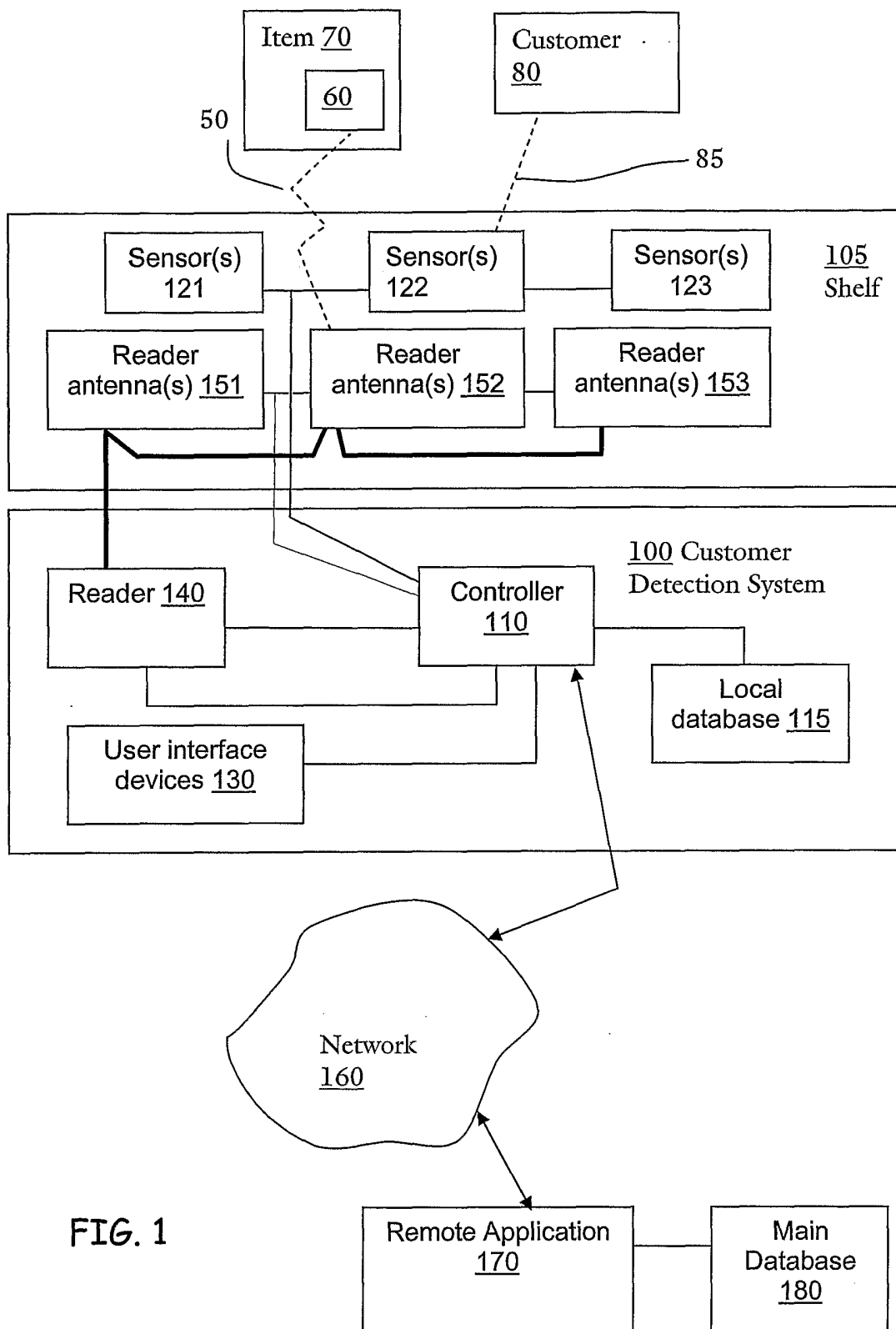


FIG. 1

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FIG. 2

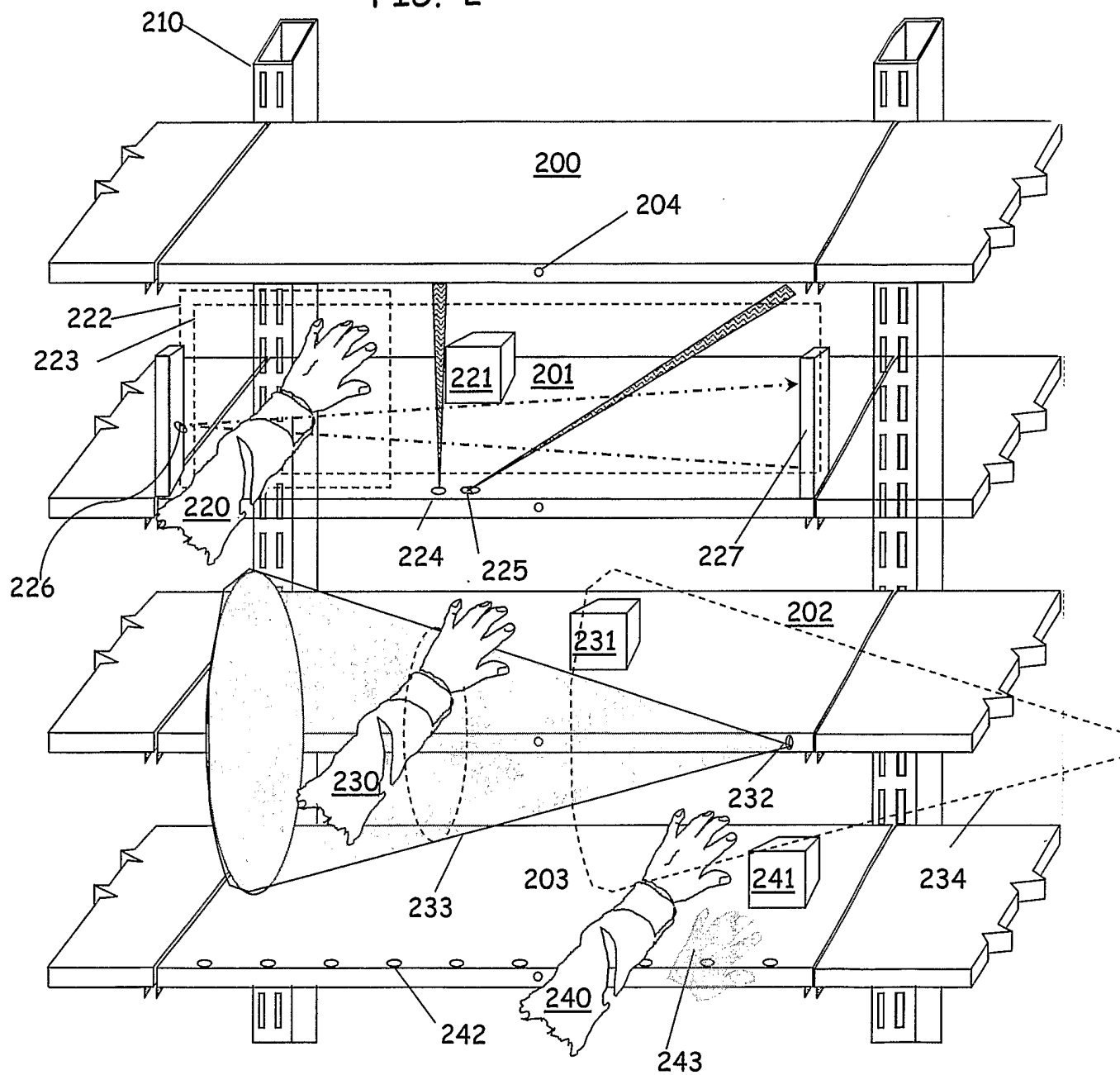


FIG. 3 Top Plan View

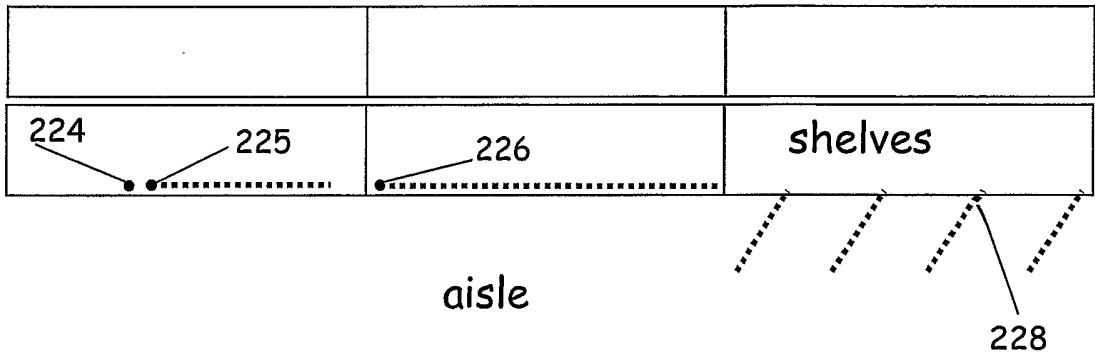


FIG. 4 Top Plan View

