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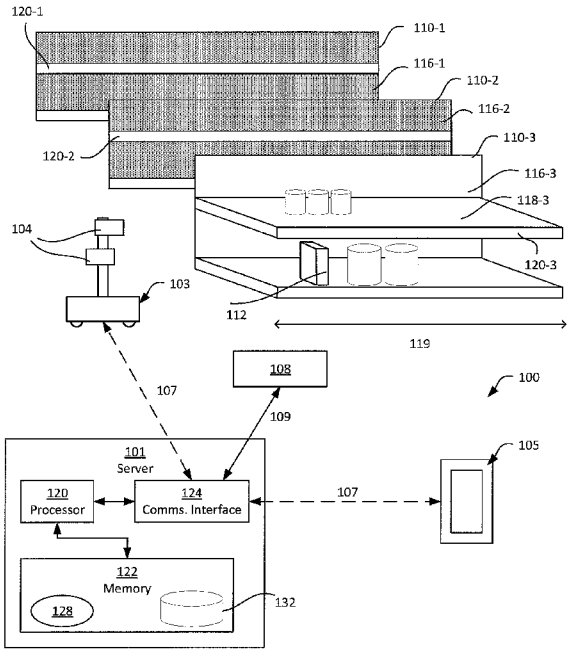

FIG 1

(57) Abstract: A product status detection system includes a mobile automation apparatus having a sensor to capture data representing a shelf supporting products, responsive to data capture instructions. The system includes a server in communication with the mobile apparatus, having: a mobile apparatus controller to generate data capture instructions for the mobile apparatus; a repository to store captured data from the mobile apparatus; a primary object generator to generate primary data objects from the captured data, each including a location in a common frame of reference; a secondary object generator to generate and store secondary data objects based on the primary data objects; a detector to identify mismatches between reference data and the secondary data objects; and an alert generator to select a subset of the mismatches, and generate and transmit a status alert corresponding to the subset. The system also includes a client device to receive and display the status alert.

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PRODUCT STATUS DETECTION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority to U.S. Provisional Application No. 62/492,670, filed May 1, 2017, by Perrella et al., entitled "Product Status Detection System," which is incorporated herein by reference in its entirety.

BACKGROUND

[0001] Environments in which objects are managed may be complex and fluid. For example, a retail environment may include objects such as products for purchase, a distribution environment may include objects such as parcels or pallets, a manufacturing environment may include objects such as components or assemblies, a healthcare environment may include objects such as medications or medical devices. A given environment may contain a wide variety of objects with different attributes (size, shape, price and the like). Further, the placement and quantity of the objects in the environment may change frequently. Still further, imaging conditions such as lighting may vary either over time or at different locations in the environment. These factors may reduce the accuracy with which information concerning the objects may be collected within the environment.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0002] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views, together with the detailed description below, are incorporated in and form part of the specification, and serve to further illustrate embodiments of concepts that include the claimed invention, and explain various principles and advantages of those embodiments.

[0003] FIG. 1 is a schematic of a mobile automation system.

[0004] FIG. 2 is a rear elevation view of a mobile automation apparatus in the system of FIG. 1.

[0005] FIG. 2A is a block diagram of certain internal components of the mobile automation apparatus in the system of FIG. 1.

[0006] FIG. 3 is a block diagram of certain internal hardware components of the server in the system of FIG. 1.

[0007] FIG. 4 is a flowchart of a method of product status detection.

[0008] FIG. 5 is a flowchart of a method of generating data capture instructions.

[0009] FIG. 6 depicts a set of image data captured by the mobile automation apparatus of FIG. 2.

[0010] FIG. 7 depicts primary data objects derived from the image data of FIG. 6.

[0011] FIG. 8A depicts secondary data objects derived from the primary data objects of FIG. 7

[0012] FIG. 8B depicts reference data employed for comparison with the secondary data objects of FIG. 8A.

[0013] FIG. 9 is a data structure for storing the secondary data objects of FIG. 8A.

[0014] FIGs. 10-11 are flowcharts depicting an embodiment of a method of generating electronic notifications based on product status detection of FIG. 4.

[0015] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the present invention.

[0016] The apparatus and method components have been represented where appropriate by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

DETAILED DESCRIPTION

[0017] Environments such as warehouses, distribution centers, fulfilment and sortation centers, cross-docking facilities, manufacturing plants, assembly lines, retail locations (e.g. grocery stores, general merchandise stores, department stores, convenience stores, restaurants), health care facilities and the like typically contain a wide variety of products. Each such product may have certain associated characteristics, such as size,

dimension, color, serial number, or weight. Certain environments may associate one or more products into a stock keeping unit (SKU) with similar features, for instance multiple shirts with an identical fashion but available in sizes of small, medium, large, or extra-large may have the same SKU. Certain environments may assign attributes to products or to SKUs to better manage the products, such as a cost, price, batch, date code, expiration date, components and/or ingredients, packaging, tracking number, order number, shipping number, storage requirements, or the like. Within the environment, products may be arranged in stocking areas: products may be supported on shelves for selection and purchase by customers or for picking by employees, vendors, or contractors; products may be placed in a particular floor zone; set on a pallet; or collected in a bin. Shelves may be arranged in a shelving module with a single module base, but multiple shelf sections, often with a module back. A shelving module may have a door, particularly if the products are refrigerated. Sometimes shelving modules are placed side to side so that individual shelf sections align, creating a longer shelf, other times a shelf is only a single shelf section. Sometimes shelving modules are placed face to face with an aisle between them to facilitate shopping by customers, picking by employees, or stocking by vendors.

[0018] The set of products within a stocking area varies over time, as products are stocked, removed and, in some cases replaced by, customers or employees. Products that have been partially or fully depleted typically require restocking, and products that have been incorrectly replaced (referred to as "plugs") typically require relocation to the correct stocking area. More specifically, "spreads" are classified as a single product distributed across adjacent shelf locations where a different product (SKU) is supposed to be located. In addition, products may be present on shelves but incorrectly oriented, or pushed back from a shelf edge further than a predefined target distance. Of course, objects other than products may be placed in a stocking area or on a shelf as well, such as bags, packing materials, mobile computers, scanners, merchandising materials, cleaning supplies, kiosks, signage, etc.

[0019] Further, products in such environments are often associated with labels placed on a shelf edge, a peg, racking , displays or the products themselves. The labels generally indicate a price of the associated product or SKU, and may include other information, such as the name, a manufacturer, SKU, color, dimensions, size, EAN,

license information, price, promotional message, nutritional information, storage requirements, safety information, date information, and the like. The information may be in text, color, graphics, digital or analog watermarking, or barcoded, and may also be associated with data stored in circuitry within the label, such as an electronic shelf label or RFID label. The labels are subject to physical disturbance (e.g. being knocked off a shelf edge), and may also be misplaced in the environment (e.g. adjacent to the incorrect products or SKUs). Further, the label price displayed on a label may not reflect a reference price associated with the relevant product in a price book employed by point-of-sale systems.

[0020] Detecting product status issues, such as restocking or plug/spread issues, product orientation issues, or labeling issues are conventionally performed by human employees, via visual assessment of the stock areas and shelves, manual barcode scanning (e.g. to compare prices displayed on labels to reference prices), and the like. This form of detection is labor-intensive and therefore costly, as well as error-prone.

[0021] Attempts to automate the detection of product status issues are complicated by the layout and dynamic nature of the environment in which an autonomous data capture system is required to operate. Areas of several thousand square feet or more, subdivided into a number of individual aisles, may need to be inspected for issues. Digital images of the shelves vary in quality depending on the available lighting, the presence of visual obstructions, and the like. The breadth of products present on the shelves and the variations in their positioning on the shelves reduces the accuracy of machine-generated status detection.

[0022] Examples disclosed herein are directed to a product status detection system comprising: a mobile automation apparatus having sensors configured to capture data representing a shelf supporting products, responsive to data capture instructions received at the mobile automation apparatus; a server in communication with the mobile automation apparatus via a network, including: a mobile apparatus controller configured to generate data capture instructions and transmit the data capture instructions to the mobile automation apparatus; a repository configured to store captured data received via the network from the mobile automation apparatus; a primary object generator configured to retrieve the captured data and generate a

plurality of primary data objects from the captured data, each of the primary data objects including a location in a common frame of reference; a secondary object generator configured to generate a set of secondary data objects based on the primary data objects, and to store the secondary data objects in the repository; a detector configured to compare the secondary data objects with reference data obtained from the repository or other data sources, and to generate mismatch records identifying mismatches between the reference data and the secondary data objects; and an alert generator configured to select a subset of the mismatch records, generate a status alert corresponding to the subset of mismatch records, and transmit the status alert via the network; and a client computing device configured to receive the status alert via the network and display the status alert.

[0023] FIG. 1 depicts a mobile automation system 100 in accordance with the teachings of this disclosure. The system 100 includes a server 101 in communication with at least one mobile automation apparatus 103 (also referred to herein simply as the apparatus 103) and at least one client computing device 105 via communication links 107, illustrated in the present example as including wireless links. In the present example, the links 107 are provided by a wireless local area network (WLAN) deployed within the retail environment by one or more access points. In other examples, the server, the client device 105, or both, are located outside the retail environment, and the links 107 therefore include wide-area networks such as the Internet, mobile networks, and the like. As will be described in greater detail below, the system 100 also includes a dock 108 for the apparatus 103. The dock 108 is in communication with the server 101 via a link 109 that in the present example is a wired link. In other examples, however, the link 109 is a wireless link.

[0024] The client computing device 105 is illustrated in FIG. 1 as a mobile computing device, such as a tablet, smart phone or the like. In other examples, the client device 105 includes computing devices such as a desktop computer, a laptop computer, another server, a kiosk, a monitor, or other suitable device. The system 100 can include a plurality of client devices 105, each in communication with the server 101 via respective links 107.

[0025] The system 100 is deployed, in the illustrated example, in a retail environment including a plurality of shelf modules 110-1, 110-2, 110-3 and so on (collectively referred to as shelves 110, and generically referred to as a shelf 110 – this nomenclature is also employed for other elements discussed herein). Each shelf module 110 supports a plurality of products 112. Each shelf module 110 includes a shelf back 116-1, 116-2, 116-3 and a support surface (e.g. support surface 118-3 as illustrated in FIG. 1) extending from the shelf back 116 to a shelf edge 120-1, 120-2, 120-3. The shelf modules may also, in some examples, including other support structures, such as pegs, commercial racking, hangers and the like. The shelf modules 110 are typically arranged in a plurality of aisles, each of which includes a plurality of modules aligned end-to-end. More specifically, the apparatus 103 is deployed within the retail environment, and communicates with the server 101 (via the link 107) to navigate, autonomously or partially autonomously, the length 119 of at least a portion of the shelves 110. The apparatus 103 is equipped with a plurality of navigation and data capture sensors 104, such as image sensors (e.g. one or more digital cameras) and depth sensors (e.g. one or more Light Detection and Ranging (LIDAR) sensors), and is further configured to employ the sensors to capture shelf data. In the present example, the apparatus 103 is configured to capture a series of digital images of the shelves 110, as well as a series of depth measurements, each describing the distance and direction between the apparatus 103 and one or more points on a shelf 110, such as the shelf itself or the product disposed on the shelf.

[0026] The server 101 includes a special purpose imaging controller, such as a processor 120, specifically designed to control the mobile automation apparatus 103 to capture data, obtain the captured data via a communications interface 124 and store the captured data in a repository 132 in a memory 122. The server 101 is further configured to perform various post-processing operations on the captured data and to detect the status of the products 112 on the shelves 110. When certain status indicators are detected by the processor 120, the server 101 is also configured to transmit status notifications (e.g. notifications indicating that products are out-of-stock, low stock or misplaced) to the mobile device 105. The post-processing of captured data and the detection of status and generation of notifications by the server 101 will be discussed below in greater detail.

[0027] The processor 120 is interconnected with a non-transitory computer readable storage medium, such as the above-mentioned memory 122, having stored thereon computer readable instructions for executing control of the apparatus 103 to capture data, as well as the above-mentioned post-processing functionality, as discussed in further detail below. The memory 122 includes a combination of volatile (e.g. Random Access Memory or RAM) and non-volatile memory (e.g. read only memory or ROM, Electrically Erasable Programmable Read Only Memory or EEPROM, flash memory). The processor 120 and the memory 122 each comprise one or more integrated circuits. In an embodiment, the processor 120, further includes one or more central processing units (CPUs) and/or graphics processing units (GPUs). In an embodiment, a specially designed integrated circuit, such as a Field Programmable Gate Array (FPGA), is designed to perform the object status detection discussed herein, either alternatively or in addition to the imaging controller/processor 120 and memory 122. As those of skill in the art will realize, the mobile automation apparatus 103 also includes one or more controllers or processors and/or FPGAs, in communication with the controller 120, specifically configured to control navigational and/or data capture aspects of the apparatus 103. The client device 100 also includes one or more controllers or processors and/or FPGAs, in communication with the controller 120, specifically configured to process (e.g. to display) notifications received from the server 101.

[0028] The server 101 also includes the above-mentioned communications interface 124 interconnected with the processor 120. The communications interface 124 includes suitable hardware (e.g. transmitters, receivers, network interface controllers and the like) allowing the server 101 to communicate with other computing devices – particularly the apparatus 103, the client device 105 and the dock 108 – via the links 107 and 109. The links 107 and 109 may be direct links, or links that traverse one or more networks, including both local and wide-area networks. The specific components of the communications interface 124 are selected based on the type of network or other links that the server 101 is required to communicate over. In the present example, as noted earlier, a wireless local and wide area networks are implemented within the retail environment via the deployment of one or more wireless access points and/or wide area network communication interfaces. The links 107 therefore include either or both wireless links between the apparatus 103 and the mobile device 105 and the above-

mentioned access points, and a wired link (e.g. an Ethernet-based link) between the server 101 and the access point.

[0029] The memory 122 stores a plurality of applications, each including a plurality of computer readable instructions executable by the processor 120. The execution of the above-mentioned instructions by the processor 120 configures the server 101 to perform various actions discussed herein. The applications stored in the memory 122 include a control application 128, which may also be implemented as a suite of logically distinct applications. In general, via execution of the control application 128 or subcomponents thereof, the processor 120 is configured to implement various functionalities. The processor 120, as configured via the execution of the control application 128, is also referred to herein as the controller 120. As will now be apparent, some or all of the functionality implemented by the controller 120 described below may also be performed by preconfigured hardware elements (e.g. one or more Application-Specific Integrated Circuits (ASICs)) rather than by execution of the control application 128 by the processor 120.

[0030] In the present example, in particular, the server 101 is configured via the execution of the control application 128 by the processor 120, to control the apparatus 103 to capture shelf data, to obtain the captured shelf data and process the data to detect status information for the products 112, and to generate status notifications.

[0031] Turning now to FIG. 2, before a discussion of the components and operation of the application 128, the apparatus 103 will be described in greater detail. The apparatus 103 includes a chassis 200 containing a locomotive mechanism 202 (e.g. one or more motors driving wheels, tracks or the like). In one embodiment, depicted in Figure 2A, a controller 220 (for example, a processor, ASIC and/or FPGA) configured to control navigational and/or data capture aspects of the apparatus 103 is also housed within the chassis 200. The controller 220 may control the locomotive mechanism to move the apparatus 103, for example via the execution of computer-readable instructions such as a navigation application 228 stored in a memory 222. The memory 222 may also store a repository 232 containing, for example, a map of the environment in which the apparatus 103 operates, for use during the execution of the application 228. The

apparatus 103 may communicate with the server 101 via a communications interface 224, for example to exchange command and control data with the server 101.

[0032] The apparatus 103 further includes a sensor mast 204 supported on the chassis 200 and, in the present example, extending upwards from the chassis 200. The mast 204 supports the sensors 104 mentioned earlier. In particular, the sensors 104 include at least one imaging sensor 208, such as a digital camera, as well as at least one depth-sensing sensor 212, such as a 3D digital camera. The apparatus 103 also includes additional depth sensors, such as LIDAR sensors 216, in the present example. The sensors 208, 212, 216 are oriented on the mast 204 such that the fields of view of each sensor face a shelf along which the apparatus 103 is travelling. In other examples, the apparatus 103 includes additional sensors, such as one or more RFID readers, temperature sensors, structured light imaging sensors, and the like.

[0033] Turning now to FIG. 3, certain components of the application 128 will be described in greater detail. As will be apparent to those skilled in the art, in other examples the components of the application 128 may be separated into distinct applications, or combined into other sets of components. Some or all of the components illustrated in FIG. 3 may also be implemented as dedicated hardware components, such as one or more ASICs or FPGAs. For example, in one embodiment, to improve reliability and processing speed, at least some of the components of FIG. 3 are programmed directly into the imaging controller 120, which may be an FPGA or an ASIC having circuit and memory configuration specifically designed to optimize image processing and detection of high volume price label image data being received from the mobile automation apparatus 103. In such an embodiment, some or all of the control application 128, discussed below, is an FPGA or an ASIC chip.

[0034] The control application 128 includes a mobile apparatus controller 300 configured to generate data capture instructions for the apparatus 103, deliver the data capture instructions to the apparatus 103, and obtain data captured by the apparatus 103 for storage in the repository 132. The control application 128 also includes a primary object generator 304 and a secondary object generator 308 configured to generate primary data objects and secondary data objects, respectively, as will be discussed below in greater detail. Further, the control application 128 includes a detector 312

configured to detect and classify mismatches between the secondary data objects provided by the generator 308 and reference data stored in the repository 132. The control application 128 also includes a notifier 316 configured to generate status notifications – for example, for transmission to the client device 105 – based on the mismatches identified by the detector 312.

[0035] The functionality of the control application 128 will now be described in greater detail, with reference to the components illustrated in FIG. 3. Turning to FIG. 4, a method 400 of object status detection is shown. The method 400 will be described in conjunction with its performance on the system 100 as described above.

[0036] At block 405, the controller 120, and particularly the mobile apparatus controller 300 of the control application 128, is configured to detect a data capture initiation event. The data capture initiation event, in some examples, is a preconfigured event stored in the repository 132. For example, the repository 132 can contain a schedule of data capture operations, and the apparatus controller 300 is therefore configured, based on a system time maintained by the controller 120, to determine whether the current time matches a scheduled data capture operation. In other examples, the data capture initiation is received at the server 101 (and specifically at the apparatus controller 300) as a request from the client device 105. In some examples, the client device 105 is configured to present on a display a layout of the retail environment and receive a selection of one or more areas of the retail environment (e.g. a selection of the shelves 110) in which to initiate a data capture operation. The client device 105 is configured, responsive to such a selection, to transmit a request to the server 101 via a link 107. The detection at block 405 in such examples is therefore the receipt, at the apparatus controller 300, of the request from the client device 105.

[0037] At block 410, having detected a data capture initiation event, the apparatus controller 300 is configured to generate data capture instructions and transmit the data capture instructions to the apparatus 103 for execution. The data capture instructions identify a region within the retail environment to be traversed by the apparatus 103 during the data capture operation. The region is identified in a common frame of reference, such as a predefined coordinate system for the retail environment. In one embodiment, the apparatus 103 is provisioned with a map of the retail environment,

and is configured to navigate, with or without additional control data from the server 101, to and within the target region identified by the data capture instructions. As will be apparent to those skilled in the art, various navigational techniques are available for use by the apparatus 103, including the above-mentioned map, as well as path planning operations, odometry and the like. For instance, in one embodiment, as an alternative or in addition to using a predetermined map of the retail environment, the apparatus 103 surveys the 3D map structure of the retail environment using 3D point data generated by one or more of its sensors and uses the surveyed 3D point data for navigation.

[0038] The data capture instructions may also specify other parameters for the data capture operation. Such parameters can include a travel speed for the apparatus 103, a frame rate for image capture, a target distance to maintain between the shelves 110 and the sensors 104 (e.g. the cameras 208). In other examples, such parameters are omitted and the apparatus 103 is instead configured to execute the data capture instructions according to an internally programmed set of parameters. In the present example, the apparatus 103 is configured to perform data capture operations travelling at speeds of about 0.3 m/s and with a frame capture rate of between 3 and 5 frames per second. Further, the apparatus 103 in the present example is configured to maintain a distance of about 60 cm between the mast 204 and the shelf 110 being captured. Thus, each image captured depicts a section of a shelf 110 with a width of about 31 cm, and a frame is captured every 6-10 cm of horizontal travel (dependent on the speed of travel). As a result, each position on the shelf 110 is imaged between three and five times during a data capture operation.

[0039] In some environments, the apparatus controller 300 is configured to perform additional functions at block 410 in association with the generation and transmission of data capture instructions. Referring to FIG. 5, a method of performing block 410 is depicted. In particular, at block 500, the apparatus controller 300 is configured to select an apparatus 103 to perform the data capture operation initiated at block 405. When more than one apparatus 103 is deployed in a retail environment, the apparatus controller 300 is configured to store status information corresponding to each apparatus 103. The status information includes the current location of the apparatus 103, a battery (or other energy source, such as fuel) level, whether a data capture operation has already

been assigned to the apparatus 103, and the like. At block 500, the apparatus controller 300 is configured to compare the data capture operation parameters (e.g. a region of the environment identified in a data capture request received at block 405) with the apparatus status information, and to select an apparatus 103 to execute the data capture operation. For example, the apparatus controller 300 can be configured to select an apparatus 103 having no current data capture assignment and a minimum threshold battery level.

[0040] At block 505, the apparatus controller 300 is configured to determine whether the requested (or otherwise initiated) data capture operation exceeds one or more operational capacities (e.g. range, on-board data storage) of the selected apparatus 103. The required travel distance of the data capture operation is determined based on the region of the retail environment to be traversed for the data capture operation, as mentioned above. If the determination at block 505 is affirmative, the apparatus controller 300 is configured, at block 510, to decompose the data capture operation by generating a package of sub-operations. Each sub-operation can, for example, include an instruction to return to the dock 108 for data transfer, recharging, or both. For example, if the requested data capture operation identifies the shelves 110-1 and 110-2, at block 510 the apparatus controller 300 can be configured to generate a package containing a first sub-operation identifying the shelf 110-1, and a second sub-operation identifying the shelf 110-2.

[0041] At block 515, the apparatus controller 300 is configured to transmit the sub-operation package, or the single operation as applicable (e.g. in the event of a negative determination at block 505) to the selected apparatus 103 via the link 107. The apparatus 103 is configured to execute the received data capture operation or sub-operations. In particular, the apparatus 103 is configured to traverse the identified region, capturing image data and depth measurements. The captured data is typically stored in on-board memory of the apparatus 103, for transfer to the server 101 after data capture is complete (e.g. via the dock 108). In other examples, however, the data is transferred to the server 101 wirelessly (e.g. over the link 107) during the data capture operation.

[0042] At block 520, the apparatus controller 300 is configured to determine whether any errors have been detected in connection with the data capture instructions sent at block 515. The apparatus 103 is configured to transmit error messages over the link 107 to the server 101 upon detecting any of a variety of operational errors during the execution of data capture instructions. Examples of such operational errors include a low battery, a sensor failure (e.g. the failure of one or more cameras 208), a path planning failure (e.g. resulting in the apparatus 103 becoming stuck) and the like. If the determination at block 520 is affirmative, the apparatus controller 300 is configured to return to block 500 to re-assign the failed data capture operation. In other examples, the apparatus controller 300 is configured to reassign the data capture operation only for certain types of errors. For other errors, the apparatus controller 300 is configured, prior to aborting and reassigning a data capture operation, to provide the apparatus 103 with intermediary instructions, such as returning to the dock 108 for charging, maintenance of the like, before returning to the data capture operation.

[0043] Returning to FIG. 4, following the transmission of data capture instructions, the apparatus controller 300 is configured to receive and store captured data from the apparatus 103. The captured data, as shown in FIG. 6, includes a plurality of images of at least one shelf 110, as well as depth measurements registered with the images (via calibration data stored by the apparatus 103 and specifying the physical relationships between image sensors 208 and depth sensors 212, 216). Each image is accompanied by a timestamp, as well as a location identifier specifying the location within the above-mentioned common frame of reference at which the image was captured.

[0044] The apparatus 103 is configured, in some examples, to perform certain pre-processing operations on the captured data prior to transferring the captured data to the server 101 (e.g. via the dock 108). For example, the apparatus 103 can be configured to downsample the captured images, or portions thereof. More specifically, the apparatus 103 can be configured to perform a barcode-detection operation on the images, and to downsample the regions of each image that do not depict a barcode, while maintaining the original resolution of regions in the images depicting barcodes. In other examples, however, such pre-processing is omitted.

[0045] FIG. 6 depicts a set of three images 600-1, 600-2 and 600-3 of the shelf 110-1 received and stored in the repository 132 at block 415. As will be apparent, the images 600 depict overlapping portions of the shelf 110-1. The images 600 depict products 112 supported on the shelf 110-1, as well as the shelf back 116-1, the shelf edge 120-1, and labels 604. The products 112, shelf back 116-1, shelf edge 120-1 and any other objects depicted in the images 600, however, are not identified in a machine-readable manner when the image data is received and stored in the repository 132 at block 415.

[0046] At block 420, the primary object generator 304 is configured to generate a plurality of primary objects based on the captured data received at block 415. The primary object generator 304 may include a number of sub-components (not shown) each configured to detect a given type of primary object in the captured data. The objects detected in the captured data, for which primary data objects are generated at block 420, include gaps between products 112 (e.g. generated by a gap detection sub-component), and product indicators corresponding to the products 112 themselves (e.g. generated by a product/item recognition engine). The primary data objects can also include shelf edges (e.g. generated by a shelf structure detection subcomponent), labels (e.g. generated by a label detection subcomponent), and the like.

[0047] Each primary data object generated at block 420 includes a location, which may be indicated by a bounding box overlaid on the relevant image, as well as one or more object attributes. In other examples, the bounding box is stored (e.g. as coordinates) separately from the image, or in image metadata. The object attributes include an object type, defining the type of the primary data object. Additional attributes may also be included, such as a confidence value indicating the level of confidence of the relevant sub-component that the primary data object correctly identifies a corresponding object depicted in the image data. Further attributes may also be included in primary data objects dependent on the type of the object.

[0048] Turning to FIG. 7, various primary objects are illustrated in connection with the images 600, following the performance of block 420. In particular, a shelf edge object 700 is shown in connection with each image 600, and includes a location attribute (illustrated by the bounding boxes in FIG. 7). Also shown in FIG. 7 are gap objects 704, each indicating a gap between products 112 (i.e. a space where the shelf back 116 is

visible to the imaging sensors of the apparatus 103). Each gap object includes a location attribute and a type attribute. The primary data objects also include label objects 708, each indicating the presence of a label in the underlying image data, as well as product indicators 712, each indicating the presence of a product 112 in the underlying image data. The label indicators 708 can include, in addition to the location and type attributes, price text string attributes, barcode location (or decoded barcode data) attributes, and the like. The product indicators 712 include location and type attributes, as well as product identifier attributes (e.g. corresponding to a SKU or other identifier of the product depicted in the image).

[0049] Returning to FIG. 4, at block 425 the secondary object generator 308 is configured to generate a set of secondary data objects based on the primary data objects, and to store the secondary data objects in the repository 132. The secondary data objects may be generated by the above-mentioned sub-components configured to generate the primary data objects; in other words, in some examples the primary object generator 304 and the secondary object generator 308 are integrated with each other.

[0050] As will be apparent from FIG. 7, at least some of the primary data objects are redundant. For example, the gap data objects 704-2 generated from the image 600-2 represent the same actual gaps on the shelf 110 as the gap data objects 704-3 generated from the image 600-3. The secondary object generator 308 is configured to detect and consolidate such redundant sets of primary data objects. The secondary object generator 308 is configured to perform such consolidation by identifying subsets of the primary data objects that have the same object type and that have overlapping locations in the common frame of reference. Having identified such a subset, the secondary object generator 308 is configured to generate a single secondary data object from the subset. Generation of the secondary data object is performed, in some examples, by selecting one of the subset of primary data objects (e.g. the primary data object with the greatest associated confidence level) and discarding the remainder. This may be performed in connection with primary data objects containing price text strings, for example.

[0051] In other examples, the secondary object generator 308 is configured to generate the secondary data object by averaging or weighting the subset of primary data objects. In further examples, the secondary data object is generated with a location (e.g. a

bounding box) consisting of the common portion of the primary data object locations (that is, the area that is shared by all primary data objects in the subset).

[0052] Turning to FIG. 8A, a set of secondary data objects is shown overlaid on the registered images 600-1, 600-2 and 600-3. In particular, three secondary gap objects 800-1, 800-2 and 800-3 are illustrated, consolidated from the six primary gap objects 704 illustrated in FIG. 7. Further, three product indicator data objects 804-1, 804-2 and 804-3 and four label data objects 808-1, 808-2, 808-3 and 808-4 are shown, consolidated from the primary product indicator objects 712 and the primary label objects 708 of FIG. 6, respectively. Further, a secondary shelf edge data object 812 is shown, consolidated from the three primary shelf edge data objects 700 illustrated in FIG. 7.

[0053] The set of secondary data objects generated at block 425 is stored in conjunction with the image data in the repository 132. The storage image data and secondary data objects may also be referred to as a "realogram", representing the current (as of the data capture operation) state of the retail environment. In other examples, the secondary data objects are stored in a data structure associated with the image data (instead of the overlay shown in FIG. 8A), such as a tree structure in which the secondary data objects are assigned to hierarchical nodes. FIG. 9 illustrates an example tree data structure 900, in which a root node 904 corresponds to the retail environment itself, and includes attributes such as a street address, store number, format, and the like. The data structure 900 further includes a first layer of child nodes each corresponding to a shelf module 110. Each shelf module 110, in turn has child nodes corresponding to the shelf structure (e.g. shelf edge secondary data objects), which in turn have child nodes corresponding to products, gaps, labels and the like. The secondary data objects shown in FIG. 8 are arranged in the data structure 900. Additional data capture operations may be performed in order to construct the data structure 900 for the shelf modules 110-2 and 110-3.

[0054] Following the generation and storage of the secondary data objects, the primary data objects are discarded in the present example. In other examples, however, the primary data objects are maintained in the repository 132.

[0055] Referring again to FIG. 4, at block 430 the detector 312 is configured to retrieve reference data from the repository 132, such as a realogram constructed from a data

capture operation performed when the retail environment is at a "full stock" state, or a planogram. FIG. 8B illustrates an example planogram 816 (more specifically a portion of a planogram depicting the same shelf module as the secondary data objects and image data shown in FIG. 8A). The planogram 816 includes reference indicators 820-1, 820-2, 820-3, and 820-4 corresponding to distinct products 112, and each defining reference locations, for example via a bounding box within the common frame of reference. Each indicator 820 also includes a product identifier, such as a text string (as shown in FIG. 8B), a SKU number or the like. Thus, the indicator 820-3 indicates that within the location on the shelf 110-1 corresponding to the bounding box of the indicator 820-3, a box of "Acme Crunch" is expected to be present. The planogram 816 also includes reference indicators 824-1, 824-2, 824-3, and 824-4 corresponding to labels associated with the products 112, and a reference shelf edge indicator 828.

[0056] At block 430, the detector 312 is configured to identify mismatches between the reference data and the secondary data objects, and to generate mismatch records corresponding to any detected mismatches. The identification of mismatches is performed by the detector 312 by comparing the reference indicators to the secondary data objects having locations coinciding with the reference indicators. The detector 312 is also configured, in examples in which the secondary data objects are stored in a tree structure such as that shown in FIG. 9, to convert the reference data to a corresponding tree structure prior to performing the comparison. For example, the repository 132 or the detector 312 can store a set of conversion rules, defining node types and expected node attributes with which to convert each reference indicator into a node in a tree structure.

[0057] Each mismatch record generated at block 430 identifies a product, label, shelf structure or the like corresponding to the reference indicator that does not match the secondary data objects. The mismatch record also includes a mismatch type and a location of the mismatch (i.e. the location of the reference indicator). The mismatch type indicates, for example, whether a product is missing (i.e. out of stock), partially depleted (i.e. low stock), incorrectly located on the shelf 110 (i.e. a "plug" and/or "spread"), and the like. Other examples of mismatch status indicators include missing labels, incorrect price text on labels, improperly arranged products on the shelves 110 (e.g. a product that is improperly angled relative to the shelf edge). Additional examples

of mismatch status will occur to those skilled in the art. Table 1 below illustrates example mismatch records generated at block 430 from the current and reference data shown in FIGS. 8A and 8B.

Table 1: Mismatch Records

Reference ID	Mismatch Type	Location
Acme Oatmeal	Out of stock	[X, Y, Z]
Acme Oatmeal Label	Missing Label	[X, Y, Z]
Acme Crunch	Incorrect Label Price	[X, Y, Z]

[0058] At block 435, the notifier 316 is configured whether to generate notifications for one or more of the mismatch records generated by the detector 312 at block 430. The determination at block 435 includes, for example, a determination of whether a previous notification has been generated for a mismatch record having the same type and location within a configurable time period (e.g. up to two hours ago). The determination at block 435 can also be based on the type of each mismatch record. For example, the notifier 316 can be configured to generate notifications only for certain types of mismatches (e.g. out of stock mismatches). In further examples, the notifier 316 is configured to generate notifications only for certain locations in the retail environment at different times of day.

[0059] When the determination at block 435 is negative, the performance of the method 400 returns to block 405 for further data capture. When the determination is affirmative, however, the notifier 316, in block 440, is configured to select a subset of the mismatch records for which to generate one or more notifications, and to generate and transmit one or more status notifications to the client device 105. Each status notification indicates, for one or more mismatch records, the relevant label, product or the like (corresponding to the reference identifier in the mismatch record), the mismatch type, and the location of the mismatch. Each status notification also contains, in some examples, an identifier of a client application executing on the client device 105. The application identifier corresponds to one of a plurality of applications executing on the client device 105, and instructs the client device 105 to handle the status notification via that one of the applications. The client device 105 can therefore executed a number

of applications, each directed to receiving and resolving different types of status notifications.

[0060] The notifier 316 is also configured, in some examples, to select a subset of client devices 105, when a plurality of client devices 105 are deployed in the system 100, to receive status notifications. Such a selection may be based, for example, on the location of the client devices 105 within the retail environment. The selection can also be based on roles assigned to the client devices 105 and stored in the repository (e.g. a stocking role, a label maintenance role, and the like).

[0061] Responsive to transmitting the status notifications, the notifier 316 is also configured to track the status notifications. In particular, the notifier 316 stores a record of any status notifications transmitted, and an indication of whether each status notification has been resolved (e.g. via the receipt of a message at the server 101 identifying a status notification and indicating that the corresponding mismatch has been resolved).

[0062] Variations to the above are contemplated. For example, the system 100 can also include an intermediate server (not shown) in communication with the server 101. Rather than sending and receiving data (e.g. data capture requests, status notifications and the like) directly to and from the client device 105, the server 101 is configured in such examples to exchange the above-mentioned data with the intermediate server, which is then configured to exchange the data with the client device 105.

[0063] FIGs. 10-11 illustrate a further embodiment of a method of generating electronic notifications, for example responsive to product status detection and generation of corresponding mismatch records of block 430 of FIG. 4. Referring to FIG. 10, in blocks 1000-1002, the notifier 316 of the server 101 identifies a mismatch record as discussed above, for example by detecting an out-of-stock item, and determines whether the corresponding item has been previously detected as being out-of-stock. If the answer is Yes, processing continues to point A in FIG. 11, which is discussed in further detail below. Otherwise, in block 1004, if the item has not been previously detected to be out-of-stock, the notifier 316 queries a database, such as a planogram database server system 1003 that also stores a realogram with the captured secondary data objects, to determine whether additional quantities of the out-of-stock item are available at the top

shelf of the same, or nearby, aisle/location based on the realogram. If the answer is Yes, the notifier 316 generates an electronic notification to restock the missing item from the top of the shelf, block 1006. In an embodiment, the electronic action notifications generated by the notifier 316 are pushed to one or both the backend order entry computer system 1005 and the client computing device 105 (FIG. 1). If the item is not available from the top shelf at the same, or nearby, location, in block 1008, the notifier 316 queries the database 1003 to determine whether the item exists at other shelf locations. If the answer is Yes and the item is actually stocked at the other shelf location(s) (e.g., based on checking realogram data), then the notifier 316 generates a notification to restock the item from the other shelf location(s), blocks 1010, 1012. If the item is either not supposed to be stocked at the other shelf location(s) or is out-of-stock at the other shelf location(s), the notifier 316 checks whether the out-of-stock item is supposed to be stocked (and whether it is actually stocked) at an endcap of one or more aisles, block 1014. When the item is at an end cap of one or more aisles, the notifier 316 generates a restock from end cap action alert, block 1016. Otherwise, in block 1018, the notifier 316 checks the inventory computer system 1017 whether the item is stocked in the backroom. If the item is stocked in the back room, in block 1020, the notifier 316 generates a restock from back room action alert. Otherwise, the notifier 318 determines whether the item is still a valid product, block 1022. If the item no longer corresponds to a valid product, the process stops and no action alert is generated, block 1024. Otherwise, in block 1026, the notifier 316 queries the order entry computer system 1005 to determine whether an order has been placed for the out-of-stock item and generates an electronic notification to place the order when the order has not been placed (block 1028). If, on the other hand, the order had previously been placed and a predetermined time interval has lapsed, the notifier 316 generates an order status inquiry alert, blocks 1030, 1032. If the predetermined time interval has not yet passed, no additional action alert is generated.

[0064] Referring to FIG. 11, when in blocks 1000, 1002 of FIG. 10 the notifier 316 determines that the mismatch record corresponding to an item has already been previously detected (e.g., an item has previously been determined to be out-of-stock), the notifier 316 determines whether an order has been placed or a restock action has been generated, block 1100. If the order for an item has already been placed, the notifier

316 determines whether a predetermined time period has passed from the order entry date and, if so, generates an order status inquiry action, blocks 1102, 1104, 1106. If the predetermined time period has not yet passed, no further action is requested, block 1110. In blocks 1108, 1112, when a restock alert has been previously generated, the notifier 316 determines whether a person has been dispatched. If the dispatched person has completed the action corresponding to the restock alert, no further action alerts are generated, blocks 1114, 1116. Otherwise, in blocks 1118, 1120, the notifier 316 determines whether a predetermined time period has passed, and if so, generates a reminder action alert. In blocks 1112, 1122, 1124, if a person has not yet been dispatched in response to a prior restock alert, the notifier 316 transmits the restock action alert to a person selected among the available personnel (e.g., based on tracking the task completion status input from a plurality of mobile devices operated by the facility personnel). In blocks 1126, 1128, when personnel to act on the outstanding restock action alert is not available, the notifier 316 checks whether the mobile automation apparatus 103 is available (e.g., whether the mobile automation apparatus is currently idle and is scheduled to remain idle for a time period estimated for the restocking action to be executed). In block 1130, if the mobile automation apparatus is available, the server 101 dispatches the mobile automation apparatus 103 to perform the restocking action (e.g., delivering the out-of-stock item to the designated location in an aisle for further handling by the store personnel). In one embodiment, the designated location to which the mobile automation apparatus delivers the out-of-stock item is the location of the missing item according to the planogram and/or realogram. In another embodiment, the location to which the mobile automation apparatus delivers the out-of-stock item is designated by the store personnel via the mobile device 105. Finally, in block 1132, if the mobile automation apparatus 103 is not available, the notifier 316 generates a notification regarding current resource unavailability to address the out-of-stock issue and forwards this notification to a communication device associated with a designated user, such as a store manager.

[0065] Embodiments of the above method of generating electronic notifications involve a multiple layered solution that addresses each of the problems outlined above so that the entire shelf management problem can be solved. An embodiment of this solution consists of the following layers:

[0066] Problem Detection layer;

[0067] Solution Generation layer;

[0068] Actor Selection layer; and

[0069] Action tracking layer;

[0070] As described above, the problem detection layer generates a list of problems from a scan of the shelf contents. Each problem will be time and location tagged. An embodiment of the solution generation layer involves specific programming of a rules based or machine learning engines (such as a Drools rules engine and/or neural networks or the like) to select the best action based upon the various inputs and desired behaviors. In an embodiment, there are interfaces to data bases that store:

[0071] Problems just discovered;

[0072] Problem priority (e.g. revenue impact of the problem);

[0073] Previously discovered problems (including copies of recently discovered problems);

[0074] Actions performed on previously discovered problems;

[0075] There may also be interfaces to computer systems that contain:

[0076] Product inventory;

[0077] Location of product;

[0078] Current and pending orders;

[0079] Product price;

[0080] Desired product location and quantity;

[0081] An embodiment of the specially configured rules operate on the combined set of problems and other sources of data to select the proper action. It should be noted that other techniques besides rules may be used to select correct action. One could utilize a neural network /AI (artificial intelligence) framework that would be "trained" to select the proper action. As those of ordinary skill in the art will realize, such a framework would be more flexible than a rules based engine but may take more time to create.

[0082] The foregoing description, including FIGs. 10-11, shows a typical decision process for dealing with an item that is out of stock in one location within a retail store. Depending on whether the problem has been seen before, whether the product is present

at other locations within the store, and/or whether an order has already been placed for more of the item, different types of actions will be generated.

[0083] The Actor selection layer will select the proper person, role, or autonomous system to perform each action. It will use a specially configured rules engine (or neural network) that will operate on the following data items in order to select the proper person, role, or system for the action:

[0084] The specific action;

[0085] Whether an autonomous system exists that can perform the action;

[0086] If there is not a suitable system, then:

[0087] The skills of each staff member;

[0088] The work schedule of each staff member;

[0089] The number of assigned action to each staff member;

[0090] In an embodiment, the rules engine will assign the action to the autonomous system or staff member best suited for the particular action. It may be that both a system and multiple staff are able to perform the action and so the system may assign the action to both a system as well as one or more personnel. If no system is available, then the action may be assigned to one or more personnel. Actions may also be assigned to "roles" (such as store manager) rather than to individual people. This may apply when several people are assigned to the position rather than just one.

[0091] An embodiment of the action tracking layer will notify each staff member of the actions assigned to them and monitor how long it takes them to accomplish it. It may also schedule an autonomous system to do the action. Each staff member will have a to do list that contains a prioritized list of actions to be taken and a means to indicate the action has been completed. It will also contain a means for a staff member to indicate that an action could not be completed along with a reason (e.g., via a mobile device with various modalities, such as voice, data, visual user interface, heads up display, and the like).

[0092] The results of the action tracking layer will be analyzed to determine the performance of each staff member as well as to determine the expected time to complete each type of action based upon the experiences of similar actions. If an action cannot

be completed, the problem and action will be resubmitted to the solution generation layer in order to devise a new action. The action tracking system will also monitor the performance of autonomous systems, including one or more mobile automation apparatuses described above, to see how well they perform the assigned tasks, including tracking the time of task completion, which may be used for notification and/or task flow adjustments.

[0093] In the foregoing specification, specific embodiments have been described. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present teachings.

[0094] The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims. The invention is defined solely by the appended claims including any amendments made during the pendency of this application and all equivalents of those claims as issued.

[0095] Moreover in this document, relational terms such as first and second, top and bottom, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," "has", "having," "includes", "including," "contains", "containing" or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises, has, includes, contains a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element proceeded by "comprises ...a", "has ...a", "includes ...a", "contains ...a" does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises, has, includes, contains the element. The terms "a" and "an" are defined as one or more unless explicitly stated otherwise herein.

The terms "substantially", "essentially", "approximately", "about" or any other version thereof, are defined as being close to as understood by one of ordinary skill in the art, and in one non-limiting embodiment the term is defined to be within 10%, in another embodiment within 5%, in another embodiment within 1% and in another embodiment within 0.5%. The term "coupled" as used herein is defined as connected, although not necessarily directly and not necessarily mechanically. A device or structure that is "configured" in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

[0096] It will be appreciated that some embodiments may be comprised of one or more generic or specialized processors (or "processing devices") such as microprocessors, digital signal processors, customized processors and field programmable gate arrays (FPGAs) and unique stored program instructions (including both software and firmware) that control the one or more processors to implement, in conjunction with certain non-processor circuits, some, most, or all of the functions of the method and/or apparatus described herein. Alternatively, some or all functions could be implemented by a state machine that has no stored program instructions, or in one or more application specific integrated circuits (ASICs), in which each function or some combinations of certain of the functions are implemented as custom logic. Of course, a combination of the two approaches could be used.

[0097] Moreover, an embodiment can be implemented as a computer-readable storage medium having computer readable code stored thereon for programming a computer (e.g., comprising a processor) to perform a method as described and claimed herein. Examples of such computer-readable storage mediums include, but are not limited to, a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a ROM (Read Only Memory), a PROM (Programmable Read Only Memory), an EPROM (Erasable Programmable Read Only Memory), an EEPROM (Electrically Erasable Programmable Read Only Memory) and a Flash memory. Further, it is expected that one of ordinary skill, notwithstanding possibly significant effort and many design choices motivated by, for example, available time, current technology, and economic considerations, when guided by the concepts and principles disclosed herein will be readily capable of generating such software instructions and programs and ICs with minimal experimentation.

[0098] The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

CLAIMS

1. A product status detection system, comprising:

a mobile automation apparatus having a sensor configured to capture data representing a shelf supporting products, responsive to data capture instructions received at the mobile automation apparatus;

a server in communication with the mobile automation apparatus via a network, and having an imaging controller including:

a mobile apparatus processor configured to generate data capture instructions and transmit the data capture instructions to the mobile automation apparatus;

a repository configured to store captured data received via the network from the mobile automation apparatus;

a primary object generator configured to retrieve the captured data and generate a plurality of primary data objects from the captured data, each of the primary data objects including a location in a common frame of reference;

a secondary object generator configured to generate a set of secondary data objects based on the primary data objects, and to store the secondary data objects in the repository;

a detector configured to compare the secondary data objects with reference data obtained from the repository, and to generate mismatch records identifying mismatches between the reference data and the secondary data objects; and

a notifier configured to select a subset of the mismatch records, generate a status notification corresponding to the subset of mismatch records, and transmit the status notification via the network; and

a client computing device configured to receive the status notification via the network and display the status notification.

2. The system of claim 1, wherein the sensor of the mobile automation apparatus includes an image sensor and a depth sensor.

3. The system of claim 1, wherein the data capture instructions indicate a data capture region within the common frame of reference.

4. The system of claim 1, wherein the primary data objects include one or more of: an object indicator identifying a product supported on the shelf, a gap indicating a space between products on the shelf, and a shelf edge indicating the position of an edge of the shelf.

5. The system of claim 1, wherein generating the secondary data objects includes at least one of: (i) discarding a primary data object with a location matching the location of another primary data object, and (ii) merging at least two primary data objects.

6. The system of claim 1, wherein the server is further configured to discard the primary data objects responsive to generation of the secondary data objects.

7. The system of claim 1, wherein the secondary object generator is further configured to store the secondary data objects as nodes in a tree data structure.

8. The system of claim 7, wherein the detector further is configured to convert the reference data into a corresponding tree data structure, and to compare the nodes of the tree data structure with nodes of the corresponding tree data structure.

9. The system of claim 1, wherein each mismatch record includes a mismatch type identifier.

10. The system of claim 9, wherein the mismatch type identifiers are selected from the group consisting of: out of stock, low stock, and plug.

11. The system of claim 1, further comprising:

an intermediate server in communication with the server via the network, configured to receive the status alert from the server and transmit the status alert to the mobile device.

12. The system of claim 11, wherein the intermediate server is further configured to receive a data capture request from the mobile device, and to transmit the request to the server for generation of data capture instructions.

13. The system of claim 1, wherein the notifier transmits the status notification to the mobile automation apparatus.

14. The system of claim 13, wherein the status notification is a restocking notification.

15. The system of claim 13, wherein the status notification is a label correction notification.

16. The system of claim 9, wherein the mismatch type identifier is an incorrect label price identifier.

17. The system of claim 9, wherein the mismatch type identifier is a missing label identifier.

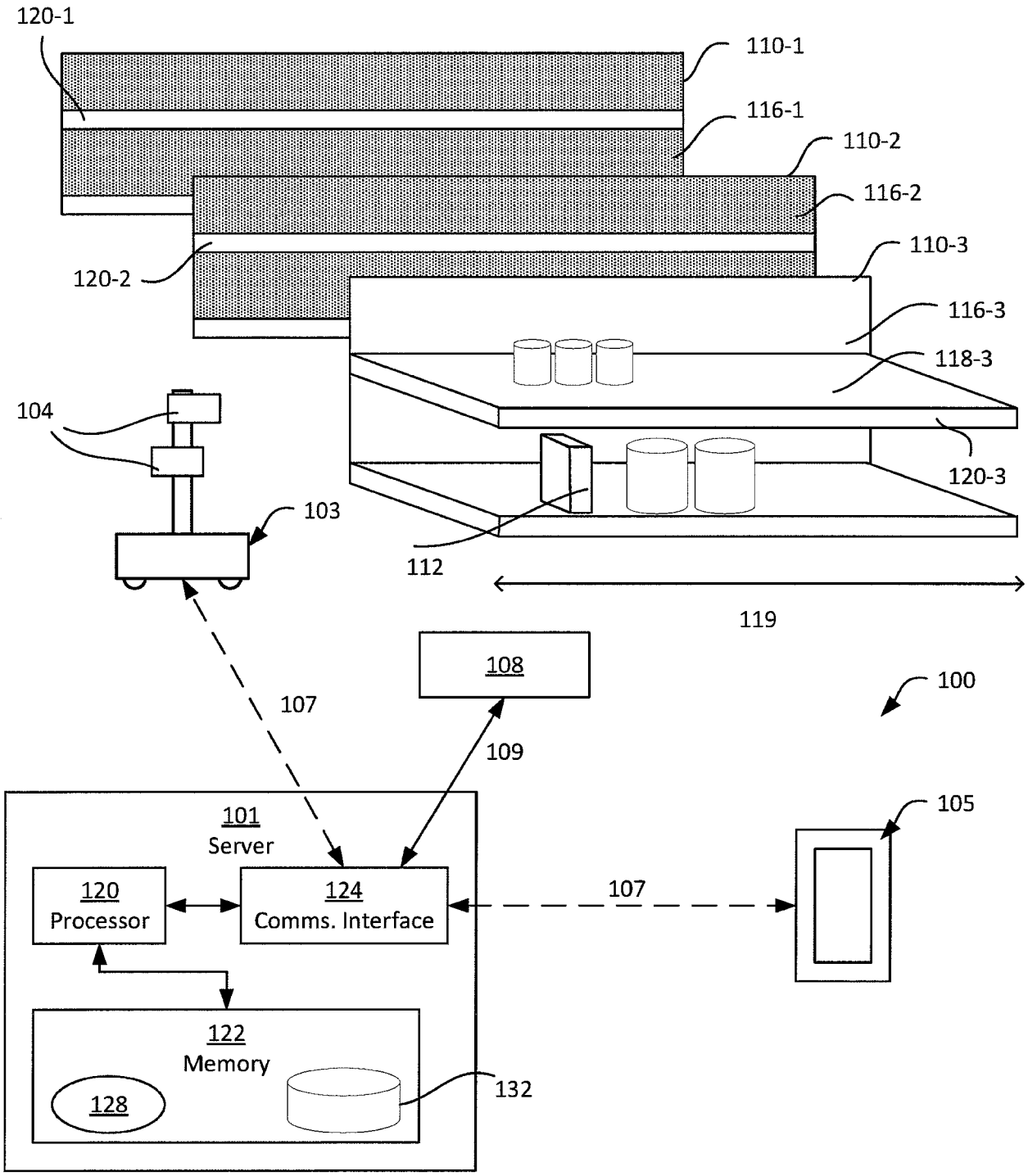
120-1
110-1
116-1
110-2
116-2
120-2
110-3
116-3
118-3
104
120-3
103
112
119
108
100
107
109
101
Server
105
120
Processor
124
Comms. Interface
107
122
Memory
128
132

FIG. 1

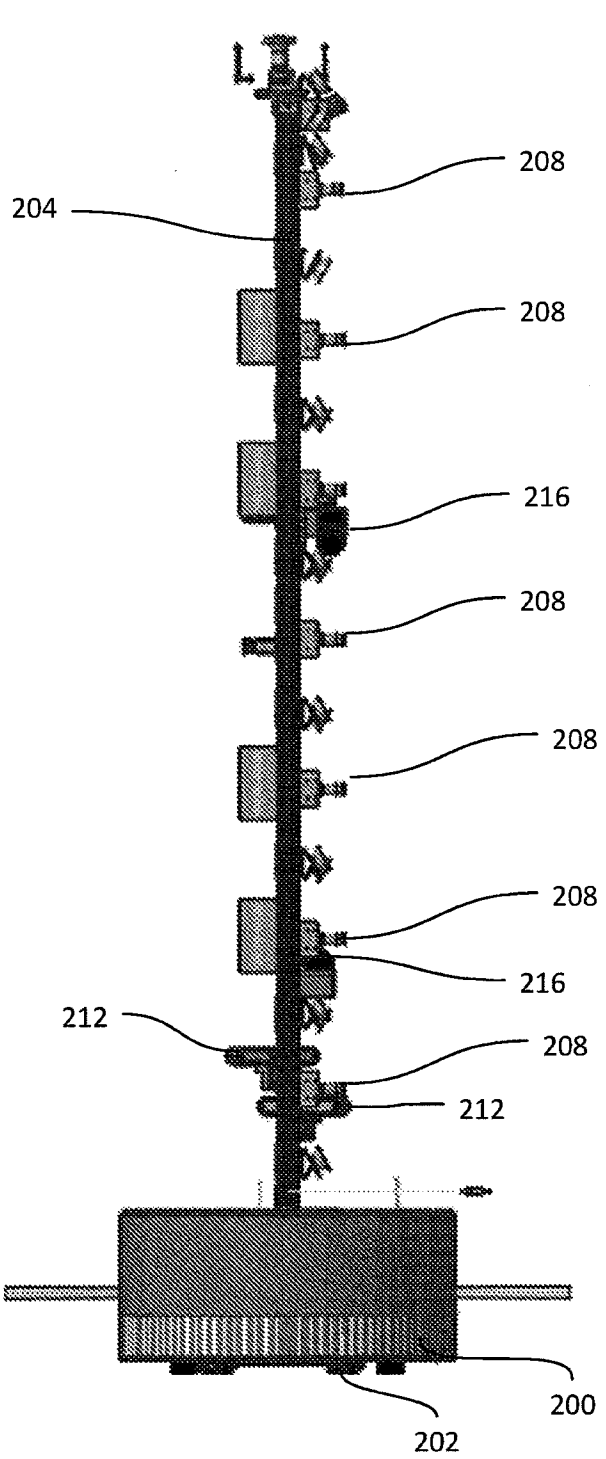
103
208
204
208
216
208
208
208
216
212
208
212
200
202

FIG. 2

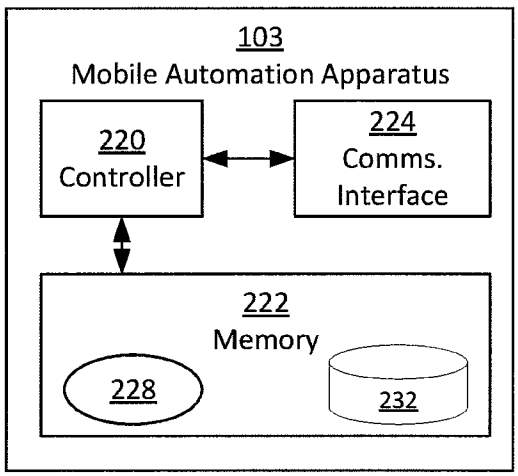
103
Mobile Automation Apparatus
220
Controller
224
Comms.
Interface
222
Memory
228
232

FIG. 2A

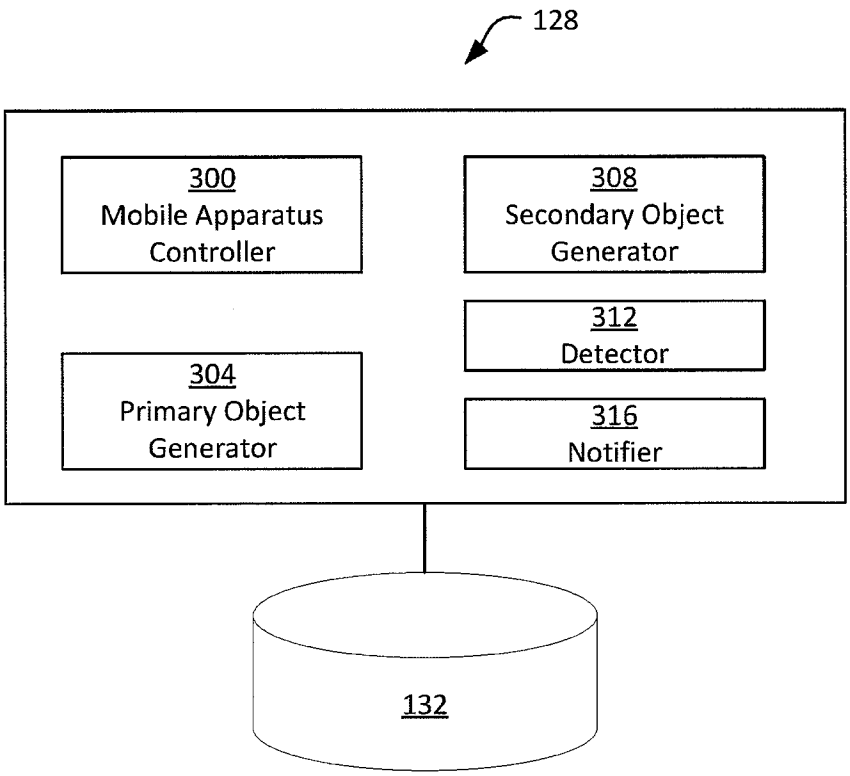
128
300
Mobile Apparatus Controller
308
Secondary Object Generator
312
Detector
304
Primary Object Generator
316
Notifier
132

FIG. 3

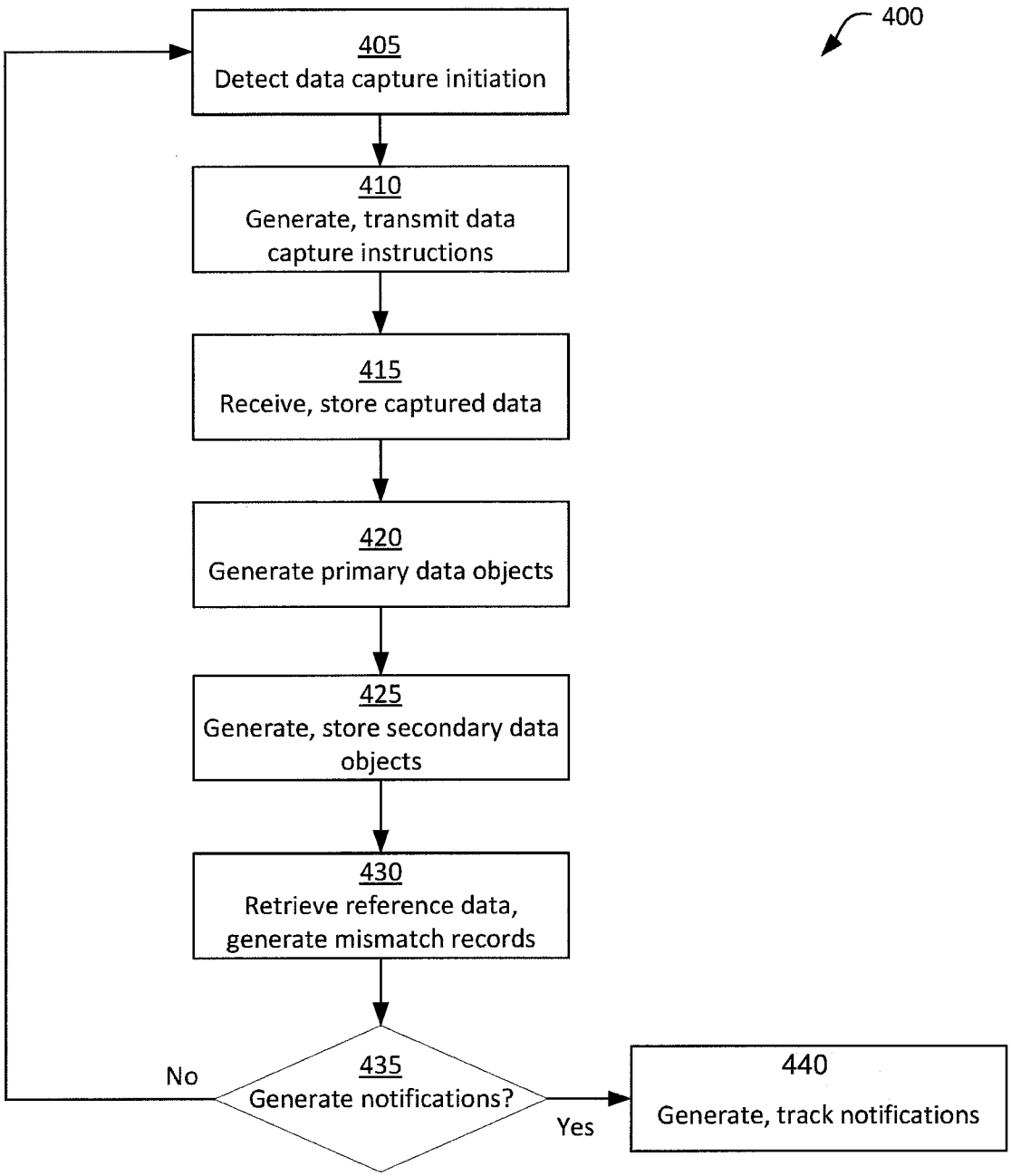
400
405
Detect data capture initiation
410
Generate, transmit data capture instructions
415
Receive, store captured data
420
Generate primary data objects
425
Generate, store secondary data objects
430
Retrieve reference data, generate mismatch records
435
Generate notifications?
No
Yes
440
Generate, track notifications

FIG. 4

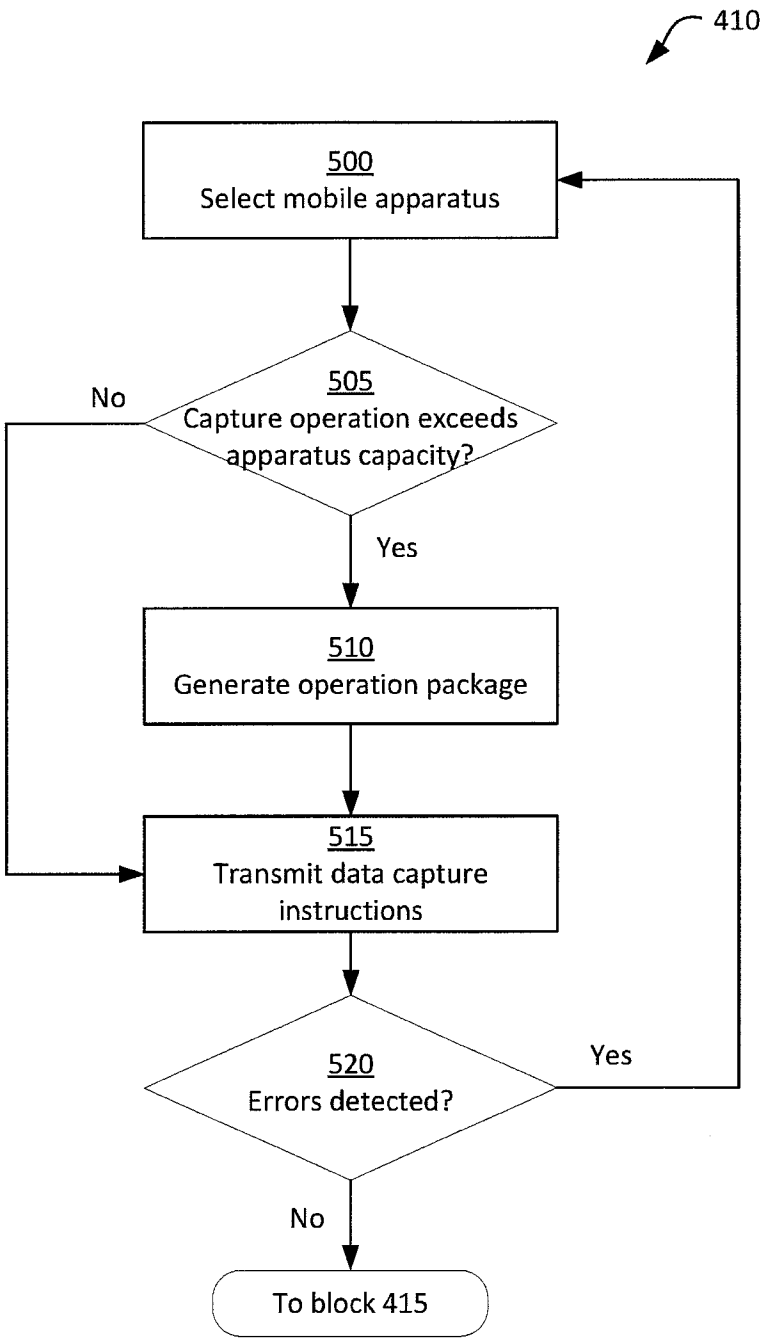
410
500
Select mobile apparatus
505
Capture operation exceeds apparatus capacity?
No
Yes
510
Generate operation package
515
Transmit data capture instructions
520
Errors detected?
Yes
No
To block 415

FIG. 5

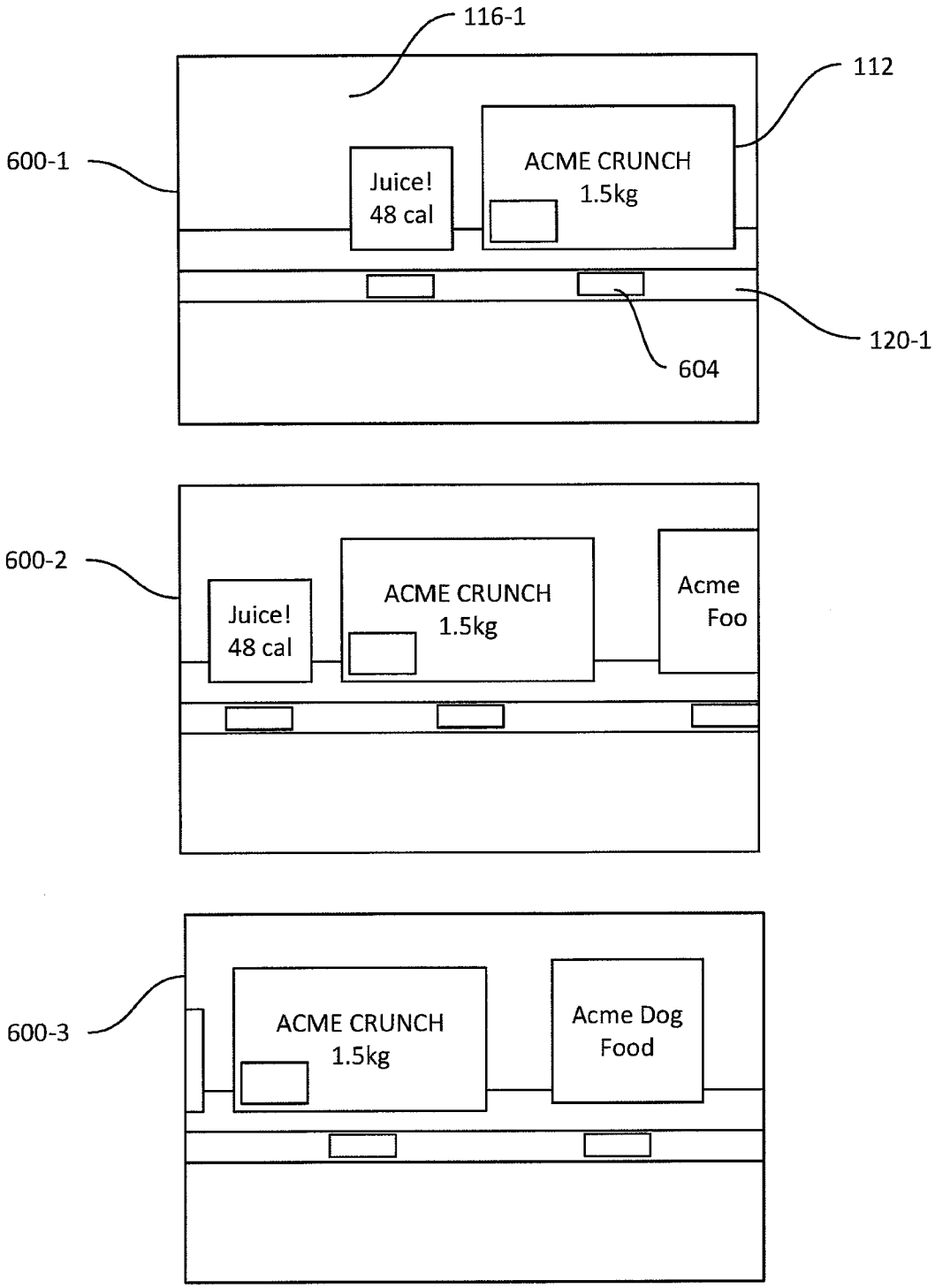
116-1
112
600-1
Juice!
48 cal
ACME CRUNCH
1.5kg
120-1
604
600-2
Juice!
48 cal
ACME CRUNCH
1.5kg
Acme
Foo
600-3
ACME CRUNCH
1.5kg
Acme Dog
Food

FIG. 6

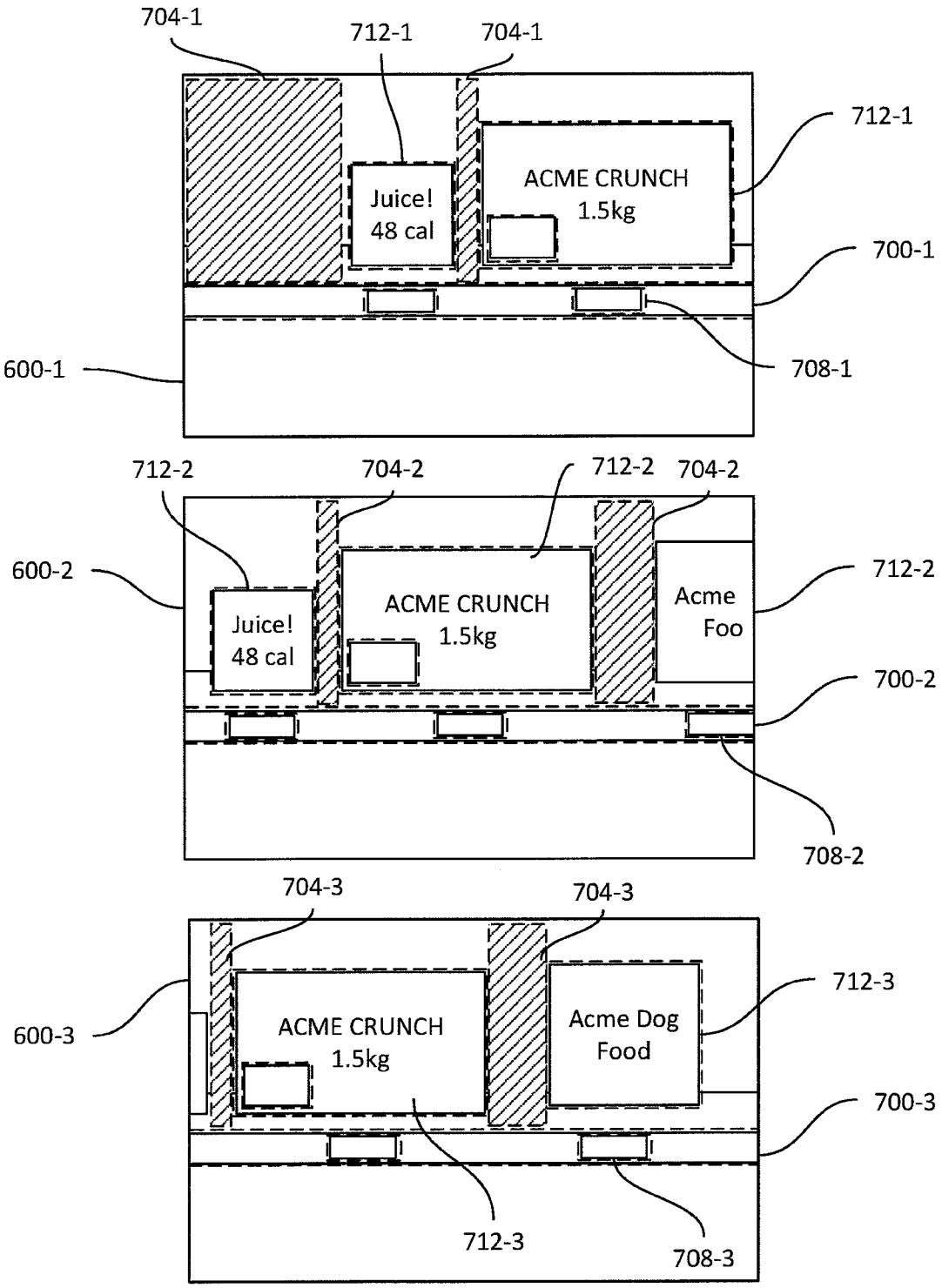
704-1
712-1
704-1
712-1
Juice!
48 cal
ACME CRUNCH
1.5kg
700-1
600-1
708-1
712-2
704-2
712-2
704-2
600-2
712-2
Juice!
48 cal
ACME CRUNCH
1.5kg
Acme
Foo
700-2
708-2
704-3
704-3
600-3
712-3
ACME CRUNCH
1.5kg
Acme Dog
Food
700-3
712-3
708-3

FIG. 7

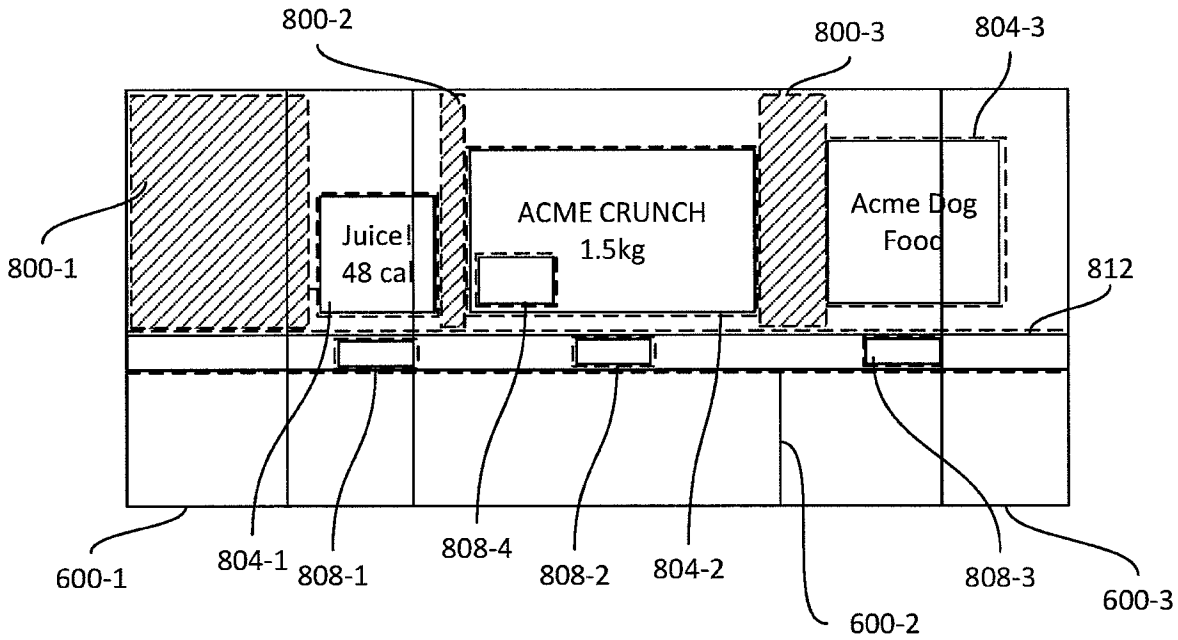
800-2
800-3
804-3
800-1
Juice!
48 cal
ACME CRUNCH
1.5kg
Acme Dog
Food
812
600-1
804-1
808-1
808-4
808-2
804-2
600-2
808-3
600-3

FIG. 8A

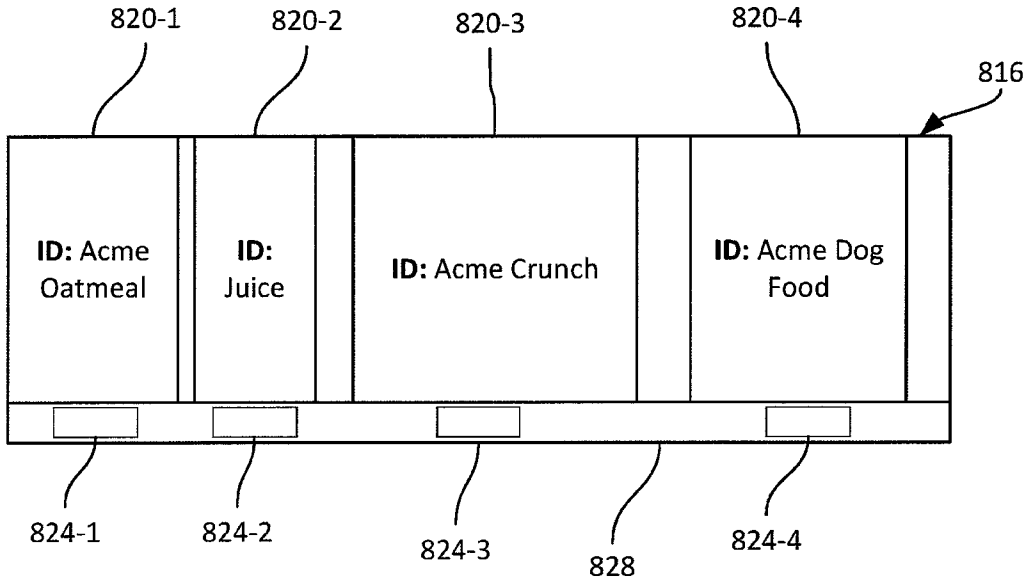
820-1
820-2
820-3
820-4
816
ID: Acme
Oatmeal
ID:
Juice
ID: Acme Crunch
ID: Acme Dog
Food
824-1
824-2
824-3
828
824-4

FIG. 8B

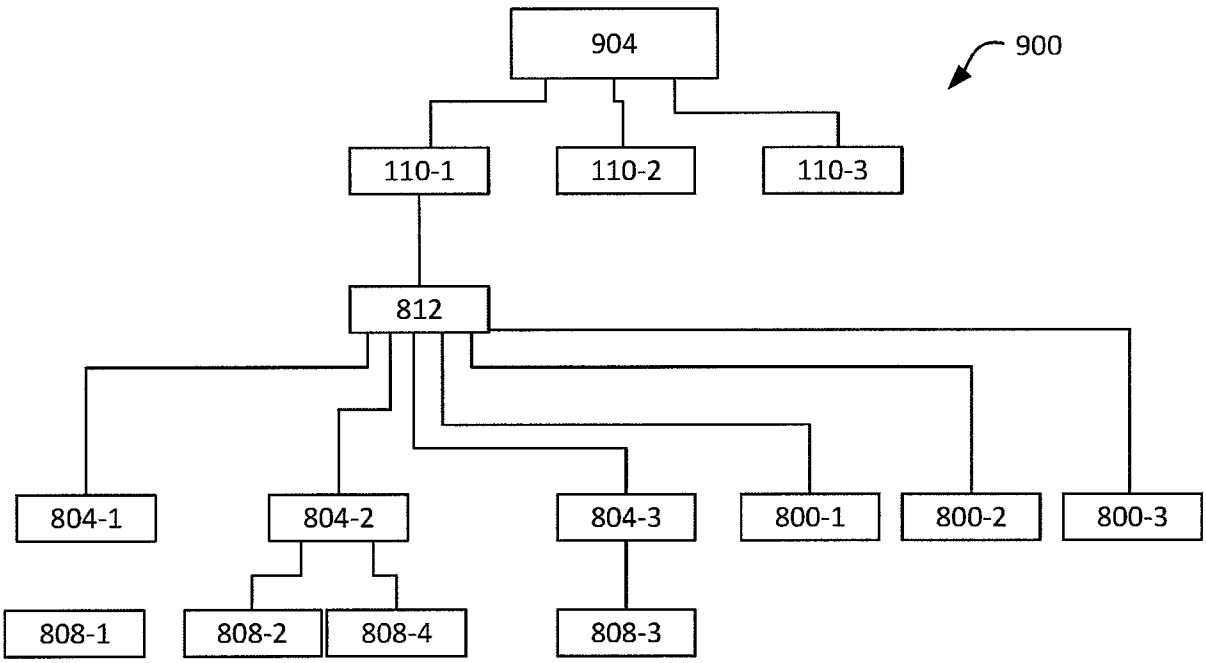
904
900
110-1
110-2
110-3
812
804-1
804-2
804-3
800-1
800-2
800-3
808-1
808-2
808-4
808-3

FIG. 9

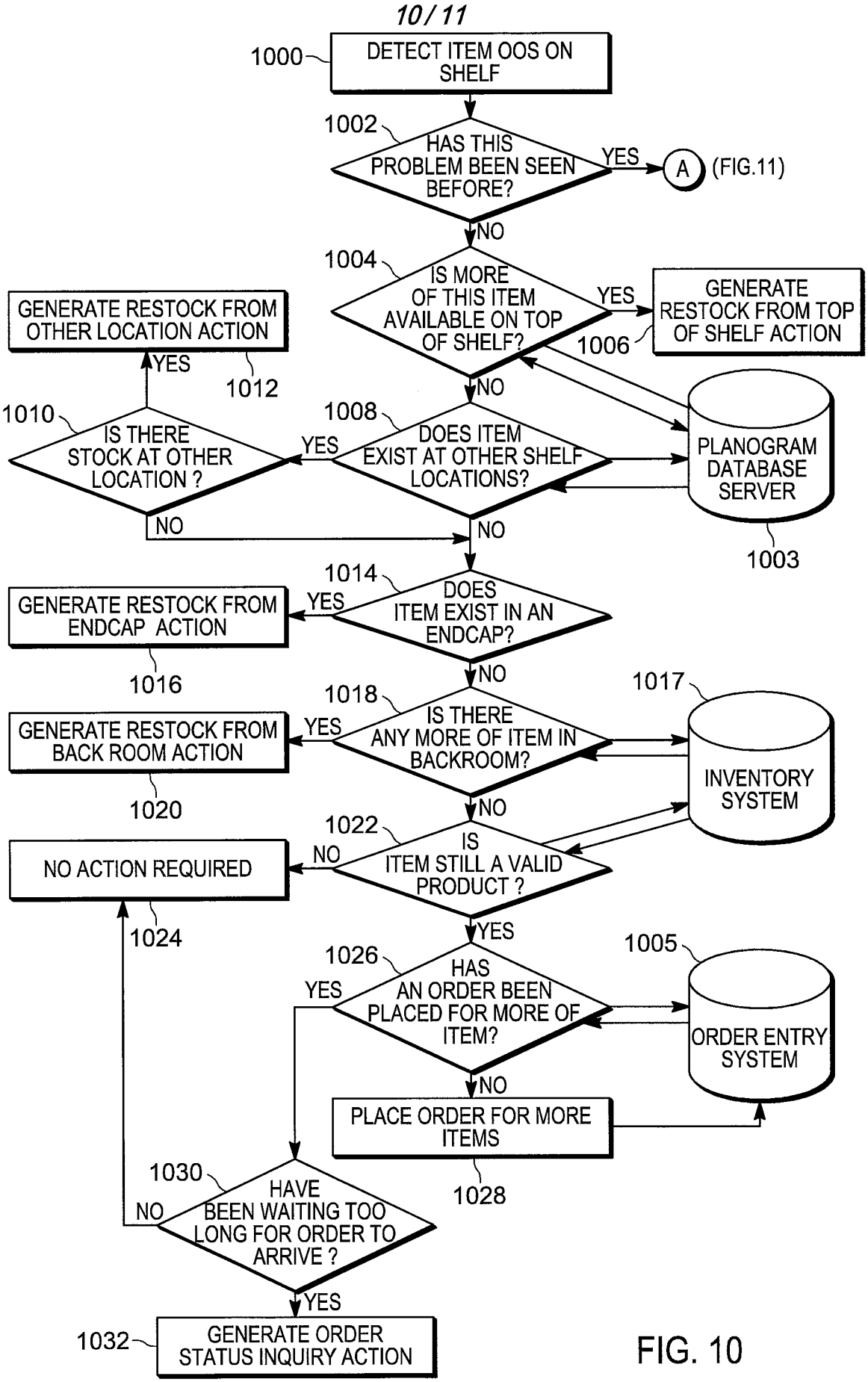
1000
DETECT ITEM OOS ON SHELF
1002
HAS THIS PROBLEM BEEN SEEN BEFORE?
YES
A
(FIG.11)
NO
1004
IS MORE OF THIS ITEM AVAILABLE ON TOP OF SHELF?
YES
GENERATE RESTOCK FROM TOP OF SHELF ACTION
1006
NO
GENERATE RESTOCK FROM OTHER LOCATION ACTION
YES
1012
1010
IS THERE STOCK AT OTHER LOCATION ?
1008
DOES ITEM EXIST AT OTHER SHELF LOCATIONS?
YES
PLANOGRAM DATABASE SERVER
1003
NO
NO
1014
DOES ITEM EXIST IN AN ENDCAP?
YES
GENERATE RESTOCK FROM ENDCAP ACTION
1016
NO
1017
1018
IS THERE ANY MORE OF ITEM IN BACKROOM?
YES
GENERATE RESTOCK FROM BACK ROOM ACTION
1020
INVENTORY SYSTEM
NO
1022
IS ITEM STILL A VALID PRODUCT ?
NO
NO ACTION REQUIRED
1024
YES
1005
1026
HAS AN ORDER BEEN PLACED FOR MORE OF ITEM?
YES
ORDER ENTRY SYSTEM
NO
PLACE ORDER FOR MORE ITEMS
1028
1030
HAVE BEEN WAITING TOO LONG FOR ORDER TO ARRIVE ?
NO
YES
1032
GENERATE ORDER STATUS INQUIRY ACTION

FIG. 10

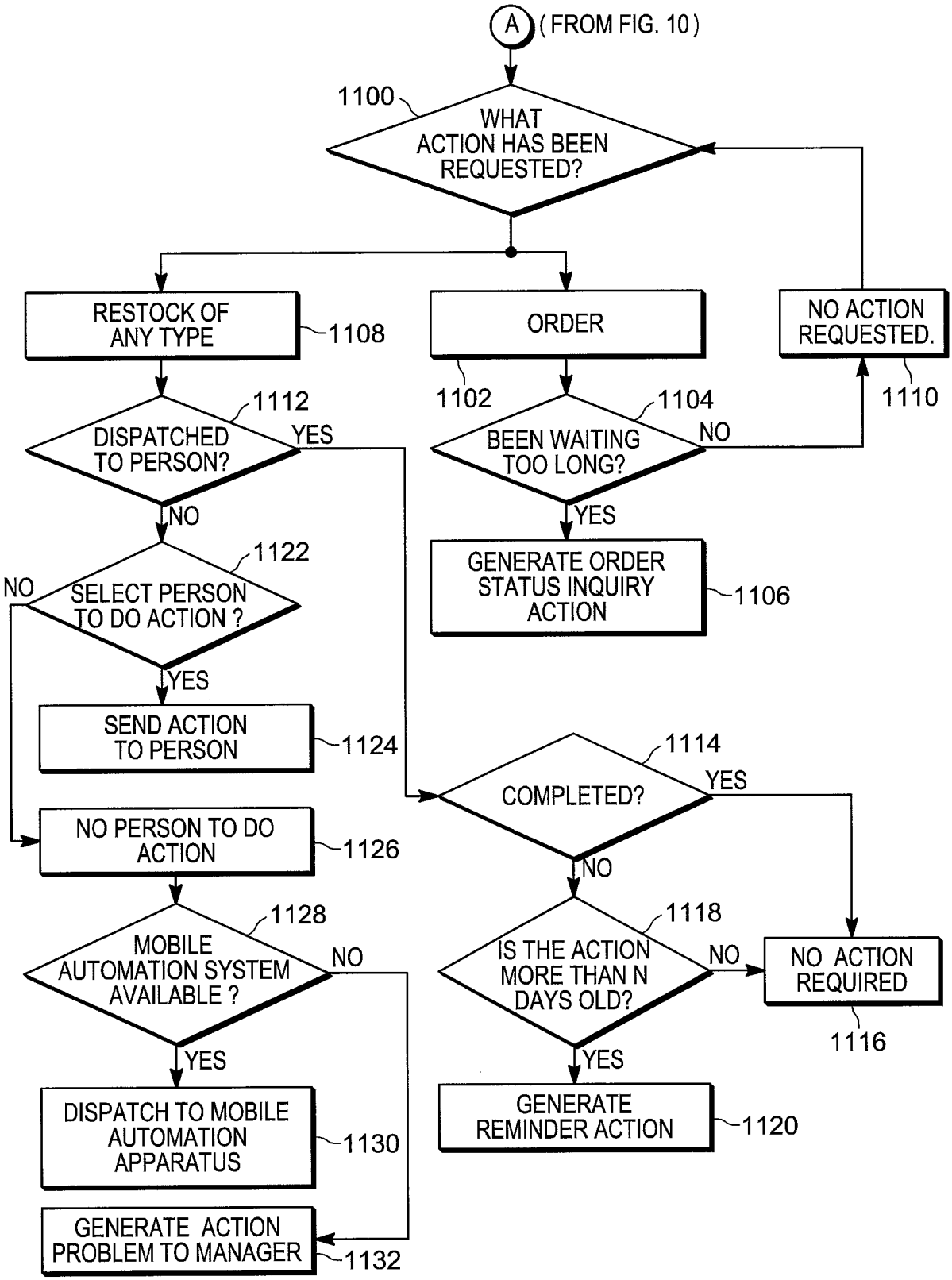
A
(FROM FIG. 10)
1100
WHAT ACTION HAS BEEN REQUESTED?
RESTOCK OF ANY TYPE
1108
ORDER
NO ACTION REQUESTED.
1110
1102
1104
1112
DISPATCHED TO PERSON?
YES
NO
BEEN WAITING TOO LONG?
NO
YES
GENERATE ORDER STATUS INQUIRY ACTION
1106
1122
NO
SELECT PERSON TO DO ACTION ?
YES
SEND ACTION TO PERSON
1124
1114
COMPLETED?
YES
NO
NO PERSON TO DO ACTION
1126
1128
MOBILE AUTOMATION SYSTEM AVAILABLE ?
NO
YES
1118
IS THE ACTION MORE THAN N DAYS OLD?
NO
NO ACTION REQUIRED
1116
YES
DISPATCH TO MOBILE AUTOMATION APPARATUS
1130
GENERATE REMINDER ACTION
1120
GENERATE ACTION PROBLEM TO MANAGER
1132

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2018/030419

A. CLASSIFICATION OF SUBJECT MATTER

G06Q 10/08(2012.01)i, G08B 17/02(2006.01)i, G06K 17/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06Q 10/08; H04N 7/18; G06Q 10/00; G07G 1/12; G08B 17/02; G06K 17/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: automation apparatus, captured image, product, inventory, location, mismatch, notification, mobile device

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2009-0063306 A1 (ANDREW FANO et al.) 05 March 2009 See paragraphs [0019]-[0031] and figures 1-4.	1-17
Y	US 2014-0006229 A1 (THOMAS A. BIRCH et al.) 02 January 2014 See paragraphs [0010]-[0025], claim 16 and figures 1-2.	1-17
Y	US 2013-0235206 A1 (NUMEREX CORP.) 12 September 2013 See paragraphs [0024]-[0027] and figure 4.	7-8
A	US 2008-0077511 A1 (THOMAS GUTHRIE ZIMMERMAN) 27 March 2008 See paragraphs [0070]-[0082] and figures 7A-9B.	1-17
A	JP 2014-170431 A (NEC CORP.) 18 September 2014 See paragraphs [0014]-[0019], [0241]-[0244], claim 1 and figures 1, 27A-27B.	1-17

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 August 2018 (31.08.2018)	**31 August 2018 (31.08.2018)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2018/030419

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