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(54) **AUTOMATED PACKAGE DELIVERY TO A DELIVERY RECEPTACLE**

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(58) **Field of Classification Search**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,266,142 B1 * 7/2001 Junkins G01S 5/163
250/559.14
7,327,258 B2 * 2/2008 Fast G01S 5/0018
340/572.1

(Continued)

FOREIGN PATENT DOCUMENTS

CN 101604830 A 12/2009
CN 101979961 A 2/2011

(Continued)

OTHER PUBLICATIONS

Singh, "U.S. Office Action issued in copending U.S. Appl. No. 14/275,545, filed May 12, 2014", dated Feb. 8, 2017, 33 pages.

(Continued)

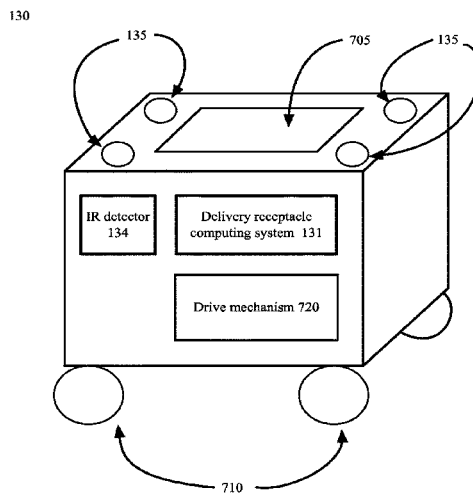
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(57) **ABSTRACT**

Improving automated package delivery to mobile delivery receptacles to allow accurate and reliable package deliveries comprises a delivery receptacle for an automated package delivery via an unmanned aerial delivery device. The delivery receptacle is notified of a pending delivery and travels to a receiving location. The delivery receptacle emits infrared ("IR") beacons from one or more IR beacon transmitters. An aerial delivery device detects the IR beacon and uses the beacons to navigate to the delivery receptacle. The delivery receptacle receives IR beacon responses from the aerial delivery device and continually or periodically directs the IR beacons in the direction of the aerial delivery device. The aerial delivery device deposits the package in the delivery receptacle. After receiving the package, the delivery receptacle transports the package to a secure location, such as into a garage.

20 Claims, 8 Drawing Sheets



Related U.S. Application Data

continuation of application No. 14/520,987, filed on Oct. 22, 2014, now Pat. No. 9,244,147.

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|--------------|-----|---------|----------------------|------------------------|
| 9,056,676 | B1 | 6/2015 | Wang | |
| 9,244,147 | B1 | 1/2016 | Soundararajan et al. | |
| 9,336,506 | B2 | 5/2016 | Shucker et al. | |
| 9,489,490 | B1 | 11/2016 | Theobald | |
| 9,652,731 | B2 | 5/2017 | Shucker et al. | |
| 2002/0065600 | A1* | 5/2002 | Oka | G08G 1/042 701/516 |
| 2002/0156645 | A1 | 10/2002 | Hansen | |
| 2003/0196358 | A1* | 10/2003 | Fratzke | G09F 7/00 40/597 |
| 2004/0054607 | A1* | 3/2004 | Waddington | G06Q 10/08 705/28 |
| 2008/0262718 | A1* | 10/2008 | Farwell | G05D 1/0244 701/445 |
| 2013/0240673 | A1 | 9/2013 | Schlosser et al. | |
| 2013/0332008 | A1* | 12/2013 | Herman | B64C 39/024 701/2 |
| 2014/0022055 | A1 | 1/2014 | Levien et al. | |
| 2014/0032034 | A1* | 1/2014 | Raptopoulos | G08G 5/0069 701/25 |
| 2014/0149244 | A1 | 5/2014 | Abhyanker | |
| 2014/0180914 | A1 | 6/2014 | Abhyanker | |
| 2014/0204360 | A1 | 7/2014 | Dowski et al. | |
| 2014/0254896 | A1 | 9/2014 | Zhou et al. | |
| 2014/0278099 | A1 | 9/2014 | Schenken | |
| 2015/0120094 | A1 | 4/2015 | Kimchi et al. | |
| 2015/0203213 | A1 | 7/2015 | Levien et al. | |
| 2015/0205301 | A1 | 7/2015 | Gilmore et al. | |
| 2015/0317596 | A1 | 11/2015 | Hejazi | |
| 2015/0332206 | A1 | 11/2015 | Trew et al. | |
| 2016/0117934 | A1 | 4/2016 | Soundararajan et al. | |
| 2016/0224932 | A1 | 8/2016 | Shucker et al. | |
| 2017/0220981 | A1 | 8/2017 | Shucker et al. | |

FOREIGN PATENT DOCUMENTS

| | | | |
|----|-----------------|----|---------|
| CN | 103424126 | A | 12/2013 |
| JP | 2003-300626 | A | 10/2003 |
| JP | 2007-257474 | A | 10/2007 |
| JP | 2014-031118 | A | 2/2014 |
| KR | 10-2013-0127585 | A | 11/2013 |
| WO | 2010/077129 | A2 | 7/2010 |
| WO | 2015/168573 | A1 | 11/2015 |
| WO | 2015/175242 | A1 | 11/2015 |

OTHER PUBLICATIONS

U.S. Appl. No. 15/486,061 to Shucker et al. filed Apr. 12, 2017.
 Ranga, "Australian Office Action issued in Australian Application No. 2015259599", dated Jun. 6, 2017, 4 pages.
 Singh, "U.S. Office Action issued in copending U.S. Appl. No. 14/275,545, filed May 12, 2014", dated Jun. 15, 2017, 27 pages.
 Perry, t., "Matternet's Package Delivery Drones", Dec. 5, 2013, 4 pages.
 Berthon, "International Search Report and Written Opinion issued in International Application No. PCT/US2015/028817", dated Jul. 14, 2015, 10 pages.
 Berthon, "International Search Report and Written Opinion issued in International Application No. PCT/US2015/028823", dated Jul. 14, 2015, 10 pages.

Dunn, "U.S. Office Action issued in copending U.S. Appl. No. 14/520,987, filed Oct. 22, 2014", dated May 28, 2015, 8 pages.
 Haque, et al., "Autonomous Quadcopter for Product Home Delivery", Electrical Engineering and Information & Communication Technology (ICEEICT), 2014 International Conference, Apr. 12, 2014, 5 pages.
 Kirk, "U.S. Office Action issued in copending U.S. Appl. No. 14/276,841, filed May 13, 2014", dated Dec. 22, 2016, 25 pages.
 Marshall, "U.S. Office Action issued in copending U.S. Appl. No. 14/268,683, filed May 2, 2014", dated Sep. 28, 2015, 6 pages.
 Marshall, "U.S. Office Action issued in copending U.S. Appl. No. 14/268,683, filed May 2, 2014", dated Apr. 20, 2015, 9 pages.
 Marshall, "U.S. Office Action issued in copending U.S. Appl. No. 15/097,125, filed Apr. 12, 2016", dated May 19, 2016, 12 pages.
 Marshall, "U.S. Office Action issued in copending U.S. Appl. No. 15/097,125, filed Apr. 12, 2016", dated Sep. 6, 2016, 6 pages.
 Rees, "Australian Office Action issued in Australian Application No. 2015252879", dated Nov. 11, 2016, 2 pages.
 Wittmann-Regis, "International Preliminary Report on Patentability issued in International Application No. PCT/US2015/028817", dated Nov. 17, 2016, 8 pages.
 Wittmann-Regis, "International Preliminary Report on Patentability issued in International Application No. PCT/US2015/028823", dated Nov. 24, 2016, 8 pages.
 Marshall, "U.S. Office Action issued in copending U.S. Appl. No. 15/486,061, filed Apr. 12, 2017", dated May 17, 2017, 6 pages.
 Watanabe, "Japanese Office Action issued in Japanese Application No. 2016-575971", dated May 8, 2017, 7 pages of English Translation and 7 pages of Japanese Office Action.
 Kim, "Korean Office Action issued in Korean Application No. 10-2016-7032993", dated Mar. 9, 2017, 7 pages of English Translation and 6 pages of Korean Office Action.
 Won, "Drone (UAV, UAV) Drones", Airstrike: Commercial Drones Bloomed Beyond Defense, retrieved from Internet Article: <http://cfille203.uf.daum.net/attach/2647D73B535155A11A68B3>, Apr. 17, 2014 19 pages.
 U.S. Appl. No. 14/275,545 to Trew et al. filed May 12, 2014.
 U.S. Appl. No. 14/521,033 to Soundararajan et al. filed Oct. 22, 2014.
 Kim, "Korean Office Action issued in Korean Application No. 10-2016-7032993", dated Jun. 30, 2017, 3 pages of English Translation and 3 pages of Korean Office Action.
 Kim, "Korean Office Action issued in Korean Application No. 10-2016-7032993", dated Aug. 11, 2017, 4 pages of English Translation and 4 pages of Korean Office Action.
 Lee, "Korean Office Action issued in Korean Application No. 10-2016-703451", dated Aug. 11, 2017, 5 pages of English Translation and 4 pages of Korean Office Action.
 Ott, "Canada Office Action received for Canada Patent Application No. 2,949,054", dated Aug. 3, 2017, 3 pages.
 Ott, "Canada Office Action received for Canada Patent Application No. 2,947,719", dated Aug. 3, 2017, 4 pages.
 U.S. Appl. No. 15/705,256 to Soundararajan et al. filed on Sep. 14, 2017.
 "Chinese Office Action issued in Chinese Application No. 201580029458.2", dated Aug. 21, 2017, 7 pages of English Translation and 6 pages of Chinese Office Action.
 Watanabe, "Japanese Office Action issued in Japanese Application No. 2016-575971", dated Sep. 15, 2017, 4 pages of English Translation and 4 pages of Japanese Office Action.
 Singh, "U.S. Office Action issued in copending U.S. Appl. No. 14/275,545 filed on May 12, 2014", dated Oct. 11, 2017, 32 pages.
 U.S. Appl. No. 15/788,680 to Trew et al. filed on Oct. 19, 2017.

* cited by examiner

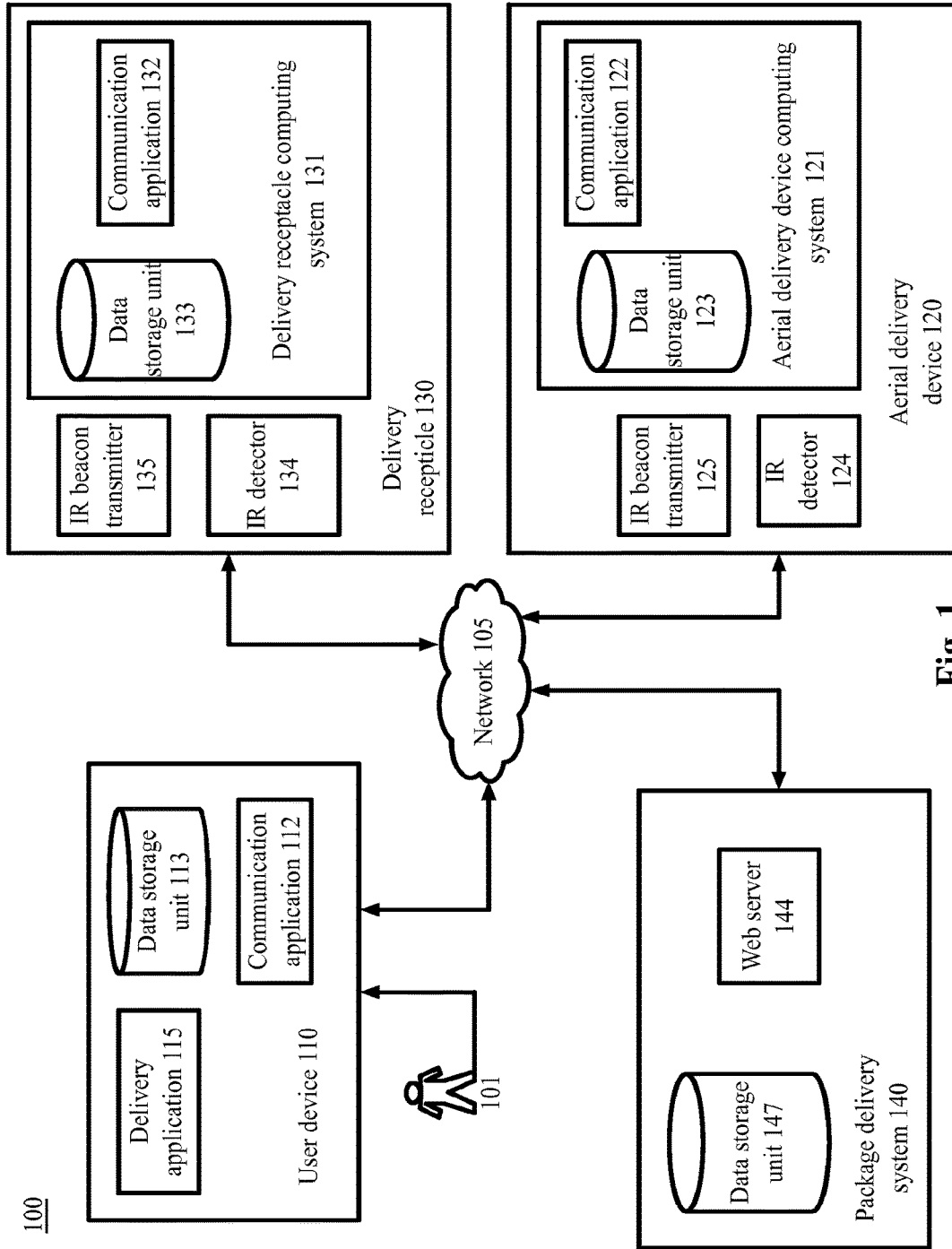


Fig. 1

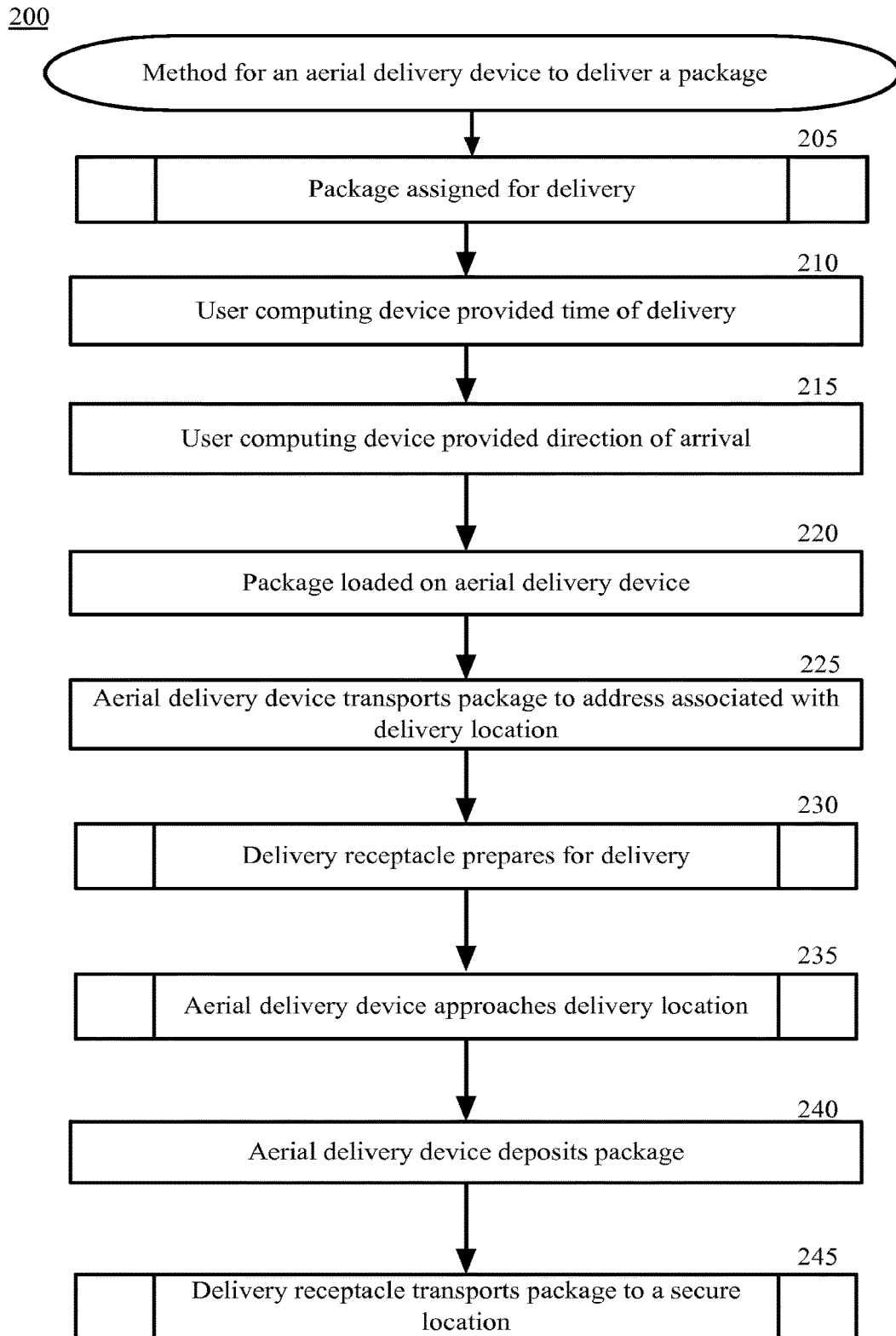


Fig. 2

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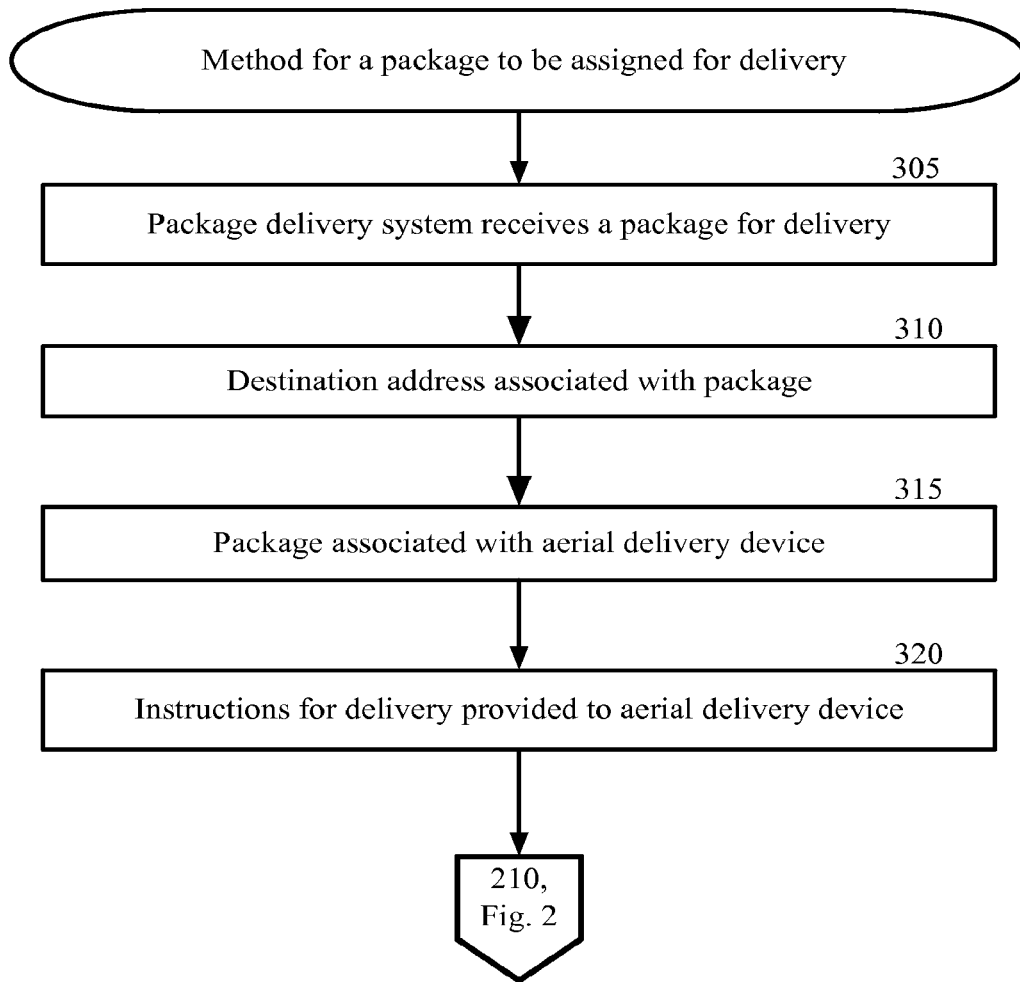


Fig. 3

230

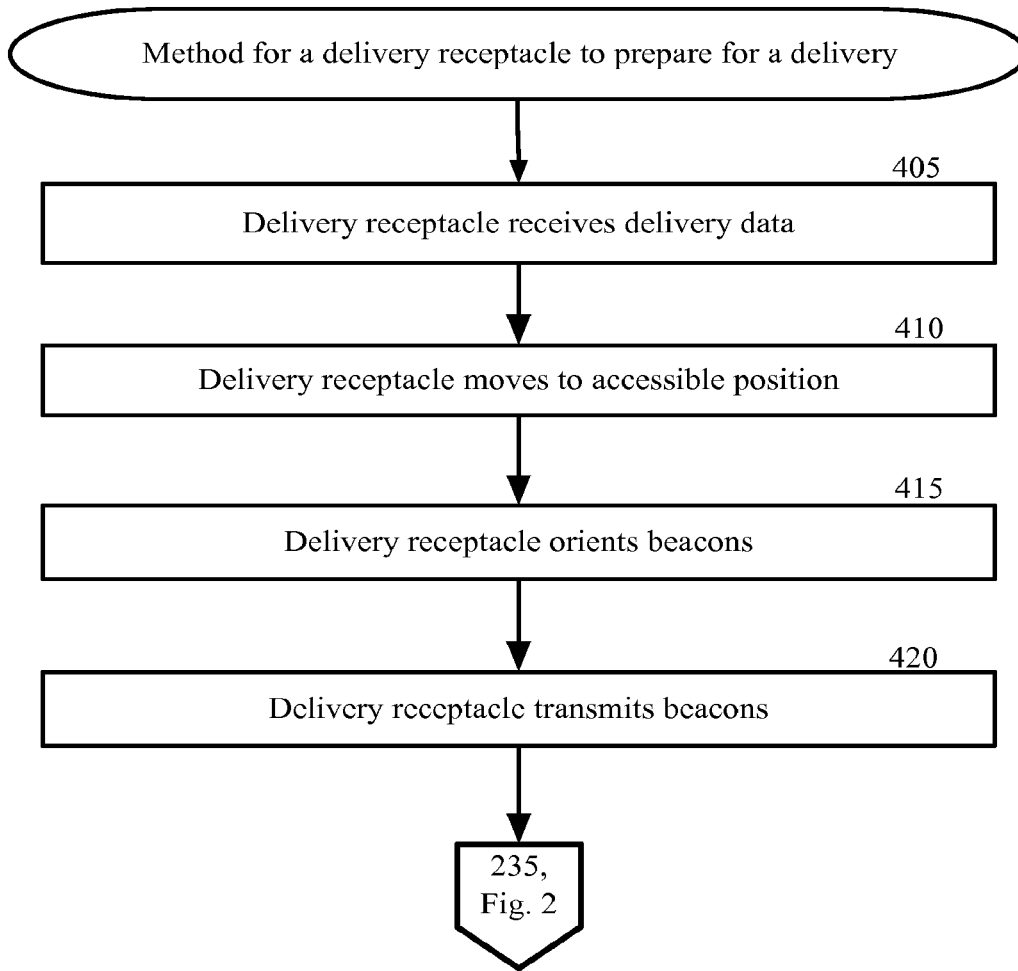


Fig. 4

235

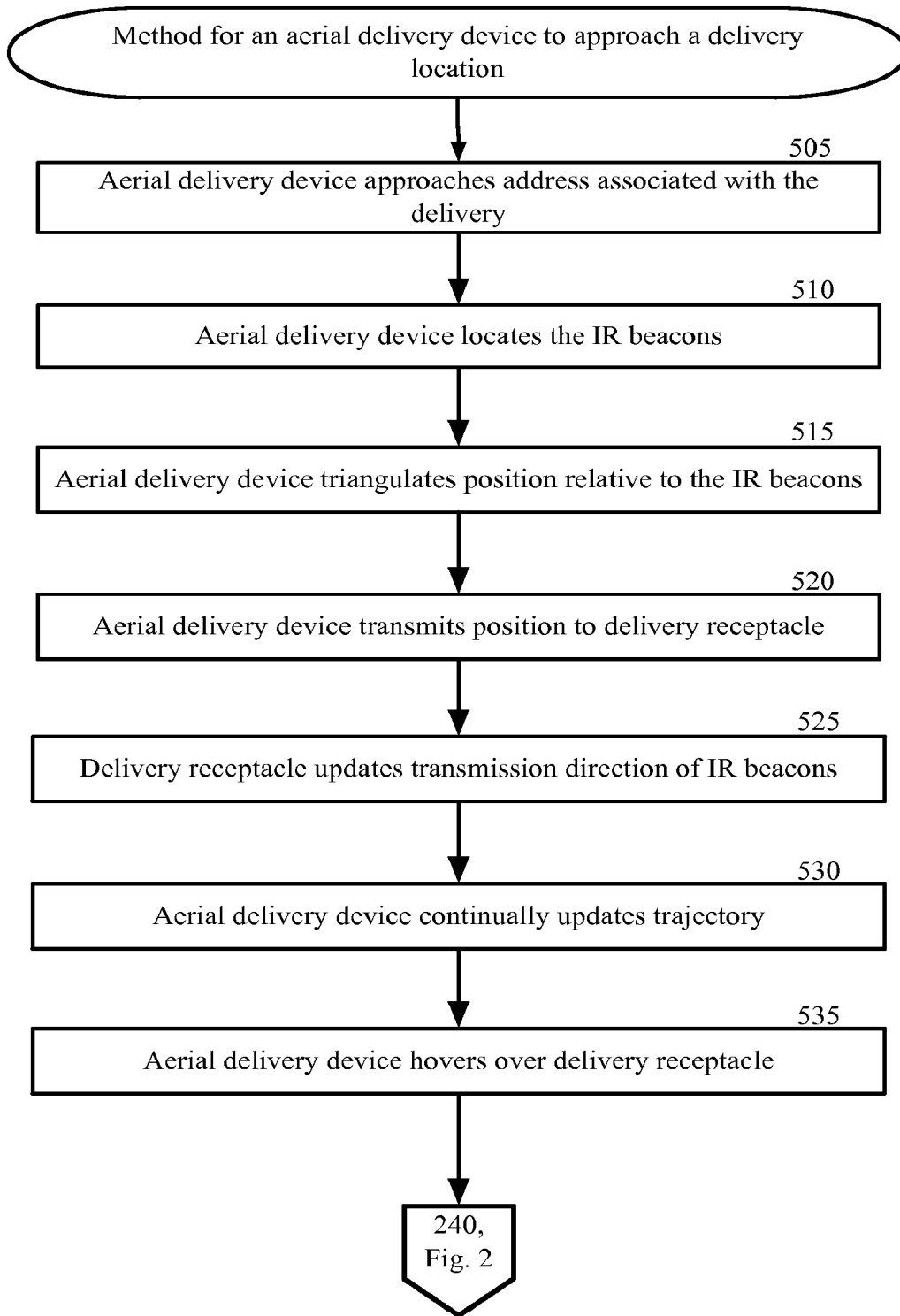


Fig. 5

245

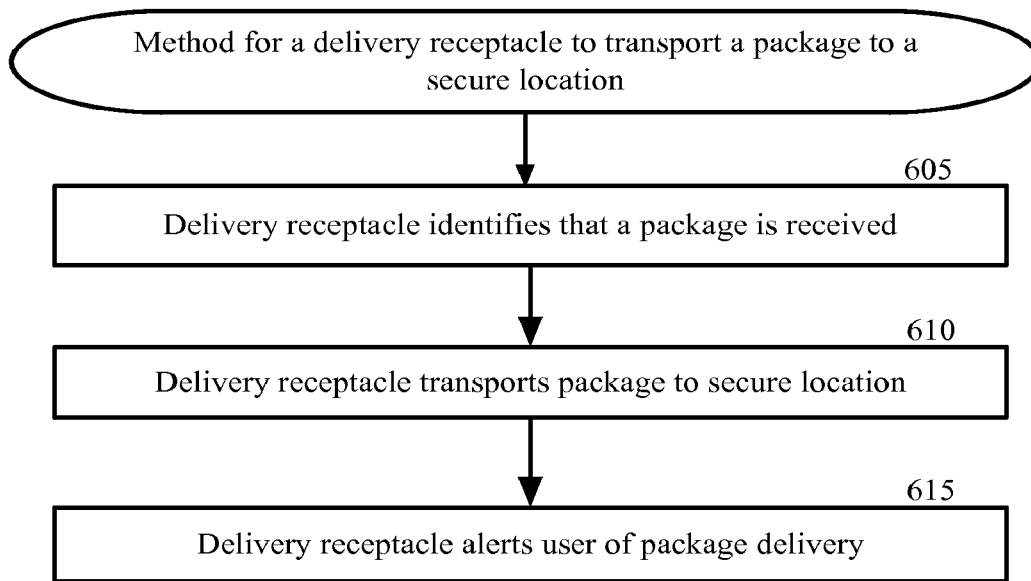


Fig. 6

130

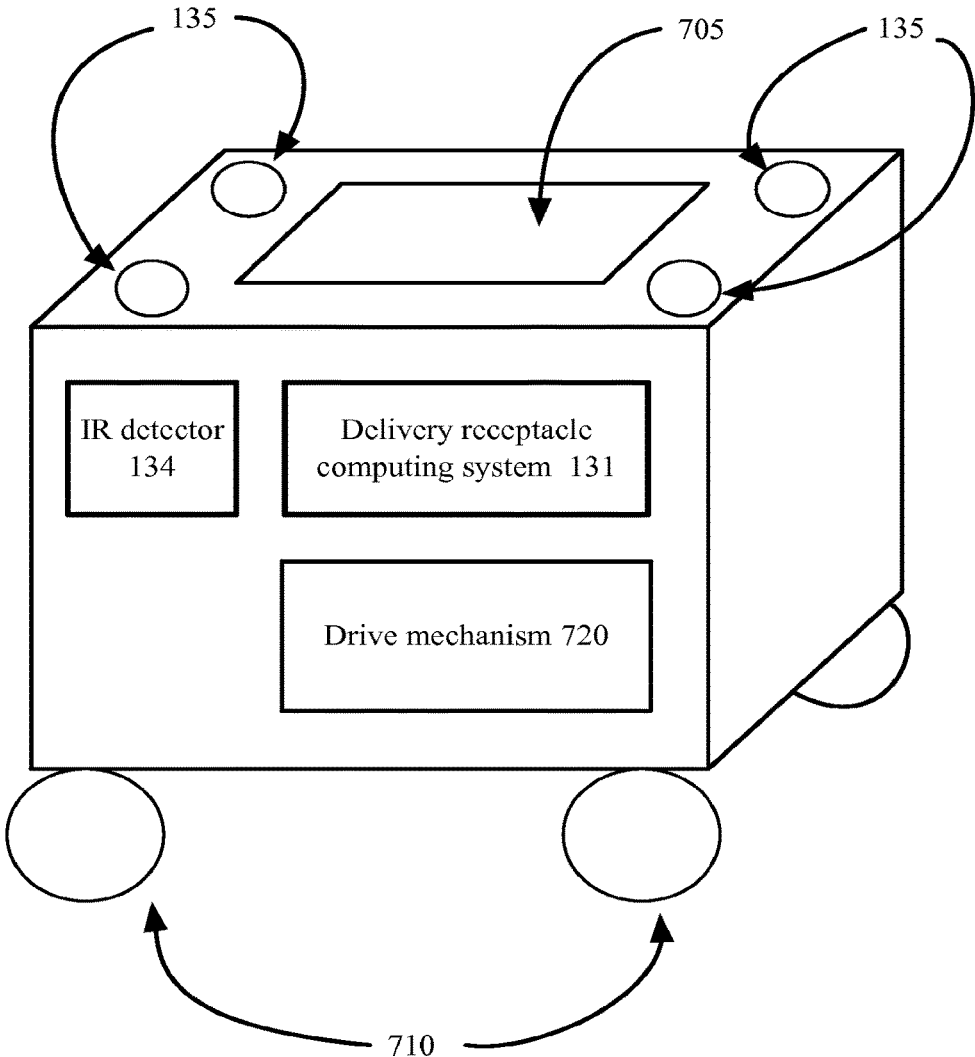


Fig. 7

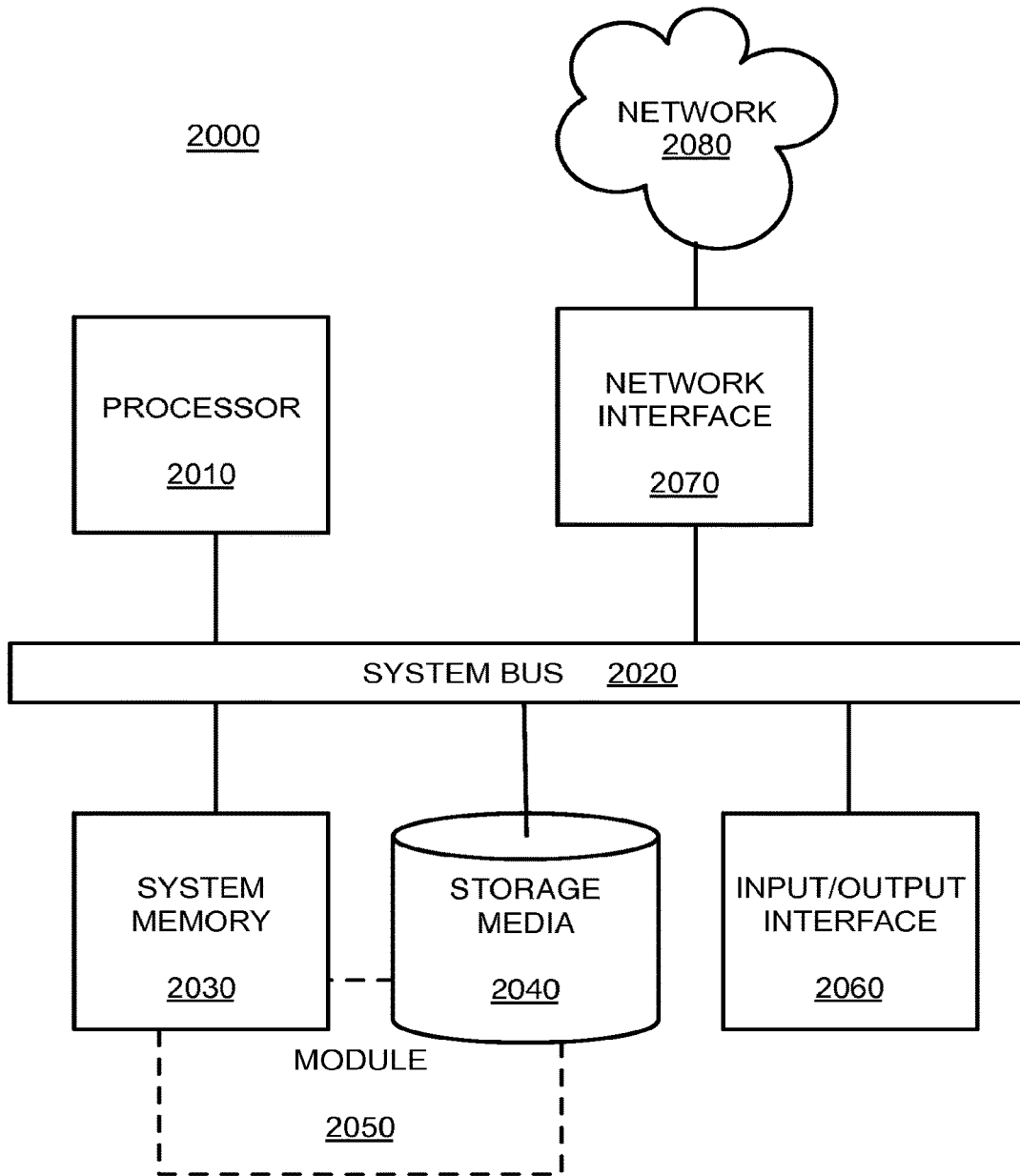


Fig. 8

AUTOMATED PACKAGE DELIVERY TO A DELIVERY RECEPTACLE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/967,254, filed Dec. 11, 2015 and entitled "Automated Package Delivery to A Delivery Receptacle," which is a continuation of U.S. patent application Ser. No. 14/520,987 filed Oct. 22, 2014 and entitled "Automated Package Delivery to A Delivery Receptacle." The entire contents of the above-identified priority applications are hereby fully incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates to improving automated package delivery to a mobile delivery receptacle to allow more accurate and reliable deliveries.

BACKGROUND

Delivery services (also known as courier services, mail services, and shipping services), such as those offered by the U.S. Postal Service and commercial carriers, provide delivery of letters, packages, and parcels (hereinafter referred to as "packages") to and from residences and businesses across the county. Other delivery services may be provided by merchants, retailers, manufacturers, or other organizations that desire to deliver products to users. Typically, such services operate in a hub and spoke architecture.

A typical nationwide or international delivery service maintains a large fleet of vehicles. Such vehicles include airplanes and semi-trailer trucks to move packages between hubs and spokes, and smaller vehicles for the "last mile" from spoke endpoints to delivery destinations (for example, a home or business). In-between, the two largest commercial delivery services in the United States operate over 100,000 last mile vehicles, each of which requires a human operator. In certain situations, some interaction with a person at pickup or delivery is desired, for example, for proof of delivery, for payment on delivery (also known as "cash on delivery" or "COD"), or payment of delivery costs on pickup. The growth of business-to-consumer e-commerce, for example, online shopping, is expected to continue to increase the demand for delivery services and hence the need for capacity and efficiency in the last mile.

Unmanned, aerial delivery devices may be problematic for delivery to users. For example, an aerial delivery device that is powered by a rotor or an impeller may be dangerous to pets, overhead power lines, ceiling fans, or other features or residents at a delivery location. Furthermore, the aerial delivery device may not recognize a safe place to deliver a package. For example, leaving the package on the front porch of a busy street address may make it more likely that the package is stolen. Detailed delivery instructions to an unmanned aerial delivery device may be difficult for the limited vision system of the aerial delivery device to interpret. Thus, conventional aerial delivery device methods do not allow for safe, secure delivery of packages to delivery locations.

SUMMARY

In certain example aspects described herein, a computer-implemented method for improving automated package

delivery to a mobile delivery receptacle to allow more accurate and reliable package deliveries is provided. In an example embodiment, the method provides receiving from a package delivery system processor, by one or more computing devices, delivery information associated with a package. The delivery device transports the package to the delivery address and locates one or more first beacons being transmitted by a delivery receptacle at the delivery address. The delivery device navigates to the delivery receptacle based on the triangulated position and transmits a second beacon to the delivery receptacle. The second beacon allows the delivery receptacle to adjust a direction of the one or more first beacons. The delivery device deposits the package into the delivery receptacle. The delivery device transports the package to a secure location.

In certain other example aspects described herein, a system and a computer program product for automated package delivery are provided.

These and other aspects, objects, features, and advantages of the example embodiments will become apparent to those having ordinary skill in the art upon consideration of the following detailed description of illustrated example embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram depicting a system for an aerial delivery device to deliver a package, in accordance with certain example embodiments.

FIG. 2 is a block flow diagram depicting a method for an aerial delivery device to deliver a package, in accordance with certain example embodiments.

FIG. 3 is a block flow diagram depicting a method for a package to be assigned for delivery, in accordance with certain example embodiments.

FIG. 4 is a block flow diagram depicting a method for a delivery receptacle to prepare for a delivery, in accordance with certain example embodiments.

FIG. 5 is a block flow diagram depicting a method for an aerial delivery device to approach a delivery location, in accordance with certain example embodiments.

FIG. 6 is a block flow diagram depicting a method for a delivery receptacle to transport a package to a secure location, in accordance with certain example embodiments.

FIG. 7 is an illustration of a delivery receptacle, in accordance with certain example embodiments.

FIG. 8 is a block diagram depicting a computing machine and module, in accordance with certain example embodiments.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

Overview

The example embodiments described herein provide computer-implemented techniques for providing a delivery receptacle for an automated package delivery via an unmanned aerial delivery device. In an example embodiment, a delivery receptacle emits infrared ("IR") beacons from one or more IR beacon transmitters. An aerial delivery device, such as a drone, detects the IR beacons and uses the beacons to navigate to the delivery receptacle. The delivery receptacle receives responses from the aerial delivery device and directs the IR beacons in the direction of the aerial delivery device. After receiving the package, the delivery receptacle transports the package to a secure location.

In an example embodiment, a package delivery system identifies a package for delivery to a user. The package delivery system may be a warehouse depot for a merchant system or manufacturer. The package delivery system may be a courier service, a package delivery agent, or any suitable delivery system. The package delivery system identifies a destination for the package, such as the residence of the user to whom the package is addressed. The package is associated with an aerial delivery device for delivery.

The user is provided with a time of delivery and an expected direction of approach of the aerial delivery device. The data is transmitted to the delivery receptacle computing system by a user computing device, the package delivery system, or another system or device. The delivery receptacle may use a robotic transportation system guided by the delivery receptacle computing system or other mechanism of relocating to a reception location. The package delivery system provides the delivery location to the aerial delivery device. For example, the package delivery system provides an address for a user residence. In another example, the package delivery system provides a GPS location to the aerial delivery device.

The delivery receptacle determines the direction from which the aerial delivery device will arrive and directs one or more IR beacons in the determined direction. Upon arrival at the user address, the aerial delivery device uses a detection technology to locate the IR beacons. For example, the aerial delivery device may hover over the specified address until the IR beacons are received. The aerial delivery device then triangulates the IR beacon sources and approaches the location. The aerial delivery device transmits an IR signal that is received by the delivery receptacle. The delivery receptacle may adjust the direction of the IR beacons transmissions to follow the movements of the aerial delivery device.

The aerial delivery device deposits the package into the delivery receptacle and notes the delivery of the package. The delivery receptacle recognizes the delivery of the package and transmits the package to a secure location, such as a base that secures the package. The delivery receptacle may notify the user computing device or others that the delivery is complete and secured.

By using and relying on the methods and systems described herein, the delivery receptacle and the aerial delivery device dynamically provide accurate and reliable automated package delivery. As such, the systems and methods described herein may be employed to prevent deliveries from automated systems from being delivered to incorrect locations, from being stored in an insecure location, from requiring user assistance, from missing the entrance to the delivery receptacle, from wasting computing processing time attempting to triangulate immobile beacons, and from other potential problems. Hence, the methods and systems described herein decrease user frustration and permit automated delivery devices to more effectively, efficiently, safely, accurately, and reliably deliver packages to users.

Example System Architecture

Turning now to the drawings, in which like numerals indicate like (but not necessarily identical) elements throughout the figures, example embodiments are described in detail.

FIG. 1 is a block diagram depicting a system 100 for an aerial delivery device 120 to deliver a package, in accordance with certain example embodiments. As depicted in FIG. 1, the system 100 includes network computing devices 110, 120, 130, and 140 that are configured to communicate

with one another via one or more networks 105. In some embodiments, a user associated with a device must install an application and/or make a feature selection to obtain the benefits of the techniques described herein.

The network 105 can include a local area network (“LAN”), a wide area network (“WAN”), an intranet, an Internet, storage area network (“SAN”), personal area network (“PAN”), a metropolitan area network (“MAN”), a wireless local area network (“WLAN”), a virtual private network (“VPN”), a cellular or other mobile communication network, Bluetooth, NFC, or any combination thereof or any other appropriate architecture or system that facilitates the communication of signals, data, and/or messages. Throughout the discussion of example embodiments, it should be understood that the terms “data” and “information” are used interchangeably herein to refer to text, images, audio, video, or any other form of information that can exist in a computer-based environment.

Each network computing device 110, 120, 130, and 140 includes a device having a communication module capable of transmitting and receiving data over the network 105. For example, each network computing device 110, 120, 130, and 140 can include a server, desktop computer, laptop computer, tablet computer, a television with one or more processors embedded therein and/or coupled thereto, smart phone, handheld computer, personal digital assistant (“PDA”), or any other wired or wireless, processor-driven device. In the example embodiment depicted in FIG. 1, the network computing devices 110, 120, 130, and 140 may be operated or configured by users 101, aerial delivery device operators, users 101, and package delivery system operators, respectively.

An example user computing device 110 comprises a data storage unit 113, a delivery application 115, and a communication application 112. In an example embodiment, a user interface enables the user 101 to interact with the delivery application 115 and/or the communication application 112. For example, the user interface may be a touch screen, a voice-based interface or any other interface that allows the user 101 to provide input and receive output from an application or module on the user computing device 110.

In an example embodiment, the data storage unit 113 comprises a local or remote data storage structure accessible to the user computing device 110 suitable for storing information. In an example embodiment, the data storage unit 113 stores encrypted information, such as HTML5 local storage.

In an example embodiment, the user 101 can use a communication application 112, such as a web browser application or a delivery application 115, to view, download, upload, or otherwise access documents or web pages via a distributed network 105.

In an example embodiment, the delivery application 115 is a program, function, routine, applet, or similar entity that exists on and performs operations on the user computing device 110. In certain embodiments, the user 101 must install the delivery application 115 and/or make a feature selection on the user computing device 110 to obtain the benefits of the techniques described herein. In an example embodiment, the user 101 may access the delivery application 115 on the user computing device 110 via a user interface. In an example embodiment, a user 101 signs in to the delivery application 115, which enables the user 101 to interact with the delivery receptacle 130, the package delivery system 140, a merchant system, or other system to arrange, alter, or cancel the delivery of a product. The delivery application 115 may be used to exchange data with

the delivery receptacle **130**. For example, the delivery application may provide instructions to the delivery receptacle **130** for receiving a product from the aerial delivery device **120**.

An example package delivery system **140** comprises a web server **144** and a data storage unit **147**. In an example embodiment, the package delivery system **140** communicates with the user device **110**, merchant systems, other package delivery systems, or any other person, group, or system that delivers or receives packages. In an example embodiment, user device **110** has a delivery application **115** distributed by the package delivery system **140** that enables the user **101** to access an account or information about a package. In another example embodiment, the user **101** accesses an account via the communication application **112** of the user device **110**. In an example embodiment, when the user **101** accesses his account via the delivery application **115** or communication application **112**, the web server **144** logs user device **110** location data.

The package delivery system **140** may represent any system that delivers or receives packages. For example, the package delivery system **140** may be a courier, a merchant system, a retailer, a shipping company, a postal service, or any suitable system.

The aerial delivery device **120** may be a drone or other unmanned vehicle. The aerial delivery device **120** may be helicopter, quadcopter, or other aerial delivery device. In alternative embodiments, a device other than an aerial delivery device can be utilized, which does not deliver packages via flight. For example, a wheeled vehicle or other vehicle that delivers packages without flight may be used.

In an example, the non-flying delivery device may utilize wheels, articulated legs, or any suitable means for propulsion. The non-flying delivery device may drive to a location, recognize the IR beacon, and proceed to the delivery receptacle **130** by rolling, walking, or via any suitable propulsion. The non-flying delivery device may deposit the package via an articulated arm, a conveyor belt, or any other suitable mechanisms.

The aerial delivery device **120** employs an aerial delivery device computing system **121**. The aerial delivery device **120** computing system **121** comprises the hardware, software, and other devices for communication, navigation, image capturing, image processing, and any other suitable computerized or automated functions.

The aerial delivery device computing system **121** comprises a communication application **122** and a data storage unit **123**. The aerial delivery device computing system **121** may utilize a communication application **122** to receive instructions for package deliveries. For example, the aerial delivery device computing system **121** may receive, via the communication application **122**, delivery addresses, GPS locations, package details, or other delivery information. The aerial delivery device computing system **121** may utilize the data storage unit **123** for storing the information received via the communication application, and other suitable data.

The aerial delivery device **120** comprises an IR detector **124**. The IR detector **124** of the aerial delivery device **120** may be any detector that captures infrared beacons or any other beacon. For example, the IR detector **124** may alternatively detect laser guidance beacons, BLUETOOTH signals, Wi-Fi, or any other suitable beacon, communication, signal, or transmission. The aerial delivery device computing system **121** analyzes received IR beacons or other signals to identify a location of the delivery receptacle **130**. The aerial delivery device computing system **121** determines

a location of the delivery receptacle **130** based on the analysis and navigates to the delivery receptacle **130**.

The aerial delivery device **120** comprises an IR beacon transmitter **125**. The IR beacon transmitter **125** may represent any beacon, signal or other transmission that is broadcast to the delivery receptacle **130**. The IR beacon transmitter **125** may broadcast the IR signal or other signal to the delivery receptacle **130** to allow the delivery receptacle **130** to more accurately direct the IR beacon transmitter **135**. In example embodiments, the IR beacon transmitter **125** may alternatively be a laser guidance beacon, BLUETOOTH signal, Wi-Fi signal, or any other suitable beacon, communication, signal, or transmission. Some functions described as being performed by one of the IR beacon transmitter **125**, the IR detector **124**, or the communication application **122** may alternatively be performed by one or more of the others applications or modules.

The aerial delivery device computing system **121** may also comprise a navigation system, such as a global positioning system (“GPS”) or other navigation system. For example, the aerial delivery device computing system **121** may have a mapping system stored in the data storage unit **123** that works alone or in conjunction with onboard GPS technology to assist the aerial delivery device computing system **121** with navigation.

The delivery receptacle **130** may be a box or other container or vessel that is capable of receiving a package. The delivery receptacle **130** may be in the shape of a cube, a cylinder, or any other suitable shape. The delivery receptacle **130** may be equipped with a hatch, bay, door, or other opening that allows a package to be placed inside. The door may be spring actuated, or actuated by any other mechanical or electrical means, to allow the door to return to a closed position after the package is delivered.

The delivery receptacle **130** may be equipped with a system to allow the delivery receptacle **130** to move to a package receiving area and back to a secure location. In an example, the delivery receptacle **130** may utilize wheels, rotors for flying, articulated legs, or any suitable means for propulsion or locomotion. The delivery receptacle **130** may proceed to a desired location by rolling, walking, flying, or via any suitable propulsion.

The delivery receptacle **130** employs a delivery receptacle computing system **131**. The delivery receptacle computing system **131** comprises the hardware, software, and other devices for communications, navigations, IR transmitting and receiving, and any other suitable computerized or automated functions.

The delivery receptacle computing system **131** comprises a communication application **132** and a data storage unit **133**. The delivery receptacle computing system **131** may utilize a communication application **132** to receive data related to package deliveries. For example, the delivery receptacle computing system **131** may receive, via the communication application **132**, delivery times, arrival directions, package details, safe receiving areas, or other delivery information. The delivery receptacle computing system **131** may use the communication application **132** to communicate with the user computing device **110**. For example, the delivery receptacle computing system **131** may communicate that a package has been delivered. The delivery receptacle computing system **131** may utilize the data storage unit **133** for storing the information received via the communication application, and other suitable data.

The delivery receptacle **130** may comprise an IR detector **134**. The IR detector **134** may be any detector that captures infrared beacons or any other beacon. For example, the IR

detector **134** may detect laser guidance beacons, BLUETOOTH signals, Wi-Fi, or any other suitable beacon, communication, signal, or transmission. The delivery receptacle computing system **131** analyzes IR beacons to identify a location of the aerial delivery device **130**. The aerial delivery device computing system **121** determines a location of delivery receptacle **130** based on the analysis and navigates to the delivery receptacle **130**.

The delivery receptacle **130** comprises an IR beacon transmitter **135**. The IR beacon transmitter **135** may represent any beacon, signal or other transmission that is broadcast to the aerial delivery device **120**. The IR beacon transmitter **135** may broadcast the IR signal or other signal to the aerial delivery device **120** to allow the aerial delivery device **120** to be guided into a position to deposit a package. In example embodiments, the IR beacon transmitter **135** may alternatively be a laser guidance beacon, BLUETOOTH signal, Wi-Fi signal, or any other suitable beacon, communication, signal, or transmission.

The delivery receptacle **130** may utilize a particular configuration of IR beacon transmitters **135** to allow the aerial delivery device **120** to triangulate a relative position. In an example, the IR beacon transmitters **135** are located on four corners of the top surface of the delivery receptacle **130**. Additionally, the IR beacon transmitters **135** may be mounted to a movable device that can be used to change the direction of the transmission of the IR beacon transmitter **135**. For example, the IR beacon transmitters **135** may be mechanically rotated to provide a 360 degree broadcast range. That is, when the direction of an aerial delivery device **120** is identified, the IR beacon transmitters **135** may be rotated to a position such that the IR beacon transmitter **135** is transmitting in a direction in which the aerial delivery device **120** is located. In an example, the movable device is a motorized mechanism that may be directed by the delivery receptacle computing system **131**. In certain embodiments, the delivery receptacle computing system **131** utilizes a compass or other direction determining device to determine an aiming configuration.

Some functions described as being performed by one of the IR beacon transmitters **135**, the IR detector **134**, or the communication application **132** may alternatively be performed by one or more of the others applications or modules.

The delivery receptacle computing system **131** may also comprise a navigation system, such as a global positioning system (“GPS”) or other navigation system. For example, the delivery receptacle computing system **131** may have a mapping system stored in the data storage unit **123** that works alone or in conjunction with onboard GPS technology to assist the delivery receptacle computing system **131** with navigation. The delivery receptacle **130** may use the navigation system to position the delivery receptacle **130** for receiving a package, for moving a package to a safe location, or for any suitable reason.

It will be appreciated that the network connections shown are example and other means of establishing a communications link between the computers and devices can be used. Additionally, those having ordinary skill in the art having the benefit of the present disclosure will appreciate that the user computing device **110**, the aerial delivery device **120**, the delivery receptacle **130**, and the package delivery system **140** illustrated in FIG. **1** can have any of several other suitable computer system configurations. For example, a user computing device **110** embodied as a mobile phone or handheld computer, or an aerial delivery device, may or may not include all the components described above.

In example embodiments, the network computing devices and any other computing machines associated with the technology presented herein may be any type of computing machine such as, but not limited to, those discussed in more detail with respect to FIG. **8**. Furthermore, any modules associated with any of these computing machines, such as modules described herein or any other modules (scripts, web content, software, firmware, or hardware) associated with the technology presented herein may be any of the modules discussed in more detail with respect to FIG. **8**. The computing machines discussed herein may communicate with one another as well as other computer machines or communication systems over one or more networks, such as network **105**. The network **105** may include any type of data or communications network, including any of the network technology discussed with respect to FIG. **8**.

Example Processes

The example methods illustrated in FIGS. **2-6** are described hereinafter with respect to the components of the example operating environment **100**. The example methods of FIGS. **2-6** may also be performed with other systems and in other environments.

FIG. **2** is a block diagram depicting a method **200** for an aerial delivery device to deliver a package, in accordance with certain example embodiments. The method **200** is described with reference to the components illustrated in FIG. **1**.

In block **205**, a package is assigned for delivery. The package may be any product for delivery to user **101**, a merchant, or other recipient. The details of block **205** are described in greater detail in FIG. **3**.

FIG. **3** is a block diagram depicting a method **205** for a package to be assigned for delivery, in accordance with certain example embodiments. The method **205** is described with reference to the components illustrated in FIG. **1**.

In block **305**, a package delivery system **140** receives a package for delivery. The package delivery system **140** may be any system, company, organization, government service, or individual that delivers packages from one location to another. For example, the package delivery system **140** may be a courier, postal service, package delivery company, a merchant system, a retailer, or any other suitable system that delivers packages. The package for delivery arrives at the package delivery system **140** with appropriate paperwork for delivery to a user **101**. The paperwork may be digital, a barcode or other machine-readable code, a sticker, or any suitable paperwork. The paperwork may contain a user **101** name, a user address, a confirmation number, a sender name and address, and other identifying information for the recipient, sender, origin location, and/or delivery location **104**.

The delivery information may be provided by the sender of the package or by the user **101**. For example, the sender or the user **101** may enter the delivery information into a website of the package delivery system **140**. In another example, the sender or the user **101** may enter the delivery information into a delivery application **115** or in any suitable manner input delivery instructions that are communicated to the package delivery system **140**.

In block **310**, a destination address is associated with the package. For example, the package delivery system **140** obtains the delivery address from the paperwork or digital information associated with the package. The delivery address is stored with identification of the package in the package delivery system **140**.

In block **315**, the package delivery system **140** associates the package with an aerial delivery device computing system **121**. The package delivery system **140** may identify an aerial

delivery device **120** that is associated with a delivery area in which the delivery address is located. For example, certain aerial delivery devices **120** may be assigned a delivery route that encompasses a particular geographic region. If the delivery address is located in that geographic region, then the package may be associated with that particular aerial delivery device **120**. In an alternate embodiment, the package is associated with the aerial delivery device **120** that is next in a queue of aerial delivery devices **120**.

In block **320**, the instructions for delivery of the package are provided to the aerial delivery device computing system **121**. In an example embodiment, the instructions are delivered to the communication application **122** of the aerial delivery device computing system **121** via near field communication, Bluetooth, Wi-Fi, or any available communication. The instructions may be transmitted to the aerial delivery device computing system **121** by a computing system associated with the package delivery system **140**. For example, an operator of the package delivery system **140** may direct a computing system to deliver the instructions, or the operator may enter the instructions directly into a user interface of the aerial delivery device computing system **121**. Any suitable manner of transmitting the instructions to the aerial delivery device computing system **121** may be used.

For example, the package delivery system **140** provides to the aerial delivery device computing system **121** an address for a user residence. In another example, the package delivery system provides a GPS location to the aerial delivery device. Additionally, the aerial delivery device computing system **121** is provided with the infrared (“IR”) beacon or other signaling technology that is associated with the delivery receptacle **130** to which the package should be delivered. Any suitable instructions that will allow the aerial delivery device to locate the delivery location **104** may be used.

From block **320**, the method **305** returns to block **210** of FIG. **2**.

Returning to FIG. **2**, in block **210**, the user **101** is provided a time to expect the delivery. The delivery time may be transmitted to the user computing device **110** by the package delivery system **140**, a merchant system, or other entity. The user computing device **110** may store the expected delivery time or communicate the expected delivery time to the delivery receptacle **130** or another computing device. The user computing device **110** may display the expected delivery time to the user **101** via the user interface of the user computing device **110**. Alternatively, the time to expect the delivery is provided directly to the delivery receptacle computing system **131**. For example, the delivery time may be transmitted to the delivery receptacle computing system **131** via cellular or other wireless technology.

In block **215**, the user **101** is provided direction of arrival of the aerial delivery device **120** when delivering the package. The delivery time may be transmitted to the user computing device **110** by the package delivery system **140**, a merchant system, or other entity. The user computing device **110** may store the expected arrival direction or communicate the expected arrival direction to the delivery receptacle **130** or another computing device. The user computing device **110** may display the expected arrival direction to the user **101** via the user interface of the user computing device **110**. Alternatively, the direction of arrival is provided directly to the delivery receptacle computing system **131**. For example, the direction of arrival may be transmitted to the delivery receptacle computing system **131** via cellular or other wireless technology.

In block **220**, the package is loaded onto the aerial delivery device **120**. The package may be loaded in in any suitable manner that allows the aerial delivery device **120** to transport the package to the delivery location. For example, the aerial delivery device **120** may be equipped with a platform for supporting the package during transit. In another example, the aerial delivery device **120** may support the package with a strap, a hook, an attached net, a winch, or with any suitable attachment device. The package may be loaded with an automated packaging process. Alternatively, the package may be loaded manually by an operator at the package delivery system **140**. The aerial delivery device computing system **121** may receive a digital confirmation of the package’s identification from an operator or a computing system of the package delivery system **140**.

In block **225**, the aerial delivery device **120** transports the package to the address associated with the delivery destination. The aerial delivery device **120** may proceed to the address associated with the user **101**. For example the aerial delivery device **120** may fly to the address via a predetermined route. In an example embodiment, the aerial delivery device computing system **121** may navigate via a mapping program to proceed to the address by following a route provided by the mapping program to reach the destination address of the user **101**. In an alternative example embodiment, the aerial delivery device computing system **121** may navigate via a global positioning system (“GPS”) technology to the destination address of the user **101**. The aerial delivery device **120** may be transported a portion of the distance to the delivery address by a separate vehicle. For example, a delivery truck may deliver multiple aerial delivery devices **120** to within a location that is central to multiple delivery addresses. The aerial delivery device **120** then leaves the delivery truck and travels the remaining distance with the package.

In an example embodiment, the aerial delivery device **120** arrives at the address of the delivery location when the aerial delivery device **120** is on or above the street directly in front of the structure at the address. In another example, the aerial delivery device **120** hovers over the property located at the address. In an example, the aerial delivery device computing system **120** may confirm the arrival at the delivery address by comparing the appearance of the delivery address with a digital image of the digital address provided by the package delivery system **140** or other suitable provider.

In block **230**, the delivery receptacle **130** prepares for the delivery. Block **230** is described in greater detail with reference to FIG. **4**.

FIG. **4** is a block flow diagram depicting a method **230** for a delivery receptacle to prepare for a delivery, in accordance with certain example embodiments. The method **230** is described with reference to the components illustrated in FIG. **1**.

In block **405**, the delivery receptacle **130** receives the delivery data. The delivery receptacle **130** may receive the delivery data from the user computing device **110**, the package delivery system **140**, a merchant system, or any suitable device or system. The delivery data may include the delivery time, direction of arrival of a aerial delivery device **120**, the expected size and shape of the package, shipper identification, package delivery system **140** identification, data related to the product being delivered, or any suitable data. The data transmission may be received by the communication application **132** of the delivery receptacle **130**.

In block **410**, the delivery receptacle **130** moves to an accessible position to receive the delivery. In an example, the delivery receptacle **130** determines, based on the deliv-

ery data, that the package will fit inside the delivery receptacle **130** or can otherwise be accommodated. The delivery receptacle determines, based on the direction of arrival of the aerial delivery device **120** and other delivery data, an appropriate location to receive the package. For example, the location may be selected to allow a safe, secure deposit of the package. For example, if the user **101** has a pet that may be injured by rotating blades on the aerial delivery device, then a location that is raised above the ground may prevent the pet from reaching the aerial delivery device **120**. In another example, the delivery receptacle **130** may select a location that is not directly under power lines or an antenna. In another example, the delivery receptacle **130** may select a location that will prevent the package from being in view of passersby. The selection by the delivery receptacle **130** may be based on a configuration by the user **101** or another party, by an analysis of the environs of the delivery location, or any other suitable criteria.

The delivery receptacle **130** may move to the delivery location by any suitable manner. For example, the delivery receptacle **130** may identify a preferred delivery location on a stored map of the property. The delivery receptacle **130** may have a layout of the property stored on the delivery receptacle computing system **131**, or the delivery receptacle **130** may develop a layout by traversing some or all of the property. The preferred locations for deliveries may be stored on the layout.

The delivery receptacle **130** may move to the location by any of the described means of locomotion. For example the delivery receptacle **130** may initiate a power source that powers the delivery receptacle **130** to drive to the preferred location. In the example, the delivery receptacle **130** may be powered by an electric motor that drives the wheels to propel the delivery receptacle **130**.

FIG. 7 is an illustration of a delivery receptacle **130**, in accordance with certain example embodiments. The delivery receptacle **130** is illustrated as a cubic receptacle for receiving packages. On the top surface of the delivery receptacle **130** is a door **705** or other opening for receiving packages. The door **705** may open with pressure, with a mechanical or electrical motor, with a pneumatic actuation, or in any suitable manner. The door **705** will allow a package to be deposited into the delivery receptacle **130**. The door **705** may close after the package has been deposited.

The delivery receptacle **130** is shown with four IR beacon transmitters **135** on the four corners of the top surface. The IR beacon transmitters **135** are described in greater detail with respect to FIG. 1. The delivery receptacle **130** is shown with wheels affixed to the bottom surface for transporting the delivery receptacle **130** and received packages. The wheels **710** may be powered the drive mechanism **720**. The drive mechanism **720** may be an electrical or mechanical motor or other suitable power source that allows the delivery receptacle **130** to move freely from one location to another location. The wheels **710** may be constructed of metal, rubber, plastic, or any suitable material. The wheels **710** may be affixed to the delivery receptacle **130** in a typical manner, such as via an axle that is powered by an electrical motor. Any suitable wheeled construction may be used.

The delivery receptacle **130** is shown with a delivery receptacle computing system **131** and IR detector **134**. The delivery receptacle computing system **131** and IR detector **134** are described in greater detail with respect to FIG. 1.

In block **415**, the delivery receptacle **130** orients the IR beacons. After arriving at the preferred delivery location, the delivery receptacle **130** consults a device or system that orients the devices direction, such as a compass. The deliv-

ery receptacle **130** compares the direction from which the aerial delivery device **120** will arrive to the orientation of the delivery receptacle **130** based on the results provided by the compass. The delivery receptacle **130** determines the direction to orient the IR beacons such that the IR beacons are directed substantially at the arriving aerial delivery device **120**.

IR beacons that are directed substantially at the aerial delivery device **120** will allow the aerial delivery device **120** to more accurately receive the IR beacons and triangulate a path to the delivery receptacle **130**. The IR beacon transmitters **135** may represent any beacon, signal, or other transmission that is broadcast to the aerial delivery device **120**. The IR beacon transmitter **135** may broadcast the IR signal or other signal to the aerial delivery device **120** to allow the aerial delivery device **120** to be guided into a position to deposit a package. In example embodiments, the IR beacon transmitter **135** may alternatively be a laser guidance beacon, BLUETOOTH signal, Wi-Fi signal, or any other suitable beacon, communication, signal, or transmission.

In block **420**, the IR beacon transmitters **135** on the delivery receptacle **130** transmit the IR beacons. The IR beacon transmitters are directed by the delivery receptacle computing system **131** to begin transmitting the IR beacon. In an example, the IR beacon transmitters **135** are located on the four corners of the top surface of the delivery receptacle **130**. The IR beacon transmitters **135** may be mounted to a movable device that can be used to change the direction of the transmission of the IR beacon transmitter **135**. For example, the IR beacon transmitters **135** may be mechanically rotated to provide a 360 degree broadcast range. That is, when the direction of an aerial delivery device **120** is identified, the IR beacon transmitters **135** may be rotated to a position such that the IR beacon transmitter **135** is transmitting in a direction in which the aerial delivery device **120** is located. In an example, the movable device is a motorized mechanism that may be directed by the delivery receptacle computing system **131**.

From block **420**, the method **230** returns to block **235** of FIG. 2.

Returning to FIG. 2, in block **235**, the aerial delivery device **120** approaches the delivery location. Block **235** is described in greater detail with reference to FIG. 5.

FIG. 5 is a block flow diagram depicting a method **235** for an aerial delivery device to approach a delivery location, in accordance with certain example embodiments. The method **235** is described with reference to the components illustrated in FIG. 1.

In block **505**, the aerial delivery device **120** approaches the address associated with the delivery. In a certain embodiment, the aerial delivery device computing system **121** has not been provided with the positioning of the delivery receptacle **130** at the delivery address. For example, the aerial delivery device computing system **121** is only provided with information specifying that the delivery receptacle **130** is located on the property associated with the destination address. The aerial delivery device **120** may proceed to a position adjacent to or over the property at the delivery address to achieve an improved perspective. Alternatively, the aerial delivery device **120** may traverse the airspace over the property of the delivery address to allow the IR detector **124** to obtain a thorough coverage of the delivery address.

In certain embodiments, the aerial delivery device computing system **121** has been provided with information associated with the positioning of the delivery receptacle

13

130 at the delivery address. For example, if the package delivery system 140 provided information that the delivery receptacle 130 is located on the back patio, then the aerial delivery device 120 flies directly to an area from which the IR beacons may be detectable from the back patio. Other example delivery receptacle 130 locations might include on a front porch, on an upstairs balcony, behind a fence gate, on a loading dock, or in any suitable location. In an exemplary embodiment, the aerial delivery device 120 is provided with coordinates on the property from which the delivery receptacle 130 may be determined. If the aerial delivery device computing system 121 has been provided with the delivery receptacle 130 location or initial coordinates to determine the location, then the aerial delivery device 120 may proceed to that general location on the property of the user 101.

In block 510, the aerial delivery device computing system 121 locates the IR beacons. For example, the aerial delivery device computing system 121 utilizes an IR detector 124 or other detection devices to scan the delivery address in search of the IR beacons. The IR detector 124 recognizes one or more IR beacons being transmitted by the one or more IR beacon transmitters 135. The IR detector 124 recognizes the location of the one or more IR beacon transmitters 135 by triangulating the incoming IR beacons. For example, the aerial delivery device computing system 121 identifies one or more IR beacon sources and performs a triangulation algorithm based on the differences in the angle of the IR beacon, signal strength, distances from one IR beacon to another, or any other detectable feature of the one or more IR beacons. In an alternative embodiment, the aerial delivery device computing system 121 interprets any data provided in the IR beacon. For example, the IR beacon may contain data instructions to the aerial delivery device computing system 121 for delivery or other suitable data. Alternatively, as the IR beacon may be comprised of a beacon created by any suitable technology other than IR, the beacon may comprise any suitable data to allow the aerial delivery device computing system 121 to determine a delivery location.

In block 515, the aerial delivery device computing system 121 triangulates its position relative to the IR beacons. The aerial delivery device computing system 121 analyzes the one or more IR beacons and performs a triangulation algorithm that produces a location of the aerial delivery device 120 relative to the IR beacons. The aerial delivery device computing system 121 may utilize any suitable algorithm to locate the position of the delivery receptacle 130. The triangulation may be based on the determination of the location of a plurality of IR beacon transmitters 135. For example, the aerial delivery device computing system 121 may be provided data that specifies that the IR beacon transmitters 135 are located on the four top corners of a receptacle that is a cube with one meter sides. In the example, based on the known distance between the IR beacons and the angles at which the IR beacons are received, the aerial delivery device computing system 121 is able to determine the distance from the aerial delivery device 120 to the delivery receptacle 130 and the relative elevation difference.

In block 520, the aerial delivery device computing system 121 transmits the position of the aerial delivery device 120 to the delivery receptacle 130. The IR beacon transmitters 125 on the aerial delivery device 120 transmit IR beacons to be received by the IR detector 134 on the delivery receptacle 130. The IR beacon transmitters 125 may be directed by the aerial delivery device 120 to begin transmitting the IR beacon. The transmission from the aerial delivery device

14

120 may provide data or other information to the delivery receptacle 130. In another embodiment, the IR beacons may be used by the delivery receptacle 130 to locate the position of the aerial delivery device 120.

In an example, the IR beacon transmitter 125 is mounted to a movable device attached to the aerial delivery device 120 that can be used to change the direction of the transmission of the IR beacon transmitter 125. For example, the IR beacon transmitter 125 may be mechanically rotated to provide a 360 degree broadcast range. That is, when the direction of the delivery receptacle 130 is identified, the IR beacon transmitter 125 may be rotated to a position such that the IR beacon transmitter 125 is transmitting in a direction in which the delivery receptacle 130 is located. In an example, the movable device is a motorized mechanism that may be directed by the aerial delivery device computing system 121.

In block 525, the delivery receptacle 130 updates the transmission direction of the IR beacons transmitters 135. When the aerial delivery device 120 provides the IR beacon to the delivery receptacle 130, the delivery receptacle computing system 131 updates the position of the aerial delivery device 120 relative to the delivery receptacle 130. The delivery receptacle 130 adjusts the direction of the transmission of the IR beacon to the current location of the aerial delivery device 120. That is, if the aerial delivery device 120 has moved from the original direction of approach, then the IR beacon transmitters 135 are adjusted accordingly.

In block 530, the aerial delivery device 120 continually updates the trajectory. As the aerial delivery device 120 moves toward the location of the delivery receptacle 130, the aerial delivery device computing system 121 continually or periodically analyzes the location of the IR beacons transmitters 135 and adjusts the direction, the height, and the speed of the aerial delivery device 120. The aerial delivery device 120 may decrease the travel velocity as the delivery receptacle 130 is approached.

In block 535, the aerial delivery device 120 hovers over the delivery receptacle 130. The aerial delivery device 120 approaches the location of the delivery receptacle 130 by following the direction of the IR beacons. The aerial delivery device 120 hovers over an area for receiving the package. The area may be a chute, bay, door, or other location on the delivery receptacle 130 for receiving the package. The area may be specified based on instructions received by the aerial delivery device 120 from the delivery receptacle 130, the package delivery system 140, a merchant system, a user computing device 110, or other device. For example, the area may be specified as a location directly between two of the IR beacon transmitters 135.

In another example, the area for the delivery may be dictated by the configuration of the IR beacon transmitters 135. For example, the area may be the exact center of four IR beacon transmitters 135 on the corners of the delivery receptacle 130.

From block 535, the method 235 returns to block 240 of FIG. 2.

Returning to FIG. 2, in block 240, the aerial delivery device 120 deposits the package into the delivery receptacle 130. For example, the aerial delivery device 120 may lower the package via a retractable line or cable and then release the package onto the specified area of the delivery receptacle 130. In another example, the aerial delivery device 120 hovers over the delivery receptacle 130 and releases the package allowing the package to drop to the delivery platform, where the vertical drop distance is maintained below a predetermined threshold height to prevent damage to the

15

package. The aerial delivery device **120** may deposit the package in any suitable manner.

After depositing the package, the aerial delivery device computing system **121** may obtain a visual image verification that the package has been delivered. For example, the aerial delivery device computing system **121** may capture a digital image of the package resting in the delivery receptacle with a camera module located on the aerial delivery device computing system **121**. Any other manner of verifying the delivery may be utilized. The aerial delivery device computing system **121** stores a confirmation that the package has been delivered. Additionally or alternatively, the aerial delivery device computing system **121** transmits the delivery confirmation to the package delivery system **140** and/or to the user computing device **110**.

The aerial delivery device **120** returns to the package delivery system location or proceeds to deliver a subsequent package.

In block **245**, the delivery receptacle **130** transports the package to a secure location. Block **245** is described in greater detail with reference to the method **245** of FIG. **6**.

FIG. **6** is a block flow diagram depicting a method **245** for a delivery receptacle **130** to transport a package to a secure location, in accordance with certain example embodiments. The method **245** is described with reference to the components illustrated in FIG. **1**.

In block **605**, the delivery receptacle **130** identifies that a package is received. The delivery receptacle **130** may utilize any hardware or software to confirm that a package has been delivered. For example, the delivery receptacle **130** may have a proximity detector that recognizes that a package has been dropped into the body of the delivery receptacle **130**. The proximity detector may utilize any suitable detection technology, such as infrared, electromagnetic, photoelectric, or capacitive. In another example, the delivery receptacle **130** may use a pressure sensor to detect the presence of a package. In certain embodiments, the delivery receptacle **130** may rely on a communication from the aerial delivery device computing system **121** to determine that the package has been delivered.

In block **610**, the delivery receptacle **130** transports the package to a secure location. After receiving the delivery, the delivery receptacle **130** moves to a secure position to deposit or store the package. The delivery receptacle computing system **131** determines, based on the size, importance, or durability of the package, an appropriate location to store the package. The delivery receptacle computing system **131** provides instructions or other suitable signals to a driving mechanism or other motive mechanism to move the delivery receptacle **130** to the secure location.

The delivery receptacle **130** may move to the storage location by any suitable manner. For example, the delivery receptacle **130** may identify a preferred storage location on a stored map of the property. The delivery receptacle **130** may have a layout of the property stored on the delivery receptacle computing system **131**, or the delivery receptacle **130** may develop a layout by traversing some or all of the property. The preferred locations for storage may be stored on the layout.

The delivery receptacle **130** may move to the storage location by any of the described means of locomotion. For example, the delivery receptacle **130** may initiate a power source that powers the delivery receptacle **130** to drive to the preferred location. In the example, the delivery receptacle **130** may be powered by an electric motor that drives the wheels to propel the delivery receptacle **130**. In another

16

example, the delivery receptacle **130** uses articulated legs to walk to the preferred location.

In an example, the delivery receptacle **130** receives a package and transports the package to a secure location, such as a garage attached to a residence on the property. The delivery receptacle **130** may enter the garage via a door or other entrance. In another example, the delivery receptacle computing system **131** engages a locking mechanism on the door through which the package was deposited in the delivery receptacle **130**. That is, the package is secured within the body of the delivery receptacle **130**. In this example, the delivery receptacle **130** may transport the package to a docking station or other base for the delivery receptacle **130**. In this example, the delivery receptacle **130** may be automatically locked in the base to secure the delivery receptacle **130** and, thus, the package. The base may comprise a locking mechanism that prevents the delivery receptacle **130** from being removed or opened without authorization.

In another example, the package may be deposited in a mail slot if the package is sufficiently small. The delivery receptacle **130** may transport the package to a facility on the property, such as a house, and deposit the package in a slot or other depository via any automated mechanical process or material handling equipment. Any suitable mechanism or method may be used to secure the package and/or the delivery receptacle **130**.

In block **615**, the delivery receptacle **130** alerts the user computing device **110** of the package delivery. The alert may be provided by a communication via the communication module **132**. For example, the delivery receptacle computing system **131** may use a Wi-Fi signal or a cellular connection to provide an email or text to the user computing device **110** that the package has been received and is secured.

Other Example Embodiments

FIG. **8** depicts a computing machine **2000** and a module **2050** in accordance with certain example embodiments. The computing machine **2000** may correspond to any of the various computers, servers, mobile devices, embedded systems, or computing systems presented herein. The module **2050** may comprise one or more hardware or software elements configured to facilitate the computing machine **2000** in performing the various methods and processing functions presented herein. The computing machine **2000** may include various internal or attached components such as a processor **2010**, system bus **2020**, system memory **2030**, storage media **2040**, input/output interface **2060**, and a network interface **2070** for communicating with a network **2080**.

The computing machine **2000** may be implemented as a conventional computer system, an embedded controller, a laptop, a server, a mobile device, a smartphone, a set-top box, a kiosk, a vehicular information system, a television with one or more processors embedded therein and/or coupled thereto, a customized machine, any other hardware platform, or any combination or multiplicity thereof. The computing machine **2000** may be a distributed system configured to function using multiple computing machines interconnected via a data network or bus system.

The processor **2010** may be configured to execute code or instructions to perform the operations and functionality described herein, manage request flow and address mappings, and to perform calculations and generate commands. The processor **2010** may be configured to monitor and control the operation of the components in the computing machine **2000**. The processor **2010** may be a general purpose processor, a processor core, a multiprocessor, a recon-

figurable processor, a microcontroller, a digital signal processor (“DSP”), an application specific integrated circuit (“ASIC”), a graphics processing unit (“GPU”), a field programmable gate array (“FPGA”), a programmable logic device (“PLD”), a controller, a state machine, gated logic, discrete hardware components, any other processing unit, or any combination or multiplicity thereof. The processor **2010** may be a single processing unit, multiple processing units, a single processing core, multiple processing cores, special purpose processing cores, co-processors, or any combination thereof. According to certain embodiments, the processor **2010** along with other components of the computing machine **2000** may be a virtualized computing machine executing within one or more other computing machines.

The system memory **2030** may include non-volatile memories such as read-only memory (“ROM”), programmable read-only memory (“PROM”), erasable programmable read-only memory (“EPROM”), flash memory, or any other device capable of storing program instructions or data with or without applied power. The system memory **2030** may also include volatile memories such as random access memory (“RAM”), static random access memory (“SRAM”), dynamic random access memory (“DRAM”), and synchronous dynamic random access memory (“SDRAM”). Other types of RAM also may be used to implement the system memory **2030**. The system memory **2030** may be implemented using a single memory module or multiple memory modules. While the system memory **2030** is depicted as being part of the computing machine **2000**, one skilled in the art will recognize that the system memory **2030** may be separate from the computing machine **2000** without departing from the scope of the subject technology. It should also be appreciated that the system memory **2030** may include, or operate in conjunction with, a non-volatile storage device such as the storage media **2040**.

The storage media **2040** may include a hard disk, a floppy disk, a compact disc read only memory (“CD-ROM”), a digital versatile disc (“DVD”), a Blu-ray disc, a magnetic tape, a flash memory, other non-volatile memory device, a solid state drive (“SSD”), any magnetic storage device, any optical storage device, any electrical storage device, any semiconductor storage device, any physical-based storage device, any other data storage device, or any combination or multiplicity thereof. The storage media **2040** may store one or more operating systems, application programs and program modules such as module **2050**, data, or any other information. The storage media **2040** may be part of or connected to, the computing machine **2000**. The storage media **2040** may also be part of one or more other computing machines that are in communication with the computing machine **2000** such as servers, database servers, cloud storage, network attached storage, and so forth.

The module **2050** may comprise one or more hardware or software elements configured to facilitate the computing machine **2000** with performing the various methods and processing functions presented herein. The module **2050** may include one or more sequences of instructions stored as software or firmware in association with the system memory **2030**, the storage media **2040**, or both. The storage media **2040** may therefore represent examples of machine or computer readable media on which instructions or code may be stored for execution by the processor **2010**. Machine or computer readable media may generally refer to any medium or media used to provide instructions to the processor **2010**. Such machine or computer readable media associated with the module **2050** may comprise a computer software product. It should be appreciated that a computer

software product comprising the module **2050** may also be associated with one or more processes or methods for delivering the module **2050** to the computing machine **2000** via the network **2080**, any signal-bearing medium, or any other communication or delivery technology. The module **2050** may also comprise hardware circuits or information for configuring hardware circuits such as microcode or configuration information for an FPGA or other PLD.

The input/output (“I/O”) interface **2060** may be configured to couple to one or more external devices, to receive data from the one or more external devices, and to send data to the one or more external devices. Such external devices along with the various internal devices may also be known as peripheral devices. The I/O interface **2060** may include both electrical and physical connections for operably coupling the various peripheral devices to the computing machine **2000** or the processor **2010**. The I/O interface **2060** may be configured to communicate data, addresses, and control signals between the peripheral devices, the computing machine **2000**, or the processor **2010**. The I/O interface **2060** may be configured to implement any standard interface, such as small computer system interface (“SCSI”), serial-attached SCSI (“SAS”), fiber channel, peripheral component interconnect (“PCI”), PCI express (PCIe), serial bus, parallel bus, advanced technology attached (“ATA”), serial ATA (“SATA”), universal serial bus (“USB”), Thunderbolt, FireWire, various video buses, and the like. The I/O interface **2060** may be configured to implement only one interface or bus technology. Alternatively, the I/O interface **2060** may be configured to implement multiple interfaces or bus technologies. The I/O interface **2060** may be configured as part of all of or to operate in conjunction with, the system bus **2020**. The I/O interface **2060** may include one or more buffers for buffering transmissions between one or more external devices, internal devices, the computing machine **2000**, or the processor **2010**.

The I/O interface **2060** may couple the computing machine **2000** to various input devices including mice, touch-screens, scanners, electronic digitizers, sensors, receivers, touchpads, trackballs, cameras, microphones, keyboards, any other pointing devices, or any combinations thereof. The I/O interface **2060** may couple the computing machine **2000** to various output devices including video displays, speakers, printers, projectors, tactile feedback devices, automation control, robotic components, actuators, motors, fans, solenoids, valves, pumps, transmitters, signal emitters, lights, and so forth.

The computing machine **2000** may operate in a networked environment using logical connections through the network interface **2070** to one or more other systems or computing machines across the network **2080**. The network **2080** may include wide area networks (WAN), local area networks (LAN), intranets, the Internet, wireless access networks, wired networks, mobile networks, telephone networks, optical networks, or combinations thereof. The network **2080** may be packet switched, circuit switched, of any topology, and may use any communication protocol. Communication links within the network **2080** may involve various digital or an analog communication media such as fiber optic cables, free-space optics, waveguides, electrical conductors, wireless links, antennas, radio-frequency communications, and so forth.

The processor **2010** may be connected to the other elements of the computing machine **2000** or the various peripherals discussed herein through the system bus **2020**. It should be appreciated that the system bus **2020** may be within the processor **2010**, outside the processor **2010**, or

both. According to some embodiments, any of the processor **2010**, the other elements of the computing machine **2000**, or the various peripherals discussed herein may be integrated into a single device such as a system on chip (“SOC”), system on package (“SOP”), or ASIC device.

In situations in which the systems discussed here collect personal information about users, or may make use of personal information, the users may be provided with an opportunity or option to control whether programs or features collect user information (e.g., information about a user’s social network, social actions or activities, profession, a user’s preferences, or a user’s current location), or to control whether and/or how to receive content from the content server that may be more relevant to the user. In addition, certain data may be treated in one or more ways before it is stored or used, so that personally identifiable information is removed. For example, a user’s identity may be treated so that no personally identifiable information can be determined for the user, or a user’s geographic location may be generalized where location information is obtained (such as to a city, ZIP code, or state level), so that a particular location of a user cannot be determined. Thus, the user may have control over how information is collected about the user and used by a content server.

Embodiments may comprise a computer program that embodies the functions described and illustrated herein, wherein the computer program is implemented in a computer system that comprises instructions stored in a machine-readable medium and a processor that executes the instructions. However, it should be apparent that there could be many different ways of implementing embodiments in computer programming, and the embodiments should not be construed as limited to any one set of computer program instructions. Further, a skilled programmer would be able to write such a computer program to implement an embodiment of the disclosed embodiments based on the appended flow charts and associated description in the application text. Therefore, disclosure of a particular set of program code instructions is not considered necessary for an adequate understanding of how to make and use embodiments. Further, those skilled in the art will appreciate that one or more aspects of embodiments described herein may be performed by hardware, software, or a combination thereof, as may be embodied in one or more computing systems. Moreover, any reference to an act being performed by a computer should not be construed as being performed by a single computer as more than one computer may perform the act.

The example embodiments described herein can be used with computer hardware and software that perform the methods and processing functions described herein. The systems, methods, and procedures described herein can be embodied in a programmable computer, computer-executable software, or digital circuitry. The software can be stored on computer-readable media. For example, computer-readable media can include a floppy disk, RAM, ROM, hard disk, removable media, flash memory, memory stick, optical media, magneto-optical media, CD-ROM, etc. Digital circuitry can include integrated circuits, gate arrays, building block logic, field programmable gate arrays (FPGA), etc.

The example systems, methods, and acts described in the embodiments presented previously are illustrative, and, in alternative embodiments, certain acts can be performed in a different order, in parallel with one another, omitted entirely, and/or combined between different example embodiments, and/or certain additional acts can be performed, without

departing from the scope and spirit of various embodiments. Accordingly, such alternative embodiments are included in the invention claimed herein.

Although specific embodiments have been described above in detail, the description is merely for purposes of illustration. It should be appreciated, therefore, that many aspects described above are not intended as required or essential elements unless explicitly stated otherwise. Modifications of, and equivalent components or acts corresponding to, the disclosed aspects of the example embodiments, in addition to those described above, can be made by a person of ordinary skill in the art, having the benefit of the present disclosure, without departing from the spirit and scope of embodiments defined in the following claims, the scope of which is to be accorded the broadest interpretation so as to encompass such modifications and equivalent structures.

What is claimed is:

1. A computer-implemented method to automate package deliveries, comprising:
 - receiving from a package delivery system processor, by one or more computing devices associated with a delivery device, delivery information associated with a package, the delivery information comprising a delivery location and instructions for the delivery device to approach the delivery location from a particular direction, the instructions further being provided to a delivery receptacle to provide a basis for directing one or more first beacons at the delivery location prior to arrival of the delivery device;
 - transporting, by the delivery device, the package to the delivery location;
 - locating, by the delivery device, the one or more first beacons being transmitted by the delivery receptacle at the delivery location; and
 - depositing, by the delivery device, the package into the delivery receptacle.
2. The method of claim 1, further comprising:
 - triangulating, by the one or more computing devices associated with the delivery device, a position of the delivery vehicle relative to the one or more first beacons;
 - navigating, by the one or more computing devices associated with the delivery device, the delivery device toward the delivery receptacle based on the triangulated position;
 - transmitting, by the one or more computing devices associated with the delivery device, a second beacon to the delivery receptacle, the second beacon providing a basis for the delivery receptacle to adjust a direction of the one or more first beacons during navigation of the delivery device toward the delivery receptacle; and
 - adjusting, by the one or more computing devices associated with the delivery receptacle, the direction of the one or more first beacons based on a determined position of the delivery device.
3. The method of claim 2, wherein the direction of the one or more first beacons is adjusted by a mechanical device.
4. The method of claim 1, wherein the one or more first beacons are infrared beacons.
5. The method of claim 1, wherein the one or more first beacons are located on a top surface of the delivery receptacle.
6. The method of claim 1, further comprising communicating, by the one or more computing devices associated with the delivery device, a notice that the package has been delivered to the delivery receptacle.

21

7. The method of claim 1, wherein the delivery information associated with the delivery address further comprises a GPS location of the delivery location.

8. The method of claim 1, wherein the delivery information associated with the delivery location further comprises an address associated with the delivery location.

9. The method of claim 1, wherein the delivery device is an unmanned aerial delivery device.

10. A system to deliver packages in specified locations, comprising:

a storage device associated with a delivery device; and
a processor communicatively coupled to the delivery device storage device, wherein the processor executes application code instructions that are stored in the storage device to cause the system to:

receive, from a package delivery computing system, delivery information associated with a package, the delivery information comprising a delivery location and instructions for the delivery device to approach the delivery location from a particular direction;

transport the package to the delivery address;

detect one or more first beacons being transmitted by a delivery receptacle at the delivery address; and

deposit the package into the delivery receptacle, and a delivery receptacle storage device; and

a processor communicatively coupled to the delivery receptacle storage device, wherein the processor executes application code instructions that are stored in the delivery receptacle storage device to cause the system to:

receive a communication that the delivery device is transporting the package to the delivery receptacle, provide a basis for directing one or more first beacons at a direction of approach of the delivery location prior to arrival of the delivery device;

transmit the one or more first beacons in an expected direction of arrival of the delivery device.

11. The system of claim 10, wherein the one or more first beacons are infrared beacons.

12. The system of claim 10, wherein the one or more first beacons are located on a top surface of the delivery receptacle.

13. The system of claim 10, wherein the delivery device is an unmanned aerial delivery device.

14. A computer program product, comprising:

a non-transitory computer-readable medium having computer-executable program instructions embodied thereon that when executed by a computer cause the computer to receive packages, the computer-executable program instructions comprising:

computer-executable program instructions to receive a communication that a delivery device is transporting a package to a delivery receptacle and instructions to

22

provide a basis for directing one or more first beacons at a direction of approach of the delivery location prior to arrival of the delivery device; and computer-executable program instructions to transmit one or more first beacons in an expected direction of arrival of the delivery device.

15. The computer program product of claim 14, wherein the one or more first beacons are infrared beacons.

16. The computer program product of claim 14, wherein the one or more first beacons are located on a top surface of the delivery receptacle.

17. The computer program product of claim 14, wherein the delivery device is an unmanned aerial delivery device.

18. The computer program product of claim 14, further comprising:

computer-executable program instructions to receive a second beacon from the delivery device;

computer-executable program instructions to determine a relative position of the delivery device with respect to the delivery receptacle based on the received second beacon; and

computer-executable program instructions to adjust the transmission direction of the one or more first beacons based on the relative position of the delivery device with respect to the delivery receptacle, wherein the direction of the one or more first beacons is adjusted by a mechanical device.

19. The computer program product of claim 10, the application code instructions executed on the processor communicatively coupled to the delivery device storage device being further executed to cause the system to:

navigate toward the delivery receptacle based on the detected one or more first beacons; and

transmit a second beacon to the delivery receptacle, the second beacon providing a basis for the delivery receptacle to adjust a direction of the one or more first beacons during navigation of the delivery device toward the delivery receptacle.

20. The computer program product of claim 10, the application code instructions executed on the processor communicatively coupled to the delivery receptacle storage device being further executed to cause the system to:

receive the second beacon from the delivery device; determine a relative position of the delivery device with respect to the delivery receptacle based on the second beacon;

adjust the transmission direction of the one or more first beacons based on the relative position of the delivery device with respect to the delivery receptacle, wherein the direction of the one or more first beacons is adjusted by a mechanical device; and

receive the package from the delivery device.

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